

Attachment E3
Vibration Technical Memorandum

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TECHNICAL MEMORANDUM

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Date: March 4, 2013

Subject: Vibration Impact Assessment of Cost-Savings Options for the Sound Transit Light Rail Transit East Link Extension – Shift Bellevue Way, 112th Road Over Rail, Optimized Selected Project and NE 6th Station

Reference: HMMH Job # 301931.002

The Sound Transit *East Link Light Rail Transit Project Final Environmental Impact Statement*¹ (Final EIS) was completed in July 2011 with the Federal Transit Administration (FTA) and Federal Highway Administration (FHWA) issuing their Records of Decision in November 2011. Since the Final EIS was completed, the City of Bellevue and Sound Transit entered into a Memorandum of Understanding (MOU), which included a review of track alignments along 112th Avenue SE and a commitment to analyze cost-saving options. This technical memorandum presents the results of the vibration analysis of potential impacts and mitigation for the following proposed project refinements:

- **Shift Bellevue Way Option:** The Shift Bellevue Way Option would shift Bellevue Way SE to the west to facilitate a track alignment east of the roadway. With this option, the track would transition from elevated guideway at the South Bellevue Station to at-grade as it heads north. The near track centerline would be more than 50 feet at-grade from the Winters House, a vibration-sensitive receptor. This option would realign Bellevue Way SE closer to residences on 109th Avenue SE where the closest receptors would be approximately 30 feet from the near lane of vehicular travel. The City of Bellevue may construct a high-occupancy vehicle (HOV) lane on the east side of the southbound lanes, which would widen the overall width of Bellevue Way. Light rail vehicle (LRV) speeds along this segment would be up to 45 mph from South Bellevue Station to 112th Avenue SE.
- **112th Road Over Rail Option:** The 112th Road Over Rail Option would raise 112th Avenue SE near SE 15th Street over an at-grade track alignment. The tracks would be on the west side of 112th Avenue SE until the East Main Station and then transition to a tunnel alignment at Main Street. LRV speeds along this segment would be up to 45 mph between Bellevue Way SE and East Main Station and up to 25 mph between East Main Station and Main Street. The following suboptions for access at SE 4th Street are also evaluated to provide access to the Surrey Downs neighborhood:
 - **SE 4th Emergency Access Suboption:** This suboption would close access at SE 4th Street except for emergency vehicles. This suboption also includes the Bellefield Access Variation to create an access road between Bellefield Park Drive and 111th Place SE.
 - **SE 4th Open Suboption:** This suboption would allow vehicle access to SE 4th Street with an at-grade light rail crossing, including pedestrian bells and gates.

¹ Sound Transit, FTA, and WSDOT. 2011. *East Link Light Rail Transit Project Final Environmental Impact Statement*. Prepared by Central Puget Sound Regional Transit Authority, U.S. Department of Transportation Federal Transit Administration, and the Washington State Department of Transportation. June.

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- **Rail Under SE 4th Suboption:** This Suboption would lower the light rail into a trench below SE 4th Street.
- **Optimized Selected Alternative Station Option:** The Optimized Selected Alternative Station Option would shift the location of the northern entrance to the Bellevue Transit Center Station to the western lane of 110th Avenue NE at NE 6th Street. This option would include horizontal and vertical changes to the track alignment and design refinements to the Bellevue Transit Center Station.
- **NE 6th Station Option:** The NE 6th Station Option would include changes to the horizontal and vertical alignments and would relocate Bellevue Transit Center Station. This option would relocate the Bellevue Transit Center Station to south of NE 6th Street and the track alignment would remain south of NE 6th Street as it goes over Interstate 405 (I-405). A crossover track is proposed between the Station and I-405.

Background information including fundamentals, impact criteria, and methodology for assessing light rail vibration and groundborne noise impact can be found in East Link Final EIS, Section 4.7.¹

Summary of Potential Vibration and Groundborne Noise Impact for All Options

There would be no vibration impact for the Shift Bellevue Way Option with or without HOV lane and no need for mitigation. There would be potential vibration impact at ten properties (nine single-family residences and the King County Courthouse, if it remains) for the 112th Road Over Rail SE 4th and Rail Under SE 4th Suboptions and impact at nine properties (eight single-family residences and the King County Courthouse) for the 112th Road Over Rail SE 4th Emergency Access Suboption. However, under the new Light Rail Overlay District adopted by the City of Bellevue in February of 2013, the occupants of each of the eight single-family residences affected can elect to be acquired, which would remove the potential vibration impacts for those residents.

For the Optimized Selected Alternative Station Option, there would be potential vibration impact at the Coast Bellevue Hotel and ground-borne noise impact at a multi-family residence, a mixed-use building and the Meydenbauer Center. For the NE 6th Station Option, there would be potential ground-borne noise impact at a multi-family residence and a mixed-use building. Table 1 summarizes potential vibration and groundborne noise impacts for all cost-savings options, and Exhibits E3-1 through E3-4 depicts the vibration impacts graphically for all the potential refinements.

Table 1. Summary of Potential Vibration and Groundborne Noise Impact for Options

Resource	Number of Impacts Prior to Mitigation (Buildings)				
	Shift Bellevue Way Option—with or without City of Bellevue HOV lane	112th Road Over Rail Option		Downtown Bellevue Options	
		SE 4th Open and Rail Under SE 4th Suboptions	SE 4th Emergency Access Suboption	Optimized Selected Alternative Station Option	NE 6th Station Option
Vibration	0	10	1 to 9*	1	0
Groundborne noise	n/a	n/a	n/a	3	2
n/a not applicable					
*Range is due to potential for acquiring effected residences.					

Shift Bellevue Way Option without City of Bellevue HOV Lane Vibration Assessment

The study area that has been assessed for potential vibration impact for the Shift Bellevue Way Option extends from the South Bellevue Station to 112th Avenue SE. LRV speeds along this segment would be up to 45 mph. Vibration has been projected based on line-source transfer mobility measurements conducted at Site V-2 (South Bellevue Park-and-Ride Lot). Sensitive receptors in this area include single-

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family homes on the west side of Bellevue Way SE and the Winters House on the east side. Single-family homes on the west would generally be farther than 100 feet from the new track alignment, and the Winters House would be 50 feet from the near track centerline.

There would be no vibration impact for this option. Vibration levels would be 52 vibration decibels (VdB) or less at single-family residences, and this is below the impact criterion of 72 VdB for Category 2 uses. Vibration levels would be 70 VdB at the Winters House, and this is below the impact criterion of 78 VdB for Category 3 uses. Table 2 presents potential groundborne vibration detailed vibration impact results for all receptors for this option.

Table 2. Potential Vibration Impact for Shift Bellevue Way Option with or without City of Bellevue HOV Lane

Vibration Sensitive Receptor Location (Map ID)	Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Vibration Impact Criterion (VdB re: 1 µ-in/sec)	Maximum Vibration Velocity in Any 1/3-Octave Band from 6.3 to 400 Hz (VdB re: 1 µ-in/sec)	1/3-Octave Band (Hz) of Maximum Vibration	No. of Vibration Impacts Prior to Mitigation (Buildings)	No. of Vibration Impacts After Mitigation (Buildings)
B2160- SFR	267	20	Elevated	72	31	16	0	0
B2183- SFR	289	25	Elevated	72	32	16	0	0
B2193- SFR	217	30	Elevated	72	35	16	0	0
B2210- SFR	198	30	Elevated	72	36	16	0	0
B2225- SFR	189	35	Elevated	72	37	16	0	0
B2235- SFR	177	40	Elevated	72	39	16	0	0
B2246- SFR	151	40	Elevated	72	39	16	0	0
B2252- SFR	162	40	Elevated	72	39	16	0	0
B2265- SFR	200	45	Elevated	72	39	16	0	0
B2275- SFR	160	45	Elevated	72	40	16	0	0
B2284- SFR	150	45	Elevated	72	40	16	0	0
B2288- SFR	155	45	Elevated	72	40	16	0	0
B2296- SFR	145	45	At-grade	72	50	16	0	0
B2300- SFR	108	45	At-grade	72	52	16	0	0
B2306- SFR	118	45	At-grade	72	51	16	0	0
B2317- SFR	200	45	At-grade	72	49	16	0	0
B2326- SFR	205	45	At-grade	72	49	16	0	0
B2333- SFR	185	45	At-grade	72	49	16	0	0
B2345- SFR	185	45	At-grade	72	49	16	0	0
B2351- SFR	215	45	At-grade	72	49	16	0	0
B2361- SFR	142	45	At-grade	72	51	16	0	0
B2358 - Winters House	50	45	At-grade	78	70	20	0	0
B2407 –SFR	110	45	At-grade	72	52	16	0	0
B2413 –SFR	95	45	At-grade	72	52	16	0	0
B2421 -SFR	105	45	At-grade	72	52	16	0	0
B3001- SFR	130	45	At-grade	72	51	16	0	0
Total Number of Impacts							0	0
Notes: The following building parcels would be acquired as part of this option: B2375, B2384, and B2397. (µ-in/sec) micro-inch per second; (mph) miles per hour; (Hz) hertz; (VdB) vibration decibel; (SFR) single-family residence								

Public comments were received during public review of the Cost Savings Options in fall 2012 regarding vibration from vehicular traffic on Bellevue Way SE. Vibration from rubber-tired vehicles is rare and there are no applicable criteria from the FHWA or local jurisdictions for vibration from vehicular traffic.

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Where vibration from vehicular traffic is noticeable it is usually due to road conditions (potholes, rough surface, expansion joints) which are under control of the City. In some instances airborne noise from vehicles may cause a structure to vibrate or the vibration frequencies from heavy vehicles can create a resonance with a structure which may also cause vibration within the building. Realigning Bellevue Way SE would move the road closer to residences on 109th Avenue SE. With the shifted roadway the closest residences would be approximately 40 feet from the near lane of travel with a retaining wall between the homes and the roadway. Depending on the road surface and ground conditions vibration, from vehicular traffic could increase but is not expected to adversely affect residences.

Shift Bellevue Way Option with City of Bellevue HOV Lane Vibration Assessment

The light rail alignment would not change with the addition of the HOV lane, therefore, potential for vibration levels from the light rail would not change from the Shift Bellevue Way Option. There would also be no vibration impact from rubber-tired vehicles with this option. Vibration impact results for all receptors for this cost-savings option are presented in Table 2.

Realigning Bellevue Way SE would move the road closer to residences on 109th Avenue SE with the HOV lane than the without HOV lane option. The closest receptors would be approximately 30 feet from the near lane of travel with a retaining wall between the homes and the roadway. Most buses would be expected to travel in the center HOV lane, so they would typically be farther from the residences than with the non-HOV option and would generate less vibration. Depending on the road surface and ground conditions, vibration from vehicular traffic could increase but is not expected to adversely affect residences.

112th Road Over Rail Options Vibration Assessment

The study area that has been assessed for potential vibration impacts for the 112th Road Over Rail Options extends from Bellevue Way SE to Main Street. LRV speeds along this segment would be up to 45 mph between Bellevue Way SE and East Main Station and up to 25 mph between East Main Station and Main Street. LRV speeds would be less than maximum speeds as trains decelerate into and accelerate from East Main Station at a typical rate for transit operations of 1.5 miles per hour per second (mphps).

Vibration has been projected based on line-source transfer mobility measurements conducted at Site V-3 (King County Courthouse parking lot). Sensitive receptors include single-family homes and the King County Courthouse (should it remain) on the west side of 112th Avenue SE in Segments B and C.

For the SE 4th Open and Rail Under SE 4th Suboptions, there would be potential vibration impact at eight residences on 111th Place SE (Parcels B4063, B4084, B5000, B5006, B5013, B5021, B5026, and B5036), one impact at a single-family residence on 110th Place SE and impact at the King County Courthouse (C2000) due to their proximity to the proposed alignment and the speed of the trains. For the SE 4th Emergency Access Suboption with the Bellefield Access Variation, Parcel B4063 would be acquired to provide an access road between Bellefield Park Drive and 111th Place SE. Therefore, for this Suboption, there would be potential vibration impact at seven residences on 111th Place SE, one residence on 110th Place SE and the King County Courthouse. Prior to mitigation, vibration levels would be up to 87 VdB at the residences and 82 VdB at the courthouse, and these levels would exceed the criteria of 72 VdB for residences and 78 VdB for institutional land use, respectively. However, under the new Light Rail Overlay District adopted by the City of Bellevue in February of 2013, the occupants of each of the single-family residences affected can elect to be acquired, which would remove the potential vibration impacts for those residents. Table 3 presents the potential vibration impact results for all receptors for the 112th Road Over Rail Options.

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With mitigation, such as ballast mats or resilient rail fasteners, these potential impacts would be mitigated. Although a vibration impact has been identified at the King County Courthouse, the courthouse is currently planned for relocation which would remove the impact.

Table 3. Potential Vibration Impact for 112th Road Over Rail Options

Vibration Sensitive Receptor Location (Map ID)	Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Vibration Impact Criterion (VdB re: 1 μ -in/sec)	Maximum Vibration Velocity in any 1/3-octave band from 6.3 to 400 Hz (VdB re: 1 μ -in/sec)	1/3-Octave Band (Hz) of Maximum Vibration	No. of Vibration Impacts Prior to Mitigation (Buildings)	No. of Vibration Impacts After Mitigation (Buildings)
B3010- SFR	161	45	At-grade	72	60	63	0	0
B4001- SFR	176	45	At-grade	72	59	63	0	0
B4005- SFR	232	45	At-grade	72	56	50	0	0
B4007- SFR	251	45	At-grade	72	55	50	0	0
B4010- SFR	205	45	At-grade	72	57	50	0	0
B4017- SFR	233	45	At-grade	72	56	50	0	0
B4050 – MFR	97	45	At-grade	72	68	63	0	0
B4063 – SFR*	40	45	At-grade	72	83	80	1	0
B4079 – SFR	87	45	At-grade	72	70	63	0	0
B4084 – SFR	67	45	At-grade	72	74	80	1	0
B5000 – SFR	32	45	At-grade	72	87	80	1	0
B5006 – SFR	40	45	At-grade	72	83	80	1	0
B5013 – SFR	70	45	At-grade	72	73	80	1	0
B5021 – SFR	56	45	At-grade	72	77	80	1	0
B5026 – SFR	63	45	At-grade	72	75	80	1	0
B5036 – SFR	68	45	At-grade	72	73	80	1	0
C2000 – Courthouse	41	45	At-grade ¹	78	82	80	1	0
C4003 – SFR	98	40	At-grade ¹	72	69	63	0	0
C4005 – SFR	154	35	At-grade ¹	72	59	63	0	0
C4007 – SFR	138	35	At-grade ¹	72	60	63	0	0
C4009 – SFR	122	32	At-grade ¹	72	61	63	0	0
C4011 – SFR	112	30	At-grade ¹	72	62	63	0	0
C4015 – SFR	110	25	At-grade ¹	72	61	63	0	0
C4019 – SFR	88	20	At-grade ¹	72	62	63	0	0
C4024 – SFR	98	10	At-grade ¹	72	55	63	0	0
C4028 – SFR	98	10	At-grade ¹	72	55	63	0	0
C4032 – SFR	100	10	At-grade ¹	72	64	63	0	0
C4036- SFR	127	15	At-grade	72	54	63	0	0
C4040- SFR	119	20	At-grade	72	58	63	0	0
C4041- SFR	135	20	At-grade	72	56	63	0	0
C4042- SFR	114	25	At-grade	72	60	63	0	0
C4044- SFR	95	25	At-grade	72	63	63	0	0
C5002- SFR	169	25	At-grade	72	54	63	0	0
C5010- SFR	90	25	At-grade	72	64	63	0	0
C5018- SFR	38	25	At-grade	72	78	80	1	0
Total Number of Impacts: SE 4th Open and Rail Under SE 4th Suboptions							10	0
Total Number of Impacts: SE 4th Emergency Access Suboption with Bellefield Access Variation							9	0

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Table 3. Potential Vibration Impact for 112th Road Over Rail Options

Vibration Sensitive Receptor Location (Map ID)	Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Vibration Impact Criterion (VdB re: 1 μ -in/sec)	Maximum Vibration Velocity in any 1/3-octave band from 6.3 to 400 Hz (VdB re: 1 μ -in/sec)	1/3-Octave Band (Hz) of Maximum Vibration	No. of Vibration Impacts Prior to Mitigation (Buildings)	No. of Vibration Impacts After Mitigation (Buildings)
<p>Notes:</p> <p>The following building parcels would be acquired as part of the project for all 112th Road Over Rail Options: B4067, B4074, B5039, C4000, C2001, C4002, C4014, C4037, C4045, C5003, C5006, C5009, C5004, C5007, C5008, C50012, and C5019.</p> <p>*Parcel B4063 would be acquired for the Option with the Bellefield Access Variation which creates an access road between Bellefield Park Drive and 111th Place SE.</p> <p>¹Track alignment is in trench for Rail Under SE 4th Option</p> <p>(μ-in/sec) micro-inch per second; (mph) miles per hour; (Hz) hertz; (VdB) vibration decibel; (SFR) single-family residence; (MFR) multifamily residence</p>								

Optimized Selected Alternative Station and NE 6th Station Options Vibration Assessment

The study area that has been assessed for potential vibration impact for these cost-savings options extends from Main Street to NE 12th Street. LRV speeds along this segment would be up to 25 mph along 110th Avenue NE and up to 35 mph between NE 6th Street and NE 12th Street. LRV speeds would be less than the maximum operating speed as trains decelerate into and accelerate from Downtown Station and into and out of the track curve at 110th Avenue NE and NE 6th Street (speed limit of 10 mph). LRV speeds at specific receptors are based on a typical acceleration and deceleration rate for transit operations of 1.5 mph/s.

Vibration has been projected based on line-source transfer mobility measurements conducted at Site V-3 (King County Courthouse parking lot) for at-grade receptors between the East Main Station and the tunnel portal and for receptors along the BNSF corridor; Site V-4a (borehole measurement at 50-foot depth on NE 12th Street between 108th Avenue NE and 110th Avenue NE) for receptors along the tunnel section; Site V-12 for the Meydenbauer Center and Site V-13 (NE 12th Street) for the Coast Bellevue Hotel. Sensitive receptors include multifamily residences, a planned hotel on 110th Avenue NE between NE 2nd and 3rd Streets, Bellevue City Hall, the Meydenbauer Center Theatre, the Coast Bellevue Hotel a medical facility and schools.

Vibration projections and groundborne noise projections for the Optimized Selected Alternative Station Option are presented in Table 4 and 5, respectively. Vibration projections and groundborne noise projections for the NE 6th Station Option are presented in Table 6 and 7, respectively.

For the Optimized Selected Alternative, there would be a potential vibration impact at the Coast Bellevue Hotel as reported in the FEIS. Potential vibration impact at the Coast Bellevue Hotel is due to the proximity and speed of the trains and the presence of a crossover. Typical vibration mitigation, such as ballast mats or resilient rail fasteners and engineered special trackwork such as flange-bearing or spring-rail frogs, might not be effective at reducing the vibration level below the FTA criterion. Therefore, this location has been considered to be a residual vibration impact. Vibration levels at the Coast Bellevue Hotel were projected based on measurements at Site V-13, on NE 12th Street which is approximately 0.5 mile from the sensitive receptor. During final design of the project, vibration propagation measurements should be conducted in closer proximity to this sensitive receptor to provide a more accurate assessment of the future vibration levels, what specific vibration mitigation measures are necessary, and whether there might be residual impact from the project.

For the Optimized Selected Alternative, there would be potential ground-borne noise impact at a multifamily residence (C5021), a mixed-use building (C8024) and the Meydenbauer Center (C9005). With

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track vibration isolation, such as ballast mats or resilient rail fasteners, the potential ground-borne noise impact at these properties would be mitigated.

For the NE 6th Station Option, there would be no potential vibration impact and potential ground-borne noise impact at a multi-family residence (C5021) and a mixed-use building (C8024). With track vibration isolation, such as ballast mats or resilient rail fasteners, the potential ground-borne noise impact at these properties would be mitigated. There would be no vibration impact at the Coast Bellevue Hotel and no groundborne noise impact at the Meydenbauer Center Theatre due to realigning the tracks farther away from these receptors.

Table 4. Potential Vibration Impact for Optimized Selected Alternative Station Option

Vibration Sensitive Receptor Location (Parcel Number)	Slant Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Vibration Impact Criterion (VdB re: 1 μ -in/sec)	Maximum Vibration Velocity in any 1/3-octave band from 6.3 to 400 Hz (VdB re: 1 μ -in/sec)	1/3-octave band (Hz) of Maximum Vibration	No. of Vibration Impacts Prior to Mitigation (Buildings)	No. of Vibration Impacts After Mitigation (Buildings)
C5021 – MFR	49	25	Tunnel	72	51	80	0	0
C8022 - Planned Hotel	75 ^a	25	Tunnel	72	47	80	0	0
C6015 – MFR	88	25	Tunnel	72	45	80	0	0
C8024 – Mixed Use	49	20	Tunnel	72	49	80	0	0
C8026 – City Hall	49	20	Tunnel	78	49	80	0	0
C9005 – Meydenbauer Center	50	20	Tunnel/elevated	72	65	50	0	0
C10001 – Coast Bellevue Hotel	22	35	Elevated	72	96 ^b	63	1	1
C10045- MFR	132	35	At-grade	72	61	63	0	0
C10050- School	71	35	At-grade	78	71	80	0	0
C10052- Medical	120	35	At-grade	78	62	63	0	0
D1205- School	50	30	At-grade	78	63	63	0	0
Total Number of Impacts							1	1
Notes: The following building parcels are not sensitive to vibration per FTA categories: C5027, C5028, C5036, C8001, C8003, C8010, C8014, C8016, C8017, C8020, C8025, C8027, C8031, and C10000. ^a Setback of hotel based on rendering of building in City of Bellevue Major Projects ^b Vibration projections include contributions from special trackwork (μ -in/sec) micro-inch per second; (mph) miles per hour; (Hz) hertz; (VdB) vibration decibel; (SFR) single-family residence; (MFR) multifamily residence; (Mixed Use) commercial on ground level and residential on upper floors								

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Table 5. Potential Groundborne Noise Impact for Optimized Selected Alternative Station Option

Groundborne Noise Sensitive Receptor Location (Parcel Number)	Slant Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Groundborne Noise Impact Criterion (dBA)	Groundborne Noise Level (dBA)	No. of Groundborne Noise Impacts Prior to Mitigation (Buildings)	No. of Groundborne Noise Impacts After Mitigation (Buildings)
C5021 – MFR	49	25	Tunnel	35	39	1	0
C8022 – Planned Hotel	75	25	Tunnel	35	34	0	0
C6015 – MFR	88	25	Tunnel	35	33	0	0
C8024 – Mixed Use	49	20	Tunnel	35	37	1	0
C8026 – City Hall	49	20	Tunnel	40	37	0	0
C9005 – Meydenbauer Center	50	20	Tunnel/elevated	35	36	1	0
Total Number of Impacts						3	0
Notes: (dBA) decibel on an A-weighted scale; (mph) miles per hour; (SFR) single-family residence; (MFR) multifamily residence; (Mixed Use) commercial on ground level and residential on upper floors							

Table 6. Potential Vibration Impact for NE 6th Station Option

Vibration Sensitive Receptor Location (Parcel Number)	Slant Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Vibration Impact Criterion (VdB re: 1 µ-in/sec)	Maximum Vibration Velocity in any 1/3-Octave Band from 6.3 to 400 Hz (VdB re: 1 µ-in/sec)	1/3-Octave Band (Hz) of Maximum Vibration	No. of Vibration Impacts Prior to Mitigation (Buildings)	No. of Vibration Impacts After Mitigation (Buildings)
C5021 – MFR	49	25	Tunnel	72	51	80	0	0
C8022 – Planned Hotel	87	25	Tunnel	72	46	80	0	0
C6015 – MFR	88	25	Tunnel	72	45	80	0	0
C8024 – Mixed Use	60	25	Tunnel	72	49	80	0	0
C8026 – City Hall	60	20	Tunnel	78	47	80	0	0
C9005 – Meydenbauer Center	130	10	Tunnel/elevated	72	43	50	0	0
C10001 – Coast Bellevue Hotel	165	35	Elevated	72	61 ^a	50	0	0
C10045- MFR	132	35	At-grade	72	61	63	0	0
C10050- School	71	35	At-grade	78	71	80	0	0
C10052- Medical	120	35	At-grade	78	62	63	0	0
D1205- School	50	30	At-grade	78	63	63	0	0
Total Number of Impacts							0	0
Notes: The following building parcels are not sensitive to vibration per FTA categories: C5027, C5028, C5036, C8001, C8003, C8010, C8014, C8016, C8017, C8020, C8024, C8025, C8031, and C10001. ^a Vibration projections include contributions from special trackwork (µ-in/sec) micro-inch per second; (mph) miles per hour; (Hz) hertz; (VdB) vibration decibel; (SFR) single-family residence; (MFR) multifamily residence; (Mixed Use) commercial on ground level and residential on upper floors								

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Table 7. Potential Groundborne Noise Impact for NE 6th Station Option

Groundborne Noise Sensitive Receptor Location (Map ID)	Slant Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Groundborne Noise Impact Criterion (dBA)	Groundborne Noise Level (dBA)	No. of Groundborne Noise Impacts Prior to Mitigation (Buildings)	No. of Groundborne Noise Impacts After Mitigation (Buildings)
C5021 – MFR	49	25	Tunnel	35	39	1	0
C8022 - Planned Hotel	87	25	Tunnel	35	33	0	0
C6015 – MFR	88	25	Tunnel	35	33	0	0
C8024 – Mixed Use	60	25	Tunnel	35	37	1	0
C8026 - City Hall	60	20	Tunnel	40	35	0	0
C9005 – Meydenbauer Center	130	10	Tunnel	35	20	0	0
Total Number of Impacts						2	0
Notes: (dBA) decibel on an A-weighted scale; (mph) miles per hour; (SFR) single-family residence; (MFR) multifamily residence; (Mixed Use) commercial on ground level and residential on upper floors							

Segment D

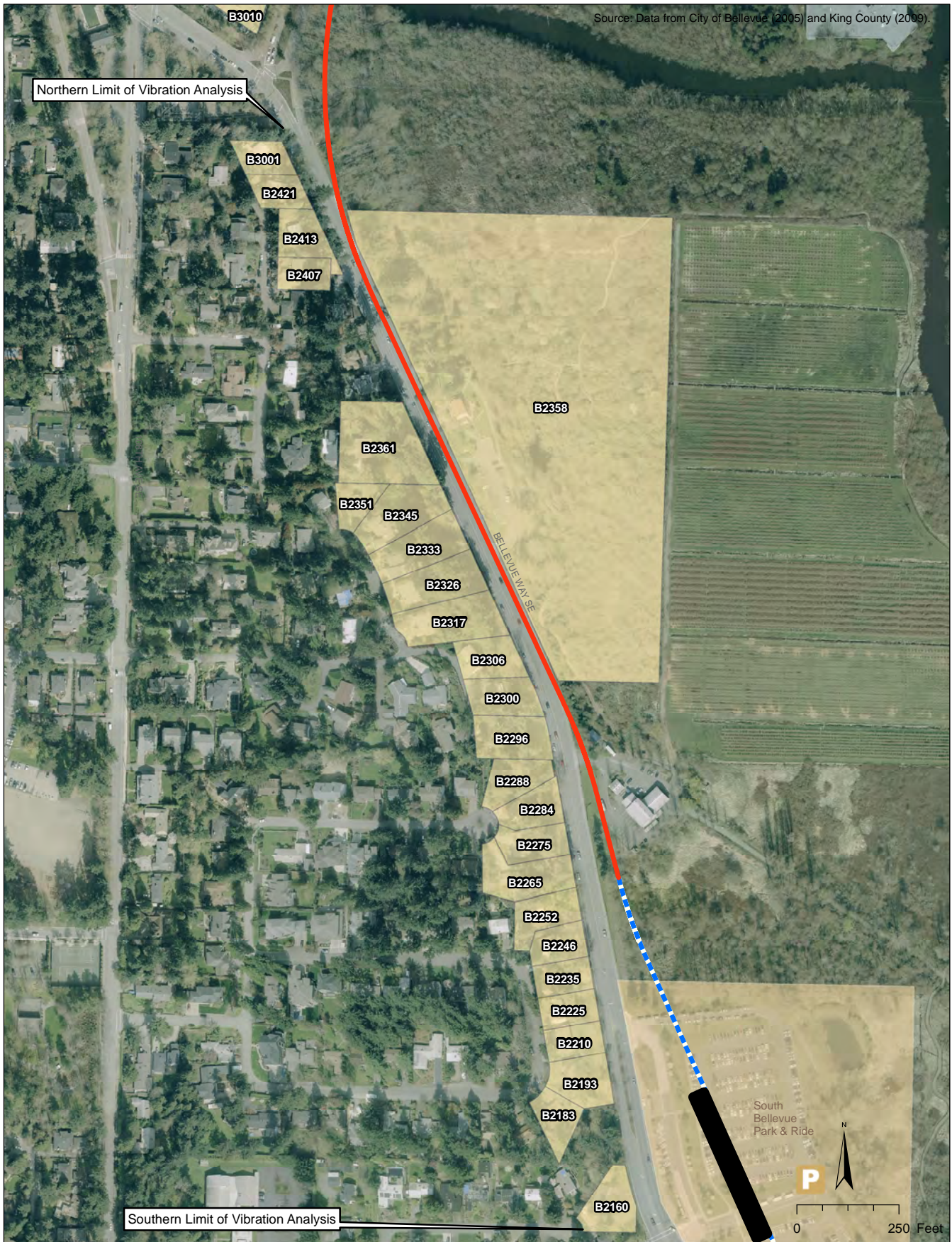
The study area of Segment D extends from NE 12th Street to SR 520. LRV speeds along this segment would be up to 30 mph. Vibration has been projected based on line-source transfer mobility measurements conducted at Site V-6 (Highland Park). Vibration projections for this option are presented in Table 8. There would be no vibration impact in Segment D.

Table 8. Potential Vibration Impact for Segment D

Vibration Sensitive Receptor Location (Parcel Number)	Slant Distance to Track Centerline (feet)	Train Speed (mph)	Track Type	Vibration Impact Criterion (VdB re: 1 μ -in/sec)	Maximum Vibration Velocity in any 1/3-octave band from 6.3 to 400 Hz (VdB re: 1 μ -in/sec)	1/3-octave band (Hz) of Maximum Vibration	No. of Vibration Impacts Prior to Mitigation (Buildings)	No. of Vibration Impacts After Mitigation (Buildings)
D1205- School	50	30	At-grade	78	63	63	0	0
Total Number of Impacts							0	0
Notes: (μ -in/sec) micro-inch per second; (mph) miles per hour; (Hz) hertz; (VdB) vibration decibel								

Potential Construction Vibration Impact

The major sources of construction vibration include impact pile-driving, augured piling, and vibratory rollers. The project activity with the greatest potential to damage buildings is impact pile-driving at locations within 25 feet of structures. Although the method for constructing column supports for elevated guideway segments has not yet been determined, there would be no buildings (that are not being acquired) within 25 feet of the proposed columns; therefore, potential structural damage is not expected.



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

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

- Vibration Impact Prior to Mitigation
- No Vibration or Groundborne Noise Impact

- ✕ Crossover Location

Exhibit E.3-1
Vibration Impacts, Shift
Bellevue Way
 SEPA Addendum
 East Link Project

Source: Data from City of Bellevue (2005) and King County (2009).

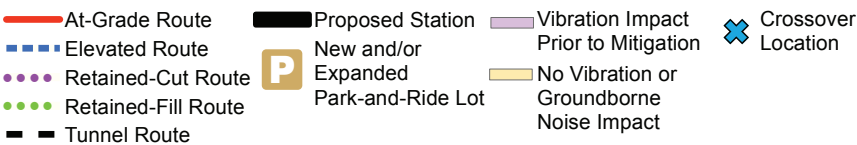
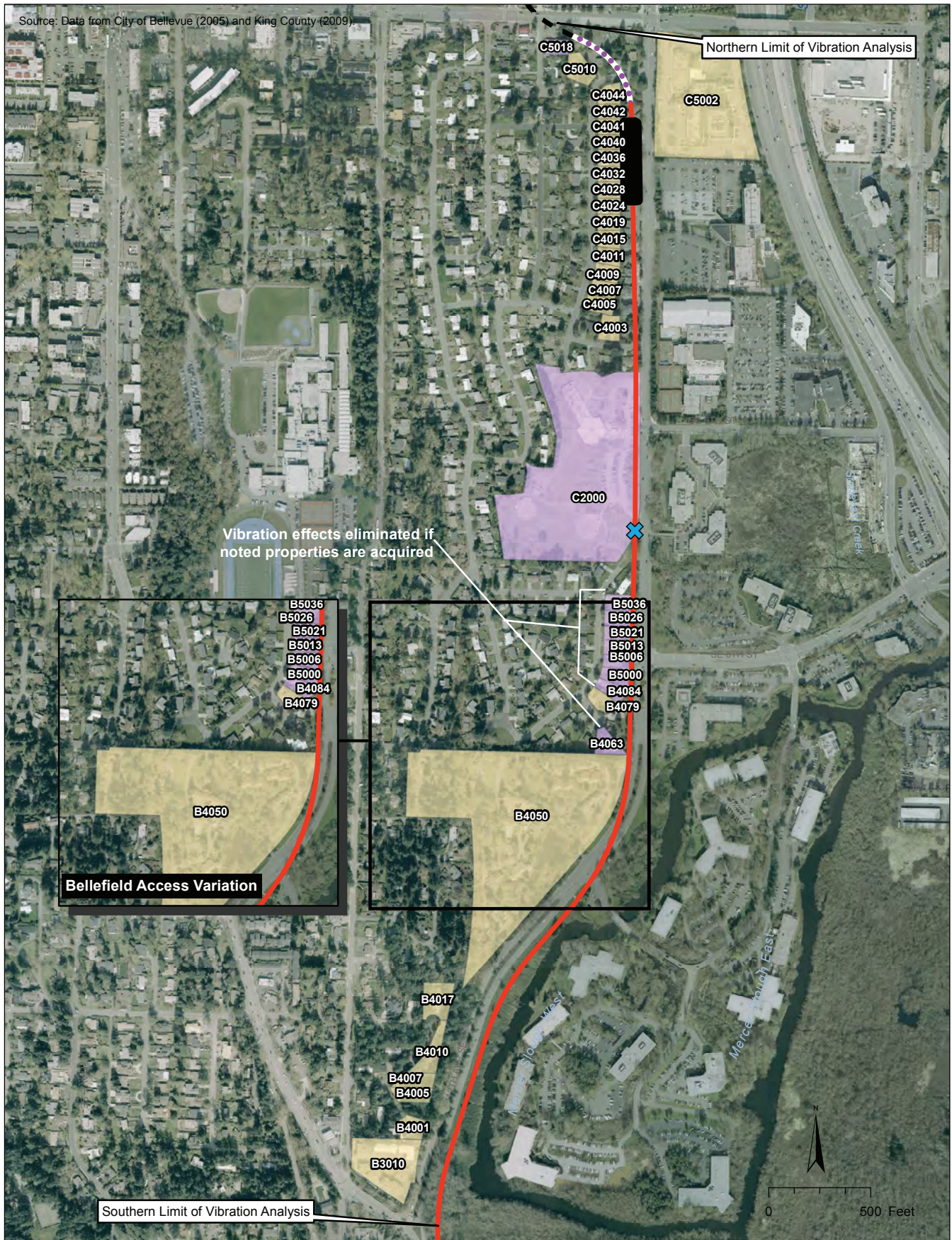


Exhibit E.3-2
Vibration Impacts, 112th Road Over Rail
 SEPA Addendum
 East Link Project



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

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

- Vibration Impact Prior to Mitigation
- Groundborne Impact Prior to Mitigation
- No Vibration or Groundborne Noise Impact

- Crossover Location

Exhibit E.3-3
Vibration Impacts,
NE 6th Station
 SEPA Addendum
 East Link Project



- | | | | |
|-----------------------|--|--|----------------------|
| — At-Grade Route | ■ Proposed Station | ■ Groundborne Impact Prior to Mitigation | ✕ Crossover Location |
| — Elevated Route | ■ Vibration Impact Prior to Mitigation | ■ No Vibration or Groundborne Noise Impact | |
| — Retained-Cut Route | ■ Vibration Impact Prior to and After Mitigation | | |
| — Retained-Fill Route | | | |
| — Tunnel Route | | | |

Exhibit E.3-4
**Vibration Impacts, Optimized
 Selected Alternative Station Option**
 SEPA Addendum
 East Link Project