

Appendix H
Noise and Vibration Memoranda

Index

SWLRT Supplemental Draft EIS Existing Noise and Vibration Monitoring Locations

SWLRT Supplemental Draft EIS Noise and Vibration Impact Assessment Assumptions

SWLRT Supplemental Draft EIS Noise and Vibration Impact Results

SWLRT Supplemental Draft EIS Overview of Noise and Vibration Criteria and Impacts and Effects on Historic and Cultural Resources

Southwest LRT MPCA Noise Rules

SWLRT Noise and Vibration Fact Sheets

SWLRT Supplemental Draft EIS Existing Noise and Vibration Monitoring Locations



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TECHNICAL MEMORANDUM

To: Nani Jacobson, Southwest LRT Project Office
From: Lance Meister, Cross-Spectrum Acoustics
Date: December 15, 2014
Project Reference: SWLRT Supplemental Draft EIS Existing Noise and Vibration Monitoring Locations

This technical memorandum provides information regarding the monitoring locations for existing noise and vibration measurements shown on Exhibit 3.4-6 of the Supplemental Draft EIS and information on the noise and vibration measurements conducted during the Draft EIS, as well as how they are planned to be incorporated into the Supplemental Draft EIS analysis.

All vibration measurements and as many noise measurements as possible were conducted during the week of July 22-26, 2013. The remaining noise measurements were completed during the week of August 5, 2013.

1 Noise Measurements

The noise monitoring of existing conditions along the corridor is used to establish the pre-project noise levels at sensitive receptors, or locations representative of sensitive receptors. The FTA noise impact criteria (described in the Draft EIS) are based on the existing noise levels, therefore the measurements of existing noise is essential in conducting a noise impact assessment. Table 1 identifies the locations of the noise measurements for the Supplemental Draft EIS. Each location is identified as either a new measurement or a repeat of a previous measurement from the DEIS. The new measurements supplement the Draft EIS measurement locations to adequately document existing noise conditions in the corridor. The repeated measurements are updates of the Draft EIS measurements taken in the St. Louis Park/Minneapolis Segment to update existing conditions in these locations due to changes in the freight train traffic and operations since the Draft EIS measurements were conducted in 2010 and 2011.

The specific dates for the measurements in July and August are shown in Table 1, along with notes for the completed measurements.

Noise measurement locations from the Draft EIS are noted in Table 2. The site numbers in this table match those for the noise measurements in the Draft EIS, along with location information and whether or not the measurements will be used in the Supplemental Draft EIS analysis.

Table 1. Noise Monitoring Locations for the Supplemental Draft EIS (SDEIS)

Noise Site No.	Noise Monitoring Locations	Measure Duration (Hours)	SDEIS Area	Date	Measurement Details	Status and Notes
2	Southwest Station Condos (new)	24	EP Segment	July 25	Condos close to proposed corridor	Complete
3	Purgatory Creek Park (new)	1	EP Segment	July 25	Sensitive site along adjustment that needs a dedicated measurement	Complete
4	Apartments on Singletree Lane (new)	24	EP Segment	August 7	Residences on Singletree Lane along adjustment	Complete
14	Brunswick Ave South and West 37th Street (repeat of DEIS 29)	24	SLP/MPLS Segment	July 23	Representative of sites to south of corridor in this area and near Beltline Station	Complete
15	3427 St. Louis Ave or nearby (repeat of DEIS 31)	24	SLP/MPLS Segment	July 23	Representative of sites in southern portion of the Kenilworth Corridor	Complete – Measurement adjacent to tracks at the Calhoun Isle Condos
16	Kenilworth Place and South Upton Ave (repeat of DEIS 30)	24	SLP/MPLS Segment	July 23	Representative of sites in middle portion of the Kenilworth Corridor	Complete
17	21st Street Station Area near Thomas Ave S and Sheridan Ave S (new)	24	SLP/MPLS Segment	July 23	Representative of sites in northern portion of the Kenilworth Corridor	Complete

Notes: Noise Site Numbers are not sequential because noise monitoring was performed at other locations not listed in the table. Those sites will either be addressed in the forthcoming Final EIS or no longer fall within the area where they would potentially be impacted by project noise due to design refinements during Project Development. There are no noise sensitive receptors identified at the proposed Hopkins OMF site.

Table 2. Draft EIS Noise Monitoring Locations

Noise Site No.	Noise Monitoring Locations	Meas. Duration (Hours)	Date	Notes
25	11905 Technology Drive	24	3/2010	Used for SDEIS assessment
7	Fox News Studio	1	3/2010	Outside SDEIS assessment area
26	Nine Mile Creek Apartments 7475 Flying Cloud Drive	24	3/2010	Outside SDEIS assessment area
27	Smetana Road and Nolan Drive	24	3/2010	Outside SDEIS assessment area
28	6th Avenue and Excelsior Blvd	24	3/2010	Outside SDEIS assessment area
9	Monroe Ave and 2nd Street North	24	3/2010	Outside SDEIS assessment area
29	Brunswick Ave South and West 37th Street	24	3/2010	Outside SDEIS assessment area
31	3427 St. Louis Ave	24	4/2010	Repeated DEIS measurement on freight for new volumes and operations (#15 in Table 1)
30	Kenilworth Place and South Upton Ave	24	3/2010	Repeated DEIS measurement on freight for new volumes and operations (#16 in Table 1)
14	Cedar Lake Park	1	3/2010	
15	Kenwood Park	1	3/2010	

2 Vibration Measurements

The vibration propagation testing is conducted to determine the response of the soil to an input force. The information gathered during this testing is combined with the input force of the vehicle (taken from previous work by other consultants on the Central Corridor LRT (METRO Green Line) project, not from the Draft EIS) to determine the projected vibration levels from transit operations in locations with no current trains in operation. The vibration propagation testing is conducted where there are no current LRT trains in operation. The four sites in Table 3 were

SWLRT SDEIS EXISTING NOISE AND VIBRATION MONITORING LOCATIONS

selected to cover the areas included within the Supplemental Draft EIS (no sensitive vibration receptors are located at the proposed OMF location in Hopkins). Typically a vibration propagation test is conducted at one location, and the results are used for a larger portion of the alignment. An example of this is the Southwest Station Condos site (Site 2) below. The results at this site can be applied to the entire Eden Prairie Segment, including the apartments on Singletree Lane and other sites. Typically, fewer vibration propagation measurements are conducted on a project, as compared with the noise measurements. The exact location of each vibration measurement site (aside from the site specific locations) was determined in the field.

There were no vibration measurements taken for the Draft EIS. All vibration measurements for the Supplemental Draft EIS were completed in July, 2013. Specific notes, where needed, are shown in Table 3.

Table 3. Vibration Monitoring Locations for the Supplemental Draft EIS

Vib Site No.	Vibration Monitoring Locations	Measure Duration (Hours)	SDEIS Area	Measurement Details	Notes
2	Southwest Station Condos	3	EP Segment	Testing for Eden Prairie Segment	
7	Edgebrook Drive/West 37th Avenue	3	SLP/MPLS Segment	Testing for residences near Louisiana and Wooddale Stations	
8	West Lake Station	3	SLP/MPLS Segment	Testing for the southern portion of the Kenilworth Corridor	Measurement site near Calhoun Isle Condos
9	21st Street area	3	SLP/MPLS Segment	Testing for the northern portion of the Kenilworth Corridor	

Notes: Vibration Site Numbers are not sequential because vibration monitoring was performed at other locations not listed in the table. Those sites will either be addressed in the forthcoming Final EIS or no longer fall within the area where they would potentially be impacted by project vibration due to design refinements during Project Developments. There are no vibration sensitive receptors identified at the proposed Hopkins OMF site.

SWLRT Supplemental Draft EIS Noise and Vibration Impact Assessment Assumptions

TECHNICAL MEMORANDUM

To: Nani Jacobson, Southwest LRT Project Office
From: Lance Meister, Cross-Spectrum Acoustics
Date: December 15, 2014
Project Reference: SWLRT Supplemental Draft EIS Noise and Vibration Impact Assessment Assumptions

This technical memorandum provides an outline of the assumptions used and information/mapping acquired that will be used for the noise and vibration analysis for the Supplemental Draft EIS study areas. Specific assumptions used in the noise impact assessment include:

- Light Rail Transit (LRT) speeds were provided by the Southwest LRT Project Office Engineering team. Speeds range from 20 mph to 55 mph for LRT revenue operations within the areas studied in the Supplemental Draft EIS. A speed of 10 mph was assumed for vehicle movements inside the proposed Hopkins Operation and Maintenance Facility (OMF). LRT speed in a tunnel was assumed to be a maximum of 45 mph.
- For freight operations, speeds were assumed to be 25 mph along the Bass Lake Spur until the City of St. Louis Park/City of Minneapolis boundary (at France Avenue). From this point north and east, the freight speed was assumed to be 10 mph in the Kenilworth Corridor.
- Distances to sensitive receptors were based on maps provided by the Engineering team (see below for details).
- Shallow tunnel depth, retained cut wall heights and other project features were based on plan sheets, found in Appendix G, supplemented with profile and typical section information provided by the Engineering team.
- LRT tracks were assumed to be ballast and tie at all locations studied in the Supplemental Draft EIS, except for the shallow tunnel segment, where the tracks were assumed to be direct fixation on slab, except at the channel crossing (see Appendix G), where the tracks are ballast and tie.
- The retaining walls and crash walls were included in the impact assessment and evaluated as noise barriers.
- LRT vehicles were assumed to use 3-car trains during all hours of operation.
- The operating hours and headways were assumed to be the same as for the Central Corridor LRT (METRO Green Line), and included the following:
 - Early morning hours (4:00 AM to 5:30 AM) – 15 minute headways
 - Peak operating hours (5:30 AM to 9:00 PM) - 10 minute headways
 - Evening hours (9:00 PM to 11 PM) - 15 minute headways
 - Late evening hours (11:00 PM to 2:00 AM) - 30 minute headways
- Vehicle reference noise levels used in the SWLRT Draft EIS (p. 4-84) are based on measurements conducted for the Draft EIS on the METRO Blue Line (Hiawatha LRT) and are shown in Table 1.

Table 1. Blue Line Reference Noise Levels

Noise Source	Sound Exposure Level, (dBA)
LRT on embedded/direct fixation track	84
LRT on ballast and tie track	81
Crossing bells	106
LRT Bells	88
LRT Horn	99

The sound exposure level or SEL is the cumulative noise from a single noise event taking into account both the level and duration of the sound.

- Vehicle force density levels (reference vehicle input force) are based on measurements conducted for the METRO Green Line project for both ballast and tie and embedded track. (*Vibration Measurements and Predictions for Central Corridor LRT Project*, ATS Consulting, July 2008. Pages 28 and 45).
- Noise at tunnel portals was assumed to increase noise levels by 1 dB for locations within 100 feet of a tunnel portal to account for reverberation inside a tunnel. Modeled using "Terrain 1.4.3.0" Olive Tree Labs sound propagation modeling software. A comparison was made between noise levels from LRT vehicles in a free field condition and LRT in a tunnel with portals. The results indicated a small (1 dB) increase in noise levels very close to the portals due to reverberation in the tunnel. This result is consistent with findings presented in the literature.
- Crossovers and turnouts increase noise levels by 6 dB and vibration levels by 10 dB in the immediate vicinity of the crossover. (Industry standards.)
- Ventilation in the light rail tunnel is only required during emergency operations and will be tested on a monthly basis, and is therefore not included in the analysis.
- Noise from bells and horns devices was based on the following assumptions:
 - LRT bells are sounded for five seconds as vehicles approach grade crossings.
 - Bells are sounded twice when entering and exiting station platforms.
 - LRT horns are sounded at grade crossings where speeds exceed 45 mph.
 - Grade crossing bells are used at grade crossings for 20 seconds for each train.
 - No horn/bell sounding assumed at tunnel portals. This was included as part of the project’s operation assumptions to limit noise levels in potentially sensitive areas, such as near residences.



TECHNICAL MEMORANDUM

To: Nani Jacobson, Southwest LRT Project Office
From: Lance Meister, Cross-Spectrum Acoustics
Date: March 5, 2015
Project Reference: SWLRT Supplemental Draft EIS Noise and Vibration Impact Results

This technical memorandum provides an outline of the impact results for the noise and vibration analysis for each of the Supplemental Draft EIS study areas. The date and location of noise monitoring and vibration testing sites is documented in the SWLRT Supplemental Draft EIS Existing Noise and Vibration Monitoring Locations (August 21, 2013). Existing noise levels and results from the vibration testing sites will be summarized in Chapter 3 of the Supplemental Draft EIS.

Proposed Operation and Maintenance Facility (OMF), Hopkins

There are no noise or vibration sensitive receptors located near the proposed site.

Eden Prairie Segment

Noise

There are moderate and severe noise impacts at the Baymont Inn and Residence Inn located on Flying Cloud Drive between Interstate 494, Highway 212, and Prairie Center Drive, due primarily to grade crossing noise.

Additionally, the auditorium at the Optum facility on Technology Drive has been identified as a noise sensitive receptor. Supplemental, site-specific measurements will be conducted at this site during the Final EIS to determine the potential for impacts and the corresponding need for any mitigation.

Based on the projected noise impacts identified in the Eden Prairie Segment and in compliance with FTA guidance, final determinations of noise mitigation measures to be incorporated into the project will be made in a noise mitigation plan and documented in the project's Final EIS and Record of Decision. The contents of that plan will include: additional noise monitoring and/or testing where appropriate; documentation of the evaluation of mitigation measures relative to their feasibility, practicability, and project-specific factors used to identify the committed noise mitigation measures; and identification of committed long-term and short-term (construction) noise mitigation measures and their effectiveness. See Section 3.1.2.8 of the Supplemental Draft EIS for additional detail on FTA noise mitigation guidance and on the contents of a noise mitigation plan.

Vibration

There are no vibration impacts in this segment. However, the auditorium at the Optum facility on Technology Drive has been identified as a vibration and ground-borne noise sensitive receptor. Assessment of the facility will be conducted during the Final EIS to determine the potential for impacts and the corresponding need for any mitigation. Based on the projected short-term vibration impacts identified in the Eden Prairie Segment and in compliance with FTA guidance, final determinations of short-term vibration mitigation measures to be incorporated into the project for this segment will be made in a vibration mitigation plan and documented in the project's Final EIS and Record of Decision. The contents of that plan will include: additional testing where appropriate; documentation of the evaluation of mitigation measures relative to their feasibility, practicability, and project-specific factors used to identify the committed mitigation measures; and identification of committed long-term and short-term (construction) mitigation measures and their effectiveness. See Section 3.1.2.9 of the Supplemental Draft EIS for additional detail on FTA noise mitigation guidance and on the contents of a vibration mitigation plan.

St. Louis Park/Minneapolis Segment

Noise

There are a total of three severe and 66 moderate Category 2 noise impacts in the St. Louis Park/Minneapolis Segment. There is also one moderate Category 3 noise impact in the St. Louis Park/Minneapolis Segment. The impact results incorporate existing conditions in the area, as well as project design elements such as LRT vehicles running on ballast and tie track when not in the tunnel (which is quieter than slab track) and the presence of the retained cut walls of the portals, which act as noise barriers. A small adjustment in the noise level was made to account for the tunnel portal, as described in the impact assumptions memorandum, but it has a minimal effect.

Category 2 Impacts

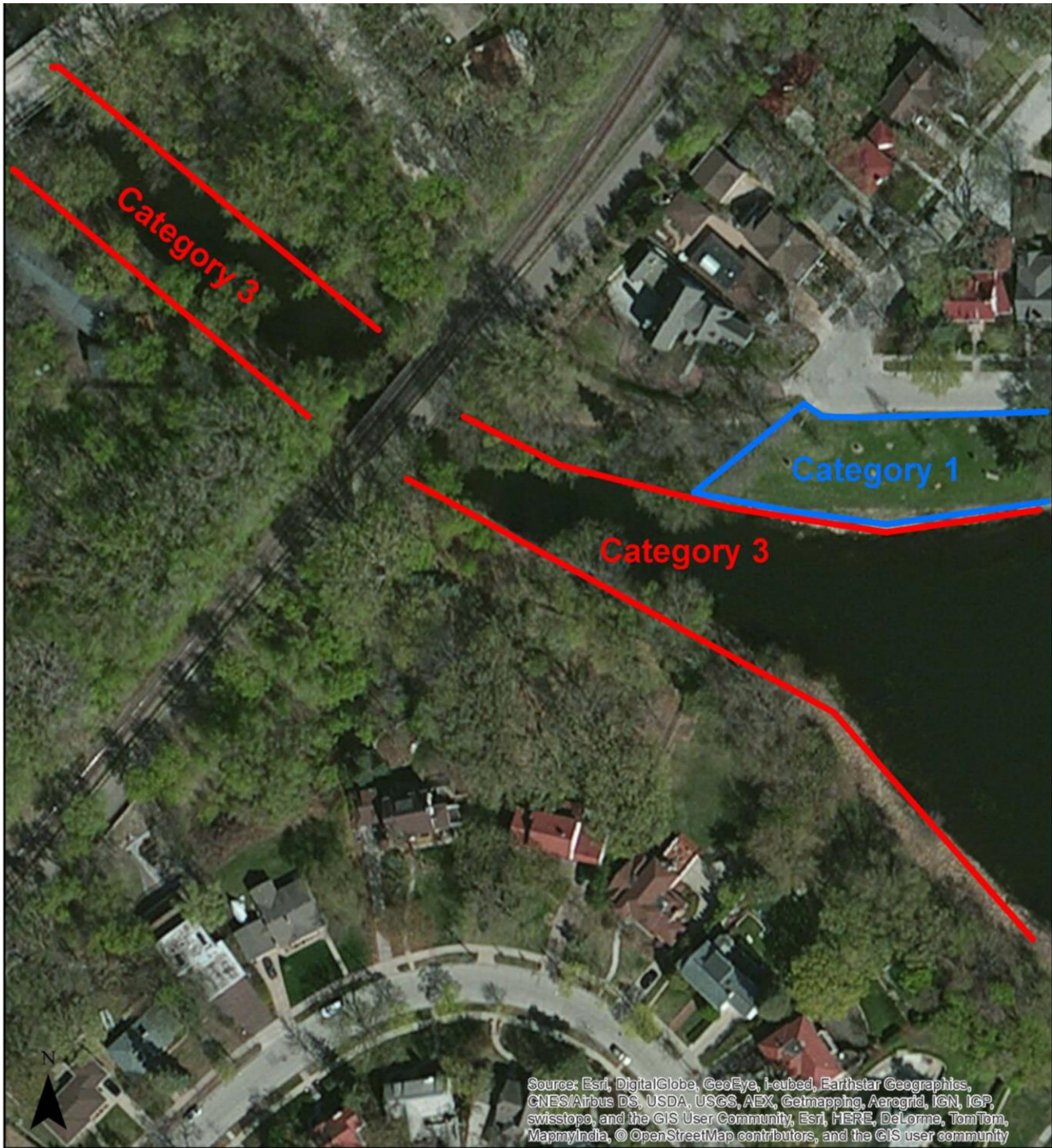
One severe noise impact and 38 moderate noise impacts are between the proposed Louisiana Station and Highway 100 on the south side of the corridor. Thirty-two of the moderate impacts are at the Hoigaard Village apartment complex near Highway 100 and the rest are at single-family residences near Railroad Avenue and W 37th Street.

The remaining noise impacts are in the at-grade section of the Kenilworth Corridor, north of the channel. There are one severe impact and six moderate noise impacts at Burnham Road, just to the north of the channel crossing. The other severe noise impact and remaining 22 moderate noise impacts are in the vicinity of the 21st Street Station and grade-crossing. The impacts are due to a combination of LRT noise, grade-crossing noise, and noise at the station. Because of the location adjacent to the grade-crossing, operations, engineering, and safety concerns will be considered in determining the mitigation options available at this location.

Category 3 Impacts

One moderate noise impact has been identified at the Kenilworth Channel crossing for the channel itself. The channel is considered a Category 3 sensitive noise receptor due to the presence of noise-sensitive activities that occur on the channel (see the graphic on the next page, which shows land use categories at the Kenilworth Channel). There would be a moderate noise impact within 40 feet of the tracks on both sides of the channel relative to the tracks. The grassy area on the banks of the lagoon is considered Category 1 land use due to the passive and noise-sensitive recreational activities that occur there (where quietude is essential feature of the park), however there would be no impact to this area because of the distance from the tracks to the sensitive location. These two sensitive noise receptors are also included within the Kenilworth Lagoon and Grand Rounds Historic District, which are Section 106 historic properties (see Section 3.4.1.3 for additional detail on the historic resources).

Exhibit 1. Kenilworth Channel/Lagoon Noise Categorization



The banks of the lagoon are considered Category 1.
The channel and lagoon are active use parks and are considered Category 3.

Based on the projected noise impacts identified in the St. Louis Park/Minneapolis Segment and in compliance with FTA guidance, final determinations of noise mitigation measures to be incorporated into the project will be made in a noise mitigation plan and documented in the project’s Final EIS and Record of Decision. The contents of that plan will include: additional noise monitoring and/or testing where appropriate; documentation of the evaluation of mitigation measures relative to their feasibility, practicability, and project-specific factors used to identify the

committed noise mitigation measures; and identification of committed long-term and short-term (construction) noise mitigation measures and their effectiveness. See Section 3.1.2.8 of the Supplemental Draft EIS for additional detail on FTA noise mitigation guidance and on the contents of a noise mitigation plan.

Vibration

There are no vibration impacts in this segment.

There are 54 ground-borne noise (GBN) impacts where the LRT tracks are in the tunnel; mostly within about 100 feet of the tracks on both sides. The GBN impacts are due to the distance to the tracks and the vehicle characteristics, which include high-frequency vibration. The vibration impact discussion for the St. Louis Park/Minneapolis Segment is found in Section 3.4.2.4 B of the Supplemental Draft EIS.

Based on the projected vibration impacts identified in the St. Louis Park/Minneapolis Segment and in compliance with FTA guidance, final determinations of vibration mitigation measures to be incorporated into the project will be made in a vibration mitigation plan and documented in the project's Final EIS and Record of Decision. The contents of that plan will include: additional testing where appropriate; documentation of the evaluation of mitigation measures relative to their feasibility, practicability, and project-specific factors used to identify the committed mitigation measures; and identification of committed long-term and short-term (construction) mitigation measures and their effectiveness. See Section 3.1.2.9 of the Supplemental Draft EIS for additional detail on FTA noise mitigation guidance and on the contents of a vibration mitigation plan.

**SWLRT Supplemental Draft EIS Overview of Noise and Vibration Criteria and Impacts and Effects on
Historic and Cultural Resources**



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TECHNICAL MEMORANDUM

To: Nani Jacobson, Southwest LRT Project Office

From: Lance Meister, Cross-Spectrum Acoustics

Date: December 15, 2014

Project Reference: SWLRT Supplemental Draft EIS Overview of Noise and Vibration Criteria, Impacts and Effects on Historic and Cultural Resources

This technical memorandum provides a summary of the Federal Transit Administration’s (FTA) noise and vibration criteria and mitigation policy, and FTA’s policy regarding effects of noise and vibration on historic and cultural resources. The last section of the memo provides information on the resources identified in the Supplemental Draft EIS segments: Eden Prairie Segment, the proposed Operations & Maintenance Facility (OMF), and the St. Louis Park/Minneapolis segment, and the potential noise or vibration effects for each resource.

1 FTA Noise Criteria

The noise impact criteria used for transit projects are based on the information contained in Chapter 3 of the FTA noise and vibration guidance manual¹. 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 existing noise with the project noise.

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

Table 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)*	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor Ldn	Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor Leq(h)*	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

* Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.

Source: FTA Guidance Manual (2006)

¹ U.S. Federal Transit Administration, “Transit Noise and Vibration Impact Assessment.” Report FTA-VA-90-1003-06, May 2006.

Category 1 includes uses where quiet is an essential element in the intended purpose, such as indoor concert halls, outdoor concert pavilions or National Historic Landmarks where outdoor interpretation routinely takes place. Category 2 includes residences and buildings where people sleep, while Category 3 includes institutional land uses with primarily daytime and evening use such as schools, places of worship and libraries. The criteria do not apply to most commercial or industrial uses because, in general, the activities within these buildings are compatible with higher noise or vibration levels. They do apply to business uses which depend on quiet as an important part of operations, such as sound and motion picture recording studios or vibration sensitive manufacturing or research facilities.

The noise impact criteria are defined by the two curves shown in Figure 1, which allow increasing project noise as existing noise levels increase, up to a point at which impact is determined based on project noise alone. The FTA noise impact criteria include three levels of impact, as shown in Figure 1. The three levels of impact include:

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

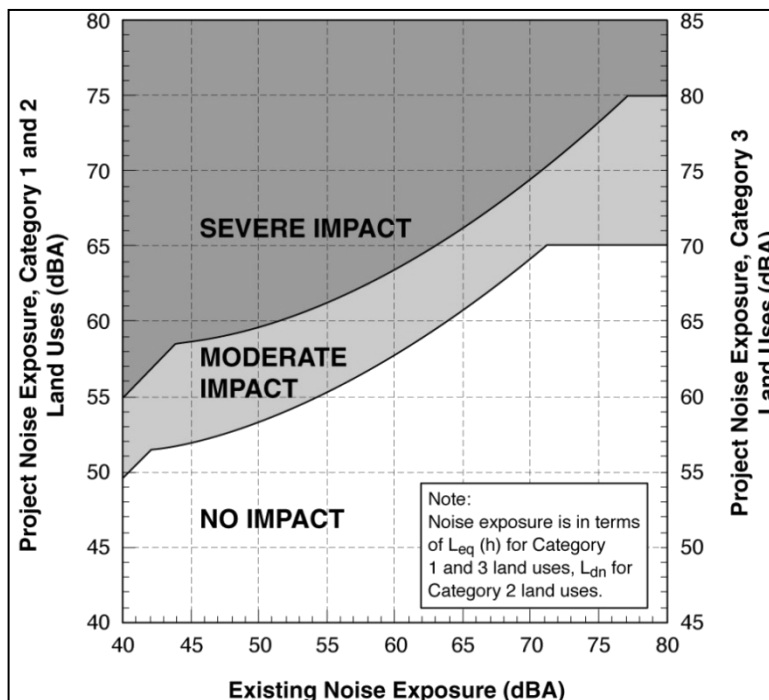


Figure 1. FTA Noise Impact Criteria

2 FTA Vibration Criteria

The vibration impact criteria used for transit projects are based on the information contained in Chapter 8 of the FTA noise and vibration guidance manual. The criteria for a general vibration assessment are based on land use and train frequency, as shown in Table 2. Some buildings, such as concert halls, recording studios and theaters, can be very

sensitive to vibration (or ground-borne noise) but do not fit into the three categories listed in Table 2. Because of the sensitivity, special attention is paid to these buildings during the environmental assessment of a project. Table 3 shows the FTA criteria for acceptable levels of vibration for several types of special buildings.

Table 2 and Table 3 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.

Table 2. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria

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

Notes:

1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

Source: FTA Guidance Manual (2006)

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

Type of Building or Room	GBV Impact Levels (VdB re 1 micro-inch /sec)		GBN Impact Levels (dBA re 20 micro Pascals)	
	Frequent Events ¹	Occasional or Infrequent Events ²	Frequent Events ¹	Occasional or Infrequent Events ²
Concert Halls	65	65	25	25
TV Studios	65	65	25	25
Recording Studios	65	65	25	25
Auditoriums	72	80	30	38
Theaters	72	80	35	43

Notes:

1. "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.
2. "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.
3. 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 pm, it should be rare that the trains interfere with the use of the hall.

Source: FTA Guidance Manual (2006)

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, such as in the tunnel south of the channel in the Kenilworth Corridor area, where airborne noise is not a factor, or at locations such as recording studios, which are well insulated from airborne noise.

Category 1 includes buildings where vibration would interfere with interior operations, Category 2 includes residences and buildings where people normally sleep and Category 3 includes institutional land uses with primarily daytime use. The criteria do not apply to most commercial or industrial uses because, in general, the activities within these buildings are compatible with higher noise or vibration levels. They do apply to business uses which depend on quiet as an important part of operations, such as sound and motion picture recording studios or vibration sensitive manufacturing or research facilities.

In addition to the criteria for annoyance and activity interference from vibration, there are additional criteria for damage to buildings. The criteria are based on the building type, as shown in Table 4. The allowable vibration levels, even for the most stringent category, are well above the typical vibration levels generated by transit operations, even at very close distances.

Table 4. Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approx Lv
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
RMS velocity in decibels (VdB) re 1 micro-inch/second.		

3 FTA Mitigation Policy

For noise, project generated noise in the No Impact category is not likely to be found annoying. Noise projections in this category are considered acceptable by FTA and mitigation is not required. At the other extreme, noise projections in the Severe Impact category represent the most compelling need for mitigation. However, before mitigation measures are considered, the project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid Severe impacts altogether.

If it is not practical to avoid severe impacts by changing the location of the project, mitigation measures must be considered. Impacts in this category have the greatest adverse effect on the community; thus there is a presumption by FTA that mitigation will be incorporated in the project unless there are truly extenuating circumstances which prevent it. The goal is to gain substantial noise reduction through the use of mitigation measures, not simply to reduce the predicted levels to just below the Severe Impact threshold.

Projected noise levels in the Moderate Impact category will also require consideration and adoption of mitigation measures when it is considered reasonable. The Moderate Impact category delineates an area where there is the potential for adverse impacts and complaints from the community, which must then be carefully considered in conjunctions with project specific requirements, as well as details concerning the affected properties, in determining the need for mitigation. While impacts in this range are not of the same magnitude as severe impacts, there can be circumstances where mitigation may be identified as necessary for the project.

4 FTA Policy on Noise and Vibration Impacts to and Mitigation for Historic and Cultural Resources

Under FTA guidance, historic sites are designated as noise or vibration 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 1². Historical 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 or vibration sensitive and the impact criteria do not apply.

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

In the Section 106 process protecting historic and cultural properties, noise may or may not be considered an “adverse effect” depending on the individual circumstances and whether or not 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 measures³.

For vibration, there is only one impact category. Vibration impacts are considered to be significant, and should be mitigated, unless it is not reasonable or feasible to provide mitigation. The need for mitigation is based on the vibration sensitivity of the land use, as with noise. One difference between noise and vibration is that outdoor land uses are not considered vibration sensitive. Only indoor land uses are considered vibration sensitive. The determination of whether or not a historic or cultural site is vibration sensitive and any additional need for mitigation is similar to that described above for noise.

5 Historic and Cultural Resources within the Supplemental Draft EIS Segments

Based on data provided by MnDOT CRU of listed and eligible historic properties within the Supplemental Draft EIS study areas, an assessment of the historic and cultural resources was conducted for the Southwest LRT Project. The assessment was conducted to determine the noise and/or vibration sensitivity of the resources along the corridor. For each resource site, a determination was made regarding the noise or vibration sensitivity of the use and the FTA category it would fall under based on FTA guidance. The result of the assessment, which is summarized in Table 5, is that the Kenilworth Lagoon/Channel is a historic resource that is potentially noise and vibration sensitive and close enough to the proposed Southwest LRT project to warrant a noise and vibration impact assessment.

In addition to the operational (long-term) assessment described above, the potential for vibration-related construction (short-term) impacts also was conducted. The criteria for construction vibration impacts to damage buildings is based on the building category and fragility of the building, not its designation or use as a historic resource. In most cases, vibration generated by construction activities does approach levels high enough to cause damage, even for very fragile buildings. The exceptions to this can be for activities such as vibratory rolling and impact pile driving. At

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

³ For historic or cultural resources, the following two circumstances in assessing impacts and mitigation measures: **1) The noise sensitivity of the property.** While Table 1 gives a comprehensive list of noise sensitive land uses, there can be differences in noise sensitivity depending on individual circumstances. For example, an 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 Department of Transportation (DOT) Act (which protects historic sites, as well as publically-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.

SWLRT SDEIS OVERVIEW OF NOISE AND VIBRATION CRITERIA AND IMPACTS AND EFFECTS ON HISTORIC AND CULTURAL RESOURCES

distances within approximately 50 feet, these activities have the potential for damage to the most sensitive structures. Based on the list of the structures contained in Table 5, they would either not be included in the most stringent category or would not be close enough for there to be any potential for damage. Therefore additional assessment is not warranted.

Table 5. Supplemental Draft EIS SWLRT Historic Properties

Inventory #	Property Name	Address	FTA Cat. ¹	Notes
Historic Districts				
XX-PRK-001	Grand Rounds Historic District (E)	Minneapolis	N/A	
HE-MPC-9860	Lake of the Isles Residential Historic District	Vicinity of E/W Lake of the Isles Parkway, Minneapolis	2	Outside the limits of noise impact
HE-MPC-18059	Kenwood Parkway Residential Historic District	1805-2216 Kenwood Pkwy, Minneapolis	2	Most of this district is outside the limits of noise impacts. A few residences near the northern end will be assessed for noise impact as a part of the standard assessment in the Final EIS.
HE-MPC-16387	StPM&M RR Historic District (E)	Minneapolis	N/A	
Individual Resources²				
HE-SLC-0008	CM&StP RR Depot (L)	6210 W. 37 th St, St. Louis Park	N/A	
HE-SLC-0009	Peavey-Haglin Concrete Grain Elevator (L, NHL)	Hwys 7 and 100, St. Louis Park	N/A	
HE-SLC-0055	Hoffman Callan Building (E)	3907 Hwy 7, St. Louis Park	N/A	
HE-MPC-17102	Minikahda Club (E)	3205 Excelsior Blvd, Minneapolis	N/A	
HE-MPC-1811	Lake Calhoun (E) ³	Minneapolis	N/A	
HE-MPC-1833	Cedar Lake Parkway (E) ³	Minneapolis	N/A	
HE-MPC-1820	Cedar Lake (E) ³	Minneapolis	N/A	
HE-MPC-1822	Kenilworth Lagoon/Channel (E) ^{3,4}	Minneapolis	1 & 3	The banks of the lagoon are considered Category 1 land use. The channel and lagoon are active use parks and are considered Category 3.(see Exhibit 1. Kenilworth Lagoon/Channel Noise Categorization)
HE-MPC-6901	Park Bridge No. 4 (E) ³	Minneapolis	N/A	
HE-MPC-1825	Lake of the Isles Parkway (E) ^{3,4}	Minneapolis	N/A	
HE-MPC-1824	Lake of the Isles (E) ^{3,4}	Minneapolis	N/A	
HE-MPC-6068	Frieda & J. Neils House (L)	2801 Burnham Blvd, Minneapolis	2	Outside the limits of noise impact
HE-MPC-6766	Mahalia & Zachariah Saveland House (aka Benjamin & Cora Franklin Residence) (E)	2405 W 22 nd St, Minneapolis	2	Outside the limits of noise impact
HE-MPC-1796	Kenwood Parkway (E) ^{3,5}	Minneapolis	N/A	
HE-MPC-6603	Frank & Julia Shaw House (E)	2036 Queen Ave S, Minneapolis	2	Outside the limits of noise impact
HE-MPC-1797	Kenwood Park (E) ³	Minneapolis	N/A	
HE-MPC-6475	Kenwood Water Tower (E) ³	Minneapolis	N/A	
HE-MPC-8763	Mac Martin House (E)	1828 Mt. Curve Ave,	2	Outside the limits of noise impact

SWLRT SUPPLEMENTAL DRAFT EIS OVERVIEW OF NOISE AND VIBRATION CRITERIA AND IMPACTS
AND EFFECTS ON HISTORIC AND CULTURAL RESOURCES

Inventory #	Property Name	Address	FTA Cat. ¹	Notes
		Minneapolis		
21HE0409 ⁶	(E)	Minneapolis	N/A	Not noise sensitive resource

(notes for Table 5)

Note: L = Listed; E = Eligible; NHL= National Historic Landmark; N/A = Not Applicable; Cat. = Category.

¹ Under FTA guidance, historic sites are designated as noise or vibration 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. Historical 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. N/A notes those resources that are not noise sensitive and thus do not fall within any of the FTA categories.

² Two existing wood pile bridges spanning the Kenilworth Lagoon were evaluated for eligibility to the NRHP as Section 106 historic resources (HE-MPC-1850, HE-MPC-1851). The Burnham Road Bridge (HE-MPC-1832), a two-lane automobile bridge with a steel beam span, was also evaluated for eligibility to the NRHP as a Section 106 historic property. The three bridges were found to be non-contributing features to the Grand Rounds Historic District and were not found to be eligible for listing on the NRHP as individual properties.

³ Eligible as a contributing feature to the Grand Rounds Historic District.

⁴ Eligible as a contributing feature to the Lake of the Isles Residential Historic District.

^e Eligible as a contributing feature to the Kenwood Parkway Residential Historic District.

⁵ This property is considered a sensitive historic resource under Section 304 of the National Historic Preservation Act of 1966, as amended. In accordance with Section 304, locational information on this sensitive historic resource may cause a significant invasion of privacy and/or put the resource at risk to harm and is not included in this document.

Southwest LRT Minnesota Pollution Control Agency Noise Rules



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TECHNICAL MEMORANDUM

To: Nani Jacobson, Metro Transit
From: Lance Meister, Cross-Spectrum Acoustics
Date: April 13, 2015
Project Reference: Southwest LRT MPCA Noise Rules

The purpose of this technical memorandum is to document 1) the Metropolitan Council's (Council) Southwest LRT Project team's understanding of the Minnesota noise rules and statute, 2) recent coordination between Southwest LRT, Minnesota Pollution Control Agency (MPCA) and Federal Transit Administration (FTA) staff on this topic, and 3) the agreed-upon approach to addressing this issue in the Supplemental Draft EIS and the Final EIS.

Background

The Draft EIS and Supplemental Draft EIS noise assessment is based on FTA criteria and guidance for assessing and mitigating project impacts⁴. Using FTA criteria for the noise analysis provides the highest standard of measurement and mitigation and most accurately reflects how humans respond to and are affected by transit noise. Additionally, Metro Transit is developing a noise mitigation approach which is based on the FTA impact criteria and guidance and will be used to apply mitigation in a reasonable and feasible manner for project noise impacts, as defined by FTA.

Southwest LRT Project Team Understanding of Minnesota Noise Rules and Statute

Within the state, the MPCA is empowered to enforce the state of Minnesota noise rules (§7030 Noise Pollution) and statute (§116.07 Powers and Duties). Minnesota's noise limits are set by "noise area classifications" based on the land use at the location of the person that hears the noise. They are also based on the sound level in decibels (dBA) over ten percent (L10) or six minutes and fifty percent (L50) or thirty minutes of an hour.

The Minnesota noise rules and statute work well if there is one dominant continuous noise source (e.g., a highway or an industrial facility). However, the Minnesota noise pollution rules and statute are not well suited to evaluate noise impacts from a transit project. They are based on L10 and L50 noise descriptors, which are the noise level exceeded 10 percent (6 minutes per hour) or 50 percent (30 minutes per hour) of the time, respectively. If these standards are applied to the Southwest LRT project only, there would never be an exceedance of these standards, as there are only two minutes of transit activity per hour, based on the current Southwest LRT operating plan. However, the Minnesota rules and statute consider all sources of noise in assessing whether an exceedance occurs.

Predicting the effects of adding a noise source to measured existing noise to assess the L10 and L50 for all noise sources can be an issue with statistical measurements such as L10 and L50. Using the L10 as an example, this is the loudest 360 seconds (6 minutes) out of 3600 seconds (60 minutes) in an hour. If measurements of existing noise levels are made, and the 120 seconds of transit operations (2 total minutes of train pass-byes⁵) are added in, the

⁴ U. S. Federal Transit Administration, "Transit Noise and Vibration Impact Assessment." Report FTA-VA-90-1003-06, May 2006.

⁵ The maximum proposed hourly operations are headways of ten minutes in each direction. The headway is the amount of time between trains. This would result in six trains per hour in each direction, for a total of twelve trains per hour. Assuming each

question becomes, which of the 120 seconds from the existing measured noise levels are replaced by the 120 seconds of transit operations (i.e., the 120 loudest seconds, the 120 quietest seconds, or a random selection)?

This becomes a subjective issue, which can have a significant effect on the L10 calculation with the future noise source added. Additionally, the choice of the hour to be used for the statistical calculation could have a large effect. There are 15 daytime and nine nighttime hours that could be used for the statistical calculation at any location, each of which would likely have different L10 values to compound the potential subjective nature of the addition of a future noise source.

Recent Coordination between the Council, MPCA and FTA

The Southwest LRT project team contacted the MPCA in March 2015 to discuss how the Minnesota noise rules would apply to the Southwest LRT project. MPCA, FTA and Southwest LRT Project staff met on April 8, 2015 to discuss the relationship between the Southwest LRT project and the Minnesota noise rules administered by MPCA. Southwest LRT staff referenced the FTA Transit Noise and Vibration Impact Assessment guidance manual and how it is applied to transit projects, including the Southwest LRT project. MPCA noted that the noise rule is not well suited to transit projects.

The three agencies agreed to continue coordination to determine the appropriate method for applying the Minnesota noise rules and statute to the Southwest LRT project. The agencies further agreed that this approach would be documented in the Southwest LRT project's Final EIS, which is expected to be completed in 2016.

Incorporation in the Supplemental Draft EIS and the Final EIS

The Supplemental Draft EIS and Final EIS will continue to use the FTA methodology and criteria for assessing and mitigating noise caused by the Southwest LRT project. Using the FTA methodology and criteria would result in impacts, as shown in both the results in the Draft EIS and Supplemental Draft EIS. These impacts are based on the well-documented FTA noise impact assessment methodology, which reflect how humans respond to noise and changes in noise in their environment. There is also a procedure within the FTA guidance for applying mitigation. Mitigation would be applied at the appropriate locations and would be based on FTA guidelines and the Metro Transit noise mitigation procedures, which utilize the FTA impact criteria and guidance for noise impacts from transit projects. This approach provides for mitigation of all severe impacts, where reasonable and feasible, and mitigation at locations with moderate impacts, based on the criteria contained in the FTA guidance manual.

The Supplemental Draft EIS acknowledges that certain areas in the vicinity of the project may already approach or exceed the L10 and/or L50 noise levels and that adding operation of the light rail vehicles in those areas may contribute to an exceedance of the statutory noise levels. These locations are likely in areas near existing highways and other roadways within the corridor in areas such as Eden Prairie, as well as areas in downtown Minneapolis. These highways and roadways are typically exempt from the noise standards (116.07 Subd. 2a). In cases where existing noise levels within the project area corridor are at or near the MPCA standards, the project may or may not contribute to an exceedance of the MPCA standards. Further, because of the way the L10 and L50 are calculated, the Project would not be able to determine if there is an exceedance of the standards, using a predictive model, prior to Southwest LRT operation, however the Council and FTA will work with MPCA to ensure that the analysis adequately considers the state standard.

The Supplemental Draft EIS also notes that the Southwest LRT project team is working with MPCA and FTA to determine the best approach to addressing Minnesota noise pollution rules and statute for those areas of the project that are subject to them. This approach and its results will be documented in the Final EIS in the project's noise analysis.

LRT vehicle takes 10 seconds to pass (a conservative estimate), there would only be 2 minutes (120 seconds) of transit operations noise per hour.

Noise Fact Sheet



How is Noise Defined?

Level: Sound level is expressed in decibels (dB). Typical sounds fall between 0 and 120 dB. A 3dB change in sound level represents a barely noticeable change outdoors; a 10 dB change is perceived as a doubling (or halving) of the sound level.

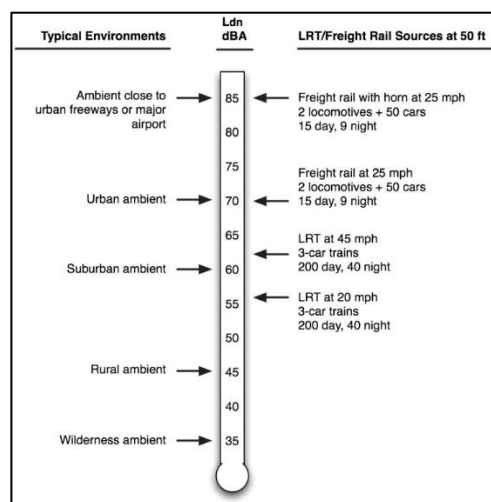
Frequency: The tone or pitch of a sound is expressed in Hertz (Hz). Human ears can detect a wide range of frequencies from about 20 Hz to 20,000 Hz. However, human hearing is not effective at high and low frequencies; we use a measure called an A-weighted level (dBA) to correlate with human response.

Time Pattern: Because environmental noise changes all the time, it is common to condense all of this information into a single number, called the “equivalent” sound level. It represents the changing sound level over a period of time.

For light rail transit (LRT) and freight rail projects, the Day-Night Sound Level (Ldn) is the common noise descriptor adopted by most agencies as the best way to describe how people respond to noise in their environment.

The Ldn is a **24-hour cumulative noise level** that includes all noises that happen within a day, with a penalty for nighttime noise (10 PM to 7 AM). This nighttime penalty means that any noise events at night are equal to ten events during the daytime.

Cumulative Noise Levels from LRT and Freight Rail



How Loud are LRT and Freight Rail?

Noise levels (in Ldn) from LRT and freight rail depend on the type of vehicle, how loud each individual vehicle could be (see table below), the number of trains per day, and train length and speed. In addition, noise levels decrease with increasing distance from the tracks.

Typical Maximum Noise Levels (dBA)

Distance	LRT @ 45 mph	Freight Rail @ 20 mph	Other Sources
50 feet	76	88	Lawnmower: 72
100 feet	71	83	Bus Idling: 66
200 feet	66	78	Diesel Generator: 67

Light Rail Transit (LRT) Vehicle



How is Noise Impact Assessed?

Noise impact from LRT and freight rail projects are assessed by comparing the existing (ambient) noise with the noise predicted to be generated by the project.

The Federal Transit Administration’s (FTA) noise criteria take into account the noise sensitivity of the receiver by land use category, including:

Category 1: Highly noise sensitive, such as recording studios

Category 2: Residences and other places where people sleep

Category 3: Schools, churches and other places with daytime use

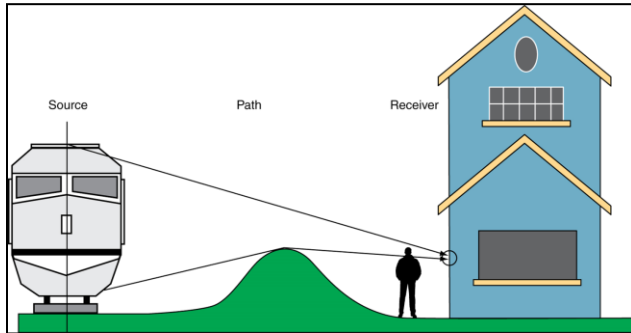
A noise assessment is broken down into three pieces:

Source: What is generating the noise (such as an LRT vehicle or freight train)?

Path: How far and over what type of ground does the noise travel?

Receiver: Who or what is experiencing the noise, such as a residence or a school?

The Source – Path – Receiver Concept



Noise impact assessments are based on applicable FTA and Federal Railroad Administration (FRA) models, and are assessed using the source-path-receiver framework. Some of the key components of a noise impact assessment include:

Source

- Noise levels of transit and freight trains
- Number, length, and speed of LRT and freight trains
- Time of day of train passing by
- Grade crossings, including horns and bells
- Track type, including elevated tracks, a tunnel, or at-grade track
- Special trackwork including crossovers

Path

- Distance to noise sensitive locations
- Rows of buildings
- Ground type

Receiver

- Type of land use (Category 1, Category 2 or Category 3)
- Sensitivity of the land use, including highly sensitive locations such as recording studios, residences or parks

Noise impact assessments also address the potential for impacts from maintenance facilities and stations.

Typical Output of a Noise Impact Assessment



The output of a noise impact assessment includes locations with Severe Impact (yellow) and Moderate Impact (orange). This information is used to determine the location and extent of any potential noise mitigation.

How is Noise Mitigated?

Noise mitigation is applied at locations where impact is identified. Severe impacts generally require noise mitigation. At the moderate impact level, noise mitigation is also addressed. Mitigation can be applied at the source of the noise, along the path, or at the receiver. Examples of typical LRT and freight rail noise mitigation include:

Typical Mitigation Measures

Mitigation measures can be applied to the source, the path and/or the receiver:

Source: Wheel damping, rail grinding, wheel truing, wheel skirts, quiet zones

Path: Noise barriers, berms, buffer zones

Receiver: Sound insulation

Vibration Fact Sheet



How is Vibration Defined?

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 light rail transit (LRT) and freight rail and is defined by the following:

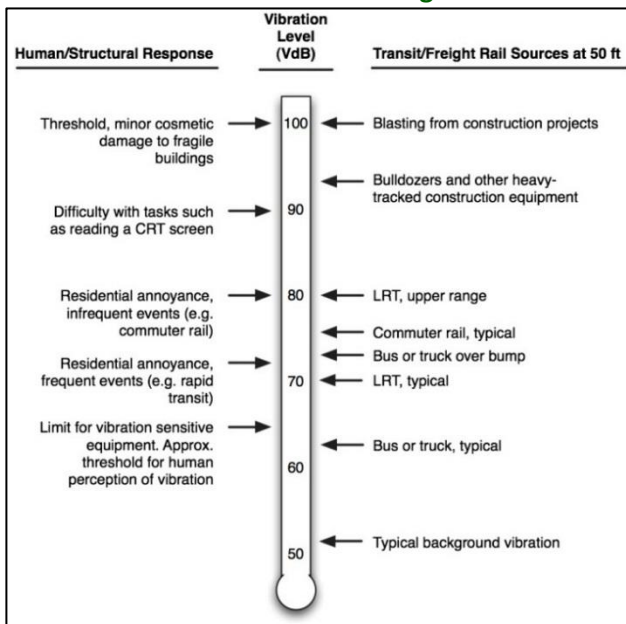
Level: Vibration is expressed in vibration decibels (VdB). The level of vibration represents how much the ground is moving. The threshold of human perception to LRT and freight rail vibration is approximately 65 VdB and annoyance begins to occur for frequent events at vibration levels over 70 VdB.

Frequency: Vibration frequency is expressed in Hertz (Hz). Human response to vibration is typically from about 6 Hz to 200 Hz.

Time Pattern: Environmental vibration changes all the time and human response is correlated to the number of vibration events during the day.

Vibration velocity (VdB) is used to describe LRT and freight rail vibration because it corresponds well to human response to environmental vibration. Vibration is defined by the maximum vibration level during a transit or freight rail event. Human sensitivity to vibration increases with increasing numbers of events during the day.

Vibration Levels from LRT and Freight Rail



Ground-borne noise (GBN) is also assessed. GBN is a form of low-frequency noise that radiates from

building walls and ceilings due to vibration caused by LRT or freight rail operation. Because airborne noise typically masks GBN for above ground (at-grade or elevated) transit systems, GBN is only assessed for operations in a tunnel (where airborne noise is not a factor) or near locations such as recording studios that are well insulated from airborne noise.

How much Vibration is Created by LRT and Freight Rail?

Vibration levels from LRT and freight rail depend on the type of vehicle, track conditions, soil type, and train speed. Vibration levels also decrease with increasing distance from the tracks. Vibration levels based on typical LRT and freight rail operations and speeds are shown below.

Vibration and GBN Levels (VdB) at 45 mph

Distance	LRT		Freight Rail
	Vib	GBN	
50 feet	71	39	88
100 feet	66	34	82
200 feet	58	26	76

Light Rail Transit (LRT) Vehicle



How is Vibration Impact Assessed?

Vibration and GBN impact from LRT and freight rail projects are assessed by comparing the levels predicted to be generated by the project with the appropriate criteria.

The vibration and GBN criteria use by the Federal Transit Administration (FTA) take into account the sensitivity of the receiver by land use category, including:

Category 1: Highly vibration sensitive, such as manufacturing facilities

Category 2: Residences and other places where people sleep

Category 3: Schools, churches and other places with daytime use

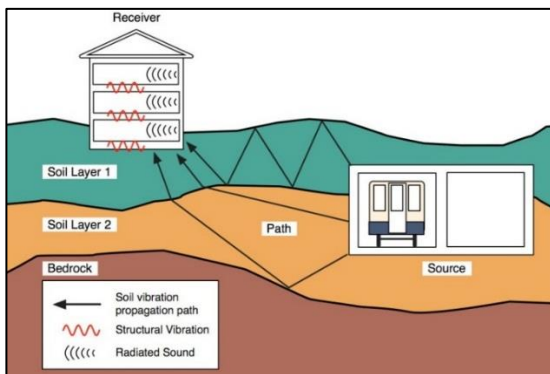
A vibration and GBN assessment is broken down into three pieces:

Source: What is generating the vibration or GBN (such as a transit vehicle or freight train)?

Path: How far and over what type of ground does the vibration or GBN travel?

Receiver: Who or what is experiencing the vibration, such as a residence or a school?

The Source – Path – Receiver Concept



Vibration and GBN impact assessments are based on applicable FTA and Federal Railroad Administration (FRA) models, and are assessed using the source-path-receiver framework. Some of the key components of a vibration impact assessment include:

Source

- Vibration levels of LRT and freight trains
- Number and speed of LRT and freight trains
- Track type, including elevated tracks, a tunnel, or at-grade track
- Special trackwork including crossovers

Path

- Distance to vibration sensitive locations
- Soil and bedrock characteristics
- Building foundations

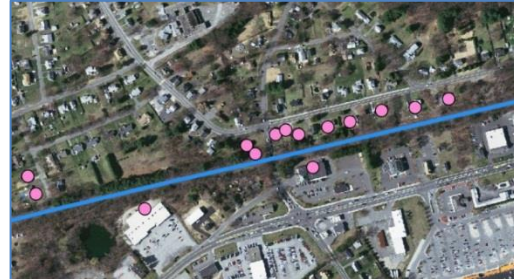
Receiver

- Type of land use (Category 1, Category 2, or Category 3)
- Sensitivity of the land use, including highly sensitive locations such as manufacturing facilities, residences or parks

Vibration and GBN impact is primarily assessed to determine the potential for human annoyance. However, vibration is also assessed for activity

interference at highly sensitive sites, and in very rare cases, damage to fragile structures, usually during construction. Vibration assessments also address the potential for impacts from maintenance facilities and stations.

Typical Output of a Vibration Impact Assessment



The output of a vibration or GBN impact assessment includes locations with vibration or GBN impact (purple). This information is used to determine the location and extent of any potential vibration mitigation.

How is Vibration Mitigated?

Vibration or GBN mitigation is applied at locations where impact is identified. Vibration impacts generally require mitigation where reasonable and feasible. Because mitigation is highly dependent on engineering details, specific mitigation measures are usually identified during the design of a project.

Vibration or GBN mitigation is most commonly applied at the source (in the tracks), but can also be applied along the path or at the receiver. Examples include:

Source: Rail grinding, wheel truing, resilient fasteners, ballast mats, floating track slabs

Path: Trenches, buffer zones

Receiver: Building modifications, isolated tables, floating floors

Example Vibration Mitigation: Resilient Fasteners

