Appendix F
Supporting Technical Reports

F.8 Noise and Vibration Technical Report

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Noise and Vibration Technical Report

May 2016

Blue Line Extension Project Technical Report

METROPOLITAN COUNCIL

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Executive Summary

This Noise and Vibration Technical Report has been prepared as a supplement to the Final Environmental Impact Statement (EIS) document, to provide additional information on the noise and vibration impact assessment for the proposed METRO Blue Line Light Rail Transit (BLRT) Extension project. The technical report contains detailed information regarding the criteria, methodology, noise and vibration measurements, impact assessment results, and proposed mitigation measures. Additional information regarding the measurements and other technical data is found in the appendices to this report. Supplemental information regarding proposed BLRT Extension project specific information is also contained in the Draft EIS Noise and Vibration Technical Report, which is referenced where appropriate.

The results of the noise and vibration assessment for the proposed BLRT Extension project indicate that with the proposed mitigation measures, most residential noise impacts which meet the threshold for mitigation will be eliminated, and all vibration impacts will be eliminated from the proposed BLRT Extension project. The majority of the noise impacts from the proposed BLRT Extension project will be eliminated through the use of Quiet Zones or wayside devices. The vibration impacts from the proposed BLRT Extension project are localized to three areas and will be mitigated through conventional mitigation measures. **Section 1** of the report provides a summary of the impacts and mitigation measures for the proposed BLRT Extension project.

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Contents

Tables

Figures

Appendixes

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1 Introduction and Summary

Cross-Spectrum Acoustics, Inc. (CSA) conducted a noise and vibration impact assessment for the proposed METRO Blue Line Light Rail Transit (BLRT) Extension project. Noise and vibration have been assessed in accordance with guidelines specified in the Federal Transit Administration's (FTA) *Transit Noise and Vibration Impact Assessment* guidance manual (FTA, 2006). The assessment was carried out in support of the Final Environmental Impact Statement (Final EIS). The objective of the assessment was to document the noise and vibration impacts at sensitive locations and identify mitigation measures as a part of the proposed BLRT Extension project.

A summary of the assessment results are described below in **Section 1**. **Section 2** provides a discussion of the regulatory context, including noise and vibration basics and details regarding the noise and vibration criteria used to assess impact. **Section 3** describes the methodology used to assess noise and vibration impact. **Section 4** discusses the existing conditions, including a description of the noise and vibration sensitive land uses and the measurements conducted to determine the existing noise and vibration conditions. **Section 5** includes the results of the noise and vibration impact assessment. Mitigation measures are discussed in **Section 6**. A**ppendices A and B** contain detailed information on the supplemental noise measurements conducted for the Final EIS. **Appendices C and D** contain figures showing the location of noise and vibration impacts, respectively. Where appropriate, references are made to the *Bottineau Transitway Draft EIS Noise and Vibration Technical Report* (December 2012).

Based on the screening distances provided in Chapters 4 and 9 of the FTA guidance manual *Transit Noise and Vibration Impact Assessment* (May 2006), the noise and vibration study area for the proposed BLRT Extension project was typically within 300 feet of the proposed BLRT Extension project except for areas near shared Federal Railroad Administration (FRA) grade crossings, where land uses within 800 feet were identified. This extended distance takes into account the light rail transit (LRT) horn sounding required at these crossings.

1.1 Noise

Prior to mitigation, there would be 366 moderate and 618 severe noise impacts at residential and institutional locations along the proposed BLRT Extension project. The majority of the noise impacts are due to the sounding of LRT horns at at-grade crossings, primarily those shared with existing freight operations. The remaining noise impacts are due primarily to the proximity of sensitive receptors to the proposed alignment.

Mitigation measures, as detailed in **Section 6**, will eliminate most residential noise impacts with meet the threshold for mitigation, based on FTA criteria, at locations throughout the proposed BLRT Extension project corridor. The primary mitigation measure will be the implementation of Quiet Zones at the shared at-grade crossings. This will eliminate the LRT horn sounding and will have the added benefit of eliminating the freight horns as well. Other mitigation measures may include wayside horns, wayside noise barriers, and sound insulation improvements. Details regarding specific mitigation measures are contained in **Section 6**.

1.2 Vibration

Prior to mitigation, there would be 28 residential vibration impacts at various locations along the proposed BLRT Extension project. Mitigation measures, as detailed in **Section 6**, will eliminate all vibration impacts at locations throughout the proposed BLRT Extension project corridor. The primary mitigation measure will be the use of ballast mats or equivalent mitigation measures. Details regarding specific mitigation measures are contained in **Section 6**.

2 Regulatory Context

2.1 Noise

2.1.1 Noise Basics

Sound is defined as small changes in air pressure above and below the standard atmospheric pressure and noise is usually considered to be unwanted sounds. The three parameters that define noise include:

- **Level:** The level of sound is the magnitude of air pressure change above and below atmospheric pressure, and is expressed in decibels (dB). Typical sounds fall within a range between 0 dB (the lower limits of human hearing) and 120 dB (the highest sound levels experienced in the environment). A 3-dB change in sound level is perceived as a barely noticeable change outdoors and a 10-dB change in sound level is perceived as a doubling (or halving) of the sound level.
- **Frequency:** The frequency (pitch or tone) of sound is the rate of air pressure changes and is expressed in cycles per second, or Hertz (Hz). Human ears can detect a wide range of frequencies from around 20 Hz to 20,000 Hz; however, human hearing is not effective at high and low frequencies, and the A-weighting system (dBA) is used to correlate with human response to noise. The A-weighted sound level has been widely adopted by acousticians as the most appropriate descriptor for environmental noise.
- **Time Pattern:** Because environmental noise is constantly changing, it is common to condense all of this information into a single number, called the "equivalent" sound level (L_{eq}). The L_{eq} represents the changing sound level over a period of time, typically 1 hour or 24-hours in transit noise assessments. For LRT and freight rail projects, the Day-Night Sound Level (L_{dn}) is the common noise descriptor used, and has been adopted by most agencies as the best way to describe how people respond to noise in their environment. L_{dn} is a 24-hour cumulative A-weighted noise level that includes all noises that happen within a day, with a 10 dB penalty for nighttime noise (10 p.m. to 7 a.m.). This nighttime penalty means that any noise events at night are equivalent to ten similar events during the day. Typical L_{dn} values for various transit and freight operations are shown in **Figure 2-1**.

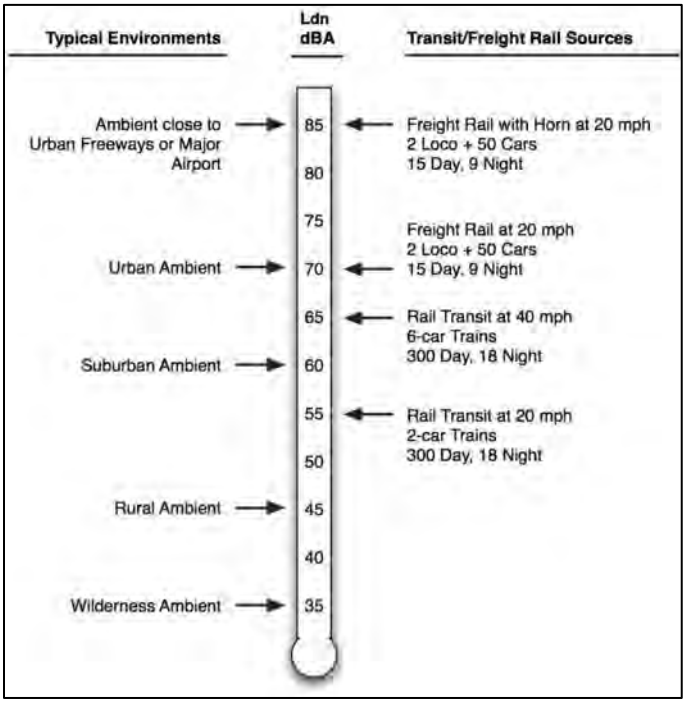
2.1.2 Noise Impact Criteria

2.1.2.1 FTA Transit Noise Criteria

The noise impact criteria used for the proposed BLRT Extension project are based on the information contained in Chapter 3 of the FTA noise and vibration guidance manual.[1] The FTA noise impact criteria are based on well-documented research on community response to noise and are based on both the existing level of noise and the change in noise exposure due to a project. The FTA noise criteria compare the proposed BLRT Extension project noise with the existing noise (not the No-Build noise).

The FTA noise criteria are based on the land use category of the sensitive receptor, and use L_{dn} for locations where people sleep (Category 2) and L_{eq} for locations with daytime and/or evening use (Category 1 or 3), as shown in **Table 2-1**.

Figure 2-1. Cumulative Noise Levels from LRT and Freight Rail



Source: CSA, 2015

[1] US Federal Transit Administration, "Transit Noise and Vibration Impact Assessment." Report FTA-VA-90-1003-06, May 2006.

The noise impact criteria are defined by the two curves shown in **Figure 2-2**, which allow increasing project noise as existing noise levels increase, up to a point at which impact is determined based on project noise alone. The FTA noise impact criteria include three levels of impact, as shown in **Figure 2-2**. The three levels of impact include:

- **No Impact:** In this range, the proposed BLRT Extension project is considered to have no impact since, on average the introduction of the proposed BLRT Extension project would result in an insignificant increase in the number of people highly annoyed by the proposed BLRT Extension project noise.
- **Moderate Impact:** At the moderate impact range, changes in the cumulative noise level are noticeable to most people, but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other proposed BLRT Extension project–specific factors must be considered to determine the magnitude of the impact and the need for mitigation, such as the existing noise level, predicted level of increase over existing noise levels and the types and numbers of noise-sensitive land uses affected.
- **Severe Impact:** At the severe impact range, a significant percentage of people would be highly annoyed by the proposed BLRT Extension project noise. Severe noise impacts are considered to be "significant" under the National Environmental Policy Act, and should be avoided if possible. Noise mitigation should be applied for severe impacts where feasible.

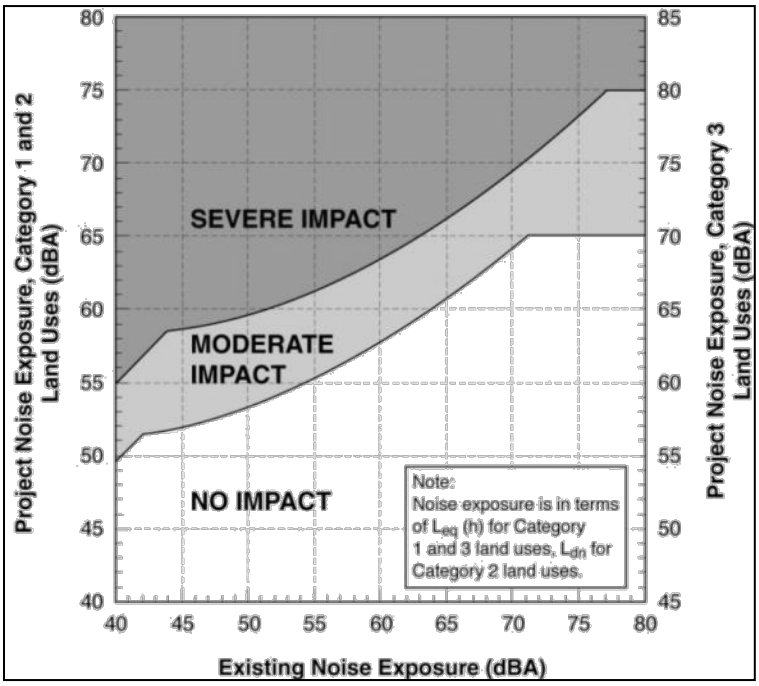
Table 2-1. Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor $L_{eq}(h)$ [1]	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor $L_{eq}(h)$ [1]	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. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

Source: FTA, 2006

[1] L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.

Figure 2-2. FTA Noise Impact Criteria



Source: FTA, 2006

2.1.2.2 Cultural Resources

Under FTA guidance, historic sites are designated as noise sensitive depending on the land use of the site, not their designation as historic. Sites of national significance with considerable outdoor use required for site interpretation would be in Category 1.[2] Historic sites that are currently used as residences would be in Category 2. Historic buildings with indoor use of an interpretive nature involving meditation and study would be in Category 3. These include museums, significant birthplaces and buildings in which significant historical events occurred.

Most downtown areas have buildings which are historically significant because they represent a particular architectural style or are prime examples of the work of a historically significant designer. If the buildings or structures are used for commercial or industrial purposes and are located in busy commercial areas, they are not considered noise sensitive and the impact criteria do not apply.

Similarly, historical transportation structures, such as terminals and railroad depots, are not considered noise sensitive land uses. These buildings or structures may however be afforded special protection under Section 4(f) of the Department of Transportation (DOT) Act and Section 106 of the National Historic Preservation Act.

In the Section 106 process protecting historic and cultural properties, noise may or may not be considered an "adverse effect" depending on the individual circumstances and whether or not the

[2] Transit Noise and Vibration Impact Assessment, Chapter 3 (FTA, 2006)

use is noise sensitive, because, as previously noted, historic and cultural properties are only noise sensitive based on how they are used. The regulatory processes stemming from these statutes require coordination and consultation with agencies and organizations having jurisdiction over these resources. Their views on the proposed BLRT Extension project's impact on protected resources are given careful consideration by FTA and the proposed BLRT Extension project sponsor, and their recommendations may influence the decision to adopt noise reduction measures.[3]

2.1.2.3 Minnesota Pollution Control Agency Noise Standards

The Minnesota Pollution Control Agency (MPCA) has an established set of Noise Standards (Minnesota Rules, Chapter 7030), which provide limits on environmental noise using the L_{10} and L_{50} descriptors, which represent the noise level exceeded 10 percent (6 minutes) and 50 percent (30 minutes) of the time during an hour, respectively. The standards include both daytime and nighttime limits for three different categories of land use or noise area classification, with residential lands included in noise area classification 1. Classifications 2 and 3 are generally for commercial and industrial land uses, respectively. The standards are shown in **Table 2-2**.

Table 2-2. MPCA Noise Standards

Noise Area Classification	Daytime		Nighttime	
	L_{10} (dBA)	L_{50} (dBA)	L_{10} (dBA)	L_{50} (dBA)
1	65	60	55	50
2	70	65	70	65
3	80	75	80	75

Source: Minnesota Rules, Chapter 7030, Noise Pollution

Because of the time limit component of the MPCA noise standards, the proposed BLRT Extension project would not exceed the standards under the proposed operating conditions. Light rail vehicles would pass by a location for approximately 10 seconds 12 times an hour (based on the operating assumptions of 10 minute headways in each direction) for a total of 120 seconds, or 2 minutes. Because the duration of exposure to LRT noise does not exceed the L_{10} (6 minutes) and L_{50} (30 minutes) time components, there is no potential for the proposed BLRT Extension project to exceed MPCA thresholds. Because the proposed BLRT Extension project would not exceed the MPCA thresholds, the FTA noise impact criteria described previously are more protective than the MPCA standards and have been used to assess and mitigate noise impacts identified within this Final EIS.

[3] For historic or cultural resources, the following two circumstances in assessing impacts and mitigation measures: (1) The noise sensitivity of the property. While Table 1 gives a comprehensive list of noise sensitive land uses, there can be differences in noise sensitivity depending on individual circumstances. For example, a historic park or recreational area could vary in its sensitivity to noise depending on the type of use of the park (active versus passive recreation) and the settings in which it is located. (2) Special protection provided by law. Section 106 of the National Historic Preservation Act and Section 4(f) of the DOT Act (which protects historic sites, as well as publicly owned parks, recreation areas, wildlife, and waterfowl refuges) come into play frequently during the environmental review of transit projects. See pages 3-12 and 3-13 of the FTA Transit Noise and Vibration Impact Assessment for additional information on considerations given to resources that have special protection provided by law.

Information regarding the existing noise levels, which are not included in the MPCA assessment, in the proposed BLRT Extension project corridor and any exceedances of the MPCA standards is described in **Section 4.1.2**.

2.1.2.4 FTA Construction Noise Criteria

FTA's construction noise criteria, summarized in **Table 2-3**, were used for the short-term noise impact analysis. The FTA construction noise criteria provide adequate protection for short-term noise impacts and allow for reasonable mitigation measures to be applied to the proposed BLRT Extension project. Additionally, MPCA noise criteria were evaluated for the proposed BLRT Extension project, and the Metropolitan Council (Council) will work with local jurisdictions to ensure that reasonable measures are taken to limit construction noise.

Table 2-3. FTA Construction Noise Criteria

	8-hour L_{eq}, dBA		Noise Exposure, dBA
Land Use	Day	Night	30-day Average
Residential	80	70	75
Commercial	85	85	80
Industrial	90	90	85

Source: FTA, 2006

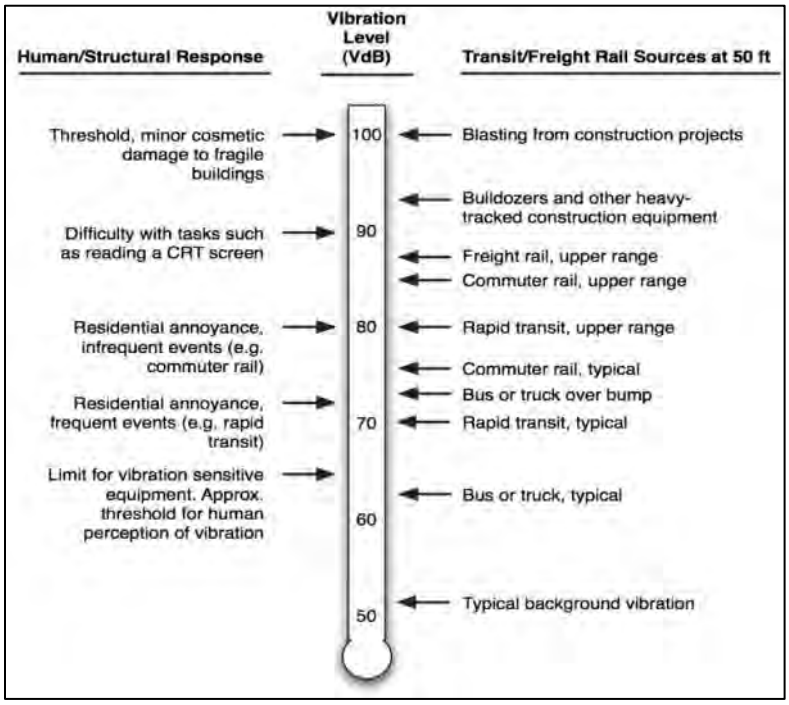
2.2 Vibration

Ground-borne vibration is the motion of the ground transmitted into a building that can be described in terms of displacement, velocity, or acceleration. Vibration velocity is used in transit and freight rail and is defined by the following:

- **Level:** Vibration is expressed in terms of vibration velocity level, using vibration decibels (VdB), with a reference of 1 micro-inch per second. The level of vibration represents how much the ground is moving. The threshold of human perception to transit and freight rail vibration is approximately 65 VdB and annoyance begins to occur for frequent events at vibration levels over 70 VdB.
- **Frequency:** Vibration frequency is expressed in Hertz (Hz). Human response to vibration is typically from about 6 Hz to 200 Hz.
- **Time Pattern:** Environmental vibration changes all the time and human response is roughly correlated to the number of vibration events during the day. The more events that occur, the more sensitive humans are to the vibration.

Figure 2-3 shows typical ground-borne vibration levels for transit and freight projects as well as the corresponding human and structural responses to vibration.

Figure 2-3. Vibration Levels from LRT and Freight Rail



Source: CSA, 2015

2.2.1 Vibration Impact Criteria

2.2.1.1 FTA Transit Vibration Criteria

The vibration impact criteria used for the proposed BLRT Extension project are based on the information contained in Chapter 8 of the FTA noise and vibration guidance manual. The criteria for a general vibration assessment are based on land use and train frequency, as shown in **Table 2-4**. Some buildings, such as concert halls, recording studios and theaters, can have a higher sensitivity to vibration (or ground-borne noise) but do not fit into the three categories listed in **Table 2-4**. Because of the sensitivity of these buildings, special attention is paid to these buildings during the environmental assessment of a project. **Table 2-5** shows the FTA criteria for acceptable levels of vibration for several types of special buildings.

Tables 2-4 and 2-5 include additional criteria for ground-borne noise, which is a low-frequency noise that is radiated from the motion of room surfaces, such as walls and ceilings in buildings due to ground-borne vibration. Ground-borne noise is defined in terms of dBA, which emphasizes middle and high frequencies, which are more audible to human ears. The criteria for ground-borne noise are much lower than for airborne noise to account for the low-frequency character of ground-borne noise; however, because airborne noise typically masks ground-borne noise for above

ground (at-grade or elevated) transit systems, ground-borne noise is only assessed for operations in tunnels, where airborne noise is not a factor, or at locations such as recording studios, which are well insulated from airborne noise.

Table 2-4. Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec)			Ground-Borne Noise Impact Levels (dBA re 20 micro-Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65[4]	65[4]	65[4]	N/A[5]	N/A[5]	N/A[5]
Category 2: Residences and buildings where people normally sleep.	72	75	80	35	38	43
Category 3: Institutional land uses with primarily daytime use.	75	78	83	40	43	48

Source: FTA, 2006

[1] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

[2] "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.

[3] "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

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

[5] Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

Table 2-5. Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec)		Ground-Borne Noise Impact Levels (dBA re 20 micro Pascals)	
	Frequent Events[1]	Occasional or Infrequent Events[2]	Frequent Events[1]	Occasional or Infrequent Events[2]
Concert halls	65	65	25	25
TV studios	65	65	25	25
Recording studios	65	65	25	25
Auditoriums	72	80	30	38
Theaters	72	80	35	43

Source: FTA, 2006

[1] "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.

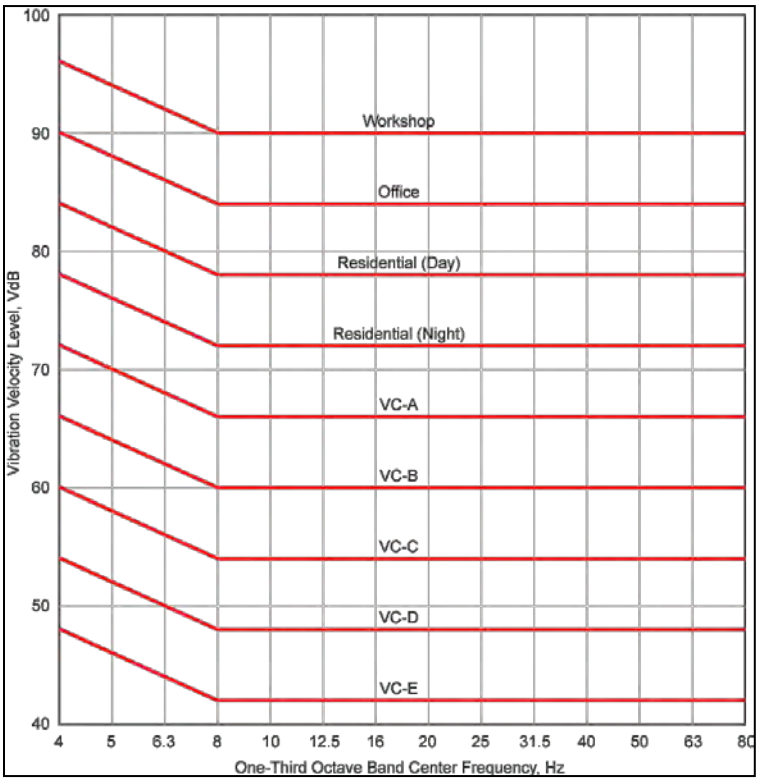
[2] "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

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

The criteria for a detailed vibration assessment are shown in **Figure 2-4** and descriptions of the curves are shown in **Table 2-6**. The curves in **Figure 2-4** are applied to the projected vibration spectrum for the proposed BLRT Extension project. If the vibration level at any one frequency exceeds the criteria, there would be impact. Conversely, if the entire proposed vibration spectrum of the proposed BLRT Extension project is below the curve, there would be no impact.

For the proposed BLRT Extension project, the general vibration assessment criteria will be used at special buildings. The detailed vibration assessment criteria will be used to assess LRT ground-borne vibration.

Figure 2-4. Detailed Vibration Criteria



Source: FTA, 2006

Table 2-6. Interpretation of Vibration Criteria for Detailed Analysis

Criterion Curve (see Figure 2-4)	Max Level (VdB)[1]	Description of Use
Workshop	90	Distinctly feelable vibration. Appropriate to workshops and non-sensitive areas.
Office	84	Feelable vibration. Appropriate to offices and non-sensitive areas.
Residential Day	78	Barely feelable vibration. Adequate for computer equipment and low-power optical microscopes (up to 20×).
Residential Night, Operating Rooms	72	Vibration not feelable, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100×) and other equipment of low sensitivity.
VC-A	66	Adequate for medium- to high-power optical microscopes (400×), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (1,000×), inspection and lithography equipment to 3 micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1 micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

Source: FTA, 2006

[1] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

2.2.1.2 Cultural Resources

Under FTA guidance, historic sites are designated as vibration sensitive depending on the land use of the site, not their designation as historic. Historical sites that are currently used as residences will be in Category 2. Historic buildings with indoor use of an interpretive nature involving meditation and study will be in Category 3. These include museums, significant birthplaces, and buildings in which significant historical events occurred. One difference between noise and vibration is that outdoor land uses are not considered vibration sensitive. Only indoor land uses are considered vibration sensitive.

Most downtown areas have buildings which are historically significant because they represent a particular architectural style or are prime examples of the work of a historically significant designer. If the buildings or structures are used for commercial or industrial purposes and are located in busy commercial areas, they are not considered vibration sensitive and the impact criteria do not apply.

Similarly, historical transportation structures, such as terminals and railroad depots, are not considered vibration-sensitive land uses. These buildings or structures may however be afforded special protection under Section 4(f) of the DOT Act and Section 106 of the National Historic Preservation Act.

In the Section 106 process protecting historic and cultural properties, vibration may or may not be considered an “adverse effect” depending on the individual circumstances and whether or not the

use is vibration sensitive, because, as previously noted, historic and cultural properties are only vibration sensitive based on how they are used. The regulatory processes stemming from these statutes require coordination and consultation with agencies and organizations having jurisdiction over these resources. Their views on the project's impact on protected resources are given careful consideration by FTA and the project sponsor, and their recommendations may influence the decision to adopt vibration reduction measures.

2.2.1.3 FTA Construction Vibration Criteria

In addition to the vibration criteria for human annoyance and interference with equipment and spaces described above, there are also vibration criteria for damage from construction activities. Typical transit operations do not have the potential for damage, so only certain construction activities are assessed for damage.

The thresholds for damage to structures are typically several orders of magnitude above the thresholds for human response to vibration. **Table 2-7** shows the FTA criteria for vibration damage to structures. This is based on the structure and construction type (and not a designation as historic). **Table 2-7** includes criteria in both VdB and peak particle velocity (PPV).

Table 2-7. FTA Vibration Damage Criteria from Construction

Building Category	PPV (in/sec)	Approximate Lv[1]
I. Reinforced-concrete, steel or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA, 2006

[1] RMS velocity in VdB re 1 micro-inch/second

3 Impact Assessment Methodology

3.1 Noise

This section describes the methodology for assessing the potential impact from the proposed BLRT Extension project.

Projected noise levels for the Final EIS Detailed Noise Analysis are based on noise measurements of the METRO Blue Line vehicles, which were conducted for the Central Corridor project, and the operating characteristics and current design of the proposed BLRT Extension project. Specific inputs used in the noise impact assessment include the following:

- Light rail train speeds would generally range from 20 miles per hour (mph) to 65 mph for revenue operations, except for entry and exit from station areas. Light rail train speeds are based on modeled speed profiles in both directions (i.e., inbound and outbound) that reflect train operating characteristics, track geometry, and station locations.
- Light rail trains would comprise three rail cars during hours of operation.
- The operating hours and headways[4] would be as follows:
  - Early morning hours (12:15 a.m. to 2:00 a.m.): 60-minute headways
  - Morning hours (4:00 a.m. to 5:30 a.m.): 30-minute headways
  - Early peak morning operating hours (5:30 a.m. to 6:30 a.m.) 15-minute headways
  - Peak operating hours (6:30 a.m. to 9:00 p.m.): 10-minute headways
  - Evening hours (9:00 p.m. to 10:15 p.m.): 20-minute headways
  - Late evening hours (10:15 p.m. to 12:15 a.m.): 30-minute headways
- The reference noise levels are shown in **Table 3-1**.

[4] Headways are the average time between transit vehicles operating in the same direction by a common point over a given period of time (e.g., four inbound light rail trains passing by a station within 1 hour will result in a 15-minute headway).

Table 3-1. Blue Line Reference Noise Levels

Noise Source	Sound Exposure Level,[1] 50 feet (dBA)
LRT on embedded track	84
LRT on ballast-and-tie track	81
Crossing bells	76[2]
LRT bells	86/87[3]
LRT horn	109/115[4]

Source: CSA, 2015

[1] The sound exposure level (SEL) is the cumulative noise from a single event, taking into account both the level and duration of the sound.

[2] The maximum noise level from crossing bells is 77 dBA at 10 feet. Crossing bells will be sounded for 20 seconds for each light rail vehicle at an at-grade crossing.

[3] The maximum noise level from LRT bells is 80 dBA at 50 feet. LRT bells will be sounded 3 times when entering and exiting stations (86 dBA SEL) and will be sounded for 5 seconds at each non-FRA at-grade crossing (8 dBA SEL).

[4] The maximum noise level from LRT horns is 96 dBA at 100 feet. LRT horns will be sounded for 5 seconds at certain higher speed at-grade crossings (109 dBA SEL) and for 15 seconds at all FRA at-grade crossings (115 dBA SEL).

- Locations of elevated structures, crossovers and embedded track were identified based on plan and profile maps provided by the engineering team.
- Crossovers increase the noise levels by up to 6 dB for nearby sensitive receptors due to the gap in the track.
- Elevated structures increase the noise levels by 4 dB for nearby sensitive receptors due to structure-borne noise.
- Anticipated use of bells and horns at each at-grade crossing and station was determined by Metro Transit Operations and proposed BLRT Extension project staff based on the following considerations:
  - Light rail vehicle bells will be sounded three times when entering and exiting station platforms
  - Light rail vehicle horns or bells will be sounded at at-grade crossings – horn or bell usage will be determined by Metro Transit Operations and will be based on a variety of factors, including train speeds at the crossing, type of crossing warning devices, at-grade crossing and adjacent roadway geometry, proximity to a freight rail crossing under the jurisdiction of FRA (the light rail vehicle horn or bell will be sounded for 5 seconds at non-FRA crossings; the light rail vehicle horn or bell will be sounded long, long, short, long for 15 seconds at FRA crossings) and other relevant factors
  - Grade crossing bells will be used at at-grade crossings for 20 seconds for each light rail train where there will be flashing lights and gates at the crossing.

- Light rail bells or horns will be sounded in the following manner for locations with stations directly adjacent to at-grade crossings:
  - For the side opposite the station, vehicles will sound their horns or bells in accordance with the procedures above for a grade crossing. No additional sounding will occur upon entering the station.
  - For the side with the station, vehicles will sound their bells in accordance with the procedure above upon entering the station. The vehicle will then sound either the horn or bell upon exiting the station until the front of the vehicle passes through the far side of the crossing.

3.2 Vibration

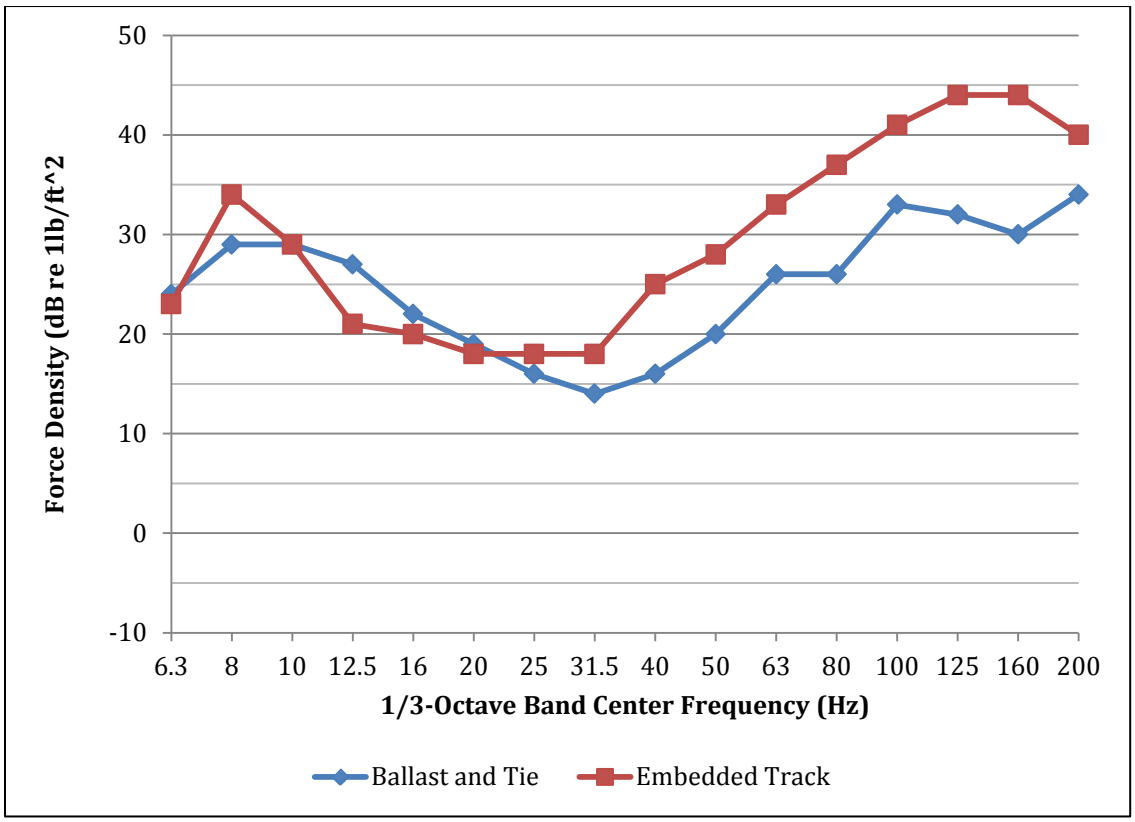
This section describes the methodology for assessing the potential impact from the proposed BLRT Extension project. Specific inputs used in the vibration impact assessment include the following:

- Projected LRT operating speeds would range from approximately 20 mph to 65 mph for LRT revenue operations, except for entry and exit from station areas. Light rail train speeds are based on modeled speed profiles in both directions (i.e., inbound and outbound) that reflect train operating characteristics, track geometry, and station locations.
- All light rail trains would consist of three cars during hours of operation.
- The operating hours and headways are described in **Section 3.1**, which would result in "frequent" events, as defined in the vibration criteria section.
- Locations of elevated structures, crossovers, and embedded track were identified based on plan and profile maps provided by the engineering team.
- Crossovers increase the vibration levels by up to 10 dB for nearby sensitive receptors due to the gap in the track.
- Elevated structures decrease the vibration levels by 10 dB for nearby sensitive receptors.
- Future vibration levels from LRT operations were based on a combination of the force density (vehicle) and propagation (soil) data at sensitive locations. The procedure for projecting future vibration levels is to measure the vibration propagation characteristics of the soil (line source transfer mobility [LSTM]) and combine that information with the vehicle information independent of the soil (force density [FD]). The formula for calculating the future vibration levels is:

  Lv = FD + LSTM

  Where: Lv is the projected train vibration level, FD is the vehicle force density, and LSTM is the line source transfer mobility at a site.
- Vehicle force density levels were based on measurements conducted for the Central Corridor LRT project (ATS Consulting, 2008) for both ballast-and-tie and embedded track. Representative force density spectra for both ballast-and-tie and embedded track are shown in **Figure 3-1**.
- Vibration propagation measurements were conducted at representative locations throughout the proposed BLRT Extension project vicinity during the Draft EIS.

Figure 3-1. Force Density Levels at 40 mph



Source: ATS, 2008

4 Affected Environment

4.1 Noise

4.1.1 Noise Sensitive Land Use

Noise-sensitive land use for the Final EIS was identified based on aerial photography, proposed BLRT Extension project drawings, and a site survey. Based on the information from these sources, the noise-sensitive land use, from south to north by city is as follows.

4.1.1.1 Minneapolis

The noise-sensitive land uses for the City of Minneapolis includes Mary's Place, Summit Academy, Sumner Branch Library, Wayman African Methodist Episcopal (AME) Church, Seed Academy, Zion Baptist Church, La Creche Early Childhood Center and a mixture of single-family and multi-family residences. The dominant noise sources are traffic on Olson Memorial Highway (Trunk Highway [TH] 55) and local street traffic for areas off Olson Memorial Highway.

4.1.1.2 Golden Valley

The noise-sensitive land uses for the City of Golden Valley includes Theodore Wirth Park, The Chalet at Theodore Wirth Park, The Family Partnership, Saint Margaret Mary Church, Loveworks Academy and primarily single-family residences with some multi-family residences as well. The dominant noise source is traffic on local streets.

4.1.1.3 Robbinsdale

The noise-sensitive land uses for the City of Robbinsdale includes Bethel World Outreach Church, Elim Lutheran Church, Sacred Heart Catholic Church and School, Robbinsdale Library Branch, Washburn McReavy Funeral Home, a Masonic Lodge, Redeemer Lutheran Church and a mixture of single-family and multi-family residences. The dominant noise sources are occasional freight trains and traffic on local streets.

4.1.1.4 Crystal

The noise-sensitive land uses for the City of Crystal includes Crystal Medical Center, Little Folks Daycare and a mixture of single-family and multi-family residences. The dominant noise sources are occasional freight trains, traffic on Bottineau Boulevard (County Road 81) and flight operations at Crystal Airport.

4.1.1.5 Brooklyn Park

The noise-sensitive land uses for the City of Brooklyn Park includes Brooklyn Crystal Cemetery, Prince of Peace Lutheran Church, Brooklyn Park Evangelical Free Church, North Hennepin Community College, Step by Step Montessori School, Berean Baptist Church, Ebenezer Community Church and a mixture of single-family and multi-family residences. The dominant noise sources are occasional freight trains, and traffic on Bottineau Boulevard and West Broadway Avenue (County State-Aid Highway 103).

4.1.2 Existing Noise Measurements

4.1.2.1 Noise Measurement Procedures and Equipment

In order to supplement the existing noise measurements conducted during the Draft EIS, a series of noise measurements were conducted during May 2015 at nine locations along the proposed BLRT Extension project corridor to refine the existing noise levels and to respond to comments received on the Draft EIS.

Because the thresholds for impact in the FTA noise criteria are based on the existing noise levels, measuring the existing noise and characterizing noise levels at sensitive locations along the corridor is an important step in the impact assessment. The noise measurements included both long-term (24-hour) and short-term (1-hour) monitoring of the A-weighted sound level at noise-sensitive locations near the proposed BLRT Extension project.

The additional noise measurements conducted during the Final EIS were performed with NTi Audio model XL2 noise monitors that conform to American National Standard Institute (ANSI) standards for Type 1 (precision) sound measurement equipment. Calibrations, traceable to the National Institute of Standards and Technology (NIST) were conducted before and after each measurement. The noise monitors were set to continuously monitor and record multiple noise level metrics, as well as obtain audio recordings during the measurement periods.

4.1.2.2 Noise Measurement Locations and Results

Table 4-1 summarizes the results of the existing noise measurement program and **Figure 4-1** shows the location of the 21 long-term noise monitoring sites (LT) and eight short-term noise monitoring sites (ST) for the proposed BLRT Extension project. The long-term noise measurements were used to characterize the existing noise at residential locations because the FTA assessment methodology uses L_{dn} (24-hour noise descriptor) for all residential locations, and the short-term noise measurements were used to characterize the existing noise at non-residential locations because the FTA assessment methodology uses L_{eq} (1-hour noise descriptor) for all non-residential locations.

At each site, the measurement was conducted at the approximate set back of the building or buildings relative to the proposed BLRT Extension project location. The results of the existing noise measurements program are used to determine the existing noise levels for all the noise-sensitive locations. The noise measurement results at each Final EIS site (which are identified by letters) are described below. See the Draft EIS Noise and Vibration Technical Report for information regarding the Draft EIS noise measurement results (which are identified by numbers).

Detailed information regarding the Final EIS noise measurement results are contained in **Appendix A** and photographs of noise measurement sites are contained in **Appendix B**.

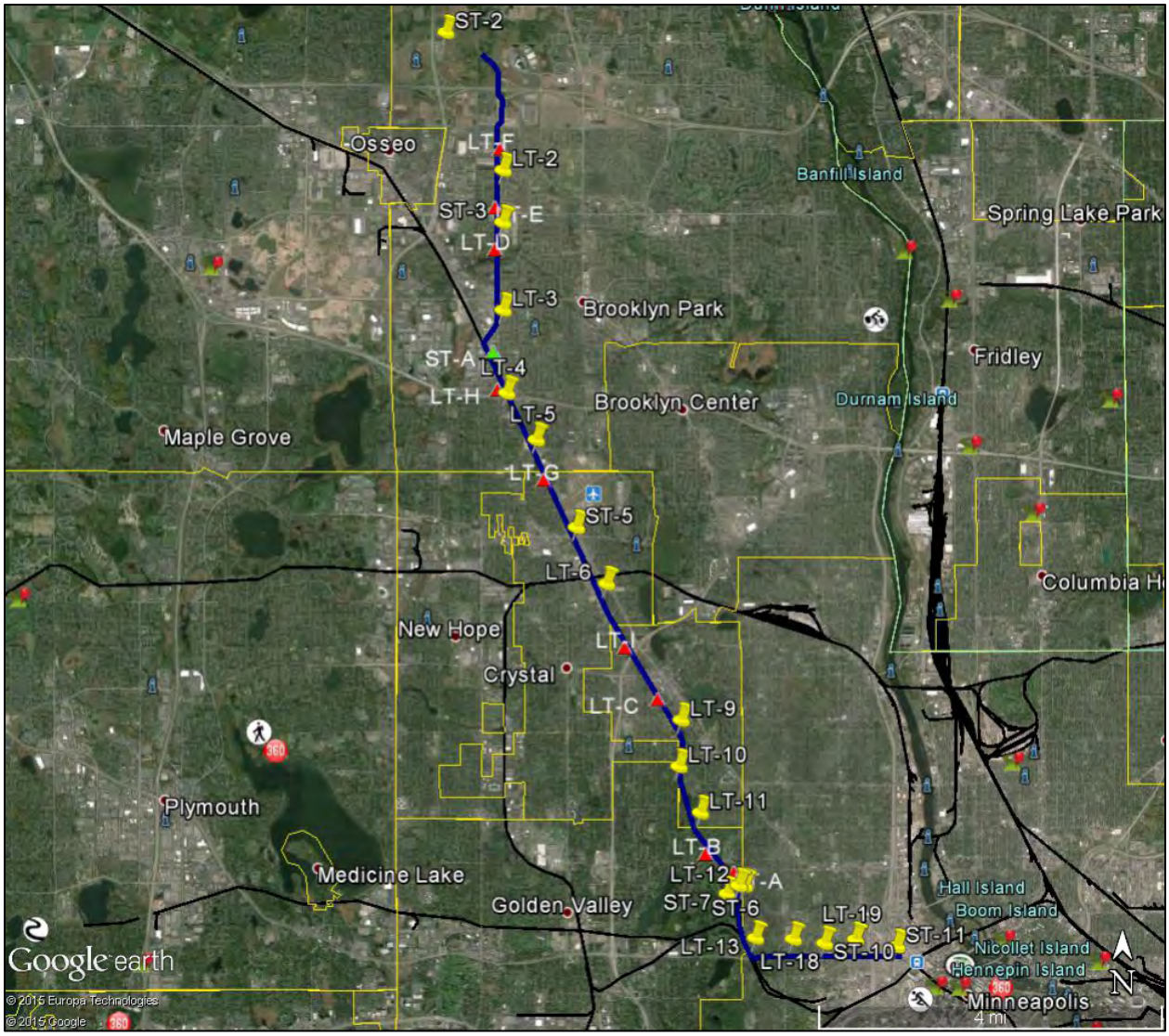
Table 4-1. Summary of Existing Noise Level Measurements

Site No.	City	Measurement Location	DEIS/ FEIS	Measurement Start		Meas. Dur. (hr)	Noise Level (dBA)[1]	
				Date	Time		L_{dn}	L_{eq}
ST-11	Minneapolis	Mary My Hope Children's Center	DEIS	5/17/12	16:09	1	65	67
LT-19	Minneapolis	1000 Olson Memorial Highway Heritage Park	DEIS	5/15/12	18:00	24	65	61
ST-10	Minneapolis	Harrison Education Center	DEIS	5/15/12	16:07	1	60	62
LT-18	Minneapolis	611 Oliver Avenue North	DEIS	5/17/12	12:00	24	62	59
LT-13	Minneapolis	623 Vincent Avenue North	DEIS	5/16/12	17:00	24	56	50
ST-6	Golden Valley	Theodore Wirth Regional Park	DEIS	5/18/12	10:01	1	47	49
ST-7	Golden Valley	The Chalet at Theodore Wirth Regional Park	DEIS	5/18/12	11:20	1	53	55
LT-12	Golden Valley	1501 Xerxes Avenue North	DEIS	7/14/11	16:00	24	55	50
LT-A	Golden Valley	1821 York Avenue	FEIS	5/11/15	16:00	24	54	47
LT-B	Golden Valley	2145 Bonnie Lane	FEIS	5/11/15	16:00	24	53	50
LT-11	Robbinsdale	3912 26th Avenue North	DEIS	7/13/11	16:00	24	50	45
LT-10	Golden Valley	3230 Kyle Avenue North	DEIS	5/5/12	14:00	24	51	45
LT-9	Robbinsdale	4400 36th Avenue North	DEIS	5/15/12	15:00	24	54	48
LT-C	Robbinsdale	3954 Noble Avenue	FEIS	5/11/15	17:00	24	55	52
LT-I	Robbinsdale	4416 Toledo Avenue North	FEIS	5/13/15	18:00	24	61	59
LT-6	Crystal	5001 Welcome Avenue North	DEIS	7/14/11	15:00	24	54	48
ST-5	Crystal	Becker Park	DEIS	5/17/12	13:51	1	54	56
LT-G	Crystal	6102 Hampshire Avenue North	FEIS	5/13/15	16:00	24	62	61
LT-5	Brooklyn Park	6288 Louisiana Court North	DEIS	5/14/12	12:00	24	63	58
LT-4	Brooklyn Park	6648 West Broadway Avenue	DEIS	5/15/12	13:00	24	61	61
LT-H	Brooklyn Park	7501 Myers Avenue	FEIS	5/13/15	16:00	24	69	68
ST-A	Brooklyn Park	Prince of Peace Lutheran Church	FEIS	5/12/15	08:38	1	60	62
LT-3	Brooklyn Park	7428 75th Circle North	DEIS	5/14/12	13:00	24	60	55
LT-D	Brooklyn Park	8220 Quebec Court North	FEIS	5/12/15	14:00	24	65	62
ST-3	Brooklyn Park	North Hennepin Community College	DEIS	5/14/12	15:33	1	58	60
LT-E	Brooklyn Park	8558 S. Maplebrook Circle	FEIS	5/12/15	17:00	24	65	62
LT-2	Brooklyn Park	8745 Oregon Avenue North	DEIS	7/14/11	10:00	24	66	62
LT-F	Brooklyn Park	9125 Nevada Court	FEIS	5/12/15	18:00	24	57	51
ST-2	Brooklyn Park	Grace Fellowship Church	DEIS	5/14/12	17:00	1	55	57

Sources: CSA, 2015; HMMH, 2012

[1] L_{dn} is used for Category 2 (residential) land use and L_{eq} is used for Category 3 (institutional) land use.

Figure 4-1. Existing Noise Measurement Locations



Sources: CSA, 2015; HMMH, 2012

Golden Valley

Site LT-A – 1821 York Avenue: The L_{dn} measured at this location was 54 dBA. The dominant noise source was traffic on local streets and distant aircraft. Noise levels were measured for 24 hours in the backyard of the residence.

Site LT-B – 2145 Bonnie Lane: The L_{dn} measured at this location was 53 dBA. The dominant noise source was traffic on local streets and distant aircraft. Noise levels were measured for 24 hours in the front yard of the residence.

Robbinsdale

Site LT-C – 3954 Noble Avenue: The L_{dn} measured at this location was 55 dBA. The dominant noise source was traffic on local streets, freight operations and distant aircraft. Noise levels were measured for 24 hours in the back yard of the residence.

Site LT-I – 4416 Toledo Avenue North: The L_{dn} measured at this location was 61 dBA. The dominant noise source was traffic on Highway 100. Other sources of noise included traffic on local streets, freight operations and distant aircraft. Noise levels were measured for 24 hours in the back yard of the residence.

Crystal

Site LT-G – 6102 Hampshire Avenue North: The L_{dn} measured at this location was 62 dBA. The dominant noise source was traffic on Bottineau Boulevard. Other sources of noise included traffic on local streets, freight operations and aircraft operations at Crystal Airport. Noise levels were measured for 24 hours in the back yard of the residence.

Brooklyn Park

Site LT-H – 7501 Myers Avenue: The L_{dn} measured at this location was 62 dBA. The dominant noise source was traffic on Bottineau Boulevard and Interstate 94. Other sources of noise included traffic on local streets and freight operations. Noise levels were measured for 24 hours in the front yard of the residence.

Site ST-A – Prince of Peace Lutheran Church: The L_{eq} measured at this location was 62 dBA. The dominant noise source was traffic on Bottineau Boulevard. Noise levels were measured for 1 hour in the parking lot of the church.

Site LT-D – 8220 Quebec Court North: The L_{dn} measured at this location was 65 dBA. The dominant noise source was traffic on West Broadway. Noise levels were measured for 24 hours in the back yard of the residence.

Site LT-E – 8558 S. Maplebrook Circle: The L_{dn} measured at this location was 65 dBA. The dominant noise source was traffic on West Broadway. Noise levels were measured for 24 hours in the front yard of the residence.

Site LT-F – 9125 Nevada Court: The L_{dn} measured at this location was 57 dBA. The dominant noise source was traffic on West Broadway. Noise levels were measured for 24 hours in the back yard of the residence.

4.1.2.3 MPCA Noise Standards Analysis

Using the noise measurement data gathered during the Draft and Final EIS at the long-term noise measurement sites described above, an analysis was also conducted using the MPCA L_{10} and L_{50} noise standards. At each location where a long-term noise measurement was conducted, the maximum L_{10} and L_{50} over a 24-hour period were calculated.

The results, shown in **Table 4-2**, show that at most locations along the proposed BLRT Extension project corridor, the L_{10} and L_{50} standards are already being exceeded by existing noise sources. Most of the exceedances are due to exempt noise sources, such as roadway noise and aircraft overflights. The higher existing L_{10} and L_{50} noise levels are at locations close to major roadways along the proposed BLRT Extension project corridor. At locations further from roadways, the L_{10} and L_{50} noise levels are lower.

Table 4-2. Summary of Existing L_{10} and L_{50} Noise Levels at Long-Term Noise Measurement Locations

Site No.	City	Measurement Location	Draft EIS/ Final EIS	Max L_{10} (dBA)[1]	Max L_{50} (dBA)[1]
LT-19	Minneapolis	1000 Olson Memorial Highway Heritage Park	Draft EIS	65	59
LT-18	Minneapolis	611 Oliver Avenue North	Draft EIS	68	63
LT-13	Minneapolis	623 Vincent Avenue North	Draft EIS	51	46
LT-12	Golden Valley	1501 Xerxes Avenue North	Draft EIS	65	63
LT-A	Golden Valley	1821 York Avenue	Final EIS	57	51
LT-B	Golden Valley	2145 Bonnie Lane	Final EIS	54	51
LT-11	Robbinsdale	3912 26th Avenue North	Draft EIS	65	53
LT-10	Golden Valley	3230 Kyle Avenue North	Draft EIS	61	55
LT-9	Robbinsdale	4400 36th Avenue North	Draft EIS	65	60
LT-C	Robbinsdale	3954 Noble Avenue	Final EIS	56	52
LT-I	Robbinsdale	4416 Toledo Avenue North	Final EIS	63	61
LT-6	Crystal	5001 Welcome Avenue North	Draft EIS	69	60
LT-G	Crystal	6102 Hampshire Avenue North	Final EIS	65	62
LT-5	Brooklyn Park	6288 Louisiana Court North	Draft EIS	67	59
LT-4	Brooklyn Park	6648 West Broadway Avenue	Draft EIS	70	65
LT-H	Brooklyn Park	7501 Myers Avenue	Final EIS	71	67
LT-3	Brooklyn Park	7428 75th Circle North	Draft EIS	56	50
LT-D	Brooklyn Park	8220 Quebec Court North	Final EIS	68	62
LT-E	Brooklyn Park	8558 S. Maplebrook Circle	Final EIS	66	61
LT-2	Brooklyn Park	8745 Oregon Avenue North	Draft EIS	71	64
LT-F	Brooklyn Park	9125 Nevada Court	Final EIS	60	55

Sources: CSA, 2015; HMMH, 2012

[1] The L_{10} descriptor represents noise levels exceeded 10 percent (6 minutes) of the time during an hour (60 minutes). This standard includes both daytime and nighttime limits.

[2] The L_{50} descriptor represents noise levels exceeded 50 percent (30 minutes) of the time during an hour (60 minutes). This standard includes both daytime and nighttime limits.

4.2 Vibration

4.2.1 Vibration Sensitive Land Use

Vibration-sensitive land use for the Final EIS was identified based on aerial photography, proposed BLRT Extension project drawings, and a site survey. Based on the information from these sources, the vibration-sensitive land use, from south to north by city is as follows.

4.2.1.1 Minneapolis

The vibration-sensitive land uses for the City of Minneapolis include Mary's Place, Summit Academy, Sumner Branch Library, Wayman AME Church, Seed Academy, Zion Baptist Church, La Creche Early Childhood Center and a mixture of single-family and multi-family residences.

4.2.1.2 Golden Valley

The vibration-sensitive land uses for the City of Golden Valley include The Chalet at Theodore Wirth Regional Park, The Family Partnership, Saint Margaret Mary Church, Loveworks Academy and primarily single-family residences with some multi-family residences as well.

4.2.1.3 Robbinsdale

The vibration-sensitive land uses for the City of Robbinsdale include Bethel World Outreach Church, Elim Lutheran Church, Sacred Heart Catholic Church and School, Robbinsdale Library Branch, Washburn McReavy Funeral Home, a Masonic Lodge, Redeemer Lutheran Church and a mixture of single-family and multi-family residences.

4.2.1.4 Crystal

The vibration-sensitive land uses for the City of Crystal include Crystal Medical Center, Little Folks Daycare and a mixture of single-family and multi-family residences.

4.2.1.5 Brooklyn Park

The vibration-sensitive land uses for the City of Brooklyn Park include Prince of Peace Lutheran Church, Brooklyn Park Evangelical Free Church, North Hennepin Community College, Step by Step Montessori School, Berean Baptist Church, Ebenezer Community Church and a mixture of single-family and multi-family residences.

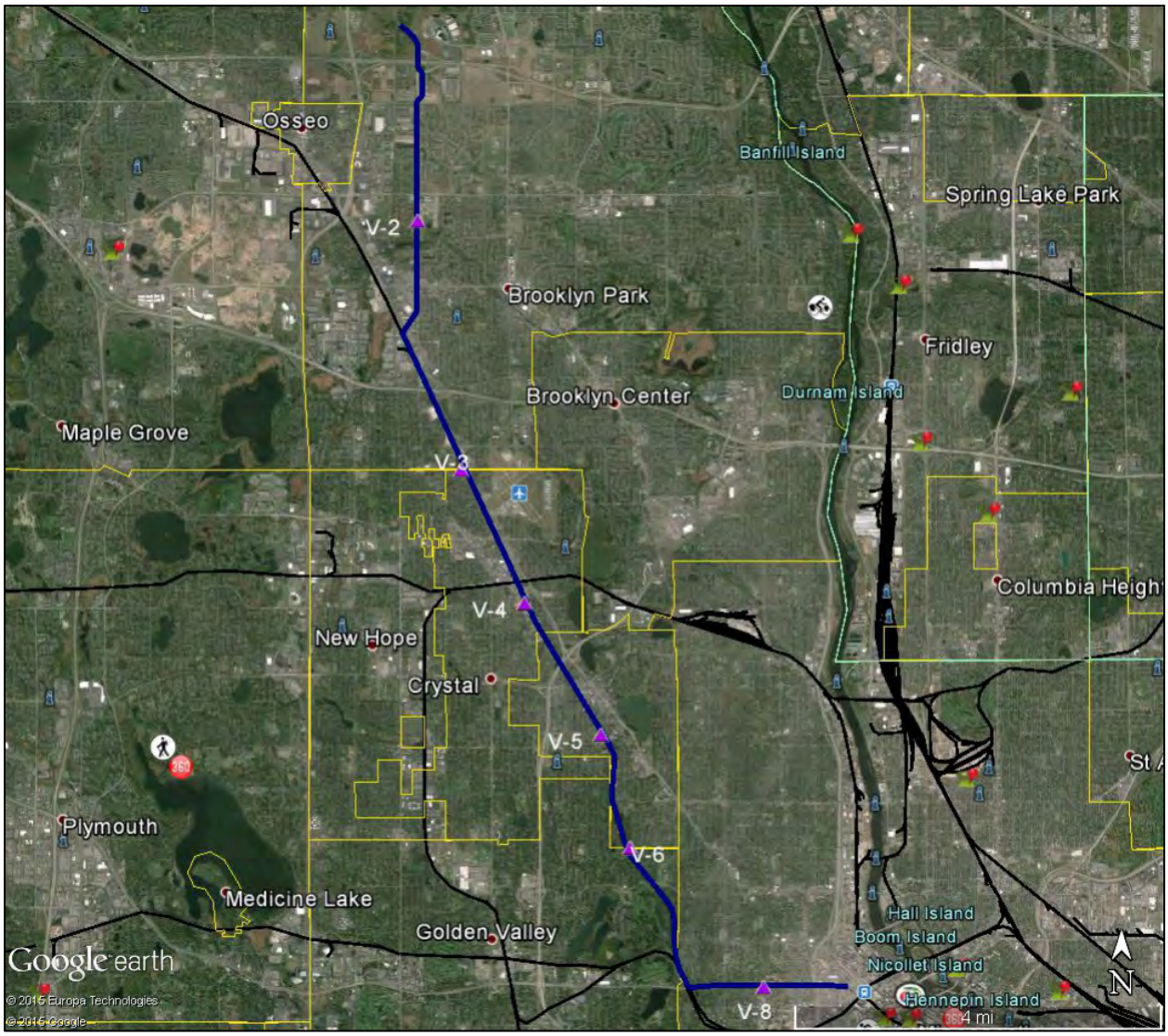
4.2.2 Existing Vibration Measurements

The existing vibration measurements for the proposed BLRT Extension project were conducted during the Draft EIS phase of the proposed BLRT Extension project. Specific information regarding instrumentation, procedures, analysis methods and measurement locations are available in the Draft EIS Noise and Vibration Technical Report. Detailed information regarding the vibration propagation measurement results are contained in the appendices of the Draft EIS Noise and Vibration Technical Report.

The vibration measurements conducted for the Draft EIS were used to characterize the response of the soil at locations within the proposed BLRT Extension project corridor. At each site, vibration propagation tests were conducted by impacting the ground with an instrumented weight and measuring the response of the soil and/or building foundations at various distances (LSTM). The results of the vibration propagation tests were combined with the force density (vehicle input force) to project vibration levels from LRT operations at locations along the proposed BLRT Extension project corridor.

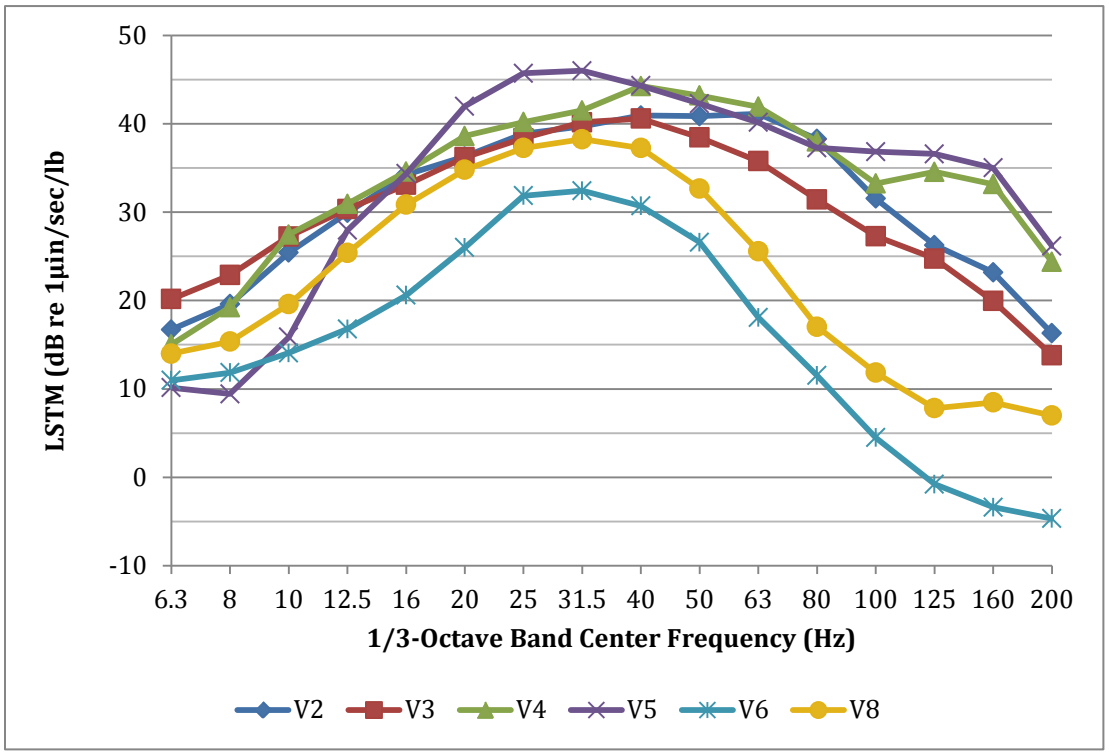
The locations of the six vibration measurement sites used in the Final EIS are shown in **Figure 4-2**. The results of the LSTM tests for the Final EIS are shown in **Figure 4-3**. **Figures 4-4 and 4-5** show the projected vibration levels (combining the force density and transfer mobility data) for the proposed BLRT Extension project for ballast-and-tie and embedded track, respectively.

Figure 4-2. Vibration Propagation Measurement Locations



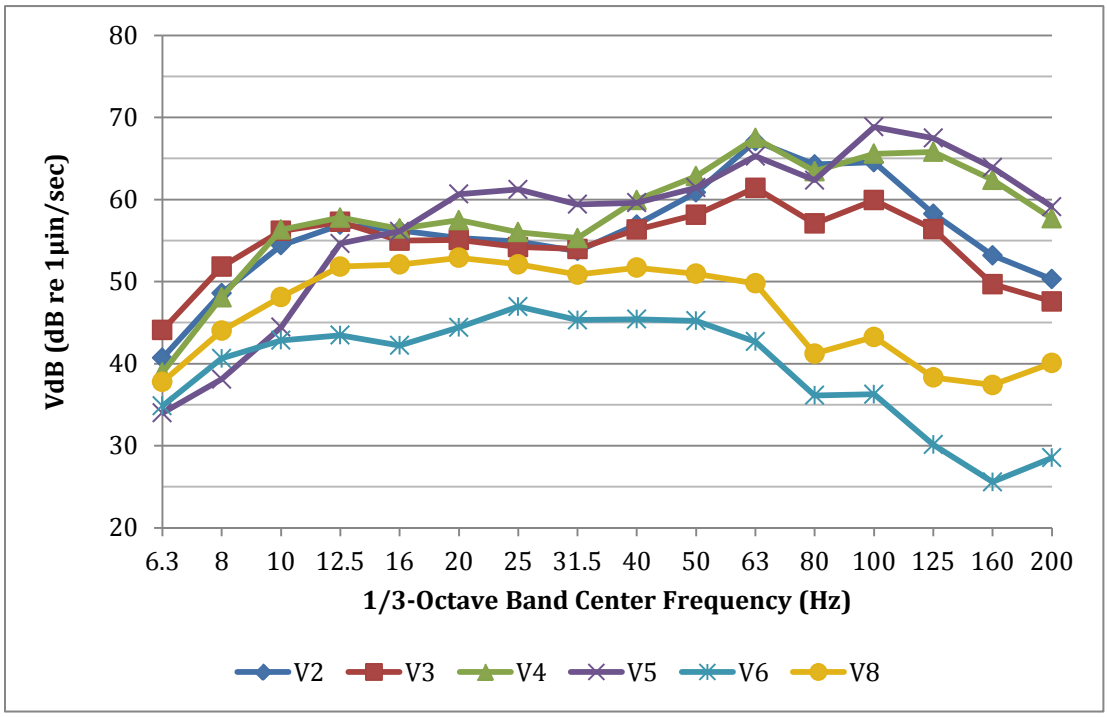
Sources: CSA, 2015; HMMH, 2012

Figure 4-3. Line Source Transfer Mobility Results at 50 feet



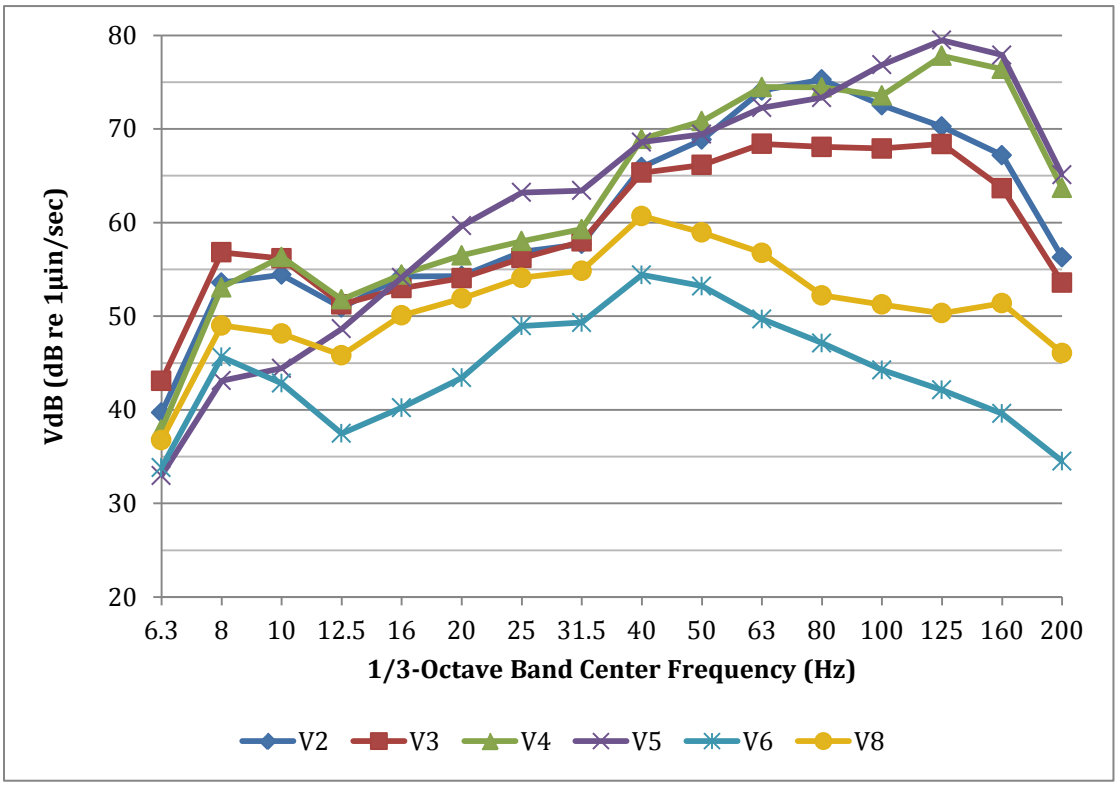
Sources: CSA, 2015; HMMH, 2012; ATS, 2008

Figure 4-4. Vibration Levels at 50 feet, Ballast and Tie Track



Sources: CSA, 2015; HMMH, 2012; ATS, 2008

Figure 4-5. Vibration Levels at 50 feet, Embedded Track



Sources: CSA, 2015; HMMH, 2012; ATS, 2008

5 Environmental Consequences

5.1 Noise

The FTA guidance manual on noise and vibration (FTA, 2006) is the primary source for the noise methodology. Noise impact has been evaluated using the Detailed Noise Assessment methodology contained in Chapter 6 of the FTA guidance manual (FTA, 2006). The noise assessment included the following steps:

- Identified noise-sensitive land uses in the proposed BLRT Extension project corridor using aerial photography, GIS data and field surveys, typically within 300 feet of the alignment.
- Measured the existing noise levels in the proposed BLRT Extension project corridor at sensitive receptors (see **Section 4.1 – Affected Environment**).
- Projected proposed BLRT Extension project noise levels from transit operations, using proposed BLRT Extension project drawings provided by the engineering team, and information on speeds, headways, track type, vehicle type, and at-grade-crossing operations.
- Assessed the impact from transit by comparing the proposed BLRT Extension project noise with the existing noise using the FTA noise impact criteria in Chapter 3 of the FTA guidance manual (FTA, 2006).
- Recommended mitigation at locations where proposed BLRT Extension project noise levels exceed the impact criteria.

5.1.1 Proposed BLRT Extension Project Noise

This section describes the noise impacts for the proposed BLRT Extension project. The results of the Detailed Noise Analysis are presented in **Tables 5-1 and 5-2** for residential and institutional (e.g., churches and schools) land uses, respectively.

The results include a tabulation of location information for each sensitive receptor group, the existing noise levels, the projections of future noise levels, the impact criteria, and whether there would be noise impacts. The tables also show the total number of moderate and severe noise impacts for each location, without mitigation measures. Because the proposed BLRT Extension project would never exceed the MPCA standards, the FTA criteria are more protective in assessing impacts from the proposed BLRT Extension project.

As shown in **Table 5-1**, the proposed BLRT Extension project would result in 366 moderate noise impacts and 618 severe noise impacts for residential land uses with the inclusion of LRT horns (see **Appendix C** for locations of impacts). The impacts represent the number of impacted units (including those in multi-family buildings), not the number of buildings. The majority of the noise impacts are related to LRT horn sounding at FRA-shared at-grade crossings in the proposed BLRT Extension project corridor. With the implementation of Quiet Zones[5] at all FRA-shared at-grade

[5] Quiet Zones are locations, at least one-half mile in length, where the routine sounding of horns has been eliminated because of safety improvements at at-grade crossings, including modifications to the streets, raised median barriers, four quadrant gates, and other improvements designed and implemented as a part of the proposed BLRT Extension

crossings, the proposed BLRT Extension project would result in 176 moderate noise impacts and 120 severe noise impacts, as shown in **Table 5-1**. A summary of each location that would experience noise impacts follows. However, if any of the municipalities decide not to apply to FRA for Quiet Zones, this decrease in moderate and severe noise impacts would not be achieved and residual noise impacts would not be mitigated.

Table 5-1. Summary of Noise Impacts for Residential Land Use – LRT With and Without Quiet Zones

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Exist Noise Level L_{dn} (dBA)	Proposed BLRT Extension Project Noise Levels- L_{dn}, (dBA)			Type and # of Impacts	
						Proposed BLRT Extension Project	FTA Criteria		Mod	Sev
							Mod	Sev		
Interstate High-way 94 (I-94) to Humboldt Ave N	Minneapolis	NB	95	20	65	62	61	66	16	0
I-94 to Humboldt Ave N	Minneapolis	SB	130	40	65	55	61	66	0	0
Humboldt Ave N to Penn Ave N	Minneapolis	NB	100	40	62	62	59	64	9	0
Humboldt Ave N to Penn Ave N	Minneapolis	SB	190	40	62	57	59	64	0	0
Penn Ave N to Upton Ave N	Minneapolis	NB	145	35	56	54	56	62	0	0
Penn Ave N to BNSF Railway (BNSF) freight tracks	Minneapolis	SB	160	40	56	53	56	62	0	0
Olson Mem Hwy to Oak Park Ave N	Minneapolis	NB	35	35	56	61	56	62	1	0
Oak Park Ave N to Plymouth Ave N	Minneapolis	NB	60	55	55	61	55	61	3	0
Plymouth Ave N to 16th Ave N	Golden Valley	NB	220	20	55	56	55	61	9	0
16th Ave N to Golden Valley Rd	Golden Valley	NB	30	45	54	64	55	61	1	0
Golden Valley Rd to 26th Ave N	Golden Valley	NB	80	55	50	65	53	60	9	14
26th Ave N to 31½ Ave N	Robbinsdale	NB	90	55	50	59	53	60	3	0
31½ Ave N to 34th Ave N	Robbinsdale	NB	20	55	50	70	53	60	4	12

project and consistent with Quiet Zone readiness. Horns are sounded in emergency situations at these locations. Municipalities must apply to FRA for approval of Quiet Zones. If the municipality fails to apply for a Quiet Zone or FRA fails to approve the Quiet Zone, the proposed BLRT Extension project may result in residual noise impacts.

Table 5-1. Summary of Noise Impacts for Residential Land Use – LRT With and Without Quiet Zones

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Exist Noise Level L_{dn} (dBA)	Proposed BLRT Extension Project Noise Levels- L_{dn}, (dBA)			Type and # of Impacts	
						Proposed BLRT Extension Project	FTA Criteria		Mod	Sev
							Mod	Sev		
34th Ave N to 36th Ave N	Robbinsdale	NB	60	55	54	62	55	61	20	5
34th Ave N to 36th Ave N	Robbinsdale	SB	140	55	54	56	55	61	1	0
36th Ave N to 38th Ave N	Robbinsdale	NB	40	55	54	91	55	61	8	27
36th Ave N to 38th Ave N	Robbinsdale	SB	295	55	54	68	55	61	15 (4)	7 (0)
38th Ave N to 40½ Ave N	Robbinsdale	NB	35	55	55	92	55	61	22 (3)	66 (20)
38th Ave N to 40th Ave N	Robbinsdale	SB	70	45	55	87	55	61	37 (20)	68 (5)
40½ Ave N to 42nd Ave N	Robbinsdale	NB	65	45	55	87	55	61	0 (5)	57 (2)
40th Ave N to 42nd Ave N	Robbinsdale	SB	130	30	55	78	55	61	34 (13)	40 (2)
42nd Ave N to MN-100	Robbinsdale	NB	115	30	61	78	59	64	9 (2)	28 (0)
42nd Ave N to MN-100	Robbinsdale	SB	100	40	61	81	59	64	14 (2)	10 (1)
MN-100 to 47th Ave N	Robbinsdale	NB	95	55	61	84	59	64	12 (10)	20 (1)
MN-100 to 47th Ave N	Robbinsdale	SB	80	55	61	82	59	64	19 (8)	39 (0)
47th Ave N to Canadian Pacific Railway (CP) rail crossing	Crystal	NB	35	55	54	94	55	61	35 (11)	93 (31)
47th Ave N to CP rail crossing	Crystal	SB	120	55	54	81	55	61	26 (0)	24 (0)
CP rail crossing to 56th Ave N	Crystal	NB	795	55	62	58	59	64	0 (0)	0 (0)
CP rail crossing to 56th Ave N	Crystal	SB	80	25	62	52	59	64	0 (0)	0 (0)
56th Ave N to 60th Ave N	Crystal	NB	440	20	62	63	59	64	5 (0)	0 (0)
56th Ave N to 60th Ave N	Crystal	SB	160	35	62	76	59	64	4 (0)	2 (0)
60th Ave N to 63rd Ave N	Crystal	NB	200	35	63	73	60	65	1 (0)	1 (0)

Table 5-1. Summary of Noise Impacts for Residential Land Use – LRT With and Without Quiet Zones

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Exist Noise Level L_{dn} (dBA)	Proposed BLRT Extension Project Noise Levels- L_{dn}, (dBA)			Type and # of Impacts	
						Proposed BLRT Extension Project	FTA Criteria		Mod	Sev
							Mod	Sev		
60th Ave N to 63rd Ave N	Crystal	SB	125	40	63	77	60	65	24 (0)	84 (0)
63rd Ave N to Interstate Highway 694 (I-694)	Brooklyn Park	NB	315	25	63	68	60	65	1 (0)	18 (0)
63rd Ave N to I-694	Brooklyn Park	SB	140	35	63	52	60	65	0 (0)	0 (0)
I-694 to 73rd Ave N	Brooklyn Park	NB	700	40	60	59	58	63	8 (0)	0 (0)
I-694 to 73rd Ave N	Brooklyn Park	SB	170	55	69	74	64	69	2 (0)	3 (0)
73rd Ave N to Brooklyn Blvd	Brooklyn Park	NB	80	35	60	59	58	63	4	0
Brooklyn Blvd to Shingle Creek	Brooklyn Park	NB	85	45	65	59	61	66	0	0
Shingle Creek to 85th Ave N	Brooklyn Park	SB	70	40	65	65	61	66	5	0
85th Ave N to 89th Ave N	Brooklyn Park	NB	85	45	66	58	61	67	0	0
85th Ave N to 89th Ave N	Brooklyn Park	SB	90	45	66	59	61	67	0	0
89th Ave N to 93rd Ave N	Brooklyn Park	NB	120	45	57	57	56	62	5	0
								Total	**366 (176)**	**618 (120)**

Source: CSA, 2015

The "Type and # of Impacts" column identifies whether the LRT noise level exceeds FTA's moderate or severe noise impact criteria thresholds, which are found under the "Proposed BLRT Extension project Noise Levels" column. It also reports the number of units that experience a moderate or severe noise impact. The numbers in parentheses represent the number of impacts remaining after implementation of Quiet Zones.

Predicted noise levels for each location are highest for each location. Projected noise levels at other receptors within each location are lower.

The reported noise levels are rounded to the nearest decibel.

Mod = moderate; Sev = severe.

- **I-94 to Humboldt Avenue North, Minneapolis.** There are sixteen multi-family residences located on the northbound side of the proposed alignment along the Olson Memorial Highway projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of bells at grade crossings.
- **Humboldt Avenue North to Penn Avenue North, Minneapolis**. There are nine single- and multi-family residences located on the northbound side of the proposed alignment along the Olson Memorial Highway projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residences and the sounding of bells at grade crossings.
- **Olson Memorial Highway to Oak Park Avenue North, Minneapolis**. There is one single-family residence located on the northbound side of the proposed alignment at 8th Avenue and Washburn Avenue projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residence.
- **Oak Park Avenue North to Plymouth Avenue North, Minneapolis**. There are three single-family residences located on the northbound side of the proposed alignment at Xerxes Avenue and Oak Park Avenue projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residences.
- **Plymouth Avenue North to 16th Avenue North, Golden Valley**. There are nine single-family residences located on the northbound side of the proposed alignment along Xerxes Avenue projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to noise from the Plymouth Avenue Station.
- **16th Avenue North to Golden Valley Road, Golden Valley**. There is one single-family residence located on the northbound side of the proposed alignment along York Avenue projected to have moderate noise impact, without noise mitigation. The noise impact at this location would be due to the proximity of the tracks to the residence.
- **Golden Valley Road to 26th Avenue North, Golden Valley**. There are 23 single-family residences located on the northbound side of the proposed alignment along Kewanee Way projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residences and the presence of a crossover.
- **26th Avenue North to 31½ Avenue North, Robbinsdale**. There are three single- and multi-family residences located on the northbound side of the proposed alignment just north of Kewanee Way projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residences.
- **31½ Avenue North to 34th Avenue North, Robbinsdale**. There are sixteen single- and multi-family residences located on the northbound side of the proposed alignment along Indiana Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residences.

- **34th Avenue North to 36th Avenue North, Robbinsdale**. There are 25 single-family residences located on the northbound side of the proposed alignment between 34th Avenue and 36th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks to the residences.
- **34th Avenue North to 36th Avenue North, Robbinsdale**. There is one single-family residence located on the southbound side of the proposed alignment between 34th Avenue and 36th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impact at this location would be due to the proximity of the tracks to the residence.
- **36th Avenue North to 38th Avenue North, Robbinsdale.** There are 35 single- and multi-family residences located on the northbound side of the proposed alignment al between 36th Avenue and 38th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks at the southern portion of this area and the sounding of horns at grade crossings in the northern portion of this area.
- **36th Avenue North to 38th Avenue North, Robbinsdale**. There are 22 single-family residences located on the southbound side of the proposed alignment al between 36th Avenue and 38th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks at the southern portion of this area and the sounding of horns at grade crossings in the northern portion of this area.
- **38th Avenue North to 40½ Avenue North, Robbinsdale**. There are 88 single-family residences located on the northbound side of the proposed alignment al between 38th Avenue and 40½ Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **38th Avenue North to 40th Avenue North, Robbinsdale**. There are 105 single- and multi-family residences located on the southbound side of the proposed alignment al between 38th Avenue and 40½ Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **40½ Avenue North to 42nd Avenue North, Robbinsdale**. There are 57single- and multi-family residences located on the northbound side of the proposed alignment between 40½ Avenue and 42nd Avenue projected to have severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **40th Avenue North to 42nd Avenue North, Robbinsdale**. There are 74 single- and multi-family residences located on the southbound side of the proposed alignment between 40½ Avenue and 42nd Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.

- **42nd Avenue North to MN-100, Robbinsdale**. There are 37 single- and multi-family residences located on the northbound side of the proposed alignment between 42nd Avenue and MN-100 projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **42nd Avenue North to MN-100, Robbinsdale**. There are 24 single- and multi-family residences located on the southbound side of the proposed alignment between 42nd Avenue and MN-100 projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **MN-100 to 47th Avenue North, Robbinsdale**. There are 32 single-family residences located on the northbound side of the proposed alignment between MN-100 and 47th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **MN-100 to 47th Avenue North, Robbinsdale**. There are 58 single- and multi-family residences located on the southbound side of the proposed alignment between MN-100 and 47th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **47th Avenue North to CP Rail Crossing, Crystal**. There are 128 single- and multi-family residences located on the northbound side of the proposed alignment between 47th Avenue and the freight track crossing projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **47th Avenue North to CP Rail Crossing, Crystal**. There are 50 single- and multi-family residences located on the southbound side of the proposed alignment between 47th Avenue and the freight track crossing projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of horns at grade crossings.
- **56th Avenue North to 60th Avenue North, Crystal**. There are five single-family residences located on the northbound side of the proposed alignment between 56th Avenue and 60th Avenue projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the Bass Lake Road grade crossing.
- **56th Avenue North to 60th Avenue North, Crystal**. There are six single-family residences located on the northbound side of the proposed alignment between 56th Avenue and 60th Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the Bass Lake Road grade crossing.

- **60th Avenue North to 63rd Avenue North, Crystal**. There is one single-family residence and a motel located on the northbound side of the proposed alignment between 60th Avenue and 63rd Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the 63rd Avenue grade crossing.
- **60th Avenue North to 63rd Avenue North, Crystal**. There are 108 multi-family residences located on the southbound side of the proposed alignment between 60th Avenue and 63rd Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the 63rd Avenue grade crossing.
- **63rd Avenue North to I-694, Brooklyn Park**. There are nineteen single- and multi-family residences located on the northbound side of the proposed alignment between 63rd Avenue and I-694 projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the 63rd Avenue grade crossing.
- **I-694 to 73rd Avenue North, Brooklyn Park**. There are eight multi-family residences located on the northbound side of the proposed alignment between I-694 and 73rd Avenue projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the West Broadway grade crossing.
- **I-694 to 73rd Avenue North, Brooklyn Park**. There are five single- and multi-family residences located on the southbound side of the proposed alignment between I-694 and 73rd Avenue projected to have moderate and severe noise impacts, without noise mitigation. The noise impacts at this location would be due to the sounding of horns at the West Broadway grade crossing.
- **73rd Avenue North to Brooklyn Blvd, Brooklyn Park**. There are four multi-family residences located on the northbound side of the proposed alignment to the south of 76th Avenue projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and sounding of bells at the 76th Avenue grade crossing.
- **Shingle Creek to 85th Avenue North, Brooklyn Park**. There are five single-family residences located on the southbound side of the proposed alignment across from the North Hennepin Community College projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the presence of a crossover and noise from the nearby station.
- **89th Avenue North to 93rd Avenue North, Brooklyn Park**. There are five single-family residences located on the northbound side of the proposed alignment near Seltzer Parkway projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location would be due to the proximity of the tracks and the sounding of bells at the Seltzer Parkway grade crossing.

As shown in **Table 5-2**, the proposed BLRT Extension project would result in one moderate noise impact and five severe noise impacts for institutional land uses (see **Appendix C** for locations of impacts). All of the noise impacts are related to LRT horn sounding at FRA-shared at-grade crossings in the proposed BLRT Extension project corridor. There would be no remaining impacts at institutional locations with the implementation of Quiet Zones. A summary of each institutional location that would experience noise impacts follows.

Table 5-2. Summary of Noise Impacts for Institutional Land Use - LRT

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Exist Noise Level L_{eq} (dBA)	Proposed BLRT Extension Project Noise Levels – L_{eq} (dBA)			Type and # of Impacts	
						Proposed BLRT Extension Project	FTA Criteria		Mod	Sev
							Mod	Sev		
Sumner Library	Minneapolis	NB	110	20	62	50	64	70	0	0
Wayman AME Church	Minneapolis	NB	135	30	62	47	64	70	0	0
Seed Academy	Minneapolis	NB	135	40	62	52	64	70	0	0
Summit Academy	Minneapolis	SB	225	20	62	54	64	70	0	0
Zion Baptist Church	Minneapolis	NB	185	40	62	55	64	70	0	0
Le Creche Early Childhood Center	Minneapolis	NB	135	40	62	52	64	70	0	0
The Family Partnership	Golden Valley	NB	55	35	50	54	58	65	0	0
Theodore Wirth Regional Park[1]	Golden Valley	SB	230	35	49	44	53	59	0	0
The Chalet[1]	Golden Valley	SB	925	20	55	31	56	61	0	0
Bethel World Outreach	Robbinsdale	NB	520	55	52	52	59	65	0	0
Elim Lutheran Church	Robbinsdale	NB	800	50	52	46	59	65	0	0
Sacred Heart Church	Robbinsdale	NB	300	35	52	68	59	65	0	1
Robbins Gallery	Robbinsdale	SB	110	20	52	77	59	65	0	1
Washburn McReavy Funeral Home	Crystal	NB	255	25	52	67	59	65	0	1
Masonic Lodge	Robbinsdale	NB	455	30	59	56	62	68	0	0
Redeemer Lutheran Church	Robbinsdale	SB	505	40	59	54	62	68	0	0
Glen Haven Memorial Gardens	Crystal	SB	610	55	48	58	58	64	1	0
Crystal Medical Center	Crystal	NB	180	30	61	71	63	69	0	1

Table 5-2. Summary of Noise Impacts for Institutional Land Use - LRT

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Exist Noise Level L_{eq} (dBA)	Proposed BLRT Extension Project Noise Levels – L_{eq} (dBA)			Type and # of Impacts	
						Proposed BLRT Extension Project	FTA Criteria		Mod	Sev
							Mod	Sev		
Little Folks Daycare	Crystal	SB	85	25	56	80	61	66	0	1
Brooklyn Crystal Cemetery	Brooklyn Park	NB	385	35	55	52	60	66	0	0
Prince of Peace Lutheran Church	Brooklyn Park	NB	385	35	62	63	64	70	0	0
Brooklyn Park Evangelical Free Church	Brooklyn Park	SB	145	45	60	51	63	68	0	0
North Hennepin Community College	Brooklyn Park	NB	75	20	60	61	63	68	0	0
Step by Step Montessori School	Brooklyn Park	SB	285	25	60	51	63	68	0	0
Berean Baptist Church	Brooklyn Park	SB	80	45	62	55	64	70	0	0
Ebenezer Community Church	Brooklyn Park	NB	135	20	51	58	59	65	0	0
								Total	**1**	**5**

Source: CSA, 2015

[1] These receptors were assessed as land use category 1 receptors. All other institutional receptors were assessed as land use category 3 receptors.

The reported noise levels are rounded to the nearest decibel.

Mod = moderate; Sev = severe.

- **Sacred Heart Church.** The Sacred Heart Church is projected to have severe noise impact, without noise mitigation. The noise impact at this location is due to the sounding of the LRT horn at grade crossings in the shared freight corridor.
- **Robbins Gallery.** The Robbins Gallery is projected to have severe noise impact, without noise mitigation. The noise impact at this location is due to the sounding of the LRT horn at grade crossings in the shared freight corridor.
- **Washburn McReavy Funeral Home.** The Washburn McReavy Funeral Home is projected to have severe noise impact, without noise mitigation. The noise impact at this location is due to the sounding of the LRT horn at grade crossings in the shared freight corridor.
- **Glen Haven Memorial Garden.** The Glen Haven Memorial Garden is projected to have moderate noise impact, without noise mitigation. The noise impact at this location is due to the sounding of the LRT horn at grade crossings in the shared freight corridor.
- **Crystal Medical Center.** The Crystal Medical Center is projected to have severe noise impact, without noise mitigation. The noise impact at this location is due to the sounding of the LRT horn at grade crossings in the shared freight corridor.
- **Little Folks Daycare.** The Little Folks Daycare is projected to have severe noise impact, without noise mitigation. The noise impact at this location is due to the sounding of the LRT horn at grade crossings in the shared freight corridor.

5.1.2 Cultural Resources

Based on data provided by the Minnesota Department of Transportation (MnDOT) Cultural Resources Unit (CRU) of listed and eligible historic properties within the proposed BLRT Extension project vicinity, an assessment of the historic and cultural resources was conducted for the proposed BLRT Extension project. The assessment was conducted to determine the noise sensitivity of the resources along the proposed BLRT Extension project corridor. For each resource site, a determination was made regarding the noise sensitivity of the use and the FTA category it would fall under based on FTA guidance.

The result of the assessment, which is summarized in **Table 5-3**, shows that there would be noise impacts at the West Broadway Avenue Residential Historic District, Former Hennepin County Library, Robbinsdale Branch, Sacred Heart Catholic Church and Homewood Residential Historic District. However, with Quiet Zones, only five residences within the two residential historic districts would have moderate noise impacts remaining. Each of these locations was assessed for impact as a part of the noise assessment detailed in **Section 5.1.1**.

Table 5-3. Summary of Historic and Cultural Resources Noise Assessment

Inventory #	Property Name	City	FTA Noise Cat.[1]	Notes
HE-CRC-199	Minneapolis & Pacific Railway Historic District (Soo Line)	Crystal	N/A	Not noise sensitive.
HE-RBC-264	Jones-Osterhus Barn	Robbinsdale	N/A	Not noise sensitive.
HE-RBC-158	West Broadway Avenue Residential Historic District	Robbinsdale	2	Severe noise impacts. Two moderate noise impacts remaining with Quiet Zone.
HE-RBC-024	Former Hennepin County Library, Robbinsdale Branch	Robbinsdale	3	Severe noise impact. No impact with Quiet Zone.
HE-RBC-286	Robbinsdale Waterworks	Robbinsdale	N/A	Not noise sensitive.
HE-RBC-1462	Sacred Heart Catholic Church	Robbinsdale	3	Severe noise impact. No impact with Quiet Zone.
XX-PRK-001	Grand Rounds Historic District – Theodore Wirth Park Segment	Golden Valley, Minneapolis	3, N/A	No noise impacts.
HE-GVC-0050	Bridge No. L9327	Golden Valley	N/A	Not noise sensitive.
HE-MPC-12101	Homewood Residential Historic District	Minneapolis	2	Three moderate noise impacts at southwestern corner of the district.
HE-MPC-9013	Floyd B. Olson Memorial Statue	Minneapolis	N/A	Not noise sensitive.
HE-MPC-7553	Labor Lyceum	Minneapolis	3	No noise impacts.
HE-MPC-8290	Wayman AME Church	Minneapolis	3	No noise impacts.
HE-MPC-8081	Sumner Branch Library	Minneapolis	3	No noise impacts.
HE-MPC-8125	Northwestern Knitting Company Factory	Minneapolis	2	No noise impacts.
HE-MPC-0441	Minneapolis Warehouse Historic District	Minneapolis	2	No noise impacts.
XX-RRD-010 (district)	St. Paul, Minneapolis & Manitoba (StPM&M)/Great Northern (GN) Railway Historic District	Minneapolis	N/A	Not noise sensitive.
Including HE-RRD-002; HE-BPC-0084; HE-CRC-0238; HE-RBC-0304; HE-MPC-16389	Osseo Branch of the StPM&M/GN Railway Historic District	Minneapolis, Golden Valley, Robbinsdale, Crystal, Brooklyn Park	N/A	Not noise sensitive.

Source: CSA, 2015

[1] N/A - Not included in any of the FTA noise-sensitive categories. Not noise sensitive.

5.1.3 Stations

The major noise source at stations, other than LRT operations, is the sounding of the LRT bells as the trains enter and exit the stations. The noise from the LRT bells has been captured in the proposed BLRT Extension project noise assessment detailed above.

5.1.4 Operations and Maintenance Facility

The operations and maintenance facility (OMF) is located more than 1,000 feet from any noise-sensitive receptors and therefore no noise impact is projected.

5.1.5 Construction Noise

This section describes the short-term (construction-phase) noise impacts of the proposed BLRT Extension project.

Construction noise levels are subject to local noise ordinances and noise rules administered by MPCA (Minnesota Rules, Chapter 7030). MPCA administers these noise rules to establish maximum allowable noise levels; where applicable, MPCA procedures allow for the issuance of noise variances. To address both the applicable local noise ordinances and the MPCA noise rules, the Council will develop a Noise Control Plan. The Noise Control Plan will contain information regarding when advanced notice of construction activities will be provided to affected communities. The Noise Control Plan will also contain other stipulations to help avoid or minimize construction noise impacts. For example, the Noise Control Plan will require that construction equipment used by contractors be properly muffled and in proper working order. Most of the construction will consist of site preparation and laying new tracks, which should occur primarily during daytime hours, except when required and allowable within local noise ordinance procedures.

Construction noise varies greatly depending on the type of construction activities, equipment used, staging of the construction process, the layout of the construction site, and the distance to sensitive receptors. Elevated noise levels during construction are, to a degree, unavoidable for this type of project, and short-term noise during construction of the proposed BLRT Extension project can be intrusive to residents near the construction sites. For most construction equipment, diesel engines are typically the dominant noise source. For other activities, such as impact pile driving and jackhammering, noise generated by the actual process dominates. The contractor will provide specific information on equipment and methods as a part of the Noise Control Plan for construction of the proposed BLRT Extension project. The contractor will also indicate whether or not the proposed BLRT Extension project would pursue a noise variance in any municipality along the proposed BLRT Extension project corridor. The Council will review noise variance requests prior to submittal to MPCA for approval.

Advanced notice will be provided to affected communities of any planned abnormally loud construction activities. In general, construction would occur within daytime hours. However, night construction may sometimes be required, for example to minimize traffic impacts or to improve safety. If nighttime construction is deemed necessary, during the proposed BLRT Extension

project's final design and construction stages, a nighttime construction mitigation plan will be developed.

Table 5-4 shows noise levels of typical construction equipment from the FTA guidance manual, in terms of the maximum levels at 50 feet. Construction noise predictions at noise-sensitive locations depends on the amount of noise during each construction phase, the duration of the noise, and the distance from the construction activities to the sensitive receptor. Conducting a construction noise impact assessment requires knowledge of the equipment likely to be used, the duration of its use, and the way it will be used by a contractor. The L_{eq} for a particular set of assumptions is estimated using typical noise levels from **Table 5-4**.

Table 5-4. Typical Construction Noise Levels

Equipment Type	Typical Noise Level (dBA) 50 ft
Backhoe	80
Compactor	82
Concrete mixer	85
Concrete pump	82
Crane, derrick	88
Crane, mobile	83
Dozer	85
Grader	85
Loader	85
Paver	89
Pump	76
Roller	74
Truck	88

Source: FTA, 2006

Table 5-5 provides an example of a construction noise projection for typical at-grade track construction. Using these assumptions, an 8-hour L_{eq} of 88 dBA would be projected at a distance of 50 feet from the construction site.

Using the criteria in **Section 2.1.2** and the example for at-grade construction in **Table 5-4**, screening distances for at-grade track construction noise impact can be determined. For residential land use, the potential for short-term at-grade track construction noise (**Table 5-5**) impact could extend to approximately 120 feet from the proposed BLRT Extension project corridor; however, if nighttime construction is conducted, the potential for short-term noise impact from at-grade construction could extend to approximately 380 feet from the proposed BLRT Extension project corridor.

See **Section 6.1.2** for more information regarding the approach to mitigating construction noise.

Table 5-5. Typical Construction Scenario, At-Grade Track Construction

Equipment Type	Typical Noise Level (dBA) 50 ft	Equipment Utilization Factor (%)	L_{eq} (dBA)
Grader	85	50	82
Backhoe	80	40	76
Compactor	82	20	75
Loader	85	20	78
Roller	74	20	67
Truck	88	40	84
Crane, mobile	83	20	76
		Total 8-hour workday L_{eq} at 50 ft	**88**

Source: CSA, 2015

5.2 Vibration

The FTA guidance manual on noise and vibration (FTA, 2006) is the primary source for the vibration methodology. The Final EIS uses a Detailed Vibration Assessment methodology, as described in Chapter 11 of the FTA guidance manual (FTA, 2006).

The vibration assessment steps employed included the following:

- Identified vibration-sensitive land uses in the proposed BLRT Extension project corridor using aerial photography, GIS data, and field surveys, typically within 300 feet of the alignment.
- Measured vibration-propagation characteristics of the soil in the proposed BLRT Extension project corridor at sensitive receptors (see **Section 4.2.2 – Affected Environment**).
- Projected proposed BLRT Extension project vibration levels from transit operations, using proposed BLRT Extension project drawings provided by the engineering team, and information on speeds, headways, track type, and vehicle vibration characteristics.
- Assessed the impact from transit by comparing the proposed BLRT Extension project vibration with the FTA vibration impact criteria in Chapter 8 of the FTA guidance manual (FTA, 2006).
- Recommended mitigation at locations where proposed BLRT Extension project vibration levels exceed the impact criteria.

5.2.1 Proposed BLRT Extension Project Vibration

This section describes the vibration impacts for the proposed BLRT Extension project. The proposed BLRT Extension project team conducted a Detailed Vibration Analysis and summaries of the analysis results are presented in **Tables 5-6 and 5-7** for residential and institutional (e.g., churches and schools) land uses, respectively.

The results include a tabulation of location information for each sensitive receptor group, the projections of future vibration levels, the impact criteria, and whether there would be vibration

impacts. The tables also show the total number vibration impacts for each location, without mitigation measures.

As shown in **Table 5-6**, the proposed BLRT Extension project would result in 28 vibration impacts for residential land uses (see **Appendix D** for locations of impacts). A summary of each residential location that would experience vibration impacts follows.

Table 5-6. Summary of Vibration Impacts for Residential Land Use

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Proposed BLRT Extension Project Vibration Levels (VdB)		# of Impacts
					Proposed BLRT Extension Project	FTA Impact Criterion	
I-94 to Humboldt Ave N	Minneapolis	NB	205	30	54	72	0
I-94 to Humboldt Ave N	Minneapolis	SB	170	30	55	72	0
Humboldt Ave N to Penn Ave N	Minneapolis	NB	100	40	58	72	0
Humboldt Ave N to Penn Ave N	Minneapolis	SB	190	40	55	72	0
Penn Ave N to Upton Ave N	Minneapolis	NB	110	35	48	72	0
Penn Ave N to BNSF freight tracks	Minneapolis	SB	155	40	46	72	0
Olson Mem Hwy to Oak Park Ave N	Minneapolis	NB	35	35	58	72	0
Oak Park Ave N to Plymouth Ave N	Minneapolis	NB	60	55	49	72	0
Plymouth Ave N to 16th Ave N	Golden Valley	NB	265	45	43	72	0
16th Ave N to Golden Valley Rd	Golden Valley	NB	30	45	55	72	0
Golden Valley Rd to 26th Ave N	Golden Valley	NB	80	55	56	72	0
26th Ave N to 31½ Ave N	Robbinsdale	NB	90	55	45	72	0
31½ Ave N to 34th Ave N	Robbinsdale	NB	20	55	66	72	0
34th Ave N to 36th Ave N	Robbinsdale	NB	60	55	67	72	0
34th Ave N to 36th Ave N	Robbinsdale	SB	140	55	54	72	0
36th Ave N to 38th Ave N	Robbinsdale	NB	35	55	77	72	26
36th Ave N to 38th Ave N	Robbinsdale	SB	75	55	63	72	0
38th Ave N to 40½ Ave N	Robbinsdale	NB	35	55	76	72	1
38th Ave N to 40th Ave N	Robbinsdale	SB	70	45	64	72	0
40½ Ave N to 42nd Ave N	Robbinsdale	NB	90	45	60	72	0
40th Ave N to 42nd Ave N	Robbinsdale	SB	130	30	57	72	0
42nd Ave N to MN-100	Robbinsdale	NB	90	50	61	72	0
42nd Ave N to MN-100	Robbinsdale	SB	70	40	61	72	0
MN-100 to 47th Ave N	Robbinsdale	NB	120	55	68	72	0
MN-100 to 47th Ave N	Robbinsdale	SB	80	55	62	72	0
47th Ave N to CP rail crossing	Crystal	NB	35	55	72	72	1
47th Ave N to CP rail crossing	Crystal	SB	120	55	58	72	0
CP rail crossing to 56th Ave N	Crystal	NB	735	40	55	72	0
CP rail crossing to 56th Ave N	Crystal	SB	80	25	57	72	0

Table 5-6. Summary of Vibration Impacts for Residential Land Use

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Proposed BLRT Extension Project Vibration Levels (VdB)		# of Impacts
					Proposed BLRT Extension Project	FTA Impact Criterion	
56th Ave N to 60th Ave N	Crystal	NB	695	30	51	72	0
56th Ave N to 60th Ave N	Crystal	SB	165	55	55	72	0
60th Ave N to 63rd Ave N	Crystal	NB	180	55	55	72	0
60th Ave N to 63rd Ave N	Crystal	SB	135	55	56	72	0
63rd Ave N to I-694	Brooklyn Park	NB	280	55	54	72	0
63rd Ave N to I-694	Brooklyn Park	SB	140	35	53	72	0
I-694 to 73rd Ave N	Brooklyn Park	NB	735	55	51	72	0
I-694 to 73rd Ave N	Brooklyn Park	SB	170	55	63	72	0
73rd Ave N to Brooklyn Blvd	Brooklyn Park	NB	75	35	57	72	0
Brooklyn Blvd to Shingle Creek	Brooklyn Park	NB	80	45	60	72	0
Shingle Creek to 85th Ave N	Brooklyn Park	SB	70	40	71	72	0
85th Ave N to 89th Ave N	Brooklyn Park	NB	85	45	59	72	0
89th Ave N to 93rd Ave N	Brooklyn Park	NB	70	45	62	72	0
						Total	**28**

Source: CSA, 2015
The vibration levels for each location are the highest levels projected for that location. Vibration projections at other receptors within each location would be lower. The threshold of human perception to LRT vibration is approximately 65 VdB or less, and annoyance begins to occur for frequent events at vibration levels over 70 VdB.

- **36th Avenue North to 38th Avenue North.** The vibration impacts at this location include the Windsor Court Apartments and a duplex to the north of the apartments. The residences are located to the east of the alignment. The impacts at this location are due to the speed of the LRT and the proximity of the residences to the proposed LRT alignment.
- **38th Avenue North to 40½ Avenue North.** The vibration impacts at this location include one single-family residence located to the east of the alignment. The impacts at this location are due to the speed of the LRT and the proximity of the residence to the proposed LRT alignment.
- **47th Avenue North to CP Rail Crossing.** The vibration impacts at this location include one single-family residence located to the east of the alignment. The impacts at this location are due to the speed of the LRT and the proximity of the residence to the proposed LRT alignment.

As shown in **Table 5-7**, the proposed BLRT Extension project would result in no vibration impacts for institutional land uses.

Table 5-7. Summary of Vibration Impacts for Institutional Land Use

Location	City	Side of Track	Near Track Dist. (ft)	Speed (mph)	Proposed BLRT Extension Project Vibration Levels (VdB)		# of Impacts
					Proposed BLRT Extension Project	FTA Impact Criterion	
Sumner Library	Minneapolis	NB	110	20	45	78	0
Wayman AME Church	Minneapolis	NB	135	30	46	78	0
Seed Academy	Minneapolis	NB	135	40	47	78	0
Summit Academy	Minneapolis	SB	225	20	41	78	0
Zion Baptist Church	Minneapolis	NB	185	40	55	78	0
Le Creche Early Childhood Center	Minneapolis	NB	135	40	47	78	0
The Family Partnership	Golden Valley	NB	55	35	46	78	0
The Chalet	Golden Valley	SB	925	20	38	78	0
Bethel World Outreach	Robbinsdale	NB	520	55	51	78	0
Elim Lutheran Church	Robbinsdale	NB	800	50	51	78	0
Sacred Heart Church	Robbinsdale	NB	300	35	53	78	0
Robbins Gallery	Robbinsdale	SB	110	20	53	78	0
Washburn McReavy Funeral Home	Crystal	NB	255	25	51	78	0
Masonic Lodge	Robbinsdale	NB	455	30	51	78	0
Redeemer Lutheran Church	Robbinsdale	SB	505	40	55	78	0
Crystal Medical Center	Crystal	NB	180	30	51	78	0
Little Folks Daycare	Crystal	SB	85	25	53	78	0
Prince of Peace Lutheran Church	Brooklyn Park	NB	385	35	39	78	0
Brooklyn Park Evangelical Free Church	Brooklyn Park	SB	145	45	52	78	0
North Hennepin Community College	Brooklyn Park	NB	75	20	56	78	0
Step by Step Montessori School	Brooklyn Park	SB	285	25	47	78	0
Berean Baptist Church	Brooklyn Park	SB	80	45	60	78	0
Ebenezer Community Church	Brooklyn Park	NB	135	20	49	78	0

Source: CSA, 2015

The vibration levels for each location are the highest levels projected for that location. Vibration projections at other receptors within each location would be lower. The threshold of human perception to LRT vibration is approximately 65 VdB or less, and annoyance begins to occur for frequent events at vibration levels over 70 VdB.

5.2.2 Cultural Resources

Based on data provided by MnDOT CRU of listed and eligible historic properties within the proposed BLRT Extension project vicinity, an assessment of the historic and cultural resources was conducted for the proposed BLRT Extension project. The assessment was conducted to determine the vibration sensitivity of the resources along the proposed BLRT Extension project corridor. For each resource site, a determination was made regarding the vibration sensitivity of the use and the FTA category it would fall under based on FTA guidance. The result of the assessment, which is summarized in **Table 5-8**, is that there are no vibration impacts at any historic or cultural resources along the proposed BLRT Extension project corridor.

In addition to the operational (long-term) assessment described above, an assessment for the potential for vibration-related construction (short-term) impacts also was conducted. The criteria for construction vibration impacts to damage buildings are based on the building category and fragility of the building, not its designation or use as a historic resource. In most cases, vibration generated by construction activities does approach levels high enough to cause damage, even for fragile buildings. The exceptions to this can be for activities such as vibratory rolling and impact pile driving. At distances within approximately 50 feet, these activities have the potential for damage to the most sensitive structures. Based on the list of the structures in **Table 5-7**, they would either not be included in the most stringent category or would not be close enough for there to be any potential for damage. Therefore additional assessment is not warranted.

5.2.3 Stations

There is no additional vibration associated with stations, and no vibration assessment for stations has been conducted.

5.2.4 Operations and Maintenance Facility

The operations and maintenance facility (OMF) is located more than 1,000 feet from any vibration-sensitive receptors and therefore no vibration impact is projected.

Table 5-8. Summary of Historic and Cultural Resources Vibration Assessment

Inventory #	Property Name	City	FTA Noise Cat.[1]	Notes
HE-CRC-199	Minneapolis & Pacific Railway Historic District (Soo Line)	Crystal	N/A	Not vibration sensitive.
HE-RBC-264	Jones-Osterhus Barn	Robbinsdale	N/A	Not vibration sensitive.
HE-RBC-158	West Broadway Avenue Residential Historic District	Robbinsdale	2	No vibration impact.
HE-RBC-024	Former Hennepin County Library, Robbinsdale Branch	Robbinsdale	3	No vibration impact.
HE-RBC-286	Robbinsdale Waterworks	Robbinsdale	N/A	Not vibration sensitive.
HE-RBC-1462	Sacred Heart Catholic Church	Robbinsdale	3	No vibration impact.
XX-PRK-001	Grand Rounds Historic District – Theodore Wirth Park Segment	Golden Valley, Minneapolis	N/A	Not vibration sensitive.
HE-GVC-0050	Bridge No. L9327	Golden Valley	N/A	Not vibration sensitive.
HE-MPC-12101	Homewood Residential Historic District	Minneapolis	2	No vibration impact.
HE-MPC-9013	Floyd B. Olson Memorial Statue	Minneapolis	N/A	Not vibration sensitive.
HE-MPC-7553	Labor Lyceum	Minneapolis	3	No vibration impact.
HE-MPC-8290	Wayman AME Church	Minneapolis	3	No vibration impact.
HE-MPC-8081	Sumner Branch Library	Minneapolis	3	No vibration impact.
HE-MPC-8125	Northwestern Knitting Company Factory	Minneapolis	2	No vibration impact.
HE-MPC-0441	Minneapolis Warehouse Historic District	Minneapolis	2	No vibration impact.
XX-RRD-010 (district)	St. Paul, Minneapolis & Manitoba (StPM&M)/Great Northern (GN) Railway Historic District	Minneapolis	N/A	Not vibration sensitive.
Including HE-RRD-002; HE-BPC-0084; HE-CRC-0238; HE-RBC-0304; HE-MPC-16389	Osseo Branch of the StPM&M/GN Railway Historic District	Minneapolis, Golden Valley, Robbinsdale, Crystal, Brooklyn Park	N/A	Not vibration sensitive.

Source: CSA, 2015

[1] N/A - Not included in any of the FTA vibration-sensitive categories. Not vibration sensitive.

5.2.5 Construction Vibration

Unlike typical LRT operations, there is the potential for damage to nearby structures at close distances due to construction vibration from activities such as pile driving, hoe rams, vibratory compaction and loaded trucks. Most limits on construction vibration are based on reducing the potential for damage to nearby structures. Although construction vibrations are only temporary, it is still reasonable to assess the potential for human annoyance and damage.

Since most of the buildings in the study area are typical engineered concrete and masonry or reinforced concrete, steel or timber construction, a vibration criterion of 98 VdB has been used to asses potential damage impact and 72 VdB has been used to assess potential vibration annoyance from construction activities. Vibration source levels at 25 feet and the distances to potential residential annoyance and potential damage are shown in **Table 5-9**. With the exception of impact pile driving, the potential for damage is limited to within 20 feet of construction activities. For impact pile driving, the distance for the potential for damage is up to 40 feet.

Because the exact location of construction equipment is important in projecting vibration levels, a more detailed assessment of potential vibration damage will be performed during final design when more accurate equipment locations are known. It is important to note that this assessment does not address potential damage to structures due to soil settlement or displacement due to construction activities. A summary of geological conditions and soils is found in Section 5.4 of the Final EIS. Section 4.3 of the Final EIS addresses issues related to potential displacement of residents and businesses resulting from the proposed BLRT Extension project.

Table 5-9. Summary of Potential Construction Vibration Impacts

Equipment	Vibration Level at 25 ft (VdB)	Distance to Potential Damage (98 VdB), ft	Distance to Potential Annoyance (72 VdB), ft
Impact pile driving	104	40	300
Push piling	84	8	62
Hoe ram	87	10	80
Caisson drilling	87	10	80
Loaded trucks	86	10	75
Clam shovel	94	20	135
Vibratory roller	94	20	135

Source: CSA, 2015

6 Mitigation Measures

6.1 Noise

FTA guidance states that severe noise impacts should be mitigated unless there are no feasible or practical means to do so (FTA, 2006). For moderate impacts, discretion should be used, and proposed BLRT Extension project–specific factors should be included in the consideration of mitigation. The proposed BLRT Extension project–specific factors can include both the existing noise levels and the projected increase in noise levels; the types and number of noise-sensitive land uses with impacts; existing sound insulation of buildings; and the cost-effectiveness of providing noise mitigation. The Council has adopted a mitigation approach that details which moderate impacts will qualify for mitigation. This approach is detailed in **Section 6.1.1** below.

6.1.1 Metro Transit Noise Mitigation Approach

6.1.1.1 Noise Mitigation Thresholds (Part A)

Per FTA guidance, noise mitigation will be provided for all "Severe" impacts that meet the criteria for reasonableness, feasibility, and cost-effectiveness, as defined under Part B below.

At the "Moderate" impact level, FTA guidance requires the proposed BLRT Extension project sponsor to consider mitigation based on a number of factors, as defined in the FTA guidance manual. For the proposed BLRT Extension project, noise mitigation will be provided for all "Moderate" impacts, caused by the proposed BLRT Extension project, that meet the criteria for reasonableness, feasibility, and cost-effectiveness, as defined under Part B below, and at locations where the proposed BLRT Extension project has a "Moderate" impact and one of the following thresholds are exceeded:

1. Location(s) where the existing noise levels without the proposed BLRT Extension project are already 65 dBA L_{dn} or greater (see Exhibit 2.1-1).[6]
2. Location(s) where there is an increase of 3 dB or more in the L_{dn} over the existing level due to the proposed BLRT Extension project.[7]
3. The predicted increase in the L_{dn} over the existing level is less than 3 dB, the location is adjacent to an area with either "Severe Impact" or "Moderate Impact" with an increase in the L_{dn} of 3 dB or greater, and the inclusion of the adjacent properties will provide a logical and equitable terminus to the mitigation.

[6] A noise level of 65 dBA or greater is considered a "normally unacceptable" noise environment by the US Department of Housing and Urban Development. This threshold is also used by the Federal Aviation Administration for compatible land use.

[7] An increase in noise of 3 dB is generally considered the threshold for a noticeable change in noise in an outdoor setting and falls roughly at the midpoint of the "Moderate" impact range. This is a common threshold used in transit agency noise mitigation policies for an increase requiring mitigation.

6.1.1.2 Noise Mitigation Criteria (Part B)

Criteria for reasonableness, feasibility, and cost-effectiveness as included in FTA guidance are described below.

1. **Reasonableness:** For noise mitigation to be considered reasonable, it must provide at least a 5-dB reduction in proposed BLRT Extension project noise.[8]
2. **Feasibility:**
   - For noise mitigation to be considered feasible it must be practical from engineering, operations, and safety standpoints.
   - Other proposed BLRT Extension project factors may need to be considered in determining feasibility of mitigation. These could include community input, visual impacts and other proposed BLRT Extension project features that might limit mitigation.
3. **Cost-Effectiveness:** For noise mitigation to be considered cost-effective, the cost per benefited should be approximately what it would cost to build a 10-foot-high noise wall.

6.1.2 Noise Mitigation Methods

Several options exist for providing noise mitigation at the source, path or receiver. The most common noise mitigation measures are described below.

6.1.2.1 Source

Resilient or Damped Wheels: Using either resilient or damped wheels can achieve approximately a 2-dB reduction in wheel/rail noise from transit vehicles on typical track sections.

Track Dampers: Using damping materials on tracks can achieve an approximately 1–3-dB reduction in noise radiated from the tracks on typical track sections.

Vehicle Design: Certain design features of transit vehicles can provide some shielding and/or absorption of the noise generated by the vehicle. Acoustical absorption under the car can provide up to a 5-dB reduction in wheel/rail noise and propulsion-system noise on rapid transit trains. Similarly, vehicle skirts (which the existing Metro Transit vehicles have) over the wheels can provide up to 5 dB of reduction in noise.

Special Trackwork: Gaps in the rails at crossovers and turnouts generates around 6 dB of increased noise for locations close to the track. If crossover are located in sensitive areas and cannot be moved, one approach is to use special trackwork, such as spring-rail, moveable point, or flange bearing frogs to eliminate the gap in the rail at the crossover.

Quiet Zones: Quiet Zones are locations, as least one-half mile in length, where the sounding of horns has been eliminated because of safety improvements at at-grade crossings, including modifications

[8] 5 dB is a typical minimum reduction used by many agencies for mitigation to be considered an effective and reasonable mitigation measure.

to the streets, raised median barriers, four quadrant gates, and other improvements. Horns will only be sounded in emergency situations at these locations.

Wayside Devices: Wayside devices are mounted at the at-grade-crossing, directed down the roadway instead of mounted on the vehicle. The wayside devices are directive and provide warning to motorists and pedestrians at the at-grade crossing while limiting the noise exposure to areas adjacent to the crossing.

6.1.2.2 Path

Noise Barriers: This is the most common approach to reducing noise impacts from transit and rail projects. For noise barriers to be effective, they must break the line-of-sight between the source of the noise and the receiver. Additionally, the barrier must be made of a material that has a minimum surface density of 4 pounds/square foot and not have any gaps or holes that could degrade the performance of the barrier. Noise barriers can be made of virtually any material that meets these requirements, and can typically provide between 5 and 10 dB of reduction, depending on the design of the barrier. Proposed BLRT Extension project features, such as retaining walls or crash walls can act as effective noise barriers.

Berms: Berms are another approach to mitigating noise at the path. Berms work in much the same way as barriers, and need to block the line of sight between the source and the receiver to be effective. Berms can also provide between 5 and 10 dB of reduction, but are not commonly used in transit applications due to the space requirements (a berm typically must be twice as wide as it is tall).

6.1.2.3 Receiver

Sound Insulation: In locations where noise barriers are not feasible or practical, for multi-story buildings, or at locations where there is no exterior use, sound insulation of buildings can be an effective approach to noise mitigation. While it does not provide mitigation for exterior use, it can be very effective for indoor uses and provide between 5 and 10 dB of reduction. Sound insulation typically focuses on improvements to windows and doors, sealing any gaps or holes and providing central ventilation and air conditioning so that windows can remain closed. The criterion for indoor noise levels is 45 dBA L_{dn}.

6.1.3 Proposed BLRT Extension Project Noise Mitigation

The results in **Table 6-1** indicate that most residential noise impacts which meet the threshold for mitigation will be eliminated, based on FTA criteria, with the proposed mitigation measures. Quiet Zones, which allow for the use of LRT bells instead of horns at at-grade crossings, will eliminate most noise impacts. Additionally, the Quiet Zones will have the additional benefit of eliminating the existing freight horns as well. Additional mitigation measures required after implementation of Quiet Zones are shown in **Table 6-1**. More detailed descriptions of the noise mitigation measures are provided below.

Table 6-1. Summary of Residential Noise Mitigation Measures

Location	City	Side of Track	Type and # of Impacts without Mitigation[1]		Noise Level Increase[2] (dB)	Proposed Mitigation Measure[3]	Residual Impacts with Mitigation	
			Mod	Sev			Mod	Sev
I-94 to Humboldt Ave N	Minneapolis	NB	16	0	0 to 1.8	None[4]	N/A	N/A
Humboldt Ave N to Penn Ave N	Minneapolis	NB	9	0	0 to 2.9	None[4]	N/A	N/A
Olson Mem Hwy to Oak Park Ave N	Minneapolis	NB	1	0	0.1 to 5.8	Interior testing to determine mitigation measure[5]	0	0
Oak Park Ave N to Plymouth Ave N	Minneapolis	NB	3	0	1.3 to 6.8	Interior testing to determine mitigation measure[5]	0	0
Plymouth Ave N to 16th Ave N	Golden Valley	NB	9	0	0.1 to 5.6	Interior testing to determine mitigation measure[5]	0	0
16th Ave N to Golden Valley Rd	Golden Valley	NB	1	0	0.2 to 3.5	Interior testing to determine mitigation measure[5]	0	0
Golden Valley Rd to 26th Ave N	Golden Valley	NB	9	14	0.9 to 15.2	Noise barrier E-2: 10 feet tall, 2,540 feet long	1	1
26th Ave N to 31½ Ave N	Robbinsdale	NB	3	0	3.8 to 9.6	Noise barrier E-2: 10 feet tall, 2,540 feet long	0	0
31½ Ave N to 34th Ave N	Robbinsdale	NB	4	12	1.8 to 19.4	Noise barrier E-3: 10 feet tall, 1,200 feet long	4	1
34th Ave N to 36th Ave N	Robbinsdale	NB	20	5	0.7 to 8.3	Noise barrier E-4: 8 feet tall, 1,325 feet long	0	0
34th Ave N to 36th Ave N	Robbinsdale	SB	1	0	2.7 to 4.1	Interior testing to determine mitigation measure[5]	0	0
36th Ave N to 38th Ave N	Robbinsdale	NB	8	27	0.9 to 16.7	Noise barrier E-6: 8 feet tall, 3,110 feet long	0	0
36th Ave N to 38th Ave N	Robbinsdale	SB	4	0	0.1 to 9.0	Noise barrier W-5: 6 feet tall, 650 feet long	0	0
38th Ave N to 40½ Ave N	Robbinsdale	NB	3	20	0 to 16.6	Noise barrier E-6: 8 feet tall, 3,110 feet long	0	0

Table 6-1. Summary of Residential Noise Mitigation Measures

Location	City	Side of Track	Type and # of Impacts without Mitigation[1]		Noise Level Increase[2] (dB)	Proposed Mitigation Measure[3]	Residual Impacts with Mitigation	
			Mod	Sev			Mod	Sev
38th Ave N to 40th Ave N	Robbinsdale	SB	20	5	0 to 11.1	Noise barrier W-7: 6 feet tall, 1,850 feet long and interior testing to determine mitigation measure	0	0
40½ Ave N to 42nd Ave N	Robbinsdale	NB	5	2	0.1 to 11.6	Wayside device and noise barrier E-6: 8 feet tall, 3,110 feet long	0	0
40th Ave N to 42nd Ave N	Robbinsdale	SB	13	2	0 to 7.3	Wayside device and interior testing to determine mitigation measure[5]	0	0
42nd Ave N to MN-100	Robbinsdale	NB	2	0	0 to 3.4	Interior testing to determine mitigation measure[5]	0	0
42nd Ave N to MN-100	Robbinsdale	SB	2	1	0 to 4.6	Wayside device	0	0
MN-100 to 47th Ave N	Robbinsdale	NB	10	1	0.1 to 5.0	Wayside device and noise barrier E-10: 10 feet tall, 1,300 feet long and interior testing to determine mitigation measure	0	0
MN-100 to 47th Ave N	Robbinsdale	SB	8	0	0 to 3.6	Wayside device and interior testing to determine mitigation measure[5]	0	0
47th Ave N to freight tracks	Crystal	NB	11	31	0 to 18.5	Wayside device, noise barrier E-10: 10 feet tall, 1,300 feet long, noise barrier E-11: 10 feet tall, 1,100 feet long, and interior testing to determine mitigation measure	0	0
47th Ave N to freight tracks	Crystal	SB	0	0	0.1 to 1.8	None required	0	0
56th Ave N to 60th Ave N	Crystal	NB	0	0	0 to 0.4	None required	0	0
56th Ave N to 60th Ave N	Crystal	SB	0	0	0 to 4.6	None required	0	0

Table 6-1. Summary of Residential Noise Mitigation Measures

Location	City	Side of Track	Type and # of Impacts without Mitigation[1]		Noise Level Increase[2] (dB)	Proposed Mitigation Measure[3]	Residual Impacts with Mitigation	
			Mod	Sev			Mod	Sev
60th Ave N to 63rd Ave N	Crystal	NB	0	0	0 to 0.7	None required	0	0
60th Ave N to 63rd Ave N	Crystal	SB	0	0	0 to 1.1	None required	0	0
63rd Ave N to I-694	Brooklyn Park	NB	0	0	0 to 0.3	None required	0	0
I-694 to 73rd Ave N	Brooklyn Park	NB	0	0	0 to 0.6	None required	0	0
I-694 to 73rd Ave N	Brooklyn Park	SB	0	0	0 to 0.7	None required	0	0
73rd Ave N to Brooklyn Blvd	Brooklyn Park	NB	4	0	0 to 2.4	None[4]	N/A	N/A
Shingle Creek to 85th Ave N	Brooklyn Park	SB	5	0 (0)	0 to 2.9	None[4]	N/A	N/A
89th Ave N to 93rd Ave N	Brooklyn Park	NB	5	0 (0)	0.3 to 0.8	None[4]	N/A	N/A

Source: CSA, 2015

N/A = not applicable

[1] The number of impacts without mitigation reflects the implementation of Quiet Zones. Quiet Zones are locations, at least one-half mile in length, where the routine sounding of horns has been eliminated because of safety improvements at at-grade crossings, including modifications to the streets, raised median barriers, four quadrant gates, and other improvements designed and implemented by the proposed BLRT Extension project and consistent with Quiet Zone readiness. Horns are sounded in emergency situations at these locations. Municipalities must apply to FRA for approval of Quiet Zones.

[2] The reported noise level increases are the range of increases in noise levels (without mitigation) due to the proposed BLRT Extension project for each location.

[3] If the proposed noise mitigation does not meet the reasonableness criteria as defined in the Regional Transitways Guidelines (March 2016) (see **Appendix F** of the Final EIS), or if the property owner(s) does not approve sound insulation, the proposed BLRT Extension project will result in additional residual noise impacts.

[4] The moderate impacts at these locations do not meet the threshold for mitigation as defined by the Regional Transitways Guidelines (March 2016) (see **Appendix F** of the Final EIS).

[5] The Council has determined that a noise barrier at these locations would not meet the reasonableness criteria for noise mitigation as defined in the Regional Transitways Guidelines (March 2016); specifically, a noise barrier at these locations does not meet cost-effectiveness criteria. As such, no noise barrier will be constructed to mitigate impacts to these residences. Final determination of mitigation measures for these residences will be assessed with on-site testing to determine if the residences meet the interior noise level criteria. Based on the results, the Council will identify the noise mitigation to be implemented for these residences during Engineering and once on-site measurements are completed. If an exceedance of interior noise level is identified at these locations, the Council will work with property owners on applicable mitigation. This could include implementation of sound insulation, which would still require approval by the property owner(s).

- **Olson Memorial Highway to Oak Park Avenue North, Minneapolis**. The potential mitigation measure at this location would include on-site testing to determine if the residences meet the interior noise level criteria.
- **Oak Park Avenue North to Plymouth Avenue North, Minneapolis**. The potential mitigation measure at this location would include on-site testing to determine if the residences meet the interior noise level criteria.

- **Plymouth Avenue North to 16th Avenue North, Golden Valley**. The potential mitigation measure at this location would include on-site testing to determine if the residences meet the interior noise level criteria.
- **16th Avenue North to Golden Valley Road, Golden Valley**. The potential mitigation measure at this location would include on-site testing to determine if the residences meet the interior noise level criteria.
- **Golden Valley Road to 26th Avenue North, Golden Valley**. The potential mitigation measure at this location would include a 10-foot-high, 2,540-foot-long noise barrier.
- **26th Avenue North to 31½ Avenue North, Robbinsdale**. The potential mitigation measure at this location would include a 10-foot-high, 2,540-foot-long noise barrier.
- **31½ Avenue North to 34th Avenue North, Robbinsdale**. The potential mitigation measure at this location would include a 10-foot-high, 1,200-foot-long noise barrier.
- **34th Avenue North to 36th Avenue North (NB), Robbinsdale**. The potential mitigation measure at this location would include an 8-foot-high, 1,325-foot-long noise barrier.
- **34th Avenue North to 36th Avenue North (SB), Robbinsdale**. The potential mitigation measure at this location would include on-site testing to determine if the residences meet the interior noise level criteria.
- **36th Avenue North to 38th Avenue North (NB), Robbinsdale.** The potential mitigation measure at this location would include an 8-foot-high, 3,110-foot-long noise barrier.
- **36th Avenue North to 38th Avenue North (SB), Robbinsdale**. The potential mitigation measure at this location would include a 6-foot-high, 650-foot-long noise barrier.
- **38th Avenue North to 40½ Avenue North, Robbinsdale**. The potential mitigation measure at this location would include an 8-foot-high, 3,110-foot-long noise barrier.
- **38th Avenue North to 40th Avenue North, Robbinsdale**. The potential mitigation measures at this location would include a 6-foot-high, 1,850-foot-long noise barrier and on-site testing to determine if the residences meet the interior noise level criteria.
- **40½ Avenue North to 42nd Avenue North, Robbinsdale**. The potential mitigation measures at this location would include a wayside device and an 8-foot-high, 3,110-foot-long noise barrier.
- **40th Avenue North to 42nd Avenue North, Robbinsdale**. The potential mitigation measures at this location would include a wayside device and on-site testing to determine if the residences meet the interior noise level criteria.
- **42nd Avenue North to MN-100 (NB), Robbinsdale**. The potential mitigation measure at this location would include on-site testing to determine if the residences meet the interior noise level criteria.
- **42nd Avenue North to MN-100 (SB), Robbinsdale**. The potential mitigation measure at this location would include a wayside device.

- **MN-100 to 47th Avenue North, Robbinsdale (NB)**. The potential mitigation measures at this location would include a wayside device, a 10-foot-high, 1,300-foot-long noise barrier, and on-site testing to determine if the residences meet the interior noise level criteria.
- **MN-100 to 47th Avenue North, Robbinsdale (SB)**. The potential mitigation measures at this location would include a wayside device and on-site testing to determine if the residences meet the interior noise level criteria.
- **47th Avenue North to CP Rail Crossing, Crystal**. The potential mitigation measures at this location would include a wayside device, a 10-foot-high, 1,300-foot-long noise barrier, and a 10-foot-high, 1,100-foot-long noise barrier and on-site testing to determine if the residences meet the interior noise level criteria.

The results of the noise assessment indicate that residential noise impacts at two locations (Golden Valley Road to 26th Avenue North and 31½ Avenue North to 34th Avenue North) are not mitigated, and that residual noise impacts would remain at these locations after mitigation. The results also indicate that all institutional noise impacts will be eliminated with the proposed mitigation measures. At all institutional locations, Quiet Zones, which allow for the use of LRT bells instead of horns at at-grade crossings, will eliminate the noise impacts. Additionally, the Quiet Zones will have the additional benefit of eliminating the existing freight horns as well. However, if the municipality fails to apply to FRA for Quiet Zone or if FRA fails to approve the Quiet Zone, the proposed BLRT Extension project would result in residual noise impacts at the associated locations.

6.1.4 Construction Noise Mitigation

The primary means of mitigating noise from construction activities is to require the contractors to prepare a detailed Noise Control Plan. A noise control engineer or acoustician will work with the contractor to prepare a Noise Control Plan in conjunction with the contractor's specific equipment and methods of construction. Key elements of a Plan include:

- Contractor's specific equipment types
- Schedule and methods of construction
- Maximum noise limits for each piece of equipment with certification testing
- Prohibitions on certain types of equipment and processes during the nighttime hours without local agency coordination and approved variances
- Identification of specific sensitive sites where near construction sites
- Methods for projecting construction noise levels
- Implementation of noise control measures where appropriate
- Methods for responding to community complaints

6.2 Vibration

Vibration and ground-borne noise impacts that exceed the FTA criteria are considered significant and should be mitigated unless there are no feasible or practical means to do so. Vibration mitigation is primarily applied at the source, generally the track structure, and is dependent on the frequency content of the vibration and any resonances of the materials. The most common vibration mitigation measures are described below.

6.2.1 Vibration Mitigation Methods

Ballast Mats: A ballast mat is a pad made of rubber or other material placed underneath the ballast and mounted on top of an asphalt or concrete base. Ballast mats provide a modest reduction in vibration levels at frequencies above 40 Hz.

Tire Derived Aggregate: Tire Derived Aggregate, or shredded tires, consists of a layer of tire shreds wrapped in geotechnical fabric placed underneath the ballast and placed on hard packed ground. This is a low-cost, but still unproven mitigation option that provides a reduction in vibration levels at frequencies above 25 Hz.

Resilient Rail Fasteners: Resilient fasteners are typically used on direct fixation track on aerial structures or in tunnels. They include a resilient component in the fastener to provide vibration isolation. Resilient rail fasteners provide a reduction in vibration at frequencies above 40 Hz.

Resiliently Supported Concrete Ties: Resiliently supported concrete ties, or undertie pads, consist of a rubber pad mounted on the bottom of a concrete tie. The pads provide vibration isolation at frequencies above 25 Hz.

Floating Slabs: Floating slabs consist of thick concrete slabs mounted on rubber or steel springs pads on a concrete foundation. Floating slabs can provide vibration isolation at very low frequencies, but are expensive to build and maintain.

Special Trackwork: Gaps in the rails at crossovers and turnouts generates around 10 dB of increased vibration for locations close to the track. If crossovers are located in sensitive areas and cannot be moved, one approach is to use special trackwork, such as spring-rail, moveable point, or flange bearing frogs to eliminate the gap in the rail at the crossover.

6.2.2 Proposed BLRT Extension Project Vibration Mitigation

The results in **Table 6-2** indicate that all residential vibration impacts will be eliminated with the proposed mitigation measures (there are no projected institutional vibration impacts). Ballast mats or the equivalent will eliminate the vibration impacts at all locations. Detailed descriptions of the noise mitigation measures are provided below.

Table 6-2. Summary of Residential Vibration Mitigation Measures

Location	City	# of Impacts without Mitigation	Proposed Mitigation Measure	Residual Impacts with Mitigation
6th Ave N to 38th Ave N	Robbinsdale	26	700-foot ballast mat	0
38th Ave N to 40½ Ave N	Robbinsdale	1	300-foot ballast mat	0
47th Ave N to CP rail crossing	Crystal	1	300-foot ballast mat	0
	Total	**28**	**1,300-foot ballast mat**	**0**

Source: CSA, 2015

- **36th Avenue North to 38th Avenue North.** The proposed mitigation at this location would be a ballast mat 700 feet in length under both tracks from Station 2246+50 to Station 2253+50. The ballast mat should be designed to provide at least 5 dB of reduction in vibration levels at 100 Hz and higher.
- **38th Avenue North to 40½ Avenue North.** The proposed mitigation at this location would be a ballast mat 300 feet in length under both tracks from Station 2260+00 to Station 2263+00. The ballast mat should be designed to provide at least 5 dB of reduction in vibration levels at 100 Hz and higher.
- **47th Avenue North to CP Rail Crossing.** The proposed mitigation at this location would be a ballast mat 300 feet in length under both tracks from Station 2335+50 to Station 2338+50. The ballast mat should be designed to provide at least 5 dB of reduction in vibration levels at 100 Hz and higher.

6.2.3 Construction Vibration Mitigation

The most effective methods for minimizing the impact from construction vibration is to limit the use of high-vibration activities such as impact pile driving and vibratory rolling and to include vibration limits in the construction specifications. To mitigate potential vibration impact from construction activities, the following measures will be applied where feasible:

- **Limit Construction Hours:** Prohibit high-vibration activities at night.
- **Construction Specifications:** Include limits on vibration in the construction specifications, especially at locations where high-vibration activities such as impact pile driving may occur.
- **Alternative Construction Methods:** Minimize the use of impact and vibratory equipment, where possible and appropriate. Use low vibration alternatives, such as push piling or pre-drilled holes for piling.
- **Truck Routes:** Use truck haul routes that minimize exposure to sensitive receptors and minimizes damage to roadway surfaces, where appropriate.
- **Pre-Construction Survey:** Perform pre-construction surveys to document the existing conditions of all structures in the vicinity of sites where high-vibration construction activities will be performed.
- **Vibration Monitoring:** If a construction activity has the potential to exceed the damage criteria at any building, the contractor is required to conduct for vibration monitoring and, if the vibration exceeds the limit, the activity must be modified or terminated.

7 References

Federal Transit Administration (FTA), 2006, *Transit Noise and Vibration Impact Assessment* guidance manual (FTA, 2006)

Vibration Measurements and Predictions for Central Corridor LRT Project, ATS Consulting, 2008

Bottineau Transitway Draft EIS, Noise and Vibration Technical Report, HMMH, 2012.

West Broadway Avenue Reconstruction Project Environmental Assessment Worksheet, Hennepin County, 2015

Appendix A. Noise Measurement Data

Figure A-1. Long-Term Noise Measurement Data – Site LT-A

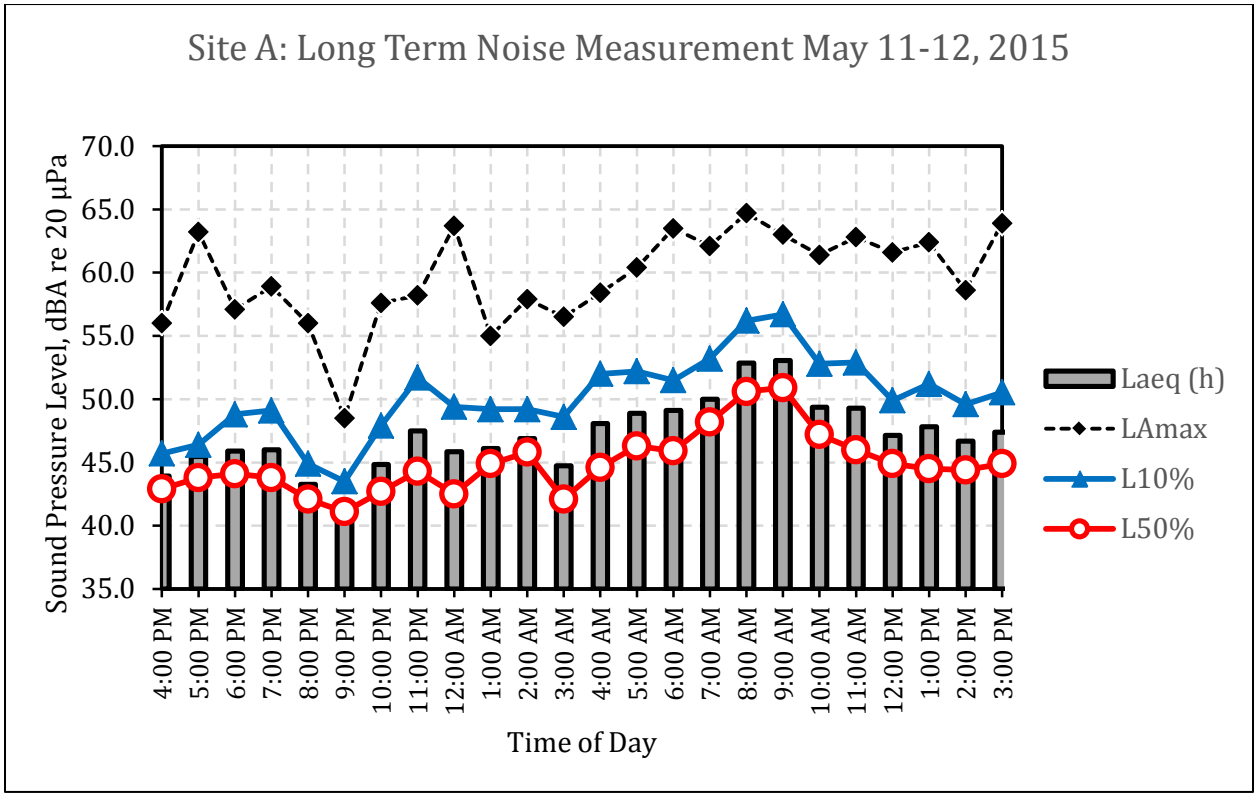


Figure A-2. Long-Term Noise Measurement Data – Site LT-B

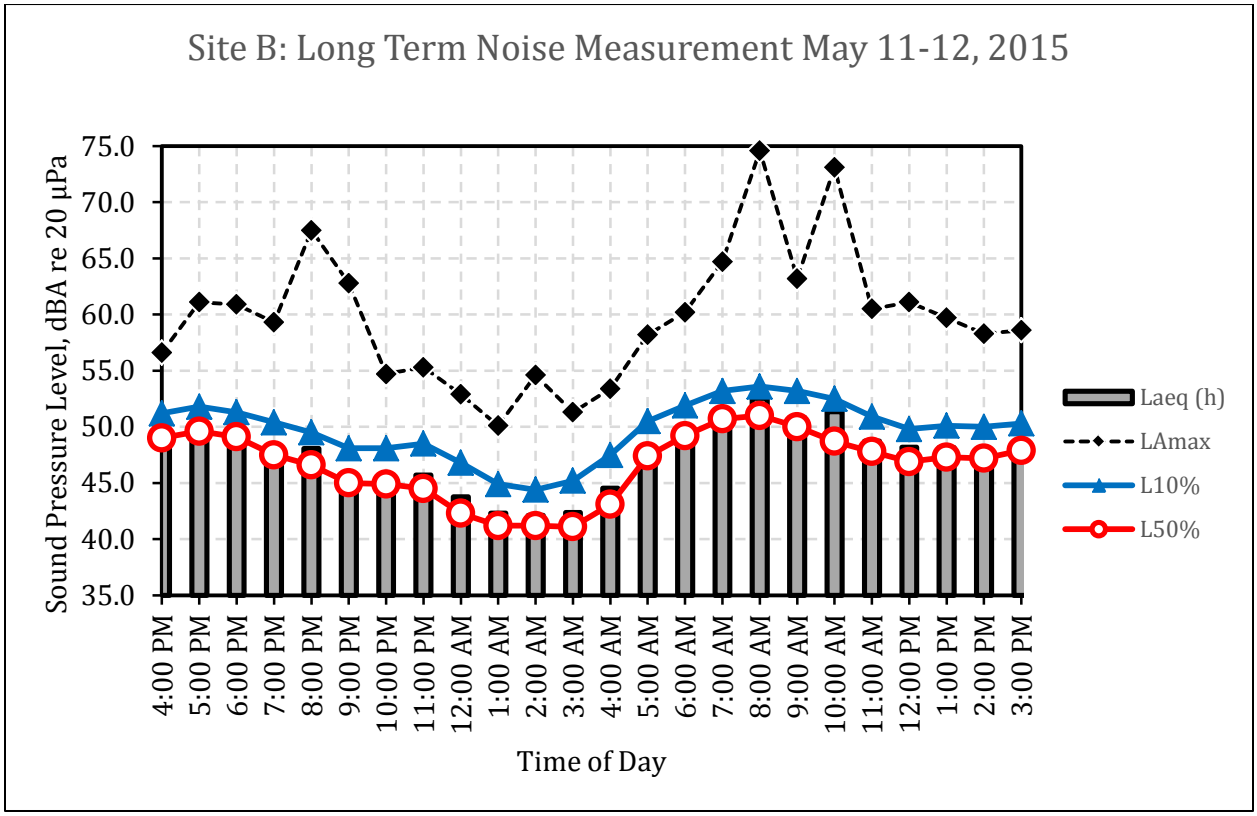


Figure A-3. Long-Term Noise Measurement Data – Site LT-C

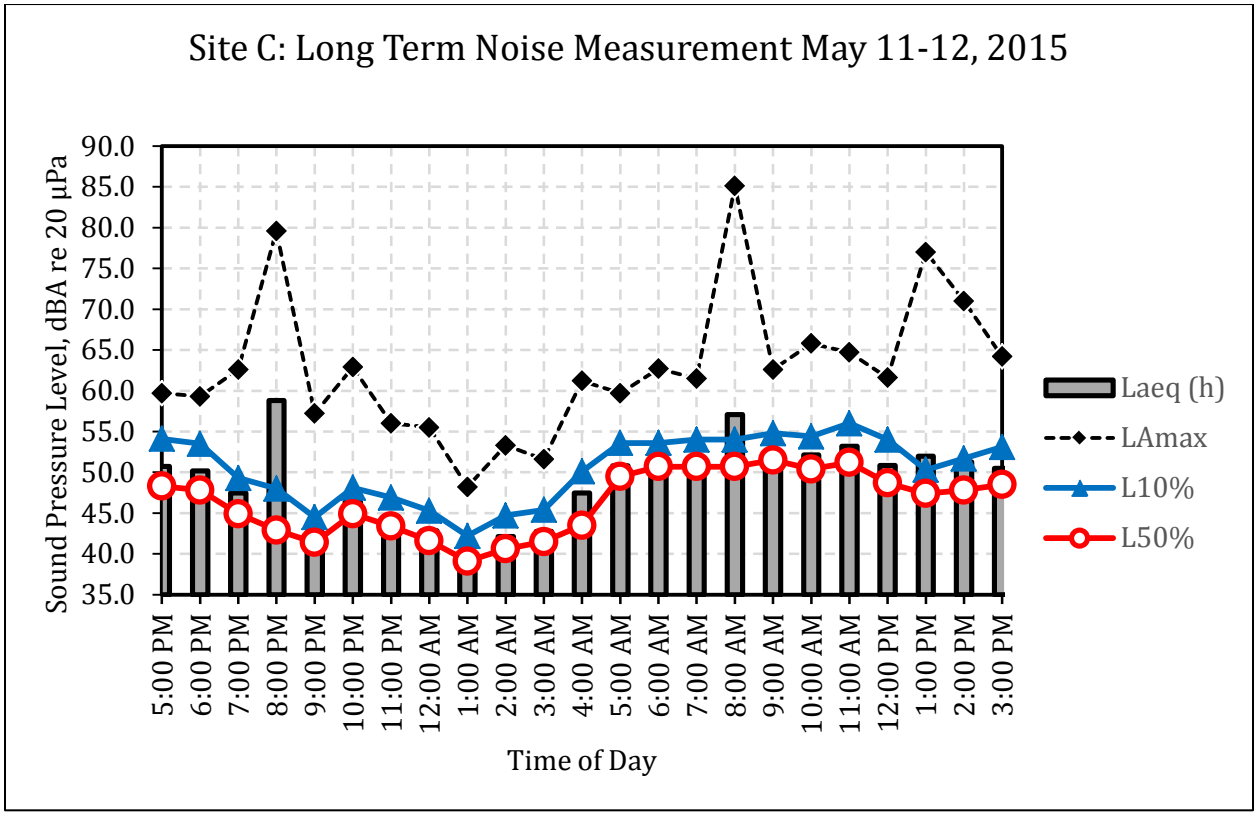


Figure A-4. Long-Term Noise Measurement Data – Site LT-D

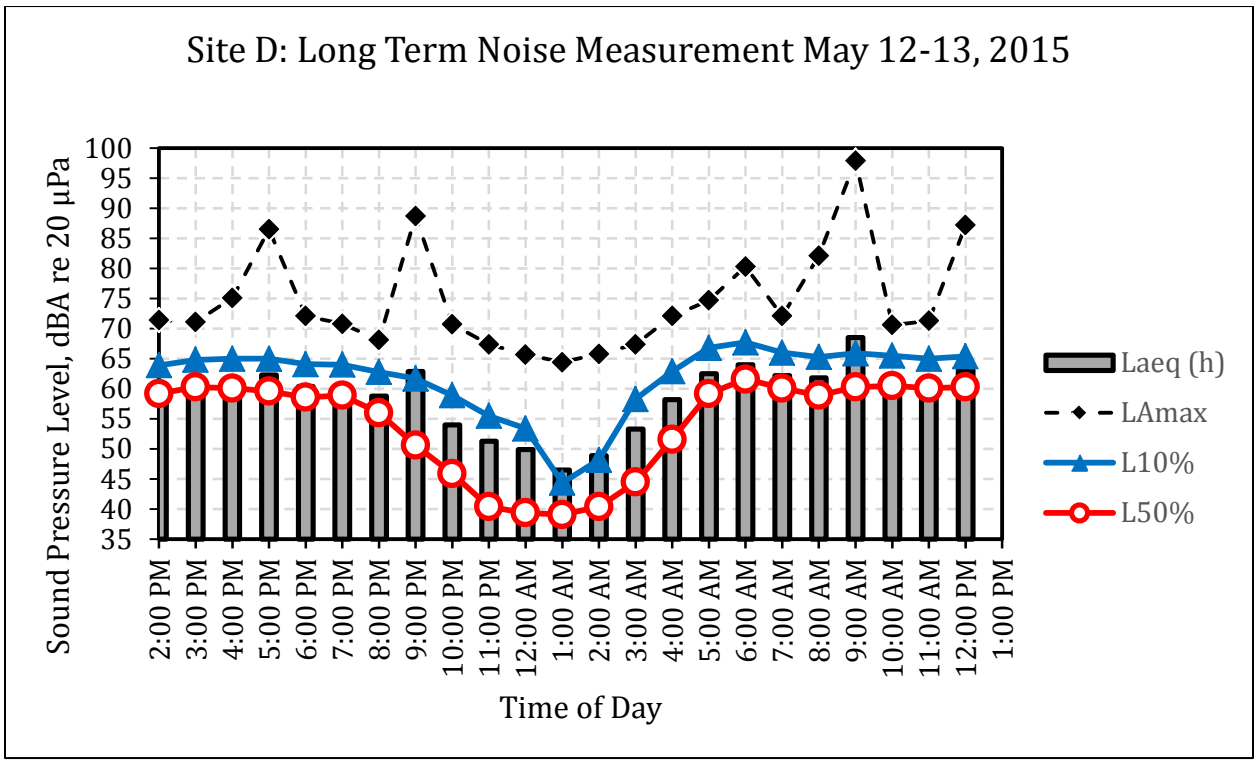


Figure A-5. Long-Term Noise Measurement Data – Site LT-E

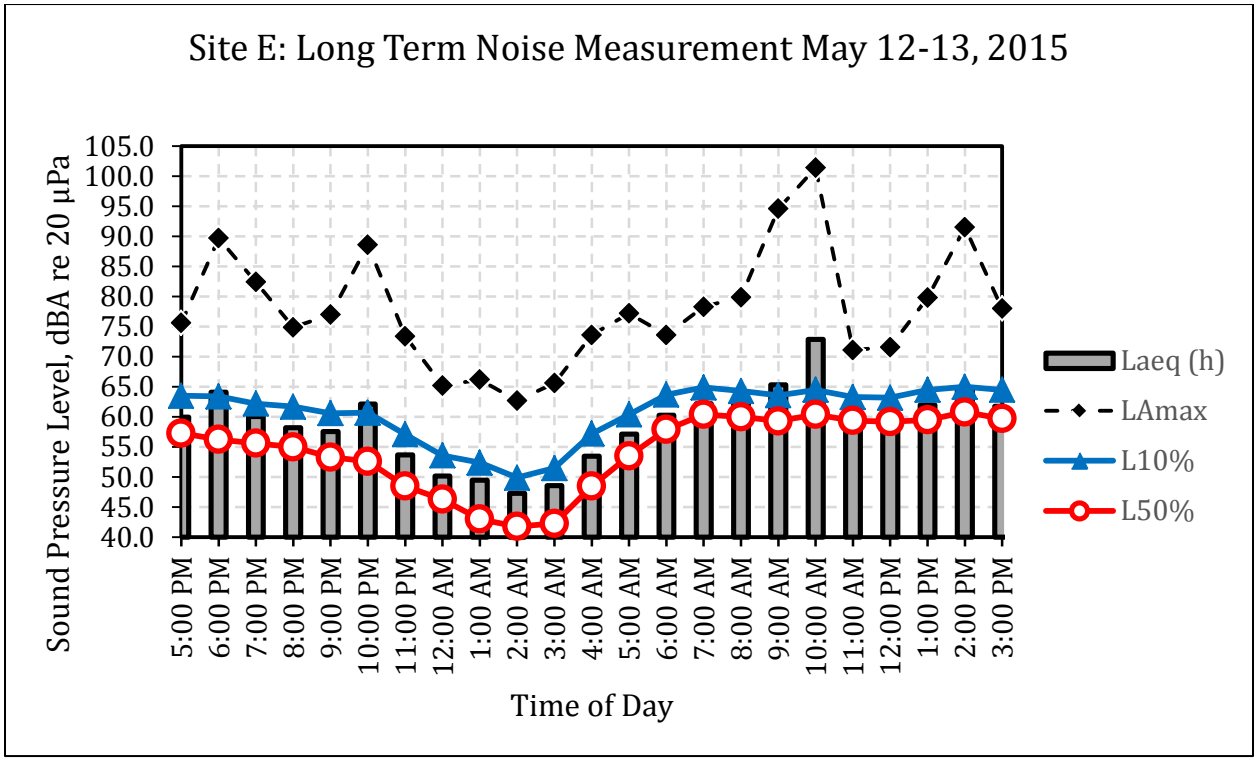


Figure A-6. Long-Term Noise Measurement Data – Site LT-F

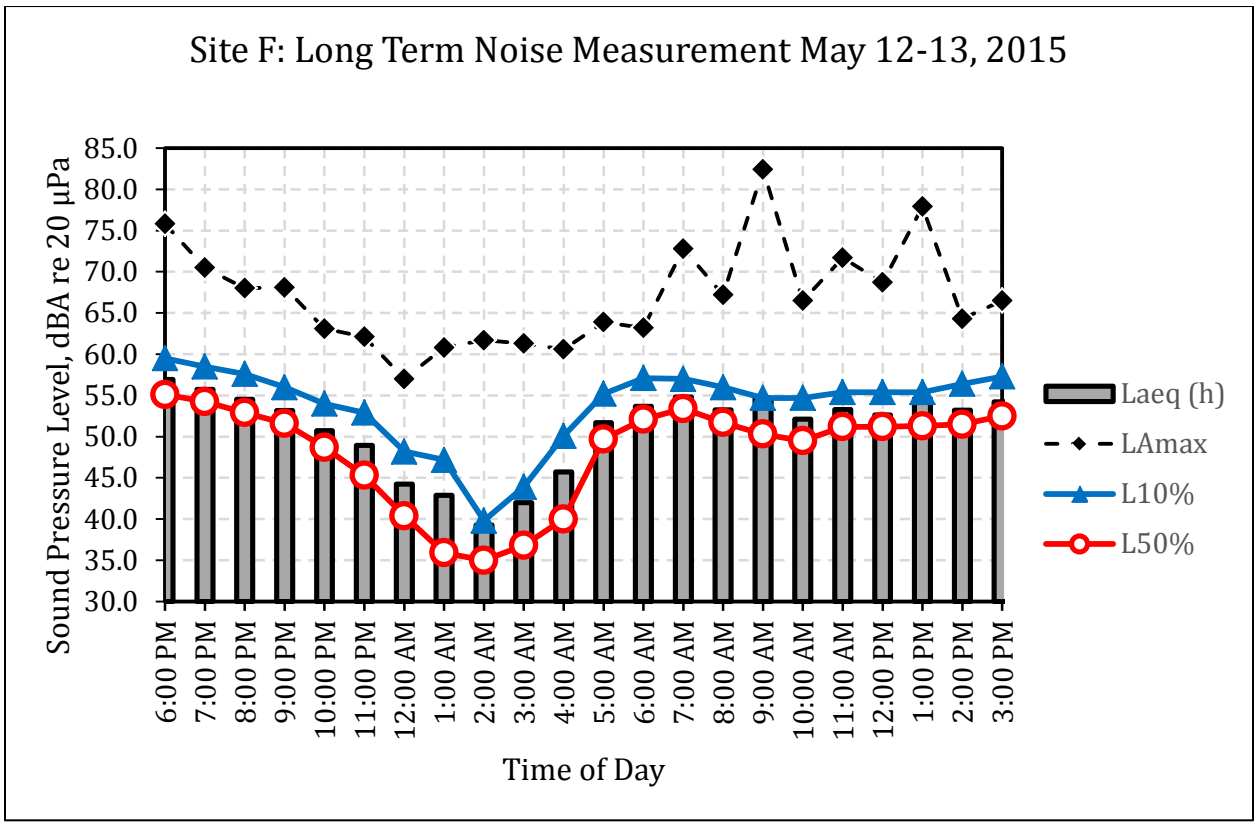


Figure A-7. Long-Term Noise Measurement Data – Site LT-G

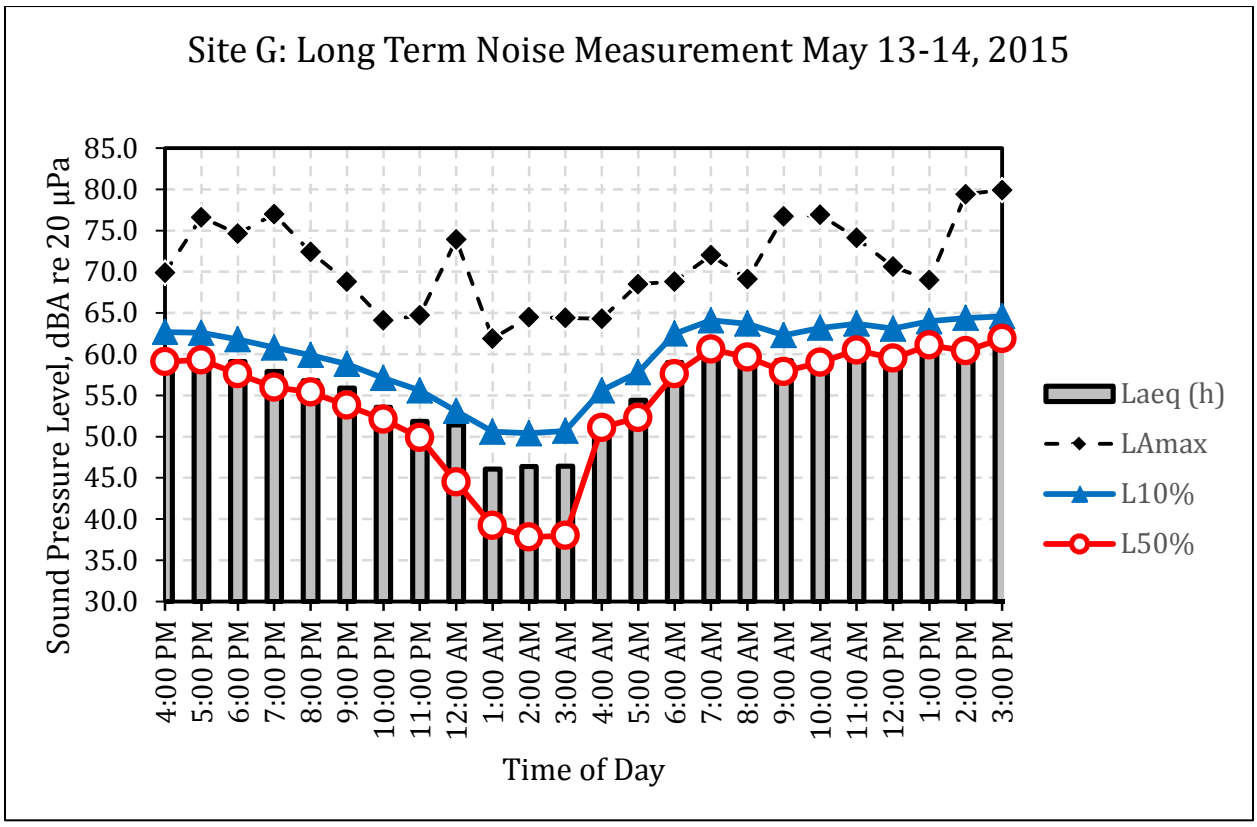


Figure A-8. Long-Term Noise Measurement Data – Site LT-H

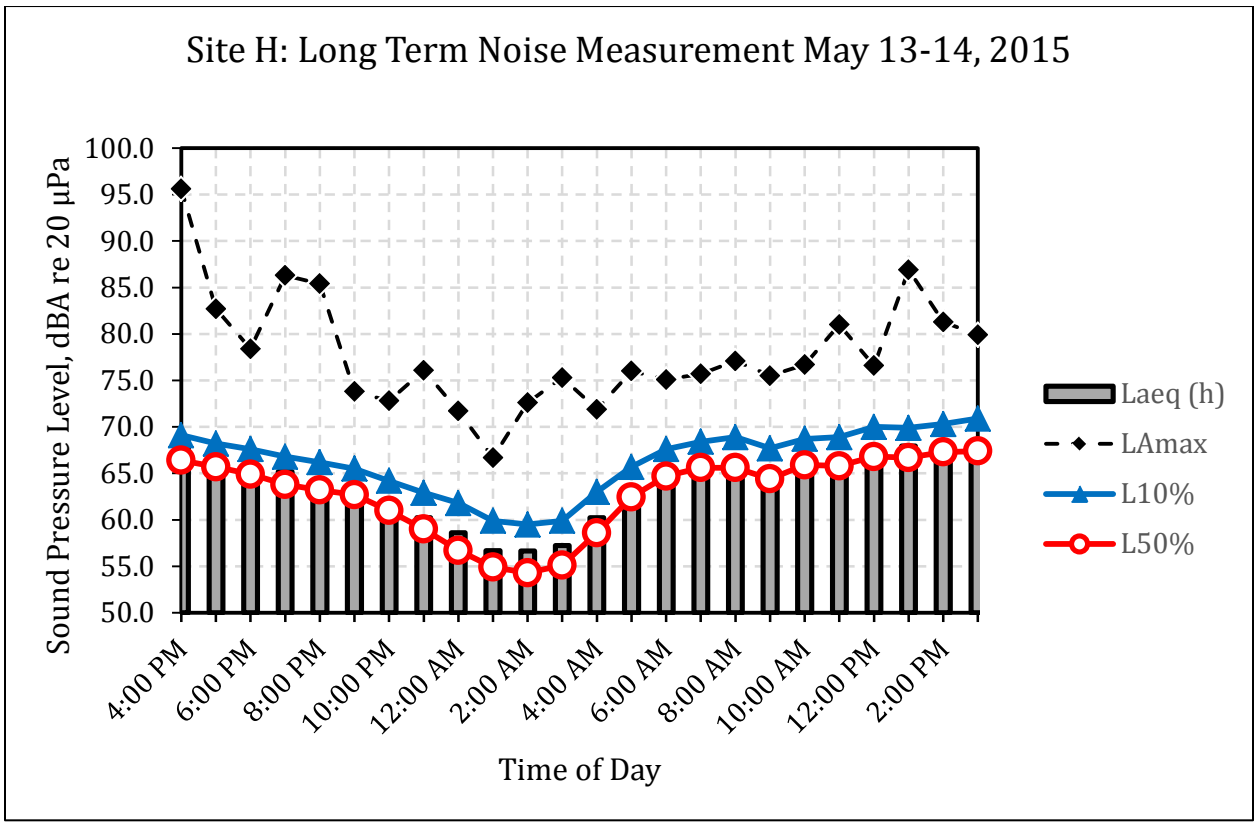
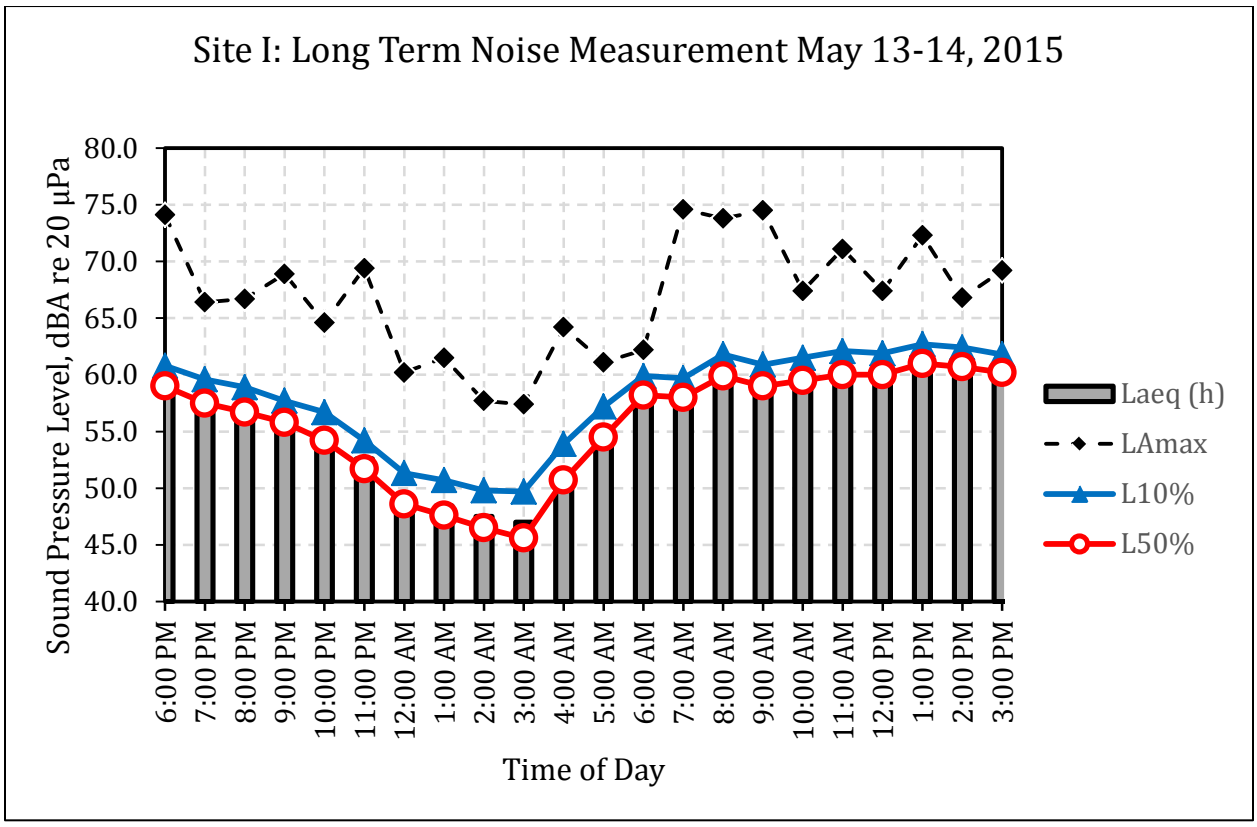


Figure A-9. Long-Term Noise Measurement Data – Site LT-I



Appendix B. Noise Measurement Site Photographs

Figure B-10. Noise Measurement Site LT-A – 1821 York Avenue

Figure B-11. Noise Measurement Site LT-B – 2145 Bonnie Lane

Figure B-12. Noise Measurement Site LT-C – 3954 Noble Avenue

Figure B-13. Noise Measurement Site LT-D – 8820 Quebec Court North

Figure B-14. Noise Measurement Site LT-E – 8558 S. Maplebrook Circle

Figure B-15. Noise Measurement Site LT-F – 9125 Nevada Court

Figure B-16. Noise Measurement Site LT-G – 6102 Hampshire Avenue North

Figure B-17. Noise Measurement Site LT-H – 7501 Myers Avenue

Figure B-18. Noise Measurement Site LT-I – 4416 Toledo Avenue North

Appendix C. Noise Impact Location Exhibits

Figure C-19. Noise Impact Locations – LRT

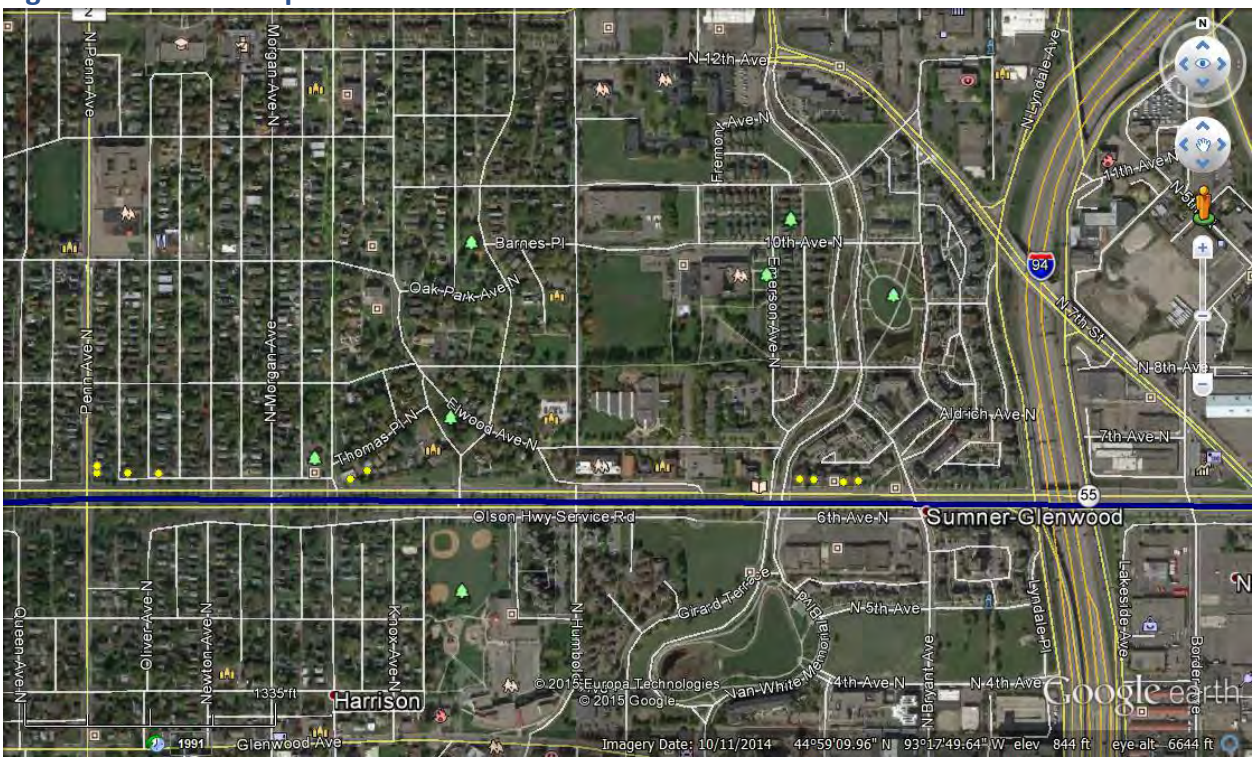


Figure C-20. Noise Impact Locations – LRT

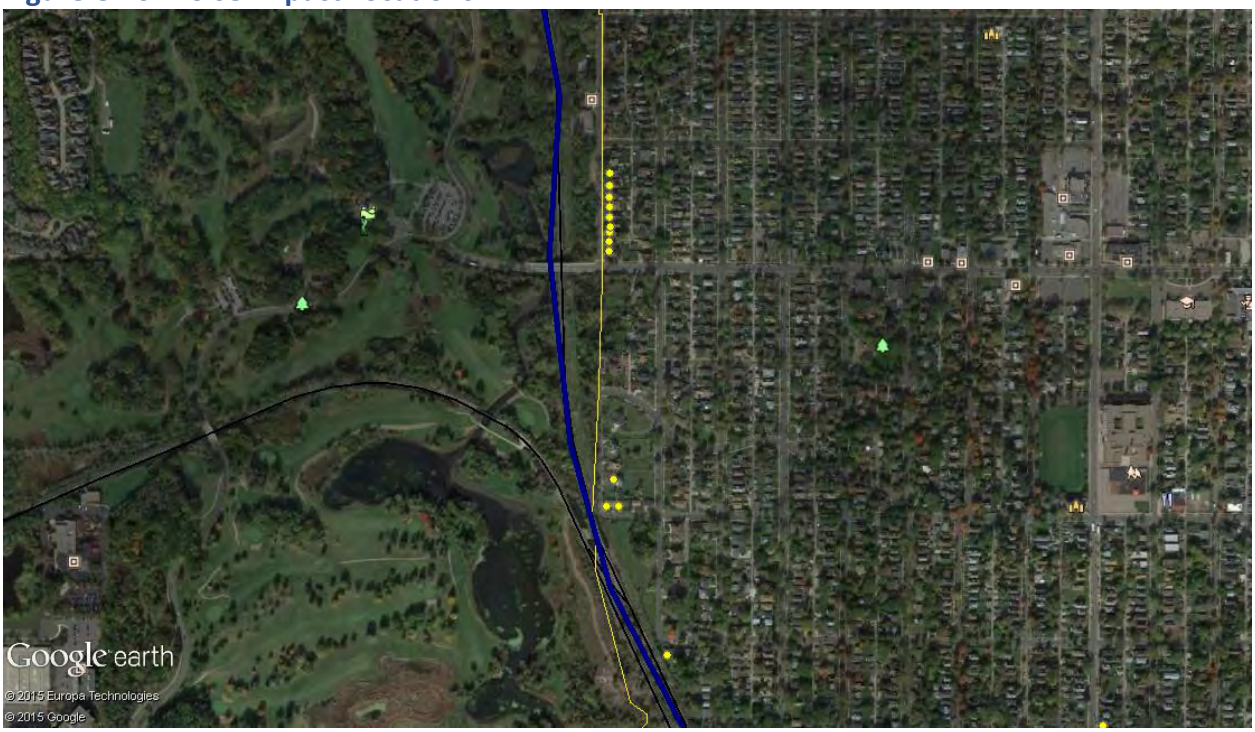


Figure C-21. Noise Impact Locations – LRT

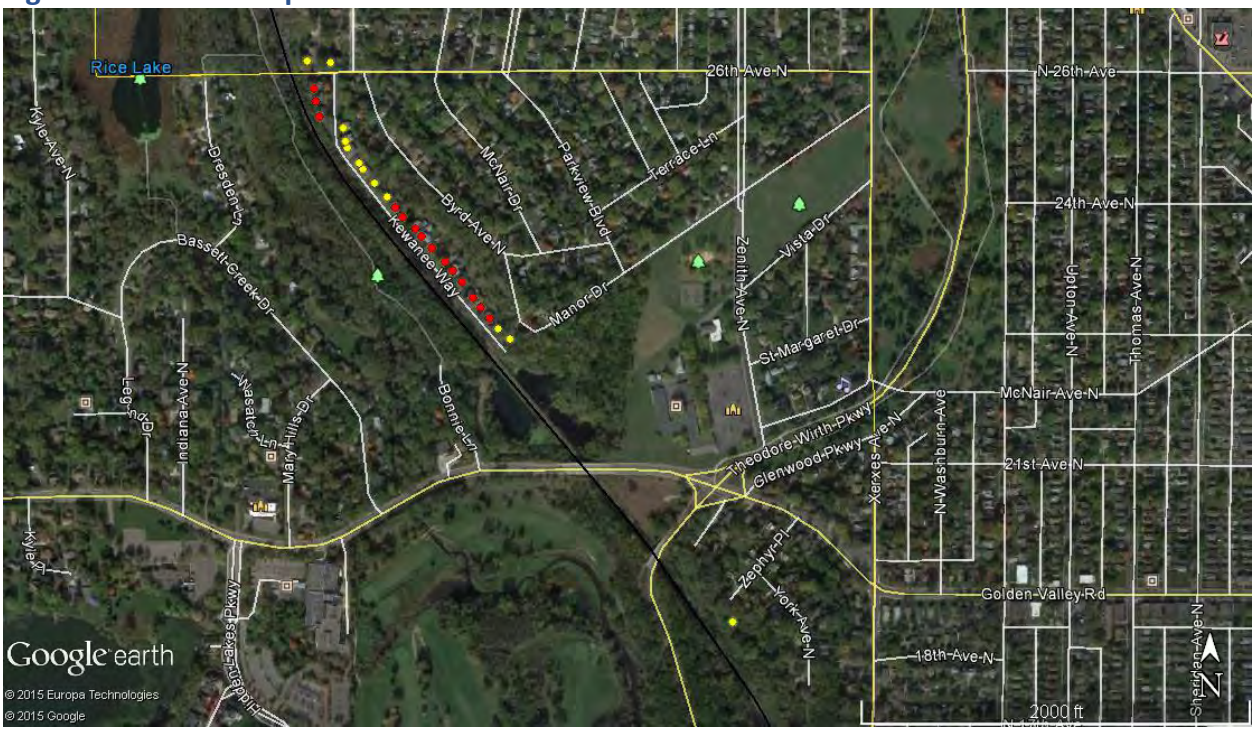


Figure C-22. Noise Impact Locations – LRT

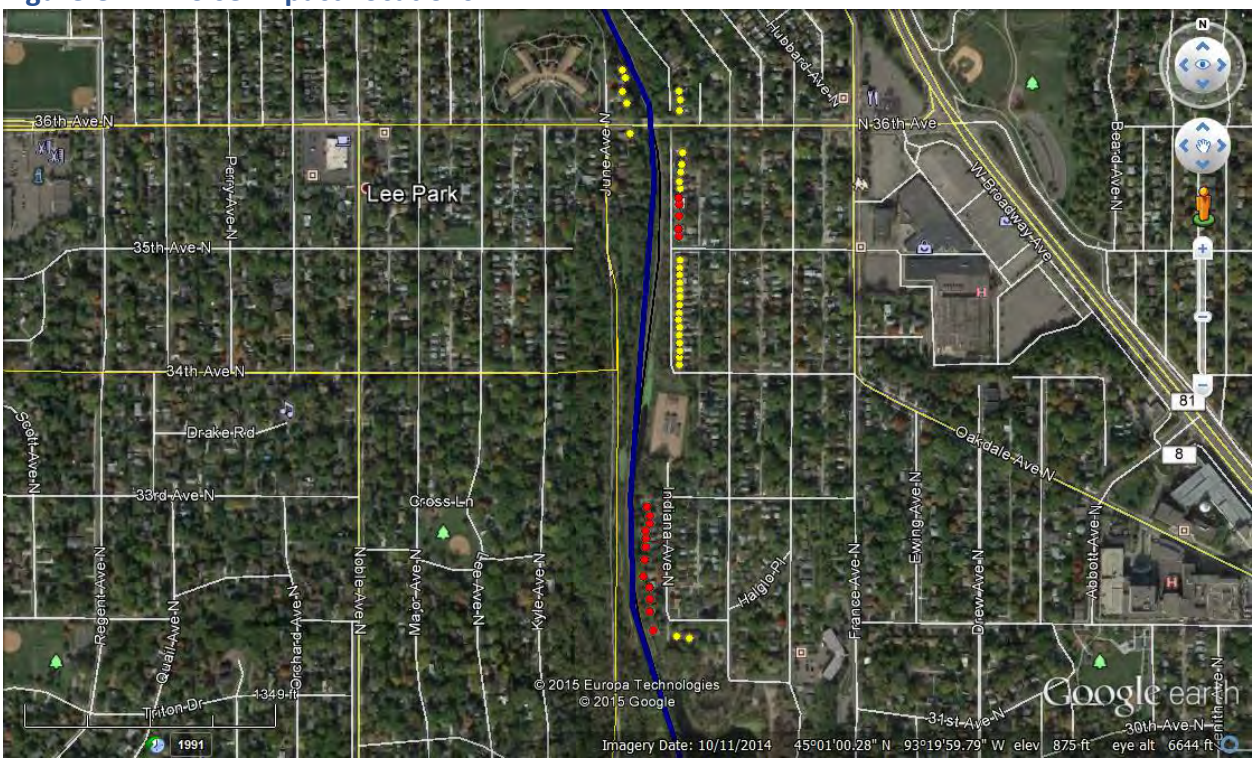


Figure C-23. Noise Impact Locations – LRT

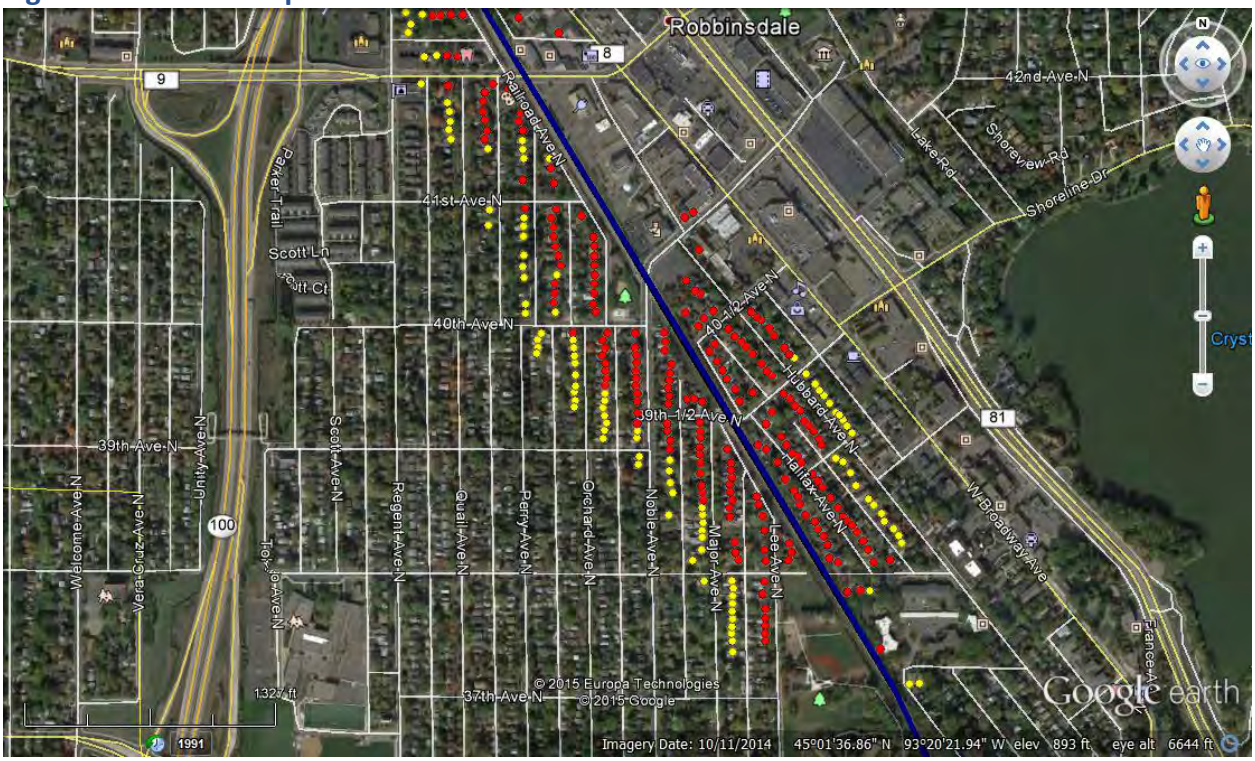


Figure C-24. Noise Impact Locations – LRT

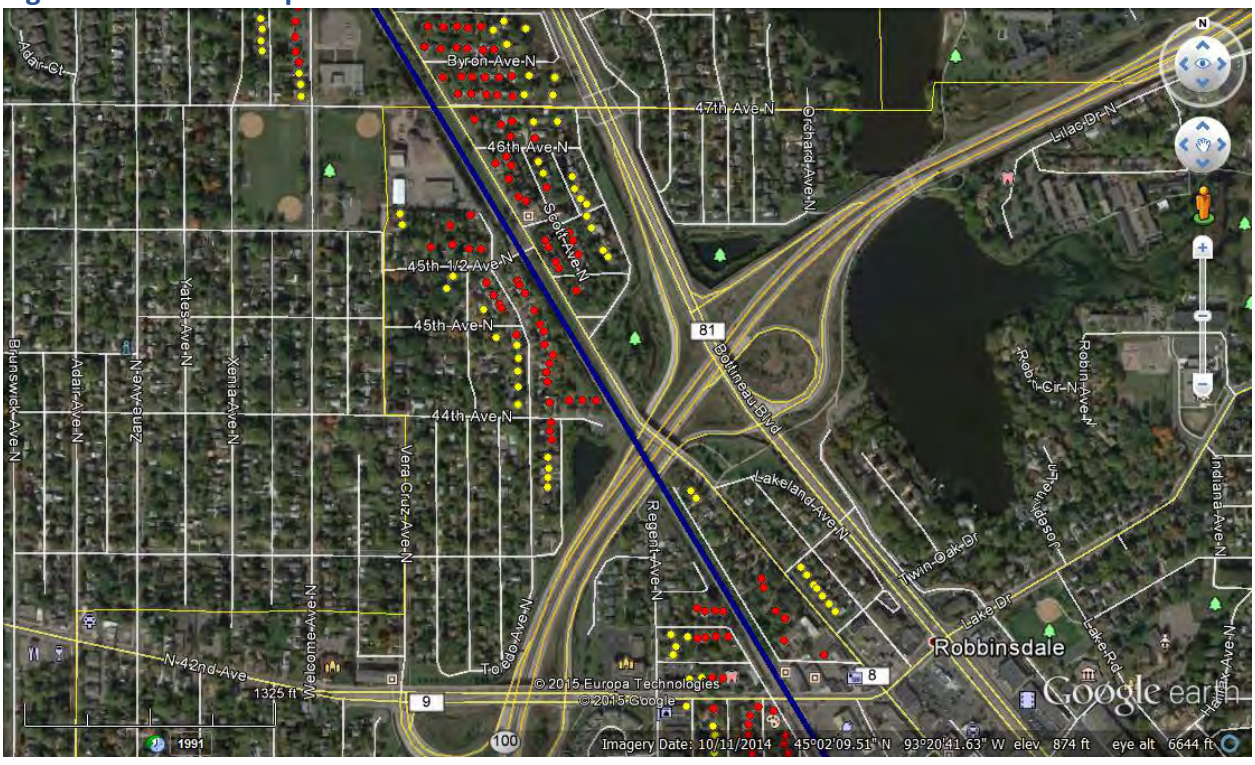


Figure C-25. Noise Impact Locations – LRT

Figure C-26. Noise Impact Locations – LRT

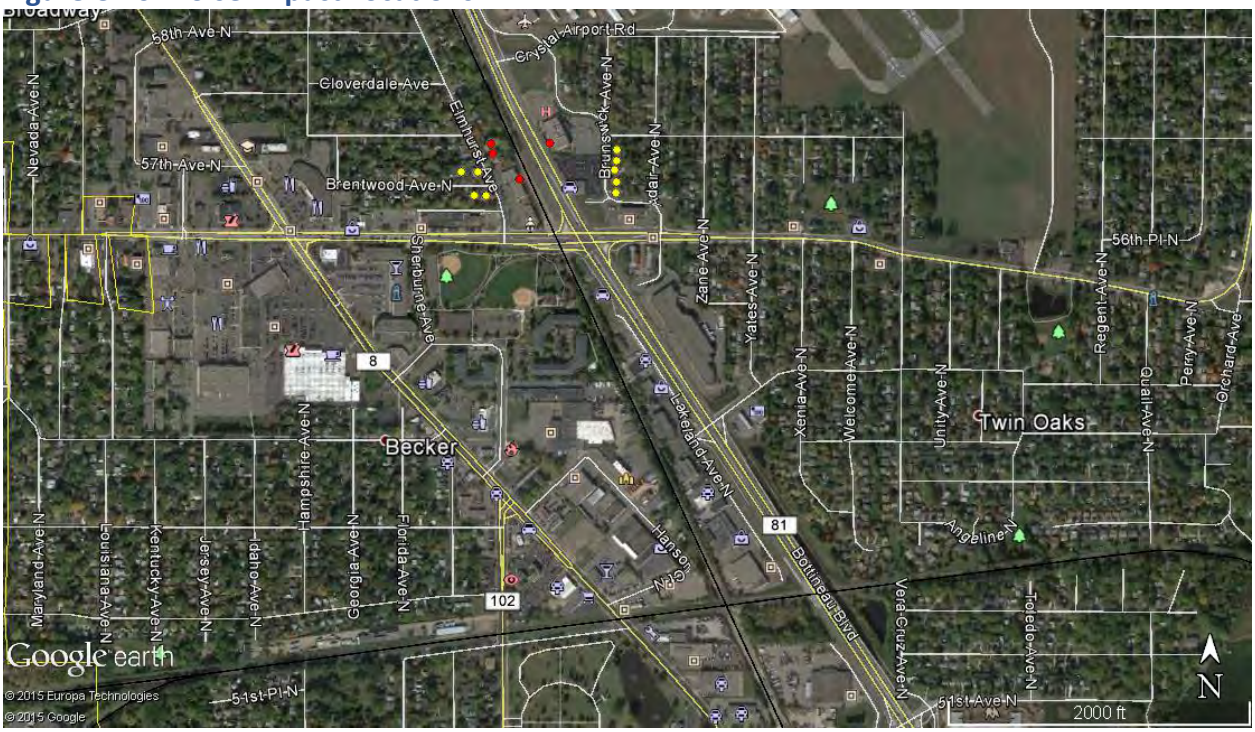


Figure C-27. Noise Impact Locations – LRT

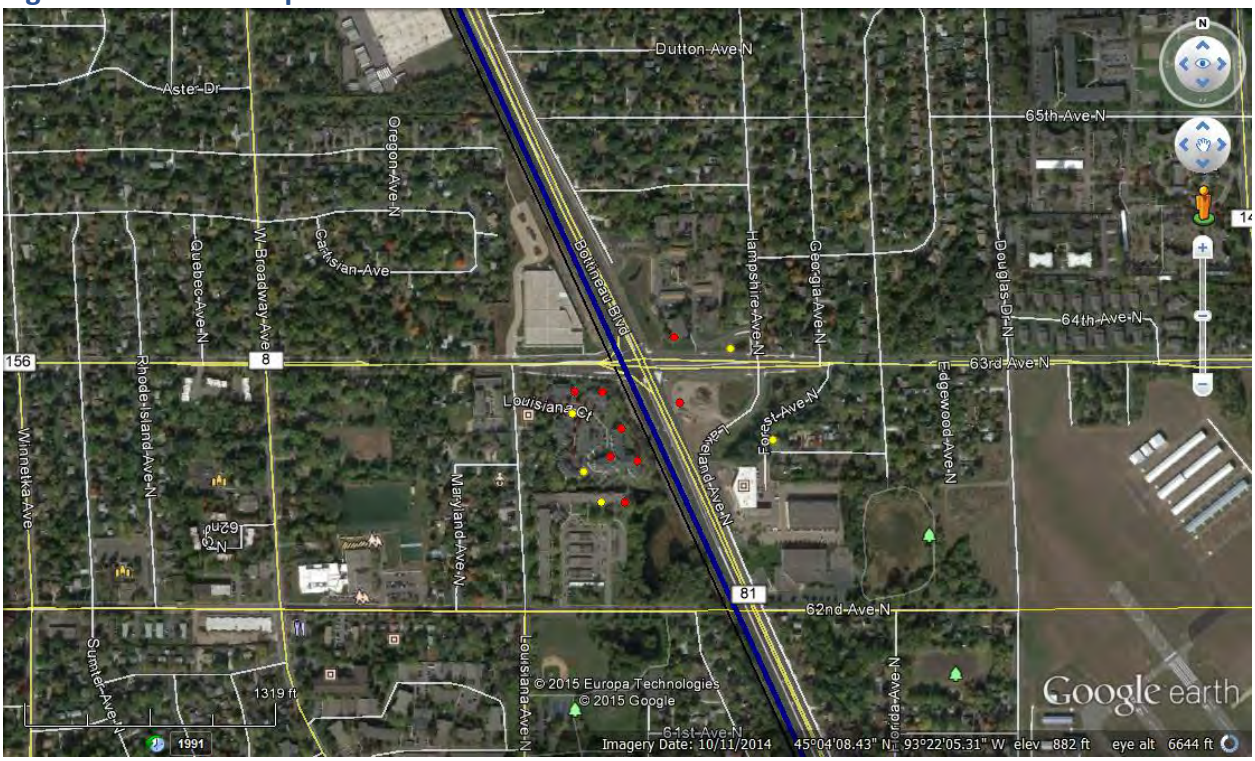


Figure C-28. Noise Impact Locations – LRT

Figure C-29. Noise Impact Locations – LRT

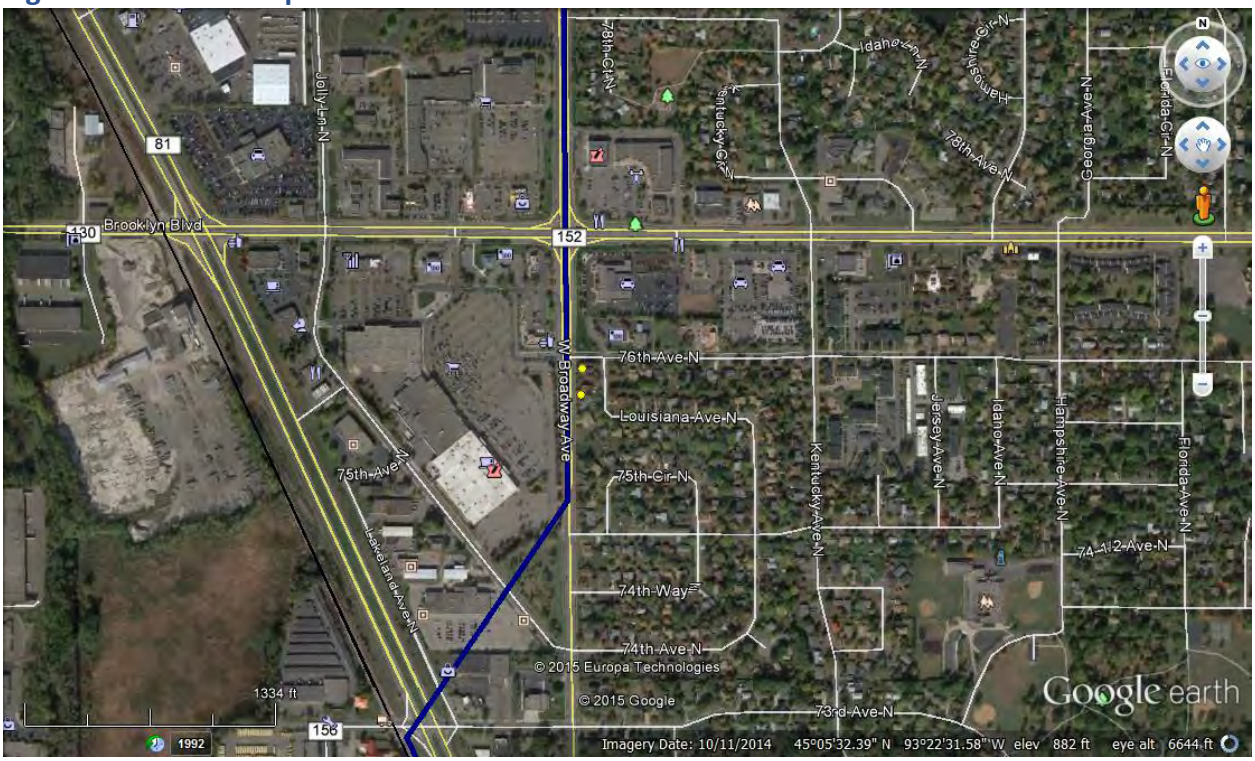


Figure C-30. Noise Impact Locations – LRT

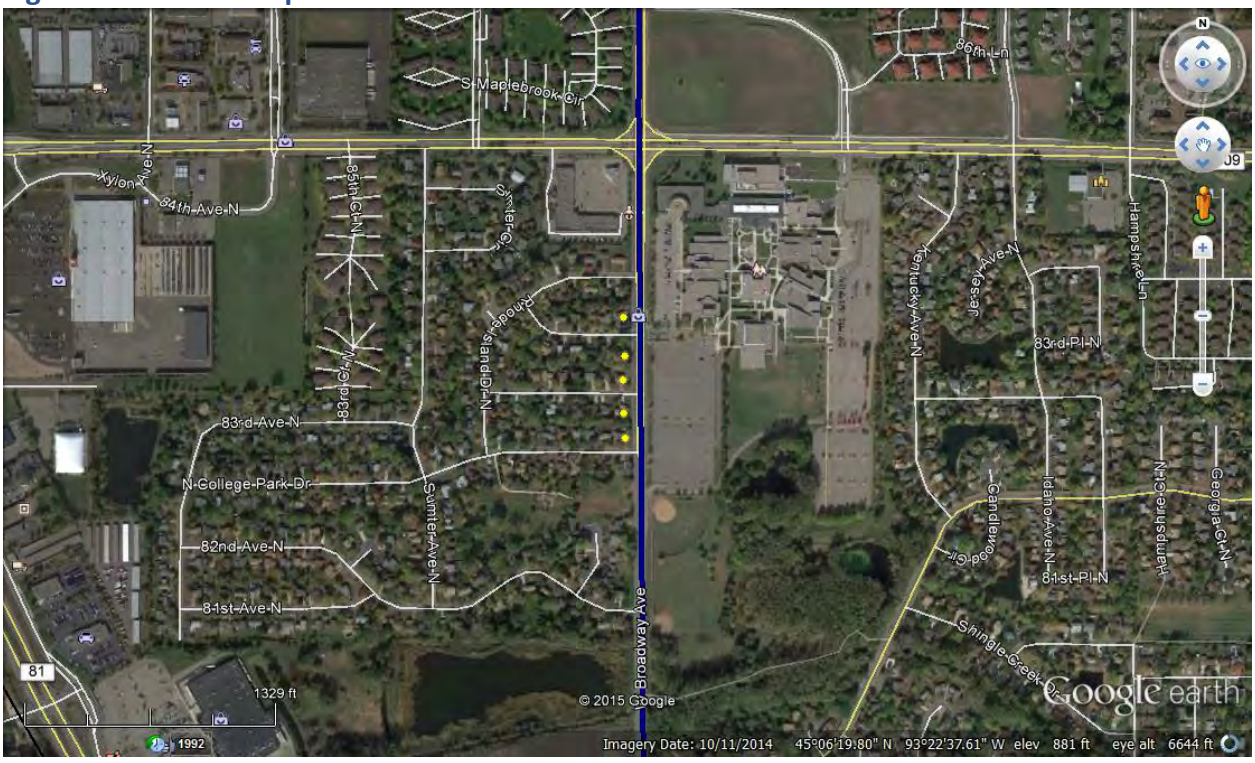


Figure C-31. Noise Impact Locations – LRT

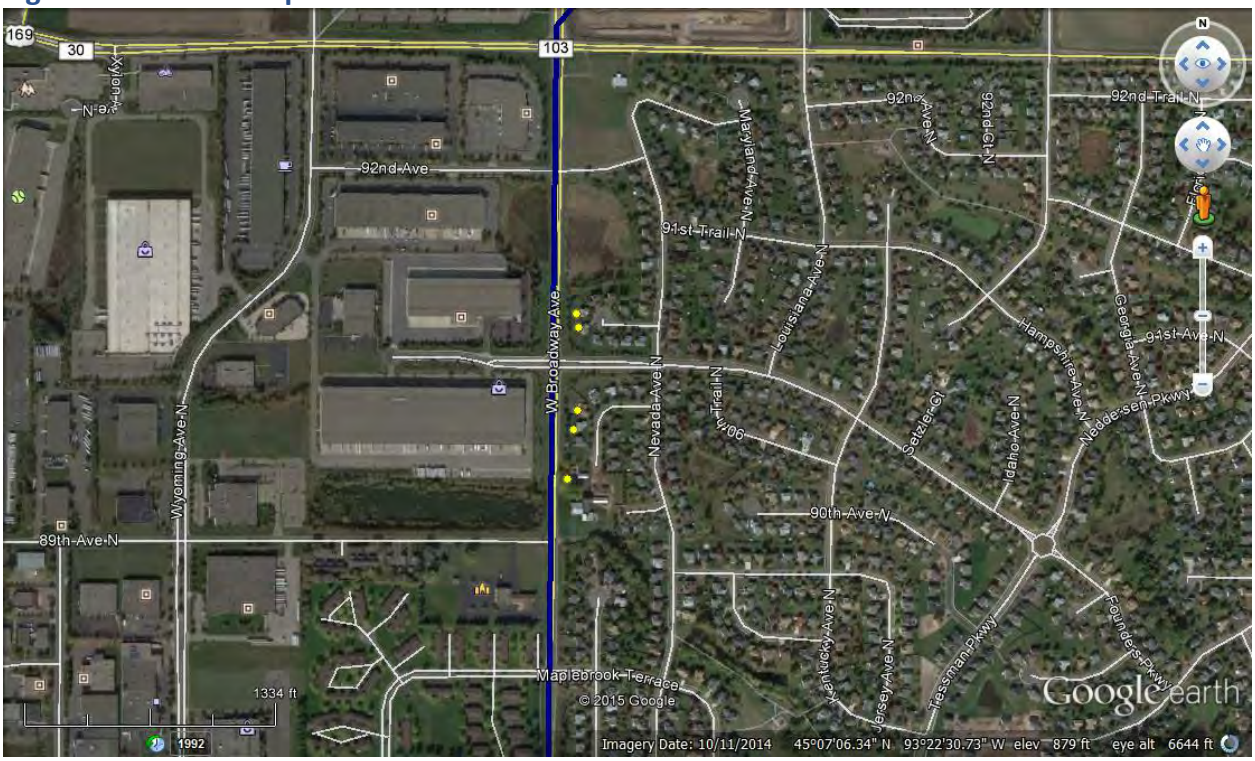
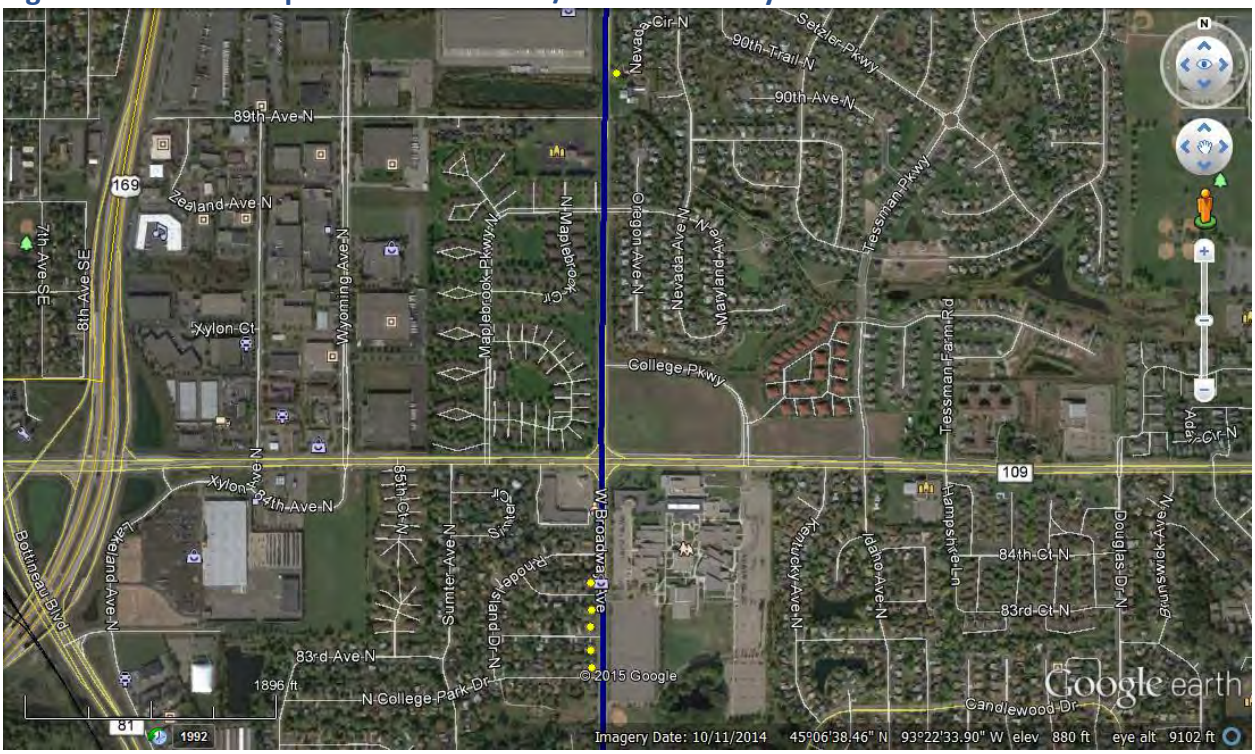


Figure C-32. Noise Impact Locations – LRT/West Broadway Avenue Cumulative



Appendix D. Vibration Impact Location Exhibits

Figure D-33. Vibration Impact Locations

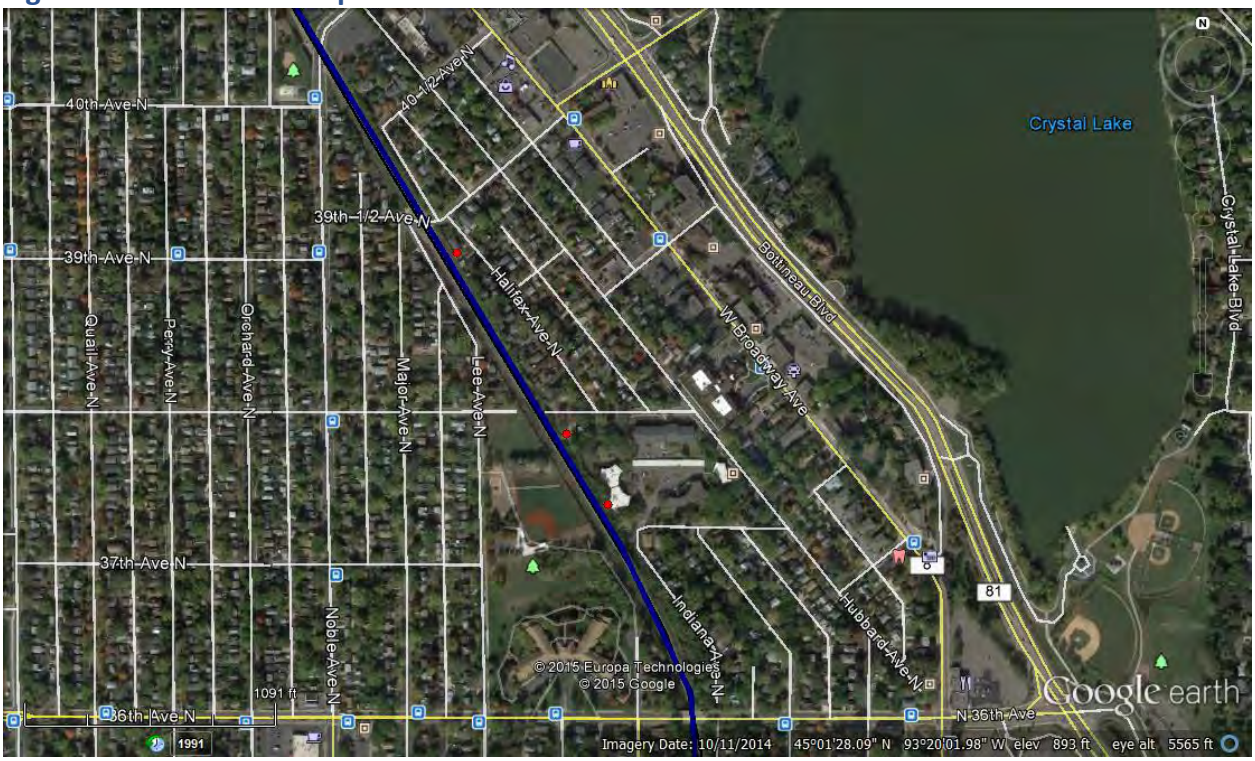


Figure D-34. Vibration Impact Locations