UPDATED ENVIRONMENTAL ASSESSMENT
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

MAY 2010

SR 520, Medina to SR 202: Eastside Transit and HOV Project

Appendix O

Noise Technical Memorandum

Washington State Department of Transportation

U.S. Department of Transportation Federal Highway Administration

SR 520, Medina to SR 202: Eastside Transit and HOV Project Environmental Assessment

Noise

Technical Memorandum

Prepared for

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Federal Highway Administration

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Exhibits

Acronyms and Abbreviations

CAD	computer-aided design
dB	Decibel
dBA	A-weighted decibel
EA	Environmental Assessment
EPA	U.S Environmental Protection Agency
CFR	Code of Federal Regulations
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HOV	high occupancy vehicle
Hz	Hertz
L_{eq}	equivalent sound level
L_{xx}	statistical sound level
NAC	noise abatement criteria
NEPA	National Environmental Policy Act
OSHA	Occupational Safety and Health Administration
SEPA	State Environmental Policy Act
SR	State Route
TNM	Traffic Noise Model
USDOT	U.S. Department of Transportation
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Introduction

Why is noise considered in an EA?

Sound is a fundamental component of daily life and the most universal method of communicating with other people. When sounds are perceived as desired, beneficial, or otherwise pleasing, they are typically considered as having a positive effect on daily life. When sound is perceived as unpleasant, unwanted, or disturbingly loud, it is considered noise.

Environmental noise may interfere with a broad range of human activities in a way that degrades public health and welfare. Examples include when noise adversely affects a person's hearing, mental state (e.g., annoyance), or the ability to engage in important activities such as sleeping or communicating.

Understanding the adverse effects of traffic and construction noise is an integral part of this environmental assessment (EA). Federal, state, and local governments provide guidance on acceptable noise levels to ensure the public's health and well being, both now and in the future. Traffic and construction noise analyses are required by law for federally funded projects and by State of Washington policy for other funded projects that (1) involve construction of a new highway, (2) substantially change the horizontal or vertical alignment, or (3) increase the number of through traffic lanes on an existing highway. State policy also requires the review and consideration of noise abatement on projects that substantially alter the ground contours surrounding a state highway.

What are the key points of this technical memorandum?

Today, there are approximately 155 residences in the SR 520 project study area that have noise levels that meet or exceed the FHWA and Washington State traffic noise abatement criteria (NAC) of 66 dBA Leq (equivalent sound pressure level in A-weighted decibels).

Under the No Build Alternative, noise levels are projected to increase in 2030 by only 1 to 2 dBA Leq in most locations, an amount that is not normally noticeable to most people. However, with this increase, noise levels would exceed the NAC at an additional 18 residences, bringing the total up to 173 from the current estimate of 155.

Number of Residences Where Noise Levels Exceed NAC under Base Alternatives

Existing	No Build	Build
155	173	36

Compared to today's and the projected 2030 No Build Alternative noise levels, the proposed Build Alternative, which includes noise walls along both sides of the SR 520 and lids at the three overpasses, would reduce the noise levels substantially throughout the project corridor. The total number of residences where noise levels would exceed the NAC would be reduced to 36 under the proposed Build Alternative. All of the remaining 36 properties exceeding the NAC do so because of noise from arterial roads, such as Bellevue Way, 92nd and 84th Avenues, Northup Way, or because area topography limits the effectiveness of noise walls.

What is the project?

The Washington State Department of Transportation (WSDOT) is proposing to construct the SR 520, Medina to SR 202: Eastside Transit and HOV Project to reduce transit and high-occupancy vehicle (HOV) travel times and to enhance travel time reliability, mobility, access, and safety for transit and HOVs in rapidly growing areas along the State Route (SR) 520 corridor east of Lake Washington. Exhibit 1 shows the project vicinity. Some of the improvements included in this project were originally part of the SR 520 Bridge and HOV Project. On June 18, 2008, the Federal Highway Administration (FHWA) authorized WSDOT to develop the SR 520, Medina to SR 202: Eastside Transit and HOV Project as an independent project. The project includes building a complete HOV system between Lake Washington and 108th Avenue NE and restriping the existing HOV lanes from the outside lanes to the inside lanes between the 108th Avenue NE interchange and SR 202 in Redmond.

The portion of the project between Evergreen Point Road and 108th Avenue NE was previously part of the SR 520 Bridge Replacement and HOV Project. The SR 520, Medina to SR 202: Eastside Transit and HOV Project has been an independent project to address needs specific to the portion of SR 520 east of Lake Washington. The project limits extend approximately 8.8 miles along SR 520 from the east shore of Lake Washington (vicinity of Evergreen Point Road) to the interchange with SR 202 in Redmond.

WSDOT is considering two alternatives for the project: the Build Alternative and the No Build Alternative.

Build Alternative

Under the Build Alternative, the proposed project would include the improvements described below.

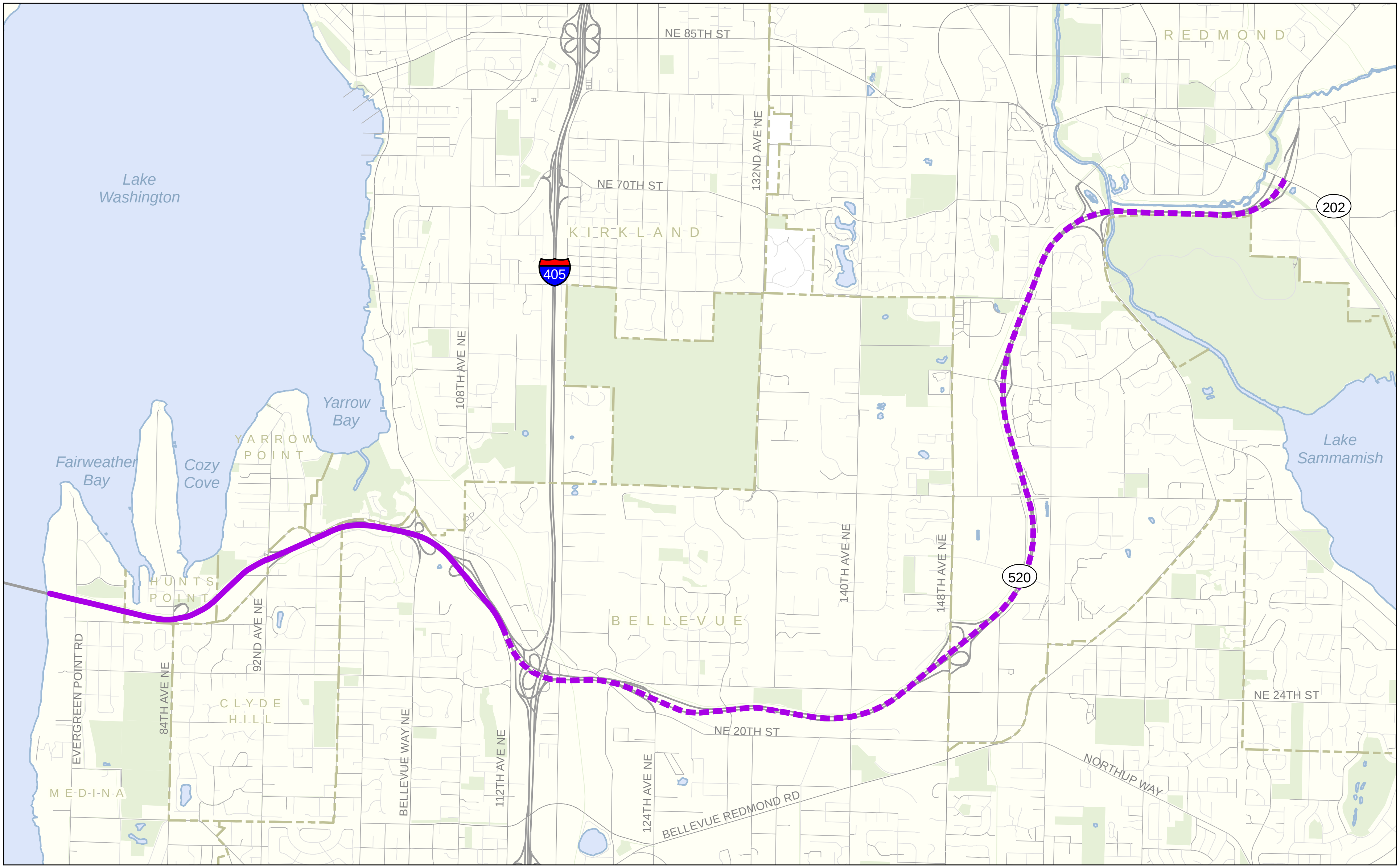
SR 520 Improvements from Lake Washington to I-405

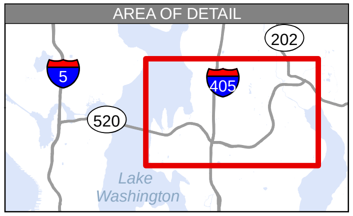
The proposed project would reconstruct SR 520 from just west of Evergreen Point Road to just east of 108th Avenue NE. Elements constructed as part of this section include the following:

- Construct a new eastbound HOV lane from Lake Washington to the existing eastbound HOV lane west of the I-405 interchange. This improvement would complete the currently discontinuous HOV network on the Eastside and improve travel time reliability for buses and carpools.
- Relocate the existing westbound HOV lane from the outside lane to the inside lane from Lake Washington to I-405. This change would enhance safety by eliminating the need for merging vehicles to weave across the faster-moving HOV lanes to reach the general-purpose lanes.
- Construct a lid with inside transit stop over SR 520 at Evergreen Point Road.
- Construct a new lid and modify the existing half-diamond interchange at 84th Avenue NE.

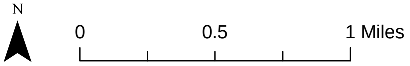
What is a lid?

The term "lid" is short for "lidded highway." Lids are long bridges that cover a length of highway. Lid surface areas can carry paths and trails to connect communities across the highway, landscaping to create open space and places for passive recreation, and items such as pergolas, seating, and transit waiting areas.





Construction Extent
Restriping Extent
Park
City Limits



Source: King County (2008) GIS Data (Streams, Streets, Water Bodies), CH2M HILL (2008) GIS Data (Parks). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 1. **Project Vicinity**

Medina to SR 202: Eastside Transit and HOV Project

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- Construct a new lid with inside transit stop over SR 520 at 92nd Avenue NE and modify the existing interchange.
- Reconfigure the existing interchange at Bellevue Way NE.
- Construct new HOV direct access ramps at 108th Avenue NE. This improvement would create a more efficient connection for transit and HOV from SR 520 to the South Kirkland Park-and-Ride via local streets.
- Add a bike/pedestrian path from Lake Washington to approximately 108th Avenue NE. This improvement would facilitate nonmotorized use of SR 520, provide transit connections for bikes and pedestrians, and complement the existing nonmotorized transportation network on the Eastside.

SR 520 Improvements from I-405 to SR 202

- Restripe existing eastbound and westbound HOV lanes from the outside to the inside lane. This change would enhance safety by eliminating the need for merging vehicles to weave across the faster-moving HOV lanes to reach the general-purpose lanes.

Other Improvements

- Provide noise walls between Evergreen Point Road and Bellevue Way NE.
- Provide retaining walls and stormwater management system improvements.
- Improve stream habitat by realigning portions of the Yarrow Creek channel and shortening some culverts.
- Improve fish passage culvert crossings to restore fish passage and open up habitat that was previously inaccessible to salmon and other fish species.
- Mitigate the project's effects on wetlands and streams at a site or sites as determined through future negotiations with permitting agencies.

No Build Alternative

Under the No Build Alternative, the project would not be built. Only routine maintenance, repair, and minor safety improvements would take place on SR 520 in the study area over the next 20 years. The No Build Alternative would not improve transit reliability and transit and HOV travel times on SR 520. Also included in the No Build Alternative for traffic modeling purposes is the assumption that the SR 520, Bridge Replacement and HOV Project would not be built until this project is complete.

WSDOT is evaluating the No Build Alternative to provide a reference point for comparing the effects, both positive and negative, associated with the proposed project.

Noise Analysis Overview

What is sound (noise)?

This section discusses how sound is evaluated—its definition, transmission characteristics, and measurement. This section also provides some typical sound levels for reference.

Sound is any change in air pressure that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. These changes in air pressure are translated to sound in the human ear. The greater the change in air pressure, the louder the sound. For example, a quiet whisper in the library creates a relatively small change in the room air pressure, whereas air pressure changes are much greater in the front row of a rock concert.

In addition to the loudness of sound, *frequency* is a term also used to describe sound. The frequency of sound is determined by the number of recurring changes in air pressure per second. A sound that contains a relatively high number of pressure changes per second is generally referred to as a high frequency noise or “high-pitched.” One common example of a high-frequency sound is a referee’s whistle. A sound that has a low number of pressure changes per second is referred to as low frequency or low-pitched sound (for example, a bass drum).

A person’s response to noise is subjective and can vary greatly from person to person. Some key factors that can influence an individual’s response include the loudness, frequency, the amount of background noise present, and the nature of the activity taking place that the noise affects. For example, boisterous children playing outside during the day, while there is background traffic noise, is generally less obtrusive than if the children were making the same amount of noise during the nighttime sleeping hours. When sounds are unpleasant, unwanted, or disturbingly loud, they are normally considered “noise.”

How Sound is Measured

Sound is measured both in terms of loudness and frequency. The unit used to measure the loudness of sound is called a decibel (dB). In simple terms, the dB scale is a logarithmic conversion of air pressure level variations (measured in units called Pascal) to a unit of measure with a more convenient numbering system. A person with average hearing can detect a wide range of sound pressures, a ratio of over a million to one. A direct application of the Pascal linear scale using sound pressures would require the use of numbers typically ranging from about 10 micro-pascals to 100,000,000 micro-pascals. The decibel scale simplifies the units of sound measurement to manageable range of numbers and is also a more accurate representation of how the human ear reacts to variations in air pressure. A range from 0 to 120 dB is the typical range of hearing.

While the loudness of sound is an easy concept for most people, a sound’s frequency is just as important in understanding how we hear sounds. Frequency is measured in terms of the number of changes in air pressure that occur per second. The unit used to measure the frequency of sound is called hertz (Hz). While the human ear can detect a wide range of frequencies from 20 Hz to 20,000 Hz, it is most sensitive to sounds at the middle frequencies (500 to 4,000 Hz). The human ear is progressively less sensitive to sound at frequencies above and below this middle range. For example, a sound level of 60 dB at 250 Hz would be considerably less noticeable to a person than 60 dB at 1,000 Hz.

Sounds expressed in terms of *dBA* provide a single number measure of a sound's **loudness** based on the ear's sensitivity to different **frequencies**.

Of course, discussing sounds in terms of both loudness and frequency can become tedious and confusing. In order to simplify matters, an adjustment is made to the dB measurement scale that, in addition to loudness, accounts for the human ear's sensitivity to frequencies. The adjusted dB scale, referred to as the A-weighted decibel scale, provides an accurate "single number" measure of what the human ear can actually hear. When the A-weighted scale is used, the decibel levels are designated as dBA. This unit of measurement is used in this report.

For a sense of perspective, normal human conversation ranges between 44 and 65 dBA when people are about 3 to 6 feet apart. Very slight changes in noise levels, up or down, are generally not detectable by the human ear. The smallest change in noise level that a human ear can perceive is about 3 dBA, while increases of 5 dBA or more are clearly noticeable. For most people, a 10-dBA increase in sound levels is judged as a doubling of sound level, while a 10-dBA decrease in sound levels is perceived to be half as loud. For example, a person talking at 70 dBA is perceived as twice as loud as the same person talking at 60 dBA.

Because decibels are expressed on a logarithmic scale, they cannot be combined by simple addition. For example, if a single vehicle pass-by produces a sound level of 60 dB at 50 feet from a roadway, two identical vehicle pass-bys would not produce a sound level of 120 dB. They would, in fact, produce a sound level of 63 dB. To combine decibels, they must first be converted to energy, then added or subtracted as appropriate, and converted back to decibels. When two decibel values differ by 10 dB or more the combined sound level is simply equal to the higher value. That is, the sound level that is lower by more than 10 dB would not increase the sound level. Using the vehicle pass-by example, if two vehicles pass-by at the same time, one which produces 60 dB and another that only produces 50 dB the sound level would be 60 dB. In this example, the louder vehicle can be considered as masking the quieter vehicle. A another practical example of this would be turning music up more than 10 dBA louder than the neighbor's barking dog so that the dog is no longer heard.

Finally, 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, they allow a more complete description of the range of sound levels during the given measurement period.

The State of Washington allows for an exceedance of the noise regulations based on the amount of time the noise source exceeds the criteria. The State of Washington noise regulations are applicable to the construction phases of transportation projects. The sound level descriptor L_{xx} is defined as the sound level exceeded xx percent of the time. To assist with compliance to the noise regulations, the statistical L_{xx} noise descriptor is very useful. For example, during a 1 hour measurement, an L_{25} of 75 dBA means the sound level was at or above 75 dBA for 15 minutes of that hour (25 percent of the time), which could be used to verify the 15-minute allowable exceedance criterion in the state's code. Similarly, two other statistical descriptors, the $L_{8.3}$ and $L_{2.5}$ can be used to verify the 5-minute and the 1.5-minute allowable exceedance criteria in the state's code.

Typical Neighborhood Noise Levels

In most neighborhoods, nighttime noise levels are noticeably lower than daytime noise levels. In a quiet rural area at night, sound levels from crickets or wind rustling leaves on the trees can range between 32 and 35 dBA. As residents start their day and local traffic increases, the same rural area can have noise levels ranging from 50 to 60 dBA. While noise levels in urban neighborhoods are louder than rural areas, they share the same pattern of lower noise levels at night than during the day. Quiet urban nighttime noise levels range from 40 to 50 dBA. Noise levels during the day in a noisy urban area are frequently as high as 70 to 80 dBA.

How Sound Changes Over Time

The Leq is used to account for the variance in loudness over time. Transportation-related noise is most often described in terms of Leq.

Sound levels from most sources tend to vary with time. For example, noise levels increase when a car approaches, then reach a maximum peak as it passes, and decrease as the car moves farther away. In this example, noise levels within a 1-minute timeframe may range from 45 dBA as the vehicle approaches, increase to 65 dBA as it passes by, and return to 45 dBA as it moves away. To account for the variance in loudness, over time, a common noise measurement is the equivalent sound pressure level (L_{eq}). The L_{eq} is defined as the energy average noise level, in dBA, for a specific time period (for example, 1 minute). Returning to the example of the passing car, let's assume the energy average noise level was 60 dBA during the entire period of time the car could be heard as it passed by. In this example, the noise level would be stated as 60 dBA L_{eq}.

How Sound Decreases Over Distance

Attenuation refers to the reduction in loudness of noise with greater distance between source and receiver.

Items considered in this traffic noise analysis that affect attenuation are as follows:

Buildings, walls, and topography that block the path between sound and receiver

Dense foliage, loose soil, or grass that can reduce noise levels between the source and receiver

Reflective surfaces such as water that can increase the transmission of noise levels to the receiver

A traffic noise analysis **does not consider** atmospheric conditions because they change frequently and are just as likely to decrease as increase noise levels.

Several factors determine how sound levels decrease, or attenuate, over a distance. There are two general rules of thumb that apply to sound sources, which can be categorized as either a *point* source (for example, a church bell) or a *line* source (such as constant flowing traffic on a busy highway).

A single point noise source will attenuate at a rate of 6 dB each time the distance from the source doubles. Thus, a point source that produces a noise level of 60 dB at a distance of 50 feet would attenuate to 54 dB at 100 feet and to 48 dB at 200 feet. A line source such as a highway, however, generally reduces at a rate of approximately 3 dB each time the distance doubles. Using the same example above, a line source measured at 60 dB at 50 feet would attenuate to 57 at 100 feet and to 54 at 200 feet.

The general rules of thumb for attenuation of point and line sources are influenced by the physical surroundings between the source and the receiver. For example, interactions of sound waves with the ground often result in slightly higher attenuation (called ground absorption effects) than the reduction factors given in the preceding paragraph. Other factors that affect the attenuation of sound with distance include existing structures, topography, foliage, ground cover, and atmospheric conditions such as wind, temperature, and relative humidity. The potential effects these factors have on sound propagation are described below.

- Existing structures can substantially affect sound levels. Buildings or walls can reduce noise levels by physically blocking the path between the source and the receiver. Measurements have shown that a single-story house has the potential, through shielding, to reduce noise levels by as much as 10 dB or greater. The actual noise reduction will depend greatly on the geometry of the noise source, receiver, and location of the structure. In cases where the source and the receiver are located on the same side of a structure, noise levels may be higher than expected due to the combination of sound transmitted directly from the source and sound reflected off the structure. Increases in noise caused by reflection are normally 3 dB or less, which is the minimum change in noise levels that can be noticed by the human ear.

- Topography includes existing hills, berms, and other ground surface features between the noise source and receiver location. As with structures, topography can reduce or increase sound, depending on the location or geometry of the surrounding terrain. Hills and berms that block the path between the noise source and receiver will reduce noise levels at the receiver location. In some locations, however, the topography can cause an overall increase in sound levels by either reflecting or channeling the noise toward a sensitive receiver location.

- Dense foliage can slightly reduce noise levels. As a general rule of thumb, if the foliage is sufficiently dense that one cannot see over it or through it, then it may be providing some additional noise level reduction from the source to the receiver. For example, the FHWA has stated that up to a 5-dBA reduction in traffic noise may result for locations that have at least 100 feet of dense evergreen foliage between the roadway and the receiver.

- Ground cover between the receiver and the noise source can also affect noise transmission. For example, sound travels across reflective surfaces, such as water or pavement, with minimal attenuation. On the other hand, sound will be more attenuated or absorbed as it travels across ground cover such as field grass, lawn, or even loose soil.

- Atmospheric conditions that can affect the transmission of noise include wind, temperature, humidity, and precipitation. Wind blowing in the direction from the source to the receiver can increase sound levels; conversely, wind can reduce noise levels when blowing in a direction from the receiver to the source. Noise levels can increase during a temperature inversion as the layer of warmer air atop the trapped layer of cooler air causes a deflection of skyward-bound sound waves back to the receivers at ground level. Other atmospheric conditions such as humidity and precipitation are rarely severe enough to noticeably affect the amount of noise attenuation. Because weather conditions change frequently, atmospheric conditions are not considered in traffic noise studies.

How Loud Noises Can Affect Hearing

Long term, or continuous, exposure to very loud noises can damage the human ear. To protect against hearing loss in the workplace, the Washington State Department of Labor and Industries has established an 8-hour continuous exposure limit of 85 dBA (WAC 296-817-300). Noise levels exceeding 85 dBA over continuous periods can result in permanent hearing loss. Noise levels above 110 dBA become intolerable and then extremely painful.

Exhibit 2 shows some common noise sources and compares their relative loudness to that of an 80-dBA source, such as a garbage disposal or food blender.

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 (2 feet)	80	Moderately loud	Reference loudness
Typical at-grade light rail vehicle	70	— — —	½ as loud
Moderately busy department store	60	— — —	1/4 as loud
Typical televison show (10 feet) Typical quiet office environment	50	— — —	1/8 as loud
Bedroom or quiet living room	40	Quiet	1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	1/32 as loud
High quality recording studio	20	Just audible	1/64 as loud
Acoustic Test Chamber	10	— — —	1/128 as loud
	0	Threshold of hearing	

Sources: Beranek (1988) and MM&A measured data from multiple projects

Exhibit 2. **Sound Levels and Relative Loudness of Typical Noise Sources**

When a Traffic Noise Study is Required

Federal and state funded projects in the state of Washington are considered Type 1 by WSDOT if the projects: 1) involve construction of a new highway, 2) substantially change the horizontal or vertical alignment, or 3) increase the number of through traffic lanes on an existing highway. The proposed project is considered a Type 1 from I-5 to Medina (west of Evergreen Point Road) due to roadway modifications that result in an increase of 3 dBA or more at several residences along the corridor. Typically, the FHWA assumes a change in the vertical or horizontal alignment that causes a 3 dBA increase in traffic noise as a substantial change, and requires a noise study be performed.

How is a noise study performed?

This section contains the primary steps that are taken to complete a traffic noise study in Washington. Together, these steps also provide the outline for the rest of this Noise Technical Memorandum.

To further assist the reader in navigating through this report, the title of each section within this report that corresponds to each step below is given in the right-hand margin. The 12 primary steps to a noise study include the following:

1. Review all applicable federal, state, and local criteria for traffic noise analyses. These criteria provide approved methods, including the proper traffic noise model and noise abatement criteria for evaluating the project's potential effects.

   ➢ Step 1: *What criteria are used to evaluate the project's potential effects?*

2. Establish the study area and perform field reconnaissance to identify noise-sensitive land uses (for example, parks) and local topography that affects the transmission of noise.

   ➢ Step 2: *What is the study area for the noise analysis?*

3. Select noise measurement locations that will best characterize the existing noise environment. Strategically-selected noise monitoring locations help to describe the overall traffic noise levels as well as identify other major noise sources in the study area.

   ➢ Step 3: *Where are the noise measurement locations?*

4. Select the proper noise measurement equipment and adhere to methods that will meet or exceed the federal, state, or local measurement standards. In addition to noise monitoring, select proper equipment to collect traffic speed and volume data.

   ➢ Step 4: *What equipment and methods were used for collecting the field data?*

5. Perform onsite noise measurements to establish the existing noise environment. Collect traffic volume and speed data and make note of all existing topography that affects the transmission of noise.

   ➢ Step 5: *What are the measured noise levels today?*

6. Develop the input to the Traffic Noise Model (TNM) using the existing roadway alignments and the counted traffic flow. Input the noise monitoring data to verify (or validate) that the TNM accurately predicts traffic noise levels at all monitoring locations.

   ➢ Step 6: *How do we verify the traffic noise model predictions?*

7. Model existing project corridor traffic noise levels using the peak-hour traffic volumes generated by the transportation discipline team and posted speed limits.

   ➢ Step 7: *What are the existing peak traffic noise levels?*

8. Model future project corridor traffic noise levels using the peak-hour traffic volumes generated by the transportation discipline team and posted speed limits. Future conditions include the Build Alternative and the No Build Alternative.

   ➢ Step 8: *What are the future peak traffic noise levels?*

9. Evaluate potential effects of construction-related noise for the Build Alternative. Calculate peak construction noise levels based on the equipment to be used, distance from the construction zones to receivers, and the duration and time of the construction.

   ➢ Step 9: *What construction noise can be expected?*

10. Compare the modeled noise level results to the project traffic noise criteria to determine where noise mitigation should be considered.

    ➢ Step 10: *Where should traffic noise mitigation be considered?*

11. Re-model the Build Alternative with noise mitigation measures and verify that the noise mitigation meets the FHWA and WSDOT criteria for noise reduction effectiveness.

    ➢ Step 11: *What traffic noise mitigation would meet the FHWA and WSDOT criteria?*

12. Identify what noise mitigation measures are recommended for traffic noise effects.

    ➢ Step 12: *What traffic noise mitigation measures are recommended for the project?*

What criteria are used to evaluate potential effects?

FHWA has published traffic noise criteria that determine when noise mitigation must be considered for a federally funded highway project. The wording of the FHWA criteria leaves some room for interpretation by the state that is conducting the study. Details on the FHWA criteria and how traffic studies are performed in Washington are provided in the following sections.

Federal Highway Administration

FHWA traffic noise criteria defined in 23 CFR 772 are compared to the project traffic-noise levels. The criteria applicable for residences, churches, schools, recreational uses, and similar areas are an exterior hourly L_{eq} that approaches or exceeds 67 dBA. The criteria applicable for other developed lands such as commercial and industrial uses are an exterior L_{eq} that approaches or exceeds 72 dBA. FHWA also requires noise abatement to be considered if future noise levels are projected to result in a "substantial increase" over existing noise levels.

There are no criteria for undeveloped lands or construction noise during daytime hours.

A summary of the FHWA noise regulations is contained in Exhibit 3.

Land Use Category	Hourly Leq (dbA)
Type A: 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	57 (exterior)
Type B: Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, (exterior) motels, hotels, schools, churches, libraries and hospitals	67 (exterior)
Type C: Developed lands, properties or activities not included in the above categories	72 (exterior)
Type D: Undeveloped land	--
Type E: Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums	52 (interior)

Source: FHWA: U.S. Department of Transportation (USDOT), 23 CFR 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise.

Exhibit 3. **FHWA Roadway Noise Abatement Criteria**

Washington State Department of Transportation

WSDOT's noise abatement criteria (NAC) further clarify the FHWA traffic noise criteria. WSDOT clarifies the meaning of "approaches" by requiring noise abatement to be considered when predicted project-related noise levels approach the criteria level within 1 dBA. Therefore, noise abatement must be considered for residential land use with projected noise levels of 66 dBA L_{eq} or higher, and for commercial land uses with noise levels of 71 dBA L_{eq} or higher.

FHWA's use of the terms **approaches** and **substantial increase** leaves room for interpretation by the State of Washington.

WSDOT defines **approaches** as within 1 dBA of the FHWA criteria and **substantial increase** as 10 dBA.

WSDOT also clarifies the meaning of "substantial increase" by considering 10 dBA to be a substantial increase if the resulting noise level is greater than 50 dBA.

Noise levels of 80 dBA L_{eq} and higher for outdoor activity areas are defined as "a severe exceedance of the NAC." A NAC exceedance is also considered severe if future design year noise levels are predicted to increase by 30 dBA or higher over existing noise levels.

There are no criteria for undeveloped lands or daytime construction noise.

This Noise Technical Memorandum uses the WSDOT NAC, which FHWA has approved for use on highway projects in Washington.

Guiding Plans and Policies

The following plans and policies were reviewed as part of the noise effects criteria analysis.

- U.S. Department of Transportation (USDOT), 23 CFR 772, *Procedures for Abatement of*

Highway Traffic Noise and Construction Noise.

- WSDOT, *Traffic Noise Analysis and Abatement, Policy and Procedures Manual*, November 1997.
- USDOT, *FHWA Highway Construction Noise: Measurement, Prediction and Mitigation*, 1997.
- USDOT, *FHWA Measurement of Highway-Related Noise*, 1996.
- USDOT, *FHWA Highway Traffic Noise Prediction Model,* TNM Version 2.5, 2004.
- Washington Administration Code (WAC), Chapter 173-60, Maximum Environmental Noise Levels.
- WSDOT *Traffic Noise Analysis and Abatement Policy and Procedures, Section 446, October 2008*.
- Federal Transit Administration (FTA), *Transit Noise and Vibration Impact Assessment Manual*, 1995.

Affected Environment

What is the study area for the noise analysis?

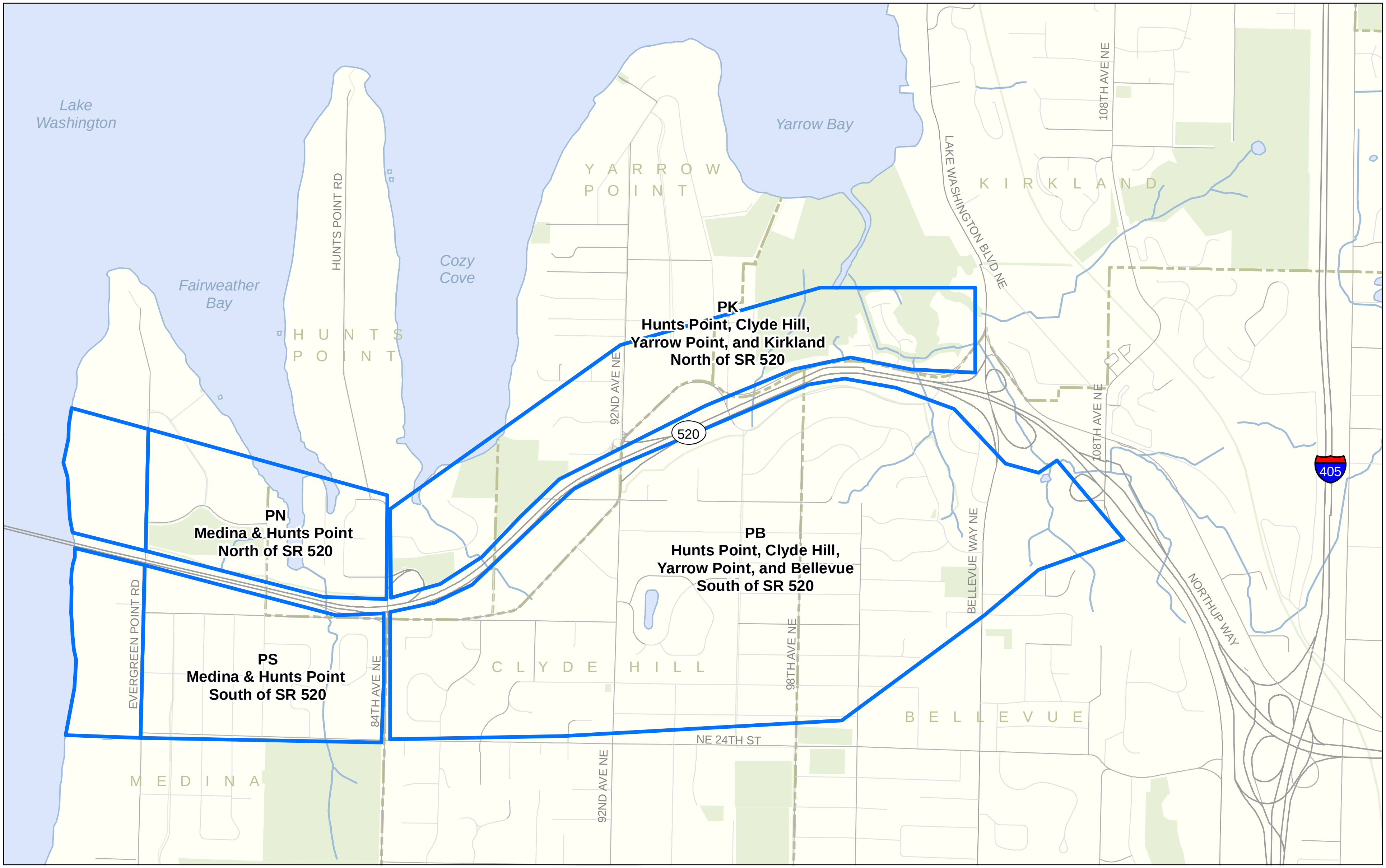
As defined in the WSDOT Policy and Procedures Manual and in 23 CFR 772, the study area should include all lands within 500 feet of the edge of asphalt line. At the request of community leaders, there are some locations greater than the 500-foot study area required by WSDOT. It is possible that some roadways farther than 500 feet from the SR 520 right of way could experience increases in traffic volumes and noise under the proposed action. Under WSDOT policy, any additional roadways that are modified as part of the project are subject to the same level of noise analysis as SR 520. For those roadways where no modifications are proposed, no noise abatement analysis was performed.

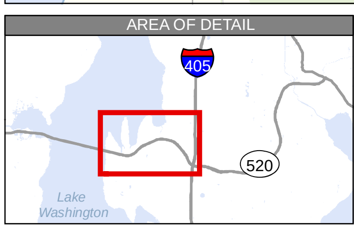
A detailed reconnaissance of the study area was performed to identify all noise-sensitive properties that are, or could be, directly affected by the Medina to SR 202: Eastside Transit and HOV Project. All noise-sensitive properties included in this analysis are located on the north and south sides of the project corridor, as listed below.

- Medina and Hunts Point North — North of SR 520 between Evergreen Point Road and 84th Avenue NE.
- Medina and Hunts Point South — South of SR 520 between Evergreen Point Road and 84th Avenue NE.
- Hunts Point, Clyde Hill, Yarrow Point and Kirkland — North of SR 520 between 84th Avenue NE and 108th Avenue NE (east of Bellevue Way NE).
- Hunts Point, Clyde Hill, Yarrow Point and Bellevue — South of SR 520 between 84th Avenue NE and 108th Avenue NE (east of Bellevue Way NE).

Physical features such as terrain and ground cover, along with any potential features that could be altered during construction are used in the analysis.

Exhibit 4 shows the four noise modeling neighborhood designations used in this analysis. East of 108th Avenue the project would only restripe the highway, and no change the vertical or horizontal alignment of the highway is planned. The restriping is not predicted to result in a 3 dBA change in noise levels and this section of the project would not qualify as a Type 1 Project. Therefore, the section of the project east of 108th Avenue, where there are no physical changes to the highway or local roadways, was not analyzed for traffic noise.





Noise Analysis Area

Park

City Limits

N

0 500 1,000 2,000 Feet

Source: King County (2005) GIS Data (Street), King County (2007) GIS Data (Waterbody), CH2M HILL (2008) GIS Data (Park), City of Bellevue (1999) GIS Data (City Limit), and Michael Minor (2009) GIS Data (Noise Analysis Area). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 4. **Noise Modeling Neighborhood Designations Used in Analysis**

Medina to SR 202: Eastside Transit and HOV Project

\\SIMBA\PROJ\PARAMETRIX\180171\GIS\MAPFILES\EA\NOISE\EA_TM_NOI_NEIGHBORHOODS.MXD 11/12/2009

What project coordination was performed?

The noise analysts worked directly with federal, state, and local agencies, and with community groups. The noise analysts coordinated with FHWA, WSDOT, Sound Transit, King County, Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland, and Bellevue. The noise analysts also attended several community meetings held throughout the project corridor and solicited and received valuable input during these meetings, which was used to select the noise monitoring and modeling locations.

The noise analysts coordinated with Mia Waters, Jim Laughlin, and John Maas of WSDOT's Air Quality, Acoustics, and Energy Program for information related to the methods required for a noise study in Washington. The noise analysts worked with WSDOT personnel, project team members, and the general public to identify all noise-sensitive land uses and to determine an acceptable method of analyzing the many parks and trails in the corridor to ensure that noise mitigation would be considered.

The noise team also coordinated with project team leads to obtain the following information:

- Project design drawings – details on the project alignment and profiles.
- Relocations – information about displacement of public facilities, residents, or commercial uses.
- Land use – details on existing study area land use, including noise sensitive receivers such as residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, auditoriums, and office space. The team also conducted research to identify where any substantial change in land use might be expected.
- Transportation – details on traffic data, including volumes, speeds, and vehicle types for all major roadways within the project corridor.
- Recreation and Section 4(f)/Section 6(f) resources – coordination with these discipline teams about potential noise effects on parks and historic properties.

What other local projects may affect the results of this study?

There are several other projects currently under consideration in the greater Puget Sound area that may affect traffic volumes, and therefore noise levels, in the SR 520 corridor. These projects are taken into account in the transportation model and are therefore included in this noise analysis.

What are the land uses in the study area?

This section provides an overview of the land use in the project corridor as it relates to the noise analysis. Land use is an important factor because it determines what criteria level is used for noise abatement. For noise studies, the actual use of the property determines the abatement criteria, not the land use zone. For example, a residential land use in a commercial or industrial zone is analyzed using the residential NAC, not the less stringent commercial or industrial criteria.

Land use in the project corridor is mainly residential, with some parklands and trails and the Bellevue Christian School/Three Points Elementary (Bellevue Christian School). Land use between Lake Washington and 95th Avenue NE is mainly residential, with some park lands and trails and a nature preserve near 84th Avenue NE. There are some commercial and undeveloped lands along the project corridor, including a park-and-ride near Evergreen Point Road, a gas station on 84th Avenue NE, and coffee shop on NE 28th Avenue, all located on the south side of SR 520.

Land use on the south side of SR 520 between 95th Avenue NE and Bellevue Way NE is residential. On the north side of SR 520, land use is residential, changing to commercial at Bellevue Way NE, with some trails and parklands and undeveloped lands. For more information on current land uses in the study area, see the Land Use, Economics, and Relocations, Technical Memorandum (WSDOT 2009).

What are the topographical characteristics of the study area?

As described previously, the transmission of sound over distance can vary greatly depending on the topographical characteristics between the noise source and receiver. This section provides an overview of the topographical conditions as they relate to the transmission of noise in the project corridor.

The Eastside is relatively level but does contain some topographical features that would affect the transmission of noise. In general, residents on the north side of SR 520 are below the highway grade, and residents on the south side of the highway are primarily above the highway grade. The highway makes a transition to below grade for bridges at Evergreen Point Road, 84th Avenue NE, and 92nd Avenue NE. The highway transitions to an at-grade configuration between the bridges. For most locations, noise reduction from topographical features is minimal in this part of the project corridor.

Where are the noise measurement locations?

The noise discipline team collected a variety of information to aid in the selection of noise measurement locations. Aerial mapping, survey data, computer-aided design (CAD) drawings, and information from the land use analysis were studied, with special attention given to residential areas and the location of SR 520 and other major connector and arterial roads. Based on that research, the general areas for noise monitoring were selected. More detailed information was then collected during onsite visits to the study area. The final selection of specific noise monitoring locations was made through a joint effort between the noise discipline team, WSDOT, Sound Transit, and the neighborhood communities and groups.

The noise discipline team measured noise levels at 43 locations in the study area. These included 4 long-term (24-hour or greater) and 39 short-term (15 to 30 minutes) monitoring locations. For the long-term monitoring locations, the team has provided an averaged peak-hour noise level in L_{eq} dBA. For short-term locations, 15 minutes is generally considered sufficient for obtaining an accurate L_{eq} on busy highways.

Exhibit 5 summarizes the number and type of measurement periods by neighborhood or area. The study area communities are further divided for the analysis later in this report.

Exhibit 5. **Noise Monitoring Locations by Neighborhood**

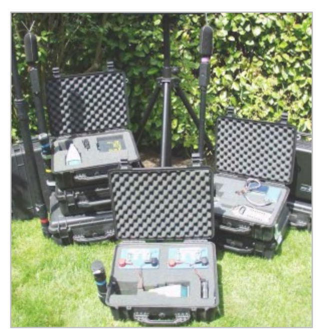
Neighborhood or Area	Short-Term	Long-Term	Total
Medina and Hunts Point North (north of SR 520 between Evergreen Point Road and 84th Avenue NE)	4	1	5
Medina and Hunts Point South (south of SR 520 between Evergreen Point Road and 84th Avenue NE)	4	1	5
Hunts Point, Clyde Hill, Yarrow Point, and Kirkland (north of SR 520 between Hunts Point Road and Bellevue Way NE)	13	1	14
Hunts Point, Clyde Hill, Yarrow Point, and Bellevue (south of SR 520 between 84th Avenue NE and Bellevue Way NE)	18	1	19
Project Totals	**39**	**4**	**43**

How were the noise measurements performed?

Sound Level Meter

The equipment used for noise monitoring included Bruel & Kjaer Type 2238 Sound Level Meters equipped with statistical analysis, Bruel & Kjaer Type 2231 Sound Level Meters equipped with Bruel & Kjaer BZ-7101 Statistical Analysis Module, a Bruel & Kjaer Type 2236 Sound Level Meter, and a Larson Davis Type 710 Sound Level Meter.

The meters were calibrated before and after the measurement periods using a Bruel & Kjaer Type 4231 Sound Level Calibrator. Each of the sound level meters receives a complete annual system calibration at a National Institute of Standards and Testing certified traceable calibration laboratory.



Typical Outdoor Systems Used for Long-Term Noise Monitoring

Systems used for long-term unattended noise monitoring included Bruel & Kjaer Type 2238 Sound Level Meters equipped with statistical analysis and Bruel & Kjaer Type 2231 Sound Level Meters equipped with a Bruel & Kjaer BZ-7101 Statistical Analysis Module. These systems are in weatherproof cases and battery-operated. The systems store detailed noise levels on an hourly basis over the measurement period, which can range from several hours to several days.

All noise measurements conform to the guidelines and procedures provided by the American National Standards Institute for community noise measurements and the *FHWA Measurement of Highway-Related Noise* (USDOT 1996) and WSDOT Traffic Noise Analysis and Abatement Policies and Procedures. Noise measurement locations were at least 5 feet from any solid structure to prevent acoustical reflections. The microphones were on tripods or poles 5 feet off the ground elevation.

Stalker Radar Gun

A Stalker II radar gun was used to measure average travel speeds at several locations in the project corridor during the noise measurement periods. The radar gun is calibrated using a 60-mph tuning fork. Typical speeds between 2:00 and 4:00 pm, which are the peak noise periods based on long-term noise monitoring data, ranged from 50 to 60 miles per hour (MPH), with an average of 55 MPH. The measured speed data were used to help to establish an accurate noise prediction model for existing conditions.

What are the measured sound levels?

The following sections provide the measured noise level results for each of the four defined neighborhood areas, with specific measurements at each monitoring location.

Overall, noise levels between Evergreen and Bellevue Way NE ranged from 48 to 72 dBA L_{eq}. Exhibit 6 presents the measured noise levels for the project corridor in aerial view. Exhibit 7 provides a tabulated list of the noise monitoring locations, land use, and measured noise levels. Descriptions of major noise sources along the project corridor are included in the following sections.

Medina and Hunts Point North

Evergreen Point Road to 84th Avenue NE

There are 4 short-term noise monitoring locations and 1 long-term noise monitoring location on the north side of SR 520 from Evergreen Point Road east to 84th Avenue NE (M49, M52, M54, M56, and M57). Measured noise levels ranged from 58 to 67 dBA L_{eq}, with an overall average noise level of approximately 63 dBA. Exhibit 7 presents the data in tabulated form.

The primary noise source was traffic on SR 520, with additional noise from arterial roads, including Evergreen Point Road and 84th Avenue NE.

Medina and Hunts Point South

Evergreen Point Road to 84th Avenue NE

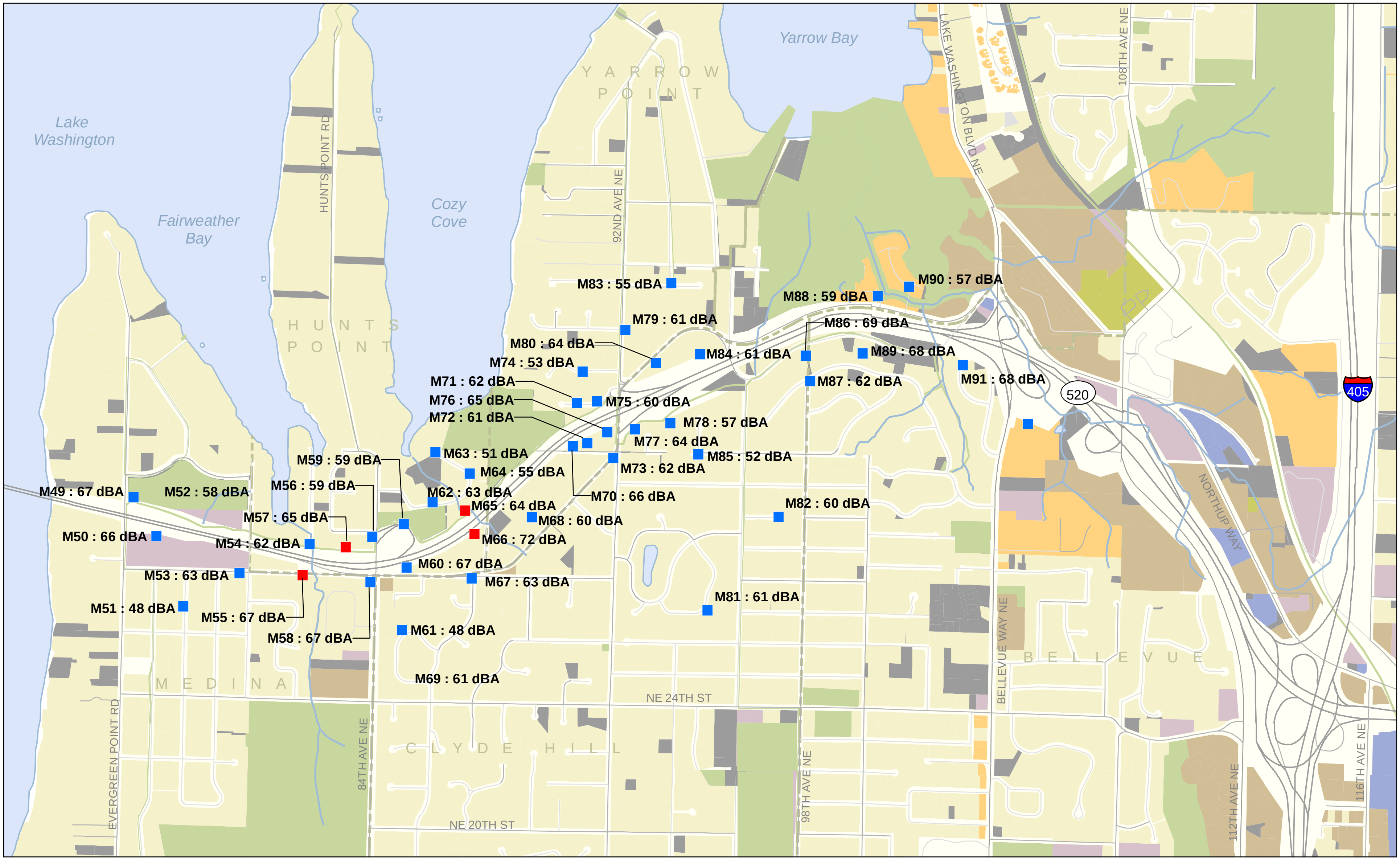
There are 4 short-term noise monitoring locations and 1 long-term noise monitoring location south of SR 520 from Evergreen Point Road east to 84th Avenue NE (M50, M51, M53, M55, and M58 shown in Exhibits 6 and 7). Measured noise levels ranged from 48 to 67 dBA L_{eq}, with an overall average noise level of approximately 64 dBA.

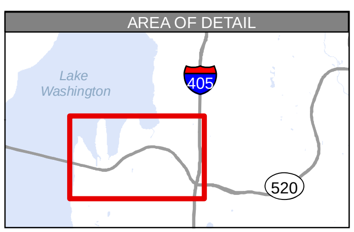
Similar to the north side, the primary noise source was traffic on SR 520, with additional noise from arterial roads, including Evergreen Point Road and 84th Avenue NE.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland

North of SR 520 between 84th Avenue NE and Bellevue Way NE

Between 84th Avenue NE and Bellevue Way NE north of SR 520, there are 13 short-term noise monitoring locations and 1 long-term noise monitoring location (see Exhibits 6 and 7). Measured noise levels ranged from 51 to 64 dBA L_{eq}, with an overall average noise level of approximately 60 dBA. The highest noise levels were recorded on the south side of SR 520 because of the area topography. Major noise sources included traffic on SR 520 and access ramps, 84th Avenue NE, NE 28th Street, Points Drive NE, and 92nd Avenue NE.





Noise Monitoring Site
- Long Term
- Short Term

Monitoring Site Identifier
M1: 59 dBA
Measured sound level

Existing Land Use
- Single Family
- Multifamily
- Park/Open Space
- Civic and Quasi-Public
- Commercial
- Industrial
- Parking
- Vacant
- Unknown

N
0 500 1,000 2,000 Feet

Source: King County (2008) GIS Data (Parcel), King County (2005) GIS Data (Stream and Street), King County (2007) GIS Data (Waterbody), City of Bellevue (1999) GIS Data (City Limit), and CH2M HILL (2008) GIS Data (Parks). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 6. **Noise Monitoring Sites in the Study Area**

Medina to SR 202: Eastside Transit and HOV Project

Exhibit 7. **Noise Monitoring Locations, Data, and Descriptions**

Number[a]	Address (closest to monitoring location)	Type	Duration	Noise Level[b]
Medina and Hunts Point North				
M49*	Playfield near tennis courts	Short-Term	15 minutes	67
M52	3010 80th Avenue NE	Short-Term	15 minutes	58
M54	3003 Fairweather Lane – near foot trail	Short-Term	15 minutes	62
M56	2831 Hunts Point Road	Short-Term	15 minutes	59
M57	8305 Hunts Point Circle (NE 30th Avenue)	Long-Term	25 hours	65
*M40, M43, M45, and M46 were reported in the SR 520 Bridge Replacement and HOV Project Draft Environmental Impact Statement. Because these are west of Evergreen Point Road, they were not analyzed for this report.				
Medina and Hunts Point South				
M50*	Bellevue Christian School	Short-Term	15 minutes	66
M51	2619 78th Avenue NE – near NE 28th Street	Short-Term	15 minutes	48
M53	7979 NE 28th	Short-Term	15 minutes	63
M55	8049 NE 28th Avenue	Long-Term	24 hours	67
M58	Intersection of 84th Avenue NE and NE 28th Street, next to the off-ramp	Short-Term	15 minutes	67
*M41, M42, M44, M47 and M48 were reported in the SR 520 Bridge Replacement and HOV Project Draft Environmental Impact Statement. Because these are west of Evergreen Point Road, they were not analyzed for this report.				
Hunts Point, Clyde Hill, Yarrow Point, and Kirkland				
M59	Fairweather Park Entrance	Short-Term	15 minutes	59
M62	8472 Hunts Point Lane	Short-Term	15 minutes	63
M63	8580 Hunts Point Lane	Short-Term	15 minutes	51
M64	8581 Hunts Point Lane	Short-Term	15 minutes	55
M65	8531 Hunts Point Lane	Long-Term	25 hours	64
M71	9043 NE 33rd Street – behind wall	Short-Term	15 minutes	62
M74	9030 NE 34th Street	Short-Term	15 minutes	53
M75	9052 NE 33rd Street	Short-Term	15 minutes	60
M79	Intersection of NE 36th Street and 92nd Avenue NE	Short-Term	15 minutes	61
M80	9243 Points Drive	Short-Term	15 minutes	64
M83	Dead-end on NE 37th Street – east of 92nd Avenue NE	Short-Term	15 minutes	55
M84	9417 Points Drive	Short-Term	15 minutes	61
M88	10015 off Points Drive and 100th Lane NE	Short-Term	15 minutes	59
M90	Intersection of 101st Way and NE 35th Court	Short-Term	15 minutes	57
Hunts Point, Clyde Hill, Yarrow Point, and Bellevue				
M60	8500 NE 28th Street – next door in field	Short-Term	15 minutes	67

Exhibit 7. **Noise Monitoring Locations, Data, and Descriptions**

Number[a]	Address (closest to monitoring location)	Type	Duration	Noise Level[b]
M61	8510 85th Avenue NE	Short-Term	15 minutes	48
M66	2827 88th Avenue NE	Long-Term	24 hours	72
M67	Intersection of NE 28th Street and 88th Avenue NE	Short-Term	15 minutes	63
M68	9010 Points Drive	Short-Term	15 minutes	60
M69	8829-8832 NE 25th Street	Short-Term	15 minutes	61
M70	9106 – on street north of NE 32nd Street	Short-Term	15 minutes	66
M72	9114 NE 32nd Street – closer to SR 520	Short-Term	15 minutes	61
M73	Intersection of Points Drive and 92nd Avenue NE	Short-Term	15 minutes	62
M76	3233 92nd Avenue NE	Short-Term	15 minutes	65
M77	3223 93rd Place NE	Short-Term	15 minutes	64
M78	3216 93rd Place NE	Short-Term	15 minutes	57
M81	2710 95th Avenue NE	Short-Term	15 minutes	61
M82	9636–9645 NE 30th Street	Short-Term	15 minutes	60
M85	8411 NE 32nd Street	Short-Term	15 minutes	52
M86	9650 98th Avenue NE – off NE 34th Place	Short-Term	15 minutes	69
M87	9660 NE 34th Place	Short-Term	15 minutes	62
M89	9836 NE 34th Place	Short-Term	15 minutes	68
M91*	3240 103rd Place	Short-Term	15 minutes	68

*****_M92 through M98 were reported in the SR 520 Bridge Replacement and HOV Project Draft Environmental Impact Statement, but are located east of Bellevue Way NE. Only re-striping will occur east of Bellevue Way NE and therefore no noise analysis will be performed in this area._

[a] See Exhibit 6 for a map of the noise monitoring locations.
[b] Measured L_{eq} noise level in decibels with A-weighting (dBA).

Hunts Point, Clyde Hill, Yarrow Point, and Bellevue

South of SR 520 between 84th Avenue NE and Bellevue Way NE

South of SR 520, between 84th Avenue NE and Bellevue Way NE, noise levels at the 18 short-term noise monitoring locations and 1 long-term noise monitoring location (shown in Exhibits 6 and 7) ranged from 48 to 72 dBA L_{eq}. The overall average noise level was 66 dBA L_{eq}. Similar to other areas along the SR 520 corridor, the highest noise levels were measured near the highway and major arterial roadways such as Bellevue Way NE. Major noise sources included traffic on SR 520 and Bellevue Way NE.

Study area noise modeling

Traffic-noise levels are calculated using the latest FHWA-approved noise model, Traffic Noise Model (TNM) version 2.5, which was released in April 2004.

Input to the model includes traffic volume generated by the transportation discipline team and posted speeds. In addition to the traffic data, noise-reducing effects of existing structures directly bordering the project roadway, roadway alignment and profiles, topography, ground cover, and foliage are included in the calculations, where appropriate. Using the information described above, the model predicts the hourly L_{eq} at selected receiver locations throughout the project corridor.

In addition to sites where noise was measured (designated M49 through M91), noise levels were modeled at 182 locations in the project corridor. Modeling was performed to determine what locations in the study area exceeded the NAC. Therefore, peak-hour traffic noise levels were calculated for existing conditions using current traffic volumes and for the future No Build and Build Alternatives using predicted 2030 traffic volumes, with and without noise mitigation measures.

The noise receiver locations were carefully selected to ensure that all potentially affected areas were studied. The noise discipline team selected 182 receivers in the study area based on aerial mapping and onsite visits. The 182 receivers collectively represent approximately 579 residences within the study area.

To help reduce the large volume of data, the team selected TNM number designations that would correspond to general neighborhood areas. The team divided the project study area into four neighborhoods as previously described. Exhibit 4 shows how the neighborhoods were grouped into receiver designation areas.

For each neighborhood, the team numbered noise modeling locations for easy and consistent identification (see the noise modeling locations provided in the *Potential Effects of the Project* section of this report). For example, PN-4 is a modeling receiver number in the Medina and Hunts Point North neighborhood. As shown later in this report, all modeling receivers with a "PN" designation represent the modeled receivers used in the Medina and Hunts Point North neighborhood. The team assigned similar modeling receiver designations (PS, PK, and PB) for the other three areas within the study area. The team developed this numbering convention to help readers navigate through the large amount of data required for this project.

Modeled Receiver Designations

Eastside Study Area

PN – Medina and Hunts Point north of SR 520

PS – Medina and Hunts Point south of SR 520

PK – Hunts Point, Clyde Hill, Yarrow Point, and Kirkland north of SR 520

PB – Hunts Point, Clyde Hill, Yarrow Point, and Bellevue south of SR 520

How is the traffic noise model verified for accuracy?

Prior to using the TNM to predict noise levels in the project corridor, the noise discipline team first verified that the model was computing accurate noise levels. This is called model verification.

The team used the existing roadway alignments and the traffic counts and speeds data observed during our monitoring sessions as input into the TNM. Major topographical features that affect the transmission of noise (for example, hills or high retaining walls) were also used as input.

Next, the team ran the TNM and compared the modeled noise levels with the measured noise levels. If the modeled and measured results agreed within $\pm$2 dBA, the model was considered accurate and met WSDOT requirements. A 2-dBA tolerance was used because a person with average hearing would need at least a 3-dBA change in noise level to notice a difference in overall loudness.

For locations where the modeled results differed by more than +2 dBA from the measured results, the team considered several corrective options:

- Identify and add missing terrain, trees, or ground zones to make sure that the model accurately represents the existing conditions in the area;
- Apply a correction factor in the TNM to manually adjust the noise levels to within the +2-dBA tolerance (this is used only in rare cases where reflections or other acoustical anomalies exist); or
- Identify and document the reason for the discrepancy (for example, non-traffic related noise sources such as construction noise that occurred during the measurement period, thus causing the measured level to be higher than the calculated noise levels).

Taking additional noise measurements was considered and rejected due to the installation of special pavement types in this corridor.

For this project, the team compared the measured with the modeled noise levels at all locations in the corridor and, with a few exceptions, all locations were within the +2-dBA validation requirement. The few exceptions were due to other non-traffic related noise sources. Results of the model validation are discussed below.

Because observed traffic volumes and speeds were used for the model validation, modeled values may differ from the typical peak-hour, existing conditions noise modeling described later in this report.

Noise levels were measured at 43 locations between Evergreen Point Road and Bellevue Way NE. Of the 43 monitoring locations, 37 were selected for noise model verification. The other 6 monitoring locations were not included because they are in areas where noise from local roadways or other activities is the dominant noise source. Most of the 43 selected monitoring locations were validated with the noise modeling results. Three locations did not meet the validation level of +2 dBA. The remaining 40 noise monitoring locations meet the WSDOT +2-dBA validation criteria. Exhibit 8 summarizes the validation process by analysis area for the Eastside study area. All Eastside validations are discussed below. The locations that were not validated are not included in the graph but are identified and explained in the discussions below.

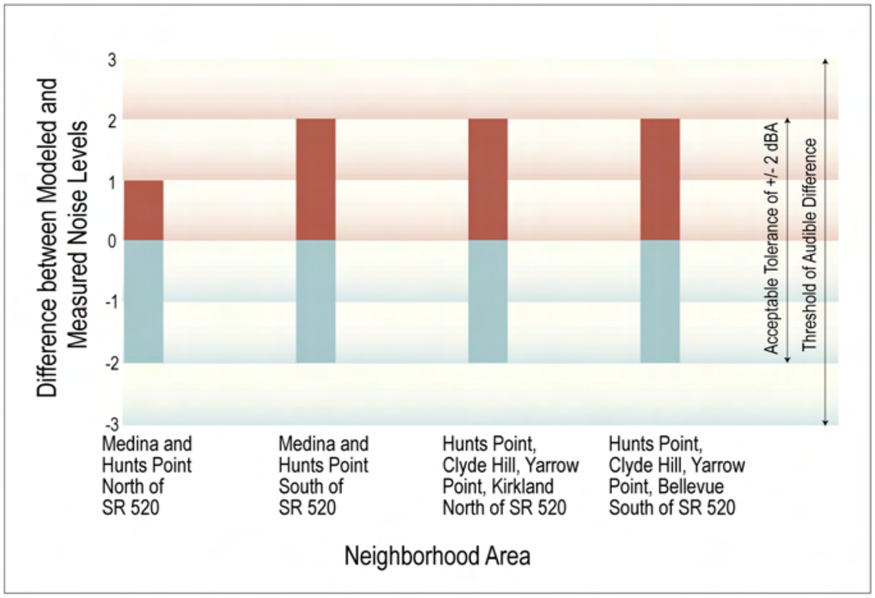


Exhibit 8**. Overall Noise Model Validation Summary for the Study Area**

Medina and Hunts Point North of SR 520

Five noise monitoring locations were in Medina and Hunts Point west of 84th Avenue NE and north of SR 520. Receiver location PN-29/M56 had a modeled noise level that was 4 dBA higher than the measured level. During the noise monitoring period, SR 520 and the on-ramp to SR 520 westbound were gridlocked, which resulted in lower than normal noise levels. For most vehicles, the higher the operating speed, the higher the noise levels.

Under a gridlocked condition, the slow-moving vehicles produce lower noise levels. All other modeling locations validated within +1 to -2 dBA of the measured noise levels.

Medina and Hunts Point South of SR 520

There were 5 noise monitoring locations in Medina and Hunts Point South of SR 520 west of 84th Avenue NE. One location (PS-29/M51) was too far from SR 520 for a reliable validation. Receiver location PS-13/M58 had a modeled noise level that was 3 dBA higher than the measured level. During the noise reading, traffic flow on SR 520 and the on-ramp to SR 520 eastbound was in a stop-and-go condition, which resulted in lower than normal noise levels. All other modeling locations validated within ±2 dBA of the measured noise levels.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520

The team selected 14 noise monitoring locations in Hunts Point, Clyde Hill, Yarrow Point, and Kirkland north of the SR 520 corridor. One location (PK-35/M83) was too far from SR 520 to provide a reliable validation. In addition, receiver location PK-4/M62 had a high measurement during the noise reading due to local noise effects that were the result of activities in Fairweather Park and some local construction, not traffic on SR 520. All other modeling locations validated within ±2 dBA of the measured noise levels.

Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520

The team selected 19 noise monitoring locations in Hunts Point, Clyde Hill, Yarrow Point, and Bellevue south of SR 520 for this analysis. Within this area, four locations (PB-52/M61, PB-62/M81, PB-63/M69, and PB-64/M82) were all too far from SR 520 to provide a reliable validation. All other modeling locations validated within ±2 dBA of the measured noise levels.

What are the existing peak-hour traffic noise levels?

After the TNM is verified to accurately predict traffic noise levels, the next step in a traffic noise study is to model the existing peak-hour traffic noise levels. Existing peak-hour traffic noise levels (using posted speeds) represent the worst case noise levels that can be expected under the current roadway alignment and traffic flow conditions. Existing peak-hour traffic noise levels were modeled using 2004 peak-hour traffic volumes generated by the transportation discipline team and posted speeds.

Existing peak-hour traffic noise levels were modeled for a total of 182 receivers throughout the study area. The receiver locations were carefully selected to ensure that all potentially affected areas would be studied.

The following sections provide detailed results for the project corridor. Exhibits showing the noise modeling locations are provided in the *Potential Effects of the Project* section of this technical memorandum.

Existing peak-hour traffic noise levels were modeled for 182 receiver locations, representing 579 residences within the project corridor. Noise levels at 55 receivers (representing 155 residences) exceeded the WSDOT NAC of 66 dBA L_{eq}.

Medina and Hunts Point North of SR 520

Existing peak-hour traffic noise levels were modeled for 35 receiver locations, representing 90 residences in Medina and Hunts Point west of 84th Avenue NE and north of SR 520. Noise levels at residential receiver locations in this area ranged from 52 to 71 dBA L_{eq}. The results for receivers PN-4 and PN-10 through PN-43 are presented in Exhibit 21 in the *Potential Effects of the Project* section of this report. Noise levels at 10 receivers (23 residences) currently exceed the NAC in this area.

Medina and Hunts Point South of SR 520

The team modeled existing peak-hour traffic noise levels for 22 receiver locations (representing 75 residences) in Medina and Hunts Point west of 84th Avenue NE and south of SR 520. Existing noise levels in this area were modeled between 56 and 72 dBA L_{eq}. The results for receivers PS-6 through PS-20 and PS-27 through PS-33 are presented in Exhibit 22 and in the *Potential Effects of the Project* section of this report. Noise levels at 10 receivers (23 residences) in this portion of the study area currently exceed the NAC.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520

Existing peak-hour traffic noise levels were modeled for 49 receiver locations (representing 116 residences) in the Hunts Point, Clyde Hill, Yarrow Point, and Kirkland areas east of 84th Avenue NE and north of SR 520. Existing peak-hour noise levels at residential land uses in this area ranged from 49 to 70 dBA L_{eq}. The results for receivers PK-1 through PK-50 are included in Exhibit 23 and in the *Potential Effects of the Project* section of this report. Noise levels at 7 receivers (24 residences) in this portion of the Eastside study area currently exceed the NAC.

Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520

Existing peak-hour traffic noise levels were modeled for 76 receiver locations (representing 263 residences) in Hunts Point, Clyde Hill, Yarrow Point, and Bellevue east of 84th Avenue NE and south of SR 520. Existing peak-hour noise levels in this area ranged from 48 to 73 dBA L_{eq}. The results for receivers PB-1 through PB-24 and PB-28 through PB-73 are included in Exhibit 23 and in the *Potential Effects of the Project* section of this report. Noise levels at 28 receivers (85 residences) in this area currently exceed the NAC.

Potential Effects of the Project

What methods were used to evaluate the potential effects?

The noise discipline team modeled future traffic noise levels using the peak-hour traffic volumes for the design year (2030) and the posted speed limits in the project corridor. Traffic noise levels increase with increasing traffic speeds. Because the actual travel speeds are projected to be lower than the posted speed limit (55 mph on SR 520), noise level projections in this report are considered conservative. Due to this conservative modeling approach, the traffic noise levels presented in this report are likely 1 to 3 dBA higher than what actual noise levels would be in the corridor under the forecasted traffic volumes. Future noise levels were projected for the No Build Alternative and the Build Alternative.

The noise-reducing effects of the proposed lids at Evergreen Point Road, 84th Avenue NE, and 92nd Avenue NE were included in the model. Because, the three proposed landscape lids are considered part of the highway design, they were not evaluated under the WSDOT traffic noise mitigation effectiveness criteria. The lid and station platforms would have acoustical treatments that would provide the additional benefit of noise reduction for transit patrons.

The TNM modeling results are presented for each study area neighborhood group within the project corridor. The team paid particular attention to whether the noise walls would lower noise levels to below the NAC for the design year 2030. The team used the existing alignment of SR 520 to model the No Build Alternative. A 6-lane alignment was used to model the Build Alternative noise levels. Major local arterial roads and all SR 520 ramps were included in the noise model and also modeled at the posted speed limits.

Public parks (e.g., Fairweather Park), the Points Loop Trail, the Lake Washington Boulevard trail, and the SR 520 bike and pedestrian path were also included in the modeling analysis. Because these types of facilities generally have a greater number of receivers than if simply counted as a residence, WSDOT has developed a method of assigning a “residential equivalents” value to noise-sensitive areas such as parks. Based on WSDOT’s *Environmental Procedures Manual* (2003), residential equivalents values were calculated for the parks along SR 520, Points Loop Trail, Lake Washington

Boulevard trail, the Yarrow Bay KinderCare Day Care Center, and the SR 520 bike and pedestrian path. In the calculations, the team assumed that the parks and trails would be used 10 hours per day, 7 days per week, and 12 months per year. Typically, less than 12 months per year are assumed for parks and trails; however, because of the high density of residential structures around the parks and because the trail would be a commuter route for bicyclists, the team assumed a full year of use. It was also assumed that a maximum of 50 people would use each facility during any one hour. At the KinderCare facility, two outdoor play areas were identified: one that primarily receives traffic noise from SR-520 and the other from 108th Avenue NE and Northup Way. The residential equivalent of 2.38 residents for each outdoor play area was calculated based on each area having 20 children, 4 hours per day, 5 days per week, and 12 months per year. (Yasmin Ali, Director, Yarrow Bay KinderCare Day Care Center, Bellevue, WA. February 24, 2010. Discussed operational hours, number of students, hours and days of outdoor use.)

For the No Build Alternative, the noise discipline team calculated future noise levels using the TNM model and compared those results to the 2004 existing levels presented in the Affected Environment section of this report. Comparing 2004 existing conditions to the 2030 No Build Alternative shows what changes in noise levels could be expected assuming nothing is done to alter SR 520 in the next 25 years.

How would project construction affect noise levels?

The noise team predicted construction noise levels using the methods described in the *FHWA Highway Construction Noise: Measurement, Prediction and Mitigation* (USDOT 1997). In addition to the methods given by the FHWA, the team also relied on team members' experience and work on major construction projects to assist in providing the most accurate information available. Information provided includes descriptions of the 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.

Front End Loader

This section discusses the regulations and criteria governing construction noise, the methods of calculating construction noise levels, and the estimated worst case noise levels for project construction. The team has also provided an introduction to construction-related vibration and information on how vibration from construction projects affects humans and structures.

Construction Noise Ordinance

Project construction would take place in several communities, and several different noise ordinances might be applicable to project construction. Most cities in Washington rely on the Washington Administrative Code (WAC), Chapter 173-60, *Maximum Environmental Noise Levels*, for their noise ordinance. Communities in the project corridor that use or base their construction noise ordinance on the WAC include Clyde Hill, Yarrow Point, Kirkland, and Bellevue. Medina and Hunts Point have adopted construction regulations specifically for residential and small developments, the type of construction that occurs in those communities.

For the purpose of discussing construction noise and potential construction noise effects, the team used the WAC. The WAC construction noise ordinance is one of the most stringent noise ordinances in the region and is used by most communities in the project corridor. WSDOT would address any site-specific requests for variances or other construction-related noise issues associated with the proposed project.

Washington State Construction Noise Regulation

Most project construction could be performed within the WAC noise ordinance if the work was performed during normal daytime hours. If construction were to be performed during nighttime hours, WSDOT would be required to meet the noise level requirements presented in Exhibit 9, or obtain a noise variance from the governing jurisdiction.

Exhibit 9. **Washington State Noise Control Regulation**

Source of Noise	Receiver of Noise (Maximum Allowable Sound Level in dBA[a])		
	Residential	Commercial	Industrial
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

[a] Between the hours of 10:00 pm and 7:00 am, the levels given above are reduced by 10 dBA.

In addition to the property-line noise standards listed in Exhibit 9, there are exemptions for short-term noise exceedances, including those outlined in Exhibit 10, that are based on the minutes per hour that the noise limit is exceeded. The corresponding statistical descriptors for each range of exceedances are also provided.

Exhibit 10. **Exemptions for Short-Term Noise Exceedances**

Statistical Descriptor[a]	Minutes Per Hour	Adjustment to Maximum Sound Level
L_{25}	15 (25% of one hour)	+5 dBA
$L_{8.3}$	5 (8.3% of one hour)	+10 dBA
$L_{2.5}$	1.5 (2.5% of one hour)	+15 dBA

[a] L_{25}, $L_{8.3}$ and $L_{2.5}$ are the noise levels that are exceeded 25%, 8.3% and 2.5% of the time.

Construction Vibration Prediction Methods and Effect Guidelines

There are no specific regulations or criteria applicable to vibration related to construction activities; however, State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) guidelines allow federal, state, and local agencies the authority to determine acceptable levels of construction vibration using guidelines, research, and professional standards. For this project, WSDOT would rely on the USDOT guidelines for acceptable vibration levels from construction activities. The guidelines, based on information given in Exhibit 11, recommend that the maximum peak-particle velocity levels remain below 1.27 inches per second at structures nearest the construction site. Vibration levels above 1.27 inches per second have the potential to cause architectural damage to normal dwellings. USDOT also states that vibration levels above 0.64 inch per second can be annoying to people and disrupt normal working or living environments (USDOT 1978).

Exhibit 11. **Peak Velocity Guidelines**

Vibration Velocity (in/sec)	Effects on Humans	Effects on Buildings
0 to 0.001	Imperceptible to people – no intrusion	Vibrations unlikely to cause damage of any type
0.04 to 0.08	Threshold of perception--possibility of intrusion	Vibrations unlikely to cause damage of any type
0.15	Vibrations perceptible	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected
0.64	Level at which continuous vibrations begin to annoy people	Virtually no risk of "architectural" damage to normal buildings
1.27	Vibrations annoying to people in buildings (this agrees with the levels established for people standing on bridges and subjected to relatively short periods of vibrations)	Threshold at which there is a risk of "architectural" damage to normal dwelling-houses with plastered ceilings and walls
2.54 to 3.81	Vibrations considered unpleasant by people subjected to continuous vibrations and unacceptable to some people walking on bridges	Vibrations at a greater level than normally expected from traffic, but would cause "architectural" damage and possible minor structural damage

in/sec = inches per second

Source: USDOT (1978).

Based on the information presented in Exhibit 11, several construction activities could produce vibration levels near the USDOT maximum recommended vibration level of 1.27 inches per second. This could include vibratory sheet installation, soil compacting, and other construction activities that have the potential to cause high levels of vibration when the activity is within 50 to 75 feet of a vibration-sensitive property. In general, structures that have vibration levels of 0.50 inch per second (or higher) could be affected by vibration.

Noise levels that could be expected during construction

The team's analysis considered temporary noise effects that construction could cause in the study area, effects that would end when project construction was completed.

Equipment required to complete the project includes normal construction equipment that is used for many roadway and structural activities. Exhibit 12 provides a list of the equipment typically used for this type of project, the activities they would be used for, and the corresponding maximum noise level as measured at 50 feet under normal use.

Exhibit 12. **Construction Equipment List, Use, and Reference Maximum Noise Levels**

Equipment[a]	Typical Expected Project Use[b]	L_{max}[c] (dBA)	Source[d]
Air Compressors	Used for pneumatic tools and general maintenance - all phases	70 - 76	1, 2, 3
Backhoe	General construction and yard work	78 - 82	2, 3
Concrete Pump	Pumping concrete	78 - 82	2, 3
Concrete Saws	Concrete removal, utilities access	75 - 80	2, 3
Crane	Materials handling, removal, and replacement	78 - 84	2, 3
Excavator	General construction and materials handling	82 - 88	2, 3
Forklifts	Staging area work and hauling materials	72	1, 2, 3
Haul Trucks	Materials handling, general hauling	86	2, 3
Jackhammers	Pavement removal	74 - 82	2, 3
Loader	General construction and materials handling	86	2, 3
Pavers	Roadway paving	88	2
Pile drivers	Support for structure and hillside	99 - 105	2, 3
Power Plants	General construction use, nighttime work	72	2, 3
Pumps	General construction use, water removal	62	2, 3
Pneumatic Tools	Miscellaneous construction work	78 - 86	3
Service Trucks	Repair and maintenance of equipment	72	2, 3
Tractor Trailers	Material removal and delivery	86	3
Utility Trucks	General project work	72	2
Vibratory equipment	Shore up hillside to prevent slides and soil compacting	82 - 88	2, 3
Welders	General project work	76	2, 3

[a] Normal equipment expected to be used for project construction.
[b] Types of construction activities expected during project construction.
[c] Maximum noise level as measured at a distance of 50 feet under normal operation.
[d] Sources of noise levels presented:
[1] Portland, Oregon, light rail, I-5 preservation, and Hawthorne Bridge construction projects.
[2] Measured data from other projects in the Portland, Oregon area.
[3] USDOT or other construction noise source.

Project Construction Phases and Noise Levels

Several different construction phases would be required to complete the Medina to SR 202: Eastside Transit and HOV Project. To provide the public with a general understanding of how loud construction might be, the team performed an analysis that assumes worst case noise levels based on five expected construction activities. The actual noise levels experienced during construction would generally be lower than those described in this report. The noise levels presented here are for periods of maximum construction activity.

Typical construction phases for the SR 520 project would include the following:

- Preparation for construction of new structures
- Construction of new structures and roadway paving
- Miscellaneous activities, including striping, lighting, and signs
- Demolition of existing structures

Preparation

Major noise-producing equipment used during the preparation stage could include concrete pumps, cranes, excavator, haul trucks, loader, tractor trailers, and vibratory equipment. Maximum noise levels could reach 82 to 86 dBA at the nearest residences (50 to 100 feet) for normal construction activities during this phase.

Other major noise sources that might be required during this phase would include the use of vibratory and impact equipment, such as vibratory sheet installations. The purpose of these activities would be to supply support for the new structure and to shore-up hillsides to stop slides before retaining walls were installed. Pile-driving noise levels are discussed below.

Other less notable noise-producing equipment expected during this phase would include backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

Construction

The loudest noise sources in use during construction of the new bridges would include cement mixers, concrete pumps, pavers, haul trucks, and tractor trailers. The cement mixers and concrete pumps would be required for construction of the superstructure and substructure. The pavers and haul trucks would be used to provide the final surface on the roadway and to construct the transitions from the at-grade roadway to the new structures. Maximum noise levels would range from 82 to 94 dBA at the closest receiver locations.

Miscellaneous Activities

Following heavy construction, general construction such as installation of bridge railing, signage, roadway striping, and other general activities would still need to occur. These less intensive activities would not be expected to produce noise levels above 80 dBA at 50 feet except during rare occasions, and even then only for short periods.

Demolition

Demolition of the existing structures would require heavy equipment such as concrete saws, cranes, excavators, hoe-rams, haul trucks, jackhammers, loaders, and tractor trailers. Maximum noise levels could reach 82 to 92 dBA at the nearest residences.

Exhibit 13 provides the noise levels for each of the four typical construction phases as measured at 50 feet from the construction activity. The construction noise analysis assumed that there would be construction staging areas along the proposed work bridges during demolition and construction. The noise levels listed in Exhibit 13 are the typical maximums and would only occur periodically during the heaviest periods of construction. Actual hourly noise levels could be substantially lower than those stated, depending on the level of activity at that time.

Using the information provided in Exhibit 13, the team projected typical construction noise levels for several distances from the project work area. Exhibit 14 shows general noise level versus distance for the phases of construction.

Exhibit 13. **Noise Levels For Typical Construction Phases**

Scenario[a]	Equipment[b]	L_m[c] (dBA)	L_{eq}[d] (dBA)
Construction preparation	Air compressors, backhoe, concrete pumps, crane, excavator, forklifts, haul trucks, loader, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment	94	87
Construction of new structures and roadway paving	Air compressors, backhoe, cement mixers, concrete pumps, crane, forklifts, haul trucks, loader, pavers, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment, welders	94	88
Miscellaneous activities, including striping, lighting and signs	Air compressors, backhoe, crane, forklifts, haul trucks, loader, pumps, service trucks, tractor trailers, utility trucks, welders	91	83
Demolition of existing structures	Air compressors, backhoe, concrete saws, crane, excavator, forklifts, haul trucks, jackhammers, loader, power plants, pneumatic tools, pumps, service trucks, utility trucks	93	88

Note: Combined worst case noise levels for all equipment at a distance of 50 feet from work site.

[a] Operational conditions under which the noise levels are projected.
[b] Normal equipment in operation under the given scenario.
[c] L_m (dBA) is an average maximum noise emission for the construction equipment under the given scenario. For this type of equipment and activities, the L_m is approximately equal to the L_{01}.
[d] L_{eq} (dBA) is an energy average noise emission for construction equipment operating under the given scenario. For this type of equipment, the L_{eq} is approximately equal to the L_{50}.

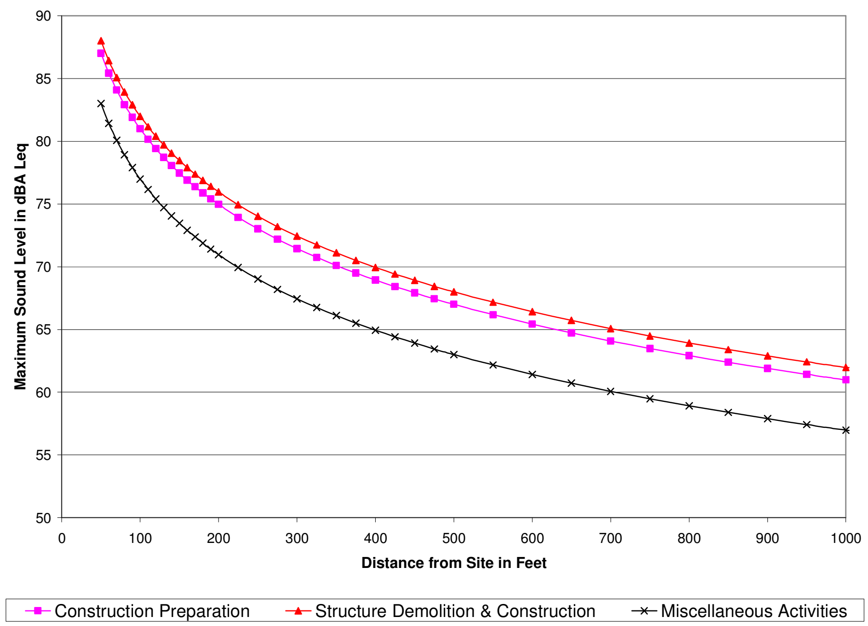


Exhibit 14. **Hourly Maximum Construction Noise for Different Distances from Construction Site**

Construction Vibration Effects

Vibration associated with general construction can result in vibration effects on surrounding receivers. Major vibration-producing activities would occur primarily during demolition and preparation for the new bridges. Activities that have the potential to produce a high level of vibration include vibratory shoring, soil compacting, and some hauling and demolition activities. Vibration effects from vibratory sheet installations could occur within 50 to 100 feet of sensitive receivers. It is unlikely that vibration levels would exceed 0.5 inch per second at distances greater than 100 feet from the construction sites.

How would operation of the project affect noise levels?

This section discusses the overall effects of the No Build and Build Alternatives in the study area, followed by discussions of the individual communities and neighborhoods.

No Build Alternative

Under the No Build Alternative, peak-hour traffic flow conditions on project roadways represent the worst case noise levels because the modeling assumed a posted speed of 55 mph (higher traffic speeds generate higher noise levels). The modeling results are presented for each neighborhood within the study area. The team paid particular attention to any increase in noise levels above existing peak-hour traffic conditions that would cause noise levels at additional residences to exceed the NAC.

The No Build Alternative peak-hour traffic noise levels were modeled for the same 182 receiver locations in the study area as under the existing peak-hour traffic conditions. Noise levels would be expected to increase slightly over today's levels because of growth in traffic volumes on SR 520 and other roadways within the study area. Of the 182 modeled receivers, 62 receivers (representing 173 residences) would have noise levels exceeding the NAC of 66 dBA L_{eq}. As previously stated, 55 receivers (representing 155 residences) currently exceed the NAC. Under the No Build Alternative, an additional 18 residences would exceed the NAC.

Build Alternative

The Build Alternative peak-hour traffic noise levels represent the worst case traffic noise levels that could be expected with 2030 traffic flow conditions.

The Build Alternative peak-hour traffic noise levels were modeled for the same 182 receiver locations (representing 579 residences) in the project study area as existing peak-hour traffic conditions. Overall, the Build Alternative would increase the number of residences where noise levels exceed the NAC from 155 today to 194. While the addition of three lids over the highway at Evergreen Point Road and 84th and 92nd Avenues NE would assist in reducing noise levels at those residences near the lids, there would be an overall increase in traffic noise levels throughout the study area.

Project Corridor Summary
(Evergreen Point Road to 108th Avenue NE [east of Bellevue Way NE])
Number of Residences Where Noise Levels Would Exceed NAC

Existing	No Build	Build
155	173	194

The four aerial photographs in Exhibits 15 through 18 show the receiver locations and modeled noise levels. For each receiver, the existing, 2030 No Build, and 2030 Build Alternative peak-hour noise levels are shown.

Effects of the Project on Neighborhoods in the Study Area

This section describes the relative audible differences for each neighborhood in the study area, and focuses on the noise level changes between the existing conditions and the No Build and Build Alternatives.

Exhibit 19 presents the results of the traffic noise analysis in terms of relative noise levels changes that could be expected for each neighborhood. The exhibit shows the noise modeling sites, notes which receivers exceed the NAC, and provides a symbol indicating whether an average person would notice an increase, decrease, or no change in traffic noise. Noise levels would be reduced by 3 dBA L_{eq} or more at locations where there would be a noticeable decrease in noise levels. Conversely, noise levels would increase by 3 dBA L_{eq} or more at receivers where there would be a noticeable increase in traffic noise. Noise levels at locations shown as having no noticeable change would remain within 2 dBA L_{eq} of current levels.

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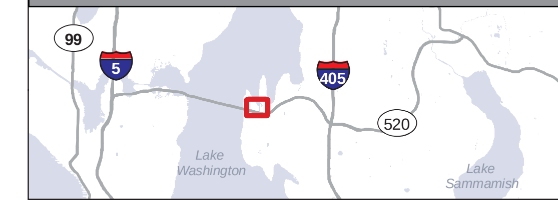

Modeling Location

Monitor and Modeling Location

Noise Analysis Area

PN-19 Ex NB 6 57 57 57 - - 52

- Modeling number
- Alternatives (Existing, No Build, 6-Lane)
- Noise level in decibels without wall
- Noise level in decibels with wall

N

0 100 200 400 Feet

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for all layers is NAVD88.

Exhibit 15. **Noise Modeling Locations and Levels in Medina and Hunts Point North of SR 520**

Medina to SR 202: Eastside Transit and HOV Project

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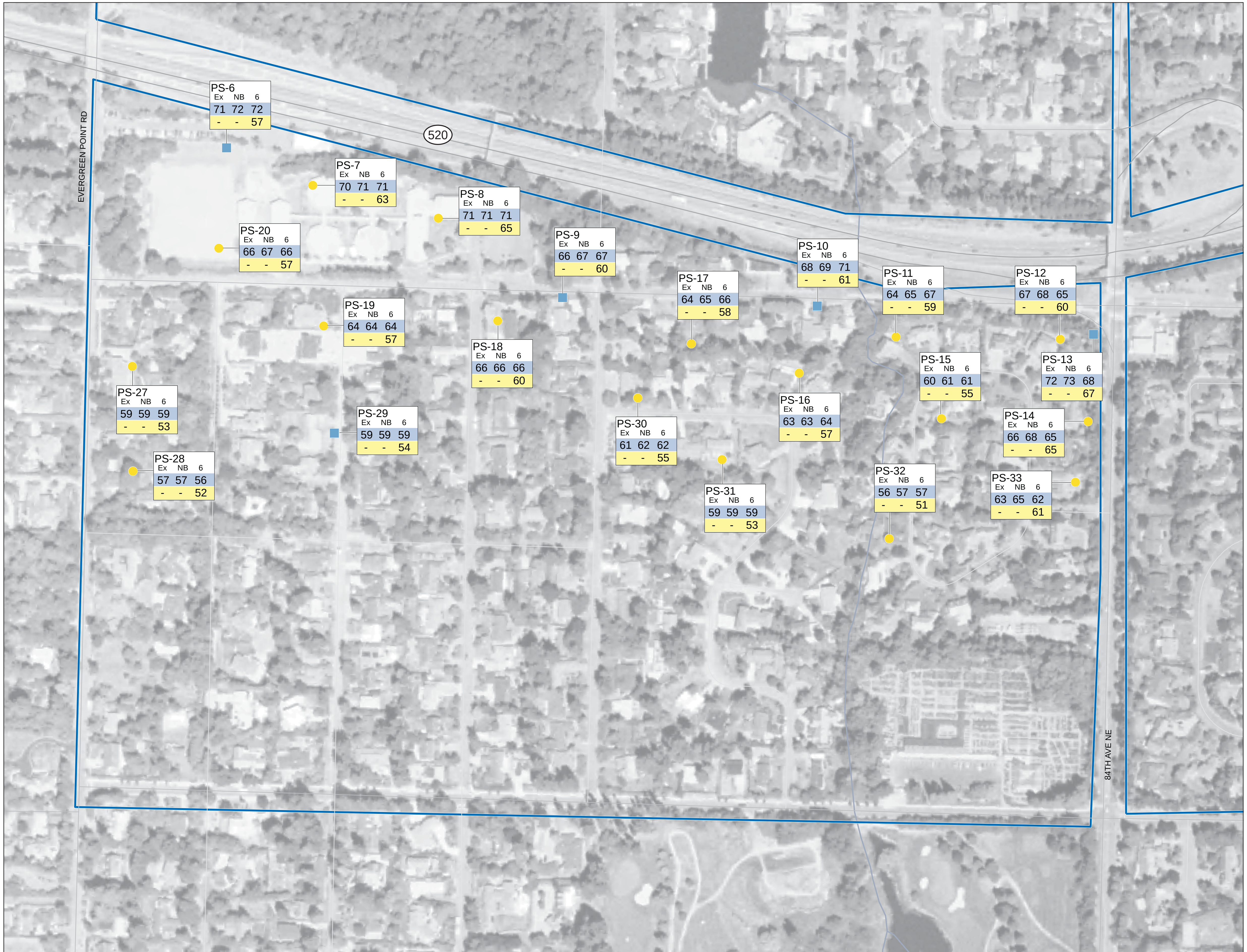

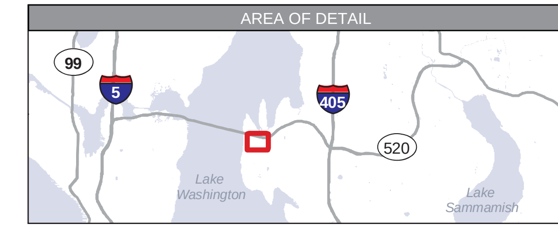

Modeling Location

Monitor and Modeling Location

Noise Analysis Area

PS-19 Ex NB 6 57 57 57 - - 52

- Modeling number
- Alternatives (Existing, No Build, 6-Lane)
- Noise level in decibels without wall
- Noise level in decibels with wall

N

0 100 200 400 Feet

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for all layers is NAVD88.

Exhibit 16. **Noise Modeling Locations and Levels in Medina and Hunts Point South of SR 520**

Medina to SR 202: Eastside Transit and HOV Project

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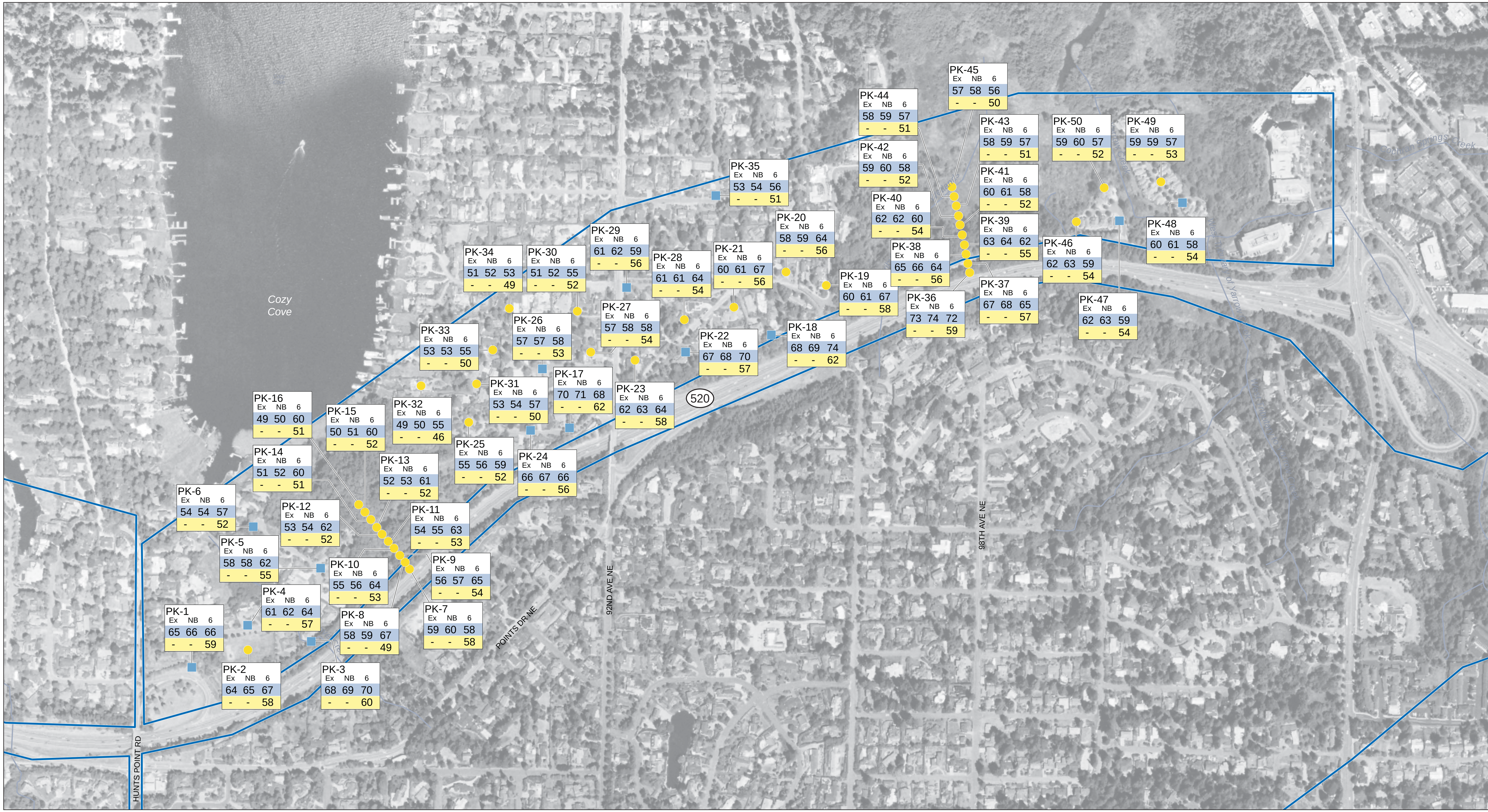

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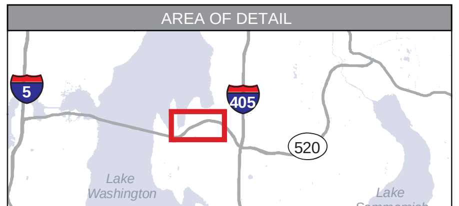

Modeling Location

Monitor and Modeling Location

Noise Analysis Area

PK-19 Ex NB 6 57 57 57 - - 52

Modeling number

Alternatives (Existing, No Build, 6-Lane)

Noise level in decibels without wall

Noise level in decibels with wall

N

0 250 500 1,000 Feet

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for all layers is NAVD88.

Exhibit 17. **Noise Modeling Locations and Levels in Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520**

Medina to SR 202: Eastside Transit and HOV Project

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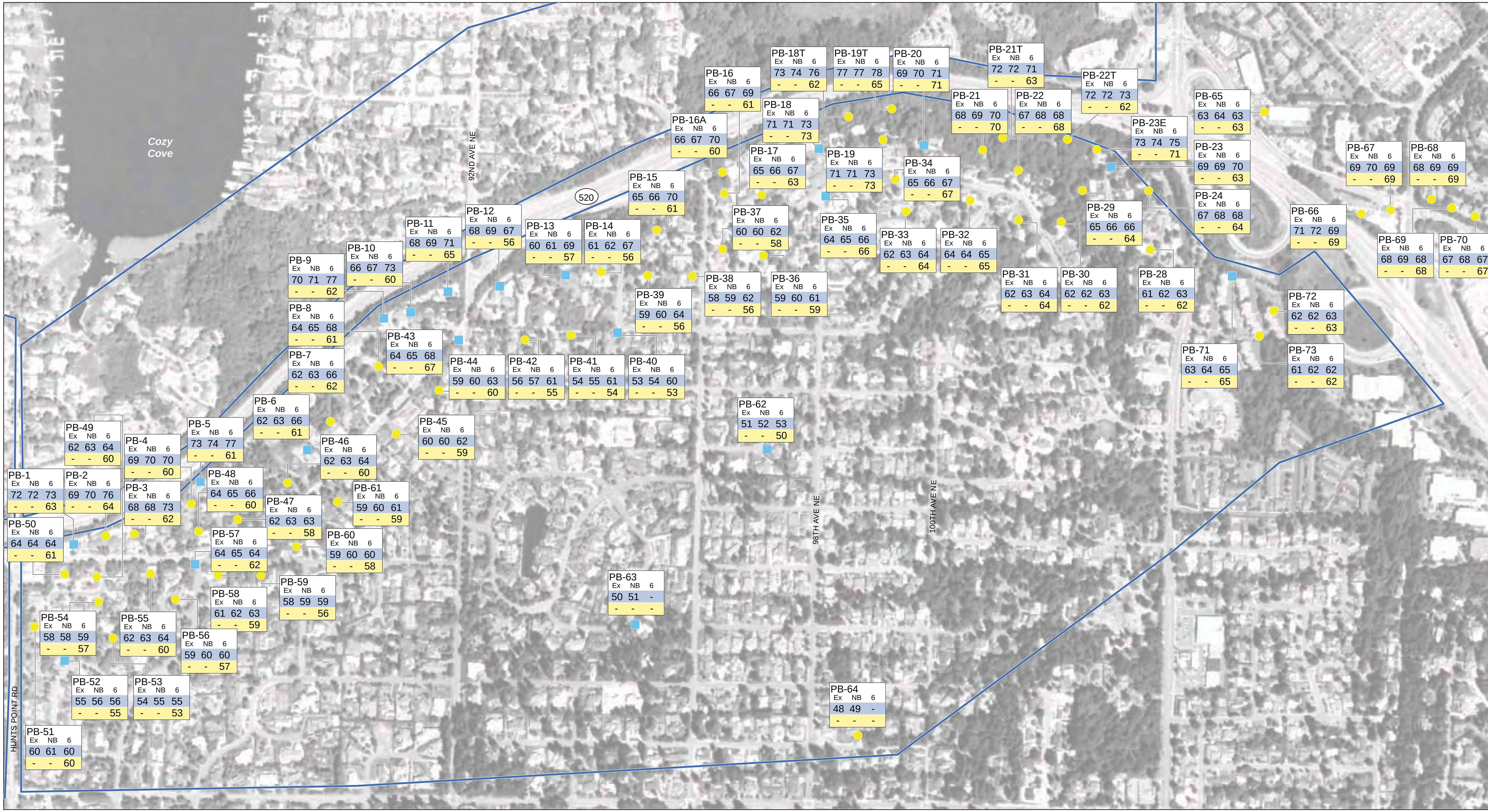

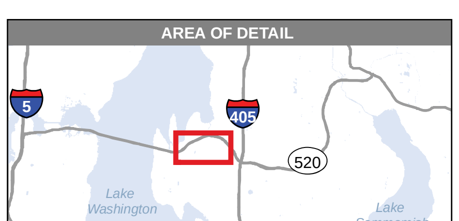

Modeling Location

Monitor and Modeling Location

Noise Analysis Area

N

0 250 500 1,000 Feet

Source: King County (2006) Aerial Photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 18. **Noise Modeling Locations and Levels in Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Medina to SR 202: Eastside Transit and HOV Project

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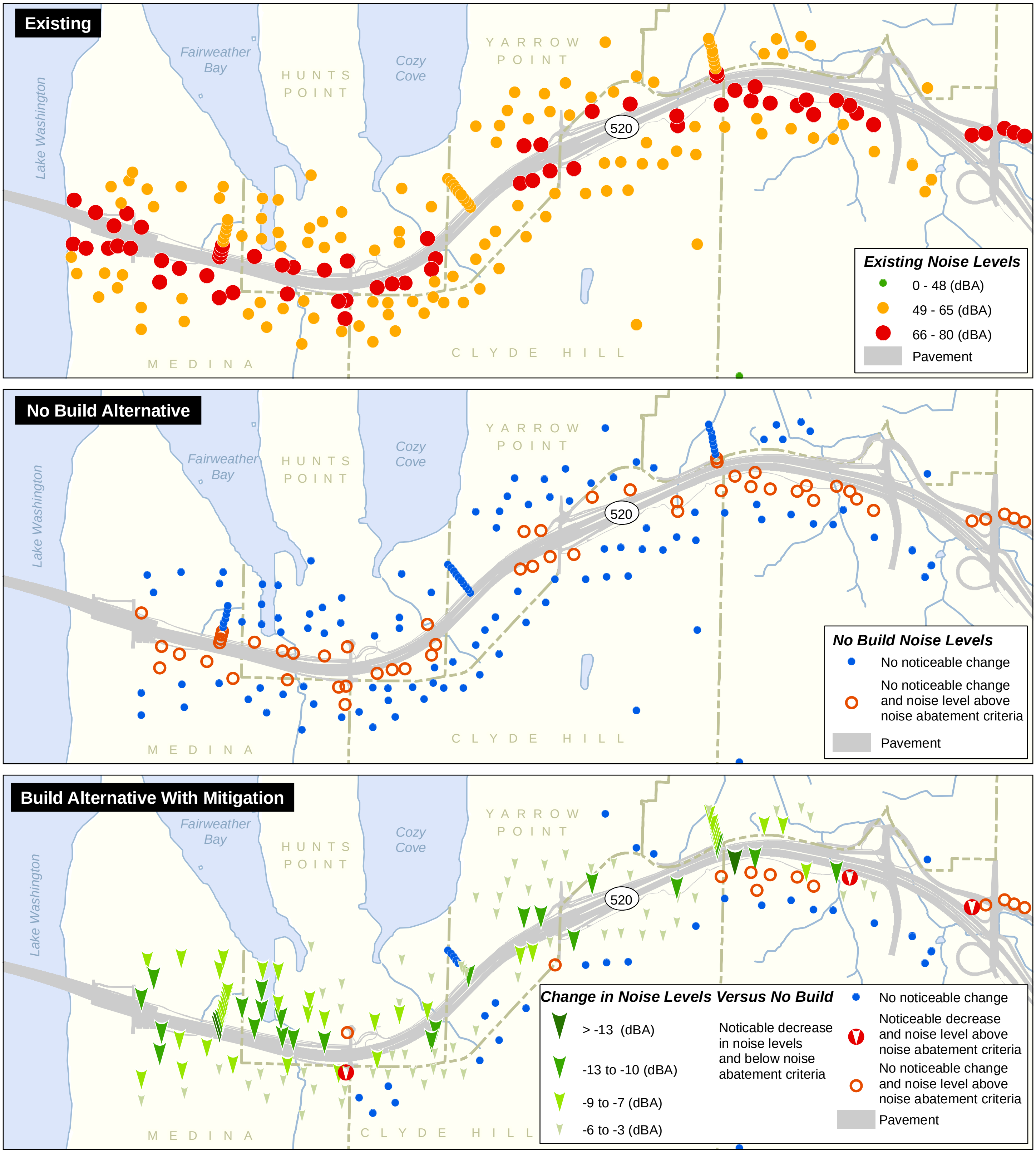

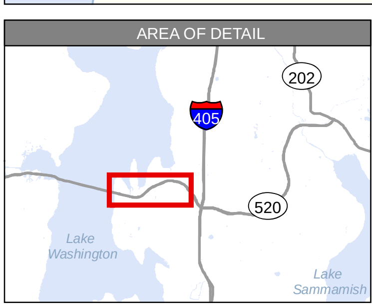

Source: King County (2007) GIS Data (Waterbody), City of Bellevue (1999) GIS Data (City Limits). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

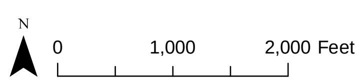

Exhibit 19. **Noise Levels Changes in the Study Area**

Medina to SR 202: Eastside Transit and HOV Project

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Exhibits 20 through 23 contain tabulated data for each receiver, showing the number of residential structures represented and the existing, No Build Alternative, and Build Alternative noise levels. Each study area neighborhood area is discussed below.

Medina and Hunts Point North of SR 520

The noise discipline team modeled peak-hour traffic noise levels for 35 receiver locations (representing 90 residences) in Medina and Hunts Point west of 84th Avenue NE and north of SR 520. Compared with existing conditions, no additional residences in this portion of the study area would have noise levels exceeding the NAC under the No Build Alternative.

Under the Build Alternative, 16 residences would have noise levels that exceed the NAC in this area. The noise reducing effect of the lids, depressed roadways, and roadway alignment would reduce traffic noise levels at 7 residences represented by PN-18, PN-25, and PN-27 to just below the NAC.

Exhibit 19 shows the noise level changes from existing noise levels under the No Build and Build Alternatives, including locations that are projected to exceed the NAC and where noise levels are projected to increase, remain the same, or decrease. Exhibit 20 provides the TNM modeling results and compares the Build Alternative to existing peak-hour traffic noise levels.

Readers familiar with the *SR 520 Bridge and HOV Replacement Project Draft Environmental Impact Statement* will notice that PN-1 through PN-3 and PN-5 through PN-9 are not included in this report. These are west of Evergreen Point Road and are addressed in the I-5 to Medina: Bridge Replacement and HOV Project.

Medina and Hunts Point North of SR 520

Number of Residences Where Noise Levels Would Exceed NAC

Existing	No Build	Build
23	23	16

Exhibit 20. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Medina and Hunts Point North of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PN-4	0	66	**70**	**71**	60
PN-10	4	66	59	60	56
PN-11	0	66	63	64	59
PN-12	4	66	57	58	56
PN-13	3	66	57	58	56
PN-14	4	66	56	57	55
PN-15	0	66	**80**	**80**	**76**
PN-16	2 [c]	66	**74**	**75**	**72**
PN-17	2 [c]	66	**72**	**72**	**70**
PN-18	3 [c]	66	**66**	**67**	65
PN-19	0	66	65	**66**	63
PN-20	0	66	64	64	62
PN-21	0	66	63	63	61

Exhibit 20. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Medina and Hunts Point North of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PN-22	0	66	61	62	59
PN-23	0	66	61	62	59
PN-24	0	66	60	61	58
PN-25	3	66	**67**	**67**	64
PN-26	2	66	**71**	**71**	**69**
PN-27	1	66	**69**	**69**	65
PN-28	6	66	**71**	**72**	**68**
PN-29	4	66	**67**	**68**	**67**
PN-30	6	66	60	61	60
PN-31	4	66	63	64	62
PN-32	3	66	63	64	62
PN-33	4	66	64	65	60
PN-34	4	66	62	63	59
PN-35	3	66	62	63	60
PN-36	4	66	61	62	58
PN-37	6	66	60	61	59
PN-38	4	66	58	59	58
PN-39	6	66	57	57	57
PN-40	4	66	60	61	57
PN-41	4	66	57	57	55
PN-42	4	66	57	57	54
PN-43	3	66	52	53	52

[a] All noise levels in the exhibit are L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout the exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Residential equivalents for park are represented by this receiver.
[d] Noise level includes noise reducing effects of the proposed lids.

Medina and Hunts Point South of SR 520

The noise discipline team modeled peak-hour traffic noise levels for 22 receiver locations (representing 75 residences) in Medina and Hunts Point west of 84th Avenue NE and south of SR 520. Compared with existing conditions, no additional residences in this portion of the study area would have noise levels exceeding the NAC under the No Build Alternative.

Under the Build Alternative, traffic noise level increases at receivers PS -11 (representing 3 residences) and PS-17 (4 residences) would cause these 7 residences to have noise levels that exceed the NAC. Traffic noise levels at PS-12 and P-14 (collectively representing 6 residences) would decrease causing these 6 residences to have noise levels that no longer exceed the NAC. Compared to existing conditions, the Build Alternative would result in 1 additional residence exceeding the NAC in this area.

Medina and Hunts Point South of SR 520

Number of Residences Where Noise Levels Would Exceed NAC		
Existing	**No Build**	**Build**
23	23	24

Exhibit 19 shows the noise level changes from existing noise levels under the No Build and Build Alternatives, including locations that are projected to exceed the NAC and where noise levels are projected to increase, remain the same, or decrease. Exhibit 21 provides the TNM modeling results and compares the Build Alternative to existing peak-hour traffic noise levels.

Readers familiar with the *SR 520 Bridge and HOV Replacement Project Draft Environmental Impact Statement* will notice that PS-1 through PS-5 and PS-26 are not included in this report. These are west of Evergreen Point Road and are addressed in the I-5 to Medina: Bridge Replacement and HOV Project.

Exhibit 21. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Medina and Hunts Point South of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PS-6	0	66	**71**	**72**	**72**
PS-7	1	66	**70**	**71**	**71**
PS-8	1	66	**71**	**71**	**71**
PS-9	4	66	**66**	**67**	**67**
PS-10	4	66	**68**	**69**	**71**
PS-11	3	66	64	65	**67**
PS-12	2	66	**67**	**68**	65
PS-13	3	66	**72**	**73**	**68**
PS-14	4	66	**66**	**68**	65
PS-15	4	66	60	61	61
PS-16	3	66	63	63	64
PS-17	4	66	64	65	**66**
PS-18	4	66	**66**	**66**	**66**
PS-19	3	66	64	64	64
PS-20	0	66	**66**	**67**	**66**
PS-27	4	66	59	59	59
PS-28	6	66	57	57	56

Exhibit 21. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Medina and Hunts Point South of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PS-29	6	66	59	59	59
PS-30	4	66	61	62	62
PS-31	5	66	59	59	59
PS-32	6	66	56	57	57
PS-33	4	66	63	65	62

[a] All noise levels in exhibit are L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout the exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Residential equivalents for park are represented by this receiver.
[d] Noise level includes noise reducing effects of the proposed lids.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520

The noise discipline team modeled peak-hour traffic noise levels for 49 receiver locations (representing 116 residences) in Hunts Point, Clyde Hill, Yarrow Point, and Kirkland east of 84th Avenue NE and north of SR 520. Currently, noise levels at 24 residences exceed the NAC. Under the No Build Alternative, noise levels at receivers PK-1 (representing 2 additional residences) and PK-38 (3 residences) would exceed the NAC, bringing the number of residences exceeding the NAC to 29.

Hunts Point, Clyde Hill, Yarrow Point and Kirkland, North of SR 520

Number of Residences Where Noise Levels Exceed NAC

Existing	No Build	Build
24	29	31

Under the Build Alternative, noise levels at the PK-1, PK-8, PK-19 and PK-21 (collectively representing 15 residences) would exceed the NAC. PK-37 (8 residences) would no longer exceed the NAC because of the proposed highway alignment. Under the Build Alternative, 7 additional residences would exceed the NAC compared to the existing conditions.

Exhibit 19 shows the noise level changes from existing noise levels under the No Build and Build Alternatives, including locations that are projected to exceed the NAC and where noise levels are projected to increase, remain the same, or decrease. Exhibit 22 provides the TNM modeling results and compares the Build Alternative with existing and No Build Alternative peak-hour traffic noise levels.

Exhibit 22. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PK-1	2	66	65	**66**	**66**
PK-2	0	66	64	65	**67**
PK-3	3	66	**68**	**69**	**70**
PK-4	3	66	61	62	64
PK-5	4	66	58	58	62
PK-6	5	66	54	54	57
PK-8	8 [c]	66	58	59	**67**
PK-9	3 [c]	66	56	57	65
PK-10	3 [c]	66	55	56	64
PK-11	0	66	54	55	63
PK-12	0	66	53	54	62
PK-13	0	66	52	53	61
PK-14	0	66	51	52	60
PK-15	0	66	50	51	60
PK-16	0	66	49	50	60
PK-17	3	66	**70**	**71**	**68**
PK-18	4	66	**68**	**69**	**74**
PK-19	2	66	60	61	**67**
PK-20	3	66	58	59	64
PK-21	3	66	60	61	**67**
PK-22	2	66	**67**	**68**	**70**
PK-23	3	66	62	63	64
PK-24	4	66	**66**	**67**	**66**
PK-25	3	66	55	56	59
PK-26	4	66	57	57	58
PK-27	0	66	57	58	58
PK-28	3	66	61	61	64
PK-29	0	66	61	62	59

Exhibit 22. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PK-30	0	66	54	55	55
PK-31	4	66	53	54	57
PK-32	0	66	49	50	55
PK-33	0	66	53	53	55
PK-34	0	66	51	52	53
PK-35	5	66	53	54	56
PK-36	0	66	**73**	**74**	**72**
PK-37	8 [c]	66	**67**	**68**	65
PK-38	3 [c]	66	65	**66**	64
PK-39	3 [c]	66	63	64	62
PK-40	0	66	62	62	60
PK-41	0	66	60	61	58
PK-42	0	66	59	60	58
PK-43	0	66	58	59	57
PK-44	0	66	58	59	57
PK-45	0	66	57	58	56
PK-46	4	66	62	63	59
PK-47	2	66	62	63	59
PK-48	4	66	60	61	58
PK-49	20	66	59	59	57
PK-50	6	66	59	60	57

[a] All noise levels in exhibit are L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Residential equivalents for park are represented by this receiver.
[d] Noise level includes noise reducing effects of the proposed lids.

Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520

Hunts Point, Clyde Hill, Yarrow Point and Bellevue, South of SR 520		
Number of Residences Where Noise Levels Exceed NAC		
Existing	**No Build**	**Build**
85	98	123

The noise discipline team modeled peak-hour traffic noise levels for 76 receiver locations (representing 263 residences) in Hunts Point, Clyde Hill, Yarrow Point, and Bellevue east of 84th Avenue NE and south of SR 520. Currently, 85 residences exceed the NAC. Under the No Build Alternative, noise levels at an additional 4 receivers (13 residences) would exceed the NAC, bringing the total number of residences exceeding the NAC to 98.

Under the Build Alternative, noise levels at an additional 12 receivers (38 residences) would exceed the NAC, bringing the total number of residences exceeding the NAC to 123.

Exhibit 19 shows the noise level changes from existing noise levels under the No Build and Build Alternatives, including locations that are projected to exceed the NAC, and where noise levels are projected to increase, remain the same, or decrease. Exhibit 23 provides the TNM modeling results and compares the Build Alternative with existing peak-hour traffic noise levels.

Receivers PB-18T through PB-22T represent areas along the Lake Washington Boulevard trail that extends along the south side of SR 520 between 96th Avenue NE (PB-18) and just west of the vicinity of 103rd Avenue NE.

Receivers PB-65 through PB-73 represent areas east of Bellevue Way NE. PB-65 represents the outdoor pool area at the La Quinta Hotel and PB-66/ PB-67 represent the two outdoor play areas at the Yarrow Bay KinderCare Day Care Center. The condominium homes in the northeast corner of 108th NE and Northup Way are represented by PB-68 through PB-70. PB-71 through PB-73 represent the condominium homes located off of Bellevue Way NE and NE 32nd Place. Receiver PB-16A was added to account for the four residences along NE 35th Place just north of PB-16. Receiver PB-23E was added to more closely evaluate the outdoor use at one of the residences represented by receiver PB-23.

Exhibit 23. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PB-1	2	66	**72**	**72**	**73**
PB-2	2	66	**69**	**70**	**76**
PB-3	2	66	**68**	**68**	**73**
PB-4	3	66	**69**	**70**	**70**
PB-5	3	66	**73**	**74**	**77**
PB-6	4	66	62	63	**66**
PB-7	2	66	62	63	**66**
PB-8	3	66	64	65	**68**
PB-9	3	66	**70**	**71**	**77**
PB-10	4	66	**66**	**67**	**73**
PB-11	3	66	**68**	**69**	**71**
PB-12	2	66	**68**	**69**	**67**
PB-13	3	66	60	61	**69**
PB-14	4	66	61	62	**67**
PB-15	4	66	65	**66**	**70**
PB-16	11 [c]	66	**66**	**67**	**69**
PB-16A	4	66	**71**	**72**	**74**
PB-17	4	66	65	**66**	**67**
PB-18	2	66	**71**	**71**	**73**
PB-18T	4 [c]	66	**73**	**74**	**76**
PB-19	2	66	**71**	**71**	**73**
PB-19T	4 [c]	66	**77**	**77**	**78**
PB-20	3	66	**69**	**70**	**71**
PB-21	0	66	**68**	**69**	**70**
PB-21T	4 [c]	66	**72**	**72**	**71**
PB-22	4	66	**67**	**68**	**68**
PB-22T	4 [c]	66	**72**	**72**	**73**
PB-23	3	66	**69**	**69**	**70**
PB-23E	1	66	**73**	**74**	**75**
PB-24	4	66	**67**	**68**	**68**
PB-28	4	66	61	62	63
PB-29	2	66	65	**66**	**66**

Exhibit 23. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PB-30	3	66	62	62	63
PB-31	4	66	62	63	64
PB-32	3	66	64	64	65
PB-33	3	66	62	**63**	64
PB-34	3	66	65	**66**	**67**
PB-35	3	66	64	65	**66**
PB-36	4	66	59	60	61
PB-37	3	66	60	60	62
PB-38	3	66	58	59	62
PB-39	4	66	59	60	64
PB-40	4	66	53	54	60
PB-41	4	66	54	55	61
PB-42	3	66	56	57	61
PB-43	3	66	64	65	**68**
PB-44	4	66	59	60	63
PB-45	3	66	60	60	62
PB-46	4	66	62	63	64
PB-47	3	66	62	63	63
PB-48	3	66	64	65	**66**
PB-49	3	66	62	63	64
PB-50	4	66	64	64	64
PB-51	4	66	60	61	60
PB-52	4	66	55	56	56
PB-53	4	66	54	55	55
PB-54	2	66	58	58	59
PB-55	2	66	62	63	64
PB-56	3	66	59	60	60
PB-57	3	66	64	65	64
PB-58	2	66	61	62	63
PB-59	4	66	58	59	59
PB-60	4	66	59	60	60
PB-61	6	66	59	60	61

Exhibit 23. **Build Alternative 2030 Peak-Hour Traffic Noise Levels for Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Receiver Number	Residential Structures	NAC	Existing[a,b]	No Build[a,b]	Build Alternative[b,d]
PB-62	4	66	51	52	53
PB-63	4	66	50	51	--[e]
PB-64	4	66	48	49	--[e]
PB-65	1	66	63	64	63
PB-66	2	66	71	72	69
PB-67	2	66	69	70	69
PB-68	2	66	68	69	69
PB-69	2	66	68	69	68
PB-70	2	66	67	68	67
PB-71	8	66	63	64	65
PB-72	6	66	62	62	63
PB-73	12	66	61	62	62

[a] All noise levels in exhibit are L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Residential equivalents for park are represented by this receiver.
[d] Noise level includes noise reducing effects of the proposed lids.
[e] TNM is not accurate for traffic noise projections past 500 feet.

Mitigation

What has been done to avoid or minimize negative effects from noise?

When project-related noise impacts are identified, traffic noise mitigation measures must be considered. Mitigation measures that meet applicable feasibility and reasonableness criteria must be recommended for inclusion into the project. Feasibility deals primarily with engineering considerations such as whether substantial noise level reductions can be achieved or whether there will be a negative effect on property access. Reasonableness is a cost benefit analysis based on predicted future noise levels.

Several different traffic noise abatement measures are evaluated whenever noise impacts are expected. Under WSDOT policy, the six abatement measures listed in FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 CFR 772, US Code of Federal Regulations, 1996 must be considered (the following list has been reordered from the original FHWA published list to correspond with the format of this report):

1. Traffic management measures (e.g., traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive land designations).
2. Highway Design Measures (e.g., alteration of horizontal/vertical alignments). Although not listed specifically in 23 CFR 772, the construction of highway lids are included in this category for this project.
3. Acquisition of property rights (either in fee or lesser interest) for construction of noise barriers.
4. Acquisition of real property or interests therein (predominantly unimproved property) to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise. This measure may be included in Type I projects only.
5. Noise insulation of public use or nonprofit institutional structures.
6. Construction of noise barriers (including landscaping for aesthetic purposes) whether within or outside the highway right-of-way. Interstate construction funds may not participate in landscaping.

Traffic Management Measures

Management measures include modifying speed limits, restricting or prohibiting truck traffic, or closing roadways or access ramps during times when noise could have an adverse effect.

Speed reduction can reduce noise levels from vehicles. However, this method is not seen as a potential mitigation or design option for this project as it would interfere with the project objectives. Furthermore, the slight noise reduction that would be achieved would not significantly reduce noise levels or noise impacts.

Restricting truck use or closing access ramps on the project would reduce noise levels at nearby receivers since trucks are louder than cars. However, this mitigation method could interfere with project objectives, and at this time is not considered a feasible form of mitigation for this project.

Highway Design Measures

Highway design measures include altering the roadway alignment and depressing roadway cut sections. Altering roadway alignment could decrease noise levels by moving the noise source farther from the affected receivers. Because of the limited right-of-way in the project corridor, and the fact that noise impacts are expected to occur along both sides of the project roadway, this method is not seen as a feasible noise-reducing design option. In addition, realigning the project roadway would lower noise levels for residences on one side of roadway, but would increase noise levels for residences on the other. Finally, the limited right-of-way within which the proposed Build Alternative alignment could be constructed is further evidenced by the fact that some residential structures would be displaced to make room for the new roadway.

The project includes other design elements that reduce noise levels. These include depressing (lowering) sections of the roadway and/or placing a lid over portions of the highway. Exhibit 24 illustrates how a depressed roadway reduces noise.

Each of the three lids evaluated for this project would be approximately 500 feet long over the highway, which is short enough to not require ventilation but long enough to help reconnect the communities along SR 520. The locations of the three lids are:

- Evergreen Point Road (with inside transit stop)
- 84th Avenue NE
- 92nd Avenue NE (with inside transit stop)

Although these lids were included in the Build Alternative as community enhancements, they are also very effective at preventing noise from reaching noise-sensitive receiver locations near the lidded area. Exhibit 25 shows an example of a depressed roadway with a lid and how the vehicle noise is contained.

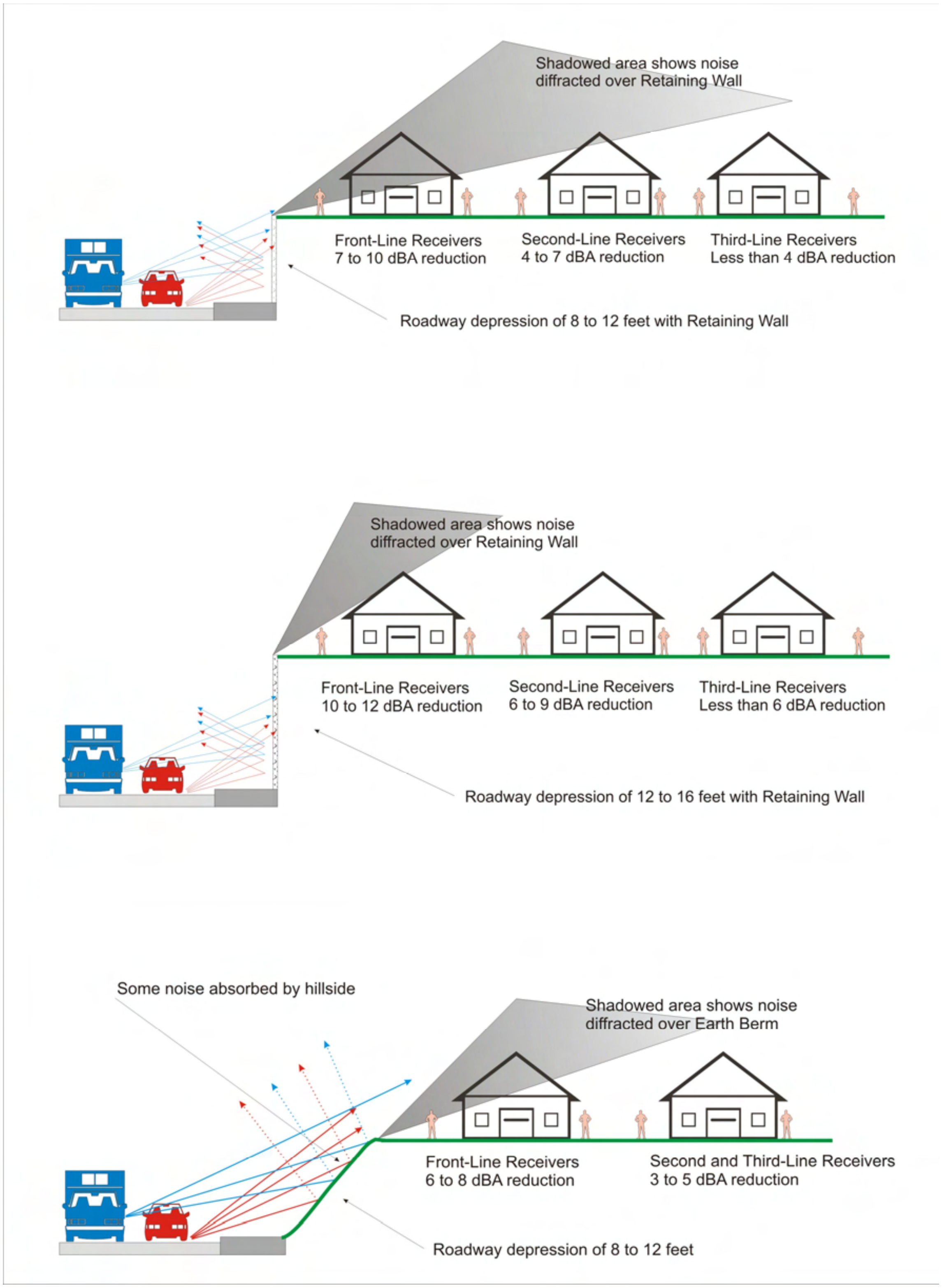


Exhibit 24. **Examples of Depressed Roadways and Typical Noise Reduction Characteristics**

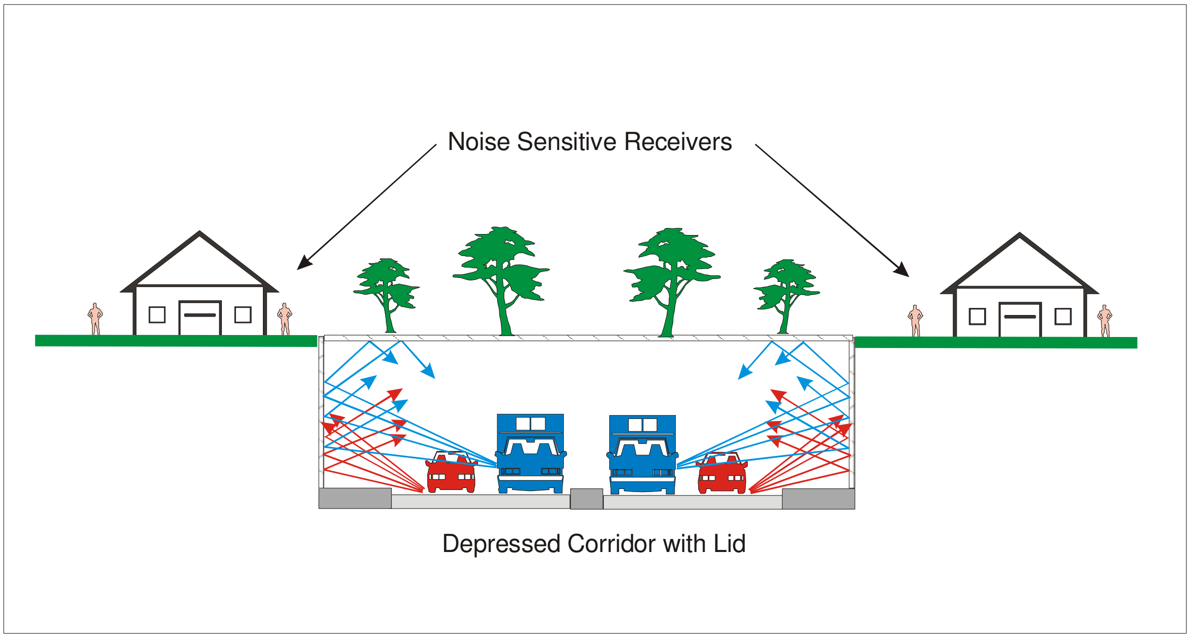


Exhibit 25. **Example of a Depressed Roadway with a Lid**

The Build Alternative includes lidded highway sections, which are very effective at reducing noise levels.

Acquisition of Property Rights for Construction of Noise Barriers

Depending on the final placement of any recommended noise barrier mitigation (berms or walls) additional property rights may be needed for the construction of the noise barriers. Under WSDOT policy, noise barriers are normally evaluated and constructed within WSDOT's rights of way. There may be cases in which department right of way is not the most prudent location for abatement, but abatement may be reasonable if constructed on adjacent property. WSDOT notes that in these cases:

- The department's mitigation cost reasonableness allowance is limited to normal cost for abatement on department right of way;
- The adjacent property owners allow access and easements as necessary to construct and maintain the abatement; and
- Any additional cost to acquire access, acquire property, provide alternative access, or provide additional infrastructure to accommodate access must be added to the barrier cost calculation and compared to the normal reasonableness cost allowance of the abatement to determine whether the proposed abatement is reasonable.

During final design, noise abatement recommendations may change due to design changes and actual right-of-way acquisitions.

Acquisition of Real Property to Serve as a Buffer Zone

In some instances, real property can be acquired to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise. FHWA limits this noise abatement measure to

Type I projects such as this project. Buffer zones are undeveloped, open spaces which border a highway. Buffer zones are created when a highway agency purchases land, or development rights, in addition to the normal right-of-way, so that future dwellings cannot be constructed close to the highway. This prevents the possibility of constructing dwellings which would otherwise experience an excessive noise level from nearby highway traffic. An additional benefit of buffer zones is improvement of the roadside appearance. However, because of the tremendous amount of land which must be purchased and because in many cases dwellings already border existing roads, creating buffer zones is often not possible. While Federal-aid highway funds may be used on a highway project to create buffer zones, this measure has not been used very often.

Within this project area, the majority of the undeveloped, open spaces which border the proposed alignment have been designated park lands or nature preserves. These park lands have been identified as a noise sensitive land use for this project and are restricted from residential development. No other open spaces within the project area that are large enough to be construed as possible buffers zones exist at this time.

Noise Insulation (public use or nonprofit institutional structures)

Architectural treatment for noise mitigation may be used for public or non-profit institutional buildings such as schools, churches or libraries. Building-retrofits are considered on a case-by-case basis and determined during the final design stage. Some possible mitigation measures to reduce interior noise levels below the impact criteria are described below.

Ventilation Systems

In public buildings where windows are used for ventilation, noise impacts may occur. Closing the windows is often sufficient to reduce interior noise levels below the impact level. To re-establish the ventilation provided by the windows, ventilation systems are needed. A forced air ventilation system can re-establish proper air circulation while providing effective noise mitigation. The air intakes should be on the north side of the building or in the same proximity as the windows. Air intakes on the roof or on the south side of the building may take in abnormally hot air and should be avoided.

Storm Windows

The installation of storm windows is often coupled with a ventilation system to provide increased noise reduction. Storm windows also reduce winter heat losses. The money saved in heating should offset any operation or maintenance costs associated with the ventilation system.

Air Conditioning

Air conditioning systems may be used in place of ventilation systems when they can be installed at the same or lower cost.

Some air conditioners, however, generate their own noise levels and may negate the traffic noise reductions. Ventilation systems can also be designed so the school or non-profit institution can add air conditioning at a later date.

Construction of Noise Barriers

Construction of noise barriers between the roadways and the affected receivers would reduce noise levels by physically blocking the transmission of traffic-generated noise. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls, and are usually constructed with a 3-to-1 slope. Earthen berms would not be a feasible form of noise abatement due to the limited amount of right-of-way available for noise barrier construction. Noise barriers should be high enough to break the line-of-sight between the noise source and the receiver. They must also be long enough to prevent significant flanking of noise around the ends of the walls.

Noise barriers and how they work are described below.

Noise Barriers and How They Work

The noise discipline team determined the height and location of the noise walls by modeling noise walls at various locations and heights. To be effective, noise walls need to be constructed to a height higher than required to break the line of sight between the highway and the receiver. Noise walls also need to be long enough to prevent flanking of noise around the ends of the walls. Openings in noise walls noise walls (for example, at driveways, bridges, and side streets) allow noise to pass through the openings, usually limiting the achievable noise level reduction to less than 3 dBA for receivers near the openings.

Other design considerations that can affect the overall effectiveness of noise walls include horizontal placement, the general topography between the receivers and the roadway, and the elevation relationship (e.g., relative height differences) between the receiver, noise wall, and roadway. In general, noise walls are most effective if they are placed as close as possible to either the noise source or the receiver locations. In addition, if sensitive receivers are located above the roadway grade, the overall effectiveness of the noise wall can be considerably reduced unless it is placed at the same elevation as the receiver. Noise walls have the greatest noise-reducing effect for receivers located close to the roadway.

As shown in Exhibit 26, noise walls reduce traffic noise either by directly absorbing it, reflecting it back across the highway, or dispersing or diffracting it upward. Reflected noise is the noise that moves back toward the traffic after hitting the noise wall. Some noise will be diffracted over the wall, while a small amount of noise will either be transmitted through, or absorbed by, the wall.

There are three zones that can reduce the effectiveness of a noise wall. The *bright zone* is the area above the wall with a direct line of sight to the noise source. The bright zone contains noise directly transmitted from the noise source. The other two zones are the *transmission zone* and the *shadow zone*. The transmission zone contains some noise that is directly transmitted by the noise source, along with some noise that is diffracted over the wall. The shadow zone is primarily all diffracted noise.

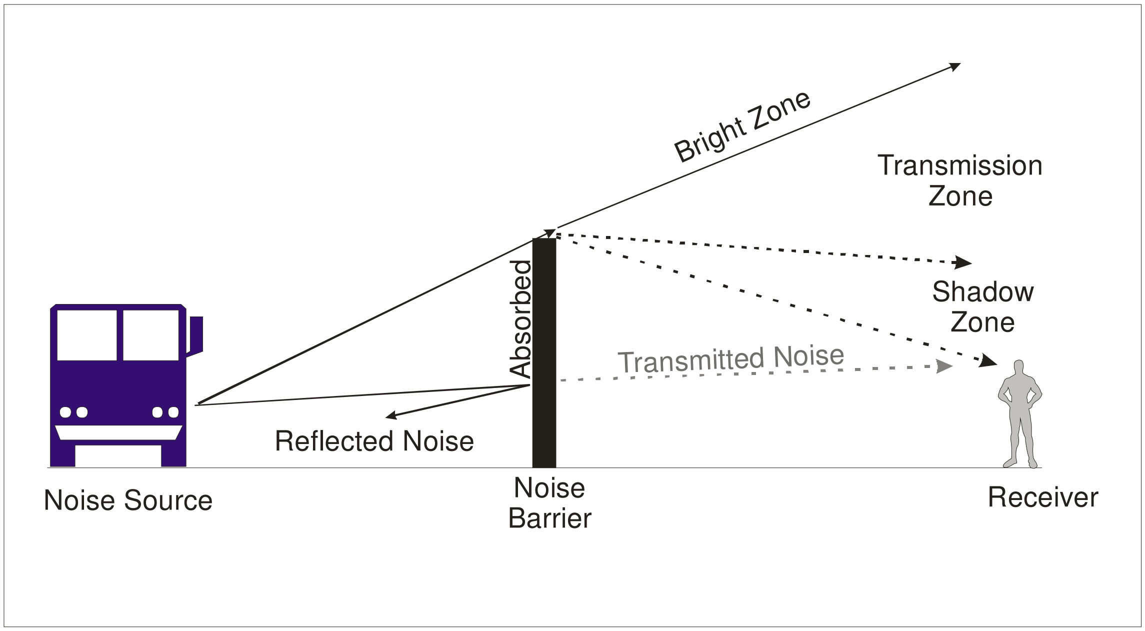


Exhibit 26. **Noise Wall Absorption, Transmission, Reflection, and Diffraction**
(Source: Adapted from *Noise Barrier Design Handbook* [USDOT 2000])

Two factors to consider when determining a noise wall's height are design feasibility and construction costs. There is a point of diminishing returns, where the additional height of a noise wall is vastly more expensive to construct while providing very little additional noise reduction.

Other factors, such as construction considerations and safety and potential noise wall reflections, are also considered when determining if a noise wall is feasible. If a noise wall is safe, feasible, and meets the WSDOT cost-effectiveness criteria (explained below), it is typically recommended for construction with the project.

WSDOT Noise Wall Feasibility and Reasonableness (Cost) Criteria

WSDOT requires that every reasonable effort be made to attain a 10-dBA (or greater) noise reduction at the first row of receivers (e.g., front-line receivers). For a noise wall to be considered a feasible form of mitigation by WSDOT, the following feasibility criteria must be met:

1. The proposed mitigation must be physically constructible,
2. A majority of the first row ground floor receivers must achieve a 5-dBA noise reduction as a result of mitigation, assuring the every reasonable effort will be made to assess ground floor use areas as appropriate, and
3. At least one receiver must have at least a 7-dBA reduction.

For most projects, noise wall construction is considered feasible if a 7-dBA noise reduction can be achieved for ground floor residences. Mitigation from noise walls is not considered for upper floors, such as second floors of single-family residences.

WSDOT has established cost-effectiveness criteria to ensure that if a noise wall is recommended, its cost is consistent with the level of reduction and is not excessive. When the construction of a noise wall has been determined feasible, WSDOT will determine whether its construction is reasonable by thoroughly considering a wide range of criteria. It is important to note that noise walls would be constructed only if WSDOT determines that they are reasonable. This decision is normally the responsibility of WSDOT and FHWA, with concurrence from design personnel. Reasonableness is based on the following factors:

1. The noise mitigation cost per residence (or residential equivalent) does not exceed the amounts indicated in Exhibit 27. This amount is determined by counting all residences (including owner-occupied, rental units, mobile homes, and residential equivalents as defined by WSDOT) that receive at least a 3-dBA noise reduction from the noise wall, and then dividing that number into the total cost of the noise abatement measure. Each benefited unit in a multifamily building is counted as a separate residence. In addition, areas such as parks and schools are counted based on the WSDOT residential equivalent calculations. The criteria used for the residential equivalency for this analysis were determined using a draft method provided by WSDOT. See the *Potential Effects of Project* section for more details on residential equivalents. Exhibit 28 shows that as the predicted future noise level increases, it is considered reasonable to implement more costly measures, as necessary, to mitigate traffic noise.
2. Consideration of aesthetic barrier treatments, artwork, revegetation, and any increased cost of alternative barrier construction materials with transmission losses lower than 20 dB per frequency range shall not be included in the noise mitigation reasonableness cost calculations for long-term noise mitigation. Decisions on aesthetic treatments, revegetation and barrier material choice is based on applicable department practices and funding availability.

Determining Noise Wall Locations and Heights

The following section provides the details on the proposed noise walls, including graphic illustrations of typical situations for receivers located at-grade, below-grade, and above-grade, and how the noise walls' overall noise reduction characteristics are affected by area topography. Also shown are detailed drawings of an aerial view of the project corridor and locations of the noise walls.

Residents in the SR 520 project corridor are either at-grade with SR 520, below the grade of SR 520, or above the grade of SR 520. The heights of noise walls would be significantly influenced by this geometry.

Noise Walls for At-Grade Receivers

Noise walls would be a very effective mitigation method for receivers located at a similar grade to the project corridor, such as near the Evergreen Point Road. The noise walls would be placed close to the roadway within the project corridor and have little room for horizontal movement because of limited right of way. Noise wall heights for locations such as these would be 10 to 14 feet high. Noise walls of this height are normal for major highways with light to moderate levels of heavy truck traffic (such as SR 520) where receivers are at approximately the same grade as the roadway. Exhibit 28 shows a typical schematic of noise wall placement and relative effectiveness for receivers located at grade for different distances from the project roadway.

Exhibit 27. **Cost Allowance for Effects Caused by Total Traffic Noise Levels**

Design Year Traffic Noise Level	Noise Level Increase as a Result of the Project [a]	Allowed Cost per Qualified Residence or Residential Equivalent[b]	Allowed Wall Surface Area per Qualified Residence or Residential Equivalent
66 dBA		$37,380	700 sq. feet (65.0 sq. meters)
67 dBA		$41,110	770 sq. feet (71.5 sq. meters)
68 dBA		$44,640	836 sq. feet (77.7 sq. meters)
69 dBA		$48,270	904 sq. feet (84.0 sq. meters)
70 dBA		$51,900	972 sq. feet (90.3 sq. meters)
71 dBA	10 (substantial, tier 1) [c]	$55,530	1,040 sq. feet (96.6 sq. meters)
72 dBA	11 (substantial, tier 1)	$59,160	1,108 sq. feet (103.0 sq. meters)
73 dBA	12 (substantial, tier 1)	$62,790	1,176 sq. feet (109.2 sq. meters)
74 dBA	13 (substantial, tier 1)	$66,420	1,244 sq. feet (115.6 sq. meters)
75 dBA	14 (substantial, tier 1)	$70,060	1,312 sq. feet (121.9 sq. meters)
76 dBA [d]	15 (substantial, tier 2) [e]	$73,690	1,380 sq. feet (128.2 sq. meters)

[a] If noise level increase as the result of the project is 10 dBA or more, follow the allowed wall surface area and cost for the level of increase in lieu of the total design year traffic noise level. For total highway-related noise levels at 76 dBA or more or project results in an increase of 15 or more decibels, continue increasing the allowance at the rate provided in the exhibit unless circumstances determined on a case-by-case basis require an alternative methodology for determining allowance.
[b] Costs shown are for 2006 and are re-evaluated each year using current construction costs. Based on $53.43 per square foot construction cost.

[c] Tier 1 is when the noise levels are 10 to 14 dBA over existing traffic noise as a result of the transportation project.

[d] If traffic-related noise level is 80 dBA or more or there is an increase of traffic-related noise of 30 dBA or more over existing traffic noise levels as a result of a proposed transportation project, then the effects are considered severe. Additional consideration for mitigation may be considered under these circumstances.

[e] Tier 2 is when the noise levels are 15 dBA or more over existing traffic noise as a result of the transportation project (or total highway-related noise levels are between 76 and 79 decibels). Additional consideration for mitigation may be considered under these circumstances.

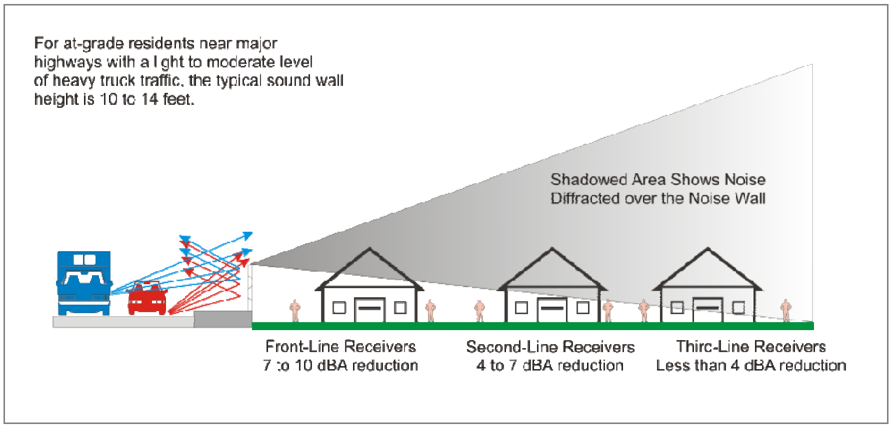


Exhibit 28. **Typical Noise Wall Effectiveness with At-Grade Receiver**

Noise Walls with Below-Grade Receivers

The overall effectiveness of a noise wall is normally increased for locations where receivers are located below the highway elevation (such as the north side of SR 520 near Yarrow Bay Wetlands Park). Because the receivers are located below the elevation of the highway, less of the noise diffracted over the top of the noise wall reaches the receivers. In most cases, the noise wall height would be lower and still provide the same level of noise reduction, as shown for receivers located at the same level as the roadway. Typical noise wall heights for below-grade receivers are 2 to 4 feet less than for at-grade receivers. The actual height of the noise wall would again depend on wall placement, distance to the receiver, and vehicle mix. Exhibit 29 provides a typical schematic of noise wall heights and relative effectiveness for receivers located below the road grade.

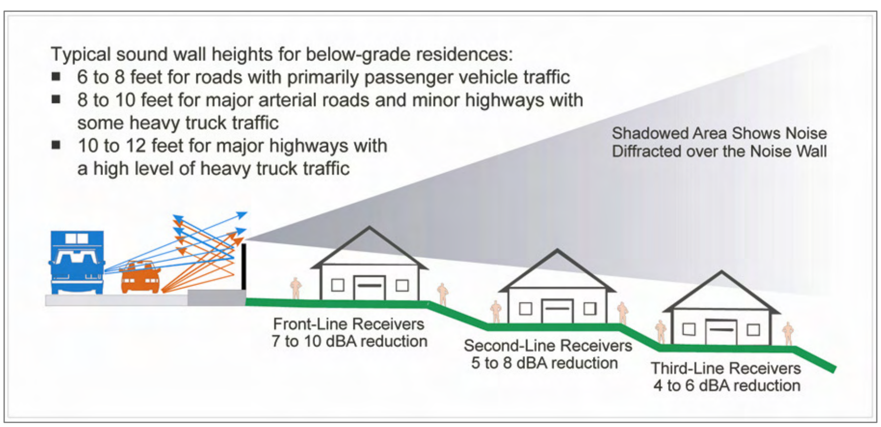


Exhibit 29. **Typical Noise Wall Effectiveness with Below-Grade Receiver**

Noise Wall with Above-Grade Receivers

Noise walls are normally less effective at reducing transportation noise at locations where receivers are elevated above the roadway (such as the residential neighborhood off 102nd Ave NE south of SR 520 near Bellevue Way NE) because the receivers are closer to noise that is diffracted over the top of the noise wall. Increasing the height of the noise wall can, in some circumstances, result in noise reductions of the same magnitude that would be achieved for at-grade receivers. The overall effectiveness would depend on the level of elevation over the roadway, vehicle mixture, noise wall placement, and other geometric considerations. Again, because of the limited right of way in the project corridor, changing the horizontal placement of the noise wall is not an option in most cases; therefore, noise walls of 18 to 20 feet and higher are being considered in certain sections of the corridor.

Exhibit 30 shows a typical schematic of noise wall heights and relative effectiveness for receivers located above the road grade.

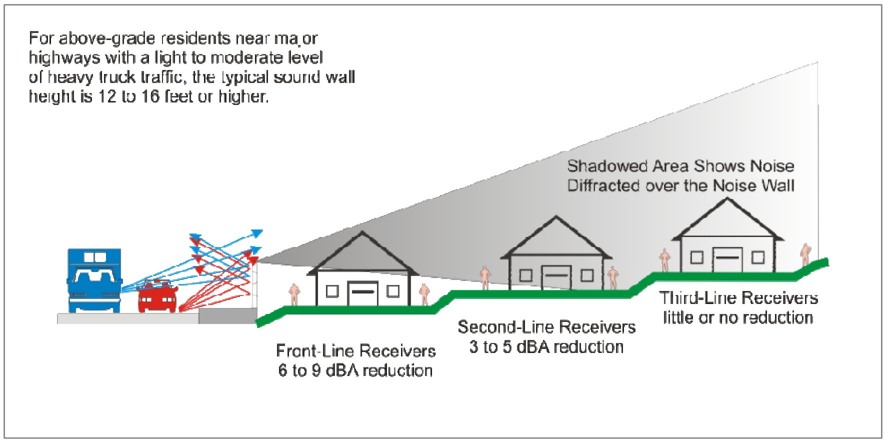


Exhibit 30. **Typical Noise Wall Effectiveness with Above-Grade Receiver**

What noise walls are proposed for the Build Alternative?

Noise walls are proposed for the Build Alternative from Evergreen Point Road to just west of Bellevue Way NE. The area between Bellevue Way and just west of 108th Avenue NE was considered for noise mitigation but none of the noise walls evaluated meet both the feasibility and reasonableness criteria required by WSDOT.

Along the north side of SR-520, the recommended noise walls would be virtually continuous through the entire area except for breaks at 84th Avenue NE and 92nd Avenue NE, where the noise walls would be integrated with the lids. Along the south side, the recommended noise walls are also essentially continuous except near the homes in the residential area along NE 34th Place and NE 34th Street (PB-18 through PB-22) that are elevated 50 to 140 feet above the project roadways. Several noise walls were evaluated for this area, including:

1. A noise wall on the hillside at 18 to 22 feet was not considered feasible due to the steep hillside and added cost to shore up the hillside to support a noise wall.

2. A noise wall along the southern edge of the pavement with heights varying from 32 to 34 feet was evaluated. The wall would reduce traffic noise levels by a maximum of 6 dBA at one residence, with the other residences in the area receiving noise reductions ranging from 2 to 4 dBA, which would not meet WSDOT's feasibility criteria. Further, due to the added cost of constructing a wall of this height, the wall would not meet WSDOT's reasonableness criteria. With subsequent project design changes that added the requirement of a detention pond in this area, two variations of this wall were also considered. The first variation considered a wall

along the south boundary of the retention pond. However, the altered wall footprint resulted in less favorable noise level reductions despite raising the heights above 34 feet, which again failed to meet WSDOT's feasibility and reasonableness criteria. The second variation considered a wall along the center of the highway which would mitigate traffic noise levels from only the westbound lanes of SR 520. The traffic noise level reductions that would be achieved by this design would be minimal resulting in a failure to meet WSDOT's feasibility criteria.

3. The final noise wall considered for this area focused on mitigating only the traffic noise along the Lake Washington Boulevard trail that extends along the south side of SR 520 between 96th Avenue NE (PB-20) and the noise wall evaluated in the vicinity of 103rd Ave NE. Although fewer traffic noise impacts would be mitigated, a noise wall with lower heights varying between 10 and 12 feet would meet WSDOT's feasibility and reasonableness criteria for the trail.

The overall project corridor noise walls would be approximately 18,000 feet long with heights varying from 8 feet to 20 feet. The taller noise walls would be necessary in areas where residents are located uphill from the project corridor. Exhibit 31 shows the locations and heights of the proposed noise walls. The heights shown on Exhibit 31 are for the height of the noise wall above any retaining walls, where applicable, or above the highest ground elevation near SR 520.

To illustrate how effective the noise walls would be at reducing traffic noise levels under the Build Alternative, noise levels with and without the proposed noise walls are shown. Because the Build Alternative includes construction of noise walls in the analysis, the number of residences experiencing traffic noise effects under this alternative would be reduced compared with existing conditions.

The Build Alternative would meet noise abatement objectives of:

- Reducing the overall noise levels in the community;
- Where possible, reducing the noise levels at all residences to below the NAC of 66 dBA L_{eq}; and
- Where possible, providing an average 7 to 10 dBA L_{eq} noise reduction for front-line receivers adjacent to SR 520.

As described earlier in this report, it takes an approximately 3 dBA change in noise for an average person to notice a difference in sound levels. The 3 dBA is a useful metric for noticeable change when comparing existing and future noise levels. When considering how effective a noise wall is at reducing noise levels, it is helpful to keep in mind that decreases of 5 dBA or more are clearly noticeable and reductions of 10 dBA are judged by most people to reduce noise to a level considered half as loud.

Adjustments in the top-of-wall elevations could be necessary during the project’s final design phase to ensure acceptable noise wall performance.

Brief descriptions of the noise walls on the north side and the south side are provided below.

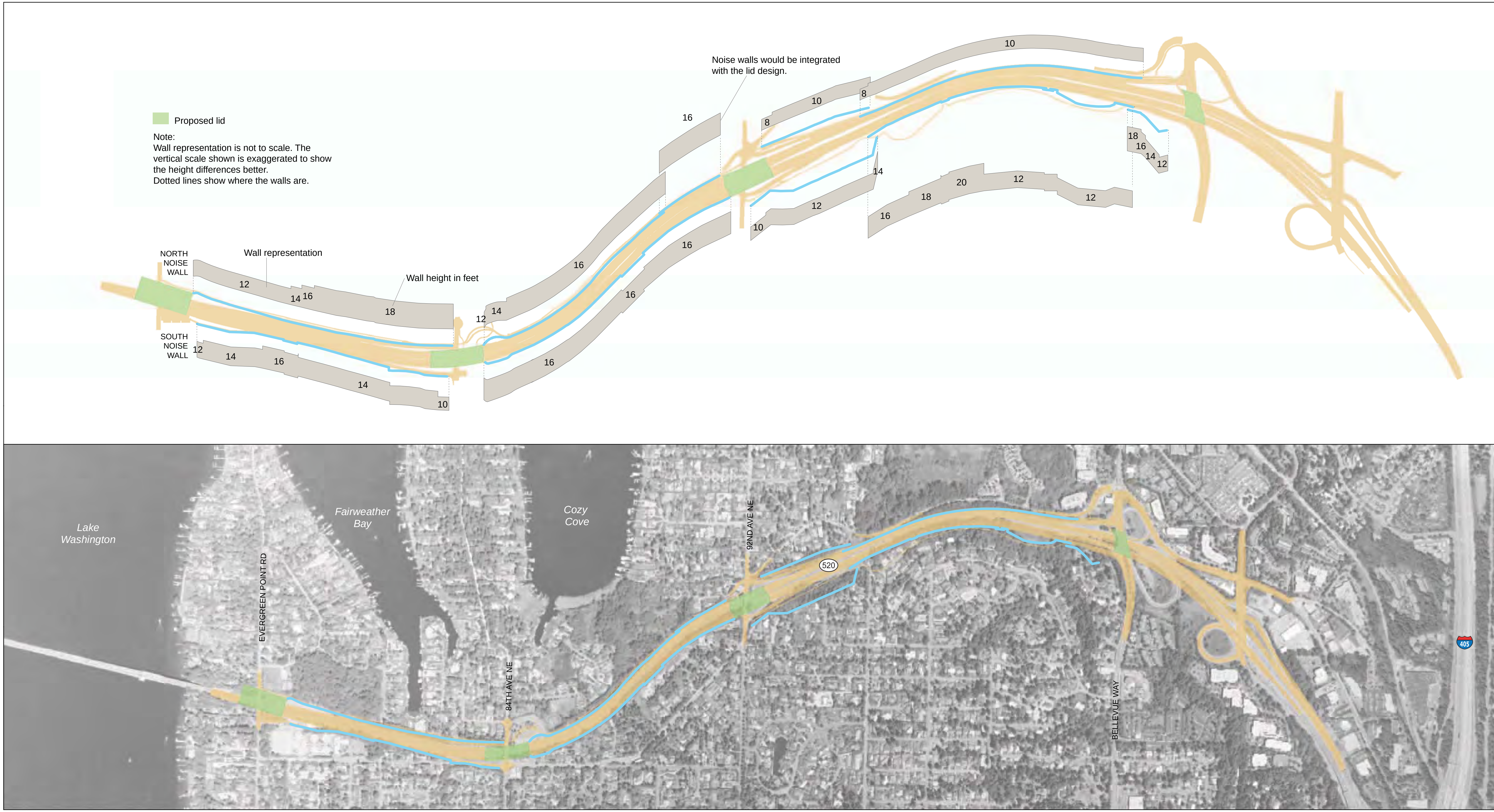
On the north side of the highway, from Evergreen Point Road to 108th Avenue NE, the noise wall heights would vary as described below.

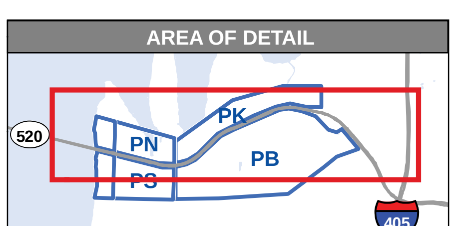
The noise wall height would be 12 feet at Evergreen Point Road, increasing to 14 feet and then 16 feet near the eastern boundary of Fairweather Park. At 80th Avenue NE (PN-25), the noise wall would increase to 18 feet and continue at that height until connecting with the 84th Avenue NE lid. From the east side of the 84th Avenue NE lid to the 92nd Avenue NE lid, the noise wall height would start at 12 feet and within the first 150 feet step up to 16 feet and remain at that height until connecting with the 92nd Avenue NE lid. From the east side of the 92nd Avenue NE lid to 96th Avenue NE (PK-20), the noise wall height would start at 8 feet and within the first 50 feet step up to 10 feet and remain at 10 feet as it extends along the north side of the westbound SR 520 off-ramp to 92nd Avenue NE. From 96th Avenue NE (PK-20) to approximately 400 feet west of Bellevue Way NE the noise wall would be 10 feet high.

On the south side of the highway, from Evergreen Point Road to 108th Avenue NE, the wall heights would be constructed as described below.

The noise wall height would start at 12 feet at the Evergreen Point Road lid and step up to 14 feet and then 16 feet at PS-8. The noise wall height would remain at 16 feet until reaching a point near PS-9, where it would step down to 14 feet high. The wall would remain at 14 feet until the last 130 feet of wall length, where it would taper down to 10 feet and terminate at the end of the off-ramp.

From the east side of the 84th Avenue NE lid to the west side of the 92nd Avenue NE lid the wall would be 16 feet high. On the east side of the 92nd Avenue NE lid, the first noise wall segment would run along the SR 520 right of way line, which is above the 92nd Avenue to SR 520 eastbound on-ramp. This wall segment would start at 10 feet high and step up to 12 feet and remain at that height until it begins to overlap the next wall segment at which point it would step up to 14 feet in the last 150-foot section.





Noise Wall

Lid

Pavement

N

0 500 1,000 2,000 Feet

Source: King County (2008) GIS Data (Streams, Streets, Water Bodies), CH2M HILL (2008) GIS Data (Parks). Horizontal datum for all layers is NAD83(91), vertical datum for layers is NAVD88.

Exhibit 31. **Noise Wall Locations and Heights for the Build Alternative**

Medina to SR 202: Eastside Transit and HOV Project

\\SIMBA\PROJ\PARAMETRIX\180171\GRAPHICS\x_EA_Eastside\NOI\EA_TM_Ex31_NOI_NOISEWALLS_FINAL_12apr10

The next wall segment would be constructed along the SR 520 shoulder and start at a height of 16 feet and rise to 18 feet at 96th Avenue NE (PB-16A). The wall would remain at 18 feet for 306 feet of wall length, at which point it would step up to 20 feet. The wall height would remain at 20 feet for 402 feet (near the cul-de-sac at the end of NE 35th Street) and then step down to 12 feet and remain at that height until overlapping with the last wall segment just west of 103rd Place NE as described below.

The last wall segment would begin just west of 103rd Place NE, run east along the new SR 520 right of way, and end after wrapping around the east side of 103rd Avenue. This wall segment height would be 18 feet from the west end and, near the midpoint of the wall length, step down to 16 feet, then to 14 feet and to 12 feet near its eastern end point.

Exhibits 32 through 36 summarize information about the proposed noise walls for Build Alternative. For the purpose of evaluating the noise walls under WSDOT cost criteria, the noise walls for each neighborhood were considered independently. With the exception of minor breaks and overlaps for highway on and off ramps or trails, each neighborhood noise wall is essentially one continuous wall for the purposes of assessing its cost effectiveness under the WSDOT cost criteria. The noise level reduction performance and the available capital under WSDOT criteria for mitigation are provided for each noise wall system.

Exhibit 32. **Noise Wall Performance Summary for Medina and Hunts Point North of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
PN-4	60	58	2	0	$0
PN-10	56	52	4	4	$149,520
PN-11	59	52	7	0	$0
PN-12	56	50	6	4	$149,520
PN-13	56	50	6	3	$112,140
PN-14	55	49	6	4	$149,520
PN-15	**76**	62	14	0	$0
PN-16	**72**	61	11	2 [d]	$118,320
PN-17	**70**	60	10	2 [d]	$103,800
PN-18	65	58	7	3 [d]	$112,140
PN-19	63	57	6	0	$0
PN-20	62	56	6	0	$0
PN-21	61	55	6	0	$0
PN-22	59	53	6	0	$0
PN-23	59	53	6	0	$0
PN-24	58	52	6	0	$0
PN-25	64	57	7	3	$112,140
PN-26	**69**	59	10	2	$96,540
PN-27	65	58	7	1	$37,380
PN-28	**68**	60	8	6	$267,840
PN-29	**67**	**66**	1	0	$0

Exhibit 32. **Noise Wall Performance Summary for Medina and Hunts Point North of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
PN-30	60	57	3	6	$224,280
PN-31	62	56	6	4	$149,520
PN-32	62	55	7	3	$112,140
PN-33	60	55	5	4	$149,520
PN-34	59	53	6	4	$149,520
PN-35	60	53	7	3	$112,140
PN-36	58	53	5	4	$149,520
PN-37	59	53	6	6	$224,280
PN-38	58	53	5	4	$149,520
PN-39	57	53	4	6	$224,280
PN-40	57	51	6	4	$149,520
PN-41	55	49	6	4	$149,520
PN-42	54	50	4	4	$149,520
PN-43	52	48	4	3	$112,140
		Total Available for Noise Mitigation			$3,614,280

[a] All noise levels in the exhibit are stated as L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Available mitigation capital from WSDOT criteria for cost evaluation.
[d] Includes residential equivalents for the park area, Points Loop Trail, and/or SR 520 bike and pedestrian path represented by this receiver.

Exhibit 33. **Noise Wall Performance Summary for Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
PK-1	**66**	59	7	2	$74,760
PK-2	**67**	58	9	0	$0
PK-3	**70**	60	10	3	$155,700
PK-4	64	57	7	3	$112,140
PK-5	62	54	8	4	$149,520
PK-6	57	51	6	5	$186,900
PK-8	**67**	48	19	8 d	$328,880
PK-9	65	54	11	3 d	$112,140
PK-10	64	53	11	3 d	$112,140
PK-11	63	52	11	0	$0
PK-12	62	52	10	0	$0
PK-13	61	51	10	0	$0
PK-14	60	51	9	0	$0
PK-15	60	51	9	0	$0
PK-16	60	51	9	0	$0
PK-17	**68**	59	9	3	$133,920

Exhibit 33. **Noise Wall Performance Summary for Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
PK-18	**74**	63	11	4	$265,680
PK-19	**67**	62	5	2	$82,220
PK-20	64	59	5	3	$112,140
PK-21	**67**	57	10	3	$123,330
PK-22	**70**	57	13	2	$103,800
PK-23	64	58	6	3	$112,140
PK-24	**66**	56	10	4	$149,520
PK-25	59	52	7	3	$112,140
PK-26	58	52	6	4	$149,520
PK-27	58	54	4	4	$149,520
PK-28	64	55	9	3	$112,140
PK-29	59	56	3	3	$112,140
PK-30	55	52	3	4	$149,520
PK-31	57	50	7	4	$149,520
PK-32	55	46	9	3	$112,140
PK-33	55	50	5	3	$112,140
PK-34	53	49	4	3	$112,140
PK-35	56	52	4	5	$186,900
PK-36	**72**	61	11	0	$0
PK-37	65	58	7	8 d	$299,040
PK-38	64	58	6	3 d	$112,140
PK-39	62	56	6	3 d	$112,140
PK-40	60	55	5	0	$0
PK-41	58	54	4	0	$0
PK-42	58	53	5	0	$0
PK-43	57	53	4	0	$0
PK-44	57	52	5	0	$0
PK-45	56	52	4	0	$0
PK-46	59	55	4	4	$149,520
PK-47	59	55	4	2	$74,760
PK-48	58	55	3	4	$149,520
PK-49	57	54	3	20	$747,600
PK-50	57	54	3	6	$224,280
			Total Available for Noise Mitigation		$5,641,750

[a] All noise levels in the exhibit are stated as L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Available mitigation capital from WSDOT criteria for cost evaluation.
[d] Includes residential equivalents for the park area, Points Loop Trail, and/or SR 520 bike and pedestrian path represented by this receiver.

Exhibit 34. **Noise Wall Performance Summary for Medina and Hunts Point South of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
PS-6	**72**	61	11	0	$0
PS-7	**71**	62	9	1	$55,530
PS-8	**71**	62	9	1	$55,530
PS-9	**67**	60	7	4	$164,440
PS-10	**71**	61	10	4	$222,120
PS-11	**67**	59	8	3	$123,330
PS-12	65	59	6	2	$74,760
PS-13	**68**	**67**	1	0	$0
PS-14	65	65	0	0	$0
PS-15	61	55	6	4	$149,520
PS-16	64	57	7	3	$112,140
PS-17	**66**	59	7	4	$149,520
PS-18	**66**	60	6	4	$149,520
PS-19	64	56	8	3	$112,140
PS-20	**66**	57	9	0	$0
PS-27	59	52	7	4	$149,520
PS-28	56	52	4	6	$224,280
PS-29	59	54	5	6	$224,280
PS-30	62	56	6	4	$149,520
PS-31	59	53	6	5	$186,900
PS-32	57	52	5	6	$224,280
PS-33	62	61	1	0	$0
			Total Available for Noise Mitigation		$2,527,330

[a] All noise levels in the exhibit are stated as L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Available mitigation capital from WSDOT criteria for cost evaluation.
[d] Includes residential equivalents for the park area, Points Loop Trail, and/or SR 520 bike and pedestrian path represented by this receiver.

Four noise walls that collectively extend along the neighborhoods south of SR 520 between 84th Avenue NE and Bellevue Way NE were evaluated. Three additional walls were evaluated east of Bellevue Way NE. Each of the seven walls is noted in Exhibit 35. Under each noise wall description, the receivers that represent those homes that would benefit from the particular noise wall are listed.

Exhibit 35. **Noise Wall Performance Summary for Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
		84th Avenue NE to 92nd Avenue NE			
PB-1	**73**	63	10	2	$125,580
PB-2	**76**	64	12	2	$132,840
PB-3	**73**	62	11	2	$125,580
PB-4	**70**	60	10	3	$155,700
PB-5	**77**	61	16	3	$199,260
PB-6	**66**	61	5	4	$149,520
PB-7	**66**	62	4	2	$74,760
PB-8	**68**	61	7	3	$133,920
PB-9	**77**	62	15	3	$199,260
PB-10	**73**	60	13	4	$251,160
PB-11	**71**	65	6	3	$166,590
PB-43	**68**	**67**	1	0	$0
PB-44	63	60	3	4	$149,520
PB-45	62	59	3	3	$112,140
PB-46	64	60	4	4	$149,520
PB-47	63	58	5	3	$112,140
PB-48	**66**	60	6	3	$112,140
PB-49	64	60	4	3	$112,140
PB-50	64	61	3	4	$149,520
PB-51	60	60	0	0	$0
PB-52	56	55	1	0	$0
PB-53	55	53	2	0	$0
PB-54	59	57	2	0	$0
PB-55	64	60	4	2	$74,760
PB-56	60	57	3	3	$112,140
PB-57	64	62	2	0	$0
PB-58	63	59	4	2	$74,760
PB-59	59	56	3	4	$149,520
PB-60	60	58	2	0	$0
PB-61	61	59	2	0	$0
PB-62	53	50	3	4	$149,520
PB-63	50	48	2	0	$0
PB-64	47	46	1	0	$0
			Total Available for Noise Mitigation		$3,171,990
		92nd Avenue NE to 96th Avenue NE			
PB-12	**67**	56	11	2	$82,220
PB-13	**69**	57	12	3	$144,810
PB-14	**67**	56	11	4	$164,440
PB-15	**70**	61	9	4	$207,600

Exhibit 35. **Noise Wall Performance Summary for Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
PB-40	60	52	8	4	$149,520
PB-41	61	53	8	4	$149,520
PB-42	61	55	6	3	$112,140
			Total Available for Noise Mitigation		$1,010,250
		96th Avenue NE to west of 103rd Place NE			
PB-16	**69**	61	8	11 [d]	$530,970
PB-16A	**74**	62	12	4	$265,680
PB-17	**67**	63	4	4	$164,440
PB-18	**73**	**72**	1	0	$0
PB-18T	**76**	62	14	4 [d]	$265,680
PB-19	**73**	**72**	1	0	$0
PB-19T	**78**	65	13	4 [d]	$265,680
PB-20	**71**	**71**	0	0	$0
PB-21	**70**	**71**	-1	0	$0
PB-21T	**71**	63	8	4 [d]	$222,120
PB-22	**68**	**69**	-1	0	$0
PB-22T	**73**	62	11	4 [d]	$251,160
PB-30	63	62	1	0	$0
PB-31	64	64	0	0	$0
PB-32	65	65	0	0	$0
PB-33	64	64	0	0	$0
PB-34	**67**	**67**	0	0	$0
PB-35	**66**	65	1	0	$0
PB-36	61	59	2	0	$0
PB-37	62	57	5	3	$112,140
PB-38	62	56	6	3	$112,140
PB-39	64	56	8	4	$149,520
			Total Available for Noise Mitigation		$2,339,530
		103rd Place NE to Bellevue Way NE			
PB-23	**70**	63[e]	7	3	$155,700
PB-23E[e]	**75**	**71**[g]	4	1	$66,420
PB-24	**68**	64	4	4	$178,560
PB-28	63	62	2	0	$0
PB-29	**66**	63[g]	3	2	$74,760
PB-65[f]	63	63	0	0	$0
			Total Available for Noise Mitigation		$475,440
		Yarrow Bay KinderCare Day Care Center - Along SR 520[h]			
PB-66	**69**	62	7	2.38	$114,929

Exhibit 35. **Noise Wall Performance Summary for Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520**

Receiver Number	Build Noise Levels without Noise Wall[a,b]	Build Noise Levels with Noise Wall[a,b]	Noise Reduction[a]	Benefited Homes[d]	Capital Available for Mitigation[c]
			Total Available for Noise Mitigation		$114,929
Yarrow Bay KinderCare Day Care Center - Along Northup Way[h]					
PB-67	**69**	64	5	2.38	$114,929
			Total Available for Noise Mitigation		$114,929
Condominium Homes at 108th NE & Northup Way					
PB-68	**69**	64	5	2	$96,540
PB-69	**68**	61	7	2	$89,280
PB-70	**67**	61	6	2	$82,220
			Total Available for Noise Mitigation		$268,040

[a] All noise levels in the exhibit are stated as L_{eq} in decibels with A-weighting (dBA).
[b] Bold numbers throughout exhibit indicate noise levels exceeding the NAC, 66 dBA L_{eq}.
[c] Available mitigation capital from WSDOT criteria for cost evaluation.
[d] Includes residential equivalents for the park area, Points Loop Trail, Lake Washington Boulevard Trail, and/or SR 520 bike and pedestrian path represented by this receiver.
[e] This receiver specifically represents the back yard main level deck of one home near PB-23 and was included to further refine the noise wall heights in this area.
[f] This receiver represents the La Quinta outdoor pool use - no noise wall required for this area.
[g] This receiver is listed under the noise wall from 103rd Place NE to Bellevue Way NE but is also partially influenced by the noise wall from 96th Avenue NE to west of 103rd Place NE.
[h] Two noise walls were evaluated for the Yarrow Bay KinderCare facility.

In accordance with the WSDOT feasibility criteria, each noise wall recommended for this project must provide 5 dBA or greater reductions for the first row of residences with at least one receiver having a minimum of 7 dBA reduction. Each noise wall meets the feasibility criteria except for the wall evaluated along Northup Way for the Yarrow Bay KinderCare Day Care Center. This noise wall would not achieve a minimum of 7 dBA for at least one receiver and is therefore not recommended for this project.

A summary of the cost analysis for each neighborhood noise wall system is provided in Exhibit 36. Four of the seven evaluated noise walls meet the WSDOT cost criteria with residual capital. On the south side of SR 520, between 96th Avenue NE and 103rd Place NE, the substantial topographical differences between the residences and the project roadway require a 32 to 24 foot high noise wall to meet WSDOT's feasibility criteria resulting in a cost that exceeds WSDOT's cost criteria. However, in this same area between 96th Avenue NE and 103rd Place NE, a lower noise wall height of 12 feet would mitigate the noise receivers representing the Lake Washington Boulevard trail and would meet WSDOT's cost criteria. The noise wall between the KinderCare facility and SR 520 would not meet WSDOT's reasonableness criteria due to the length and height required to mitigate the outdoor play area. The noise wall evaluated for the condominium homes at 108th NE & Northup Way would not meet the WSDOT reasonableness criteria. The outdoor uses (2nd floor balconies) that face the project roadways are elevated with respect to the roadways and the required higher wall height would be cost-prohibitive.

A total of 437 residential equivalents (65 with noise levels of 70 dBA or higher) would benefit from construction of the proposed noise walls.

Exhibit 36. **Details and Cost Analysis for Each Neighborhood Noise Wall System**

Noise Wall Description	Heights Along Wall (ft)[a]			Length (ft)[b]	Wall Area (sq ft)[c]	Cost[d]	Available Capital[e]	Residual Capital[f]
	Min	Avg	Max					
Medina and Hunts Point North of SR 520								
Evergreen Point Road Lid to 84th Ave NE Lid	12	15	18	2,355	36,128	$1,929,235	$3,614,280	+$1,685,045
Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520								
84th Ave NE Lid to Bellevue Way NE	12	16	16	2,542	40,343	$2,154,316	$2,562,260	+$407,944
Medina and Hunts Point South of SR 520								
Evergreen Point Road Lid to 84th Ave NE Lid	10	14	16	2,319	32,703	$1,746,340	$2,527,330	+$780,990
Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520								
84th Ave NE Lid to 92nd Ave NE	16	16	16	2,599	41,578	$2,220,265	$3,171,990	+$951,725
92nd Avenue NE to west of 103rd Place NE	10	14.6	20	1,685	26,986	$1,441,052	$2,339,530	+$898,478
103rd Place NE to Bellevue Way NE	12	15	18	420	6,295	$336,153	$475,440	+$139,287
Yarrow Bay KinderCare Day Care Center								
108th Ave NE On ramp to SR 520 Westbound	11	14	15	350	4,799	$256,267	$114,929	-$141,338
Condominium Homes at 108th NE & Northup Way								
Northup Way east of 108th Ave NE	14	16	18	522	8,347	$445,730	$268,040	-$177,690

[a] Minimum, average, and maximum noise wall heights in feet.
[b] Length of proposed noise walls in feet.
[c] Total noise wall surface area in square feet.
[d] Cost of noise wall based on $53.40 per square foot from WSDOT criteria for cost evaluation.
[e] Available mitigation capital from WSDOT criteria for cost evaluation.
[f] Residual mitigation capital: positive value is within the allowable capital based on WSDOT criteria; negative value exceeds the criteria.

How could the project compensate for noise levels above the noise abatement criteria?

Although the Build Alternative would include noise walls and lids, noise levels at some residences would continue to exceed the NAC. In accordance with FHWA and WSDOT requirements, noise mitigation measures are considered at locations along alignments where traffic noise levels are predicted to exceed the NAC as a result of a project. There are several locations where the NAC exceedances would not be due entirely to the project, and there are no reasonable or feasible methods of reducing noise. The following sections summarize the locations expected to exceed the NAC even with the proposed noise abatement measures, and why no additional noise abatement measures are recommended.

Under the Build Alternative, peak-hour noise levels at 36 residences or residential equivalents (PN-29, PS-13, PB-18, PB-19, PB-20, PB-22, PB-23E, PB-34, PB-43, PB-66 through PB-70) would exceed the NAC. Residences represented by PN-29 and PS-13 would continue to receive unmitigated traffic noise from 84th Avenue NE. Increasing the noise wall height along SR 520 would not reduce noise levels at PN-29 or PS-13. Residences represented by PB-18, PB-19, PB-20, PB-22, PB-23E and PB-34 are elevated between 50 and 140 feet above the grade of SR 520. The elevation difference between the receivers and SR 520 precludes a noise wall design that could meet both the feasibility and reasonableness criteria established by WSDOT. PB-43 would continue to receive traffic noise levels from 92nd Avenue NE; therefore, no additional noise reduction could be achieved with the project noise walls.

The Yarrow Bay KinderCare Day Care Center has two outdoor play areas, one near SR-520 (PB-66) and another near Northup Way (PB-67). Noise walls were evaluated for each of the areas. The wall along the 108th Avenue NE on ramp to SR 520 westbound meets WSDOT's feasibility criteria but does not meet the reasonableness (cost-effective) criteria. Similarly, the noise wall along Northup Way evaluated for the outdoor use area in front of the KinderCare building meets WSDOT's feasibility criteria but does not meet the reasonableness (cost-effective) criteria. Therefore, the two walls evaluated for the KinderCare Day Care Center are not recommended.

The condominiums located in the northeast corner of Northup Way and 108th Avenue NE were constructed with the living area above the garages. Six of these condominium homes have outdoor balconies that face Northup Way and SR 520 (PB-68, PB-69 and PB-70). The noise wall evaluated for these 6 balconies meets WSDOT's feasibility criteria but does not meet the reasonableness criteria due to the higher wall height necessary to achieve the required noise level reductions at these second floor residential uses. Traffic noise levels at these outdoor balconies would exceed the NAC with the Build Alternative.

What construction noise and vibration mitigation measures could be used on this project?

Construction Noise Mitigation

Several construction noise abatement methods, including operational methods, equipment choice, or acoustical treatments, could be implemented to limit the effects of construction noise. The methods used might vary in the project corridor depending on the project's construction criteria. Operation of construction equipment could be prohibited within 500 feet of any occupied dwelling unit in evening or nighttime hours (7 p.m. to 7 a.m.) or on Sundays or legal holidays, when noise and vibration would have the most severe effect. Mufflers would be required on all engine-powered equipment, installed according to the manufacturer's specifications, and all equipment would be required to comply with U.S. Environmental Protection Agency equipment noise standards.

WSDOT could limit activities that produce the highest noise levels (such as hauling, loading spoils, jackhammering, and using other demolition equipment) to 7 a.m. to 7 p.m. A construction log could be kept for each of the construction staging areas. The log would contain general construction information such as the time an activity took place, type of equipment used, and any other information that might help with potential noise effects.

A complaint hot-line could also be established to investigate noise complaints and compare them to the construction logs. A construction monitoring and complaint program could help to ensure that all equipment met state, local, and any manufacturer's specifications for noise emissions. Equipment not meeting the standards could be removed from service until proper repairs were made, and the equipment re-tested for compliance. This procedure is recommended for all haul trucks, loaders, excavators, and other equipment that would be used extensively at the construction sites and that would contribute to potential noise effects.

The following is a list of recommended noise mitigation measures that could be implemented:

- Require all engine-powered equipment to have mufflers that were installed according to the manufacturer's specifications.
- Require all equipment to comply with pertinent U.S. Environmental Projection Agency equipment noise standards.
- Limit jackhammers, concrete breakers, saws, and other forms of demolition to daytime hours of 7:00 a.m. to 7:00 p.m. on weekdays, with more stringent restrictions on weekends.
- Minimize noise by regular inspection and replacement of defective mufflers and parts that do not meet the manufacturer's specifications.
- Install temporary or portable acoustic barriers around stationary construction noise sources.
- Locate stationary construction equipment as far from nearby noise-sensitive properties as possible.
- Shut off idling equipment.
- Reschedule construction operations if possible to avoid periods of noise annoyance identified in complaints.
- Notify nearby residents whenever extremely noisy work would be occurring.

- Restrict the use of back-up beepers and require onsite spotters during evening and nighttime hours.
- Additional noise mitigation measures might be implemented as more detail on the actual construction processes were identified.

Construction Vibration Mitigation

WSDOT could require vibration monitoring of all activities that might produce vibration levels at or above 0.5 inch per second whenever there were structures located near the construction activity. This would include vibratory sheet installation, soil compacting, and other construction activities that had the potential to cause high levels of vibration. There is virtually no effective method to reduce vibration effects from construction; however, by restricting and monitoring vibration-producing activities, vibration effects from construction could be kept to a minimum.

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