Stride Bus Rapid Transit S3 Line

Noise Report - Additional Analysis

D3458616.04-01

March 2024

Prepared by the STRIDE BRT General Engineering Consultant

Stride Bus Rapid Transit

Project No:	D3458616
Document Title:	Noise Report – Additional Analysis
Document No.:	231117174623_21ad8ebd
Revision:	003
Document Status:	Draft
Date:	03-04-2024
Client Name:	Sound Transit
Client No:	
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File Name:	Noise Report – Additional Analysis

Summary

This additional noise analysis was prepared to address design refinements in the State Route (SR) 522/NE 145th Bus Rapid Transit (BRT) Project that have occurred since the noise and vibration analysis was completed in March 2021 (Sound Transit 2021; hereafter referred to as 2021 Noise Report). This report addresses the project design refinements and compares impacts between the 2021 Noise Report and the current noise and vibration analysis based on 90 percent design plans. This report also includes additional analysis conducted to respond to public comments Sound Transit received after the publication of the 2021 Noise Report. This report concludes that the 2021 analysis is still valid and confirms that no noise mitigation is required.

Proposed Design Refinements

Since publishing the 2021 Noise Report, several project design refinements have affected the noise and vibration analysis. These refinements include the displacement of four residences along NE 145th Street in Seattle and one office building along SR 522 in Lake Forest Park. These displacements will require the removal of the building structure and could change the noise environment. All other displacements resulting from the project are in commercial areas and not considered noise sensitive.

Operational changes include changing the 2 diesel hybrid buses to battery electric buses (BEBs) for a completely electrified bus fleet of 12 BEBs total. This would result in a small overall reduction in total noise because the BEBs are notably quieter at slower speeds and when accelerating from a bus stop, stop sign, or signalized intersection than diesel hybrid or diesel buses. Other project refinements shown in the 90 percent design plans would have no effect on noise or vibration.

Comparison of Impacts

The 2021 Noise Report predicted no operational noise or vibration impacts from the project. The additional analysis of the 90 percent project design refinements similarly shows no impacts. Overall, noise levels will essentially remain the same as the current conditions with slight variations at those sites with removed building structures, new retaining walls, and shifting of general purpose travel lanes. The lack of substantial changes in the overall noise from the project is due to the high existing volumes of traffic in the two main corridors: NE 145th Street and SR 522. The average daily vehicle count for NE 145th Street is 29,139 for 2022 (counts taken at NE 145th Street at 15th Avenue NE). The average daily vehicle count for SR 522 is 34,545 for 2022 (counts taken at SR 522 at Ballenger Way NE). The BRT project would add 220 BEB trips per day, or 110 in each direction, which results in no change in the peak hour traffic noise levels or the 24-hour day-night average sound level (Ldn) noise levels. The dominant noise source is now, and will continue to be, general purpose traffic.

At locations near demolished buildings, there is a potential for general purpose traffic noise increases of 1 to 4 decibels (dB) due to structural shielding being removed. However, even with these slight increases, project noise levels remain below the appropriate residential noise criteria established by the Federal Transit Administration (FTA) for transit-related projects.

To address public comments raising concern about the effects of noise reflections off the retaining wall structures on SR 522 between NE 155th Street and NE 170th Street in Lake Forest Park, additional traffic noise modeling was performed. The majority of residences at this location will have no measurable change in noise levels (+/- 1 dB), while others will benefit from the new retaining walls and may experience overall noise reductions of 2 to 4 dB. Existing noise levels in this area are dominated by general purpose traffic on SR 522, as previously described, and there are no new project-related noise impacts in this area.

In summary, no operational noise or vibration impacts are predicted as a result of project design refinements, and no noise or vibration mitigation is recommended. Construction noise and vibration levels and potential mitigation measures are the same as provided in the 2021 Noise Report.

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Acronyms and Abbreviations

ADA	Americans with Disabilities Act
BEB	battery electric bus
BRT	Bus Rapid Transit
dB	decibel(s)
dBA	A-weighted decibel(s)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
ICE	internal combustion engine
Ldn	day-night average sound level
Leq	equivalent sound level
Lmax	maximum sound level over a measurement period
mph	mile(s) per hour
NAC	Noise Abatement Criteria
SEPA	State Environmental Policy Act
SR	State Route
TNM	Traffic Noise Model
WSDOT	Washington State Department of Transportation

1. Introduction

This additional noise analysis was prepared to address the design refinements in the State Route (SR) 522/NE 145th Bus Rapid Transit (BRT) Project that have occurred since the noise and vibration analysis was completed in March 2021 (Appendix E in Sound Transit 2021), hereafter referred to as 2021 Noise Report. The project will provide BRT service along 9 miles of existing public roadway between Shoreline/Seattle and Bothell, including portions of NE 145th Street, SR 522, and local arterial streets. Design refinements were made between the 2021 Noise Report and current design (90 percent) that could affect the transmission of noise; therefore, this additional noise analysis was performed to evaluate those refinements. This report also includes additional analysis conducted to respond to public comments Sound Transit received after the publication of the 2021 Noise Report.

2. Project Description

The March 2021 State Environmental Policy Act (SEPA) Checklist described the project as follows:

> *Sound Transit proposes to implement the SR 522/NE 145th Bus Rapid Transit (BRT) Project, providing BRT service along 9 miles of existing public roadway between Shoreline/Seattle and Bothell, including portions of NE 145th Street, State Route (SR) 522 and local arterial streets. The proposed BRT project will increase regional mobility and improve transit speed and reliability along the corridor, with interconnections to Link light rail and to other bus services. This State Environmental Policy Act (SEPA) Environmental Checklist evaluates construction and operation of the following project components:*
>
> - *Two BRT stations in Shoreline/Seattle, three BRT stations in Lake Forest Park, three BRT stations in Kenmore, and four BRT stations in Bothell*
> - *New park-and-ride garages in Lake Forest Park, Kenmore and Bothell*
> - *Transit queue bypass lanes, business access and transit (BAT) lanes, and bus-only lanes*
> - *Transit signal priority (TSP) improvements at certain intersections*

A variety of bicycle and pedestrian improvements are also associated with some of these project aforementioned components. Other elements related to this project have been reviewed in environmental documents prepared by the Washington State Department of Transportation (WSDOT), in partnership with Sound Transit. The SEPA environmental documentation included the whole SR 522 BRT project corridor and the analysis was described by project segments (or jurisdiction) as follows:

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

2.1 Design Refinements from 30 to 90 Percent Design that May Affect Noise

As design has progressed from 30 percent (used in the 2021 SEPA checklist) to 90 percent, there have been some refinements to project-related property acquisitions, changes in right-of-way needs, and retaining wall design. In addition, the proposed fleet of buses has been changed to all battery electric buses (BEBs). The 90 percent plans were reviewed for design refinements that warrant additional noise analysis and are described below. Refinements were identified in Segment 1 (Seattle) and Segment 2 (Lake Forest Park). There are no refinements in Segment 1 (Shoreline), Segment 3 (Kenmore) or Segment 4 (Bothell) that warrant additional noise analysis and therefore are not discussed further in this report.

Construction of the parking garages will be deferred per Sound Transit Resolution R2021-05 (August 2021). The Lake Forest garage is deferred until 2044 and the Kenmore and Bothell garages are deferred until 2034. The were no noise impacts related to the operation of the parking garages, and deferring the construction will have no effect on project noise impacts.

2.1.1 Segment 1: Seattle

In Segment 1, Seattle, there are new right-of-way needs that include the full acquisition of four duplex buildings along NE 145th Street, identified here by the Sound Transit property identification number (BRS) and the King County parcel identification number (PIN): BRS-123 (PIN 6632300644), BRS-125 (PIN 6632300645), BRS-127 (PIN 6632300646), and BRS-129 (PIN 6632300647) (shown with the analysis on Figure 6-1). Removal of these structures could increase noise levels at residential uses that are currently shielded from traffic noise along NE 145th Street by these buildings.

2.1.2 Segment 2: Lake Forest Park

In Segment 2, Lake Forest Park, there is one full acquisition of one commercial building on SR 522: BRS-253 (PIN 6744700123) (shown with the analysis on Figure 6-2). Removal of this structure could increase noise levels at residential uses that are currently shielded from traffic noise along SR 522 by this building.

The other design refinement in Segment 2, Lake Forest Park, is related to the retaining walls between NE 155th Street and NE 170th Street. Earlier in design (between 30 percent and 60 percent), the retaining walls on the west side of SR 522 were designed as a thinner wall type with tiebacks. These tiebacks were estimated to extend 50 to 80 feet into the adjacent parcel and would have been installed under adjacent existing homes. To avoid this issue, Sound Transit modifed the design to soldier pile walls, which would avoid using tiebacks. This type of wall required more right-of-way (the wall would cut deeper into the hillside due to its thickness). As the project design continued, the design team determined that the required drainage would also require additional right-of-way. The combination of these modifications resulted in slightly taller retaining walls in some areas and walls that are the same height or slightly lower in other areas. The overall change in the wall heights from the 30 percent design to 90 percent design is negligible in most locations; however, the top of wall elevations are now smoother and vary less than in the 30 percent design. The retaining wall heights vary from 4 feet up to 17 feet and may include safety fences on top in some locations.

Sound Transit has received comments from the public expressing concern about the shift of the roadway alignment through parts of Lake Forest Park. Impacts related to the roadway alignment shift were covered in the 2021 Noise Report and 2021 SEPA Checklist. For this additional analysis, the noise analyst compared the 30 percent design used in the 2021 Noise Report to the current 90 percent design and confirmed that no horizontal changes to the roadway have occurred between the design phases; there are no design refinements related to the roadway alignment.

3. Supporting Acoustical Information

The 2021 Noise Report has a comprehensive introduction to acoustics complete with noise and the measurement of noise, methods used for the noise analysis, data sources, and detailed information on the noise monitoring performed for the noise analysis. The following information is included to provide some general acoustical information to aid in the understanding of the results of this additional analysis.

3.1 General Introduction to Acoustics

Noise is generally defined as unwanted sound. Noise is measured in terms of sound pressure level. It is usually expressed in terms of decibels (dB). The human ear is less sensitive to higher and lower frequencies than to mid-range frequencies. Therefore, sound level meters used to measure environmental noise generally incorporate a weighting system that filters out higher and lower frequencies like the human ear. This system produces noise measurements that approximate the normal human perception of noise. Measurements made with this weighing system are termed "A-weighted" and are specified as "dBA" readings. All data in this report are presented in A-weighted decibels (dBA).

The following noise level descriptors are used in this analysis:

- 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, where “T” is normally 1 hour. The peak hour Leq is the primary noise descriptor for traffic noise studies using Federal Highway Administration (FHWA) and WSDOT criteria. The Leq is also used for Federal Transit Administration (FTA) analysis of schools, churches, libraries, parks, and other sensitive uses with primarily daytime use.
- Ldn (day-night average sound level): A 24-hour equivalent continuous level in dBA where 10 dB is added to nighttime noise levels from the hours of 10:00 p.m. to 7:00 a.m. This 10 dB penalty covers the time when noise is typically most disturbing. The Ldn is the primary descriptor for residential land use under the FTA criterion.
- Lmax (maximum sound pressure level): The maximum sound level in dBA over a specific measurement period of any time length. This Lmax is typically used for construction noise.

3.2 General Rules of Acoustics

- A 3 -decibel (dB) change in broadband noise, like that from traffic, is the minimum change in noise most people will notice in urban environments, and a 5-dB change in noise levels is typically perceivable by most people. 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.
- 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 between the noise source and receiver. 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.
- Traffic noise from busy roadways, like NE 145th Street or SR 522 typically reduce at 3 dB per doubling of distance. For example, if the noise level at 50 feet was 70 dBA, at 100 feet it would be reduced to 67 dBA. Conversely, at 25 feet it would increase by 3 dB to 73 dBA.
- Combining two 60 dB noises 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 televisions. Section 3.3 provides more information on how to add decibels.
- Vehicle speeds: A 10 mile per hour (mph) increase in speed typically results in an increase in traffic noise levels of 3 dB, and conversely, a reduction of 10 mph would reduce the noise levels by 3 dB. For speeds

under 25 to 30 mph this is no longer true because engine noise tends to dominate and no reduction in noise can be expected for speeds lower than 25 mph (except for battery electric vehicles).

- Traffic volumes: Maintaining the travel speeds and vehicle mixture of passenger cars, medium trucks, and heavy trucks the same, it takes a doubling of the traffic volume to increase noise by 3 dB, and, conversely, if traffic volumes are cut in half, noise would be reduced by 3 dB.
- Foliage and ground cover: Dense foliage can slightly reduce noise levels. The FHWA assumes up to a 3- to 5-dBA reduction in traffic noise for locations that have at least 100 feet of dense evergreen foliage. There are no areas where the removal of foliage would be predicted to have a measurable effect on noise levels. Ground cover between the receiver and the noise source can also affect noise transmission. For example, sound will travel very well across reflective surfaces such as water and pavement but can be attenuated when the ground cover is field grass, lawn, or even loose soil. There are no changes in ground cover that would be predicted to have a measurable effect on noise levels.
- It is conceivable for noise to reflect off retaining walls or noise walls and bounce back across the roadway to receivers on the other side of the road. These reflections have the potential to increase noise levels by 2 to 3 dB when all (100 percent) of the noise is reflected directly back across the roadway with no additional obstructions. This direct reflection condition would also require a smooth flat perpendicular wall where the reflection occurs. However, due to the attenuation from the added distance the noise must travel, diffraction, or scattering of noise in different directions at the wall surface, and additional attenuation caused by the reflected noise being disrupted by other vehicles on the roadway (obstructions), the actual increase in noise is typically 1 to 2 dB. Additional discussion on reflected noise is provided in Section 6.1.2.3, focused on the retaining walls along SR 522 in Lake Forest Park.

3.3 Decibel Math

The following decibel calculation information is included to aid in understanding of project noise analysis. 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 total 120 dB. Instead, combining two 60 dB sources yields 63 dB due to the logarithmic nature of the decibel scale. To allow for simple additions of different noise sources, Table 3-1 is provided. The information in the table was derived using standard logarithmic formulas and allows for a quick estimate of the total noise when two sources are added together.

Using the addition factors in Table 3-1, adding 60 dBA and 65 dBA noise sources would equal approximately 66 dBA because the difference of 5 dB would have an addition factor of 1 dB, which is added to the louder of the two noise sources (the actual result is 66.19 dBA). When two similar sounding noise sources are 10 dB apart in magnitude, the addition factor is 0 dB, and for similar noise sources, like traffic noise, an average person would only be able to hear the louder of the two sources.

Table 3-1. Decibel Addition Factors

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

4. Regulatory Overview

Sound Transit prepared the 2021 Noise Report and this current updated transit noise analysis, both following the FTA methods and criteria. In addition to a noise analysis of the BRT operations, the FTA criteria include reviewing the removal of shielding that could increase traffic noise at noise-sensitive properties using the FHWA and WSDOT analysis methodologies.

The 2021 Noise Report provides complete details on the noise impact criteria from the FTA, FHWA, WSDOT, state of Washington, and local noise control codes from the five cities along the SR 522 BRT project corridor (Seattle, Shoreline, Lake Forest Park, Kenmore, and Bothell). Therefore, only a brief summary of the FTA and FHWA criteria is provided here for reference.

4.1 FTA Criteria

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 three categories, two of which apply to this analysis: FTA Category 2 for residences and other buildings where people sleep, and FTA Category 3 for schools, churches, daycares, and other sensitive uses with primarily daytime activities. The FTA has two levels of impact included in the criteria, moderate and severe, which are based on the existing noise levels at the receiver location under consideration.

The Ldn metric is used to characterize noise exposure for residential areas (FTA Category 2). For other noise-sensitive land uses, such as schools and churches (FTA Category 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. A summary of the criteria is provided on Figure 4-1. To provide an understanding of how the criteria work, a sample using the red arrows on the figure shows that for a residence (FTA Category 2) with an existing noise level of 65 dBA Ldn, a moderate noise impact would occur if the noise from the BRT operations exceeds 61 dBA Ldn, and a severe impact would occur at 66 dBA Ldn. More information is available in the 2021 Noise Report (Sound Transit 2021).

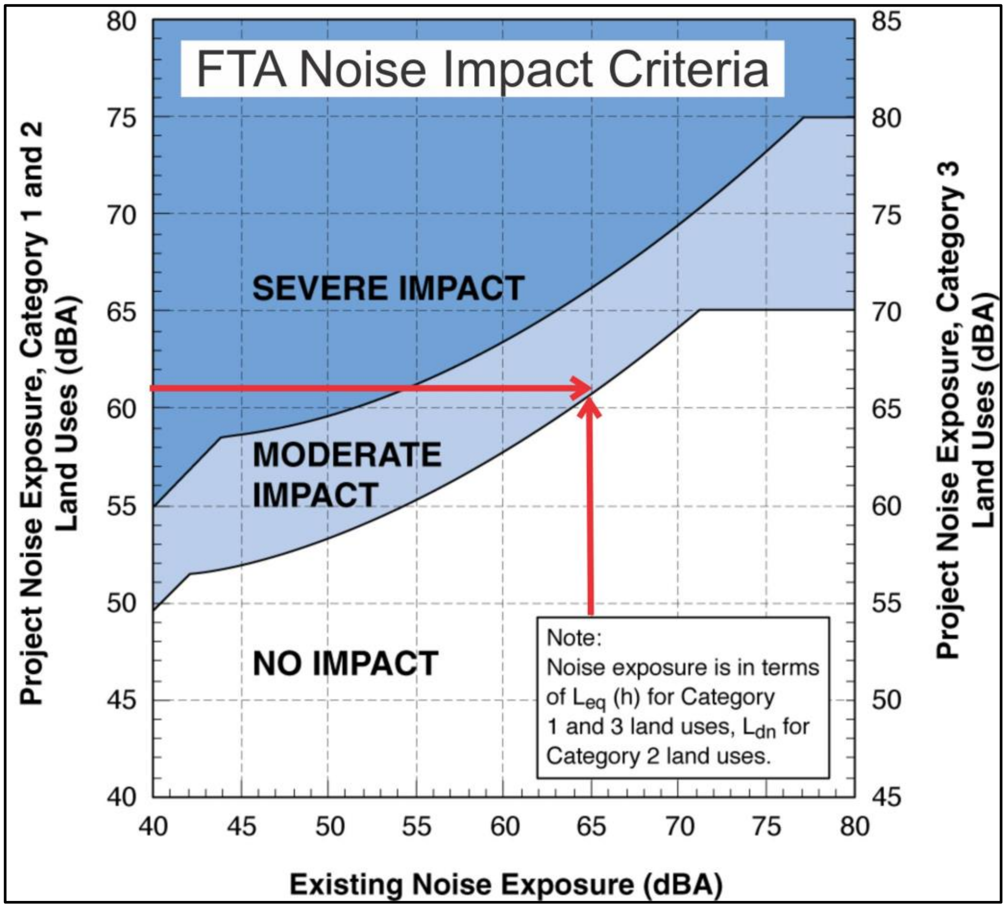
4.2 FHWA Criteria

The FTA uses the FHWA modeling methods for evaluation of traffic noise. In contrast to the FTA, the FHWA criteria for traffic noise impacts are the same regardless of the existing noise levels and occur at 66 dBA Leq during the peak traffic hour for residences (FHWA Category B), and also for schools, hospitals, libraries and other sensitive uses (FHWA Category C). Hotels, motels, offices, restaurants/bars, and other developed lands have an impact criterion of 71 dBA Leq, also during peak hour (FHWA Category E). There is also a substantial increase criterion under FHWA and WSDOT, which occurs if the future traffic noise levels exceed the existing levels by 10 dB or more. More information on all the federal noise criteria is available in the 2021 Noise Report (Sound Transit 2021).

4.3 Local Noise Control Criteria

The local criteria for noise impacts are used when evaluating impacts from ancillary facilities, like park-and-rides, maintenance bases, and other supporting facilities along with noise related to construction. Discussions of all relevant local and state ordinances were provided in the 2021 Noise Report and are primarily related to project construction and stationary facilities, like the park-and-rides. There are no notable changes to any project-related stationary facilities or to project construction since the 2021 Noise Report that would result in any new noise impacts. However, construction of the parking garages is being deferred until 2034 for the Kenmore and Bothell garages, and 2044 for the garage in Lake Forest Park.

Figure 4-1. FTA Noise Impact Criteria



Source: FTA 2018

5. Methodology

The methods for this noise analysis are the same as presented in the 2021 Noise Report (Sound Transit 2021). Noise related to BRT operations are performed using the FTA criteria. Under the FTA criteria, if a structure is removed that is providing acoustical shielding of traffic noise from a noise-sensitive property, those potential traffic-related noise level increases are analyzed using the FHWA Traffic Noise Model (TNM). TNM modeling was used for structure removal in Seattle, Shoreline, and Lake Forest Park, see Section 6.1 for the results. Traffic noise modeling using TNM can also be used to understand future noise levels in areas where minor roadway modifications would occur.

The locations of receivers used in a noise analysis are based on the criteria or regulation being considered. For the FTA analysis of the Ldn, the noise levels are predicted at the structure because the Ldn is a 24-hour noise level applicable to the noise level inside residences. For noise from traffic using FHWA methods, the noise levels are predicted at the frequent outdoor use at the property. This is usually in the backyard, on a deck or other frequently used area for outdoor gatherings at the property. Finally, most local and state regulations, applicable to ancillary facilities, like parking garages and construction, the noise level is predicted at the property line. The analysis in Section 6.1 is only applicable to traffic noise and uses the FHWA methods, and therefore all noise levels predicted are for the frequent outdoor use, with some exceptions, in an effort to provide a complete understanding of noise levels along the corridor.

Since the publication of the 2021 Noise Report there have been some refinements to the proposed BRT system as described in Section 2.1. One of the notable updates is changing the fleet of buses to all BEBs. The 2021 Noise Report assumed 10 BEBs and 2 diesel hybrid buses. Some recently published noise information on BEBs is provided in Section 5.1 for reference.

The hourly operations of the buses, with 220 bus trips per day, or 110 trips in each direction, is the same as used in the 2021 Noise Report. 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 for the Ldn calculation, which is included in the noise projections. BRT speeds are assumed to be the posted speed limit of 35 mph on NE 145th Street from I-5 to 15th Avenue, reducing to 30 mph along NE 145th Street from 15th Avenue to Lake City Way (SR 522). Along SR 522, starting at NE 145th Street, the posted speed limit is 40 mph throughout Lake Forest Park and Kenmore, reducing to 35 mph near Bothell.

5.1 Battery Electric Buses Compared to Internal Combustion Engine Buses

Noise from BEBs is typically lower than that from traditional diesel and hybrid buses, with the most notable difference occurring at slower speeds and in quiet areas. A case study found that when compared to an internal combustion engine (ICE) bus, operating at a constant speed of 20 mph, an electric bus was 10 dB quieter, with measured levels of 76 dBA for the ICE bus and 66 dBA for a BEB (Laib et al. 2018). As speeds increase, the difference in loudness between the two buses becomes less noticeable, and typically, for speeds above 40 mph, the noise levels of the two bus types are virtually the same due to the dominance of tire, roadway, and wind noise.

Therefore, one of the primary benefits from BEBs occurs when leaving a bus stop, signalized intersection, or stop signs, where noise emissions from a BEB are notably less than an ICE bus and the BEB will not produce the engine roar as the bus accelerates from a stop. At increasing speeds of 10 to 20 mph, a typical ICE bus produces 73 to 76 dBA, while a BEB would produce a consistent level of 62 dBA, or 11 to 14 dB lower than the ICE buses (Laib et al. 2018). The lower noise levels from BEBs at slower speeds are most notable in quiet areas and near residences, schools, and other noise-sensitive sources.

5.2 Analysis Year(s) and Noise Monitoring Data

Concern was expressed during public comments related to noise monitoring for the BRT project, which was performed in 2016, and that these data may no longer be valid. The dominant noise source in the SR 522 corridor is traffic on SR 522, and because the traffic volumes in 2016 are higher than current volumes, noise level measurements taken in 2016 are also likely the same or higher than what would be measured today. The reason for this is that traffic volumes along SR 522 and other project roadways are still lower today than they were in 2016, after the notable reduction in traffic volumes that occurred during the COVID-19 pandemic in 2020.

According to the WSDOT Traffic Data Website, the annual average traffic data, including passenger cars, medium trucks, heavy trucks, and buses counted on SR 522 just south of Ballinger Way NE (SR104) in Lake Forest Park in 2016, was, on average, 41,791 vehicles per day. The most recent counts from April 2022 taken at the same location were, on average, only 34,545 vehicles per day (WSDOT n.d.). This is a net daily reduction of traffic volumes on SR 522 through this area of 7,246 vehicles per day. This reduction in volumes would be expected to reduce the 24-hour Leq traffic noise levels by approximately 0.8 dB, or a change of -1 dB with rounding. Therefore, the noise monitoring data from 2016 are not only still valid but could slightly overestimate the current overall noise levels in the corridor.

The database information (WSDOT n.d.) can also be used to further support the negligible change in noise levels predicted with the SR 522 BRT project. Considering that a reduction in traffic volumes of 7,246 vehicles per day only results in a noise reduction of 0.8 dB, adding 220 vehicles for BRT service would not be expected to have any measurable effect on the overall noise levels in this corridor. Additionally, the BEB vehicles would be quieter than the standard ICE bus.

Finally, the analysis also uses the future predicted traffic volumes for the year 2042 when evaluating noise related to traffic. This allows for growth in the corridor and provides potential noise levels likely to occur in about 20 years. If mitigation was necessary, that mitigation, which is based on year 2042 traffic volumes, should also be effective for 20 years or more from this analysis.

6. Changes in Impacts

This section summarizes how the design refinements for the project affect noise and vibration in the corridor; and how that compares to the analysis provided in the 2021 Noise Report. The discussion is divided into long-term operational noise and vibration and short-term construction-related noise and vibration impacts. This section also includes additional analysis conducted to respond to public comments Sound Transit received after the publication of the 2021 Noise Report; this discussion is in Sections 6.1.2.2 (traffic noise levels) and 6.1.2.3 (retaining wall noise reflection).

6.1 Permanent (Long-term)

Long-term, or permanent, noise and vibration impacts are those caused by the normal operation of the proposed BRT project. For each city with potential impacts (Seattle, Shoreline, and Lake Forest Park), a review of the project refinements was performed and, where necessary, an additional analysis for noise impacts was performed.

The following analysis sections are included:

- Section 6.1.1: Traffic noise modeling for removal of four residential buildings in Seattle.
- Section 6.1.2: Noise modeling in Lake Forest Park.
  - Section 6.1.2.1: Traffic noise modeling for removal of one commercial building.
  - Section 6.1.2.2: Traffic noise modeling to confirm traffic noise levels and review retaining wall refinements along SR 522 from NE 155th Street to NE 170th Street.
  - Section 6.1.2.3: Calculation of reflected noise from a flat perpendicular retaining wall.

6.1.1 Segment 1: Seattle Building Displacements

There are four new front row (i.e., street front) residential building displacements in the city of Seattle. For this analysis, four duplexes south of NE 145th Street at the intersection with 12th Avenue NE are anticipated to be displaced by the project. Removal of these buildings could allow noise from NE 145th Street traffic to propagate to the second row receivers, including a four-story apartment building and one single-family residence south of NE 145th Street. These second row receivers located south of the duplexes were assessed for a potential increase in traffic noise.

Traffic noise modeling was performed following FTA methods and used the FHWA TNM. Existing conditions, future year 2042 No-build, and future year 2042 Build traffic noise levels were predicted along the NE 145th Street corridor at 16 receivers, including 12 that would be exposed to NE 145th Street with the potential displacements. Modeling locations are at the frequent outdoor use on the property, like the backyards, decks, and patios, as required by the FHWA. Refer to Figure 6-1 for modeling locations and Table 6-1 for noise levels.

The 12 receivers for the apartment building are identified as SEA-1abc through SEA-4abc, with a, b, and c representing second, third, and fourth floor levels. Modeling sites D-1 through D-4 represents the four displaced duplex buildings, on properties that are identified as BRS-123, BRS-125, BRS-127, and BRS-129, respectively (see Figure 6-1). The existing condition was modeled using 2017 PM peak traffic volumes from the Appendix H: SR 522/NE 145th Transportation Technical Memorandum, Sound Transit 2021, hereafter referred to as 2021 Transportation Memorandum, with the acoustical shielding of the four potentially displaced residential structures still in place. Noise levels for the existing conditions ranged from 53 to 62 dBA Leq. There are no receivers that meet the WSDOT Noise Abatement Criteria (NAC) of 66 dBA Leq, and under existing conditions there is no project and therefore no project noise impacts.

The future No-build condition was modeled using 2042 PM peak traffic volumes from the 2021 Transportation Memorandum with the acoustical shielding of the four potentially displaced residential structures still in place. The noise levels range from 54 to 63 dBA Leq with variations of 0 to +1 dB over the existing conditions. The increased noise levels are due to future increased traffic along NE 145th Street. There are no receivers that would meet the WSDOT NAC under the future No-build conditions, and because there is no project there are no project noise impacts.

The future 2042 Build condition was modeled using the same 2042 PM peak traffic volumes from the 2021 Transportation Memorandum used in the No-build conditions with proposed BRT operations, but with the acoustical shielding from the four displaced duplex buildings (D-1 through D-4) removed and BRT operations added. Noise levels at the apartment building (SEA-1 through SEA-4), located behind the duplexes, range from 62 to 63 dBA Leq with variations of 0 to +3 dB when compared to the future No-build and +1 to +4 dB over the existing conditions. While the noise increases slightly at most of the receivers for the future 2042 Build condition, there are no receivers that meet the WSDOT NAC (traffic noise levels of 66 dBA Leq or greater, or 10 dB substantial increase); therefore, no traffic noise impacts were identified.

Table 6-1. Seattle Building Displacement Traffic Noise Level Summary

Receiver[a]	WSDOT NAC Criteria (dBA Leq)[b] 66	Existing (Leq dBA)[c]	Future No-Build (Leq dBA)[c]	Future Build (Leq dBA)[c]	Future Build vs. Existing (in dB)[d]	Future Build vs. Future No-Build (in dB)[e]
SEA-1a	66	58	59	62	4	3
SEA-1b	66	60	61	63	3	2
SEA-1c	66	61	62	63	2	1
SEA-2a	66	58	59	62	4	3
SEA-2b	66	60	61	62	2	1
SEA-2c	66	60	61	62	2	1
SEA-3a	66	59	60	62	3	2
SEA-3b	66	60	61	63	3	2
SEA-3c	66	61	62	63	2	1
SEA-4a	66	60	61	63	3	2
SEA-4b	66	61	62	63	2	1
SEA-4c	66	62	63	63	1	0
D-1[f]	66	56	56	--	--	--
D-2[f]	66	53	54	--	--	--
D-3[f]	66	55	56	--	--	--
D-4[f]	66	58	59	--	--	--
Summary	**Minimum**	**53**	**54**	**62**	**1**	**0**
	Maximum	**62**	**63**	**63**	**4**	**3**
					Total Meeting NAC =	**0**

[a] All receivers are shown on Figure 6-1.
[b] WSDOT traffic NAC for residential land use type.
[c] Predicted peak hour noise levels in dBA Leq for condition stated, taken from the FHWA TNM.
[d] Change in noise: Future 2042 Build compared to existing environment.
[e] Change in noise: Future 2042 Build compared to Future 2042 No-build conditions.
[f] Denotes displacements that are not modeled under the future 2042 Build conditions.

Figure 6-1. Segment 1: Seattle Noise Modeling Locations

6.1.2 Segment 2: Lake Forest Park

Three separate noise analyses were performed in Lake Forest Park to address design refinements. The first analysis evaluates one new front row displacement in the city of Lake Forest Park. Because removal of this building could allow noise from SR 522 to propagate into the neighborhood and potentially affect a second row receiver, a traffic noise analysis was performed for this area.

The second analysis is noise modeling using FHWA and WSDOT methods along SR 522 for the residential area between NE 155th Street and NE 170th Street to address concerns of area residents and to account for design refinements to the retaining walls. This traffic study was performed to provide traffic noise level information to the residents of Lake Forest Park and verify the results of the 2021 Noise Report, which concluded that the alignment of the general purpose traffic lanes is not moving the lanes closer to the homes by half the distance or more; therefore, there are no noise impacts that require noise abatement measures. As discussed in Section 3.2, noise from traffic on a busy roadway will decrease or increase at approximately 3 dB per doubling or halving of distance between the traffic lanes and the receiver. Therefore, if the noise modeling shows that the noise from the SR 522 general purpose traffic lanes is not increased by 3 dB, then the roadway modifications are not sufficient to meet the requirements for traffic noise abatement measures.

The third analysis addressed the potential for reflected noise from retaining walls based on the 90 percent design. The city of Lake Forest Park adopted -Amending Ordinance 23-1270 – Interim Regulations regarding Retaining Walls (Emergency) on June 22, 2023. The interim ordinance includes requirements for retaining wall design and aesthetics, including designs intended to reduce noise reflection impacts. The city's requirements will be addressed in the permitting phase of the project. Information on reflected noise is provided here as part of the discussion of the potential for noise to reflect back across the highway to potential receivers; see Section 6.1.2.3.

6.1.2.1 Lake Forest Park Building Displacement

An office building at 15500 Bothell Way (D-6, BRS-253 on Figure 6-2) will likely be demolished due to the roadway modifications, which would remove or limit building access and parking to the property. Existing and future traffic noise modeling was performed for a single-family residence behind the building using the FHWA TNM. The exposed residence is labeled as E-1 and the displaced building labeled D-6 (BRS-253) are shown on Figure 6-2, with modeling results provided in Table 6-2.

Table 6-2. Lake Forest Park Building Displacement Traffic Noise Level Summary

Receiver[a]	WSDOT NAC Criteria (dBA Leq)[b] 66	Existing (Leq dBA)[c]	Future No-Build (Leq dBA)[c]	Future Build (Leq dBA)[c]	Future Build vs. Existing (in dB)[d]	Future Build vs. Future No-Build (in dB)[e]
E-1	66	62	62	63	1	1
Summary					**Total Meeting NAC =**	**0**

[a] All receivers are shown on Figure 6-2.
[b] WSDOT traffic NAC by land use type.
[c] Predicted peak hour noise levels in dBA Leq for condition stated, taken from the FHWA TNM.
[d] Change in noise: Future 2042 Build compared to existing environment.
[e] Change in noise: Future 2042 Build compared to Future 2042 No-build conditions.

Figure 6-2. Segment 2: Lake Forest Park Building Removal Modeling Location

The existing PM peak traffic noise level at the residence without the proposed displacement is 62 dBA Leq. The same 62 dBA Leq noise level was also predicted under the future 2042 No-build. Both existing and future 2042 No-build condition noise levels are below the WSDOT NAC of 66 dBA Leq, and because there is no project, there are no project noise impacts.

The future 2042 Build condition was modeled using the same 2042 PM peak traffic volumes used in the future 2042 No-build conditions, but with BRT operations and the shielding from the displaced building removed. The noise level at the now exposed residence was modeled at 63 dBA Leq, which is a +1 dB increase over the No-build conditions. The increase is slight due in part to the additional acoustical shielding by a large apartment complex to the north of the residence. Based on the modeled results, there is no impact at the residence (E-1) for the future 2042 Build condition due to the removal of the structure and noise levels remain below the WSDOT NAC of 66 dBA Leq.

6.1.2.2 SR 522 Traffic Noise Modeling NE 155th to NE 170th Streets

The 2021 Noise Report reviewed the roadway realignment along the SR 522 corridor between NE 155th Street and NE 170th Street; this roadway realignment remains the same in the 90 percent design. Under FHWA criteria, halving the distance between the receiver and roadway, or increasing the noise level by 3 dB, would require consideration of noise abatement measures. The purpose of this analysis is to provide a summary of traffic noise levels along the corridor and compare the existing and future conditions.

Traffic noise modeling was performed using the FHWA TNM along the SR 522 corridor between NE 155th Street and NE 170th Street. The modeling is used to provide a comparison between the three conditions: existing conditions (year 2017 traffic), future No-build (year 2042 traffic), and future Build (year 2042 traffic) noise levels with BRT operations. All traffic data is taken from the 2021 Transportation Memorandum. For the future 2042 Build condition, the analysis includes the proposed roadway lane configuration from the 90 percent design, as well as the retaining walls, additional pavement for roadway widening, and sidewalks, where applicable.

The traffic noise modeling was performed for 28 receiver locations on the west side of SR 522 (W-1 to W-28) and 27 receiver locations on the east side of SR 522 (E-2 to E-28). Receiver E-1, also in this area, was used for the removal of structure analysis in Section 6.1.2.1 and has existing and future noise levels of 62 to 63 dBA Leq and no impact; receiver E-1 is shown on Figure 6-2. This analysis for the roadway realignment is focused on the front row single-family residences along SR 522 from NE 155th Street to NE 170th Street. For some residences, there is a single modeling receiver, while most of the other modeling receivers are able to represent two or more residences at the same distance and elevations from the roadway. In addition to the existing and proposed retaining walls, building structures are also included in the modeling effort, as well as the topographical conditions in the area.

Along the west side of SR 522 the primary concern is the front row residences, because the second row is shielded from SR 522 by the front row of houses and the hillside, which slopes down toward SR 522. In addition, the second row of residences is at a notably greater distance from SR 522, with most being across 39th Avenue NE, and have outdoor uses in the backyards, which are well shielded by the second row building structures.

On the east side of SR 522, most receivers are located at the frequent outdoor use area, like a deck or patio, with some receivers located in front yards along SR 522 for reference. The topographical conditions on the east side include a rather steep decline in elevation in most areas from the SR 522 roadway elevation, which allows noise to flank over the top of many exterior use areas, thereby reducing noise levels for those receivers located downhill from SR 522. Furthermore, because most outdoor uses on the east side of SR 522 are in the back of the house, facing east toward Lake Washington, they are also well shielded from SR 522 by the building structure.

Figures 6-3 through 6-5 show all modeling locations used in this analysis and the location of the retaining walls. Discussion of the noise levels along SR 522 between NE 155th Street and NE 170th Street follows the graphics.

Figure 6-3. Segment 2: SR 522 Traffic Noise Modeling Locations Page 1 of 3

Figure 6-4. Segment 2: SR 522 Traffic Noise Modeling Locations Page 2 of 3

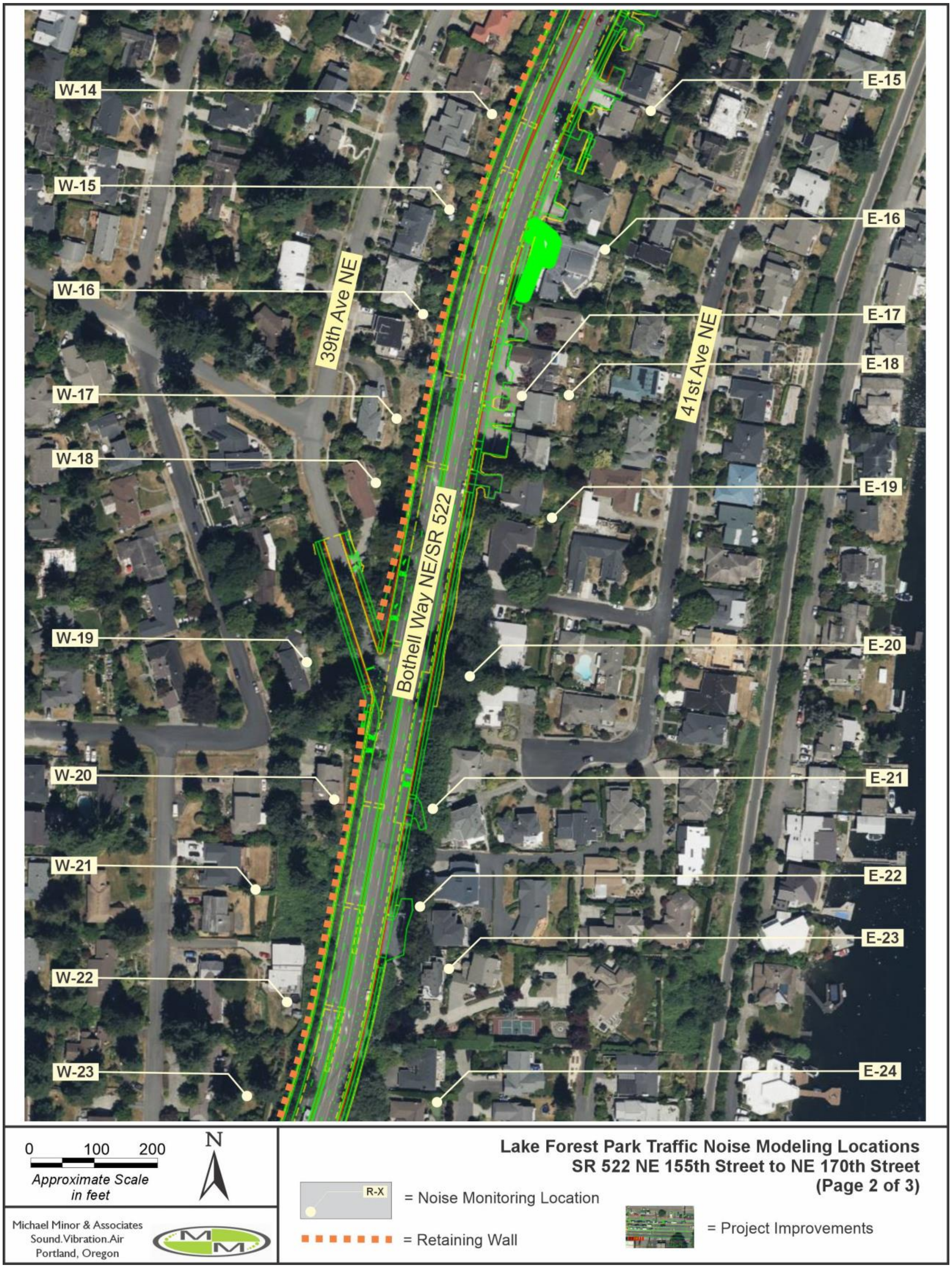
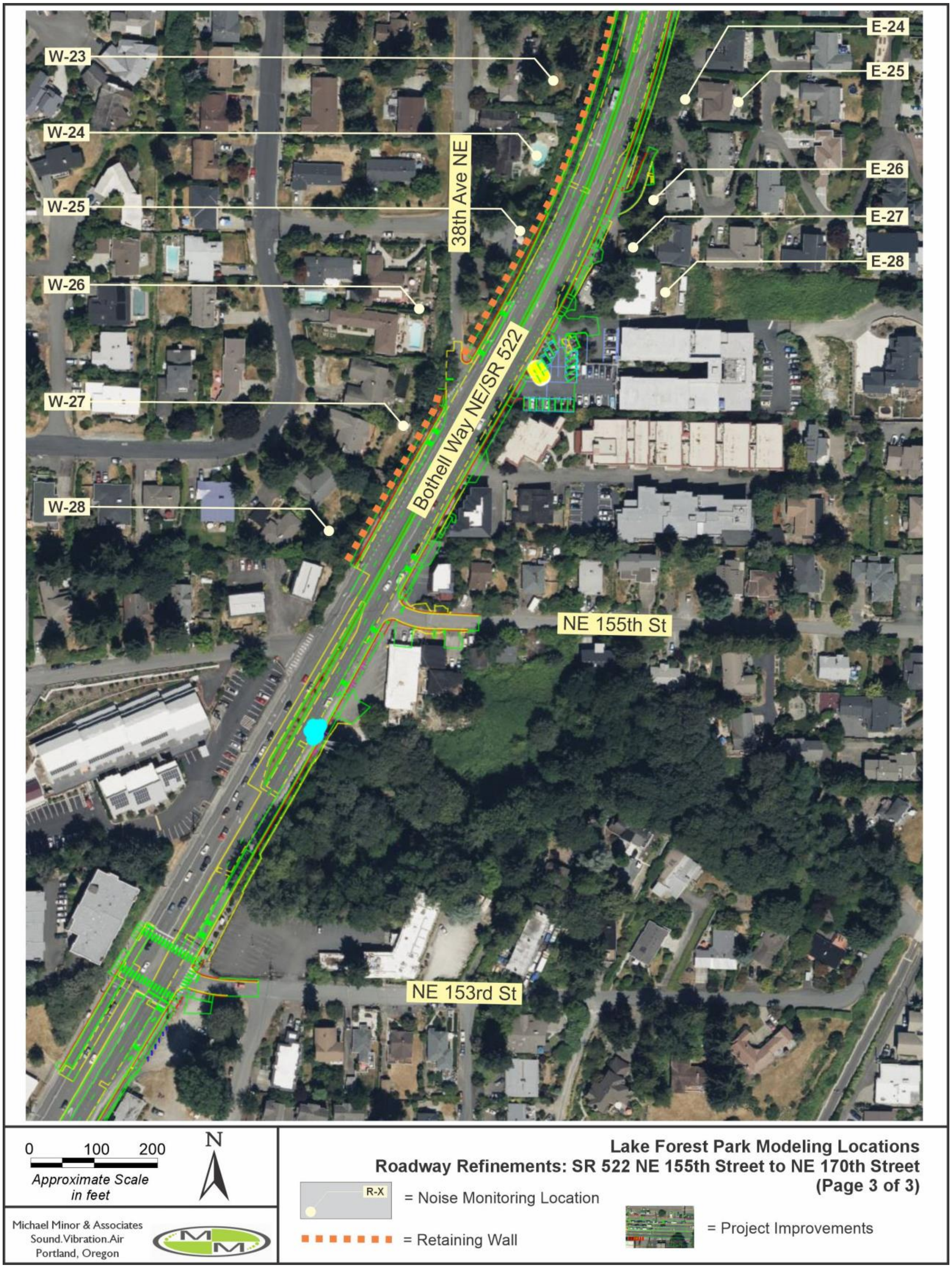


Figure 6-5. Segment 2: SR 522 Traffic Noise Modeling Locations Page 3 of 3



Discussion of Noise Levels in Lake Forest Park West of SR 522

Table 6-3 summarizes the modeled noise levels for each location along the west side of SR 522. Overall, existing noise levels ranged from 65 to 71 dBA Leq, with all residences except one, W-21, having existing noise levels at or above the WSDOT NAC of 66 dBA Leq. The 65 dBA Leq noise level at W-21 is due to the greater distance of this residence from SR 522. Receivers W-4, W-19, and W-26, which are also located farther from the roadway than most other residences, also have slightly lower noise levels (66 dBA Leq) than most other receivers.

Under the future 2042 No-build condition, noise levels remain essentially the same as the existing conditions, with some receivers (W-3, W-13, and W-16) registering slight increases of less than 1 dB, an increase in traffic noise that is not normally perceptible. The overall change in noise is consistent with the previous discussion on traffic volumes and noise levels (Section 3.2).

Under the future 2042 Build condition, with relocation of the general purpose lanes up to 8 feet closer to the west side residences, BEB operations and the new taller retaining walls, noise levels are predicted to increase slightly, less than 1 dB, for 3 of the 28 receivers (W-11, W-20, and W-25). All other 25 receivers have no change or a slight reduction in noise levels. However, the small reduction of 1 to 2 dB at most receivers would not normally be perceptible.

Most receivers with a noise reduction are provided with that slight noise reduction from the taller retaining walls blocking some of the tire-roadway noise. There are five receivers north of NE 165th Street with noise reductions of 2 to 4 dB (W-3 through W-8) below the 2042 No-build conditions. Receivers W-3 through W-8, which currently have a short retaining wall or no retaining wall, would have a new retaining wall that ends near receiver W-3. The new retaining wall would be taller than any of the existing retaining walls, which would provide some acoustical shielding, reducing noise levels by 2 to 4 dB at these receivers.

Receiver W-15, also in an area with no existing retaining wall, would also receive some limited benefit from the new taller retaining walls (2 dB reduction). Most other receivers are within 1 dB of the existing and 2042 No-build conditions (i.e., not perceptible).

The increase in future 2042 Build traffic noise levels during peak hour for residences along the west side of SR 522 are all 1 dB or less, a level typically not perceptible. Therefore, it is unlikely that anyone will notice any real increase or decrease in the overall traffic noise from SR 522 under the 2042 Build condition. Some receivers, in areas with no existing retaining walls, may notice a slight reduction in traffic noise due to predicted noise reductions of 3 to 4 dB (W-4, W-5, and W-7).

The overall average existing noise level among all modeling sites on the west side of SR 522 is 69 dBA Leq. The average noise level remains at 69 dBA Leq for the future 2042 No-build conditions; however, the average noise level is reduced by 1 dB under the future 2042 Build condition, to 68 dBA Leq. The reduction is due to the reduced noise levels in areas with new taller retaining walls.

Currently 32 residences on the west side of SR 522 have noise levels equal to or greater than the WSDOT NAC of 66 dBA Leq for Category C (residential) uses. Under the future 2042 No-build conditions, the same 32 residences will continue to exceed the 66 dBA Leq NAC. Because there is no project under existing conditions or the future No-build condition, no project traffic noise impacts were identified. Under the future 2042 Build condition, the number of residences meeting or exceeding the WSDOT NAC is reduced to 28. The project would not result in traffic noise levels increase of 3 dB or more, and the distance between the receivers and general purpose lanes is not reduced by half (as presented in the 2021 Noise Report). Therefore, no project-related traffic noise impacts were identified, and no traffic abatement is required.

Table 6-3. Segment 2: Lake Forest Park Traffic Noise Level Summary- West Side of SR 522

Receiver[a]	WSDOT NAC Criteria (dBA Leq)[b] 66	Existing (Leq dBA)[c]	Future No-Build (Leq dBA)[c]	Future Build (Leq dBA)[c]	Future Build vs. Existing (in dB)[d]	Future Build vs. Future No-Build (in dB)[e]
W-1	66	**71**	**71**	**71**	0	0
W-2	66	**70**	**70**	**70**	0	0
W-3	66	**67**	**68**	**66**	-1	-2
W-4	66	**66**	**66**	62	-4	-4
W-5	66	**70**	**70**	**67**	-3	-3
W-6	66	**70**	**70**	**68**	-2	-2
W-7	66	**69**	**69**	**66**	-3	-3
W-8	66	**70**	**70**	**68**	-2	-2
W-9	66	**70**	**70**	**70**	0	0
W-10	66	**70**	**70**	**70**	0	0
W-11	66	**70**	**70**	**71**	1	1
W-12	66	**70**	**70**	**70**	0	0
W-13	66	**69**	**70**	**70**	1	0
W-14	66	**70**	**70**	**70**	0	0
W-15	66	**69**	**69**	**67**	-2	-2
W-16	66	**69**	**70**	**70**	1	0
W-17	66	**68**	**68**	**67**	-1	-1
W-18	66	**68**	**68**	**68**	0	0
W-19	66	**66**	**66**	**66**	0	0
W-20	66	**70**	**70**	**71**	1	1
W-21	66	65	65	64	-1	-1
W-22	66	**69**	**69**	**69**	0	0
W-23	66	**67**	**67**	**67**	0	0
W-24	66	**69**	**69**	**68**	-1	-1
W-25	66	**71**	**71**	**72**	1	1
W-26	66	**66**	**66**	**66**	0	0
W-27	66	**70**	**70**	**70**	0	0
W-28	66	**67**	**67**	**67**	0	0
Summary	**Minimum**	**65**	**65**	**62**	**-4**	**-4**
	Maximum	**71**	**71**	**72**	**+1**	**+1**
	Average	**69**	**69**	**68**	**-1**	**-1**
					Total Meeting NAC =	**0**

a. All receivers are shown on Figures 6-3 to 6-5.
b. WSDOT traffic NAC by land use type.
c. Predicted peak hour noise levels taken from the FHWA TNM with **bold red** typeface used to indicate levels that are equal to or greater than the WSDOT NAC of 66 dBA Leq for FHWA Category B (residential) uses.
d. Change in noise: Future 2042 Build compared to existing condition.
e. Change in noise: Future 2042 Build compared to future 2042 No-build conditions.

Discussion of Noise Levels in Lake Forest Park East of SR 522

On the east side of SR 522, existing noise levels range from 55 to 71 dBA Leq during peak hours. Several front row residences have noise levels that currently meet or exceed the WSDOT NAC of 66 dBA Leq for Category C (residential) uses. However, most residences on the east side have frequent outdoor uses at the rear of the residence, which is provided acoustical shielding by the house itself. This shielding reduces the noise levels in backyards by 3 dB or more (E-24 and E-25), depending on location. In rare cases, near the area with steeper topography in addition to the structural shielding, the combination can result in a reduction of up to 10 dB (E-17 and E-18).

Under the future No-build conditions, with the year 2042 traffic volumes and posted speeds, noise levels essentially remain the same as the existing conditions, with 5 of the 27 modeling locations predicted to have an increase of 1 dB. A change in traffic noise of this level is not normally perceptible.

For the future Build condition, the 2042 traffic volumes, BEB operations and the roadway alignment result in a slight reduction in noise levels for receivers on the east side of SR 522. Although predicted traffic noise level reductions of -1 to -2 dB are not likely to be perceptible. The future Build condition shows the noise level at one receiver, (E-11) with a reduction of 2 dB at 64 dBA Leq, reducing it to below the 66 dBA Leq WSDOT criteria by 2 dB compared to the future No-build condition.

The overall average existing conditions noise level among the modeling sites on the east side of SR 522 is 63 dBA Leq. The average noise level remains at 63 dBA Leq for the future No-build conditions; however, the average noise level is reduced by 1 dB under the future 2042 Build condition, to 62 dBA Leq. Table 6-4 summarizes the modeled noise levels for each location along the east side of SR 522.

Currently five residences on the east side of SR 522 have noise levels equal to or greater than the NAC of 66 dBA Leq. Under the future No-build conditions the same five residences will continue to exceed the 66 dBA Leq NAC. Because there is no project under existing conditions or No-build, no project traffic noise impacts were identified. Under the future Build condition, the number of residences meeting or exceeding the NAC is reduced to two due to the lanes moving west, farther away from many residences in this area. Because the project would not result in a traffic noise level increase of 3 dB or more, and the distance between the receivers and general purpose lanes is not reduced by half, no project-related traffic noise impacts were identified; therefore, no traffic noise abatement is required.

Table 6-4. Segment 2: Lake Forest Park Traffic Noise Level Summary- East Side of SR 522

Receiver[a]	WSDOT NAC Criteria (dBA Leq)[b] 66	Existing (Leq dBA)[c]	Future No-Build (Leq dBA)[c]	Future Build (Leq dBA)[c]	Future Build vs. Existing (in dB)[d]	Future Build vs. Future No-Build (in dB)[e]
E-2	66	**66**	**66**	**66**	0	0
E-3	66	**69**	**69**	**69**	0	0
E-4	66	55	55	55	0	0
E-5	66	60	60	59	-1	-1
E-6	66	60	60	59	-1	-1
E-7	66	61	61	60	-1	-1
E-8	66	**67**	**67**	**66**	-1	-1
E-9	66	60	60	59	-1	-1
E-10	66	65	65	64	-1	-1
E-11	66	**66**	**66**	64	-2	-2
E-12	66	64	64	63	-1	-1

Receiver[a]	WSDOT NAC Criteria (dBA Leq)[b] 66	Existing (Leq dBA)[c]	Future No-Build (Leq dBA)[c]	Future Build (Leq dBA)[c]	Future Build vs. Existing (in dB)[d]	Future Build vs. Future No-Build (in dB)[e]
E-13	66	65	65	64	-1	-1
E-14	66	62	62	61	-1	-1
E-15	66	62	62	61	-1	-1
E-16	66	60	60	60	0	0
E-17	66	**71**	**71**	**70**	-1	-1
E-18	66	61	61	60	-1	-1
E-19	66	58	58	58	0	0
E-20	66	62	62	62	0	0
E-21	66	63	63	63	0	0
E-22	66	65	65	64	-1	-1
E-23	66	61	61	61	0	0
E-24	66	61	61	61	0	0
E-25	66	58	58	58	0	0
E-26	66	64	64	63	-1	-1
E-27	66	64	65	64	0	-1
E-28	66	60	60	60	0	0
Summary	**Minimum**	**55**	**55**	**55**	-2	**-2**
	Maximum	**71**	**71**	**70**	**0**	**0**
	Average	**63**	**63**	**62**	**-1**	**-1**
					Total Meeting NAC =	**0**

a. All receivers are shown on Figure 6-3 to 6-5.
b. WSDOT traffic NAC by land use type.
c. Predicted peak hour noise levels in dBA Leq for condition stated, taken from the FHWA TNM with **bold red** typeface used to indicate noise levels that are equal to or greater than the NAC of 66 dBA Leq for FHWA Category B (residential) uses.
d. Change in noise: Future 2042 Build compared to existing environment.
e. Change in noise: Future 2042 Build compared to future 2042 No-build conditions.

6.1.2.3 Reflected Noise from Retaining Wall

Because TNM will not calculate reflection off retaining and noise walls, a separate acoustical analysis was performed to assess potential reflected noise effects from the retaining wall structure on the west side of SR 522. Receiver location E-17 was selected for this analysis because it is directly across from one of the taller retaining walls under the Build scenario. This receiver has a future 2042 Build condition peak hour traffic noise level of 70 dBA Leq from TNM (see E-17 in Table 6-4). This analysis provides a better understanding of reflected noise.

To model the acoustical reflections, the following assumptions were used:

- Assume an attenuation rate for traffic noise on free-flowing roadway of 3 dB per doubling of distance.
- To simplify the analysis, it was assumed that all four general purpose lanes on SR 522 (two northbound lanes and two southbound lanes) would have the same traffic volume, vehicle types, and vehicle speeds.
- A reference traffic noise level of 65 dBA for one lane of traffic was taken from TNM for receiver E-17, which is 58 feet from the nearest general purpose traffic lane. Correcting for distance (3 dB per doubling of distance),

noise from each of the other three lanes can be calculated at the receiver and logarithmic summed to arrive at the total noise from all four lanes.

- Reflected noise will travel to the wall and then back to the receiver, again, each lane must be calculated individually, and then logarithmic summed to arrive at the total noise at the receiver.
- Figure 6-6 is an aerial view with the locations of the general purpose travel lanes, retaining wall, receiver location and the distance between each in feet using the 90 percent design plan computer-aided design (CAD) drawings. The four lanes are denoted from the east side to the west side of SR 522 as follows:
  - Lane 1: Eastern most lane, northbound, 58 feet from E-17, 54 feet from retaining wall.
  - Lane 2: Center east lane, northbound, 69 feet from E-17, 43 feet from retaining wall.
  - Lane 3: Center west lane southbound, 82 feet from E-17, 31 feet from retaining wall.
  - Land 4: Western most lane southbound, 96 feet from E-17, 15 feet from retaining wall.
- Assumed a flat hard retaining wall perpendicular to the roadway surface to assess the maximum reflection of noise. The distance from Receiver E-17 to retaining wall is 119 feet.

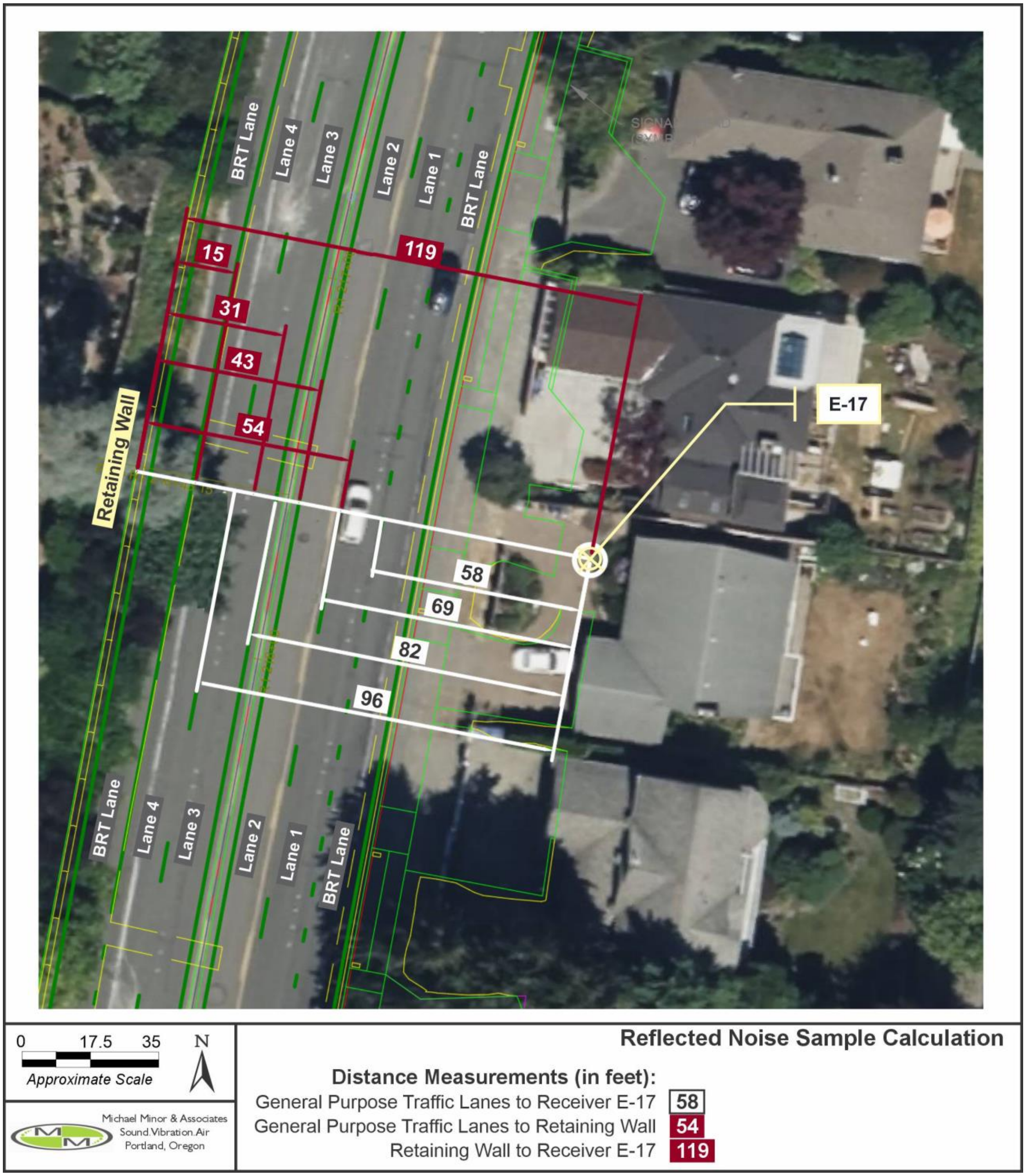
Table 6-5 summarizes how the calculations are performed. The table shows the reference noise level, distance between each lane and E-17, distance correction factor at 3 dB per doubling of distance, traffic noise for each lane at E-17 and the total noise of 70 dBA Leq. For lane one there is no attenuation because the distance from the lane to the receiver is the same as the reference level. For Lane 2, the added distance of 11 feet (from 58 to 69 feet) results in a noise reduction of 0.8 dB, Lane 3 has a reduction of 1.5 dB, and Lane 4, with an increased distance of 38 feet has a 2.2 dB reduction. The corrected noise level for each lane is provided in the far-right column. Summing up the noise contributions from each of the four lanes equals 70 dBA Leq, matching the modeled and measured noise levels in this area. See Section 3.1 to aid in understanding these results.

Table 6-5. Direct Noise Levels per Lane and Total Direct Noise

Lane Number[a]	Distance between Lane and Receiver E-17 (feet)[b]	Reference Noise Level at 58 feet (dBA Leq)[c]	Distance Correction (dB)[d]	Reference Noise Level Plus Distance Correction	Each Lane and Total Noise Level at E-17 (dBA Leq)[e]
Lane 1	58	65.0	0	= 65 + 0	65.0
Lane 2	69	65.0	-0.8	= 65 + (-0.8)	64.2
Lane 3	82	65.0	-1.5	= 65 + (-1.5)	63.5
Lane 4	96	65.0	-2.2	= 65 + (-2.2)	62.8
Total Direct Noise Level (all four lanes combined)					**70.0 dBA Leq[f]**

a. Lane locations shown on Figure 6-6.
b. Distance measurement shown on Figure 6-6.
c. Reference noise level of 65 dBA Leq per lane at 58 feet.
d. Atmospheric absorption of sound based on reference distance of 58 feet and 3 dB per doubling of distance.
e. Corrected noise level at E-17 for each of the four lanes.
f. Logarithmic sum of the four lanes of traffic.

Figure 6-6. Distance Measurements for Reflected Noise at Receiver E-17



Reflected and Total Noise Level Calculations

Using the same general distance and reference traffic noise level from above, a second set of calculations was performed for potential noise that is reflected off the wall and back toward the residence (E-17). The increased distance the noise must travel is accounted for and includes the distance from the lanes to the wall and from the wall back to the receiver location as shown on Figure 6-6. For example, from Lane 1, noise would travel 54 feet to the retaining wall and an additional 119 feet from the retaining wall back to the receiver, for a total distance of

173 feet, reducing the reference noise level by 4.7 dB to 60.3 dBA Leq (Lane 1 in Table 6-6). Aggregating the reflected noise from all four travel lanes results in a total reflected noise level of 66.8 dBA (Table 6-6).

Table 6-6. Reflected Noise Levels per Lane and Total Reflected Noise

Lane Number[a]	Distance from Lane to Wall and Wall to Receiver[b]	Reference Noise Level in dBA Leq at 58 feet[c]	Distance Correction (dB)[d]	Reference Noise Level Plus Distance Correction	Noise Level in dBA Leq[e]
Lane 1	54 + 119 = 173	65.0	-4.7	= 65 + (-4.7)	60.3
Lane 2	43 + 119 = 162	65.0	-4.5	= 65 + (-4.5)	60.5
Lane 3	31 + 119 = 150	65.0	-4.1	= 65 + (-4.1)	60.9
Lane 4	15 + 119 = 134	65.0	-3.6	= 65 + (-3.6)	61.4
Total Reflected Noise Level (all four lanes combined)					**66.8 dBA Leq[f]**

a. Lane locations shown on Figure 6-6.
b. Distance measurement shown on Figure 6-6.
c. Reference noise level of 65 dBA Leq per lane at 58 feet.
d. Atmospheric absorption of sound based on reference distance of 58 feet and 3 dB per doubling of distance.
e. Corrected noise level at E-17 for each of the four lanes.
f. Logarithmic sum of the four lanes of traffic.

A logarithmic addition of the direct noise of 70.0 dBA Leq and the reflected noise of 66.8 dBA Leq equates to 71.7 dBA Leq, or a 1.7 dB increase in noise levels over the direct noise of 70 dBA Leq (see Table 6-5). However, this analysis assumes perfect reflection from the retaining wall and fails to account for a fractured wall surface, which breaks up the sound waves reducing reflection, and that other vehicles along the roadway would break up the sound waves and reflect some back away from the receiver. During peak traffic hours, the increase in vehicles in the general purpose lanes would disrupt the sound waves and most reflections would not make it back to the receiver location. It is expected that there is too much traffic for reflections off these retaining walls to cause a measurable or noticeable increase in the overall noise levels.

A more reasonable example of traffic noise reflection would be during periods of light traffic in the lane nearest to the retaining wall, Lane 4. Using just this lane, and assuming the same 65.0 dBA Leq reference level, the direct noise level would still be 62.8 dBA and the reflected noise 61.4 dBA Leq (refer to distance corrected noise levels for Lane 4 in Tables 6-5 and 6-6), for a total of 65.2 dBA Leq or a 2.4 dB increase from the reflection. The center two lanes show slightly lower increases, with a 1.9 dB increase for Lane 3 and a 1.5 dB increase for Lane 2. Lane 1, the farthest from the retaining wall, is the lowest with an increase of 1.3 dB from noise reflections. Again, all of these calculations assume perfect reflections off the retaining wall with no other disruptions, such as a fractured wall surface or other vehicles, to the acoustical pathway to the receiver. Except for Lane 4, the reflection increase is less than 2 dB, a change in traffic noise that is generally not perceptible. Considering the retaining wall design, the increase in total noise from any retaining wall reflection would be expected to be below 2 dB.

6.2 Temporary (Short-term)

Noise impacts during construction are essentially the same as provided in the 2021 Noise Report (Sound Transit 2021). Construction activities along NE 145th Street, SR 522, NE 185th, and Beardslee Boulevard would occur within a few feet of some residences and businesses. The project would, in some locations, install new sidewalks and improve access for persons with disabilities (Americans with Disabilities Act [ADA]). These activities, along with construction of the transit queue lanes and new BRT stations 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 nearby heavy construction. These short-term increases in noise levels are the same as those associated with city roadway construction activity such as paving and repaving, installation of ADA ramps, curbs, gutters, utilities, or construction of new development.

7. Mitigation Measures

No noise or vibration impacts were predicted by the 2021 Noise Report, and no new noise or vibration impacts are predicted in this additional analysis. Overall, future 2042 Build condition traffic noise levels will essentially remain the same as the existing and future No-build conditions with some slight variations at those sites with removal of existing buildings, addition of retaining walls, and/or slight shifts in general purpose travel lanes. Noise levels at some locations along the corridor near building removals could increase 1 to 4 dB due to the removal of the structure that provides acoustical shielding.

SR 522 traffic noise levels in Lake Forest Park between NE 155th Street and NE 170th Street are predicted to decrease on average by 1 dB with the project. There are individual residences that could see reductions of up to 3 to 4 dB, while a few will have slight increase of 1 dB over existing conditions and future 2042 No-build condition noise levels.

Project noise levels for long-term operations for all segments of the project (Seattle, Shoreline, Lake Forest Park, Kenmore, and Bothell) remain below the criteria for residential land use, and no noise mitigation is recommended.

Construction noise levels and mitigation are the same as provided in the 2021 Noise Report, and no new or revised construction noise or vibration mitigation is recommended. Because the Lake Forest parking garage is deferred until 2044, and the Kenmore and Bothell garages are deferred until 2034, a review of local noise regulations related to construction should be performed before starting construction of the garages.

8. References

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