Appendix C.
I-25 over Crossroads Boulevard Loveland, Colorado, Traffic Noise Technical Report (Wilson & Company, 2016)

I-25 over Crossroads Boulevard
Loveland, Colorado

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Traffic Noise
Technical Report

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1.0 INTRODUCTION

The purpose of this project is to reconstruct the I-25 interchange over Crossroads Boulevard (exit 259) in Loveland, Colorado. The project would correct profile issues and widen the roadway in preparation for the ultimate I-25 expansion to six lanes between Longmont and Fort Collins.

The project scope includes the reconstruction of approximately 1.5 miles of the existing roadway and replacement of two existing bridges that carry I-25 over Crossroads Boulevard as shown in **Figure 1.** Additionally, the project includes construction of a new 0.67 mile segment of Byrd Drive to connect Byrd Drive between Crossroads Boulevard and Earhart Road as part of the removal of the NW Frontage Road. The project is located within the city limits of Loveland, in Larimer County. The project limits extend to mile post 258.67 to the south of the interchange and milepost 260.16 to the north of the interchange.

The project will include grading activities, roadway widening of I-25 and Crossroads Boulevard under I-25, removal of frontage roads, addition of the new segment of Byrd Drive, safety improvements to the pedestrian, roadway and bridges, installation of new storm drainage systems that will tie to the existing systems, demolition and construction of roadway structures including bridges, paving, signing, striping, seeding, and excavation as needed to accomplish the final geometry of the proposed interstate highway and bridge improvements.

The no action alternative would maintain the existing geometry with no improvements.

Figure 1. I-25 over Crossroads Boulevard Project Area

This Traffic Noise Technical Memorandum describes the results of a noise study conducted along this corridor.

2.0 APPLICABLE NOISE STANDARDS

The Crossroads Boulevard Proposed Action would use state and federal funds and thus is subject to regulations that govern highway traffic noise for Federal-aid and Federal action projects contained in Part 772 of Title 23 of the Code of Federal Regulations (23CFR772). These regulations describe the methods that must be followed in the evaluation and mitigation of highway traffic noise in Federal-aid and Federal action highway projects. The regulations require each state highway agency to prepare and adopt written guidelines specific to that state which must demonstrate compliance with 23CFR772.

CDOT's Noise Analysis and Abatement Guidelines dated January 15, 2015 (attached as Appendix A), describe CDOT policy and program to implement 23CFR772. These guidelines establish noise abatement criteria as well as design and cost requirements for noise mitigation. Traffic noise impacts occur when noise levels, for different categories of land uses and activities, meet or exceed the CDOT Noise Abatement Criteria (NAC) shown in **Table 1.** The noise impact threshold for noise sensitive land uses included amphitheaters (Category C) at 66 A-weighted decibels [dB(A)] and hotels/restaurants outdoor use areas (Category E) receptors at 71 dB(A). These are the primary noise-sensitive receptor types in the corridor. Much of the corridor includes land uses that fall into activity category F and are not sensitive to traffic noise. The guidelines also state that noise mitigation must be considered for any receptors where predicted noise levels for future conditions are at least 10 dB(A) over existing noise levels.

Table 1. CDOT Noise Abatement Criteria

Activity Category	Activity Leq(h)*	Evaluation Activity Location	Description
A	56	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 its intended purpose.
B[1]	66	Exterior	Residential
C[1]	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	51	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[1]	71	NA	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	NA	NA	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	NA	NA	Undeveloped lands that are not permitted for development.

[1] Includes undeveloped lands permitted for this activity category.
* Hourly A- weighted sound level in dB(A), reflecting a 1-dB(A) approach value below 23CFR772 values.

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

- Can a 5 dB(A) noise reduction be achieved by constructing a noise barrier or berm?
- Are there any fatal flaw drainage, terrain, safety, or maintenance issues involving the proposed noise barrier or berm?
- Can a noise barrier less than or equal to 20 feet tall be constructed?

Reasonableness issues include:

- Has the design goal of 7 dB(A) noise reduction for mitigation measure been met for at least one impacted receptor?
- Is the Cost Benefit Index below $6,800 per receptor per dB(A) reduced?
- Are more than 50% of benefitted resident/owners in favor of the recommended noise mitigation measure?

This noise analysis complies with regulatory requirements defined in 23CFR772 and CDOT Noise Analysis and Abatement Guidelines approved January 15, 2015 by FHWA.

3.0 NOISE PREDICTION METHODOLOGY

Noise levels were predicted using the TNM 2.5 highway noise level prediction software program developed by the Federal Highway Administration, which is approved for use on CDOT and Federal-aid projects. TNM calculates the hourly noise level at a receptor location based on the following factors:

- the noise emission level of automobiles, medium trucks, heavy trucks, buses, and motorcycles
- the volume and speed of each of these vehicle types on each key roadway
- the relative location of all roadways, receptors, and terrain features
- the type of land cover between each receptor and each roadway

Sub-section 3.1 describes the TNM input data used to predict existing and 2035 design-year conditions. Sub-section 3.2 describes the validation of the model.

The following paragraphs from the Colorado Noise Analysis and Abatement Guidelines explain the technical terminology for the units of measurement that the model uses:

> *Since sound travels in waves, there are also varying frequencies associated with each sound event. The human ear does not respond equally to all frequencies, however, and filtering of these frequencies must be done in order to obtain accurate measurements and descriptions of highway traffic noise, as this noise is comprised of many frequencies. The filtering (weighting of frequencies) of the "A" scale on sound-level meters most closely approximates the average frequency response of the human ear, and is the scale that is used for traffic noise analyses. Decibel units described in this manner are referred to as A-weighted decibels, or dB(A).*
>
> *As sound intensity tends to fluctuate with time, a method is required to describe a noise source, such as a highway, in a steady state condition. The descriptor most commonly used in environmental noise analysis is the equivalent steady state sound level, or Leq. This value is representative of the same amount of acoustic energy that is contained in a time-varying sound measurement over a specified period. For highway traffic noise analyses in Colorado that time period is one hour, and the value then reflects the hourly equivalent sound level, or Leq(h).*

3.1 TNM Model Input and Assumptions

Vehicle Emission Levels

Vehicle emission levels refer to the noise level of vehicles measured at a reference distance and a reference speed. TNM provides separate emission levels for automobiles, medium trucks (trucks with two axles, six tires, and a gross vehicle weight greater than 4,500 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).

Traffic

The loudest hour for noise occurs when the highest volume of traffic is traveling at the highest free flow speed for the particular roadway. This is often not the peak hour, when heavy traffic volumes result in lower speeds. This is the case with I-25 when the high volumes during the peak hour slow the average travel speeds. To replicate the loudest possible noise condition for existing, No-Action, and the Proposed Action, all lanes of I-25, including cross streets, were modeled with a theoretical maximum traffic volume per lane at the posted speed. This is the worst-case noise scenario for modeling purposes. These traffic volumes, presented in the January 15, 2015 Noise Abatement Guidelines, were developed by CDOT using the Highway Capacity Manual (2000) and TNM. Truck percentages were developed for the I-25 North Environmental Impact Statement for existing and future 2035. The resulting modeled traffic volumes are shown in **Table 2.** The No-Action model used the 2035 truck percentages with the existing roadway geometry.

Table 2. Assumed Loudest Hour I-25 Traffic

Posted Speed	Volume/Lane/Hour			
	Total	Automobiles	Midsize Trucks	Heavy Trucks
Existing				
75	1,600	1,424	88	88
	100%	89%	5.5%	5.5%
2035 / No-Action				
75	1,600	1,472	64	64
	100%	92%	4%	4%

Terrain

The terrain surrounding I-25 is fairly level with limited natural and man-made features that directly affect the propagation of traffic noise to the surrounding area and receptors. The locations and elevations of the features along I-25 were determined using the CAD topographic files and included in the TNM model.

Ground Cover

Throughout the study area, ground cover adjacent to I-25 consists primarily of field grass with landscaped areas at the Crossroads interchange.

Buildings

Developed areas along I-25 are a mix of commercial properties. Large building structures that impede the transmission of sound from the roadway to the receptors were included in the TNM model. Three-sided barriers are used to replicate the effects of large structures. The locations and elevations of these features was determined using the CAD topographic files.

Receptors

Modeled receptors are located in the outdoor use areas of individual commercial properties with noise sensitive outdoor uses within 500 feet, or more as needed for the analysis, of the I-25 and Byrd Road project limits. Field reconnaissance and a complete review of all development plans of the area revealed two noise activity category C receptors, Thunder Mountain amphitheaters and Larimer County Fairgrounds, and five noise activity category E commercial receptors: (1) Embassy Suites outdoor restaurant and (2) Spa, (3) Thunder Mountain Harley outdoor seating, (4) Hooters outdoor seating and (5) Castlewood Suites outdoor grill area with noise-sensitive outdoor uses. All other land uses in the project area do not have noise-sensitive outdoor use and are noise activity category F and were not modeled. The locations and elevations of all features were determined using the CAD topographic files and included in the TNM model. Individual receptors locations are identified in **Figure 2.** To provide a better scale for clarity, **Figure 2** does not show the entire project area but focuses on the areas that include noise-sensitive receptors.

Roadways

The existing and proposed roadway alignments, including profiles and pavement width, for I-25, Byrd Drive striping area, and Crossroads Boulevard, were determined using the CAD roadway design files and topographical survey data and included in the TNM model.

3.2 Validation of Noise Model

The above-described modeling procedures were validated by measuring noise levels at three locations along the corridor and comparing the measured readings with the TNM model predictions for these locations with the traffic counted during the measurement times. These sites are shown in **Figures 2**. Noise levels were measured on December 17, 2015 which was a warm, dry, wind free (less than 10 mph) day, using a Quest 2900 integrating/logging level meter. The meter is calibrated annually by a certified laboratory to verify accuracy and field-calibrated before and re-checked after the measurements.

Figure 2 –Monitoring and Receptor Locations

At the same time that noise levels were measured, the associated traffic counts, vehicle type data, and average speeds were collected. Noise measurements were collected during off-peak hours to ensure free flow traffic. Two readings were conducted at each site. Modifications to the TNM model were made to ensure the model was sufficiently replicating the site conditions and the manner in which sound propagates through the environment.

The measured and predicted noise levels are compared in **Table 3.** When the noise model predicts noise levels with an accuracy of ± 3 dB(A) when compared to the measured levels, the model is considered validated and suggests the model is accurately predicting the noise environment.

Table 3 - Noise Model Validation

Site #	Location	Field (dB(A) Leq)	Direction of Travel	Traffic (Hourly Equivalent)					Model (dB(A) Leq)	Variance (dB(A) Leq)	Notes/ Issues in Field
				Auto	HT	MT	MO	Bus			
1 - 1	South and east of I-25 Crossroads Interchange	**72.0**	NB	2484	144	108			**72.4**	**0.4**	
			SB	2112	108	72					
1 – 2		**71.3**	NB	2310	132	102			**72.1**	**0.8**	
			SB	1848	114	90					
2 - 1	East of I-25 between Embassy Suites and Fairgrounds	**74.7**	NB	2934	96	72			**74.4**	**0.3**	
			SB	2424	106	84					
2 - 2		**75.0**	NB	2796	120	72			**74.4**	**0.6**	
			SB	2358	144	108					
3 - 1	West of I-25, South of Earhart Road	**67.6**	NB	2472	132	126			**66.5**	**1.1**	
			SB	2316	160	96					
3 - 2		**67.2**	NB	2352	144	90			**66.7**	**0.5**	
			SB	2406	138	126					

Note: “Auto” represents passenger vehicles, “MT” represents medium delivery trucks, “HT” presents heavy 18 wheel trucks, “MO” represents motorcycles, “Bus represents buses and motorhomes.

As can be seen in Table 3, the variance between monitored and model-predicted noise levels ranged from 0.3 to 1.1 dB(A) which is well within the 3 dB(A) criteria for model validation.

4.0 NOISE IMPACT ASSESSMENT AND MITIGATION ANALYSIS

The validated noise models were the basis for the development of the noise prediction models for the Existing, 2035 No Action, and 2035 Proposed Action traffic scenarios. These models were then used to predict noise levels for all receptor locations.

4.1 Noise Impact Assessment

Traffic noise impacts occur when noise levels, for different categories of land uses and activities, meet or exceed the CDOT Noise Abatement Criteria (NAC) shown in **Table 1.** The noise impact threshold for active outdoor use area (Category C) receptors is 66 dB(A) and noise sensitive commercial area (Category E) receptors is 71 dB(A). The guidelines also state that noise mitigation must be considered if the increase is at least 10 dB(A) over existing noise.

4.2 Mitigation Analysis

Any and all receptors determined to be impacted by noise must be evaluated for traffic noise mitigation. This requires that the overall social, economic, and environmental effects of the mitigation be evaluated against the benefits. When determining mitigation measures, primary consideration is to be given to exterior areas surrounding residential areas or areas of frequent human use for other uses such as parks and commercial districts where a reduced noise level

would be of benefit. All feasible and reasonable mitigation measures are required to be included in the highway project.

The following are common mitigation measures that may be incorporated in roadway projects to reduce traffic noise impacts.

- Traffic management measures, such as lane-use restrictions, designated truck routes, and speed limit reductions. While lesser speeds do decrease noise levels, it generally will take a reduction in speed of approximately 20 miles per hour to achieve a readily perceptible (5 dB(A)) reduction of noise at its source
- Alteration of horizontal and vertical alignments to reduce noise impacts.
- Acquisition of undeveloped land for buffer zone creation. This is not an option as the area is a highly developed corridor with residential uses adjacent to the roadway.
- Noise insulation, but for NAC Activity Category D structures only.
- Construction of noise barriers or earthen berms within highway right of way is the most common mitigation measure employed by CDOT and will be evaluated for this project.

The cost-benefit index is not intended to function as an accurate cost itemization for the design and construction of a noise barrier, but rather to provide a consistent level of consideration that will be used for CDOT noise mitigation decision-making. For purposes of the mitigation evaluation, the unit cost for a generic wall, as prescribed by CDOT, is $45 per exposed square foot, which approximates the typical costs in construction of a standard concrete/masonry barrier that does not require special site considerations. This cost is based on an average of 2005 to 2009 noise wall square footage costs collected from CDOT cost tabulations. This cost does not include engineering design, right-of-way acquisition, or utility mitigations.

The analysis includes:

- Predicted Existing, No Action, and 2035 Proposed Action noise levels,
- Change in noise levels between the Existing and the Proposed Action,
- Determination of whether predicted noise levels equal or exceed CDOT's abatement criteria, as presented in Section 2.0 Applicable Noise Standards,
- Noise mitigation analysis with feasible and reasonable evaluation (as presented in Section 2.0, Applicable Noise Standards), and
- Mitigation recommendation.

4.3 Impact Assessment

Using the prediction methodology described in Section 3.0, receptors were developed for the noise sensitive land use as shown in **Figure 2.** Noise levels were predicted at each sensitive receptor for both Existing, No-Action, and Proposed Action conditions. The increase between Existing and Proposed Action, and whether or not each receptor is considered impacted are shown in **Table 4.** No receptors equal or exceed CDOT impact criteria for sensitive commercial properties currently or in the future with the Proposed Action.

Noise mitigation at the modeled noise sensitive locations, shown in **Figure 2**, do not meet CDOT/FHWA criteria for implementation and thus mitigation is not recommended and no further abatement criteria need to be evaluated. However, during final design, alignment shifts or profile changes beyond project tolerances could trigger a re-evaluation and re-analysis of noise impacts and mitigation.

Because no receptors met CDOT impact criteria, no Noise Abatement Determination forms were completed for this project.

Table 4 –Noise Model Results without Mitigation

Receptors			Modeled Noise Levels (dB(A))				CDOT Noise Abatement Criteria	
ID No.	Description	NAC Activity Category	Existing	No-Action	Proposed 2035	Change in Levels (Prop – NB)	Approach or Exceed Activity Value	Increase Over Existing
1	Fairgrounds	E	57	56	58	0.6	No	No
2	Embassy Suites Restaurant	E	66	66	67	1.4	No	No
3	Embassy Suites Spa	E	66	66	68	1.4	No	No
4	Tndr Mtn Parking Lot Tables	E	62	62	64	1.8	No	No
5	Tndr Mtn Amphitheater	C	56	55	57	0.9	No	No
6	Hooters Outdoor Seating	E	60	60	60	0.1	No	No
7	Castlewood Outdoor Seating	E	66	65	66	0.6	No	No

Note: Model values are calculated to the nearest tenth decimal; however, for impact identification, CDOT requires noise level values to be arithmetically round to the nearest whole number e.g. 65.5 is round to 66. Based on this rounding changes in noise levels from the existing to the proposed will not appear to be arithmetically correct. This table contains no impacted receptors

4.4 Statement of Likelihood and Summary of Recommendations

No receptors on the I-25 corridor equal or exceed CDOT impact criteria. Noise mitigation is not recommended. However, during final design alignment shifts or profile changes beyond project tolerances could trigger a re-evaluation and re-analysis of noise impacts and mitigation.

4.5 Coordination with Local Agencies

The 2035 71 dB(A) and 66 dB(A) contour lines are approximately 225-275 feet and 350-400 feet from the edge of pavement on I-25 as shown on **Figure 3**. It is recommended that future noise sensitive land uses not be permitted by the local agencies within these noise contours. Byrd Drive is a local facility and will not be under CDOT jurisdiction.

Figure 3 - 2035 Noise Contours

5.0 CONSTRUCTION NOISE IMPACTS

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, and compressors. 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, 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.

REFERENCES

CDOT. 2015. Colorado Department of Transportation Noise Analysis and Abatement Guidelines.