3.11 Noise and Vibration

Major transportation projects cause noise and vibration as existing structures are demolished, debris is removed, and new structures are built. Although these impacts are temporary, they can affect the quality of life for area residents, as well as cause people to avoid areas near construction or demolition, which in turn can affect businesses in or near the project area. If noise and vibration exceed certain levels, these impacts can change from simply being nuisances to actually causing harm to humans or to already unstable buildings and structures. In addition to construction impacts, the design of transportation projects can create long-term impacts in the form of increased noise and vibration levels.

This section discusses noise and vibration effects on people and structures. For a discussion of noise and vibration effects on fish and wildlife, please see Section 3.16, Ecosystems.

This section summarizes the guidelines and standards for evaluating noise and vibration impacts, the estimated noise and vibration impacts that would result from the project, and mitigation measures for these impacts. This section addresses impacts within the main project area, the casting and staging areas, Ruby Junction, and on the Steel Bridge. See Chapter 2, Description of Alternatives, for a map of these areas. The information presented in this section is based on the Noise and Vibration Technical Report, which is included as an electronic appendix to this FEIS. The CRC project team followed relevant federal and state guidance and standards to identify and analyze noise and vibration impacts and to identify potential mitigation measures for these impacts. In particular, the project team followed standards and guidelines established by the FHWA and the Oregon and Washington state departments of transportation for analyzing and mitigating highway noise, as well as guidelines established by the FTA for analyzing and mitigating transit noise and vibration. A comparison of impacts from the LPA and the DEIS alternatives is summarized in Exhibit 3.11-11. A more detailed description of the impacts of the DEIS alternatives on noise and vibration is in the DEIS starting on page 3-287.

How do decibels relate to loudness?

The human ear generally cannot detect very slight changes in noise levels. The smallest change in noise level that a human ear can perceive is about 3 decibels, while increases of 5 decibels or more are clearly noticeable. For most people, a 10 decibel increase in noise levels is perceived as a doubling of sound level.

3.11.1 New Information Developed Since the Draft EIS

Since publication of the DEIS, additional information has been gathered and analyzed in order to better assess the project's noise and vibration impacts and to avoid and/or mitigate adverse effects. The additional information includes updates to the LPA's highway and transit alignments and a more detailed understanding of light rail vibration effects.

In addition to new information developed since the DEIS, the FEIS includes refinements in design, impacts and mitigation measures. Where new information or design changes could potentially create new significant environmental impacts not previously evaluated in the DEIS, or could be meaningful to the decision-making process, this information and these changes were applied to all alternatives, as appropriate. However, most of the new information did not warrant updating analysis of the non-preferred alternatives because it would not meaningfully change the impacts, would not result in new significant impacts, and would not change other factors that led to the choice of the LPA. Therefore, most of the refinements were applied only to the LPA. As allowed under Section 6002 of SAFETEA-LU [23 USC 139(f)(4)(D)], to facilitate development of mitigation measures and compliance with other environmental laws, the project has developed the LPA to a higher level of detail than the other alternatives. This detail has allowed the project to develop more specific mitigation measures and to facilitate compliance with other environmental laws and regulations, such as Section 4(f) of the DOT Act, Section 106 of the National Historic Preservation Act, Section 7 of the Endangered Species Act, and Section 404 of the Clean Water Act. FTA and FHWA prepared NEPA re-evaluations and a documented categorical exclusion (DCE) to analyze changes in the project and project impacts that have occurred since the DEIS. Both agencies concluded from these evaluations that these changes and new information would not result in any new significant environmental impacts that were not previously considered in the DEIS. These changes in impacts are described in the re-evaluations and DCE included in Appendix O of this FEIS. Relevant refinements in information, design, impacts and mitigation are described in the following text.

3.11.2 Existing Conditions

Understanding Sound

HOW ARE SOUND LEVELS MEASURED?

The effects of sound are complex to analyze. Two important aspects of sound that partially determine its impacts are loudness and frequency. The loudness of sound is a result of the energy of the sound, which is measured in decibels (dB). The frequency of sound refers to how quickly the sound wave changes or vibrates. While most sounds are quite complex, sounds that we perceive as musical tones have a basic or *fundamental* frequency that determines what we perceive as the pitch of the sound. Sounds with lower fundamental frequencies sound lower to us, sounds with higher fundamentals sound higher—like the difference between the low and high notes on a piano or violin.

In order to simplify matters, sound studies typically adjust the absolute dB measurement scale to a scale that reflects not simply the absolute energy of the sound, but that also accounts for the human ear's sensitivity to various sound frequencies. This adjusted dB scale, referred to as the A-weighted dB scale, provides a more accurate "single number" measure of what the human ear can actually hear. When the A-weighted dB scale is used, the dB levels are designated as dBA. This unit of measurement is used in this report and is also referred to as the *noise level* when discussing project effects. Additional information on how humans perceive sound is available in the Noise and Vibration Technical Report, which is included as an electronic appendix to this FEIS.

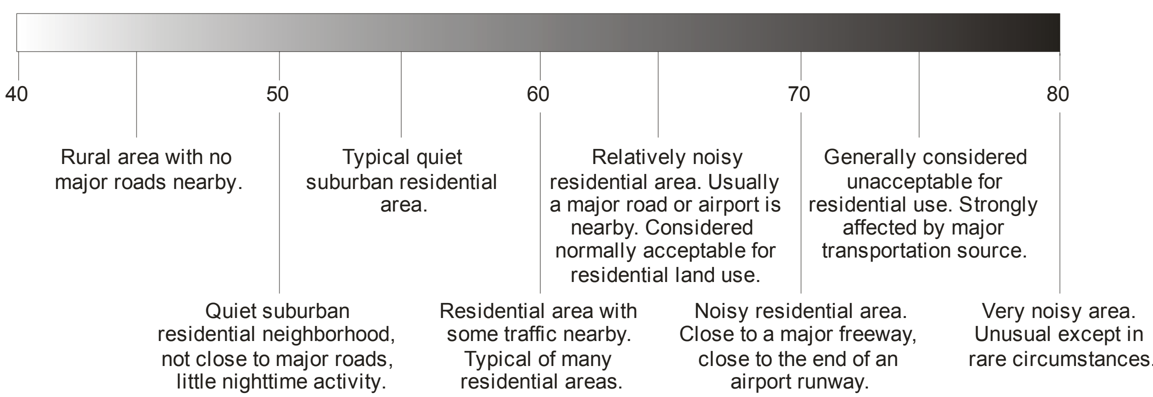
The emotional and physiological effects of sound depend on how often the sound occurs and how long it lasts on each occurrence. Most noise levels at a given location vary over time. To account for this variation, a common noise measurement used is the *equivalent sound pressure* level (L_{eq}). This is an average of sound levels over a given period of time, but an average that gives more weight to the highest and longest lasting levels. Thus, the L_{eq} is a good indicator of how individuals within a community experience noise. L_{eq} is measured in dBA for a specific time period (for example, dBA over a 1 minute period). The CRC noise analysis uses L_{eq} to describe traffic and transit noise at schools, libraries, and other noise-sensitive institutions. This analysis also gives more weight to noise that occurs at night (from 10:00 p.m. to 7 a.m.), which is consistent with federal noise regulations. Calculations that use this method produce the *day-night equivalent sound level*, which is abbreviated as L_{dn}.

WHAT ARE TYPICAL NOISE LEVELS?

Most urban and suburban neighborhoods have L_{dn} levels in the range of 50 to 70 dBA. Exhibit 3.11-1 shows typical community noise levels. Exhibit 3.11-2 indicates the noise levels for various noise sources and the typical human response to each noise level.

Exhibit 3.11-1

Typical Community Noise Levels in L_{dn}



Source: FTA, April 1995.

Exhibit 3.11-2
Typical Noise Levels in dBA

Sound Level (dBA)	Noise Source of Activity	Relative Loudness (Human judgement of different sound levels)	Subjective Impression
140	Jet aircraft takeoff from carrier (50 feet)	64 times as loud	Threshold of pain
130	50-horsepower siren	32 times as loud	
120	Loud rock concert near stage Jet takeoff (200 feet)	16 times as loud	Uncomfortably loud
110	Float plane takeoff (100 feet)	8 times as loud	
100	Jet takeoff (2,000 feet)	4 times as loud	Very loud
90	Heavy truck or motorcycle (25 feet)	2 times as loud	
80	Garbage disposal (2 feet)	Reference loudness	Moderately loud
70	Typical at-grade light rail vehicle	1/2 as loud	
60	Moderately busy department store	1/4 as loud	
50	Typical television show (10 feet) Typical quiet office environment	1/8 as loud	
40	Bedroom or quiet living room	1/16 as loud	Quiet
30	Quiet library, soft whisper (15 feet)	1/32 as loud	Very quiet
20	High-quality recording studio	1/84 as loud	Just audible
10	Acoustic Test Chamber	1/128 as loud	
0			**Threshold of hearing**

Sources: Beranek (1988) and US EPA (1971).

NOISE CRITERIA AND ANALYSIS METHODS

What are the highway traffic noise criteria?

Exhibit 3.11-3 summarizes FHWA traffic noise abatement criteria. ODOT is responsible for implementing the FHWA regulations in Oregon. Under ODOT policy, a traffic noise impact occurs if predicted noise levels approach within two (2) dBA of the FHWA criteria. These criteria apply to the peak noise impact hour. WSDOT administers the FHWA regulations in Washington. Under WSDOT policy, a traffic noise impact occurs if predicted noise levels approach within one (1) dBA of the FHWA criteria. Both agencies consider an increase of 10 dBA or more to be a substantial impact.

Exhibit 3.11-3

FHWA Traffic Noise Abatement Criteria

	Land Use Category	Hourly L_{eq} (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, 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 1982.

What are the Construction Noise Criteria?

In Washington, daytime construction noise is exempt from regulations in the Washington Administrative Code (WAC). Therefore, within Washington, project construction could be performed during the normal daytime hours of 7:00 a.m. to 10:00 p.m. without specific noise mitigation requirements. If construction were to be performed during nighttime hours, the contractor would be required either to meet the noise-level requirements presented in Exhibit 3.11-4 or to obtain a noise variance from the governing jurisdiction.

Exhibit 3.11-4

Washington State Noise Control Regulation

Source of Noise	Receiver of Noise (Maximum Allowable Nighttime Sound Level in dBA[a])		
	Residential	Commercial	Industrial
Residential	45	57	60
Commercial	47	60	65
Industrial	50	65	70

a The sound level limits are based on measurements taken at the property line of receiving properties.

As the requirements presented in Exhibit 3.11-4 cannot be met with conventional construction equipment and practices, a variance would be needed for nighttime construction. In addition to the noise standards listed in Exhibit 3.11-4, there are exemptions for short-term noise exceedances, including those outlined in Exhibit 3.11-5, based on the minutes per hour that the noise limit is exceeded.

Exhibit 3.11-5

Washington State – Exemptions for Short-term Noise Exceedances

Statistical Descriptor[a]	Minutes Exceeded 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 percent, 8.3 percent, and 2.5 percent of the time (1 hour, in this case).

Section 292.32 of the ODOT Standard Specifications (Section 292.32) includes construction noise abatement measures that apply to highway construction activities within Oregon. This is considered mitigation and is discussed in greater detail in Section 3.11.5.

What are the Transit Noise Criteria?

The FTA Transit Noise and Vibration Impact Assessment, Final Report (May 2006) provides FTA transit noise impact criteria that would apply to noise generated by the light rail transit elements of the LPA and to bus rapid transit. Under these criteria, the degree to which transit operations are allowed to change the overall noise environment is reduced with increasing levels of existing noise. The FTA noise impact criteria identify the following noise-sensitive land use categories.

Category 1: Buildings or parks where quiet is an essential element of their purpose.

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

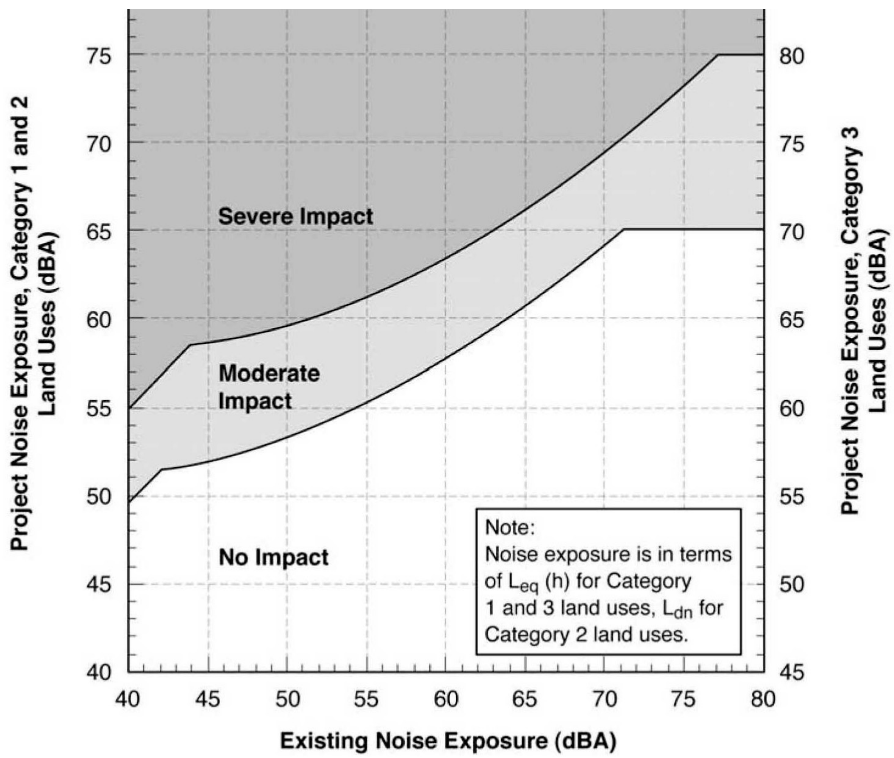
Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, churches, office buildings, and other commercial and industrial land uses.

There are two levels of impact specified in the FTA transit noise criteria; these are shown quantitatively in Exhibit 3.11-6:

- **Severe Impact:** Severe noise impacts are considered "significant", as used in the National Environmental Policy Act (NEPA) and its implementing regulations. Noise mitigation will normally be required for severe impact areas unless there is no practical method of mitigating the noise.
- **Moderate Impact:** In this range, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These other factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost-effectiveness of mitigating noise to more acceptable levels.

The FTA transit noise impact criteria above (Exhibit 3.11-6) apply to both transit vehicles and transit-related stationary noise sources such as park and ride lots, transit stops, and maintenance facilities. In addition to FTA criteria, state regulations also set allowable noise levels for stationary noise sources. State regulations are typically more stringent than FTA criteria, and in such cases, state regulations are used to estimate project impacts from stationary noise sources. However, FTA criteria still apply, and are used to determine noise impacts from stationary sources where there are no state or local noise regulations or where FTA criteria are more stringent. In Oregon, the Oregon Department of Environmental Quality (DEQ) Noise Control Regulations, shown in Exhibit 3.11-7, would apply to any noise levels generated by the Ruby Junction Maintenance Facility and proposed Hayden Island light rail station.

Exhibit 3.11-6
FTA Transit Noise Abatement Criteria



Source: FTA, 2006.

Exhibit 3.11-7
DEQ Industrial and Commercial Noise Source Standards

Statistical Descriptor	Existing Noise Source (dBA)		New Noise Source (dBA)		New Source in Quiet Area (dBA)	
	7 a.m.-10 p.m.	10 p.m.-7 a.m.	7 a.m.-10 p.m.	10 p.m.-7 a.m.	7 a.m.-10 p.m.	10 p.m.-7 a.m.
L_1	75	60	75	60	60	55
L_{10}	60	55	60	55	55	50
L_{50}	55	50	55	50	50	45

Source: OAR 340-35-035, Tables 7 and 8.

a L_1, L_{10}, and L_{50} are the noise levels that are exceeded 1 percent, 10 percent, and 50 percent of the time (1 hour, in this case).

The Washington Administrative Code (WAC) (Exhibits 3.11-4 and 3.11-5) applies to proposed park and ride lots and transit stations in Vancouver.

What City Noise Standards Affect the Project?

The City of Portland has restrictive noise regulations that apply to construction from 7:00 p.m. to 7:00 a.m. and all day on Sundays. The full regulations are given in the City of Portland Municipal Code, Title 18, Noise Control. Under the City's noise control ordinance, virtually all major construction projects require a noise variance if work is planned during nighttime hours or on Sundays.

The City of Vancouver has incorporated WAC noise regulations (Exhibits 3.11-4 and 3.11-5) into the Vancouver Municipal Code (VMC).

Understanding Vibration

HOW ARE VIBRATION LEVELS MEASURED?

Ground-borne vibration is a form of energy that travels from a source through the ground to another location. Two types of vibration were analyzed for the CRC alternatives—vibration from the operation of the proposed light rail system, and vibration that would result from project construction.

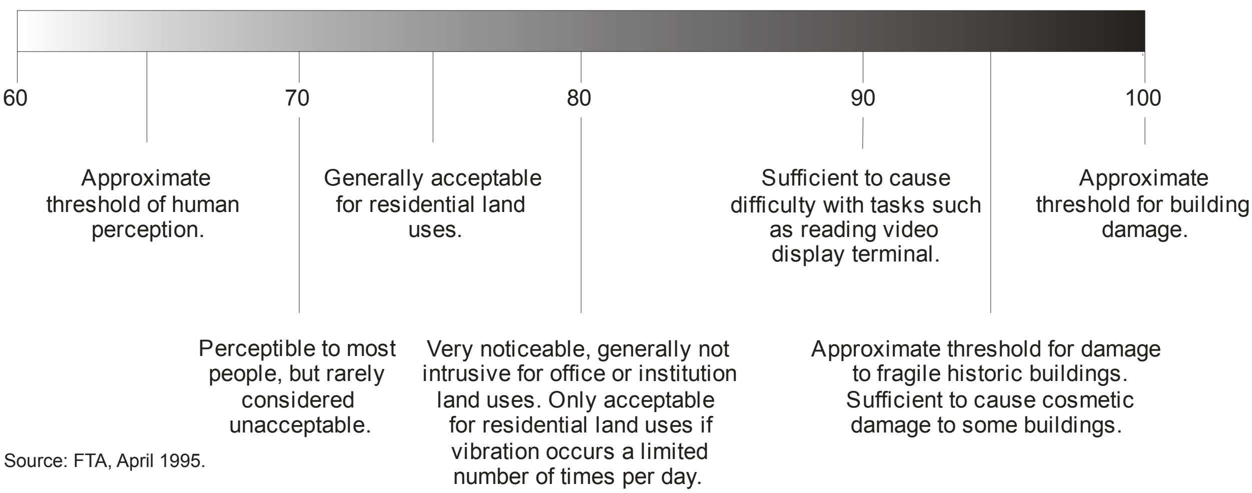
The severity of impact caused by vibration is related to its velocity and is discussed in this FEIS in terms of both inches per second and decibels, as appropriate. Where the FEIS measures velocity of vibration in decibels, it is noted as "VdB" to minimize confusion with sound decibels.

WHAT ARE SOME TYPICAL VIBRATION LEVELS?

Exhibit 3.11-8 gives a general idea of human and building responses to different levels of vibration in VdB. Existing levels of building vibration from traffic and other local sources is usually in the range of 40 to 50 VdB, which is well below the range of human perception.

Exhibit 3.11-8

Human and Building Response to Ground-borne Vibration Levels



Source: FTA, April 1995.

Ground-borne Vibration vs. Ground-borne Noise

The effects of ground-borne vibration include perceived movement of building floors, rattling of windows, or shaking of items on shelves. When ground-borne vibration creates a rumbling noise inside buildings, it is called ground-borne noise.

VIBRATION CRITERIA AND ANALYSIS METHODS

What are the vibration criteria?

The FTA has developed impact criteria for acceptable levels of both ground-borne vibration and ground-borne noise that would apply to the light rail transit components of the project. Exhibit 3.11-9 summarizes these FTA impact criteria as they affect most buildings. Some buildings, such as concert halls, TV and recording studios, and theaters, can be very sensitive to ground-borne vibration and ground-borne noise but do not fit into any of the three categories in Exhibit 3.11-9. Because of the sensitivity of these buildings, the FTA has developed ground-borne vibration and ground-borne noise criteria for "special buildings," as shown in Exhibit 3.11-10.

Exhibit 3.11-9

FTA Ground-borne Vibration and Noise Impact Criteria

Land Use Category	Ground-borne Vibration Impact Levels		Ground-borne Noise Impact Levels	
	Frequent[a] Events	Infrequent[b] Events	Frequent[a] Events	Infrequent[b] Events
Category 1: Buildings where low ambient vibration is essential for interior operations.	65 VdB [c]	65 VdB [c]	N/A[d]	N/A[d]
Category 2: Residences and buildings where people normally sleep.	72 VdB	80 VdB	35 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	83 VdB	40 dBA	48 dBA

a “Frequent Events” is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.

b “Infrequent Events” is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

c This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research equipment will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC system and stiffened floors.

d Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

Exhibit 3.11-10

FTA Ground-borne Vibration and Noise Impact Criteria for Special Buildings

Type of Building or Room	Ground-borne Vibration Impact Levels		Ground-borne Noise Impact Levels	
	Frequent[a] Events	Infrequent[b] Events	Frequent[a] Events	Infrequent[b] Events
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Notes: If the building will rarely be occupied when the trains are operating, there is no need to consider impacts. As an example, consider locating a commuter rail line next to a concert hall. If no commuter trains will operate after 7 p.m., it should be rare that the trains interfere with the use of the hall.

a ”Frequent Events” is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.

b “Infrequent Events” is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

What City Vibration Standards Affect the Project?

The City of Vancouver has incorporated vibration regulations into the Vancouver Municipal Code (VMC). The VMC prohibits off-site vibration impacts that are discernible without instruments at the property line. This prohibition applies to all nighttime construction activities associated with the CRC project and the operations of rail transit stations and park and ride lots. Construction activity is exempt from these vibration regulations between the hours of 7 a.m. and 8 p.m. The operations of public streets and sidewalks, rail maintenance yards, and essential public facilities such as the Interstate highway system or intercity passenger rail are also exempt from these regulations 24 hours a day.

Multnomah County and the City of Portland do not regulate vibration.

What are noise-sensitive receptors and residential equivalents?

A noise-sensitive receptor is any property where frequent exterior human use occurs and where a lowered noise level would be beneficial. The nuisance level for traffic noise is perceived differently by people depending on the situation. For instance, roadway noise may not bother people walking to a commercial establishment, but may disturb people at a backyard pool or while they are sleeping. Residential equivalency is a measurement of the amount of use at special sites such as schools, parks, churches, and hospitals. A single-family residence or an apartment unit would have a residential equivalency of 1, whereas a school or a park would have a residential equivalency of more than 1 depending on the number of hours, days, and months the facility would be occupied. Establishing the total number of residential equivalents allows for a standardized method of calculating a project or project alternative's total noise impacts and determining the reasonableness of proposed mitigation measures.

Existing Noise Levels in the CRC Main Project Area

Existing noise levels were measured at 68 locations from North Portland Harbor to SR 500 in Vancouver. Each of these locations has one or more noise receptors that constitute sensitive land uses, such as a residence, hotel, motel, or park (see sidebar). Existing noise levels in the project corridor range from 53 to 75 dBA L_{eq}, with 24-hour L_{dn} noise levels also ranging from 53 to 75 dBA.

Currently, estimated noise levels meet or exceed the traffic noise criteria for 40 noise-sensitive receptors representing 230 residential equivalents in the main CRC project area. This includes single- and multi-family residences along with several hotels and the residential equivalents for parks, schools, and a cemetery. Of the existing impacts identified in the CRC project area, 96 are located in Portland and 134 are located in Vancouver. Overall, noise levels in the main project area are dominated by traffic on I-5.

3.11.3 Long-term Effects

Without added mitigation, such as new sound walls, the locally preferred alternative (LPA) and No-Build Alternative would result in additional noise effects beyond the current noise impacts. Exhibit 3.11-11 compares the long-term unmitigated noise and vibration impacts of the LPA to the other build and No-Build alternatives.

Exhibit 3.11-11

Comparison of Long-term Noise and Vibration Impacts (Before Mitigation)

	Locally Preferred Alternative[a]						
Environmental Metric	LPA Option A	LPA Option B	No-Build[b]	Alt 2: Repl Crossing with BRT	Alt 3: Repl Crossing with LRT	Alt 4: Suppl Crossing with BRT	Alt 5: Suppl Crossing with LRT
Number of Highway Noise Impacts[c]	325 (312)	Same as Option A	270	334	334	329	329
Number of Moderate Transit Noise Impacts[d]	31	39	0	50	23	46	26
Number of Severe Transit Noise Impacts[d]	0	Same as Option A	Same as LPA	7	Same as LPA	26	Same as LPA
Number of Transit Vibration Impacts	15	Same as Option A	0	0	12	0	12

Note: The impacts described above assume no mitigation. Impacts would be lessened with mitigation, as described in Section 3.11.5.

a Information in parentheses indicates impacts if the LPA Option A or B is constructed with highway phasing.

b The No-Build study area is the same as under the LPA.

c In the DEIS analysis of the build alternatives (Alternative 2 through Alternative 5), retention of the existing highway noise walls was assumed in the future traffic noise model analysis. The number of highway noise impacts listed for the LPA and LPA with highway phasing are higher than they would be otherwise because they assume the removal, with no replacement, of the existing noise walls. If retention of the existing noise walls were assumed for the LPA analysis, the number of impacts from the LPA would be reduced to slightly higher than shown above for the No-Build.

d The number of transit noise impacts reported for Alternative 2 through Alternative 5 are taken from the DEIS, assuming the Clark College MOS transit terminus option and McLoughlin Street alignment. The LPA assumes a 17th Street alignment that was not evaluated in the DEIS.

Currently, there are an estimated 230 traffic noise impacts to noise-sensitive land uses; that number would rise to 270 under the No-Build Alternative. Under the No-Build Alternative, routine maintenance of the existing noise walls in Vancouver would occur, but no new noise walls would be constructed. Background traffic growth would cause an increase in traffic noise levels throughout the project area.

Without mitigation, traffic noise impacts are expected to increase with the LPA (Options A and B) compared to existing conditions and the No-Build Alternative. Without mitigation, the traffic noise impacts under the LPA would occur at 325 residential equivalents. The LPA with highway phasing option would defer various ramp improvements including improvements at the SR 500 interchange with I-5. By delaying this improvement, 13 traffic noise impacts to homes south of SR 500 would be deferred. Mitigation that is recommended to be constructed along this deferred ramp improvement would be constructed at the time the ramp improvements are built.

In the DEIS analysis of the other build alternatives (Alternative 2 through Alternative 5), the existing noise walls were included in the future traffic noise model analysis. For the FEIS, the number of highway noise impacts listed for the LPA and LPA with highway phasing include the effect of removing the existing noise walls along I-5 in Vancouver. This change in methodology for the FEIS ensures that any proposed noise wall heights are appropriately established by crediting the new walls with the total amount of noise reduction each wall would ultimately provide. If the existing noise walls were included in the LPA analysis, the number of impacts from the LPA would decrease by approximately 50 residential equivalents in the Vancouver area where the existing noise walls are located. The design of the LPA within the Portland area includes 3.5-foot safety barriers along all of the elevated structures. The traffic noise modeling in the Portland area indicates that there would be no traffic noise impacts to any of the noise-sensitive properties identified.

Moderate light rail transit noise impacts were also identified for several floating homes and single-family residences, including 31 impacts under LPA Option A and 39 impacts under LPA Option B. Under LPA Option A, there are 16 floating homes predicted to meet or exceed the FTA noise impact criteria. With LPA Option B, the number of floating homes exceeding the FTA criteria increases to 24. All floating-home impacts are in Portland, near the Jantzen Beach area. LPA Option A provides a lower number of impacts because its local traffic lanes would help shield floating homes from light rail operations and because of the increased distance from the light rail alignment to the floating homes. No other light rail impacts were identified in the Portland segment of the transit corridor.

In the Vancouver area, noise levels were evaluated for all sensitive properties along the corridor. Along 17th Street between C and G Streets, 15 single-family residences were identified with light rail noise levels (prior to mitigation) that meet or exceed the FTA criteria. East of G Street, the existing background highway noise levels are high enough that there would be no noise impacts due to light rail operations. The noise analysis includes the added noise related to the warning bells at the proposed crossing gates.

Finally, unmitigated vibration levels are predicted to exceed the FTA criteria on the lower floors of Smith Tower. There are also vibration impacts predicted at 14 homes along E 17th Street between C and G Streets. Vibration impacts are the same regardless of the selected LPA alternative. No other vibration impacts were identified in the corridor.

Ruby Junction Maintenance Facility

The Ruby Junction Maintenance Facility in Gresham, Oregon, would need to be expanded to accommodate the additional light rail vehicles (LRVs) associated with the CRC project. Improvements include additional storage for LRVs and other maintenance material, expansion of LRV maintenance bays, and expanded parking for additional personnel. A new operations command center would also be required, and would be located either at Ruby Junction or at the existing central TriMet facility. DEQ Noise Control Regulations (Exhibit 3.11-7) apply to any noise levels generated by the Ruby Junction Maintenance Facility. The operation of the expanded Ruby Junction Maintenance Facility is not expected to result in noticeable increases in long-term noise or vibration levels.

Park and Rides

With the LPA, the following three park and ride lots would be built in Vancouver along the light rail transit alignment:

- **Columbia Park and Ride.** Located within the block bounded by Washington, Columbia, and 5th Streets, and the block between 3rd and 4th Streets. This facility would have five floors above ground and would contain approximately 570 parking spaces.
- **Mill Park and Ride.** Located in the block surrounded by Washington and Main Streets and 15th and 16th Streets. This facility would have four floors, with active use space (which could include retail) on the ground floor. The current design includes 420 parking spaces.
- **Clark Park and Ride.** The largest park and ride would be built at the Clark College terminus. This facility would have five floors and contain approximately 1,910 parking spaces.

The noise generated by these park and rides would be subject to VMC regulations. Based on the proposed locations of the three park and rides and the distance to noise-sensitive land uses, the operation of the park and rides is not expected to result in long-term noise impacts.

Indirect Effects

The indirect effect of the LPA on population and employment distribution and land use patterns is expected to promote more transit-oriented development (TOD) around the new transit stations and to support a minor redistribution in future population and employment growth from outlying areas to the I-5 corridor. This increased density and activity would likely result in further minor increases in ambient noise in the main project area. Because this new residential and commercial development is expected to occur in highly urbanized areas that already experience a fairly high level of background noise, indirect noise effects are anticipated to be minor. This development is also not expected to produce any long-term adverse vibration effects.

3.11.4 Temporary Effects

Temporary effects have been divided into "on-site" and "off-site" construction effects. On-site refers to construction-related activities within the main project area and at the Ruby Junction Maintenance Facility. Off-site refers to construction activities that would take place at major project casting and staging areas, some of which are located outside the main project area.

On-site Construction

CONSTRUCTION ACTIVITIES

Constructing the CRC project would require equipment and machinery that are common to roadway, transit, and structural projects. Exhibit 3.11-12 provides a list of the typical types of equipment used for this kind of construction, the corresponding activities, and the corresponding maximum noise levels as measured at 50 feet from the noise source, under normal use.

Exhibit 3.11-12

Construction Equipment List, Use, and Reference Maximum Noise Level

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

Notes:

a Maximum noise level as measured at a distance of 50 feet under normal operation. Maximum noise level estimates are based on measurements of noise generated by equipment used in the construction of similar projects.

CONSTRUCTION NOISE

From a construction noise perspective, four general construction phases would be required to complete the project:

- Preparing for construction of new structures.
- Constructing new structures and paving roadways.
- Conducting miscellaneous activities, including striping, lighting, and erecting signs.
- Demolishing existing bridge structures.

Preparation

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

Other major noise sources that may be required during this phase would include the use of vibratory and impact equipment to install piles or sheet piles. The purpose of these activities would be to supply support for the new structure and to shore up hillsides to prevent slides before retaining walls are installed. Pile driving noise levels are discussed in a separate section below.

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

Constructing New Structures

The loudest noise sources during construction of the new bridges would include pile drivers, cement mixers, concrete pumps, pavers, haul trucks, and tractor trailers. The cement mixers and concrete pumps would be required for construction of the superstructure. The pavers and haul trucks would be used to provide the final surface for 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 the heavy construction, general construction activities would occur, such as installation of bridge railings, signage, lighting, roadway striping, and others. These less intensive activities are not expected to produce noise levels above 80 dBA at 50 feet except on rare occasions, and then only for short periods of time.

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. Demolition would occur at various locations and times during the construction process.

Exhibit 3.11-13 provides the noise levels for each of the four typical construction phases as measured at 50 feet from the construction activity. The noise levels in Exhibit 3.11-13 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 and the distance from the work site to the noise-sensitive properties.

Exhibit 3.11-13

Noise Levels for Typical Construction Phases at 50 Feet from Work Site

Scenario[a]	Equipment[b]	L_{max}[c] (dBA)	L_{eq}[d] (dBA)
Preparing for construction of new structures.	Air compressor, backhoe, concrete pump, crane, excavator, forklift, haul truck, loader, water pump, power plant, service truck, tractor trailer, utility truck, and vibratory equipment.	94	87
Constructing new structures and paving roadways.	Air compressor, backhoe, cement mixer, concrete pump, crane, forklift, haul truck, loader, paver, pump, power plant, service truck, tractor trailer, utility truck, vibratory equipment, and welder.	94	88
Conducting miscellaneous activities, including striping, lighting, and providing signs.	Air compressor, backhoe, crane, forklift, haul truck, loader, pump, service truck, tractor trailer, utility truck, and welder.	91	83
Demolishing existing structures.	Air compressor, backhoe, concrete saw, crane, excavator, forklift, haul truck, jackhammer, loader, power plant, pneumatic tools, water pump, service truck, and utility truck.	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.

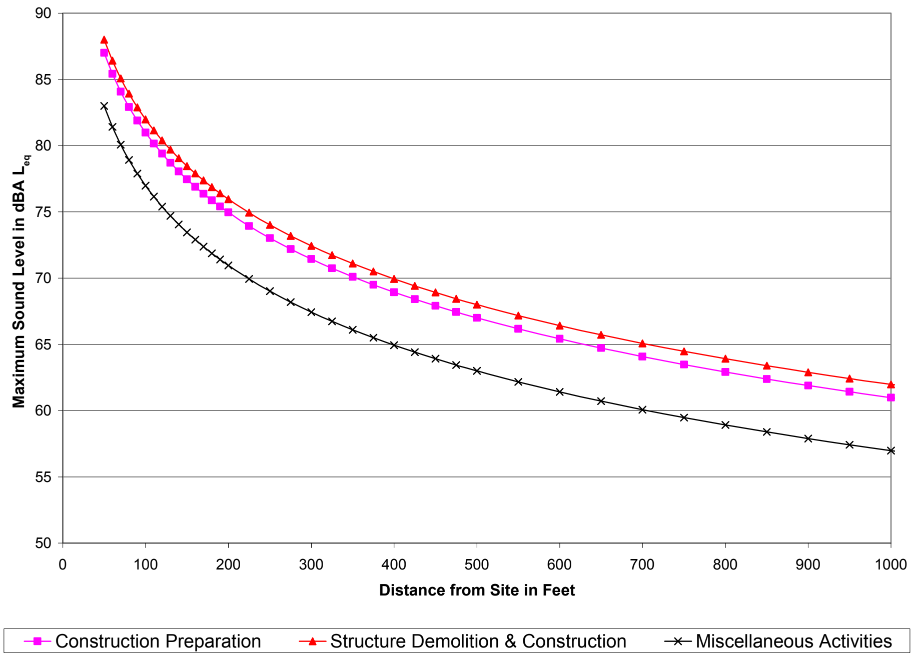
c L_{max} (dBA) is an average maximum noise emission for the construction equipment under the given scenario.

d L_{eq} (dBA) is an energy average noise emission level for construction equipment operating under the given scenario. For this type of equipment, the L_{eq} is approximately equal to the L50 (that is, noise level that is exceeded 50 percent of the time).

Project staff performed a construction noise study that assumed worst-case noise levels during each of the four general construction phases. The noise levels presented in this report are for periods of maximum construction activity. The actual noise levels experienced during construction would generally be lower than those described below.

The information in Exhibit 3.11-13 was used to predict construction noise levels for several distances from the project work area. Exhibit 3.11-14 is a graph of the construction noise level versus distance for the phases of project construction listed in Exhibit 3.11-13.

Exhibit 3.11-14
Noise Level versus Distance for Typical Construction Phases



Source: CRC Noise and Vibration Technical Report.

CONSTRUCTION VIBRATION

Vibration generated by general construction can result in vibration effects to 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 pile driving, vibratory shoring, soil compacting, and some hauling and demolition activities. Vibration effects from pile driving or 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 (approximate threshold for building damage) at distances greater than 100 feet from the construction sites. Although analysis indicates that buildings in the project area would not experience adverse vibration-related impacts from construction, owners of two historic structures (Barracks Post Hospital and Clark County Museum) have expressed concerns. See Section 3.8, Historic and Archaeological Resources, of this FEIS for further discussion of efforts to measure, monitor, and if necessary, mitigate vibration impacts to these historic structures.

The mitigation measures intended to protect marine life from pile driving hydroacoustic impacts, as described in the CRC Ecosystems Technical Report (included as an electronic appendix to this FEIS), would further reduce the potential for noise and vibration impacts to nearby noise-sensitive land uses.

Off-site Staging and Casting

Constructing the river crossing would require at least one large site to stage equipment and materials, and may also require a large site for use as a casting yard for fabricating segments of the new bridges. The potential sites for staging and bridge assembly/casting areas include the Port of Vancouver (POV) Parcel 1A, the Red Lion at the Quay Hotel site, the vacant Thunderbird Hotel site, the POV Alcoa/Evergreen West site, and the Sundial site (see Exhibit 2.3-4 in Chapter 2). Staging and casting activities would generate noticeable noise level increases at the staging and casting sites as well as in the surrounding areas. Noise-sensitive land uses nearest the Alcoa/Evergreen West, Port of Vancouver, and Red Lion at the Quay sites are located approximately 1,000 to 1,500 feet from the sites. The nearest noise-sensitive properties to the Sundial site are over 5,000 feet away. Given the distance between the noise-sensitive land uses and these staging/casting sites, no temporary noise effects are expected, based on DEQ or VMC regulations that would apply to these project construction-related activities.

The western boundary of the Thunderbird Hotel Site is within 50 feet of the adjacent Hayden Island manufactured home community. Depending on the scheduling of staging activities, the particular equipment used, and the location of the activities on the staging site, the DEQ Noise Source Standards could be exceeded at locations within the adjacent neighborhood. If this site is selected for project staging activities, additional construction noise monitoring and mitigation measures, beyond those discussed in Section 3.11.5, could be required.

3.11.5 Mitigation or Compensation

Mitigation for Long-term Adverse Effects

HIGHWAY TRAFFIC NOISE MITIGATION

Based on the locations of the predicted highway noise impacts, noise walls are the only feasible form of traffic noise mitigation. ODOT and WSDOT have established two criteria for evaluating the suitability of a noise wall for noise abatement: feasibility and reasonableness. Feasibility deals primarily with engineering considerations, such as whether substantial noise level reductions can be achieved or whether there would be a negative effect on property access. Reasonableness assesses the practicality of the abatement measure given a number of factors including cost, amount of noise reduction, and future traffic noise levels. More detailed information regarding feasibility and reasonableness criteria is presented in the CRC Noise and Vibration Technical Report, which is included as an electronic appendix to this FEIS.

Sixteen potential noise walls were evaluated for areas within the main project area where traffic noise levels are expected to approach or exceed the FHWA noise abatement criteria (NAC) (Exhibits 3.11-15 through 3.11-17). Eleven of the 16 evaluated noise walls would be included as mitigation for the project. These noise walls are all in Vancouver and are numbered Noise Walls 1 through 11. Each of these 11 noise walls was evaluated against the feasibility criteria and whether it was cost effective (a reasonableness factor) according to the WSDOT standards. See the Noise and Vibration Technical Report (included as an electronic appendix to this FEIS) for more information on this analysis.

As shown in Exhibits 3.11-15 through 3.11-17, with mitigation, the LPA traffic noise impacts to residential equivalents are reduced to 110. This is 160 fewer than the No-Build traffic noise impacts of 270.

In the Vancouver area, some neighborhoods that were evaluated for noise-wall mitigation currently have noise walls, but impacts are expected due to the inability of the existing wall designs to maintain future noise levels below the NAC. Therefore, the existing noise walls that would provide inadequate noise level reductions would be removed to allow for the construction of new, higher noise walls. In certain situations, the existing noise walls would be removed prior to constructing the project's retaining walls.

The final decision and recommendation to include noise-wall mitigation will be made during the final design process. As the project is advanced through final design, factors that affect the feasibility and cost-effectiveness of sound walls can change. In addition, should the noise-impacted residents be in opposition to the recommended noise mitigation, the recommended abatement for that particular area may not be incorporated into the project.

A detailed evaluation of each identified noise wall is given under the discussion titled Feasibility and Reasonableness Analysis of Evaluated Noise Walls, below.

Feasibility and Reasonableness Analysis of Evaluated Noise Walls

VNHR Noise Wall/East of I-5

One noise wall was evaluated to mitigate traffic noise impacts to the 33 residences and residential equivalents within the VNHR area east of I-5 and north of SR 14 that would have future peak-hour noise levels that meet or exceed the NAC. This wall, designated as Noise Wall No. 1 on Exhibit 3.11-15, begins on the north side of SR 14, follows the SR 14 on-ramp to northbound I-5, and extends along the east side of I-5 to the proposed I-5 Community Connector just south of E Evergreen Boulevard. This wall would provide noise level reductions in the range of 6 to 15 dBA for the 33 residential equivalents that would have future noise levels that meet or exceed the NAC.

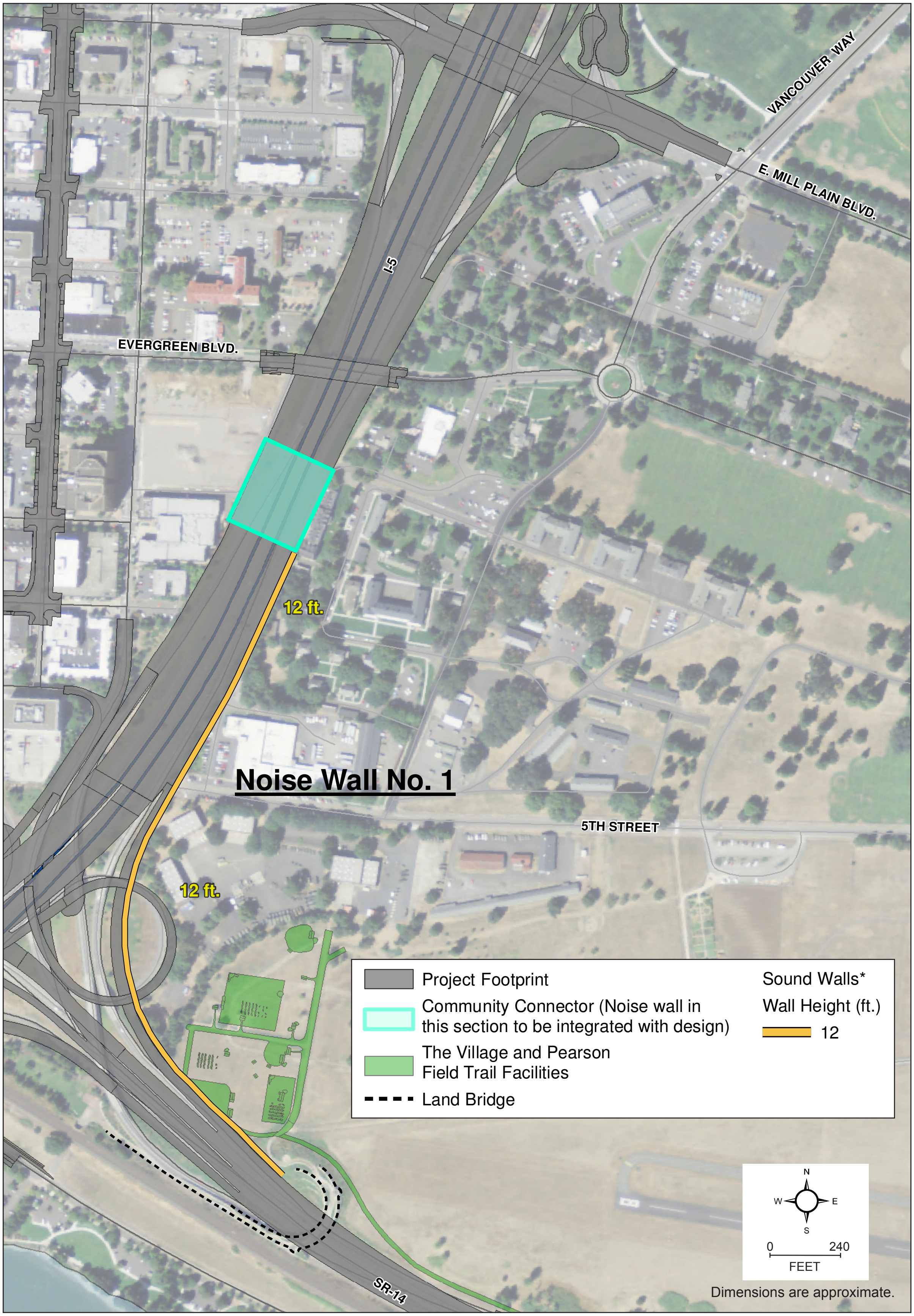
In the State of Washington, any residence or residential equivalent that receives a 3 dBA or greater reduction in noise from a noise wall is also considered to *benefit* from the wall. This is true, even if the receiver does not have noise levels that meet or exceed the NAC. The total number of benefitted properties is used to help determine the cost effectiveness of the noise wall. In addition to the 33 residential equivalents discussed above, the noise wall would provide a 5- to 7-dBA reduction to 29 residential equivalents whose noise levels did not exceed the NAC, bringing the total number of residential equivalents benefiting from the wall to 62. The proposed wall would satisfy WSDOT's feasibility requirement. The wall would also meet WSDOT's cost criteria, with the benefit exceeding the cost by $974,245. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

Downtown Vancouver Noise Wall/West of I-5

Four noise walls were evaluated for traffic noise impacts to the 71 residential equivalents in the downtown Vancouver area west of I-5. The first wall was evaluated for the 24 apartments located in the northwest corner of W 5th Street and Main Street. The apartments begin on the second floor of the five-story mixed residential/commercial building. The wall would not provide

Exhibit 3.11-15

Traffic Noise Impacts After Mitigation – VNHR



Note: Noise wall heights and locations are subject to change based on final project design.
*Sound wall symbols are not to scale.

any noticeable noise reduction for the elevated apartment homes and therefore is not recommended for the LPA or LPA with highway phasing option.

A second noise wall was evaluated for the traffic noise impacts predicted at the EconoLodge motel. A wall with heights up to 16 feet was evaluated for 12 residential equivalents but would provide less than the required noise level reduction to meet WSDOT's reasonableness criteria. There are no outdoor use areas at this motel. This wall would also not meet the WSDOT cost criteria, with the cost exceeding the benefit. This wall is not recommended for the LPA or LPA with highway phasing option.

A third wall in the downtown Vancouver area was evaluated for the six traffic noise impacts at the Normandy Apartments located at the corner of C Street and E 7th Street. A noise wall with heights ranging from 10 to 12 feet would reduce noise levels by 10 dBA for the three lower level apartments; however, all six units would still have noise levels that exceed the NAC. The wall is designated as Noise Wall No. 2 on Exhibit 3.11-16. This wall would meet WSDOT's feasibility criteria. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $165,475. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

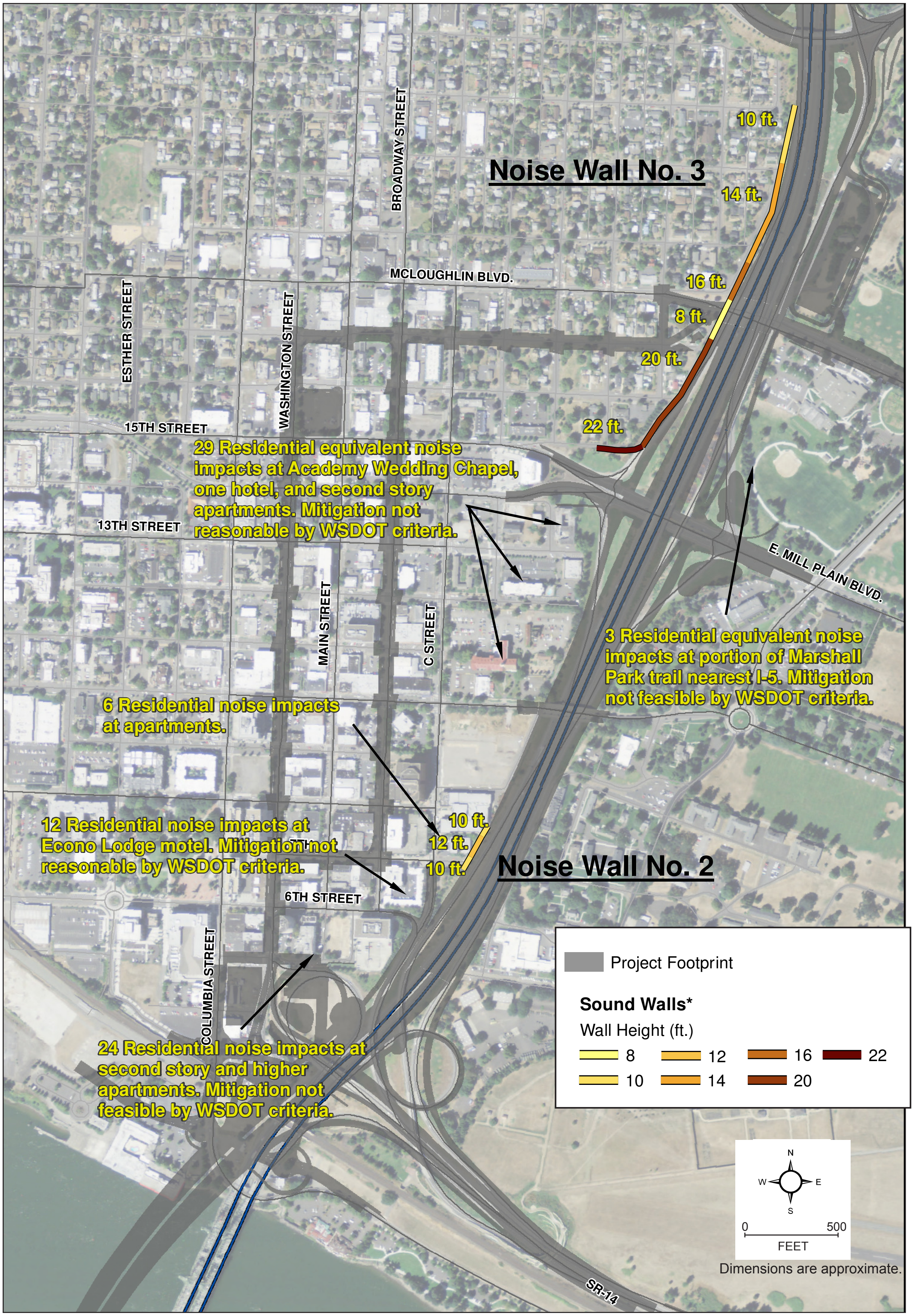
A fourth wall in the downtown Vancouver area was evaluated for the collective 29 traffic noise impacts at the outdoor pool area at the Comfort Inn & Suites, the apartments at E Street and E 13th Street, and the Academy Chapel (church used for weddings). The apartment homes are all on the second floor, with parking on the first floor. At a height of 20 feet, the noise wall would reduce noise levels at the apartment homes by 1 dBA, the outdoor motel pool area by 6 dBA, and at the wedding chapel by 4 dBA. Because, according to WSDOT criteria, at least one receiver must achieve a 7 dBA reduction, a 20-foot noise wall is not feasible by WSDOT criteria. Increasing the wall height above 20 feet was not considered because it would exceed cost-effectiveness criteria and would therefore not meet WSDOT's reasonableness requirement. This noise wall is not recommended for the LPA or LPA with highway phasing option.

E Mill Plain to E Fourth Plain Noise Wall/West of I-5
One noise wall was evaluated to mitigate the future LPA traffic noise levels that would approach or exceed the NAC at 27 residences west of I-5, between E Mill Plain and Fourth Plain.

To mitigate traffic noise impacts in this area west of I-5, a noise wall was evaluated that extends from E Mill Plain to E Fourth Plain. This wall is designated as Noise Wall No. 3 on Exhibit 3.11-16. This wall would provide noise level reductions in the range of 4 to 10 dBA for the 27 residential equivalents that would have future noise levels that meet or exceed the NAC, fully mitigating them. In addition, the noise wall would provide a 3- to 6-dBA reduction for 17 more residences, bringing the total number of residential equivalents benefiting from the wall to 44. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT's cost criteria, with the benefit exceeding the cost by $13,880. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

Exhibit 3.11-16

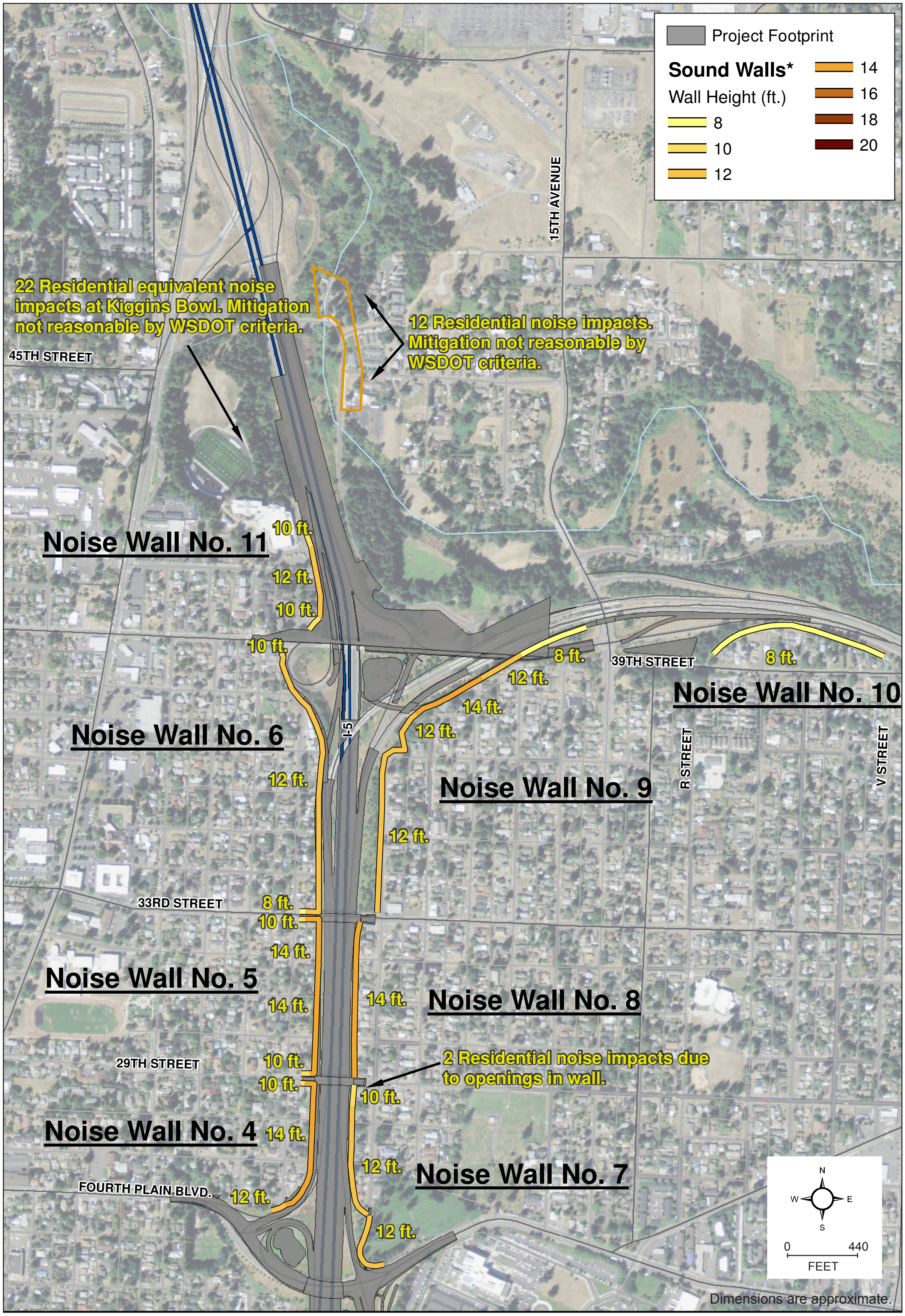
Traffic Noise Impacts After Mitigation – Downtown Vancouver



Note: Noise wall heights and locations are subject to change based on final project design.
*Sound wall symbols are not to scale

Exhibit 3.11-17

Traffic Noise Impacts After Mitigation – North Vancouver



Note: Noise wall heights and locations are subject to change based on final project design.
*Sound wall symbols are not to scale

E Mill Plain to E Fourth Plain Noise Wall/East of I-5
One noise wall was evaluated to mitigate the future LPA traffic noise levels that would approach or exceed the NAC at three residential equivalents east of I-5, between E Mill Plain and Fourth Plain.

To mitigate traffic noise impacts along the Marshall Park perimeter walking trail near I-5, a noise wall was evaluated that extends from E Mill Plain to E McLoughlin Boulevard. This wall would provide a noise-level reduction of less than 4 dBA for the three residential equivalents that would have future noise levels that meet or exceed the NAC. This noise wall would therefore not meet the WSDOT feasibility criteria and is not recommended for the LPA or LPA with highway phasing option.

E Fourth Plain to E 39th Street Noise Walls/West of I-5
Three separate noise walls (Nos. 4, 5, and 6 on Exhibit 3.11-17) were evaluated to mitigate the future LPA traffic noise levels that would approach or exceed the NAC at 62 residences west of I-5 between E Fourth Plain and E 39th Street. The three noise walls would be separated by E 29th Street and E 33rd Street. To reduce the amount of I-5 traffic noise transmission through these openings in the wall, the wall ends would wrap along E 29th Street and E 33rd Street.

To mitigate traffic noise impacts in the area west of I-5 between E Fourth Plain and E 29th Street, a noise wall was evaluated that extends from E 26th Street at E Fourth Plain along the east shoulder of J Street to E 29th Street. This wall is designated as Noise Wall No. 4 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 4 to 13 dBA for the 26 residences that would have future noise levels that meet or exceed the NAC, fully mitigating them. No other residences would receive a minimum 3-dBA reduction from the noise wall. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $892,501. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

A noise wall was evaluated to mitigate traffic noise impacts in the area west of I-5 between E 29th Street and E 33rd Street. This wall is designated as Noise Wall No. 5 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 5 to 12 dBA for the 13 residences that would have future noise levels that meet or exceed the NAC, fully mitigating them. In addition, the noise wall would provide a 5- to 8-dBA reduction for six more residences, bringing the total number of residences benefiting from the wall to 19. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $237,800. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

A noise wall was also evaluated to mitigate traffic noise impacts in the area west of I-5 between E 33rd Street and E 39th Street. This wall is designated as Noise Wall No. 6 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 9 to 13 dBA for the 23 residences that would have future noise levels that meet or exceed the NAC, fully mitigating them. In addition, the noise wall would provide a 4- to 7-dBA reduction for 14 more residences, bringing the total number of residences benefiting from the wall to 37. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $693,431. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

E Fourth Plain to SR 500 Noise Walls/East of I-5

Four separate noise walls (Nos. 7, 8, 9 and 10 on Exhibit 3.11-17) were evaluated to mitigate the future LPA traffic noise levels that would approach or exceed the NAC at 87 residences and residential equivalents east of I-5 from E Fourth Plain to areas east along SR 500. The first three noise walls would be separated by E 29th Street and E 33rd Street. The fourth wall would be located near the east end of the project along the south edge of SR 500.

A noise wall was evaluated to mitigate traffic noise impacts in the area east of I-5 between E Fourth Plain and E 29th Street. This wall is designated as Noise Wall No. 7 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 3 to 13 dBA for the 25 residential equivalents that would have future noise levels that meet or exceed the NAC. Of the 25 residences that would benefit from the wall, 23 would be considered fully mitigated; two residences would continue to have noise levels exceeding the NAC due to the required opening in the noise wall at E 29th Street. No other residences would receive a minimum 3-dBA reduction from the noise wall. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $827,512. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

A noise wall was evaluated to mitigate traffic noise impacts in the area east of I-5 between E 29th Street and E 33rd Street. This wall is designated as Noise Wall No. 8 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 7 to 13 dBA for the 19 residences that would have future noise levels that meet or exceed the NAC, fully mitigating them. One additional residence would receive a 7-dBA reduction from the noise wall. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $489,992. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

A noise wall was evaluated to mitigate traffic noise impacts in the area east of I-5 between E 33rd Street and NE 15th Street. This wall is designated as Noise Wall No. 9 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 3 to 10 dBA for 30 residences that would have future noise levels that meet or exceed the NAC, fully mitigating them. In addition, the noise wall would provide a 4- to 7-dBA reduction for 13 more residences, bringing the total number of residences benefiting from the wall to 43. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $364,119. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

To mitigate traffic noise impacts south of SR 500, a noise wall was evaluated that extends along the south side of SR 500 between R Street and V Street.

This wall is designated as Noise Wall No. 10 on Exhibit 3.11-17. This wall would provide noise level reductions in the range of 8 to 10 dBA for 13 homes that would approach or exceed the NAC, fully mitigating them. This wall would satisfy WSDOT's feasibility requirement. This wall would also meet WSDOT cost criteria, with the benefit exceeding the cost by $71,661. This wall would be included as mitigation for the LPA. This wall is outside the project area for the LPA with highway phasing option.

North of SR 500 Noise Wall/East of I-5

A noise wall was evaluated along the east side of I-5 northbound to mitigate traffic noise impacts that would occur to 12 homes north of SR 500. This wall would provide noise level reductions in the range of 4 to 7 dBA for the 12 homes. No additional homes would receive a noise-reduction benefit from the noise wall. This wall would satisfy WSDOT's feasibility requirement. However, this wall would not meet WSDOT cost criteria, with the cost exceeding the benefit. This wall is not recommended for the LPA or LPA with highway phasing option.

North of E 39th Street Noise Wall/West of I-5

To mitigate traffic noise impacts to the eight residences in this area and the 22 residential equivalents for Kiggins Bowl, a long noise wall was evaluated that would begin along the north side of E 39th Street and would wrap north along the western side of I-5 southbound. Although this wall would provide noise level reductions in the range of 3 to 11 dBA for the collective 30 residences/residential equivalents, fully mitigating them, this wall would not satisfy WSDOT's feasibility requirement. A separate wall design of shorter length was considered for the eight residences. This noise wall, designated as Noise Wall No. 11 on Exhibit 3.11-17, would be constructed on the west side of I-5 from East 39th Street to the southern portion of the Discovery Middle School. Noise Wall No. 11 would provide a noise level reduction of 12 dBA for the 8 residences, fully mitigating them. This wall would not, however, provide mitigation for Kiggins Bowl. This wall meets WSDOT's feasibility requirement and cost criteria, with the benefit exceeding the cost by $97,334. This wall would be included as mitigation for the LPA and LPA with highway phasing option.

Noise Wall Recommendation Summary

Eleven of the 16 noise walls evaluated in Vancouver meet the WSDOT feasibility and reasonableness requirements. All 11 noise walls would be included as mitigation for LPA Options A and B. Of the 11 noise walls, all but Noise Wall No. 10 are recommended for the LPA with highway phasing options, as this wall is outside these options' smaller project area. The five noise walls analyzed but not recommended for the LPA either did not provide sufficient noise reduction and/or had costs that exceeded their benefit under WSDOT criteria. In total, installation of the 11 noise walls would reduce the number of traffic impacts under the LPA from 325 to 110. With mitigation, the LPA would have 160 fewer traffic noise impacts than under the No-Build Alternative.

LIGHT RAIL NOISE AND VIBRATION MITIGATION

Light rail noise and vibration impacts were considered for mitigation measures as required by the FTA. The following sections provide an overview of typical noise and vibration mitigation measures and those measures included with the project.

Light Rail Noise Mitigation

Several forms of noise mitigation are commonly considered for light rail noise impacts. Potential mitigation measures evaluated for reducing noise impacts from light rail for the CRC project include:

- **Sound Barriers.** Construction of sound barriers between a roadway or guideway and the affected receivers reduces noise levels by physically blocking the transmission of noise. The heights of barriers depend on the proximity of the roadway or tracks to the barrier, location of the noise-sensitive properties, and topographical conditions. Typically, barriers for light rail are from 4 to 8 feet tall.
- **Track Lubrication at Curves.** Trackside lubricators are effective at reducing wheel squeal that sometimes occurs on tight-radius curves. There are currently several areas on existing light rail alignments that use trackside lubricators, and their effectiveness at reducing wheel squeal is documented. All curves with a radius of 300 feet or less would have lubricators installed.
- **Special Trackwork at Crossovers and Turnouts.** Gaps at some sections of special trackwork increase light rail noise by 6 dBA or more. The use of spring-rail, flange-bearing, and moveable-point frogs in place of standard rigid frogs allows gaps to remain closed, thus reducing noise levels. Another option is to install risers on standard crossovers that support the wheels over gaps, thereby reducing noise.
- **Building Sound Insulation.** Insulating affected structures can reduce noise levels inside homes that would be impacted by transit noise. This technique does not reduce exterior noise levels and is typically used as a final measure to reduce noise to acceptable levels for sensitive receptors such as residences. Although this technique is commonly used by the FTA to mitigate light rail noise impacts, the FHWA does not insulate residential structures to mitigate highway noise impacts.

Noise impacts at the floating homes would be mitigated with the installation of a sound barrier along the elevated local multimodal bridge structure (Exhibit 3.11-18). For LPA Option A, installing a 3- to 4-foot acoustical absorbent sound wall between the vehicular traffic lanes and the light rail alignment, or increasing the height of the traffic barrier on the west side of the local multimodal bridge structure to 6 feet, would result in acceptable mitigation for noise related to the train. Under Option B, a 2- to 3-foot acoustical absorbent sound wall or 4- to 5-foot reflective sound wall would also be effective at mitigating noise impacts to the floating homes. The selection of an absorbent or reflective wall would be made during final design.

For the 15 noise impacts along E 17th Street, the only feasible form of mitigation would be sound insulation (Exhibit 3.11-19). Because the alignment along E 17th Street is at-grade in the center of the roadway, sound walls are not feasible. Therefore, a residential sound insulation program would be used to mitigate impacts at the residences on E 17th Street.

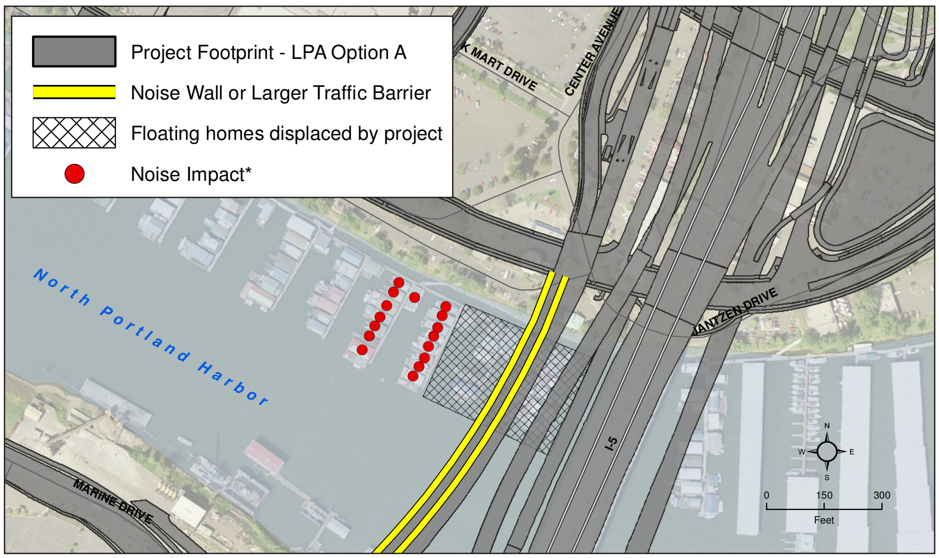
Note that the insulation of homes will not reduce the exterior noise levels. However, for the single-family residences along E 17th Street, the back yards are all well shielded from the train by the homes, so exterior noise levels in the back yards, which most people use as their primary outdoor use, are predicted to have noise levels below the FTA criteria. Only the front yards would continue to exceed the FTA criteria along E 17th Street. Finally, the warning bells for the at-grade crossing at E 17th Street and G Street would be equipped with directional shrouds to minimize noise from the bells reaching nearby residents.

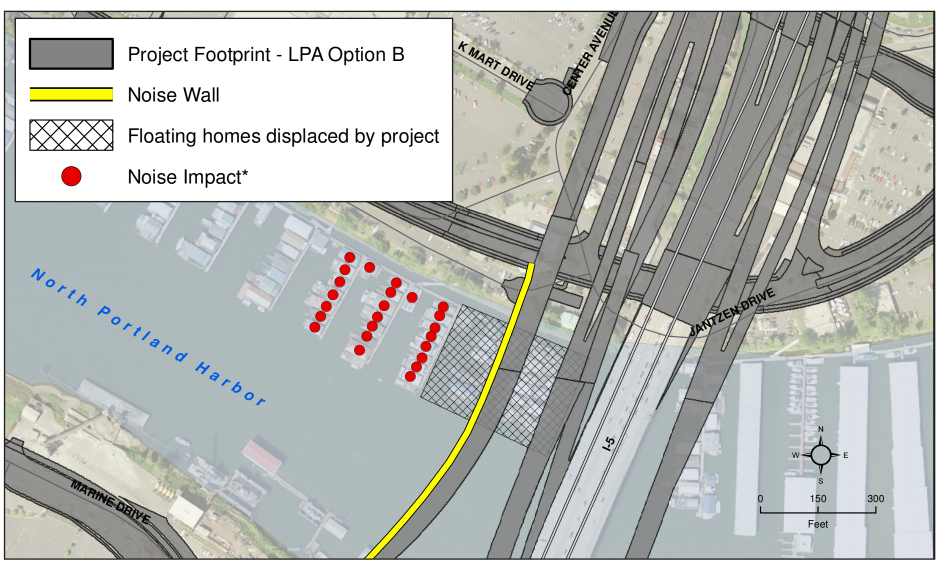
As stated in the introduction to noise mitigation, all curves with a radius of less than 300 feet would be equipped with wayside lubricators. After construction of the alignment, during the initial testing, if any additional curves are identified with wheel squeal, wayside track lubricators would be installed, as necessary.

No other light rail noise mitigation is recommended for this project.

Exhibit 3.11-18

Light Rail Noise Impact to Floating Homes in Portland



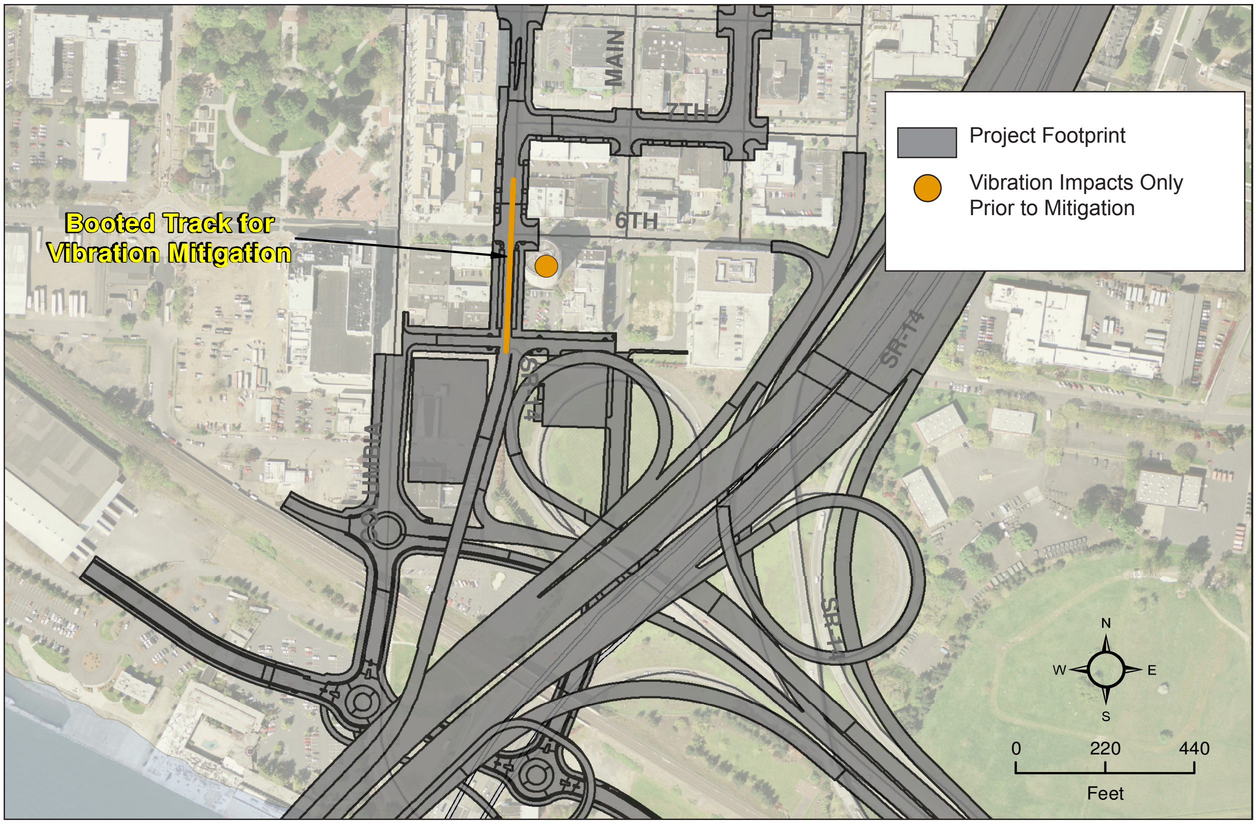


Note: Noise wall heights and locations are subject to change based on final project design. Dimensions are approximate.

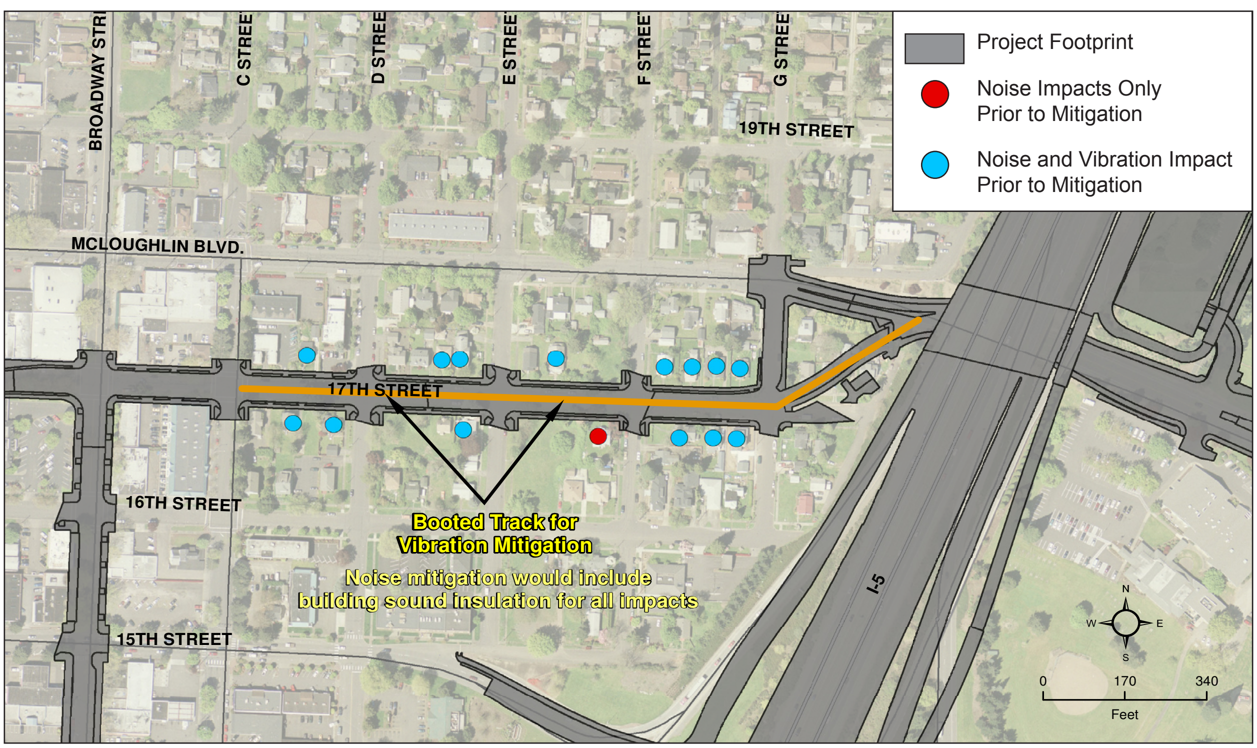
*Unlike prior exhibits for traffic noise impacts, these transit noise exhibits show impacts without mitigation. With mitigation, there are no transit noise impacts.

Exhibit 3.11-19

Light Rail Noise and Vibration Impacts to Smith Tower and E 17th in Vancouver



Dimensions are approximate.



Dimensions are approximate.

Light Rail Vibration Mitigation

Where vibration impacts are considered to be significant, they warrant consideration of reasonable and feasible mitigation. The following vibration mitigation measures were evaluated for use on this project.

- **Ballast Mats.** Ballast mats are a rubber-type material that is placed between the track ballast and the supporting concrete base. Ballast mats can be effective at reducing vibration when the frequency of the vibration impact is included as a design consideration.
- **Resilient Fasteners and Rail Boots.** Resilient fasteners are vibration-reducing fasteners that attach between the rail and ties. Rail boots are similar to resilient fasteners, but are used for embedded track. As with ballast mats, fasteners can be effective at reducing vibration when the frequency of the vibration impact is included as a design consideration. For locations with embedded track, rail boots can accomplish similar vibration reduction.
- **Tire Derived Aggregate (TDA).** TDA normally consists of 12 inches of shredded rubber ballast under the standard ballast. This mitigation method has been employed by transit agencies, but further research is needed before committing to TDA as a vibration mitigation measure.
- **Special Trackwork at Crossovers and Turnouts.** According to the FTA, rail gaps of special trackwork may increase light rail vibration by about 10 VdB under some conditions. The use of spring-rail, flange-bearing, or moveable-point frogs in place of standard rigid frogs allows the gaps to remain closed as LRVs travel across the trackwork, reducing vibration levels.

Without mitigation, vibration impacts are expected at the Smith Towers and 14 single-family residences along E 17th Street (Exhibit 3.11-19). No impact was identified at 700 Washington. Because all the vibration impacts are along embedded guideway, which does not use ballast, the use of rail boots is the only feasible form of mitigation. With the LPA, rail boots would be installed along the entire embedded track portion of the alignment; this is expected, on average, to reduce vibration levels by 5 VdB. This vibration reduction is predicted to reduce vibration levels at impacted properties to, or below, the FTA 72 VdB criteria for residential land uses. No other vibration mitigation would be required for the LPA. Additional testing will be performed during final design to assure that vibration levels at all impacted receivers are below the 72 VdB criteria.

In addition to residential vibration mitigation, the LPA includes minor modifications to the existing light rail track and electrical system on the Steel Bridge. These improvements will allow for increased travel speeds of LRVs, travel speeds that would otherwise result in vibration impacts disrupting the LRV signaling and electrification system. More information on Steel Bridge improvements is included in Section 2.2 of this FEIS.

Summary of Noise and Vibration Mitigation Effectiveness

With the identified mitigation measures, the number of expected noise impacts would be reduced substantially throughout the project area. The mitigation measures for the transit vibration impacts would likely eliminate the projected vibration impacts at all vibration-sensitive land uses. Exhibit 3.11-20 summarizes the effectiveness of the recommended noise and vibration mitigation measures. The projected impacts for the No-Build Alternative are included for comparative purposes. No mitigation measures would be included with the No-Build Alternative.

Exhibit 3.11-20
Noise and Vibration Impacts With and Without Recommended Mitigation

Environmental Metric	Locally Preferred Alternative (without Mitigation)[a]		Locally Preferred Alternative (with Mitigation)		No-Build Alternative (Mitigation not Provided)
	LPA Option A	LPA Option B	LPA Option A	LPA Option B	
Number of Highway Noise Impacts	325 (312)	Same as Option A	110	Same as Option A	270
Number of Moderate Transit Noise Impacts	31	39	0	Same as Option A	Same as LPA
Number of Severe Transit Noise Impacts	0	Same as Option A	0	Same as Option A	Same as LPA
Transit Vibration Impacts	15	Same as Option A	0	Same as Option A	Same as LPA

a Information in parentheses indicates impacts if the LPA Option A or B is constructed with highway phasing.

It should be noted that the noise and vibration mitigation measures discussed in this section are based on the existing land uses and the most current project design files. The noise and vibration analysis would be refined during the final project design to determine the details of the final mitigation measures. If at that time there is a change in the location or severity of noise and vibration impacts due to design modifications or land use changes, the mitigation measures presented would be modified to meet the requirements of the revised project design or project area land use.

Mitigation for Adverse Effects during Construction

ODOT's Section 292.32 identifies the following construction noise abatement measures:

- No construction will be performed within 1,000 feet of an occupied dwelling unit on Sundays, legal holidays, or between the hours of 10 p.m. and 6 a.m. on other days, without the approval of the ODOT construction project manager.
- All equipment used will have sound-control devices no less effective than those provided on the original equipment. No equipment will have unmuffled exhaust.
- All equipment will comply with pertinent equipment noise standards of the U.S. Environmental Protection Agency.
- No pile driving or blasting operations will be performed within 3,000 feet of an occupied dwelling unit on Sundays, legal holidays, or between the hours of 8 p.m. and 8 a.m. on other days, without the approval of the ODOT construction project manager.

- The noise from rock crushing or screening operations performed within 3,000 feet of any occupied dwelling will be mitigated by strategic placement of material stockpiles between the operation and the affected dwelling or by other means approved by the ODOT construction project manager.

Per Section 292.32, if a specific noise impact complaint is received during construction, the contractor may be required to implement one or more of the following noise mitigation measures at the contractor's expense, as directed by the project manager:

- Locate stationary construction equipment as far from nearby noise-sensitive properties as feasible.
- Shut off idling equipment.
- Reschedule construction operations to avoid periods of noise annoyance identified in the complaint.
- Notify nearby residents whenever extremely noisy work will be occurring.
- Install temporary or portable acoustic barriers around stationary construction noise sources.
- Operate electrically powered equipment using line voltage power rather than generators.

Although WSDOT does not have construction standard specifications, WSDOT would voluntarily comply with Section 292.32 for work completed in Washington.

In addition to Section 292.32, ODOT and WSDOT would also implement additional noise abatement methods, including:

- Operation of construction equipment would be prohibited within 500 feet of any occupied dwelling unit during evening and nighttime hours (7:00 p.m. to 7:00 a.m.) and on Sundays and legal holidays, when noise and vibration would have the most severe effect.
- Limit activities that produce the highest noise levels (such as hauling, loading spoils, jack hammering, and using other demolition equipment) to 7:00 a.m. to 7:00 p.m. Maximum noise levels associated with pile driving could reach 105 dBA at distances of 50 feet. Mitigation of the noise associated with pile driving would, when possible, include auguring rather than driving piles (however, using an auger is not likely to be feasible or practical for all locations) or limiting the times the activity could take place. Other less effective methods of reducing noise from pile driving include coating the piles, using pile pads, or using piston mufflers. In the event that pile driving exceeds the limits set forth in Exhibit 3.11-5, a noise variance would be requested from the local jurisdiction.
- A construction log would 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 hotline would also be established to investigate noise complaints and compare them to the construction logs. A construction

monitoring and complaint program would help to ensure that all equipment meets state, local, and any manufacturer's specifications for noise emissions. Equipment not meeting the standards would be removed from service until proper repairs were made and the equipment retested for compliance. This procedure would apply to 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.

- Use broadband backup alarms, or restrict the use of backup beepers during evening and nighttime hours, and use spotters. In all areas, the Occupational Safety and Health Administration (OSHA) will require backup warning devices and spotters for haul vehicles.

CONSTRUCTION VIBRATION

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

Additional vibration mitigation measures intended to protect marine life are described in the CRC Ecosystems Technical Report, which is included as an electronic appendix to this FEIS.