APPENDIX E

Noise and Vibration Technical Report

Bus Rapid Transit

SR 522 corridor

Noise and Vibration Technical Report

March 2021

SoundTransit

Summary

The SR 522/NE 145th BRT Project (project) is part of a new bus rapid transit (BRT) system that would provide fast, frequent and reliable bus service along the State Route (SR) 522/NE 145th project corridor, with interconnections to light rail and other bus service in the region. The project includes capital improvements and BRT service along 9 miles of roadway from the Sound Transit Link light rail Shoreline South/148th Station to the SR 522/I-405 Transit Hub. The project includes constructing business access and transit lanes, signal upgrades for transit speed and reliability, three park-and-ride garages (in Lake Forest Park, Kenmore and Bothell), and twelve BRT stations.

The proposed project includes transit priority improvements (e.g., bus access and transit lanes, transit queue bypass lanes, transit signal priority), new transit stations, new park-and-ride garages, frequent service operating 17 to 19 hours per day, and a dedicated fleet of uniquely branded, new BRT buses. An important note is that 10 of the 12 new uniquely branded BRT buses would be 100 percent Battery Electric Buses (BEBs), greatly reducing the noise and emissions from BRT operations.[1]

This technical report presents a noise and vibration impact study for the project. The objective of the study was to assess potential noise and vibration impacts of the project. The potential noise and vibration impacts from the proposed project were evaluated using the current Federal Transit Administration (FTA) *Transit Noise and Vibration Impact Assessment* (September 2018) methodology.

The noise analysis was performed for 786 residences, churches, schools, parks and other noise-sensitive land uses in the corridor. Overall, the change in noise levels with the project would be from -1 to +1 decibels (dB), a change that is not discernible to most people. The low change in the overall noise levels would be due to the mostly electric fleet of buses and high existing noise levels in the entire corridor. In some locations, slight realignment of the roadway could result in a slight decrease in total noise, resulting in the 1 dB reduction projected by the analysis. BRT operations would result in no noise impacts.

A noise analysis of the three proposed park-and-ride garages was also performed. Results of the analysis were compared to the FTA criteria as well as to each local jurisdiction's noise control code. The analysis identified no noise impacts related to the park-and-ride garages, in part because of the limited capacity of each garage (300 stalls) and the noise reduction provided by the walls of the park-and-ride garage structures.

The analysis did not find that any vibration impacts would occur during project operation because the use of rubber-tired on-road vehicles (the BRT buses) produces low levels of vibration.

[1] Twelve buses would be in use on the route at any one time. A total of 14 buses would be available for the service, including 2 backup buses and 10 BEBs.

This report also includes an analysis of potential construction noise and a review of construction noise regulations for each jurisdiction. No construction noise or vibration impacts are anticipated to occur with the project, beyond those typical for a roadway paving project or construction of a new multistory building.

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Acronyms and Abbreviations

BAT	business access and transit
BEB	Battery Electric Bus
BMC	Bothell Municipal Code
BRT	bus rapid transit
dB	decibels
dBA	A-weighted decibels
EDNA	Environmental Designation for Noise Abatement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
Hz	Hertz
I-405	Interstate 405
I-5	Interstate 5
KMC	Kenmore Municipal Code
Ldn	Day-Night Equivalent Sound Level
Leq	equivalent sound level
LFPMC	Lake Forest Park Municipal Code
mph	miles per hour
PPV	peak particle velocity
RCNM	Roadway Construction Noise Model
RMS	Root Mean Square
SEPA	State Environmental Policy Act
SMC	Seattle Municipal Code
SR	State Route
TSP	transit signal priority
UW	University of Washington
VdB	vibration decibels
WAC	Washington Administrative Code
WMC	Woodinville Municipal Code
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

This technical report presents a noise and vibration impact study for the Sound Transit SR 522/NE 145th BRT Project (project). The objective of the study was to assess the potential noise and vibration impacts of the proposed project.

Section 2 of this report describes the project; Section 3 discusses environmental noise and vibration basics; and Section 4 describes the criteria used to assess noise and vibration impacts, and any contacts and coordination required to complete the study. The methods of analysis are described in Section 5. Section 6 summarizes the affected environment, existing noise and vibration conditions and measurement results, and Section 7 summarizes the noise and vibration projections with the project and the impact assessment. Finally, Section 8 discusses any potential noise and vibration project mitigation.

There are several appendices included with this report: **Appendix A** (References) provides references; **Appendix B** (Introduction to Acoustics) is a detailed introduction to acoustics; **Appendix C** (Noise Monitoring Locations) contains noise monitoring location photos and details; **Appendix D** (Traffic Data and Counts) contains traffic data and counts; and **Appendix E** (Noise Modeling Results) contains the noise modeling results and related details.

2. PROJECT DESCRIPTION

The SR 522/NE 145th BRT Project is part of a new bus rapid transit (BRT) system that would provide fast, frequent, and reliable bus service along the State Route (SR) 522/NE 145th project corridor, with interconnections to light rail and other bus service in the region. The project would provide BRT service (to be called "Stride") along about 9 miles of roadway between the Sound Transit Shoreline South/148th Station link light rail station[2] and the SR 522/I-405 Transit Hub. The transit hub is in the design phase and is being provided by the Washington Department of Transportation (WSDOT) I-405/SR 522 Vicinity to SR 527 Express Toll Lanes Improvement Project.

The project would include business access and transit (BAT) lanes, transit queue bypass lanes, signal upgrades and transit signal priority (TSP) for transit speed and reliability, three new park-and-ride garages (Lake Forest Park, Kenmore and Bothell), and twelve BRT stations[3] between the Shoreline South/148th Link light rail station and the SR 522/I-405 Transit Hub.

The project would also include constructing or reconstructing sidewalks where BAT lanes and transit queue bypass lanes are constructed and at some intersections in the immediate vicinity of BRT stations. Some transit queue bypass lanes and BAT lanes would result in roadway widening. Intersection and sidewalk construction includes upgrading curb ramps to current Americans with Disabilities Act standards.

[2] Environmental review of the Shoreline South/148th Station occurred as part of the Sound Transit Lynnwood Link Extension Project State Environmental Policy Act Environmental Impact Statement.
[3] Each station proposed for construction as part of this project includes an eastbound platform and a westbound platform.

Right-of-way acquisitions and easements would occur to allow for construction and operation of the BRT service and related access improvements. Stormwater management would be provided as needed to comply with pertinent law and codes. Utility connections would be provided as necessary.

Most BRT station platforms (e.g., the sidewalk that the shelter sits upon) would be double-length platforms (accommodating two 60-foot coaches) to accommodate shared use by Sound Transit with King County Metro and Community Transit buses (the three transit agencies operating in the corridor). SR 522/NE 145th BRT service would be provided with 12 three-door articulated coaches with the Stride brand, including 10 Battery Electric Buses (BEBs) and 2 diesel hybrid buses. Service headways (the amount of time between bus arrivals at a stop) would be 10 minutes, which translates to 12 total BRT vehicles per hour along the project corridor. Sound Transit would prioritize use of the BEBs for this service as much as possible, and the BEBs (rather than the diesel hybrid buses) would be the bus type used for most of the service, all day. The span of service would be 19 hours on Monday through Saturday and 17 hours on Sunday. The estimated 2042 ridership forecast for the SR 522/NE 145th BRT system is approximately 8,900 riders per day.

Station shelters would have a consistent look and feel throughout the BRT system, but individual platform design would vary based on site conditions and transit integration assumptions at each location. Each station would include Stride-branded shelters, lighting, and most platforms would be elevated 9 inches to ease boarding and alighting. Platform types would be either flow-through (sidewalk passes through the platform) or pass-behind (sidewalk passes behind the platform). The project would also include intelligent transportation systems elements: off-board fare payment, electronic rider information with bus arrival times, Computer-Aided Dispatch/Automatic Vehicle Location, TSP, and enhanced safety and security at certain stations.

Figure 2-1 (SR 522/NE 145th BRT Project) shows the proposed project, including the route, station locations and park-and-ride garage locations. The State Environmental Policy Act (SEPA) Checklist document includes layouts for the three park-and-ride garages. This report reflects the project as described and as shown in the Conceptual Engineering Design Plans (see Appendix A of the SEPA Checklist).

The following is a summary of the proposed project’s major elements, by segment:

- **Segment 1: Seattle/Shoreline** (NE 145th Street): westbound transit queue bypass lane on NE 145th Street between a point east of 8th Avenue NE and 5th Avenue NE, transit queue bypass lanes on NE 145th Street at 15th Avenue NE in each direction, two stations (15th Avenue NE and 30th Avenue NE), and an additional lane eastbound on NE 145th Street approaching SR 522 to provide a shared bus left-turn/general-purpose traffic through lane.

- **Segment 2: Lake Forest Park**: northbound/eastbound BAT lane from approximately NE 145th Street to south of Brookside Boulevard NE; reconstructed BAT lane southbound/westbound between Beach Drive and 38th Avenue NE; a new 300-stall park-and-ride garage located at the Lake Forest Park Town Center; three stations (NE 153rd Street, NE 165th Street and Lake Forest Park Town Center); retaining walls in certain locations; and minor roadway, roadside and intersection improvements in certain locations where other improvements would occur.
- **Segment 3: Kenmore**: three stations (61st Avenue NE, 68th Avenue NE and Kenmore Park-and-Ride) and a new park-and-ride garage providing 300 additional stalls at the Kenmore Park-and-Ride, including vehicle access modification.
- **Segment 4: Bothell**: northbound/eastbound center bus-only lane to bus-only left-turn lane along SR 522 beginning approximately 700 feet south of Hall Road (just north of the Yakima Fruit Market & Nursery) to 98th Avenue NE; four stations (98th Avenue NE at NE 182nd Street, NE 185th Street at 104th Avenue NE, Beardslee Boulevard at University of Washington [UW] Bothell/Cascadia College, and Beardslee Boulevard near NE 195th Street); a new park-and-ride garage at a site (northwest of where 98th Avenue NE would meet NE 185th Street) providing 300 net additional parking spaces; new traffic signal and intersection reconstruction on NE 185th Street at 104th Avenue NE and at Beardslee Boulevard; and sidewalks, planting strips and minor intersection improvements at certain locations where other improvements would occur.

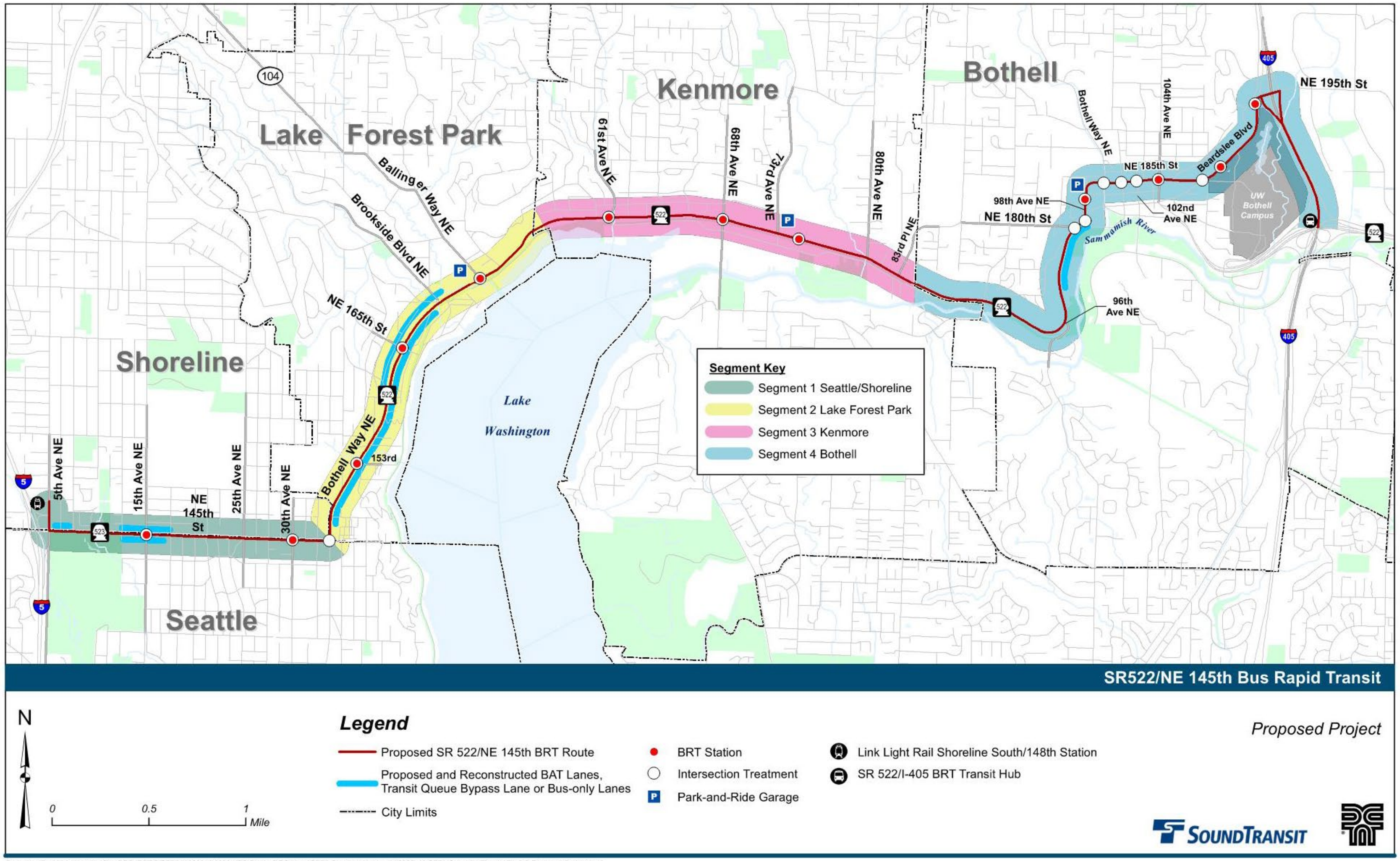

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Figure 2-1 SR 522/NE 145th BRT Project

3. INTRODUCTION TO ACOUSTICS AND VIBRATION

This section introduces acoustics and vibration. It also includes discussion of the typical noise and vibration measurement descriptors that are used in this report to document the noise and vibration levels for the construction and operation of the proposed project.

3.1. Introduction to acoustics

What we hear as sound is a series of continuous air pressure fluctuations superimposed on the atmospheric pressure that surrounds us. The amplitude of fluctuation is related to the energy carried in a sound wave; the greater the amplitude, the greater the energy and the louder the sound. The full range of sound pressures encountered in the world is so great that it is more convenient to compress the range by using a logarithmic scale, resulting in the fundamental descriptor used in acoustics, the sound pressure level, in decibels (dB). When sounds are unpleasant, unwanted, or disturbingly loud, we tend to classify them as noise.

Another aspect of sound is the quality described as its pitch. Pitch is established by frequency, which is a measure of how rapidly a sound wave fluctuates as measured in cycles per second or Hertz (Hz). Most sounds are a composite of many individual frequencies. When a sound is analyzed, its energy content at individual frequencies is displayed over the frequency range of interest, usually the range of human audibility, from about 20 Hz to about 20,000 Hz. This display is called a frequency spectrum.

Sound is measured using a sound level meter with a microphone designed to respond accurately to all audible frequencies. The human hearing system does not respond equally to all frequencies. Low frequency sounds below about 400 Hz are progressively and severely attenuated, as are high frequencies above 8,000 Hz. To approximate the way humans interpret sound, a filter circuit with frequency characteristics similar to the human hearing mechanism is built into sound level meters. Measurements with this filter enacted are called A-Weighted Sound Levels, expressed in dBA.

Community noise is usually characterized in terms of the A-weighted sound level. **Figure 3-1** (Typical A-weighted sound levels) illustrates the A-weighted levels of common sounds. When sounds exceed 110 dBA, there is a potential for hearing damage, even with relatively short exposures. In quiet suburban areas far from major freeways, the noise levels during the late-night hours will drop to about 30 dBA. Outdoor noise levels lower than this only occur in isolated areas where there is a minimum of natural noises such as leaves blowing in the wind, crickets or flowing water.

Another characteristic of environmental noise is that it is constantly changing. The increase in noise level that occurs when a train passes is an example of a short-term change. The lower average noise levels during nighttime hours, when human activities are at a minimum, and the higher noise levels during daytime hours are daily patterns of noise level fluctuation. The instantaneous A-weighted sound level is insufficient to describe the overall acoustic “environment.” A more useful descriptor is the Day-Night Equivalent Sound Level, Ldn, which is defined as the 24-hour equivalent sound level (Leq) but with a 10 dB penalty assessed to noise events occurring at night (defined as 10 p.m. to 7 a.m.). The effect of this penalty is that any event during the nighttime hours is equivalent to 10 events during the daytime hours. This strongly weights Ldn toward nighttime noise to reflect the fact that most people are more easily annoyed by noise during the nighttime hours, when background noise levels are lower and most people are sleeping.

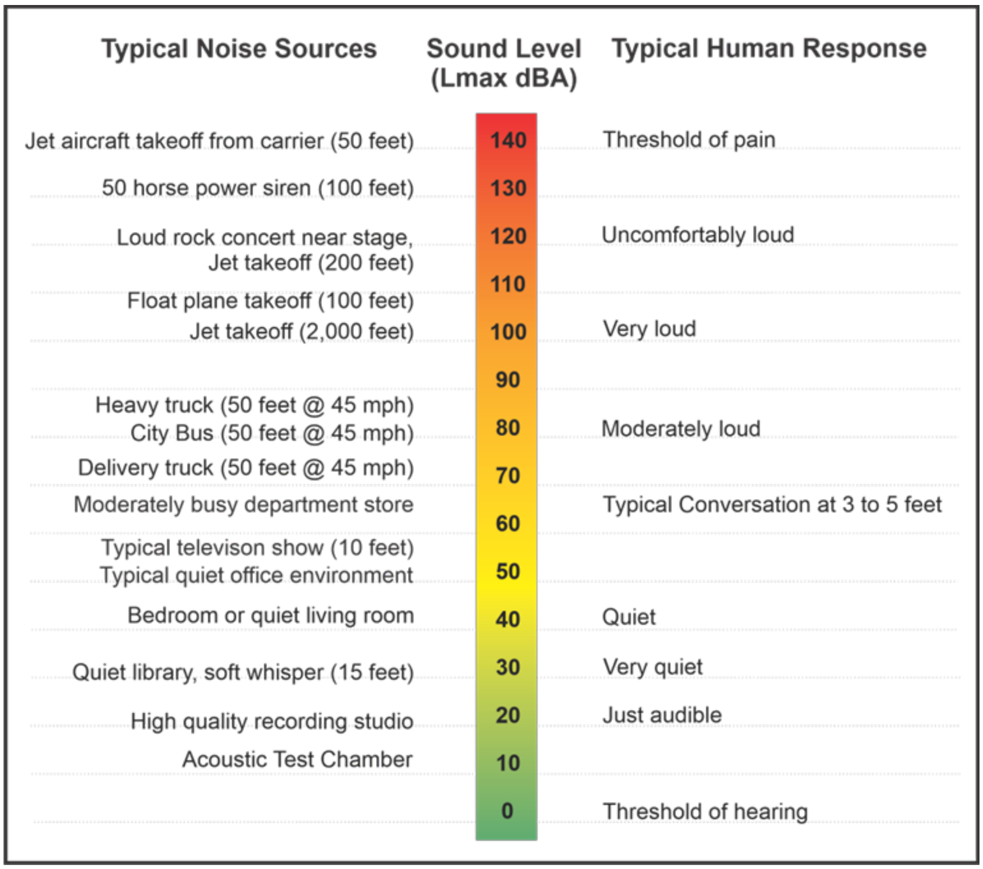
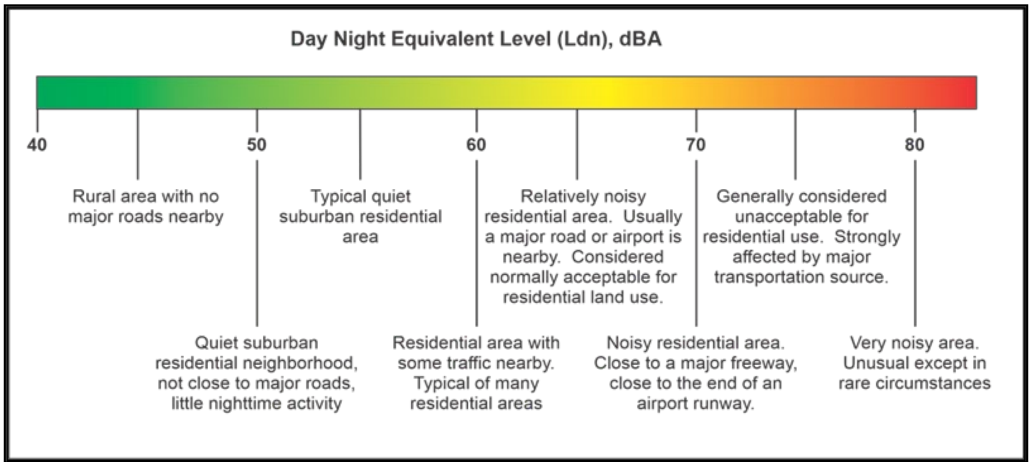


Figure 3-1 Typical A-weighted sound levels

Environmental impact assessments for high-capacity transit projects in the United States typically use Ldn to describe the community noise environment. Studies of community response to a wide variety of noises indicate that Ldn is a good measure of the noise environment. Efforts to derive measures that are better correlated to community response have not been successful, although there are still efforts in the acoustical community to develop improved measures. **Figure 3-2** (Typical Ldn levels) defines typical community noise levels in terms of Ldn. Most urban and suburban neighborhoods will be in the range of Ldn 50 dBA to 70 dBA. An Ldn of 70 dBA is a relatively noisy environment that might be found at buildings on a busy surface street, close to a freeway or near a busy airport. It would usually be considered unacceptable for residential land use without special measures taken to enhance outdoor-indoor sound insulation. Residential neighborhoods that are not close to major sound sources will usually be in the range of Ldn 55 dBA to 60 dBA. If there is a freeway or moderately busy arterial nearby or any nighttime noise, Ldn is usually in the range of 60 dBA to 65 dBA.



Source: FTA 2018.

Figure 3-2 Typical Ldn levels

3.1.1. General rules related to community noise

Some general rules related to community noise are:

- A 3 dB change is the minimum most people can detect in most environments.
- Under free-field conditions, where there are no reflections or additional attenuations, a *point sound source* is known to decrease at a rate of 6 dB for each doubling of distance. This is commonly known as the inverse square law. For example, a sound level of 70 dB at a distance of 100 feet would decrease to 64 dB at 200 feet. However, traffic on a busy roadway is a *line source*, which reduces at approximately 3 dB for each doubling of distance.
- Sounds such as sirens, bells and horns are more noticeable and more annoying than normal noise.
- A 10 dB increase in sound level is perceived as an approximate doubling of the loudness of the sound and represents a substantial change in loudness.

3.1.2. Decibel mathematics

An important factor to recognize is that noise is measured on a decibel scale and combining two noise sources is not achieved by simple addition. For example, combining two 60 dB noise sources does not give 120 dB (which is near the pain threshold), but yields 63 dB, which is lower than the volume at which most people listen to their TVs. For reference, if two noise sources are 10 dB apart, for example 50 dB and 60 dB, the sum of the two noise levels will simply be the louder of the two, in this case 60 dB. This is to say that for similar noise sources that are 10 dB apart in magnitude, a person would only be able to hear the louder of the two sources.

Examples of simplified decibel addition, based on the difference between the two levels, are provided below for reference, to aid in the understanding of the total project noise and impact analysis presented in this report.

Difference between the two noise sources	Amount added to the higher of the two noise levels
0 to 1 dB	3 dB
2 to 3 dB	2 dB
4 to 9 dB	1 dB
10 dB or more	0 dB

This information is important, because it is used to add the new noise (the noise related to the BRT project) to the existing measured noise levels along the project corridor, providing the new total noise with the project. For example, if BRT noise was 4 dB to 9 dB below the existing noise levels, the project-related increase would be approximately 1 dB or less, an increase which is not perceptible to an average person.

3.2. Introduction to vibration

Ground-borne vibration consists of oscillatory waves that propagate from the source through the ground to adjacent buildings. Although the vibration is sometimes noticeable outdoors, it is almost exclusively an indoor problem. The primary concern is that the vibration and radiated noise can be intrusive and annoying to building occupants.

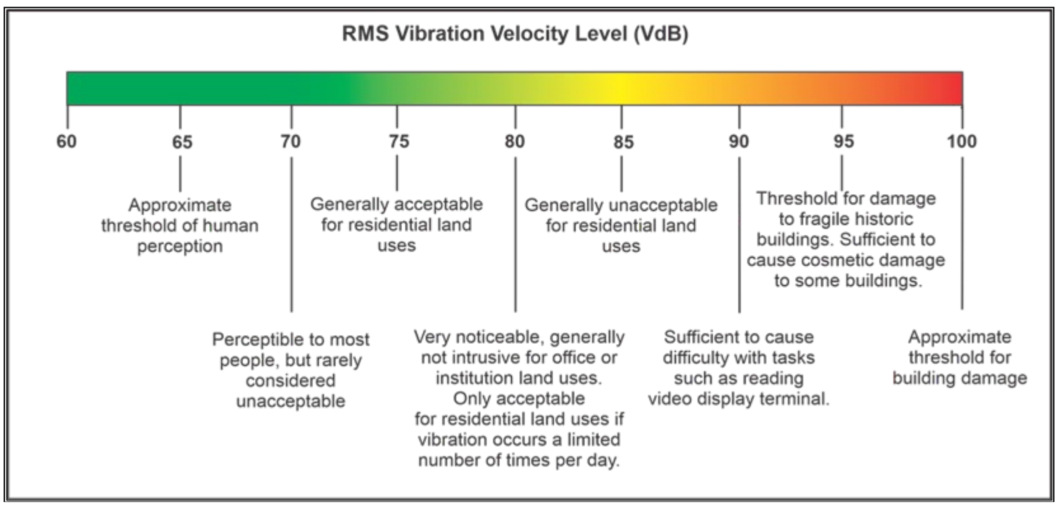
Factors that influence the amplitude of ground-borne vibration from vehicles include vehicle suspension parameters, condition of the wheels, type of building foundation, the properties of the soil and rock layers through which the vibration propagates, and the condition of the roadway.

Although all vehicular traffic causes some level of ground-borne vibration, the vibration is not usually perceptible because of the vibration isolation characteristics of the pneumatic tires and suspension systems. For vehicles with rubber tires, most of the vibration produced is absorbed by the tires and the suspension system, and vibration is usually only a problem if the roadway surface is very rough or has potholes and other abnormalities.

Vibration velocity is usually given in terms of either inches per second or decibels. The following equation defines the relationship between vibration velocity in inches per second and decibels:

Lv = 20 x log (V/Vref): where V is the velocity amplitude in inches/second; Vref is 10-6 inches/second; and Lv is the velocity level in decibels.

The abbreviation VdB is used for vibration decibels in this report, to minimize confusion with sound decibels. **Figure 3-3** (Typical RMS vibration levels) gives a general idea of human and building response to different levels of vibration. Existing background building vibration is usually in the range of 40 VdB to 50 VdB, which is well below the range of human perception. Although the perceptibility threshold is about 65 VdB, human response to vibration is usually not bothersome unless the Root Mean Square (RMS) vibration velocity level exceeds 70 VdB. Buses and trucks rarely create vibration that exceeds 70 VdB unless there are large bumps or potholes in the road and the travel lanes are close to the structure.



Source: FTA 2018.

Figure 3-3 Typical RMS vibration levels

4. REGULATIONS AND STANDARDS

This section of the report describes the methods and data the project team used to assess potential long-term noise and vibration impacts of the proposed project. The assessment of potential noise and vibration impacts from the project was based on the current Federal Transit Administration (FTA) *Transit Noise and Vibration Impact Assessment* (September 2018), which this report refers to as the FTA Manual (2018). Other regulatory information and ordinances reviewed and applicable to the project include the Washington Administrative Code (WAC) and codes and ordinances from the cities of Seattle, Shoreline, Lake Forest Park, Kenmore and Bothell.

The FTA criteria recommend the use of the Federal Highway Administration (FHWA) regulations for traffic noise analysis on roadways directly affected by the project. In Washington state this would be the WSDOT regulations. However, traffic noise is only considered if the project includes certain specific elements. Section 4.1.5 discusses in more detail the FHWA and WSDOT regulations and criteria with respect to traffic noise.

In addition to analyzing noise and vibration from operation of the project, this report discusses noise and vibration from construction of the project. The methods for analyzing construction noise and vibration follow the methods given in the FTA Manual (2018). Local noise control regulations and ordinances for construction noise were reviewed and considered and are summarized in the following sections. All the jurisdictions exempt most construction activities during daytime hours and require noise variances for nighttime work; therefore, the analysis of construction noise and vibration use the FTA-recommended construction noise and vibration levels.

4.1. Federal regulatory information

Based on FTA's guidance and a review of the design specifics of the project, the project study team followed the General Assessment as defined in the FTA Manual (2018) for the noise analysis. Because the project would use only rubber-tired vehicles and because vibration impacts are unlikely, the vibration analysis also used the General Assessment methods as defined in the FTA Manual (2018). All locations that were identified to have project-related noise or vibration impacts were considered for mitigation measures.

4.1.1. FTA transit operational noise criteria

Transit operational noise impacts of the project were determined based on the criteria defined in the FTA Manual (2018). The FTA noise impact criteria are based on documented research on community reaction to noise and on change in noise exposure rated using a sliding scale. Although more transit noise is allowed in neighborhoods with high levels of existing noise, as existing noise levels increase, smaller increases in total noise exposure are allowed than in areas with lower existing noise levels. The FTA noise impact criteria group noise-sensitive land uses into the following three categories:

Category 1: Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and land uses that rely upon a quiet background, such as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included in this category are recording studios and concert halls.

Category 2: Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.

Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material. Places for meditation or study, cemeteries, monuments, museums, campgrounds and recreational facilities are also considered to be in this category. Certain historical sites and parks are also included, but their sensitivity to noise must be related to their defining characteristics, and generally parks with active recreational facilities are not considered noise-sensitive.

It is important to note that no criteria exist for noise impacts to commercial or industrial uses, including most office buildings, restaurants or other commercial uses, because activities within these buildings are compatible with higher noise levels, unless sensitivity to noise is assumed to be of utmost importance for operations of that facility (for example, an audiology laboratory).

The Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise-sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-hour Leq during the facility's operating period is used. There are no noise impact criteria for most commercial and industrial land uses.

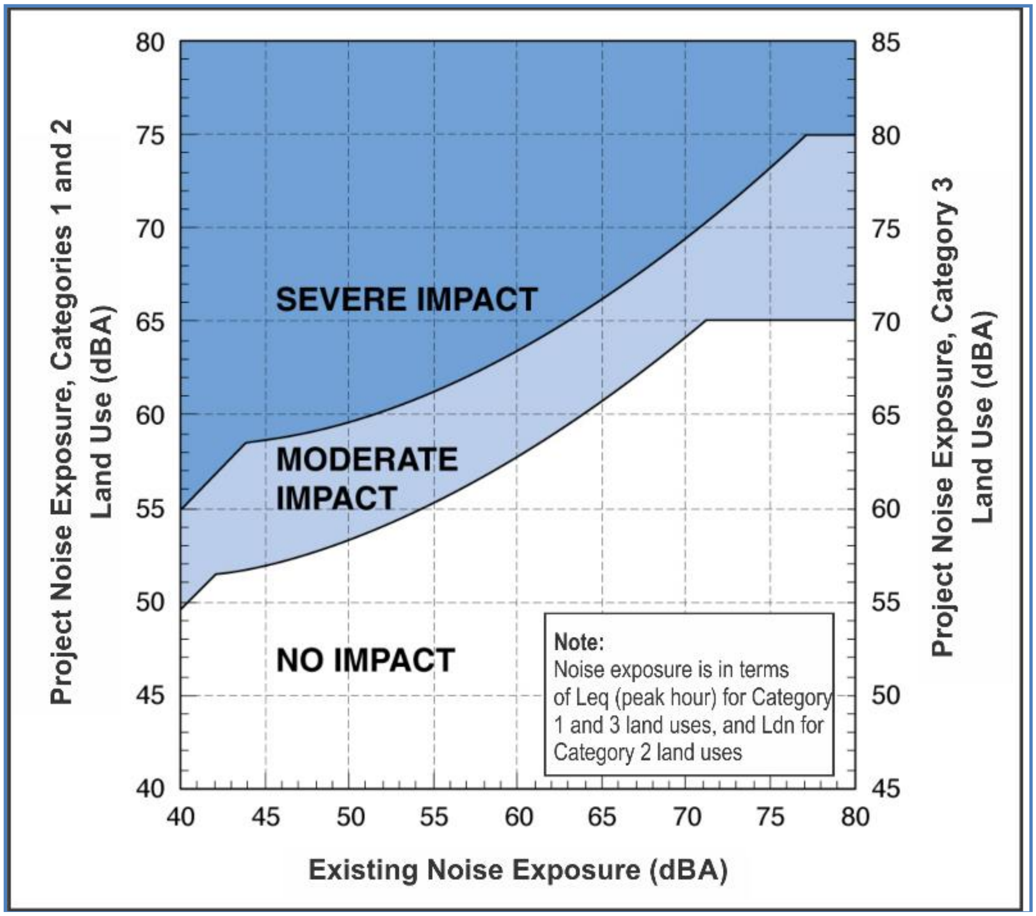
There are two levels of impact included in the FTA criteria—severe and moderate—interpreted as follows:

Severe Impact: Project-generated noise in the severe impact range can be expected to cause a large percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances that prevent mitigation.

Moderate Impact: In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing noise level, the projected level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views and the cost of mitigating noise to more acceptable levels.

Figure 4-1 (FTA noise impact criteria) and **Table 4-1** (FTA noise impact criteria) provide the FTA impact criteria. As shown in the table and figure, the impact level is based on the existing noise environment. As the existing noise levels increase, the allowable noise from transit operations decreases. The following two **examples** help provide an understanding of the FTA criteria and determination of noise impacts:

- A residence with an existing noise level of 64 dBA Ldn and a predicted project noise level of 63 dBA Ldn: For a residential land use (FTA Category 2) with an existing Ldn of 64 dBA, a moderate impact would occur if the project noise exceeded 61 dBA Ldn, or a severe impact would occur if the project noise exceeded 65 dBA Ldn. If the project were predicted to produce 63 dBA Ldn, this would be a moderate noise impact.
- A residence with an existing noise level of 72 dBA Ldn and a predicted project noise level of 63 dBA Ldn: For a residential land use (FTA Category 2) with a 72 dBA Ldn, the moderate criteria is 66 dBA, and the severe criteria is 71 dBA. If the project were predicted to produce 63 dBA Ldn, no noise impact would be predicted.



Source: FTA 2018

Figure 4-1 FTA noise impact criteria

Table 4-1 FTA noise impact criteria (all noise levels in dBA)

Existing Noise Exposure Leq or Ldn[1]	Allowable Project Noise Level Increases, Leq or Ldn[1]			
	Category 1 or Category 2 Sites		Category 3 Sites	
	Impact	Severe Impact	Impact	Severe Impact
60	58–63	>63	63–68	>68
61	59–64	>64	64–69	>69
62	59–64	>64	64–69	>69
63	60–65	>65	65–70	>70
64	61–65	>65	66–70	>70
65	61–66	>66	66–71	>71
66	62–67	>67	67–72	>72
67	63–67	>67	68–72	>72
68	63–68	>68	68–73	>73
69	64–69	>69	69–74	>74
70	65–69	>69	70–74	>74
71	66–70	>70	71–75	>75
72	66–71	>71	71–76	>76
73	66–71	>71	71–76	>76
74	66–72	>72	71–77	>77
75	66–73	>73	71–78	>78

[1] Ldn is used for land uses where nighttime sensitivity is a factor; daytime Leq is used for land uses involving only daytime activities.

Source: FTA 2018.

4.1.2. FTA construction noise criteria

FTA has developed methods for evaluating construction noise levels. These methods are not standardized criteria, but they include noise impact guidelines for sensitive land uses that describe levels that have the potential to result in a negative community reaction. These methods are discussed in Chapter 7 of the FTA Manual (2018). Based on FTA's general assessment methodology, for residences, the guideline is 90 dBA Leq (1-hour) during daytime hours (7 a.m. to 10 p.m.) and 80 dBA Leq (1-hour) during nighttime hours (10 p.m. to 7 a.m.).

4.1.3. FTA vibration criteria

The FTA vibration impact criteria are based on the maximum indoor vibration level as the bus passes. There are no impact criteria for outdoor spaces such as parks. The FTA Manual (2018) provides two sets of criteria: one based on the overall vibration velocity level for use in a General Vibration Impact Assessment, and one based on the maximum vibration level in any 1/3-octave band (the band maximum level) for use with a Detailed Vibration Assessment. The second set of criteria (the band maximum level) is used only if impacts are identified under the General Vibration Impact Assessment. An FTA vibration impact exists when vibration levels meet or exceed both criteria.

The FTA General Assessment criteria for vibration from transit systems is 72 VdB for residences and other locations where people sleep, and 75 VdB for vibration-sensitive land uses with daytime use. As previously discussed, vibration impacts from bus systems almost never occur, and vibration levels in the project corridor are dominated by heavy truck traffic, not bus traffic. Also, concrete pads at station platforms would further reduce the potential for vibration levels to exceed the FTA criteria, because the hard concrete pads are less likely to rut or develop potholes, which are the major source of vibration from rubber-tired vehicles on paved roadways.

4.1.4. FTA construction vibration damage criteria

FTA has established a set of criteria for construction-related vibration based on the potential for building damage. The criteria are divided into four building types and are provided in **Table 4-2** (FTA construction vibration damage criteria). The levels are listed in terms of peak particle velocity (PPV) and vibration decibels (Lv in VdB) for reference.

Table 4-2 FTA construction vibration damage criteria

Building/Structure Category	PPV, Inches/Second	Lv (VdB)
Reinforced-concrete, steel or timber (no plaster)	0.5	102
Engineered concrete and masonry (no plaster)	0.3	98
Non-engineered timber and masonry buildings	0.2	94
Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA 2018.

Most of the project construction activities would be short-term and are predicted to have similar vibration levels as previous roadway paving projects along the corridor or construction of multistory buildings.

4.1.5. FHWA traffic noise criteria

FTA recommends using the FHWA criteria for noise from general-purpose traffic on public roadways that are modified or constructed as part of a transit project. Therefore, criteria for traffic noise impacts are from the FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, Code of Federal Regulations Title 23, Subchapter H, Section 772 (2011). A traffic noise impact occurs if predicted traffic noise levels approach the criteria levels for specific land use categories or substantially exceed existing noise levels (e.g., a 10-dbA increase). The FHWA has land use categories that are similar to those used by FTA, although the FHWA categories use letters instead of numbers, and the land uses can be slightly different depending on the category.

The land uses of greatest concern in the project corridor are FHWA Type B and Type C, which include residences, motels, hotels, playgrounds, active sports areas, parks, schools, places of worship, libraries and hospitals. The noise abatement criterion used to determine impacts on these land uses is "approach or exceed 67 dBA." Under WSDOT policy (WSDOT 2012), a traffic noise impact occurs if predicted noise levels approach within 1 decibel of the noise abatement criterion. Therefore, an impact on Type B land uses would occur at 66 dBA. Traffic noise impacts can also occur if the future noise levels exceed the existing levels by 10 dB or more. WSDOT defines its impact levels (shown in **Table 4-3** (Noise abatement criteria by land use category)) as noise abatement criteria. The WSDOT impact levels are based on hourly Leq levels for the peak hour of traffic noise.

WSDOT is responsible for implementing the FHWA regulations in Washington state. Under FHWA and WSDOT regulations, traffic noise studies are performed only for projects meeting one or more of the following criteria:

1. The construction of a highway on a new location
2. The physical alteration of an existing highway where there is either:
    a. Substantial Horizontal Alteration: A project that halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition or
    b. Substantial Vertical Alteration: A project that removes shielding, therefore exposing the line-of-sight between the receptor and the traffic noise source; this is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor
3. The addition of a through-traffic lane(s); this includes the addition of a through-traffic lane that functions as a high-occupancy vehicle lane, high-occupancy toll lane, bus lane or truck climbing lane
4. The addition of an auxiliary lane, except when the auxiliary lane is a turn lane
5. The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange

6. Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane
7. The addition of a new or substantial alteration of a weigh station, rest stop, rideshare lot, or toll plaza

The project was reviewed to determine whether it met the criteria for modifications to the horizontal or vertical roadway alignments. Because the proposed project would include modification of the alignment of an existing roadway or highway and the removal of structural shielding, a review of these modifications was performed. In the areas where the modifications would meet the Type 1 requirements, a traffic noise analysis using the FHWA and WSDOT methods was performed. Section 7.2 provides the results of that analysis.

Table 4-3 Noise abatement criteria by land use category

Activity Category	WSDOT Noise Abatement Criteria (Hourly Leq dBA)	Evaluation Location	Activity Description
A	56	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose
B[1]	66	Exterior	Residential (single-family and multifamily units)
C[1]	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails and trail crossings
D	51	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools and television studios
E[1]	71	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, and properties or activities not included in Categories A–D or F
F	--[2]	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical) and warehousing
G	--	--	Undeveloped lands that are not permitted

[1] Includes undeveloped lands permitted for this activity category.

[2] "--" = no criteria.

4.2. Local noise control regulations

Project construction and operation would take place in the Washington cities of Seattle, Shoreline, Lake Forest Park, Kenmore and Bothell. Therefore, five different noise ordinances would be applicable to the operation of ancillary facilities (the park-and-ride garages) and to project-related construction activities. Sounds created by motor vehicles when operated on public roadways are exempt from the Washington Administrative Code (WAC) section described below and other local noise ordinances. However, noise coming from vehicles operated off public roadways, such as vehicle movement in park-and-ride garages, would be required to meet the state and local noise control ordinances. State and local ordinances are also applicable to noise from project construction.

4.2.1. Washington Administrative Code noise criteria

In Chapter 173-60 of the WAC, the Washington Department of Ecology has adopted Maximum Environmental Noise Levels for residential, commercial, industrial and construction areas. However, WAC 173-60-110 states that:

> *The department conceives the function of noise abatement and control to be primarily the role of local government and intends actively to encourage local government to adopt measures for noise abatement and control. Wherever such measures are made effective and are being actively enforced, the department does not intend to engage directly in enforcement activities.*

Each of the five cities has adopted measures for noise abatement and control. Seattle, Kenmore and Bothell have adopted ordinances that are based upon WAC 173-60, while Shoreline and Lake Forest Park have taken different approaches, as discussed in Sections 4.2.3 through 4.2.4 below.

WAC Chapter 173-60 (Maximum Environmental Noise Levels) defines three classes of property use, called Environmental Designation for Noise Abatement (EDNA), and states maximum allowable noise levels for each, as shown in **Table 4-4** (Washington state noise control regulations). For example, the noise caused by a commercial property must be less than 57 dBA at the closest residential property line. From 10 p.m. to 7 a.m., the allowable maximum sound levels shown in **Table 4-4** are reduced by 10 dBA in Class A EDNAs (residential zones). Although not specified in these regulations, the noise analysis assumes the hourly Leq for comparison with the noise levels in **Table 4-4**. The WAC contains short-term exemptions to the property line noise standards shown in **Table 4-4** based on the minutes per hour that the noise limit is exceeded. These exceedances are outlined in **Table 4-5** (Washington state exemptions for short-term noise exceedances).

Table 4-4 Washington state noise control regulations

EDNA Source of Noise	EDNA Receiver of Noise (Maximum Allowable Sound Level in dBA[1])		
	Residential	Commercial	Industrial
Class A Residential	55	57	60
Class B Commercial	57	60	65
Class C Industrial	60	65	70

[1] Between 10 p.m. and 7 a.m., the levels given above are reduced by 10 dBA in Class A EDNAs.

Table 4-5 Washington state exemptions for short-term noise exceedances

Minutes per Hour	Adjustment to Maximum Sound Level
15	+5 dBA
5	+10 dBA
1.5	+15 dBA

WAC Construction Noise Criteria

Sounds received in Class A EDNAs that originate from construction sites are exempt from the limits of the WAC regulations during normal daytime hours (7 a.m. to 10 p.m.). If construction is performed during the nighttime, the contractor must still meet the WAC noise-level requirements for sounds received in Class A EDNAs, as presented in **Table 4-4** (Washington state noise control regulations) or obtain a noise variance from the governing jurisdiction.

The WAC also contains a set of construction-specific allowable noise-level limits. These construction noise regulations are organized by type of noise and, among other things, include criteria for haul trucks and backup safety alarms.

Construction Haul Truck Noise Criteria

Maximum permissible sound levels for haul trucks on public roadways are limited to 86 dBA for speeds of 35 miles per hour (mph) or less, and 90 dBA for speeds over 35 mph when measured at 50 feet (Chapter 173-62, WAC). For trucks operating within staging areas, the general construction equipment noise criteria would be used to determine compliance during nighttime hours in Class A EDNAs.

Construction Noise Related to Backup Alarms

Sounds created by backup alarms are essentially prohibited by the WAC during nighttime hours (between 10 p.m. and 7 a.m.) in Class A EDNAs, and during these hours, other forms of backup safety measures would need to be used. These measures could include using smart backup alarms, which automatically adjust the alarm level based on the background level, or switching off backup alarms and replacing them with spotters.

4.2.2. Seattle

The City of Seattle has maximum permissible environmental noise level requirements that are similar to those contained in the WAC (Seattle Municipal Code [SMC] Chapter 25.08; SMC Section 25.08.410). However, while the WAC does not define a noise descriptor to be used for purposes of applying the limits shown in **Table 4-4** (Washington state noise control regulations), the City of Seattle explicitly mandates that the Leq descriptor be used. In addition, during a measurement interval, maximum noise levels (Lmax) may exceed the Leq exterior sound level limits (shown in **Table 4-4** above) by no more than 15 dBA (SMC Section 25.08.410(B)).

The SMC also imposes the following three limitations, which are more restrictive than the WAC limitations, on the maximum permissible sound level limits:

- The Seattle ordinance extends the 10 dBA reduction in maximum nighttime noise levels to 9 a.m. on weekends and legal holidays, whereas under the WAC, the reduction stops at 7 a.m.
- For any source of sound (other than an electrical substation) that has a pure tone component, the exterior sound level limits established under SMC Section 25.08.410 are reduced by 5 dBA.
- For any source of sound that is impulsive and not measured with an impulse sound level meter, the exterior sound level limits established under SMC Section 25.08.410 are reduced by 5 dBA.

The SMC regulations are used for park-and-ride garages and construction noise, and the hourly Leq is the basis for the impact analysis.

Construction Noise Criteria

The WAC exempts construction noise from maximum permissible noise levels except during nighttime hours in residential zones, but the SMC provides upper limits on construction noise at all times. Under SMC Section 25.08.425, the sound level limits established by SMC Section 25.08.410 may be exceeded for non-impact construction equipment used on public projects, such as this project, between 7 a.m. and 10 p.m. on weekdays, and between 9 a.m. and 10 p.m. on weekends and legal holidays, by no more than the following:

- **25 dBA** for equipment on construction sites, including, but not limited to, crawlers, tractors, dozers, rotary drills and augers, loaders, power shovels, cranes, derricks, graders, off-highway trucks, ditchers, trenchers, compactors, compressors and pneumatic-powered equipment.

- **20 dBA** for portable-powered equipment used in temporary locations in support of construction activities or used in the maintenance of public facilities, including, but not limited to, chainsaws, log chippers, lawn and garden maintenance equipment, and hand-powered tools.
- **15 dBA** for powered equipment used in temporary or periodic maintenance or repair of the grounds and appurtenances of residential property, including, but not limited to, lawnmowers, powered hand tools, snow-removal equipment and composters.

For impact types of equipment, including, but not limited to, pavement breakers, pile-drivers, jackhammers, sandblasting tools, or other types of equipment that create impulse sound or impact sound, the sound level limits established by SMC Section 25.08.425 may be exceeded in any one-hour period between 8 a.m. and 5 p.m. on weekdays and 9 a.m. and 5 p.m. on weekends and legal holidays, but in no event may the sound level for impact types of equipment exceed the following:

- Leq 90 dBA continuously
- Leq 93 dBA for 30 minutes
- Leq 96 dBA for 15 minutes
- Leq 99 dBA for 7.5 minutes

Sound levels in excess of Leq 99 dBA are prohibited unless authorized by variance, and impact equipment that produces sound levels less than 90 dBA must comply with the sound level requirements for non-impact equipment construction between 7 a.m. and 8 a.m. and again between 5 p.m. and 10 p.m. on weekdays, and between 9 a.m. and 10 p.m. on weekends and legal holidays.

The sound levels for all types of construction equipment are measured at the property line of the receiver or at a distance of 50 feet from the equipment making the sound, whichever is greater. Furthermore, any type of equipment that exceeds the sound level limits in SMC Section 25.08.410, when measured from the interior of buildings within a commercial district, is prohibited between 8 a.m. and 5 p.m.

Construction Haul Truck Noise Criteria

Sounds created by motor vehicles on public roadways, including haul trucks, are exempt from the City of Seattle's previously described maximum permissible environmental noise levels and, instead, maximum permissible sound levels for haul trucks on public roadways are simply limited to 95 dBA (SMC Section 25.08.430 et seq.). However, the previously described maximum permissible environmental noise level requirements do apply to vehicles operating off highways, such as trucks at staging areas, when the sounds are received within a residential district.

Noise Related to Backup Alarms

Sounds created by warning devices or alarms not operated continuously for more than 30 minutes per incident are exempt from the City of Seattle noise control requirements (SMC Section 25.08.530). For nighttime construction activity, the noise from the alarms would be addressed in permit conditions.

4.2.3. Shoreline

The City of Shoreline regulates noise pursuant to Chapter 9.05, Public Disturbance Noise, of the Shoreline Municipal Code. A public disturbance noise is one that unreasonably disturbs or interferes with the peace and comfort of owners or possessors of real property. The City of Shoreline does not have any maximum permissible environmental noise level requirements that are similar to those contained in the WAC (as outlined in Section 4.2.1 of this report) or otherwise. Therefore, the WAC regulations are used for ancillary facilities (the park-and-ride garages) and construction noise, and the hourly Leq is the basis for the impact analysis.

Construction Noise Criteria

Sounds originating from construction sites including, but not limited to, sounds from construction equipment, power tools and hammering, between 10 p.m. and 7 a.m. on weekdays and 1 p.m. and 9 a.m. on weekends may constitute “public disturbance noise” depending on the location of the construction site and the receiving property (Shoreline Municipal Code Section 9.05.010(C)(8)). Noise from construction activities is, therefore, generally permitted on weekdays between 7 a.m. and 10 p.m., and on weekends between 9 a.m. and 10 p.m. In addition, construction activities in the city’s right-of-way that have been conditioned by the city to minimize the impact on adjacent property owners are exempt from regulation as public disturbance noise, while the creation within a residential district of frequent, repetitive or continuous sounds in connection with the operation of any motor vehicle may be a public disturbance noise.

The City of Shoreline has a noise variance process for any construction outside of the exempt hours.

4.2.4. Lake Forest Park

The City of Lake Forest Park regulates noise pursuant to Chapter 8.24, Noise Control, of the Lake Forest Park Municipal Code (LFPMC). A public nuisance noise is one that unreasonably disturbs or interferes with the peace and comfort of owners or possessors of real property. The City of Lake Forest Park does not have any maximum permissible environmental noise level requirements that are similar to those contained in the WAC (as outlined in Section 4.2.1 of this report) or otherwise. Therefore, the WAC regulations are used for ancillary facilities (the park-and-ride garages) and construction noise, and the hourly Leq is the basis for the impact analysis.

Construction Noise Criteria

Sounds originating from construction sites including, but not limited to, sounds from construction equipment, power tools and hammering, between 9 p.m. and 7 a.m. on weekdays and 9 p.m. and 8 a.m. on weekends and holidays may constitute "public nuisance noise" depending on the location of the construction site and the receiving property (LFPMC Section 8.24.040(H)). Noise from construction activities is, therefore, generally permitted on weekdays between 7 a.m. and 9 p.m. and on weekends and holidays between 8 a.m. and 9 p.m. Construction outside these hours would require a variance from the City of Lake Forest Park, which is available on the city website.

4.2.5. Kenmore

The City of Kenmore regulates noise pursuant to Chapter 8.05, Noise, of the Kenmore Municipal Code (KMC). The KMC sets maximum permissible environmental noise level requirements according to those contained in WAC 173-60-040 (as outlined in Section 4.2.1 of this report). Therefore, the WAC regulations are used for ancillary facilities (the park-and-ride garages) and construction noise, and the hourly Leq is the basis for the impact analysis.

Construction Noise Criteria

Sounds originating from construction sites including, but not limited to, sounds from construction equipment, power tools and hammering, between 7 p.m. and 7 a.m. on weekdays, 5 p.m. and 9 a.m. on Saturdays, and any time on Sundays and holidays may constitute "public nuisance and disturbance noise" depending on the location of the construction site and the receiving property (KMC Section 8.05.025(F)). Noise from construction activities is, therefore, generally permitted on weekdays between 7 a.m. and 7 p.m. and on Saturdays between 9 a.m. and 5 p.m., and prohibited on Sundays and holidays. The City of Kenmore issues construction noise variances under the direction of the city manager or a designee for projects where special circumstances, such as the need to maintain traffic flow and public safety, exist.

4.2.6. Bothell

The City of Bothell regulates noise pursuant to Chapter 8.26, Noise, Regulation, of the Bothell Municipal Code (BMC). The BMC sets maximum permissible environmental noise level requirements according to those contained in WAC 173-60-040 (as outlined in Section 4.2.1 of this report) as well as the exemptions to the maximum permissible environmental noise levels set forth in WAC 173-60-050. Therefore, the WAC regulations are used for ancillary facilities (the park-and-ride garages) and construction noise, and the hourly Leq is the basis for the impact analysis.

Construction Noise Criteria

Sounds originating from construction sites including, but not limited to, sounds from construction equipment, power tools and hammering, between 8 p.m. and 7 a.m. on weekdays, 6 p.m. and 9 a.m. on Saturdays, and any time on Sundays and eight specified holidays (see BMC 8.26.065(C)(2)) may constitute "public nuisance noise" depending on the location of the construction site and the receiving property (BMC Section 8.26.065(C)). Noise from construction activities is, therefore, generally permitted on weekdays between 7 a.m. and 8 p.m. and on Saturdays between 9 a.m. and 6 p.m., and prohibited on Sundays and specified holidays.

The City of Bothell does have regulations that address exceptions for certain types of construction-related noise (BMC Section 8.26.065(D)) as well as noise variances (BMC 8.26.090, Variances).

5. METHODS

This section provides an overview of the methods used to predict noise and vibration levels related to the project, as well as methods for the noise and vibration analysis. The ambient noise measurement methods used for the project comply with the FTA and FHWA noise assessment guidance. The methodology addresses both the long-term operational impacts and the short-term construction impacts related to the project. Long-term operational impacts are related to system operation after construction. Short-term construction impacts are related only to noise and vibration generated during project construction.

5.1. Contacts and coordination

All of the project data used in the analysis was obtained from the project team at Sound Transit and David Evans and Associates, Inc.

5.2. Data sources and collection methods

The following data sets were obtained from the project team for the noise analysis:

- Existing and proposed transit routes, bus headways and schedules, locations of stations
- Project design files in electronic format (CAD files) that were used to construct the noise models used in this analysis
- Land use information for the cities of Seattle, Shoreline, Lake Forest Park, Kenmore and Bothell, and on-site inspections
- General operational information on the proposed buses to be used for the project (the specific buses planned for use on the project would include 12 new buses: 10 BEBs and 2 diesel hybrid buses
- Information on anticipated property displacements that might have an effect on the transmission of noise
- Traffic data and tube counts along project roadways (see **Appendix D** (Traffic Data and Counts))
- Parking spots and general design drawings for the three park-and-ride garages

In addition to obtaining the data described above, the noise analyst performed an on-site inspection of the project corridor. This inspection included taking ambient noise measurements for the project at representative locations along the corridor. Section 6.3 provides the results of the ambient measurements.

5.2.1. Bus types and noise emissions

To aid in the understanding of the results of this analysis and noise emissions related to different bus propulsion systems, a review of bus types and noise emissions was prepared. The review looked at three types of buses: diesel buses, hybrid buses and BEBs.

Most buses currently in use are powered by diesel engines. Diesel buses have typical idling noise levels ranging from 72 to 76 dBA at 25 feet, and during acceleration from a stop, the maximum levels can reach 78 to 84 dBA. When cruising at 35 mph, a diesel bus can produce noise levels of 77 to 80 dBA, increasing to 80 to 83 dBA at 45 mph.

Hybrid buses are powered by an electric motor and a smaller than normal conventional internal combustion engine. Noise emissions of most hybrid buses are actually slightly louder than those of a diesel bus at cruising speeds and when accelerating; however, they are often quieter when at a stop.

BEBs are powered by an electric motor and obtain energy from on-board batteries. When stopped, BEBs can produce a whining noise originating from the transformers, which power equipment on the bus, including air conditioning and other associated equipment. However, this idle noise from a BEB is typically in the 60 dB range and is much quieter than a comparable diesel or hybrid bus. At cruising speeds of 35 mph or higher, BEBs produce noise levels that approach the noise levels of a diesel or hybrid bus due to the wind noise and tire roadway friction. The main noise benefit of a BEB occurs when the bus is accelerating from a bus stop or intersection. Because its propulsion is electric, a BEB can be 5 to 10 dB, or more, quieter than a comparable diesel bus. Therefore, the use of BEB systems would provide the largest benefit for receivers near the bus stops, stop signs and signal intersections.

5.3. Planned and permitted projects

No FTA criteria exist for noise impacts to commercial or retail operations unless they contain noise-sensitive uses (e.g., an acoustic lab). The commercial and retail operations located along the corridor were reviewed, and none was considered to be noise-sensitive under FTA regulations. No FTA Category 1 land uses exist along the corridor. The analysis identified locations of any FTA Category 2 or Category 3 land uses (defined in Section 4.1.1 above) in the project vicinity and evaluated potential project impacts to those locations, considering both the existing uses as well as developments that are in construction or already permitted by the cities of Seattle, Shoreline, Lake Forest Park, Kenmore and Bothell.

The analysis, which was based on property uses known or anticipated at the time, identified only one jurisdiction along the corridor—the City of Bothell—where there were future, permitted residential uses. Three new multifamily buildings were identified near 98th Avenue NE at Fir Street. No other planned and permitted FTA Category 1, Category 2 or Category 3 land uses were identified along the project corridor.

5.4. Selection of noise monitoring locations

Locations for noise monitoring were selected using several criteria, including their ability to establish a representative background, or ambient, noise level for multiple noise-sensitive receiver locations to help understand the existing noise environment along the corridor. The FTA noise impact criteria are based on the existing noise levels; therefore, the measurements of these existing noise levels are critical to the noise study. As shown in **Table 4-1** (FTA noise impact criteria) and **Figure 4-1** (FTA noise impact criteria), the FTA impact criteria level is based on the existing noise levels, and these measurements can be extrapolated to provide existing noise levels for receivers in the same general area using standard acoustical formulas. For example, because noise from traffic decreases at a rate of 3 dB per doubling of distance (see Section 3.1), measured noise levels can be corrected to provide noise levels at noise-sensitive properties with similar traffic volumes, but at different distances from the roadway. Using this methodology, noise levels at sites without measurements can be predicted using measured data from a nearby site with the appropriate distance correction factor.

Using the selection method above, background noise measurements were made at 23 locations along the project corridor. These were considered to be representative locations, as described in Section 5.5.1. Measurements included short-term (15 to 30 minutes) and long-term (more than 24 hours) noise readings. The focus of the noise monitoring was at FTA Category 2 residential areas along with other areas with FTA noise-sensitive properties. **Table 6-1** (Summary of on-site noise measurements) and **Figure 6-1** (Noise monitoring locations: Segment 1 - Seattle/Shoreline) through **Figure 6-3** (Noise monitoring locations: Segment 4 - Bothell) provide a table and maps, respectively, of the 23 locations where noise measurements were made for the analysis. The measurements include more than 150 hours of noise readings along the project corridor as well as traffic counts as needed for the noise analysis.

All noise measurements were taken in accordance with FTA procedures for community noise measurements. The equipment used for noise monitoring—Bruel & Kjaer Type 2238 Sound Level Meters—was calibrated before and after the measurement period using a reference sound level calibrator. Complete system calibration of the equipment is performed on an annual basis to ensure it meets or exceeds the requirements for an ANSI Type 1 noise measurement system. Section 6.3 of this report provides details on the results of the monitoring and measurements.

5.5. Approach to long-term operational impact analysis

5.5.1. BRT noise analysis methods

This project is a bus transit project and would not add any new general-purpose through lanes; therefore, FTA methods were used for this noise and vibration analysis. Noise sources due to project operation would include: (1) bus operations, (2) traffic noise generated by vehicles using the park-and-ride garages, and (3) traffic noise generated by vehicles utilizing roadway improvement components of the project, such as new turn lanes.

The analysis process consisted of the following steps:

1. Existing noise: Existing noise level measurements were taken throughout the corridor as described above in Section 5.4. Using the measured noise levels and standard acoustical corrections, existing noise levels were predicted for each noise-sensitive property or group of properties along the BRT project corridor. This corrected data was also used to determine the impact criteria for each noise-sensitive property or group of properties using **Table 4-1** (FTA noise impact criteria).

2. Project noise: The analysis determined the noise levels that would be caused by the proposed project. In this case, the change in noise level would be related to the projected operational noise from the new BRT system, which was determined based on bus headways (buses per hour), speeds and transit station locations. The project operations would include one early morning bus in each direction just before 5 a.m., followed by 15-minute headways from 5 to 6 a.m., 10-minute headways from 6 a.m. to 11 p.m., and three final BRT buses in each direction between 11 p.m. and midnight. Total operations during weekdays along NE 145th Street, SR 522, from the Seattle and Shoreline areas through Bothell on NE 185th Street to Beardslee Boulevard, and continuing to the Transit Hub, are predicted to be 220 bus trips per day, or 110 trips in each direction. Nighttime operations, which would occur between the hours of 10 p.m. and 7 a.m., are predicted to be 40 bus trips, or 20 bus trips in each direction. The nighttime operations are subject to the 10 dB penalty, which is included in the noise projections. BRT speeds are assumed to be the posted speed limit along the project corridor.

3. Noise impact determination: If the anticipated noise levels from BRT operations exceed the allowable noise levels provided in **Table 4-1** (FTA noise impact criteria) (shown graphically in **Figure 4-1** (FTA noise impact criteria)), then an impact would be anticipated, and noise mitigation would be considered.

Selection of FTA receivers for noise modeling

For the FTA analysis, *modeling receivers* (not to be confused with *monitoring locations* used to establish the existing conditions – see Section 6.3) were selected based on distance from the roadway, land use type and existing noise environment. In many cases one modeling receiver was used to represent many nearby structures that are at the same distance and would have the same noise levels as the modeling receiver. One modeling receiver was also frequently used to represent multiple units at an apartment building. In total, 156 receiver locations were used to represent the noise levels at approximately 786 single-family and multifamily residences, churches, schools and parks.

The primary receivers are those adjacent to the project corridor roadways, which are also the receivers most likely to have noise impacts. Several receivers that are considered second-line locations, which have some shielding (i.e., buildings between the receiver and the BRT operating area), were also considered and included in this analysis. Finally, additional receivers were added to represent schools and parks for an analysis of FTA Category 3 land use types.

5.5.2. Park-and-ride garages

For operation of the proposed park-and-ride garages, the FTA method for a general analysis of a new transit parking garage was used. The analysis assumed 300 parking stalls in each of the three garages. Project design files were used to measure distances from the garages to nearby sensitive receivers. The nearest two to three receivers were evaluated to identify any potential impacts. If impacts were identified, additional analysis was performed for other receivers to assess all potential noise impacts. The analysis of park-and-ride garages also considered local code criteria.

5.5.3. FHWA analysis and review

Under FTA guidelines and FHWA regulations, a transit project (such as this project) is only required to analyze traffic noise for new roadways, realigned roadways or removal of shielding (e.g., structures or topography) that meets the FHWA requirements described in Section 4 of this report. There are potential traffic revisions planned as part of the project that could result in increased traffic noise levels. In most locations, the project's proposed slight modifications to traffic are not predicted to cause a measurable change in traffic noise levels, and no traffic noise analysis would be required. To provide clarity on this issue, Section 7.3, Traffic noise impacts analysis, provides a summary of those locations, the potential for change in noise and the potential change in the overall noise from traffic with the proposed project.

The removal of some trees and other vegetation along the project corridor would be required; however, trees and vegetation generally do not act as noise shielding, and their removal would not be predicted to have any measurable effect on noise in the corridor. Only the removal of solid structures could trigger a traffic noise study.

5.6. Approach for short-term construction impact analysis

Construction noise predictions were performed using the methods and construction noise levels described in the FTA Manual (2018), as well as noise criteria in local codes. In addition to the information provided in the FTA Manual (2018), the noise analysts also relied on their experience and work on major construction projects to identify likely types of construction activities required for this type of project, noise levels associated with specific construction equipment, and overall construction-related noise and vibration projections. Noise from construction is exempt in most jurisdictions if performed during the hours and days that are exempt. Construction performed outside the hours allowed by a jurisdiction would require a noise variance or some other construction exemption from the jurisdiction where construction noise could exceed the local criteria.

Vibration impacts related to construction were also considered and projected using the methods in the FTA Manual (2018). With the exception of the park-and-ride garages, most construction-related vibration, while it may be noticeable or annoying, is not expected to exceed that of a typical roadway paving project and would be short-term in nature; only minimal construction-related vibration impacts would be expected for the project.

6. AFFECTED ENVIRONMENT

This section provides information on the affected environment (existing noise conditions) along the project corridor. This information includes details on land use and measured noise levels along the project corridor, and is reported according to the four project segments (see **Figure 2-1** (SR 522/NE 145th BRT Project)):

- Segment 1: Seattle/Shoreline
- Segment 2: Lake Forest Park
- Segment 3: Kenmore
- Segment 4: Bothell

6.1. Analysis area

The analysis area is based on the guidance in the FTA Manual (2018). The minimum recommended screening distance for BRT systems on existing arterial roadways is 200 feet in areas with an unobstructed view of the roadway and 100 feet for areas with intervening buildings; the area encompassing this screening distance constitutes the analysis area.

6.2. Land use

Existing land uses within 200 feet of the proposed components and alignment of the project are: single-family and multifamily residences, medical facilities, churches, schools, parks and recreation facilities, and commercial facilities. The following sections discuss the land uses considered sensitive under the FTA noise and vibration criteria (see Section 4.1.1). Figure B-2 (Zoning) and Figure B-3 (Comprehensive Plan Designations) in the SEPA Checklist provide detailed graphics of the land use in the project area.

6.2.1. Segment 1: Seattle/Shoreline

Segment 1 has a mix of land uses. Land uses directly adjacent to the proposed BRT corridor are a mix of residential uses, a golf course, commercial and service uses, skilled nursing and rehabilitation centers, public utility buildings, churches, a preschool and a monastery.

The south side of this segment is bounded by Seattle and three of its neighborhoods (Pinehurst-Northgate, Olympic Hills-Lake City and Cedar Park-Lake City). The north side of this segment is bounded by Shoreline and two of its neighborhoods (Ridgecrest and Briarcrest).

Under the FTA criteria, the noise-sensitive land uses identified within the noise analysis area (a distance of 100 feet to 200 feet) include the residences, churches, nursing and rehabilitation centers, the preschool and the monastery. FTA Category 2 residences line the north side of NE 145th Street from the I-5 ramps to 15th Avenue NE, where land use transitions to commercial (which is not a noise-sensitive land use under FTA criteria). On the south side of NE 145th Street, land use near I-5 includes a golf course, which is not noise-sensitive under FTA criteria. East of the golf course, there are three FTA Category 2 multifamily residences and one single-family residence just west of commercial uses at the intersection of NE 145th Street and 15th

Avenue NE. From 17th Avenue NE to SR 522, land use is primarily FTA Category 2 residential, including single-family and multifamily structures.

In this segment, churches/places of worship, which are an FTA Category 3 land use, include the Prince of Peace Lutheran Church, the Carmelite Monastery and the Shoreline United Methodist Church. All three churches are on the north side of NE 145th Street between 20th Avenue NE and 25th Avenue NE. East of 32nd Avenue NE to SR 522, land use is commercial, and is not considered noise-sensitive under FTA criteria.

6.2.2. Segment 2: Lake Forest Park

Segment 2 begins at the intersection of NE 145th Street and SR 522. The project corridor continues along SR 522 to the Lake Forest Park/Kenmore city limits, just north of 43rd Avenue NE. The west side of the project corridor between NE 145th Street and NE 149th Street is located in Shoreline, with the remainder of the project corridor located in Lake Forest Park.

This segment is developed with residential uses (including public housing), commercial and service uses, a 60-acre funeral home with cemetery and memorial park, professional services, and parks and recreation facilities.

Land use at the connection to Segment 1, at NE 145th Street and SR 522, is all commercial, continuing along SR 522 to around NE 147th Street, where there are FTA Category 2 multifamily apartments on the west side of SR 522, and FTA Category 2 single-family and multifamily residences on the west side behind an existing commercial structure.

The Acacia Memorial Park & Funeral Home (FTA Category 3) is located at 14951 Bothell Way NE, on the west side of SR 522, north of NE 149th Street, and there are some FTA Category 2 multifamily buildings located along SR 522 north of the funeral home. On the east side of SR 522, from NE 148th Street north to NE 153rd Street, land use is primarily multifamily residential (FTA Category 2). North of NE 155th Street, continuing to Brookside Boulevard NE/NE 170th Place, land use is almost entirely FTA Category 2 residential. Multifamily units are located along the east side of SR 522 from NE 155th Street to NE 157th Place, and single-family residences are located along SR 522 from NE 157th Street to NE 170th Place. On the west side in this same area, land use is almost entirely single-family residential. Blue Heron Park is located at SR 522 and Hamlin Road NE and was included in this analysis as an FTA Category 3 land use due the quiet areas of the park near McAleer Creek.

From Brookside Boulevard NE/NE 170th Place to Ballinger Way NE, land use is commercial on the north side of SR 522 and FTA Category 2 residential on the south side of SR 522. The Burke-Gilman Trail parallels SR 522 starting just south of Brookside Boulevard NE and continues along SR 522 into Segment 3. Because the Burke-Gilman Trail is primarily a transportation corridor, it is not considered a noise-sensitive use. The proposed park-and-ride garage would be located on the north side of SR 522, just west of Ballinger Way NE. Land use from Ballinger Way NE to the beginning of Segment 3 is entirely single-family residential.

6.2.3. Segment 3: Kenmore

The project corridor in Segment 3 continues along SR 522 to the Bothell city limits just east of 63rd Place NE. Land uses in this segment include residential uses, commercial and service uses, light industrial uses, building and landscape supplies, professional services, churches, a motel, a library, schools, a museum, a golf course, and parks and recreation facilities. The Burke-Gilman Trail parallels SR 522 throughout Segment 3. As previously noted, because the Burke-Gilman Trail is a transportation corridor, it is not considered a noise-sensitive use.

Beginning at the west end of Segment 3, and continuing to 60th Avenue NE, land use on the north side of SR 522 is all FTA Category 2 single-family residential. The south side of SR 522 is mainly commercial, with some exceptions, including the Log Boom Park and two large multifamily complexes located on the south side of SR 522 near NE at 61st Avenue NE. Just east of 61st Avenue NE, commercial and industrial uses include a marina, float plane docks, maintenance and repair facilities, storage yards and a landscaping supply facility (Evergreen Topsoil Sand & Gravel).

Although east of 61st Avenue NE land uses on both sides of SR 522 are primarily commercial and not noise-sensitive under FTA criteria, there are an FTA Category 2 multifamily residence and an FTA Category 3 church located between 62nd Avenue NE and 63rd Avenue NE on the north side of SR 522. In addition, the Kenmore Library is set back on the north side of SR 522 at 67th Avenue NE. There are some other multifamily residences and manufactured homes located near 73rd Avenue NE; however, these residences are outside the analysis area and are not predicted to have any change in noise from the project.

The existing Kenmore Park-and-Ride is located in this segment, just east of 73rd Avenue NE, on the north side of SR 522. Sensitive land use in this area includes FTA Category 2 single-family and multifamily residences along both sides of SR 522, the Kenmore Community Church and the Columbia Crest Montessori School, and the Kenmore Blue Heron Rookery. Although the apartments and the Kenmore Community Church are near the proposed BRT route, there would be no roadway improvements in this segment of the project corridor, and no change in noise levels is predicted from project operations. Also, the Columbia Crest Montessori School and the Kenmore Blue Heron Rookery are more than 450 feet from SR 522 and have shielding from existing commercial structures, and therefore would not be affected by the project.

6.2.4. Segment 4: Bothell

Land use at the west end of Segment 4 includes single-family and multifamily residential, a park (Red Brick Road Park), a golf course and some commercial uses. The Burke-Gilman Trail parallels SR 522 until 96th Avenue NE, where the trail transitions to the southeast side of the Sammamish River. North of 96th Avenue NE, noise-sensitive uses include the FTA Category 3 Northlake Montessori School and several large FTA Category 2 multifamily complexes. A park (the Park at Bothell Landing) and the Bothell Historical Museum are located near where the BRT route would transition to 98th Avenue NE, but most noise-sensitive parts of the park and the museum are located outside of the project noise analysis area.

The project corridor continues north along 98th Avenue NE and then transitions onto NE 185th Street. The corridor continues along NE 185th Street until it intersects Beardslee Boulevard. The corridor continues along Beardslee Boulevard to the Beardslee Boulevard Station, and then continues to the Transit Hub.

This segment is developed with a variety of land uses including residential uses, commercial and service uses, a library, municipal government buildings, schools, churches and a fire station. There are three FTA Category 2 single-family residences on 98th Avenue NE north of Dawson Street, directly across from the Bothell Library (FTA Category 3). There are also several large FTA Category 2 multifamily buildings and the Birch Tree Academy preschool as the project corridor transitions over to NE 185th Street. The Bothell Park-and-Ride garage would also be located in this area, near the intersection of 98th Avenue NE and NE 185th Street.

Land use along NE 185th Street is primally FTA Category 2 single-family and multifamily residential on the north side, and FTA Category 2 multifamily residential on the south side, with several office buildings intermixed that are not noise-sensitive uses under the FTA criteria. The Bothell Fire Department, which is an FTA Category 2 land use due to the sleeping quarters it contains, is located at the intersection of NE 185th Street and Beardslee Boulevard. North of NE 185th Street along Beardslee Boulevard, land use includes FTA Category 2 single-family and multifamily residential (including university student housing) and the UW Beardslee Dental facility and the Village at Beardslee mixed-use buildings, which have retail uses on the lower floors and FTA Category 2 uses on the upper floors.

6.3. Project area noise levels

Noise levels along the project corridor are currently dominated by traffic along both NE 145th Street and SR 522, and along major and minor arterial crossings; these conditions are anticipated to continue in the foreseeable future. To provide detailed information on the existing noise environment, noise levels were measured at 23 locations along the project corridor. Section 5.3 discusses the methods used for noise monitoring.

Long-term noise measurements covering approximately 24 continuous hours or more were taken at six sites (M-2, M-8, M-11, M-16, M-20 and M-21 (see **Figure 6-1** (Noise monitoring locations: Segment 1 - Seattle/Shoreline) through **Figure 6-3** (Noise monitoring locations: Segment 4 - Bothell)). The remaining 17 sites were monitored twice for 15 minutes each time, at different times of the day. All monitoring was performed between October 6 and October 8, 2019. The 23 monitoring locations are shown on **Figure 6-1** (Noise monitoring locations: Segment 1 - Seattle/Shoreline) through **Figure 6-3** (Noise monitoring locations: Segment 4 - Bothell). **Appendix C** (Noise Monitoring Locations) includes detailed site photographs and aerial photographs.

Based on monitoring, noise levels along the project corridor ranged from 58 to 78 dBA Ldn and 57 to 74 dBA Leq during daytime hours. Noise levels in this range are typical along major arterial roadways and in urban areas. **Table 6-1** (Summary of on-site noise measurements) summarizes the measured noise levels at each monitoring site, and the following sections discuss the identified noise sources.

Table 6-1 Summary of on-site noise measurements

Site[1]	Seg-ment	Location	Leq (dBA)[2]	Ldn (dBA)[2]	Notes[3]
M-1	1	522 NE 145th St.	69	71	Short-term: peak-hour Leq, predicted Ldn
M-2	1	1020 NE 145th St.	71	72	Long-term: peak-hour Leq, predicted Ldn
M-3	1	NE 145th St. at 17th Ave. NE (south side)	71	72	Short-term: peak-hour Leq, predicted Ldn
M-4	1	14511 22nd Ave. NE	67	69	Short-term: peak-hour Leq, predicted Ldn
M-5	1	14349 32nd Ave. NE	68	70	Short-term: peak-hour Leq, predicted Ldn
M-6	2	14812 Bothell Way NE	74	76	Short-term: peak-hour Leq, predicted Ldn
M-7	2	15000 Bothell Way NE (rear)	67	68	Short-term: peak-hour Leq, predicted Ldn
M-8	2	3640 NE 155th St.	74	78	Long-term: peak-hour Leq, predicted Ldn
M-9	2	4001 NE 160th St. (front)	57	58	Short-term: peak-hour Leq, predicted Ldn
M-10	2	On NE 165th St. at 16294 39th Ave. NE	67	69	Short-term: peak-hour Leq, predicted Ldn
M-11	2	16727 41st Ave. NE (backyard)	66	69	Long-term: peak-hour Leq, predicted Ldn
M-12	2	Blue Heron Park (Hamlin Rd. NE)	67	69	Short-term: peak-hour Leq, predicted Ldn
M-13	2	4500 NE 171st St.	66	68	Short-term: peak-hour Leq, predicted Ldn
M-14	2/3	17364 Beach Dr. NE	64	66	Short-term: peak-hour Leq, predicted Ldn
M-15	3	On 60th Ave. NE at 5857 NE 180th St.	67	69	Short-term: peak-hour Leq, predicted Ldn
M-16	4	17432 Bothell Way NE (north building)	64	66	Long-term: peak-hour Leq, predicted Ldn
M-17	4	SR 522 at Hall Rd.	70	71	Short-term: peak-hour Leq, predicted Ldn
M-18	4	18215 98th Ave. NE (library)	62	64	Short-term: peak-hour Leq, predicted Ldn
M-19	4	10106 NE 185th St.	65	67	Short-term: peak-hour Leq, predicted Ldn
M-20	4	18516 104th Ave. NE	67	67	Long-term: peak-hour Leq, predicted Ldn
M-21	4	10736 Beardslee Blvd.	66	69	Long-term: peak-hour Leq, predicted Ldn
M-22	4	Campus Way NE (on UW Bothell Campus)	58	60	Short-term: peak-hour Leq, predicted Ldn
M-23	4	18829 Beardslee Blvd.	72	74	Short-term: peak-hour Leq, predicted Ldn

[1] Sites are shown in **Figures 6-1** through **6-3**.

[2] The peak hour Leq is used for FTA Category 1 and Category 3 land uses, while the 24-hour Ldn is used for FTA Category 2 residential land uses.

[3] Short-term measurements were twice for 15 minutes each time over the monitoring period; the long-term measurements were continuous for approximately 25 continuous hours.

6.3.1. Segment 1: Seattle/Shoreline

Noise levels along NE 145th Street were measured at five sites (M-1 through M-5). Overall, the typical daytime hourly Leq noise levels remained fairly constant, ranging from 67 to 71 dBA Leq. Site M-4 had the lowest reading of 67 dBA Leq, because it is located the farthest from the roadway. The Ldn for front-line homes along NE 145th Street is fairly consistent at 70 to 72 dBA Ldn. The Ldn at M-4, a second-line residence, was predicted to be 69 dBA Ldn based on the measured Leq.

The dominant existing noise source along the project corridor in this segment is from traffic, with some additional noise from commercial and retail activities. Traffic counts were taken by project traffic engineers at NE 145th Street and 5th Avenue NE in August 2017. The counts were averaged for a typical weekday: 23,563 vehicles westbound and 16,475 vehicles eastbound, for a total average daily traffic volume of 40,038 vehicles along NE 145th Street. In contrast, BRT operations during weekdays are predicted to add a total of 354 bus trips per day (177 trips in each direction). **Appendix D** (Traffic Data and Counts) provides the traffic data tables.

6.3.2. Segment 2: Lake Forest Park

Noise levels in Segment 2 were characterized by monitoring sites M-6 through M-13. The Ldn noise levels ranged from 58 to 78 dBA Ldn. The typical daytime Leq in this segment ranges from 57 to 74 dBA Leq. The loudest monitoring site, M-8, is located only 44 feet from the near lane of SR 522 and slightly uphill from the roadway. The lowest noise level of 58 dBA Ldn (57 dBA Leq) was measured at monitoring site M-9, which is located in the front yard of a residence in the NE 160th Street cul-de-sac; this site provided a measurement at a second-line residence that is below the grade of SR 522 and has structural shielding.

The dominant noise source along the project corridor in this segment is from traffic, with some additional noise from commercial and retail activities. Traffic counts were taken along SR 522 at NE 149th Street in May 2019. The counts were averaged for a typical weekday: 21,654 vehicles northbound and 21,874 vehicles southbound, for a total average daily traffic volume of 43,528 vehicles.

6.3.3. Segment 3: Kenmore

Because there would be minimal roadway improvements in Segment 3, two monitoring sites (M-14 and M-15) were included in the south end of this segment and two more sites (M-16 and M-17) in the north end near downtown Bothell. The measured noise levels in the south end (M-14 and M-15) ranged from 66 to 69 dBA Ldn and 64 to 67 dBA Leq. Site M-14 is located along Beach Drive NE, well below the grade of SR 522, and has a large retaining wall between SR 522 and Beach Drive NE.

Noise levels closer to downtown Bothell, as measured at monitoring sites M-16 and M-17, ranged from 66 to 71 dBA Ldn and 64 to 70 dBA Leq. M-16 is located at a multifamily building more than 150 feet from SR 522, while M-17 is a short-term monitoring site located just north of the Northlake Montessori School at 17511 Bothell Way NE. As in the rest of the project corridor, the dominant noise source in this segment is traffic; the published average daily traffic volumes are approximately 41,000 to 48,000 vehicles.

6.3.4. Segment 4: Bothell

Segment 4 includes eight monitoring sites, because the BRT route would be along streets where traffic volumes are much lower than in other segments in the corridor. These sites (M-16 through M-23) include three long-term sites at residential land uses and five short-term sites (Northlake Montessori School, Bothell Public Library, the UW Bothell campus, and two residential land uses).

The measured Ldn noise levels ranged from 60 to 74 dBA Ldn, and typical daily hourly Leq noise levels ranged from 58 to 72 dBA Leq. The highest noise levels were along Beardslee Boulevard at site M-23 because of the higher traffic volume at this location. The average daily traffic volume along Beardslee Boulevard, based on counts taken in May 2019, is 11,914 vehicles. The lowest noise level measured in this segment—an hourly Leq of 58 dBA—was on the UW Bothell campus (M-22). The noise level at the Bothell Public Library was measured at 62 dBA Leq (M-18).

Noise levels at residences and the Bothell Fire Department located near and along NE 185th Street ranged from 67 to 69 dBA Ldn (M-19 through M-21). Average daily traffic volumes along NE 185th Street, based on counts performed in May 2019, ranged from 5,218 to 5,779 vehicles.

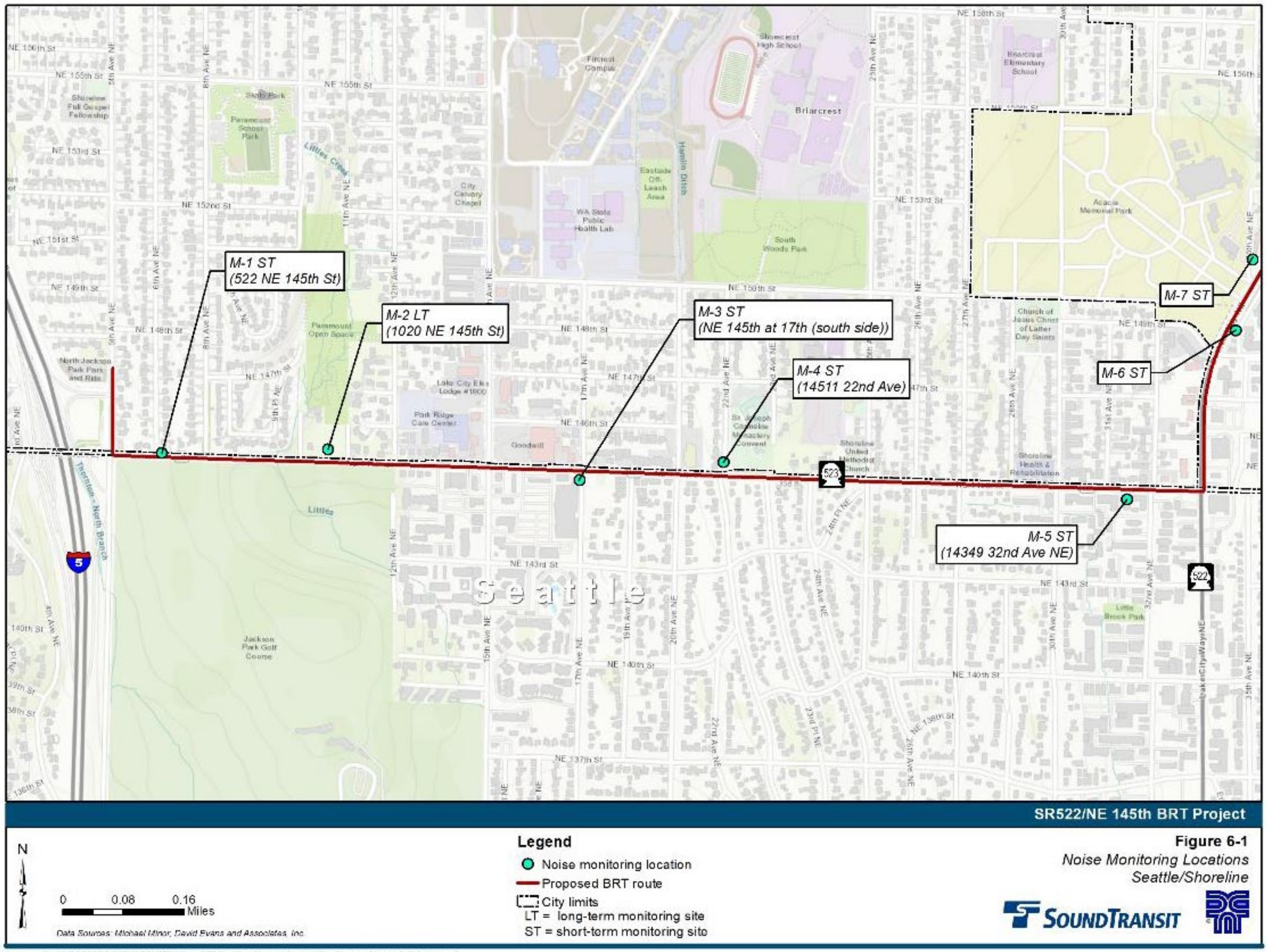


Figure 6-1 Noise monitoring locations: Segment 1 - Seattle/Shoreline

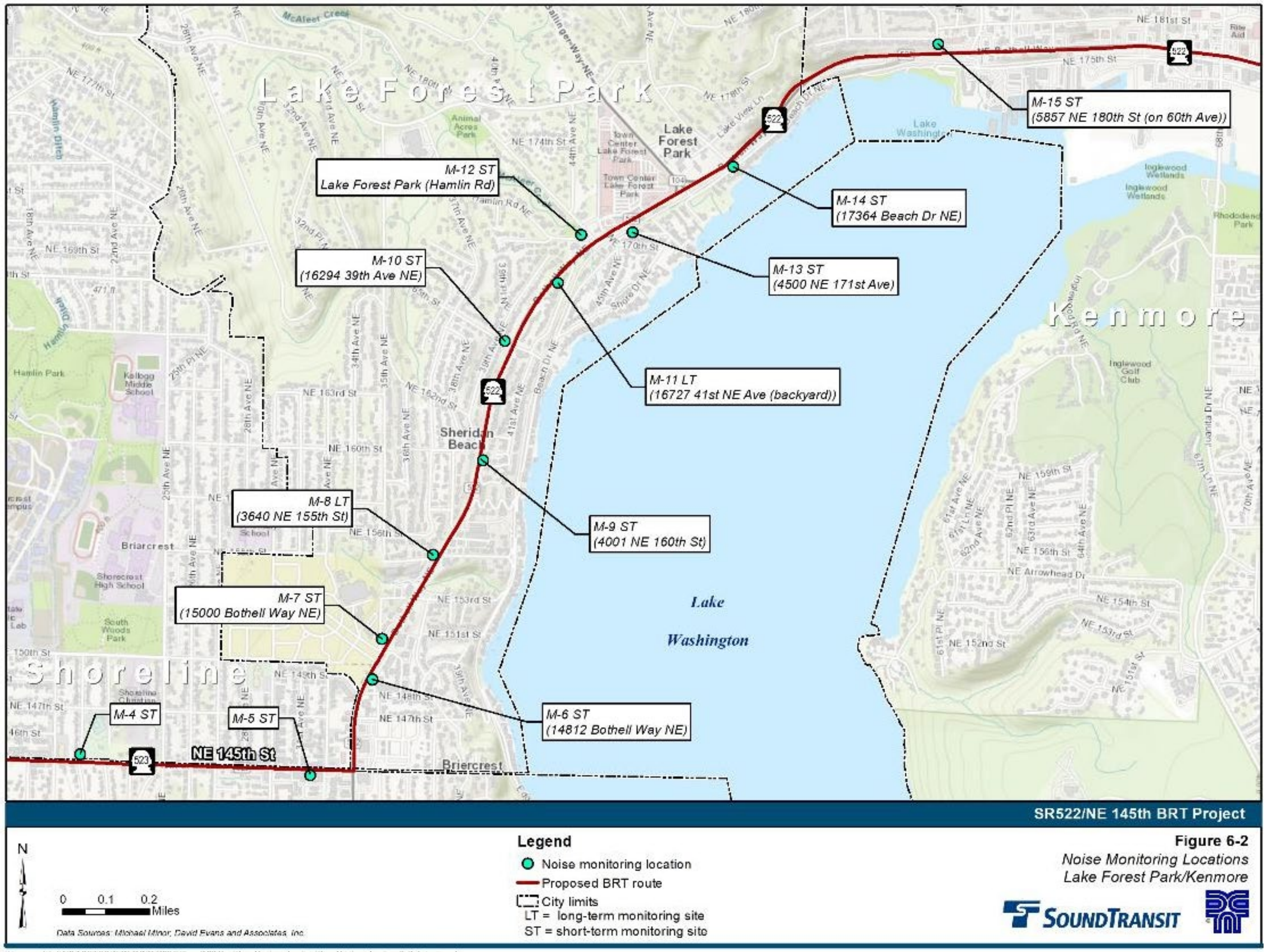


Figure 6-2 Noise monitoring locations: Segments 2/3 - Lake Forest Park/Kenmore

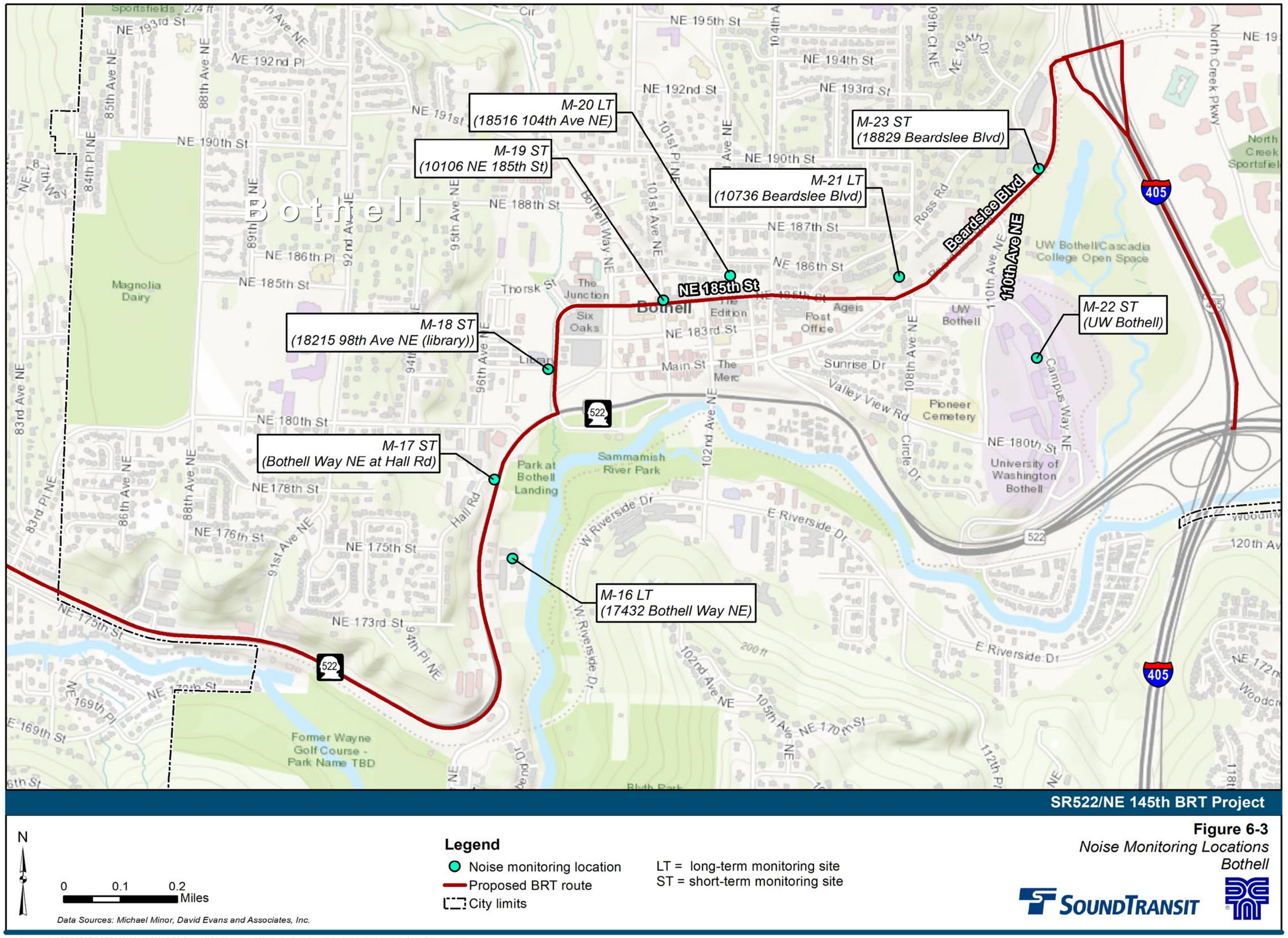


Figure 6-3 Noise monitoring locations: Segment 4 - Bothell

6.4. Project vibration levels

Existing vibration levels in the project corridor and the vicinity of the proposed park-and-ride garages are dominated by heavy trucks and buses in most locations. Vibration levels in these areas are not predicted to exceed 70 VdB unless there are potholes or other pavement breaks that cause increased vibration levels. One exception to this would be in the central downtown Bothell area, which is undergoing substantial development activity. In this area, the ongoing construction of multifamily housing, improved pedestrian access, roadway upgrades and roadway paving would be the dominant vibration source.

Vibration impacts are not expected to result from the project operation, because the project would use only rubber-tired vehicles. Vibration levels from a typical bus, traveling at 30 mph on smooth pavement is approximately 72 VdB at 20 feet, reducing to 65 VdB at 65 feet.

7. NOISE AND VIBRATION IMPACTS

This section provides the results of the noise and vibration analysis for the project and discusses both the likely noise and vibration related to BRT system operations and the short-term construction-related noise and vibration.

Local noise codes and regulations are applicable only to the project's ancillary facilities (park-and-ride garages) and to project construction. Noise from BRT operations on public roadways is exempt from the local noise codes and ordinances.

7.1. Assessment of long-term noise impacts of BRT operations

The following acoustical information is provided to support the noise impact discussions, by segment:

- There are no impact criteria for most businesses, and no noise-sensitive businesses were identified along the project corridor.
- Traffic noise and noise from a BRT system reduce at a level of approximately 3 dB per doubling of distance. Therefore, a measured noise level of 70 dBA at 50 feet would reduce to 67 dBA at 100 feet.
- Keeping the mix of vehicles and speeds constant, it takes a doubling of the traffic volumes to increase noise levels by 3 dB. Therefore, based on the traffic volumes in many parts of the project corridor, the BRT system would not be expected to cause a measurable change in the overall noise environment.
- As the existing noise levels increase, the amount of noise the project can add before an impact is identified decreases. See **Table 4-1** (FTA noise impact criteria) and **Figure 4-1** (FTA noise impact criteria**)** for the impact criteria.
- Noise levels from multiple sources are not directly additive. For example, 60 dBA plus 60 dBA is not equal to 120 dBA; rather, it equals only 63 dBA, an increase of 3 dB, which is barely perceptible to the average person. For more information, see Section 3.1.2.

- Local noise codes and ordinances were also considered and are only applicable to park-and-ride garages and project construction.

Long-term impacts are impacts associated with the normal revenue service of the proposed BRT system. To briefly restate the noise analysis assumption, the new buses proposed for use in the project corridor would consist of 12 new branded buses, 10 of which would be BEBs and 2 of which would be diesel hybrid buses. The proposed project is predicted to add 220 bus trips per day, or 110 trips in each direction, with 20 trips in each direction during nighttime hours, when the 10 dB penalty is applicable. Overall, new bus trips would be a very small percentage of the total daily traffic volumes, and therefore BRT operations would not be expected to result in a measurable change in the total noise from all traffic. As stated previously, it typically takes a doubling of traffic volumes to cause an increase of 3 dB.

The noise analysis was performed for 156 receiver locations, representing 786 individual receivers. The selected monitoring locations included all types of land uses: single-family and multifamily residential uses, schools, churches, medical facilities and noise-sensitive parks. These locations are representative of receivers throughout the project corridor and range in distance from 10 feet to more than 300 feet from the project corridor, with existing Ldn levels of 61 to 78 dBA.

The noise analysis predicted that noise levels with the project would increase by no more than 1 dB along the corridor due in part to the lower emissions from the BEBs and to the low number of nighttime BRT trips (20 in each direction). Some locations may see a slight decrease in total noise due to slight realignments of the SR 522 roadway; however, overall, the project is not predicted to have any notable effect on the noise levels along any of the project segments due to the high existing traffic volumes on most project roadways.

Table 7-1 (Summary of existing and future noise levels and potential impacts) summarizes the results according to the four project segments, and **Appendix E** (Noise Modeling Results) provides complete details on the noise analysis for the representative receivers.

Table 7-1 Summary of existing and future noise levels and potential impacts

Project Segment	Existing (Ldn/Leq)	BRT Noise Levels (Ldn/Leq)	Future Noise with BRT Project (Ldn/Leq)	Change in Total Noise	No. of Individual Properties with Noise Impacts
Segment 1	67 to 78 dBA	51 to 63 dBA	68 to 78 dBA	0 to 1 dB	0
Segment 2	61 to 77 dBA	49 to 63 dBA	61 to 78 dBA	-1 to 1 dB	0
Segment 3	62 to 73 dBA	52 to 60 dBA	62 to 73 dBA	0 dB	0
Segment 4	64 to 76 dBA	56 to 63 dBA	65 to 76 dBA	-1 to 1 dB	0
Totals	**61 to 78 dBA**	**49 to 63 dBA**	**61 to 78 dBA**	**-1 to 1 dB**	**0**

See **Appendix E** for detailed results.

Noise impacts from the operation of the project-related park-and-ride garages were also assessed. The analysis follows the FTA methods and was based on a worst-case level of traffic to and from the park-and-ride garages. The noise study included an analysis for the 24-hour Ldn using the FTA criteria as well as the local noise control code applicable in each jurisdiction. No noise impacts from operations were identified at any of the stations. The following subsections discuss the projected noise levels and any identified noise impacts in each segment.

7.1.1. Segment 1: Seattle/Shoreline

This segment of the project corridor includes 52 modeling receivers representing approximately 214 single-family and multifamily residences, and a church. Background noise levels along this segment were developed from on-site measurements at five representative monitoring sites (M-1 through M-5). Existing noise levels, which are dominated by traffic along NE 145th Street, 15th Avenue NE and Lake City Way/SR 522, range from 67 dBA to 78 dBA Ldn, with the highest levels at residences located directly on NE 145th Street. When corrected for distances from the roadway, the existing noise levels at receivers used in the Segment 1 noise analysis ranged from 67 to 78 dBA.

Noise levels related to the operation of BRT at receivers in Segment 1 would range from 51 to 63 dBA. With the project, noise levels are predicted to increase by 0 to 1 dB over the existing conditions, with future noise levels ranging from 68 to 78 dBA. The analysis did not identify any noise impacts along the project corridor on NE 145th Street between I-5 and Lake City Way/SR 522 in Segment 1.

7.1.2. Segment 2: Lake Forest Park

The project corridor in Segment 2 runs along SR 522 from the NE 145th Street to Ballinger Way NE. There are 60 receivers and receiver groups representing 252 single-family and multifamily residences, and the Acacia Memorial Park & Funeral Home. There is one noise-sensitive park in this segment (Blue Heron Park), which is located along SR 522 at Brookside Boulevard NE.

There are eight monitoring sites used for this segment (M-6 through M-14, shown in **Figure 7-1** (Segment 2: Lake Forest Park - FHWA Type 1 noise analysis review)). The existing Ldn in this segment ranged from 57 to 78 dBA, with the highest level at some single-family and multifamily residences located directly on SR 522. The traffic on SR 522 is the dominant noise source along this segment of the project corridor. When corrected for distances from the roadway, the existing noise levels at modeling receivers in Segment 2 ranged from 61 to 77 dBA.

Noise levels related to the operation of BRT at receivers in Segment 2 would range from 49 to 63 dBA. With the project, noise levels are predicted to increase by 0 to 1 dB over the existing conditions, with future noise levels ranging from 68 to 78 dBA. The analysis did not identify any noise impacts in Segment 2. Although the analysis predicts a very slight noise reduction where travel lanes are moved farther from some residences, any reduction would be minimal and is not expected to be noticeable. Noise levels in Blue Heron Park are not predicted to change with the BRT project.

7.1.3. Segment 3: Kenmore

In Segment 3, there are 2 receivers representing approximately 25 residences. The existing noise levels are defined by monitoring sites M-14 and M-15, and range from 66 to 68 dBA Ldn. When corrected for distances from the roadway, the existing noise levels at modeling receivers in Segment 3 ranged from 62 to 71 dBA.

No increase in the overall Ldn or Leq noise level is predicted in Segment 3, and no noise impacts were identified.

7.1.4. Segment 4: Bothell

There are 42 modeling locations in Segment 4, representing approximately 295 primarily multifamily residences, along with some single-family residences, the Northlake Montessori School, a fire department, a church and the Bothell Library. The number of residences represented by the multifamily buildings was estimated using a view of the windows and decks as well as by using online information from the apartment websites. The actual number of units with impacts is likely to be less than the estimates used for this analysis. Existing noise levels were determined using noise monitoring sites M-16 through M-23. The current measured noise levels ranged from 66 to 74 dBA Ldn. When corrected for distances from the roadway, the existing noise levels at modeling receivers in Segment 3 ranged from 63 to 76 dBA. The measured Leq near the Northlake Montessori School was 69 to 70 dBA Leq during daytime hours.

Noise levels with the BRT operations would range from 49 to 61 dBA at modeling receivers, with total increase of no more than 1 dB. As in Segment 2, the analysis predicts a very slight noise reduction where travel lanes are moved farther from some residences; however, any reduction would be minimal and is not expected to be noticeable. There were no noise impacts identified in Segment 4.

7.2. Park-and-ride garage noise impacts

There are three new park-and-ride garages associated with the proposed project. The park-and-ride garages include a new 300-stall park-and-ride garage located at the Lake Forest Park Town Center; a new park-and-ride garage providing 300 additional stalls at the Kenmore Park-and-Ride; and a new park-and-ride garage at Lot P, northwest of where 98th Avenue NE would meet NE 185th Street, also providing 300 net new parking spaces.

To determine any potential noise impacts from the garages, the FTA method for predicting noise from a transit parking garage was used. Inputs assumed that during the peak early morning hour, 200 vehicles would access each garage between 6 and 7 a.m. During the PM peak hour, from 5 to 6 p.m., 300 vehicles would leave the garage. The traffic model found that the loudest morning and afternoon hours (6 to 7 a.m. and 5 to 6 p.m., respectively) had traffic volumes of 200 vehicles in the AM peak hour and 300 vehicles in the PM peak hour. In addition, for the 24-hour Ldn calculations, it was assumed that each garage would have 600 vehicles during daytime hours (7 a.m. to 10 p.m.) and 300 total vehicles during nighttime hours (10 p.m. to 7 a.m.). Although it is unlikely the actual traffic at these facilities would be this high, using these numbers ensures an analysis that identifies all potential noise impacts. Based on the design drawings of the garages, there would be a safety barrier that would reduce noise from the tire-roadway interface as well as some exhaust noise, with a total noise reduction of 5 dB.

Based on these calculations, at 50 feet from the garage, the peak hour daytime Leq would be 51 dBA, and the peak hour nighttime Leq (6 p.m. to 7 a.m.) would be 49 dBA Leq, while the 24-hour Ldn, which includes the 10 dB penalty for nighttime operations, would be 58 dBA Ldn. Using these reference noise levels, a noise impact analysis for both the FTA criteria and the local noise ordinance was performed. The results for each of the three garages are provided below.

7.2.1. Lake Forest Park Park-and-Ride garage noise analysis

The Lake Forest Park-and-Ride garage would be located in the Lake Forest Park Town Center shopping complex, along SR 522 at Ballinger Way NE, just west of the Lake Forest Park City Hall. The nearest noise-sensitive land uses are residences located approximately 240 feet to the east of Ballinger Way NE. Due to distance attenuation and some shielding from the Lake Forest Park City Hall, noise levels at these residences would be below 30 dBA Leq during peak daytime and nighttime BRT operations, and the Ldn (which includes the 10 dB penalty for nighttime operations) would be approximately 36 dBA. The peak daytime and nighttime noise levels would be well below the levels in the local noise control code for Lake Forest Park (which are 57 dBA Leq for daytime and 47 dBA Leq for nighttime). In addition, the predicted Ldn of 36 dBA also would be below any FTA impact criteria.

Other nearby noise-sensitive uses include residences located to the south of the garage site, along Beach Drive NE and Brentwood Place NE; however, these residences are more than 400 feet from the garage site and would not be affected by the park-and-ride garage operations. Based on the analysis, no noise impacts would be predicted from the operations of the new Lake Forest Park-and-Ride garage.

7.2.2. Kenmore Park-and-Ride garage noise analysis

The Kenmore Park-and-Ride garage would be constructed at the existing Kenmore Park-and-Ride lot, on the north side of SR 522, just east of 73rd Avenue NE. The nearest noise-sensitive properties are the Kenmore Community Church and the Cedar Creek Apartments. Unlike the Lake Forest Park Park-and-Ride garage, this location has noise-sensitive residences within 150 feet (Cedar Creek Apartments) and the Kenmore Community Church that is only 50 feet east of the proposed garage.

The existing noise levels for the apartments and church were predicted using data from monitoring sites M-15 and M-16. Because there are several apartments located farther away from SR 522, near the heron rookery, two locations at the apartments were included in the analysis: *Apartments South*, located approximately 300 to 350 feet from SR 522, and *Apartments North*, located approximately 450 to 550 feet from SR 522. Section 4.1.1 above provides the FTA criteria used for the analysis. **Table 7-2** (Kenmore Park-and-Ride garage FTA noise analysis) shows the results of the noise analysis for the Kenmore Park-and-Ride garage using the FTA criteria.

Table 7-2 Kenmore Park-and-Ride garage FTA noise analysis

Receiver[1]	FTA Land Use[2]	Existing Noise (Ldn or Leq)[3]	Garage Noise[4]	FTA Criteria[5]		Impact?[6]
				Moderate	Severe	
Church	Cat. 3	67 dBA Leq	46 dBA Leq	68 dBA Leq	73 dBA Leq	No
Apartments South	Cat. 2	63 dBA Ldn	41 dBA Ldn	60 dBA Ldn	66 dBA Ldn	No
Apartments North	Cat. 2	58 dBA Ldn	41 dBA Ldn	57 dBA Ldn	63 dBA Ldn	No

[1]Receiver = Noise-sensitive property considered. Apartments South are in the center of the complex, and Apartments North are near the heron rookery.
[2]FTA land use category from Section 4.1.1.
[3]Existing Ldn or Leq based on measurement and standard acoustical formulas.
[4]Noise from operations of the park-and-ride garage.
[5]FTA criteria for moderate and severe impacts from Section 4.1.1.
[6]Impacts identified by the analysis.

As is shown in **Table 7-2** (Kenmore Park-and-Ride garage FTA noise analysis), noise levels from operation of the park-and-ride garage would not meet the FTA criteria; no noise impacts were predicted.

To show compliance with the Kenmore city code for noise, an analysis of the worst-case Leq during nighttime and daytime hours was conducted. The criteria for residences and churches are both the same (EDNA Class A), and local code impacts would occur at 57 dBA Leq during daytime hour and 47 dBA Leq during nighttime hours. The park-and-ride garage is considered to be a commercial land use (EDNA Class B) under the city code for this analysis. Noise from the park-and-ride garage would be the same for all the nearby apartments; therefore, separate predictions for the north and south portions of the garage were not necessary. **Table 7-3** (Kenmore Park-and-Ride garage local code noise analysis) provides the results for the local code noise impact analysis for the Kenmore Park-and-Ride garage.

Table 7-3 Kenmore Park-and-Ride garage local code noise analysis

Receiver[1]	Land Use[2]	Time Period[3]	Garage Noise[4]	City Code[5]	Impact?[6]
Church	Class A	Daytime	46 dBA Leq	57 dBA Leq	No
		Nighttime	44 dBA Leq	47 dBA Leq	No
Apartments	Class A	Daytime	34 dBA Leq	57 dBA Leq	No
		Nighttime	33 dBA Leq	47 dBA Leq	No

[1]Receiver = Noise-sensitive property considered.
[2]EDNA land use category from Table 4-4.
[3]Period for the noise analysis, either peak daytime or peak nighttime hour.
[4]Noise from operations of the park-and-ride garage.
[5]Local code criteria for noise impacts from Section 4.2.5.
[6]Impacts identified by the analysis.

As is shown in **Table 7-3** (Kenmore Park-and-Ride garage local code noise analysis), no noise impacts are predicted for operations of the new Kenmore Park-and-Ride garage.

7.2.3. Bothell Park-and-Ride garage noise analysis

The Bothell Park-and-Ride garage would be located at Lot P, just west of the curve where 98th Avenue NE transitions to NE 185th Street. This four-story garage, like the others, would result in a net increase of 300 parking stalls. The garage would be located in an area with several mixed-use buildings with residential uses on the upper floors and a preschool, commercial uses, restaurants, shopping and other small businesses on the ground floor. Other noise-sensitive uses near the garage include the Bothell Library, a primary care clinic, a dental school and the McMenamins Anderson School (a building eligible for listing on the National Register of Historic Places, constructed between 1931 and 1948, that includes a hotel). Project construction noise is not expected to adversely affect the McMenamins Anderson School, because it is well-shielded by an existing five-story building and is located 210 feet from the nearest proposed construction activity associated with the garage.

The nearest residences are located directly west of the garage in the Live at the Landing Townhomes, where units are as close as 45 feet to the proposed garage structure. The Pop Apartments, which are just to the north of the garage, would be within 80 feet of the structure. Just in front of the Pop Apartments is the Birch Tree Academy preschool, which is also about 45 feet from the parking garage. These two residential locations and the preschool were used for the park-and-ride garage noise analysis for this area. All other noise-sensitive properties would be farther from the garage site and therefore would have lower noise levels. **Table 7-4** (Bothell Park-and-Ride garage FTA noise analysis) provides a summary of the FTA noise analysis, and **Table 7-5** (Bothell Park-and-Ride garage local code noise analysis) shows the local code noise analysis for these three locations. Existing noise levels for this area were taken from measurements at monitoring site M-18, with supporting data from M-19. The noise code in Bothell is also taken from the WAC, which indicates noise impacts occurring at 57 dBA Leq during daytime hours and 47 dBA Leq during nighttime hours.

Table 7-4 Bothell Park-and-Ride garage FTA noise analysis

Receiver[1]	FTA Land Use[2]	Existing Noise (Ldn or Leq)[3]	Garage Noise[4]	FTA Criteria[5]		Impact?[6]
				Moderate	Severe	
Live at the Landing Townhomes	Cat. 2	60 dBA Ldn	56 dBA Ldn	58 dBA Ldn	63 dBA Ldn	No
Pop Apartments	Cat. 2	64 dBA Ldn	47 dBA Ldn	61 dBA Ldn	66 dBA Ldn	No
Birch Tree Academy	Cat. 3	62 dBA Ldn	51 dBA Ldn	64 dBA Ldn	69 dBA Ldn	No

[1]Receiver = Noise-sensitive property considered. Live at the Landing Townhomes are located directly west of the proposed garage site; Pop Apartments are located to the north.
[2]FTA land use category from Section 4.1.1.
[3]Existing Ldn or Leq based on measurement and standard acoustical formulas.
[4]Noise from operations of the park-and-ride garage.
[5]FTA criteria for moderate and severe impacts from Section 4.1.1.
[6]Impacts identified by the analysis.

Table 7-5 Bothell Park-and-Ride garage local code noise analysis

Receiver[1]	Land Use[2]	Time Period[3]	Garage Noise[4]	City Code[5]	Impact?[6]
Live Townhomes	Class A	Daytime	47 dBA Leq	57 dBA Leq	No
		Nighttime	45 dBA Leq	47 dBA Leq	No
Pop Apartments	Class A	Daytime	40 dBA Leq	57 dBA Leq	No
		Nighttime	38 dBA Leq	47 dBA Leq	No
Birch Tree Academy	Class B	Daytime	51 dBA Leq	60 dBA Leq	No
		Nighttime	49 dBA Leq	50 dBA Leq	No

[1]Receiver = Noise-sensitive property considered.
[2]EDNA land use category from Table 4-4.
[3]Period for the noise analysis, either peak daytime or peak nighttime hour.
[4]Noise from operations of the park-and-ride garage.
[5]Local code criteria for noise impacts from Section 4.2.6.
[6]Impacts identified by the analysis.

Results in both tables show that the operation of the park-and-ride garage would not result in any noise impacts under the FTA criteria or the local City of Bothell noise code.

7.3. Traffic noise impacts analysis

This section provides a general discussion of project-related areas considered for traffic noise impacts. There are potential traffic revisions planned as part of the project that could result in increased traffic noise levels. In most locations, the project's slight modifications to traffic lanes are not predicted to cause a measurable change in traffic noise levels, and therefore FHWA regulations would not require a traffic noise analysis. Each of the four project segments is discussed below in terms of locations where increased traffic noise levels could occur and where analysis of traffic noise was required.

7.3.1. Segment 1: Seattle/Shoreline

There are no planned roadway realignments or shielding removal that would affect properties considered to be noise-sensitive under FTA or FHWA criteria for Segment 1. Property acquisition at the southeast corner of NE 145th Street and 15th Avenue NE would result in removal of shielding, but this removal would not affect noise-sensitive properties. Therefore, there are no projected traffic noise impacts in the area.

7.3.2. Segment 2: Lake Forest Park

In Segment 2, the proposed widening of SR 522 near NE 165th Street was evaluated to determine whether it would meet FHWA Type 1 requirements for a detailed noise analysis (as described in Section 4.1.4). Five analysis locations (see **Figure 7-1** (Segment 2: Lake Forest Park - FHWA Type 1 noise analysis review) were evaluated to determine whether the project's roadway realignment would move the nearest travel lane at least half the distance closer to the exterior use at each of the properties and, therefore, would meet the FHWA and WSDOT criterion requiring a Type 1 noise analysis. As shown in **Table 7-6** (Segment 2: FHWA Type 1 traffic noise analysis), the proposed widening would not reduce the distance between any noise-sensitive properties and the proposed roadway by at least half the distance between the existing properties and the existing roadway, and the resulting changes in traffic noise would not result in a perceptible change in traffic noise levels. Therefore, because the project fails to meet the Type 1 criterion for modifications to the horizontal alignment in Segment 2, a detailed noise analysis is not required.

Table 7-6 Segment 2: FHWA Type 1 traffic noise analysis

Receiver[1]	Current Distance[2] (ft)	Distance with Project[3] (ft)	Change in Distance[4] (ft)	dB Change	Half Current Distance[5] (ft)	Current Distance Reduced by Half or More
M-1	59	57	2	0.1	29.5	No
M-2	59	55	4	0.3	29.5	No
M-3	55	52	3	0.2	27.5	No
M-4	71	66	5	0.3	35.5	No
M-5	66	62	4	0.3	33	No

[1]Analysis sites are shown in **Figure 7-1**.

[2]Current Distance = Distance between the noise-sensitive property and the existing nearest travel lane.

[3]Distance with Project = Distance between the noise-sensitive property and the proposed nearest travel lane.

[4]Change in Distance = Difference (in feet) between the current distance and the proposed distance with the project.

[5]Half Current Distance = The minimum distance that the proposed nearest travel lane would have to be realigned to meet the FHWA criteria requiring a Type 1 noise analysis.

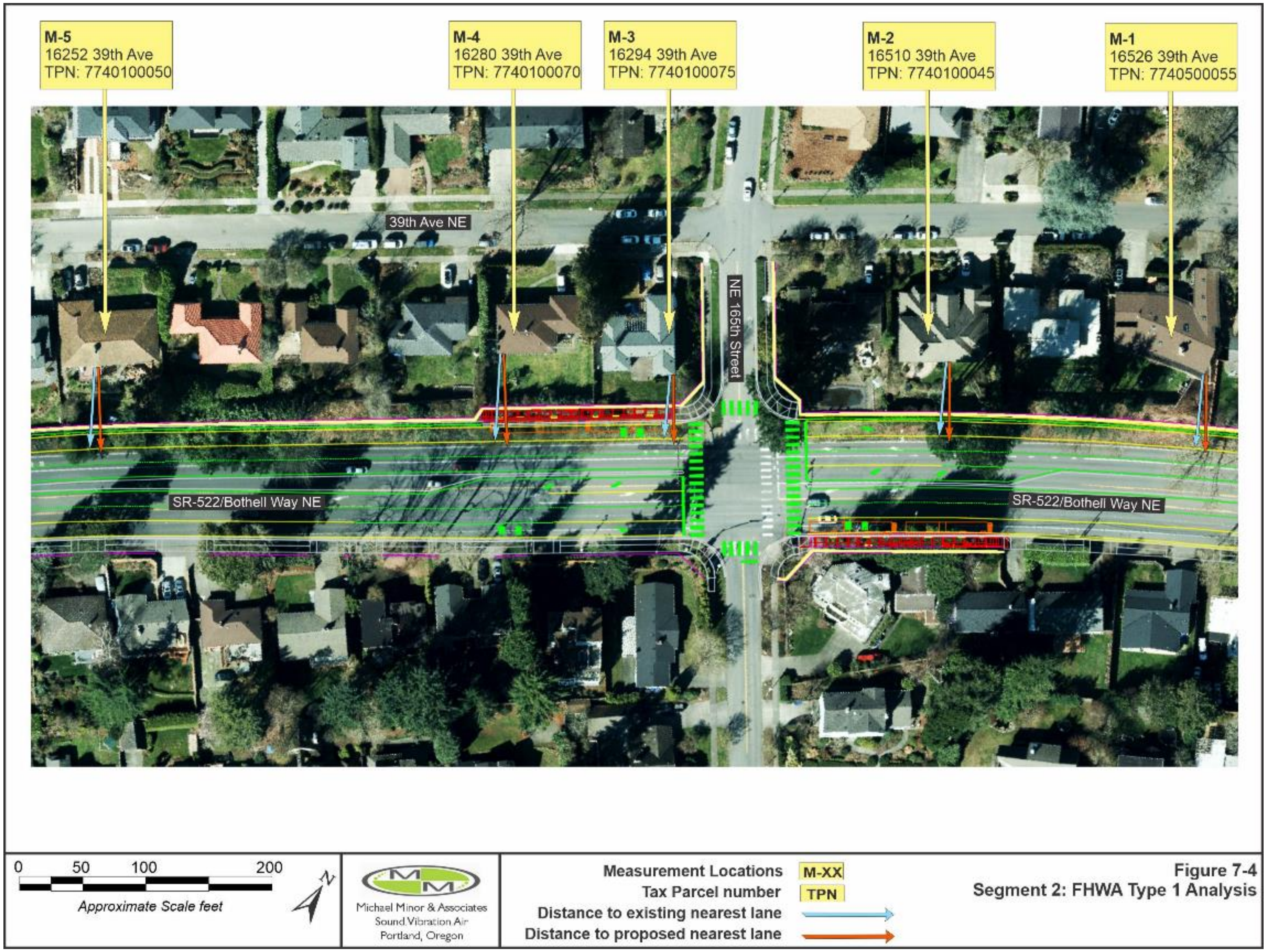


Figure 7-1 Segment 2: Lake Forest Park - FHWA Type 1 noise analysis review

7.3.3. Segment 3: Kenmore

There are no planned roadway realignments or shielding removal for Segment 3 and, therefore, there are no projected traffic noise impacts in the area, including at the Northlake Montessori School.

7.3.4. Segment 4: Bothell

There are no planned roadway realignments or shielding removal for Segment 4 and, therefore, there are no projected traffic noise impacts in the area.

7.4. Long-term vibration impacts

The project would use rubber-tired vehicles, and all of the BRT platforms would be poured cement concrete slabs in order to prevent wear and maintain a smooth surface. With these considerations, the maximum vibration levels from the project are projected to range from 60 to 70 VdB at the nearest residences. Therefore, the FTA vibration criteria of 72 VdB for residences or 75 VdB for schools, churches and other institutional uses would not be exceeded, and no vibration impacts are predicted.

7.5. Short-term construction noise and vibration impacts

Maximum allowable noise from construction activities is governed by the local codes provided in Section 4.2. In most cases, construction noise during daytime hours is exempt from noise ordinances; however, construction during nighttime hours would require a variance from local jurisdictions. Section 4.2 provides details on local ordinances related to construction noise.

The construction predictions presented here are based on typical equipment used for these types of construction projects. Noise levels provided are generally worst-case and would occur only for short periods of time during periods of heavy construction. Also, because of the unique noise and issues associated with pile-driving, a discussion on pile-driving was kept separate and is provided in Section 7.5.2. Finally, when design is finalized, the construction contract specifications would include required mitigation measures and other construction information specific to noise and vibration.

7.5.1. Construction noise

Noise related to construction varies greatly depending on the type of construction activity, the duration of the activity, the distance between the receiver and the source, and the topographical conditions between the source and the receiver. In general, noise levels produced in the construction of this project would be similar to noise produced with most roadway paving projects and construction of multistory buildings. Consistent with the guidance in the FTA Manual (2018), typical construction noise levels were predicted using the FHWA Roadway Construction Noise Model (RCNM) (FHWA 2006). These predictions use reference noise levels from typical construction equipment and account for typical equipment operation, including typical noise levels under load and typical operational times.

Project construction would involve the use of construction equipment typically used for transportation construction projects. **Table 7-7** (Construction equipment and typical maximum noise levels) lists the typical equipment used for this type of project, the activities the equipment would be used for, and the corresponding maximum noise levels that would be produced when measured at 50 feet from the sources under normal use.

Table 7-7 Construction equipment and typical maximum noise levels

Equipment	Typical Use	Lmax (dBA)
Air compressor	Pneumatic tools and general maintenance (all phases)	81
Backhoe	General construction and yard work	80
Compactor	Soil compaction	82
Concrete mixer	Concrete mixing and delivery	85
Concrete pump	Pumping concrete	82
Concrete vibrator	Concrete compacting	76
Crane, mobile	Materials handling: removal and replacement	88
Dozer	General construction use	85
Excavator	General construction, demolition, removal of soils	85
Generator	General construction use and night work	81
Grader	General construction use	85
Haul trucks	Material and soil hauling and general construction	88
Impact wrench	General construction use	85
Jackhammer	Pavement removal	88
Loader	General construction and materials handling	85
Pavement saw	Demolition and general construction	
Paver	Roadway paving	89
Pump	Staging area work and hauling materials	76
Roller	Soil compaction	74
Saw	Concrete removal and utilities access	76
Saw cutter	Surface preparation	83
Scraper	General construction use	89
Shovel	General construction use	82
Truck	General project work	88
Vibratory compactor	Soil compaction and paving	88

Source: FTA 2018, FHWA 2006.

Construction of the project would require several construction phases. **Table 7-8** (Summary of construction phases and reference noise levels) provides a summary of the major construction phases and shows worst-case noise levels for each of these phases as measured at a distance of 50 feet from the construction site. This estimate uses reference noise levels from **Table 7-7** (Construction equipment and typical maximum noise levels) and data provided in the FHWA RCNM. The actual noise levels expected during construction would generally be lower than those presented in the table because all equipment would likely not be running at once at a given site.

Table 7-8 Summary of construction phases and reference noise levels

Phase	Equipment	Lm (dBA)[1]	Leq (dBA)[2]
Demolition, site preparation and utilities relocation	Air compressors, backhoes, concrete pumps, crane, excavator, haul trucks, loader, pumps, power plants, service trucks, pavement saw cutters, tractor-trailers, utility trucks, vibratory compactor	94	87
Park-and-ride garage construction, and roadway and sidewalk paving	Air compressors, backhoes, cement mixers, concrete pumps, crane, haul trucks, loader, pavers, pumps, power plants, service trucks, tractor-trailers, utility trucks, vibratory compactor, welders	94	88
Miscellaneous activities (signage, roadway stripping, installation of electric equipment, etc.)	Air compressors, backhoes, crane, haul trucks, loader, pumps, service trucks, tractor-trailers, utility trucks, welders	91	83

Source: Michael Minor & Associates, Inc. modeling of construction noise using the FHWA Roadway Construction Noise Model (FHWA 2006).

[1] Lm is approximately equal to the Lmax, or the loudest one-second period.

[2] The Leq is for a typical worst-case hour of active construction.

Major noise-producing equipment in use during the site preparation phase would include saw cutters, concrete pumps, cranes, excavators, haul trucks, loaders, tractor-trailers and vibratory equipment. Maximum noise levels could reach 82 to 88 dBA at the nearest residences (i.e., within 50 to 100 feet) for normal construction activities during this phase. Other less notable noise-producing equipment expected to be used during this phase would include backhoes, air compressors, forklifts, pumps, power plants, service trucks and utility trucks.

During construction of the parking structures, the equipment needed would include cement mixers, concrete pumps, cranes, pavers, haul trucks and tractor-trailers. Saw cutters, back-hoes, pavers, haul trucks and material deliveries on flatbed trucks are likely to be used to provide the final surface and structures at stations. Maximum noise levels from these activities would range from 82 to 88 dBA at 50 feet.

Following heavy construction, general construction would still be required, such as installation of signage, and communication and power systems, as well as other miscellaneous activities such as roadway stripping. These less intensive activities are not expected to produce noise levels above 80 dBA at 50 feet except during rare occasions. Even then, noise levels from these activities would exceed 80 dBA at 50 feet only for short periods of time, during which combined maximum noise levels could reach 86 dBA Lmax at 50 feet.

Pile-driving

The use of pile-driving to install support piles or sheet piles may be required for construction of the three park-and-ride garages or the retaining walls proposed in Segments 1, 2 and 4, as described in Tables A-1 through A-4 of the SEPA Checklist. If workers were to use standard impact pile-drivers, this equipment can produce an impact noise of 90 to 105 dBA depending on the type of piles being driven and the specific type of pile-driver used. If pile-driving occurs near residential areas, alternative methods for pile installation could be considered, such as driving the piles using an auger instead of an impact driver. In addition, any pile-driving would be subject to the regulatory requirements of the local jurisdiction. Pile-driving at night is typically prohibited.

Figure 7-2 (Pile-driving noise versus distance based on 105 dBA at 50 feet) provides an estimate of the noise level versus distance for worst-case conditions with pile-driving. The figure shows how pile-driving noise level would decrease with distance based on a reference level of 105 dBA at 50 feet.

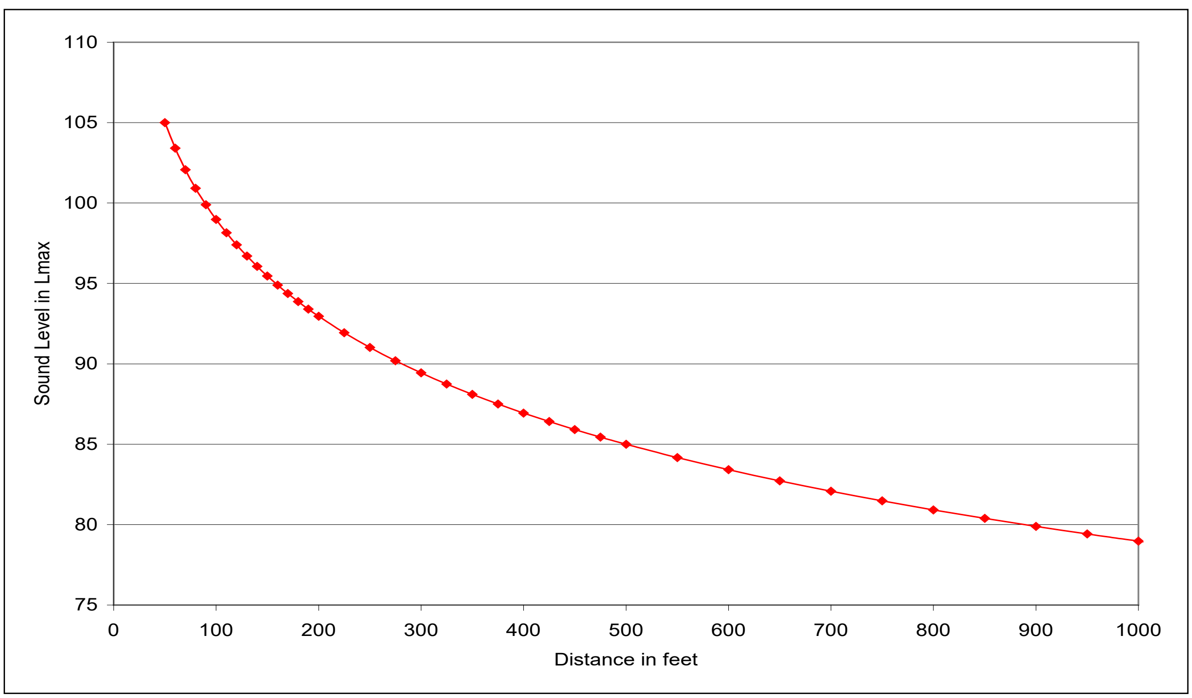


Figure 7-2 Pile-driving noise versus distance based on 105 dBA at 50 feet

Segment 1: Seattle/Shoreline

Construction activities along NE 145th Street would install new sidewalks and improve access for persons with disabilities. These activities, along with construction of the transit queue bypass lanes and new BRT stations along NE 145th Street, could result in short-term noise levels of 85 to 90 dBA Lmax, with hourly averages in the 70 to 80 dBA range during periods of heavy construction.

Construction noise on the south side of NE 145th Street is governed by the City of Seattle. Unlike most other jurisdictions, Seattle places limits on noise levels from construction during weekday daytime hours. Due to the proximity of some residences to the project construction area, construction noise levels could be close to those limits set by the SMC when project construction is occurring close to residences along NE 14th Street. This would include construction of the 30th Avenue NE Station, where some multifamily units could be as close as 10 feet to the project construction. Construction of the 15th Avenue NE Station platform on the south side of NE 145th Street (including potential demolition of two buildings) would produce similar noise levels; however, the 15th Avenue NE Station will be in a commercial area.

The north side of NE 145th Street is within the City of Shoreline's jurisdiction. As described in Section 4.2.3, the City of Shoreline exempts construction during weekdays between 7 a.m. and 10 p.m., and on weekends between 9 a.m. and 10 p.m. The closest residences to project construction in Shoreline would include residences near the NE 8th Street bypass lanes, a multifamily building near the 15th Avenue NE Station, and at the 30th Avenue NE Station (where project construction could occur as close as 20 feet to a large multifamily building).

Comparing the construction noise levels along the project route on NE 145th Street to the recommended limits under the FTA criteria, the noise levels predicted would be in the normal range of acceptable construction noise during daytime hours.

If nighttime work is required on the Seattle side of NE 145th Street, Sound Transit, a project construction representative, or the contractor would be required to follow the methods of obtaining a noise variance from the City of Seattle (Seattle, Washington Municipal Code). For nighttime construction on the north side of NE 145th Street in Shoreline, a noise variance checklist could be prepared (Shoreline, Washington Municipal Code). Any work that could exceed city noise limits would require a variance.

Segment 2: Lake Forest Park

In Segment 2, construction would occur on the east side of SR 522 from NE 145th Street to just before the start of Segment 3. Construction would include road construction, BRT stations, new sidewalks and improved access for persons with disabilities. Although the majority of this segment is in Lake Forest Park, a small portion on the west side of SR 522, from NE 145th Street to NE 149th Street, is within Shoreline.

Residences in this project segment would be as close to the project construction as those described under Segment 1, with the closest residences identified at multifamily residences at 35th Avenue NE and NE 155th Place, and at single-family residences along both sides of SR 522 from NE 155th Street to NE 170th Street. These residences vary from as close as 10 to 15 feet from sidewalk construction to more than 50 feet from project construction in areas with minimal improvements. Construction of the BRT station at NE 165th Street would occur as close as 10 to 15 feet to a residence on the east side of SR 522, and 20 to 30 feet from residences on the west side of SR 522.

Construction of the park-and-ride garage at the Lake Forest Park Town Center would occur in the commercial area near the Lake Forest Park City Hall. The first phase of the construction would be the removal of an existing two-story commercial structure (the Lake Forest Park Professional Building). Construction of the multistory garage would primarily affect nearby commercial uses during daytime hours. The nearest residences are located approximately 165 feet to the east of the garage site, along NE 174th Place and NE 175th Street. Maximum noise levels at these residences are predicted to range from 75 to 77 dBA, and typical hourly Leq noise levels during construction are predicted to be similar to the existing traffic noise levels for this area. As stated in Section 4.2.3, construction is exempt from noise restrictions on weekdays between 7 a.m. and 9 p.m., and on weekends and holidays between 8 a.m. and 9 p.m. Construction outside of these hours would require a variance from the City of Lake Forest Park (Chapter 8.24, Lake Forest Park, Washington Municipal Code).

Comparing the construction noise levels along the project route on SR 522 in Lake Forest Park to the recommended limits under the FTA criteria, the noise levels predicted would be in the normal range of acceptable construction noise during daytime hours. Any work that could exceed city noise limits would require a variance.

Segment 3: Kenmore

The only major construction in the Kenmore segment would be the new park-and-ride garage at the existing Kenmore Park-and-Ride lot. Nearby noise-sensitive properties include a church, an apartment complex, the Columbia Crest Montessori School and the heron rookery.[4] The closest residences are at the apartment complex, which is 100 to 125 feet from the proposed project construction site, and the church is closer, at about 50 feet. The maximum short-term construction noise level could reach 80 to 85 dBA at the apartments and 85 to 90 dBA at the church. Construction noise would also be noticeable at the Montessori school and within the heron rookery. Noise levels at the Montessori school would not be expected to exceed 70 dBA due to the distance from the site. Noise levels at the heron rookery would be highest in the southern portion, nearest the Kenmore Park-and-Ride garage. Maximum construction noise levels could reach 80 dBA at the property line of the heron rookery for short periods of heavy construction. Construction noise levels north of NE 181st Street, approximately 200 feet from project construction, would not be expected to exceed 68 to 70 dBA.

Project construction in this segment would also include installation of new or improved BRT stations at 61st Avenue NE, 68th Avenue NE, and at the park-and-ride. Most land use near these construction sites is commercial, and only minimal construction noise impacts would be expected. Overall, construction noise would be within the limits recommended by FTA.

[4] Noise impacts at the heron rookery are addressed in the project's Ecosystem Resources Technical Report.

The City of Kenmore generally permits construction on weekdays between 7 a.m. and 7 p.m. and on Saturdays between 9 a.m. and 5 p.m. Construction is prohibited on Sundays and holidays. If nighttime work is found to be necessary, a variance can be requested by submitting a written request to the City of Kenmore at least two business days before the requested time.

Comparing the construction noise levels along the project route on SR 522 in Kenmore to the recommended limits under the FTA criteria, the noise levels predicted would be in the normal range of acceptable construction noise during daytime hours. Any work that could exceed city noise limits would require a variance.

Segment 4: Bothell

Construction in Bothell will include several BRT stations and a new park-and-ride garage, as well as local access improvements. Construction of the park-and-ride garage would occur as close as 45 feet to the west and less than 80 feet to the north of existing residences. Other nearby land uses that could be affected by construction include several multifamily communities, row houses, several single-family homes and several businesses, including restaurants and shops. The maximum short-term construction noise level could reach 80 to 90 dBA or more at the nearest residences and would be slightly less (70 to 85 dBA Lmax) at most nearby businesses. These levels are at the top end of the FTA construction noise criteria because of the proximity of some of these noise-sensitive uses to the proposed project construction.

The City of Bothell permits noise from construction activities on weekdays between 7 a.m. and 8 p.m. and on Saturdays between 9 a.m. and 6 p.m., and prohibits noise from construction activities on Sundays and specified holidays. The City of Bothell has regulations that address exceptions for certain types of construction-related noise (BMC Section 8.26.065(D)) as well as noise variances (BMC 8.26.090, Variances) for construction outside of the allowable days and hours (Bothell 2013).

Comparing the construction noise levels along the project route on SR 522 and city streets in Bothell to the recommended limits under the FTA criteria, the noise levels predicted would be in the normal range of acceptable construction noise during daytime hours. Any work that could exceed city noise limits would require a variance.

7.5.2. Construction vibration impacts

Vibration associated with general construction activities can result in increased vibration levels at nearby buildings. As previously stated, because of the short-term nature of vibration-causing construction activities, annoyance from construction-related vibration was not quantified, and the analysis focuses on the potential for damage to buildings. Construction activities that may cause high levels of vibration are pile-driving (at garages and retaining walls), jackhammering, demolition and soil compacting. **Table 7-9** (Vibration source levels at 25 feet) provides a summary of typical vibration levels 25 feet from typical construction equipment used for this type of project. Vibration levels from other construction activities are rarely high enough to cause any sort of structural damage.

Table 7-9 Vibration source levels at 25 feet

Equipment	Typical Use	PPV (in/sec)[1]	Lv (VdB)[2]
Pile-driver (impact)	Structures and support	0.644 (1.518)	104 (112)
Pile-driver (sonic)	Structures and support	0.170 (0.734)	93 (105)
Vibratory roller	Paving	0.210	94
Hoe ram (track jackhammer)	Demolition	0.089	87
Jackhammer	Demolition	0.035	79
Large bulldozer	Clearing and grading	0.089	87
Loaded trucks	Haul materials	0.076	86

Source: FTA 2018.
[1] PPV = peak particle velocity in inches per second (in/sec). Levels in parentheses are upper limits of vibration.
[2] Root mean square (RMS) vibration velocity level (Lv) in decibels (VdB) with a reference quantity of 1 micro-inch/second.

It is important to note that the vibration levels presented are estimations based on general measurements, and the actual vibration level could be more or less than those in **Table 7-9** (Vibration source levels at 25 feet). Typically, construction vibration levels over 90 VdB are more likely to be noticeable inside nearby residences and businesses. Vibration levels over 100 VdB have a slight chance of resulting in some cosmetic damage to fragile buildings. **Table 4-2** (FTA construction vibration damage criteria) lists the typical building damage criteria as provided by FTA. The table shows that, with the exception of pile-driving and in some cases a vibratory roller, most activities would not produce vibration levels that would approach the minimal building damage level of 90 to 98 VdB, which is applicable for most of the sensitive buildings along the corridor.

Park-and-ride garage construction vibration levels may be noticeable at the closest residences and businesses. The review of buildings near proposed construction activity locations did not identify any vibration-sensitive buildings near the Lake Forest Park or Kenmore Park-and-Ride garages. A primary care clinic and a dental school exist near the location of the Bothell Park-and-Ride garage; during periods of heavy construction, vibration could be noticeable inside these two buildings. Based on a review of the corridor, there are no buildings sensitive to vibration that are close enough to the future park-and-ride garage construction activity that construction vibration would have the potential for structural damage to buildings. It is possible that vibration levels could reach 90 VdB or more in some locations, which could be noticeable inside some buildings.

Project construction vibration is not expected to adversely affect the McMenamins Anderson School, because the McMenamins Anderson School is located 210 feet from the nearest proposed construction activity associated with the park-and-ride garage.

8. NOISE AND VIBRATION MITIGATION

8.1. Long-term BRT operational noise and vibration mitigation

No long-term noise or vibration impacts were identified; therefore, no operational mitigation is proposed.

8.2. Short-term construction noise and vibration mitigation

Before construction, the contractor would develop a Noise and Vibration Control Plan to demonstrate how local noise limits would be achieved and vibration impacts avoided. To ensure that noise and vibration impacts would be within the local and state requirements, Sound Transit would approve this plan before initiating construction of the project. This section discusses several construction-related noise and vibration abatement measures that could be included in the Noise and Vibration Control Plan.

8.2.1. Construction noise mitigation

Construction noise impacts can be reduced with operational methods as well as scheduling, equipment choice and acoustical treatments. Project construction noise must meet the local noise control regulations, as defined in Section 4. In most cases, construction noise is exempt from local ordinances during daytime hours, or the criteria are less stringent for construction.

Any potential nighttime or weekend construction would require a noise variance from the appropriate jurisdictions. In some areas of the project corridor, this could mean obtaining variances from multiple jurisdictions. For example, construction along NE 145th Street would require variances from the City of Seattle and the City of Shoreline. The contractor would have the flexibility of either prohibiting certain noise-generating activities during nighttime hours or providing additional noise control measures to meet these noise limits.

Where construction noise could exceed noise criteria at nearby noise-sensitive properties, measures may be required to limit the exposure to construction noise. Noise control measures could include the following:

- Install construction site sound walls near noise-sensitive receivers
- During nighttime work, use smart backup alarms that automatically adjust or lower the alarm level or tone based on the background noise level
- Use low-noise emission equipment
- Implement noise-deadening measures for truck loading and operations
- Conduct monitoring and maintenance of equipment to meet noise limits
- Use sound-deadening material to line or cover storage bins, conveyors and chutes
- Use acoustic enclosures, shields or shrouds for equipment and facilities

- Prohibit the use of impact pile-driving, jack-hammering or other noisy activities during nighttime hours
- Minimize the use of generators or use quiet generators to power equipment

8.2.2. Construction vibration mitigation

Depending on the specific location, time of day and type of construction activity, vibration from construction may elevate levels of vibration and be disruptive to nearby vibration-sensitive properties. To reduce the potential for construction-related vibration impacts, the Noise and Vibration Control Plan mentioned above would include best practices to reduce construction vibration at adjacent sensitive buildings, so that vibration will not exceed the FTA vibration damage criteria (see **Table 4-2** (FTA construction vibration damage criteria)).

Measures to mitigate the potential for building damage from construction vibration could include the use of alternative methods such as drilled shafts in place of driven piles, or the use of static roller compactors rather than vibratory roller compactors.

The use of high-vibration construction equipment (e.g., pile drivers, hoe-rams and vibratory rollers) would be limited near sensitive receivers such as residences, schools and hospitals, if possible. If use of this type of equipment were required, the project would provide advance notification of its use to nearby sensitive receivers.

A pre-construction survey would be conducted and vibration monitoring would be carried out at any buildings identified as sensitive structures, as well as at locations where a construction vibration damage limit is applicable. If pile-driving is determined to be necessary near sensitive structures, test piles would be monitored before starting production pile-driving to ensure that vibration would not result in damage to structures. Even with these measures, it is possible that some residences and business may still find construction-related vibration to be an annoyance.

APPENDIX A

References

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Lake Forest Park, Washington Municipal Code. 2016. Chapter 8.24, Noise Control.

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Seattle, Washington Municipal Code. 2018. Chapter 25.08; SMC Section 25.08.410.

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Washington State Department of Transportation (WSDOT). 2012. 2011 Traffic Noise Policy and Procedures. October 2012.

APPENDIX B

Introduction to Acoustics

Sound is defined as any pressure variation that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. The magnitude of the variations of the air pressure from the static air pressure is a measure of the sound level. The number of cyclic pressure variations per second is the frequency of sound. When sounds are unpleasant, unwanted, or disturbingly loud, we tend to classify them as noise.

Compared with the static air pressure, the audible sound pressure variations range from the threshold of hearing, a very small 20 μPa (20 x 10^{-6} Pascal), to 100 Pa, a level so loud it is referred to as the threshold of pain. Because the ratio between these numbers is more than a million to one, using Pascal to describe sound levels can be awkward. The “dB” measurement is a logarithmic conversion of air pressure level variations from Pascal to a unit of measure with a more convenient numbering system. This conversion not only allows for a more convenient scale, but it is also a more accurate representation of how the human ear reacts to variations in air pressure. Measurements made using the decibel scale are denoted dB.

The smallest noise level change that can be detected by the human ear is approximately 3 dB. A doubling in the static air pressure amounts to a change of 6 dB, and an increase of 10 dB is roughly equivalent to a doubling in the perceived sound level. Under free-field conditions, where there are no reflections or additional attenuation, sound is known to decrease at a rate of 6 dB for each doubling of distance. This is commonly known as the inverse square law. For example, a sound level of 70 dB at a distance of 100 feet would decrease to 64 dB at 200 feet, or 58 dB at 400 feet. The mathematical definition of sound pressure level in dB is listed below.

L_p (sound pressure level). The sound pressure in dB is 20 times the log of the ratio of the measured pressure, p, to the static pressure, p_o, where p_o is 20 μPa.

$$L_{pa} = 20\,Log_{10}\left(\frac{p}{p_o}\right) dB \quad (re\ 20\ \mu Pa)$$

In acoustic measurements where the primary concern is the effect on humans, the sound readings are sometimes compensated by an “A”-weighted filter. The A-weighted filter accounts for humans’ limited hearing response in the upper and lower frequency bands. Sound pressure level measurements made using the A-weighted filter are denoted dBA.

General Measurement Descriptors

Leq (equivalent continuous sound level). The constant sound level in dBA that, lasting for a time "T," would have produced the same energy in the same time period "T" as an actual A-weighted noise event.

$$L_{eq} = 20\,Log_{10}\,\frac{1}{T}\int_{T}^{0}\left(\frac{p(t)}{p_o}\right)^2 dt$$

MaxPeak (maximum A-weighted sound level). The greatest continuous sound level, in dBA, measured during the preset measurement period.

Lmax (maximum A-weighted root-mean square [RMS] sound level). The greatest RMS sound level, in dBA, measured during the preset measurement period.

Lmin (minimum A-weighted RMS sound level). The lowest RMS sound level, in dBA, measured during the preset measurement period.

Statistical Noise Level Descriptors

Public response to sound depends greatly upon the range that the sound varies in a given environment. For example, people generally find a moderately high, constant sound level more tolerable than a quiet background level interrupted by high-level noise intrusions. In light of this subjective response, it is often useful to look at a statistical distribution of sound levels over a given time period. Such distributions identify the sound level exceeded and the percentage of time exceeded. Therefore, it allows for a more complete description of the range of sound levels during the given measurement period.

The sound level descriptor L_{xx} is defined as the sound level exceeded XX percent of the time, where XX is a percentage from 0.1 percent to 99.9 percent. Some of the more common versions of this descriptor and their corresponding definitions are listed below:

L01: The sound level is exceeded 1 percent of the time. This is a measure of the loudest sound levels during the measurement period. Example: During a 1-hour measurement, an L01 of 95 dBA means the sound level was at or above 95 dBA for 36 seconds.

L50: The sound level is exceeded 50 percent of the time. This level corresponds to the median sound level. Example: During a 1-hour measurement, an L50 of 67 dBA means the sound level was at or above 67 dBA for 30 minutes.

L90: The sound level is exceeded 90 percent of the time. This is a measure of the nominal background level. Example: During a 1-hour measurement, an L90 of 50 dBA means the sound level was at or above 50 dBA for 54 minutes.

Other commonly used L_{XX} values include $L_{2.5}$, $L_{8.3}$ and L_{25}. These correspond to the 5-, 10- and 15-minute time levels for a 1-hour measurement period, respectively.

Typical Sound Levels

Two figures are included as sound level reference material. **Table B-1** contains some common noise sources, their nominal maximum sound level in dBA and the usual public response. The levels in this graph are comparable to the Lmax noise level descriptor. This graph would be useful when comparing the loudest noise produced with other familiar noise sources a person may have experienced.

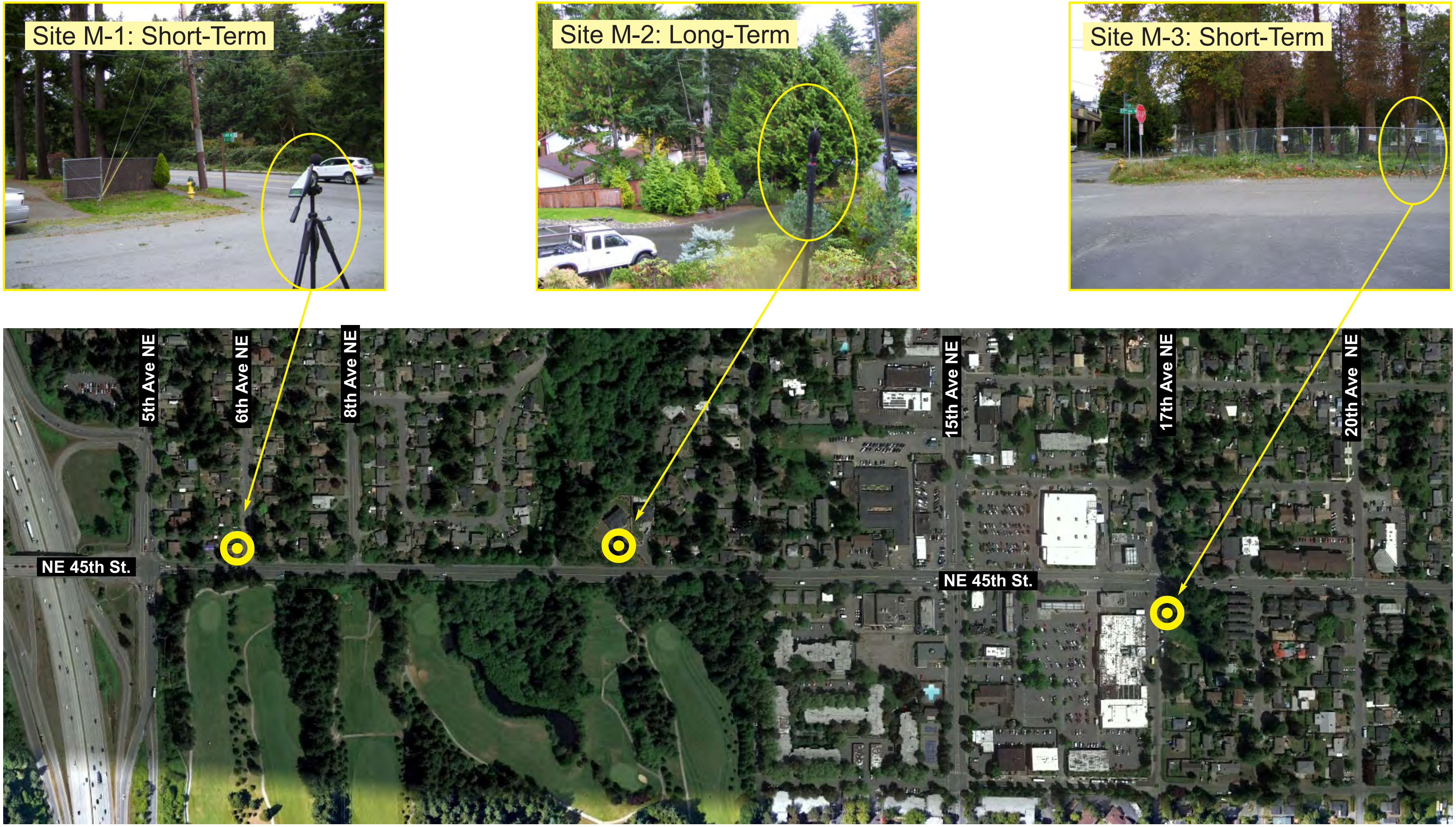
Table B-1 Typical Maximum Sound Levels

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal, food blender (2 feet), pneumatic drill (50 feet)	80	Moderately loud	Reference loudness
Vacuum cleaner (10 feet), passenger car at 65 mph (25 feet)	70		1/2 as loud
Large store air-conditioning unit (20 feet)	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room, bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and U.S. EPA (1971).

APPENDIX C

Noise Monitoring Locations



0 250 500 1000
1.00 in
N

Approximate Scale 1 inch to 500 feet

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

SR 522 BRT Noise Monitoring Sites

0 250 500 1000

1.00 in

N

Approximate Scale 1 inch to 500 feet

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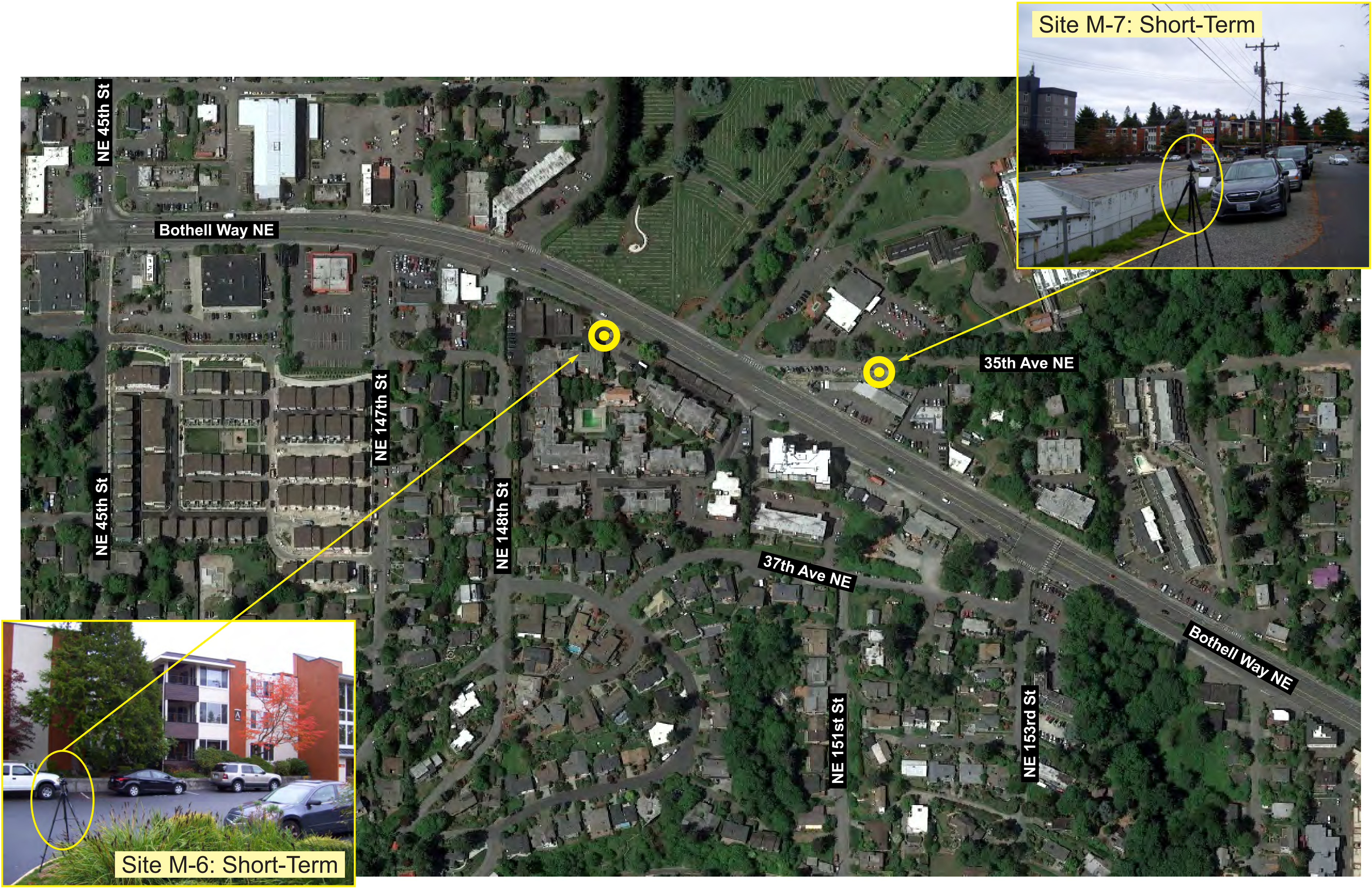
Sound.Vibration.Air
Portland, Oregon

SR 522 BRT Noise Monitoring Sites



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N

Approximate Scale 1 inch to 300 feet

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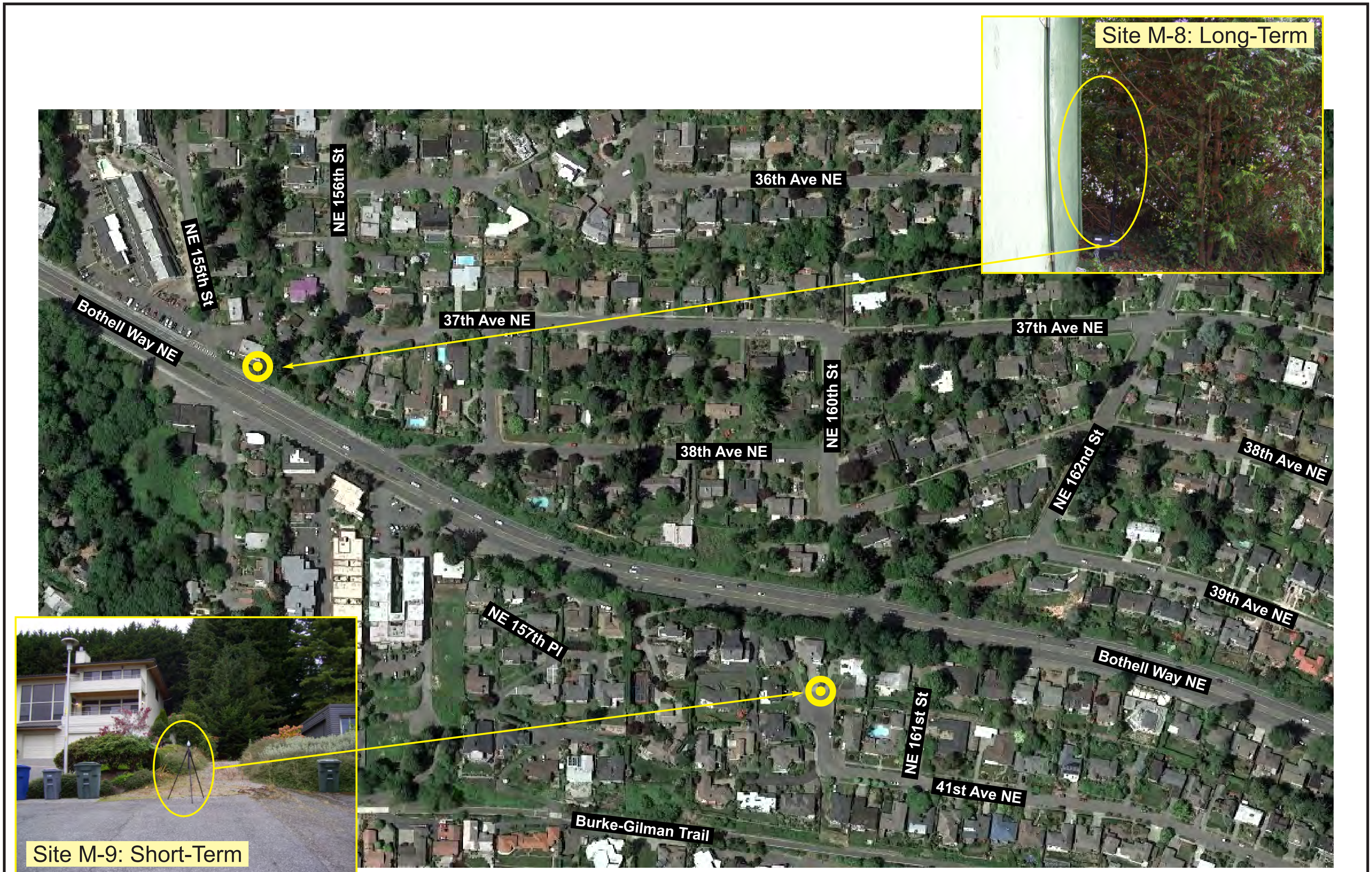
Portland, Oregon

SR 522 BRT Noise Monitoring Sites



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Approximate Scale 1 inch to 300 feet

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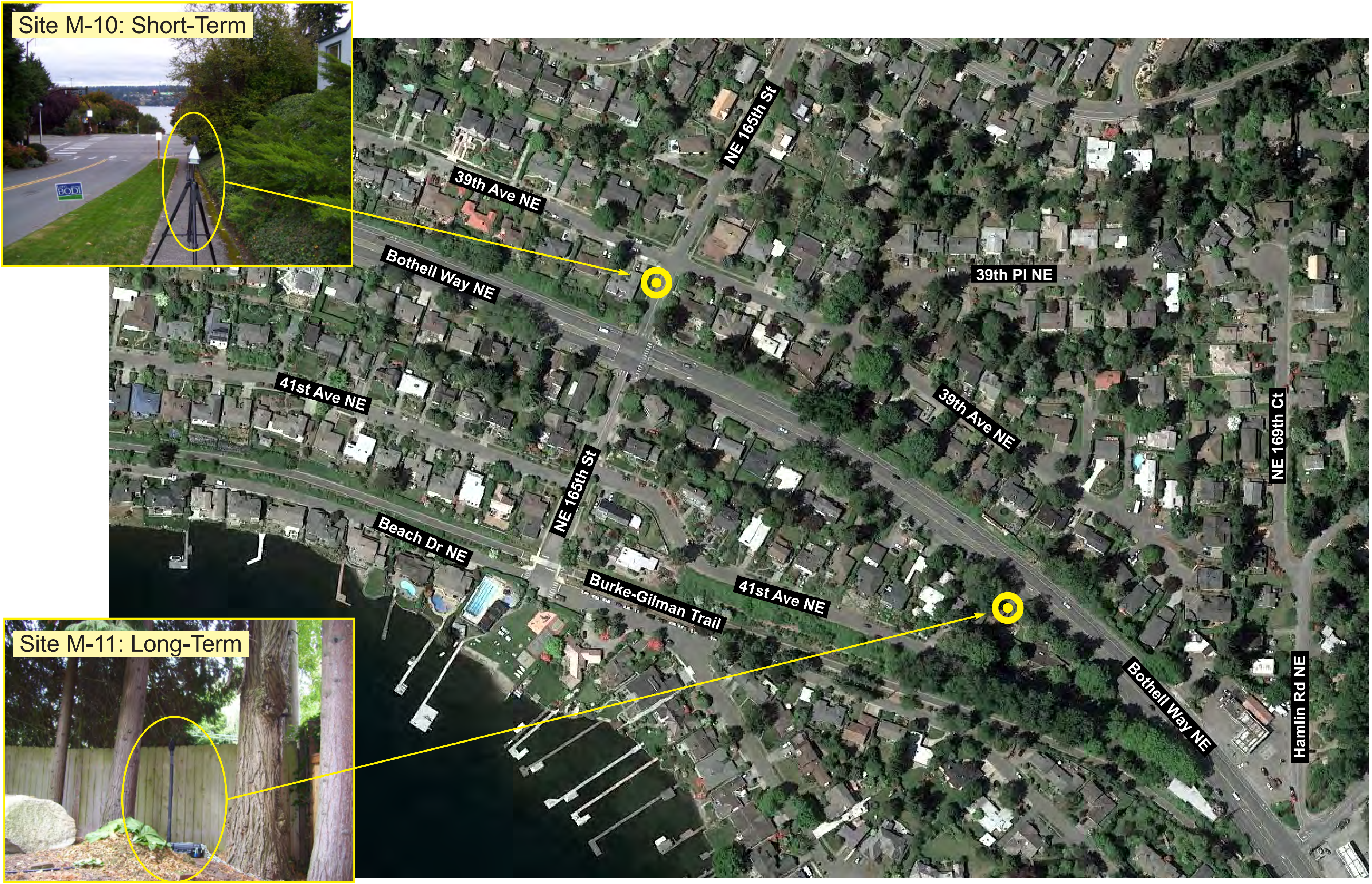
SR 522 BRT Noise Monitoring Sites

SR 522 BRT Noise Monitoring Sites



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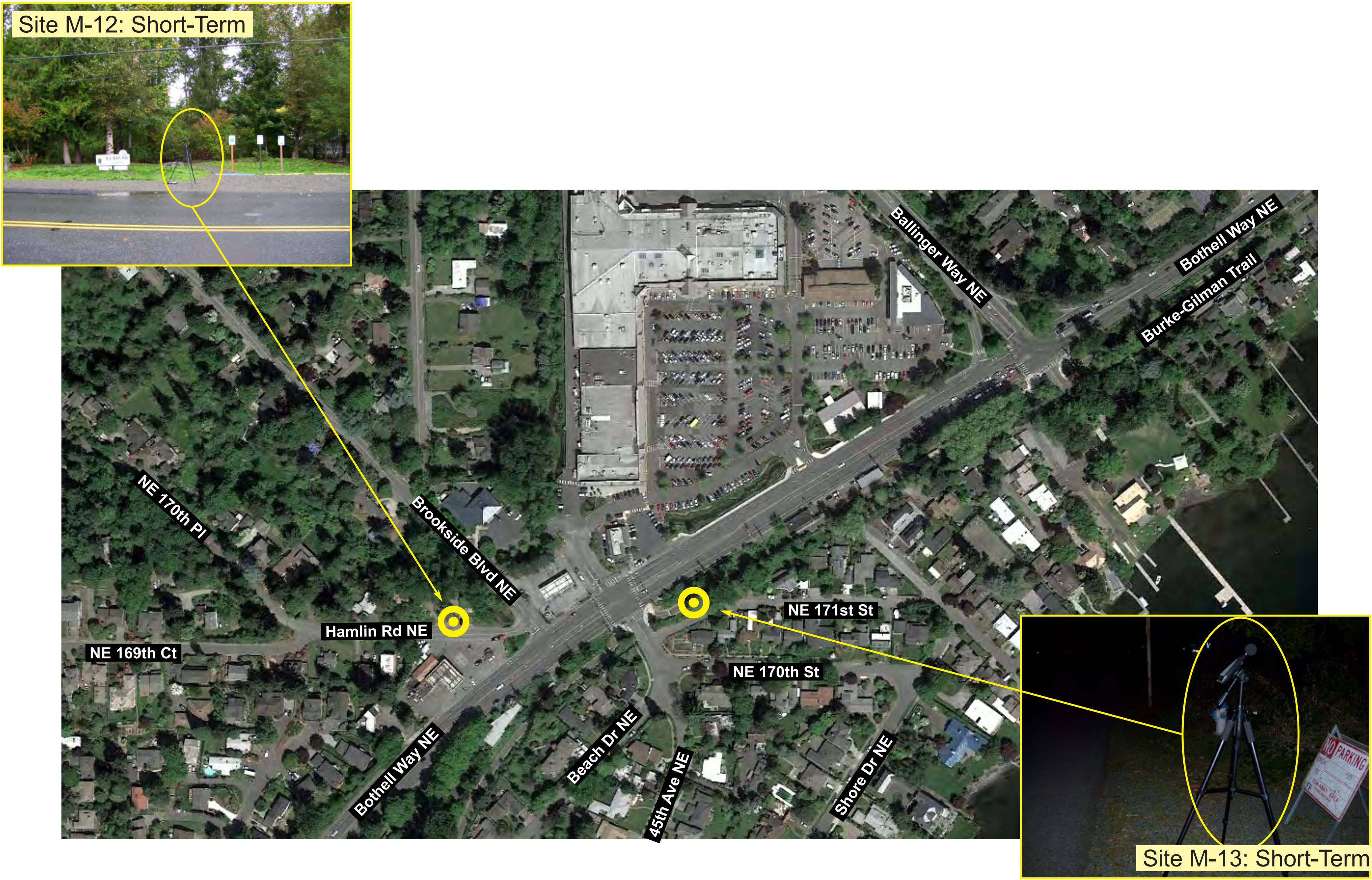
Portland, Oregon



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N

Approximate Scale 1 inch to 300 feet

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SR 522 BRT Noise Monitoring Sites

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1.00 in

Approximate Scale 1 inch to 400 feet

N

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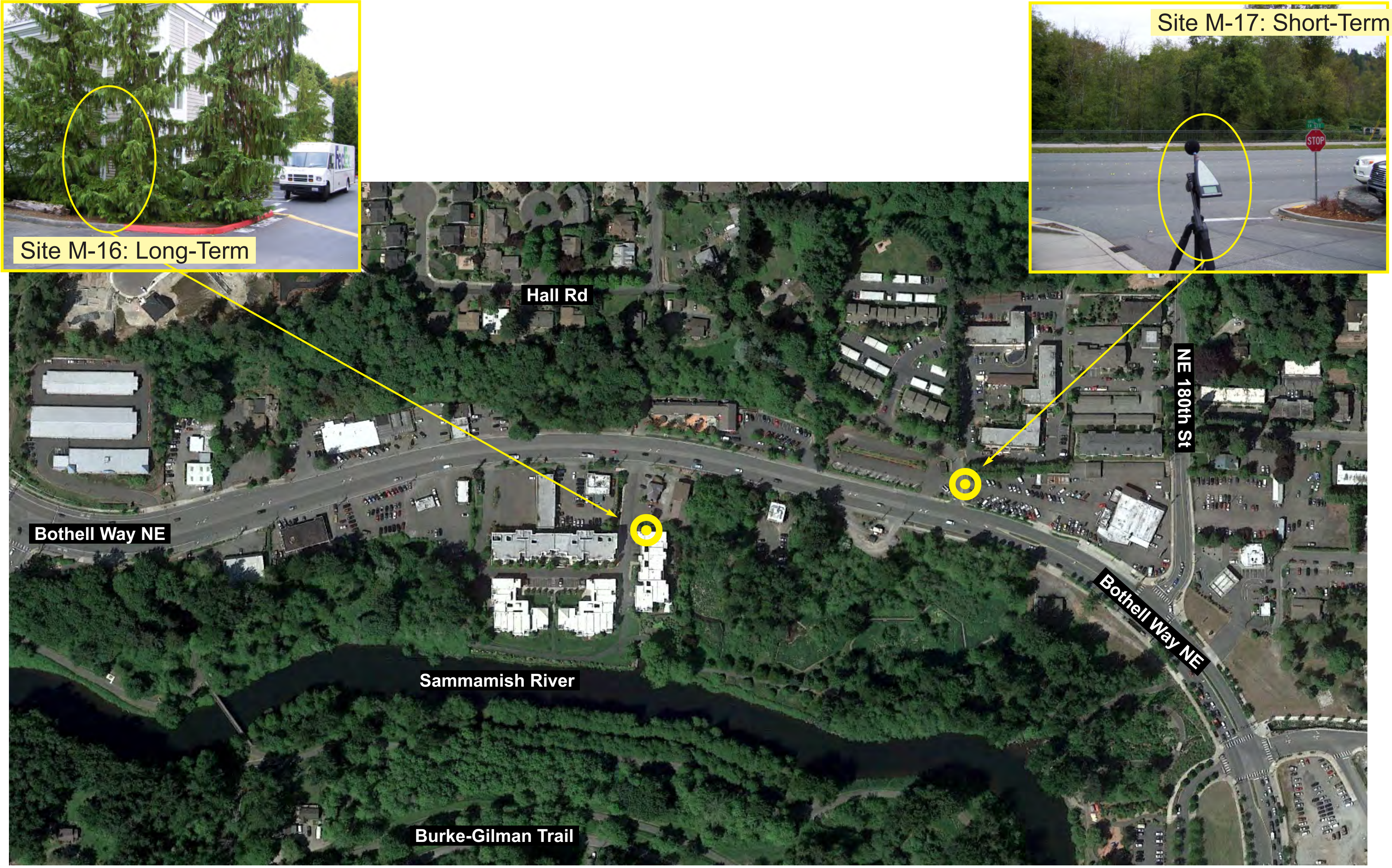
SR 522 BRT Noise Monitoring Sites



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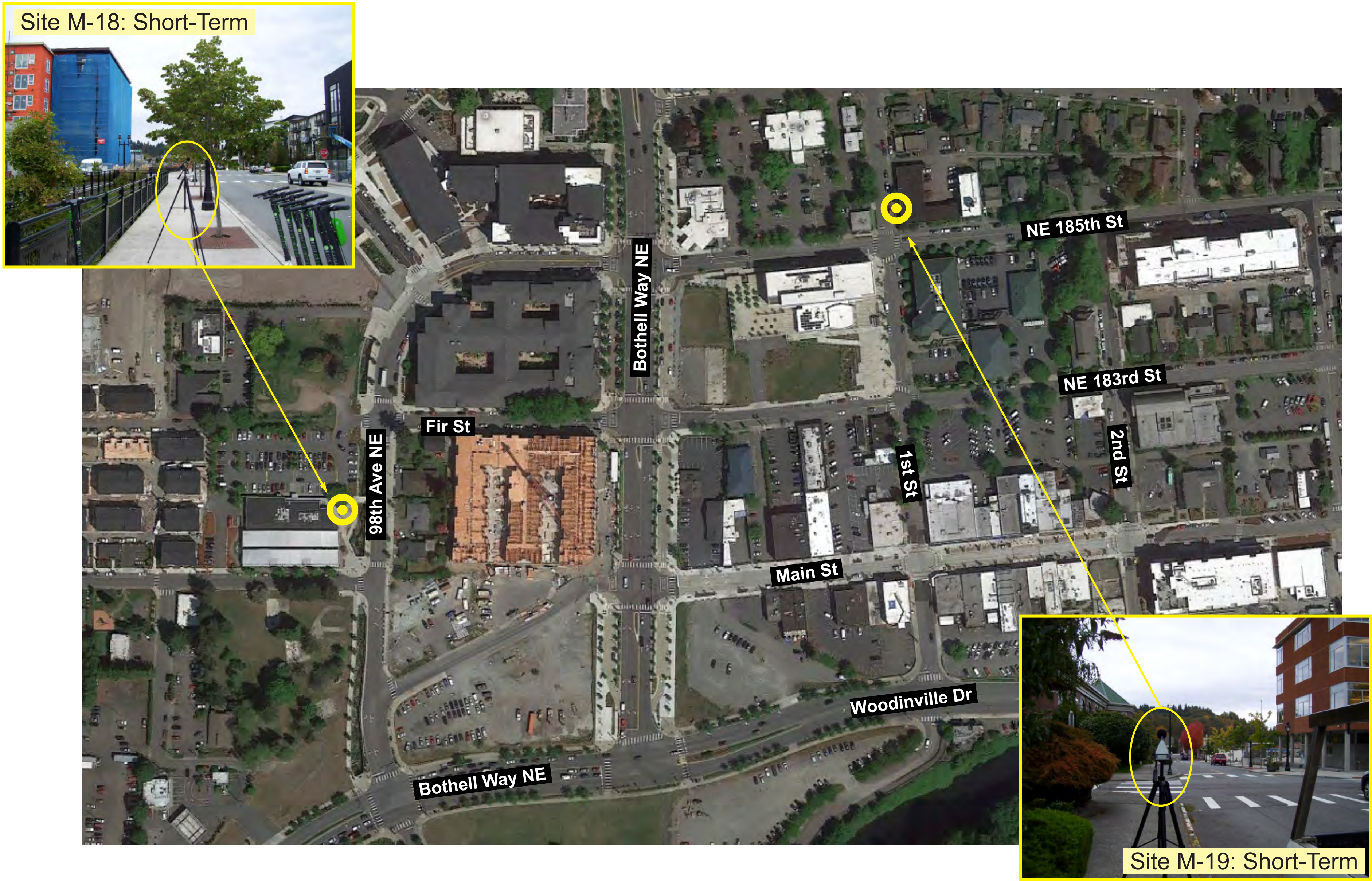
SR 522 BRT Noise Monitoring Sites



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Approximate Scale 1 inch to 300 feet
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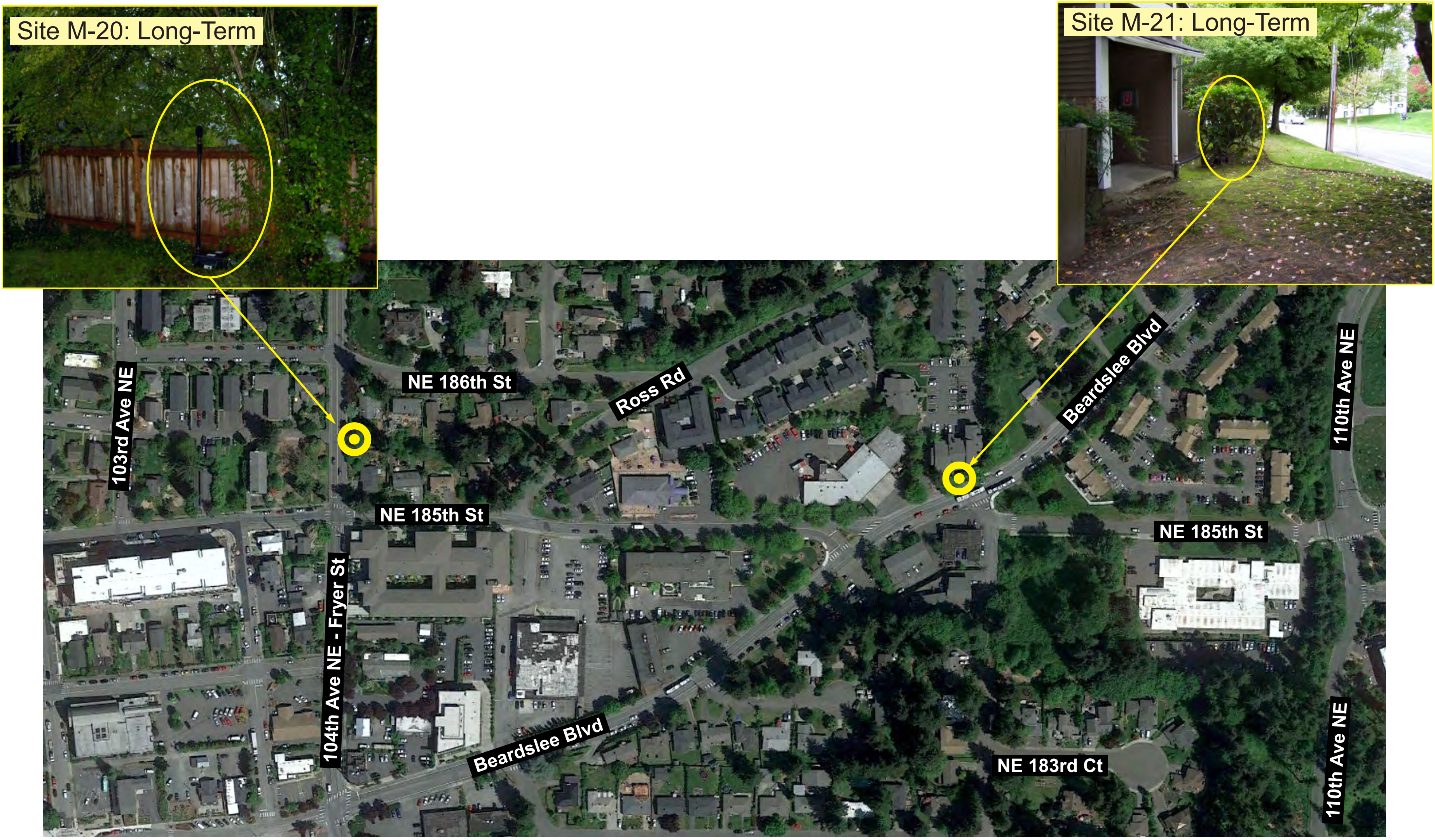
SR 522 BRT Noise Monitoring Sites



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Approximate Scale 1 inch to 300 feet

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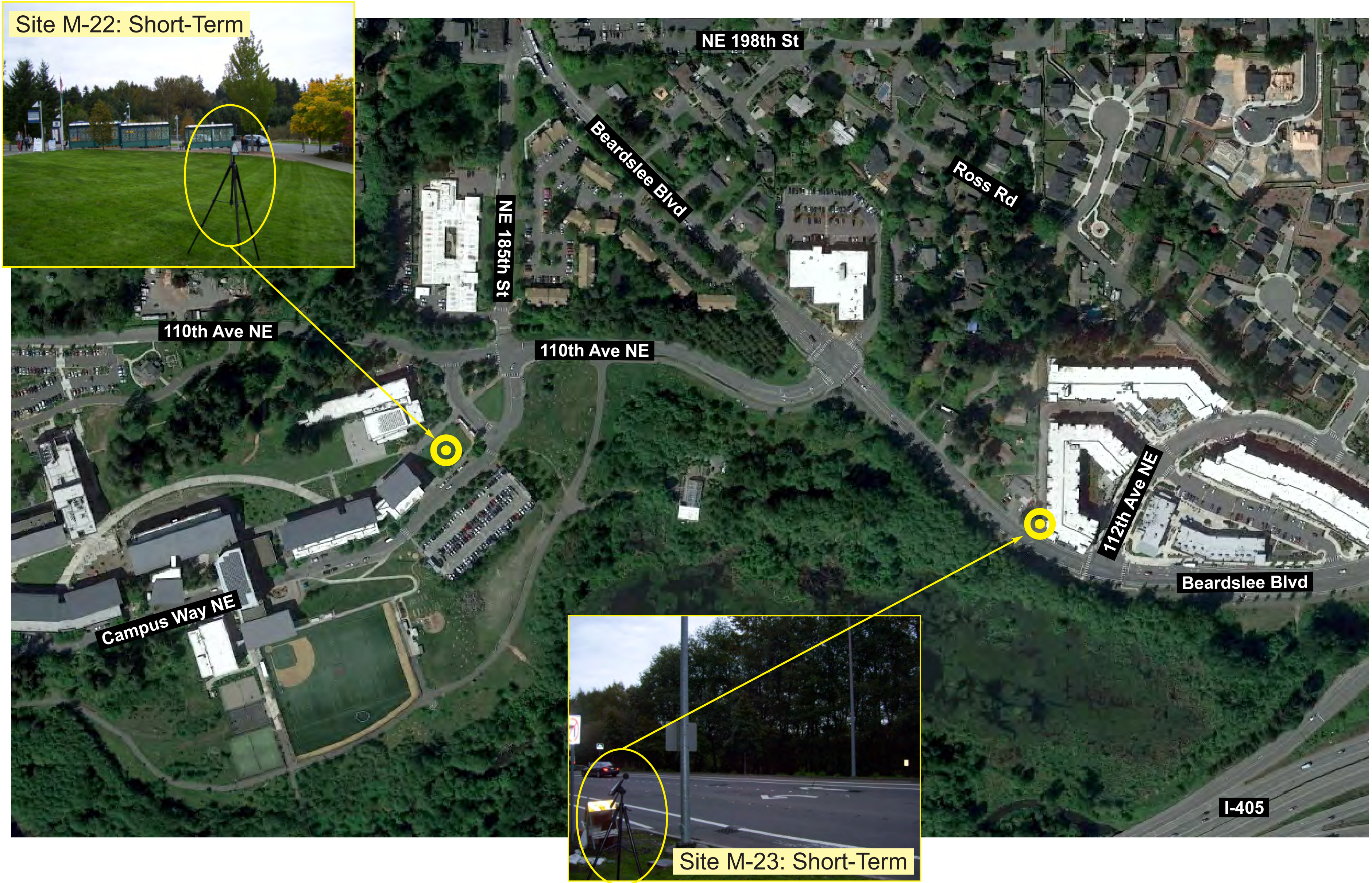
SR 522 BRT Noise Monitoring Sites



0 150 300 600

1.00 in

N

Approximate Scale 1 inch to 300 feet

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SR 522 BRT Noise Monitoring Sites

APPENDIX D

Traffic Data and Counts

Seattle Department of Transportation

AUTOMATIC TRAFFIC COUNT- 1 Hour Detail Report

STUDY 324016	NE 145TH ST, W/O 5TH AVE NE; E FLOW; CHSENSOR A; 29Aug2017 10:00 8/29/2017 10:00:00 AM THRU 9/5/2017 10:00:00 AM

COUNTER: 019	CHAN: SENSOR A	FLOW: E	LANE CODE: STANDARD

Interval	03 Sep 2017 SUN	04 Sep 2017 MON HOLIDAY	29 Aug 2017 TUE	30 Aug 2017 WED	31 Aug 2017 THURS	01 Sep 2017 FRI	02 Sep 2017 SAT
1:00	204	105	146	138	143	159	189
2:00	140	58	83	77	81	93	144
3:00	107	57	72	75	59	84	106
4:00	73	33	58	44	66	67	74
5:00	70	95	115	125	100	123	72
6:00	112	244	313	321	303	316	133
7:00	203	376	489	495	470	504	239
8:00	298	527	683	694	692	665	390
9:00	380	581	764	765	743	785	570
10:00	636	588	802	774	765	864	718
11:00	816	653	809	861	788	881	886
12:00	869	664	893	872	925	998	979
13:00	884	723	935	953	1,053	1,144	1,042
14:00	762	733	966	965	1,079	1,219	990
15:00	866	833	1,099	1,095	1,057	1,196	1,077
16:00	955	918	1,178	1,209	1,256	1,225	960
17:00	1,021	982	1,302	1,292	1,296	1,229	981
18:00	1,004	966	1,273	1,272	1,342	1,110	912
19:00	919	883	1,114	1,163	1,171	1,041	824
20:00	742	714	913	939	953	829	794
21:00	655	630	803	828	825	838	747
22:00	482	463	619	610	658	697	622
23:00	340	327	438	431	507	558	502
24:00	179	172	227	227	283	339	352
Daily Total	**12,717**	**12,325**	**16,094**	**16,225**	**16,615**	**16,964**	**14,303**
AM Peak Vol	869	684	893	901	925	998	979
AM Peak Hr	11:00-12:00	10:15-11:15	11:00-12:00	10:15-11:15	11:00-12:00	11:00-12:00	11:00-12:00
AM Peak Fac	0.909	0.940	0.946	0.939	0.929	0.911	0.900
AM 15min Hi	12:00	10:45	11:30	10:45	11:45	12:00	12:00
PM Peak Vol	1,043	1,004	1,302	1,321	1,385	1,273	1,077
PM Peak Hr	16:30-17:30	16:30-17:30	16:00-17:00	16:30-17:30	16:45-17:45	15:30-16:30	13:45-14:45
PM Peak Fac	0.977	0.977	0.957	0.977	0.967	0.944	0.951
PM 15min Hi	17:30	17:30	17:00	17:30	17:30	15:45	14:30
Max8 Vol	7,352	6,738	8,713	8,869	9,067	8,939	7,862
Max8 %/DT	0.578	0.547	0.541	0.547	0.546	0.527	0.550
Max8 Time	16:30-24:30	16:30-24:30	16:00-24:00	16:30-24:30	16:45-24:45	15:30-23:30	13:45-21:45

Average Daily Traffic (ADT) =	**15,628**	**based on 6 days**
Average Weekday Traffic (AWDT) =	**16,475**	**based on 4 weekday**
AWDT Max8 Volume =	**8,897**	**54.0% of AWDT**
AWDT AM Peak Hour Volume =	**929**	**based on 4 weekday**
AWDT PM Peak Hour Volume =	**1,320**	**based on 4 weekday**

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END OF REPORT

Seattle Department of Transportation

AUTOMATIC TRAFFIC COUNT- 1 Hour Detail Report

STUDY 324017	NE 145TH ST, W/O 5TH AVE NE; W FLOW; CHSENSOR A; 29Aug2017 10:00 8/29/2017 10:00:00 AM THRU 9/5/2017 10:00:00 AM

COUNTER: 057	CHAN: SENSOR A	FLOW: W	LANE CODE: STANDARD

Interval	03 Sep 2017 SUN	04 Sep 2017 MON HOLIDAY	29 Aug 2017 TUE	30 Aug 2017 WED	31 Aug 2017 THURS	01 Sep 2017 FRI	02 Sep 2017 SAT
1:00	322	259	147	185	204	259	364
2:00	182	153	94	104	122	114	193
3:00	187	125	98	83	83	124	160
4:00	98	103	100	74	76	98	97
5:00	106	109	209	215	192	211	97
6:00	152	227	700	698	710	714	228
7:00	284	439	1,387	1,375	1,395	1,283	432
8:00	451	463	1,625	1,717	1,708	1,626	601
9:00	634	657	1,651	1,753	1,783	1,624	932
10:00	1,012	974	1,474	1,413	1,468	1,456	1,171
11:00	1,140	1,186	1,377	1,370	1,381	1,427	1,279
12:00	1,204	1,197	1,320	1,280	1,234	1,305	1,261
13:00	1,263	1,179	1,237	1,301	1,222	1,290	1,215
14:00	1,138	1,285	1,208	1,224	1,194	1,238	1,190
15:00	1,196	1,244	1,197	1,333	1,310	1,410	1,313
16:00	1,047	1,202	1,363	1,376	1,275	1,334	1,231
17:00	1,188	1,166	1,365	1,366	1,268	1,297	1,188
18:00	1,173	1,170	1,402	1,478	1,202	1,381	1,091
19:00	1,034	1,056	1,377	1,451	1,395	1,288	1,101
20:00	983	1,007	1,130	1,200	1,234	1,120	996
21:00	948	901	1026	1,013	1,085	1,014	958
22:00	762	680	745	836	885	839	856
23:00	606	488	525	598	712	804	694
24:00	440	294	320	349	440	548	486
Daily Total	**17,550**	**17,564**	**23,077**	**23,792**	**23,578**	**23,804**	**19,134**
AM Peak Vol	1,204	1,232	1,654	1,767	1,783	1,640	1,286
AM Peak Hr	11:00-12:00	10:15-11:15	06:45-7:45	07:45-8:45	08:00-9:00	08:15-9:15	09:30-10:30
AM Peak Fac	0.971	0.987	0.933	0.936	0.902	0.936	0.965
AM 15min Hi	11:45	11:15	07:00	08:00	09:00	08:30	10:30
PM Peak Vol	1,263	1,309	1,429	1,483	1,404	1,445	1,313
PM Peak Hr	12:00-13:00	13:15-14:15	16:30-17:30	16:45-17:45	17:45-18:45	14:30-15:30	14:00-15:00
PM Peak Fac	0.951	0.940	0.953	0.936	0.929	0.896	0.946
PM 15min Hi	12:45	14:15	17:00	17:15	18:15	14:45	14:45
Max8 Vol	9,349	9,605	11,829	12,124	11,708	11,639	9,686
Max8 %/DT	0.533	0.547	0.513	0.510	0.497	0.489	0.506
Max8 Time	12:00-20:00	13:15-21:15	06:45-14:45	07:45-15:45	08:00-16:00	08:15-16:15	14:00-22:00

Average Daily Traffic (ADT) =	**22,071**	**based on 6 days**
Average Weekday Traffic (AWDT) =	**23,563**	**based on 4 weekday**
AWDT Max8 Volume =	**11,825**	**50.2% of AWDT**
AWDT AM Peak Hour Volume =	**1,711**	**based on 4 weekday**
AWDT PM Peak Hour Volume =	**1,440**	**based on 4 weekday**

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END OF REPORT

APPENDIX E

Noise Modeling Results

SR522/NE 145th BRT Project
Noise Modeling Results

Rec #	Address and/or Site Description	Land Use	Number of Units	Existing Ldn or Leq (dBA)	BRT Ldn or Leq (dBA)	FTA Moderate Impact	FTA Severe Impact	Number of Noise Impacts	Total Ldn or Leq (dBA)	Change in Ldn or Leq (dB)
Segment 1: 145th I-5 to Bothell Way										
Seg1-1	501/516/522 NE 145th	SF Residence	3	73.0	60.0	66	72	--	74	1.0
Seg1-2	6th to 8th Ave, north side of 145th	SF Residence	4	73.0	58.0	66	72	--	73	0.0
Seg1-3	8th to 10th Ave, north side of 145th (west)	SF Residence	4	74.0	59.0	66	73	--	74	0.0
Seg1-4	8th to 10th Ave, north side of 145th (east)	SF Residence	4	71.0	56.0	66	71	--	71	0.0
Seg1-5	Golf Course, south side of 145th	Park	1	69.0	52.0	63	69	--	69	0.0
Seg1-6	10th to 12th Ave, north side of 145th	SF Residence	3	71.0	56.0	65	70	--	71	0.0
Seg1-7	14503 12th Ave NE	SF Residence	1	75.0	59.0	66	74	--	75	0.0
Seg1-8	1202/1206/1216 NE 145th	SF Residence	3	72.0	57.0	66	72	--	72	0.0
Seg1-9	1222 NE 145th	SF Residence	1	71.0	57.0	66	71	--	72	1.0
Seg1-10	1232 NE 145th	MF Residence	2	71.0	56.0	65	70	--	71	0.0
Seg1-11	1234 NE 145th	MF Residence	1	74.0	60.0	66	73	--	74	0.0
Seg1-12	1250 NE 145th	MF Residence	1	70.0	55.0	64	70	--	70	0.0
Seg1-13	1201 NE 145h	MF Residence	2	76.0	63.0	66	75	--	76	0.0
Seg1-14	1207/1213/1219 NE 145th	MF Residence	5	75.0	62.0	66	74	--	75	0.0
Seg1-15	17th to 20th Ave, north side	MF Residence	8	75.0	59.0	66	74	--	75	0.0
Seg1-16	17th to 20th Ave, south side	MF Residence	8	76.0	60.0	66	74	--	76	0.0
Seg1-17	20th to 23rd Ave, north side of 145th	SF Residence	1	76.0	60.0	66	74	--	76	0.0
Seg1-18	20th to 23rd PL, south side of 145th	SF Residence	5	76.0	60.0	66	75	--	76	0.0
Seg1-19	St. Joseph's Carmelite Monastery	Church	1	67.0	51.0	63	68	--	68	1.0
Seg1-20	23rd to 24th Ave, north side of 145th	SF Residence	1	74.0	59.0	66	73	--	74	0.0
Seg1-21	23rd to 24th Ave, north side of 145th	SF Residence	2	71.0	56.0	65	70	--	71	0.0
Seg1-22	23rd to 24th Ave, north side of 145th	SF Residence	3	76.0	60.0	66	74	--	76	0.0
145th - 24th Ave to 27th Ave										
Seg1-23	2412 NE 145th	SF Residence	1	76.0	60.0	66	74	--	76	0.0
Seg1-24	14511 25th Ave NE (Shoreline Methodist Church)	Church	1	68.0	52.0	63	68	--	68	0.0
Seg1-25	23rd PL to 24th Ave, south side of 145th	SF Residence	2	76.0	61.0	66	75	--	77	1.0
Seg1-26	2407 NE 145th	SF Residence	1	74.0	59.0	66	72	--	74	0.0
Seg1-27	14335 24th Ave NE	SF Residence	2	71.0	56.0	65	70	--	71	0.0
Seg1-28	14343 24th Ave	SF Residence	1	75.0	59.0	66	73	--	75	0.0
Seg1-29	2504 NE 145th	SF Residence	1	72.0	57.0	66	72	--	73	1.0
Seg1-30	2510/2516 NE 145th St	SF Residence	2	75.0	59.0	66	73	--	75	0.0
Seg1-31	2524 NE 145th St	SF Residence	1	75.0	59.0	66	73	--	75	0.0
Seg1-32	2511 NE 145th St	SF Residence	1	70.0	56.0	65	70	--	71	1.0
Seg1-33	2513/2519 NE 145th	SF Residence	2	73.0	57.0	66	72	--	73	0.0
Seg1-34	2527 NE 145th	SF Residence	1	76.0	61.0	66	75	--	77	1.0
Seg1-35	2604/2610 NE 145th	SF Residence	2	75.0	59.0	66	73	--	75	0.0
Seg1-36	14507 27th Ave NE	SF Residence	1	76.0	61.0	66	75	--	77	1.0
Seg1-37	2603/2605 NE 145th	SF Residence	2	75.0	59.0	66	73	--	75	0.0
Seg1-38	2609/2613 NE 145th	SF Residence	2	75.0	59.0	66	73	--	75	0.0
145th - 28th Ave to 30th Ave										
Seg1-39	27th to 28th Ave, north side of145th	SF Residence	4	74.0	58.0	66	72	--	74	0.0
Seg1-40	27th to 28th Ave, south side of145th	SF Residence	5	76.0	61.0	66	75	--	77	1.0
Seg1-41	2818 NE 145th	MF Residence	8	73.0	60.0	66	72	--	73	0.0
Seg1-42	14371 30th Ave NE	MF Residence	8	75.0	61.0	66	73	--	75	0.0
145th - 30th Ave to Bothell Way										
Seg1-43	30th to 31st, north side of 145th, west end	MF Residence	2	75.0	59.0	66	73	--	75	0.0
Seg1-44	30th to 31st, north side of 145th, middle	MF Residence	8	78.0	62.0	66	75	--	78	0.0

SR522/NE 145th BRT Project
Noise Modeling Results

Rec #	Address and/or Site Description	Land Use	Number of Units	Existing Ldn or Leq (dBA)	BRT Ldn or Leq (dBA)	FTA Moderate Impact	FTA Severe Impact	Number of Noise Impacts	Total Ldn or Leq (dBA)	Change in Ldn or Leq (dB)
Seg1-45	30th to 31st, north side of 145th, east end	MF Residence	8	72.0	57.0	66	72	--	72	0.0
Seg1-46	31st to 32nd, north side of 145th, west end	MF Residence	2	77.0	61.0	66	75	--	77	0.0
Seg1-47	31st to 32nd, north side of 145th, middle	SF Residence	2	74.0	59.0	66	73	--	74	0.0
Seg1-48	31st to 32nd, north side of 145th, east end	MF Residence	8	78.0	62.0	66	75	--	78	0.0
Seg1-49	14326 30th Ave NE (center)	MF Residence	20	75.0	59.0	66	73	--	75	0.0
Seg1-50	3101 NE 145th (West)	MF Residence	20	76.0	58.0	66	74	--	76	0.0
Seg1-51	3101 NE 145th (East)	MF Residence	16	74.0	58.0	66	73	--	74	0.0
Seg1-52	14349 NE 32nd	MF Residence	16	76.0	59.0	66	74	--	76	0.0
End Segment 1										
Segment 2: Shoreline and Lake Forest Park, SR 522 from NE 145th Street										
Seg2-1	14727 Bothell Way	MF Residence	8	76.0	62.0	66	74	--	76	0.0
Seg2-2	ACACIA Memorial Park	Church	1	73.0	57.0	66	72	--	73	0.0
Seg2-3	ACACIA Memorial Park	Church	0	65.0	49.0	61	66	--	65	0.0
Seg2-4	3520 NE 153rd St	MF Residence	12	73.0	56.0	66	72	--	73	0.0
Seg2-5	Empty									
Seg2-6	Empty									
Seg2-7	14812 BOTHELL NE Way - Watercrest Apts	MF Residence	48	72.0	56.0	66	71	--	72	0.0
Seg2-8	15020 Bothell (upper floors residential)	MF Residence	16	76.0	63.0	66	75	--	76	0.0
Seg2-9	Empty									
Seg2-10	3705 NE 153rd	SF Residence	1	67.0	54.0	63	68	--	67	0.0
Seg2-11	Empty									
Seg2-12	3532 NE 53rd	MF Residence	12	77.0	60.0	66	75	--	77	0.0
Seg2-13	3615 NE 155th	MF Residence	24	75.0	56.0	66	74	--	75	0.0
NE 155 to 157th - NB										
Seg2-14	15514 Bothell Way NE	MF Residence	6	67.0	56.0	63	68	--	68	1.0
Seg2-15	Empty									
Seg2-16	Empty									
Seg2-17	3820 NE 155th	MF Residence	12	75.0	60.0	66	74	--	75	0.0
Seg2-18	15548 Bothell	MF Residence	12	73.0	57.0	66	72	--	73	0.0
Seg2-19	3911 NE 157th	SF Residence	1	65.0	55.0	61	66	--	65	0.0
Seg2-20	3909 NE 157th	SF Residence	1	66.0	56.0	62	68	--	66	0.0
Seg2-21	3902/3906 NE 157th	SF Residence	2	66.0	56.0	62	68	--	66	0.0
157th to 161st - NB										
Seg2-22	3908/3917/3911 157th/158th	SF Residence	3	66.0	56.0	62	68	--	66	0.0
Seg2-23	4005/4001/4004 NE 160th	SF Residence	3	67.0	57.0	63	68	--	67	0.0
Seg2-24	4007 NE 161st	SF Residence	1	67.0	57.0	62	68	--	66	-1.0
Seg2-25	4006 NE 161st	SF Residence	1	68.0	58.0	63	68	--	68	0.0
161st to 165th - NB										
Seg2-26	16112/16118 Bothell Way	SF Residence	2	68.0	58.0	63	68	--	68	0.0
Seg2-27	16124 Bothell Way	SF Residence	1	67.0	57.0	62	68	--	67	0.0
Seg2-28	16130 Bothell	SF Residence	1	69.0	59.0	64	70	--	69	0.0
Seg2-29	16136/16144/16154/16242 Bothell Way	SF Residence	4	68.0	58.0	63	68	--	68	0.0
Seg2-30	16248 Bothell Way	SF Residence	1	67.0	58.0	63	68	--	68	1.0
Seg2-31	16252 Bothell Way	SF Residence	1	67.0	56.0	62	68	--	66	-1.0
Seg2-32	16260 Bothell Way	SF Residence	1	67.0	57.0	63	68	--	67	0.0
Seg2-33	16266 Bothell Way	SF Residence	1	67.0	56.0	62	68	--	67	0.0
Seg2-34	16280 Bothell Way	SF Residence	1	67.0	57.0	63	68	--	67	0.0
Seg2-35	16286 Bothell Way	SF Residence	1	66.0	56.0	61	67	--	66	0.0

SR522/NE 145th BRT Project
Noise Modeling Results

Rec #	Address and/or Site Description	Land Use	Number of Units	Existing Ldn or Leq (dBA)	BRT Ldn or Leq (dBA)	FTA Moderate Impact	FTA Severe Impact	Number of Noise Impacts	Total Ldn or Leq (dBA)	Change in Ldn or Leq (dB)
Seg2-36	4005 NE 165th	SF Residence	1	67.0	57.0	63	68	--	67	0.0
165th to Ballinger - NB (stop at 165th & Ballinger) - NOTE 4004 NE 165th										
Seg2-37	4004 NE 165th St	SF Residence	1	70.0	61.0	65	70	--	70	0.0
Seg2-38	16516/16524 Bothell Way	SF Residence	2	68.0	59.0	63	68	--	68	0.0
Seg2-39	16530 Bothell Way	SF Residence	1	70.0	62.0	64	70	--	71	1.0
Seg2-40	16536 Bothell Way	SF Residence	1	68.0	58.0	63	68	--	69	1.0
Seg2-41	16540 Bothell Way	SF Residence	1	66.0	56.0	62	68	--	67	1.0
Seg2-42	16551/16555 41st	SF Residence	2	64.0	54.0	60	66	--	64	0.0
Seg2-43	16703/16709 41st	SF Residence	2	66.0	56.0	62	68	--	67	1.0
Seg2-44	16715 41st	SF Residence	1	66.0	56.0	62	68	--	67	1.0
Seg2-45	16721 41st	SF Residence	1	66.0	55.0	61	67	--	66	0.0
Seg2-46	16727 41st	SF Residence	1	66.0	56.0	62	68	--	66	0.0
Seg2-47	16747 41st	SF Residence	1	70.0	60.0	64	70	--	70	0.0
Seg2-40	16829/16835/16841 Beach Dr	SF Residence	3	65.0	54.0	61	66	--	65	0.0
Seg2-41	4506 NE 170th	SF Residence	1	64.0	54.0	60	66	--	64	0.0
Seg2-42	4500/4504/4508 171st/17118 Brentwood	SF Residence	4	61.0	51.0	58	64	--	61	0.0
Seg2-43	17114/17124 Brentwood/17228/17228 Beach	SF Residence	4	63.0	52.0	60	66	--	63	0.0
NE 155 to Ballinger Way - SB										
Seg2-44	3640 NE 155th	MF Residence	4	77.0	57.0	66	75	--	77	0.0
Seg2-45	3627/3637 NE 156th/15600/15604 37th NE	SF Residence	4	74.0	55.0	66	72	--	74	0.0
Seg2-46	15612 38th NE	SF Residence	1	77.0	59.0	66	75	--	77	0.0
Seg2-47	15630/15800 38th NE	SF Residence	2	74.0	55.0	66	72	--	74	0.0
Seg2-48	15836 38th/3821 160th	SF Residence	2	77.0	59.0	66	75	--	78	1.0
Seg2-49	16002 38th NE	SF Residence	1	73.0	54.0	66	72	--	73	0.0
Seg2-50	16030 39th NE	SF Residence	1	75.0	57.0	66	74	--	75	0.0
Seg2-51	16200/16210/16218/16226 39th NE	SF Residence	4	74.0	56.0	66	73	--	75	1.0
Seg2-52	16234/16244/16252/16266/16274 39th NE	SF Residence	5	75.0	57.0	66	73	--	76	1.0
Seg2-53	16274/16276/16280/16294 39th NE	SF Residence	4	72.0	59.0	66	71	--	73	1.0
Seg2-54	16502/16510/16518/16526 39th NE	SF Residence	4	71.0	56.0	65	70	--	72	1.0
Seg2-55	16534/16706/16710/16722 39th NE	SF Residence	4	71.0	56.0	66	71	--	72	1.0
Seg2-56	16728/16740/16744/16756 39th NE	SF Residence	4	72.0	57.0	66	71	--	72	0.0
Seg2-57	16756/16764/16776/16815 39th NE	SF Residence	5	74.0	58.0	66	73	--	75	1.0
Seg2-58	Blue Heron Park	Park	1	66.0	48.0	62	68	--	66	0.0
Seg2-59	4616 NE 174th	SF Residence	1	68.0	54.0	63	69	--	68	0.0
End Segment 2										
Segment 3: Bothell Way Ballinger to Glenwood										
Seg3-1	5857 NE 180th	SF Residence	1	71.0	55.0	66	71	--	71	0.0
Seg3-2	6121 NE 175th	SF Residence	24	62.0	52.0	59	65	--	62	0.0
Seg3-3	BRT Stop at 68th Ave	No FTA Criteria								
Seg3-4	BRT Stop at 73rd	No FTA Criteria								
Seg3-5	BRT Stop at 80th	No FTA Criteria								
End Segment 3										
Segment 4: Glenwood-185th-Beardslee										
Seg4-1	17426 Bothell NE Way	MF Residence	24	66.0	52.0	61	67	--	66	0.0
Seg4-2	17432 Bothell NE Way	MF Residence	16	66.0	53.0	62	68	--	66	0.0
Seg4-3	Park Area near Hall, east side	Park	1	63.0	49.0	60	66	--	63	0.0
Seg4-4	Bothell City Park	Park	1	68.0	53.0	63	68	--	67	-1.0
Seg4-5	17511 Bothell Way NE (Northlake Montessori)	School	1	73.0	57.0	66	72	--	73	0.0

SR522/NE 145th BRT Project
Noise Modeling Results

Rec #	Address and/or Site Description	Land Use	Number of Units	Existing Ldn or Leq (dBA)	BRT Ldn or Leq (dBA)	FTA Moderate Impact	FTA Severe Impact	Number of Noise Impacts	Total Ldn or Leq (dBA)	Change in Ldn or Leq (dB)
Seg4-6	17721 HALL Rd	MF Residence	24	66.0	52.0	62	68	--	66	0.0
Seg4-7	9523/9525 NE 180TH S	MF Residence	48	67.0	53.0	62	68	--	67	0.0
Seg4-8	18204 98TH AVE NE (Glenwood)	SF Residence	1	67.0	60.0	63	68	--	68	1.0
Seg4-9	18212 98TH AVE NE (Glenwood)	SF Residence	1	67.0	58.0	63	68	--	68	1.0
Seg4-10	18220 98TH AVE NE (Glenwood)	SF Residence	4	67.0	59.0	63	68	--	68	1.0
Seg4-11	Bothell Library 18215 98th Ave NE	School	1	64.0	53.0	61	66	--	64	0.0
Seg4-12	18333 Bothell Way	MF Residence	12	68.0	60.0	63	69	--	69	1.0
Seg4-13	18333 Bothell Way	MF Residence	12	70.0	60.0	65	70	--	70	0.0
Seg4-14	18505 Bothell Way	MF Residence	12	68.0	57.0	63	69	--	68	0.0
Seg4-15	18420 102nd Ave NE	MF Residence	12	68.0	57.0	63	69	--	68	0.0
Seg4-16	18414 104th Ave Ne (The 104 Apartments)	MF Residence	12	68.0	61.0	63	69	--	69	1.0
Seg4-17	10605 NE 185th (St Aegis of Bothell - Retirement home)	MF Residence	12	67.0	56.0	63	68	--	67	0.0
Seg4-18	10733 Beardslee Blvd	MF Residence	6	67.0	56.0	63	68	--	67	0.0
Seg4-19	10719 Beardslee Blvd	MF Residence	6	67.0	55.0	63	68	--	67	0.0
Seg4-20	10106 NE 185th	MF Residence	6	68.0	58.0	63	69	--	69	1.0
Seg4-21	10116 NE 185th	Church	1	66.0	54.0	62	68	--	67	1.0
Seg4-22	10120/10126 NE 185th	SF Residence	2	67.0	56.0	62	68	--	67	0.0
Seg4-23	10132/10202 NE 185th	SF Residence	2	65.0	54.0	61	66	--	65	0.0
Seg4-24	10212/10216 NE 185th	SF Residence	2	67.0	56.0	62	68	--	67	0.0
Seg4-25	10304 NE 185th	SF Residence	1	66.0	55.0	61	67	--	66	0.0
Seg4-26	10326 NE 186th	MF Residence	2	66.0	58.0	62	68	--	67	1.0
Seg4-27	18504 104th	SF Residence	1	67.0	56.0	63	68	--	68	1.0
Seg4-28	10412 NE 185th	SF Residence	1	67.0	55.0	62	68	--	67	0.0
Seg4-29	10418 NE 185th	SF Residence	1	68.0	57.0	63	69	--	68	0.0
Seg4-30	10426 NE 185th/10504 Ross	SF Residence	2	65.0	54.0	61	67	--	66	1.0
Seg4-31	10508 NE 185th / 10600 NE 18th	School	2	65.0	53.0	61	66	--	65	0.0
Seg4-32	10726 Beardslee	MF Residence	1	65.0	54.0	61	67	--	66	1.0
Beardslee to end										
Seg4-33	10736 Beardslee	MF Residence	4	68.0	58.0	63	69	--	69	1.0
Seg4-34	18607 Beardslee	SF Residence	1	65.0	57.0	61	67	--	66	1.0
Seg4-35	16805 Beardslee	SF Residence	1	66.0	57.0	62	68	--	67	1.0
Seg4-36	16823 Beardslee	SF Residence	1	65.0	54.0	61	66	--	65	0.0
Seg4-37	16705 Beardslee	SF Residence	1	65.0	55.0	61	67	--	66	1.0
Seg4-38	19115 112TH NE Ave	MF Residence	12	76.0	60.0	66	74	--	76	0.0
Seg4-39	19116 Beardslee Blvd	MF Residence	12	74.0	59.0	66	72	--	74	0.0
Seg4-40	19128 112TH NE Ave	MF Residence	12	74.0	60.0	66	72	--	74	0.0
Seg4-41	18612 Beardslee Blvd	MF Residence	3	68.0	61.0	63	69	--	69	1.0
Seg4-42	18612 Beardslee Blvd	MF Residence	18	68.0	56.0	63	69	--	68	0.0
End: Project										

Analysis Summary		Existing Ldn or Leq (dBA)	BRT Ldn or Leq (dBA)	FTA Moderate Impact	FTA Severe Impact	Number of Noise Impacts	Total Ldn or Leq (dBA)	Change in Ldn or Leq (dB)
Total Units:	786							
Count:	156				Total Impacts:	0		
Maximum Levels:		78.0	63.0	66.0	75.0		78.0	1.0
Minimum Levels:		61.0	48.0	58.0	64.0		61.0	-1.0

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