LIGHT RAIL PERMITTING
ADVISORY COMMITTEE MEETING

Date: May 29, 2015

To: Light Rail Permitting Advisory Committee

From: Matthews Jackson (425-452-2729, mjackson@bellevuewa.gov)
Carol Helland (425-452-2724, chelland@bellevuewa.gov)
Liaisons to the Advisory Committee
Development Services Department

Subject: June 3, 2015 Advisory Committee Meeting

Enclosed you will find an agenda packet for your 33nd Advisory Committee meeting next Wednesday, June 3. We will begin at 3:30 p.m. in Room 1E-113 at Bellevue City Hall. The meeting will be chaired by Doug Mathews and Marcelle Van Houten.

This packet includes:

1. Agenda
2. May 6 Meeting Minutes
3. City PowerPoint Presentation from May 20
4. Sound Transit Advise Response
5. Central Bellevue Noise Study

We will have hard copies of all electronic packet materials for you on June 3rd. Materials will also be posted on the City's project web site at http://www.bellevuewa.gov/light-rail-permitting-cac.htm.

Please let us know if you have any questions prior to our meeting. We look forward to seeing you next week.

LIGHT RAIL PERMITTING ADVISORY COMMITTEE MEETING

Wednesday, June 3, 2015
3:30 p.m. – 5:30 pm • Room 1E-113
Bellevue City Hall • 450 110th Ave NE

AGENDA

3:30 p.m.	1.	Call to Order, Approval of Agenda, Approval of May 6th and 20th Meeting Minutes *Committee Co-Chairs Mathews and Van Houten*
3:40 p.m.	2.	Public Comment *Limit to 3 minutes per person*
4:00 p.m.	3.	East Main Station Elements *Sound Transit*
4:30 p.m.	4.	Central Bellevue Corridor Landscaping *Matthews Jackson*
5:00 p.m.	5.	Central Bellevue Noise Report *Sound Transit*
5:20 p.m.	6.	Public Comment *Limit to 3 minutes per person*
5:30 p.m.	7.	Adjourn

Project web site located at: http://www.bellevuewa.gov/light-rail-permitting-cac.htm . For additional information, please contact the Light Rail Permitting Liaisons: Matthews Jackson (425-452-2729, mjackson@bellevuewa.gov) or Carol Helland (425-452-2724, chelland@bellevuewa.gov). Meeting room is wheelchair accessible. American Sign Language (ASL) interpretation available upon request. Please call at least 48 hours in advance. Assistance for the hearing impaired: dial 711 (TR).

CITY OF BELLEVUE
LIGHT RAIL PERMITTING
ADVISORY COMMITTEE
MEETING MINUTES

May 6, 2015 | Bellevue City Hall
3:30 p.m. | Room 1E-113

MEMBERS PRESENT: Doug Mathews, Marcelle Van Houten, Susan Rakow Anderson, Joel Glass, Wendy Jones, Don Miles

MEMBERS ABSENT: Ming-Fang Chang

OTHERS PRESENT: Matthews Jackson, Carol Helland, Department of Development Services; Kate March, Department of Transportation; Paul Cornish, John Walser, Justin Lacson, Sound Transit

RECORDING SECRETARY: Gerry Lindsay

1. CALL TO ORDER, APPROVAL OF AGENDA, APPROVAL OF MINUTES

Co-Chair Van Houten called the meeting to order at 3:30 p.m.

The agenda was approved by consensus.

A motion to approve the minutes of the April 15, 2015, was made by Mr. Glass. The motion was seconded by Ms. Anderson and it carried unanimously.

2. PUBLIC COMMENT

Mr. Joe Rossman, 921 109th Avenue SE, commented that the Sound Transit board at its meeting two weeks ago completed the Memorandum of Understanding that had been adopted by the city several days prior. There were some 250 people in the audience, a substantial majority of whom appeared to be members of the development community present to hear Sound Transit's commitment to accomplishing transit-oriented development. Throughout the course of the afternoon, the term "TOD" was used 125 times. No other single use or benefit of light rail was mentioned as much, which would seem to argue that transportation is less important than some of the other agendas. A comment was made by Capital Committee Chair Fred Butler at the end of the meeting to the effect that the Sound Transit board is fully committed to accomplishing transit-oriented development everywhere light rail is taken, including in south Bellevue. Two years ago the Bellevue City Council voted unanimously to exclude the South Bellevue park and ride station and the southwest quadrant of the area around the 112th Avenue SE and Main Street station from any consideration of implementation of transit-oriented development initiatives and programs.

Ms. Betsy Blackstock, a resident of Surrey Downs, reminded the Committee members that the residents of Bellevue are counting on them. The City Council chose each individual member and gave the Committee the power to guide the ship regardless of what city staff says. She encouraged the Committee members to ask for and even demand transparency. Noise cannot be fully mitigated if it is not even fully understood. The Committee can put whatever it wants in the final document and should act to do just that.

3. EAST LINK PROJECT UPDATE

Planning Manager Matthews Jackson noted that Sound Transit staff had at the request of Ms. Anderson provided maps showing the alignment and what the systems and facilities will look like along different stages. He encouraged the Committee members to review the information.

Mr. Jackson reminded the Committee that public comment was previously offered on a couple of occasions regarding the city's request to mitigate for the impacts to Mercer Slough resulting from the conversion of park land to light rail by swapping in a different property that is surrounded by Mercer Slough property. On April 9 the RCO board in Olympia voted unanimously to accept the request.

The Council took action on April 20 regarding the revised Memorandum of Understanding and unanimously approved it. The Sound Transit Board subsequently approved it as well on April 23.

Mr. Jackson informed the Committee that the shoreline appeal was withdrawn by the appellants on April 21, so the shoreline permitting process is complete, and noted that the Bel-Red segment design and mitigation permit was issued on April 23.

With regard to the property trade, Mr. Miles asked if it will involve wetland improvements. Mr. Jackson said there is no mitigation planned for the site. The six-acre parcel is located on the northeast side of the park and is surrounded by city-owned park property.

Paul Cornish with Sound Transit addressed the issue of what will be seen of the Slough by those walking along Bellevue Way and 112th Avenue SE. He noted that there will be noise walls in some locations, a barrier with a picket fence on top of it in other places, and in some areas a mesh between the pickets. He showed the Committee members a sample of the mesh. Responding to a statement made at the previous meeting about being able to see through the mesh, Mr. Cornish said the architects searched for and found a different product with thinner wire that will improve visibility through it.

Ms. Jones asked if there is any kind of a clear product that could be placed in front of the Winters House so there would still be a view of it for those passing by. Mr. Cornish reminded her that the track is in the trench as it runs in front of the Winters House and the fence protecting it is not that tall. He said those who have used plexiglass-type products have encountered issues with keeping them clean and having them fade and yellow over time.

The Committee members took a few minutes to review the various maps supplied by Sound Transit showing what the sound walls and facilities will look like along the alignment. John Walser, senior architect with Sound Transit, stressed that the guideway will be fenced on both sides to keep people off the tracks. He also clarified that heights of the walls on the maps were shown relative to the street level.

Co-Chair Mathews thanked Ms. Anderson for asking for the maps.

Mr. Glass called attention to Section F just to the south of the Winters House and noted that the map showed the transmission wires right at grade. He asked how long the section is and he was told by Mr. Walser it is about 400 hundred feet long. Mr. Glass asked if there are alternative solutions for the height of the wires in that stretch that could obviate the need for such a high fence or walls for that long stretch. He said the new mesh option is a huge improvement but it still is very dense. Mr. Walser commented that the section to the south of the Winters House driveway and parking lot will have the mesh. To the north of the driveway there is a stretch roughly 100 feet long with opening before the lid in front of the Winters House that will have the mesh, and then to the north of Winters House there will be another 400-foot stretch that will have the fencing with the mesh. Window screens have a very fine mesh pattern that allows for seeing through them; the mesh to be used to protect the alignment will have a much more open weave and it will be possible to see through it. He also noted that the height of the overhead wires is dictated by the pantograph on top of the light rail vehicle. It has a little spring and can accommodate a couple of feet of variation in the wires, but that is all. The alignment in front of the Winters House will be trenched in order to get the wires under the lid. That will bring the wires within the range of an individual walking along the sidewalk, which will be cantilevered over the trench to allow for a wider sidewalk, resulting in the need to protect people from the wires.

Answering a question asked by Co-Chair Van Houten, Mr. Walser said the pickets in the fence are six inches on center and the pickets are almost three inches wide, leaving a three-inch clear gap between pickets.

Mr. Glass asked if two-foot-eight-inch barriers that will be installed in places will essentially be Jersey barriers. Mr. Walser said they will not have the Jersey barrier face but they will be designed to withstand the impact of a car jumping the curb. The intent is for the barriers to be cast in place.

Responding to a question asked by Ms. Jones, Mr. Walser clarified that to the south of the Surrey Downs Park near the signal bungalow the retaining wall behind the structure will need to have a fence on top of it to keep people from going over the wall. Otherwise there will generally not be a need to have a fence on top of the retaining walls.

Co-Chair Van Houten asked if a color other than black had been considered for the mesh.

Mr. Walser said black is a color that easily disappears into the background and that is why it has been used by Sound Transit on other projects. Co-Chair Van Houten said she would like to at least see another color considered, such as dark green, particularly where the train stops.

Mr. Glass asked what type of rail fencing will be used to keep people from falling down the hill at the park. Mr. Cornish said it is the standard Bellevue pedestrian/bicycle railing that is currently in place along the back of the sidewalk on Bellevue Way.

Land Use Director Carol Helland added that the rail fencing design criteria differs depending on the context. Fencing used for freeway overcrossings have one design, and the ones along 112th Avenue SE have a different design.

Turning to the April 15 version of the advisory document, Mr. Jackson said he had made no changes to it since the last meeting, leaving to the Committee members the any decisions to revise it.

The Committee worked from the version of the document that began on page 50 of the packet and included the comments and suggestions made by Ms. Anderson regarding the original document as revised by Mr. Glass. There was agreement to make no changes to pages 50. No changes were made to page 51, except that in the penultimate paragraph the change suggested by Mr. Glass to use the phrase "shall demonstrate" was not made given that the language of paragraph (a) was taken directly from the code.

Mr. Glass pointed out that as drafted it is not clear that the language is in fact from the code. Ms. Anderson agreed that throughout the document it should be made very clear where the code is quoted and that the Committee is simply responding to it.

Mr. Jackson reminded the Committee members that at the last meeting Ms. Helland made it clear that the Committee is not tasked with amending the decision criteria that is written into code. He said the Committee could choose to not include quotes from the code, or to clarify which paragraphs are in fact taken directly from the code.

Mr. Glass agreed that quotes from the code should be identified as such. He said his conclusion was that the application does not meet some of the Comprehensive Plan policies. He said that was why he wanted the advisory document to specifically say the applicant shall demonstrate compliance. Mr. Jackson pointed out that there is specific code language that requires Sound Transit to do certain things in order to show they have met all decision criteria. He said they have done all of those things and that is why he drafted language indicating that the applicant has demonstrated compliance.

Ms. Helland suggested using italics to indicate where the code is directly quoted. The Committee members agreed to use that format to lessen some of the confusion.

It was noted that paragraph (b) on page 52 is quoted code language.

Ms. Anderson commented that the revisions suggested by Mr. Glass paraphrase items discussed by the Committee and comments made by the public. Ms. Jones said she appreciated the revisions as being very explanatory of the context.

Co-Chair Mathews expressed discomfort to the way in which the discussion and recommendation in paragraphs (a)(i) and (a)(ii) bolts together bits and pieces of conversations and discussions. He said he did not see it as being necessary to include. The Committee minutes will back up the decisions made. Approval of the Memorandum of Understanding by the city and Sound Transit actually changes some of what is said in paragraph (a)(i). Additionally, the construction mitigation plan is not part of the Committee's purview. There are hundreds of pages of documentation associated with the permit that backs up the basic advisory document and it makes no sense to discuss it in the advisory document something the city will require regardless, namely that Sound Transit is going to have to meet all of the city's code requirements.

Answering a question asked by Ms. Anderson, Mr. Miles said the construction mitigation plan was referred to by Sound Transit when they commented about what they would be doing in certain areas.

Mr. Glass allowed that it had been a month or so since he drafted his proposed revisions to the advisory document. He said his intent was to say the project is large and significant and as such the construction mitigation plan should have some public input. He said he was not suggesting it should be addressed by the Committee.

Ms. Anderson agreed that allowing the public to comment on the construction mitigation plan would be a good idea.

Mr. Jackson said there is always opportunity for public input regarding any major city or outside agency project. There will continue to be significant outreach conducted going forward.

Co-Chair Van Houten said the suggested revisions offered by Mr. Glass could be viewed as simply reiterating the Committee's understanding of the process. The question is whether or not the comments make the document more useful. She said her preference would be to focus on the recommendations and avoid rehashing all the reasons behind the Committee's conclusions.

Ms. Jones expressed the view that the revisions offered by Mr. Glass give more context and strength to the recommendations. She added that throughout the process there have been varying opinions as to what the Committee's purview is, and by including the revisions voice will be given to what the Committee discussed, even if a discussion did not result in an actual recommendation.

Co-Chair Mathews said the question is whether or not the additional language adds weight to the message of what the Committee wants to see from Sound Transit. All of the discussions held by the Committee are reflected in the meeting minutes.

Co-Chair Van Houten commented that the advisory document represents a synthesis of all the Committee's discussions and public input. The record created by the minutes offers plenty of evidence for how the Committee reached its decisions.

Mr. Miles agreed the advisory document should take more of an outline form listing the specific code requirements and what the Committee decided should be done to meet each requirement.

There was consensus to take that approach.

There was agreement to delete the discussion paragraph.

With regard to the recommendation paragraph, Mr. Jackson pointed out that modifying wall heights to lower them would be contrary to the goal of providing sound protection to meet city code. The two approaches contradict each other. The intent of the noise study is to demonstrate that Sound Transit will provide the minimum height necessary to mitigate for additional noise created by the light rail train.

Ms. Jones said she came away from the last Committee meeting with an understanding that sound absorptive walls are less aesthetically pleasing, so there is a tradeoff between having a taller wall that is more visually pleasing and a lower wall that has an industrial look and feel. Mr. Jackson said there are walls where the line enters the Mt. Baker tunnel that have sound absorption materials. He suggested an application of that sort would not be welcomed in South Bellevue.

Mr. Cornish said he put to the Sound Transit noise people the question of whether the effectiveness of noise barriers is based on their height. The answer given was that height is directly related to effectiveness. Noise essentially follows a line of sight, so regardless of the materials used, walls height is the primary determining factor when it comes to noise mitigation.

Mr. Glass commented that the picket fences and mesh as described by Sound Transit do not fit with a park-like context. Co-Chair Van Houten said there is no getting around the fact that the fences are needed. Mr. Glass said there are a lot of different fence formats out there and the Committee should not be afraid to say the proposed approach does not look very good and to recommend they try again.

Co-Chair Van Houten said that is covered by the call for sound walls more compatible with the surrounding built environment. She suggested the recommendation could go on to say that the fences should be designed to minimize blocked views and maintain to the extent possible maintain the visual context of a city in a park.

Ms. Jones said she would like to see direction added to explore other color options.

There was agreement to delete the references to walls being sound absorptive and lower in height.

With regard to page 53, there was agreement to remove references to wall height from the paragraph (b)(ii) recommendation.

Co-Chair Mathews pointed out that the concepts of living walls and green roofs is already in the Committee's recommendation and did not need to be reiterated. Mr. Glass argued that the reference goes along with the Comprehensive Plan policy to protect residential areas from impacts.

Co-Chair Mathews also commented that the language in the recommendation paragraph about complying with city code is also not necessary since that is a given.

Ms. Jones suggested the (b)(ii) recommendation is essentially the same as the (a)(ii) recommendation. Co-Chair Van Houten said that is because policies LU-9 and land use-22 are very similar. She proposed combining the responses to both of those policies.

Co-Chair Mathews agreed and added that saying the same thing over and over does not make the statement any stronger.

Mr. Jackson proposed pulling the discussion and recommendation paragraphs from the body of the document, extracting out the actual advisory elements and folding them into the final advisory document. There was consensus to take that approach.

Mr. Jackson said the Committee could make public the list of recommendations as spelled out by Mr. Glass by posting it as a separate document. There was agreement to do that.

With regard to paragraph (c)(ii) on page 53, Ms. Jones questioned including the reference to accessing Mercer Slough from the west during construction. Mr. Glass said it was his understanding that during construction access to Mercer Slough will be completely walled off and it would be nice to maintain what little access there is currently.

Co-Chair Mathews suggested that access through a construction zone would not be safe at any rate.

There was agreement not to recommend access to Mercer Slough from the west.

With regard to requiring the multiuse path to be at least 12 feet wide, Mr. Glass said his intent was to assure having a usable path. Mr. Jackson said there are some pinch points that get down to a width of about eight feet. It is not possible to extend too far to the east because of the critical area buffer. The pinch point near the Winters House is dictated by the lid and the general lack of space. The way things have been designed the intent is to maintain the standard to the greatest extent possible.

Mr. Walser explained that at the pinch points the landscape zone width is sacrificed in order to maintain a minimum of eight feet of width for the path. Mr. Jackson added that where the landscape buffer is reduced city staff and Sound Transit have worked on alternative landscape options, including median landscaping, to assure a total gateway feature at the Y intersection.

Mr. Glass allowed that there is a critical area near the pinch point close to the Y intersection, but pointed out that the plan is to allow a wide train track to run through it. He said it appeared to him the reason for not maintaining full width for the path at the pinch point is an economic decision rather than an attempt to avoid the critical area. Mr. Jackson said the city code is clear in saying impacting critical areas must be avoided to the greatest extent possible. The train will go through the critical area but mitigation for the disturbance will be required. Offsetting the loss of landscaping at the pinch point will bring about a better result than encroaching further into the critical area buffer.

Ms. Jones asked if the sidewalk could be cantilevered out over the critical area at the pinch point. Mr. Jackson explained that the area presents several challenges. Feedback has been received about the number of trees that will be lost along with the tree-lined character. The restoration planting targeted for the area will not involve a tall canopy, but there has been a call for having trees at least up to the street level. Cantilevering out over the critical area would take away from the ability to plant trees there.

Co-Chair Mathews voiced support for eliminating the full 12-foot path requirement from the recommendation. By at least keeping the path to a minimum of eight feet, pedestrian and bicycle access will be maintained. Co-Chair Van Houten agreed and said she would rather lose a little of the landscaping than encroach further into the critical area.

There was agreement to remove all of the recommendation paragraph (c)(ii).

Turning to paragraph (d)(ii) on page 54, Co-Chair Van Houten said it appeared to her the meat of the recommendation was that the construction mitigation plan should be subject to some public scrutiny.

Mr. Miles commented that all plans for projects are available to the public. Mr. Glass said he would like to see there be an opportunity for public comment.

There was agreement to include language reiterating the importance of public outreach and comment opportunities on the construction mitigation plan.

With regard to paragraph (e)(ii) on page 55, Ms. Anderson said as drafted by Mr. Glass it appeared to be a commentary on what the Committee is charged with doing. She suggested that as such it was not needed. There was agreement not to include the paragraph as a recommendation but to include it somewhere in the introduction to the document. There was agreement to do the same for paragraph (f)(i).

Commenting on paragraph (g)(ii), Mr. Glass said the wetlands plantings are often quite small. Particularly at the Y where it is adjacent to the road, in addition to the saplings and plants the wetland should receive some larger trees. In time some thinning may be required. Additionally, along with having unique specimen trees there should here and there be a large signature tree, and the Committee should identify the locations. He proposed the large pasture area on the east side of the road near the freeway. Mr. Jackson said that recommendation is included in the report. He agreed to verify that and to make it more specific for the locations if need be.

Co-Chair Van Houten suggested that recommendations in paragraph (g)(ii) do not specifically relate to policy TR-75.7 which is more focused on land use and transportation.

Answering a question asked by Ms. Jones, Mr. Jackson said the city has templates for critical area mitigation planting that specifies size and types of trees based on environments. Many of the plantings Sound Transit has proposed are larger than the city's minimums.

Mr. Glass said he was not trying to suggest that all of the trees in the wetland area should have a caliper of two inches. The important thing is to be able to see them at the time of planting. Mr. Jackson said he would avoid being too specific but would add a call for some larger trees intermixed in the mitigation planting, and would verify locations for specimen trees.

Turning to paragraph (h) on page 55, Co-Chair Van Houten commented that much of what it includes reiterates the critical areas report. She said the process for reviewing environmental regulations obviates the need to include the section. The exception should be the last part of paragraph (h)(ii)(2). She proposed retaining the sentence "Ensure that all impacts have been sufficiently identified, avoided where possible and exceptionally mitigated." The last sentence of the paragraph as proposed is a moot point given that the shoreline permitting process has been completed. There was agreement to do that.

Ms. Jones pointed out that the term "exceptional mitigation" has been bandied about quite a lot and she asked if there is some way it could be succinctly defined. Co-Chair Van Houten said in her view the term would mean going above and beyond the minimum requirements of the code.

Mr. Jackson clarified that the term "exceptional mitigation" came about prior to having a light rail section in the Land Use Code. A lot of exceptional mitigation was put into the actual code requirements.

Co-Chair Van Houten suggested the recommendation in paragraph (i)(ii) reiterates what has already been talked about relative to trees. As such the recommendation is not needed.

Answering a question asked by Mr. Glass, Mr. Jackson said Sound Transit has identified all of the trees. They had provided the city with the broad data but not with information about size and type. A public records request was submitted which yielded that helpful information, but the city has not gone yet gone through the entire alignment with an eye on identifying additional trees that could be saved; that work will be done. Language could be added to the report reinforcing the notion of saving trees to the greatest extent possible. There was agreement to add some reinforcing language.

Co-Chair Van Houten suggested that the recommendation in paragraphs (j)(i) and (k)(ii) only reiterate what has been included elsewhere. There was agreement not to include either one.

With regard to paragraph (m)(ii), Ms. Jones raised the issue of sound walls to attenuate the noise of trains from impacting adjacent parks. Mr. Glass recalled that the Committee had discussed considering the parks as sensitive receptors.

Mr. Jackson commented that adding a wall is a specific thing and as drafted the last part of paragraph (m)(ii) would require interpretation as to intent.

Mr. Glass said he assumed that all properties considered to be sensitive receptors will need to have walls, including parks if they are deemed to fall into that category. Mr. Jackson reminded the Committee that Mercer Slough was not identified by Sound Transit as a sensitive receptor as part of complying with the FTA requirements. However, the city puts the Slough into that category and will require mitigation accordingly. In some locations there is a distance between the rail corridor and trails used by people, but in other places they are quite close. If the Committee elects to recommend including a sound wall, it will need to demonstrate what is to be mitigated and to what extent. He added that the Committee has also recommended not including walls that will impact visual access to the park.

Mr. Glass commented that if birds are chased from the park because of the noise from the train, it will not be the same park people enjoy currently. Not all birds are chased by noise, but some certainly are.

Mr. Jackson said the city asked for additional information about the sound walls on the east side of the guideway. He added, however, that he was not aware of Sound Transit doing any additional analysis of what a wall on the east side would achieve. The general feedback has been that without a wall on the east side of the guideway, the impacts to the recreational uses in the park would not be significant. Displacement of birds will likely be greatest during construction, particularly as trees are removed. Some will come back and some will establish elsewhere. Animals that live in urban environments are generally very resilient and the impacts will largely be temporary. Having a wall probably would not achieve much in the greater scheme of things.

Mr. Glass argued that Mercer Slough is a far different park from Downtown Park and should be treated differently. He said he would defer to the notion of exceptional mitigation and call for having the park designated as a sensitive receptor.

Co-Chair Mathews commented that he visited several light rail operations while serving as a member of the Light Rail Best Practices Committee. He said it was observed that train noise primarily flows from curves in the alignment and at stations where trains stop and start. Most of the run through the Slough will not be very noisy at all. The existing road traffic will be the same once the light rail project is completed and the train simply will not make much of a difference.

Mr. Glass said horror stories have been told about noise generated by Central Link. East Link is required to install sound walls in order to meet the federal standards, so it stands to reason that the system will be generating some noise.

Mr. Miles said using his own equipment he measured the noise associated with the light rail and SR-520 four blocks away, and the noise from the freeway was three times louder. Every effort should be put into mitigating noise, but the efforts should be qualified and not just demanded.

Co-Chair Mathews said he would not want to see walls erected where they are not needed. He suggested that the light rail best practices are referred to in the transmittal and nothing more needs to be said.

Mr. Glass proposed calling for parks to be considered sensitive receptors and that sound walls should be required where needed.

Ms. Anderson recommended including "The CAC recommends that Sound Transit conduct additional noise analysis for impacts to users of Mercer Slough as a sensitive receptor." There was agreement to delete paragraph (m)(ii) and to include the proposed language in the recommendation.

Co-Chair Van Houten suggested that as drafted the discussion in paragraph (n) is more of a statement that construction noise should be mitigated. Mr. Glass agreed but noted that the Committee had previously reached consensus that Sound Transit should offer residential sound packages to frontline properties. There was consensus to retain paragraph (n)(ii).

Co-Chair Mathews commented that the discussion and recommendation in paragraph (o) is nothing more than what is included in basic city regulations. As such it did not need to be retained. The Committee members agreed.

There was agreement that paragraph (p)(ii) was redundant and could be eliminated.

Answering a question asked by Mr. Glass, Mr. Jackson said the transmittal includes a recommendation from the Committee to install the sound walls as early as possible. The same topic is covered by the Memorandum of Understanding.

It was agreed that the recommendation in paragraph (b)(ii) on page 62 was included elsewhere and as such could be deleted.

There was agreement not to delete the last sentence of the bullet under paragraph (i) on page 64.

There was agreement not to include a recommendation to use sound absorptive panels for freestanding noise walls as outlined in the eighth bullet under paragraph 3 on page 68.

Co-Chair Van Houten observed that along I-405 many of the really high walls have ivy growing on them and she asked if that could be the case on some of the sound walls in Bellevue. Mr. Jackson said that is in the Committee's recommendation already.

The Committee addressed next the list of recommendations starting on page 71. It was agreed that the first two had already been addressed. With regard to the third, Mr. Jackson noted that the permit just issued includes a monitoring and mitigation plan. Sound Transit will be directed to undertake a series of actions to verify the analysis they have done is accurate and that their mitigations are adequate.

Mr. Glass suggested that is different from addressing nighttime operations with the city's code in mind. He said he was not know if the analysis seen by the Committee takes into account the extended hours associated as getting the line charged and the OMSF operations. Mr. Jackson said the Committee was given information about the number of trains going out and the times that would happen. Additional environmental analysis will be done on the OMSF and that analysis likely will include anything to do with noise that has not already been studied. He agreed it would not hurt to include the recommendation. There was consensus to do so.

With regard to the fourth recommendation, Co-Chair Van Houten asked if additional traffic to and from the park and ride is within the purview of the Committee to comment on. Mr. Miles suggested that while the Committee may not be able to recommend specific changes, it is free to comment on the situation.

There was agreement to include the seventh recommendation statement.

With regard to air quality, Co-Chair Van Houten noted the Committee had previously agreed not to include the topic given that it falls outside the scope of the Committee's charge.

There was consensus to include the eighth recommendation.

With regard to the changes proposed by Mr. Chang found on page 72, there was agreement that the issue had already been discussed and would not be included in the recommendation.

Mr. Miles said his comments captured on page 73 were only observations and not recommendations.

Mr. Jackson said he would take the feedback, put together a document for the Committee members to review, and seek a thumbs up/thumbs down response before finalizing it for the transmittal. He said the central Bellevue section would be the topic of the next meeting.

Ms. Helland thanked the Committee members for their diligent work in working through the details and providing recommendations.

5. PUBLIC COMMENT

Mr. John King, a resident of Surrey Downs, said the discussion of the park as a sensitive receptor was very illuminating. He said where there are no homes between the park and the track there is only an open space. The homes on the west side of the park are liable to feel the noise impact of the trains going by because there will be nothing between them and tracks. The Committee members were commended for paying close attention to that issue. Surrey Downs Park has been downgraded to more of a neighborhood park. The city, the neighbors and the Committee area all approaching the park from different angles, but the fact that it will become more of a contemplative space should be part of the consideration. It should be considered a sensitive receptor.

6. ADJOURN

Co-Chair Van Houten adjourned the meeting at 6:06 p.m.

ST RESPONSE TO CAC ADVISORY DOCUMENT
DOWNTOWN SEGMENT PRE-DEVELOPMENT REVIEW
ISSUED JULY 15, 2014

20.25M.040 RLRT system and facilities development standards

1. Building Height – No concerns expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: ST appreciates the comment

2. Setbacks – No concerns expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: ST appreciates the comment

3. Landscape Development: The CAC recommends that landscape development at the Hospital Station, particularly in the vicinity of NE 8th Street, be designed in a way which does not create a site obstruction for motorists.

ST Response: ST has uses AASHTO design guidelines for sight distance found in the Policy on Geometric Design of Highways and Streets manual. These guidelines ensure adequate site distances for motorists, pedestrians, bicycles, and other street users based on the size, type, and design speeds of NE 8th Street.

4. Fencing – No concerns were expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: ST appreciates the comment.

5. Light and Glare - No concerns expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage. The CAC recommends that no stations should have up lights that could shine into neighboring buildings or residential areas. All lighting should remain within the confines of the stations to the greatest extent possible.

ST Response: ST has lighting standards that are included in the design plans and specification. These standards include prohibiting uplighting and controlling site lighting to prevent spillover lighting concerns from neighboring properties.

6. Mechanical Equipment - No concerns were expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: ST appreciates the comment.

7. Recycling and Solid Waste - No concerns were expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: ST appreciates the comment.

8. Critical Areas - No concerns expressed by the CAC. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: ST appreciates the comment.

9. Use of City Right of Way – See comment above regarding landscape development. More project specific information will be included during the Design and Mitigation Permit review stage.

ST Response: Please see ST comment response number 3.

20.25M.050 Design guidelines

1. Design Intent – Downtown Subarea - In addition to complying with all applicable provisions of the Downtown Subarea Plan, the design intent for the RLRT system and facility segment that passes through this subarea is to enhance Downtown Bellevue's identity as an urban center that serves as the residential, economic, and cultural heart of the Eastside. The above-ground expression of the Downtown Station is envisioned as a highly utilized urban "place" with an architectural vocabulary that not only reflects and communicates the high quality urban character of Downtown as a whole, but also complements the immediately adjacent civic center uses including Bellevue City Hall, Meydenbauer Convention Center, the Transit Center, Pedestrian Corridor, and the Downtown Art Walk. The alignment crossing over I-405 will be prominent to visitors entering, leaving, and passing through the Downtown, and its design should be viewed as an opportunity to create a landmark that connects Downtown Bellevue with areas of the City to the east. The station and freeway crossing should reflect Bellevue's branding, and should be comfortable and attractive places to be and experience, with high quality furnishings and public art that capitalize on place-making opportunities.

   Design Intent – Wilburton/NE 8th Street Subarea - In addition to complying with all applicable provisions of the Wilburton/N.E. 8th Street Subarea Plan, the design intent for the RLRT system and facility segment that passes through this subarea is to focus on the hospital station's role as a gateway location to points east of Downtown on to Bel-Red and beyond. The alignment crossing over I-405 should create a cohesive connection between the

Downtown and hospital stations, but the Hospital station itself should have its own identity. With significant ridership anticipated to be generated from the Medical Institution District to the west, the hospital station should take design cues from the hospital, the ambulatory health care center, and the medical office buildings that were designed to be responsive to the Medical Institution Design Guidelines that are shaping the character of this area.

ST Response: ST appreciates the comments. ST has worked hard over the past three years of design development incorporating input from Bellevue citizens, evaluating code compliance and design standards from the Design and Value Engineering (DAVE) Committees, and through meetings with City of Bellevue staff. ST believes we have met and often have exceeded expectations for architectural design, use of materials, and landscaping plans. Continued review and specific comments from the CAC are welcomed.

2. Context and Design Considerations - The CAC was tasked with evaluating the existing context setting characteristics included in the Land Use Code in order to verify that the design of the stations and alignment is consistent with the vision for the Downtown and Wilburton/NE 8th Street Subareas. The Land Use Code states that the character of this area is defined by:

Downtown Subarea

- Private entertainment and cultural attractions;
- High quality urban amenities such as pedestrian oriented development and weather protection that encourages people to linger and not just pass through;
- High rise buildings that attract a creative and innovative work force;
- Multifamily developments that attract urban dwellers that are less tied to their vehicles to accomplish day-to-day tasks;
- Great public infrastructure including roadways, transit and pedestrian improvements, parks and public buildings; and
- Stable property values that make it a desirable place for businesses to locate and invest.

Wilburton/NE 8th Street

- Outdoor spaces that promote visually pleasing, safe, and healing/calming environments for workers, patients accessing health care services, and visitors;
- Buildings and site areas which include landscaping with living material as well as special pavements, trellises, screen wall planters, water, rock features, art, and furnishings;
- Institutional landmarks that convey an image of public use and provide a prominent landmark in the community; and
- Quality design, materials, and finishes to provide a distinct identity that conveys a sense of permanence and durability.

The CAC advised that the following additional context and design considerations should be considered when evaluating the East Link project in the Downtown Bellevue and

Wilburton/NE 8th Street Subareas for context sensitivity during future CAC and permit review phases. The following items pertain to the Downtown Segment:

Downtown Subarea

The CAC advises that the following additional context and design considerations should be considered when evaluating the East Link project in the Downtown Subarea for context sensitivity during future CAC and permit review phases.

a. The Downtown Station should convey a sense of arrival at a bustling economic hub that provides access to retail, visitor services, offices, and urban residential neighborhoods.
b. The station should convey a future focus on smart growth, and the importance of transit to the success of sustainable development.
c. The aesthetics of the station roof should be taken into account and finished to enhance views down on the Downtown station for adjacent high rise and convention center development.
d. Clear connectivity, accessibility, and way finding should be provided between the Downtown Station and the Bus Transit Center.

ST Response: ST meets these Downtown Subarea context design considerations with its 60% design shared with the City in March of 2014. Specific comments on this design's meeting of these objectives are welcomed from the CAC as design continues to advance towards 90% in spring/summer 2015. Specifically:

a. The station is unique in that it is simultaneously an underground, an at-grade, and an elevated station. Views of the surrounding high rise buildings, Meydenbauer Convention Center, and City Hall from the station platforms as well as entry/exit plazas provide a sense of arrival at a bustling hub and let the visitor know they will encounter all that is expected of a vibrant downtown.
b. The location of the station in close proximity to the Downtown Bellevue Transit Center lets visitors know the focus that has been placed on smart growth in Bellevue.
c. The station roof was designed to enhance the experience of the users of the station. ST agrees that that experience is also shared by the adjacent high rise and convention center users. The station roofs also allow visual access to the trains arriving and departing as well as glimpses of passengers entering and leaving the station providing a dynamic visual from surrounding developments.
d. Connectivity and way finding has been provided and will be further detailed as the design progresses towards 90%. There is a strong visual link between the Station entrance and the Transit Center.

Wilburton/NE 8th Street Subarea

The CAC advises that the following additional context and design considerations should be considered when evaluating the East Link project in the Wilburton/NE 8th Street Subarea for context sensitivity during future CAC and permit review phases.

a. Height of the flyovers (freeway, 116th Ave NE, and NE 8th) between the Downtown Station and the Hospital Station presents unique opportunities and challenges.
   i. Design attention should be given to the under-portions of the flyover structures that will be visible from vehicles and pedestrians that pass underneath them.
   ii. Required railings on the flyover structures could present an art opportunity if they could be employed without further emphasizing the mass of the structure.

b. The aesthetics of the Hospital station roof should be taken into account and finished to enhance views down on the station for adjacent development on Midlakes Hill to the east and future development anticipated in the Wilburton Village.

c. Clear connectivity, accessibility, and way finding should be provided between the Hospital Station and the Medical Institution District where Overlake Hospital and the Group Health Ambulatory Care Center are located.

d. Weather protection should be provided on the route between the Hospital Station and the Medical Institution District.

e. References to the freight hub and rail platform that served Bellevue's historic truck farming industry should be incorporated into the Hospital Station.

f. The Hospital station context should convey a sense of institutional permanence and quality that is broader in focus than accessibility to health care.

ST Response:

a.i. The design of the understructure of the I-405 structure is tightly controlled by WSDOT and FHWA highway design standards. Visual complexity under this structure could cause motorist safety concerns. The same applies to travelled ways along the city streets. However, ST will look for ways to innovate design within these tight guidelines. The visual design features (color, railings, details) for the crossing of I-405 will be consistent with the adjacent overpass features established by WSDOT and Bellevue for the I-405 Corridor. The underside of the guideway throughout will maintain simple, clean, uniform lines to maintain an attractive appearance without calling undue attention to the structure.

ii. Railing and art opportunities will be advanced with the 90% design in spring/summer of 2015.

b. The station roof was designed to enhance the experience of the users of the station as well as the surrounding area. It provides an attractive appearance with appropriate scale for viewing from a distance as well as up close.

c. Clear connectivity, accessibility, and way finding has been provided within the Hospital Station. ST is working with the City to acquire the necessary easement for a new City sidewalk which will provide a shorter connection from the north end of the station to the Hospital District (and also serve as a future connection to the potential County/City multi-use path in the rail corridor).

d. Additional weather protection outside ST ROW is not currently contemplated with the 60% design. The potential for weather protection along the new sidewalk could be a future station area planning/City project.

e. Signage and interpretive displays referencing the area truck farming history will be further developed with the 90% design in Spring/Summer of 2015.

f. The light rail guideway structure and station provides a strong sense of institutional permanence at the Hospital Station that is much stronger than just access to medical care. This station serves more than just the Hospital District and is intended to reach out to the surrounding neighborhood.

3. Additional General Design Guidelines

- The CAC recommends that the issue of lighting be uncoupled from the issue of meeting the needs of those with disabilities and that both audio and visual cues be included in station design.

ST Response: ST has not included the specific visual clues requested by the public at CAC meetings in any of its stations currently in operation. However, ST will continue to evaluate this input.

- The CAC recommends that the design of the Downtown Transit Center Station should complement the existing City Hall and new plaza design while providing distinct elements that demarcate the different uses.

ST Response: ST's60% design meet the design standard. ST would appreciate any other specific guidance that the CAC could provide on complementary elements to consider.

- The CAC recommends enhanced weather protection at the corners between the existing bus transit center and the new Downtown Transit Center Station.

ST Response: Weather protection at the street corners between the existing bus transit center and the Downtown Station are within the purview of Bellevue's Downtown Livability process.

- The CAC recommends that restroom facilities be incorporated into the Downtown Transit Center Station design.

ST Response: ST Board policy does not include restroom facilities for this station. There are public restroom facilities at the bus transit center for passengers making transit connections. With train service frequencies in the range of every 8 minutes (as opposed to some bus frequencies of 20-30 minutes) dwell times at the station are very short.

- The CAC recommends that variable seating heights be provided at all light rail stations in Bellevue.

ST Response: ST will evaluate variable seating heights with its 90% design in spring/summer of 2015.

- The CAC recommends that Sound Transit include places for people to rest along the walkway connecting the Hospital Station to 116th Ave NE.

ST Response: ST appreciates the betterment that could be provided by resting locations between these destinations. However, ST does not own nor will it maintain the majority of the walk way between these destinations. If a user can not cover this distance without rest, transit provided by King County metro routes 226, 234, and 235 will get a rider closer to the hospital than the light rail station for an equivalent public transit price. Other options include use of the car park at the hospital which closer in proximity to the hospitals and the King County para-transit service for the mobility impaired.

- The CAC recommends a signature treatment of the railing for the entire span from the Downtown Transit Center Station to the Hospital Station. The CAC recommends painting the underside of the elevated guideway green and for Sound Transit to look for opportunities to further enhance the aesthetics of the NE 8th Street crossing south of the Hospital Station.

ST Response: Please see response to # ai, and aii above.

In addition to the items noted above, the CAC also makes the following recommendation that should be forwarded to the Station Area Planning team:

- The CAC recommends that Sound Transit work with the City to establish a multipurpose path for pedestrians and bicyclists over I-405.

ST Response: WSDOT has provided very wide and accommodating modern pedestrian and bike paths over the newly constructed NE 10th and NE 12th bridges. NE 10th is the City designated bike lane/path across 405 in Downtown. This path provides direct access to the hospital and Wilburton areas. In addition, NE 4th has a relatively wide pedestrian and bike path across it. Bellevue's Light Rail Best Practices Manual indicates it is the City's role to plan and implement pedestrian and bicycle connections extending out into the surrounding neighborhoods.

ATTACHMENT S

REQUESTED ADMINISTRATIVE MODIFICATIONS EXHIBITS

Attachment S is not used for the Central Bellevue Design and Mitigation Permit Application.

ATTACHMENT T

NOISE IMPACT ASSESSMENT USING BELLEVUE CITY CODE

FINAL DESIGN PARTNERS.

East Link | South Bellevue to Overlake Transit Center
Contract No. RTA/AE 0143-11

Contract E335
Noise, Vibration and Groundborne Noise Report

December 22, 2014

Prepared for:

SOUNDTRANSIT

Prepared by:

FINAL DESIGN PARTNERS.

Contract E335
Noise, Vibration and Groundborne Noise Report

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Acronyms and Abbreviations

AWD	Audible Warning Device
dBA	A-weighted decibel
AVCP	Acoustical vermiculite cement plaster
DCM	Design Criteria Manual
DBT	Downtown Bellevue Tunnel
DF	Direct Fixation
EDNA	Environmental designation for noise abatement
EIS	Environmental Impact Statement
FDL	Force Density Level
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
Ldn	24-hr day-night sound level
Hertz	Frequency in cycles per second
Leq	Equivalent sound level
Lmax	Maximum sound level
LRT	Light Rail Transit
LRV	Light Rail Vehicle
LSTM	Line Source Transfer Mobility
MFR	Multi-Family Residence
MOA	Memorandum of Agreement
mph	Miles per hour
NR	Noise reduction
ROD	Record of Decision
SEL	Sound Exposure Level
SFR	Single-Family Residence
ST	Sound Transit
TNM	Traffic Noise Model
TPSS	Traction Power Substation
VdB	Vibration decibel with reference to 1 µin/sec

1.0 Introduction

This Noise and Vibration Report for Contract E335 presents the results of the Federal Transit Administration (FTA) noise and vibration impact assessment and the train noise impact assessment using Bellevue City Code (BCC). It includes the recommended final design mitigation measures for sensitive receivers located within the contract limits in compliance with the FTA noise impact thresholds and the Bellevue City Code maximum permissible sound levels. The FTA noise and vibration impact assessment is presented in Sections 4.0 through 6.0. The BCC train noise impact assessment is presented in Section 7.0 and the BCC noise assessment for stationary sources such as traction power substations, public address systems, condenser units, and electrical transformers operating at stations is presented in Sections 5.6 and 5.8.

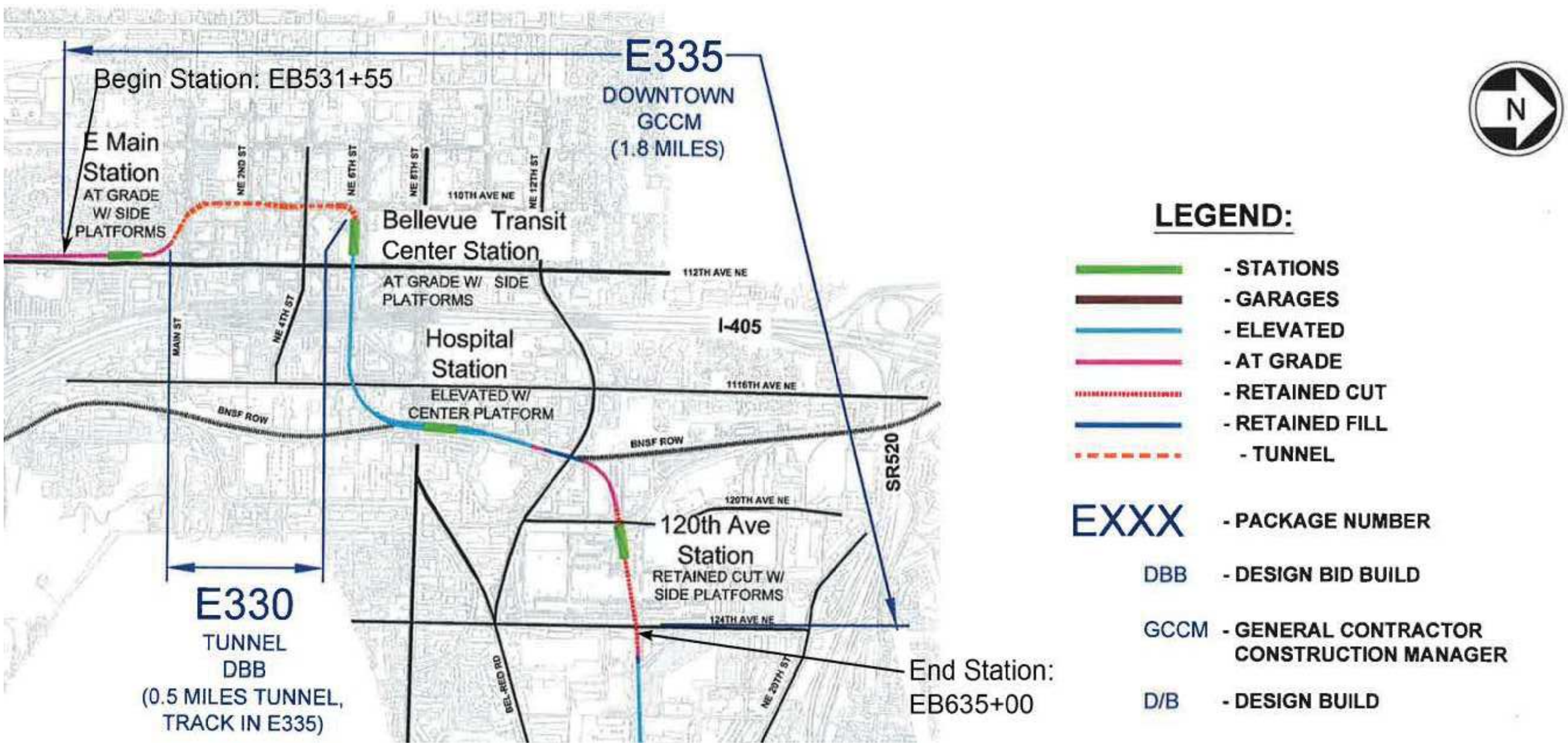
Contract E335 begins south of the East Main Station at EB 531+55 and ends east of 124th Avenue NE at Station EB635+00. The package includes the East Main Station, South Portal Electrical Power Building, finishes and equipment in the Downtown Bellevue Tunnel (DBT), the Mid-Tunnel Access Shaft Headhouse, Bellevue Transit Center Station, the aerial structure over the I-405 freeway, elevated guideway, Hospital Station, a guideway trestle structure, and at-grade, retained fill, and retained cut track structure north of the Hospital Station, and the 120th Avenue Station. Figure 1-1 shows a site map of the East Link project within the contract limits. Note that Contract E330 will build the initial phase of the Downtown Bellevue Tunnel. All finishing work on the tunnel is part of Contract E335 therefore, the tunnel is included in this Contract E335 Operational Noise and Vibration report. No operational noise and vibration report will be prepared for Contract E330.

This report includes a noise impact assessment of operation of light-rail transit including noise from light-rail vehicles, traction power substation (TPSS) units, station acoustics, emergency ventilation fans, ancillary equipment at stations, public address (PA) announcements at stations, and warning bell noise used during the operation of the light rail vehicles. The information in this report is an update to the noise and vibration impact assessment presented in the East Link Project Final Environmental Impact Statement (EIS), Appendix H2: Noise and Vibration Technical Report (July 2011). The recommendations in this report are based on additional measurement and analyses, including assessment of existing Sound Transit LRT operations, performed by ATS Consulting from March through September of 2013.

The noise and vibration impact assessment presented in this report is consistent with the guidelines and methodology presented in the following documents:

- FTA's Transit Noise and Vibration Impact Assessment guidance manual (referred to in this report as the FTA guidance manual);
- Sound Transit's Link Noise Mitigation Policy, February 2004;
- the East Link Project Final Environmental Impact Statement, July 2011; and
- City's Noise Control Code, Chapter 9.18 Bellevue City Code.

Figure 1-1: East Link Site Map



2.0 Executive Summary

2.1 FTA Noise Impact Assessment

This report presents a detailed noise analysis and mitigation recommendations for noise sensitive receivers where predicted noise levels approach or exceed the FTA moderate noise impact threshold. The mitigation measures considered are construction of sound walls, residential sound insulation, track lubrication system for tight-radius curves, and "low-impact frogs" for crossovers and turnouts.

The recommended sound wall lengths and heights within the Contract E335 limits are summarized in Table 2-1. Table 2-1 includes the start and end stationing for the walls, wall heights, wall lengths, and wall locations. Additional mitigation recommendations include:

- Mitigation measures for station noise at East Main Station include reducing the level of the PA announcements from 10 dB to 5 dB above the ambient noise during nighttime and early morning hours (10 p.m. to 7 a.m.).
- At East Main Station pedestrian crossings providing adjustable level audible warning devices (AWD). The AWDs would be set to a lower level during nighttime and early morning hours (10 p.m. to 7 a.m.) when the ambient noise levels are lower.
- Mitigation measures for station noise at Bellevue Transit Center Station include reducing the level of the PA announcements from 10 dB to 5 dB above the ambient noise during nighttime and early morning hours (10 p.m. to 7 a.m.) and enclosing the condenser units.

Noise impact is predicted at the Coast Bellevue Hotel (parcel EL242). A three foot high sound wall above top of rail would be needed on the aerial structure to mitigate the train noise at the exterior of the Hotel.

Noise sensitive receivers near special track work include: (1) Meydenbauer Center (parcel EL240) near a crossover and (2) Lake Bellevue Condominiums (parcel EL261) near a turnout. Figure 5-2 shows the location of the Meydenbauer Center and Figure 5-4 shows the location of the Lake Bellevue Condominiums with respect to the special trackwork. No noise impact is predicted at the Meydenbauer Center and a sound wall is recommended at the Lake Bellevue Condominiums that reduces the noise level to below the moderate impact threshold. Therefore, no "low-impact" frogs are included in the mitigation recommendations.

Installation of lubricators is recommended to minimize wheel squeal at low radius curves. The DCM commits the project to installation of lubricators on curves with a radius less than 600 ft. On curves of 600- to 1,250-foot radius, the project will be designed to accommodate a lubrication system if wheel squeal occurs during operations. Low-radius curves within the E335 contract limits where lubricators are recommended include:

- The curve north of East Main Station as the tracks transition into the DBT. Lubricators are recommended for both the eastbound and westbound track.
- The curve west of Bellevue Transit Center Station as the tracks transition from 110th Avenue NE onto NE 6th Street. Lubricators are recommended for both the eastbound and westbound track.
- The curve east of I-405 as the tracks transition into the BNSF ROW. Installation of lubricators is recommended for both the eastbound and westbound track, even though the EB track has a curve with radius 715.75 feet. We recommend the design for the EB track include a lubrication

system even though the curve radius is greater than 600 ft because of the proximity to a noise sensitive receiver and because the WB track will include a lubrication system (the radius of the WB curve is less than 600 ft).

The predicted emergency ventilation fan operations noise are compared to the ST Design Criteria of Lmax=85 dBA for fan rooms, noise criteria of Lmax=75 dBA for station platforms, and the National Fire Protection Association (NFPA) Standard 130 noise limits for in tunnel operations. The ST fan noise criteria and the NFPA Standard 130 noise limits will be exceeded. Acoustical vermiculite cement plaster (AVCP) shall be applied to the ceiling and wall surfaces of the fan room and the ceiling and walls of the fan niche in accordance with E335 Specification Section 09 82 19, Sprayed Acoustic Insulation.

The acoustical design of the East Main Station, Bellevue Transit Center Station, Hospital Station, 120th Avenue NE Station were assessed based on the ST Design Criteria of a reverberation time goal of 1.2 seconds. The East Main Station, Bellevue Transit Center Station, and Hospital Station are not fully enclosed but are open to the outside area. Due to the large area of the station ceiling and side walls that are open to the outside area the station acoustics will not exceed the ST reverberation time goal of 1.2 seconds and will not need any acoustical treatment. The 120th Avenue NE Station is a partially enclosed space that is located in a retained cut section of the alignment. More than half of the ceiling area is open to the outside area. The remaining ceiling surfaces are either perforated metal canopies located over the platform area and perforated metal ceilings at the underside of the slab above the station. Due to the large area of the station ceiling and side walls that are open to the outside area the station acoustics will not exceed the ST reverberation time goal of 1.2 seconds and will not need any acoustical treatment.

This report also presents a detailed vibration analysis. The detailed vibration analysis included vibration propagation tests at seven of the sensitive receivers and vibration measurements of the existing Sound Transit Central Link line to ensure the validity of analyses. Vibration impact was not identified at any sensitive receivers within the Contract E335 limits. No vibration mitigation is recommended.

Table 2-1 Recommended Sound Wall Lengths and Heights

Wall	Start Station	End Station	Wall Length	Wall Height	Wall Location	Comments
1	WB531+55	EB540+15 South Tunnel Portal	860 ft	6 ft above ground level at ROW line	Along WB right-of-way line	Near south tunnel portal, wall is to be a continuation of the E320 Sound Wall 4.
2	EB577+00	EB583+00	600 ft	3 ft above top of rail	Along east edge of EB guideway	Mitigation for Coast Bellevue Hotel
3	EB601+50	EB609+50	800 ft	6 ft above top-of-rail	Along east edge of EB guideway and at-grade trackway	Mitigation for the Lake Bellevue Condominiums

2.2 Bellevue City Code Noise Impact Assessment

The predicted nighttime noise levels of train operations with the noise mitigation required by the Record of Decision at the EDNA Class A parcels within the E335 Contract are compared to the maximum permissible noise levels defined in the Bellevue City Code (BCC). Predicted nighttime noise levels do not exceed the BCC maximum permissible noise level at any of the EDNA Class A parcels.

There are two Traction Power Substations (TPSS) units located within the Contract E335 limits. One TPSS unit will be located near the DBT south portal in Downtown Bellevue near station 540+00, east of the tracks. The nearest sensitive receiver is parcel EL206, a residence, located west of the tracks. The other TPSS unit is located adjacent to the storage track west of 120th Avenue. The nearest receiver is EL278, a commercial land use. TPSS noise is regulated by the City of Bellevue noise code. The predicted noise does not exceed the allowable noise levels. No noise mitigation is recommended for the TPSS units.

3.0 ROD Commitments

The impact analysis and mitigation recommendations presented in this report are consistent with the ROD commitments. The noise and vibration ROD commitments applicable to the final design are:

1. Noise mitigation measures would be provided that is 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 predicted impacts and mitigation measures will be reviewed for verification. During final design, if it is discovered that equivalent 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. Prior FTA approval is required for any elimination or substantial modification to mitigation measures. The potential mitigation options available for noise from transit operations on the East Link Project are primarily sound walls, special track work, lubricated curves, and residential building sound insulation. Sound walls are proposed where feasible and reasonable, as determined by Sound Transit (and the Federal Transit Administration, at its discretion) 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 will include where feasible the use of 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 track work, such as movable point or spring rail frogs, eliminates the gap between tracks at crossovers that causes noise and vibration at these locations and will be used where feasible. 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. While the mitigation provided herein is based on predicted impacts, noise mitigation shall be provided if, after operations commence, noise impacts occur for which mitigation is deemed necessary and appropriate under FTA noise standards.
2. Traffic noise impacts will be mitigated by sound walls, where determined to be reasonable. For locations with residual traffic noise impacts caused by the project, residential sound insulation might also be considered by Sound Transit.

3. Wheel Squeal: For curves of 600-foot radius or less, a trackside or vehicle-mounted lubrication system will be used to mitigate wheel squeal noise. For curves of 600- to 1,250[1]-foot radius, the project will be designed to accommodate a lubrication system if wheel squeal occurs during operations.
4. Vibration and groundborne noise impacts that exceed FTA criteria warrant and will receive from Sound Transit effective mitigation measures, as described below, when determined to be reasonable and feasible. The locations requiring mitigation will be refined during final design and will be included, where needed, in the project's final design specifications. At some locations, however, light rail trackways or guideways could be within 20 feet of buildings and vibration mitigation may not be effective at reducing the vibration level to below the FTA criteria. At these locations, project design modification and additional information on affected buildings could eliminate these impacts. For instance, the type of building foundation might reduce vibration impacts and therefore, these residual impacts might be eliminated. In addition, each building will 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 are predicted to occur, and the vibration is not predicted to 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. Vibration mitigation measures will be employed at those areas where vibration impacts have not been anticipated but are shown evident after operations commence. Options for mitigating vibration impacts include the following: 1) 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. 2) 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. 3) Tire-derived aggregate (TDA), which consists of shredded tires wrapped with filter fabric that is added to the base below the track ties. 4) 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. 5) 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.

The mitigation recommendations in this report meet the ROD commitments.

[1] The ROD says curves of 600 to 1,000 feet should be designed to accommodate a lubrication system, but the Design Criteria Manual (DCM V-3) states lubrication systems shall be accommodated within the track design on all curves less than 1,250 feet except bored tunnels. The ROD text in this section has been modified to be consistent with the DCM.

4.0 Impact Assessment Methodology

4.1 Noise Impact Thresholds and Noise Limits

FTA Impact Thresholds

This report includes a noise impact assessment using the prediction methodology and impact thresholds set forth in the FTA guidance manual. The FTA noise impact thresholds apply only to land uses defined as noise sensitive in the FTA guidance manual. The FTA guidance manual defines three categories of noise sensitive land uses:

- Category 1: Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet. Included are outdoor amphitheaters, recording studios, and concert halls.
- Category 2: Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where nighttime sensitivity to noise is assumed to be of utmost importance.
- Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material.

Category 2 land uses within the Contract E335 limits include residences and the Red Lion Hotel near East Main Station, the Bravern Condominiums near BTC Station, Lake Bellevue Condominiums north of Hospital Station, and the Coast Bellevue Hotel. Category 3, or institutional land uses, within the E335 contract limits include the Meydenbauer Theater and Mercer Education, a tutoring facility. Noise predictions using the FTA noise impact thresholds are presented for these sensitive receivers. The noise impact thresholds are presented graphically in Table 3-1 of the FTA guidance manual.

Bellevue City Code Noise Limits

Chapter 9.18 of the Bellevue City Code (BCC) addresses noise control. The chapter includes maximum permissible noise levels and exemptions to those noise limits. The BCC applies to stationary noise sources associated with the Project and to nighttime train operations in Class A EDNAs. The stationary noise sources within the E335 contract are PA announcements and transformer noise at stations and noise from TPSS units. Noise from these stationary sources are assessed for impact using the maximum permissible noise levels presented in BCC 9.18.030.B. Those maximum permissible noise levels are summarized in Table 4-1. The BCC noise impact assessment of nighttime train operations at Class A EDNA properties is presented in Section 7.0.

Table 4-1: Applicable Maximum Permissible Sound Levels, Bellevue City Code

EDNA of Noise Source	EDNA Of Receiving Property	
	Class A	Class B
Class A	55 dBA	57 dBA
Class B	57 dBA	60 dBA
Source: Bellevue City Code Chapter 9.18		

Noise from train and wayside warning devices such as bells and horns are exempt from the BCC maximum permissible sound levels as safety warning devices.

4.2 Vibration Impact Thresholds

This report includes a vibration impact assessment using the using the prediction methodology and impact thresholds set forth in the FTA guidance manual. The FTA vibration impact thresholds apply only to land uses defined as vibration sensitive in the FTA guidance manual. The FTA guidance manual defines three categories of vibration sensitive land uses:

- Category 1: Buildings where vibration would interfere with interior operations. This includes spaces with vibration sensitive equipment.
- Category 2: Residences and buildings where people normally sleep.
- Category 3: Institutional land uses with primarily daytime use.

There are some buildings that are vibration sensitive, but do not fit into the above categories which include theaters and concert halls. Groundborne vibration and groundborne noise criteria for these special buildings are presented in Table 8-2 of the FTA guidance manual. The groundborne vibration and groundborne noise criteria for a detailed analysis for the other vibration sensitive land uses are shown in Figure 8-1 of the FTA guidance manual.

There are no vibration limits presented in the Bellevue City Code. Therefore, potential for vibration impact is assessed using only the FTA methodology and criteria.

4.3 Airborne Noise

Wheel/Rail Noise from Light-Rail Vehicles

The FTA detailed noise analysis procedure and the BCC noise impact assessment procedure for predicting noise from light-rail vehicles (LRVs) is a spreadsheet model using formulas presented in the FTA guidance manual. The formulas take into account the following specific operating characteristics of the Sound Transit system:

- Measured reference sound level of existing Sound Transit LRVs,
- the train operating schedule,
- train speed, and
- track structure

ATS Consulting took reference sound level measurements on the existing ST Central Link light-rail system in August 2014[2]. Measurements were taken on at-grade, ballast-and-tie track and aerial structure direct fixation track. The measurements were made using a 3-car train consist travelling at controlled speeds during non-revenue service hours and measurements of 2-car train consists during regular revenue service hours. The results of the noise measurements showed that the noise levels on the Central Link system are about 2 decibels higher than the FTA reference noise level for LRVs. The reference sound exposure level (SEL) used for the predictions in this analysis is 84 dBA at 50 ft for a one-car train traveling at 50 mph for ballast-and-tie track (2 decibels higher than the FTA reference level of 82 dBA). The measured reference levels for ballast-and-tie track and direct fixation track are shown in Table 4-2.

[2] The sound level measurements of the existing ST Central Link light rail system are documented in the report: *Noise Measurements of Existing Sound Transit Trains* dated August 21, 2014.

Table 4-2: Measured SEL Reference Levels

Track-type	SEL Reference Level, dBA[1]
Ballast-and-Tie (at-grade)	84
Direct Fixation (aerial structure)	88
[1]SEL reference level is for a one-car train traveling at 50 mph at 50 ft.	

The train schedule from Sound Transit's Revised 2035 Light Rail Operation Plans, shown in Table 4-3, was used for the noise predictions. Note that the revised 2035 operating schedule is different than the assumptions used in the Final EIS predictions. The revised operating schedule assumes 8 minute peak headways and 4-car train consists, while the Final EIS schedule assumed 7-minute peak headways and 3-car train consists. In addition to the operations shown in Table 4-3 there will be early morning non-revenue trains operating through the E335 alignment. The increase in the 24-hour Ldn noise level due to these two trains will be negligible and will not change the mitigation recommended in this report. The operating speeds and track structure type assumed in the predictions are based on the information in the design drawings dated December 20, 2013.

Table 4-3: East Link Operating Plan

Hours	Headway (minutes)	Total train cars (assuming 4-car trains)
5-6 a.m.	15	16
6-7 a.m.	8	30
7-8:30 a.m.	8	45
8:30 a.m.-3:00 p.m.	10	156
3-6:30 p.m.	8	105
6:30-10 p.m.	10	84
10 p.m.-1:00 a.m.	15	48
1-5 a.m.	0	0

In addition to the operating characteristics of the system, the noise formulas also account for distance from the sensitive receiver, ground absorption effects, and noise from bells. The methodology for the analysis in this report follows the procedures in the FTA guidance manual and the Final EIS. The exception is that the analysis in this report includes a ground absorption factor in some areas and the Final EIS does not. In the Final EIS, the ground absorption was assumed to be 0 for all areas to standardize predictions. A ground absorption factor, which results in a lower predicted noise level, is included in the predictions in this report where it is clear that there is soft ground between the receiver and the source. Applying a ground absorption factor to areas with soft ground is consistent with the FTA guidance manual.

The assumptions used for bell predictions are based on the Sound Transit bell policy. Included in the predictions are noise from the warning bells on the light-rail vehicles and audible warning devices at crossings. The assumptions for the different types of bells are:

- Trains will have a high bell, low bell, and horn. The horn is for emergency situations only and is not used in the noise analysis. Consistent with the practice on the Central Link line, the train-mounted bell will be sounded two to three times as a train approaches and passes through an at-grade crossing and for arrivals and departures at a station. The high bell has a sound pressure level of 80 dBA at 50 feet and is used during the daytime hours from 6 a.m. to 10 p.m. The low bell has a sound pressure level of 72 dBA at 50 feet and is used during the nighttime hours from 10 p.m. to 6 a.m.

- Wayside pedestrian audible warning devices (AWDs) located at the at-grade crossings will operate at 10 decibels above the ambient noise levels. The predictions assume the AWDs have an Lmax of 77 dBA at 15 feet and will sound for approximately 40 seconds per train. The noise analysis does not assume that the noise levels of the audible warning devices would be reduced during nighttime hours (a worst case assumption).

TPSS Noise

The primary noise sources on TPSS units are the air conditioning units. The noise levels from the TPSS units were predicted using the manufacturer's measured sound levels for the Bard wall mounted package air conditioner model W38A1. The manufacturer's measured noise level at a distance of 50 feet from the unit is 50 dBA, which is consistent with a noise measurement ATS Consulting performed at a TPSS unit from the Gold Line, an LRT system in Los Angeles, CA. The predictions for this analysis assume that the air conditioner unit would be operating continuously, which is a worst-case assumption. The noise of the TPSS units is compared to the noise limits in the Bellevue City Code to determine potential impacts. The noise level at the nearest receiving property is predicted using the following equation:

$$Leq(1hr) = Leq_{ref} - 20 \cdot \log(dist/50)$$

Station Acoustics

In an enclosed environment such as a transit station sound can continue to reflect for a period of time after a source has stopped emitting sound. This prolongation of the sound is called reverberation. Reverberation time (RT_{60}) is defined as the time required, in seconds, for the average sound in a room to decrease by 60 decibels after a source stops generating sound. Reverberation time is the primary descriptor of an acoustic environment.

Reverberation time is affected by the size of the space and the amount of reflective or absorptive surfaces within the space. A space with highly absorptive surfaces will absorb the sound and stop it from reflecting back into the space. This would yield a space with a short reverberation time. In general, larger spaces have longer reverberation times than smaller spaces. Therefore, a large space will require more absorption to achieve the same reverberation time as a smaller space.

Reverberation time for the transit stations are calculated using the Sabine Formula:

$$RT_{60} = 0.049 \cdot V/a$$

where V is the volume of the space (ft^3) and a is the total room absorption at a given frequency in sabins. It is important to note that the absorption and surface area must be considered for every material within a space in order to calculate sabins. The number of sabins is determined by multiplying the noise reduction coefficients of different surfaces within the station by the surface area of that material.

This calculation method is used to determine if the design of a transit station will achieve the Sound Transit Design Criteria goal of a reverberation time of 1.2 seconds in station platform areas, and 1.0 seconds in enclosed public spaces, and other areas where transit patrons rely on the PA system for information and directions. The FTA and BCC do not have noise criteria relating to station reverberation time. The Sound Transit Design Criteria are the only criteria that apply to the acoustical design of stations.

Station Equipment Noise

Stationary noise sources associated with the LRT stations are the operation of electrical transformers, condenser units, and PA announcements. Noise from these sources are subject to the limits in the BCC.

75 KVA transformers will be used at the stations. Manufacturer's sound level data of a transformer between 51 KVA and 150 KVA is 50 dBA at 3 feet. The noise level at the nearest receiving property is predicted using the following equation:

$$Leq(1hr) = Leq_{ref} - 20*\log(dist/3)$$

where Leq_{ref} is the reference noise level of 55 dBA at 3 feet and *dist* is the distance from the transformer to the property line of the receiving property. Note that this prediction methodology assumes the transformer operates continuously.

The Bellevue Transit Center Stations will use two 4 ton condenser units as part of their HVAC system. The manufacturer's sound level data for the condenser units are a sound power level (Lw) of 85 dBA per unit. This data was used to predict the operating noise level at the nearest receiving properties based on the following equations:

$$Leq(1hr) = \mathrm{Lw}_{ref} - 20*\log(dist)-11$$

The PA speakers at the station will operate at 10 dB above the ambient noise level at a distance of 10 feet from the speaker. The noise level from the PA announcements at the nearest receiving property is predicted using the following equation:

$$Leq(1hr) = L_{ref} + 10*\log(duration) - 20*\log(dist/10)$$

where L_{ref} is the reference noise level of 10 dB above the ambient, *duration* is the total duration in seconds of announcements over one hour, and *dist* is the distance from the speaker to the property line of the receiving property. The noise limits from the BCC is used to assess noise impact from the PA system.

Emergency Ventilation Noise

There will be emergency ventilation fans located in mid-tunnel fan room and in fan niches inside the DBT. The ST Design Criteria Manual specifies noise limits for fan noise inside mechanical equipment rooms and on the station platforms. There are no limits for fan noise inside of the tunnel included in the DCM; however, emergency ventilation fan noise in the tunnel may interfere with speech communication during an emergency evacuation and may approach noise levels that present a risk of hearing damage. The National Fire Protection Association (NFPA) Standard 130: Standard for Fixed Guideway Transit and

Passenger Rail Systems limits noise exposure to 115 dBA for a few seconds and 92 dBA for the remainder of the exposure. The NFPA Standard 130 is used as the noise limit for emergency ventilation noise inside the tunnel.

The emergency ventilation fan noise is predicted using the methodology and formulas presented in Chapter 10 of the Urban Handbook of Noise and Vibration Control[3] The fan noise inside the mid-tunnel fan room and in the fan niches inside the tunnel was predicted using the equation:

$$Lp = Lw + 10*\log(24.8*T/V)$$

where:

Lp = Sound pressure level,
Lw = Sound power level of the fans,
T = Reverberation time in seconds, and
V = Volume of the room in m^3.

Fans located in the fan room are limited to Lmax = 85 dBA. Fan noise on the station platforms are limited by the ST DCM to an Lmax of 75 dBA. The intent of the criteria is to ensure that during an emergency the PA announcements are intelligible.

4.4 Groundborne Vibration and Groundborne Noise

Perceptible groundborne vibration is when building occupants feel the vibration of the floor or other building surfaces. The vibration of room surfaces will radiate sound waves that may be audible to humans; this is referred to as groundborne noise. When audible groundborne noise occurs, it usually sounds like a low frequency rumble. For a surface rail systems, the groundborne noise is usually masked by the normal airborne noise radiated from the transit vehicle. Therefore, impact from groundborne noise is only assessed for those receivers adjacent to the tunnel section of the project, where the airborne noise is blocked by the tunnel.

The FTA detailed vibration analysis procedure is an empirical method based on testing of the vibration propagation characteristics of the soil near sensitive receivers and measurements of the vibration characteristics of a similar LRV. The vibration propagation test is used to determine the line source transfer mobility (LSTM). The LSTM quantifies how easily vibration travels through the earth. A high transfer mobility indicates that there is relatively little attenuation as vibration travels through the earth. The vibration characteristics of the LRV are quantified by the force density level (FDL). The basic relationship used for the vibration predictions is:

Lv = LSTM + FDL + Train Length Adjustment + Safety Factor
where:

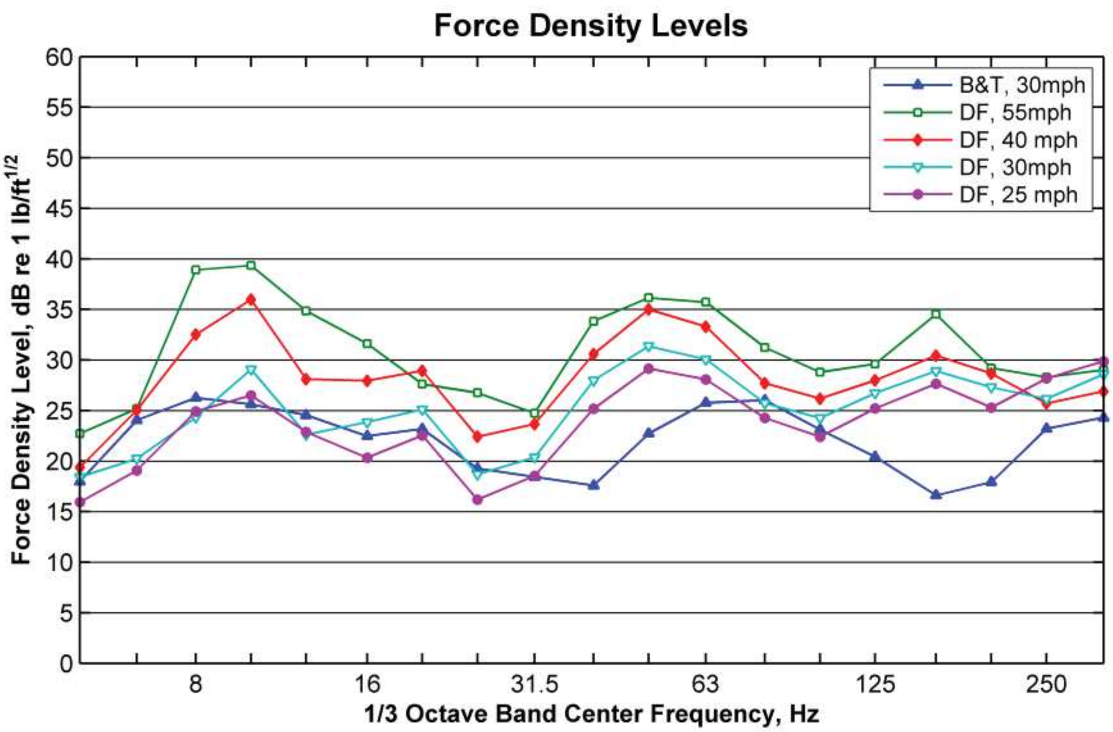
Lv	Predicted train vibration velocity
LSTM	Measured line source transfer mobility that characterizes the vibration propagation through the soil
FDL	Measured force density level that characterizes the vibration forces generated by the train and the track
Train Length Adjustment	A+0.5 dB adjustment to account for a 4-car train consist
Safety Factor	+3 dB adjustment to account for uncertainty in the measurement results

[3] Handbook of Urban Rail Noise and Vibration Control. Report No. UMTA-MA-06-0099-82-1. October 1982.

Vibration propagation tests were conducted near the vibration sensitive receivers located within the Contract E335 limits. The results from the tests are presented in Section 6.0.

ATS Consulting measured the FDL on the existing ST Central Link light rail system in April 2013. Measurements were taken on at-grade track, direct fixation track in a retained cut, and on an aerial structure with DF track to determine the FDL for different track types. The FDL of DF track in retained cut is representative of DF track in tunnel. The FDL measurements were made using a 3-car train consist. The FDL results are documented in the report: Vibration Measurements of Existing Sound Transit Trains, August 20, 2014. The FDLs for the different track types and train speeds used in the analysis are shown in Figure 4-1.

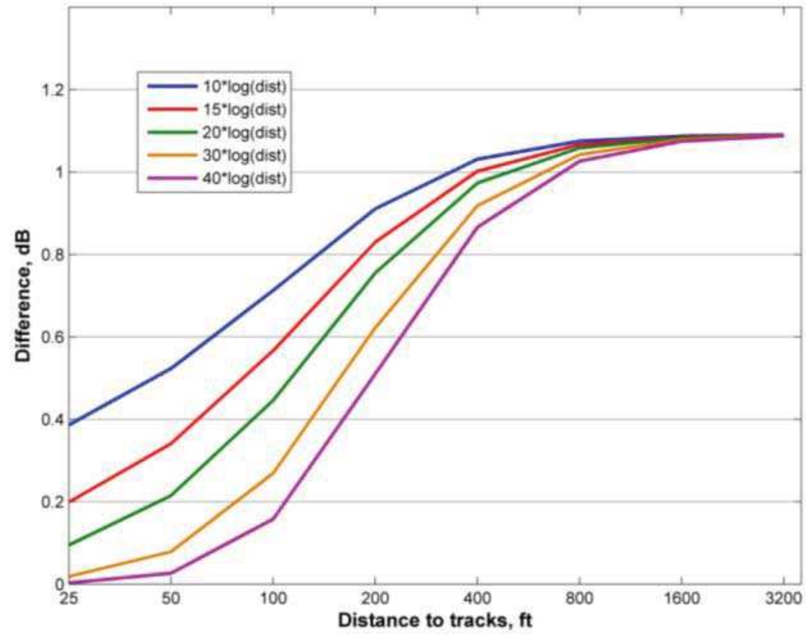
Figure 4-1: Force Density Levels used for Vibration Predictions



The current East Link operating plan calls for four-car trains. A train length adjustment is included in the predictions to account for the fact that the FDL measurement test was conducted with a three-car train. The train length adjustment was derived using a spreadsheet model. The effect of train length on vibration levels at a sensitive receiver will depend on the vibration propagation characteristics of the soil at the receiver and the distance from the tracks to the receiver. Therefore, the effect of train length varies depending on site specific conditions. Figure 4-2 shows the expected vibration difference for four car trains compared to three car trains. The horizontal axis is the distance from the tracks and the vertical axis is the expected increase in vibration levels for a four-car train compared to a three-car train. The different lines on the plot represent different soil propagation characteristics. For example, the blue line represents soil where vibration travels very efficiently and the pink line represents soil where vibration does not travel very efficiently.

The train length adjustment used for the predictions is a +0.5 dB adjustment applied to all frequency bands and to receivers at all distances. This adjustment was chosen because the +0.5 dB adjustment is conservative (most likely an overestimate) for receivers closer than 100 ft to the tracks and all sensitive receivers identified with potential for impact in the Final EIS are located closer than 100 ft to the tracks.

Figure 4-2: Expected Vibration Difference for a 4-Car Train Compared to a 3-Car Train



The relationship between the predicted groundborne vibration, Lv, and the predicted groundborne noise, La, is:

La = Lv + Ka-wt + Krad,

where Ka-wt is the A-weighting adjustment at the 1/3 octave band center frequency and Krad is an adjustment to account for the conversion from vibration velocity level to sound pressure level such as any acoustical absorption in the room. The FTA guidance manual recommends a Krad value of zero for typical residential rooms although recent research indicates the average Krad for residential construction is closer to -5 dBA. The analysis in this report assumes a Krad of 0, which is a conservative assumption to ensure predicted groundborne noise levels are not underestimated.

5.0 Operational Noise Impact Assessment

This section presents a detailed noise impact analysis of LRT operations, a noise impact analysis of proposed TPSS sites, emergency ventilation jet fans, ancillary equipment at stations, and station acoustical design. There are no Sound Transit park-and-ride garages within the Contract E335 limits. Where noise impact is predicted, mitigation measures are proposed. The noise predictions reference noise sensitive receivers by parcel number. Appendix B includes a table that lists all parcel numbers included in this report and their corresponding street address.

5.1 Existing Noise Levels

Determining the existing noise exposure at sensitive receivers is an important step in the noise impact assessment because the thresholds for noise impacts are based on existing noise. The noise impact thresholds are higher for areas with high existing noise and lower for areas with low existing noise. ATS Consulting performed additional noise measurements at sensitive receivers throughout the project area to better evaluate the existing noise exposure. The measurement data was used in conjunction with the measurement results reported in the Final EIS to determine the existing noise exposure at the sensitive receivers within the package limits.

Table 5-1 shows the existing noise levels measured by ATS Consulting in 2013. The measurements conducted were long-term (24-hour) unattended noise measurements. Appendix C presents aerial photographs showing the measurement locations.

Table 5-1: Existing Noise Measurement Results

Parcel	Address	Measured Noise Level, Ldn (dBA)
EL206	11102 SE 1st Pl	65
EL236	Bravern Condominiums 688 110th Avenue NE	71
EL242	Coast Bellevue Hotel 625 116th Avenue NE	70
EL261	Lake Bellevue condominiums 4 Lake Bellevue Drive	56

5.2 EB Station 531+55 to 540+00: East Main Station and South Tunnel Portal

This section presents the noise impact assessment for the area north of the East Main Station up to the DBT south portal. The sensitive receivers in this area are the residences west of 112th Avenue SE and the Red Lion Hotel located at the southeast corner of 112th Avenue SE and Main Street. Once the LRVs enter the tunnel, all sensitive receivers will be shielded from noise. Therefore, sensitive receivers located in Downtown Bellevue above the tunnel are not included in the detailed noise analysis, but are assessed for operational vibration and groundborne noise impact. Figure 5-1 shows the location of the parcels assessed in this section. Note that residences south of parcel EL187 are included in the noise impact analysis for the E320 contract.

Table 5-2 shows the existing noise level, impact threshold, and predicted level for sensitive receivers. All sensitive receivers in this area are Category 2, or residential land uses, and all noise levels in the table are the Ldn, or day-night sound level. Key notes on the prediction assumptions for this area include:

- The existing noise level was measured at parcel EL206 in May 2013 and at parcel EL196 as part of the Final EIS study. The existing noise level at EL199 (the Red Lion Hotel) is based on the noise level measured at Hotel Bellevue in May 2013. Hotel Bellevue is located about 800 ft south of the Red Lion Hotel, also on 112th Avenue SE. The measured noise level at Hotel Bellevue was adjusted for distance to 112th Avenue SE to estimate the existing noise level at Red Lion Hotel because Red Lion Hotel is located closer to the street and traffic noise is the dominant existing noise source at the Red Lion Hotel.

- We have assumed a shielding factor of -2 dB at the Red Lion Hotel due to the 10 foot high concrete masonry unit (CMU) wall on the eastside of the alignment that extends from the South Portal of the tunnel south past the TPSS. The wall will provide partial shielding between the LRT tracks and the Bellevue Red Lion Hotel (EL199).
- There is direct fixation track in the retained cut near the Downtown Bellevue Tunnel South Portal beginning at the north end of the East Main Station at EB536+55. The predicted level for parcels L195 and EL206 assume a reference noise level for direct fixation track. The predicted level for parcels EL187 to EL194 assume a reference noise level for ballast-and-tie track.
- Ground absorption is included for the residences west of 112th Avenue SE, because the project will include a landscaped buffer area. Ground absorption was not included for the Red Lion Hotel (EL199) because there is generally paved ground between the tracks and the receiver.
- Audible warning devices for pedestrian crossings and train bell noise associated with the East Main Station are included in the predictions for all receivers in Table 5-2.
- Train speeds will be generally slow as the LRVs enter and exit the East Main Station, and as they enter or exit the curve north of the station. The train speeds assumed for the predictions are shown in Table 5-2.
- Wheel squeal from the curve north of the station is not included in the predictions because the Project is committed to the installation of lubricators on curves with a radius of less than 600 feet. The curves in both the eastbound and westbound track have a radius less than 600 feet.
- Noise at the tunnel portal may be up to 3 dB higher than train noise in an open area due to reflections off of the hard surfaces of the tunnel and the portal wall. However, noise from the tunnel portal will be very localized and will diminish at distances of 50 feet or more from the portal. There are no sensitive receivers within 100 ft of the tunnel portal therefore any increase in train noise due to the tunnel is not included in the predicted levels for any of the sensitive receivers.

As shown in Table 5-2, noise impact is predicted at the residential parcels located west of 112th Avenue SE. The predicted noise level for parcel EL199 (the Red Lion Hotel) does not exceed the moderate noise impact threshold. The locations of the parcels are shown in Figure 5-1.

The recommended mitigation for the residential parcels west of 112th Avenue SE is a sound wall. The sound wall is a continuation of the wall recommended in the Contract E320 Noise and Vibration Report. The sound wall for the E335 contract begins at station 531+55. There should be no gap or space between the end of the wall in Contract E320 and the beginning of the wall in Contract E335. The location of the sound wall presented in Table 5-3 and shown in Figure 5-1. The sound wall generally follows the right-of-way boundary and extends to the DBT South Portal.

Table 5-2: Predicted Noise Levels at Parcels near South Tunnel Portal

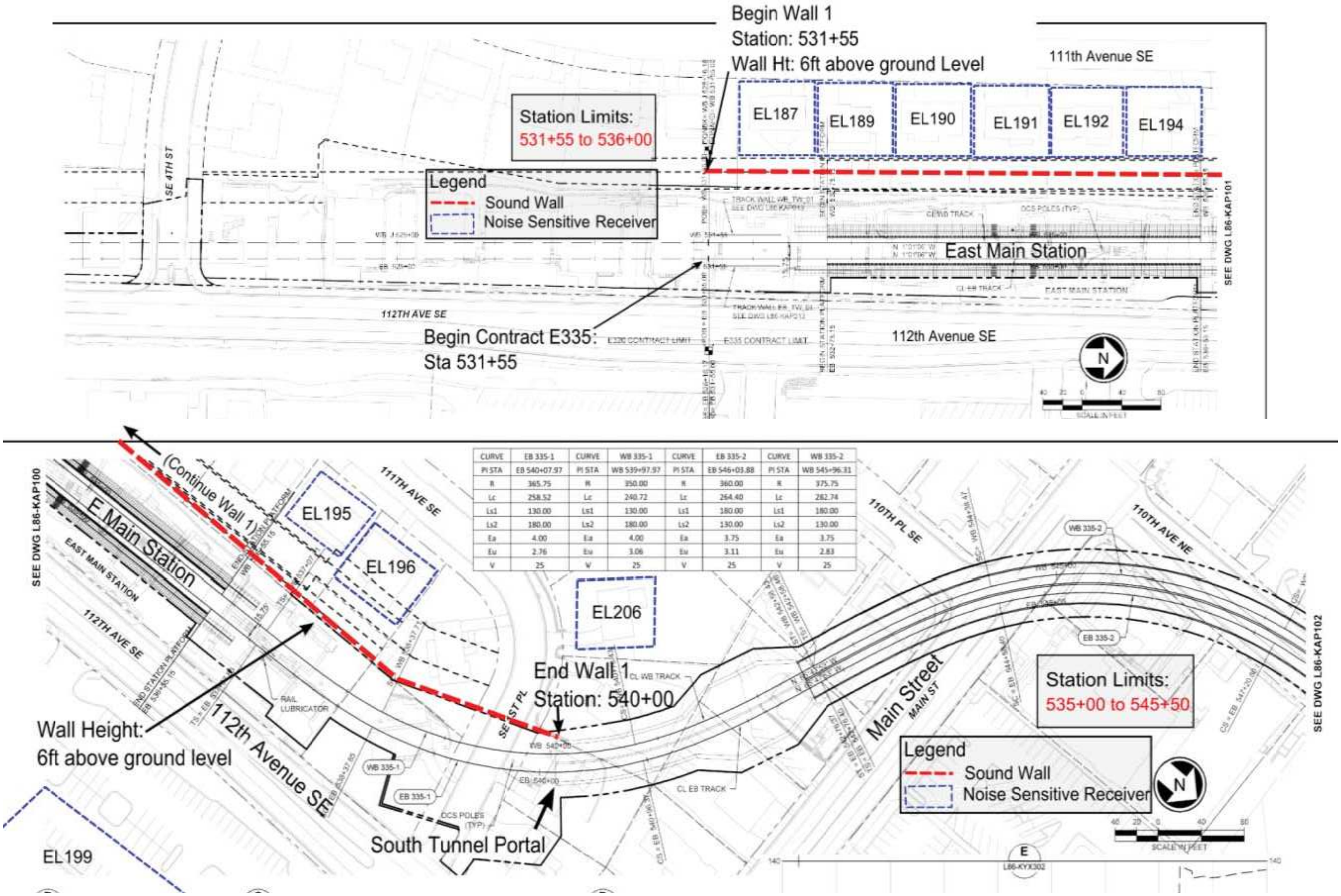
Parcel	Distance to WB track, ft	Speed (mph)	Ground Absorption, dB	Bell Noise, Ldn dBA	Existing Noise Level, Ldn dBA	Impact Threshold[1], Ldn dBA		Predicted Level, Ldn dBA	Amount Exceeds Moderate	Mitigated Level, Ldn dBA
						Mod-erate	Severe			
EL187	106	35	2.8	58	63	60	66	62	2	45
EL189	93	35	2.5	59	64	61	66	63	2	46
EL190	96	25	2.5	59	64	61	66	61	0	44
EL191	100	25	2.6	58	64	61	66	61	0	44
EL192	97	25	2.5	58	64	61	66	61	0	44
EL194	93	25	2.4	59	64	61	66	62	1	46
EL195	105	25	2.6	58	64	61	66	63	2	47
EL196	75	25	1.6	61	64	61	66	66	5	50
EL199 (Red Lion Hotel)	200 (Dist. to EB track)	25	--	53	64	61	65	60	-1	--
EL206	115	25	3	57	65	61	67	63	2	47

[1] Noise Impact Thresholds are based on Table 3-1 of the FTA 2006 Guidance Manual.

Table 5-3: Recommended Sound Wall Height and Length near East Main Station

Wall	Start Station	End Station	Wall Length	Wall Height
1	531+55	540+15 (DBT South Portal)	860 ft	~6 ft above ground level at ROW line

Figure 5-1: Recommended Sound Wall for Parcels EL187-EL196, EL199 (the Red Lion Hotel), and EL206



CURVE	EB 335-1	CURVE	WB 335-1	CURVE	EB 335-2	CURVE	WB 335-2
PI STA	EB 540+07.97	PI STA	WB 539+97.97	PI STA	EB 546+03.88	PI STA	WB 545+96.31
R	365.75	R	350.00	R	360.00	R	375.75
Lc	258.52	Lc	240.72	Lc	264.40	Lc	282.74
Ls1	130.00	Ls1	130.00	Ls1	180.00	Ls1	180.00
Ls2	180.00	Ls2	180.00	Ls2	130.00	Ls2	130.00
Ea	4.00	Ea	4.00	Ea	3.75	Ea	3.75
Eu	2.76	Eu	3.06	Eu	3.11	Eu	2.83
V	25	V	25	V	25	V	25

5.3 EB Station 564+00 to 570+00: North Tunnel Portal

This section presents the noise impact assessment for the noise sensitive receivers located near the north portal of the DBT. The noise sensitive receivers in this area are the Bravern Condominiums (parcel EL236) and the Meydenbauer Center (parcel EL240), which is a convention center that also houses a theater. In this area, the tracks transition from the tunnel through the Bellevue Transit Center (BTC) Station onto an aerial structure. The track type is direct fixation. Figure 5-2 shows the noise sensitive receivers and track plan.

There is no noise impact assessment for receivers located between EB540+00 and EB564+00 because the LRVs will be traveling in the DBT and all noise will be shielded by the tunnel structure. The sensitive receivers located near the tunnel are included in the groundborne vibration and ground noise impact assessment in Section 6.0.

Table 5-4 shows the existing noise level, impact threshold, and predicted level for sensitive receivers near the DBT north portal. Key notes on the prediction assumptions for this area include:

- The Meydenbauer Center is assumed to be a Category 3 land use because it houses a theater. The FTA defines a Category 3 land use as institutional land uses with primarily daytime and evening use which includes schools, libraries, and theaters. The Bravern Condominiums are a Category 2 (residential) land use.
- Existing noise levels were measured at the Bravern Condominiums in April 2013. The existing noise level used in the analysis for the Meydenbauer Center is the peak hour measured at the Bravern Condominiums.
- Ground absorption is not included in the predictions because the ground between the tracks and the sensitive receivers is paved.
- A train speed of 25 mph is assumed as LRVs pass the Bravern Condominiums. The trains will travel relatively slowly as they enter and exit the BTC station and as they navigate the curve from 110th Avenue NE onto NE 6th Street. A train speed of 40 mph is assumed as the LRVs pass the Meydenbauer Center. Assuming an acceleration of 3 mph/sec, the LRV will reach a speed of 40 mph in 190 ft, which is about half the length of a four-car train.
- We assume a shielding factor of -3 dB for both the Meydenbauer Center and the Bravern Condominiums. The shielding factor is assumed because the train will be partially in the tunnel as it passes by the receivers and to account for the shielding from the station platform and other architectural features of the station.
- The predictions for both the Meydenbauer Center and the Bravern Condominiums include noise from the train bells that are sounded as LRVs enter and exit the station.
- A crossover is located 300 feet from the Meydenbauer Center. The crossover was assumed to add 10 decibels to the train noise at 35 feet and to decay with distance with a rate of 10*log(distance/35). This is consistent with the methodology used in the Final EIS and is based on measurements of crossovers on the existing Central Link System.
- Wheel squeal from the curve west of the station is not included in the predictions because the Project is committed to the installation of lubricators on curves with a radius of less than 600 feet. The curves in both the eastbound and westbound track have a radius less than 600 feet.
- Noise at the tunnel portal may be up to 3 dB higher than train noise in an open area due to reflections off of the hard surfaces of the tunnel and portal wall. However, noise from the tunnel

portal will be very localized and will diminish at distances beyond 50 feet from the portal. There are no sensitive receivers within 100 ft of the tunnel portal therefore any increase in train noise due to the tunnel is not included in the predicted levels for any of the sensitive receivers.

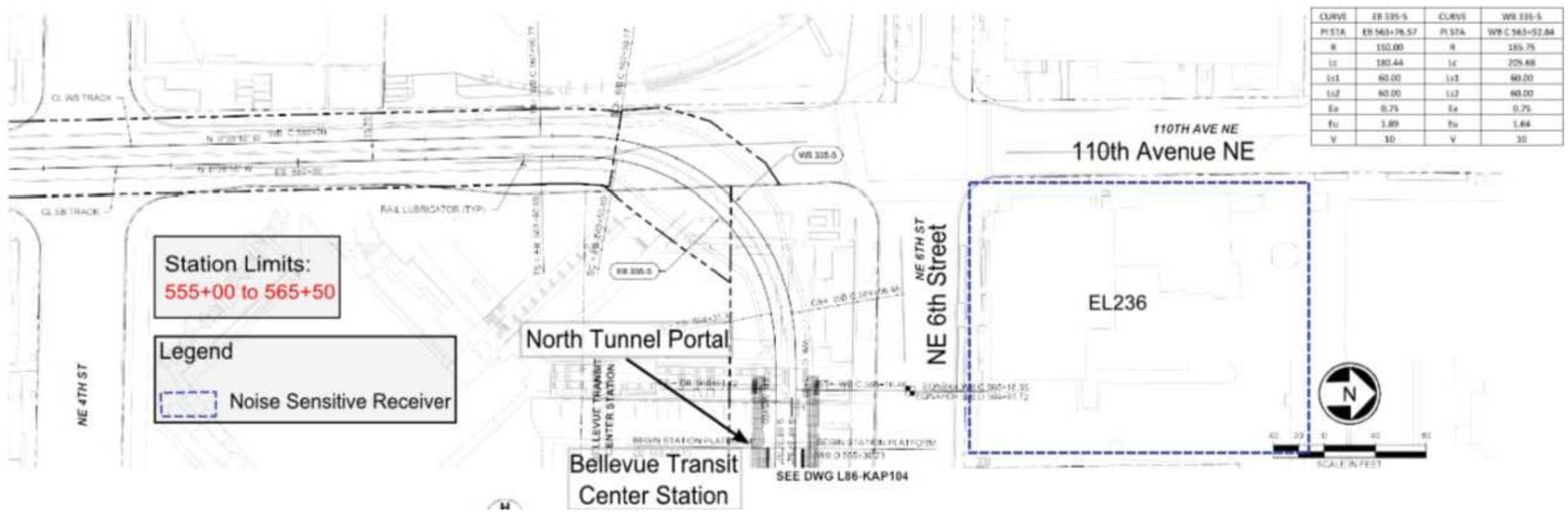
The predicted noise levels at the Bravern Condominiums and the Meydenbauer Center do not exceed the moderate noise impact threshold. Therefore, no noise mitigation is recommended.

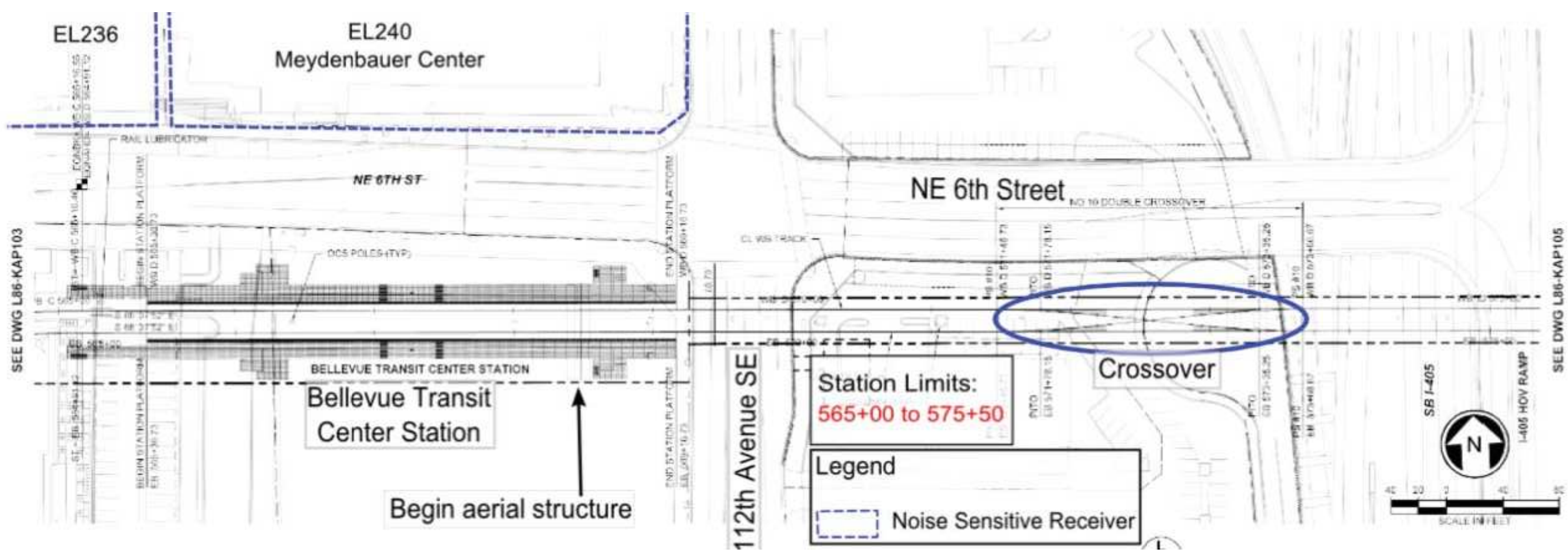
Table 5-4: Predicted Noise Levels at Parcels EL236 (Bravern Condominiums) and EL240 (Meydenbauer Center)

Parcel	Distance to WB track, ft	Speed (mph)	Bell Noise, dBA	Existing Noise Level, dBA	Impact Threshold[1], dBA		Predicted Level, Ldn dBA	Amount Exceeds Moderate
					Moderate	Severe		
EL236	145	25	53 (Ldn)	71 (Ldn)	66 (Ldn)	71 (Ldn)	63 (Ldn)	-3
EL240	125	40	54 (Leq)	69 (Leq)	69 (Leq)	75 (Leq)	64 (Leq)	-5

[1] Noise Impact Thresholds are based on Table 3-1 of the FTA 2006 Guidance Manual.

Figure 5-2: Parcels EL236 (Bravern Condominiums) and EL240 (Meydenbauer Center)





5.4 EB Station 570+00 to 592+00: Aerial Structure Over I-405 Freeway to South of Hospital Station

This section presents the noise impact assessment for the noise sensitive receivers located near the aerial structure from EB570+00 to EB592+00, just south of Hospital Station. The aerial structure begins on NE 6th Street just east of the Meydenbauer Center, then passes over the I-405 freeway, and curves north into the BNSF right-of-way east of 116th Avenue. The only noise sensitive receiver in this area is the Coast Bellevue Hotel (parcel EL242). The location of the parcel is shown in Figure 5-3.

Table 5-5 shows the existing noise level, impact threshold, and predicted noise level for the Coast Bellevue Hotel. Key notes for the prediction assumptions in this area include:

- The existing noise level at the Coast Bellevue Hotel was measured in April, 2013.
- There will be direct fixation track on the aerial structure.
- No ground absorption is included in the model.
- The WB track has a radius curve of 500 feet as the tracks approach Hospital Station. The EB track has a curve with radius curve of 715.75 feet in this same area. Sound Transit's Design Criteria Manual (DCM) requires a lubrication system on curves of 600 ft radius or less to mitigate wheel squeal and requires design curves to accommodate a lubrication system if they have a radius of 600 to 1,250 ft. In this area, the WB will include a lubrication system and we also recommend that the EB curve include a lubrication system in the design because of the proximity to a sensitive receiver. Since both curves will include a lubrication system wheel squeal is not included in the predictions.
- Assume a speed of 45 mph. The design speed for the curve east of the hotel is 35 mph and the design speed for the tangent track west of the hotel is 55 mph.

As shown in Table 5-5, the predicted noise level at the Coast Bellevue Hotel (EL242) is 2 decibels above the moderate impact threshold. A sound wall 3 foot above top of rail on the aerial structure would be needed to mitigate the train noise. The sound wall would extend from EB Sta. 577+00 to EB Sta. 583+00 approximately 600 feet long (Table 5-6 and Figure 5-3).

Table 5-5: Predicted Noise Levels at Coast Bellevue Hotel (Parcel EL242)

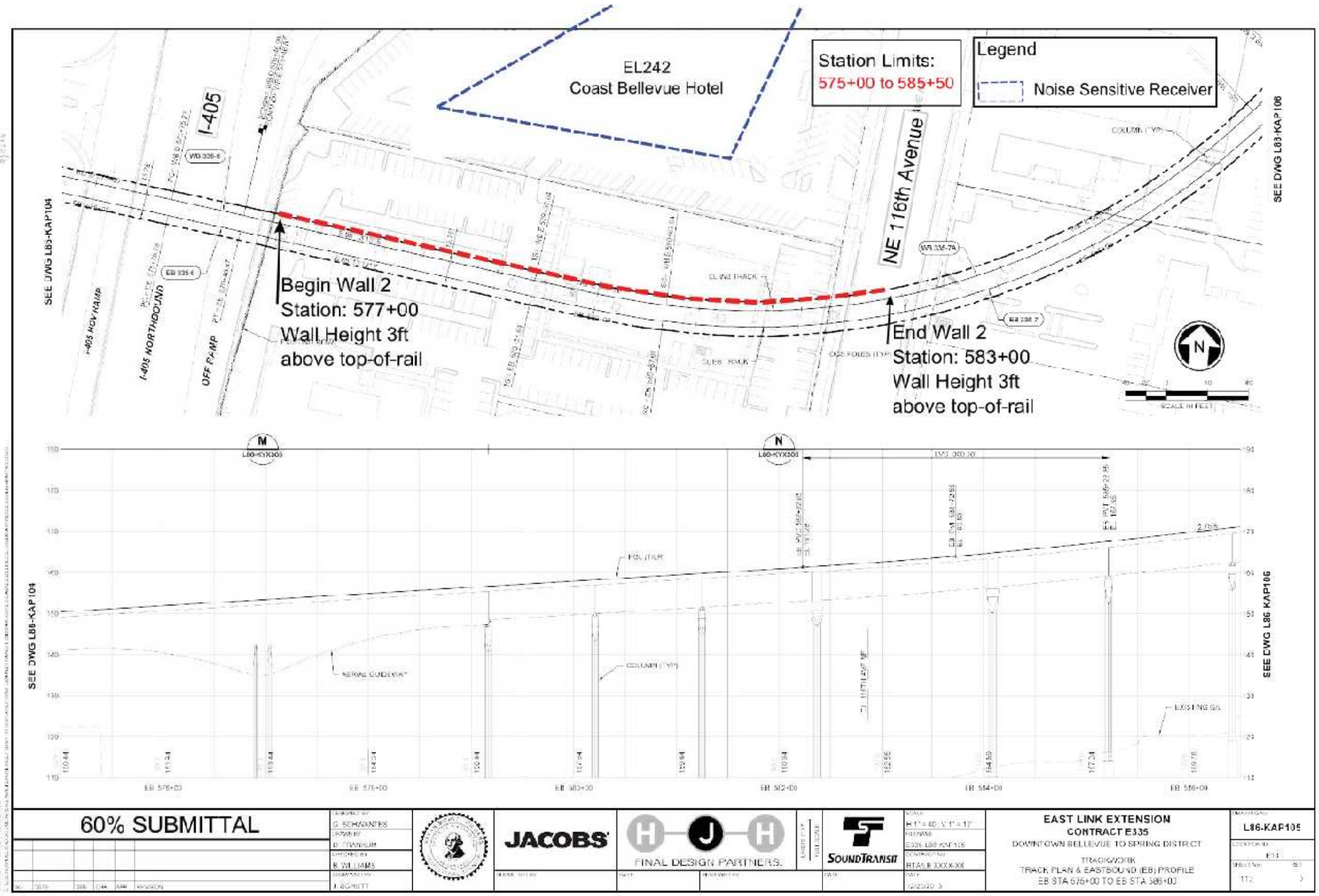
Parcel	Distance to WB track, ft	Speed (mph)	Existing Noise Level, dBA	Impact Threshold[1], dBA		Predicted Level, Ldn dBA	Amount Exceeds Moderate	Mitigated Level, dBA Ldn
				Moderate	Severe			
EL242	164	45	70	65	79	67	2	61

[1] Noise Impact Thresholds are based on Table 3-1 of the FTA 2006 Guidance Manual.

Table 5-6: Recommended Sound Wall for Coast Bellevue Hotel (Parcel EL242)

Wall	Start Station	End Station	Wall Length	Wall Height
2	EB 577+00	EB 583+00	600 ft	3 ft above top-of-rail

Figure 5-3: Location of Coast Bellevue Hotel (Parcel EL242)



5.5 EB Station 592+00 to 635+00: Hospital Station to 124th Street Crossing

This section presents the noise impact assessment for the noise sensitive receivers located in the section of track that begins in the BNSF right-of-way at the Hospital Station and extends to the 124th Street crossing, which is the east end of Contract E335. The noise sensitive receivers in this area are the Lake Bellevue Condominiums (EL261) and the Mercer Education facility (EL263). The locations of the sensitive receivers are shown in Figure 5-6.

Table 5-8 shows the existing noise levels, impact thresholds, and predicted noise levels for the sensitive receivers. Key notes on the prediction assumptions for this area include:

- Mercer Education (parcel EL263) provides educational enrichment programs and counseling. It is considered a Category 3 land use in this analysis. The FTA defines a Category 3 land use as an institutional land use with primarily daytime and evening use which includes schools, libraries, and theaters.
- The existing noise levels at the Lake Bellevue Condominiums (EL261) were measured by ATS Consulting in April 2013. The existing noise level used for the analysis of Mercer Education is the peak hour measured at the Lake Bellevue Condominiums.
- The Lake Bellevue Condominiums (EL261) and the Mercer Education building (EL263) are adjacent to the trestle which will have DF track. The trestle is where the guideway structure transitions from aerial to at-grade.
- There is a crossover about 250 feet from the units in the north end of the Lake Bellevue complex. Noise from the crossover is included in the predictions for parcel EL261b.
- The Hospital Station is about 500 feet south of the sensitive receivers. The only noise associated with the station will be the train bells and the PA system. These noise sources will not affect the predicted Ldn at the sensitive receivers and are therefore not included in the predictions.

As shown in Table 5-7, impact is predicted at the Lake Bellevue Condominiums (EL261). A sound wall is recommended for the Lake Bellevue Condominiums. The recommended length and height of the wall are shown in Table 5-8. Figure 5-4 shows the location of the wall. The wall begins on the aerial guideway, extends onto the trestle and then to the at-grade track section.

The recommended sound wall will effectively mitigate noise from the crossover to below the FTA moderate impact threshold. Therefore, no low-impact frog is necessary to reduce noise levels from the crossover located north of the Lake Bellevue Condominiums.

Table 5-7: Predicted Noise Levels at Lake Bellevue Condominiums (Parcel EL261) and Mercer Education (Parcel EL263)

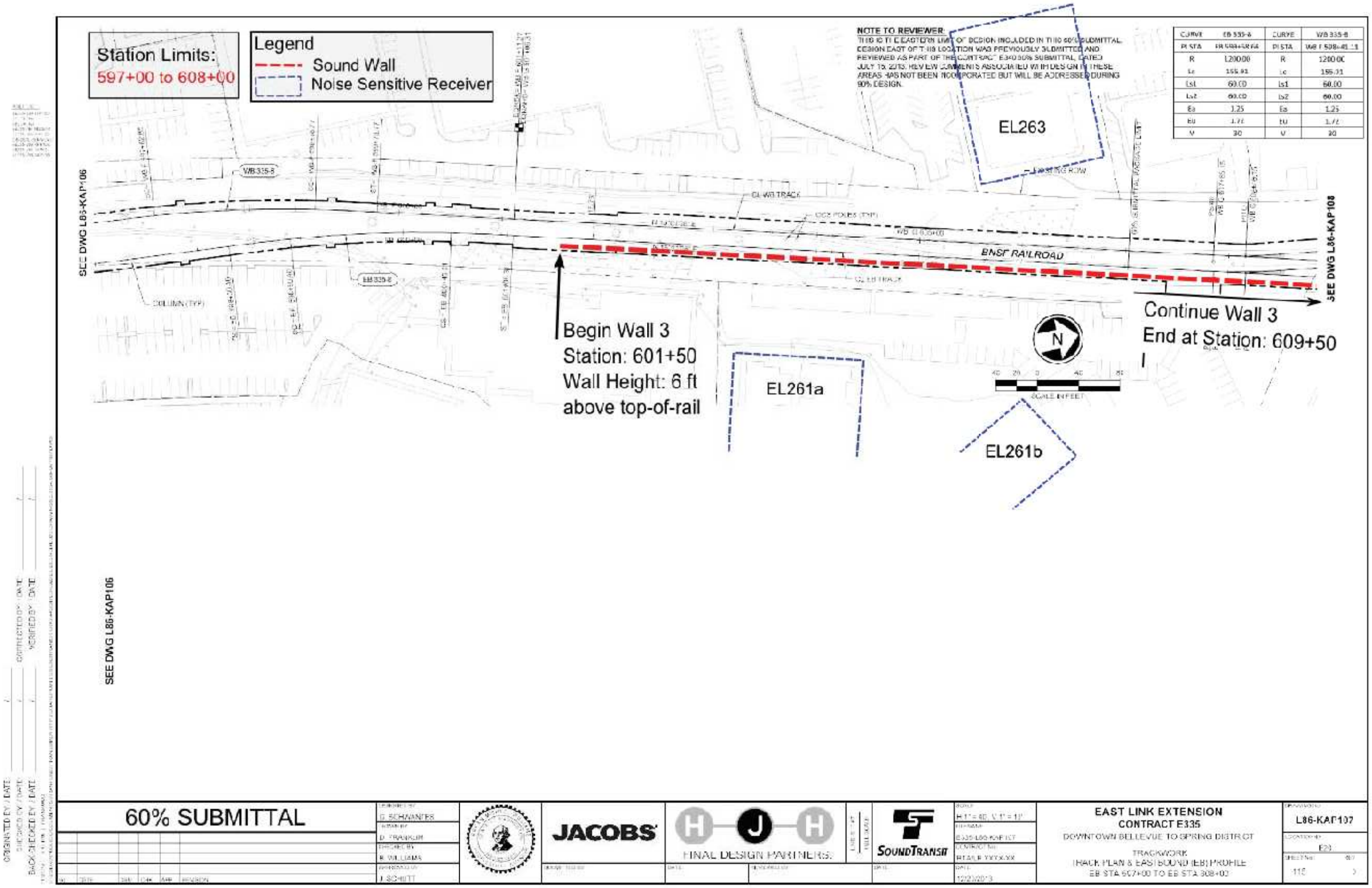
Parcel	Distance to track, ft	Speed (mph)	Existing Noise Level, dBA	Impact Threshold[1], dBA		Predicted Level, Ldn dBA	Amount Exceeds Moderate	Mitigated Level, dBA Ldn
				Moderate	Severe			
EL261a	105	30	56 (Ldn)	56 (Ldn)	63 (Ldn)	65 (Ldn)	9	53
EL261b	245 (distance to crossover	30	56 (Ldn)	56 (Ldn)	63 (Ldn)	63 (Ldn)	7	52
EL263	80	30	59 (Leq)	63 (Leq)	69 (Leq)	61 (Leq)	-2	--

[1] Noise Impact Thresholds are based on Table 3-1 of the FTA 2006 Guidance Manual.

Table 5-8: Recommended Sound Wall for Lake Bellevue Condominiums (Parcel EL261)

Wall	Start Station	End Station	Wall Length	Wall Height
3	601+50	609+50	800 ft	6 ft above top-of-rail

Figure 5-4: Sound Wall for Lake Bellevue Condominiums (Parcel EL261)



5.6 TPSS Noise Analysis

There are two TPSS units located within the Contract E335 limits. One TPSS unit will be located near the DBT south portal near station 539+00, east of the tracks. The nearest sensitive receiver is parcel EL196, located west of the tracks. The location of the TPSS unit is shown in Figure 5-5. The other TPSS unit is located adjacent to the storage track west of 120th Avenue, shown in Figure 5-6. The nearest receiver is EL278, a commercial land use.

TPSS noise is regulated by the City of Bellevue noise code. The TPSS site near the south tunnel portal is currently a residential land use in a Class A EDNA. The receiving property (parcel EL196) is also a Class A EDNA. The allowable daytime noise level defined in the City of Bellevue noise code for these land use designations is 55 dBA and the allowable nighttime noise level is 45 dBA. The TPSS site adjacent to the storage track west of 120th Avenue is currently a Class B EDNA, so the TPSS noise is assumed to originate from a Class B EDNA. The receiving property is a commercial land use, or Class B EDNA. The allowable daytime and nighttime noise level defined in the City of Bellevue noise code for this land use designations is 60 dBA.

The predicted level for each TPSS unit is shown in Table 5-9. The predicted noise does not exceed the allowable noise levels. Therefore, no noise mitigation is recommended for the TPSS units.

Table 5-9: Predicted Noise Level for TPSS Unit

Receiver	Distance from TPSS to property line(ft)	Predicted Noise Level (Leq)[1]	Daytime Noise Limit	Nighttime Noise Limit
EL196	100 ft	39 dBA[2]	55	45
EL278	30 ft	54 dBA	60	60

[1]Predicted noise level assumes continuous operation. This is a worst-case assumption because the primary noise source is a fan that will operate intermittently.

[2]This predicted level includes a 5 dB reduction from the sound wall that will be constructed to mitigate train noise.

Figure 5-5: Location of TPSS Unit in Downtown Bellevue

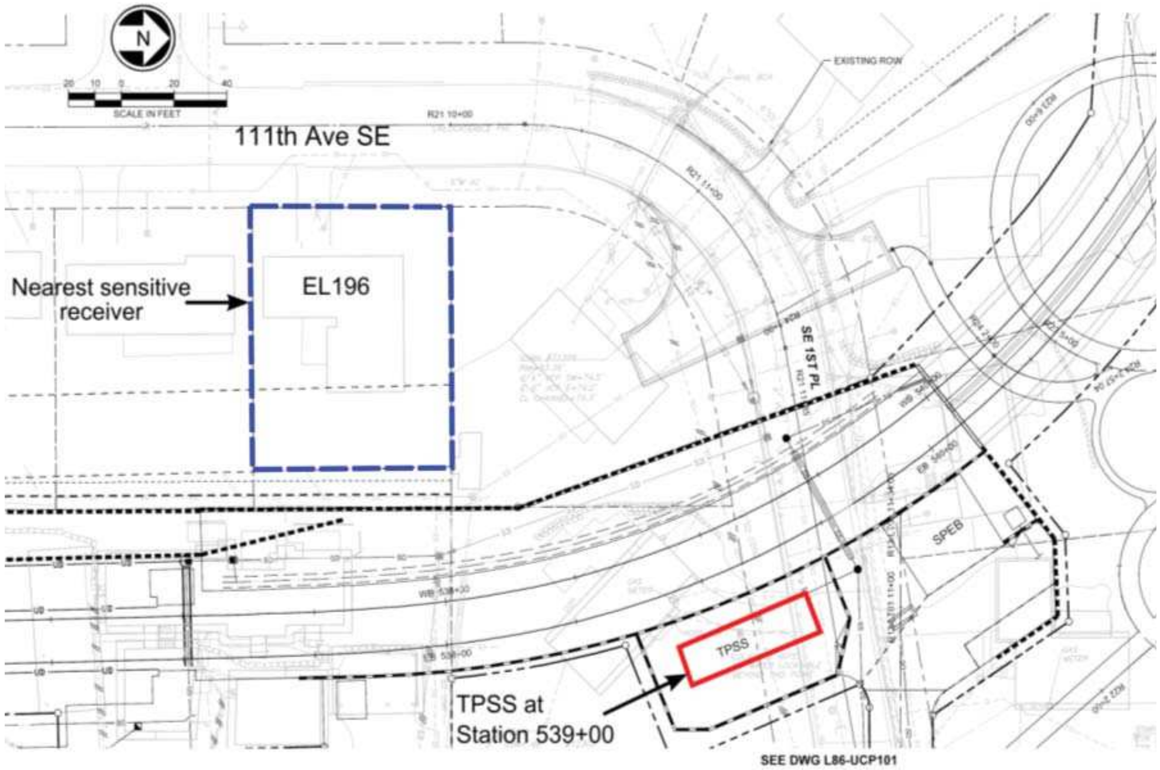


Figure 5-6: Location of TPSS Unit Adjacent to Storage Track

5.7 Acoustical Design of Stations

Obtaining maximum benefit from acoustic treatment of transit stations requires that suitable amounts of the material be installed in the proper locations. In general, for control of any noise source, it is best if absorption treatment can be located close to the noise source so that some of the sound energy can be absorbed before it reaches the reverberant sound field. Inappropriate placement of treatment can control reverberation without obtaining satisfactory or efficient reduction of train noise. Newer subway station designs have acoustical treatment on ceiling and under platform overhang surfaces. Due to these designs noise levels from the transit train operations are much more acceptable than those found in older systems with completely untreated, highly reverberant stations. The reverberation times measured in acoustically treated stations are typically 1.3 to 1.5 seconds at 500 Hz, as compared with 7 to 9 seconds for untreated stations.

Because of the frequency characteristics of transit system noise and the lack of low-frequency absorption in untreated stations, an acoustical treatment with a high sound absorption coefficient at 500 Hz should be used. This requires a relatively thick material because thin materials do not have good low-frequency absorption. It also minimizes the total area of treatment required. The most flexible and most durable material is a sprayed-on acoustical vermiculite plaster. A facing may be needed to provide a more finished surface than that of the sprayed vermiculite plaster which tends to form a relatively coarse surface. This material is applied in different thicknesses in the range of ½” to 1-5/8” depending on the sound absorption needed. The thicker the application the less area needs to be treated.

East Main Street Station

The East Main Street Station is an at-grade station that is not fully enclosed but is open to the outside area. Due to the large area of the station ceiling and side walls that are open to the outside area the station acoustics will not exceed the ST reverberation time goal of 1.2 seconds and will not need any acoustical treatment.

Bellevue Transit Center Station

The Bellevue Transit Center Station platform begins at the edge of the DBT north portal and extends away from the portal where it is at-grade and opens to the outside. Due to the large area of the platform ceiling and side walls that are open to the outside area the station acoustics will not exceed the ST reverberation time goal of 1.2 seconds at the platform and will not need any acoustical treatment.

Hospital Station

The Hospital Station is an elevated station that is not fully enclosed but is open to the outside area. Due to the large area of the station ceiling and side walls that are open to the outside area the station acoustics will not exceed the ST reverberation time goal of 1.2 seconds at the platform and will not need any acoustical treatment.

120th Avenue NE Station

The 120th Avenue NE Station is a partially enclosed space that is located in a retained cut section of the alignment. More than half of the ceiling area is open to the outside area. The remaining ceiling surfaces are either perforated metal canopies located over the platform area and perforated metal ceilings at the underside of the slab above the station. Due to the large area of the platform ceiling and side walls that are open to the outside area the station acoustics will not exceed the ST reverberation time goal of 1.2 seconds at the platform and will not need any acoustical treatment.

5.8 Station Noise Analysis

The stationary noise sources associated with the stations in the E335 contract are electrical transformers and the PA announcements. These noise sources are subject to the City's noise limits. The stations within the contract E335 limits are East Main Station, Bellevue Transit Center Station, Hospital Station, and 120th Station. Below are the predicted noise levels at the property line of the nearest parcel for each station.

East Main Station

The nearest receiving properties to the East Main station are the single family residences on 111th Avenue SE (parcels EL189 through EL194) in a Class A EDNA. The station itself is also located in the Class A EDNA. The City's noise limit for these land use designations is 55 dBA (Leq) for daytime hours and 45 dBA (Leq) for nighttime hours. Predicted noise levels are presented for the peak nighttime hour because it has the strictest limit.

A 75kVa transformer is proposed for this station. The PA system will have a level that is adjusted to 10 dB above the ambient noise level. The closest 24-hour noise measurement to the East Main Station was conducted at 240 111th Avenue SE (Parcel EL187). The noise level at this location from 6 a.m. to 7 a.m. is an Leq= 59 dBA. Based on this ambient, the level of the PA announcements would be 69 dBA at 10 feet from the PA speaker at the station platform. The 6 a.m. to 7 a.m. ambient is used in the analysis because it is the nighttime hour which has the highest ambient noise level. The property line of the nearest parcel to the station is 40 feet from the station platform. Between the station and the residences on 111th Avenue SE we have recommended a six foot high sound wall on the right-of-way of the transit guideway to mitigate train noise impacts (see Table 5-3). The predicted noise levels with and without the mitigation recommended for the train noise impacts is presented in Table 5-10. There are no predicted noise impacts from the East Main Station operations.

Table 5-10: Predicted Noise Levels of Station Equipment at East Main Station

Noise Source	Receiver	Distance to property line	Predicted Noise Level (Leq)	Mitigated Noise Level (Leq)	BCC Nighttime Noise Limit (Leq)
Electrical Transformer	Single-family residences on 111th Avenue SE (EL189 through EL194)	40 ft	52 dBA[1]	40 dBA	45 dBA
PA Announcements	Single-family residences on 111th Avenue SE (EL189 through EL194)	40 ft	57 dBA[2]	45 dBA	45 dBA

[1]Predicted noise level assumes continuous operation.
[2]Predicted noise level assumes the PA announcements will not exceed 5 minutes in a one hour period.

Bellevue Transit Center Station

The nearest receiving property to the Bellevue Transit Center Station is Bellevue City Hall (parcel EL229). The station and nearest parcels are located in a Class B EDNA. The City's noise limit for receiving and source Class B EDNAs is 60 dBA (Leq).

The noise sources at the Bellevue Transit Center Station that could potentially affect the nearby residents are the electrical transformers, condenser units, and the PA announcements. A 75kVa transformer is proposed for this station. The PA system will have a level that is adjusted to 10 dB above the ambient noise level. The closest 24-hour noise measurement to the Bellevue Transit Center Station was conducted at the Bravern Condominiums (Parcel EL236). The peak hour Leq measured at this location is 69 dBA. Based on this ambient, the level of the PA announcements would be 79 dBA at 10 feet from the PA speaker at the station platform. The property line of the nearest parcel (City Hall) is 30 feet from the station platform. The predicted noise levels are presented in Table 5-11.

Table 5-11: Predicted Noise Levels of Station Equipment at Bellevue Transit Center Station

Noise Source	Receiver	Distance to property line	Predicted Noise Level (Leq)	BCC Noise Limit
Electrical Transformer	City Hall (EL229)	30 ft	35 dBA[1]	60 dBA
Condenser Units	City Hall (EL229)	30 ft	47 dBA[1]	60 dBA
PA Announcements	City Hall (EL229)	30 ft	53 dBA[2]	60 dBA

[1]Predicted noise level assumes continuous operation.
[2]Predicted noise level assumes the PA announcements will not exceed 5 minutes in a one hour period.

Hospital Station

The nearest receiving property to the Hospital Station is parcel EL256, commercial property east of the station. The station and nearest parcels are located in a Class B EDNA. The City's noise limit for receiving and source Class B EDNAs is 60 dBA (Leq).

The closest noise measurement to the Hospital Station was conducted at the Lake Bellevue Condominiums (parcel EL261). The peak hour Leq measured at this location is 55 dBA. The noise level of the PA announcements would be 10 dBA above the ambient, or 65 dBA at 10 feet from the PA speaker on the station platform. The property line of the nearest parcel is 30 feet from the station platform. Electrical transformers have a noise level of 55 dBA at three feet from the transformer. The predicted noise levels for PA announcements and transformer noise at the property line of the closest parcel are shown in Table 5-12. No noise impact is predicted.

Table 5-12: Predicted Noise Levels of Station Equipment at Hospital Station

Noise Source	Receiver	Distance to property line	Predicted Noise Level (Leq)	BCC Noise Limit
Electrical Transformer	EL256	30 ft	35 dBA[1]	60 dBA
PA Announcements	EL256	30 ft	53 dBA[2]	60 dBA
[1]Predicted noise level assumes continuous operation. [2]Predicted noise level assumes the PA announcements will not exceed 5 minutes in a one hour period.				

120th Avenue NE Station

The nearest property to the 120th Avenue NE Station is parcel EL283a, commercial property located north of the station. The station and nearest parcels are located in a Class B EDNA. The City's noise limit for receiving and source Class B EDNAs is 60 dBA (Leq).

The closest noise measurement to 120th Avenue NE Station was conducted at the Pacific Northwest Ballet School (parcel EL310). The peak hour Leq measured at this location is 59 dBA. The noise level of the PA announcements would be 10 dBA above the ambient, or 69 dBA at 10 feet from the PA speaker on the station platform. The property line of the nearest parcel is 30 feet from the station platform. Electrical transformers have a noise level of 55 dBA at three feet from the transformer. The predicted noise levels for PA announcements and transformer noise at the property line of the closest parcel are shown in Table 5-13. No noise impact is predicted.

Table 5-13: Predicted Noise Levels of Station Equipment at 120th Avenue NE Station

Noise Source	Receiver	Distance to property line	Predicted Noise Level (Leq)	BCC Noise Limit
Electrical Transformer	EL256	30 ft	35 dBA[1]	60 dBA
PA Announcements	EL256	30 ft	53 dBA[2]	60 dBA
[1]Predicted noise level assumes continuous operation. [2]Predicted noise level assumes the PA announcements will not exceed 5 minutes in a one hour period.				

5.9 Emergency Ventilation Noise

Jet fans are used in the DBT to provide ventilation during emergency conditions. The jet fans are located in fan niches near the south and north portals and in a fan room mid-tunnel that is located at the top of the tunnel separated by a concrete slab from the tunnel section where the trains operate. The fan noise analysis for the fan room assumed two Flakt Jet Fans, Model 160JMTS/63/6/12/27 with one diameter reversible silencer. The analysis of the fan niches assumed two Flakt Jet Fans, Model 160JMTS/63/6/12/27 with two diameter reversible silencer.

The predicted fan noise in the fan room and fan niche is presented in Table 5-14. The applicable noise limit for the fan room is Lmax = 85 dBA from the ST DCM. The applicable noise limit for the fan niche is Lmax = 92 dBA from the NFPA Standard 130. The fan noise exceeds the applicable noise limit in both the fan room and in the fan niche without acoustical treatment.

The recommended noise control treatment for the emergency fans are:

- Within the Fan Room, acoustical vermiculite cement plaster (AVCP) shall be applied to the dome of the fan room in accordance with E335 Specification Section 09 82 19, Sprayed Acoustic Insulation (Figure 5-7). AVCP shall also be applied to any of the wall/ceiling surfaces feasible within the fan room. The AVCP shall be a minimum of 1-5/8 thick. Even with treatment on every surface in the fan room, it is not possible to achieve the ST Design Criteria when the fans are operational. However, the treatment does lower the predicted noise levels to be within the OSHA guidance provided that exposure to the fan noise is less than 4 hours.
- In the Fan Niches AVCP shall be applied to the ceiling and walls within the fan niche. The treatment should be a minimum of 1” thick (Figure 5-8 and Figure 5-9).

Table 5-14: Emergency Ventilation Fan Predicted Noise Levels - Lmax

Location	No Treatment	With Treatment	ST Design Criteria	NFPA Standard 130 Noise Limits
Fan Room	104 dBA	92 dBA	85 dBA	NA
Fan Niche	99 dBA	89 dBA	NA	92 dBA

The ST DCM also specifies noise limits for fan noise on the station platforms. There are no stations within the DBT; however, the predicted fan noise during emergency operations at the East Main Station platform is 55 dBA for the fans in one tunnel and 58 dBA for the fans in both tunnels. At the Bellevue Transit Center Station platform the fan noise is 69 dBA for one tunnel and 72 dBA for both tunnels. The predicted emergency fan noise at both stations do not exceed the ST Design Criteria of Lmax=75 dBA.

Figure 5-7: Acoustical Treatment for Mid-Tunnel Fan Room

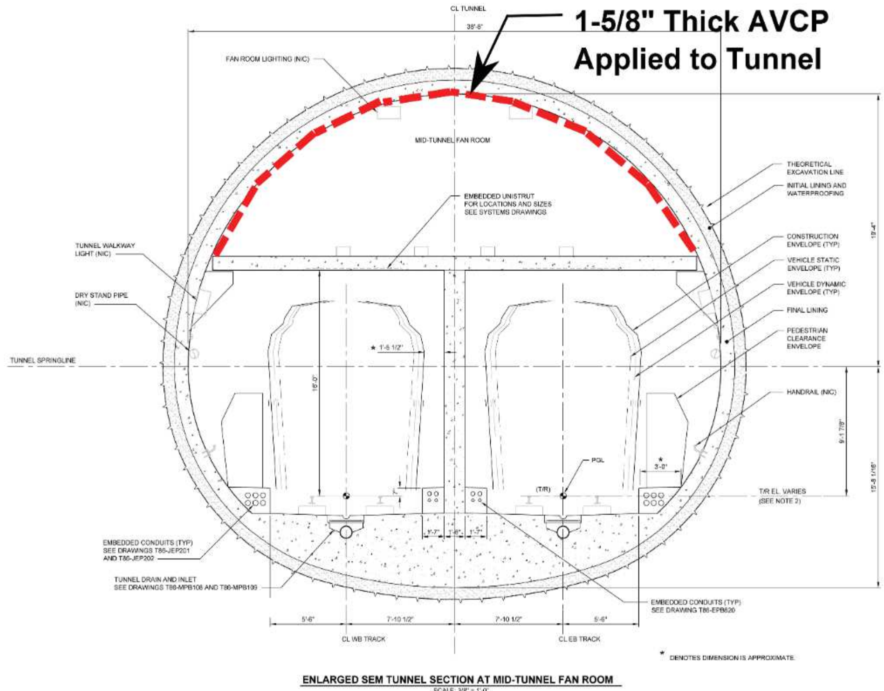


Figure 5-8: Acoustical Treatment for Fan Niche, Plan View

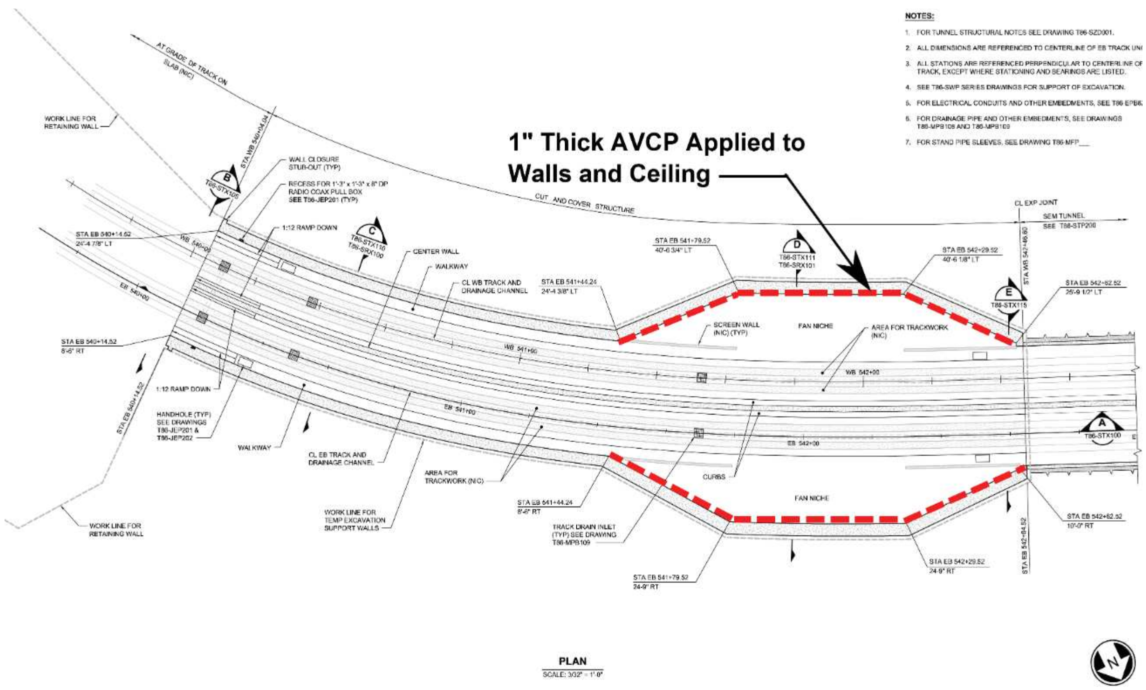
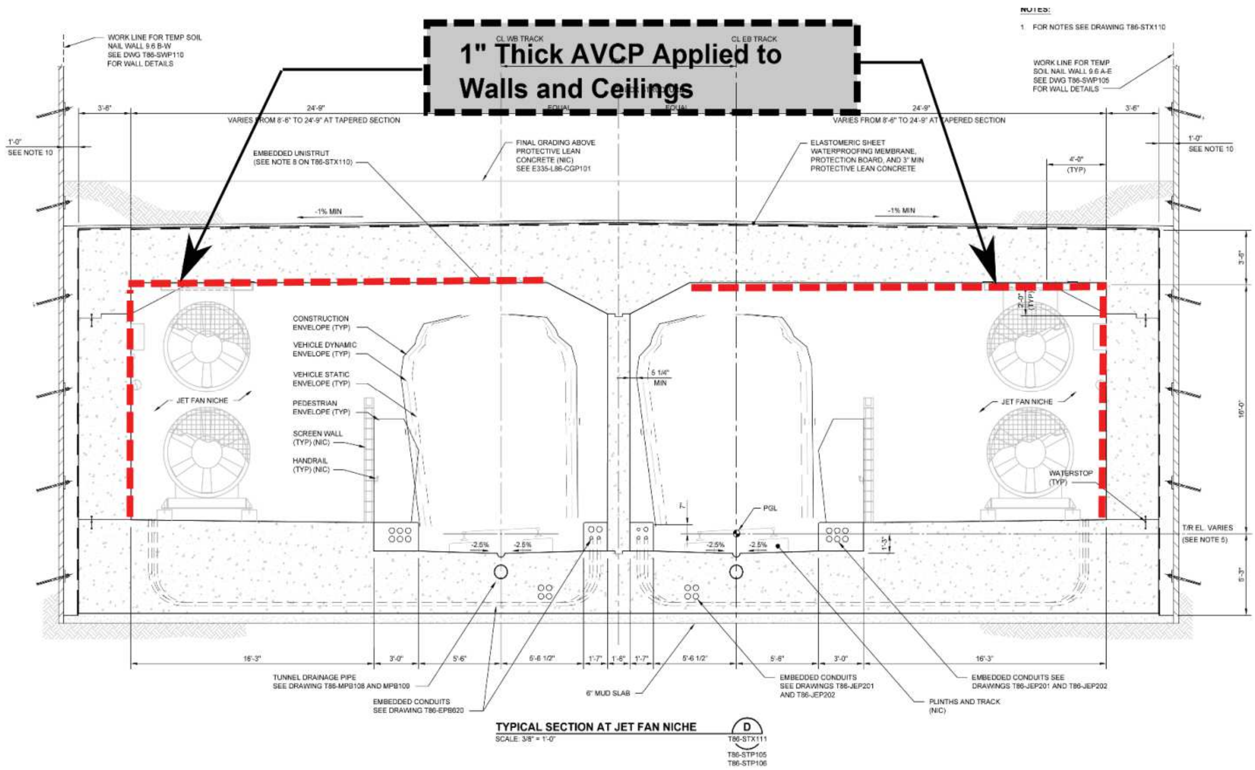


Figure 5-9: Acoustical Treatment for Fan Niche



6.0 Operational Vibration Impact Assessment

This section presents a detailed vibration impact analysis of LRT operations. Vibration propagation tests were performed at locations where groundborne noise or vibration impacts were identified during the environmental analysis. The data from the vibration propagation tests are used to refine the vibration predictions and recommend appropriate mitigation measures. The sensitive receivers included in the analysis are:

- Residences adjacent to the East Main Station (parcels EL187 to EL206) and the Red Lion Hotel (parcel EL199)
- Residential land uses adjacent to the DBT (parcels EL208, EL210, and EL227)
- Office/Institutional land uses adjacent to the DBT
- Bravern Condominiums (parcel EL236)
- Meydenbauer Center (parcel EL240)
- Coast Bellevue Hotel (parcel EL242)
- Lake Bellevue Condominiums (parcel EL261)
- Mercer Education Center (parcel EL263)

6.1 Residences Adjacent to East Main Station

A vibration propagation test was conducted at the residential parcel EL184 in July 2013. The results of the propagation test was used to estimate the LSTM and to predict the vibration levels from LRT operations at the single family residences in the area north of Surrey Downs Park and south of the

Downtown Bellevue Tunnel. The prediction methodology follows the FTA detailed vibration analysis procedure.

The measurement locations from the vibration propagation test at EL184 are shown in Figure 6-1. A drop hammer was used to incite vibration along the sidewalk of 112th Avenue SE. The tracks will be west of the sidewalk; however, we could not incite vibration at the future track location due to the existing Carriage Place Condominiums that will be acquired and demolished as part of the project. The accelerometers were located at 25 ft, 37 ft, 50 ft, 75 ft, 105 ft, 135 ft, 155 ft, and 160 ft from the vibration source.

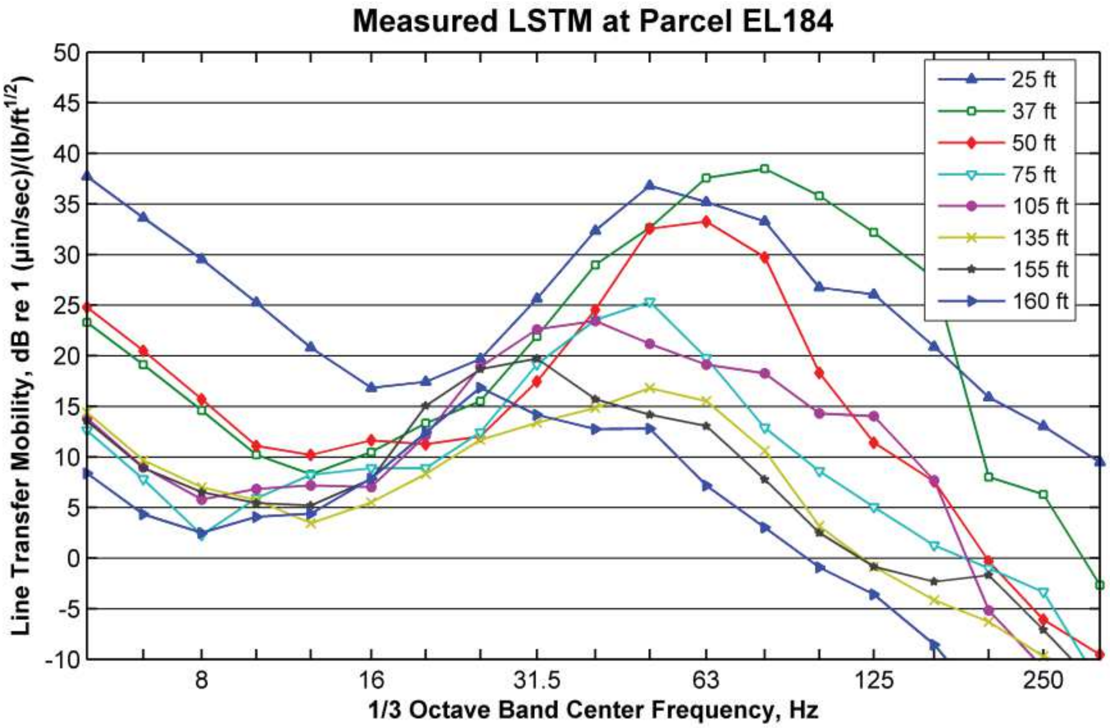
Figure 6-1: Measurement Diagram for Surface Vibration Propagation Test at EL184

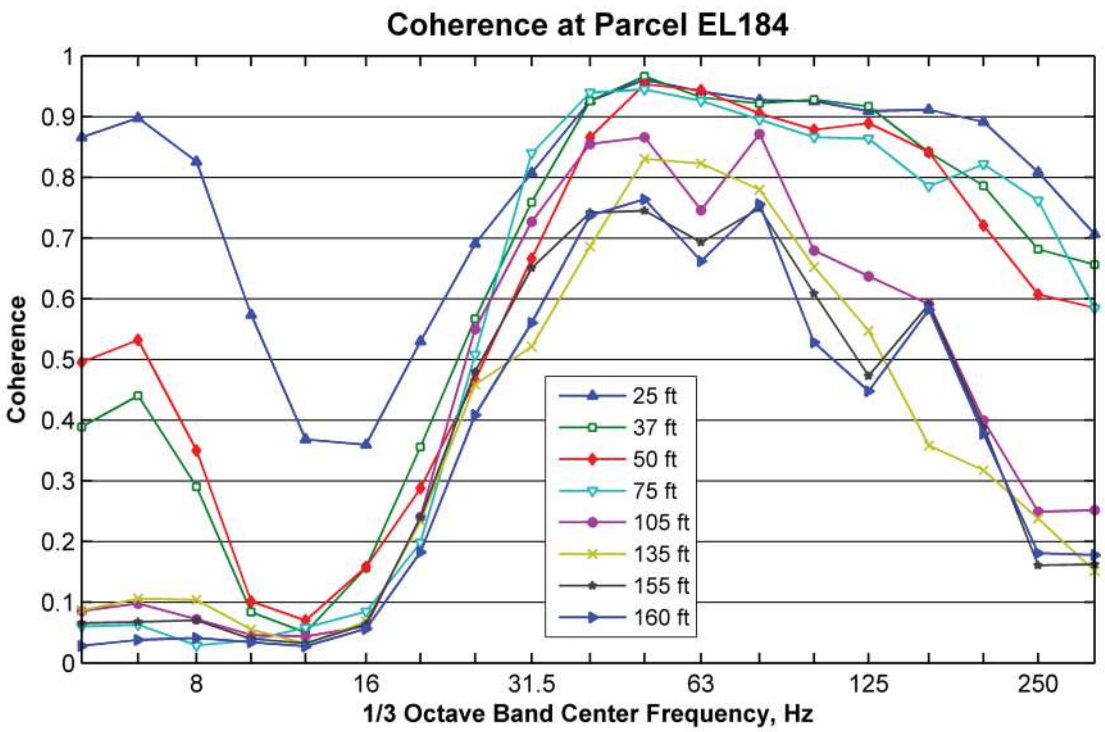
The measured LSTM and coherence for all measurement positions from the test at parcel EL184 are shown in Figure 6-2. The LSTM data was used to predict the vibration levels at the parcels north of Surrey Downs Park. The predicted levels assume ballast-and-tie track for parcels EL187 to EL192 and direct fixation track for parcels EL194 to EL206. As shown in Table 6-1, the predicted vibration levels are below the impact threshold of 72 VdB at all parcels. Therefore, no vibration mitigation is recommended.

Table 6-1: Predicted Vibration Levels at Parcels North of Surrey Downs Park and South of Downtown Bellevue Tunnel

Parcel Number	Distance to WB track (ft)	Predicted level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold, Max. 1/3 octave band (VdB)
EL187	106	48	63 Hz	72
EL189	93	50	63 Hz	72
EL190	96	45	63 Hz	72
EL191	100	45	63 Hz	72
EL192	97	45	63 Hz	72
EL194	93	53	50 Hz	72
EL195	105	52	50 Hz	72
EL196	75	57	50 Hz	72
EL206	115	51	50 Hz	72
EL199	200	44	50 Hz	72

Figure 6-2: Measured LSTM and Coherence at Parcel EL184

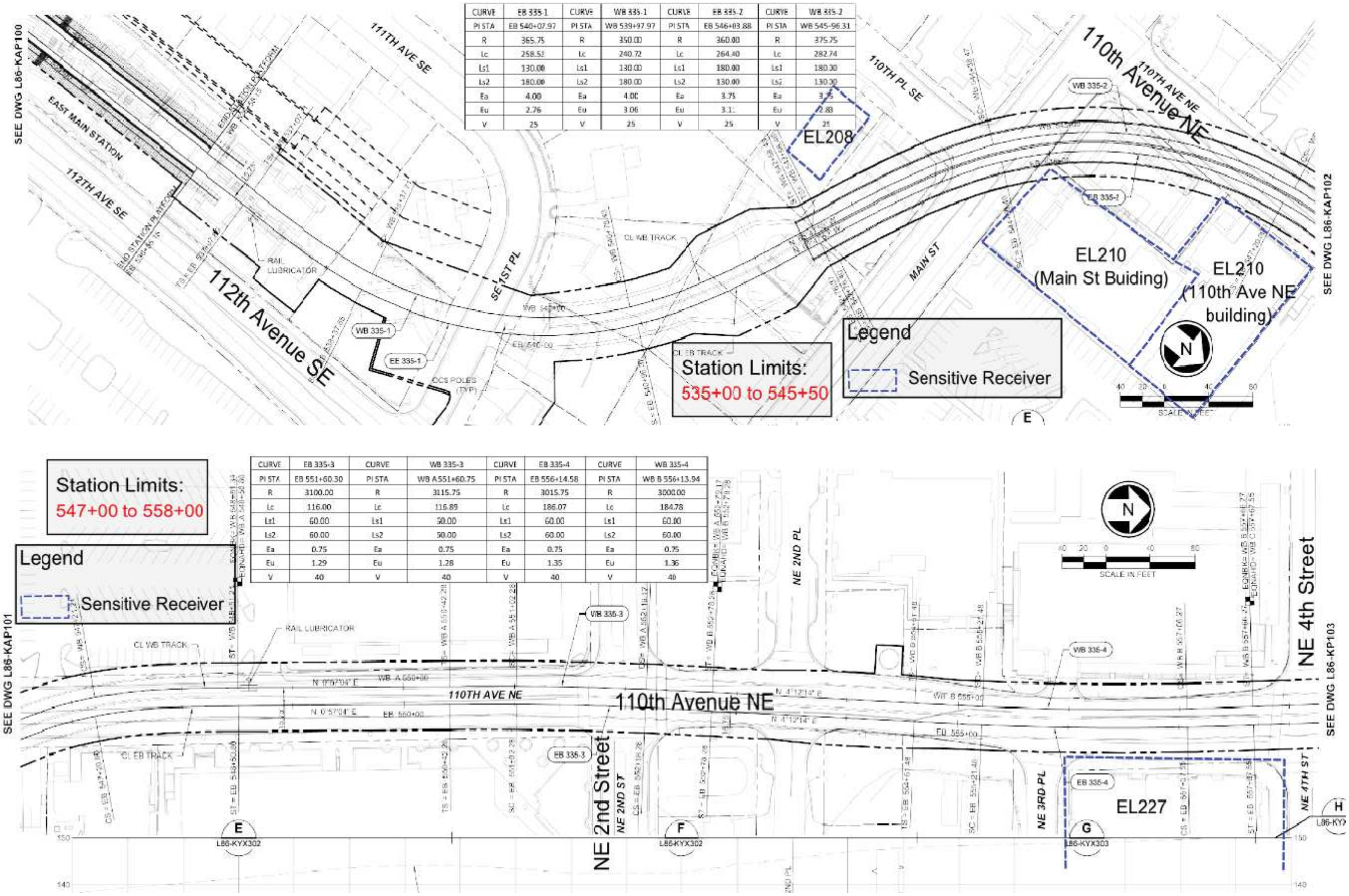




6.2 Downtown Bellevue Tunnel Residential Receivers

The LRT tracks will run in a tunnel through Downtown Bellevue. Vibration propagation measurements were conducted at two measurement sites near the tunnel to characterize the vibration propagation characteristics of the soil. The vibration propagation tests were conducted adjacent to the parcels where vibration or groundborne noise impact was predicted during the environmental impact assessment. The propagation tests included measurements inside the sensitive receivers to better characterize the building response to vibration. The parcels where measurements were performed include EL208 (a single family residence), EL210 (multi-family residence), and EL227 (multi-family residence). Other receivers assessed for impact include parcels EL222 (future site of Marriott Hotel) and parcel EL223a (multi-family residence). The LSTMs for parcels EL222 and EL223a were estimated using the results from the vibration propagation test performed at EL227. The location of the parcels and the LRT tracks are shown in Figure 6-3.

Figure 6-3: Location of Parcels EL208 (SFR), EL210 (MFR), EL222 (future hotel), EL223a (MFR), and EL227 (MFR)



CURVE	EB 335-1	CURVE	WB 335-1	CURVE	EB 335-2	CURVE	WB 335-2
PI STA	EB 540+07.97	PI STA	WB 539+97.97	PI STA	EB 546+03.88	PI STA	WB 545-96.31
R	365.75	R	350.00	R	360.00	R	375.75
Lc	258.53	Lc	240.72	Lc	264.40	Lc	282.74
Ls1	130.00	Ls1	130.00	Ls1	180.00	Ls1	180.00
Ls2	180.00	Ls2	180.00	Ls2	130.00	Ls2	130.00
Ea	4.00	Ea	4.00	Ea	3.75	Ea	3.75
Eu	2.76	Eu	3.06	Eu	3.11	Eu	2.83
V	25	V	25	V	25	V	25

CURVE	EB 335-3	CURVE	WB 335-3	CURVE	EB 335-4	CURVE	WB 335-4
PI STA	EB 551+60.30	PI STA	WB A551+60.75	PI STA	EB 556+14.58	PI STA	WB B 556+13.94
R	3100.00	R	3115.75	R	3015.75	R	3000.00
Lc	116.00	Lc	116.89	Lc	186.07	Lc	184.78
Ls1	60.00	Ls1	50.00	Ls1	60.00	Ls1	60.00
Ls2	60.00	Ls2	50.00	Ls2	60.00	Ls2	60.00
Ea	0.75	Ea	0.75	Ea	0.75	Ea	0.75
Eu	1.29	Eu	1.28	Eu	1.35	Eu	1.36
V	40	V	40	V	40	V	40

Two borehole vibration propagation tests were conducted near the sensitive receivers to develop an LSTM estimate. For a borehole vibration propagation test, a borehole is drilled to the approximate depth of the tunnel and a pneumatic hammer on the drill rig is used to incite vibration at the bottom of the borehole. The vibration response is measured at several locations on the surface. The measurement locations are shown in Figure 6-4 and Figure 6-5. A summary of the vibration propagation measurements in Downtown Bellevue follows:

- Borehole test near parcel EL208 and EL210 (Main Street borehole):
  - Measurements at three drill depths: 20 ft, 30 ft, and 40 ft
  - Borehole locations: Center turn lane of Main Street, 40 ft south of the intersection with 110th Place.
  - 5 accelerometer locations on Main Street at 27 ft, 50 ft, 100 ft, 125 ft, and 175 ft from the borehole
  - EL208 accelerometer locations: outdoors at front facade of residence (labeled SFR1) and inside the residence (labeled SFR2)
  - EL210 accelerometer locations: outdoors at Main Street facade of the building (labeled MFR1) and two locations indoors on the second floor (labeled MFR2 and MFR3). There are no residential units on the first floor.
- Borehole test near parcel EL227 (NE 4th Street borehole):
  - Measurements at three drill depths: 30 ft, 40 ft, and 50 ft
  - Borehole location: Center turn lane of NE 4th Street, near the intersection with 110th Avenue NE
  - 6 outdoor accelerometer locations on NE 4th Street at 25 ft, 37 ft, 50 ft, 80 ft, 125 ft, and 175 ft from the borehole
  - EL 227 accelerometer locations: outdoors at NE 4th Street facade of residence (labeled MFR1), inside the building on the first floor (labeled MFR2), and two locations inside the building on the second floor (labeled MFR3 and MFR4). No residential units are located on the first floor.

Figure 6-4: Borehole Vibration Test Layout for Parcels EL210 (MFR) and EL208 (SFR)

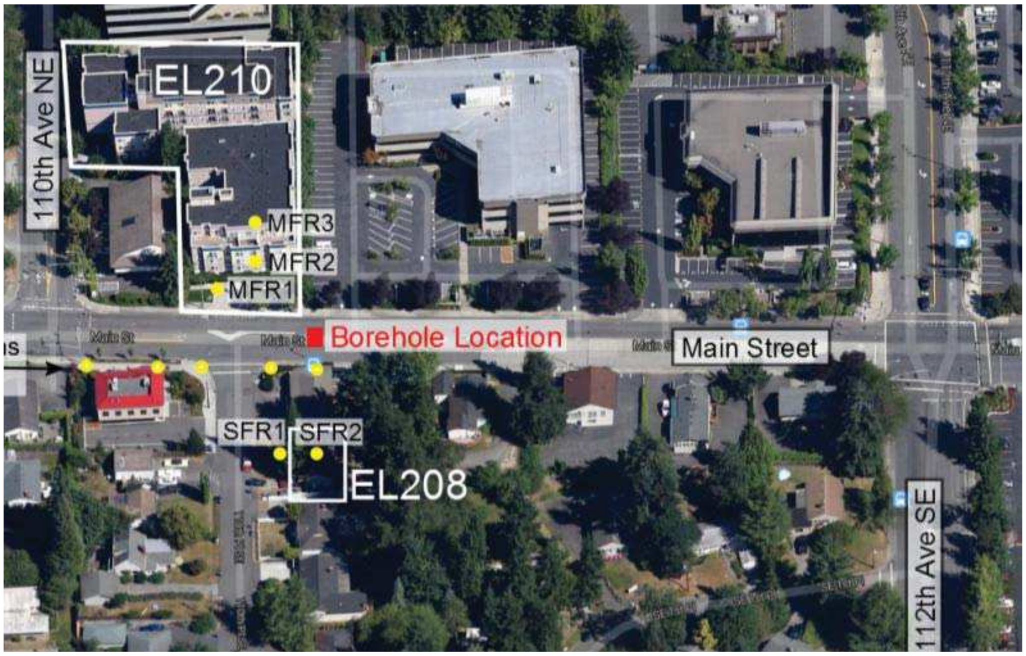
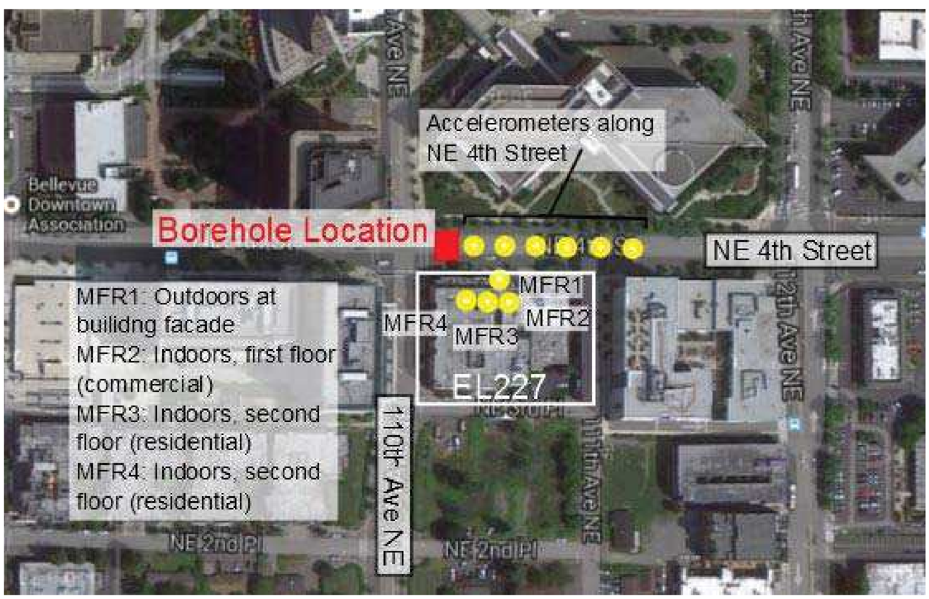


Figure 6-5: Borehole Vibration Propagation Test Layout for Parcel EL227 (MFR)



The vibration prediction methodology using data from borehole vibration tests is slightly different than using data from surface vibration tests. For surface vibration tests, drop-hammer impacts are used to incite vibration at several locations along a line on the ground to simulate the length of the train. The point source transfer mobility (PSTM) measured at each point along the line is combined to determine the line source transfer mobility (LSTM). However, with borehole vibration tests, hammer impacts are used to incite vibration at several depths of the borehole rather than in a line along the surface. The procedure for predicting the indoor LSTM using the borehole vibration propagation data is as follows:

- Use the PSTM measured from all test depths and all outdoor measurement locations to estimate the PSTM at several points along a line at the depth of the tunnel to simulate the length of the train.
- Use the estimated PSTM data to calculate the LSTM from the tunnel to the building facade. This calculation is done in the same way as for the surface vibration tests where the PSTM is measured at several points along a line.
- Compare the PSTM data from the indoor measurement locations and the measurement locations at the building facade to determine a Building Adjustment for each sensitive receiver.

The formula for predicting the indoor train vibration, Lv, using the borehole vibration propagation data is:

Lv = FDL + LSTM + Building Adjustment + SF + Train Length Adjustment

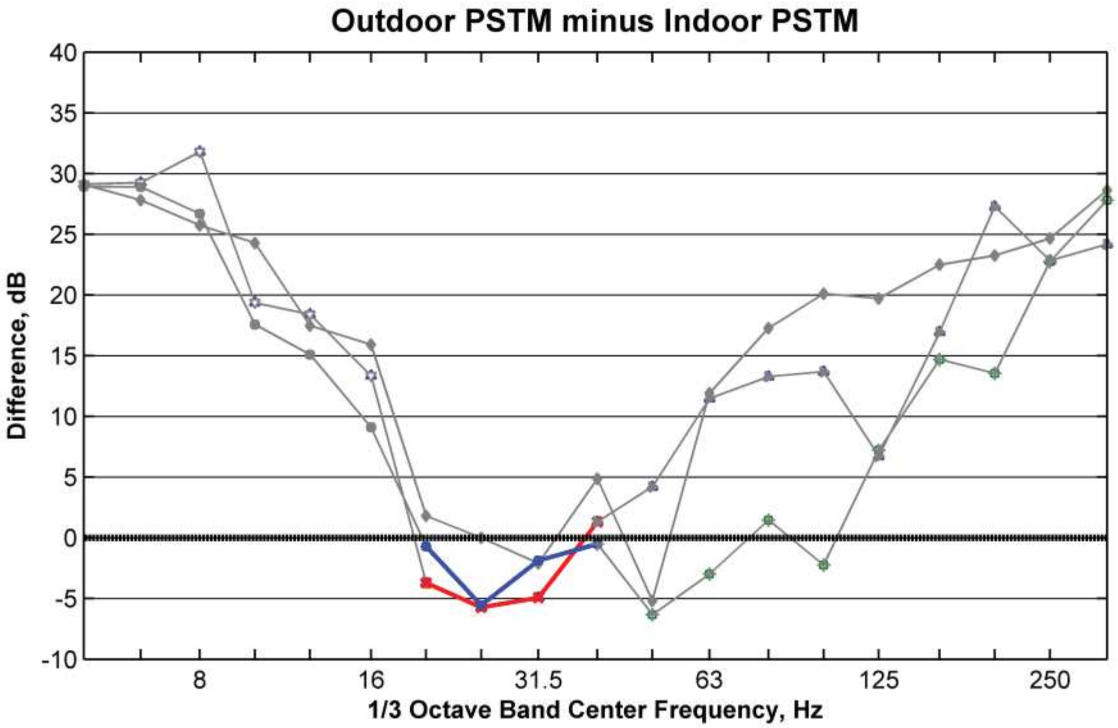
As explained in Section 4.4, the safety factor (SF) included in the predictions is +3 decibels and the train length adjustment is +0.5 decibels.

Results and Predictions for Parcel EL208 (SFR)

Parcel EL208 is a single family residence located at 112 110th Place SE. The residence is a one-story structure. Appendix C includes figures showing the measured PSTM and coherence for all of the measurement locations for the Main Street borehole test, including the measurements at parcel EL208. Those figures show that there is very low coherence for the measurement inside of parcel EL208. Due to the low coherence, a measure of data quality, most of the data from the indoor measurement location at EL208 is not included in the predictions.

The building adjustment included in the predictions is calculated by subtracting the indoor PSTM from the outdoor PSTM. Figure 6-6 shows the outdoor minus indoor PSTM for the indoor measurement location for the three test depths. The results from 1/3 octave bands where the results are corrupted by high background vibration levels are plotted in grey. The frequency range with acceptable data quality is approximately 20 Hz to 40 Hz. As shown in Figure 6-6, the difference between indoor and outdoor PSTM is between 0 and -5 decibels in the 1/3 octave bands with acceptable data quality. This implies the building is not amplifying vibration. A building adjustment of 0 dB is assumed for the predictions.

Figure 6-6: Building Adjustment Measured at Parcel EL208 (MFR)



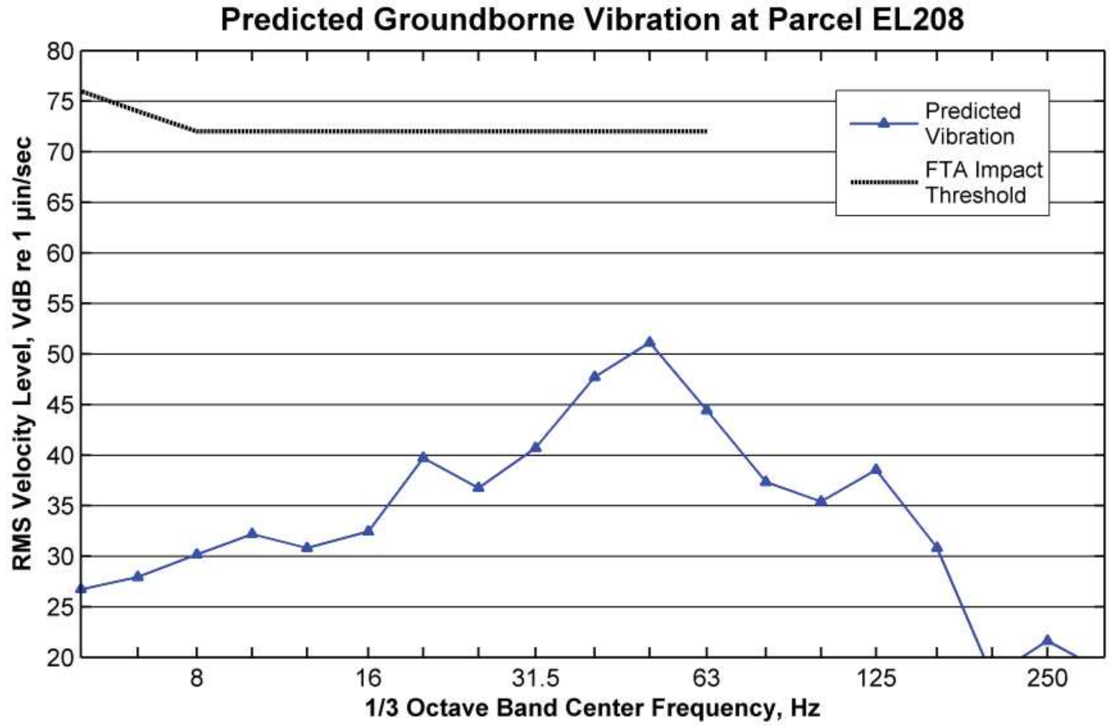
The predicted groundborne vibration level and the predicted groundborne noise level for parcel EL208 is shown in Table 6-2. The predictions assume direct fixation track and a train speed of 25 mph. The FTA impact threshold for groundborne vibration for residential and uses is 72 VdB in the maximum 1/3 octave band. The FTA impact threshold for groundborne noise is an overall level of 35 dBA. The overall level is the energy sum of the level over all of the frequency bands. The predicted groundborne vibration and groundborne noise levels are shown in Figure 6-7.

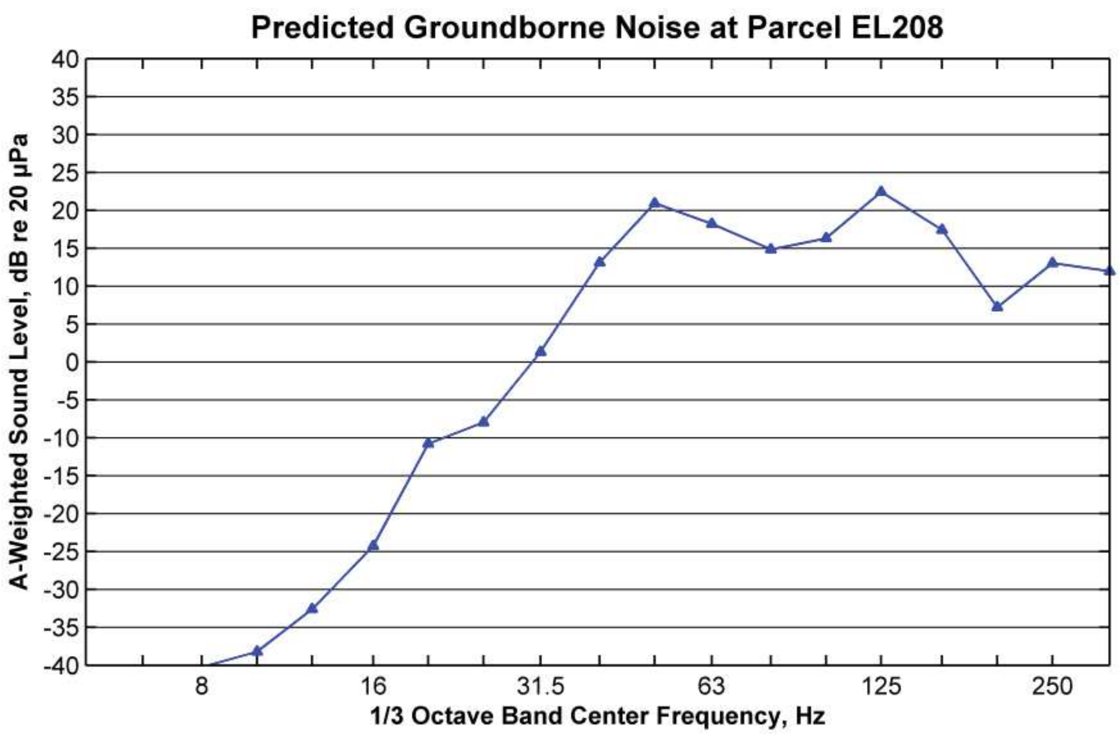
The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds. Therefore, no vibration mitigation is recommended.

Table 6-2: Predicted Groundborne Vibration and Groundborne Noise Levels for Parcel EL208 (SFR)

Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	Groundborne Noise Impact Threshold (dBA)
Parcel EL208, (building adjustment = 0 dB)	51	50 Hz	72	27	35

Figure 6-7: Predicted Groundborne Vibration and Groundborne Noise at Parcel EL208 (SFR)





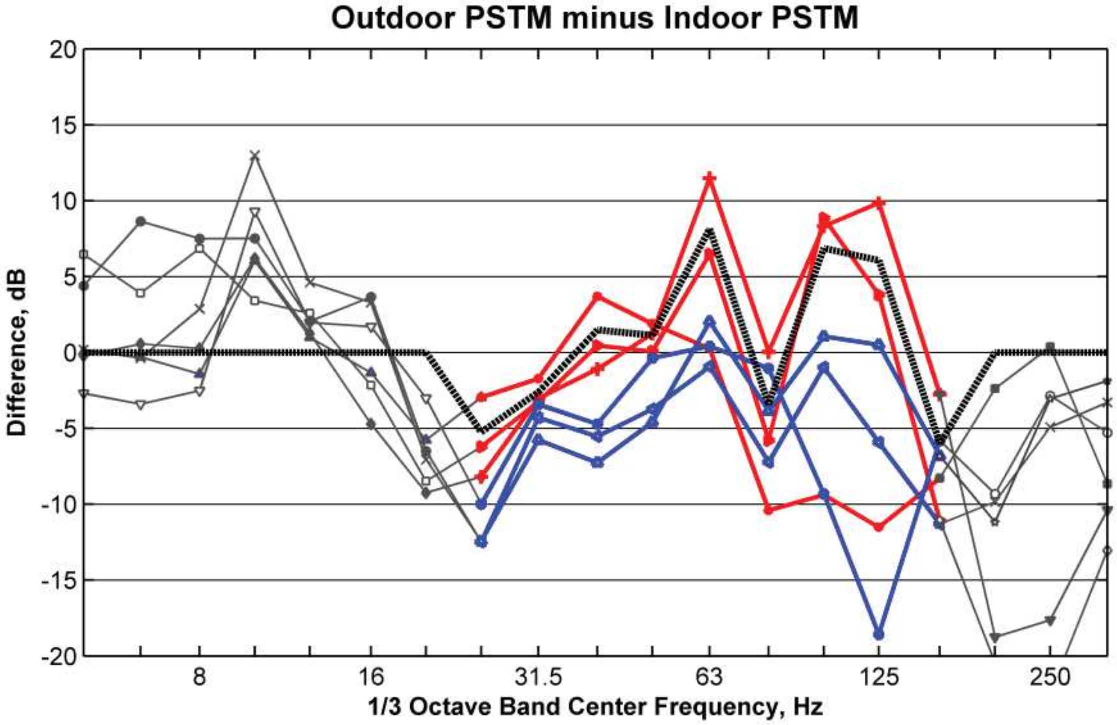
Results and Predictions for Parcel EL210 (MFR)

Parcel EL210 is a multi-family residential community located at the corner of Main Street and 110th Avenue NE. The parcel consists of two buildings: one with a facade on Main Street and one with a facade on 110th Avenue NE. Measurements were taken in the building on Main Street due to the location of the borehole. However, predictions are included for both the Main Street building and the 110th Avenue NE building, taking into account the distance to the tracks of each building. Appendix C includes figures showing the measured PSTM and coherence for all measurement locations form the borehole vibration propagation test on Main Street.

Figure 6-8 shows the building adjustment measured at parcel EL210. The building adjustment is the difference between the PSTM measured at the building facade outdoors and the PSTM measured inside. Figure 6-8 shows the building adjustment for the two indoor measurement locations and the three test depths. Key observations from the figure are:

- The data plotted in grey is not included in the building adjustment calculation due to interference from existing background vibration. For the PSTM measurements, signal-to-noise ratio is often quantified using coherence (plots of coherence are presented in Appendix C). There is low coherence at frequencies below 25 Hz and frequencies above 160 Hz. Low coherence indicates a weak relationship between the force from the impact hammer and the measured response. Low coherence often results when the vibration generated from the impact hammer is less than the ambient background vibration level and is an indication that there is no significant building amplification. Therefore, the building adjustment is assumed to be zero in the frequency ranges with low coherence.
- The data from one of the indoor measurement locations show there may be a resonance at 63 Hz and 100 Hz (data plotted in red). The second indoor measurement location did not show the same resonance at those frequencies (data plotted in blue). It is not uncommon for floor resonances to be measured at certain locations on a floor, but not others.
- The building adjustment used in the predictions is plotted as a thick dashed black line. The building adjustment is the average of the adjustment measured for the three test depths for the indoor location that showed the resonances at 63 Hz and 100 Hz. The data from the measurement location that did not show resonances is not included in the building adjustment.
- Predictions are provided with and without the building adjustment to reflect that some locations within the building may show a resonance and some locations may not.

Figure 6-8: Building Adjustment Measured at Parcel EL210 (MFR)



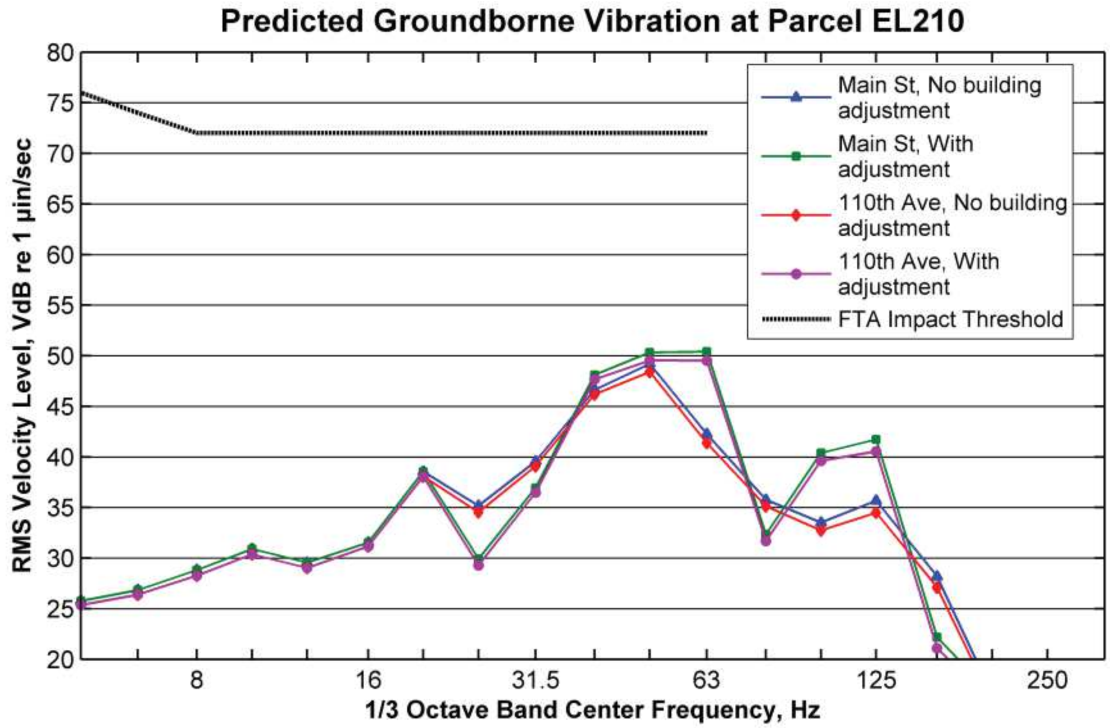
The predicted groundborne vibration levels and the predicted groundborne noise levels for parcel EL210 are shown in Table 6-3. The FTA impact threshold for groundborne vibration for residential land uses is 72 VdB in the maximum 1/3 octave band. The FTA impact threshold for groundborne noise is an overall level of 35 dBA. The overall level is the energy sum of the level over all of the frequency bands. The predicted groundborne vibration and groundborne noise levels are shown in Figure 6-9.

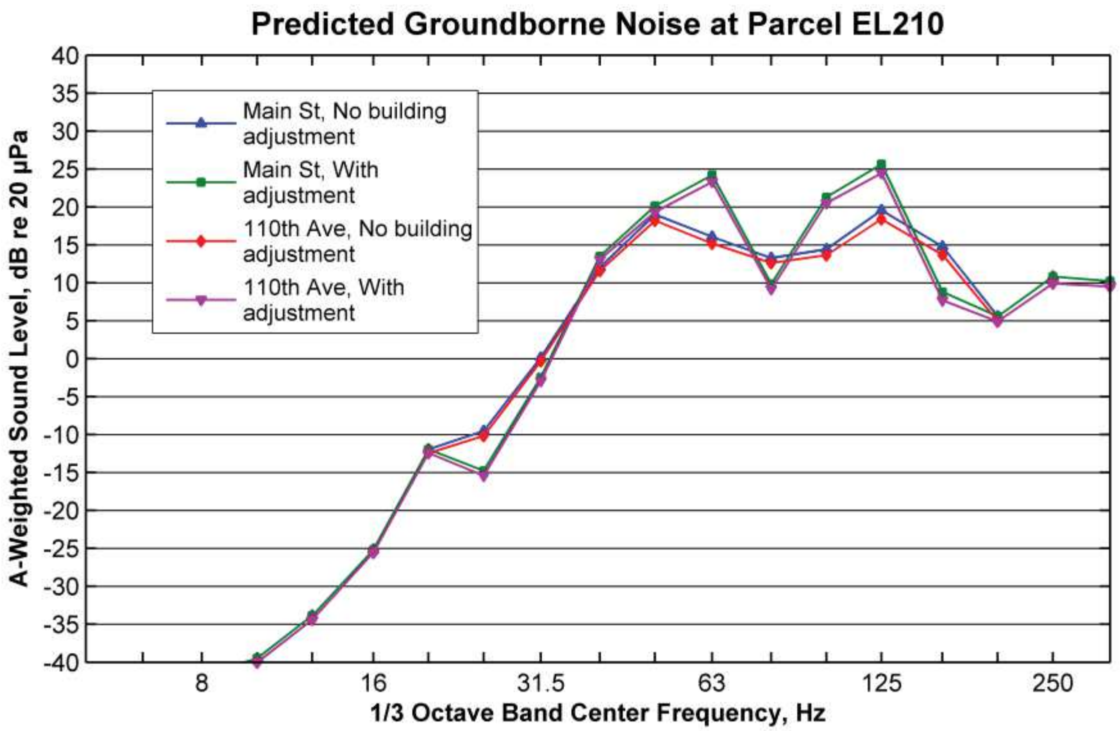
The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds. Therefore, no vibration mitigation is recommended.

Table 6-3: Predicted Groundborne Vibration and Groundborne Noise Levels for Parcel EL210 (MFR)

Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	Groundborne Noise Impact Threshold (dBA)
Parcel EL210, Main St, no building adjustment (58 ft slant distance to tracks)	49	50 Hz	72	25	35
Parcel EL210, Main St, with building adjustment (58 ft slant distance to tracks)	50	63 Hz	72	30	35
Parcel EL210, 110th Ave, no building adjustment (63 ft slant distance to tracks)	48	50 Hz	72	24	35
Parcel EL210, 110th Ave, with building adjustment (63 ft slant distance to tracks)	50	50 Hz	72	29	35

Figure 6-9: Predicted Groundborne Vibration and Groundborne Noise Levels at Parcel EL210 (MFR)





Predictions for Parcel EL222

Parcel EL222 is currently a vacant lot and is the proposed site for a future Marriott Hotel. The parcel is assessed for groundborne noise and vibration impact as a Category 2 (residential) land use. The vibration prediction for parcel EL222 assumes DF track and a train speed of 40 mph. The vibration propagation test results from the outdoor measurement locations from the NE 4th Street test were used to estimate the LSTM at the future hotel location. The LSTM and coherence from the outdoor measurement locations for the NE 4th Street vibration propagation test are shown in Figure 10-7, Figure 10-9, and Figure 10-11.

The predicted groundborne vibration level and groundborne noise level for parcel EL222 is shown in Table 6-4. The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds, therefore, no vibration mitigation is recommended.

Table 6-4: Predicted Vibration Levels for Parcel EL222 (site of future Marriott Hotel)

Parcel	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	Groundborne Noise Impact Threshold (dBA)
EL222 (future Marriott Hotel)	47	40 Hz	72	30	35

Predictions for Parcel EL223a

Parcel EL223a is a multi-family residential complex located at 10822 NE 2nd Street. The parcel is assessed for groundborne noise and vibration impact as a Category 2 (residential) land use. The vibration prediction for parcel EL223a assumes DF track and a train speed of 40 mph. The vibration propagation test results from the outdoor measurement locations from the NE 4th Street test were used to estimate the LSTM at the sensitive receiver. The LSTM and coherence from the outdoor measurement locations for the NE 4th Street vibration propagation test are shown in Figure 10-7, Figure 10-9, and Figure 10-11.

The predicted groundborne vibration level and groundborne noise level for parcel EL223a is shown in Table 6-5. The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds, therefore, no vibration mitigation is recommended.

Table 6-5: Predicted Vibration Levels for Parcel EL223a

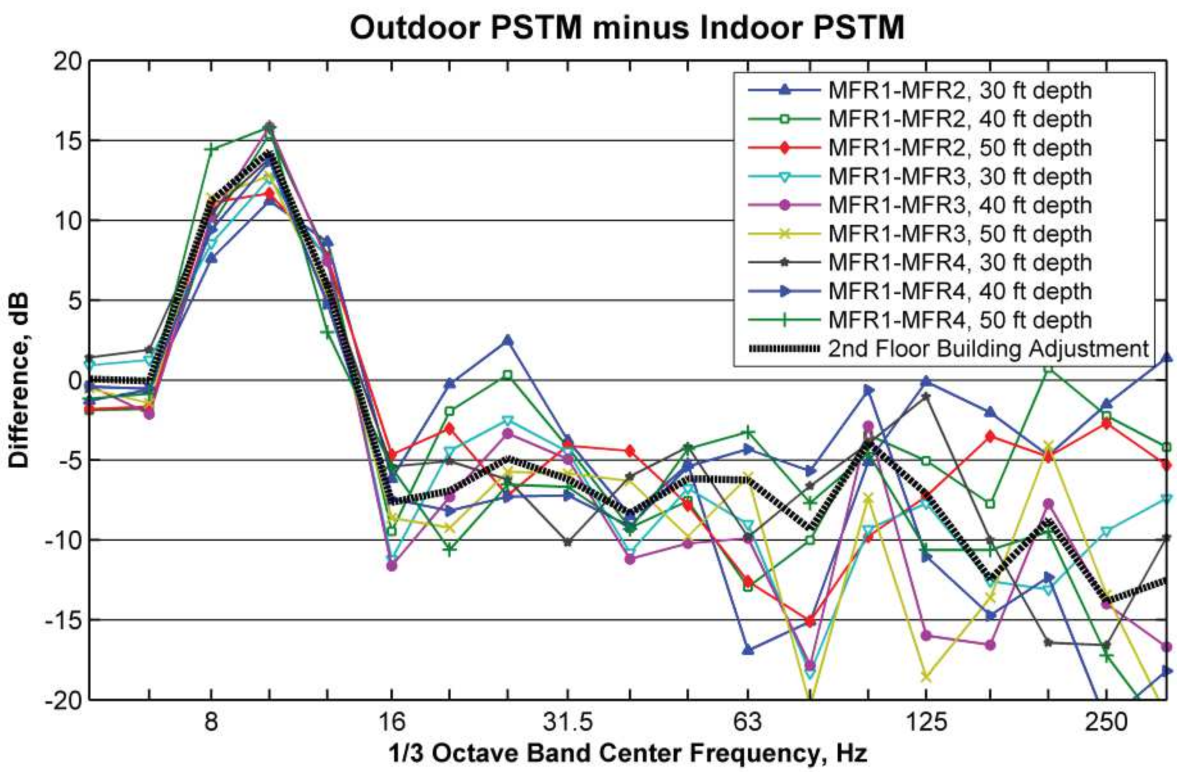
Parcel	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	Groundborne Noise Impact Threshold (dBA)
EL223a 10822 NE 2nd St	47	40 Hz	72	30	35

Results and Predictions for Parcel EL227 (MFR)

Parcel EL227 is a mixed-use building located at the corner of 110th Avenue NE and NE 4th Street. The ground floor of the building is commercial and the second floor and above are residential apartments. The data from the borehole test was used to assess potential for vibration impact at parcel EL227. Appendix C includes figures showing the measured PSTM and coherence for all of the measurement locations from the 4th Street borehole test.

Figure 6-10 shows the outdoor minus indoor PSTM for the three indoor measurement locations and for the three test depths. The outdoor PSTM is from the measurement located at the building facade (MFR1). For all indoor measurements, there is a similar building response. There is a resonance at 10 Hz that amplifies vibration levels by 10 to 15 decibels and a general reduction in vibration levels at frequencies greater than 12.5 Hz. The building adjustment used in the vibration predictions is the average difference for the two second floor measurement positions (MFR3 and MFR4), because the first floor of the building is a commercial land use. The average difference for the second floor measurement locations is the dashed black line in Figure 6-10.

Figure 6-10: Building Response for Parcel EL227 (MFR), Outdoor PSTM minus Indoor PSTM



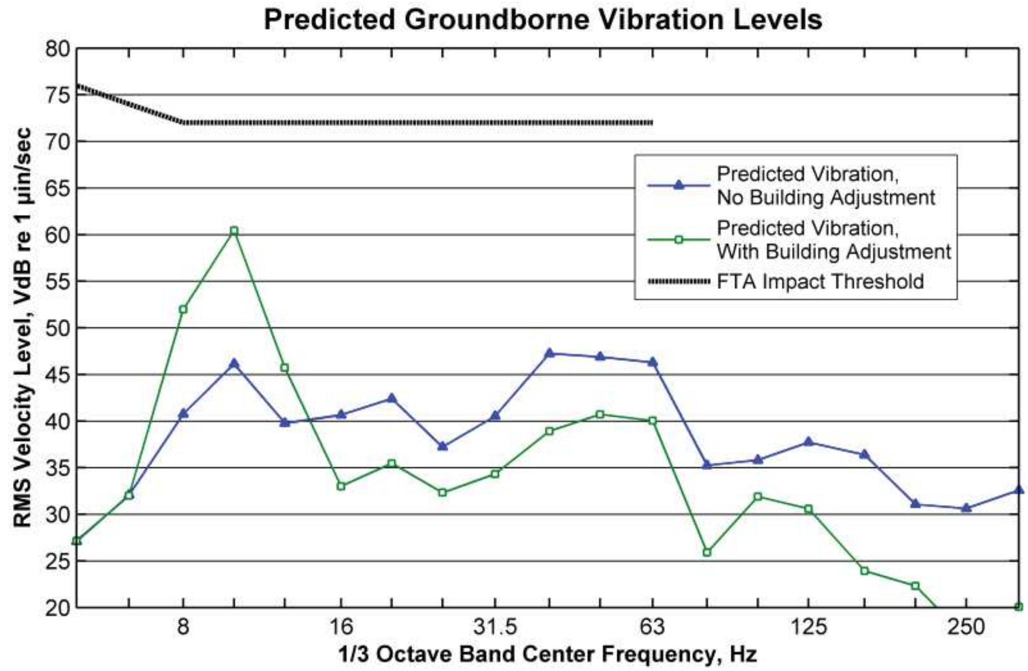
The predicted groundborne vibration level and the predicted groundborne noise level for parcel EL227 is shown in Table 6-6. The predictions with and without the building adjustment are presented. The FTA impact threshold for groundborne vibration for residential land uses is 72 VdB in the maximum 1/3 octave band. The FTA impact threshold for groundborne noise is an overall level of 35 dBA. The overall level is the energy sum of the level over all of the frequency bands. The predicted groundborne vibration and groundborne noise levels are shown in Figure 6-11.

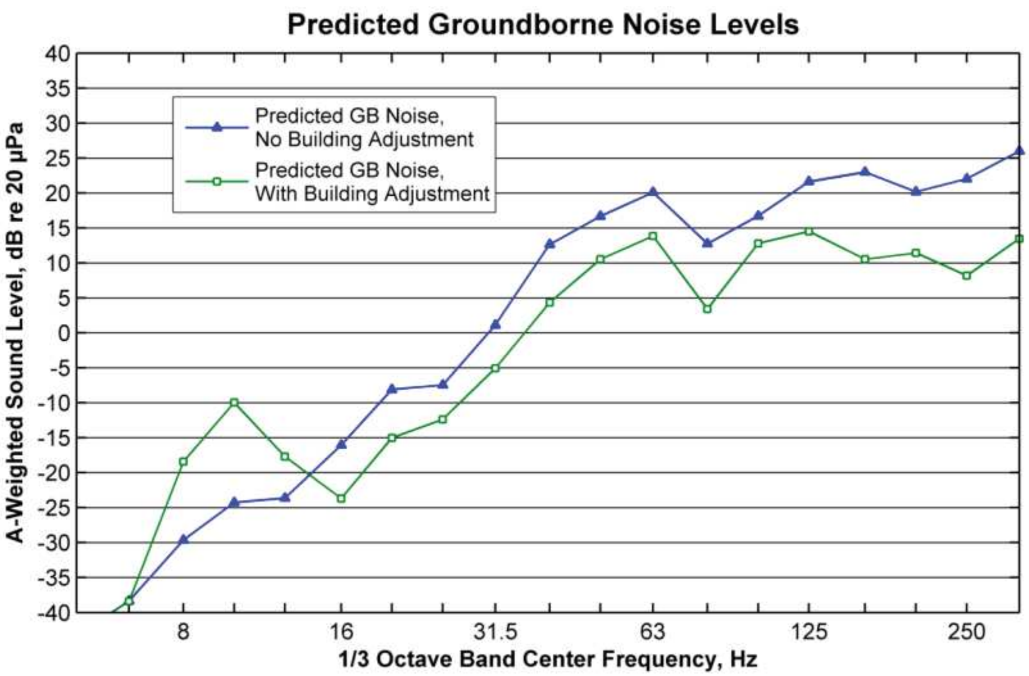
The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds. Therefore, no vibration mitigation is recommended.

Table 6-6: Predicted Groundborne Vibration and Groundborne Noise Levels for Parcel EL227 (MFR)

Measurement Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	Groundborne Noise Impact Threshold (dBA)
Parcel EL227, no building adjustment	47	40 Hz	72	28	35
Parcel EL227, with building adjustment	60	10 Hz	72	20	35

Figure 6-11: Predicted Groundborne Vibration and Groundborne Noise Levels for Parcel EL227 (MFR)





6.3 Offices near Downtown Bellevue Tunnel

There are several office buildings located within close proximity to the Downtown Bellevue Tunnel (DBT). Quiet office space is considered Category 3 (institutional) land use using the FTA land use categories. The detailed vibration impact threshold for office space is 84 VdB in the maximum 1/3 octave band and the groundborne noise impact threshold is 40 dBA. These impact thresholds would also apply to the City Council meeting room at City Hall 9Parcel EL299). The vibration predictions for the office spaces assume DF track and a train speed of 25 mph. The vibration propagation test results from the outdoor measurement locations from the NE 4th Street test were used to estimate the LSTM level at the office spaces. The LSTM and coherence for the outdoor measurement locations for the NE 4th Street vibration propagation test are shown in Figure 10-7, Figure 10-9, and Figure 10-11.

The predicted groundborne vibration level and groundborne noise level for each office buildings located within 100 feet of the tracks are shown in Table 6-7. The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds, therefore, no vibration mitigation is recommended.

Table 6-7: Predicted Vibration Levels for Office Spaces Near DBT

Measurement Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	Groundborne Noise Impact Threshold (dBA)
110 Atrium Parcel EL216	46	40 Hz	84	26	40
Skyline Tower Parcel EL228	47	40 Hz	84	29	40
City Hall Parcel EL229	47	40 Hz	84	31	40

6.4 Bravern Condominiums

The Bravern Condominiums (parcel EL236) are located in a mixed use building across the street from the Bellevue Transit Center Station. Vibration prediction for the parcel is presented for DF track and a train speed of 25 mph. A vibration propagation test was conducted nearby for the Meydenbauer Center; the location of the vibration propagation measurement is shown in Figure 6-12. The outdoor measurement locations were used to estimate the LSTM for the Bravern Condominiums. The LSTM and coherence for the outdoor measurement locations for the Meydenbauer Center vibration propagation test are shown in Figure 10-13.

The predicted vibration level for the Bravern Condominiums (parcel EL236) is presented in Table 6-8. The predicted vibration level is below the FTA vibration impact threshold, therefore, no vibration mitigation is recommended.

Table 6-8: Predicted Vibration Level for Bravern Condominiums (Parcel EL236)

Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	FTA Groundborne Vibration Impact Threshold (VdB)
Bravern Condominiums Parcel EL236	43	50 Hz	72

6.5 Meydenbauer Center (Parcel EL240)

The Meydenbauer Center (parcel EL240) is a convention center facility that also houses a theater. It is assessed using the criteria for theaters in Table 8-2 Groundborne Vibration and Noise Impact Criteria for Special Buildings in the FTA guidance manual. The Meydenbauer Center is located east of the north portal of the DBT. The LRT tracks transition from the tunnel onto an aerial structure as the LRVs pass the Meydenbauer Center. Predictions are included for both at-grade DF track and aerial structure DF track. The train speed assumed for the predictions is 55 mph.

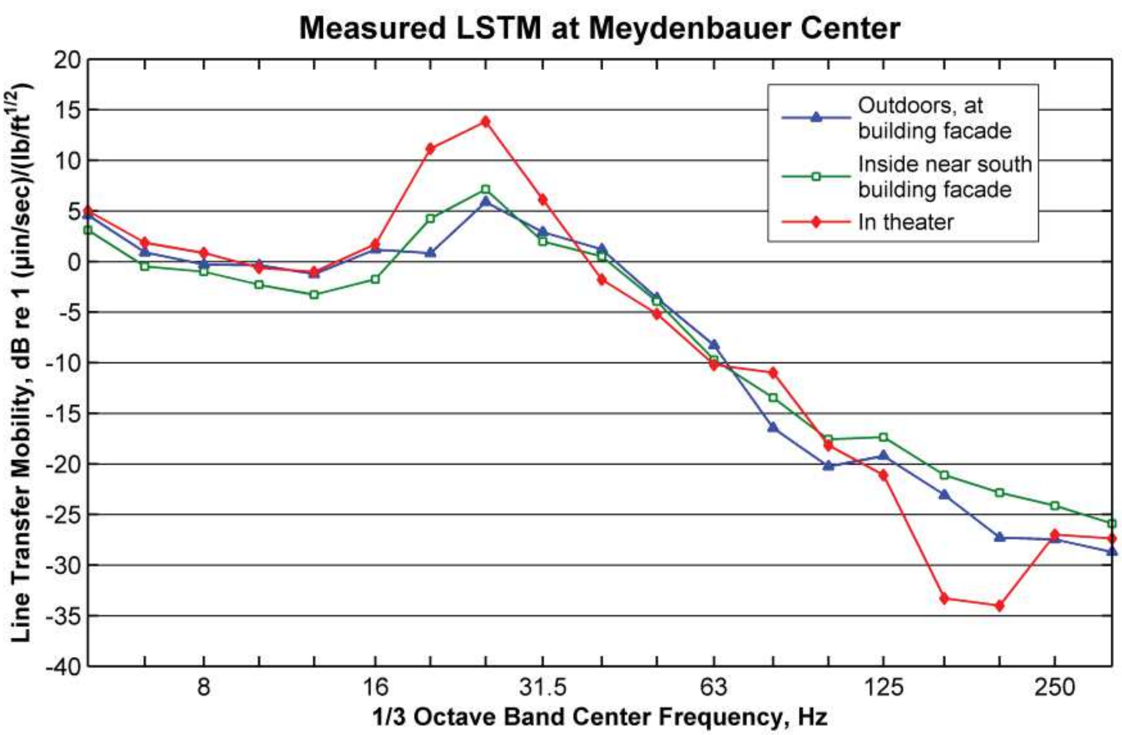
A vibration propagation test was conducted at the Meydenbauer Center to determine the soil propagation characteristics into the building. The measurement locations from the test are shown in Figure 6-12. A summary of the vibration propagation measurement follows:

- Impact locations: On the south sidewalk of NE 6th Street, 95 feet from the building facade
- Outdoor accelerometer locations: 25 ft, 37 ft, 50 ft, 75 ft, 125 ft, 175 ft, and 225 ft from the impact line (extending south)
- Meydenbauer Center accelerometer locations: outside at building facade, inside the building on cement floor near the south building facade, and inside the theatre.

Figure 6-13 shows the measured LSTM for the Meydenbauer Center accelerometer locations. Appendix C includes figures of the measured LSTM and coherence for all measurement positions. The LSTM measured in the theater is about five to ten decibels greater than the LSTM measured at the building facade in the 20 Hz and 25 Hz 1/3 octave bands. This implies there is a floor resonance in the 20 Hz and 25 Hz 1/3 octave bands inside the theater.

Figure 6-12: Vibration Propagation Measurement Locations at Meydenbauer Center (Parcel EL240)

Figure 6-13: Measured LSTM at Meydenbauer Center (Parcel EL240)



The groundborne noise and vibration prediction methodology follows the procedure described in Section 4.4. In addition, the following assumptions and adjustments were included in the predictions:

- The westbound LRT track will be 130 ft from the building facade and the impact locations from the LSTM measurement were 95 feet from the building facade. An adjustment was applied to the LSTM data measured inside the theater to account for the extra distance to the tracks. The distance adjustment was calculated by taking the difference between the LSTM at 90 ft and at 130 ft.

- There is a crossover on the aerial structure located 300 feet east of the Meydenbauer Center. The FTA guidance manual recommends an adjustment of +10 dB for crossovers, but in our experience, the additional vibration from a crossover does not exceed +5 dB at distances greater than 150 ft. A +5 dB adjustment was included in the aerial structure prediction to account for the crossover.
- The predictions include an adjustment for the attenuation from the aerial track structure. The FTA guidance manual recommends an adjustment of -10 dB in all 1/3 octave bands. This analysis assumes a -10 dB adjustment in all 1/3 octave bands except 10 Hz and 12.5 Hz, where there is a 0 dB adjustment. The aerial structure adjustment we use is based on measurements from aerial structure track from the existing Central Link[4], and is more conservative than the FTA guidance manual recommendation.

The predicted groundborne vibration levels and predicted groundborne noise levels for the Meydenbauer Center is shown in Table 6-9. There are separate predictions for at-grade DF track and aerial structure track with crossover. The track will be both at-grade and on aerial structure as it passes the Meydenbauer Center. The FTA impact threshold for groundborne vibration for theaters is 72 VdB. The impact threshold for groundborne noise is 35 dBA. The predicted groundborne vibration and groundborne noise spectra are shown in Figure 6-14.

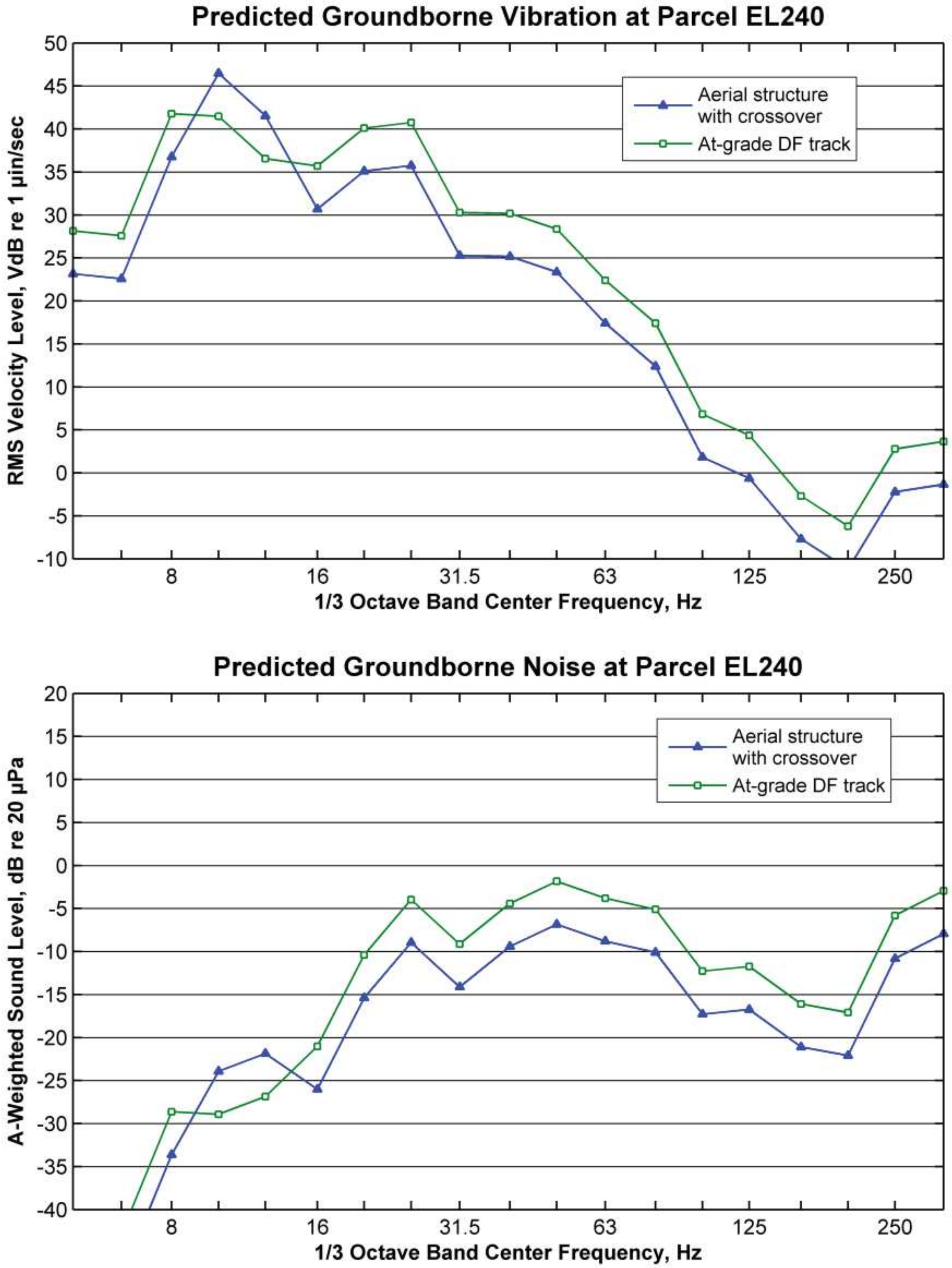
The predicted groundborne vibration and groundborne noise levels are below the FTA impact thresholds. Therefore, no vibration mitigation is recommended.

Table 6-9: Predicted Groundborne Vibration and Groundborne Noise Levels for Meydenbauer Center (Parcel EL240)

Prediction Location	Predicted Overall Groundborne Vibration (VdB)	FTA Groundborne Vibration Impact Threshold (VdB)	Predicted Overall Groundborne Noise (dBA)	FTA Groundborne Noise Impact Threshold (dBA)
Parcel EL240, at-grade DF Track	48	72	5	35
Parcel EL240, aerial DF Track with crossover adjustment	49	72	0	35

[4] The results of the ST Central Link vibration measurements are documented in the report: *Vibration Measurements of Existing Sound Transit Trains*, dated July 14, 2013.

Figure 6-14: Predicted Groundborne Vibration and Groundborne Noise for Meydenbauer Center (Parcel EL240)



6.6 Coast Bellevue Hotel (Parcel EL242)

The tracks will be on an aerial structure as they cross above I-405 and 116th Avenue NE and then turn north as they enter the BNSF right-of-way. The only sensitive receiver near the aerial structure is the Coast Bellevue Hotel (parcel EL242).The Hotel is located at 625 116th Avenue NE, east of I-405. The LRT aerial structure will be located 155 feet south of the hotel building. The aerial structure will have DF track. The train speed assumed for the predictions is 55 mph.

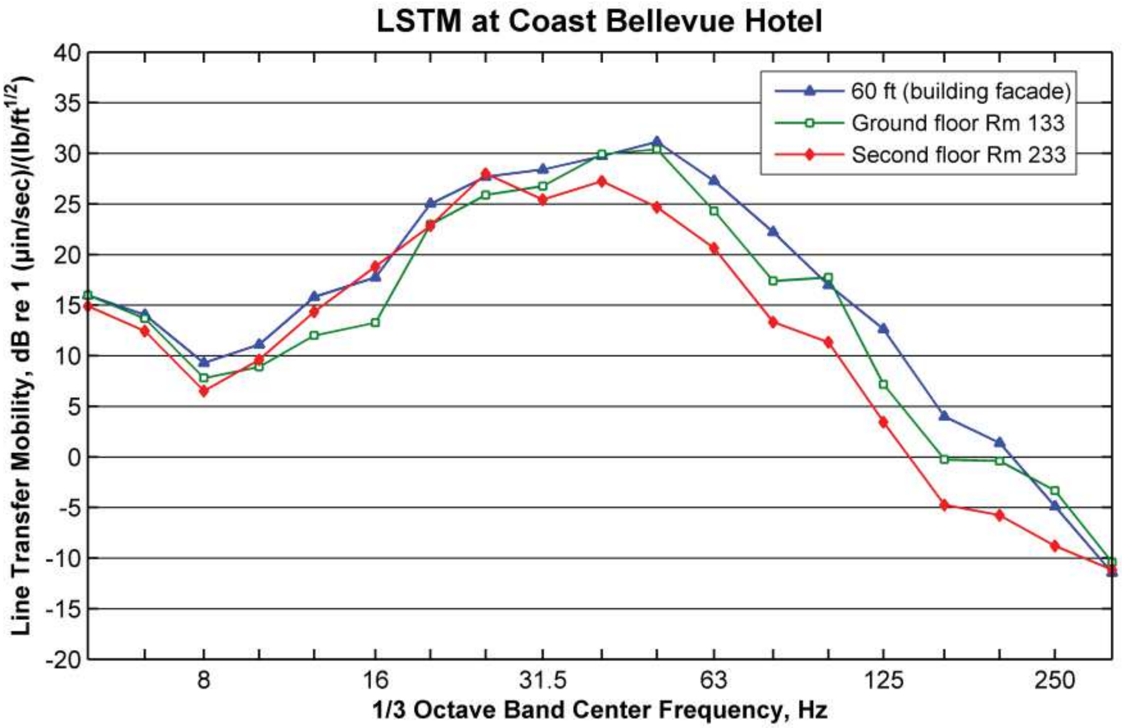
A vibration propagation test was conducted near the Coast Bellevue Hotel to determine the vibration propagation characteristics into the hotel. The measurement locations from the test are shown in Figure 6-15. A summary of the vibration propagation measurement follows:

- Impact Locations: At the southern edge of the hotel property, 60 feet from the building facade
- Outdoor accelerometer locations: 25 ft, 50 ft, 85 ft, 135 ft, and 175 ft from the impact line
- Indoor accelerometer locations: ground floor room 133 and second floor room 233

Figure 6-16 shows the measured LSTM for the indoor measurement locations and the LSTM at the building facade outdoors. As shown in Figure 6-16, the indoor and outdoor LSTMs have comparable levels. Therefore, the building adjustment used in the predictions for the Coast Bellevue Hotel is 0 decibels in all 1/3 octave bands. Appendix C includes figures of the measured LSTM and coherence for all measurement positions.

Figure 6-15: Vibration Propagation Measurement Locations at Parcel EL242 (Coast Bellevue Hotel)

Figure 6-16: LSTM Measured Indoors at Coast Bellevue Hotel (Parcel EL242)



The groundborne vibration prediction methodology follows the procedure described in Section 4.4. The predictions also include the following adjustments and assumptions:

- The LRT tracks will be 155 ft from the south building facade and the impact line is 60 feet from the south building facade. The outdoor LSTM data was used to estimate the LSTM at a distance of 155 feet.
- The indoor data did not show any floor resonance, therefore a building adjustment of 0 dB was used in the predictions.
- An adjustment for the attenuation from the aerial track structure was included in the predictions. The FTA guidance manual recommends an adjustment of -10 dB in all 1/3 octave bands. This analysis assumes a -10 dB adjustment in all 1/3 octave bands except 10 Hz and 12.5 Hz, where there is a 0 dB adjustment. The aerial structure adjustment we use is based on measurements from aerial structure track from the existing Central Link[5], and is more conservative than the FTA guidance manual recommendation.

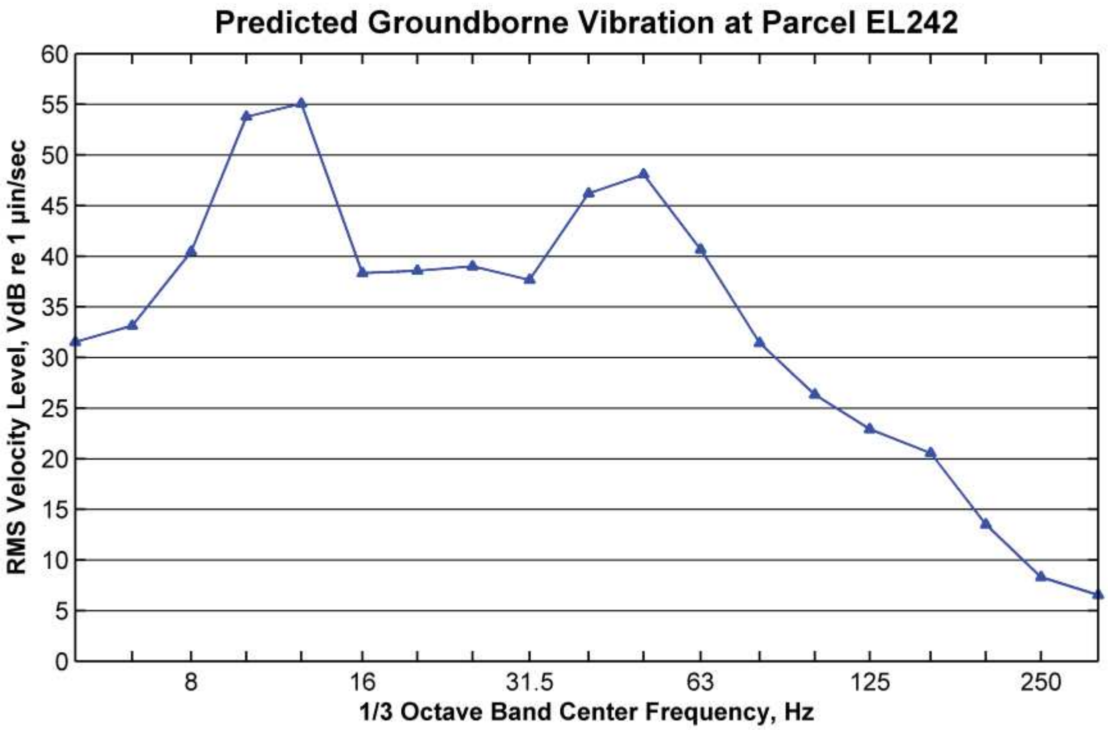
The predicted groundborne vibration levels for the Coast Bellevue Hotel are shown in Table 6-10. The FTA impact threshold for residential land uses (including hotels) is a maximum level of 72 VdB in any 1/3 octave band. The predicted groundborne vibration spectrum is shown in Figure 6-17. The predicted groundborne vibration is below the FTA impact threshold. Therefore, no vibration mitigation is recommended.

[5] The results of the ST Central Link vibration measurements are documented in the report: *Vibration Measurements of Existing Sound Transit Trains,* dated July 14, 2013.

Table 6-10: Predicted Groundborne Vibration Levels for Coast Bellevue Hotel (Parcel EL242)

Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	FTA Groundborne Vibration Impact Threshold (VdB)
Parcel EL242	55	12.5 Hz	72

Figure 6-17: Predicted Groundborne Vibration Spectra at Coast Bellevue Hotel (Parcel EL242)



6.7 Lake Bellevue Condominiums (Parcel EL261)

This section presents the vibration impact assessment for the Lake Bellevue Condominiums, located adjacent to the BNSF right-of-way north of the Hospital Station. The Condominiums are on a site with unusual soil conditions and construction.

A vibration propagation test was conducted at the Lake Bellevue Condominiums to determine the vibration propagation characteristics from the tracks into the Condominiums. The Condominiums are constructed on piles over Lake Bellevue and the parking area between the tracks and the Condominiums has a geofoam layer underneath the paved surface. The measurement locations from the test are shown in Figure 6-18. A summary of the vibration propagation measurement follows:

- Impact Locations: In the existing BSNF right-of-way, in the center of the east-most existing track.
- Parking lot accelerometer locations: 30 ft, 60 ft, 80 ft, 110 ft, 160 ft, and 175 ft from the impact line. Note that there is layer of geofoam under the parking lot.
- Two accelerometers located on the piles of the deck between the condominiums.

Figure 6-20 shows the LSTM and coherence for the measurement positions. There is very poor coherence for the LSTM data measured on the piles of the Lake Bellevue Condominiums and at the further distances (160 ft and 175 ft). Coherence is a measure of the relationship between the impact force and the acceleration response. Low coherence indicates that the measured response is not related to the input force, and is sign of low confidence in the data. Because the low coherence indicates there was no measurable vibration response on the piles, we infer that there is no significant amplification form the construction of the condominium structure on top of the piles. Therefore, the building adjustment used in the predictions for the Lake Bellevue Condominiums was 0 decibels.

Figure 6-18: Vibration Propagation Measurement Locations, Lake Bellevue Condominiums (Parcel EL261)

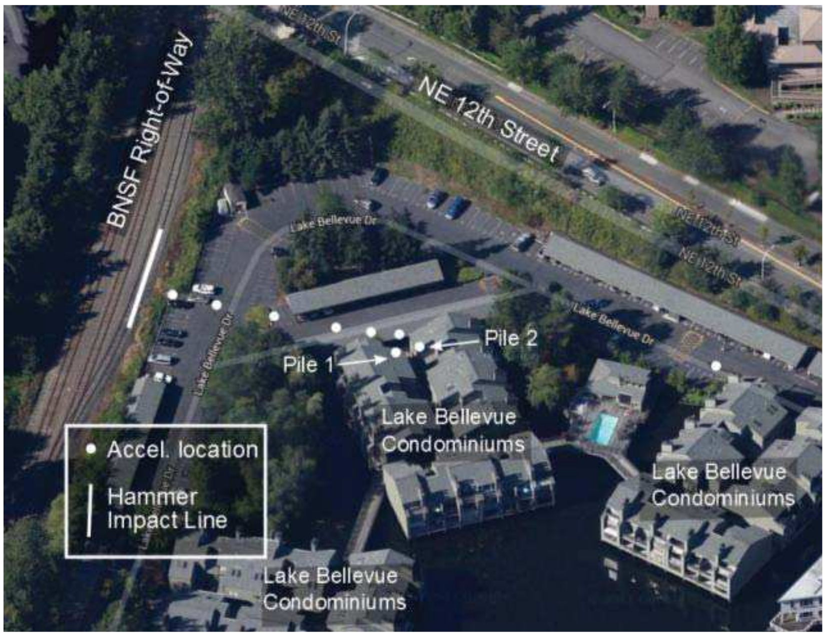


Figure 6-19: Accelerometer Location on top of a Pile (Orange Cone)

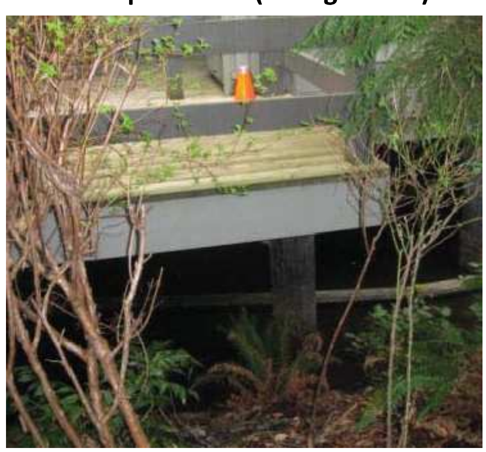
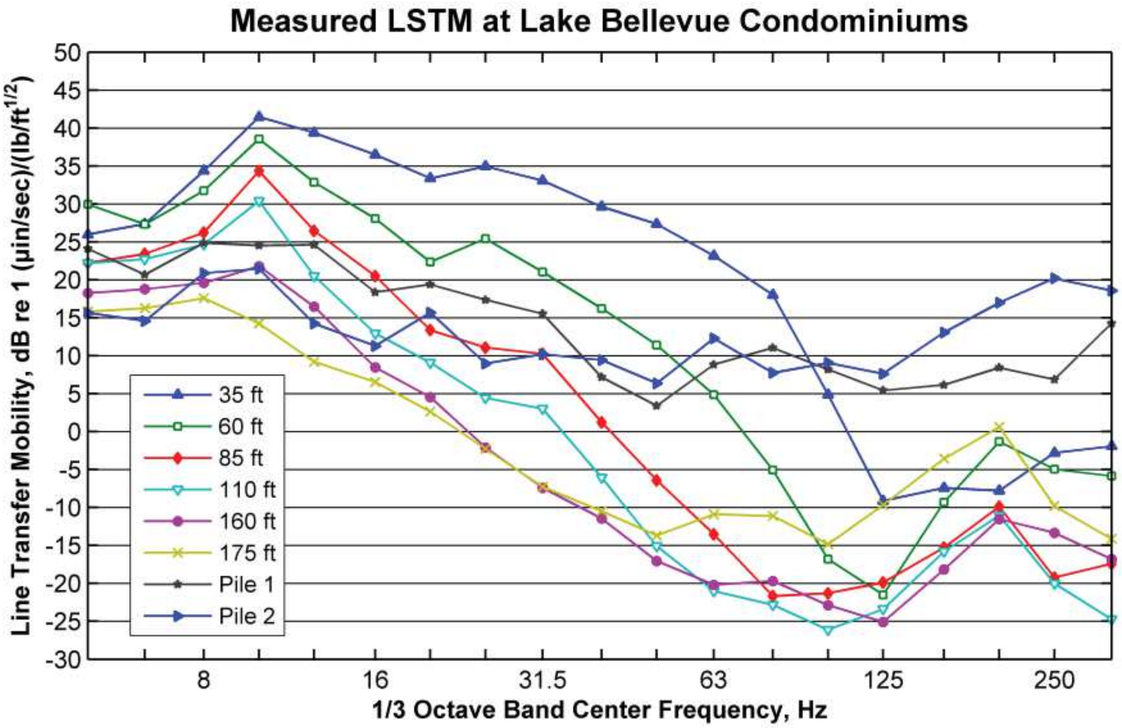
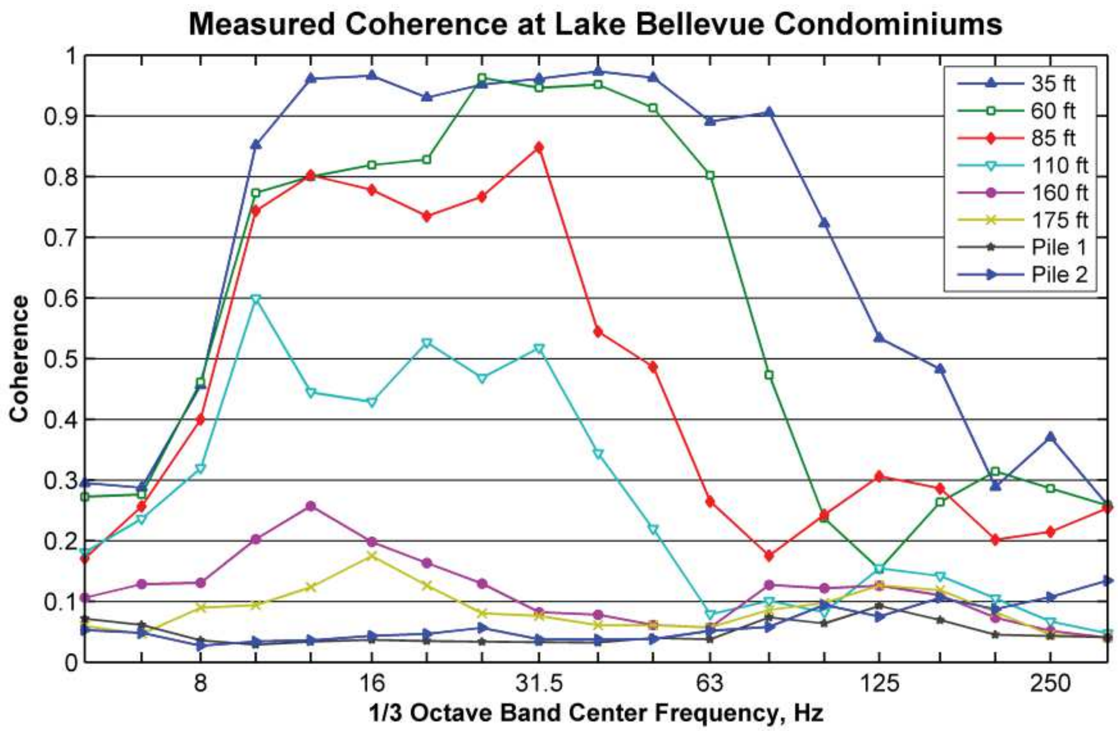


Figure 6-20: Measured LSTM and Coherence at Lake Bellevue Condominiums (Parcel EL261)





The groundborne vibration prediction methodology follows the procedure described in Section 4.4. The predictions also include the following adjustments and assumptions:

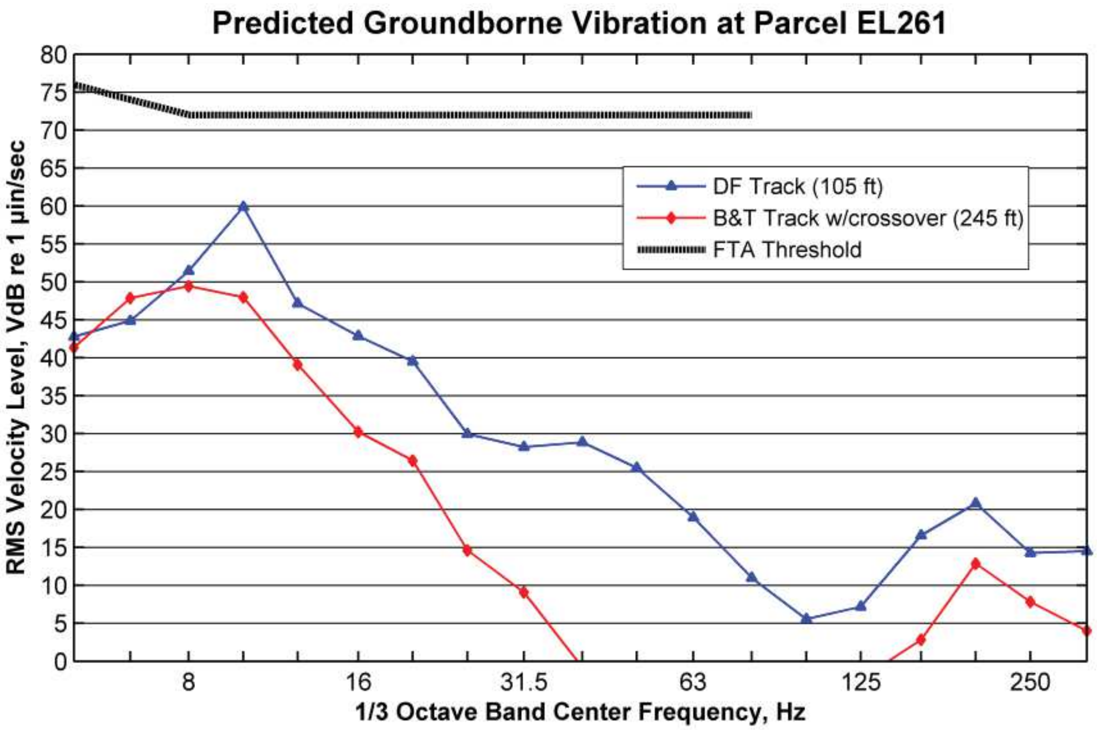
- The LRT tracks transition from direct-fixation on a retained fill to ballast and tie track type near the Lake Bellevue Condominiums. Predictions are included for both track types.
- A crossover is located approximately 245 feet from the Lake Bellevue Condominiums. The FTA guidance manual recommends an adjustment of +10 dB for crossovers, but in our experience, the additional vibration from a crossover does not exceed +5 dB at distances greater than 150 ft. A +5 dB adjustment was included in the prediction to account for the crossover.
- The measurement data on top of the piles did not show evidence of vibration amplification; therefore, a building adjustment of 0 decibels was used in the predictions.

The predicted groundborne vibration levels for the Lake Bellevue Condominiums are shown in Table 6-11. The FTA impact threshold for residential land uses is a maximum level of 72 VdB in any 1/3 octave band. The predicted groundborne vibration spectra are shown in Figure 6-21. The predicted groundborne vibration is below the FTA threshold in all 1/3 octave bands. Therefore, no vibration mitigation is recommended.

Table 6-11: Predicted Groundborne Vibration Levels at Lake Bellevue Condominiums (Parcel EL261)

Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	FTA Groundborne Vibration Impact Threshold (VdB)
Parcel EL261, DF Track (105 ft)	60	10 Hz	72
Parcel EL261, B&T Track with Crossover (245 ft)	49	8 Hz	72

Figure 6-21: Predicted Groundborne Vibration at Lake Bellevue Condominiums (Parcel EL261)



6.8 Mercer Education (Parcel EL263)

Mercer Education (parcel EL263) offers tutoring, enrichment programs, and counseling. The Mercer Education facility is assessed using the Residential (Day) criteria for detailed vibration analysis. The FTA Guidance Manual does not specify a detailed vibration criteria for institutional land uses such as schools and churches, so the Residential (Day) criteria is commonly used. The vibration prediction for this parcel assumes DF track and a train speed of 35 mph. The results from the vibration propagation test at the Coast Bellevue Hotel (parcel EL242) were used to estimate the LSTM for Mercer Education. The LSTM and coherence for the Coast Bellevue Hotel vibration propagation test are shown in Figure 10-15.

The predicted vibration level for Mercer Education (parcel EL263) is presented in Table 6-12. The predicted vibration level is below the FTA vibration impact threshold, therefore, no vibration mitigation is recommended.

Table 6-12: Predicted Groundborne Vibration Levels at Mercer Education (Parcel EL263)

Location	Predicted Vib. Vel. level in max. 1/3 octave band (VdB)	Max. 1/3 octave band	FTA Groundborne Vibration Impact Threshold (VdB)
Mercer Education Parcel EL263	65	50 Hz	78

7.0 Noise Impact Assessment Using Bellevue City Code

This section presents the results of the Contract E335 noise impact assessment of light-rail operations using the Bellevue City Code (BCC) noise limits. Included in the analysis are parcels from the East Main Station to the Downtown Bellevue Tunnel south portal that are in the City of Bellevue (COB) Environmental Designation for Noise Abatement (EDNA) Class A.

The noise impact thresholds used for this noise impact assessment are the maximum permissible sound levels set by BCC 9.18.030. The predicted light-rail operations noise levels are compared to those thresholds. The modeling for this report predicts that after installation of the mitigation required by the FTA Record of Decision, noise from train operations will comply with Chapter 9.18 of the BCC at all EDNA Class A properties

7.1 Bellevue City Code Noise Limits

Exemptions Applicable to Train Noise

Chapter 9.18 of the Bellevue City Code states maximum permissible sound levels within the City. BCC 9.18.020.B.5 exempts from these maximum permissible sound levels all sounds created by the operation of motor vehicles at all times when the receiving property is in a commercial or industrial zone (Class B or C EDNA), but this exemption applies only during the defined daytime of 7 a.m. to 10 p.m. weekdays and 9 a.m. to 10 p.m. on weekends when the receiving property is in a residential zone (Class A EDNA).

This noise report presents predicted noise levels from train operations at Class A EDNA properties during the defined nighttime hours of 10 p.m. to 7 a.m. when a 10 dBA maximum permissible sound level reduction is in effect per BCC 9.18.030.C. This report does not predict noise levels from 7 a.m. to 9 a.m. on weekends because the 10 dBA maximum permissible sound level reduction for nighttime noise does not apply after 7 a.m. and the noise from train operations is predicted to comply with the maximum permissible sound levels defined by BCC 9.18.030. Noise from train and wayside warning devices such as bells and horns are exempt from the BCC maximum permissible sound levels as safety warning devices.

Maximum Permissible Sound Levels

The maximum permissible sound levels for residentially zoned properties are presented in BCC 9.18.030.B. The maximum permissible sound levels are reduced by 10 dBA during nighttime hours, from 10 p.m. to 7 a.m. (BCC 9.18.030.C.1) and are increased for short duration noise events (BCC 9.18.030.C.3). The duration of the train events is between 90 seconds and 5 minutes in one hour for peak hour train headways, which is considered a short duration noise event, so the maximum permissible noise levels increase by 10 dBA. The definition of the duration of a train event is presented in the following section for various train speeds.

The maximum permissible noise levels used in this analysis are presented in Table 7-1. The levels in the table include the 10 dB reduction for nighttime noise and a 10 dB increase for short duration events. The maximum permissible sound level is only presented for Class A EDNA receiving properties because LRT noise is exempt from the BCC noise limits for Class B and Class C EDNA receiving properties per BCC 9.18.020.B.5.

Table 7-1: Maximum Permissible Sound Levels for Light Rail Vehicles

EDNA of Source	Maximum Permissible Sound Level for Class A EDNA Receiving Property, Leq(10pm to 7am), dBA
Class A	55 dBA
Class B	57 dBA
Class C	60 dBA
Source: Bellevue City Code Chapter 9.18	

BCC 9.18.030 does not specify which noise metric applies to the maximum permissible sound levels. A noise metric is a descriptor of what the reported sound level represents, such as a maximum level or an average level over a given period of time. Two different noise metrics are defined in the noise code, Leq and Ldn. Ldn cannot be used for nighttime sound levels because it is, by definition, a 24-hour noise metric. This report therefore uses Leq as the noise metric.

Chapter 9.18 BCC also does not identify what time period should be used to model noise from train operations, and does not identify how the duration of train events should be defined. As explained below, this report uses a one-hour Leq and defines the duration of train events in a manner that is consistent with the FTA's guidance manual, in order to apply the code in a conservative manner that does not understate the noise from nighttime train operations.

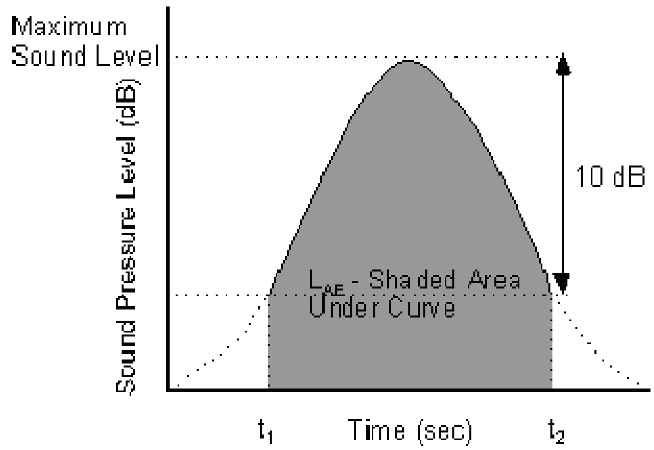
Leq is an energy average of the noise levels over a defined period of time. The noise code does not specify the period of time for the Leq. Since the noise code defines a maximum permissible noise level for nighttime hours and defines nighttime as the period between 10 p.m. to 7 a.m., it would be consistent with the code to use a 9-hour Leq corresponding to the nighttime period. However, light rail trains will not run throughout the night, and ambient noise will also be less during the middle of the night. This report therefore uses a 1-hour Leq to predict the noise from the train events during the two nighttime hours when the noise from trains will be most perceptible. For comparison purposes this report also models ambient noise during those two nighttime hours.

Using 1-hour Leq, this report predicts train noise during the 6 a.m. to 7 a.m. hour, the nighttime hour with the highest number of trains and therefore highest train noise 1-hour Leq. There will be eight-minute train headways during this hour. This report also presents the existing ambient 1-hr Leq during these same hours for reference.

7.2 Duration of Train Event

It is difficult to define train duration because it is not a fixed noise source, therefore the duration of the event will depend on train speed and train length. A reasonable definition for duration of a train event is to use the duration applied when calculating the sound exposure level (SEL). The SEL is a noise metric used in the FTA noise analysis and is defined in the FTA guidance manual as the level of sound accumulated over a given time interval or event. The FTA manual does not specifically state the duration of the time interval or event; however it is common practice to use the 10 dB down points to define the duration of the train event when determining the SEL. The 10 dB down points are the points before and after the maximum level that are 10 dB below the maximum. The Federal Highway Administration's Traffic Noise Model User's Guide states that as a minimum the SEL should encompass the 10 dB down points. In Figure 7-1, the 10 dB down points are at t_1 and t_2, and the duration of the event would be the time elapsed between t_1 and t_2. The time between the 10 dB down points is reasonably interpreted to be the acoustical duration of a train event.

Figure 7-1: Noise Event Illustrating 10 dB Down Points



Source: FHWA Traffic Noise Model Users Guide,

Table 7-2 shows the duration of train events using the 10 dB down point definition for a receiver at 50 feet and a 4-car train. The distance of 50 feet is commonly used as a reference distance for train noise events because the sound level at 50 feet generally exceeds the ambient noise level by at least 10 dB.

Table 7-2 shows the duration of a single train event and the duration of all train events for the hour with the most train events. The nighttime hour with the most train events is 6 a.m. to 7 a.m. During this hour the operating plan (see Table 7-2 below) shows 7.5 events in each direction, for this analysis this is rounded up to be 8 events in each direction resulting in a conservative total of 16 events in the hour. . The duration of train events in 1 hour for train speeds from 25 mph to 55 mph is between 1.5 minutes and 3.5 minutes. This duration corresponds to a 10 dBA increase to the maximum permissible sound levels for any receiving property per BCC 9.18.030.C.3.c. The 10 dBA increase is applied to the maximum permissible sound level for nighttime hours (10 p.m. to 7 a.m.).

Table 7-2: Duration of Train Events for Different Train Speeds

Train Speed:	55 mph	50 mph	45 mph	40 mph	25 mph
Train Length:	380 ft.	380 ft.	380 ft.	380 ft.	380 ft.
Duration of 1 event (seconds):	6.0 sec	6.6 sec	7.2 sec	8.2 sec	13.0 sec
Max events per hour[1]:	16	16	16	16	16
Duration of train events in 1-hour:	1.6 min	1.8 min	1.9 min	2.2 min	3.5 min
[1]There are 15 scheduled events per hour, but the calculation assumes 16 events in order to be conservative.					

The BCC does not define the duration of a train noise event and the definition presented in this section is not the only possible interpretation. An alternative interpretation is defining the time it takes the train to travel past a point. The duration of a train event using this alternative interpretation is the train length divided by the train speed, which would result in a shorter duration and therefore a higher permissible noise level (an increase of 15 dBA instead of 10 dBA per 9.18.030.C.3.c) for some train speeds than the definition of train duration adopted in this report.

7.3 Prediction Location

BCC 9.18.030.A states “the point of measurement shall be at the property boundary of the receiving property or anywhere within.” Therefore, predicted noise levels should be presented at the location within the property where the noise will be the highest. In general, noise levels decrease with distance so the highest noise levels will be at the property line closest to the LRT tracks. However, when a sound wall is located close to the property line, the sound wall will provide the highest noise reduction at the property line and the noise level may be higher somewhere between the property line and the building facade where the sound wall is less effective.

To illustrate this point, Table 7-3 shows the difference in noise reduction for a sound barrier placed 20 feet from the LRT tracks and a barrier placed close to the property line (55 feet from the LRT tracks), where the property line is 60 feet from the track. The calculations assume flat topography and an 8 feet barrier height.

As shown in Table 7-3, the predicted noise reduction for the barrier located close to (20 feet from) the tracks has very little variation with distance. Noise levels decrease with distance; therefore, the highest noise level is expected to be at the property line and not at the building facade. However, for the barrier located close to the property line (55 feet from the tracks), noise levels may be higher at 100 feet compared to the 60 feet position, because the sound barrier is about 4 decibels less effective.

Table 7-3: Effect of Sound Barrier Location on Noise Reduction

Distance to Measurement Position	Predicted Noise Reduction for barrier located 20 ft. from tracks, dB	Predicted Noise Reduction for barrier located 55 ft. from tracks, dB
60 ft.	12.6	13.3
70 ft.	12.6	10.5
80 ft.	12.5	9.6
90 ft.	12.5	9.1
100 ft.	12.5	8.9
Note: Predicted noise reduction from barrier assumes 8 ft. barrier height and flat topography.		

Any location on a receiving property further away from the LRT track than the building structure will receive noise reduction from acoustical shielding from the structure itself. Therefore, noise predictions are presented at the building facade on the property for parcels where a sound wall is located close to the property line. The prediction location (property line or building facade) is indicated in the footnote in the bottom row of Table 4-1.

7.4 Noise Impact Assessment Methodology

The noise from light-rail vehicle (LRV) operations is predicted using the FTA detailed noise analysis procedure presented in the FTA Transit Noise and Vibration Impact Assessment guidance manual[6]. The FTA detailed noise analysis procedure is a spreadsheet model that uses formulas presented in the FTA guidance manual. The formulas take into account the following specific operating characteristics of the Sound Transit system:

- Measured reference sound level of existing Sound Transit LRVs,
- train operating schedule,
- train speed, and
- track structure

ATS Consulting took reference sound level measurements on the existing ST Central Link light-rail system in August 2014[7]. Measurements were taken on at-grade, ballast-and-tie track and on direct-fixation track on an aerial structure. The measurements were made using a 3-car train consist traveling at controlled speeds during non-revenue service hours and measurements of 2-car train consists during regular revenue service hours. The results of the noise measurements showed maximum noise levels from the light rail vehicle of 79 dBA at 50 feet and 40 mph. The noise levels on the Central Link system are about 2 decibels higher than the FTA reference noise level for LRVs. The measured maximum noise levels of the existing light rail vehicle was converted to a reference sound exposure level (SEL) which is the train passby compressed into a 1-second period. The referenced SEL used for the predictions in this analysis is 84 dBA at 50 feet for a one-car train traveling at 50 mph for ballast-and-tie track (2 decibels higher than the FTA reference level of 82 dBA). The 1-car referenced SEL is adjusted to the number of rail vehicles per train which for East Link is a 4-car train consists. The measured reference levels for ballast-and-tie track and direct fixation track are shown in Table 7-4.

Table 7-4: Measured SEL Reference Levels

Track-type	SEL Reference Level, dBA[1]
Ballast-and-Tie	84
Direct Fixation	88
[1]SEL reference level is for a one-car train traveling at 50 mph at 50 ft.	

The train schedule from Sound Transit's Revised 2035 Light Rail Operation Plans, shown in Table 7-5, was used for the noise predictions. Note that the revised 2035 operating schedule is different than the assumptions used in the Final EIS predictions. The revised operating schedule assumes 8 minute peak headways and 4-car train consists, while the Final EIS schedule assumed 7-minute peak headways and 3-car train consists. The operating speeds and track structure type assumed in the predictions are based on the information in the 60% design drawings.

[6] FTA-VA-90-1003-06. May 2006.

[7] The sound level measurements of the existing ST Central Link light-rail system are documented in the report: *Noise Measurements of Existing Sound Transit Trains* dated August 21, 2014.

Table 7-5: East Link Operating Plan

Hours	Headway (minutes)	Total Trains in One Direction
5-6 a.m.	15	4
6-7 a.m.	8	7.5
7-8:30 a.m.	8	11.25
8:30 a.m.-3:00 p.m.	10	39
3-6:30 p.m.	8	26.25
6:30-10 p.m.	10	21
10 p.m.-1:00 a.m.	15	12
1-5 a.m.	0	0
Total Nighttime (10 p.m. - 7 a.m.)	-	23.5[1]
Notes: Schedule is for trains in one direction. [1]Total number of nighttime trains in one direction is rounded up to 24 when calculating predicted noise levels.		

In addition to the operating characteristics of the system, the noise formulas also account for distance from the sensitive receiver to the tracks, ground absorption effects, and noise reduction from barriers recommended in the final design noise mitigation analysis using the FTA noise impact thresholds. The sound barrier lengths and locations recommended in the final design noise mitigation analysis are summarized in Table 7-6. The locations of the barriers are shown in Figure 4-1.

Table 7-6: Recommended Sound Wall Lengths and Heights from FTA Noise Impact Analysis

Wall	Start Station	End Station	Wall Length	Wall Height
1	531+55	540+15 (DBT South Portal)	860 ft.	~6 ft. above ground level at WB track right-of-way line.

7.5 Noise Impact Assessment

This section presents a detailed noise impact analysis of light-rail vehicle operations. Table 4-1 presents the predicted nighttime noise levels for Class A EDNA land uses within the Contract E335 limits. Each Class A parcel is identified in the first column of the table. Table 7-8 is a list of all parcel labels and corresponding street addresses. The location of all the EDNA Class A parcels with respect to the light-rail tracks, as well as the sound walls included in the analysis are shown in Figure 7-2.

The predicted nighttime noise levels with the noise mitigation required by the Record of Decision are compared with the maximum permissible noise levels defined in the Bellevue City Code. Predicted nighttime noise levels do not exceed the BCC maximum permissible noise level at any of the EDNA Class A parcels within the E335 Contract.

Figure 7-2: Recommended Sound Wall for Parcels EL187-EL196, and EL206

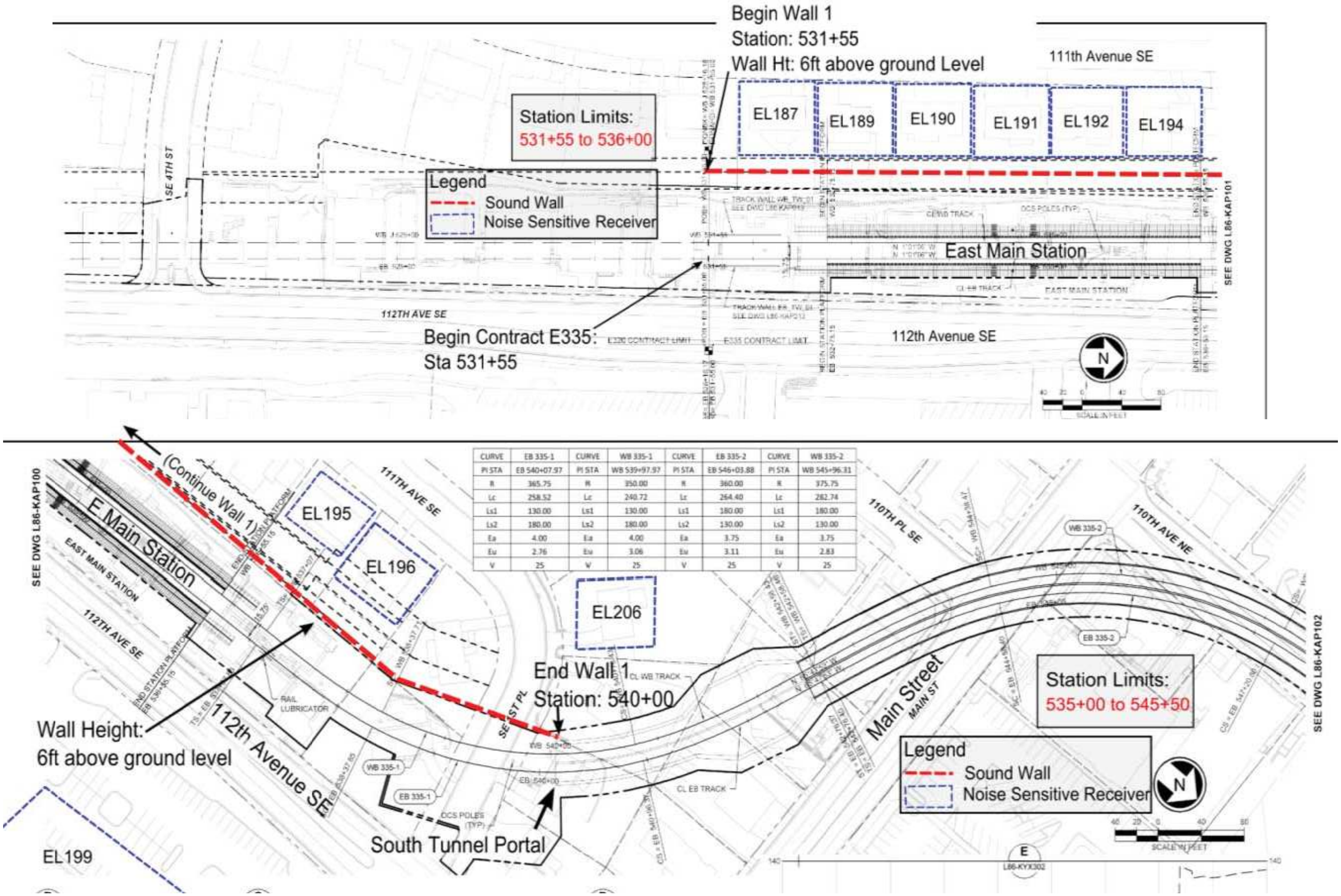


Table 7-7: Predicted Nighttime Noise Levels, with FTA Mitigation Included - 6am to 7am

Parcel	Distance[1] (ft)	Speed (mph)	Ambient Noise Level, Leq[2], dBA	Predicted Train Noise, Leq, dBA	Nighttime Impact Threshold, Leq(1-hr)[3], dBA	Amount Exceeds Threshold, dBA
EL187	106	35	59	43	55	-12
EL189	93	35	59	43	55	-12
EL190	96	25	59	41	55	-14
EL191	100	25	59	41	55	-14
EL192	97	25	59	41	55	-14
EL194	93	25	59	46	55	-9
EL195	100	25	59	45	55	-10
EL196	70	25	59	47	55	-8
EL206	115	25	***61***	44	55	-11

Notes:

[1]The distance is to the building facade, because the predicted noise level is higher at the building facade than at the property line due to the location of the sound wall

[2] Ambient noise level shown in bold italics is for the parcels where the noise level was measured. At all other parcels the ambient noise level was estimated based on the measurement and the relative distances to the roadway.

[3]Nighttime impact threshold is from the maximum permissible sound levels from the BCC applicable to train noise received in residential properties.

Table 7-8 lists the addresses of the parcels that are referenced in this report.

Table 7-8: List of Parcel Numbers and Corresponding Addresses

Parcel	Address
EL187	240 111TH AVE SE
EL189	236 111TH AVE SE
EL190	226 111TH AVE SE
EL191	220 111TH AVE SE
EL192	212 111TH AVE SE
EL194	204 111TH AVE SE
EL195	200 111TH AVE SE
EL196	112 111TH AVE SE
EL206	11102 SE 1TH PL

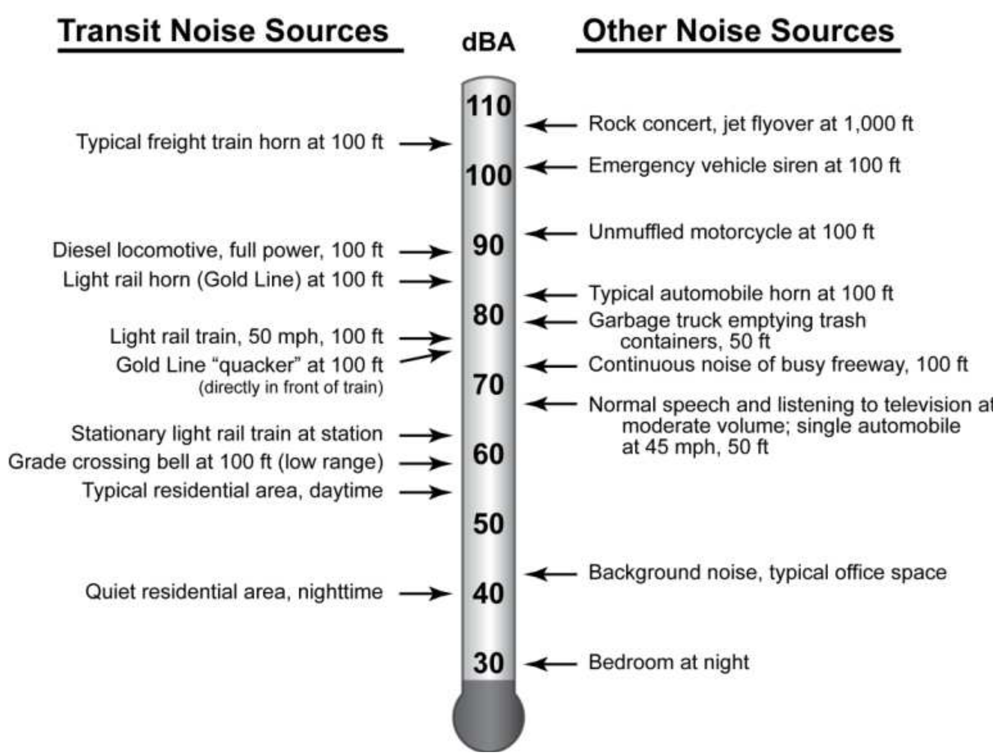
Appendix A: Background on Noise and Vibration

Noise Fundamentals

Sound is mechanical energy transmitted by pressure waves in a compressible medium such as air. Noise is generally defined as unwanted or excessive sound. Sound can vary in intensity by over one million times within the range of human hearing. Therefore, a logarithmic scale, known as the decibel scale (dB), is used to quantify sound intensity and compress the scale to a more convenient range.

Sound is characterized by both its amplitude and frequency (or pitch). The human ear does not hear all frequencies equally. In particular, the ear deemphasizes low and very high frequencies. To better approximate the sensitivity of human hearing, the A-weighted decibel scale has been developed. A-weighted decibels are abbreviated as “dBA.” On this scale, the human range of hearing extends from approximately 3 dBA to around 140 dBA. As a point of reference, Figure A-1includes examples of A-weighted sound levels from common indoor and outdoor sounds.

Figure A-1. Typical Indoor and Outdoor Noise Levels



Using the decibel scale, sound levels from two or more sources cannot be directly added together to determine the overall sound level. Rather, the combination of two sounds at the same level yields an increase of 3 dB. The smallest recognizable change in sound level is approximately 1 dB. A 3-dB increase in the A-Weighted sound level is generally considered perceptible, whereas a 5-dB increase is readily perceptible. A 10-dB increase is judged by most people as an approximate doubling of the perceived loudness.

The two primary factors that reduce levels of environmental sounds are increasing the distance between the sound source and the receiver and having intervening obstacles such as walls, buildings, or terrain features that block the direct path between the sound source and the receiver. Factors that act to make environmental sounds louder include moving the sound source closer to the receiver, sound enhancements caused by reflections, and focusing caused by various meteorological conditions.

Following are brief definitions of the measures of environmental noise used in this study:

- *Maximum Sound Level (L_{max}):* L_{max} is the maximum sound level that occurs during an event such as a train passing. For this analysis L_{max} is defined as the maximum sound level using the slow setting on a standard sound level meter.
- *Equivalent Sound Level (L_{eq}):* Environmental sound fluctuates constantly. The equivalent sound level (L_{eq}) is the most common means of characterizing community noise. L_{eq} represents a constant sound that, over a specified period of time, has the same sound energy as the time-varying sound. L_{eq} is used by the FTA to evaluate noise effects at institutional land uses, such as schools, churches, and libraries, from proposed transit projects.
- *Day-Night Sound Level (L_{dn}):* L_{dn} is basically a 24-hour L_{eq} with an adjustment to reflect the greater sensitivity of most people to nighttime noise. The adjustment is a 10 dB penalty for all sound that occurs between the hours of 10:00 p.m. to 7:00 a.m. The effect of the penalty is that, when calculating L_{dn}, any event that occurs during the nighttime is equivalent to ten occurrences of the same event during the daytime. L_{dn} is the most common measure of total community noise over a 24-hour period and is used by the FTA to evaluate residential noise effects from proposed transit projects.
- *L_{XX}:* This is the percent of time a sound level is exceeded during the measurement period. For example, the L_{99} is the sound level exceeded during 99 percent of the measurement period. For a 1-hour period, L_{99} is the sound level exceeded for all except 36 seconds of the hour. L_1 represents typical maximum sound levels, L_{33} is approximately equal to L_{eq} when free-flowing traffic is the dominant noise source, L_{50} is the median sound level, and L_{99} is close to the minimum sound level.
- *Sound Exposure Level (SEL):* SEL is a measure of the acoustic energy of an event such as a train passing. In essence, the acoustic energy of the event is compressed into a 1-second period. SEL increases as the sound level of the event increases and as the duration of the event increases. It is often used as an intermediate value in calculating overall metrics such as L_{eq} and L_{dn}.
- *Sound Transmission Class (STC):* STC ratings are used to compare the sound insulating effectiveness of different types of noise barriers, including windows, walls, etc. Although the amount of attenuation varies with frequency, the STC rating provides a rough estimate of the transmission loss from a particular window or wall.

Vibration Fundamentals

One potential community effect from the proposed project is vibration that is transmitted from the tracks through the ground to adjacent houses. This is referred to as *groundborne vibration*. When evaluating human response, groundborne vibration is usually expressed in terms of decibels using the root mean square (RMS) vibration velocity. RMS is defined as the average of the squared amplitude of the vibration signal. To avoid confusion with sound decibels, the abbreviation VdB is used for vibration decibels. All vibration decibels in this report use a decibel reference of 1 micro-inch/second (µin/sec.).[8] The potential adverse effects of rail transit groundborne vibration are as follows:

- **Perceptible Building Vibration:** This is when building occupants feel the vibration of the floor or other building surfaces. Experience has shown that the threshold of human perception is around 65 VdB and that vibration that exceeds 75 to 80 VdB may be intrusive and annoying to building occupants.
- **Rattle:** The building vibration can cause rattling of items on shelves and hanging on walls, and various different rattle and buzzing noises from windows and doors.
- **Reradiated Noise:** The vibration of room surfaces radiates sound waves that may be audible to humans. This is referred to as *groundborne noise*. When audible groundborne noise occurs, it sounds like a low-frequency rumble. When the LRT tracks are at-grade, the groundborne noise is usually masked by the normal airborne noise radiated from the transit vehicle and the rails.
- **Damage to Building Structures:** Although it is conceivable that vibration from a light-rail system could cause damage to fragile buildings, the vibration from light-rail transit systems is usually one to two orders of magnitude below the most restrictive thresholds for preventing building damage. Hence the vibration effect criteria focus on human annoyance, which occurs at much lower amplitudes than does building damage.

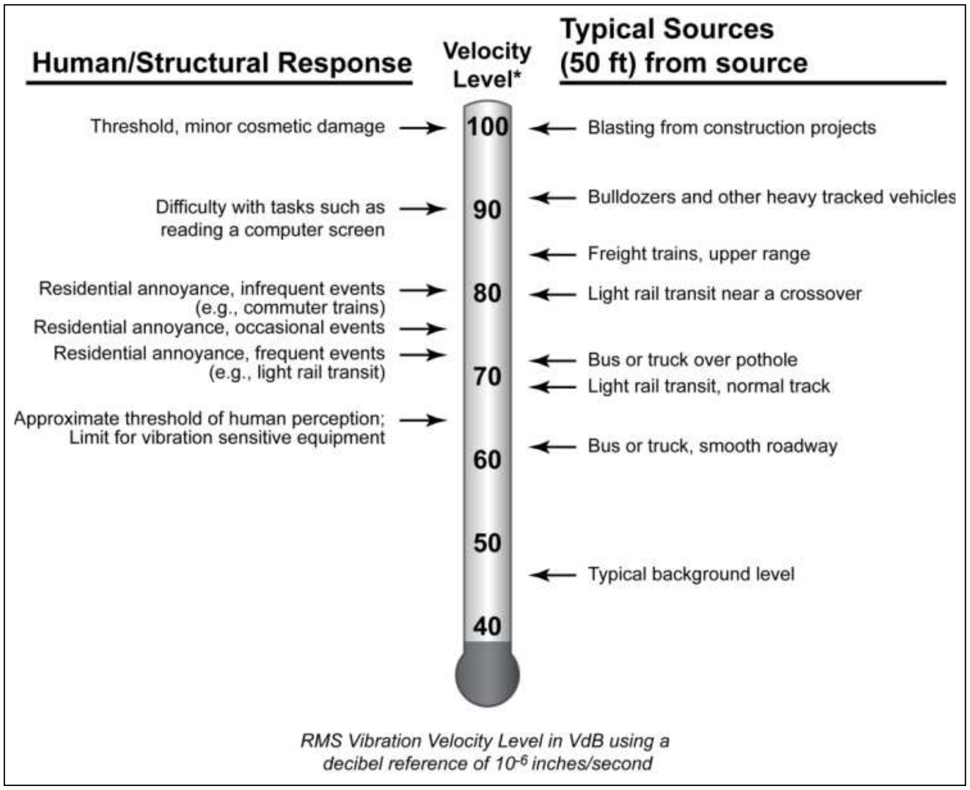
Vibration is an oscillatory motion that can be described in terms of the displacement, velocity, or acceleration of the motion. The response of humans to vibration is very complex. However, the general consensus is that for the vibration frequencies generated by passenger trains, human response is best approximated by the vibration velocity level. Therefore, vibration velocity has been used in this study to describe train-generated vibration levels.

When evaluating human response, groundborne vibration is usually expressed in terms of decibels using the root mean square (RMS) vibration velocity. RMS is defined as the average of the squared amplitude of the vibration signal. To avoid confusion with sound decibels, the abbreviation VdB is used for vibration decibels. All vibration decibels in this report use a decibel reference of 1 µin/sec.

Figure A-2 shows typical vibration levels from rail and non-rail sources as well as the human and structure response to such levels.

[8] One µin/sec= 10^{-6} in/sec.

Figure A-2: Typical Vibration Levels



Although there has been relatively little research into human and building response to groundborne vibration, there is substantial experience with vibration from rail systems. In general, the collective experience indicates that:

- It is rare that groundborne vibration from transit systems results in building damage, even minor cosmetic damage. The primary consideration therefore is whether vibration will be intrusive to building occupants or will interfere with interior activities or machinery.
- The threshold for human perception is approximately 65 VdB. Vibration levels in the range of 70 to 75 VdB are often noticeable but acceptable. Beyond 80 VdB, vibration levels are often considered unacceptable.
- For human annoyance, there is a relationship between the number of daily events and the degree of annoyance caused by groundborne vibration. The FTA Guidance Manual includes an 8 VdB higher impact threshold if there are fewer than 30 events per day and a 3 VdB higher threshold if there are fewer than 70 events per day.

Often it is necessary to determine the contribution at different frequencies when evaluating vibration or noise signals. The 1/3-octave band spectrum is the most common procedure used to evaluate frequency components of acoustic signals. The term “octave” has been borrowed from music where it refers to a span of eight notes. The ratio of the highest frequency to the lowest frequency in an octave is 2:1. For a 1/3-octave band spectrum, each octave is divided into three bands where the ratio of the lowest frequency to the highest frequency in each 1/3-octave band is $2^{1/3}$:1 (1.26:1). An octave consists of three 1/3 octaves.

The 1/3-octave band spectrum of a signal is obtained by passing the signal through a bank of filters. Each filter excludes all components except those that are between the upper and lower range of one 1/3-octave band. The FTA Guidance Manual is a good reference for additional information on transit noise and vibration and the technical terms used in this section.

Appendix B: List of Sensitive Receivers

Parcel Number	Address
EL187	240 111TH AVE SE
EL189	236 111TH AVE SE
EL190	226 111TH AVE SE
EL191	220 111TH AVE SE
EL192	212 111TH AVE SE
EL193	204 111TH AVE SE
EL194	200 111TH AVE SE
EL196	112 111TH AVE SE
EL199	11211 MAIN ST
EL206	11102 SE 1TH PL
EL208	112 110TH PL SE
EL210	11030 MAIN ST
EL216	110 Atrium
EL222	Future Marriott Hotel
EL223a	10822 NE 2nd St
EL227	300 110TH AVE NE
EL228	Skyline Tower
EL229	City Hall
EL240	11100 NE 6th ST
EL242	625 116TH AVE NE
EL261	4 LAKE BELLEVUE DR
EL263	1260 116TH AVE NE

Appendix C: Summary of Noise Measurements

Figure C-1: Noise Measurement Position at Parcel EL206 (11102 SE 1st Place)

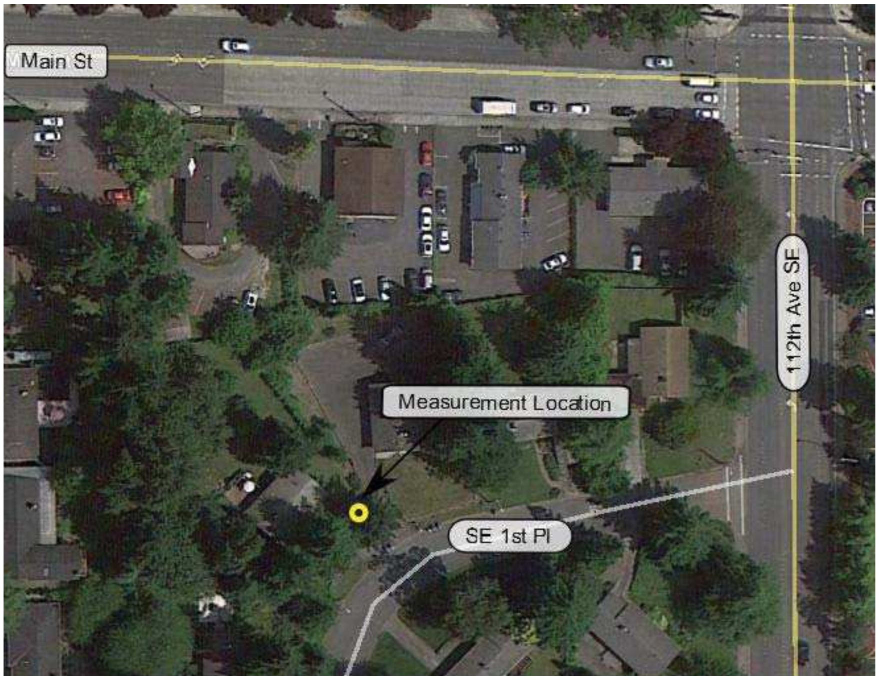


Figure C-2: Noise Measurement Position at Parcel EL236 (Bravern Condominiums, 688 110th Ave NE)

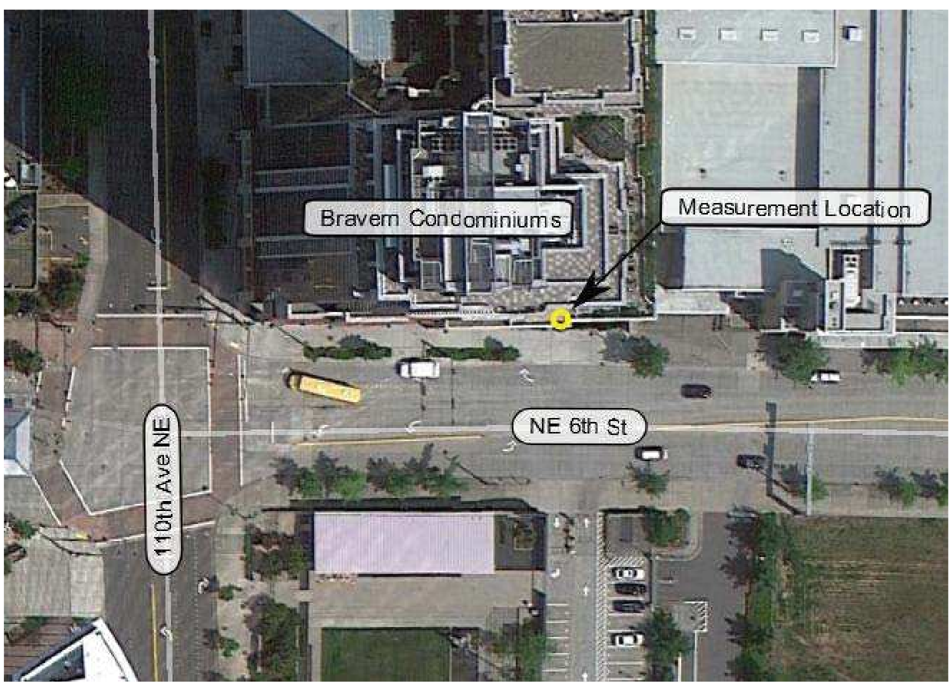
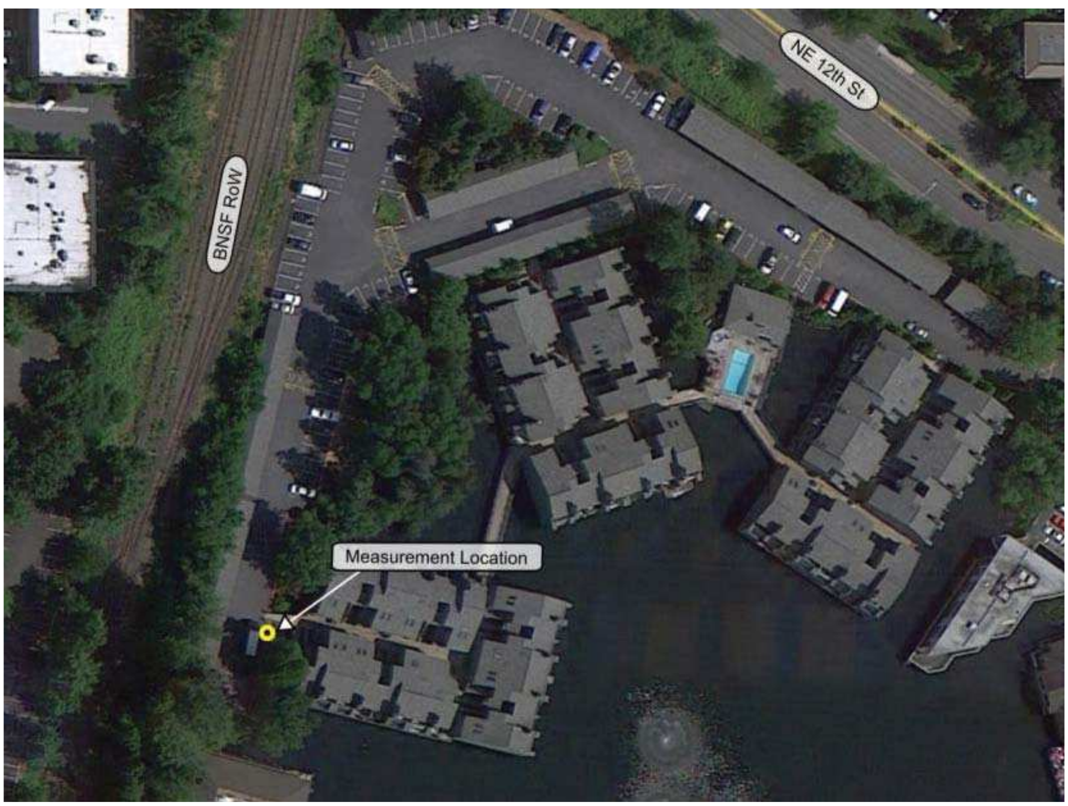


Figure C-3: Noise Measurement Position at Parcel EL242 (Coast Bellevue Hotel, 625 116th Ave NE)

Figure C-4: Noise Measurement Position at Parcel EL261 (4 Lake Bellevue Drive)



Appendix D: Vibration Propagation Measurement Results

Figure D-1: Measured PSTM and Coherence for Main Street Borehole, 20 ft Depth at Main Street Measurement Locations

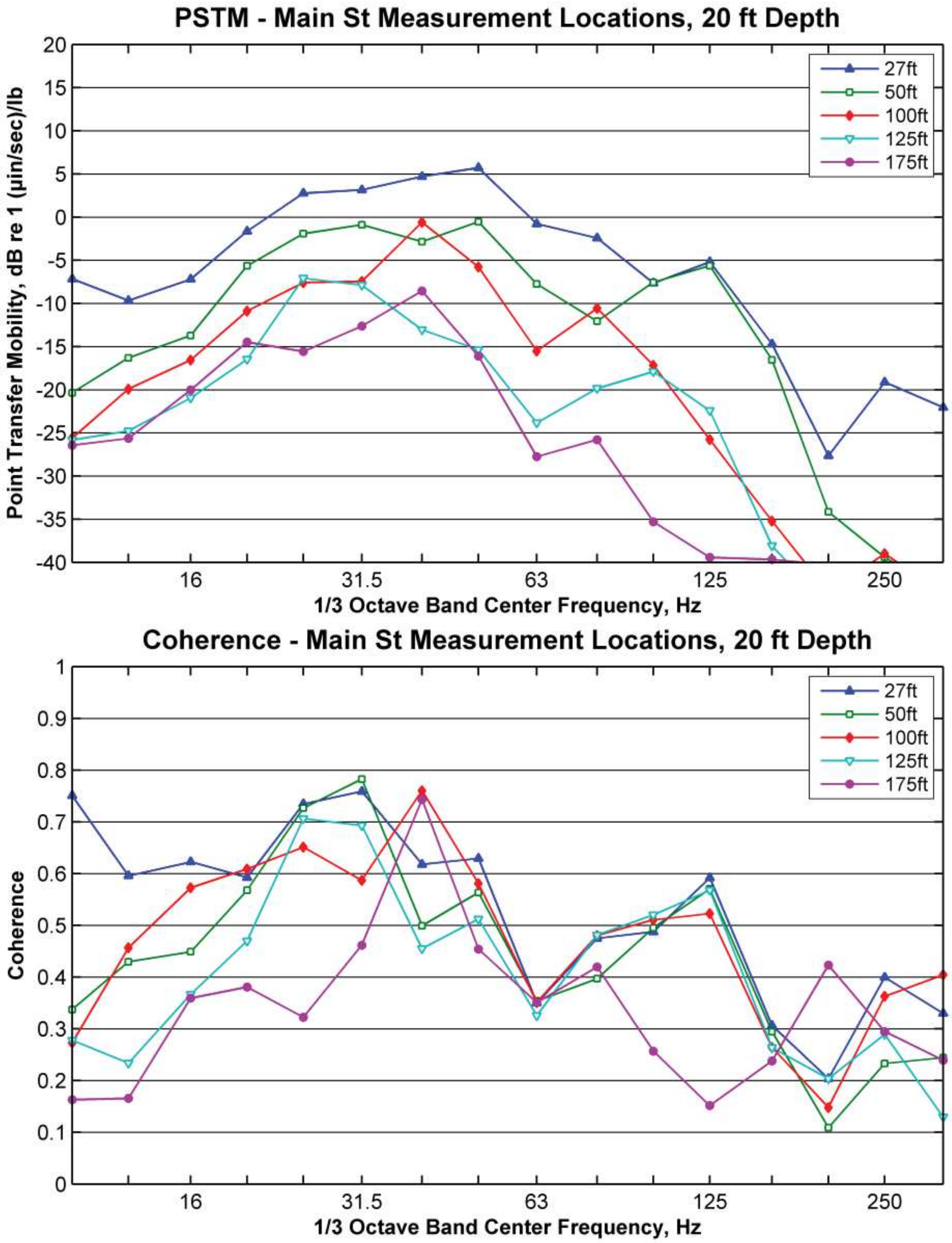
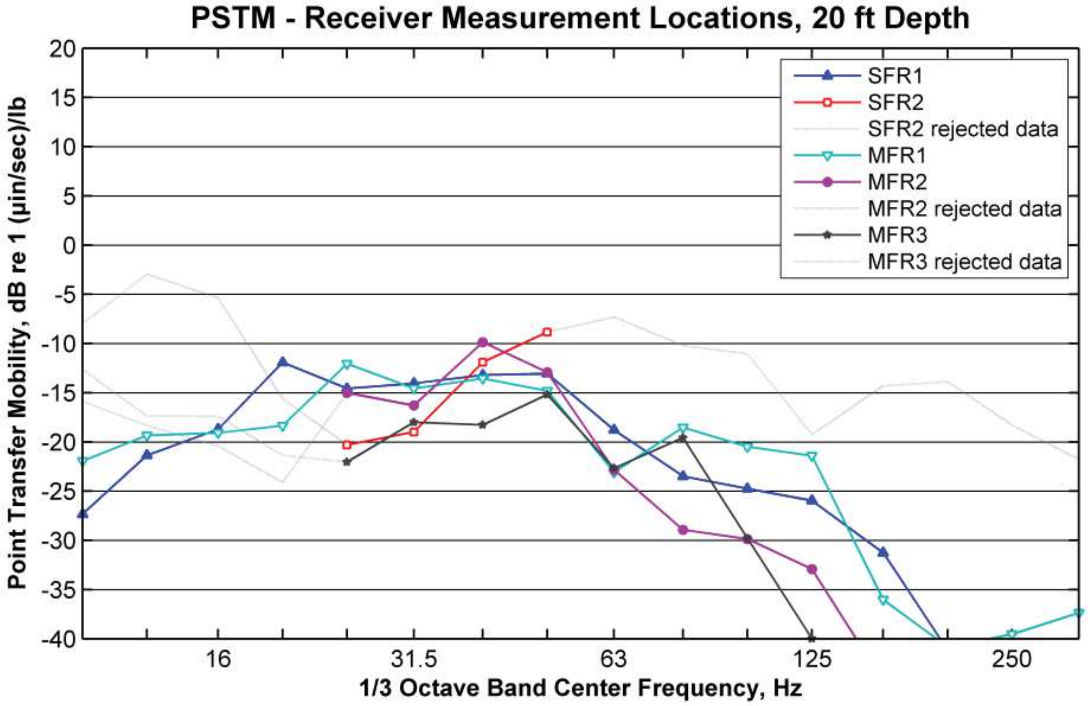


Figure D-2: Measured PSTM and Coherence at Main Street Borehole, 20 ft Depth, Indoor Measurement Locations



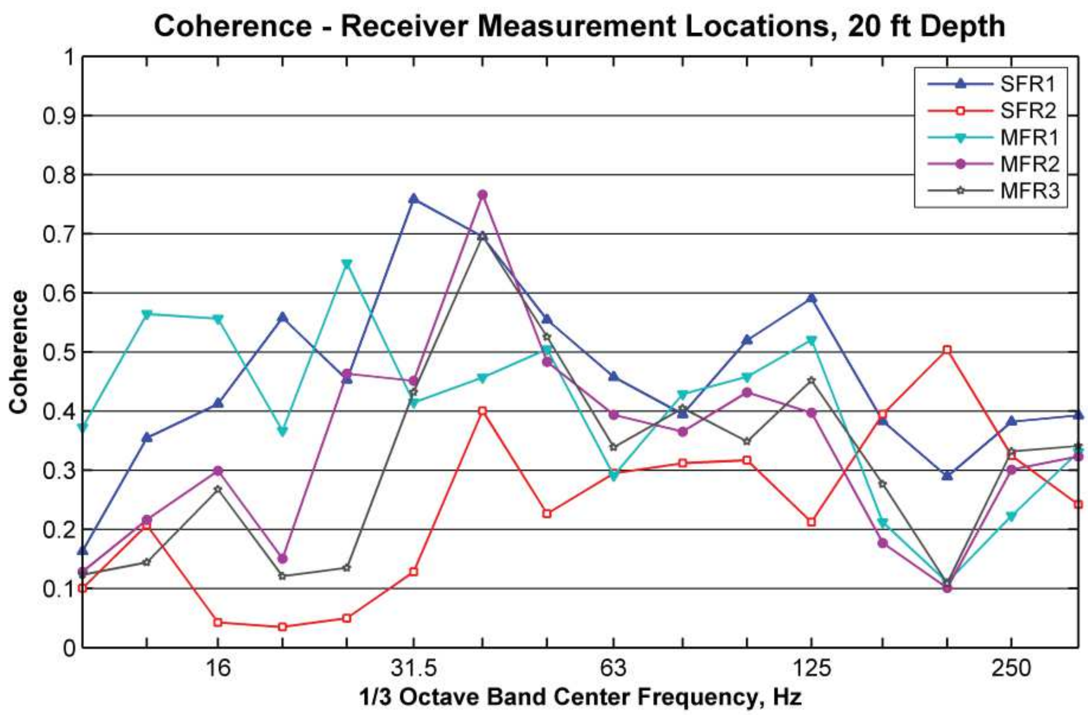


Figure D-3: PSTM and Coherence at Main Street Borehole, 30 ft Depth at Main Street Measurement Locations

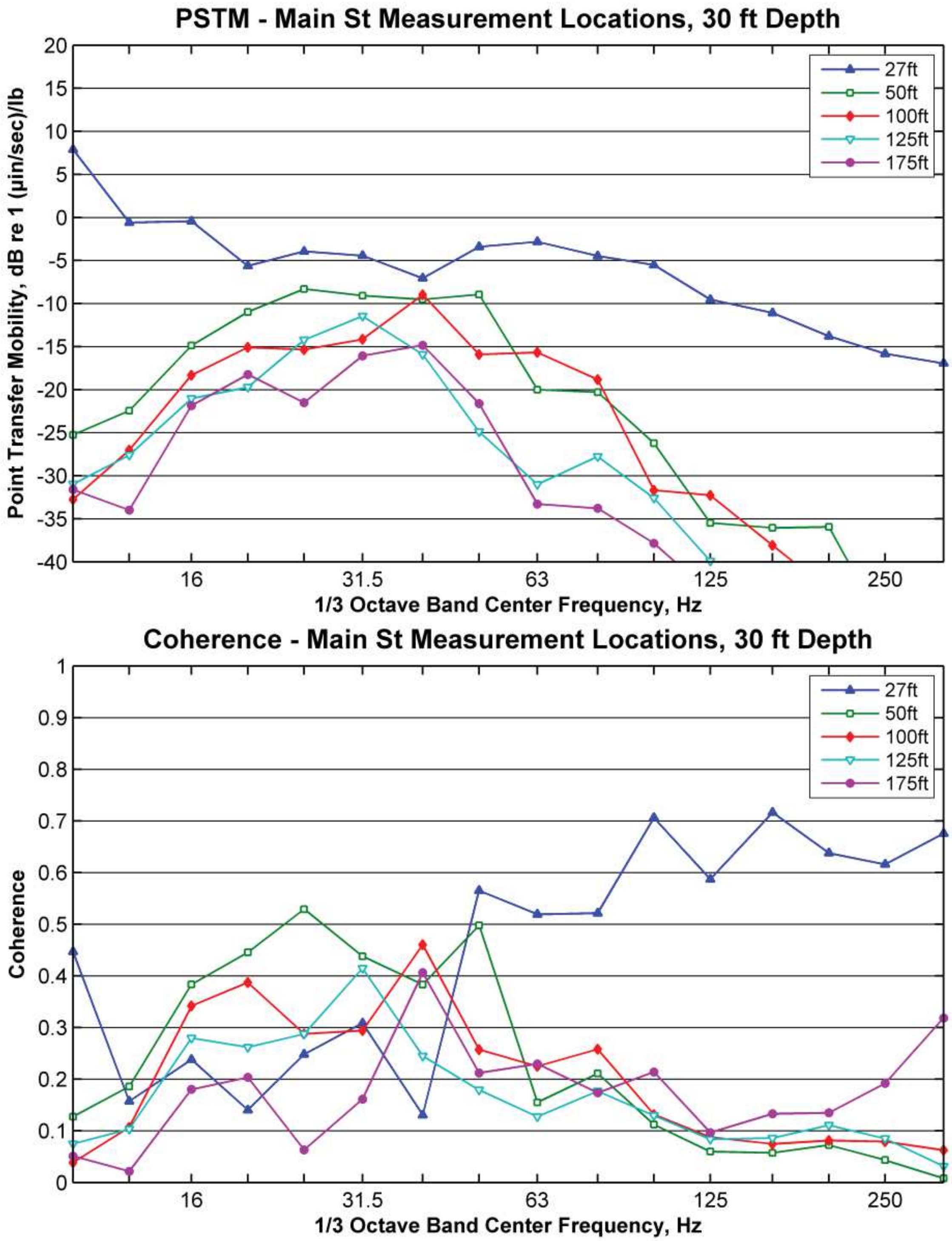


Figure D-4: PSTM and Coherence at Main Street Borehole, 30 ft Depth at Indoor Measurement Locations

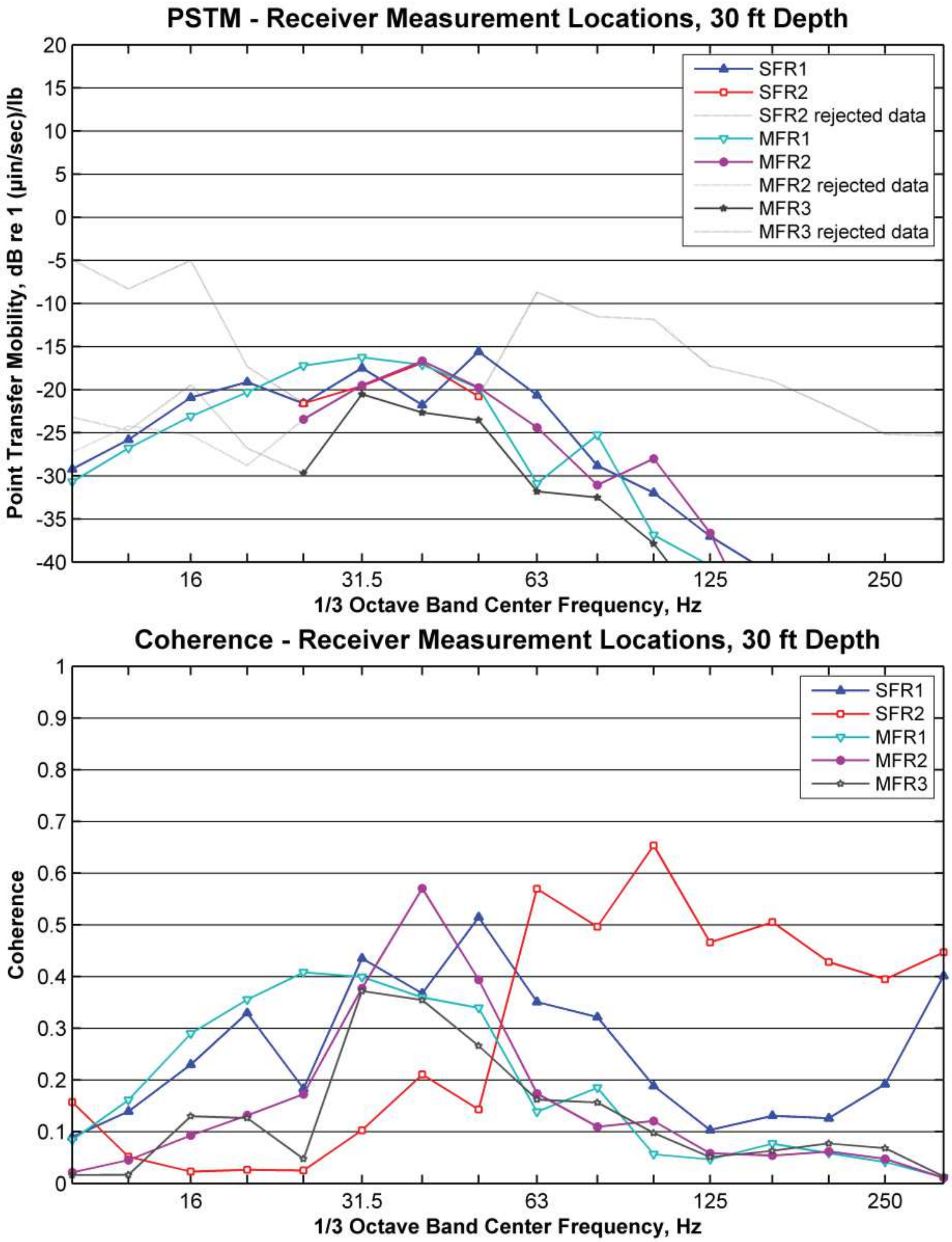
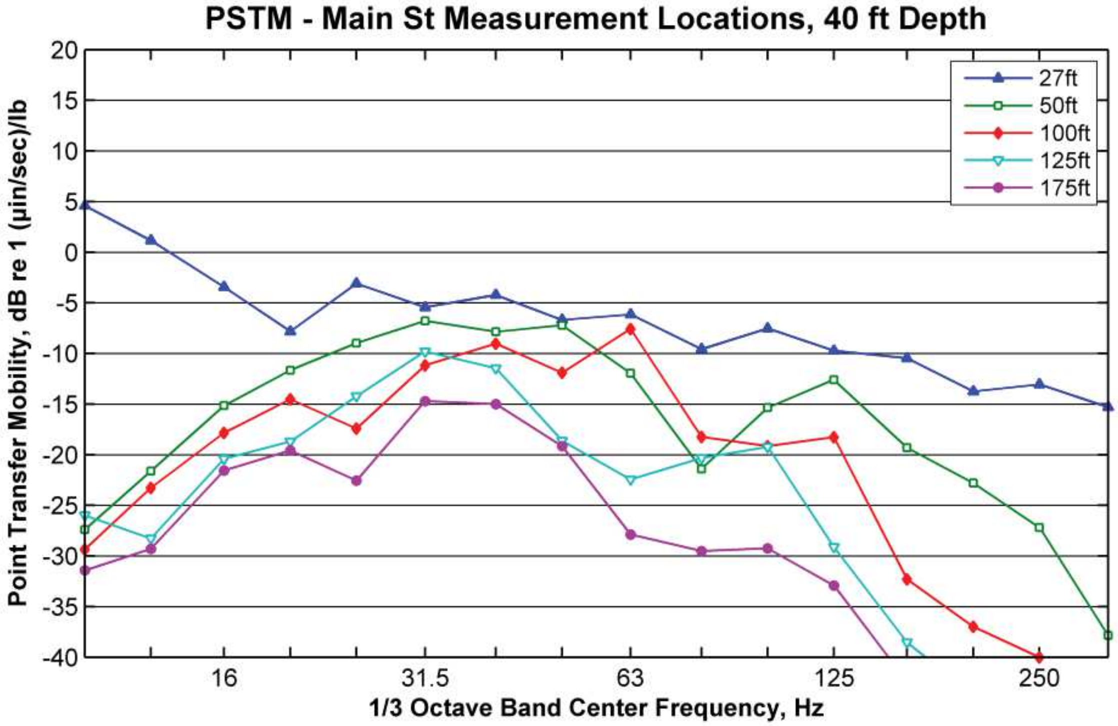


Figure D-5: Measured PSTM and Coherence for Main Street Borehole, 40 ft Depth at Main Street Measurement Locations



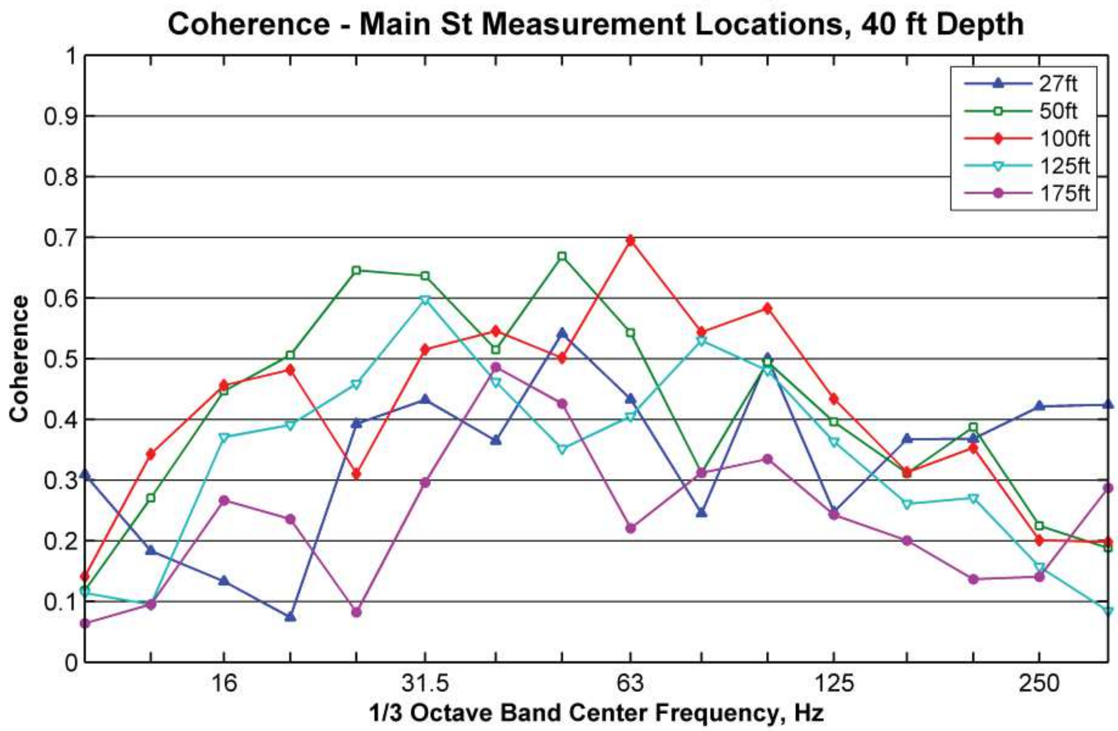


Figure D-6: PSTM and Coherence for Main Street Borehole, 40 ft Depth at Indoor Measurement Positions

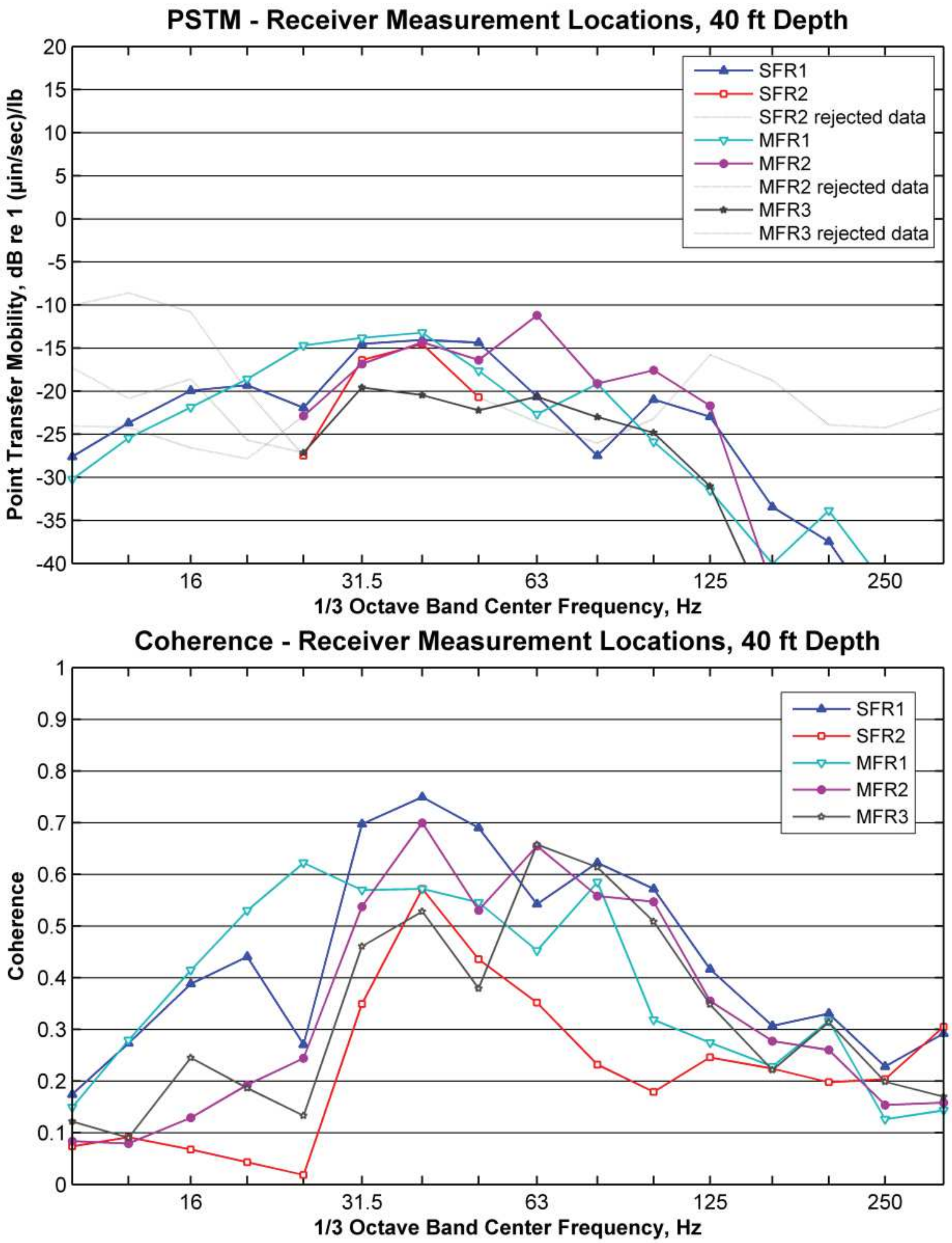


Figure D-7: Measured PSTM and Coherence at NE 4th Street Borehole, 30 ft Depth at NE 4th Street Measurement Locations

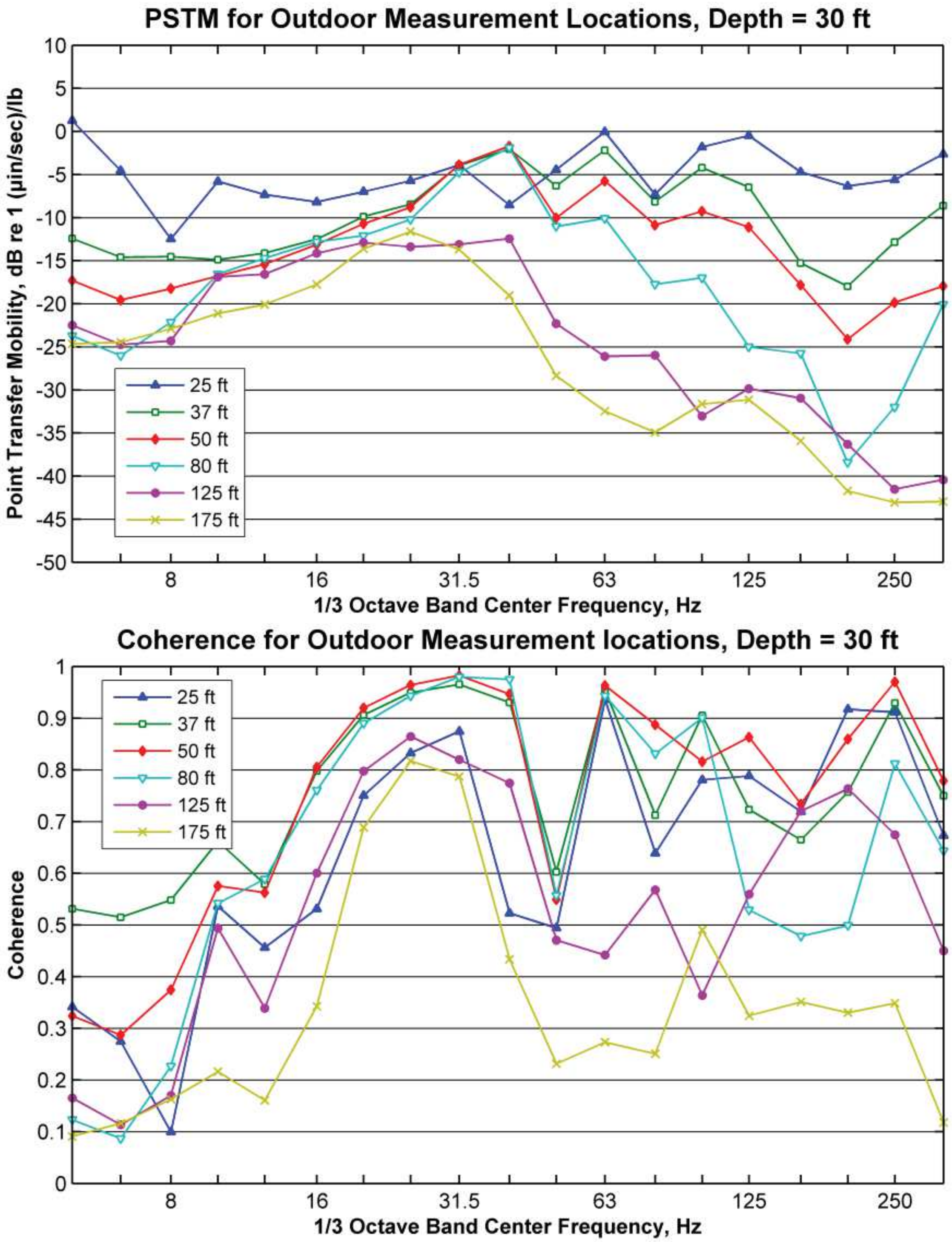


Figure D-8: Measured PSTM and Coherence for NE 4th Street Borehole, 30 ft Depth at Indoor Measurement Locations

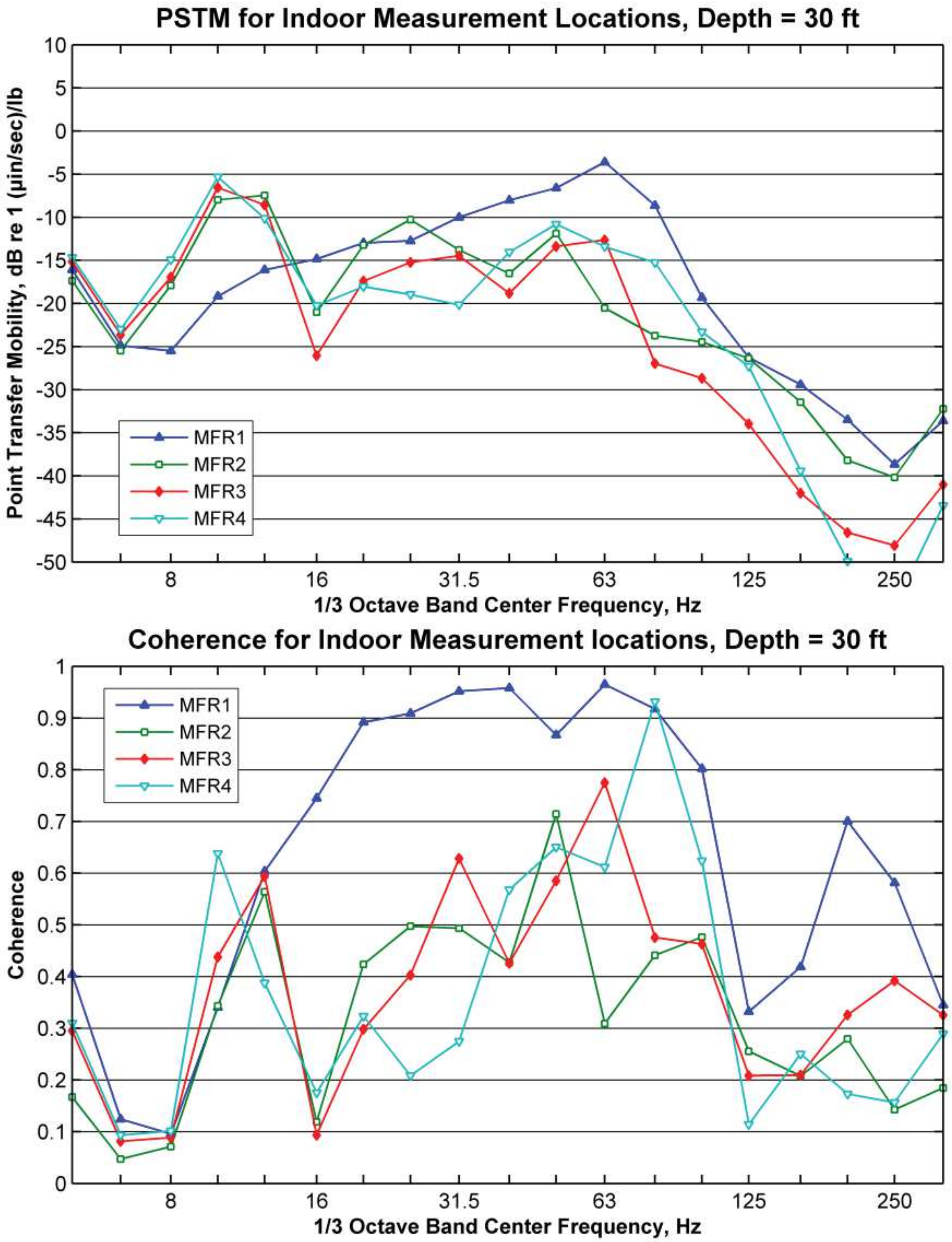
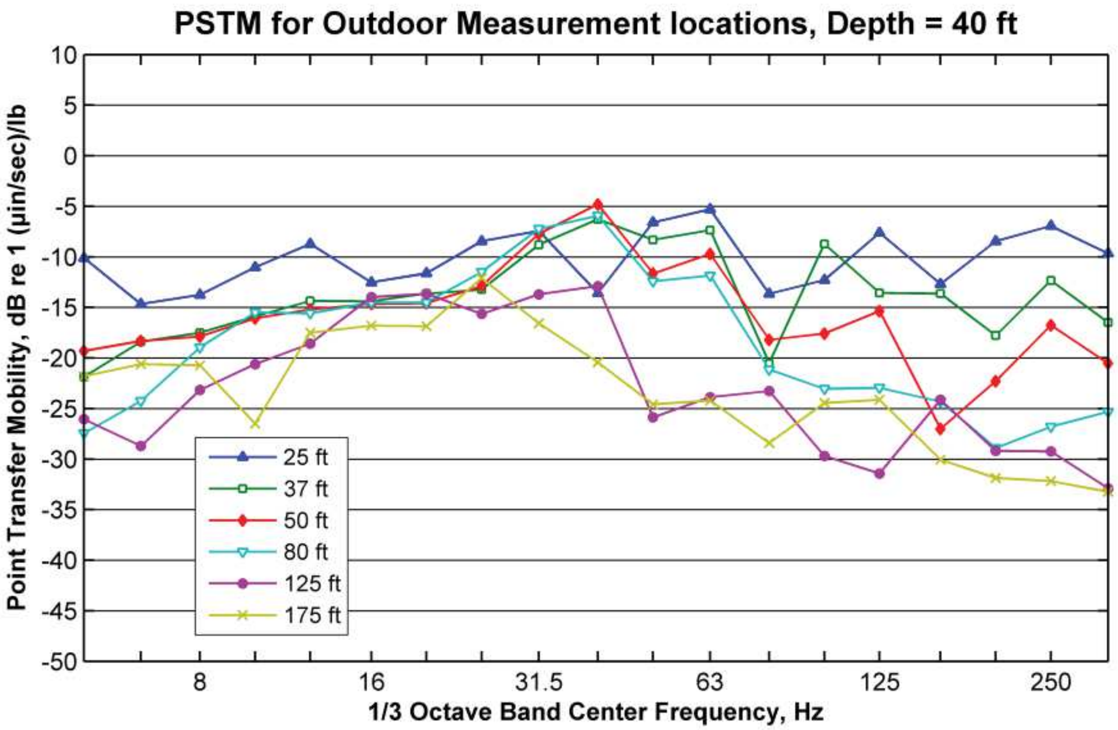


Figure D-9: Measured PSTM and Coherence for NE 4th Street Borehole, 40 ft Depth at NE 4th Street Measurement Locations



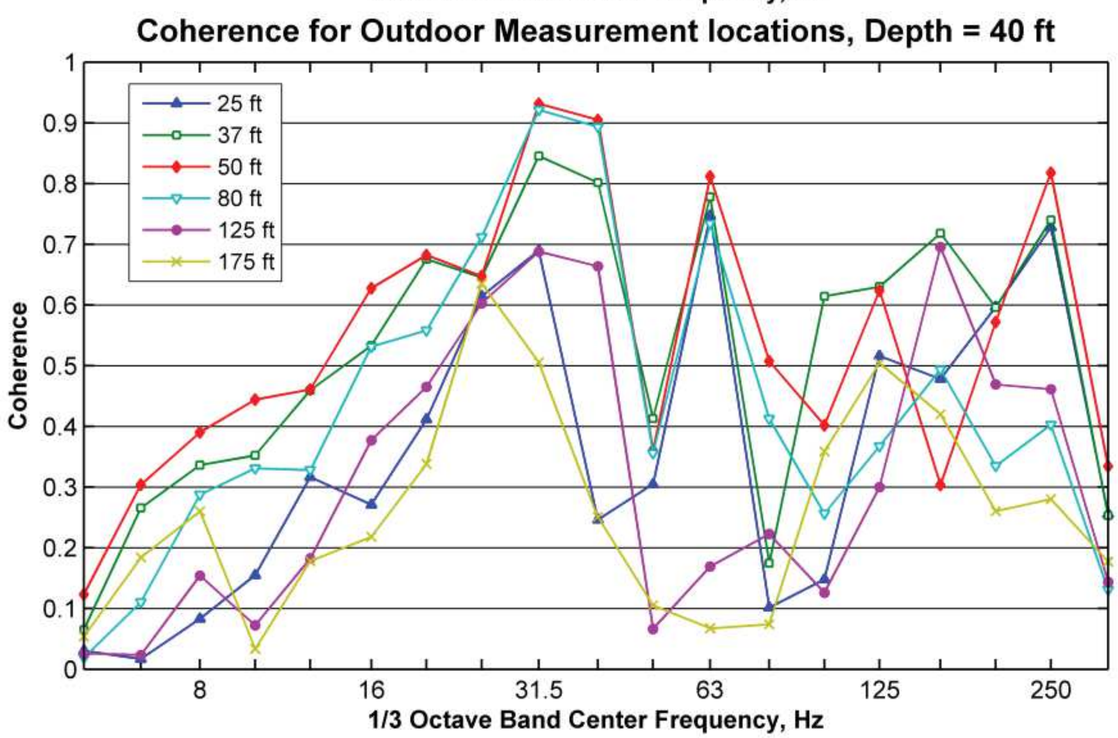
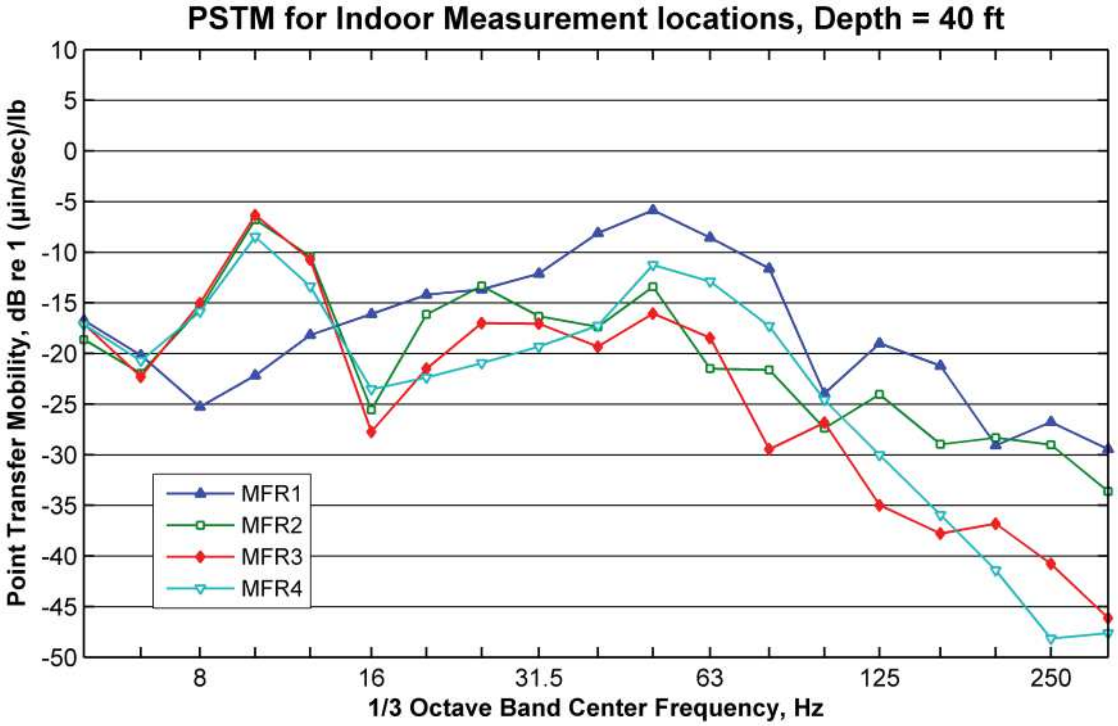


Figure D-10: Measured PSTM and Coherence for NE 4th Street Borehole, 40 ft Depth at Indoor Measurement Locations



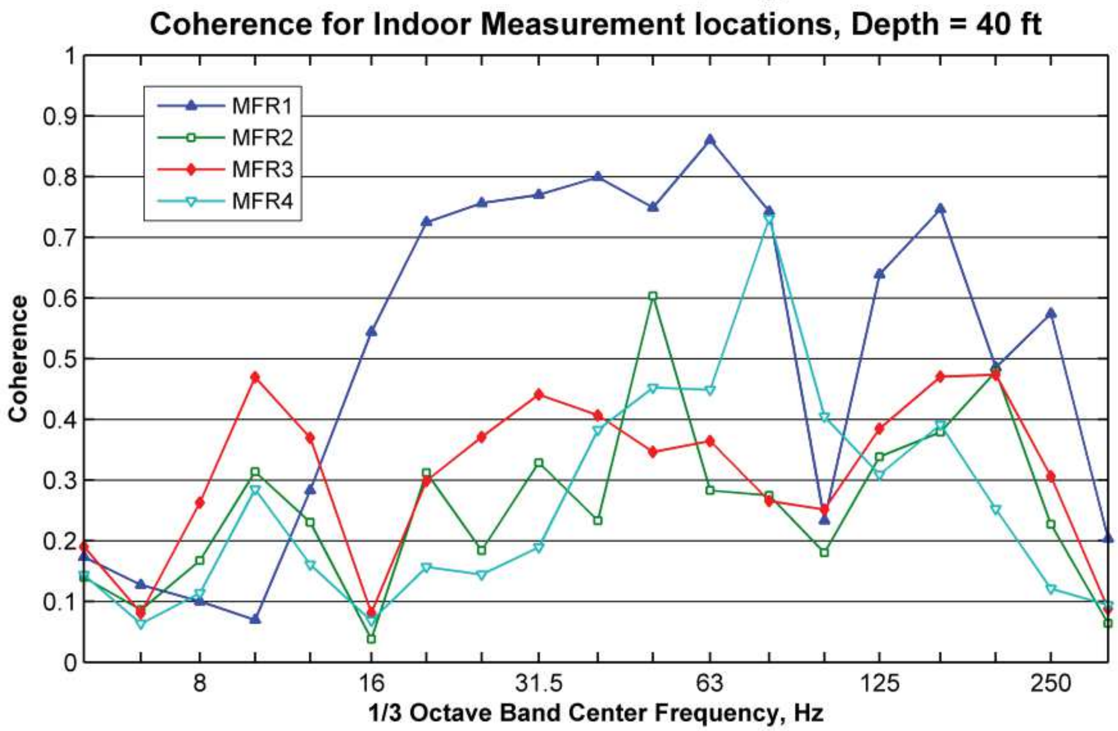
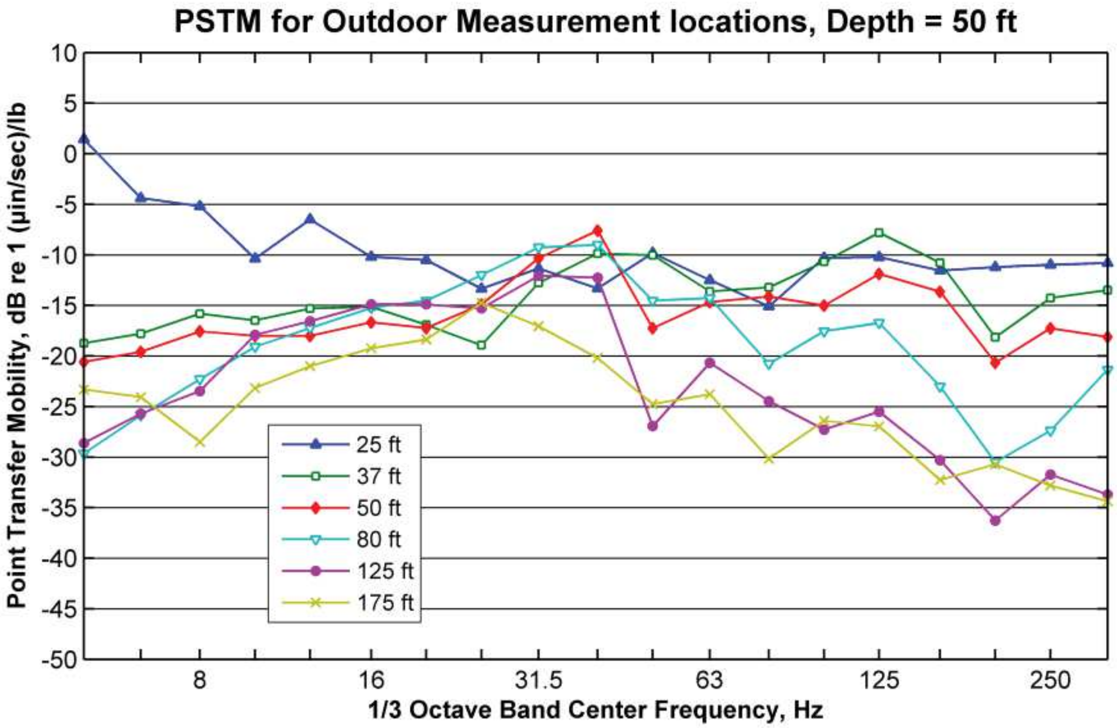


Figure D-11: Measured PSTM and Coherence at NE 4th Street Borehole, 50 ft Depth at NE 4th Street Measurement Locations



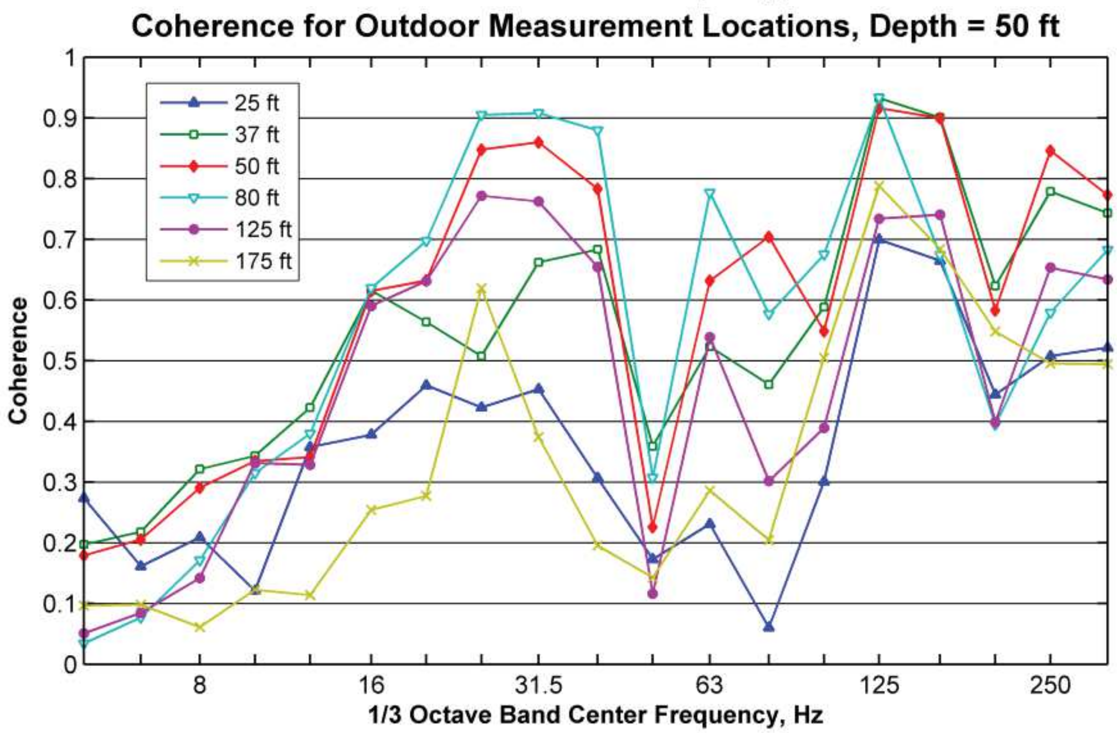
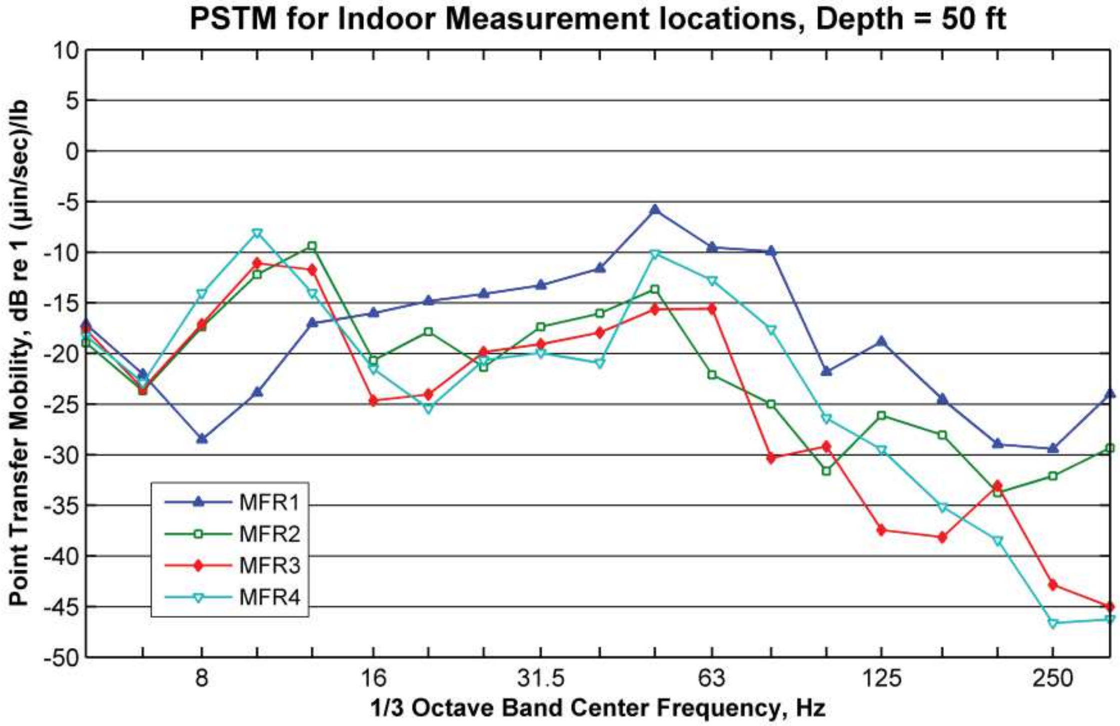


Figure D-12: Measured PSTM and Coherence at NE 4th Street Borehole, 50 ft Depth at Indoor Measurement Locations



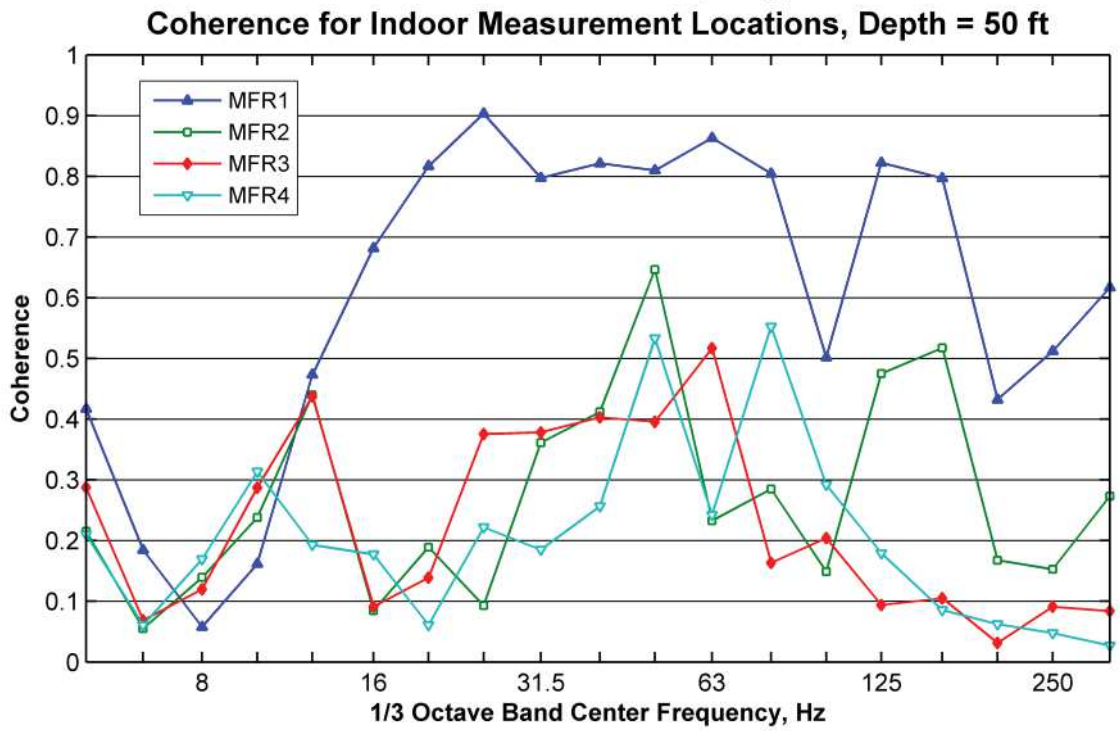
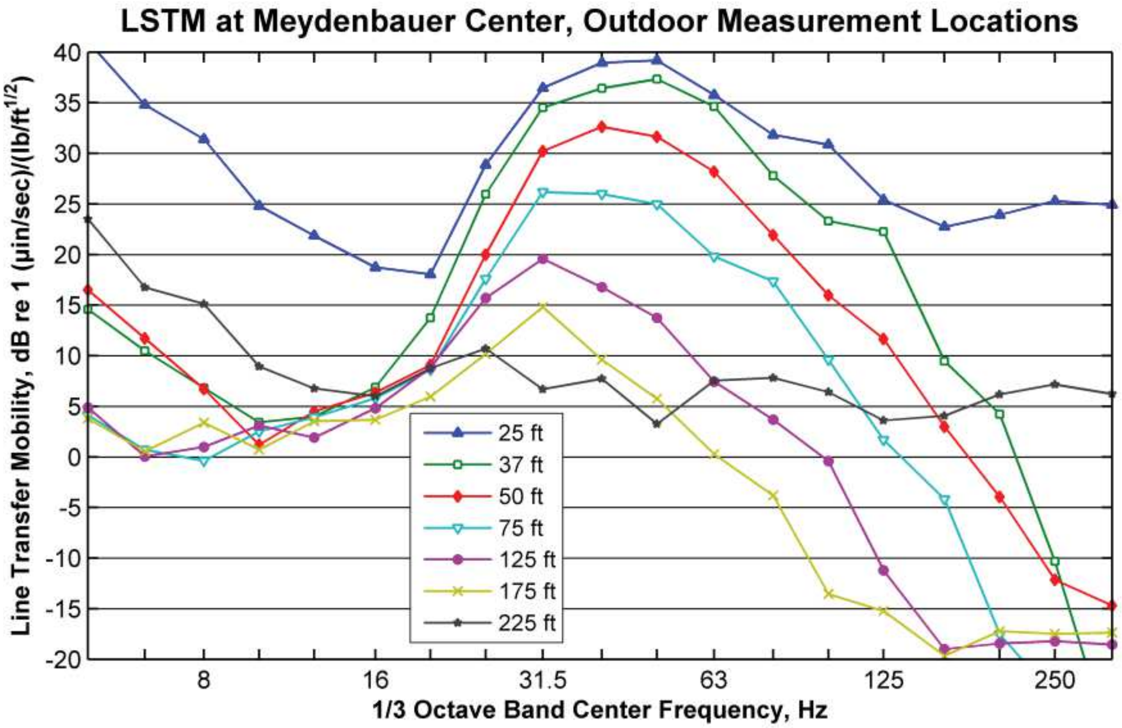


Figure D-13: LSTM and Coherence at Meydenbauer Center, Outdoor Measurement Locations



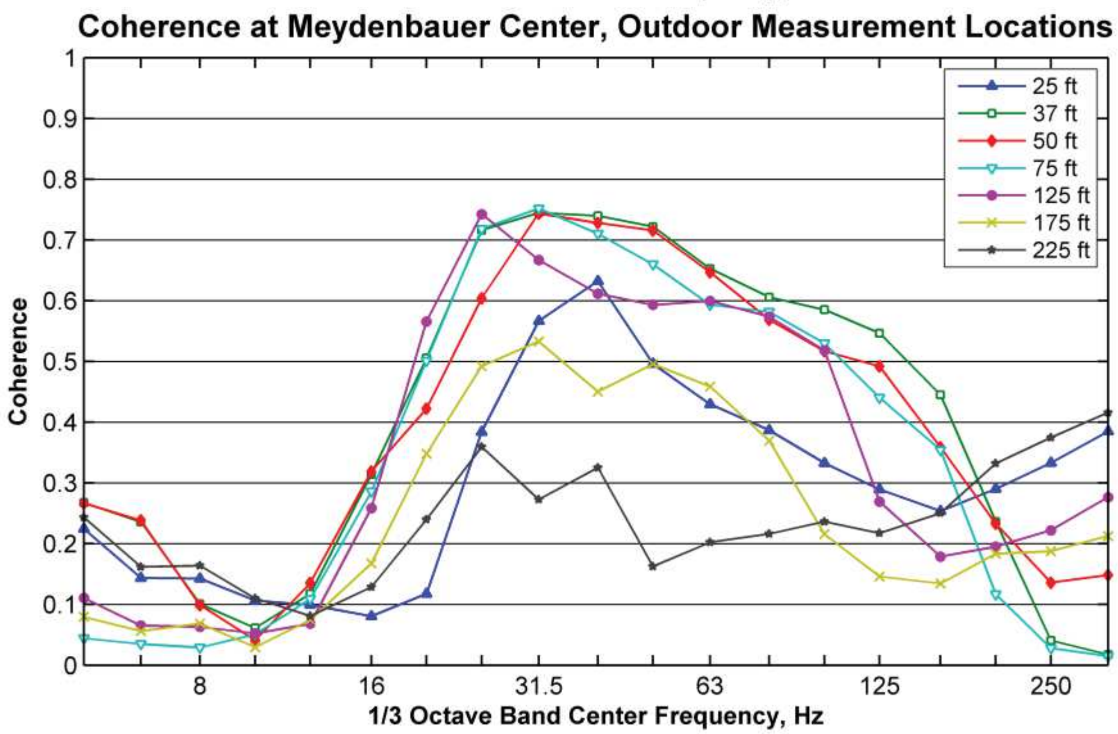
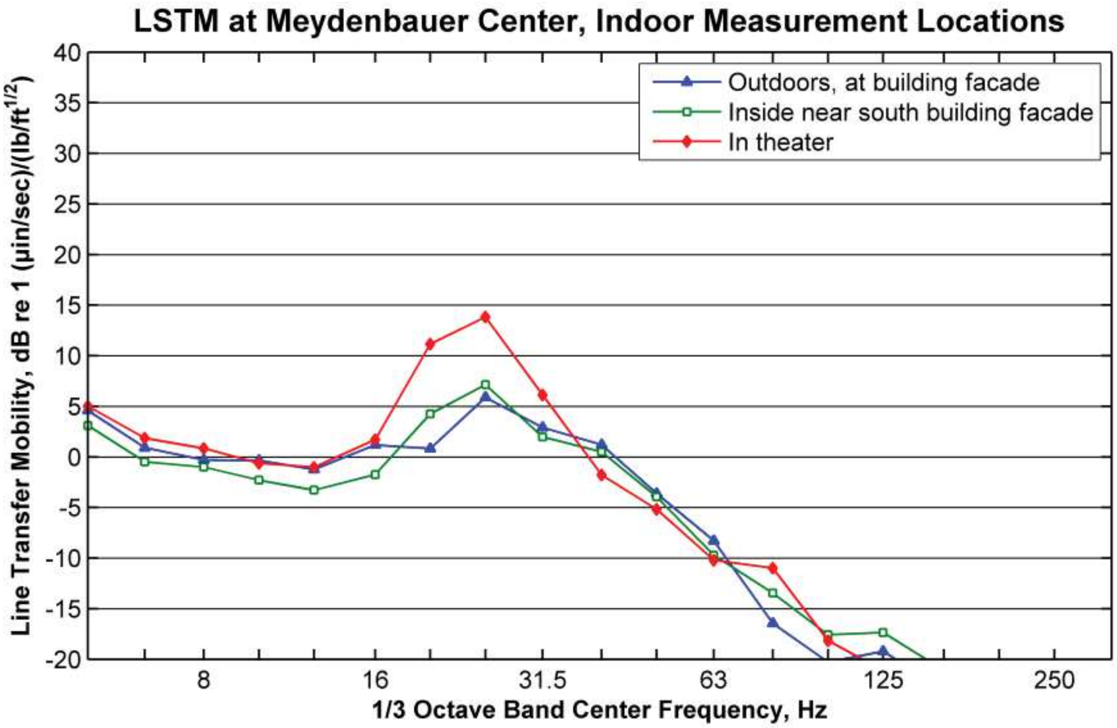


Figure D-14: LSTM and Coherence at Meydenbauer Center, Indoor Measurement Locations



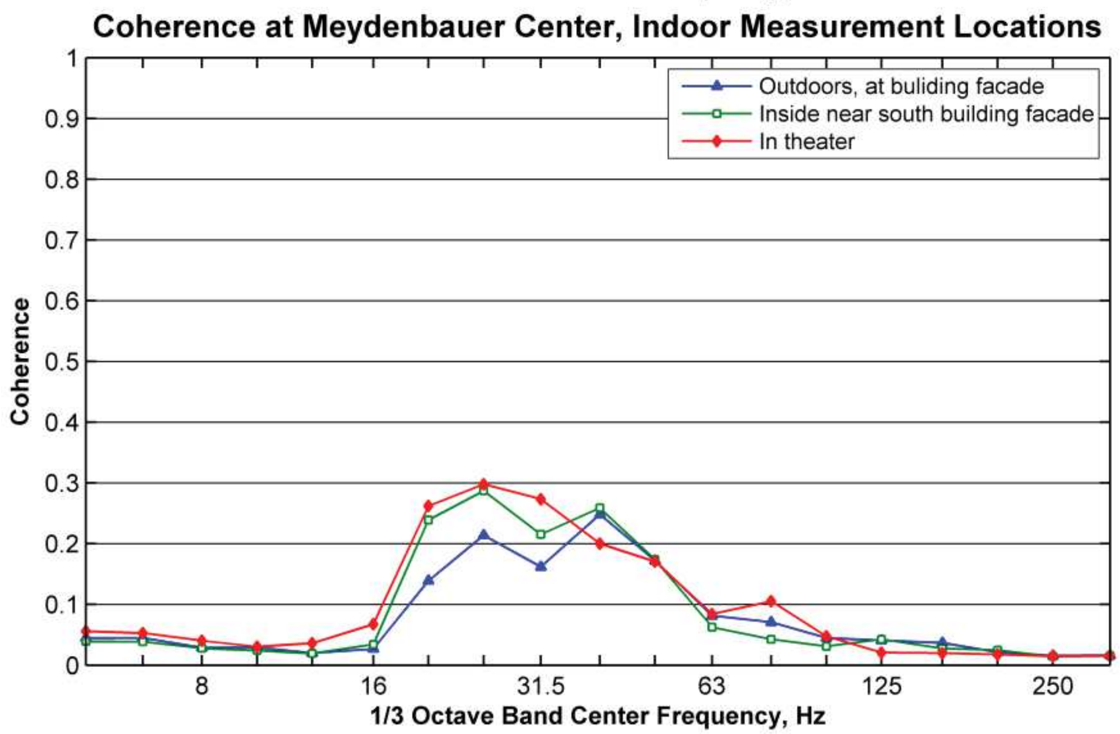


Figure D-15: Measured LSTM and Coherence at Coast Bellevue Hotel (Parcel EL242)