NOISE AND VIBRATION IMPACT ASSESSMENT FOR THE VALLEY HIGHWAY EIS DENVER, COLORADO

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Federal Highway Administration
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1.0 INTRODUCTION

The Colorado Department of Transportation (CDOT) is evaluating alternative sets of improvements to Interstate 25 (I-25) in central Denver through the Valley Highway Environmental Impact Statement (EIS). The general region covered in the EIS is I-25 from Logan Street to 6th Avenue and 6th Avenue from I-25 to Federal Boulevard (see **Figure 1**). This portion of I-25 and its supporting connections has become out of date, under serves the traffic demand placed on them, and will soon be surrounded by reaches of I-25 that have been improved to accommodate greater traffic capacities. CDOT Project IM 0252-315 (12194) through the EIS is examining several alternatives that will modernize this stretch of I-25 by reconfiguring interchanges and creating a highway profile consistent with the other improved I-25 sections abutting the project corridor. The following document presents an overall analysis that was performed as part of the EIS to assess potential impacts from noise and vibration to properties neighboring the proposed improvements.

1.1 Project Description

The proposed project could involve a number of changes to this transportation corridor, but is generally expected to increase the number of through lanes each direction on I-25 from three lanes to four. I-25 interchanges at Broadway, Santa Fe Drive and Alameda Avenue, along with 6th Avenue at Federal Boulevard and Bryant Street, may be redesigned along with the connecting surface streets. The consolidated freight railroad corridor east of I-25 may be shifted to accommodate the changes. Santa Fe Drive and Kalamath Street may be grade-separated from the freight railroad.

The Draft EIS includes three possible System Alternatives along with the No Action Alternative. Each of these scenarios is being examined for impacts as an integral part of the EIS by Felsburg, Holt & Ullevig (FHU). Discussion of the System Alternatives is presented in **Section 2.3.**

Existing land uses bordering roads in the project corridor are variable. Most of the land uses are commercial or railroad, but there are areas of residences, motels, parks and a church (see **Figure 2**). Residential areas are considered to be the most sensitive to traffic noise and vibration impacts. The main residential area closest to I-25 along the project corridor is the West Washington Park neighborhood east of Broadway and north of I-25. There are also homes near 6th Avenue and Federal Boulevard and homes west of the South Platte River, but at somewhat greater distances from I-25. There are a few homes scattered in otherwise commercial areas and a few motels and public parks in the project area.

Currently, there is a wooden noise barrier along the Lincoln Avenue off-ramp from I-25. Even though this barrier is within the EIS project corridor, this barrier is slated to be replaced by the separate Transportation Expansion (T-REX) project. Therefore, an improved noise barrier at this location was a baseline condition for the future scenarios in this noise analysis.

Figure 1 Valley Highway EIS Project Area Map

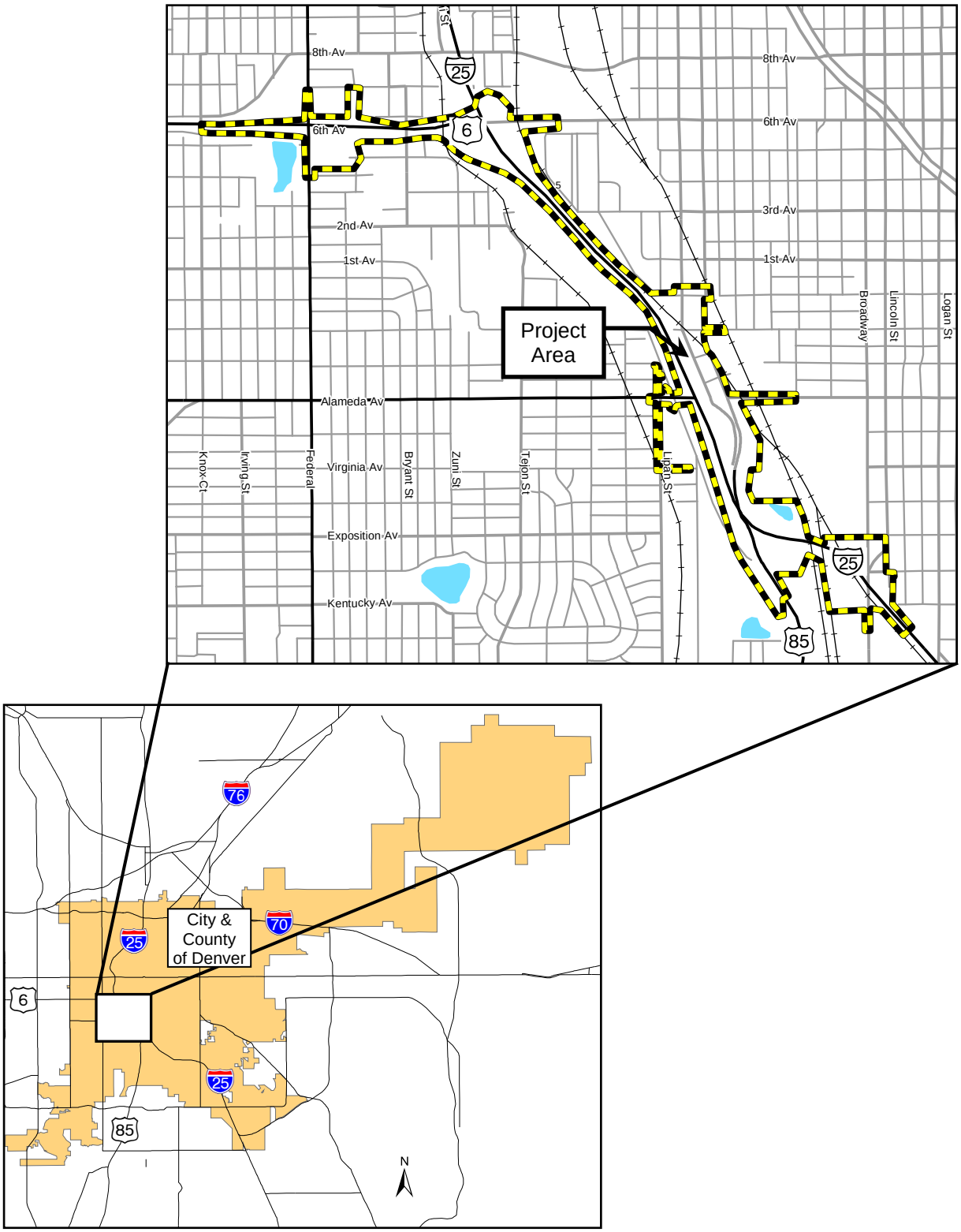
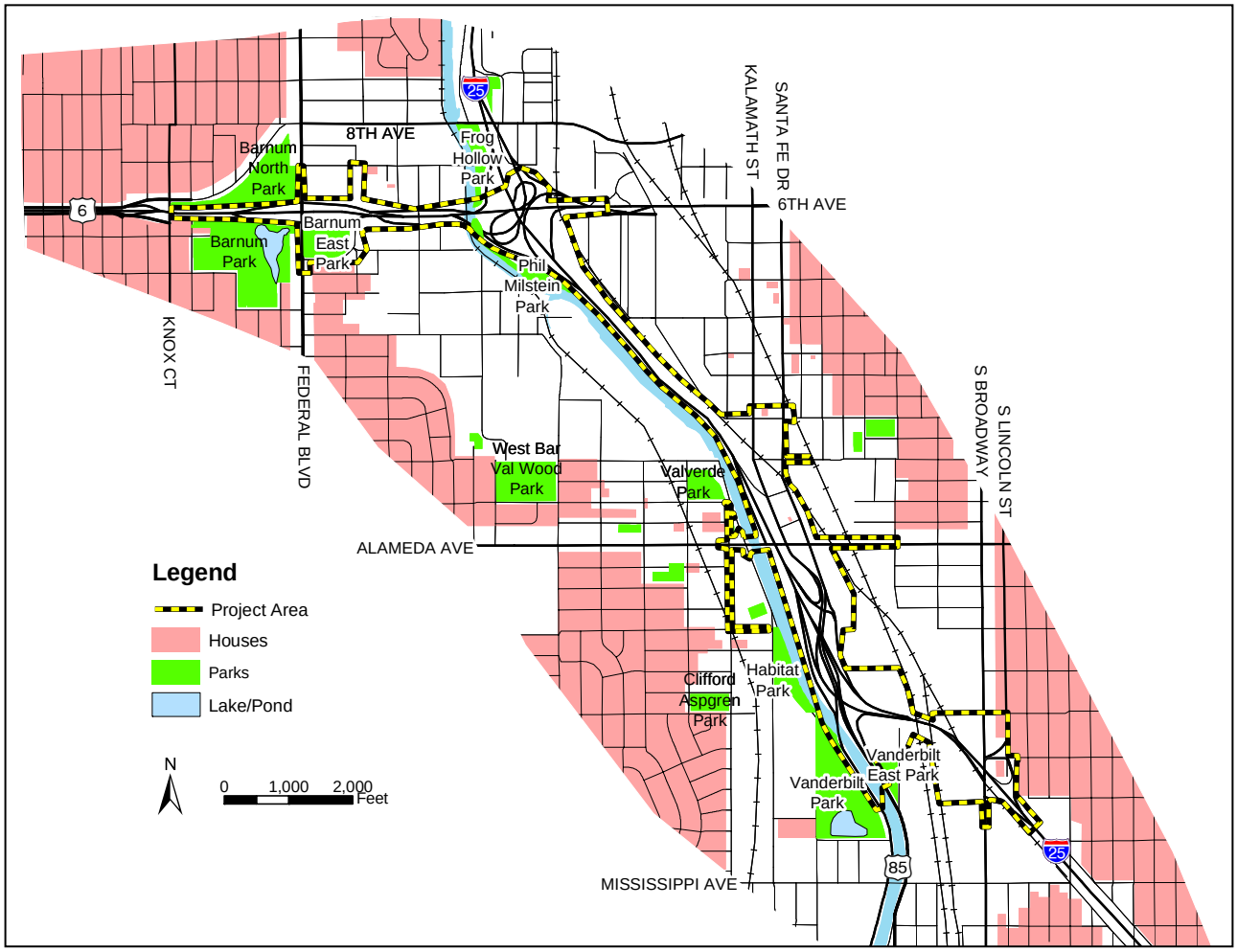


Figure 2 Noise Sensitive Areas Along Project Corridor



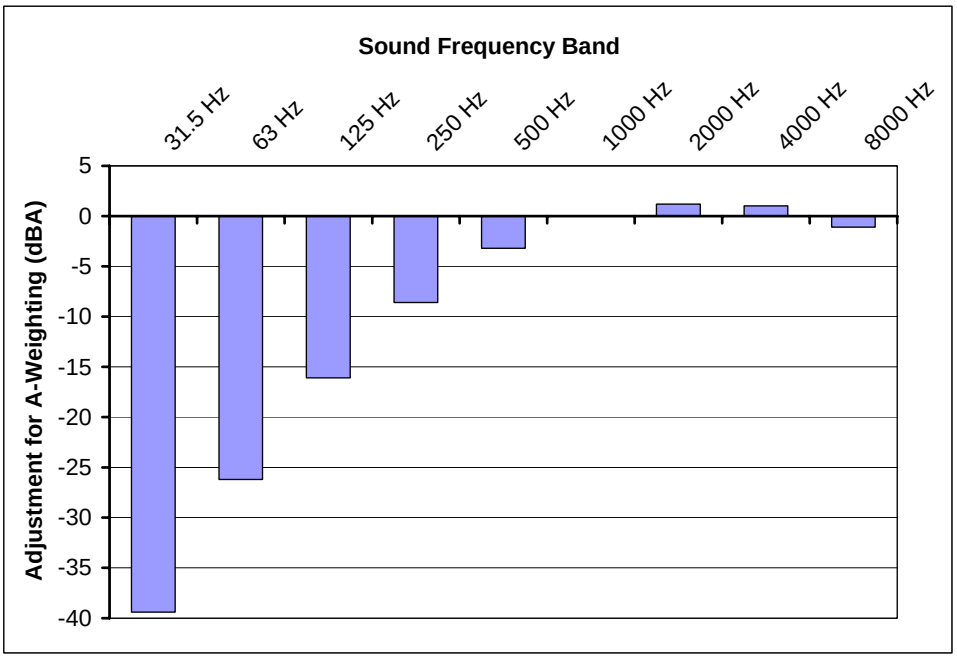
1.2 Basics of Sound

Sound is created when an object vibrates and radiates part of that energy as acoustic pressure or waves through a medium, such as air, water, or a solid. Sound and noise are measured in units of decibels (dB). The dB scale is logarithmic, not linear. As an example, two identical noise sources, each producing 60 dB, will produce 63 dB when operated together. Likewise, a 10-dB increase in sound levels represents ten times as much sound energy.

The human ear is receptive to a wide range of sound energy levels but is not equally receptive to all sound frequencies. A-weighting of sound levels is a method used to approximate how the human ear perceives sound, mostly by reducing the contribution from lower frequencies by a specified amount (see **Figure 3**). A-weighted sound levels are reported in dBA. Most people will not notice a difference in loudness of sound levels of less than 3 dBA, which is a two-fold change in the sound energy. Most people relate a 10-dBA change in sound levels to a doubling of sound loudness.

Sound levels diminish with distance from the source because of spreading, atmospheric absorption, interference from other objects and ground effects. "Hard" ground (such as asphalt) and "soft" ground (such as grass) transmit sound differently. “Hard” ground is more reflective and will produce louder sound levels farther from the source. With traffic noise, a 3-dBA increase in noise could be caused by doubling the traffic volume or cutting the distance from the roadway in half (for “hard” ground).

Figure 3 A-Weighting Adjustments



Traffic noise tends to fluctuate over time in accordance with traffic volumes, vehicle types, and speeds. This fluctuation makes it difficult to describe the noise impact through a single value. Nonetheless, the Federal Highway Administration (FHWA) and CDOT use the one-hour equivalent sound level (L_{eq}) as the metric for assessing traffic noise impacts. The L_{eq} is the “average” of the fluctuating noise levels over a time period, or the constant noise level that would produce the same sound energy as the fluctuating noise level over the time period. On congested highways like I-25, the loudest traffic noise generally occurs when the largest traffic volume can travel at the highest speed, which is usually not when traffic becomes overly congested and slows. This condition generally describes Level of Service (LOS) C for a highway.

1.3 Noise Analysis Approach

The purpose of the noise analysis was to assess the impact of traffic noise and vibration on properties near the proposed project and conclude whether mitigation considerations are necessary in the project design. The analysis presented in the following sections roughly encompasses I-25 from 6th Avenue to Logan Street, 6th Avenue from I-25 to Federal Boulevard, Alameda Avenue from Cherokee Street to Pecos Street, Santa Fe Drive/Kalamath Street from Mississippi Avenue to 1st Avenue, and Broadway/Lincoln Street from Mississippi Avenue to Virginia Avenue. The corresponding I-25 interchanges were included. The consolidated freight

railroad corridor extending from approximately Alameda Avenue to 6th Avenue was also of interest.

The overall traffic noise analysis was based on measurements of existing noise conditions and on computer modeling of traffic noise for both existing (2003) and expected future (2025) traffic conditions. FHU performed short-term measurements of existing traffic noise at numerous locations in the study area in October and November, 2003. Computer modeling was used to predict existing and expected future average traffic noise, focusing on probable impacts to the most sensitive receivers. Presently, these are residences, parks and businesses adjoining the corridor (see **Figure 2**). The vibration analysis focused on impacts from the freight railroad and followed the process developed by the Federal Transit Administration (FTA) supplemented with procedures from the International Organization for Standardization (ISO).

2.0 NOISE IMPACT ANALYSIS METHODS

Noise impacts were evaluated through a combination of measurements and computer modeling. Potential impact from traffic noise was assessed on the basis of the predicted noise levels' relationship to CDOT's implementation of the FHWA Noise Abatement Criteria (NAC). The FHWA NAC for residences and other Category B receivers is an L_{eq} of 67 A-weighted decibels (dBA), and for commercial areas (Category C) is an L_{eq} of 72 dBA for the peak hour (see **Table 1**). Under CDOT guidelines, "approaching" the FHWA NACs is a concern that will trigger an investigation of noise mitigation measures. "Approaching" the FHWA NACs has been specified by CDOT as noise 1 dBA below each FHWA NAC, which equates to 66 dBA for residential or other Category B land use areas and 71 dBA for Category C areas. CDOT has established their own NACs at these levels (see **Table 1**). CDOT NACs are the most restrictive of these criteria, and are the basis of comparison for the remainder of the evaluation. For comparison, typical noise levels and other standards are shown in **Figure 4**.

In addition to exceeding the CDOT NACs, a substantial noise increase is indicated if the future noise level is expected to increase by 10 dBA or more over existing levels at any location modeled. This would also lead to evaluation of traffic noise mitigation actions.

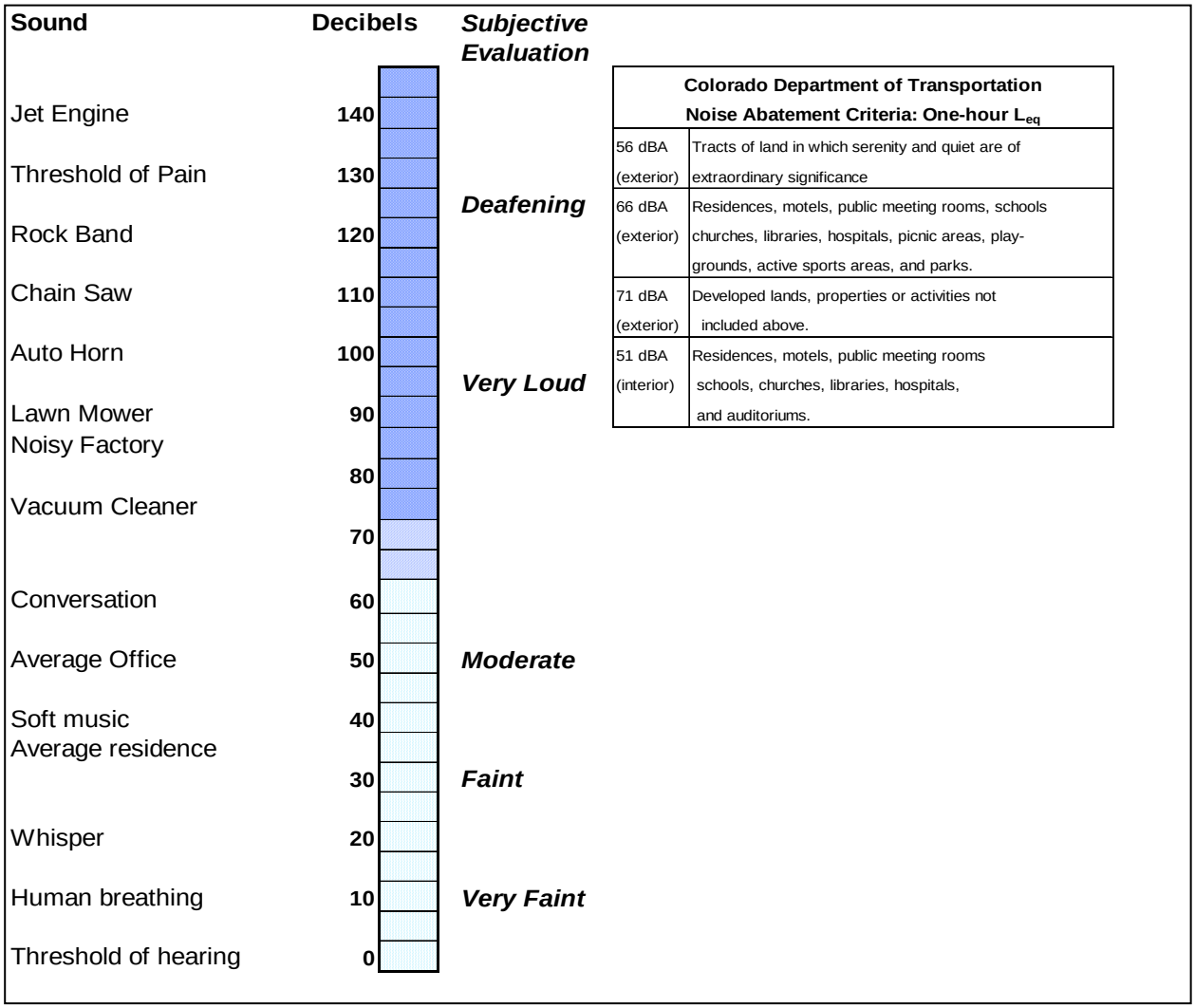
For this discussion, the peak hour refers to the highest traffic noise hour, which may or may not correspond to the hour of most traffic. Traffic noise from overloaded and congested roads can decrease with more traffic due to lower vehicle speeds. Traffic noise from local streets more closely mirrors the traffic volume, generally.

Table 1 Noise Abatement Criteria

Land Use Category	FHWA NAC (L_{eq})	CDOT NAC (L_{eq})	Description of Land Use Category
A	57 dBA exterior	56 dBA exterior	Tracts of land in which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks, or open spaces which are recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	67 dBA exterior	66 dBA Exterior	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, playgrounds, active sports areas, and parks.
C	72 dBA Exterior	71 dBA Exterior	Developed lands, properties or activities not included in categories A and B above.
D	—	—	Undeveloped lands.
E	52 dBA Interior	51 dBA Interior	Residences, motels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Train noise was assessed using the FTA process. FTA uses several noise metrics for assessing noise impacts, but for this analysis the one-hour L_{eq} was used. The trains must sound their horn at crossings at Santa Fe Drive and Kalamath Street within the project corridor.

Figure 4 Typical Noise Levels



2.1 Noise Measurements

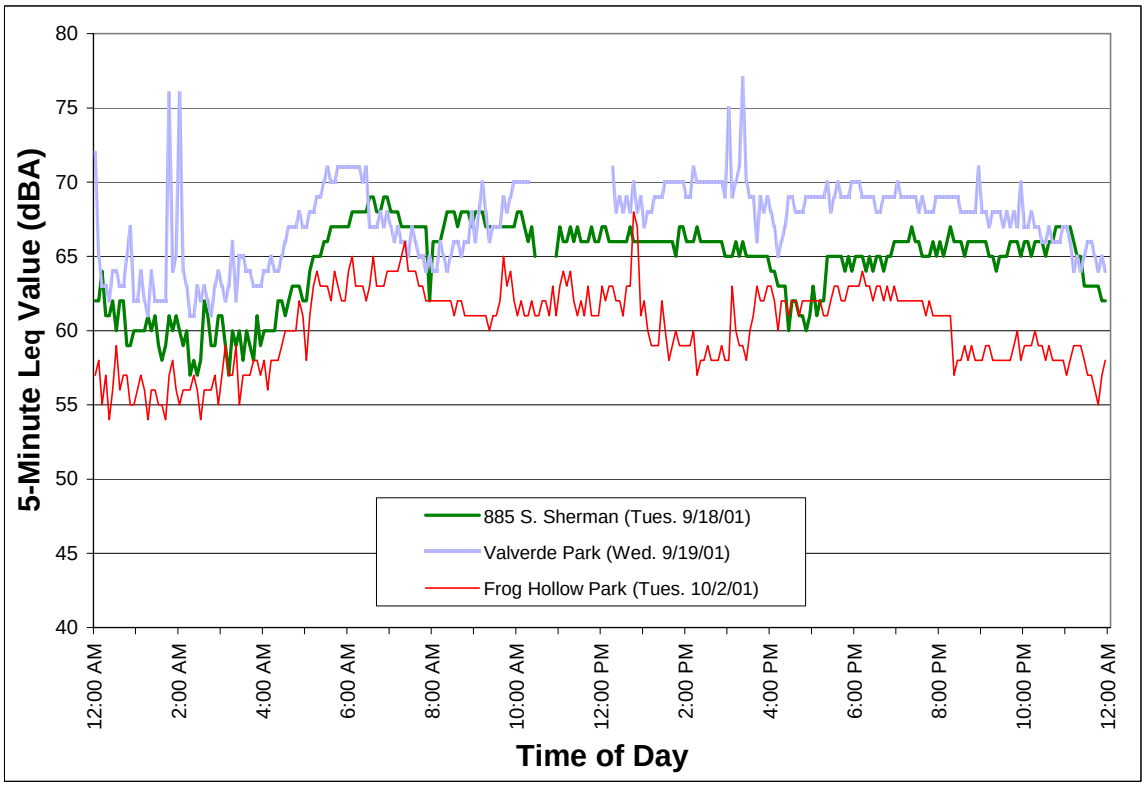
Existing noise level data from pre-EIS stages of this roadway improvement project were used to guide the noise measurement program. The pre-EIS data consisted of 24-hour logging measurements at several locations (see **Figure 5**). These data showed that peak traffic noise levels each day along this portion of I-25 persisted for several hours during the late morning and afternoon and that the levels were relatively constant during those periods. Therefore, representative peak noise hour measurements along I-25 could be taken during the early afternoon hours. This approach was used for the EIS noise measurement program.

Forty-six short-term (20-minute) traffic noise measurements were performed in the afternoon along the study area (see **Figure 6**) to document ambient conditions. These locations included residential, park and commercial areas along the project corridor. Actual traffic counts, including the number of large trucks, were collected when possible during the noise measurement periods

(see **Appendix A**); however, clear views of traffic on I-25 were not available at all of the measurement locations.

The EIS noise measurements were performed using a Svantek 945A Type 1 sound level meter calibrated at the site with a Norsonic 1251 calibrator. Measurements were made during meteorological conditions, including wind speed, that were acceptable according to FHWA guidance. Measured noise levels (other than those in Washington Park) are summarized in **Table 2**. The results indicate that the existing traffic noise environment exceeds the applicable CDOT NAC at a few locations.

Figure 5 24-Hour Noise Measurement Data



In addition, one noise measurement was made specifically for train noise (see **Figure 6**). The location was the intersection of Lipan Street and Ellsworth Avenue, about 180 feet from the tracks. One freight train passed during the 1-hour monitoring period and an L_{eq} of 65 dBA was measured. It should be noted that this included noise from nearby traffic as well.

2.2 Noise Modeling

Modeling is used because day-to-day variations in traffic or weather conditions that affect noise levels cannot be captured or quantified by brief noise measurements alone. The ultimate purpose of the models is to show whether future traffic noise levels caused by the proposed project would be high enough to impact neighboring properties and whether noise mitigation should be considered for any such impacts within the study area.

Figure 6 20-Minute Noise Measurement Locations

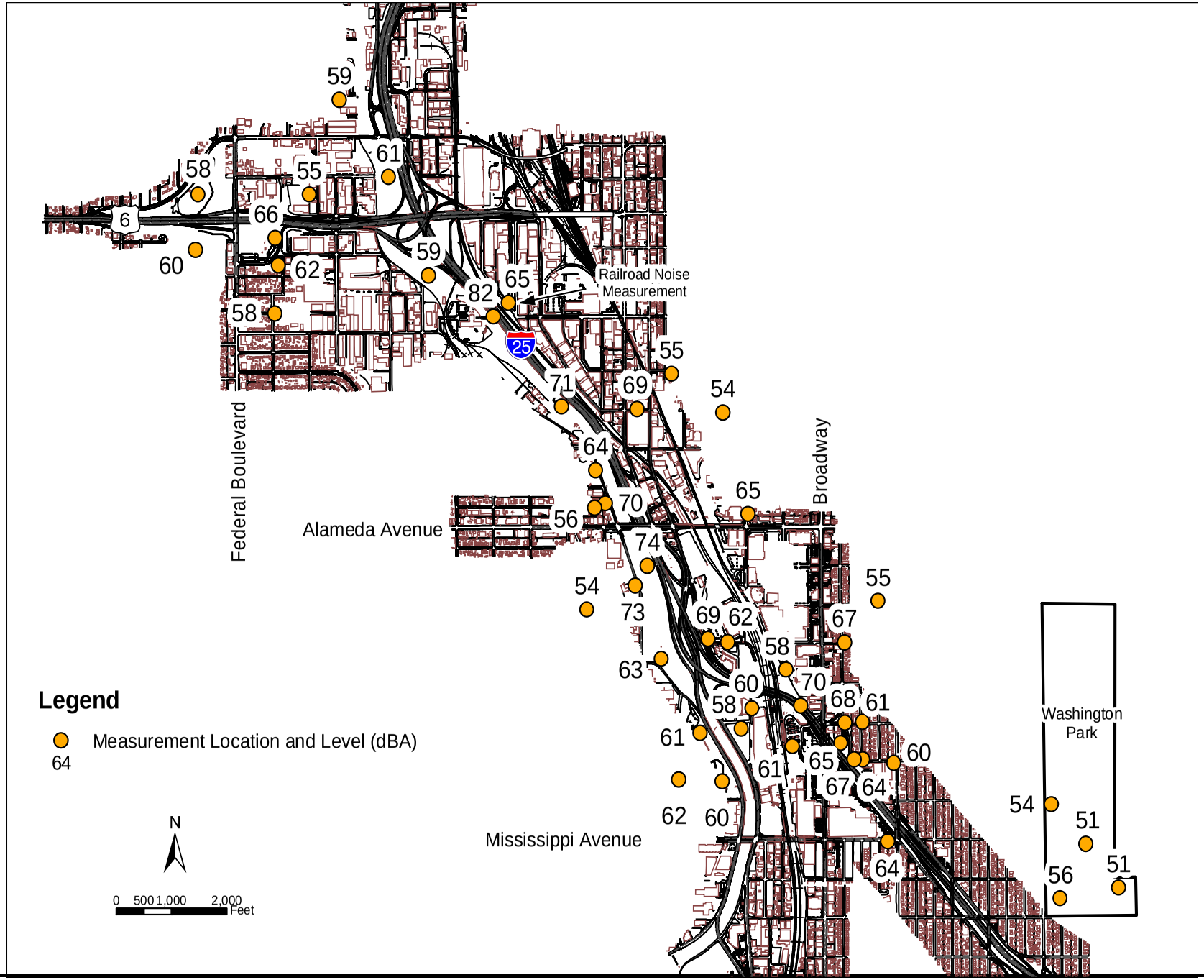


Table 2 Short-Term Noise Monitoring Results

Location Number	Address	L_{eq} (dBA)	Land Use Category	CDOT NAC (dBA)
1	833 S. Lincoln Street	65	B	66
2	794 S. Lincoln Street	68[a]	B	66
3	890 S. Sherman Street	64	B	66
4	792 S. Sherman Street	61	B	66
5	Vanderbilt Park	60	B	66
6	947 S. Huron Street	62	B	66
7	Vanderbilt Park	61	B	66
8	Habitat Park	63	B	66
9	1100 S. Grant Street	64	B	66
10	Vanderbilt East Park	58	B	66
11	800 S. Cherokee Street	60	D	--
12	192 W. Byers Place	65	B	66
13	I-25/Dakota Avenue	74	D	--
14	Church of God	73[a]	B	66
15	Motel 5	70[a]	B	66
16	Raritan/Quivas	65	C	71
17	Barnum East Park	66[a]	B	66
18	451 Decatur Street	62	B	66
19	Barnum Park	60	B	66
20	Barnum North Park	58	B	66
21	Home Depot	62	C	71
22	Home Depot	69	C	71
23	1216 W. Byers Place	56	B	66
24	Valverde Park	64	B	66
25	Phil Milstein Park	59	B	66
26	Platte bike path	82[a]	B	66
27	Platte bike path	71*	B	66
28	649 N. Canosa Court	55	B	66
29	Frog Hollow Park	61	B	66
30	Denver Design Center	58	C	71
31	Broadway Station	61	C	71
32	885 S. Sherman Street	67[a]	B	66
33	Post Office complex	60	C	71
34	933 W. Ellsworth Ave.	69[a]	B	66
35	Near 714 W. 1st Avenue	55	B	66
36	Near 1230 W. Virginia Avenue	54	B	66
37	3rd Ave. & Decatur St.	58	B	66
38	Near 2501 W. 9th Ave.	59	B	66
39	Dailey Park	54	B	66
40	Under I-25 Viaduct	70	D	--
41	598 S. Lincoln St.	67	B	66
42	480 S. Grant St.	55	B	66

[a] Value exceeds applicable NAC.

The traffic noise modeling software used for the analyses was the implementation of FHWA-RD-77-108 (i.e., STAMINA) contained in SoundPlan® Version 6.1 using CDOT vehicle noise emission values. Models were built to estimate the noise levels from existing (2003) traffic and projected design year (2025) traffic in the project vicinity. The existing traffic conditions were modeled that included the current road configurations and traffic volumes. Four 2025 traffic conditions were modeled that included the projected 2025 traffic and the relevant to the System Alternatives or the No Action Alternative road design (see **Section 2.3**). The conditions examined in these analyses were LOS C for I-25 and 6th Avenue and the morning peak hour traffic volumes for the city streets. (The AM hour tended to have higher traffic volumes closer to homes.) The ultimate purpose of the models is to show whether noise levels will be high enough to cause impacts to neighboring properties and mitigation should be considered for current and/or expected future land uses within the study area.

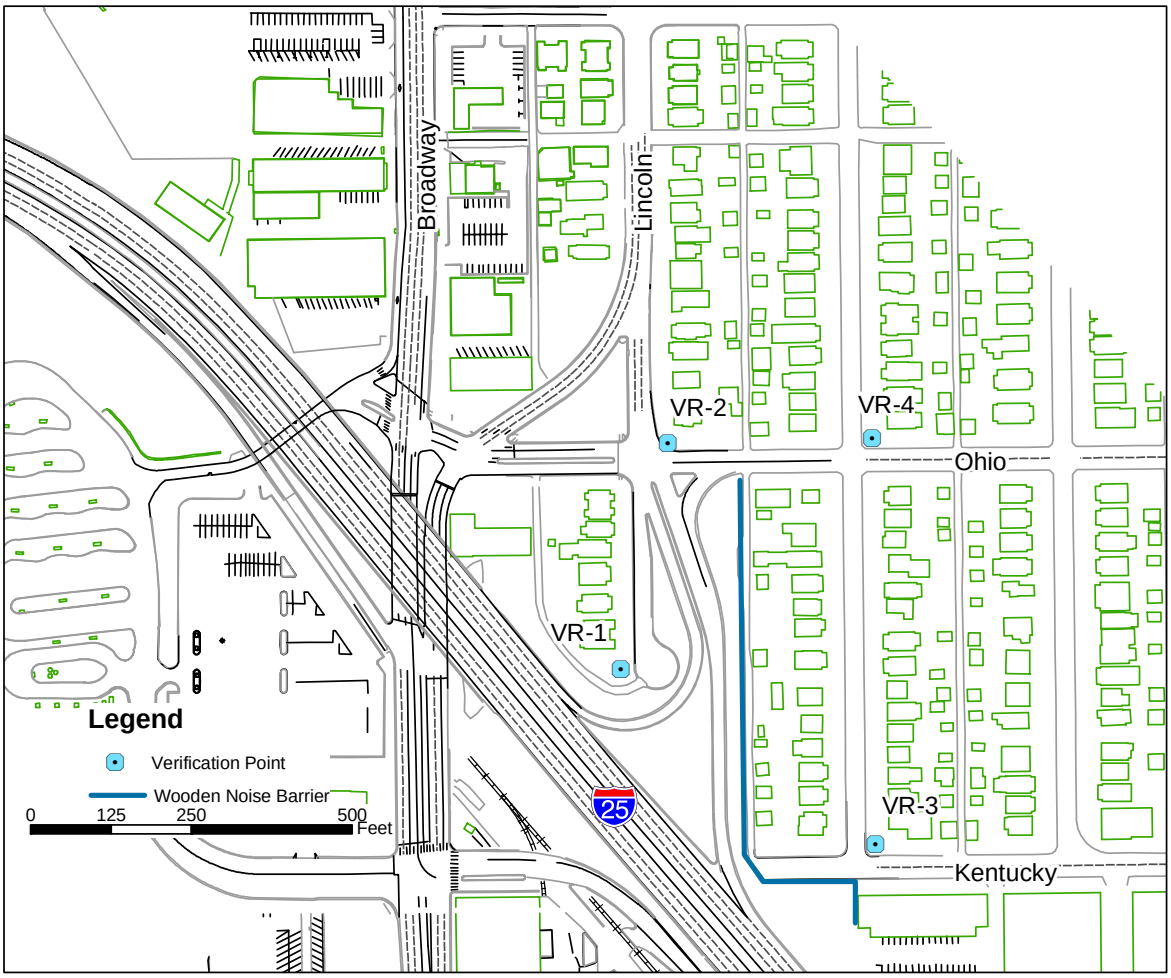
SoundPlan® can calculate noise levels at discrete receiver locations and at grid nodes to generate contour lines for larger areas. Traffic noise levels during an average peak noise hour were modeled at 67 receiver points that represent discrete locations within the project corridor. In addition, traffic noise levels were calculated at more than 28,500 grid nodes covering the project area to create detailed noise contours for areas between the discrete receivers. The same grid area and grid size was evaluated for each model. A primary study area was defined as the area within 500 feet of the roads in the noise model.

The computer noise models require a considerable amount of input data regarding the geometry of the roadways as well as traffic volumes, vehicle mix, and speeds. Detailed traffic studies were completed for the project corridor (FHU, 2005) to provide traffic volumes. The existing road/street layout was mapped for existing and No Action conditions. Three System Alternatives were developed in the EIS as possible future improvements for I-25 (FHU, 2005). Input data were obtained from these sources for the models. In general, the following data were used in the models:

- Units – meters and kilometers per hour
- Current Roadway Alignments – XY coordinates from CAD drawings and aerial photographs
- Future Roadway Alignments – X, Y coordinates from CAD drawings
- Vehicle Speeds – ranged from 48-100 KPH (30-60 MPH), depending on road type
- Traffic Volumes – from traffic study (LOS C or AM peak hour)
- Vehicle Mix – ranged from 2.3-8.5% trucks, from CDOT count data
- Elevations – from ground surface contours of the project area; receivers 5 feet tall
- Barriers – structure and terrain barriers used as needed to emulate the area

As a check on model parameters, the traffic conditions observed during some noise measurement episodes were used to construct a verification model. Because the project area is so large, the verification model consisted of a smaller piece of the project area near the I-25/Broadway interchange (see **Figure 7**). Verification models were constructed in both SoundPlan® and the CDOT STAMINA software for comparison. The verification model results are presented in **Table 3**.

Figure 7 Verification Model Locations



In general, the results were in close agreement, as the measured and modeled results for the noise measurement locations differed by 2 dBA or less. The differences for VR-1 were the highest examined, probably because of the complex topography and geometry in this unique location. Even with these unusual conditions, results were in the acceptable range without having to modify the model.

Table 3 Verification Model Results

Location	Measured Sound Level (dBA)	Sound Level from SoundPlan® Model (dBA)	Sound Level from STAMINA Model (dBA)
VR-1	65	67	68
VR-2	68	68	68
VR-3	64	62	64
VR-4	61	61	62

In addition, train noise was evaluated because a consolidated freight rail corridor passes through the project corridor and the railroad will be affected by the proposed project. The rails will be relocated by as much as 50 feet in some areas and a new grade separation will be constructed between the rails and Santa Fe Drive and Kalamath Street. The evaluation followed an adaptation of the process developed by FTA for transit projects (FTA, 1995), as this was deemed the most applicable process. For the modeling, 2.5 freight trains per hour, consisting of three locomotives and 50 cars moving at 30 miles per hour, were assumed to use the railroad corridor.

2.3 Alternatives

Several alternative roadway designs are being considered in the EIS, and each of those designs was considered for potential traffic noise impacts. The first alternative is the No Action Alternative where the road layout does not include any new improvements beyond the new viaduct already under construction. Additionally, there are three distinct System Alternatives (System Alternatives 1-3) consisting of comprehensive system-wide improvements to the project corridor. There is some overlap of improvements between these three System Alternatives, but each is a unique assemblage of system-wide roadway improvements. All of the System Alternatives grade-separate Santa Fe Drive and Kalamath Street from the freight railroad tracks and all keep the I-25 alignment essentially where it is today. A summary of each System Alternative is presented below, but more design details are presented in the Draft EIS.

System Alternative 1 is designed to maximize use of existing right of way. It keeps the 6th Avenue/Federal Boulevard interchange largely unchanged but adds one new directional movement. The Alameda Avenue/Santa Fe Drive/Kalamath Street intersection is largely unchanged. A fly-over ramp is added to I-25/Alameda Avenue. The I-25/Santa Fe Drive interchange is extensively reworked including a new fly-over ramp. One ramp at I-25/Broadway is relocated.

System Alternative 2 is designed to maximize operational performance and safety. The footprint of 6th Avenue/Federal Boulevard is reduced by moving a ramp. Santa Fe Drive and Kalamath Street are brought together at a new interchange at Alameda Avenue and pass over Alameda Avenue. A northbound ramp is added to the I-25/Alameda Avenue interchange. The I-25/Santa Fe Drive interchange is extensively reworked including a new fly-over ramp. One ramp at I-25/Broadway is relocated. This alternative removes the homes in the 800 block of S. Lincoln Street for a relocated ramp.

System Alternative 3 is designed to maximize facilitation of local government objectives. The 6th Avenue/Federal Boulevard interchange becomes an urban interchange, reducing its overall footprint. The Alameda Avenue/Santa Fe Drive/Kalamath Street interchange is similar to System Alternative 2, although the grade-separation passes under Alameda Avenue. A fly-over ramp is added to I-25/Alameda Avenue. The I-25/Santa Fe Drive interchange is similar to System Alternative 2. One ramp at I-25/Broadway is added and another is relocated. Two homes on the 800-block of S. Lincoln Street are removed.

3.0 NOISE FINDINGS AND RECOMMENDATIONS

The modeling effort was conducted as described above to assess whether future noise levels near the project corridor will exceed the relevant CDOT NAC or cause a substantial noise increase. If so, noise mitigation measures protecting these areas were considered and evaluated following CDOT guidelines. The overall feasibility and reasonableness of noise barriers that provide the minimum acceptable mitigation benefit for the impacted receivers are evaluated and mitigative actions are either recommended or not.

3.1 Predicted Noise Levels

Noise models were constructed as described in **Section 2.2**. Traffic model runs were made for I-25 and the other major project streets using existing (2003) or predicted future (2025) traffic volumes and road layouts. The input and output data for the model runs are presented in Appendix B. Discrete noise receiver results are presented in **Figure 8** and **Table 4**. The model noise contour results are presented in **Figures 9** through **13**. Train noise impacts were assessed using the FTA process.

3.1.1 Existing Traffic Conditions Model Results

The existing conditions model results generally agree with the measurement results in that several Category B areas currently meet or exceed the CDOT NAC (**Figure 9**) and are therefore impacted. These locations include several homes, parks, two motels and a church. The impacts are summarized in **Figure 14** and **Table 5**.

Several residential areas are estimated to have subareas that exceed the Category B NAC. The areas include:

- Three homes on the 800 block of S. Sherman Street
- Homes on S. Lincoln Street in the Study Area
- 900 block of W. Ellsworth Avenue
- 2900 block of W. Short Place
- 3300 block of W. 5th Avenue
- 919 W. Byers Place

The 800 block of S. Sherman Street has already been selected for traffic noise mitigation as part of the ongoing T-REX project and a replacement noise barrier is planned. Essentially all residential lots on S. Lincoln Street in the Study Area are estimated to have portions that exceed the NAC. However, the exceedences on S. Lincoln Street north of Ohio Avenue are due to vehicles using Lincoln Street. From field observations and modeling, local traffic noise generally is louder than highway traffic noise for residences that are more than about 300 feet from I-25 or 6th Avenue, though local traffic is more intermittent. It is estimated from the model results that approximately 62 residences within the Study Area are at or above the CDOT NAC. Of these, approximately 44 homes are either on S. Lincoln Street north of Ohio or on S. Sherman Street behind the noise barrier.

Figure 8 Noise Model Receiver Locations

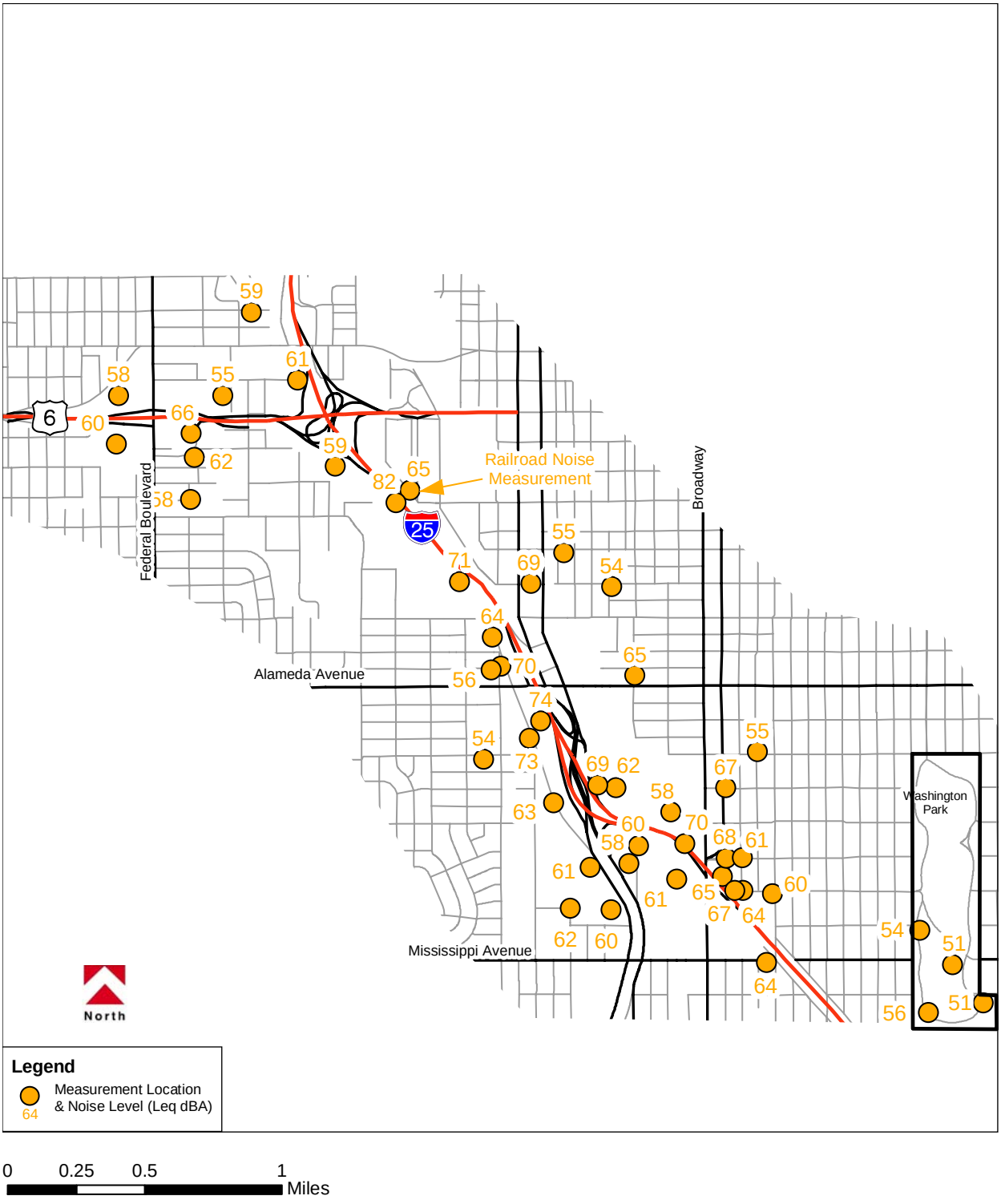


Table 4 Noise Model Receiver Results

Receiver	Predicted Noise Level (dBA)					Land Use
	Existing	2025 No Action	2025 System 1	2025 System 2	2025 System 3	
C1	72	72	73	73	73	Commercial—1500 W. 3rd
C2	71	71	72	72	72	Commercial—1500 W. 2nd
C3	71	71	72	72	72	Commercial—1400 W. 2nd
C4	71	71	72	72	72	Commercial—1400 W. 1st
C5	71	71	72	72	72	Commercial—1400 W. 1st
C6	72	72	73	73	73	Commercial—1100 W. Ellsworth
C7	71	71	72	71	71	Commercial—1100 W. Ellsworth
C8	71	72	73	74	70	Commercial—100 S. Kalamath
C9	71	72	72	70	69	Commercial—250 S. Kalamath
C10	72	73	73	71	71	Commercial—250 S. Kalamath
C11	70	72	72	70	70	Commercial—300 S. Kalamath
C12	70	71	72	73	72	Commercial—300 W. Center
C13	70	71	73	73	73	Commercial—300 W. Center
C14	67	68	71	72	71	Commercial—300 W. Exposition
C15	74	76	76	76	76	Commercial—2400 W. 5th
C16	70	72	72	72	72	Commercial—2400 W. 6th
C17	71	73	74	73	73	Commercial—900 S. Broadway
C18	73	74	75	74	74	Commercial—900 S. Lincoln
C19	72	74	77	75	75	Commercial—900 S. Sherman
C20	71	73	75	74	74	Commercial—900 S. Grant
C21	69	70	73	71	71	Commercial—1000 S. Grant
P1	69	70	70	70	68	Park—Vanderbilt
P2	64	65	65	65	64	Park—Vanderbilt
P3	65	66	66	66	66	Park—Vanderbilt
P4	70	71	71	71	71	Park—Vanderbilt
P5	65	66	67	67	67	Park—Habitat
P6	63	63	62	62	62	Park—Habitat
P7	65	65	66	66	66	Park—Habitat
P8	68	69	69	69	69	Park—Valverde
P9	64	64	65	65	65	Park—Valverde
P10	69	69	69	69	69	Park—Bike Path
P11	77	77	75	75	75	Park—Bike Path
P12	70	72	72	72	72	Park—Frog Hollow
P13	72	73	73	73	73	Park—Phil Milstein
P14	65	66	66	67	66	Park—Barnum East
P15	66	67	68	64	64	Residential—2900 W. Short
P16	69	70	71	71	71	Park—Barnum
P20	66	68	68	68	68	Park—Barnum North
P21	65	66	67	67	67	Park—Vanderbilt East
P22	66	67	67	67	67	Park—Phil Milstein
R1	69	70	71	71	67	Residential—700 S. Lincoln
R2	69	70	71	71	69	Residential—700 S. Lincoln
R3	69	70	70	70	70	Residential—700 S. Lincoln

Table 4 Noise Model Receiver Results (continued)

Receiver	Predicted Noise Level (dBA)					Land Use
	Existing	2025 No Action	2025 System 1	2025 System 2	2025 System 3	
R4	68	68	70	68	68	Residential—800 S. Sherman
R5	63	64	66	64	64	Residential—800 S. Sherman
R6	64	65	67	65	65	Residential—800 S. Sherman
R7	60	61	62	61	61	Residential—800 S. Sherman
R8	71	72	72	72	71	Residential—700 S. Lincoln
R9	66	68	68	68	68	Residential—3300 W. 5th
R10	65	67	67	67	67	Residential—3300 W. 5th
R11	65	66	66	66	66	Residential—3300 W. 5th
R12	58	59	61	59	59	Residential—800 S. Sherman
R13	67	68	67	67	68	Residential—900 W. Ellsworth
R14	68	69	69	71	68	Residential—900 W. Byers
R15	68	68	68	68	68	Church—455 S. Platte River
RB1	67	68	72	72	74	Residential—800 S. Lincoln
RB2	66	67	71	71	72	Residential—800 S. Lincoln
RB3	65	66	70	71	73	Residential—800 S. Lincoln
RB4	65	66	68	71	70	Residential—800 S. Lincoln
RB5	67	68	69	70	71	Residential—800 S. Lincoln
RB6	67	69	75	74	78	Residential—800 S. Lincoln
RF1	65	66	69	74	69	Residential—800 S. Lincoln
RF2	65	67	68	74	66	Residential—800 S. Lincoln
RF3	65	67	68	73	65	Residential—800 S. Lincoln
RF4	66	67	68	73	64	Residential—800 S. Lincoln
RF5	67	69	68	73	64	Residential—800 S. Lincoln
RF6	65	67	70	74	72	Residential—800 S. Lincoln

Portions of the following parks are estimated to have traffic noise levels above the CDOT NAC for Category B:

- Barnum Park
- Barnum East Park
- Barnum North Park
- Frog Hollow Park
- Phil Milstein Park (not officially a park but was treated as a park)
- Valverde Park
- Habitat Park
- Vanderbilt Park
- Vanderbilt East Park
- South Platte River bike path (treated as a park for this evaluation)

Figure 9 Existing Conditions Model Noise Contours

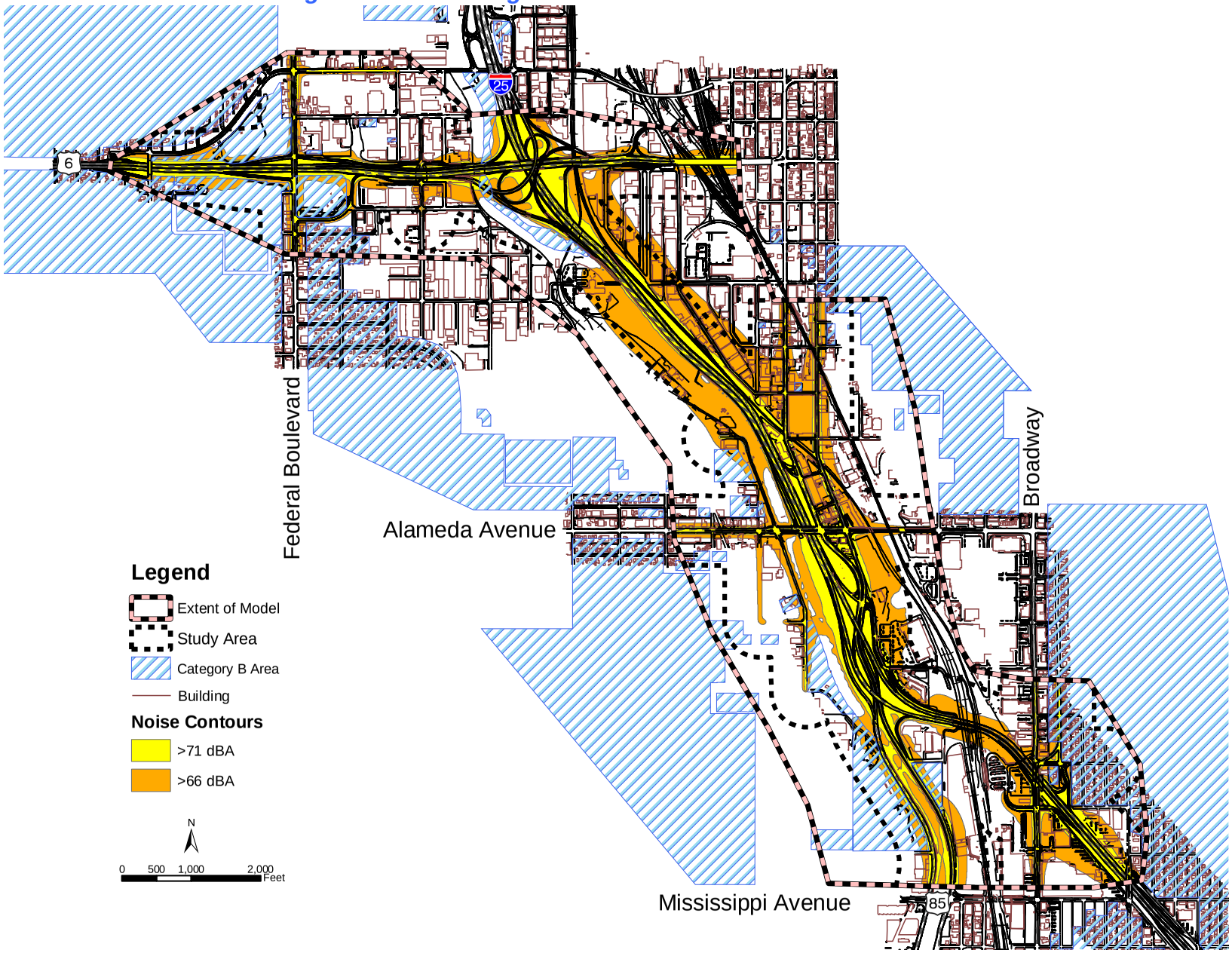


Figure 10 2025 No Build Conditions Model Noise Contours

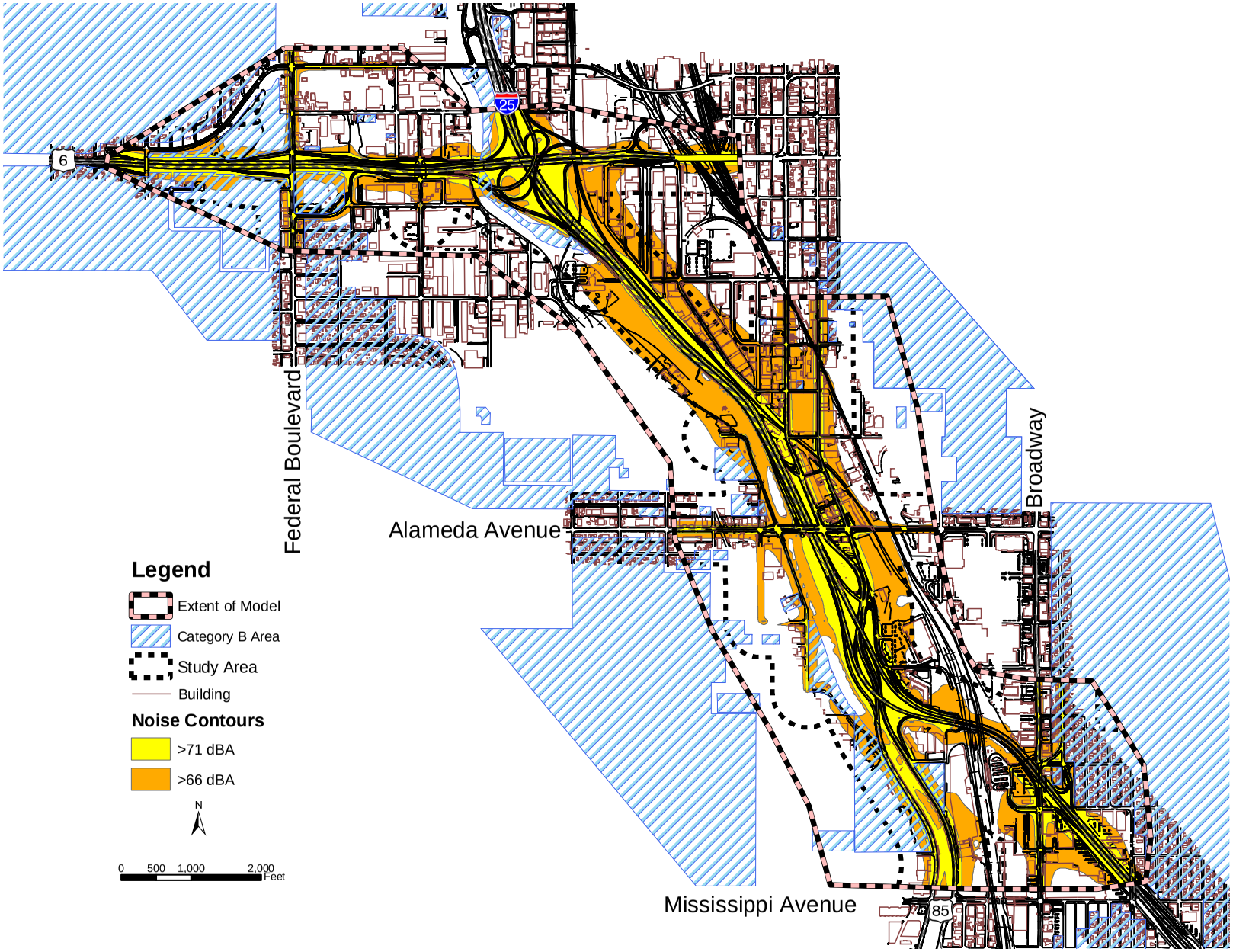


Figure 11 2025 System Alternative 1 Model Noise Contours

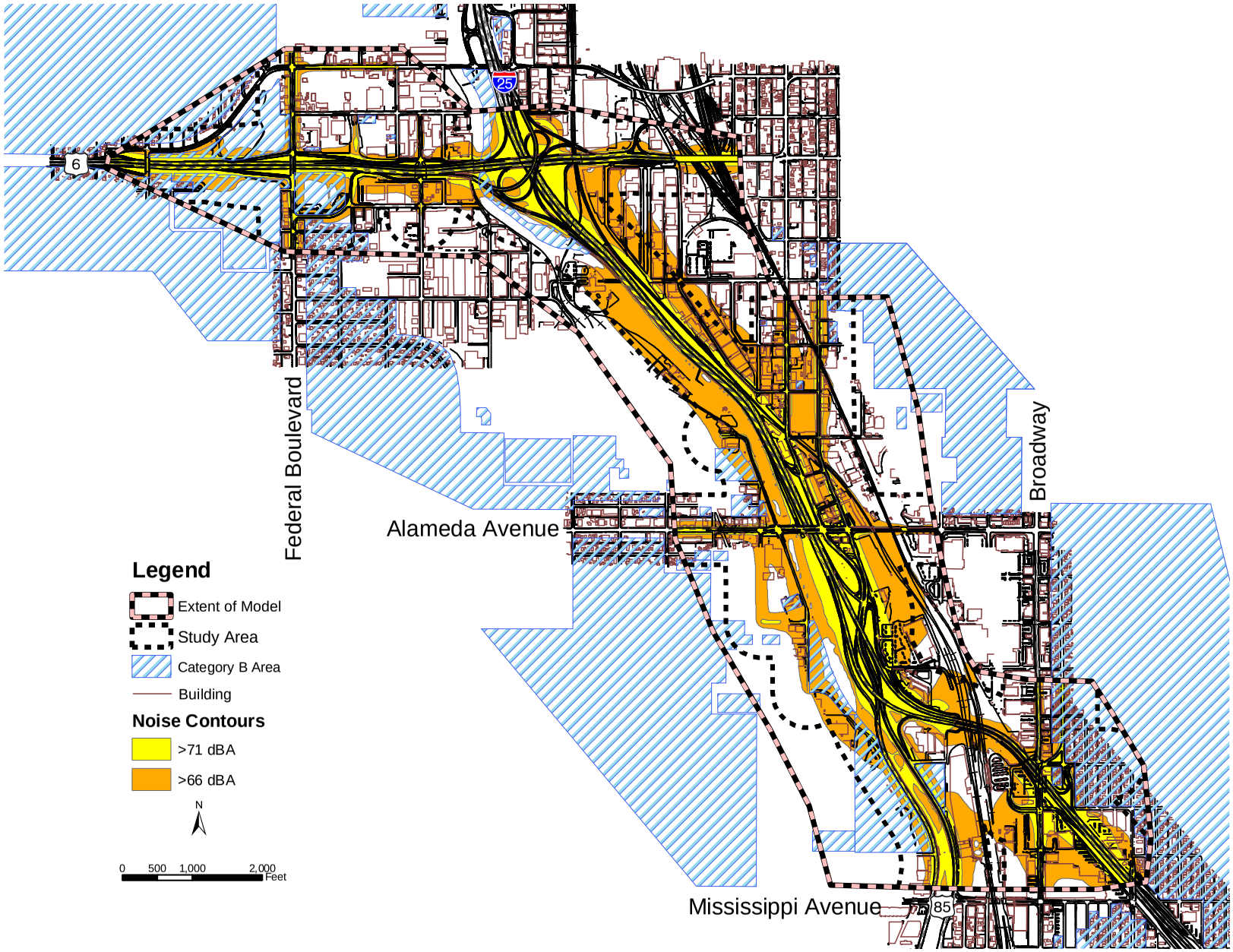


Figure 12 2025 System Alternative 2 Model Noise Contours

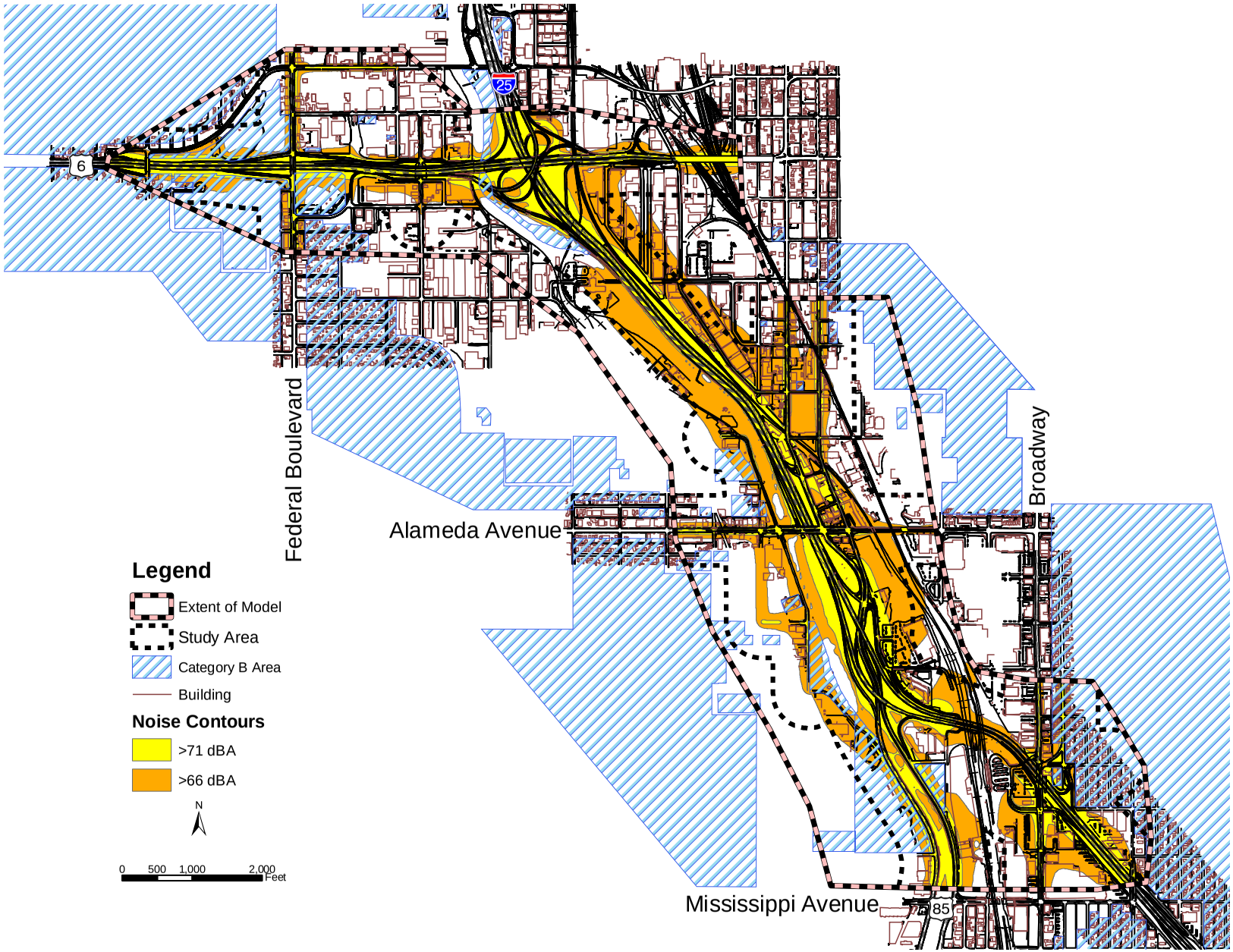


Figure 13 2025 System Alternative 3 Model Noise Contours

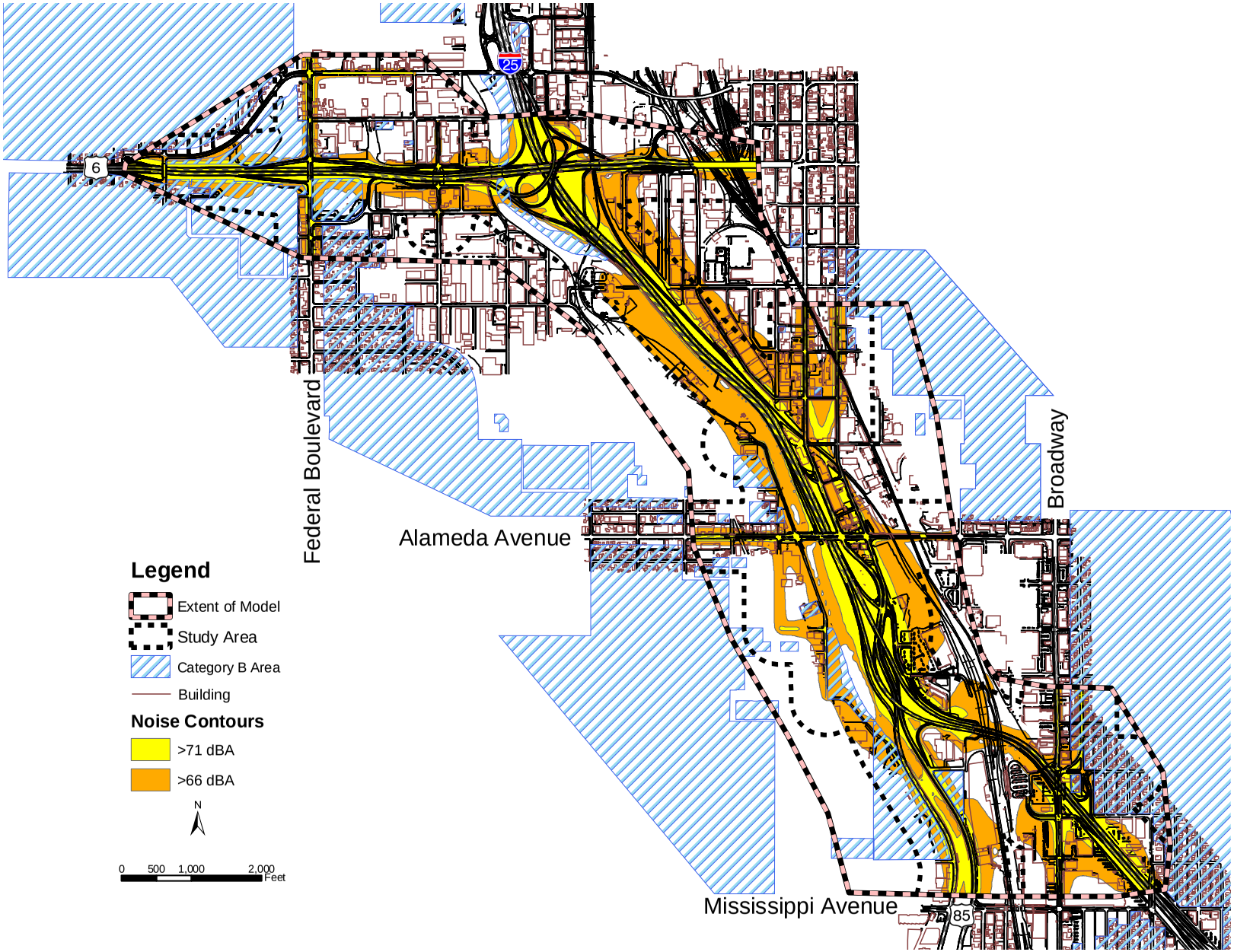


Figure 14 Noise Impacted Areas

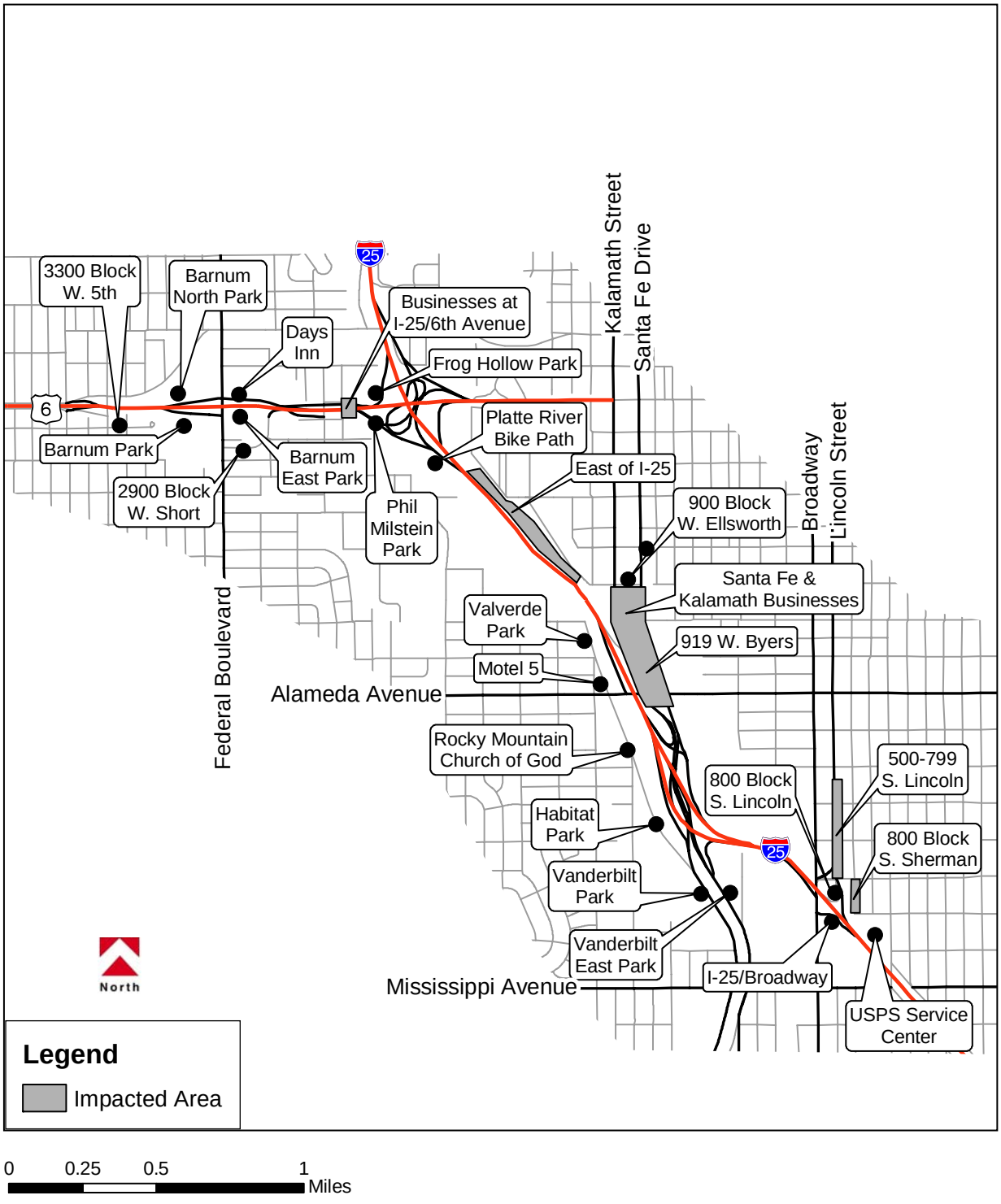


Table 5 Noise Impact Summary

Location	Land Type	Number of Noise-Impacted Properties (without mitigation)				
		Existing Conditions	2025 No Action	System Alternative 1	System Alternative 2	System Alternative 3
Category B						
800 block S. Sherman Street	Residential	3	4	7	4	4
800 block S. Lincoln Street	Residential	6	6	6	0	4
500-799 S. Lincoln Street	Residential	41	41	41	41	41
900 block W. Ellsworth Avenue	Residential	3	3	3	3	3
2900 block W. Short Place	Residential	5	5	5	0	0
3300 block W. 5th Avenue	Residential	3	3	3	3	3
919 W. Byers Place	Residential	1	1	1	1	1
Barnum Park	Park	1	1	1	1	1
Barnum East Park	Park	1	1	1	1	1
Barnum North Park	Park	1	1	1	1	1
Frog Hollow Park	Park	1	1	1	1	1
Phil Milstein Park	Park	1	1	1	1	1
Valverde Park	Park	1	1	1	1	1
Habitat Park	Park	1	1	1	1	1
Vanderbilt Park	Park	1	1	1	1	1
Vanderbilt East Park	Park	1	1	1	1	1
South Platte River bike path	Park	1	1	1	1	1
Motel 5	Motel	1	1	0	0	0
Days Inn	Motel	1	1	1	1	1
Rocky Mountain Church of God	Church	1	1	1	1	1
Category C						
I-25/6th Avenue	Commercial	1	2	2	2	2
East of I-25	Commercial	7	7	7	5	5
Post Office Service Center	Commercial	1	1	1	1	1
I-25/Broadway	Commercial	2	2	2	2	2
Santa Fe Drive/Kalamath Street	Commercial	37	44	42	27	28

Noise levels are also estimated to exceed the CDOT NAC at:

- Motel 5 (1101 W. Alameda Avenue)
- Days Inn Motel (620 Federal Boulevard)
- Rocky Mountain Church of God (455 S. Platte River Drive)

However, none of these properties have exterior facilities (e.g., swimming pools) in the impacted areas, so the Category E NAC is more relevant. Standard building construction should be sufficient to reduce interior noise levels to meet Category E NAC criteria, provided windows are not open. It should also be noted that all three System Alternatives remove Motel 5, so it is not a noise concern under the System Alternatives.

Finally, there are several commercial properties with portions estimated to reach or exceed the Category C NAC:

- One business near the I-25/US 6 interchange several businesses along the east side of
- I-25 between 4th Avenue and Virginia Avenue
- The U.S. Postal Service vehicle maintenance facility
- Two businesses near the I-25/Broadway interchange
- Several businesses along Santa Fe Drive/Kalamath Street

Category C areas by definition are less sensitive to traffic noise than Category B.

3.1.2 2025 No Action Traffic Model Results

Model results for 2025 No Action Alternative (see **Figure 10**) are very similar to the existing conditions results (see **Table 4**). Not surprisingly, the traffic noise patterns are similar with the noise contours pushed out a bit farther from the roads due to increased traffic volumes, so the impacted areas are slightly larger overall. The impacts are summarized in **Table 5**. For residences that are more than about 300 feet from I-25 or 6th Avenue, local traffic noise generally is louder than highway traffic noise. The same Category B areas are affected as under existing conditions with approximately 63 residences predicted to be at or above the CDOT Category B NAC. One additional residence on the 800-block of S. Sherman Street may be above the CDOT NAC.

No noise-sensitive areas are expected to experience a 10-dBA increase as the largest increase is predicted to be 3 dBA.

There are several commercial properties with portions estimated to reach or exceed the Category C NAC. It is the same list of affected properties presented in Section 3.1.1 for existing conditions, with one additional business near the I-25/6th Avenue interchange.

3.1.3 2025 System Alternative 1 Traffic Model Results

Model results for 2025 System Alternative 1 (see **Figure 11**) are similar to the 2025 No Action model results (see **Table 4**), even with the proposed roadway changes. The impacts are summarized in **Table 5**. The same Category B areas are affected, however, three additional residences on the 800-block of S. Sherman Street may be above the CDOT NAC. A small noise benefit is realized by grade-separating Santa Fe Drive and Kalamath Street under the railroad for properties adjacent to the underpass. The new fly-over ramps at I-25/Alameda Avenue and I-25/Santa Fe Drive do not impact any neighboring Category B areas, using CDOT/FHWA criteria. Results show that for residences that are more than about 300 feet from I-25 or 6th Avenue, local traffic noise generally is louder than highway traffic noise. Approximately 66 residences are predicted to be at or above the CDOT Category B NAC. No noise-sensitive areas are expected to experience a 10-dBA increase as the largest increase is predicted to be 5 dBA.

There are several commercial properties with portions estimated to reach or exceed the Category C NAC. The same commercial properties would be affected as listed in Section 3.1.2.

3.1.4 2025 System Alternative 2 Traffic Model Results

Model results for 2025 System Alternative 2 (see **Figure 12**) are similar to the 2025 No Action model results (see **Table 4**), even with the proposed roadway changes. The impacts are summarized in **Table 5**. The same Category B areas are affected. A small noise benefit is realized by grade-separating Santa Fe Drive and Kalamath Street under the railroad for properties adjacent to the underpass. A small noise benefit is realized by moving the Federal-to-eastbound-6th ramp closer to 6th Avenue. The new separation of Santa Fe Drive/Kalamath Street over Alameda Avenue does not impact any neighboring Category B areas, using CDOT/FHWA criteria. The new fly-over ramp at I-25/Santa Fe does not impact any neighboring Category B areas, using CDOT/FHWA criteria. For residences that are more than about 300 feet from I-25 or 6th Avenue, local traffic noise generally is louder than highway traffic noise. Approximately 52 residences are predicted to be at or above the CDOT Category B NAC. No noise-sensitive areas are expected to experience a 10-dBA increase as the largest increase is predicted to be 4 dBA.

There are several commercial properties with portions estimated to reach or exceed the Category C NAC. The same commercial properties would be affected as listed in Section 3.1.2. It should be noted that this alternative may remove two buildings near I-25/Bayaud Avenue and the buildings between Santa Fe Drive, Kalamath Street, Bayaud Avenue and Dakota Avenue.

3.1.5 2025 System Alternative 3 Traffic Model Results

Model results for 2025 System Alternative 3 (see **Figure 13**) are similar to the 2025 No Action model results (see **Table 4**), even with the proposed roadway changes. The impacts are summarized in **Table 5**. The same Category B areas are affected. A larger noise benefit than either System Alternatives 1 or 2 is realized by grade-separating Santa Fe Drive and Kalamath Street under both the railroad and Alameda Avenue for properties adjacent to the underpass. A small noise benefit is realized by moving the Federal-to-eastbound-6th ramp closer to 6th Avenue. A localized noise penalty is realized from a realigned ramp at the I-25/Broadway interchange. The new fly-over ramps at I-25/Alameda Avenue and I-25/Santa Fe Drive do not

impact any neighboring Category B areas, using CDOT/FHWA criteria. For residences that are more than about 300 feet from I-25 or 6th Avenue, local traffic noise generally is louder than highway traffic noise. Approximately 56 residences are predicted to be at or above the CDOT Category B NAC. No noise-sensitive areas are expected to experience a 10-dBA increase as the largest increase is predicted to be 8 dBA. The noise increase is greater for System Alternative 3 than the other alternatives because System Alternative 3 realigns an I-25 off-ramp closer to the remaining homes on the 800-block of S. Lincoln Street.

There are several commercial properties with portions estimated to reach or exceed the Category C NAC. The same commercial properties would be affected as listed in Section 3.1.2. It should be noted that this alternative may remove two buildings near I-25/Bayaud Avenue and the buildings between Santa Fe Drive, Kalamath Street, Bayaud Avenue and Dakota Avenue.

3.1.6 Railroad Model Results

Most of the properties adjacent to the railroad in the project corridor are commercial, so the distance from the center of the railroad to an L_{eq} of 71 dBA was used to assess impacts to commercial properties. This noise level corresponds to the CDOT Category C NAC. The distance to the 71 dBA L_{eq} line was calculated for trains with and without locomotive horns sounding. Using the FTA tools, the distance to L_{eq} 71 dBA is 170 feet with train horns and 50 feet without train horns. Numerous commercial buildings are presently within the 170 feet of the rails, while fewer than six commercial buildings north of Alameda Avenue appear to be within 50 feet.

The home nearest the rails is 919 W. Byers Place at a distance of 330 feet. The distance from the center of the railroad to an L_{eq} of 66 dBA was used to assess impacts to residential properties. This noise level corresponds to the CDOT Category B NAC. The distance to the 66 dBA L_{eq} line was calculated for trains with and without locomotive horns. Using the FTA tools, the distance to L_{eq} 66 dBA is 330 feet with train horns (the distance to the nearest home) and 110 feet without train horns.

Under all three System Alternatives, the rails will be grade-separated from Santa Fe Drive and Kalamath Street, which will serve to eliminate the need for train horns in the project corridor and eliminate the noise impacts from them. This is a net noise benefit from the proposed project. The rails are also expected to be relocated approximately 50 feet to the east at two locations: 4th Avenue and Ellsworth Avenue. This move will require removal of some commercial buildings and bring the rails closer to some remaining buildings. This move would add about 3 buildings to the 50-foot commercial impact zone, but the 170-foot impact zone would be eliminated along with the horns. The rail relocation will not affect the distance (or the results) to the nearest homes in the corridor, however, the grade separation would eliminate the 330-foot zone along with the horns and substantially reduce the train noise at homes in the larger area.

Overall, the changes in train noise due solely to the proposed relocation of the rails will be minor because the move is not that great. However, the proposed grade separation would reduce train noise in the larger area by eliminating noise from locomotive horns. The proposed changes would provide a net noise benefit to the larger railroad corridor and no mitigation actions are necessary.

3.2 Mitigation

Noise mitigation evaluations for the project were performed because areas along the project corridor are predicted to be above the applicable CDOT NAC (see **Section 3.1**) under the proposed "action" conditions. This includes multiple geographic areas and multiple land uses. The impacted areas are not guaranteed mitigation measures, but mitigation measures must be evaluated. Typically, noise barriers are the mitigation action evaluated but other kinds of mitigation were also considered. For reasons described below, barriers appeared to be the only viable mitigation action and were the only mitigation evaluated in detail. CDOT's goal for noise barriers is a reduction of 10 dBA with a minimum of 5 dBA.

The locations evaluated for barrier placement are shown in **Figure 15**. To permit the evaluations, barriers protecting each of the impacted areas were developed for the System Alternative computer models and the models were re-run to assess barrier effectiveness. After the minimum parameters for an effective barrier were established in a given area for a feasible barrier (if possible), each barrier was processed through a reasonability assessment according to CDOT guidance (see **Appendix C**). The feasibility and reasonableness of each barrier determined which barriers were recommended.

The topography of the project corridor plays a very important role in the overall noise environment. There are some significant topographic changes from I-25 to the adjoining areas throughout the corridor, and this also has a significant impact on the constructability of noise barriers. Barriers can easily be put into a computer model, but actually placing these barriers in the real world may not always be possible. Because of the topographic changes, a model barrier may not be a constant height throughout its length although the top elevation may be constant. These factors contribute to complication of the barrier evaluations. The barrier evaluations for each impacted area discussed in **Section 3.1** are described below.

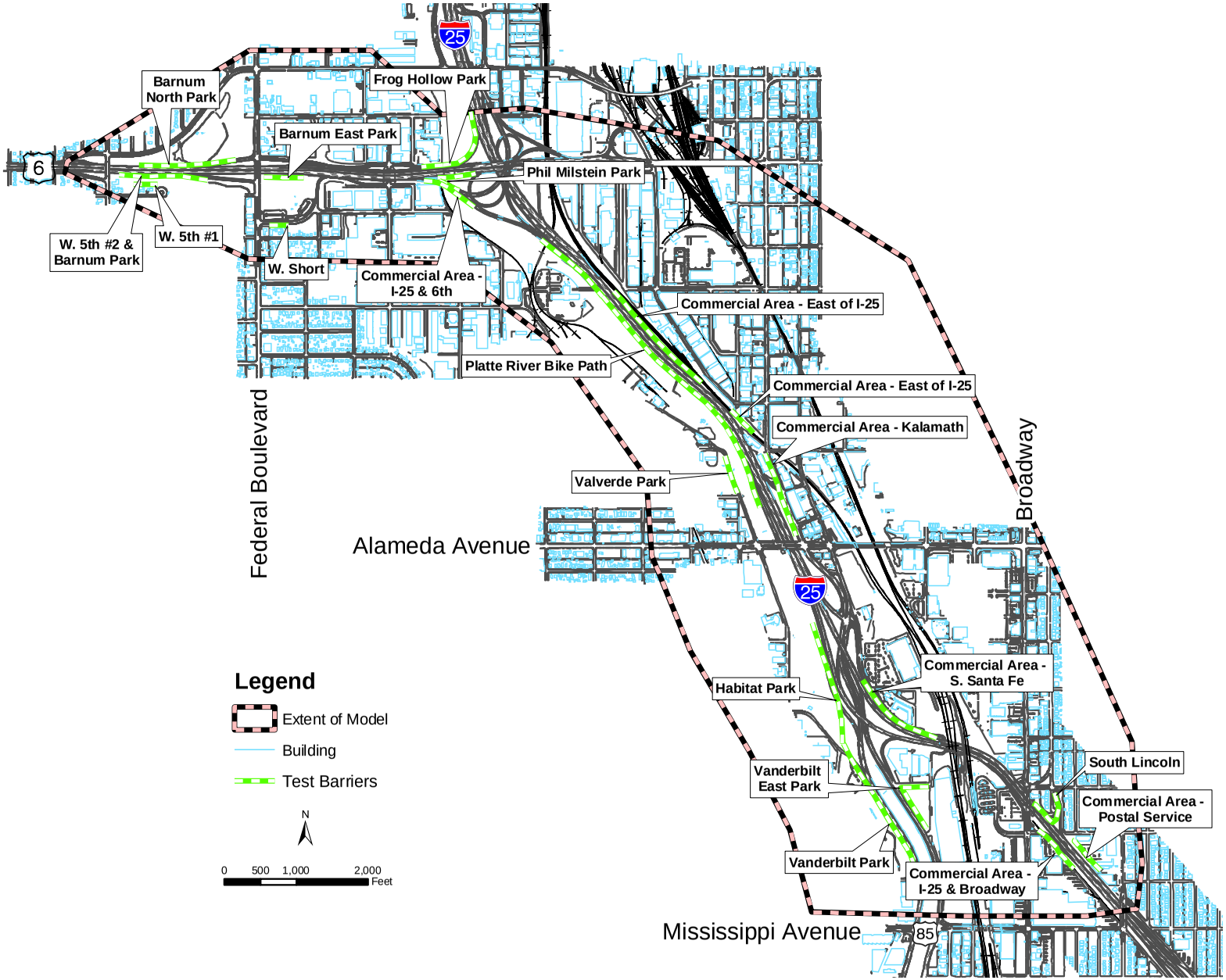
3.2.1 Non-Barrier Mitigation Evaluation

CDOT guidelines require the evaluation of several non-noise-barrier mitigation alternatives. For a variety of reasons that are described below, none of these alternatives appear to be viable for the project corridor.

Traffic management measures such a lane closures or reduced speeds do not appear to be reasonable for the roads of primary interest to the project. One of the stated reasons for the proposed improvements to I-25 is to add lanes to be consistent with adjoining sections of I-25, so closing lanes would be counterproductive. I-25 is a major interstate highway, and while reducing vehicle speeds could reduce traffic noise, it is not consistent with the function of an interstate highway. These same concepts apply to US 6 west of I-25. The other ramps and intersections that are included in the project must operate as safely and efficiently as possible in concert with the project highways and connecting city streets, and are relatively minor noise sources in comparison.

Changes in horizontal and vertical alignments have limited possibilities in the project corridor. Horizontal alignments are severely constrained by the South Platte River and the complete development of land adjacent to the project highways. Moving the highways horizontally could conceivably reduce noise impacts to the impacted areas but could transfer the impacts to other neighboring areas and require disruptions of adjoining property uses. Changes in vertical

Figure 15 Mitigation Barriers Evaluated



alignments are being considered in the EIS as alternatives for some parts of the project corridor. Santa Fe Drive and Kalamath Street are being considered for grade separation from Alameda Avenue and the railroad, and noise reductions could be realized from some of the alternatives. Other parts of the project corridor have fewer possibilities for vertical alignment. Logically, the most beneficial change regarding traffic noise would be to lower the roads into cuts like the I-25 “narrows,” but the Broadway viaduct is being rebuilt now as a separate project and its final elevations cannot be changed under the EIS. Other parts of the corridor involve multi-level interchanges and the various roadbed levels must tie back to the connecting road network in a reasonable manner. Some of the project corridor has hazardous material, groundwater quality and subsurface utility conflicts if roads are lowered, so vertical re-alignment for noise mitigation is problematic in that it could cause other types of environmental impacts. Therefore, the horizontal and vertical alignments are being evaluated under the EIS, but there are few opportunities available solely to reduce traffic noise.

There really is no available undeveloped land along the project highways that could be used for a noise buffer zone or a vegetative planting area that would provide significant noise benefit. None of the privately-owned buildings are calculated to be so severely impacted by traffic noise that noise insulation measures are justified.

Pavement types and surfaces were a significant discussion topic throughout the EIS. CDOT has stated that quieter pavement types will be preferred for the project corridor when minimum requirements for safety, durability, etc. are also met. So pavement type may be available to help reduce traffic noise in the corridor. However, this cannot be counted as a mitigation action under the noise reduction evaluation, so this will be an “unofficial” noise reduction action if it can be accommodated.

3.2.2 800 Block of S. Sherman Street

The southernmost homes of the 800-block on the west side of S. Sherman Street are some of the residences closest to I-25 throughout the entire project corridor. There presently is a wooden noise barrier between these homes and I-25. This area and its barrier were previously evaluated as part of the T-REX project and a new 12-foot-high barrier is planned to replace the wooden barrier under T-REX. As a new noise mitigation action is already planned for this area, further evaluation was not performed as part of this study.

As an additional evaluation measure, a 12-foot tall barrier on the I-25 viaduct over Broadway was modeled. This barrier did not measurably reduce noise levels in the adjacent neighborhood.

3.2.3 South Lincoln Street

For purposes of this discussion, this area is being divided into two subareas: north of Ohio Avenue and south of Ohio Avenue. The north area is discussed first.

3.2.3.1 NORTH OF OHIO AVENUE

Section 3.1 described how essentially all residences on S. Lincoln Street north of Ohio Avenue will have noise levels above the NAC, due to the traffic on Lincoln Street. Because Lincoln Street is a major arterial street in Denver, this condition will remain unchanged whether project improvements are built or not. Furthermore, it is not feasible to construct a noise barrier to

protect these homes from traffic noise from Lincoln Street as a barrier would cut off front access to these homes. This area is a mature urban neighborhood where Lincoln Street serves as one of the neighborhood streets. Separating residences from their neighborhood streets with a barrier is not a desirable action. Even a barrier along the south side of 794 S. Lincoln Street to reduce I-25 noise is not warranted because it would do little to reduce traffic noise from Lincoln Street or the off ramp, the major noise sources to the residence. Therefore, no noise barriers are recommended for any residences on S. Lincoln Street north of Ohio Avenue.

3.2.3.2 SOUTH OF OHIO AVENUE

Lincoln Street south of Ohio Avenue in the Study Area consists solely of the homes on the 800 block. Along with the homes on S. Sherman Street, these homes are the closest residences to I-25 in the entire project corridor. This is an unusual area as this block is literally surrounded by busy roads and streets. The homes on this block also have an uncertain future under the EIS, as their future status could range from being completely untouched to being completely removed, depending on the alternative. Noise barriers for this block were considered for each System Alternative.

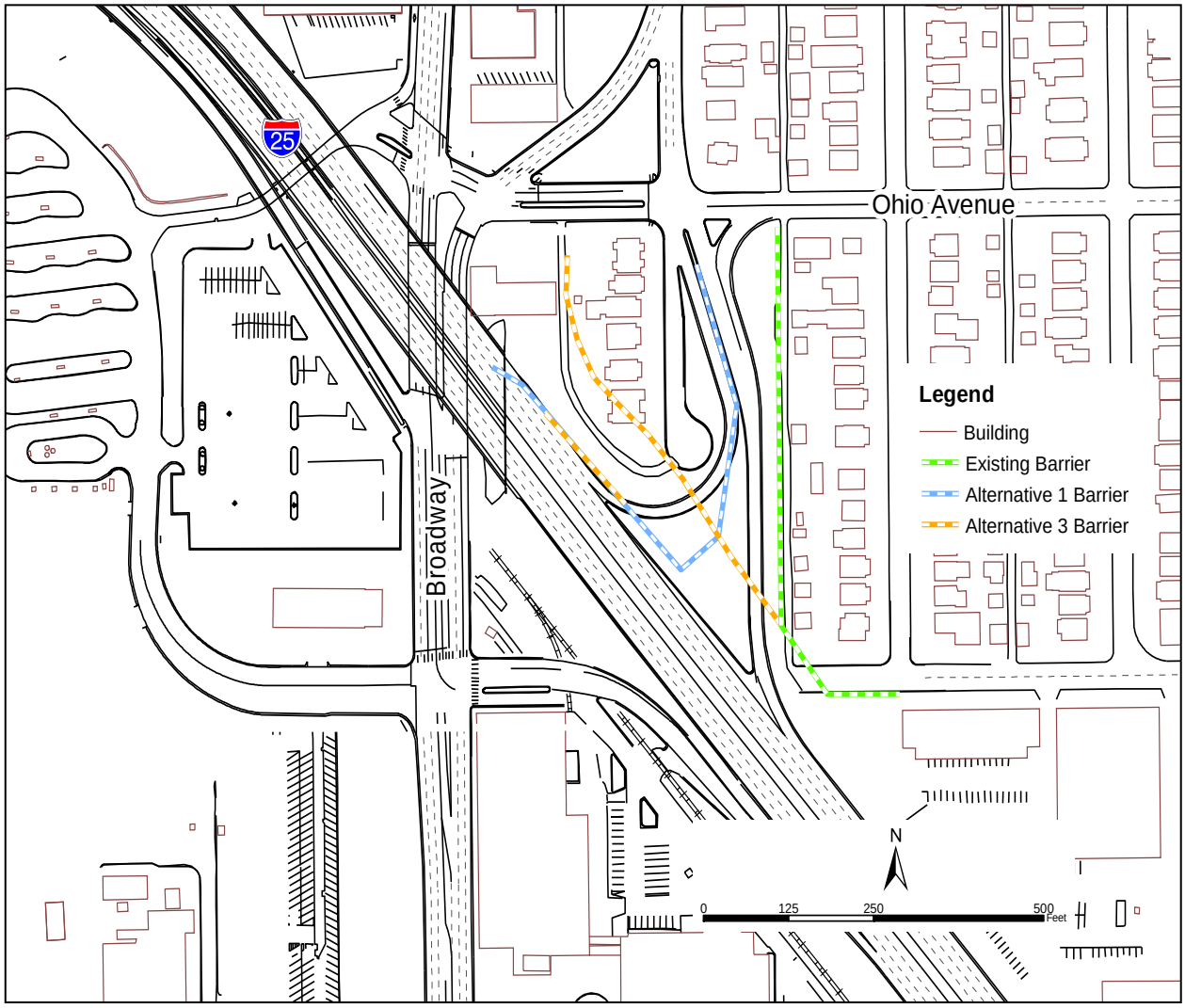
With the complex traffic noise situation in this area, a 10-dBA noise reduction could not be achieved short of completely encircling the homes with barriers, which is not acceptable. Therefore, mitigation for a 10-dBA noise reduction is not discussed further. The minimum 5-dBA noise reduction is feasible.

Under System Alternative 1, none of the homes on this block will be physically disturbed. This alternative will leave the future roads similar to the current roads. A barrier was modeled in a semicircle between the homes and both I-25 and the future off-ramp (see **Figure 16**). With the current understanding of future ground contours, a continuous barrier varying in height from 6 to 8 feet and 840 feet long will provide a 5-dBA noise reduction for most of the homes on the block. The cost/benefit calculation for this barrier was in the unreasonable category following CDOT guidelines. However, the noise abatement barrier is recommended, given the unusual circumstances of these houses being closely surrounded by busy streets.

Under System Alternative 2, all of the homes on this block will be removed. Therefore, no mitigation for this block is necessary under this alternative.

Under System Alternative 3, the two southernmost homes on this block will be removed; the other homes on the block will remain. The I-25 off-ramp will be relocated from the east to west sides of the homes. Two barriers were necessary between the remaining homes and I-25 and the off-ramp (see **Figure 16**) to provide a 5-dBA noise benefit. The first barrier abuts the existing T-REX barrier and parallels the off-ramp toward Lincoln Street. The second barrier is on the north edge of I-25 between I-25 and the off-ramp and abuts the viaduct. With the current understanding of future ground contours, the first barrier varies in height from 8 to 10 feet for 840 feet while the second barrier is 5 feet high for 170 feet. The cost/benefit calculation for this barrier was in the unreasonable category of CDOT guidelines. However, the noise abatement barriers are still recommended, given the unusual circumstances of these houses.

Figure 16 South Lincoln Street Mitigation Barriers



3.2.4 900 Block of W. Ellsworth Avenue

Section 3.1 described how the residences on W. Ellsworth Avenue will have noise levels above the NAC. This condition will remain unchanged whether the proposed project is built or not. Furthermore, it is not feasible to construct a noise barrier to protect these homes from traffic noise from Ellsworth Avenue, Santa Fe Drive and Kalamath Street as a barrier would cut off access to these homes or the neighboring commercial properties. This is a mixed-use area and the traffic noise comes from the local streets. There is no alley access in this area. Separating the residences from their neighborhood streets with a barrier is an unacceptable action. Therefore, no noise barrier walls are recommended for the homes on the 900-block of W. Ellsworth Avenue.

3.2.5 919 W. Byers Place

Section 3.1 described how 919 W. Byers Place will have noise levels above the NAC. This condition will remain unchanged whether the proposed project is built or not. Furthermore, it is not feasible to construct a noise barrier to protect this home from traffic noise from Byers Place, Santa Fe Drive and Kalamath Street as the house is surrounded by commercial area parking and a barrier would cut off access to the home. This house is isolated in a commercial area and the noisy streets also serve as the neighborhood streets. Separating the residence from the neighborhood streets with a barrier wall is an unacceptable action. Therefore, no noise barrier walls are recommended for 919 W. Byers Place.

3.2.6 2900 Block of W. Short Place

Section 3.1 described how four residences on W. Short Place will have noise levels above the NAC due to the traffic on the ramp from Federal Boulevard to eastbound 6th Avenue. There currently are small fences at the rear of these properties facing the ramp. Replacing these fences with a barrier approximately 8 feet by 260 feet will (see **Figure 17**) provide a 5-dBA noise reduction for these properties and this barrier was found to be both feasible and reasonable. To achieve a 10-dBA noise reduction at this position, a barrier 25 feet tall and 420 feet long was necessary, which was found to be unreasonable. The 8-foot barrier is being recommended only for System Alternative 1. System Alternatives 2 and 3 will relocate this ramp closer to 6th Avenue and remove the traffic noise impact from these homes, so this barrier is not needed for System Alternatives 2 or 3.

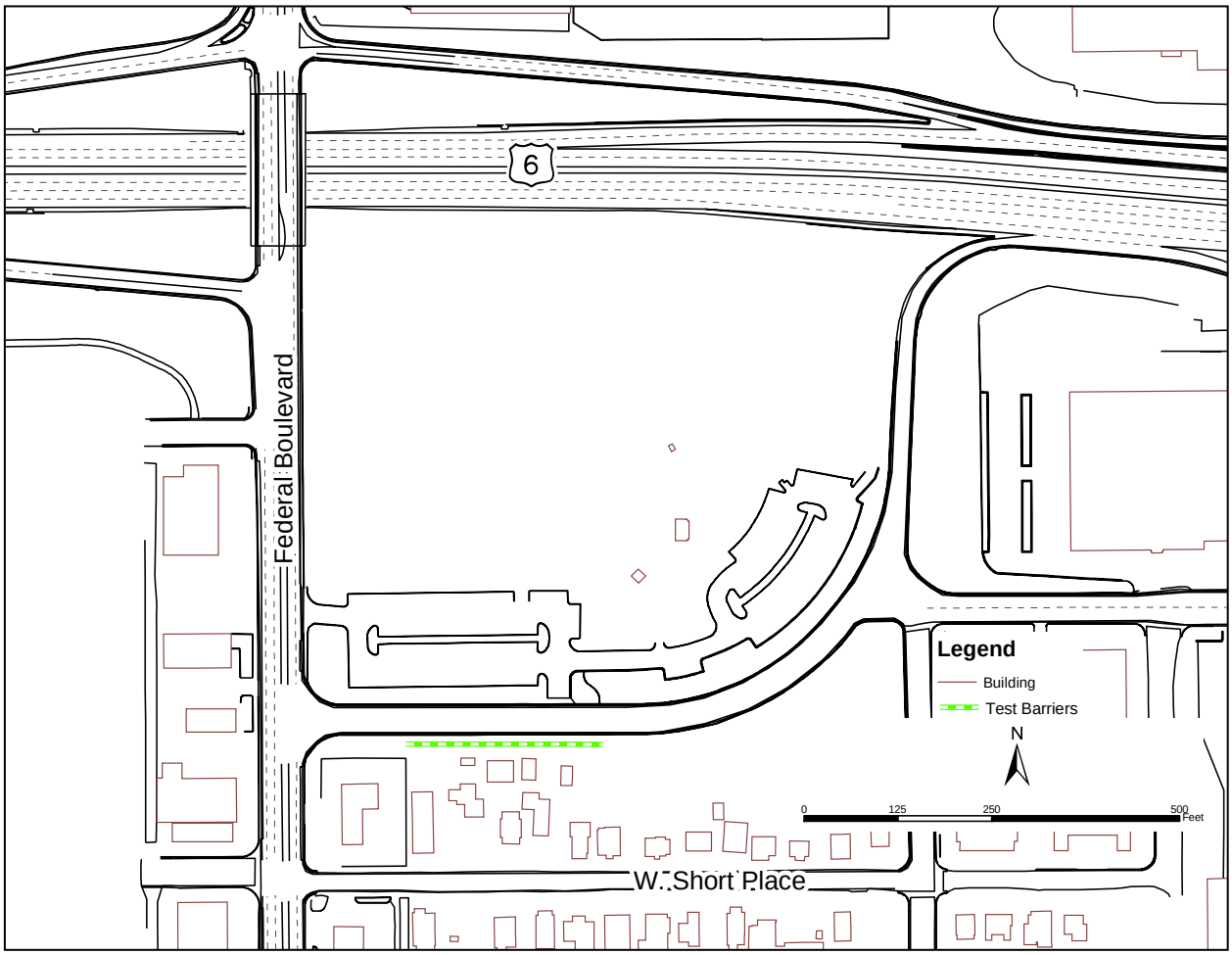
3.2.7 3300 Block of W. 5th Avenue

Section 3.1 described how three residences on W. 5th Avenue will have noise levels above the NAC. This condition is due to the traffic on 6th Avenue, across a narrow finger of Barnum Park. There currently are small fences at the rear of these properties facing 6th Avenue.

Two barrier positions were evaluated for these homes. Replacing the existing fences with a barrier approximately 10 feet by 300 feet was calculated to provide a 5-dBA noise abatement for these properties (see **Figure 18** Barrier #1). A 25-foot-tall barrier at this position was insufficient to provide a 10-dBA reduction, so a 10-dBA reduction does not appear to be feasible. The second barrier position was along the 6th Avenue right of way (see **Figure 18** Barrier #2). This barrier would be 870 feet long by 12-14 feet tall to provide a 5-dBA noise reduction. This barrier does not provide a 10-dBA noise reduction even if it is 25 feet tall.

The cost/benefit value for barriers in both positions was found to be higher than the guidelines suggest is reasonable (see **Appendix C**). The cost/benefit for Barrier #2 was calculated to be $23,000/dBA/receiver and this barrier is not recommended. It is not clear at this time if Barrier #1 is truly feasible because its position is between the homes and Barnum Park and is not in road right of way. If right-of-way cannot be obtained for this location, this barrier is not feasible and not recommended. Barrier #1 is suggested for further evaluation when an alternative has been selected.

Figure 17 West Short Place Mitigation Barrier



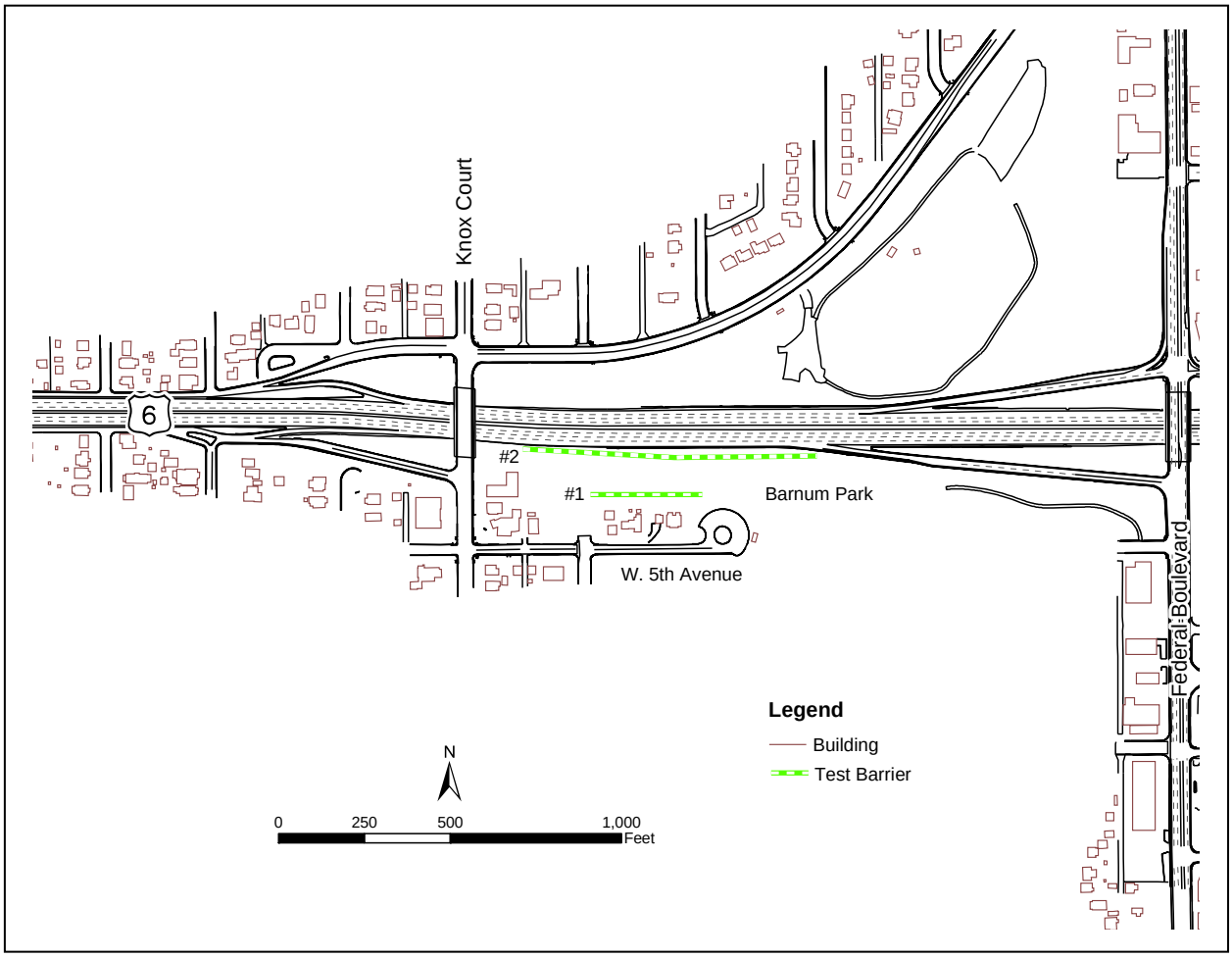
3.2.8 Barnum Park

The northern portion of Barnum Park along 6th Avenue will have noise levels above the NAC. A barrier between 6th Avenue and the park was evaluated. A 5-dBA noise reduction required a barrier at least 10-11 feet high by 1200 feet long, however, it would provide relatively little benefit. The affected area does not contain primary park facilities and most park activity appears to be in an area not impacted by traffic noise. This barrier is not being recommended.

3.2.9 Barnum East Park

This park is situated between 6th Avenue, Federal Boulevard and an on-ramp. All four sides of the park are predicted to exceed the NAC, although the south side is a parking lot. Part of the park may be lost to ramp relocation with System Alternatives 2 and 3. Modeling indicated that the park would essentially need to be surrounded by barriers to achieve a 5-dBA noise reduction for all of the alternatives. This was assessed to be infeasible. Therefore, no barrier is recommended for this park.

Figure 18 West 5th Avenue Mitigation Barrier



3.2.10 Barnum North Park

The southern portion of Barnum North Park along 6th Avenue will have noise levels above the NAC. A barrier between 6th Avenue and the park was evaluated. A 5-dBA noise reduction required a barrier at least 14 feet high by 1350 feet long, however, it would provide relatively little benefit. The affected area does not contain primary park facilities (mainly a parking lot) and most park activity appears to be in areas not impacted by traffic noise. This barrier is not being recommended.

3.2.11 Frog Hollow Park

This park extends to the north, outside the primary study area of the EIS. It is mainly this northern portion of the park along I-25 that is impacted by traffic noise, although a southern portion along 6th Avenue is also impacted. It was concluded that a noise abatement barrier should protect the entire park, so that was the condition evaluated. A 5-dBA noise reduction required a barrier approximately 8 feet high by 1500 feet long and was found to be unreasonable. This barrier is not being recommended.

3.2.12 Phil Milstein Park

The northern portion of the park along 6th Avenue will have noise levels above the NAC. A barrier between 6th Avenue and the park was evaluated. This area primarily lies within the footprint of the busy I-25/6th Avenue interchange and serves primarily as a conduit for the South Platte River bike path. A 5-dBA noise barrier would need to be in two pieces totaling 6 feet high by 850 feet long, however, it would provide relatively little benefit in the center of a major highway interchange. A 1-meter-high jersey barrier along the south edge of the ramp is sufficient to protect the park area south of the ramp. The affected area does not contain primary park facilities and most park activity appears to be in an area not impacted by traffic noise. This barrier is not being recommended.

3.2.13 Valverde Park

The eastern portion of Valverde Park along Platte River Drive will have noise levels above the NAC. A barrier between Platte River Drive and the park was evaluated. A 5-dBA noise reduction required a barrier 10 feet high by 550 feet long, however, it would provide relatively little benefit. The park ball field appears to be beyond the benefit area because of the distance. The barrier would cut off a major access point from Platte River Drive and would obstruct access from the park to the bike path and South Platte River. This barrier is not being recommended.

3.2.14 Habitat Park

The western portion of Habitat Park will have noise levels above the NAC due to traffic on I-25 and Jason Street. Effective noise reduction would require barriers along both I-25 and Jason Street, effectively surrounding the park with barriers. This is not a feasible situation as it would cut off most access to the park, so these barriers are not being recommended.

3.2.15 Vanderbilt Park

The eastern portion of Vanderbilt Park along Santa Fe Drive will have noise levels above the NAC. A barrier between Santa Fe Drive and the park was evaluated. A 5-dBA noise reduction required a barrier 6-7 feet high by 2100 feet long; however, it would provide relatively little benefit. This barrier is not being recommended.

3.2.16 Vanderbilt East Park

The western portion of Vanderbilt East Park along Santa Fe Drive will have noise levels above the NAC. It should be noted that this park has no park facilities and resembles an undeveloped lot; it is isolated in a warehouse district. A barrier between Santa Fe Drive and the park was evaluated. A 5-dBA noise reduction required a barrier to cover 2 of the 3 sides of the park and be 14 feet high by 1050 feet long. It would provide relatively little benefit. This barrier is not being recommended.

3.2.17 Motel 5

The Motel 5 property (1107 W. Alameda Avenue) was calculated to have noise levels above the NAC. However, the motel is targeted for removal under all three of the System Alternatives. Therefore, no mitigation is recommended for this location.

3.2.18 Days Inn Motel

The extreme southern edge of the Days Inn Motel property (620 Federal Boulevard) overlooking 6th Avenue was calculated to have noise levels above the NAC. This area is primarily for car parking without any other visible exterior uses. This side of the motel building holds a relatively small portion of the motel rooms and it serves as a noise barrier for the rest of the motel. There are only a couple of ground level rooms with exterior access on this side of the motel. Therefore, no mitigation is recommended for this location.

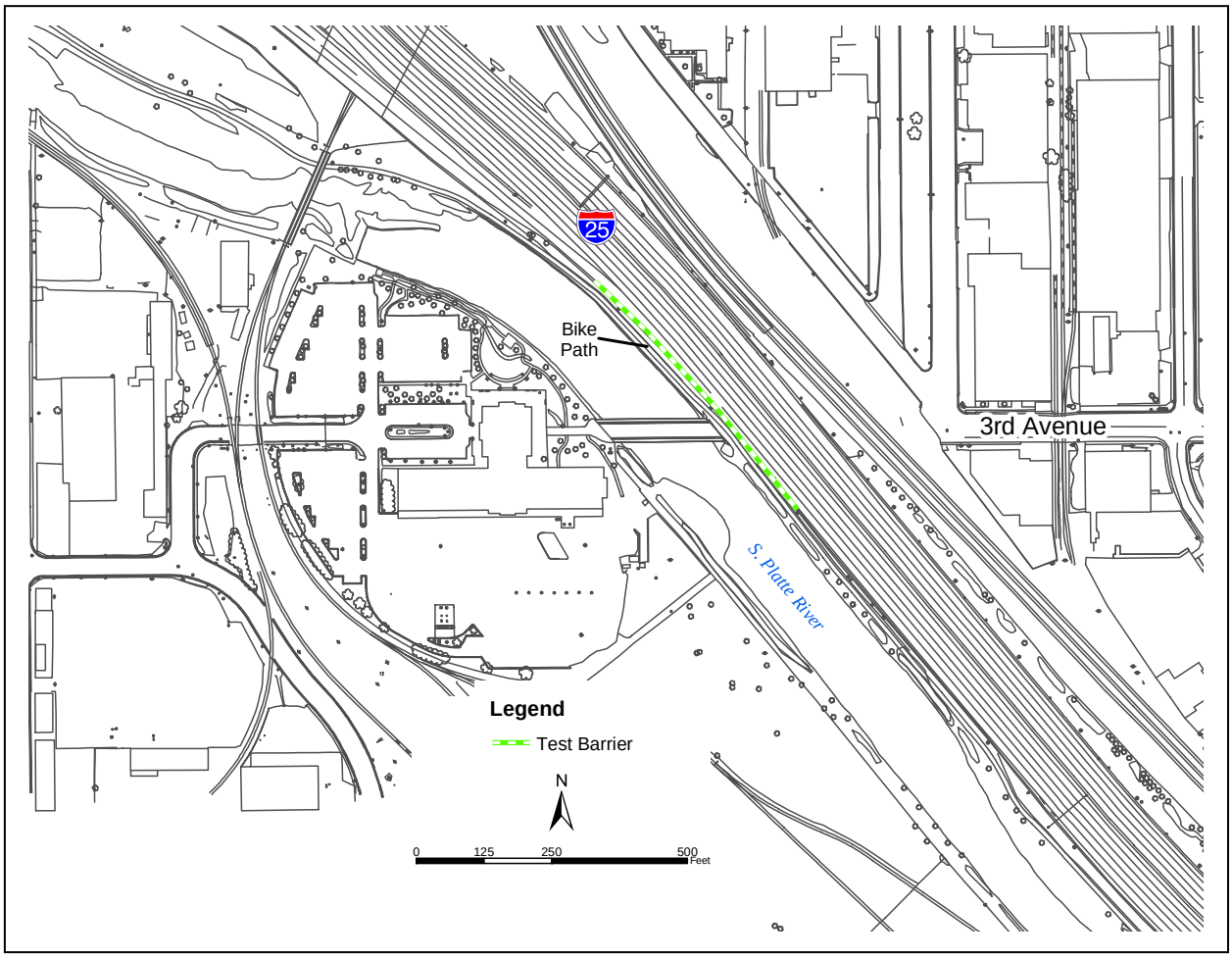
3.2.19 Rocky Mountain Church of God

The Rocky Mountain Church of God (455 S. Platte River Drive) was calculated to have noise levels above the NAC. The church is close to the street and is surrounded by paved parking lots. There are two curb cuts close to the building providing access to these parking lots that prevent construction of a continuous barrier. There are no major exterior uses apparent at the church. Because of the property layout, any noise barrier would necessarily need to be very close to the church building, which would protect relatively little area and provide little benefit. Standard building construction should be sufficient to provide interior noise levels that comply with the NAC. Therefore, no mitigation is recommended for this location.

3.2.20 South Platte River Bike Path

Parts of the South Platte River bike path were calculated to have noise levels that exceed the Category B NAC. The portion of the bike path covered by this evaluation is the section between Phil Milstein Park and Alameda Avenue. For most of this length, the bike path is along the river at a lower elevation than I-25. To protect this entire length of the bike path, a barrier 12 feet high by 2100 feet long would be needed to provide a 5-dBA noise reduction. This barrier was found to be too costly for the benefit provided and, therefore, is not being recommended. However, there is a shorter segment of the bike path at 3rd Avenue where the path is at the same elevation as I-25 and as little as 10 feet from I-25 traffic. This segment is very noisy and could be made safer. For this segment of the bike path, a barrier 9 feet high by 500 feet long (see **Figure 19**) could provide more than 5 dBA of noise reduction and could provide a safety benefit to bicyclists. (A 13-foot barrier could provide 10-dBA of noise reduction on the bike path.) This barrier is recommended.

Figure 19 Bike Path Mitigation Barrier



3.2.21 Various Commercial Areas

Several commercial properties were described in **Section 3.1** that were calculated to exceed the Category C NAC. The System Alternatives may require removal of several commercial buildings that otherwise could be impacted. Noise mitigation barriers were evaluated for each of the impacted areas. However, businesses tend not to want noise barriers as they could obstruct advertising or site recognition and could cause site access problems. Normally, commercial areas do not have noise-sensitive exterior property uses. Typically, noise barriers are recommended for commercial areas only under extraordinary conditions, but no such conditions were observed for the affected properties. As is often the case with commercial areas, the mitigation costs were calculated to be excessive for the benefit that would be provided. Therefore, no mitigation is recommended for any of the affected commercial areas.

3.3 Construction Noise

Adjoining properties in the project area would be exposed to noise from I-25 construction activities when the proposed project is built. Construction noise differs from traffic noise in several ways:

- Construction noise lasts only for the duration of the construction event, with most construction activities in noise-sensitive areas being conducted during hours that are least disturbing to adjacent and nearby residents;
- Construction activities generally are of a short-term nature, and depending on the nature of the construction operations, could last from seconds (e.g., a truck passing a receptor) to months (e.g., constructing a bridge); and
- Construction noise also is intermittent and depends on the type of operation, location, and function of the equipment, and the equipment usage cycle. Traffic noise, on the other hand, is present in a more continuous fashion after construction activities are completed.

Construction noise impacts will be minimized somewhat by the fact that very little of the project corridor abuts residential areas. To address the temporary elevated noise levels that may be experienced during construction, standard mitigation measures should be incorporated into construction contracts. These would include:

- Exhaust systems on equipment will be in good working order. Equipment will be maintained on a regular basis, and equipment may be subject to inspection by the project manager to ensure maintenance.
- Properly designed engine enclosures and intake silencers will be used where appropriate.
- New equipment will be subject to new product noise emission standards.
- Stationary equipment will be located as far from sensitive receivers as possible.
- Most construction activities in noise sensitive areas will be conducted during hours that are least disturbing to adjacent and nearby residents.

In addition, construction noise from future project activities must comply with the City and County of Denver noise ordinance (Chapter 36 of the Municipal Code). Construction noise that complies with the noise ordinance can be viewed as not having an impact on neighboring properties. If a construction activity must occur at night and is likely to violate the noise ordinance, an impact is possible. Such a situation will require a variance from the City and County of Denver. As part of the variance, the City and County of Denver typically requires specific mitigation actions and monitoring to ensure that impacts are minimized. Compliance with future noise variance requirements, if any, could be viewed as not having a significant impact on neighboring properties. No additional mitigation would be necessary.

3.4 Nuisance Noise Considerations

The noise Citizen's Working Group for the EIS provided a means for neighbors of the Valley Highway project corridor and interested citizens to express issues and concerns to CDOT. The members of the Citizens Working Group made clear that noise from the project corridor is a major concern to them.

Noise impacts were examined as a standard part of the EIS in accordance with CDOT/FHWA guidelines. These guidelines specify that a noise impact occurs when a property approaches or exceeds the NAC specific to the property use, or when a property will experience a noise increase of 10 dBA or more. The guidelines further specify that impacted properties be evaluated for noise mitigation measures on the basis of feasibility and reasonableness of the mitigation measure. Specific noise mitigation measures (i.e., barriers) may or may not be recommended based on this mitigation evaluation. Properties that do not fit the definition of a noise impact typically are not considered for noise mitigation.

Members of the Citizens Working Group made clear that they are bothered by traffic noise from the Valley Highway corridor, even if the sound levels are less than those specified in the CDOT/FHWA guidance. Working Group members were very interested in trying to reduce this "nuisance noise" that is not captured by the typical CDOT/FHWA noise analysis process. For purposes of this discussion, the "nuisance noise" of interest includes the following characteristics:

- Encompasses noise from traffic
- Is below CDOT/FHWA NAC levels
- Bothers/annoys people
- Interferes with quality of life
- Includes low-frequency sounds not adequately covered by A-weighted sound levels (i.e., C-weighted sounds)
- Impacts property values

In light of this, the Citizens Working Group developed the following suggestions to be considered to reduce "nuisance noise" and improve the quality of life for neighbors of the project corridor.

- **Alternative Selection** – Consider the alternative or improvement that has the least impacts from a noise perspective as evaluation criteria.
- **Pavement Type** – Choose the quietest pavement type throughout the corridor that can meet the safety and durability requirements. Stone mastic asphalt, which has been selected for use on the I-25/Broadway viaduct currently being replaced, was provided as an example of a quieter pavement type.
- **Taller Barriers** – Use the taller Type 7 jersey barriers or similar in the corridor to maximize noise reduction benefits from these necessary project components.
- **Absorptive Material** – Use sound-absorptive material wherever possible in the project corridor. This includes pavement type and vegetation.

- **Aesthetic Treatment/Landscaping** – Use aesthetic treatments and landscaping in the project to reduce traffic noise where possible. Combine visual treatments with noise-reducing properties, such as rough/uneven surfaces that reflect less sound rather than flat surfaces. Use earthen berms where possible. Use multipurpose barriers wherever possible, e.g. traffic control and noise reduction. Coordinate planning and design so that noise reduction actions are considered throughout the corridor.
- **Focused Actions** – Focus noise reduction actions to provide the most benefit to the most sensitive noise receptors.

In response to these concerns and suggestions, CDOT has agreed to consider additional noise reduction measures through project design. These are not viewed as mitigation actions and are not directed toward the traffic-noise-impacted properties. These are project enhancements that may be implemented as feasible to address concerns that are beyond the project impacts and project mitigation actions. Therefore, for project enhancement and betterment purposes, CDOT will evaluate the technological and economic feasibility of the following actions in final design of the Valley Highway project:

- Adopt traffic noise reduction as a goal in project development
- Evaluate noise barriers and other noise reduction techniques
- Examine noise impacts from a broader perspective
- Plan for noise reduction actions comprehensively throughout design
- Include noise-reducing technologies systematically

3.5 Summary

The recommendations provided in **Section 3.2** and summarized here are based on assumed specific project layouts. If the final layouts in the future differ from that assumed in these evaluations, corresponding adjustments to the mitigation evaluations may be required. From the feasibility and reasonableness evaluations for the barriers, highway traffic noise barriers are recommended between traffic and receivers for the following locations:

- 800-block of S. Lincoln Street for System Alternatives 1 and 3 (see **Figure 16**)
- 2900-block of W. Short Place for System Alternative 1 (see **Figure 17**)
- S. Platte River bike path at 3rd Avenue for all System Alternatives (see **Figure 19**)

In addition, a barrier is recommended for further study for the 3300-block of W. 5th Avenue (see **Figure 18** Barrier #1) when an alternative has been selected to see if the barrier is feasible and reasonable. The overall noise barrier findings are summarized in **Table 6**. Estimated traffic noise reductions from barriers that are recommended or suggested for further study are summarized in **Table 7**.

Table 6 Noise Mitigation Barrier Summary

Noise Impacted Area	Barrier Length (feet)	Barrier For 5 dBA Noise Reduction					Barrier For 10 dBA Noise Reduction				
		Barrier Height (feet)	Feasible?[1]	Reasonable?[1]	Recommended?	Comment	Barrier Height (feet)	Feasible?[1]	Reasonable?[1]	Recommended?	Comment
Category B											
800 block S. Sherman Street	NA	NA	NA	NA	NA	This area is covered by a new T-REX barrier.	NA	NA	NA	NA	This area is covered by a new T-REX barrier.
800 block S. Lincoln Street-Alternative 1	840	6-8	Yes	No	Yes	Cost/benefit is high but still recommended.		No		No	10 dBA reduction could not be achieved.
800 block S. Lincoln Street-Alternative 3	1010	5-10	Yes	No	Yes	Cost/benefit is high but still recommended.		No		No	10 dBA reduction could not be achieved.
500-799 S. Lincoln Street	NA	NA	No		No	A noise barrier would prohibit access to the homes.		No		No	A noise barrier would prohibit access to the homes.
900 block W. Ellsworth Avenue	NA	NA	No		No	A noise barrier would prohibit access to the homes.		No		No	A noise barrier would prohibit access to the homes.
2900 block W. Short Place-Alternative 1	260	8	Yes	Yes	Yes	For Alternative 1 only.	25	Yes	No	No	This barrier needed to be 420 feet long.
3300 block W. 5th Avenue	300	10	Yes	No	No	Needs further study when alternative is selected.		No		No	10 dBA reduction could not be achieved.
919 W. Byers Place	NA	NA	No		No	A noise barrier would prohibit access to the home.		No		No	A noise barrier would prohibit access to the home.
Barnum Park	1200	10-11	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Barnum East Park	NA	NA	No		No	Could not achieve 5-dBA reduction.					Not analyzed.
Barnum North Park	1350	14	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.

Table 6 Noise Mitigation Barrier Summary *(continued)*

Noise Impacted Area	Barrier Length (feet)	Barrier For 5 dBA Noise Reduction					Barrier For 10 dBA Noise Reduction				
		Barrier Height (feet)	Feasible?[1]	Reasonable?[1]	Recommended?	Comment	Barrier Height (feet)	Feasible?[1]	Reasonable?[1]	Recommended?	Comment
Frog Hollow Park	1500	8	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Phil Milstein Park	850	6	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Valverde Park	550	10	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Habitat Park	NA	NA	No		No	A noise barrier would prohibit access to the park.					Not analyzed.
Vanderbilt Park	2100	6-7	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Days Inn	NA	NA	No		No	No exterior uses in the impacted area.					Not analyzed.
Vanderbilt East Park	1050	14	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Platte River bike path	2100	12	Yes	No	No	Barrier provides relatively little benefit.					Not analyzed.
Platte River bike path at 3rd Avenue	500	9	Yes	No	Yes	Cost/benefit is high but still recommended	13	Yes	No	No	Cost/benefit is too high
Motel 5	NA	NA	NA	NA	NA	All System Alternatives remove this motel					Not analyzed.
Rocky Mountain Church of God	NA	NA	No		No	Barrier conflicts with access; no exterior uses.					Not analyzed.
Category C											
I-25/6th Avenue	750	6-9	Yes	No	No	Cost/benefit is too high.					Not analyzed.
East of I-25	2200	10	Yes	No	No	Cost/benefit is too high.					Not analyzed.
Post Office Service Center	580	9	Yes	No	No	Cost/benefit is too high.					Not analyzed.
I-25/Broadway	725	11-14	Yes	No	No	Cost/benefit is too high.					Not analyzed.
Santa Fe Drive/Kalamath Street	NA	NA	No			Could not get 5 dBA reduction. Barrier blocking noise also blocks property access.					Not analyzed.
S. Santa Fe/I-25	1300	5-12	Yes	No	No	Cost/benefit is too high.					Not analyzed.

[1]According to CDOT guidelines (CDOT, 2002a). NA - not applicable

Table 7 Modeled Noise Mitigation Reductions

Model Receiver (Figure 8)	2025 System Alternative 1 Noise Level (dBA)		
	Without Barrier	With Barrier	Reduction
RB1	72	65	7
RB2	71	65	6
RB3	70	67	3
RB4	68	67	1
RB5	69	68	1
RB6	75	64	11
RF1	69	62	7
RF2	68	62	6
RF3	68	63	5
RF4	68	64	4
RF5	68	66	2
RF6	70	62	8
P15	68	61	7
P11	75	66	9
R9	68	65	3
R10	67	60	7
R11	66	59	7

4.0 VIBRATION

4.1 Vibration Impact Criteria

Vibration from trains has the potential to be noticeable and intrusive to people in buildings. There has been limited research of how people respond to vibration from trains. With greater densification of land use, more knowledge is being gained on how communities react to various levels of building vibration. This knowledge along with the available national and international standards represents a good foundation for predicting the impact from vibration caused by passing trains.

The impact criteria for people in buildings subjected to ground-borne vibration and noise from trains shown in **Table** (FTA 1995). Vibration Category 3 includes schools, churches, other institutions and quiet offices that do not have vibration-sensitive equipment, but still have the potential for interference of functions. While it is generally appropriate to include office buildings in this category, it is not appropriate to include all buildings that have any office space. For example, most industrial buildings contain office space, but buildings primarily industrial in nature are not intended to be included in this category. As a comparison, industrial buildings are often categorized in the "ISO Workshop" environment with a threshold of 90 velocity decibels (Vdb) (ISO 6897-1984(E)).

Table 8 Ground Borne Vibration Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels (Vdb relative to 1 microinch/sec)	
	Frequent[1] Events	Infrequent[2] Events
Category 1: Buildings where low ambient vibration is essential for interior operations	65 Vdb[3]	65 Vdb[3]
Category 2: Residences and buildings where people normally sleep	72 Vdb	80 Vdb
Category 3: Institutional land uses with primarily daytime use.	75 Vdb	83 Vdb

[1] "Frequent" is defined as more than 70 vibrations per day. Most rapid transit falls into this category.
[2] "Infrequent" is defined as less than 70 vibrations per day. This category includes most commuter rail systems.
[3] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration sensitive manufacturing or research land uses will require detailed evaluation to define the acceptable vibration levels.

Although the impact thresholds given in **Table** are based on experience with vibration from rail transit systems, they can be applied to freight train vibrations as well.

4.2 Vibration Impact Assessment

The potential vibration impacts associated with the Valley Highway EIS corridor are described below. Highway traffic and maintenance facility activities typically do not generate significant vibration, so the vibration assessment focused on the relocation of the consolidated mainline railroad corridor that is directly east of and parallel to I-25 from Alameda Avenue to the 6th Avenue interchange (see **Figure 20**). The analysis was conducted according to the FTA's guidelines because FHWA does not have specific standards or analytical procedures for addressing vibration from transportation or railroad sources.

Figure 20 Railroad Corridor Relocation Area

The vibration analysis was carried out using FTA's preliminary screening and general assessment procedures. **Table** lists the FTA screening distances from commuter railroads where ground-borne vibration impacts are possible for various land uses. Buildings or property beyond the screening distances from the railroad are unlikely to be impacted by vibration and require no further analysis. FTA does not include freight trains as a type of project to assign screening distances, therefore, the conventional commuter rail project values were used (see **Table**).

Table 9 FTA Screening Distances for Conventional Commuter Rail

Category		Distance to no impacts (feet)
Category 1:	Buildings where low ambient vibration is essential for interior operations	600
Category 2:	Residences and buildings where people normally sleep	200
Category 3:	Institutional land uses with primarily daytime use.	120

The buildings closest to the railroad in the rail relocation area are shown in **Figure 20**. These 14 buildings are all industrial facilities. Part of Building 1 must be demolished to accommodate the track relocation. As noted above, FTA Category 3 does not typically include industrial buildings, but for this analysis, the Category 3 screening distance of 120 feet was the closest category match and was conservative. From the preliminary screening, three of the 14 buildings (4, 11 and 13) were eliminated from further analysis because they would be farther than 120 feet from the relocated railroad.

A general vibration impact analysis was performed for the 11 buildings within the screening distance. This general assessment procedure uses a base curve (see **Figure 21**) of overall ground-surface vibration as a function of distance from the track to estimate vibration impacts. These vibration values represent maximum likely levels during the event and are therefore not dependent on the number of vehicles. The estimates were adjusted for site-specific train speed, track structure, site geology, and building coupling according to FTA procedures to assess vibration levels at the 11 subject buildings.

As noted above, FTA's impact thresholds are based on experiences with vibration from rail transit systems, but they can be applied to freight rail vibrations as well. FTA recommends a dual approach with separate consideration of the locomotive and rail car vibration. Therefore, the locomotive vibration assessment utilized the impact level for Category 3 with an "infrequent event" limit from **Table** and the "Locomotive Powered Passenger or Freight" curve of **Figure 21** to determine the projected vibration. The rail car assessment used the impact level for Category 3 with a "frequent event" limit from **Table** and the "Rapid Transit or Light Rail Vehicles" curve of **Figure 21** because available data show that heavy rail and light rail transit vehicles create similar levels of ground-borne vibration.

The results of the vibration impact assessment are summarized in **Table** . This table lists the building number from **Figure 20,** its address, the distance to the nearest proposed track and the timetable speed of the train. In addition, the predicted vibration level and FTA criterion are indicated. The Industrial Impact Criterion is from ISO 6897-1984(E).

As **Table** shows, the predicted vibration from both the locomotives and rail cars are less than the ISO 90 Vdb impact level for industrial buildings. In addition, all the buildings analyzed, except for Buildings 1 and 14, satisfy the more restrictive vibration requirements of FTA Category 3. It is not necessary for these buildings to meet the Category 3 limits, but rail ballast mats could be used near Buildings 1 and 14 to lower the vibration levels.

In conclusion, no vibration mitigation is necessary.

Figure 21 Vibration Impact Curves

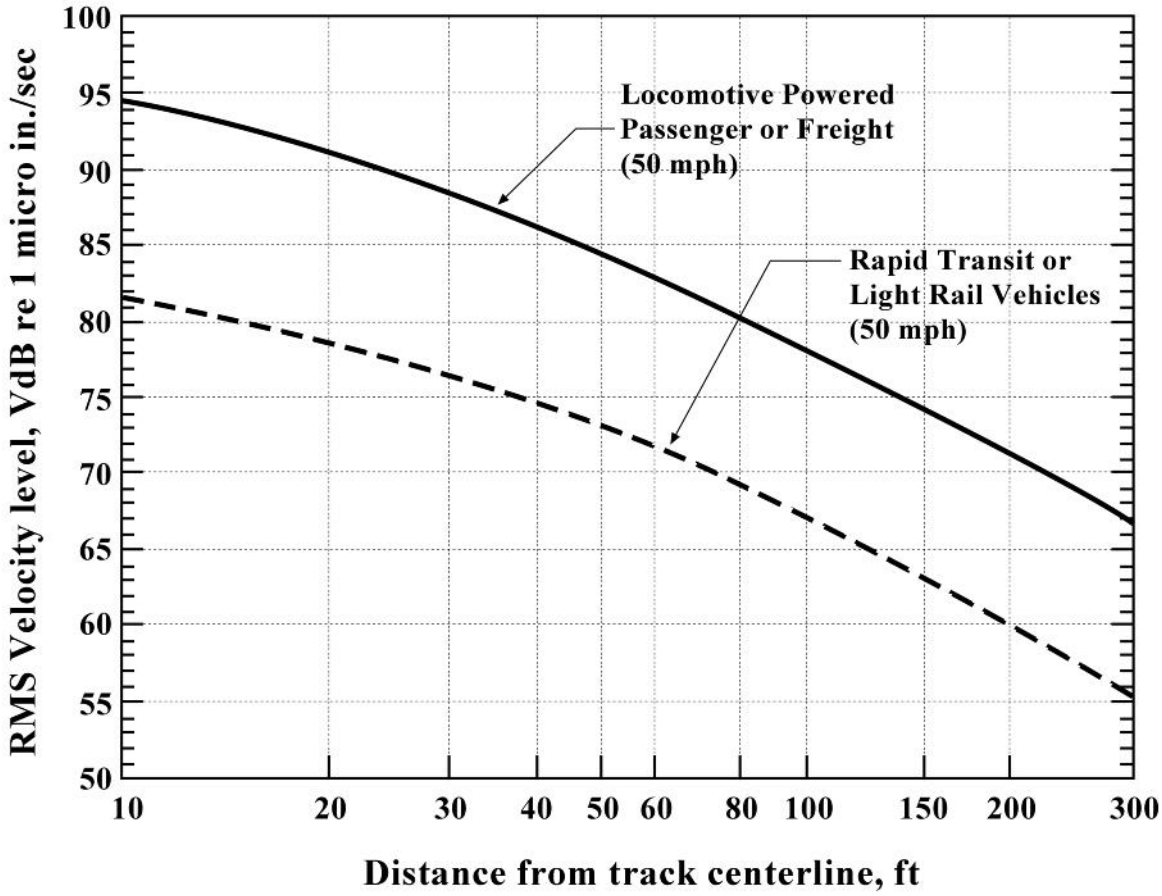


Table 10 Vibration Impact Projections without Mitigation

Building[1]	Address	Distance from Near Track CL	Train Design Speed	ISO Industrial Impact Criterion (Vdb)	Rail Car Vibration		Locomotive Vibration	
					Impact Criterion (Vdb)	Projected Vibration (Vdb)	Impact Criterion (Vdb)	Projected Vibration (Vdb)
1	1030 W. Ellsworth Avenue	25	30	90	75	73	83	86
2	50 Rio Grande Boulevard	103	30	90	75	63	83	75
3	70 Rio Grande Boulevard	108	30	90	75	63	83	74
5	95 Rio Grande Boulevard	55	30	90	75	69	83	80
6		52	30	90	75	69	83	81
7	123 Rio Grande Boulevard	59	30	90	75	68	83	79
8	201 Rio Grande Boulevard	58	30	90	75	68	83	79
9	275 Rio Grande Boulevard	54	30	90	75	69	83	80
10	1480/1490 W. 3rd Avenue.	36	30	90	75	72	83	83
12	400 Raritan Way	104	30	90	75	63	83	75
14	401 Quivas Street	33	30	90	75	72	83	84

[1] Buildings 4, 11, and 13 were beyond the screening distance and are not included.

5.0 REFERENCES

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Colorado Department of Transportation, *1996 highway traffic count data*, 1996.

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International Organization for Standardization, Standard 6897-1984(E), *Guidelines for the evaluation of the response of occupants of fixed structures, especially buildings and off-shore structures, to low-frequency horizontal motion*.

U.S. Code of Federal Regulations, Title 23, Part 772. *Procedures for Abatement of Highway Traffic Noise and Construction Noise*.