Noise Technical Report

SH 115 – Red Rocks Canyon
El Paso County, Colorado

Project No.: STA 1151-013
Sub Account 13479

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Prepared for:
Colorado Department of Transportation – Region 2

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1.0 Introduction

This report describes the results of a noise study conducted for the State Highway (SH) 115 – Red Rocks Canyon widening project. The project study area runs from Milepost (MP) 35.5 to MP 36.4 and is shown in Figure 1.

The proposed improvements consist of:

- Widening SH 115 from two to four lanes (new lanes are climbing and passing lanes)
- Adding left turn lanes at Calle Del Fuente and Roca Roja intersections
- Replacing existing bridge located south of Roca Roja Circle with concrete box culvert
- Replacing existing bridge located south of Calle Del Fuente with concrete box culvert

The primary purpose of the noise analysis was to determine if any of the existing residential or commercial receptors located within the project study area are considered impacted by noise per the Colorado Department of Transportation's (CDOT) noise guidelines, and if so is mitigation feasible and reasonable.

A secondary purpose of the analysis was to generate noise level contours that can be used to graphically show those areas where certain types of future development would be incompatible with traffic noise. This information should be provided to local planning organizations such that persons or organizations developing property within the study area will be aware of potential noise impacts.

This report is organized as follows. Section 2 describes the noise standards used to assess noise impacts and analyze mitigation on this project. Section 3 describes the methodology used to predict noise levels. Section 4 describes the predicted noise levels and the results of the noise impact assessment. Section 5 discusses general mitigation measures. Section 6 describes the noise level contours, and construction noise is addressed in Section 7. A discussion of relevant noise terminology is provided in Appendix A, and a completed CDOT Noise Abatement Determination form for this project is shown in Appendix B.

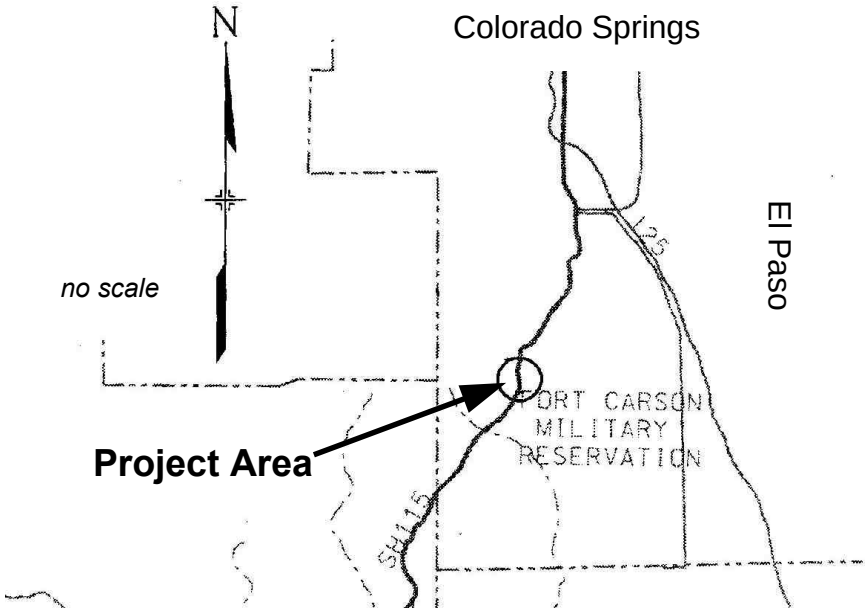

Figure 1: Project Area

2.0 Applicable Noise Standards

This project, as it involves state and Federal funds, is subject to CDOT noise guidelines, which are set forth in the document entitled *CDOT Noise Analysis and Abatement Guidelines*, February 1, 1995. The CDOT noise guidelines are consistent with those of the Federal Highway Administration (FHWA) (23 CFR 772) and have been approved by the FHWA. FHWA guidelines primarily consider protection of areas where there is frequent outdoor use. CDOT's guidelines establish noise abatement (impact) criteria and design and cost requirements for noise mitigation. The guidelines state that noise mitigation should be considered for any receptor or group of receptors where predicted traffic noise levels, using future traffic volumes and roadway conditions, approach or exceed the noise abatement criteria (NAC) shown in Table 1, below. Traffic noise is considered to "approach" a criterion at a level 1 dB(A) less than the criterion (e.g. 66 dB(A) for Category B receptors). The guidelines also state that noise mitigation should be considered for any receptors where predicted noise levels for future conditions are greater than existing noise levels by 10 dB(A) or more.

CDOT guidelines also outline a method for determining the "feasibility and reasonableness" of proposed mitigation measures. Feasibility issues include:

- If a noise barrier is to be constructed, can it be constructed in a continuous manner (gaps in noise barriers, e.g. for driveways, significantly degrade their performance)?
- Can at least 5 dB(A) of noise reduction be achieved (minimum significant reduction)?
- Are there any "fatal flaw" maintenance or safety issues involved with the proposed mitigation measure?

Reasonableness issues include:

- Do existing and future noise levels exceed the aforementioned standards?
- What is the cost per affected receptor per decibel of noise reduction (must meet $3,000 limit)?
- What are the desires of area residents?
- What is the percentage of Category B development in the area?

TABLE 1
CDOT NOISE ABATEMENT CRITERIA

Activity Category	L_{eq} (1), (2) (dB(A))	Description of Activity Category
A	57 (Exterior)	Lands on 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	67 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals.
C	72 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	Undeveloped lands.
E	52 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

(1) Hourly A-weighted equivalent level for the noisiest hour of the day in the design year
(2) CDOT noise impact analysis uses the "approach criteria" which is 1 dB(A) less than shown in the table.

3.0 Noise Level Prediction Methodology

Noise levels were predicted using the STAMINA 2.0 highway noise level prediction software program developed by the Federal Highway Administration, which is approved for use on CDOT and Federal-aid projects. STAMINA calculates the hourly, A-weighted L_{eq} at a receptor location given the noise emission level of automobiles, medium, and heavy trucks, the volume and speed of each of these vehicle types on each roadway of interest, the relative location of all roadways, receptors, and terrain features (i.e. natural and man-made barriers), and the type of terrain between each receptor and each roadway. Sub-section 3.1 describes the STAMINA input data used to predict noise levels for both existing and design-year (2020) conditions on this project. Sub-section 3.2 describes the validation measurements and the comparison of measured and predicted noise levels.

3.1 STAMINA Input Data

Vehicle Emission Levels

Vehicle emission levels refer to the noise level of vehicles measured at a reference distance and a reference speed. STAMINA requires separate emission levels for automobiles, medium trucks (trucks with two axles, six tires, and a gross vehicle weight greater than 4500 kg and less than 12,000 kg), and heavy trucks (trucks with three or more axles and a gross vehicle weight greater than 12,000 kg). The Colorado-specific Reference Energy Mean Emission Levels were used for all vehicle types in all of the predictions. These emission levels were developed by CDOT, and are published in the document entitled *Reference Energy Mean Emission Levels Used in STAMINA 2.0 for Highway Noise Prediction in the State of Colorado*, CDOT, February 1995.

Traffic Volumes and Speeds

The traffic volumes used in the noise analysis were those developed for the project by Parsons Transportation Group Inc. Table 2 shows the existing (2000) peak-hour volumes and speeds of automobiles, medium trucks, and heavy trucks used in the analysis. Table 3 shows the 2020 peak-hour volumes and speeds used in the analysis. The directional split percentages are based on traffic counts conducted by Parsons Transportation Group.

TABLE 2
PEAK-HOUR TRAFFIC VOLUMES – EXISTING CONDITIONS

Roadway	Automobiles	Medium Trucks	Heavy Trucks	Speeds (mph)
SH 115 Southbound	273	8	25	60
SH 115 Northbound	410	12	38	60

TABLE 3
PEAK-HOUR TRAFFIC VOLUMES – 2020 CONDITIONS

Roadway	Automobiles	Medium Trucks	Heavy Trucks	Speeds (mph)
SH 115 Southbound	500	15	46	60
SH 115 Northbound	749	22	69	60

Location of Roadways

Referring to Figure 2, the location and elevation of the existing alignment of SH 115 was determined using the CAD topographical maps developed for the project. The location and elevation of the proposed alignment of SH 115 was taken directly from the CAD design files developed for the project. The effect of roadway slope was taken into account for both conditions.

Location of Receptors

As shown in Figure 2, 15 Category B (refer to Table 1) receptors were identified within the project study area. A description of each of the receptors is shown in Table 4. The exact locations and elevations of the receptors were determined using the CAD topographic files developed for the project. The elevations were checked visually during a site visit. In the STAMINA model, 5 feet was added to the ground elevation at each receptor location to account for the height of a typical person's ear above the ground.

TABLE 4
DESCRIPTION OF RECEPTORS

Receptor Number	Land Use Description	CDOT Receptor Category
1	Single Family Residential	B
2	Single Family Residential	B
3	Single Family Residential	B
4	Single Family Residential	B
5	Single Family Residential	B
6	Single Family Residential	B
7	Single Family Residential	B
8	Single Family Residential	B
9	Single Family Residential	B
10	Single Family Residential	B
11	Single Family Residential	B
12	Single Family Residential	B
13	Single Family Residential	B
14	Single Family Residential	B
15	Single Family Residential	B

Location of Terrain Features and Structures

Existing terrain features such as embankments and structures can act as barriers. As shown in Figure 2, the following features were modeled as barriers on this project:

- the edge of the bench on which Receptors 3 – 5 are located
- the edge of the bench on which Receptors 10 – 15 are located

The elevation of these terrain lines was estimated based project CAD files and on field observations.

Terrain Type

STAMINA allows the user to select one of two types of ground for each receiver-roadway pair: hard or soft. This selection is made using the alpha factor input variable. An alpha factor of zero represents hard ground such as pavement and water, as well as the case where either the source or the receptor are significantly elevated above the ground. An alpha factor of 0.5 represents acoustically soft terrain, which is representative of vegetated ground with both source and receiver located close to the ground. As a majority of the terrain within the study area is hard, and the lines of sight between all receptors and the highway is elevated, an alpha factor of 0 was used in all of the predictions.

3.2 Validation of Noise Prediction Procedures

The previously described modeling procedures were validated by measuring noise levels at one location, using the STAMINA model to predict noise levels at this location, and comparing the measured and predicted results. Noise levels were measured on March 19, 2001. The measurement location is shown as M1 in Figure 2. The noise level was measured for one hour (1:30 - 2:30p.m.) using a Larson Davis Model 820 analyzer, which meets ANSI Type I specifications. The meter was field-calibrated before the measurement and rechecked after the measurement and was within normal limits. During the measurement, the number of automobiles, medium trucks, and heavy trucks, which passed in each direction on SH 115 was tabulated.

Using the measured traffic volumes, along with the roadway and other input data described above for existing conditions, noise levels were predicted at the measurement location. The measured and predicted noise levels are compared in Table 5, below. STAMINA is generally expected to predict noise levels with an accuracy ±3.0 dB(A). The result in Table 5 is within this range.

TABLE 5
MEASURED VERSUS PREDICTED NOISE LEVELS
(L_{eq}, dB(A))

Location	Time	Measured Level	Predicted Level	Difference (pred. – meas.)
M1	1:30 - 2:30 p.m.	64.2	66.9	2.7

4.0 Noise Impact Assessment

Using the above described prediction methodology, noise levels were predicted at each of the 15 receptor locations shown in Figure 2 for both existing and design-year conditions. Table 6, below, shows the noise levels predicted at each receptor, the increase in levels between existing and design-year conditions, and whether or not each receptor is considered impacted. None of the receptors are considered impacted.

TABLE 6
RESULTS OF IMPACT ASSESSMENT

Receptor	Existing (dB(A))	Build (dB(A))	Increase (dB(A))	Impacted (yes/no)
1	62	65	3	No
2	57	60	3	No
3	60	63	3	No
4	58	61	3	No
5	56	59	3	No
6	58	61	3	No
7	60	63	3	No
8	58	60	2	No
9	56	58	2	No
10	57	60	3	No
11	55	57	2	No
12	54	56	2	No
13	54	56	2	No
14	55	57	2	No
15	57	58	1	No

5.0 Noise Mitigation

As discussed in the previous section, none of the receptors are considered impacted by noise on this project. Therefore, no mitigation was analyzed. The following information on general mitigation alternatives is provided for informational purposes only.

Jacobs Engine Brake (Jake Brake) Restriction

The residents of this area have mentioned at public meetings that they find the use of "Jake Brakes" particularly annoying. The Jake Brake was designed by Jacobs Vehicle Systems™, and is the process where a truck uses the compression of its engine to assist with braking. These systems were designed to meet the federal noise requirement of 80 dB(A) at a distance of 50 feet (set forth in 1978), but a vehicle with a worn, defective or modified exhaust system may emit noise levels that exceed this limit.

CDOT does not have the legal authority to restrict the use of Jake Brakes. "Noise Ordinance Enforced" signs can only be placed along SH 115 if an appropriate and enforceable noise ordinance is in place. Enforcement of the ordinance would be the responsibility of the appropriate local police jurisdiction.

Restricting Access to Heavy Trucks

A method of reducing noise along a highway would be to restrict heavy trucks from operating on it altogether or at certain times. Modeling shows that eliminating trucks entirely from this section of SH 115 would reduce hourly average noise levels by approximately 4 dB(A). This would be a noticeable reduction. However, CDOT can not completely restrict trucks from a highway. State highways are funded by state and federal tax dollars with the intent of providing travel for all users, including trucks. Moreover, given the gravel mining operations that occur along SH 115 corridor and the lack of alternate routes it is not reasonable to prohibit or restrict trucks on SH 115.

Acquisition of Property To Form Buffer Zone

Generally, this mitigation measure is a viable alternative only for undeveloped lands where noise impact prevention is the goal. In this area, the west side of SH 115 has already been developed and the east side is the Fort Carson Army Base. Thus, this is not a viable option for this area.

Alteration of Horizontal and Vertical Alignments

In order to provide a significant noise reduction (at least 5 dB(A)) at a given receptor, the horizontal alignment of SH 115 would have to be approximately twice the distance that currently exists between the highway and the receptor. For example, if residences are 100 feet from the center of SH 115, the highway would need to be moved 100 feet further in order to achieve at least 4 to 5 dB(A) of reduction. This is not cost effective on this project or feasible due to the presence of Fort Carson to the east.

Changing the vertical alignment of SH 115, that is depressing it into the ground, could provide a significant reduction in noise at roadside receptors. This is not possible given the terrain in the area.

Reducing Speed Limits

The reduction of speed limits is another option to control vehicle noise. On this project, the existing and proposed speed limit is 60 mph. Table 7 shows the noise reduction that STAMINA predicts if all traffic obeyed the speed limits shown. Conventional science says that residents would not notice a difference in traffic noise levels until that difference was a least 3 dB(A). This is from a purely scientific standpoint based on testing. From a psychological standpoint, residents may perceive a change in noise levels with as little as a 10 mph lowering of speed. However, changing speed limits requires a detailed study that involves numerous factors including accident data, roadway geometric conditions and the speed of the traveling public. Regardless of the posted speed limit the key is enforcement of the speed limit. Reducing the speed limit on this portion of SH 115 for noise mitigation is not recommended.

TABLE 7
PREDICTED NOISE REDUCTION DUE TO SPEED RESTRICTION ON SH 115

Speed	55 mph	50 mph	45 mph	40 mph	35 mph	30 mph
Reduction (L_{eq} (dB(A))	0.8	1.6	2.4	3.4	4.5	5.7

Noise Insulation of Buildings

The insulation or soundproofing of buildings typically involves the installation of double-pane windows that are specially designed to provide a high degree of noise attenuation. CDOT guidelines state that noise insulation only be applied to public or non-profit buildings, such as schools and churches, unless there is a severe impact (absolute noise levels of 75 dB(A) or an increase of 30 dB(A) over existing levels) and other exterior noise mitigation measures are not as cost effective. There are no such situations on this project.

Noise Barriers

Noise barriers, either in the form of walls or earthen berms, are the most commonly employed highway noise mitigation measure. Noise walls are more common than berms because they require less of a footprint. Noise walls were not analyzed on this project because there are no impacted receptors.

6.0 Noise Level Contours

In addition to the noise level predictions at individual receptor locations, noise level contours were produced for this project. Noise level contours are lines drawn along both sides of a roadway that represent a certain noise level. Contours are useful to show those areas where certain types of future development would be inconsistent with highway noise levels. For example, all of the area between a 66 dB(A) contour and a roadway has a predicted noise level equal to or greater than 66 dB(A). Therefore, this area is not suitable for residential development according to CDOT impact criteria.

Figure 2 shows the location of the 66 dB(A) noise contours. The noise contour lines lie approximately 125 feet from the centerline of SH 115. Variations in the 66 dB(A) contour line distance occur due to interactions with the existing terrain.

7.0 Construction Noise

Construction of the project will generate noise from diesel-powered earth moving equipment such as dump trucks and bulldozers, back-up alarms on certain equipment, compressors, and pile drivers (near bridge abutments and retaining walls, if necessary). Construction noise at off-site receptor locations will usually be dependent on the loudest one or two pieces of equipment operating at the moment. Noise levels from diesel-powered equipment range from 80 to 95 dB(A) at a distance of 50 feet. Impact equipment such as rock drills and pile drivers can generate louder noise levels.

Construction noise impacts, while temporary, can be mitigated by limiting work to daylight hours, requiring the contractor to use well-maintained equipment (particularly with respect to mufflers), and through the use of mitigation measures such as temporary noise barriers where applicable.

Figure 2 – Site Plan and Noise Contours for SH 115 / Red Rocks Canyon (page holder only)

Appendix A

Relevant Noise Terminology

Relevant Noise Terminology

Noise, often defined as unwanted sound, is the result of pressure fluctuations in the air. The range of sound pressures which the human ear is capable of detecting is very large (0.00002 to 200 Pa). To facilitate easier discussion, sound pressures are described on a decibel (dB) scale. Sound pressure level in dB is equal to $10Log_{10}(p^2/p_o^2)$ where p is the instantaneous sound pressure and p_o is the reference sound pressure of 0.00002 Pa. This results in a scale of 0 dB (threshold of audibility) to 120 dB (threshold of pain).

In addition to level or loudness, sound has both frequency and time components. The human ear is, in general, capable of detecting frequencies between 20 to 20,000 Hertz. The human ear is more sensitive to high frequency sounds than to low frequency sounds. Because of this, the A-weighting network was developed and is applied to either measured or predicted noise levels to mimic the ear's varying sensitivity to frequency. Resulting noise levels are expressed in dB(A). Figure B1 shows the A-weighted noise levels of some common noise sources.

Different methods have been developed to quantify the time-varying nature of environmental noise levels (environmental noise levels are those found outdoors as the result of sources such as traffic, industry, and wind). The method used to describe noise levels along highways is the equivalent level (L_{eq}). The L_{eq} is essentially the average noise level over a given time period. Technically, it is called the energy-average noise level because of the fact that noise levels are expressed in decibels which must be converted to absolute values of pressure before being averaged. The L_{eq} is a single level that has the same sound energy as the time-varying sound level over the stated time period. The time period used for highway noise analysis is one hour. All noise levels described in this report are hourly, A-weighted L_{eq}'s.

TABLE A1
TYPICAL NOISE LEVELS

Noise Source	**Noise Level (dB(A))**
Amplified rock band	115 – 120
Commercial jet takeoff at 200 feet	105 – 115
Community warning siren at 100 feet	95 – 105
Busy urban street	85 – 95
Construction equipment at 50 feet	75 – 85
Freeway traffic at 50 feet	65 – 75
Normal conversation at 6 feet	55 – 65
Typical office interior	45 – 55
Soft radio music	35 – 45
Typical residential interior	25 – 35
Typical whisper at 6 feet	15 – 25
Human breathing	5 – 15
Threshold of hearing	0 - 5

Appendix B

Noise Abatement Determination Form

COLORADO DEPARTMENT OF TRANSPORTATION

NOISE ABATEMENT DETERMINATION

Instructions: To complete this form refer to Noise Anaylsis and Abatement Guidelines (23 CFR 772 & CDOT Procedural Directive 1601.1 supplement)

Project #	Project code (SA#)	STIP #	Project location:
STA 1151-013	13479		SH 115 – Red Rocks Canyon, El Paso County, CO

A. Feasibility

1. Can a continuous noise barrier or berm be constructed? ☐ yes ☐ no
2. Can a 5 dB(A) noise reduction be achieved by constructing a noise barrier or berm? ☐ yes ☐ no
3. Can a 5 dB(A) noise reduction be achieved by insulation of the receiver? (Normally limited to public and non-profit buildings.) N/A ☐ yes ☐ no
4. Are there any "fatal flaw" safety or maintenance issues involving the proposed noise barrier or berm? ☐ yes ☐ no

B. Reasonableness:

	very reasonable	reasonable	marginally reasonable	unreasonable
1. Build level dB(A)	___	___	___	___
2. Build level dB(A) greater than existing	___	___	___	___
3. Cost/receiver/decibel	___	___	___	___
4. Impacted persons' desires N/A	___	___	___	___
5. Development type	___	___	___	___
6. Development vs. highway timing	___	___	___	___
7. Development existence N/A	___	___	___	___
8. Land use control N/A	___	___	___	___

C. Insulation consideration N/A

1. Are normal noise abatement measures physically infeasible or economically unreasonable? ☐ yes ☐ no
   If the answer to #1. is YES, then:
2.a. Is private residential property affected by a 30 dB(A) or more noise level increase? ☐ yes ☐ no
   b. Are private residences impacted by 75 dB(A) or more? ☐ yes ☐ no
3.a. Does this project have noise impacts to public or non-profit buildings? ☐ yes ☐ no
   b. If yes, is it reasonable and feasible to provide insulation for these buildings? ☐ yes ☐ no

D. Additional considerations:

none

E. Decision:

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? (if C-1=yes) ☐ yes ☐ no
4. Shall noise mitigation measures be provided? ☐ yes ☐ no

F. Decision description and justification:

No mitigation measures will be provided for this project as they are not reasonable due to the predicted 2020 noise levels being below CDOT noise criteria.

Completed by	Date
Jeff Cerjan – *Hankard Environmental*	June 13, 2001

CDOT Form #1209 4/95