Washington State
Department of Transportation

SR 167
8th Street E. Vicinity to 277th Street SW Vicinity, HOT Lanes

MP 10.48 to MP 18.24

Noise Discipline Report

April, 2014

Prepared by:
Akberet Ghebreghzabiher
Washington State Department of Transportation
Air, Noise, and Energy Program
15700 Dayton Ave. North
PO Box 330310
Seattle, WA 98133-9710

Table of Contents

Exhibits

Acronyms

dB	Decibels
dBA	A-weighted decibels
DOT	Department of Transportation
Ecology	Washington State Department of Ecology
EDNA	Environmental designation for noise abatement
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
Ft^2	Square foot
HZ	Hertz
HOV	High-Occupancy Vehicle
L_{eq}	Equivalent A-weighted sound level
$L_{eq}h$	Equivalent A-weighted sound level averaged hourly
L_{max}	maximum sound level during a period of time
L_{min}	Minimum sound level during a period of tme
L_n	n representing the percentage of time the sound level exceeded
NAC	Noise abatement criteria
SEL	Sound exposure level
SR	State Route
TNM	Traffic Noise Model
USDOT	U.S. Department of Transportation
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Executive Summary

Project Objectives

This report re-evaluates the traffic noise analysis for the SR 167 Hot Lane project to account for combining Stage 4 (8th Street E. Vic. to SR 277th Street Vic. Southbound HOT Lane) and Stage 5 (8th Street E. to 15th Street SW Vic. Northbound HOT Lane) projects as well as for the preparation of the new NEPA documentation. The project extends SR 167 from milepost (MP) 10.48 in Pierce County to 18.24 in Kent, King County, Washington.

The analysis of the noise impacts in the project area is based on a comparison of future sound levels with existing levels and applicable criteria. Construction noise impacts are based on the maximum noise levels of construction equipment published by the U.S. environmental Protection Agency (EPA).

Current Noise Environment

Land use adjacent to the highway consists of residential properties, commercial properties, industrial properties and undeveloped vacant land. Also, noise sensitive properties such as a church, a community center and a trial are located within the noise study area.

Predicted peak hour noise levels were compared to Federal Highway Administration's (FHWA's) Noise Abatement Criteria (NAC) and a substantial increase from the existing environment of 10 dBA or more to determine if the project would result in traffic noise impacts.

- Existing noise levels within the existing project area are between 57 and 73 dBA.
- In the design year 2036, without the project, noise levels are predicted to increase to between 58 and 74 dBA.
- In design year 2036, with the project, noise levels are predicted to increase to between 62 and 74 dBA.

Noise Impacts of Alternatives

The analysis of the noise impacts in the project area is based on a comparison of future sound levels with existing levels and applicable criteria. Construction noise impacts are based on the maximum noise levels of construction equipment published by the USEPA (EPA, 1971).

The Washington State Department of Transportation (WSDOT) used Federal Highway Administration (FHWA) noise abatement criteria to evaluate traffic noise impacts. Traffic noise levels are predicted at sensitive receivers based on projected future traffic operations using FHWA Traffic Noise Model (TNM) version 2.5. Abatement measures that may be taken to avoid or reduce potential noise impacts are discussed where appropriate.

The project environment was evaluated for the presence of receivers sensitive to traffic noise. One hundred fourteen receivers were modeled to identify current and future noise impacts under this project's Build and No-Build conditions. Predicted peak-hour noise levels were compared to FHWA's Noise Abatement Criteria (NAC) to determine if the project would result in traffic noise impacts.

WSDOT's noise analysis revealed that 65 receivers currently approach or exceed the FHWA noise abatement criteria (NAC) for noise of 66 dBA Leq (equivalent sound pressure level in A-weighted decibels). Analysis of the future modeled No-Build alternative projects an increase to 71 receivers without the project due to a slight increase in traffic noise levels. Under the 2036 Build alternative, 82 receivers are expected to exceed the NAC of 66 dBA, by the year 2036 without abatement.

Considered Abatement

Noise walls along the right-of-way evaluated to protect most of the affected homes were evaluated for feasibility and reasonableness at two locations, on the east side of the project. Noise walls with an average height of 11 and 12 feet were considered for construction at both locations. The walls are found to be feasible and reasonable to build along the right-of-way to protect the potentially affected homes. However, the wall proposed at the southeast end of the project was evaluated and found to be feasible but not cost effective.

Therefore, a noise wall is recommended to be constructed at one of the two locations for this project. Exhibit 1 summarizes the existing and predicted noise conditions at the modeled locations.

Exhibit 1: Summary of Noise Impacts and Abatement

Alternative	Construction Noise	Operational Impacts	Abatement Measures
Existing 2011 Conditions (pm peak)	None	Noise levels exceed 66 dBA NAC at 65 locations.	None required.
2036 No-Build (pm peak)	None	Noise levels exceed 66 dBA NAC at 71 locations.	None required.
2036 Build (pm peak)	Nearby receivers could experience temporary noise impacts during construction. Potential nighttime construction will require noise variances from local jurisdictions.	Noise levels exceed a 66 dBA NAC at 82 locations.	Noise walls were considered at two locations within the project limits. Only one of the noise walls is recommended for construction, because the wall meets WSDOT's feasibility and reasonableness criteria.

Introduction

Project Description

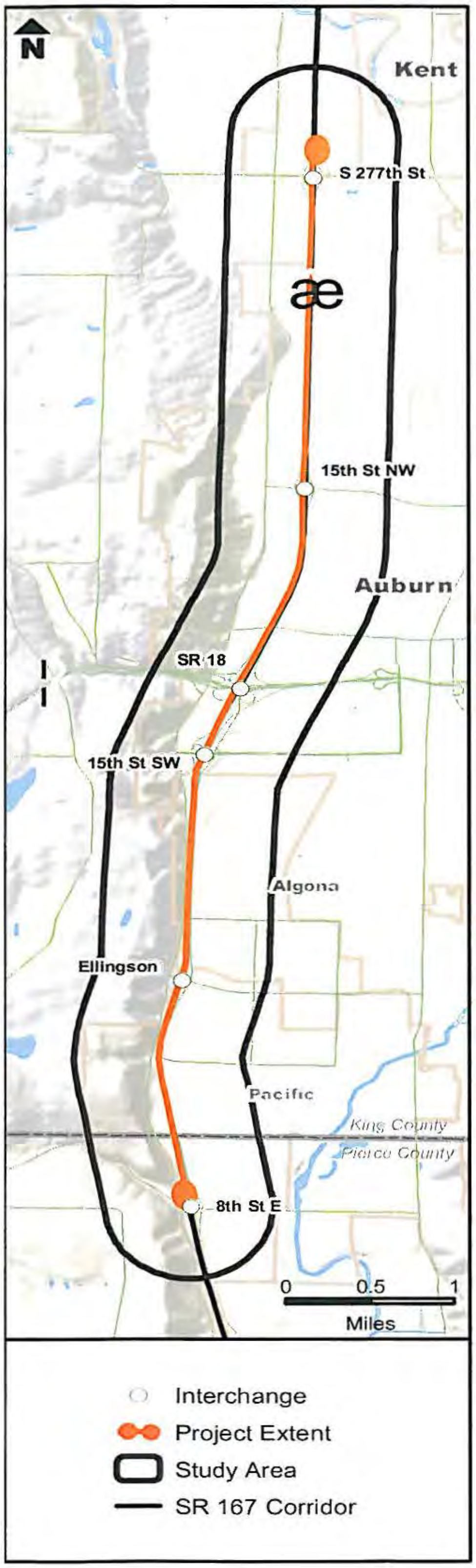
This project proposes to widen State Route 167 roadway to construct a new single high-occupancy toll (HOT) lane in each direction. The southbound lane will extend from the vicinity of 8th Street E. (MP 10.48) in Pierce County, Washington to the Vicinity of S. 277th in Kent (MP 18.24), King county, Washington. The northbound HOT lane will extend from the vicinity of 8th Street E. (MP 10.48) in Pierce County, Washington, to the vicinity of 15th Street SW in Auburn (MP 14.26), King County, Washington. The project lies within the jurisdictional boundaries of Pacific, Algona, Kent and Auburn in King and Pierce counties.

Ramp meters will be installed at southbound on-ramps at the SR 167 interchanges with 15th Street SW, Ellingson Road, and 8th Street E, in Pierce County. In addition, new signals will be installed at the SR 167 southbound ramp terminals with Ellingson Road and 8th Street E. SR 167 is an important thoroughfare for cars, trucks, and transit in the Green River Valley. The additional capacity will relieve congestion and improve safety for commuters traveling southbound on SR 167. The new lanes will be a continuation of the existing HOT lanes that extend from the I-405 interchange in Renton to S. 277th Street in Kent.

The construction of the southbound lane will require widening the roadway to the outside of the existing pavement between 6th Avenue N. in Algona and 5th Avenue SW in Pacific. The remainder of the roadway will be widened to the median. Ramp meters will be installed at the northbound on-ramps at the SR 167 interchanges with 8th Street E. and Ellington Road. All of the proposed widening work will occur within WSDOT right-of-way.

In addition to roadway improvements WSDOT will develop an off-site flood storage site located in the city of Auburn west of SR 167 between SR 18 and West Main Street. The site will provide flood storage for the project's flow control requirements and compensatory mitigation for unavoidable wetland impacts.

Exhibit 2: Project Vicinity



Type 1 Trigger for Noise Analysis

A traffic noise analysis is required by law[1] for federally funded projects and required by state policy[2] for other funded projects that:

- Involve construction of a new highway on new alignment,
- Significantly change the horizontal or vertical alignment,
- Increase the number of through traffic lanes on an existing highway, or
- Alter terrain to create new line-of-sight to traffic for noise sensitive receivers.

The project proposes to construct toll lanes on both directions of SR 167 (Increase the number of through traffic lanes on an existing highway) to address safety and improve mobility. The additional capacity that this project will provide to SR 167 will relieve congestion and improve safety for commuters traveling through this corridor and it is an important thoroughfare for trucks and other transit in the Green River Valley. Implementation of this project to build new HOT lanes is a Type 1 trigger for traffic noise analysis.

Noise Relevant Project Information

The proposed project would provide a solution to the immediate and long-range regional transportation mobility needs within the project vicinity. The completed project will provide an additional lane on each direction of SR 167 which will improve mobility. Installing ramp meters and new signals will ensure efficient movements and serves general traffic needs through to the design year 2036.

The land use includes areas of industrial, open space, commercial, and residential (Exhibit 3). The current existing conditions of undeveloped parcels located within the project area along with agriculture use near S 277th Street. Along the east side of SR 167, north of Boundary Boulevard, land use is either undeveloped or commercial. Between 9th Avenue N and 11th Avenue N, land use is primarily residential, with some commercial use between 8th Avenue and 9th Avenue N. Between 8th Avenue N and 4th Avenue N, land use is a mixture of residential, commercial, some undeveloped land and other sensitive receivers such as a church and a community center. South of 4th Avenue N to 5th Avenue NW, land use is all single-family residential. South of 5th Avenue NW, land use is entirely commercial.

---

[1] 23 CFR 772, "Procedures for Abatement of Highway Traffic Noise and Construction Noise"

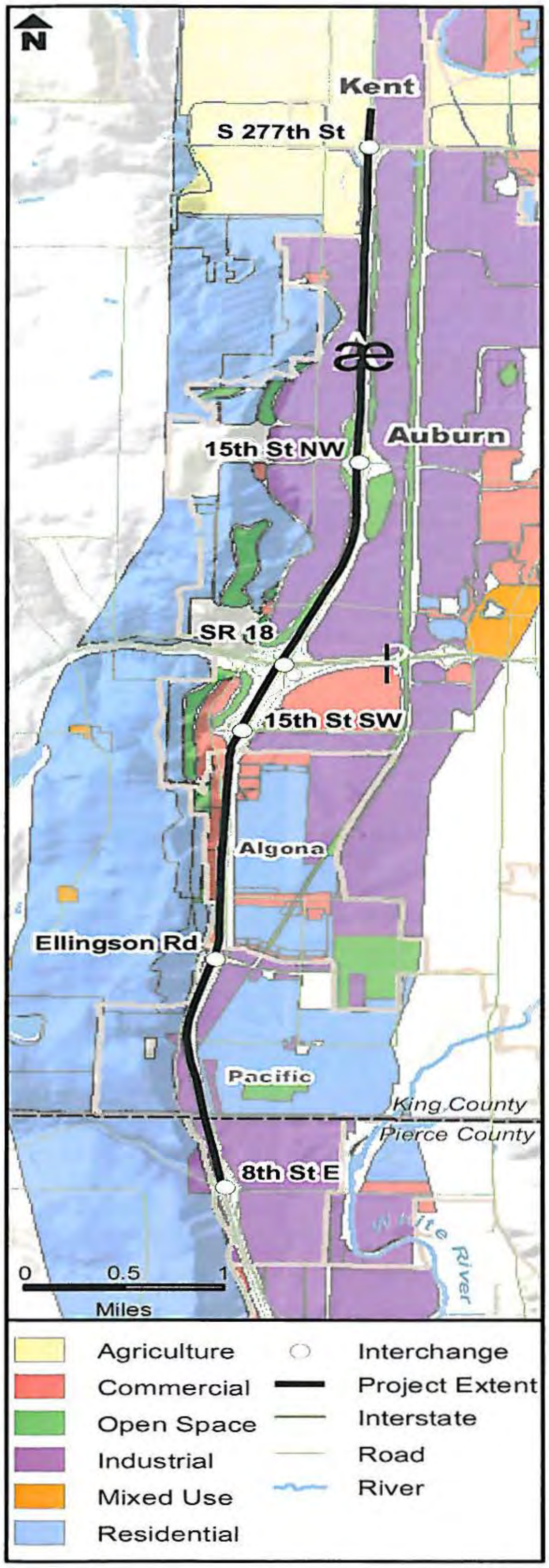
[2] 2011 WSDOT Traffic Noise Policy and Procedures, WSDOT

On the west side of SR 167, land use is primarily commercial and undeveloped. Several single-family homes can be found west of the West Valley Highway S. near 4th Avenue N. A few other noise sensitive properties occur near the Ellingson Road ramps.

South of 3rd Avenue SW and north of County Line Road the Beaver Meadows is a residential development with six duplex and 51 single family residences. The development is approximately 300 feet from the existing shoulder. No other noise sensitive properties were identified in the study area.

FHWA requirements and WSDOT policy dictates that noise studies assess properties adjacent to highway projects that may be potentially affected by traffic noise. Primary consideration must be given to areas of frequent outdoor human use such as residences with yards, decks, or patios. Parks and schools with outdoor play areas also warrant primary consideration of potential noise impacts. With that in mind, the project area was assessed for these types of areas.

Exhibit 3: Land Use Map



Characteristics of Sound and Noise

Definition of Sound

Sound is created when objects vibrate, resulting in a minute variation in surrounding atmospheric pressure, called sound pressure. The human response to sound depends on the magnitude of a sound as a function of its frequency and time pattern (EPA, 1974). Magnitude is a measure of the physical sound energy in the air. The range of magnitude the ear can hear, from the faintest to the loudest sound, is so large that sound pressure is expressed on a logarithmic scale in units called decibels (dB). Loudness refers to how people subjectively judge a sound and varies between people.

Sound is measured using the logarithmic decibel scale, so that doubling the number of noise sources, such as the number of cars on a roadway, increases the sound level by 3 dBA. Therefore, when you combine two sources emitting 60 dBA, the combined sound level is 63 dBA, not 120 dBA. The human ear can barely perceive a 3 dBA increase, while a 5 dBA increase is about one and one-half times as loud and readily noticed. A 10 dBA increase appears to be a doubling in noise level to most listeners. A tenfold increase in the number of noise sources will add 10 dBA.

In addition to magnitude, humans also respond to a sound's frequency or pitch. The human ear is very effective at perceiving frequencies between 1,000 and 5,000 Hz, with less efficiency outside this range. Environmental noise is composed of many frequencies. A-weighting (dBA) of sound levels is a filter applied electronically by a sound level meter and combines the many frequencies into one sound level that simulates how an average person hears sounds.

Definition of Noise

Noise is unwanted or unpleasant sound. Noise is a subjective term because, as described above, sound levels are perceived differently by different people. Magnitudes of typical noise levels are presented in Exhibit 4.

Traffic Noise Sources

An increase in traffic volumes, vehicle speeds, or the amount of heavy trucks will increase traffic noise levels. Traffic noise is a combination of noises from the engine, exhaust, and tires. Defective mufflers, truck compression braking on steep grades. The terrain and vegetation near the roadway, shielding by barriers and buildings and the distance from the road can also contribute to minimizing the traffic noise heard for traffic on roadway.

Exhibit 4: Typical Noise Levels

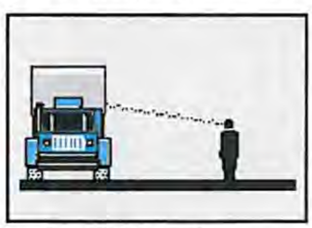
Transportation Noise Sources	Noise Level (dBA)	Other Sources	Description
	130		
Jet takeoff (200 feet)	120		Painfully loud
Car horn (3 feet)	110		
	100	Shout (.5 foot)	Very annoying
Heavy truck (50 feet)	90	Jack hammer (50 feet)	Hearing loss with prolonged exposure
Train on structure (50 feet)	85	Backhoe (50 feet)	
City bus passing (50 feet)	80	Bulldozer (50 feet)	
		Vacuum cleaner (3 feet)	
Train (50 feet)	75	Blender (3 feet)	Annoying
City bus at stop (50 feet)	70		
Freeway traffic (50 feet)		Lawn mower (50 feet)	
Train in station (50 feet)	65	Washing machine (3 feet)	
Light traffic (50 feet)	60	TV (10 feet)	Intrusive
		Talking	
Light traffic (100 feet)	50		Quiet

Source: FTA, 1995

Sound Propagation

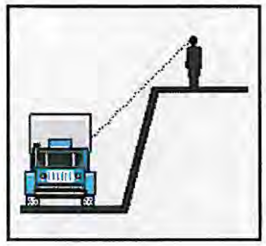
Sound propagation, or how far the sound travels, is affected by the terrain and the elevation of the receiver relative to the noise source. Breaking the line of sight between the receiver and the noise source can reduce noise levels .

- Level ground: noise travels in a straight path between the source and receiver.



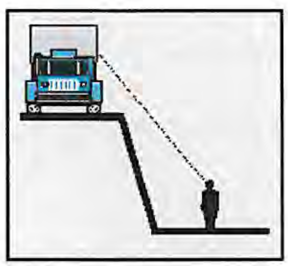
Level Ground

- Depressed source/elevated receiver: terrain may act like a partial noise barrier and reduce noise levels if it crests between the source and receiver.



Depressed source/elevated receiver

- Elevated source/depressed receiver: the edge of the roadway acts as a partial noise barrier. Even a short barrier, like a concrete safety barrier, can reduce the noise level.



Elevated source/depressed receiver

Line and Point Sources

Noise levels decrease with distance from the source. For a line source, like a highway, noise levels decrease 3 dBA for every doubling of distance, e.g., from 66 dB at 50' to 63 dB at 100', between the source and the receiver over hard ground (concrete, pavement) or 4.5 dBA over soft ground (grass). For point sources, like most construction noise, the levels decrease between 6 and 7.5 dBA for every doubling of distance depending on ground hardness.

Effects of Noise

The FHWA noise abatement criteria are based on speech interference, which is a well documented impact that is relatively reproducible in human response studies. Environmental noise indirectly affects human welfare by interfering with sleep, thought, and conversation.

Prolonged exposure to very high levels of environmental noise can cause hearing loss and the Environmental Protection Agency (EPA) has established a protective level 70 dBA $L_{eq}(24)$[3] for hearing loss.

Noise Level Descriptors

The equivalent sound level (L_{eq}) is a measure of the average noise level during a specified period of time. A one-hour period, or hourly L_{eq} [$L_{eq}(h)$], is used to measure highway noise. L_{eq} is a measure of total noise during a time period that places more emphasis on occasional high noise levels that accompany general background noise levels. For example, if you have two different sounds, and one contains twice as much energy, but lasts only half as long as the other, the two would have the same L_{eq} noise levels.

Either the total noise energy or the highest instantaneous noise level can describe short-term noise levels, such as those from a single truck passing by. The sound exposure level (SEL) is a measure of total sound energy from an event, and is useful in determining what the L_{eq} would be over a period in time when several noise events occur. L_{max} is the maximum sound level that occurs during a single event and is related to impacts on speech interference and sleep disruption. L_{min} is the minimum sound level during a period of time.

With L_n, where "n" is the percent of time that a sound level is exceeded and is used describe the range of sound levels recorded during the measurement period. For example, the L_{10} level is the noise level that is exceeded 10% of the time. Sound varies in the environment and people will generally find a higher, but constant, sound level more tolerable than a quiet background level interrupted by higher sound level events. For example, steady traffic noise from a highway is normally less bothersome than occasional aircraft flyovers in an otherwise quiet area.

Noise Regulations and Impact Criteria

Traffic noise impacts occur when predicted L_{eq} (h) noise levels approach or exceed noise abatement criteria (NAC) established by the FHWA, or substantially exceed existing noise levels[4]. WSDOT considers a noise impact to occur if predicted L_{eq} (h) noise levels approach within 1 dBA of the noise abatement criteria. The FHWA noise abatement criteria specify exterior $L_{eq}(h)$ noise levels for various land activity categories as described in Exhibit 5. WSDOT also considers an increase of 10 dBA or more to be a substantial increase and constitute a traffic noise impact.

[3] U.S. EPA, 1974

[4] U.S. Department of Transportation, 1982, Noise Abatement Council

Exhibit 5: FHWA Noise Abatement Criteria by Land Use

Activity Category	$L_{eq}(h)$* at Evaluation Location (dBA)	Description of Activity Category
A	57 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Residential (single and multi-family units)
C	67 (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools , television studios, trails, and trail crossings
D	52 (interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F. Includes undeveloped land permitted for these activities.
F	-	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	-	Undeveloped lands that are not permitted

Construction Noise Levels Limits

Traffic and construction noise are exempt from the Washington Administrative Code (WAC) property line noise limits during daytime hours, but noise limits still apply to construction noise at night. Noise levels in Exhibit 6 apply only to construction noise at residential properties at "night": between 10 p.m. and 7 a.m. At night, construction noise must meet Washington State

Department of Ecology property line regulations[5] that set limits based on the Environmental Designation for Noise Abatement (EDNA) of the land use: residential (Class A), commercial (Class B), and industrial (Class C).

Allowable nighttime (10:00 PM to 7:00 AM) noise levels at Class A receiving properties (residential) are reduced by 10 dBA. WAC 173-60

Exhibit 6: Maximum Permissible Environmental Noise Levels

EDNA of Noise Source	EDNA of Receiving Property (dBA)		
	Class A	Class B	Class C
Class A	55	57	60
Class B	57	60	65
Class C	60	65	70

Short-term exceedance of the sound levels in Exhibit 5 is allowed. During any one-hour period, the maximum level may be exceeded by:

- 5 dBA for a total of 15 minutes,
- 10 dBA for a total of 5 minutes, or
- 15 dBA for a total of 1.5 minutes[6].

The allowed exceptions are defined by the percentage of time a given level is exceeded. For example, L_{25} is the noise level exceeded 15 minutes during an hour. Therefore, the permissible L_{25} would be 5 dBA greater than the values in Exhibit 6, provided that the noise level is below the permissible level for the rest of the hour and never exceeds the permissible level by more than 5 dBA.

[5] WAC Chapter 173-60-040

[6] WAC 173-60-040

Traffic Noise Analysis Methodology

Determination of the Traffic Noise Study Area

The project area consists of residential, industrial, commercial and open space undeveloped land. The current existing conditions of undeveloped parcels located within the project area along with agriculture use near S. 277th Street. Along the east side of SR 167, north of Boundary Boulevard, land use is either undeveloped or commercial. Between 9th Avenue N. and 11th Avenue N., land use is primarily residential, with some commercial use between 8th Avenue and 9th Avenue N. Between 8th Avenue N. and 4th Avenue N., land use is a mixture of residential, commercial and other sensitive receivers such as a church and a community center. South of 4th Avenue N. to 5th Avenue NW, land use is all single-family residential. South of 5th Avenue NW, land use is entirely commercial.

On the west side of SR 167, land use is primarily commercial and undeveloped. Several single-family homes can be found west of the West Valley Highway S. near 4th Avenue N. A few other noise sensitive properties occur near the Ellingson Road ramps.

South of 3rd Avenue SW and north of County Line Road the Beaver Meadows is a residential development with duplexes and single family homes. The development is located approximately 300 feet from the existing shoulder. Other noise sensitive properties identified in the vicinity are located outside the study area.

This noise study analyzes traffic noise affects up to 500 feet from both sides of both highways throughout the project limits. A straight-line traffic noise model was not used to establish the 500 foot study area, because the study area was established during the 2008 noise study for this project by Michael Minor & Associates.

Traffic Noise Measurement and Validation

The existing noise environment is composed primarily of traffic noise from SR 167 and other major arterial roads, such as 15th Street SW and Ellingson Road. Additional noise sources include commercial and industrial activities, ongoing minor construction activities, and other general noise sources, such as residential activities.

Ambient sound levels were measured to describe the existing noise environment, identify major noise sources in the project area, and validate the noise model. Noise measurements were collected out to 500 feet from the roadway in the 2008 noise study to confirm the model predictions and validate the noise model.

Fifteen-minute L_{eq} measurements were collected at locations representative of all sound level environments within the study area during free-flowing traffic conditions. FHWA allows 15-min L_{eq} measurements to represent the L_{eq} (h).

To ensure that the noise model used to predict traffic noise impacts accurately reflects the sound levels in the noise study area, a model is constructed using the same traffic volumes, speed, and vehicle types that were present during the sound level measurements. Modeled values must be within ±2.0 dBA of the measured levels to validate the model.

FHWA's Traffic Noise Model (TNM) Version 2.5 (FHWA, 2004) was used for validation and to predict future L_{eq} (h) traffic noise levels. TNM calculates precise estimates of noise levels at discrete points. The model estimates the sound levels from a series of straight-line roadway segments. TNM also considers the effects of existing barriers, topography, vegetation, and atmospheric absorption. Noise from sources other than traffic is not included so when non-traffic noise is present, such as aircraft noise, TNM will under predict the actual noise level. To create the model, design files outlining major roadways, topographical features, and sensitive receptors were imported into the TNM model as background features and the corresponding values were entered manually. Aerial photographs and site visits were used to verify site conditions.

Exhibit 7 describes the validation locations and the comparison of measured to modeled values. Noise levels were field measured at ten locations adjacent to the existing alignment. Fifteen-minute noise measurements were taken at each location. The measured noise levels were used to validate the noise model as described in the methodology section of this report. The noise levels at all ten measured sites were modeled using TNM. All of these sites were within 2.0 dBA of the measured values indicating that the model accurately represented site conditions.

The noise monitoring was performed on Monday, April 24, 2006, between 1:00 pm and 4:00 pm with supplemental monitor readings taken on June 23, 2008 at approximately 9:30 am. This report used these measured values because to re-do the measurements for an already validated model was found to be redundant and traffic conditions are not expected to have changed since these measurements were collected. The time periods selected were weekdays when traffic is free-flowing and noise levels are highest. As traffic slows from congestion during the peak hours of 6:00 am to 8:00 am and again from 4:00 pm to 6:00 pm, noise levels are lower than when traffic is free flowing.

Measured noise levels ranged from 64 to 71 dBA Leq. In general, front-row receivers (receivers directly adjacent to the project roadway) have existing noise levels of 69 to 71 dBA Leq during peak noise hours. Second line receivers (receivers behind the front-row, receivers with some shielding) have noise levels of about 64 dBA Leq.

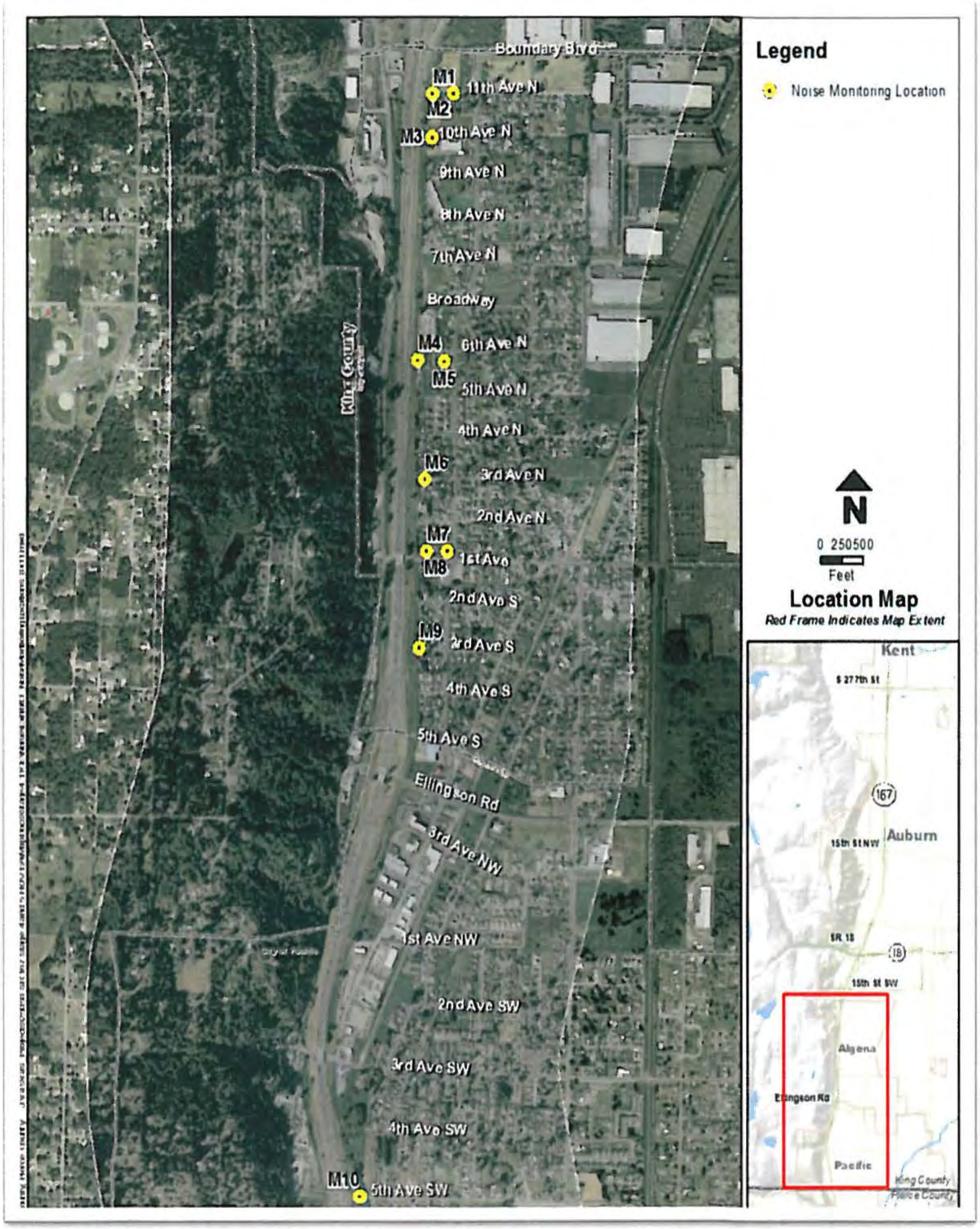
Exhibit 7: Noise Model Validation

Location	Date	Start Time	Measured L_{eq} (dBA)	Modeled L_{eq} (dBA)	Difference (dBA)
M1	04/24/2006	11th Ave N	**71**	**70.8**	-0.2
M2	04/24/2006	11th Ave N	64	64.7	0.7
M3	04/24/2006	10th Ave N	**69**	**70.8**	1.8
M4	04/24/2006	6th Ave N	**70**	**70.3**	0.3
M5	04/24/2006	6th Ave N	64	64.3	0.3
M6	04/24/2006	3rd Ave N	**69**	**68.1**	-0.9
M7	04/24/2006	1st Ave N	**66**	65.0	-1.0
M8	04/24/2006	1st Ave N	64	62.7	-1.3
M9	06/23/2008	3rd Ave S	64	**65.5**	1.5
M10	06/23/2008	5th Ave SW	**66**	64.9	-1.1

Bold numbers represent noise levels at or above WSDOT impact level of 66 dBA or greater

Exhibit 8 shows the noise measurement locations. Measured receivers are denoted by letter M followed by a number.

Exhibit 8: Traffic Noise Measurement Locations



Traffic Noise Levels

Operational Traffic Noise

FHWA requirements and WSDOT policy dictate that noise studies assess properties adjacent to highway projects that may be potentially affected by traffic noise. Primary consideration must be given to areas of frequent outdoor human, use such as residences with yards, decks, or patios. Parks and schools with outdoor play areas also warrant primary consideration of potential noise impacts. With that in mind, the project area was assessed for these types of areas. See Exhibit 7 for aerial view of the project area with all measured and modeled sites denoted.

- Existing condition traffic noise impacts – Sixty-five receivers representing 70 residences, a church, and a community center.
- No-Build condition traffic noise impacts – Seventy-one receivers representing 87 residences a church, and a community center.
- Build condition traffic noise impacts – Eighty-two receivers representing 111 residences a church, and a community center.

Existing Noise Level (2011)

Existing traffic noise levels for all modeled receivers are described in Exhibits 9 through 13. One hundred-four more receivers were added to the TNM model to represent properties within the existing alignment. Exhibits 9 through 21 identify the location of the modeled sites labeled with numbers preceded by the letter R. Existing PM peak traffic data was input into the TNM model and the model was run. Traffic office directed us to use the traffic data that was provided in 2008 for the existing traffic report shows no varation in the peak hour traffic volume from the 2008. Results of this model run are listed in Appendix E. Sixty-five receivers representing 70 residences, a church, and a community center were modeled at or above impact level under the existing conditions.

Design year Traffic Noise Level – No-Build (Year 2036)

Under the No-Build Alternative, noise levels are projected to increase by about 0.3 dBA to 0.5 dBA over the existing noise levels (Exhibits 9-13). This change is a result of projected increases in traffic volumes in the design year of 2036. The result shows that seventy-one receivers representing 87 residences a church, and a community center are projected to be at or above impact level under the No-Build condition. Actual maximum noise level increases may be less than the predicted increase, since congestion may reduce traffic speed during peak traffic hours. Should this occur, peak noise levels may be similar to existing noise levels; however, they would occur for a longer period each day.

Design Year Traffic Noise Level - Build (Year 2036)

Under the Build Alternative, noise levels are projected to increase 0.5 dBA to 3.9 dBA over the existing noise levels in this area. The modeling result shows that Eighty-two receivers representing 111 residences a church, and a community center are projected to be at or above impact under the Build Condition. All properties projected to approach or exceeds impact level in the Build scenario are analyzed for noise abatement later in this report.

Residential equivanency calculation is used for the church and the community center. The church is equivalent to two residences and the community center is equivalent to six residences. Appendix D provides detailed calcualtions.

Exhibit 9: Modeled Noise Results

Site #	Location (see Exhibit 7)	Dwelling Units	Existing (2011) L_{eq} (dBA)	No-Build (2036) L_{eq} (dBA)	Build (2036) L_{eq} (dBA)	Build Vs Existing (dB)	Build Vs No-Build (dB)
R1 (1st Row)	Residential property	1	**71.2**	**71.5**	**71.7**	0.5	0.3
R2- M1 (1st Row)	Residential property	3	**72.6**	**73.0**	**73.0**	0.4	0.4
R3-M2	Residential property	2	**66.4**	**66.8**	**67.4**	1	0.4
R4-M3 (1st Row)	Residential property	1	**71.4**	**71.8**	**72.1**	0.7	0.4
R5 (1st Row)	Residential property	1	**71.7**	**72.1**	**72.8**	1.1	0.4
R6-M4	Residential property	1	63.9	64.3	**65.9**	2	0.4
R7-M5 (1st Row)	Residential property	1	**71.7**	**72.1**	**72.4**	0.7	0.4
R8	Residential property	1	**67.6**	**68.0**	**69.1**	1.5	0.4
R9-M6	Residential property	1	65.2	**65.6**	**66.0**	0.8	0.4
R10 (1st Row)	Residential property	1	**70.1**	**70.5**	**71.3**	1.2	0.4
R11 (1st Row)	Residential property	2	**69.2**	**69.6**	**70.1**	0.9	0.4
R12	Residential property	1	64.1	64.5	65.0	0.9	0.4
R13 (1st Row)	Residential property	2	**68.6**	**69.0**	**69.1**	0.5	0.4
R14-M7 (1st Row)	Residential property	1	65.0	65.4	**65.6**	0.6	0.4
R15-M8 (1st Row	Residential property	1	62.2	62.7	63.2	1	0.5
R16 (1st Row)	Residential property	1	***68.7***	***69.1***	***69.1***	*0.4*	*0.4*
R17- M9	Residential property	1	**68.6**	**69.1**	**69.1**	0.5	0.5
R18	Residential property	1	**65.6**	**66.0**	**66.0**	0.4	0.4
R19 (1st Row)	Residential property	1	**67.1**	**67.5**	**68.3**	1.2	0.4
R20	Residential property	1	65.0	65.4	**66.1**	1.1	0.4
R21	Residential property	2	64.0	64.4	64.8	0.8	0.4
R22	Residential property	1	62.2	62.6	63.4	1.2	0.4
R23 (1st Row)	Residential property	1	63.0	63.3	**66.9**	3.9	0.3
R24	Residential property	1	61.5	61.9	63.0	1.5	0.4

Bold numbers represent noise levels at or above WSDOT impact level of 66 dBA or greater.

Exhibit 10: Modeled Noise Results

Site #	Location (see Exhibit 7)	Dwelling Units	Existing (2011) L_{eq} (dBA)	No-Build (2036) L_{eq} (dBA)	Build (2036) L_{eq} (dBA)	Build Vs Existing (dB)	Build Vs No-Build (dB)
R56 (1st Row)	Residential property	1	63.9	64.3	65.4	1.5	1.1
R62	Residential property	1	64.6	65.0	**65.8**	1.2	0.8
R64 (1st Row)	Residential property	1	**65.6**	**66.0**	**66.7**	1.1	0.7
R65 (1st Row)	Residential property	1	65.2	**65.6**	**65.9**	0.7	0.3
R67 (1st Row)	Residential property	1	**66.1**	**66.5**	**67.6**	1.5	1.1
R68 (1st Row)	Residential property	1	**67.3**	**67.7**	**67.8**	0.5	0.1
R69	Residential property	4	62.8	63.3	63.8	1.0	0.5
R71 (1st Row)	Residential property	1	**67.7**	**68.2**	**68.0**	0.3	-0.2
R72	Residential property	2	65.3	**65.7**	**66.2**	0.9	0.5
R74	Residential property	2	**66.1**	**66.5**	**66.9**	0.8	0.4
R75	Residential property	2	65.0	65.4	**65.9**	0.9	0.5
R76 (1st Row)	Residential property	1	**65.8**	**66.2**	**66.6**	0.8	0.4
R78 (1st Row)	Residential property	1	**68.5**	**69.0**	**69.3**	0.8	0.3
R79	Residential property	1	**65.7**	**66.2**	**66.1**	0.4	-0.1
R80	Residential property	1	**69.3**	**69.7**	**70.1**	0.8	0.4
R81	Residential property	1	**67.4**	**67.8**	**68.0**	0.6	0.2
R82	Residential property	1	**66.8**	**67.2**	**67.3**	0.5	0.1
R84	Residential property	2	64.3	64.8	65.1	0.8	0.3
R86	Residential property	1	**67.2**	**67.7**	**68.1**	0.9	0.4
R88 (1st Row)	Residential property	1	**70.1**	**70.5**	**71.3**	1.2	0.8
R89 (1st Row)	Residential property	1	**69.8**	**70.2**	**71.2**	1.4	1.0
R90	Residential property	1	**68.0**	**68.4**	**69.0**	1.0	0.6
R91	Residential property	1	**68.4**	**68.8**	**69.4**	1.0	0.6
R93(1st Row)	Residential property	1	**68.4**	**68.8**	**69.5**	1.1	0.7

Bold numbers represent noise levels at or above WSDOT impact level of 66 dBA or greater.

Exhibit 11: Modeled Noise Results

Site #	Location (see Exhibit 7)	Dwelling Units	Existing (2011) L_{eq} (dBA)	No-Build (2036) L_{eq} (dBA)	Build (2036) L_{eq} (dBA)	Build Vs Existing (dB)	Build Vs No-Build (dB)
R94 (1st Row)	Residential property	1	**72.0**	**72.4**	**72.9**	0.9	0.5
R95 (1st Row)	Residential property	1	**73.1**	**73.5**	**74.4**	1.3	0.9
R97 (1st Row)	Church	2*	**72.1**	**72.5**	**72.7**	0.6	0.2
R98	Residential property	1	**66.6**	**67.1**	**67.6**	1.0	0.5
R99	Residential property	5	65.3	**65.8**	**66.4**	1.1	0.6
R100 (1st Row)	Community Center	6*	**71.7**	**72.1**	**71.6**	-0.1	-0.5
R101 (1st Row)	Residential property	1	**66.5**	**66.9**	**68.4**	1.9	1.5
R102 (1st Row)	Residential property	1	**67.0**	**67.5**	**69.2**	2.2	1.7
R103 (1st Row)	Residential property	1	**68.7**	**69.1**	**70.6**	1.9	1.5
R104 (1st Row)	Residential property	1	**70.2**	**70.5**	**71.6**	1.4	1.1
R105 (1st Row)	Residential property	1	**68.4**	**68.8**	**70.5**	2.1	1.7
R106 (1st Row)	Residential property	1	**69.3**	**69.3**	**71.2**	1.9	1.9
R107 (1st Row)	Residential property	1	**69.9**	**70.3**	**71.6**	1.7	1.3
R108 (1st Row)	Residential property	1	**72.2**	**72.6**	**73.2**	1.0	0.6
R109 (1st Row)	Residential property	1	**70.5**	**70.9**	**71.4**	0.9	0.5
R111 (1st Row)	Residential property	1	**72.4**	**72.8**	**73.0**	0.6	0.2
R112 (1st Row)	Residential property	1	**67.4**	**67.8**	**68.8**	1.4	1.0
R113	Residential property	1	**65.8**	**66.2**	**67.4**	1.6	1.2
R114 (1st Row)	Residential property	1	**73.3**	**73.7**	**73.8**	0.5	0.1
R115	Residential property	1	**68.9**	**69.3**	**70.1**	1.2	0.8
R116 (1st Row)	Residential property	1	**72.7**	**73.1**	**73.0**	0.3	-0.1
R118 (1st Row)	Residential property	1	**72.0**	**72.4**	**72.6**	0.6	0.2
R119	Residential property	3	**66.7**	**67.1**	**69.3**	2.6	2.2

Bold numbers represent noise levels at or above WSDOT impact level of 66 dBA or greater. * Residential Equivalency

Exhibit 12: Modeled Noise Results

Site #	Location (see Exhibit 7)	Dwelling Units	Existing (2011) L_{eq} (dBA)	No-Build (2036) L_{eq} (dBA)	Build (2036) L_{eq} (dBA)	Build Vs Existing (dB)	Build Vs No-Build (dB)
R121	Residential property	3	65.0	65.4	**67.2**	2.2	1.8
R122	Residential property	4	65.2	65.6	**68.0**	2.8	2.4
R124	Residential property	2	63.6	64.0	65.1	1.5	1.1
R128	Residential property	2	61.8	61.8	63.0	1.2	1.2
R133	Residential property	5	**65.7**	**66.2**	**67.3**	1.6	1.1
R135	Residential property	6	64.5	64.9	**65.6**	1.1	0.7
R25 (1st Row)	Residential property	1	**66.8**	**67.2**	**67.9**	1.1	0.7
R26 (1st Row)	Residential property	1	**67.4**	**67.8**	**68.5**	1.1	0.7
R27 (1st Row)	Residential property	1	64.8	65.3	**66.0**	1.2	0.7
R28	Residential property	4	61.0	62.1	62.2	1.2	0.1
R29	Residential property	1	62.6	63.7	63.8	1.2	0.1
R30 (1st Row)	Residential property	1	62.0	63.2	63.2	1.2	0.0
R31	Residential property	2	60.8	60.8	62.0	1.2	1.2
R32	Residential property	6	61.8	63.0	63.0	1.2	0.0
R33/M-10 (1st	Residential property	1	63.7	64.8	**65.5**	1.8	0.7
R34 (1st Row)	Residential property	1	64.7	**65.9**	**66.9**	2.2	1.0
R35 (1st Row)	Residential property	1	65.0	**66.2**	**66.6**	1.6	0.4
R36	Residential property	8	62.9	64.1	63.7	0.8	-0.4
R150 (1st Row)	Residential property	1	65.0	**66.2**	**66.8**	1.8	0.6
R151 (1st Row)	Residential property	1	65.0	**66.2**	**66.8**	1.8	0.6
R152 (1st Row)	Residential property	1	65.0	**66.2**	**66.8**	1.8	0.6
R153 (1st Row)	Residential property	1	64.7	**65.9**	**66.6**	1.9	0.7

Bold numbers represent noise levels at or above WSDOT impact level of 66 dBA or greater.

Exhibit 13: Modeled Noise Results

Site #	Location (see Exhibit 7)	Dwelling Units	Existing (2011) L_{eq} (dBA)	No-Build (2036) L_{eq} (dBA)	Build (2036) L_{eq} (dBA)	Build Vs Existing (dB)	Build Vs No-Build (dB)
R154 (1st Row)	Residential property	1	63.7	64.9	**66.6**	2.9	1.7
R155	Residential property	1	63.8	65.0	64.6	0.8	-0.4
R157 (1st Row)	Residential property	1	63.1	64.2	**65.7**	2.6	1.5
R158 (1st Row)	Residential property	1	62.7	63.8	64.9	2.2	1.1
R159 (1st Row)	Residential property	1	62.2	63.3	64.3	2.1	1.0
R160 (1st Row)	Residential property	1	61.4	62.5	63.7	2.3	1.2
R161	Residential property	1	63.3	64.5	63.0	-0.3	-1.5
R162	Residential property	1	60.7	61.8	64.4	3.7	2.6
R163	Residential property	1	61.3	62.4	61.8	0.5	-0.6
R165 (Business)	Business property	1	64.5	**65.8**	62.5	-2.0	-3.3
R166 (Business)	Business property	1	65.7	**67.0**	65.2	-0.5	-1.8
R168 (1st Row)	Residential property	1	**65.7**	**65.7**	**66.5**	0.8	0.8
R170 (Business)	Business property	1	**69.7**	**70.2**	**69.9**	0.2	-0.3
R172 (Business)	Business property	1	**68.7**	**69.2**	**70.1**	1.4	0.9
R174 (Business)	Business property	1	58.7	59.1	60.6	1.9	1.5
R175 (1st Row)	Residential property	1	58.0	58.5	59.8	1.8	1.3
R176 (1st Row)	Residential property	1	57.1	57.5	58.7	1.6	1.2
R177 (1st Row)	Residential property	1	57.6	58.5	59.5	1.9	1.0
R179 (1st Row)	Residential property	1	57.6	58.1	59.5	1.9	1.4
R180 (1st Row)	Residential property	1	57.0	57.5	58.8	1.8	1.3
R182(Trail)	Trail	1	62.6	63.7	64.0	1.4	0.3

Bold numbers represent noise levels at or above WSDOT impact level of 66 dBA or greater.

Construction Noise

Construction Noise Background

Construction creates temporary noise. Construction is usually carried out in reasonably discrete steps, each with its own mix of equipment and noise characteristics. For example, roadway construction typically involves demolition, construction, and paving.

The most constant noise source at construction sites is usually engine noise. Mobile equipment generally operates intermittently or in cycles of operation, while stationary equipment, such as generators and compressors, generally operates at fairly constant sound levels. Trucks are present during most phases of construction and are not confined to the project site, so noise from trucks may affect more receivers than other construction noise. Other common noise sources typically include impact equipment, which could be pneumatic, hydraulic, or electric powered.

Noise levels during the construction period depend on the type, amount, and location of construction activities.

- The type of construction methods establishes the maximum noise levels.
- The amount of construction activity establishes how often certain construction noises occur throughout the day.
- The location of construction equipment relative to adjacent properties determines the effect of distance in reducing construction noise levels.

The maximum noise levels of construction equipment is expected to be similar to the maximum construction equipment noise levels presented in Exhibit 14 and typically range from 69 to 106 dBA at 50 feet. As a point source, construction noise decreases by 6 dBA per doubling of distance from the source moving away from the equipment. The various pieces of equipment are almost never operating simultaneously at full-power and some will be turned off, idling, or operating at less than full power at any time. Therefore, the average L_{eq} noise levels will be less than aggregate of the maximum noise levels in Exhibit 14.

Construction Noise Variance for Night Work

Construction noise is exempt from state and local property line regulations during daytime hours. If nighttime construction is required for this project, WSDOT will apply for variances or exemptions from local noise ordinances for the night work. Noise variances or exemptions require construction noise abatement measures that vary by jurisdiction. If night work is mandated for this project, noise variances will be obtained from the local jurisdictions.

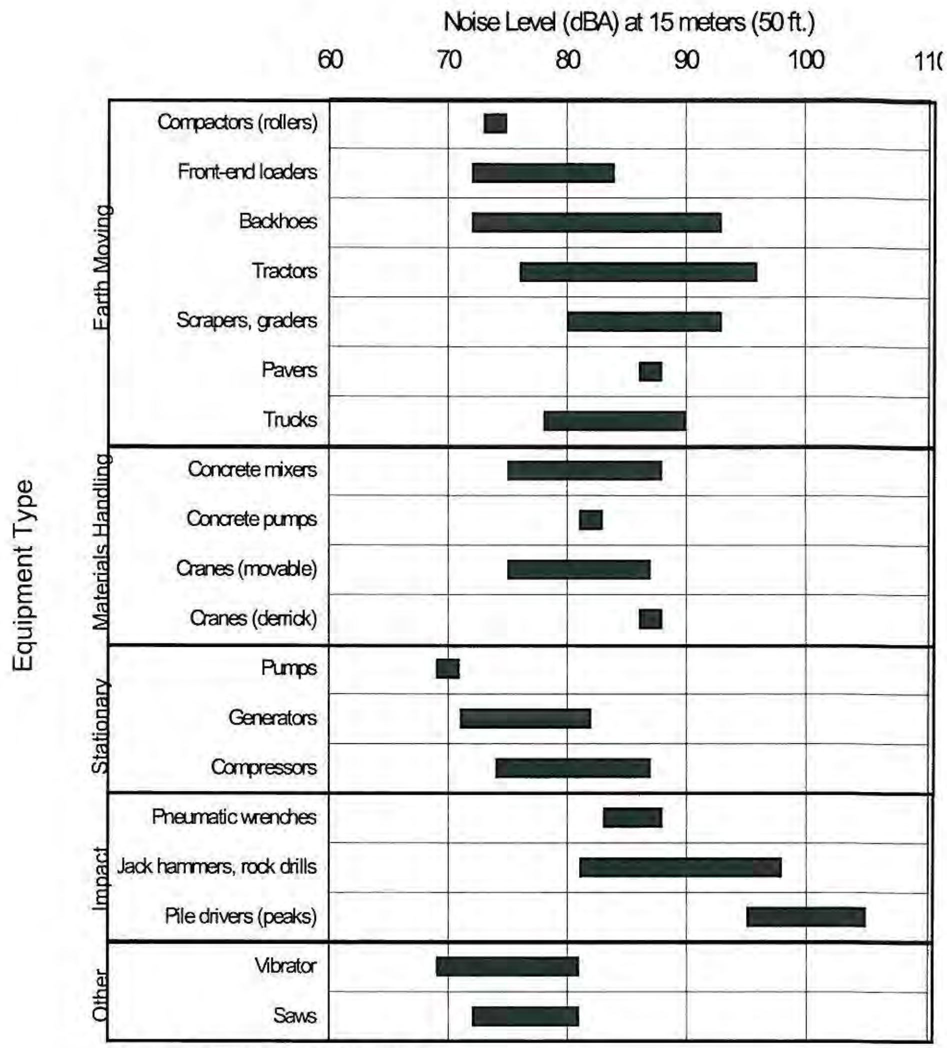
Construction Noise Abatement

Construction noise can be reduced by using enclosures or walls to surround noisy equipment, installing mufflers on engines, substituting quieter equipment or construction methods, minimizing time of operation, and locating equipment farther away from noise sensitive receivers, e.g., homes. To reduce construction noise at nearby receptors, the following abatement measures can be incorporated into construction plans and contractor specifications:

- Limiting construction activities to between 7 a.m. and 10 p.m. would reduce construction noise levels during sensitive nighttime hours
- Using haul vehicles with rubber bed-liners would reduce noise from loading trucks
- Equipping trucks with ambient backup alarms would reduce the noise for equipment backing
- Equipping construction equipment engines with adequate mufflers, intake silencers, and engine enclosures would reduce their noise by 5 to 10 dBA (U.S. EPA, 1971)
- Specifying the quietest equipment available would reduce noise by 5 to 10 dBA
- Turning off construction equipment during prolonged periods of nonuse would eliminate noise from construction equipment during those periods
- Requiring contractors to maintain all equipment and train their equipment operators would reduce noise levels and increase efficiency of operation
- Locating stationary equipment away from receiving properties would decrease noise from that equipment in relation to the increased distance
- Constructing temporary noise barriers or curtains around stationary equipment that must be located close to residences would decrease noise levels at nearby sensitive receptors

These measures are typical for construction noise but aren't necessarily recommended for this project.

Exhibit 14: Construction Equipment Noise Ranges



Source: EPA, 1971 and WSDOT, 1991.

Traffic Noise Abatement

Traffic Noise Abatement - Background

Noise abatement is considered only where there is an expected noise level of 66 dBA or higher in the design year Build scenario or an increase of 10 dBA over existing conditions for Exhibit 5 land use categories A, B, C, D and E. If such a situation exists, abatement is considered only where frequent human use occurs and where a lower noise level would have benefits (U.S. DOT, 1982). Noise levels can be reduced by the following types of abatement: (1) traffic management, such as restrictions on the types of vehicles and the time they may use a certain roadway; (2) change in vertical or horizontal alignment of the roadway; (3) acquisition of property; and (4) construction of noise barriers, such as noise walls.

Abatement was considered for this project's traffic noise impacts. Some of the modeled noise levels approach or exceed the WSDOT and FHWA NAC levels. Increases were modeled between the existing and Build conditions.

Abatement must be both feasible and reasonable for it to be recommended.

Feasibility

Feasibility is a combination of acoustic and engineering considerations. All of the following must occur for abatement (e.g., noise barrier) to be considered feasible.

- Abatement must be physically constructible.
- The majority first row impacted receivers must obtain a minimum 5 dBA of noise reduction as a result of abatement (insertion loss); assuring that every reasonable effort will be made to assess outdoor use areas as appropriate.

For this project, noise barriers were evaluated at two locations to determine whether abatement could sufficiently reduce traffic noise levels. The two locations were found to be feasible. At these locations, where noise walls were found to be feasible, barriers of up to 14 feet hieght will reduce traffic noise level by at least 5 dBA for a majority of the first row residents in the noise study area. (See Exhibits 15 and 16).

Noise wall 1 along the proposed alignment to protect the properties shown in Exhibit 17 was found feasible. At this location, an average of 11 foot wall was able to reduce traffic noise level by at least 5 dBA for the majority of the first row residens. Noise wall 1 appears to be physically constructible. Once this wall is found reasonable, verification of constructability will be confirmed.