TRAFFIC NOISE IMPACT AND ABATEMENT ANALYSIS TECHNICAL REPORT

FOR THE

6TH AVENUE PARKWAY EXTENSION ENVIRONMENTAL ASSESSMENT

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LIST OF ACRONYMS

AFB..... Air Force Base
CDOT ..... Colorado Department of Transportation
City ..... City of Aurora
dB ..... decibels
dBA..... A-weighted decibels
E-470 ..... E-470 Tollway
EA..... Environmental Assessment
FHWA ..... Federal Highway Administration
Ldn..... day-night sound level
L_{eq} ..... one-hour equivalent sound level
mph..... miles per hour
NAC ..... Noise Abatement Criterion
SH 30..... State Highway 30
TNM..... FHWA's Traffic Noise Model

1. INTRODUCTION

This technical report has been prepared in support of the 6th Avenue Parkway Extension Environmental Assessment (EA) extending 6th Avenue from State Highway 30 (SH 30) to the E-470 Tollway (E-470). This technical report evaluates the effects of the Proposed Action and the No Action Alternative with respect to traffic noise.

1.1 Proposed Action

The Proposed Action would extend the 6th Avenue Parkway for approximately 2 miles along a new alignment, connecting existing 6th Avenue/SH 30 to the west with the existing 6th Avenue Parkway at E-470 to the east. This would close a gap in the existing major arterial street system, reducing out of direction travel and improving the efficiency and reliability of the transportation system. The Proposed Action would be a six-lane arterial roadway with a raised median and sidewalks.

Six initial alternatives were developed and screened through three screening levels to identify the Proposed Action. The alternatives screening is summarized in **Appendix A1** *Alternatives Technical Report* of the EA. Details of the Proposed Action are presented in **Appendix A2** *Conceptual Design Plans* of the EA.

The Proposed Action is shown on **Figure 1**. Major elements of the Proposed Action are identified by number from west to east on **Figure 1**, and include the following:

Element 1. Tie into existing 6th Avenue/SH 30: 6th Avenue/SH 30 is an existing two-lane arterial. At the western end of the Proposed Action, a signalized "thru-tee" type intersection would be constructed connecting the Proposed Action roadway to existing 6th Avenue/ SH 30. This new signalized intersection would include bypass lanes for the eastbound SH 30 through movement or a thru-tee signalized intersection with bypass lanes for both the eastbound SH 30 through movement. The tie-in would be an urban curb and gutter section with three 12-foot travel lanes in each direction to connect to future 6-lane section to the west. A 10-foot sidewalk would be located on both the north and south sides of the roadway.

Element 2. Triple Creek Trail realignment and connections: A portion of the existing Triple Creek Trail would be realigned and would pass beneath the Proposed Action roadway which would be on a bridge at this location (see Element 3 in **Figure 1**). The Triple Creek Trail would be connected to 6th Avenue via a spur trail to the sidewalk constructed along the south side of the new roadway. The Triple Creek Trail is a 10–foot wide soft surface trail that serves equestrians, bicyclists and pedestrians. The realigned portion would match the existing width and surface. A 10-foot sidewalk on both sides of the bridge (Element 3) would provide connections to the trail. The southern terminus of the trail is currently at the Coal Creek Arena, and further extension to the south is planned by the City of Aurora.

Element 3. Roadway bridge over Sand Creek: Immediately east of the new intersection with existing 6th Avenue/SH 30 (Element 1 in **Figure 1**), the roadway would be elevated onto a six-lane bridge crossing over Sand Creek and its associated floodplain/floodway, and over the Triple Creek Trail. The bridge length and profile would be set to minimize impacts to Sand Creek, while still providing a minimum 10-foot vertical clearance over the Triple Creek Trail. The bridge would have a median and sidewalks. The bridge would be approximately 680 feet in length with 5 variable length spans supported on four piers. The bridge would be

designed to be compatible with the surrounding environment and to allow wildlife connectivity along Sand Creek and the Triple Creek Trail.

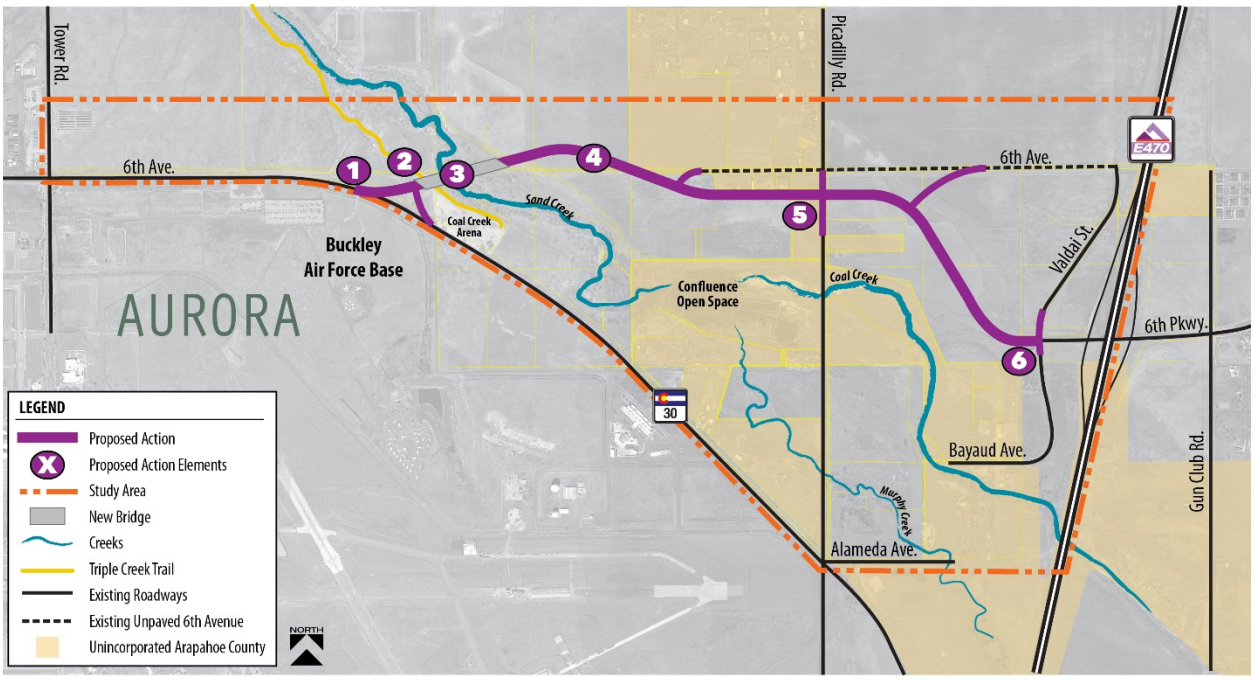
Element 4. 6th Avenue Parkway arterial roadway: The 6th Avenue Parkway extension would consist of a 144-foot wide, six-lane arterial roadway (three lanes in each direction) with a raised vegetated median. There would be curb and gutter and 10-foot wide sidewalks on the north and south sides of the roadway. The Proposed Action would provide two new access connections from the Proposed Action to two existing portions of 6th Avenue. One of these connections would provide access to the existing residences along unpaved 6th Avenue, west of Picadilly Road. The second connection would extend northeast from the Proposed Action to unpaved 6th Avenue to areas planned for development east of Picadilly Road.

Element 5. Intersection with Picadilly Road: The Proposed Action roadway would cross Picadilly Road, which is an existing north-south road. A signalized intersection would be constructed at this location. Picadilly Road is currently two lanes, but the City of Aurora anticipates that expansion to six lanes would occur in the future as a different project. Therefore, the intersection would be configured such that future expansion of Picadilly Road to six lanes can be accommodated and is not precluded.

Element 6. Tie into existing 6th Avenue Parkway at E-470: On its eastern end, the Proposed Action roadway would tie into the existing E-470 interchange, which currently truncates at this location, forming a connection with the existing 6th Parkway to the east of the interchange. The intersection tie-in at Valdai Street and 6th Avenue Parkway would be signalized. This connection would allow access from the west via the Proposed Action to the E-470 interchange and to the existing 6th Avenue Parkway extending to the east of E-470.

In addition to these transportation elements, the Proposed Action would include permanent roadway stormwater drainage with water quality features for roadway runoff and accommodate offsite stormwater flows. Details of drainage and water quality features are presented in **Appendix A6** *Floodplains and Drainage Assessment Technical Report* of the EA.

Figure 1 Proposed Action and Study Area



Note: Numbers in graphic correspond with text above.

1.2 No Action Alternative

If the Proposed Action is not selected for implementation, there would be no improvements made to 6th Avenue by this project. The 6th Avenue Parkway extension would not be constructed, and the existing gap in the arterial street system would remain. The No Action Alternative was carried forward as a baseline comparison for environmental analysis purposes.

2. TRAFFIC NOISE ABATEMENT AND IMPACT ANALYSIS

The purpose of the analyses presented in this report is to conclude whether noise levels from the project alternatives at properties (i.e., receptors) near the prospective road improvements may exceed applicable thresholds, according to Colorado Department of Transportation (CDOT) or Federal Highway Administration (FHWA) guidelines. This report presents an overall analysis that was performed to evaluate existing and future traffic noise levels and to assess for potential impacts to properties near the road improvements from traffic noise levels.

2.1 Project Description

The City of Aurora (City) has begun the design and evaluation process for an extension of 6th Avenue Parkway between SH 30 and E-470. The purpose of the project is to implement a transportation solution that will close a critical gap in the regional transportation network to enhance east-west mobility.

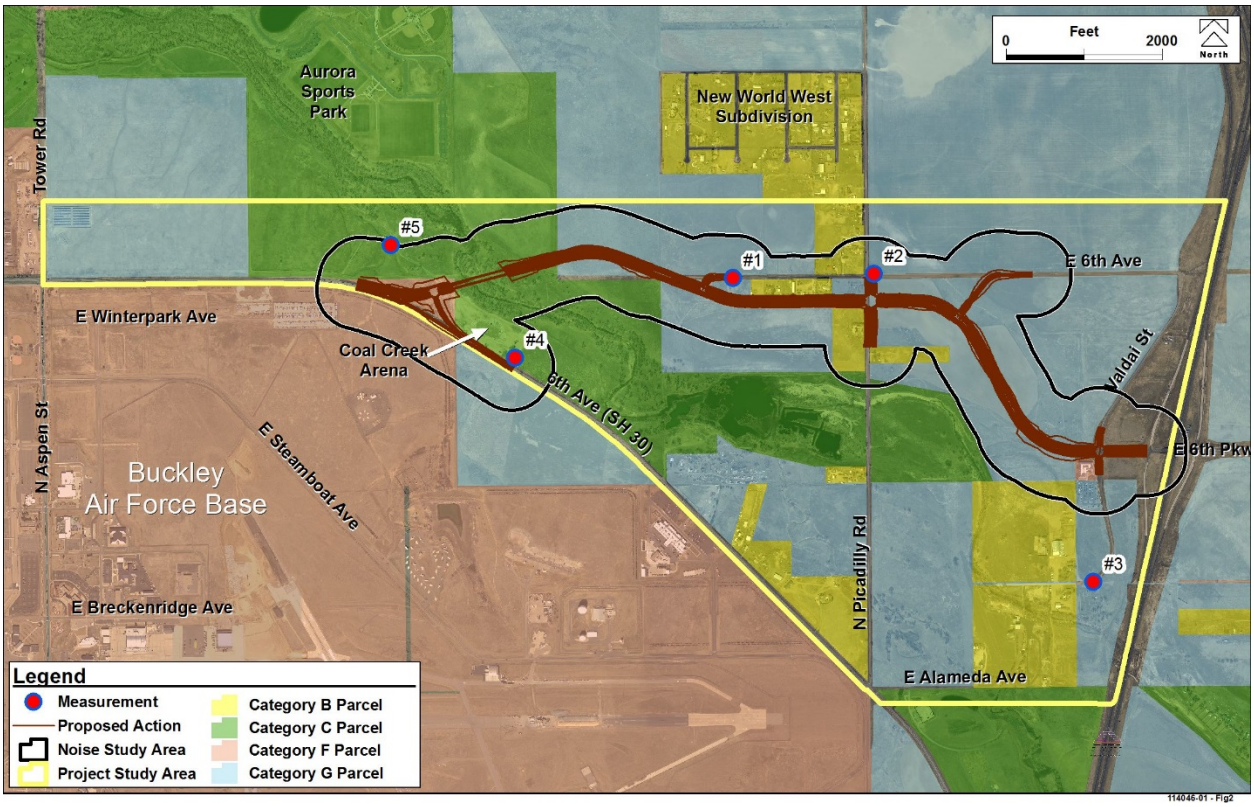
The study area primarily includes undeveloped lands (**Figure 2**), a sizeable portion of which are designated parks, open spaces and recreation areas (hereafter collectively referred to as recreation areas) along several creeks in the area. Several dispersed rural residences are also in the project study area. A few commercial/industrial properties—one of which has an outdoor patio—are present. Buckley Air Force Base (AFB) abuts the west side of the study area and is a source of aircraft noise.

Two future alternatives are being considered in the analysis: the No Action Alternative (No Action) and the Proposed Action (**Figure 2**). The No Action Alternative would make no road improvements as part of this project; however, No Action includes Picadilly Road widened to six lanes by 2035 by other projects in the study area. The Proposed Action would construct the proposed extension of 6th Avenue Parkway along the selected alignment. The Proposed Action would include a six-lane road with an open median, and sidewalks on both the north and south sides. The overall typical cross section would be approximately 144 feet in width.

The Proposed Action would construct a new roadway on a new alignment. Therefore, the Proposed Action is a Type I project under CDOT/FHWA guidelines and warrants a traffic noise analysis, which is the reason for this report.

Several undeveloped parcels of land were present in the study area (**Figure 2**). At the time of the noise analysis, the online development review sites for the City and Arapahoe County were reviewed for active development applications. No applications or active building permits in the vicinity of the project were identified. Therefore, there were no new noise receivers imminent along the Proposed Action that needed to be considered.

Figure 2 Noise Study Area Land Uses and Noise Measurement Locations



2.2 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 in loudness 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 a million times the sound energy of the minimum levels. The human ear is not equally receptive to all frequencies of sound vibrations. Mathematical adjustments to sound levels according to sound frequency bands using the “A” weighting network are often used to approximate how the human ear perceives sounds. In simple terms, the weighting consists of reducing the contributions from low and extremely high sound frequencies by specified amounts. Sound levels that have been weighted this way are reported in A-weighted dB (dBA).

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.

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. The many fluctuations can make quantifying noise through a single value difficult, but CDOT uses the one-hour equivalent sound level (L_{eq}) as the metric for assessing traffic noise impacts (CDOT, 2015a. 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 may be barely noticeable to most people.

On busy roads and highways, the loudest traffic noise generally occurs when the largest traffic volume can travel at the highest speed. This may not occur during rush hour if the traffic volumes become so high that roads become congested and speeds slow. This noisiest traffic condition generally corresponds to Level of Service C or D for a highway (CDOT, 2015a.

2.3 Noise Analysis Approach

A primary purpose of the noise analysis is to conclude whether noise levels at any sensitive receptors within approximately 500 feet (per CDOT guidance) of prospective project road improvements (**Figure 2**) may exceed applicable impact thresholds. If so, abatement actions for the impacted receptors are considered for the project.

The analysis examined roads that would be changed or newly built by the project, would have substantially different traffic volumes because of an alternative, or would be important local traffic noise sources. The overall analysis was based on 2015 measurements of ambient conditions and on modeling of both existing (2014) traffic conditions and future design year (2035) conditions for the two build alternatives (**Section 3**).

Computer modeling was used to examine 2014 and expected 2035 conditions for numerous locations in the Noise Study Area, focusing on potential impacts to the most sensitive receptors (**Section 4** and **Section 5**). The resulting noise levels were compared to applicable criteria to assess for and identify impacted areas (**Section 5**). 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 6**).

3. ANALYSIS METHODS

Noise impacts from vehicle traffic were evaluated through a combination of measurements and computer modeling. The specific methods used for each part of the analysis are described below.

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 based on the federal standard (CDOT, 2015a. All highway projects that involve federal lands or funds must follow these federal regulations and state highway guidelines. Because the proposed project may use federal funds, if available, the project must comply with the federal and state highway guidelines. **Table 1** lists the CDOT Noise Abatement Criterion (NAC) that set the noise impact threshold levels.

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 essential if the area 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 dBA (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.

To summarize the traffic noise analysis process, noise impacts occur when properties near the project roads will have traffic noise levels at or above the relevant CDOT NAC (**Table 1**) or when future noise levels will increase by 10 dBA or more over existing conditions. Typically, the most crucial NAC on road projects is for homes (Activity Category B), which is an hourly L_{eq} of 66 dBA. Parks and other outdoor recreation areas typically fall within Activity Category C, also with a NAC of 66 dBA. Activity Category A is very uncommon, and is not applicable to the type of land uses present in this project study area.

Most of the NAC are aimed toward exterior areas of frequent human use on the properties (**Table 1**). These areas include uses such as yards/decks for Category B, park activity areas for Category C or exterior dining areas at restaurants for Category E. For a noise impact to occur, an applicable area of frequent human use must be present on the property and the noise level must meet one of the impact thresholds described above.

The traffic noise levels are evaluated through computer modeling. Any properties found to be impacted by noise (**Section 5**) are then considered for abatement actions (**Section 6**). Noise abatement actions that are found to be both feasible and reasonable according to CDOT guidelines are recommended for construction under the proposed improvements. Note that 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.

3.1 Traffic Noise Measurements

Five measurements were collected on January 16, 2015 (**Figure 2**). 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. These meters undergo annual laboratory calibration and meters with current calibrations were used.

Noise measurements were made during calm weather conditions that were acceptable according to FHWA guidance (FHWA, 1996). Weather conditions, including wind speed, were monitored during the measurements. 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. The traffic noise measurements were spread across the Noise Study Area (**Figure 2**). One location was selected that was intended to represent homes that are currently remote from the local roads, and therefore likely to be especially quiet, but close to the proposed future roads. Short-term (15-minute) traffic noise measurements were performed at each location (**Section 3.2**) to document existing ambient conditions in the Noise Study Area.

Traffic counts, including the number of large trucks, were collected during the noise measurement periods for model verification. Vehicles were concluded to be traveling at the posted speed limits during the measurements—traffic was not congested. Coincidently, no aircraft operations at Buckley AFB occurred during the measurements. The measurement results were used to document ambient conditions and to evaluate the performance of the computer models.

3.2 Traffic Noise Modeling Methods

Computer modeling was performed for both existing conditions (2014) and the two project alternatives for Year 2035. The traffic noise modeling software was FHWA's Traffic Noise Model (TNM) Version 2.5. The primary purposes of the models were to examine whether traffic noise levels would be high enough to impact neighboring properties, and subsequently whether noise abatement should be considered for any such impacts within the Noise Study 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. Modeling of noise

levels is used to simulate future noise levels using projected traffic volumes and vehicle compositions. In addition, the modeling can evaluate many more locations than can reasonably be measured. The modeling results represent predicted typical average traffic conditions during peak noise periods.

The existing traffic conditions model included the 2014 road configurations and traffic volumes representing the noisiest hour operating conditions of the day. Two future alternatives were evaluated—No Action and the Proposed Action (**Figure 2**)—for their respective 2035 conditions (**Section 2.1**).

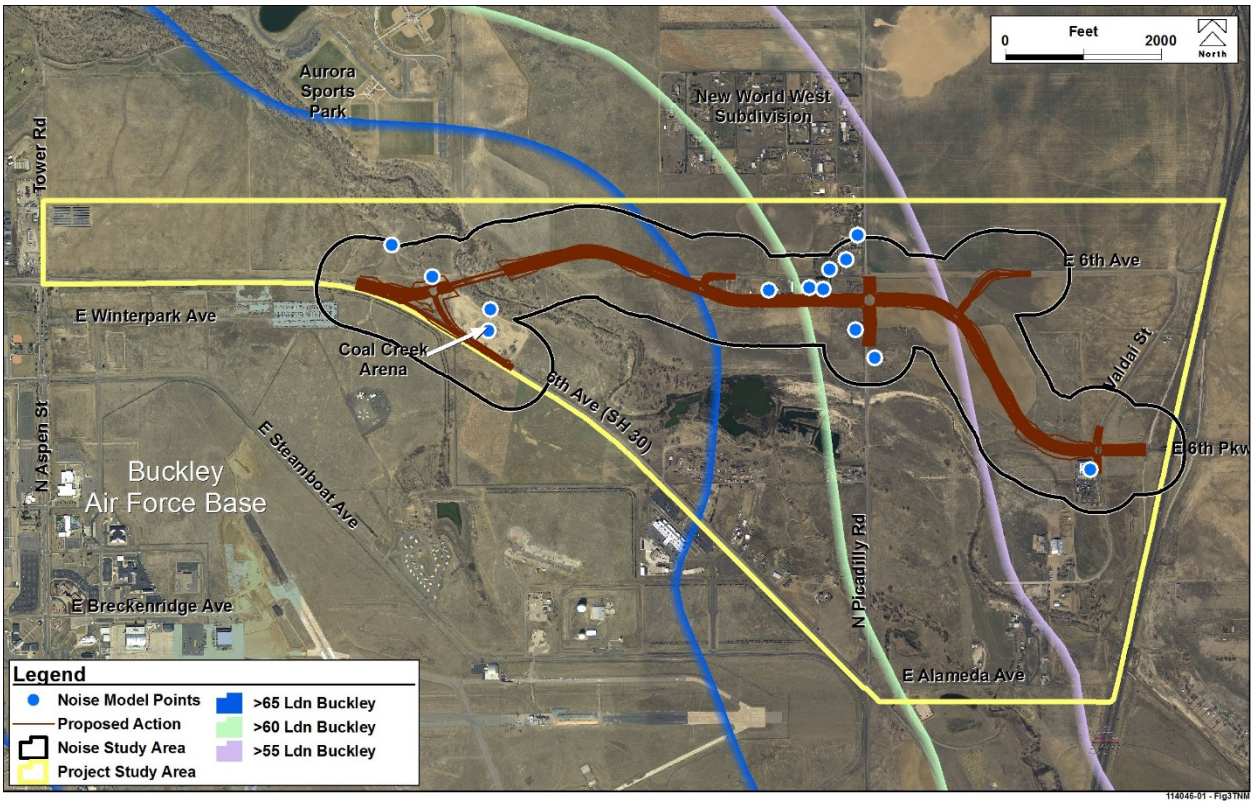
TNM was used to calculate noise levels at 13 points up to 500 feet from a modeled roadway, as illustrated on **Figure 3**. This distance follows CDOT guidance (CDOT, 2015a and was chosen as the project zone for noise to identify the receptors that could be impacted by the alternatives. A single model point may represent several nearby receptors/properties where traffic and geography were similar (e.g., one point for several apartments), so the number of modeled TNM "points" may not always equal the number of individual "receptors" or dwelling units. Note that the residential buildings in the Noise Study Area are single family homes and each model point represents one receptor (**Appendix A**). Each Category C (park) and E (commercial) model point represents one activity area (CDOT, 2015a and one receptor (**Appendix A**).

The modeled roadways were the roads that would be built or changed by the Proposed Action or are important local noise sources. SH 30 and Picadilly Road were the most substantial traffic noise sources for the project, but E-470 is an important traffic noise source on the east side of the Noise Study Area and was included. The other modeled roads were 6th Avenue, Valdai Street and E-470 interchange ramps.

Buckley AFB is a substantial nearby noise source (**Figure 3**). Airports typically use an annualized average day-night level (Ldn) sound metric to evaluate noise impacts, which is basically a 24-hour average sound level with an added penalty for noise at night. The City of Aurora has established an Airport Influence District around Buckley AFB, with relevant restrictions included in the City's zoning code. Note that the Ldn is different from the L_{eq} used by CDOT/FHWA and that the TNM software does not include aircraft noise. Therefore, airport noise is not considered for the Proposed Action.

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. The same receptors were used in each model for consistency. 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 (**Figure 3**) was modeled to assess the possible noise impacts from the proposed roadway changes. The model points shown in **Figure 3** correspond to the noise receptor locations in the modelled area. **Appendix A** contains more detailed information on the modeling.

Figure 3 Modeled Traffic Noise Points

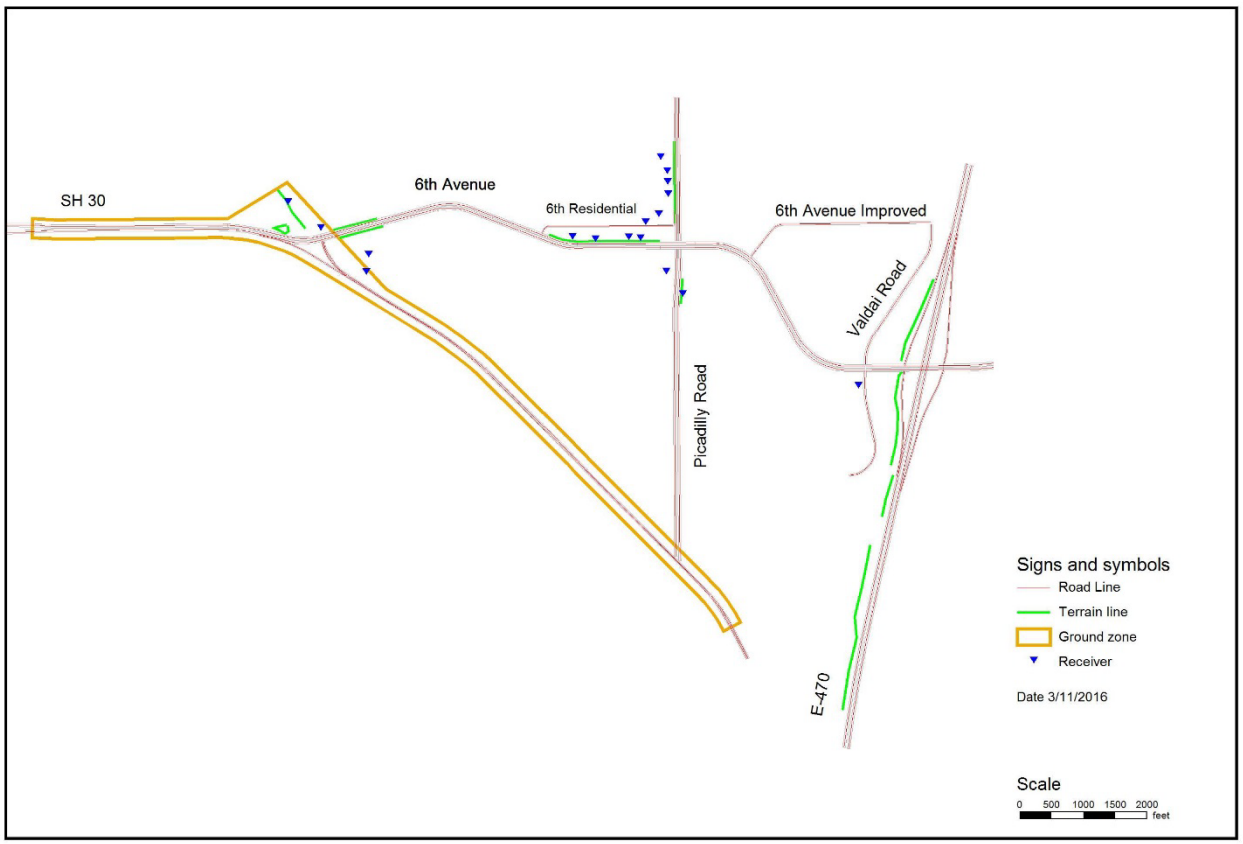


In general, the following data were used in the models:

- 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 for the Proposed Action 6-lane section
- Vehicle Speeds – posted speed limits: 75 miles per hour (mph) for E-470; 25-55 mph for other roads
- Traffic Volumes – from **Appendix A3** *Traffic Analysis Technical Report* of the EA
- Vehicle Mix – from published CDOT traffic count data (CDOT, 2015b)
- Elevations – from ground surface contours of the study area and preliminary road designs; model receptors were 5 feet above existing ground
- Structural and terrain barriers were used as needed to simulate the existing area; abatement barriers were added to models where appropriate for noise abatement evaluations

The modeled TNM objects are illustrated in **Figure 4**. In addition to the receiver locations, the modeled roads are shown and labeled. Road traffic data are provided in **Appendix A**. Several terrain lines were used, which followed the existing natural terrain, in areas where significant topographic features were observed. Based on the findings from the field measurements and verification model, a ground zone along SH 30 was incorporated that used "pavement" rather than the default "lawn" ground type. No building rows or existing structural barriers were included in the models. The numerous TNM input data attached to each of these objects can be found in the TNM model files, provided to CDOT with this report.

Figure 4 TNM Model Objects for Proposed Action



4. AFFECTED ENVIRONMENT

The current traffic noise conditions in the Noise Study Area were assessed through a combination of measurements and modeling. There are residential, recreation and business properties within the Noise Study Area that are of interest for the analysis (**Figure 2**), as well as several undeveloped and unpermitted properties.

4.1 Traffic Noise Measurement Results

Short-term traffic noise measurements were performed at five locations over several hours to document ambient conditions for noise model verification (**Figure 2**). **Table 2** presents the measurement results. One measurement result reached or exceeded the CDOT NAC for Category B (**Table 2**), though this was not at a formal noise receptor location. Note that no planes from Buckley AFB were observed during the measurements.

Table 2 Existing Traffic Noise Measurement Results

Location Number	Location Description	Activity Category	CDOT NAC (dBA)	Measured L_{eq} (dBA)
1	6th Avenue	G	None	43
2	Picadilly & 6th Avenue	G	None	56
3	22500 East Bayaud	G	None	59
4	Coal Creek Arena	C	66	67
5	Picnic shelter	C	66	56
Note: Noise measurements on undeveloped properties were adjacent to sensitive receptor locations				

4.2 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 measurements. A close match between model results and field measurements ensured that the TNM models provided accurate noise results (CDOT, 2015a.

The verification models covered the areas where noise level measurements were made (**Figure 2**). The models were constructed in TNM using the same approach as the alternatives models (**Section 3.2**).

The verification results were in close agreement, as shown in **Table 3**. The results were acceptable according to the CDOT guidelines (CDOT, 2015a which require the difference in results to be no more than 3 dBA.

Table 3 Verification Noise Model Results

Location Number	Location Description	Measured L_{eq} (dBA)	Verification Model Result (dBA)	Difference (dBA)
1	6th Avenue	43	NA	NA
2	Picadilly & 6th Avenue	56	56	0
3	22500 East Bayaud	59	58	-1
4	Coal Creek Arena	67	67	0
5	Picnic shelter	56	56	0

NA = not applicable; the measurement location was near homes that currently are distant from existing roads but would be near the future 6th Avenue extension; TNM would not be expected to calculate existing noise levels accurately under such conditions.

4.3 Existing Conditions Traffic Noise Model Results

A noise model was developed (**Section 3.2**) to evaluate existing conditions. The existing conditions model included the major existing roads that may be affected by the project, with existing (2014) traffic volumes and road layouts. Thirteen points were modeled for traffic noise, as shown on **Figure 3** and **Appendix A**. **Appendix A** presents the calculated result for each model point.

Overall, the calculated noise level range for the model points was 47-64 dBA. These results showed none of the modeled points were impacted from existing traffic noise levels being at or above the respective NAC during the peak noise hour.

5. ENVIRONMENTAL CONSEQUENCES

The alternatives being considered for the project were described in **Section 1.1**. Future roadway traffic scenarios were modeled to predict noise levels for Noise Study Area receptors if nothing is built by the project (No Action Alternative) or the proposed improvements are built as planned (Proposed Action). The traffic noise modeling effort was conducted as described in **Section 2** to assess whether future noise levels in the Noise Study Area 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 6**).

Traffic noise models were developed as described in **Section 3.2** for each alternative. The models included the major project roads using predicted future (2035) traffic volumes and road layouts. The model noise results are tabulated in **Appendix A**.

Appendix D provides a compiled table of the impacts for insertion into the EA.

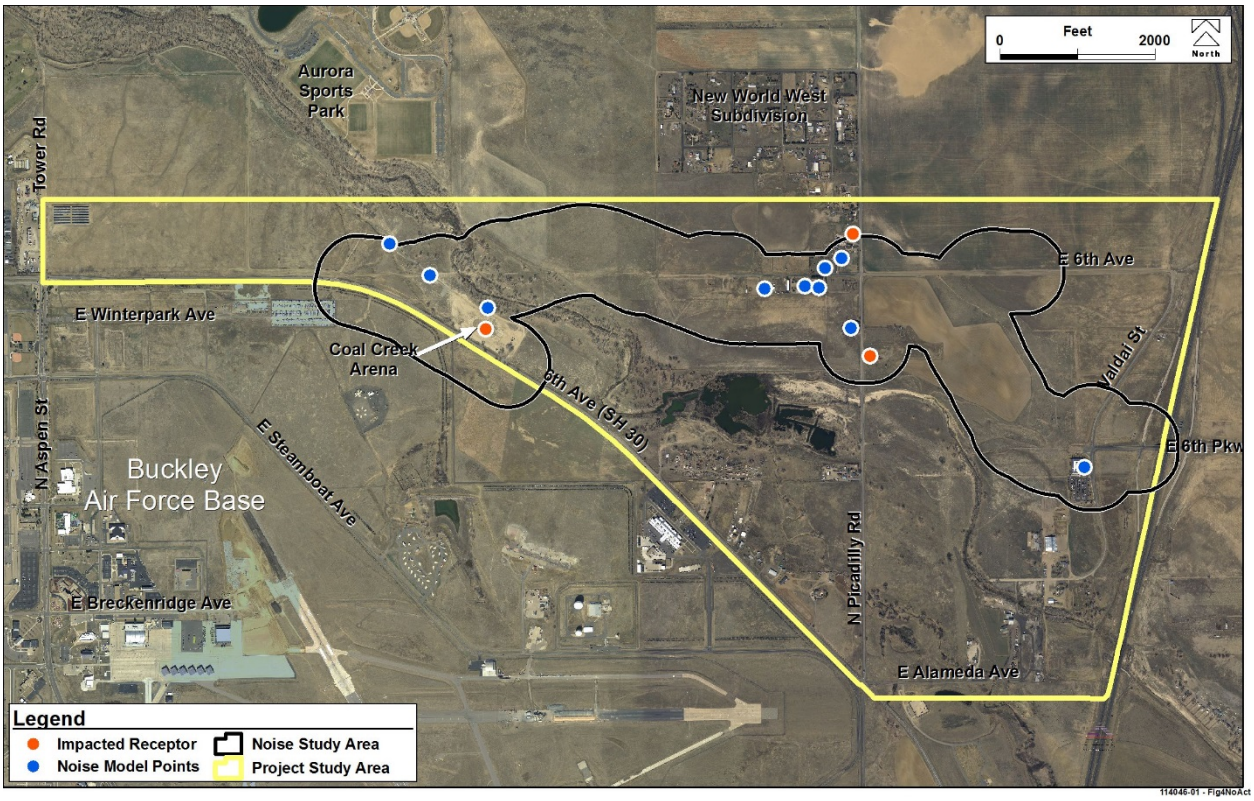
5.1 No Action Alternative

Thirteen points were modeled for traffic noise, as shown on **Figure 3** and **Appendix A**. **Appendix A** presents the calculated result for each model point.

Overall, the calculated noise level range for the model points was 52-68 dBA. These results showed three of the modeled points would be impacted from 2035 traffic noise levels being above the NAC during the peak noise hour. One modeled point was calculated to have a substantial (11 dBA) noise increase over existing levels; however, that point would also be above the NAC and, therefore, was already counted as an impact.

Of the three identified noise impacts, two homes along Picadilly Road would be impacted by noise due to growth in traffic **(Figure 5**). The other impacted receptor would be the Coal Creek Arena, which is a Category C property owned by the City of Aurora.

Figure 5 2035 No Action Alternative Noise Model Results



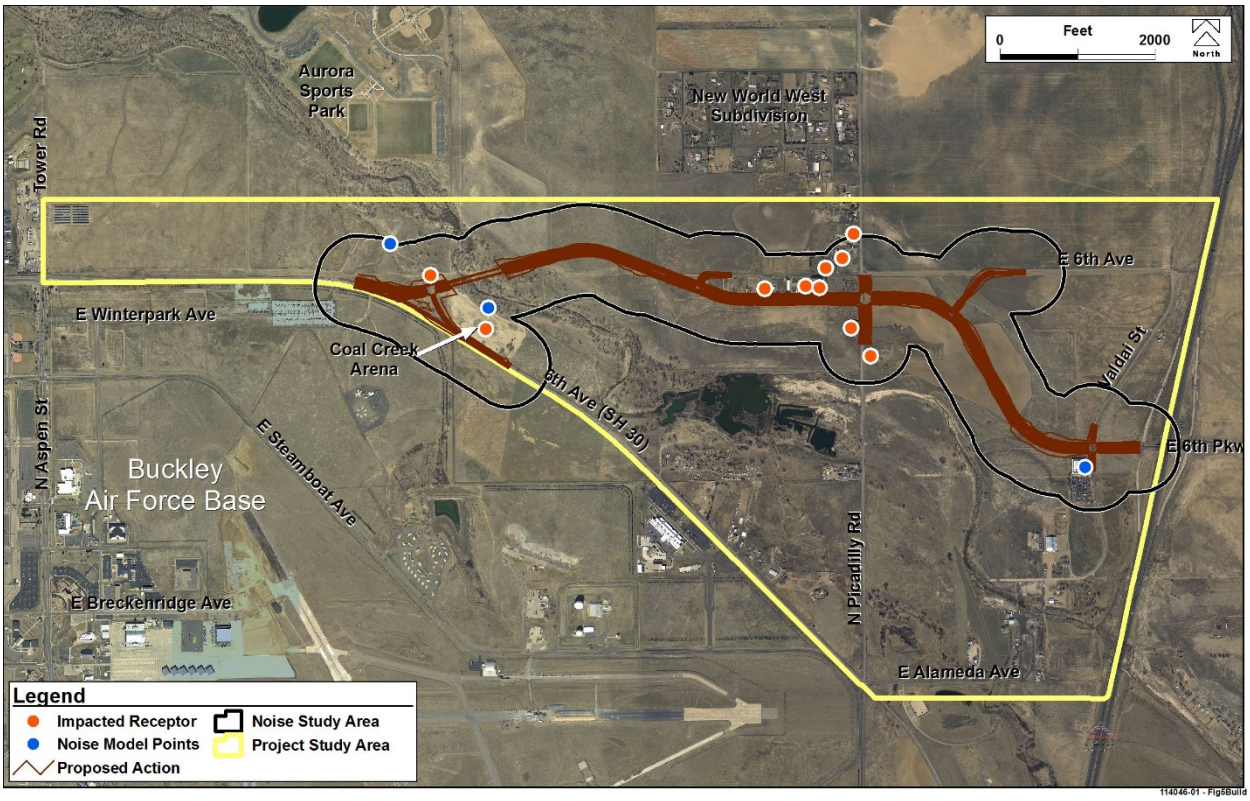
5.2 Proposed Action

Thirteen points were modeled for traffic noise, as shown on **Figure 6** and **Appendix A**. **Appendix A** presents the calculated result for each model point.

Overall, the calculated noise level range for the model points was 61 to 68 dBA. These results showed seven of the modeled points would be impacted from 2035 traffic noise levels being at or above the NAC during the peak noise hour. Eight modeled points were calculated to have a noise increase of 10 dBA or more over existing levels; the largest calculated increase was 20 dBA. Five of these points were also calculated to be above the NAC and already counted as impacted, so three of the points were not above the NAC. Therefore, a total 10 of the model points were found to be impacted by noise (**Figure 6**), which was seven more impacts than No Action.

Of the 10 impacted receptors, eight are residences in the Noise Study Area and two are recreation areas in the Triple Creek Greenway Corridor owned by the City of Aurora.

Figure 6 Proposed Action Noise Model Results



5.3 Construction Noise

Adjoining properties in the Noise Study Area could be exposed to noise from construction activities from the Proposed Action. 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 (e.g., a truck passing a receptor) to months (e.g., 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. Therefore, no construction noise impacts have been identified for the Proposed Action. However, construction noise would be subject to relevant local regulations and ordinances, and any construction activities would be expected to comply with them.

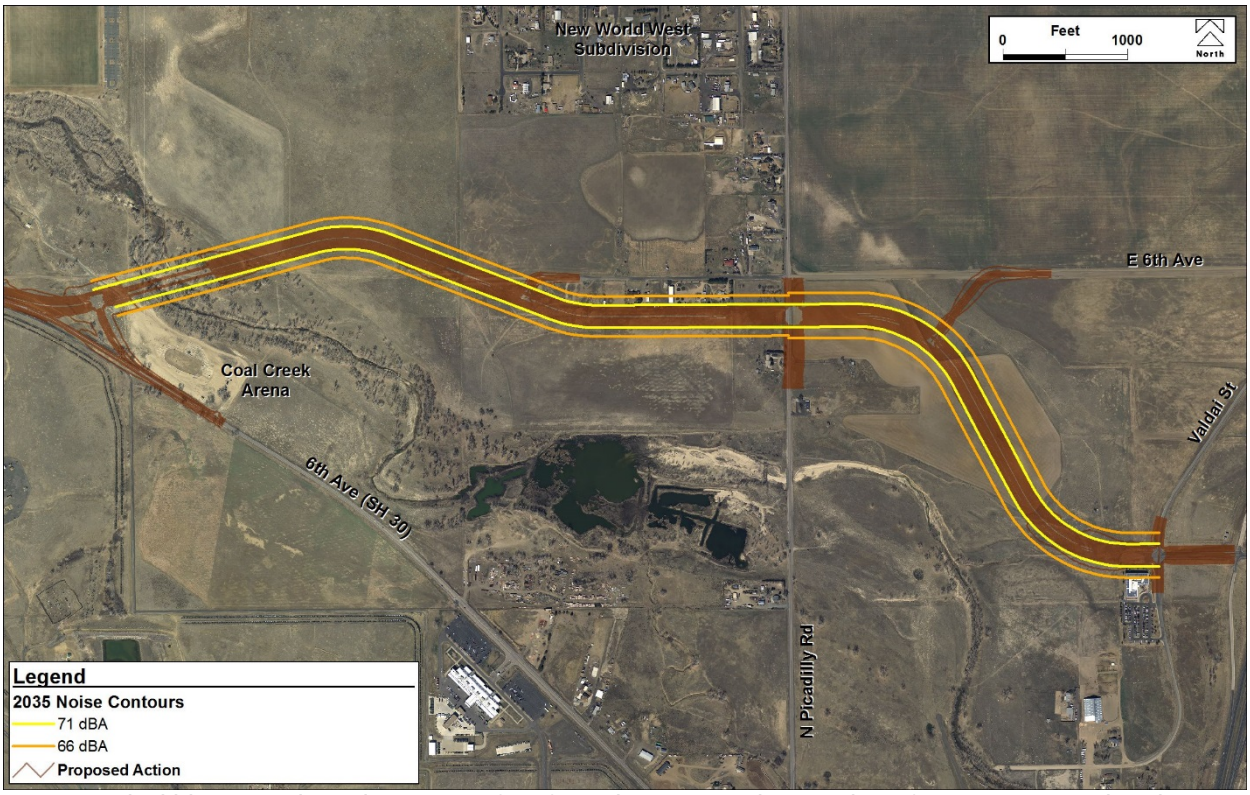
The Proposed Action abuts several residences and parks. To minimize construction noise levels, typical best practices should be incorporated into construction contracts where it is appropriate to do so. These may include:

- 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.
- Exhaust systems on equipment would be in good working order. Equipment would be maintained on a regular basis, and equipment may be subject to inspection by the construction project manager to ensure maintenance.
- Properly designed engine enclosures and intake silencers would be used where appropriate.
- New equipment would be subject to new product noise emission standards.
- Stationary equipment would be located 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.

5.4 Information for Local Officials

To support local land use planning decisions and future development, the 2035 distances to the CDOT Category B/C (66 dBA) and E (71 dBA) NACs were evaluated. **Figure 7** illustrates the estimated noise contour lines for the Proposed Action. The distances will vary somewhat over the corridor due to topography and changing road alignments, but in general, land within approximately 130-150 feet from the proposed new edge of pavement may be above 66 dBA during peak traffic noise hours. Under CDOT and FHWA guidelines, undeveloped properties may not be compatible with residential uses without mitigation for traffic noise. The distance to 71 dBA for sensitive commercial properties will be approximately 45 feet from the proposed new edge of pavement.

Figure 7 2035 Proposed Action Noise Level Contours



Note: Land within approximately 130-150 feet from the proposed new edge of pavement may be above 66 dBA during peak traffic noise hours.

6. NOISE ABATEMENT EVALUATION

The results from the traffic noise analysis indicated that receptors in the Noise Study Area would be impacted by noise in 2035 under the Proposed Action. Therefore, potential abatement actions for the impacted receptors were investigated in accordance with relevant guidelines (CDOT, 2015; FHWA, 2011). Impacted receptors are not guaranteed abatement measures under these guidelines, but abatement measures for the areas must be evaluated for feasibility and reasonableness. Reasonableness includes the amount of noise reduction, cost/benefit of the abatement and the preferences on abatement actions from the benefitting receptors.

Noise impacts with the Proposed Action were previously described (**Section 5.2**). Several types of noise abatement for the impacts were considered. Barriers are a common abatement action and were evaluated, but other kinds of abatement were also considered. The overall feasibility and reasonableness of noise abatement actions that would provide a substantive benefit for the impacted receptors were evaluated. Abatement actions found to be both feasible and reasonable are recommended for inclusion in the project.

CDOT has several criteria to evaluate noise barriers (CDOT, 2015a. CDOT's required minimum noise reduction is 5 dBA for a barrier to be feasible, with a 7-dBA noise reduction design goal for barriers. For reasons described below, barriers appeared to be the only viable noise abatement action and were the only abatement action evaluated through modeling.

6.1 Evaluation of Abatement Other than Barriers

The CDOT guidelines present several non-barrier noise abatement options. For various reasons that are described below, none of these options appeared to be viable for the project.

Traffic management measures such as lane closures or reduced speeds could reduce noise but broad application of these concepts is neither reasonable for the roads of primary interest to the project nor compatible with the purpose of the project. Some of the reasons for the proposed improvements in the Noise Study Area are to improve future traffic access and flow. The Proposed Action would add a new road on a new alignment to accommodate expected future travel demand, so then closing lanes for noise abatement would not be reasonable. Traffic speeds would need to be reduced approximately 25 mph to achieve a 7-dBA noise reduction, which would require speed limits of 20 mph or less on the arterial streets.

Changes in horizontal alignments of the roads near the impacted receptors could reduce noise but are not practical as a noise abatement action. Other road alignments were considered as part of an alternatives evaluation conducted for the project, but these were rejected for a number of reasons as described in **Appendix A1** *Alternatives Screening Report* of the EA. Requiring selection of a previously rejected alternative alignment just for noise abatement is not reasonable.

Changes in vertical alignments (cuts or fills) could reduce noise. However, wholesale changes in road elevations would require a much larger and expensive project and could have secondary impacts to connecting or adjoining roads that would not be reasonable or desirable. Most likely, 6th Avenue and Picadilly Road would need to be in cuts to be effective for noise reduction, which would cause the project footprint to expand to accommodate the sidewalks and slope laybacks needed. Additional right-of-way would be needed, which would increase other impacts. Surface drainage would become more complex, with added associated design and construction costs. Several properties have access directly onto Picadilly Road, which would be difficult if the main

road is in a cut. 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 no opportunities in the Noise Study Area due to the prior development. Generally, the impacted properties would be near the main roads, so sufficient space for buffers is not available at the noise impact areas.

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.

6.2 Traffic Noise Barrier Evaluations

To evaluate noise barriers, computer models with barriers protecting the impacted areas were developed in TNM. Multiple barrier locations should be evaluated (CDOT, 2015a. A preferred barrier location often is near the ROW line, so that future road improvements are less likely to disturb the barriers. An alternative effective barrier location often is near the edge of the road pavement, so that smaller barriers may be possible. These barrier locations were evaluated. However, the Proposed Action will be relatively narrow between the edge of pavement and ROW line (approximately 20 feet) and the ground will also be relatively level at most locations in the corridor, so the physical differences between these barrier placements are relatively minor. Therefore, the barrier evaluation results presented below are nearly identical whether for ROW placement or edge of pavement placement.

The potential barriers were assessed for effectiveness and feasibility. If the minimum parameters for a feasible barrier were met, the barrier was checked for reasonableness according to CDOT guidance (CDOT, 2015a. The feasibility and reasonableness of each barrier determined whether the barrier was recommended for inclusion in the project (**Appendix C**).

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.)
- Be constructible using reliable and common practices
- Not exceed 20 feet in height

For an abatement action to be reasonable it must:

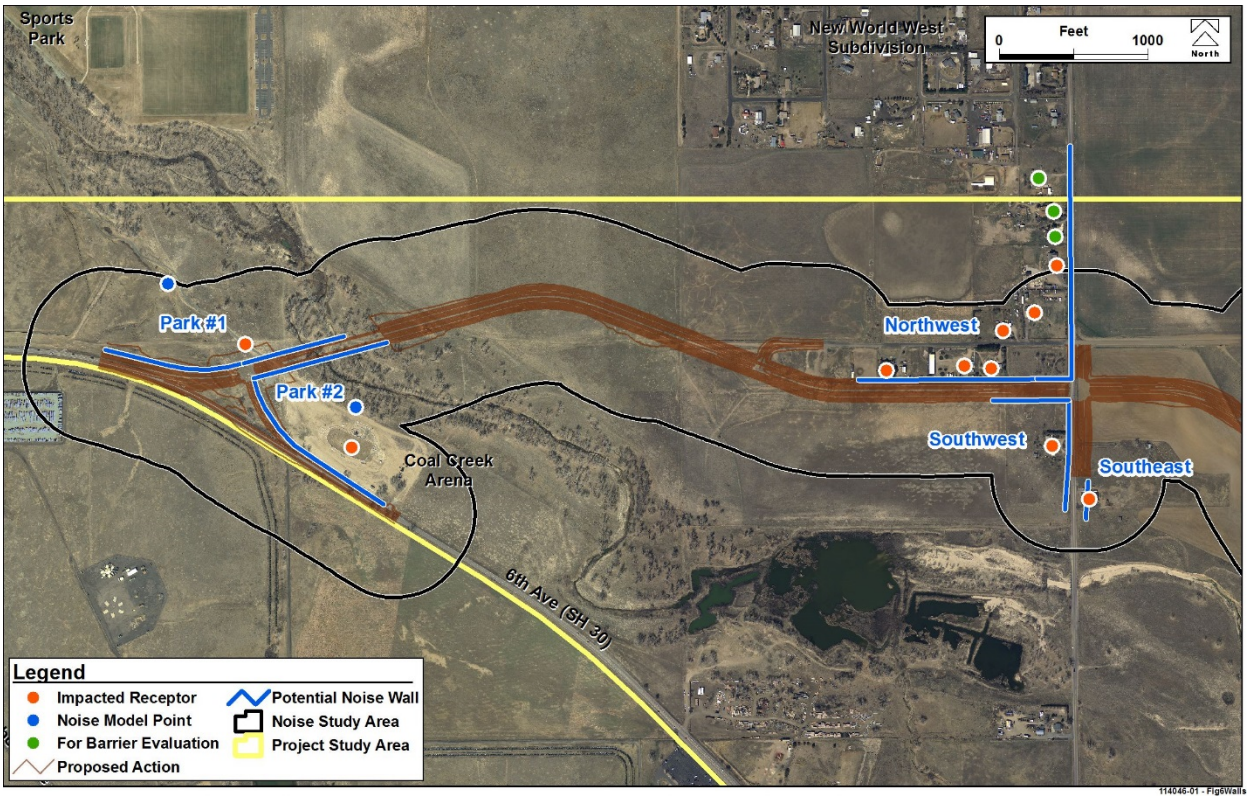
- Meet the minimum design goal of at least 7 dBA of noise reduction at one receptor
- Meet the cost/benefit index of not more than $6,800/dBA/receptor of benefit
- Have support from more than 50 percent of the potentially benefitting receptors

From the TNM results, 10 receptors were calculated to be impacted by noise for the Proposed Action in 2035 (**Figure 6**). The residential receptors were generally level with the proposed project roads. The recreation area receptors were in the creek bottom and generally would be lower than the nearby roads.

Fifteen model points were included in the abatement assessments using TNM (**Figure 8**). Three of these were new points added north of the Noise Study Area on Picadilly Road that were viewed as being within the contiguous neighborhood for impacted homes in the Noise Study Area and a logical break point for a noise barrier (**Appendix B**). Each impacted exterior area of frequent human use was modeled individually.

The abatement evaluations were divided into five separate areas to evaluate barriers (**Figure 8**): two recreation areas near SH 30; one larger residential area northwest of 6th Avenue/Picadilly Road; and, two areas with a dispersed home off Picadilly Road. All the potential barriers were assessed for feasibility and reasonableness (CDOT, 2015a, and barrier recommendations were made based on the results.

Figure 8 Traffic Noise Abatement Barrier Locations Evaluated



It is important to note that the noise barriers can be earth berms or constructed walls and that many materials can be effective noise walls. Berms can be very effective but occupy considerably more space than walls. There are also more property access and drainage challenges with berms. The impacted receptors in the Noise Study Area and/or the driveways to

those receptors tended to be close to project roads. This made the choice of earth berms as the noise barriers impossible, so the barriers likely would need to be walls.

Barrier cost-effectiveness was based on an assumed cost of $45/square foot of barrier and compared to the CDOT upper threshold of $6,800/dBA/receptor of benefit. The potential barrier locations evaluated are illustrated on **Figure 8**, and the results of the evaluation are described in the following sections. The barrier performance results are presented in **Appendix B**.

6.2.1 Park #1 Barrier — Triple Creek Greenway Corridor North of 6th Avenue

An abatement barrier along the north side of 6th Avenue that would protect the recreation area trail was evaluated (**Figure 8**). Note that part of this barrier would need to be on the edge of the proposed bridge over Sand Creek to be effective, so a barrier placement near the edge of pavement was evaluated to take advantage of elevation differences.

This continuous barrier was approximately 1,420 feet long. It was determined that a barrier height of at least 7 feet was needed to provide a 5-dBA noise reduction benefit to the trail receptor. This alignment was not found to have any obvious fatal safety flaws, etc., so the barrier was found to be feasible.

For reasonableness, the evaluation indicated that a barrier ranging in height from 8-9 feet above the adjacent road elevation was needed to meet the 7-dBA noise reduction design goal. One receptor (the trail) would benefit from this barrier. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From the results, the Park #1 barrier (**Figure 8**) was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

Table 4 Summary of Noise Abatement Barriers Evaluated

Barrier	Barrier Option	Barrier Dimensions (feet)	Total Barrier Size (square feet)	Approximate Total Barrier Cost
Park #1	Full area	8 x 368 9 x 128 10 x 628	10,370	$466,600
Park #2	Full area	7 x 899 12 x 62 14 x 187 15 x 1,006	24,780	$1,115,000
Northwest	Full area	12 x 3,056	36,670	$1,650,000
	6th Ave. only	10 x 1,200	12,000	$540,000
	Picadilly only	8 x 50 9 x 50 10 x 550 11 x 50 12 x 100 13 x 345	12,580	$566,300
Southwest	Full area	8 x 99 11 x 100 12 x 99 15 x 947	17,280	$777,700
Southeast	Full area	6 x 50 7 x 225	1,875	$84,370

Table 5 Summary of Barrier Performance and Abatement Conclusions

Barrier	Barrier Option	Number of Benefitting Receptors	Total Decibels of Benefit Provided	Benefit Cost Analysis ($/dBA/ receptor)	Is Barrier Feasible?	Is Barrier Reasonable?	Is Barrier Recommended?
Park #1	--	1	7.0	66,660	Yes	No	No
Park #2	--	2	12.1	92,150	Yes	No	No
Northwest	Full area	9	71.8	22,980	Yes	No	No
	6th Ave. only	3	20.0	27,000	Yes	No	No
	Picadilly only	4	26.8	21,130	Yes	No	No
Southwest	--	1	7.0	111,100	Yes	No	No
Southeast	--	1	8.0	10,550	Yes	No	No

6.2.2 Park #2 Barrier — Triple Creek Greenway Corridor South of 6th Avenue

An abatement barrier along the south side of 6th Avenue that would protect the Coal Creek Arena and possibly some picnic tables was evaluated (**Figure 8**). Note that part of this barrier would need to be on the edge of the proposed bridge over Sand Creek to be effective, so a barrier placement near the edge of pavement was evaluated to take advantage of elevation differences.

This continuous barrier was approximately 2,160 feet long. It was determined that a barrier height of 7-10 feet was needed to provide a 5-dBA noise reduction benefit to the Arena receptor. This alignment was not found to have any obvious fatal safety flaws, etc., so the barrier was found to be feasible.

For reasonableness, the evaluation indicated that a barrier ranging in height from 7-15 feet above the adjacent road elevation was needed to meet the 7-dBA noise reduction design goal. Two receptors would benefit from this barrier. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From the results, the Park #2 barrier (**Figure 8**) was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

6.2.3 Barriers Northwest of 6th Avenue and Picadilly Road Intersection

The majority of the impacted residences are in this area to the northwest of the proposed 6th Avenue/Picadilly Road intersection (**Figure 8**). Given the size of the area and distribution of residences, the following barrier options were considered: all the properties as a single group; those along 6th Avenue as a separate group; and, those along Picadilly Road as a separate group. For completeness, three homes on Picadilly Road just north of the Noise Study Area but within the same “contiguous neighborhood” and logical end point that might benefit from a barrier (**Figure 8**) were included because they may improve the barrier performance results.

To assess feasibility for the entire northwest area as a single group, an abatement barrier along the ROW was evaluated (**Figure 8**). Note that the barrier was between Picadilly Road and the proposed frontage road. This continuous barrier was approximately 3,000 feet long. It was

determined that a barrier height of at least 7 feet would provide a 5-dBA noise reduction benefit to several residences in the Noise Study Area. This alignment was not found to have any obvious fatal safety flaws, etc., so the barrier was found to be feasible.

For reasonableness for the entire northwest area as a single group, a barrier height of 12 feet would provide at least 5 dBA of noise reduction for all impacted receptors in the Noise Study Area. Nine receptors would benefit from this barrier. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From these results, the barrier for the full northwest area (**Figure 8**) was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

For completeness, a barrier for just the impacted receptors along the future 6th Avenue in the northwest area (**Figure 8**) was also considered. This evaluation indicated that a barrier height of 10 feet would provide at least 5 dBA of noise reduction to three receptors. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From these results, the barrier for just 6th Avenue was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

Finally, for completeness, a barrier for just the impacted receptors along the future Picadilly Road in the northwest area was also considered. This evaluation indicated that a barrier height of 8-13 feet would have four receptors benefit—three of which would be outside the Noise Study Area. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From the results, the barrier for just Picadilly Road (**Figure 8**) was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

6.2.4 Barrier Southwest of 6th Avenue and Picadilly Road Intersection

An abatement barrier near the ROW and southwest of the proposed 6th Avenue and Picadilly Road intersection that would protect the home at 455 Picadilly Road was evaluated (**Figure 8**). This continuous barrier was approximately 1,250 feet long. It was determined that a barrier height of at least 9 feet along 6th Avenue and Picadilly Road was needed to provide a 5-dBA noise reduction benefit to the receptor. To facilitate evaluation of the potential noise reduction, the property access problems that would be introduced by building the wall illustrated on **Figure 8** were ignored. Therefore, this alignment was not found to have any obvious fatal safety flaws, etc., so the barrier was found to be feasible.

For reasonableness, the evaluation indicated that a barrier ranging in height from 8-15 feet above the existing ground surface was needed to meet the 7-dBA noise reduction design goal. One receptor would benefit from this barrier. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From the results, the Southwest barrier (**Figure 8**) was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

6.2.5 Barrier Southeast of 6th Avenue and Picadilly Road Intersection

An abatement barrier southeast of the proposed 6th Avenue and Picadilly Road intersection that would protect the home at 500 Picadilly Road was evaluated (**Figure 8**). This home would be very near Picadilly Road pavement and only a barrier at the future ROW was evaluated. This continuous barrier was approximately 280 feet long. It was determined that a barrier height of at least 6 feet along Picadilly Road was needed to provide a 5-dBA noise reduction benefit to the receptor. To facilitate evaluation of the potential noise reduction, the property access problems that would be introduced by building the wall illustrated on **Figure 8** were ignored. Therefore, this alignment was not found to have any obvious fatal safety flaws, etc., so the barrier was found to be feasible.

For reasonableness, the evaluation indicated that a barrier ranging in height from 6-7 feet above the existing ground surface was needed to meet the 7-dBA noise reduction design goal. One receptor would benefit from this barrier. **Table 4** summarizes general characteristics of the potential barrier and **Table 5** summarizes the cost/benefit criterion and overall result. From the results, the Southeast barrier (**Figure 8**) was found to be not feasible and reasonable because the cost index was too high and is not recommended for the Proposed Action.

6.2.6 Mitigation Barrier Summary

Five impacted areas and a total of seven potential noise abatement barriers were evaluated for the Proposed Action. None of the potential barriers (**Figure 8**) were found to be feasible and reasonable. None of the potential barriers were found to meet the stipulated cost/benefit index of not more than $6,800/dBA/receptor of benefit. Therefore, no noise abatement barriers are recommended for the Proposed Action.

6.3 Statement of Likelihood

Ten receptors were concluded to be impacted by traffic noise in 2035 for the Proposed Action (**Figure 6**). For a noise abatement action to be implemented, it must be both feasible and reasonable according to the evaluation guidelines (CDOT, 2015a. The noise abatement analysis and the associated abatement measures for the Proposed Action were described in **Section 6.2** and the conclusion was that none of the abatement barriers would be both feasible and reasonable. Consequently, none of the receptors identified as impacted (**Figure 6**) have feasible and reasonable noise abatement alternatives. No noise barriers have been recommended for inclusion in the Proposed Action (**Section 6.2.6**). Note that these feasibility and reasonableness determinations for this project may change if there are changes in final design after approval of the NEPA documentation.

Appendix E provides a compiled table of the mitigation measures for insertion into the EA.

7. REFERENCES

Colorado Department of Transportation (CDOT). 2015a. Noise Analysis and Abatement Guidelines, January.

CDOT. 2015b. OTIS online traffic data at http://dtdapps.coloradodot.info/otis/TrafficData, accessed May.

Federal Highway Administration (FHWA). 1996. Measurement of Highway-Related Noise, May.

FHWA. 2011. Highway Traffic Noise: Analysis and Abatement Guidance, December.

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

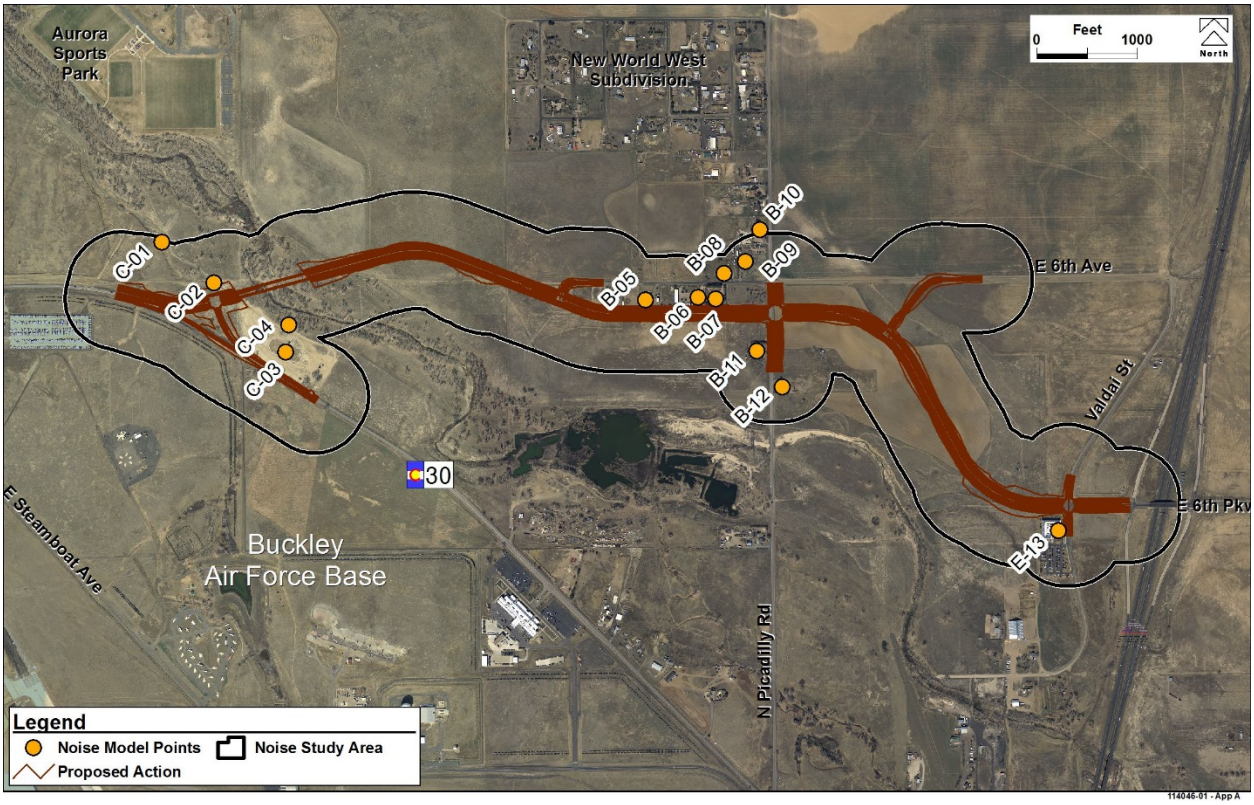
Appendix A TNM Noise Modeling Input and Impact Results

Existing Conditions Model Traffic Data				
Road	**Cars per hour**	**Medium Trucks per hour**	**Heavy Trucks per hour**	**Speed (MPH)**
6th Ave EB	781	19	25	55
6th Ave Gravel	48	1	1	35
6th Ave WB	298	7	9	55
6th Parkway	127	7	6	35
6th residential	2	0	0	25
E-470 NB	726	42	33	75
E-470 SB	1451	83	66	75
Frontage Road Narrow	169	3	2	30
Frontage Road	169	3	2	35
NB Off	41	2	2	40
NB On	32	2	1	40
Picadilly NB1	107	2	1	45
Picadilly NB2	98	2	1	45
Picadilly SB1	180	4	2	45
Picadilly SB2	201	4	2	45
SB Off	28	2	1	40
SB On	61	3	3	40
Valdai	47	1	1	35
2035 No Build Conditions Model Traffic Data				
Road	**Cars per hour**	**Medium Trucks per hour**	**Heavy Trucks per hour**	**Speed (MPH)**
6th Ave improved	980	20	10	35
6th EB1	999	21	10	35
6th EB2	951	20	10	25
6th EB3	1009	21	10	35
6th residential	28	2	0	25
6th WB1	611	13	6	35
6th WB2	572	12	6	25
6th WB3	369	8	4	35
E-470 NB	1043	60	47	75
E-470 SB	2086	120	94	75
Frontage Road Narrow	369	8	4	30
Frontage Road	369	8	4	35
NB Off	254	15	11	40
NB On	236	14	11	40
Picadilly NB1	888	18	9	45
Picadilly NB2	1004	21	10	45
Picadilly SB1	1319	27	14	45
Picadilly SB2	951	20	10	45
SB Off	200	11	9	40
SB On	417	24	19	40
US30 EB	1439	35	46	55
US30 WB	701	17	22	55
Valdai	922	19	10	35

From **Appendix A3** *Traffic Analysis Technical Report* of the EA and CDOT, 2015b.

2035 Proposed Action Model Traffic Data				
Road	Cars per hour	Medium Trucks per hour	Heavy Trucks per hour	Speed (MPH)
6th Ave improved	980	20	10	35
6TH EB1	1922	47	61	40
6TH EB2	2050	50	65	40
6th EB3	1885	46	60	35
6th EB4	1790	43	57	25
6th EB5	407	10	13	35
6th residential	28	2	0	25
6th WB1	1023	25	32	35
6th WB2	1004	24	32	25
6th WB3	824	20	26	35
6TH WB4	1127	27	36	40
6TH WB5	1099	27	35	40
E-470 NB	1043	60	47	75
E-470 SB	2086	120	94	75
Frontage Road Narrow	461	10	5	30
Frontage Road	461	10	5	35
NB Off	272	16	12	40
NB On	1614	93	73	40
Picadilly NB1	640	13	7	45
Picadilly NB2	1113	27	35	45
Picadilly SB1	1563	38	50	45
Picadilly SB2	980	24	31	45
SB Off	218	12	10	40
SB On	490	28	22	40
T SB	20	0	0	30
US30 EB RT	824	20	26	40
US30 EB1	2765	67	88	55
US30 EB2	843	20	27	55
US30 WB1	521	13	17	55
US30 WB2	1572	38	50	55
Valdai	1043	22	11	35

From **Appendix A3** *Traffic Analysis Technical Report* of the EA and CDOT, 2015b.

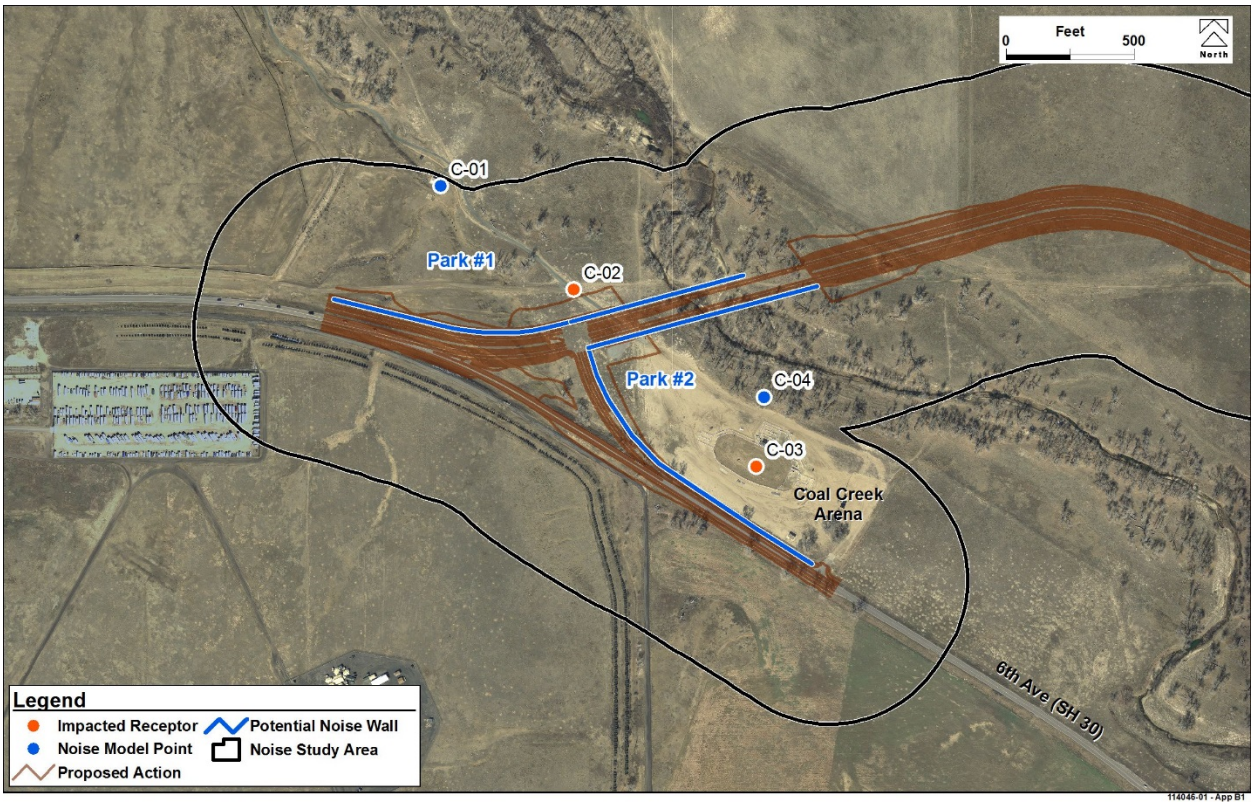


TNM Model Point*	CDOT NAC (dBA)	No. of Units	Existing L_{eq} (dBA)	Existing Result	2035 No Action L_{eq} (dBA)	No Action Result	2035 Proposed Action L_{eq} (dBA)	Proposed Action Result
C-01 (tables)	66	1	57.5	----	60.5	----	63.3	----
C-02 (trail)	66	1	58.8	----	61.9	----	66.3	Impact
C-03 (arena)	66	1	64.4	----	67.4	Impact	65.9	Impact
C-04 (tables)	66	1	60.6	----	63.6	----	63.5	----
B-05	66	1	47.9	----	51.9	----	67.0	Impact
B-06	66	1	47.4	----	52.9	----	66.0	Impact
B-07	66	1	47.6	----	54.8	----	67.2	Impact
B-08	66	1	47.4	----	55.8	----	61.2	Impact
B-09	66	1	49.8	----	59.2	----	62.6	Impact
B-10	66	1	57.6	----	65.5	Impact	67.4	Impact
B-11	66	1	54.9	----	63.3	----	65.4	Impact
B-12	66	1	57.6	----	68.3	Impact	68.2	Impact
E-13 (tables)	71	1	56.0	----	59.7	----	64.0	----

* The leading letter in the name indicates the associated CDOT Activity Category for the receptor.

Appendix B TNM Noise Abatement Barrier Modeling Results

Barrier Analysis Zones Park #1 and #2



Park #1

Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
8 x 368 9 x 128 10 x 628	10,370	$466.600

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
1	7.0	7.0	66,660

Park #2

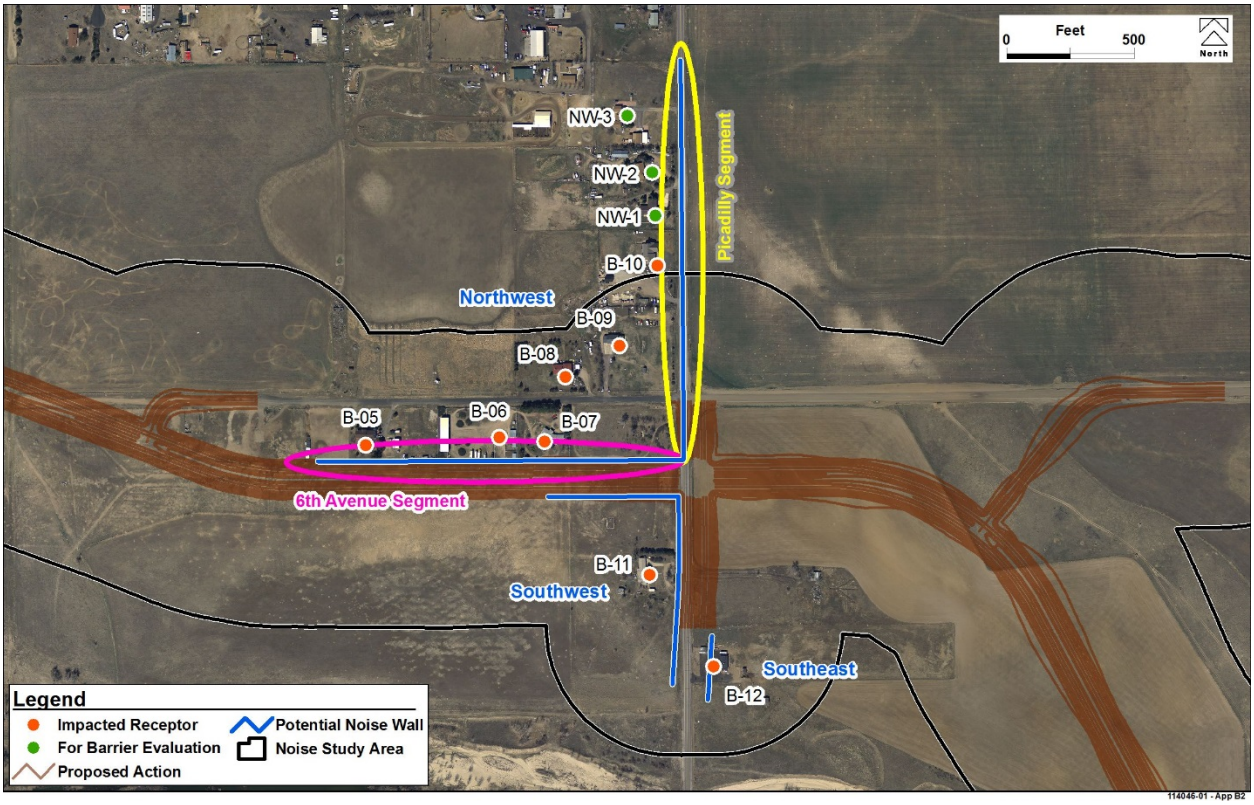
Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
7 x 899 12 x 62 14 x 187 15 x 1,006	24,780	$1,115,000

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
2	12.1	6.0	92,150

Barrier Analysis Zones Northwest, Southwest and Southeast



Northwest—6th Avenue and Picadilly Segments

Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
12 x 3,056	36,670	$1,650,000

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
9	71.8	8.0	22,980

Northwest—6th Avenue Segment only

Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
10 x 1,200	12,000	$540,000

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
3	20.0	6.7	27,000

Northwest—Picadilly Segment only

Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
8 x 50 9 x 50 10 x 550 11 x 50 12 x 100 13 x 345	12,580	$566,300

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
4	26.8	6.7	21,130

Southwest

Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
8 x 99 11 x 100 12 x 99 15 x 947	17,280	$777,700

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
1	7.0	7.0	111,100

Southeast

Approximate dimensions of the selected noise abatement wall:

Barrier Height & Length (feet)	Overall Barrier Size (sq. ft.)	Overall Cost
6 x 50 7 x 225	1,875	$84,370

Noise abatement results from TNM for the above barrier are:

No. Benefiting Receptors	Total Decibels of Benefit Provided	Average Benefit (dBA/receptor)	Cost Benefit Index ($/dBA/receptor)
1	7.3	7.3	11,560

Appendix C Noise Abatement Evaluation Worksheets

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Park #1 Barrier

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO NA

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:

Cost index is too high. Barrier is not recommended.

Completed by: Dale Tischmak Date: 6-16-15

CDOT Form #1209 Revised 02/15

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Park #1 Barrier

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO NA

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:
Cost index is too high. Barrier is not recommended.

Completed by: Dale T. Schmale Date: 6-16-15

CDOT Form #1209 Revised 02/15

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Northwest -- All

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
☐ YES ☐ NO NA

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:
Cost index is too high. Barrier is not recommended.

Completed by: Dale Tischmak Date: 6-16-15

CDOT Form #1209 Revised 02/15

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Northwest 6th Ave Segment

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO NA

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:

Cost index is too high. Barrier is not recommended.

Completed by: Dale Tischmak Date: 6-16-15

CDOT Form #1209 Revised 02/15

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Northwest Picadilly Segment

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO NA

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:

Cost index is too high. Barrier is not recommended.

Completed by: Dale Tischmak Date: 6-16-15

CDOT Form #1209 Revised 02/15

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Southwest

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO NA

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:

Cost index is too high. Barrier is not recommended.

Completed by: Dale Tischmak Date: 6-16-15

CDOT Form #1209 Revised 02/15

Noise Analysis and Abatement Guidelines

COLORADO DEPARTMENT OF TRANSPORTATION
NOISE ABATEMENT DETERMINATION WORKSHEET

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

STIP # _____ Date of Analysis: 6-16-15

Project Name & Location: 6th Ave Southeast

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 responding benefited resident/owners in favor of the recommended noise abatement measure?
   ☐ YES ☐ NO NA

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:
Cost index is too high. Barrier is not recommended.

Completed by: Dale Tischmak Date: 6-16-15

CDOT Form #1209 Revised 02/15

Appendix D Resource Impact Table

Resource	Context	No Action Alternative	Proposed Action
Traffic Noise	Traffic noise is considered in the context of the noise levels at exterior areas of frequent human use at noise-sensitive properties such as homes. Noise impacts occur when noise levels will reach the CDOT Noise Abatement Criteria (NAC) or future levels increase by 10 decibels over existing levels. Existing noise conditions were examined within and adjacent to the Proposed Action footprint. No receptors are currently impacted by equaling or exceeding the NAC and the range of noise levels at noise receptors was 47 to 64 dBA.	The 2035 traffic conditions with no project improvements to the study area were examined. Two homes and one recreation area were identified as impacted by traffic noise. The receptors were impacted by equaling or exceeding the NAC; one of these was also calculated to have a noise increase of at least 10 dBA. The range of noise levels at these three locations was 66 to 68 dBA.	The 2035 traffic conditions with the Proposed Action were examined. Eight homes and two recreation areas were identified as impacted by traffic noise—seven more than No Action. Receptors were predicted to be impacted in two ways: by equaling or exceeding the NAC or having a noise increase of at least 10 dBA. Of the eight homes that would be impacted by traffic noise, five would exceed the NAC while three would not exceed the NAC but would have a noise of at least 10 dBA. The two recreation area receptors that would be impacted would both exceed the NAC. Construction noise could temporarily affect adjoining properties within and adjacent to the Proposed Action footprint.

Appendix E Resource Mitigation Table

Mitigation Category	Proposed Action Impact	Mitigation Commitments for the 6th Avenue Extension Project	Responsible Branch	Timing/Phase that Mitigation will be Implemented
Noise	Temporary noise during construction	Noise abatement barriers to mitigate traffic noise impacts were evaluated. None of the barriers were found to meet the requirements to be both feasible and reasonable. Therefore, no noise abatement barriers are recommended for the Proposed Action. The Proposed Action abuts several residences and parks. To minimize construction noise levels, typical best practices will be incorporated into construction contracts where it is appropriate to do so. These may include: ■ Notify neighbors in advance when construction noise may occur. ■ Keep noisy activities as far from sensitive receptors as possible. ■ Exhaust systems on equipment be in good working order. Equipment maintained on a regular basis and will be subject to inspection by the construction project manager to ensure maintenance. ■ Properly designed engine enclosures and intake silencers will be used where appropriate. ■ New equipment subject to new product noise emission standards. ■ Stationary equipment located as far from sensitive receptors as possible.	City of Aurora	Design Construction

		▪ Perform construction activities in noise sensitive areas during hours that are least disturbing to nearby residents.		