Appendix F – Noise Technical Report

RideKC STREETCAR

Kansas City Street Car Main Street Extension

Noise and Vibration Technical Report

February 1, 2019

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Acronyms and Abbreviations

dB	decibels
dBA	A-weighted decibel
FTA	Federal Transit Administration
GBN	ground-borne noise
GBV	ground-borne vibration
Hz	hertz
KCSA	Kansas City Streetcar Authority
L_{dn}	day-night sound level
L_{eq}	equivalent sound level
$L_{eq(h)}$	1-hour equivalent average sound level
L_{max}	maximum noise level
Project	Kansas City Streetcar Main Street Extension Project
RMS	root mean square
SEL	sound exposure level
SPL	sound pressure level
SWL	sound power level
VdB	vibration decibels

Executive Summary

The Kansas City Streetcar Authority is conducting the environmental review process for the Kansas City Streetcar Main Street Extension. The proposed project includes a 3.5-mile extension of the existing streetcar alignment along Main Street, from the current streetcar terminus at Union Station to the Country Club Plaza / University of Missouri – Kansas City. In addition, the proposed project would add 8 new stations, up to 7 traction power substations, 6 new streetcar vehicles, and an expansion of the existing vehicle maintenance facility on property owned by the City of Kansas City to accommodate the expanded fleet.

This Noise and Vibration Technical Report has been prepared in support of the Environmental Assessment documentation for the Project. The objective of this report is to evaluate the Project's anticipated effects on noise- and vibration-sensitive land use in the Project area. This evaluation as completed in accordance with Federal Transit Administration (FTA) 2018 methodologies for general noise and vibration assessment of a transit project. The modeling results presented in this report indicate potential moderate noise impacts are anticipated to occur at one location with implementation of the Project. The noise mitigation recommendation is to retrofit the portion of the building that is inside the moderate noise impact contour with upgraded windows and doors.

1. Introduction

This report presents the technical assessment of noise and vibration effects of the Kansas City Streetcar Main Street Extension Project (Project). The noise and vibration impact assessment has been prepared in support of a Categorical Exclusion and in accordance with Federal Transit Administration (FTA) guidelines

1.1. Project Background

For more than three decades, transit planning studies have identified the River Market to Country Club Plaza corridor as the highest priority for fixed-guideway transit improvements. In 2012 and 2013 – while final design and construction were progressing on the Downtown Starter Line – the City of Kansas City, Missouri (KCMO), in coordination with the Kansas City Transportation Authority (KCATA), Mid-America Regional Council (MARC), and Jackson County, initiated a $1.9 million planning study called *NextRail KC* to evaluate the potential impacts, feasibility, and cost of streetcar expansions in eight designated corridors. Through a phased process that included public/stakeholder engagement, systems overview, route screening, and detailed route analysis, the Main Street corridor streetcar extension, along with two others, was selected by KCMO's City Council for endorsement. Since that time, the proposed project has been included in the region's adopted long-range transportation plan, Transportation Outlook 2040; it has also been included in the RideKC Smart Moves 3.0 Transit and Mobility Plan for the Kansas City Region; and MARC adopted the Locally Preferred Alternative (LPA) into the regional Long-Range Transportation Plan on March 20, 2018. In addition, in August 2017, voters along the Main Street corridor approved the formation of a new streetcar taxing district that would provide local funding for a streetcar extension along the Main Street corridor and approved the tax structure in June 2018. A data-driven Best Lane Analysis was completed in August 2018 that examined which lane the streetcar should run in and resulted in selection of an outside-lane running alternative.

1.2. Project Description

1.2.1. No Build Alternative

The No Build Alternative will not introduce any additional streetcar service. Therefore, no analysis is required.

1.2.2. Build Alternative

The Build Alternative would extend the streetcar approximately 3.5 miles south from its current terminus at Union Station, ending at 51st Street at the University of Missouri – Kansas City (UMKC). The Streetcar would operate primarily in mixed traffic in the outside travel lane, both northbound and southbound on Main Street. In the southern portion of the proposed corridor, starting near Emanuel Cleaver II Boulevard, it would operate within the existing Country Club Right-Of-Way, an existing transportation property. The Streetcar facilities would be constructed and would operate within existing street right-of-way. Streetcar stops would be spaced approximately every ½-mile with a platform for exiting and loading in each travel direction. A new vehicle maintenance facility (VMF)

would be not needed for the proposed extension, but the existing VMF would be expanded to accommodate the expanded fleet. For consistency and compatibility with the existing streetcar service, an overhead contact system (OCS) would be installed to power the streetcar vehicle. The OCS would require the poles be placed along the alignment along with up to seven traction power substations (TPSSs).

2. Regulatory Context

The noise and vibration analyses for the Project were prepared in accordance with FTA's noise and vibration guidance manual, *Transit Noise and Vibration Impact Assessment* (FTA 2018). The manual includes noise and vibration assessment methods and impact thresholds. Operation of the Project will not be subject to state or local noise regulations. Construction contractors will have to comply with local construction noise limits, if they exist.

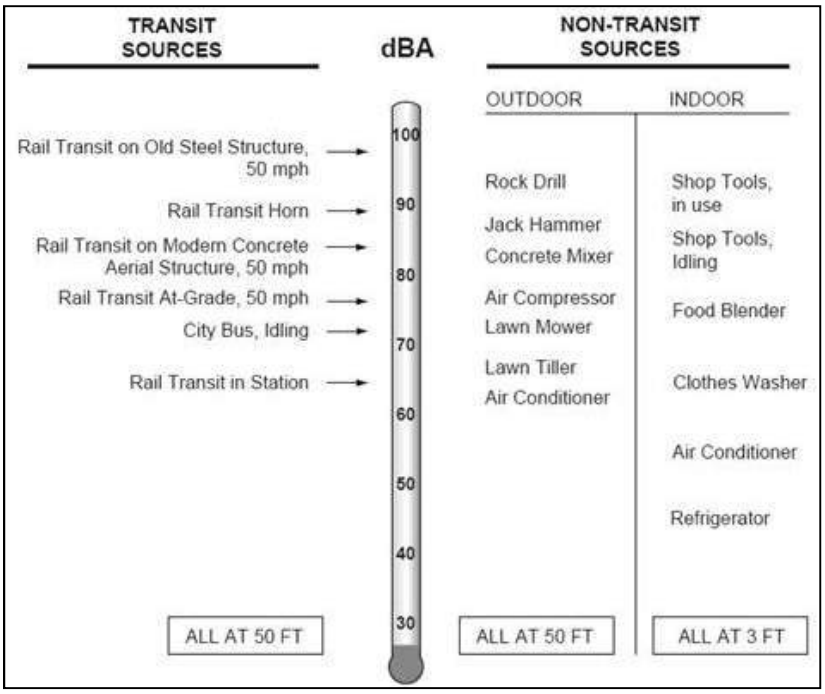
2.1. Noise

Noise is typically defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, speech, or recreation. Sound is what we hear when fluctuations in air pressure occur above and below the standard atmospheric pressure. Three variables define characteristics of noise: level (or amplitude), frequency, and time pattern.

Sound pressure level is expressed in decibels (dB) on a logarithmic scale. Typical sound levels generally fall between 20 and 120 dB, similar to the range of human hearing. A 3 dB change in sound level is widely considered to be barely noticeable in outdoor environments, and a 10 dB change in sound level is perceived as a doubling (or halving) of the loudness.

The frequency of sound is the rate at which fluctuations in air pressure occur and is expressed in cycles per second, or hertz (Hz). Most sounds consist of a broad range of sound frequencies. The average human ear does not perceive all frequencies equally. Therefore, the A-weighted decibel (dBA) scale was developed to approximate the way the human ear responds to sound levels; it mathematically applies less "weight" to frequencies we do not hear well and applies more weight to frequencies we do hear well. Typical A-weighted noise levels for various types of sound sources are summarized in Figure 1.

Figure 1: Typical Noise Levels



Source: FTA 2018.

As stated in the FTA guidance manual (FTA 2018), human reaction to environmental noise depends on the number of noise events, how long they last, and whether they occur during the daytime or nighttime. While the maximum noise level provides information about the amplitude of noise generated by a source, it does not provide any information about how long the noise event lasted. The sound exposure level (SEL) is a noise metric that takes into account both how loud a noise source is and how long the event occurs. The SEL of a noise event is a building block used to determine cumulative noise exposure over a one-hour or 24-hour long period.

Analysts use two primary noise measurement descriptors to assess noise impacts from transit projects. They are the equivalent sound level (L_{eq}) and the day-night sound level (L_{dn}). The L_{eq} is often used to describe sound levels that vary over time, typically for a 1 hour period. Using 24 consecutive 1 hour L_{eq} values, it is possible to calculate daily cumulative noise exposure. The L_{dn} is a 24 hour cumulative A-weighted noise level that includes all noise that occurs throughout a 24 hour period, with a 10 dBA penalty on noise that occurs during nighttime hours (between 10 PM and 7 AM) where sleep interference might be an issue. The 10 dBA penalty makes the L_{dn} useful when assessing noise in residential areas or other land uses where overnight sleep occurs.

2.1.1 FTA Transit Noise Criteria

The FTA noise impact criteria are based on well-documented studies regarding community response to noise. These thresholds are based on the land use of the noise-sensitive receptor and existing noise level. The L_{dn} is used to assess transit-related noise for residential areas and land uses where overnight

sleep occurs (Land Use Category 2), and the 1-hour L_{eq} [$L_{eq(h)}$] is used to assess impact at locations with daytime and/or evening use (Land Use Category 1 or 3), as shown in Table 1.

Table 1: FTA Noise Land Use Categories

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

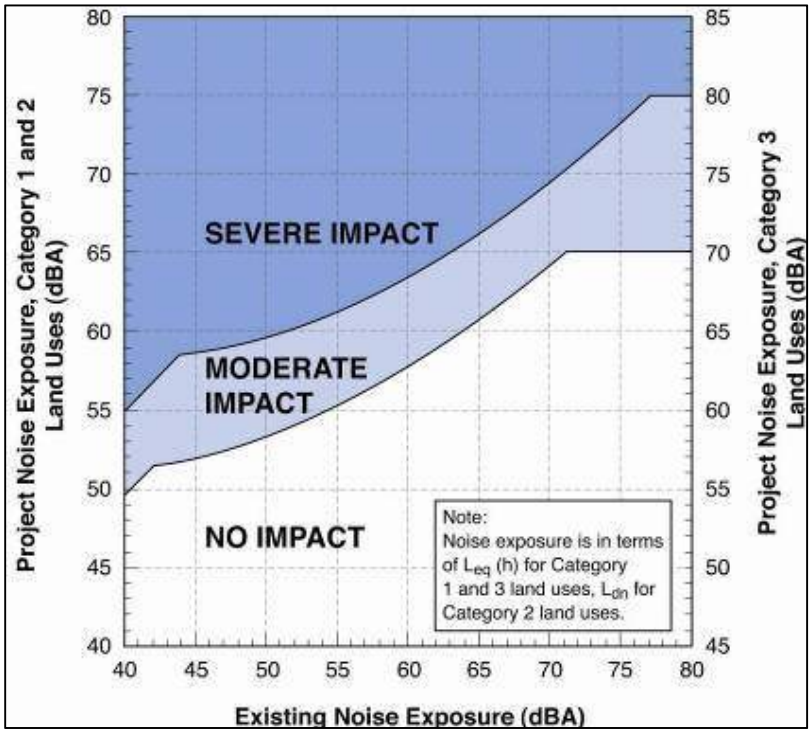
Source: FTA 2018.
Notes: Outdoor $L_{eq(h)}$ uses the noisiest hour of transit-related activity during hours of noise sensitivity
[a] 1-hour L_{eq}

The FTA noise impact criteria are defined by two curves that allow a varying amount of project noise based on the existing noise level, as shown in Figure 2. Below the lower curve, a project is considered to have no impact because the introduction of the project noise would result in an insignificant increase in noise level and number of people highly annoyed. The two degrees of noise impact defined by the FTA criteria are defined as follows:

Severe Impact: In the severe impact range, a large percentage of people would be highly annoyed by the project noise. Noise mitigation will normally be specified for severe impact areas unless it is not feasible or reasonable (meaning there is no practical method of mitigating the impact or mitigation measures are cost-prohibitive).

Moderate Impact: In the moderate impact range, changes in the cumulative noise level are noticeable, but may not be sufficient to cause strong, adverse reactions from the community. In this range, other project-specific factors are considered to determine the magnitude of the impact and the need for mitigation. Other factors include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost-effectiveness of mitigating noise to more acceptable levels.

Figure 2: FTA Noise Impact Criteria



Source: FTA 2018.

2.1.2 FTA Construction Noise Criteria

FTA's guidance manual does not provide standardized criteria for construction noise impacts. However, the manual suggests that the guidelines in Figure 2 are reasonable criteria for assessment. These construction noise criteria are intended to be compared with the combined 1 hour L_{eq} [$L_{eq(h)}$] of the two noisiest pieces of construction equipment during 1 hour.

Table 2: FTA Construction Noise Limits

Land Use	Daytime Noise Limit (dBA)	Nighttime Noise Limit (dBA)
Residential	90	80
Commercial and industrial	100	100

Source: FTA 2018.
Note: Noise limit is the combined $L_{eq(h)}$ of the two noisiest pieces of construction equipment during 1 hour.

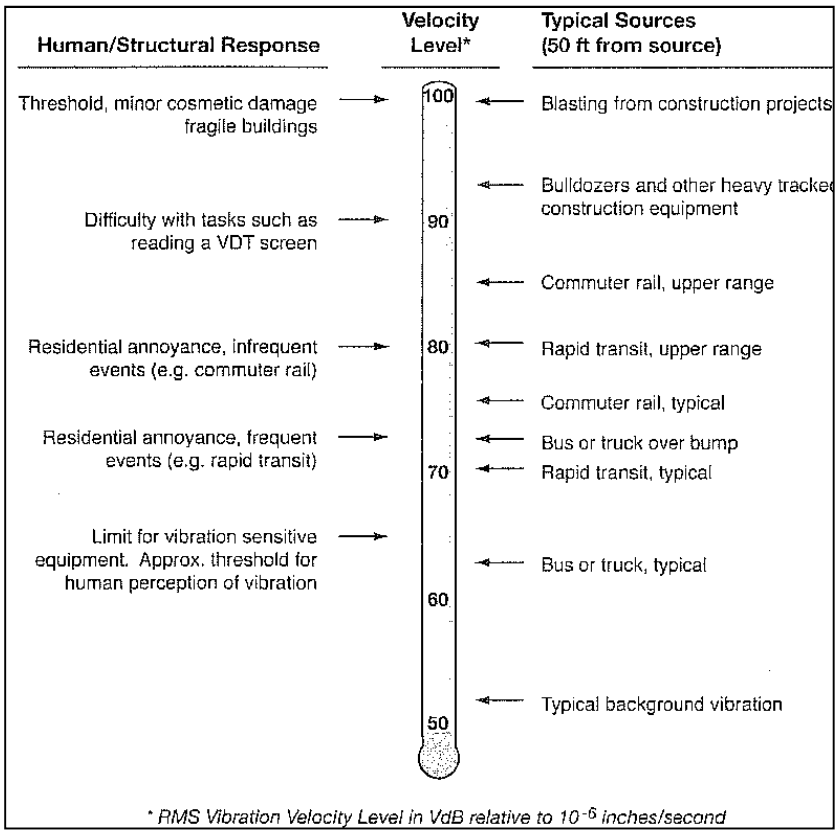
2.2. Vibration

Ground-borne vibration (GBV) consists of rapidly fluctuating motions of the ground transmitted into a receptor (building) from a vibration source, such as transit trains. FTA uses vibration velocity to describe vibration levels for transit projects.

The root mean square (RMS) amplitude of a motion over a 1 second period is commonly used to predict human response to vibration. The vibration velocity level is expressed in terms of vibration decibels (VdB), which is decibels relative to a reference quantity of 1 micro-inch per second. The level of vibration represents how much the ground is moving. The background vibration level in residential areas is usually 50 VdB or lower—well below the threshold of perception for humans, which is around 65 VdB. Annoyance begins to occur for frequent transit events at vibration levels over 70 VdB.

Vibration frequency is also expressed in Hz, and the human response to vibration generally falls between 6 and 200 Hz. Human response to vibration is a function of the average motion over a period of time, such as 1 second. Human response to vibration also roughly correlates to the number of vibration events during the day. The more events that occur, the more sensitive humans are to vibration. **Figure 3** illustrates common vibration sources and associated human and structural responses to GBV.

Figure 3: Typical Vibration Levels



Source: FTA 2018.

2.2.1 FTA Transit Vibration Criteria

FTA identifies separate criteria for both GBV and ground-borne noise (GBN). GBN is often masked by airborne noise; therefore, GBN criteria are primarily applied to subway operations in which airborne

noise is negligible. FTA differentiates vibration-sensitive land uses into three distinct categories—similar but not identical to the noise-sensitive land use categories, as shown in Table 3. The vibration thresholds vary based on the land use and the frequency of the vibration events. The proposed Project will include approximately 116 streetcar pass-by events depending on the weekday, subjecting the Project to the frequent event thresholds.

Table 3: FTA Vibration Impact Criteria

Land Use Category	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
	GBV impact level (VdB re 1 micro-inch/second)		
Category 1[d] (highly sensitive, where vibration would interfere with operations)	65	65	65
Category 2 (where overnight sleep occurs)	72	75	80
Category 3 (institutional with primarily daytime use)	75	78	83
GBN impact level (dBA re 20 micropascals)			
Category 2 (where overnight sleep occurs)	35	38	43
Category 3 (institutional with primarily daytime use)	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 in this category.

[b] Occasional events is defined as between 30 and 70 vibration events of the same source per day. Most commuter rail 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] The Category 1 criteria limits are 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. Vibration-sensitive equipment is generally not sensitive to GBN.

2.2.2 FTA Construction Vibration Criteria

Vibration attributable to construction activities is usually temporary. Thus, the principal concern for construction vibration is potential damage to structures. Table 4 lists damage criteria that can be applied to protect sensitive or fragile structures. These criteria can be used to identify locations that should be considered more carefully during the Project's final design phases.

Table 4: FTA Vibration Damage Criteria

Building Category	Peak Particle Velocity (inch/second)	RMS Velocity (VdB)
I. Reinforced-concrete, steel, or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA 2018.
Note: RMS velocity is provided as a reference to the general magnitude of vibration, compared with the operational vibration impact thresholds; assumes a crest factor of 4 (12 VdB).

3. Methodology

3.1. Noise

3.1.1 Operation Noise Evaluation Methods

This section describes the methodology used to assess potential noise impacts from operation of the Project. The noise assessment was conducted according to the FTA manual's General Assessment methods. The methodology and modeling assumptions used in this noise analysis were based on the methods and default data presented in FTA's guidance manual, except where use of measurement data was noted. Operational information was provided to HDR by other members of the project design team.

The FTA manual provides noise screening distances for different types of transit projects. The screening distance defines the noise study area for the Project and identifies noise-sensitive land use in the noise study area.

Noise-sensitive receptors were identified by reviewing a combination of available land use-related geographic information system data, windshield surveys, and available digital aerial photography, including publicly available internet imagery. Noise-sensitive receptors in the study area were identified and then categorized for noise sensitivity based on the descriptions in Table 1.

The existing noise environment was characterized by measuring outdoor noise in the Project area, as described in Section 4.1.2. The noise impact thresholds used for this assessment were based on measured existing noise levels and the FTA limits of allowable increase in noise levels when compared to existing noise levels. The FTA manual provides a method for calculating the noise emissions of rail-related noise sources and the propagation from the source to a receptor. This project used measurements of the KC Streetcar vehicle pass-byes, and bells performed during the Riverfront Extension project. For the proposed Project, the noise sources included the rolling and propulsion noise of the transit vehicle, the vehicle rolling over crossovers, and the transit vehicle's warning bells. For the general noise assessment, the sound exposure level (SEL) for a streetcar measured at 50 feet was adjusted for the sound attenuation over distance, the operation volumes, and the speeds of the proposed Project.

The noise modeling assumptions used in this assessment, including noise levels for proposed noise sources and operating characteristics, are described below:

The noise analysis used a SEL of 85 dBA at 50 feet for the streetcar vehicle, as measured from an existing RideKC streetcar vehicle pass-by in March 2018 by HDR. The proposed streetcar will consist of one electric articulated vehicle during hours of operation.

The noise analysis used a SEL of 72 dBA at 50 feet for the streetcar's audible warning bell, as measured from an existing RideKC streetcar vehicle pass-by in March 2018 by HDR. The streetcar will sound an audible warning bell when entering and exiting stations. Onboard warning bells were assumed to be used within 100 feet of the center of station platforms.

The RideKC streetcar will only use horns in emergency circumstances, they are not used under normal operating circumstances. Therefore horns are not included in this noise analysis.

The schedule is based on the *Streetcar Main Street Extension Operating Plan*. A separate weekday train schedule was given for Monday through Thursday operations and Friday operations. Friday is projected to have the highest volume of streetcar traffic, and was therefore selected for use in the modeling. The Friday projections are: 90 daytime streetcars (7 am to 10 pm), 26 nighttime streetcars (10 pm to 7 am), which resulted in 6 streetcars per daytime hour and 2.89 streetcars per nighttime hour.

Locations of crossovers and station platforms were identified based on conceptual engineering drawings provided by the engineering team. The speed of the streetcar was modeled at 15.6 miles per hour.

3.1.2 Construction Noise Evaluation Methods

The construction noise assessment was based on the methodology described in FTA's guidance manual. The construction noise analysis identified construction equipment commonly used for this type of Project. Data from similar projects were used to estimate sound levels for internal combustion engines, numbers of equipment to be used during each phase of construction, the rated horsepower for each piece of equipment, and the duration that each piece of equipment is anticipated to operate during construction activities.

To estimate construction noise levels from construction equipment with engines, a sound power level (SWL) was calculated by converting horsepower to kilowatts, then to SWL. A utilization factor representing the percentage of time items would be in use during an hour was developed using FTA's guidance manual. An adjusted SWL was determined by accounting for the number of pieces of equipment and their utilization factor. The adjusted SWL was then converted to sound pressure level (SPL) at distances of 100, 200, 500, and 1,000 feet. The SPL is expressed as $L_{eq(h)}$ in dBA and is an energy-based average noise level over a 1 hour period.

3.2 Vibration

3.2.1 Operation Vibration Evaluation Methods

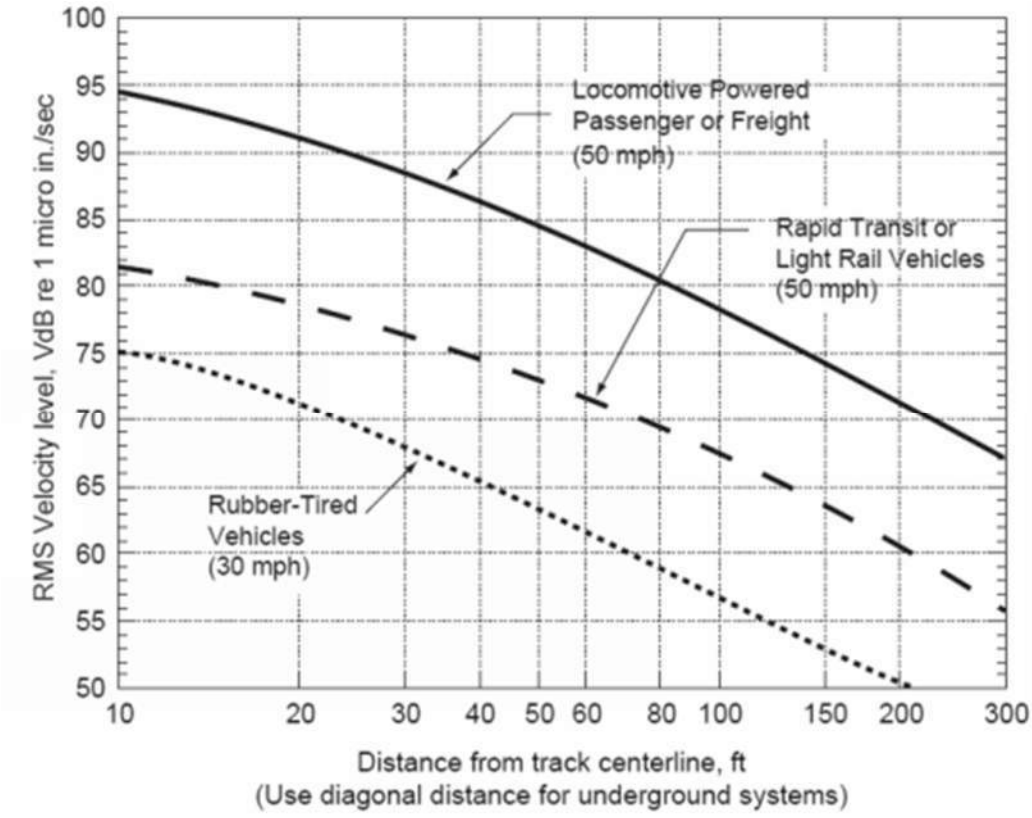
This section describes the methodology used to assess potential vibration impacts from operation of the Project. The vibration assessment was conducted according to the FTA manual's General Assessment methods. The methodology and modeling assumptions used in this vibration analysis were based on the methods and default data presented in FTA's guidance manual. Operational information was provided to HDR by other members of the project design team.

The FTA manual provides vibration screening distances for different types of transit projects in Chapter 9. The screening distance defines the vibration study area for the Project and identifies vibration-sensitive land uses in the study area.

Vibration-sensitive receptors were identified by reviewing a combination of available land use-related geographic information system data, windshield surveys, and available digital aerial photography, including publicly available internet imagery. Receptors in the study area were identified and then categorized for vibration sensitivity based on the descriptions in **Table 3**.

Projected GBV levels from streetcar pass-by events were predicted using the default ground-surface vibration curves in FTA's guidance manual. These GBV curves are shown in Figure 4. The streetcars will travel at 15.6 miles per hour. Following FTA guidance, the surface vibration curve for Rapid Transit or Light Rail Vehicles in Figure 4 was adjusted to reflect changes in train speed, and special trackwork such as crossovers. No adjustments were applied for corrugated rail, wheel flats, or other unmaintained rolling stock. The adjustment for coupling loss at foundations of 1-2 story masonry buildings was accounted for in this assessment.

Figure 4: FTA Surface Vibration Curves



Source: FTA, 2018

3.1.2 Construction Vibration Evaluation Methods

FTA's guidance manual provides guidance for construction vibration assessment. Most construction equipment can cause ground-borne vibration, which rapidly diminishes in strength with distance. A quantitative construction vibration assessment is generally necessary only when the construction activities have potential for damaging fragile buildings or interfering with equipment or activities that are highly sensitive to GBV. Examples include projects that use blasting, pile driving, pavement breaking, vibratory compaction, and drilling or excavating the ground near sensitive structures. Construction vibration was not evaluated quantitatively because the primary vibration sources or activities of concern are not currently proposed. Other activities have potential to create temporary, perceptible vibrations when construction activities move very close to a structure, but these impacts will be temporary and will occur only while the construction equipment moves through that location.

A brief qualitative assessment is provided, as suggested by FTA's guidance manual.

4 Affected Environment

4.1 Noise

This section discusses noise-sensitive land use in the Project Area and presents noise measurement results.

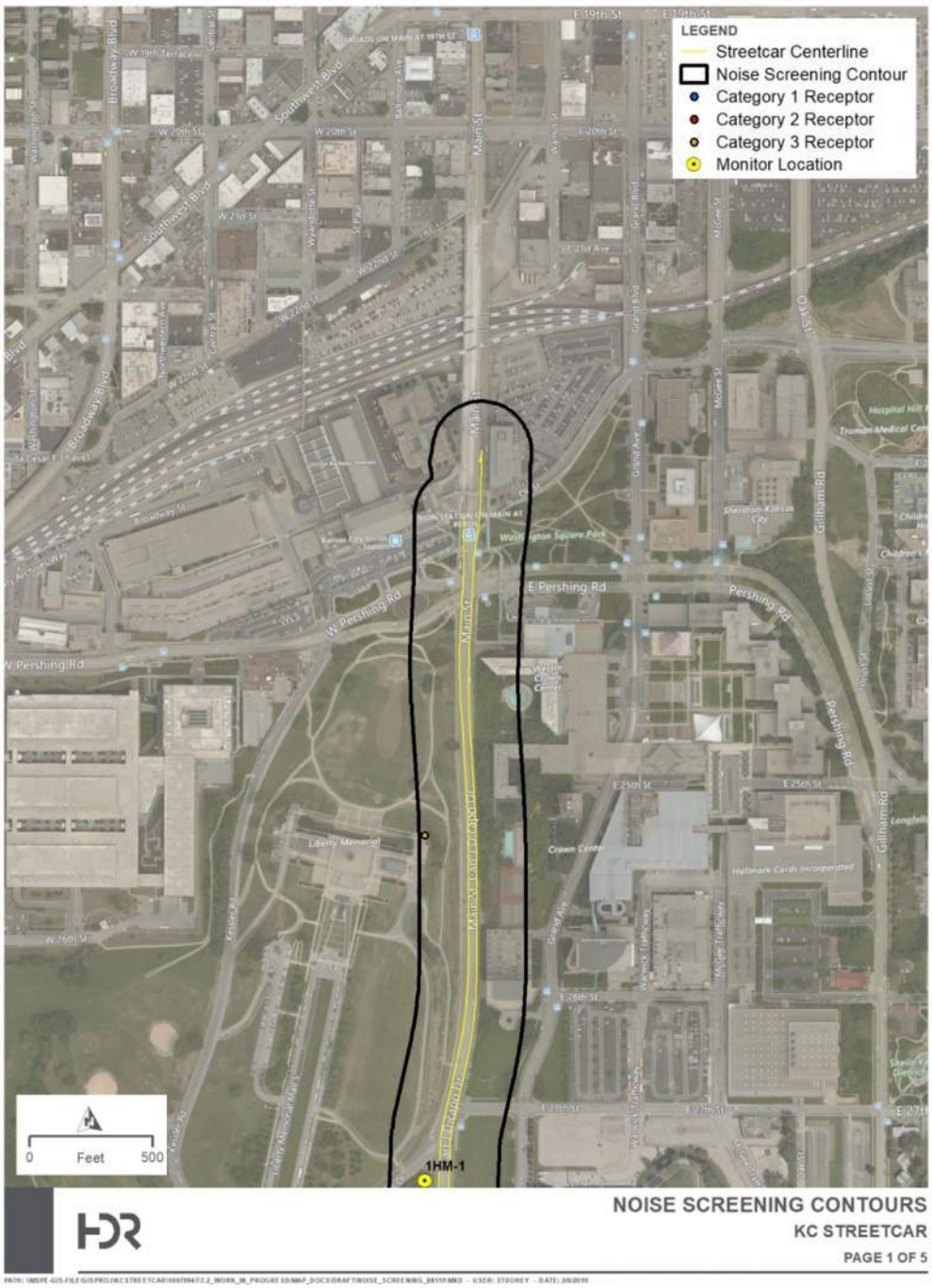
4.1.1 Noise-Sensitive Land Use and Noise Screening

The noise screening distance for a streetcar project without intervening buildings is 200 feet and 100 feet for obstructed views, and any noise-sensitive land uses within this distance from the proposed track centerline were evaluated in the general noise assessment. Noise-sensitive land use where overnight sleep occurs in the study area includes:

- Union Hill Apartments 2975 Main Street;
- Fairfield Inn hotel 3001 Main Street;
- Studio 6 hotel 3517 Main Street;
- the former Hawthorne Plaza Apartments 3835 Main Street;
- the loft apartments on the second floor 4301 Main Street;
- the Marriott hotel 4445 Main Street;
- the Holiday Inn hotel One East 45th Street;
- Seville Plaza Apartments 4545 main Street;
- Ponce de Leon Condominiums 4555 Main Street, and;
- the residential building at 5000 Oak Street.

Other noise-sensitive land uses within the screening distances include Cypher Sound Studios, St. Paul's Episcopal Church and day school, The Community Christian Church, a radio station (KKFA), Metropolitan Ensemble Theater, Kansas City Young Audiences theater, and passive use recreation such as outdoor areas at the National WWI Museum and Memorial. Figure 5 presents the noise screening results for the Project, and also shows where noise measurements occurred.

Figure 5: Noise Screening Area




LEGEND
Streetcar Centerline
Noise Screening Contour
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Monitor Location
1HM-1
24HM-1
Penn Valley Park
Union Cemetery
Main St
Broadway St
W 31st St
E 31st St
W Linwood Blvd
E Linwood Blvd
0
Feet
500
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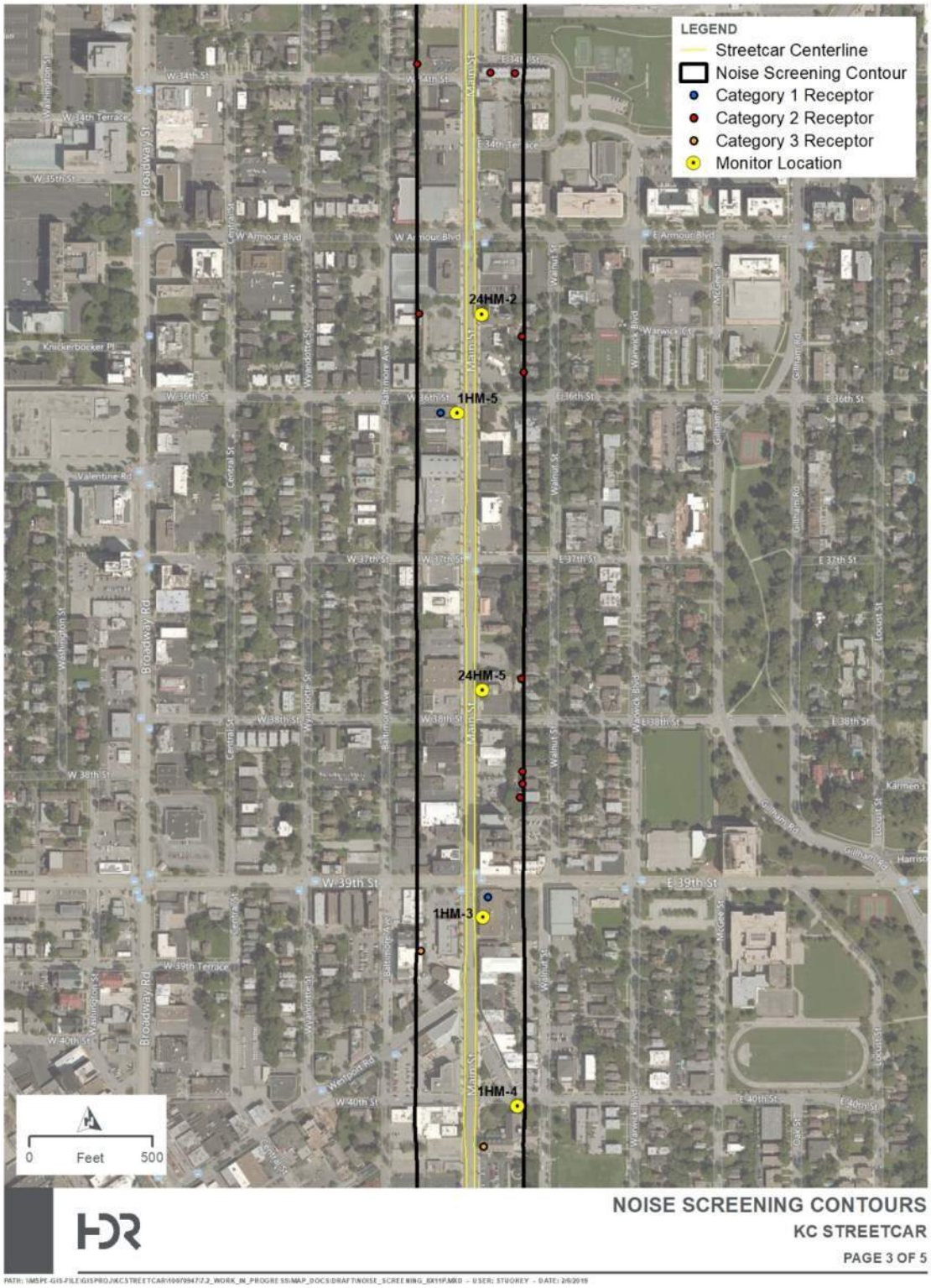
LEGEND
Streetcar Centerline
Noise Screening Contour
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Monitor Location
24HM-2
1HM-5
24HM-5
1HM-3
1HM-4
0
Feet
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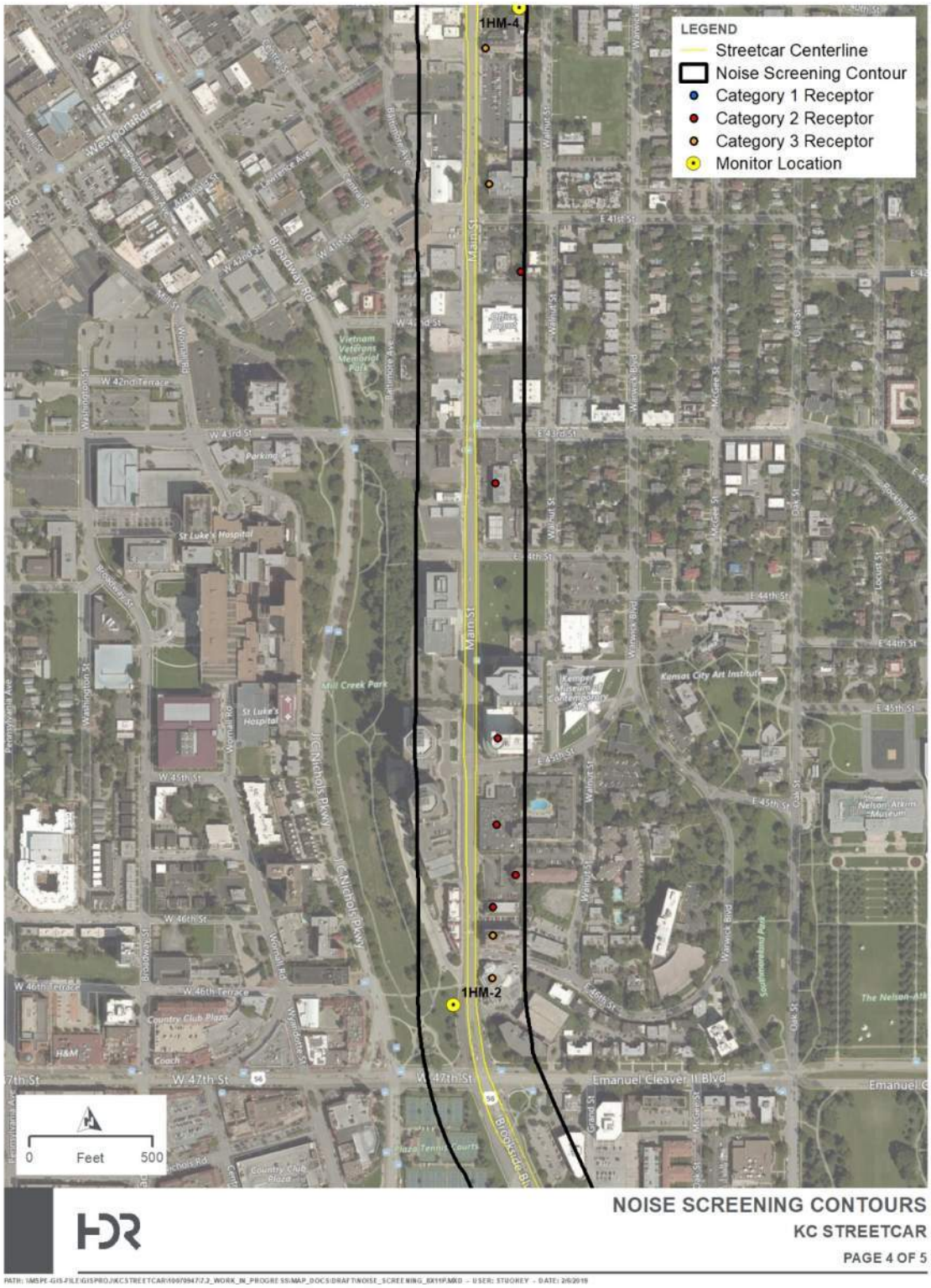
LEGEND
Streetcar Centerline
Noise Screening Contour
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Monitor Location
1HM-4
1HM-2
Main St
Broadway Rd
W 42nd Terrace
W 43rd St
W 45th St
W 46th St
W 47th St
E 41st St
E 43rd St
E 44th St
E 45th St
Mill Creek Park
Vietnam Veterans Memorial Park
St Luke's Hospital
Kansas City Art Institute
Country Club Plaza
Emanuel Cleaver II Blvd
Brookside Blvd
JC Nichols Pkwy
Warwick Blvd
Walnut St
Oak St
McGee St
Wornall Rd
Washington St
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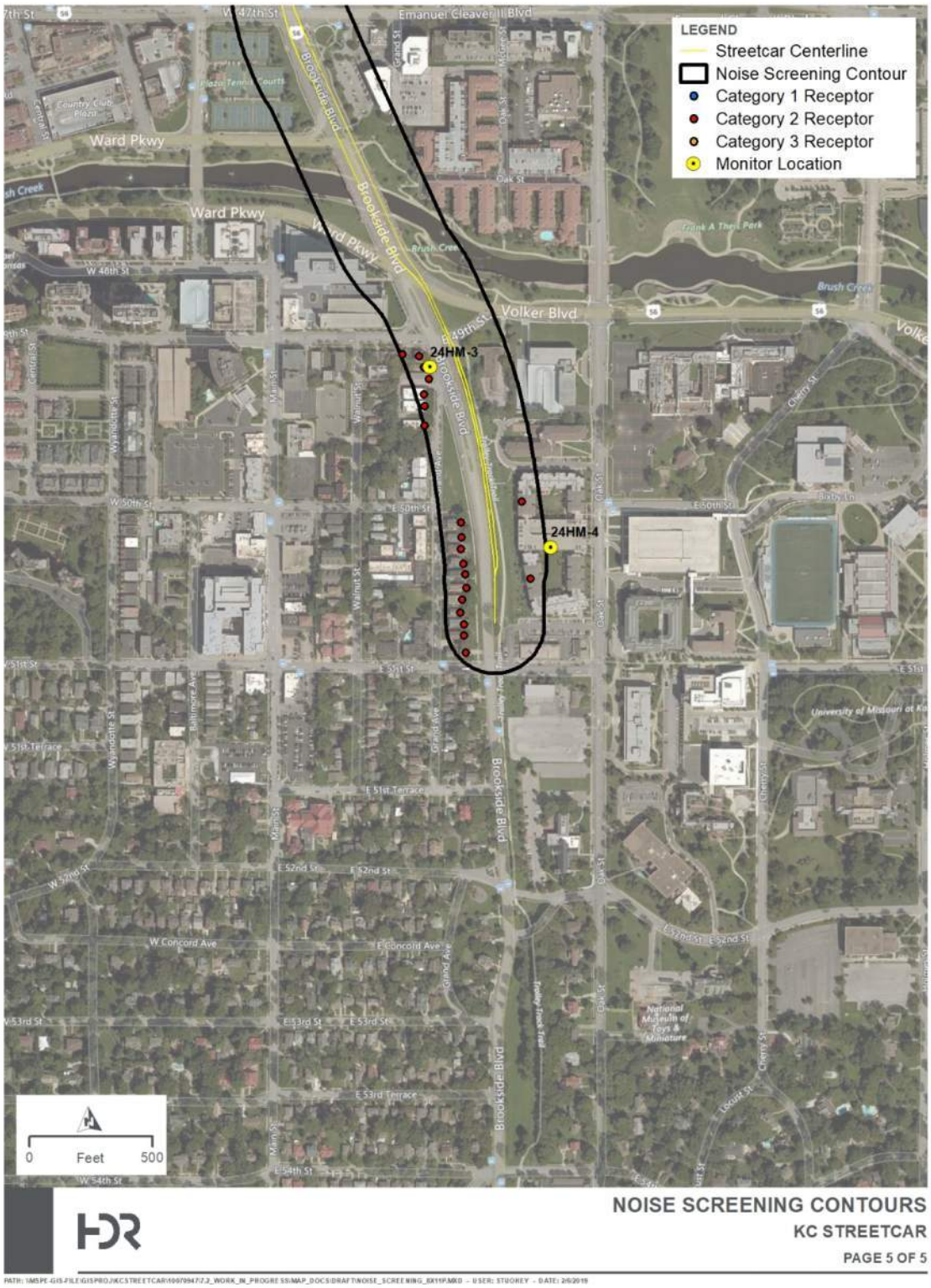
LEGEND
Streetcar Centerline
Noise Screening Contour
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Monitor Location
24HM-3
24HM-4
Ward Pkwy
Brookside Blvd
Volker Blvd
Emanuel Cleaver II Blvd
W 47th St
W 46th St
E 49th St
E 50th St
E 51st St
E 51st Terrace
E 52nd St
E 53rd St
E 53rd Terrace
E 54th St
W Concord Ave
E Concord Ave
Oak St
Main St
Walnut St
Grand Ave
Cherry St
Bixby Ln
Locust St
Frank A Theis Park
Brush Creek
National Museum of Toys & Miniature
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4.1.2 Existing Noise Conditions

In support of the planned extension of the Kansas City streetcar line, HDR acousticians measured existing ambient noise levels at locations along the proposed streetcar corridor. Measurements occurred throughout the week of December 4-7, 2018. The measurement locations represent noise-sensitive areas throughout the proposed streetcar corridor and include various land uses and soundscapes. HDR performed 24-hour measurements at properties where overnight sleep occurs, and 1-hour measurements at other land uses including quiet outdoor reflection (ML-6), worship (ML-7, ML-9), broadcast studio (ML-8), and a recording studio (ML-10).

Two measurement locations were shifted to locations near the original targets due to poor noise measurement conditions at the planned sites. The 2-story brick façade of the building hosting KKFI 90.1FM broadcast studio (3901 Main St.) is offset from the street only by the width of the sidewalks. The CVS parking lot directly across Main St. (3902 Main St.) served as an alternative location to measure noise levels representative of those at the broadcast station. A similar measurement environment was encountered near Cypher Sound Studios (3600 Main St.). The representative noise measurement location was the parking lot adjoining the building formerly housing the Metropolitan Ensemble Theatre (MET) at 3604 Main St.

Table 5 summarizes the measurement locations; they are also shown in Figure 5.

Table 5: FTA Vibration Damage Criteria

Location		Dominant Noise Source(s)
Code	Description	
ML-1	Apartment units are offset approximately 25 feet from street and situated 10 to 15 feet above road grade on grass-covered slope.	Traffic noise from both north- and south-bound Main St. is predominant noise source.
ML-2	West face of hotel is offset 15 feet from street at road grade. L-shaped façade opens to the street to the west and to two small parking lots to the north. Front of hotel is landscaped with retaining walls, grass, and small shrubs.	Traffic noise from both north-and south-bound Main St. is predominant noise source. Bus and truck noise was particularly prominent.
ML-3	One-story, single-family residence is offset 27 feet from street with grass-covered lawn. Home is adjacent to 2-story apartment complex whose depth spans the length of the house.	Traffic noise from both Brookside Blvd. and 49th St. is the predominant source of noise.
ML-4	Rear of building fronts Brookside Blvd. Location for measurement approximately 150 feet north of 50th St; offset 70 feet from street and down a gradual grass-covered slope. Measurement height was approximately at road grade level. The crushed limestone Harry Wiggins Trolley Track Trail runs between the street and measurement location.	Traffic noise from both north- and south-bound Brookside Blvd. is predominant noise source.
ML-5	Parking lot on the north-east corner of Main St. and 38th St. is offset from Main St. 12 feet and elevated 3 feet above road grade with concrete retaining wall.	Traffic noise from both north- and south-bound Main St. is predominant noise source.

Location		Dominant Noise Source(s)
Code	Description	
ML-6	Measurement location was positioned near the memorial park walking path approximately, 100 feet to the west of Main St. and about 30 feet up the grass-covered embankment. Open green space.	Traffic noise from both north- and south-bound Main St. is predominant noise source. Sporadic aircraft also contributed to noise levels.
ML-7	Grass-covered lawn offset 15 feet from Main St. and 46th St. Location is in area where Main St. slopes up from south to north at angle estimated to be 4°.	Traffic from Main St. is predominant noise source with contributions from Cleaver II Blvd. (US-56).
ML-8	Open paved parking lot 25 feet from Main St. and 20 feet from 39th St. Measurement location was elevated 1 foot above road grade.	Traffic from both Main and 39th streets were predominant noise sources. Frequent bus transit flows on 39th St. with stops at Main St.
ML-9	Open green space between Main St. and the church; administrative wing offset from street only by 12 feet by sidewalk. Measurement location 15 feet from Main St. and 50 feet from 40th St. Location is in area where Main St. slopes up from south to north at angle estimated to be 3°.	Traffic from Main St. is the predominant noise source. Adjacent St. Paul's Episcopal Day School contributes school bus and car traffic noise during pick-up/drop-off periods. Idling traffic during pick-up is a daily occurrence when school is in session.
ML-10	150-foot parking lot runs parallel to Main St. it is bounded to the north by 1-story office building housing Cypher Sound Studios, to the west by a 1-story retail office space, and to the south by the 3-story "Silo" building. The lot is 50-feet deep from the sidewalk (62 feet from the street). Measurement location was offset 15 feet from Main St.	Traffic from Main St. is the predominant noise source.

Noise measurements were conducted using Larson Davis 824 and 831 real-time analyzers that conform to American National Standard Institute standards for Type 1 (precision) sound measurement equipment. Photographs of each measurement site are provided in Appendix A.

4.2 Vibration

This section discusses vibration-sensitive land uses in the Project Area.

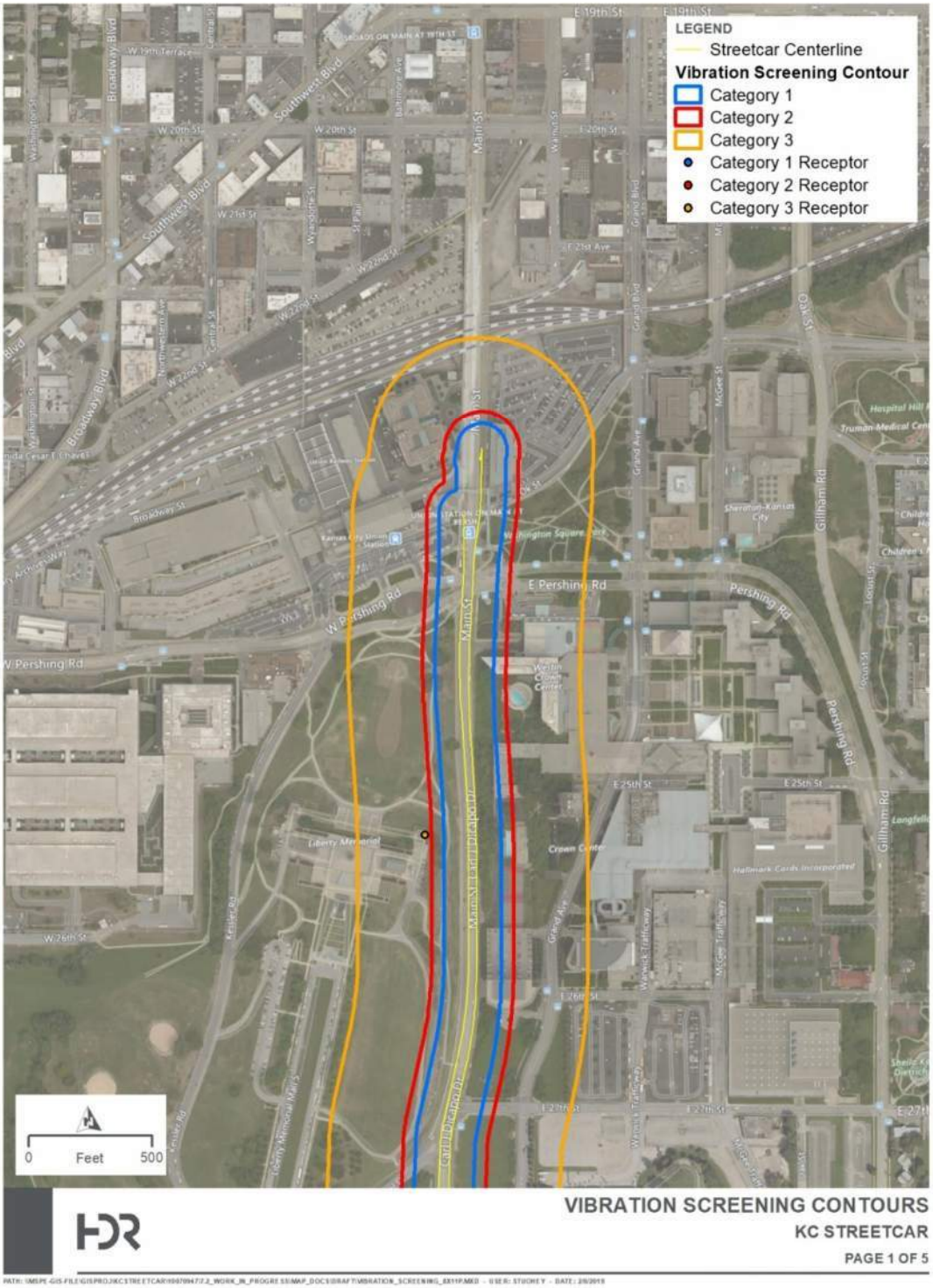
4.1.1 Vibration-Sensitive Land Use and Vibration Screening

The vibration screening distance for a streetcar project is 450 feet for Category 1 receptors, 150 feet for Category 2 receptors and 100 feet for Category 3 receptors. Vibration-sensitive land use in the study area includes:

- Union Hill Apartments 2975 Main Street;
- Fairfield Inn hotel 3001 Main Street;
- Studio 6 hotel 3517 Main Street;
- the former Hawthorne Plaza Apartments 3835 Main Street;
- the loft apartments on the second floor 4301 Main Street;
- the Marriott hotel 4445 Main Street;
- the Holiday Inn hotel One East 45th Street;

- Seville Plaza Apartments 4545 main Street;
- Ponce de Leon Condominiums 4555 Main Street, and;
- the residential building at 5000 Oak Street.

Other vibration-sensitive land uses within the screening distances include Cypher Sound Studios, St. Paul's Episcopal Church and day school, The Community Christian Church, a radio station (KKFA), Metropolitan Ensemble Theater, the Warwick Theater, Kansas City Young Audiences theater. Some of these land uses are considered "special buildings" that do not fit into one of the three land use categories used for vibration assessment by FTA.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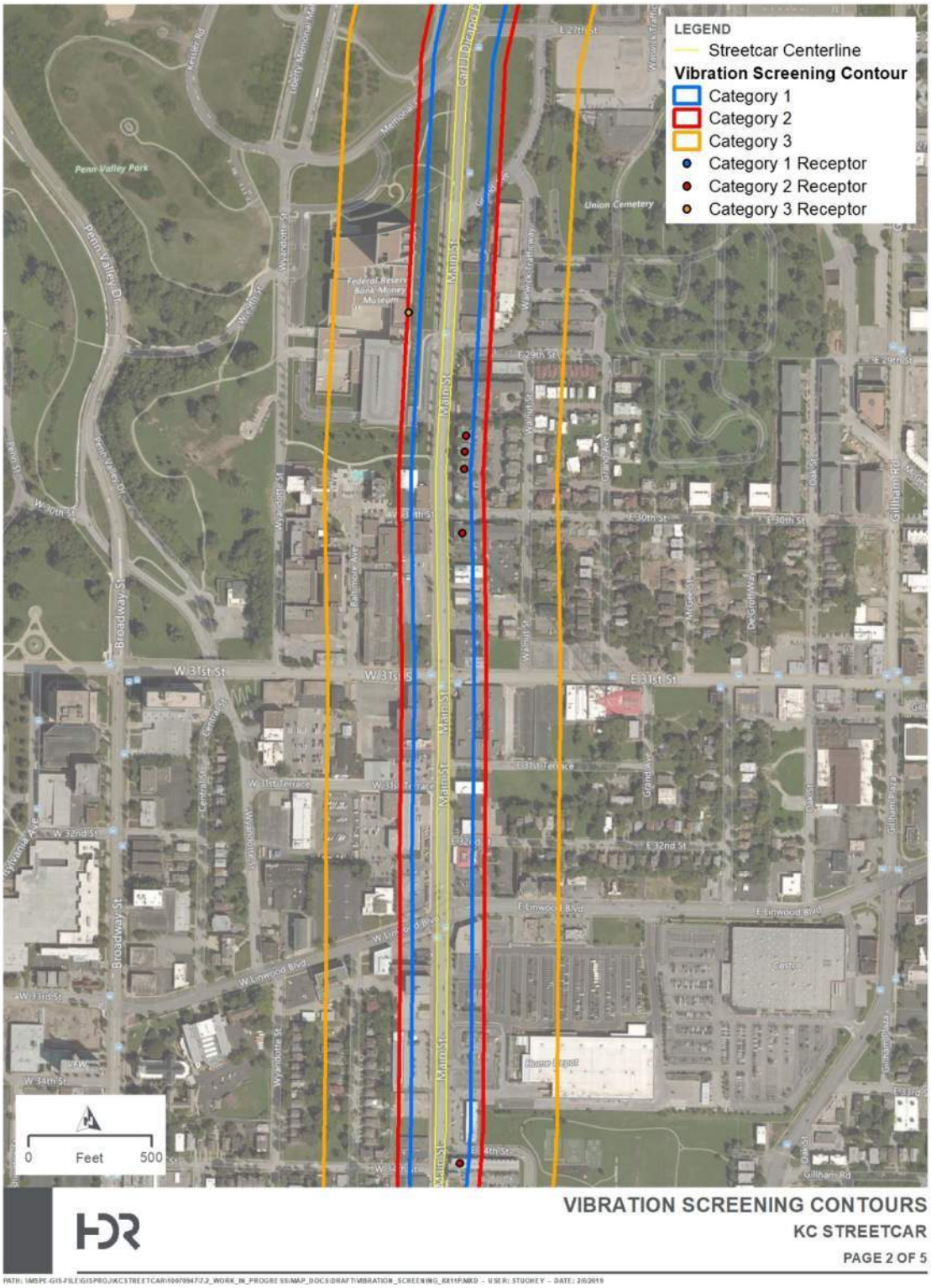
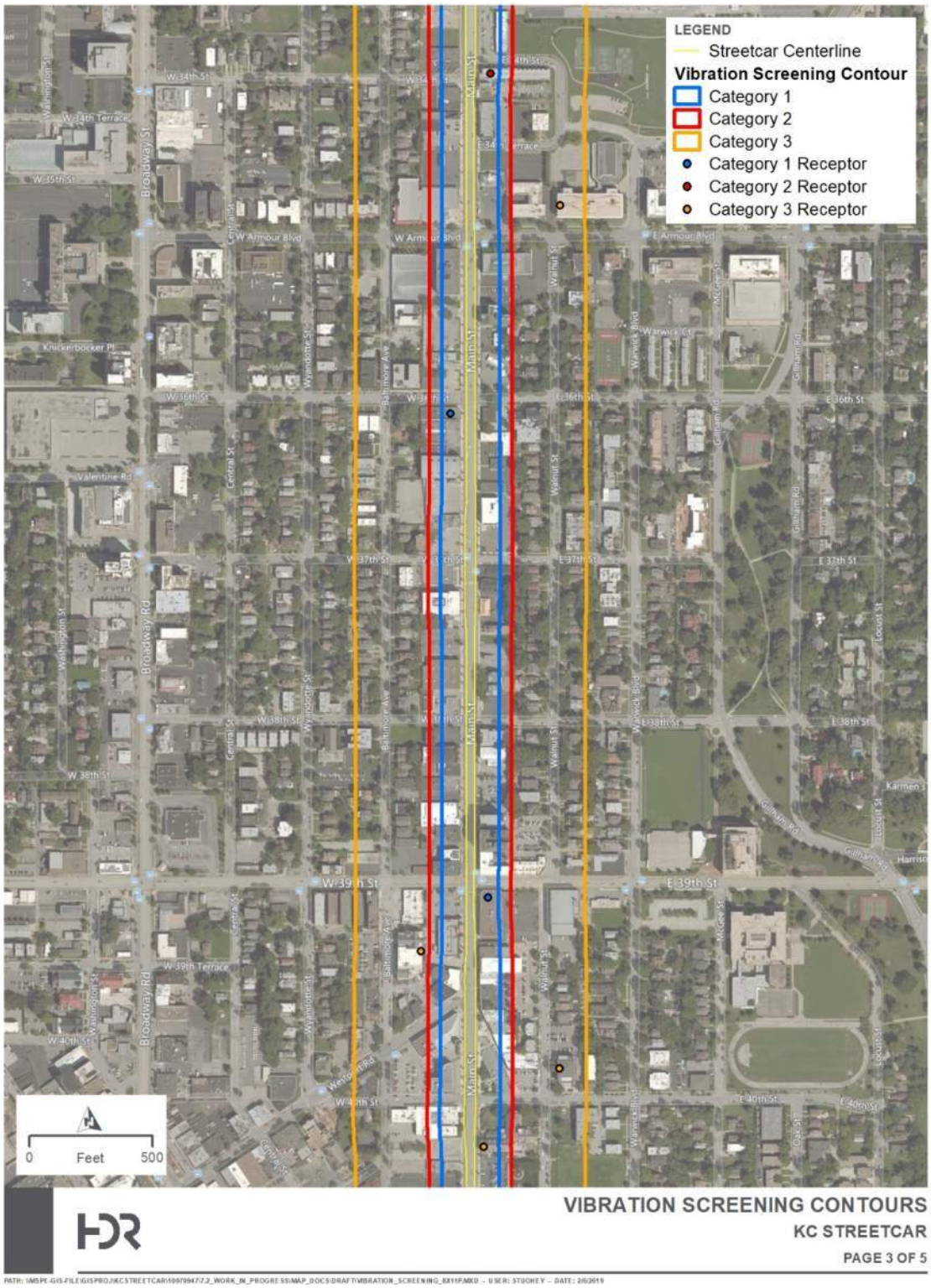
Streetcar Centerline
Vibration Screening Contour
Category 1
Category 2
Category 3
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
0
Feet
500
VIBRATION SCREENING CONTOURS
KC STREETCAR
PAGE 1 OF 5


LEGEND
Streetcar Centerline
Vibration Screening Contour
Category 1
Category 2
Category 3
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Penn Valley Park
Union Cemetery
Main St
Broadway St
W 31st St
E 31st St
W 30th St
E 30th St
W 32nd St
E 32nd St
W Linwood Blvd
E Linwood Blvd
W 34th St
0
Feet
500
VIBRATION SCREENING CONTOURS
KC STREETCAR
PAGE 2 OF 5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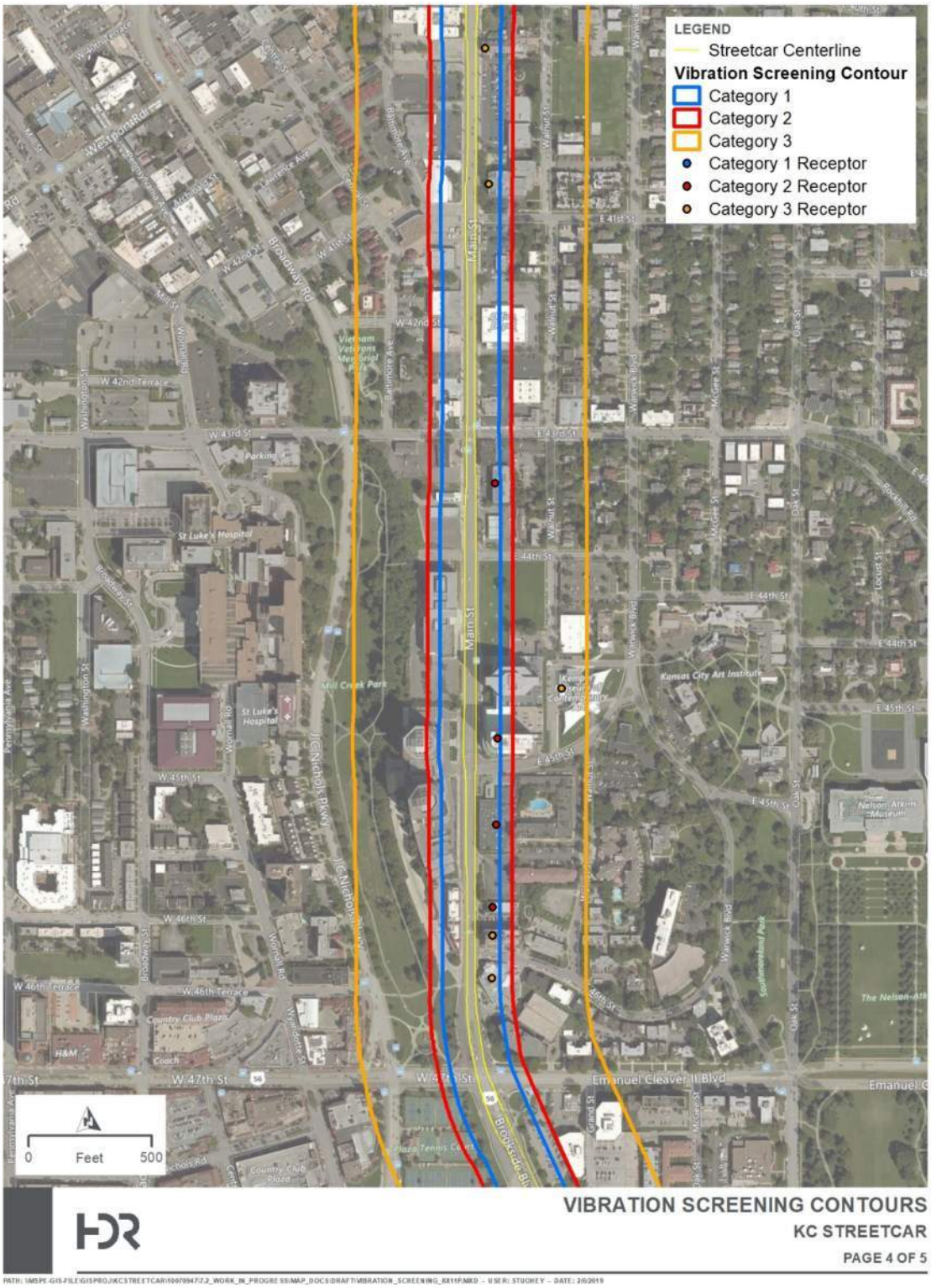
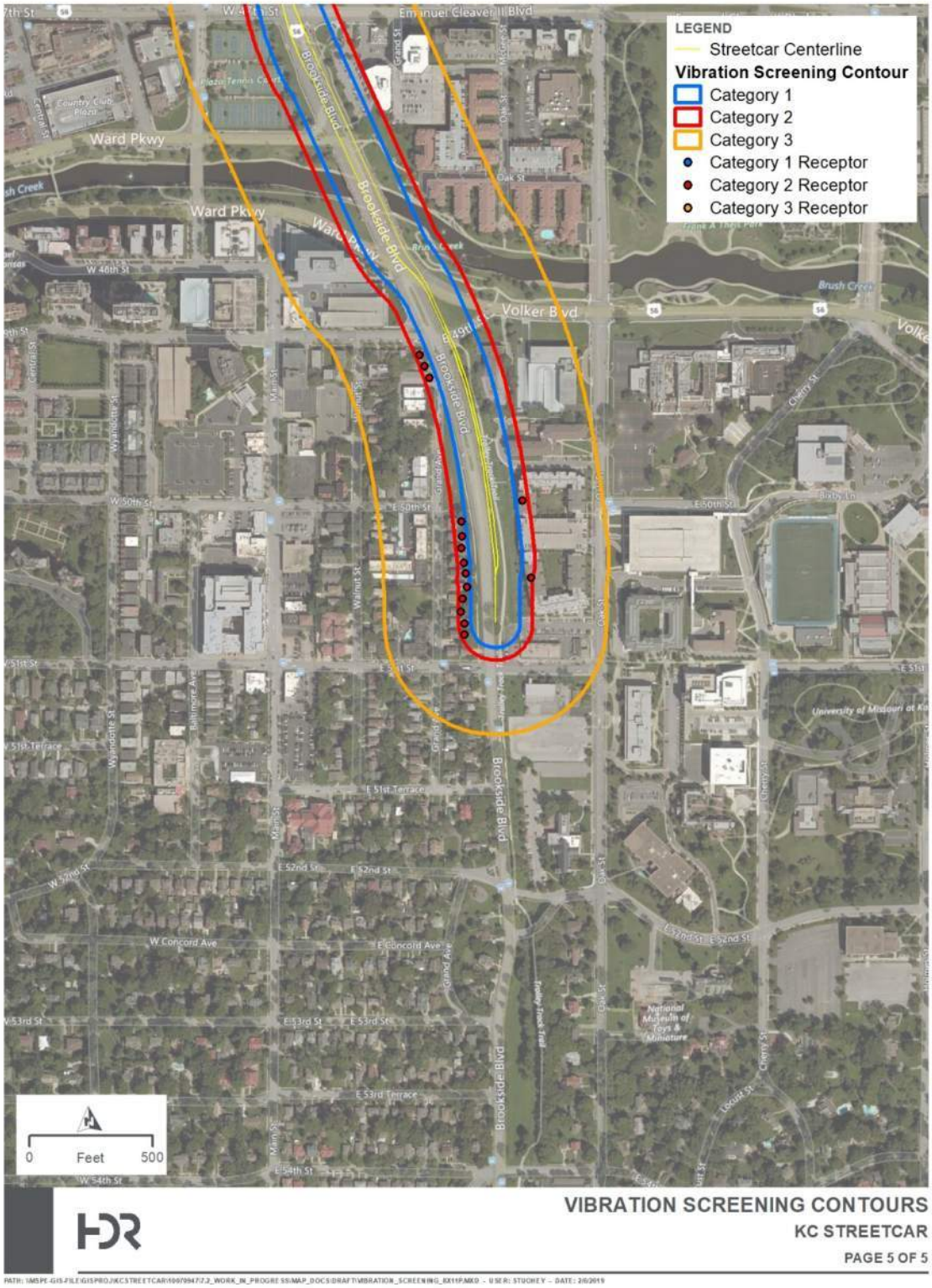
Streetcar Centerline
Vibration Screening Contour
Category 1
Category 2
Category 3
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
0
Feet
500
VIBRATION SCREENING CONTOURS
KC STREETCAR
PAGE 3 OF 5


LEGEND
Streetcar Centerline
Vibration Screening Contour
Category 1
Category 2
Category 3
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Main St
Broadway Rd
W 42nd St
W 43rd St
W 44th St
W 45th St
W 46th St
W 47th St
E 41st St
E 43rd St
E 44th St
E 45th St
Mill Creek Park
Kansas City Art Institute
Country Club Plaza
Emanuel Cleaver II Blvd
Brookside Blvd
0
Feet
500
VIBRATION SCREENING CONTOURS
KC STREETCAR
PAGE 4 OF 5


LEGEND
Streetcar Centerline
Vibration Screening Contour
Category 1
Category 2
Category 3
Category 1 Receptor
Category 2 Receptor
Category 3 Receptor
Ward Pkwy
Brookside Blvd
Volker Blvd
W 46th St
W 50th St
E 50th St
W 51st St
E 51st St
E 51st Terrace
W 52nd St
E 52nd St
W Concord Ave
E Concord Ave
W 53rd St
E 53rd St
E 53rd Terrace
W 54th St
0
Feet
500
VIBRATION SCREENING CONTOURS
KC STREETCAR
PAGE 5 OF 5

5 Environmental Consequences

5.1 Noise

5.1.1 Long-term Operating Effects

Using FTA methods, this analysis calculated the distance from the proposed streetcar centerline to the point at which noise impacts will no longer occur for each of the three land use categories. A noise impact contour was drawn around the proposed streetcar centerline, and the radius of that contour is the distance at which noise impacts no longer occur. Noise-sensitive land uses inside the noise impact contour are considered impacted. Analysis results indicate that the proposed project will cause a moderate noise impact, as defined by FTA, at the building located on the southeast corner of Main Street and East 34th in the western-most group of residential units on the side that faces East 34th Street. The units that face Main Street are commercial, and therefore not projected to experience a moderate noise impact. Figures in Appendix C shows noise impact contours.

As shown by the figures, the noise impact contours also encompass or cross other noise-sensitive parcels. Following is a discussion of those parcels and the potential for noise impact.

At Union Hill Apartments at 2975 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. These are modern apartment buildings with modern windows facing Main Street, and they are assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At Fairfield Inn hotel at 3001 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. This is a modern hotel, with a modern brick façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At Studio 6 hotel at 3517 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. This is a modern hotel, with a modern brick façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At the former Hawthorne Plaza Apartments at 3835 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. This building is being renovated for use as a modern apartment/mixed use building, with a recently restored brick façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At the loft apartments on the second floor at 4301 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. These loft apartments have recently been renovated including installation of modern windows, and they are assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At the Marriott hotel at 4445 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. This is a modern hotel, with a modern brick façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At the Holiday Inn hotel at One East 45th Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. This is a modern hotel, with a modern brick façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At Seville Plaza Apartments at 4545 Main Street, the area within the moderate noise impact contour includes the front porch and second floor outdoor balcony. Neither of these locations is considered noise-sensitive, and therefore noise impacts are not projected to occur at this location.

At Ponce de Leon Condominiums at 4555 Main Street, the areas within the moderate noise impact contour do not have any outdoor activity. Therefore the indoor criterion is applied. This is a modern hotel, with a modern brick façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

At the residential building at 5000 Oak Street, units in the northwest corner of the building are within the moderate noise impact contour but do not have any outdoor activity areas. Therefore the indoor criterion is applied. This is a modern apartment building, with a modern façade and modern windows, and it is assumed to meet the indoor noise criterion. Therefore noise impacts are not projected to occur at this location.

Analysis results indicate that noise impacts are not projected to occur at the category 1 land uses (Cypher Sound Studios, and KKFA radio station), nor at the category 3 land uses (St. Paul's Episcopal Church and day school, The Community Christian Church, Metropolitan Ensemble Theater, the Warwick Theater, Kansas City Young Audiences theater).

5.1.2 Short-term Construction Effects

Construction of the Project will likely result in a temporary increase in noise levels during the construction process. Pieces of equipment used to move soil and other earthen materials are often the loudest construction noise sources. Table 6 presents typical noise levels, by construction phase. This is based on the typical equipment used for different phases of railroad construction with typical noise levels, quantities, and estimated uses for each type of equipment. Table C-1 in Appendix C shows the typical equipment, uses, and sound levels for construction equipment by phase. The table also shows the SWL used to determine the SPL at different distances.

The noise level estimates presented in Table 6Table conservatively overestimate actual expected construction noise levels by assuming that all of the equipment (i.e., all of the dump trucks or all of the pickup trucks) will operate at the same location simultaneously. Typically, construction equipment is spread throughout the construction work zone. Given the linear nature of the Project and the

relatively confined width of the streetcar ROW, it is reasonable to assume that all pieces of equipment will not operate next to each other in the same (stationary) location for the entirety of 1 hour.

Using this conservative construction noise assessment approach, analysis results shown in Table 6 indicate the total combined noise for all construction equipment types, and construction phases will never exceed the 90 dBA threshold at 200 feet. The estimated noise levels presented in Table C-1 show that numerous single pieces of equipment may exceed the FTA recommendations if running constantly for 1 hour within 100 feet of a receptor. The installation of track has the potential to exceed 90 dBA at 100 feet, although this assumes all equipment required for this construction is running at the same time at one location. During the final design and construction phase, KCSA will require construction contractors to develop a construction noise management plan which includes identifying and complying with any applicable local noise ordinances; therefore, construction noise impacts will not be anticipated to occur.

Table 6: Estimated Noise Levels by Construction Phase

Construction Phase	SPL (dBA) at 100 feet	SPL (dBA) at 200 feet	SPL (dBA) at 500 feet	SPL (dBA) at 1,000 feet
Utility relocation	86	80	72	66
Earthwork	86	80	72	66
Bridge construction for overpasses	82	76	68	62
Retaining walls	76	70	62	56
Signals	75	69	61	55
Track installation	91	85	77	71
Demolish existing bridge	82	76	68	62
Track and subballast installation	85	79	71	65
Final cut-over and removal of turnouts	85	79	71	65

5.2 Vibration

5.2.1 Long-term Operating Effects

Analysis results indicate that the proposed Project will not cause vibration impacts at any Category 1, 2, or 3 land uses. The vibration assessment considered frequency of operations, proposed streetcar speed, and the adjustment for foundation coupling loss for 1-2 story masonry buildings.

Crossovers are proposed to be installed close to the Warwick Theater. The theater is a land use category that FTA calls special buildings. This category includes special-use facilities that are very sensitive to vibration and noise that are not included in the three land use categories and require special consideration. However, FTA guidance says that since the building will rarely be occupied when the source of the vibration (e.g., the train) is operating, there is no need to evaluate for impact. Therefore there is no vibration impact at this location.

5.2.2 Short-term Construction Effects

Construction-related ground-borne vibration very rarely damages buildings. Construction activities that typically generate the most severe vibrations with the potential for building damage including blasting and pile-driving. No blasting or pile-driving activities are expected to be included on this Project. Examples of other construction activities with a potential for vibration impact include concrete pavement breaking, vibratory compaction, and drilling or excavating in the ground near sensitive structures. During the final design and construction phase, KCSA will require construction contractors to develop a construction vibration management plan and include vibration performance specifications in the construction contract documents; therefore, construction-related ground-borne vibration impacts are not be anticipated to occur.

6 Mitigation Measures

The residential units projected to experience a moderate noise impact at the building on southeast corner of Main Street and East 34th Street already have modern doors and windows. The area of outdoor use is limited to the front porch, which is not considered noise-sensitive. The building itself will provide shielding to some noise from the proposed streetcars. There are no options for mitigation in the propagation path. Therefore this report does not recommend mitigation measures for this moderate noise impact. No other noise or vibration impacts are predicted to occur for the Project; therefore, no other mitigation measures are recommended or required.

7 Conclusions

Noise analysis results presented in this report indicate that the project has potential to cause a moderate noise impact at residential units in an apartment building at the southeast corner of Main Street and East 34th Street. Mitigation is not recommended at that location. The modeling results presented in this report indicate that noise or vibration impacts are not anticipated to occur at other locations in the study area with implementation of the Project; therefore, mitigation is not recommended or required.

8 References

FTA. 2018. *Transit Noise and Vibration Impact Assessment*.

Appendix A: Noise Monitoring Results

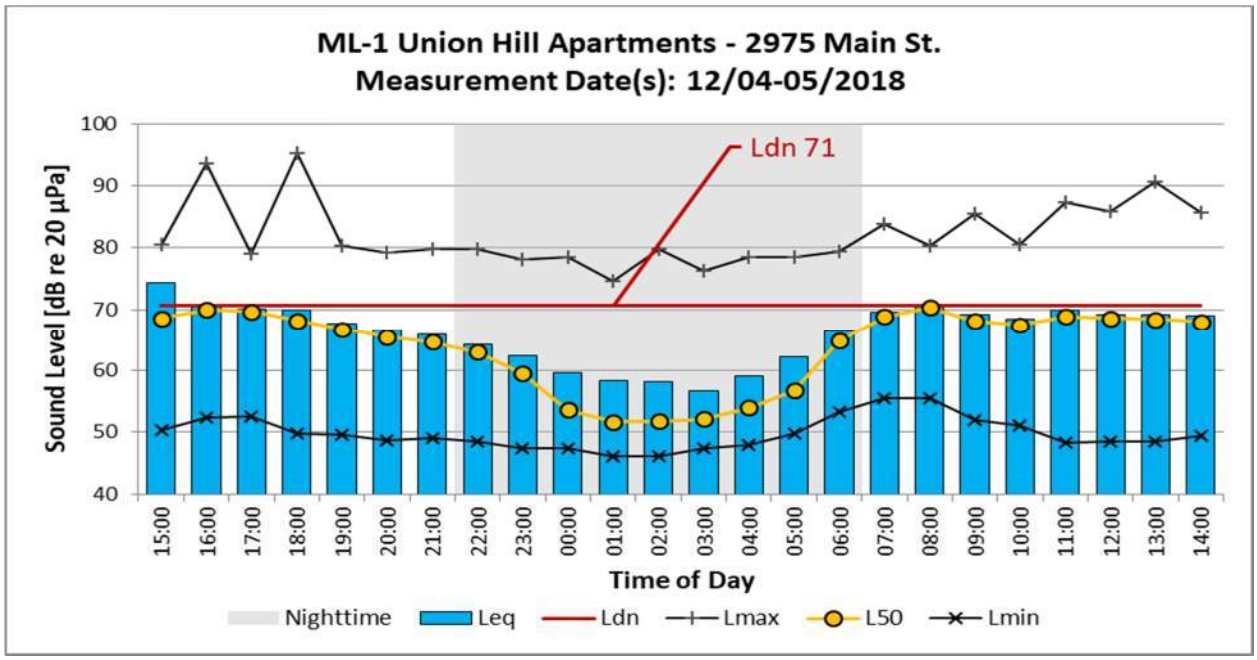


Figure 1 24-hr. noise measurement results for location ML-1 Union Hill Apartments, 2975 Main St., conducted 12/04-05/2018.

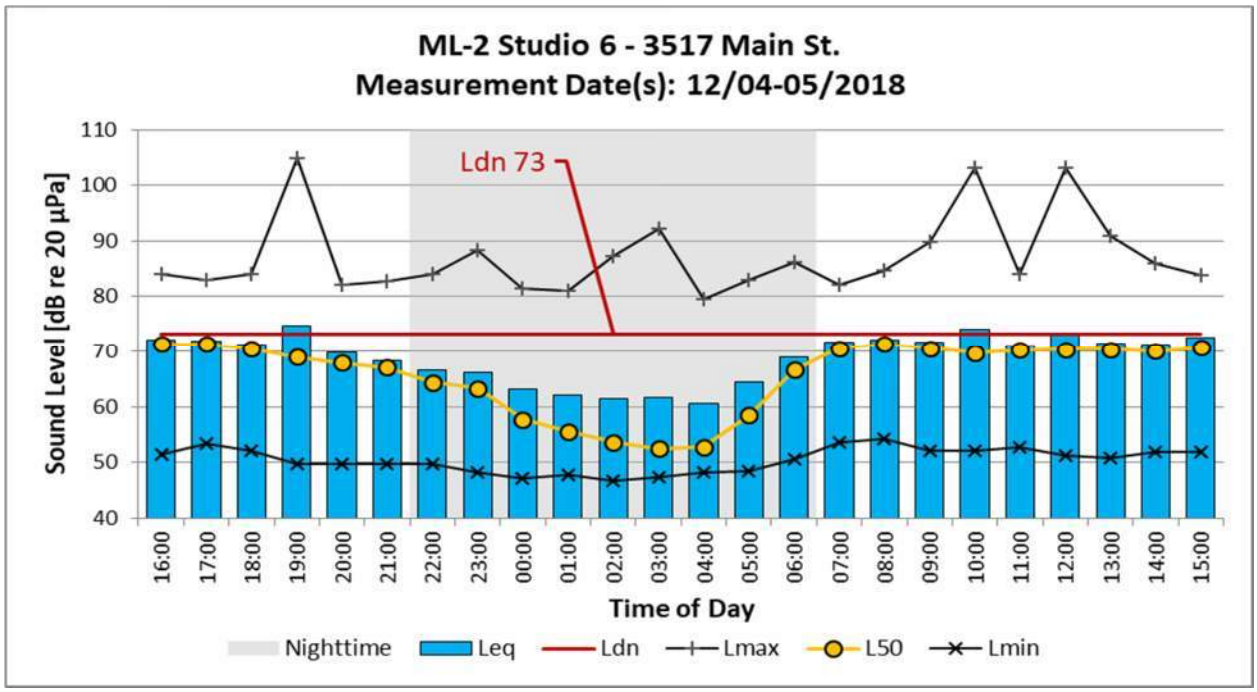


Figure 2 24-hr. noise measurement results for location ML-2 Studio 6, 2975 Main St., conducted 12/04-05/2018.

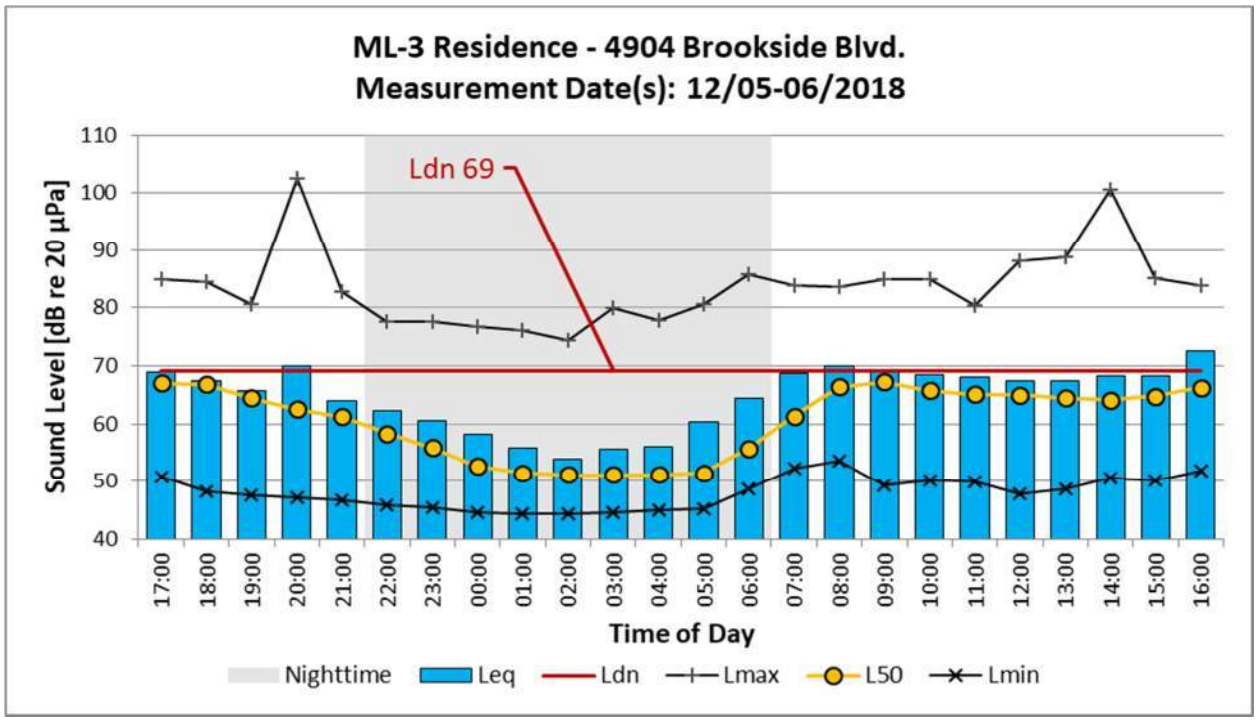


Figure 3 24-hr. noise measurement results for location ML-3 Residence, 4904 Brookside Blvd., conducted 12/05-06/2018.

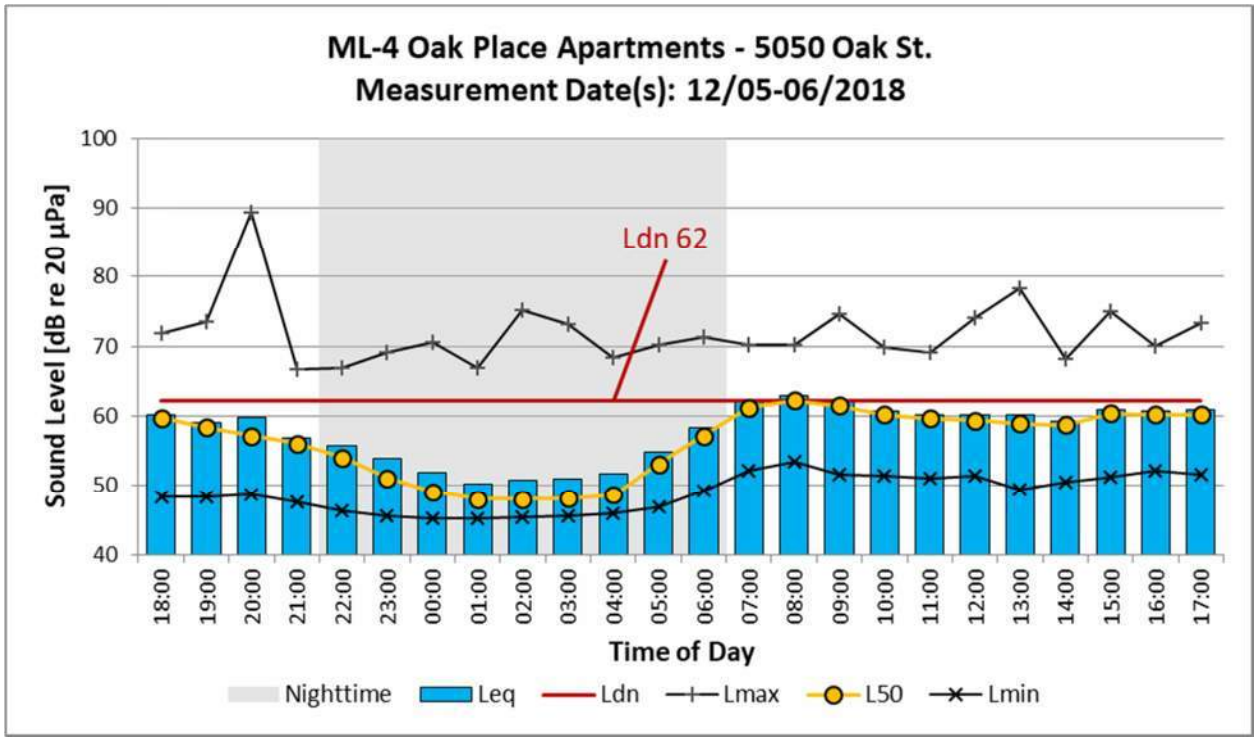


Figure 4 24-hr. noise measurement results for location ML-4 Oak Place Apartments, 5050 Oak St., conducted 12/05-06/2018.

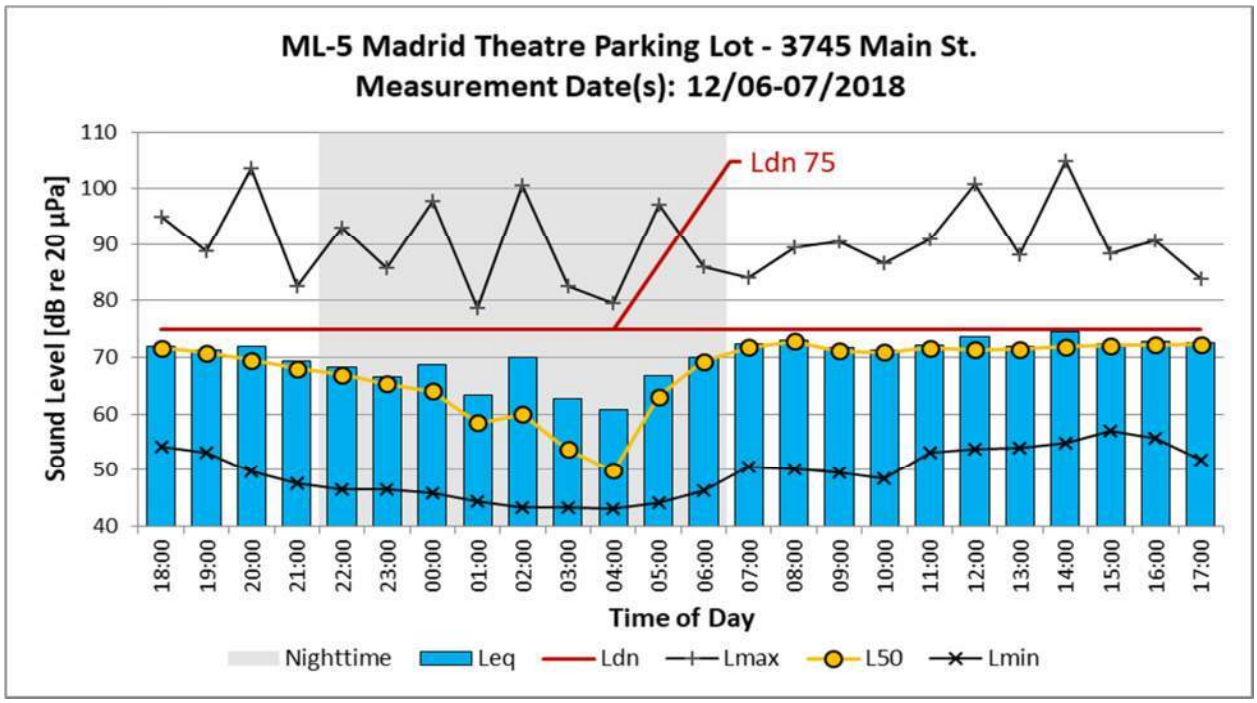


Figure 5 24-hr. noise measurement results for location ML-5 Madrid Theatre Parking Lot, 3745 Main St., conducted 12/06-07/2018.

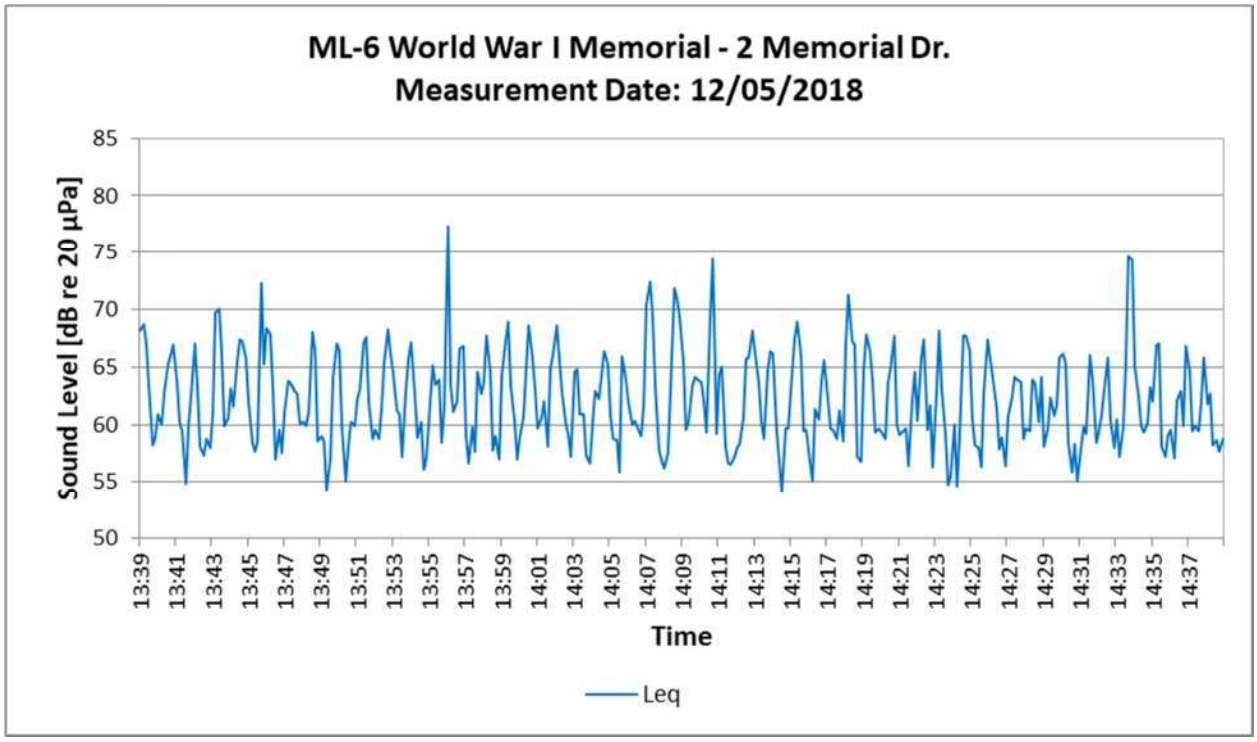


Figure 6 1-hr. noise measurement results for location ML-6 World War I Memorial, 2 Memorial Dr., conducted 12/05/2018.

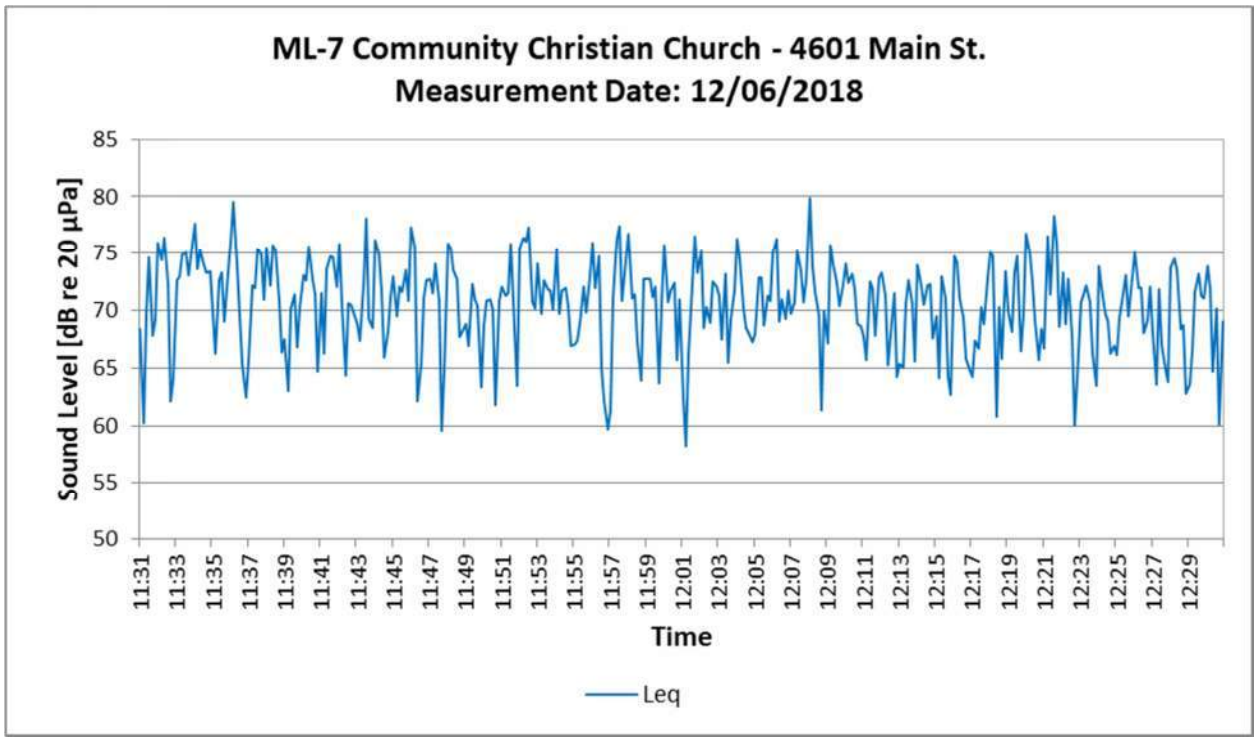


Figure 7 1-hr. noise measurement results for location ML-7 Community Christian Church, 4601 Main St., conducted 12/06/2018.

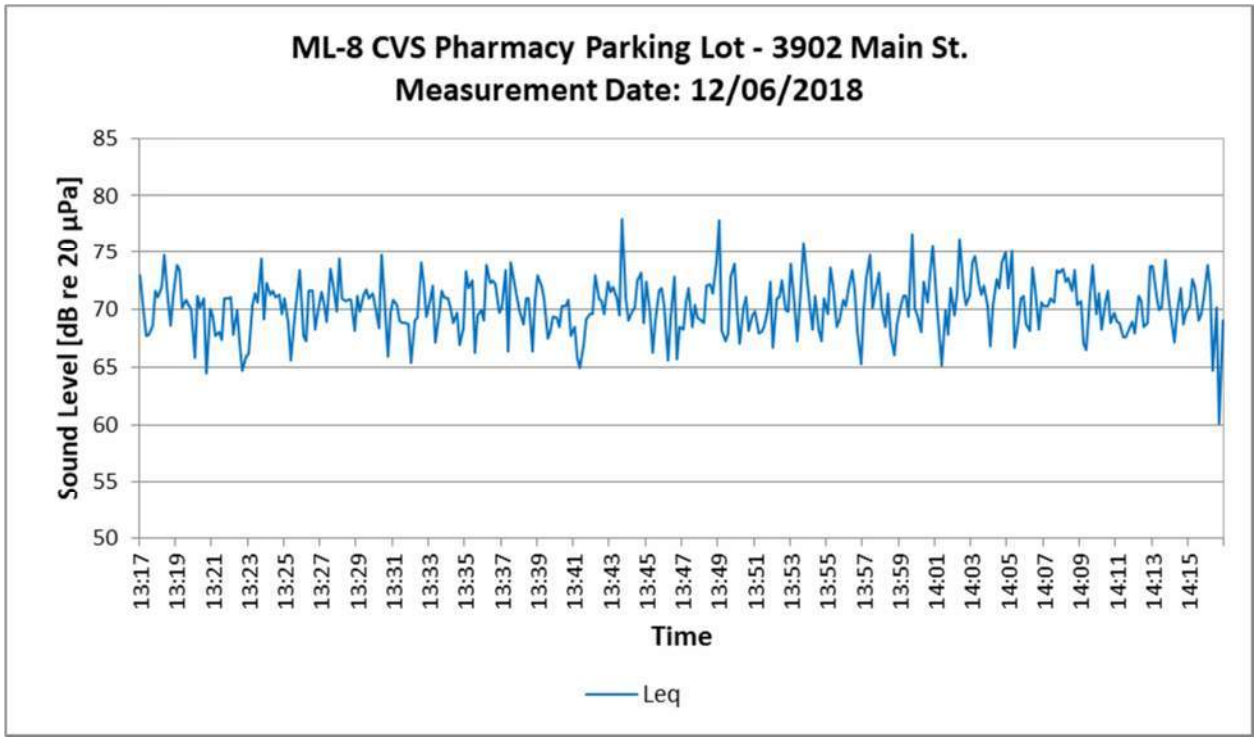


Figure 8 1-hr. noise measurement results for location ML-8 CVS Pharmacy, 3902 Main St., conducted 12/06/2018. CVS is across Main St. from KKFI 90.1FM.

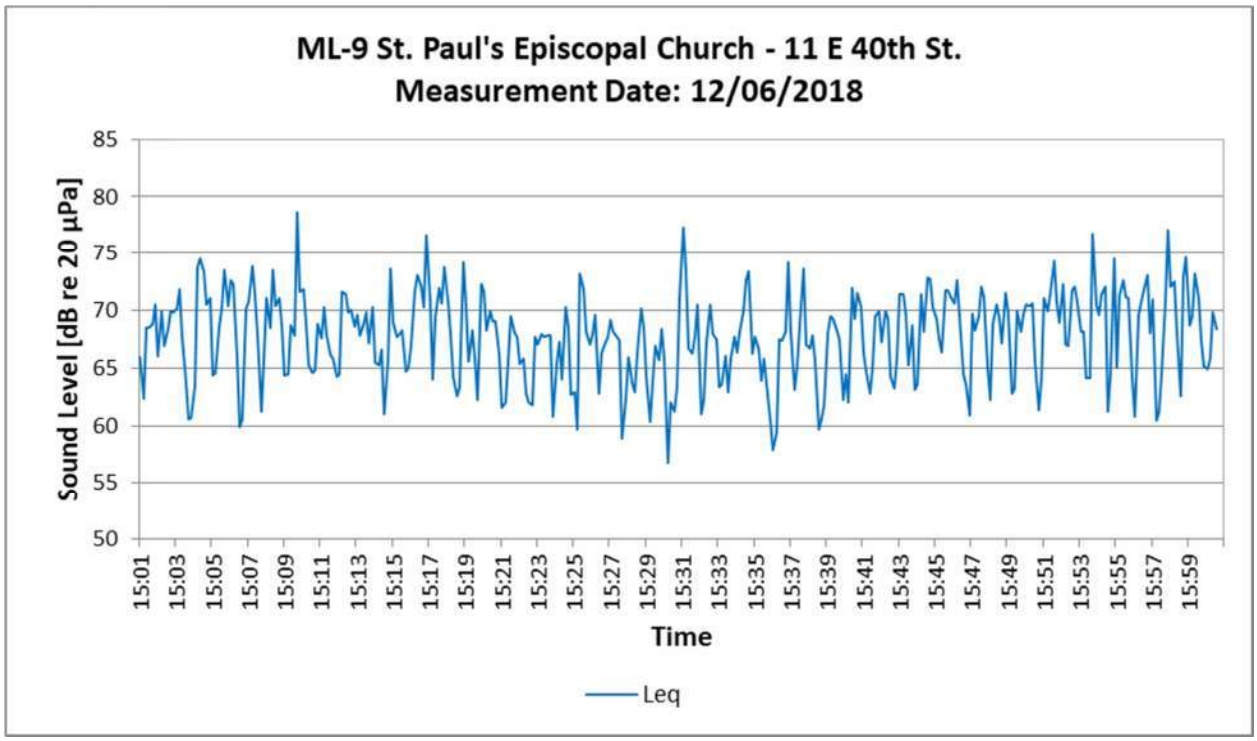


Figure 9 1-hr. noise measurement results for location ML-9 St. Paul's Episcopal Church, 11 E 40th St., conducted 12/06/2018.

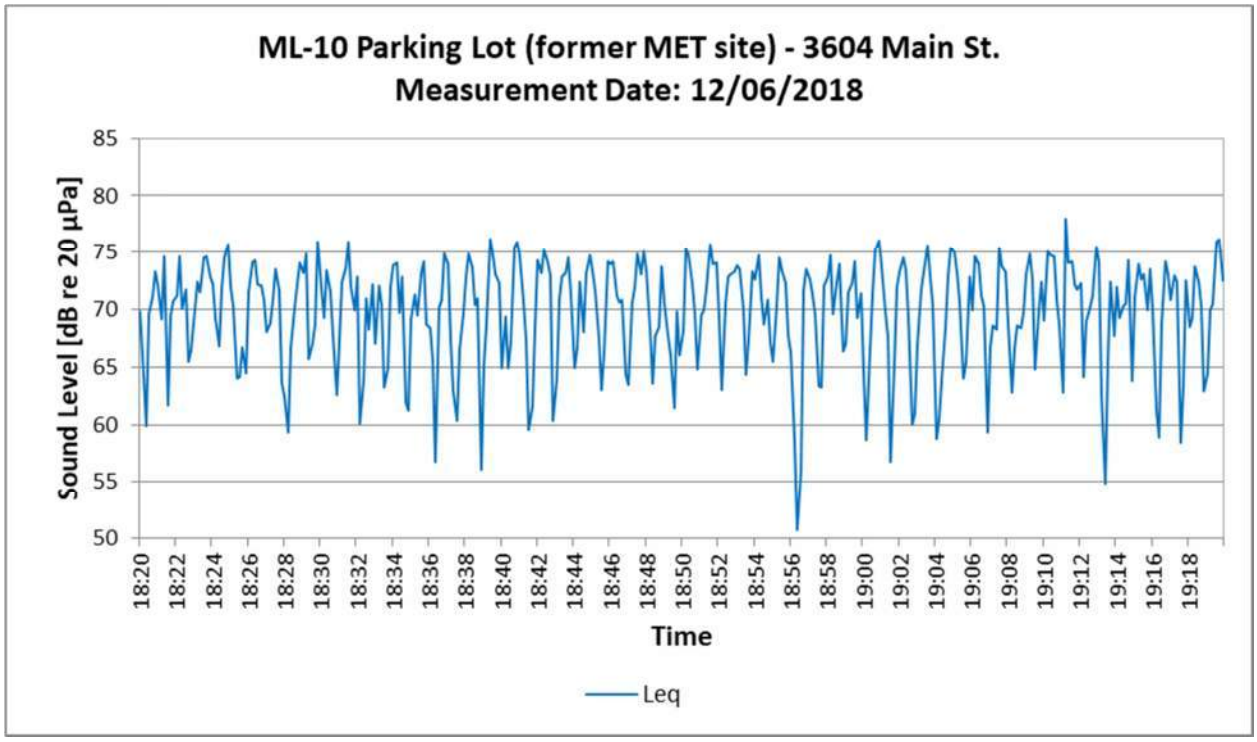


Figure 10 1-hr. noise measurement results for location ML-10 Parking Lot (prior MET location), 3604 Main St., conducted 12/06/2018. This location is in close proximity to Cypher Sound Studios, 3600 Main St.

Appendix B: Noise Monitoring Locations

Figure B-1 Microphone placement for 24-hr. noise measurement at Union Hill Apartments (left) looking SE (right) looking ENE

Figure B-2 Microphone placement for 24-hr. noise measurement at Studio 6 Hotel (left) looking SE (right) looking SW

Figure B-3 Microphone placement for 24-hr. noise measurement at residence 4904 Brookside Blvd. (left) looking E (right) looking S

Figure B-4 Microphone placement for 24-hr. noise measurement at Oak Place Apartments (left) looking E (right) looking S

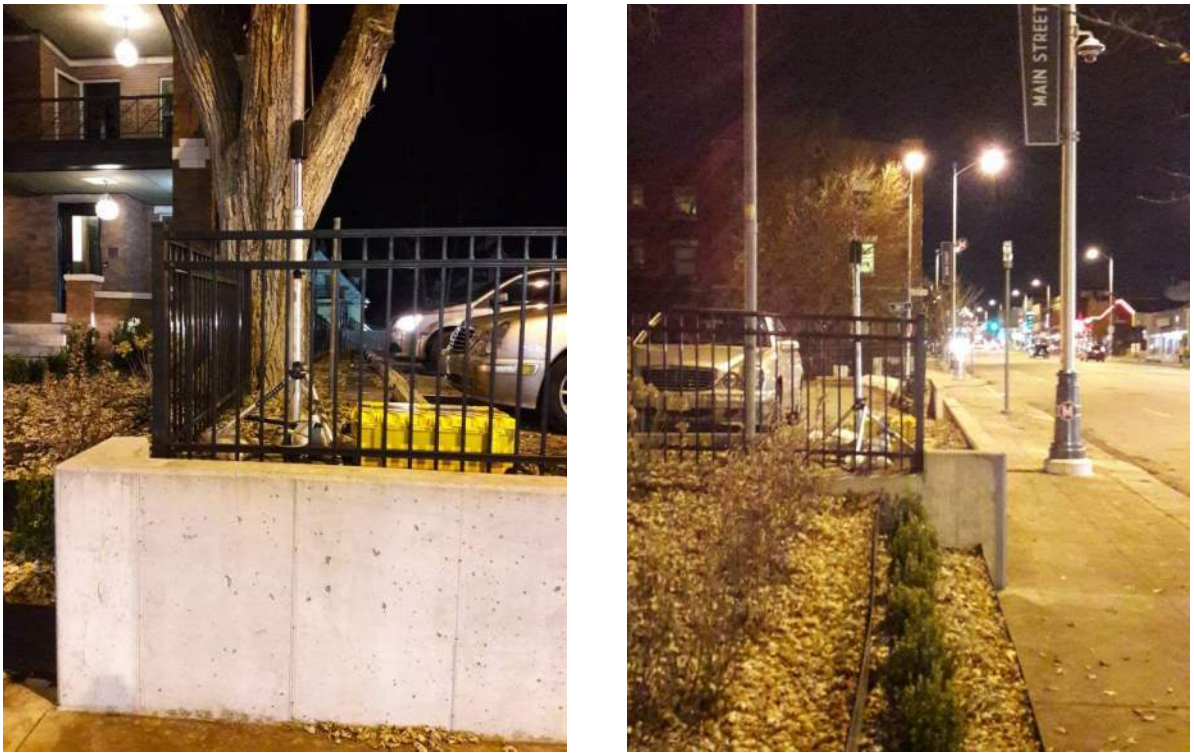


Figure B-5 Microphone placement for 24-hr. noise measurement at the Madrid Theatre Parking Lot (left) looking E (right) looking S

Figure B-6 Microphone placement for 1-hr. noise measurement at the World War I Memorial (left) looking NE (right) looking E

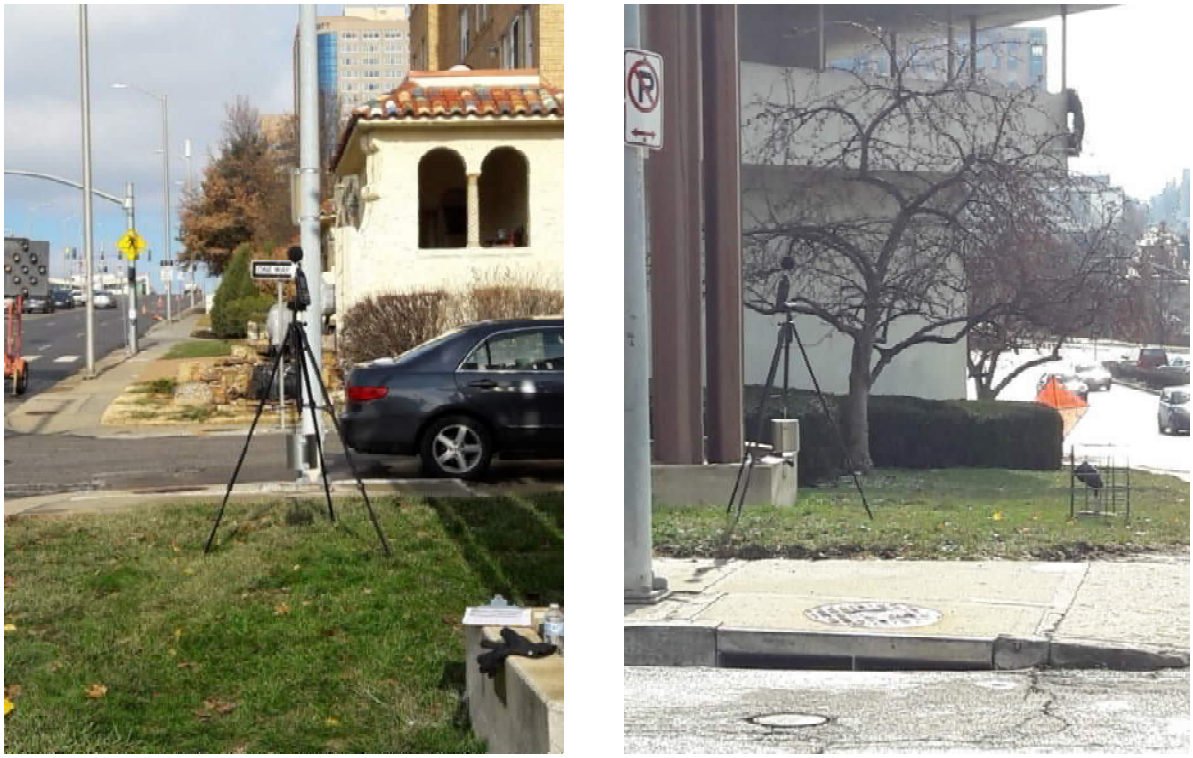


Figure B-7 Microphone placement for 1-hr. noise measurement at the Community Christian Church (left) looking N (right) looking S

Figure B-8 Microphone placement for 1-hr. noise measurement at the CVS Pharmacy Parking Lot (left) looking E (right) looking N

Figure B-9 Microphone placement for 1-hr. noise measurement at the St. Paul's Episcopal Church (left) looking N (right) looking S

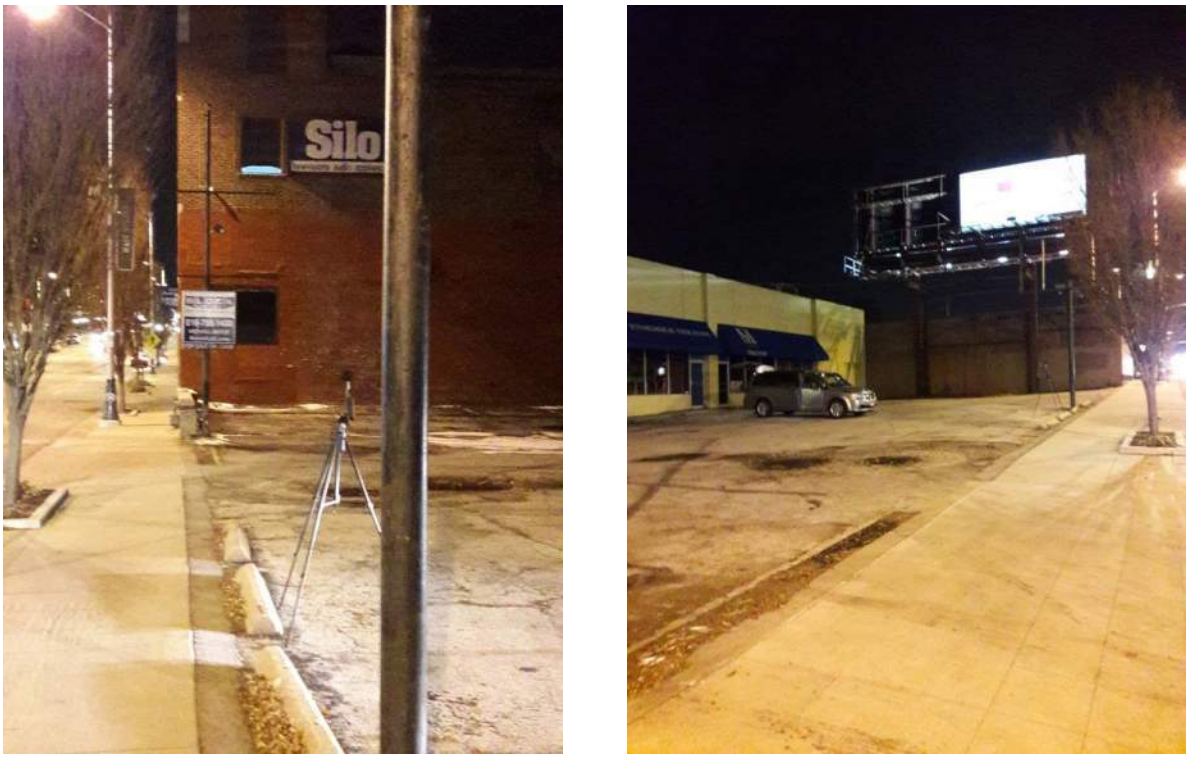


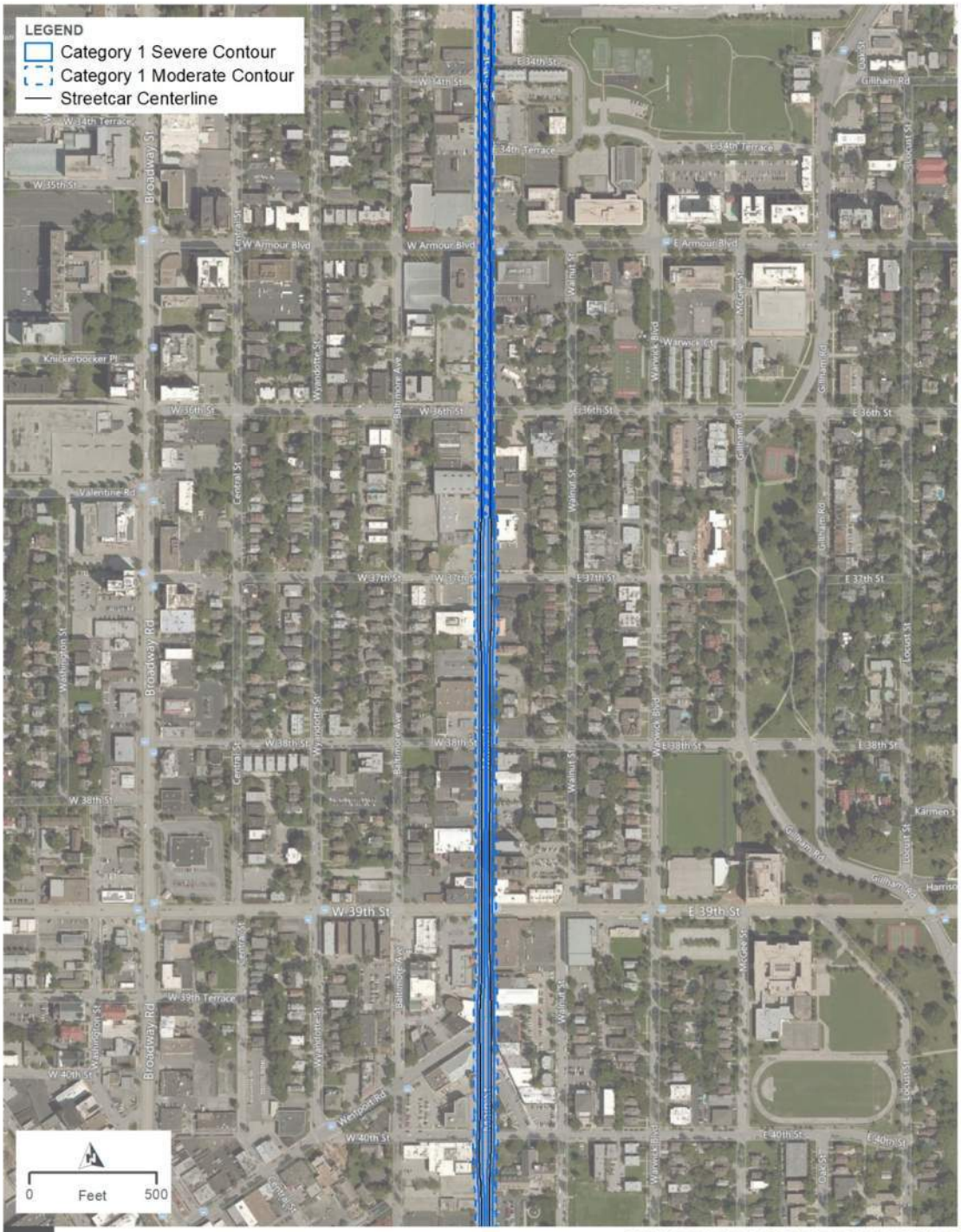
Figure B10 Microphone placement for 1-hr. noise measurement at the parking lot of the former MET site at 3604 Main St. (left) looking S (right) looking NNW

Appendix C: Noise and Vibration Contours

CATEGORY 1 NOISE CONTOURS
KC STREETCAR
PAGE 1 OF 5

PATH: \\MSPE-GIS-FILE\GIS\PROJ\KCSTREETCAR\100709472\2_WORK_IN_PROGRESS\MAP_DOCS\DRAFTC1_NOISE_8X11P.MXD - USER: STUOHEY - DATE: 2/5/2019


LEGEND
Category 1 Severe Contour
Category 1 Moderate Contour
Streetcar Centerline
Penn Valley Park
Union Cemetery
Federal Reserve Bank Money Museum
Broadway St
Grand Ave
Gillham Rd
W 31st St
E 31st St
W 30th St
E 30th St
W 32nd St
E 32nd St
W Linwood Blvd
E Linwood Blvd
W 34th St
E 34th St
0
Feet
500
CATEGORY 1 NOISE CONTOURS
KC STREETCAR
PAGE 2 OF 5


LEGEND
Category 1 Severe Contour
Category 1 Moderate Contour
Streetcar Centerline
0
Feet
500
CATEGORY 1 NOISE CONTOURS
KC STREETCAR
PAGE 3 OF 5


LEGEND
Category 1 Severe Contour
Category 1 Moderate Contour
Streetcar Centerline
0
Feet
500
W 47th St
Emanuel Cleaver II Blvd
CATEGORY 1 NOISE CONTOURS
KC STREETCAR
PAGE 4 OF 5

CATEGORY 1 NOISE CONTOURS
KC STREETCAR
PAGE 5 OF 5

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LEGEND
Category 2 Moderate Impact
Category 2 Severe Contour
Category 2 Moderate
Streetcar Centerline
0
Feet
500
CATEGORY 2 NOISE CONTOURS
KC STREETCAR
PAGE 1 OF 5

CATEGORY 2 NOISE CONTOURS
KC STREETCAR
PAGE 2 OF 5

PATH: \\MSPE-GIS-FILE\GIS\PROJ\KCSTREETCAR\100709472\2_WORK_IN_PROGRESS\MAP_DOCS\DRAFTIC2_NOISE_8X11P.MXD - USER: STUDHEY - DATE: 2/4/2019


LEGEND
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Category 2 Severe Contour
Category 2 Moderate
Streetcar Centerline
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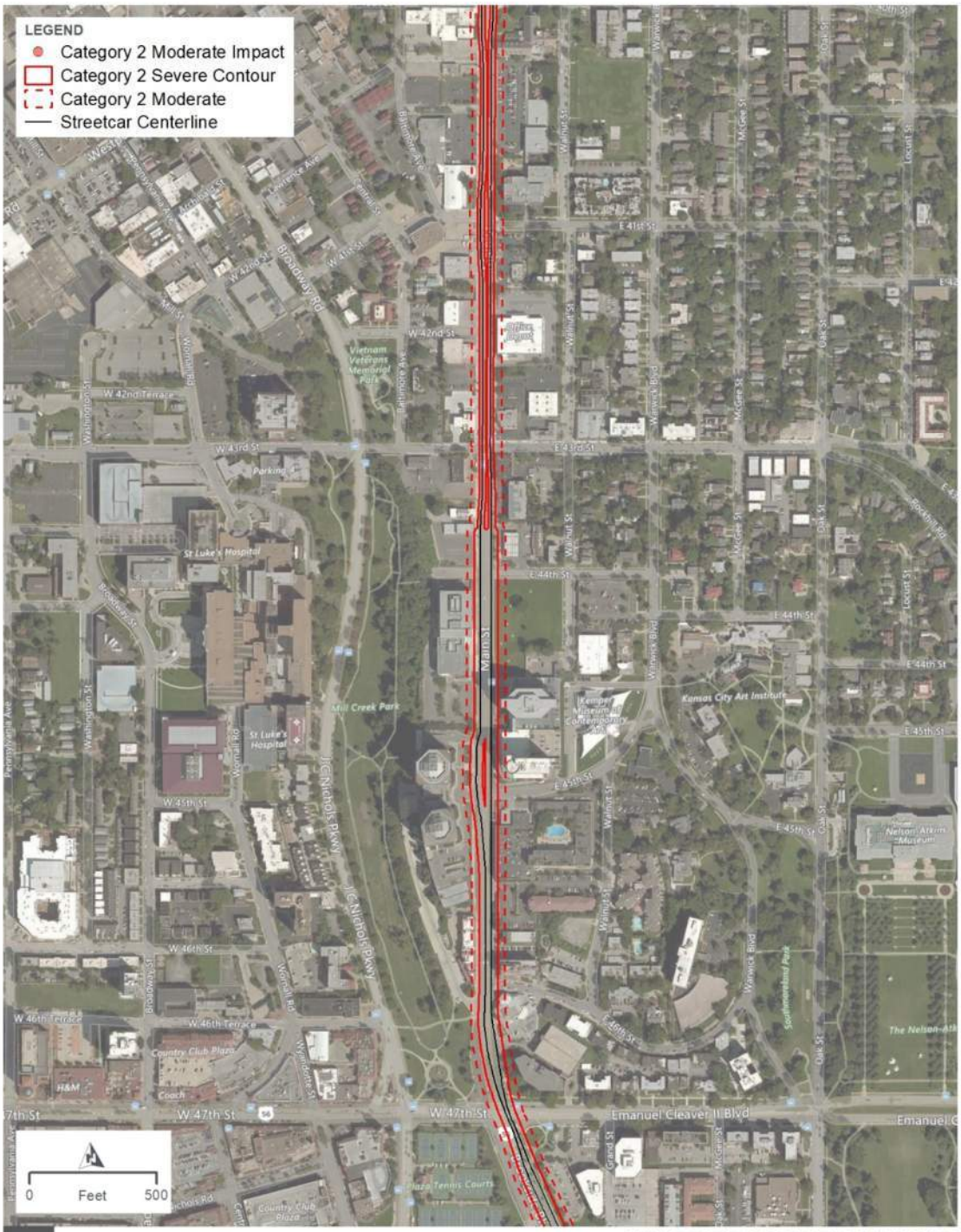
Feet
500
CATEGORY 2 NOISE CONTOURS
KC STREETCAR
PAGE 3 OF 5

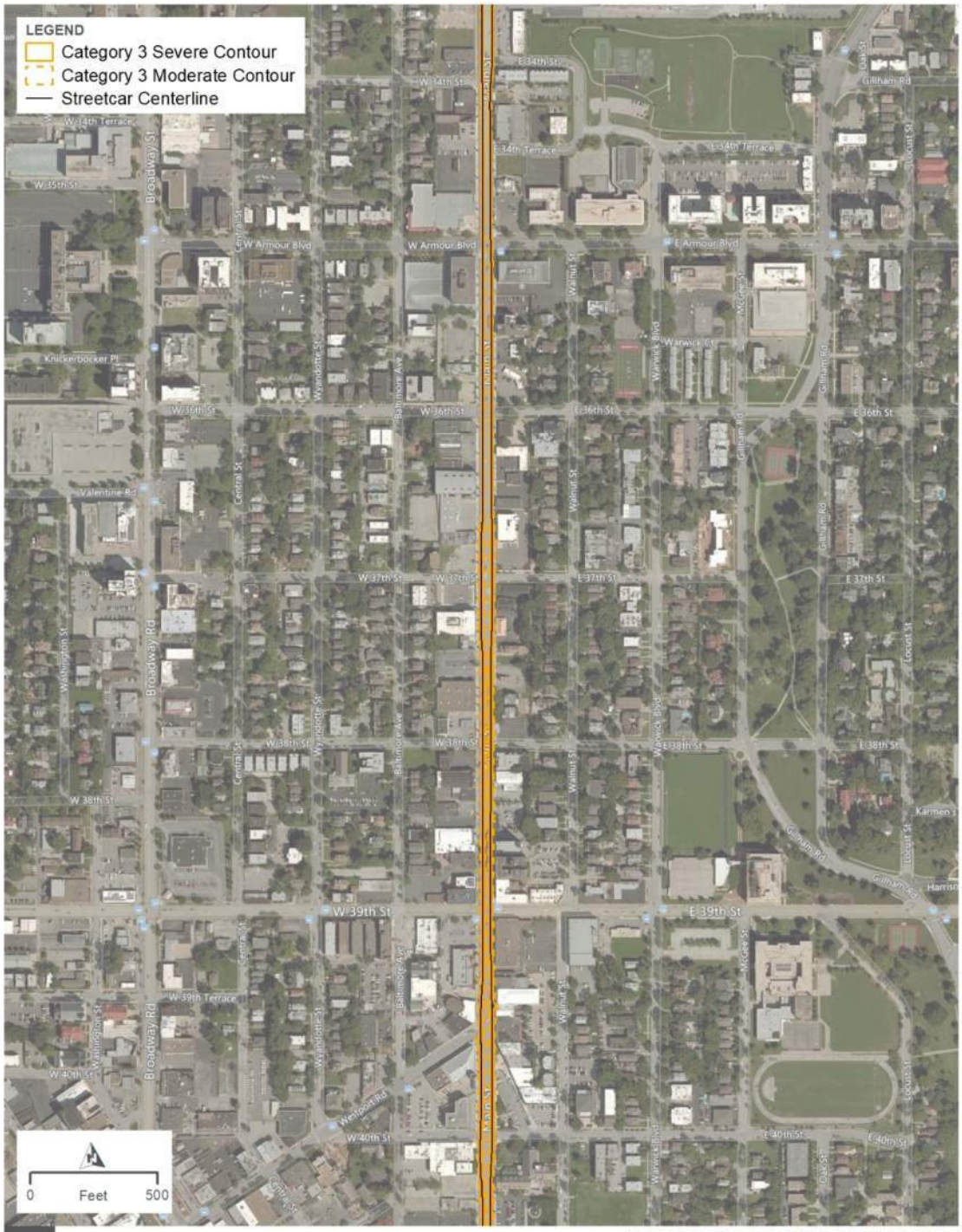


CATEGORY 2 NOISE CONTOURS
KC STREETCAR
PAGE 4 OF 5


LEGEND
Category 2 Moderate Impact
Category 2 Severe Contour
Category 2 Moderate
Streetcar Centerline
Ward Pkwy
Volker Blvd
Emanuel Cleaver II Blvd
Brookside Blvd
Main St
Oak St
Cherry St
Grand Ave
W 47th St
W 46th St
W 50th St
E 50th St
E 51st St
E 51st Terrace
E 52nd St
E 53rd St
E 53rd Terrace
W 54th St
W Concord Ave
E Concord Ave
E 47th Terrace
Pierce St
Rockhill Rd
Brush Creek
Frank A Theis Park
Bixby Ln
National Museum of Toys & Miniature
0
Feet
500
CATEGORY 2 NOISE CONTOURS
KC STREETCAR
PAGE 5 OF 5

CATEGORY 3 NOISE CONTOURS
KC STREETCAR
PAGE 1 OF 5


LEGEND
Category 3 Severe Contour
Category 3 Moderate Contour
Streetcar Centerline
Penn Valley Park
Union Cemetery
Federal Reserve Bank Money Museum
W 31st St
E 31st St
E Linwood Blvd
W Linwood Blvd
Broadway St
Main St
Home Depot
0
Feet
500
CATEGORY 3 NOISE CONTOURS
KC STREETCAR
PAGE 2 OF 5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Category 3 Severe Contour
Category 3 Moderate Contour
Streetcar Centerline
0
Feet
500
CATEGORY 3 NOISE CONTOURS
KC STREETCAR
PAGE 3 OF 5


LEGEND
Category 3 Severe Contour
Category 3 Moderate Contour
Streetcar Centerline
0
Feet
500
CATEGORY 3 NOISE CONTOURS
KC STREETCAR
PAGE 4 OF 5

CATEGORY 3 NOISE CONTOURS
KC STREETCAR
PAGE 5 OF 5

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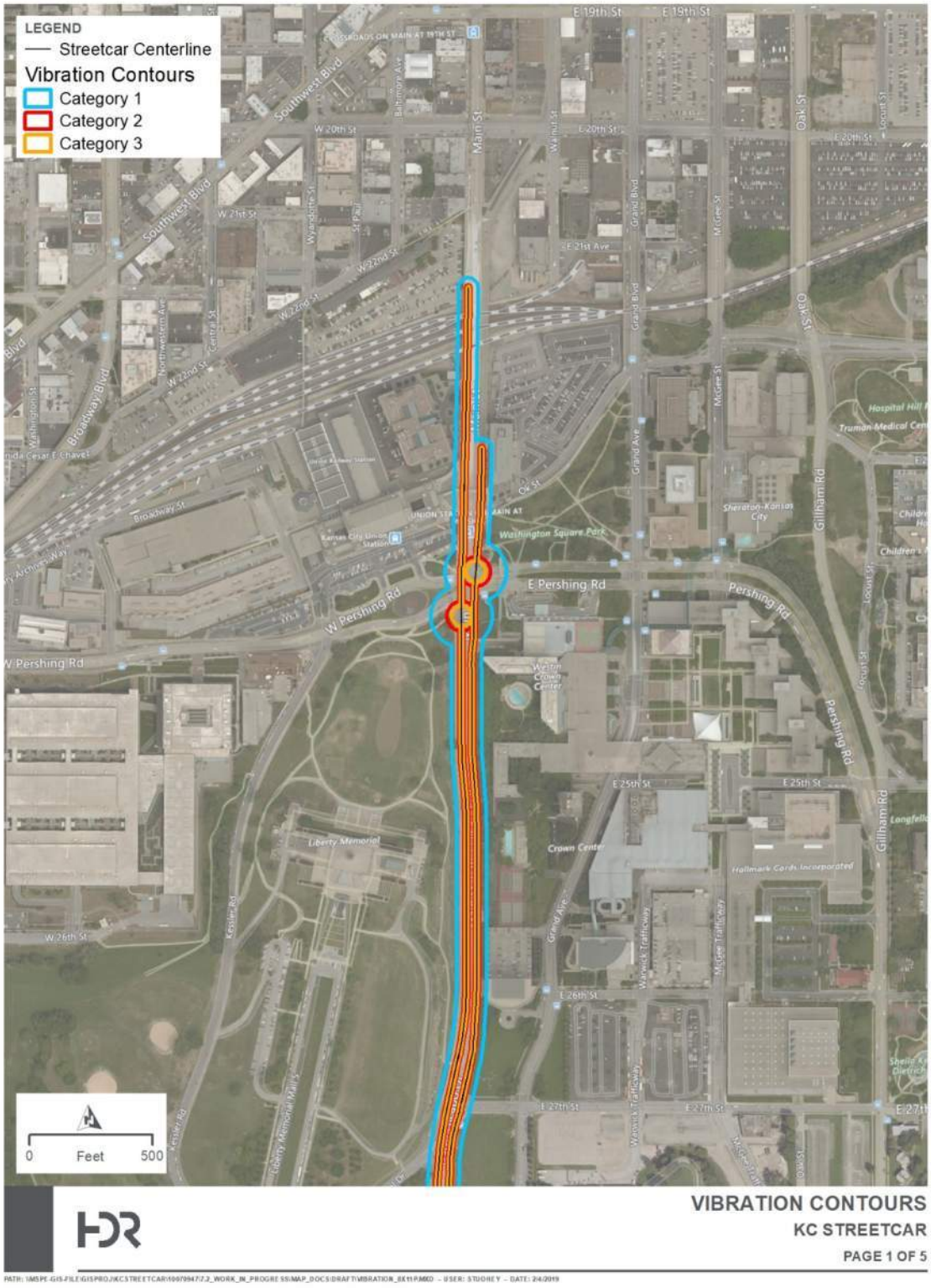
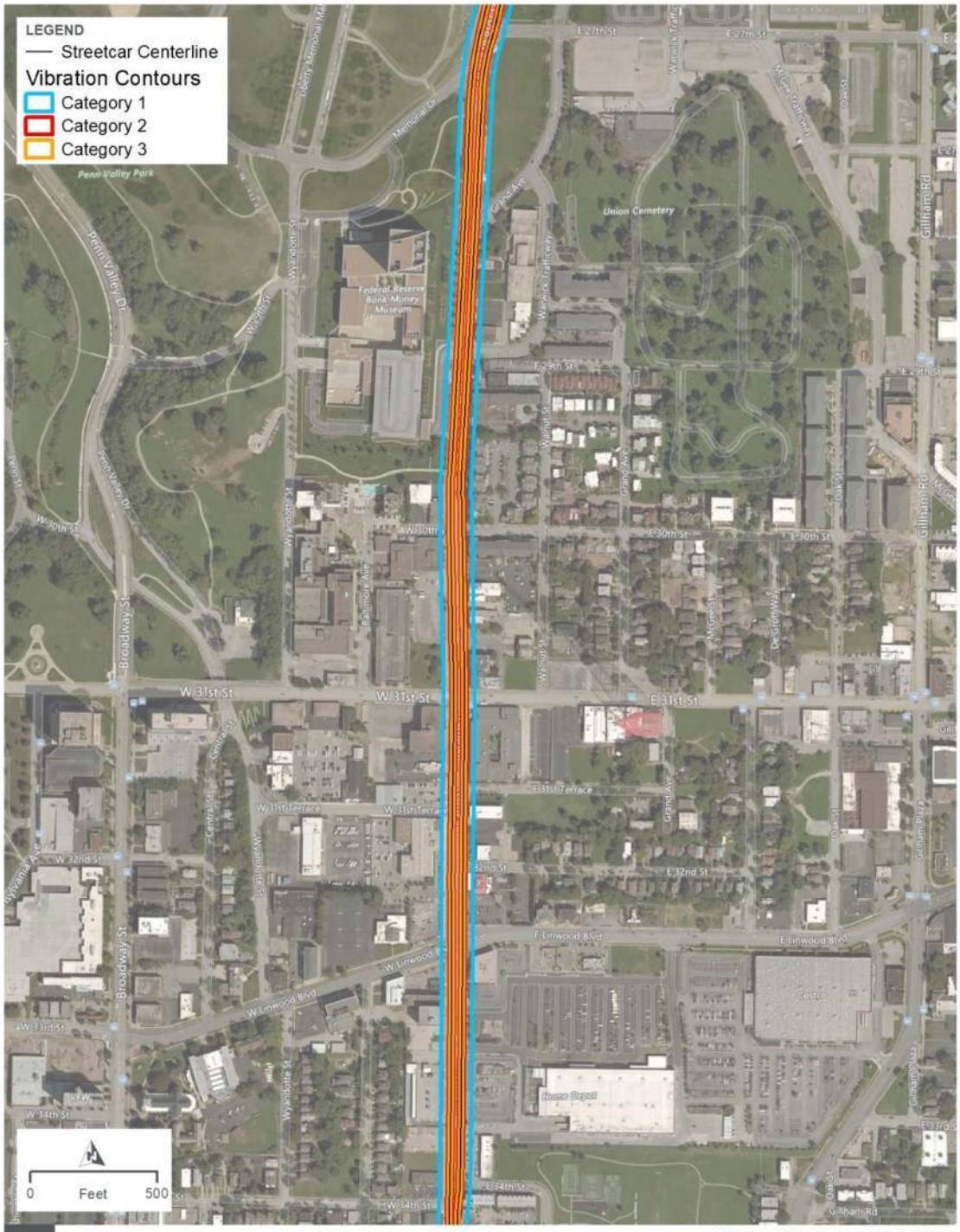

LEGEND
Streetcar Centerline
Vibration Contours
Category 1
Category 2
Category 3
0
Feet
500
VIBRATION CONTOURS
KC STREETCAR
PAGE 1 OF 5



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KC STREETCAR
PAGE 2 OF 5

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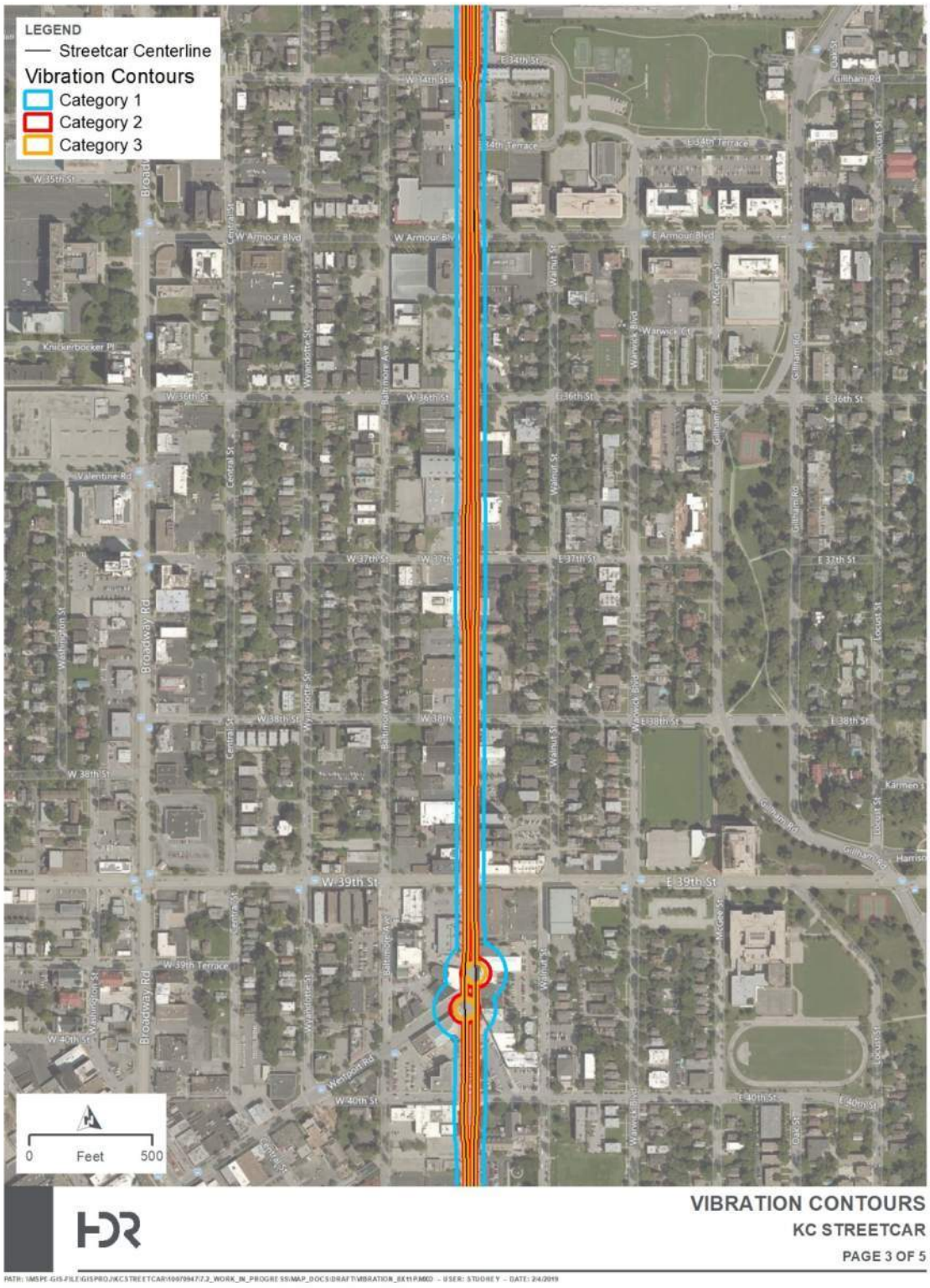
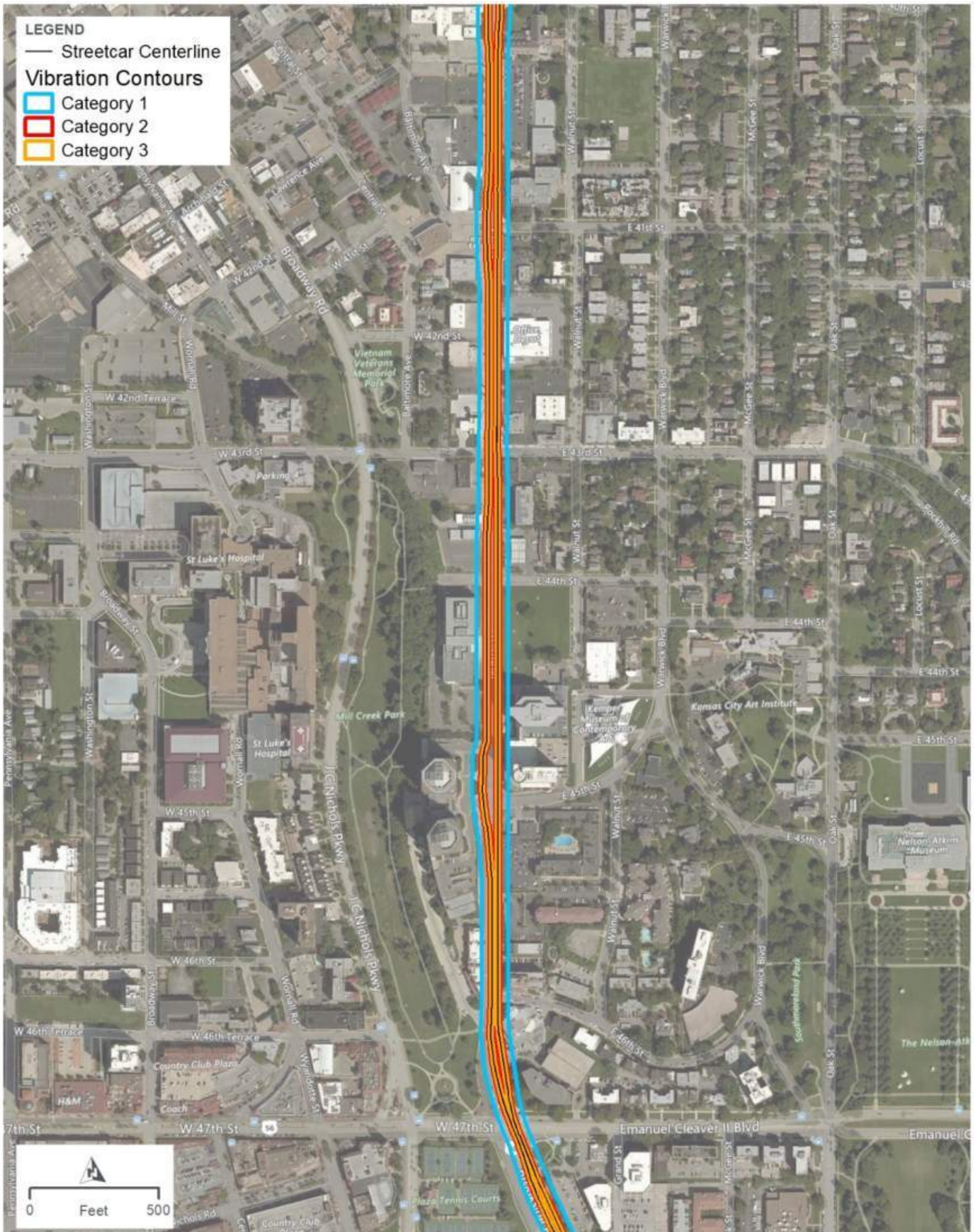

LEGEND
Streetcar Centerline
Vibration Contours
Category 1
Category 2
Category 3
0
Feet
500
VIBRATION CONTOURS
KC STREETCAR
PAGE 3 OF 5



VIBRATION CONTOURS
KC STREETCAR
PAGE 4 OF 5

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LEGEND
Streetcar Centerline
Vibration Contours
Category 1
Category 2
Category 3
W 47th St
Emanuel Cleaver II Blvd
Ward Pkwy
W 46th St
Volker Blvd
Brookside Blvd
Oak St
Main St
Walnut St
Grand Ave
W 50th St
E 50th St
E 51st St
E 51st Terrace
W 52nd St
E 52nd St
W Concord Ave
E Concord Ave
W 53rd St
E 53rd St
E 53rd Terrace
W 54th St
E 54th St
Cherry St
Locust St
Rockhill Rd
E 47th Terrace
Pierce St
Brush Creek
Frank A Theis Park
Bixby Ln
University of Missouri at Kansas City
National Museum of Toys & Miniature
0
Feet
500
VIBRATION CONTOURS
KC STREETCAR
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Appendix D: Construction Noise Assessment

Table D-1: Estimated Construction Equipment Noise Levels by Construction Phase

Construction Phase	Equipment	Number	Hours /day	Utiliz-ation	Horse power	kilo watt	SWL/ unit	Total SWL	SPL (dBA) at distance (ft.)			
									100	200	500	1000
Utility Relocation	Off-Highway Trucks	4	4	40%	350	261	123	125	85	79	71	65
	Rubber Tired Loaders	1	4	40%	199	148	121	117	76	70	62	56
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Combined Noise Level								86	80	72	66
Earthwork	Off-Highway Trucks	4	4	40%	350	261	123	125	85	79	71	65
	Rollers	1	6	60%	80	60	117	115	74	68	60	54
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Combined Noise Level								86	80	72	66
Bridge Construction for Overpasses	Cranes	1	3	30%	226	169	121	116	75	69	61	55
	Generator Sets	2	4	40%	84	63	117	116	75	69	61	55
	Tractors/Loaders/Backhoes	2	6	60%	97	72	118	118	78	72	64	58
	Welders	2	6	60%	46	34	114	115	74	68	60	54
	Combined Noise Level								82	76	68	62
Retaining Walls	Tractors/Loaders/Backhoes	2	4	40%	97	72	118	117	76	70	62	56
	Combined Noise Level								76	70	62	56
Signals	Cranes	1	2	20%	226	169	121	114	74	68	60	54
	Tractors/Loaders/Backhoes	1	2	20%	97	72	118	111	70	64	56	50
	Combined Noise Level								75	69	61	55
Track Installation	Air Compressors	1	6	60%	78	58	117	114	74	68	60	54
	Cranes	1	7	70%	226	169	121	120	79	73	65	59
	Forklifts	3	8	80%	89	66	117	121	80	74	66	60
	Generator Sets	1	8	80%	84	63	117	116	75	69	61	55
	Track Laying Machine	1	8	80%	1500	1119	129	129	88	82	74	68

	Track Tamper	1	8	80%	200	149	121	120	79	73	65	59
	Track Stabilizer	1	8	80%	700	522	126	125	85	79	71	65
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Welders	1	8	80%	46	34	114	113	73	67	59	53
	Combined Noise Level								91	85	77	71
Demolish Existing Bridge	Concrete/Industrial Saws	2	8	80%	85	63	117	119	78	72	64	58
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Combined Noise Level								82	76	68	62
Install Track and Subballast Over Bridge	Air Compressors	1	6	60%	78	58	117	114	74	68	60	54
	Cranes	1	7	70%	226	169	121	120	79	73	65	59
	Forklifts	3	8	80%	89	66	117	121	80	74	66	60
	Generator Sets	1	8	80%	84	63	117	116	75	69	61	55
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Welders	1	8	80%	46	34	114	113	73	67	59	53
	Combined Noise Level								85	79	71	65
Final Cut-Over and Removal of Turnouts	Cranes	1	7	70%	226	169	121	120	79	73	65	59
	Forklifts	3	8	80%	89	66	117	121	80	74	66	60
	Generator Sets	1	8	80%	84	63	117	116	75	69	61	55
	Tractors/Loaders/Backhoes	3	7	70%	97	72	118	121	80	74	66	60
	Welders	1	8	80%	46	34	114	113	73	67	59	53
	Combined Noise Level								85	79	71	65