FINAL EIS

EAST LINK PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

Appendix H2
Noise and Vibration Technical Report

SOUNDTRANSIT
CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

Washington State
Department of Transportation

U.S. Department of Transportation
Federal Transit
Administration

July 2011

SOUNDTRANSIT

SOUND TRANSIT EAST LINK PROJECT

Appendix H2

Noise and Vibration Technical Report

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Contents

Appendixes

Exhibits

Tables

Acronyms and Abbreviations

ANSI	American National Standards Institute
CFR	Code of Federal Regulations
DAT	digital audio tape
dB	Decibel
dBA	A-weighted decibel
DNL	Day-Night Equivalent Sound Level (also Ldn)
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HVAC	heating ventilation and air conditioning
Hz	Hertz
HUD	Department of Housing and Urban Development+
HVAC	heating, ventilation, air conditioning
I-90	Interstate 90
I-405	Interstate 405
Ldn	24-hour, time-averaged, A-weighted sound level (day-night)
Leq	equivalent continuous sound level
Lmax or Lm	maximum noise level
Lv	vibration velocity level
LRV	light rail vehicle
mph	miles per hour
NIOSHA	National Institute for Occupations Safety and Health
NIST	National Institute of Standards and Technology
OSHA	Occupation and Health and Safety Administration
PPV	peak particle velocity
rms	root mean square
SR	state route
TDA	tire-derived aggregate
TNM	traffic noise model
V	Velocity
VdB	vibration decibels
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

1.0 Introduction and Summary

This technical report presents a noise and vibration impact study for the Sound Transit East Link Project. The objective of the study was to assess the potential noise and vibration impacts of the planned light rail transit project.

Section 1 of this report describes the background and results of the assessment. Section 2 discusses environmental noise and vibration basics, and Section 3 describes the existing noise and vibration conditions and measurement results. The criteria used to assess noise and vibration impacts are presented in Section 4, and future noise and vibration conditions projections are described in Section 5. Section 6 summarizes the impact assessment, and Section 7 outlines potential mitigation measures. Appendix A includes noise and vibration impacts by affected alternative; Appendix B includes vibration measurement site photographs; Appendix C and Appendix D include detailed noise and vibration measurement data, respectively; Appendix E contains the detailed noise impact assessment data; and Appendix F contains two project memoranda on supplemental noise analyses.

1.1 Background

The proposed project consists of constructing and operating an 18-mile light rail system, known as East Link, between Seattle and Redmond. This system would connect with Sound Transit's Central Link at the International District/ Chinatown Station; travel east across Lake Washington via Interstate 90 (I-90) to Mercer Island, Downtown Bellevue, and Overlake; and terminate in Downtown Redmond. For evaluation purposes, the East Link study area was divided into five segments along distinct geographic boundaries. There are 24 alternatives and 5 design options spread over the following five segments:

- **Segment A, Interstate 90**
  - *Preferred Interstate 90 Alternative (A1)*
- **Segment B, South Bellevue**
  - *Preferred 112th SE Modified Alternative (B2M)*
  - Bellevue Way Alternative (B1)
  - 112th SE At-Grade Alternative (B2A)
  - 112th SE Elevated Alternative (B2E)
  - 112th SE Bypass Alternative (B3)
    - B3 - 114th Extension Design Option
  - BNSF Alternative (B7)
- **Segment C, Downtown Bellevue**
  - *Preferred 108th NE At-Grade Alternative (C11A)*
  - *Preferred 110th NE Tunnel Alternative (C9T)*
    - C9T – East Main Station Design Option
  - Bellevue Way Tunnel Alternative (C1T)
  - 106th NE Tunnel Alternative (C2T)
  - 108th NE Tunnel Alternative (C3T)
  - Couplet Alternative (C4A)
  - 112th NE Elevated Alternative (C7E)
  - 110th NE Elevated Alternative (C8E)
  - 110th NE At-Grade (C9A)
  - 114th NE Elevated (C14E)

- **Segment D, Bel-Red/Overlake**
  - *Preferred NE 16th At-Grade Alternative (D2A)*
    - D2A - 120th Station Design Option
    - D2A - NE 24th Design Option
  - NE 16th Elevated Alternative (D2E)
  - NE 20th Alternative (D3)
  - SR 520 Alternative (D5)
- **Segment E, Downtown Redmond**
  - *Preferred Marymoor Alternative (E2)*
    - E2 - Redmond Transit Center Design Option
  - Redmond Way Alternative (E1)
  - Leary Way Alternative (E4)

Within Segments D and E, there are four alternative sites for a new light rail maintenance facility:

- 116th Maintenance Facility (MF1)
- BNSF Maintenance Facility (MF2)
- SR 520 Maintenance Facility (MF3)
- SE Redmond Maintenance Facility (MF5)

The build alternatives are made up of a range of light rail routes and stations, some with adjoining park-and-ride lots. Maintenance facility alternatives are evaluated separately from the alternative routes and stations.

1.2 Summary of Results

1.2.1 Noise Impact Assessment

The results of the noise analysis indicate that the environment in the project vicinity is already affected by existing noise from traffic on major highways and local roads and from general community noise. Based on Federal Transit Administration (FTA) criteria, the East Link Project is projected, without mitigation, to cause noise impacts at the locations listed in Table 1-1. Detailed information regarding the impacts can be found in Section 6.1 and Appendix D of this report. A number of noise mitigation measures would be considered for the impacts. The two most likely methods of noise mitigation would be sound walls and sound insulation. Sound insulation treatments are typically applied to buildings in areas where walls would not be effective. The final mitigation design will depend on more detailed noise analysis during final design; however, all noise impacts can be mitigated.

In addition to the required noise analyses, Sound Transit conducted an analysis for select stations that are located within or over freeway corridors. These analyses are not reflected in Table 1-1 below. These unique locations present the potential for noise impacts on light rail patrons; however, there are no standards for this type of receptor. With sound walls at some of these stations, projected noise levels at these station locations were found to be within the range identified by the U.S. Environmental Protection Agency (EPA) as appropriate for communication at close distances.

1.2.2 Vibration Impact Assessment

Based on FTA criteria, it is projected that without mitigation, the East Link Project would cause some level of vibration and groundborne noise impacts at the locations listed in Table 1-2. However, these impacts would be related to annoyance impacts and not to building damage impacts. Section 6.2 includes detailed information regarding the impacts, and Section 7.5 discusses proposed mitigation measures. Although most impacts can be mitigated, there might be some residual impacts remaining after mitigation.

There are a number of options available for mitigating vibration impacts. The most common method is ballast mats and high compliance track fasteners. Ballast mats consist of pads made of rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. Because the vibration reduction provided by ballast mats is limited at lower frequencies, their effectiveness is dependent on the frequency content of the vibration. Track fasteners can be used to provide vibration isolation between rails and concrete slabs for direct fixation track on elevated structures or in tunnels. Mitigation measures will be evaluated in more detail during final design, and the most appropriate measures would be selected based on feasibility and cost-effectiveness.

TABLE 1-1
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe[b]			
Segment A						
Preferred Interstate 90 Alternative (A1)	N/A	1	0	0	Potential sound wall	0
Segment B						
Preferred 112th SE Modified Alternative (B2M)	*Preferred Alternative C11A*	79	0	0	Sound walls, special trackwork, and building insulation	10
	Preferred Alternative C9T	66				
	Preferred Alternative C9T with C9T - East Main Station Design Option	64	2	0		
Bellevue Way Alternative (B1)[d]	N/A	128	4	136	Special trackwork, and building insulation	141
112th SE At-Grade Alternative (B2A)[e]	N/A	77	1	17	Sound walls, special trackwork, and building insulation	17
112th SE Elevated Alternative (B2E)	N/A	85	21	0	Sound walls, special trackwork, and building insulation	5
112th SE Bypass Alternative (B3)[f]	N/A	79	4	17	Sound walls, special trackwork, and building insulation	17
B3 - 114th Extension Design Option[f]	N/A	76	1	17	Sound walls, special trackwork, and building insulation	31
BNSF Alternative (B7)	N/A	108	68	0	Sound walls and special trackwork	0
Segment C						
Preferred 108th NE At-Grade Alternative (C11A)	*Preferred Alternative B2M*	119	65	0	Sound walls, special trackwork, and building insulation	108
	Alternative B3, B3 – 114th Extension Design Option, or B7	152	52			144
Preferred 110th NE Tunnel Alternative (C9T)	*Preferred Alternative B2M*	62	57	0	Sound walls, special trackwork, and building insulation	50
	Alternative B3, B3 – 114th Extension Design Option, or B7	88	52			84
C9T – East Main Station Design Option	*Preferred Alternative B2M*	67	52	0	Sound walls, special trackwork, and building insulation	50
Bellevue Way Tunnel Alternative (C1T)[g]	Alternative B1	48	52	18	Sound walls, special trackwork, and building insulation	69
106th NE Tunnel Alternative (C2T)	Alternative B2A	48	52	0	Sound walls, special trackwork, and building insulation	48
	Alternative B2E	113	66			
	Alternative B3 or B7	66	70			

TABLE 1-1 CONTINUED
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe[b]			
108th NE Tunnel Alternative (C3T)	Alternative B2A	26	0	0	Sound walls	0
	Alternative B2E	91	14		Sound walls and special trackwork	32
	Alternative B3 or B7	44	18		Sound walls	0
Couplet Alternative (C4A)	Alternative B2A or B2E	435	15	0	Sound walls, special trackwork, and building insulation	364
	Alternative B3 or B7	420	19	0	Sound walls and building insulation	400
112th SE Elevated Alternative (C7E)	Alternative B2A or B2E	270	12	0	Sound walls and special trackwork	0
	Alternative B3 or B7	208	0		Sound walls	
110th NE Elevated Alternative (C8E)	Alternative B3 or B7	353	72	0	Sound walls	0
110th Avenue NE At-Grade Alternative (C9A)	Alternative B2A	185	56	0	Sound walls, special trackwork, and building insulation	120
	Alternative B3, B3 – 114th Extension Design Option, or B7	145	54			156
114th Avenue NE Elevated Alternative (C14E)	Alternative B3, B3 – 114th Extension Design Option, or B7	36	112	0	Sound walls and special trackwork	0
Segment D						
Preferred NE 16th At-Grade Alternative (D2A)	*Preferred Alternative C11A* or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
D2A - 120th Station Design Option	*Preferred Alternative C11A* or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
D2A - NE 24th Design Option	*Preferred Alternative C11A* or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
NE 16th Elevated Alternative (D2E)	Alternative C3T, C4A, C7E, or C8E	2	0	0	Sound wall and potential building insulation	1
	Preferred Alternative C11A or *C9T*, Alternative C1T, C2T, C9A or C14E	1	0	0	Sound wall and potential building insulation	1
NE 20th Alternative (D3)	Alternative C3T, C4A, C7E, or C8E	1	0	0	Sound wall	0
	Preferred Alternative C11A or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
SR 520 Alternative (D5)	Alternative C3T, C4A, C7E, or C8E	1	10	0	Sound wall	0
	Preferred Alternative C11A or *C9T*, Alternative C1T, C2T, C9A or C14E	0	10	0	Sound wall	0

TABLE 1-1 CONTINUED
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts[a,b]		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe[b]			
Segment E						
Preferred Marymoor Alternative (E2)	All Segment D alternatives	33	148	0	Sound wall, special trackwork, and building insulation	168
E2 - Redmond Transit Center Design Option	All Segment D alternatives	81	100	0	Sound wall, special trackwork, and building insulation	168
Redmond Way Alternative (E1)	All Segment D alternatives	167	150	0	Sound wall, special trackwork, and building insulation	288
Leary Way Alternative (E4)	All Segment D alternatives	66	32	0	Sound wall, special trackwork, and building insulation	48

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

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

[c] These traffic noise impacts are based on the Federal Highway Administration 66 A-weighted decibel (dBA) equivalent continuous sound level (L_{eq}) impact criteria.

[d] Under Alternative B1 all but nine of the traffic noise impacts would also have light rail noise impacts; conversely, there are only five light rail impacts that would not have traffic noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 141; 5 would be impacted by light rail noise only, 9 would be impacted by traffic noise only, and 127 would be impacted by both traffic noise and light rail noise.

[e] Under Alternative B2A all but one of the traffic noise impacts would also have light rail noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 79; 62 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise.

[f] Under Alternatives B3 and B3 – 114th Extension Design Option all but one of the traffic noise impacts would also have light rail noise impacts. For B3, the total number of residences impacted (single- and multifamily) would be 84; 67 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise. For B3 – 114th Extension Design Option, the total number of residences impacted (single- and multifamily) would be 78; 61 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise.

[g] Under Alternative C1T all the traffic noise impacts are separate from light rail noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 118; 100 would be impacted by light rail noise only, 18 would be impacted by traffic noise only, and 0 would be impacted by both traffic noise and light rail noise.

TABLE 1-2
Summary of Potential Vibration Impacts

Alternative	Connection Alternatives	Before Mitigation: Number of Vibration Impacts[a]	Before Mitigation: Number of Groundborne Noise Impacts[b]	After Mitigation: Number of Vibration Impacts	After Mitigation: Number of Groundborne Noise Impacts[b]
Segment A					
Preferred Interstate 90 Alternative (A1)	N/A	None	25 single-family	None	None
Segment B					
Preferred 112th SE Modified Alternative (B2M)	*Preferred Alternative C11A* or *C9T*	None	1 (Winters House)	None	None
Preferred 112th SE Modified Alternative (B2M)	C9T – East Main Station Design Option	1 single-family	1 (Winters House)	None	None
Bellevue Way Alternative (B1)	N/A	1 single-family	None	None	None
112th SE At-Grade Alternative (B2A)	N/A	None	None	None	None
112th SE Elevated Alternative (B2E)	N/A	None	None	None	None
112th SE Bypass Alternative (B3)[c]	N/A	None	None	None	None
BNSF Alternative (B7)	N/A	None	None	None	None
Segment C					
Preferred 108th NE At-Grade Alternative (C11A)	*Preferred Alternative B2M*	2 single-family, 3 multifamily (108 units), 1 hotel	None	1 hotel	None
	Alternative B3 or B7	1 single-family, 3 multifamily (108 units), 1 hotel	None	1 hotel	None
Preferred 110th NE Tunnel Alternative (C9T)	*Preferred Alternative B2M*	7 single-family, 1 hotel	1 theater (Meydenbauer Center)	1 hotel	None
	Alternative B3 or B7	1 single-family, 1 hotel	1 theater (Meydenbauer Center)	1 hotel	None
C9T – East Main Station Design Option	*Preferred Alternative B2M*	2 single-family, 1 hotel	1 theater (Meydenbauer Center)	1 hotel	None
Bellevue Way Tunnel Alternative (C1T)	Alternative B1	1 single-family, 1 hotel	1 single-family	None	None
106th NE Tunnel Alternative (C2T)	Alternative B2A	None	None	None	None
	Alternative B2E	None	1 single-family	None	None
	Alternative B3 or B7	None	None	None	None
108th NE Tunnel Alternative (C3T)	Alternative B2A	None	12 single-family	None	None
	Alternative B2E	None	2 single-family	None	None
	Alternative B3 or B7	None	1 single-family	None	None
Couplet Alternative (C4A)	Alternative B2A, B2E, B3 or B7	1 single-family, 6 multifamily (729 units)	None	2 multifamily (176 units)	None
112th NE Elevated Alternative (C7E)	Alternative B2A, B2E, B3, or B7	None	None	None	None
110th NE Elevated Alternative (C8E)	Alternative B3 or B7	2 single-family, 3 multifamily (418 units), 1 hotel	None	1 multifamily (38 units), 1 hotel	None
110th Avenue NE At-Grade Alternative (C9A)	Alternative B2A, B3, or B7	2 single-family, 3 multifamily (108 units), 1 hotel	None	2 multifamily (68 units), 1 hotel	None

TABLE 1-2 CONTINUED
Summary of Potential Vibration Impacts

Alternative	Connection Alternatives	Before Mitigation		After Mitigation	
		Number of Vibration Impacts[a]	Number of Groundborne Noise Impacts[b]	Number of Vibration Impacts	Number of Groundborne Noise Impacts[b]
114th NE Elevated Alternative (C14E)	Alternative B3 or B7	3 hotels	None	1 hotel	None
Segment D					
All alternatives	N/A	None	None	None	None
Segment E					
Preferred Marymoor Alternative (E2)[d]	N/A	3 single-family	None	1 single-family	None
Redmond Way Alternative (E1)	N/A	3 single-family	None	1 single-family	None
Leary Way Alternative (E4)	N/A	1 single-family, 1 multifamily, 1 hotel	None	None	None

[a] Commercial and industrial buildings are only assessed for vibration impact if they contain vibration-sensitive uses.
[b] Groundborne noise is only assessed for tunnel locations.
[c] Impacts for B3 – 114th Extension Design Option would not vary from those of Alternative B3.
[d] Impacts for E2 - Redmond Transit Center Design Option would not vary from those of *Preferred Alternative E2*.

2.0 Environmental Noise and Vibration Basics

2.1 Noise Fundamentals and Descriptors

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

Another aspect of sound is the quality described as its pitch. Pitch of a sound is established by the frequency, which is a measure of how rapidly a sound wave fluctuates. The unit of measurement is cycles per second, called hertz (Hz). When a sound is analyzed, its energy content at individual frequencies is displayed over the frequency range of interest, usually the range of human audibility from 20 Hz to 20,000 Hz. This display is called a frequency spectrum.

Sound is measured using a sound-level meter with a microphone designed to respond accurately to all audible frequencies. However, the human hearing system does not respond equally to all frequencies. Low-frequency sounds below about 400 Hz are progressively and severely attenuated, as are high frequencies above 10,000 Hz. To approximate the way humans interpret sound, a filter circuit with frequency characteristics similar to the human hearing mechanism is built into sound-level meters. Measurements with this filter enacted are called A-weighted sound levels, expressed in A-weighted decibels (dBA). Community noise is usually characterized in terms of the A-weighted sound level. Exhibit 2-1 illustrates the A-weighted levels of common sounds.

The range of human hearing extends from about 0 dBA for young healthy ears (that have not been exposed to loud noise sources) to about 140 dBA. When sounds exceed 110 dBA, there is a potential for hearing damage, even with relatively short exposures. In quiet suburban areas far from major freeways, the noise levels during the late night hours will drop to about 30 dBA. Outdoor noise levels lower than this only occur in isolated areas where there is a minimum even of natural noises, such as leaves blowing in the wind, crickets, or flowing water.

Another characteristic of environmental noise is that it is constantly changing. The noise-level increase when a train passes is an example of a short-term change. The lower average noise levels occur during nighttime hours, when activities are at a minimum, and higher noise levels during daytime hours are caused by daily patterns of noise-level fluctuation. The instantaneous A-weighted sound level is insufficient to describe the overall acoustic "environment." Thus, it is common practice to condense the fluctuating noise levels into a single number, called the "equivalent" sound level (Leq). Leq can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period (typically 1 hour or 24 hours). Often the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the Day-Night Equivalent Sound Level (Ldn, also abbreviated DNL), which is defined as the 24-hour Leq but with a 10-dB penalty assessed to noise events occurring at night (defined as 10 p.m. to 7 a.m.). The effect of this penalty is that any event during nighttime hours is equivalent to 10 events during the daytime. This strongly weights Ldn toward nighttime noise to reflect most people being more easily annoyed by noise at night, when background noise is lower and most people are resting.

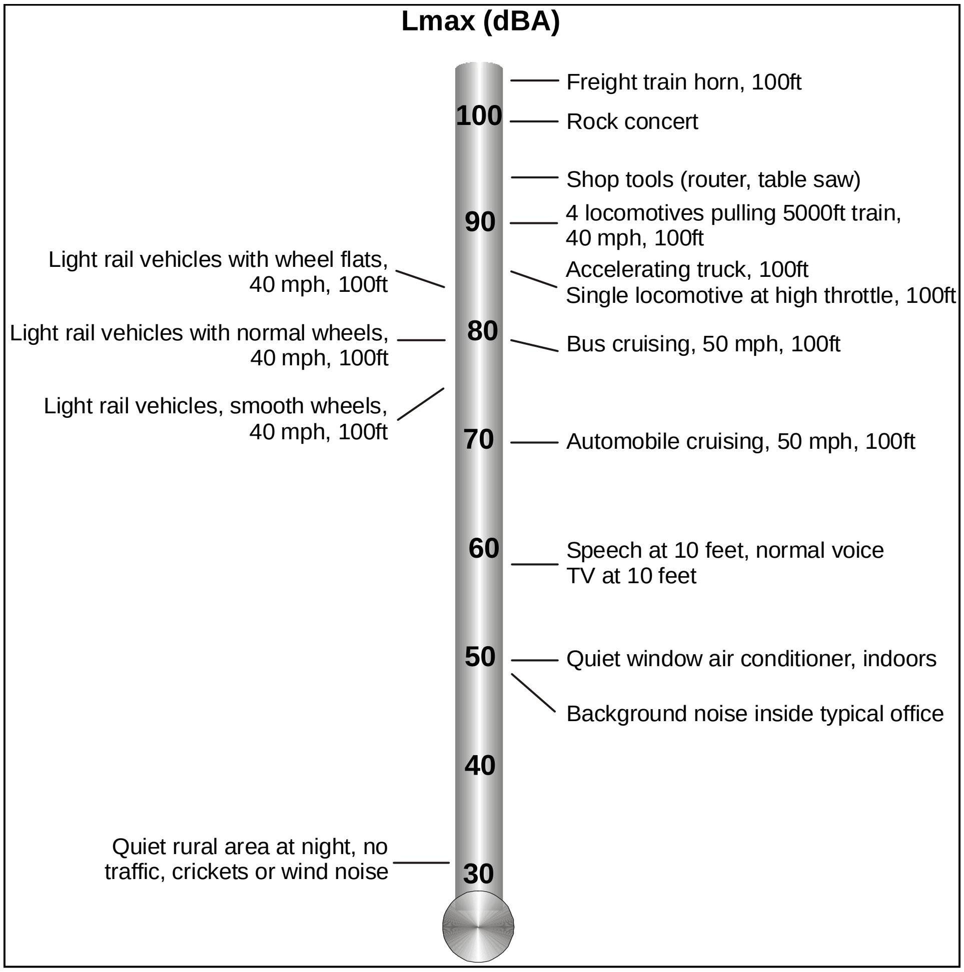


EXHIBIT 2-1
Comparison of Various Noise Levels

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

Ldn is the designated noise metric of choice for many federal agencies, including the Department of Housing and Urban Development (HUD), Federal Aviation Administration (FAA), FTA, and EPA. Although Ldn does have recognized limitations and there is still considerable discussion within the acoustical community about whether improved metrics are possible, there is general consensus that Ldn, or similar energy-based metrics, are the best available means of describing community noise environments. Most federal and state agency criteria for noise impacts are based on some measurement of noise energy. For example, the FAA and HUD use Ldn, and the Federal Highway Administration (FHWA) uses peak hour Leq. The noise impact criteria applicable to residential areas, and included in the FTA manual *Transit Noise and Vibration Impact Assessment*, use both Leq and Ldn to characterize community noise.

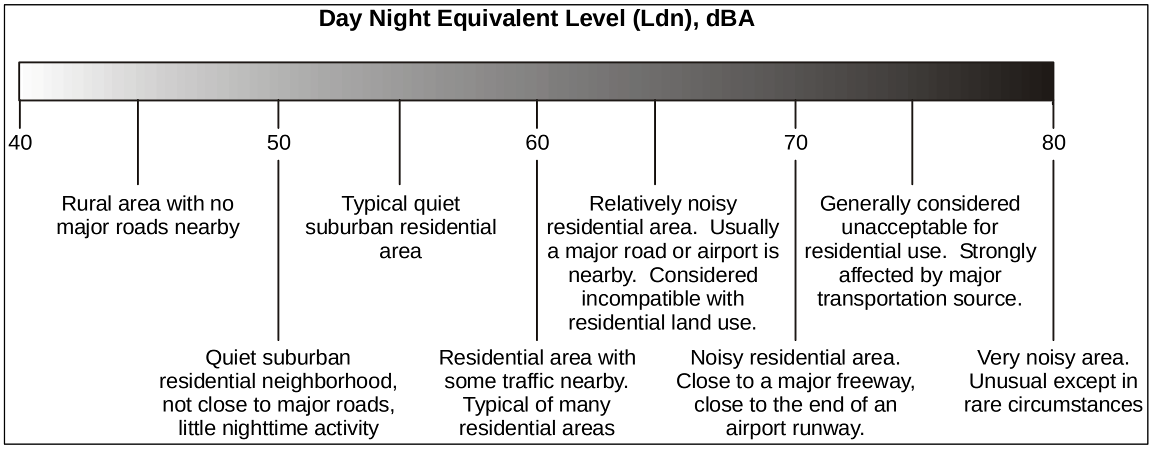


EXHIBIT 2-2
Examples of Typical Outdoor Noise Exposure

The Washington State Administrative Code (WAC) uses the maximum noise level with a set of allowable exceedances in their noise control ordinance, which is applicable to the noise analysis of ancillary facilities such as park-and-ride lots and maintenance facilities, as well as construction activities. To qualify the allowable exceedances, the commonly used noise metric—the Lnn—is used for compliance verification. The sound level descriptor Lnn is defined as the sound level exceeded "n" percent of the time. For example, the L25 is the sound level exceeded 25 percent of the time; therefore, during a 1-hour measurement, an L25 of 60 dBA means the sound level equaled or exceeded 60 dBA for 15 minutes during that hour. More detailed information on the WAC is provided in Section 4.4.1.

2.2 Vibration Fundamentals and Descriptors

Groundborne vibration is the oscillatory motion of the ground about some equilibrium position, which can be described in terms of displacement, velocity, or acceleration. Displacement refers to the distance an object moves away from its equilibrium position. Velocity refers to the rate of change in displacement or the speed of this motion. Acceleration refers to the time rate of change in the velocity of the object. At any given frequency of oscillation, vibration displacement, velocity, and acceleration are related. However, the relationship between these descriptors is complex and can vary greatly in different situations. Therefore, the relationship between the overall vibration levels in terms of these descriptors depends on the frequency content of the vibration energy.

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing groundborne vibration. One reason for this is that most sensors used for measuring groundborne vibration are designed to provide output signals proportional to either velocity or acceleration. Even more important, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration. Because sensitivity to vibration typically corresponds to a constant level of vibration-velocity amplitude within the low-frequency range that is of most concern for environmental vibration (i.e., roughly 5 to 100 Hz), vibration velocity is used in this analysis as the primary measure to evaluate the impacts of vibration.

There are several different measures used to quantify vibration amplitude. One of the most common is the peak particle velocity (PPV), defined as the maximum instantaneous positive or negative peak of the vibratory motion. PPV is often used to monitor blasting vibration because it is related to the stresses experienced by building components. Although PPV is appropriate for evaluating the potential for building damage, it is less suitable for evaluating human response, which is better related to an average vibration amplitude. Because the net average of a vibration signal about its equilibrium position is zero, the root mean square (rms) amplitude is often used to describe the "smoothed" vibration amplitude. The rms amplitude is defined as the square root of the average of the squared amplitude of the signal and is typically evaluated over a 1-second period of time.

Although vibration velocity is normally described in units of inches per second in the United States, the decibel notation, which acts to compress the range of numbers required to describe vibration, can also be used. In this notation, the vibration magnitude can be expressed in terms of velocity level, in decibels, defined as follows:

$$L_v = 20\log_{10}(v/v_{ref}), \text{VdB}$$

where:

v = rms velocity, inches/second
v_{ref} = $1\text{x}10^{-6}$ inches/second

Thus, the descriptor used for this assessment of groundborne vibration is the rms vibration velocity level, Lv, expressed in vibration decibels (VdB) relative to one micro-inch per second. Exhibit 2-3 illustrates typical groundborne vibration levels for common sources, as well as human and structural response to groundborne vibration. As shown, the range of interest is from approximately 50 VdB to 100 VdB (i.e., from imperceptible background vibration to the threshold of damage). Although the threshold of human perception to vibration is approximately 65 VdB, annoyance does not usually occur unless the vibration exceeds 70 VdB.

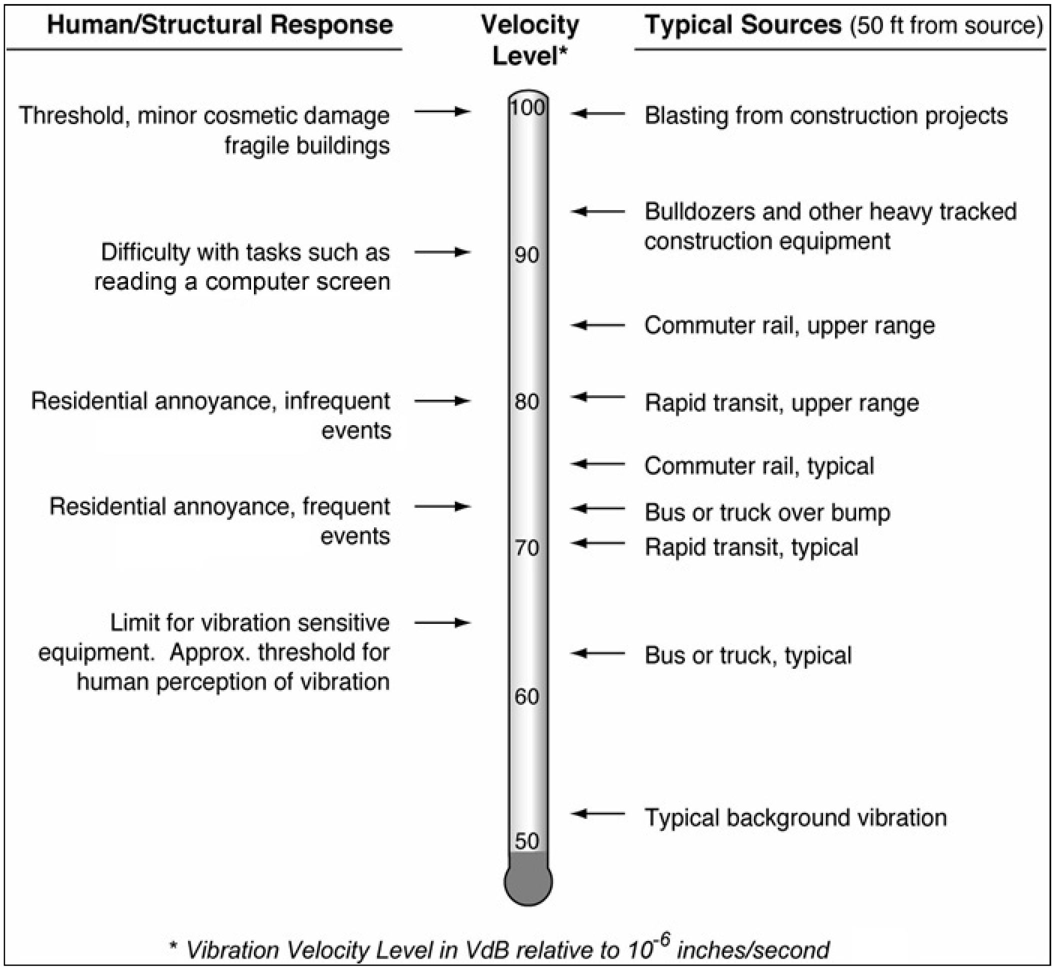


EXHIBIT 2-3
Typical Groundborne Vibration Levels and Human/Structural Response

When groundborne vibrations propagate from transit vehicles to nearby buildings, the floors and walls of the building structure will respond to the motion and may resonate at natural frequencies. The vibration of the walls and floors may cause perceptible vibration, rattling of items such as windows or dishes on shelves, or a rumbling noise. The rumble is the noise radiated from the motion of the room surfaces. In essence, the room surfaces act like a giant loudspeaker. This is called groundborne noise.

The potential annoyance of groundborne noise is often assessed using the A-weighted sound level, although there are potential problems in using the A-weighted sound level to characterize low-frequency groundborne noise. Human hearing is non-linear, which causes sounds with substantial low-frequency content to seem louder than broadband sounds that have the same A-weighted level. This is accounted for by setting A-weighted impact criteria limits lower for groundborne noise than would be the case for broadband noise.

3.0 Existing Conditions

The project corridor was examined to identify noise-sensitive locations and to select locations where noise monitoring would be performed. The following sections describe the land use along the project corridor, the existing noise-level measurements, and the current noise sources in the project corridor. While a more detailed presentation of land use can be found in Section 4.3, Land Use, in Chapter 4 of the East Link Final Environmental Impact Statement (EIS), the following land uses are summarized for their potential sensitivity to noise and vibration. Most identified land uses are sensitive to both noise and vibration. The exceptions include outdoor parks, which may be noise-sensitive, depending on usage, but are not vibration-sensitive, and vibration-sensitive equipment (such as an MRI), which is not sensitive to noise. Exhibits 3-1 through 3-5 show the different alternatives, noise monitoring locations, and existing land uses.

3.1 Land Use

3.1.1 Segment A

The Central Link connection to the East Link Project corridor is located in the International/Chinatown District, which is within walking distance to Downtown Seattle and Pioneer Square to the north, sports stadiums to the west and south, and an industrial area also to the south. Land use near the connection is mainly commercial; however, the route is already in the existing transit tunnel and therefore would not have the potential to affect adjacent land uses. The route continues along the 5th Avenue ramps of I-90, remaining in the existing I-90 corridor to the I-90 tunnel portals. I-90 crosses I-5, passing by predominantly commercial uses to the north and large greenbelt parks, residential, and commercial uses on Beacon Hill to the south. Land use along this section of the route is mainly commercial until 12th Avenue South, where there is a large group of single-family and multifamily residences along Sturgus Avenue South. Several single-family residences are also located above the Mount Baker Ridge Tunnel. The route then transitions from the tunnel to the floating bridge in an area that is also primarily single-family residential.

The I-90 corridor and light rail routes are well below grade across Mercer Island. At the western end of the island, near the I-90 bridge and tunnel, land use is residential. Most residences in this area are more than 300 feet from the proposed light rail route. Land use near the proposed Mercer Island Station includes a new park-and-ride structure and single-family residences to the north and a large multifamily building to the east. West and south of the station are the highway and connector roadways that lead to the I-90 on- and off-ramps. Also to the south of the station are midrise, mixed-use developments that either are under construction or newly opened. At the eastern end of Mercer Island, land use is primarily single-family residential with some commercial use to the south of I-90.

Parks in Segment A include Judkins Park and Playfield located near the entrance to the Mount Baker Ridge Tunnel and Sam Smith Park located above the tunnel. Other parks in Segment A include Daejeon Park and East Portal Park. There are also several parks on Mercer Island, including Park on the Lid and Luther Burbank Park, both of which are near I-90. None of these parks are considered noise-sensitive under the FTA criteria because of their proximity to I-90 and the high existing noise levels.

3.1.2 Segment B

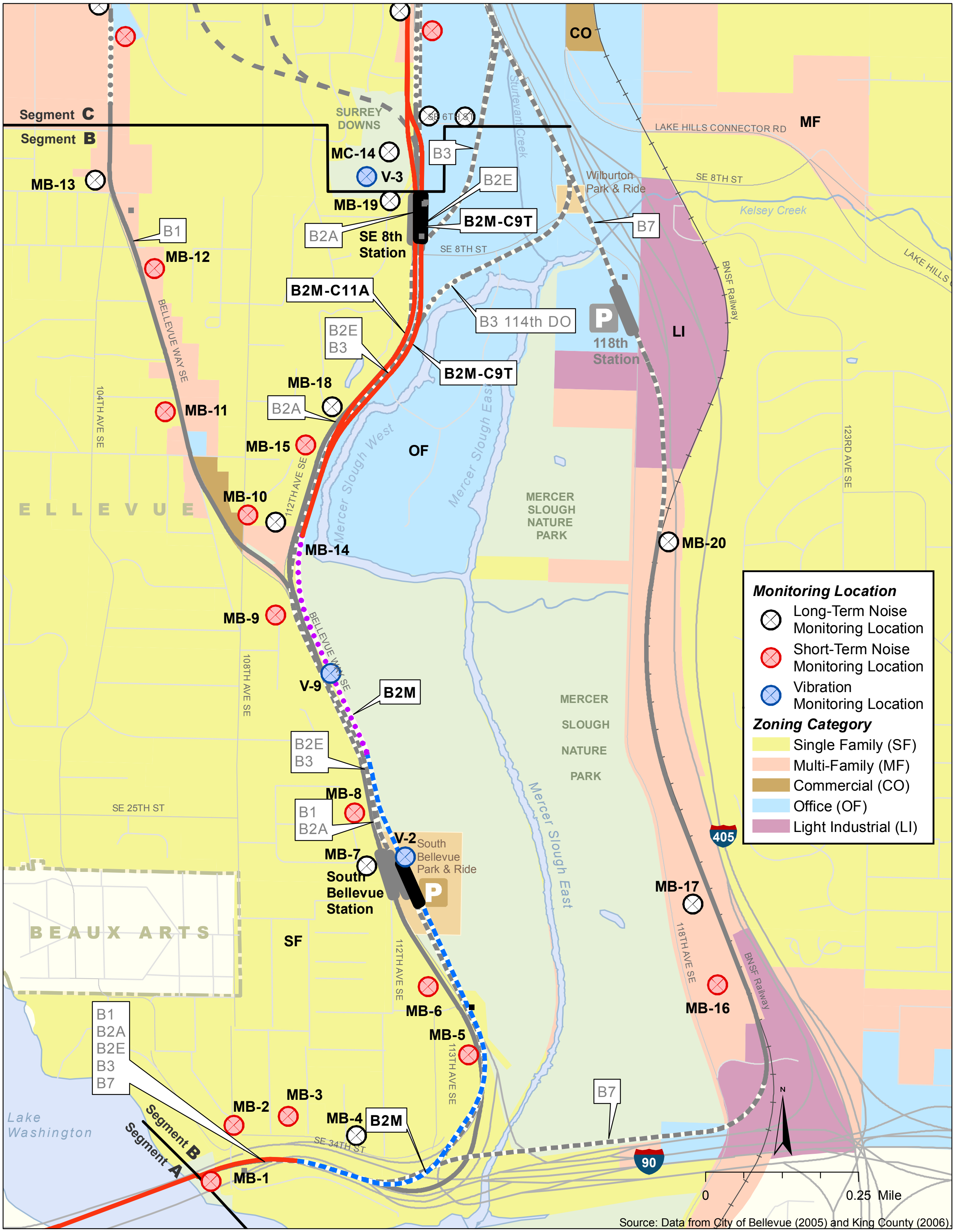
Land use in Segment B consists primarily of residences and parks, with some institutional and commercial uses. Land use in the southern end of Segment B, near Lake Washington, includes single-family residences and Enatai Beach Park. Along the west side of the Bellevue Way SE, land use is entirely residential from SE 34th Street to the intersection at 112th Avenue SE. Mercer Slough Nature Park dominates the east side of Bellevue Way. Along Bellevue Way SE between 112th Avenue SE and where Segment C begins, land use is also primarily residential; however, there are also several churches, commercial structures, and a daycare in this portion of Segment B.

The Winters House, a historic structure used for nonresidential uses, is located along the east side of Bellevue Way SE, adjacent to the Mercer Slough Nature Park. Along 112th Avenue SE, land use to the west is entirely single- and multifamily residential; to the east, land use is commercial between the intersection of Bellevue Way and SE 8th Street, transitioning to mixed commercial and hotel use from SE 8th Street to Segment C at

Source: Data from City of Seattle (2006), Sound Transit (2007), King County (2006), and City of Mercer Island (2001 and 2006).

Long-Term Noise Monitoring Location
Short-Term Noise Monitoring Location
Vibration Monitoring Location
At-Grade Route
Elevated Route
Retained-Cut Route
Retained-Fill Route
Tunnel Route
Traction Power Substation
Proposed Station
Central Link Alignment and Station
Existing Park

Exhibit 3-1 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment A**
East Link Project



Monitoring Location

- Long-Term Noise Monitoring Location
- Short-Term Noise Monitoring Location
- Vibration Monitoring Location

Zoning Category

- Single Family (SF)
- Multi-Family (MF)
- Commercial (CO)
- Office (OF)
- Light Industrial (LI)

Preferred Alternative B2M

- At-Grade Route
- Elevated Route
- Retained-Cut Route
- Retained-Fill Route
- Tunnel Route

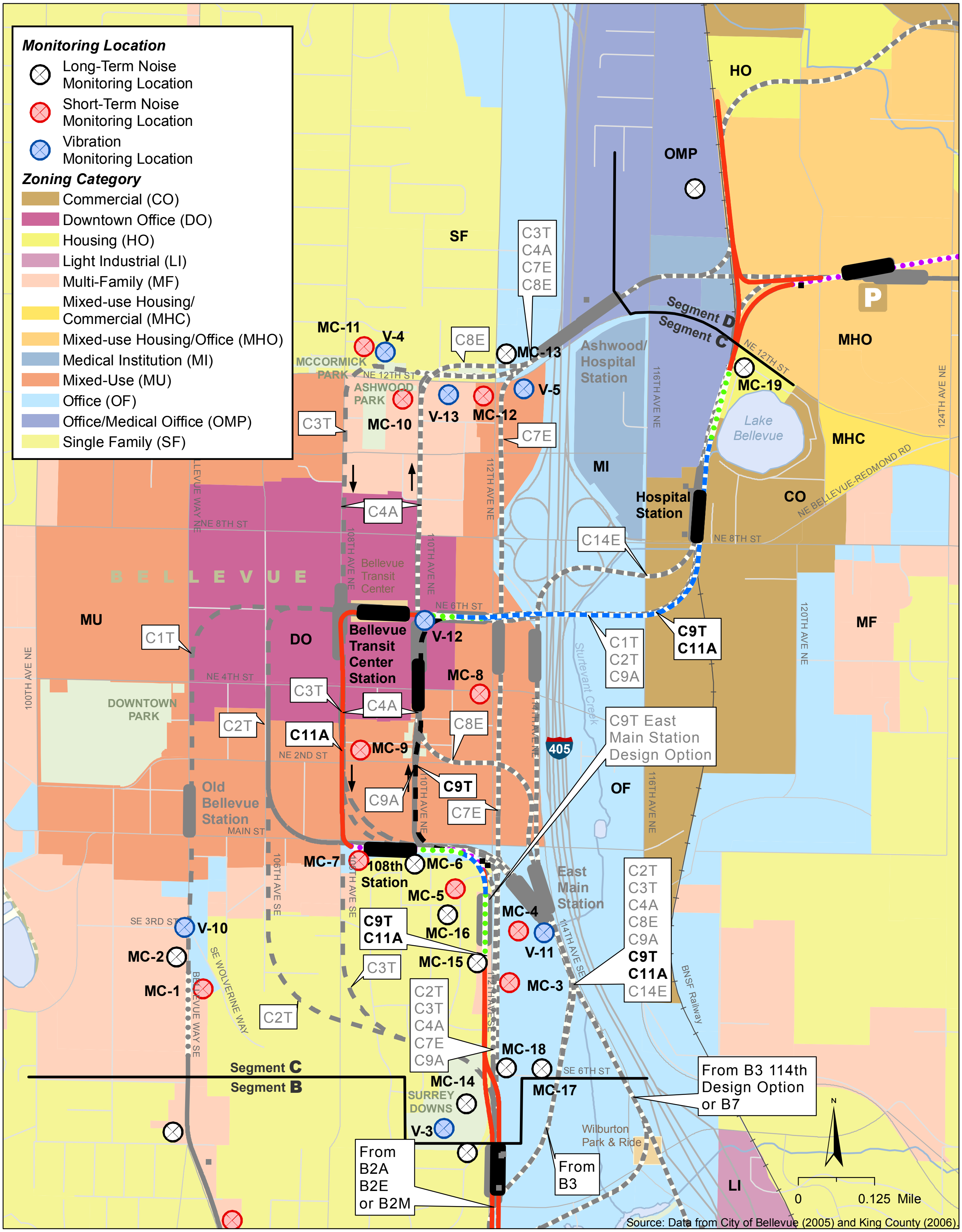
Other Alternatives B2A

- At-Grade Route
- Elevated Route
- Retained-Cut or Retained-Fill Route
- Tunnel Route

- Traction Power Substation
- Proposed Station
- New and/or Expanded Park-and-Ride Lot

Exhibit 3-2 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment B**

East Link Project



Preferred Alternative
- At-Grade Route
- Elevated Route
- Retained-Cut Route
- Retained-Fill Route
- Tunnel Route
- C9T

Other Alternatives
- At-Grade Route
- Elevated Route
- Retained-Cut or Retained-Fill Route
- Tunnel Route
- C14E

- Traction Power Substation
- Proposed Station
- P New and/or Expanded Park-and-Ride Lot

Exhibit 3-3 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment C**
East Link Project

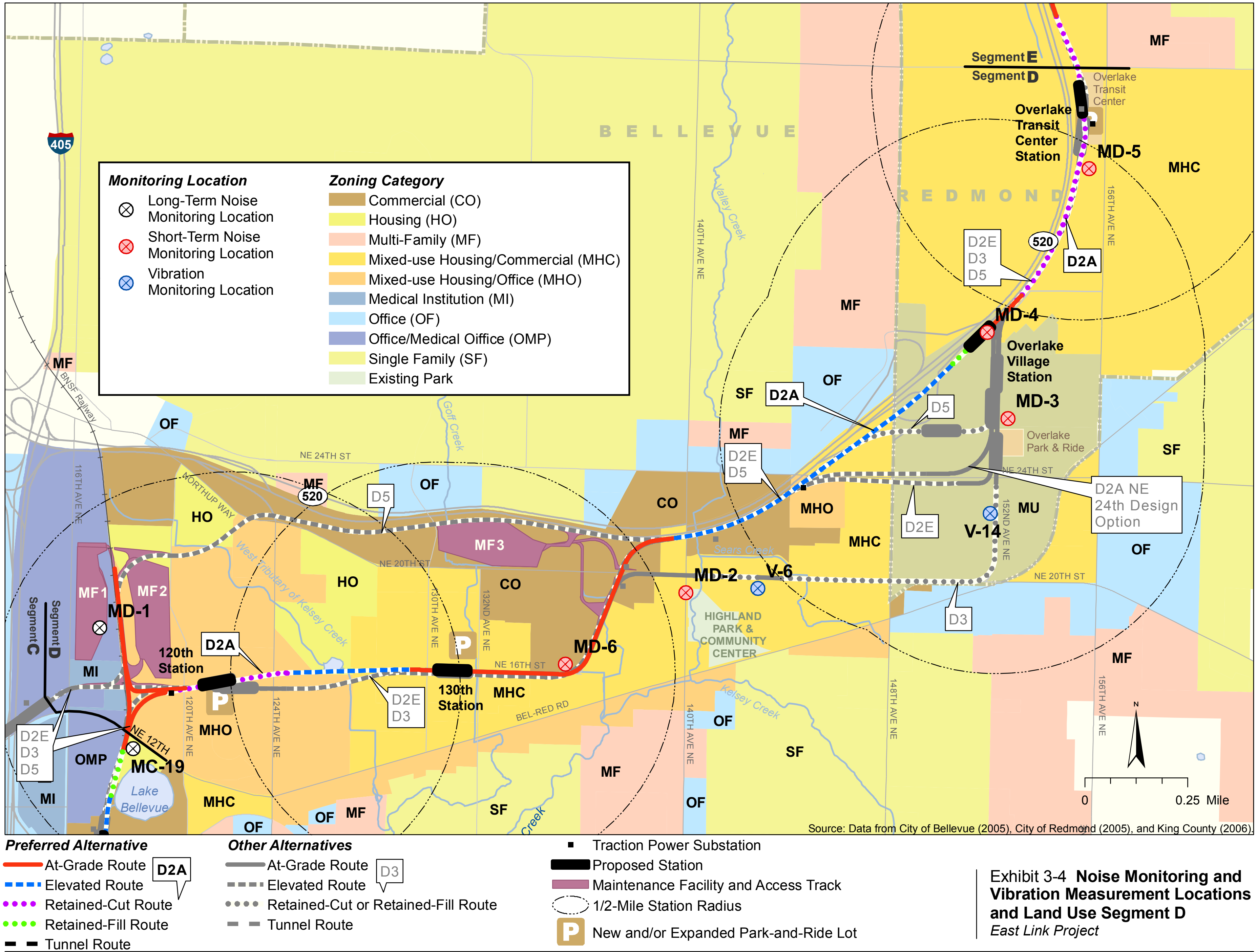
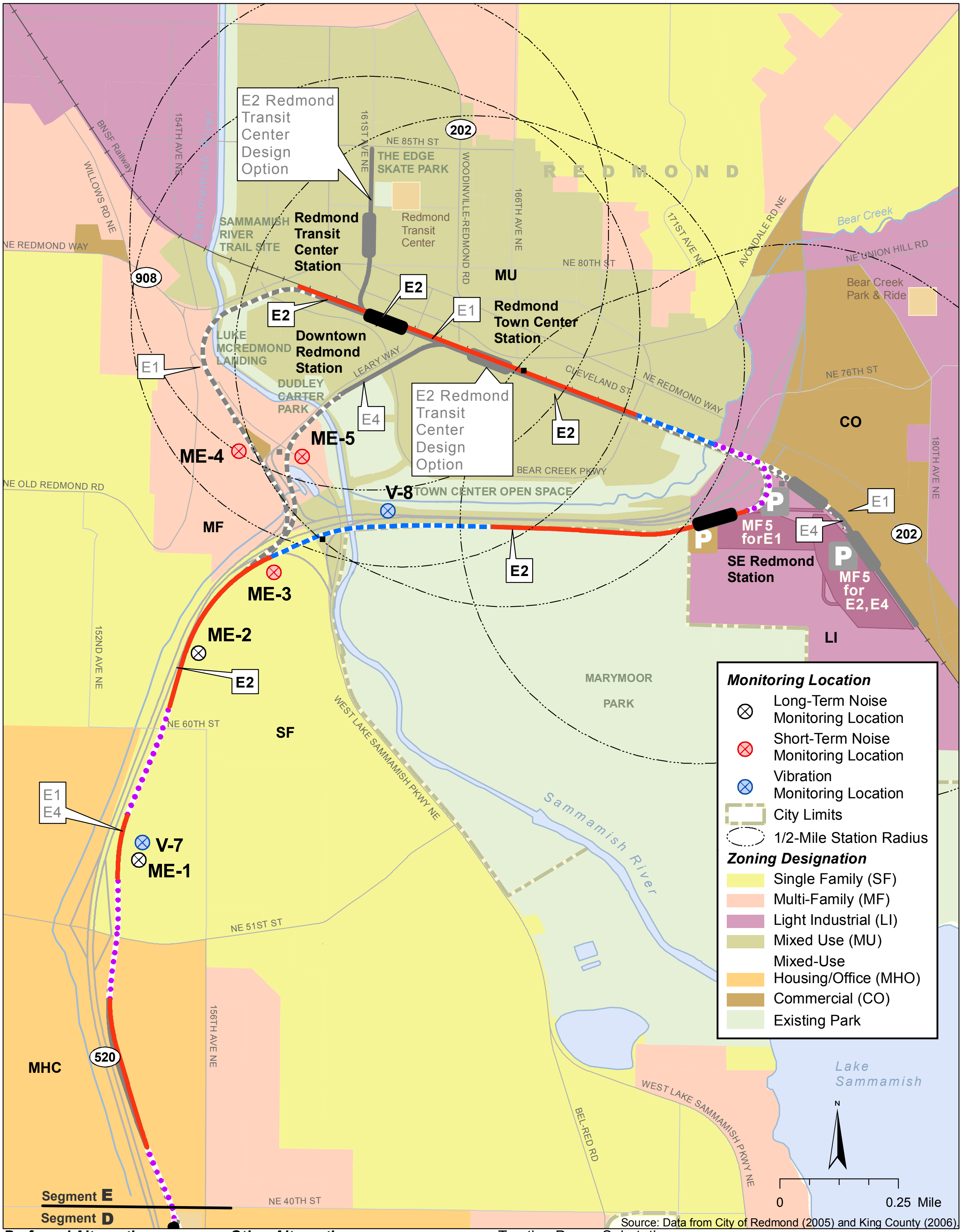


Exhibit 3-4 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment D**

East Link Project



Preferred Alternative (E2)
- At-Grade Route
- Elevated Route
- Retained-Cut Route
- Retained-Fill Route
- Tunnel Route

Other Alternatives (E1)
- At-Grade Route
- Elevated Route
- Retained-Cut or Retained-Fill Route
- Tunnel Route

- Traction Power Substation
- Proposed Station
- Maintenance Facility and Access Track
- P New and/or Expanded Park-and-Ride Lot

Exhibit 3-5 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment E**
East Link Project

SE 6th Street. Land use along the BNSF Alternative (B7) is primarily parkland north of the route, with some multifamily and commercial land uses where the alternative transitions to the former BNSF Railway corridor. Land use along the former BNSF Railway corridor includes multifamily residential and some commercial between SE 32nd Street and SE 8th Street.

Parks in Segment B include the Enatai Beach Park and the Mercer Slough Nature Park. Portions of the Enatai Beach Park and the Mercer Slough Nature Park that could be affected by the proposed project are near a major highway or major arterial roadways, including I-90 and Bellevue Way SE, and therefore are not considered noise-sensitive under FTA criteria. The only parklands in Segment B considered noise-sensitive under the FTA criteria are interior portions of Mercer Slough Nature Park, which are 350 feet or more from the proposed alternatives.

3.1.3 Segment C

Land uses in the southern section of Segment C consists of the Surrey Downs residential area and park, transitioning to commercial and office use at Main Street. Land uses along Bellevue Way and 112th Avenue SE south of Main Street are similar as in Segment B. There are some mixed-use buildings in Downtown Bellevue, with commercial uses on the ground floors and residential units on the upper floors. The Downtown Park is located near the Bellevue Way Alternative (C1T) west of Bellevue Way. Some Segment C alternatives pass by the Bellevue City Hall, the Meydenbauer Convention Center, the Bellevue Regional Library, and Ashwood Park.

In addition, residential land uses were identified along the northern edge of Downtown Bellevue. There are several multifamily residential units along 108th Avenue NE, 110th Avenue NE, and 112th Avenue NE near NE 12th Street. The Bellevue Regional Library and Ashwood Park are also located near NE 12th Street. McCormick Park is located on the north side of NE 12th Street, between 112th Avenue NE and 106th Place NE. North of McCormick Park, land use is primarily single- and multifamily residential.

Noise-sensitive land uses east of I-405 include Overlake Hospital, Group Health Medical Center, and a broad range of medical offices supporting the hospital. There is also a multifamily residential area at the north end of Lake Bellevue, along NE 12th Street.

Surrey Downs Park, an active park with playfields; Downtown Park; Ashwood Park; and McCormick Park were all reviewed for their sensitivity to noise. Because all these parks do not have noise-sensitive uses, and are located along established transportation corridors, none meet the FTA criteria for a noise-sensitive use.

3.1.4 Segment D

Land uses in the Segment D portion of the project are mainly commercial and light industrial, including retail, distribution facilities, and office spaces. There are single- and multifamily residences along 116th Avenue NE, north of NE 12th Street. There is also a multifamily residential structure along NE 21st Place, just south of State Route (SR) 520. The Pacific Northwest Ballet School is located on NE 16th Street and 136th Place NE. No other residential land use was identified near the light rail alternatives between Segment C and Overlake Center.

The noise-sensitive land use in the Overlake area is an assisted living facility. In addition, the former Eastside Hospital property is being redeveloped to a mixed residential and commercial use facility. The remaining land use in Segment D is commercial, including the Microsoft Campus and several retail complexes.

The only park in Segment D near any of the proposed alternatives is the Highland Park and Community Center, an active recreation facility with sports fields, near the NE 20th Alternative (D3). Since this park does not have noise-sensitive uses, and is located along established transportation corridors, it does not meet the FTA criteria for a noise-sensitive use.

3.1.5 Segment E

All light rail alternatives in Segment E begin at the Overlake Transit Center in the commercial area near the NE 40th Street SR 520 overpass. North of NE 51st Street, land use changes to single-family residential. Most residences in this area are located behind a sound wall along SR 520. Land use remains single-family residential to the West Lake Sammamish Parkway exit, where land uses change to multifamily residential, park, and commercial land uses south of Downtown Redmond. The *Preferred Marymoor Alternative (E2)* follows SR 520 just north of Marymoor Park, while the Redmond Way (E1) and Leary Way (E4) Alternatives pass through multifamily and commercial areas adjacent to NE Redmond Way and Leary Way.

Land use in the Downtown Redmond area varies but is mainly commercial and retail, with some mixed-use buildings with residential use on their upper floors. There are also several hotels in Downtown Redmond, including the Residence Inn on 164th Avenue NE and the Redmond Inn on Redmond Way near the proposed SE Redmond Station.

Other land uses in Segment E include Marymoor Park, and several other parks and green spaces, including Luke McRedmond Landing Park; Dudley Carter Park; the Edge Skate Park; and the Sammamish River, East Lake Sammamish and Bear Creek trails. All of these parks are near SR 520 and other major arterial roadways and are not considered noise-sensitive under FTA criteria due to active park uses and high existing noise levels. The one exception to this review is the portion of Marymoor Park that is near Lake Sammamish, which is 2,500 to 3,000 feet from the above-mentioned transportation noise sources, and is a portion of the park where low noise levels are part of its intended purpose. This portion of the park would be considered noise-sensitive under FTA criteria.

3.2 Noise Measurements

The existing noise environment was characterized through on-site inspections and on-site noise monitoring. Monitoring was performed at 55 locations, including 21 long-term (24-hour or greater) and 34 short-term (20-minute) sites. Exhibits 3-1 through 3-5 show the locations of the noise monitoring sites. The exhibits also show land use in the project vicinity and light rail alternatives. Selection of monitoring sites was based on land use, existing noise sources, alternative proximity and profile type, and ability to represent nearby noise-sensitive land uses.

All noise measurements were taken in accordance with the FTA manual *Transit Noise and Vibration Impact Assessment* and the American National Standards Institute (ANSI) procedures for community noise measurements and guidelines provided in the FTA manual. Measurement locations were at least 5 feet from any solid structure to prevent acoustical reflections and at a height of 5 feet off the ground as required by FTA and ANSI standards. The equipment used for noise monitoring included Bruel & Kjaer Type 2238 Sound Level Meters and a Larson Davis Model 820 Sound Level Meter. The meters were calibrated before and after measurement periods using a sound-level calibrator. Complete system calibration is performed on an annual basis by an accredited testing laboratory. The laboratory system calibration is traceable to the National Institute of Standards and Technology (NIST). The systems meet or exceed the requirements for an ANSI Type 1 or Type 2 noise measurement systems.

For long-term monitoring locations, the Ldn was calculated using logarithmic energy averaging for the 24-hour data with a 10-dBA penalty for noise measured between 10 p.m. and 7 a.m. For short-term monitoring locations, the Ldn levels were projected using formulas in the FTA manual *Transit Noise and Vibration Impact Assessment* and comparison to other nearby long-term noise monitoring sites.

The following sections describe the existing noise environment by project segments.

3.2.1 Segment A

Segment A had one long-term and four short-term monitoring locations. Noise levels along the proposed light rail alternative in Segment A are dominated by traffic noise from area highways, including I-5, I-90, and major arterial roadways such as Airport Way and Rainier Avenue South. The modeled Ldn near *Preferred Interstate 90 Alternative (A1)* in the Seattle area was 69 dBA. Peak-hour noise levels measured at two different representative locations ranged from 67 to 68 dBA Leq.

Near the entrance to the Mercer Island Tunnel, the modeled Ldn was 65 dBA and the measured peak-hour Leq was 65 dBA. At residences near the existing Mercer Island Park-and-Ride Lot, the modeled Ldn was 54 dBA and the measured peak-hour noise level was 51 dBA Leq. The measured Ldn at the east end of Mercer Island was 55 dBA and the peak-hour Leq was 56 dBA. It is also important to note that the short-term maximum noise levels in Segment A, which is dominated by heavy trucks on I-90, frequently exceeded 74 to 81 dBA maximum noise level (Lmax). Table 3-1 summarizes the noise monitoring for Segment A, and Exhibit 3-1 shows the monitoring sites.

TABLE 3-1
Segment A Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location No. [a]	Address	Land Use Type	Type of Measurement	Leq (peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MA-1	Taejon Park	Park	Short-term	68	69
MA-2	East Portal Park	Park	Short-term	68	69
MA-3	West Mercer Way Park	Park	Short-term	65	65
MA-4	2257 80th Avenue SE	Single-family	Short-term	51	54
MA-5	3700 East Mercer Way	Single-family	Long-term	56	55

[a] Sites shown on Exhibit 3-1.

3.2.2 Segment B

Segment B has the highest number of noise-sensitive receivers and, therefore, had the highest number of noise-monitoring locations. There were 20 noise monitoring locations in Segment B, including 7 long-term sites and 13 short-term sites. Measured existing Ldn ranged from 53 to 72 dBA. Overall peak-hour noise levels in south Bellevue ranged from 50 to 72 dBA Leq. The highest noise levels were measured at locations near I-90 and along 112th Avenue SE and Bellevue Way SE. The main source of noise in Segment B is traffic on I-90, Bellevue Way SE, I-405, and 112th Avenue SE, with heavy trucks producing the highest average noise levels.

Measured peak-hour noise levels at Enatai Beach Park were 62 dBA Leq. Noise levels at this location are lower than other locations near I-90 because the site is well below the highway and is shielded somewhat from traffic noise by crash barriers. For the residential areas along SE 34th Street (noise monitoring sites MB-2 through MB-4), the Ldn was modeled to range from 66 to 72 dBA, with peak-hour noise levels from 64 to 72 dBA Leq.

Existing noise levels at residential land uses along the southern end of Bellevue Way (MB-5 though MB-9) ranged from 53 to 72 dBA Ldn. Site MB-7 is located uphill from Bellevue Way, with some shielding from roadway noise by existing topography, resulting in lower noise levels in this area. The locations with the highest measured levels are directly adjacent to Bellevue Way and have little or no shielding from the roadway. Noise levels along the northern section of Bellevue Way SE (MB-10 through MB-13), from 112th Avenue SE to SE 6th Street, ranged from 60 to 67 dBA Leq during peak hours, and the Ldn ranged from 62 to 69 dBA. Maximum noise levels between I-90 and 112th Avenue SE ranged from 67 to 80 dBA Lmax, with an average of 74 dBA Lmax. The highest noise levels were measured at locations near I-90 and along Bellevue Way.

Along 112th Avenue SE, north of the intersection with Bellevue Way, for *Preferred Alternative B2M* and the 112th SE At-Grade (B2A), 112th SE Elevated (B2E), and 112th SE Bypass (B3) Alternatives, the Ldn ranged from 55 to 66 dBA, with peak-hour levels ranging from 55 to 62 dBA Leq (MB-14, MB-15, MB-18, and MB-19). North of the intersection of 112th Avenue SE and Bellevue Way, maximum noise levels on Bellevue Way or along 112th Avenue SE and vicinity ranged from 75 dBA Lmax to over 96 dBA Lmax. For Alternative B7 along I-405, noise levels at the nearby multifamily units were measured at 58 to 65 dBA Leq and the Ldn levels were modeled to range from 60 to 69 dBA (MB-16, MB-17, and MB-20). The multifamily units along the former BNSF Railway corridor are somewhat shielded from I-405 traffic noise by topographical conditions and a recently installed sound wall near monitoring site MB-20. Table 3-2 summarizes the noise measurements and projections for Segment B, and Exhibit 3-2 shows the monitoring sites.

TABLE 3-2
Segment B Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location No. [a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MB-1	Enatai Beach Park	Park	Short-term	62	62
MB-2	3457 107th Avenue SE	Single-family	Short-term	64	66
MB-3	3246 109th Avenue SE	Single-family	Short-term	72	72

TABLE 3-2 CONTINUED
Segment B Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location No. [a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MB-4	3264 111th Avenue SE	Single-family	Long-term	64	66
MB-5	3218 113th Avenue SE	Single-family	Short-term	70	72
MB-6	3005 113th Avenue SE	Single-family	Short-term	67	69
MB-7	11035 SE 26th Street	Single-family	Long-term	50	53
MB-8	11038 SE 25th Street	Single-family	Short-term	61	63
MB-9	1928 109th Avenue SE	Single-family	Short-term	64	66
MB-10	1850 108th Avenue SE	Single-family	Short-term	63	65
MB-11	1435 Bellevue Way SE	Single-family	Short-term	64	66
MB-12	1030 Bellevue Way SE	Multifamily	Short-term	67	69
MB-13	10256 SE 8th Street	Multifamily	Long-term	60	62
MB-14	1638 SE 17th Street	Single-family	Long-term	58	60
MB-15	1600 109th Avenue SE	Single-family	Short-term	55	55
MB-16	1018 111th Avenue SE	Single-family	Short-term	62	64
MB-17	2500 118th Avenue SE, Unit 303	Multifamily	Short-term	62	64
MB-18	Bellefield Residential Park Condominiums	Multifamily	Long-term	64	64
MB-19	900 111th Avenue SE	Single-family	Long-term	62	66
MB-20	1600 118th Avenue SE, Brookshire Condominiums	Multifamily	Long-term	65	69

[a] Sites shown on Exhibit 3-2.

3.2.3 Segment C

There were 19 noise-monitoring locations in Downtown Bellevue, including 9 long-term sites and 10 short-term sites. Peak-hour noise levels ranged from 55 dBA Leq in quiet areas away from major arterial roads to 75 dBA Leq near the Hilton Hotel along I-405 (monitoring site MC-3). The modeled Ldn at the Hilton Hotel was 75 dBA. Noise levels at residences along Bellevue Way ranged from 66 dBA Ldn for properties near the roadway to 60 dBA Ldn for properties shielded from roadway noise. For front-line residences along 112th Avenue SE (represented by MC-15), the measured peak-hour noise level was 68 dBA Leq and the Ldn was 70 dBA.

Along 112th Avenue north of Surrey Downs Park, noise levels are dominated by local traffic and vehicles on I-405. Measured traffic noise levels in this area ranged from 57 (at MC-5) to 75 (at MC-3) dBA Leq, depending on the proximity to the roadway and shielding from existing structures. Noise levels at single-family residences along NE 12th Street ranged from 60 dBA Ldn for shielded properties (MC-13) increasing to as high as 70 dBA Ldn (MC-15) for residences directly adjacent to major arterial roads. The measured noise level at the Bellevue Regional Library (MC-10) was 62 dBA Leq. Noise levels for residences near NE 12th Street ranged from 60 dBA Ldn at MC-13 to 70 dBA Ldn at MC-15. Finally, noise levels near Lake Bellevue (MC-19) were measured at 58 dBA Ldn. Maximum noise levels in Segment C ranged from 68 to 90 dBA Lmax, with maximum noise levels along 112th Avenue SE consistently in the mid to upper 80 decibel range. For example, over a 70-hour measurement period the Lmax at the condominiums on 112th Avenue SE (MC-15) ranged from 70 to 93 dBA Lmax, with an average Lmax of 80 dBA Lmax. Table 3-3 summarizes the noise measurements and modeled 24-Hour Ldn for Segment C, and Exhibit 6 shows the monitoring sites.

TABLE 3-3
Segment C Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location No. [a]	Address	Land Use Type	Type of Measurement	Leq (peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MC-1	420 Bellevue Way SE	Multifamily	Short-term	66	66
MC-2	321 Bellevue Way SE	Multifamily	Long-term	60	60
MC-3	300 112th Avenue SE	Hotel	Short-term	75	75
MC-4	221 112th Avenue SE, No. 221	Multifamily	Short-term	69	71
MC-5	11039 SE 2nd Street	Single-family	Short-term	57	58
MC-6	80 110th Avenue NE	Single-family	Long-term	57	59
MC-7	100 108th Avenue SE	Office	Short-term	61	63
MC-8	225 112th Avenue SE	Commercial	Short-term	62	63
MC-9	308 108th Avenue NE	Commercial	Short-term	64	65
MC-10	Bellevue Regional Library, 1111 110th Avenue NE	Mixed-use	Short-term	62	63
MC-11	10814 NE 12th Place	Single-family	Short-term	58	59
MC-12	11121 NE 12th Street	Commercial	Short-term	67	68
MC-13	1245 112th Avenue NE	Single-family	Long-term	57	60
MC-14	Surrey Downs Park	Park	Long-term	62	64
MC-15	281 112th Avenue SE	Multifamily	Long-term	68	70
MC-16	112 111th Avenue SE	Single-family	Long-term	58	64
MC-17	Bellevue Hotel and Club	Hotel	Long-term	59	62
MC-18	112th Avenue SE at SE 6th Street	N/A	Long-term	62	64
MC-19	Bellevue Lake Condominiums, Building 7, Unit 112	Multifamily	Long-term	55	58

[a] Sites shown on Exhibit 3-3.

3.2.4 Segment D

Because much of Segment D is commercial and light industrial uses, which are not typically sensitive to light rail noise, only six sites were monitored, with only one long-term monitoring site at a residential area along 116th Avenue NE. Noise levels for these residences were dominated by traffic on I-405 and 116th Avenue NE. An Ldn of 58 dBA was measured along the side of 116th Avenue NE facing the SR 520 Alternative (D5), which is well shielded from I-405. There was also a monitoring location near the Highland Park and Community Center, where the peak-hour level was measured at 65 dBA Leq. The main noise sources included SR 520, Bel-Red Road, and NE 20th Street.

Three additional noise measurement sites were located near the Overlake area, including one near the former Group Health Eastside Hospital, one at the Overlake Assisted Living Center, and one on the Microsoft Campus near Building 44. Estimated noise levels at these sites ranged from 65 to 71 dBA Ldn, with measured peak hour Leq levels ranging from 64 to 70 dBA Leq. Finally, a short-term monitoring session was performed at the Pacific Northwest Ballet School on NE 16th Street to assist with analysis of potential impacts at the school. The measured daytime noise level at the school was 56 dBA Leq, while the maximum noise level of 83 dBA Lmax was due to truck traffic. Table 3-4 summarizes the noise measurements and modeled 24-Hour Ldn for Segment D, and Exhibit 3-4 shows the monitoring sites.

TABLE 3-4
Segment D Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location No. [a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MD-1	1815 116th Avenue NE	Single-family	Long-term	58	58
MD-2	Near Highland Park (on pathway 50 feet from NE 20th Street)	Park	Short-term	65	65
MD-3	Former Group Health Campus, 2700 152nd Avenue NE (to be redeveloped as mixed use)	Commercial	Short-term	64	65
MD-4	Overlake Assisted Living Center, 2956 152nd Avenue NE	Commercial	Short-term	64	65
MD-5	Near Microsoft Building 44	Mixed-use	Short-term	70	71
MD-6	13440 NE 16th Street (Pacific Northwest Ballet School)	Mixed-use	Short-term	56	56

[a] Sites shown on Exhibit 3-4.

3.2.5 Segment E

There were five noise-monitoring locations in Segment E—two long-term sites and three short-term sites The initial portion of all light rail alternatives in Segment E is along the east side of SR 520, shielded from nearby residences by existing sound walls. For locations with existing sound walls (represented by ME-1), Ldn ranged from 60 to 64 dBA, with peak-hour levels of 58 to 60 dBA Leq. A small group of homes along 156th Avenue NE does not have a sound wall (ME-2), and the measured Ldn was 68 dBA at this location.

Noise at the multifamily units along 156th Place NE (ME-4) was also dominated by traffic on SR 520 and arterial roads, with an estimated Ldn of 64 dBA. The apartments along NE Leary Way and West Lake Sammamish Parkway (ME-5) had an estimated Ldn of 64 dBA, with most noise coming from the two main arterial roadways. Table 3-5 summarizes the noise measurements and modeled 24-hour Ldn for Segment E, and Exhibit 3-5 shows the monitoring sites.

TABLE 3-5
Segment E Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location No.[a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
ME-1	5409 154th Avenue NE	Single-family	Long- term	60	64
ME-2	15516 61st Court	Single-family	Long-term	65	68
ME-3	15834 NE 67th Place	Single-family	Short-term	58	60
ME-4	7250 Old Redmond Road	Multifamily	Short-term	63	64
ME-5	15821 Leary Way NE	Multifamily	Short-term	62	64

[a] Sites shown on Exhibit 3-5.

3.2.6 Maintenance Facilities

The maintenance facilities are proposed in areas that are currently light industrial land uses and have no nearby noise-sensitive land uses. The exception is the 116th Maintenance Facility (MF1) (see Exhibit 3-4), where some residences are located to the west between 116th Avenue NE and I-405, and the new Children's Hospital Bellevue Clinic and Surgery Center (BCSC) is located to the south. The maintenance facility sites in Segment D are characterized by monitoring data discussed in Section 3.2.4. Existing background noise levels for the maintenance facility sites in Segment E are discussed in Section 3.2.5.

3.3 Vibration Measurements

3.3.1 Locations and Tests

Vibration measurement test sites were selected based on a review of aerial photographs and were supplemented by a visual land-use survey. Unlike noise, human response to vibration is not dependent on existing vibration levels. Humans respond to a new source of vibration based on the frequency of the events. Therefore, rather than measuring existing vibration levels, the vibration measurements for the project focused on characterizing the vibration propagation through the ground at representative locations. Eight sites, designated as V-1 through V-8, were selected during the Draft EIS process to represent a range of soil conditions in areas along the East Link Project corridor near sensitive land uses. An additional six measurement locations, designated as V-9 through V-14, were selected during the Final EIS process to refine the projections at locations where impacts would occur, as identified during the Draft EIS; several of these were conducted at specific buildings to measure the response of the foundation to vibration. Measurements were conducted at selected sites in Seattle, Bellevue, and Redmond. The locations of these measurement sites are indicated in Exhibits 3-1 through 3-5, along with the noise monitoring locations, and are described below; site photographs are included in Appendix B of this report:

- **Site V-1:** This site was located at the corner of 32nd Avenue and South Day Street in Seattle, above the I-90 tunnel. The vibration measurements at this site are representative of Segment A.
- **Site V-2:** This site was located in the parking lot of the South Bellevue Park-and-Ride Lot. The vibration measurements at this site are representative of the southern portions of Segment B.
- **Site V-3:** This site was located in the parking lot of the King County District Court in Surrey Downs Park. The vibration measurements at this site are representative of the northern portion of Segment B and the at-grade and elevated alternatives in Segment C, except for Overlake Hospital.
- **Site V-4a and V-4b:** This site was located in the median of NE 12th Street, between 108th Avenue NE and 110th Avenue NE. The vibration measurements at this site, taken at two different depths (V-4a and V-4b), are representative of the tunnel alternatives in Segment C.
- **Site V-5:** This site was located in the parking lot of Overlake Hospital, adjacent to NE 12th Street. The vibration measurements at this site represent Overlake Hospital and were used to assess the vibration-sensitive equipment, including the mobile MRI and the optical surgery unit within this facility.
- **Site V-6:** This site was located in Highland Park off Bel-Red Road in Bellevue. The vibration measurements at this site are representative of Segment D.
- **Site V-7:** This site was located at the corner of 154th Avenue NE and NE 54th Street in Redmond, in a residential neighborhood. The vibration measurements at this site are representative of the southern portion of Segment E, along SR 520.
- **Site V-8:** This site was located at the Redmond Town Center, along Bear Creek Trail to the south of the commercial buildings. The vibration measurements at this site are representative of the areas along the northern portion of Segment E, near the Redmond Town Center.
- **Site V-9:** This site was located at the Winters House in Bellevue, and the vibration measurements at this site were used to assess vibration and groundborne noise impact at the Winters House.
- **Site V-10:** This site was located on SE 3rd Street in a residential neighborhood. The vibration measurements at this site are representative of the residential area just to the south of Downtown Bellevue.
- **Site V-11:** This site was located at the Bellevue Hilton, and the vibration measurements at this site were used to assess impacts at the Hilton Hotel.
- **Site V-12:** This site was located at the Meydenbauer Center Theater in Bellevue, and the vibration measurements at this site were used to assess the vibration and groundborne noise levels in the theater at the Meydenbauer Center.

- **Site V-13:** This site was located at NE 12th Street in Bellevue, and the vibration measurements at this site are representative of the sensitive receptors in Downtown Bellevue associated with the at-grade and elevated alternatives.
- **Site V-14:** This site was located at 152nd Avenue NE in Redmond and the vibration measurements at this site were used to supplement the measurement Site V-6 for Segment D.

3.3.2 Instrumentation and Procedures

Vibration propagation is characterized by the relationship between an input force and the resulting ground-surface vibration, called the transfer mobility. Transfer mobility measurements are made by producing an impulsive force and measuring the vibration response at accelerometers located at a range of distances. With the transfer mobility, it is possible to estimate the ground vibration that would be caused by sources, such as a train, by substituting the impact force with the train forces. The vibration propagation test system for surface alternatives is shown schematically in Exhibit 3-6, and Exhibit 3-7 shows the test system for tunnel alternatives. As shown in the cross-section view at the top of Exhibit 3-6, the surface test consists of dropping a 60-pound weight from a height of 3 to 4 feet onto the ground to generate a force. For tunnel testing, a drill rig is used to generate the force at the required tunnel depth.

The measurement equipment includes a load cell to measure the forces produced by the weight, high-sensitivity accelerometers, amplifiers, and an eight-channel digital audio tape (DAT) recorder. The accelerometers are located on either paved surfaces or on top of steel stakes driven into soil and mounted with a clay compound in the vertical orientation. During the measurements, personnel continually monitor the recording levels and listen to the acceleration signals to make sure that acceptable data are collected. The sketch in the lower half of Exhibit 3-6 shows how the dropped weight point source was used to simulate a line vibration source such as a train. Impact tests were made at regular intervals in a line along the rail alternative. For these tests, impacts were done at 11 points spaced 15 feet apart. Six accelerometers were placed perpendicular to the impact locations at distances between 25 and 150 feet away. For each impact location, approximately 25 impacts were produced in order to obtain a statistically accurate sample.

3.4 Vibration Propagation Results

Data recorded in the field were analyzed in the laboratory using digital signal processing software that calculates the point-source transfer mobility and coherence between each impact and accelerometer location. Coherence is a measure of how accurate the transfer mobility is calculated; following are the basic analysis steps:

- Each impulse signal from the load cell and response signals from the accelerometers was identified in the recordings.
- Narrowband transfer functions and coherences were computed from an average of all the impulses at a specific impact location.
- The narrowband transfer functions and coherences were summed into 1/3-octave band levels.
- A linear or quadratic regression was calculated for all of the point-source transfer mobilities in each 1/3 octave band. These transfer mobility regressions were used to compute smooth point-source transfer mobility versus distance relationship.
- Each of the 1/3-octave band point-source transfer mobility relationships were then integrated into an equivalent line-source transfer mobility using Simpson's rule for numerical integration. The end result was an estimate of line source transfer mobility based on the distance from the source of the vibration.

Examples of the resulting smoothed line source transfer mobilities are provided in Exhibits 3-8 through 3-10E, which provide the spectra at a distance of 100 feet for each test site. More details on the propagation test and analysis procedures are given in the FTA guidance manual *Transit Noise and Vibration Impact Assessment*. Detailed vibration propagation data for the project are included in Appendix C of this report.

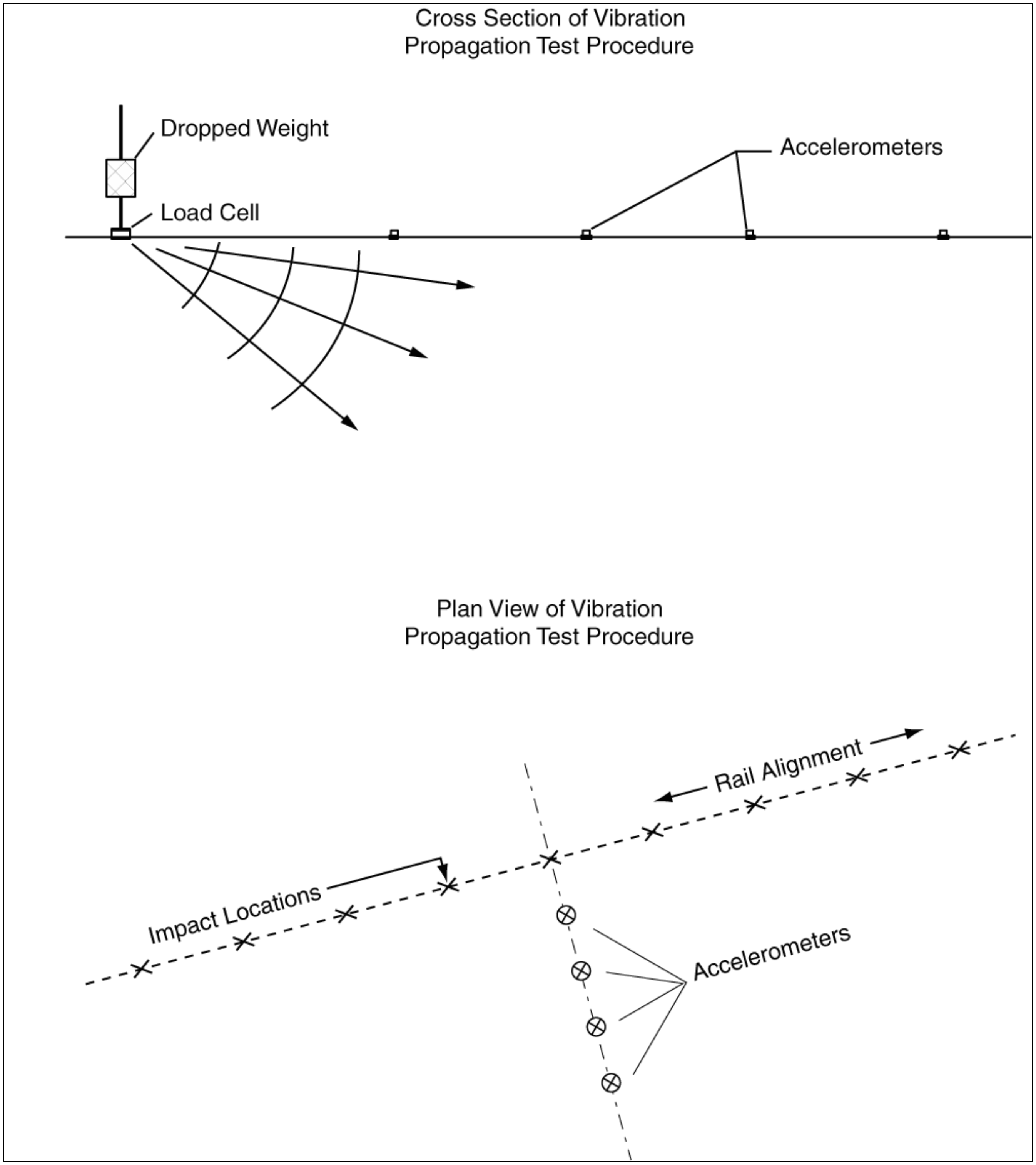


EXHIBIT 3-6
Surface Vibration Propagation Test Procedure

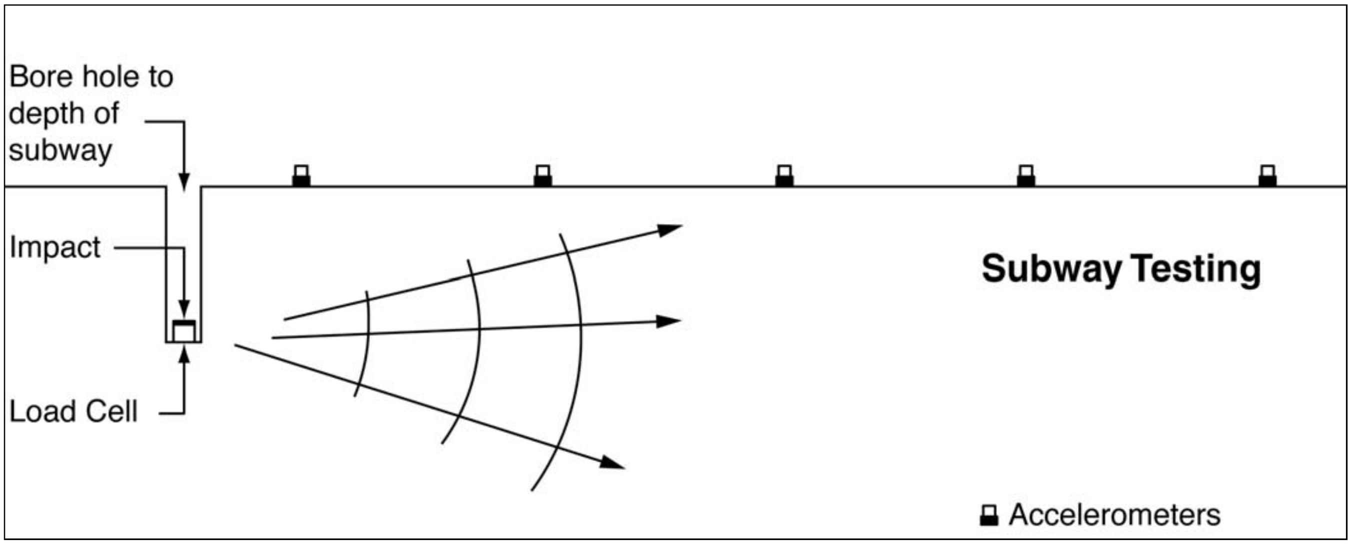


EXHIBIT 3-7
Vibration Propagation Test Procedure for Tunnels

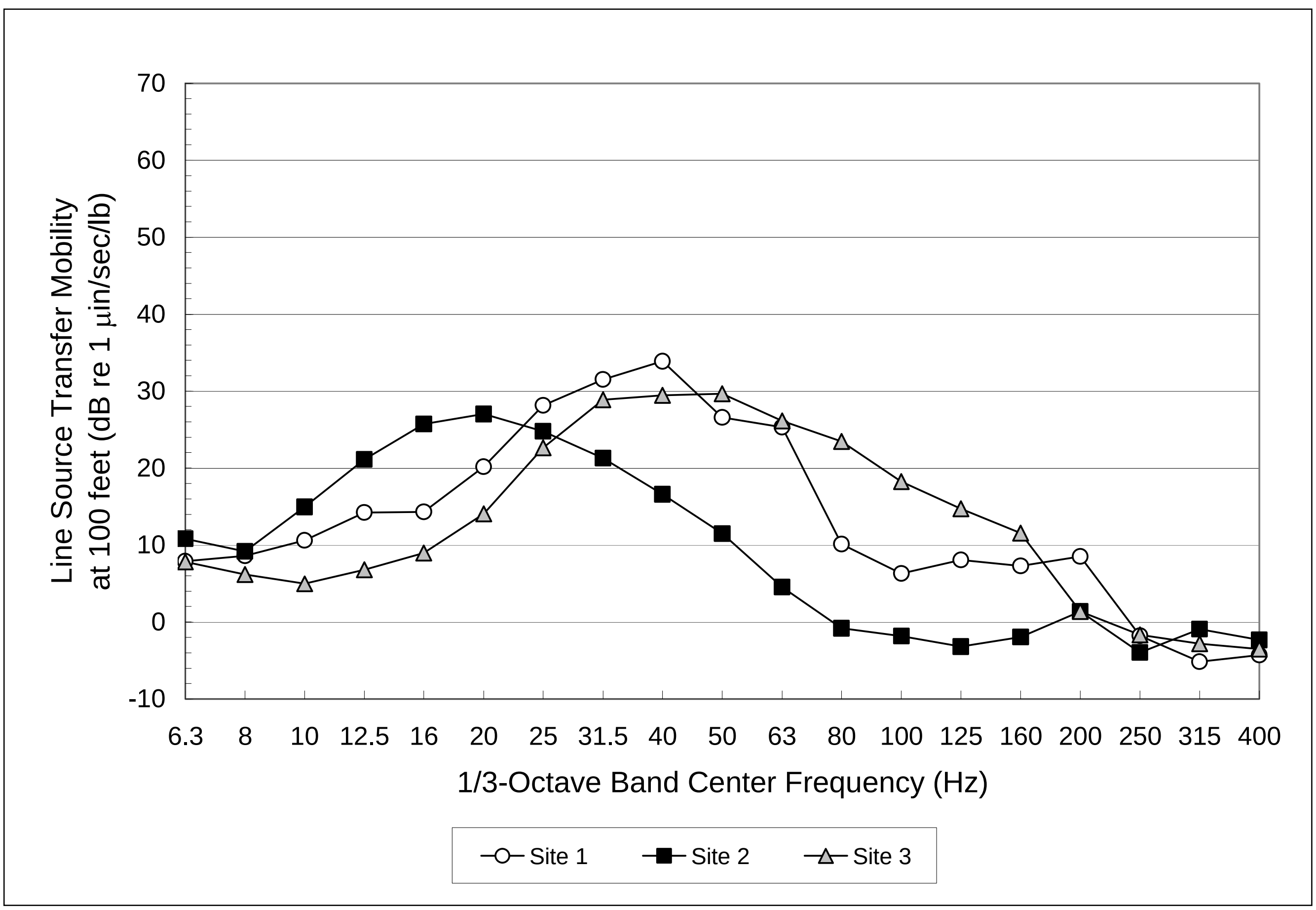


EXHIBIT 3-8
Line Source Transfer Mobilities for Sites V-1 to V-3

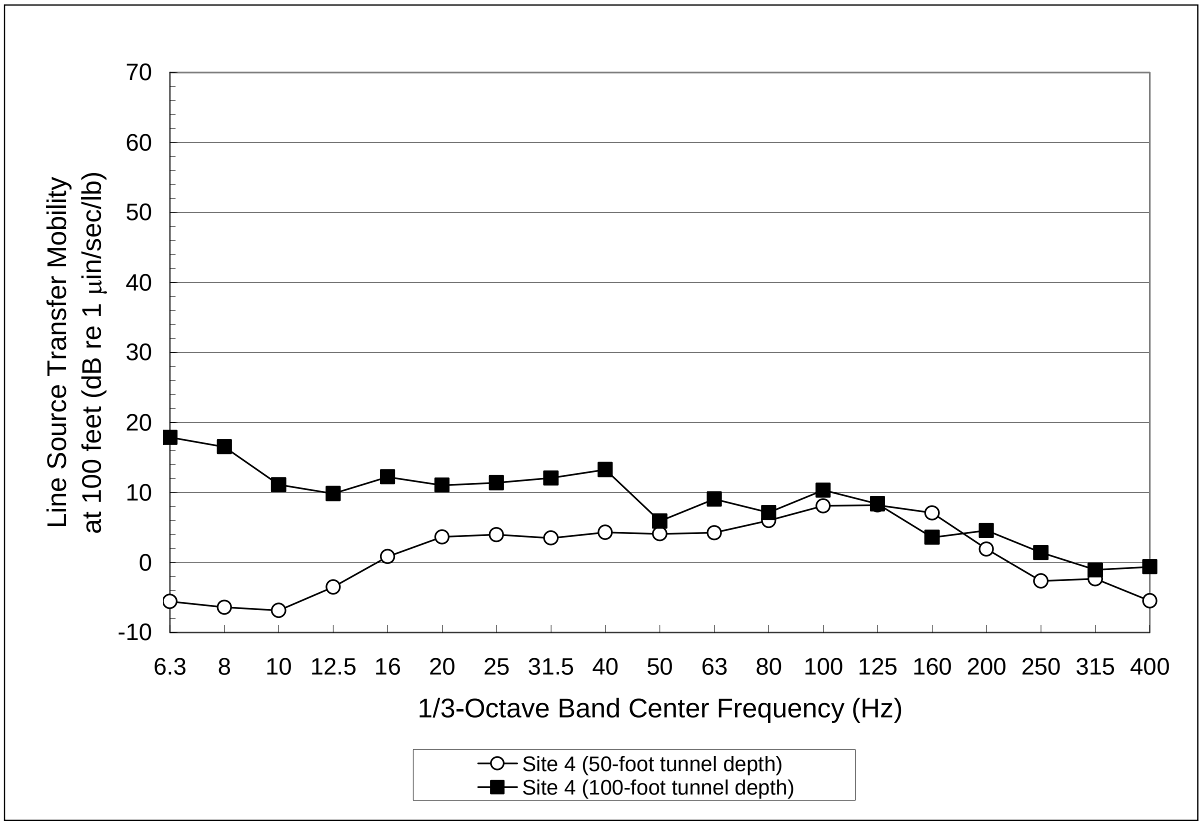


EXHIBIT 3-9
Line Source Transfer Mobilities for Site V-4

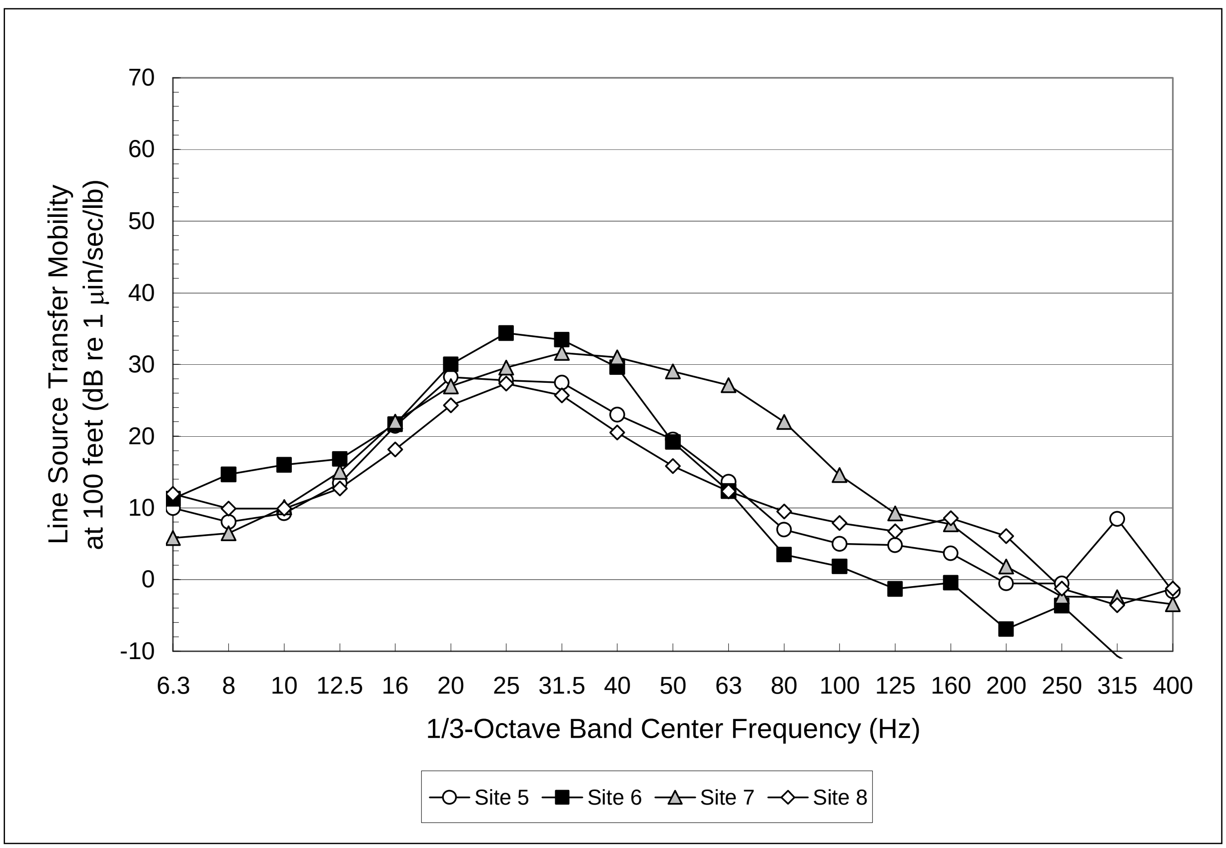


EXHIBIT 3-10A
Line Source Transfer Mobilities for Sites V-5 to V-8

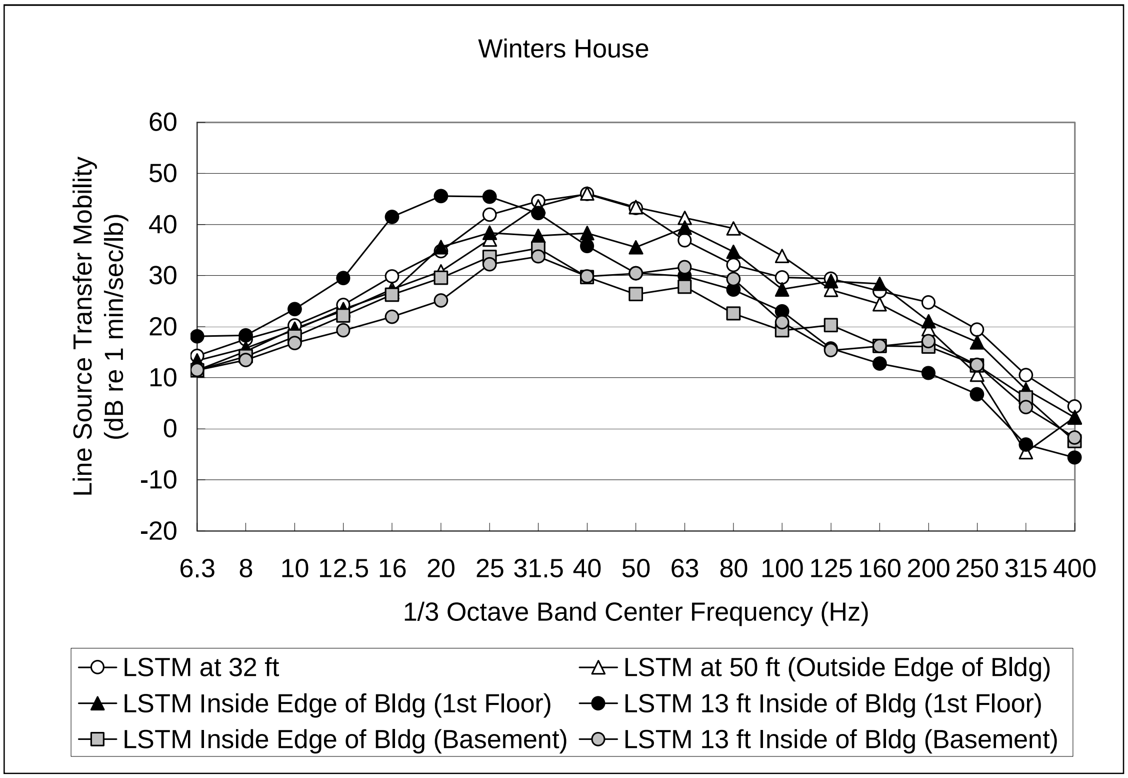


EXHIBIT 3-10B
Line Source Transfer Mobilities for Site V-9, Winters House

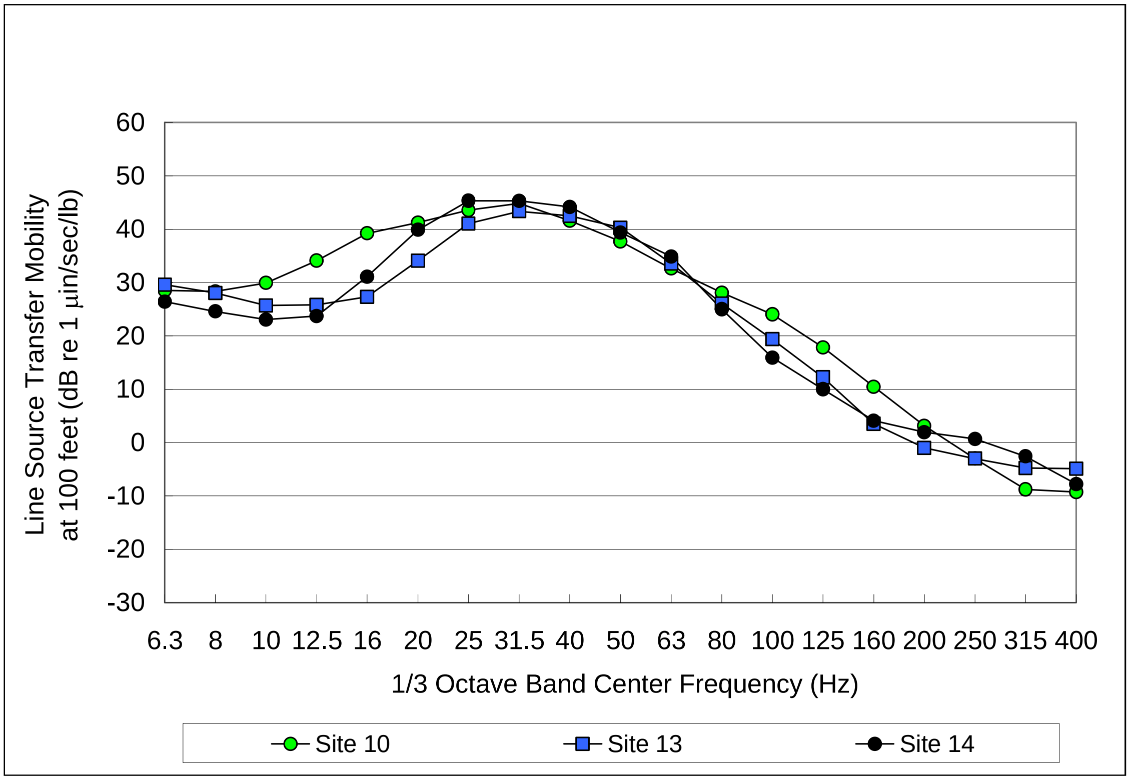


EXHIBIT 3-10C
Line Source Transfer Mobilities for Sites V-10, V-13, and V-14

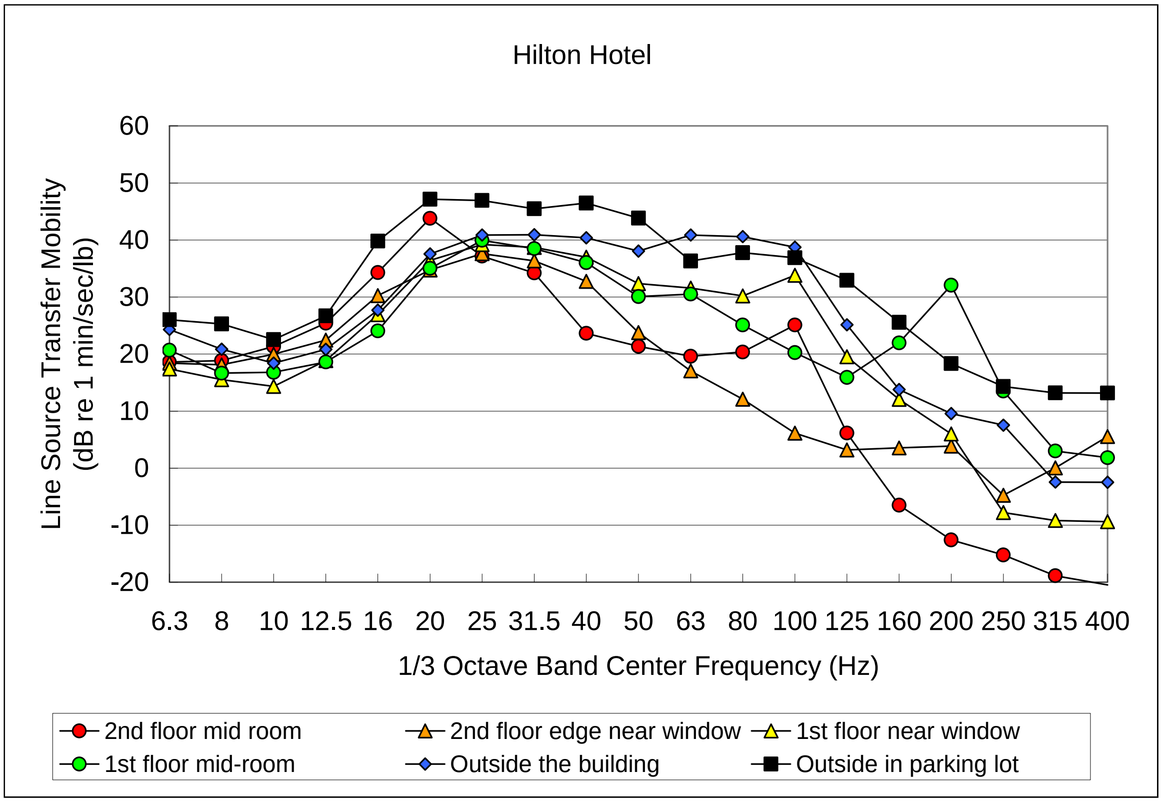


EXHIBIT 3-10D
Line Source Transfer Mobilities for Site V-11, Hilton Hotel

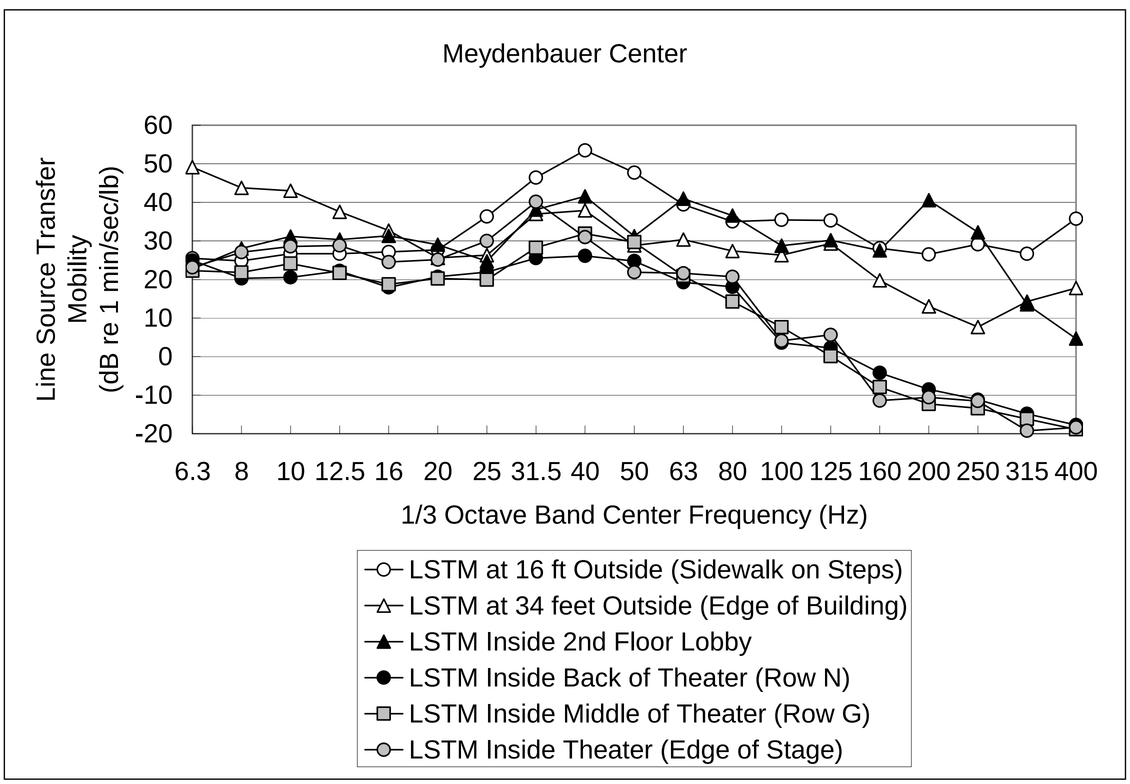


EXHIBIT 3-10E
Line Source Transfer Mobilities for Site V-12, Meydenbauer Center

4.0 Noise and Vibration Impact Criteria

The operation of a light rail system can cause noise and vibration that can be a major public concern. Noise impacts can be caused by either transit operations or changes in traffic resulting from a roadway being widened or realigned for the project, and different criteria exist for each source of noise. In addition, groundborne noise caused by vibration has different impact criteria. This section summarizes what defines a noise and vibration impact, as applicable to the East Link Project.

4.1 Transit Noise Criteria

Noise impacts for this project are determined based on the criteria defined in the FTA guidance manual *Transit Noise and Vibration Impact Assessment* (FTA, 2006). The FTA noise impact criteria are based on well-documented research on community reaction to noise and on change in noise exposure rated using a sliding scale. Although more transit noise is allowed in neighborhoods with high levels of existing noise, as existing noise levels increase, smaller increases in total noise exposure are allowed than in areas with lower existing noise levels. The FTA Noise Impact Criteria group noise-sensitive land uses into the following three categories:

- **Category 1**: 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, and active parks.

Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise-sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-hour Leq during the facility's operating period is used.

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

- **Severe Impact:** Project-generated noise in the severe impact range can be expected to cause a large percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances that prevent it.
- **Moderate Impact:** In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing level, the projected level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views, and the cost of mitigating noise to more acceptable levels.

The FTA noise impact criteria are summarized in graphical form in Exhibit 4-1, which shows the existing noise exposure and the additional noise exposure from the transit project that would cause either moderate or severe impact. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure caused by the transit project. Exhibit 4-2 expresses the same criteria in terms of the increase in total or cumulative noise that can occur in the overall noise environment before an impact occurs.

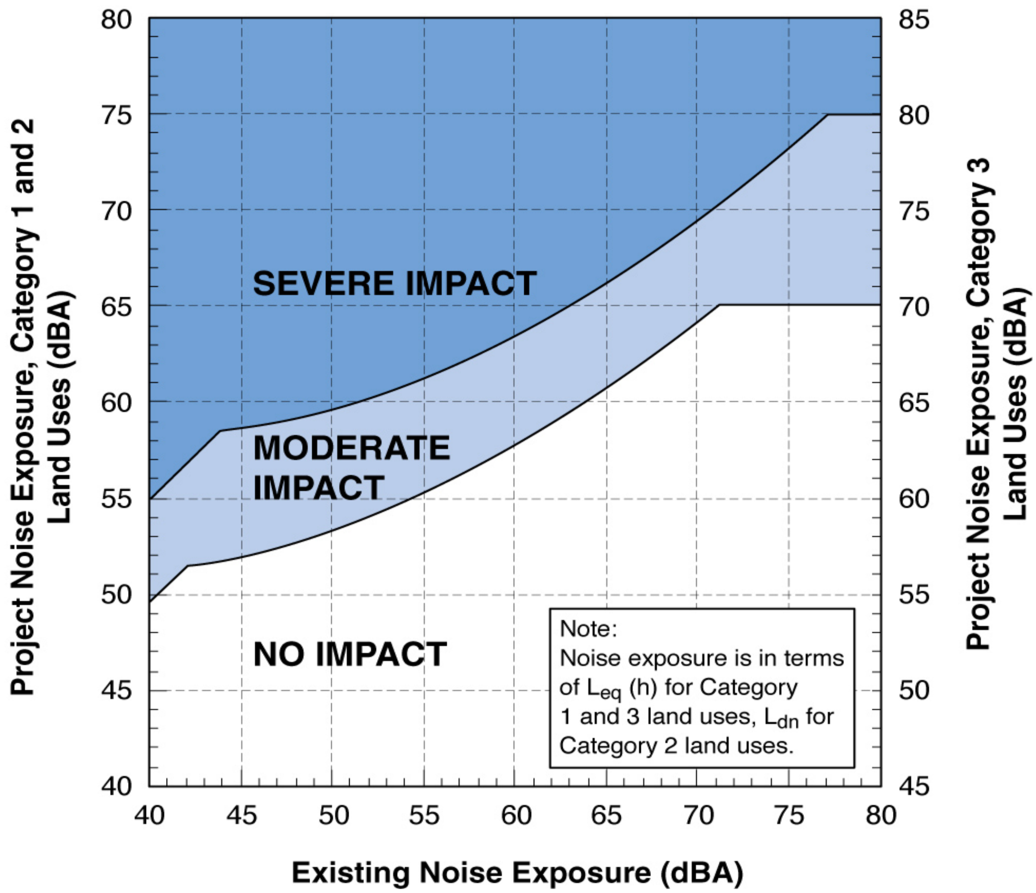


EXHIBIT 4-1
FTA Project Noise Impact Criteria
Note: Leq(h) = hourly Leq

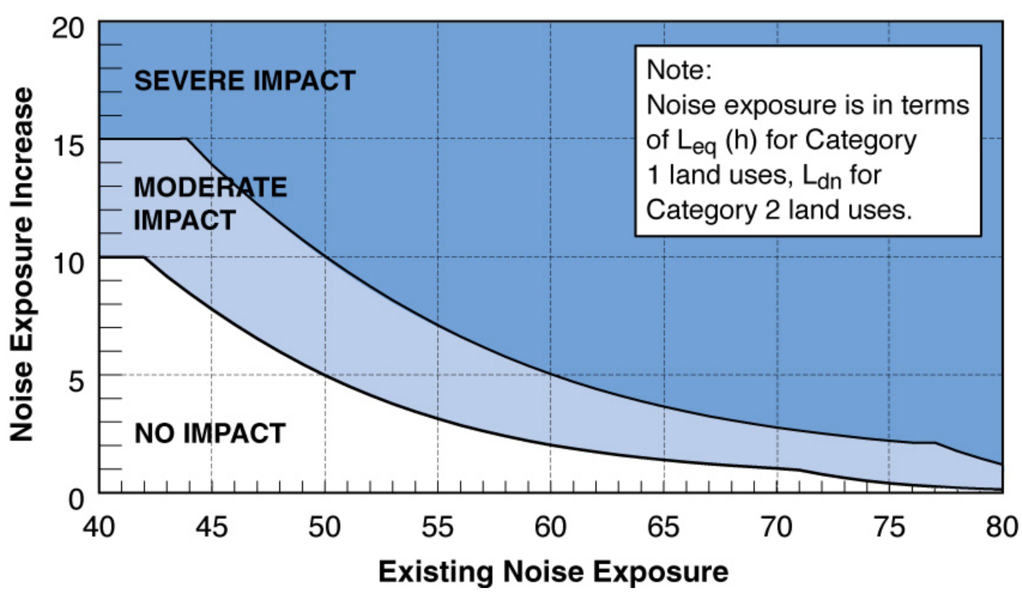


EXHIBIT 4-2
Increase in Cumulative Noise Exposure Allowed by FTA Criteria
Note: Leq(h) = hourly Leq

The FTA Manual provides guidance on how parks are analyzed for noise in Chapter 3, Section 2, Application of Noise Impact Criteria. The FTA assumes that parks are a special case, and how they are used and where they are located should be considered when considering whether or not that particular park, or an area in that park, is considered noise-sensitive. In general, most parks used for outdoor recreation are not considered noise-sensitive. This includes parks with baseball diamonds, soccer fields, basketball courts, football fields, and other active recreation areas.

Parks that are noise-sensitive would be those where quiet is an essential element in their intended purpose or places where it is important to avoid interference with activities such as talking, meditation, and concentration on reading material. The existing noise levels at a park can provide some indication of the sensitivity of its use. All parks along the project corridor were evaluated for noise, and the results are provided in Section 6.1 in Chapter 6, Noise and Vibration Impact Assessment.

4.2 Traffic Noise Criteria

Consistent with the FTA Manual, FHWA methodology and criteria are used to evaluate traffic noise impacts. The criteria for highway noise impacts are taken from the FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, United States Code of Federal Regulations (CFR) 23 772, 1982. Table 4-1 lists the traffic noise abatement criteria. A noise impact occurs if projected noise levels approach the levels listed in Table 4-1 or substantially exceed existing noise levels. Each state defines their own quantitative levels considered to approach or substantially exceed existing noise levels. Projects that include construction of new highways, reconstruction of existing highways that includes significantly changing either the horizontal or vertical profile, or an increase in the number of through traffic lanes require analysis and consideration of abatement. A significant change in the horizontal or vertical profile occurs when the change is likely to result in increased noise levels to developed lands.

TABLE 4-1
FHWA Traffic Noise Abatement Criteria

Land Use Category		Hourly Leq (dBA)
Type A	Lands on which serenity and quiet are of extraordinary significance and which 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)

The Washington State Department of Transportation (WSDOT) is responsible for implementing the FHWA regulations in Washington. Under WSDOT policy, a traffic noise impact occurs if projected noise levels are within 1 dB of the FHWA criteria; therefore, a residential impact occurs at 66 dBA Leq and a commercial impact occurs at 71 dBA Leq. WSDOT also considers a 10-dB increase in noise a substantial increase impact, regardless of the existing noise level. Potential noise from park-and-ride lots were assessed using the local noise criteria, which is discussed later in Section 4.4.1 for construction noise.

4.3 Transit Vibration and Groundborne Noise Criteria

The FTA groundborne vibration impact criteria are based on land use and train frequency. The criteria for most land uses are shown in Table 4-2. The FTA vibration criteria are applied primarily to residential (including hotels and other places where people sleep) and institutional land uses. Commercial land uses are only considered when they contain vibration-sensitive uses, such as medical offices or sensitive manufacturing equipment. The criterion applied to these locations is dependent on the sensitivity of the use. Some buildings, such as concert halls, recording studios, and theaters, can be particularly sensitive to vibration but do not fit into any of the three categories listed in Table 4-2. Due to their sensitivity, these buildings usually warrant special attention during the impact assessment. Table 4-3 gives criteria for acceptable levels of groundborne vibration for various types of special buildings.

Table 4-4 provides vibration criteria for detailed vibration analyses at highly sensitive locations . The criteria in Table 4-4 are based on exceedances of the 1/3-octave-band vibration levels over the frequency range 8 to 80 Hertz (Hz). In addition, these detailed criteria would be used to assess vibration impact at highly sensitive locations, such as the Overlake Hospital, the Group Health Hospital, and the new Children's Hospital BCSC because of potentially sensitive medical equipment and procedures. These criteria are also shown graphically in Exhibit 4-3.

It should also be noted that Tables 4-2 and 4-3 include separate FTA criteria for groundborne noise, the "rumble" that can be radiated from the motion of room surfaces in buildings due to groundborne vibration. The vibration of floors and walls causes them to act like loudspeakers, generating noise due to the movement of the surfaces. Although expressed in dBA, which emphasizes the more audible middle and high frequencies, the criteria are set considerably lower than for airborne noise to account for the annoying low-frequency character of groundborne noise. Because airborne noise often masks groundborne noise for aboveground (i.e., at-grade or elevated) transit systems, groundborne noise criteria are primarily applied to subway operations where airborne noise is not a factor. For above-grade transit systems, groundborne noise criteria are applied only to buildings that have sensitive interior spaces that are well insulated from exterior noise.

TABLE 4-2
Groundborne Vibration and Noise Impact Criteria

	Groundborne Vibration Impact Levels (VdB re 1 microinch/second)			Groundborne Noise Impact Levels (dB re 20 micro-Pascals)		
Land Use Category	**Frequent Events[a]**	**Occasional Events[b]**	**Infrequent Events[c]**	**Frequent Events[a]**	**Occasional Events[b]**	**Infrequent Events[c]**
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB[d]	65 VdB[d]	65 VdB[d]	N/A[e]	N/A[e]	N/A[e]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

[a] "Frequent Events" are defined as more than 70 vibration events of the same source per day; most rapid transit projects fall into this category.

[b] "Occasional Events" are defined as between 30 and 70 vibration events of the same source per day; most commuter trunk lines have this many operations.

[c] "Infrequent Events" are defined as fewer than 30 vibration events of the same kind per day; this category includes most commuter rail branch lines.

[d] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research requires detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the heating, ventilation, and air conditioning (HVAC) systems and stiffened floors.

[e] Not applicable. Vibration-sensitive equipment is generally not sensitive to groundborne noise.

TABLE 4-3
Groundborne Vibration and Noise Impact Criteria for Special Buildings

Type of Building or Room[a]	Groundborne Vibration Impact Levels (VdB re 1 micro-inch/sec)		Groundborne Noise Impact Levels (dB re 20 micro Pascals)	
	Frequent Events[b]	Occasional or Infrequent Events[c]	Frequent Events[b]	Occasional or Infrequent Events[c]
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

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

[b] "Frequent Events" are defined as more than 70 vibration events per day; most transit projects fall into this category.

[c] "Occasional or Infrequent Events" are defined as fewer than 70 vibration events per day; this category includes most commuter rail systems.

TABLE 4-4
Vibration Criteria for Detailed Analysis at Highly Sensitive Locations

Criterion Curve	Maximum Lv (VdB)[a]	Description of Use
Workshop	90	Distinctly detectable vibration; appropriate to workshops and nonsensitive areas
Office	84	Detectable vibration; appropriate to offices and nonsensitive areas
Residential day	78	Barely detectable vibration; adequate for computer equipment and low-power optical microscopes (up to 20X)
Residential night, operating rooms/ sensitive hospital equipment	72	Vibration not detectable, but groundborne noise might be audible inside quiet rooms; suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment
VC-B	60	Adequate for high-power optical microscopes (1,000X) and inspection and lithography equipment up to 3 micron-line widths
VC-C	54	Appropriate for most lithography and inspection equipment to 1 micron detail size
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment

[a] As measured in one-third-octave bands of frequency over the frequency range 8 to 80 Hz.

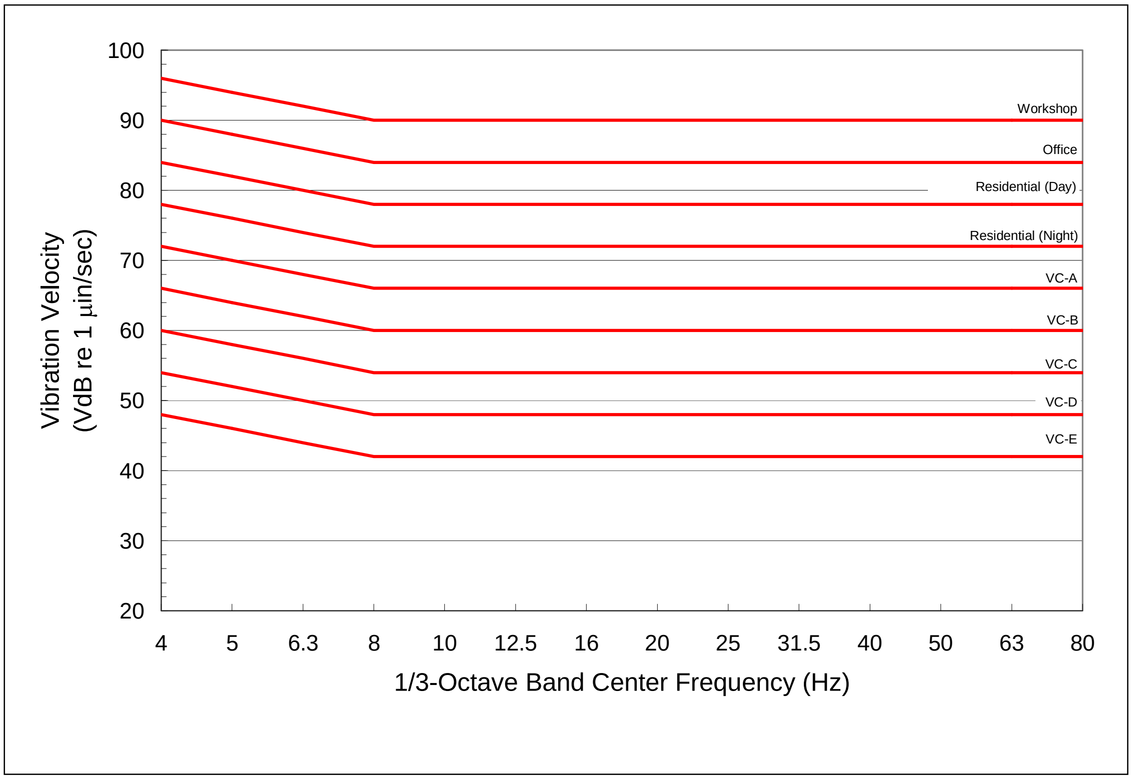


EXHIBIT 4-3
Vibration Criteria for Highly Sensitive Locations

4.4 State and Local Noise Ordinances

Project operation and construction would take place in four cities within King County, so several different noise ordinances might be applicable to the operation of ancillary facilities and project construction. Most cities in Washington, including all those in the project corridor, rely, at least in part, on the Washington State Administrative Code (WAC), Chapter 173-60, Maximum Environmental Noise Levels, for residential, commercial, and industrial noise limits, along with construction noise limits. The City of Seattle has a set of specific construction criteria that would be followed for all construction work in Segment A. Construction work in other segments would follow the WAC noise control ordinance. However, local noise ordinances can include different provisions from the State law. For example, the City of Bellevue applies its exemption for construction noise more stringently, with fewer evening and weekend hours considered exempt.

4.4.1 Washington State Noise Regulation

The Washington State Noise Control Ordinance (together with local noise regulations) applies to general construction activities, park-and-ride lots, and maintenance facilities. The WAC does not contain a section specific to highway or light rail noise. State law exempts mobile noise sources, including freight rail, aircraft in flight, and vehicles traveling in public right-of-way, as well as safety warning devices (i.e., bells). For stationary land uses with noises originating from outside public roadways and rights-of-way, the Washington State Noise Control Ordinance defines three classes of property usage, called Environmental Designation for Noise Abatement (EDNA), and maximum allowable noise levels for each, as shown in Table 4-5. For example, the noise caused by a commercial property must be less than 57 dBA at the closest residential property line. From 10 p.m. to 7 a.m., the maximum allowable levels shown in Table 4-5 are reduced by 10 dBA. Besides the property line noise standards in Table 4-5, there are exemptions in the WAC for short-term noise exceedances, including those outlined in Table 4-6 that are based on the minutes per hour that the noise limit is exceeded. The allowable exceedances presented in Table 4-6 are commonly measured using the statistical distribution measurement metrics, with the L25 equal to the 15-minute exceedance, the L8.3 for the 5-minute exceedance, and the L2.5 for the 1.5-minute exceedance.

TABLE 4-5
Washington State Noise Control Regulation (WAC 173-60)

Land Use	Maximum Allowable Sound Level (dBA)[a]		
	Residential	Commercial	Industrial
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

[a] Between 10 p.m. and 7 a.m. the levels given above are reduced by 10 dBA.
WAC Washington Administrative Code

TABLE 4-6
WAC 173-60 Exemptions for Short-Term Noise Exceedance

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

WAC Washington Administrative Code

4.4.2 WAC Construction Noise Criteria

For the purpose of discussing construction noise and potential construction noise impacts, this study used the WAC. Most project construction can be performed within the limits of the WAC noise ordinance if the work is conducted during normal daytime hours. If construction is performed during the nighttime, the contractor must still meet the WAC noise-level requirements presented in Table 4-5 or get a noise variance from the governing jurisdiction. The construction contracts would contain sections specific to construction noise and address any site-specific requests for variances or other construction-related noise issues associated with the East Link Project.

The State of Washington has also developed a set of construction-specific allowable noise-level limits that would apply to the construction of the East Link Project. These construction noise regulations are organized by type of noise and include general construction equipment; impulse equipment, such as jackhammers and pile-drivers; haul trucks; and safety alarms, such as back-up beepers.

4.4.3 Haul Truck Noise Criteria

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

4.4.4 Noise Related to Back-Up Alarms

Sounds created by backup alarms are exempt, except between 10 p.m. and 7 a.m. when “beep-beep” backup alarms are essentially prohibited by the WAC in urban areas and would be replaced with smart back-up alarms, which automatically adjust the alarm level based on the background level or switch off back-up alarms and replace with spotters. This criterion is included because, just like noise from construction activities, noise from back-up beepers would exceed the WAC nighttime criteria, even with the allowable exceedance, at distances up to 800 feet, or more, from the construction site.

4.5 Construction Vibration Criteria

Construction vibration, unlike vibration from operations, has the potential to cause damage to structures at very close distances, from activities such as blasting and pile-driving. Because of this, the construction vibration discussion includes both annoyance impact criteria and damage criteria.

Generally, because of the short duration of construction vibration activities, annoyance is usually not an issue. For longer-term activities, such as tunneling and associated muck train use (a muck train removes excavated material from a tunnel during construction), annoyance impact would be addressed. When vibration and associated groundborne noise are assessed for particular construction activities, the transit vibration impact criteria are used to determine the potential for impact. Because the transit vibration criteria are based on the frequency of events, it is important to know the frequency of events for a particular construction activity.

In order to assess the potential for damage from construction activities, criteria in terms of PPV (as discussed in Section 2.2) have been developed based on the building type (Swiss Consultants for Road Construction Association, 1992). These criteria include the following (vibration velocity levels are noted in parentheses):

- Reinforced concrete, steel, or timber: 0.5 PPV (102 VdB)
- Engineered concrete and masonry: 0.3 PPV (98 VdB)
- Nonengineered timber and masonry buildings: 0.2 PPV (94 VdB)
- Buildings extremely susceptible to vibration damage: 0.12 VdB (90 VdB)

As can be seen from the corresponding vibration velocity levels in parentheses, the thresholds for damage for even the most sensitive buildings are 1 to 2 orders of magnitude higher than the criteria for annoyance from vibration.

5.0 Future Build Conditions

This section summarizes the models used to predict future noise and vibration levels for potential sources of community impact related to the East Link Project. These sources include light rail operation, changes in traffic due to the project, and construction activities.

5.1 Light Rail Noise Projections

Noise from light rail operations was modeled using the methods described in the FTA *Transit Noise and Vibration Assessment Manual*. Input to the model included the following:

- Three-car trains with 7-minute headways during peak hours, 10-minute headways during midday and early evening, and 15-minute headways during late evening, nighttime, and early morning hours. (See Appendix E of the Final EIS for a summary of the Operations Plan.)
- Measured reference noise levels for the new light rail vehicles that are being used on the Central Link system, which have wheel skirts. The reference measurements were taken along the ballast and tie segment of the initial segment in south Seattle in March 2010. Curves of modeled Ldn and maximum noise level (Lmax) versus distance assuming a train speed of 50 mph are shown in Exhibit 5-1. (The noise projections in Exhibit 5-1 are corrected to account for speed, track type, and topographical conditions.)
- Digital terrain in 5-foot-elevation contour intervals.
- Plan and profile of the proposed light rail alternatives and design options, including the locations of special trackwork, such as crossovers, where wheel impacts make a clicking noise and vibration levels can be increased. For this analysis, measured increases in the light rail pass-by at crossovers were taken from the embedded crossovers along Martin Luther King Jr. Way South in Seattle. The measured data used for the crossovers were taken before noise-reducing modifications were recently added to these crossovers.
- Proposed maximum speeds along each of alternatives/design options.
- Adjustments based on track type, as shown in Table 5-1.
- Train-mounted bells were measured and validated in October 2009, with several supplemental measurements over the last two years. Under the current Sound Transit bell policy, train-mounted bells would be sounded two to three times as a train approaches and passes through an at-grade crossing, producing maximum levels of 80 dBA Lmax at 50 feet between 6:00 a.m. and 10:00 p.m. and reducing to 72 dBA Lmax between 10:00 p.m. and 6:00 a.m.
- For gated at-grade crossings, the project proposes to use electrical bells that are adjustable, with typical noise levels ranging from approximately 75 dBA to 85 dBA Lmax at 10 feet. For this analysis, the gate bells were analyzed using the default methods from the FTA Manual (2006), which assumes a typical Lmax of 85 to 86 dBA at 10 feet (or a single event level [SEL] of 109 dBA at 50 feet) and a 360 degree directional sound output. The bells would sound for approximately 25 seconds per train (10 to 13 seconds each, while lowering and raising the gates). Although it is plausible to lower the bell noise levels to 75 dBA, the default setting are being used to ensure a conservative analysis. Other noise mitigation alternatives, such as directional shrouds and turning off the bells while the gates are raised, were also not considered in this analysis.
- Sound Transit is currently investigating the use of nonaudible warnings for gated and ungated at-grade crossings. If nonaudible warning devices are found to be viable, this option could be used to reduce or eliminate bell noise at specific crossings, and could also reduce the number or severity of noise impacts presented in this study.
- Wheel squeal was assumed on all curves with a radius of less than 600 feet based on experience with the Central Link system. Wheel squeal is not included in the model because Sound Transit has committed to lubricating all curves in noise-sensitive areas with a radius of less than 600 feet, and preparing all curves with radius of less than 1,000 feet for lubrication.

The procedure used to evaluate the impacts of the project alternatives is based on the change in noise levels that would be caused by each alternative and the number of dwelling units potentially affected by project noise. For this analysis, attenuation for the noise reducing effects of ground coverage was not included, and all front-line receivers were assumed to have a line-of-sight view of the light rail route unless the route was in a retained cut, directly shielding the receptor from the tracks. This conservative methodology ensures that all potential noise impacts will be identified. This method is consistent with the FTA *Transit Noise and Vibration Manual*. Based on the results of the analysis provided in this section, noise impacts were determined for each alternative and for ancillary facilities. These impacts are identified in Section 6. Noise mitigation options were evaluated for all locations where the projected levels of noise exposure would exceed the FTA noise impact thresholds. The noise mitigation measures for the alternatives are discussed in Section 7.

TABLE 5-1
Light Rail Track-Type Adjustments

Track Type	Adjustment in dB
At-grade ballast and tie-track (ballast exposed)	0
Elevated structure	+4
Embedded track or retained-fill trackway	+3
Retained cut	-6
Crossover	+10

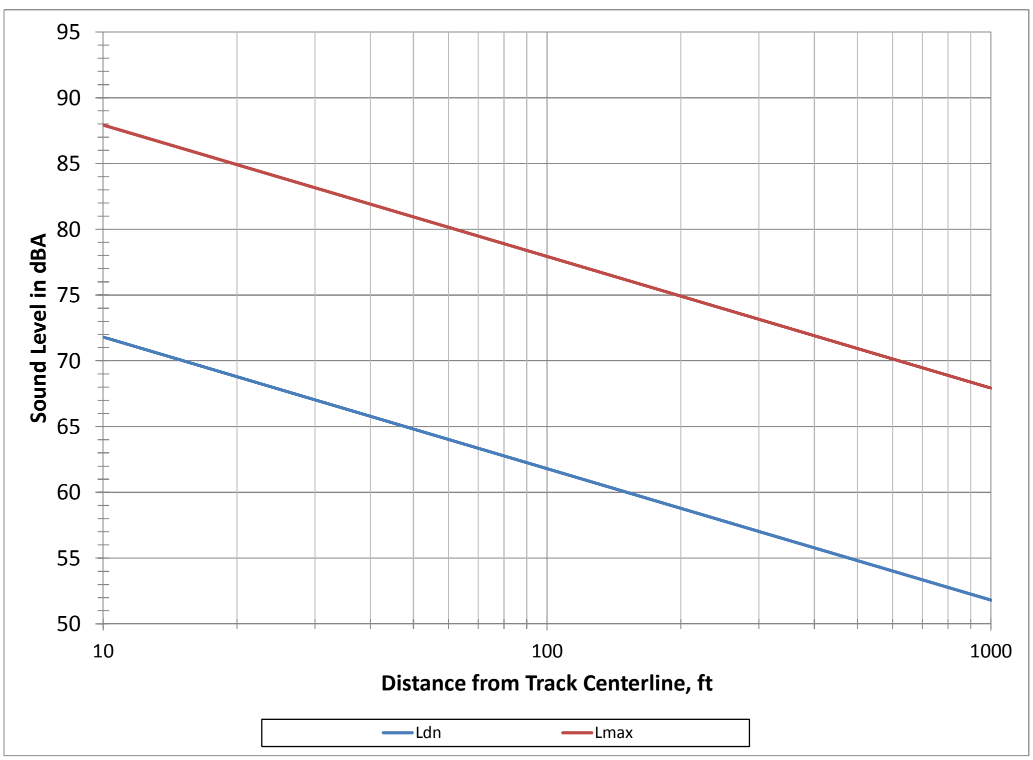


EXHIBIT 5-1
Projected Noise Levels from Light Rail Operations, 50 mph

5.2 Light Rail Vibration Projections

The projection of groundborne vibration from East Link Project light rail operations was based on the following:

- Vibration source levels were based on measurement data for the Sound Transit light rail vehicle, as measured by Wilson Ihrig & Associates, Inc. (2007).
- Vibration propagation tests were conducted at representative sites along the corridor near sensitive receptors (described in Section 3.3). The test results were combined with the vehicle vibration source level measurement data to project vibration levels from vehicles operating on the East Link Project alternatives.
- Vehicle operating speeds were taken from the operations plans. The speeds are dependent on location, with a maximum operating speed of 55 mph.
- Wheel impacts at crossovers typically cause localized vibration increases of 10 VdB.

The assumed vehicle vibration characteristics (represented by the force density spectra in Exhibit 5-2) at the appropriate speeds were combined with the ground-vibration propagation test results described in Section 3.3 and represented by transfer mobility spectra such as those shown in Exhibits 3-8 through 3-10E. Vibration levels were projected as a function of distance and speed for each of the test sites along the proposed corridor. The results of these transfer mobility tests are presented in Appendix D of this report. The results suggest dividing the rail corridor into ten regions for the purposes of vibration projection (excluding the site-specific vibration testing at the Winters House, Hilton Hotel, and Meydenbauer Center), defined based on the test sites as follows:

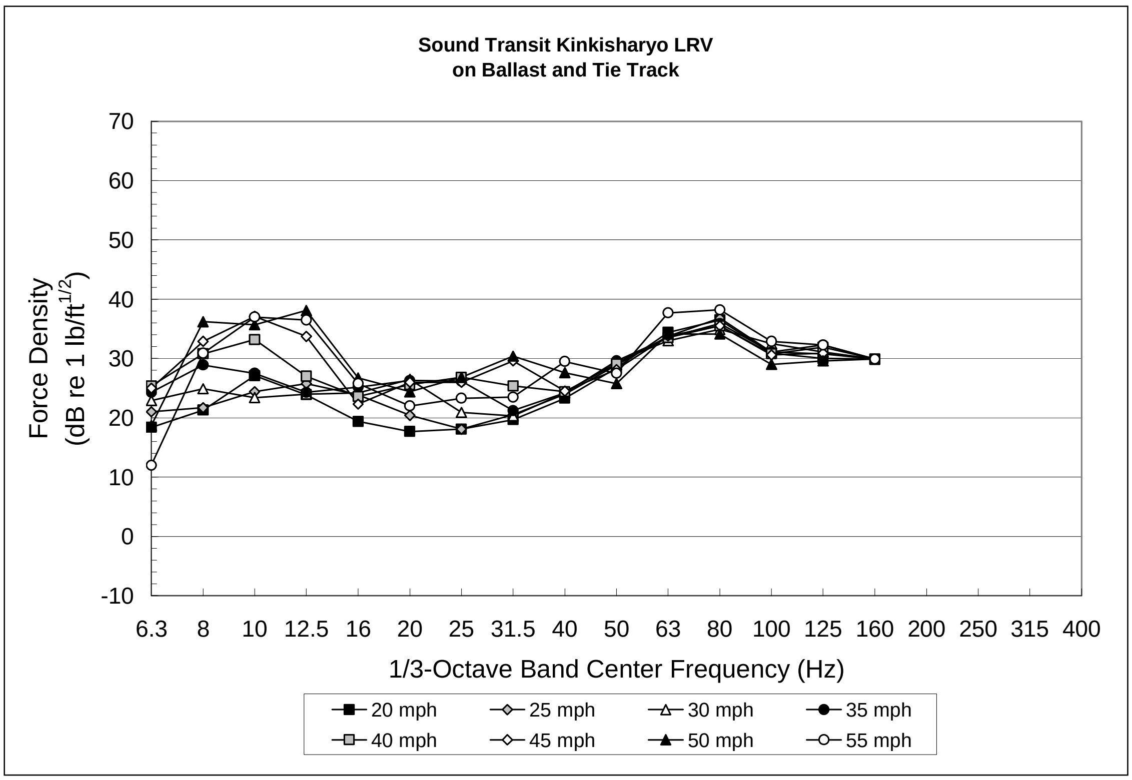


EXHIBIT 5-2
Light Rail Vehicle (LRV) Force Density Spectra on Ballast and Tie Track

- Region 1: Segment A (Site V-1)
- Region 2: The southern section of Segment B (Site V-2)
- Region 3: The northern section of Segment B and (Site V-3)
- Region 4: The southern section of Segment C (V-10)
- Region 5: The at-grade and elevated alternatives for Segment C (Site V-13)
- Region 6: The tunnel alternatives for Segment C (Site V-4)
- Region 7: Overlake Hospital (Site V-5)

- Region 8: Segment D (Sites V-6 and V-14)
- Region 9: The southern portion of Segment E (Site V-7)
- Region 10: The northern portion of Segment E (Site V-8)

The projections of maximum ground-vibration levels from light rail operations at 100 feet and 55 mph for each of the above ten regions are provided in Exhibits 5-3 through 5-5B. The curve for each site has a different spectral characteristic, which determines the distance to each region. The results suggest that there is relatively inefficient propagation of vibration throughout the proposed corridor, which will limit potential vibration impacts. However, there is substantial energy at higher frequencies (i.e., above 50 Hz), which suggests the potential for groundborne noise impacts in tunnel sections.

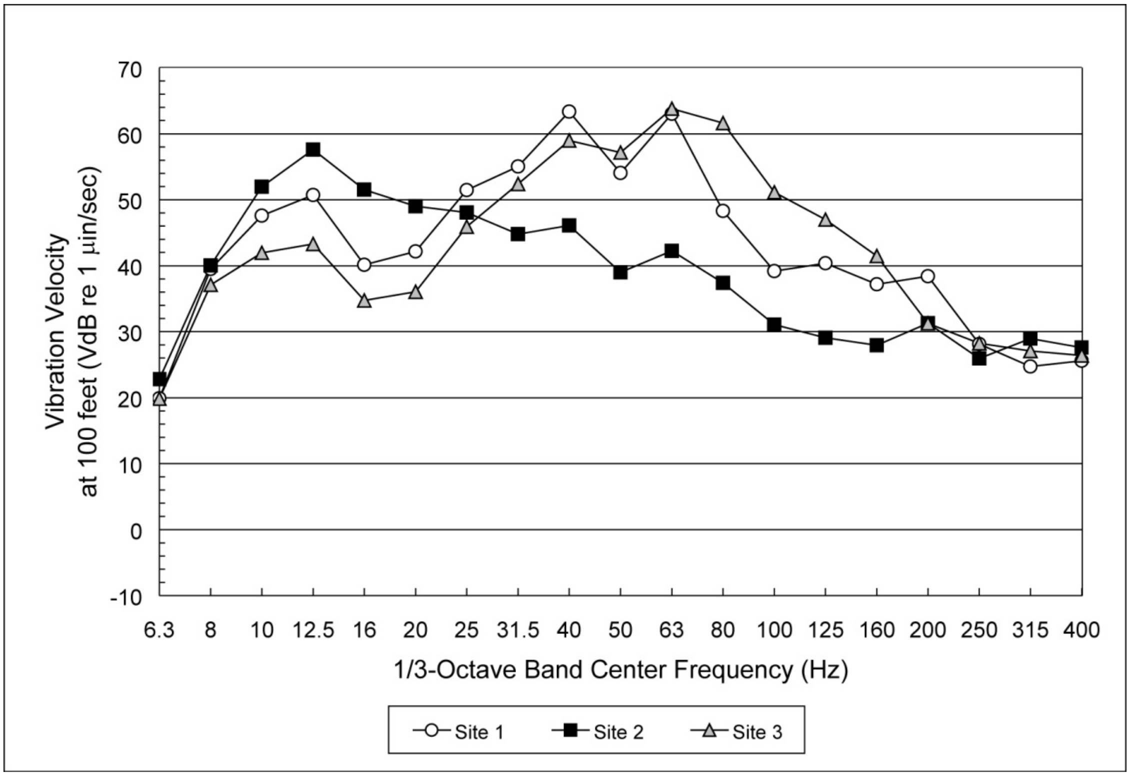


EXHIBIT 5-3
Projected Light Rail Ground Vibration Spectra at 55 mph, Sites V-1 to V-3

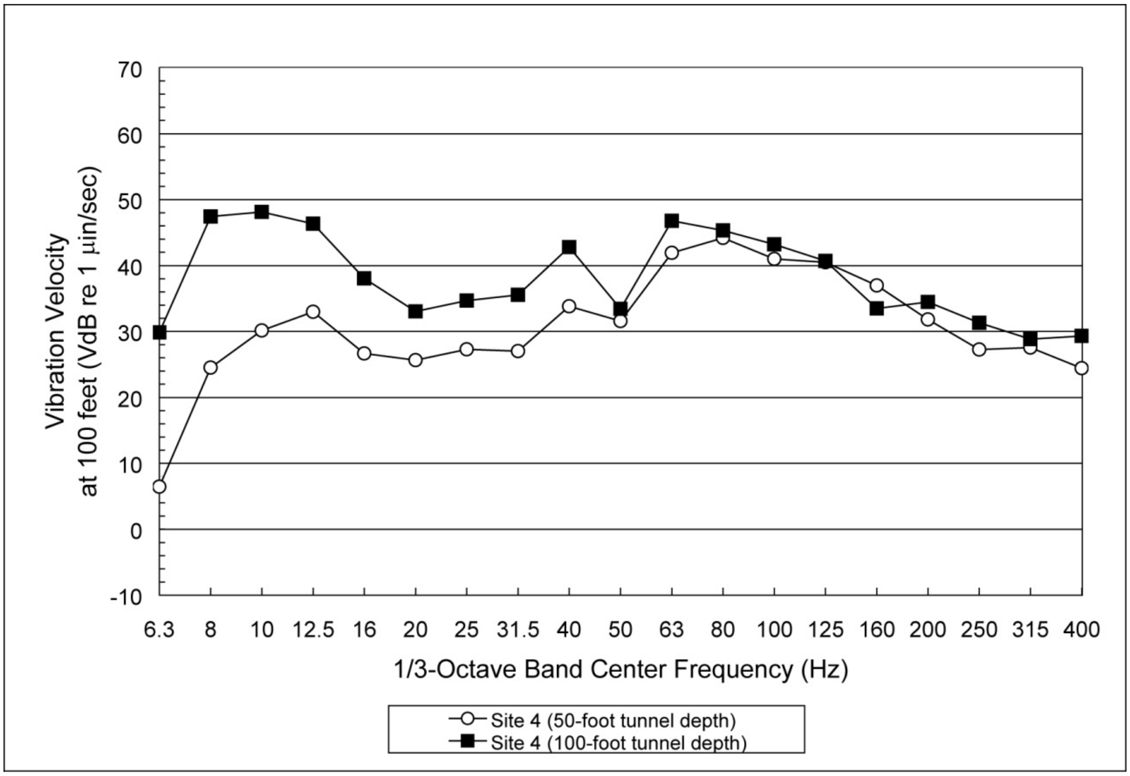


EXHIBIT 5-4
Projected Light Rail Ground Vibration Spectra at 55 mph, Site V-4

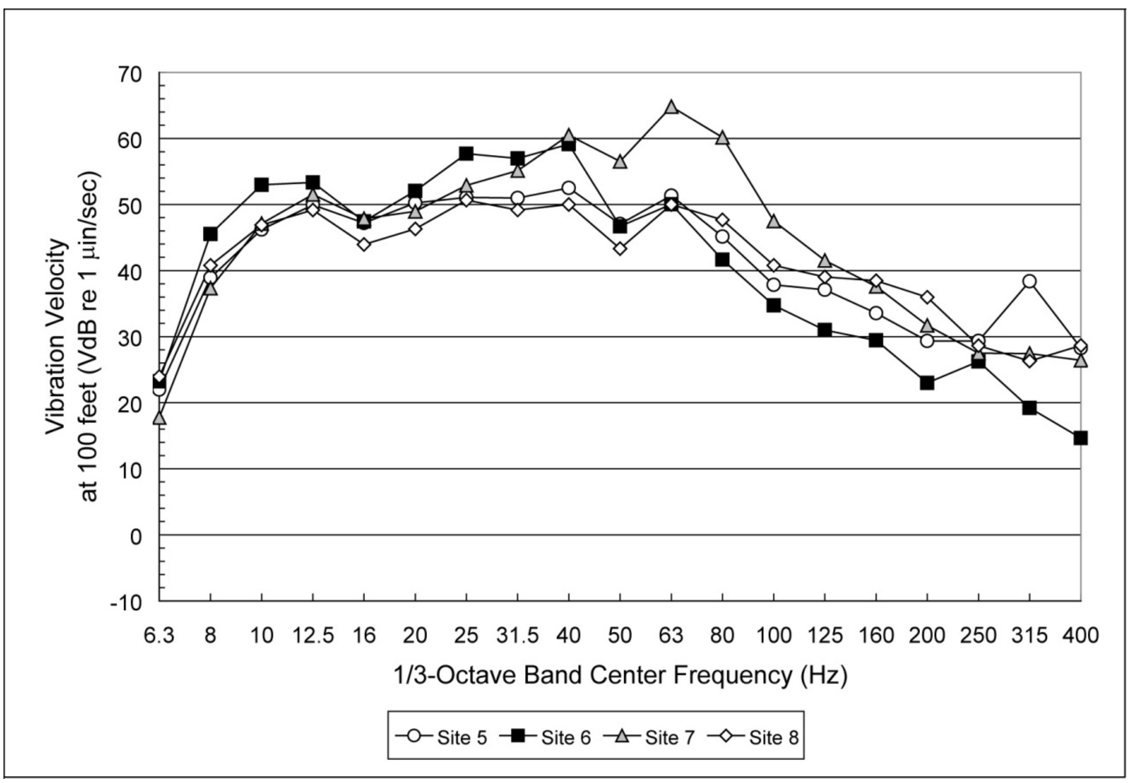


EXHIBIT 5-5A
Projected Light Rail Ground Vibration Spectra at 55 mph, Sites V-5 to V-8

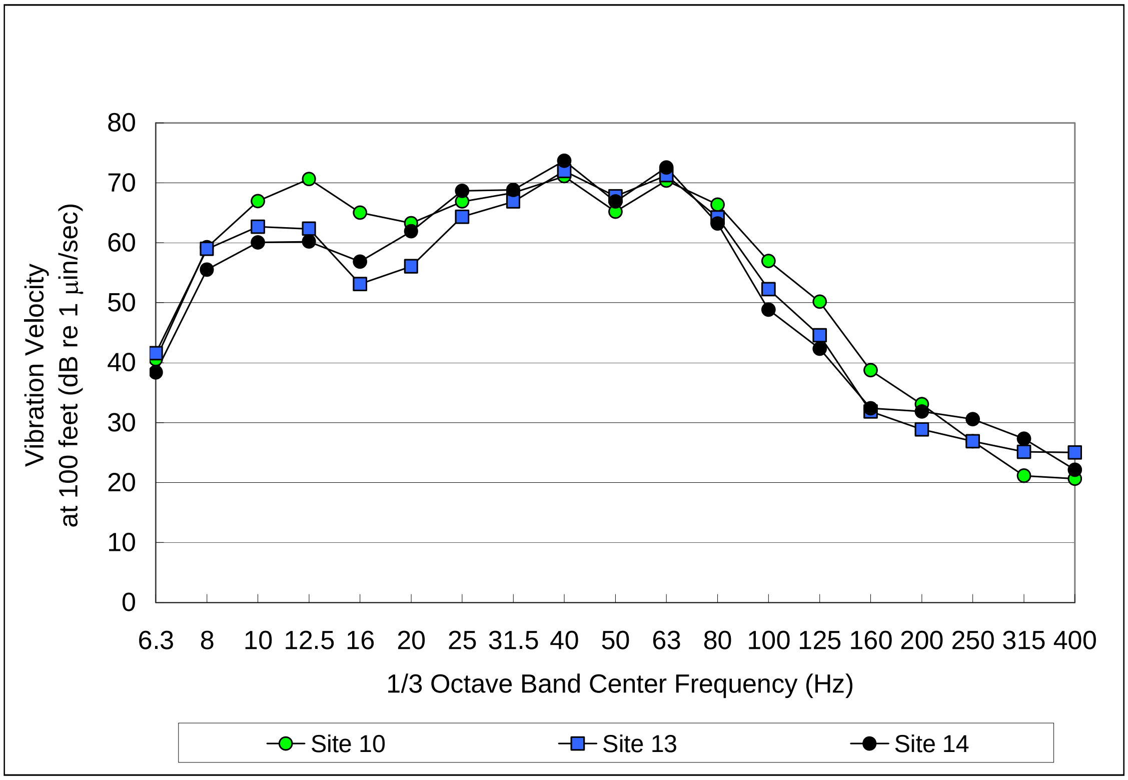


EXHIBIT 5-5B
Projected Light Rail Ground Vibration Spectra at 55 mph, Sites V-10, V-13, and V-14

5.3 Construction Noise Projections

The construction noise analysis considers the temporary noise impacts that construction would cause in the project vicinity. These impacts would end when project construction is completed.

Noise and vibration related to construction would result from the operation of heavy equipment needed to construct various project components, including bridges, retaining walls, roads, park-and-ride lots, and stations. The contractor would be required to adhere to local ordinances regulating noise, discussed in Section 4.4. Construction outside normal weekday daytime hours might require a noise variance from the city or county where the work is being performed if regulatory noise levels are exceeded.

Equipment required to complete the project includes normal construction equipment typically used for transportation construction projects. Table 5-2 provides a list of the typical equipment used for this type of project, the activities they would be used for, and the corresponding Lmax that would be produced as measured at 50 feet, under normal use.

TABLE 5-2
Construction Equipment List, Reference Noise Levels

Equipment	Expected Project Use	Lmax[a, b] (dBA)
Air compressors	Pneumatic tools and general maintenance (all phases)	70 to76
Backhoe	General construction and yard work	78 to 82
Concrete pump	Pumping concrete	78 to 82
Concrete saws	Concrete removal and utilities access	75 to 80

TABLE 5-2 CONTINUED
Construction Equipment List, Reference Noise Levels

Equipment	Expected Project Use	Lmax[a, b] (dBA)
Crane	Materials handling: removal and replacement	78 to 84
Excavator	General construction and materials handling	82 to 88
Forklifts	Staging area work and hauling materials	72
Haul trucks	Materials handling: general hauling	86
Jackhammers	Pavement removal	74 to 82
Loader	General construction and materials handling	86
Pavers	Roadway paving	88
Pile-drivers	Support for structure and hillside	99 to 105
Power plants	General construction use: nighttime work	72
Pumps	General construction use: water removal	62
Pneumatic tools	Miscellaneous construction work	78 to 86
Tractor trailers	Material removal and delivery	86
Utility trucks	General project work	72
Vibratory equipment	Shoring up hillside to prevent slides and soil compacting	82 to 88
Welders	General project work	76

[a] Typical maximum noise level under normal operation as measured at 50 feet from the noise source.

[b] Noise levels presented are based on measured data from the Portland Light Rail and I-5 Preservation and Hawthorne Bridge construction projects and other measured data and USDOT construction noise documentation and other construction noise sources.

5.4 Construction Vibration Projections

Construction vibration, similar to noise, is highly dependent on the specific equipment and methods employed. Construction vibration can cause a variety of potential effects, including influence on vibration-sensitive equipment at lower levels, low rumbling or groundborne noise, vibrations perceptible to humans at moderate levels, and slight damage to buildings at the highest levels. Generally, construction vibration was assessed at locations where prolonged annoyance or building damage could be expected.

In most cases, the main concern for construction vibration is the potential for damage. However, most construction processes do not generate high enough vibration levels to approach damage criteria. Because construction is a short-term, temporary impact, annoyance is usually not an important issue. The only time annoyance is usually addressed for construction vibration is for longer-term impacts, such as those related to the tunneling in Segment C. However, the thresholds for annoyance from construction vibration are substantially lower than those for damage.

Damage from construction vibration is generally limited to pile-driving and vibratory rolling, the only two activities with PPV levels at 25 feet that are higher than the damage criteria discussed in Section 4.5, Construction Vibration Criteria. Because of this, care should be taken to limit these activities near structures as much as possible.

Tunnel construction in Segment C is most likely to have potential temporary, short-term vibration annoyance impacts. Some sections of the proposed tunnel alternatives are expected to be constructed using a tunnel-boring machine with muck trains to transport the excavated material. Other tunnel sections and stations would use cut-and-cover techniques with sheet piling or augered pile techniques at the stations and portals.

The methodology for assessing construction vibration annoyance impacts is consistent with the approach provided in the FTA guidance manual, which includes obtaining reference 1-second rms overall vibration levels and 1/3-octave band spectra for each source at a distance of 25 feet. The propagation of vibration as a function of distance is an important factor in predicting vibration levels. Generally, surface or bore-hole-based vibration propagation measurements at the specific sensitive sites are needed to provide a detailed assessment. The following general prediction model is used to calculate vibration levels at the sensitive locations in each 1/3-octave band using the following propagation adjustment:

$$Lv(distance) = Lv(25\ feet) - 30 * \log(distance/25\ feet)$$

Adjustment factors are then applied according to the geological conditions that could promote efficient vibration propagation, coupling to the building foundation, floor-to-floor attenuation, and the amplification of vibrations due to the resonances of floors, walls, and ceilings. Vibration levels at the sensitive locations are then assessed against the vibration criteria for detailed analysis at highly sensitive locations shown in Table 4-4.

In accordance with FTA guidance, groundborne noise is assessed by converting the 1/3-octave band vibration velocity levels into A-weighted noise levels. Assessment of groundborne noise levels only applies to human annoyance because research equipment and other receptors are rarely sensitive to noise. The projected A-weighted noise levels are then assessed against the groundborne noise impact criteria shown in Tables 4-2 and 4-3.

6.0 Noise and Vibration Impact Assessment

A detailed noise and vibration impact assessment was performed based on the criteria discussed in Section 4 and on the projections described in Section 5 of this report. The assessment results are described below.

6.1 Light Rail and Traffic Noise Impact Assessment

Evaluation of the environmental noise impacts of the East Link alternatives was based on the change in the environmental noise level due to each project alternative and the number of dwelling units potentially affected by project noise. The transit noise methodology is consistent with the FTA *Transit Noise and Vibration Manual*. The FTA noise assessment methodology was also applied to the park-and-ride facilities and transit centers.

Because of the magnitude of properties analyzed for noise impacts, this report only summarizes and presents the impacts. Appendix A provides detailed maps showing all parcels analyzed, noise impacts, and severity of impact along with mitigation measures. Appendix E includes complete tabulated data, including the project parcel identification, existing noise levels, project noise levels, criteria, and other information.

6.1.1 Transit Noise

East Link Project light rail operational noise impacts were determined using the following approach:

- Perform a land-use survey of potential noise-sensitive receptors near the project alternatives. This process involved site visits and review of area land-use maps. Receivers located near each other and at the same distance from the proposed light rail alternatives were grouped together in clusters. All of the receivers in a given cluster would be within the same distance of light rail tracks and under similar conditions (such as track type and train speed); they would therefore have the same noise exposure.
- Establish existing noise levels for the potentially affected area through long-term (24-hour) and short-term (20-minute periods) noise monitoring. Ambient noise monitoring data from previous studies were used along with supplemental data taken specifically for this project. The criteria for monitoring selection included land use, existing ambient noise, number of sensitive receivers in the area, and level of expected impact.
- Use the field-noise measurements to project ambient sound levels for the noise-sensitive receptors, based on similarities in noise-source characteristics.
- Use the existing ambient sound levels to determine the noise impact criteria at each cluster. The FTA criteria for noise impacts for a particular area are based on the existing noise level.
- Make projections of light rail noise levels based on track type, train speed, vehicle type, and distance of receiver from tracks, with adjustments for shielding and ground attenuation.
- Compare projections to affect thresholds to determine if the receiver or cluster would be impacted by light rail operations, and where noise impacts are identified, consider mitigation and review any mitigation with the FTA *Transit Noise and Vibration Manual* and the Sound Transit's 2004 *Noise Mitigation Policy*.

In addition to the light rail operational noise analysis, a general noise analysis was also performed for park-and-rides and maintenance bases. These facilities were analyzed following the FTA *Transit Noise and Vibration Manual* for fixed ancillary facilities, which include an analysis using the local noise control ordinance, as provided in the WAC, Chapter 173-60. In addition, all parks along the proposed alternatives were reviewed for noise sensitivity under the FTA *Transit Noise and Vibration Manual*.

The only parks that are considered noise-sensitive under the FTA regulations are the sections of Mercer Slough Nature Park and Marymoor Park where peace and quiet are an essential part of the park's purpose. In both of these parks, these areas of peace and quiet are over 350 feet from the project alternatives, highways, and major arterial roadways. In addition, the distance to these areas, along with existing shielding, are sufficient to reduce noise to below the existing environment in sensitive areas. All other parks and park areas along the alternatives are near major highway or arterial roadways, including I-90, SR520, Bellevue Way SE, 112th Avenue SE, NE 12th Street, and other major roadways, and therefore are not considered noise-sensitive under FTA criteria.

6.1.2 Traffic Noise

Traffic noise was analyzed using the WSDOT methods given in the *Traffic Noise Abatement Policy and Procedures* (WSDOT, 2006). Traffic noise was only evaluated where required by FTA and FHWA, where the following conditions apply:

- A new roadway is planned as part of the project
- The project results in a significant change in the horizontal or vertical profile of an existing roadway
- The number of through-traffic lanes increases

Existing and future year 2030 peak-hour traffic noise levels were calculated using FHWA Traffic Noise Model (TNM) Version 2.5. Input to this model included traffic-volume and speed information from roadway traffic counts and data generated by Sound Transit traffic engineers. Input to the model relating to the existing and future roadway alignments and profiles was taken from engineering drawings and aerial photographs prepared by Sound Transit for the East Link Project. Traffic-noise emission levels used in the model were nationwide averages for automobiles, medium trucks, and heavy trucks. The noise-reducing effects of adjacent residences, roadway depressions, and topography were included in the calculations where appropriate. Project-related traffic noise impacts were identified by evaluating the TNM 2.5 model output against the traffic noise impact criteria. Noise monitoring data were used to validate the model.

6.1.3 Segment A

Segment A begins in the existing Downtown Seattle transit tunnel, continues along the I-90 D2 Roadway, and remains in the existing I-90 corridor to the I-90 Mount Baker Tunnel portals. Noise levels from rail operations in Seattle were projected for the residential area along Sturgus Avenue South, residences north of South Massachusetts Street, and at residences and parklands near the Mount Baker Tunnel. Projected project-related noise levels ranged from 55 to 63 dBA Ldn at residences and 61 dBA Leq at Judkins Park and Playfield.

Installing light rail on the I-90 floating bridge would require expansion joints at each end of the floating bridge structure that could create noise. Based on current projections, noise levels at a single home on Lake Washington Boulevard, just south of the bridge, could meet the FTA criteria, with a projected level of 63 dBA Ldn, when worst-case additional noise from the expansion joint is added to the analysis.

There are no existing expansion joints that could be measured for noise like the one proposed. Sound Transit is currently constructing a sample expansion joint for testing purposes. At that time, additional noise testing will be performed to determine if this impact would actually occur and what mitigation measures would be best suited to reduce noise levels from the joints.

In addition to the expansion joints, there would also be double crossovers located at each end of the floating bridge to facilitate single-track operations in the case of an emergency or for track maintenance. These crossovers are located over 400 feet from the nearest residences, would also be partly shielded from the residences by the safety barriers along the sides of the structure, and are not predicted to cause noise impacts.

On Mercer Island, noise projections were performed for the residences located on the west end of Mercer Island, to the I-90 lid, and near the east end of the island. Future project-related noise levels would range from 55 dBA Ldn to 58 dBA Ldn at the nearest homes on the west end of the island. The parks on Mercer Island are all well above the grade of the light rail trackway and would not be affected by noise from transit operations. There are no projected changes in the noise levels at any residences on Mercer Island, and no light rail noise impacts were identified. Table 6-1 summarizes noise impacts in Segment A, and Appendix E provides the tables of the modeled light rail noise levels.

TABLE 6-1
Summary of Potential Noise Impacts for Segment A

Alternative	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
Preferred Interstate 90 Alternative (A1)	1	0	0

6.1.4 Segment B

Table 6-2 summarizes noise impacts in Segment B, and then a detailed description of the impacts for each alternative follows. Transit noise impacts were identified under all of the Segment B alternatives; traffic noise impacts would only occur for 112th SE Bypass (B3), B3 - 114th Extension Design Option , 112th SE At-Grade (B2A), and Bellevue Way (B1) Alternatives because of changes in the travel lanes in relation to sensitive receptors. Before mitigation, the *Preferred 112th SE Modified Alternatives (B2M)* connecting to *Preferred Alternative C9T*, both with and without the C9T – East Main Station Design Option, would have the fewest impacts with 66 noise impacts. Maps showing the locations of the Segment B alternatives impacts are provided in Appendix A, and full tables of all modeled light rail and traffic noise levels are in Appendix E.

TABLE 6-2
Summary of Potential Noise Impacts for Segment B

Alternative	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
Preferred 112th SE Modified Alternative (B2M) to C11A	79	0	0
Preferred 112th SE Modified Alternative (B2M) to C9T	66	0	0
Preferred 112th SE Modified Alternative (B2M) to C9T – East Main Station Design Option	64	2	0
Bellevue Way Alternative (B1) [a]	128	4	136
112th SE At-Grade Alternative (B2A) [b]	77	1	17
112th SE Elevated Alternative (B2E)	85	21	0
112th SE Bypass Alternative (B3) [c]	79	4	17
B3 - 114th Extension Design Option [c]	76	1	17
BNSF Alternative (B7)	108	68	0

[a] Under Alternative B1 all but nine of the traffic noise impacts would also have light rail noise impacts; conversely, there are only five light rail impacts that would not have traffic noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 141; 5 would be impacted by light rail noise only, 9 would be impacted by traffic noise only, and 127 would be impacted by both traffic noise and light rail noise.

[b] Under Alternative B2A all but one of the traffic noise impacts would also have light rail noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 79; 62 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise.

[c] Under Alternatives B3 and B3 – 114th Extension Design Option all but one of the traffic noise impacts would also have light rail noise impacts. For B3, the total number of residences impacted (single- and multifamily) would be 84; 67 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise. For B3 – 114th Extension Design Option, the total number of residences impacted (single- and multifamily) would be 78; 61 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise.

All Segment B alternatives except Alternative B7 travel along the west side of Mercer Slough Nature Park. This park is bordered on two sides by two interstate highways—I-90 and I-405—and on a third side by the major arterial Bellevue Way SE, a park-and-ride, and a commercial office park, where "quiet" is not an essential element as outlined in the FTA criteria for park noise analysis. The active uses along the west perimeter include the boat launch, blueberry farm, and Winters House and are not considered noise-sensitive. The central portions of Mercer Slough Nature Park contain uses that do meet the criteria as noise-sensitive, such as nature watching and protected trails.

Sound Transit conducted a noise impact analysis for park users in noise-sensitive areas of the Mercer Slough Nature Park and also predicted noise levels for the areas of the park near Bellevue Way SE. Typical noise levels at the edge of the park, near Bellevue Way SE, are between 61 dBA and 67 dBA Leq. Noise levels in noise sensitive areas of the park, near the center, were measured at 58 dBA Leq during normal daytime hours. The FTA Category 3, which includes certain parks and recreational areas, was used to determine compliance with FTA noise impact criteria at the interior noise-sensitive parts of the park. Light rail noise levels from operation of *Preferred Alternatives B2M* to *C11A* or *B2M* to *C9T* are predicted to be lower than the existing noise levels in the interior noise-sensitive areas of the park, and are under the FTA noise impact criteria for a Category 3 land use.

The only other park in Segment B is the Enatai Beach Park, which is well-shielded from light rail noise by I-90, and therefore would have no project-related noise impacts.

6.1.4.1 Preferred 112th SE Modified Alternative (B2M)

Under *Preferred Alternative B2M*, the level of noise impacts would vary with the different connections. Under *Preferred Alternative B2M to C11A*, 79 moderate light rail noise impacts are predicted. Forty-one impacts would occur along the elevated segment from I-90 to the intersection with 112th Avenue SE, affecting single-family residences adjacent to SE 34th Street and Bellevue Way SE. North of the Bellevue Way SE/112th Avenue SE intersection, seven noise impacts are predicted at the single-family residences west of 112th Avenue SE, near SE 17th and SE 14th Streets. All noise impacts between I-90 and the retained cut at the Winters House would be related to the elevated guideway, a crossover near SE 30th Street, and, to a lesser extent, train bells at the station.

Under *Preferred Alternative B2M to C11A*, 19 moderate noise impacts were also identified at the Bellefield Residential Park Condominiums as well as 12 moderate impacts at single-family residences along 111th Avenue SE just south of Surrey Downs Park. Impacts in this area would be due to lower impact criteria as a result of lower ambient noise levels, gated crossings, and train wayside noise.

Under *Preferred Alternative B2M to C9T*, 66 moderate light rail noise impacts were identified. Noise impacts from I-90 to 112th Avenue SE would be the same as with *Preferred Alternative B2M to C11A*, with 41 moderate impacts along this portion of the alternative. There would also be six impacts on single-family residences west of 112th Avenue SE, near SE 17th and SE 14th Streets, and nine moderate noise impacts at the Bellefield Residential Park Condominiums. Finally, there would be 10 moderate impacts at single-family residences along 111th Avenue SE just south of Surrey Downs Park.

Noise impacts with *Preferred Alternative B2M to C9T* would occur for the same reasons as with *Preferred Alternative B2M to C11A*, although some impacts would occur in different locations and with different severity. There are no roadway modifications that would move traffic closer to any noise-sensitive properties; therefore, no traffic noise impacts were identified under either of the *Preferred Alternative B2M* connection options.

Under *Preferred Alternative B2M to C9T* with the C9T - East Main Station Design Option, the SE 8th Station would be relocated to the north in Segment C, and a crossover from Segment C would be relocated to the SE 8th Station site in Segment B, just north of SE 8th Street. This change would increase the noise levels at several homes along 111th Place SE by 1 to 4 dB over the default station location. In addition, two of the moderate noise impacts would now be considered severe under the FTA criteria. The overall results under *Preferred Alternative B2M to C9T* with the C9T - East Main Station Design Option are 64 moderate impacts and 2 severe impacts. Table 6-3 summarizes a comparison between the two *Preferred Alternative* connections and the connection to the C9T – East Main Station Design Option based on land use type.

TABLE 6-3
Noise Impact Comparison for Preferred Alternative B2M to Preferred Alternative C11A, C9T, and C9T – East Main Station Design Option

Land Use Type	*To Preferred Alternative C9T*		*To Preferred Alternative C11A*		*To Preferred Alternative C9T with East Main Station Design Option*	
	Moderate	**Severe**	**Moderate**	**Severe**	**Moderate**	**Severe**
Single-family	57	0	60	0	55	2
Multifamily	9	0	19	0	9	0
Hotel	0	0	0	0	0	0
Hospital	0	0	0	0	0	0
School	0	0	0	0	0	0
Recording/concert (FTA Category-1)	0	0	0	0	0	0
Parks and recreation (FTA Category-3)	0	0	0	0	0	0
Church	0	0	0	0	0	0
Sensitive medical facilities (nonsleeping)	0	0	0	0	0	0
Total Impact Before Mitigation	**66**	**0**	**79**	**0**	**64**	**2**

6.1.4.2 Bellevue Way Alternative (B1)

In Segment B, 260 residential units and 3 church buildings were evaluated for noise impacts; the analysis projected an overall total of 141 noise impacts under Alternative B1. This includes 128 moderate light rail impacts, 4 severe light rail noise impacts, and 136 traffic noise impacts. It is important to note that all but nine of the units identified with traffic noise impacts would also have noise impacts related to light rail. The four sites identified with severe light rail noise impacts are all located near a crossover at SE 30th Street. Light rail noise levels under this alternative ranged from 52 to 75 dBA Ldn, with the highest noise levels, and severe impacts, occurring near the crossover near SE 30th Street.

6.1.4.3 112th SE At-Grade Alternative (B2A)

For Alternative B2A, a total of 78 light rail noise impacts were identified, including one severe impact near the crossover at SE 30th Street. Light rail operational noise levels are projected to range from 53 to 69 dBA Ldn at noise-sensitive properties along Bellevue Way SE and 112th Avenue SE, with one receiver near the crossover where noise levels are projected to reach 72 dBA Ldn before any mitigation measures are applied.

Alternative B2A would require some roadway widening along Bellevue Way SE, between the South Bellevue Station and the 112th Avenue SE intersection. Along 112th Avenue SE, Alternative B2A would replace the existing median, and minimal roadway modifications would be required. Future traffic noise levels with the project along Bellevue Way are projected to increase by up to 6 dBA, with future traffic noise levels of 66 to 72 dBA Leq during peak hours at affected residences. Under Alternative B2A, 17 residences are projected to have traffic noise impacts because of the roadway widening. The East Link Project would be required to consider mitigation for these residences.

6.1.4.4 112th SE Elevated Alternative (B2E)

Under Alternative B2E, 85 moderate and 21 severe noise impacts are projected. One severe impact occurs at a single-family residence near the crossover at SE 30th Street. North of the South Bellevue Transit Station, the proximity of the elevated structure to homes near SE 23rd Street and 109th Avenue SE would result in an additional 15 severe impacts. The remaining five severe impacts would be just south of Bellefield Residential Park Condominiums at a group of single-family residences off of SE 17th Street. Light rail-related noise levels range from 53 to 74 dBA Ldn at the 148 locations used in the noise analysis. Alternative B2E would require no substantial changes in the roadway alignments; therefore, no traffic noise impacts are projected.

6.1.4.5 112th SE Bypass Alternative (B3)

There were 79 moderate and 4 severe noise impacts identified for Alternative B3. One of the severe impacts would be due to the crossover at SE 30th Street. The remaining severe impacts would be to single-family residences just south of Surrey Downs Park, along 111th Avenue SE, because of the added noise associated with the elevated structure. Light rail-related noise levels at the 148 residences evaluated under this alternative ranged from 53 to 72 dBA Ldn.

Traffic noise impacts under Alternative B3 would be at the same 17 residences predicted with traffic noise impacts under Alternative B2A.

There were 76 moderate noise impacts and 1 severe impact identified for the B3 - 114th Extension Design Option. As with Alternative B3, a severe impact would occur due to the crossover at SE 30th Street. The other residences that would have severe impacts under Alternative B3 would not have a severe impact with this design option because of the added distance between the elevated guideway and the homes. Light rail-related noise levels at the 148 residences evaluated under this design option ranged from 53 to 72 dBA Ldn. Traffic noise impacts under B3 – 114th Extension Design Option would be the same as those described above for Alternative B2A.

6.1.4.6 BNSF Alternative (B7)

For Alternative B7, 108 moderate and 68 severe light rail noise impacts are projected along the corridor. Sixteen single-family residences near I-90, west of Bellevue Way SE, were identified with moderate noise impacts. Along the west side of the light rail route along 118th Avenue SE, there would be 160 noise impacts, of which 68 are projected to be in the FTA severe category, with the other 92 being moderate. Thirty of the severe noise impacts would be due to the nearby crossover, while the other 38 would result from the proximity to the tracks and the higher train speed under this alternative. Maps of the impacts are provided in Appendix A. Complete tabulated modeled noise levels for Alternative B7 are provided in Appendix E of this report. Alternative B7 would require no substantial changes in the roadway alignments; therefore, no traffic noise impacts are projected.

6.1.5 Segment C

Table 6-4 summarizes light rail noise impacts in Segment C, and a detailed description of the impacts for each alternative follows. The two preferred alternatives in Segment C, *Preferred 108th At-Grade Alternative (C11A)* and *Preferred 110th Tunnel Alternative (C9T)* (both from *Preferred Alternative B2M*) are compared in Table 6-5, and each alternative is discussed after that. Note that *Preferred Alternatives C11A* and *C9T* can also be connected to Alternative B3, B3 – 114th Extension Design Option, or B7; those connections are discussed below and included in Table 6-4. Traffic noise impacts were identified for the Bellevue Way Alternative (C1T) only and are discussed with that alternative. The remaining Segment C alternatives will not substantially change the existing roadway alignments, and therefore no traffic noise impacts were identified for these alternatives.

There are several parks and parklands in Segment C, including the Surrey Downs Park, Downtown Park, Ashwood Park, and McCormick Park. Surrey Downs Park is located along 112th Avenue SE, an established transportation corridor. The Downtown Park, as its name implies, is located in Downtown Bellevue near NE 2nd Street. Ashwood Park and McCormick Park are both located near NE 12th Street, which is also an established transportation corridor. These parks were all reviewed for sensitivity to noise. Since these parks do not have noise-sensitive uses and are located along established transportation corridors, none meet the FTA criteria for a noise-sensitive use; therefore, no light rail operational noise impacts were identified in Segment C.

Complete maps and tabulated modeled noise levels for Segment C alternatives are included in Appendices A and E of this report.

TABLE 6-4
Summary of Potential Noise Impacts for Segment C

Alternative	Connection (from Alternative)	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
Preferred 108th NE At-Grade Alternative (C11A)	*Preferred 112th SE Modified Alternative (B2M)*	119	65	0
	112th SE Bypass (B3), B3 – 114th Extension Design Option, or BNSF (B7) Alternative	152	52	0
Preferred 110th NE Tunnel Alternative (C9T)	*Preferred 112th SE Modified Alternative (B2M)*	62	57	0
	Alternative B3, B3 – Design Option, or B7	88	52	0
C9T – East Main Station Design Option	*Preferred 112th SE Modified Alternative (B2M)*	67	52	0
Bellevue Way Tunnel Alternative (C1T) [a]	Bellevue Way Alternative (B1)	48	52	18
106th NE Tunnel Alternative (C2T)	112th SE At-Grade Alternative (B2A)	48	52	0
	112th SE Elevated Alternative (B2E)	113	66	0
	Alternative B3 or B7	66	70	0
108th NE Tunnel Alternative (C3T)	Alternative B2A	26	0	0
	Alternative B2E	91	14	0
	Alternative B3 or B7	44	18	0
Couplet Alternative (C4A)	Alternative B2A	435	15	0
	Alternative B2E			
	Alternative B3 or B7	420	19	0

TABLE 6-4 CONTINUED
Summary of Potential Noise Impacts for Segment C

Alternative	Connection (from Alternative)	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
112th SE Elevated Alternative (C7E)	Alternative B2A or B2E	270	12	0
	Alternative B3 or B7	208	0	0
110th NE Elevated Alternative (C8E)	Alternative B3 or B7	353	72	0
110th NE At-Grade Alternative (C9A)	Alternative B2A	185	56	0
	Alternative B3, B3 – Design Option, or B7	145	54	0
114th NE Elevated Alternative (C14E)	Alternative B3, B3 – Design Option, or B7	36	112	0

[a] Under Alternative C1T all the traffic noise impacts are separate from light rail noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 118; 100 would be impacted by light rail noise only, 18 would be impacted by traffic noise only, and 0 would be impacted by both traffic noise and light rail noise.

6.1.5.1 Preferred 108th NE At-Grade Alternative (C11A)

Under *Preferred Alternative C11A* from *Preferred Alternative B2M*, 119 moderate and 65 severe light rail noise impacts are predicted. Some of the severe impacts would occur at single-family homes along 111th Avenue SE because of a nearby crossover and loss of shielding from displaced buildings. Severe impacts, which are predicted at several multifamily units along 108th Avenue NE, would occur because of bells and proximity to the tracks. Finally, the severe noise impacts at the Lake Bellevue Village Condominiums would be due to lower impact criteria because this area has lower ambient noise levels. Severe impacts are also projected at the Coast Bellevue Hotel because of a nearby crossover and the proximity of the tracks to the hotel rooms. Along the at-grade segment through Downtown Bellevue, an additional 108 moderate noise impacts were identified. No roadway modifications would be required nor would there be any traffic noise impacts. Overall, the project-related noise levels were projected to range from 53 to 69 dBA Ldn, with the Coast Bellevue Hotel projected to have a severe impact and a projected 80 dBA Ldn due to a crossover and high train speed on the structure. No roadway realignment is planned as part of this alternative; therefore, no project-related traffic noise impacts are anticipated.

Preferred Alternative C11A from Alternatives B3, B7, or B3 – 114th Extension Design Option would result in 152 moderate and 52 severe light rail noise impacts. The severe impacts that would occur at the single-family residences along 111th Avenue SE would not occur under the Alternatives B3 or B7 connection options. Instead, there would be 36 new moderate noise impacts at the Hilton Hotel and 8 moderate impacts at single-family residences south of Main Street. Noise impacts in the downtown corridor, at the Coast Bellevue Hotel, and at Lake Bellevue Condominiums would be the same with connection options to Alternative B3, B3 – 114th Extension Design Option, or B7. The change in the number and severity of impacts under Alternatives B3, B7, or B3 – 114th Extension Design Option when compared to *Preferred Alternative B2M* is due to changes in the alignment related to the different alternative connection. The range of noise levels with the Alternative B3 or B7 connections would be the same as given under the *Preferred Alternative B2M* connection.

6.1.5.2 Preferred 110th NE Tunnel Alternative (C9T)

Noise levels under *Preferred Alternative C9T* from *Preferred Alternative B2M* would range from 48 to 79 dBA Ldn with 62 moderate and 57 severe impacts. The severe impacts would occur at five single family homes along 111th Place SE, a multifamily building on NE 6th Street in Downtown Bellevue and the Lake Bellevue Village

Condominiums. Depending on the location, the severe impacts would result from one or more of the following: proximity to the track, bells at crossings, and crossovers.

Under the C9T – East Main Station Design Option from *Preferred Alternative B2M*, the relocation of the crossover and insertion of the new station site would reduce the number of severe impacts when compared to the scenario with the SE 8th Street Station. The reduced noise from relocating the crossover is the reason for the reduction in the severity of impacts. There would still be a total of 119 noise impacts, however, with the East Main Station—52 severe and 67 moderate. No roadway modifications are predicted to result in a noticeable increase in traffic noise levels, and therefore no project-related traffic noise impacts are predicted.

Preferred Alternative C9T from Alternatives B3, B7, or B3 – 114th Extension Design Option would result in 88 moderate and 52 severe light rail noise impacts. With *Preferred Alternative B2M,* the total number of impacts would increase from 119 to 140. The change in the number of impacts, as with *Preferred Alternative C11A*, would be due to reduced noise impacts along 112th Avenue SE and an increase in noise impacts at the Hilton Hotel rooms facing toward the tracks. Impacts at the Coast Bellevue Hotel and the Lake Bellevue Condominiums would remain, along with impacts at four single-family homes south of Main Street. Table 6-5 compares the two Segment C *Preferred Alternatives*. This table summarizes in detail the number of moderate and severe impacts for each alternative by type of land use. As would be expected, the at-grade *Preferred Alternative C11A* would have more noise impacts than the tunnel *Preferred Alternative C9T*. The increased impacts would be along the at-grade segment on 108th Avenue NE in Downtown Bellevue.

TABLE 6-5
Noise Impact Comparison for Preferred Alternatives C11A or C9T from Preferred Alternative B2M

Land Use Type	***Preferred Alternative C11A***		***Preferred Alternative C9T***		***Preferred Alternative C9T* with C9T - East Main Station Design Option**	
	Moderate	**Severe**	**Moderate**	**Severe**	**Moderate**	**Severe**
Single-family	11	13	14	5	19	0
Multifamily	108	16	48	16	48	16
Hotel	0	36	0	36	0	36
Hospital	0	0	0	0	0	0
School	0	0	0	0	0	0
Recording/concert (FTA Category 1)	0	0	0	0	0	0
Parks and recreation (FTA Category 3)	0	0	0	0	0	0
Church	0	0	0	0	0	0
Sensitive Medical Facilities (Non-sleeping)	0	0	0	0	0	0
Total Impact Pre-Mitigation	**119**	**65**	**62**	**57**	**67**	**52**

6.1.5.3 Bellevue Way Tunnel Alternative (C1T)

There are 48 moderate and 52 severe light-rail-related noise impacts projected for the Bellevue Way Tunnel Alternative (C1T). The impacts would occur at multifamily units at The Bravern and Lake Bellevue Condominiums, and at the Coast Bellevue Hotel. Up to 16 units are projected to exceed the FTA severe impact criteria at Lake Bellevue Village Condominiums, and 48 units are projected to experience moderate impacts at The Bravern.

With Alternative C1T, the roadway would be widened, thereby moving the traffic lanes closer to several properties; this would result in traffic noise impacts on 18 multifamily units along Bellevue Way near the connection to Segment B. All 18 units are on the west side of Bellevue Way, between the retained-cut section and just north of the tunnel portal.

6.1.5.4 106th NE Tunnel Alternative (C2T)

Under Alternative C2T, the number of impacts would vary with the connection alternative. Connecting from Alternative B2A, there would be 48 moderate and 52 severe light rail noise impacts. The impacts would occur at multifamily units at Lake Bellevue, The Bravern, and the Coast Bellevue Hotel.

Connecting from Alternative B2E, the number of impacts would increase from a total of 100 under Alternative B2A to 179. The increased number of impacts is due to the elevated structure along 112th Avenue SE, where 47 impacts were identified, including 14 severe impacts due to the proximity to a crossover.

When connecting from Alternative B3 or B7, Alternative C2T would have moderate noise impacts on 48 multifamily units and 18 hotel rooms and severe impacts on 16 multifamily units and an additional 54 hotel rooms.

6.1.5.5 108th NE Tunnel Alternative (C3T)

Twenty-six moderate light rail noise impacts were identified under the 108th NE Tunnel Alternative (C3T) connecting from Alternative B2A. All 26 impacts would be near the tunnel portal along NE 12th Street. With Alternative C3T from Alternative B2E, there would be severe noise impacts at 2 single-family units and 12 multifamily units. The 14 severe impacts would be all along 112th Avenue SE and due to a double crossover. There would be 59 moderate impacts, comprised of 13 single-family and 46 multifamily units. The noise analysis also predicts 32 moderate impacts on the Bellevue Club hotel rooms facing 112th Avenue SE. Impacts with Alternative C3T from Alternative B2E would occur along 112th Avenue SE and near the tunnel portal along NE 12th Street.

When connecting from Alternative B3 or B7, Alternative C3T would have severe noise impacts on 18 hotel rooms and moderate impacts on 5 single-family units, 21 multifamily units, and 18 more hotel rooms. Alternative C3T would require no substantial changes in the roadway alignments; therefore, no traffic noise impacts are projected.

6.1.5.6 Couplet Alternative (C4A)

For the Couplet Alternative (C4A) connecting from Alternative B2A or B2E, there would be 15 severe noise impacts and 435 moderate noise impacts. The high numbers of noise impacts would be due to the dense multifamily units along the at-grade sections along 110th and 108th Avenues NE and NE 12th Street.

For the connections from Alternative B3 or B7, there would be moderate impacts on 13 single-family units, 365 multifamily units, and 42 hotel rooms along with severe impacts on 1 single-family unit and 18 hotel rooms. The severe noise impact at the single-family unit would be due to added noise from bells at the at-grade crossings.

6.1.5.7 112th NE Elevated Alternative (C7E)

Several noise impacts are projected for the 112th NE Elevated Alternative (C7E), and they vary depending on connection. Under the connection to Alternatives B2A or B2E, there would be severe noise impacts at 12 multifamily residential units south of Main Street due to crossovers. In addition to the 12 severe impacts, there are also moderate noise impacts at 40 single- and multifamily units south of Main Street and along 112th Avenue SE. As the alignment continues along 112th Avenue NE, an additional 228 moderate impacts were identified at multifamily units and hotels along the corridor. Finally, there are also 6 single-family residences north of NE 12th Street that would also exceed the FTA moderate criteria.

When connecting to Alternative B3 or B7, Alternative C7E would have moderate noise impacts at 208 single and multifamily residences, and several hotel rooms. There are no severe impacts projected under Alternative C7E from Alternatives B3 or B7. Maps of analysis and impact locations are provided in Appendix A.

6.1.5.8 110th NE Elevated Alternative (C8E)

Alternative C8E only connects to Alternative B3 or B7. Under Alternative C8E, 72 multifamily residences near NE 2nd Street are projected to have severe noise impacts due to the proximity of the elevated structure to the units. Moderate light rail-related noise impacts were also identified at an estimated 9 single-family units, 224 multifamily units, and 120 hotel rooms along elevated structure.

6.1.5.9 110th NE At-Grade Alternative (C9A)

Alternative C9A connecting to Alternative B2A is projected to have 56 severe impacts and 185 moderate impacts. Severe impacts at 4 single-family residences would be due to crossovers and bells, while the 16 multifamily severe impacts at the Lake Bellevue Condominiums would be due to the low existing noise levels in this area. The remaining 36 severe impacts would be at the Coast Bellevue Hotel, due to a double crossover and higher train speed.

With a connection from Alternative B3, B3 – 114th Extension Design Option, or B7, the total number of impacts would be reduced from 241 to 199, with 54 severe impacts. The severe impacts are related to bells south of Main Street, proximity and speed at the Coast Bellevue Hotel, and impacts at the same units as described above at the Lake Bellevue Condominiums.

6.1.5.10 114th NE Elevated Alternative (C14E)

Alternative C14E only connects to Alternative B3, B3 – 114th Extension Design Option, or B7 and remains near I-405 along 114th Avenue NE. It connects to Segment D near the Lake Bellevue Condominiums, where 16 severe impacts are projected. Alternative C14E would also have severe impacts at 96 hotel rooms and moderate impacts at an additional 36 hotel rooms.

6.1.6 Segment D

Table 6-6 summarizes light rail noise impacts in Segment D, and the impacts for each alternative are then described in detail. There would be no substantial changes to the existing roadway alignments in Segment D; therefore, no traffic noise impacts were identified for these alternatives. There are no noise-sensitive parks located near any of the project alternatives in Segment D. For each Segment D alternative, detailed impact figures are provided in Appendix A, and noise level tables are provided in Appendix E.

TABLE 6-6
Summary of Potential Noise Impacts for Segment D

Alternative	Connection (from Alternative)	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
Preferred NE 16th At-Grade Alternative (D2A)	*C11A*, *C9T*, C1T, C2T, C9A, and C14E (former BNSF Railway corridor)	0	0	0
D2A - 120th Station Design Option or D2A - NE 24th Design Option	*C11A*, *C9T*, C1T, C2T, C9A, and C14E (former BNSF Railway corridor)	0	0	0
NE 16th Elevated Alternative (D2E)	*C11A*, *C9T*, C1T, C2T, C9A, and C14E (former BNSF Railway corridor)	1	0	0
	C3T, C4A, C7E, or C8E (NE 12th Street)	2	0	0
NE 20th Alternative (D3)	*C11A*, *C9T*, C1T, C2T, C9A, and C14E (former BNSF Railway corridor)	0	0	0
	C3T, C4A, C7E, or C8E (NE 12th Street)	1	0	0
SR 520 Alternative (D5)	*C11A*, *C9T*, C1T, C2T, C9A, and C14E (former BNSF Railway corridor)	0	10	0
	C3T, C4A, C7E, or C8E (NE 12th Street)	1	10	0

6.1.6.1 Preferred NE 16th At-Grade Alternative (D2A)

Under *Preferred NE 16th At-Grade Alternative (D2A)* connecting to *Preferred Alternative C11A* or *C9T* and Alternative C1T, C2T, C9A, or C14E (the former BNSF Railway corridor alternatives), there are no noise impacts projected because the alternatives are located along commercial and industrial land uses in Segment D. The only noise-sensitive land use is the Pacific Northwest Ballet School, located in an industrial building at the intersection of NE 16th Street and 136th Place NE. Noise levels from light rail operations at the school are predicted to be 62 dBA Leq during peak hour operations, which is below the impact criteria of 63 dBA Leq. Noise impacts with the D2A design options (120th Station or D2A - NE 24th, with or without the 130th Station) would be the same as with *Preferred Alternative D2A*.

6.1.6.2 NE 16th Elevated Alternative (D2E)

Noise impacts under the NE 16th Elevated Alternative (D2E) would include a moderate impact at the Pacific Northwest Ballet School because of the added noise from the elevated structure. If connected to the alternatives along the former BNSF Railway corridor, then there would be no other noise impacts; however, with a connection to the NE 12th Street alternatives, there would be an additional moderate noise impact at the Children's Hospital BCSC.

6.1.6.3 NE 20th Alternative (D3)

There would be no noise impacts with the NE 20th Alternative (D3) if connecting from Segment C alternatives along the former BNSF Railway corridor. However, with a connection to the NE 12th Street alternatives, there would be one moderate noise impact at the Children's Hospital BCSC. There would be no impact on the Pacific Northwest Ballet School.

6.1.6.4 SR 520 Alternative (D5)

Severe noise impacts under the SR 520 Alternative (D5) are predicted at 10 multifamily units just south of SR 520 near Northup Way. Additionally, if Alternative D5 were connected to the NE 12th Street alternatives, then there would be one moderate noise impact at the Children's Hospital BCSC. If, however, Alternative D5 were connected to Segment C alternatives along the former BNSF Railway corridor, then there would be no additional noise impacts besides those 10 at the multifamily units near SR 520.

6.1.7 Segment E

Light rail noise impacts in Segment E would occur under all Segment E alternatives, as shown in Table 6-7. The Segment E alternatives would not substantially change the existing roadway alignments; therefore, no traffic noise impacts were identified for these alternatives.

Parks and trails in Segment E include Marymoor Park, Luke McRedmond Landing Park, Dudley Carter Park, the Edge Skate Park, and the Sammamish River, East Lake Sammamish, and Bear Creek trails. Marymoor Park could be divided into three distinct sections: the section along SR 520, the central section, and the portion near Lake Sammamish. The section near SR 520 and the central section of Marymoor Park are primarily used for active sports; concerts; major events, such as circuses; and other events with large crowds, and/or amplified music or entertainment. These sections of the park are also located near SR 520 and adjacent to a commercial and industrial area to the east. Therefore, the sections of Marymoor Park along SR 520 and the central section would not be considered noise-sensitive under FTA criteria. Only the southern section of the Marymoor Park, near Lake Sammamish, was determined to meet the FTA criteria for a noise-sensitive area in a park. Because the project alternatives are approximately 2,500 to 3,000 feet or more from this section of the park, project noise levels are predicted to be below ambient noise levels and below FTA criteria, and no noise impacts are projected. The Luke McRedmond Landing Park, Dudley Carter Park, Edge Skate Park, and the Sammamish River, East Lake Sammamish, and Bear Creek trails parks are located along established transportation corridors, and therefore none meets the FTA criteria for a noise-sensitive use.

Maps of the Segment E alternatives impacts are in Appendix A, and complete tabulated modeled noise levels are included in Appendix E.

TABLE 6-7
Summary of Potential Noise Impacts for Segment E

Alternative	Connection (from Alternative)	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
Preferred Marymoor Alternative (E2)	All Segment D alternatives	33	148	0
E2 - Redmond Transit Center Design Option	All Segment D alternatives	81	100	0
Redmond Way Alternative (E1)	All Segment D alternatives	167	150	0
Leary Way Alternative (E4)	All Segment D alternatives	66	32	0

6.1.7.1 Preferred Marymoor Alternative (E2)

Under *Preferred Alternative E2* there would be 148 severe and 33 moderate noise impacts; these include 9 moderate and 4 severe single-family impacts near SR 520 at West Lake Sammamish Parkway NE, 144 severe impacts at newly constructed multifamily units, and 24 moderate impacts at a hotel. The four single-family severe noise impacts would be due the higher speed and the elevated structure. The remaining 144 severe noise impacts would be related to multiple gated crossings and station bells along the former BNSF Railway corridor. No traffic noise impacts are projected because there would be no roadway alignment changes in this segment.

The total number of noise impacts under the E2 - Redmond Transit Center Design Option would be the same as *Preferred Alternative E2*; however, under this design option, 81 of the impacts would be moderate and 100 would be severe. This difference is because one of the newly constructed multifamily buildings would not have noise impacts as it would under *Preferred Alternative E2*; however, another multifamily building near the Redmond Transit Center terminus would have the same number (48) moderate noise impacts.

6.1.7.2 Redmond Way Alternative (E1)

Under Alternative E1, light rail noise impacts were identified at 9 single-family units, 236 multifamily units, and 72 hotel rooms; these include severe impacts at two single-family residences and 148 multifamily units. As with *Preferred Alternative E2*, the severe impacts at the multifamily units would be due to multiple gated crossings and station bells along the former BNSF Railway corridor.

6.1.7.3 Leary Way Alternative (E4)

Alternative E4 would have 66 moderate impacts and 32 severe impacts related to light rail operations. The 8 multifamily severe impacts would be due to the extra noise from the elevated structure, while the 24 severe impacts at the Residence Inn Hotel would be due to bells at gated crossing. No traffic impacts were identified.

6.1.8 Wheel Squeal

Wheel squeal is caused by the oscillation of the wheel against the rail on curved sections of rail. Wheel squeal noise levels were measured at several different locations along the Central Link corridor and were used for reference. Based on these measurements, curves with a radius of less than 600 feet can produce maximum noise levels of 83 to 85 dBA at 50 feet. The highest noise levels typically occur on tight radii curves of less than 100 to 300 feet.

Substantial research into methods of reducing wheel squeal noise, including using lubricants that are not oil-based (such as water), has found such methods to effectively reduce or eliminate wheel squeal. The lubricants can be applied by personnel working trackside or by an automated applicator. Because the East Link Project would maintain a method of reducing or eliminating wheel squeal if it were to occur, no wheel squeal impacts are projected.

6.1.8.1 Preferred Alternative Wheel Squeal Analysis

The *Preferred Alternative* (*Preferred Alternatives A1, B2M, C11A* or *C9T, D2A,* and *E2*) was evaluated for any curves where, based on experience on the existing Central Link light rail system, wheel squeal could result. During final design, these curves will be reevaluated and have wayside lubricators installed as part of project construction. Table 6-8 lists the locations of curves to be evaluated for lubricator installation. Also, note that if any additional curves are planned during final design, then they will be evaluated for potential wheel squeal and treated with wayside lubricators as necessary.

6.1.8.2 Wheel Squeal under Other Alternatives

The project corridor was evaluated for locations with tight radii curves where wheel squeal could occur. In Segment B, there are no curves with a radius of less than 300 feet, so no wheel squeal is projected. Segment A has one location, and Segment C has several locations with tight radius curves, including Alternatives C4A, C7E, and C8E. Areas with tight radii curves in Segment D include Alternatives D2E and D3 connecting from Alternative C1T or C2T. Alternatives D2E and D3 also could experience wheel squeal on 136th Place NE and at the intersection of NE 20th Street and 152nd Avenue NE, respectively. Segment E could experience wheel squeal near Redmond Way at SR 520 with all Segment E alternatives. Table 6-9 provides a summary of curves for the other alternatives. Two design options are not listed in this table because curves with the C9T – East Main Station

Design Option would not differ from *Preferred Alternative C9T*, and curves with the D2A – 120th Station Design Option would not differ from *Preferred Alternative D2A.*

TABLE 6-8
Preferred Alternative Curves where Wayside Lubrication would be Evaluated and Installed as Part of the Project Construction

Preferred Alternative	Area	Radius (feet)	Lubricator Notes
Preferred Interstate 90 Alternative (A1)	Entry to I-90 express lanes	235	Potential – no receivers
	I-90 near South Dearborn Street	586	Potential – no receivers
	I-90 at Rainier Avenue South	990	No
	Mercer Island west end	More than 1,000	No – in tunnel
Preferred 112th SE Modified Alternative (B2M) with connections to *Preferred Alternative C11A* or *C9T*	I-90 near Bellevue Way and SE 34th Avenue	510	Yes
	Bellevue Way, south of SE 30th Street	780	Potential – reevaluation during design
	Bellevue Way at 112th Avenue SE	1,200	No
	112th Avenue SE north of SE 15th Street	900	Potential – reevaluation during design
Preferred 108th NE At-Grade Alternative (C11A)	112th Avenue SE at Main Street	300	Yes
	Main Street at 108th Avenue NE	120	Yes
	108th Avenue NE at NE 6th Street	120	Yes
	116th Avenue NE to NE 8th Street	510	Yes
Preferred 110th NE Tunnel Alternative (C9T)	112th Avenue SE at Main Street	300	Yes
	Main Street at 108th Avenue NE	120	No – in tunnel
	108th Avenue NE at NE 6th Street	120	No – in tunnel
	116th Avenue NE to NE 8th Street	510	Yes
Preferred NE 16th At-Grade Alternative (D2A)	BNSF Railway east toward 120th Avenue NE and NE 16th Street	510	Yes
	NE 16th Street to 136th Place NW	400	Yes
	136th Place NW to SR 520	510	Potential – reevaluation during design
Preferred Marymoor Alternative (E2)	SR 520 to Marymoor Park	1,800	No
	Redmond Way to old freight corridor	300	Yes

TABLE 6-9
Summary of Curves with Potential Wheel Squeal with Non-Preferred Alternatives

Alternative	Curves with Radius of 600 feet or less
Segment B	
Bellevue Way Alternative (B1)	I-90 to Bellevue Way
112th SE At-Grade Alternative (B2A)	I-90 to Bellevue Way
112th SE Elevated Alternative (B2E)	I-90 to Bellevue Way
112th SE Bypass Alternative (B3)	I-90 to Bellevue Way; SE 8th Street to I-405
B3 - 114th SE Design Option	I-90 to Bellevue Way; 112th Avenue SE to the commercial area
BNSF Alternative (B7)	I-90 to I-405/118th Avenue SE
Segment C[a]	
Bellevue Way Tunnel Alternative (C1T)	NE 6th Street to the former BNSF Railway corridor
106th NE Tunnel Alternative (C2T)	Main Street (B2A, B3, B7); NE 6th Street to the former BNSF Railway corridor

TABLE 6-9 CONTINUED
Summary of Curves with Potential Wheel Squeal with Non-Preferred Alternatives

Alternative	Curves with Radius of 600 feet or less
108th NE Tunnel Alternative (C3T)	Main Street (B2A, B3, B7); 112th Avenue NE at NE 12th Street
Couplet Alternative (C4A)	Main Street (B2A, B3, B7); Main Street and 110th Avenue NE; Main Street and 108th Avenue NE; NE 12th Street and 110th Avenue NE; NE 12th Street and 108th Avenue NE; 112th Avenue NE along NE 12th Street
112th NE Elevated Alternative (C7E)	112th Avenue NE along NE 12th Street (all connections); t112th Avenue SE south of Main Street (B3 and B7)
110th NE Elevated Alternative (C8E)	114th Avenue NE to NE 2nd Street; NE 2nd Street to 108th Avenue NE; 108th Avenue NE to NE 12th Street; 112th Avenue NE along NE 12th Street (all connections)
110th NE At-Grade Alternative (C9A)	Main Street from 112th Avenue SE; Main Street to 108th Avenue NE; 108th Avenue NE to NE 6th Street; NE 6th Street to the former BNSF Railway corridor; south of the Hilton Hotel under B3 - 114th Extension Design Option
114th NE Elevated Alternative (C14E)	I-405 at NE 7th Street; NE 7th Street to the former BNSF Railway corridor; South of the Hilton Hotel under B3 - 114th Extension Design Option
Segment D[b]	
D2A – NE 24th Design Option	Former BNSF Railway corridor to NE 16th Street; NE 16th Street to 134th Avenue NE; 134th Avenue NE to SR 520; NE 24th Street to 152nd Avenue NE; 152nd Avenue NE to SR 520
NE 16th Elevated Alternative (D2E)	Former BNSF Railway corridor to NE 16th Street; NE 16th Street to 134th Avenue NE; 134th Avenue NE to SR 520; NE 24th Street and 152nd Avenue NE; 152nd Avenue NE and SR 520
NE 20th Alternative (D3)	Former BNSF Railway corridor to NE 16th Street; NE 16th Street to 134th Avenue NE; 134th Avenue NE and NE 20th Street; NE 20th Street and 152nd Avenue NE; 152nd Avenue NE and SR 520
SR 520 Alternative (D5)	NE 12th Street (C3T, C4A, C7E, and C8E); two curves between NE 16th Street and SR 520; 152nd Avenue NE; 152nd Avenue NE to SR 520
Maintenance Facilities	All alternatives
Segment E	
E2 - Redmond Transit Center Design Option	SR 520 and Redmond Way; 161st Avenue NE to the Redmond Transit Center
Redmond Way Alternative (E1)	SR 520 to the elevated structure; Redmond Way; former BNSF Railway corridor
Leary Way Alternative (E4)	“S” curves from SR 520 to Leary Way; Leary Way to the former BNSF Railway corridor
Maintenance Facilities	All alternatives

[a]Curves with the C9T – East Main Station Design Option would not differ from *Preferred Alternative C9T*. See Table 6-8.
[b]Curves with the D2A – 120th Station Design Option would not differ from *Preferred Alternative D2A*. See Table 6-8.

6.1.9 Maintenance Facility Alternatives

There are three maintenance facility alternative sites in Segment D: 116th Maintenance Facility (MF1), BNSF Maintenance Facility (MF2), and SR 520 Maintenance Facility (MF3). MF1 is located along 116th Avenue NE, just west of the former BNSF Railway corridor. MF2 is located just east of MF1 in an established industrial area. MF3 is located along the south side of SR 520, also in an established industrial area. MF1 is the only potential maintenance facility located near residential properties because there are several single-family residences to the west of the proposed site. The new Seattle Children’s Hospital BCSC is also located south of the MF1 site. There are also several other residential-style structures along 116th Avenue NE that have been converted to office spaces.

Because light rail maintenance facilities would be in operation 24 hours a day, 7 days a week, with much of the services being performed at night when the system is not in operation, nighttime noise can be an issue. Because a maintenance facility is considered a stationary transit facility and fixed commercial use (WAC 173-60 Class B EDNA), it would be required to meet the City of Bellevue noise regulations for industrial properties. When a final maintenance facility site is selected, a full site design with the location of noise-producing sources would be completed, and a detailed noise analysis would be performed to ensure compliance with the City of Bellevue noise control ordinance. However, because MF1 is near residences and a hospital, a detailed noise analysis of the operations was conducted. The following information and assumptions, consistent with the FTA methods and criteria, were used for the MF1 noise analysis:

- Measured noise levels taken at the existing Sound Transit maintenance facility in South Seattle were used as baseline data.
- Train speeds would be limited to 5 mph inside the facility and horns would be sounded for at-grade employee crossings for safety.
- Wheel squeal noise on the tight radius curves would not be as severe as noise from normal train operations outside the maintenance facility because of the slower speed and because some form of lubrication or friction modifier would be used to contain noise from wheel squeal.
- The majority of noise-producing maintenance operations would occur inside the facility building, shielding nearby properties from the operations.
- The typical maximum number of trains at the facility is based on the proposed size and is not likely to exceed 40 to 50 light rail vehicles at any one time.

Using the above assumptions, worst-case operational noise levels were projected at six single-family residences along 116th Avenue NE and the Children's Hospital BCSC. The projected 24-hour Ldn ranged from 48 to 57 dBA at the sensitive receivers near MF1. A moderate noise impact was identified under the FTA criteria at the rear of the Children's Hospital BCSC. The impact would be due to the lower existing Ldn at the rear of the building, which results from the shielding the building provides from traffic noise along NE 12th Street. The noise analysis also included two single-family residences that are located immediately west of MF1 across 116th Avenue NE, and four single-family residences located slightly farther west, and no noise impacts were identified at these six residences. It is important to note that most of the structures along 116th Avenue NE have been converted to commercial use.

A noise analysis was not conducted for the other two Segment D maintenance facility alternatives (MF2 and MF3) because there are no noise-sensitive properties nearby. Therefore, no noise impacts related to the operation of MF2 or MF3 are anticipated.

If one of these maintenance facility alternatives were selected, then a full site design with the location of noise-producing sources would be completed, and a detailed noise analysis would be performed to ensure compliance with the City of Bellevue noise control ordinance. It is assumed that because this is a fixed site, with most noise-producing activities occurring indoors, any potential noise-related issues would be remedied through design modifications or treatments.

There is one maintenance facility alternative in Segment E, the SE Redmond Maintenance Facility (MF5), with two potential site locations. Both of the MF5 sites are located near the end of SR 520, in an established industrial area, with no nearby noise-sensitive properties. Due to the location of Alternative MF5, no noise analysis was conducted and no impacts are anticipated; however, when the site design is finalized, a detailed noise analysis would be performed to ensure compliance with the City of Redmond noise control ordinance.

6.1.10 Park-and-Ride Facilities

Most park-and-ride lots proposed as part of the East Link Project are at or near existing park–and-ride lots, and no noise impacts are projected. In Segment A, no new park-and-rides are planned, and all light rail stations are along I-90. Therefore, there no noise-related impacts would result from park-and-rides in Segment A.

The only park-and-ride with *Preferred Alternative B2M* is the park-and-ride lot at the South Bellevue Station, which is the same regardless of the connection to Segment C, and would be part of all Segment B alternatives except Alternative B7. The South Bellevue Park-and-Ride Lot is an existing facility, and under the proposed project, the facility would be improved to hold approximately 1,400 vehicles. Noise levels for park-and-ride operations were predicted using worst-case operational assumptions that all 1,400 parking spots would be used, and that approximately 450 buses would serve the facility in addition to light rail. The nearest residential properties to the park-and-ride lot are located west of the facility at 100 to 200 feet from the entrance and bus access areas. The projected Ldn at 100 feet from the park–and-ride is 60 dBA Ldn. Based on the existing Ldn noise levels of 67 to 69 dBA, the FTA criteria of 63 to 64 dBA Ldn is not predicted to be exceeded, and no noise impacts were identified. During final design, final station layout and bus route and light rail operations will be reviewed to ensure compliance with the City of Bellevue noise control ordinance. Under Alternative B7, a new park-and-ride lot would be constructed at the 118th Avenue Station. The station would be located along I-405, and no noise impacts were identified because of the high existing noise levels and lack of adjacent noise-sensitive receivers.

There are no new park-and-rides planned in Segment C. Noise from station activities, including bells from trains arriving and departing, are included in the segment analysis (Section 6.1.5).

There are three potential park-and–ride lots with *Preferred Alternative D2A*: a new park-and-ride near the 120th Station; a new park-and-ride near the 130th Station; and expansion of the existing park-and-ride at the Overlake Transit Center Station near SR 520 and NE 40th Street. The new park-and-ride lots near the 120th and 130th Stations are both in existing industrial and commercial areas where no noise-sensitive receivers were identified; therefore, no noise impacts are projected. The expanded park-and-ride at Overlake Transit Center has no noise-sensitive receivers that would be impacted by facility operation. Under Alternatives D2E and D3, the park-and-ride lot at the 130th Station would have no noise impacts, similar to *Preferred Alternative D2A*. An existing park-and-ride lot near the Overlake Village Station on 152nd Avenue NE would remain under Alternatives D2E and D3, and no noise impacts are predicted. Alternatives D2E, D3, and D5 would have a park-and-ride at the Overlake Transit Center Station at the existing Overlake Transit Center near SR 520 and NE 40th Street. The Overlake Transit Center is an existing facility, and no noise-sensitive receivers are predicted to have impacts related to the new park-and-ride operations.

The park-and-ride lot with *Preferred Alternative E2* is located near an established commercial and industrial area east of Marymoor Park. No noise impacts are predicted at this site because of the existing land use, high existing noise levels from SR 520, and the commercial and industrial uses near the site.

6.1.11 Freeway Noise at Proposed Freeway Stations

One additional noise assessment was conducted due to the unique position of some proposed stations in the center of or above a freeway in locations where freeway traffic noise might affect East Link patrons. This noise assessment only pertains to the Rainier and Mercer Island Stations in Segment A and the Ashwood/Hospital Station in Segment C, where the station is directly above I-405. The detailed analysis is provided in Appendix F.

There are no federal standards for noise exposure from traffic noise on patrons at stations. Sound Transit has generally used a design goal of 78 dBA Leq (15-minute and 1-hour) for noise from exterior sources at station platforms. The National Institute for Occupations Safety and Health (NIOSHA) standard for workplace noise exposure is 85 dBA for up to 8 hours or 100 dBA for 15 minutes (NIOSHA, 1998). For comparison, measurements taken at the SR 520 Montlake and Evergreen Road flyer stops ranged from 76 to 89 dBA Leq at the Montlake flyer stop and 72 to 75 dBA Leq at the Evergreen flyer stop. The EPA states that communication at close proximity (2 to 4 feet) can be understood, even with ambient noise levels of 72 to 78 dBA (EPA, 1974). It is unlikely that a patron would spend more than 15 minutes at an East Link station platform.

Based on bus flyer stop measurements and the short amount of time a person would spend at the station, Sound Transit will use a 78 dBA 15-minute Leq platform noise level goal for stations that are not able to meet the 72-dBA design goal due to traffic noise.

Traffic noise levels on I-90 and I-405 are loudest during the midday from 11 a.m. to 3 p.m. due to the higher speeds and level of truck traffic. Peak commute traffic noise levels on these same highways are typically lower (by 2 to 3 dBA) due to reduced speeds associated with congested highways. Based on these factors, the maximum traffic noise levels during the daytime were used in the analysis. The analysis also assumes the worst-case, 15-minute headways for the maximum time a person would spend at a platform.

Using typical daytime traffic volumes and speed provided by traffic engineers, a noise model was constructed using the FHWA traffic noise model (TNM), which produces hourly Leq noise levels based on hourly traffic volumes. For transit stations near major highways, a short-term Leq measurement of 10 minutes is typically long enough to provide an accurate reading of the noise exposure. This is due to the relatively steady noise from passing vehicles on major highways such as I-90. Measurements at the Mercer Island and Ashwood/Hospital stations verified this, as the running Leq stabilized after only 2 minutes of measurements and varied by less than 1 dBA after 5 minutes, even during heavy truck passbys where 1-second Leq sound levels exceeded 92 dBA. Because of the constant traffic volumes on a major highway like I-90, the short-term Leq experienced by patrons at the stations would be the same as the hourly Leq.

6.1.11.1 Rainier Station

Noise readings were taken at the proposed station location below the 23rd Avenue South overpass. The 15-minute Leq was measured at 86.3 dBA Leq. Five receivers were modeled along the proposed platform, with two at each end and one in the middle. The modeled noise levels ranged from 84.6 to 85.3 dBA Leq, which verified the accuracy of the model against the noise reading but also exceeded the 78 dBA goal for platform noise.

Ten-foot sound walls were modeled on the outside of the light rail station, along the edge the I-90 mainlines. With the walls in place, the noise levels along the platform were reduced by 8.2 to 9.7 dBA. Table 6-10 summarizes the noise model results along five points (Receivers R1 through R5) of the station platform with and without the sound walls.

TABLE 6-10
Rainier Station Noise Analysis

Receiver No.	Measured Levels (dBA)	Modeled Levels (dBA)	Modeled Levels with Sound Walls (dBA)	Sound Wall Reduction (dBA)	Wall Details
R1	N/A	85.3	76.4	8.9	These are 10-foot walls along the outside of the tracks, between the rail alignment and the I-90 traffic lanes; they could be integrated with the crash barriers to save room.
R2	N/A	85.1	76.9	8.2	
R3	N/A	85.0	75.8	9.2	
R4	N/A	84.9	75.2	9.7	
R5	86.3	84.6	75.4	9.2	

With sound walls, the platform would have noise levels below 78 dBA. The walls are proposed to extend approximately 800 feet west of the Mount Baker Tunnel portals. Sound walls would be designed during project final design.

6.1.11.2 Mercer Island Station

Noise readings were taken at the proposed Mercer Island Station location below the 77th Avenue SE overpass. Two receivers located along the platform (R2 and R3) were modeled, and the modeled noise at both locations was 88 dBA Leq (Table 6-11).

TABLE 6-11
Mercer Island Station Noise Analysis

Receiver No.	Measured Levels (dBA)	Modeled Levels[a] (dBA)	Modeled Levels with Sound Walls (dBA)	Sound Wall Reduction (dBA)	Wall Details
R2	N/A	87.9	77.6	10.3	These are 10-foot walls along the outside of the tracks, with the base of the wall at the same elevation as the tracks.
R3	N/A	87.9	78.3	9.6	

[a] The 87-dBA Leq is an average of the two measurement sessions.

By adding 10-foot sound walls on the outside of the light rail route along the edge nearest the train tracks, physically blocking the traffic noise on both sides of I-90 (see Appendix F for more information), the modeled noise levels along the platform were reduced by 10 dBA at the center of the platform. Table 6-11 summarizes the noise modeling results with and without the sound walls.

6.1.11.3 Ashwood/Hospital Station

Noise modeling for the proposed Ashwood/Hospital Station was performed using projected 2030 traffic data and speeds for I-405. For patrons on the station platforms, noise levels would range from 75 to 78 dBA Leq. The lower noise levels on the platform would be due to the noise-reducing effects of the light rail route and bridge over I-405. Because the noise levels at the platform are projected to remain below 78 dBA Leq, no noise-reducing design improvements were investigated.

6.1.11.4 Overlake Station and Overlake Transit Center

Both of Overlake and Overlake Transit Center Stations are located along SR 520, and the highway is the dominant noise source at each location. Existing noise levels from traffic along this section of the corridor were recently measured at 60 to 69 dBA Leq and remain below the 72 dBA Leq design criteria, and no additional noise mitigation would be required at either location.

6.2 Light Rail Vibration and Groundborne Noise Impact Assessment

The approach used for assessing vibration impact uses many of the same inputs as the noise impact assessment, such as speed, frequency of vehicle events, and distance from the receiver to the tracks. The vibration impact assessment combines vehicle characteristics with soil propagation properties to estimate vibration levels at sensitive receptors. The FTA impact threshold for residential (Category 2) nighttime vibration is 72 VdB in each 1/3-octave band for a detailed vibration assessment. There is only one Category 3 receptor (the Winters House) identified with groundborne noise impact along any of the proposed segments. The FTA impact threshold for residential groundborne noise is 35 dBA. As stated in Chapter 3 of this report, groundborne noise is only assessed for tunnel sections or for buildings that have sensitive interior spaces that are well-insulated from exterior noise.

For each East Link segment, a table is provided below that lists the locations, the distance to the nearest track, and the projected speed at each location. In addition, the projected project vibration level or groundborne noise level and the impact criterion level are indicated along with the number of impacts (single-family or multifamily buildings) projected for each receptor. The number of actual impacts in each building will be determined during final engineering and design. All impacts described in this section are shown in Appendix A of this report, with individual maps for each alternative that would have noise and/or vibration impacts. In multistory buildings, vibration levels generally decrease as the vibration travels up through the building, and therefore impacts are not likely to be felt above the first few floors, depending on the type of building construction.

The impacts reported in this section are before mitigation and do not include mitigation measures for potential vibration and groundborne noise levels and impacts reported in this section. Mitigation for potential impacts is discussed in Section 7.5.

6.2.1 Segment A, *Preferred Interstate 90 Alternative (A1)*

Table 6-12 provides the estimated vibration-velocity levels for sensitive receptors at representative distances. No vibration impacts were identified in Segment A. Table 6-13 shows the estimated groundborne noise levels for sensitive receptors. The project vibration or groundborne noise level listed is the maximum for that location. In many cases, the vibration or groundborne noise levels for other receptors would be much lower than the reported value. The following section provides a brief description of the Category 2 land use area impacted by groundborne noise, identified in Table 6-13.

TABLE 6-12
Segment A Vibration Impacts

Location	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
12th Avenue South to 23rd Avenue South	288	55	56	40	72	0
23rd Avenue South to Martin Luther King, Jr. Way South	134	55	61	40	72	0
Martin Luther King, Jr. Way South to Lake Washington	146	55	66	40	72	0
Mercer Island to West Mercer Way	160	50	57	12.5	72	0
West Mercer Way to 76th Avenue SE	202	50	56	12.5	72	0
76th Avenue SE to SE Shorewood Drive	187	55	59	12.5	72	0
SE Shorewood Drive to Lake Washington	179	55	60	12.5	72	0
					Total	**0**

Notes:

Vibration levels are measured in VdB referenced to 1 microinch per second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

All reported distances are slant distances from the top of rail for tunnel sections.

TABLE 6-13
Segment A Groundborne Noise Impacts

Location	Distance to Near Track (feet)	Speed (mph)	Maximum Groundborne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
Martin Luther King, Jr. Way South to Lake Washington	146	55	41	35	25 single-family
				Total	**25 single-family**

Notes:

The reported groundborne noise level represents the maximum level for each location.

All reported distances are slant distances from the top of rail for tunnel sections.

Martin Luther King Jr. Way south to Lake Washington: There are 25 buildings with projected groundborne noise impact; these 25 single-family residences are located above the I-90 Mount Baker Tunnel. Groundborne noise impacts are projected at this location because of efficient propagation of high-frequency vibration. However, the impact assessment at this location is based on a surface propagation test above the tunnel. During further engineering and design of the project, propagation testing should be conducted in the Mount Baker Tunnel to determine if the propagation of groundborne noise from the tunnel would occur as projected.

At the East Link Project connection with the Central Link light rail system, there will be four new switches introduced to allow trains to operate on both light rail systems. These would be located under residential and mixed-use buildings. In order to keep East Link vibration levels the same as from Central Link system operations, special trackwork, such as movable point or spring rail frogs, would be needed at this location.

6.2.2 Segment B

6.2.2.1 Preferred 112th SE Modified Alternative (B2M)

Table 6-14 provides the estimated vibration velocity levels and impacts in Segment B for sensitive receptors at representative distances. Under *Preferred Alternative B2M*, there would be no vibration impacts and only one groundborne noise impact (see Table 6-15) at the Winters House. The Winters House is no longer used as a residence and is occupied by the Eastside Heritage Center; therefore, it is considered a Category 3 land use—an institutional land use with primarily daytime use—for purposes of vibration and groundborne noise analysis. The FTA impact criteria for groundborne noise, measured in weighted decibels (dBA), are 40 dBA. A groundborne noise impact is projected at the Winters House because of the proximity of the alignment to the foundation of the building. The projected groundborne noise levels would range from 44 to 54 dBA.

For the Winters House, the operational vibration levels, measured in VdB, are projected to be 76 VdB, which would be below the FTA detailed impact criteria of 78 VdB for human annoyance. In addition, the projected operational vibration levels would be well below even the most stringent criteria for damage to structures, which is 90 VdB for buildings extremely susceptible to vibration. The Winters House is in a slightly less susceptible category, which is for nonengineered timber and masonry buildings, with a 94 VdB criteria for damage.

Under *Preferred Alternative B2M* with the C9T – East Main Station Design Option, there would be one vibration impact at a single-family residence due to the relocated crossover at SE 8th Street as well as the same groundborne noise impact at the Winters House as described in the previous paragraphs.

6.2.2.2 Other Segment B Alternatives

Table 6-14 identifies a vibration impact at one Category 2 building with Alternative B1, as described below. No groundborne noise impacts were identified because there are no tunnels in this segment.

Bellevue Way SE and 112th Avenue SE to SE 10th Street: There is one single-family residence at this location that is projected to have a vibration impact. The impact would be due to the proximity of the residence and the efficient propagation of vibration through the soil at this location.

No vibration impacts were identified for the remaining Segment B alternatives.

TABLE 6-14
Segment B Vibration Impacts

Alternative	Location	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Preferred 112th SE Modified Alternative (B2M)	Beginning of Segment B to Bellevue Way SE	163	45	50	16	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride	212	30	35	16	72	0
	South Bellevue Park-and-Ride to Bellevue Way SE and 112th Avenue SE	103	45	52	16	72	0
	Winters House	18	45	76	63	78	0
	Bellevue Way SE and 112th Avenue SE to SE 8th Street	146	45	67	31.5	72	0
	SE 8th Street to end of Segment B (SE 6th Street)	294	45	60	16	72	0
Preferred 112th SE Modified Alternative (B2M) with C9T - East Main Station Design Option	Beginning of Segment B to Bellevue Way SE	163	45	50	16	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride	212	30	35	16	72	0
	South Bellevue Park-and-Ride to Bellevue Way SE and 112th Avenue SE	103	45	52	16	72	0

TABLE 6-14 CONTINUED
Segment B Vibration Impacts

Alternative	Location	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	Winters House	18	45	77	63	78	0
	Bellevue Way SE and 112th Avenue SE to SE 8th Street	146	45	67	31.5	72	0
	SE 8th Street to end of Segment B (SE 6th Street)	120	45	83	80	72	1 single-family
Bellevue Way Alternative (B1)	Beginning of Segment B to Bellevue Way SE	165	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride	103	55	67	12.5	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Avenue	31	35	66	63	72	0
	Bellevue Way SE and 112th Avenue to SE 10th Street	46	35	73	80	72	1 single-family
	SE 10th Street to end of Segment B (SE 6th Street)	50	35	71	80	72	0
112th SE At-Grade Alternative (B2A)	Beginning of Segment B to Bellevue Way SE	164	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride Lot	117	30	43	20	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Avenue SE	41	35	59	50	72	0
	Bellevue Way SE and 112th Avenue SE to SE 8th Street	76	35	64	80	72	0
	SE 8th Street to end of Segment B (SE 6th Street)	59	20	69	80	72	0
112th SE Elevated Alternative (B2E)	Beginning of Segment B to Bellevue Way SE	164	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride	174	55	45	12.5	72	0
	South Bellevue Park-and-Ride to Bellevue Way SE and 112th Avenue SE	20	55	70	63	72	0
	Bellevue Way SE and 112th Avenue SE to SE 8th Street	119	55	51	63	72	0
	SE 8th Street to end of Segment B (SE 6th Street)	102	55	53	63	72	0
112th SE Bypass Alternative (B3)[a]	Beginning of Segment B to Bellevue Way SE	164	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride Lot	193	55	49	12.5	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Avenue SE	41	35	59	50	72	0
	Bellevue Way SE and 112th Avenue SE to SE 8th Street	80	35	63	80	72	0

TABLE 6-14 CONTINUED
Segment B Vibration Impacts

Alternative	Location	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	SE 8th Street to end of Segment B (SE 6th Street)	166	25	43	50	72	0
BNSF Alternative (B7)	Beginning of Segment B to Mercer Slough	164	50	57	12.5	72	0
	Mercer Slough to SE 32nd Street/Henry Bock Road	231	55	43	12.5	72	0
	SE 32nd Street/Henry Bock Road to 118th Street crossing/118th Station	35	55	67	63	72	0

Notes:

Vibration levels are measured in VdB referenced to 1 microinch per second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

[a] The vibration impacts for the B3 – 114th Extension Design Option are the same as for Alternative B3.

TABLE 6-15
Segment B Groundborne Noise Impacts

Alternative	Location	Distance To Near Track (feet)	Speed (mph)	Maximum Groundborne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
Preferred 112th SE Modified Alternative (B2M) with *Preferred Alternative C9T* and C9T - East Main Station Design Option	Winters House	18	45	54	40	1
					Total	**1**

Note:

The reported groundborne noise level represents the maximum level for each location.

6.2.3 Segment C

Tables 6-16 and -17 show the estimated vibration velocity and groundborne noise levels for sensitive receptors at representative distances in Segment C. However, for highly sensitive locations, such as hospital and theater locations, additional analyses were required. This analysis follows the standard vibration analysis located in Section 6.2.3.4. Each impacted Category 2 land use area is described by alternative below.

TABLE 6-16
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Preferred 108th NE At-Grade Alternative (C11A)	Beginning of Segment C to 112th Avenue NE and Main Street	*Preferred 112th SE Modified Alternative (B2M)*	85	35	75	63	72	1 single-family
	112th Avenue NE and Main Street to 108th Avenue NE	All	34	20	80	63	72	1 single-family
	108th Avenue NE from Main Street to NE 6th Street	All	37	30	87	63	72	3 multifamily
	I-405 to end of Segment C	All	27	30	95	63	72	1 hotel

TABLE 6-16 CONTINUED
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Preferred 110th NE Tunnel Alternative (C9T)	Beginning of Segment C to Main Street Tunnel Entrance	*Preferred Alternative B2M*	87	35	81	63	72	6 single-family
	112th Avenue NE and Main Street to 110th Avenue NE	All	37	20	87	63	72	1 single-family
	I-405 to end of Segment C	All	22	35	96	63	72	1 hotel
C9T – East Main Station Design Option	Beginning of Segment C to Main Street Tunnel Entrance	*Preferred Alternative B2M*	87	35	75	63	72	1 single-family
	112th Avenue NE and Main Street to 110th Avenue NE	*Preferred Alternative B2M*	37	20	87	63	72	1 single-family
	I-405 to end of Segment C	*Preferred Alternative B2M*	22	35	96	63	72	1 hotel
Bellevue Way Tunnel Alternative (C1T)	Beginning of Segment C to Main Street	Bellevue Way Alternative (B1)	46	35	73	80	72	1 single-family
	Main Street to Bellevue Way and NE 6th Street	Alternative B1	105	55	48	10	72	0
	I-405 to NE 8th Street	Alternative B1	26	55	75	80	72	1 hotel
	NE 8th Street to end of Segment C	Alternative B1	161	20	53	63	72	0
106th NE Tunnel Alternative (C2T)	Beginning of Segment C to Main Street	112th SE At-Grade Alternative (B2A)	86	55	48	8	72	0
		112th SE Elevated Alternative (B2E)	48	55	65	63	72	0
		112th SE Bypass (B3) or BNSF (B7) Alternative	15	55	65	100	72	0
	Main Street to 106th Avenue NE	Alternative B2A	162	55	48	10	72	0
		Alternative B2E	56	55	62	63	72	0
		Alternative B3 or B7	52	55	50	80	72	0
	I-405 to NE 8th Street	All	26	30	71	80	72	0
	NE 8th Street to end of Segment C	All	161	20	53	63	72	0
108th NE Tunnel Alternative (C3T)	Beginning of Segment C to 108th Avenue NE	Alternative B2A	80	55	49	63	72	0
	108th Avenue NE to Main Street		57	55	49	80	72	0
	Main Street to NE 6th Street/Bellevue Transit Center		88	55	48	10	72	0
	Beginning of Segment C to 112th Avenue NE and Main Street	Alternative B2E	48	55	65	63	72	0
		Alternative B3 or B7	15	30	65	100	72	0
	112th Avenue NE and Main Street to 108th Avenue NE	Alternative B2E	138	55	59	63	72	0
		Alternative B2E	202	55	48	10	72	0
		Alternative B7	85	55	48	63	72	0

TABLE 6-16 CONTINUED
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
108th NE Tunnel Alternative (C3T)	108th Avenue NE to NE 4th Street	Alternative B2E	109	55	48	10	72	0
		Alternative B3 or B7	148	55	48	10	72	0
	6th Street/Bellevue Transit Center to NE 10th Street	All	92	55	48	10	72	0
	NE 10th Street to NE 12th Street	All	101	55	48	10	72	0
	NE 12th Street to 110th Avenue NE	All	39	55	53	40	72	0
	110th Avenue NE to 112th Avenue NE	All	85	55	66	63	72	0
	112th Avenue NE to I-405/Ashwood/Hospital Station	All	31	20	70	80	72	0
	I-405/Ashwood/Hospital Station to End of Segment C (116th Avenue NE)	All	257	20	38	50	72	0
Couplet Alternative (C4A)	Beginning of Segment C to 112th Avenue NE and Main Street (eastbound)	Alternative B2E	76	20	55	63	72	0
	Base connect to NE 2nd Street (eastbound)	All	159	20	43	63	72	0
	NE 2nd Street to NE 4th Street (eastbound)	All	44	20	69	80	72	0
	NE 8th Street to NE 10th Street (eastbound)	All	32	20	73	80	72	2 multifamily
	NE 10th Street to 110th Avenue NE and NE 12th Street (eastbound)	All	34	20	72	80	72	2 multifamily
	Eastbound/westbound matchline to 112th Avenue NE (eastbound)	All	106	20	49	63	72	0
	I-405/Hospital Station to end of Segment C (eastbound)	All	182	20	33	31.5	72	0
	Beginning of Segment C to 112th Avenue SE and Main Street (westbound)	Alternative B2A or B2E	51	55	61	80	72	0
		Alternative B3 or B7	15	25	65	100	72	0
	112th Avenue SE and Main Street to beginning of Segment C (westbound)	Alternative B2A or B2E	89	20	52	63	72	0
		Alternative B3 or B7	94	20	51	63	72	0
	Begin Westbound Segment C to 108th Avenue NE (westbound)	All	82	20	63	63	72	0
	108th Avenue NE to NE 2nd Street (westbound)	All	24	20	85	80	72	2 multifamily
	NE 2nd Street to NE 4th Street (westbound)	All	61	20	68	80	72	0

TABLE 6-16 CONTINUED
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	NE 8th Street to NE 10th Street (westbound)	All	51	20	71	80	72	0
	NE 10th Street to NE 12th Street (westbound)	All	52	20	71	80	72	0
	NE 12th Street to 110th Avenue NE (westbound)	All	27	20	83	80	72	1 single-family
	110th Avenue NE to eastbound/westbound matchline (westbound)	All	95	20	61	63	72	0
	Eastbound/westbound matchline to 112th Avenue NE (westbound)	All	31	20	70	80	72	0
	112th Avenue NE to end of Segment C (westbound)	All	278	20	37	50	72	0
112th NE Elevated Alternative (C7E)	Beginning of Segment C to 112th Avenue NE and Main Street	Alternative B2A or B2E	70	55	59	63	72	0
		Alternative B3 or B7	15	20	65	100	72	0
	112th Avenue NE and Main Street to base connect	All	113	55	52	63	72	0
	Base connect to NE 2nd Street		89	55	55	63	72	0
	NE 2nd Street to NE 4th Street		74	45	54	63	72	0
	NE 10th Street to NE 12th Street		76	55	58	63	72	0
	NE 12th Street to end of Segment C		152	20	44	63	72	0
110th NE Elevated Alternative (C8E)	Beginning of Segment C to 112th Avenue NE and Main Street	All	26	55	65	100	72	0
	112th Avenue NE and Main Street to base connect		41	55	67	63	72	0
	Main Street to NE 2nd Street between 114th and 112th Avenues NE		2 [a]	55	100 [a]	160	72	1 hotel
	NE 2nd Street between 110th and 112th Avenues NE to NE 4th Street		30	55	72	80	72	1 multifamily
	NE 4th Street to NE 6th Street		51	55	64	63	72	0
	NE 8th Street to NE 10th Street		29	55	73	80	72	1 multifamily
	NE 10th Street to NE 12th Street		11	55	90	80	72	1 multifamily
	NE 12th Street to 112th Avenue NE		21	20	77	80	72	1 single-family

TABLE 6-16 CONTINUED
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	112th Avenue NE to end of Segment C		16	55	83	80	72	1 single-family
110th NE At-Grade Alternative (C9A)	112th Avenue NE and Main Street to 110th Avenue NE	All	54	20	80	63	72	2 single-family
	110th Avenue NE from Main Street to NE 6th Street	All	30	30	94	63	72	3 multifamily
	I-405 to end of Segment C	All	15	30	96	63	72	1 hotel
114th NE Extended Alternative (C14E)	Begin Segment C to Main Street	Alternative B3, B3 – Design Option, or B7	36	55	85	63	72	1 hotel
	Main Street to NE 4th Street	Alternative B3, B3 – Design Option, or B7	39	55	84	63	72	1 hotel
	I-405 Crossing to end of Segment C	Alternative B3, B3 – Design Option, or B7	44	20	73	63	72	1 hotel

Notes: Vibration levels are measured in VdB referenced to 1 microinch per second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted. All reported distances are slant distances from the top of rail for tunnel sections.

Base connect = point between Main Street and NE 2nd Street

[a] The vibration impact at this location is based on the close distance projected from the preliminary alignment location. The alignment location would need to be verified to provide an accurate projection at this location. However, based on testing at the Hilton Hotel, the vibration levels would be much lower than projected.

TABLE 6-17
Segment C Groundborne Noise Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Groundborne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
Preferred 110th NE Tunnel Alternative (C9T)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C9T – East Main Station Design Option	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bellevue Way Tunnel Alternative (C1T)	Beginning of Segment C to Main Street	N/A	59	35	35	35	1 single-family
	Main Street to Bellevue Way and NE 6th Street		105	55	32	35	0
106th NE Tunnel Alternative (C2T)	Beginning of Segment C to 106th Avenue NE	All	78	35	34	35	0
	106th Avenue NE to Main Street	112th SE At-Grade Alternative (B2A)	162	55	29	35	0
		112th SE Elevated Alternative (B2E)	62	55	35	35	1 single-family
		112th SE Bypass (B3) or BNSF (B7) Alternative	100	55	33	35	0

TABLE 6-17 CONTINUED
Segment C Groundborne Noise Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Groundborne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
108th NE Tunnel Alternative (C3T)	Beginning of Segment C to 108th Avenue NE	Alternative B2A	71	35	36	35	2 single-family
	108th Avenue NE to Main Street		57	55	36	35	9 single-family
	Main Street to NE 6th Street/Bellevue Transit Center		88	55	34	35	0
	Beginning of Segment C to 112th Avenue NE and Main Street	Alternative B3 or B7	104	55	30	35	0
	112th Avenue NE and Main Street to 108th Avenue NE	Alternative B2E	60	55	36	35	1 single-family
		Alternative B3	79	55	33	35	0
		Alternative B7	85	55	34	35	0
	108th Avenue NE to NE 4th Street	Alternative B2E	109	55	32	35	0
		Alternative B3 or B7	118	20	30	35	0
	6th Street/Bellevue Transit Center to NE 10th Street		92	55	33	35	0
	NE 10th Street to NE 12th Street	All	101	55	32	35	0
	NE 12th Street to 110th Avenue NE	All	40	30	39	35	1 single-family

6.2.3.1 Preferred 108th NE At-Grade Alternative (C11A)

Impacts from *Preferred Alternative C11A* would be due to the proximity of the alternative and to the speed of the light rail vehicles.

Beginning of Segment C to Main Street: A vibration impact is projected at one single-family residence at this location.

112th Avenue NE and Main Street to 108th Avenue NE: A vibration impact is projected at one single-family residence at this location.

108th Avenue NE from Main Street to NE 6th Street: Vibration impact is projected at three multifamily residences along the at this location.

I-405 to the end of Segment C: Vibration impacts are projected at the Coast Bellevue Hotel.

6.2.3.2 Preferred 110th NE Tunnel Alternative (C9T)

Impacts from *Preferred Alternative C9T* would be due to the proximity of the alternative and to the speed of the light rail vehicles.

Beginning of Segment C to Main Street: Vibration impact is projected at six single-family residences at this location. Five of the impacts would be due to the presence of the crossover near Main Street.

112th Avenue NE and Main Street to 110th Avenue NE: A vibration impact is projected at one single-family residence at this location.

I-405 to the end of Segment C: Vibration impacts are projected at the Coast Bellevue Hotel.

Impacts from the C9T – East Main Station Design Option would be due to the proximity of the alternative and to the speed of the light rail vehicles.

Beginning of Segment C to Main Street: A vibration impact is projected at one single-family residence at this location.

112th Avenue NE and Main Street to 110th Avenue NE: A vibration impact is projected at one single-family residence at this location.

I-405 to the end of Segment C: Vibration impacts are projected at the Coast Bellevue Hotel.

6.2.3.3 Bellevue Way Tunnel Alternative (C1T)

Impacts from Alternative C1T would result from its proximity to and the speed of the light rail vehicles.

Beginning of Segment C to Main Street: With Alternative C1T, one single-family residence at this location is projected to have vibration impacts and one with a groundborne noise impact.

I-405 to NE 8th Street: Vibration impacts are projected at the Coast Bellevue Hotel.

6.2.3.4 106th NE Tunnel Alternative (C2T)

Impacts from Alternative C2T would result from its proximity to and the speed of the light rail vehicles. There would be no vibration or groundborne noise impacts from the connector to Alternative B2A, B3, or B7.

Main Street to 106th Avenue NE (connecting to Alternative B2E): Groundborne noise impact is projected at one single-family residence on the south side of Main Street at this location.

6.2.3.5 108th NE Tunnel Alternative (C3T)

Impacts from Alternative C3T would result from its proximity to and the speed of the light rail vehicles.

Beginning of Segment C to 108th Avenue NE (connecting to Alternative B2A): A groundborne noise impact is projected at two single-family residences just south of 110th Avenue SE at this location.

108th Avenue NE to Main Street (connecting to B2A): A groundborne noise impact is projected at nine single-family residences along NE 108th Avenue at this location.

NE 12th Street to 110th Avenue NE: A groundborne noise impact is projected at one single-family residence north of NE 12th Street for all four connectors to Alternative C3T.

112th Avenue NE and Main Street to 108th Avenue NE (connecting Alternative B2E): A groundborne noise impact is projected at one single-family residence on the south side of Main Street at this location.

6.2.3.6 Couplet Alternative (C4A)

Impacts from Alternative C4A would result from its proximity to the buildings along its route.

NE 8th Street to NE 10th Street: A vibration impact is projected at two multifamily buildings along the northbound couplet at this location for all connections to Segment B.

NE 10th Street to 110th Avenue NE and NE 12th Street: A vibration impact is projected at two multifamily residences along the northbound couplet at this location for all connections to Segment B.

NE 12th Street to 110th Avenue NE: A vibration impact is projected at one single-family residence along the northbound couplet for all four alternatives. The impact would be a result of the residence's very close proximity to Alternative C4A.

108th Avenue NE to NE 2nd Street: A vibration impact is projected at two multifamily residences along the southbound couplet at this location for all connections to Segment B.

6.2.3.7 112th NE Elevated Alternative (C7E)

No vibration or groundborne noise impacts are projected for this alternative.

6.2.3.8 110th NE Elevated Alternative (C8E)

The impacts from Alternative C8E would result from its proximity to the Sheraton Hotel and from the speed of the light rail vehicles.

Main Street to NE 2nd Street between 114th Avenue NE and 112th Avenue NE: A vibration impact is projected at the Sheraton Hotel due to its extremely close projected distance from the alternative. The alignment location would need to be further refined to determine the level of impact. Additional testing could also be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce the projected vibration levels. In addition, the building needs to be surveyed to determine the specific locations of vibration-sensitive uses within the structure. Based on testing at the Hilton Hotel, which is a similar building type nearby, the projected vibration levels likely would be significantly lower, depending on the distance from the alignment to the hotel.

NE 2nd Street between 110th Avenue NE and 112th Avenue NE to NE 4th Street: A vibration impact is projected at one multifamily residence at this location.

NE 8th Street to NE 10th Street: A vibration impact is projected at one multifamily residence at this location.

NE 10th Street to NE 12th Street: A vibration impact is projected at one multifamily residence at this location.

NE 12th Street to 112th Avenue NE: A vibration impact is projected at one single-family residence to the north of NE 12th Street at this location.

112th Avenue NE to the end of Segment C: A vibration impact is projected at one single-family residence to the north of NE 12th Street at this location.

6.2.3.9 110th NE At-Grade Alternative (C9A)

The impacts from Alternative C9A would be due to the proximity of the alternative to the hotel and to the speed of the light rail vehicles.

112th Avenue NE and Main Street to 110th Avenue NE: A vibration impact is projected at two single-family residences at this location.

110th Avenue NE from Main Street to NE 6th Street: Vibration impact is projected at three multifamily residences at this location.

I-405 to the end of Segment C: Vibration impacts are projected at the Coast Bellevue Hotel.

6.2.3.10 114th NE Elevated Alternative (C14E)

The impacts from Alternative C14E would result from its proximity to the hotel and from the speed of the light rail vehicles.

Beginning of Segment C to Main Street: Vibration impacts are projected at the Red Lion Hotel.

Main Street to NE 4th Street: Vibration impacts are projected at the Sheraton Hotel.

I-405 crossing to the end of Segment C: Vibration impacts are projected at the Coast Bellevue Hotel.

6.2.3.12 Highly Sensitive Locations Analysis

In addition to sensitive residential land uses, vibration and groundborne noise impacts were assessed for other sensitive locations, including the Bellevue Arts Museum, the theater at Meydenbauer Center, and the Overlake Hospital MRI and Optical Surgery Unit. For this assessment, the museum was treated as an auditorium because quiet is important to the use of a museum (see Table 4-3). In addition, groundborne noise was also assessed for the Bellevue Arts Museum and the theater at Meydenbauer Center. Hospital equipment is not sensitive to groundborne noise. The MRI and optical surgery unit impact levels are based on the criteria for highly sensitive sites (see Section 4.3, Transit Vibration and Groundborne Noise Criteria). The potential for vibration impacts on the new Group Health Bellevue Medical Center was evaluated, but all alternatives would be located at a great enough distance to prevent impacts to sensitive equipment within the facility.

The results presented in Table 6-18 identify no vibration impacts at any of the highly sensitive locations under any of the Segment C alternatives. Table 6-19 shows that a groundborne noise impact is projected at the theater at Meydenbauer Center with *Preferred Alternative C9T* and the C9T – East Main Station Design Option. The groundborne noise impact under this alternative and the design option would be due to the at-grade track in front of the theater. All other alternatives are on elevated guideway structures in front of the theater, which would significantly reduce vibration and groundborne noise levels.

TABLE 6-18
Segment C Vibration Impacts for Highly Sensitive Locations

Location	Alternative	Distance to Near Track (feet)	Speed (mph)	Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Bellevue Arts Museum	Bellevue Way Tunnel Alternative (C1T)	65	20	51	N/A	72	0
Meydenbauer Center Theater	*Preferred 108th NE At-Grade Alternative (C11A)*	50	30	55	N/A	72	0
	Preferred 110th NE Tunnel Alternative (C9T)	50	20	65	N/A	72	0
	Bellevue Way Tunnel Alternative (C1T)	50	45	63	N.A	72	0
	106th NE Tunnel Alternative (C2T)	50	45	63	N/A	72	0
	110th NE At-Grade Alternative (C9A)	50	20	55	N/A	72	0
Overlake Hospital MRI	108th NE Tunnel (C3T), Couplet (C4A), 112th NE Elevated (C7E), or 110th NE Elevated (C8E) Alternative	196	20	33	31.5	60	0
Overlake Hospital Optical Surgery Unit	108th NE Tunnel (C3T), Couplet (C4A), 112th NE Elevated (C7E), or 110th NE Elevated (C8E) Alternative	208	20	33	31.5	54	0

Notes:
Vibration levels are measured in VdB referenced to 1 microinch per second.
The reported vibration level represents the maximum vibration level for each location.
The maximum vibration level reported is for the 1/3-octave band noted.

TABLE 6-19
Segment C Groundborne Noise Impacts for Highly Sensitive Locations

Location	Alternative	Distance to Near Track (feet)	Speed (mph)	Groundborne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
Bellevue Arts Museum	Bellevue Way Tunnel Alternative (C1T)	65	20	34	35	0
Meydenbauer Center	*Preferred 108th NE At-Grade Alternative (C11A)*	50	30	26	35	0
	Preferred 110th NE Tunnel Alternative (C9T)	50	20	36	35	1
	110th NE Tunnel Alternative (C9T) - East Main Station Design Option	50	20	36	35	1
	Bellevue Way Tunnel Alternative (C1T)	50	45	27	35	0
	106th NE Tunnel Alternative (C2T)	50	45	27	35	0
	110th NE At-Grade Alternative (C9A)	50	20	26	35	0

Note: The reported groundborne noise level represents the maximum level for each location.

6.2.4 Segment D

Table 6-20 provides the estimated vibration velocity levels for sensitive receptors at representative distances in Segment D. An additional analysis of the potential for vibration impacts on the new Children's Hospital BCSC was conducted and the results are provided in Table 6-21. No impacts were identified from the Segment D alternatives.

6.2.5 Segment E

Table 6-22 provides the estimated vibration velocity levels for sensitive receptors at representative distances in Segment E. Each impacted Category 2 land use area is described by alternative below.

TABLE 6-20
Segment D Vibration Impacts

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Preferred NE 16th At-Grade Alternative (D2A) [a]	Beginning of Segment D to BNSF Railway line route split	Former BNSF Railway	203	55	53	25	72	0
	Overlake Village Station to Overlake Transit Center Station	All	270	35	53	25	72	0
D2A - NE 24th Design Option	NE 24th Street and 152nd Avenue NE	Former BNSF Railway	151	30	63	31.5	72	0
NE 16th Elevated Alternative (D2E)	Beginning of Segment D to BNSF Railway line route split	BNSF Railway	203	35	55	25	72	0
		NE 12th Street	83	55	51	40	72	0
	Overlake Village Station to Overlake Transit Center Station	All	270	35	53	25	72	0
NE 20th Alternative (D3)	Beginning of Segment D to BNSF Railway line route split	BNSF Railway	203	55	53	25	72	0
		NE 12th Street	83	45	55	31.5	72	0
	136th Place NE and NE 20th Street to 140th Avenue NE	All	158	35	57	25	72	0
	148th Avenue NE to 152nd Avenue NE	All	40	20	65	40	72	0
	152nd Avenue NE to NE 24th Street	All	182	35	56	25	72	0
	NE 24th Street to SR 520	All	219	35	55	25	72	0
SR 520 Alternative (D5)	Beginning of Segment D to BNSF Railway line route split	BNSF Railway	145	55	55	25	72	0
		NE 12th Street	125	55	56	25	72	0
	124th Avenue NE to 130th Avenue NE	All	33	50	66	31.5	72	0
	NE 24th Street and 152nd Avenue NE to SR 520	All	234	35	54	25	72	0

Notes:
Vibration levels are measured in VdB referenced to 1 microinch per second.
The reported vibration level represents the maximum vibration level for each location.
The maximum vibration level reported is for the 1/3-octave band noted.
[a] The vibration impacts for the D2A – 120th Station Design Option are the same as for *Preferred Alternative D2A*.

TABLE 6-21
Segment D Vibration Impacts for Highly Sensitive Locations

Location	Alternative	Distance to Near Track (feet)	Speed (mph)	Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Children's Hospital	*Preferred NE 16th At-Grade Alternative (D2A)*	600	55	49	80	60	0
	NE 16th Elevated Alternative (D2E)	160	55	41	80	60	0
	NE 20th Alternative (D3)	160	55	51	80	60	0
	SR 520 Alternative (D5)	300	55	49	80	60	0

Notes:

Vibration levels are measured in VdB referenced to 1 microinch per second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

TABLE 6-22
Segment E Vibration Impacts

Alternative	Location	Distance to Near Track (feet)	Speed (mph)	Maximum Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Preferred Marymoor Alternative (E2) [a]	NE 51st Street to NE 60th Street	37	55	77	63	72	1 single-family
	NE 60th Street to West Lake Sammamish Parkway	28	55	82	40	72	2 single-family
	166th Avenue NE to Leary Way	78	55	54	63	72	0
	Leary Way to 162nd Avenue NE	73	55	56	63	72	0
Redmond Way Alternative (E1)	NE 51st Street to NE 60th Street	37	55	77	63	72	1 single-family
	NE 60th Street to West Lake Sammamish Parkway	31	55	80	40	72	2 single-family
	West Lake Sammamish Parkway to 154th Avenue NE	21	25	65	63	72	0
	154th Avenue NE to BNSF Railway corridor	286	25	30	20	72	0
	BNSF Railway corridor to Leary Way	252	55	48	12.5	72	0
	Leary Way to 166th Avenue NE	73	55	56	63	72	0
	SR 520 to NE 70th Street	76	20	42	63	72	0
Leary Way Alternative (E4)	NE 51st Street to NE 60th Street	37	55	77	63	72	1 single-family
	NE 60th Street to West Lake Sammamish Parkway	57	55	72	63	72	0
	West Lake Sammamish Parkway to NE Leary Way	209	25	31	20	72	0
	NE Leary Way to NE 76th Street	5	55	96	63	72	1 multifamily, 1 hotel
	SR5 20 to NE 70th Street	76	20	52	63	72	0

Notes:

Vibration levels are measured in VdB referenced to 1 microinch per second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

[a] The vibration impacts for the E2 - Redmond Transit Center Design Option would not differ from those under *Preferred Alternative E2*.

6.2.5.1 Preferred Marymoor Alternative (E2)

The impacts from *Preferred Alternative E2* would be a result of the speed of the light rail vehicles.

NE 51st Street to NE 60th Street: One single-family residence at this location, just to the south of NE 60th Street, would have a projected vibration impact.

NE 60th Street to West Lake Sammamish Parkway: Vibration impacts are projected at two single-family residences located in the residential community just before the alternative crosses SR 520.

The impacts from the E2 - Redmond Transit Center Design Option are the same as for *Preferred Alternative E2*.

6.2.5.2 Redmond Way Alternative (E1)

The impacts from Alternative E1 would result from the speed of the light rail vehicles.

NE 51st Street to NE 60th Street: One single-family residence at this location, located just to the south of NE 60th Street, would have a vibration impact.

NE 60th Street to West Lake Sammamish Parkway: There would be impacts on two single-family residences in the residential community at this location, just before the alternative crosses SR 520.

6.2.5.3 Leary Way Alternative (E4)

The impacts from Alternative E4 would be a result of its proximity to the Residence Inn Hotel and of the speed of the light rail vehicles.

NE 51st Street to NE 60th Street: One single-family residence at this location, located just to the south of NE 60th Street, would have a vibration impact.

NE Leary Way to NE 76th Street: There are two projected impacts at this location. One would be at the Residence Inn Hotel at the Redmond Town Center, which is within 5 feet of the alternative, and the other would be on the south side of NE Leary Way, where a multifamily building is located within 20 feet of the alternative.

6.2.6 Maintenance Facility Alternatives

No vibration impacts are projected to occur from operation and maintenance activities.

6.3 Construction Noise Assessment

Several construction phases would be required to complete the East Link Project. The analysis assumes the worst-case noise levels based on three major types of construction described below and shown in Table 6-23. The actual noise levels experienced during construction would generally be lower than those given in this report. The noise levels presented here are for periods of maximum construction activity and would occur for a limited period of time.

TABLE 6-23
Noise Levels for Typical Construction Phases[a]

Scenario[b]	Equipment[c]	Lm[d]	Leq[e]
Utilities preparation and relocation	Air compressors, backhoe, concrete pumps, crane, excavator, forklifts, haul trucks, loader, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment	94	87
Structures construction, track installation, and paving activities	Air compressors, backhoe, cement mixers, concrete pumps, crane, forklifts, haul trucks, loader, pavers, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment, welders	94	88
Miscellaneous activities	Air compressors, backhoe, crane, forklifts, haul trucks, loader, pumps, service trucks, tractor trailers, utility trucks, welders	91	83

[a] Combined worst-case noise levels for all equipment at a distance of 50 feet from work site.

[b] Operational conditions under which the noise levels are projected.

[c] Normal equipment in operation under the given scenario.

[d] Lm (dBA) is an average maximum noise emission for the construction equipment under the given scenario; for this type of equipment and activities, the Lm is slightly less than the Lmax.

[e] Leq (dBA) is an energy average noise emission for construction equipment operating under the given scenario.

6.3.1 Demolition, Site Preparation, and Utilities Relocation

Major noise-producing equipment used during the construction preparation stage could include saw cutters, concrete pumps, cranes, excavator, haul trucks, loader, tractor-trailers, and vibratory equipment. Maximum noise levels could reach 82 to 86 dBA at the nearest residences (i.e., within 50 to 100 feet) for normal construction activities during this phase. Other, less notable noise-producing equipment expected during this phase includes backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

6.3.2 Structures Construction, Track Installation, and Paving Activities

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

6.3.3 Miscellaneous Activities

Following the heavy construction, general construction such as installation of bridge railing, signage, roadway striping, communication and power systems, and other general activities would still need to occur. These less intensive activities are not expected to produce noise levels above 80 dBA at 50 feet except during rare occasions, and even then only for short periods of time. Using the information in Table 6-23, typical construction noise levels were projected for several distances from the project work area. Exhibit 6-1 is a graph of general construction noise level versus distance for project phases of construction.

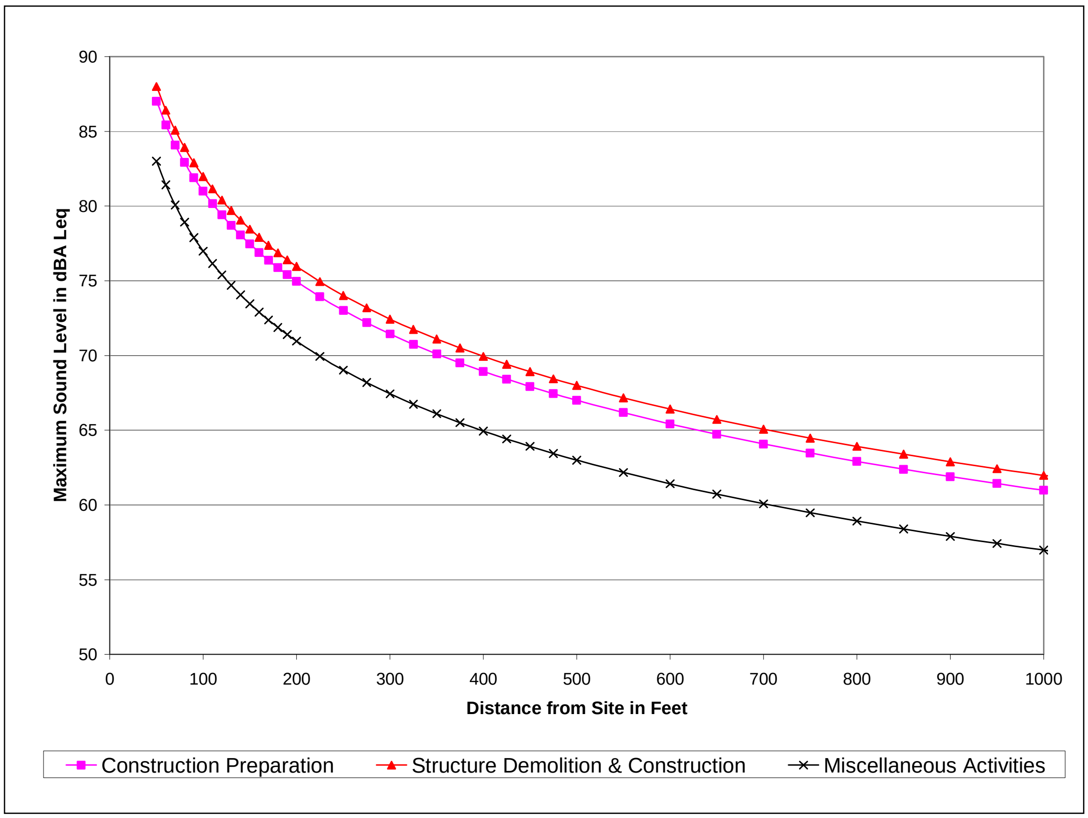


EXHIBIT 6-1
Maximum Noise Level Versus Distance for Typical Construction Phases

6.3.4 Pile-Driving

Pile-driving would likely be required to support permanent structures such as piers for elevated structures and cut-and-cover tunnel walls. Pile-driving can produce maximum short-term noise levels of 99 to 105 dBA at 50 feet. Actual levels can vary and would depend on the distance and topographical conditions between the pile-driving location and the receiver location. Exhibit 6-2 is a graph of maximum pile-driving noise levels versus distance.

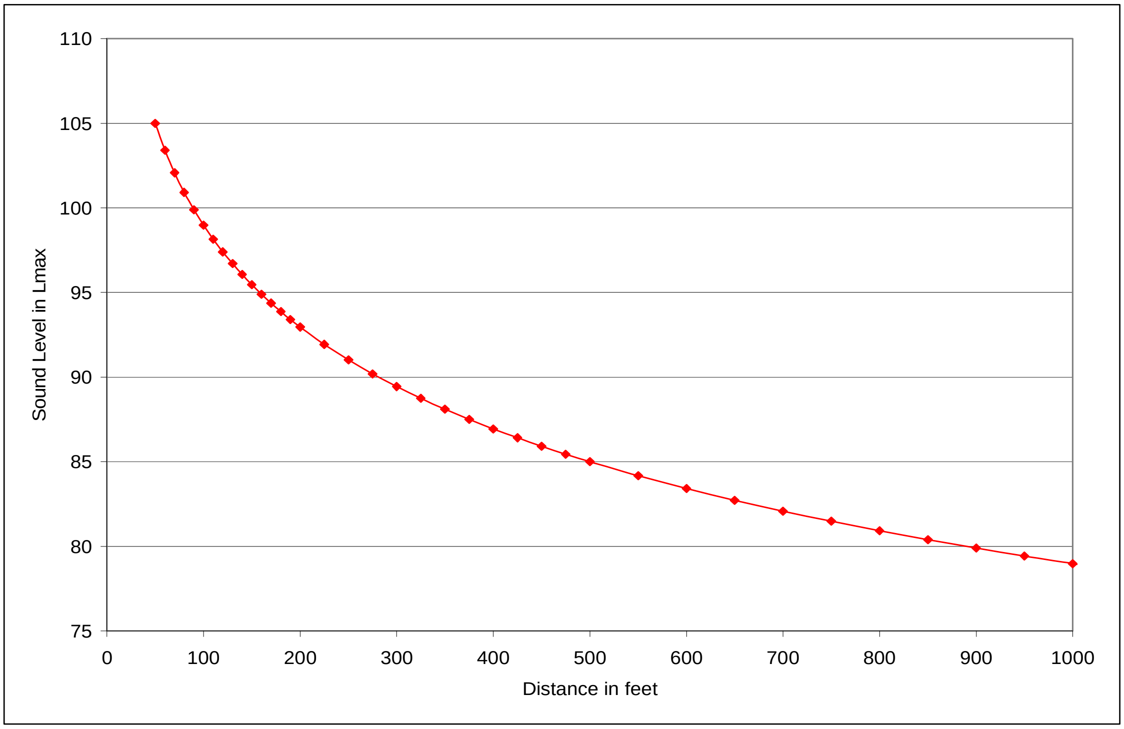


EXHIBIT 6-2
Pile-Driving Noise Level Versus Distance

6.3.5 Nighttime Construction Activities

Some construction activities might be required during nighttime hours because of the nature of the construction or to avoid daytime traffic impacts or impacts to some adjacent land uses. In order to perform construction at night, a noise variance from the local governing agency would be required. When a final alternative is selected, Sound Transit would work with the local governments and agencies to provide a construction plan that would allow the project to be constructed cost-effectively with minimal disruption to local areas and traffic flow. If nighttime construction is deemed necessary, then Sound Transit would work with each governing agency to obtain any necessary noise variance specific to project construction.

6.3.6 Segment A Construction Noise

Because much of the light rail alternative in Segment A would be in commercial and industrial areas or in the I-90 highway corridor, many noise-sensitive areas would be shielded from much of the construction noise sources.

Construction in the I-90 corridor, west of the Mount Baker Tunnel, would result in increased noise levels at the residential areas along Sturgus Avenue South and south of I-90 near the tunnel portal. Maximum noise levels from construction at these homes should not exceed 75 to 78 dBA under any phase of construction. Maximum construction noise levels at residential locations on the east end of the Mount Baker Tunnel, near 35th Avenue South, are projected to reach up to 85 dBA Lmax during brief periods of heavy construction. Typical construction noise during daytime hours would be approximately the same as the existing traffic noise levels in this area.

On Mercer Island, most of the *Preferred Alternative A1* route would be in a deep, retained cut with I-90, and the construction sites would be well shielded from noise-sensitive land uses. Residences located near the connection to the I-90 floating bridge and the East Channel bridge would likely notice an increase in noise from construction activities for short periods of time. There would also be construction activities for the station platforms and access; however, station construction would likely be during the daytime and would meet the local noise ordinance.

6.3.7 Segment B Construction Noise

There are a large number of single-family and multifamily residences along the Segment B alternatives. Under the Bellevue Way alternatives (i.e., *Preferred Alternative B2M* and Alternatives B1, B2A, B2E, and B3 and B3 – 114th Extension Design Option), noise levels at adjacent residences would have short periods of time with maximum noise levels exceeding 80 dBA Lmax. Major construction noise would occur when relocating utilities, installing retaining walls (where required), repaving Bellevue Way, and constructing the Alternative B2E, B3, or B3 – 114th Extension Design Option elevated guideway structures. Pile-driving and sheet-pile installation might also be required. Pile-driving could produce Lmax noise levels of 105 dBA at 50 feet. Although there would be periods of relatively loud construction, noise levels would decrease as tasks are completed and construction activities move to other areas.

Under Alternative B1, the impacts and noise levels described above would continue to the tunnel portal in Segment C. Alternatives B2A, B2E, B3, and B3 – 114th Extension Design Option would be located on 112th Avenue SE, where residences in some areas are set back farther from the construction sites than they are on Bellevue Way. Therefore, noise levels on 112th Avenue SE would have a lower impact. The highest noise levels would occur when relocating utilities, repaving, and constructing the Alternatives B2E, B3, and B3 – 114th Extension Design Option elevated guideway structures.

Under Alternative B7, noise levels at the multifamily apartments and condominiums adjacent to the alternative in the former BNSF Railway corridor could reach 80 dBA Lmax for short periods. Because this alternative would not be on a major roadway, it would be less likely that nighttime work would be required near the noise-sensitive units. Pile-driving might also be required under this alternative along the I-90 corridor to SE 32nd Street. Noise from the pile-driver could exceed 85 dBA Lmax at the nearby multifamily residences south of SE 32nd Street. The pile-driving would also increase noise levels in the southern section of the Mercer Slough Nature Park. Worst-case noise levels of up to 100 dBA Lmax can be expected within 100 feet of the construction site, as shown on Exhibit 6-2.

There are also several commercial structures that would be affected by construction noise in Segment B. Businesses located along Bellevue Way SE would have short periods of time with maximum noise levels exceeding 80 dBA Lmax under Alternative B1. The business parks located south of 112th Avenue SE would also experience elevated noise levels under Alternatives B2A, B2E, B3, and B3 – 114th Extension Design Option. Alternative B7 would also increase noise at some commercial structures; however, traffic noise from I-405 would remain a significant noise source at commercial structures along this alternative.

6.3.8 Segment C Construction Noise

Construction in downtown areas is often difficult due to high traffic volumes and general congestion. Major noise sources would include haul truck traffic to and from tunnel-staging areas, pile-driving for elevated structures, cement-pumping trucks, and cement delivery trucks. Major noise-producing activities would include utilities relocation, repaving project roadways, and construction of elevated structures. The projected construction noise levels are typical for transportation construction projects, such as roadway paving projects. The main differences between a typical paving operation and the tunnel construction are the length of time to complete the project and the level of haul truck activity.

Noise levels at residences near tunnel portals, at-grade alignments, and staging areas on Bellevue Way, 112th Avenue SE, Main Street along NE 6th Street and on 110th Avenue NE between NE 3rd Street and NE 2nd Place could exceed 80 dBA Lmax during heavy construction periods for all alternatives. Typical daytime noise levels from the staging areas are projected to be 73 to 84 dBA, depending on the level and type of activity at the time. Maximum noise levels of over 80 dBA Lmax could still occur in locations where the homes are directly on 112th Avenue SE, such as for the single-family and multifamily homes between SE 6th Street and Main Street, for all alternatives except C1T. Noise levels would also exceed 80 dBA Lmax along the residential area on 110th Avenue NE for *Preferred Alternative C11A* or *C9T*, C9T – East Main Station Design Option, and Alternatives C3T, C4A, and C8E. Alternatives C3T, C4A, and C8E would also result in noise levels exceeding 80 dBA Lmax at the single-family residences north of NE 12th Street. Noise levels at the residential area on Lake Bellevue are not projected to exceed 80 dBA Lmax, except during pile-driving, structure construction, or utilities relocations.

Noise levels near the tunnel portal and staging areas along Main Street are also projected to range from 73 to 84 dBA Lmax at 50 feet from the site. Construction noise levels at residences in the Surrey Downs neighborhood would vary and depend on how close the residence is to the site and the level of shielding the residence has from existing homes. The highest levels would be at residences directly adjacent to the construction site. Similar construction noise levels are also projected for the tunnel portal and staging areas near McCormick Park under

Alternatives C3T, C4A, and C8E. Constructing the elevated structure under Alternative C7E would also result in construction noise at residential and commercial land uses along 112th Avenue NE.

Alternatives C3T, C4A, C7E, and C8E would require construction along NE 12th Street near the Overlake Medical Center, the Children's Hospital BCSC, and nearby supporting offices. Maximum noise levels at the hospital are projected to reach up to 82 dBA Lmax, with typical noise levels ranging from 71 to 75 dBA. The parking structure at both hospitals is expected to act as a sound wall and provide some noise reduction from construction activities. Construction noise through Downtown Bellevue under the two at-grade alternatives (Alternatives C4A and C9A) would be similar to those described for *Preferred Alternative C11A*, although Alternative C4A noise would occur along 108th and 110th Avenues NE, and Alternative C9A noise would occur along 110th Avenue NE.

Commercial land uses in Segment C would also experience elevated noise levels during construction. With Alternatives C1T and C2T, elevated noise levels would be experienced along the entire corridor due to cut-and-cover construction methods. With Alternative C3T, which would use bored tunneling construction methods, most construction-related noise would be at the portals and the Bellevue Transit Center Station. Alternative C4A would require heavy at-grade construction along 108th and 110th Avenues NE, including relocating utilities, installing track, and paving. Maximum levels could exceed 80 dBA Lmax during periods of heavy construction. Alternatives C7E and C8E are both elevated and would install the elevated structure along 110th Avenue NE (C8E) or 112th Avenue NE (C7E), resulting in maximum levels of 80 to 85 dBA at 50 feet from the project work site.

6.3.9 Segment D Construction Noise

Segment D has a limited number of residential land uses that would be affected by East Link Project construction noise. There would be an increase in noise at the residential area on Lake Bellevue when connecting to Alternative C1T or C2T. Construction noise would also affect the multifamily building on NE 21st Place, just south of SR 520, and the Children's Hospital BCSC on 116th Avenue NE.

The former Group Health Eastside Hospital Campus is currently being redeveloped to mixed residential commercial land use. Constructing *Preferred Alternative D2A* or Alternative D2E or D3 would have the highest impact on the new mixed-use development planned for this site, due to the proximity of these alternatives. Maximum noise levels are projected to reach up to 82 dBA Lmax, with typical noise levels ranging from 69 to 78 dBA. Commercial and retail land uses along the proposed corridors would also experience maximum levels of 80 to 85 dBA at 50 feet from the project work site during periods of heavy construction.

6.3.10 Segment E Construction Noise

Removing and replacing existing sound walls adjacent to SR 520 could be required from the beginning of Segment E to West Lake Sammamish Parkway. During wall replacement, noise levels at the residences would increase not only from construction noise but also from traffic noise on SR 520. During heavy periods of construction, noise levels could reach 85 dBA Lmax, with typical hourly average noise levels ranging from 70 to 80 dBA. When the sound walls are replaced, work on the light rail construction would be mostly shielded by the walls, and noise levels should not exceed 60 to 70 dBA.

Constructing the elevated portion of Alternative E4 near the Redmond Town Center would result in noise-level increases at the multifamily units along Leary Way. Maximum noise levels are projected to range from 80 to 85 dBA Lmax during the heaviest construction periods. Pile-driving might also be required for the elevated structures, which could result in peak noise levels exceeding 100 dBA. Construction of the at-grade portions of all alternatives through Downtown Redmond would increase noise levels during utilities relocations, paving, and track installation, with maximum noise levels of 80 to 85 dBA Lmax. Construction noise levels in Marymoor Park are projected to reach 80 to 85 dBA Lmax during heavy construction for *Preferred Alternative E2* and E2 – Redmond Transit Center Design Option. Pile-driving might be required for the Sammamish River crossing, which could result in peak noise levels exceeding 100 dBA.

6.3.11 Maintenance Facility and Park-and-Ride Lot Construction Noise

Except for the 116th Maintenance Facility (MF1), the maintenance facility alternatives are not near residential land uses that would be affected by construction noise. Some residences are present on the west side of 116th Avenue NE, near MF1, and the Children's Hospital BCSC is just south of the site. Construction of the maintenance bases and park-and-ride lots is projected to produce maximum noise levels of 75 to 85 dBA Lmax at 50 feet during periods of heavy construction. The loudest noise sources would include cement mixers, concrete pumps, cranes, and haul trucks. Cement mixers, cranes, and concrete pumps would be required for construction of multistory parking facilities and maintenance buildings. For surface lots and station construction, the loudest construction noise sources are pavers and haul trucks that would be used to apply the asphalt and construct access roads. Other, less notable noise-producing equipment would include backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

6.4 Construction Vibration Assessment

Based on the damage criteria described in Section 4.5, the only activity likely to cause vibration damage would be impact pile-driving at locations within 25 feet of structures. However, many of the alternatives would require impact pile-driving. The Coast Bellevue Hotel is the only structure within 25 feet of *Preferred Alternative C9T* and Alternative C9A. If pile driving were performed at this location, there would be the potential for damage. The locations of where there would be piles will not be available until final design for the project, but they would likely be at elevated structures or retained cuts approaching tunnels. As specific locations of piles are developed, more analysis should be conducted. To prevent damage, care should be taken to avoid pile-driving too close to buildings.

Constructing a retained cut near the Winters House, including construction of underground piles to structurally support the cut, could result in vibration impacts. Because of the property's age and type, damage to the building could occur without construction vibration-minimization techniques. The criteria for damage for this type of structure are 94 VdB or 0.2 peak particle velocity (PPV); construction vibration is projected to be 0.2 PPV. Using the techniques and construction methods described in Section 7.7 below as mitigation would prevent vibration damage or limit damage to minor cosmetic damage.

To assess the potential for temporary, short-term construction vibration impacts, construction vibration levels were projected for tunnel construction operations in Segment C and for piling and vibratory rolling along the entire corridor. Reference vibration levels have been collected from other environmental vibration studies. Data for tunnel-boring machines include tunneling in rock and in soil. However, based on the geotechnical investigations to date, the East Link Project would not require tunneling in rock. Table 6-24 shows the reference vibration levels for these sources at 25 feet.

TABLE 6-24
Vibration Levels for Construction Equipment

Construction Equipment	Maximum Lv at 25 feet (VdB)
Tunnel-boring machine (in rock)	85
Tunnel-boring machine (in soil)	69
Muck trains	72
Vibratory roller	94
Impact pile-driving	112

Vibration levels are projected on the ground floors inside buildings. This assumes no coupling attenuation (i.e., reduction in vibration level due to the foundation) for single-family residences, a 10-dB building coupling attenuation for large masonry buildings, and no floor-to-floor attenuation. Table 6-25 shows the distances at which groundborne vibration impacts would occur for single-family residences and large masonry buildings for each piece of construction equipment. These distances correspond to vibration in any 1/3-octave band between 8 and 80 Hz that exceeds the criterion (see Section 4.3).

The results of this analysis show that temporary, short-term vibration impact would not be an issue for tunnel construction. As discussed in Section 4.5, criteria levels for impacts to buildings range from 94 VdB for nonengineered timber and masonry buildings to 102 VdB for reinforced concrete, steel, or timber buildings. The maximum VdBs provided in Table 6-24 are at or below the lowest impact criteria level. The only likely source of construction vibration annoyance would be pile-driving. If alternative methods of pile-driving can be employed, then the distance to vibration impact can be greatly reduced.

TABLE 6-25
Distances from Sources to Groundborne Vibration Impact

Construction Equipment	Distance to Groundborne Vibration Impact (feet)
Tunnel-boring machine in rock (large masonry buildings)	17
Tunnel-boring machine in rock (single-family residences)	36
Tunnel-boring machine in soil (large masonry buildings)	6
Tunnel-boring machine in soil (single-family residences)	13
Muck trains (large masonry buildings)	8
Muck trains (single-family residences)	16
Vibratory roller (large masonry buildings)	18
Vibratory roller (single-family residences)	36
Impact pile-driving (large masonry buildings)	70
Impact Pile-driving (single-family residences)	150

Table 6-26 shows the range of distances from various sources to the threshold for groundborne noise impact for both single-family residences and large masonry buildings. The groundborne noise impact criterion is 40 dBA, based on frequent events for Category 3 land uses (see Table 4-2 in Section 4.3). These results show that groundborne noise impact could result from muck-train activities; however, this would depend on the depth of the tunnel at any particular location. It is important to note that these are temporary impacts, and the annoyance from these activities would be limited in duration. For most activities, including tunneling, the duration would be a few days to a few weeks for each activity. The only activity with a longer duration would be using muck trains near the tunnel portals, which could be required for between 1 month and 18 months, depending on the tunnel alternative chosen and the speed of tunneling.

TABLE 6-26
Distances from Sources to Groundborne Noise Impact

Construction Equipment	Distance to Groundborne Noise Impact (feet)
Tunnel-boring machine in soil (large masonry buildings)	7
Tunnel-boring machine in soil (single-family residences)	14
Muck trains (large masonry buildings)	24
Muck trains (single-family residences)	51

7.0 Potential Mitigation of Noise and Vibration Impacts

Sound Transit has developed and adopted the Sound Transit Noise Mitigation Policy, Motion M2004-08 (Sound Transit Policy, 2004). This policy (Sound Transit Policy, 2004), was designed to provide guidance on the analysis and mitigation of noise impact associated with Link light rail projects. The following policies shall guide Sound Transit's assessment and control of potential Link noise impacts:

A. Sound Transit shall comply with applicable federal, state, and local noise requirements in evaluating noise impacts, determining appropriate mitigation measures, and implementing Link projects.

B. Sound Transit will seek to identify potential noise impacts and potential mitigation measures early in the project development process, as practicable.

C. Sound Transit will seek to reduce expected noise impacts, as practicable, through reductions in source emissions and project design.

D. Sound Transit will seek to work with local jurisdictions to provide that development that occurs is compatible with expected or existing project operational noise.

It is also important to note that during final design, all impacts and mitigation measures will be reviewed to verify projections. If, at that time, it is discovered that mitigation can be achieved by a less costly means through more detailed testing, or that the noise impact at the location would not occur even without mitigation, then the mitigation measure may be eliminated.

7.1 Potential Light Rail Noise Mitigation Options

One of the most effective forms of noise mitigation is to attempt to reduce noise at the source. Source noise reduction is normally accomplished through vehicle specifications. Sound Transit has purchased state-of-the-art, low-noise vehicles equipped with noise-reducing wheel skirts covering the wheel-rail interface. Several additional operational measures can also be used to reduce noise levels at the source. Table 7-1 lists operational and maintenance measures that Sound Transit would perform on a regular basis and the benefit that each measure would provide.

TABLE 7-1
Systemwide Light Rail Operational Mitigation

Operational Measure	System Benefit
Rail grinding and replacement	As rails wear, both noise and vibration levels from light rail operations can increase. By grinding or replacing worn rails, noise and vibration levels will remain at the projected levels. Rail grinding or replacement is normally performed every 3 to 5 years.
Wheel truing and replacement	Wheel truing is a method of grinding down flat spots (commonly called "wheel flats") on the vehicle wheels. Flat spots occur primarily because of hard braking. When flat spots occur they can cause increases in both the noise and vibration levels produced by the light rail vehicles.
Vehicle maintenance	Vehicle maintenance includes performing scheduled and general maintenance on items such as air conditioning units, bearings, wheel skirts, and other mechanical units on the light rail vehicles. Keeping the mechanical systems on the light rail vehicles in top condition will also help to maintain the projected levels of noise and vibration.
Operator training	Operators will be trained to operate light rail vehicles at the speeds given in the operation plan that was used for the analysis and to avoid "hard-braking," which can cause wheel flats and may also damage the track. Furthermore, by training operators to identify potential wheel flats and other mechanical problems with the trains, proper maintenance can be performed in a more timely manner.

For locations where potential noise impacts have been identified, mitigation measures would be considered and reviewed using Sound Transit's Mitigation Policy (Sound Transit Policy, 2004). Under the Sound Transit Mitigation Policy, mitigation measures would be considered for all noise impacts. As described above, source treatments that Sound Transit is currently using to minimize noise impacts include requiring wheel skirts, maintaining smooth tracks, vehicle maintenance and wheel truing, and operator training.

For any noise impacts predicted using the baseline information on light rail operations, the next type of mitigation considered would be applied between the noise source and receiver. Typical path mitigation includes sound walls, earth berms, and buffer zones. Constructing sound walls between the light rail tracks and the affected receivers would reduce noise levels by physically blocking the transmission of noise generated by light rail. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls and are usually constructed with a 3-to-1 slope. For the East Link Project, berms would not generally be feasible due to topographical conditions and limited right-of-way. For at-grade or elevated guideway structures, sound walls should be high enough to break the line of sight between the noise source and the receiver. Typical height for at-grade sound walls is 6 to 8 feet and 4 to 6 feet when on elevated structures. Sound walls must also be long enough to prevent flanking of noise around the ends of the walls. Openings in sound walls for driveway connections or intersecting streets greatly reduce the effectiveness of these walls.

Buffer zones are undeveloped, open spaces between the noise source and receiver. Buffer zones are created when an agency purchases land or development rights in addition to the normal right-of-way, so that future dwellings cannot be constructed close to the noise source. This prevents the possibility of constructing dwellings that would otherwise experience an excessive noise levels. However, because the East Link Project is in an urban setting where land is at a premium, creating buffer zones is not a feasible form of noise mitigation.

For situations where path mitigation is either not feasible or ineffective, building sound insulation would be considered. Sound insulation programs are developed to make sure that the interior noise levels in sleeping and living quarters in residential land uses or in noise-sensitive areas of schools and other institutional uses remain within the guidelines set by the Department of Housing and Urban Development (HUD). Under these guidelines, noise levels in sensitive areas of residential land uses should not exceed 45 dBA Ldn and some form of fresh air exchange must be maintained. The air exchange can be achieved by opening a window or using some form of ventilation system. Sound insulation is normally only used on older dwellings with single-pane windows, or in buildings with double-pane windows that are no longer effective due to leakage. Sound insulation would not reduce exterior noise levels.

Finally, when a light rail vehicle travels over a crossover, there is a loud clicking noise as the steel wheels go over the gap between the tracks. This can increase noise levels from the train by as much as 10 dBA compared to a smooth track with no gaps. Mitigation for noise impacts from crossover tracks can include relocating the crossover away from noise-sensitive properties, or the use of special trackwork, such as special frogs that include gap-closing mechanisms, or using movable point frogs. A "frog" in this context is a rail-crossing structure at track crossovers, which allows the train to cross over to another track or continue moving on the same track. A gap is provided on top of the frog so that vehicle wheels can pass regardless of which track is in use. With standard rigid frogs, vibration occurs when the wheels pass over the gap, but a moveable point frog eliminates the gap and one end of the frog moves in the direction of train travel. Other similar options are spring-rail or flange-bearing frogs.

The FTA considers impacts in the severe category as those requiring the most thorough noise mitigation consideration if the project cannot avoid the impact. Sound Transit is committed to reducing or eliminating severe impacts. For impacts in the moderate category, the FTA provides more leeway regarding required mitigation, and several factors can be considered, such as the existing noise levels, existing and future land use, and the severity of the moderate impact. Finally, any proposed noise mitigation measure must be considered reasonable and feasible to be included with the project. Feasibility includes two main factors: the overall noise-reduction of the mitigation and its constructibility. The reasonability criteria of noise mitigation are related to the cost and noise-reduction of the proposed mitigation. Other items that may be considered include community input, land use, whether the impact occurs on a ground floor or upper floor, and safety.

Although the mitigation measures presented above provide for reduced noise levels from all forms of light rail operation, including audible warning devices such as train-mounted horns and bells at crossing gates, Sound Transit is currently evaluating additional methods to assist in reducing noise from audible warning devices. For example, Sound Transit recently modified their train-mounted bell policy. Under the new policy, train-mounted bells would be sounded two to three times as a train approaches and passes through an at-grade crossing, producing maximum levels of 80 dBA Lmax at 50 feet between 6:00 a.m. and 10:00 p.m. and reducing to 72 dBA Lmax between 10:00 p.m. and 6:00 a.m. This is a reduction of 5 dBA Lmax during the daytime and a reduction of 13 dBA between 10:00 p.m. and 6:00 a.m. when compared to the initial bell policy. This change reduces the overall bell noise levels and reduces bell noise levels even further during hours when the bells could have the most negative impact on nearby residential uses.

Sound Transit is also evaluating the use of reduced noise levels from the warning bells used for gated at-grade crossings. For this analysis, the gate bells were analyzed using the default methods from the FTA Manual (2006), which assumes a typical Lmax of 85 to 86 dBA at 10 feet (single event level [SEL] of 109 dBA at 50 feet), 360 degree directional sound output, and that the bells would sound for approximately 25 seconds per train (10 to 13 seconds while raising gates and 10 to 13 seconds when lowering gates). Sound Transit is considering the use of lower bell noise levels. Depending on the location of the gates and background ambient noise levels, gate warning bells noise levels could be reduced by up to 10 dBA Lmax (from 85 dBA to 75 dBA). Sound Transit is also considering the use of bell shrouds, which are mechanical devices used to modify bells and direct the sound from the bells at the traffic and pedestrian areas of concern. The shrouds thereby reduce bell-related noise to the sides, where there are often noise-sensitive properties. Because these bell noise mitigation measures are still under investigation, they were not assumed in the noise projections; therefore, the gated bells analysis used in this environmental document is a worst-case projection of operational noise levels. These methods of further reducing noise from system operations are being reviewed. If they are found to be effective at reducing noise, while not jeopardizing operational safety, these methods could be included in the project during final design. It is important to note that operational safety is of the utmost importance and cannot be jeopardized.

7.2 Potential Traffic Noise Mitigation Options

For locations with traffic-noise impacts caused by the East Link Project, Sound Transit may consider sound insulation if no other form of mitigation is found to be reasonable and effective at reducing the noise impact. Use of FHWA or WSDOT funds for sound insulation of residences for traffic noise abatement is allowed only in specific situations. WSDOT and FHWA policies and procedures, and 23 CFR 772.13(c)(6), limit sound insulation for traffic-noise abatement to public use or nonprofit institutional structures and only in situations where a barrier is ineffective, unreasonable, and/or infeasible and interior noise levels are above the impact criteria. Sound insulation of residences is allowed only when noise impacts are severe (i.e., above 80 dBA exterior or above 60 dBA interior) and no other type of abatement is possible. In contrast, Sound Transit considers residential sound insulation for any noise impacts related to light rail projects if a barrier is ineffective, unreasonable, and/or infeasible, including impacts from traffic caused by road realignment or additional lanes constructed during light rail construction. The mitigation proposed follows Sound Transit policy.

Several different traffic-noise abatement measures are evaluated whenever noise impacts are expected. These include traffic management measures, highway design measures, and sound walls such as earthen berms. Other mitigation measures, such as property acquisition, were not considered for the East Link Project. Specific mitigation measures recommended as part of the project must be feasible and reasonable. Possible mitigation measures are provided below.

7.2.1 Traffic Management Measures

Traffic management measures include modification of speed limits and restricting or prohibiting truck traffic. Restricting truck use on the project roadways would reduce noise levels at nearby receivers because trucks are louder than cars. However, displacing truck traffic from one roadway to another would only shift noise impacts from one area to another and conflict with the project objective.

7.2.2 Highway Design Measures

Highway design measures include altering the roadway alignment and depressing roadways in cut sections. Alteration of a roadway alignment could decrease noise levels by moving the noise source farther away from the affected receivers. Topographical and built-environment considerations determine the proposed project profile. There are no opportunities on the East Link Project for highway design options that could be used to provide noise mitigation.

7.2.3 Sound Walls

Construction of sound walls between the roadways and the affected receivers would reduce noise levels by physically blocking the transmission of traffic-generated noise. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls and are usually constructed with a 3-to-1 slope. For the East Link Project, berms would generally not be feasible because of the right-of-way requirements.

Sound walls should be high enough to break the line-of-sight between the noise source and the receiver. They must also be long enough to prevent substantial flanking of noise around the ends of the walls. For a sound wall to be considered feasible, 60 percent of the first-row receivers must have a minimum 5-dB noise reduction and at least one receiver must have a 7-dB reduction. Openings in the sound walls for driveways and walkways can considerably reduce the barrier effectiveness.

The relationship of the location of a sound wall to the receptors to be protected would be considered in making a reasonableness determination. Very tall barriers located close to the receptors can have a negative visual impact.

For locations where there is a potential for traffic noise to reflect off the sound walls, Sound Transit would propose to use absorptive treatments to remedy this issue.

7.3 Potential Noise Mitigation Measures

This section provides general details on the potential noise mitigation measures that would be used for the different alternatives. The noise mitigation commitments herein are firm commitments to meet the FTA and FHWA noise criterion applicable at each location. However, if during final design Sound Transit determines that the relevant noise criterion can be achieved by a less costly means, or that the noise impact at that location would not occur even without mitigation, then the mitigation measure might be eliminated or modified as needed. Conversely, if any additional noise impacts are identified during final design, then Sound Transit would make every attempt to provide mitigation that is consistent with the Sound Transit Policy (2004).

Appendix E provides complete details on mitigation, including projected noise levels with the proposed noise mitigation measures for each receiver. Alternative specific mitigation measures are presented below, and Table 7-2 provides a complete summary of mitigation measures.

TABLE 7-2
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe [b]			
Segment A						
Preferred Interstate 90 Alternative (A1)	N/A	1	0	0	Potential sound wall	0
Segment B						
Preferred 112th SE Modified Alternative (B2M)	*Preferred Alternative C11A*	79	0	0	Sound walls, special trackwork, and building insulation	10
	Preferred Alternative C9T	66				
	Preferred Alternative C9T with C9T - East Main Station Design Option	64	2	0		
Bellevue Way Alternative (B1) [d]	N/A	128	4	136	Special trackwork, and building insulation	141
112th SE At-Grade Alternative (B2A) [e]	N/A	77	1	17	Sound walls, special trackwork, and building insulation	17
112th SE Elevated Alternative (B2E)	N/A	85	21	0	Sound walls, special trackwork, and building insulation	5

TABLE 7-2 CONTINUED
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe[b]			
112th SE Bypass Alternative (B3)[f]	N/A	79	4	17	Sound walls, special trackwork, and building insulation	17
B3 - 114th Extension Design Option[f]	N/A	76	1	17	Sound walls, special trackwork, and building insulation	31
BNSF Alternative (B7)	N/A	108	68	0	Sound walls and special trackwork	0
Segment C						
Preferred 108th NE At-Grade Alternative (C11A)	*Preferred Alternative B2M*	119	65	0	Sound walls, special trackwork, and building insulation	108
	Alternative B3, B3 – 114th Extension Design Option, or B7	152	52			144
Preferred 110th NE Tunnel Alternative (C9T)	*Preferred Alternative B2M*	62	57	0	Sound walls, special trackwork, and building insulation	50
	Alternative B3, B3 – 114th Extension Design Option, or B7	88	52			84
C9T – East Main Station Design Option	*Preferred Alternative B2M*	67	52	0	Sound walls, special trackwork, and building insulation	50
Bellevue Way Tunnel Alternative (C1T)[g]	Alternative B1	48	52	18	Sound walls, special trackwork, and building insulation	69
106th NE Tunnel Alternative (C2T)	Alternative B2A	48	52	0	Sound walls, special trackwork, and building insulation	48
	Alternative B2E	113	66			
	Alternative B3 or B7	66	70			
108th NE Tunnel Alternative (C3T)	Alternative B2A	26	0	0	Sound walls	0
	Alternative B2E	91	14		Sound walls and special trackwork	32
	Alternative B3 or B7	44	18		Sound walls	0
Couplet Alternative (C4A)	Alternative B2A or B2E	435	15	0	Sound walls, special trackwork, and building insulation	364
	Alternative B3 or B7	420	19	0	Sound walls and building insulation	400
112th SE Elevated Alternative (C7E)	Alternative B2A or B2E	270	12	0	Sound walls and special trackwork	0
	Alternative B3 or B7	208	0		Sound walls	
110th NE Elevated Alternative (C8E)	Alternative B3 or B7	353	72	0	Sound walls	0
110th Avenue NE At-Grade Alternative (C9A)	Alternative B2A	185	56	0	Sound walls, special trackwork, and building insulation	120
	Alternative B3, B3 – 114th Extension Design Option, or B7	145	54			156
114th Avenue NE Elevated Alternative (C14E)	Alternative B3, B3 – 114th Extension Design Option, or B7	36	112	0	Sound walls and special trackwork	0

TABLE 7-2 CONTINUED
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe[b]			
Segment D						
Preferred NE 16th At-Grade Alternative (D2A)	*Preferred Alternative C11A* or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
D2A - 120th Station Design Option	*Preferred Alternative C11A* or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
D2A - NE 24th Design Option	*Preferred Alternative C11A* or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
NE 16th Elevated Alternative (D2E)	Alternative C3T, C4A, C7E, or C8E	2	0	0	Sound wall and potential building insulation	1
	Preferred Alternative C11A or *C9T*, Alternative C1T, C2T, C9A or C14E	1	0	0	Sound wall and potential building insulation	1
NE 20th Alternative (D3)	Alternative C3T, C4A, C7E, or C8E	1	0	0	Sound wall	0
	Preferred Alternative C11A or *C9T*, Alternative C1T, C2T, C9A or C14E	0	0	0	None	0
SR 520 Alternative (D5)	Alternative C3T, C4A, C7E, or C8E	1	10	0	Sound wall	0
	Preferred Alternative C11A or *C9T*, Alternative C1T, C2T, C9A or C14E	0	10	0	Sound wall	0
Segment E						
Preferred Marymoor Alternative (E2)	All Segment D alternatives	33	148	0	Sound wall, special trackwork, and building insulation	168
E2 - Redmond Transit Center Design Option	All Segment D alternatives	81	100	0	Sound wall, special trackwork, and building insulation	168
Redmond Way Alternative (E1)	All Segment D alternatives	167	150	0	Sound wall, special trackwork, and building insulation	288
Leary Way Alternative (E4)	All Segment D alternatives	66	32	0	Sound wall, special trackwork, and building insulation	48

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

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

[c] These traffic noise impacts are based on the Federal Highway Administration 66 A-weighted decibel (dBA) equivalent continuous sound level (L_{eq}) impact criteria.

[d] Under Alternative B1 all but nine of the traffic noise impacts would also have light rail noise impacts; conversely, there are only five light rail impacts that would not have traffic noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 141; 5 would be impacted by light rail noise only, 9 would be impacted by traffic noise only, and 127 would be impacted by both traffic noise and light rail noise.

TABLE 7-2 CONTINUED
Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Connection Alternatives	Light Rail Impacts		Traffic Noise Impacts[c]	Proposed Mitigation	Locations Considered for Sound Insulation
		Moderate[a]	Severe[b]			

[e] Under Alternative B2A all but one of the traffic noise impacts would also have light rail noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 79; 62 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise.

[f] Under Alternatives B3 and B3 – 114th Extension Design Option all but one of the traffic noise impacts would also have light rail noise impacts. For B3, the total number of residences impacted (single- and multifamily) would be 84; 67 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise. For B3 – 114th Extension Design Option, the total number of residences impacted (single- and multifamily) would be 78; 61 would be impacted by light rail noise only, 1 would be impacted by traffic noise only, and 16 would be impacted by both traffic noise and light rail noise.

[g] Under Alternative C1T all the traffic noise impacts are separate from light rail noise impacts. The total number of residences impacted (single- and multifamily) under this alternative would be 118; 100 would be impacted by light rail noise only, 18 would be impacted by traffic noise only, and 0 would be impacted by both traffic noise and light rail noise.

7.3.1 Segment A

The only noise impact in Segment A would be near the transition from the Mount Baker Tunnel to the floating bridge structure. An expansion joint is required to allow for bridge movement, and increased noise related to the expansion joint could result. If the expansion joint were determined to cause an increased noise level that resulted in a noise impact, then mitigation would likely be a short absorbent sound wall along the side of the structure or absorbent material applied to the existing traffic safety barriers. There would be no traffic-related noise impacts in Segment A.

7.3.2 Segment B

In Segment B, light rail and traffic noise impact would vary with alternative and segment connection. All Segment B alternatives would have light rail noise impacts along the corridor. Alternatives B1, B2A, B3, and B3 – 114th Extension Design Option would have traffic noise impacts in addition to light rail-related noise impacts. *Preferred Alternative B2M* and Alternatives B2E and B7 are designed with no roadway modifications projected to increase noise levels at any noise-sensitive properties and, therefore, would have no traffic noise impacts.

7.3.2.1 Preferred 112th SE Modified Alternative (B2M)

The impacts and mitigation under each of the two *Preferred Alternative B2M* design options would be slightly different. Under *Preferred Alternative B2M* connecting to *Preferred Alternative C11A,* there would be 79 moderate light rail noise impacts projected; 41 of the impacts would occur along the elevated segment from I-90 to the intersection with 112th Avenue SE. These 41 impacts would occur to single-family residences that border SE 34th Street and Bellevue Way, and all would be mitigated with 4- to 6-foot reflective sound walls or 3- to 5-foot acoustical sound walls installed along the elevated structure. When the alternative transitions from the elevated guideway structure to a retained fill, the sound wall would also make a similar transition and might change to an at-grade-style reflective wall, with heights ranging from 6 to 8 feet. The wall would continue reducing in size to ground level where the light rail descends into a retained cut.

North of the 112th Avenue SE intersection, there would be an additional seven noise impacts projected at the single-family residences west of 112th Avenue SE, near SE 17th and SE 14th Streets. There would also be 19 moderate noise impacts identified at the Bellefield Residential Park Condominiums and 12 moderate impacts at single-family residences along 111th Avenue SE just south of the Surrey Downs Park. A continuous sound wall would be installed along the west side of the alternative, beginning just south of the end of the retained cut segment and ending just south of the transition of the alignment to the center of 112th Avenue SE. A second sound wall would begin along the west side of SE 112th Avenue SE, just south of the Bellefield Residential Park Condominiums, continuing to Surrey Downs Park. The sound wall heights would vary as the topographical conditions vary, but is expected to range from 8 to 12 feet in the southern section and could increase to 16 to 18 feet, or taller, near Surrey Downs Park. This wall would also help to reduce traffic noise levels at the single- and multifamily residences in the Bellefield Residential Park Condominiums and the single-family residences along 111th Avenue SE. Building insulation would be considered for up to 10 single- and multifamily homes located near openings in the sound wall for the at-grade crossings at SE 15th Street and SE 8th Street and near Surrey Downs Park .

Under *Preferred Alternative B2M* connecting to *Preferred Alternative C9T*, there would be 66 moderate light rail noise impacts. Noise impacts from I-90 to 112th Avenue SE would be the same as noted above with the connection to *Preferred Alternative C11A*, with 41 moderate impacts. Noise mitigation for this area of the corridor would also be the same as described above for *Preferred Alternative B2M* to *Preferred Alternative C11A*.

North of the intersection of Bellevue Way and 112th Avenue SE, there would be also six impacts at single-family residences west of 112th Avenue SE, near SE 17th and SE 14th Streets, and nine moderate noise impacts identified at the Bellefield Residential Park Condominiums. In addition, there would be 10 moderate impacts at single-family residences along 111th Avenue SE just south of Surrey Downs Park. Mitigation for all of these impacts would include installing a sound wall along the west side of the tracks, beginning just south of the retained cut, and ending just south of SE 8th Street. A second sound wall would be placed along the west side of the station and continue to just south of the 112th Avenue SE at-grade crossing. Openings in the wall would also be required at SE 15th Street for access to the business park.

Impacts under *Preferred Alternative B2M* connecting to Alternative C9T – East Main Station Design Option would be similar to the connection to *Preferred Alternative C9T*, and consequently the proposed mitigation for the connection to this design option would be similar to the connection to *Preferred Alternative C9T*.

Under *Preferred Alternative B2M* connections to *Preferred Alternatives C11A* or *C9T*, or the C9T – East Main Station Design Option, up to 10 single- and multifamily homes located near openings in the sound wall for the at-grade crossings at SE 15th Street and SE 8th Street and near Surrey Downs Park would be evaluated for sound insulation.

7.3.2.2 Bellevue Way Alternative (B1)

With Alternative B1 there would be 4 severe light rail noise impacts, 128 moderate noise impacts, and 136 traffic noise impacts. The severe light rail noise impacts would be near SE 30th Street, due in part to a nearby crossover track. The traffic noise impacts, which would occur along Bellevue Way beginning near SE 30th Street, would be due to roadway widening and would occur at single- and multifamily structures along the entire project corridor. The total number of residences (single- and multifamily) affected with Alternative B1 would be 141, which would include the 128 moderate and 4 severe light rail noise impacts along with the 136 traffic noise impacts, as the vast majority of residences are projected to have both light rail and traffic noise impacts.

Mitigation measures for Alternative B1 would include a variety of mitigation measures, including sound insulation of structures as needed, special trackwork at the crossovers, and potentially some sound walls, if it is determined that they would be effective at reducing noise. One of the primary issues of using sound walls along Alternative B1 is the required openings for driveways and vehicle and pedestrian access at intersections and for access to many of the single- and multifamily units along the corridor. In order to evaluate the worst-case scenario, Sound Transit determined, after reviewing the corridor and location of intersections and driveways, that sound walls would not be a feasible form of mitigation in most of the corridor; therefore, sound insulation is assumed to be the main form of mitigation. Based on this assumption, there are up to 141 units that would be considered for sound insulation. If, during final design, Sound Transit determines that sound walls could be installed, then the number of buildings considered for insulation could be lower.

7.3.2.3 116th SE Tunnel Alternative (B2A)

With Alternative B2A, there would be 78 light rail noise impacts and along with 17 traffic noise impacts. Light rail noise impacts would occur along the elevated section from I-90, past the South Bellevue Park-and-Ride, and continue to the at-grade segment just south of the 112th Avenue SE intersection. There would also be light rail noise impacts along 112th Avenue SE at the single- and multifamily residences from SE 17th Street to Surrey Downs Park. Traffic noise impacts are only projected to occur between the South Bellevue Station and 112th Avenue SE due to road widening.

Mitigation for Alternative B2A would include sound walls, sound insulation, and special trackwork at the crossovers. Sound walls would be used along the elevated segment near I-90 and along Bellevue Way. When the alternative profile transitions to at-grade, sound walls might not be feasible due to pedestrian and vehicle access requirements; in those areas, sound insulation would be used to provide mitigation to the single- and multifamily residences. An estimated 17 residences, along the at-grade segment on Bellevue Way, would be considered for sound insulation. If, during final design, Sound Transit determines that sound walls could be installed, then this number could be reduced.

7.3.2.4 112th SE Elevated Alternative (B2E)

Light rail noise impacts were identified at 106 single- and multifamily residences under Alternative B2E; this includes 21 impacts considered severe under the FTA criteria. There would be no traffic noise impacts under Alternative B2E. For Alternative B2E, sound walls and special trackwork would be effective at mitigating all but five of the projected noise impacts. The remaining five impacts, all along Bellevue Way SE, would be further evaluated during final design and could receive sound insulation, taller sound walls, or other mitigation methods to assist in reducing the noise levels.

7.3.2.5 112th SE Elevated Alternative (B3)

Project noise impacts from Alternative B3 would be very similar to those described for Alternative B2A and would include 79 moderate and 4 severe light rail noise impacts, along with 17 traffic noise impacts. Mitigation for Alternative B3 would include sound walls, sound insulation, and special trackwork at the crossovers. There would be an estimated 17 residences evaluated for sound insulation, all located along the at-grade segment on Bellevue Way SE. These 17 residences are projected to have noise impacts from traffic noise, with 16 of those also meeting or exceeding the FTA criteria for light rail noise. If, during final design, Sound Transit determines that sound walls could be installed, then this number could be reduced.

Proposed mitigation for the B3 – 114th Extension Design Option would be similar to that proposed for Alternative B3.

7.3.2.6 BNSF Alternative (B7)

Alternative B7 along the former BNSF Railway corridor would result in 176 light rail noise impacts, including 68 severe impacts. The severe impacts would be a result of the alternative's crossover near the Emerald Apartments and the trains' high speed and proximity to the Brookshire Condominiums. Mitigation for Alternative B7 would include sound walls and special trackwork at the crossovers. With the proposed mitigation measures, all noise impacts would be mitigated and no sound insulation would be needed.

7.3.3 Segment C

In Segment C, light rail noise impacts would vary with alternative and segment connection. All of the Segment C alternatives would have light rail noise impacts along the corridor, although only Alternative C1T would have traffic noise impacts. The design of *Preferred Alternatives C11A* and *C9T* have no roadway modifications that are projected to increase noise levels at any noise-sensitive properties and, therefore, would have no traffic noise impacts.

7.3.3.1 Preferred 108th NE At-Grade Alternative (C11A)

Under *Preferred Alternative C11A* connecting from *Preferred Alternative B2M* there would be 119 moderate light rail noise impacts and 65 severe impacts projected. The severe impacts would occur to several homes along 111th Avenue SE due to a nearby crossover and loss of shielding from existing buildings. The other severe impacts would occur at several multifamily units along 108th Avenue NE from bells and proximity to the tracks, and at the Lake Bellevue Village Condominiums. Severe impacts are also projected at the Coast Bellevue Hotel from a nearby crossover and the proximity of the tracks to the hotel rooms. There would be no roadway modifications and no traffic noise impacts associated with this alternative.

Mitigation measures would include a sound wall along the west side of the alignment beginning near SE 6th Street and continue as a sound barrier to 108th Avenue NE, just south of Main Street. The wall would be located near the tracks on the retained fill and elevated structure to the 108th Station. The sound wall/barrier, along with special trackwork at the crossover along 112th Avenue SE, would mitigate all impacts along this section of the corridor. Sound walls and special trackwork for the crossover would also be used to mitigate impacts on the Coast Bellevue Hotel and Lake Bellevue Village Condominiums. Multifamily units located on Main Street, 108th Avenue NE, and NE 6th Street would be mitigated with sound insulation where necessary. Based on the current analysis, up to 108 units would be evaluated for sound insulation.

If *Preferred Alternative C11A* were connected to Alternative B3, B3 - 114th Extension Design Option, or Alternative B7, then the noise mitigation measures would be similar to those described above. Because this alternative connection is not along 112th Avenue SE, however, the sound wall along this section would not be needed, but an elevated sound wall would be required near the Hilton Hotel. Under this alternative connection, 144 units would be evaluated for sound insulation.

7.3.3.2 Preferred 110th NE Tunnel Alternative (C9T)

Preferred Alternative C9T connecting from *Preferred Alternative B2M* is projected to result in 119 light rail noise impacts, including 62 moderate and 57 severe. The severe impacts would occur at a multifamily building in Downtown Bellevue, one hotel, and the Lake Bellevue Village Condominiums, and depending on the location, would be a result of the proximity to the tracks and crossovers, and bells related to at-grade crossings.

Mitigation measures would be the same as those described for *Preferred Alternative C11A*. Through most of the downtown area, however, the alternative profile is in a tunnel, and therefore the total number of noise impacts would be reduced. The only units requiring sound insulation evaluation would be two single-family residences because of their proximity to an at-grade crossing with gates and warning bells, and at a newly constructed highrise on NE 6th Street where the only feasible form of mitigation would be sound insulation.

If *Preferred Alternative C9T* connected to Alternative B3, B3 - 114th Extension Design Option, or Alternative B7, then the noise mitigation measures would be similar to those described above. Because the alternative route would not travel along 112th Avenue SE with these connections, however, the sound wall along this section would not be needed, but a sound wall on the elevated guideway would be required near the Hilton Hotel. The revised alternative connection is still projected to result in 84 residential units being evaluated for sound insulation.

Proposed mitigation for Alternative C9T – East Main Station Design Option would be similar to that proposed for *Preferred Alternative C9T*, with 50 residential units being evaluated for sound insulation.

7.3.3.3 Bellevue Way Tunnel Alternative (C1T)

South of Main Street, Alternative C1T would be the only Segment C alternative with traffic noise impacts, which would result from roadway modifications on Bellevue Way that would impact 18 multifamily units. Light rail related-impacts under Alternative C1T would result in 48 moderate and 52 severe impacts. Mitigation for the 18 multifamily units with traffic noise impacts would likely be sound insulation, although if this alternative were selected, sound walls would be evaluated during final design. Given the requirements for pedestrian and vehicle access, upper floor units, balconies, and lanais, however, sound walls would not likely be a feasible form of mitigation in this area. In addition, 51 units, for a total of 69 units, would be evaluated for sound insulation. Sound walls and special trackwork would be used to mitigate noise levels at the Coast Bellevue Hotel and the Lake Bellevue Village Condominiums.

7.3.3.4 106th NE Tunnel Alternative (C2T)

Alternative C2T connecting from Alternative B2A is projected to have the same light rail impacts as Alternative C1T but without any traffic noise impacts. When connecting from Alternative B2E, Alternative C2T would have severe light rail noise impacts at 2 single-family residences, 28 multifamily residences, and 36 hotel rooms, in addition to 113 moderate light rail noise impacts. When connecting to Alternative B3 or B7, Alternative C2T would have 48 moderate light rail noise impacts and 16 severe light rail noise impacts at multifamily residences. There would also be 54 severe impacts and 18 moderate impacts at hotel rooms, for a total of 136 impacts. There would be no traffic noise impacts under any of the Alternative C2T connection options.

Mitigation measures for Alternative C2T, under all connections, would include sound walls, special trackwork at crossovers, and sound insulation. Sound walls and special trackwork would be used to mitigate impacts for the connections from Alternative B2E, B3, or B7 south of Main Street. The 48 multifamily impacts along NE 6th Street would receive sound insulation, and sound walls and special trackwork would be used to mitigate noise levels at the Coast Bellevue Hotel and the Lake Bellevue Village Condominiums.

7.3.3.5 108th NE Tunnel Alternative (C3T)

Alternative C3T would result in a total of 26 light rail impacts when connecting to Alternative B2A, 105 impacts when connecting to Alternative B2E, and 62 impacts when connecting to Alternative B3 or B7. The connection to Alternative B2A would have the fewest impacts due to the tunnel, with 21 multifamily impacts and 5 single-family impacts, all located along NE 12th Street near 112th Avenue NE. With the connection to Alternative B2E, there would be an additional 79 impacts, including severe impacts at 2 single- and 12 multifamily residences and 91 moderate impacts along the project corridor. Finally, Alternative C3T connecting to Alternative B3 or B7 is projected to have 62 light rail noise impacts, including 18 severe impacts at the Bellevue Hilton Hotel along the side of the structure facing I-405.

Mitigation measures under Alternative C3T would vary slightly, depending on the connection alternative. When connecting to Alternative B2A, the primary mitigation measure would be sound walls along 112th Avenue SE and on NE 12th Street. Sound walls, along with special trackwork and building insulation, would be required to mitigate the impacts under the connection to Alternative B2E. Finally, impacts with the connection to Alternative B3 or B7 could be fully mitigated with sound walls. Therefore, all noise impacts under Alternative C3T would be mitigated regardless of the Segment B connection alternative.

7.3.3.6 Couplet Alternative (C4A)

Alternative C4A connecting from Alternative B2A would have the highest number of noise impacts because of the highrise apartments along 108th and 110th Avenues NE, with 435 moderate and 15 severe impacts throughout the alternative corridor. When connecting from Alternative B2E, Alternative C4A would have a similar level of noise impacts, with a potential for a slight change, depending on the location of a crossover. When connecting to Alternative B3 or B7, Alternative C4A would have moderate light rail noise impacts at 420 residences and hotels and an additional severe impact at one single-family residence and 18 hotel rooms.

Mitigation measures for Alternative C4A would combine sound walls, special trackwork at crossovers, and sound insulation. Sound walls along the elevated guideway structure would effectively mitigate impacts south of Main Street under all Segment B connection alternatives. North of Main Street, the large number of highrise apartments and condominiums would be mitigated with sound insulation. Finally, there are possible locations for sound walls along the at-grade segment north of NE 12th Street; however, an opening in the sound wall for the gated crossing at 110th Avenue NE and SE 12th Street, could allow noise to be transmitted back into the single-family residential area north of NE 12th Street. Due to the large number of highrise apartments and condominiums along 108th and 110th Avenues NE, there would be approximately 364 units under the connections to Alternatives B2A or B2E, and 400 units under the connection to Alternatives B3 or B7, that would be evaluated for sound insulation.

7.3.3.7 112th NE Elevated Alternative (C7E)

Under Alternative C7E, the connector from Alternative B2A would cause severe light rail noise impacts at 12 multifamily units and moderate impacts at 13 single-family residences, 197 multifamily residences, and 60 hotel rooms. With the elevated connection to Alternative B2E, the number of impacts would be the same as those from Alternative B2A. When connecting to Alternative B3 or B7, Alternative C7E would have moderate light rail noise impacts at 4 single-family residences, 168 multifamily residences, and at 36 hotel rooms along 114th Avenue SE.

For an elevated alternative such as Alternative C7E, all noise impacts could be mitigated by using sound walls and special trackwork at crossovers. With the proposed acoustical sound walls on the elevated structure and special trackwork at crossovers, all noise impacts could be mitigated.

7.3.3.8 110th NE Elevated Alternative (C8E)

Alternative (C8E) would have 425 impacts, including severe impacts at 72 multifamily units and moderate light rail noise impacts at 120 hotel rooms, 224 multifamily, and 9 single-family residences.

Mitigation for Alternative C8E would include acoustical sound walls on the elevated guideway. With the proposed mitigation measures, all noise impacts would be mitigated.

7.3.3.9 110th NE At-Grade Alternative (C9A)

Alternative C9A only connects to Alternative B2A, B3, B7, or B3 – 114th Extension Design Option. With the connection to Alternative B2A, 185 moderate and 56 severe light rail noise impacts are projected. With a connection to Alternative B3, B3 – 114th Extension Design Option, or B7, those numbers would be reduced to 145 moderate and 54 severe light rail impacts. Mitigation for Alternative C9A would include sound walls, special trackwork, and sound insulation. Sound walls would be used along the retained fill and elevated section from Alternative B2A, and the elevated section from Alternative B3, B3 – 114th Extension Design Option, or B7, along with special trackwork at crossovers. Sound walls, along with special trackwork at crossovers, would also be used to mitigate noise levels at the Coast Bellevue Hotel and the Lake Bellevue Village Condominiums. Under the connection to Alternative B2A, 120 units would be evaluated for sound insulation. Under the connection to Alternatives B3, B3 – 114th Extension Design Option, or B7, 156 units would be evaluated for sound insulation.

7.3.3.10 112th NE Elevated Alternative (C14E)

Alternative C14E, which is elevated along 114th Avenue NE, is projected to have 16 severe impacts at multifamily residences along with 96 severe and 36 moderate impacts at hotel rooms.

Mitigation for Alternative C14E would include acoustical sound walls on the elevated structure and special trackwork at crossovers. With the proposed mitigation measures, all noise impacts would be mitigated.

7.3.4 Segment D

In Segment D there would be noise impacts only under Alternatives D2E, D3, and D5. No roadway modifications are planned that would increase noise levels at any noise-sensitive properties; therefore, no traffic noise impacts were identified.

7.3.4.1 Preferred NE 16th At-Grade Alternative (D2A)

No noise impacts were identified for *Preferred Alternative D2A*; therefore, no noise mitigation is proposed.

7.3.4.2 D2A - 120th Station or NE 24th Design Option

No noise impacts were identified for the D2A - 120th Station or D2A - NE 24th Design Options, so no noise mitigation is proposed.

7.3.4.3 NE 16th Elevated Alternative (D2E)

Under the connections from NE 12th Street (Alternatives C3T, C4A, C7E, and C8E), noise impacts are projected under Alternative D2E at the new Children's Hospital BCSC on 116th Avenue NE and to the exterior of the Pacific Northwest Ballet School on NE 16th Street and 136th Place NE. The noise impact on the hospital would be mitigated with a sound wall along the north side of the tracks. Noise mitigation for the school would be evaluated during final design, and could include building sound insulation, if needed.

Under Alternative D2E when connected to the alternatives along the former BNSF Railway corridor (Alternatives C1T and C2T), the only noise impact would be at the exterior of the Pacific Northwest Ballet School. Noise mitigation would be evaluated during final design and could include building sound insulation, if needed. No further noise mitigation would be required for Alternative D2E.

7.3.4.4 NE 20th Alternative (D3)

With the connections from NE 12th Street (Alternatives C3T, C4A, C7E, and C8E), noise impacts are projected under Alternative D3 at the new Children's Hospital BCSC on 116th Avenue NE. The noise impacts would be mitigated with a sound wall along the north side of the tracks. No noise impacts are projected under Alternative D3 when connected to the alternatives along the former BNSF Railway corridor (Alternatives C1T and C2T), and no further mitigation would be required.

7.3.4.5 SR 520 Alternative (D5)

Severe noise impacts were identified under Alternative D5 for 10 units at an apartment building near SR 520, off of Northup Way. These 10 severe impacts would occur regardless of the connection options. Under the connections from NE 12th Street (Alternatives C3T, C4A, C7E, and C8E), noise impacts are also projected at the new Children's Hospital BCSC on 116th Avenue NE. All impacts would be mitigated with sound walls. For the 10 apartment units, the sound wall would be on the south side of the tracks, and the Children's Hospital BCSC on 116th Avenue NE would be mitigated with a sound wall along the north side of the tracks.

7.3.5 Segment E

In Segment E, light rail noise impacts were identified for all build alternatives. Because of the variance in the locations of the alternatives, the impacts and mitigation would vary when the route is north of the West Sammamish Parkway exit from SR 520. No roadway modifications are planned that increase noise levels at any noise-sensitive properties, and therefore, no traffic noise impacts were identified.

7.3.5.1 Preferred Marymoor Alternative (E2)

Under *Preferred Alternative E2,* 148 severe and 33 moderate noise impacts were identified; this includes 9 moderate and 4 severe single-family impacts near SR 520 at West Lake Sammamish Parkway NE, 144 severe impacts at newly constructed multifamily units, and 24 moderate impacts at a hotel. Mitigation for *Preferred Alternative E2* includes sound walls near SR 520 at West Lake Sammamish Parkway NE, special trackwork at crossovers, and sound insulation at several multifamily buildings and a hotel. Based on the current analysis, up to 144 residential units and 24 hotel rooms could be evaluated for sound insulation.

Noise impacts under the E2 - Redmond Transit Center Design Option would be the same as *Preferred Alternative E2*; however, under this design option, 81 of the impacts would be moderate and 100 would be severe. This difference is because one of the newly constructed multifamily buildings would not have a noise impact as it would under the *Preferred Alternative E2*; however, another building near the terminus would have the same number of moderate impacts. Mitigation would still include sound walls near SR 520 at West Lake Sammamish Parkway NE, special trackwork at crossovers, and sound insulation at several multifamily buildings and a hotel.

7.3.5.2 Redmond Way Alternative (E1)

Under Alternative E1, light rail noise impacts were identified at 9 single-family units, 236 multifamily units, and 72 hotel rooms; these include severe impacts at two single-family residences and 148 multifamily units. Mitigation would include sound walls near SR 520 at West Lake Sammamish Parkway NE, special trackwork at crossovers, and sound insulation at several multifamily buildings and a hotel. An estimated 288 noise impacts at a hotel and multifamily structures adjacent to the corridor would be considered for sound insulation.

7.3.5.1 Leary Way Alternative (E4)

Alternative E4 would have 66 moderate impacts and 32 severe impacts related to light rail operations; no traffic or other noise impacts were identified in Segment E. Mitigation would include sound walls near SR 520 at West Lake Sammamish Parkway NE continuing along the elevated trackway to Leary Way, special trackwork at crossovers, and sound insulation at several multifamily buildings and a hotel.

7.3.6 Station Noise Mitigation

To reduce noise levels at station platforms, Sound Transit would incorporate design measures to reduce freeway noise for patrons waiting at station platforms. These design measures would be considered at any station where Sound Transit's design goal of 78 dBA Leq (15-minute and 1-hour) for noise from exterior sources at station platforms is exceeded.

7.3.7 Maintenance Facility Noise Mitigation

The only maintenance facility alternative located in an area with nearby noise-sensitive uses is MF1. Noise impacts were identified at the Children's Hospital BCSC under the FTA impact criteria. Because the maintenance facilities are fixed sites, with most noise-producing activities occurring indoors, the potential noise impacts would all be due to train activity along the tracks in the facility. Noise impacts would be mitigated through the installation of a sound wall approximately 12 feet tall along southern side of the site. The proposed sound wall would mitigate the noise impacts at the hospital.

7.4 Potential Light Rail Vibration Mitigation Options

This assessment assumes that the vehicle wheels and track would be maintained in good condition with regular wheel truing and rail grinding, in accordance with Sound Transit maintenance procedures. Beyond this, there are several approaches to reduce groundborne vibration from light rail operation, described in the following subsections. In almost all cases, vibration mitigation is possible with either ballast mats or resilient rail fasteners. At some locations, however, the tracks are within less than 20 feet of buildings, and the vibration levels are too high for mitigation to be completely effective. At these locations, project design modification and additional information on affected buildings could eliminate these impacts. For example, the type of building foundation might reduce vibration impacts; therefore, these residual impacts might be eliminated.

7.4.1 Ballast Mats

A ballast mat consists of a pad made of rubber or rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. The reduction in groundborne vibration provided by a ballast mat strongly depends on the vibration frequency content and the design and support of the mat.

7.4.2 Resilient Rail Fasteners

Resilient fasteners can be used to provide vibration isolation between rails and concrete slabs for direct fixation track typically on elevated structures or in tunnels. These fasteners include a soft, resilient element to provide greater vibration isolation than standard rail fasteners in the vertical direction. This type of mitigation can be used in tunnels instead of floating slabs, where appropriate.

7.4.3 Tire-Derived Aggregate

Also known as shredded tires, a typical tire-derived aggregate (TDA) installation consists of an underlayer of 12 inches of nominally 3-inch-size tire shreds or chips wrapped with filter fabric, covered with 12 inches of subballast, and 12 inches of ballast above that to the base of the ties. This type of mitigation can only be used on ballast and tie track. Tests suggest that the vibration-attenuation properties of this treatment are midway between that of ballast mats and floating slab track. While this is a low-cost option, it has only recently been installed on two U.S. light rail transit systems—in San Jose and Denver—and its long-term performance is unknown.

7.4.4 Floating Slabs

Floating slabs consist of thick concrete slabs supported by resilient pads on a concrete foundation; the tracks are mounted on top of the floating slab. Although floating slabs are designed to provide vibration reduction at lower frequencies than ballast mats, they are extremely expensive and are rarely used, except in the most extreme situations. Most successful floating-slab installations are in subways, and their use for at-grade track is less common and often not reasonable.

7.4.5 Special Trackwork

Because the impacts of vehicle wheels over rail gaps at track turnout locations increases groundborne vibration by about 10 VdB, turnouts are a major source of vibration impact when they are located in sensitive areas. If turnouts cannot be relocated away from sensitive areas, then another approach is to use spring-rail, flange-bearing or moveable-point frogs in place of standard rigid frogs at turnouts. These devices allow the flangeway gap to remain closed in the main traffic direction for revenue service trains.

7.5 Potential Light Rail Vibration Mitigation Measures

Vibration and groundborne noise impacts that exceed FTA criteria are considered to be significant and warrant mitigation, if reasonable and feasible. In almost all cases, vibration mitigation is possible with either ballast mats or resilient rail fasteners. Table 7-3 lists the number of proposed light rail vibration and groundborne noise impacts and the distances of contiguous locations along each alternative where mitigation measures are recommended.

TABLE 7-3
Vibration Mitigation Locations

Alternative	Connection	Length of Mitigation Locations (feet)	Before Mitigation		With Mitigation	
			No. of Vibration Impacts	No. of Groundborne Noise Impacts	No. of Vibration Impacts	No. of Groundborne Noise Impacts
Segment A						
Preferred Interstate 90 Alternative (A1)	N/A	1,900	0	25 single-family	0	0

TABLE 7-3 CONTINUED
Vibration Mitigation Locations

Alternative	Connection	Length of Mitigation Locations (feet)	Before Mitigation		With Mitigation	
			No. of Vibration Impacts	No. of Groundborne Noise Impacts	No. of Vibration Impacts	No. of Groundborne Noise Impacts
Segment B						
Preferred 112th SE Modified Alternative (B2M)	*Preferred NE At-Grade (C11A) or Preferred 110th NE Tunnel (C9T) Alternative*	600	0	1 (Winters House)	0	0
Preferred 112th SE Modified Alternative (B2M)	C9T - East Main Station Design Option	600	1 single-family	1 (Winters House)	0	0
Bellevue Way Alternative (B1)	N/A	200	1 single-family	0	0	0
Segment C						
Preferred NE At-Grade Alternative (C11A)	*Preferred Alternative (B2M)*	300	1 single-family	0	0	0
		300	1 single-family	0	0	0
		1,200	3 multifamily	0	0	0
		600	1 hotel	0	1 hotel	0
	Alternative B3 or B7	300	1 single-family	0	0	0
		1,200	3 multifamily	0	0	0
		600	1 hotel	0	1 hotel	0
Preferred 110th NE Tunnel Alternative (C9T)[a]	*Preferred Alternative (B2M)*	300	1 single-family	0	0	0
		300	1 single-family	0	0	0
		500	0	1 theater	0	0
		600	1 hotel	0	1 hotel	0
	Alternative B3 or B7	300	1 single-family	0	0	0
		500	0	1 theater	0	0
		600	1 hotel	0	1 hotel	0
C9T - East Main Station Design Option	*Preferred Alternative (B2M)*	300	1 single-family	0	0	0
		300	1 single-family	0	0	0
		500	0	1 theater	0	0
		600	1 hotel	0	1 hotel	0
Bellevue Way Tunnel Alternative (C1T)	Alternative B1	1,200	0	1 single-family	0	0
		700	1 single-family	0	0	0
		600	1 hotel	0	0	0
106th NE Tunnel Alternative (C2T)	Alternative B2A	None	0	0	0	0
	Alternative B2E	200	0	1 single-family	0	0
	Alternative B3 or B7	None	0	0	0	0

TABLE 7-3 CONTINUED
Vibration Mitigation Locations

Alternative	Connection	Length of Mitigation Locations (feet)	Before Mitigation		With Mitigation	
			No. of Vibration Impacts	No. of Groundborne Noise Impacts	No. of Vibration Impacts	No. of Groundborne Noise Impacts
108th NE Tunnel Alternative (C3T)	Alternative B2A	300	0	2 single-family	0	0
		900	0	9 single-family	0	0
		700	0	1 single-family	0	0
	Alternative B2E	300	0	1 single-family	0	0
		200	0	1 single-family	0	0
	Alternative B3 or B7	300	0	1 single-family	0	0
Couplet Alternative (C4A)	Alternative B2A or B2E	400	4 multifamily	0	2 multifamily	0
		1,200	1 single-family, 2 multifamily	0	0	0
	Alternative B3 or B7	400	4 multifamily	0	2 multifamily	0
		1,200	1 single-family, 2 multifamily	0	0	0
112th NE Elevated Alternative (C7E)	Alternative B2A or B2E	None	0	0	0	0
	Alternative B3 or B7	None	0	0	0	0
110th NE Elevated Alternative (C8E)	Alternative B3 or B7	1,100	1 multifamily, 1 hotel	0	1 hotel	0
		1,800	2 single-family, 2 multifamily	0	1 multifamily	0
110th NE At-Grade Alternative (C9A)	Alternative B2A, B2E, B3, or B7	600	2 single-family	0	0	0
		1,500	3 multifamily	0	2 multifamily	0
		600	1 hotel	0	1 hotel	0
114th NE Elevated Alternative (C14E)	Alternative B3 or B7	600	1 hotel	0	0	0
		600	1 hotel	0	0	0
		600	1 hotel	0	1 hotel	0
Segment D	There would be no vibration impacts in Segment D.	N/A	0	0	0	0
Segment E						
Preferred Marymoor Alternative (E2)	N/A	300	1 single-family	0	0	0
		400	2 single-family	0	1 single-family	0
E2 – Redmond Transit Center Design Option	N/A	300	1 single-family	0	0	0
		400	2 single-family	0	1 single-family	0
Redmond Way Alternative (E1)	N/A	300	1 single-family	0	0	0
		400	2 single-family	0	1 single-family	0

TABLE 7-3 CONTINUED
Vibration Mitigation Locations

Alternative	Connection	Length of Mitigation Locations (feet)	Before Mitigation		With Mitigation	
			No. of Vibration Impacts	No. of Groundborne Noise Impacts	No. of Vibration Impacts	No. of Groundborne Noise Impacts
Leary Way Alternative (E4)	N/A	300	1 single-family	0	0	0
		200	1 multifamily	0	0	0
		400	1 hotel	0	0	0

[a]Mitigation for *Preferred Alternative C9T* connecting to *Preferred Alternative B2M* would include either relocating the crossover on 112th Avenue SE or using special track work to eliminate the impact from the crossover. This would eliminate five vibration impacts.

At some locations, light rail trackways or guideways would be within 20 feet of buildings and vibration mitigation would not be effective at reducing the vibration level to below the FTA criteria. At these locations, project design modification and additional information on affected buildings could eliminate these impacts. For instance, the type of building foundation might reduce vibration impacts and therefore, these residual impacts might be eliminated.

In addition, each building would need to be examined in detail to determine where the vibration-sensitive uses are located. For example, the side of a building nearest the proposed alternative might be a vibration-sensitive use. Buildings that are mixed-use might not have sensitive uses on lower floors where impacts would occur, and the vibration would not be noticeable by the time it reached higher floors with sensitive uses, such as sleeping quarters. Outdoor-to-indoor vibration testing, which tests how the vibration changes from the soil outside to a sensitive space inside a building, would also help to refine the vibration projections at these locations. A summary of segment-specific vibration mitigation is provided below.

In Segment A, approximately 1,900 feet of vibration mitigation would be required along the Mount Baker Tunnel area to mitigate groundborne noise impacts at single-family homes along the top of the hillside. No other vibration impacts were identified in Segment A.

In Segment B, mitigation measures under *Preferred Alternative B2M* connecting to *Preferred Alternatives C11A* or *C9T* would include up to 600 feet of vibration isolation at the Winters House. Standard vibration mitigation methods, such as resilient fasteners or ballast mats, would reduce the groundborne noise level at the Winters House, but may not eliminate the impact and would be determined in final design. A floating slab might be needed to eliminate the groundborne noise impact. For *Preferred Alternative B2M* connecting to the C9T – East Main Station Design Option, the crossover at SE 8th Street would need to be relocated or special trackwork would need to be used to eliminate the gap due to the crossover. The only other vibration impact in Segment B would be with Alternative B1, where vibration mitigation would be required at one single-family residence near SE 13th Street.

In Segment C, under *Preferred Alternative C11A*, vibration mitigation would be required at two single-family residences south of Main Street, three multifamily structures along 108th Avenue NE, and the elevated structure by the Coast Bellevue Hotel. Under *Preferred Alternative C9T*, vibration mitigation would also be required at the same two single-family residences and the Coast Bellevue Hotel identified under *Preferred Alternative C11A*, along with five single-family residences near the crossover on 112th Avenue SE. These five single-family residential impacts could be eliminated by the relocation of the crossover or the use of special trackwork to eliminate the gap. *Preferred Alternative C9T* would have groundborne noise impacts at the Meydenbauer Center, a highly sensitive location, where impacts would be mitigated using ballast mats or resilient rail fasteners. For the C9T – East Main Station Design Option, the impacts and required mitigation would be identical to that described above for *Preferred Alternative C9T*, except for the five single-family residences on 112th Avenue SE, which would not have vibration impacts with this design option because the crossover would be relocated to Segment B and replaced with the East Main Station.

Vibration mitigation under Alternative C1T would be included near the tunnel portal and tunnel segment along Bellevue Way for one single-family residence, and on the elevated structure for the Coast Bellevue Hotel. Under Alternative C2T mitigation would only be required at one single-family residence south of Main Street when connecting to Alternative B2E. No other vibration or groundborne noise impacts were identified under Alternative C2T.

With Alternative C3T, the connection to Alternative B2A would require mitigation for groundborne noise at 12 single-family residences. All except one of the impacts are located on top of the tunnel south of Main Street. Under the Alternative C3T connection to Alternative B2E, one single-family residence on the south side of Main Street is identified as having groundborne noise impacts. Under the Alternative C3T connection to Alternative B2E, B3, or B7, one single-family residence near McCormick Park is identified as having groundborne noise impacts. Alternative C4A would require vibration mitigation for six multifamily residences and one single-family residence, regardless of the connection options. The multifamily impacts are along 108th and 110th Avenues NE, while the single-family impact is just south of Main Street.

With Alternative C7E no vibration or groundborne noise impacts are predicted. Alternative C8E would have vibration mitigation along the elevated guideway just north of Main Street for a hotel and multifamily residence, and again along 108th Avenue NE for two additional multifamily units. There would also be vibration mitigation north of NE 12th Street to mitigate two single-family residences with vibration impacts. Alternative C9A would require vibration mitigation for two single-family residences south of Main Street, three multifamily residences along 110th Avenue NE, and at the Coast Bellevue Hotel. Alternative C14E would also require vibration mitigation along the elevated guideway for impacts predicted at three hotels.

For *Preferred Alternatives C11A* and *C9T*, and the C9T – East Main Station Design Option, the only residual vibration impact would at the Coast Bellevue Hotel. For Alternative C4A, residual vibration impacts would include two multifamily buildings on the southbound couplet track. For Alternative C8E, residual vibration impacts would occur at the Sheraton Hotel and one multifamily building. Additional testing could be performed at these locations to determine the response of the building foundations to light rail vibration, which would likely reduce the projected vibration levels. In addition, a survey of the buildings needs to be performed to determine the specific locations of vibration sensitive uses within the structures to assess actual impacts. For Alternative C9A, there would be a residual vibration impact at two multifamily buildings and at the Coast Bellevue Hotel. For Alternative C14E, there would be a residual vibration impact at the Sheraton Hotel.

There would be no vibration or groundborne noise impacts in Segment D, and no vibration mitigation is recommended.

With *Preferred Alternative E2* and the E2 – Redmond Transit Center Design Option, an estimated 700 feet of vibration mitigation would be required along SR 520 to mitigate vibration impacts on three single-family residences. Vibration impacts and mitigation would be the same under Alternative E1 as described for *Preferred Alternative E2*. With Alternative E4, vibration mitigation would be required at one single-family residence along SR 520, a group of multifamily units off Leary Way, and the Residence Inn Hotel. For *Preferred Alternative E2*, the E2 – Redmond Transit Center Design Option, and Alternative E1, one single-family residence would be a residual impact after mitigation.

7.5.1 Potential Vibration Mitigation for Highly Sensitive Locations

The groundborne noise impact on the Meydenbauer Center from *Preferred Alternative C9T* and the C9T – East Main Station Design Option could be mitigated through the installation of ballast mats or resilient rail fasteners.

7.6 Potential Construction Noise Mitigation Measures

Sound Transit has developed a Construction Noise Mitigation Policy. Under this policy, Sound Transit would seek to limit construction noise levels and impacts and meet applicable noise regulations and ordinances. Typical mitigation measures that could be applied are discussed below, and a specific construction noise analysis will be performed with the selection of the *Preferred Alternative*. Contractors would be required to meet the criteria in city noise ordinances.

Several noise-mitigation measures can be implemented to limit construction noise impacts. Sound Transit would, as practical, limit construction activities that produce the highest noise levels during daytime hours, or when disturbance to sensitive receivers would be minimized. For operation of construction equipment that could exceed allowable noise limits during nighttime hours (between 10 p.m. and 7 a.m.) or on Sundays or legal holidays, Sound Transit would obtain the appropriate noise variance from the City of Seattle, the City of Mercer Island, the City of Bellevue, or the City or Redmond. Sound Transit would control nighttime construction noise levels by applying noise-level limits and noise-control measures where necessary. The contractor would have the flexibility of either prohibiting certain noise-generating activities during nighttime hours or providing additional noise-control measures to meet these noise limits. Noise-control mitigation might include the following measures, as necessary, to meet required noise limits:

- Install construction site sound wall by noise-sensitive receivers.
- During nighttime work, use smart back-up alarms that automatically adjusts or lowers the alarm level or tone based on the background noise level, or switch off back-up alarms and replace with spotters.
- Use low-noise emission equipment.
- Implement noise-deadening measures for truck loading and operations.
- Conduct monitoring and maintenance of equipment to meet noise limits.
- Use lined or covered storage bins, conveyors, and chutes with sound-deadening material.
- Use acoustic enclosures, shields, or shrouds for equipment and facilities.
- Install high-grade engine exhaust silencers and engine-casing sound insulation.
- Prohibit aboveground jack-hammering and impact pile driving during nighttime hours.
- Minimize the use of generators or use whisper quiet generators to power equipment.
- Limit use of public address systems.
- Use movable noise barriers at the source of the construction activity.
- Limit or avoid certain noisy activities during nighttime hours.

To mitigate noise related to pile-driving, using an augur to install the piles instead of a pile-driver would greatly reduce the noise levels. If pile-driving is necessary, then the only mitigation would be to limit the time of day the activity can occur. Pile-driving is not expected at most construction locations.

7.6.1 Segment A Construction Noise Mitigation

Construction noise mitigation for Segment A would include the mitigation measures described above. No additional noise mitigation other than those provide should be required.

7.6.2 Segment B Construction Noise Mitigation

Construction noise mitigation for Segment B would include the mitigation measures described above. No additional noise mitigation other than those provide should be required.

7.6.3 Segment C Construction Noise Mitigation

Construction noise mitigation for Segment C would include the mitigation measures described above. Because of the staging areas and tunnel portals along Bellevue Way, 112th Avenue SE, Main Street, and NE 12th Street, temporary sound walls could be constructed near tunnel staging areas to reduce noise levels at nearby residential land uses in the Surrey Downs neighborhood and near McCormick Park.

7.6.4 Segment D Construction Noise Mitigation

Construction noise mitigation for Segment D would include the mitigation measures described above. No additional noise mitigation other than those provide should be required.

7.6.5 Segment E Construction Noise Mitigation

Construction noise mitigation for Segment E would include the mitigation measures described above. Constructing the East Link route along SR 520 near 51st Street NE could move existing sound walls; every attempt should be made to replace the wall early in the project to minimize impacts on nearby residents before track construction.

7.7 Potential Construction Vibration Mitigation Measures

In general, building damage from construction vibration would only be anticipated from impact pile driving close to buildings. If piling is more than 50 to 100 feet from buildings, or if alternate methods, such as auger cast piling or drilled shafts are used, then damage from construction would not be anticipated. Other sources of construction vibration, including potential ground improvement activities in Segment B such as construction of subsurface stone columns, could generate high enough vibration levels for localized damage to occur, depending on the soil type and distance between the source of vibration and the nearest building. In any locations of concern, preconstruction surveys would be conducted to document the existing condition of buildings, in case there was an issue during or after construction, and vibration monitoring would be implemented during construction to establish levels of vibration. Where levels of vibration exceed preset limits for damage, the contractor would be required to stop work and switch to alternate construction methods.

Measures to minimize short-term annoyance from groundborne vibration and groundborne noise from construction activities such as pile installation or compaction of earth fills include use of alternate methods that result in less vibration or noise, such as auger cast piles or drilled shafts in place of driven piles, or use of static roller compactors rather than vibratory compactors. The hours and duration of these types of activities can also be restricted to hours when vibrations and noise are less noticeable. Vibration monitoring would be considered for pile driving, tunnel boring, vibratory sheet installation, and other construction activities that have the potential to cause high levels of vibration.

Sound Transit would minimize vibration at the Winters House during construction and prevent damage or limit to minor cosmetic damage by using the following methods:

- Install monitoring equipment and monitor vibration during construction.
- Place limits on the construction vibration levels for the contractor, with the contractor selecting one or more of the following measures or other measures of equivalent effectiveness to limit construction:
  - Using auger-drilling methods
  - Using low vibration or nonimpact methods of installing steel casing required to support construction of drilled shaft or secant pile foundations
  - Using slurry confinement (i.e., temporarily filling the cavity with slurry material to replace the removed soil)
  - Underpinning foundation and employing structural support or soil stabilization if needed
  - Adjusting excavation methods based on monitoring results
  - Installing a shallow temporary supporting wall
  - Monitoring vibration levels associated with equipment to be used for the East Link Project at other construction sites with similar soils before project construction to determine which vibration-minimization method would be necessary
  - Beginning vibration-inducing construction at the site at points more distant from the Winters House to enable the contractor to determine which vibration-minimization method would be necessary
- Photographing and inventorying the building to establish existing conditions to determine if any damage is caused by construction, and repair the building in a manner consistent with the U.S. Department of the Interior Secretary's standards for treating historic properties.

8.0 References

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