APPENDIX A5

TRAFFIC NOISE TECHNICAL REPORT

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TRAFFIC NOISE TECHNICAL REPORT

Project Number 21685

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Prepared for:

Colorado Department of Transportation
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LIST OF ABBREVIATIONS AND ACRONYMS

AGS	Advanced Guideway System
CDOT	Colorado Department of Transportation
CFR	Code of Federal Regulations
dBA	A-weighted decibels
EB	eastbound
EOS	edge of shoulder
FHWA	Federal Highway Administration
ft^2	square feet
Guidance	FHWA's Highway Traffic Noise: Analysis and Abatement Guidance
I-70	Interstate 70
ID	identification
Leq	one-hour equivalent sound level
mph	miles per hour
NAC	Noise Abatement Criterion
NAAG	Noise Analysis and Abatement Guidelines
NB	northbound
NEPA	National Environmental Policy Act
SB	southbound
TNM	FHWA's Traffic Noise Model
WB	westbound

1 EXECUTIVE SUMMARY

This traffic noise technical report has been prepared in support of the I-70 West Vail Pass Auxiliary Lane project. An executive summary of this project's traffic noise analysis and abatement evaluation is included in Table 1.

Table 1 Project Overview

Project Location and Type I Status Explanation	This project is located in Eagle and Summit Counties, Colorado (See Figures 1A and 1B), with the eastern termini just east of the Vail Pass Rest Area and the western termini in the Town of Vail. It is a Type I project because it would include construction of two new auxiliary lanes of accumulated length greater than 2,500 feet.
Noise Level and Impact Overview	• Existing (2017) modeled noise levels range from 50.5 to 73.4 A-weighted decibels (dBA) at 69 receivers[1], which represent 202 receptors. • Future (2045) modeled noise levels for the No Action Alternative range from 52.8 dBA to 75.8 dBA at 69 receivers, which represent 202 receptors. • Future (2045) modeled noise levels for the Proposed Action range from 54.1 dBA to 76.2 dBA at 69 receivers, which represent 202 receptors. The Proposed Action is expected to impact the following receivers and receptors: o 29 Activity Category B receivers/29 receptors o 4 Activity Category C receivers/6 receptors
Noise Abatement Considerations and Commitments Overview	5 noise barriers were evaluated, as shown in Figure 6. Evaluated Barrier 1 was determined to be feasible and reasonable. The remaining 4 evaluated barriers were determined to be feasible but not reasonable because the Cost Benefit exceeded the Cost Benefit Index.
Information for Local Officials	This project's Noise Study Zone does not include any land that is unpermitted and undeveloped (i.e., Activity Category G). Therefore, Part 772.17 of Title 23 of the Code of Federal Regulations (23 CFR 772.17) is not applicable and information does not need to be provided to local officials.

[1] A receiver is a modeled point that represents one or more receptors. Additional modeling points were used for informational purposes but were not used as receptors in the noise analysis (See Table 9). Receptor types are listed in Table 3, in the column titled "Description of Land Use Category."

2 PROJECT INTRODUCTION

The I-70 West Vail Pass Auxiliary Lanes project is located in Eagle and Summit Counties, with the eastern termini just east of the Vail Pass Rest Area and the western termini in the Town of Vail. The project study limits include eastbound (EB) and westbound (WB) I-70 from mile post (MP) 179.5 to MP 191.5. The project location and approximate study area are shown in Figures 1A and 1B.

As part of the initial National Environmental Policy Act (NEPA) analysis, a Tier 1 Environmental Impact Statement (EIS) for the I-70 Mountain Corridor (C-470 to Glenwood Springs) was completed

in 2011. This EIS, the *I-70 Mountain Corridor Programmatic Final Environmental Impact Statement* (PEIS), recommended the addition of auxiliary lanes EB and WB on the west side of Vail Pass from MP 180 to MP 190 as part of the Preferred Alternative's Minimum Program of Improvements. The PEIS also identified the potential for an elevated Advanced Guideway System (AGS) for transit along the I-70 corridor, including the West Vail Pass project corridor. A follow-up AGS Feasibility Study in 2014 analyzed potential alignments and costs for an AGS system and determined there were three feasible alignments for future AGS. While AGS is not part of the West Vail Pass Auxiliary Lanes project, the AGS Feasibility Study was used to ensure the project did not preclude the favored alignment of the three, which would be partially within CDOT right-of-way (ROW).

A Tier 2 NEPA analysis is the next step required to move highway improvements forward. The project is following the Colorado Department of Transportation (CDOT) and Federal Highway Administration (FHWA) NEPA process to confirm the needs for improvements to the West Vail Pass, identify a Proposed Action, investigate the anticipated benefits and impacts of the proposed improvements (through an Environmental Assessment), produce conceptual design plans, and make funding, scheduling, and phasing recommendations.

The improvements, which are described in Table 2 and hereafter called the Proposed Action, constitute a Type I project because it would include construction of two new auxiliary lanes of accumulated length greater than 2,500 feet. Because the project is Type I and because there is at least one Activity Category A, B, C, D, and/or E receptor within the Noise Study Zone, a noise analysis is needed to determine if noise levels will be impacted as a result of building the project. Illingworth & Rodkin, Inc., acting on behalf of CDOT, conducted a noise analysis for the project and prepared this report. Table 2 includes information about this project and provides context for this traffic noise analysis.

Table 2 Project Background

Project Location	This project is located in Eagle and Summit Counties, Colorado (See Figures 1A and 1B), with the eastern termini just east of the Vail Pass Rest Area and the western termini in the Town of Vail.
Affected Roadways	Interstate 70 (I-70)
Project Purpose	The purpose of the project is to improve safety and operations on EB and WB I-70 on West Vail Pass.
Project Need	This project is needed to address safety concerns and operational issues due to geometric conditions (steep grades and tight curves) and slow-moving vehicle and passenger vehicle interactions that result in inconsistent and slow travel times along the corridor. The I-70 Mountain Corridor Programmatic Environmental Impact Statement (PEIS) identified safety and mobility issues on West Vail Pass related to speed differentials due to slow-moving vehicles. (Mobility is defined as the ability to travel along the I-70 Mountain Corridor safely and efficiently in a reasonable amount of time.) • Safety Concerns: A high number of crashes occur along the corridor related to speed, tight curves, narrow roadway area, and inclement weather/poor road conditions. Speed differentials between passenger vehicles and slow-moving vehicles cause erratic lane changes and braking maneuvers resulting in crashes

	and spin outs. Emergency response is hampered by vehicular speeds and lack of roadway width to provide room for emergency vehicles to pass. • Operational Issues: The steep grades and resulting speed differentials causes slow and unreliable travel times through the corridor. Tight curves also cause drivers to slow down. The corridor is frequently closed by vehicle incidents, due to lack of width to maintain a single lane of traffic adjacent to emergency responders, resulting in substantial traffic backups and delays. During winter months, the travel lanes and shoulders are severely impacted by snow accumulation, impacting the overall capacity of the corridor. (Operations is intended to describe the flow of traffic at desirable speeds given the geometric and prevailing weather conditions.)
Proposed Action Description	The Proposed Action Alternative (Figure 2) will add a 12-foot auxiliary lane, both EB and WB, for 10 miles from approximately the East Vail exit (MP 179.5) to the Vail Pass Rest Area exit (MP 191.5). Existing lanes will be maintained at 12 feet and the shoulders would be widened to a minimum of 6 feet for inside shoulders and will be maintained at 10 feet for outside shoulders. All existing curves will be modified as needed to meet current federal design standards. Intelligent Transportation System (ITS) equipment will also be installed along the I-70 project corridor, consistent with recent study recommendations. Additional variable message signs (VMSs) will be installed at key locations to warn drivers of upcoming curves, grades, and incidents. Additional variable speed limit signs will be installed to manage driver speeds to conditions. Automated lane closure signage will be installed approaching the East Vail exit on EB I-70 and approaching the WB I-70 Vail Pass Rest Area exit to quickly and efficiently close lanes when needed. Additional elements of the Proposed Action include: • The Vail Pass Recreation Trail will be directly impacted by the addition of the I-70 auxiliary lane and therefore relocated for approximately two miles from MP 185 to MP 187. • Existing emergency truck ramps, located at approximately MP 182.2 and 185.5, will be upgraded to current design standards. • Six wildlife underpasses and wildlife fencing will be constructed throughout the corridor. • Additional capacity will be added to the existing commercial truck parking area at the top of Vail Pass. • Widened shoulders (minimum of eight feet of additional width beyond the 10’ shoulder) at multiple locations to accommodate emergency pull-offs, emergency truck parking, and staging for tow trucks.

	• Improved median emergency turnaround locations to accommodate emergency and maintenance vehicle turnaround maneuvers. • Improved chain station located at approximately MP 182.5 with additional parking, signage, lighting, and separation from the I-70 mainline. • Avalanche protection located at approximately MP 186.
No Action Alternative Description	The No Action Alternative is included as a baseline for comparison to the action alternative. Under the No Action Alternative, only programmed projects that are planned and funded by CDOT or other entities would be completed. Currently, there are no large-scale transportation projects to add safety improvements, operational improvements, vehicular capacity, and multimodal facilities along I-70 within the project area. The No Action Alternative would leave West Vail Pass as it currently is configured and would not provide substantial improvements beyond typical current maintenance (e.g. resurfacing and plowing) activities. The roadway would remain the same, with 2 EB and 2 WB lanes (each 12 feet in width), an inside shoulder typically 4 feet in width, and an outside shoulder typically 10 feet in width.
Prior National Environmental Policy Act (NEPA) Approvals	As part of the initial National Environmental Policy Act (NEPA) analysis, a Tier 1 Environmental Impact Statement (EIS) for the I-70 Mountain Corridor (C-470 to Glenwood Springs) was completed in 2011. This EIS, the I-70 Mountain Corridor Programmatic Final Environmental Impact Statement (I-70 Final PEIS), recommended the addition of auxiliary lanes EB and WB on the west side of Vail Pass from MP 180-190 as part of the minimum program. A follow-up AGS Feasibility Study in 2014 analyzed potential alignments and costs for an AGS system and determined there were three feasible alignments for future AGS. Subsequent to this, CDOT identified the Hybrid Alignment as the favored alignment of the three. The PEIS measured loudest hour noise levels in representative locations throughout the PEIS study area in periods between 2001 and 2004 and predicted noise increases anticipated under a variety of alternatives, including a no action alternative. Loudest hour noise levels at three Vail sites, all located west of the project area, ranged from 63 to 67 dBA L_{eq}. The PEIS predicted noise increases of 2 to 3 dBA in the Vail, depending on the alternative. Vail was found to "experience noise impacts above the NAC under all alternatives, primarily because the existing noise level already exceeds the NAC."

3 BACKGROUND

This noise analysis was done as required by 23 CFR 772 in accordance with CDOT's *Noise Analysis and Abatement Guidelines* (NAAG) (CDOT, 2015) and FHWA's *Highway Traffic Noise: Analysis and Abatement Guidance* (Guidance) (FHWA, 2011). The analysis determines whether 2045 traffic noise levels from the Proposed Action will exceed applicable impact thresholds at properties (i.e., receptors) within the Proposed Action Noise Study Zone, which is described in Section 4.1. Traffic noise abatement is evaluated for any such impacted receptors.

This noise analysis included the following tasks:

- Conducting field measurements of existing sound levels (see Section 4.1)
- Validating a noise model using field measurement results (see Section 4.2)
- Modeling existing noise conditions for existing roadways (see Sections 4.3 and Chapter 5)
- Modeling Proposed Action and a future No Action Alternative for design roadways (see Sections 4.3 and Chapter 5)
- Completing a noise abatement evaluation (see Chapter 6)

3.1 Characteristics of Noise

Fundamental information about noise, such as terminology, how sound travels, and sound intensity, is included in CDOT's NAAG. It is incorporated by reference to supplement this report.

3.2 Applicable Regulations, Guidelines, and Tools

The following regulation, guidelines, and tools were used to complete this noise analysis:

- ***23 CFR Part 772 (Procedures for Abatement of Highway Traffic Noise and Construction Noise)*** (23 CFR §772, 2010)**:** Federal highway noise standard that must be followed in analyzing and abating highway traffic noise. This regulation required states to adopt state-specific guidelines, which included adopting specific parameters such as the noise reduction design goal.

- **CDOT NAAG** (CDOT, 2015): Fulfilled Federal requirement to adopt state-specific guidelines. Provides Colorado's procedural and technical requirements for analyzing highway project traffic noise and evaluating noise abatement.

- **FHWA Guidance** (FHWA, 2011***)*:** Provides FHWA guidance for applying 23 CFR Part 772 in the analysis and abatement of highway traffic noise.

- ***Noise Measurement Handbook*** (FHWA, 2018): Includes procedures for measuring highway noise.

- **FHWA Traffic Noise Model (TNM) Version 2.5,** (FHWA, February 2004): Model used to determine existing and design year noise levels.

3.3 CDOT Noise Abatement Criteria and Land Use Activity Categories

A traffic noise impact occurs if either of the following conditions is met:

- Predicted design year traffic noise level approaches (i.e., equals) or exceeds CDOT's Noise Abatement Criteria (NAC) at a minimum of one receptor
- Predicted design year traffic noise level substantially exceeds the existing highway traffic noise level at a minimum of one receptor. "Substantial" is defined as a noise increase of 10 dBA or more between the existing and design years.

CDOT's NAC are shown in Table 3. CDOT's NAAG require that the one-hour equivalent sound level (Leq) be used in the analysis.

The NAC for Activity Category D applies to interior areas of frequent human use. All other NACs apply to exterior areas of frequent human use. Exterior area examples include yards for Activity

Category B, park activity areas for Activity Category C, and exterior restaurant dining areas for Activity Category E.

Undeveloped lands for which development has been permitted before the Date of Public Knowledge must be treated as though the development has already been constructed. CDOT considers a proposed development to be permitted when a formal building permit has been issued to the developer.

Table 3 CDOT Noise Abatement Criteria

Activity Category	Activity L_{eq} (dBA)[1]	Evaluation Location	Description of Land Use Category
A	56	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[2]	66	Exterior	Residential
C[2]	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreational areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	51	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[2]	71	Exterior	Hotels, motels, time-share resorts, vacation rental properties, 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), and warehousing.
G	Not Applicable	Not Applicable	Undeveloped lands that are not permitted for development.

[1] Hourly A-weighted sound level in dBA, reflecting a 1-dBA approach value below 23 CFR 772 values

[2] Includes undeveloped lands permitted for this activity category.

4 NOISE ANALYSIS METHODS

Prior to running a noise model, the analysis includes identifying the Noise Study Zone, identifying the land uses within the Noise Study Zone, taking noise measurements within the Noise Study Zone, validating the noise model, and inputting several parameters into the noise model. These steps are described in this chapter.

4.1 Noise Study Zone Identification

The Noise Study Zone for this project extends 500 feet in all directions from the proposed edge of travel lanes throughout the project extent, as shown in Figure 3.

4.2 Land Use Identification

Table 4 identifies the land use categories and noise receivers and receptors included in the noise analysis. Figure 3 identifies land uses in the Noise Study Zone.

Table 4 Land Use Considerations

Receiver Activity Category Summary **(see Table 9)**	Receivers with the following Activity Categories were modeled in the existing condition and design year scenarios: • Activity Category B: 59 receivers representing 190 receptors • Activity Category C: 10 receivers representing 12 receptors
Other Considerations	• The Noise Study Zone does not contain any permitted receptors that have not been built. • The Noise Study Zone contains USFS Lands that are not trails or other identified areas. These lands would be considered Activity Category F. The Noise Study Zone does not contain any Activity Category G land. • The Noise Study Zone contains trails, campgrounds, and residential uses that could be considered under Section 4(f). These sites are being evaluated within Activity Categories B and C, as appropriate. • The Noise Study Zone may include potential Section 106 sites. These sites are addressed within Activity Category B and C, as appropriate.

4.3 Noise Measurements

Tables 5 and 6 summarize the noise measurement information for this analysis. Seventeen (17) short-term noise measurement locations and three (3) long-term locations were selected to complete the noise monitoring survey. Noise measurement field data sheets are in Appendix A.

Short-term traffic noise measurements were performed to acquire data for TNM model validation. Traffic counts and speeds, listed in Table A-1 of Appendix A, were collected during short-term noise measurement periods to facilitate model validation.

Due to the non-urban setting, with traffic patterns not following typically commuter traffic patterns, long-term noise monitoring was used to identify the loudest traffic hour. Long-term measurements are not used to validate the TNM model and are not meant to be representative of noise levels in noise sensitive areas. Long-term monitoring is used only to identify the loudest traffic hour through review of the diurnal trend in noise levels. The diurnal trend in traffic noise levels is not sensitive to location, given that the primary noise source remains dominant; therefore, heights greater than 5 - feet are used in some cases for security purposes. The diurnal trends in noise levels at the long-

term locations is shown in Appendix E. The loudest noise hour was determined based on the L_{eq}, or average, noise level data. The other noise descriptors shown in Appendix E are used by the noise analyst to understand the variation in the traffic noise levels within a sample period and to identify any anomalies in the data.

Traffic noise levels along WB I-70 (L1) were within 1 dBA of the loudest traffic noise hour between 7:00 am and 6:00 pm on weekdays (Tuesday, June 5th, 2018 through Friday, June 8th, 2018 and Monday, June 11th, 2018) and Saturday and from 9:00 am and 8:00 pm on Sunday, June 10th, 2018. The loudest traffic noise level did not vary by day of the week at the WB location.

The loudest hour at EB location L2, which was measured over a 24-hour weekday period from Tuesday, June 5th, 2018 to Wednesday, June 6th, 2019, occurred during the 6:00 and 7:00 am hours on Wednesday, June 6th, 2018. Noise monitoring at L2 was relocated to location L3 on June 6th, 2019 and due to concern that water flow noise from the nearby creek may influence the data at location L2. Review of the data shows that this interference was minimal and did not affect the identification of the loudest hour. At EB location L3, the 5:00 pm hour on Sunday, June 10th, 2018 resulted in the loudest traffic noise hour. The loudest traffic noise level on measured weekdays and Saturday was 3 to 4 dBA lower than the Sunday loudest traffic noise level. Sunday summer peak hour traffic volumes were used to analyze noise levels for existing (2017) and future (2045) conditions.

Table 5 Noise Measurement Summary

Measurement Location ID	Location	Date	Time (a.m. or p.m.)		Length (minutes)
			Start	Stop	
S1-1	Lawn area north of Fall Line Drive, Vail	06/07/18	12:15 p.m.	12:30 p.m.	15
S1-2	Lawn area north of Fall Line Drive, Vail	06/07/18	12:30 p.m.	12:45 p.m.	15
S2-1	3891 Big Horn Road Units B & C, Vail	06/07/18	11:30 a.m.	11:45 a.m.	15
S2-2	3891 Big Horn Road Units B & C, Vail	06/07/18	11:45 a.m.	12:00 p.m.	15
S3-1	3941-4 & 4011-6 Big Horn Road, Vail	06/07/18	10:45 a.m.	11:00 a.m.	15
S3-2	3941-4 & 4011-6 Big Horn Road, Vail	06/07/18	11:00 a.m.	11:15 a.m.	15
S4-1	4073 Spruce Way, Vail	06/07/18	10:00 a.m.	10:15 a.m.	15
S4-2	4073 Spruce Way, Vail	06/07/18	10:15 a.m.	10:30 a.m.	15
S5-1	4193a Spruce Way, Vail	06/06/18	1:15 p.m.	1:28 p.m.	13
S5-2	4193a Spruce Way, Vail	06/06/18	1:30 p.m.	1:45 p.m.	15
S6-1	4396 Columbine Way, Vail	06/07/18	1:00 p.m.	1:15 p.m.	15

Measurement Location ID	Location	Date	Time (a.m. or p.m.)		Length (minutes)
			Start	Stop	
S6-2	4396 Columbine Way, Vail	06/07/18	1:15 p.m.	1:30 p.m.	15
S7-1	4335 Spruce Way, Vail	06/06/18	12:30 p.m.	12:45 p.m.	15
S7-2	4335 Spruce Way, Vail	06/06/18	12:45 p.m.	1:00 p.m.	15
S8-1	4545 Big Horn Road, Vail	06/06/18	11:45 a.m.	12:00 p.m.	15
S8-2	4545 Big Horn Road, Vail	06/06/18	12:00 p.m.	12:15 p.m.	15
S9-1	4770 Vail Racquet Club Townhouse Drive, Vail	06/06/18	1:20 p.m.	1:30 p.m.	10
S9-2	4770 Vail Racquet Club Townhouse Drive, Vail	06/06/18	1:30 p.m.	1:45 p.m.	15
S10-1	L1 & L3 Condos, Vail Racquet Club Townhouse Drive, Vail	06/06/18	11:00 a.m.	11:15 a.m.	15
S10-2	L1 & L3 Condos, Vail Racquet Club Townhouse Drive, Vail	06/06/18	11:15 a.m.	11:30 a.m.	15
S11-1	Pool area, Main Gore Place, Vail	06/06/18	12:30 p.m.	12:45 p.m.	15
S11-2	Pool area, Main Gore Place, Vail	06/06/18	12:45 p.m.	1:00 p.m.	15
S12-1	5040 Prima Court Unit 1, Vail	06/06/18	11:45 a.m.	12:00 p.m.	15
S12-2	5040 Prima Court Unit 1, Vail	06/06/18	12:00 p.m.	12:15 p.m.	15
S13-1	5177 Gore Circle, Vail	06/06/18	10:45 a.m.	11:00 a.m.	15
S13-2	5177 Gore Circle, Vail	06/06/18	11:00 a.m.	11:15 a.m.	15
S14-1	Bike Trail, north of I-70, approximate PM 184.5	06/07/18	12:45 p.m.	1:00 p.m.	15
S14-2	Bike Trail, north of I-70, approximate PM 184.5	06/07/18	1:00 p.m.	1:15 p.m.	15
S15-1	Bike Trail, south of I-70, approximate PM 185.5	06/07/18	11:50 a.m.	12:00 p.m.	10
S15-2	Bike Trail, south of I-70, approximate PM 185.5	06/07/18	12:00 p.m.	12:15 p.m.	15

Measurement Location ID	Location	Date	Time (a.m. or p.m.)		Length (minutes)
			Start	Stop	
S16-1	Black Lakes Trailhead	06/07/18	9:45 a.m.	10:00 a.m.	15
S16-2	Black Lakes Trailhead	06/07/18	10:00 a.m.	10:15 a.m.	15
S17-1	White River National Forest Trailhead	06/07/18	10:30 a.m.	10:45 a.m.	15
L1	North of I-70, near PM 183.62	06/05/18 to 06/11/18	1:45 p.m.	11:45 a.m.	142 hr 0 min
L2	South of I-70, East of Columbine Drive, Vail	06/05/18 to 06/06/18	2:45 p.m.	1:45 p.m.	23 hr 0 min
L3	South of I-70, 4335 Spruce Way, Vail	06/06/18 to 06/11/18	2:30 p.m.	11:00 a.m.	116 hr 30 min

Table 6 Noise Measurement Details

Number of Noise Measurement Locations	20
Noise Measurement Locations	Traffic noise measurement locations are shown on Figure 2. Short-term locations were selected to be representative of noise sensitive land uses within the Noise Study Zone. Long-term locations were selected to be representative of the trend in noise levels for EB and WB I-70, allowing for the identification of the loudest traffic noise hour for receptors on either side of I-70.
Basis for Measurement Length	Short-term noise measurements were conducted over 15-minute periods at representative receiver locations. Two 15-minute duration measurements were made at each short-term location, where feasible. Where noise interference occurred at the short-term site, shorter measurement periods, ranging from 10 to 13 minutes were used to eliminate noise contamination. Long-term measurements were made over periods of several days, including both weekday and weekend periods, to establish the loudest traffic noise hour.
Method to Estimate Traffic Volume During Noise Measurement	Traffic volumes were counted in real time, using handheld clickers, and videotaped as reference.
Method to Estimate Traffic Speed	Based on periodic speed measurements, using a radar gun, measured speeds were approximately 5 mph below the posted speed limit. Measured speeds were used for noise model validation.

Weather Conditions Summary (See Appendix A)	Noise measurements were made during weather conditions acceptable according to FHWA guidance (FHWA, 2018). Weather conditions, including temperature and wind speed, were monitored during the measurements.
Sound Level Meter Used	Larson Davis Model 820; Type I
Sound Level Meter Laboratory Calibration Date	IR1: February 2017 IR3: November 2016 IR4: December 2017 IR8: July 2017 Measurements made June 2018.
Field Calibrator Used	Larson Davis Model CAL200 Calibrations traceable to the United States National Institute of Standards and Technology were performed in the field before each set of measurements and checked in the field after each set of measurements and was always found to be within 0.2 dBA.
Height of Noise Measurement Above Grade	S1 to S17: 5 feet, L1: 8 feet, L2: 6 feet, L3: 5 feet
Reason for Delay Between Noise Measurements and Modeling	Noise measurements were made in early summer 2018 to account for higher summer traffic volumes and during a period when shielding from snow did not occur. Noise modeling was conducted once the final traffic volumes and project plans were available for use in the noise model, summer of 2019. No major roadway changes have occurred between when noise measurements were made and noise modeling conducted. Noise model validation is based on traffic counts conducted concurrent with noise measurements; therefore, model validation is unaffected by the time delay. Noise modeling of Existing, No Action, and Proposed Action is based on traffic volumes provided in the Project's traffic study.

4.4 Model Validation

Existing noise levels were measured in the field, as described in Section 4.1, and compared to computer predictions using the traffic data taken during noise measurements to verify the accuracy of the computer model. This process is called model validation. If the predicted and measured levels are within ±3 dBA of each another, the model is within the accepted level of accuracy and is considered to have been validated. Measured noise levels, corresponding modeled noise levels, and the differences between the two are presented in Table 7.

Table 7 Noise Measurement Results and Model Validation Summary

Noise Measurement Location ID	Location (see Figure 2)	Measured Leq (dBA)	Modeled Leq (dBA)	Difference (dBA)	Validation Factor (dBA)
S1	Lawn area north of Fall Line Drive, Vail	64.3	63.5	-0.8	0
		65.1	64.2	-0.9	
S2	3891 Big Horn Road Units B & C, Vail	53.1	56.1	3.0	0
		55	56.7	1.7	

Noise Measurement Location ID	Location (see Figure 2)	Measured Leq (dBA)	Modeled Leq (dBA)	Difference (dBA)	Validation Factor (dBA)
S3	3941-4 & 4011-6 Big Horn Road, Vail	54.9	55	0.1	0
		57.8[1]	56.6	-1.2	
S4	4073 Spruce Way, Vail	57.2	57.7	0.5	0
		57.3	57.7	0.4	
S5	4193a Spruce Way, Vail	55.4[1]	52	-3.4	0
		49.8	51.1	1.3	
S6	4396 Columbine Way, Vail	60.8	62.9	2.1	0
		61.8	62.9	1.1	
S7	4335 Spruce Way, Vail	54.8	58.9[1]	4.1	0
		55.7	57.5	1.8	
S8	4545 Big Horn Road, Vail	56.9	58.2	1.3	0
		58	58.3	0.3	
S9	4770 Vail Racquet Club Townhouse Drive, Vail	58	60.1	2.1	0
		59	59.3	0.3	
S10	L1 & L3 Condos, Vail Racquet Club Townhouse Drive, Vail	57.1	55.6	-1.5	0
		55.3	55.4	0.1	
S11	Pool area, Main Gore Place, Vail	50.8	52.6	1.8	0
		51.6	51.5	-0.1	
S12	5040 Prima Court Unit 1, Vail	51.3	56.2	4.9	-1.5
		52.5	56.5	4.0	
S13	5177 Gore Circle, Vail	54.8[1]	56.9	2.1	-2
		52.1	57.1	5.0	
S14	Vail Pass Recreation Trail, north of I-70, PM 184.5	72.2	70.6	-1.6	0
		72.6	71.5	-1.1	
S15	Vail Pass Recreation Trail, south of I-70, PM 185.5	77.4	76.3	-1.1	0
		77.9	76.2	-1.7	
S16	Black Lakes Trailhead	45.6	52	6.4	-3.2
		45.9	52	6.1	
S17	White River National Forest Trailhead	57.5	59.8	2.3	0

[1] Loud intermittent noise occurring within the interval affected the L_{eq} value. Therefore, noise model was validated using the other measurement interval.

Differences between measured and predicted levels are within the allowable ±3 dBA tolerance for 14 of the 17 measurement locations. For three of the locations (S12, S13, and S16), the traffic noise model results were 4 to 6.4 dBA above measured levels. These locations are depressed 50 to 60 feet below the elevation of I-70 and a short solid concrete safety barrier is constructed at the edge of I-70. The point source height distribution for heavy-duty trucks in TNM 2.5 has been documented to be inconsistent with measured data (NCHRP 2017), with TNM applying more source strength at a height of 12 feet, whereas measured beam-forming results have shown the primary noise source to be at or near ground level. The situation of a low barrier at a height of 50 feet above the location of a receptor, therefore, results in additional noise reduction in real-life conditions (where the traffic noise source is close to the ground) than the modeled results indicate (with a higher elevation noise source overlooking the short barrier). Therefore, the noise model is considered to be validated for this project with validation factors included for the three measured locations indicated.

4.5 TNM Model Inputs

The noise model software being used on this project was TNM Version 2.5, as required by FHWA. It was used to analyze noise levels for existing (2017) and future (2045) conditions. As part of the analysis, noise levels were calculated by the model at receivers in the Noise Study Zone. Receivers included those used for informative purposes and those used to represent one or more receptors. Modeling results represent predicted traffic conditions during worst-hour noise periods. Table 8 describes model inputs and methods.

Table 8 TNM Model Inputs

Noise Sensitive Receptors	Noise sensitive receptors are defined according to Table 3. Receivers (modeled points) have been selected to represent these receptors within the Noise Study Zone. Two Noise Study Areas (NSA) were identified, including residential and recreational receptors located within the City of Vail and trails, parks, and picnic areas located east of the City.
Receivers	Receivers are listed in Table 9 and shown in Figures 4 and 5.
Modeled Roadways	The following roadways were modeled: • I-70 Mainline • EB On Ramp, East Vail • WB Off Ramp, East Vail • EB On Ramp, Rest Area • EB Off Ramp, Rest Area • WB On Ramp, Rest Area • WB Off Ramp, Rest Area For the Proposed Action, the analysis included roads that would be changed or newly built by the project, would have substantially different traffic volumes, or would be important local traffic noise sources.
Differences in How Roadways Were Modeled Between Alternatives	The Existing and No Action Alternatives contain the same geometry, but different traffic volumes, with the No Action Alternative having higher traffic volumes. The No Action and Proposed Action used the same traffic volumes. Under the Proposed Action, changes were made to the alignment of portions of I-70 and an auxiliary lane was added for each direction of the highway (2 lanes total).
TNM Objects and Elevations	The following objects were modeled: receivers, roadways, terrain lines, buildings modeled as noise barriers, noise barriers, and ground zones. These are shown in Figure 3.
Existing Noise Barriers	One concrete noise barrier, approximately 650 feet in length, is located within the project Noise Study Zone. This existing barrier is located along the edge of shoulder of EB I-70, about 2,000 feet east of the Big Horn Road overpass. This noise barrier will not be impacted by the project. In addition, short solid concrete safety barriers are located in the I-70 median and edge of shoulder along most of the project alignment through

	the Town of Vail. Some of these barriers will be relocated to account for project alignment changes.
Modeled Pavement Type	Average (FHWA requirement)
Default Ground Type	Field Grass
Traffic Data (See Appendix B)	• Roadway coordinates generated: from CAD and aerial photographs • Traffic volumes are from: DEA Project Team • Vehicle mix(es) is/are from: DEA Project Team • Basis for identifying traffic noise worst-hour: Long-term noise measurement results, I&R Project Team

5 TNM RESULTS

In the analysis, 69 receivers representing 202 receptors were modeled (see Table 9). The modeled noise levels were used to identify which, if any, receptors would be impacted as a result of the Proposed Action. Six (6) additional locations were modeled to help in the selection of receiver locations for trails but were not found to be representative receptors in accordance with Section 3.1.3 of the 2015 CDOT Noise Analysis and Abatement Guidelines. Noise levels at the extra receivers for trails that were not selected to represent receptors are not included in the noise level ranges given in 5.1, 5.2, or 5.3 and are not considered impacts.

Table 9 Modeled Noise Levels Without Abatement

Receiver ID[1]	Receiver Description	Activity Category / CDOT NAC (dBA)	Number of Receptors Represented by Receiver	Existing (2017) L_{eq} (dBA)	No Action (2045) L_{eq} (dBA)	Proposed Action (2045) L_{eq} (dBA)	Proposed Action Change From Existing (dBA)	Proposed Action Causes Impact? (Yes or No)
S1[3]	Residential	B (66 dBA)	0 (See M1a-w)[3]	65.6	67.9	68.9	3.3	N/A
S2	Residential	B (66 dBA)	9	58.4	60.7	61.2	2.8	No
S3	Residential	B (66 dBA)	15	58.3	60.6	60.7	2.4	No
S4	Residential	B (66 dBA)	7	60.3	62.6	62.9	2.6	No
S5	Residential	B (66 dBA)	12	52.8	55.1	56.6	3.8	No
S6	Residential	B (66 dBA)	1	65.0	67.4	69.5	4.5	Yes
S7	Residential	B (66 dBA)	9	60.3	62.6	61.9	1.6	No

Receiver ID[1]	Receiver Description	Activity Category / CDOT NAC (dBA)	Number of Receptors Represented by Receiver	Existing (2017) L_{eq} (dBA)	No Action (2045) L_{eq} (dBA)	Proposed Action (2045) L_{eq} (dBA)	Proposed Action Change From Existing (dBA)	Proposed Action Causes Impact? (Yes or No)
S8	Residential	B (66 dBA)	8	59.8	62.2	60.4	0.6	No
S9	Residential	B (66 dBA)	16	62.0	64.3	63.4	1.4	No
S10	Residential	B (66 dBA)	8	56.9	59.2	57.8	0.9	No
S11	Residential	B (66 dBA)	1	54.0	56.3	56.0	2.0	No
S12[4]	Residential	B (66 dBA)	3	56.4	58.7	58.7	2.3	No
S13[4]	Residential	B (66 dBA)	5	58.2	60.5	59.4	1.2	No
M1a[5]	Residential	B (66 dBA)	1	70.6	73.0	73.1	3.2	Yes
M1b[5]	Residential	B (66 dBA)	1	69.6	72.0	72.1	2.5	Yes
M1c[5]	Residential	B (66 dBA)	1	69.3	71.7	71.6	2.5	Yes
M1d[5]	Residential	B (66 dBA)	1	68.5	70.8	70.7	2.3	Yes
M1e[5]	Residential	B (66 dBA)	1	65.5	67.8	67.7	2.2	Yes
M1f[5]	Residential	B (66 dBA)	1	67.3	69.6	69.5	2.2	Yes
M1g[5]	Residential	B (66 dBA)	1	65.2	67.5	67.3	2.2	Yes
M1h[5]	Residential	B (66 dBA)	1	59.2	61.6	61.5	2.1	No
M1i[5]	Residential	B (66 dBA)	1	63.8	66.1	66.2	2.3	Yes
M1j[5]	Residential	B (66 dBA)	1	66.3	68.7	68.6	2.4	Yes
M1k[5]	Residential	B (66 dBA)	1	65.6	68.0	68.0	2.3	Yes

Receiver ID[1]	Receiver Description	Activity Category / CDOT NAC (dBA)	Number of Receptors Represented by Receiver	Existing (2017) L_{eq} (dBA)	No Action (2045) L_{eq} (dBA)	Proposed Action (2045) L_{eq} (dBA)	Proposed Action Change From Existing (dBA)	Proposed Action Causes Impact? (Yes or No)
M1l[5]	Residential	B (66 dBA)	1	64.5	66.8	67.0	2.4	Yes
M1m[5]	Residential	B (66 dBA)	1	63.6	66.0	65.9	2.5	Yes
M1n[5]	Residential	B (66 dBA)	1	63.0	65.3	65.1	2.3	No
M1o[5]	Residential	B (66 dBA)	1	53.6	56.0	56.1	2.1	No
M1p[5]	Residential	B (66 dBA)	1	65.5	67.9	67.6	2.5	Yes
M1q[5]	Residential	B (66 dBA)	1	69.2	71.6	71.6	2.1	Yes
M1r[5]	Residential	B (66 dBA)	1	69.7	72.1	72.1	2.4	Yes
M1s[5]	Residential	B (66 dBA)	1	69.0	71.4	71.5	2.4	Yes
M1t[5]	Residential	B (66 dBA)	1	62.9	65.3	65.7	2.5	Yes
M1u[5]	Residential	B (66 dBA)	1	67.0	69.3	69.5	2.8	Yes
M1v[5]	Residential	B (66 dBA)	1	68.2	70.5	70.7	2.5	Yes
M1w[5]	Residential	B (66 dBA)	1	70.0	72.3	72.4	2.5	Yes
M2a[5]	Residential	B (66 dBA)	1	69.3	71.6	71.7	2.4	Yes
M2b[5]	Residential	B (66 dBA)	1	65.5	67.9	68.1	2.6	Yes
M2c[5]	Residential	B (66 dBA)	1	66.8	69.1	69.4	2.6	Yes
M2d[5]	Residential	B (66 dBA)	1	68.6	71.0	71.4	2.8	Yes
M2e[5]	Residential	B (66 dBA)	1	66.0	68.3	68.4	2.4	Yes

Receiver ID[1]	Receiver Description	Activity Category / CDOT NAC (dBA)	Number of Receptors Represented by Receiver	Existing (2017) L_{eq} (dBA)	No Action (2045) L_{eq} (dBA)	Proposed Action (2045) L_{eq} (dBA)	Proposed Action Change From Existing (dBA)	Proposed Action Causes Impact? (Yes or No)
M2f[5]	Residential	B (66 dBA)	1	68.2	70.5	70.8	2.6	Yes
M2g[5]	Residential	B (66 dBA)	1	70.3	72.7	73.1	2.8	Yes
M2h	Trailhead	C (66 dBA)	1	64.9	67.2	68.2	3.3	Yes
M3a	Residential	B (66 dBA)	1	65.6	68.0	69.6	4.0	Yes
M3b	Residential	B (66 dBA)	1	57.8	60.1	61.7	3.9	No
M3c[5]	Residential	B (66 dBA)	1	54.3	56.7	57.8	3.5	No
M3d	Trailhead	C (66 dBA)	1	53.1	55.5	56.9	3.8	No
M3e[5]	Residential	B (66 dBA)	1	56.5	58.9	61.2	4.7	No
M3f	Residential	B (66 dBA)	1	50.5	52.8	54.1	3.6	No
M3g[5]	Residential	B (66 dBA)	1	55.8	58.2	59.5	3.7	No
M3h[5]	Residential	B (66 dBA)	1	58.1	60.4	61.6	3.5	No
M3i[5]	Residential	B (66 dBA)	1	59.1	61.5	63.3	4.2	No
M4	Residential	B (66 dBA)	6	57.0	59.4	58.5	1.5	No
M5	Residential	B (66 dBA)	5	59.9	62.2	62.1	2.2	No
M6	Residential	B (66 dBA)	7	62.2	64.5	63.1	0.9	No
M7	Residential	B (66 dBA)	25	58.9	61.2	60.5	1.6	No
M8	Residential	B (66 dBA)	9	55.7	58.1	57.6	1.9	No

Receiver ID[1]	Receiver Description	Activity Category / CDOT NAC (dBA)	Number of Receptors Represented by Receiver	Existing (2017) L_{eq} (dBA)	No Action (2045) L_{eq} (dBA)	Proposed Action (2045) L_{eq} (dBA)	Proposed Action Change From Existing (dBA)	Proposed Action Causes Impact? (Yes or No)
M9[3]	Residential	B (66 dBA)	7	59.9	62.3	63.1	3.2	No
S14	Trail	C (66 dBA)	1	73.4	75.8	76.2	2.8	Yes
S15[2]	Trail	C (66 dBA)	0 (See M15) [2]	78.7	81.1	80.5	1.8	N/A
S16[4]	Trailhead	C (66 dBA)	1	51.9	54.2	54.1	2.2	No
S17	Rest Area & Trailhead	C (66 dBA)	3	63.9	66.3	67.6	3.7	Yes
M10[2]	Trail	C (66 dBA)	0 (See S14) [2]	64.2	66.6	68.0	3.8	N/A
M11[2]	Trail	C (66 dBA)	0 (See S14) [2]	63.2	65.5	66.0	2.8	N/A
M12[2]	Trail	C (66 dBA)	0 (See S14) [2]	60.5	62.9	63.7	3.2	N/A
M13[2]	Trail	C (66 dBA)	0 (See S14) [2]	71.7	74.1	74.3	2.6	N/A
M14[2]	Trail	C (66 dBA)	0 (See M15) [2]	78.2	80.5	80.5	2.3	N/A
M15	Trail	C (66 dBA)	1	67.4	69.7	70.0	2.6	Yes
M16[3]	Fishing Pier	C (66 dBA)	1	57.9	60.3	59.5	1.6	No
M17	Fishing Pier	C (66 dBA)	1	56.9	59.2	59.0	2.1	No
M18	Trail Crossing	C (66 dBA)	1	61.3	63.6	65.0	3.7	No
M19	Recreation	C (66 dBA)	1	59.7	60.3	59.6	1.7	No

[1] Measurement locations for model validation were chosen to also be representative of noise sensitive areas (e.g., receptors) that would be modeled as receivers for calculation of Existing and Future Design Year traffic noise levels. These locations are identified in this table and throughout the report with an "S". Modeled receiver locations that did not include a measurement are identified with an "M".

[2] This receiver was modeled to help identify the location of the worst expected traffic noise condition for the trail but was not used as a receptor in the noise analysis. In accordance with Section 3.1.3 of the 2015 CDOT Noise Analysis and

Abatement Guidelines, one receptor was selected for each trail at a distance no closer than 50 feet from the edge of pavement in the 'worst expected traffic noise condition' location. Receiver S14 was used to represent the trail located northeast of I-70. Receivers M10, M11, M12, and M13 were not selected as receptor locations because noise levels at these locations were below those at the selected receptor location, S14. Receiver M15 was used to represent the trail located southwest of I-70. Although noise levels at S15 and M14 are higher than those at M15, these locations are closer than 50 feet from the edge of pavement.

[3] This measurement location was used for validation of the traffic noise model but was not used as a receiver in the noise analysis. Modeled receivers M1a through M1w are representative of receptors in the vicinity of S1.

[4] Validations factors were applied to these receivers, as described in Section 4.4.

[5] These receivers are representative of upper story balconies and are modeled at a height of 5 feet above the height of the balcony to represent a standing receptor.

5.1 Existing Conditions Summary

Under existing conditions (2017), modeled noise levels at 69 receivers range from 50.5 to 73.4 dBA. Figure 4 shows the locations of all modeled receivers. Table 9 has the modeled noise level at each receiver. Existing conditions are not described as having noise impacts. If the project were not built, the project would not be responsible to mitigate noise via an abatement measure regardless of if existing noise levels exceeded NACs.

5.2 No Action Alternative Summary

Under the No Action Alternative (2045), modeled noise levels at 69 receivers range from 52.8 to 75.8 dBA. Figure 4 shows the locations of all modeled receivers. Table 9 has the modeled noise level at each receiver. No Action Alternatives are not described as having noise impacts. If the project were not built, the project would not be responsible to mitigate noise via an abatement measure regardless of if No Action Alternative noise levels exceeded NACs.

5.3 Proposed Action Summary

Under the Proposed Action (2045), modeled noise levels at 69 receivers range from 54.1 to 76.2 dBA. 33 receivers, representing 35 receptors, would exceed the NAC. None of the receivers, and therefore receptors, would experience a substantial noise increase of at least 10 dBA. Therefore, a total of 33 receivers, representing 35 receptors, would be impacted during the design year worst-hour noise period (see Figure 5). Table 9 has the modeled noise level at each receiver.

5.4 Considered Alternative Summary

This project does not have any Considered Alternatives.

6 NOISE ABATEMENT EVALUATION

As described in Chapter 5, 35 receptors in the Noise Study Zone would be impacted by noise in 2045 under the Proposed Action. Therefore, abatement for the impacted receptors was evaluated in accordance with guidelines from CDOT's NAAG and FHWA's Guidelines. Although abatement was required to be evaluated, it is only recommended for inclusion in the project when determined to be both feasible and reasonable.

Abatement is feasible if it:

- Provides at least 5 dBA of noise reduction for at least one receptor
- Does not have any "fatal flaw" issues (e.g., safety, maintenance, access, drainage)
- Does not exceed 20 feet in height in order to reduce noise by at least 7 dBA

If abatement is not feasible, further evaluation is not needed. However, if it is feasible, reasonableness is evaluated. Abatement is reasonable if it:

- Meets the minimum noise reduction design goal of at least 7 dBA for at least one receptor
- The Cost Benefit ($/dBA/receptor) equals or is less than the Cost Benefit Index ($6,800/dBA/receptor)
- Has support from more than 50 percent of the potentially benefited receptors (Support determined through Benefited Receptor Preference Survey, which may be conducted after the NEPA process and is documented in a separate report.)

6.1 Noise Abatement Options Considered

Noise barriers (walls and, to a lesser extent, berms) are commonly used as noise abatement and must be evaluated for all impacted receptors, per 23 CFR 772.13(c)(1). Other mitigation measures may also be considered, including traffic management measures (e.g., 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); alteration of horizontal and vertical alignments; and acquisition of real property or interests therein to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise. However, these mitigation measures are generally not feasible and/or reasonable. For this project, noise walls and/or berms were the only abatement evaluated.

6.2 Noise Abatement: Noise Insulation

The Noise Study Zone does not have any Activity Category D receptors. Therefore, noise insulation was not considered as abatement for this project.

6.3 Noise Barrier Evaluation

The Proposed Action has 5 impacted areas. Barrier placement for each impacted area was considered in multiple locations. The location determined to be the best performer for each set of impacted receivers was optimized, and those results are described in Table 10. Barriers to shield Vail Pass Recreation Trail, which runs parallel to I-70, were modeled to shield the entire portion of the trail that would benefit from the construction of a barrier, not just the section of the trail that was selected as a receptor location.

Figure 6 shows the best performing evaluated barrier location. Appendix D has 5 CDOT Noise Abatement Determination Worksheet(s) (CDOT Form 1209); one was completed for each optimized barrier.

Of the 5 evaluated barriers, only Evaluated Barrier 1 was found to be both feasible and reasonable, as described in Table 10. The remaining 4 evaluated barriers were determined to be feasible but not reasonable because the Cost Benefit exceeded the Cost Benefit Index. With construction of the Proposed Action, the trail would be moved further from I-70 in some areas, resulting in reduced noise levels from Existing levels.

Table 10 Noise Barrier Evaluation

Barrier ID	Evaluated Barrier 1	Evaluated Barrier 2	Evaluated Barrier 3	Evaluated Barrier 4	Evaluated Barrier 5
Barrier Location (approximate)	WB EOS, MP 180	WB EOS, MP 180.5	WB EOS, MP 182 to 185.5	EB EOS, MP 185.5 to 189	EB EOS, MP 190
Barrier Location: Distance from Proposed Edge of Roadway (feet)	Edge of Shoulder (EOS)	Edge of Shoulder (EOS)	Edge of Shoulder (EOS)	Edge of Shoulder (EOS)	Edge of Shoulder (EOS)
Benefited Receiver IDs	S1, M1(b-m, p-w), M2(a-h)	S6, M3(a, b, c, e)	S14	M15	S17
Figure #	6a	6a & 6b	6c	6d	6e
Recommended Barrier Height & Length (feet)[1]	20 ft high x 1,350 ft long	20 high x 520 ft long	20 high x 15,550 ft long	8 high x 19,440 ft long	18 high x 1,160 ft long
Barrier Area (square feet)	27,000 ft^2	10,400 ft^2	311,200 ft^2	155,520 ft^2	20,880 ft^2
Unit Cost	\$45/ft^2	\$45/ft^2	\$45/ft^2	\$45/ft^2	\$45/ft^2
Total Cost	\$1,215,000	\$468,000	\$13,995,000	\$6,998,400	\$939,600
No. Benefited Receptors	28	5	1	1	3
Total Decibels of Benefit Provided	266.8	39.8	12.2	9.4	21.6
Average Benefit (dBA/receptor)	9.5	8.0	12.2	9.4	7.2
Cost Benefit (\$/dBA/receptor)	\$4,554	\$11,759	\$1,147,131	\$744,511	\$43,500
Design year Leq Range Without Abatement (dBA)	61.5 to 73.1	57.8 to 69.6	76.2	70.0	67.6
Design year Leq Range With Abatement (dBA)	52.3 to 65.9	52.3 to 59.9	64.0	60.6	60.4
Feasible?	Yes	Yes	Yes	Yes	Yes
Reasonable?	>\$6,800/dBA/ receptor	>\$6,800/dB A/receptor	>\$6,800/dB A/receptor	>\$6,800/dB A/receptor	>\$6,800/dB A/receptor
Recommended?	Yes	No	No	No	No

[1] Barriers were assessed at barrier heights ranging from 8 to 20 feet. Barrier heights resulting in the lowest cost benefit (\$/dBA/receptor) are recommended.

Table 11A Modeled Noise Levels With and Without Barrier: Evaluated Barrier 1

Benefited Receiver ID	Benefited Receiver Description	Number of Benefited Receptors Represented per Receiver	Proposed Action (2045) (dBA)		
			L_{eq} Without Abatement	L_{eq} With Abatement	Insertion Loss
M1a	Pitkin Creek Unit 23	1	73.1	69.1	4.0
M1b	Pitkin Creek Unit 22	1	72.1	65.9	6.2
M1c	Pitkin Creek Unit 21	1	71.6	64.0	7.6
M1d	Pitkin Creek Unit 20	1	70.7	61.9	8.8
M1e	Pitkin Creek Unit 19	1	67.7	60.6	7.1
M1f	Pitkin Creek Unit 18	1	69.5	62.4	7.1
M1g	Pitkin Creek Unit 17	1	67.3	59.0	8.3
M1h	Pitkin Creek Unit 16	1	61.5	52.3	9.2
M1i	Pitkin Creek Unit 15	1	66.2	59.2	7.0
M1j	Pitkin Creek Unit 14	1	68.6	61.9	6.7
M1k	Pitkin Creek Unit 13	1	68.0	62.0	6.0
M1l	Pitkin Creek Unit 12	1	67.0	61.5	5.5
M1m	Pitkin Creek Unit 7	1	65.9	61.1	4.8
M1n	Pitkin Creek Unit 6	1	65.1	60.6	4.5
M1o	Pitkin Creek Unit 5	1	56.1	55.0	1.1
M1p	Pitkin Creek Unit 11	1	69.5	60.5	9.0
M1q	Pitkin Creek Unit 10	1	70.7	62.2	8.5
M1r	Pitkin Creek Unit 9	1	70.6	62.2	8.4
M1s	Pitkin Creek Unit 8	1	72.4	63.2	9.2
M1t	Pitkin Creek Unit 4	1	66.7	54.1	12.6
M1u	Pitkin Creek Unit 3	1	67.6	55.0	12.6
M1v	Pitkin Creek Unit 2	1	71.6	60.8	10.8
M1w	Pitkin Creek Unit 1	1	71.5	59.4	12.1
M2a	4030 Fall Line Drive, Unit A	1	71.7	60.0	11.7
M2b	4030 Fall Line Drive, Unit B	1	68.1	53.7	14.4
M2c	4030 Fall Line Drive, Unit C	1	69.4	54.8	14.6
M2d	4030 Fall Line Drive, Unit D	1	71.4	58.2	13.2
M2e	4040 Fall Line Drive, Unit A	1	68.4	57.6	10.8

Benefited Receiver ID	Benefited Receiver Description	Number of Benefited Receptors Represented per Receiver	Proposed Action (2045) (dBA)		
			L_{eq} Without Abatement	L_{eq} With Abatement	Insertion Loss
M2f	4040 Fall Line Drive, Unit B	1	70.8	58.1	12.7
M2g	4040 Fall Line Drive, Unit B	1	73.1	60.1	13.0
M2h	Pitkin Trailhead	1	68.2	59.3	8.9

Table 11B Modeled Noise Levels With and Without Barrier: Evaluated Barrier 2

Benefited Receiver ID	Benefited Receiver Description	Number of Benefited Receptors Represented per Receiver	Proposed Action (2045) (dBA)		
			L_{eq} Without Abatement	L_{eq} With Abatement	Insertion Loss
S6	4396 Columbine Drive	1	69.5	57.7	12.3
M3a	4367 Columbine Drive	1	69.6	59.9	9.7
M3b	4406 Columbine Drive	1	61.7	54.1	7.6
M3c	4410 Columbine Drive	1	57.8	52.3	5.5
M3d	Bighorn Trailhead	1	56.9	53.3	3.6
M3e	4413 Columbine Drive - 1	1	61.2	56.5	4.7
M3f	4413 Columbine Drive - 2	1	54.1	51.0	3.1
M3g	4414 Columbine Drive - 1	1	59.5	56.5	3.0
M3h	4414 Columbine Drive - 2	1	61.6	58.5	3.1
M3i	4416 Columbine Drive	1	63.3	63.3	0

Table 11C Modeled Noise Levels With and Without Barrier: Evaluated Barrier 3

Benefited Receiver ID	Benefited Receiver Description	Number of Benefited Receptors Represented per Receiver	Proposed Action (2045) (dBA)		
			L_{eq} Without Abatement	L_{eq} With Abatement	Insertion Loss
S14	Vail Pass Recreation Trail	1	76.2	64.0	12.2

Table 11D Modeled Noise Levels With and Without Barrier: Evaluated Barrier 4

Benefited Receiver ID	Benefited Receiver Description	Number of Benefited Receptors Represented per Receiver	Proposed Action (2045) (dBA)		
			L_{eq} Without Abatement	L_{eq} With Abatement	Insertion Loss
M15	Vail Pass Recreation Trail	1	70.0	60.6	9.4

Table 11E Modeled Noise Levels With and Without Barrier: Evaluated Barrier 5

Benefited Receiver ID	Benefited Receiver Description	Number of Benefited Receptors Represented per Receiver	Proposed Action (2045) (dBA)		
			L_{eq} Without Abatement	L_{eq} With Abatement	Insertion Loss
S17	Vail Pass Rest Area White and River National Forest Trailhead	3	67.6	60.4	7.2

7 STATEMENT OF LIKELIHOOD

The noise abatement evaluation for the Proposed Action is described in Chapter 6. 33 receivers, representing 35 receptors, were determined to be impacted by traffic noise in 2045 for the Proposed Action. Noise impacted areas include Activity Category B and C uses located northeast of I-70 between MP 180 and MP 182 (S1, S6, M1a-g, M1i-m, M1p-w, M2a-h, M3a) and Activity Category C areas located on both sides of I-70, east of MP 182 (S14, S17, and M15). Noise abatement was evaluated for each impacted area. Of the 5 evaluated barriers, only Evaluated Barrier 1 was found to be both feasible and reasonable, as described in Section 6.3 and Table 10. Therefore, the following noise wall is recommended to be constructed:

- Evaluated Barrier 1: WB I-70 Edge of Shoulder near MP 180, 20 feet high by 1,350 feet long

Noise abatement at 4 impacted areas were determined to be feasible but not reasonable because the Cost Benefit exceeded the Cost Benefit Index, as described in Section 6.3 and Table 10.

Note that feasibility and reasonableness determinations for this project may change if there are changes in final design after approval of the NEPA documentation. In addition, abatement won't be built if the Benefited Receptor Preference Survey results in 50 percent or less support for the abatement.

8 CONSTRUCTION NOISE

This chapter describes construction noise implications, construction noise mitigation strategies, and applicable local noise ordinances.

8.1 Construction Noise Implications

Properties adjoining project construction may be exposed to noise from construction activities from the Proposed Action. Examples of noise from construction equipment are shown in Table 12. Construction noise differs from traffic noise in several ways:

- Construction noise lasts only for the duration of construction, with most construction activities in noise-sensitive areas being conducted during hours that are least disturbing to most nearby residents, when feasible.
- Construction activities generally are short term and, depending on the nature of the construction operations, last from seconds (e.g., a truck passing a receptor) to months (e.g., bridge construction).
- Construction equipment noise is intermittent and depends on the type of operation, location, and function of the equipment, as well as the equipment usage cycle.
- As opposed to operational traffic noise, construction noise is not analyzed; there are no FHWA or CDOT construction NACs. However, construction noise is subject to relevant local regulations and ordinances (see Section 8.3).

Table 12 Typical Construction Equipment Noise

Equipment	Maximum Noise Level (dBA at 50 feet)[1]
Scraper	89
Dozer (Bulldozer)	85
Truck (Heavy Truck)	88[2]
Pickup Truck	55
Concrete Pump Truck	82
Backhoe	80
Pneumatic Tools	85

Notes:

1. Noise levels are from Table 9.1 of FHWA's 2006 Construction Noise Handbook (FHWA, 2006).
2. This noise level is from Table 9.9 of FHWA's 2006 Construction Noise Handbook (FHWA, 2006), which is taken from Chapter 12 of the FTA Transit Noise and Vibration Guidance Handbook.

8.2 Construction Noise Mitigation Strategies

To minimize construction noise levels, typical best management practices will be incorporated into construction contracts where it is appropriate to do so. These may include:

- Notify neighbors in advance when construction noise may occur.
- Keep noisy activities as far from sensitive receptors as possible.
- Keep exhaust systems on equipment in good working order. Maintain equipment on a regular basis; it should be subject to inspection by the construction project manager to ensure maintenance is being conducted.
- Use properly designed engine enclosures and intake silencers if appropriate.
- Place stationary equipment as far from sensitive receptors as possible.

- Perform construction activities in noise sensitive areas during hours that are least disturbing to nearby residents, as feasible.

8.3 Local Noise Ordinances

The project occurs in Vail, Colorado and Unincorporated Eagle and Summit Counties, Colorado.

The Town of Vail prohibits the "making and creating of an excessive or an unusually loud noise at any location within the town heard and measured in a manner hereinafter set forth ... except when made under and in compliance with a permit." Construction equipment operation is limited to between the hours of 7:00 a.m. and 7:00 p.m. During allowable hours, the operation of the construction equipment shall not exceed 90 dBA.

Unincorporated Eagle County does not have any local noise ordinances. Therefore, Colorado Noise Statute 25-12-103 applies in areas outside the Town of Vail. Colorado Noise Statute 25-12-103 limits noise at 25 feet from the project boundary to 80 dBA or less between the hours of 7:00 a.m. and 7:00 p.m. and 75 dBA or less between the hours of 7:00 p.m. until 7:00 a.m.

9 INFORMATION FOR LOCAL OFFICIALS

This project's Noise Study Zone does not include any land that is unpermitted and undeveloped (i.e., Activity Category G). Therefore, 23 CFR 772.17 is not applicable and related information does not need to be provided to local officials.

10 SOURCES AND REFERENCES

CEQ, 1997. *Environmental Justice: Guidance under the National Environmental Policy Act. Council on Environmental Quality (CEQ). December 10, 1997. Accessed January 2017.*

CDOT, 2017. *CDOT NEPA Manual, Colorado Department of Transportation (CDOT), August 2017. Accessed January 2017 and April 2018.*

CDOT. 2015. *Noise Analysis and Abatement Guidelines*, January.

David Evans and Associates. *Draft traffic volumes, provided July 29, 2019. (Once final traffic report is available, Traffic Noise Technical Report may be updated, as appropriate.)*

FHWA. 2018. Noise *Measurement Handbook*, June.

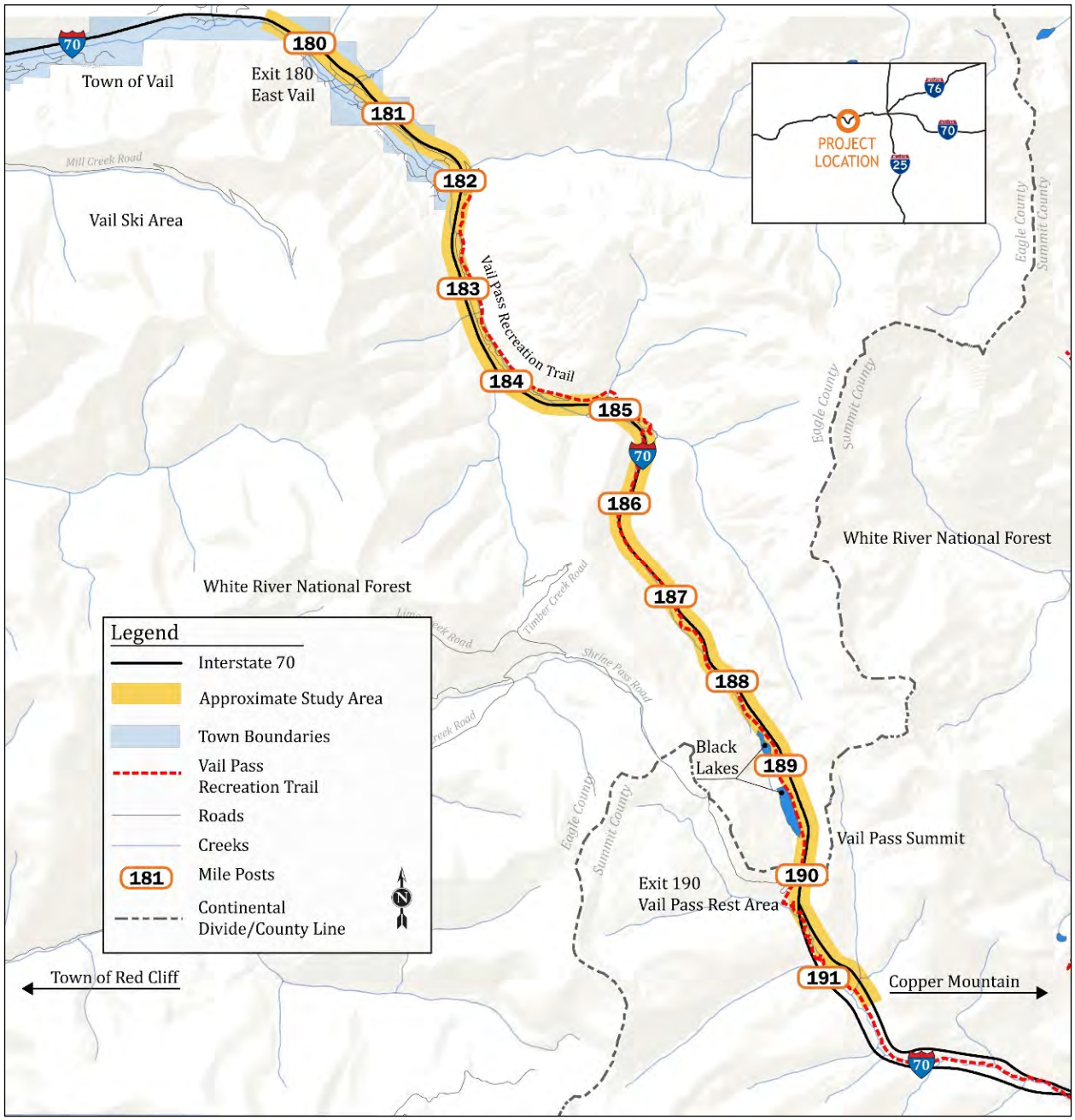
FHWA. 2006. *Construction Noise Handbook*, August.

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

NCHRP 2017. *Mapping Heavy Vehicle Noise Source Heights for Highway Noise Analysis,* Research Report 842.

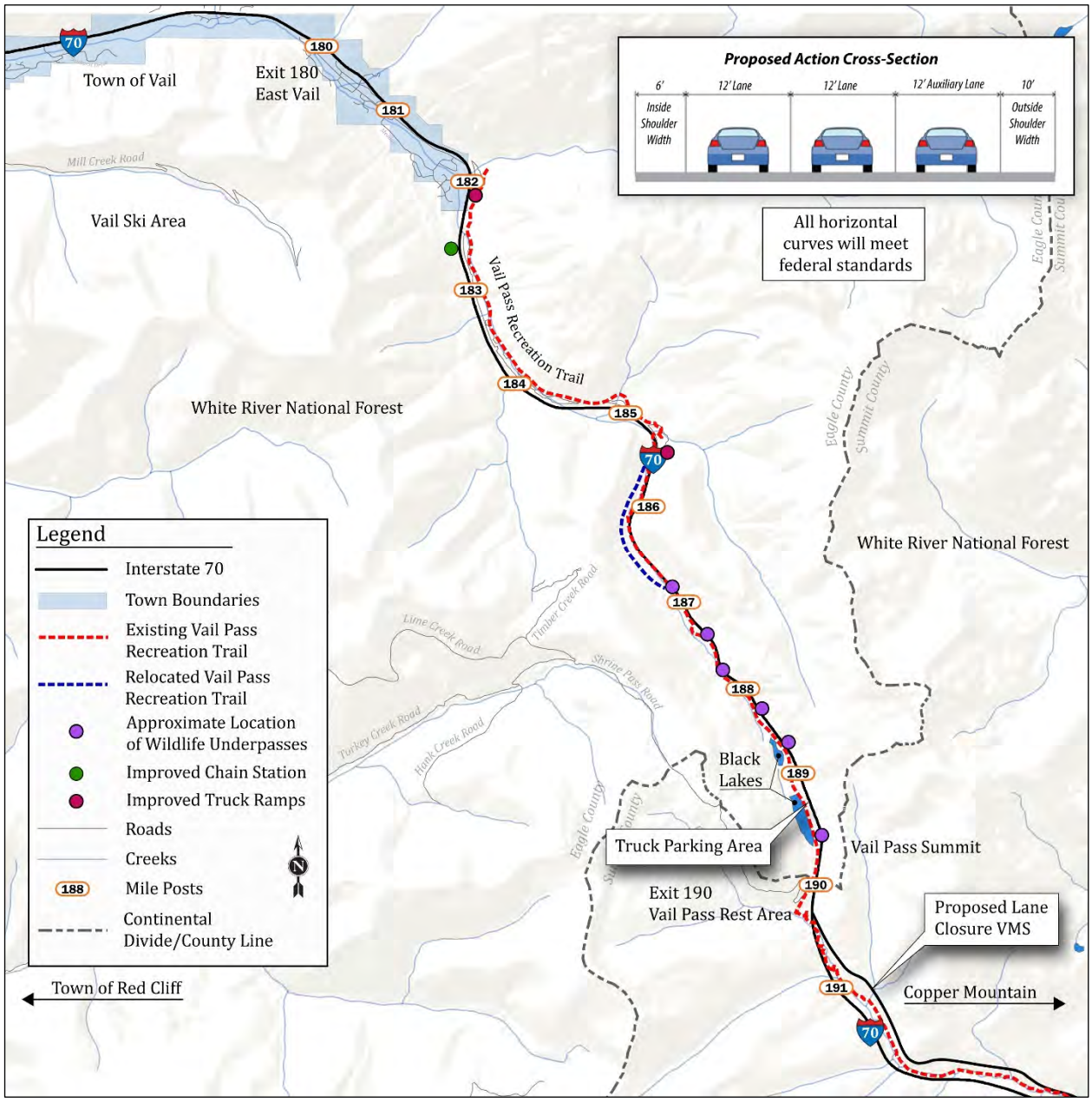
Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 C.F.R. § 772 (2010)

Figure 1A I-70 West Vail Pass Auxiliary Lanes Project Location and Study Area

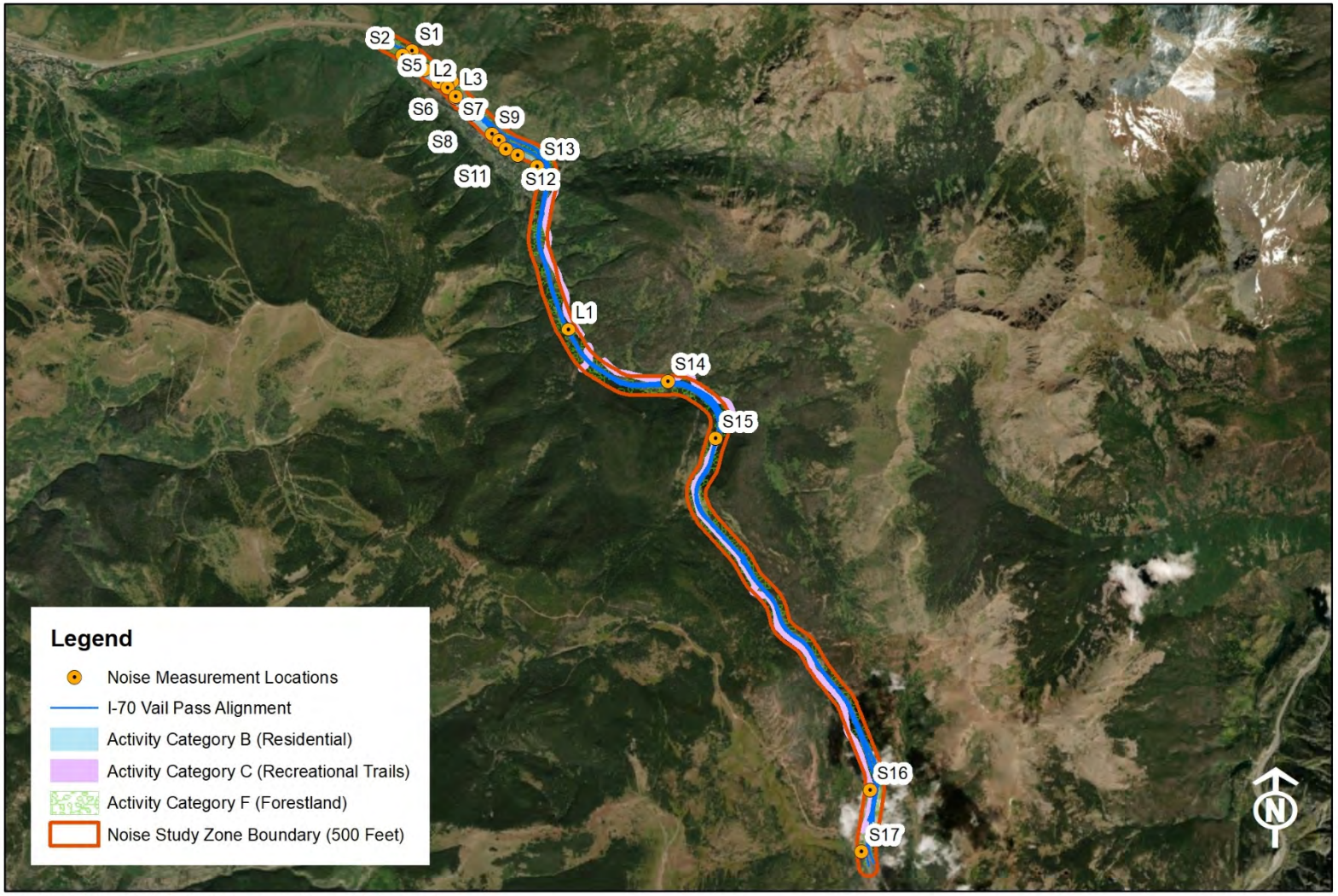


Source: DEA Project Team

Figure 1B I-70 West Vail Pass Auxiliary Lanes Proposed Action Alternative



Source: DEA Project Team



I-70 West Vail Pass Auxiliary Lanes
Figure 2: Noise Study Zone, Activity Categories, and Noise Measurement Locations

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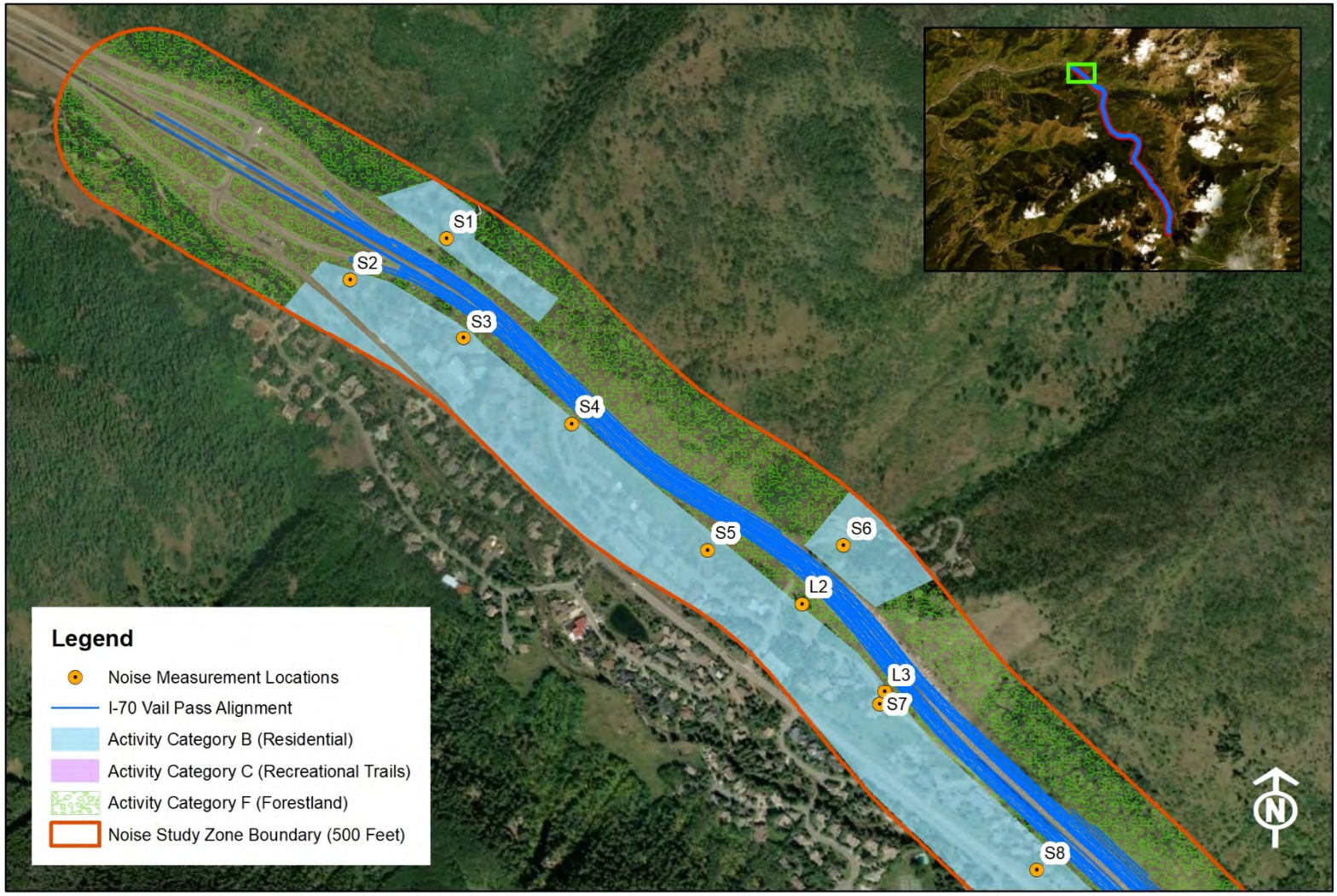
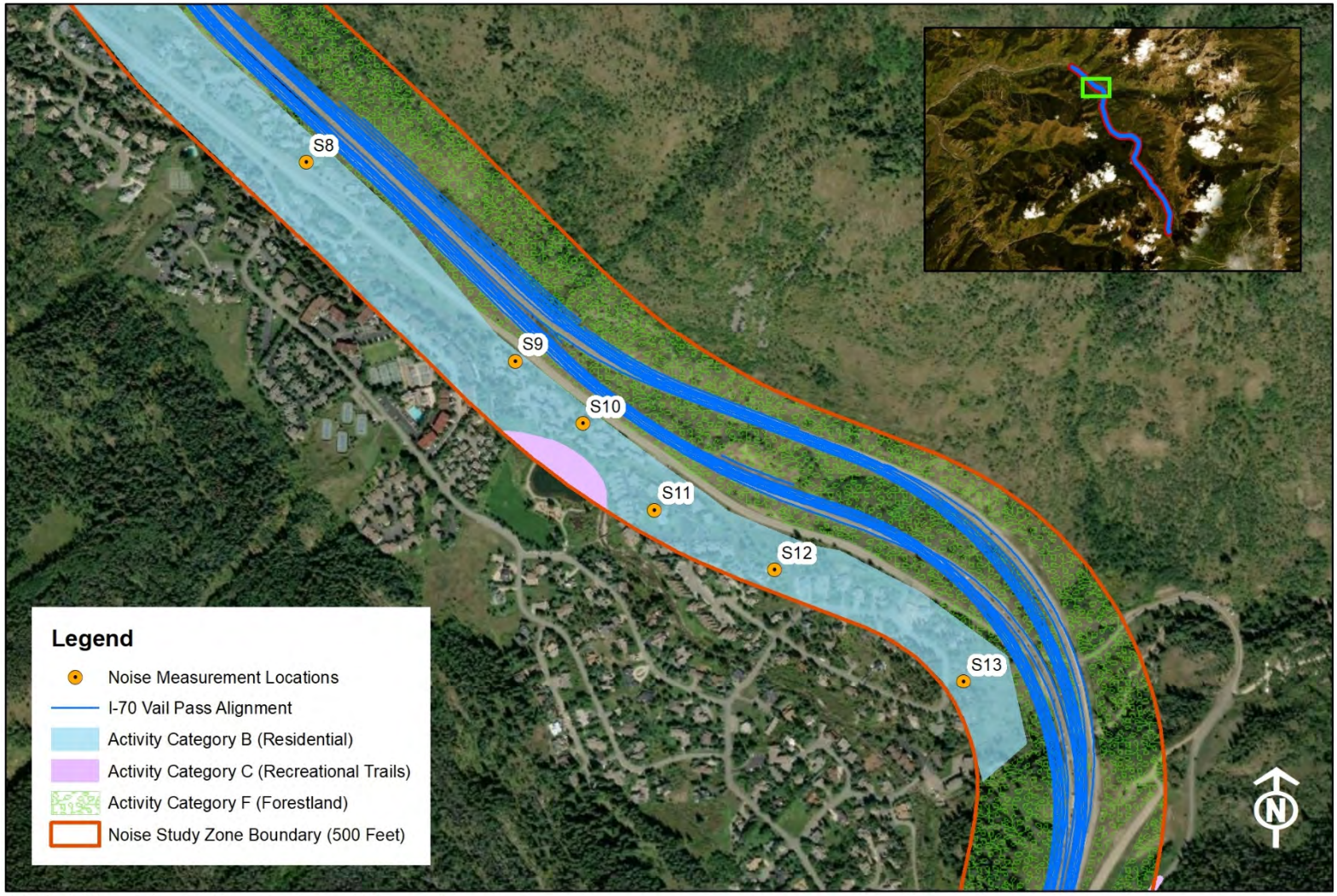


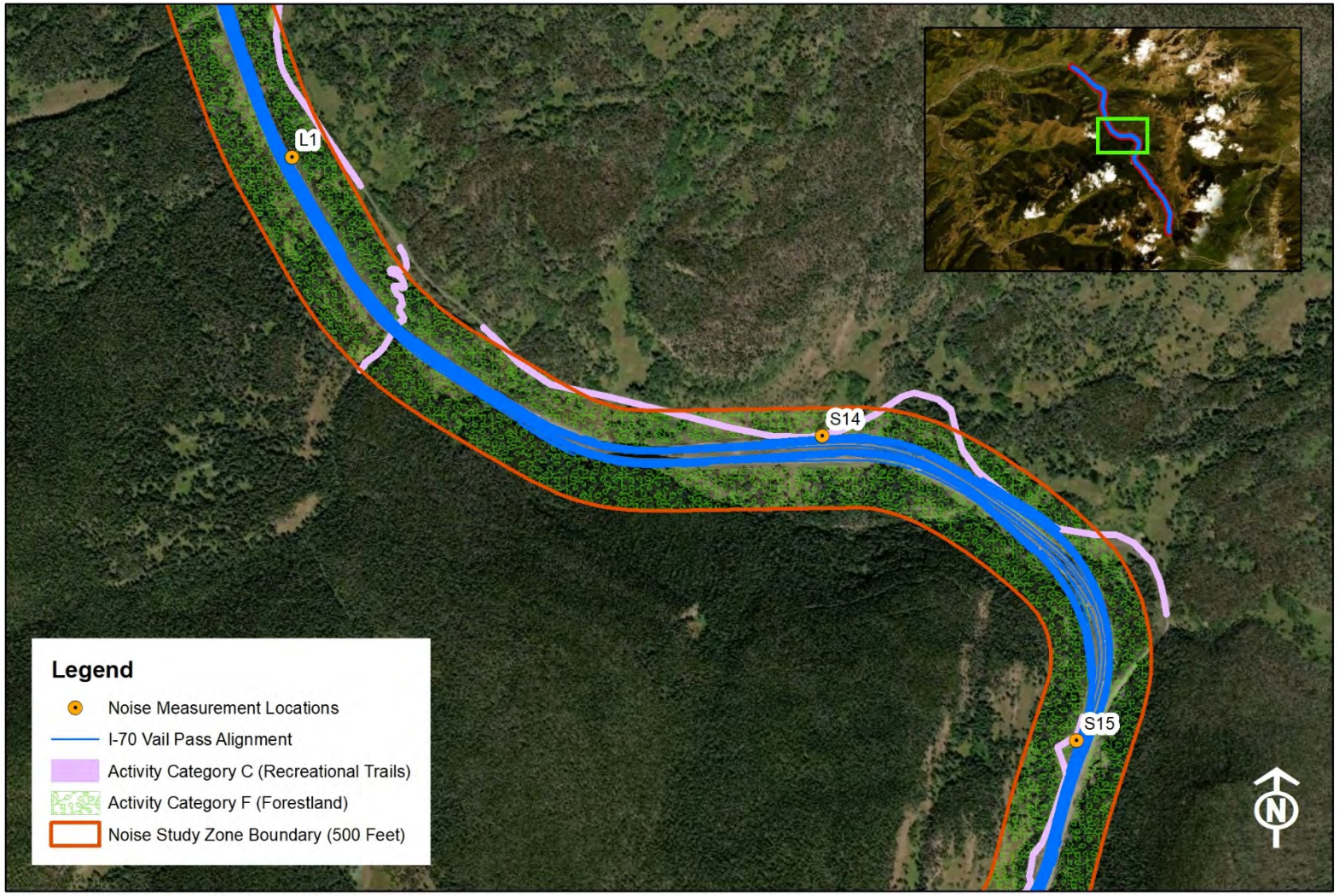
I-70 West Vail Pass Auxiliary Lanes
Figure 2a: Noise Study Zone, Activity Categories, and Noise Measurement Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



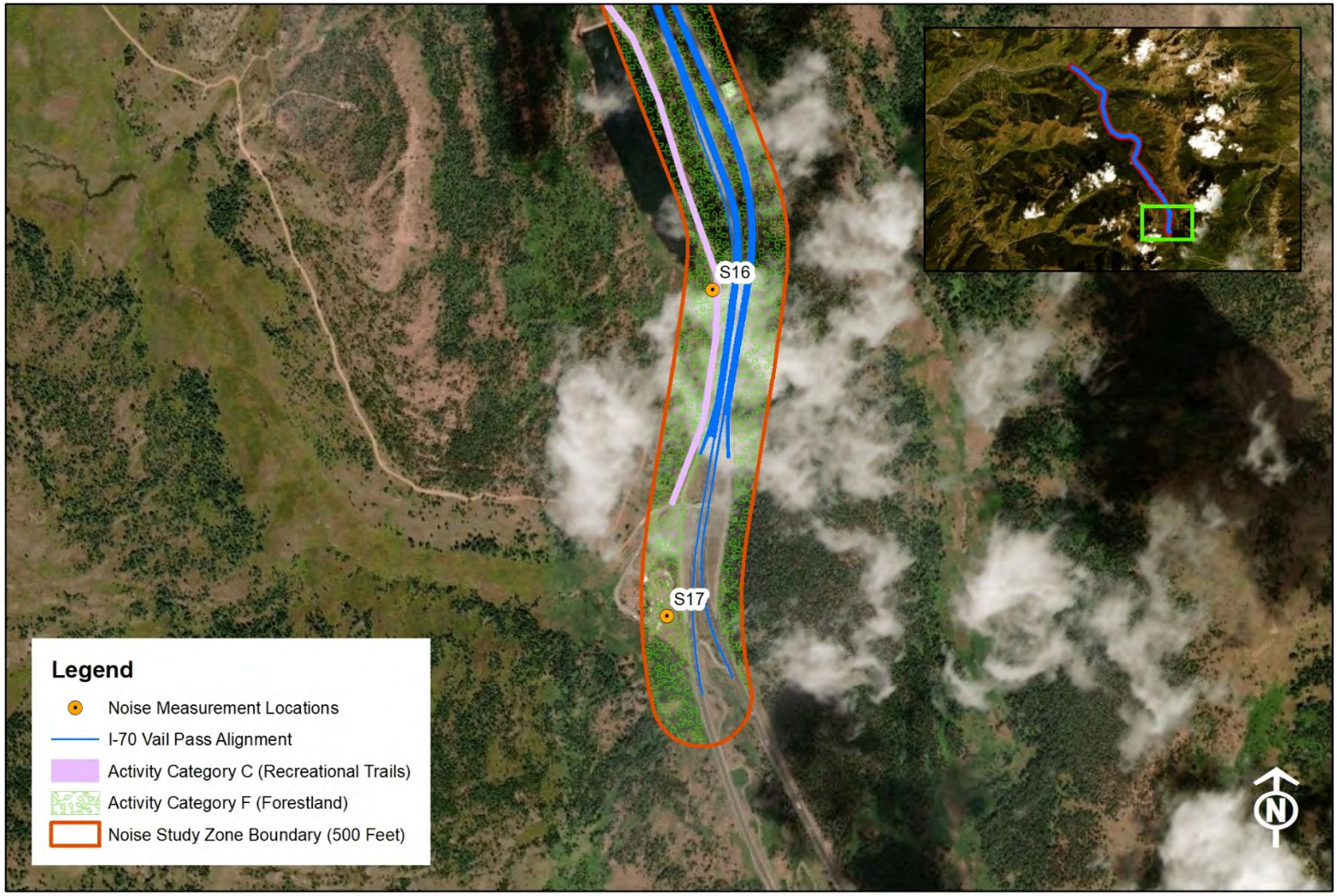
I-70 West Vail Pass Auxiliary Lanes
Figure 2b: Noise Study Zone, Activity Categories, and Noise Measurement Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



I-70 West Vail Pass Auxiliary Lanes
Figure 2c: Noise Study Zone, Activity Categories, and Noise Measurement Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



I-70 West Vail Pass Auxiliary Lanes
Figure 2d: Noise Study Zone, Activity Categories, and Noise Measurement Locations

ILLINGWORTH & RODKIN, INC.
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Figure 3A TNM Model Objects for 2045 Proposed Action: East Vail, West Side

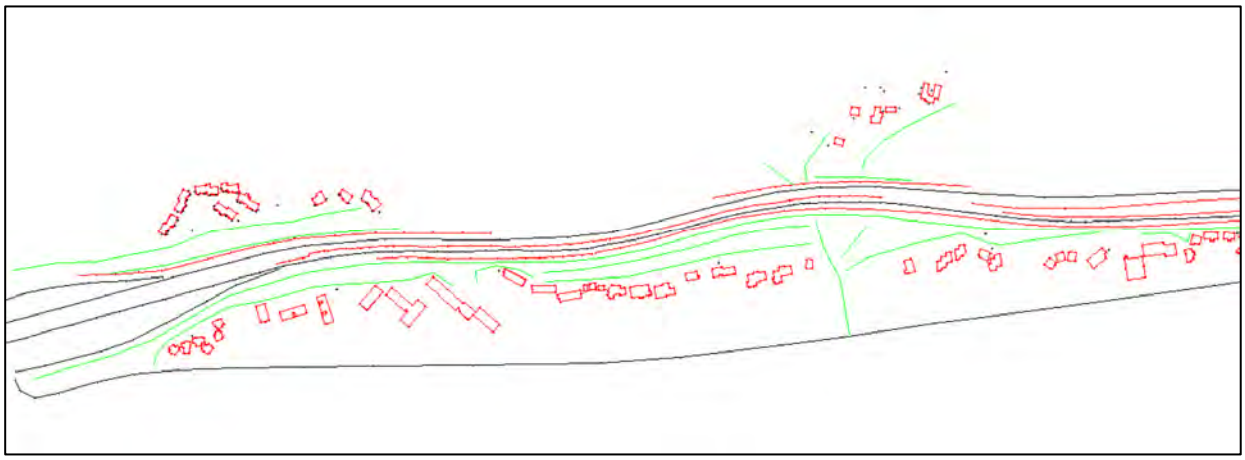


Figure 3B TNM Model Objects for 2045 Proposed Action: East Vail, East Side

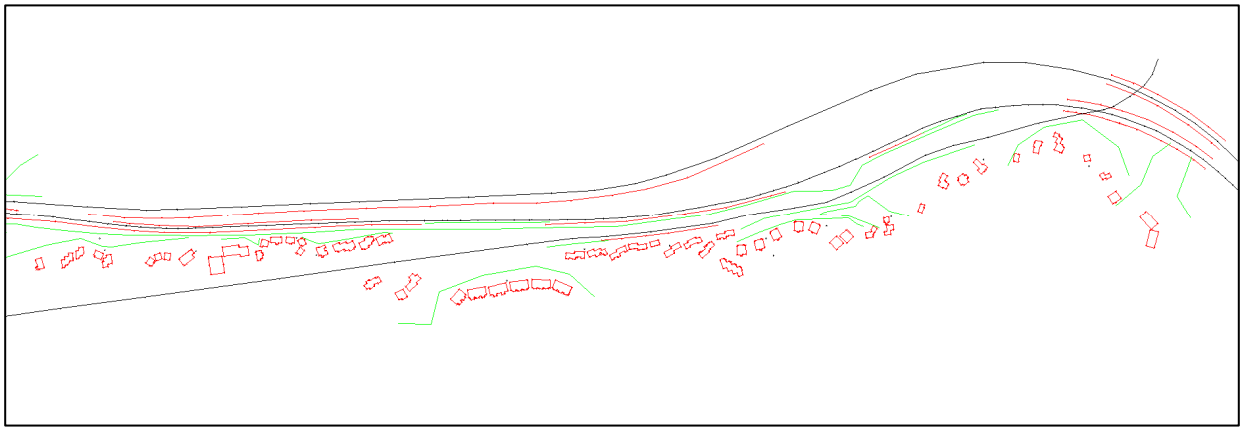
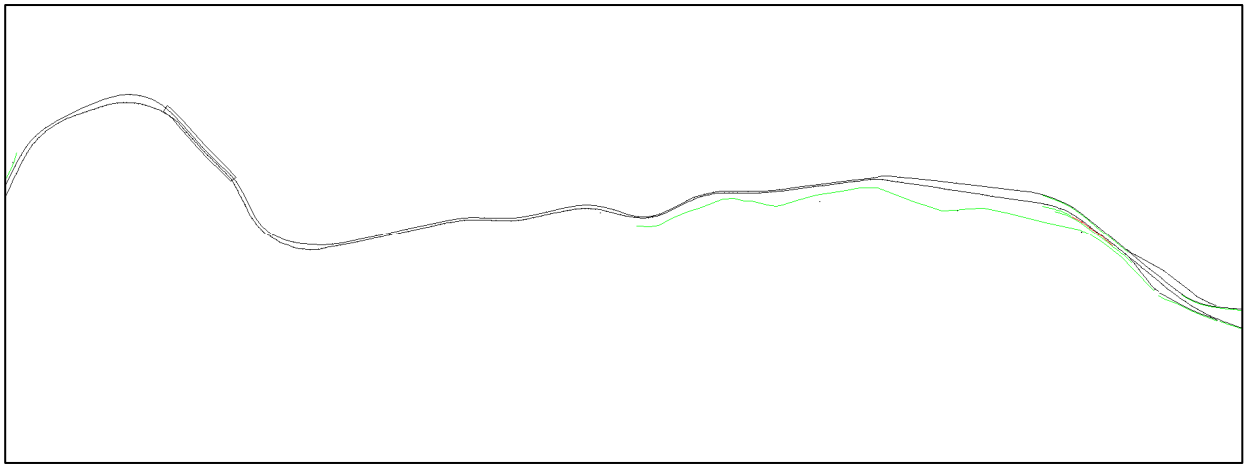
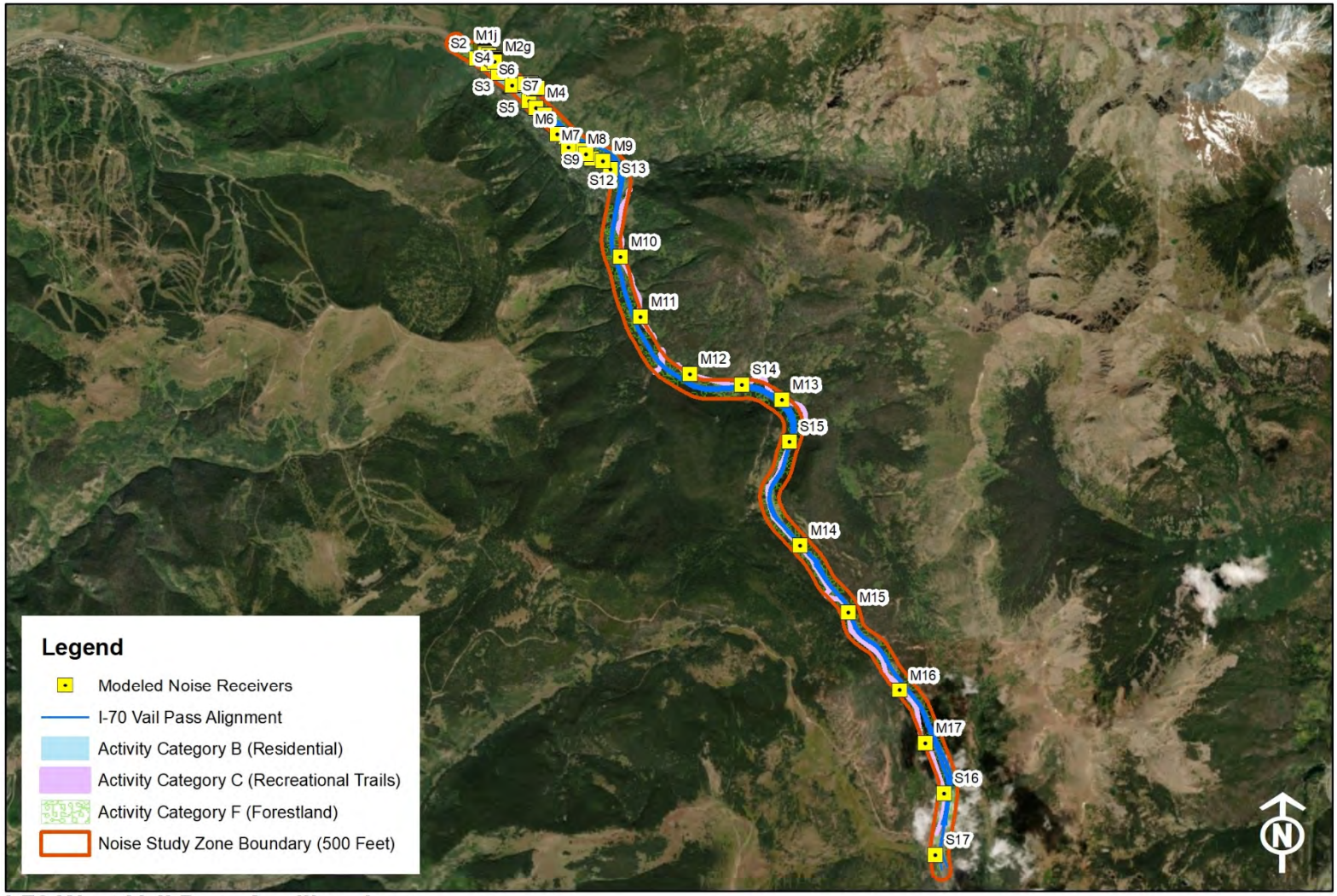


Figure 3C TNM Model Objects for 2045 Proposed Action: Eastern Portion of Project Area





I-70 West Vail Pass Auxiliary Lanes
Figure 4: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
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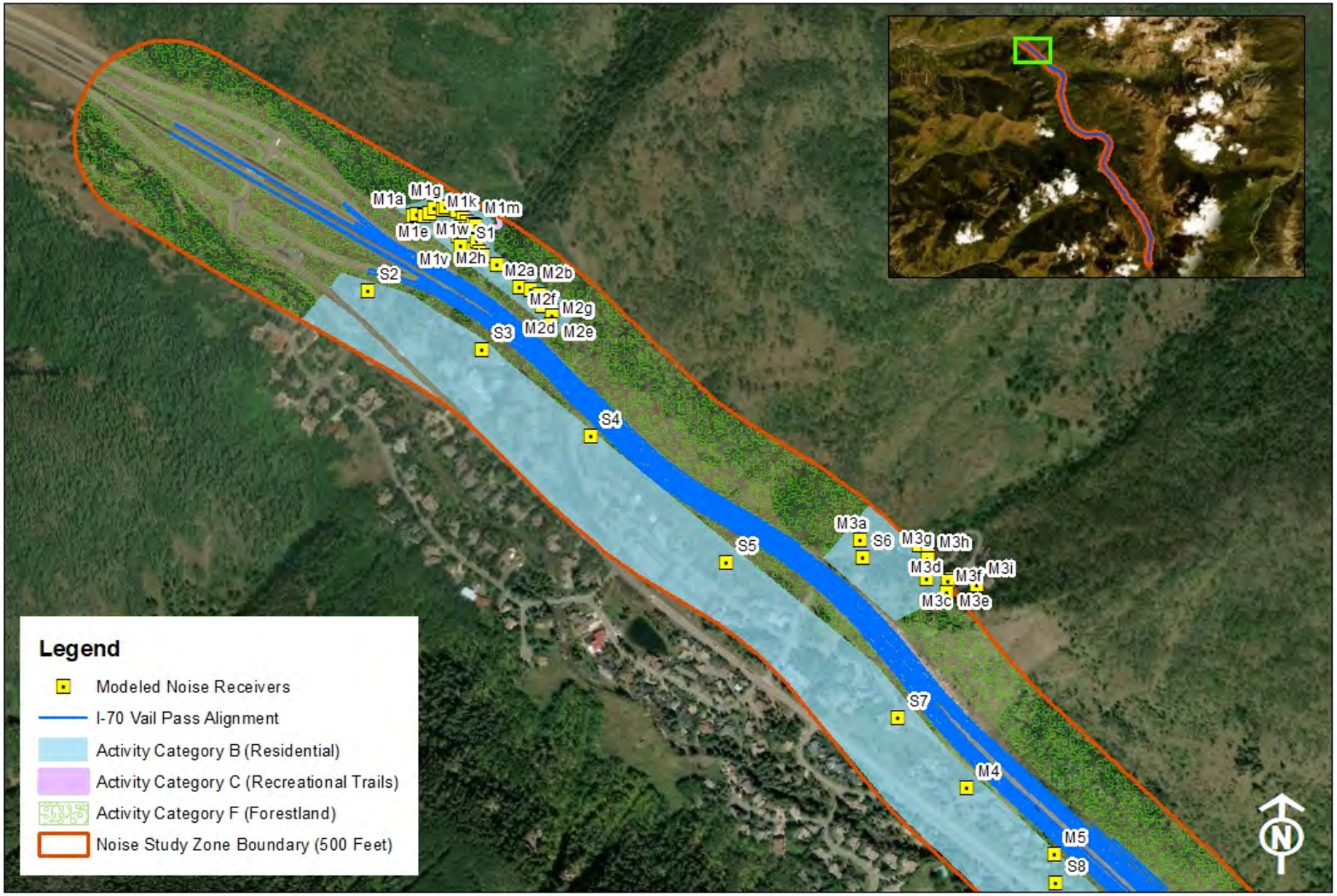
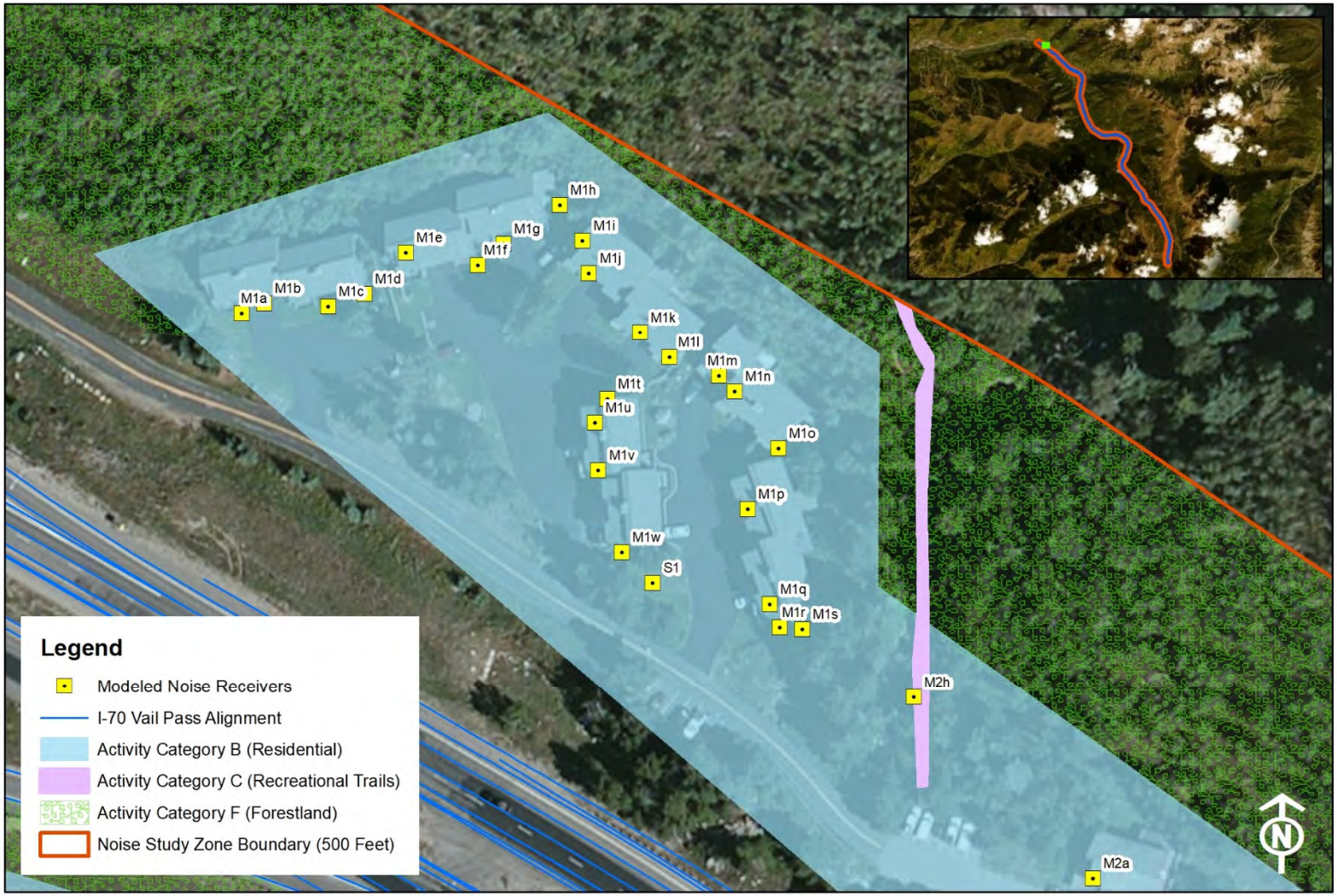
0 3,000 6,000 12,000 18,000 24,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4a: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

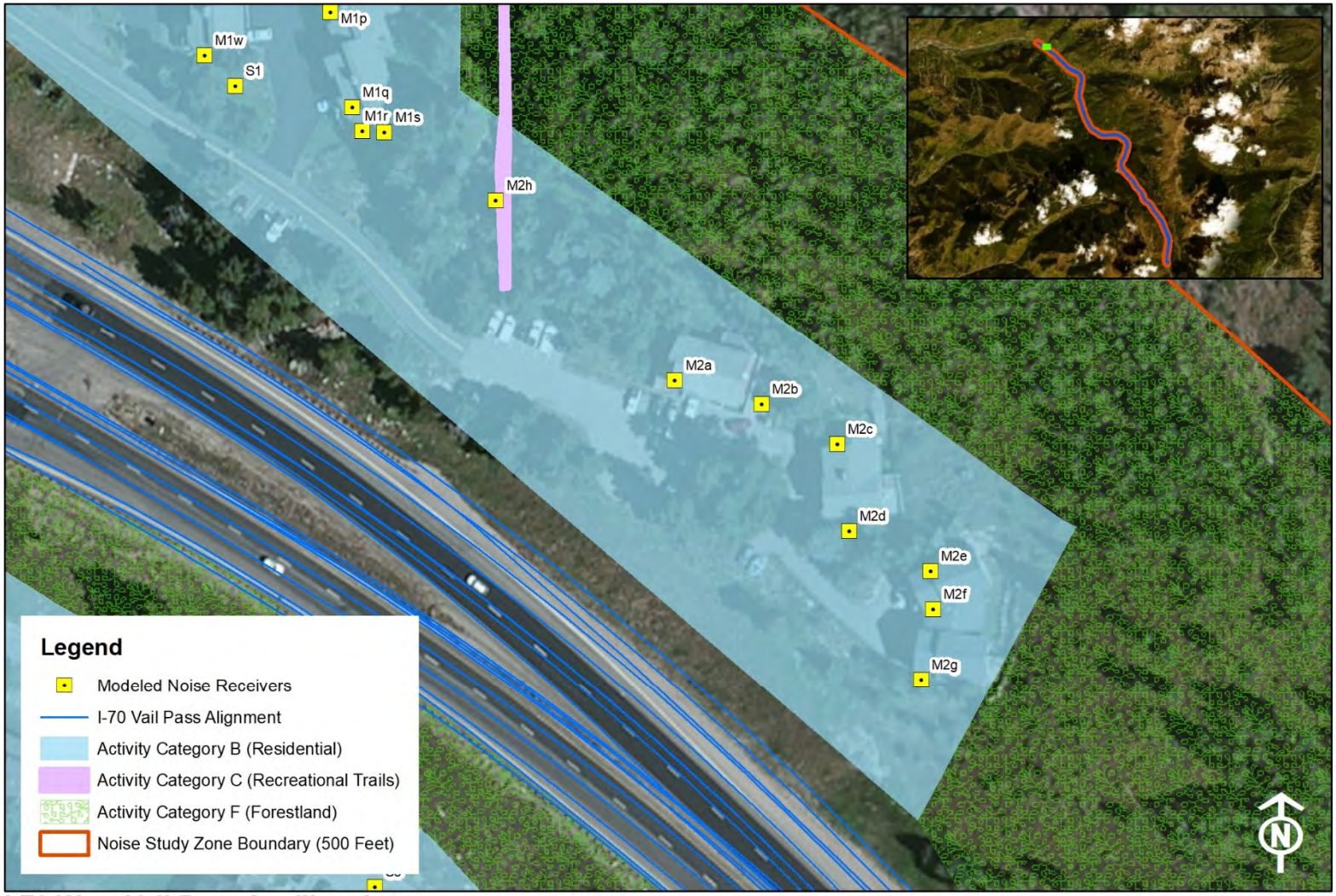
0 250 500 1,000 1,500 2,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4b: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

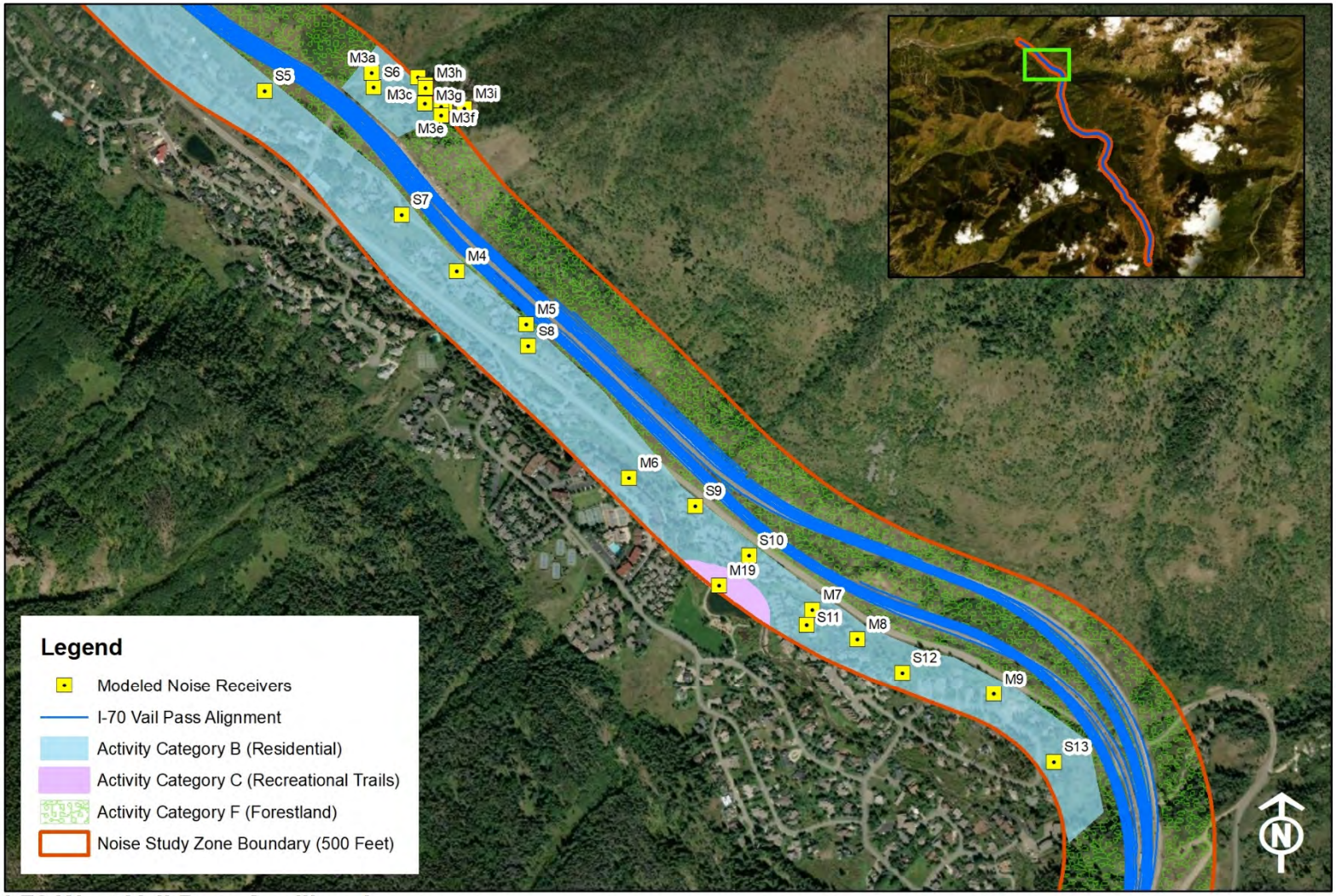
0 25 50 100 150 200 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4c: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

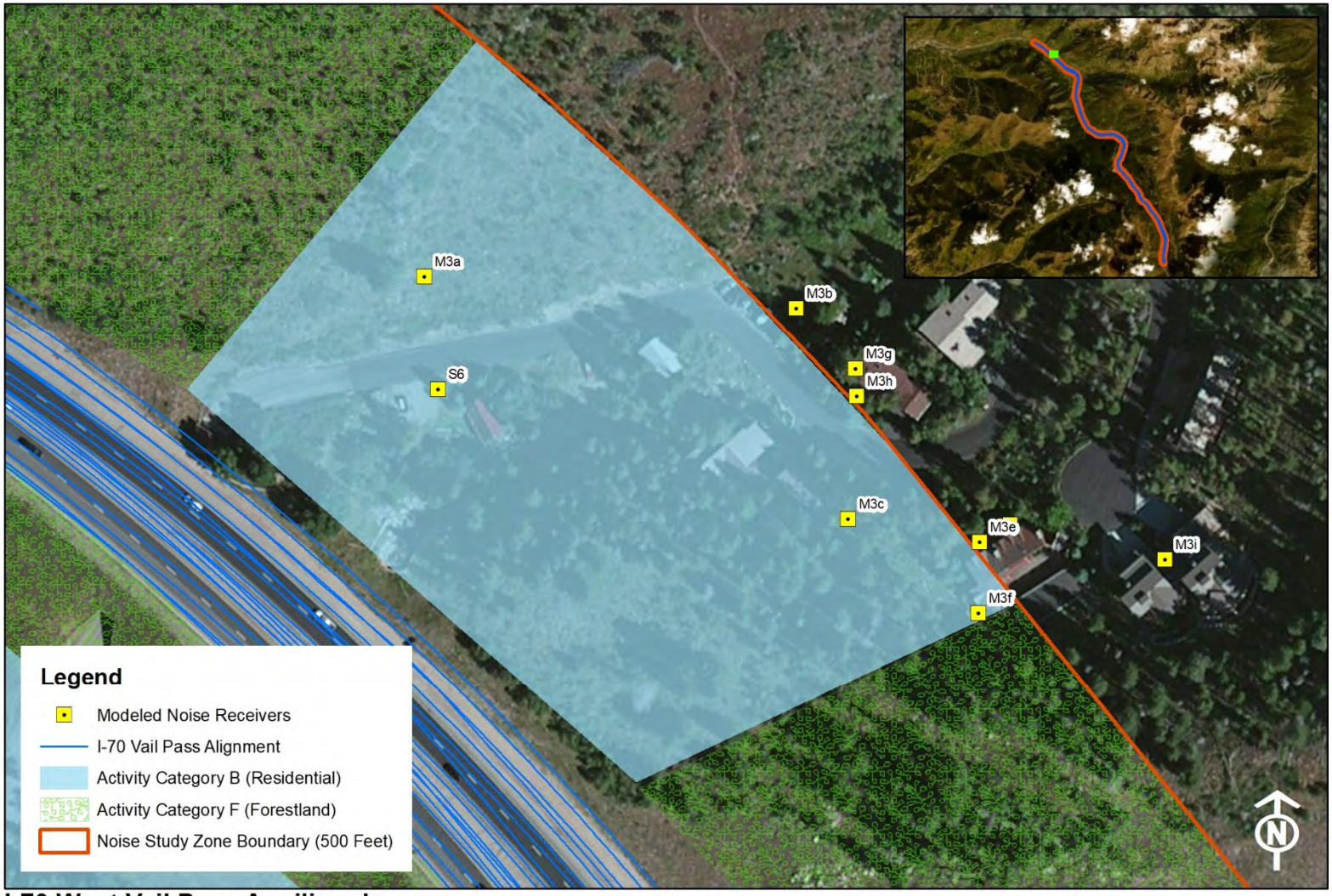
0 25 50 100 150 200
Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4d: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

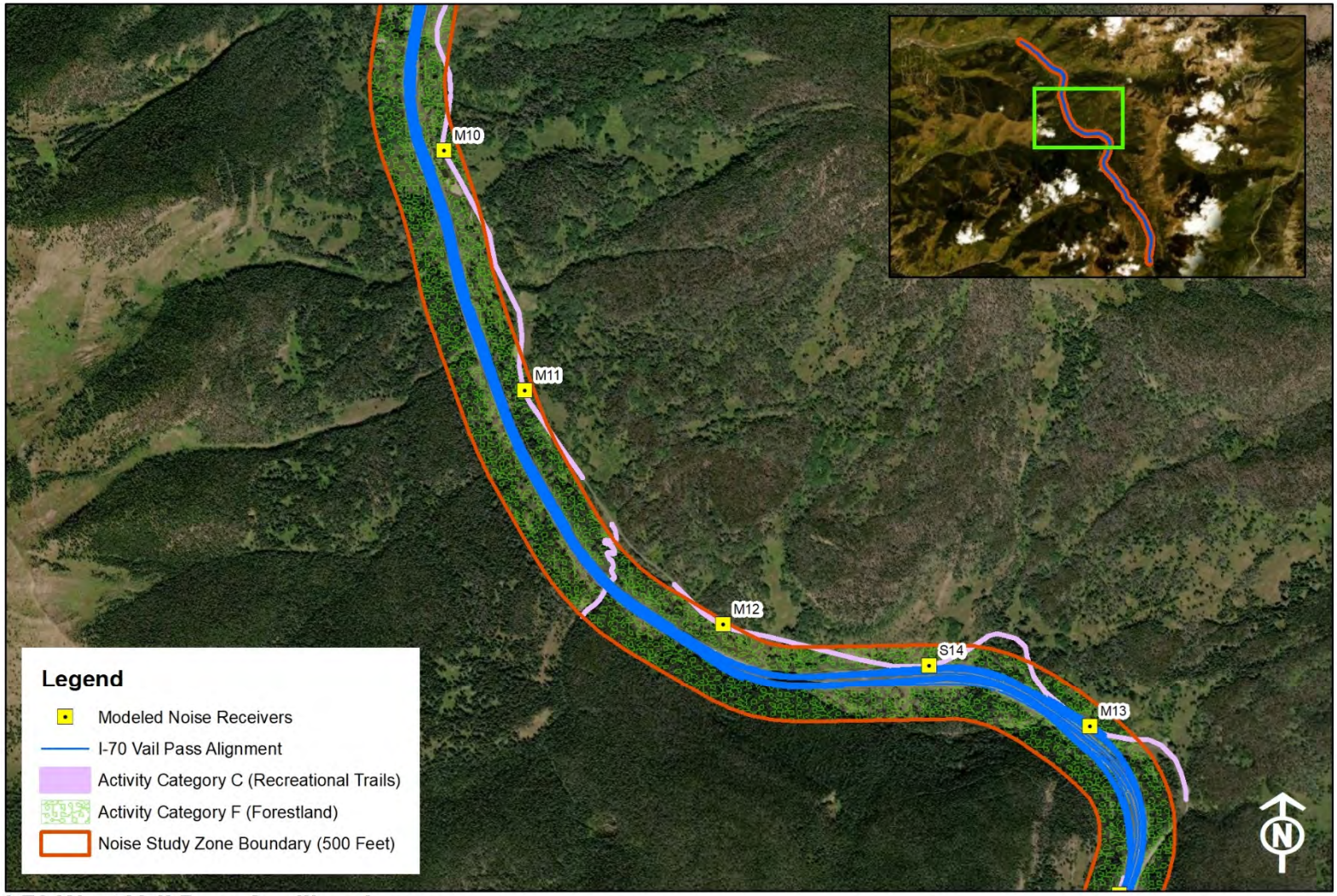
0 500 1,000 2,000 3,000 4,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4e: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

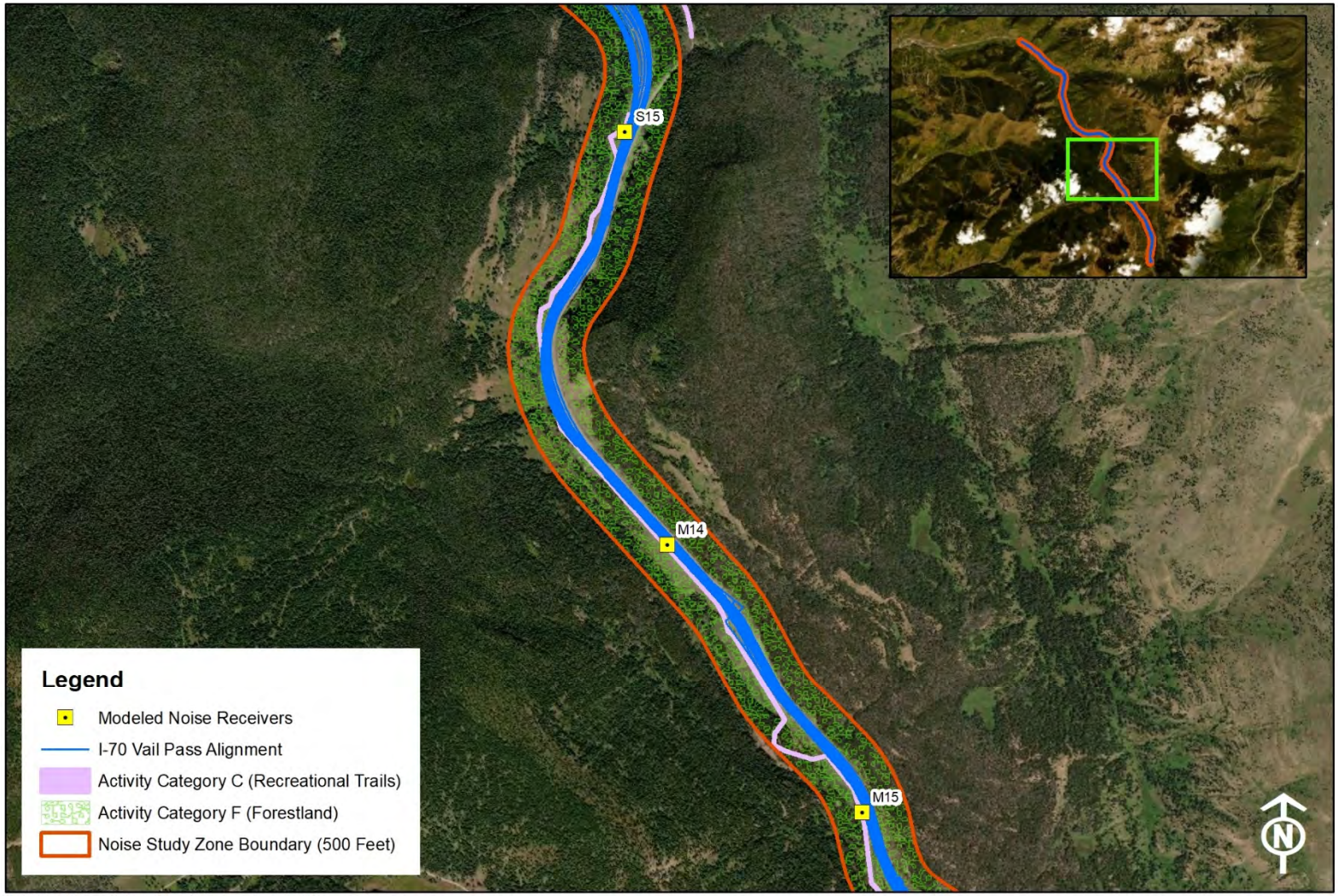
0 25 50 100 150 200
Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4f: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

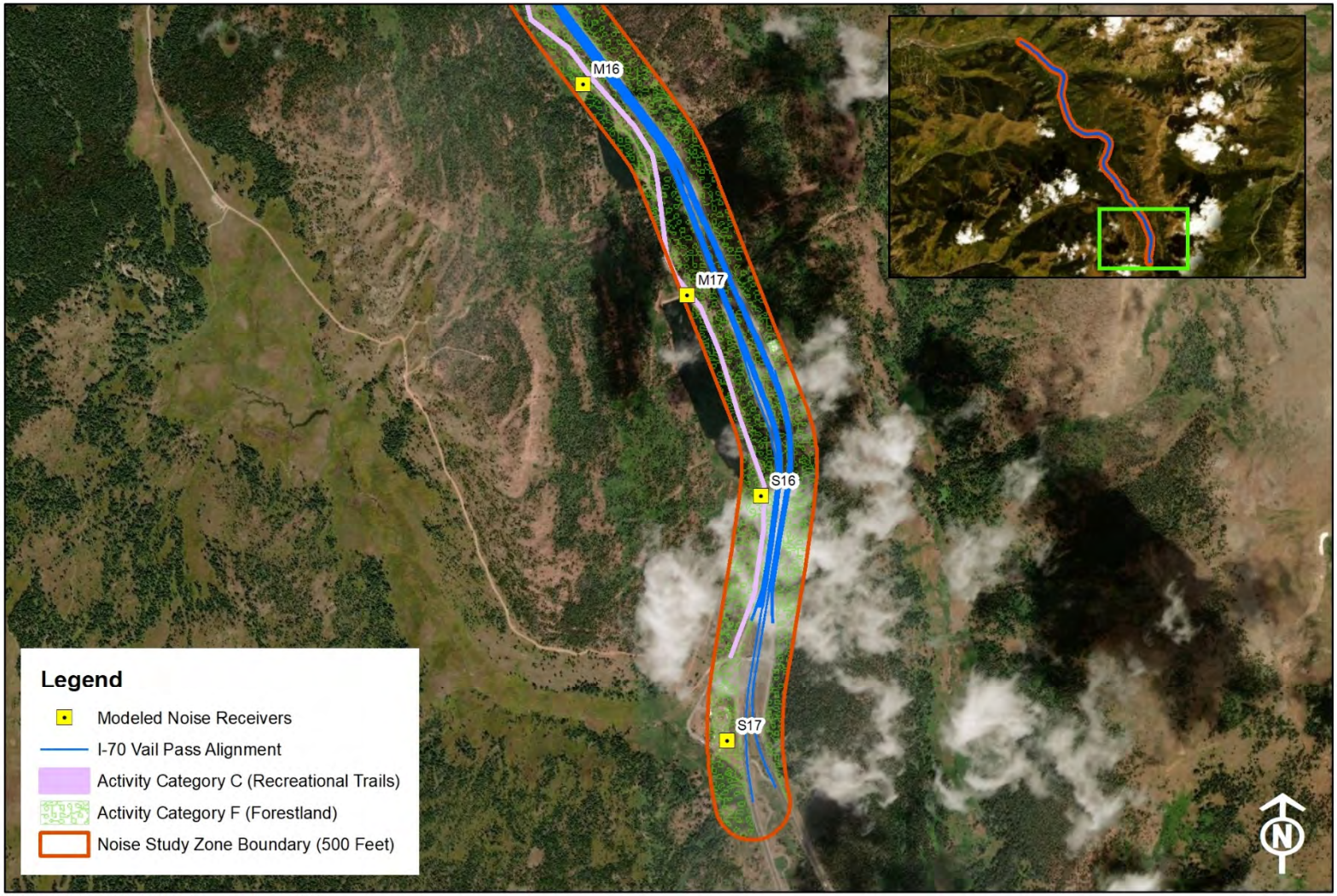
0 750 1,500 3,000 4,500 6,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4g: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

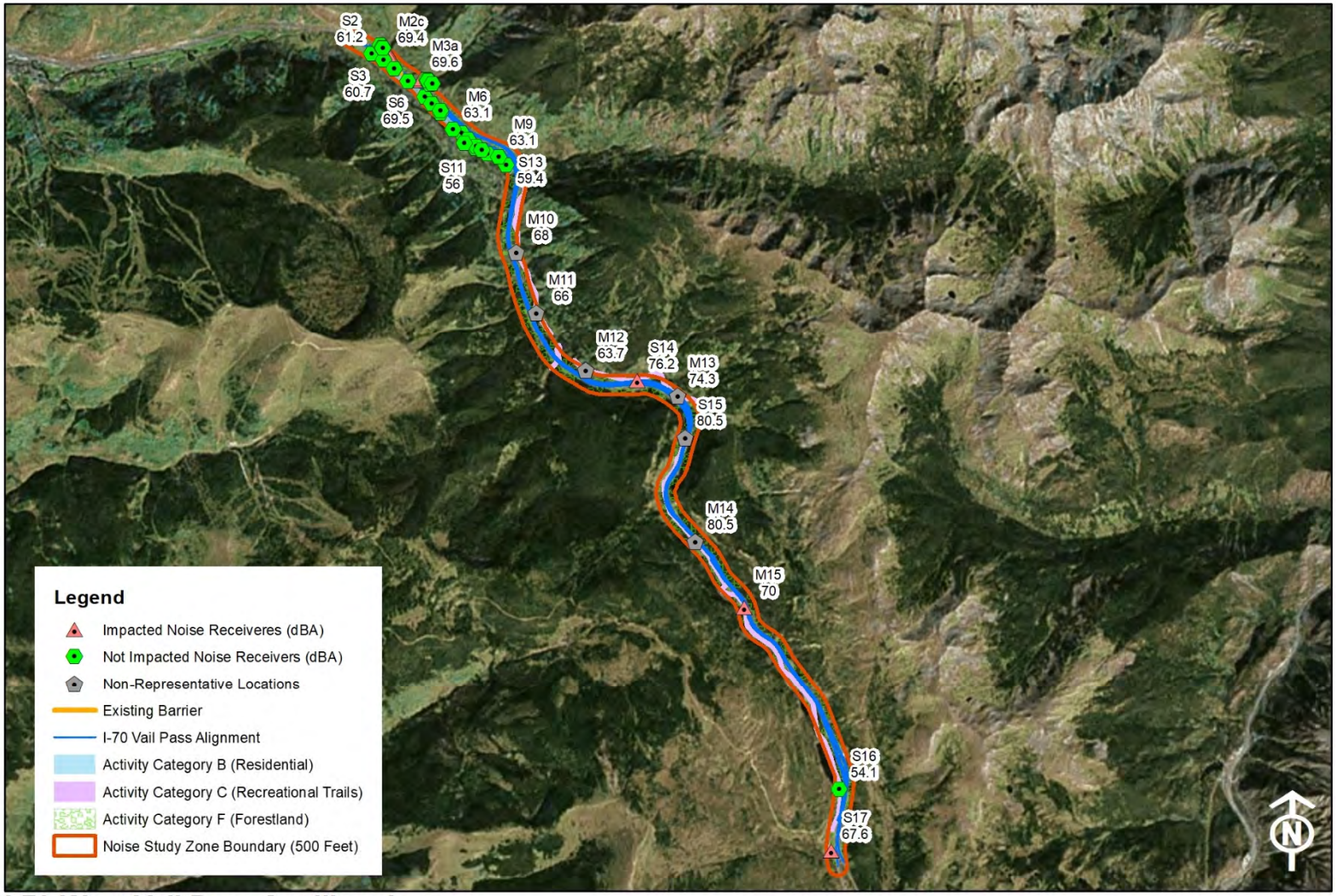
0 750 1,500 3,000 4,500 6,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 4h: Roadways and Receiver Locations for Existing (2017) and 2045 No Action Alternative Conditions

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

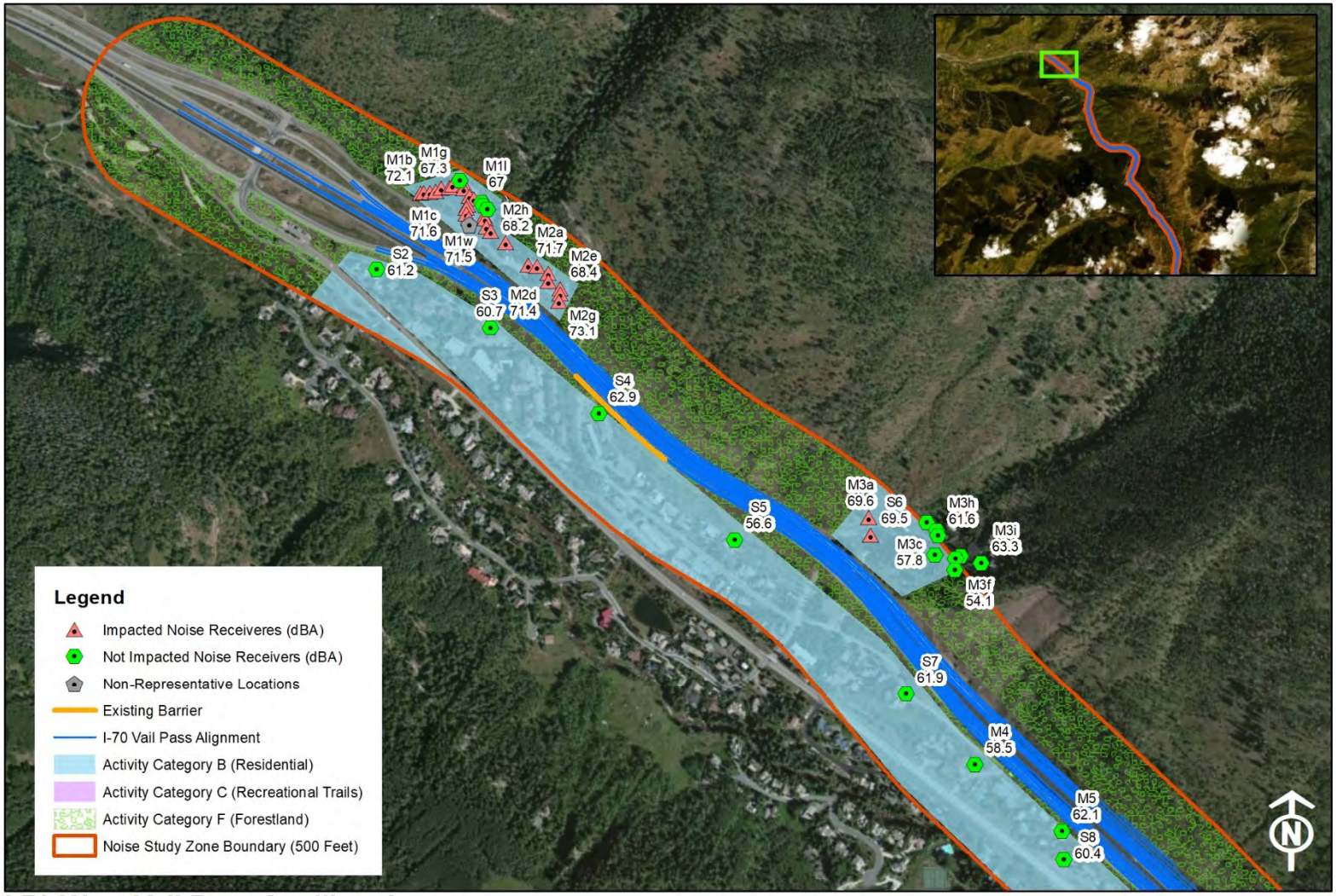
0 750 1,500 3,000 4,500 6,000
Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 5: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

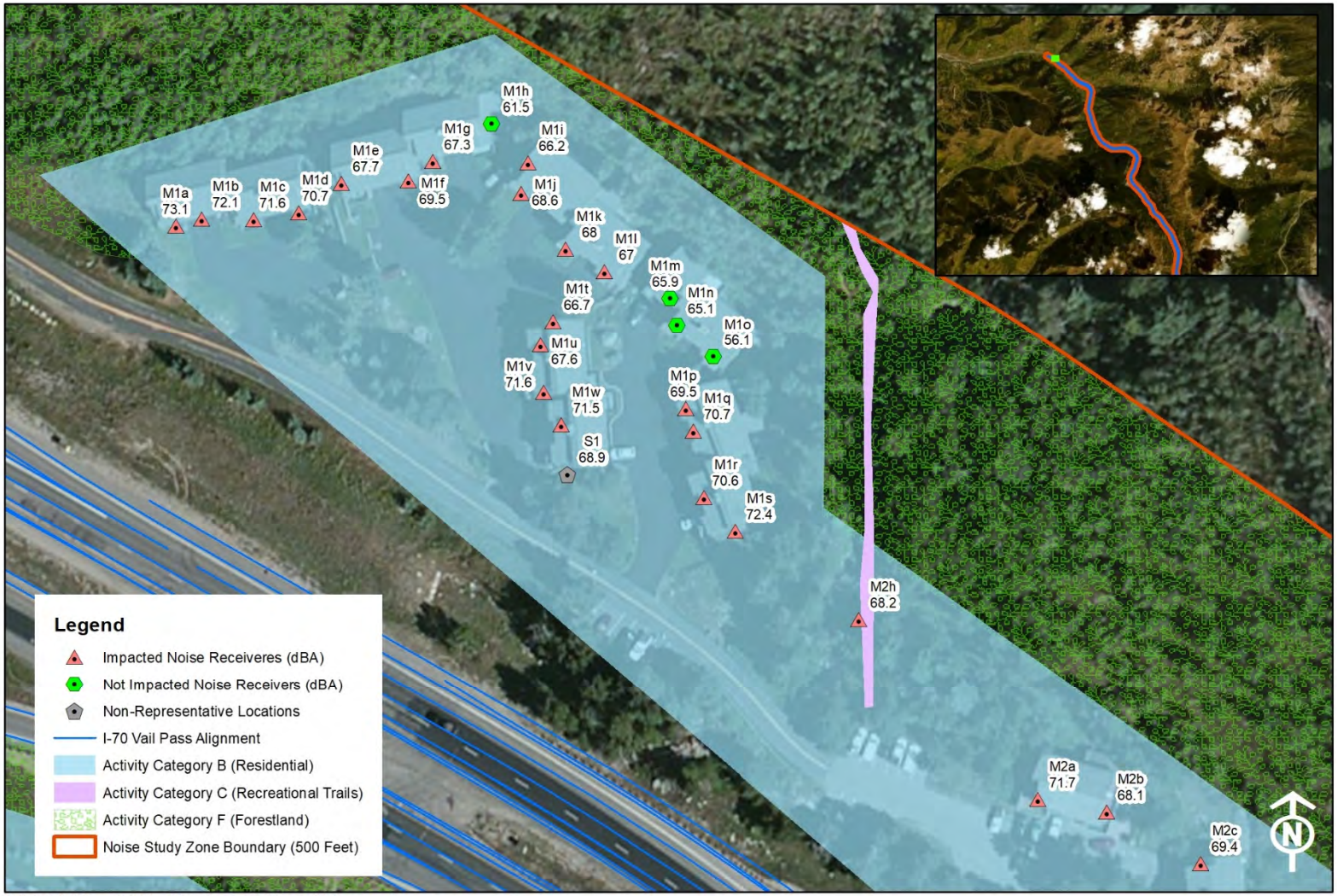
0 3,000 6,000 12,000 18,000 24,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 5a: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

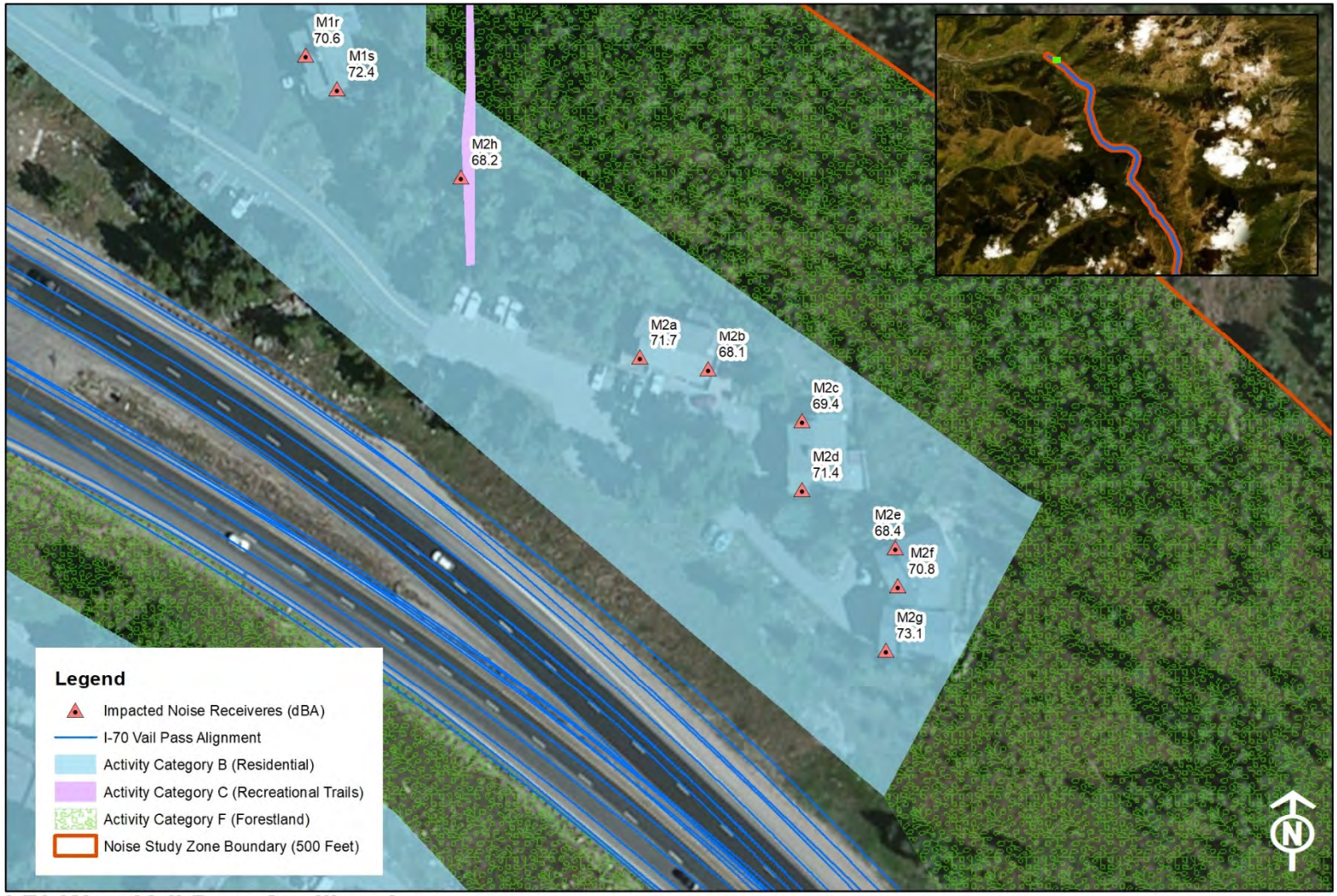
0 250 500 1,000 1,500 2,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 5b: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

0 25 50 100 150 200 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 5c: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

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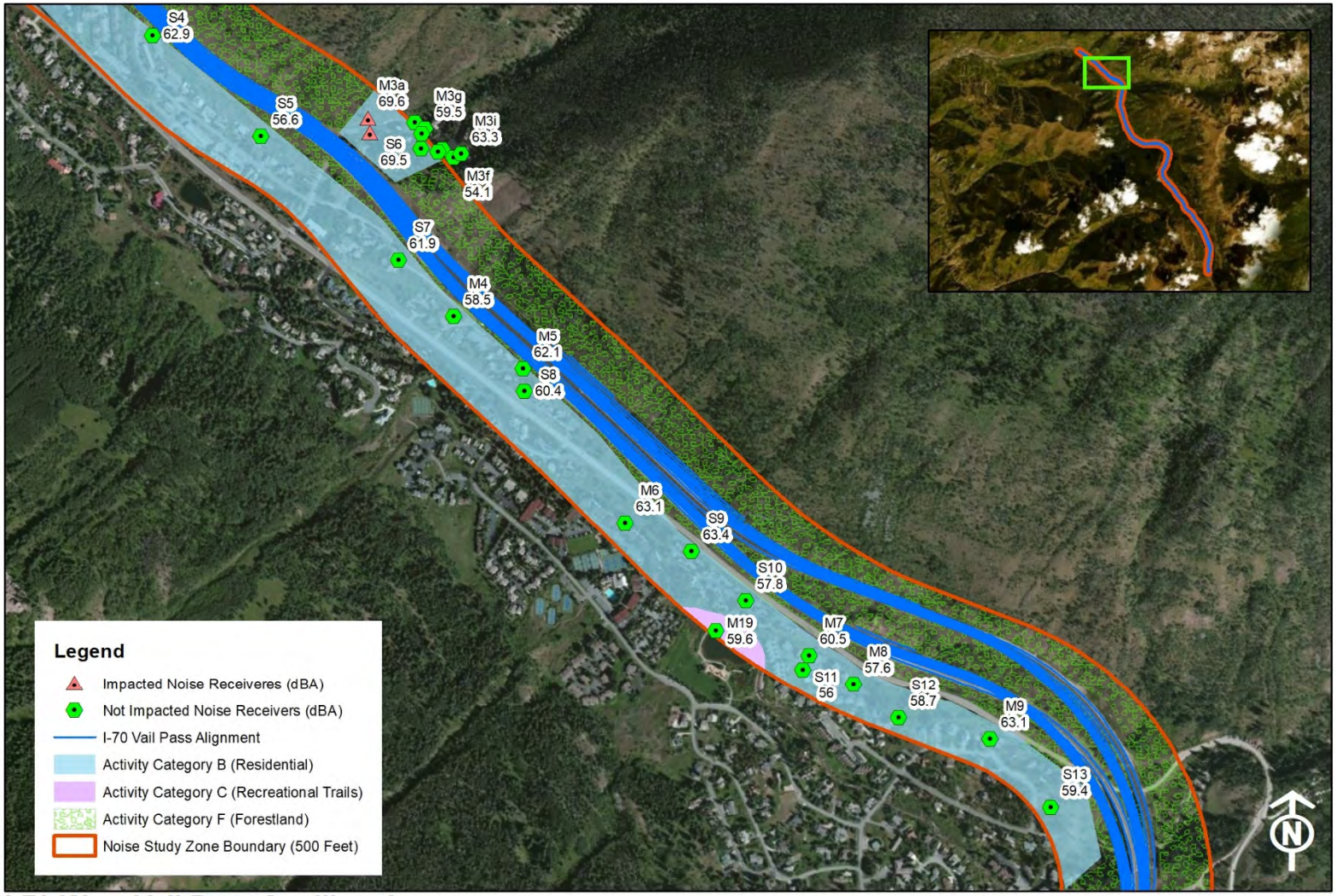
Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 5d: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
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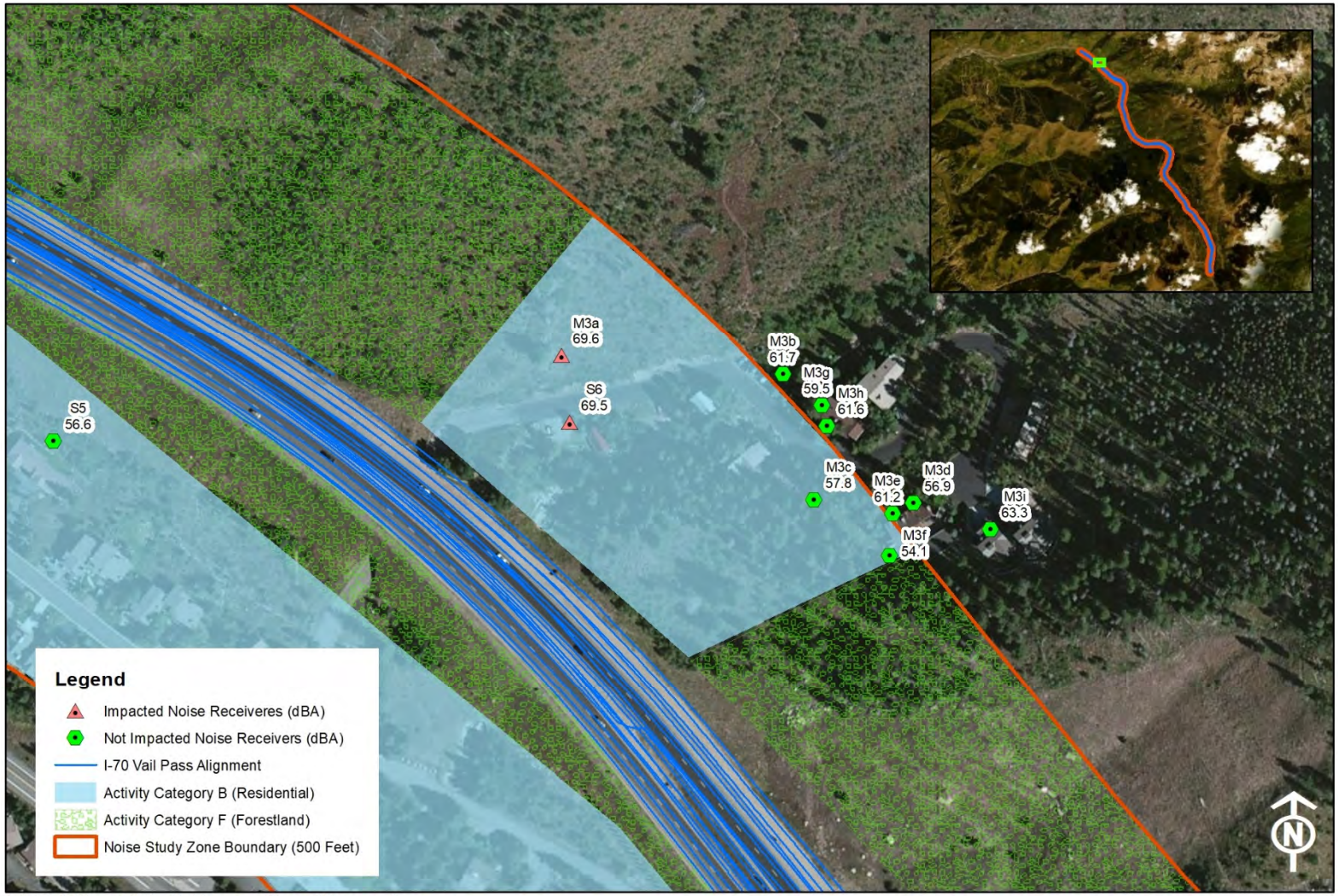
0 300 600 1,200 1,800 2,400
Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 5e: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

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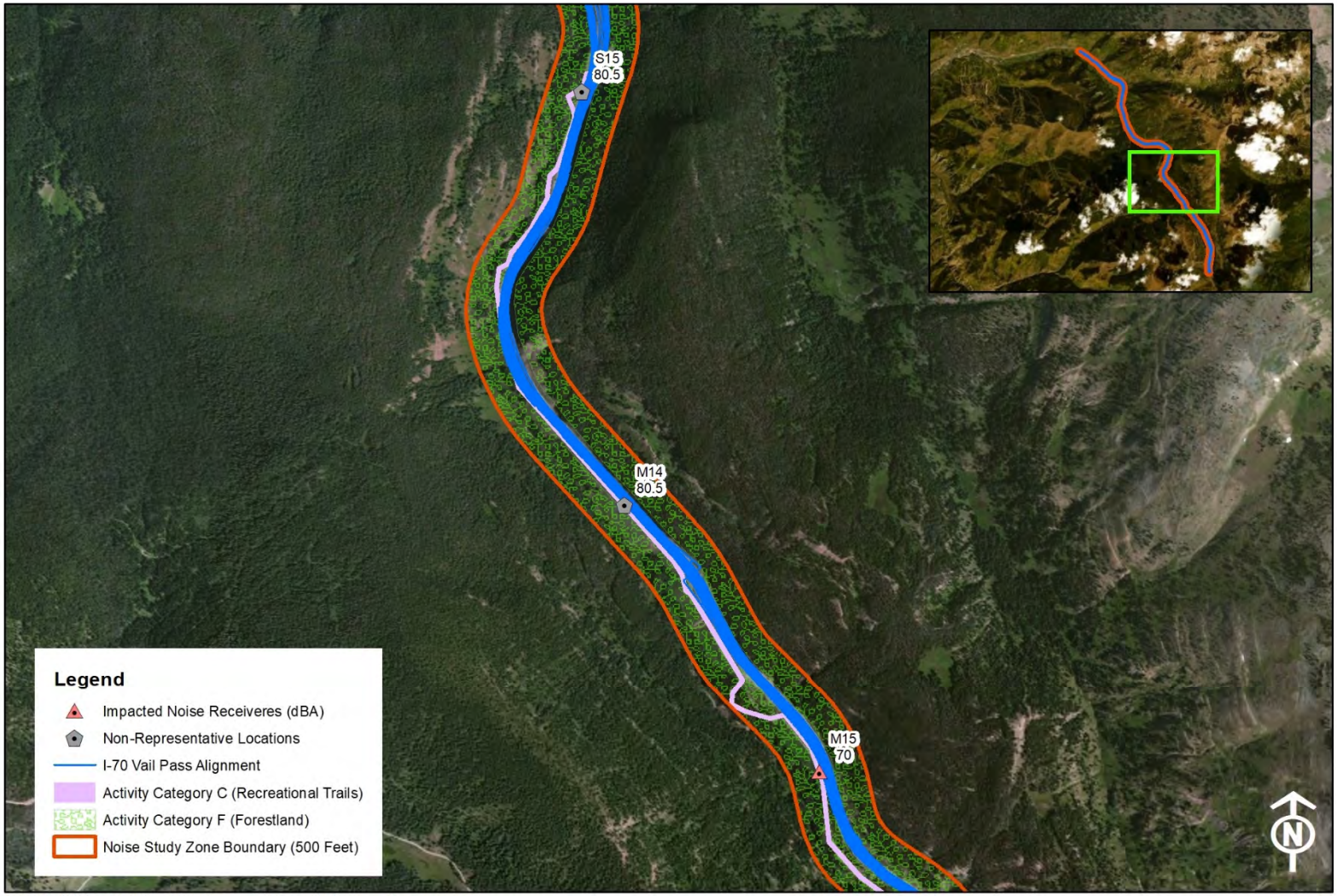
Feet

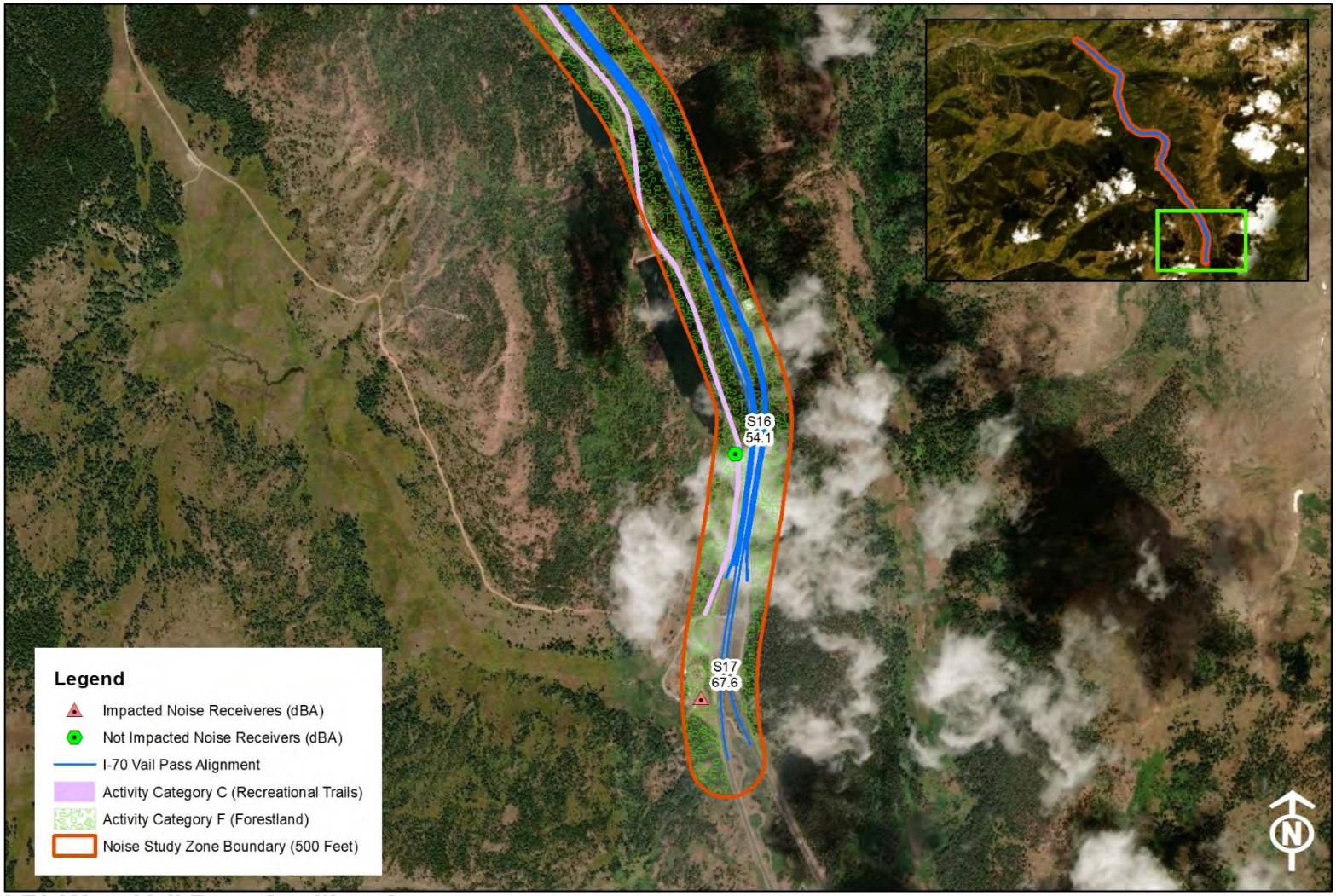


I-70 West Vail Pass Auxiliary Lanes
Figure 5f: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

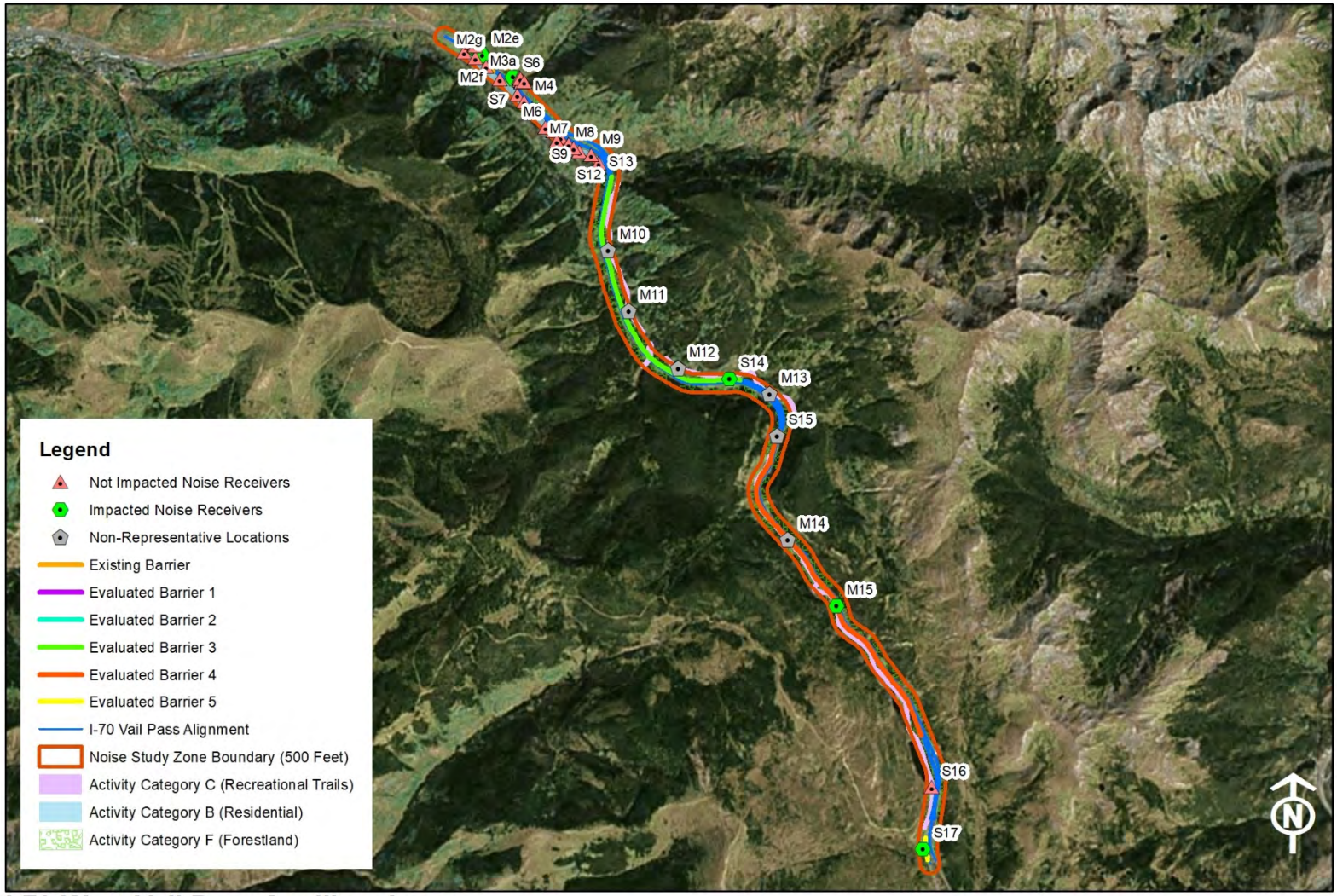
I-70 West Vail Pass Auxiliary Lanes
Figure 5g: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



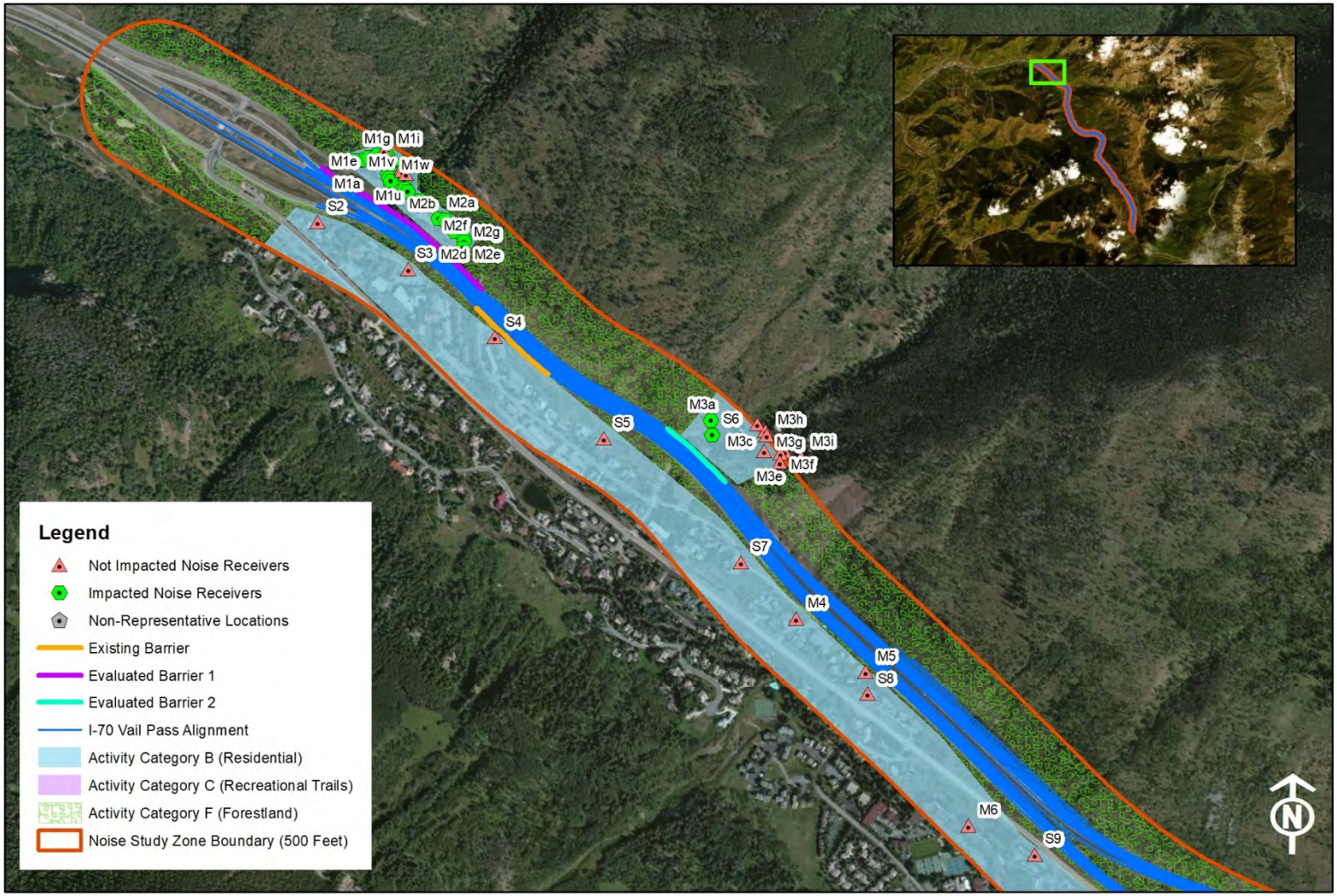
I-70 West Vail Pass Auxiliary Lanes
Figure 5h: Roadways and Receiver Noise Levels for 2045 Proposed Action (Impacts Identified)

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



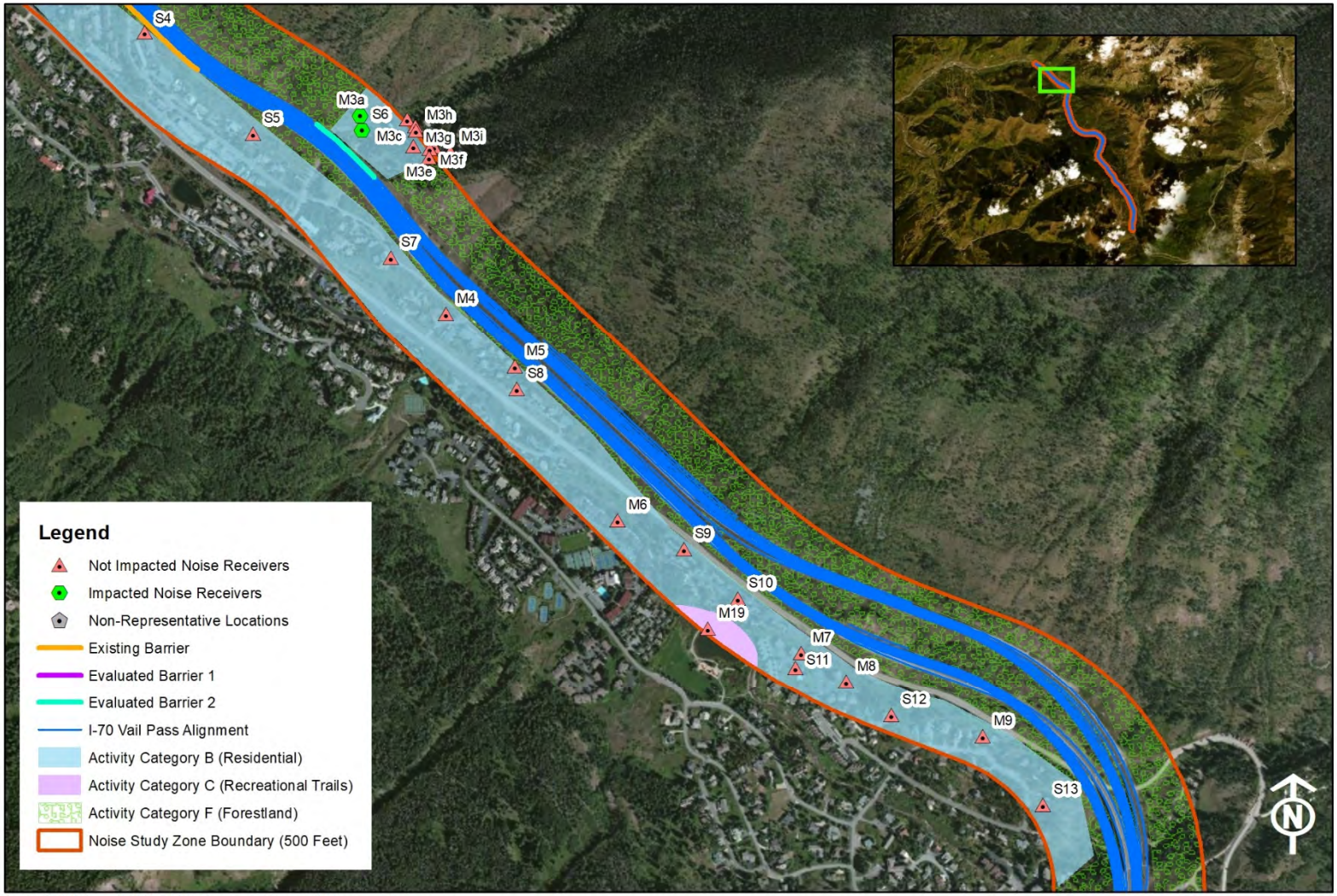
I-70 West Vail Pass Auxiliary Lanes
Figure 6: Noise Barrier Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



I-70 West Vail Pass Auxiliary Lanes
Figure 6a: Noise Barrier Locations

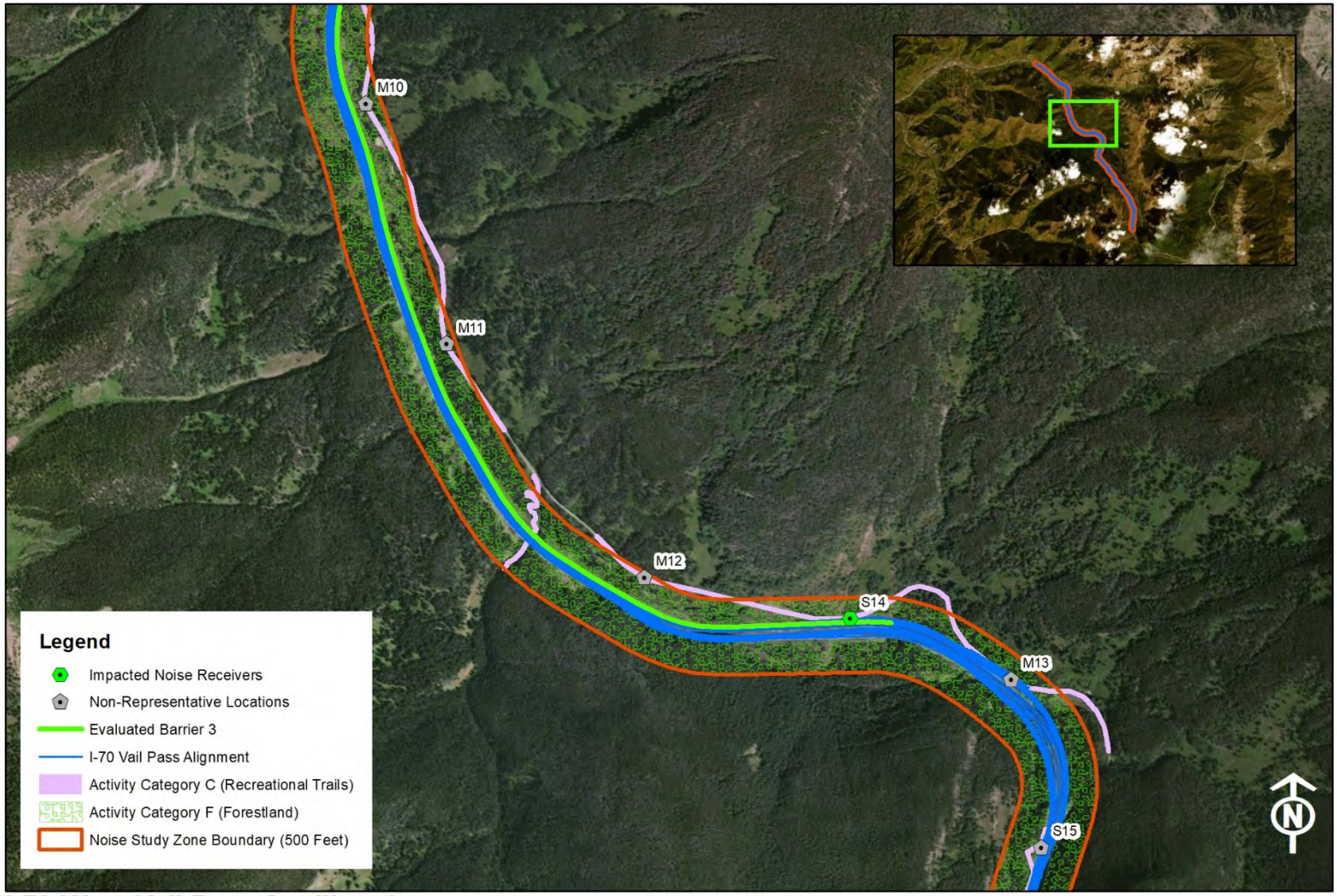
ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



I-70 West Vail Pass Auxiliary Lanes
Figure 6b: Noise Barrier Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

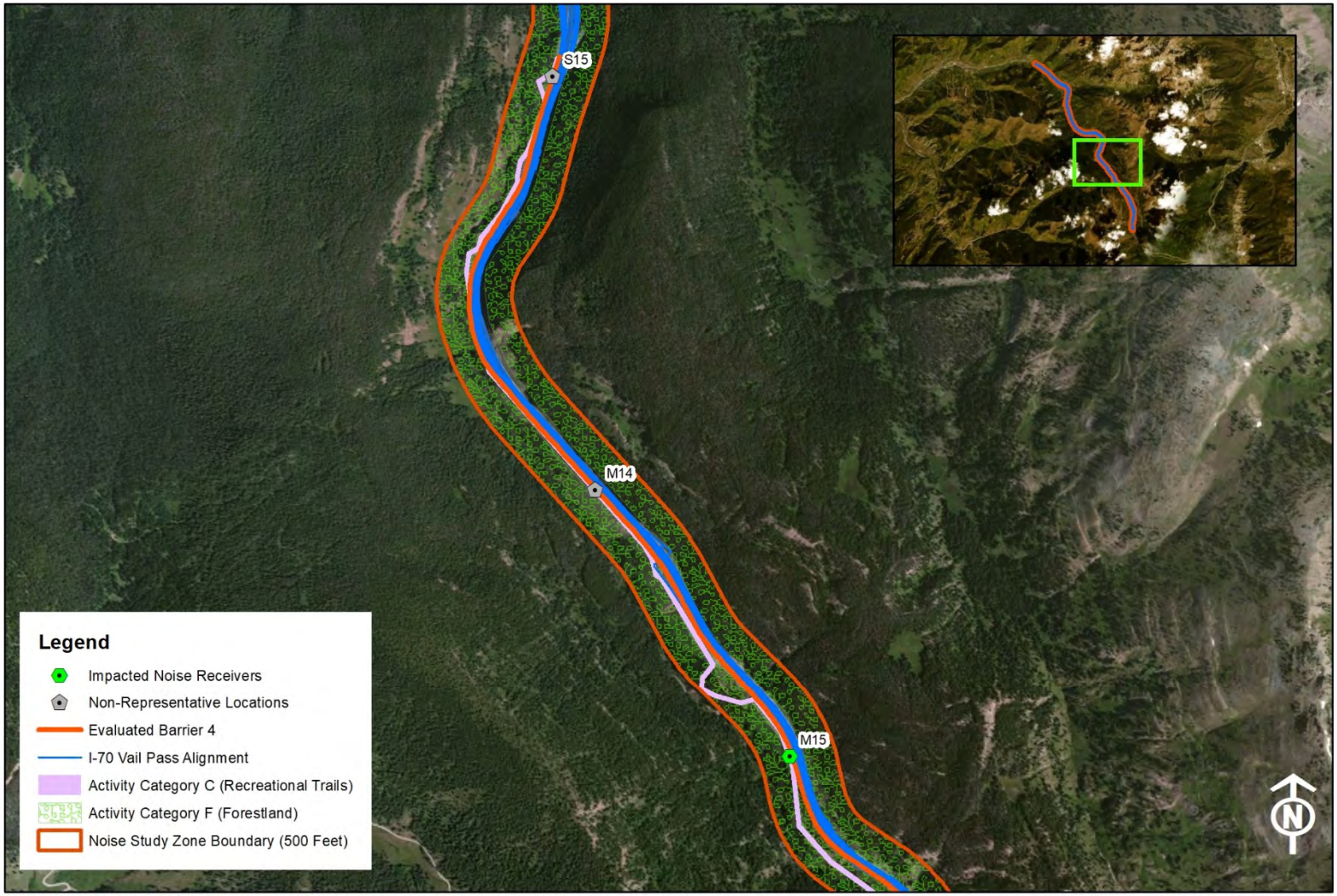
0 500 1,000 2,000 3,000 4,000 Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 6c: Noise Barrier Locations

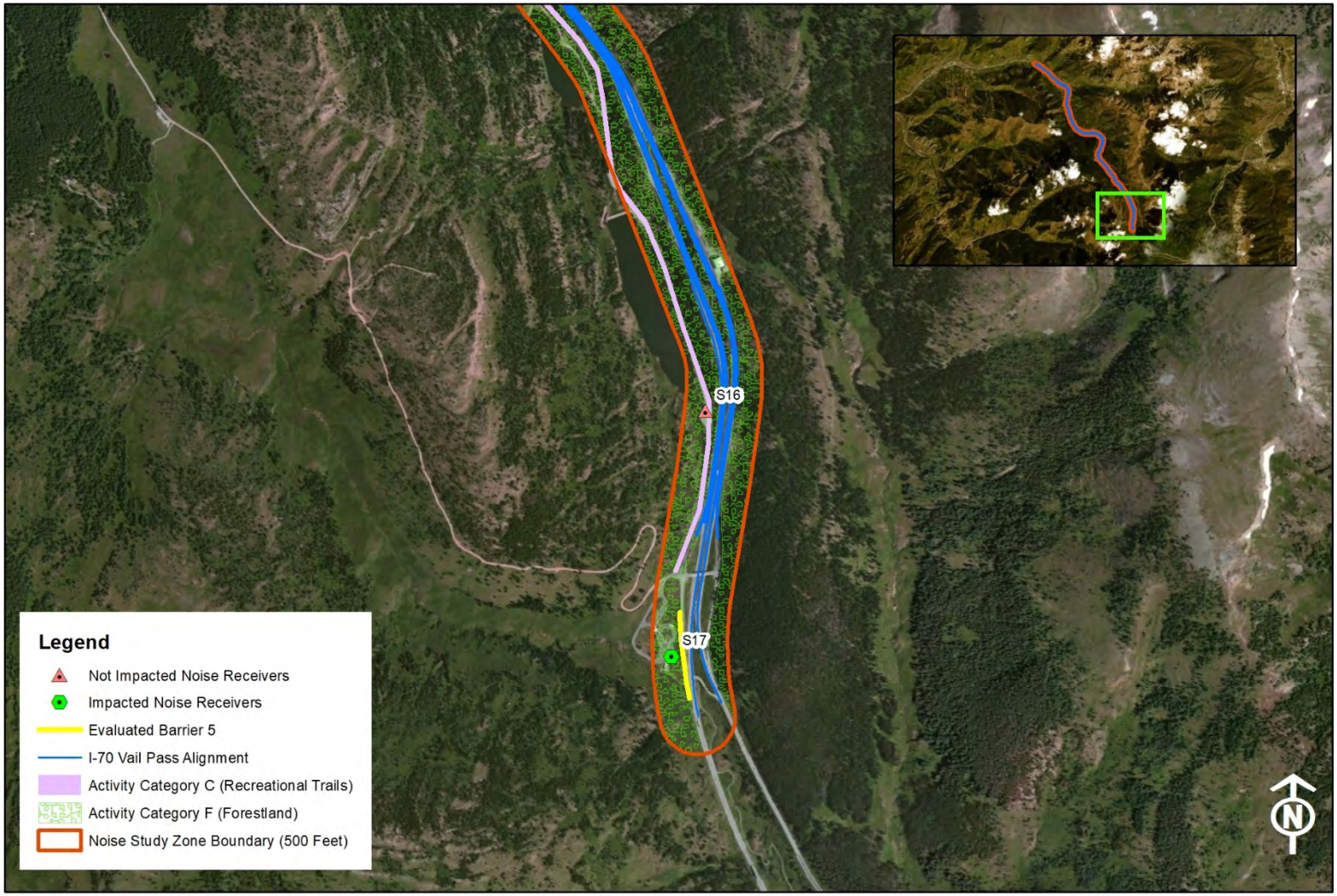
ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

0 750 1,500 3,000 4,500 6,000
Feet



I-70 West Vail Pass Auxiliary Lanes
Figure 6d: Noise Barrier Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality



I-70 West Vail Pass Auxiliary Lanes
Figure 6e: Noise Barrier Locations

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality