

# Noise Analysis and Abatement Guidelines

September 21, 2020



This document supersedes CDOT Noise Analysis and Abatement Guidelines  
dated January 15, 2015

## Revision History

Version Date	Version	Modification Summary
1995	1	Original CDOT noise guidance
2002	2	Major update to modernize noise guidance
2011	3	Major update in response to major changes in 23 CFR 772
2013	4	Minor modifications to add Section 7.3 and wall survey form.
2015	5	Multiple text modifications including several technical clarifications.
2020	6	Significant modifications including: Changed units of Cost Benefit Index, changed number of receptors needed for feasibility and reasonableness criteria; changed applicability to non-Federal projects; changed number of receptors needed for some receptor types; rearranged text; added information and clarification on various topics including reevaluations and when the Date of Public Knowledge changes.

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## List of Abbreviations and Acronyms

23 CFR 772	Title 23, Code of Federal Regulations, Part 772 (FHWA Noise Regulation)
ANSI	American National Standards Institute
a.m.	antemeridian
CatEx	categorical exclusion
CBI	cost benefit index
CDOT	Colorado Department of Transportation
CFR	Code of Federal Regulations
CM	Construction Manager
CMGC	Construction Manager/General Contractor
dB	decibel
dba	A-weighted decibels
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPB	Environmental Programs Branch
FAQ	Frequently Asked Question
FFS	free-flow speed
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
ft <sup>2</sup>	square foot or feet
FTA	Federal Transit Administration
GIS	Geographic Information System
GMP	Guaranteed Maximum Price
HCM	Highway Capacity Manual

HOT	high-occupancy toll
HOV	high-occupancy vehicle
Hz	hertz
kHz	kilohertz
Leq	one-hour equivalent sound level
LOS	level of service
mPa	micro-Pascal
mph	miles per hour
MPO	Metropolitan Planning Organization
NAC	Noise Abatement Criterion
NAAG	Noise Analysis and Abatement Guidelines
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
NRDG	noise reduction design goal
OTIS	Online Transportation Information System
PEL	Planning and Environmental Linkages
p.m.	postmeridian
ROD	Record of Decision
ROW	right-of-way
RV	recreational vehicle
SPL	sound pressure level
STAMINA	Standard Model Instrumentation for Noise Assessments
TNM	FHWA's Traffic Noise Model
TPR	transportation planning region
USPS	United States Postal Service

## 1. INTRODUCTION

The main purpose of a highway traffic noise analysis is to determine if a project will cause noise impacts and if noise abatement will be built as part of the project. In Part 772 of Title 23 of the Code of Federal Regulations (23 CFR 772), Section 772.7(b) requires that each state highway agency prepare and adopt written guidelines specific to that state to demonstrate compliance with 23 CFR 772. This Colorado Department of Transportation (CDOT) *Noise Analysis and Abatement Guidelines* (NAAG) fulfills that requirement. Therefore, all highway projects developed in conformance with this NAAG will be deemed to comply with 23 CFR 772.

CDOT understands the importance of the issue of highway traffic noise and is committed to evaluating traffic noise impacts during the planning, design, and construction of highway and transportation improvements. This NAAG provides procedural and technical requirements for the analysis of highway project traffic noise and evaluation of noise mitigation where noise impacts are identified. It is intended to provide a consistent, equitable approach in addressing highway traffic noise. However, not all studies are the same; therefore, this NAAG is intended to allow flexibility based on the type and complexity of the analysis to be undertaken. The companion CDOT traffic noise technical report template ensures that traffic noise technical reports contain all required information and are consistent within Colorado.

Interim amendments may be made to this NAAG, as needed, likely via memoranda. These will be considered, upon approval, to be in addition to or as a replacement of existing NAAG text.

### 1.1 *Federal Applicability to Projects*

The National Environmental Policy Act (NEPA) process provides broad authority and responsibility for evaluating and mitigating adverse environmental effects of transportation projects, including highway traffic noise. The Federal-Aid Highway Act of 1970 mandated that Federal Highway Administration (FHWA) develop a noise regulation (also referred to as a standard) for the mitigation of highway traffic noise. This noise regulation, which applies to Federal-aid and Federal action projects, is contained in 23 CFR 772 and is titled "Procedures for Abatement of Highway Traffic Noise and Construction Noise."

23 CFR 772 describes methods that must be followed in the analysis and abatement evaluation of highway traffic noise in Federal-aid and Federal action highway projects. For FHWA to approve plans and specifications for any federally-aided or Federal action highway project for which noise abatement measures were deemed to be feasible and reasonable, the measures must be included in the project and built. Applicability of FHWA's noise regulation is described in 23 CFR 772.7.

This NAAG applies to projects with FHWA involvement. For projects led by other Federal agencies, CDOT will follow the applicable guidance for those agencies.

The determination of whether to use FHWA or Federal Transit Administration (FTA) noise analysis and procedures depends on specific project circumstances. FHWA's regulation applies to multimodal projects, but "multimodal" is not defined in the regulation. Transit-only projects with limited FHWA participation that meet all three criteria provided in FHWA's noise policy Frequently Asked Questions (FAQ) A10 are not considered multimodal projects for purposes of 23 CFR Part 772

and thus are not Type I projects. Such a project uses FTA guidance<sup>1</sup> to evaluate noise associated with the transit project and any highway elements directly affected by the transit project. The three criteria are:

- a. **Lead Agency:** The FTA is the lead agency in the NEPA process. The FHWA's limited participation is as a cooperating agency.
- b. **Project Purpose:** The main transportation purpose of the project, as stated in the purpose and need statement of the NEPA document, is transit-related and not highway-related.
- c. **Funding:** No Federal-aid highway funds are being used to fund the project.

## 1.2 *Federal Criteria to be Set by CDOT*

FHWA gave state highway agencies flexibility in implementing some aspects of 23 CFR 772, as follows:

- ▶ **Approach level:** 23 CFR 772.11(e) requires that state highway agencies establish an approach level that is at least 1 decibel (dB) less than the Noise Abatement Criteria (NAC) for Activity Categories A to E listed in Table 1 of 23 CFR 772. CDOT uses an approach level that is 1 dB less than those listed in Table 1 of 23 CFR 772.
- ▶ **Assessment of benefited receptors:** 23 CFR 772.13(e) requires that state highway agencies define a threshold for the noise reduction to determine if a receptor is benefited due to abatement. The threshold must be at or above 5 dB, but not to exceed the highway agency's reasonableness noise reduction design goal (NRDG). CDOT defines benefited receptors as those that receive at least 5 dB reduction from the noise mitigation. Any receptor with a reduction of 5.0 dB or more is a benefited receptor.
- ▶ **Cost effectiveness:** 23 CFR 772.13(d)(2)(ii) requires that state highway agencies determine, and receive FHWA approval for, the allowable cost of abatement by determining a baseline cost reasonableness value. CDOT uses \$34,000 per benefited receptor as the baseline cost reasonableness value and calls this value the Cost Benefit Index. CDOT uses a Unit Cost of \$45 per square foot (ft<sup>2</sup>) of noise wall to calculate the Cost Benefit, which is compared to the Cost Benefit Index.
- ▶ **Cost effectiveness re-analysis:** 23 CFR 772.13(d)(2)(ii) requires that state highway agencies re-analyze the allowable cost for abatement on a regular interval, not to exceed 5 years. CDOT most recently re-analyzed the Cost Benefit Index and Unit Cost while revising the NAAG in 2020.
- ▶ **Cost effectiveness by geographic area:** 23 CFR 772.13(d)(2)(ii) allows state highway agencies to justify, for FHWA approval, different cost allowances for a particular geographic area(s) within a state. CDOT has not identified geographic areas that would use different Unit Costs.
- ▶ **Noise Reduction Design Goal (NRDG):** 23 CFR 772.13(d)(2)(iii) requires that highway agencies define, and receive FHWA approval for, a NRDG of at least 7 dB but not more than 10 dB. This goal is part of the reasonableness determination. CDOT's NRDG is 7 dBA. Any predicted noise reduction of 7.0 dB or more meets the NRDG

<sup>1</sup> When this NAAG was published, the current FTA guidance was [Transit Noise and Vibration Impact Assessment Guidance Manual](#) (September 2018)

- ▶ **Number of receptors, Feasibility:** 23 CFR 772.13(d)(1)(i) requires that state highway agencies define, and receive FHWA approval for, the number of impacted receptors that must achieve 5 dB reduction for a noise abatement measure to be acoustically feasible. CDOT uses three impacted receptors that must achieve 5 dB reduction from a single potential abatement measure (e.g., wall). Any impacted receptor with a reduction of 5.0 dB or more meets this requirement.
- ▶ **Number of receptors, Reasonableness:** 23 CFR 772.13(d)(2)(iii) requires that highway agencies define, and receive FHWA approval for, the number of benefited receptors that must achieve the NRDG. CDOT uses two receptors that must achieve the NRDG.
- ▶ **Number of receptors, Viewpoints:** 23 CFR 772.13(d)(2)(i) requires that state highway agencies define, and receive FHWA approval for, the number of benefited receptors that are needed to constitute a decision for a potential abatement measure. CDOT has determined that only one receptor needs to submit a vote to determine if a noise barrier is reasonable. If no votes are submitted, the barrier is not built.
- ▶ **Optional reasonableness factors:** 23 CFR 772.13(d)(2)(v) allows state highway agencies to use optional reasonableness factors in addition to the required reasonableness factors listed in §772.13(d)(5)(i), (ii), and (iii). CDOT has not identified optional reasonableness factors.
- ▶ **Pavement type:** 23 CFR 772.9(b) allows state highway agencies to use pavement type other than "average" in the future project noise models if justification can be shown and is approved by FHWA. CDOT has not requested such approval and uses "average" pavement type.
- ▶ **Sound level:** Table 1 of 23 CFR 772 allows state highways agencies to use either Leq(h) or L10(h) on a project, but not both. CDOT uses Leq(h).
- ▶ **Substantial noise increase:** 23 CFR 772.11(f) requires that state highway agencies define as a noise increase between 5 dB to 15 dB over existing noise levels. CDOT has defined substantial noise increase as 10 dB or more over existing noise levels. Any predicted increase over an existing value that equals or exceeds 10.0 dB represents a noise impact.
- ▶ **Type II project:** 23 CFR 772.7(d) does not require that state highway agencies participate in a Type II program. CDOT had a Type II program, but it was discontinued in 1999.

### 1.3 *Applicability to State-only Projects*

Although adherence to 23 CFR 772 is only required for Federal or Federal-aid Highway Projects authorized under Title 23, United States Code, per Section 772.7, CDOT's *Environmental Stewardship Guide* broadens the applicability of traffic noise analyses. To assure the citizens of Colorado are afforded consistent application and implementation of noise analyses and abatement consideration, CDOT requires noise analyses for some state, local, and public-private partnership projects overseen by CDOT or requiring CDOT approval:

- ▶ Projects that add capacity via through lanes, if the lane(s) requires additional pavement beyond the existing roadway geometry profile. The existing profile includes medians and inside shoulders.
- ▶ Projects that are adjacent to prior projects to which 23 CFR 772 applied and for which noise abatement was built, if the current project meets any Type I criteria, as described in Section 3.1.1.

## 1.4 Project Analysis Types

A noise analysis may be brief, such as when documenting that a project is Type III<sup>2</sup> or for projects with limited or no receptors. Generally, large projects are Type I and need a more detailed noise analysis and noise technical report.

For Type I projects, a noise analysis requires modeling unless the Noise Study Zone has only limited or no noise sensitive receptors. Modeling is also required to determine locations of noise contour lines if there are any Activity Category G areas.

## 1.5 National Guidance

National guidance for completing highway-related noise analyses includes:

- ▶ FHWA - [website](#): Highway Traffic Noise, updated ongoing basis
- ▶ FHWA - [Highway Traffic Noise: Analysis and Abatement Guidance, December 2011](#)
- ▶ FHWA - Noise Policy [Frequently Asked Questions \(Noise FAQs\)](#)
- ▶ FHWA - [Recommended Best Practices for the Use of the FHWA Traffic Noise Model \(TNM\)](#) (FHWA-HEP-16-018), December 2015
- ▶ FHWA - [Noise Measurement Handbook](#) (FHWA-HEP-18-065), June 2018
- ▶ FHWA - [Noise Measurement Field Guide](#) (FHWA-HEP-18-066), June 2018
- ▶ National Cooperative Highway Research Program (NCHRP) - [NCHRP Report 791: Supplemental Guidance on the Application of FHWA's Traffic Noise Model \(TNM\)](#), 2014

## 1.6 Project Noise Model Overview

In March 1998, FHWA released the FHWA Traffic Noise Model (TNM), Version 1.0. This state-of-the-art computer model for highway traffic noise prediction and analysis replaced an older model, Standard Model Instrumentation for Noise Assessments (STAMINA) 2.0. Since then, FHWA has released updates of TNM. TNM 3.0 was released in February 2020. CDOT will issue a memorandum when the use of TNM should shift from version 2.5 to 3.0.

In addition to accounting for the sources of traffic noise, TNM also:

- ▶ Has built-in calculations that determine how the sound waves travel through the air based on inputted atmospheric conditions
- ▶ Accounts for the effects of vehicle acceleration and deceleration (e.g., due to highway grades)
- ▶ Allows input of objects that affect how sound travels: ground types, topography, noise barriers, buildings, and heavy vegetation.
- ▶ The simplest project noise models have only one road with traffic and one receptor (e.g., home). A receptor is a location of a noise-sensitive area for land uses listed in Table 1 of Chapter 3. A receptor that is modeled is referred to as a receiver. A receiver may represent more than one receptor. For example, if a highway has three houses next to each other that are all the same distance from the highway and if there is no other element that would independently affect the acoustic environment, one receiver can be used in the project

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<sup>2</sup> Type III projects are described in Section 3.1.3

noise models to represent all three homes. If the situation being modeled is more complex, the following can also be included in the project noise models: ground zones (e.g., a lake that is between the highway and receiver); terrain lines (e.g., when the topography between the road and receiver is not essentially a straight line); vertical surfaces between the road and receiver such as existing solid walls (e.g., existing noise walls) and buildings (e.g., the first row of buildings, closest to the road, shields noise for the second row of buildings).

Traffic data that is input into the project noise models acts as the noise source. The model calculates noise levels at each receiver. When a noise analysis is performed for a transportation project, the model is run for existing and design year conditions. The most common changes between these model runs are the highway alignment and/or number of lanes (depending on the project), traffic volumes, and, perhaps, mix (percent of automobiles versus trucks).

To ensure that the existing condition noise model is a reasonable representation of the current real-world landscape, it must be validated using existing traffic and noise levels measured in the field<sup>3</sup>. Traffic volume, vehicle mix, traffic speed, and noise (measured in dBA) are recorded at two or more locations. Those measured traffic volumes and traffic speeds are then input into the existing condition noise model and the resulting modeled noise is compared to the measured noise to see if they match. If the modeled noise and measured noise are within 3.0 dB of each other, the existing condition noise model is considered to be accurate and is thus validated.

Once the existing condition noise model is validated, it can be used to predict existing and design year noise levels at project receivers. This is done at the worst-noise hour, which is generally just before or after congested periods when traffic is free flowing. Existing year worst-noise hour noise levels are predicted by inputting existing year conditions into the validated existing condition noise model. These conditions include the existing worst-noise hour traffic volume, vehicle mix, and traffic speed. Similarly, design year noise levels are predicted by inputting predicted design year conditions, including the proposed highway design alignment. The design year noise model is used to determine impacts and analyze the effectiveness of proposed noise mitigation.

## 1.7 Traffic Noise and Wildlife

Noise effects on wildlife can be a topic of interest on projects. However, 23 CFR 772 applies only to human receptors. Traffic noise effects on wildlife populations are not considered under 23 CFR 772. Information describing the effect of traffic noise on wildlife populations is in a 2004 report titled *Synthesis of Noise Effects on Wildlife Populations*, which is available at: [https://www.fhwa.dot.gov/environment/noise/noise\\_effect\\_on\\_wildlife/effects/wild00.cfm](https://www.fhwa.dot.gov/environment/noise/noise_effect_on_wildlife/effects/wild00.cfm). It contains a summary of ongoing work on the effects of noise on wildlife populations and related topics.

## 1.8 Tier 1 Environmental Impact Statements

Tiered Environmental Impact Statement (EIS) documents are a special case requiring consultation with FHWA. The level of noise analyses required for a Tier 1 EIS would be more general in nature, deferring a Type I project noise analysis for a subsequent Tier 2 NEPA study. CDOT and FHWA will jointly determine the appropriate scope of noise analysis for the Tier 1 EIS. A Tier 1 document does

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<sup>3</sup> FHWA *Highway Traffic Noise: Analysis and Abatement Guidance*, December 2011, page 31.

not have a Date of Public Knowledge. The Date of Public Knowledge is considered in the Tier 2 stage of NEPA documentation.

## 1.9 *Planning and Environmental Linkages Study*

The goal of a Planning and Environmental Linkages (PEL) study is to identify potential environmental issues related to potential transportation projects. The analysis should be conducted at the planning level and consider potential red flags related to each resource. A detailed noise analysis is not appropriate. For PEL study reports, the noise section should include the following:

- ▶ Figure with the boundary of the anticipated Noise Study Zone
- ▶ High level overview of types of areas/structures with frequent exterior human use
- ▶ List of regulations governing noise
- ▶ Next steps identifying the level of noise analysis anticipated during NEPA (e.g., detailed or not detailed), and if noise mitigation is anticipated to be required

## 1.10 *Consultant Qualifications*

A noise analyst who performs the highway traffic noise evaluation must hold a certificate of completion from an approved training course for use of TNM. In addition, consultants performing noise analyses for CDOT must have the experience and training described in the most current CDOT Statewide Scope of Work. At the time this NAAG was written, the most current version was *CDOT Statewide Non-Project Specific Environmental & Traffic Modeling Engineering Services - FY 2019 - FY 2021 Scope of Work*. Noise consultant requirements were listed under Section Three (“As Needed” Services), Part C (Environmental Services), Part 5 (Traffic Noise Analysis and Modeling) as follows:

- ▶ Familiarity with FHWA noise regulations contained in 23 CFR 772
- ▶ Familiarity with traffic NAC
- ▶ Demonstrated familiarity with CDOT and FHWA noise program
- ▶ Expertise with noise modeling techniques and methodologies used in the State of Colorado (current required version of TNM) and completion of Noise Analysis Training
- ▶ Expertise conducting noise studies and analyses for highway projects following CDOT NAAG
- ▶ Expertise gathering, evaluating, and assessing highway traffic data for noise analysis
- ▶ Knowledge of AutoCAD/Microstation/Geographic Information System (GIS) for engineering level design and for planning purposes, design of noise mitigation and alternative analysis
- ▶ Expertise with noise model mitigation analysis to optimize cost and benefit with impacts

## 2. PROJECT SCOPING AND INTERAGENCY COORDINATION

Project scoping is the task of establishing and documenting a list of project goals, tasks, deliverables, and deadlines. Properly scoping the level of analysis required for a noise assessment early in the process can be a critical element in support of completing the NEPA document.

CDOT conducts several types of scoping activities, including project scoping, PEL scoping, NEPA scoping, and noise scoping. Project scoping is project specific to identify potential physical constraints and project goals, which may include physical or operational changes to a road. Environmental resources are usually considered at a high level. PEL scoping usually selects a very high level of noise evaluation; PELs would not model traffic noise. NEPA scoping<sup>4</sup> discusses environmental resources, including noise, to identify an appropriate level of technical analysis. When warranted, a project may also have a formal noise scoping meeting to discuss and determine the technical aspects in more detail.

For Environmental Assessments (EAs) and EISs, the Project Management Team holds project and NEPA scoping meetings for each proposed project to give other state and federal agencies an opportunity to inform on which project aspects are important to them, which laws are applicable, and how the agencies would like to be involved. FHWA is part of the Project Management Team, although their level of participation will vary based on risk-based stewardship and oversight. Depending on project scope and complexity, staff from other agencies, such as FTA and local governments, might also participate in the NEPA agency scoping meeting. It is generally determined at the NEPA agency scoping meeting whether a noise scoping meeting is warranted.

For Categorical Exclusions (CatExs), the Project Management Team hosts a project kickoff meeting. During the meeting, it is determined if the project requires interagency coordination. Noise scoping does not typically occur unless the project will be Type I (see Section 3.1.1).

If technical scoping for noise is chosen, several topics should be considered for discussion. Field work associated with noise measurements is an important aspect of the noise analysis and should be discussed, including the locations and number of locations that will be used, so that fieldwork does not have to be repeated. This becomes more important the further that the noise analyst is based from the project site.

During the noise scoping meeting, agencies may determine that a noise modeling protocol should be developed. The protocol specifies parameters such as how many noise measurements will be taken, the general or specific locations of the measurements, which roadways will be included in the project noise models, and the length of noise measurements. If a protocol is developed, it will be determined if a noise modeling protocol memo will be created or if email consultations will suffice. After the noise scoping meeting, a meeting summary, including decisions made at the noise scoping meeting, will be sent to confirm that all decisions were captured.

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<sup>4</sup> More information about NEPA scoping is available in Chapters 4 (EISs), 5 (CatExs), and 6 (EAs) of the *CDOT NEPA Manual*.

### 3. HIGHWAY TRAFFIC NOISE IMPACT ANALYSIS

The main purposes of a highway traffic noise analysis are to determine if the project causes noise impacts and if noise abatement will be built as part of the project. Abatement may be built only if there are noise impacts.

#### 3.1 *Project Classification*

As early as is reasonable in the process, an assessment must be made to determine whether or not the project will require a noise analysis. This is usually done in conjunction with the environmental scoping of the project. All CDOT highway projects are classified as either Type I or Type III. CDOT's Type II program was discontinued in 1999. Per 23 CFR 772.7(c) and (f), Type I transportation projects require noise analyses. The following sections describe these classifications.

##### 3.1.1 Type I Projects

Type I projects are defined by 23 CFR 772.5 as described below. CDOT guidance is also provided. For additional guidance to determine whether a project is Type I, see FHWA Guidance and FHWA FAQs. To avoid performing an unnecessary analysis (i.e., the project is Type III) and to avoid project delay when a noise analysis was not scoped appropriately, it is recommended that Type determinations be approved by a CDOT noise specialist during project scoping or as soon after as possible and before any noise analysis begins.

A project is Type I if it meets any of the following criteria:

1. *Construction of a highway<sup>5</sup> on a new location.*

CDOT note: Construction of a highway on new location means there is no highway before the construction, and there will be one afterwards. A road that is being realigned would not be considered a new highway. However, if the realigned road includes changes comparable to a physical alteration of an existing highway (see criterion #2), it would be considered Type I.

2. *The physical alteration of an existing highway where there is either:*

- (i) *Substantial Horizontal Alteration. A project that halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition;*

CDOT note: The traffic noise source should be measured from the nearest edge of the travel lane to the closest receiver location, unless another location is appropriate, based on consultation with a CDOT noise specialist. Measure from a through lane; do not measure from an auxiliary lane or a turn lane. Generally, when the noise analysis is being conducted during NEPA, the design is only at a conceptual level. Minor shifts may occur during final design. If the distance during the NEPA analysis is so close that a minor change in alignment could affect whether the distance is halved, the project may need to be considered to be Type I, based on consultation with a CDOT noise specialist. If the final design distance is not halved, then the project could be reclassified to be Type III. This might be considered during the project reevaluation, if a reevaluation had been triggered.

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<sup>5</sup> "Highway" is defined in Appendix A.

OR

- (ii) *Substantial Vertical Alteration. A project that removes shielding therefore exposing the line-of-sight between the receptor and the traffic noise source. This is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor.*

CDOT note: An example of this would be a case where, to improve sight distance on a highway, an existing earth berm or hillside is flattened, resulting in a direct line-of-sight between the highway and an existing receptor. Generally, vegetation does not have sufficient noise abatement properties, and thus cannot be considered for these shielding effects.

Vertical alteration should be measured for through lanes. Generally, a substantial vertical alteration is considered to be a change in the vertical profile of 5.0 feet or more. Therefore, a change of 4.9 feet would not be considered a substantial alteration, but a change of 4.95 feet would be considered a substantial alteration. However, if the vertical change is 5.0 feet or more for only a small portion of the project, it may not be considered a substantial vertical alteration. This would be determined via consultation with a CDOT noise specialist. If a vertical change of 5.0 feet or more would increase shielding (e.g., lowering a road, thereby creating topography that interrupts the line of sight to receptors), that would not constitute a substantial vertical alteration for noise purposes. This determination must be documented.

3. *The addition of a through-traffic lane(s). This includes the addition of a through-traffic lane that functions as a high-occupancy vehicle (HOV) lane, high-occupancy toll (HOT) lane, bus lane, or truck climbing lane.*

CDOT note: If the lane is less than 2,500 feet, it is considered an auxiliary lane.

4. *The addition of an auxiliary lane, except when the auxiliary lane is a turn lane.*

CDOT note: Auxiliary lanes are the portion(s) of the roadway adjoining the traveled way for speed change, turning, weaving, truck climbing, maneuvering of entering and leaving traffic, and other purposes supplementary to through-traffic movement. This includes lanes that function as passing lanes or continuous access lanes. Addition of an auxiliary lane classifies the project as Type I if the auxiliary lane is 2,500 feet or longer. The 2,500 feet threshold applies to the new portion of the auxiliary lane and does not apply to the total lane length. If a project is adding more than one non-contiguous auxiliary lane, each lane should be considered separately to determine the length. See Appendix A for lane-specific definitions. To determine the length of an auxiliary lane that tapers, measure to the beginning of the taper, which is the widest part.

5. *The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange.*
6. *Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane.*

CDOT note: An auxiliary lane classifies the project as Type I if it is 2,500 feet or longer. Auxiliary lanes include lanes that function as passing lanes or continuous access lanes. See Appendix A for lane-specific definitions.

7. *The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot, or toll plaza.*

CDOT note: Park-n-ride lots are treated as ride-share lots.

As per 23 CFR 772.5, if a project is determined to be a Type I project under this definition, the entire project area as defined in the environmental document is a Type I project unless CDOT agrees that part of the project does not need to be modeled. In that case, the traffic noise technical report must provide justification of why part of the project was not modeled. Some example situations:

- Work that causes no permanent change to any of the roadway features within the area (e.g., adding a sidewalk, storm sewer repair/replacement, boring for utilities) and that portion of the project is not physically adjacent to the portion that causes the project to be a Type I project. In that case, noise analysis is not required for that portion of the project.
- “Lumping” or “bundling” discontinuous areas into one project, such as for bridge replacements. Areas between the bridge replacements would not be included in the Noise Study Zone.

### 3.1.2 Type II Projects

23 CFR 772 defines Type II projects as those that provide noise abatement on an existing highway and require, to be eligible for Federal-aid funding, that the state highway agency develop and implement a Type II program in accordance with 23 CFR 772.7(e). Type II projects are not part of a Type I project. FHWA limits funding participation of Type II noise abatement for projects approved before November 28, 1995, or for projects proposed along land where land development or substantial construction predated the highway. FHWA will not approve noise abatement at locations previously determined not to be feasible and reasonable for a Type I project.

Type II noise abatement projects were constructed in Colorado in the past. Projects were proposed for Federal-aid participation based on the outcome of a noise analysis and prioritization, at the option of CDOT. Money spent on Type II abatement was deducted from funds that otherwise would have been available for highway construction. This was a voluntary program in which FHWA funded 80 percent of the cost of Type II barrier construction. The state portion of Type II projects were funded through the Colorado Transportation Commission.

The Colorado Transportation Commission participated in the Type II Noise Barrier Program beginning in the 1970s. However, state funding has been unavailable for this program since 1999. Therefore, Colorado does not have an active Type II program.

### 3.1.3 Type III Projects

Projects that do not meet Type I or Type II criteria are Type III projects and are not required to undergo noise analysis, except in rare cases, as described at the end of this section.

Type III projects do not involve added capacity, construction of new through lanes, construction of auxiliary lanes that are 2,500 feet or more in length, changes in the horizontal or vertical alignment of the roadway or exposure of noise sensitive land uses to a new or existing highway noise source.

As long as a project does not have any components that make it Type I, projects that are classified as Type III include:

- ▶ adding an auxiliary lane that is shorter than 2,500 feet
- ▶ maintenance operations
- ▶ bridge rehabilitations
- ▶ resurfacing or white-topping projects
- ▶ adding shoulders
- ▶ ride-sharing programs that pair riders with carpools
- ▶ commuting assistance
- ▶ minor operational projects, such as changing a speed limit
- ▶ chain-up areas along highways<sup>6</sup>

In rare cases, limited noise modeling is required for Type III projects. For example, if a project would alter or replace an older noise wall, the project is Type III and limited modeling is performed to ensure that the replacement wall functions as well as the original noise wall.

### 3.2 *Noise Analysis Steps*

When a noise analysis is required, it consists of the following steps. The order of some of the steps can be changed. Steps 1 through 12 represent the impact analysis. Steps 13 and 14 represent the abatement evaluation. Steps 15 through 21 represent additional noise analysis considerations. This chapter and Chapters 4 through 8 describe these steps in more detail.

1. **Project Classification:** Determine project classification (see Section 3.1). If it is Type I, the analysis continues. If it is Type III, further analysis is not required, although a memo may be needed in somewhat rare situations to explain and document the classification conclusion.
2. **Noise Scoping:** Some Type I projects require a scoping meeting (see Chapter 2).
3. **Noise Study Zone:** Define the boundary of the Noise Study Zone for the project (see Section 3.3).
4. **Identify Receptors:** All receptors within the Noise Study Zone are identified and assigned an Activity Category (see Section 3.5).
5. **Determine if Further Analysis Needed:** Noise Study Zones with Activity Category A through E receptors require further analysis. If the Noise Study Zone has only Activity Category F receptors<sup>7</sup>, further analysis is not required and a memo should be written to document the lack of receptors. If the project Noise Study Zone has only Activity Category G areas, the analysis is abbreviated to develop noise contours as described in the CDOT Traffic Noise Technical Report Template.
6. **Noise Measurements:** Noise measurements are taken within the Noise Study Zone (see Section 3.7).

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<sup>6</sup> Chain-up areas are used to provide heavy trucks and vehicles with designated facilities for safe refuge to abide with state chain law requirements during inclement weather. These facilities are consistently signed with 30 minute occupancy restrictions or are access controlled as needed. Due to the occupancy (idling) time restrictions and seasonal nature of chain-up area use, these facilities are considered both a temporary and infrequent use.

<sup>7</sup> This means if there are any Activity Category B, C, or E receptors that have not been built but have been permitted prior to the Date of Public Knowledge, those receptors must be modeled. Activity Category F receptors are the only receptor type that do not get modeled in any way.

7. **Create Initial Existing Condition Noise Model:** An initial existing condition noise model is created that contains at a minimum the information needed to validate the existing condition noise model (see Section 3.6).
8. **Validate Model:** Validate the existing condition noise model using noise levels and traffic data from the noise measurements (see Section 3.7).
9. **Gather Model Data Inputs:** All remaining project noise model inputs are gathered (e.g., existing and design year worst-noise hour traffic volumes and proposed design modifications) and incorporated into relevant project noise model runs (see Section 3.8).
10. **Existing Condition Noise Model:** If this hasn't been done yet, add receivers representing all noise-sensitive receptors. This complete existing condition noise model is run using existing worst-noise hour conditions (see Section 3.8).
11. **Design Year Noise Model(s):** Run the design year noise model for each design year condition being examined (see Section 3.9). If the Noise Study Zone has any Activity Category G receptors, develop noise contour lines for those areas (see Section 6.2).
12. **Impact Analysis:** Determine if alternatives in the design year have any noise impacts (see Section 3.10). If there are no noise impacts, noise abatement is not evaluated and the noise analysis is complete.
13. **Abatement Analysis:** Evaluate noise abatement for all receivers that will be impacted by noise with the build alternative(s) in the design year as follows:
  - i. Feasibility is evaluated. If the abatement is feasible, reasonableness is evaluated. If abatement is not feasible, reasonableness is not evaluated and abatement is not recommended (see Section 4.3).
  - ii. Reasonableness, if applicable: Two of three reasonableness criteria are evaluated (dB reduction and cost). If abatement is reasonable for both criteria, it is recommended in the Statement of Likelihood (see next step). The third criterion (receptor viewpoint) is usually evaluated later in the design process. If abatement is not reasonable for either dB reduction or cost, the third criterion (receptor viewpoint) will not be evaluated (see Section 4.4).
14. **Statement of Likelihood:** Abatement that is feasible and reasonable (for the dB reduction and cost criteria), as described in Step 13, is recommended for construction in the Statement of Likelihood. This Statement of Likelihood is included in all traffic noise technical reports and is included in the NEPA document for EAs and EISs (see Section 4.5). For CatExs, a reference to the noise mitigation recommendation will be added to the notes on the Form 128.
15. **Construction Noise:** Determine whether the project is in an area with local ordinances for construction noise. If not, noise from the project is regulated by a Colorado statute (see Chapter 5).
16. **Information for Local Officials:** If the Noise Study Zone has any Activity Category G areas, complete and submit information for Local Officials, including traffic noise contour lines (see Chapter 6).
17. **Technical Report:** Write a traffic noise technical report using the CDOT Traffic Noise Technical Report Template and submit it to CDOT for review and approval (see Chapter 7).

18. **NEPA Document:** Summarize the noise analysis in the EA or EIS NEPA document or reference it on Form 128 for CatExs (see Chapter 8).
19. **Noise Verification:** During final design, evaluate the traffic noise technical report written during NEPA to determine if it is still valid. This Noise Verification must be documented. (see Section 9.5).
20. **Design Noise Abatement:** During final design, design noise abatement that is both feasible and reasonable (probably barring Benefited Receptor Survey voting results).
21. **Benefited Receptor Preference Survey:** If the NEPA Statement of Likelihood recommended one or more abatement measures and if abatement is still feasible and reasonable at final design, conduct a Benefited Receptor Preference Survey. Survey results are the final criterion for reasonableness to determine if abatement is built (see Section 4.4.3).

### 3.3 *Noise Study Zone*

The Noise Study Zone boundary is set at a distance, which depends on roadway type, in all directions from the proposed edge of traveled lane(s) throughout the project extents. The distance is set at 500 feet for freeways and expressways<sup>8</sup> and 300 feet for all other types of roads. Because projects may include improvements on different types of roads, the boundary could be bigger in some areas than others. The boundary does not expand around non-highway portions of the project (e.g., where a trail crosses a road, sidewalks). Receptors within the Noise Study Zone are evaluated for noise impacts.

The 500-foot and 300-foot Noise Study Zones represent the minimal area that is evaluated. If modeling shows impacts at or near the Noise Study Zone boundary, the Noise Study Zone is generally expanded to include nearby receptors. Expanding the Noise Study Zone should be discussed with a CDOT noise specialist and explained in the Traffic Noise Technical Report.

The Noise Study Zone must include noise-sensitive receptors on all sides of the highway. Although every receptor is not required to be included in the project noise models as a receiver, receivers must adequately represent all receptors. Generally, it is more important to individually model receptors that are closer to the highway. Receptors that are further from the highway are more likely to be grouped together.

A Noise Study Zone may be broken up into Noise Sensitive Areas, which are generally geographical areas covering multiple receptors with similar land uses and noise environments that may benefit from a single noise barrier. Noise Sensitive Areas must be contiguous and cover the entire Noise Study Zone, including Activity Category F and/or G lands<sup>9</sup>. A Noise Sensitive Area may contain a single isolated receptor or an entire neighborhood. The number and locations of modeled receivers within each Noise Sensitive Area are selected to represent all the noise-sensitive receptors within that Noise Sensitive Area.

### 3.4 *Noise Abatement Criteria*

NAC are noise levels associated with interference of speech communication and are a compromise between noise levels that are desirable and those that are achievable. Residential outdoor

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<sup>8</sup> See definitions of freeways and expressways in Appendix A

<sup>9</sup> Activity Category F and G lands are not noise sensitive. However, the entire Noise Study Zone must be evaluated. Therefore, if it is going to be broken up into Noise Sensitive Areas, some of those areas may not actually be noise sensitive.

activities and areas of frequent human use, such as schools, parks, hotels, and commercial centers, are evaluated for noise impacts.

23 CFR 772.11(e) requires state highway agencies to establish an approach level that is at least 1 dB less than the NAC for Activity Categories A to E listed in Table 1 of 23 CFR 772. CDOT uses an approach level that is 1 dB less than the Federal NACs, as shown in Table 1, column “Activity Leq(h).” When comparing project noise model results to the NAC, the results should not be rounded up to the nearest integer (e.g., 65.9 dB would not meet or exceed the Activity Category B NAC; 66.0 dB would).

Table 1. Land Use Categories and CDOT Noise Abatement Criteria

Activity Category	Activity Leq(h) <sup>1, 2</sup>	Evaluation Location	Activity Description
A	56.0	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 <sup>3</sup>	66.0	Exterior	Residential
C <sup>1</sup>	66.0	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, recreational areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	51.0	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 <sup>3</sup>	71.0	Exterior	Hotels, motels, time-share resorts <sup>4</sup> , offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	Not Applicable	Not Applicable	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, ship yards, utilities (water resources, water treatment, electrical), warehousing, malls <sup>5</sup> , stores <sup>5</sup> , shops <sup>5</sup> , and Government managed land <sup>4,6</sup> .
G	Not Applicable	Not Applicable	Undeveloped lands that are not permitted.

<sup>1</sup> Table 1 of 23 CFR 772 allows state highway agencies to use either Leq(h) or L10(h) on a project, but not both. CDOT uses Leq(h), which is an Hourly A-weighted sound level in dBA.

<sup>2</sup> NACs are for impact determination only. They are not design standards for noise abatement measures.

<sup>3</sup> Includes undeveloped lands permitted for this activity category.

<sup>4</sup> This activity description is not listed in Table 1 of 23 CFR 772.

<sup>5</sup> This activity description is not listed in Table 1 of 23 CFR 772, but it is in FHWA's FAQ D7.

<sup>6</sup> Areas of frequent human use within the Government (Federal, State, and County) managed land will be treated as the appropriate land use (e.g., a campground would be Activity Category C, as described in Section 3.5).

### 3.5 *Identification of Land Uses*

Proper identification of noise sensitive receptors adjacent to a highway project is essential to the success of the analysis. Each noise sensitive receptor within the Noise Study Zone must be reflected in the project noise models, either as a grouped receiver or as its own receiver. If a group of individual receptors share similar acoustical properties and settings, a receiver representative of the common noise environment may be used in modeling. The total number of individual receptors represented by each receiver must be clearly documented<sup>10</sup>. In some cases, more receivers, representing fewer receptors per receiver, will be modeled when evaluating abatement than were used to determine impacts. A receptor will not be modeled by more than one receiver. The distinction between receptors and receivers is described in Section 3.6.2.

The primary focus for most noise sensitive receptors is the exterior area of frequent human use. The receiver will be placed where noise from the highway would be loudest, which is generally in the area facing the highway, unless the only area representative of the receptor is shielded from the highway. For residences, the receiver will generally face the highway and will be placed in the front or back yard, communal gathering/activity area, or porch.

The following subsections provide guidelines to facilitate statewide consistency of receptor identification. Coordination among CDOT, federal land management agencies, and local jurisdictions is encouraged to provide appropriate context for and resolve identification of complex receptor-land use issues. FHWA will make final determinations of how to address receptors based on information provided by the noise analyst and possibly on additional research. Additional information about how to identify and place receivers is available in FHWA Guidance and FAQs.

#### 3.5.1 Permitted Development

The noise analysis must include undeveloped land for which development has been permitted as an Activity Category B, C, or E receptor before the Date of Public Knowledge<sup>11</sup>. A permit indicates that a definite commitment has been made to develop the property as the type of receptor that was permitted. Receptors that fit this category must be treated in the NEPA-level noise analysis as though the development has already been built.

CDOT considers a proposed development as being permitted when the local agency of authority issues a formal building permit to the developer.

#### 3.5.2 Activity Category A

Activity Category A receptors are 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. These receptors are extremely rare and apply only to extraordinary special public needs where the existing environment is of a serene nature that needs to be preserved to allow the area to continue to serve its purpose. At the time this NAAG was published, Activity Category A receptors have not been identified in Colorado. Determination of whether a specific receptor qualifies as an Activity Category A will be made on a

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<sup>10</sup> In limited cases (i.e., projects with a very large number of receptors), it may be appropriate to not identify the number of receptors that correspond to non-impacted and non-benefited receivers. A CDOT noise specialist must provide approval that the situation allows this relaxation of the requirement to document the total number of individual receptors.

<sup>11</sup> See Appendix A for the definition of Date of Public Knowledge.

case-by-case basis in consultation with CDOT and FHWA (including FHWA Headquarters). The number of receivers and receptors assigned to an Activity Category A location will be determined in consultation with CDOT and FHWA.

### 3.5.3 Activity Category B

Activity Category B receptors are residential homes. They include single- and multi-family residences, which are also referred to as dwelling units.

Examples of Activity Category B receptors and how to select receivers are as follows:

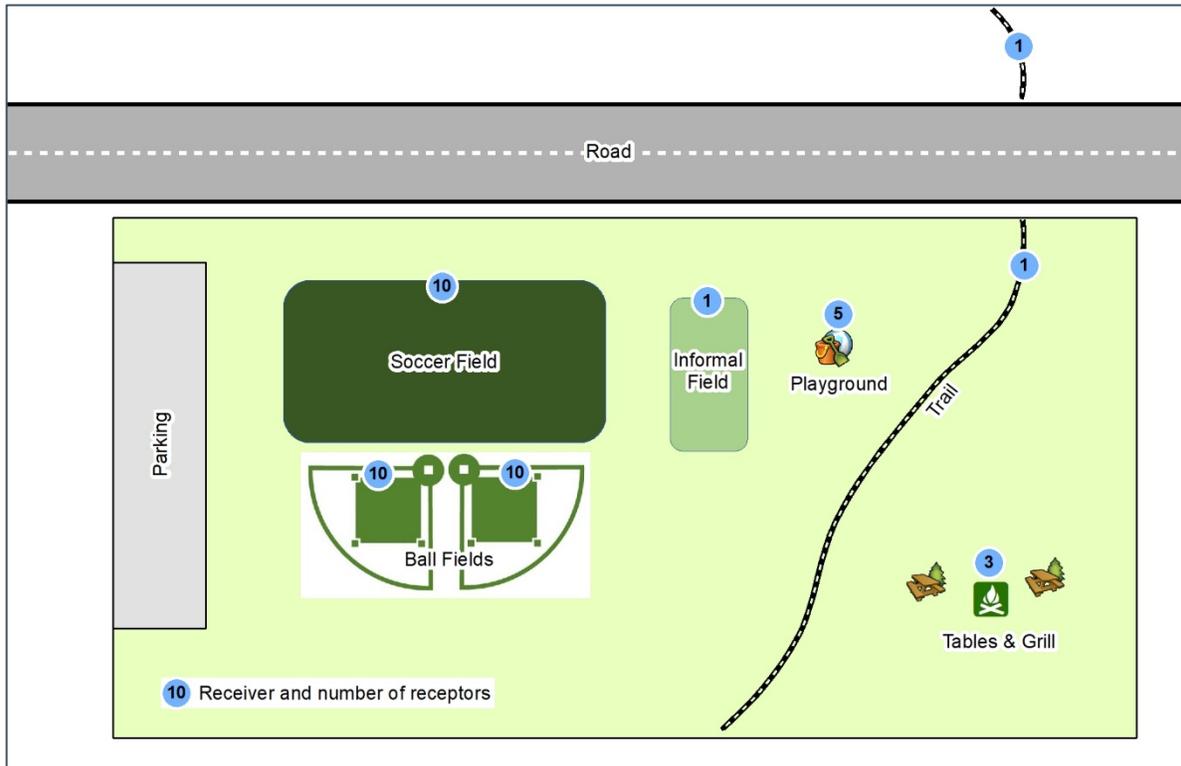
- ▶ **Single-Family Dwelling Units:** Each dwelling unit counts as one receptor. Some homes have multiple outdoor use areas, some of which may be higher than the ground floor (e.g., decks). In that case, a receiver should be placed at the anticipated loudest area of frequent human use.
- ▶ **Multi-Family Dwelling Units:** Each dwelling unit on each floor is considered to be a noise sensitive receptor if it has an outdoor activity area (e.g., balcony). Evaluation of all the floors in multi-storied buildings is required to identify impacted receptors. This category includes dormitories and assisted living centers.
- ▶ **Single-Family Multi-Tenant Dwelling Units:** This category represents situations such as an apartment above a garage and mother-in-law apartments within a home. Treat this type of dwelling unit as part of the single-family home to which it is associated; thus, a separate receptor is not assigned.
- ▶ **Common Areas for Multi-Family Dwelling Units:** Outdoor activity areas should be represented with one receiver. The number of receptors will be the number of residential units divided by four, up to a maximum of 10, unless it is a use that is already defined in this NAAG (e.g., basketball courts would be an active sport area).
- ▶ **Trailer Parks:** Mobile homes are considered single-family dwelling units for receiver placement and numbers of receptors but might be considered multi-family dwelling units for benefited receptor voting, as described in Section 4.4.3.
- ▶ **Prisons and Jails:** For each exterior area of frequent human use, model one receiver representing one receptor for every four units of living capacity up to 10 receptors.

### 3.5.4 Activity Category C

Activity Category C receptors can be 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, recreational areas, Section 4(f) sites, schools, television studios, trails, or trail crossings. They can be identified as either individual sites, such as buildings, or as properties with multiple areas of diverse activities, such as parks. Communal or recreational properties may be divided into individual receivers based on individual activity areas. However, multiple receivers must not be used for individual pieces of a single common activity functional area, unless described otherwise in this NAAG. For activity areas spread across a property or for properties that lack defined facilities or formal activity areas, a single receiver should be placed within the property that best represents the worst expected traffic noise condition, based on professional judgment of the noise specialist. Consultation with the local jurisdiction is

recommended to resolve these issues. The hypothetical property shown in Figure 1 provides several Activity Category C examples and would have a total of eight receivers representing 41 receptors based on activity area identification.

Figure 1. Illustration of Activity Category C Receivers for Impact Analysis



Examples of Activity Category C receptors and how to select receivers include the following:

- ▶ **Active Sport Areas:** One receiver should be modeled for each formal sports field. Less formal areas such as grassy areas of a park or recreation area, which are commonly used for informal sports activities, should be modeled as one receiver per area which has been observed or exhibits attributes that demonstrate common active use. At formal sports fields, each receiver represents one receptor per player on the field at a time, with a maximum of 10 receptors. Informal field receivers represent one receptor. For golf courses, one receiver which represents one receptor should be modeled at each hole (tee-off areas or fairway-green combination) of the golf course that best represents the worst expected traffic noise condition based on professional judgment of the noise specialist. If the golf club has other outdoor areas of frequent human use (e.g., picnic areas, restaurant patios), see guidance in this section for the number of receivers and receptors.
- ▶ **Amphitheaters:** One receiver should be modeled representing one receptor for every 10 seats or seating capacity, up to 25 receptors (e.g., if it has capacity of 100 or has 100 seats, it would have  $100 \div 10 = 10$  receptors).
- ▶ **Auditoriums, Libraries, Medical Facilities, Public Meeting Rooms, Radio Studios, Recording Studios, and Television Studios:** Each facility should have one receiver representing one receptor.

- ▶ **Campgrounds/RVs:** One receiver should be modeled representing one receptor for each 10 formal campsites, informal campsite areas located within formal campgrounds, camping cabins capable of human occupation, recreational vehicles (RVs), or unoccupied RV lots.
- ▶ **Cemeteries:** One receiver representing one receptor should be modeled for each formal memorial gathering facility. Individual grave sites, access ways, and informal activity areas are not considered individually sensitive receptors. However, each section of the cemetery, as defined through consultation with the operator, may have formal gathering areas and should be assigned a receiver and receptor. If there are no formal gathering areas, then place one receiver at one of the gravesites that is closest to the highway.
- ▶ **Day Care Centers and Schools:** Each day care center and school has one receiver, representing 10 receptors, representing the area designated for dropping off and picking up children and/or by the main entrance that would be most affected by traffic noise. For each exterior area of frequent human use, such as playgrounds and soccer fields, see guidance in this section for the number of receivers and receptors.
- ▶ **Hospitals:** At least one receiver, representing one receptor, should be modeled at the entrance that receives the most noise from the project highway. This location is generally the closest to the highway, although it may not be (e.g., if the closest entrance is shielded from noise). The total number of receivers and receptors depends on the nature of exterior areas of frequent human use, if any. For example, at respite areas (e.g., garden areas, intended for relief), one or more receivers, depending on location(s), should be modeled representing one receptor per seating area.
- ▶ **Parks and Recreational Areas:** Parks range in size and amenities. Recreation areas may encompass multiple activity areas within a large parcel of land. Receivers should be located within the park or recreation area boundary for each area with a formal outdoor activity, representing 10 receptors (see “Playgrounds” below or “Active Sport Areas” above for examples). If the park or recreational area has no discernable formal activity areas (e.g., recreational trails, camping facilities, picnic areas, ball fields), a minimum of one receiver should be modeled representing one receptor to represent typical traffic noise on the property by using best professional judgment and by consultation with the jurisdictional authority for the property.
- ▶ **Picnic Areas:** One receiver should be modeled for each area of picnic tables or fire pits/grills, which are a single functional area, representing one receptor per picnic table or fire pit/grill with a maximum of 10 receptors per area.
- ▶ **Places of Worship, Public or Nonprofit Institutional Structures:** One receiver representing 10 receptors should be modeled at the main entrance unless there is reason to model more receivers as determined in consultation with a CDOT noise specialist. No more than 10 receptors will be assigned for each place of worship or structure.
- ▶ **Playgrounds at Day Cares and Schools:** One receiver should be modeled representing 10 receptors.
- ▶ **Playgrounds for Communities:** One receiver should be modeled representing 5 receptors.
- ▶ **Pools, Community or Public:** One receiver should be modeled representing 10 receptors.
- ▶ **Trails and Trail Crossings<sup>12</sup>:** Two types of areas are considered for trails: trails crossing the highway and trails that are near the highway. A single trail may exhibit both features.

<sup>12</sup> Trails and trail crossing are defined in the context of 23 CFR 772 by 23 USC 206(a)(2)(A-F), according to FHWA’s FAQ D4.e.

- *Trail crossings*: One receiver should be modeled representing one receptor for each formal recreational trail crossing, one on each side of the roadway, regardless of the pathway orientation. The receiver should be placed no closer than 50 feet from the edge of pavement on the recreational trail that best represents the worst expected traffic noise condition based on professional judgment of the noise specialist.
- *Trails near the highway*: Recreational trails should be assigned receivers at all areas where user congregating would be expected, such as trailheads, rest areas with benches, or scenic viewing areas; each represents one receptor. Consultation with the local jurisdiction is recommended to resolve any questions.
- ▶ **Section 4(f) Sites**: Siting of receptors/receivers for Section 4(f) sites focuses on exterior areas with frequent human use. If a site does not have an exterior area with frequent human use, noise analysis under 23 CFR 772 is not necessary for the site and this finding should be documented in the noise technical report. Section 4(f) sites encompass three types of sites:
  - *Parks and Recreation Areas*: Addressed previously in this section.
  - *Wildlife Refuges*: Wildlife or wildfowl refuges or preserves typically have limited human activity areas. Some do not have any human activity areas and thus would not be subject to noise analysis. Each scenic or wildlife observation area within a refuge has one receiver representing one receptor per bench or overlook as determined in consultation with a CDOT noise specialist. On-site trails within the refuge should be included as addressed previously in this section.
  - *Historic Sites*: For historic sites that have exterior areas with frequent human use (e.g., historic houses), one receiver should be modeled for each site with such use. Historic sites may qualify as noise sensitive receptors in other categories (e.g., Activity Category B for residences, Activity Category C as a hospital or park, Activity Category E as a hotel). If the property is already considered a noise sensitive receptor, being a Section 4(f) property does not add an additional receptor to that location. However, if the property is normally a Category E receptor, it would be considered a Category C receptor instead because it is a historic site. Historic sites without frequent outdoor human use are not modeled. Coordination with a CDOT historian is required for all historic Section 4(f) site receptor identification and reporting, including selecting the number of receptors each receiver represents. Note: Section 106 considerations for noise impacts on historic properties differ from highway traffic noise requirements and are considered separately under the Section 106 compliance process.

### 3.5.5 Activity Category D

Activity Category D receptors have an interior impact criterion for a subset of Activity Category C receptors: 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. Such a receptor is Activity Category D rather than C as specified in 23 CFR 772.11(c)(2)(iv).

Because Activity Category D receptors require extra consideration, FHWA and a CDOT noise specialist should be consulted while conducting the noise analysis if such a receptor is included in the Noise Study Zone. This consultation would include discussing the number and locations of receivers and receptors.

In most cases, interior traffic noise levels are calculated by subtracting noise reduction factors (see Table 2) from exterior modeled noise levels. Interior noise measurements should be taken at final design if noise insulation is being considered as an abatement measure.

Table 2. Building Noise Reduction Factors for Interior Noise Evaluation

Building Type	Window Condition	Noise Reduction Factor (Due to Exterior of Structure)
All	Open	10 dB
Light Frame	Ordinary Sash (closed)	20 dB
Light Frame	Storm Windows	25 dB
Masonry	Single Glazed	25 dB
Masonry	Double Glazed	35 dB

The windows will be considered open unless it is confirmed that the windows are closed almost every day of the year. See FHWA-DP-45-1R, *Sound Procedures for Measuring Highway Noise: Final Report*.

Source: FHWA A-HEP-10-025 *Highway Traffic Noise: Analysis and Abatement Guidance*, December 2011.

### 3.5.6 Activity Category E

Activity Category E receptors are hotels, motels, time-share resorts, offices, restaurants, bars, and other developed lands, properties or activities not included in Activity Category A-D or F. They are commercial in nature and are less sensitive to highway traffic noise.

Examples of Activity Category E receptors and how to select receivers include the following:

- ▶ **Hotel, Motels, Time-Share Resorts:** One receiver should be modeled at each outdoor area of frequent use such as grills, the front door (i.e., if a hotel employee is stationed outside, such as a bellhop), designated smoking areas, pools, playgrounds, picnic tables, and outdoor corridors connecting rooms (one per floor). Each receiver represents one receptor. Hotels and motels might function as apartment buildings, although this is rare. Longer-term stays are generally not considered to be residential occupation. If it is determined that the hotel or motel functions as an apartment building upon consultation with FHWA and/or CDOT, it would be classified as Activity Category B instead of E.
- ▶ **Offices:** Examples of outdoor noise-sensitive use areas at offices include patios with tables that are used for eating lunch or having outdoor meetings and outdoor training areas. One receiver representing one receptor should be modeled at each area.
- ▶ **Restaurants and Bars:** One receiver should be modeled representing one receptor per outdoor table with a maximum of 10 receptors.

### 3.5.7 Activity Category F

Activity Category F receptors are agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), warehousing, malls, stores, shops, and Government managed land. This activity category is not sensitive to traffic noise and is not subject to a NAC. Because these uses are not considered noise sensitive, they are not represented with receivers and are not evaluated for noise impacts.

### 3.5.8 Activity Category G

Activity Category G receptors are undeveloped lands that are not permitted, which means they do not have a building permit prior to the Date of Public Knowledge. They are not sensitive to traffic noise and are not subject to a NAC; therefore, they are not represented with receivers. Because such lands may be developed in the future, noise impact contours for these properties should be developed during the analysis and provided to the local jurisdiction, including local planning, zoning and/or building permit offices, and where applicable, metropolitan planning organizations (MPOs) and transportation planning regions, for future land use planning purposes.

## 3.6 Creating the Project Noise Models

Traffic noise levels are calculated and evaluated through modeling with TNM software. The project noise models are intended to simulate the landscape and traffic noise conditions within the Noise Study Zone. An initial existing condition noise model is developed and undergoes validation. This becomes the basis for the existing condition and design year noise models.

Create the project noise models using the most current, CDOT approved version of TNM. The existing condition noise model that will be validated represents the existing highway configuration. It includes applicable features affecting the noise environment<sup>13</sup>, such as highways, topographic features, and buildings. Guidance regarding TNM inputs includes FHWA's *Recommended Best Practices for the Use of the FHWA Traffic Noise Model* and NCHRP's *Report 791: Supplemental Guidance on the Application of FHWA's Traffic Noise Model*.

### 3.6.1 Highways

Highways in the Noise Study Zone that are substantive contributors to the noise environment must be included in the project noise models. This generally refers to the highway being studied, as well as all crossing and nearby roads that carry substantial traffic. For highways of a minor residential nature, only throughways carrying substantial traffic volume need to be modeled, as determined via professional judgment. If a road is excluded from the project noise models that could reasonably be expected to be included, an explanation of why the road is being excluded should be provided in the traffic noise technical report.

Highway alignment for most projects will be the same for existing year conditions and the No Action Alternative. Highway alignment is also needed for the design year for each considered alternative (e.g., Proposed Action).

### 3.6.2 Receivers

Model receivers are the locations where traffic noise levels will be calculated. The receivers are selected based on the identified land uses. Each receiver will represent one or more receptors or a validation measurement location. Each individual receptor does not have to be modeled separately. A receiver can be chosen that represents several receptors within a common noise environment. All relevant receptors must be represented in the analysis. How many receptors are represented by each modeled receiver is important and must be documented.

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<sup>13</sup> For validation of the initial existing condition noise model, it is only necessary to include TNM objects that could affect noise at measured locations, although all objects used in the complete existing condition noise model could be included in the validation model.

A receptor will not be represented in the project noise models by more than one receiver. The receiver should be placed in the loudest anticipated area of frequent human use. For example, if a single-family home has multiple outdoor uses (e.g., front yard, back yard, upper floor balcony), and the front yard faces traffic but the back yard and balcony are on the other side of the house from traffic, the receiver would be placed in the front yard.

Receivers are typically modeled at a height of 5 feet (1.5 meters) above the ground level elevation to approximate the height of an average human ear. For analysis of areas above ground level, such as a balcony, receivers are modeled at a height 5 feet above the floor.

Receivers may be added to the existing condition noise model before or after validation. The only receivers that must be in the existing condition noise model while validating it are noise measurement locations.

Receivers will be the same for the existing condition and design year noise models for most projects. If the project involves the acquisition or removal of properties that are noise-sensitive receptors, they would not be included in the design year noise model (except for the No Action Alternative noise model, if applicable). If the project will be relocating noise-sensitive receptors, those new locations will be modeled in the design year noise model.

### 3.6.3 Other TNM Objects

Other TNM objects should be included in the project noise models to represent real-world objects that may affect the transmission of traffic noise in the Noise Study Zone. These objects include terrain lines, noise barriers, buildings modeled as building rows, buildings modeled as noise barriers, tree zones, and ground zones. Partial barriers, jersey barriers, and solid panel bridge walls may be modeled as noise walls. Landscape berms may be represented by terrain lines. These objects vary by project and are identified through examination of the project's physical setting.

### 3.6.4 Pavement

The default pavement type in TNM should be used in most cases. An exception could be when the actual pavement type is used for both validation and in the existing condition noise model. The default average pavement type must still be used in the design year noise model, as described in 23 CFR 772.9(b).

### 3.6.5 Existing Noise Barriers

Existing noise barriers should be included in the project noise models. To be considered a noise barrier, the structure must be solid. It may be an existing noise barrier designed specifically to abate noise or it may be a solid wall, such as a jersey barrier, that was not put in place specifically to abate noise. If there is doubt about the durability of a wall, it should not be modeled as a noise barrier; see Section 3.6.6 on existing privacy fences. Information about the consideration of existing noise barriers is available in FHWA's *Consideration of Existing Noise Barrier in a Type I Noise Analysis*.

For projects that include one or more existing noise barrier(s), the existing condition and design year No Action Alternative noise models must include the barrier. Reported noise levels for those situations include the barrier. For the Proposed Action design year noise model, treat existing noise barriers as follows:

- ▶ **Project Does Not Modify Barrier:** Determine if any receptors near the barrier are impacted. If there are no impacts, further evaluation of the barrier is not needed. If any receptors are impacted in the area with the barrier, model another case without the barrier. Compare noise levels for the design year with and without the existing barrier. If the existing barrier is found to provide 7.0 dB of noise reduction for at least two receptors, it meets the NRDG and further evaluation of noise abatement is not needed for this barrier. If the barrier does not meet the NRDG, evaluation of additional noise abatement for the existing barrier is required for the Proposed Action. A barrier evaluation needs to be done to determine if it needs to be longer and/or taller or if it needs to be replaced so that it will meet the NRDG. If it is not possible to modify the barrier to provide a barrier that is feasible and reasonable, the existing barrier will be left in place.
- ▶ **Project Modifies Barrier:** Model the design year without the barrier if the existing barrier is to be demolished under the project. Perform a barrier evaluation as if the existing barrier is not in place. If a new barrier is determined not to be feasible and reasonable, the evaluated barrier would not be built. However, a replacement barrier would be built that is the same dimensions as the demolished barrier. This rebuilt barrier would not be considered to be a noise abatement action. Generally, wooden barriers will be replaced with modern noise abatement materials (e.g., concrete). However, in limited cases, they may be rebuilt with wood in consultation with CDOT and FHWA.

Existing physical structures that may block noise transmission should be included in the analysis as either a wall or a building row despite not being built to function as noise barriers. For projects that include one or more such structure, it is recommended that the existing condition noise model include the structure. The design year model would include the structure(s) if they are expected to remain in place or if they will be added as a result of the project. These structures do not take the place of potential noise barriers, but they may reduce noise levels at receivers.

### 3.6.6 Existing Privacy Fences

Wooden privacy fences, which are not normally constructed to abate noise, are not considered to be noise barriers because they generally do not provide an appreciable amount of noise reduction. These fences contain many gaps, each of which allows transmission of noise, and often are not made of material sufficiently dense enough to reduce noise transmission. Privacy fences should not be included as a TNM barrier object in analytical modeling unless they are constructed gap-free and provide the required acoustical properties, as defined by Chapter 18 of CDOT's *Roadway Design Guide*.

When continuous masonry or composite-material privacy or other development-related fences are present, consideration will be given as to whether the fence will remain in good condition over the life of the project (20 years for projected future noise levels). If there is doubt as to the durability of the fence, it should not be modeled as a noise barrier. Including a privacy fence in the project noise models must be approved by a CDOT noise specialist. If it can be considered a noise barrier in the project noise models, see Section 3.6.5 on existing noise barriers.

## 3.7 Validating the Model

To ensure that project noise models are a reasonable representation of the current real-world landscape, the existing condition noise model must be validated using field-measured traffic data

and noise levels, per 23 CFR 772.11(d)(2). Traffic data consists of traffic volume, mix, and speed. This field traffic data and locations where traffic noise was measured is input into the initial or complete existing condition noise model. For each measurement location input as a receiver, the resulting modeled noise level is compared to the measured noise level.

Validation is performed so that the model can be used with confidence to predict existing and design year noise levels. Chapter 4 of FHWA's *Noise Measurement Handbook* provides guidance on field measurements for validation.

To determine whether the model validates, compare modeled results to field measured noise levels. The maximum acceptable difference between the field noise measurements and the modeling results is 3.0 dB. If the difference is within 3.0 dB, the existing condition noise model is considered validated.

If the difference is not within 3.0 dB, the noise modeler should double-check model inputs, coordinates, and other variables to determine if the discrepancy can be explained. If the discrepancy can be explained, either the inputs are corrected or the data point is removed or recollected in another field visit. After examination, if the difference still exceeds 3.0 dB, the reason for the difference will be adequately explained in the traffic noise technical report. A CDOT noise specialist must concur with the explanation. If the discrepancy cannot be explained, a consultation with the analyst, project team, and a CDOT noise specialist will be held to determine how to move forward. A second measurement may be required to be taken in some instances.

For projects with a new highway on a new location, it is not generally possible to validate the existing condition noise model of the new highway location except where the new highway ties into or is very close to an existing highway. In that case, the existing condition noise model near the existing highway may be validated.

Noise measurements from the Noise Study Zone must be collected as part of the validation process. Noise data are collected as follows:

- ▶ **Equipment:** Field noise measurements must be made using an American Nation Standards Institute (ANSI) Type I or Type II<sup>14</sup> integrating sound level meter that has been calibrated by the manufacturer or a certified laboratory within one year prior to taking the measurements.
- ▶ **Timing of Fieldwork:** Validation does not require field measurements during the worst-noise hour because the purpose is only to confirm that the existing condition noise model was created accurately, such that when a defined traffic set is entered, the receivers will show the correct, corresponding noise levels. It is best to measure when traffic is relatively free flowing at or near the posted speed limit. Traffic volume and vehicle mix must be collected at the measurement locations at the same time the noise measurements are taken. It is preferable to measure traffic speed at the same time noise measurement are taken. However, it may be measured within 30 minutes before or after taking the noise measurements if the traffic is still representative of when measurements were taken. Traffic data and noise levels will need to be normalized to an hourly basis.

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<sup>14</sup> 23 CFR 772.11(d)(3) says that an ANSI Type I or Type II integrating sound level meter should be used. The regulation is from 2010. The current ANSI standard categorizes the sound level meters as Class I and Class II. It is anticipated that when the regulation is revised, this change will be made.

- ▶ **Instrument Field Calibration:** Calibrations traceable to the United States National Institute of Standards and Technology must be performed in the field at least once per day before starting measurements. The calibration should be checked after each measurement prior to moving to the next location.
- ▶ **Duration of Field Measurements:** For high-volume roads (400 or more vehicles/lane/hour), a 15-minute sample is usually statistically accurate enough to obtain a good measurement. For low-volume roads (less than 400 vehicles/lane/hour), measurements should generally last 20 to 30 minutes. Typically, more time is needed the lower the volume; a 20-minute reading is sufficient if noise levels have stabilized within that time. If a measurement is taken that is longer than 30 minutes, but not longer than 60 minutes<sup>15</sup>, an explanation of why the longer measurement was needed must be provided in the traffic noise technical report.
- ▶ **Number of Locations:** A minimum of two field measurements are required within the Noise Study Zone to validate the existing condition noise model. More than two locations may be needed depending on the number of residential areas, if the area already has noise walls, and topography. Less than 20 locations would be needed for most projects.
- ▶ **Location of Field Measurements:** Field noise measurements should represent sensitive receptors best illustrating the existing traffic noise environment. They should be as free from the influence of local non-traffic generated noise sources (e.g., firehouse, industrial site, railways) and shielding as practical. At least one location will be in a residential area, if the Noise Study Zone has any such areas. Depending on the size of the Noise Study Zone, a measurement might be taken at each major residential area, at a representative number of residential areas, or at multiple locations within a residential area where noise levels could differ (e.g., due to topography changes). Generally, measurements should not be taken at an intersection because traffic is not free-flowing. It is not necessary to measure noise at project receptors, although measurements should represent them.
- ▶ **Number of Field Measurements per Location:** One reading is required at each measurement location.
- ▶ **Traffic Volume:** A directional traffic count should be taken for highways adjacent to the measurement sites (e.g., differentiate between traffic moving south and north). Volume can be determined by using a video camera, on-site counting, or another FHWA approved method (e.g., see methods described in Section 17.6 of FHWA's 2018 *Noise Measurement Handbook*).
- ▶ **Vehicle Mix:** Automobiles, medium trucks (2-axle), heavy trucks (3 or more axles), buses, and motorcycles are counted separately.
- ▶ **Vehicle Speeds:** Determination of the approximate speed that the vehicles were traveling can be determined by driving a test vehicle through the traffic stream, by radar detector, or another FHWA approved method.
- ▶ **Weather Conditions:** Noise measurements should be taken during weather conditions acceptable according to FHWA guidance (e.g., *Noise Measurement Handbook*). Noise measurements taken during non-acceptable conditions should not be reported. Wind speed and direction should be site-specific and contemporaneous with the sound level

<sup>15</sup> CDOT uses Leq(h), which is the hourly value of Leq. It is not helpful to measure more than one hour of noise levels in the field when validating a noise model.

measurements. Therefore, generally an anemometer or handheld wind speed and direction instrument should be used.

### 3.8 Existing Condition Noise Levels

The purpose of determining existing noise levels is to gain an understanding of the existing noise environment, to determine whether a substantial noise increase occurs as a result of the Proposed Action or Preferred Alternative, and to provide a baseline against which changes can be measured for NEPA. Most projects involve modifications to existing highways and do not involve new highways on new locations. If modifying an existing highway, existing worst-noise hour data (traffic volume, mix, and speed) is needed to model existing noise levels at receivers once the existing condition noise model has been created and validated, as described in Sections 3.6 and 3.7. If building a new highway on a new location, the existing noise conditions are assessed through noise measurements. If a project involves both modifications to an existing highway and a new highway on a new location, existing conditions may be determined using a hybrid of both methods.

#### 3.8.1 Existing Conditions if Modifying Existing Highways

To model existing worst-noise hour conditions at model receivers, the following data are needed:

- ▶ Existing year worst-noise hour traffic volumes, which include a count of automobiles, medium trucks (2-axle, 6-tire), and heavy trucks (3 or more axles) for each direction of modeled highways. Bus and motorcycle counts should be provided if they are available.
- ▶ Current posted speed limit for all modeled highways.

To model the worst-noise hour existing condition, use the highest volume of traffic that can travel at the highest relevant speed for the particular highway. In congested corridors, this is generally just before or just after the congested time periods.

For volumes, the best traffic data available for the project should be used, which is usually a project-specific traffic study. If a project-specific study is not available, use CDOT's MS2 Transportation Data Management System<sup>16</sup> (<https://cdot.ms2soft.com>) or Online Transportation Information System (OTIS) (<http://dtdapps.coloradodot.info/otis>), which have traffic data that are measured at least every three years, for a given road segment. If applicable MS2 or OTIS data is not available, try to obtain data from another source, such as a Travel Demand Model<sup>17</sup> or non-project specific traffic study (e.g., long-range traffic study conducted by CDOT, local agencies, consultants, or developers). If none of these sources are available, the traffic noise technical report should explain that and explain how traffic data was developed. Regardless of the source, traffic volumes in excess of those shown in Table 3 should not be used in TNM modeling. In that case, Table 3 data should be used.

<sup>16</sup> CDOT's Automatic Traffic Recorder (ATR) data is pushed daily to MS2 and monthly to OTIS. MS2 includes speed data, offsystem roads, and more vehicle classifications than OTIS (including motorcycles and buses).

<sup>17</sup> CDOT developed a Statewide Travel Demand model in 2019. At the time this NAAG was published, the model contained data for only 2015, 2030, and 2045. Some MPOs have their own Travel Demand Model. If the project is wholly within the boundary of an MPO, the MPO's Travel Demand Model should be used. Otherwise, the Statewide Travel Demand model should be used.

Table 3. Suggested Maximum Traffic Volumes for Worst-Noise Hour

Posted Speed Limit (mph)	Maximum Traffic Volumes by Facility Type (vehicles/lane/hour) <sup>1</sup>		
	Freeway	Non-Freeway Multiple Lane	Two-lane Highway
75 or above	1,600	NA	NA
70	1,700	NA	NA
65	1,800	1,700	1,300
60	1,900	1,800	1,300
55	2,000	1,900	1,300
50	2,100	2,000	1,400
45	2,200	2,100	1,500
40	Not applicable	2,200	1,600
35 or below	Not applicable	2,200	1,600

<sup>1</sup> Appendix C contains technical support documentation for worst-noise hour equivalent capacity.  
 mph = miles per hour

If it is not known which hour is the worst-noise hour and there is reason to believe that it occurs other than at the typical AM/PM peaks of rush hour, long-term measurements up to 24 hours may be used to make that determination. Corresponding traffic data would then be used in the existing condition noise model. Prior to conducting long-term measurements, consult with a CDOT noise specialist, who must approve long-term measurements.

### 3.8.2 Existing Conditions if Building New Highway at New Location

For portions of projects that have a new highway being constructed on a new location<sup>18</sup>, field measurements typically are used to define existing noise conditions at the applicable receivers representing existing and permitted receptors. Usually, only a few measurements will be collected that may need to be applied to numerous receptors, so an appropriate measurement strategy must be developed to fit the project.

When measuring to establish existing noise levels for a new alignment, the worst-noise hour should be established. Generally, the worst-noise hour will be between 6 a.m. and 7 p.m. Ambient nighttime noise levels are usually lower than daytime levels. Typically, the worst-noise hour occurs on weekdays, although it may be weekends in tourist or recreation areas. In rural settings, the worst-noise hour may be uncertain. When there is uncertainty, a longer measurement may be taken in one location to help determine the appropriate time to take briefer measurements at other locations. The noise analyst needs to develop an understanding of existing ambient conditions, such as through field reconnaissance or discussions with local governments, to inform an appropriate measurement plan.

<sup>18</sup> This section applies to construction of a new highway (i.e., through lanes) in a new location. It does not apply to adding pavement associated with an existing highway, such as additional auxiliary lanes or completing an interchange.

The following recommended measurement periods may be used in combination for a project, as appropriate for each location:

- ▶ Recommended period of 30 minutes when the worst-noise hour is known
- ▶ Minimum period of 2 hours (usually between 6 a.m. to 8 a.m. and/or 3 p.m. to 7 p.m.) when the uncertainty is moderate as to the worst-noise hour
- ▶ Up to 13 hours (6 a.m. to 7 p.m.) when the uncertainty is high as to the worst-noise hour

Even if the worst-noise hour is not exactly captured using this approach, noise sensitive receptors will be safeguarded. The measured noise levels would be lower than otherwise, meaning existing noise levels would be described as being quieter than they really are. Therefore, it would be more likely that an impact due to a substantial noise increase will be identified. Prior to conducting long-term measurements (i.e., more than one hour and not more than 24 hours), consult with a CDOT noise specialist.

### *3.9 Design Year Noise Levels*

The purpose of determining design year noise levels is to check if the project will negatively affect receptors and if noise mitigation should be evaluated. Each design year alternative being considered for a project must be modeled. Although 23 CFR 772 does not require analysis of the design year No Action Alternative, for the purposes of NEPA, CDOT requires that a No Action Alternative be modeled for EAs and EISs. For CatExs, there will likely be only one alternative (i.e., Proposed Action), but EAs and EISs may have several alternatives (No Action, Proposed Action or Preferred Alternative, and other alternatives).

For projects modifying an existing highway, the existing condition noise model created and validated as described in Sections 3.6 and 3.7 may be modified with the new alignment (e.g., additional lanes) and design year worst-noise hour traffic data, as follows:

- ▶ Add and adjust the alignment of driving lanes within the TNM models, as needed.
- ▶ Use design year traffic volumes, which include counts of automobiles, medium trucks (2-axle, 6-tire), and heavy trucks (3 or more axles) for each direction of modeled highways. Bus and motorcycle counts should be used if they are available.
- ▶ Design year posted speed limit for all modeled highways.

For volumes, the best traffic data available for the project should be used. Potential sources of data are described in Section 3.8.1. If none of these sources are available, the traffic noise technical report should explain that and explain how traffic data was developed. Traffic volumes from Table 3 might be used, as described in Section 3.8.1.

In most cases, the No Action Alternative may use the design year traffic data on the existing highway alignment. However, other unrelated projects may be planned within the Noise Study Zone that need to be included for the No Action Alternative.

### 3.10 *Identifying Traffic Noise Impacts*

Output from project noise models described in Sections 3.8 and 3.9 is used to determine if a project is predicted to result in noise impacts to noise sensitive receptors within the Noise Study Zone. A traffic noise impact occurs if either of the following conditions is met for build alternatives:

- ▶ Predicted design-year traffic noise level equals or exceeds CDOT's NAC at any receptor
- ▶ Predicted design-year traffic noise level substantially exceeds, by 10.0 dB or more, the existing noise level at any receptor

The substantial increase criterion applies regardless of the noise levels. For example, an increase from an existing 45.0 dBA to a predicted design year condition of 55.0 dBA for an Activity Category B receptor would result in a noise impact because the noise increase is 10.0 dB, which meets the 10.0 dB substantial increase threshold.

A change in noise levels from 62.0 dBA to 69.0 dBA for Activity Categories B or C would result in an impact because the NAC, 66.0 dBA, would be exceeded, even though it would not be a substantial increase. If the predicted design year noise level equals or exceeds the NAC, there is an impact regardless of whether or not the proposed project is the cause. For example, if the existing noise level at a home is 68.0 dBA and the design year noise level is 66.0 dBA, the home is impacted.

Noise increases are not calculated between the existing and design year for the No Action Alternative. Existing conditions and No Action Alternatives are not described as having noise impacts. If the project wasn't built, the project would not be responsible to build noise mitigation regardless of existing or design year noise levels, even if noise levels exceed NACs. Impacts are determined for Proposed Action, Preferred Alternative, and other alternatives<sup>19</sup>.

If the project does not result in any traffic noise impacts, the analysis is complete and noise abatement is not evaluated.

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<sup>19</sup> Other alternative is a term that refers only to design year build alternatives. It does not include the No Action Alternative.

## 4. EVALUATION OF HIGHWAY TRAFFIC NOISE ABATEMENT

Receptors determined to be impacted by highway noise from design year build alternative(s) must be evaluated for traffic noise abatement. Abatement is evaluated using feasibility and reasonableness criteria as described in this chapter. The Noise Abatement Evaluation Worksheet, CDOT Form 1209<sup>20</sup>, is completed for each distinct area of the project evaluated for a noise barrier and is used to document abatement evaluation. The completed form(s) is included in the traffic noise technical report. All abatement measures determined in the final abatement evaluation to be feasible and reasonable, including the Benefited Receptor Preference Survey results, are required to be constructed.

The traffic noise technical report written during the NEPA process may not represent final design conditions. Therefore, the report contains a Statement of Likelihood, which indicates that the findings of the traffic noise technical report, including feasibility and reasonableness, may change in final design.

Noise sources such as aircraft, rail, ground transit modes, or industrial noise sometimes contribute substantially to the noise environment at a specific receptor. The quantitative context of these non-highway noise sources is not addressed by the FHWA TNM modeling software. Therefore, in cases where substantial noise contribution is expected from non-highway transportation or non-transportation noise sources, consultation among CDOT noise specialist(s), CDOT project manager, local agency project sponsor(s) (if applicable), and FHWA is required to resolve the noise impact and abatement evaluation.

### 4.1 *Noise Abatement Options*

Although 23 CFR 772.15(c) allows various abatement options to be considered for incorporation into a Type I or Type II project, 23 CFR 772.13(c)(1) requires that noise barriers be considered. The following subsections discuss abatement options.

#### 4.1.1 *Non-Barrier Abatement Options*

The following abatement options may be evaluated and incorporated in highway projects to reduce traffic noise impacts, per 23 CFR 772.15(c)(2) through 23 CFR 772.15(c)(5):

- ▶ Traffic management measures including, but not limited to, traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive lane designations. (CDOT note: Measures such as these may or may not be beneficial or possible given the constraints of the project and the immediate area. While lower speeds do decrease noise levels, it may take a reduction in speed of approximately 20 mph to achieve a readily perceptible (5 dB) reduction of noise.)
- ▶ Alteration of horizontal and vertical alignments.
- ▶ Acquisition of real property or interests therein (predominantly unimproved property) to serve as a buffer zone to preempt development that would be adversely impacted by traffic noise. This measure may be included in Type I projects only. (CDOT note: While buffer zones

<sup>20</sup> Form 1209 is available in the CDOT Traffic Noise Technical Report Template.

are a good strategy in overall noise compatible land use planning, it is often not a practical solution, due to the large amount of land that must be purchased. In many instances, the existing developments already border the highway. Federal dollars cannot be used to purchase developed property for noise mitigation.)

- ▶ Noise insulation of Activity Category D receptors listed in Table 1<sup>21</sup>. Post-installation maintenance and operational costs for noise insulation are not eligible for Federal-aid funding. (CDOT note: This evaluation will be made on a case-by-case basis<sup>22</sup>. Any decisions in this regard must be thoroughly and completely documented in the traffic noise technical report.)

The following measures cannot be incorporated as noise abatement in Federal highway projects:

- ▶ **Quieter pavement:** Different tires, pavements, and pavement surfacing textures result in varying noise levels. However, it is difficult to forecast the overall pavement surface condition 20 years into the future. Because noise mitigation must be permanent, use of different pavement types or surface textures cannot be considered as a noise abatement measure. This does not preclude CDOT from using quieter pavement on non-Federal-aid projects. Also, CDOT may use quieter pavement on Federal-aid projects, although the pavement cannot be classified as noise abatement.
- ▶ **Vegetation and/or landscaping:** Studies have shown that for vegetation to provide a 5 dB reduction, it must be at least 100 feet thick, at least 20 feet high, and sufficiently dense (100% opacity) throughout the year. States may use Federal-aid funds for vegetation near barriers or for landscaping near roadsides for aesthetic and visual purposes, but it will not be considered to be noise abatement, per 23 CFR 772.15(c)(1).

#### 4.1.2 Noise Barrier Abatement Options

CDOT typically uses two noise abatement measures: the noise wall and/or the earthen berm. Both barriers work by blocking the path of sound waves from the highway, forcing the sound to travel around or over the barrier. If a noise barrier is tall enough to break the line of sight between the highway and the receptor, constructed of sufficiently dense material<sup>23</sup> to meet reduction requirements, and does not have any openings or gaps, a noise reduction will be possible ranging from being readily perceptible to less than half as loud (5 to 15 dB for most barriers) depending on the height and location of the barrier. CDOT has determined that a barrier must be designed to achieve a minimum 5.0 dB for at least three impacted receptors to be feasible and 7.0 dBA for at least two benefited receptors to be reasonable.

The most common type of highway noise barrier is a noise wall, which can be constructed out of a variety of materials, including concrete, masonry block, composite synthetic materials, and transparent acrylic or other plastic products. Wood is not an acceptable material for noise barriers.

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<sup>21</sup> FHWA *Highway Traffic Noise: Analysis and Abatement Guidance*, December 2011, states: "Highway agencies may only consider noise insulation for public use or nonprofit institutional structures, e.g., places of worship, schools, hospitals, libraries, etc. "Public use or nonprofit institutional structures" means the facility is open for public use, owned by the public or that a nonprofit organization owns the facility."

<sup>22</sup> More information about noise insulation is available in Chapter 18 of CDOT's *Roadway Design Guide*.

<sup>23</sup> Material must meet guidelines provided in Chapter 18 of CDOT's *Roadway Design Guide*, including having an acceptable Sound Transmission Class of 30, as of the 2017 version.

An earthen berm is essentially a man-made mound of materials such as soil and gravel. Berms appear more natural than noise walls; however, they require much more land. Combination barriers have also been constructed by placing walls on top of berms or by interspersing walls and berms.

Chapter 18 of the CDOT *Roadway Design Guide* contains information concerning design, structural, and aesthetic considerations of noise barrier construction.

### 4.1.3 Noise Impact Compensation

Property owners or residents cannot receive Federal funds as monetary compensation in lieu of noise abatement or receive direct monetary compensation for highway traffic noise impacts, per FHWA FAQ A7. As directed by 23 CFR 772.15(a), Federal funds may be used only to build feasible and reasonable noise abatement.

### 4.1.4 Third-Party Funding

Per 23 CFR 772.13(j), private or third-party funding is not allowed on a Federal or Federal-aid Type I or Type II project to discount the cost of the noise abatement to influence the feasibility or reasonableness determination. Private or third-party funding cannot be used to augment the dimensions or change the cost benefit of noise abatement recommended on a Federal-aid project.

Per 23 CFR 772.13(j), private or third-party funding can be used on projects to make functional enhancements to noise abatement already determined to be feasible and reasonable, such as adding absorptive treatment, access doors, or aesthetic enhancements.

Local agency sponsored and non-CDOT, non-federally funded noise abatement can be constructed on right-of-way (ROW) in limited situations, as described in Appendix D.

## 4.2 Noise Barrier Evaluation Considerations

Evaluations of potential noise barriers are conducted using design year noise models for the build alternatives. Various locations, heights, and lengths of barriers can be input into the model, which calculates noise reductions resulting from each potential barrier configuration. The amount of noise reduction, referred to as insertion loss, is calculated at individual receivers by subtracting the noise level with the noise barrier from the noise level without the noise barrier. If more detailed TNM modeling results are desired for the barrier analysis than are needed for the noise impact evaluation, "pooled" receivers for a common noise environment may be supplemented with additional individual receivers.

The total area evaluated for noise abatement should be considered case-by-case. For example, a neighborhood being evaluated for noise abatement may extend beyond the Noise Study Zone boundary and warrant extending the potential noise barrier. A CDOT noise specialist will decide where abatement would end for this situation.

The following sections describe barrier optimization and considerations for reflected noise, parallel barriers, and absorptive treatments.

### 4.2.1 Barrier Optimization

Maximizing barrier effectiveness is critical to developing satisfactory feasibility and reasonableness data. Earth berms can be used as barriers but tend to be impractical for CDOT projects because they require a large footprint. Therefore, this optimization section is specific to noise walls, although similar concepts can be applied to berms.

The goal of noise wall optimization is to develop potential noise abatement that provides more noise reduction benefit with less noise wall. This involves attempting to maximize the number of benefited receptors and their calculated noise reductions with the smallest wall area to minimize costs. Projects differ, so a one-size-fits-all optimization approach is not practical. The process is iterative and may not be simple. Often, multiple wall dimensions can provide satisfactory abatement results. Ultimately, one optimized prospective noise wall needs to be selected for a group of impacted receptors and evaluated for feasibility and reasonableness.

Three fundamental parameters to consider when developing prospective noise barriers for analysis in TNM are:

- ▶ **Location:** For noise abatement to be effective, barriers must be located between the receptors and the dominant traffic noise source(s). Noise barriers are generally most effective if they are located close to the source (i.e., highway), close to receptors, or on intervening high ground (if applicable). Barrier locations should first be evaluated within either existing or proposed future CDOT ROW. If effective noise reduction cannot be achieved by a barrier located within the ROW, adjacent land can be evaluated for placement of an abatement measure after consultation with CDOT noise specialist. More than one wall alignment should be considered. The alignment most favorable for noise reduction should be selected. Barriers close to the road mean considering design requirements for parameters such as shoulders, traffic clear zones, drainage, barrier crashworthiness, and driver sight lines. Barriers close to receptors mean the wall will usually be placed inside the ROW boundary by 5 to 10 feet, to provide access to both sides of the barrier for CDOT maintenance. The most favorable barrier alignment will often be apparent; it is typically where the ground elevation of the wall base will be highest. When the most favorable barrier alignment is apparent, the location optimization can be done outside the TNM model. Otherwise, multiple wall alignments can be modeled and evaluated until the best choice can be identified. The traffic noise technical report must describe the justification for choosing the barrier location, including whether the location was determined via modeling. Note that adding a barrier to a project noise model introduces new terrain data that can affect the modeled noise levels even when the wall height is set to zero.
- ▶ **Length:** Prospective noise walls should span the entire distance along the road for the receptors being evaluated. Barriers should initially be modeled longer than expected to be necessary and then trimmed to appropriate lengths during wall optimization. For example, the final proposed barrier should extend past the receptor on each end of the evaluated area by at least four times the distance from the road to those receptors. Each barrier needs to be divided into wall segments in TNM so that they can be optimized.
- ▶ **Height:** CDOT policy is that noise walls should be no shorter than 8 feet and no taller than 20 feet. If the wall is constructed adjacent to the shoulder, the maximum recommended height is generally 12 feet, at the discretion of a project engineer.

Each prospective wall needs to be evaluated to determine the wall's feasibility and reasonableness. Evaluations are done via a TNM barrier analysis. It can be a complex process with several factors to consider simultaneously. Multiple wall configurations that satisfy CDOT abatement criteria can often be found. The process to select the optimized wall should consider these factors:

- ▶ Determine whether a 20 foot tall noise wall can meet the CDOT 5 dB feasibility requirement and the NRDG. If it does not meet these criteria, the evaluation is done. If it does, proceed with evaluation.
- ▶ It is possible that not all impacted receptors will benefit from a noise barrier and some non-impacted receptors might benefit, but priority should be given to impacted receptors.
- ▶ Ensure that unnecessary wall segments have been removed from the wall analysis to minimize wall size and costs. For example, wall-end segments should not be unduly long and interfere with the trimming of unnecessary wall length. This may be an iterative process to determine the optimized segment length. Also, consider where the wall ends in relations to nearby land uses, such as the extent of a neighborhood (see Section 4.2).
- ▶ Consider noise benefits to receptors above the level of the roadway (e.g., apartment balconies) but do not prioritize them due to the difficulties in using noise walls to provide benefits to these kinds of receptors.
- ▶ Review the Cost Benefit for the prospective noise wall and consider if it can be improved.
- ▶ Select the noise wall configuration that provides the best combination of more benefits and less cost based on the Cost Benefit and other technical details relevant to the site.
- ▶ When optimizing, it is generally recommended that noise abatement will benefit as many receptors as possible, as long as it meets the Cost Benefit Index.

#### 4.2.2 Existing Noise Barriers

Highway noise barriers are installed and maintained in perpetuity to protect the noise sensitive environment impacted by highway projects. When a new project may change the performance of an existing barrier, the existing barrier must be assessed in terms of both remaining service life and effectiveness.

The remaining service life of the existing barrier as defined within an engineering evaluation must also be considered to ensure that it is a permanent solution as required by FHWA. If an existing barrier poses ongoing functionality or maintenance problems, it should be replaced with acceptable materials either as a part of the Type I highway project or as a state funded noise wall replacement project.

An example of a service life issue is a wooden noise barrier built by CDOT that deteriorated over time. An engineering assessment can determine whether an acceptable service life remains with cost-effective repair. The engineering assessment may determine that repair of the existing wall is not cost-effective and that the wall should be replaced with materials deemed acceptable. Decisions concerning these situations will be made on a case-by-case basis in consultation with CDOT.

Effectiveness of the existing barrier will be assessed using the design year noise model by reviewing the noise reduction from the barrier with the Proposed Action. If the existing barrier is found to meet the NRDG, further action is not necessary for the existing barrier. If the barrier will not meet the NRDG, alterations to the existing barrier will be evaluated so that it will meet the current

NRDG, and appropriate recommendations should be made to improve the barrier. If the NRDG cannot be achieved, the replacement must provide noise reduction similar to what the existing barrier did when it was first constructed, or be of a similar size if that noise reduction is not possible.

If structural integrity, inadequate footing design, load carrying capacity, or other construction issues prevent the existing wall from being adequately modified and no remedy is readily found, consultation with CDOT Project Management Team will determine whether a replacement wall will be built to meet the current NRDG. The existing wall may be left in place. Any existing noise barrier removed for construction of a new transportation project will be replaced with a barrier of similar length and height on a new location. All noise abatement analyses recommendations must be documented on a CDOT Form 1209, the Noise Abatement Evaluation Worksheet. It is part of the CDOT Traffic Noise Technical Report Template.

### 4.2.3 Reflected Noise Considerations

Noise barriers reduce noise levels at receptors located behind the barrier. However, barriers may reflect traffic noise and negatively affect the noise conditions at other nearby receptors. Generally, this occurs when there are receptors on the opposite side of the road from a noise barrier. In these cases, the barrier may act as a secondary noise source because it may reflect sound. It is possible that reflected noise from a noise barrier could increase noise overall levels by as much as 3 dB, but in practice will normally increase noise levels by 1 dB or less. Absorptive treatments may be considered, as described in Section 4.2.4. Some of the more common situations where reflective barriers may be a concern include:

- ▶ Sensitive receptors are present across the road from a proposed barrier but are not being considered for a noise barrier.
- ▶ Parallel barriers on each side of a road are proposed that have a ratio of the distance between the barriers versus the height of the barriers of less than 10:1.
- ▶ A large building or other man-made reflective surface is immediately across the road from a proposed barrier, which may simulate a parallel barrier effect.
- ▶ A large rock cut or other natural reflective surface is immediately across the road from a proposed barrier, which may simulate a parallel barrier effect.

Due to multiple sound reflections, performance degradation of parallel barriers needs to be investigated if the distance between the barriers is less than 10 times the height of the barriers. Separate analysis of parallel walls under these configurations could lead to incorrect abatement calculations. Possible solutions include raising the height of the barriers to overcome the degradation or investigating the use of absorptive treatments on either or both barriers to reduce the reflections. Retaining walls or vertical rock face cut slopes, if present, should be treated as barriers in the analysis.

For situations not clearly defined by this NAAG, decisions regarding modeling reflected noise should be made on a case-by-case basis, through consultation with FHWA and a CDOT Noise Specialist(s).

### 4.2.4 Absorptive Treatments Considerations

Surface treatment of a proposed barrier to reduce reflected noise may be beneficial. Such treatments could include sound-absorptive surfacing or an irregular barrier surface. CDOT may

consider special barrier surface treatments for projects where a sensitive receptor or a large sound-reflecting object (e.g., natural outcrop, highly reflective building, or man-made feature) is present across the road from a proposed noise barrier and at a distance no greater than 10 times the proposed barrier height. Absorptive noise barriers must be designed so that the absorptive portion on the highway side has a minimum noise reduction coefficient of 0.70, as described in Chapter 18 of CDOT's *Roadway Design Guide*. As described in 23 CFR 772.13(c)(2), if an absorptive treatment is used as a functional enhancement, CDOT shall adopt a standard practice for using it, which is consistent and uniformly applied statewide.

### 4.3 *Barrier Feasibility*

If a noise barrier is determined to be feasible, an assessment of reasonableness is required for that barrier. Otherwise, the noise abatement evaluation for that barrier is complete and abatement will not be recommended. There are two feasibility criteria: noise reduction and design/construction factors.

#### 4.3.1 *Noise Reduction*

A barrier must provide a reduction of at least 5.0 dB to at least three impacted receptors (receptors, not receivers) to be feasible. Only feasible barriers are recommended for inclusion in the project.

In cases where a prospective barrier cannot benefit at least three impacted receptors because there are fewer than three impacted receptors behind the prospective barrier, the barrier does not need to be modeled to be determined that it is not feasible.

Sometimes it is not possible to construct a continuous barrier for the entire length of the impacted area. One potential solution is to wrap barrier end-segments or overlap barriers. A barrier with gaps (e.g., for driveways) would typically not reduce noise by at least 5.0 dB because the gaps reduce the barrier's acoustic performance. However, an effort must be made via modeling to evaluate possible abatement. It cannot simply be stated that a wall with gaps will not be feasible; the design year noise model must show that the wall(s) cannot reduce noise by at least 5.0 dB at three impacted receptors.

#### 4.3.2 *Design and Construction Factors*

As with any structure, several engineering, safety, and maintenance factors must be considered to determine its feasibility. As per 23 CFR 772.13(d)(1), factors to be considered in whether it is possible to design and construct a noise abatement measure are safety, barrier height, topography, drainage, utilities, abatement maintenance, maintenance access to adjacent properties, and access to adjacent properties (i.e., arterial widening projects). When one or more of these factors causes an abatement measure to be infeasible, it is called a "fatal flaw." Fatal flaws should be addressed during the preliminary and final project design.

What initially seem to be fatal flaws can usually be resolved through the design process. If they cannot, the barrier is deemed not feasible. However, this conclusion is only for situations that are clear and must be thoroughly documented and justified in the traffic noise technical report. Except for wall heights, which are generally determined by the noise analyst via modeling, maintenance and traffic engineering CDOT staff must be consulted to determine whether these potential fatal

flaws can be redesigned to an acceptable level or if they cause a feasibility fatal flaw to noise barrier installation.

If a barrier is determined to have a fatal flaw during the NEPA noise analysis, the fatal flaw must be reevaluated during final design. If the fatal flaw cannot be resolved, the barrier is not feasible and the evaluation must be included in the Noise Verification document (see Section 9.5).

Examples of situations that can be considered fatal flaws include:

- ▶ Unsafe reduction of driver sight distance for roadways and driveways.
- ▶ Emergency access to the property cannot be maintained.
- ▶ Wall would need to be too tall: CDOT has determined that for Colorado terrain and weather conditions, including common high wind events, 20 feet is the maximum allowable wall height without compromising structural integrity under typical construction design specifications. If an optimized barrier location (Section 4.2.1) results in a 20-foot high noise barrier that does not reduce noise by the required amount, the barrier is not feasible.
- ▶ Berm would not fit: Ideally, berm flanks will be no steeper than a 3:1 slope. However, an earthen berm is deemed not feasible if the necessary slope ratio is steeper than 2:1<sup>24</sup> or if adequate ROW cannot be acquired to construct the berm to safety or slope ratio specifications. The ends of the berm should have a lead-in slope of 10:1. If a berm cannot be built, a wall should be evaluated.

Feasibility dependent on barrier heights must be determined through TNM modeling, unless it can be shown without modeling that a 20-foot high barrier would not break the line of sight between the edge of the travel lane and the impacted receptors (e.g., impacted receptors are on a slope uphill of the highway). If part of a potential barrier has engineering issues (e.g., access or sight distance), any portion without the engineering issue must be modeled. If an entire potential barrier is deemed not feasible for a fatal flaw reason other than wall height, the traffic noise technical report must include documentation (email or memorandum) written by or signed off by the appropriate specialist (e.g., design engineer, utility specialist) explaining the reasons for the fatal flaws. The reasons must also be summarized in the traffic noise technical report.

Noise barriers may have challenges that are not fatal flaws or reasons for infeasibility. These issues include those related to potential or perceived changes in property values, loss of views, feeling of confinement (e.g., a wall is built close to homes), a wall being a potential graffiti target, reduction of foot traffic access (e.g., wall may cause longer walking distance from a residence to street parking or a bus stop), and minor shading issues (e.g., will not create excessive icing of driving lanes, but may cause issues for some vegetation including landscaping). These issues can be considered by the receptor owners and tenants during the survey process if the barrier is otherwise feasible and reasonable.

#### 4.4 *Barrier Reasonableness*

Reasonableness of noise abatement evaluates three criteria: environmental (via the NRDG), economic (via the cost-benefit evaluation), and social (via the Benefited Receptor Preference Survey). This process ensures a prudent use of public funds. Failure to achieve any of these criteria results in not building noise abatement.

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<sup>24</sup> A berm slope of 2:1 must be approved by CDOT. Approval will depend on issues such as material type and method of plant establishment.

Barrier dimensions must be optimized in terms of overall noise reduction and cost-benefit, which are two of the reasonableness factors. The goal is a barrier design that provides the best balance between cost and noise reduction benefit. This is not a trivial task, as the benefit versus cost relationship is not simple and a point of diminishing returns may be reached. An iterative process, however, can result in a barrier that will provide optimal benefit.

#### 4.4.1 Noise Reduction Design Goal

CDOT defines the NRDG as 7.0 dB noise reduction at a minimum of two benefited receivers. If the NRDG cannot be achieved at two benefited receptors, the barrier is not reasonable.

Other considerations include situations where a barrier will shield receptors from a highway but not a frontage road. In these cases, although the wall may cause reflection of frontage road noise, the reduction in noise from the highway may still provide an overall noise benefit.

#### 4.4.2 Cost Benefit Evaluation

The cost benefit evaluation consists of calculating the Cost Benefit for each potential noise barrier and comparing it to the Cost Benefit Index. The Cost Benefit is calculated by multiplying the barrier area by the Unit Cost and then dividing by the number of benefited receptors. For a noise barrier to be considered reasonable, the Cost Benefit must not exceed the Cost Benefit Index<sup>25</sup> of \$34,000 per benefited receptor.

The Cost Benefit is not intended to function as an accurate cost itemization for the design and construction of a noise barrier. Instead, it provides a consistent level of consideration across Colorado. If a noise barrier Cost Benefit is initially calculated to be not more than 10 percent above the Cost Benefit Index, the noise barrier can likely be optimized so that it meets the Cost Benefit Index.

For purposes of the abatement evaluation, the wall Unit Cost is \$45/ft<sup>2</sup>, which approximates the typical costs in construction of a standard concrete/masonry barrier that does not require special site considerations. The Unit Cost is based on an average of 2006 to 2016 noise wall square footage costs collected from CDOT cost tabulations. The Unit Cost does not include engineering design, ROW acquisition, or utility mitigations.

An example of determining the Cost Benefit for a noise wall is as follows. Consider a wall 10 feet high and 1,000 feet long that will benefit (i.e., reduce noise by at least 5.0 dB) 16 homes and meets the NRDG:

- ▶ Cost = (10 ft.) \* (1,000 ft.) \* (\$45/sq. ft.) = \$450,000;
- ▶ Number of Benefited Receptors = 16;
- ▶ Cost Benefit = \$450,000/16 receptors = \$28,125/receptor.

This example wall would be considered reasonable based on cost because the Cost Benefit, \$28,125 per receptor, is less than the Cost Benefit Index of \$34,000 per receptor.

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<sup>25</sup> This Cost Benefit Index was calculated based on the value from the 2015 NAAG, as discussed in Appendix C. The 2015 NAAG value was in units of cost per benefited receptor per dB reduction. The 2015 value was selected such that a typical noise barrier for a typical suburban/urban neighborhood housing density would be reasonable.

For berms, use a Unit Cost of \$15 per cubic yard of fill material brought in from offsite. If the berm will be constructed using on-site excess materials, use a project-specific Unit Cost, to be determined by the Project Design Engineer. CDOT determines which berm Unit Cost will be used in the cost-benefit calculation.

Receivers sometimes represent more than one receptor. It is important to properly quantify these receptors to obtain an accurate number of benefited receptors. For the Cost Benefit calculation, each benefited receptor (e.g., individual residence, business) should be counted as a separate receptor. For multi-family residences, each benefited dwelling unit counts as one receptor. For example, if a multi-family structure with four units is represented by a single receiver and each unit is predicted to receive a benefit of at least 5.0 dB, the structure would count as four receptors in the Cost Benefit Index calculation.

The length of a barrier should be minimized but still optimized to the least cost per most benefited receptors. Logical break points may include cross streets, alleys, commercial property, waterways, or other manmade and natural features interfering with the continuum of the barrier.

Generally, extraordinary costs related to implementation of engineering design, structural reinforcement, or ROW purchase for the purpose of noise abatement implementation are not included in the Cost Benefit calculation. Typically these types of extraordinary costs are not identified until design is at the final design stage. CDOT must approve use of extraordinary costs in the Cost Benefit calculation.

#### 4.4.3 Benefited Receptor Preference Survey

A benefited receiver, whether impacted or not, is one that receives at least 5.0 dB of noise reduction from an abatement action. This 5.0 dB reduction is based on the addition of the noise barrier only but does consider shielding effects, such as rows of buildings.

Benefited receptor viewpoints must be considered in the reasonableness evaluation of noise abatement. This is done via a Benefited Receptor Preference Survey. The noise analyst must identify applicable benefited receptors, in consultation with a CDOT noise specialist and/or FHWA. A benefited receptor is any property containing a noise sensitive receptor that receives 5.0 dB or more noise reduction from a prospective noise abatement measure. For abatement to be reasonable, it must be supported by a majority of the survey respondents.

#### Public Involvement During the NEPA Process

The public involvement process during NEPA may not be used to substitute for the Benefited Receptor Preference Survey. However, using the public involvement process to inform the affected public of the recommended abatement can be beneficial. This can include open houses, public hearings, and/or neighborhood mailers. A NEPA-related public venue may include a station providing noise abatement displays and analyses adequate to inform the public on recommendations.

Written and spoken communications will be in English and in the dominant secondary language of the community, if applicable. More than two languages may be used, if applicable.

## Survey Timing

Benefited receptors will be surveyed when the final abatement design is completed, the project final design is in progress, and construction is scheduled. Timing may be different in special circumstances, if agreed to by CDOT.

## Survey Timing, Design-Build

See Section 10.2 for information on design-build survey timing.

## Who Votes

If there are multiple owners, residents, and/or tenants of an individual receptor, a consensus is required for each vote. Owner ballots must be given or sent to the owner (i.e., not simply mailed to a business “in care of” the owner). Only one owner needs to be identified; it is up to the owner to discuss the ballot with other owners, if applicable. A ballot for a non-owner resident or tenant does not need to list the non-owner resident or tenant name but must identify the unit (e.g., “Resident of Apt 10-5”).

Benefited receptors receive ballots as follows, depending on the type and ownership of receptor, as shown in Table 4.

Table 4. Benefited Receptor Voting Distribution

Activity Category	Property Type	Vote Distribution
A	Lands on which serenity and quiet are of extraordinary significance	Property owner or land manager, as determined via consultation with CDOT and FHWA, receives one ballot worth two votes per receptor.
B <sup>3</sup>	Residential	<p><b>Single-family Dwelling Unit</b> - If owner-occupied, owner receives one ballot worth two votes. If not owner-occupied, the owner and resident each receive a ballot, each worth one vote.</p> <p><b>Multi-family Dwelling Units</b> - Owners and tenants each receive a ballot. The owner’s ballot counts for as many votes as there are benefited units. Tenants of benefited units get one vote per unit. If a unit is not rented and thus unoccupied, the unit will only generate one vote: that of the owner. If the multi-family dwelling unit has any common areas (e.g., pool, basketball court), the owner’s ballot will include two votes per common area.</p> <p><b>Mobile Home Parks</b> - Mobile home parks or sections of parks in which land is not owned by home owners or renters, then the park or section of the park will be treated as multi-family dwelling units. For land owned by the home owners, the homes will be treated as single-family dwelling units.</p> <p><b>Prisons and Jails</b>- Owners receive one ballot worth two votes per receptor.</p>

Activity Category	Property Type	Vote Distribution
C	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, recreational areas, Section 4(f) sites, schools, television studios, trails, and trail crossings	<b>Government Owned</b> - Owner receives one ballot worth two votes per receptor. <b>Non-Government Owned</b> - If owner-operated, owner receives one ballot worth two votes per receptor. Sites not owner-operated: the owner and tenant each receive a ballot, each worth one vote per receptor.
D	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	Same voting distribution as Activity Category C
E	Hotels, motels, time-share resorts, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F	Same voting distribution as Activity Category C
F	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, ship yards, utilities (water resources, water treatment, electrical), warehousing, malls, stores, shops, and Government managed land	Not Applicable
G	Undeveloped lands that are not permitted	Not Applicable

## Number of Surveys per Abatement Measure

Each proposed noise abatement will have one survey.

## Survey Conductor

The survey will be conducted by CDOT (generally Construction or Project Management with help from a CDOT noise specialist) or the project sponsor. CDOT or the project sponsor may use a consultant or contractor to conduct the survey, but the consultant or contractor must receive approval from CDOT or the project sponsor for all survey-related materials prior to sending them to survey participants.

## Survey Method

At a minimum, one attempt to contact each identified benefited receptor (both property owner and resident or tenant) must be made and documented using the United States Postal Service (USPS) or commercial mailing services, door-to-door contact, or other defensible, targeted means. The survey method depends on the area and project. The most common method is using USPS certified mail since that can prove that surveys were sent to benefited receptors. An alternate method may be used if it is approved by CDOT.

## Survey Content

Ballots will be in English and in the dominant secondary language of the community, if applicable. More than two secondary languages may be used, if applicable.

Survey ballots will include the following information:

- ▶ Highway and project name
- ▶ Name, address, and/or receiver identification number of receptor
- ▶ Noise barrier height and length
- ▶ Noise barrier location (using street and highway names)
- ▶ Date response due and a statement that this is the date a mailed response is post marked
- ▶ Vote (noise barrier is wanted, yes or no)
- ▶ Statement that says if no ballots are returned, the barrier is not reasonable and it will not be built
- ▶ Method by which survey results will be shared

The survey should be accompanied by an explanatory cover letter and, unless an alternate return method has been approved by CDOT, a stamped, self-addressed envelope. A secure website may be used in addition to, but not in place of, paper ballots.

## Survey Duration

Receptors are generally given 30 days to respond to surveys. Allow for mailing time when calculating due dates. A survey can be considered complete if all ballots have been returned prior to the due date.

## Counting Late Ballots

Ballots postmarked after the deadline, or otherwise determined to be late if an alternate method was used to submit the ballots, will likely not be counted. It is up to the discretion of CDOT whether late ballots can be counted. CDOT will consider whether the ballot is received prior to completion of processing ballots.

## Minimum Number of Returned Ballots

If no ballots are returned, the barrier is not reasonable and it will not be built.

## How Survey Results Are Determined

The decision on whether a noise abatement measure is supported by the benefiting receptors is based on a simple majority of the responses. If more than 50 percent of the responding benefited receptors support the proposed abatement, it will be determined to be reasonable.

If the survey results in a tie vote, majority support will not have been reached and the abatement measure will be not reasonable. A project team could optionally choose to do additional balloting and/or seek responses from those who didn't vote to try to break the tie.

## Documenting the Survey

Surveys are documented in the Noise Verification document or as a stand-alone document that is referenced by the Noise Verification document (see Section 9.5). Documentation must include examples of all materials that were sent to receptors. The final result (i.e., whether the recommended barrier will be built) will be included. The choice and percentage of the majority vote will be provided. Completed ballots will not be included in the report to protect the privacy of voters. However, completed ballots must be retained in the project file.

## Sharing Survey Results

Receptors will be notified of survey results via the method identified on the ballot. This will generally be via either a project website or a letter.

## 4.5 *Statement of Likelihood*

The noise analysis will be completed to the extent that design information is available at the time the NEPA decision document (e.g., Finding of No Significant Impact [FONSI]) is completed. Many CDOT projects do not progress immediately to a point that the Benefitted Receptor Preference Survey is appropriate for the NEPA process, so survey results often are not available. A Statement of Likelihood that abatement will or will not be included in the project will be included in the NEPA decision document based on the feasibility and reasonableness determinations that are available. The feasibility and reasonableness may change due to changes in final project design after approval of the NEPA decision document.

The Statement of Likelihood in the traffic noise technical report and NEPA decision document will:

- ▶ Identify locations where noise impacts are predicted to occur or state that no receptors in the Noise Study Zone were impacted;
- ▶ Identify where noise abatement appears feasible and reasonable (if applicable);
- ▶ Recommend construction of noise abatement, if applicable, and provide the barrier dimensions and Cost Benefit value;
- ▶ Identify locations with impacts that have no feasible or reasonable noise abatement and provide the reason abatement was not feasible and/or reasonable (if applicable);
- ▶ Include a statement that a Benefitted Receptor Preference Survey will be conducted for benefited receptors at each recommended barrier at the time of final design of the construction project (if applicable);

- ▶ If fewer than three receptors were impacted in the NEPA analysis, include a statement that if during final design it is determined that at least three receptors are impacted, noise abatement will be evaluated and may be provided; and
- ▶ Indicate that the final noise abatement decision will be made during the project's final design.

#### *4.6 Date of Public Knowledge*

The Date of Public Knowledge is the date of approval of the environmental decision document for a highway project (i.e., signed Form 128, FONSI, or ROD). Federal participation in noise abatement measures will not be considered for lands that are not permitted by the Date of Public Knowledge. The Date of Public Knowledge can change, in limited situations, as described in Section 9.6.

## 5. CONSTRUCTION NOISE CONSIDERATIONS

The construction noise discussion in the traffic noise technical report and NEPA document should be general in scope and consider the temporary nature of construction activities. Types of activities that are expected to be performed and the equipment that will be used for the project should be described. Noise levels associated with these activities may be researched through product or process literature and may be presented in the traffic noise technical report. Computerized prediction models have been developed for the calculation of noise from construction but are sophisticated and require construction staging and planning input that is not available to CDOT during the NEPA process. Therefore, modeling construction noise is not required.

### 5.1 *Construction Noise*

Receptors that may be affected by construction noise caused by Type I and Type II projects will be identified. The FHWA construction noise model and suggested mitigations can be found at [www.fhwa.dot.gov/environment/noise/construction\\_noise](http://www.fhwa.dot.gov/environment/noise/construction_noise); however, detailed analysis is not required. The noise analysis must at a minimum identify low-cost, readily implemented abatement measures that can be included on the project. Examples are limiting work to daytime hours, ensuring that equipment uses properly maintained mufflers, identifying the location of haul roads, and using public outreach.

During final design, a construction noise plan may be developed to detail mitigation needs and abatement measures employed during construction activities, especially in large, complex projects in major urban areas that are anticipated to last one year or more. In these cases, a more detailed discussion of the impacts and mitigation measures is necessary for the project. This type of mitigation plan could include, but is not limited to, construction noise monitoring, heavy truck routing, temporary noise abatement measures, noise complaint hotlines, project construction noise limits and violation procedures. This plan should be identified as a NEPA mitigation strategy for noise or construction, and it should be fully developed and approved prior to final project design implementation (pre-construction). Coordinate with a CDOT noise specialist and/or FHWA to determine if a construction noise plan is appropriate for the project.

### 5.2 *Construction Vibration*

There are no Federal requirements specific to highway traffic induced vibration. A vibration analysis is generally not necessary for construction activities unless vibration-sensitive businesses or other properties (e.g., historic buildings) are in the area and high vibration construction methods are proposed. Before construction begins, each vibration-sensitive area must be identified and a temporary vibration mitigation plan will be developed. Coordinate with a CDOT noise specialist and/or FHWA to determine if consideration of vibration effects is necessary.

### 5.3 *Local Ordinances*

Some local governments have passed local noise ordinances that may restrict the amount of noise that can be emitted from construction operations during certain hours or in certain areas (i.e., residential neighborhoods). The contractor must obtain noise-related permits and variances if required by the applicable local agency(ies). This may be needed if the work is expected to be extensive or at night. County, city, or local noise ordinances and noise control plans should be investigated with local agencies and variances fully resolved with identified jurisdictional authorities, councils, and/or boards prior to commencing work.

## 5.4 *Colorado Noise Statute*

Colorado Noise Statute 25-12-103 addresses maximum permissible noise levels from construction projects. If the applicable local government agency has more restrictive requirements (i.e., local ordinances) regarding construction noise, those requirements would supersede the state statute.

## 6. COORDINATION WITH LOCAL AGENCIES

Noise compatible land use planning is likely the best approach to preventing highway traffic noise from becoming an issue for land that is currently not developed. The premise is simple: refrain from placing noise sensitive developments adjacent to highways. Because jurisdiction over this land generally belongs to local governments, it is up to them to consider the best interests of their citizens when determining how land should be developed. CDOT encourages local governments to plan their developments to minimize highway traffic noise impacts. Methods include creating buffer zones and placing less sensitive land uses near the highway. However, CDOT does not have the authority to prohibit noise sensitive development adjacent to highways.

The regulatory triggers for CDOT to provide noise-related information to local governments are 23 CFR 772.11(c)(2)(vii)(C) and 23 CFR 772.17. CDOT is responsible for determining and documenting noise levels on undeveloped land that is not permitted for development by the Date of Public Knowledge. CDOT must provide information for these areas to local agency official(s) within whose jurisdiction(s) the Type I project is located. More information about this process is described in the following sections.

### 6.1 *Responsibility for Noise Abatement*

CDOT is not required to provide noise abatement for development that occurs on undeveloped land permitted for development after the Date of Public Knowledge, which is defined as the date on which the final environmental project document is approved (i.e., signed Form 128, FONSI, or Record of Decision [ROD]). The Date of Public Knowledge can change, as described in Section 9.6. Decisions and construction of noise abatement on these lands are the responsibility of local government agencies and private developers.

### 6.2 *Information to Provide to Local Agency(ies)*

The traffic noise technical report should be provided to the applicable local agency(ies) for Type I projects that include Activity Category G lands within the project Noise Study Zone. The report includes:

1. **Modeled noise levels:** Design year noise levels at various distances from the edge of the nearest travel lane of the project highway improvement for Activity Category G lands may be provided to the local officials. At a minimum, the distance to the exterior NAC in Table 1 must be identified. Noise contour maps of the project area clearly showing the design year 66.0 dBA and 71.0 dBA contours on the most current available base mapping or aerial photography of the Noise Study Zone may be provided to local agencies (e.g., local agency planning department, zoning department, or building permit department). If contour maps were not generated or if the distance to the contours is so short that they would not meaningfully show up on a map showing the Noise Study Zone, the information may be provided via a table or text. The table or text should clearly identify the Activity Category G areas and refer to a map that shows the areas.
2. **Non-eligibility for Federal-aid participation for a Type II project:** The Noise Technical Report Template includes a statement indicating that Colorado does not currently have a Type II program.

3. **Noise compatible planning concepts:** The following examples are listed in the noise technical report template:
- ▶ *The Audible Landscape: A Manual for Highway Noise and Land Use* (Urban Systems Research and Engineering, Inc.; 1974);
  - ▶ *Guidelines for Considering Noise in Land Use Planning and Control* (Federal Interagency Committee on Urban Noise; 1980);
  - ▶ *Entering the Quiet Zone: Noise Compatible Land Use Planning* (FHWA brochure; 2002); and
  - ▶ Additional available material and technical support, upon request.

### 6.3 *Information Transmittal*

Generally, the project manager or environmental project manager provides the project final traffic noise technical report to local officials<sup>26</sup>. Some projects include a local agency stakeholder. In those cases, local agencies receive the traffic noise technical report in the NEPA document or decision document as a result of their involvement in the project. Otherwise, the report is sent via email or a hardcopy is mailed with a cover letter. The email or cover letter will include text that describes why the contour information is being provided, for example:

*CDOT is required to provide noise related information to local governments under 23 CFR 772.11(c)(2)(vii)(C) and 23 CFR 772.17 when a CDOT transportation project contains undeveloped, unpermitted land within the Noise Study Zone. The [environmental decision document title] for [project name] was signed on [date signed]. This project included a Traffic Noise Technical Report, which is attached. It contains information about where noise levels will exceed thresholds if development is approved and built. It also contains references to resources that provide information about noise compatible planning concepts.*

*Noise compatible land use planning is likely the best approach to preventing highway traffic noise from becoming an issue for land that is currently not developed. The premise is simple: refrain from placing noise sensitive developments adjacent to highways. Because jurisdiction over this land generally belongs to local governments, it is up to them to consider the best interests of their citizens when determining how land should be developed. CDOT encourages local governments to plan their developments to minimize impacts of highway traffic noise. Methods include creating buffer zones and placing less sensitive land uses near the highway.*

Transmittal is made after the environmental decision document is signed. The report might be the final NEPA traffic noise technical report or a report that was done during final design, as described in Section 9.5. If subsequent modeling results in changes to the contour information after transmittal, the later traffic noise technical report will also be sent to the local official with an updated email or cover letter explaining the update.

<sup>26</sup> Local officials may include local planning, zoning and/or building permit offices as well as MPOs or transportation planning regions

## 7. NEPA NOISE MEMORANDA AND TECHNICAL REPORTS

NEPA noise evaluations may be documented using either an email, memorandum, or a technical report, depending on the situation:

- ▶ **Email or Memorandum, Type III Justification:** Type III projects for which project classification determination required evaluation beyond a simple comparison to Type I definitions, to explain why the project is Type III. For example, if a roadway is being shifted closer to receptors, the evaluation may include the distance(s) between the roadway and receptors to show that the horizontal distance will not be halved by the project.
- ▶ **Email or Memorandum, Non-modeled Type I:** Type I project that did not require modeling because the Noise Study Zone does not contain any existing or permitted noise sensitive land use areas (i.e., Activity Category A through E) or undeveloped, unpermitted land (i.e., Activity Category G). The email or memorandum should explain why modeling was not required and include the project description, a map of the project and Noise Study Zone, and a statement that none of the following are present: noise sensitive receptors (Activity Category A-E), permitted but undeveloped noise sensitive receptors (Activity Category A-E), or Activity Category G lands. Activity Category F receptor(s) should be briefly described (e.g., identify the types of land use in the Noise Study Zone).
- ▶ **Traffic Noise Technical Report<sup>27</sup>:** Type I project that required modeling. In some cases, a less detailed traffic noise technical report may be appropriate, as described in the directions sections of the Traffic Noise Technical Report Template.
- ▶ **Benefited Receptor Survey Memorandum:** For any Type I project where a survey of benefited receptors was needed to determine abatement reasonableness. The memorandum will document the vote results, describe all noise barriers that will or will not be built as a result of the vote, and provide the name and date of the document containing the final noise barrier evaluation. Rather than creating a separate memorandum to document the Benefited Receptor Preference Survey, the information described in this paragraph may instead be included in a Noise Verification document.

Noise evaluations must be submitted to a CDOT noise specialist for review and approval. Construction of noise mitigation cannot commence until a CDOT noise specialist approves the traffic noise technical report, Benefited Receptor Preference Survey results, and Noise Verification. The Noise Verification, which represents the final design as described in Section 9.5, must be included in the project file.

### 7.1 *Type I Traffic Noise Technical Report Template*

The CDOT Traffic Noise Technical Report Template provides thorough documentation of the noise analysis. This template must be used as directed in the template instructions. Prior to starting a noise analysis, confirm that the correct template is being used by checking the CDOT noise website. If the template has been updated, it will be posted there. As directed in the template, traffic noise technical reports should retain the original TNM results decimal data format to the tenths place.

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<sup>27</sup> Applicability of the Traffic Noise Technical Report Template is described in the directions section of the template.

## 7.2 *Type III Description*

The following template language should be included in Type III documentation (e.g., clearance letter for CatExs):

*This project meets the criteria for a Type III project established in 23 CFR 772. Therefore, the project requires no analysis for highway traffic noise impacts. Type III projects do not involve construction of a highway on a new location; added capacity; construction of new through lanes or auxiliary lanes, other than those associated with a turn motion; substantial changes in the horizontal or vertical alignment of the highway; exposure of noise sensitive land uses to a new or existing highway noise source; or any other activity classified as a Type I or Type II project. CDOT acknowledges that a noise analysis is required if changes to the proposed project result in reclassification as a Type I project.*

If the project classification determination required evaluation beyond a simple comparison to Type I definitions, explain why the project is Type III as described at the beginning of this chapter.

## 8. NEPA PROCESS AND DOCUMENT REQUIREMENTS

The CDOT *NEPA Manual* provides guidance on preparing and processing documents that comply with NEPA and other applicable state and federal environmental laws affecting transportation projects in Colorado. A noise analysis performed to satisfy 23 CFR 772 generally satisfies NEPA requirements. Four major differences between NEPA and 23 CFR 772 are:

- ▶ NEPA requires a comparison of proposed alternatives with a No Action Alternative for EAs and EISs;
- ▶ 23 CFR 772 uses the opportunity provided by a proposed project to consider mitigating current as well as future noise problems. Under 23 CFR 772, if the predicted noise level approaches or exceeds the NAC, there is a traffic noise impact regardless of whether the proposed project is the direct cause;
- ▶ NEPA would consider a noise level change of less than 3 dB to be negligible since it would be barely perceptible, but if the design year noise for a Proposed Action receptor meets or exceeds the NAC, it does not matter if the change was less than 3 dB; and
- ▶ NEPA document requirements are based on the class of action; CatExs and EAs/EISs have different requirements. This is not the case under 23 CFR 772.

TNM analytical results are expressed to the nearest tenth decimal in the NEPA document.

### 8.1 *Categorical Exclusions*

For CatEx projects, an environmental document is usually not published. Rather, a CDOT form, Form 128, is used to document CatEx environmental decisions. A traffic noise technical report, when applicable, is included as part of the noise clearance letter and includes a Statement of Likelihood. The date that the traffic noise technical report was accepted is noted on Form 128. The final approval of the front part of Form 128 represents the Date of Public Knowledge.

### 8.2 *Environmental Assessments and Environmental Impact Statements*

EAs and EISs provide a summary of the noise technical report within the body of the NEPA document. The summary should be brief with high level data and include the existing noise condition, impacts that are expected, and evaluation of any potential noise abatement. Although final design information is not available at early stages of the environmental analysis and documentation effort, an initial determination of impacts and evaluation of abatement measures must be made, including the Statement of Likelihood. Final noise abatement decisions are made during the final design process.

Before adoption of the decision document, noise abatement and noise impacts for which abatement was determined to be either not feasible or not reasonable must be identified by a Statement of Likelihood (see Section 4.5). This information must be included in the environmental decision document. Intentions regarding noise abatement must be made as early as possible.

The traffic noise technical report will be in the technical appendix of the environmental document. The report must be finalized and approved by a CDOT noise specialist before the environmental decision document is approved and signed.

## 9. POST-NEPA ANALYSIS AND REEVALUATIONS

Because noise analyses are typically conducted in the NEPA process when project design is typically no more advanced than the Field Inspection Review level, it must be verified post-NEPA whether the noise analysis is still valid at the final design level. Most projects have reevaluations, unless final design and construction occur soon after NEPA.

Three issues often need to be addressed prior to construction: assess changes to project design, complete final noise abatement design, and complete the Benefited Receptor Preference Surveys. Alterations in barrier dimensions and deviations from proposed siting plans should be well-documented and analyzed. Larger or more complex projects are more likely to result in modified highway horizontal or vertical alignments during the final design or design-build process. These issues are documented via a Noise Verification.

The project Date of Public Knowledge, which in some cases determines whether barriers need to be considered for impacted receptors, may change from the original date of the initial NEPA decision document. That change would also be documented in the Noise Verification.

Noise abatement measures recommended by the NEPA decision document and affirmed by the Benefited Receptor Preference Survey cannot be removed or “value engineered” from a project as a cost-savings device unless adequate replacement acoustic benefit is restored. Adequate abatement must be provided to sensitive receptors as identified in the NEPA noise abatement analysis.

### 9.1 *Changes to Project Design*

When the noise analysis is completed during NEPA, the project typically is at an early level of design. As the project nears construction, the design may have changed. Design changes can also occur during the construction process. If a project is undergoing a NEPA reevaluation but nothing in the project scope, design, and location has changed, it is not necessary to redo the noise analysis unless the construction year will be after the design year of the original noise analysis (see Section 9.2). Changes that could trigger a new noise analysis, including modeling, include:

- ▶ Horizontal change that halves the distance from the nearest edge of a travel lane to the receptor as compared to the design analyzed in the NEPA document. This generally is a difference between reevaluation design and the NEPA design. However, if the NEPA design did not have a noise analysis, the reevaluation design will be compared to the existing condition;
- ▶ Vertical change of the roadway of more than 5.0 feet that removes shielding or exposes a line of sight between the edge of the travel lane and the receptor. This generally is a difference between reevaluation design and the NEPA design. However, if the NEPA design did not have a noise analysis, the reevaluation design will be compared to the existing condition;
- ▶ Removal of shielding that exposes a line of sight between the edge of the travel lane and the receptor;
- ▶ Traffic predictions for the final design have doubled or more from the NEPA design; or
- ▶ Any other change between the reevaluation design and the NEPA design that would constitute a Type I project on its own.

If the project did not trigger remodeling, the design changes and the thought process and noise decision that modeling was not triggered will be documented as described for Noise Verifications (Section 9.5).

If a project has been modified such that a new noise analysis is required, the most current NAAG and FHWA regulation must be used. Noise receptors that were not included in the original NEPA noise analysis must be analyzed (e.g., areas that had previously been Activity Category G but have since had homes permitted or built). However, if the predicted noise levels at such receptors are within 3.0 dB of the noise contour lines identified in the original NEPA noise analysis, new noise abatement will not be considered for the new development due to the Date of Public Knowledge. It is not required to reanalyze the No Action Alternative unless traffic predictions for the final design have doubled or more from the NEPA design.

## 9.2 *Age of Date of Public Knowledge*

If the reevaluation is for a construction date that will be after the design year of the original noise analysis, the previous Date of Public Knowledge is no longer valid. In that case, a new traffic noise analysis is required regardless of whether the design has changed.

## 9.3 *Final Noise Abatement Design*

For noise abatement measures found to be feasible and reasonable, excluding a Benefited Receptor Preference Survey, the final noise abatement measure must be developed during final design. This is typically the most detailed look at defining exact dimensions, materials, and placements to ensure adequate acoustic performance and to produce the final optimized noise wall design in preparation for construction.

The design year noise model used for the final noise abatement design must reflect the final roadway configuration. If enough time has passed that the traffic study date has changed (e.g., 2050 is now available rather than 2040), the wall evaluation model run should use the updated traffic data.

## 9.4 *Benefited Receptor Preference Surveys*

Benefited receptors are surveyed when the final abatement design is completed. This ensures that the barrier information presented to the benefited receptors is correct. See Section 4.4.3 for information about Benefited Receptor Preference Surveys. Completion of a survey is essential to concluding the reasonableness of a recommended abatement measure.

## 9.5 *Noise Verification Requirements*

Documentation for Noise Verification items described in Sections 9.1 to 9.4 can range from an email to a report, depending on the situation:

- ▶ **Email:** Project was Type III and final design still results in a Type III project.
- ▶ **Email or memorandum:** NEPA traffic noise technical report for a Type I project did not recommend any noise abatement measures and the final design did not change enough to affect the noise analysis. Therefore, further analysis is not needed and NEPA traffic noise technical report recommendations are valid.

- ▶ **Memorandum:** NEPA traffic noise technical report recommended at least one noise barrier and the final design did not change enough to affect the noise analysis. Therefore, the only additional modeling needed is to support final noise barrier design.
- ▶ **Traffic noise technical report:** The final design changed enough to require new noise modeling (not just for noise abatement design) or there are substantial changes to noise abatement recommendations. This may apply due to several scenarios, including reevaluations and design-build projects.

Noise Verification documents should include the following information:

- ▶ Title, author, and date of the original NEPA traffic noise technical report, memorandum, or email, as applicable.
- ▶ Statement whether the project is Type I or Type III and whether the project Type changed (and why).
- ▶ Statement that says whether the final design changed enough from the NEPA design to affect the noise analysis. The design change(s) should be described.
- ▶ Statement, including the justification, whether the project needed a new noise model as a result of changes, including the following:
  - Whether there has been new development in the project area and whether the new receptor(s) must be analyzed due to changes in the design.
  - What the noise impacts are and if they are different from those identified in the NEPA traffic noise technical report.
  - For projects that have noise impacts, a summary that describes how many barriers were evaluated, how many were found to be feasible and reasonable, reasons why any barriers were not found to be feasible and reasonable, dimensions and noise reductions of barriers found to be feasible and reasonable, and that clearly identifies where additional walls are recommended or where previously recommended walls are no longer recommended.
- ▶ Date of Public Knowledge for Type I projects that originally recommended at least one noise barrier and whether the Date of Public Knowledge has changed, and why (if applicable).
- ▶ For projects in which at least one noise wall will be built, provide all available information that will be needed for the FHWA triennial wall inventory report, as described in Chapter 11, from the optimized wall TNM model (e.g., wall dimensions, average noise reduction, Activity Category(s) protected).
- ▶ Benefited Receptor Preference Survey(s) for Type I projects that recommended at least one noise barrier. This includes a summary, the ultimate result (whether the barrier will be built), and either survey details or a reference to a separate survey document that contains the details. Survey details include a sample ballot, all documents that were provided to benefited receptors as part of the survey, and survey results. Completed ballots will not be made publicly available to ensure the privacy of voters.

## 9.6 *Changing Date of Public Knowledge*

Generally, the Date of Public Knowledge occurs when the decision document or CatEx finding is signed. If a new noise model must be run due to changes in the project design (see Section 9.1),

then the Date of Public Knowledge may change under the following scenarios, and additional coordination with FHWA is required:

- ▶ If the reevaluation is for a construction date that will be after the design year of the original noise analysis; or
- ▶ There is a substantial increase (10.0 dB or more) within the project corridor from the design year noise levels predicted in the prior analysis to the design year noise levels predicted in the new analysis; or
- ▶ There are additional noise impacts within the project corridor that are caused by perceptible increases of noise levels of 3.0 dB or more in an area where no noise abatement is recommended; or
- ▶ If new noise abatement is recommended or if previously recommended noise abatement is no longer recommended.

Generally, the new Date of Public Knowledge applies in only the area(s) of the changes from the previous analysis, not the entire project area. If a previously recommended noise abatement measure is removed from the project, the nearby<sup>28</sup> receptors (whether benefited or not) must be notified, and a new Date of Public Knowledge is applicable only in the area of the removed abatement measure.

Even if the Date of Public Knowledge does not change, the project changes would still be evaluated for noise impacts, as appropriate.

## 9.7 *Timing of Noise Abatement Implementation*

Noise abatement must be constructed at the same time as the project aspects that triggered the Type I analysis (e.g., addition of lanes). If the project sponsor cannot afford the abatement, the project cannot be built.

## 9.8 *Information for Construction Contractors*

For projects that are not design-build (see Section 10.2 for design build) and that have recommended noise abatement, the following items should be included in all plan sets and/or specifications. All items listed below must be compiled by the CDOT project team, which includes a noise specialist, and clearly documented in the Bid Package.

- ▶ Definition of geographic siting, dimensions and material requirements of recommended noise abatement, including:
  - Materials selection
  - Construction method (e.g., post and panel, pour in place)
  - Any required structural elements
  - Aesthetic treatments
  - Absorptive treatment, if required
- ▶ Identification of phasing issues where salient features such as existing noise walls or existing shielding once removed or regraded during construction could trigger temporary noise

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<sup>28</sup> "Nearby" receptors are those that would have been behind the barrier as far back as the furthest benefitted receptor.

abatement requirements during the construction period until the final abatement measure is reevaluated and/or constructed.

- ▶ As project construction proceeds, CDOT and contractor noise personnel will ensure that noise abatement measures are constructed in accordance with the plans.

## 10. ALTERNATE CONSTRUCTION DELIVERY PROCESSES

The NEPA-level noise analysis documents all noise impacts and proposed noise abatement. In standard contracting (“design-bid-build”), the final design of the project is completed and all necessary post-NEPA noise activities described in Chapter 9 will be completed by CDOT prior to advertisement for construction. When alternative construction delivery processes are used, the timing and party responsible for the completion of the activities in Chapter 9 may change.

### 10.1 Construction Manager/General Contractor Projects

For construction manager/general contractor (CMGC) projects, CDOT hires a Construction Manager (CM) to provide pricing, constructability reviews, and risk analysis during development of the final design. The CM negotiates a lump sum Guaranteed Maximum Price (GMP) for the construction. If CDOT accepts the GMP, the CM manages the construction project. Although the CM provides advice during final design, changes to the design, and noise analysis if needed, are the responsibility of CDOT. Therefore, the process outlined in Chapter 9 remains the same.

### 10.2 Design-Build Projects

In a design-build contract, the contractor is given a preliminary design for the project and is responsible for developing the final design, often just before construction occurs. Noise abatement measures identified in a design-build contract are based on the NEPA-level noise abatement design developed in the traffic noise technical report for the Proposed Action or Preferred Alternative design. The final design may be substantively different. Noise abatement will be considered, developed, and constructed in accordance with this NAAG and in conformance with the provisions of 40 CFR 1506.5(c) for EISs, 23 CFR 772.13(i), and 23 CFR 636.109.

For Type I projects, the following items should be included in all design-build bid engineering design plan sets and/or specifications to provide consistency and clarity to the contractor. All items listed below must be compiled by the CDOT project team, which includes a noise specialist, and clearly documented in the Bid Package. CDOT Project Management and Contracts personnel will develop a contractual mechanism to assure that the following elements are fulfilled as required or, in cases of optional features, as best practicable:

- ▶ Definition of geographic siting, dimensions, and material requirements of recommended noise abatement, including:
  - Materials selection
  - Construction method (e.g., post and panel, pour in place)
  - Any required structural elements
  - Aesthetic treatments
  - Absorptive treatment, if required
- ▶ Definition of the alignment shifts and profile elevation tolerances triggering a re-analysis of noise impacts and abatement.
- ▶ Definition of the process for reevaluation of original recommended abatement in response to alignment shifts or profile changes.

- ▶ Identification of required deliverables and submittals for potential changes in design that could trigger reanalysis
- ▶ Identification of phasing issues where salient features such as existing noise walls or existing shielding once removed or regraded during construction would trigger temporary noise abatement requirements during the construction period until the final abatement measure is reevaluated and/or constructed.
- ▶ A Benefited Receptor Preference Survey is generally conducted during final design, as defined in Section 4.4.3. The Project Management Team, in conjunction with the contractor noise analyst, will initiate a new Benefited Receptor Preference Survey for any new abatement measure(s).
- ▶ Noise analysis will follow the procedures identified for non-design-build projects. This includes evaluation of new impacts and new abatement as a result of design changes.
- ▶ Clear responsibility of contractor to monitor and report alignment and profile changes; communication chain and authority to instigate new noise impact and abatement evaluation.
- ▶ Clear responsibility of contractor to conduct, report, recommend, and document new noise impact evaluation(s).
- ▶ Clear responsibility of contractor to develop, site, and communicate construction requirements for new abatement measures in the field.
- ▶ Timing of design and changes in the noise environment may require multiple Noise Verifications.
- ▶ As design-build project construction proceeds, CDOT and contractor noise personnel will ensure noise abatement measures are constructed in accordance with the plans.

## 11. NOISE ABATEMENT TRIENNIAL REPORTING

FHWA requires that each state highway agency maintain an inventory of all constructed noise abatement, per 23 CFR 772.13(f). States submit the inventory to FHWA every three years. The Environmental Programs Branch submits the inventory. Each CDOT engineering region will report the following inventory parameters to a CDOT Environmental Programs Branch (EPB) noise specialist as each project incorporating a noise abatement measure is constructed:

- ▶ Type of abatement<sup>29</sup> (wall, berm, combination wall/berm)
- ▶ Cost (overall cost and unit cost per square foot or per cubic yard)
- ▶ Average height (feet)
- ▶ Length (feet)
- ▶ Area (square feet) for noise walls or volume (cubic yards) for berms
- ▶ Location (county, city, and route)
- ▶ Year of construction
- ▶ Average noise reduction as reported by the model in the noise analysis
- ▶ Activity Category(s) protected
- ▶ Material(s) used (precast concrete, berm, block, cast in place concrete, brick, metal, wood, fiberglass, plastic [transparent, opaque, other])
- ▶ Features (absorptive or reflective; surface texture)
- ▶ Foundation (ground mounted or on structure)
- ▶ Project type (Type I or Type II)
- ▶ Optional project types such as State funded, county funded, tollway/turnpike funded, other, or unknown)

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<sup>29</sup> 23 CFR 772.13(f) indicates that "Type of Abatement" will be listed in the inventory. However, the inventory spreadsheet template provided by FHWA does not include a column for "Type of Abatement" (e.g., wall, berm, or combination wall/berm). Instead, this information is conveyed by the columns for "Primary Construction Material" and "Secondary Construction Material," where "berm" is considered a material.

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## Appendix A Definitions

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## Definitions

**Abatement**—Mitigation measure used to reduce traffic noise levels.

**Ambient Noise**—All-encompassing sound that is associated with a given environment.

**Approach**— Noise levels within 1 dBA of the NAC for a corresponding Activity Category.

**Automobiles**—All vehicles with 2 axles and 4 tires. Includes passenger cars, vans, and pick-up trucks.

**Auxiliary Lane**—Portion of the roadway adjoining travel lanes and used for speed change, turning, weaving, truck climbing, maneuvering of entering and leaving traffic, and other purposes supplementary to through-traffic movement. They facilitate the operations of the highway and are not intended to increase road capacity. Examples include any lanes that connect the on-ramp of one interchange with the off-ramp of the next interchange, truck climbing lanes, passing lanes, acceleration and deceleration lanes, and turn lanes. Auxiliary lanes that are turn lanes (see definition) are exempt from Type I projects.

**Benefited Receptor**— Receptor that is estimated via a design year noise model to receive a noise reduction of at least 5.0 dB from an abatement action regardless of whether the receptor is impacted.

**Berm**—Earthen mound constructed for use as a noise barrier.

**Bus**—Vehicles designed to carry more than nine passengers.

**CDOT Form 1209**—This form is titled “Noise Abatement Evaluation Worksheet.” It is required to be filled out for each distinct evaluated noise barrier.

**Cost Benefit**—Performance value calculated for each noise barrier. It is compared to the Cost Benefit Index to determine if the barrier performance is reasonable based on cost.

**Cost Benefit Index**—Value determined by CDOT and used to determine the cost-reasonableness of a noise barrier. It is based on a Unit Cost and the number of benefited receptors. If the barrier Cost Benefit is the same or less than the Cost Benefit Index, the barrier cost is reasonable.

**Date of Public Knowledge**—Date of approval of the environmental decision document for a highway project (signed Form 128, FONSI, or ROD). The Date of Public Knowledge can change, in limited situations, as described in Section 9.6.

**Decibel**—Unit of measure used to express the relative level of a sound in comparison with a standard reference level. To approximate the range of frequencies of sound most audible to the human ear, an A-weighting factor is applied. These sound levels are reported in A-weighted dB, which have units of dBA. When comparing between two A-weighted noise levels, the difference is expressed by units of dB.

**Design Year**—Future year used to estimate the probable traffic volume for which a highway is designed (usually 20 years from start of construction). Traffic from this year is the basis for calculating predicted future noise levels.

**Design Year Noise Level**—Predicted worst one-hour equivalent sound level in dBA in the design year.

**Existing Noise Level**—Level of noise measured or modeled at a receptor for the pre-construction condition of the highway project.

**Expressway**—These highways provide directional travel lanes that are usually separated by some type of median or physical barrier, and their access and egress points are limited to on- and off-ramp locations or a limited number of at-grade intersections. These highways are designed and constructed to maximize their mobility function, and abutting land uses are not directly served by them. The terms “freeway” and “expressway” can be used interchangeably.

**Feasibility**—The combination of acoustical and engineering factors considered in the evaluation of a noise abatement measure. One of two types of criteria used to evaluate a noise abatement measure; reasonableness is the other criteria type.

**Federal Action**—A Federal action includes actions with effects that trigger Federal control and responsibility to projects, programs, funding, or regulatory application.

**Freeway**—These highways provide directional travel lanes that are usually separated by some type of median or physical barrier, and their access and egress points are limited to on- and off-ramp locations or a very limited number of at-grade intersections. These highways are designed and constructed to maximize their mobility function, and abutting land uses are not directly served by them. The terms “freeway” and “expressway” can be used interchangeably.

**Frequent Human Use**—Activity that results in prolonged human exposure to traffic noise on a regular basis over the course of a year in a given location.

**Heavy Trucks**—Cargo vehicle with three or more axles.

**Highway**—Broad term that not only includes what are commonly considered to be highways, but also can include roadways such as roads, streets, and parkways.

**Impacted Receptor**—Receptor, which, under design year conditions, has a traffic noise impact (see definition).

**Insertion Loss**—Predicted reduction in noise levels resulting from building noise abatement. It is calculated at individual receivers by subtracting the design year noise level for a receiver that includes the noise barrier from the noise level that does not include the noise barrier.

**Loudness**—Perceived assessment of the intensity of sound or noise.

**Medium Trucks**—Cargo vehicle with 2 axles and 6 tires.

**Motorcycle**—Vehicles with two or three tires and an open-air driver/passenger compartment.

**Multi-family Dwelling**—Residential structure containing more than one residence. Each residence of a multi-family dwelling that has an outdoor activity area (e.g., balcony) is counted as one receptor when determining impacted and benefited receptors.

**Noise**—Unwanted sound (e.g., annoying or offensive).

**Noise Abatement Criteria (NAC)**—Absolute noise levels used to determine that a noise impact occurs when the noise level is equaled or exceeded.

**Noise Barrier**—Mitigation measure used to reduce traffic noise levels at receptors. It may be a berm, noise wall, or a combination of both. It is constructed between the highway noise source and noise sensitive receptors.

**Noise Reduction Design Goal (NRDG)**—Predicted minimum noise level reduction provided by the noise abatement measure. It is a reasonableness trigger. CDOT's NRDG is 7 dB and must be achieved for at least two receptors. It is determined if the NRDG is met for the Proposed Action by calculating the difference between design year noise levels with and without abatement.

**Noise Sensitive Receptor**—Activity Category A, B, C, D, or E receptors where frequent exterior human use occurs and where a lowered noise level would be beneficial. For Activity Category D receptors that do not have exterior activities, noise levels in the interior of the building are used.

**Noise Study Zone**—The area encompassed within a 300- or 500-foot halo around the extents of a project which must be considered in the noise analysis. The 300- or 500-foot halo is measured from the proposed edge of the traveled lane(s). If there is a reasonable expectation that noise impacts would extend beyond the Noise Study Zone, it will be expanded to include those receptors, as described in Section 3.3.

**Parallel Barriers**—Two barriers that face each other from opposite sides of a highway.

**Permitted Development**—Planned development on currently undeveloped land for which a building permit has been issued from the local jurisdiction or by the appropriate governing entity.

**Predicted Future Noise Levels**—Post-construction noise levels as determined via use of a traffic noise prediction model for the design year.

**Privacy Fence**—Fence constructed by someone other than CDOT (e.g., developer, private citizen, or local government agency), on private property and typically at the edge of development.

**Property Owner**—Individual or group of individuals that holds a title, deed, or other legal documentation of ownership of a property or a residence.

**Quasi-Governmental Entity**—Entity with authority to issue local land use approvals.

**Reasonableness**—Combination of environmental, economic, and social factors considered in the evaluation of a noise abatement measure. One of two criteria (also see "feasibility") used to evaluate noise abatement.

**Receiver**—Discreet TNM modeling point that represents one or more receptors of a single Activity Category with a similar noise environment (e.g., one receiver may represent one or more homes but cannot also represent a restaurant patio regardless of how close it is to the homes).

**Receptor**—Noise sensitive location of frequent human activity for land uses under Activity Categories A through E, as shown in Table 1.

**Residence**—Either a single family residence or each dwelling unit in a multi-family dwelling.

**Resident**—Person who occupies a primary home or place of abode, in which a person's habitation is fixed. The difference between a resident and a property owner is that a resident secures a lease to occupy a permanent building or part of a building and may include a house, a condominium, an apartment, or a mobile home; a property owner owns the building but does not necessarily live there.

**Shielding**—Any man-made or natural structure or feature that provides an auditory barrier between a highway and receptor (e.g., top of a cut or an intervening hill). The presence or absence of landscaping or vegetation does not generally affect shielding.

**Sound**—Mechanical energy produced by pressure fluctuations in a medium (e.g., air, water) that travels in waves and can be detected by the human ear.

**Sound Level Meter**—Device used to measure sound levels. Also called a sound level analyzer or dosimeter.

**Statement of Likelihood**—Statement provided in the environmental decision document based on the feasibility and reasonableness analysis completed at the time the environmental document is approved.

**Substantial Noise Increase**—For a Type I project, a predicted noise level increase at a receptor in the design year of 10.0 dB or more over the existing noise level at that receptor.

**Through Lane**—A through lane is any general purpose or managed lane that provides capacity to the highway.

**Traffic Noise Impact**—Impacts that occur when the predicted traffic noise levels approach or exceed the NAC or if there is a Substantial Noise Increase (see definition).

**Turn Lane**—For the purposes of noise analysis, a turn lane is considered to be the designated lanes required for storage and for completion of a full turning movement at intersections. This includes striped deceleration and acceleration lanes that merge into existing through lane traffic. FHWA advises that highway agencies should take a broad approach to define turn lanes. Under these definitions, the addition of a turn lane would constitute a Type III project.

**Type I Project**—Project for the construction of a highway on a new location or the physical alteration of an existing highway that substantially changes either the horizontal or vertical alignment or increases the number of through traffic lanes. See Section 3.1.1 for the full definition.

**Type II Project**—Proposed Federal action or Federal-aid highway project for noise abatement on an existing highway. Colorado does not have an active Type II program.

**Type III Project**—Federal action or Federal-aid highway project that does not meet the classifications of a Type I or Type II project. Type III projects are not required to undergo noise analysis.

**Unit Cost**—A value determined by CDOT to represent the average cost per square foot of a noise wall or average cost per cubic yard of a berm. Berms and noise walls have different Unit Costs. These costs are used to calculate the Cost Benefit of each evaluated noise barrier.

**Worst-Noise Hour**—One-hour period during the day that represents the peak noise hour. In general, this is when the highest volume of traffic travels at the highest possible speed, which is generally the highway design hour traffic volume at the posted speed limit.

## Appendix B Noise Fundamentals

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The following is a discussion of fundamental traffic noise concepts.

## Sound, Noise, and Acoustics

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air) to a human ear. Noise is defined as loud, unexpected, or annoying sound.

In the science of acoustics, the fundamental model consists of a sound (or noise) source, a receptor, and the propagation path between them. The loudness of the noise source and obstructions or atmospheric factors affecting the propagation path to the receptor determine the sound level and characteristics of the noise perceived by the receptor. The field of acoustics deals primarily with the propagation and control of sound.

## Frequency

Continuous sound can be described by frequency (pitch) and amplitude (loudness). A low-frequency sound is perceived as low in pitch. Frequency is expressed in terms of cycles per second, or hertz (Hz) (e.g., a frequency of 250 cycles per second is referred to as 250 Hz). High frequencies are sometimes more conveniently expressed in kilohertz (kHz), or thousands of Hertz. The audible frequency range for humans is generally between 20 Hz and 20,000 Hz.

## Sound Pressure Levels and Decibels

The amplitude of pressure waves generated by a sound source determines the loudness of that source. Sound pressure amplitude is measured in micro-Pascals (mPa). One mPa is approximately one hundred billionth (0.0000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 to 100,000,000 mPa. Because of this huge range of values, sound is rarely expressed in terms of mPa. Instead, a logarithmic scale is used to describe sound pressure level (SPL) in terms of dB. The threshold of hearing for young people is about 0 dB, which corresponds to 20 mPa.

## Addition of Decibels

Because dB are logarithmic units, SPL cannot be added or subtracted through ordinary arithmetic. Under the decibel scale, a doubling of sound energy corresponds to a 3-dB increase. In other words, when two identical sources are each producing sound of the same loudness, the resulting sound level at a given distance would be 3 dB higher than one source under the same conditions. For example, if one automobile produces an SPL of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB; they would combine to produce 73 dB. Under the decibel scale, three sources of equal loudness together produce a sound level 5 dB louder than one source.

## A-Weighted Decibels

The decibel scale alone does not adequately characterize how humans perceive noise. The dominant frequencies of a sound have a substantial effect on the human response to that sound. Although the intensity (energy per unit area) of the sound is a purely physical quantity, the loudness or human response is determined by the characteristics of the human ear.

Human hearing is limited in the range of audible frequencies, as well as in the way it perceives the SPL in that range. In general, people are most sensitive to the frequency range of 1,000 to 8,000 Hz, and perceive sounds within that range better than sounds of the same amplitude in higher

or lower frequencies. To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies. Then, an “A-weighted” sound level (expressed in units of dBA) can be computed based on this information.

The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. When people make judgments of the relative loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. Other weighting networks have been devised to address high noise levels or other special problems (e.g., B-, C-, and D-scales), but these scales are rarely used in conjunction with highway-traffic noise. Noise levels for traffic noise reports are typically reported in terms of dBA. Table B-1 describes typical A-weighted noise levels for various noise sources.

Table B-1. Typical A-Weighted Noise Levels

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	– 110 –	Rock band
Jet fly-over at 1000 feet		
	– 100 –	
Gas lawn mower at 3 feet		
	– 90 –	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	– 80 –	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	– 70 –	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	– 60 –	
		Large business office
Quiet urban daytime	– 50 –	Dishwasher next room
Quiet urban nighttime	– 40 –	Theater, large conference room (background)
Quiet suburban nighttime		
	– 30 –	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	– 20 –	
		Broadcast/recording studio
	– 10 –	
Lowest threshold of human hearing	– 0 –	Lowest threshold of human hearing

Source: Caltrans 2013.

## Human Response to Changes in Noise Levels

As discussed previously, doubling sound energy results in a 3-dB increase in sound. However, given a sound level change measured with precise instrumentation, the subjective human perception of a doubling of loudness will usually be different from what is measured.

Under controlled conditions in an acoustical laboratory, the trained, healthy human ear is able to discern 1-dB changes in sound levels, when exposed to steady, single-frequency (“pure-tone”) signals in the midfrequency (1,000 Hz to 8,000 Hz) range. In typical noisy environments, changes in noise of 1 to 2 dB are generally not perceptible. However, it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typical noisy environments. Further, a 5-dB increase is generally perceived as a distinctly noticeable increase, and a 10-dB increase is generally perceived as a doubling of loudness. Therefore, a doubling of sound energy (e.g., doubling the volume of traffic on a highway) that would result in a 3-dB increase in sound, would generally be perceived as barely detectable.

## Noise Descriptors

Noise in our daily environment fluctuates over time. Some fluctuations are minor, but some are substantial. Some noise levels occur in regular patterns, but others are random. Some noise levels fluctuate rapidly, but others slowly. Some noise levels vary widely, but others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels.

CDOT uses Equivalent Sound Level (Leq), which represents an average of the sound energy occurring over a specified period. In effect, Leq is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour A-weighted equivalent sound level (Leq[h]) is the energy average of A-weighted sound levels occurring during a one-hour period and is the basis for NAC used by CDOT and FHWA.

## Sound Propagation

When sound propagates over a distance, it changes in level and frequency content. The manner in which noise reduces with distance depends on the geometric spreading, ground adsorption, atmospheric effects, and shielding by natural or human-made features.

## Geometric Spreading

Sound from a localized source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound level decreases at a rate of 6 dB for each doubling of distance from a point source. Highways consist of several localized noise sources on a defined path and, hence, can be treated as a line source, which approximates the effect of several point sources. Noise from a line source propagates outward in a cylindrical pattern, often referred to as cylindrical spreading. Sound levels attenuate at a rate of 3 dB for each doubling of distance from a line source.

## Ground Absorption

The propagation path of noise from a highway to a receptor is usually close to the ground. Noise attenuation from ground absorption and reflective-wave canceling adds to the attenuation associated with geometric spreading. Traditionally, the excess attenuation has also been expressed in terms of attenuation per doubling of distance. This approximation is usually sufficiently accurate for distances of less than 200 feet. For acoustically hard sites (i.e., sites with a reflective surface

between the source and the receptor, such as a parking lot or body of water), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., those sites with an absorptive ground surface between the source and the receptor, such as soft dirt, grass, or scattered bushes and trees), an excess ground-attenuation value of 1.5 dB per doubling of distance is normally assumed. When added to the cylindrical spreading, the excess ground attenuation results in an overall drop-off rate of 4.5 dB per doubling of distance.

## Atmospheric Effects

Receptors located downwind from a source can be exposed to increased noise levels relative to calm conditions, whereas locations upwind can have lowered noise levels. Sound levels can be increased at large distances (e.g., more than 500 feet) from the highway due to atmospheric temperature inversion (i.e., increasing temperature with elevation). Other factors such as air temperature, humidity, and turbulence can also have significant effects.

## Shielding by Natural or Human-Made Features

A large object or barrier in the path between a noise source and a receptor can substantially attenuate noise levels at the receptor. The amount of attenuation provided by shielding depends on the size of the object and the frequency content of the noise source. Natural terrain features (e.g., hills and dense woods) and human-made features (e.g., buildings and walls) reduce noise levels. Walls are often constructed between a source and a receptor specifically to reduce noise. A barrier that breaks the line of sight between a source and a receptor will typically result in at least 5 dB of noise reduction. Taller barriers provide increased noise reduction. Vegetation between the highway and receptor is rarely effective in reducing noise because it does not create a solid barrier.

## Appendix C

### Technical Support Documentation



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## CDOT White Paper: Review of General Barrier Cost/Benefit Data for CDOT Noise Guidelines

The purpose of this memorandum is to document analyses performed as part of an update to the traffic noise analysis guidance document. Specifically, this memorandum addresses the determination of a new Cost Benefit Index as it relates to barrier “reasonableness” assessments under the new regulations.

### Overview

The evaluation of noise barriers for highway projects as specified by 23 CFR 772 consists of two primary considerations—feasibility and reasonableness. One of several criteria under reasonableness is a comparison to the Cost Benefit Index, which is a cost/benefit ratio of the noise abatement from a proposed barrier (e.g., wall).

CDOT’s previous NAAG, published in 2015, set the Cost Benefit Index at \$6,800/receptor/decibel (dB). This assumed a barrier Unit Cost of \$45/ft<sup>2</sup> and counted all receptors receiving at least 5 dB of noise reduction. The Cost Benefit Index needed to be updated for 2020 because it was determined the units would be changed from \$/receptor/dB to \$/receptor. This change was made to be consistent with other state DOTs and because it is easier for the public to understand units based on cost per receptor. The consensus among the CDOT staff participating in the guidance update was that the 2015 Cost Benefit Index threshold had worked well and that a comparable threshold using new units was appropriate.

### Data Review

To develop the new Cost Benefit Index, CDOT multiplied the 2015 Cost Benefit Index by both 5 dB and 7 dB, compared the results to Cost Benefit Indexes used by other State DOTs (shown in Table 1 and summarized in Table 2), and determined which value would be the new Cost Benefit Index. This comparison was made using both unweighted values and values weighted considering the different Unit Costs used by State DOTs.

Table 1. State DOT Cost Related Data

Cost Benefit Index (\$/receptor) <sup>1</sup>		Unit Cost (\$/sf) <sup>1</sup>	Prorate for CO Unit Cost (\$/receptor) <sup>2</sup>		Noise Reduction Design Goal (dB) <sup>1</sup>			
Base	Max/Severe		Base	Max/Severe	7	8	9	10
11,000	105,600	44	11,250	108,000	x			
21,000		44	21,477		x			
36,127	71,222	51.61	31,500	62,100	x			
50,000	55,000	70	32,143	35,357	x			
50,000	55,000	70	32,143	35,357	x			
20,000		25	36,000		x			
25,000	30,000	30	37,500	45,000	x			



Cost Benefit Index (\$/receptor) <sup>1</sup>		Unit Cost (\$/sf) <sup>1</sup>	Prorate for CO Unit Cost (\$/receptor) <sup>2</sup>		Noise Reduction Design Goal (dB) <sup>1</sup>			
Base	Max/Severe		Base	Max/Severe	7	8	9	10
40,000		44	40,909		x			
24,250	48,250	24.25	45,000	89,536	x			
25,000	30,000	30	37,500	45,000	x			
30,000	37,500	30	45,000	56,250	x			
31,000		31	45,000		x			
40,000		40	45,000		x			
40,000		38	47,368		x			
42,244		37.16	51,157		x			
35,000		30	52,500		x			
30,000		25	54,000		x			
30,000	40,000	25	54,000	72,000	x			
25,000		20	56,250		x			
40,000		30	60,000		x			
36,127	71,222	51.61	31,500	62,100	x			
25,000		18	62,500		x			
42,000		30	63,000		x			
35,000		25	63,000		x			
49,000		35	63,000		x			
40,000		28	64,286		x			
36,000		25	64,800		x			
45,000		30	67,500		x			
40,000		25	72,000		x			
24,250	48,250	24.25	45,000	89,536	x			
43,500		20	97,875		x			
55,000		20	123,750		x			
30,000		35	38,571			x		
24,000	37,000	25	43,200	66,600		x		
24,000	37,000	25	43,200	66,600		x		
30,000		20	67,500			x		
36,000		35	46,286				x	
30,000		18	75,000				x	
42,509		45	42,509					x
25,000		25	45,000					x

Cost Benefit Index (\$/receptor) <sup>1</sup>		Unit Cost (\$/sf) <sup>1</sup>	Prorate for CO Unit Cost (\$/receptor) <sup>2</sup>		Noise Reduction Design Goal (dB) <sup>1</sup>			
Base	Max/Severe		Base	Max/Severe	7	8	9	10
30,000		30	45,000					x
30,000	37,500	30	45,000	56,250				
30,000	40,000	25	54,000	72,000				

**Notes:**

1. Data source: State DOT survey presented at Noise Summit, Baltimore, October 2015
2. Calculated values, prorating Cost Benefit Indexes from State DOTs to a Colorado weighted Cost Benefit Index using the Colorado Unit Cost (\$45/sq. ft.) and each State DOTs Unit Cost.

## Results

Multiplying the 2015 Cost Benefit Index by 5 dB, which is the noise reduction that must be achieved by a receptor to be considered a benefited receptor, results in a Cost Benefit Index of \$34,000/receptor. These values were compared to the unweighted and weighted Cost Benefit Indexes from other State DOTs, summarized in Table 1.

Table 2. Summary of State DOT Cost Related Data

Other State DOTs Cost Benefit Indexes (CBIs)	Unweighted	Weighted
Average Base CBI of other State DOTs (\$/receptor)	\$33,675	\$51,144
Average Base including Max/Severe CBIs (\$/receptor)	\$37,785	\$54,498
Average Base CBI (\$/receptor), states with NRDG of 7 dB	\$34,891	\$51,685
Average Base with Max/Severe CBI (\$/receptor), states with NRDG of 7 dB	\$39,734	\$54,748

Although weighted Cost Benefit Indexes were considered, it was determined that they would not be used. CDOT is moving to a Cost Benefit Index that uses units of \$/receptor. Because those costs are the final cost thresholds used by states to determine if noise barriers are reasonable, it was determined it made more sense to consider those than a weighted version. If CDOT had moved to a Cost Benefit Index that used \$/sq. ft., the differences in Unit Costs between states would have been more relevant. With units of \$/receptor, the calculation considers how many receptors can be benefited for a certain cost regardless of the size of the wall.

Weighted Cost Benefit Indexes range from approximately \$15,000 to \$17,500 more per receptor than unweighted values. Because CDOT staff agreed that the 2015 Cost Benefit Index had worked well and that a comparable threshold under the new units was appropriate, it was determined that the new Cost Benefit Index should be within the range of multiplying the 2015 Cost Benefit Index by 5 and 7 dBA.

## Summary

The new Cost Benefit Index selected for CDOT was \$34,000/receptor. This value represents the 2015 Cost Benefit Index multiplied by 5 dB, which is the noise reduction that must be reached in order for a receptor to be considered a benefited receptor. This value is similar to the average unweighted base Cost Benefit Index from other states.

## CDOT White Paper: General Methodology for Determining Proper Traffic Volumes for Use in Noise Analyses

One of the requirements for predicting noise levels in highway traffic noise studies is to capture what is usually referred to as the “worst-noise hour,” or the point in time where the traffic noise from a given system is at its highest (in the new 23 CFR 772.9 (d) the term used to describe this is officially “the worst traffic noise impact”). This will be when the highest volume of traffic is traveling at the highest possible speed, or typically just before or after the corresponding “rush” hour, when traffic on some facilities begins to slow with increasing volumes.

When attempting to predict noise under future conditions for highway projects, traffic volumes are either provided by a separate traffic study or derived from existing information. These volumes, however, are usually given as “peak-hour” volumes, representing only the highest traffic throughput and, in many cases, a congested situation. As such, it is not appropriate to use peak hour volumes in the noise analysis unless it can be shown that those volumes are below the threshold in which noise levels begin to decrease. Additionally, it is not valid to take congestion-level peak hour volumes and model them at the peak speed limit.

For simplicity, many State Highway Agencies have defined the worst-noise hour as the point in time where traffic Levels of Service (LOS), as described in the *Highway Capacity Manual (HCM)*, are at a rating of between “C” and “D.” While this has been a functional approach, it does have limitations as the parameters that are used may not be something that can be universally used over all facilities. Based on this question, the Colorado DOT performed a general evaluation of highway traffic and corresponding noise levels.

The first task undertaken was to determine at what speeds different volumes (which will be based on vehicles per lane per hour) of traffic will be able to travel. The 2000 version of the HCM was used to investigate this question. Initially, freeway facilities were investigated, as it was the simplest methodology provided (Chapter 23 of the HCM) but also because most of the major noise impacts are associated with these facilities. Chapter 23 of the HCM shows the criteria for freeway facilities and is not included in its entirety here, but the basics of the methodology involve identifying a free-flow speed (FFS) for a facility and the traffic characteristics for that facility. The main calculation that is performed determines the actual vehicle speed based on the volume of traffic per lane per hour. Also determined is the LOS of a facility, which is based on traffic density (calculated by dividing the traffic per lane by the speed).

Based on the equations shown in the HCM, there are inflection points with traffic volumes where traffic will begin to slow. These range from 1,150 vehicles/lane/hr. for a FFS=75 mph facility to 1,750 vehicles/lane/hr. for a facility with a FFS=55 mph. It is interesting to note that based on the LOS definitions in the HCM, the LOS levels for these inflection points (as shown on Figure 23-3 in the HCM) range from B to D. As such, this would indicate that a blanket LOS C or D approach may not result in the highest noise levels for all facilities.

Exhibit 1 illustrates the speeds by volume for different FFS facilities.

### Exhibit 1. Traffic Volume Effect on Traffic Speed

Volume (vehicles/ln/hr)	Traffic Speed (mph)				
	FFS=75	FFS=70	FFS=65	FFS=60	FFS=55
1,500	74.21	69.80	64.99	60.00	55.00
1,600	73.48	69.43	64.88	60.00	55.00
1,700	72.44	68.80	64.54	59.94	55.00
1,800	71.04	67.85	63.90	59.66	54.99
1,900	69.26	66.55	62.89	59.02	54.78
2,000	67.05	64.85	61.45	57.93	54.18

These numbers illustrate that adding volume to a facility affects the speeds with higher FFS values to a greater extent than facilities with a lower FFS. Thus, it is possible to continue to increase volumes on some facilities more and still increase noise levels up to a certain point.

Exhibit 2 illustrates the approximate traffic volumes and corresponding speeds for the high end of the LOS C condition (defined as a facility density of 26 vehicles/hour/lane).

### Exhibit 2. Traffic Speeds for LOS C Conditions

FFS (mph)	Volume (vehicles/ln/hr)	Actual Speed (mph)
75	1,832	70.52
70	1,771	68.16
65	1,680	64.63
60	1,600*	60.00*
55	1,750*	55.00*

\*Represents LOS D conditions, traffic will begin to slow with higher volumes

Exhibit 2, when reviewed along with the Exhibit 1, illustrates that a blanket consideration of LOS traffic volumes may not result in a true representation of the actual worst-noise hour conditions.

To determine the vehicle traffic/speed combination that would result in the worst-noise hour condition, the FHWA Traffic Noise Model (TNM) was used. For this analysis, a very basic model was constructed, which simulates the physical conditions of a rural interstate (2-lanes per direction with a median; receptors placed 50 feet from the nearest centerline). Traffic was input as all passenger vehicles, as the interest is not the actual noise levels but the combination of traffic/speed values that would result in the highest levels. By using TNM for this analysis, the worst-noise hour can be determined directly rather than anecdotally.

To perform the TNM analysis, the major assumption that was made was to treat the FFS of a particular segment as being equivalent to the posted speed limit. There are some drawbacks to performing the analysis in this manner because, for some facilities, the FFS can be higher than the posted speed, especially if the engineered facility design speed is greater. This can result in

potentially underestimating noise levels. However, for the purposes of this analysis, it was felt that as volumes increase to the point of congestion, the overall speeds of the vehicles will tend to congregate around the posted speed limit. Traffic/speed combinations were input into TNM based on the HCM calculations.

Many model iterations were performed in TNM to determine the worst-noise hour levels; those values are shown in Exhibit 3.

### Exhibit 3. Summary of Highest Traffic Noise Level Conditions

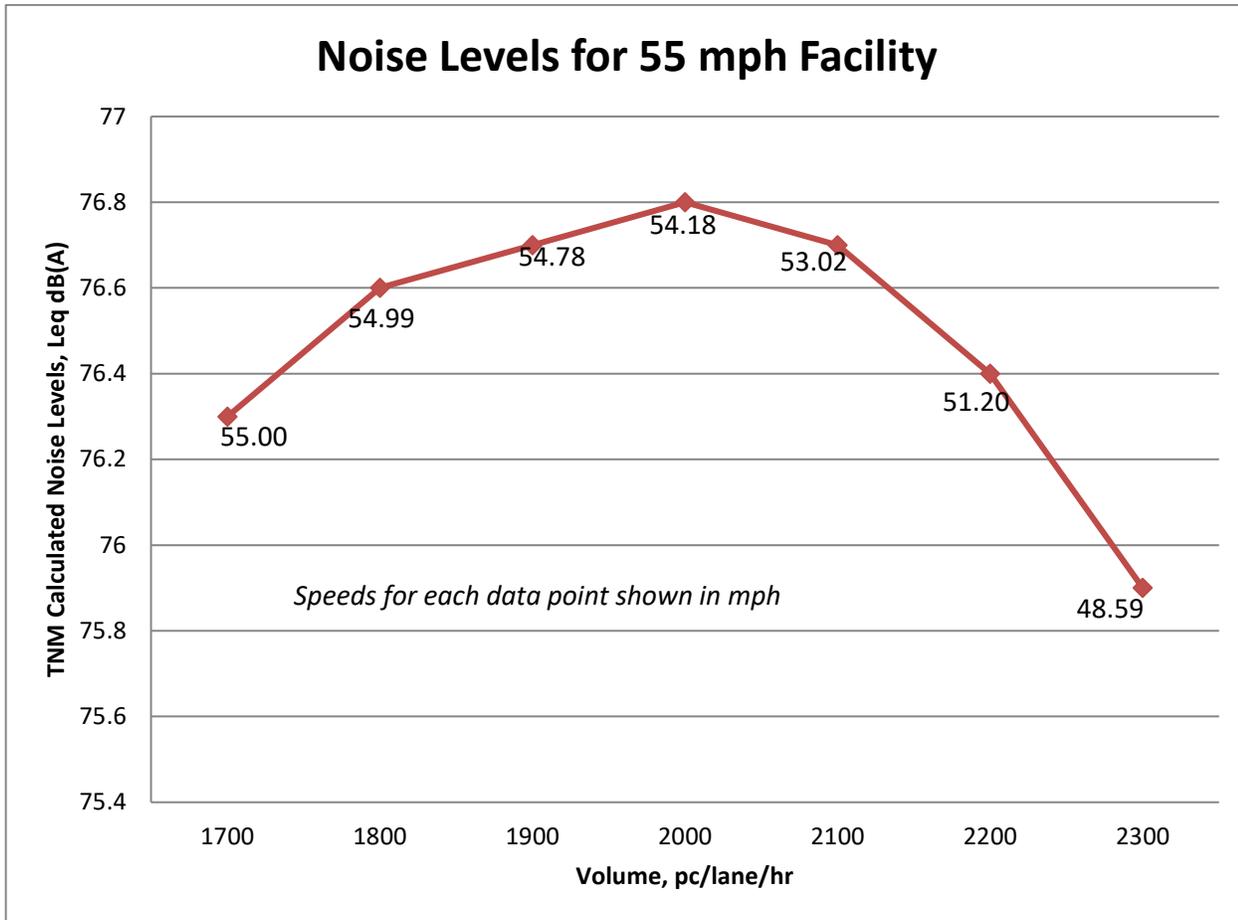
FFS (mph)	Volume (vehicles/ln/hr)	Actual Speed (mph)	TNM Leq Value (dBA)*	LOS
75	1,600	73.48	80.6	C
70	1,700	68.8	79.8	C
65	1,800	63.9	79.0	D
60	1,900	59.02	78.0	D
55	2,000	54.18	77.0	E

\* These values were obtained using the FFS, not the actual speed

For ease of use, CDOT recommends that, for freeway facilities, these volumes be used to represent the worst-noise hour for different facilities based on the posted speed limit. Additionally, although the worst-noise hour was calculated based on the actual speeds, for simplicity, CDOT recommends using the posted speed, not the actual speed as calculated. This will increase the noise level that will be predicted by TNM, but this over-prediction ranges from only 0.2 dBA for FFS=55 to 0.3 dBA for FFS=75, which is not felt to be significant.



Exhibit 4. Volume/Speed vs. Noise Level Chart, Example illustrates FFS=55 mph



This detailed analysis was shown for freeway facilities. Additional analysis was also performed for multi-lane facilities (non-freeway) and 2-lane facilities. The methodology for multi-lane facilities is almost identical to that for freeways, and the base results were similar. However, the impact of other factors with these facilities, for example at-grade intersections, resulted in lower recommended maximum volumes for the worst-noise hour. Two lane facilities use an entirely different approach for determining speed and LOS based on an overall capacity of 1,600 vehicles/ln/hr. This methodology was combined with the freeway methodology to arrive at the recommended maximum volumes for those facilities.

Admittedly, this approach does not result in a major change in TNM calculated noise levels over the basic LOS approach and may appear to over-simplify some of these variables. Having performed this analysis, however, has provided the data that supports the overall approach. Having this data allows an expansion on the LOS concept, which identifies discrete values that can be easily used for the analysis so that the worse-noise hour levels will be reasonably identified. This also allows noise analysts to concentrate on building their models without having to be experts in traffic analysis.

## Appendix D

### Non-CDOT, Non-Federally Funded Noise Barriers on State Highway Right-of-Way

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The purpose of Appendix D is to establish consistent criteria regarding applications by applicants and application evaluation by Colorado Department of Transportation (CDOT) for non-CDOT, non-federally funded noise barriers on state highway right-of-way (ROW). These noise barriers must meet criteria established by CDOT.

## D.1 Associated Regulation

Colorado Revised Statute (C.R.S.) 43-2-401 through 43-2-404<sup>30</sup> (*Noise Mitigation*) and Code of Colorado Regulations (CCR), 2 CCR 601-17<sup>31</sup> (*Rules Regarding the Use of Waste Tires for Noise Mitigation Purposes Along Colorado State Highways Pursuant to § 43-2-401 C.R.S.*) contain requirements for citizens who want to build noise barriers on state highway ROW. The C.R.S. and CCR use different terms than CDOT for some things. For example, the C.R.S. and CCR refer to “noise mitigation measures” while CDOT noise guidance refers to “noise barriers.”

If the noise barrier is proposed to be built on interstate ROW, the National Environmental Policy Act (NEPA) and Federal Highway Administration’s (FHWA’s) noise regulation apply. The noise regulation is contained in Part 772 of Title 23 of the Code of Federal Regulations (23 CFR 772) and is titled *Procedures for Abatement of Highway Traffic Noise and Construction Noise*.

## D.2 CDOT Contacts

The primary contact for requests from applicants is the CDOT Region Permitting Unit and/or CDOT Property Management where the proposed noise barrier would be located.

## D.3 Applicant Definition

Per the C.R.S. and CCR, only qualified people, referred to as “applicants,” can submit applications to build a noise barrier on ROW. Definitions of “applicant” are available at C.R.S. 43-2-401(1) and 2 CCR 601-17, Rule 3.01.

It is the responsibility of the applicant to establish and prove that they qualify to be an applicant.

## D.4 Eligible Area/Barrier Location

Per the C.R.S. and CCR, applicants must reside in or be located in an eligible area to submit an application to build a noise barrier on ROW. Definitions of “Eligible Area” are available at C.R.S. 43-2-401(3) and 2 CCR 601-17, Rule 3.03. Additional requirements related to barrier location are available at C.R.S. 43-2-403(4) and 2 CCR 601-17, Rule 4.01.

It is the responsibility of the applicant to establish and prove that they reside in or operate in an eligible area.

Noise barriers built on private property are not subject to the C.R.S., CCR, or CDOT jurisdiction. Noise barriers may be built on ROW only if the applicant provides justification that no other reasonable alternative location is available. The justification shall use established CDOT approved

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<sup>30</sup> The C.R.S. is available [here](#). This link may not work in the Google Chrome web browser.

<sup>31</sup> The CCR is available [here](#).

engineering standards and show that no barrier placed on private property can reduce noise by the required amount<sup>32</sup>.

C.R.S. 43-2-401(3)(c) and 2 CCR 601-17, Rule 4.01 require that noise barriers be located within boundaries of a local government that, as of the date of the application, has adopted an ordinance or resolution to mitigate the effects of noise in future residential or other noise-sensitive development adjacent to state highways within the boundaries of that local government. The applicant must specify the applicable ordinance or resolution in the application.

## D.5 Barrier Removal

Removal of noise barriers built on ROW is not addressed in the C.R.S. or CCR.

Noise barriers built on ROW under the C.R.S. and/or CCR may be removed at CDOT's discretion without compensation as specified in the CDOT Special Use Permit. Barriers might be removed as part of a construction project, such as widening a highway. A new noise barrier may or may not be built in the same area. However, if built, it cannot be guaranteed that the replacement would provide the same noise reduction.

## D.6 ROW Issues

C.R.S. 43-2-403(4) says that barriers may be built in ROW with CDOT's approval or on private land. It also says that CDOT may sell ROW subject to the provisions of C.R.S. 43-1-210(5).

CDOT is only allowed to grant easements for public utility purposes per C.R.S. 24-82-201 and C.R.S. 24-82-202. Applicants should first explore buying ROW from CDOT. If the necessary ROW is purchased by the applicant, the noise barrier would be built on private property and would thus not be subject to the C.R.S., CCR, or CDOT jurisdiction. If ROW is not purchased, a noise barrier built on ROW needs a CDOT Special Use Permit. This permit includes requirements that must be met by the applicant.

## D.7 Responsibility to Build/Construction

C.R.S. 43-2-402(5)(a) and C.R.S. 43-2-402(5)(b) indicate that CDOT is responsible to construct noise barriers that are funded at least 50 percent by local governments.

For noise barriers with less than 50 percent funding by local governments, the applicant is responsible to build the noise barrier. CDOT must approve the construction of the noise barrier, via the permit process.

## D.8 Construction Funding

C.R.S. 43-2-403(2)(b) requires that applicants of privately funded noise barriers must specify the source of funding that will be used to build the noise barrier. C.R.S. 43-2-402(2)(b) and C.R.S. 43-2-402(3) describe additional funding related requirements.

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<sup>32</sup> The required noise reduction is defined by the CDOT *Noise Analysis and Abatement Guidelines*.

Costs associated with the noise barrier application, construction, and maintenance, which include all studies and engineering design, will be the responsibility of the applicant. A decision will be made on a case-by-case basis whether to seek reimbursement for the cost of CDOT's review and coordination. Costs consistent with a typical permit review will be absorbed by CDOT.

## D.9 Maintenance Funding and Performance

C.R.S. 43-2-403(5) requires that applicants of privately funded noise barriers be responsible for maintaining the noise barrier. 2 CCR 601-17, Rule 4.03 requires that applications for noise barriers must contain evidence satisfactory to CDOT that a Local Entity has committed to providing funding for noise barrier maintenance and repair.

Applicants shall maintain proposed barriers, including all repairs, regardless of the noise barrier funding source or type (e.g., material used in construction). Evidence of this commitment shall be documented using the following agreements:

- Intergovernmental agreement (IGA) between CDOT and the applicable local governmental agency (i.e., has jurisdiction in area in which the noise barrier will be built).
- Agreement between the applicant and the applicable local governmental agency. This agreement is required regardless of whether the local governmental agency provides any funding to the noise barrier.

Both agreements must be signed prior to noise barrier construction. The agreements will identify, at a minimum:

- Applicant's responsibility for all costs.
- Applicant's responsibility for repair and maintenance of the noise barrier following completion of construction.
- Applicant's agreement that if the applicant does not perform maintenance within a certain timeframe, to be determined by CDOT, the applicable local governmental agency will do the maintenance and charge the applicant.
- Applicant's responsibility to obtain all applicable permits, including a permit from CDOT. A permit, issued by CDOT, is required to do any work in ROW, including maintenance.

## D.10 Application Requirements for Neighborhood Support

C.R.S. 43-2-402(2)(a), C.R.S. 43-2-403(2)(a), and 2 CCR 601-17, Rule 4.01.1.1(a) require applications for noise barriers to include a petition in support of the noise barrier that was signed by 75 percent or more of the households or homeowners in the eligible area who live up to 4/10<sup>ths</sup> of one mile from the nearest edge of the state highway ROW.

The petition must consider a minimum distance of 500 feet from the nearest edge of the traveled lane(s). The applicant shall obtain a land use list from the applicable county and include the list in the application. This will show the complete list of all addresses in the area that were to be considered for the petition. The area boundary should be shown on a map. A column shall be added

to the list to indicate which households or owners signed the petition in favor of the noise barrier. This will allow a determination of whether at least 75 percent of the eligible households or owners signed the petition. A copy of the petition must be submitted as part of the application, in order to show the signatures and the petition language that was provided to households. Each page with petition signatures must include the petition language (e.g., to show that people knew what they were signing).

## D.11 Application and Barrier Analysis

C.R.S. 43-2-403(3)(c)(I), C.R.S. 43-2-403(3)(c)(II), and 2 CCR 601-17, Rule 4.01.1.1 require that the noise barrier comply with the CDOT *Noise Analysis and Abatement Guidelines*. C.R.S. 43-2-403(3)(c)(III) and 2 CCR 601-17, Rule 4.01.1.2 require that noise barriers be compatible with any existing barriers in the eligible area. C.R.S. 43-2-403(3)(c)(IV) and 2 CCR 601-17, Rule 4.01.1.3 require that noise barriers comply with zoning and building requirements established by the local government. C.R.S. 43-2-402(2)(c), C.R.S. 43-2-403(2)(c), 2 CCR 601-17, Rule 4.01.1, and CCR 601-17, Rule 4.02 describe additional application related requirements.

Prior to application submittal, the applicant shall consult with a CDOT noise specialist to scope the noise analysis.

Complete proposals for noise barriers shall be submitted to the appropriate CDOT Region Permitting Unit and/or CDOT Property Management. The application shall include a noise analysis documenting the justification, need, and effectiveness of the proposed noise barrier. The noise analysis shall be consistent with requirements of the CDOT *Noise Analysis and Abatement Guidelines* that are typically used for Type I projects. For example, a qualified person, as defined by CDOT, must use FHWA's approved noise model as part of the noise analysis.

If the barrier is going to be built on state highway ROW, CDOT may require analysis to understand potential environmental impacts and the need for mitigation. Consult with a CDOT NEPA specialist and CDOT's [NEPA Manual](#) to determine NEPA applicability and analysis requirements. A public meeting may need to be held by the applicant. If the noise barrier is going to be built on interstate ROW, NEPA applies and the action needs to be approved by FHWA.

Applications for a noise barrier shall include a design of the proposed barrier, which shall contain the endorsement seal of a Professional Engineer registered in the State of Colorado. In order for the proposed noise barrier to be built, the final design is subject to approval by CDOT. The design shall include all geometric, structural, and materials details and comply with the most recent CDOT Standard Specifications for Road and Bridge Construction. Designs shall not impair the highway nor interfere with the free and safe flow of traffic. CDOT will provide the following at no cost to applicants: standard noise barrier specifications and CDOT's *Noise Analysis and Abatement Guidelines*.

## D.12 Application and Evaluation Timing

C.R.S. 43-2-402(1), 43-2-402(4)(a), 43-2-402(4)(b), 43-2-402(5)(c), 43-2-403(1), and 43-2-403(3)(a) describe application timing and the timing of CDOT's evaluation.

The same requirements shall apply to noise barrier applications under the CCR. Privately funded barrier applications have more latitude in when applications can be submitted to CDOT. Depending on the funding source and application date, CDOT may have less time to review the application. In no cases shall CDOT have less than three months to review the application. An application is not considered to be submitted unless and until it is submitted in full.

### D.13 Application Evaluation by CDOT

C.R.S. 43-2-403(3)(b) and C.R.S. 43-2-404 contain information related to CDOT's evaluation of applications. 2 CCR 601-17, Rules 4.05 and 5.00 contain a procedure for CDOT to follow to rank noise barrier projects for noise barriers that incorporate recycled waste tires.

CDOT Permitting staff shall coordinate with CDOT staff such as Property Management, Region Engineering, Region Right-of-Way, Staff Bridge, Division of Highway Maintenance, Environmental, and a CDOT Noise Specialist(s) during the noise barrier application evaluation.

All requests for noise barriers will be reviewed and evaluated in a fair and consistent manner. In evaluating each request, CDOT will consider whether all requirements are met from the C.R.S., CCR, other related statutory requirements, and CDOT's requirements. CDOT requirements are described in various documents, including this appendix, and include appropriate environmental documentation, plans for future transportation construction, and any other impacts or consequences of the proposed barrier.

All applications for a noise barrier shall be subject to approval by CDOT. In addition, noise barriers located on the interstate highway system shall be separately reviewed and approved by FHWA. CDOT's approval of a noise barrier by permit shall expire after three years unless actual construction of the project has been initiated and unless otherwise agreed to by CDOT.

## Appendix E References

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