# Appendix A-5: Noise and Vibration Technical Report

Appendix A-5: Noise and Vibration Technical Report is a companion document to the Supplemental Final Environmental Impact Statement containing Chapter 5 (Physical and Environmental Analysis). Metropolitan Council and the United States Department of Transportation - Federal Transit Administration are committed to ensuring that information is available in appropriate alternative formats to meet the requirements of persons who have a disability. If you require an alternative version of this file, please contact FTAWebAccessibility@dot.gov.

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# METRO Blue Line Light Rail Extension Project Noise and Vibration Technical Report

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# 1 Introduction

Cross-Spectrum Acoustics Inc. (CSA) conducted a noise and vibration impact assessment for the proposed METRO Blue Line Light Rail Extension Project (Project) Supplemental Final Environmental Impact Statement (EIS). Noise and vibration have been assessed in accordance with guidelines specified in the Federal Transit Administration's (FTA's) *Transit Noise and Vibration Impact Assessment* guidance manual (FTA 2018). 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 Project.

A summary of the assessment results is described below in Section 2. Section 3 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 4 describes the methodology used to assess noise and vibration impact. Section 5 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 6 includes the results of the noise and vibration impact assessment. Mitigation measures are discussed in Section 7. Appendices A and B contain detailed information on the noise measurements conducted for the Project. Appendices C and D contain detailed information on the vibration measurements conducted for the Project.

Based on the screening distances provided in Chapters 4 and 9 of the FTA guidance manual, the noise and vibration study area included the area 350 feet from the center line of the Project Alignment.

# 2 Summary of Assessment Results

## 2.1 Noise

This section contains a summary of the noise impacts by city and sensitive land use type before mitigation is considered. Most of the impacts are due to the proximity of the tracks (wheel/rail interaction) to the sensitive land use, grade crossing bells, and the location of the crossover.

**Table 2-1 Summary of Noise Impacts by Municipality**

| Building Type | # of Properties Affected (# of Dwelling Units [DU]) | | Cause of Impact |
|---|---|---|---|
| | Moderate Impact | Severe Impact | |
| **City of Brooklyn Park** | | | |
| Single-family | 5 | 0 | Nearby crossover. |
| Multi-family | 0 | 0 | |
| Institutional | 0 | 0 | |
| **City of Crystal** | | | |
| Single-family | 0 | 0 | No impacts in the City of Crystal. |
| Multi-family | 0 | 0 | |
| Institutional | 0 | 0 | |
| **City of Robbinsdale** | | | |
| Single-family | 0 | 0 | No impacts in the City of Robbinsdale. |
| Multi-family | 0 | 0 | |
| Institutional | 0 | 0 | |

| Building Type | # of Properties Affected (# of Dwelling Units [DU]) | | Cause of Impact |
|---|---|---|---|
| | Moderate Impact | Severe Impact | |
| **City of Minneapolis** | | | |
| Single-family | 11 | 8 | Wheel/rail interaction, LRV bells, and crossovers. |
| Multi-family | 9 (256 DUs)* | 4 (62 DUs)* | |
| Institutional | 2 | 0 | |

Source: *Noise and Vibration Technical Report.* Cross-Spectrum Acoustics, Inc. 2024.
*Includes total number of DUs at the affected properties. Additional noise measurements and analysis will be performed to determine potential impacts at each dwelling unit and the reasonable and feasible mitigation measures that would be implemented.

## 2.2 Vibration

The detailed vibration analysis identified 30 vibration impacts in the City of Minneapolis. These impacts are due to proximity of sensitive receptors to the Project Alignment and crossovers.

# 3 Regulatory Context

## 3.1 Noise

### 3.1.1 Noise Basics

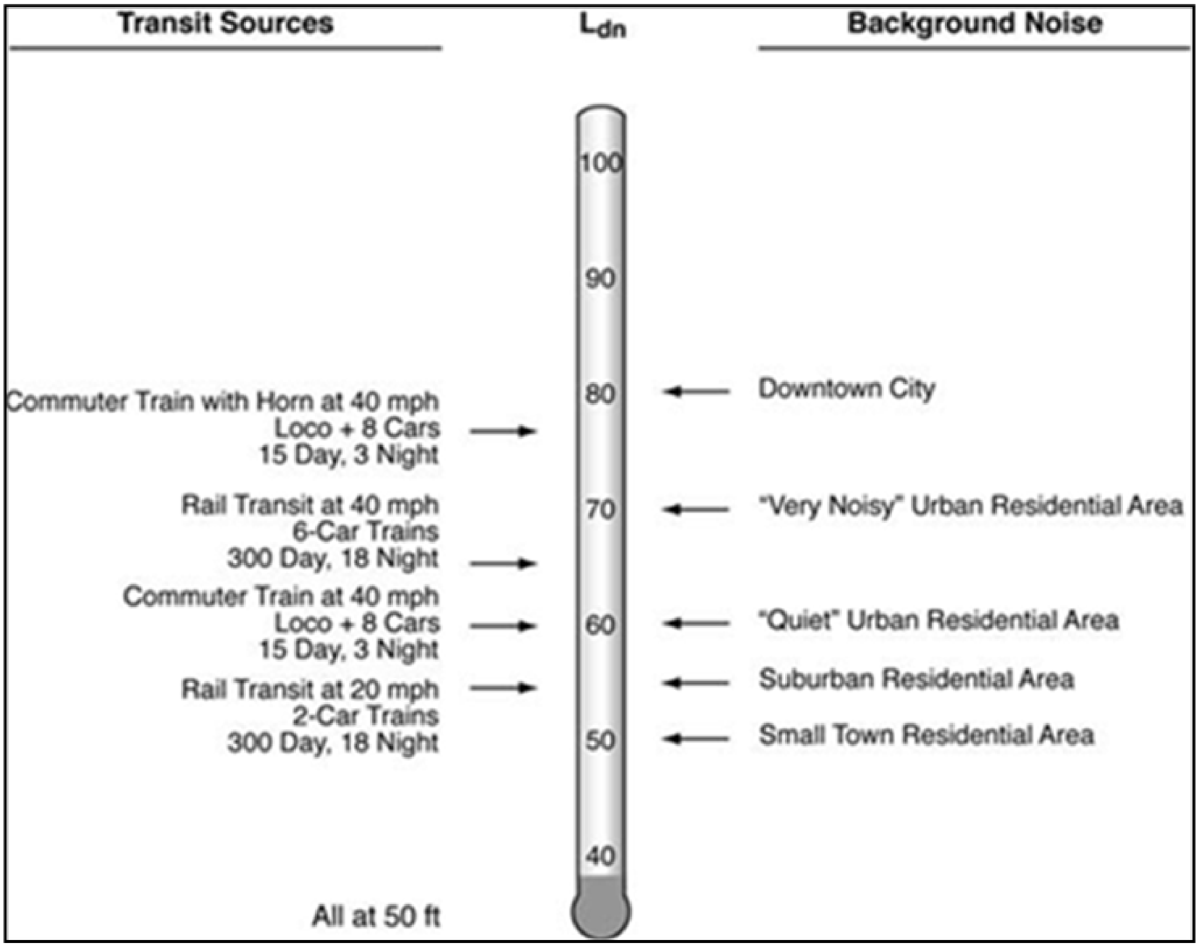
Sound is defined as small changes in air pressure above and below the standard atmospheric pressure and noise is usually considered to be unwanted sounds. The three parameters that define noise include:

- ***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 this information into a single number, called the equivalent sound level (Leq). The Leq represents the changing sound level over a period of time, typically 1 hour or 24-hours in transit noise assessments. For light rail transit (LRT) and freight rail projects, the day-night sound level (Ldn) is the common noise descriptor used, and it has been adopted by most agencies as the best way to describe how people respond to noise in their environment. Ldn 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 10 similar events during the day.

Typical Ldn values for various transit operations are shown on Figure 3-1. The operations shown in the figure represent typical operations for transit systems. For example, the second entry in the left column of the figure represents a light rail system with six car trains, traveling at 40 miles per hour (mph), with

300 operations during the daytime and 18 operations during the nighttime, at 50 feet from the tracks. The actual noise level would depend on the specific project factors and the distance from the receiver to the tracks.

**Figure 3-1 Cumulative Noise Levels from Transit Sources**




Source: CSA 2023.

## 3.1.2 Noise Impact Criteria

### 3.1.2.1 FTA Transit Noise Criteria

The noise impact criteria used for the Project are based on the information contained in Section 4 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 project noise with the existing noise (not the noise associated with the No-Build Alternative).

[1] FTA, "Transit Noise and Vibration Impact Assessment Manual." FTA Report No. 0123, September 2018.

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

The noise impact criteria are defined by the two curves shown in Figure 3-2, 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 on Figure 3-2. The three levels of impact include:

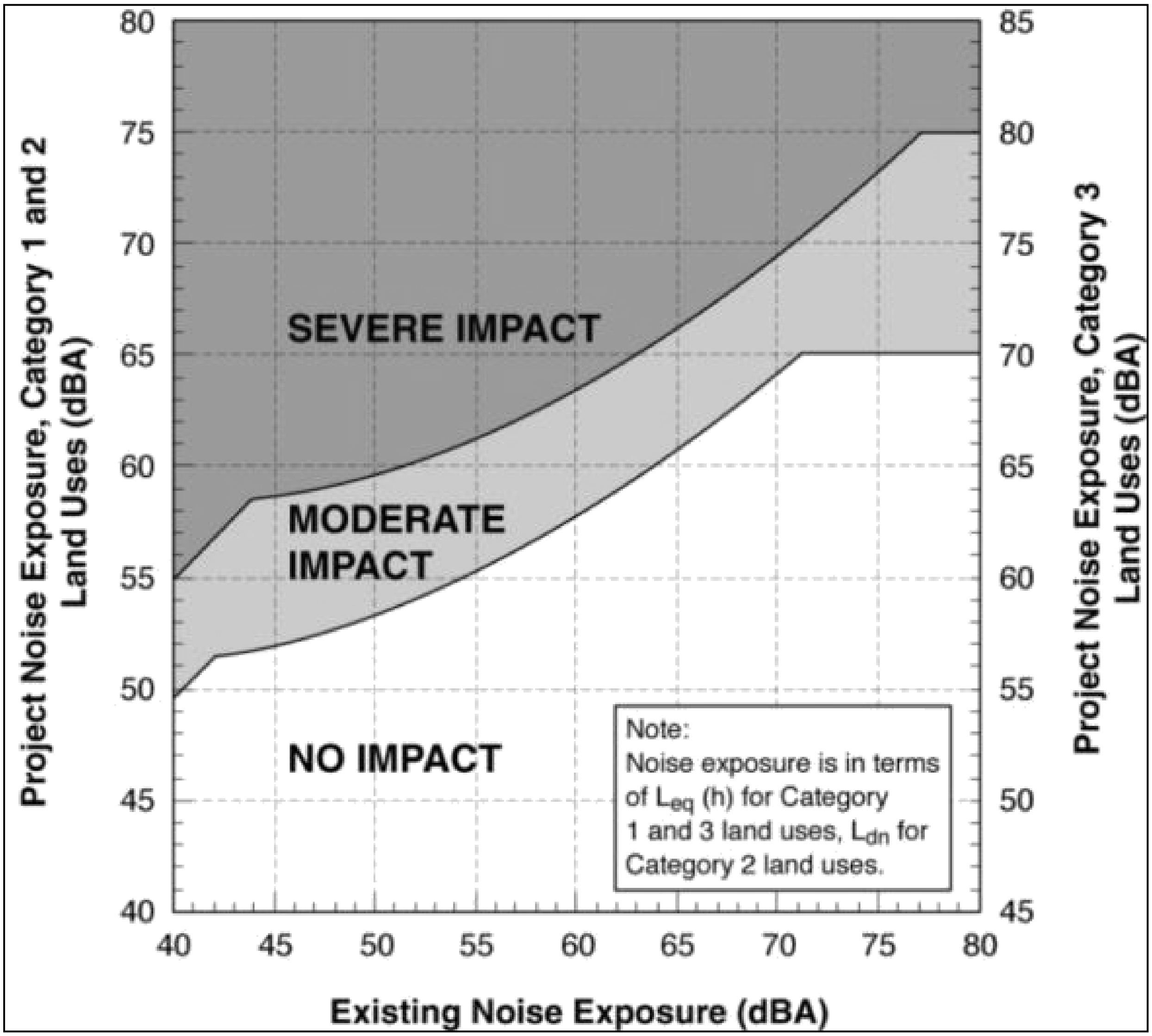
- ***No Impact:*** Project-generated noise is not likely to cause community annoyance. Noise projections in this range are considered acceptable by FTA and mitigation is not required.
- ***Moderate Impact:*** Project-generated noise in this range is considered to cause impact at the threshold of measurable annoyance. Moderate impacts serve as an alert to Project planners for potential adverse impacts and complaints from the community. Mitigation should be considered at this level of impact based on project specifics and details concerning the affected properties.
- ***Severe Impact:*** Project-generated noise in this range is likely to cause a high level of community annoyance. The Project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid severe impacts altogether. In densely populated urban areas, evaluation of alternative locations may reveal a trade-off of affected groups, particularly for surface rail alignments. Projects that are characterized as point sources rather than line sources often present greater opportunity for selecting alternative sites. This guidance manual and FTA's environmental impact regulations both encourage Project sites which are compatible with surrounding development when possible. If it is not practical to avoid severe impacts by changing the location of the Project, mitigation measures must be considered.

**Table 3-1 Land Use Categories and Metrics for Transit Noise Impact Criteria**

| Land Use Category | Noise Metric (dBA) | Description of Land Use Category |
|---|---|---|
| 1 | Outdoor Leq(h)[a] | Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheaters and concert pavilions, and national historic landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category. |
| 2 | Outdoor Ldn | This category is applicable to all residential land use and buildings where people normally sleep, such as hotels and hospitals. |
| 3 | Outdoor Leq(h)[a] | This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include 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 are also included in this category. |

Source: FTA 2018.
[a] Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.

**Figure 3-2 FTA Noise Impact Criteria**




Source: FTA 2018.

### 3.1.2.2 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. 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 United States Department of Transportation 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 the 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 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 noise reduction measures.[2]

#### 3.1.2.3 Minnesota Pollution Control Agency Noise Standards

The Minnesota Pollution Control Agency (MPCA) has an established set of Noise Standards (Minnesota Rules ch. 7030), which provide limits on environmental noise using the L10 and L50 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 3-2.

**Table 3-2 Land Use Categories and Metrics for Transit Noise Impact Criteria**

| Noise Area Classification | Daytime L10 (dBA) | Daytime L50 (dBA) | Nighttime L10 (dBA) | Nighttime L50 (dBA) |
|---|---|---|---|---|
| 1 | 65 | 60 | 55 | 50 |
| 2 | 70 | 65 | 70 | 65 |
| 3 | 80 | 75 | 80 | 75 |

Source: MPCA

Because of the time limit component of the MPCA noise standards, the Project will not exceed the standards under the proposed operating conditions. Light-rail vehicles (LRVs) will 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 L10 (6 minutes) and L50 (30 minutes) time components, there is no

[2] For historic or cultural resources, the following two circumstances are considered 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 United States Department of Transportation 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.

potential for the Project to exceed MPCA thresholds. Because the Project does 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 Supplemental Draft EIS.

Information regarding existing L10 and L50 noise levels is described in Section 5.1.2.3.

#### 3.1.2.4 FTA Construction Noise Criteria

The FTA's construction noise criteria, summarized in Table 3-3, 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 Project. Additionally, MPCA noise criteria were evaluated for the Project, and the Metropolitan Council (Council) will work with local jurisdictions to ensure that reasonable measures are taken to limit construction noise.

**Table 3-3 FTA Construction Noise Criteria**

| Land Use Category | 8-hour Leq, dBA Day | 8-hour Leq, dBA Night | Noise Exposure, dBA 30-day Average |
|---|---|---|---|
| 1 | 80 | 70 | 75 |
| 2 | 85 | 85 | 80 |
| 3 | 90 | 90 | 85 |

Source: FTA 2018

## 3.2 Vibration

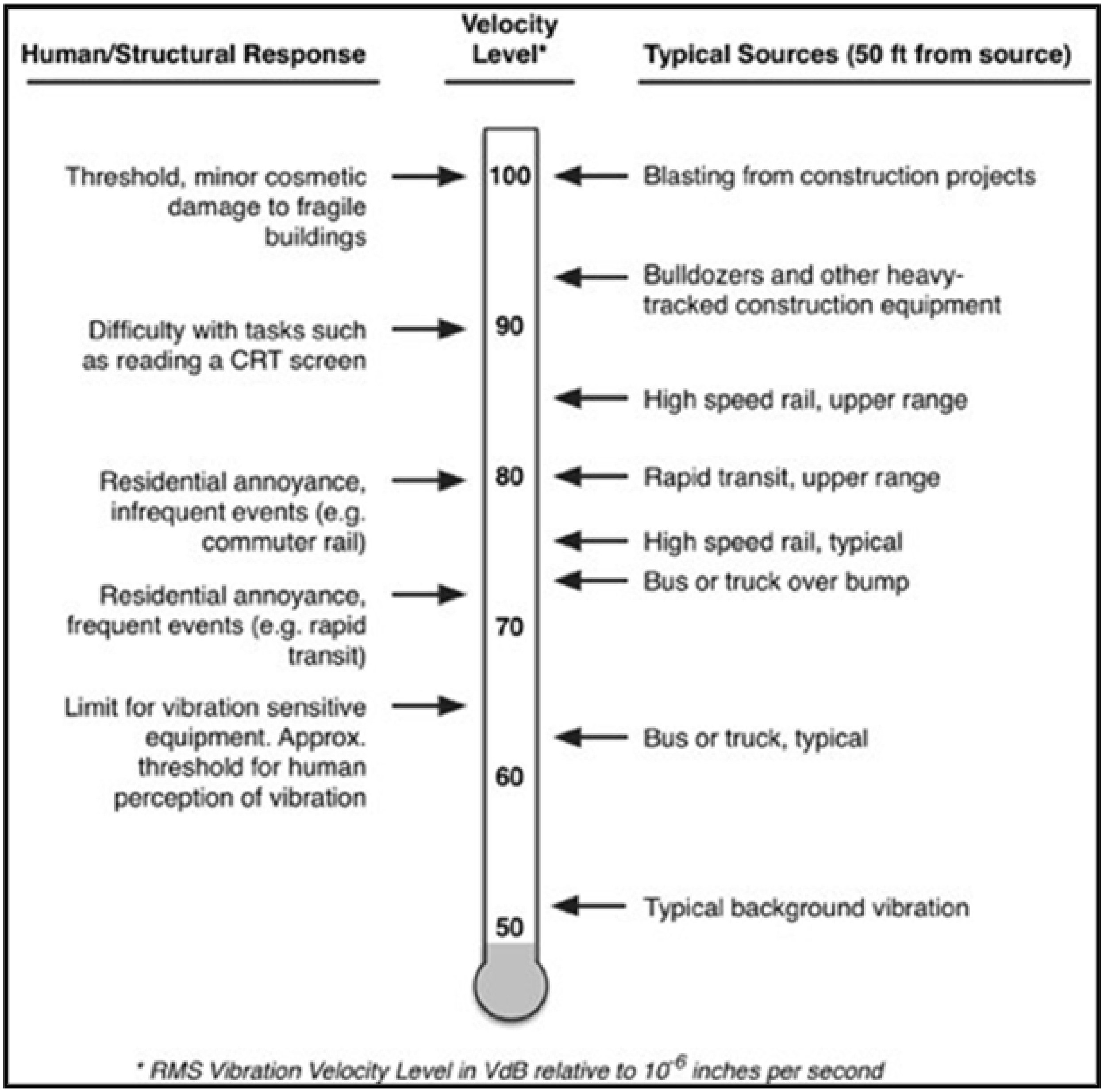
Ground-borne vibration is the motion of the ground transmitted into a building that can be described in terms of displacement, velocity, or acceleration. Vibration velocity is used in transit and freight rail and is defined by the following:

- ***Level:*** Vibration is expressed in terms of vibration velocity level, using vibration decibels (VdB), with a reference of one 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. Human response to vibration is typically from about 6 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 3-3 shows typical ground-borne vibration levels for typical sources as well as the corresponding human and structural responses to vibration.

Ground-borne vibration can lead to ground-borne noise, which is a low-volume, low-frequency rumble inside buildings that occurs when ground vibration causes the flexible walls of the buildings to resonate and generate noise. Ground-borne noise is normally not a consideration when trains are elevated or at grade. In these situations, the airborne noise usually overwhelms ground-borne noise, so that the airborne noise level is the major consideration. However, ground-borne noise becomes an important consideration where sensitive interior spaces are well-isolated from the airborne noise. In these situations, the airborne noise path is impeded, and ground-borne noise dominates inside buildings. In rare situations, ground-borne noise may also need to be considered where the airborne noise from a Project is substantially mitigated by a sound wall.

**Figure 3-3 Vibration Levels from Typical Sources**




Source: CSA 2023.

### 3.2.1 Vibration Impact Criteria

#### 3.2.1.1 FTA Transit Vibration Criteria

The vibration impact criteria used for the Project are based on the information contained in Section 6 of the FTA noise and vibration guidance manual. The criteria for a general vibration assessment are based on land use and LRV frequency, as shown in Table 3-4. 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 3-4. Because of the sensitivity of these buildings, special attention is paid to these buildings during the environmental assessment of a project. Table 3-5 shows the FTA criteria for acceptable levels of vibration for several types of special buildings.

Table 3-4 and Table 3-5 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 3-4 Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment**

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

Source: FTA 2018

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

[b] "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.

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

[d] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research 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.

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

**Table 3-5 Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special Buildings**

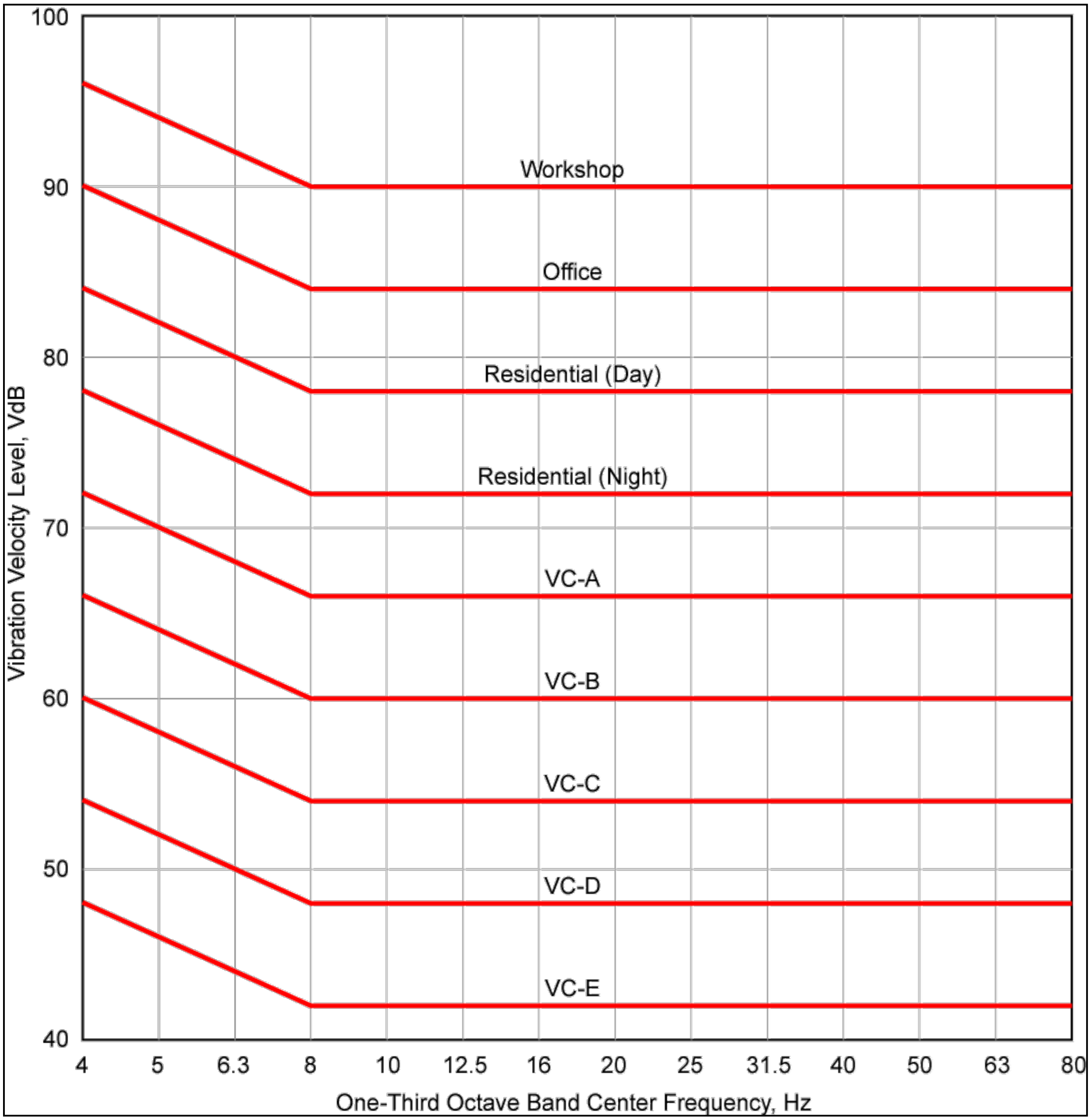
| Type of Building or Room | Ground-Borne Vibration Impact Levels for Frequent Events (VdB re 1 micro-inch/sec)[a] | Ground-Borne Vibration Impact Levels for Occasional or Infrequent Events (VdB re 1 micro-inch/sec)[b] | Ground-Borne Noise Impact Levels for Frequent Events (dBA re 20 micro Pascals)[a] | Ground-Borne Noise Impact Levels for Occasional Events (dBA re 20 micro Pascals)[b] |
|---|---|---|---|---|
| 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 2018
Note: 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 will operate after 7 p.m., it should be rare that the trains interfere with the use of the hall.
[a] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
[b] "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

The criteria for a detailed vibration assessment are shown in Figure 3-4 and descriptions of the curves are shown in Table 3-6. The curves in Figure 3-4 are applied to the projected vibration spectrum for the Project. If the vibration level at any one frequency exceeds the criteria, there is impact. Conversely, if the entire proposed vibration spectrum of the Project is below the curve, there will be no impact.

For the 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 3-4 Detailed Vibration Criteria




Source: FTA 2018.

**Table 3-6 FTA Construction Vibration Criteria**

| Criterion Curve (See Figure 2-4) | Max Level (VdB)[a] | 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 20X). |
| Residential Night, Operating Rooms | 72 | Vibration not feelable, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity. |
| VC-A | 66 | Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment. |
| VC-B | 60 | Adequate for high-power optical microscopes (1,000X), 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 2018
[a] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

#### 3.2.1.2 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 United States Department of Transportation 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 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.

#### 3.2.1.3 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 3-7 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 3-7 includes criteria in both VdB and peak particle velocity (PPV).

**Table 3-7 FTA Vibration Damage Criteria from Construction**

| Building Category | PPV (in/sec) | Approximate Lv[a] |
|---|---|---|
| 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 2018
PPV = peak particle velocity; Lv = vibration level
[a] Root Mean Square (RMS) velocity in VdB re 1 micro-inch/second.

# 4 Impact Assessment Methodology

This section describes the methodology for assessing the potential noise and vibration impact due to the Project.

## 4.1 Noise

This section describes the methodology for assessing the potential noise impact due to the Project.

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

- LRV speeds will generally range from 15 to 55 mph for revenue operations, except for entry and exit from station areas. LRV speeds are based on modeled speed profiles in both directions (i.e., inbound and outbound) that reflect LRV operating characteristics, track geometry, and station locations.
- LRVs will be comprised of three rail cars during hours of operation.
- The operating hours and headways will be as follows:
    - Early morning hours (12:15 to 2 a.m.): 60-minute headways
    - Morning hours (4 to 5:30 a.m.): 30-minute headways
    - Early peak morning operating hours (5:30 to 6:30 a.m.): 15-minute headways

- Peak operating hours (6:30 a.m. to 9 p.m.): 10-minute headways
- Evening hours (9 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 4-1.

**Table 4-1 Blue Line Reference Noise Levels**

| Noise Source | Sound Exposure Level[a], 50 ft (dBA) |
|---|---|
| LRT on embedded track | 84 |
| LRT on ballast-and-tie track | 81 |
| Crossing bells | 76[b] |
| LRT bells | 86/87[c] |

Source: CSA 2023

[a] The sound exposure level is the cumulative noise from a single event, considering both the level and duration of the sound.

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

[c] The maximum noise level from LRT bells is 80 dBA at 50 feet. LRT bells will be sounded three times when entering and exiting stations (sound level exposure of 86 dBA) and will be sounded for 5 seconds at each at-grade crossing (sound level exposure of 87 dBA).

- Locations of elevated structures, crossovers, and embedded track were identified based on plan and profile maps provided by the engineering team in September 2024.
- 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 at each at-grade crossing and station was determined by Metro Transit Operations and Project staff based on the following considerations:
  - LRV bells will be sounded three times when entering and exiting station platforms.
  - LRV bells will be sounded at at-grade crossings.
  - Grade crossing bells will be used at at-grade crossings for 20 seconds for each LRV where there will be flashing lights and gates at the crossing.
- Light rail bells 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 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 LRV will then sound the bell upon exiting the station until the front of the LRV passes through the far side of the crossing.
  - Horns will only be sounded in case of emergency.

## 4.2 Vibration

This section describes the methodology for assessing the potential vibration impact due to the Project. Specific inputs used in the vibration impact assessment include the following:

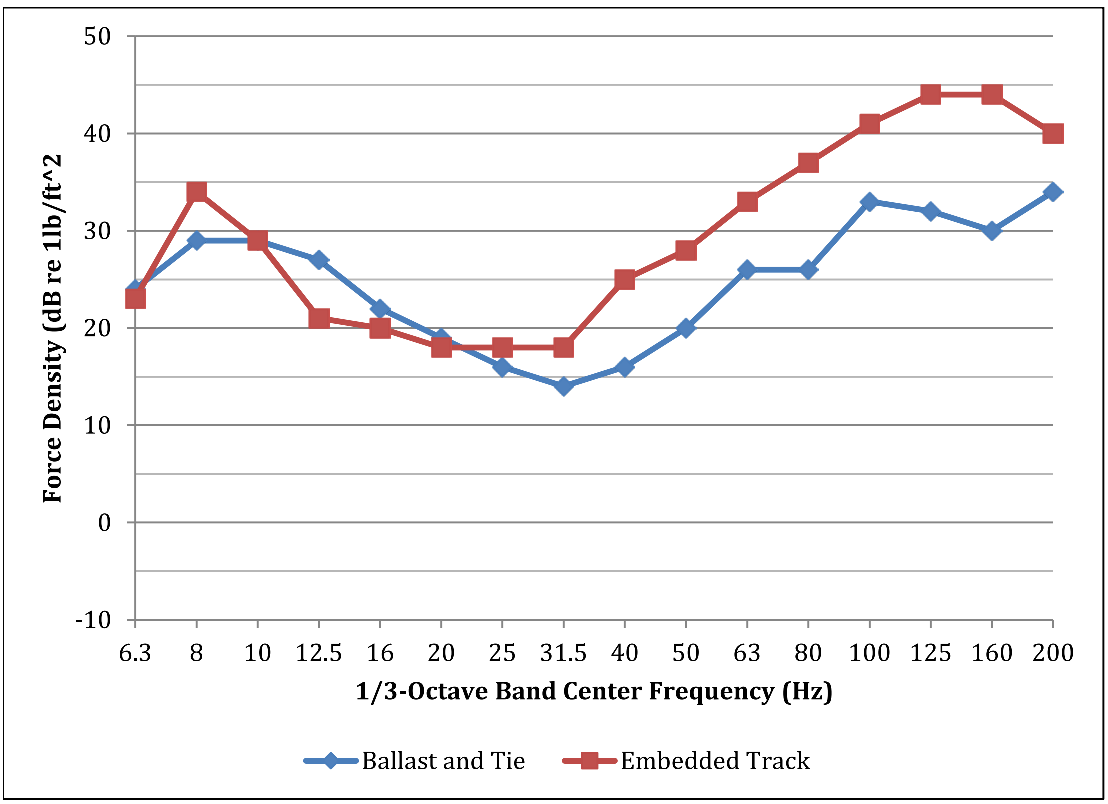
- Projected LRT operating speeds will range from approximately 15 to 55 mph for LRT revenue operations, except for entry and exit from station areas. LRV speeds are based on modeled speed profiles in both directions (i.e., inbound and outbound) that reflect LRV operating characteristics, track geometry, and station locations.

- All LRVs will consist of three cars during hours of operation.
- The operating hours and headways are described in Section 4.1, which will 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 LRV 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 LRV vibration level, FD is the LRV force density, and LSTM is the line source transfer mobility at a site.
- LRV FD levels were based on measurements conducted for the Central Corridor LRT Project (ATS Consulting 2008) for both ballast-and-tie and embedded track. Representative FD spectra for both ballast-and-tie and embedded track are shown on Figure 4-1.

**Figure 4-1 Force Density Levels at 40 mph**




Source: ATS, 2008.

## 4.3 Construction Noise Assessment Methodology

Construction noise and impacts are assessed using a combination of the methods and construction source data contained in the FTA guidance manual and the Federal Highway Administration Roadway Construction Noise Model from the FHWA Construction Noise Handbook (Final Report FHWA-HEP-06-015, August 2006). Typical noise levels generated by representative pieces of equipment are listed in Table 4-2. The noise exposure at a receiver location may be calculated using decibel addition of all operating construction equipment using the following equation:

$$Leq(n) = Lmax + 10 \times Log(U.F.) - 20 \times Log(D/50) - Ashielding$$

where:

Leq(n) = noise exposure at a receiver resulting from the operation of a single piece of equipment over n hours,

Lmax = noise emission level of the particular piece of equipment at the reference distance of 50 feet (taken from Table 4-2),

Ashielding = shielding provided by barriers, building, or terrain,

D = distance from the receiver to the piece of equipment in feet, and

U.F. = usage factor that accounts for the fraction of time that the equipment is in use over the specified time period. For Leq (1) assume a U.F. equal to 100 percent, and for 8 hours or more use the values in Table 4-2.

The combination of noise from several pieces of equipment operating during the same time period is obtained from decibel addition of the Leq of each single piece of equipment calculated using the above equations.

**Table 4-2 Construction Equipment Noise Emission Levels**

| Equipment | Typical Noise Level (dBA) 50 feet | Usage Factor (%) |
|---|---|---|
| Air Compressor | 80 | 40 |
| Backhoe | 80 | 40 |
| Ballast Equalizer | 82 | 50 |
| Ballast Tamper | 83 | 50 |
| Compactor | 82 | 20 |
| Concrete Mixer | 85 | 40 |
| Concrete Pump | 82 | 20 |
| Crane, Derrick | 88 | 16 |
| Crane, Mobile | 83 | 16 |
| Dozer | 85 | 16 |
| Generator | 82 | 50 |
| Grader | 85 | 40 |
| Impact Wrench | 85 | 50 |
| Jack Hammer | 88 | 20 |
| Loader | 80 | 40 |
| Paver | 85 | 50 |

| Equipment | Typical Noise Level (dBA) 50 feet | Usage Factor (%) |
|---|---|---|
| Pile Driver (Impact) | 101 | 20 |
| Pile Driver (Vibratory) | 95 | 20 |
| Pneumatic Tool | 85 | 50 |
| Pump | 77 | 50 |
| Rail Saw | 90 | 20 |
| Rock Drill | 85 | 20 |
| Roller | 85 | 20 |
| Saw | 76 | 20 |
| Scarifier | 83 | 20 |
| Scraper | 85 | 40 |
| Shovel | 82 | 40 |
| Spike Driver | 77 | 20 |
| Tie Cutter | 84 | 20 |
| Tie Handler | 80 | 20 |
| Tie Inserter | 85 | 20 |
| Truck | 84 | 40 |

Sources: FTA 2018 and FHWA 2006

## 4.4 Construction Vibration Assessment Methodology

Construction vibration is assessed for areas where there is potential for impact from construction activities. Such activities include blasting, pile driving, demolition, and drilling or excavation near sensitive structures. Typical vibration levels generated by representative pieces of equipment are listed in Table 4-3. For damage assessment, the following equation is used:

$$PPV_{equip} = PPV_{ref} \times [(25/D)]^{1.5}$$

where:

PPVequip = the peak particle velocity in in/sec of the equipment adjusted for distance,

PPVref = the reference vibration level in in/sec at 25 feet from Table 4-3, and

D = the distance from the equipment to the receiver in feet.

For annoyance assessment, the following equation is used:

$$Lv(D) = Lv(25\ ft) - 30 \times Log(D/25)$$

where:

Lv(D) = RMS vibration level at distance D,

Lv(25 ft) = RMS vibration level at 25 feet from Table 4-3, and

D = the distance from the equipment to the receiver in feet.

**Table 4-3 Construction Equipment Vibration Source Levels**

| Equipment | | PPV at 25 feet (in/sec) | Approximate Level* at 25 feet (VdB) |
|---|---|---|---|
| Pile Driver (impact) | upper range | 1.518 | 112 |
| | typical | 0.644 | 104 |
| Pile Driver (vibratory) | upper range | 0.734 | 105 |
| | typical | 0.170 | 93 |
| Clam shovel drop (slurry wall) | | 0.202 | 94 |
| Hydromill (slurry wall) | in soil | 0.008 | 66 |
| | in rock | 0.017 | 75 |
| Vibratory roller | | 0.210 | 94 |
| Hoe ram | | 0.089 | 87 |
| Large bulldozer | | 0.089 | 87 |
| Caisson drilling | | 0.089 | 87 |
| Loaded trucks | | 0.076 | 86 |
| Jackhammer | | 0.035 | 79 |
| Small bulldozer | | 0.003 | 58 |

Source: FTA 2018
*RMS velocity in decibels (VdB) re 1 micro-inch/second

# 5 Affected Environment

## 5.1 Noise

### 5.1.1 Noise-Sensitive Land Use

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

#### 5.1.1.1 City of Brooklyn Park

The noise-sensitive land uses for the City of Brooklyn Park include Ebenezer Community Church, Berean Baptist Church, Brooklyn Park Library, Fire International Embassy, North Hennepin Community College, Revive Church, Children's Music Academy of Brooklyn Park, Hampton Inn Brooklyn Park, and a mixture of single-family and multi-family residences. The dominant existing noise sources are occasional freight trains and traffic on Bottineau Blvd and W Broadway Ave.

#### 5.1.1.2 City of Crystal

The noise-sensitive land uses for the City of Crystal include Crystal Medical Center, North Star Inn and Suites, and single-family and multi-family residences. The dominant existing noise sources are occasional freight trains, traffic on Bottineau Blvd, and flight operations at the Crystal Airport.

#### 5.1.1.3 City of Robbinsdale

The noise-sensitive land uses for the City of Robbinsdale include North Memorial Health Hospital, Elim Lutheran Church, and a mixture of single-family and multi-family residences. The dominant existing noise source is traffic on Bottineau Blvd.

#### 5.1.1.4 City of Minneapolis

The noise-sensitive land uses for the City of Minneapolis include Parkway United Church of Christ, Good News Minneapolis Church, True Vine Missionary Baptist Church, Kipp Legacy School, St Anne-St Joseph Hien Church, Morning Star Assembly of God, All Nations Seventh-day Adventist Church, PYC Arts & Technology Alternative High School, Capri Theater, KMOJ radio station, Star Child Development Center LLC, St. Andrews Episcopal Church, Shiloh Temple International Ministries, Real Believers Faith Center Church, Episcopal Church in Minnesota, Full Proof Ministry COGIC, Liberty Community Church, United Deliverance Temple, Sanctuary Covenant Church, Faith Tabernacle Gospel Fellowship International, Masjid An-Nur Mosque, United Faith Pentecostal Church, Metro Schools College Prep, MN International Middle Charter School, Lundstrom Performing Arts, Token Media and a mixture of single-family and multi-family residences. The dominant existing noise sources are traffic on Interstate 94 (I-94), W Broadway Ave, and Washington Ave.

### 5.1.2 Existing Noise Measurements

#### 5.1.2.1 Noise Measurement Procedures and Equipment

Noise measurements were conducted during the week of April 3, 2023, on May 2, 2023, and during the week of September 23, 2024, at a total of 18 representative locations along the Project Alignment.

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 Project Alignment 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 Project.

The noise measurements were performed with NTi Audio model XL2 noise monitors and Larson Davis LD831-C noise monitors that conform to American National Standards Institute standards for Type 1 (precision) sound measurement equipment. Calibrations, traceable to the National Institute of Standards and Technology, 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.

In all cases, the measurement microphone was protected by a windscreen and supported on a tripod at a height of 4 to 6 feet above the ground and was positioned to characterize the exposure of the site to the dominant noise sources in the area. For example, microphones were located at the approximate setback lines of the receptors from adjacent roads and were positioned to avoid acoustic shielding by landscaping, fences, or other obstructions.

#### 5.1.2.2 Noise Measurement Locations and Results

Table 5-1 summarizes the results of the existing noise measurement program, and Figure 5-1 shows the location of the 13 long-term noise monitoring sites (designated by LT in the site number) and five short-term noise monitoring sites (designated by ST in the site number) for the Project. The long-term noise measurements were used to characterize the existing noise at residential locations, and the short-term noise measurements were used to characterize the existing noise at non-residential locations.

At each site, the noise measurement was conducted at the approximate set back of the building or buildings relative to the 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 location are described below.

### Table 5-1 Summary of Existing Noise Level Measurements

| Site No. | City | Measurement Location | Measurement Start Date | Measurement Start Time | Meas. Dur. (hrs) | Noise Level Ldn (dBA) | Noise Level Leq (dBA) |
|---|---|---|---|---|---|---|---|
| **LT-13** | Minneapolis | 1020 N 3rd St | September 26, 2024 | 12 p.m. | 24 | 71.8 | 68.9 |
| **LT-12** | Brooklyn Park | 8819 Oregon Ave | April 4, 2023 | 4 p.m. | 24 | 62.0 | 59.0 |
| **LT-11** | Brooklyn Park | 7431 78th Ct | April 4, 2023 | 4 p.m. | 24 | 65.3 | 59.4 |
| **LT-10** | Brooklyn Park | 7013 Dutton Ave | April 4, 2023 | 5 p.m. | 3* | 56.4 | 58.8 |
| **LT-9** | Crystal | 5906 Elmhurst Ave | April 3, 2023 | 3 p.m. | 24 | 63.4 | 61.1 |
| **LT-8** | Crystal | 5257 Xenia Ave | April 3, 2023 | 3 p.m. | 24 | 58.7 | 57.5 |
| **LT-8a** | Crystal | 4807 Lakeside Ave | September 24, 2024 | 3 p.m. | 24 | 71.4 | 69.7 |
| **LT-7** | Robbinsdale | 4536 Regent Ave | April 3, 2023 | 4 p.m. | 24 | 60.5 | 58.6 |
| **LT-6** | Robbinsdale | 3369 W Broadway Ave | April 4, 2023 | 11 a.m. | 24 | 70.2 | 68.6 |
| **LT-5** | Minneapolis | 2741 N Upton Ave | April 4, 2023 | noon | 24 | 69.3 | 68.1 |
| **LT-4** | Minneapolis | 2239 W Broadway Ave | April 5, 2023 | 5 p.m. | 24 | 69.1 | 67.6 |
| **LT-3** | Minneapolis | 1931 N Morgan Ave | May 2, 2023 | 3 p.m. | 24 | 64.9 | 61.6 |
| **LT-2** | Minneapolis | 2117 Dupont Ave | April 5, 2023 | 1 p.m. | 24 | 54.7 | 53.5 |
| **ST-5** | Brooklyn Park | Prince of Peace Lutheran Church | April 6, 2023 | 10:06 a.m. | 1 | 63.9** | 65.9 |
| **ST-4** | Robbinsdale | 3978 W Broadway Ave | April 3, 2023 | 4 p.m. | 1 | 56.7** | 56.7 |
| **ST-3** | Minneapolis | 1127 W Broadway Ave | April 6, 2023 | 10:30 a.m. | 1 | 66.3** | 68.3 |
| **ST-2** | Minneapolis | Token Media | September 24, 2024 | 12:15 p.m. | 1 | 60.6** | 62.6 |
| **ST-1** | Minneapolis | Element Minneapolis Downtown | April 5, 2023 | 11:48 a.m. | 1 | 64.5** | 66.5 |

Source: CSA 2024
LT = long-term; ST = short-term
* The sound level meter's battery failed prior to completion of 24-hour measurement. Ldn estimated using methods described in Appendix E of the FTA guidance manual.
** Ldn estimated using methods described in Appendix E of the FTA guidance manual.

### City of Brooklyn Park

***LT-12: 8819 Oregon Ave, City of Brooklyn Park*** **–** The Ldn measured at this location was 62.0 dBA, and the measured peak hour Leq was 59.0 dBA. This location is representative of all noise-sensitive land uses between 85th Ave and Trunk Highway (TH) 610. The ambient noise levels were dominated by traffic on W Broadway Ave.

***LT-11: 7431 78th Ct, City of Brooklyn Park*** **–** The Ldn measured at this location was 65.3 dBA, and the measured peak hour Leq was 59.4 dBA. This location is representative of all noise-sensitive land uses between N 73rd Ave and 85th Ave. The ambient noise levels were dominated by traffic on W Broadway Ave.

***LT-10: 7013 Dutton Ave, City of Brooklyn Park*** **–** The Ldn calculated at this location was 56.4 dBA, and the measured peak hour Leq was 58.8 dBA. This location is representative of all noise-sensitive land uses between 62nd Ave and I-94. The ambient noise levels were dominated by traffic on Bottineau Blvd. This measurement was conducted behind an existing noise barrier. The sound level meter's battery failed prior to completion of 24-hour measurement. The Ldn was estimated using methods described in Appendix E of the FTA guidance manual.

***ST-5: Prince of Peace Lutheran Church, City of Brooklyn Park*** **–** The hourly Leq measured at this location was 65.9 dBA, and the calculated Ldn was 63.9 dBA. This location is representative of all noise-sensitive land uses along W Broadway Ave between I-94 and 73rd Ave including the Prince of Peace Lutheran Church. The ambient noise levels were dominated by traffic on W Broadway Ave and freight traffic.

### City of Crystal

***LT-9: 5906 Elmhurst Ave, City of Crystal*** **–** The Ldn measured at this location was 63.4 dBA, and the measured peak hour Leq was 61.1 dBA. This location is representative of all noise-sensitive land uses between Bass Lake Rd and 62nd Ave. The ambient noise levels were dominated by traffic on Bottineau Blvd, flight operations at Crystal Airport, and trains on the freight line to the west.

***LT-8: 5257 Xenia Ave, City of Crystal*** **–** The Ldn measured at this location was 58.7 dBA, and the measured peak hour Leq was 57.5 dBA. This location is representative of all noise-sensitive land uses between 51st Ave and Bass Lake Rd. The ambient noise levels were dominated by traffic on Bottineau Blvd and TH 100.

***LT-8a: 4807 Lakeside Ave, City of Crystal*** **–** The Ldn measured at this location was 71.4 dBA, and the measured peak hour Leq was 69.7 dBA. This location is representative of all noise-sensitive land uses between 47th Ave and 51st Ave. The ambient noise levels were dominated by traffic on Bottineau Blvd.

### City of Robbinsdale

***LT-7: 4536 Regent Ave, City of Robbinsdale*** **–** The Ldn measured at this location was 60.5 dBA, and the measured peak hour Leq was 58.6 dBA. This location is representative of all noise-sensitive land uses between Lake Dr and 47th Ave. The ambient noise levels were dominated by traffic on Bottineau Blvd. This measurement was conducted behind an existing noise barrier.

***LT-6: 3369 W Broadway Ave, City of Robbinsdale*** **–** The Ldn measured at this location was 70.2 dBA, and the measured peak hour Leq was 68.6 dBA. This location is representative of all noise-sensitive land uses along W Broadway Ave between Lowry Ave and Lake Ave. The ambient noise levels were dominated by traffic on W Broadway Ave.

***ST-4: 3978 W Broadway Ave, City of Robbinsdale*** **–** The hourly Leq measured at this location was 56.7 dBA, and the calculated Ldn was 56.7 dBA. This location is representative of the noise at Elim Lutheran Church. The ambient noise levels were dominated by traffic on Bottineau Blvd.

## City of Minneapolis

***LT-13: 1020 N 3rd Street, City of Minneapolis*** **–** The Ldn measured at this location was 71.8 dBA, and the estimated peak hour Leq was 68.9 dBA. This location is representative of the residential noise-sensitive land use along N 10th Ave and N Washington Ave. The ambient noise levels were dominated by traffic on N 10th Ave and the I-94 on- and off-ramps to the south.

***LT-5: 2741 N Upton Ave, City of Minneapolis*** **–** The Ldn measured at this location was 69.3 dBA, and the measured peak hour Leq was 68.1 dBA. This location is representative of all noise-sensitive land uses along W Broadway Ave between 26th Ave and Lowry Ave. The ambient noise levels were dominated by traffic on W Broadway Ave.

***LT-4: 2239 W Broadway Ave, City of Minneapolis*** **–** The Ldn measured at this location was 69.1 dBA, and the measured peak hour Leq was 67.6 dBA. This location is representative of the residential noise-sensitive land uses along W Broadway Ave between N Logan Ave and 26th Ave. The ambient noise levels were dominated by traffic on W Broadway Ave.

***LT-3: 1931 N Morgan Ave, City of Minneapolis*** – The Ldn measured at this location was 64.9 dBA, and the measured peak hour Leq was 61.6 dBA. This location is representative of the residential noise-sensitive land uses along W Broadway Ave between I-94 and N Logan Ave. The ambient noise levels were dominated by traffic on W Broadway Ave.

***LT-2: 2117 Dupont Ave, City of Minneapolis*** **–** The Ldn measured at this location was 54.7 dBA, and the measured peak hour Leq was 53.5 dBA. This location is representative of the residential noise-sensitive land uses along N 21st Ave. The ambient noise levels were dominated by local traffic on N 21st Ave.

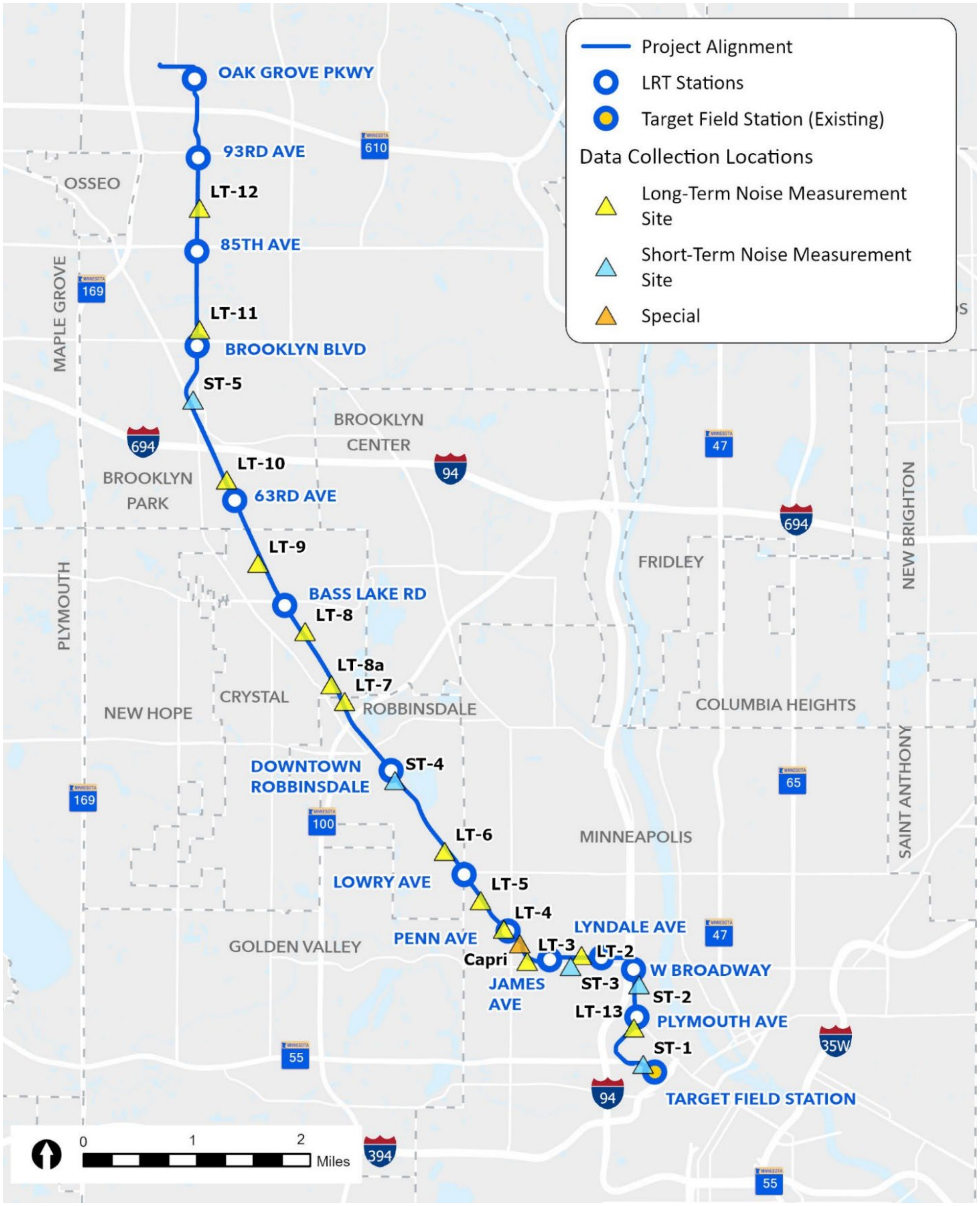
***ST-3: 1127 W Broadway Ave, City of Minneapolis*** **–** The hourly Leq measured at this location was 68.3 dBA, and the calculated Ldn was 66.3 dBA. This location is representative of the institutional noise-sensitive land uses along N 21st Ave and W Broadway Ave between James Ave and I-94. The ambient noise levels were dominated by traffic on W Broadway Ave.

***ST-2: Token Media, City of Minneapolis*** **–** The hourly Leq measured at this location was 62.6 dBA, and the calculated Ldn was 60.6 dBA. This location is representative of the institutional noise-sensitive land uses on the east side of I-94 north of 7th Ave. The ambient noise levels were dominated by traffic on 17th Avenue.

***ST-1: Element Minneapolis Downtown, City of Minneapolis*** **–** The hourly Leq measured at this location was 66.5 dBA, and the calculated Ldn was 64.5 dBA. This location is representative of noise-sensitive land uses along 6th Ave and 7th St between 5th St and Lyndale Ave.

Detailed information regarding the noise measurement results is contained in Appendix A, and photographs of noise measurement sites are contained in Appendix B.

## Figure 5-1 Existing Noise Measurement Locations




Sources: CSA 2023 and 2024
The Capri is a “special” case and is separate and distinguished as the orange triangle.

For the Capri Theater, identified as "Special" in Figure 5-1, sound insulation testing was conducted to determine the interior noise levels in sensitive spaces inside the building due to LRV operations. The testing was conducted in accordance with the American Society for Testing and Materials (ASTM) Standard Guide for Field Measurements of Airborne Sound Attenuations of Building Facades and Façade Elements (ASTM E966-10). The sound insulation measurements were conducted with equipment that conforms to American National Standards Institute standards for Type 1 (precision) microphones. Predicted interior Project noise levels were calculated in accordance with ASTM Standard Classification for Rating Outdoor-Indoor Sound Attenuation (ASTM E1332-10a) using a reference source spectrum of a typical LRV passby.

### 5.1.2.3 MPCA Noise Standards Analysis

Using the noise measurement data gathered at the long-term noise measurement sites described above, an analysis was also conducted using the MPCA L10 and L50 noise standards. At each location where a long-term noise measurement was conducted, the hourly L10 and L50 for both daytime and nighttime over a 24-hour period were calculated.

The results, shown in Table 5-2, show the range of existing (without the Project) L10 and L50 values for both daytime and nighttime. At most locations along the Project Alignment, the L10 and L50 standards are already being exceeded by existing noise sources during many hours of the day. Most of the existing exceedances of the thresholds are due to exempt noise sources, such as roadway noise and aircraft overflights. The higher existing L10 and L50 noise levels are at locations close to major roadways along the Project Alignment. At locations further from roadways, the L10 and L50 noise levels are lower.

**Table 5-2 Summary of Existing L10 and L50 Noise Levels at Long-Term Noise Measurement Locations**

| Site No. | City | Measurement Location | Max L10 (dBA)[a] | Max L50 (dBA)[b] |
|---|---|---|---|---|
| **LT-13** | Minneapolis | 1020 N 3rd Street | 71.7 | 67.6 |
| **LT-12** | Brooklyn Park | 8819 Oregon Ave | 65.1 | 60.6 |
| **LT-11** | Brooklyn Park | 7431 78th Court | 63.9 | 59.4 |
| **LT-10** | Brooklyn Park | 7013 Dutton Ave | 61.8 | 59.3 |
| **LT-9** | Crystal | 5906 Elmhurst Ave | 68.4 | 64.4 |
| **LT-8** | Crystal | 5257 Xenia Ave | 61.7 | 58.5 |
| **LT-8a** [c] | Crystal | 4807 Lakeside Ave | 73.3 | 68.7 |
| **LT-7** | Robbinsdale | 4536 Regent Ave | 61.0 | 58.9 |
| **LT-6** | Robbinsdale | 3369 W Broadway Ave | 73.8 | 69.5 |
| **LT-5** | Minneapolis | 2741 N Upton Ave | 73.7 | 67.8 |
| **LT-4** | Minneapolis | 2239 W Broadway Ave | 72.1 | 66.3 |
| **LT-3** | Minneapolis | 1931 N Morgan Ave | 65.9 | 62.2 |
| **LT-2** | Minneapolis | 2117 Dupont Ave | 58.1 | 53.2 |

Sources: CSA 2023 and 2024
LT = long-term
[a] The L10 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.
[b] The L50 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.
[c] The alpha character "a" was added because this was an additional site added after the Supplemental Draft EIS and used to preserve consistency in the numbering order for the Supplemental Final EIS.

## 5.2 Vibration

### 5.2.1 Vibration-Sensitive Land Use

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

#### 5.2.1.1 City of Brooklyn Park

The vibration-sensitive land uses for the City of Brooklyn Park includes Ebenezer Community Church, Berean Baptist Church, Brooklyn Park Library, Fire International Embassy, North Hennepin Community College, Revive Church, Children's Music Academy of Brooklyn Park, Hampton Inn Brooklyn Park, and a mixture of single-family and multi-family residences.

#### 5.2.1.2 City of Crystal

The vibration-sensitive land uses for the City of Crystal includes Crystal Medical Center, North Star Inn and Suites, and single-family and multi-family residences.

#### 5.2.1.3 City of Robbinsdale

The vibration-sensitive land uses for the City of Robbinsdale includes North Memorial Health Hospital, Elim Lutheran Church, and a mixture of single-family and multi-family residences.

#### 5.2.1.4 City of Minneapolis

The vibration-sensitive land uses for the City of Minneapolis includes Parkway United Church of Christ, Good News Minneapolis Church, True Vine Missionary Baptist Church, Kipp Legacy School, St Anne-St Joseph Hien Church, Morning Star Assembly of God, All Nations Seventh-day Adventist Church, PYC Arts & Technology Alternative High School, Capri Theater, KMOJ radio station, Star Child Development Center LLC, St. Andrews Episcopal Church, Shiloh Temple International Ministries, Real Believers Faith Center Church, Episcopal Church in Minnesota, Full Proof Ministry COGIC, Liberty Community Church, United Deliverance Temple, Sanctuary Covenant Church, Faith Tabernacle Gospel Fellowship International, Masjid An-Nur Mosque, United Faith Pentecostal Church, Metro Schools College Prep, MN International Middle Charter School, Lundstrum Performing Arts, Token Media and a mixture of single-family and multi-family residences.

### 5.2.2 Existing Vibration Measurements

#### 5.2.2.1 Vibration Measurement Procedures and Equipment

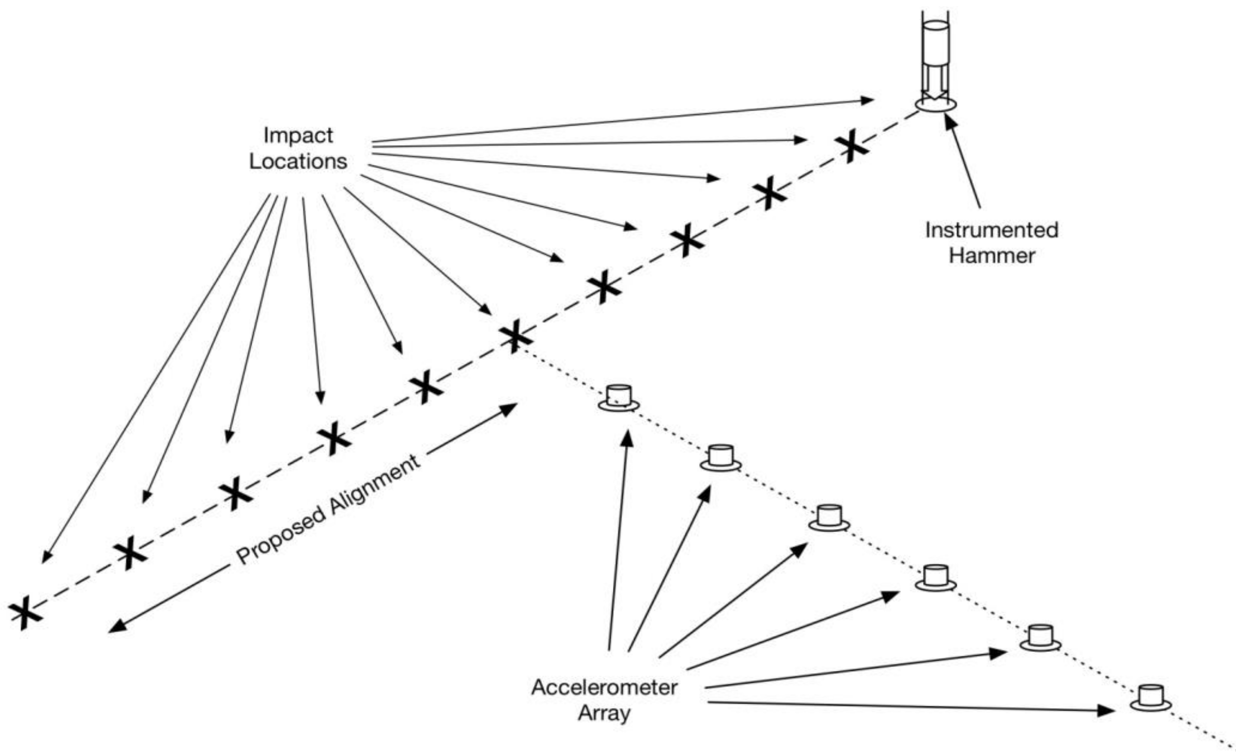
The vibration measurements conducted were used to characterize the response of the soil at locations within the Project Alignment. At each site, vibration propagation tests were conducted by impacting the ground with an instrumented weight and measuring the response of the soil and/or building foundations at various distances (LSTM). The results of the vibration propagation tests were combined with the FD (LRV input force) to Project vibration levels from LRT operations at locations along the Project Alignment.

A custom-built instrumented hammer was used to impart an impulsive force to the ground to determine the ground response. The magnitude of the force was calculated based on the acceleration and mass of the falling hammer. The resulting vibration signals were measured using high-sensitivity accelerometers

(PCB Model 393B05) mounted in a vertical direction magnetically adhered to washers on bricks. The signals from the hammer and accelerometers were recorded using Data Translation DT 9837A digital Acquisition hardware. DATA translation's QuickDAQ software, running on a laptop computer, was used to review the measurement data.

The vibration propagation test procedure is shown schematically in Figure 5-2. The instrumented hammer was used to generate impulses at specific locations spaced 15 feet apart along a line on or parallel to the Project Alignment. A line of accelerometers was placed perpendicular to the line of impacts as shown in Figure 5-2. The relationship between the input force and the resulting vibration measured by the accelerometers, called the transfer mobility, was calculated using proprietary software in the CSA laboratory. The transfer mobility represents the vibration propagation characteristics of the ground at the measurement site and along the alignment options.

**Figure 5-2 Vibration Propagation Measurement Schematic**




#### 5.2.2.2 Vibration Measurement Locations and Results

Existing vibration measurements were conducted to supplement the measurements made during the initial Draft EIS for the Project. Because portions of the current Project at the northern end of the Project Alignment are the same as those studied during the Supplemental Draft and Supplemental Final EIS for the Project, the vibration measurements conducted in these areas are still valid for use in this assessment.

A series of vibration propagation measurements was conducted during the week of April 3, 2023, and September 23, 2024, at nine locations along the Project Alignment.

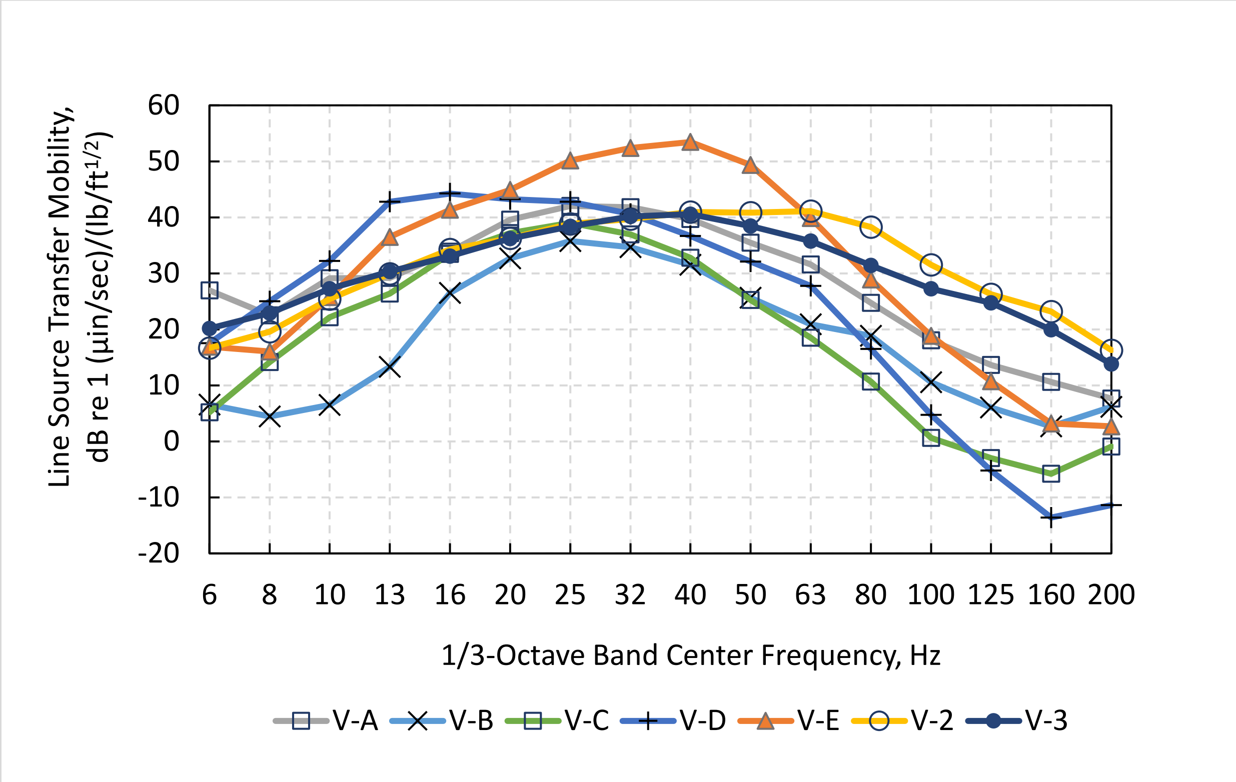
The locations of the nine vibration propagation measurement sites (including two from the 2016 Alignment) used in the assessment are shown in Figure 5-3. The location of vibration measurement V-A was selected to be representative of land uses between Target Field Station and Lyndale Station. Vibration measurements V-A-1 and V-A-2 were conducted for specific locations on 10th Ave and Washington Ave. The results of the LSTM tests are shown in Figure 5-4. Detailed information regarding the vibration measurement results for the tests conducted as a part of the Supplemental Draft EIS are contained in Appendix C, and photographs of vibration measurement sites are contained in Appendix D.

An additional set of vibration testing was conducted at the Capri Theater to determine specific vibration and ground-borne noise levels in sensitive spaces inside the building. Outdoor-to-indoor vibration measurements were conducted to measure the effect that the building foundation and structure has on vibration levels inside the building.

### Figure 5-3 Vibration Propagation Measurement Locations


Sources: CSA 2023 and 2024

**Figure 5-4 Line Source Transfer Mobility Results at 50 Feet**




Note: Measurements V-A-1 and V-A-2 were conducted at specific buildings, and 50-foot spectra were not measured.

# 6 Environmental Consequences

The FTA noise and vibration guidance manual is the primary source for the noise methodology. Noise impact has been evaluated using the Detailed Noise Assessment methodology contained in Section 6 of the FTA guidance manual. The noise assessment includes the following steps:

- Identified noise-sensitive land uses in the Project Alignment using aerial photography, geographic information system (GIS) data, and field surveys, typically within 350 feet of the alignment.
- Measured the existing noise levels in the Project Alignment at sensitive receptors (See Affected Environment in Section 4.1).
- Projected Project noise levels from transit operations, using Project drawings provided by the engineering team, and information on speeds, headways, track type, LRV type, and at-grade-crossing operations.
- Assessed the impact from transit by comparing the Project noise with the FTA noise impact criteria in Section 4 of the FTA guidance manual.
- Recommended mitigation at locations where Project noise levels exceed the impact criteria.

The results of the impact assessment in the Supplemental Final EIS differ from those presented in the Supplemental Draft EIS due to a number of changes that have occurred during design advancement. The changes include:

- Areas where the track location or track type (ballast and tie vs embedded track) has changed,
- Updates to the design, resulting in revised acquisitions,
- Relocation of crossovers, and
- Changes in the speed profile.

Additionally, supplemental existing noise measurements were conducted as a part of the Supplemental Final EIS, both in response to comments on the Supplemental Draft EIS and to refine the analysis from the Supplemental Draft EIS. Because the impact criteria for the noise assessment are based on the existing noise levels, updated existing noise levels will change the impact thresholds and the location and number of impacts.

## 6.1 Project Noise

This section describes the noise impacts for the Project. Most of the impacts are due to proximity of the tracks (wheel/rail interaction) to sensitive land use, grade crossing bells, and location of crossovers.

Table 6-1 through Table 6-8 present the results of the noise impact assessment for residential and institutional (e.g., churches and schools) land uses for each city. The sources of Project noise are described in Section 3.1 and the specific source of noise for each impact location is described in the text below each table. The results include a tabulation of location information for each sensitive receptor group, the existing noise levels, the Project noise levels, the impact criteria, and whether there will be noise impacts. The tables also show the total number of properties and DUs with moderate and severe noise impacts for each location. Because the Project would never exceed the MPCA standards, the FTA criteria are more protective in assessing impacts from the Project. A summary of each location that will experience noise impacts follows the respective tables.

The moderate and severe noise impact criteria for the noise assessment are determined by the existing noise level, as described in Section 2.1.2.1 and shown in Figure 2.2. The Project noise level is compared to the moderate and severe impact thresholds at each location to determine the potential for noise impact from the Project. If the Project noise level is above the criteria, there would be either a moderate or severe noise impact. If the Project noise level is below the moderate impact criterion, there would be no noise impact.

### Table 6-1 Summary of Noise Impacts for Residential Land Use in the City of Brooklyn Park

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Ldn (dBA) | Project Noise Level Ldn (dBA) | FTA Mod Impact Noise Level Ldn (dBA) | FTA Sev Impact Noise Level Ldn (dBA) | Noise Level Increase (dB) | Mod Noise Impacts # of properties /DUs | Sev Noise Impacts # of properties /DUs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 93rd Ave N to TH 610 | Brooklyn Park | NB | 272 | 24 | 62 | 46 | 59 | 64 | 0.1 | 0 | 0 |
| 93rd Ave N to TH 610 | Brooklyn Park | SB | * | * | * | * | * | * | * | * | * |
| 85th Ave N to 93rd Ave N | Brooklyn Park | NB | 107 | 38 | 62 | 58 | 59 | 64 | 1.5 | 0 | 0 |
| 85th Ave N to 93rd Ave N | Brooklyn Park | SB | 90 | 54 | 62 | 58 | 59 | 64 | 1.4 | 0 | 0 |
| Shingle Creek to 85th Ave N | Brooklyn Park | NB | * | * | * | * | * | * | * | * | * |
| Shingle Creek to 85th Ave N | Brooklyn Park | SB | 88 | 39 | 65 | 64 | 61 | 66 | 2.3 | 5/5 | 0 |
| Brooklyn Blvd to Shingle Creek | Brooklyn Park | NB | 98 | 52 | 65 | 59 | 61 | 66 | 0.9 | 0 | 0 |
| Brooklyn Blvd to Shingle Creek | Brooklyn Park | SB | * | * | * | * | * | * | * | * | * |
| N 73rd Ave to Brooklyn Blvd | Brooklyn Park | NB | 86 | 34 | 65 | 58 | 61 | 66 | 0.8 | 0 | 0 |
| N 73rd Ave to Brooklyn Blvd | Brooklyn Park | SB | 169 | 37 | 65 | 51 | 61 | 66 | 0.2 | 0 | 0 |
| I-94 to N 73rd Ave | Brooklyn Park | NB | * | * | * | * | * | * | * | * | * |
| I-94 to N 73rd Ave | Brooklyn Park | SB | 271 | 46 | 56 | 49 | 56 | 62 | 0.7 | 0 | 0 |
| N 63rd Ave to I-94 | Brooklyn Park | NB | 111 | 44 | 56 | 51 | 56 | 62 | 1.2 | 0 | 0 |
| N 63rd Ave to I-94 | Brooklyn Park | SB | 225 | 40 | 56 | 51 | 56 | 62 | 1.2 | 0 | 0 |
| N 60th Ave to N 63rd Ave | Brooklyn Park | NB | 121 | 54 | 63 | 57 | 60 | 65 | 0.8 | 0 | 0 |
| N 60th Ave to N 63rd Ave | Brooklyn Park | SB | 204 | 54 | 63 | 53 | 60 | 65 | 0.4 | 0 | 0 |

Source: CSA 2024
Notes:
Predicted noise levels shown 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.
Includes the total number of DUs at the affected properties. Additional noise measurements and analysis will be performed to determine potential impacts at each DU and the reasonable and feasible mitigation measures that would be implemented.
Mod = moderate; Sev = severe.
*No noise-sensitive land uses.

- ***Shingle Creek to 85th Avenue (SB):*** Based on FTA criteria, the Council identified five moderate noise impacts at single-family residences. Compared to existing conditions, outdoor noise levels would increase by up to 2.3 dB at these residences due to the proximity of the tracks (wheel/rail interaction) and the speed of the train, and a nearby crossover.

**Table 6-2 Summary of Noise Impacts for Institutional Land Use in the City of Brooklyn Park**

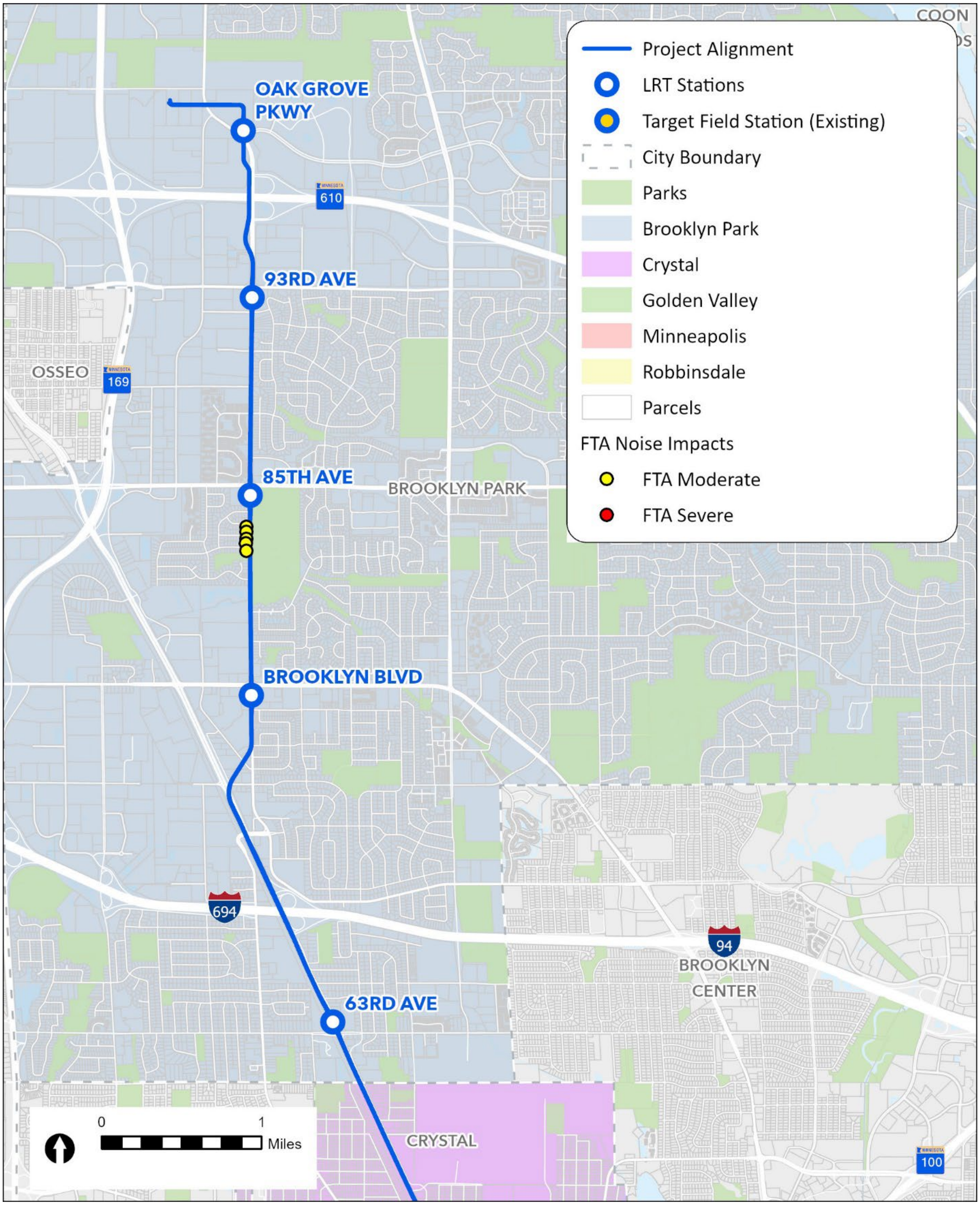
| Name | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Leq (dBA) | Project Noise Levels Leq (dBA) | FTA Mod Impact Noise Level Leq (dBA) | FTA Sev Impact Noise Level Leq (dBA) | Noise Level Increase (dB) | Type of Impact |
|---|---|---|---|---|---|---|---|---|---|---|
| Ebenezer Community Church | Brooklyn Park | NB | 136 | 32 | 59 | 54 | 62 | 68 | 1.2 | -- |
| Berean Baptist Church | Brooklyn Park | SB | 88 | 41 | 59 | 58 | 62 | 68 | 2.4 | -- |
| Brooklyn Park Library | Brooklyn Park | NB | 99 | 40 | 59 | 53 | 62 | 68 | 1.1 | -- |
| Fire Inter-national Embassy | Brooklyn Park | SB | 333 | 30 | 59 | 36 | 62 | 68 | 0.0 | -- |
| North Hennepin Community College | Brooklyn Park | NB | 215 | 40 | 59 | 47 | 62 | 68 | 0.2 | -- |
| Revive Church | Brooklyn Park | SB | 162 | 53 | 59 | 51 | 62 | 68 | 0.6 | -- |
| Children's Music Academy of Brooklyn Park | Brooklyn Park | NB | 301 | 38 | 66 | 44 | 66 | 72 | 0.0 | -- |

Source: CSA 2024
Note: The reported noise levels are rounded to the nearest decibel.
Mod = moderate; Sev = severe.

There are no institutional noise impacts in the City of Brooklyn Park.

The locations of the noise impacts for the City of Brooklyn Park are shown in Figure 6-1. Impacts have been reduced since the publication of the Supplemental Draft EIS because speeds were reduced north of 85th Ave N resulting in the elimination of noise impacts to five properties.

**Figure 6-1 Project Noise Impacts in the City of Brooklyn Park**




Source: CSA 2024

**Table 6-3 Summary of Noise Impacts for Residential Land Use in the City of Crystal**

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph)[a] | Exist Noise Level Ldn (dBA) | Project Noise Levels Ldn (dBA) | FTA Mod Impact Noise Level Ldn (dBA) | FTA Sev Impact Noise Level Ldn (dBA) | Noise Level Increase (dB) | Mod Noise Impacts # of properties /DUs | Number of Sev Noise Impacts |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N 56th Ave to N 60th Ave | Crystal | NB | 338 | 29 | 63 | 40 | 60 | 65 | 0.0 | 0 | 0 |
| N 56th Ave to N 60th Ave | Crystal | SB | 227 | 54 | 63 | 52 | 60 | 65 | 0.3 | 0 | 0 |
| Canadian Pacific Kansas City (CPKC) Rail Line to N 56th Ave | Crystal | NB | 128 | 25 | 63 | 58 | 60 | 65 | 1.1 | 0 | 0 |
| CPKC Rail Line to N 56th Ave | Crystal | SB | 295 | 32 | 63 | 44 | 60 | 65 | 0.0 | 0 | 0 |
| N 47th Ave to CPKC Rail Line | Crystal | NB | 133 | 54 | 71 | 62 | 65 | 70 | 0.5 | 0 | 0 |
| N 47th Ave to CPKC Rail Line | Crystal | SB | 91 | 54 | 71 | 64 | 65 | 70 | 0.7 | 0 | 0 |

Source: CSA 2024
[a] LRV speed varies within the segment. Speed (mph) listed here reflects noise analysis assumptions.
Notes:
Predicted noise levels shown 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.
Includes the total number of DUs at the affected properties. Additional noise measurements and analysis will be performed to determine potential impacts at each DU and the reasonable and feasible mitigation measures that would be implemented. Mod = moderate; Sev = severe.
*No noise-sensitive land use.

For the changes to the roadway as a part of the project at Bass Lake Rd, a Federal Highway Administration Traffic Noise Model noise assessment was conducted. The assessment modeled the existing noise on Bass Lake Rd and the future noise levels with the new intersection. The results of the noise assessment indicated that at all sensitive locations near Bass Lake Rd, the noise levels in the future would be lower than existing noise levels. This is due to the reduction in traffic volumes and the shielding of traffic noise provided by safety barriers on the elevated structures. Because the traffic noise levels would be lower with the project, the noise levels shown above for the City of Crystal near Bass Lake Rd would be conservative, and no additional impacts would occur due to traffic noise.

There are no residential noise impacts in the City of Crystal. The change in noise impacts are due to supplemental existing noise measurements, which identified higher existing noise levels compared to the Supplemental Draft EIS analysis and a reduction in the number of impacts.

**Table 6-4 Summary of Noise Impacts for Institutional Land Use in the City of Crystal**

| Name | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Leq (dBA) | Project Noise Levels Leq (dBA) | FTA Mod Impact Noise Level Leq (dBA) | FTA Sev Impact Noise Level Leq (dBA) | Noise Level Increase (dB) | Type of Impact |
|---|---|---|---|---|---|---|---|---|---|---|
| Crystal Medical Center | Crystal | NB | 98 | 43 | 61 | 55 | 63 | 69 | 0.9 | -- |

Source: CSA 2024
Note: The reported noise levels are rounded to the nearest decibel.
Mod = moderate; Sev = severe.

There are no institutional noise impacts in the City of Crystal.

**Table 6-5 Summary of Noise Impacts for Residential Land Use in the City of Robbinsdale**

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Ldn (dBA) | Project Noise Levels Ldn (dBA) | FTA Mod Impact Noise Level Ldn (dBA) | FTA Sev Impact Noise Level Ldn (dBA) | Noise Level Increase (dB) | Mod Noise Impacts # of properties /DUs | Sev Noise Impacts # of properties /DUs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TH 100 to N 47th Ave | Robbinsdale | NB | 136 | 51 | 61 | 49 | 58 | 64 | 0.3 | 0 | 0 |
| TH 100 to N 47th Ave | Robbinsdale | SB | 201 | 39 | 61 | 52 | 58 | 54 | 0.6 | 0 | 0 |
| N 42nd Ave to TH 100 | Robbinsdale | NB | 91 | 38 | 61 | 56 | 58 | 64 | 1.2 | 0 | 0 |
| N 42nd Ave to TH 100 | Robbinsdale | SB | 103 | 39 | 61 | 56 | 58 | 64 | 1.2 | 0 | 0 |
| N 40th Ave to N 42nd Ave** | Robbinsdale | NB | 112 | 25 | 70 | 53 | 64 | 70 | 0.1 | 0 | 0 |
| N 40th Ave to N 42nd Ave** | Robbinsdale | SB | * | * | * | * | * | * | * | * | * |
| N 36th Ave to N 40th Ave** | Robbinsdale | NB | 102 | 40 | 70 | 57 | 64 | 70 | 0.2 | 0 | 0 |
| N 36th Ave to N 40th Ave** | Robbinsdale | SB | 80 | 39 | 70 | 60 | 64 | 70 | 0.4 | 0 | 0 |
| N Lowry Ave to N 36th Ave | Robbinsdale | NB | 147 | 53 | 70 | 60 | 64 | 70 | 0.4 | 0 | 0 |
| N Lowry Ave to N 36th Ave | Robbinsdale | SB | 109 | 53 | 70 | 63 | 64 | 70 | 0.7 | 0 | 0 |

Source: CSA 2024
Notes:
Predicted noise levels shown 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.
Includes the total number of DUs at the affected properties. Additional noise measurements and analysis will be performed to determine potential impacts at each DU and the reasonable and feasible mitigation measures that would be implemented.
Mod = moderate; Sev = severe.
*No noise-sensitive land use.
**There are no differences in the predicted noise levels or impacts for the three options for the Downtown Robbinsdale Station.

There are no residential noise impacts in the City of Robbinsdale. Impacts have been reduced since the publication of the Supplemental Draft EIS because of speed reductions due to design refinement. The reduced speeds south of TH 100 resulted in the elimination of noise impacts to two properties.

**Table 6-6 Summary of Noise Impacts for Institutional Land Use in the City of Robbinsdale**

| Name | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Leq (dBA) | Project Noise Levels Leq (dBA) | FTA Mod Impacts Noise Level Leq (dBA) | FTA Sev Impact Noise Level Leq (dBA) | Noise Level Increase (dB) | Type of Impact |
|---|---|---|---|---|---|---|---|---|---|---|
| Elim Lutheran Church | Robbinsdale | SB | 156 | 40 | 57 | 49 | 61 | 67 | 0.7 | -- |

Source: CSA 2024
Note: The reported noise levels are rounded to the nearest decibel.
Mod = moderate; Sev = severe.

There are no institutional noise impacts in the City of Robbinsdale.

## Table 6-7 Summary of Noise Impacts for Residential Land Use in the City of Minneapolis

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Ldn (dBA) | Project Noise Levels Ldn (dBA) | FTA Mod Impact Noise Level Ldn (dBA) | FTA Sev Impact Noise Level Ldn (dBA) | Noise Level Increase (dB) | Mod Noise Impacts # of properties /DUs | Sev Noise Impacts # of properties /DUs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N 26th Ave to N Lowry Ave | Minneapolis | NB | 43 | 34 | 69 | 66 | 64 | 69 | 1.5 | 2/2 | 0 |
| N 26th Ave to N Lowry Ave | Minneapolis | SB | 40 | 34 | 69 | 65 | 64 | 69 | 1.3 | 2/2 | 0 |
| N Knox Ave to N 26th Ave | Minneapolis | NB | 56 | 16 | 69 | 64 | 64 | 69 | 1.3 | 1/104 | 0 |
| N Knox Ave to N 26th Ave | Minneapolis | SB | 42 | 30 | 69 | 60 | 64 | 69 | 0.5 | 0 | 0 |
| N Emerson Ave to N Knox Ave | Minneapolis | NB | 51 | 39 | 55 | 69 | 55 | 61 | 14.0 | 2/3 | 2/3 |
| N Emerson Ave to N Knox Ave | Minneapolis | SB | 25 | 38 | 55 | 74 | 55 | 61 | 19.4 | 0 | 4/15 |
| Lyndale Ave to N Emerson Ave | Minneapolis | NB | 33 | 19 | 55 | 70 | 55 | 61 | 15.0 | 7/8 | 3/32 |
| Lyndale Ave to N Emerson Ave | Minneapolis | SB | 18 | 19 | 55 | 74 | 55 | 61 | 19.4 | 0 | 1/18 |
| I-94 to Lyndale Ave | Minneapolis | NB | 54 | 39 | 55 | 62 | 55 | 61 | 8.3 | 2/4 | 2/2 |
| I-94 to Lyndale Ave | Minneapolis | SB | * | * | * | * | * | * | * | * | * |
| I-94 to Plymouth Ave N | Minneapolis | NB | 46 | 20 | 72 | 66 | 65 | 71 | 0.9 | 2/5 | 0 |
| I-94 to Plymouth Ave N | Minneapolis | SB | * | * | * | * | * | * | * | * | * |
| N 8th Ave to Plymouth Ave N | Minneapolis | NB | 29 | 39 | 72 | 67 | 65 | 71 | 1.2 | 1/30 | 0 |
| N 8th Ave to Plymouth Ave N | Minneapolis | SB | 27 | 32 | 72 | 69 | 65 | 71 | 1.7 | 1/109 | 0 |
| Target Field Station to N 8th Ave | Minneapolis | NB | 50 | 8 | 65 | 44 | 60 | 66 | 0.0 | 0 | 0 |
| Target Field Station to N 8th Ave | Minneapolis | SB | * | * | * | * | * | * | * | * | * |

Source: CSA 2024

Notes:

Predicted noise levels shown 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.

Includes the total number of DUs at the affected properties. Additional noise measurements and analysis will be performed to determine potential impacts at each DU and the reasonable and feasible mitigation measures that would be implemented.

Mod = moderate; Sev = severe.

*No noise-sensitive land use.

Based on FTA criteria, moderate impacts would occur at 20 residential properties, and severe impacts would occur at 11 residential properties, as summarized:

- ***Between N Lowry Ave and N 26th Ave:*** Based on FTA criteria, the Council identified four moderate noise impacts at single-family residences. Compared to existing conditions, outdoor noise levels would increase by up to 1.5 dB at these residences due to the proximity of the tracks (wheel/rail interaction) and the speed of the train.
- ***Between N 26th Ave and N Knox Ave:*** Based on FTA criteria, the Council identified one moderate noise impact at an apartment building with 104 dwelling units. Compared to existing conditions, outdoor noise levels would increase by up to 1.3 dB at this residential property, due to the proximity of the tracks (wheel/rail interaction) and LRV bells at Penn Ave Station.
- ***Between N Knox Ave and N Emerson Ave:*** Based on FTA criteria, the Council identified two moderate noise impacts, one at a single-family home and one at a two-family home, and severe noise impacts at six properties, including one two-family and four single-family homes and an apartment building with 12 dwelling units. Compared to existing conditions, outdoor noise levels at these residences would vary, increasing between 5 and 19 dB depending on the location. Existing noise is relatively low along this segment – recorded at 55 dBA – and the proximity of the tracks (wheel/rail interaction), a nearby crossover, and bells at N Girard Ave, N Fremont Ave, and N Emerson Ave would cause the noise increase.
- ***Between N Emerson Ave and N Lyndale Ave:*** Based on FTA criteria, the Council identified seven moderate noise impacts – six at single-family homes and one at a two-family home. The Council identified four severe noise impacts – two at single-family homes and two at apartment buildings, one with 30 dwelling units and one with 18 dwelling units. Compared to existing conditions, the increase in outdoor noise levels at these residences would vary, increasing between 3 and 19 dB depending on the location. Existing noise is relatively low along this segment – recorded at 55 dBA – and the proximity of the tracks (wheel/rail interaction), a nearby crossover, and bells at Bryant Ave and Lyndale Ave would cause the noise increase.
- ***Between I-94 and N Lyndale Ave:*** Based on FTA criteria, the Council identified two moderate impacts – at two two-family residences – and two severe noise impacts at two single-family residences. Compared to existing conditions, outdoor noise levels at these residences would vary, increasing between 3 and 8 dB depending on the location. Existing noise is relatively low along this segment – recorded at 55 dBA – and the proximity of the tracks (wheel/rail interaction) and the bells at Lyndale Ave would cause the noise increase.
- ***Between Plymouth Ave N and I-94:*** Based on FTA criteria, the Council identified two moderate noise impacts at two apartment buildings with 2 and 3 dwelling units, respectively. Compared to existing conditions, outdoor noise levels at these residential properties would increase by 0.9 dB due to the proximity of the tracks and the bells at the nearby station.
- ***Between Plymouth Ave N and N 8th Ave:*** Based on FTA criteria, the Council identified two moderate noise impacts at two apartment buildings with 30 and 109 dwelling units, respectively. Compared to existing conditions, outdoor noise levels at these residential properties would increase by between 1.2 dB and 1.7 dB due to the proximity of the tracks and bells at N 3rd Street.

Additional noise monitoring and analysis will be performed as the design advances to determine potential impacts at single-family residences and each dwelling unit within multi-family properties and whether mitigation measures would be cost effective based on noise mitigation criteria (see Section 5.6.4).

In addition to the noise impacts at residential properties, two moderate noise impacts would occur at institutional receivers. A moderate noise impact would occur at the Liberty Community Church, where outdoor noise levels would increase by 7.6 dB. This impact would be due to the proximity of the tracks (wheel/rail interaction), the proximity of a nearby crossover, and bells at N Emerson Ave.

A moderate noise impact would occur at the Sanctuary Covenant Church, where outdoor noise levels would increase by 5.6 dB. This impact would be due to the proximity of the tracks (wheel/rail interaction) and LVT bells at Lyndale Avenue Station.

Noise impacts were reduced since the publication of the Supplemental Draft EIS north of 26th Ave N where a crossover was removed through design coordination. The results eliminated seven moderate noise impacts and reduced three from severe to moderate impacts. The locations of the noise impacts for the City of Minneapolis along the N 21st Ave and east of I-94 to Washington Ave are shown in Figure 6-2.

**Table 6-8 Summary of Noise Impacts for Institutional Land Use in the City of Minneapolis**

| Name | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Exist Noise Level Leq (dBA) | Project Noise Levels Leq (dBA) | FTA Mod Impact Noise Level Leq (dBA) | FTA Sev Impact Noise Level Leq (dBA) | Noise Level Increase | Type of Impact |
|---|---|---|---|---|---|---|---|---|---|---|
| Parkway United Church of Christ | Minneapolis | NB | 307 | 18 | 68 | 40 | 68 | 73 | 0.0 | -- |
| Good News Minneapolis Church | Minneapolis | NB | 152 | 42 | 68 | 48 | 68 | 73 | 0.4 | -- |
| True Vine Missionary Baptist Church | Minneapolis | SB | 111 | 34 | 68 | 56 | 68 | 73 | 1.1 | -- |
| KIPP Legacy | Minneapolis | NB | 200 | 42 | 68 | 52 | 68 | 73 | 0.1 | -- |
| St Anne-St Joseph Hien Church | Minneapolis | NB | 323 | 39 | 68 | 43 | 68 | 73 | 0.0 | -- |
| All Nations Seventh-day Adventist Church | Minneapolis | SB | 182 | 16 | 68 | 48 | 68 | 73 | 0.0 | -- |
| PYC Arts & Technology Alternative High School | Minneapolis | SB | 55 | 19 | 62 | 58 | 64 | 69 | 1.6 | -- |
| Capri Theater* | Minneapolis | SB | 41 | 24 | 62 | 63 | 64 | 69 | -- | -- |
| Star Child Development Center LLC | Minneapolis | SB | 39 | 18 | 62 | 63 | 64 | 69 | 3.7 | -- |
| Real Believers Faith Center Church | Minneapolis | SB | 236 | 39 | 68 | 43 | 68 | 73 | 0.0 | -- |
| Liberty Community Church | Minneapolis | NB | 44 | 41 | 62 | 68 | 64 | 69 | 4.1 | Moderate |
| United Deliverance Temple Inc | Minneapolis | NB | 250 | 18 | 62 | 36 | 64 | 69 | 0.0 | -- |
| Sanctuary Covenant Church | Minneapolis | SB | 16 | 7 | 62 | 66 | 64 | 69 | 1.9 | Moderate |
| Metro Schools College Prep | Minneapolis | SB | 162 | 21 | 67 | 48 | 67 | 72 | 0.0 | -- |
| Lundstrum Performing Arts | Minneapolis | NB | 270 | 46 | 66 | 45 | 66 | 72 | 0.1 | -- |
| Token Media | Minneapolis | NB | 281 | 46 | 63 | 45 | 59 | 65 | 0.1 | -- |

Source: CSA 2024
The reported noise levels are rounded to the nearest decibel.
*This represents the results for non-special use spaces in the Capri Theater.

## Figure 6-2 Project Noise Impacts in the City of Minneapolis


Source: CSA 2024

### 6.1.1 Capri Theater

The Capri Theater is a special use building that contains several different noise- and vibration-sensitive spaces, including a theater, recording studio, community hall, dance studio, and classrooms. The community hall, dance studio, and classrooms are all Category 3 (institutional) receivers. The noise and vibration assessments for the Category 3 uses at Capri Theater are discussed in Sections 6.1 and 6.2.1, respectively. No noise or vibration impacts are projected for any of the Category 3 uses.

The theater and the recording studio are considered separately from the rest of the building and require site-specific measurements to determine the potential for noise and vibration impact. The FTA Guidance manual includes specific vibration and ground-borne noise criteria for both spaces. For the noise assessment, the calculated indoor Project noise levels in the theater, which has an outer wall facing the Project Alignment, were compared to the measured ambient noise level to determine the potential for impact. Because the recording studio is located in the interior of the building, a noise assessment was not conducted because there is no path for outdoor noise to affect the space. The criteria used in the assessment for both spaces are shown in Table 6-9.

**Table 6-9 FTA Noise and Vibration Criteria for the Capri Theater**

| Location | Existing Noise Level (dBA) | FTA Vibration Criteria (VdB) | FTA Ground-Borne Noise Criteria (dBA) |
|---|---|---|---|
| Theater | 46.2 | 72 | 35 |
| Recording Studio | -- | 65 | 25 |

Source: CSA 2023

The outdoor-to-indoor noise measurements conducted for the theater focused on the southeast façade of the building, which is an outer wall for the theater. The northeast façade of the building includes an atrium, and an additional wall and doors between the outside of the building and the theater space. The light rail noise levels inside the theater would be much lower through that façade than the outer wall on the southeast side. The results of the noise measurements inside the theater indicate that noise levels from LRV passbys would be 5 dB below the existing noise levels in the theater. Therefore, there would be no noise impacts from light rail operations.

The results of the vibration and ground-borne noise measurements inside the theater indicate that both the vibration and ground-borne noise levels are well below the impact thresholds and no impacts are projected.

The results of the vibration and ground-borne noise assessment for the recording studio indicate that both the vibration and ground-borne noise levels are below the impact thresholds. The vibration and ground-borne noise measurements for the recording studio conducted on the second story of the building showed that the building provides a significant reduction in both vibration and ground-borne noise levels from the outside of the building to the second floor.

A summary of the noise and vibration impact assessment for the Capri Theater is shown in Table 6-10.

**Table 6-10 Summary of Project Noise and Vibration Levels for the Capri Theater**

| Location | Project Noise Level (dBA) | Project Vibration Level (VdB) | Project Ground-Borne Noise Level (dBA) |
|---|---|---|---|
| Theater | 40.9 | 57 | 24 |
| Recording Studio | -- | 30 | 10 |

Source: CSA 2023

### 6.1.2 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 Project noise assessment detailed above.

### 6.1.3 Operations and Maintenance Facility

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

### 6.1.4 Construction Noise

Elevated noise levels from construction activities are, to a degree, unavoidable for this type of project. Construction noise levels are subject to local noise ordinances and noise rules administered by the MPCA (Minnesota Rules ch. 7030). MPCA administers these noise rules to establish maximum allowable noise levels; where applicable, MPCA procedures allow for the issuance of noise variances. The Council will require that construction equipment used by contractors be properly muffled and in proper working order. Advanced notice will be provided to affected communities of any planned abnormally loud construction activities. In general, construction will 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 Project's final design and construction stages, a nighttime construction mitigation plan will be developed.

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. Short-term noise during construction of the Project can be intrusive to residents near the construction sites. Most of the construction will consist of site preparation and laying new tracks, and should occur primarily during daytime hours, except when required and within City noise ordinance procedures for a waiver. At some locations, more extensive work will occur, such as pile driving for elevated structures and retaining walls.

Table 6-11 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 Leq for a particular set of assumptions is estimated using typical noise levels from Table 6-11.

### Table 6-11 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 2018

Table 6-12 provides an example of a construction noise projection for typical at-grade track construction. Using these assumptions, an 8-hour Leq 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 6-11, 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 6-12) impact could extend to approximately 120 feet from the Project Alignment; 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 Project Alignment.

Typically, a contractor will provide this information as a part of a noise control plan for construction. See Section 7.1.4 for more information regarding the approach to mitigating construction noise.

### Table 6-12 Summary of Historic and Cultural Resources Noise Assessment

| Equipment Type | Typical Noise Level (dBA) 50 ft | Equipment Utilization Factor (%) | Leq (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 Leq at 50 ft** | | | 88 |

Source: CSA 2024

## 6.2 Project Vibration

The FTA guidance manual on noise and vibration (FTA 2018) is the primary source for the vibration methodology. The assessment uses the Detailed Vibration Assessment methodology, as described in Section 6 of the FTA guidance manual.

The vibration assessment steps employed includes the following:

- Identified vibration-sensitive land uses in the Project Alignment using aerial photography, GIS data, and field surveys, typically within 350 feet of the alignment.
- Measured vibration-propagation characteristics of the soil in the Project Alignment at sensitive receptors (See Affected Environment in Section 5.2).
- Projected Project vibration levels from transit operations, using Project drawings provided by the engineering team, and information on speeds, headways, track type, and LRV vibration characteristics.
- Assessed the impact from transit by comparing the Project vibration with the FTA vibration impact criteria in Section 6 of the FTA guidance manual.
- Recommended mitigation at locations where Project vibration levels exceed the impact criteria.

### 6.2.1 Project Vibration

This section describes the vibration impacts for the Project Build Alternative.

Table 6-13 through Table 6-20 includes a tabulation of location information for each sensitive receptor group, Project vibration levels, the impact criteria, and whether there will be vibration impacts. The tables also show the total number of dwelling units with vibration impacts for each location.

**Table 6-13 Summary of Vibration Impacts for Residential Land Use in the City of Brooklyn Park**

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Number of Impacts |
|---|---|---|---|---|---|---|---|
| 93rd Ave N to TH 610 | Brooklyn Park | NB | 272 | 33 | 50 | 72 | 0 |
| 93rd Ave N to TH 610 | Brooklyn Park | SB | * | * | * | * | * |
| 85th Ave N to 93rd Ave N | Brooklyn Park | NB | 110 | 48 | 54 | 72 | 0 |
| 85th Ave N to 93rd Ave N | Brooklyn Park | SB | 90 | 54 | 58 | 72 | 0 |
| Shingle Creek to 85th Ave N | Brooklyn Park | NB | * | * | * | * | * |
| Shingle Creek to 85th Ave N | Brooklyn Park | SB | 88 | 48 | 68 | 72 | 0 |
| Brooklyn Blvd to Shingle Creek | Brooklyn Park | NB | 81 | 51 | 60 | 72 | 0 |
| Brooklyn Blvd to Shingle Creek | Brooklyn Park | SB | * | * | * | * | * |
| N 73rd Ave to Brooklyn Blvd | Brooklyn Park | NB | 87 | 34 | 57 | 72 | 0 |
| N 73rd Ave to Brooklyn Blvd | Brooklyn Park | SB | 169 | 39 | 51 | 72 | 0 |
| I-94 to N 73rd Ave | Brooklyn Park | NB | * | * | * | * | * |
| I-94 to N 73rd Ave | Brooklyn Park | SB | 300 | 47 | 48 | 72 | 0 |
| N 63rd Ave to I-94 | Brooklyn Park | NB | 111 | 53 | 55 | 72 | 0 |
| N 63rd Ave to I-94 | Brooklyn Park | SB | 226 | 54 | 53 | 72 | 0 |
| N 60th Ave to N 63rd Ave | Brooklyn Park | NB | 121 | 54 | 56 | 72 | 0 |
| N 60th Ave to N 63rd Ave | Brooklyn Park | SB | 204 | 51 | 53 | 72 | 0 |

Source: CSA 2024
Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.
*There are no vibration-sensitive receivers at this location.

### Table 6-14 Summary of Vibration Impacts for Institutional Land Use in the City of Brooklyn Park

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Impact |
|---|---|---|---|---|---|---|---|
| Ebenezer Community Church | Brooklyn Park | NB | 136 | 32 | 54 | 78 | -- |
| Berean Baptist Church | Brooklyn Park | SB | 88 | 44 | 58 | 78 | -- |
| Brooklyn Park Library | Brooklyn Park | NB | 99 | 43 | 54 | 78 | -- |
| Fire International Embassy | Brooklyn Park | SB | 333 | 30 | 49 | 78 | -- |
| North Hennepin Community College | Brooklyn Park | NB | 215 | 40 | 51 | 78 | -- |
| Revive Church | Brooklyn Park | SB | 162 | 53 | 52 | 78 | -- |
| Children's Music Academy of Brooklyn Park | Brooklyn Park | NB | 301 | 38 | 49 | 78 | -- |

Source: CSA 2024

Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.

### Table 6-15 Summary of Vibration Impacts for Residential Land Use in the City of Crystal

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Number of Impacts |
|---|---|---|---|---|---|---|---|
| N 56th Ave to N 60th Ave | Crystal | NB | 334 | 38 | 49 | 72 | 0 |
| N 56th Ave to N 60th Ave | Crystal | SB | 215 | 54 | 53 | 72 | 0 |
| Freight Tracks to N 56th Ave | Crystal | NB | 128 | 28 | 55 | 72 | 0 |
| Freight Tracks to N 56th Ave | Crystal | SB | 295 | 32 | 49 | 72 | 0 |
| N 47th Ave to Freight Tracks | Crystal | NB | 133 | 54 | 62 | 72 | 0 |
| N 47th Ave to Freight Tracks | Crystal | SB | 91 | 54 | 65 | 72 | 0 |

Source: CSA 2024

Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.

### Table 6-16 Summary of Vibration Impacts for Institutional Land Use in the City of Crystal

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Impact |
|---|---|---|---|---|---|---|---|
| Crystal Medical Center | Crystal | NB | 98 | 52 | 56 | 78 | -- |

Source: CSA 2024
Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.

### Table 6-17 Summary of Vibration Impacts for Residential Land Use in the City of Robbinsdale

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Number of Impacts |
|---|---|---|---|---|---|---|---|
| TH 100 to N 47th Ave | Robbinsdale | NB | 135 | 50 | 57 | 72 | 0 |
| TH 100 to N 47th Ave | Robbinsdale | SB | 201 | 43 | 52 | 72 | 0 |
| N 42nd Ave to TH 100 | Robbinsdale | NB | 91 | 38 | 66 | 72 | 0 |
| N 42nd Ave to TH 100 | Robbinsdale | SB | 103 | 44 | 65 | 72 | 0 |
| N 40th Ave to N 42nd Ave | Robbinsdale | NB | 112 | 29 | 62 | 72 | 0 |
| N 40th Ave to N 42nd Ave | Robbinsdale | SB | * | * | * | * | * |
| N 36th Ave to N 40th Ave | Robbinsdale | NB | 103 | 48 | 65 | 72 | 0 |
| N 36th Ave to N 40th Ave | Robbinsdale | SB | 65 | 44 | 68 | 72 | 0 |
| N Lowry Ave to N 36th Ave | Robbinsdale | NB | 147 | 53 | 51 | 72 | 0 |
| N Lowry Ave to N 36th Ave | Robbinsdale | SB | 112 | 53 | 52 | 72 | 0 |

Source: CSA 2024
Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.
*There are no vibration-sensitive receivers at this location.

### Table 6-18 Summary of Vibration Impacts for Institutional Land Use in the City of Robbinsdale

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Impact |
|---|---|---|---|---|---|---|---|
| Elim Lutheran Church | Robbinsdale | SB | 156 | 40 | 61 | 78 | -- |

Source: CSA 2024
Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.

### Table 6-19 Summary of Vibration Impacts for Residential Land Use in the City of Minneapolis for the Build Alternative

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Number of Impacts |
|---|---|---|---|---|---|---|---|
| N 26th Ave to N Lowry Ave | Minneapolis | NB | 43 | 39 | 60 | 72 | 0 |
| N 26th Ave to N Lowry Ave | Minneapolis | SB | 40 | 39 | 61 | 72 | 0 |
| N Knox Ave to N 26th Ave | Minneapolis | NB | 41 | 29 | 60 | 72 | 0 |
| N Knox Ave to N 26th Ave | Minneapolis | SB | 36 | 28 | 62 | 72 | 0 |
| N Emerson Ave to N Knox Ave | Minneapolis | NB | 34 | 35 | 61 | 72 | 0 |
| N Emerson Ave to N Knox Ave | Minneapolis | SB | 25 | 39 | 73 | 72 | 12 (1) |
| Lyndale Ave to N Emerson Ave | Minneapolis | NB | 55 | 43 | 63 | 72 | 0 |
| Lyndale Ave to N Emerson Ave | Minneapolis | SB | 18 | 38 | 74 | 72 | 18 (1) |
| I-94 to Lyndale Ave | Minneapolis | NB | 54 | 39 | 55 | 72 | 0 |
| I-94 to Lyndale Ave | Minneapolis | SB | * | * | * | * | * |
| Plymouth Ave N to I-94 | Minneapolis | NB | 46 | 20 | 61 | 72 | 0 |
| Plymouth Ave N to I-94 | Minneapolis | SB | * | * | * | * | * |
| N 8th Ave to Plymouth Ave N | Minneapolis | NB | 29 | 39 | 65 | 72 | 0 |
| N 8th Ave to Plymouth Ave N | Minneapolis | SB | 30 | 39 | 69 | 72 | 0 |

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Number of Impacts |
|---|---|---|---|---|---|---|---|
| Target Field Station to N 8th Ave | Minneapolis | NB | 50 | 15 | 47 | 72 | 0 |
| Target Field Station to N 8th Ave | Minneapolis | SB | * | * | * | * | * |

Source: CSA 2024
Notes:
The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.
The impact numbers outside the parentheses represent the total number DUs impacted (including apartments and other multi-family buildings), and the numbers inside the parentheses represent the total number of buildings impacted.
*There are no vibration-sensitive receivers at this location.

- ***N Emerson Ave to N Knox Ave (SB):*** There are 12 multi-family residences, representing one building, along the southbound side of the Project Alignment between N Emerson Ave and N Knox Ave predicted to have a vibration impact. These impacts are due to the proximity of the tracks and a nearby crossover.
- ***Lyndale Ave to N Emerson Ave (SB):*** There are 18 multi-family residences, representing one building, along the southbound side of the Project Alignment between Lyndale Ave and N Emerson Ave predicted to have a vibration impact. These impacts are due to the proximity of the tracks.

**Table 6-20 Summary of Vibration Impacts for Institutional Land Use in the City of Minneapolis (N 21st Ave to Washington Ave)**

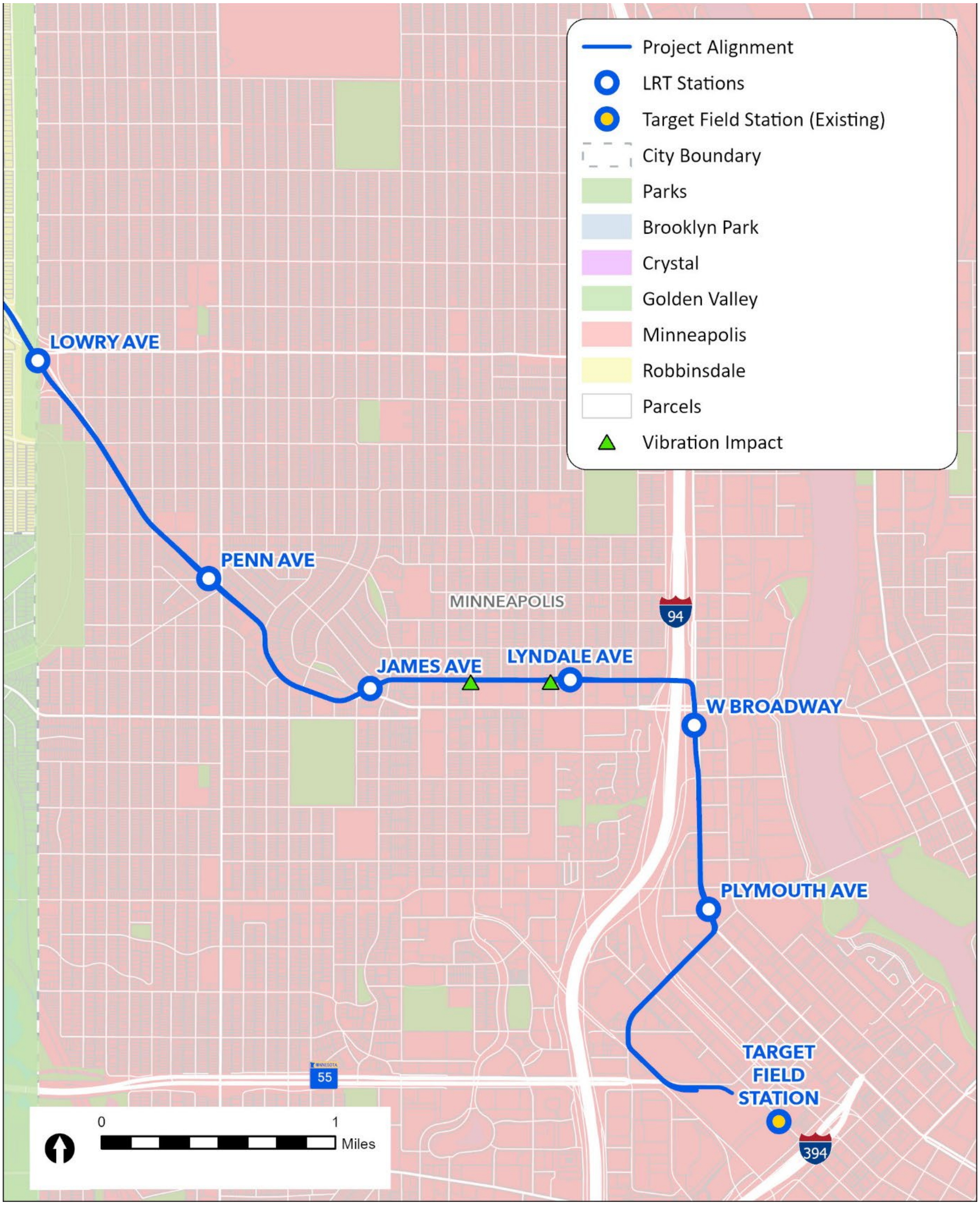
| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Impact |
|---|---|---|---|---|---|---|---|
| Parkway United Church of Christ | Minneapolis | NB | 307 | 18 | 33 | 78 | -- |
| Good News Minneapolis Church | Minneapolis | NB | 152 | 42 | 45 | 78 | -- |
| True Vine Missionary Baptist Church | Minneapolis | SB | 111 | 44 | 46 | 78 | -- |
| KIPP Legacy | Minneapolis | NB | 200 | 42 | 43 | 78 | -- |
| St Anne-St Joseph Hien Church | Minneapolis | NB | 323 | 39 | 39 | 78 | -- |
| All Nations Seventh-day Adventist Church | Minneapolis | SB | 182 | 28 | 41 | 78 | -- |
| PYC Arts & Technology Alternative High School | Minneapolis | SB | 55 | 24 | 53 | 78 | -- |
| Capri Theater* | Minneapolis | SB | 41 | 24 | 60 | 78 | -- |

| Location | City | Side of Track | Near Track Dist. (ft) | Speed (mph) | Max Project Vibration Level (VdB) | FTA Vibration Criteria (VdB) | Impact |
|---|---|---|---|---|---|---|---|
| Star Child Development Center llc | Minneapolis | SB | 39 | 18 | 59 | 78 | -- |
| Real Believers Faith Center Church | Minneapolis | SB | 236 | 39 | 38 | 78 | -- |
| Liberty Community Church | Minneapolis | NB | 44 | 41 | 69 | 78 | -- |
| United Deliverance Temple Inc | Minneapolis | NB | 250 | 18 | 35 | 78 | -- |
| Sanctuary Covenant Church | Minneapolis | SB | 16 | 31 | 75 | 78 | -- |
| Metro Schools College Prep | Minneapolis | SB | 162 | 21 | 53 | 78 | -- |
| Lundstrum Performing Arts | Minneapolis | NB | 270 | 46 | 48 | 78 | -- |
| Token Media** | Minneapolis | NB | 281 | 46 | 48 (20) | 65 (25) | -- |

Source: CSA 2024
Note: The vibration levels shown for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower.
*This level represents the non-special use spaces in the Capri Theater.
**Token Media is a recording studio that FTA considers a special use case where both vibration and ground-born noise are analyzed. The levels in the project vibration and FTA vibration criteria columns that are in parentheses are ground-born noise levels.

The location of the vibration impacts for the City of Minneapolis along N 21st Ave and east of I-94 to Washington Ave are shown in Figure 6-3.

## Figure 6-3 Project Vibration Impacts in the City of Minneapolis along N 21st Ave and Washington Ave




Source: CSA 2024

### 6.2.2 Stations

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

### 6.2.3 Operations and Maintenance Facility

The OMF is located more than 1,000 feet from any vibration-sensitive receptors; therefore, no vibration impact is projected.

### 6.2.4 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.

Because 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 assess 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 6-21. Except for 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.

**Table 6-21 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 2023

# 7 Mitigation Measures

## 7.1 Noise

FTA guidance states that severe noise impacts should be mitigated unless there are no feasible or practical means to do so (FTA 2018). For moderate impacts, discretion should be used, and project-specific factors should be included in the consideration of mitigation. The 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. Metro Transit has adopted a mitigation approach that details which moderate impacts will qualify for mitigation. This approach is detailed in Section 7.1.1 below.

### 7.1.1 Metro Transit Noise Mitigation Approach

#### 7.1.1.1 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 project sponsor to consider mitigation based on several factors, as defined in the FTA guidance manual. For the Project, noise mitigation will be provided for all “Moderate” impacts, caused by the Project, that meet the criteria for reasonableness, feasibility, and cost effectiveness, as defined under Part B below, and at locations where the Project has a “Moderate” impact and one of the following thresholds are exceeded:

1. Location(s) where the existing noise levels without the Project are already 65 dBA Ldn or greater (see Exhibit 2.1-1).[3]
2. Location(s) where there is an increase of 3 dB or more in the Ldn over the existing level due to the Project.[4]
3. The predicted increase in the Ldn 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 Ldn of 3 dB or greater, and the inclusion of the adjacent properties will provide a logical and equitable terminus to the mitigation.

[3] A noise level of 65 dBA or greater is considered a “normally unacceptable” noise environment by United States Department of Housing and Urban Development. This threshold is also used by Federal Aviation Administration for compatible land use.
[4] 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.

#### 7.1.1.2 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 Project noise.[5]
2. Feasibility:
    a. For noise mitigation to be considered feasible it must be practical from engineering, operations, and safety standpoints.
    b. Other Project factors may need to be considered in determining feasibility of mitigation. These could include community input, visual impacts, and other Project features that might limit mitigation.
3. Cost Effectiveness: For noise mitigation to be considered cost effective, the cost per benefited receptor must not exceed $43,500.

### 7.1.2 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.

#### 7.1.2.1 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 to 3 dB reduction in noise radiated from the tracks on typical track sections.

***LRV 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, LRV 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 generate around 6 dB of increased noise 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.

#### 7.1.2.2 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

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

typically provide between 5 and 10 dB of reduction, depending on the design of the barrier. 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).

#### 7.1.2.3 Receiver

***Building Sound Insulation:*** When other noise mitigation measures are not feasible, the only practical noise mitigation measure may be to provide sound insulation for individual buildings. This mitigation only treats the indoor sound level and is not recommended for places that rely on outdoor use. Depending on the original construction, sound insulation can improve noise reduction by 5 to 20 dB. However, due to the nature of modifying buildings, this is one of the least cost-effective mitigation measures.

### 7.1.3 Project Noise Mitigation

There are few locations where source or path mitigation is feasible along the Project Alignment. The projected noise impacts are due to a combination of speed, proximity to the tracks, LRV bells, and crossovers. Per the Metro transit noise mitigation policy, severe noise impacts are required to be mitigated if they meet the feasibility criteria, and certain moderate impacts should be mitigated as well. However, in all locations where noise mitigation thresholds are met, noise barriers would not be effective due to gaps at cross streets nor would barriers meet the cost effectiveness threshold.

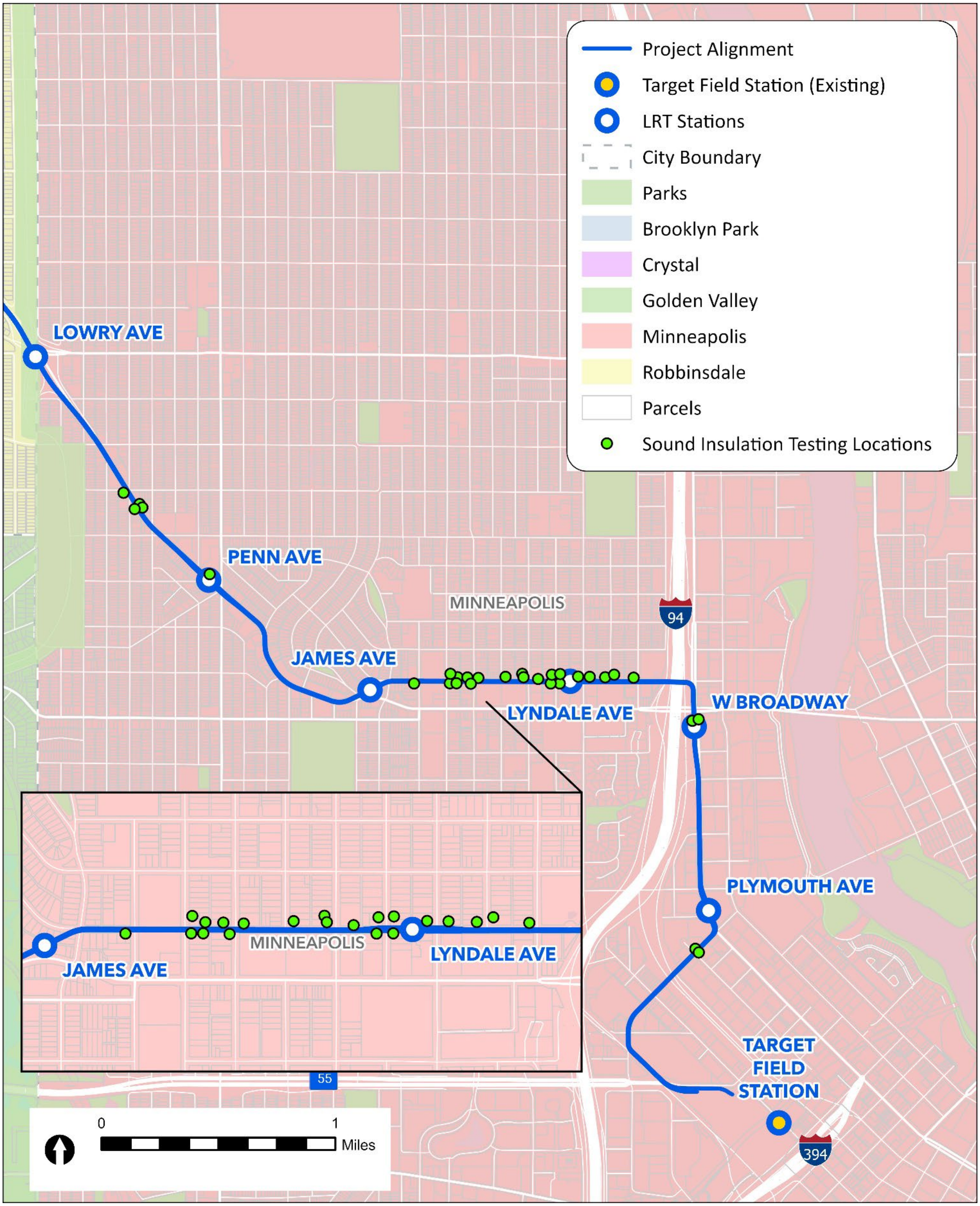
Because noise barriers would not be feasible, other methods of noise mitigation would potentially be required. There are two locations with moderate and severe impacts due to crossovers. The two locations where crossovers are generating noise impacts are:

- ***Brooklyn Park:*** W Broadway Ave between College Park Dr and 85th Ave. This crossover is causing noise impact at five single-family buildings.
- ***Minneapolis:*** N 21st Ave between Emerson Ave and Bryant Ave. This crossover is causing noise impact at nearby single and multi-family buildings.

At both locations, spring-rail frogs would be utilized to reduce or eliminate noise impacts. With spring rail frogs, all the moderate impacts in Brooklyn Park along W Broadway Ave would be eliminated. Along N 21st Ave, the spring-rail frog would eliminate moderate noise impacts at two single family residences and two multi-family residences, and one severe impact would be reduced to a moderate impact.

At all other locations, including both residential and institutional buildings, sound insulation would be considered for noise mitigation. The remaining severe and moderate impacts after the implementation of the spring-rail frogs meet Metro Transit's criteria for consideration of mitigation. Figure 7-1 shows the locations where sound insulation would be explored as a mitigation option.

**Figure 7-1 Noise Impacts Requiring Sound Insultation Testing for Potential Mitigation**



Sound insulation programs are developed to reduce the interior noise levels in residential sleeping and living quarters, as well as sensitive areas in institutional settings, to meet the guidelines established by the United States Department of Housing and Urban Development. Under these guidelines, interior noise levels for residential land uses should not exceed an Ldn of 45 dBA and a form of fresh air exchange must be maintained. Sound insulation is only typically used on older dwellings with single-paned windows or in buildings with double-paned windows that are no longer effective because of leakage. Sound insulation would not reduce exterior noise levels.

The process for determining candidates for sound insulation begins with sound insulation testing. Testing at the locations identified in Figure 7-1 would determine which buildings currently meet the interior criterion of 45 dBA Ldn (where no further improvements would be needed) and which buildings do not meet the interior criterion and would require additional measures to improve the outdoor to indoor noise reduction.

After determining the buildings that would require sound insulation improvements, the cost effectiveness criterion would need to be applied with the input of architects familiar with sound insulation. Once that has been determined, the Council will work with individual owners to determine the appropriate measures, if any, to incorporate.

### 7.1.4 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

## 7.2 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.

### 7.2.1 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 generate 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.

### 7.2.2 Project Vibration Mitigation

There are two locations along N 21st Ave where vibration mitigation is recommended. The first location is adjacent to the crossover between Emerson Ave and Bryant Ave. With the implementation of the spring-rail frog, the vibration impact would be eliminated. The second location is an approximately 300-foot section starting just east of Aldrich Ave and extending west which would be mitigated through track-based mitigation. The specific mitigation method would need to be determined during final design, but a ballast mat highly resilient fasteners would be effective at eliminating the impact at this location.

### 7.2.3 Construction Vibration Mitigation

The most effective methods for minimizing the impact from construction vibration are 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 minimize 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 vibration monitoring and, if the vibration exceeds the limit, the activity must be modified or terminated.

# 8 References

Federal Transit Administration (FTA), 2018, *Transit Noise and Vibration Impact Assessment* guidance manual (FTA 2018).

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 Ave (CSAH 103) Reconstruction Project Environmental Assessment Worksheet, Hennepin County, 2015.

# Appendix A Existing Outdoor Noise Measurement Location Photographs

Figure A-1 Long-Term Noise Measurement Location LT-13: 1020 N 3rd St

Figure A-2 Long-Term Noise Measurement Location LT-12: 8819 Oregon Ave

Figure A-3 Long-Term Noise Measurement Location LT-11: 7431 78th Ct

**Figure A-4 Long-Term Noise Measurement Location LT-10: 7013 Dutton Ave**

**Figure A-5 Long-Term Noise Measurement Location LT-9: 5906 Elmhurst Ave**

Figure A-6 Long-Term Noise Measurement Location LT-8: 5257 Xenia Ave

Figure A-7 Long-Term Noise Measurement Location LT-8a: 4807 Lakeside Ave

Figure A-8 Long-Term Noise Measurement Location LT-7: 4536 Regent Ave

Figure A-9 Long-Term Noise Measurement Location LT-6: 3369 Broadway Ave

**Figure A-10 Long-Term Noise Measurement Location LT-5: 2741 Upton Ave**

**Figure A-11 Long-Term Noise Measurement Location LT-4: 2239 W Broadway Ave**

Figure A-12 Long-Term Noise Measurement Location LT-3: 1927 N Morgan Ave

Figure A-13 Long-Term Noise Measurement Location LT-2: 2117 Dupont Ave

**Figure A-14 Long-Term Noise Measurement Location LT-1: 626 Harry Davis Ln**


**Figure A-15 Short-Term Noise Measurement Location ST-5: Prince of Peace Lutheran Church**

**Figure A-16 Short-Term Noise Measurement Location ST-4: 3978 W Broadway Ave**

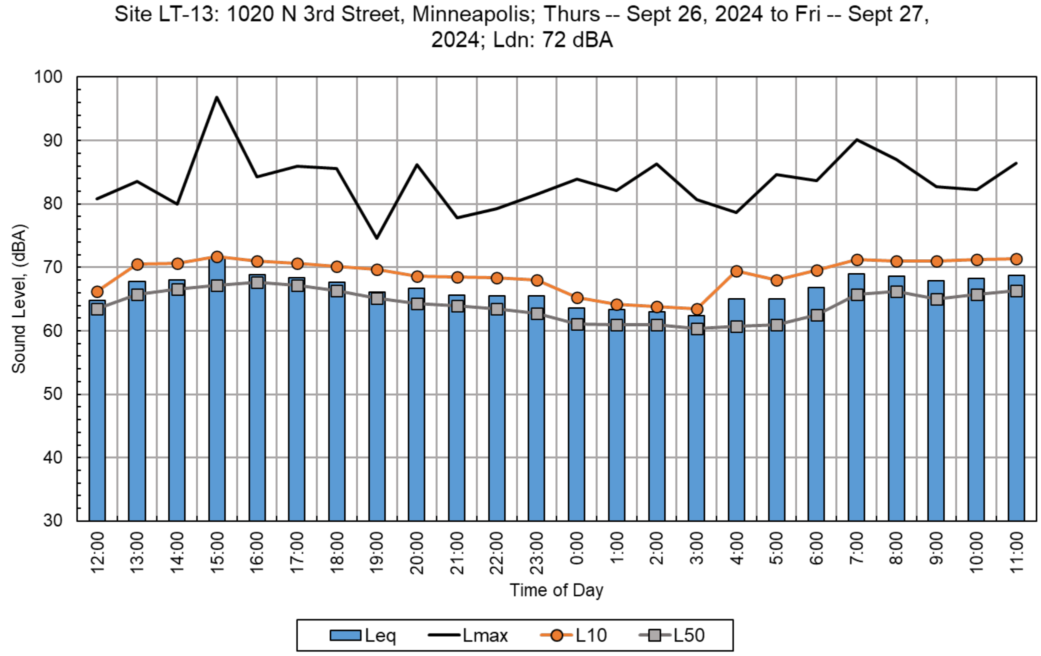
**Figure A-17 Short-Term Noise Measurement Location ST-3: 1127 W Broadway Ave**

**Figure A-18 Short-Term Noise Measurement Location ST-2: Token Media**

**Figure A-19 Short-Term Noise Measurement Location ST-1: Element Minneapolis Downtown**

# Appendix B Noise Measurement Data

## Figure B-1 Long-Term Noise Measurement Location LT-13: 1020 N 3rd St




## Figure B-2 Long-Term Noise Measurement Location LT-12: 8819 Oregon Ave

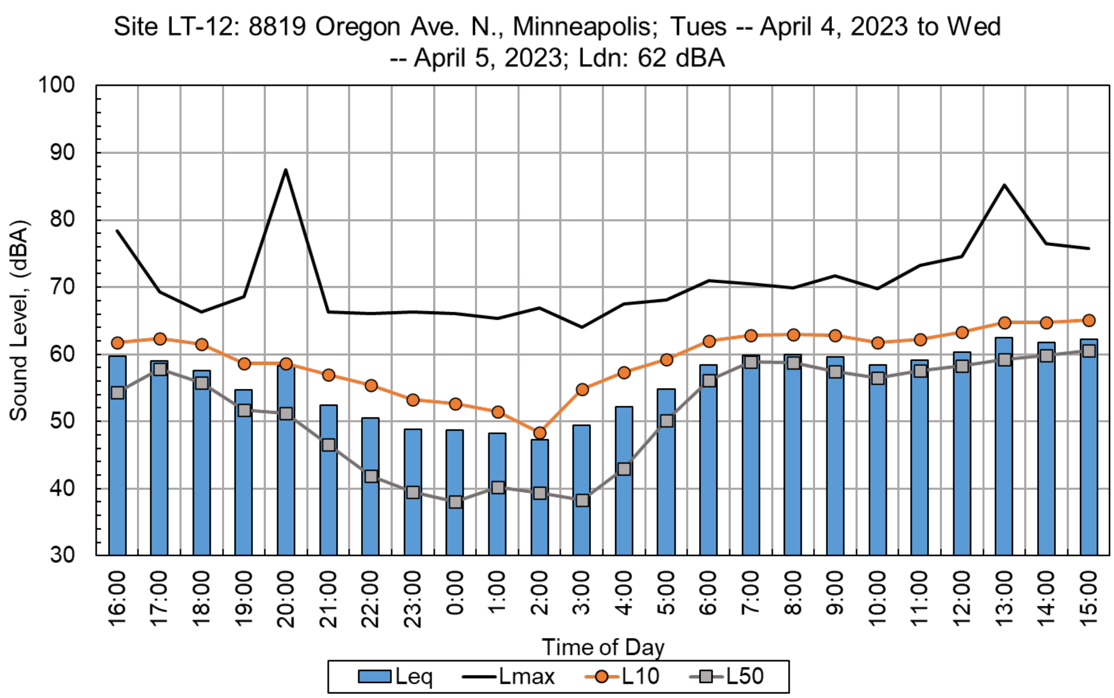


**Figure B-3 Long-Term Noise Measurement Location LT-11: 7431 78th Ct**

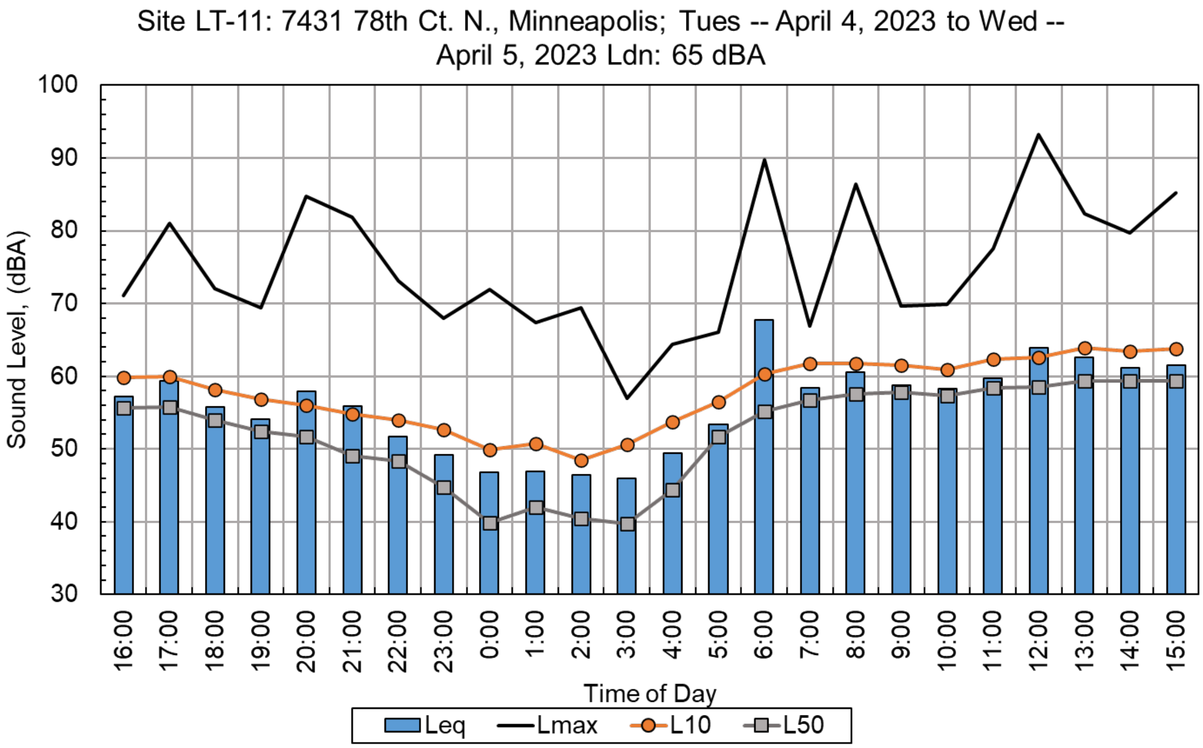
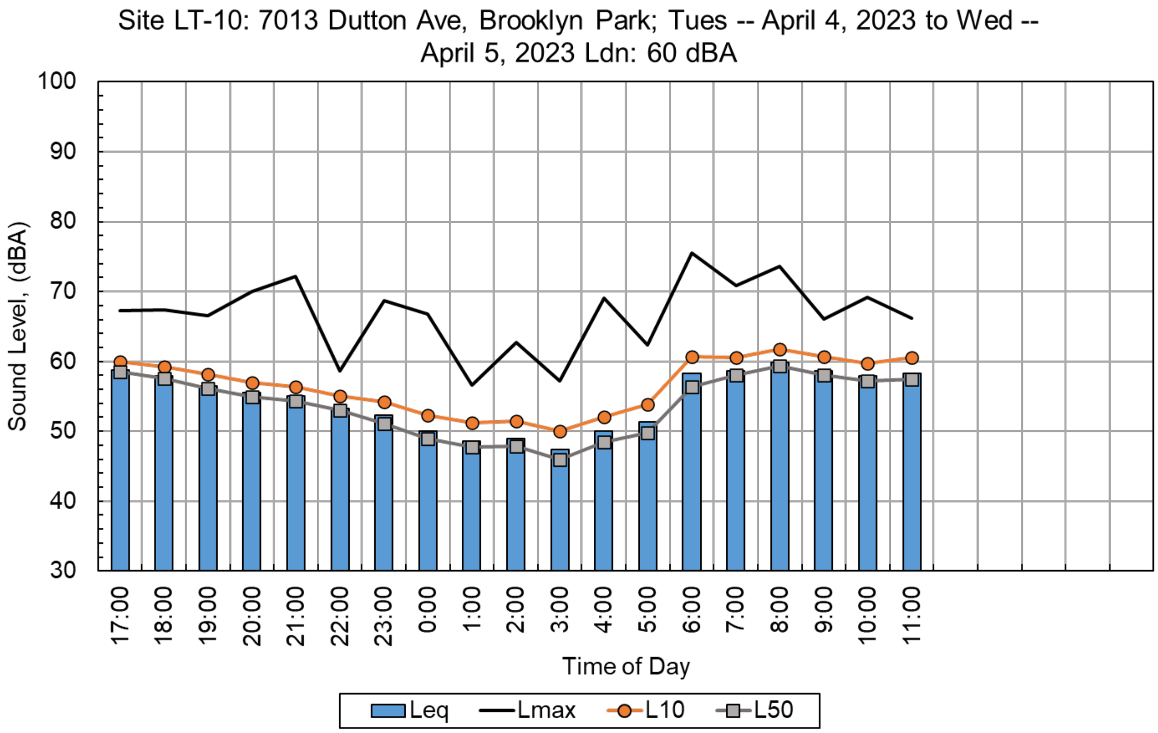


**Figure B-4 Long-Term Noise Measurement Location LT-10: 7017 Dutton Ave[6]**




[6] Sound level meter's battery failed prior to completion of 24-hour measurement.

**Figure B-5 Long-Term Noise Measurement Location LT-9: 5906 Elmhurst Ave**

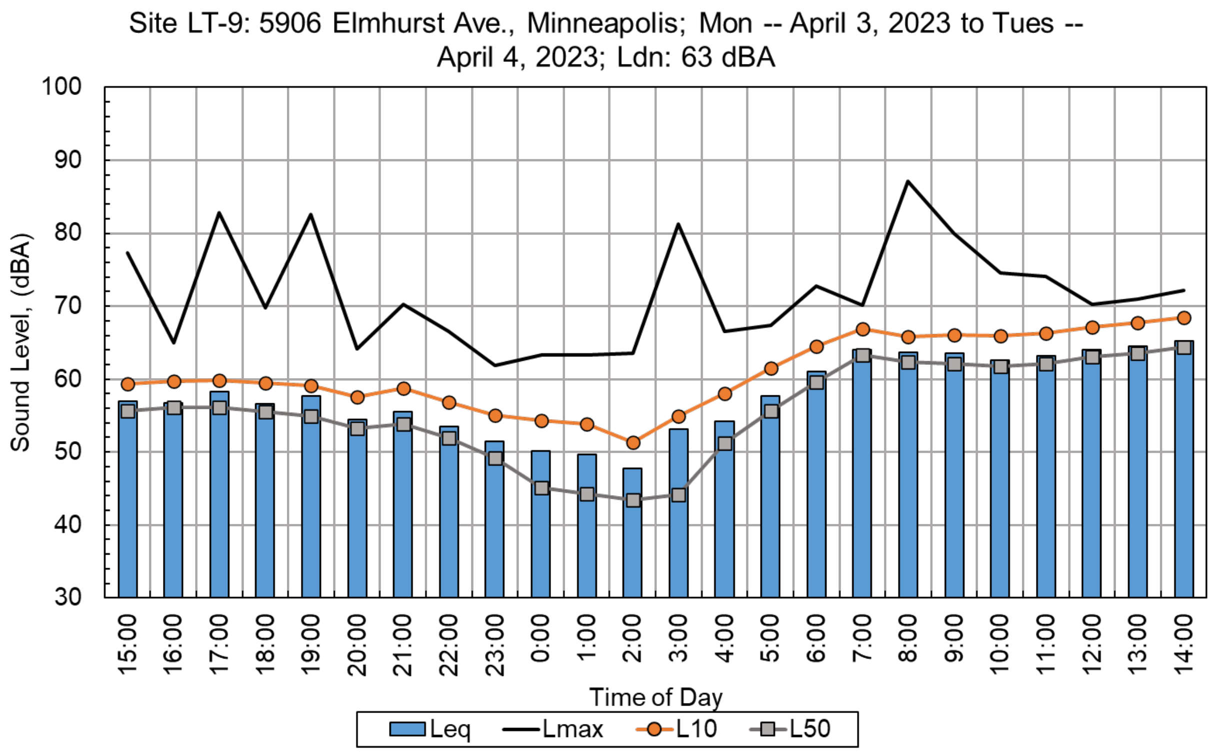
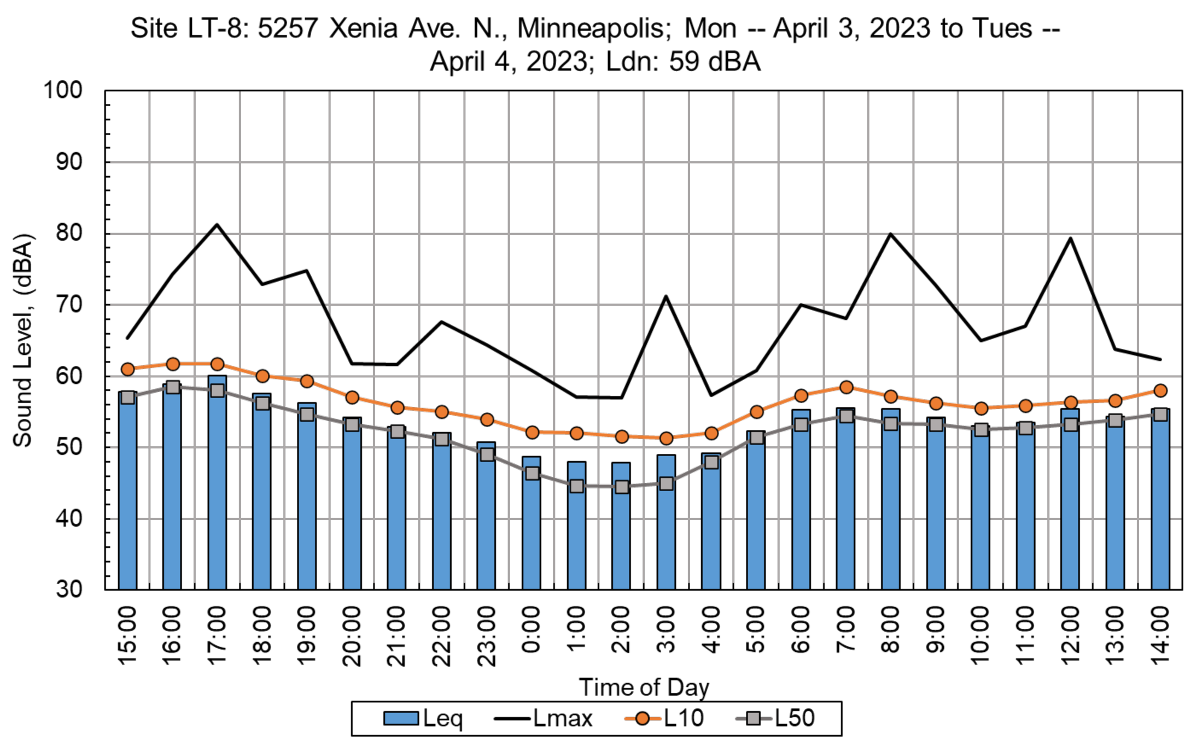
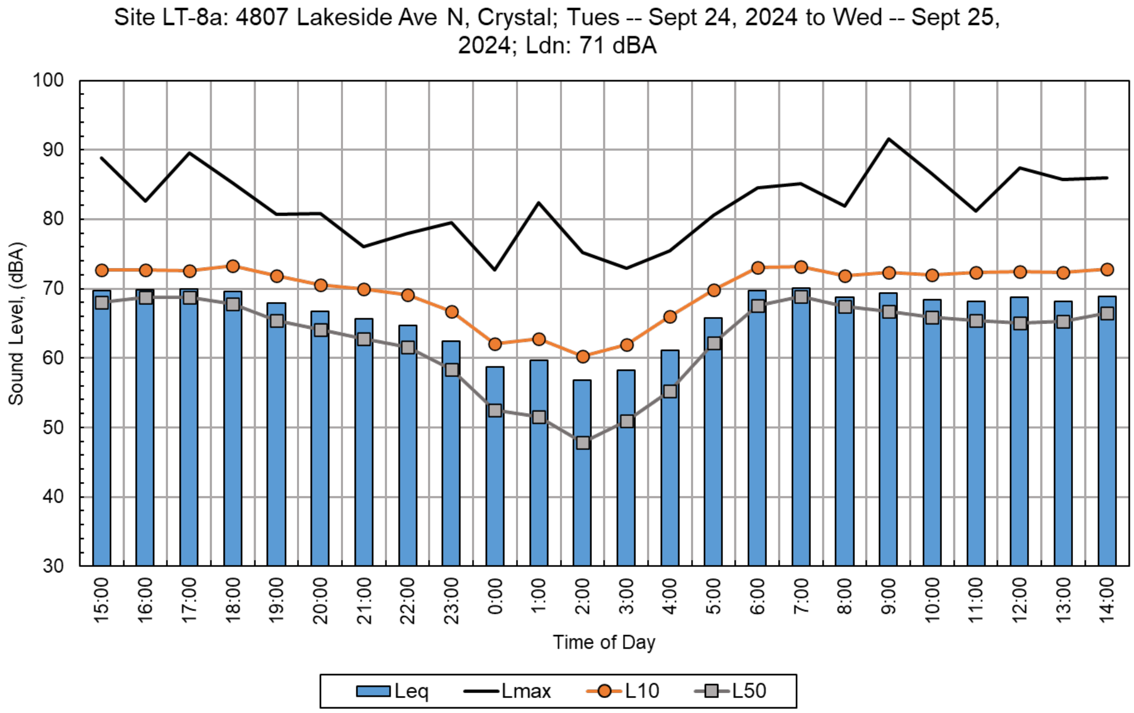



**Figure B-6 Long-Term Noise Measurement Location LT-8: 5257 Xenia Ave**



### Figure B-7 Long-Term Noise Measurement Location LT-8a: 4807 Lakeside Ave




### Figure B-8 Long-Term Noise Measurement Location LT-7: 4536 Regent Ave

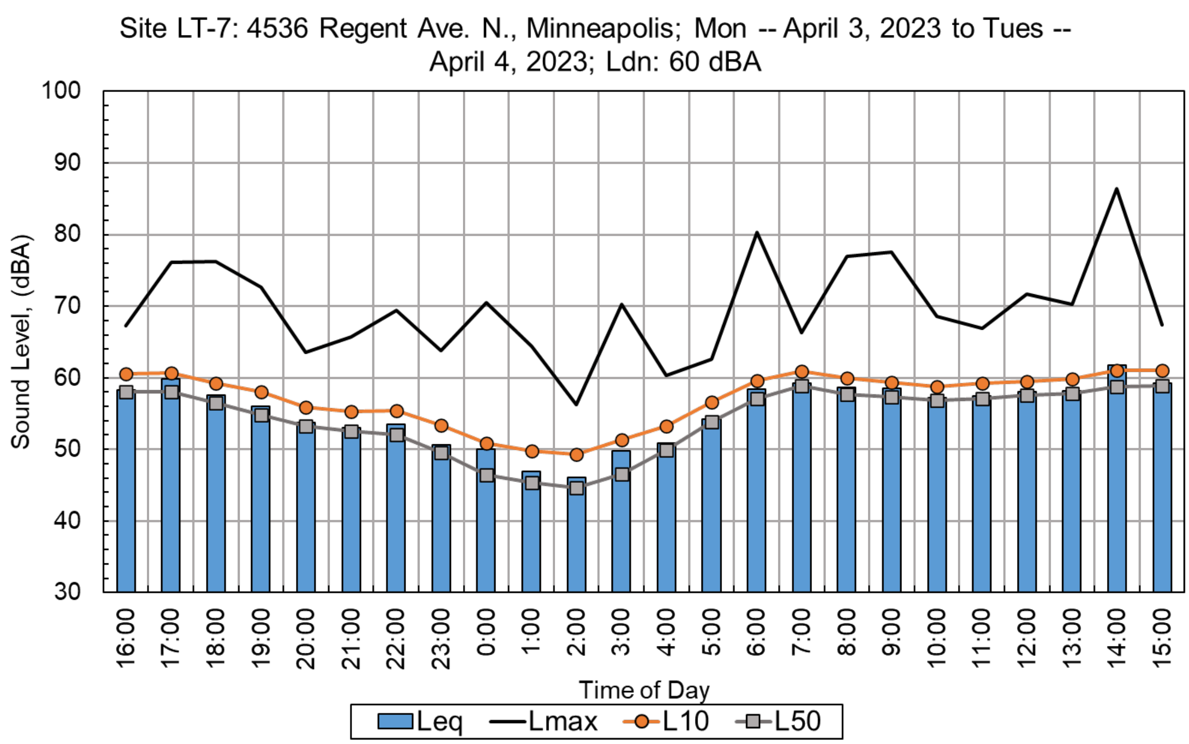


**Figure B-9 Long-Term Noise Measurement Location LT-6: 3369 Broadway Ave**

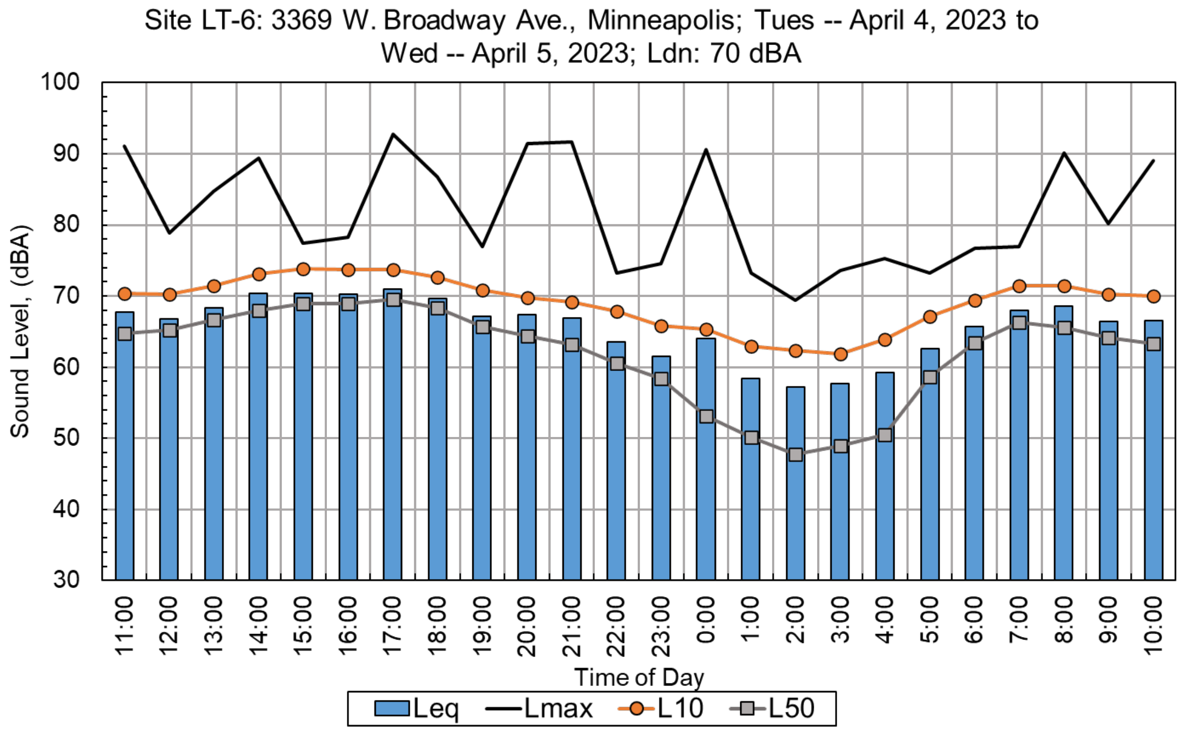
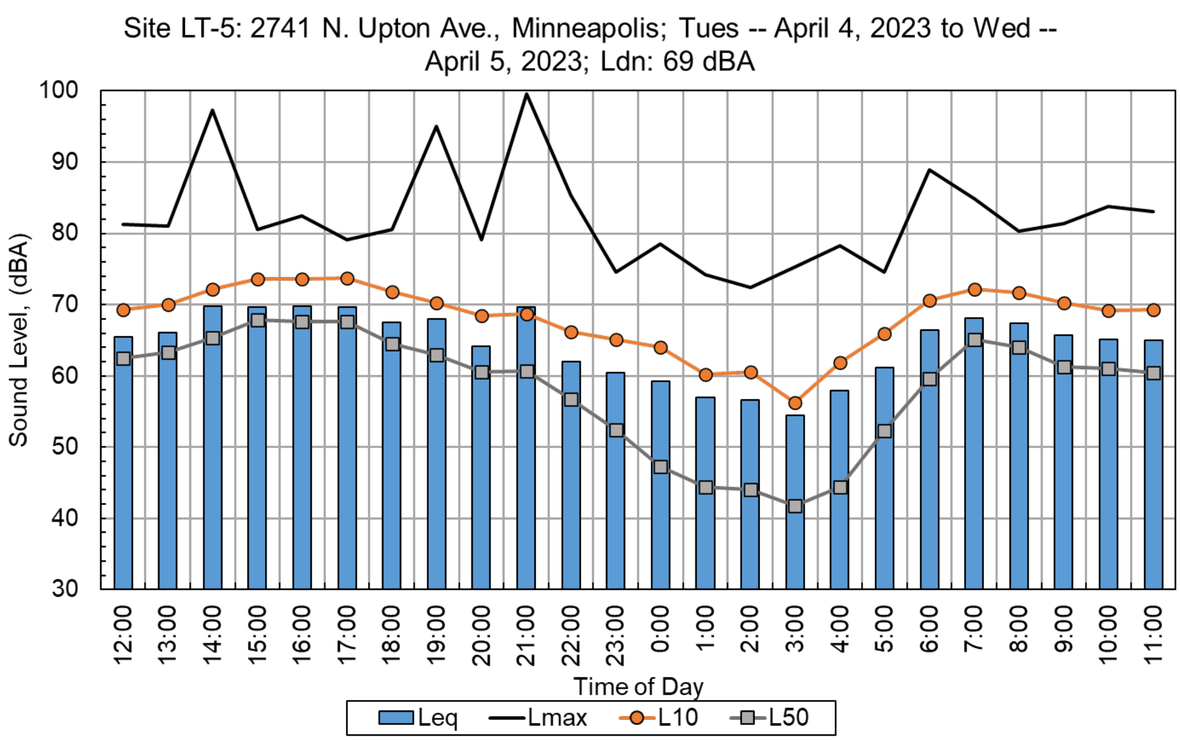
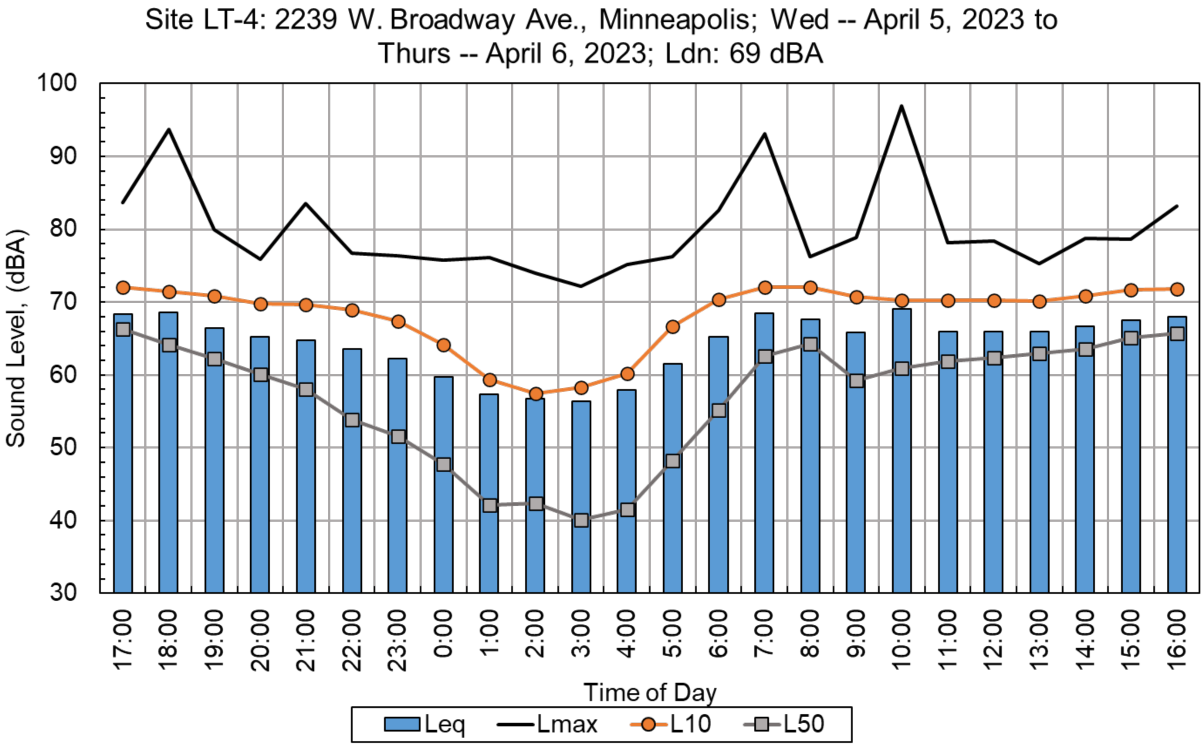



**Figure B-10 Long-Term Noise Measurement Location LT-5: 2741 Upton Ave**



### Figure B-11 Long-Term Noise Measurement Location LT-4: 2235 Broadway Ave




### Figure B-12 Long-Term Noise Measurement Location LT-3: 1927 Morgan Ave

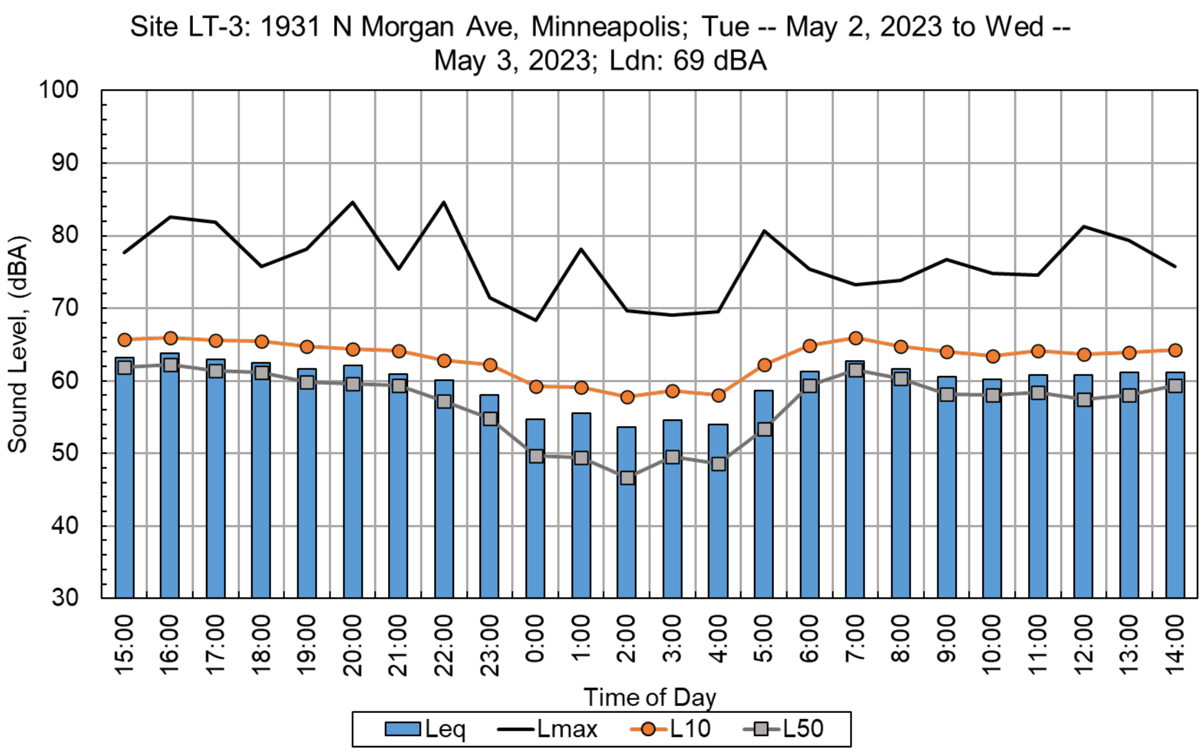


**Figure B-13 Long-Term Noise Measurement Location LT-2: 2117 Dupont Ave**

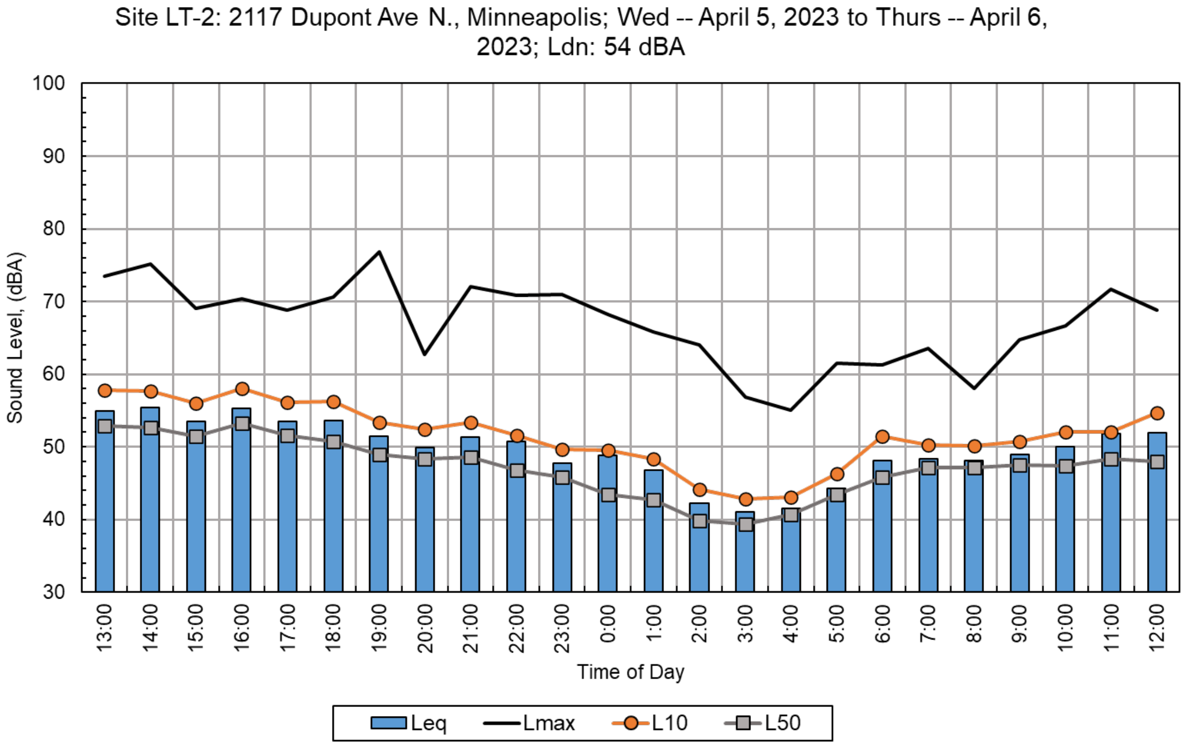
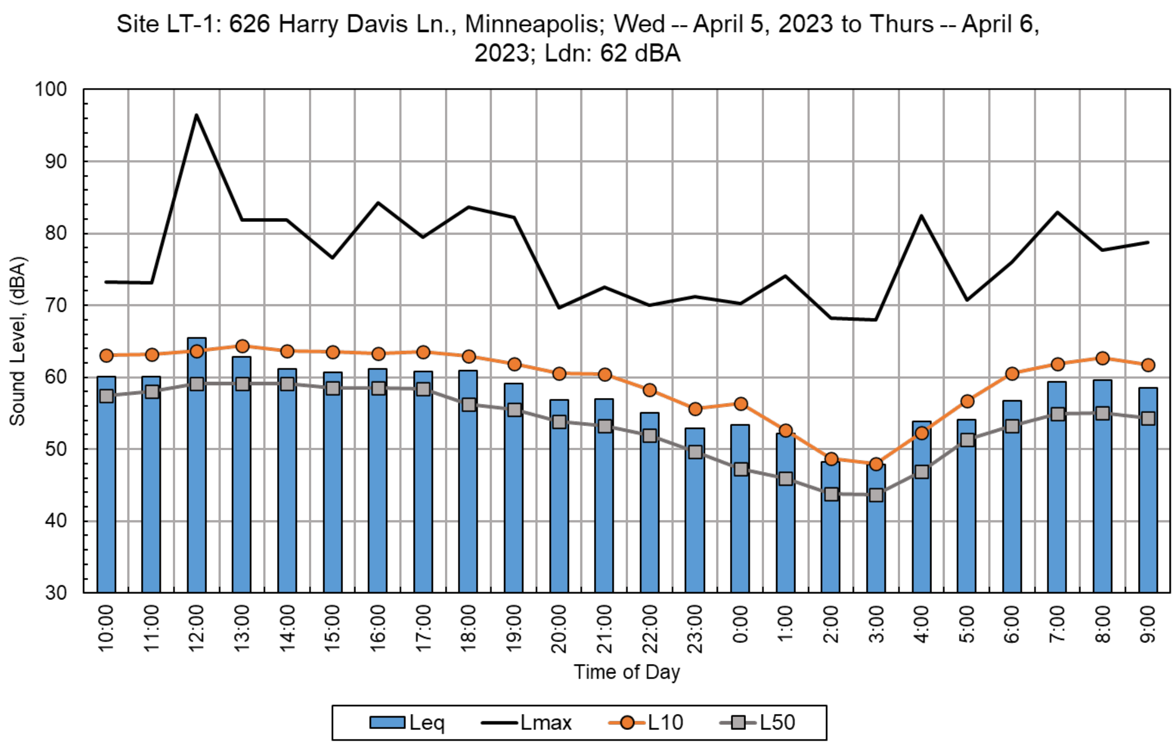



**Figure B-14 Long-Term Noise Measurement Data – LT-1: 626 Harry Davis Ln**



# Appendix C Vibration Measurement Location Photographs

**Figure C-1 Vibration Measurement Location VP-E: 5200 48th Ave**


**Figure C-2 Vibration Measurement Location VP-D: Lakeview Terrace Park**

## Figure C-3 Vibration Measurement Location VP-C: 2700 27th Ave

## Figure C-4 Vibration Measurement Location VP-B: N 21st Ave and Dupont Ave

**Figure C-5 Vibration Measurement Location VP-A: Lyndale Ave and 14th Ave**

**Figure C-6 Vibration Measurement Location VP-A-1: Washington Ave and 17th Ave**

Figure C-7 Vibration Measurement Location VP-A-2: 10th Ave and 3rd St

# Appendix D Vibration Measurement Data

### Table D-1 Location VP-2 North Hennepin Community College 1/3-Octave Band Transfer Mobility Coefficients

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 32.5 | 41 | 45.3 | 52 | 57.7 | 61.1 | 22.6 | 24.8 | 20.9 | 18.1 | 24.5 | 25.2 | 41.2 | 94.9 | 88.6 | 76.1 |
| B | -9.3 | -12.6 | -11.7 | -13 | -13.8 | -14.6 | 38.8 | 39.7 | 49 | 55.7 | 49.7 | 50 | 28.8 | -40.4 | -38.5 | -35.2 |
| C | 0 | 0 | 0 | 0 | 0 | 0 | -17.2 | -18.2 | -21.9 | -24.9 | -23.5 | -24.9 | -20.3 | 0 | 0 | 0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

### Figure D-1 Line Source Transfer Mobility Location VP-2 North Hennepin Community College

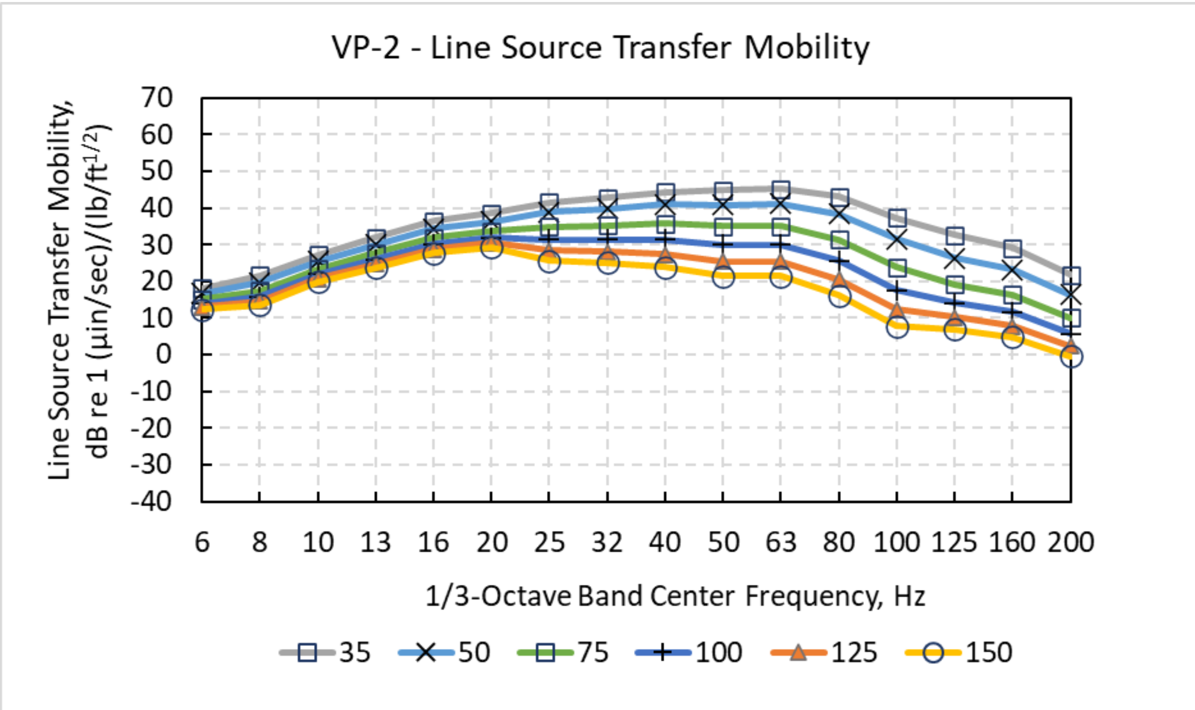
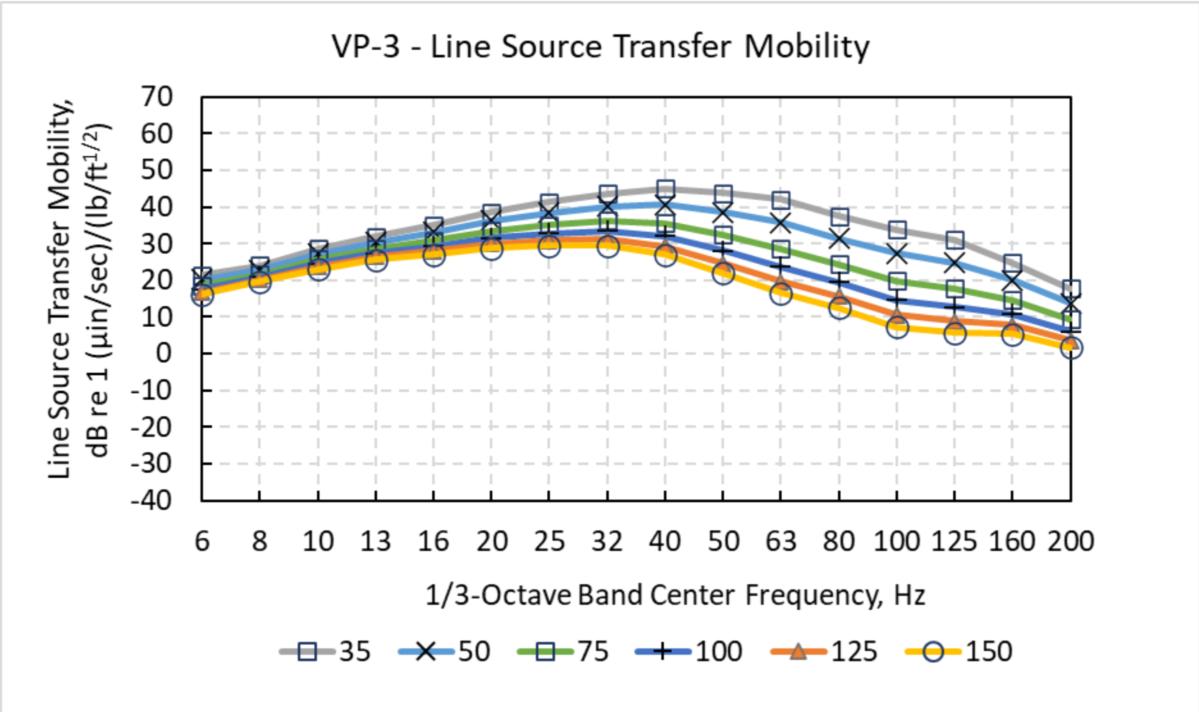


**Table D-2 Location VP-3 62nd Ave and Hampshire Ave 1/3-Octave Band Transfer Mobility Coefficients**

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 34.6 | 34.6 | 42.2 | 47 | 54.5 | 62.7 | 70.3 | 78.4 | 89 | 97.4 | 104.4 | 98.7 | 98.8 | 92.7 | 72.1 | 57.3 |
| B | -8.5 | -6.9 | -8.8 | -9.8 | -12.6 | -15.6 | -18.8 | -22.5 | -28.5 | -34.7 | -40.4 | -39.6 | -42.1 | -40 | -30.7 | -25.6 |
| C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

**Figure D-2 Line Source Transfer Mobility Location VP-3 62nd Ave and Hampshire Ave**

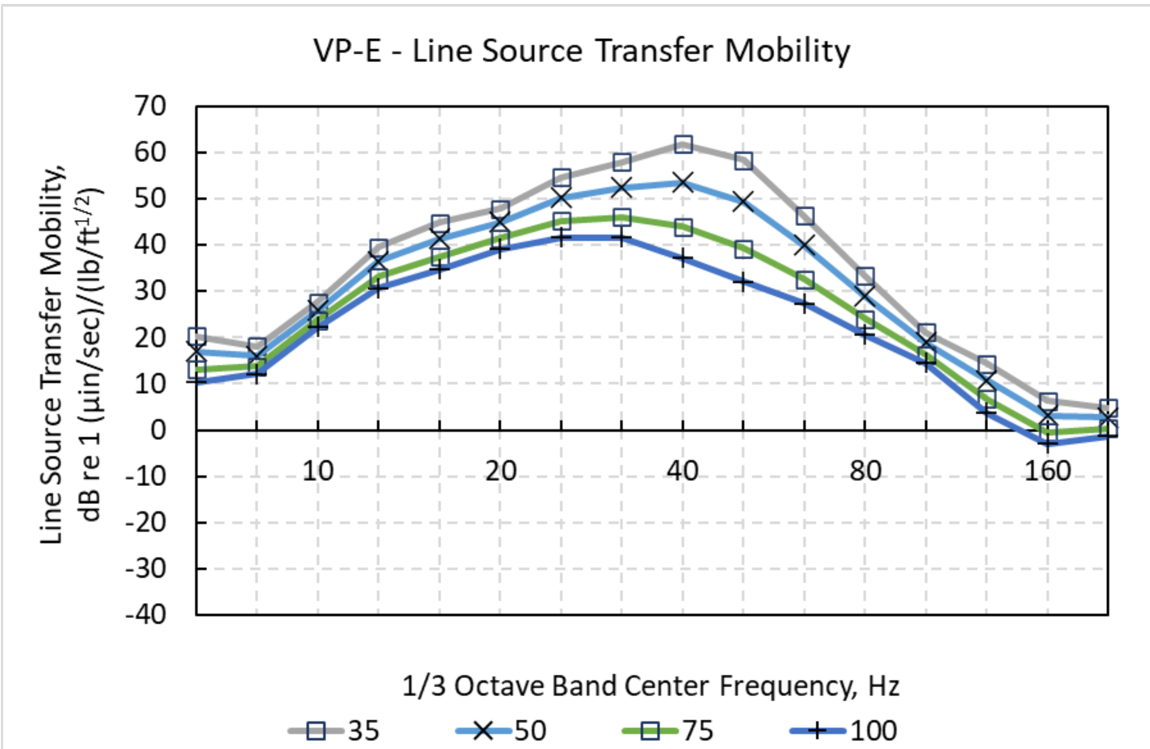


### Table D-3 Location VP-E 5200 48th Ave 1/3-Octave Band Transfer Mobility Coefficients

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 54.1 | 38.0 | 46.1 | 69.5 | 79.0 | 77.6 | 98.4 | 113.6 | 145.2 | 147.1 | 110.5 | 76.3 | 43.7 | 50.4 | 38.0 | 25.5 |
| B | -21.9 | -13.0 | -11.9 | -19.4 | -22.2 | -19.3 | -28.4 | -36.0 | -54.0 | -57.5 | -41.6 | -27.9 | -14.6 | -23.3 | -20.5 | -13.4 |
| C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

### Figure D-3 Line Source Transfer Mobility Location VP-E 5200 48th Ave

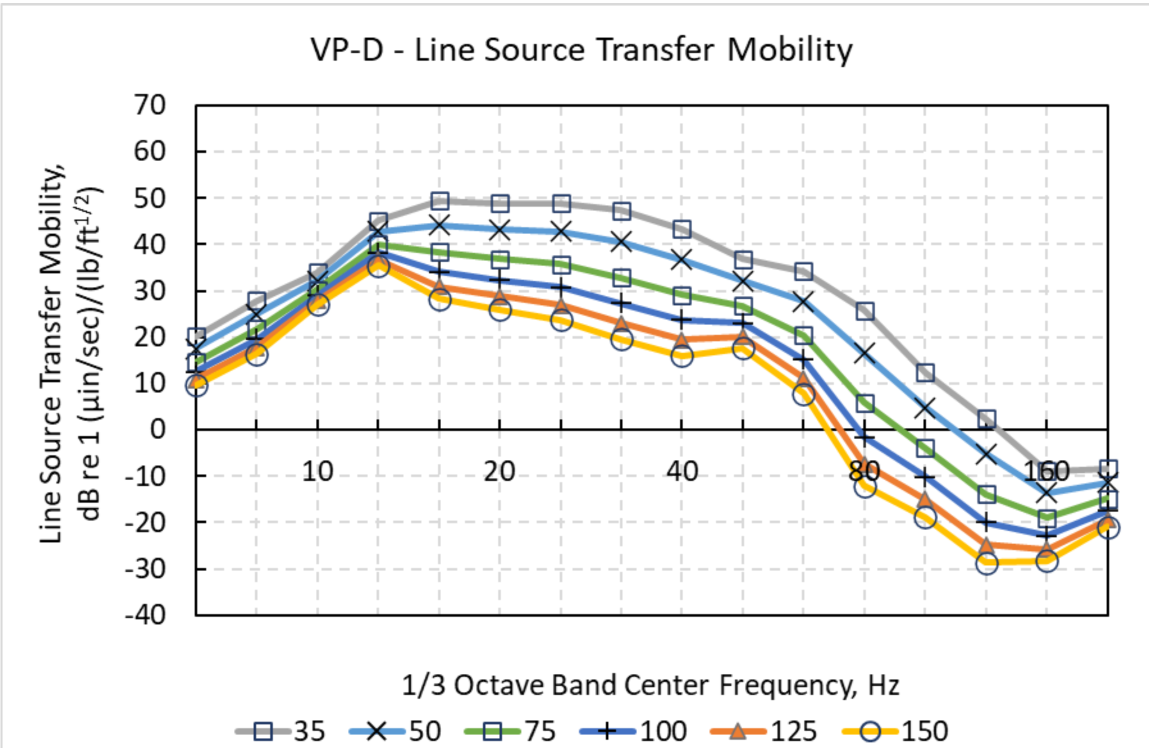


### Table D-4 Location VP-D Lakeview Terrace Park 1/3-Octave Band Transfer Mobility Coefficients

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 45.9 | 55.9 | 50.8 | 68.6 | 101.2 | 104.9 | 110.4 | 115.4 | 110.1 | 83.5 | 98.5 | 118.5 | 88.8 | 78.1 | 38.4 | 22.6 |
| B | -16.7 | -18.2 | -10.9 | -15.2 | -33.5 | -36.3 | -39.8 | -44.0 | -43.2 | -30.3 | -41.6 | -60.0 | -49.5 | -49.0 | -30.6 | -20.0 |
| C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

### Figure D-4 Line Source Transfer Mobility Location VP-D Lakeview Terrace Park



## Table D-5 Location VP-C 2700 27th Ave 1/3-Octave Band Transfer Mobility Coefficients

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 37.0 | 40.1 | 45.4 | 60.8 | 74.3 | 98.1 | 107.7 | 113.3 | 102.2 | 87.6 | 80.5 | 83.2 | 70.4 | 72.2 | 50.1 | 34.7 |
| B | -18.8 | -15.3 | -13.6 | -20.2 | -24.1 | -35.9 | -40.4 | -44.9 | -40.9 | -36.7 | -36.5 | -42.7 | -41.1 | -44.2 | -32.9 | -21.0 |
| C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

### Figure D-5 Line Source Transfer Mobility Location VP-C 2700 27th Ave

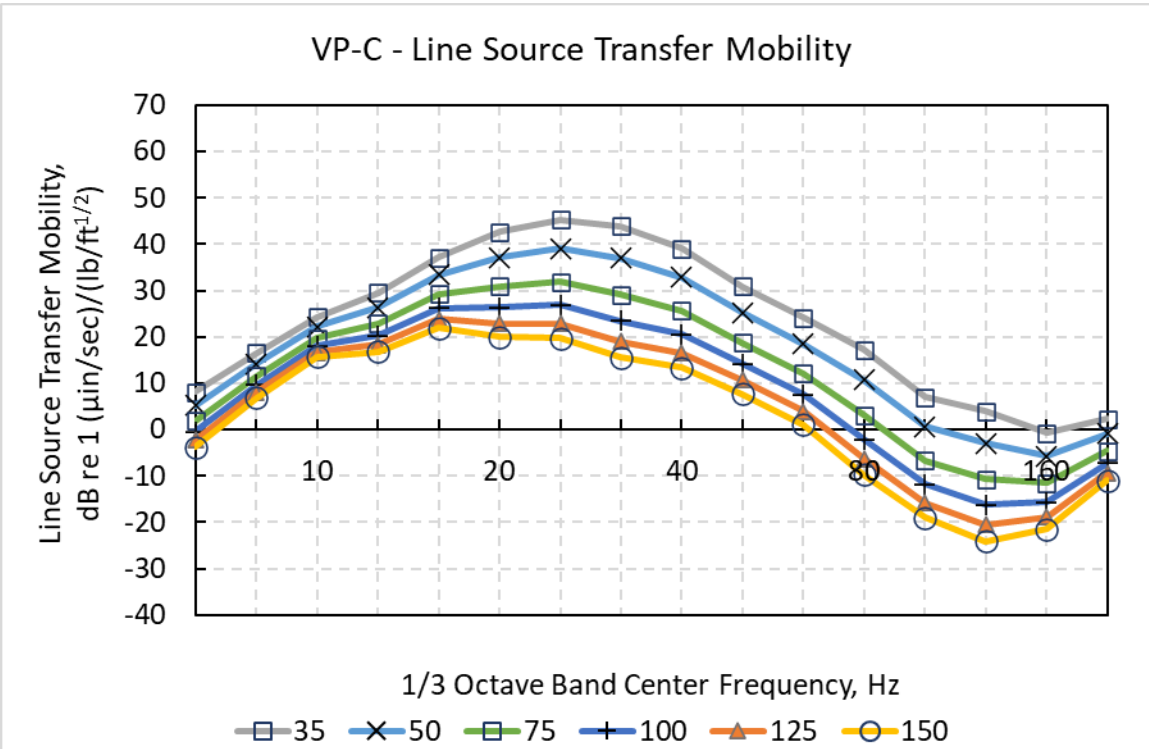


**Table D-6 Location VP-B N 21st Ave and Dupont Ave 1/3-Octave Band Transfer Mobility Coefficients**

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 33.1 | 29.5 | 29.7 | 32.8 | 54.6 | 80.5 | 107.9 | 110.3 | 96.5 | 85.8 | 77.1 | 85.2 | 76.6 | 49.3 | 28.0 | 26.6 |
| B | -15.6 | -14.8 | -13.7 | -11.5 | -16.5 | -28.2 | -42.5 | -44.5 | -38.2 | -35.4 | -33.1 | -39.1 | -38.8 | -25.5 | -14.9 | -12.0 |
| C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

**Figure D-6 Line Source Transfer Mobility Location VP-B N 21st Ave and Dupont Ave**

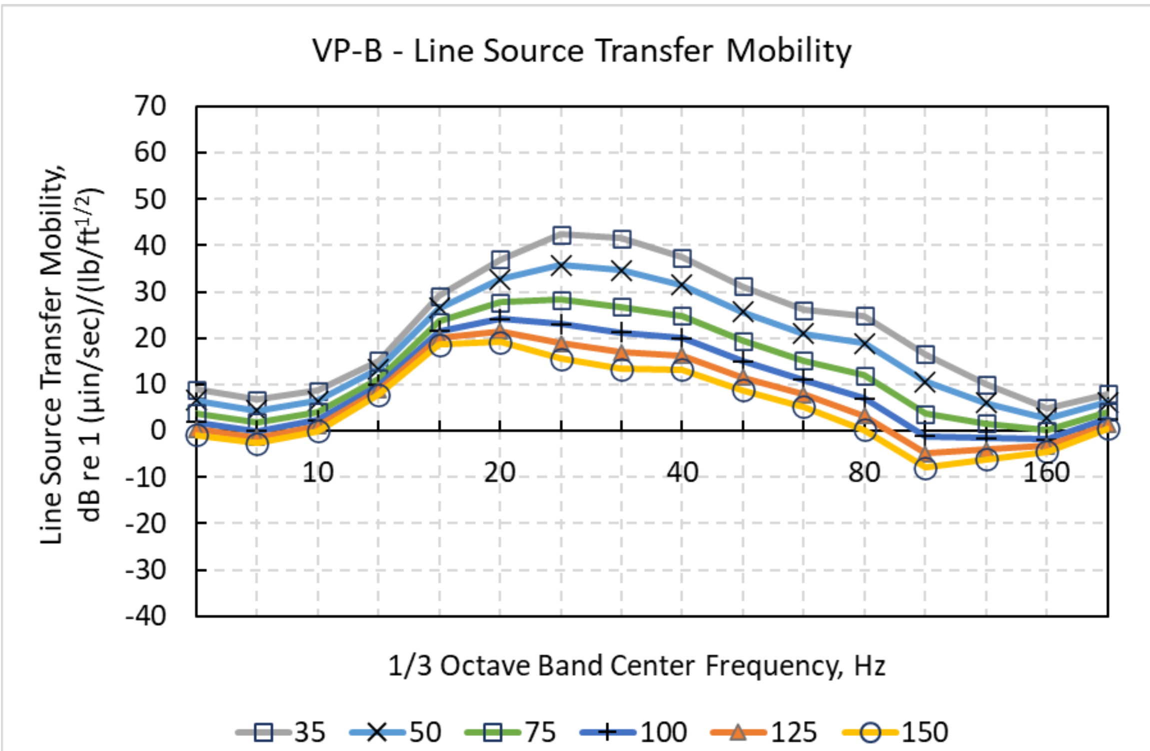


**Table D-7 Location VP-A Lyndale Ave and 14th Ave 1/3-Octave Band Transfer Mobility Coefficients**

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 34.0 | 31.8 | 33.5 | 42.8 | 45.4 | 62.2 | 77.8 | 90.5 | 88.2 | 78.7 | 78.9 | 82.5 | 78.3 | 70.6 | 52.5 | 24.5 |
| B | -4.1 | -5.4 | -2.6 | -8.0 | -6.8 | -13.3 | -21.1 | -28.6 | -28.5 | -25.4 | -27.8 | -34.0 | -35.5 | -33.5 | -24.7 | -9.9 |
| C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

**Figure D-7 Line Source Transfer Mobility Location VP-A Lyndale Ave and 14th Ave**

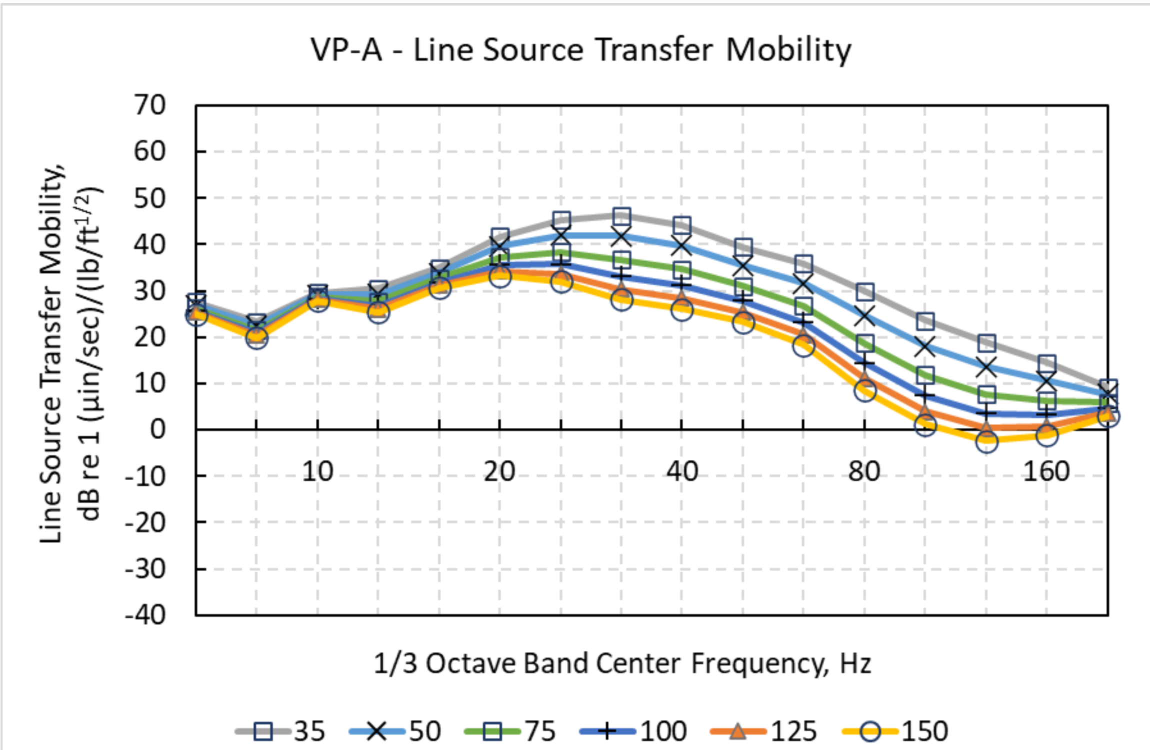


**Table D-8 Location VP-A-1 Washington Ave and 17th St 1/3-Octave Band Transfer Mobility Coefficients**

| Coeff. | 6.3 Hz | 8 Hz | 10 Hz | 12.5 Hz | 16 Hz | 20 Hz | 25 Hz | 31.5 Hz | 40 Hz | 50 Hz | 63 Hz | 80 Hz | 100 Hz | 125 Hz | 160 Hz | 200 Hz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 33.1 | 40.1 | 46.4 | 51.7 | 38.6 | 51.1 | 58.3 | 65.1 | 78.7 | 69.4 | 64.4 | 85.5 | 92.7 | 77.3 | 70.2 | 60.4 |
| B | -7.4 | -10.4 | -13.1 | -14.6 | -5.1 | -10.5 | -15.2 | -19.3 | -27.1 | -23.4 | -21.9 | -34.4 | -40.3 | -34.9 | -34.6 | -31.5 |
| C | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

$$LSTM = A + B * \log(dist) + C * \log(dist)^2$$

**Figure D-8 Line Source Transfer Mobility Location VP-A-1 Washington Ave and 17th St**

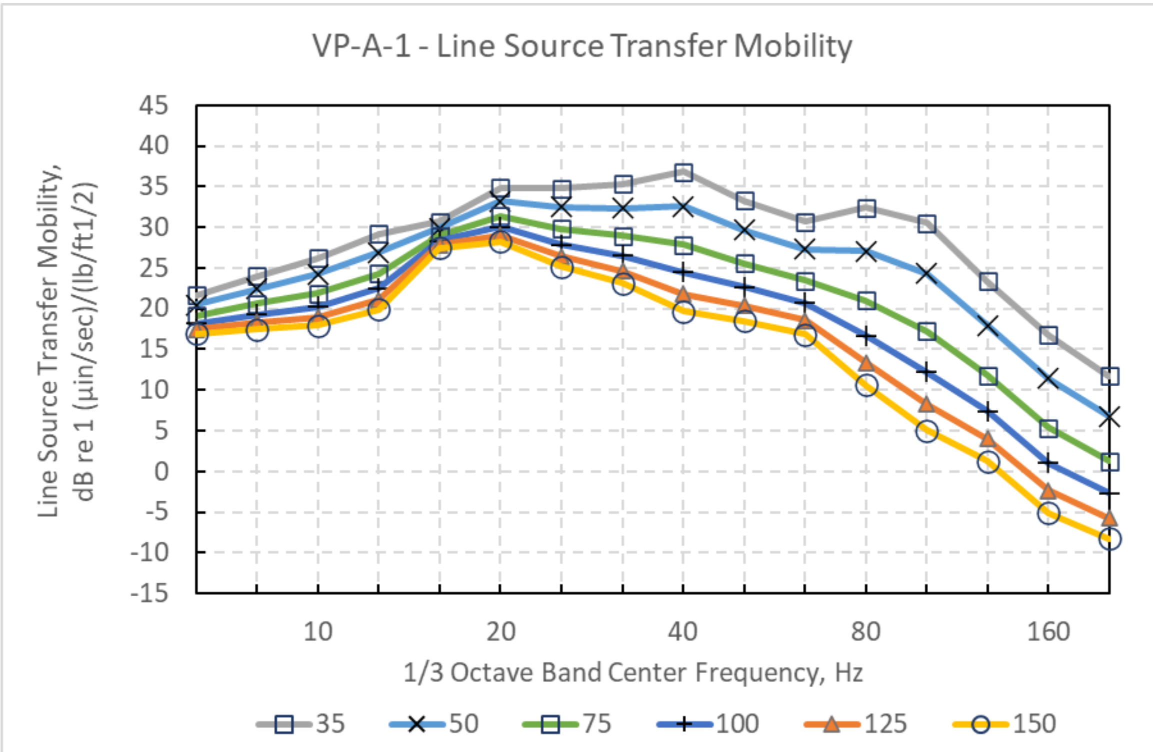


**Figure D-9 Line Source Transfer Mobility Location VP-A-2 10th Ave and 3rd St**