4.7 Noise and Vibration

4.7.1 Introduction to Resources and Regulatory Requirements

4.7.1.1 Noise and Vibration Basics

Noise

Noise is defined as unwanted sound; it is measured in terms of sound pressure level and is usually expressed in decibels (dB). The human ear is less sensitive to higher and lower frequencies than it is to midrange frequencies. To provide a measurement meaningful to humans, a weighting system was developed that reduces the sound level of higher and lower frequency sounds, similar to what the human ear does. This filtering system is used in virtually all noise ordinances. Measurements taken with this "A-weighted" filter are referred to as "dBA" readings.

There are two primary noise measurement descriptors that are used to assess noise impacts from traffic and transit projects, the Leq and the Ldn, described below:

- **Leq:** The equivalent sound level (Leq) is the level of a constant sound for a specified period of time that has the same sound energy as an actual fluctuating noise over the same period of time. The peak-hour Leq is used for all traffic and light rail noise analyses at locations with daytime use, such as schools and libraries.
- **Ldn:** The day-night sound level (Ldn) is an Leq over a 24-hour period, with 10 dBA added to nighttime sound levels (between 10 p.m. and 7 a.m.) as a penalty to account for the greater sensitivity and lower background sound levels during this time.

The Ldn is the primary noise-level descriptor for light rail noise at residential land uses. Exhibit 4.7-1 is a graph of typical Ldn noise levels and residential land use compatibility. More detail on noise and noise descriptors are provided in the Noise and Vibration Technical Report (Appendix H2).

In addition to Leq and Ldn, there is also a descriptor called the Lmax. The Lmax is the loudest 1 second over a measurement period and is used in many local and state ordinances for noise coming from private land uses and for construction impact evaluation.

Vibration

Travel of light rail trains on trackways and guideways associated with the East Link Project would result in vibration that might be felt on adjacent properties. The project was analyzed for two types of vibration impacts:

- **Groundborne vibration:** the movement of the ground (vibration can be experienced either outdoors or indoors)
- **Groundborne noise**: noise generated by the movement of room surfaces, such as walls, resulting from vibration of a building (groundborne noise can only be experienced indoors)

Groundborne vibration can be described in terms of displacement, velocity, or acceleration when evaluating impacts from transit projects. Groundborne noise occurs as a perceptible rumble and is caused by the noise radiated from the vibration of room surfaces. Vibration above certain levels can damage buildings, disrupt sensitive operations, and cause annoyance to humans within buildings.

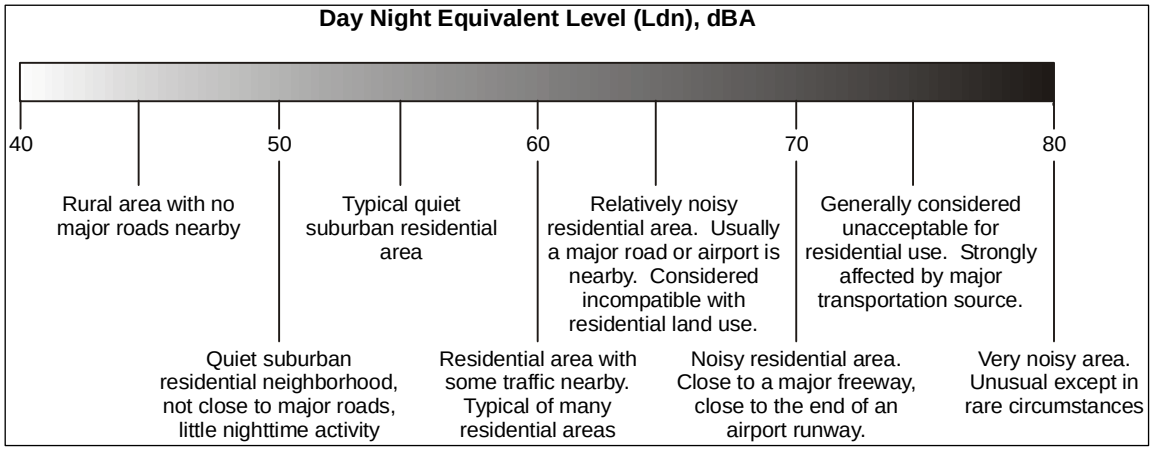


EXHIBIT 4.7-1
Typical 24-hour Ldn Noise Levels and Land Use Compatibility
Source: Federal Transit Administration, 2006

The response of humans, buildings, and equipment to vibration is most accurately described using velocity or acceleration. Vibration velocity is used in this analysis as the primary measurement to evaluate the effects of vibration.

Exhibit 4.7-2 illustrates typical groundborne vibration velocity levels for common sources as well as thresholds for human and structural response to groundborne vibration. As shown, the range of interest is from approximately 50 vibration velocity decibels (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.

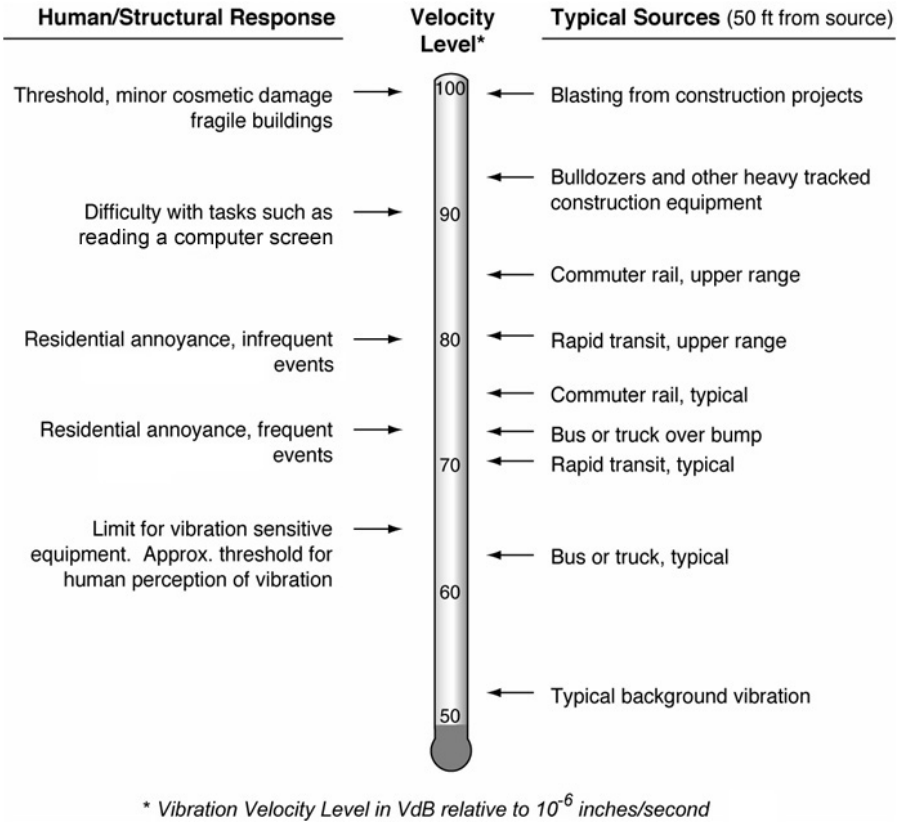


EXHIBIT 4.7-2
Examples of Groundborne Vibration Levels and Human/Structural Response
Source: Federal Transit Administration, 2006

4.7.1.2 Noise and Vibration Impact Criteria

The following sections provide an overview of the criteria used for evaluating East Link Project noise and vibration impacts, which are defined by the Federal Transit Administration (FTA) for transit-related noise and vibration and by the Federal Highway Administration (FHWA) for traffic-related noise. The FTA and FHWA analyses are performed based on actual land use, not land use zoning. Therefore, if a residence is located in an area that has been zoned commercial, the analysis still considers that location to be a residential land use.

Transit Noise Criteria

Noise impacts for the East Link Project are based on the criteria defined in the FTA guidance manual *Transit Noise and Vibration Impact Assessment* (2006). The FTA noise impact criteria are founded on well-documented research of community reaction to noise and are based on changes in noise levels 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.

FTA's noise impact criteria are grouped into the following noise-sensitive land use categories:

- **Category 1**: Buildings or parks where quiet is an essential element of their purpose
- **Category 2**: Residences and buildings where people normally sleep, including residences, hospitals, and hotels where nighttime sensitivity is assumed to be important
- **Category 3**: Institutional land uses with primarily daytime and evening use, including 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; the interpretation of these two levels of impact is summarized below:

- **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 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 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 predicted 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.

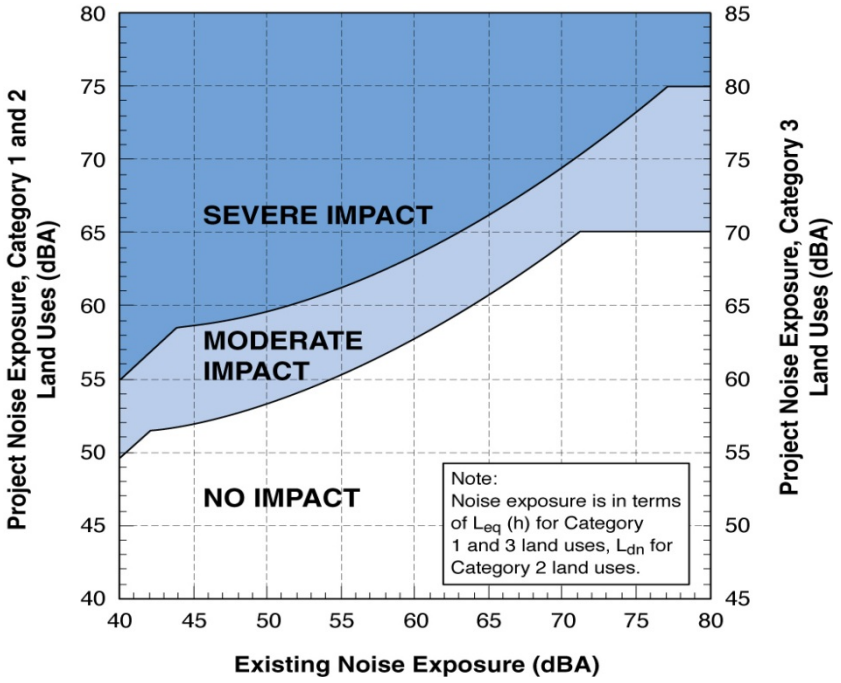


EXHIBIT 4.7-3
FTA Project Noise Impact Criteria
Source: Federal Transit Administration, 2006

Exhibit 4.7-3 depicts the noise impact criteria, as well as the existing noise exposure and the additional noise exposure from a transit project that would cause either moderate or severe impacts. The future noise exposure is determined by combining the existing noise exposure and the additional noise exposure caused by a transit project.

Parks are considered a special case under the FTA criteria. Whether a park is considered noise-sensitive is dependent on the typical use of the park. Parks that are primarily used for recreational activities or sporting events, such as football, baseball, soccer, and other active sports and recreation, are not considered noise-sensitive. Parks that are primarily used for passive activities, such as reading, conversation, and meditation, in contrast, could be considered noise-sensitive, but only those parks with low existing noise levels.

Parks along the proposed corridor were reviewed for use, existing noise levels, and proximity to major noise sources, such as highways and major arterial roadways. Each of these was considered when evaluating the parks and making the determination of the noise sensitivity of the park. In general, parks used for sporting activities or located near highways or major arterial roadways are not considered noise-sensitive.

Traffic Noise Criteria

The criteria for traffic noise impacts are taken from the FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, Title 23, Code of Federal Regulation (CFR) Subchapter H, Section 772 (1982). Table 4.7-1 lists the traffic noise abatement criteria. A noise impact occurs if predicted noise levels approach the levels for specific land use categories listed in Table 4.7-1 or substantially exceed existing noise levels, as defined by the Washington State Department of Transportation (WSDOT). According to these regulations, only projects that include construction of new highway, reconstruction of existing highways with a substantial change in the horizontal alignment or vertical profile, or an increase in the number of through traffic lanes require a traffic noise analysis. If impacts are identified, then noise abatement must be considered. WSDOT is responsible for implementing FHWA regulations in Washington. Under WSDOT policy, a traffic-noise impact occurs if predicted noise levels are within 1 dB of the FHWA criteria shown in Table 4.7-1; therefore, a residential impact occurs at 66 dBA Leq, and a commercial impact occurs at 71 dBA Leq.

WSDOT considers a 10-dB increase in noise to be a substantial impact, regardless of the original noise level.

TABLE 4.7-1
FHWA Traffic Noise Abatement Criteria

Land Use Category		Hourly Leq
Type A	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose	57 dBA (exterior)
Type B	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals	67 dBA (exterior)
Type C	Developed lands, properties or activities not included in the above categories	72 dBA (exterior)
Type D	Undeveloped land	—
Type E	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums	52 dBA (interior)

Source: FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise (23 CFR 772)

WSDOT policy states that reducing the distance between a noise-sensitive property and traffic lanes by half (or increasing the noise level by 3 dBA) constitutes a substantial change in the horizontal alignment or vertical profile of a roadway, and therefore would also require a traffic noise analysis.

Transit Vibration Criteria

FTA's groundborne vibration impact criteria are based on existing land use and planned train frequencies. Table 4.7-2 shows the criteria for a general vibration assessment. 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 very sensitive to vibration but do not fit into any of the three categories listed in Table 4.7-2. Due to their sensitivity, these buildings usually warrant special attention during the vibration analysis.

Within the project corridor, these buildings include the theater at Meydenbauer Center, Bellevue Arts Museum, Overlake Hospital Magnetic Resonance Imaging (MRI) Unit, Overlake Hospital Optical Surgery Unit, Group Health Medical Center, and Children's Hospital Bellevue Clinic and Surgery Center (BCSC). Based on consultation with these facilities, the existing sensitive uses have been identified at the locations described below.

The following criteria apply for these locations:

- Theater at Meydenbauer Center and Bellevue Arts Museum: 72VdB for vibration, 35 dBA for groundborne noise.
- MRI Units at Overlake Hospital, Group Health Medical Center, and Children's Hospital BCSC: 60 VdB for vibration, no criterion for groundborne noise because vibration-sensitive equipment is not sensitive to groundborne noise.

TABLE 4.7-2
Groundborne Vibration and Noise Impact Criteria for Light Rail Transit Service Frequency

Land Use Category	Groundborne Vibration Impact Levels (VdB re 1 micro inch/second): Frequent Events	Groundborne Noise Impact Levels (dB re 20 micro Pascals): Frequent Events
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB[a]	N/A[b]
Category 2: Residences and buildings where people normally sleep	72 VdB	35 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	40 dBA

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

[b] Vibration-sensitive equipment is generally not sensitive to groundborne noise.
VdB vibration velocity decibels

- Overlake Hospital Optical Surgery Unit: 54 VdB for vibration, no criterion for groundborne noise because vibration-sensitive equipment is not sensitive to groundborne noise.

Table 4.7-2 includes separate FTA criteria for groundborne noise—the "rumble" that can radiate 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 lower than they are for airborne noise to account for the annoying low-frequency character of groundborne noise. Because airborne noise often masks groundborne noise for aboveground transit systems (i.e., at-grade or elevated), groundborne noise criteria are primarily applied to light rail operations in a tunnel 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.

Washington State Noise Criteria

The State of Washington has a noise control ordinance that applies (together with local noise regulations) to general construction activities, park-and-rides, and maintenance facilities. The Washington State Noise Control Ordinance (WAC 173-60) 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 and the maximum noise levels allowable for each (Table 4.7-3). For example, the noise caused by a commercial property must be less than 57 dBA at the closest residential property line. Between 10 p.m. and 7 a.m., the maximum allowable levels shown in Table 4.7-3 are reduced by a 10-dBA "penalty."

In addition to the property line noise standards, there are exemptions for short-term noise exceedance based on the minutes per hour that the noise limit is exceeded (Table 4.7-4). Local noise limits for construction equipment and specific exceedance exemptions are discussed in Section 4.7.3.5, Impacts during Construction.

TABLE 4.7-3
Washington State Noise Limits

Property Usage	Maximum Allowable Sound Level (dBA)		
	Residential	Commercial	Industrial
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

Source: WAC Chapter 173-60-040.

TABLE 4.7-4
Washington State Short-Term Noise Exceedance Exemptions

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

Source: WAC Chapter 173-60-040.

Local Noise Ordinances and Regulations

Because the East Link Project covers several cities, including Seattle, Mercer Island, Bellevue, and Redmond, several additional local noise ordinances are applicable to construction activities, park-and-rides, maintenance facilities, and other ancillary project-related facilities. Most of the cities in the corridor have adopted noise control ordinances similar to WAC 173-60. However, local noise ordinances can include different provisions from the State law. For example, Bellevue applies its exemption for construction noise more stringently, with fewer evening and weekend hours considered exempt. Mercer Island has a noise nuisance code, which would not be applicable to the project, and the WAC 173-60 would govern construction noise. The City of Seattle has a Noise Control Ordinance that is also similar to the WAC 173-60 for ancillary facilities; however, Seattle has an updated section that is specifically for construction that would be applicable to project construction in Segment A. Summaries of the applicable noise regulations for each city are provided in Appendix H2.

4.7.1.3 Methodology

The light rail noise and vibration analysis was performed in accordance with FTA's *Transit Noise and Vibration Guidance Manual* (revised May 2006). An FTA screening level analysis was performed during the initial alternative screening. The noise and vibration analysis that follows was performed using current

conceptual project design files and follows the detailed analysis methods described in the FTA manual.

Light rail noise and vibration impacts were evaluated using measured noise and vibration levels from Sound Transit's fleet of light rail vehicles. Detailed noise and vibration prediction models were developed using the methods given in the FTA manual. Input to the models is described in Sections 4.7.3.1 and 4.7.3.2. Locations identified with noise or vibration impacts are considered for noise abatement or vibration reduction options.

A traffic noise analysis was also performed for those locations where project construction would require a substantial movement of the horizontal alignment or vertical profile of existing roadways. Traffic noise levels were projected using FHWA's Traffic Noise Model (TNM) and following the FHWA methods for predicting traffic noise levels. Traffic noise impacts were identified using the WSDOT traffic noise abatement criteria.

4.7.2 Affected Environment

This section summarizes land uses along the project corridor, as well as existing noise and vibration levels measured for the East Link analysis. Exhibits 4.7-4 and 4.7-5 show where existing noise and vibration were measured. More detailed maps showing the locations of the noise-monitoring sites and planned land uses are provided in Appendix H2.

4.7.2.1 Noise- and Vibration-Sensitive Land Uses

While a more detailed presentation of land use can be found in Section 4.3, Land Use, of this Final 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 MRI equipment in a hospital), which is not sensitive to noise. It is important to note that the noise and vibration analysis is based on existing land use and not zoning. For example, if a residence is legally located in an area that was rezoned for commercial use, the property would still be considered as a residence for the analysis.

For most of the project corridor, land use and zoning appear to match. Areas that are in transition include the southern end of Downtown Bellevue, the area near Lake Bellevue, and some areas along the former BNSF Railway corridor in Redmond. Other areas where land use is planned to change in the future based on current zoning include the Bel-Red corridor and the Overlake neighborhood. Long-term monitoring locations were measured for 24 hours, while short-term monitoring locations were measured for 20 minutes. Table 4.7-5 summarizes the noise levels at these monitoring locations as measured in February and March 2007, March 2009, September and October 2010, and February 2011. A discussion of land use and noise levels by segment is given below.

Segment A

Land use near the connection to the existing Downtown Seattle transit tunnel is mainly commercial; however, there are multifamily residences on the upper floors of Uwajimaya Village at 6th Avenue South and South Lane Street, where the route is in the transit tunnel. The route continues eastbound along the D2 Roadway, remaining in the existing Interstate 90 (I-90) corridor to the Mount Baker Ridge Tunnel. Land use along this section of Segment A is mainly commercial until it reaches 12th Avenue South, where there is a large group of single- and multifamily residences. The route then transitions from the tunnel to the floating bridge through an area that is primarily single-family residential.

Land use along Mercer Island is primarily single-family residential with multifamily apartment buildings near the Mercer Island Station. At the east side of Mercer Island, land use is primarily single-family residential with some office buildings south of the highway.

Judkins Park and Playfield is located near the entrance to the Mount Baker Ridge Tunnel. Other parks in Segment A include Taejon 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.

Five locations were monitored in Segment A, one long term and four short term. Existing noise levels along Segment A are dominated by traffic noise from area highways, including Interstate 5 (I-5), I-90, and major arterial roadways. The measured existing Ldn near Segment A in the Seattle area was 69 dBA. Peak-hour noise levels measured at two different representative locations between 4 p.m. and 5 p.m. were 68 dBA Leq. This noise level is typical for sites near major highways and transportation corridors. Noise levels measured at three sites on Mercer Island ranged from 54 to 65 dBA Ldn.

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

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

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

Source: Data from City of Bellevue (2005) and King County (2006).

Exhibit 4.7-5 **Noise and Vibration Monitoring Locations Segments D and E**
East Link Project

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

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

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

Source: Data from City of Bellevue (2005) and King County (2006).

Exhibit 4.7-4 **Noise and Vibration Monitoring Locations Segments A, B, and C**
East Link Project

TABLE 4.7-5
Existing Conditions Noise Monitoring Summary

Monitoring Location[a]	Site Address	Land Use Type	Type of Measurement	Leq (dBA)	Ldn (dBA)
Segment A					
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
Segment B					
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
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	1354 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
Segment C					
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[b]	Hotel	Long-term	59	62

TABLE 4.7-5 CONTINUED
Existing Conditions Noise Monitoring Summary

Monitoring Location[a]	Site Address	Land Use Type	Type of Measurement	Leq (dBA)	Ldn (dBA)
MC-18	112th Avenue SE at SE at SE 6th Street[c]	N/A	Long-term	62	64
MC-19	Lake Bellevue Village Condominiums, Building 7, Unit 112	Multifamily	Long-term	55	58
Segment D					
MD-1	1815 116th Avenue NE	Single-family	Long-term	58	58
MD-2	Near Highland Park (trail 50 feet from NE 20th Street)	Park	Short-term	65	65
MD-3	152nd Avenue NE, 550 feet north of NE 26th Street	Commercial	Short-term	64	65
MD-4	Overlake Assisted Living Center	Commercial	Short-term	64	65
MD-5	Near Microsoft Building 44	Mixed-use	Short-term	70	71
MD-6	13440 NE 16th St	Mixed-use	Short-term	56	56
Segment E					
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 Exhibits 4.7-4 and 4.7-5

[b] This site was near the tennis courts, which is below grade and well shielded from traffic noise on 112th Avenue SE and SE 6th Street.

[c] This site was near the Bellevue Club Hotel, approximately 75 feet from 112th Avenue SE with some shielding.

Segment B

Land use along 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. Land use along Bellevue Way is primarily residential from I-90 to Downtown Bellevue, although there are several churches and some commercial structures north of its intersection with 112th Avenue SE.

Major sources of noise in Segment B include traffic noise from I-90, I-405, Bellevue Way SE, and 112th Avenue SE. Mercer Slough Nature Park and Winters House, a historic structure used for nonresidential uses, are both located along the east side of Bellevue Way SE. The parts 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, and therefore are not considered noise-sensitive under FTA criteria. Land use along the west side of the 112th Avenue SE is entirely single- and multifamily residential, with commercial use on the east side transitioning to mixed commercial and hotel use from SE 8th Street to the boundary with Segment C.

Land use along the BNSF Alternative (B7) includes Mercer Slough Nature Park, multifamily residences, and commercial land use.

The only parklands in Segment B considered noise-sensitive under the FTA criteria are interior portions of Mercer Slough Nature Park; these parts of the park are 350 feet or more from the proposed alternatives. The portions of Mercer Slough Nature Park adjacent to the project are already dominated by traffic noise from Bellevue Way, I-90, and I-405.

Noise monitoring was conducted at 20 sites, 7 of which were long-term sites. Overall peak-hour noise levels in south Bellevue ranged from 50 to 72 dBA Leq. Maximum noise levels between I-90 and 112th Avenue SE ranged from 67 to 80 dBA Lmax, with an average of 74 dBA Lmax. North of the intersection of Bellevue Way SE and 112th Avenue SE, maximum noise levels on Bellevue Way or along 112th Avenue SE and vicinity ranged from 75 to over 96 dBA Lmax. The highest noise levels were measured at locations near I-90 and along Bellevue Way SE and 112th Avenue SE. Along the residential areas on Bellevue Way and 112th Avenue SE, noise levels are typical of those that would be expected to occur in a busy urban area near transportation corridors.

Segment C

Land use in the southern section of Segment C includes Surrey Downs Park and the Surrey Downs residential area, which transitions to commercial and office uses around Main Street. Surrey Downs Park is an active park with playfields, located along 112th Avenue SE, a major arterial roadway, and therefore is not considered noise-sensitive. Hotels and office parks are also present along the east side of 112th Avenue SE in this segment. Along Bellevue Way, north of the intersection with 112th Avenue SE under Bellevue Way Alternative (B1), land use is mainly single- and multifamily residential, and also includes the Bellevue Fire Department, churches, and some commercial uses. The commercial core of Downtown Bellevue is located on Bellevue Way between NE 4th Street and NE 8th Street, and includes several large shopping centers and office towers. There are some mixed-use buildings in Downtown Bellevue with commercial use on the ground floor and residential units on the upper floors. Other noise-sensitive properties in this area include the theater at Meydenbauer Convention Center and the Bellevue Regional Library. Parks along the downtown segment of the corridor include the Pocket Parks at NE 2nd Place and 110th Avenue NE, McCormick Park, and the Ashwood Playfield just west of the Bellevue Regional Library. The parks in this area do not have noise-sensitive uses and are near major arterial roadways and therefore are not considered noise-sensitive by the FTA. In addition, single-family residential land uses were identified along the northern edge of Downtown Bellevue, north of NE 12th Street. Sensitive land uses east of I-405 include Overlake Hospital, a broad range of nearby medical offices, and the Group Health medical building. There is also a multifamily residential area at the north end of Lake Bellevue, south of NE 12th Street.

Nineteen locations were monitored in Segment C: ten short-term and nine long-term. Peak-hour noise levels ranged from 55 dBA Leq in quiet areas away from major arterial roads to 75 dBA Leq near the Bellevue Hilton Hotel between 112th Avenue SE and I-405. 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.

Along 112th Avenue, north of Surrey Downs Park, noise levels are dominated by local traffic and vehicles on I-405. Measured 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 located 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 80s 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.

Segment D

Land use in Segment D is mainly commercial and light industrial, including retail, distribution facilities, and office spaces, which are generally not noise-sensitive. The only noise-sensitive land uses are the Children's Hospital BCSC on 116th Avenue NE, the Pacific Northwest School on NE 16th Street, and several single- and multifamily residences along 116th Avenue NE and on the south side of SR 520. The Overlake area is predominantly office parks and commercial land uses. Major sources of noise in this segment include traffic noise from SR 520 and major arterials, such as Bel-Red Road.

Six locations were monitored in Segment D: one long-term site and five short-term sites. The long-term site was at a residential area along 116th Avenue NE, near the 116th Maintenance Facility Alternative (MF1). The Ldn at residences along 116th Avenue NE was measured at 58 dBA. A short-term site was located near Highland Park, where the Leq and estimated Ldn were 65 dBA. Three short-term sites were located near the Overlake area, including one near the former Group Health Campus, one at the Overlake Assisted Living Center, and one near Microsoft. Estimated Ldn at these sites ranged from 65 to 71 dBA, 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 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 caused by truck traffic.

Segment E

Segment E begins in the commercial area at NE 40th Street and is adjacent to SR 520 and office parks until NE 51st Street. 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 use changes to multifamily residential, park, and commercial south of Downtown Redmond. Other land uses 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. Land use in the Downtown Redmond area varies but is mainly commercial and retail, with some mixed-use buildings that have residential use on upper floors. Major sources of noise in this segment include traffic noise from SR 520 and major arterials, such as West Lake Sammamish Parkway and SR 202.

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.

4.7.2.2 Vibration Measurements

Vibration measurement test sites were selected based on a review of aerial photographs, 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, vibration measurements focused on characterizing the vibration propagation through the ground at representative locations in the project vicinity. This information was used as input for the analysis model. Eight sites, designated as Sites V-1 through V-8, were selected to represent a range of soil conditions near residences and other sensitive land uses along the rail corridor (Exhibits 4.7-4 and 4.7-5). Measurements were conducted at sites in Seattle, Bellevue, and Redmond in March 2007. A refined vibration analysis added six more sites, designated as Sites V-9 through V-14, which were selected to measure both soil conditions and building response at specific locations. Measurements were conducted in Bellevue during May 2010. Appendix H2 provides more detail.

4.7.3 Environmental Impacts

This section summarizes the models used to predict future noise and vibration levels and identifies where levels are predicted to exceed accepted criteria, causing an impact. These sources include light rail operation, changes in traffic due to the project, and construction activities. The projection models for these sources are described below. More detailed information is provided in Appendix H2.

Sound Transit has begun service on the Central Link light rail system in Seattle, which allows for operational noise monitoring that was not available at the time the 2008 Draft EIS was published. Noise measurements of actual train operations on Central Link allow more accurate noise modeling for future light rail conditions. This information, together with further design development, results in a more detailed noise impact analysis. New information includes updated reference noise levels from the existing fleet of light rail vehicles; locations of track crossovers; light rail operational characteristics for at-grade crossings, including train-mounted warning bells and gated crossing bells; and the effectiveness of lubrication to control wheel squeal.

4.7.3.1 Project Assumptions for Noise Analysis

Noise from East Link operations was modeled using the methods described in FTA's *Transit Noise and Vibration Assessment Manual* (2006). Input to the model included the following assumptions:

- Light rail train headways and speeds as described in Appendix E, Operating Plan Summary. The speeds depend on location, track type, and curvature, with a maximum operating speed of 55 miles per hour (mph). Measured reference

noise levels for Sound Transit's new state-of-the-art, light rail vehicles equipped with wheel skirts. The reference measurements were taken along the ballast and tie segment of the Central Link Initial Segment in south Seattle in March 2010. The projected Ldn and Lmax assuming a train speed of 50 mph are shown in Appendix H2. Typical noise levels from a light rail pass-by range from 78 to 79 dBA at 50 feet at 40 mph. In comparison, a typical diesel bus produces 82 to 84 dBA Lmax at 50 feet at 40 mph.

- Elevations of sensitive properties and any shielding or other topographical features that could affect noise transmission.
- Plan, profile, and track type of all proposed East Link alternatives and design options. Track types that could be used under the different alternatives include at-grade with ballast and tie or embedded track, and direct fixation track types used for retained cut, retained fill, and elevated track sections. Special track work includes the locations of crossovers, where noise levels could increase as train wheel impact occurs when the train travels over a gap in the rail. For this analysis, measured increases in the light rail pass-by at crossovers was taken from the embedded crossovers along Martin Luther King Jr. Way South in Seattle.
- Noise levels associated with at-grade crossings, including the train-mounted and warning bells that would be used at crossings where gates would be required. The train-mounted bells were measured and validated in October 2009, with several supplemental measurements taken over the last 2 years. Under Sound Transit policy, train-mounted bells would be sounded as a train enters and exits a station and one to three times as it approaches and passes through an at-grade crossing. Train-mounted bells would produce maximum noise levels of 80 dBA Lmax at 50 feet between 6:00 a.m. and 10:00 p.m., reducing to 72 dBA Lmax between 10:00 p.m. and 6:00 a.m. For gated at-grade crossings, the warning bells mounted on the gates would sound as gates are lowered and raised; these bell volumes are adjustable but are typically set to 75 to 85 dBA Lmax at 10 feet near residential properties. For this analysis, the bell volume was conservatively assumed at 85 dBA and the bells were assumed to sound for approximately 25 seconds per train (10 to 13 seconds while rising and 10 to 13 seconds while lowering). Note that the train would also sound the bell as it travels to and through the crossing. As shown on Exhibit 4.7-6, noise levels from the warning bells would reduce at approximately 6 dB per doubling of distance. For example, a noise level of 80 dBA at 50 feet would reduce to 74 dBA at 100 feet.
- 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 upon the change in the noise level 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 trackway unless the trackway 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*. The FTA noise assessment methodology was also applied to the park-and-rides and maintenance facilities, which are analyzed as stationary transit facilities.

All ancillary facilities would be analyzed using any applicable local noise ordinance or regulations. Therefore, all transit maintenance facilities and park-and-rides must meet the local noise ordinances. This means that the three maintenance base alternatives south of SR 520 in Bellevue and the proposed park-and-ride options would be required to meet the City of Bellevue noise ordinance. In addition, the maintenance base and park-and-rides in Redmond would be required to meet the City of Redmond noise control ordinance.

Traffic noise was evaluated where required by FTA and FHWA. Traffic noise was analyzed using the FHWA methods provided in the *Traffic Noise Abatement Policy and Procedures* (WSDOT, 2006). In accordance with FHWA policy, traffic noise was evaluated for specific locations, meeting the criteria described in Section 4.7.1.2.

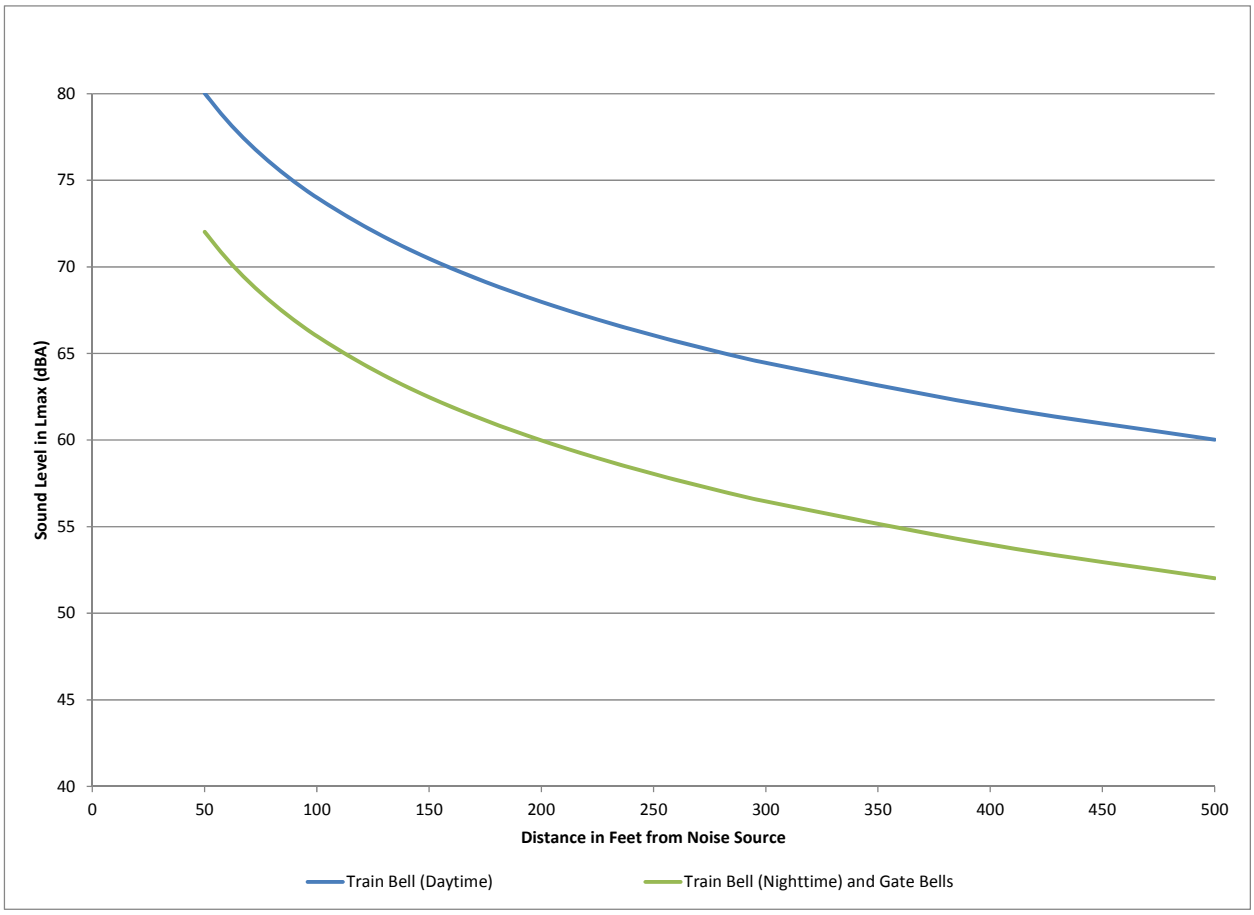


EXHIBIT 4.7-6
Noise Level Reduction with Distance (train bells and warning gate bells)

4.7.3.2 Project Assumptions for Vibration Analysis

Projections of groundborne vibration from East Link operations were based on the following assumptions:

- Vibration source levels were based on measurement data for the Sound Transit new light rail vehicles, as measured by Wilson Ihrig & Associates, Inc. (2007).
- Vibration propagation tests were conducted at representative sites along the corridor near sensitive receptors, as described in Section 4.7.2.2. The results of these tests were combined with the vehicle vibration source-level measurement data to provide projections of vibration levels from vehicles operating on the East Link Project alternatives.
- Light rail train headways and speeds are as described in Appendix E, Operating Plan Summary. The speeds are dependent on location, with a maximum operating speed of 55 mph.
- Wheel impacts at turnouts and crossovers typically cause localized vibration increases of 10 VdB.

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, as described in detail in previous sections. The FTA impact threshold for residential vibration is 72 VdB and the impact threshold for residential groundborne noise is 35 dBA, as presented in Table 4.7-2.

4.7.3.3 No Build Alternative

Under the No Build Alternative, there would be no project-related noise or vibration impacts. However, there are areas in the project vicinity where existing and future traffic noise levels would exceed the WSDOT criteria for traffic noise.

4.7.3.4 Impacts during Operations

Light Rail and Traffic Noise Impacts

The following sections present project-related light rail and traffic noise impacts before mitigation. Table 4.7-6 summarizes the noise impacts for the different alternatives, and the general locations of these impacts are shown in Exhibits 4.7-7 through 4.7-11. All noise impacts identified are discussed in this section by segment. Additional information about these impacts is provided in Appendix H2.

Potential impacts on wildlife would be construction-related only and are discussed in Section 4.8, Ecosystems Resources. The parks along the proposed alternatives were reviewed for sensitivity to noise, proximity to the alternative, and the potential for noise impacts. 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 are several hundred feet from the project alternatives, highways, and major arterial roadways. The distance to these areas, and the existing shielding from structures and/or dense vegetation, are sufficient to reduce project noise to below the existing levels. All other park areas along the alternatives do not have noise-sensitive uses and are near major highway or arterial roadways, including I-90, SR 520, Bellevue Way SE, 112th Ave SE, NE 12th Street, and other major roadways, and therefore are not considered noise-sensitive under FTA criteria.

All proposed park-and-rides are at existing park-and-ride lot locations or in well-established transportation corridors that are not near noise-sensitive properties. The one exception to this is the proposed park-and-ride lot at the South Bellevue Station. While this park-and-ride lot would be located at the existing South Bellevue Park-and-Ride Lot, there are noise-sensitive properties nearby (i.e., homes to the west across Bellevue Way SE). In the sections that follow, park-and-ride lots are discussed briefly with the *Preferred Alternatives*. A more general discussion of the park-and-rides is provided at the end of each segment discussion.

Segment A

In Segment A, *Preferred Interstate 90 Alternative (A1)* is in the center of I-90 for most areas where there are noise-sensitive properties; therefore, no wayside noise impacts from light rail operations were identified. However, installing light rail on the I-90 floating bridge would require movable rail joints at the existing bridge expansion joints located at each end of the floating bridge structure, which could create added noise. There are no existing joints like the one currently proposed in a location that could be measured for noise levels. Based on the current evaluations, noise levels at a single home could meet the FTA criteria, with a predicted level of 63 dBA Ldn, when a worst-case noise impact from the movable rail joint is included in the analysis. If this impact occurred, it could be mitigated with sound walls near the joints. Sound Transit is currently constructing a prototype of the movable rail joint for testing purposes and will include measuring actual noise levels from the joint. Additional noise analysis 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 are four other standard crossovers in Segment A: one west of the Mount Baker Ridge Tunnel in Seattle, two on the floating bridge structure (between the two expansion joints), and another on Mercer Island near the Shorewood Drive overpass. The crossover near the tunnel is shielded from nearby residences and park areas by traffic safety barriers and was not predicted to increase noise levels in that area. The western crossover on the floating bridge structure is over 350 feet from any residence, while the eastern crossover is shielded from residences by the structure and traffic safety barriers.

The crossover on Mercer Island is located in an area that is well shielded from residences in a depressed segment of the highway, and therefore no noise impacts were predicted.

There are no new park-and-ride lots or maintenance bases in Segment A, and the new stations are along I-90. Therefore, there would be no noise-related impacts from ancillary facilities in Segment A.

Although there are several parks in Segment A, the parks are not considered noise-sensitive under the FTA criteria, or the parks are well shielded from the alternative and therefore would not be impacted by light rail operations. No other noise impacts from East Link operations or traffic are expected on any adjacent sensitive land uses in Segment A.

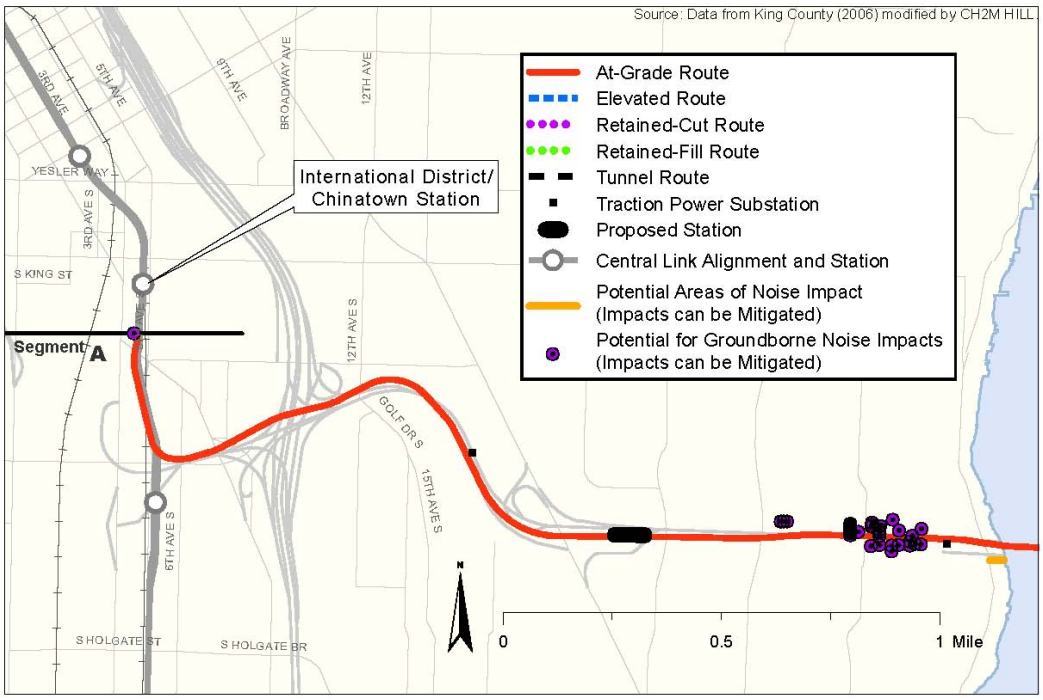


EXHIBIT 4.7-7
Noise and Vibration Impacts, Segment A
Preferred Alternative A1

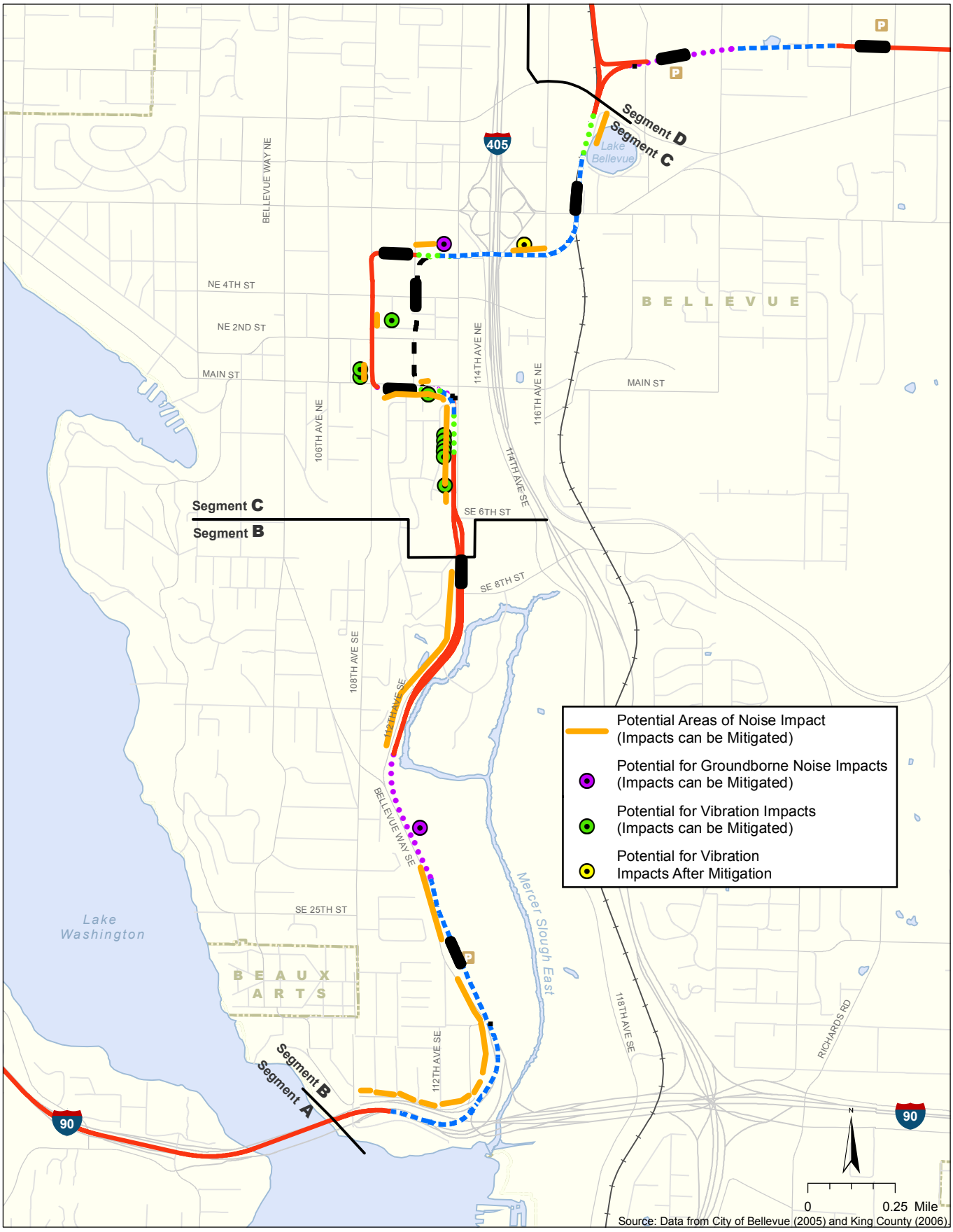
TABLE 4.7-6
Summary of Potential Noise Impacts

Alternative	Connection Alternatives	Light Rail Impacts[a]		Traffic Noise Impacts[b]	Proposed Mitigation
		Moderate	Severe		
Segment A					
Preferred Interstate 90 Alternative (A1)	N/A	1	0	0	Impact due to light rail expansion joint will be reviewed during final design; sound wall if necessary
Segment B					
Preferred 112th SE Modified Alternative (B2M)	*Preferred C11A*	79	0	0	Sound walls, special trackwork, and building insulation
	Preferred C9T	66			
	C9T - East Main Station Design Option	64	2		
Bellevue Way Alternative (B1)[c]	N/A	128	4	136	Special trackwork and building insulation
112th SE At-Grade Alternative (B2A)[d]	N/A	77	1	17	Sound walls, special trackwork, and building insulation
112th SE Elevated Alternative (B2E)	N/A	85	21	0	Sound walls, special trackwork, and building insulation
112th SE Bypass Alternative (B3)[e]	N/A	79	4	17	Sound walls, special trackwork, and building insulation
B3 – 114th Extension Design Option[e]	N/A	76	1	17	Sound walls, special trackwork, and building insulation
BNSF Alternative (B7)	N/A	108	68	0	Sound walls and special trackwork
Segment C					
Preferred 108th NE At-Grade Alternative (C11A)	*B2M*	119	65	0	Sound walls, special trackwork, and building insulation
	B3, B3 – 114th Design Option, or B7	152	52		
Preferred 110th NE Tunnel Alternative (C9T)	*B2M*	62	57	0	Sound walls, special trackwork, and building insulation
	B3, B3 – 114th Design Option, or B7	88	52		

TABLE 4.7-6 CONTINUED
Summary of Potential Noise Impacts

Alternative	Connection Alternatives	Light Rail Impacts[a]		Traffic Noise Impacts[b]	Proposed Mitigation
		Moderate	Severe		
C9T – East Main Station Design Option	*B2M*	67	52	0	Sound walls, special trackwork, and building insulation
Bellevue Way Tunnel Alternative (C1T)[f]	B1	48	52	18	Sound walls, special trackwork, and building insulation
106th NE Tunnel Alternative (C2T)	B2A	48	52	0	Sound walls, special trackwork, and building insulation
	B2E	113	66		
	B3 or B7	66	70		
108th NE Tunnel Alternative (C3T)	B2A	26	0	0	Sound walls
	B2E	91	14		Sound walls and special trackwork
	B3 or B7	44	18		Sound walls
Couplet Alternative (C4A)	B2A or B2E	435	15	0	Sound walls, special trackwork, and building insulation
	B3 or B7	420	19		Sound walls and building insulation
112th NE Elevated Alternative (C7E)	B2A or B2E	270	12	0	Sound walls and special trackwork
	B3 or B7	208	0		Sound walls
110th NE Elevated Alternative (C8E)	B3 or B7	353	72	0	Sound walls
110th NE At-Grade Alternative (C9A)	B2A	185	56	0	Sound walls, special trackwork, and building insulation
	B3, B3 – 114th Design Option, or B7	145	54		
114th NE Elevated Alternative (C14E)	B3, B3 – 114th Design Option, or B7	36	112	0	Sound walls and special trackwork
Segment D					
Preferred NE 16th At-Grade Alternative (D2A)[g]	*Preferred C11A* or *C9T,* C9A, or C14E	0	0	0	None
NE 16th Elevated Alternative (D2E)	C3T, C4A, C7E, or C8E	2	0	0	Sound wall and potential building insulation
	C1T or C2T	1	0	0	Sound wall and potential building insulation
NE 20th Alternative (D3)	C3T, C4A, C7E, or C8E	1	0	0	Sound wall
	C1T or C2T	0	0	0	None
SR 520 Alternative (D5)	C3T, C4A, C7E, or C8E	1	10	0	Sound wall
	C1T or C2T	0	10	0	Sound wall
Segment E					
Preferred Marymoor Alternative (E2)	All Segment D alternatives	33	148	0	Sound wall, building insulation, and special trackwork
E2 - Redmond Transit Center Design Option	All Segment D alternatives	81	100	0	Sound wall, building insulation, and special trackwork
Redmond Way Alternative (E1)	All Segment D alternatives	167	150	0	Sound wall, building insulation, and special trackwork
Leary Way Alternative (E4)	All Segment D alternatives	66	32	0	Sound wall, building insulation, and special trackwork

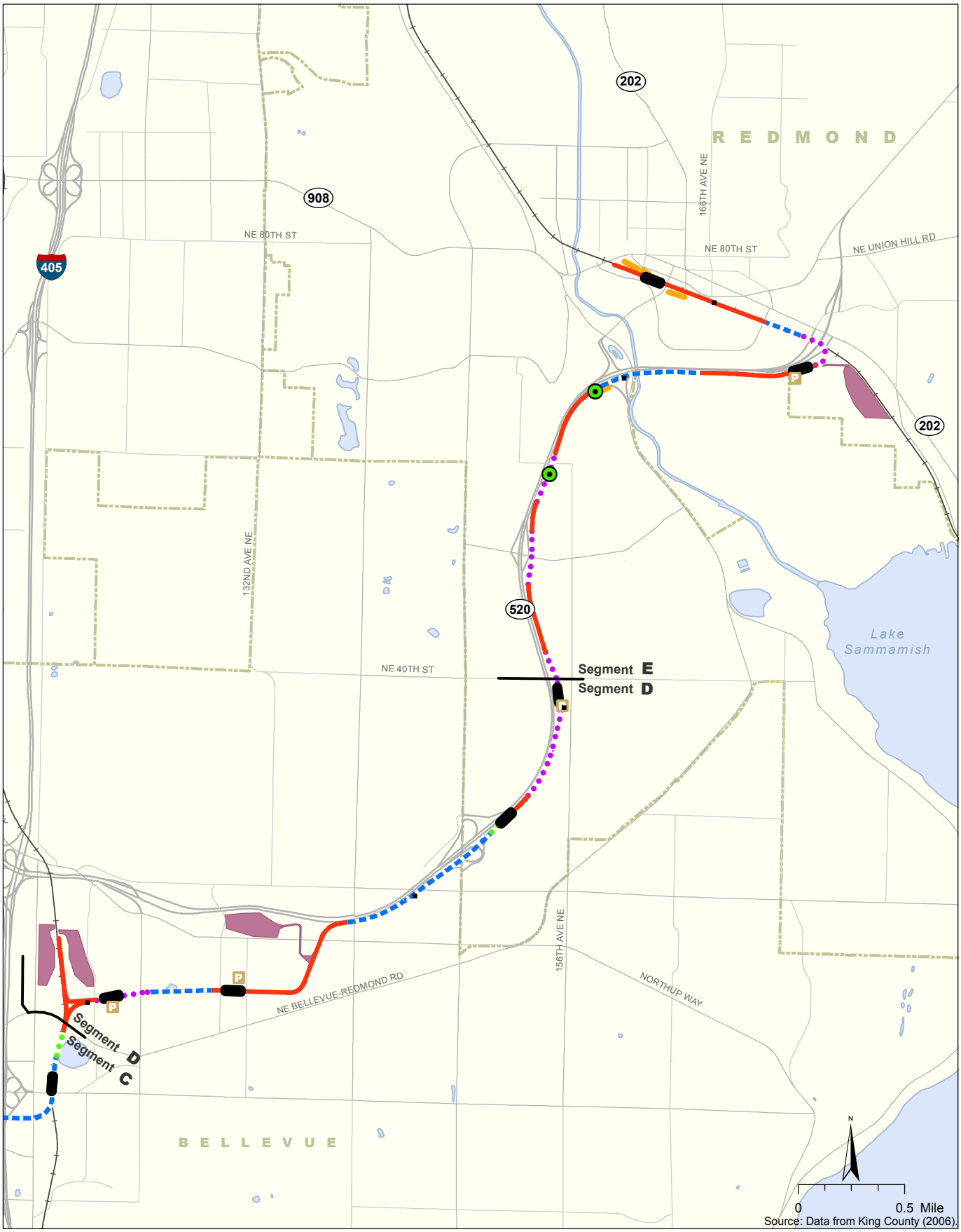
[a] Moderate and severe noise impacts using the FTA noise impact criteria
[b] Traffic noise impacts based on the FHWA 66 dBA Leq impact criteria.
[c] Under Alternative B1 all but nine of the traffic noise impacts would also have light rail noise impacts; conversely, there are only five light rail impacts 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.
[d] 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.
[e] 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.
[f] 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.
[g] Impacts for D2A - 120th Station and NE 24th Design Options would not vary from those of *Preferred Alternative D2A*.



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

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

Exhibit 4.7-8
Noise and Vibration Impacts, Segments B and C Preferred Alternative
East Link Project

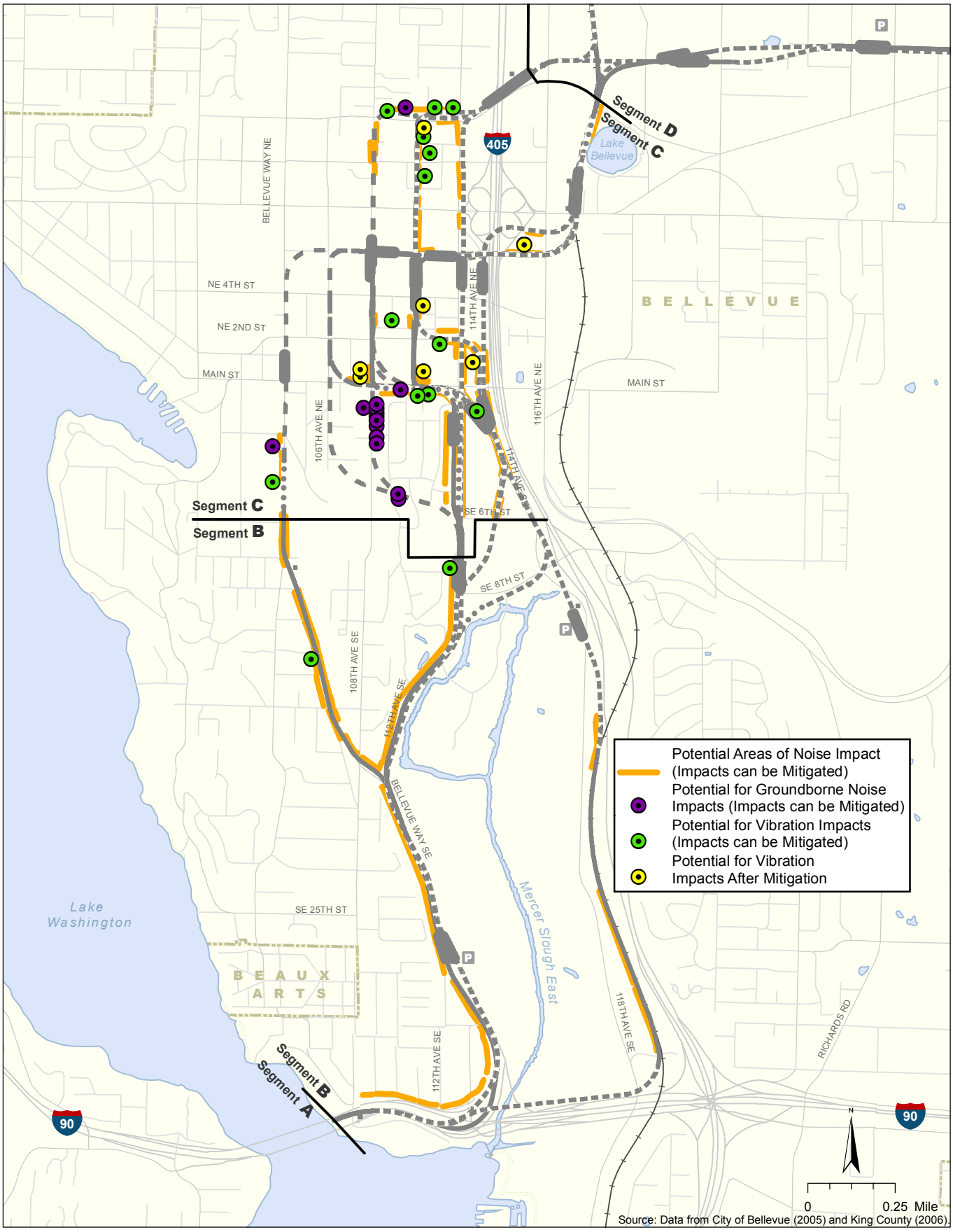


At-Grade Route
Elevated Route
Retained-Cut Route
Retained-Fill Route
Tunnel Route

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

Potential Areas of Noise Impact (Impacts can be Mitigated)
Potential for Vibration Impacts (Impacts can be Mitigated)

Exhibit 4.7-9
Noise and Vibration Impacts, Segments D and E Preferred Alternative
East Link Project



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 4.7-10
Noise and Vibration Impacts, Segments B and C Other Alternatives
East Link Project

At-Grade Route
Elevated Route
Retained-Cut or Retained-Fill Route
Tunnel Route
Traction Power Substation
Proposed Station
Maintenance Facility and Access Track
New and/or Expanded Park-and-Ride Lot
Potential Areas of Noise Impact (Impacts can be Mitigated)
Potential for Vibration Impacts (Impacts can be Mitigated)
Potential for Vibration Impacts After Mitigation

Exhibit 4.7-11
Noise and Vibration Impacts, Segments D and E Other Alternatives
East Link Project

Segment B

Under *Preferred 112th SE Modified Alternative (B2M)*, the level of noise impacts would vary with the different connections to Segment C. Under *Preferred Alternative B2M* connecting to *Preferred Alternative 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* connecting to *C11A,* 19 moderate noise impacts were also identified at the Bellefield Residential Park Condominiums, and 12 moderate impacts would occur 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* connecting to *Preferred Alternative 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* connecting 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. There would also be 10 moderate impacts at single-family residences along 111th Avenue SE just south of Surrey Downs Park.

Noise impacts with *Preferred Alternative B2M* connecting to *C9T* would occur for the same reasons as with *Preferred Alternative B2M* connecting 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* connecting to *C9T* with the East Main Station Design Option, the SE 8th Station would be relocated to the north in Segment C, and the crossover from Segment C would be relocated to 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 *Preferred Alternative* 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* connecting to *C9T* with the East Main Station Design Option are 64 moderate impacts, and two severe impacts.

The only park-and-ride under *Preferred Alternative B2M* is the South Bellevue Park-and-Ride, 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 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 per day would serve the facility in addition to light rail. The nearest residential properties to the park-and-ride 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 the Bellevue Way Alternative (B1), there would be 4 severe light rail noise impacts, 128 moderate noise impacts, and 136 traffic noise impacts. Severe light rail noise impacts would occur near SE 30th Street because of the nearby crossover track. Traffic noise impacts along Bellevue Way SE, beginning near SE 30th Street, would result from roadway widening and occur at single- and multifamily structures along the project corridor. The total number of residences impacted (single- and multifamily) under Alternative B1 would be 141, and most would be impacted by both light rail noise and traffic noise.

With the 112th SE At-Grade (B2A) and 112th SE Bypass (B3) Alternatives, there would be 78 and 83 light rail noise impacts, respectively, and 17 traffic noise impacts each. The 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 Bellevue Way SE/112th Avenue SE intersection. Light rail noise impacts were identified along 112th Avenue SE at the

single- and multifamily residences from SE 17th Street to Surrey Downs Park.

Under Alternative B3 with the Alternative B3 - 114th Extension Design Option, the alternative would divert from 112th Avenue SE and transition to an elevated structure closer to I-405. This would result in a reduction in noise impacts when compared to Alternative B3. The B3 - 114th Extension Design Option would add a new gated crossing near the Bellefield Residential Park Condominiums resulting in three new noise impacts in this area. The design option would divert the alignment away from the single family residences along 111th Place SE, reducing the number of impacts in this area. This results in a net reduction of six noise impacts when compared with Alternative B3. Furthermore, the number of severe impacts is reduced from four to one with the B3 - 114th Extension Design Option.

Noise impacts under Alternatives B2A, B3, and B3 - 114th Extension Design Option would be caused by wayside noise from the elevated structure, crossovers, and, to a lesser extent, train bells at stations. Traffic noise impacts are projected to occur only between the South Bellevue Station and 112th Avenue SE as a result of road widening.

Under 112th SE Elevated Alternative (B2E), 85 moderate and 21 severe noise impacts are projected. There would be no traffic noise impacts under Alternative B2E. Because there are no at-grade crossings with this alternative, the only bell-related noise would be at the stations. Wayside noise from the elevated structure would be the dominant noise source for Alternative B2E.

Alternative B7 along the former BNSF Railway corridor would result in 176 light rail noise impacts, including 68 severe impacts resulting from a crossover near the Emerald Apartments. All other impacts to multifamily residences in this portion of the alternative would be due to higher speeds and close proximity to the alignment.

Under Alternative B7, a new park-and-ride would be constructed at the 118th Avenue Station. The station would be located along 118th Avenue near I-405, and no noise impacts were identified because of the high existing noise levels and lack of adjacent noise-sensitive receivers. 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 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.

Segment C

Under *Preferred 108th NE At-Grade Alternative (C11A)* connecting from *Preferred Alternative B2M,* 119 moderate and 65 severe light rail noise impacts are predicted. The 65 severe impacts would include several homes along 111th Avenue SE because of a nearby crossover and loss of shielding from displaced buildings. There would also be severe impacts at several multifamily units along 108th Avenue NE that would occur because of bells and proximity to the tracks. The other severe noise impacts would occur at the Lake Bellevue Village Condominiums and would be due to lower impact criteria because this areas 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. No roadway modifications would be required nor would there be any traffic noise impacts. *Preferred Alternative C11A* from Alternative B3, B7, or B3 – 114th Extension Design Option would result in 152 moderate and 52 severe light rail noise impacts. The change in the number and severity of impacts under Alternatives B3, B7, or B3 – 114th Extension Design Option would be due to the different alternative connections.

Preferred 110th NE Tunnel Alternative (C9T) connecting from *Preferred Alternative B2M* would result in 119 light rail noise impacts, including 62 moderate and 57 severe impacts. The severe impacts would occur at single-family residences along 111th Avenue SE, a multifamily building on NE 6th Street in Downtown Bellevue, and the Lake Bellevue Village Condominiums, and, depending on the location, would result from their proximity to the track, bells at crossings, and crossovers. *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 no noise impacts at the single-family residences along 111th Avenue SE because of the different Segment B connector alignments.

Under the C9T – East Main Station Design Option connecting from *Preferred Alternative B2M*, the relocation of the crossover and the new station site would reduce the number of severe impacts when compared to the scenario with the SE 8th Street Station. Relocating the crossover is the reason for the reduction in the severity of impacts. There would still be 119 noise impacts, however, with the East Main Station, 52 severe and 67 moderate.

The number and severity of noise impacts with other alternatives in Segment C would vary depending on the alternative and its connector from Segment B. South of Main Street, the Bellevue Way Tunnel Alternative (C1T) would be the only Segment C alternative with traffic noise impacts, the result of roadway modifications on Bellevue Way that would impact 18 multifamily units. Because the alternative profile transitions to a tunnel on Bellevue Way, there are no at-grade crossing bells in Segment C along Bellevue Way with Alternative C1T. Under Alternative C1T, 48 multifamily units along NE 6th Street would experience moderate impacts and 52 would experience severe impacts, including 36 hotel rooms at the Coast Bellevue Hotel and 12 units with severe impacts at the Lake Bellevue Village Condominiums. Impacts would result from proximity to tracks, a crossover near the Coast Bellevue Hotel, and low existing noise levels at the Lake Bellevue Village Condominiums.

106th NE Tunnel Alternative (C2T) connecting to Alternative B2A would likely have similar light rail impacts as predicted under Alternative C1T, but without any traffic noise impacts because both alternatives are similar when not in the tunnel through Downtown Bellevue. When connecting from Alternative B2E, Alternative C2T would result in 113 moderate and 66 severe light rail impacts. These impacts would result from the elevated profile and a crossover along 112th Avenue SE.

Alternative C2T connecting from Alternatives B3 or B7 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 under this alternative. Furthermore, Alternative C2T would not have any traffic noise impacts with any of its connection options. Impacts east of the tunnel would be due to proximity to the tracks, and a crossover.

The 108th NE Tunnel Alternative (C3T) would result in 26 noise impacts connecting from Alternative B2A, 105 impacts with an Alternative B2E connection, and 62 impacts connecting from Alternative B3 or B7. The Alternative B2A connection would have the fewest impacts because of the longer tunnel, with 21 multifamily impacts and 5 single-family impacts all located along NE 12th Street near 112th Avenue NE. With the Alternative B2E connection, there would be 15 single family impacts, 2 considered severe; 58 multifamily impacts, of which 12 are considered severe; and 32 hotel room moderate impacts. Finally, the Alternative B3 or B7 connection is predicted to have 18 severe impacts at the Bellevue Hilton Hotel along the side of the structure facing I-405.

Impacts under Alternative C3T near the northern tunnel portal would be the same for all connections because of wayside noise from the transition and elevated structure. South of Downtown Bellevue, the reason for and the location of impacts would vary with each different connection. With the Alternative B2A connection, there would be no impacts due to the tunnel. With the Alternative B2E connection, impacts along 112th Avenue SE would result from the elevated structure and crossover, while with the Alternative B3 or B7 connections, impacts would result from the proximity to the Hilton Hotel.

The Couplet Alternative (C4A) from the 112th SE At-Grade Alternative (B2A) connector would have the most noise impacts because of the high-rise apartments along 108th and 110th Avenues NE, with 435 moderate and 15 severe impacts throughout the alternative corridor. When connecting to Alternative B2E, Alternative C4A would have the same number of noise impacts as the connection to B2A. When connecting to Alternatives B3 or B7, Alternative C4A would have moderate light rail noise impacts on 420 residences and hotel rooms and additional severe impacts on 1 single-family residence and 18 hotel rooms.

South of Main Street, Alternative C4A impacts would result from general wayside noise and a crossover (with the Alternatives B2A or B2E connection), or proximity to a hotel (with the Alternatives B3 or B7 connection). North of Main Street, the impacts would be the result of train bells at each intersection from Main Street to (and including) NE 12th Street and noise from bells at gated crossings.

Under the 112th NE Elevated Alternative (C7E), the connection from Alternative B2A would result in 270 moderate and 12 severe light rail noise impacts. With the elevated connection from Alternative B2E, the number of impacts would be the same as with Alternative B2A. When connecting to Alternative B3 or B7, Alternative C7E would have 208 moderate light rail noise impacts and no severe impacts. All impacts would be related to wayside noise from the elevated structure and a crossover. There are no train bells or crossing bells under Alternative C7E, except at the NE 12th Street Station.

The 110th NE Elevated Alternative (C8E) would have moderate light rail noise impacts at 120 hotel rooms, 9 single-family residences, and 224 multifamily residences. This alternative would also have 72 severe light rail noise impacts at multifamily residences. Alternative C8E only connects to Alternatives B3 or B7. As with the other elevated alternatives, there are no at-grade crossings, so the only train bells would be at the stations; therefore, all impacts under Alternative C8E would be due to wayside noise from the elevated light rail.

The 110th NE At-Grade Alternative (C9A) connects to Alternatives B2A, B3, B3 – 114th Extension Design Option, or B7. Connecting from Alternative B2A, 241 light rail noise impacts are predicted, including 10 moderate and 4 severe impacts at single-family residences, 143 moderate and 16 severe impacts at multifamily residences, and 32 moderate and 36 severe hotel room impacts. With a connection to Alternative B3, B3 – 114th Extension Design Option or B7, that number would decline to 199 total impacts, with severe impacts at 2 single-family units, 16 multifamily units, and 36 hotel rooms. An additional 145 moderate impacts would also occur at residences and hotel rooms along this corridor.

Impacts under Alternative C9A would result from the crossover and elevated light rail south of Main Street, bells and proximity through the Bellevue central business district, and proximity and the crossover east of I-405.

The 114th NE Elevated Alternative (C14E), which is elevated along 114th Avenue NE, is predicted to have 16 severe impacts at multifamily residences, along with 96 severe and 36 moderate impacts at hotel rooms. Impacts would be the result of wayside noise from the elevated structure, crossovers and, at the Lake Bellevue Village Condominiums, low existing noise levels.

There are no park-and-rides in Segment C.

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, also an established transportation corridor. These parks were all reviewed for sensitivity to noise. Since all these parks have active uses and are located along established transportation corridors, none meet the FTA criteria for a noise-sensitive use.

Segment D

No light rail noise impacts were identified for *Preferred NE 16th At-Grade Alternative (D2A)*.

There are three potential park-and–ride lot locations with *Preferred Alternative D2A*: a new park-and-ride south of the corridor, just east of 120th Avenue SE or 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 lot at Overlake Transit Center has no noise-sensitive receivers that would be impacted by facility operation.

With connections from the former BNSF Railway corridor (*Preferred Alternatives C11A* and *C9T*, and Alternatives C1T, C2T, C9A and C14E), no noise impacts were identified for Alternative D2A - 120th Station Design Option, Alternative D2A - NE 24th Design Option, or NE 20th Alternative (D3). The NE 16th Elevated Alternative (D2E) is predicted to result in a noise impact at the Pacific Northwest Ballet School at the NE 16th Street/136th Place NE intersection. (The ballet school impact would only occur under Alternative D2E.) Alternative D5 would have severe noise impacts at 10 units at an apartment building near SR 520, off Northup Way. The noise impacts would be the result of proximity and the speed of the train in this area.

With connections from NE 12th Street (Alternatives C3T, C4A, C7E, and C8E), one moderate noise impact is predicted under Alternatives D2E, D3, and D5 at the new Children's Hospital facility on 116th Avenue NE; one moderate noise impact is predicted under Alternative D2E at the Pacific Northwest Ballet School; and 10 severe noise impacts are predicted under Alternative D5 at the same apartment identified in the previous paragraph for the connection from the former BNSF Railway corridor. No other noise impacts are expected under Alternative D3. The impact at the Children's Hospital BCSC would be due to the land use type and proximity to tracks.

Under Alternatives D2E and D3, the park-and-ride lot at the 130th Station would have no noise impacts, similar to *Preferred Alternative D2A*. 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.

There are no noise-sensitive parks located near any of the project alternatives in Segment D.

Segment E

Under *Preferred Marymoor Alternative (E2),* 148 severe and 33 moderate noise impacts were identified, for a total of 181 impacts. These include nine moderate and four severe impacts at single-family residences near SR 520 at West Lake Sammamish Parkway NE, 144 severe impacts at newly constructed multifamily units, and 24 moderate impacts at a hotel. No traffic noise impacts are predicted.

Noise impacts near SR 520 would be due to the higher speed of the train on the elevated structure. Noise impacts in other areas would result from crossovers, at-grade and gated crossings, and proximity of the light rail to sensitive land uses.

The park-and-ride under *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.

Noise impacts under the Alternative E2 - Redmond Transit Center Design Option would be similar to the *Preferred Alternative E2*; however, this design option would have 81 moderate and 100 severe noise impacts, also totaling 181 noise impacts. The reason for this difference is because under this design option, one of the newly constructed multifamily buildings would not be impacted as it would be under *Preferred Alternative E2.* However, another building near the terminus would have the same number of severe impacts.

Under Redmond Way 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.

The Leary Way Alternative (E4) would have 66 moderate noise impacts and 32 severe noise impacts related to light rail operations. No traffic or other noise impacts were identified in Segment E.

All new Segment E park-and-rides are located near an established commercial and industrial area, and no noise impacts were identified.

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 project alternatives are approximately 2,500 to 3,000 feet, or greater, from this section of the park, project noise levels are predicted to be below ambient levels and below FTA impact 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.

Maintenance Facilities

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, as there are several single-family residences west of 116th Avenue NE. However, most of the buildings directly along 116th Avenue NE have been converted to office buildings. The new Seattle Children's Hospital BCSC is also located to the south of the MF1 site. Because a maintenance facility is considered a stationary transit facility that is near noise-sensitive properties, a noise analysis was performed using the following assumptions, consistent with FTA methods and criteria:

- Measured noise levels from 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 revenue train operations because of the slower speed and because some form of lubrication or friction modifier would be used to minimize or avoid noise from wheel squeal.
- The majority of noise-producing maintenance operations would occur inside the facility building, thus shielding nearby properties from the operations.
- The typical maximum number of trains at the facility is based on the proposed size and would not exceed 40 to 50 light rail vehicles.

Using the above assumptions, worst-case operational noise levels were projected at several 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 further 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.

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 the maintenance facility alternatives 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.

Wheel Squeal

Wheel squeal is caused by the oscillation of the wheel against the rail on curved sections of train track. Curves with a radius of less than 600 feet will likely produce wheel squeal; curves with a radius of 600 to 1,000 feet have also been known to produce squeal, depending on train speed and track type. Light rail wheel squeal could produce maximum noise levels of 83 to 85 dBA at 50 feet. Table 4.7-7 lists all curves that would have a 600-foot radius or less, are not located in a tunnel, and have the potential for wheel squeal in proximity to noise-sensitive receivers.

Vibration and Groundborne Noise Impacts

Table 4.7-8 summarizes the vibration and groundborne noise impacts for the different build alternatives; the general locations of these impacts are shown in Exhibits 4.7-7 through 4.7-11. Groundborne noise is only assessed for tunnel sections or for buildings with sensitive interior spaces that are well-insulated from exterior noise. At other locations, because of the masking effects of airborne noise, groundborne noise is not a factor.

TABLE 4.7-7
Summary of Curves with Potential Wheel Squeal

Alternative	Curves with Radius of 600 Feet or Less
Segment A	
Preferred Interstate 90 Alternative (A1)	6th Avenue South; Dearborn Street and I-90 just east of 12th Avenue South
Segment B	
Preferred 112th SE Modified Alternative (B2M)	I-90 to Bellevue Way
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 Extension 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	
Preferred 108th NE At-Grade Alternative (C11A)	112th Avenue SE at Main Street; Main Street and 108th Avenue NE (all connections); 108th Avenue NE and NE 6th Street; NE 6th Street to the former BNSF Railway corridor; south of the Hilton Hotel under B3 - 114th Extension Design Option
Preferred 110th NE Tunnel Alternative (C9T)[a]	112th Avenue SE at Main Street (all connections); NE 6th Street to the former BNSF Railway corridor; south of the Hilton Hotel under B3 - 114th Extension Design Option
Bellevue Way Tunnel Alternative (C1T)	NE 6th Street to the former BNSF Railway corridor
106th NE Tunnel Alternative (C2T)	Main Street (connecting from Alternatives B2A, B3, and B7); NE 6th Street to the former BNSF Railway corridor
108th NE Tunnel Alternative (C3T)	Main Street (connecting from Alternatives B2A, B3, and B7); 112th Avenue NE at NE 12th Street
Couplet Alternative (C4A)	Main Street (connecting from Alternatives B2A, B3, and 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 (connecting from Alternatives 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	
Preferred NE 16th At-Grade Alternative (D2A)[b]	BNSF Railway corridor to NE 16th Street; NE 16th Street to 134th Avenue NE; 134th Avenue NE to SR 520
D2A – NE 24th Design Option	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)	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)	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 (connecting from Alternatives 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	
Preferred Marymoor Alternative (E2)	SR 520 and Redmond Way

TABLE 4.7-7 CONTINUED
Summary of Curves with Potential Wheel Squeal

Alternative	Curves with Radius of 600 Feet or Less
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*
[b]Curves with the D2A – 120th Station Design Option would not differ from *Preferred Alternative D2A*

TABLE 4.7-8
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]
Segment A					
Preferred Interstate 90 Alternative (A1)	N/A	None	25 single-family	None	None
Segment B					
Preferred 112th SE Modified Alternative (B2M)	*Preferred 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 B2M*	2 single-family, 3 multifamily (108 units), 1 hotel	None	1 hotel	None
	B3 and B7	1 single-family, 3 multifamily (108 units), 1 hotel	None	1 hotel	None
Preferred 110th NE Tunnel Alternative (C9T)	*Preferred B2M*	7 single-family, 1 hotel	1 theater (Meydenbauer Center)	1 hotel	None
	B3 and B7	1 single-family, 1 hotel	1 theater (Meydenbauer Center)	1 hotel	None
C9T – East Main Station Design Option	*Preferred B2M*	2 single-family, 1 hotel	1 theater (Meydenbauer Center)	1 hotel	None
Bellevue Way Tunnel Alternative (C1T)	B1	1 single-family, 1 hotel	1 single-family	None	None
106th NE Tunnel Alternative (C2T)	B2A	None	None	None	None
	B2E	None	1 single-family	None	None
	B3 and B7	None	None	None	None

TABLE 4.7-8 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]
108th NE Tunnel Alternative (C3T)	B2A	None	12 single-family	None	None
	B2E	None	2 single-family	None	None
	B3 and B7	None	1 single-family	None	None
Couplet Alternative (C4A)	B2A, B2E, B3, and B7	1 single-family, 6 multifamily (729 units)	None	2 multifamily (176 units)	None
112th NE Elevated Alternative (C7E)	B2A, B2E, B3, and B7	None	None	None	None
110th NE Elevated Alternative (C8E)	B3 and 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)	B2A, B3, and B7	2 single-family, 3 multifamily (108 units), 1 hotel	None	2 multifamily (68 units), 1 hotel	None
114th NE Elevated Alternative (C14E)	B3 and 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*.

In Table 4.7-8, the columns for the number of vibration and groundborne noise impacts refer to the number and type of buildings where vibration or groundborne noise impact is projected to occur. The number of units for multifamily buildings is provided, although it is likely that not all units would be affected. For multifamily buildings, the actual number of units impacted in each building would be determined after further testing during final engineering and design.

All impacts identified in the sections below are related to the proximity of the proposed tracks to individual buildings and to the speed of the light rail vehicle. In most cases, the impacts would be limited to buildings within 50 feet of the proposed tracks.

Potential vibration and groundborne noise levels and impacts reported in this section are described prior to mitigation considerations. Although most impacts can be mitigated, the residual impacts remaining after mitigation are provided in Table 4.7-8. Detailed information and exhibits for each impact are located in Appendix H2.

Segment A

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 vibration levels the same as from Central Link system operations, special trackwork would be needed at this location.

Under *Preferred Alternative A1*, groundborne noise impacts would occur at 25 single-family residences above the Mount Baker Ridge Tunnel. These impacts would occur because high-frequency vibration travels easily through the ground in this area.

Segment B

Under *Preferred Alternative B2M*, there would be no vibration impacts and only one groundborne noise

impact (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.

Under all other Segment B alternatives, the only vibration impact would be to a single-family residence with Alternative B1. This impact would occur because of the proximity of the residence to the track and because high-frequency vibration travels easily through the ground in this area.

Segment C

The vibration impacts in Segment C would result from the proximity of the proposed alternatives and the speed of the light rail vehicles.

In addition to the residential land uses in this corridor, vibration and groundborne noise impacts were also assessed for the special sensitive receptors in this segment, including the Bellevue Arts Museum, the theater in Meydenbauer Center, the Overlake Hospital MRI Unit, the Overlake Hospital Optical Surgery Unit, as well as the MRI unit at the Group Health Medical Center. The results of the vibration analysis at these locations indicated there is no projected impact at the hospitals and MRI units. Details regarding the groundborne noise and vibration levels at these sensitive sites are included in Tables 4-2, 4-3, 4-4, and 7-3 of Appendix H2.

Under *Preferred Alternative C11A*, there would be vibration impacts at two single-family residences, three multifamily buildings, and one hotel.

Preferred Alternative C9T would result in vibration impacts at seven single-family residences and one hotel. Five of the single-family residential impacts would be due to the crossover on 112th Avenue SE. In addition, there would be a groundborne noise impact at the Meydenbauer Center. Under the C9T – East Main Station Design Option, the replacement of this crossover with the East Main Station would reduce the vibration impacts to two single-family residences and one hotel. The groundborne noise impact at the Meydenbauer Center would also still occur as described above under *Preferred Alternative C9T*.

Alternatives C2T connecting from B2A, B3, and B7, and Alternative C7E would not have any projected vibration impacts. All the other Segment C alternatives would have vibration impacts, with the greatest number of impacts occurring with Alternatives C4A, C8E, or C9A. The impacted structures would be mixed use buildings that have ground floor commercial uses with multifamily residences above. The distance to sensitive uses in these buildings might eliminate these impacts.

Segment D

No vibration impacts are projected for Segment D, including at the Children's Hospital BCSC medical facility.

Segment E

Preferred Alternative E2 would result in vibration impacts on three single-family residences. These vibration impacts would result because high-frequency vibration would travel easily through the ground in this area and because of the track's proximity to the residences. These impacts would also occur with the E2 - Redmond Transit Center Design Option.

For the other Segment E alternatives, vibration impacts would occur at three single-family residences with Alternative E1. Alternative E4 would have vibration impacts on one single-family residence, one multifamily building, and one hotel. These vibration impacts would be due to the proximity of the residences and because high-frequency vibration travels easily through the ground in this area.

Maintenance Facilities

Maintenance facility alternatives are not expected to result in any vibration impacts.

4.7.3.5 Impacts during Construction

This section summarizes potential construction noise and vibration impacts. More detailed information is provided in Appendix H2.

Noise

Noise related to construction would result from the operation of heavy equipment needed to construct the project. State and local ordinances regulate construction noise, and the contractor would be required to adhere to these regulations. This section provides a general understanding of average and worst-case noise levels from construction. Because of the varying types of construction activities, the location of noise-sensitive properties, distances from construction sites and staging areas to noise-sensitive properties, and other construction-related variables, it is not possible to provide exact construction noise levels.

The primary construction noise regulations are found in the WAC. The state provisions have been adopted, in some form, by most cities and counties around the state, including the Cities of Seattle, Bellevue, and Redmond. No specific construction noise ordinance was identified for Mercer Island, and therefore the Washington State construction ordinance would also be the governing criteria for construction activities on the island. Information in the WAC, which outlines the specific construction regulations for most locations, is provided below, followed by a construction noise analysis.

Sound Transit would, as practical, limit construction activities that produce the highest noise levels to daytime hours, or when disturbance to sensitive receivers would be minimized.

Contractors would be required to meet the criteria of the noise ordinance for the city within which they are working. Construction outside normal weekday hours (i.e., 7 a.m. to 10 p.m. for locations governed by the WAC) may require a noise variance from the city or county where the work is being performed. For example, the City of Bellevue only exempts construction noise from 7 a.m. to 6 p.m. on weekdays, and from 9 a.m. to 6 p.m. on Saturdays, so any major construction activities outside these hours in the City of Bellevue would require a noise variance.

It is also important to note that unlike the light rail noise analysis, which uses the Ldn and Leq for impact assessment, the WAC and other construction noise ordinances use several other noise metrics in addition to the Ldn and Leq. Instantaneous sound pressure levels in dBA (SPL in dBA), maximum 1-second noise levels in dBA (Lmax), and statistical noise descriptors are all terms that are used to ensure compliance with the WAC. Finally, because of possible restrictions on daytime construction along major arterials (because of traffic disruptions), it is likely that at least some construction along major corridors could occur during nighttime hours. Under alternatives with bored tunnels, it is likely that that the tunnel portals could operate 24 hours per day, and up to 7 days per week. Due to the WAC and local noise control regulations, work outside the allowable hours would require obtaining a noise variance from the local jurisdiction.

Listed below are allowable noise exceedances (referred to "as exempt") for general construction equipment, haul trucks, and alarms, as provided in the WAC.

- **General Equipment:** For construction activities, the limits in Table 4.7-3 may be exceeded between 7 a.m. and 10 p.m. on weekdays, and 9 a.m. and 10 p.m. on weekends, as shown in Table 4.7-4.
- **Haul Trucks:** Noise from haul trucks is exempt when operating on public roadways. Maximum permissible sound levels for haul trucks at the construction site are limited to 86 dBA for speeds of 35 mph or less and 90 dBA for speeds over 35 mph.
- **Alarms:** Sounds created by back-up alarms are exempt when operated for less than 30 minutes per incident.

Project Construction Phases

Several construction phases would be required to complete the East Link Project. This analysis assumes the worst-case noise levels based on three major construction phases, further defined in Table 4.7-9:

- Demolition, site preparation, and utility relocation
- Structure construction, track installation, and paving
- Miscellaneous activities

The actual noise levels experienced during construction would generally be lower than those presented in this section and in Table 4.7-9. The noise levels discussed here (and presented in Table 4.7-9) are for periods of maximum construction activity and are considered worst-case for the major phases of construction, measured at a distance of 50 feet from the construction site. Residential and commercial land uses are most sensitive to construction noise.

General Construction

In Segments B through E, constructing elevated guideways, at-grade trackways, tunnels, stations, and tunnel portals would increase the amount of truck traffic near construction staging areas. Haul truck and delivery truck volumes and times of travel would vary depending on the specific site activities occurring at any one time.

The highest levels shown in Table 4.7-9 would be experienced during the heaviest construction periods. Noise levels would be 5 to 15 dBA lower than the highest levels during minor construction work, such as finishing work and system installation. Constructing bridges and elevated structures might require pile driving, which could produce maximum noise levels of 99 to 105 dBA Lmax at 50 feet from the work site. Actual levels can vary and would depend on the distance and topographical conditions between the pile-driving location and the receiver location. Pile driving might be required in Segments B, C, D, and E for the elevated profiles and might also occur in areas of retained cuts in Segments C and D. Pile driving would be required to meet the WAC impact criteria. Following are segment-specific discussions related to construction noise.

Segment A

In Segment A under *Preferred Alternative A1*, most construction activities would occur during weekday daytime hours in the I-90 corridor, which is some distance from commercial and residential uses. Noise from construction could reach 75 to 78 dBA Lmax because of the distance between the construction and noise-sensitive properties and shielding from the retaining walls along I-90, and no impacts are expected.

Segment B

Preferred Alternative B2M and most other Segment B alternatives consist of a combination of elevated, retained cut, retained fill, and at-grade track types; therefore, the construction techniques for each alternative would be very similar. The main differences would be long-term fixed-site construction, such as those associated with the tunneling alternatives, compared with moving operations, such as paving, at-grade track construction, and elevated structure installations.

Under the Segment B alternatives single- and multifamily residences and several businesses could be affected by construction noise. Under *Preferred Alternative B2M* and Alternatives B1, B2A, B2E, and B3, adjacent properties would experience maximum noise levels exceeding 80 dBA Lmax for short periods, assuming that these properties are 100 to 125 feet from the construction activity. Construction noise would occur when relocating utilities, installing retaining walls (where required), constructing the lidded retained cut at the Winters House under *Preferred Alternative B2M*, repaving Bellevue Way SE, and constructing the elevated guideways for *Preferred Alternative B2M* and Alternatives B2A, B2E, B3, and B7. Noise levels would be greatest for properties adjacent to Bellevue Way SE and near the elevated segments on I-90, but would be less for those located along 112th Avenue SE, where residences and business parks are set back farther from the project corridor in many places. During construction of elevated structures, noise from pile driving could produce Lmax noise levels of 98 to 105 dBA Lmax at 50 feet from the work site.

With Alternative B7, noise levels at the multifamily apartments and condominiums adjacent to the former BNSF Railway corridor could reach 80 dBA Lmax for short periods. Because this alternative is not on a major roadway, it is unlikely that nighttime work would be required near the noise-sensitive units. Construction of Alternative B7 would also increase noise at some commercial buildings;

In Segment B, construction noise would be exempt if performed between 7:00 a.m. and 6:00 p.m. Monday through Friday, and between 9:00 a.m. and 5:00 p.m. on Saturdays. Construction during all other hours would require authorization from the applicable Bellevue department director, consistent with the criteria set out in the City of Bellevue noise ordinance

TABLE 4.7-9
Maximum Noise Levels for Typical Construction Phases at 50 Feet from the Work Site

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

Note: Combined worst-case noise levels for all equipment at a distance of 50 feet from work site.
[a] Operational conditions under which the noise levels are projected.
[b] Normal equipment in operation under the given scenario.
[c] Lm (dBA) is an average maximum noise emission for the construction equipment under the given scenario.
[d] Leq (dBA) is an energy average noise emission for construction equipment operating under the given scenario.

Segment C
In Segment C, the longest period of high-intensity construction activities would occur at cut-and-cover tunneling sites and bored tunnel staging areas. Maximum noise levels exceeding 80 dBA Lmax, assuming a distance of 100 to 125 feet from the construction activity, could occur during periods of heavy construction activity. Noise levels would be highest during periods of spoil hauling, when noise levels from haul trucks would be the dominant noise source, with maximum noise levels of 86 dBA Lmax at 50 feet. *Preferred Alternative C9T* would require such a staging area near the portals at Main Street, along NE 6th Street, and on 110th Avenue NE between NE 3rd Place and NE 2nd Place. Under *Preferred Alternative C11A*, staging areas would still be required; however, the level of activity at staging areas for the at-grade profile would typically be less intense than those for tunnels.

Noise levels near the tunnel portals and at-grade alignments along 112th Avenue SE and Main Street with *Preferred Alternatives C11A* and *C9T*, and Alternatives C2T, C3T, C4A, C7E, and C9A, and on Bellevue Way for Alternative C1T, could exceed 80 dBA Lmax at nearby residences during heavy construction periods. Noise levels near the tunnel portals and construction areas during general construction activities are predicted to range from 73 to 84 dBA Lmax at 50 feet from the work site. Similar levels are projected along NE 6th Street with *Preferred Alternative C9T* and Alternatives C1T and C2T. Staging areas along NE 12th Street and McCormick Park for Alternatives C3T, C4A, and C8E would also experience similar noise levels. To construct elevated structures along 112th Avenue NE under Alternative C7E and along 110th Avenue NE under Alternative C8E, maximum noise levels would range from 80 to 85 dBA Lmax at 50 feet from the project construction area. Constructing the light rail along NE 12th Street would increase noise levels at Overlake Hospital. The hospital parking garage would provide shielding for some patient rooms. Construction noise under the other two at-grade alternatives (C4A and C9A) would be similar to those described for *Preferred Alternative C11A*, although Alternative C4A would occur along 108th Avenue NE and 110th Avenue NE, and Alternative C9A would occur only along 110th Avenue NE.

As previously described for Segment B, construction noise in Segment C would be exempt if performed between 7:00 a.m. and 6:00 p.m. Monday through Friday, and between 9:00 a.m. and 5:00 p.m. on Saturdays. Construction during all other hours would not be exempt under the City of Bellevue noise ordinance, and would require a noise variance.

Segment D
In Segment D, *Preferred Alternative D2A* and the other alternatives would produce construction-related noise levels similar to those already discussed in Segments B and C. In Segment D, however, there are fewer residences; therefore, construction noise is not expected to impact as many residences as in Segments B or C.

Constructing the at-grade and elevated profiles through Segment D would result in short-term high noise levels at commercial and retail structures located along the corridor. Constructing the light rail along NE 12th Street would increase noise levels at the Children's Hospital BCSC. Levels would increase to the levels listed in Table 4.7-9 when construction activities are near these properties and would decrease as the activities move away.

Commercial and retail land uses along the proposed corridors would experience maximum noise levels of 80 dBA Lmax, assuming 100 to 125 feet from the construction activity. Constructing Segment D along the south and east shoulder of SR 520 would also increase construction noise and traffic east of 140th Avenue NE to the Segment E connection, depending on the alternative selected. In this area, maximum construction noise levels of 91 to 94 dBA Lmax can be expected for short periods, with typical hourly average noise levels ranging between 70 and 80 dBA Lmax at 50 feet.

Because Segment D is situated in Bellevue and Redmond, two construction noise regulations would apply. In this type of situation, the contract specifications typically would use the most stringent regulations in most areas to ensure compliance. Therefore, in most areas construction noise would be exempt if performed between 7:00 a.m. and 6:00 p.m. Monday through Friday and between 9:00 a.m. and 5:00 p.m. on Saturdays. However, in the Overlake area, it might be possible for work to continue later in the day because the WAC regulations allow for construction until 10:00 p.m. on weekdays.

Segment E
Constructing *Preferred Alternative E2*, and the other Segment E alternatives along the shoulder of SR 520 from NE 40th Street to West Lake Sammamish Parkway NE, could result in relocating sound walls along the single-family residential area along 156th Avenue NE. During that time, construction noise and traffic would increase for the residential area north of NE 51st Street to maximum noise levels exceeding

80 dBA Lmax, assuming 100 to 125 feet from the construction activity.

Constructing the elevated structures and at-grade profiles would elevate noise levels at the multifamily units along West Lake Sammamish Parkway NE, 156th Place NE, and along Leary Way NE because Alternatives E1 and E4 would require using heavy construction in this immediate area. Pile driving for the Sammamish River crossing for all alternatives and along Leary Way NE for Alternative E4 could result in peak levels exceeding 100 dBA Lmax. In Downtown Redmond, construction noise would be prevalent along the former BNSF Railway corridor under all Segment E alternatives. Constructing the E2 - Redmond Transit Center Design Option would increase noise levels along 161st Avenue NE.

Maintenance Facilities

Construction of the potential maintenance facility alternatives located in Segment D (MF1, MF2, and MF3) could have some impact on adjacent properties. MF1 would have the most likelihood of noise impacts during construction because it is located near several single-family residences and the Children's Hospital BCSC. The MF2 and MF3 maintenance facility alternative sites are located in primarily industrial and commercial areas, which are generally less sensitive to construction noise levels. MF5 would be in an area of primarily commercial use and high existing noise levels, reducing the potential for construction noise impacts.

Vibration

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

In most cases, the main concern for construction vibration is potential damage to structures. Most construction processes do not generate high enough vibration levels to approach damage criteria. The thresholds for building damage are 1 to 2 orders of magnitude higher than criteria for annoyance. Because construction is a short-term, temporary impact, the potential for structural damage is considered more critical than the potential for annoyance. 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 to structures.

The major sources of construction vibration include impact pile driving, augered piling, vibratory rollers, and tunnel boring machines, including associated muck trains. The only project activity with potential to cause building damage is impact pile driving at locations within 25 feet of structures. 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.

There are many alternatives to impact pile driving, including sonic pile driving, and augered or drilled pile construction. Specific locations of piling would not be available until final design, but would likely include locations of elevated structures or retained cuts approaching tunnels. As specific locations of piles are developed, more analysis would be conducted to assess specific impacts. To prevent damage, care would be taken not to pile drive 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 below as mitigation would prevent vibration damage or limit damage to minor cosmetic damage. For a discussion of vibration descriptors and damage criteria, refer to Sections 2.2 and 4.5 in Appendix H2.

In order to assess the potential for annoyance from construction vibration, vibration levels for impact pile driving, vibratory rolling, tunneling and muck trains were predicted for the ground floors inside buildings using conservative assumptions. These assumptions include no coupling attenuation (i.e., reduction in vibration levels due to the foundation of the building) for single-family residences, a 10-decibel building coupling attenuation for large masonry buildings, and no floor-to-floor attenuation. The criteria used to assess construction vibration and groundborne noise are the same as those used to assess transit operation impacts.

Table 4.7-10 shows the typical distances at which groundborne vibration annoyance would occur for

both single-family residences and large masonry buildings for each piece of construction equipment. The only locations where impacts from tunnel boring and muck trains could occur would be in the tunnel alternative segments. Impacts from pile driving would only occur at locations where piling is planned.

TABLE 4.7-10
Typical Distances from Sources to Vibration and Groundborne Noise Impact

Construction Equipment	Distance to Groundborne Vibration Impact (feet)	Distance to Groundborne Noise Impact (feet) [a]
Tunnel-boring machine in soil (large masonry buildings)	6	7
Tunnel-boring machine in soil (single-family residences)	13	14
Muck trains (large masonry buildings)	8	24
Muck trains (single-family residences)	16	51
Vibratory roller (large masonry buildings)	18	N/A
Vibratory roller (single-family residences)	36	N/A
Impact pile driving (large masonry buildings)	70	N/A
Impact pile driving (single-family residences)	150	N/A

[a] Groundborne noise is only assessed for tunnel locations.

At all other locations, the vibration generated by construction activities would be minimal. However, most activities would be far enough away from buildings that there would not be any impacts.

It is important to note that these are temporary impacts, and the annoyance from these activities would be very limited in duration. For most activities, including tunneling, the duration would be only a few days to a few weeks for each activity. The only activity with a longer duration would be the muck trains near the portals of the tunnels, which could be running between 1 month and 18 months, depending on the tunnel alternative chosen and the speed of tunneling. Sound Transit's experience in monitoring vibration during tunneling on Central Link has found no vibration impacts associated with annoyance to residences throughout the length of the tunnel.

For more information on construction vibration, refer to Appendix H2.

4.7.4 Station Platform Noise Levels

Because of the unique setting of several stations in proximity to major freeways, Sound Transit modeled potential noise levels at proposed station platforms where light rail patrons might be exposed to noise from heavy freeway traffic volumes. These stations included the Rainier, Mercer Island, and Ashwood/ Hospital stations, which are all located within or above a major freeway. The proposed East Link operations plan would result in a typical maximum of 15 minutes between train arrivals at any of these stations, and therefore 15 minutes would typically be the longest period patrons would be exposed to noise while waiting for trains to arrival. Although it is possible that a patron could wait up to 15 minutes or more (if trains are running late), the Leq over a 20-minute period is expected to be the same as for a 15-minute period because of the steady-state nature of traffic along SR 520.

There are no federal standards for noise exposure on transit passengers at station platforms due to traffic noise. The National Institute for Occupational Safety and Health (NIOSH) standard for workplace noise exposure is 85 dBA for up to 8 hours, or 100 dBA for 15 minutes (NIOSH, 1998). The U.S. Environmental Protection Agency (EPA) states that communication at close proximity (2 to 4 feet) can be understood with ambient noise levels of 72 to 78 dBA (EPA, 1974). For contextual comparison, Sound Transit measured noise levels at two existing flyer bus stops located adjacent to heavy freeway traffic. Existing noise levels at the Rainer I-90 flyer stop were measured at 76 dBA Leq, while the typical existing noise level at the SR 520 flyer stop at Montlake was 81 dBA Leq. Based on these standards and existing bus flyer stop noise levels, Sound Transit will use a 78 dBA 15-minute Leq platform noise level goal for designing stations within or above freeways, where reasonable and feasible.

During peak noise hours, station patrons may experience noise levels ranging as high as 85 to 86 dBA at the Rainier Station and 88 dBA at the Mercer Island Station. The higher noise levels on Mercer Island are due to the highway's retained cut and traffic noise being reflected around the station platform off the adjacent retaining walls. Sound Transit would consider including noise-reducing sound walls between the tracks and I-90 traffic lanes for both stations. Modeling sound walls for each station shows that they would reduce noise levels by approximately 8 to 10 dBA on the platform, bringing the station platform noise at both sites to within Sound Transit's station platform design goal of

78 dBA. Complete details on the station analysis are provided in Appendix H2.

4.7.5 Potential Mitigation Measures

4.7.5.1 Noise Mitigation During Operation

Sound Transit is committed to minimizing noise levels at the source. This includes using only state-of-the-art vehicles equipped with wheel skirts to reduce noise. In addition, Sound Transit has committed to a maintenance program that includes periodic rail grinding or replacement, wheel truing or replacement, vehicle maintenance, and operator training, which all help to reduce noise levels along transit corridors. For noise impacts that still exist after these source noise treatments, noise mitigation measures would be provided that are consistent with Sound Transit's Light Rail Noise Mitigation Policy (Motion No. M2004-08). The FTA manual also defines when mitigation is needed and bases this on the impact's severity, with severe impacts requiring the most consideration. During final design, all impacts and mitigation measures will be reviewed for verification. During final design, if it is discovered that mitigation can be achieved by a less costly means or if the detailed analysis show no impact, then the mitigation measure may be eliminated or modified.

The mitigation proposed below follows Sound Transit policy. Table 4.7-6 summarizes potential project light rail and traffic noise mitigation for each alternative.

Transit Noise Mitigation

The potential mitigation options available for noise from transit operations on the East Link Project are primarily sound walls, special trackwork, lubricated curves, and residential building sound insulation. Sound walls are proposed where feasible and reasonable, as determined by Sound Transit based on specific site conditions. Sound walls would be located on the ground for at-grade profiles and on the guideway structure for elevated profiles. Sound walls are preferred because they are effective at reducing noise. For locations where there is a potential for traffic noise to be reflected off the sound walls, Sound Transit would propose to use absorptive treatments to remedy this issue.

A crossover track uses a frog (a rail-crossing structure) to allow the train to either 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 typical frogs, noise and vibration are generated when the wheels pass over the gap. Special trackwork, such as movable point or spring rail frogs, eliminates the gap between tracks at crossovers that causes noise and vibration at these locations.

Sound Transit is currently investigating the use of non-audible warnings for gated and ungated at-grade crossings. If non-audible warning devices are found to be viable, this option could be used to reduce or eliminate bell noise at specific crossings. Where practical, grade separation of at-grade light rail crossings would also be considered to eliminate the need for bells or other audible warning devices. If bells are used at gated crossings, the bells would be set at the minimum noise level that maintains a safe crossing. Finally, the use of acoustic bell shrouds would be examined during final design; the shrouds would direct the bell noise at gated crossings to the intersection.

When source mitigation measures or sound walls are infeasible or not entirely effective at reducing noise levels below the FTA impact criteria, then residential sound insulation would be evaluated and implemented at impacted properties where the existing building does not already achieve a sufficient exterior-to-interior reduction of noise levels. Many newer buildings, particularly in Downtown Bellevue, have good interior noise reduction and additional sound insulation may not be necessary.

Consistent with FTA methods and criteria, residential properties are considered "noise-sensitive" because people sleep there and "nighttime sensitivity to noise is assumed to be of utmost importance" (FTA, 2006). Accordingly, FTA analysis methods artificially increase measured existing noise and predicted project noise levels by 10 dBA (a perceived doubling of the noise level by most people) between 10:00 p.m. and 7:00 a.m. While noise measurements and impacts are analyzed at the exterior of residential properties, FTA methods clearly emphasize noise sensitivity for residential properties at night, because project noise could affect the ability of people to sleep. During the daytime hours, light rail noise levels are very similar to (in many cases less than) common noise levels in urban settings like Downtown Bellevue or along transportation corridors (like I-90, Bellevue Way, 112th Avenue SE, or I-405) where the predominant noise is from existing traffic (buses, trucks, and heavy traffic volumes). During those times of the day when outdoor uses are most frequent, noise from light rail would typically be less noticeable because of the higher ambient noise levels from traffic and other urban sources.

Traffic Noise Mitigation

Traffic noise impacts would be mitigated by sound walls, where determined to be reasonable and feasible.

For locations with residual traffic noise impacts caused by the project, sound insulation might also be considered by Sound Transit. Use of FHWA or WSDOT funds to insulate residences from sound for traffic noise abatement is allowed only in specific situations. Federal regulation 23 CFR 772.13(c)(6), and WSDOT and FHWA policies and procedures 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 sound wall is ineffective, unreasonable, and/or infeasible.

Segment A

In Segment A, the only potential noise impact resulting from *Preferred Alternative A1* would be near the transition from the Mount Baker Ridge Tunnel to the floating bridge structures. A light rail expansion joint would be required to allow for bridge movement; as a result, increased noise related to this joint could occur. If, after testing of the expansion joint prototype, the expansion joint near the Mount Baker Ridge Tunnel were determined to cause a noise impact, then mitigation would likely be a short, absorbent sound wall along the structure's side or absorbent material applied to the existing traffic safety barriers.

To reduce noise levels on the Rainier Station and Mercer Island Station platforms, Sound Transit would incorporate design measures to reduce freeway noise for patrons waiting at station platforms.

Segment B

In Segment B, mitigation measures under *Preferred Alternative B2M* when connecting to *Preferred Alternative C11A* would include a sound wall running continuously from the elevated section on I-90 to the retained cut section south of the Winters House along Bellevue Way SE. North of the 112th Avenue SE intersection, a sound wall is proposed at-grade, along the west side of the guideway, to just south of the Bellefield Residential Park Condominiums. A new sound wall would start along the west side of 112th Avenue SE and continue to the Segment C connection. The second sound wall would need to overlap with the first wall and would be effective at reducing traffic noise at the Bellefield Residential Park Condominiums. Openings in the wall would be required for vehicle and pedestrian access to the Bellefield Residential Park Condominiums, reducing the overall effectiveness. Supplemental sound insulation might also be required at six multifamily and four single-family residences.

Noise mitigation for *Preferred Alternative B2M* when connecting to *Preferred Alternative C9T* would be identical to *Preferred Alternative B2M* connecting to *Preferred Alternative C11A* south of 112th Avenue SE. A second wall would be installed just north of the 112th Avenue SE intersection, on the west side of the guideway, to just north of the SE 8th Station. Openings would be required for pedestrian and vehicle access at SE 15th Street and SE 8th Street. Special trackwork would also be used for the crossovers. Up to ten residences along 112th Avenue SE might also be provided with sound insulation to complete the noise mitigation measures if the sound walls are not effective at mitigating all impacts.

Impacts under *Preferred Alternative B2M* connecting to C9T – East Main Station Design Option would be similar to *Preferred Alternative B2M* connecting to *Preferred Alternative C9T*; therefore, the proposed mitigation would be similar to that described above for *Preferred Alternative B2M* to *Preferred Alternative C9T*.

For the other Segment B alternatives, a combination of sound walls and sound insulation would be used to mitigate impacts, except for Alternative B7, where all impacts could be mitigated with sound walls. In addition, all crossovers near noise-sensitive properties would include special trackwork to mitigate crossover-related impacts.

There are several locations along Bellevue Way under Alternative B1 where sound walls would block local access, and therefore sound insulation might be considered as the primary mitigation measure. Under Alternatives B2A, B2E, and B3 (including the B3 - 114th Extension Design Option), sound walls would be installed beginning at I-90 and continue past the South Bellevue Park-and-Ride. Under Alternative B2E, the walls would be continuous through to Segment C. Under Alternatives B2A and B3, the walls would end just south of 112th Avenue SE, and several homes in along 112th Avenue SE would be treated with sound insulation. Sound walls would also be used north of the 112th Avenue SE intersection, continuing to Segment C under Alternative B2A, and with the elevated structure for Alternative B3 and the B3 - 114th Extension Design Option. There would be three sound walls along Alternative B7: one along I-90 near Bellevue Way SE, one at the multifamily units north of I-90 along 118th

Avenue SE, and one at a multifamily community near the former BNSF Railway corridor I-405 crossing.

Segment C

In Segment C under *Preferred Alternative C11A* from *Preferred Alternative B2M*, mitigation 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. Under connections from B3, B3 - 114th Extension Design Option, or B7, sound walls along the elevated structure would be used for mitigation.

Noise mitigation under *Preferred Alternative C9T* from *Preferred Alternative B2M*, would be similar to that proposed for *Preferred Alternative C11A* and would also include a sound wall along the west side of the alignment beginning near SE 6th Street continuing to the tunnel transition. The wall would likely be located on a retaining wall to the west of the tracks, with final placement determined during final design. This sound wall, 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 at the crossover would also be used to mitigate impacts on the Coast Bellevue Hotel and Lake Bellevue Village Condominiums. Impacts located on SE 4th Street would be mitigated with a sound wall if possible, otherwise sound insulation would be employed for mitigation. Single- and multifamily units located on Main Street and NE 6th Street would be mitigated with sound insulation where necessary. Under connections from B3, B3 - 114th Extension Design Option, or B7, sound walls along the elevated structure would be used for mitigation.

For the other Segment C alternatives, impacts from the elevated portions could be mitigated with sound walls, while the areas with at-grade profiles could require sound insulation. As with Segment B, crossover related impacts would be mitigated with special trackwork.

There are several traffic noise impacts under Alternative C1T on Bellevue Way that would likely receive sound insulation because sound walls would not be effective due to openings for driveways. Sound insulation would also be used for multifamily units in the Downtown Bellevue area. Finally, east of I-405, a combination of sound walls and special trackwork would mitigate the remaining impacts at the Coast Bellevue Hotel and the Lake Bellevue Village Condominiums. This same mitigation would be used for all alternatives following the same general alignment east of I-405, including Alternatives C2T, C9A, and C14E. Even though Alternative C14E runs north of the Coast Bellevue Hotel, sound walls and special trackwork would still be employed.

South of Main Street, all Segment C alternative connections from Alternatives B2A or B2E along 112th Avenue SE would provide mitigation with a combination of sound walls and special trackwork, except Alternatives C2T and C3T from B2A, which would be in a tunnel in this area. For connections from Alternatives B3, B3 - 114th Extension Design Option, and B7, mitigation would include sound walls along the elevated structures.

Through Downtown Bellevue and the central business district, at-grade alternatives would use sound insulation where existing buildings do not provide sufficient sound reduction because there is no other form of mitigation available for the high-rise residences. Elevated guideways in the same area would use sound walls as the primary form of mitigation. North of Downtown Bellevue along NE 12th Street, under Alternatives C3T, C4A, and C8E, a combination of sound walls, where practical, and sound insulation would be the recommended mitigation measures.

Segment D

There are no anticipated noise impacts for *Preferred Alternative D2A* or the D2A design options, so no noise mitigation is proposed.

For Segment D alternatives that connect to Segment C on NE 12th Street (i.e., Alternatives D2E, D3, and D5), the mitigation for the Children's Hospital BCSC impact would be a sound wall along the north side of the tracks. The impact on the Pacific Northwest Ballet School under Alternative D2E would be reviewed during final design because there are no apparent exterior uses at this facility. Based on a site visit, the interior areas of the building are expected to have noise levels compatible with a school, and additional mitigation may not be warranted. Under Alternative D5, a sound wall would be required near the multifamily units south of SR 520 for both the NE 12th Street and the former BNSF Railway corridor connections to Segment C.

Segment E

Noise mitigation for *Preferred Alternative E2* and the E2 - Redmond Transit Center Design Option would include sound walls along the elevated structures from SR 520, near NE 67th Place, to the at-grade transition by Marymoor Park. All remaining noise impacts would occur at high-rise apartments on Cleveland Street and a hotel on NE 76th Street. If necessary, sound insulation along with special trackwork for the crossover would be used to mitigate these impacts. Under the E2 - Redmond Transit Center Design Option, one of the buildings impacted under *Preferred Alternative E2* would no longer have noise impacts, however, a separate new multifamily building on 161st Avenue NE north of Redmond Way is predicted to have noise impacts, and would receive sound insulation for noise mitigation if necessary.

Alternatives E1 and E4 would both have a sound wall along the at-grade and retained fill transitions to an elevated structure near NE 67th Place. There would also be sound walls along the elevated structures as they transition to the at-grade profiles. All other noise impacts, including those along the former BNSF Railway corridor, would be mitigated with sound insulation. All crossovers would receive special trackwork to keep crossover noise to a minimum.

When Segment E is funded and the design is advanced, Sound Transit will evaluate potential noise impacts again at Marymoor Park, based on the uses in place at that time, consistent with FTA methods and criteria.

Maintenance Facilities

There are three maintenance facility alternatives in Segment D. MF1 is located near several single-family residences, a hospital, and several office buildings. Of the three Segment D maintenance facility options, MF1 has the highest potential for noise impacts. Because noise impacts were identified at the Children's Hospital BCSC, mitigation measures were evaluated for the MF1 site. Noise impacts would be mitigated through the installation of a sound wall approximately 12 feet in height along the southern part of the site. The proposed sound wall would mitigate the noise impact at the hospital. MF2 and MF3 are in established industrial areas and are not anticipated to result in any exceedance of the City of Bellevue noise control ordinance. During the facility design process, mitigation measures (such as lubricating rails on curves and locating compressors and other noise-producing sources in buildings or in a part of the facility that would be shielded from the residences) could be included in the design to ensure compliance with the City of Bellevue noise control ordinance. If necessary, a sound wall could also be installed along the site perimeter to block noise from affecting nearby noise-sensitive properties.

There is one maintenance facility alternative in Segment E. MF5 is in an established industrial area and is not anticipated to result in any exceedance of the City of Redmond noise control ordinance. During the facility design process, if noise impacts are identified, mitigation measures could be included in the design to ensure compliance with the City of Redmond noise control ordinance.

Wheel Squeal

For curves of 600-foot radius or less, a trackside or vehicle-mounted lubrication system would be used to mitigate wheel squeal noise. For curves of 600- to 1,000-foot radius, the project would be designed to accommodate a lubrication system if wheel squeal occurs during operations.

4.7.5.2 Construction Noise Mitigation Measures

As previously described, several different jurisdictions are responsible for the regulation of construction noise. In addition, most daytime construction activities would be exempt from the noise control ordinances. When required, Sound Transit or its contractor would seek the appropriate noise variance from the local jurisdiction. Sound Transit would control nighttime construction noise levels by applying noise level limits, established through the variance process, and use 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 for nighttime or daytime work may include the following measures, as necessary, to meet required noise limits:

- Install construction site noise barrier wall by noise-sensitive receivers.
- During nighttime work, use smart backup alarms that automatically adjust or lower 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.

Pile driving might be required in Segments B, C, D, and E for construction of elevated profiles and bridges, and might also occur in areas of retained cuts in Segments C and D. To mitigate noise related to pile driving, the use of an augur to install the piles instead of a pile driver would greatly reduce the noise levels. If pile driving is necessary, the only mitigation would be to limit the time of day the activity can occur. Pile driving is not expected at most construction locations.

No segment-specific construction mitigation would be necessary for Segments A, B, or D during allowable daytime construction hours. In Segment C, at the tunnel staging areas near the Surrey Downs neighborhood and McCormick Park, a mitigation measure that could be used includes construction of temporary noise barriers adjacent to the construction staging area. Construction of Segment E alternatives along SR 520 near NE 51st Street could require moving existing sound walls and, if practical, these would be replaced early in project construction.

4.7.5.3 Vibration Mitigation During Operation

Vibration and groundborne noise impacts that exceed FTA criteria warrant mitigation when determined to be reasonable and feasible. The locations requiring mitigation in Table 4.7-8 would be refined during final design. At some locations, however, 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. Exhibits 4.7-7 through 4.7-11 identify these locations as residual vibration impacts. 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.

Options for mitigating vibration impacts include the following:

- Install ballast mats, which consist of a pad made of rubber or rubberlike 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 is strongly dependent on the vibration frequency content and the design and support of the mat.
- Use resilient fasteners 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 between the rail and concrete to provide greater vibration isolation than standard rail fasteners.
- Use tire-derived aggregate (TDA), which consists of shredded tires wrapped with filter fabric that is added to the base below the track ties.
- Install special trackwork, such as movable point or spring rail frogs, to eliminate the gap between tracks at crossovers that causes noise and vibration at these locations.
- Install floating slabs, which 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 reduce vibration 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.

In Segment A, approximately 1,900 feet of vibration mitigation would be required along the Mount Baker

Ridge 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 Alternative 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 might 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 C9T – East Main Station Design Option, the crossover located 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. Both *Preferred Alternatives C9T* and *C11A* identified 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 Alternative C9T – East Main Station Design Option, the impacts and required mitigation would be identical to that described above under *Preferred Alternative C9T*, except for the five single-family residences on 112th Avenue SE, which would not have vibration impacts under 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 two single-family residences, 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 11 single-family residences. All of the impacts are located on top of the tunnel south of Main Street. Under the Alternative C3T connection to Alternatives B2E, B3 or B7, only one single-family residence, on the south side of Main Street, is identified as having a groundborne noise impact. Alternative C4A would require vibration mitigation for six multifamily residences and one single-family residence, regardless of the connection options. The multifamily noise 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.

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.

4.7.5.4 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 alternative 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 construction, 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
  - Photograph and inventory 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.