US 50 West: Purcell Boulevard to Wills Boulevard (Milepost 309 to Milepost 313) and McCulloch Boulevard Intersection Improvements (Milepost 307)

Project Number: STA 050A-022
Project Code: 19056

Traffic Noise and Vibration Impact Assessment

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FHU Reference No. 112407-02

February 2014

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List of Acronyms and Abbreviations

Ave.	Avenue
Blvd.	Boulevard
CDOT	Colorado Department of Transportation
EA	Environmental Assessment
dB	decibels
FHU	Felsburg Holt & Ullevig
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
L_{eq}	one-hour equivalent sound level (L_{eq})
LOS	level of service
mph	miles per hour
NAC	Noise Abatement Criterion
PEL	Planning and Environmental Linkages
Rd.	Road
ROW	right-of-way
TNM	FHWA's Traffic Noise Model

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1. Introduction

The Colorado Department of Transportation (CDOT) is conducting an Environmental Assessment (EA) for proposed improvements to US Highway 50 (US 50) from Purcell Boulevard (Blvd.) to Wills Blvd. and the intersections of US 50 and Purcell Blvd., Pueblo Blvd., and McCulloch Blvd. (i.e., US 50 West EA) (**Figure 1** and **Figure 2**).

The Proposed Action includes elements of the recommended Preferred Alternative identified in the *US 50 West Planning and Environmental Linkages (PEL) Study* (*US 50 West PEL Study*) (2012a). The PEL recommended Preferred Alternative identified improvements to address peak-hour congestion and above average crash rates along US 50 from Swallows Road (Rd.) to Baltimore Avenue (Ave.) (**Figure 3**). Appendix A2, *US 50 West PEL Study* (CDOT, 2012a), and A3 of the EA, *US 50 West Implementation Plan* (CDOT, 2012b), include additional information on the recommended PEL Preferred Alternative.

A noise analysis was conducted in support of the US 50 West EA. The purpose of the analyses presented in this report is to determine whether noise or vibration levels at properties (that is, receptors) near the potential road improvements from the project alternatives may exceed applicable thresholds, according to CDOT or Federal Highway Administration (FHWA) guidelines. This report presents the analysis that was performed as part of the EA to evaluate existing and future traffic noise levels and to assess potential mitigation for impacted properties near the road improvements from noise and vibration from road traffic.

1.1 Project Description

1.1.1 Proposed Action

The Proposed Action would include widening 3.4 miles of US 50 to include a third eastbound lane from Purcell Blvd. to Wills Blvd. The Proposed Action would also provide intersection improvements at the Purcell Blvd./US 50, Pueblo Blvd./US 50, and McCulloch Blvd./US 50 intersections (**Figure 1** and **Figure 2**). The intersection improvements at Purcell Blvd. and McCulloch Blvd. would modify the northbound to eastbound turn lane geometry to US 50, and add a channelizing curb island for improved traffic flow and pedestrian/bicycle refuge. Intersection improvements at Pueblo Blvd./US 50 would include an eastbound through lane, an eastbound deceleration lane and ramp onto Pueblo Blvd., and a northbound ramp and acceleration lane onto eastbound US 50. The proposed improvements would also include widening the eastbound bridge at Wild Horse Dry Creek (CDOT Structure K-18-CW). The bridge improvements would include extending the existing piers within the Wild Horse Dry Creek drainage area, adding a third eastbound lane, and incorporating a multi-use pedestrian/bicycle trail on the bridge to accommodate a proposed future multi-use trail on the southbound side of US 50. The multi-use trail would be a separate project to be built by others. The Proposed Action would also include drainage improvements and water quality features.

The proposed transportation and water quality improvements would be constructed within the existing CDOT right-of-way (ROW). Permanent easements for drainage would be required in three locations adjacent to CDOT ROW. The main text and figures of the EA provide additional detail about the Proposed Action, while Appendix A1 of the EA includes project drawings.

Figure 1. Proposed Action – Purcell Boulevard to Wills Boulevard

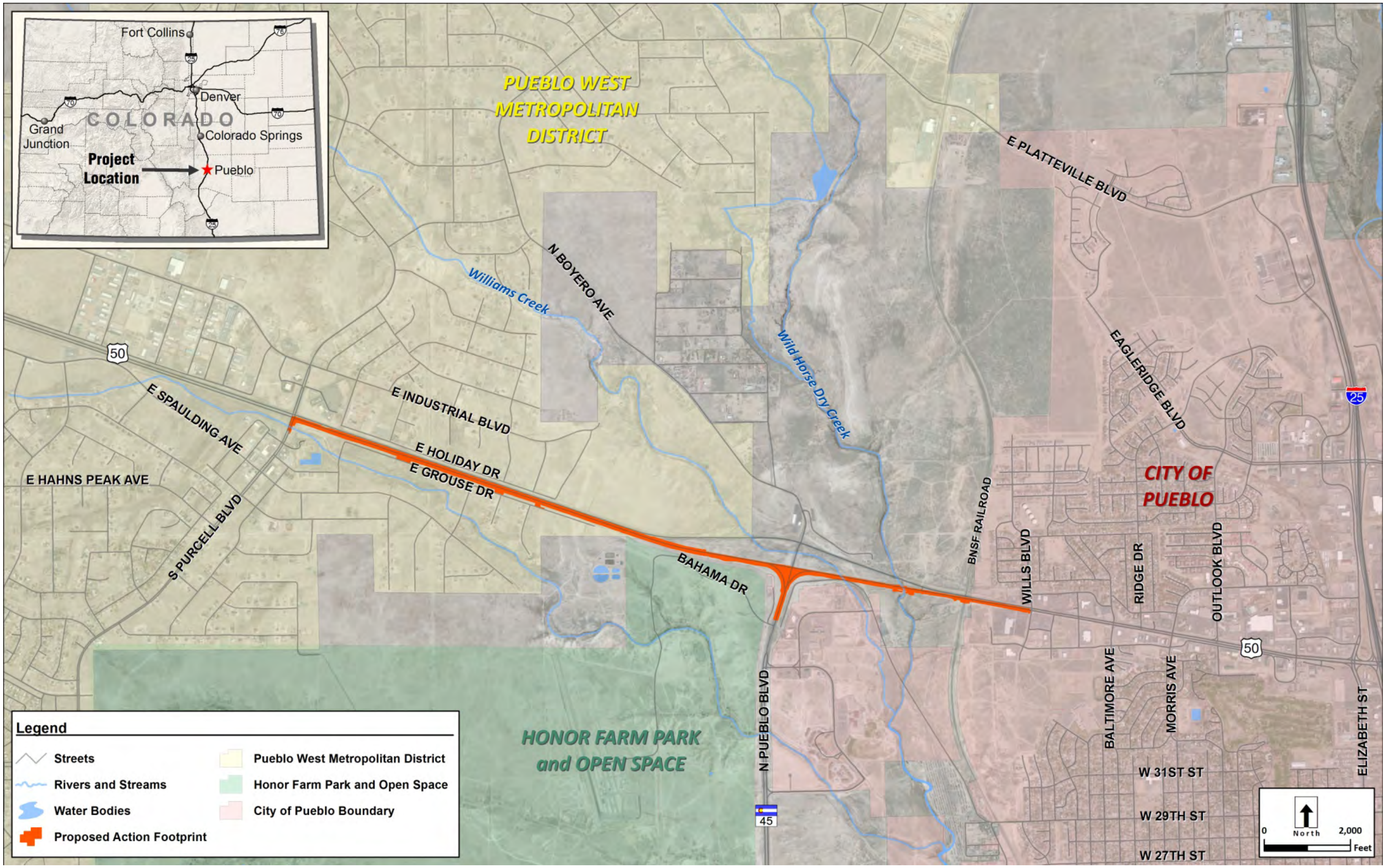


Figure 2. Proposed Action – McCulloch Boulevard/US 50 Intersection

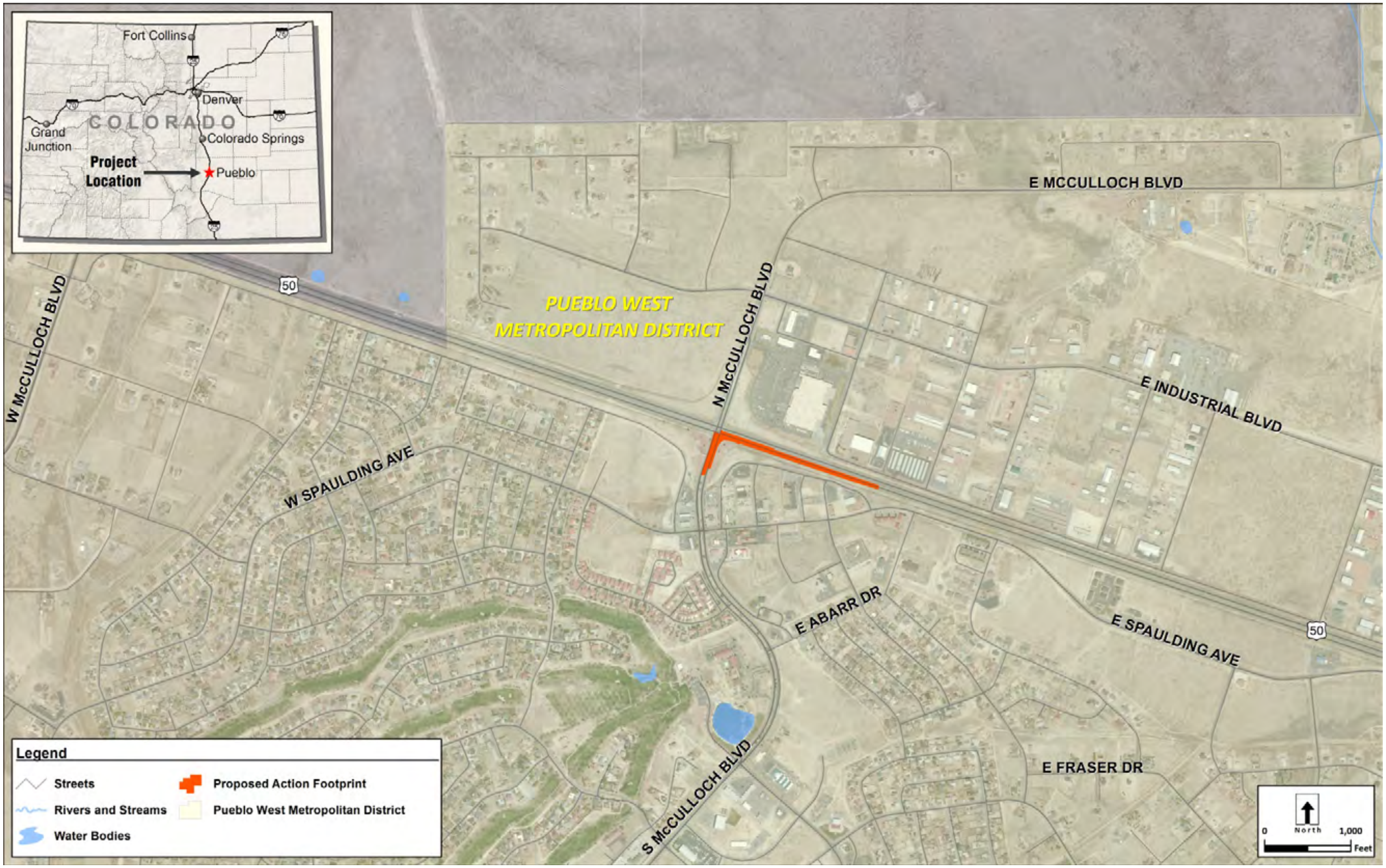
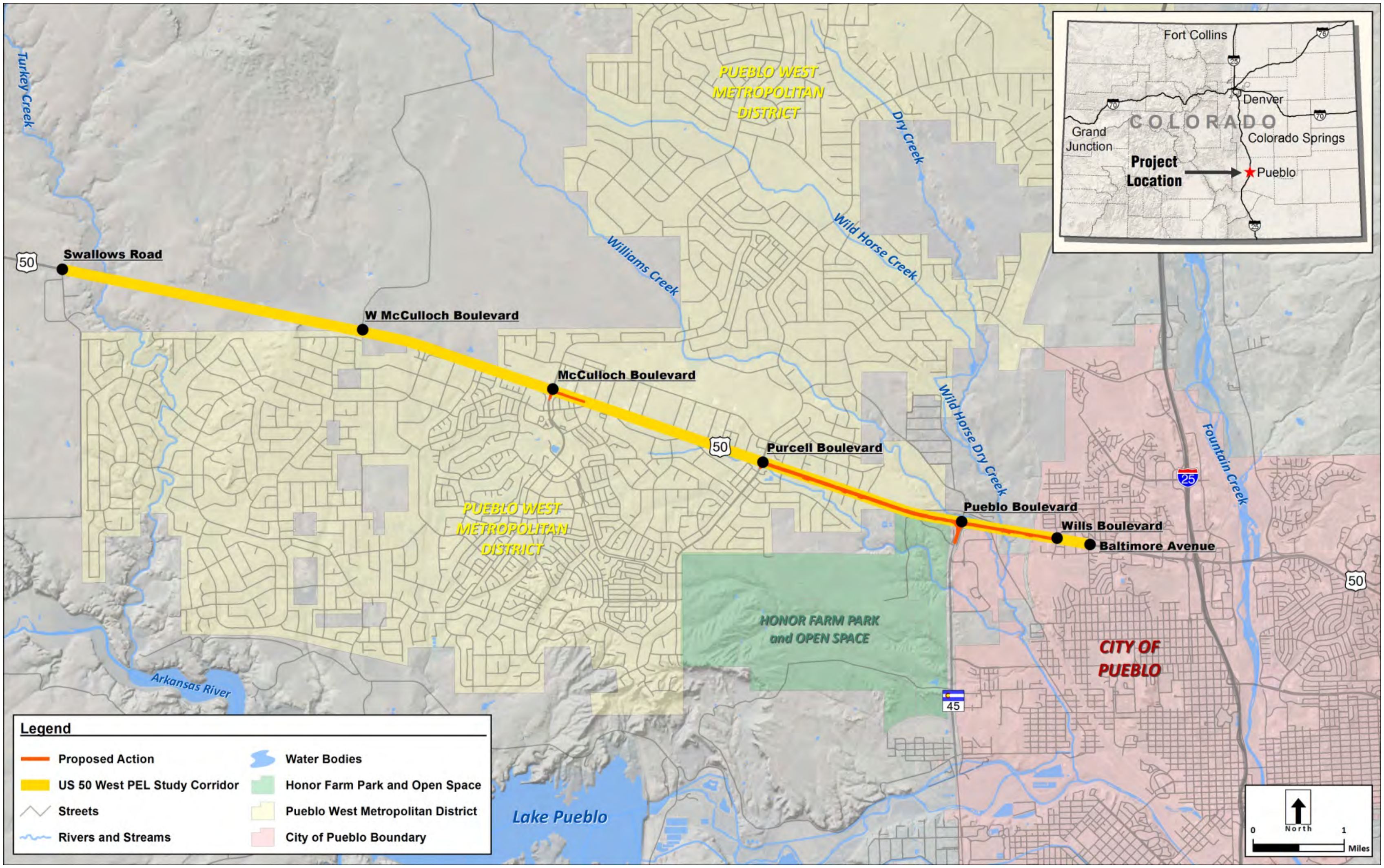


Figure 3. US 50 West PEL Study Corridor



1.1.2 No Action Alternative

The No Action Alternative would include any transportation projects that have not been built, but for which funding has been committed. As identified in the *US 50 West PEL Study* (CDOT, 2012a), the No Action Alternative assumes that no major capacity improvements would occur along US 50 from Swallows Rd. to Baltimore Ave. (CDOT, 2012a). However, the No Action Alternative would include routine maintenance to keep the existing transportation network in good operating condition. The main text of the EA provides additional detail about the No Action Alternative.

1.1.3 Summary of Project Noise Environment

The Proposed Action would add a travel lane to US 50; therefore, the Proposed Action is a Type 1 project in terms of noise and requires a noise analysis. Two future alternatives were considered for the analysis: the No Action Alternative and the Proposed Action (**Section 4**).

Generally, the third lane would be added outside the existing US 50 pavement. The existing alignment of US 50 would be adjusted toward the center median to accommodate new stormwater treatment facilities within the existing US 50 ROW. The existing elevations of US 50 would not be altered substantively. Corresponding improvements to the connecting roads to accommodate the third lane would be made.

The McCulloch Blvd. intersection improvements were reviewed in terms of the project noise analysis. There are no sensitive receptors within 500 feet of the Proposed Action at McCulloch Blvd. (**Figure 2**). Therefore, the proposed McCulloch Blvd. improvements were not included in the noise modeling, and there is no further discussion of the Proposed Action at McCulloch Blvd. in this report.

The project noise analysis area includes residences, businesses, and undeveloped areas abutting US 50 (**Figure 4**). Most of the project area is currently undeveloped, with a few dispersed rural residential areas and retail sites.

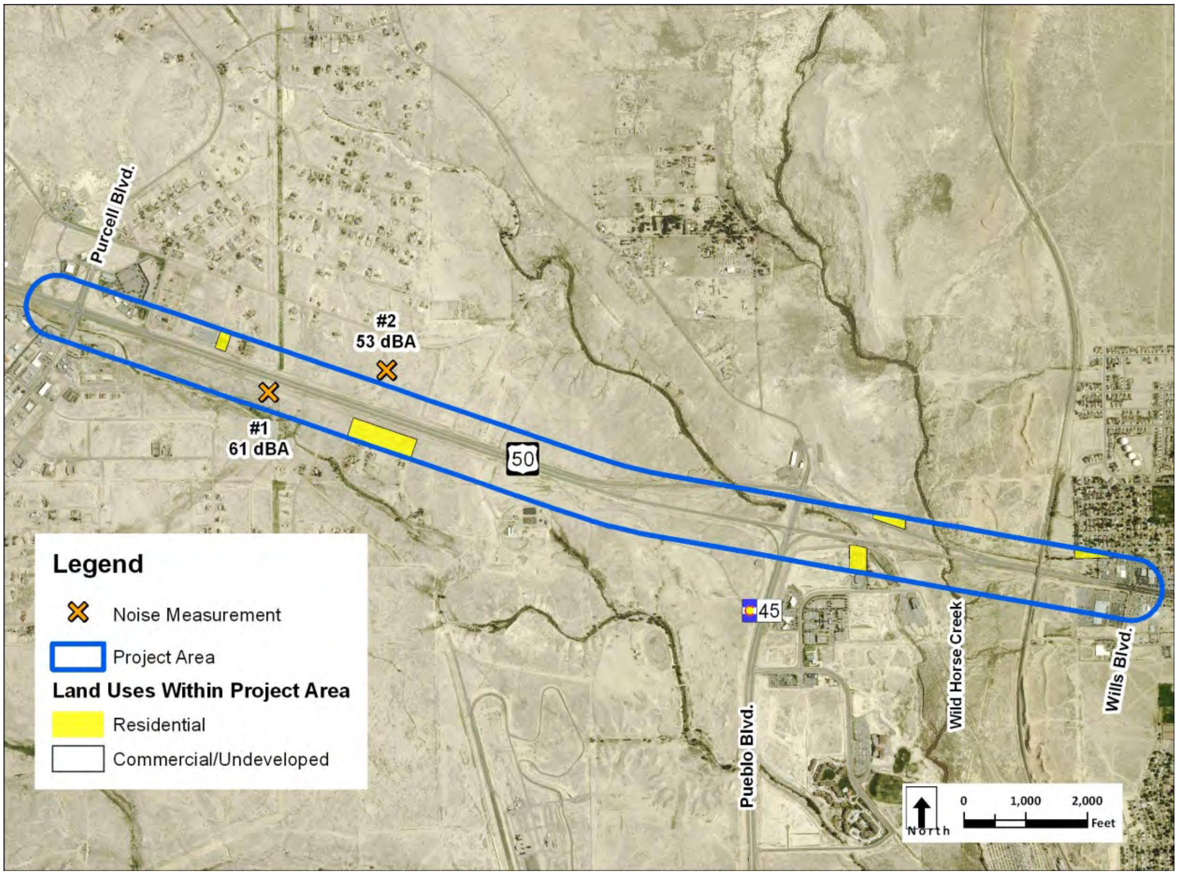
1.2 Basics of Sound

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. Noise is commonly defined as unwanted sound. Sound and noise have many characteristics that are important to consider for impacts, including loudness (energy intensity), frequency, and fluctuations over time.

Sound pressure levels are measured in units of decibels (dB). The dB scale is logarithmic. To illustrate this, consider that two identical noise sources, each producing 60 dB, would produce 63 dB when added together.

The human ear can sense a wide range of sound energy levels, with the maximum levels having more than 1 million times the sound energy of the minimum levels. The human ear is not equally receptive to all frequencies of sound-producing vibrations. Mathematical adjustments to sound levels by the sound frequency bands using the "A" weighting network are often used to approximate how the human ear perceives a sound. In simple terms, the weighting consists of reducing the contributions from low and extremely high sound frequencies by a specified amount. Sound levels that have been weighted this way are reported in dBA.

Figure 4. Project Analysis Area, Land Uses, and Noise Measurement Results

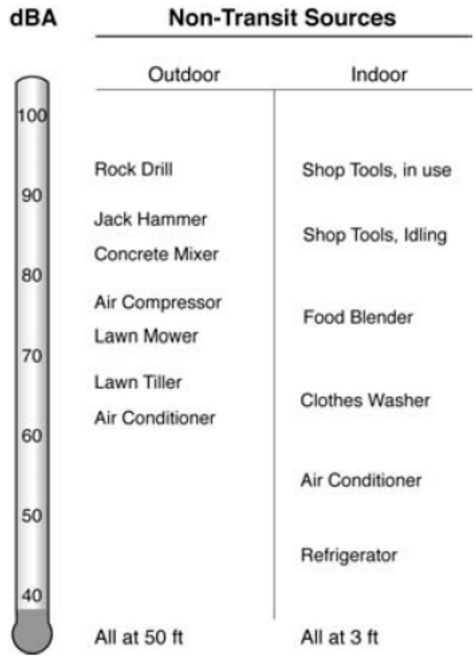


Research has shown that most people do not notice a difference in loudness between sound levels of less than 3 dBA, which corresponds to a two-fold change in the sound energy. Most people relate a 10-dBA increase in sound levels to a doubling of sound loudness, though it represents a 10-fold increase in sound energy. **Figure 5** shows example sound levels.

Noise often is not constant and fluctuates over time because of the characteristics of the source. For example, traffic noise will fluctuate from changes in traffic volumes, vehicle types, and vehicle speeds. This fluctuation makes it difficult to describe adequately the many aspects of noise through a single value, but CDOT uses the one-hour equivalent sound level (L_{eq}) as the metric for assessing traffic noise impacts (CDOT, 2013). In simple terms, the L_{eq} is the "average" of the fluctuating noise levels over a time period, or more precisely, it is the constant sound level that would produce the same amount of overall sound energy as the naturally fluctuating noise levels.

Sound levels decrease with distance from the source because of spreading, atmospheric absorption, interference from objects and ground effects. "Hard" ground (such as asphalt) and "soft" ground (such as grass) affect sound transmission differently. "Hard" ground is more reflective and will lead to louder sound levels farther from the source. Using traffic noise passing over "hard" ground as an example, either doubling the traffic volume or cutting the distance from the listener to the roadway in half, could cause a 3-dBA increase in noise levels, which would be barely noticeable to most people.

Figure 5. Typical Sound Levels



Source: FTA, 2006

On busy roads and highways, the loudest traffic noise generally occurs when the largest traffic volume can travel at the highest speed, which is not necessarily during rush hour because the traffic volume can be so high that roads become congested and speeds slow. This noisiest traffic condition generally corresponds to Level of Service (LOS) C or D for a highway (CDOT, 2013).

1.3 Basics of Vibration

Ground-borne vibration is the oscillatory motion of the ground about an equilibrium position and can be described in terms of displacement, velocity, or acceleration. Because human sensitivity to vibration typically corresponds best to the amplitude of vibration velocity within the low frequency range of most concern (approximately 5-100 Hertz), vibration velocity is the preferred measure for evaluating ground-borne vibration from transportation projects.

There are no federal or state requirements directed specifically to traffic-induced vibration. Studies to assess the impact of traffic vibrations have shown that both measured and predicted traffic vibration levels are less than any known criteria for causing structural damage to buildings (FHWA, 2011). Often, normal indoor activities like closing doors have been shown to create greater levels of vibration in homes than nearby highway traffic. Because of these findings, vibration from road traffic has been concluded not to be a concern within the EA and will not be examined further in this analysis.

Vibration from road construction could be a concern if high-vibration construction techniques, such as pile driving or blasting, are used. Issues with construction-generated vibrations would depend on high-vibration activities occurring close to vibration-sensitive locations (**Section 1.1**). It is not known if a contractor would use these types of construction techniques near sensitive properties. If such construction techniques are necessary at a specific location, the vibration concerns will be addressed during construction planning on a case-by-case basis and appropriate abatement action taken for the specific situation. Therefore, vibration from road construction will not be examined further in this analysis.

1.4 Noise Analysis Approach

The overall purpose of the following noise analysis is to determine whether noise levels at any sensitive receptors within approximately 500 feet of potential project improvements may exceed applicable impact thresholds because of a project alternative. If so, abatement actions for the impacted receptors are considered for the project design. The analysis examined roads that would be changed or newly built by the project or would have substantially different traffic volumes because of an alternative.

The overall analysis was based on measurements of current conditions (2013) and on modeling of both existing (2011) traffic conditions and future design year (2035) conditions (**Section 2**). Existing conditions and two future alternative conditions being considered in the analysis were examined. Much of the corridor is undeveloped, although there are some residences, churches, and businesses near US 50.

Several measurements of current noise were performed in the project area in 2013 (**Section 3**). Computer modeling was used to examine 2011 and expected 2035 conditions for many locations in the project area, focusing on potential impacts to the most sensitive receptors (**Section 1.1**). The resulting noise levels were compared to applicable criteria to assess for and identify impacted areas (**Section 4**). The efficacy of various abatement measures for the impacted areas was evaluated and abatement measures were recommended if appropriate according to CDOT feasibility and reasonableness guidelines (**Section 5**).

2. Analysis Methods

Noise impacts from automobile traffic were evaluated using a combination of measurements and computer modeling. The specific methods used for each part of the analysis are described below. For comparisons, **Figure 5** shows typical noise levels.

The state and federal transportation departments have developed traffic noise evaluation criteria specifically for their environmental impact analyses. United States Code of Federal Regulations Title 23 Part 772 establishes federal standards for the abatement of highway traffic noise (FHWA, 2012). CDOT has developed traffic noise analysis guidance (CDOT, 2013). Because US 50 is the road of interest for the proposed project, the appropriate noise impact criteria are these federal and state highway guidelines. CDOT has the more restrictive noise limits of the two and these thresholds are shown in **Table 1**.

Table 1. CDOT Noise Abatement Criteria

Activity Category	CDOT NAC (L_{eq})	Description of Activity Category
A	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.
B	66 dBA (Exterior)	Residential
C	66 dBA (Exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, schools, Section 4(f) sites, trails, trail crossings, and television studios
D	51 (Interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or non-profit institutional structures, radio studios, recording studios, schools and television studios
E	71 dBA (Exterior)	Hotels, motels, offices, restaurants, bars and other developed lands, properties or activities not included in A-D or F.
F	NA	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, ship yards, utilities (water resources, water treatment, electrical), and warehousing
G	NA	Undeveloped lands that are not permitted for development

Source: CDOT, 2013

To summarize the traffic noise analysis process, noise impacts occur when properties near the project roads will have future design year noise levels at or above the relevant CDOT Noise Abatement Criterion (NAC), as shown in **Table 1**, or future noise levels that increase by 10 dBA or more over existing conditions. The noise levels are evaluated through computer modeling. Properties that are found to be impacted by noise (**Section 4**) are then considered for abatement actions (**Section 5**). Noise abatement actions that are found to be both feasible and reasonable according to the guidelines are recommended for construction under the proposed improvements.

Most of the NAC target exterior areas of frequent human use on properties, as shown in **Table 1**. These areas include uses such as yards for Category B, playgrounds at parks for Category C, or exterior dining areas at restaurants for Category E. Typically the most crucial NAC on highway projects is for homes (Activity Category B), which has an hourly L_{eq} of 66 dBA. For a noise impact to occur, the noise levels must meet one of the thresholds described above and an applicable exterior area of frequent human use must be present on the property.

For the noise impact discussion, the "peak hour" refers to the highest traffic noise hour, which may or may not correspond to the hour of largest traffic volume. Note that traffic noise can decrease during rush hour due to lower vehicle speeds from overloaded and congested roads.

2.1 Traffic Noise Measurements

The traffic noise measurements were taken with an NTI XL2 Type 1 sound level meter calibrated at the site with a Larson-Davis CAL200 calibrator. This equipment conforms to American National Standards Institute Standard S1.4 for Type 1 sound level meters. Calibrations traceable to the US National Institute of Standards and Technology were performed in the field before and after each set of measurements using the acoustical calibrator. The measurement microphone was protected by a windscreen and located on a tripod approximately 5 feet above the ground. The microphone was positioned at each site to characterize the exposure to the dominant noise sources in the area.

Noise measurements were made during weather conditions, including wind speed, that were acceptable according to FHWA guidance (FHWA, 1996) and weather conditions were monitored during the measurements. The traffic noise measurements were spread over the project area (**Figure 4**). Short-term (15-minute) traffic noise measurements were performed in the morning at each location (**Section 3.1**) to document existing ambient conditions in the project area. Traffic counts, including the number of large trucks, were collected during the noise measurement periods for model verification. The measurement results were used to document ambient conditions and to evaluate the performance of the computer models.

2.2 Traffic Noise Modeling Methods

Computer modeling was performed for both existing conditions and the two project alternatives for Year 2035. The traffic noise modeling software is FHWA's Traffic Noise Model (TNM) Version 2.5. The ultimate purpose of the models is to examine whether traffic noise levels would be high enough to impact neighboring properties, and subsequently whether noise abatement should be provided for any such impacts within the project area.

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 and because future noise levels cannot be measured now. In addition, the modeling can evaluate many more locations than can reasonably be field measured. The modeling results represent predicted typical average traffic conditions during peak noise periods.

The existing traffic conditions model included the 2011 road configurations and traffic volumes. The two future alternatives were modeled for their respective 2035 conditions (**Section 4**). Note that the 2035 peak traffic volumes for some segments of US 50 were predicted to exceed LOS C capacities, so the US 50 volumes used for these segments followed CDOT's guidelines for overcapacity conditions (J.F. Sato, 2013; CDOT, 2013). The parameters for the other highways and arterial roads used the predicted morning peak traffic volumes.

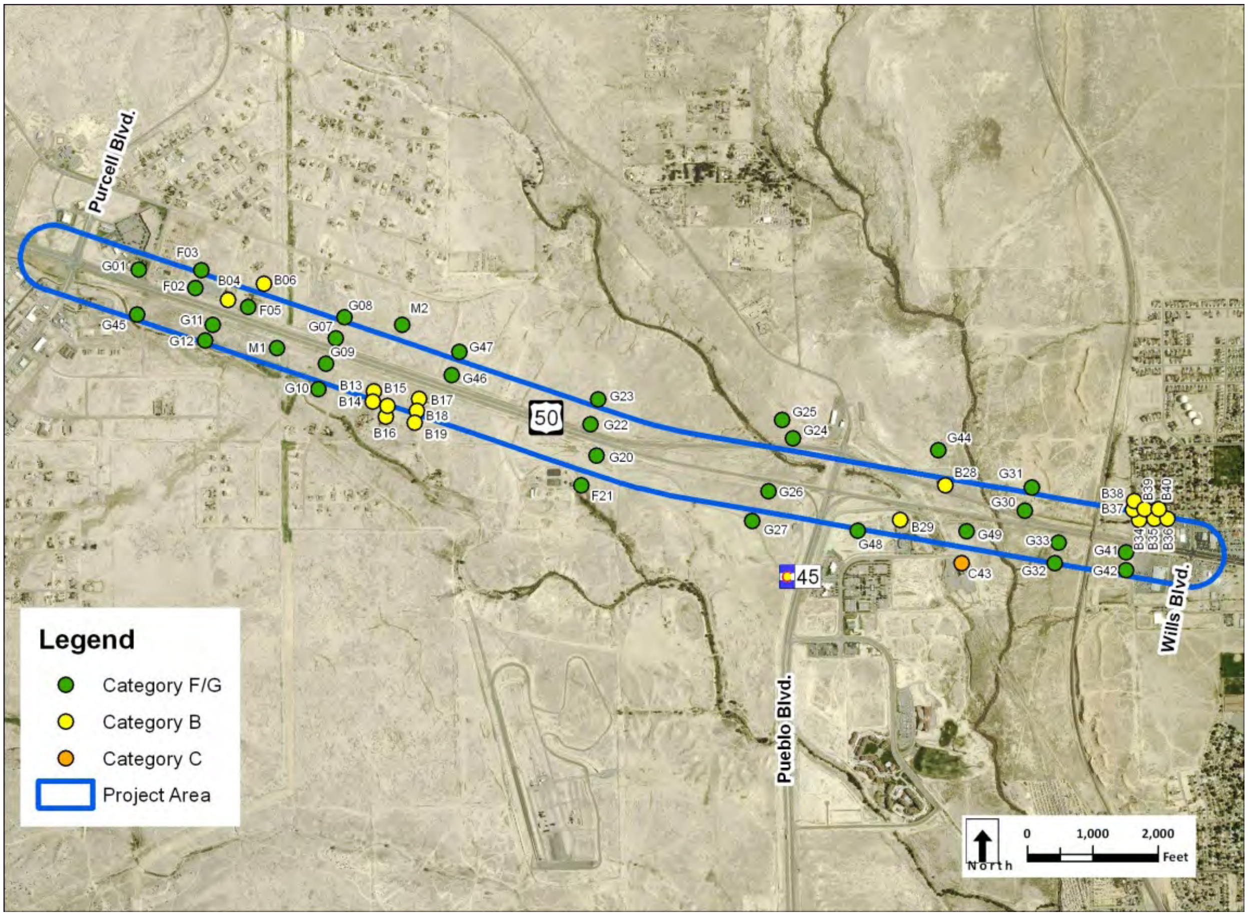
TNM was used to calculate noise levels at approximately 50 points up to 500 feet from a modeled roadway, as illustrated in **Figure 6**. This distance followed CDOT guidance (CDOT, 2013) and was chosen as the project zone for noise to identify the receptors that the alternatives would impact. In some cases, a single model point represented several nearby receptors/properties where traffic and geography were similar (for example, one point for a multi-unit apartment building). Therefore, the number of model "points" was not always the same as the number of individual "receptors." The modeled roadways were the roads that would be built or changed by the build alternatives or are important local noise sources. US 50 was the most substantial noise source observed in the project area. The same model points were used in each model for consistency.

The TNM models require a considerable amount of input data regarding the geometry of the roadways, as well as traffic volumes, vehicle mix, and vehicle speeds. A traffic study was completed for the PEL Study (CDOT, 2012a) and was the source of traffic volumes.

The current positions of roads and streets were mapped and used in both the existing and No Action Alternative models, though individual road parameters differed between the two models. The Proposed Action (**Section 1.1**) was modeled to assess the possible noise impacts from the proposed roadway changes. In general, the models used the following data:

- Units – feet and miles per hour
- Current Roadway Alignments – XY coordinates from CAD files and aerial photographs
- Future Roadway Alignments – XY coordinates from CAD files
- Vehicle Speeds – posted speed limits: 65 mph Purcell Blvd. to Pueblo Blvd.; 55 mph Pueblo Blvd. to Wills Blvd. and Pueblo Blvd.; 30 to 45 mph for other minor streets
- Traffic Volumes – from traffic study or CDOT-recommended volumes (CDOT, 2013)
- Vehicle Mix – from published CDOT traffic count data
- Elevations – from ground surface contours of the project area and preliminary road designs; field measurement locations and model receptors were 5 feet above ground
- Structural and terrain barriers as needed to emulate the existing area; addition of abatement barriers to models where appropriate for the abatement evaluations

Figure 6. Modeled TNM Traffic Noise Points



3. Affected Environment

The current traffic noise conditions in the project area were assessed through a combination of measurements and modeling. There are residential, religious, and business areas near US 50 that were of examined for the project. The existing conditions for traffic noise for these areas are presented below.

3.1 Traffic Noise Measurements

The short-term noise measurements described below were intended to be representative of traffic noise conditions across the project area. Short-term traffic noise measurements were performed in the morning (to avoid frequent strong winds) to document existing ambient conditions. **Table 2** presents the measurement results. The two locations, as illustrated in **Figure 7**, were at undeveloped properties but were representative of other nearby properties that may have the same or different land uses. Neither of the measurement results reached the CDOT NAC for Categories B or C, as shown in **Table 2**.

Table 2. Existing Traffic Noise Measurement Results

Location Number	Location Description	Activity Category*	CDOT NAC (dBA)*	Measured L_{eq} (dBA)
1	1100 block E. Grouse Dr.	G	Not applicable	61
2	Approximately 60 N. Somerset Dr.	G	Not applicable	53

** See Table 1.*

Source: Felsburg, Holt & Ullevig (FHU) field data, 2013.

3.2 Traffic Noise Verification Model

As a check on noise model parameters, the traffic conditions observed during the noise measurements were used to construct a verification model in TNM. The intent was to check the accuracy of the noise levels calculated through a model that reflected the road alignment, traffic volumes, and model receptors at the time of field measurement. A close match between model results and field measurements ensured that the models provided accurate noise results (CDOT, 2013).

The verification model covered the areas where noise level measurements were made (**Figure 4**). The model was constructed in TNM using the same approach as the alternatives models (**Section 2.2**). "Field grass" ground type was used rather than the default "lawn" type; this was carried through all the TNM models.

The verification results were in close agreement, as shown in **Table 3**. The results were acceptable according to the CDOT guidelines (CDOT, 2013), which required the difference in results to be no more than 3 dBA.

Figure 7. Noise Impacts for Existing and No Action Condition Models

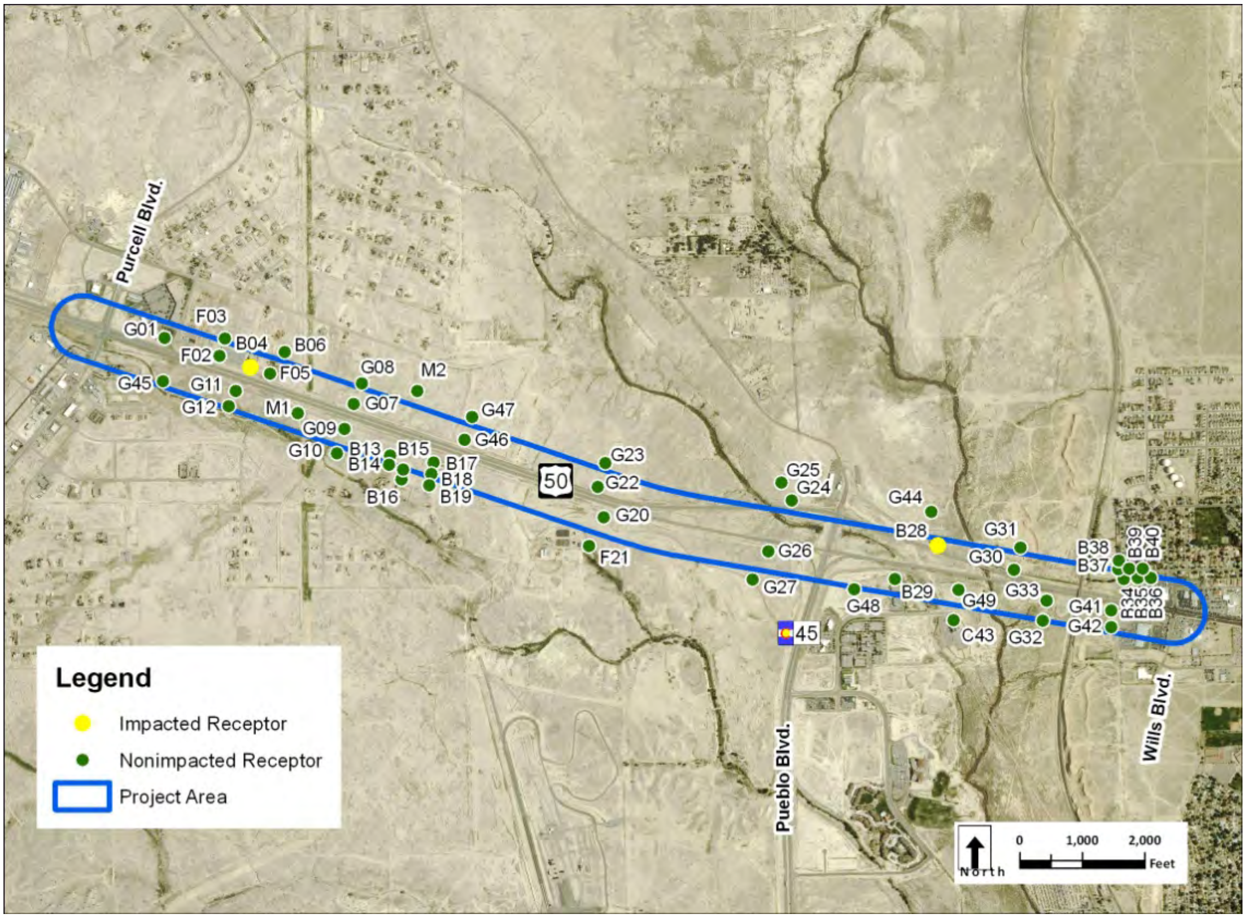


Table 3. Verification Noise Model Results

Location Number	Location	Measurement L_{eq} (dBA)	Verification Model Result (dBA)	Difference (dBA)
1	1100 block E. Grouse Dr.	61	63	+2
2	60 N. Somerset Dr.	53	52	-1

Source: FHU modeling results, 2013

3.3 Existing Conditions Traffic Noise Model Results

A noise model was developed (**Section 2.2**) to evaluate existing conditions on a broader basis than allowed by the field measurements alone. The existing conditions model included the major existing roads that may be affected by the US 50 West Project, with existing (2011) traffic volumes and road layouts.

Approximately 50 points were modeled for traffic noise, as shown in **Figure 6** and **Table 4**. Overall, the calculated noise level range for the model points was 54 to 72 dBA.

Figure 7 shows the two modeled points calculated to be impacted because of existing traffic noise levels being above the respective NAC during the peak hour. These points represent three residential (Category B) receptors located near the westbound lanes of US 50, which will not be affected by the Proposed Action.

Table 4. TNM Modeling and Impacts Results

Model Point	Activity Category / CDOT NAC (dBA)	Dwelling Units	Existing (2011) L_{eq} (dBA)	Existing Above CDOT NAC?	No Action Alternative (2035) L_{eq} (dBA)	No Action Above CDOT NAC?	No Action Increase Over Existing (dBA)	Proposed Action (2035) L_{eq} (dBA)	Proposed Action Above CDOT NAC?	Proposed Action Increase Over Existing (dBA)
G01	G / NA	0	69	----	71	----	2	71	----	2
F02	F / NA	0	70	----	72	----	2	72	----	2
F03	F / NA	0	60	----	61	----	1	62	----	3
B04	B / 66	1	71	Yes	73	Yes	2	73	Yes	2
F05	F / NA	0	71	----	72	----	2	73	----	2
B06	B / 66	1	58	----	59	----	1	60	----	3
G07	G / NA	0	72	----	74	----	1	74	----	1
G08	G / NA	0	60	----	61	----	1	62	----	3
G09	G / NA	0	66	----	66	----	1	66	----	0
G10	G / NA	0	55	----	56	----	1	57	----	2
G11	G / NA	0	71	----	71	----	1	70	----	-1
G12	G / NA	0	58	----	59	----	1	59	----	1
B13	B / 66	1	62	----	62	----	1	63	----	1
B14	B / 66	1	58	----	58	----	1	59	----	2
B15	B / 66	1	55	----	56	----	1	57	----	2
B16	B / 66	1	58	----	59	----	1	59	----	1
B17	B / 66	1	65	----	65	----	1	65	----	0
B18	B / 66	1	59	----	60	----	1	60	----	1
B19	B / 66	1	56	----	57	----	1	57	----	1
G20	G / NA	0	70	----	70	----	0	70	----	1
F21	F / NA	0	54	----	55	----	1	56	----	2
G22	G / NA	0	71	----	73	----	2	73	----	2
G23	G / NA	0	58	----	59	----	1	60	----	2
G24	G / NA	0	69	----	71	----	3	71	----	3
G25	G / NA	0	62	----	64	----	2	64	----	2
G26	G / NA	0	71	----	72	----	0	72	----	1
G27	G / NA	0	57	----	58	----	1	59	----	2
B28	B / 66	2	69	Yes	71	Yes	3	71	Yes	3

Model Point	Activity Category / CDOT NAC (dBA)	Dwelling Units	Existing (2011) L_{eq} (dBA)	Existing Above CDOT NAC?	No Action Alternative (2035) L_{eq} (dBA)	No Action Above CDOT NAC?	No Action Increase Over Existing (dBA)	Proposed Action (2035) L_{eq} (dBA)	Proposed Action Above CDOT NAC?	Proposed Action Increase Over Existing (dBA)
B29	B / 66	2	64	----	65	----	2	67	Yes	4
G30	G / NA	0	69	----	72	----	2	72	----	3
G31	G / NA	0	58	----	60	----	2	60	----	3
G32	G / NA	0	56	----	58	----	2	58	----	3
G33	G / NA	0	66	----	68	----	2	68	----	3
B34	B / 66	3	59	----	61	----	2	63	----	3
B35	B / 66	3	58	----	60	----	2	61	----	3
B36	B / 66	5	57	----	59	----	2	60	----	3
B37	B / 66	2	56	----	58	----	2	59	----	3
B38	B / 66	1	54	----	56	----	2	56	----	3
B39	B / 66	3	55	----	57	----	2	58	----	3
B40	B / 66	6	55	----	57	----	2	58	----	3
G41	G / NA	0	70	----	72	----	2	72	----	2
G42	G / NA	0	56	----	58	----	2	59	----	3
C43	C / 66	0	54	----	56	----	2	57	----	3
G44	G / NA	0	55	----	57	----	2	57	----	3
G45	G / NA	0	61	----	62	----	1	62	----	1
G46	G / NA	0	70	----	72	----	2	73	----	2
G47	G / NA	0	57	----	58	----	1	59	----	2
G48	G / NA	0	57	----	59	----	2	60	----	2
G49	G / NA	0	65	----	66	----	2	69	----	4
M1	G / NA	0	69	----	69	----	1	67	----	-2
M2	G / NA	0	56	----	57	----	1	58	----	2

---- = not above CDOT NAC

NA = not applicable

4. Environmental Consequences

Section 1.1 described the alternatives being considered for the US 50 West Project. The traffic noise modeling effort was conducted as described in **Section 2** to assess whether future noise levels near the project alternatives would exceed relevant CDOT thresholds. If so, abatement measures to alleviate the predicted impacts were considered and evaluated for the Proposed Action following CDOT guidelines (**Section 5**).

Traffic noise models were developed as described in **Section 2.2** for each alternative. The models included the major project roads using predicted future (2035) traffic volumes and road layouts. **Table 4** lists the model noise results.

4.1 No Action Alternative 2035 Results

The impact results for the No Action Alternative were the same as the existing conditions results (**Figure 7**). The locations impacted under existing conditions would also be impacted under the No Action Alternative. The traffic noise patterns would be similar to existing conditions with the noise levels a bit higher due to increased traffic volumes.

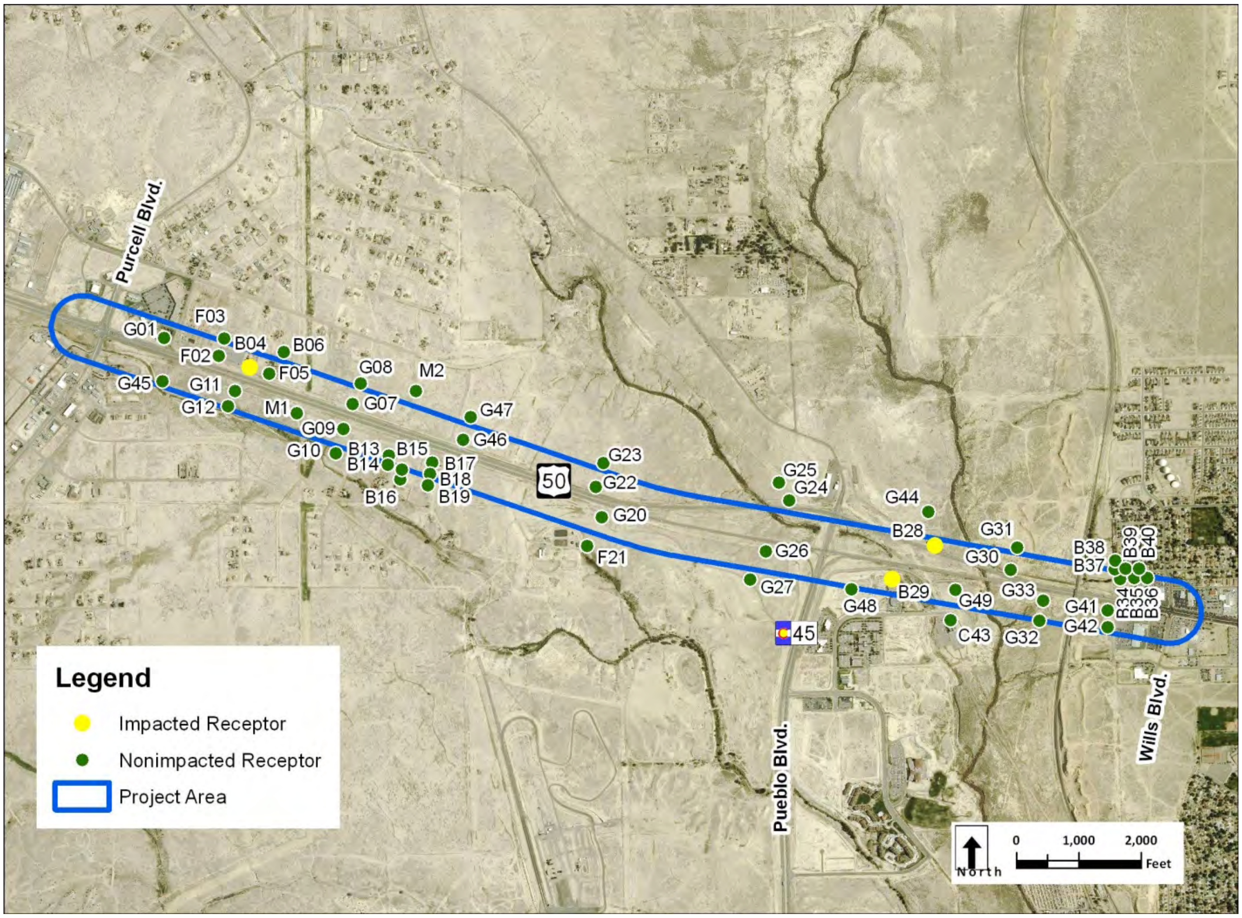
For the No Action Alternative, three Category B receptors (two model points) would be at or above the NAC and impacted by traffic noise (**Table 4**). Overall, the calculated noise level range at the model points would be 55 to 74 dBA. No receptors are expected to experience a 10-dBA increase; the largest increase is predicted to be 3 dBA.

4.2 Proposed Action 2035 Results

The noise impact results for the Proposed Action were similar to results for existing conditions and the No Action Alternative, but one more model point was calculated to be impacted as shown in **Figure 8**. The additional model point represented two additional Category B receptors, as shown in **Table 4**.

Overall, the calculated noise level range at the model points would be 56 to 74 dBA. No receptors are expected to experience a 10-dBA increase; the largest increase is predicted to be 4 dBA.

Figure 8. Noise Impacts for Proposed Action—Year 2035



4.3 Summary of Traffic Noise Impacts

Traffic noise impacts were predicted for each alternative for 2035. **Table 4** summarized the predicted impacts (without abatement). There was little that separated the two alternatives in terms of noise; the noise results were similar. **Figure 9** illustrates the predicted noise contour lines for the Proposed Action in 2035, which have been provided to support land use planning decisions in the area.

4.4 Construction Noise

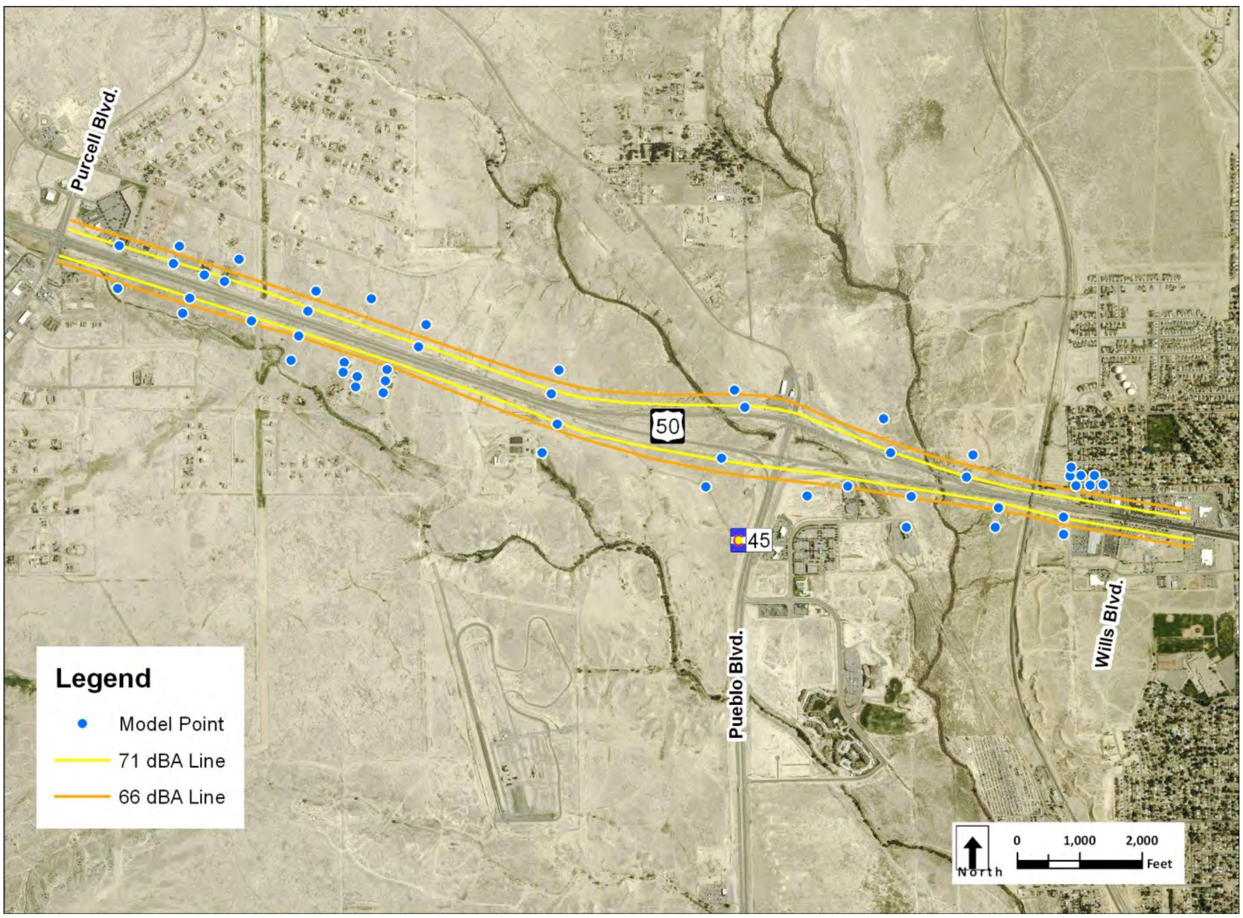
The Proposed Action could expose adjoining properties in the project area to noise from construction activities. Construction noise differs from traffic noise in several ways:

- 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 short term and, depending on the nature of the construction operations, could last from seconds (for example, a truck passing a receptor) to months (for example, constructing a bridge).
- Construction noise is intermittent and depends on the type of operation, location, and function of the equipment, and the equipment usage cycle.

Construction noise is not assessed like operational traffic noise; there are no CDOT NACs for construction noise. Construction noise would be subject to relevant local regulations and ordinances, and any construction activities would be expected to comply with them. The City of Pueblo has noise regulations that may affect construction; Pueblo County and Pueblo West do not.

Figure 9. Noise Level Contour Lines—Proposed Action Year 2035



The project area abuts residential areas. To address the temporary elevated noise levels that may be experienced during construction, standard abatement measures shall be incorporated into construction contracts, where it is feasible to do so. These will include:

- Notify neighbors in advance when construction noise may occur and its expected duration so that they may plan appropriately.
- Manage construction activities to keep noisy activities as far from sensitive receptors as possible.
- Keep exhaust systems on equipment in good working order. Maintain equipment on a regular basis and subject it to inspection by the construction project manager to ensure maintenance.
- Use properly designed engine enclosures and intake silencers where appropriate.
- Use temporary noise barriers where appropriate and possible.
- Subject new equipment to new product noise emission standards.
- Locate stationary equipment as far from sensitive receptors as possible.
- Perform construction activities in noise sensitive areas during hours that are least disturbing to adjacent and nearby residents.

5. Noise Abatement Evaluation

The results from the traffic noise analysis indicated that receptors would be impacted by noise from each alternative. Therefore, potential abatement actions for the impacted receptors under the Proposed Action were investigated in accordance with relevant guidelines (CDOT, 2013; FHWA, 2011). Impacted areas are not guaranteed abatement measures under these guidelines, but abatement measures for the areas must be evaluated for feasibility and reasonableness. Reasonableness includes assessment of abatement benefits and costs.

Section 4 described noise impacts from the alternatives. Several types of noise abatement for the impacts were considered. Barriers, a common abatement action, and other kinds of abatement were considered. The overall feasibility and reasonableness of noise abatement actions that provided a substantive benefit for the impacted receptors were evaluated. Those actions found to be feasible and reasonable were then recommended for inclusion in the US 50 West Project.

For reasons described below, barriers appeared to be the only viable abatement action and were the only abatement evaluated through modeling. CDOT has several criteria to evaluate noise barriers (CDOT, 2013). CDOT's required minimum noise reduction is 5 dBA for a barrier to be feasible, with a 7 dBA noise reduction goal.

5.1 Evaluation of Abatement Other than Barriers

CDOT guidelines require the evaluation of several non-barrier abatement options. For various reasons described below, none of these options appear to be viable for the US 50 West Project.

Traffic management measures, such as lane closures or reduced speeds, could reduce noise but broad application of these concepts is not reasonable for the roads of primary interest to the project or compatible with the purpose of the project. One of the reasons for the proposed improvements in the project area is to improve access and traffic flow. Because the Proposed Action would add an eastbound lane to US 50 for peak period traffic volumes, closing lanes would not be reasonable. Some of the impacted residential receptors would need a noise reduction of 7 dBA to be below the NAC. Traffic speeds would need to be reduced approximately 25 mph to achieve a 7-dBA noise reduction, which would not be compatible with the intended function of US 50 in the project corridor.

Changes in horizontal alignments of the roads near the impacted receptors could reduce noise but have limited possibilities as a separate abatement. The Proposed Action is intended to preserve as much of the eastbound US 50 infrastructure in the corridor as possible. Because the US 50 corridor has development on each side, to shift the roads where the impacts occur would be prohibitively expensive. Note that a planned future project for US 50 may realign the westbound lanes and may be able to address some noise impacts using this method.

Changes in vertical alignments (cuts or fills) could reduce noise. However, wholesale changes in road elevations would require a much larger and expensive project that could have secondary impacts to connecting or adjoining roads that would not be reasonable or desirable. Other undesirable impacts, such as to drainage or utilities, could be created. In summary, vertical elevation changes were evaluated, but vertical realignments just to reduce traffic noise are not practical.

Noise buffer zones could reduce noise levels, but there are limited opportunities in the project area due to prior development of parcels. Often, the development has been purposely built near the roads for access, which leaves little or no space for a buffer. In the few places where there are noise impacts, sufficient space for buffers is generally not available.

Pavement types and surfaces can affect traffic noise. Research efforts to learn more about the long-term noise benefits of different pavement types and surface treatments are ongoing. Quieter pavement types can be preferred for the project when minimum requirements for safety, durability, and other materials requirements are also met. However, this cannot be counted as an abatement action under the noise reduction evaluation because it is not a "permanent" solution.

5.2 Traffic Noise Barrier Evaluations

To permit the evaluation of noise barriers, computer models with barriers protecting the impacted areas were developed in TNM. Each potential barrier was assessed for effectiveness and feasibility. If the minimum parameters for an effective barrier were met and the barrier was feasible, the barrier was checked for reasonability according to CDOT guidance (CDOT, 2013). The feasibility and reasonableness of each barrier determined whether the barrier was recommended for the project (**Appendix B**).

Briefly, for an abatement action to be feasible it must:

- Provide at least 5 dBA of noise reduction.
- Not have any "fatal flaw" issues (safety, maintenance, access, drainage, etc.).
- Not exceed 20 feet in height.

For an abatement action to be reasonable, it must:

- Meet the minimum design goal of at least 7 dBA of noise reduction.
- Meet the cost/benefit index of not more than $6,800/receptor/dBA of benefit.
- Have support from more than 50 percent of the potentially benefitting receptors.

Figure 10 shows the locations evaluated for new noise barriers. Each barrier was assessed for feasibility and reasonableness (CDOT, 2013), and barrier recommendations were made based on the findings.

The locations for the abatement barriers were 10 feet in toward US 50 from CDOT's ROW to provide access for maintenance. It is important to note that the noise barriers can be earth berms or constructed walls and that many materials can be effective barriers. Berms can be very effective but occupy considerably more space than comparable walls. The impacted receptors tend to be close to project roads and there are also drainage considerations. This usually makes earth berms impractical or impossible choices for the noise barriers.

Barrier cost-effectiveness was based on a generic 5-year average unit cost of $45/square foot of barrier and compared to the CDOT upper threshold of $6,800/receptor/decibel of benefit. **Table 5** and the following sections summarize the barriers that were evaluated. **Table 6** and **Appendix A** present the barrier performance results.

Figure 10. Locations of Traffic Noise Abatement Barriers Evaluated

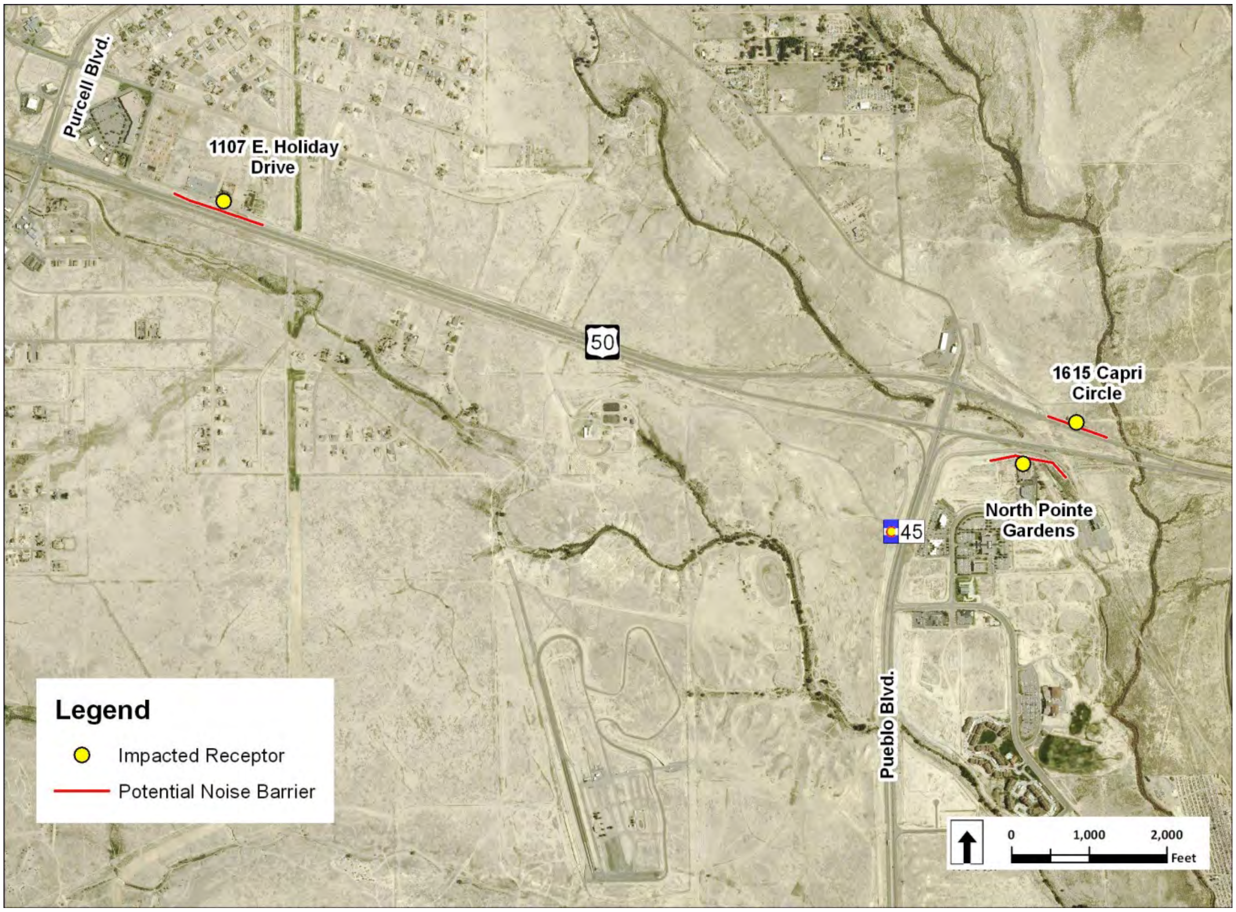


Table 5. Summary of Noise Abatement Barriers Evaluated

Noise Impacted Area	Approximate Barrier Segment Dimensions (feet)	Total Barrier Size (square feet)	Approximate Barrier Cost
1107 E. Holiday Drive	8 x 310 10 x 100 11 x 200 12 x 400	10,500	$471,000
1615 Capri Circle	8 x 280 10 x 300	5,200	$235,000
North Pointe Gardens (assisted living center)	8 x 260 10 x 240	4,500	$202,000

Source: FHU modeling results, 2013.

Table 6. Summary of Barrier Performance and Abatement Conclusions

Noise Impacted Area	Number of Benefitting Dwelling Units	Total Benefit Provided (dBA)	Cost Analysis ($/ total dBA)	Is Barrier Feasible?	Is Barrier Reasonable?	Is Barrier Recommended?	Comment
1107 E. Holiday Drive	1	7	67,000	Yes	No	No	Not recommended for Proposed Action.
1615 Capri Circle	2	14	17,000	Yes	No	No	Not recommended for Proposed Action.
North Pointe Gardens	2	14	14,000	Yes	No	No	Not recommended for Proposed Action.

Source: FHU modeling results, 2013.

5.2.1 1107 E. Holiday Drive

Traffic noise under the Proposed Action would have an impact on one home at 1107 E. Holiday Drive due to westbound US 50 traffic. The home is approximately even with US 50 in elevation. An abatement barrier extending along the US 50 ROW (**Figure 10**) was evaluated to mitigate the predicted noise impacts. **Table 5** presents the wall dimensions that were evaluated.

A continuous barrier about 1,100 feet long varying in height between 8 to12 feet was calculated to provide a 7-dBA noise reduction benefit to the home. Based on these results, this barrier was found to be feasible and met CDOT's design goal. **Table 6** summarizes the cost/benefit criterion result for this barrier, which exceeded CDOT's limit for reasonableness. Therefore, the abatement barrier is feasible but not reasonable and is not recommended for the Proposed Action (**Table 6**).

5.2.2 1615 Capri Circle

Traffic noise under the Proposed Action would have an impact on one home at 1615 Capri Circle, with what appeared to be a garage apartment, due to westbound US 50 traffic. The home is approximately even with US 50 in elevation. An abatement barrier extending along the US 50 ROW (**Figure 10**) was evaluated to mitigate the predicted noise impacts. **Table 5** presents the wall dimensions that were evaluated.

A continuous barrier approximately 580 feet long varying in height between 8 and 10 feet was calculated to provide a 7-dBA noise reduction benefit to the home. Based on these results, this barrier was found to be feasible and met CDOT's design goal. **Table 6** summarizes the cost/benefit criterion result for this barrier, which exceeded CDOT's limit for reasonableness. Therefore, the abatement barrier is feasible but not reasonable and is not recommended for the Proposed Action (**Table 6**).

5.2.3 North Pointe Gardens

North Pointe Gardens is a property consisting of an assisted living facility with apartments. The apartments did not have individual exterior areas, such as patios, but did have two shared exterior areas, such as tables. Traffic noise under the Proposed Action would have an impact on the exterior areas due to eastbound US 50 traffic. The facility is approximately even with US 50 in elevation. An abatement barrier extending along the street ROW (**Figure 10**) was evaluated to mitigate the predicted noise impacts. **Table 5** presents the wall dimensions that were evaluated.

A continuous barrier about 500 feet long varying in height between 8 to10 feet was calculated to provide a 7-dBA noise reduction benefit to the facility. Based on these results, this barrier was found to be feasible and met CDOT's design goal. **Table 6** summarizes the cost/benefit criterion result for this barrier, which exceeded CDOT's limit for reasonableness. Therefore, the abatement barrier is feasible but not reasonable and is not recommended for the Proposed Action (**Table 6**).

5.3 Impacted Receptors After Recommended Abatement

For a noise abatement action to be recommended, it must be both feasible and reasonable according to the evaluation guidelines (CDOT, 2013). Several areas were identified with traffic noise impacts (**Section 4**), but noise barriers were determined to be not appropriate for any of them (**Section 5.2**). Therefore, no areas have been recommended for noise abatement.

5.3.1 No Action Alternative

Because the No Action Alternative does not include any noise abatement actions, there would be no change in the traffic noise impacts (**Section 4.1**). Traffic noise would still have an impact on the same three Category B receptors, as shown in **Figure 7**.

5.3.2 Proposed Action

Because the Proposed Action would not include any recommended noise abatement actions, there would be no change in the traffic noise impacts (**Section 4.2**). The same five Category B receptors would still be impacted by traffic noise (**Figure 8**).

5.4 Statement of Likelihood

The analysis described above concluded that no noise abatement actions would be both feasible and reasonable. The barrier along Holiday Drive was found to be not reasonable and was not recommended. The barrier along Capri Circle was found to be not reasonable and was not recommended. The barrier along North Pointe Gardens was found to be not reasonable and was not recommended. Therefore, no noise barriers have been recommended for inclusion with the Proposed Action. Final noise abatement decisions will be made during the final design and public involvement phases of the project. Coordination on noise abatement decisions may occur at that time, as necessary.

6. References

Colorado Department of Transportation (CDOT). 2012a. *US 50 West Planning and Environmental Linkages (PEL) Study*. June.

—. 2012b. *US 50 West PEL Implementation Plan*. June.

Colorado Department of Transportation. 2013. *Noise Analysis and Abatement Guidelines*, February.

Federal Highway Administration. 1996. *Measurement of Highway-Related Noise*, May.

Federal Highway Administration. 2011. *Highway Traffic Noise: Analysis and Abatement Guidance*, December.

Federal Highway Administration. 2012. *Procedures for Abatement of Highway Traffic Noise and Construction Noise*. Code of Federal Regulations, Title 23, Part 772.

Federal Transit Administration. 2006. *Transit Noise and Vibration Impact Assessment*, FT-VA-90-1003-06, May.

J.F. Sato and Associates. 2013. Traffic data for the US 50 corridor study, July.

Appendix A

TNM Noise Abatement Barrier Modeling Results

1107 E. Holiday Drive Wall

Approximate dimensions of the traffic noise abatement wall.

Barrier	Barrier Height & Width (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
1107 E. Holiday Drive (B04)	8 x 310 10 x 100 11 x 200 12 x 400	10,500	$471,000

Noise abatement results from TNM for the above walls.

TNM Model Receptor	Units	NAC (dBA)	Noise Level w/o Abatement (dBA)	Result from Modeling	Noise reduction w/ Abatement (dBA)	Noise Level w/ Abatement (dBA)	Does Receptor Benefit?
B04	1	66	72.9	Impact	7.0	65.9	Yes

Total Barrier Benefit = 7.0 dBA

Cost Benefit Index = $471,000 / 7.0 = $67,000/receptor▪decibel

1615 Capri Circle and North Pointe Gardens Walls

Approximate dimensions of the optimized traffic noise abatement walls.

Barrier	Barrier Height & Width (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
1615 Capri Circle (B28)	8 x 280 10 x 300	5,200	$235,000
North Pointe Gardens (B29)	8 x 260 10 x 240	4,500	$202,000

Noise abatement results from TNM for the above walls.

TNM Model Receptor	Units	NAC (dBA)	Noise Level w/o Abatement (dBA)	Result from Modeling	Noise reduction w/ Abatement (dBA)	Noise Level w/ Abatement (dBA)	Does Receptor Benefit?
B28	2	66	71.3	Impact	7.1	64.2	Yes
B29	2	66	67.0	Impact	7.3	59.7	Yes

<u>1615 Capri Circle</u>
Total Barrier Benefit = 14.2 dBA
Cost Benefit Index = $235,000 / 14.2 = $17,000/receptor▪decibel

<u>North Pointe Gardens</u>
Total Barrier Benefit = 14.6 dBA
Cost Benefit Index = $202,000 / 14.6 = $14,000/receptor▪decibel

Appendix B

Noise Abatement Evaluation Worksheets

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

Instructions: To complete this form refer to CDOT Noise Analysis Guidelines

STIP # SR26637.001 Date of Analysis: 9-5-2013

Project Name & Location: US 50 1107 E. Holiday

A. FEASIBILITY:

1. Can a 5dBA noise reduction be achieved by constructing a noise barrier or berm?
   ☑ YES ☐ NO
2. Are there any fatal flaw drainage, terrain, safety, or maintenance issues involving the proposed noise barrier or berm?
   ☐ YES ☑ NO
3. Can a noise barrier or berm less than 20 feet tall be constructed?
   ☑ YES ☐ NO

B. REASONABLENESS:

1. Has the Design goal of 7 dBA noise reduction for abatement measure been met for at least one impacted receptor?
   ☑ YES ☐ NO
2. Is the Cost Benefit Index below $6800 per receptor per dBA?
   ☐ YES ☑ NO
3. Are more than 50% of benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO

C. INSULATION CONSIDERATION:

1. Are normal noise abatement measures physically infeasible or economically unreasonable?
   ☑ YES ☐ NO

   If the answer to 1 is YES, then:
2. a. Does this project have noise impacts to NAC Activity Category D?
   ☐ YES ☑ NO

   b. If yes, is it reasonable and feasible to provide insulation for these buildings?
   ☐ YES ☐ NO

D. ADDITIONAL CONSIDERATIONS:

None.

E. STATEMENT OF LIKELIHOOD:

1. Are noise mitigation measures feasible?
   ☑ YES ☐ NO
2. Are noise mitigation measures reasonable?
   ☐ YES ☑ NO
3. Is insulation of buildings both feasible and reasonable?
   ☐ YES ☑ NO
4. Shall noise abatement measures be provided?
   ☐ YES ☑ NO

F. ABATEMENT DECISION DESCRIPTION AND JUSTIFICATION:

A typical noise wall would be effective, but this is an isolated home, so the cost/benefit index is too high. A barrier is not recommended.

Completed by: [illegible] Date: 9-5-2013

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

Instructions: To complete this form refer to CDOT Noise Analysis Guidelines

STIP # SR 26627.001 Date of Analysis: 9-5-2013

Project Name & Location: US 50 1615 Capri Circle

A. FEASIBILITY:

1. Can a 5dBA noise reduction be achieved by constructing a noise barrier or berm?
   ☑ YES ❒ NO
2. Are there any fatal flaw drainage, terrain, safety, or maintenance issues involving the proposed noise barrier or berm?
   ❒ YES ☑ NO
3. Can a noise barrier or berm less than 20 feet tall be constructed?
   ☑ YES ❒ NO

B. REASONABLENESS:

1. Has the Design goal of 7 dBA noise reduction for abatement measure been met for at least one impacted receptor?
   ☑ YES ❒ NO
2. Is the Cost Benefit Index below $6800 per receptor per dBA?
   ❒ YES ☑ NO
3. Are more than 50% of benefited resident/owners in favor of the recommended noise abatement measure?
   ❒ YES ❒ NO

C. INSULATION CONSIDERATION:

1. Are normal noise abatement measures physically infeasible or economically unreasonable?
   ☑ YES ❒ NO
   If the answer to 1 is YES, then:
2. a. Does this project have noise impacts to NAC Activity Category D?
      ❒ YES ☑ NO
   b. If yes, is it reasonable and feasible to provide insulation for these buildings?
      ❒ YES ❒ NO

D. ADDITIONAL CONSIDERATIONS:

This is an isolated home that appeared to have a garage apartment.

E. STATEMENT OF LIKELIHOOD:

1. Are noise mitigation measures feasible?
   ☑ YES ❒ NO
2. Are noise mitigation measures reasonable?
   ❒ YES ☑ NO
3. Is insulation of buildings both feasible and reasonable?
   ❒ YES ☑ NO
4. Shall noise abatement measures be provided?
   ❒ YES ☑ NO

F. ABATEMENT DECISION DESCRIPTION AND JUSTIFICATION:

A typical noise wall would be effective, but this is an isolated home. The cost/benefit index is too high. A barrier is not recommended.

Completed by: Dale Tischmak Date: 9-5-2013

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

Instructions: To complete this form refer to CDOT Noise Analysis Guidelines

STIP # SR 26627.001 Date of Analysis: 9-5-2013

Project Name & Location: US 50 North Pointe Gardens

A. FEASIBILITY:

1. Can a 5dBA noise reduction be achieved by constructing a noise barrier or berm?
   ☑ YES ☐ NO
2. Are there any fatal flaw drainage, terrain, safety, or maintenance issues involving the proposed noise barrier or berm?
   ☐ YES ☑ NO
3. Can a noise barrier or berm less than 20 feet tall be constructed?
   ☑ YES ☐ NO

B. REASONABLENESS:

1. Has the Design goal of 7 dBA noise reduction for abatement measure been met for at least one impacted receptor?
   ☑ YES ☐ NO
2. Is the Cost Benefit Index below $6800 per receptor per dBA?
   ☐ YES ☑ NO
3. Are more than 50% of benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO

C. INSULATION CONSIDERATION:

1. Are normal noise abatement measures physically infeasible or economically unreasonable?
   ☑ YES ☐ NO
   If the answer to 1 is YES, then:
2. a. Does this project have noise impacts to NAC Activity Category D?
   ☐ YES ☑ NO
   b. If yes, is it reasonable and feasible to provide insulation for these buildings?
   ☐ YES ☑ NO

D. ADDITIONAL CONSIDERATIONS:

This is an assisted living facility with 2 shared exterior use locations. Individual apartments do not have private exterior areas.

E. STATEMENT OF LIKELIHOOD:

1. Are noise mitigation measures feasible?
   ☑ YES ☐ NO
2. Are noise mitigation measures reasonable?
   ☐ YES ☑ NO
3. Is insulation of buildings both feasible and reasonable?
   ☐ YES ☑ NO
4. Shall noise abatement measures be provided?
   ☐ YES ☑ NO

F. ABATEMENT DECISION DESCRIPTION AND JUSTIFICATION:

A typical noise wall would be effective, but there are few exterior use areas. The cost/benefit index would be too high. A barrier is not recommended.

Completed by: Dale Tischmak Date: 9-5-2013