# Arizona Statewide Wildlife-Vehicle Conflict Study

*Final Report*

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ADOT | Arizona Department of Transportation

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The project team would like to thank and acknowledge the technical advisory committee for their excellent guidance and support throughout this entire planning effort. A listing of the project team and the technical advisory committee members is found below.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AADS | Animal-Activated Detection System |
| ACIS | Arizona Crash Information System |
| ADOT | Arizona Department of Transportation |
| AGFD | Arizona Game and Fish Department |
| ALISS | Arizona Accident Location Identification Surveillance System |
| AZPDES | Arizona Pollution Discharge Elimination System |
| BLM | Bureau of Land Management |
| CE | Categorical Exclusion |
| CWA | Clean Water Act |
| DCR | Design Concept Report |
| DOT | Department of Transportation |
| DPS | (Arizona) Department of Public Safety |
| EP | (ADOT) Environmental Planning |
| FHWA | Federal Highway Administration |
| ESA | Endangered Species Act |
| GIS | Geographic Information System |
| IPaC | Information Planning and Consultation |
| I-17 | Interstate 17 |
| I-19 | Interstate 19 |
| I-40 | Interstate 40 |
| LGV | Little Green Valley |
| MBTA | Migratory Bird Treaty Act |
| MOU | Memorandum of Understanding |
| OHSA | ArcGIS Getis-Ord Optimized Hot Spot Analysis tool |
| NAU | Northern Arizona University |
| NCHRP | National Cooperative Highway Research Program |
| NEPA | National Environmental Policy Act |
| NRHP | National Register of Historic Places |
| PISA | Preliminary Initial Site Assessment |

| | |
|---|---|
| P2P | (ADOT) Planning to Programming |
| ROW | Right-of-way |
| RTA | (Pima County) Regional Transportation Authority |
| SR | State Route |
| SR 202L | State Route Loop 202 South Mountain Freeway |
| STIP | State Transportation Improvement Program |
| TAC | Technical Advisory Committee |
| TCE | Temporary Construction Easement |
| TON | Tohono O'odham Nation |
| US | United States Highway |
| USFS | U.S. Forest Service |
| USFWS | U.S. Fish and Wildlife Service |
| WOTUS | Waters of the United States |
| WVC(s) | Wildlife-Vehicle Collision(s) |

## LIST OF SPECIES

| | |
|---|---|
| Bison | *Bison bison* |
| Desert Bighorn Sheep | *Ovis canadensis nelsonii* |
| Mexican Bighorn Sheep | *Ovis canadensis mexicana* |
| Rocky Mountain Bighorn Sheep | *Ovis canadensis canadensis* |
| Black bear | *Ursus americanus* |
| Coyote | *Canis latrans* |
| Mule Deer | *Odocoileus hemionus* |
| White-tailed Deer | *Odocoileus virginianus* |
| Coues White-tailed Deer | *Odocoileus virginianus couesi* |
| Elk | *Cervus elaphus* |
| Jaguar | *Panthera onca* |
| Javelina | *Tayassu tajacu* |
| Mountain Lion | *Puma concolor* |
| Mexican Pronghorn | *Antilocapra americana mexicana* |
| Sonoran Pronghorn | *Antilocapra americana sonoriensis* |
| Raccoon | *Procyon lotor* |
| Mexican spotted owl | *Strix occidentalis lucida* |
| Mojave Desert tortoise | *Gopherus agassizii* |
| Sonoran Desert tortoise | *Gopherus morafkai* |

# CHAPTER 1 - INTRODUCTION

## NEED AND PURPOSE OF THE STUDY

As expressed by the Arizona Department of Transportation (ADOT), wildlife-vehicle collisions (WVCs) are an ongoing, serious concern in the state that can result in fatalities, incapacitating injuries, property damage, loss of wildlife, and create a risk for liability claims to the State. Also, highways act as barriers to the movement of wildlife and landscape connectivity, a significant ecological concern. Collectively, these two concerns are the focus of our efforts to address and develop strategies to resolve wildlife-vehicle conflicts in the state. To evaluate this topic, a broad-based high-level planning study is proposed to:

- Evaluate, assess, synthesize information on the topic.
- From the research – develop, prioritize, and provide estimates and project level scopes for high priority projects intended to mitigate the identified conflicts.

With Arizona's greater than 28,000 lane miles of state and federal highways, it is expected that with increased growth and number of vehicles on the highways, wildlife-vehicle conflicts are going to increase. This study will help ADOT be proactive in identifying additional safety and operational needs to consider in resolving conflicts.

Human population growth and future traffic conditions in Arizona will exacerbate WVCs and increase potential for wildlife-vehicle conflict. Wildlife-vehicle conflict includes all known and unknown collisions, and other impacts of roads and traffic on wildlife. Arizona's current population of 7.1 million is predicted to grow to approximately 10.5 million by 2055 (Source: Arizona Department of Administration, Office of Employment and Population Statistics). WVCs are and will increasingly become a threat to motorists, and wildlife populations. This study examines the past and current conditions in Arizona that are factors in wildlife-vehicle conflict and presents solutions for the future with potential mitigation projects, and a planning approach to help bring wildlife concerns into ADOT's planning process.

## STUDY OBJECTIVES

The Technical Advisory Committee (TAC) for the Statewide Wildlife-Vehicle Conflict Study has developed, reviewed, and confirmed the following project objectives:

1. Identify the significant wildlife-vehicle conflict areas throughout Arizona.
2. Prioritize significant problem areas – including conflict areas with Threatened and Endangered Species and Special Status Species.
3. Present solutions – mitigation projects, measures or techniques in an implementation plan that can be applied to the prioritized conflict areas.
4. Prepare project level scopes and estimates to implement the highest priority, specifically recommended solutions.
5. Develop a planning approach that allows ADOT to examine existing and future roads more holistically for wildlife presence and landscape connectivity needs in the face of increasing human populations and traffic.

## BACKGROUND AND HISTORY

Arizona is in its third decade as a leader in wildlife-transportation mitigation research, projects, and future planning. ADOT got there by considering the needs of wildlife to move across landscapes while also protecting motorists from wildlife. Over this time, ADOT funded (and continues to fund) research projects with Arizona Game and Fish Department (AGFD), planned for and built wildlife crossing structures and fences which were built into large transportation projects, and coordinated planning across the state for wildlife connectivity needs. Arizona has improved highway safety while helping protect populations of ungulate species, tortoises, and others, and led the nation in how transportation and wildlife agencies can partner together to promote wildlife connectivity and improve motorist safety.

Arizona pioneered research that analyzed wildlife movements across highways with radio and later GPS collars. Arizona's crown jewel research study on State Route (SR) 260 east of Payson looked at elk, mule deer, and white-tailed deer movements to help locate where to place wildlife crossing structures, assess what structures worked best for multiple species, and where fences were necessary (Dodd et al. 2006, 2007*a-d;* Dodd et al. 2012*a*; Dodd and Gagnon 2011; Gagnon et al. 2007*a-b*; Gagnon et al. 2011, 2018). WVCs decreased by 84-97 percent (depending on the species) over time. This study was so groundbreaking ADOT won the first Federal Highway Administration (FHWA) Exemplary Ecosystem award in 2004 for the partnerships and its adaptive management process. AGFD built on these research and monitoring methods to investigate bighorn sheep-highway relationships and to help ADOT justify three overpasses on US 93 (Cunningham and Hanna 1992, McKinney and Smooth 2007). This study resulted in the nation's first wildlife overpasses built for bighorn sheep which have been used by thousands of sheep, improving highway permeability over 500 percent (Gagnon et al. 2012*a*, 2017*a*). Further studies evaluated how pronghorn were approaching but not crossing key Arizona highways (Dodd et al. 2009) with some populations exhibiting signs of genetic isolation (Theimer et al. 2012). Innovative fence designs were experimented with to encourage pronghorn to cross low traffic volume roads. Mitigations were built to guide desert tortoises to existing culverts with reptile fence. ADOT highway roadsides are now planted with native vegetation to promote movement corridors for pollinators (e.g., ADOT Roadside Vegetation Management Guidelines; https://azdot.gov/business/environmental-planning/biology/roadside-vegetation-management-guidelines).

Studies by universities and other organizations helped provide a blueprint for planning for connectivity. The highest profile study and planning tool is the state's award-winning Arizona's Wildlife Linkages Assessment (Arizona Wildlife Linkages Workgroup 2006) which garnered several FHWA awards in 2007. Seven county-level wildlife connectivity assessments were completed to complement this work (AGFD 2011, 2012*a-b*, 2013*a-c*).

On top of research partnerships, ADOT works with regional, county, and Tribal organizations. In 2014, ADOT worked with Pima County's Regional Transportation Authority (RTA) to build an RTA-funded overpass and underpass on SR 77 (AGFD 2020). In 2011, ADOT along with the RTA and the Tohono O'odham Nation (TON) built two wildlife underpasses on SR 86 on Tribal land, the state's first "drop-in" structures; two wildlife overpasses are planned and funded on this route for 2022. The 2018 Department of Interior Secretarial Order 3362 provided funds for Arizona to collar, track, and compile and map mule deer, elk, and pronghorn movements (Kauffman et al. 2020) that will all be used to inform future wildlife mitigation projects on Arizona highways. Arizona was and continues to be a leader in working partnerships, and with sustained efforts across multiple species, ecosystems, ADOT divisions, and partners, it will continue its role as a national leader in transportation ecology.

Since 2002, ADOT has put forth a comprehensive effort to minimize the state's exposure to liability associated with WVC. In a 2002 jury ruling (and subsequent 2004 appeal ruling), the state of Arizona was found negligent in the *Booth v. State of Arizona case* for injuries suffered by a motorist that hit a dead elk on Interstate 40 (I-40) in 1998. ADOT then funded and implemented several connectivity projects, funded over 20 highway-wildlife research projects, and completed several wildlife-accident reduction studies. These comprehensive efforts contributed substantially to the state being found not negligent in 2012 in a strikingly similar 2009 incident where a motorcyclist on SR 260 hit a dead elk along the highway in the *Sayer v. State of Arizona* case. In Chapter 2, Current Conditions, we will go into more detail into the history of the crash data, linkage assessments, lessons learned from a wide range of studies and evaluations.

The financial and human cost of WVCs can be quite high. In Arizona, there are on average 1,270 reported WVCs each year, with an average of one fatal crash annually, both considered underreported. Across the nation, there were on average over 347,000 reported annual crashes with animals, and 202 fatal crashes (Cramer, in press, 2021). Conover (2019) reported 47,000 injuries and >440 deaths each year in WVC in the US. Up to two million vertebrates are killed annually by vehicles on North American highways (Bissonette and Cramer 2008). We have highlighted severe and fatal crash locations around the state (Figure 1-1). Arizona is not immune to serious injuries, tragic loss of life and economic impacts to the state.

To accomplish this study, we evaluated a 16-year period of crash data in Arizona from 2003 through 2018. It should be noted that there are limitations with the data and that this data does not fully reflect the situation statewide. Of note in Figure 1-1 is the lack of data in Tribal areas. Throughout this paper we note study strengths and limitations, but also provide recommendations to ADOT.

Regardless of some of the limitations with the dataset, this assessment has some strong scientifically defendable evidence that shows wildlife-vehicle conflicts have significant impacts in Arizona. This study will provide ADOT with a planning tool that can inform the Planning to Programming (P2P) process. By incorporating and using this planning tool it can assist ADOT in their proactive pursuit of creating safer highways for the travelling public and animals alike.

Over time, state Departments of Transportation (DOT) have seen declines in funding levels. As a result, DOTs must spend their resources wisely and be fiscally prudent with taxpayer dollars. ADOT has had some very successful major new construction and reconstruction efforts in the past, but those will be few and far between in the future. As a result, wildlife connectivity and mitigation measures need to be reviewed from a broad perspective and a variety of tools and techniques can be used to help the state minimize risk. This can include shorter-term strategies that may not be ideal as a full-blown reconstruction but can nonetheless be effective. Mitigation measure strategies will be discussed in more detail, focusing on evaluation criteria, alternatives analysis, funding levels/sources and recommended improvements.

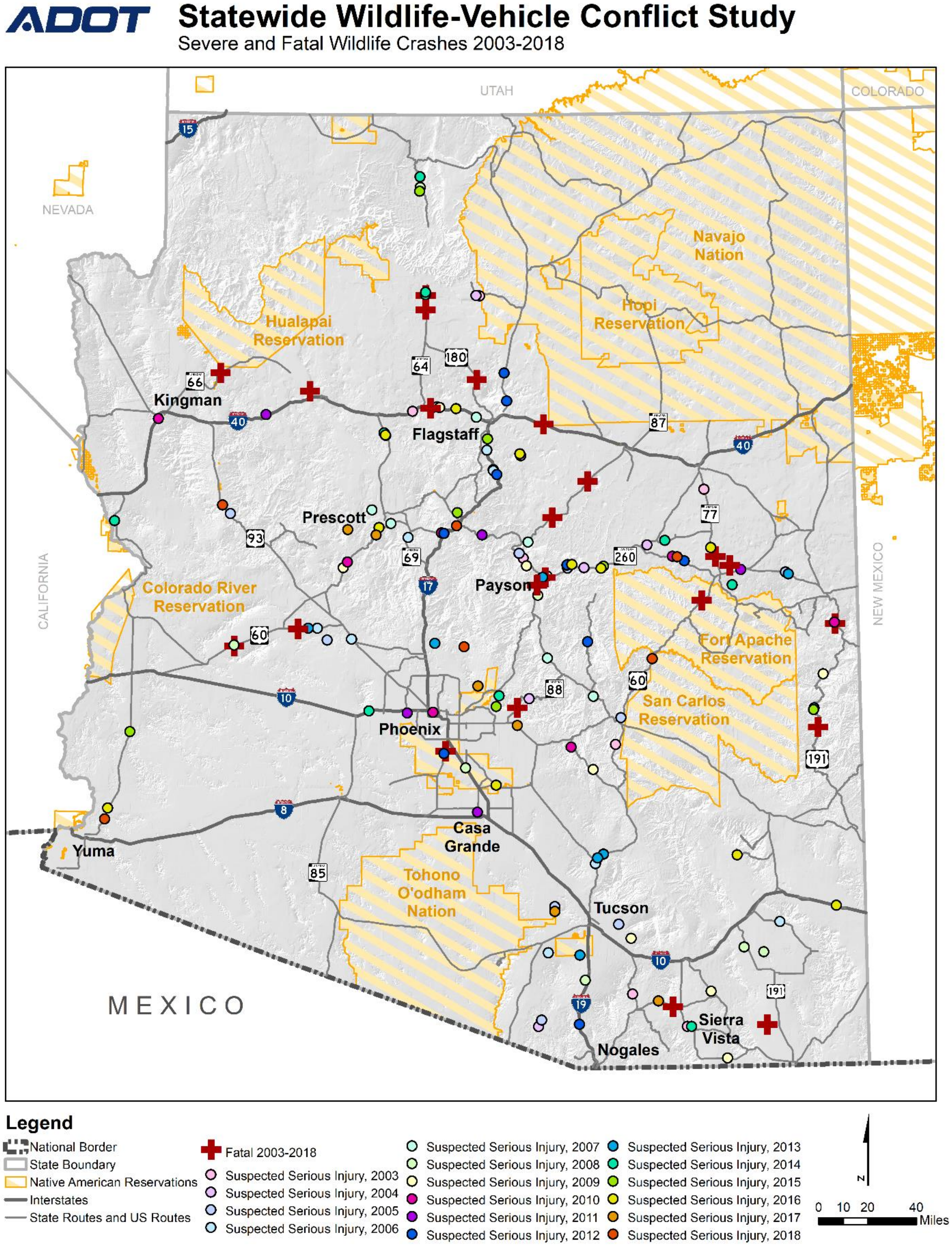


*Figure 1- 1 Severe and fatal wildlife crashes 2003-2018.*

## STUDY PROCESS

Our study process involves four discrete tasks largely tied to their associated deliverables. Task 1 has been ongoing since summer 2020; its key deliverables span the bookends of the Task's activities, from project kick-off to submission of this technical paper. Task 1 included three key activities: 1) assessments, 2) development of a statewide wildlife needs list, and 3) high-level screening of priority WVC hotspots (Figure 1-2). This critical assessment phase included: 1) organizing and conditioning of the Arizona Crash Information System (ACIS) database needed to accomplish our assessment and hotspot modeling, (2) compiling past and ongoing ADOT mitigation projects, research and corridor/linkage assessments done since 2000, 3) development of numerous GIS layers including ADOT organizational (highways, Districts), ecological factors, and threatened, endangered, and sensitive (TES) species occurrences for use in hotspot modeling, and 4) WVC hotspot modeling to yield our statewide wildlife needs listing, all reported in Chapter 3. Under the guidance of our project TAC, we accomplished the high-level screening to derive priorities for field assessment and development of mitigation strategies and projects, to be accomplished next under Task 2. Also, under high-level screening we considered several ecological considerations to complement the hotspot modeling focus on WVCs. With the completion of Task 1, we lay out our path forward for developing mitigation strategies for priority hotspots in Chapter 4.

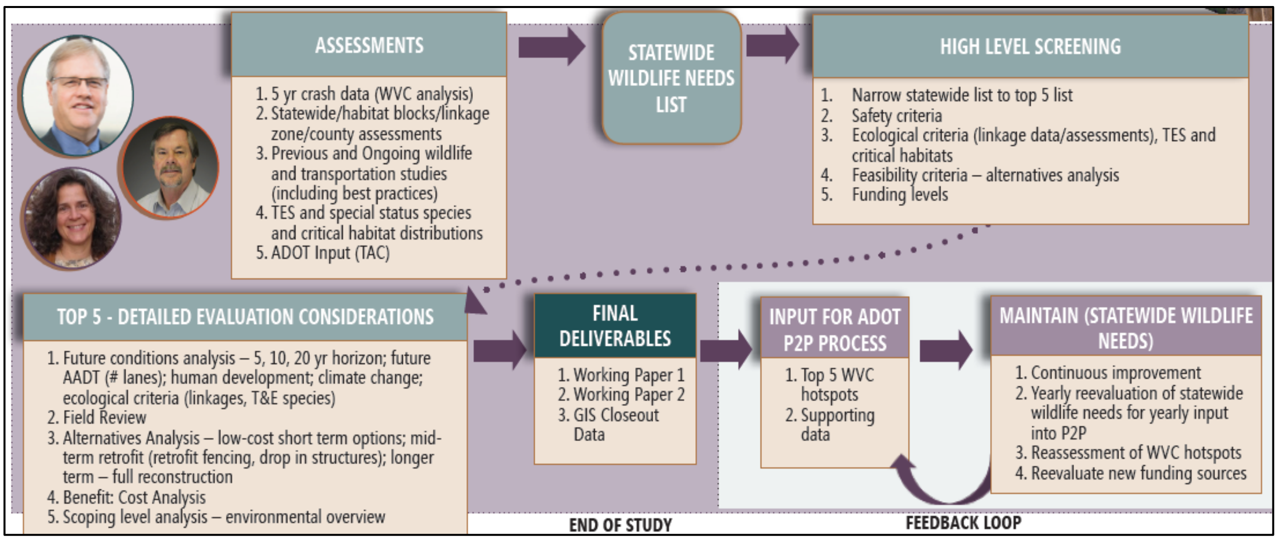


*Figure 1- 2 Project study process and implementation plan.*

# CHAPTER 2 – CURRENT CONDITIONS

## INVENTORY OF ARIZONA CRASH INFORMATION SYSTEM

### STATEWIDE CRASH DATABASE ANALYSIS

ADOT's Arizona Crash Information System (ACIS) formed the foundation for our inventory and analysis of wildlife-related vehicular crashes across Arizona. ADOT maintains the ACIS database for use by public safety agencies to submit vehicular crash reports that occur on Arizona's 6,611 center-lane miles of highways, of which 5,824 miles (88 percent) are classified as Rural highways (Source: FHWA Highway Statistics 2020). The ACIS database is populated largely by accident reports filed by the Arizona Department of Public Safety (DPS), primarily responsible for law enforcement on state roadways, though other agencies provide information. This includes crashes involving wildlife where they result in significant property damage and/or human injuries or deaths. As such, this database represents the most consistent source available across years and highways for use in making comparisons. However, since accidents reported in ACIS reflect the relative degree of property damage and/or human injuries, crashes involving smaller-bodied wildlife species are recognized as being underreported; a comprehensive study in British Columbia (Hesse and Rea 2016) found that only 34% of WVC were reflected in their crash databases. Also, under ACIS, wildlife-related accidents are reported under the "First Harmful" factor descriptor as "Animal Wild Game" and wildlife species were not specified. Some reported accidents, especially along interstates start with a WVC only to result in an even more serious crash, often with serious human injury or death in which the first harmful event is not reported as a WVC; these accidents are not reflected in our analysis. ACIS records are geospatially referenced for Geographic Information System (GIS) analyses.

Our team analyzed crash data for a 16-year period, 2003 to 2018, of which a total of 1,955,224 crashes were assessed, or an average of 122,201/year which has trended downward over the period. ADOT made a change in the crash form used by reporting agencies in 2017 whereby all animal-related crashes on highways were combined with wildlife, including livestock and pets which accounted for 8,000 records. This necessitated a time-consuming effort by our team and ADOT staff to manually search all animal-related crashes for 2017 and 2018 using the Arizona Accident Location Identification Surveillance System (ALISS) database to sort out livestock and pet records. One benefit of this effort was the identification of wildlife species associated with wildlife crash records for the 2018 dataset, providing insight into the species represented in ACIS; we also confirmed that >98 percent of Animal Wild Game records were classified properly (versus misclassified pet or livestock). We found that ACIS crash records for Tribal lands were inconsistent, as most Tribes maintain their own crash records; except for major highways where DPS has primary responsibility (e.g., US 60), we thus excluded Tribal lands from our analysis.

A total of 20,326 wildlife-related crashes were recorded in ACIS, or an average of 1,270 crashes/year (Figure 2-1). While comprising just 1 percent of the total statewide crashes, wildlife-related crashes on some Arizona highways comprise over 40 percent of all crashes, based on the 2014 ADOT crash assessment (ADOT 2014*a*); this points to the concentrated nature of WVCs and the opportunities for developing targeted mitigation strategies with this study.

One apparent trend with wildlife-related crashes is an increasing upward annual incidence over time (Figure 2-2), despite increasing numbers of highways (7 total) where mitigation projects have been implemented since 2002 to reduce large-animal (e.g., elk, deer) WVCs and promote wildlife connectivity. In fact, the annual incidence of wildlife-related crashes increased 72 percent between 2003 through 2007 (964.4 crashes/year) and 2014 through 2018 (1,657.2 crashes/year) averages. While several factors may account for this trend including wildlife population levels or climatic (e.g., drought) and economic (e.g., recession) conditions, Arizona's steadily growing human population (with its attendant increase in highway vehicle miles driven) alone explains 84 percent of the variation ($r = 0.916$) in annual wildlife crash incidence (Figure 2-2). The state's expected upward population trend underscores the importance and timeliness of this study in developing strategies to mitigate the incidence and impact of future wildlife-related crashes.

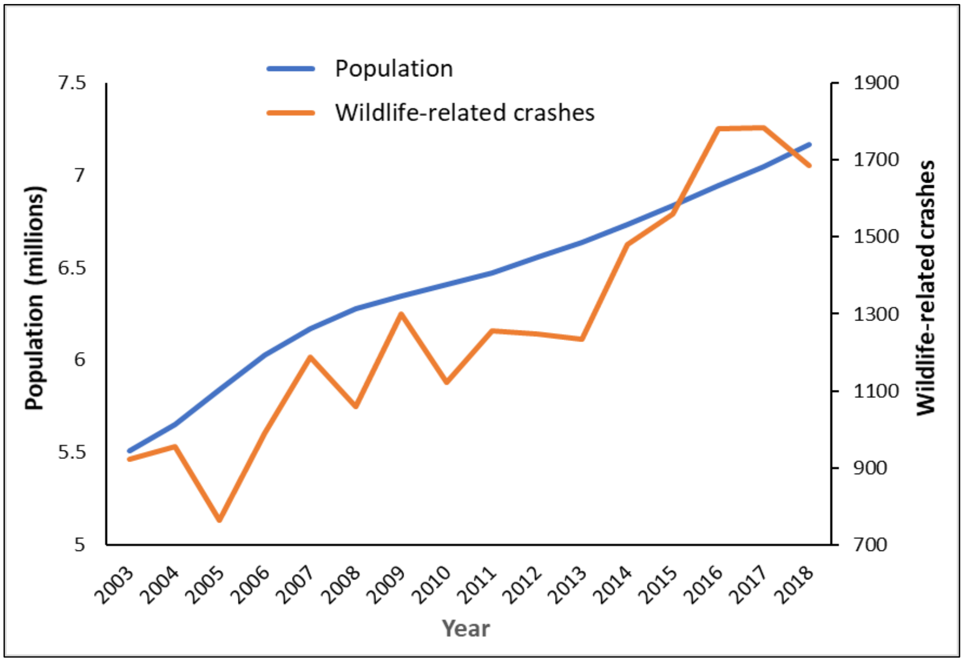


*Figure 2- 1. Annual incidence of wildlife-related crashes from ADOT's ACIS and annual Arizona population estimate (source: U.S. Census Bureau), 2003 through 2018.*

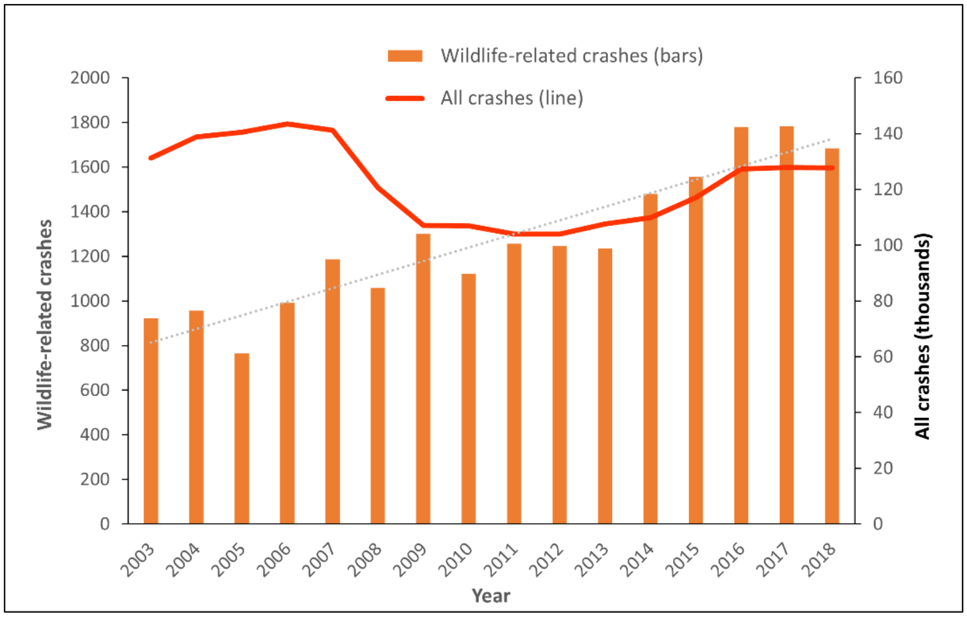


*Figure 2- 2. Annual incidence of all statewide vehicular crashes and wildlife-related crashes (with linear trendline) from ADOT's ACIS, 2003 through 2018.*

Of Arizona's 15 counties, Coconino County accounted for 30 percent of all wildlife-related crashes (Figure 2-3); the next two highest were Yavapai and Navajo counties with 12 percent and 10 percent, respectively. When considered by ADOT District (see Figure 2-6), the Northcentral District that encompasses much of Coconino and neighboring counties alone accounts for 41 percent of all statewide wildlife-related crashes, followed by the Southcentral District with 14% (Figure 2-4).

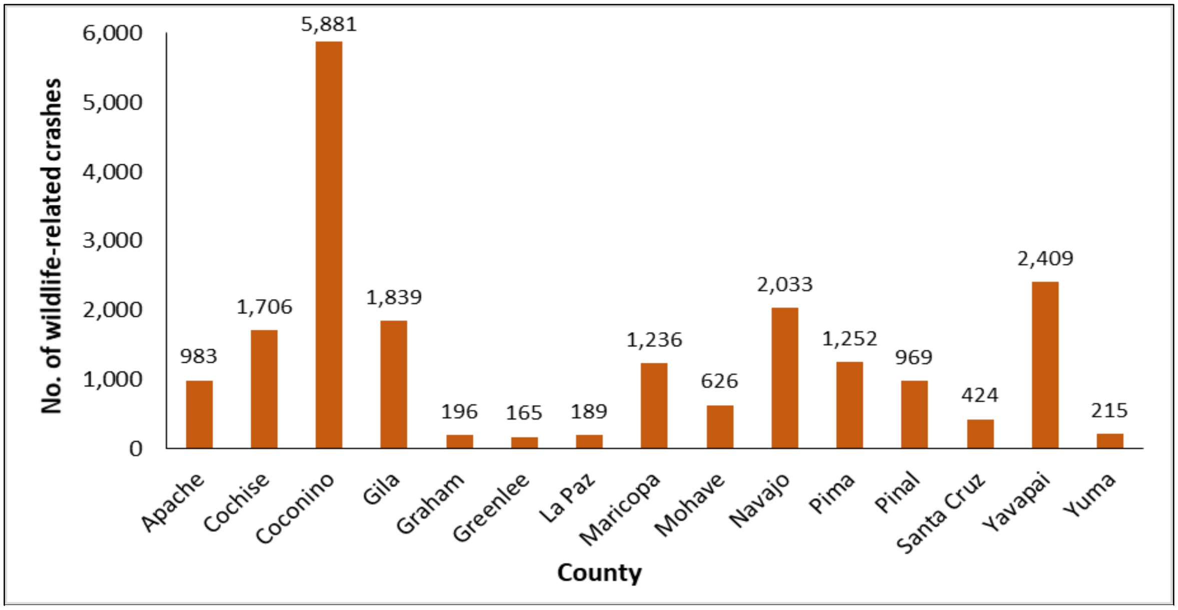


*Figure 2- 3. Total number of wildlife-related crashes by Arizona county, 2003 through 2018.*

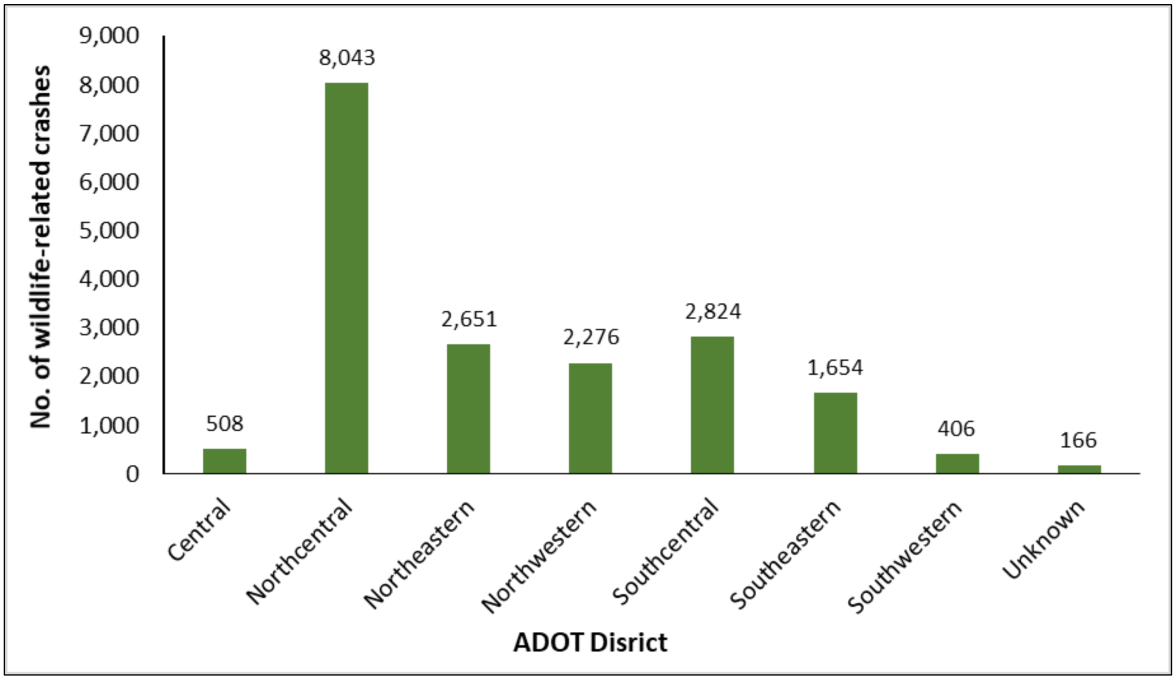


*Figure 2- 4 Total number of wildlife-related crashes ADOT District, 2003 through 2018.*

Of the highways on which wildlife-related crashes were recorded, the top nine highways accounted for half of all crashes recorded for the entire state (Table 2-1). All or part of all nine highways traverse the northern half the state where elk are most prevalent. Four of the highways alone (SR 260, I-40, Interstate 17 [I-17], and US 87) account for nearly a third of all statewide wildlife-related crashes. Considering the length of roadway, we assessed (from ADOT 2014*a*) for these highways, the average incidence of wildlife crashes/mile/year ranged from 0.20 on United States Highway (US) 60 to 1.0 on SR 260, averaging 0.44 wildlife crashes/mile/year. Our hotspot analysis identified sections of these highways that had considerably higher wildlife-related crash incidence/mile, some more than 10 times as high.

*Table 2- 1. Arizona highways with the highest incidence of wildlife-related crashes that when combined account for half of all crashes that occurred in Arizona between 2003 and 2018, along with the average crashes/mile/year and the number of crashes with human fatalities.*

| Highway | Number of wildlife crashes | Percent of all crashes | Average wildlife crashes/mile/year (rank)* | Fatal crashes |
|---|---|---|---|---|
| SR 260 | 2,540 | 12.5 | 1.00 (1) | 1 |
| I-40 | 1,648 | 8.1 | 0.35 (4) | 2 |
| I-17 | 1,235 | 6.1 | 0.61 (3) | 0 |
| SR 87 | 994 | 4.9 | 0.26 (6) | 3 |
| US 60 | 983 | 4.8 | 0.20 (9) | 3 |
| SR 64 | 964 | 4.7 | 0.82 (2) | 2 |
| US 180 | 690 | 3.4 | 0.29 (5) | 1 |
| SR 77 | 587 | 2.9 | 0.26 (6) | 1 |
| US 89 | 492 | 2.4 | 0.26 (6) | 0 |
| **Total** | **10,133** | **49.8** | **0.44** | **14** |

*Total miles of assessed highways used in calculations from 2014 crash assessment (ADOT 2014*a*)

ACIS includes crash severity associated with wildlife-related crash records. While most crashes resulted in no injuries and those that resulted in human fatalities were rare (annual average of 1.4/year; range 0-3), crashes resulting in suspected serious injuries (10.1/year; range = 6-20) and other injuries (suspected minor and unspecified injuries; 102.2/year; range = 64-122) point to the impact these crashes potentially have on motorist and highway safety. Of potential concern is the increasing trend in wildlife-related crashes resulting in injuries, increasing 41 percent in the last five years from a mean of 90.6 injury (minor and unspecified) accidents/year between 2003 and 2013 to 127.6 between 2014 and 2018. Of the 22 total wildlife crashes with a human fatality that are recorded in the ACIS dataset, nearly two-thirds (14) occurred on seven of our nine top crash incidence highways (Table 2-1).

Of the wildlife-related crashes in the ACIS 2018 dataset where we were able to ascertain the species involved; deer (recorded as either mule deer or unspecified but likely includes white-tail deer) accounted for the highest recorded involvement in crashes, 59.3 percent. This reflects their abundance and wide distribution across the state and on southern Arizona highways (e.g., SR 90, SR 92, Interstate 19 [I-19]) where deer account for as high as 80 percent of all crashes.

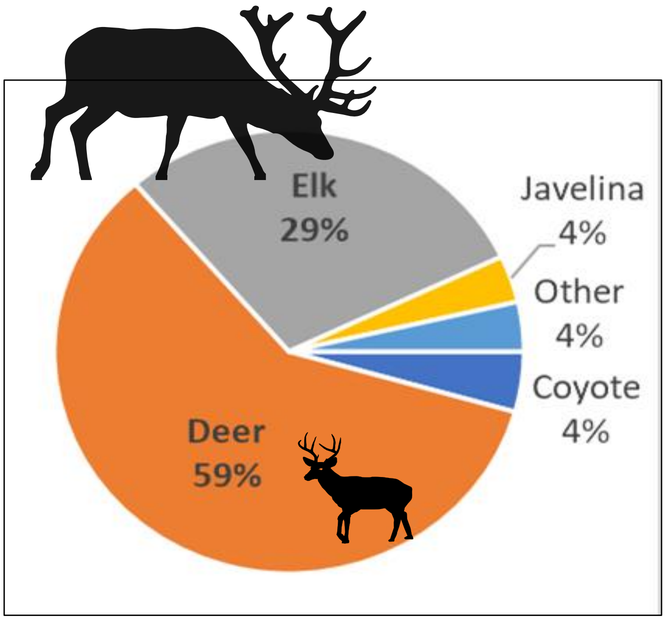


*Figure 2- 5. Percentage of the total 2018 wildlife-related crashes classified by wildlife species.*

Elk, second largest of the state's species (after bison), accounted for nearly a third of the statewide crashes, though most occurred in the northern portion of the state where elk accounted for over half all crashes on several highways (e.g., SR 260, I-17). Coyote and javelina each accounted for 4 percent of crashes, and eight species (e.g., pronghorn, black bear, mountain lion, bighorn sheep, raccoon) combined to account for another 4 percent of all crashes (Figure 2-5).

## WILDLIFE CRASH HOTSPOT MODELING

The reported crashes with all animals along ADOT highways from 2014 through 2018 were mapped and modeled to identify the priority WVC hotspots based on the number of crashes per mile within each hotspot. The researchers used the ArcGIS Optimized Hot Spot Analysis tool (OHSA) using the Getis-Ord statistic to identify 51 hotspots across Arizona. The OHSA allows the analyst to adapt model parameters to ensure proper values are used given the spatial distribution of the occurrence data. The tool also enables the analyst to select the most appropriate aggregation method, that is, the method by which the points or occurrences may be counted or summarized, for a given area. The ability to summarize data within a given aggregation area is the differentiating feature from the standard Hot Spot Analysis (Getis-Ord Gi*) tool available in ArcGIS (Cramer and McGinty 2018).

The resultant OHSA shapefile segments were aggregated into hotspots based on the crash data using the 90%, 95%, and 99% confidence intervals as well as only the 95% and 99% confidence intervals. The research team conferred with the agency advisory panel members on the five most important variables of the crash analysis: (1) the length of the road segment, (2) the width of the road segment, (3) search distance, (4) the years of crash data, and (5) inclusion of confidence intervals.

The final values for each of these five variables that were used for the final, master animal-vehicle crash hotspot analysis are presented below in Table 2-2.

*Table 2- 2. Final Variable Values Used in the Master Top 25 Animal-Vehicle Crash Hotspots in Arizona,*

| Segment Length | Buffer Width | OHSA Analysis Buffer | Crash Data Year Range | Confidence Intervals |
|---|---|---|---|---|
| 1 mile (5,280 ft) | 200 meter (656.168 ft) | 1 mile (1609 m) | 5 Year (2014-2018) | 90, 95, and 99 |

Detailed methods to this modeling process are provided in Appendix A. The master map (Figure 2-6) provides an overview of the modeled statewide hotspots.

Multiple runs of the model with slight adjustments to different variables resulted in many of the hotspots remaining in the top 25 list. Some, such as hotspots 1 and 2, remained in their position under all the different scenarios of model run, building greater confidence in the results. See Appendix A for a comparison of hotspots with 95-99 confidence intervals compared to 90-95-99 confidence intervals.

The hotspots largely identified areas where mule deer and elk collisions are reported to occur.

Table 2-3 presents the top 25 wildlife-vehicle crash hotspots statewide. The six tables below the statewide table present hotspots for six of the seven ADOT districts. The Central District did not have wildlife-vehicle crash hotspots.

The majority of wildlife-vehicle crash hotspots were located in northern Arizona, with 19 hotspots in the Flagstaff area (Figure 2-7), and 15 in the Payson to Show Low corridor (Figure 2-8).

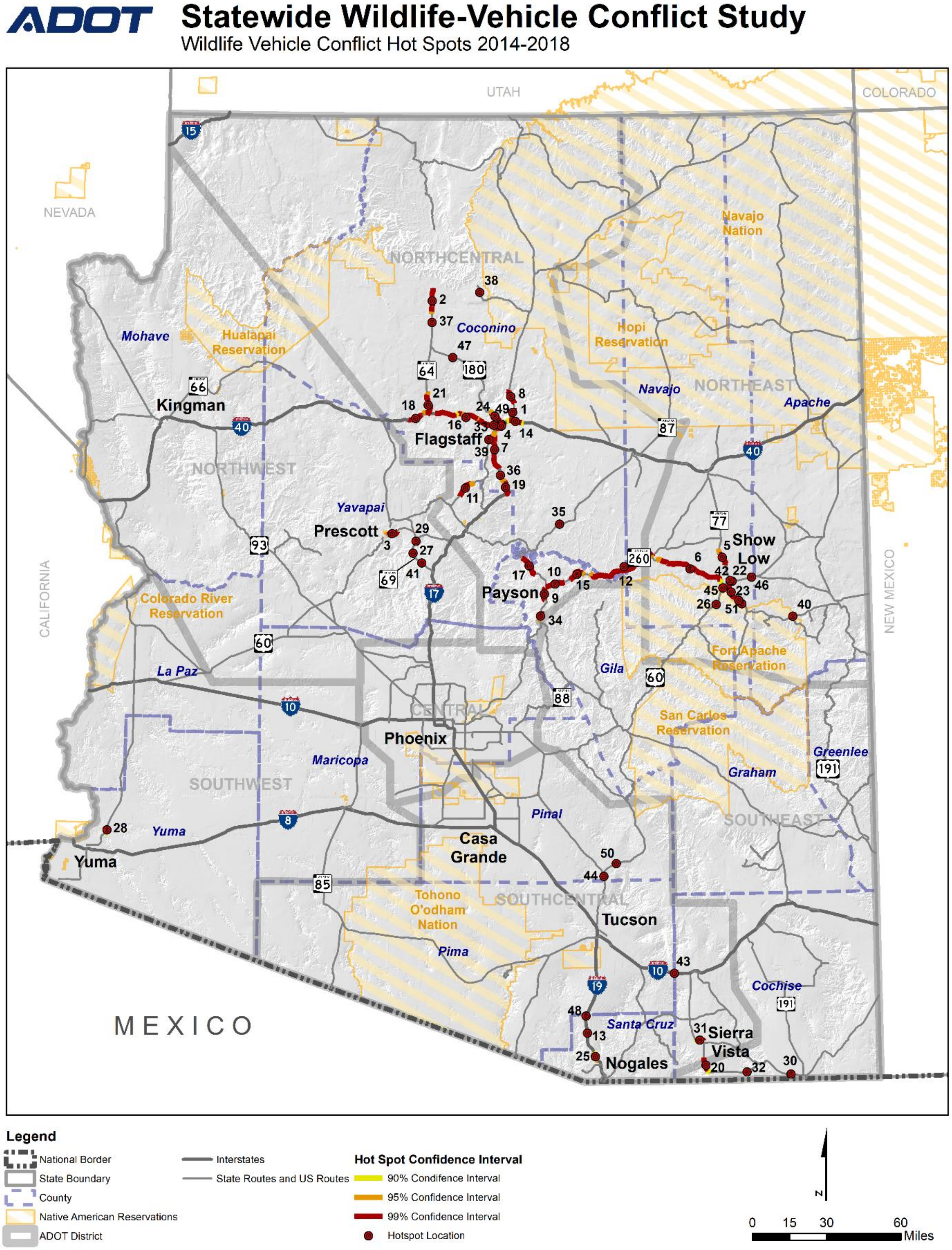


*Figure 2- 6. Arizona wildlife-vehicle crash top 51 hotspots 2014 through 2018.*

*Table 2- 3. Top 25 Wildlife-Vehicle crash hotspots ranked by annual average WVC crashes per mile. (Blue = Northcentral District, Tan = Northwest District, Yellow = Southcentral District, Green =Northeast District, Brown = Southwestern District).*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile | ADOT District |
|---|---|---|---|---|---|---|---|---|
| 1 | US 89 North of Flagstaff | U S89 | 420-424 | 4 | 79 | 19.75 | 3.95 | Northcentral |
| 2 | SR 64 South Rim Grand Canyon | SR 64 | 227-237 | 10.4 | 141 | 13.57 | 2.71 | Northcentral |
| 3 | SR 69 Prescott | SR 69 | 291.5-296 | 5.6 | 75 | 13.45 | 2.69 | Northwest |
| 4 | I-40 Flagstaff from I-17 to Walnut Canyon | I-40 | 195.5-199.5 | 4.2 | 47 | 11.29 | 2.26 | Northcentral |
| 4 | SR 77 North of Show Low | SR 77 | 349-356 | 7 | 79 | 11.29 | 2.26 | Northeast |
| 6 | SR 260 Heber to Show Low | SR 260 | 309-339 | 30 | 338 | 11.27 | 2.25 | Northeast |
| 7 | I-17 Munds Park to Flagstaff Pulliam Airport | I-17 | 321-338 | 17.2 | 187 | 10.86 | 2.17 | Northcentral |
| 8 | US 89 Sunset Crater Volcano NM | US 89 | 426-432 | 6 | 65 | 10.83 | 2.17 | Northcentral |
| 9 | SR 87 South Payson | SR 87 | 246.5-251.5 | 5 | 53 | 10.60 | 2.12 | Northcentral |
| 10 | SR 260 East of Payson | SR 260 | 252-260 | 8.2 | 87 | 10.59 | 2.12 | Northcentral |
| 11 | SR 89A Page Springs North to Sedona | SR 89A | 361-369 | 8 | 82 | 10.25 | 2.05 | Northcentral |
| 12 | SR 260/SR 277 Mountain Meadow to Heber | SR 260 | SR 260: 275-306<br>SR 277: 305-307 | 33 | 336 | 10.18 | 2.04 | Northcentral /Northeast |
| 13 | I-19 Rio Rico Northeast | I-19 | 21.5 -22.5 | 1 | 10 | 10.00 | 2 | Southcentral |
| 14 | I-40 East Flagstaff Wildcat Hill | I-40 | 201-207 | 7.7 | 73 | 9.50 | 1.9 | Northcentral |

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile | ADOT District |
|---|---|---|---|---|---|---|---|---|
| 15 | SR 260 Payson – Kohls Ranch | SR 260 | 263-271 | 8 | 75 | 9.37 | 1.87 | Northcentral |
| 16 | I-40 West Flagstaff to Williams | I-40 | 168-195 | 26.5 | 248 | 9.35 | 1.87 | Northcentral |
| 17 | SR 87/SR 260 NW Payson | SR 87 | 261-270 | 9 | 84 | 9.33 | 1.87 | Northcentral |
| 18 | I-40 Pine Springs | I-40 | 156-162 | 2 | 58 | 9.24 | 1.85 | Northcentral |
| 19 | I-17 Rattlesnake Canyon to South of Munds Park | I-17 | 309-317 | 8 | 73 | 9.12 | 1.82 | Northcentral |
| 20 | SR 92 North of Mexican Border-Nicksville | SR 92 | 327-334 | 7 | 63 | 9.00 | 1.8 | Southcentral /Southeast |
| 21 | I-40-SR 64 North of Williams | I-40/ SR 64 | I-40: 163-166 SR 64 185-194.5 | 12 | 103 | 8.58 | 1.72 | Northcentral |
| 22 | SR 73 South of Show Low | SR 73 | 343-350 | 7 | 56 | 8.00 | 1.6 | Northeast |
| 22 | US 60 East of Show Low | US 60 | 342-343 | 1 | 8 | 8.00 | 1.6 | Northeast |
| 24 | US 180 North Flagstaff | US 180 | 216-222 | 6 | 47 | 7.83 | 1.57 | Northcentral |
| 25 | US 60 Forest Dale Canyon South of Show Low | US 60/ SR 77 | 329.5-331.5 | 2 | 15 | 7.50 | 1.5 | Northeast |
| 25 | SR 69 Poland Junction | SR 69 | 273-275 | 2 | 15 | 7.50 | 1.5 | Northwest |
| 25 | I-19 North of Nogales | I-19 | 10-14 | 4 | 30 | 7.50 | 1.5 | Southcentral |

*Table 2- 4. ADOT Northcentral District wildlife-vehicle crash hotspots.*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 1 | US 89 North of Flagstaff | US 89 | 420-424 | 4.00 | 79 | 19.75 | 3.95 |
| 2 | SR 64 South Rim Grand Canyon | SR 64 | 227-237 | 10.39 | 141 | 13.57 | 2.71 |
| 4 | I-40 Flagstaff from I-17 to Walnut Canyon | I-40 | 195.5-199.5 | 4.16 | 47 | 11.29 | 2.26 |
| 7 | I-17 Munds Park to Flagstaff Pulliam Airport | I-17 | 321-338 | 17.21 | 187 | 10.86 | 2.17 |
| 8 | US 89 Sunset Crater Volcano NM | US 89 | 426-432 | 6.00 | 65 | 10.83 | 2.17 |
| 9 | SR 87 South Payson | SR 87 | 246.5-251.5 | 5.00 | 53 | 10.60 | 2.12 |
| 10 | SR 260 East of Payson | SR 260 | 252-260 | 8.22 | 87 | 10.59 | 2.12 |
| 11 | SR 89A Page Springs North to Sedona | SR 89A | 361-369 | 8.00 | 82 | 10.25 | 2.05 |
| 12 | SR 260/SR 277 Mountain Meadow to Heber | S 260 | SR 260 275-306; SR 277 305 - 307 | 33.00 | 336 | 10.18 | 2.04 |
| 14 | I-40 East Flagstaff Wildcat Hill | I-40 | 201-207 | 7.69 | 73 | 9.50 | 1.90 |
| 15 | SR 260 Payson – Kohls Ranch | SR 260 | 263-271 | 8.00 | 75 | 9.37 | 1.87 |
| 16 | I-40 West Flagstaff to Williams | I-40 | 168-195 | 26.53 | 248 | 9.35 | 1.87 |
| 17 | SR 87/SR 260 NW Payson | SR 87 | 261-270 | 9.00 | 84 | 9.33 | 1.87 |
| 18 | I-40 Pine Springs | I-40 | 156-162 | 2.00 | 58 | 9.24 | 1.85 |
| 19 | I-17 Rattlesnake Canyon to South of Munds Park | I -17 | 309-317 | 8.00 | 73 | 9.12 | 1.82 |
| 21 | I-40-SR 64 North of Williams | I -40/ SR 064 | I-40: 163-166 SR 64: 185-194 | 12.00 | 103 | 8.58 | 1.72 |
| 24 | US 180 North Flagstaff | US 180 | 216-222 | 6.00 | 47 | 7.83 | 1.57 |

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 29 | I-40 Business Loop into W Flagstaff -West Historic Rte. 66 | I-40 | 393-394 | 1.00 | 7 | 7.00 | 1.40 |
| 34 | I-17 South of Munds Park | I-17 | 318-320 | 2.00 | 13 | 6.50 | 1.30 |
| 34 | SR 87 NW Boundary of Mogollon Rim | SR 87 | 297-298 | 2.00 | 13 | 6.50 | 1.30 |
| 34 | SR 87 Deer Creek Village | SR 87 | 236-240 | 4.00 | 26 | 6.50 | 1.30 |
| 37 | SR 64 South Rim Grand Canyon- Red Horse Wash | SR 64 | 223-224 | 1.00 | 6 | 6.00 | 1.20 |
| 37 | SR 64 South Rim Grand Canyon - Desert View | SR 64 | 270-272 | 2.00 | 12 | 6.00 | 1.20 |
| 39 | SR 89 A Forest Highlands | SR 89A | 394-397 | 3.00 | 17 | 5.67 | 1.13 |
| 43 | US 180 Kaibab National Forest - Ebert Mountain | US 180 | 255-256 | 1.00 | 4 | 4.00 | 0.80 |
| 49 | I-40 Entrance Ramp East Flagstaff | I-40 | 197-198 | 2.00 | 7 | 3.50 | 0.70 |

*Table 2- 5. ADOT Northeastern District wildlife-vehicle crash hotspots.*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 4 | SR 77 North of Show Low | SR 77 | 349-356 | 7.00 | 79 | 11.29 | 2.26 |
| 6 | SR 260 Heber to Show Low | SR 260 | 309-339 | 30.00 | 338 | 11.27 | 2.25 |
| 12 | SR 260/SR 277 Mountain Meadow to Heber | SR 260 | SR 260 275 - 306; SR 277 305 - 307 | 33.00 | 336 | 10.18 | 2.04 |
| 22 | SR 73 / SR 260 South of Show Low | SR 73 | 343-350 | 7.00 | 56 | 8.00 | 1.60 |
| 22 | US 60 East of Show Low | US 60 | 342-343 | 1.00 | 8 | 8.00 | 1.60 |
| 25 | US 60 Forest Dale Canyon South of Show Low | US 60/ SR 77 | 329.5-331.5 | 2.00 | 15 | 7.50 | 1.50 |
| 40 | SR 260 / US 60 Show Low | SR 260 | SR 260 - 378; US 60 376-379 | 4.00 | 21 | 5.25 | 1.05 |
| 42 | SR 77 Downtown Show Low | SR 77 | 342-343 | 1.12 | 5 | 4.45 | 0.89 |
| 43 | US 60 Apache Reservation Boundary - Show Low | US 60 | 237-238 | 1.00 | 4 | 4.00 | 0.80 |
| 43 | US 60 East of Show Low – Bell | US 60 | 350-351 | 1.00 | 4 | 4.00 | 0.80 |
| 51 | SR 260 South of Show Low | SR 260 | 351-352 | 1.00 | 2 | 2.00 | 0.40 |

*Table 2- 6. ADOT Northwestern District wildlife-vehicle crash hotspots.*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 3 | SR 69 Prescott | SR 69 | 291.5-296 | 5.58 | 75 | 13.45 | 2.69 |
| 25 | SR 69 Poland Junction | SR 69 | 273-275 | 2.00 | 15 | 7.50 | 1.50 |
| 29 | SR 69 Humboldt | SR 69 | 79-80 | 1.00 | 7 | 7.00 | 1.40 |
| 41 | SR 69 N Spring Valley | SR 69 | 268-269 | 1.00 | 5 | 5.00 | 1.00 |

*Table 2- 7. ADOT Southcentral District wildlife-vehicle crash hotspots.*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 13 | I-19 Rio Rico Northeast | I-19 | 21.5 -22.5 | 1.00 | 10 | 10.00 | 2.00 |
| 20 | SR 92 North of Mexican Border-Nicksville | SR 92 | 327-334 | 7.00 | 63 | 9.00 | 1.80 |
| 25 | I-19 North of Nogales | I-19 | 10-14 | 4.00 | 30 | 7.50 | 1.50 |
| 29 | SR 90 Sierra Vista | SR 90 | 317-320 | 3.00 | 21 | 7.00 | 1.40 |
| 43 | I-10 West of Benson | I-10 | 296-297 | 1.00 | 4 | 4.00 | 0.80 |
| 43 | I-19 Tumacacori | I-19 | 29-30 | 1.00 | 4 | 4.00 | 0.80 |
| 43 | SR 77 Catalina | SR 77 | 89-90 | 1.00 | 4 | 4.00 | 0.80 |
| 50 | SR 77 Biosphere 2 | SR 77 | 97-98 | 1.00 | 3 | 3.00 | 0.60 |

*Table 2- 8. ADOT Southeastern District wildlife-vehicle crash hotspots.*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 20 | SR 92 North of Mexican Border-Nicksville | SR 92 | 327-334 | 7.00 | 63 | 9.00 | 1.80 |
| 29 | SR 92 Naco - Mexico Border | SR 92 | 349-350 | 1.00 | 7 | 7.00 | 1.40 |
| 29 | SR 80 West of Douglas - Mexico Border | SR 80 | 358-361 | 3.00 | 21 | 7.00 | 1.40 |

*Table 2- 9. ADOT Southwestern District wildlife-vehicle crash hotspots.*

| WVC Crash Hotspot Rank | Name | Route | Mile post range | Length (mi) | No. of Animal Crashes | Animal Crashes per Mile | Annual Avg. Animal Crashes per Mile |
|---|---|---|---|---|---|---|---|
| 28 | US 95 North Yuma | US 95 | 40-43 | 3.00 | 22 | 7.33 | 1.47 |

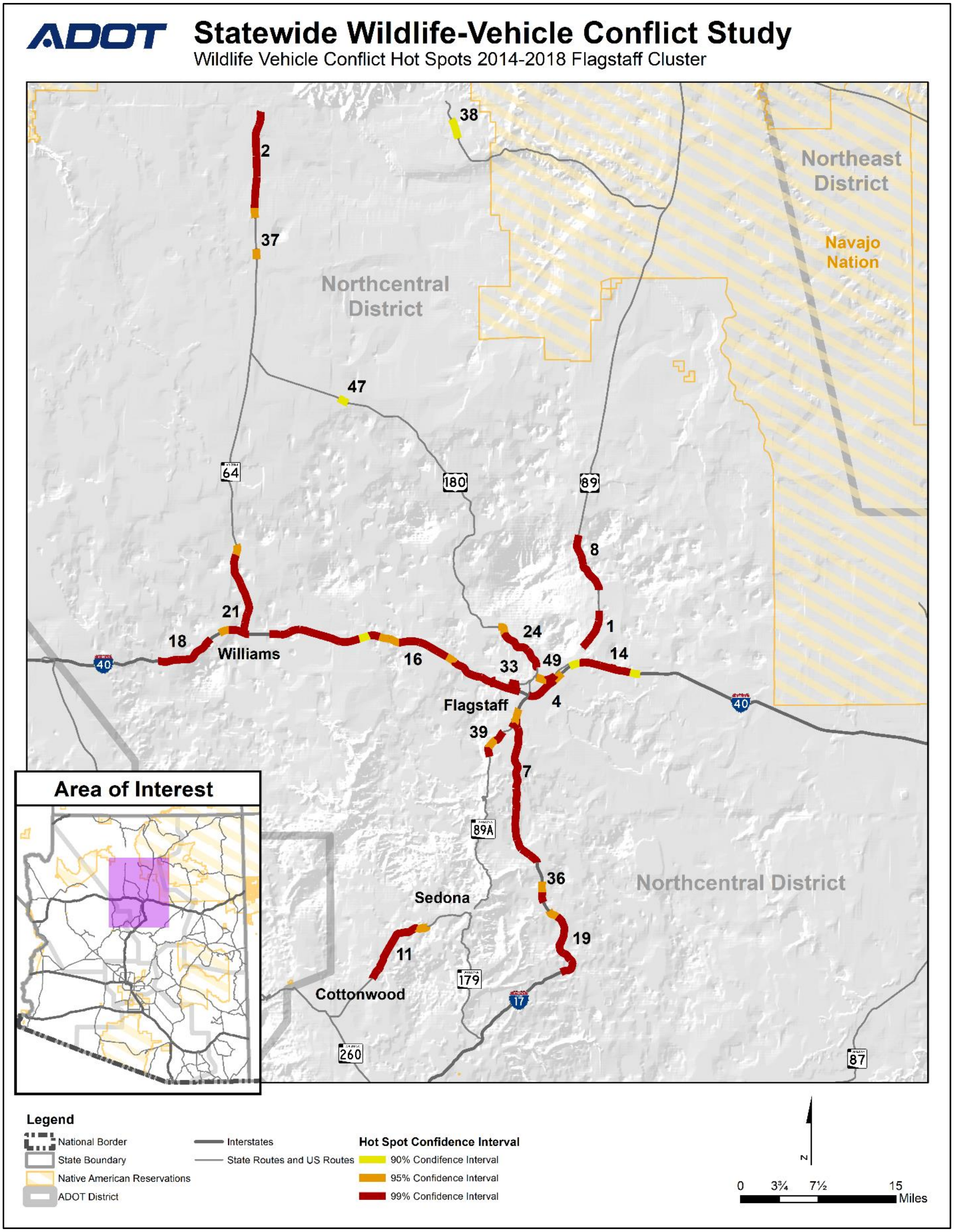


*Figure 2- 7. Flagstaff area top wildlife-vehicle crash hotspots, 2014 through 2018.*

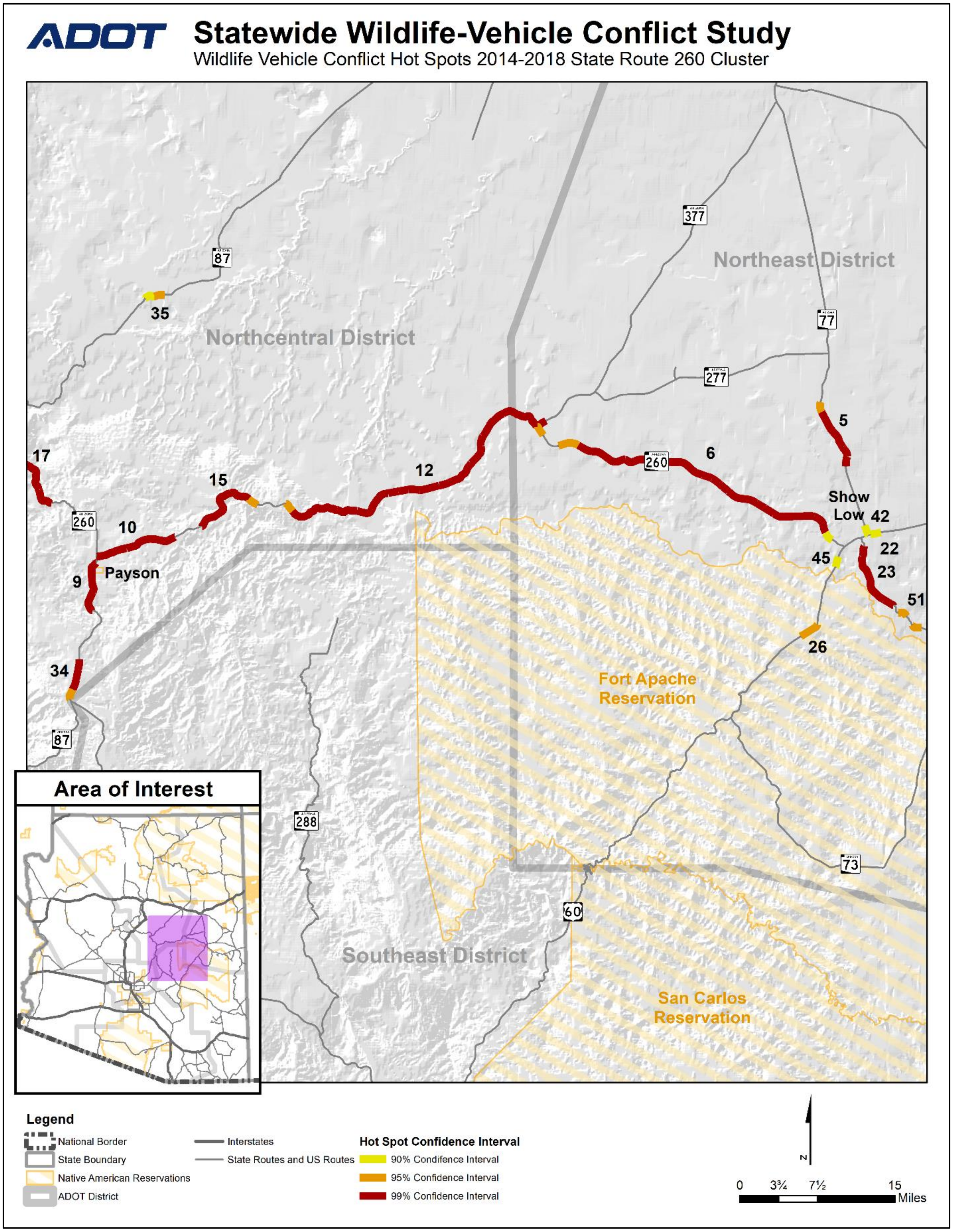


*Figure 2- 8. Payson to Show Low area wildlife-vehicle crash hotspots, 2014 through 2018.*

Crash hotspots are informative; however, these hotspots were based solely on numbers of reported crashes per mile. These are often the areas where mule deer and elk encounter highway traffic as they migrate and move daily through their habitat. The hotspots were the driving factor in this study. Additional transportation and ecological data on these areas were added to the maps and analyses to understand how other factors may be considered when deciding on potential wildlife mitigation efforts. These factors can assist ADOT and its partners to arrive at a common understanding of necessary actions, funding sources, other partners in efforts, and future projections in areas within long- term projects to be mitigated for not only mule deer and elk, but other wildlife species of concern.

Appendix B presents the GIS layers used in this overall analysis of ADOT roads and ecological factors. The other factors were brought together in a scorecard matrix organized by the 51 hotspots, and with factors analyzed as transportation- and ecological-related data. Appendix C presents these transportation and ecological scorecard factors and how each of the hotspots were evaluated with respect to them. In Chapter 5 the various overall top 10 ranking of hotspots with respect to these factors are presented.

The hotspot analysis provides both the overall statewide view of top areas where WVCs occurred and a detailed analysis of the smaller, peak hotspots within the larger hotspot areas. In this report, clear recommendations are made to address wildlife-vehicle conflicts with lower cost fixes and maintaining what has already been achieved.

## WILDLIFE LINKAGE, CONNECTIVITY, AND CORRIDOR ASSESSMENTS

The detrimental effects of highways and traffic on wildlife connectivity can begin to be addressed by identification of the top areas where wildlife are believed to be moving across the landscape and where those areas are bisected by roads. Arizona has worked to identify potential wildlife linkage areas and associated highway features as a step within a holistic approach of looking at the entire problem rather than the more typical piecemeal approach.

Highways constitute one of the most significant forces altering natural ecosystems in North America (Forman et al. 2003). Indirect barrier and fragmentation effects associated with highways pose an equal or greater threat to wildlife than the direct wildlife mortality from WVCs. Highways contribute to diminished habitat connectivity and permeability, or ability to cross highways, for many species (Forman et al. 2003, Bissonette and Cramer 2008). Highways are barriers to wildlife movement that fragment populations and habitats, and limit juvenile dispersal (Beier 1995), genetic interchange (Epps et al. 2005, Riley et al. 2006) and even population viability.

To proactively preserve and restore landscape connectivity and develop comprehensive plans to address landscape connectivity (Beier and Noss 1998), several agencies including ADOT, nongovernmental organizations, and universities collaboratively developed connectivity and linkage assessments, at three scales: 1) the statewide *Arizona's Wildlife Linkage Assessment*, 2) focused county-level assessments, and 3) individual linkage design modeling. Also, through cooperative ADOT and AGFD highway and wildlife studies that employed GPS telemetry tracking of elk, deer and pronghorn, data-driven migration corridors and high-use areas associated with highways have been delineated (Kauffman et al. 2020), also serving to validate linkage assessments. Each scale has its appropriate applications to addressing wildlife connectivity needs during various phases of ADOT's transportation planning process. The availability of

GIS data is particularly useful in integrating the linkage information into the wildlife needs identification and prioritization process.

## STATEWIDE ARIZONA'S WILDLIFE LINKAGE ASSESSMENT

The *Arizona's Wildlife Linkages Assessment* (Arizona Wildlife Linkages Workgroup 2006) resulted from a comprehensive analysis and 2004 stakeholder workshop in which 152 potential wildlife linkage zones (Figure 2-9) were identified, rated, and prioritized. This landmark assessment, endorsed by both ADOT and FHWA, was intended to provide a starting point for detailed consultation and coordination among the various organizations and agencies that have responsibility and interest in preserving habitat connectivity. The potential linkage zones were identified from various map overlays including land ownership, undeveloped habitat blocks, vegetation types; expert opinion of workshop participants was used to define fracture zones between habitat blocks and to identify corresponding linkage zones.

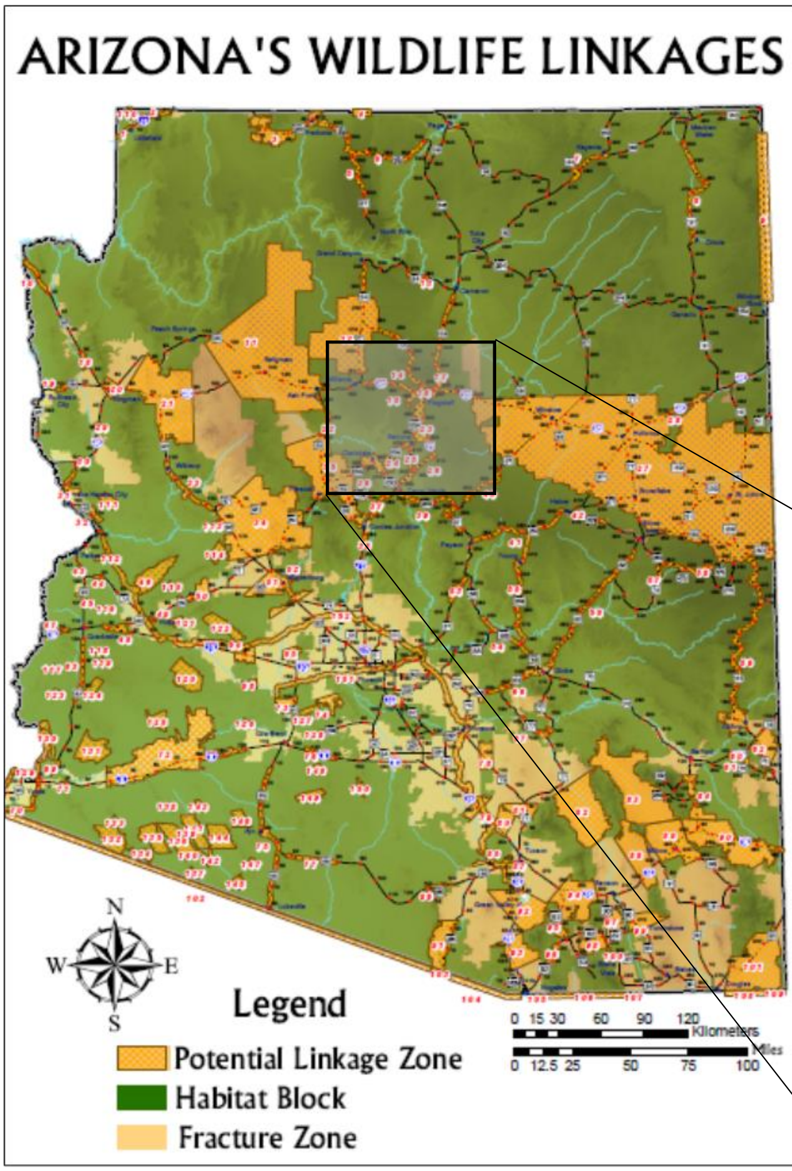


*Figure 2- 9. Map of the 152 linkage zones and associated habitat blocks identified in the Arizona's Wildlife Linkages Assessment and an enlarged view of the individual linkage zones identified in the Coconino County area around the Flagstaff area that correspond to the shaded inset on the statewide map.*

As part of the statewide linkage assessment, each identified linkage zone was prioritized based on its relative biological and corresponding threat/opportunity value. Biological values (60 percent weighting) were derived (and weighted) from several factors including: 1) size of and degree of impact to the wildland blocks that linkages connect; 2) presence of special status, linkage-dependent species, or special habitats such as riparian; 3) conservation ownership, and 4) whether a linkage facilitates seasonal wildlife migration. Threat and Opportunity values (40 percent weighting) reflected threats from highways, urbanization, and other potential wildlife barriers (e.g., canals, railroads). Over half the opportunity value (55 percent) related to whether a linkage zone was included within projects listed in ADOT's STIP or long-range plans, and another 20 percent weight was assigned if there was an existing active conservation effort or willing landowner. Based on the statewide assessment prioritization of biological and threat/opportunity values, 28 of the linkage zones (18 percent of the total) were identified as "top priorities" for attention (Arizona Wildlife Linkages Workgroup 2006).

## COUNTY-LEVEL WILDLIFE LINKAGE ASSESSMENTS

After the statewide assessment, six county-level wildlife connectivity assessments were completed with a goal of refining the identification of the statewide linkages. These assessments assembled current knowledge of wildlife linkages and barriers while helping build collaborative partnerships with local jurisdictions for implementation efforts.

Each county assessment report and associated GIS data was intended to identify wildlife linkages at a finer scale or that may have been overlooked in the statewide assessment (Figure 2-10). Stakeholder workshops were held in each county to map the general locations of wildlife linkages and barriers to wildlife movement. Whereas the statewide plan identified potential linkages as "fracture zones" through habitat blocks, county-level plans identified specific landscape movement corridors (linkages) linking wildland or core habitat blocks (Figure 2-10).

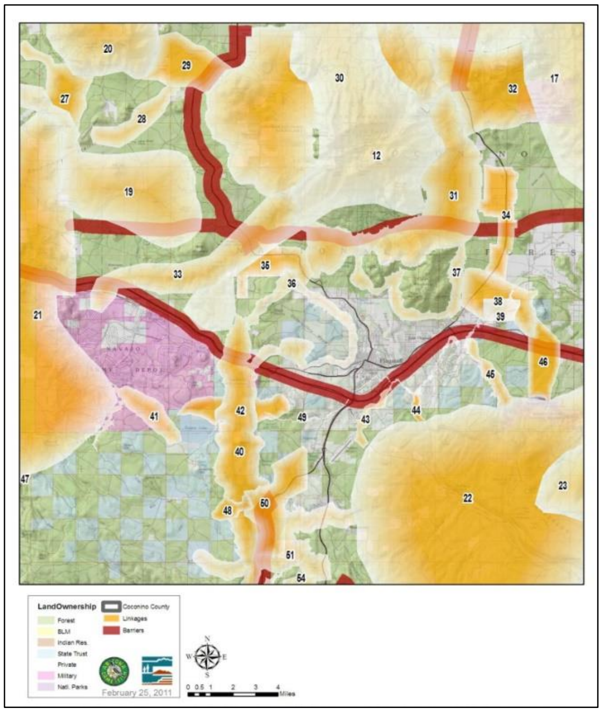

*Figure 2- 10. County-level linkage assessment for Coconino County depicting barriers (red lines) and wildlife linkages (yellow) located in the Flagstaff area. This map covers the same area as Figure 2-9.*

Available county-level linkage assessments include:

- Coconino County (AGFD 2011)
- Maricopa County (AGFD 2012*a*)
- Pima County (AGFD 2012*b*)
- Apache & Navajo counties (AGFD 2013*a*)
- Pinal County (ADFD 2013*b*)
- Yavapai County (AGFD 2013*c*)

## LINKAGE DESIGN MODELS

Individual linkage-scale corridor design assessments have been accomplished across Arizona by both Northern Arizona University (NAU) and AGFD. These refined linkage designs identified and mapped multi-species corridors that best maintain wildlife movements between wildland blocks (Figure 2-11), as well as highlight specific planning and road mitigation measures required to maintain connectivity within these corridors. Linkage-level assessments were accomplished utilizing the GIS-aided least-cost modeling and mapping tools at www.corridordesign.org (Beier et al. 2008). Their modeling efforts yield linkage designs for individual and multiple species that are more specific than the statewide or county-level plans to help plan and implement mitigations to reduce WVC and promote connectivity.

NAU has completed detailed linkage designs for 16 priority linkages identified in the *Arizona's Wildlife Linkages Assessment* (Arizona Wildlife Linkages Workgroup 2006) and can be accessed at www.corridordesign.org/linkages/Arizona, where both the reports and GIS datasets are available.

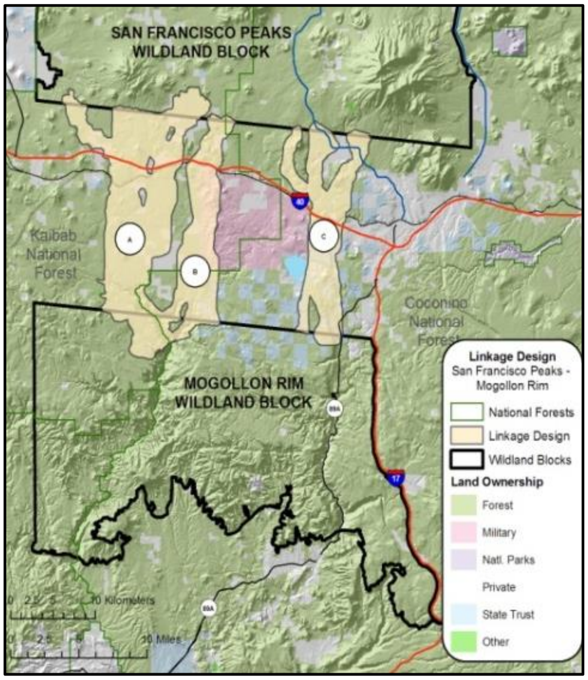


*Figure 2- 11. Corridor design for the San Francisco-Mogollon Rim Linkage west of Flagstaff, Coconino County, showing wildlife movement corridors derived from multi-species modeling to promote movement between wildland blocks. This is the same general coverage as Figures 2-9 and 2-10.*

## MIGRATION CORRIDORS MAPPING

In 2018, U. S. Department of Interior Secretarial Order 3362 (https://www.nfwf.org/programs/rocky-mountain-rangelands/improving-habitat-quality-western-big-game-winter-range-and-migration-corridors/state-action-plans) placed emphasis on the protection and improvement of Western big game wildlife winter ranges and important migration corridors they use to travel to and from them. An interagency Corridor Mapping Team was assembled to develop a standardized and scientifically rigorous approach employing available wildlife movement data to comprehensively map corridors, stopovers, routes, and winter ranges in several western states, including in Arizona where mule deer (Figure 2-12), elk, and pronghorn corridors were mapped (Kauffman et al. 2020; https://westernmigrations.net/). While the statewide and county-level linkage plans, and even the corridor design models are largely unvalidated by empirical data, these mapped migration corridors are based on extensive AGFD Global Positioning System (GPS)-telemetry data, much funded by ADOT as part of comprehensive studies to develop long-range WVC and connectivity mitigation strategies (see next section). Further, they indeed validate the corresponding wildlife movement studies and the statewide and the Coconino County linkage assessments with empirical data. Additional corridors are being developed and may be available in the future.

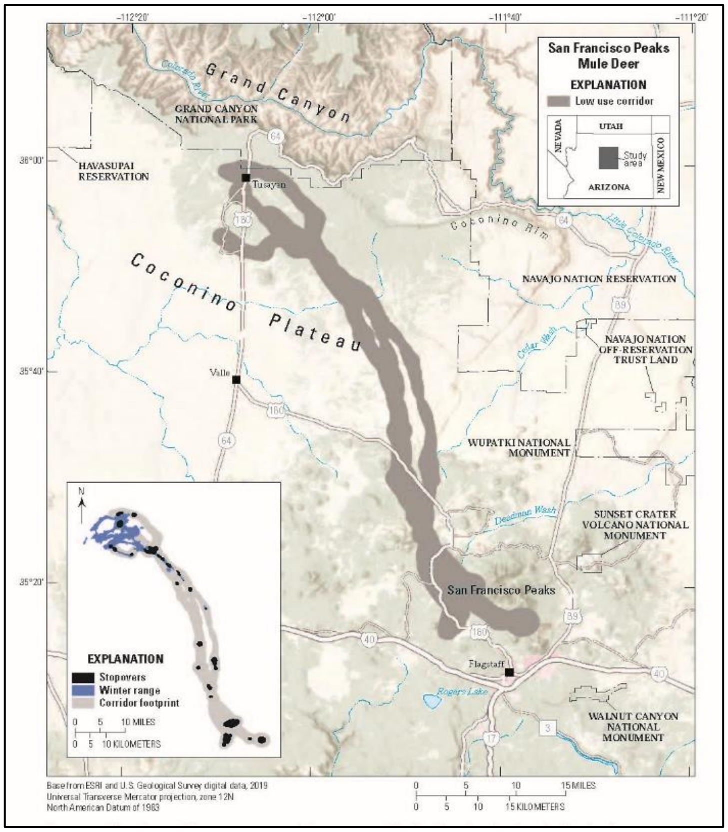


*Figure 2- 12. Mapped San Francisco Peaks Mule Deer corridor from AGFD GPS telemetry studies; deer crossed US 180 and SR 64 (Kauffman et al. 2020).*

## LESSONS LEARNED FROM TWO DECADES OF WILDLIFE MITIGATION PROJECTS AND RESEARCH

Over the past two decades, ADOT and its partners have engaged in a comprehensive strategy to resolve highway wildlife-vehicle conflicts affecting both highway safety and wildlife connectivity. This strategy has been predicated on the integration of wildlife mitigation projects and sound monitoring/research, much of it funded by ADOT's Research Center. This integrated strategy yielded important insights into mitigation project effectiveness supporting continuous improvement and road ecology; this study is an extension of that integrated strategy.

Since 2000, ADOT has implemented a diverse array of 24 wildlife mitigation projects on 12 Arizona highways (Table 2-10). Several landmark wildlife-vehicle conflict resolution projects with large wildlife passage structures occurred during the "big-project era" spanning 2000 to 2012. This included major reconstruction of SR 260, SR 68, and US 93, which together account for two-thirds of the wildlife passage structures in place today (Table 2-10). Since 2012, many wildlife projects have occurred as part of more limited or targeted widening or enhancement projects or were cooperatively funded under the RTA tax allocation to wildlife connectivity (e.g., SR 86, SR 77; Table 2-10); the lone exception has been the new construction of the State Route Loop 202 South Mountain Freeway (SR 202L) and its five multi-use underpasses, wildlife-friendly culverts, and wildlife and reptile fencing. Together, wildlife mitigation projects have erected wildlife (ungulate) and reptile fence (in some places together) along 76 miles of Arizona highways.

On several of the major reconstruction projects with wildlife passages and fencing, ADOT funded eight before- and after-construction research projects on four highways and installed permanent automatic traffic recorders to investigate traffic and wildlife relationships; RTA is now funding studies on a fifth highway. Key lessons learned from these research projects are highlighted below. ADOT also funded five wildlife movement (GPS telemetry) research projects on highways to develop data-driven wildlife mitigation strategies for future reconstruction projects, as well as many other studies ranging from pronghorn genetic to desert tortoise habitat studies. Compared to the big-project era, ADOT faces reduced funding for major reconstruction projects and such conditions will last well into the future; thus, wildlife mitigation projects identified for highways will likely not be implemented through major reconstruction projects. This necessitates our development of alternative approaches to achieve short-term resolution of wildlife-vehicle conflicts.

*SR 260 elk; AGFD photo*

Lastly, as our ACIS database spans 16 years, we were afforded the opportunity to conduct before- and after-mitigation wildlife crash comparisons for those projects where sufficient data exists. Insights from seven projects with sufficient data is also presented here.

## MONITORING OF HIGHWAY MITIGATION PROJECTS

### SR 260 RECONSTRUCTION

The single most insightful monitoring/research project was the phased 17-mile reconstruction of SR 260 between Payson and the Mogollon Rim, which lasted nearly a decade.

Research spanning reconstruction of four of five sections lasted nearly a decade; the phased reconstruction facilitated a before-after-control impact (BACI; Roedenbeck et al. 2007) experimental design as well as an adaptive management approach to construction implementation and subsequent design (recognized by FHWA with its first Exemplary Ecosystem Award in 2004). Once completed, 11 wildlife underpasses were interspersed with six large bridges for an average spacing of one passage structure/mile. Initially, extensive wildlife (ungulate) exclusion fencing was planned on the first sections but was not constructed; thus, fencing's role in reducing WVC and promoting permeability became a focus of AGFD's research.

*SR 260 wildlife underpass*

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*Table 2- 10. Arizona highways along which wildlife mitigation projects have been implemented, including project extent, year completed, type, number of new or retrofitted wildlife passage structures, and fencing by type.*

| Highway | Milepost range | Project year | Project type | No. new wildlife passage structures | | | | No. retrofit passage structures | | Fencing (linear feet) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Underpass | | | Overpass | | | | |
| | | | | Bridge | Arch | Culvert | | Bridge | Culvert | Ungulate | Reptile |
| I-17 | 316–323 | 2012 | Retrofit fencing | - | - | - | - | 2 | 3 | 61,277 | - |
| SR 68 | 7–13 | 2002 | Reconstruction | 3 | - | - | - | - | 1 | 46,735 | - |
| SR 77 | 82–88 | 2014 | Reconstruction | - | 1 | - | 1 | - | - | 31,911 | 31,911 |
| | 81–84 | 2019 | Fencing | - | - | - | - | 2 | - | 9,900 | 9,900 |
| SR 85 | 142–146 | 2005 | Reconstruction | - | - | - | - | - | 6 | - | 53,437 |
| SR 86 | 106-143 | 2009 | Widening | - | - | - | - | - | 6 | - | 17,084 |
| | 129–136 | 2015 | Widening/Drop in | - | 2 | - | - | - | - | 66,329 | 66,329 |
| SR 87 | 204–205 | 2010 | Widening | - | - | - | - | - | - | - | 7,585 |
| SR 188 | 227 | 2005 | Reconstruction | - | 1 | - | - | - | 3 | 1,219 | - |
| SR 195 | 6-24 | 2001 | New | - | - | - | - | - | - | - | 97,128 |
| SR 202 | 56-78 | 2019 | New | 5 | - | 27 | - | - | - | 47,125 | 47,125 |
| SR 260 | 260–263 | 2001 | Reconstruction | 2 | - | - | - | | - | - | - |
| | 260-263 | 2006 | Retrofit fencing | | - | - | - | 1 | | 31,836 | - |
| | 263–265 | 2012 | Reconstruction | 1 | - | - | - | 1 | - | 152,999 | - |
| | 265–270 | 2006 | Reconstruction | 1 | - | - | - | 1 | - | | - |
| | 270–272 | 2014 | Reconstruction | 3 | - | - | - | 1 | - | | - |
| | 272–277 | 2004 | Reconstruction | 4 | - | - | - | 2 | - | | - |
| US 60 | 218–222 | 2008 | Reconstruction | - | - | - | - | 3 | - | - | - |
| US 93 | 1–17 | 2011 | Reconstruction | 2 | - | 82 | 3 | 1 | - | - | - |
| | 103–106 | 2009 | Reconstruction | - | - | - | - | - | 11 | 174,402 | - |
| | 109–116 | 2012 | Reconstruction | - | - | - | - | - | 3 | - | - |
| | 116–119 | 2020 | Reconstruction | 1 | - | 5 | - | - | - | - | - |
| | 144–160 | 2002+ | Reconstruction | - | - | 2 | - | - | - | 5,570 | 137,161 |
| **All** | | | | **22** | **4** | **122** | **4** | **15** | **39** | **629,303** | **467,660** |

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Key SR 260 research lessons learned include:

- Wildlife funnel fencing proved critical to underpass effectiveness, as elk and mule deer underpass passage rates increased nearly 5-fold after fencing was erected. Further, WVC incidence was nearly three times higher on unfenced, reconstructed sections (Dodd et al. 2006, 2007*a*). Along with underpasses, fencing was also critical to promoting permeability (Dodd et al. 2007*d*). Ultimately, the entire 17-miles were fenced, though some sections with the first applications of short-term retrofit elk fencing (existing 42" ROW game fence raised to 8') are not holding up well.
- Research yielded insights into why underpasses are effective, as increasing traffic volume had minimal effect on below-grade (via underpass) elk and deer passage rates compared to the strong negative influence traffic has when animals attempt to cross at grade (Figure 2-13; Gagnon et al. 2007*a, b*). Fencing serves a critical function of funneling animals to underpasses where they cross unimpeded by traffic. White-tail deer permeability benefitted similarly from underpasses (Dodd and Gagnon 2011). Underpasses and fencing improved permeability for elk (58 percent) and white-tailed deer (433 percent) while reducing WVCs 84 percent to 97 percent.
- Though underpass spacing averaged one mile, spacing was not uniform across sections. The spacing between underpasses strongly influenced elk passage rates ($r = -0.986$), with spacing of less than 1.6 miles necessary to attain average (of four sections) elk permeability across SR 260.
- Underpass design characteristics influenced wildlife use, especially side walls that were perceived as ledges where predators might lie in wait (Dodd et al. 2007*c*), or obstructions (e.g., soil embankments) to line-of sight visibility through underpasses (Gagnon et al. 2011, Dodd et al. 2012). Elk exhibited a continuous 7-year learning curve in adapting to all but one of six monitored underpasses.

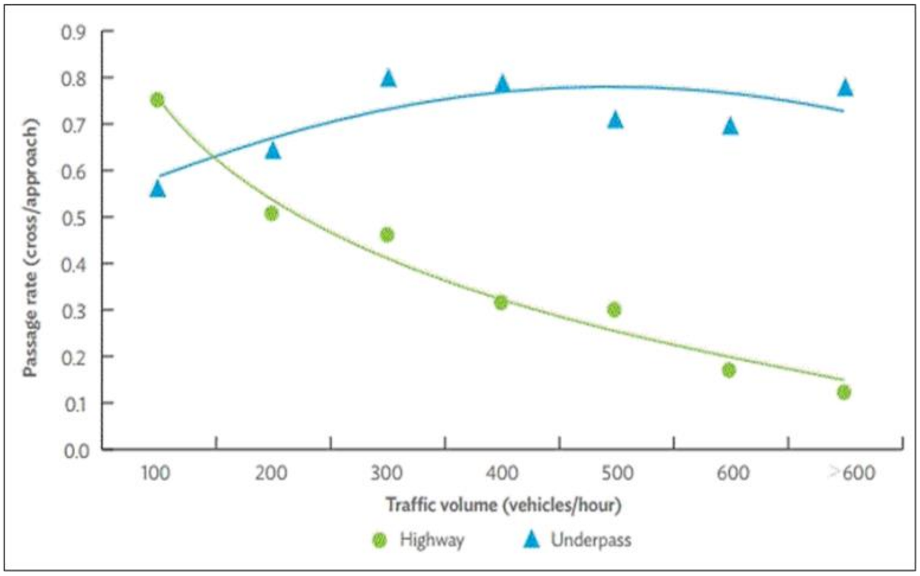



*Figure 2- 13. Effect of increasing traffic on elk highway passage rates when crossing at underpasses (blue line; Gagnon et al. 2007a) compared to at-grade crossings (green line; Gagnon et al. 2007b).*

### SR 68 RECONSTRUCTION

The 14-mile reconstruction of SR 68 where it bisects desert bighorn sheep range through the Black Mountains east of Bullhead City (Figure 2-14) was completed in 2002. The primary purpose of this project was to promote permeability for sheep via three underpasses linked by six miles of 8-foot wildlife fencing and four miles of 5-foot high barbed and woven wire fence; fencing was also intended to prevent WVCs. This project proactively sought to limit the highway barrier effect that could fragment the habitat core of Arizona's largest sheep population (Figure 2-14). ADOT funded post-construction project monitoring (Bristow and Crabb 2008).

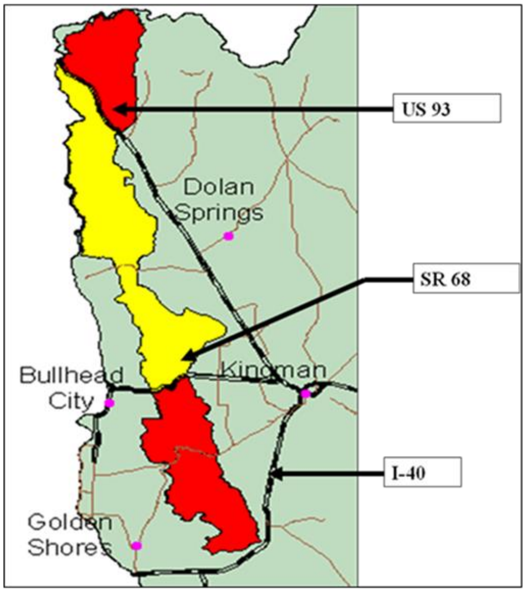



*Figure 2- 14. The Black Mountains bisected into 3 subunits by SR 68 and US 93 where mitigation projects were implemented to reduce fragmentation.*

Key SR 68 lessons learned from Bristow and Crabb (2008) include:

- Overall, bighorn sheep crossings at the underpasses were limited and no ewes or lambs were recorded crossing. Most crossings occurred at the underpass situated in the most suitable (rugged) sheep habitat. It was stressed that bighorn passage structures should be placed within existing travel corridors to ensure effectiveness.
- One underpass, "the Hole" was never used by bighorn sheep during monitoring due to its limited line-of-sight visibility though the bridges; in fact, the southern bridge approach is largely obscured by terrain such that animals have difficulty recognizing it as a passage (Figure 2-15).
- Monitoring likely was of insufficient duration and/or done too soon after construction to document the learning curve typically associated with animals adapting to new passage structures, especially those with design limitations. This points to the need for longer-term monitoring. AGFD is reevaluating underpass use (2021-2022).
- Bighorn sheep-vehicle collisions occurred along the stretch fenced with lower barbed and woven wire due to insufficient height and durability. This underscores the importance of properly designing fence (and other mitigations) to minimize maintenance and improve effectiveness.

*Figure 2- 15. SR 68 underpass at MP 10.8 which has very poor line-of-sight visibility affecting bighorn sheep use (photo from Bristow and Crabb 2008).*

## US HIGHWAY 93 RECONSTRUCTION

US 93 is arguably Arizona's premiere example of efforts to comprehensively address wildlife-vehicle conflicts. The reconstruction of a 17-mile segment at the northern end of the Black Mountains (Figure 2-14) was completed in 2011 with three wildlife overpasses, the states' first, and 2 bridged underpasses linked with wildlife fencing to promote desert bighorn sheep connectivity and reduce WVCs. This project reflected a long-term commitment made to assessing wildlife movement patterns for data-driven selection of passage structure locations (Cunningham and Hanna 1992, McKinney and Smith 2007), the first Arizona highway where this was done. Overpass sites were based on bighorn preference traversing ridgelines (McKinney and Smith 2007) and to address limited sheep use of the SR 68 underpasses (Bristow and Crabb 2008).

ADOT funded a before- and during-reconstruction evaluation of impacts to bighorn sheep. This study documented the degree to which even the original narrow 2-lane highway was a barrier to sheep crossing the highway; permeability averaged just 0.07 crossings/approach (Gagnon et al. 2012*a*).

After-reconstruction monitoring highlighted the benefit of before-reconstruction studies to locate passage structures and the tremendous benefit to bighorn sheep permeability and reduced WVCs (Gagnon et al. 2017*a*). Key after-reconstruction lessons learned include:

- Over four years, 5,894 bighorn sheep crossed at the three overpasses, exhibiting a strong preference (90 percent of all crossings) over underpasses (474 crossings) and large concrete box culverts (196 crossings). By year 3, the overpass passage rate averaged 0.90 crossings/approach, a rapid learning curve reflecting the benefit of overpass siting studies and adaptive management.
- Bighorn sheep highway permeability increased dramatically over four years, increasing 1,367 percent between years 1 (0.03 crossings/approach) and 4 (0.44), and representing a dramatic improvement over the before-construction baseline level (0.07 crossings/approach).
- As with elk and white-tailed deer at SR 260 underpasses, increasing traffic levels did not impact bighorn sheep permeability at the overpasses, illustrating the benefit of passage structures and the wildlife fencing that funnels them there, especially for a species active at peak traffic levels.
- Before-mitigation bighorn WVC levels (Cunningham and Hanna 1992) declined 97 percent after breach points in wildlife fencing and lateral access roads were repaired.
- Like SR 260, monitoring allowed for an adaptive management approach to construction and mitigation measure enhancement, including additional slope cutting at the overpass approach to enhance visibility, modifying escape ramp design, and improving lateral road access measures to prevent sheep encroachment into the fenced corridor.

## SR 260 PREACHER CANYON RETROFIT FENCING AND CROSSWALK

After a large bridge and two wildlife underpasses were constructed on the first 3-mile reconstructed section (Preacher Canyon) in 2002 without wildlife fencing, WVCs involving elk increased 20 percent above before-construction levels (Dodd et al. 2007*a*). An enhancement grant was obtained to use three cost-effective retrofit fencing designs to raise existing right-of-way (ROW) fence to 8-feet, including electrified fence, to funnel elk to structures and reduce WVCs. This was done in 2006.

However, to prevent an animal end-run effect at the west fence terminus when fence was erected, an experimental animal-activated detection system (AADS) was installed to create a defined wildlife "crosswalk" integrated with triggered motorist alert signage when animals were present (Figure 2-16). An electrified mat was later installed (2011) to prevent breeches of the fenced corridor.

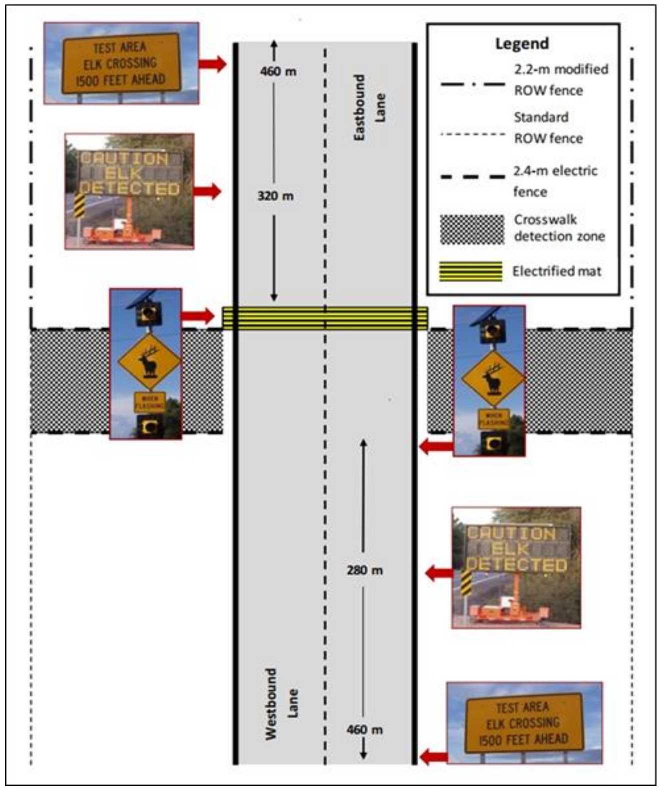



*Figure 2- 16. Layout of the SR 260 crosswalk and motorist alert signage.*

Key project lessons learned from Gagnon et al. (2019) include:

- Since implementation in early 2007, the AADS and alert signage has effectively prevented WVC with animals crossing at the crosswalk zone with just a single WVC (white-tailed deer) recorded there.
- Elk-related WVC were reduced 98% on the 3-mile section despite increasing traffic levels (Figure 2-17); economic benefits associated with reduced collisions (Huijser et al. 2007, 2009) exceeded total project costs in five years.
- Significant motorist habituation did not occur in response to the triggered alert signage, either for reduced speeds (13 percent) or motorist awareness over the 9-year evaluation period. The project's success is tied to its time- and place-specific flashing and variable message signs to alert motorists when animals are present.

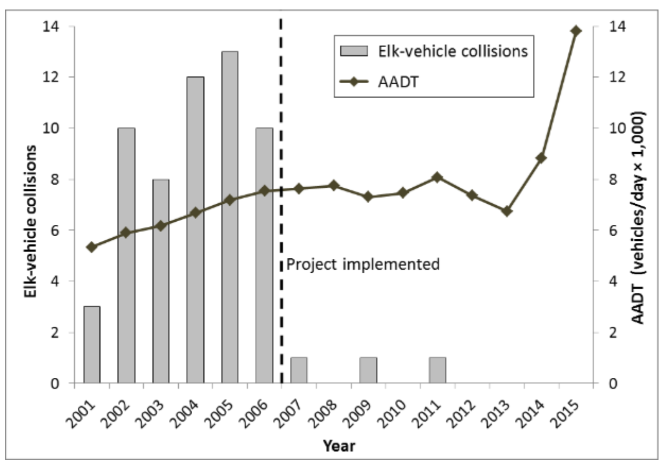
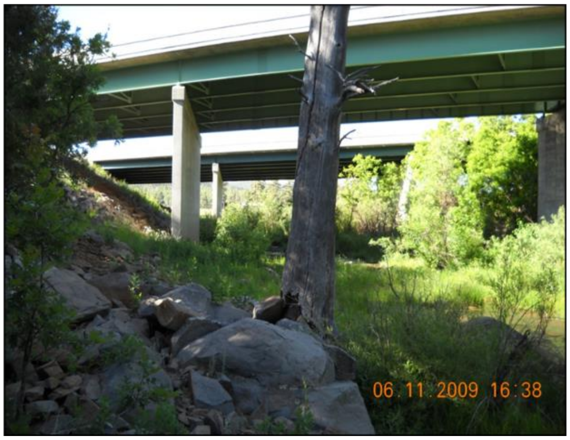



*Figure 2- 17. Elk-vehicle collision incidence and traffic levels (AADT) before and after retrofit fence was erected along 3 miles of SR 260.*

### I-17 MUNDS CANYON FENCING RETROFIT




Since 2006, ADOT has been evaluating the reconstruction of I-17 to address increased traffic volume and highway safety issues with development of a wildlife-vehicle conflict DCR (Design Concept Report) (Gagnon et al. 2013) to address planned reconstruction from SR 179 to the I-40 junction in Flagstaff. Recognizing that I-17 reconstruction was unlikely to occur for greater than 15 years, ADOT and AGFD investigated a retrofitting option that could provide a short-term option to address an elk-vehicle collision hotspot near Munds Park.

The Munds Canyon wildlife fencing enhancement project was completed in late-2011. The project entailed retrofitting existing ROW fence to block wildlife passage across I-17, funneling animals toward the large Munds Canyon and Woods Canyon (right) bridges to enhance their functionality for wildlife passage. In addition, two traffic interchanges were linked with fencing and retrofitted to serve as dual-use passage structures, and three large box culverts provided passage for wildlife; all were monitored but received limited use compared to the larger bridges (Gagnon et al. 2015).

A total of 11.6 miles of the highway received fencing treatments: 8.4 mile of ROW fence was raised to 8-feet by retrofitting and 3.2 miles of new 8-feet barbed-wire fence was erected. Other features included gabion basket escape ramps, fence jump outs built into the fence on slopes, and eight electrified mats at traffic interchange on- and off-ramps.

Key lessons learned from monitoring this project (Gagnon et al. 2015):

- Post-fencing camera monitoring recorded a 217 percent increase in wildlife use of the two bridges over two years (Figure 2-18), including use by 14 species; 2,340 elk were recorded at the retrofitted structures. Funnel fencing increased functionality of bridges as underpasses.
- Elk-vehicle collisions declined by 97 percent after fencing; economic benefits associated with reduced collisions (Huijser et al. 2007, 2009) exceeded total project costs in just four years.

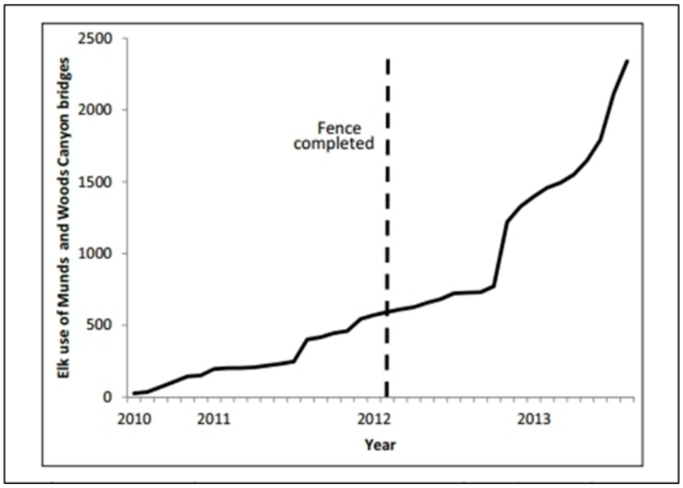



*Figure 2- 18. Elk crossings recorded at two retrofitted I-17 bridges before and after funnel fencing was erected.*

- Retrofitting of existing suitable passage structures represents one of the most expeditious and cost-effective approach to addressing wildlife-vehicle conflicts (Knitsch and Cramer 2011).

### SR 86 WIDENING AND DROP-IN UNDERPASS PROJECT

SR 86 is the highway linking Tucson to the TON and Sells. As ADOT embarked on a sustained program of widening this 2-lane roadway to promote motorist safety, a project of opportunity surfaced in 2011 as the Kitt Peak and Santa Rosa segments were nearing implementation. The statewide *Arizona's Wildlife Linkages Assessment* identified these stretches as the "Kitt Peak Linkage," one of the 28 highest priority linkages in the state reflecting high biological value and opportunity (e.g., inclusion in the STIP). The linkage serves as a landscape connectivity corridor for far-ranging species such as mountain lion, bighorn sheep, and jaguar due to its strategic location at the northern end of the Baboquivari Mountain Range that extends into Mexico.

To address wildlife connectivity within the Kitt Peak Linkage before the widening project was implemented, the TON pursued funding from the RTA to address Kitt Peak Linkage wildlife connectivity and WVC reduction. The RTA funded two "drop in" precast arch underpasses which were completed in 2014 during widening, along with 6-miles of fencing and escape ramps. RTA also committed to deferred funding for a future wildlife overpass. The two underpasses were the first drop-in structures in Arizona (Figure 2-19), necessitating no changes to highway grade or major disruptions to traffic flow. A second deferred overpass on the San Isidro segment was approved in 2014, and along with the one approved in 2011, will be designed and implemented this year as a stand-alone project.

*Figure 2- 19. Installation of the first half of the drop-in SR 86 Kitt Peak arch underpass in 2011.*

Key lessons learned from this project:

- Drop-in precast arches represent a cost-effective and efficient option for addressing stand-alone wildlife mitigation needs, especially where no suitable existing structures are present. Installation can be accomplished quickly and with minimal disruption to traffic flows.
- As the first wildlife passage structures on a Sonoran Desert highway, camera monitoring by ADOT and TON found that 11 wildlife species readily and regularly used the underpasses, particularly after wildlife fence was erected.
- Wildlife-vehicle collision incidence declined 82 percent after the underpasses and fencing were implemented.
- RTA funding was critical to facilitating ADOT's ability to capitalize on this urgent project of opportunity.

## COMPARISON OF BEFORE- AND AFTER-WILDLIFE MITIGATION CRASH INCIDENCE

Our analysis of the 16-year ACIS dataset allowed us to conduct before- and after-mitigation project WVC incidence comparisons where sufficient data exists for five of the highways where projects were done. These comparisons provide important insights into the short- and long-term efficacy of the mitigations.

While adequate before- and after-mitigation time intervals exist for a sixth highway, US 93, there were limited records (3) in the 9-year before-mitigation ACIS dataset involving bighorn sheep due to the post-September 11, 2001 terrorist attack closure of Hoover Dam with reduced traffic accounting for a reduction in WVCs. Cunningham and Hanna (1992) reported an average of 11.7 sheep WVCs/year on this stretch of US 93 determined from field surveys, underscoring the magnitude of this reduction in WVC

### STATE ROUTE 260 RECONSTRUCTION SECTIONS

We were able to make before- and after-mitigation project comparisons of WVC incidence for five reconstructed sections of SR 260 (Figure 2-20). However, in our analysis of the ACIS data, we noticed a disparity within after-mitigation data as considerably different results occurred over the first three years following mitigation compared to the subsequent years; this disparity was consistent among four of the sections (as well as for the retrofit fence project on I-17). The section where this did not occur was the Preacher Canyon Section (MP 260 – MP 263) where retrofit elk fence (including a section with electrified rope) was erected under the experimental enhancement project described earlier; regular fence maintenance is being conducted by the contractor that implemented the project. Here, elk retrofit fencing resulted in a greater decline in WVCs beyond the first three years of erection, achieving an overall 69.3 percent reduction in reported WVCs since 2007 (Figure 2-20); this fence is designed to limit elk entry to the highway yet remains semi-permeable to other species including deer and black bear (explaining the disparity in 98 percent post-mitigation reduction reported by Gagnon et al. (2019) that only considered elk). While the single 2018 (only year in ACIS with species information) WVC involved an elk, it is likely that after-mitigation WVC for other years involved deer and other species.

For the four sections with the disparate after-mitigation results, two sections employed well-constructed and durable wildlife fence: Doubtful Canyon and Christopher Creek. In both cases, sizeable reductions in WVC incidence were recorded in the first three years, averaging 83 percent (Figure 2-20). In both cases however, the reduction in WVCs over before-mitigation levels dropped following the third year after

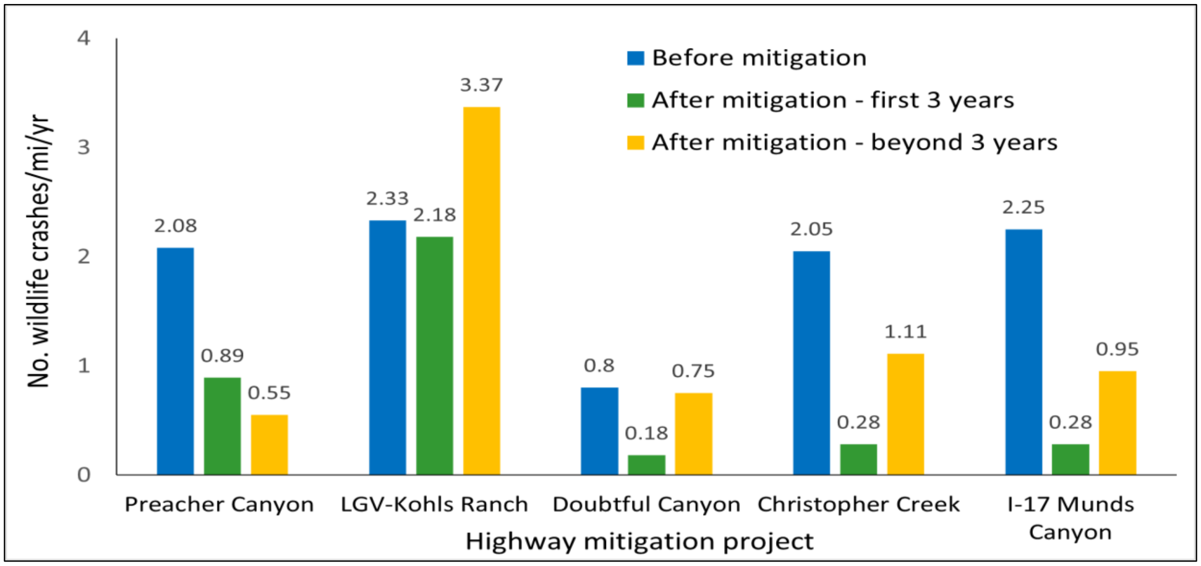



*Figure 2- 20. Comparison of before- and after-wildlife mitigation project WVC incidence (no./mile/year) for SR 260 sections and I-17 (Munds Canyon), with after-mitigation WVC incidence shown separately by the first three years after mitigation and beyond three years.*

mitigation, to 46 percent for Christopher Creek and just 7 percent for Doubtful Canyon (Figure 2-20). We conducted a field inspection in October 2020 of the Doubtful Canyon Section and found multiple breach points (breaks) in the fence which had yet to be repaired (and were reported to ADOT), but fence condition overall was good. Thus, it appears wildlife fencing retains its integrity well over the first three years, but maintenance issues arise thereafter (e.g., treefall, washouts in small drainages) that can reduce effectiveness of mitigation efforts.

The situation on the neighboring Little Green Valley (LGV) and Kohls Ranch Sections is quite different from the others. Elk retrofit fence was employed on both sections (as well as Christopher Creek in 2004 where it was replaced with wildlife fence in 2012) where the existing ROW fence was extended upward. This fence was initially used on the sections under the research adaptive management process as a short-term solution to reduce WVCs after the Preacher Canyon and Christopher Creek sections were constructed without wildlife fence and it was installed as part of initial construction of the Little Green Valley and Kohls Ranch section. With retrofitting from 3.5 to eight feet, the ROW game fence, even with buttressing has not held up to normal fence wear and tear (sagging, rising in dips), persistent efforts by elk to breach the fence, and snow loading. Furthermore, elk, deer and other species have been able to crawl under the fence to the point that well-established trails are commonplace, especially on the Kohls Ranch Section. Despite apparent maintenance efforts, this fence is not performing adequately as a long-term alternative to 8-foot woven-wire wildlife fence; the LGV Section fence remains in serviceable condition due to its more recent implementation, while the Kohls Ranch fence condition has deteriorated to the point it cannot be repaired (e.g., sagging, many breaks). In our analysis, these issues are apparent even in the first three years after erection as WVC were reduced only 6.4 percent. And after that, WVC increased over before-mitigation levels by 45 percent.

### I-17 MUNDS CANYON ENHANCEMENT/RETROFIT

The 5.9-mile Munds Canyon Wildlife Fencing Enhancement Project (MP 316 to MP 322.7) was completed in 2011, as described earlier. The project entailed retrofitting 8.4 miles of existing ROW fence to 8 feet and constructing 3.2 miles of new 8-feet barbed wire fence to block elk passage across I-17. This fencing remains semi-permeable to deer, black bear, and other species.

After-mitigation performance of this project mirrors the results for the SR 260 Christopher Creek and Doubtful Canyon sections (Figure 2-20); overall after-implementation WVC declined 78 percent compared to before-implementation levels. However, WVCs declined 87 percent in the first 3 years after implementation but only a 56% reduction in WVCs thereafter (Figure 2-20). This disparity again likely reflects the inadequacy of its design (versus that of a more durable fence standard), aging of the alternative retrofit fencing, pressures exerted by elk and snow loads, breaches in fencing and deterioration of other measures (e.g., erosion around escape ramps). All of these result in a need for increased maintenance efforts.

### SR 77 PINAL COUNTY LINE TO TANGERINE BOULEVARD WIDENING

As part of ADOT's 6-mile widening of SR 77 (MP 82 to MP 88), a wildlife underpass and overpass were constructed in 2014, linking Catalina State Park with the Tortilla Mountains to the west via the undeveloped Big Wash riparian corridor. Approximately half the corridor was fenced with new 8-feet wildlife and tortoise fence during the project. Additional fencing was erected in 2018 by Pima County to fence off the east side of the highway and to funnel animals to 2 large existing bridges and seal off the eastern at-grade movement by wildlife. Both projects were funded by the RTA. While these projects focused more on promoting landscape connectivity than WVCs, WVCs were still a concern.

This project fenced just half the project area until additional fence was erected in 2018; nonetheless the project resulted in a 70.1 percent reduction in WVCs (Figure 2-21) while also promoting connectivity via 10,800 wildlife crossings at the underpass and overpass in just five years since construction (AGFD 2020).

### SR 86 KITT PEAK AND SANTA ROSA SEGMENTS WIDENING/UNDERPASS DROP-IN PROJECT

An ADOT safety-focused widening project on six miles of the SR 86 Kitt Peak and Santa Rosa segments (MP 131 to MP 136) in 2013 provided an opportunity to address wildlife connectivity within the priority Kitt Peak Linkage. The Pima County RTA funded 2 "drop-in" wildlife underpasses, one on each segment, as well as the retrofitting of 6 miles of ROW fence to 6-feet height to limit mule deer and other species' access to the roadway. Like SR 77, WVC incidence was a secondary issue but was important, nonetheless.

Though WVC were not a driver with this project, the underpasses and retrofit fencing resulted in an 81.6 percent reduction in WVC (Figure 2-21); the 6-feet high retrofit deer fence appears to be holding up better than elk retrofit fence, especially without the impact of elk, snow loading, and treefall.

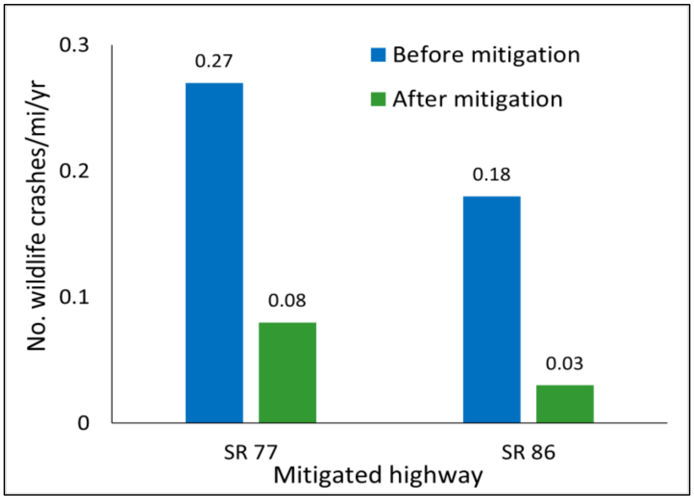



*Figure 2- 21. Comparison of before- and after-wildlife mitigation project WVC incidence (no./mile/year) for SR 77 and SR 86.*

## WILDLIFE MOVEMENT, WVC, AND DESIGN CONCEPT STUDIES

As several corridor-level DCR studies were done between 2005 and 2014, ADOT engaged AGFD to conduct comprehensive wildlife movement (GPS telemetry) and WVC research along five of the highest WVC incidence highways in the state (Table 2-11). These studies supported the data-driven development of wildlife-highway conflict mitigation strategies and recommendations for use in future reconstruction DCR.

The five wildlife DCR mitigation recommendations for addressing WVC and wildlife connectivity were developed using the best available science related to passage structure spacing for multiple species, generally striving to achieve spacing between passage structures of approximately 3 miles (Figure 2-22). Thus, for the five highways, the reports recommend a combined 46-47 underpass and 20-21 overpass structures (67 total) along 215 miles of roadway (Table 2-11).

In addition to developing reconstruction project mitigation strategies, these DCR studies contributed considerably to the collective knowledge of wildlife-highway relationships including furthering our understanding of the impact of traffic volume on wildlife passage, as well as the degree to which the highways constitute barriers to wildlife movement that fragments populations, especially for pronghorn adjacent to SR 64 and US 89 (Dodd et al. 2009, 2012*b*; Theimer et al. 2012).

*Table 2- 11. Arizona highways along which wildlife movement and WVC studies were commissioned by ADOT for the development of DCRs.*

| Highway | Miles | Milepost range | Target species | Recommended passages | | Citation |
|---|---|---|---|---|---|---|
| | | | | Underpass | Overpass | |
| US 89 | 28 | 430-458 | Pronghorn | - | 3 | Dodd et al. (2009) |
| SR 64 | 50 | 185–235 | Elk, mule deer, pronghorn | 6 | 5 | Dodd et al. (2012*b*) |
| I-17 | 46 | 294–340 | Elk | 14 | 5 | Gagnon et al. (2013) |
| I-40 | 31 | 183-214 | Elk | 19 | 5 | Gagnon et al. (2012*b*) |
| SR 260 | 60 | 280-340 | Elk, mule deer | 7-8 | 2-3 | Gagnon et al. (2017b) |
| **Totals** | **215** | | | **46-47** | **20-21** | |

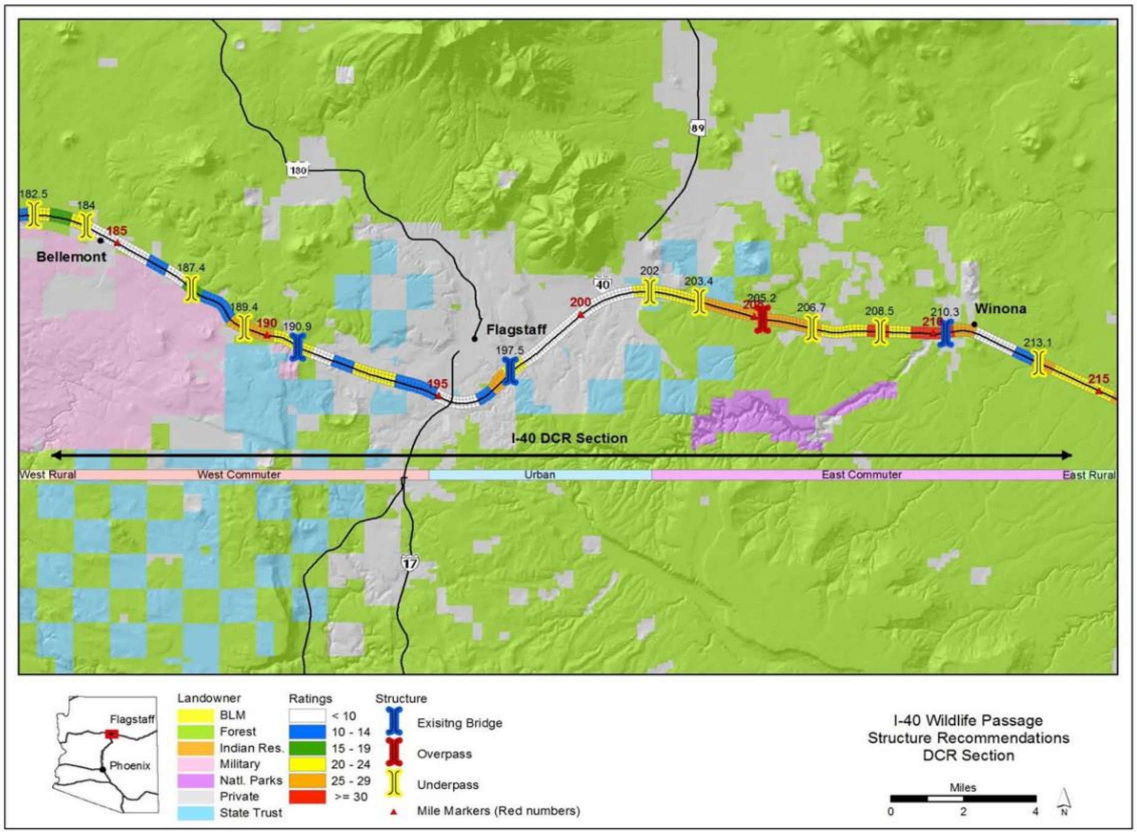



*Figure 2- 22. Wildlife passage structures (yellow underpasses/red overpass/blue existing bridges) recommended in the wildlife DCR for I-40 (Gagnon et al. 2012).*

Though unlikely to see any reconstruction projects on the five highways in the foreseeable future due to ADOT budget limitations, these studies will still form the basis for development of shorter-term strategies to address priority wildlife-vehicle conflicts under this study. These strategies will focus on potential retrofitting of existing structures, targeted use of "drop in" structures, and other strategies.

## HIGH LEVEL LESSONS LEARNED

The lessons learned above are largely Arizona-driven, but also include lessons learned from past and ongoing studies in transportation and wildlife across the U.S. and Canada. There are common steps to addressing wildlife-vehicle conflict. These are detailed below.

**CRASH DATA**: Addressing any challenge starts with documenting its extent. States begin the process of addressing WVCs by looking at crash data. States that have crash reporting forms that allow for species pull-down menus can identify what species of animal are involved in crashes. In turn, the identification of wild and domestic animals in these reporting forms help determine the best strategies, which became invaluable to Nevada (Cramer and McGInty 2018) and New Mexico (Cramer et al. 2020), as examples.

**CRASH HOTSPOT MAPS**: Mapping of crashes with wildlife is a valuable tool to identify hotspots. All western states have created such maps. The more rigorous Getis-Ord hotspots mapping that was done in this study has been carried out in Utah (Cramer et al. 2020), Nevada (Cramer and McGinty 2018), and is being conducted in New Mexico (Cramer et al. 2021). Colorado recently completed a similar analysis (Kintsch et al. 2019). This study helps Arizona use the best cutting edge scientific methods to map WVC hotspots and is directly comparable to those done in neighboring states.

**WILDLIFE CARCASS DATA AND MAPS**: Carcass (roadkill) data are important as well. Crash reports typically do not document smaller animals getting killed on highways, or any crashes with wildlife that are under $1,500 in damages. Carcass data collection and mapping can be critical to identifying areas of concern for several taxa of animals. AGFD has created the Carcass Reporting for Arizona Streets and Highways (CRASH) that has been approved for use by Government entities and is currently in beta testing mode. CRASH will collect and consolidate roadkill data for future mitigation recommendations (Figure 2-23).

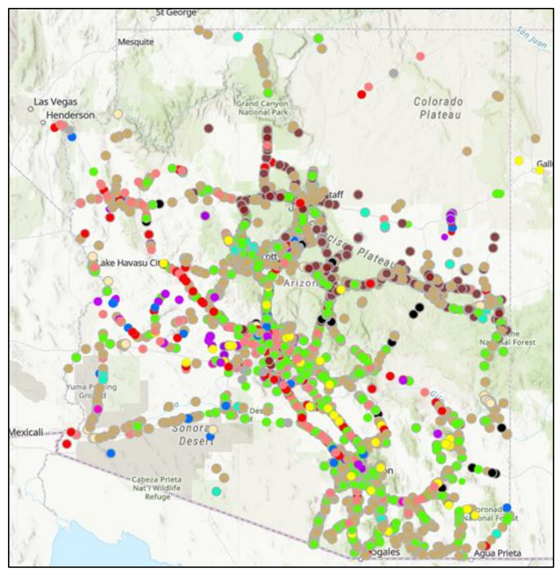



*Figure 2- 23. Arizona's carcass data map, based on user protected AGFD website (February 7, 2021).*

**WILDLIFE TELEMETRY STUDIES**: As demonstrated above, Arizona studies on wildlife movements have been conducted across the state and often in conjunction with ADOT to locate where these populations need to move beneath or above the road. These studies are critical to identifying solutions to potential crash locations, and wildlife-vehicle conflicts where a species of concern avoids roads or is in such low numbers carcass and crash data do not fully address resolution needs. With federal funds provided under Interior Secretarial Order 3362 and other sources of funding, additional true (empirical) wildlife corridors and movement areas will be identified. This information can help ADOT prioritize wildlife mitigation projects. Arizona research has taught us that where new construction opportunities exist, there is a need for detailed studies identifying wildlife movement patterns ahead of time as done for US 93.

**LINKAGE ANALYSES**: Arizona has been a leader in scientifically mapping where wildlife species are potentially impacted by barrier effects that limit connectivity. These maps were often based on theoretical wildlife corridors and known habitat blocks. With the advent of better technologies in both GPS collars and camera traps, Arizona like other states have been able to verify actual places where wildlife approach and cross beneath or above highways. Arizona's statewide, county-level, and local linkage analyses are still important, especially for planning. The level of a wildlife linkage plan or study can be very important when it comes to seeking additional funding, such as was the case with the RTA funding in Pima County, and federal funds in conjunction with Interior Secretarial Order 3362.

**BENEFIT-COST ANALYSES:** Increasingly, benefit-cost analyses are being applied in transportation agencies and processes that include value of wildlife (Huijser et al. 2009). Recently Colorado DOT included the value of wild animals lost to vehicle collisions in its benefit-cost analyses (Kintsch et al. 2019). The use of WVC data to help DOT Traffic Safety divisions is becoming critical to convincing decisions makers and funding agencies as to the safety importance of reducing collisions and the benefit derived from reduced human deaths and injuries, property damage, and value associated with the wildlife killed.

**PLANNING FOR WILDLIFE:** ADOT began the process of integrating wildlife-vehicle conflict resolution into its planning efforts over two decades ago. This approach may need further institutionalization to ensure all transportation projects consider a range of wildlife and wildlife-vehicle conflict areas, or potential areas for stand-alone mitigation projects or retrofits. Planning includes transportation data such as hotspot maps and traffic volume, and ecological data on wildlife, ecosystems, land cover, landownership, etc. One approach recently created by Texas DOT (TxDOT) was a study that made recommendations for changes to 18 operating manuals for various TxDOT divisions ensuring wildlife is considered in all aspects of transportation where potentially impacted (Loftus-Otway et al. 2019). ADOT is a partner in a current pooled fund study, *The Wildlife Vehicle Collision Reduction and Habitat Connectivity Pooled Fund Project TPF 5(358) Strategic Integration of Wildlife Mitigation into Transportation Procedures*, that is documenting how transportation agencies consider wildlife. The results will be a national manual on how agencies can better accomplish this (see URL: https://www.pooledfund.org/Details/Study/610). Initial results are finding that codifying the actions needed to consider wildlife have a strong probability of lasting through budget and political fluctuations.

**WILDLIFE MITIGATION STUDIES**: Monitoring is a critical component before, during, and after construction of wildlife mitigations to assess effectiveness of measures. Arizona has a history of such studies as detailed above. As wildlife crossing structure dimensions and types have been researched and affirmed for ungulate species, the research has trended to monitoring associated structures such as escape ramps and wildlife deterrents (Gagnon et al. 2020). Smaller species of animals, particularly threatened and endangered mammals, reptiles, and pollinators are starting to receive more attention and research. As was learned earlier in this century, research is necessary to learn of the most effective *and* cost-effective designs for various species in different ecosystems. This research is also important for adaptive management and maintenance.

**ADAPTIVE MANAGEMENT AND MAINTENANCE**: Monitoring studies and regular check-ups on wildlife mitigation structures, fences, escape ramps, guards and other deterrents are all critical to help in the maintenance and design of this infrastructure. As demonstrated above, there was a decline in effectiveness of wildlife mitigation measures over time due to alternative fence design and maintenance issues. Maintenance crews are critical to the planning, design, construction, and care of infrastructure but traditionally have not been included in early project planning. As the very people entrusted to maintain infrastructure, they should have input in design to minimize long-term maintenance.

**FUNDING:** Paying for wildlife friendly infrastructure will continue to be a challenge. New transportation construction projects and especially major reconstruction efforts will be limited in the future due to declining revenues. Arizona has benefitted from incorporating wildlife mitigations into large construction projects, but now needs to adapt different approaches to implementing mitigations. The lessons learned are twofold: partner organizations help fund projects, and proactive measures can be built into everyday actions. The goal should be to institutionalize the concerns for wildlife and ecosystems. From that, a range of actions can be incorporated into the simplest of plans that allow a flow of funding opportunities. This can mean Safety funds by looking at wildlife-vehicle conflict from the standpoint of the risk they pose to motorists. It can entail partnering with AGFD to secure federal funding through wildlife funding programs available to wildlife agencies or working with the Pima County RTA to build wildlife structures, or Tribal entities to identify and build structures for wildlife on Tribal lands.

**PARTNERSHIPS**: ADOT and AGFD have developed very effective working relationships to research, plan, create, and adaptively manage wildlife mitigation. ADOT has also partnered with the U.S. Forest Service and other federal agencies, Pima County RTA, and Tribal governments to help create opportunities for wildlife connectivity across Arizona roads and help tap additional funding sources to support these efforts.

## KEY TAKE-AWAYS AND RECOMMENDATIONS

Among the many lessons learned over the past two decades in Arizona, some key recurring and critical items stand out:

- ADOT has made a substantial commitment to funding monitoring and research associated with highway projects and priority highways exhibiting wildlife-vehicle conflicts. It has embraced innovation and adaptive management implementation in wildlife mitigations to ensure their effectiveness. This study attempts to embrace these concepts and insights in developing strategies for ADOT to consider in resolving these conflicts.
- Wildlife passage structures integrated with fencing work very well at resolving *both* WVC and ecological issues associated with highway barrier effects to connectivity.
- Conversely, wildlife passage structures do not perform well without appropriately designed and maintained fencing in reducing WVC or promoting wildlife connectivity and permeability; it is critical to effective mitigations.
- Arizona's wildlife fencing is an asset that requires regular maintenance. Insufficient maintenance can compromise fence performance and its critical role in effective mitigations. ADOT should consider options for ensuring adequate wildlife fence maintenance is accomplished in the future, such as establishing a statewide wildlife fencing maintenance program. Elk retrofit fencing, intended as a short-term alternative to sturdier, more durable wildlife fencing is not holding up well and should be considered for replacement and removed as a future mitigation option.

  Over the last decade, much of the significant wildlife project activity has focused on highways in Pima Country where RTA tax revenues dedicated to wildlife connectivity are helping ADOT implement comprehensive studies. This points to the importance of having access to alternative funding sources to support resolution of wildlife-vehicle conflicts. Other funding sources, including those that may arise from Interior Secretarial Order 3362 may be available to assist in the funding of ecological priorities on Arizona's highways. Partnerships will be important in securing alternative funding, including for studies and mitigation.

- Under limited budgets, major ADOT reconstruction projects may be few and far between in the immediate future, necessitating innovative strategies to resolve wildlife-vehicle conflicts.
- Research and monitoring are critical components of understanding and learning from projects, especially when before-, during- and after-construction monitoring evaluates effectiveness of mitigation measures and supports informed adaptive management. Pre- and post-construction research and monitoring should be conducted at hotspots identified in this study.
- The ACIS database, even with its limitations is a valuable planning resource for ADOT, including supporting its P2P process or assisting with project-level planning and identification of hotspots outside the 51 we identified. The 2017 change in the reporting form where all animal records were combined is severely limiting the ability to easily parcel out wildlife-associated crash data. We recommend this be rectified and changed to the pre-2017 protocol. Additional changes to the form could facilitate more accurate evaluation and mitigation efforts in the future including adding wildlife species to the reporting of WVCs. We believe there is important information regarding WVCs and associated injuries and deaths that is being missed with "First Harmful Event" tracking; improved capability in tracking WVCs with other harmful events would help capture underreported injury- and death-related information, especially on Arizona's interstate highways.
- Future mitigation efforts for highways around the state should consider recommendations from any previous studies including DCRs (Table 2-11), available Wildlife Accident Reduction Studies (WARS) or Research Reports prepared through ADOT's research center. Many of these studies and reports are documented in the reference sections of this final report.

## THREATENED/ENDANGERED SPECIES OR SPECIAL STATUS SPECIES CONCERNS

Records in the ACIS crash database overwhelmingly reflect WVCs involving large-bodied mammals such as deer and elk, combined comprising 88% of all records. Many smaller species are underrepresented since they typically do not result in sufficient vehicular property damage to file a crash report. Entire wildlife taxa that are impacted by WVCs go virtually unreported though it is estimated that two million vertebrates are killed each day in the US by vehicles (Bissonette and Cramer 2008), including 340 million birds annually (Loss et al. 2014). Arizona has unparalleled reptile species diversity yet limited knowledge of the short- and long-term impacts of vehicular mortality and no reliable carcass/roadkill database, though AGFD is working to address this. While the scope of our project does not allow us to address all underreported species affected by barrier effects, we focused on four species (2 desert tortoise and 2 pronghorn) incorporated into the ecological component of our hotspot analyses.

### DESERT TORTOISE

Reptiles, especially tortoises due to their defense inclination to hide in place, are highly susceptible to WVCs (Andrews et al., 2015; Peaden et. al. 2017). Also, as with many small animals, tortoises are virtually unreported in the ACIS database. Mojave Desert tortoise WVCs have been better documented the past 40-years, though mitigation strategies to reduce WVC impacts are thought to be similar for Sonoran Desert tortoise (Grandmaison et. al. 2012). Geographically separated by the Colorado River, the Sonoran Desert tortoise has a wider distribution in Arizona than the Mojave Desert tortoise (Figure 2-24). The Mojave Desert tortoise is confined to the northwest Arizona, whereas suitable habitat for Sonoran Desert tortoise is found on rocky slopes and bajadas in Sonoran Desert scrub and semi-desert grassland throughout much of western and southern Arizona (Figure 2-24).

Direct mortality from WVCs is the most intuitive wildlife-vehicle conflict affecting desert tortoise. For example, surveys along 15-miles of highway over a 2.5-year period in the western Mojave Desert documented 39 dead tortoises, and surveys along 3 miles of SR 87 recorded 22 dead Sonoran Desert tortoises (Boarman et al. 1993; Grandmaison et. al. 2012). This mortality is thought to be the primary cause of a zone with lower tortoise density that extends 0.25 mile or further from highways through occupied tortoise range (Boarman 2002; Boarman and Sazaki 2006).

Other deleterious effects of highways on desert tortoise result from habitat and population fragmentation as well as habitat degradation caused by roads. Increased carapace temperatures and movement speeds which indicate stress, have also been documented in desert tortoise along roads (Peaden et. al. 2017). Motorist behavior when detecting desert tortoise on a roadway is another conflict that has the potential to cause serious traffic hazards. Grandmaison and Frary (2012) reported that between 16 and 61 percent of passing motorists responded to a desert tortoise placed on the road with responses varying from sudden slowing, to stopping and pulling over to move the tortoise or illegally collect it. Both hazards to motorists and effects to desert tortoise from wildlife-vehicle conflicts are reduced with proper implementation and regular maintenance of mitigations such as fencing (Grandmaison et. al. 2012; Peaden et. al. 2017). Providing effective highway passage is a critical need for these species, and their wide distribution coupled with declining populations across their range makes it a priority for ADOT consideration on highways that bisect tortoise range (Table 2-12). ADOT is a signatory to the Sonoran Desert Tortoise Candidate Conservation Agreement.

*Table 2- 12. Arizona highways which pass though desert tortoise habitats.*

| Desert tortoise species | Highways with Suitable Habitat | |
|---|---|---|
| Mojave (*G. agassizii*) | I-15 | |
| Sonoran (*G. morafkai)* | I-10 | I-19* |
| | I-40 | US 60 |
| | US 93 | US 95 |
| | SR 68 | SR 69* |
| | SR 87* | SR 88 |
| | SR 72 | SR 77* |
| | SR 83 | SR 85 |
| | SR 86 | SR 96 |
| | SR 177 | SR 286 |
| | SR 70 | |

* *denotes those highways where we identified hotspots and where desert tortoise suitable habitats were present.*

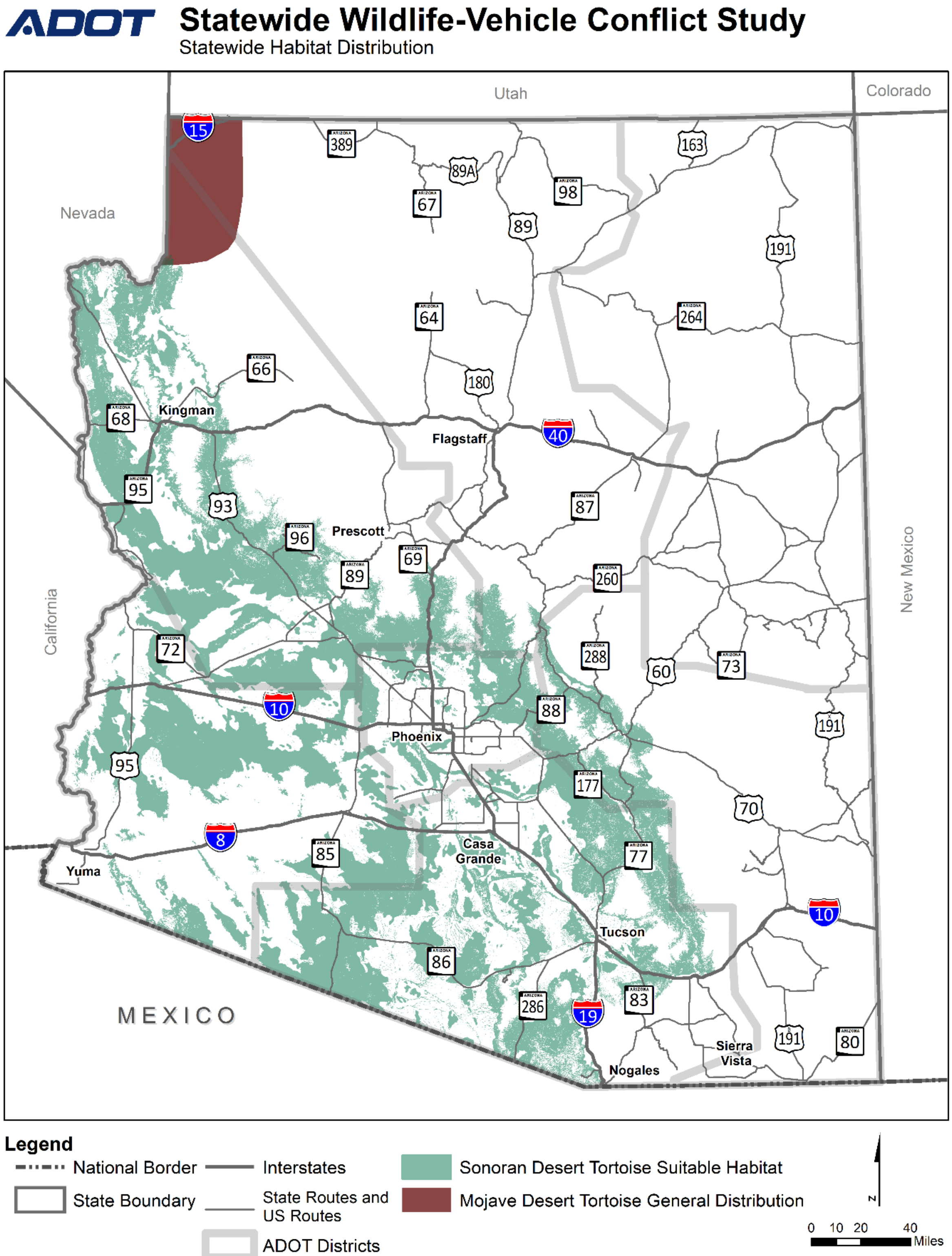



*Figure 2- 24. Desert tortoise habitat and the Arizona highways through which highways bisect their habitats.*

### PRONGHORN


Some iconic large mammals in Arizona, particularly desert bighorn sheep and pronghorn suffer from the combination of WVC underreporting (compared to deer and elk) *and* highway barrier effects that can preclude them from even crossing highways and being subject to collisions with vehicles. GPS telemetry studies on US 93 (Gagnon et al. 2012*a*), SR 64 (Dodd et al. 2012*b*) and US 89 (Dodd 2011) point to the degree to which even 2-lane highways constitute movement barriers to these species. For pronghorn, the situation is most dire, as average permeability along SR 64 and US 89 averaged just 0.004 and 0.006 crossings/approach, respectively, indicating that these highways constitute near total barriers to passage that is potentially isolating subpopulations each side of the highways (Dodd et al. 2011, 2012*b*; Figure 2-25). The 2018 ACIS database includes just a *single* pronghorn record for the entire state, reflective of this barrier effect.

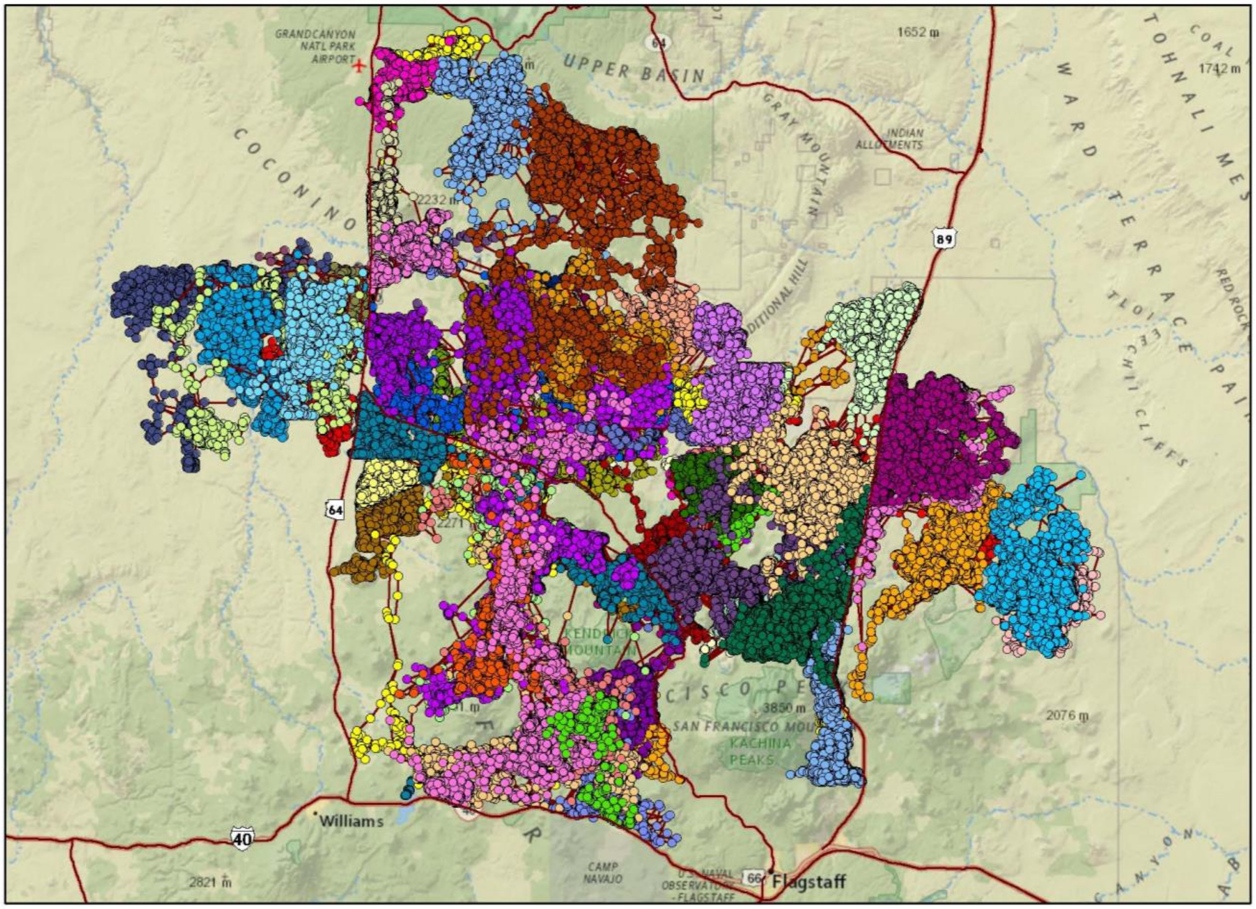



*Figure 2- 25. Compilation of GPS locations from pronghorn fitted with GPS telemetry collars along US 89, SR 64, and US 180, illustrating the barrier effect associated with these highways where very few animals crossed the three highways. Graphic from AGFD.*

*Figure 2- 26. Drop-in precast arch pronghorn overpass on US Highway 191 in Wyoming. Wildlife Conservation Society photo.*

Theimer et al. (2102) employed genetic sampling and modeling techniques to address highway barrier effects for pronghorn. They found indications that pronghorn genetic variation reflects that US 89, SR 64, and US 180 are indeed barriers to gene flow. The genetic barrier effect was strongest for US 89, weaker for SR 64, and weakest for US 180, which fall on a continuum of decreasing average traffic volume, as well as highway age and width. Consistent with this finding of a genetic highway barrier effect that is strongest on US 89 (Theiner et al. 2012), Dodd et al. (2009) raised concerns regarding population viability for the isolated pronghorn subpopulation situated east of US 89 and west of the Little Colorado River. This subpopulation had been in steady decline for over a decade and recruitment (of young) averaged 40 percent lower than the larger subpopulation west of US 89. The US 89 study (Dodd et al. 2009) stressed that the construction of one or more overpasses would be critical to restoring permeability, genetic flow, and population health as is being done successfully with drop-in overpasses in Wyoming (Sawyer et al. 2012; Figure 2-26). Pronghorn are widely distributed across Arizona and its grasslands (Figure 2-27), and consideration of highway passage and connectivity remain a critical need for ADOT to consider on highways which bisect pronghorn range (Table 2-13).

*Table 2- 13. Arizona highways which pass through pronghorn (2 subspecies) suitable habitats.*

| Pronghorn subspecies | Highways with Suitable Habitat | |
|---|---|---|
| Mexican (*A.a. mexicana*) | I-17* | I-40* |
| | US 60* | US 89* |
| | US 180* | SR 61 |
| | SR 64* | SR 66 |
| | SR 69* | SR 77* |
| | SR 80 | SR 82 |
| | SR 83 | SR 87 |
| | SR 89 | SR 89A* |
| | SR 260 | SR 377 |
| | SR 389 | |
| Sonoran (*A. a. sonoriensis*) | I-8 | SR 85 |

* *denotes those highways where we identified hotspots and where pronghorn suitable habitats were present.*

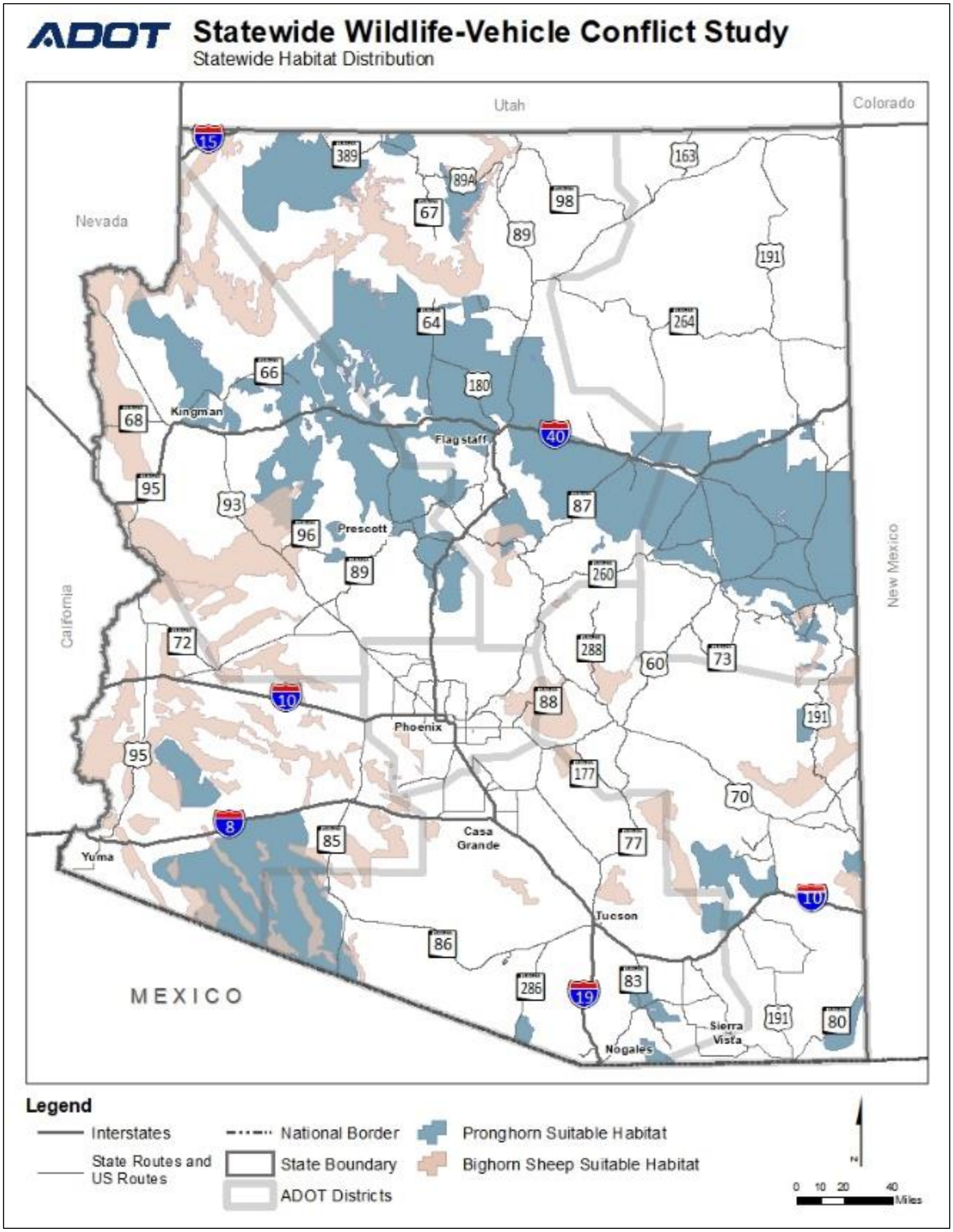



*Figure 2- 27. Pronghorn and bighorn sheep suitable habitat and the Arizona highways which bisect their habitats.*

### BIGHORN SHEEP

Like pronghorn, highways are strong barriers to desert bighorn sheep passage and permeability. Along 2-lane US 93 before it was widened, bighorn permeability averaged just 0.07 crossings/approach (Gagnon et al. 2012*a*). This degree of barrier effect has the same potential to isolate and fragment desert bighorn sheep populations as for pronghorn. Fragmentation is recognized as a key threat to many of the state's sheep populations, most which remain small (<100 animals) and isolated (Krausman and Leopold 1986). The importance of traditional sheep movement corridors to maintaining connectivity is well documented (Epps et al. 2007). Loss or obstruction of such traditional travel corridors and fragmentation of habitats can have significant implications to long-term population persistence and lead to genetic isolation of subpopulations (Giest 1971; Epps et al. 2007). Epps et al.'s (2005) landmark assessment of the barrier effect of highways and resulting impact to desert bighorn sheep genetic diversity among 27 southern California populations found that highways indeed limit gene flow. The degree of genetic diversity reduction was tied to years of isolation attributable to highways, and continued isolation poses a severe threat to the persistence of naturally fragmented bighorn sheep populations (Epps et al. 2005).

As demonstrated for US 93, especially with its three overpasses, passage structures are highly effective in promoting permeability (and connectivity) for desert bighorn sheep; there, permeability after four years increased over 500%, to 0.44 crossings/approach (Gagnon et al. 2017*a*). And like pronghorn, bighorn are grossly underrepresented in ACIS, with no records in the 2018 database. Thus, it is important that ADOT consider the ecological necessity of considering desert and Rocky Mountain bighorn sheep needs on Arizona's highways that cross through their habitat (Table 2-14; Figure 2-27).

*Table 2- 14. Arizona highways which pass though bighorn sheep (3 subspecies) suitable habitats.*

<table>
<tr><th>Bighorn sheep subspecies</th><th colspan="2">Highways with Suitable Habitat</th></tr>
<tr><td rowspan="2">Nelson<br>(O. C. nelsonii)</td><td>I-15</td><td>US 93</td></tr>
<tr><td>SR 68</td><td>SR 96</td></tr>
<tr><td rowspan="4">Mexican<br>(O. C. mexicana)</td><td>I-8</td><td>I-10</td></tr>
<tr><td>US 85</td><td>US 86</td></tr>
<tr><td>US 95*</td><td>SR 88</td></tr>
<tr><td>SR 177</td><td>SR 288</td></tr>
<tr><td>Rocky Mountain<br>(O. c. canadensis)</td><td>US 191</td><td>SR 260</td></tr>
</table>

** denotes those highways where we identified hotspots and where bighorn sheep suitable habitats were present.*

# CHAPTER 3 – HOTSPOT MITIGATION STRATEGY DEVELOPMENT

## HOTSPOT MITIGATION STRATEGY DEVELOPMENT OPTIONS

While most of the high-profile WVC reduction and connectivity projects implemented in Arizona since 2000 have been associated with major highway reconstruction projects (Table 2-9), ADOT's current and foreseeable budgets will accommodate few such projects outside of urban areas and interstate highways. During reconstruction projects, a significant portion of the project costs were directed to the integration of wildlife passage structures and fencing to achieve "proper" ecological spacing to optimize wildlife permeability, averaging one passage structure every two to three miles for ungulate species, though Bissonette and Cramer (2008) recommended spacing of one mile for deer species; these projects typically expended $1.5-2.0 million/mile on wildlife mitigations (wildlife fencing alone costs over $158,000/mile for one side). Those hotspots for which AGFD wildlife movement studies were done (Table 2-10) include wildlife-vehicle conflict resolution strategies that were predicated on major highway reconstruction and achievement of target spacing of wildlife passage structures.

Since most highways with hotspots likely will not be reconstructed in the foreseeable future (except for part of SR 260 Hotspot #10) we explored other avenues to address wildlife-vehicle conflicts. In addition to the strategies predicated on reconstruction in the AGFD wildlife studies and ADOT DCRs that overlap 10 of the top 21 hotspots, which remains the long-term goal for addressing wildlife needs, we worked to develop lower-cost, more-focused strategies to provide increased ADOT opportunity and flexibility to address conflicts in the short term. Yet, it is important to stress that these options are focused on WVC reduction and motorist safety and often do not provide for optimum passage spacing for wildlife. We pursued development of alternative approaches to wildlife-conflict resolution employing the following options or even a mix of these options, including passage structure construction:

### NONSTRUCTURAL MITIGATION PROJECTS

All or part of four top-10 hotspots fall within urban/semi-urban settings where fencing and passage opportunities may be limited (Table 3-1). In these situations, measures to modify driver behavior with enhanced signage (e.g., variable message boards, flashing signs) and traffic calming devices (e.g., rumble strips) can be employed to alert and slow motorists; such approaches can be effective and the most expedient option to reduce WVCs in some cases (Table 3-1). This option could also present the lowest cost resolutions where they are appropriate, anticipated of cost less than $100,000/mile.

### SENSOR TECHNOLOGY PROJECTS

The innovative SR 260 wildlife crosswalk project that integrated an Infra-red (IR)-camera based animal detection system which triggered motorist alert signage to help address a fencing end-run associated with retrofit fencing (reducing WVCs 97%; Gagnon et al. 2018) demonstrated the successful application of sensor technology in Arizona. This technology effectively alerted and slowed motorists such that thousands of elk and deer have crossed SR 260 at-grade with only a single documented crosswalk WVC since 2006. Sensor technology has now evolved into broader coverage open road radar detection systems that can detect animals approach roadways out a mile or more in each direction, alerting motorists with signs spaced along the detection zones. This approach can reduce or completely avoid installation of costly and maintenance-intensive wildlife fencing.

### RETROFITTING PROJECTS

These strategies capitalize upon utilizing wildlife fencing to limit at-grade crossings by wildlife while funneling animals to existing *suitable* drainage structures which can serve as functional wildlife passages. Aside from requiring the presence of suitable structures, another limitation is having suitable situations in which to terminate wildlife fencing such that concentrated wildlife end-runs are not created. This option has been implemented on I-17 and SR 260 with excellent success, reducing elk-vehicle collisions greater than 97 percent (Gagnon et al. 2017, 2018); they typically can cost around $200,000-$300,000/mile (<1/3 of major reconstruction). Where applicable, retrofitting can be one of the most effective short-term options available to ADOT (Kintsch and Cramer 2011).

### "DROP-IN" PASSAGE STRUCTURE PROJECTS

Many Arizona highway stretches lack sufficient numbers and distribution of suitable drainage structures to support fully viable retrofitting options and extensive applications of wildlife fence. In priority situations, the integration of stand-alone "drop-in" passage structures can provide an opportunity to address WVCs and connectivity. Drop-in structures were used on the SR 86 Kitt Peak and Santa Rosa sections widening projects (2 underpasses; Figure 2-19) in 2014, and two overpasses will be designed and implemented this year as a standalone project. Drop-in structures are primarily prefabricated concrete arches for both underpass and overpass applications, that are increasingly being used along highways in the western US, even interstates (Figure 3-1). These structures are relatively cost effective and can be done quickly in a phased manner to limit the need for extensive traffic control. These options would be anticipated to cost approximately $650,000/mile between wildlife fencing and new drop-in structures.

*Figure 3- 1. Precast concrete arch wildlife overpass being constructed on I-80 in Nevada as a stand-alone drop-in structure project.*

*Table 3- 1. General options/project types that can be employed in developing wildlife-vehicle conflict mitigation projects, with predominant mitigation elements and estimated costs/mile.*

| Mitigation option | Mitigation elements | Cost/mile |
|---|---|---|
| Nonstructural projects | Enhanced signage (e.g., VMS, flashing)<br>Traffic calming measures | <$100,000 |
| Sensor technology projects | Animal detection systems at end runs<br>Open-road radar detection systems/signage | $150,000-$200,000 |
| Retrofitting projects | Wildlife fencing + associated measures | $250,000 |
| Drop-in structure projects | Prefabricated passage structures<br>Wildlife fencing + associated measures | $650,000+ |
| Full reconstruction projects | New passage structures<br>Wildlife fencing + associated measures | $1,500,000+ |

## PRIORITY HOTSPOTS FOR MITIGATION STRATEGY DEVELOPMENT

With the guidance of the project TAC, the top five hotspot priorities were selected for mitigation strategy development and field assessment (Table 3-2). In addition, enough information was readily available for four hotspots to allow their addition in development of mitigation strategies, including I-17 Hotspot # 7 south of Flagstaff, where ADOT's Northcentral District in collaboration with AGFD proposed two P2P projects for drop-in overpasses. While half of SR 260 Hotspot #10 is being addressed with the ongoing Lion Springs Section reconstruction design, the other half between Payson and Star Valley with a high incidence of WVCs appears suited for a nonstructural strategy. A resolution strategy for the SR 260 Hotspot #15 on the Little Green Valley and Kohls Ranch sections with wildlife mitigations (e.g., underpasses/bridges) centers on upgrading/replacing elk retrofit fencing for which the design has not proven to be a long-term alternative to wildlife fence. Lastly, the SR 64 portion of Hotspot #21 was addressed due to the presence of a highly suitable bridge to support a retrofitting strategy and was visited while addressing SR 64 Hotspot #2. In developing our mitigation strategies, we utilized a "toolbox" of available and proven effective mitigation actions and measures (Table 3-3).

*Table 3- 2. Wildlife-vehicle collision hotspots for which we developed mitigation strategies and associated mitigation project options available and considered for each hotspot. The green shaded hotspots are those where field reconnaissance was conducted, and gold denotes those hotspots where sufficient information was available to develop resolution strategies.*

| WVC Rank | Route | Location | MP range | Potential mitigation options: Non-structural | Retrofit bridge | Drop-in | Comments |
|---|---|---|---|---|---|---|---|
| 1 | US 89 | Flagstaff | 420-424 | X | | X | Semi-urban area |
| 2 | SR 64 | Tusayan | 227-237 | X | | X | DCR*; deer migration corridor; sensor technology |
| 4 | I-40 | Flagstaff | 195-200 | X | X[1] | | DCR; urban area [1]Rio de Flag bridge |
| 4 | SR 77 | Shumway | 349-356 | X | X[2] | X | [2]Show Low Creek bridge |
| 6 | SR 260 | Heber to Show Low | 309-339 | X | X[3] | X | DCR; [3]Pierce, Decker, & Cottonwood Wash bridges |
| 7 | I-17 | South of Flagstaff | 321-338 | | X | X | DCR; P2P projects for 2 overpasses; Munds Canyon retrofit fence replacement |
| 10 | SR 260 | Star Valley | 252-256 | X | | | Semi-urban area; MP 256-260 within Lion Springs design project |
| 15 | SR 260 | Kohls Ranch | 263-271 | | X | | Retrofit fence upgrade/ replacement |
| 21 | SR 64 | North of I-40 | 185-194 | | X[4] | X | DCR; [4]Cataract Canyon bridge |

**DCR = ADOT design concept reports and AGFD wildlife movement studies (Table 2-11)*

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*Table 3- 3. Potential wildlife mitigation measures to resolve wildlife-vehicle conflicts on Arizona's highways by mitigation strategy. Actions/measures are categorized as those that target motorists and those that target wildlife, while a mix of actions/measures may be appropriate.*

| Mitigation action/measure | Effectiveness | Cost | Maintenance requirements | Applicability to mitigation strategies | | | |
|---|---|---|---|---|---|---|---|
| | | | | Nonstructural | Retrofit | Drop-in | Construction |
| **Actions/Measures that Target Motorist Behavior** | | | | | | | |
| **Signage** | | | | | | | |
| Motorist alert signage - static | Very low | Low | Low | X | X | X | X |
| Motorist alert signage – flashing continuously | Low | Low | Low | X | X | X | X |
| Motorist alert signage – time-specific flashing (migrations) | Low - Moderate | Low | Low | X | X | X | X |
| Motorist alert signage – time- and place-specific flashing | Moderate | Low | Low | X | X | X | X |
| Motorist alert signage – VMS on continuously | Low - Moderate | Moderate | Moderate | X | X | X | X |
| Motorist alert-signage – VMS on at time and/or place-specific (migration corridor) | Moderate - High | Moderate | Moderate | X | X | X | X |
| **Signage + Wildlife Crosswalks (with fencing)** | | | | | | | |
| Motorist alert signage (static) and crosswalk (including at fence end runs) | Medium | Low-Moderate | Low | X | X | X | |
| Motorist alert signage integrated with animal-activated detection systems (AADS), either open-road radar or animal crosswalk | Medium-High | Moderate | Moderate | X | X | X | |

| Mitigation action/measure | Effectiveness | Cost | Maintenance requirements | Applicability to mitigation strategies | | | |
|---|---|---|---|---|---|---|---|
| | | | | Nonstructural | Retrofit | Drop-in | Construction |
| **Roadside Vegetation Management** (Note: these measures require periodic vegetation retreatment and cost to maintain effectiveness) | | | | | | | |
| Vegetation thinning to improve visibility and motorist response (and ice /snow melting) | Low | Low-moderate | Low | X | X | X | X |
| Roadside vegetation thinning + enhanced motorist alert signage | Moderate | Low-Moderate | Low | X | X | X | X |
| **Motorist Speed Zones** | | | | | | | |
| Speed reduction zone with any of above measures | Low-Moderate | Low | Low | X | X | X | X |
| Speed reduction zone + motorist alert signage + animal crosswalk with fencing (no AADS) | Moderate | Low-Moderate | Low | X | X | X | |
| Speed reduction zone + motorist alert signage + animal crosswalk with fencing + AADS | High | Moderate | Moderate | X | X | X | |
| **Traffic Calming Measures** | | | | | | | |
| Construction design features to reduce motorist speeds (curves, narrower lanes and shoulders) | Moderate | Low | None | | | | X |
| Retrofit measures to reduce speeds (chicanes, rumble/mumble strips, speed humps, striping to narrow lanes) | Moderate-High | Moderate | Low-Moderate | X | X | X | |
| Retrofit measures with signage and fencing to create animal crosswalk (including end runs) | Moderate-High | Moderate-High | Low-Moderate | X | X | X | |

| Mitigation action/measure | Effectiveness | Cost | Maintenance requirements | Applicability to mitigation strategies | | | |
|---|---|---|---|---|---|---|---|
| | | | | Nonstructural | Retrofit | Drop-in | Construction |
| **Public Awareness Campaign** | | | | | | | |
| Statewide awareness campaign on hotspots | Low | Low | None | X | X | X | X |
| Statewide awareness campaign + unique hotspot signage | Moderate | Low-Moderate | Low | X | X | X | X |
| **Actions/Measures that Target Wildlife** | | | | | | | |
| **Habitat Enhancement Adjacent to Highways** (Note: these measures may require periodic maintenance and cost to maintain effectiveness) | | | | | | | |
| Forage/salt enhancement away from highways to draw animals, water development on both sides to reduce crossings | Low-Moderate | Low-Moderate | Low-Moderate | X | X | X | X |
| **Retrofit Modifications to Existing Infrastructure** | | | | | | | |
| Install wildlife fence to link existing suitable structures to funnel animals for below- and above-grade passage | Moderate-High | Moderate-High | Moderate-High | | X | | |
| Retrofit bridges and culverts (light wells) and to enhance suitability for wildlife passage | Moderate | Moderate | Low | | X | | |
| Adapt/replace fences and gates at passage structure approaches | Moderate | Low-Moderate | Moderate | | X | | |
| Add lateral road/access control measures (cattle guards) to prevent breaches by animals | Moderate | Moderate | Low-Moderate (may present bicyclist issues) | | X | | |
| Add escape ramps along fence (avoid rock baskets) | Moderate | Moderate | Low | | X | | |

| Mitigation action/measure | Effectiveness | Cost | Maintenance requirements | Applicability to mitigation strategies | | | |
|---|---|---|---|---|---|---|---|
| | | | | Nonstructural | Retrofit | Drop-in | Construction |
| **Drop-in Structures to Provide Passage Structures** | | | | | | | |
| Install new underpass or overpass structures at strategic locations to provide passage and link to other structures with wildlife fence | High | High | Moderate | | | X | |
| Add lateral road/access control measures (cattle guards) to prevent breaches by animals | Moderate | Moderate | Low-Moderate (may present bicyclist issues) | | | X | |
| Add escape ramps and escape mechanisms along fence (avoid rock baskets) | Moderate | Moderate | Low | | | X | |
| **New Construction/Reconstruction Passages Structures and Associated Infrastructure** | | | | | | | |
| Install new underpass or overpass structures to meet species spacing needs and link to other structures with wildlife fence | Very High | Very High | Moderate | | | | X |
| Add lateral road/access control measures (cattle guards) to prevent breaches by animals | Moderate | Moderate | Low-Moderate (may present bicyclist issues) | | | | X |
| Add escape ramps and escape mechanisms along fence (avoid rock baskets) | Moderate | Moderate | Low | | | | X |

## HOTSPOT MITIGATION STRATEGY DEVELOPMENT APPROACH AND METHODS

We took a comprehensive approach to assessing wildlife-vehicle conflicts, especially those related to WVCs in the identification of potential conflict resolution strategies and recommended projects. We developed hotspot profiles that considered within-hotspot WVC peaks and incidence by milepost (MP) as well as monthly/seasonal patterns to further identify resolution priorities.

To develop appropriate resolution strategies for each of the nine hotspots, we considered and incorporated a wide range of available information, prior assessments, and potential constraints associated with land use and environmental considerations. The information we considered in our hotspot strategy development included but was not limited to:

- Locations and dimensions of existing drainage and other structures that could be integrated into strategies, assessing their suitability to function as wildlife passage structures with fencing (Kintsch and Cramer 2011). This information served as our initial, default approach to attempting to resolve WVC conflicts based on retrofit wildlife fencing strategies;
- Current highway design (e.g., number of lanes, posted speed limits, road geometry) including AADT and temporal traffic patterns, where available;
- History of prior wildlife-vehicle conflicts and land use associated with hotspots to help establish the geopolitical context for hotspot resolution;
- Available ADOT-commissioned Wildlife Accident Reduction Studies (WARS) conducted by engineering firms with recommendations for mitigating WVCs for incorporation into ADOT highway reconstruction design concept reports (DCR);
- Available AGFD wildlife movement studies with recommendations for mitigating WVCs and other wildlife-highway conflicts; these mainly focused on reconstruction but have considerable applicability to shorter-term strategy development;
- Review of wildlife-conflict resolution projects and strategies pursued in other western states and Canadian provinces that might hold applicability to Arizona;
- Consultation with vendors that support efforts to resolve wildlife-vehicle conflicts, including for the application of drop-in passage structures and sensor technology; and
- Delineated wildlife corridors across highways arising from analysis under the 2018 US Department of Interior Secretarial Order 3362 that established an interagency Corridor Mapping Team (Kauffman et al. 2020) which analyzed data from AGFD wildlife telemetry studies.

We conducted field review of seven hotspots to gain a better understanding of hotspot roadway and land use conditions, challenges, and to identify potential and appropriate resolution strategy options. We relied on the available information above to assist in strategy development for all hotspots but particularly for those where field reviews were not conducted.

In developing recommended conflict resolution strategies, we strove to develop a wide range of recommended mitigation options and project types, estimated costs, and timeframes for potential implementation based on difficulty of project deployment (e.g., time, effort, planning required). We assumed that identified short-term projects could generally be implemented within six to 12 months with available funding, intermediate-term projects could require a year to 18 months largely due to agency coordination, and long-term projects reflect lower priorities, higher cost, and/or significant coordination.

Recommended project cost estimates were derived from the most current ADOT estimates for wildlife fencing, escape ramps and other associated measures (ADOT 2014*a*), P2P project cost estimates for drop-in overpasses (I-17), and consultation with vendors pertaining to drop-in passage structures and sensor technology.

## ENVIRONMENTAL OVERVIEWS FOR MITIGATION PROJECTS

ADOT Environmental Planning (EP) will determine if there are any special environmental concerns and will prepare the required environmental clearance documentation during the final design for each of the proposed hotspot mitigation projects. If no federal nexus is identified, the proposed mitigation projects will be applicable to ADOT District permit requirements, and State requirements. Mitigation projects which have a federal nexus require compliance with the National Environmental Policy Act (NEPA). ADOT assumed FHWA responsibility for carrying out NEPA environmental approvals under the Categorical Exclusions (CE) Assignment (23 USC 326) and NEPA Assignment (23 USC 327). The CE Assignment Memorandum of Understand (MOU) was signed on January 3, 2018 and renewed on January 4, 2021, and the NEPA Assignment MOU was signed on April 16, 2019. With these assignments, ADOT is responsible for complying with all applicable federal environmental laws, regulations, Executive Orders, and policies, and is solely legally responsible for environmental decisions made on all ADOT federal-aid highway projects. If NEPA is required for the proposed mitigation projects, it is anticipated they would be cleared with ADOT CE Assignment under C-list (c)22 or (c)23i. C-List (c)22 is recommended for the proposed projects that will take place within ADOTs existing right-of-way (ROW) or easement, and C-list (c)23i is recommended for projects that may require additional ROW or temporary construction easement (TCE). For projects that use federal funds, a Section 4(f) analysis will likely be needed if the proposed project is located near publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites.

Agency scoping and request for comment will be required for all the proposed mitigation projects regardless of a federal nexus. Agency scoping would follow ADOT EP scoping guidelines and include county, nearest local municipalities, federal landowners (forest, state, federal), nearest emergency services (including fire, police, hospital, and ambulances), council of government, and potentially chambers of commerce. Public scoping and request for comment is not anticipated to be required for the environmental clearance of the proposed mitigation projects due to the limited impacts to the traveling public and adjacent landowners. Any public notification of project details per ADOTs standard practice, would be conducted by ADOT Communication within the appropriate period prior to construction.

All areas that will potentially be disturbed during construction were reviewed for impacts to environmental resources in the technical study documents and clearance. The area of potential disturbance includes any staging areas, easements, or off-site locations used during construction and temporary traffic control limits. The environmental clearance effort for each of the proposed mitigation projects would at a minimum review impacts to cultural and biological resources, hazardous materials and surface waters. Floodplains will be considered during the environmental clearance and design plans would be sent to the appropriate floodplain manager or administrator for review. However, project impact to floodplains are anticipated to be minor with no Letter of Map Revision (LOMR) required.

Cultural review for the proposed projects will be completed by the ADOT Historic Preservation Team. At a minimum, each of the proposed projects will undergo consultation by ADOT pursuant to Section 106 of the National Historic Preservation Act of 1966. Surveys may be required in areas of existing ADOT ROW or easement to reassess the current location of cultural sites and determine their National Register of Historic Places (NRHP) eligibility. Additional survey for proposed projects that require new ROW or TCEs can be anticipated. Avoidance of known cultural site is anticipated for most of the proposed projects, though mitigation may be required at some locations.

The hazardous materials assessment would include a search of databases for potential hazardous material concerns in the proposed projects area and surrounding vicinity. At a minimum, a Preliminary Initial Site Assessment (PISA) would be completed and approved as part of the environmental clearance process. Testing for asbestos containing materials and lead-based paint will be required for proposed projects that impact existing structures such as culverts, bridges or cattleguards.

The biological resources review for the environmental clearance will be led by ADOT Biology Team. At a minimum, the U.S. Fish and Wildlife Service (USFWS) Information Planning and Consultation (IPaC) system and Arizona Game and Fish Department (AGFD) Online Review Tool, will be accessed to obtain a list of threatened, endangered, proposed and candidate species and critical habitats federally protected by Endangered Species Act (ESA) in the vicinity of the proposed project. Likewise, for those projects located on ADOT easement through lands managed by the U.S. Forest Service (USFS) or Bureau of Land Management (BLM), sensitive species with suitable habitat in the projects' vicinity should also be considered. Bridges and culverts are often used by nesting birds protected by the Migratory Bird Treaty Act (MBTA) and by bats for roosting. Any project impacting existing bridges or culverts will likely require a pre-construction survey to identify if nesting birds or roosting bats are present and could require mitigation such as species exclusion or monitoring to avoid project impacts to these resources. We also assessed existing landownership and biological resource considerations associated with each proposed mitigation project.

Discharge of fill and dredge to Waters of the U.S. (WOTUS) is not anticipated for most of the proposed projects, thus a Clean Water Act (CWA) Section 404 permit and CWA Section 401 water quality certification should not be required. However, ADOT EP will review each of the proposed projects during their final design for impacts to surface waters and determine if project authorization under Section 404 and Section 401 is needed, as well as which proposed projects have the potential to impact WOTUS. The amount of ground disturbance will also be determined during final design. If more than one acre of land will be disturbed, an Arizona Pollutant Discharge Elimination System (AZPDES) Permit and a Storm Water Pollution Prevention Plan (SWPPP) will likely be required as CWA Section 402 compliance for the project.

## HOTSPOT MITIGATION STRATEGY DEVELOPMENT RESULTS

We completed our assessment and mitigation strategy development for all nine hotspots identified in Table 3-2. We conducted field reviews for seven of the nine, with prior knowledge and other information (e.g., AGFD wildlife movement studies/DCRs) sufficient to support development of resolution strategies for hotspots for which a field review was not conducted.

For the nine hotspots, a total of 22 separate conflict resolution projects were identified (Table 3-4): one immediate-term, 12 short-term, five intermediate-term, and four long-term projects. Of the 13 recommended immediate- and short-term implementation projects, 12 were assigned very-high priority for ADOT action due to their low deployment/implementation difficulty, impact in addressing hotspot WVC incidence, and estimated cost (Table 3-4). While seven structural/drop-in passage structure projects were identified, only one was a very-high priority (I-17) while four were moderate and low priorities due to coordination and potential need for additional ADOT ROW and temporary constructions easements (Table 3-5). Conversely, all seven nonstructural projects were identified as very-high priorities for short-term implementation (Table 3-6). Table 3-7 summarizes the environmental resource considerations for each of the proposed mitigation projects. Since all proposed projects are located within attainment areas and will not be adding capacity or shifting roadway alignments, all are exempt from noise and air quality analysis. We provide separate, stand-alone assessment reports with conflict resolution strategies, recommendations, and environmental overviews for each of the nine priority hotspots. Also provided are large-format field maps of our proposed mitigation projects and associated conflict resolution features for each hotspot (Appendix D).

## RESOLUTION STRATEGIES BY TYPE

A range of wildlife-vehicle conflict resolution strategies and types were identified for the nine hotspots (Table 3-4 and Table 3-5) corresponding to the types listed in Table 3-1. Some of our recommended resolution types and actions have heretofore not been used in Arizona, though similar projects are being pursued in other western states and Canadian provinces. This is especially the case with nonstructural projects where the complexity and difficulty of resolving WVC issues with other types of projects are not feasible or appropriate. Where most successful Arizona wildlife-vehicle conflict mitigation projects focused on modifying animal (crossing) behavior with fencing and passage structures, we put forth hotspot resolution strategies and recommendations for five hotspots focusing on modifying motorist behavior (Table 3-4 and Table 3-5); these strategies rely on both nonstructural- and technology-based projects. We have labeled several of these projects as experimental, both to reflect that they have not previously been used in Arizona and that we believe their effectiveness should be formally monitored or researched to allow evaluation of their applicability to other hotspots.

RETROFITTING PROJECTS: When pursuing short-term cost-effective strategies to resolve WVC, retrofitting (with fencing) options capitalizing on existing drainage structures/bridges suitable to provide wildlife passage are generally the default starting point, as done on SR 260 (Gagnon et al. 2018) and I-17 (Gagnon et al. 2015). In the case of our nine focal hotspots, only two were suitable for true retrofitting projects centered on fencing to existing suitable bridges: I-40 Hotspot #4 (Rio de Flag bridges) and SR 64 Hotspot #21 (Cataract Canyon bridge). These projects are very high priorities though I-40 is the higher priority of the two.

Retrofit fencing on four other highways is predicated on other mitigation measures; fencing of three hotspots can be done only in concert with the construction of new drop-in passage structures (1 underpass, 4 overpasses) to augment existing suitable structures to achieve reasonable spacing. These drop-in structures make such projects costly, and thus only one project (I-17) is considered a very high priority while two were identified as high priorities (Table 3-5).

NONSTRUCTURAL PROJECTS: Where retrofitting and other mitigation types are not possible or applicable, we recommend nonstructural strategies intended to modify driver behavior in terms of reduced vehicular speed and/or increased alertness. Increased motorist alertness can reduce vehicle stopping distances by as much as 68 feet at 55 mph, enough to avoid or reduce the severity of WVCs (Huijser et al., 2009*b*). The risk of WVCs increases exponentially with increasing vehicular speed (Kloden et al. 1997). Thus, increasing motorist alertness and vehicular speed holds the potential to result in meaningful reductions in WVC incidence (Huijser et al. 2009*b*).

*Table 3- 4. Wildlife-vehicle conflict hotspot resolution projects by term and type, behavioral change focus, deployment difficulty (time and effort), percentage of hotspot WVC addressed, estimated cost (from individual hotspot strategies), and implementation priority.*

| Hotspot | Strategy term | Strategy type | Behavioral change focus | Deployment difficulty | % of WVC | Cost | Project description | Priority |
|---|---|---|---|---|---|---|---|---|
| #1 US 89 | Short | Nonstructural | Motorists | Low | 85% | $48,000 | Wildlife Collision Prevention Zone | Very high |
| | | Technology | Motorists | Low-moderate | 75% | $450,000 | Open-road radar detection system | Very high |
| | Intermediate | Retrofit | Wildlife | Difficult | 25% | $688,400 | Wildlife fencing | Moderate |
| | Long | Structural | Wildlife | Difficult | 25% | $2,500,000 | Drop-in overpass | Low |
| #2 SR 64 | Immediate | Technology | Motorists | Low | 28% | $120,000 | Open-road radar detection system | Very high |
| | | Nonstructural | Motorists | Low | 11% | $48,000 | Wildlife Collision Prevention Zone | Very high |
| | Short | Technology/ fence | Motorists and wildlife | Low-Moderate | 58% | $1,001,600 | Open-road radar detection systems (2) and wildlife fencing | Very high |
| | Intermediate | Retrofit | Wildlife | Moderate | 20% | $980,800 | Wildlife fencing | Moderate |
| | Long | Structural | Wildlife | Difficult | 20% | $2,500,000 | Drop-in overpass | Low |
| #4 I-40 | Short | Fencing retrofit | Wildlife | Low-Moderate | 85% | $613,200 | Wildlife fencing | Very high |
| #4 SR 77 | Short | Nonstructural | Motorists | Low | 60% | $48,000 | Wildlife Collision Prevention Zone | Very high |
| | | Nonstructural | Motorists | Low | 21% | $10,000 | Enhanced motorist alert signage | Very high |
| | Long | Structural/fence | Wildlife | Moderate-high | 21% | $1,721,200 | Drop-in underpass/wildlife fencing | High |
| #6 SR 260 | Short | Nonstructural | Motorists | Low | 45% | $96,000 | Seasonal Speed Limit Zones | Very high |
| | Intermediate | Structural/fence | Wildlife | Moderate-high | 42% | $9,081,200 | Drop-in overpass/wildlife fencing | Moderate |
| #7 I-17 | Short-Intermediate | Structural/fence | Wildlife | Moderate | 43% | $6,422,800 | Drop-in overpass/wildlife fencing | Very high |
| | | Structural/fence | Wildlife | Moderate | 35% | $6,568,800 | Drop-in overpass/wildlife fencing | High |
| | Intermediate | Fence upgrade | Wildlife | Low | N/A | $1,248,000 | Munds Canyon retrofit fence upgrade/replacement | High |
| # 10 SR 260 | Short | Nonstructural | Motorists | Low | 100% | $48,000 | Wildlife Collision Prevention Zone | Very high |
| | | | | | | $74,000 | Seasonal Speed Limit Zone | Very high |
| #15 SR 260 | Short | Fence upgrade | Wildlife | Low | 100% | $1,172,000 | Retrofit fence upgrade | Very high |
| | Long | Fence upgrade | Wildlife | Moderate | N/A | $624,000 | Retrofit fence upgrade | Moderate |
| #21 SR 64 | Short | Retrofit | Wildlife | Low-Moderate | 54% | $1,492,000 | Wildlife fence | Very high |
| | Long | Structural | Wildlife | Moderate-high | N/A | $2,250,000 | Drop-in overpass | Moderate |

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*Table 3- 5. Recommended wildlife-vehicle conflict hotspot resolution projects by project type and implementation priority; note, more than one project type may apply to individual projects.*

| Resolution project type | Implementation priority | | | |
|---|---|---|---|---|
| | Very high | High | Moderate | Low |
| **Nonstructural projects** | | | | |
| Wildlife Collision Prevention Zone | 4 | - | - | - |
| Enhanced motorist alert signage | 1 | - | - | - |
| Seasonal nighttime speed reduction zones | 2 | - | - | - |
| **Technology projects** | | | | |
| Open-road radar detection systems/signage | 3 | - | - | - |
| **Fencing projects** | | | | |
| Wildlife (retrofit) fencing | 4 | 2 | 3 | - |
| Elk retrofit fencing upgrade/replacement | 1 | 1 | 1 | - |
| **Structural projects** | | | | |
| Drop-in passage structures | 1 | 2 | 2 | 2 |
| **All projects (some have a mix of types)** | **16** | **5** | **6** | **2** |


*Figure 3- 2. Conceptual motorist alert signs at the approaches to a designated Wildlife Collision Prevention Zone; the signs should be LED-enhanced for maximum nighttime impact.*

We recommend experimental designated *Wildlife Collision Prevention Zones* on four hotspots (Table 3-4); these zones are recommended in semi-urban settings and are confined to peak WVC areas within the hotspots; all four zones are 2.5 miles in length or shorter. These zones include gateway warning signage (Figure 3-2), preferably enhanced with LED lights to inform/alert motorists of the approaching zones. We recommend that transverse rumble strips also be cut into the pavement at these locations to further alert motorists; additional rumble strips within the zone would be ideal to maintain motorist alertness. Within the zones, posted speed limits are reduced 10 mph.

On two hotspots (SR 260 Hotspots #6 and #10) we recommend somewhat longer (5 mile) seasonal speed limit reduction zones where the speed limits are reduced 10 mph only during dusk/nighttime (18:00-06:00 hours), when the vast majority of WVCs occur. The Federal Highway Administration (FHWA; 2012) proscribes that nighttime speed limits can be established on highways where safety issues require a lower speed than those set for daytime, including "…roads crossing the routes and movement patterns of large-

*sized, nocturnal wildlife*." To accomplish this, we recommend gateway signs and electronic digital speed limit signs that post the reduced speed limit during the proscribed season and hours.

Similar wildlife collision risk alert and speed reduction zones have been employed in other areas including Wyoming, Colorado (Wildlife Crossing Zones program; CDOT 2014), British Columbia (Wildlife Collision Prevention Program; BC Conservation Foundation 2016), and others. And while the results have been mixed (e.g., Wyoming; Riginos et al. 2019) we have endeavored to combine nontraditional (for Arizona) alert signage combined with other measures to potentially enhance effectiveness. These strategies are relatively inexpensive; experimental status and evaluation is vital to a better understanding and evaluation of their effectiveness and potential for application elsewhere on other hotspots. The effectiveness of such a program could also be enhanced with an ADOT coordinated public awareness campaign to raise awareness of statewide WVC conflicts and the heightened risk within hotspots.

TECHNOLOGY PROJECTS: One of the more exciting recent developments in the pursuit of effective WVC mitigation tools has been the development and implementation of open-road radar animal detection systems. This technology differs from the IR-camera animal-activated detection system associated with the SR 260 wildlife crosswalk project where animals are detected within a narrow zone at the end of wildlife fencing in that it reduces or even avoids the need to erect costly and maintenance-intensive fencing altogether, though fencing may be needed in areas with poor line-of-sight visibility.

Open-road radar animal detection systems integrated with triggered motorist alert signage have proven successful in preventing WVCs (e.g., British Columbia, Canada) and are now being developed for Colorado. These systems employ 360-degree rotational Frequency Modulated Continuous Wave radar detection unit(s) integrated with two types of alert signage: 1) static gateway signs as motorists approach the WVC avoidance zone, and 2) hybrid static/dynamic (Blank-Out) "slow down" message signs (Figure 3-3) at intermediate locations along the zone that are triggered when animals are detected (Figures 3-3 and Figure 3-4). The number and spacing of intermediate signs are tied to posted speed and detection zone length; a single radar detection unit can be effective on up to three miles on roadway stretches with direct line-of-sight (a critical consideration).

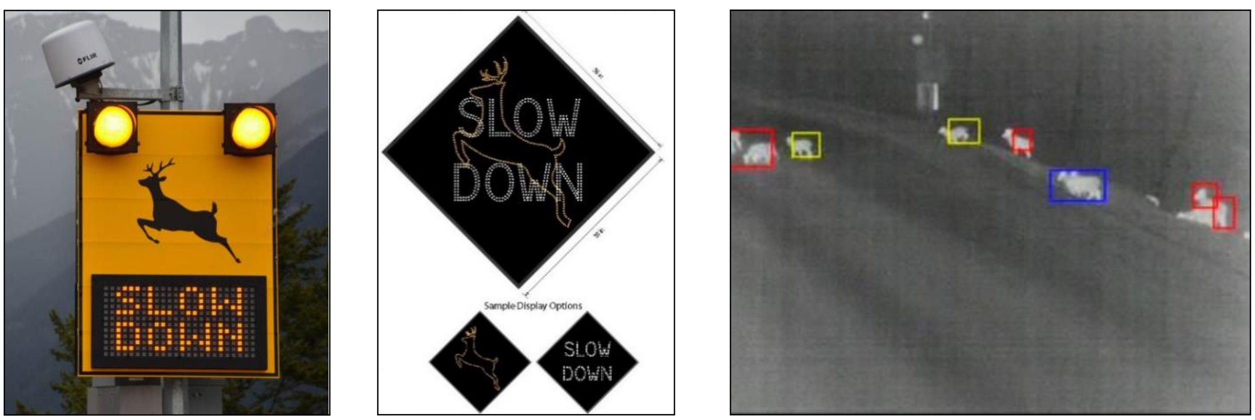


*Figure 3- 3. Pole-mounted variable message sign and radar unit for open-road radar detection system (left), static/dynamic Blank-Out message sign display options (center), and ITS-integrated detection of animals approaching and crossing a highway (right; photos courtesy Crosstek Wildlife Solutions).*

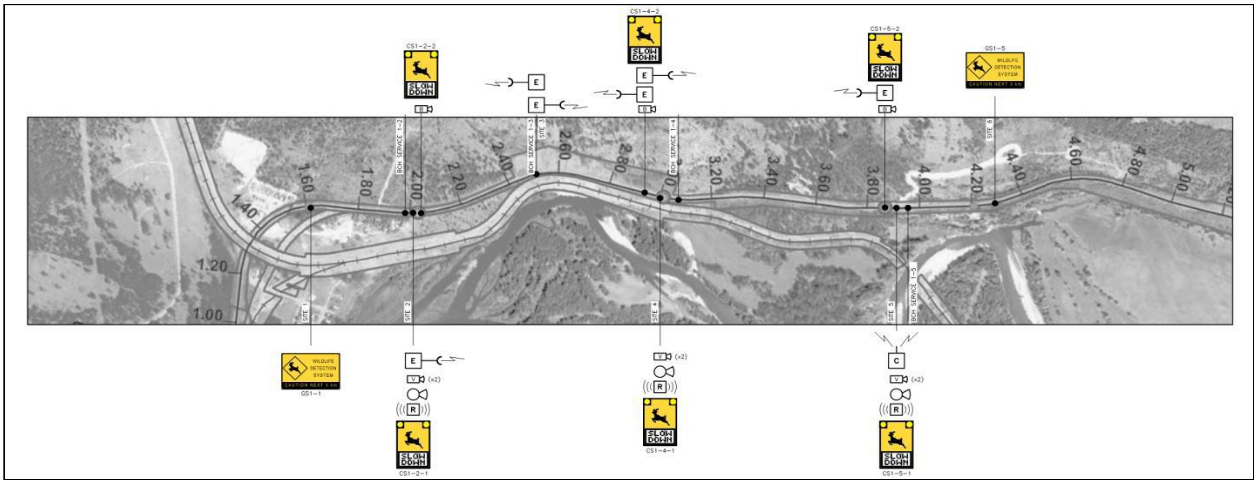

*Figure 3- 4. Schematic of the layout of a radar-based animal detection system and motorist alert gateway and triggered intermediate static/dynamic signage along a British Columbia highway (Source: PBX Engineering, Vancouver, BC).*

Crosstek Wildlife Solutions LLC (currently responsible for the SR 260 crosswalk with its animal detection system) is the proprietary vendor of open-road radar animal detection systems (ORAD™) in the US. Their ORAD™ systems have successfully integrated Intelligent Transportation System (ITS) components with high-performance security technologies for application in highway-wildlife conflict resolution. For each mile of ORAD™ application, four static/dynamic Blank-Out signs are recommended. Crosstek Wildlife Solutions LLC offers multiple purchase options for their ORAD™ animal detection and integrated signage system:

1) Purchase of a permanent ORAD™ integrated system including planning, design, electrical infrastructure installation (Phase 1), and radar and signage installation (Phase 2). The estimated ORAD™ system cost with six blank-out message signs is $595,000 - $655,000. We are hesitant to recommend permanent systems for hotspots on highways that may be reconstructed in the future, as this would likely necessitate removal of much of the electrical infrastructure associated with such a system.
2) Purchase of a Mobile Autonomous Radar Unit (estimated cost $250,000) and six mobile Blank-Out message signs ($25,000 each) is estimated to cost $400,000.
3) Lease of a Mobile Autonomous Radar Unit and six Blank-Out message signs for 6-12 months, estimated at $10,000/month including setup and operation by the vendor. This approach would allow ADOT to formally evaluate ORAD™ for one year; Crosstek has indicated that half the lease payment ($60,000) would apply toward subsequent purchase.

In evaluating ORAD™ procurement options, it is important to stress that a system replaces the need to erect (and maintain) wildlife fence. Using an example from SR 64 Hotspot #2, an ORAD™ would replace 3.6 miles of fence (estimated cost $568,800), three pair of escape jumps (6 total; $66,000), and two cattle guard grate extension units ($60,000), totaling $694,800. Further, without suitable existing drainage structures for retrofitting, fencing would necessitate an at-grade crosswalk with animal detection system to allow wildlife passage, costing another approximately $150,000 and bringing total cost to $844,800. Thus, the cost of the ORAD™ radar system and signage can be a lower cost option than the wildlife fence and crosswalk that it replaces.

We recommend the immediate experimental leasing of a mobile ORAD™ system for one-year evaluation on SR 64 Hotspot #2. This hotspot constitutes the *best-case* application of a system of all nine hotspots due to its rural 2-lane roadway, long stretches with excellent line-of-sight visibility, and rapidly declining traffic after sunset. The vendor will maintain and operate the system and even train ADOT maintenance staff. If proven successful, we recommend the purchase of this system (with half the lease payment applied to purchase) and the purchase of a second system for SR 64, with a short stretch of wildlife fencing linking the two systems to address most of the WVCs associated with this hotspot.

Also, after experimental evaluation on SR 64, we recommend the purchase or lease of a mobile ORAD™ for initial use and evaluation along US 89 Hotspot #1. Here, we consider an ORAD™ application to be a *worst-case* application due to the 4-lane (with a center turn lane) hotspot's high traffic volume and numerous driveways and side roads. If proven successful here, the technology would likely be suitable for seasonal use on a variety of other highways.

ORAD™ technology holds considerable potential for the resolution of wildlife-vehicle conflicts across the state. As such, we recommend that ADOT consider the experimental application of an initial system followed by others under a formal research evaluation program, potentially funded and coordinated by the Arizona Transportation Research Center.

RETROFIT FENCE UPGRADE/REPLACEMENT: We recommend three elk retrofit fence upgrade/replacement projects on two previously mitigated highways, with one being a very high priority (SR 260 Hotspot #15). The other two projects would proactively upgrade or replace the retrofit fence on stretches that are in better condition than the earliest remaining application of elk retrofit fencing along SR 260 (dating to 2004); the first SR 260 retrofit application (Christopher Creek) has already been replaced. Originally conceived as a short-term alternative to the stouter wildlife fence design, elk retrofit fence that raises existing 42" high ROW barbed-wire game fence design to eight feet with additional barbed wire has not held up well to normal fence wear and tear, the impact of elk attempts to breach the fence, and snow loading in forested parts of the state. It increasingly creates a maintenance burden to ADOT. In the case of the very high priority project on SR 260, current WVCs now exceed the before-reconstruction levels and compromises the considerable mitigation investment in wildlife underpasses; when retrofitted, escape ramps were not constructed further adding to the impact of deteriorating fence; we recommend the construction of escape ramps on all fencing-related projects where they do not exist.

## VERY-HIGH PRIORITY MITIGATION PROJECTS

As listed in Table 3-4, we identified a total of 12 very-high priority WVC mitigation projects on the nine hotspots (Table 3-6). For the most part, the difficulty of implementing these projects is relatively low in terms of time and effort, including anticipated planning and interagency coordination. On average, these projects address 59% of all WVCs on their respective hotspots. These 12 projects include the full gamut of project types and estimated costs (Table 3-4), including:

- Wildlife retrofit fencing with existing suitable bridges (2)
- Nonstructural *Wildlife Collision Prevention Zones*, seasonal speed reduction zone, or enhanced signage (6)

- Open-road radar detection systems with integrated signage (2)
- Elk retrofit fence upgrade/replacement (1)
- Structural drop-in overpass and wildlife fencing (1)

The total estimated project costs of all 12 very-high priority projects is $11,119,600 including the I-17 drop-in overpass construction project; without this project, the other 11 projects total $4,696,800. We envision that these projects provide ADOT short-term opportunity to begin to address wildlife-vehicle conflicts on each of the nine hotspots. Along with the other identified resolution projects in Table 3-4, these projects facilitate ADOT's ability to capitalize on future new highway construction funding programs (e.g., Interior Secretarial Order 3362) that could support implementation of identified projects.

*Table 3- 6. Compilation of the very-high priority projects (from Table 3-4) by hotspot, deployment difficulty, cost, and percent of hotspot WVCs that are addressed by the project.*

| Hotspot | Project | Deployment difficulty | Cost | % WVC addressed |
|---|---|---|---|---|
| **#1 – US 89** | Wildlife Collision Prevention Zone | Low | $48,000 | 85% |
| **#2 – SR 64** | Open-road radar detection system (1-year experimental evaluation) | Low | $120,000 | 28% |
| | Wildlife Collision Prevention Zone | Low | $48,000 | 11% |
| | Open-road radar detection systems (2) and wildlife fencing | Low-Moderate | $1,001,600 | 58% |
| **#4 – I-40** | Wildlife retrofit fencing | Low | $613,200 | 85% |
| **#5 – SR 77** | Wildlife Collision Prevention Zone | Low | $48,000 | 60% |
| | Enhanced motorist alert signage | Low | $10,000 | 21% |
| **#6 – SR 260** | Seasonal Speed Limit Zones | Low | $96,000 | 45% |
| **#7 – I-17** | Drop-in overpass and wildlife fencing | Moderate | $6,422,800 | 43% |
| **#10 – SR 260** | Wildlife Collision Prevention Zone | Low | $48,000 | 100% |
| **#15 – SR 260** | Retrofit fencing upgrade/ replacement | Low | $1,172,000 | 100% |
| **#21 – SR 64** | Wildlife retrofit fencing | Low-Moderate | $1,492,000 | 54% |
| **Total cost (all projects) and average % WVC addressed** | | | **$11,119,600** | **58%** |
| **Total cost (excluding #7 on I-17) and average % WVC addressed** | | | **$4,696,800** | **59%** |

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*Table 3- 7. Summary of environmental clearance considerations for the proposed mitigation projects identified for the nine priority hotspots.*

| Hotspot | Strategy Options | Strategy Type | MP Limits | Landownership | In existing ROW or easement? | Environmental Clearance Considerations | | | | CE if NEPA is required? * |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Biological Resources | Cultural Resources | Surface Waters | Hazardous Materials | |
| **#1 US 89** | Short Term (A) | Wildlife Collision Prevention Zone | 420.5 - 422.8 | Private, Coconino National Forest | No | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)23(i) |
| | Short Term (B) | Integrated Radar Detection and Signage System | 421.0 - 423.2 | Private, Coconino National Forest | No | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)23(i) |
| | Intermediate Term | Wildlife Fencing | 420.4 - 421.4 | Private, Coconino National Forest | No | No ESA concerns, potential for MBTA and bat mitigation | Known sites, recommend survey | No impacts to WOTUS | Testing Required | (c)23(i) |
| | Long Term | Drop-in Overpass | 420.8 | Coconino National Forest | Potential TCE needed | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)23(i) |
| **#2 SR 64** | Immediate Term (A) | Integrated Radar Detection and Signage System | 231.0 - 232.8 | Kaibab National Forest | Yes | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Immediate Term (B) | Wildlife Collision Prevention Zone | 236.2 - 237.0 | Kaibab National Forest | Yes | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Short Term | Integrated Radar Detection and Signage System Wildlife Fencing | 228.0 - 230.4<br>230.4-231.0 | Kaibab National Forest | Yes | No ESA concerns, potential for MBTA and bat mitigation | Known sites, recommend survey | No impacts to WOTUS | Testing Required | (c)22 |
| | Intermediate Term | Wildlife Fencing | 232.8 - 235.1 | Private, Kaibab National Forest | Yes | No concerns | Known sites, recommend survey | No impacts to WOTUS | Testing Required | (c)22 |
| | Long Term | Drop-in Overpass | 234.4 | Kaibab National Forest | Potential TCE needed | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)22 or (c)23(i) |
| **#4 I-40** | Short Term | Wildlife Fencing | 196.2 - 198.3 | Private | Yes | No ESA concerns, potential for MBTA and bat mitigation | Previously surveyed and mitigated in ROW | No impacts to WOTUS | Testing required | (c)22 |
| **#5 SR 77** | Short Term (A) | Wildlife Collision Prevention Zone | 350.5 - 353.0 | Private, Apache-Sitgreaves National Forest, Bureau of Land Management | Yes | No concerns | Known sites in vicinity, avoid or reassess to avoid | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Short Term (B) | Enhanced Motorist Alert Signage | 354.1 - 355.3 | Private, Arizona State Trust Land | Yes | No concerns | Known sites in vicinity, avoid or reassess to avoid | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Long Term | Drop-in Underpass and Wildlife Fencing | 354.4<br>354.1 - 355.3 | Private, Arizona State Trust Land | Potential TCE needed | No ESA concerns, potential for MBTA and bat mitigation | Known sites, recommend survey | Potential impacts to WOTUS | Testing Required | (c)22 or (c)23(i) |
| **#6 SR 260** | Short Term | Seasonal Dusk/Nighttime Speed Reduction Zones | 309.5 - 337.5 | Private, Apache-Sitgreaves National Forest | Yes | No ESA concerns, potential for MBTA and bat mitigation | Known sites in vicinity, avoid or reassess to avoid | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Intermediate Term | Drop-in Overpass and Wildlife Fencing | 315.7, 319.3<br>310.1 - 321.3 | Private, Apache-Sitgreaves National Forest | Potential TCE needed | No ESA concerns, potential for MBTA and bat mitigation | Known sites, recommend survey | No impacts to WOTUS | Testing Required | (c)22 or (c)23(i) |

| Hotspot | Strategy Options | Strategy Type | MP Limits | Landownership | In existing ROW or easement? | Environmental Clearance Considerations: Biological Resources | Cultural Resources | Surface Waters | Hazardous Materials | CE if NEPA is required? * |
|---|---|---|---|---|---|---|---|---|---|---|
| **#7 I-17** | Short Term (A) | Drop-in Overpass and Retrofit Fencing | 333.3<br>331.1 - 337.4 | Private, Coconino National Forest | Potential TCE needed | Consider noise effects to Mexican spotted owl, potential for MBTA and bat mitigation | Known sites, recommend survey | No impacts to WOTUS | Testing Required | (c)22 or (c)23(i) |
| | Short Term (B) | Drop-in Overpass and Retrofit Fencing | 327.4<br>322.0 - 328.8 | Private, Coconino National Forest | Potential TCE needed | Consider noise effects to Mexican spotted owl, potential for MBTA and bat mitigation | Known sites, recommend survey | No impacts to WOTUS | Testing Required | (c)22 or (c)23(i) |
| | Intermediate Term | Elk Retrofit Fencing Upgrade/Replacement | 216.8 - 222.7 | Private, Coconino National Forest | Yes | Consider noise effects to Mexican spotted owl, potential for MBTA and bat mitigation | Known sites, reassess to mitigate and/or avoid | No impacts to WOTUS | Testing Required | (c)22 |
| **#10 SR 260** | Option (A) | Wildlife Collision Prevention Zone | 253.0 -255.5 | Private, Tonto National Forest | Yes | No concerns | Known sites in vicinity, avoid or reassess to avoid | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Option (B) | Seasonal Dusk/Nighttime Speed Reduction Zones | 253.0 - 255.5 | Private, Tonto National Forest | Yes | No concerns | Known sites in vicinity, avoid or reassess to avoid | No impacts to WOTUS | Assessment recommended | (c)22 |
| | Option (C) | Enhanced Motorist Alert Signage | 252.9 - 255.6 | Private, Tonto National Forest | Yes | No concerns | Known sites in vicinity, avoid or reassess to avoid | No impacts to WOTUS | Assessment recommended | (c)22 |
| **#15 SR 260** | Short Term | Elk Retrofit Fencing Upgrade/Replacement | 263.0 - 263.2<br>264.5 - 268.4 | Tonto National Forest | Yes | Consider noise effects to Mexican spotted owl, potential for MBTA and bat mitigation | Known sites, reassess to mitigate and/or avoid | No impacts to WOTUS | Testing Required | (c)22 |
| | Long Term | Elk Retrofit Fencing Upgrade/Replacement | 260.2 - 262.6 | Tonto National Forest | Yes | Consider noise effects to Mexican spotted owl, potential for MBTA and bat mitigation | Known sites, reassess to mitigate and/or avoid | No impacts to WOTUS | Testing Required | (c)22 |
| **#21 SR 64** | Short Term | Wildlife Fencing | 186.3 - 190.1 | Private, Arizona State Trust Land, Kaibab National Forest | Yes | No ESA concerns, potential for MBTA and bat mitigation | Known sites, reassess to mitigate and/or avoid | No impacts to WOTUS | Testing Required | (c)22 or (c)23(i) |
| | Long Term | Drop-in Overpass | 189.2 | Kaibab National Forest | Potential TCE needed | No concerns | Known sites, recommend survey | No impacts to WOTUS | Assessment recommended | (c)23(i) |

Definitions:
CE = Categorical Exclusion ESA = Endangered Species Act; MBTA = Migratory Bird Treaty Act; MP = Milepost; NEPA = National Environmental Policy Act; ROW = Right-of-Way; TCE = Temporary Construction Easement; WOTUS = Waters of the United States

*Reference 23 CFR 771.117 C-list exemption parameters.

## HOTSPOT #1: US HIGHWAY 89 - NORTH OF FLAGSTAFF (MP 420.0-424.0)

The state's top-ranked hotspot is a 4-mile semi-urban stretch of US Highway 89 that begins on the east side of Flagstaff and extends through the largely residential Doney Park area. This 4-lane improved (with center turn lane; Figure 3-5) stretch of highway is travelled by residents and commuters, tourists, and commercial traffic. The current AADT is the third highest among all hotspots. The stretch crosses though a mix of forest green belts, low-density residential neighborhoods, and scattered businesses. The hotspot's high traffic volume coupled with the prevalence of human development presents challenges to the resolution of wildlife-vehicle conflicts, especially those involving structural measures including extensive wildlife fencing.

*Figure 3- 5. Typical stretch of US 89 where it passes through a residential area near Doney Park.*

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 79

**WVCs/mile/year:** 3.95

**WVC percentage of all crashes:** 41.4%

**2018 WVC species composition** (15 WVC)**:** Mule deer – 87% Elk – 13%

**AADT:** 31,119 vehicles/day

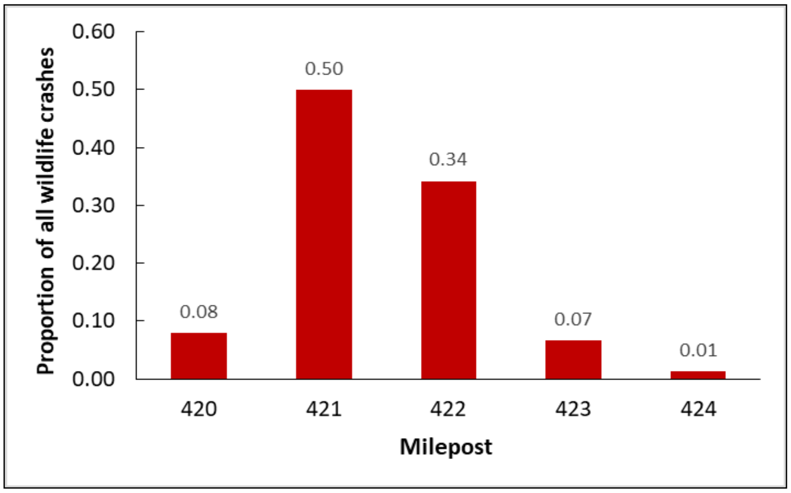


*Figure 3- 6. Proportion of all US 89 WVCs by milepost within Hotspot #1 (2014-2018).*

The high proportion of US 89 WVC-related crashes, 41.4% of all crashes is remarkable with its high traffic volume and prevalence of driveways, side roads, and intersections. The proportion of all WVCs which occurred by MP ranged from 0.01-0.50 (Figure 3-6); two mileposts alone (MP 421-422) accounted for 84% of all WVCs (Figure 3-6 and Figure 3-7); six locations along the hotspot had six or more WVCs during the five-year period (Figure 3-7).

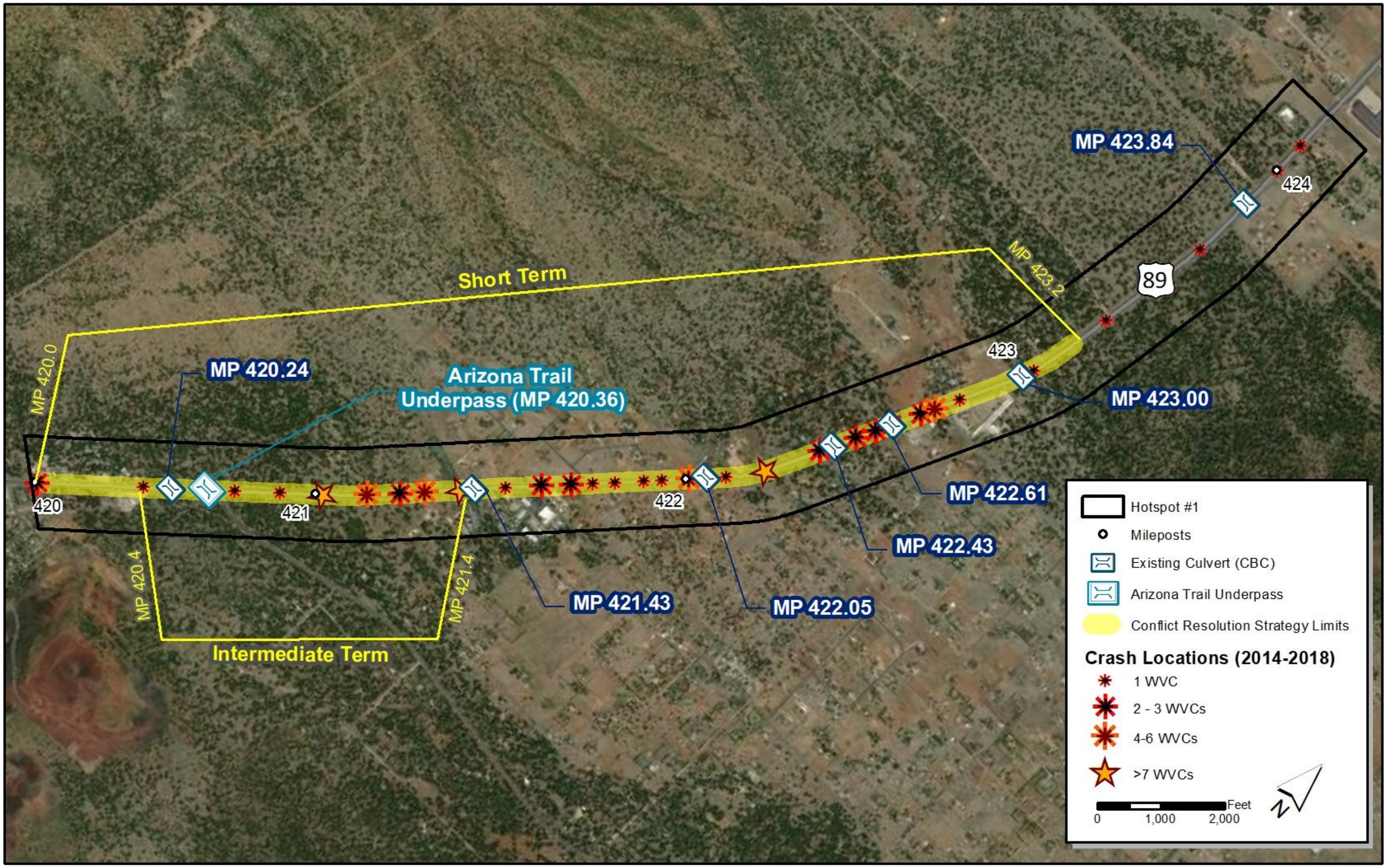


*Figure 3- 7. The US Highway 89 Hotspot #1 located north of Flagstaff, showing WVC locations occurring between 2014-2018, existing drainage structures (see Table 3-8 for dimensions), as well as the location of the Arizona Trail underpass.*

A major driver of the WVC conflict on US 89 stems from the 1977 Mount Elden (Radio) Fire which burned 4,600 acres on the eastern slopes and foothills of the mountain extending across the highway where the WVC peak occurs (MP 421-422). The burn enhanced habitat conditions for mule deer, and the population has since grown dramatically (J. Gagnon, AGFD; personal communication) accounting for the high proportion of US 89 collisions involving deer. Further, deer appear to have adapted well to the area's semi-urban setting.

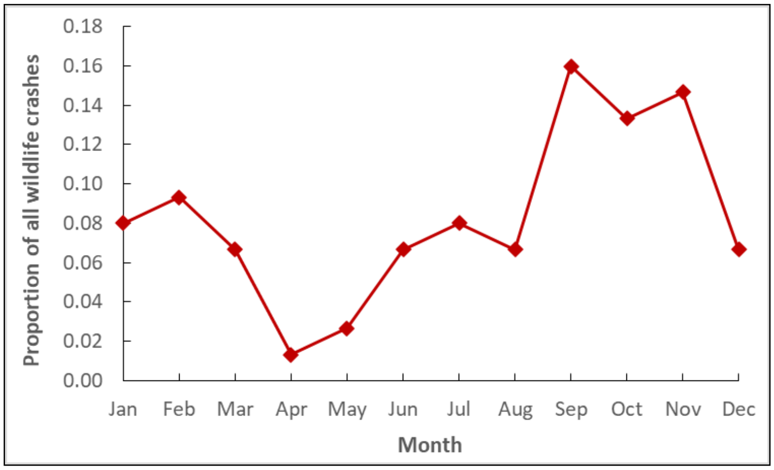


*Figure 3- 8. Monthly proportion of all WVCs that occurred along US 89 Hotspot #1 (2014-2018).*

US 89 WVC incidence exhibited a seasonal peak in the fall months (Sep-Nov) which accounted for 44% of crashes (Figure 3-8). Conversely, the spring months (Mar-May) accounted for just 11%. The winter months (Dec-Feb) accounted for 24% of WVCs and the summer months of June-August just 21% though this period was likely the peak tourist traffic period.

### CONFLICT RESOLUTION STRATEGY

US Highway 89's high incidence of WVCs have been of concern for several years among residents, Coconino County officials, and AGFD; due to the unique challenges of high traffic volume and human development, resolution to date has been elusive (J. Gagnon, AGFD; personal communication).

#### EXISTING DRAINAGE STRUCTURES

To consider their potential for retrofitting options, we assessed existing drainage structures; there are six concrete box culverts (CBC) spread across the hotspot. Reflective of the width of the roadway (length of the culverts) and their relatively small dimensions, all openness indices are very low (all ≤0.10: Table 3-8). Thus, employing these structures in a retrofitting strategy as wildlife passage structures is not a feasible option due to their unsuitability.

*Table 3- 8. Existing drainage (and trail access) structures located along US 89 Hotspot #1.*

| MP | Structure | No. barrels | Width (ft) | Height (ft) | Openness index* |
|---|---|---|---|---|---|
| 421.43 | CBC | 2 | 6 | 4 | 0.06 |
| 422.08 | CBC | 2 | 6 | 3 | 0.05 |
| 422.43 | CBC | 1 | 6 | 6 | 0.10 |
| 422.61 | CBC | 1 | 10 | 3 | 0.08 |
| 423.00 | CBC | 2 | 6 | 4 | 0.06 |
| 423.85 | CBC | 2 | 6 | 3 | 0.05 |

*Width × Height / Length (metric units; Length assumed to be 112')

While existing drainage structures may not be suitable as passage structues, the pedestrian underpass for the Arizona Trail located just south of the Townsend-Winona Road intersection(MP 420.4) appears somewhat more suitable for retrofitting. This structure is a 16 foot wide × 8 foot high metal plate arch, which is 112 feet long (Figure 3-9). While considerably larger than all drainage structures, this arch's openness index is only 0.35, still marginal for deer passage (Gordon and Anderson 2003).

*Figure 3- 9. Arizona Trail pedestrian arch underpass under US 89 near the junction with the Townsend-Winona Road (MP 420.7).*

## FIELD REVIEW

We conducted a field review of the hotspot on 19-March-2021 with participation by ADOT and Coconino NF TAC representatives. This review focused on evaluating a range of potential actions that might be feasible for this section. In earlier discussions, the AGFD TAC representative believed that fencing the western, largely forested portion of the hotspot (≈MP 420.4 to 421.4) may be warranted on the short term to prevent WVCs (without impacting the deer population), even without accomodation of passage across US 89 (J. Gagnon, personal communication). In particular, such an approach would be warranted if longer-term resolution focusing on conserving connectivity within the Turkey Hills-Picture Canyon-Elden Pueblo Linkage (Figure 3-10) were pursued, including the potential construction of a drop-in wildlife overpass.

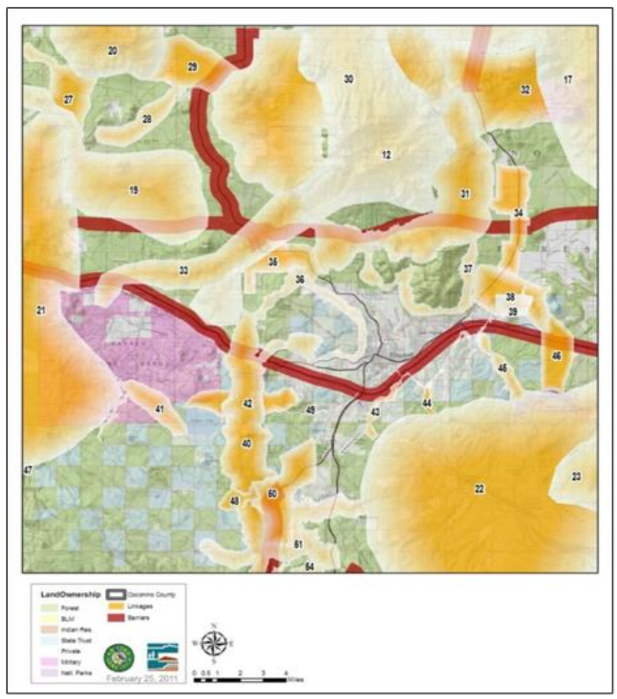

*Figure 3- 10. Location of the Turkey Hills-Picture Canyon-Elden Pueblo Wildlife Linkage (red circle) that crosses US 89 along Hotspot #1, identified as part of the Coconino County Wildlife Connectivity Assessment (Source: AGFD 2011).*

We concluded that short-term fencing would only be feasible if it were erected along Townsend-Winona Road approximately 0.4-mile (with a cattle guard or flashing signs at the terminus) as an alternative to a very large cattle guard at the junction with US 89. Such fencing would require the cooperation of Coconino County, which has long been concerned by the high incidence of WVCs along the hotspot. However, even if fenced, this section would address only about a quarter of all hotspot WVCs; fencing elsewhere on the hotspot is not feasible due to the prevalence of private driveways and parking lots.

We noted that street lighting was recently installed along US 89 by the City of Flagstaff up to the

Townsend-Winona Road junction, corresponding to the low-WVC incidence at MP 420 (Figure 3-6) suggesting that this might be a means to reduce WVCs (deterring deer approaches/improving motorist visibility). However, upon review of the long-term ACIS database, this does not appear to be the case as WVC incidence did not change with lighting installation.

The posted speed limit throughout much of the hotspot is 55 mph, with a reduction to 45 mph only near the approaches to Silver Saddle Road (≈MP 422.7). High motorist speeds, especially during nighttime hours are likely a contributor to WVCs and efforts to reduce motorist speeds in concert with increasing awareness of WVC potential could mitigate WVCs.

## RECOMMENDED CONFLICT RESOLUTION STRATEGY

Given the challenges of high traffic volume and its semi-urban setting, resolution options appear limited. There are no easily implementable mitigation actions that alone could address WVCs along the US 89 hotspot, and some that we suggest have heretofore not been implemented in Arizona. Our strategy includes two short-term options, an intermediate fencing option, and a long-term option.

### *SHORT-TERM STRATEGY OPTIONS*

We have included two short-term nonstructural options for ADOT consideration along the US 89 Hotspot #1; both options revolve around modifying motorist behavior. Each option can be pursued separately or with the other short-term and/or intermediate-term fencing options (Table 3-9).

*WILDLIFE COLLISION PREVENTION ZONE: SIGNAGE, TRAFFIC CALMING MEASURES, AND SPEED REDUCTION:* We recommend that ADOT consider options to alter motorist behavior within the limited 2.5-mile stretch that encompasses 85% of US 89 WVCs, the worst single stretch in the state. This nonstructural approach would be the most cost effective and readily implementable. This option includes considering a combination of measures to create an experimental Wildlife Collision Prevention Zone in the urbanized stretch where WVCs account for over 40% of all accidents. We recognize that these measures may not be particularly popular with residents, but a joint local public awareness campaign by Coconino County and ADOT could mitigate this. The components of this option include:

- Erect innovative motorist alert signage like that used in other states and Canada to highlight WVC hotspots (Figure 3-11 and Figure 3-12); install gateway signs at the entry points to the high-incidence WVC zone between MP 420.5 and MP 422.8. The signage should be as large as possible and preferably be LED-enhanced for nighttime impact.
- Cut transverse mumble strips into the pavement at the approaches to the *Wildlife Collision Prevention Zone* in conjunction with the signage to maximize impact in raising motorist WVC risk awareness/alertness, and thus wildlife avoidance response (Figure 3-12). Ideally, additional rumble strips (1-2) should be installed at intermediate points along the zone to maintain driver awareness though the zone.


*Figure 3- 11. Conceptual layout for motorist alert signs at the approaches to a designated Wildlife Collision Prevention Zone; the signs should be LED-enhanced for maximum nighttime impact.*

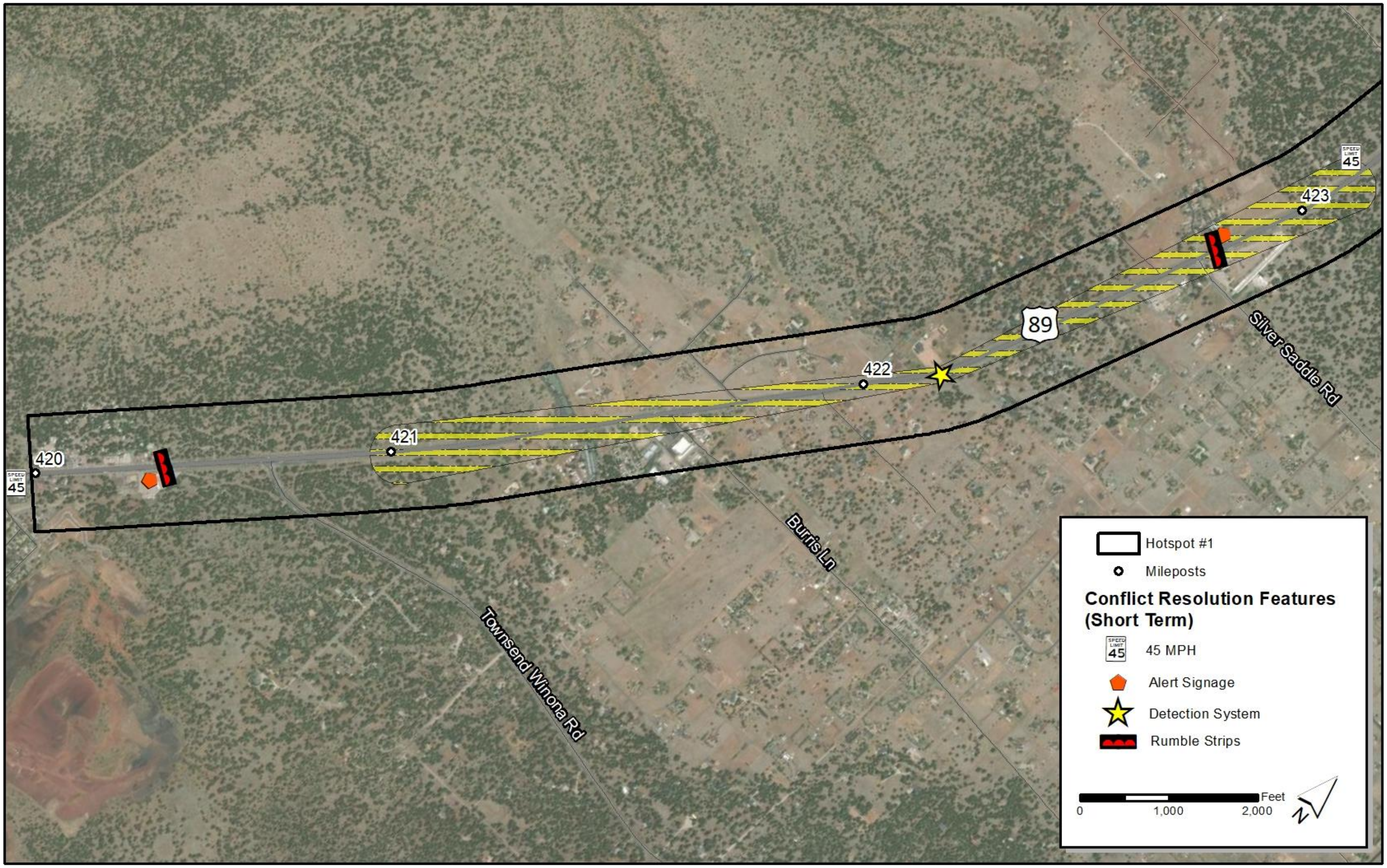


*Figure 3- 12. US 89 Hotspot #1 wildlife-vehicle conflict short-term resolution options including a Wildlife Collision Avoidance Zone option with special signage, rumble/mumble strips and reduced posted speed, a wildlife fencing option, and an open-road radar animal detection system which can cover over two miles of the highway.*

- Reduce the posted speed limit throughout the zone from 55 to 45 mph. This will increase response time and distance to allow motorists to avoid WVCs or reduce the damage from WVCs.
- Narrow the travel lanes through the zone with paint restriping to create the perception on the part of motorists that the road is narrower thus promoting lower speeds.

*EXPERIMENTAL OPEN-ROAD ANIMAL DETECTION SYSTEM AND ALERT SIGNAGE OPTION:* Despite the high traffic volume and semi-urban setting, open-road animal detection systems integrated with triggered motorist alert signage may be appropriate for experimental application along the peak portion of the US 89 hotspot. Open-road radar animal detection systems integrated with triggered motorist alert signage have proven successful in preventing WVCs (e.g., British Columbia, Canada).

These systems employ 360-degree rotational Frequency Modulated Continuous Wave radar detection unit(s) integrated with two types of alert signage: 1) static gateway signs as motorists approach the WVC avoidance zone, and 2) hybrid static/dynamic (Blank-Out) "slow down" message signs (Figure 3-13) at intermediate locations along the zone that are triggered when animals are detected (Figure 3-13 and Figure 3-14). The number and spacing of intermediate signs are tied to posted speed and detection zone length; radar detection can be effective up to three miles on roadway stretches with direct line-of-sight.

Crosstek Wildlife Solutions LLC (currently responsible for the SR 260 crosswalk with its animal detection system) is the proprietary vendor of open-road radar animal detection systems (ORAD™) in the US. Their ORAD™ systems have successfully integrated Intelligent Transportation System (ITS) components with high-performance security technologies for application in highway-wildlife conflict resolution (Figure 3-13). For each mile of ORAD™ application on US 89, four static/dynamic message signs are recommended.

- As ORAD™ can effectively scan three miles of line-of-sight highway, we recommend that a single radar-based animal detection system be installed along US 89 in the vicinity of MP 422.2 to detect animals one mile in each direction along the stretch that accounts for nearly 75% of the hotspot's WVC (Figure 3-12).
- This detection system should be integrated with eight static/dynamic Blank-Out message signs spaced along the stretch to alert motorists to the presence of animals.

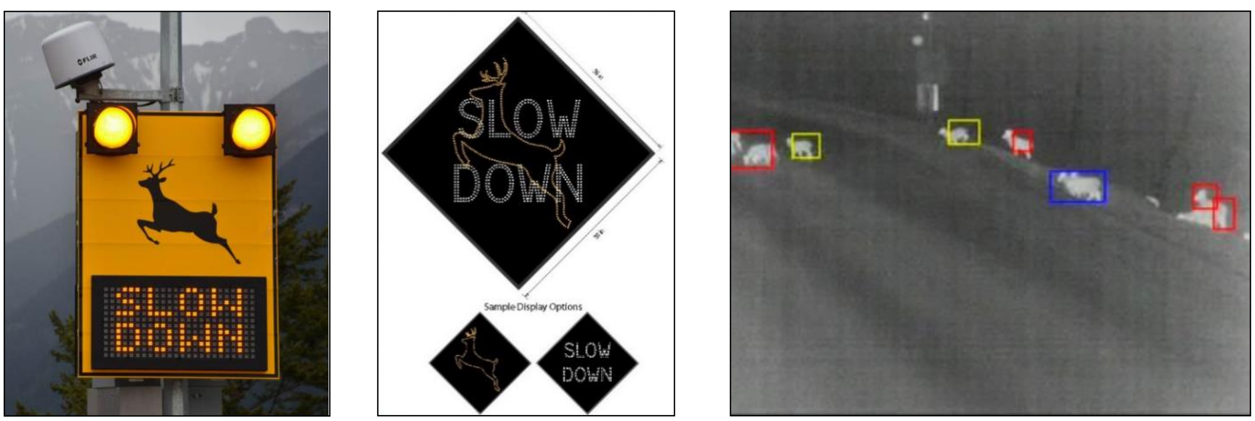


*Figure 3- 13. Pole-mounted variable message sign and radar unit for open-road radar detection system (left), static/dynamic Blank-Out message sign display options (center), and ITS-integrated detection of animals approaching and crossing a highway (right; photos courtesy Crosstek Wildlife Solutions).*

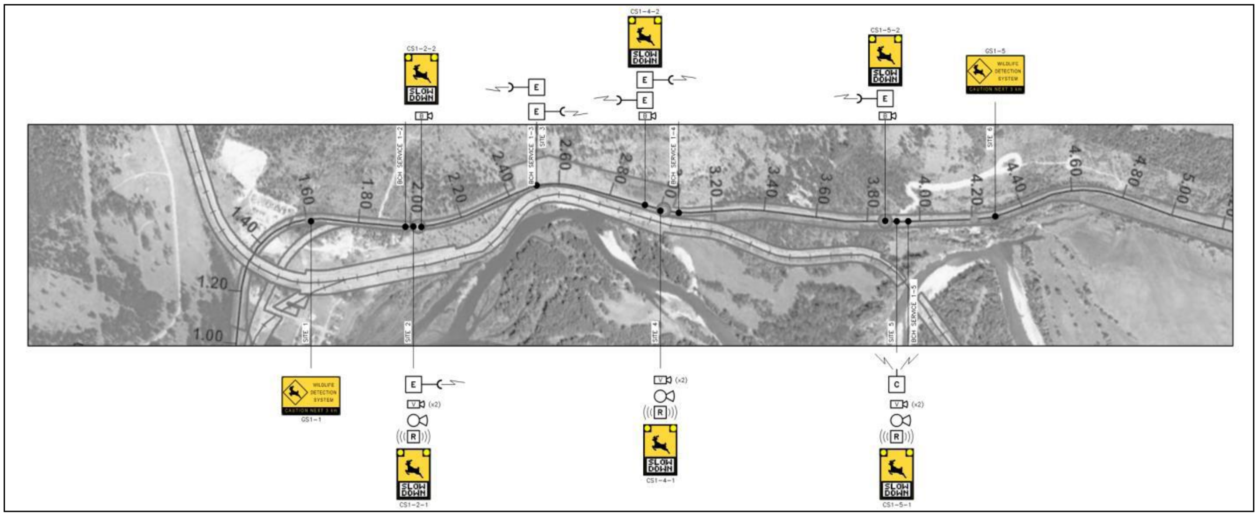

*Figure 3- 14. Schematic of the layout of a radar-based animal detection system and motorist alert gateway and triggered intermediate static/dynamic signage along a British Columbia highway (Source: PBX Engineering, Vancouver, BC).*

If pursued, this experimental application of an open-road radar animal detection system will be one of the state's first. As such, we urge ADOT to support a minimum one-year formal monitoring/research study to evaluate the efficacy and reliability of the technology as well as a comparison of before- and after-mitigation WVC incidence. With its high traffic levels and semiurban setting with numerous driveways, this highway represents a "worst case" scenario for an ORAD™ application; yet, if it is effective here, it likely would be effective on all other highways with suitable direct line-of-sight stretches. With its seasonal peak, an experimental mobile application could be evaluated on US 89 for six months and another highway where the technology is applicable for another six months. Thus, we recommend that ADOT consider the lease of an ORAD™ radar system and signage for up to 12 months (see below).

Crosstek Wildlife Solutions LLC offers multiple purchase options for their ORAD™ animal detection and integrated signage system:

1) Purchase of a permanent ORAD™ integrated system including planning, design, electrical infrastructure installation (Phase 1), and radar and signage installation (Phase 2). The estimated ORAD™ system cost with six Blank-Out message signs is $595,000 - $655,000.
2) Purchase of a Mobile Autonomous Radar Unit (estimated cost $250,000) and six mobile Blank-Out message signs ($25,000 each) is estimated to cost $400,000.
3) Lease of a Mobile Autonomous Radar Unit and six Blank-Out message signs for 6-12 months, estimated at $10,000/month including setup and operation by the vendor. This approach would allow ADOT to formally evaluate ORAD™ for one year; Crosstek has indicated that a half ($60,000) of the lease payments would apply toward subsequent system purchase.

*INTERMEDIATE-TERM WILDLIFE FENCING OPTION*

Wildlife fencing could be erected along US 89 within the largely forested eastern stretch with relatively few driveways. At best, this fencing would address the portion of the hotspot where 25% of all WVCs occurred. This option entails:

- Erecting 1.8 miles of wildlife fencing beginning near commercial business in the vicinity of MP 420.4 and extending east to commercial business in the vicinity of 421.4, and along both sides of Townsend-Winona Road 0.4-mile (Figure 3-15). While marginal for wildlife passage, fencing would be integrated with the Arizona Trail underpass side walls to promote potential deer crossings (Figure 3-15).
- Fencing necessitates the installation of five sets of double-wide cattle guards at driveways (10 grates; Figure 3-15).
- To allow for animals to escape the fenced corridor, four pair of evenly spaced (0.5-mile) escape ramps (8 total) need to be installed (Figure 3-15).

To alert motorists to the potential for animals crossing at the three fence termination points (end-runs), motorist alert signage (preferably flashing or LED-enhanced should be erected (Figure 3-15).

*LONG-TERM OPTION (DROP-IN PASSAGE STRUCTURE)*

If a coordinated campaign is mounted to conserve/secure the long-term integrity of the Turkey Hills-Picture Canyon-Elden Pueblo Wildlife Linkage (Figure 3-10) in respone to the threat posed by rural development south of US 89 (AGFD 2011), promoting wildlife (mule deer, elk, meso-carnivores) passage across US 89 would be warranted. A drop-in overpass in the vicinity of MP 420.8 (east of the Townsend-Winona Road junction) would promote permeability and present a more viable approach to fencing the highway corridor than currently exisits without a suitable passage structure, though still only for a limited distance (Figure 3-15). An overpass at this site is estimated to cost $2.5 million.

**ENVIRONMENTAL OVERVIEW**

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Pending the outcome of technical studies and approvals, the anticipated impacts of this undertaking are expected to be beneath the threshold of significant. The City of Flagstaff owns US 89 from the beginning of this hotspot at MP 420.0 to approximately MP 421.95, and at least a portion of each proposed project would occur outside existing ADOT ROW. Early coordination with the City of Flagstaff, local business, and private landowners should be anticipated for all proposed projects in Hotspot #1, but especially for the proposed Intermediate-Term project that would require wildlife fencing to extend approximately 0.4-mile along Townsend-Winona Road. If NEPA is required, the proposed projects are anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) under C-list (c)23(i): “Federally funded project that received less than $5,000,000…”. Similarly, if the projects are federally funded, then a Section 4(f) analysis will be required due to the projects proximity to the Arizona Trail, Camp Townsend and Elden Pueblo.

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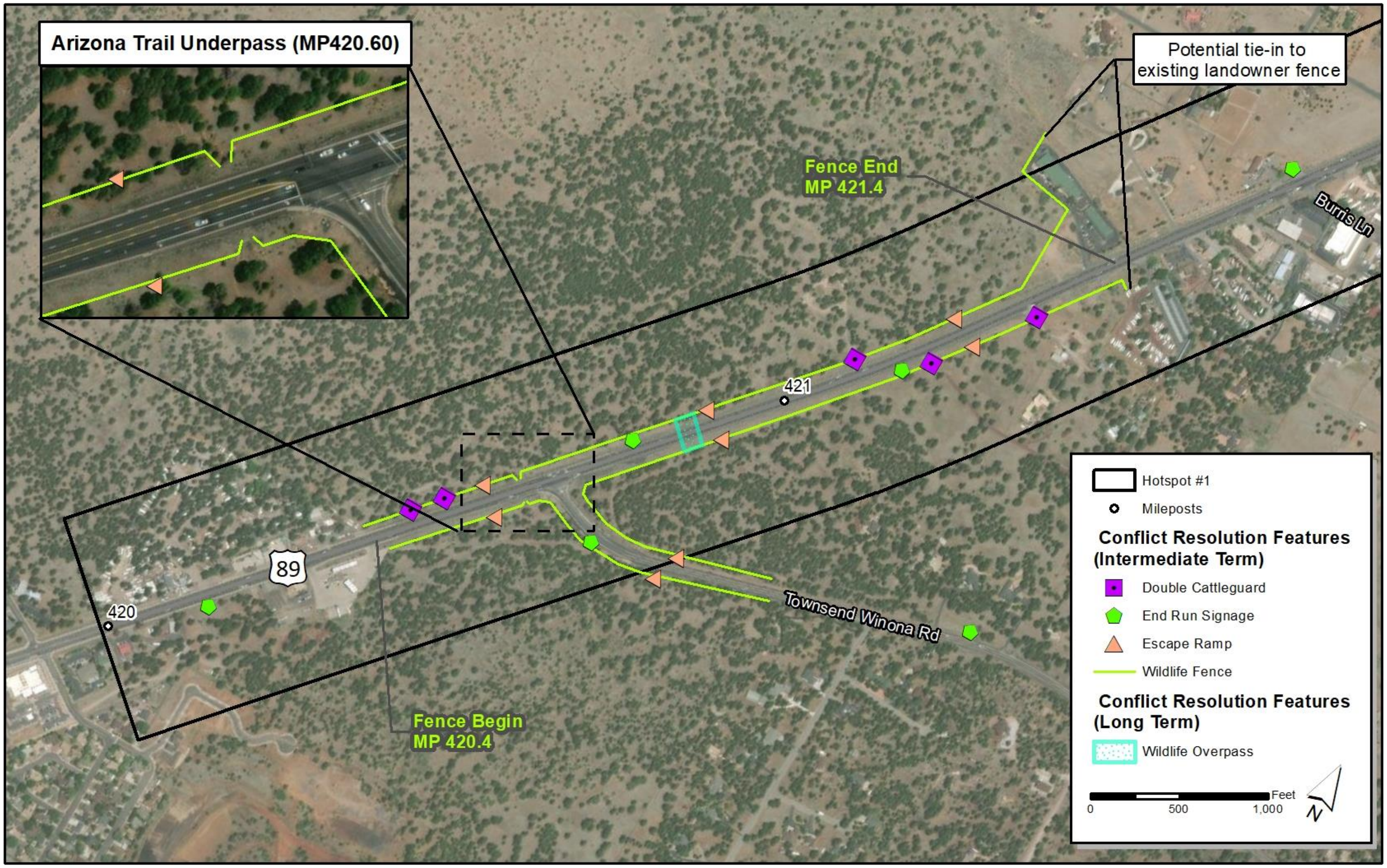


*Figure 3- 15. US 89 Hotspot #1 wildlife-vehicle conflict intermediate-term option involving wildlife fencing and associated measures, and a long-term option for installation of a wildlife overpass integrated with wildlife fencing.*

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*Table 3- 9. US 89 Hotspot #1 resolution option components and estimated costs to address wildlife-vehicle conflicts.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Short-Term Option (Wildlife Collision Prevention Zone)** | | | | |
| Motorist alert signage | Each | 2 | $10,000 | $20,000 |
| Speed limit signs | Each | 4 | $2,000 | $8,000 |
| Transverse rumble strips | Each | 2 | $10,000 | $20,000 |
| **Total** | | | | **$48,000** |
| **Short-Term Option (Integrated radar detection and signage system)** | | | | |
| Mobile ORAD™ radar unit and 8 Blank-Out signs (12-month lease) | Months | 12 | $10,000 | $120,000 ($60,000 applied to purchase) |
| Mobile ORAD™ radar unit and 8 Blank-Out signs (purchase) | Each | 1 | $450,000 | $450,000 |
| **Intermediate-Term Option (Wildlife fencing)** | | | | |
| Wildlife fence | Miles | 1.8 | $158,000 | $284,400 |
| Escape ramps | Each | 8 | $11,000 | $88,000 |
| Cattle guards | Each | 10 | $30,000 | $300,000 |
| Alert signage | Each | 4 | $4,000 | $16,000 |
| **Total** | | | | **$688,400** |
| **Long-term Option (Drop-in overpass)** | | | | |
| Drop-in overpass | Each | 1 | $2,500,000 | $2,500,000 |

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of all the proposed projects, and surveys are recommended to reassess the current location of cultural sites and determine their NRHP eligibility. A hazardous materials assessment should be performed for all proposed projects to address any potential hazardous material concerns. Additionally, hazardous materials testing will be required for the Intermediate Term project because the proposed fencing will tie into existing structures. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. None of the proposed projects are located within currently designated or proposed critical habitat for any species. For the Intermediate Term project, wildlife fencing will tie into the existing Arizona Trail underpass which may provide habitat to roosting bats or nesting birds federally protected by the MBTA. Further investigation of this structure will be necessary during the environmental clearance of the Intermediate Term project, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required for any of the projects.

## REFERENCES

Arizona Game and Fish Department. 2011. The Coconino County wildlife connectivity assessment: report on stakeholder input. Habitat Branch, Phoenix, Arizona, USA.

Gordon, K. M., and S. H. Anderson. 2003. Mule deer use of underpasses in western and southeastern Wyoming. *In* 2003 Proceedings of the International Conference on Ecology and Transportation, Center for Transportation and the Environment, North Carolina State University, Raleigh.

## HOTSPOT #2: STATE ROUTE 64 (MP 227.0-237.4)

Hotspot #2 is the 10.4-mile northernmost extent of SR 64 where it terminates at the village of Tusayan and the South Rim entrance to the Grand Canyon National Park. This narrow, largely 2-lane stretch of highway is travelled predominately by tourists (Figure 3-16). The highway passes through Ponderosa pine-dominated forest interspersed with small openings in draws and flats vegetated by sagebrush and other shrubs.

*Figure 3- 16. Typical daytime tourist traffic along the SR 64 Hotspot #2 south of Tusayan.*

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 141

**WVCs/mile/year:** 2.71

**WVC percentage of all crashes:** 64.1%

**2018 WVC species composition** (29 WVC)**:** Elk – 62% Mule deer – 38%

**AADT:** 8,119 vehicles/day

The proportion of all WVC which occurred by MP within the hotspot varied from 0.04-0.18 (Figure 3-17). Milepost 232 accounted for the highest proportion, 18% of all WVC (Figures 3-17; also see Figure 3-20).

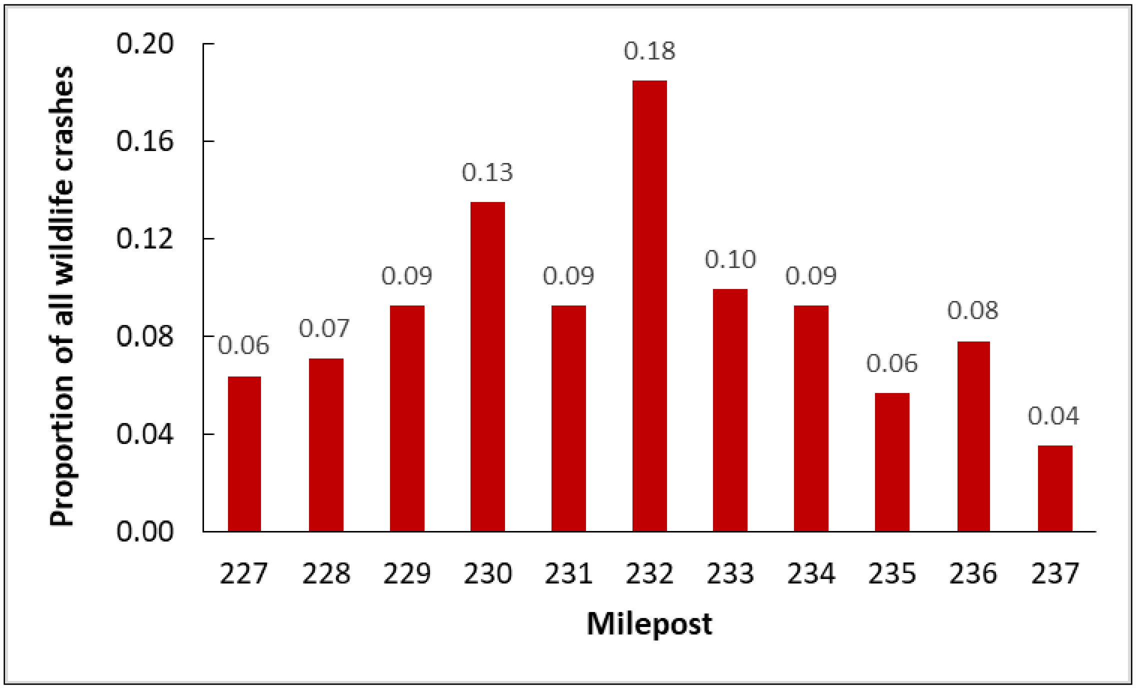


*Figure 3- 17. Proportion of all SR 64 Hotspot #2 WVCs by milepost (2014-2018).*

SR 64 Hotspot #2 WVC incidence varied by month, with April having the highest proportion (0.18) of WVCs of all months (Figure 3-18); this likely corresponds to the time when mule deer wintering in the area begin returning to summer range. The lowest incidence of WVCs occurred during the winter months of December and January, which combined accounted for just 8% of all WVCs; this is also the time when traffic levels are at their lowest (Dodd et al. 2012).

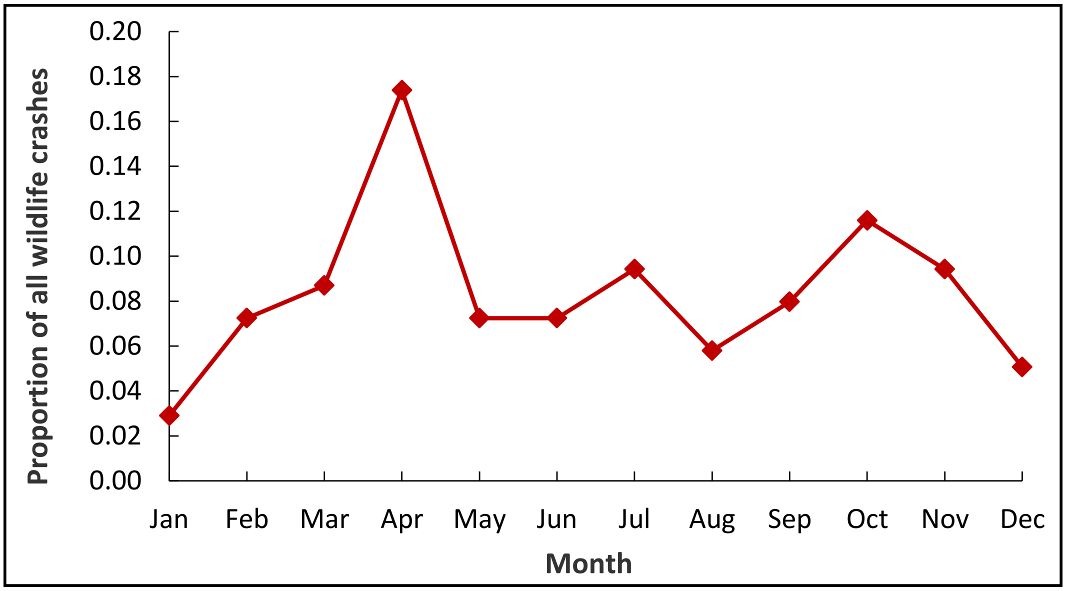


*Figure 3- 18. Monthly proportion of all WVCs that occurred along SR 64 Hotspot #2 (2014-2018).*

While the hotspot's AADT is 8,119 vehicles/day, Dodd et al. (2012) reported that peak June-August traffic was three times that of winter (Dec-Feb). The hotspot's daily traffic pattern is unique as peak daytime traffic levels decline rapidly after dark and even approach zero in the early morning hours; this reflects the highway's tourist-dominated traffic (Figure 3-19). While 50% of WVC occurred between 17:00 and 22:00 hours, another 39% occurred between 23:00 and 4:00 when traffic was at its lowest and animals frequented the roadside to forage (Dodd et al. 2012). Thus, even with very low traffic levels, the risk of collisions with mule deer and elk was very high. This traffic pattern has ramifications on potential strategies to resolve the hotspot's wildlife-vehicle conflicts.

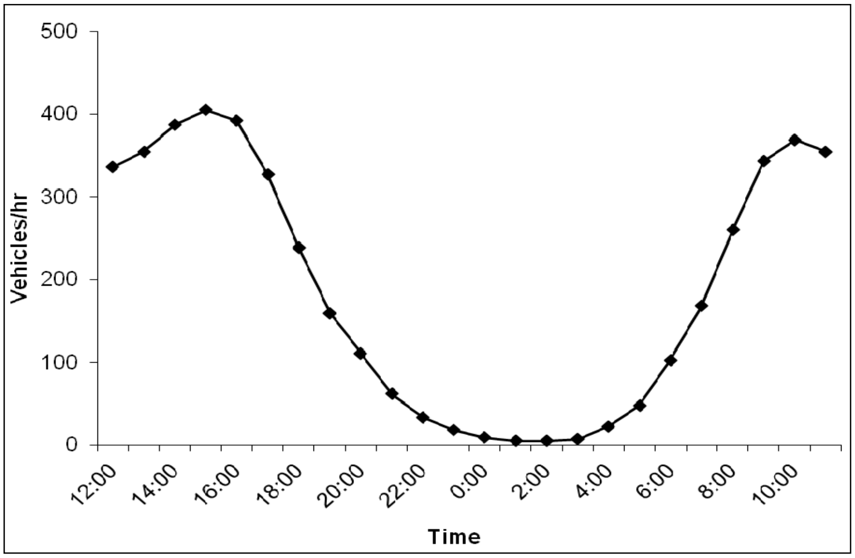


***Figure 3- 19. Hourly traffic levels (vehicles/hour) recorded along the SR 64 Hotspot #2 (From: Dodd et al. 2012).***

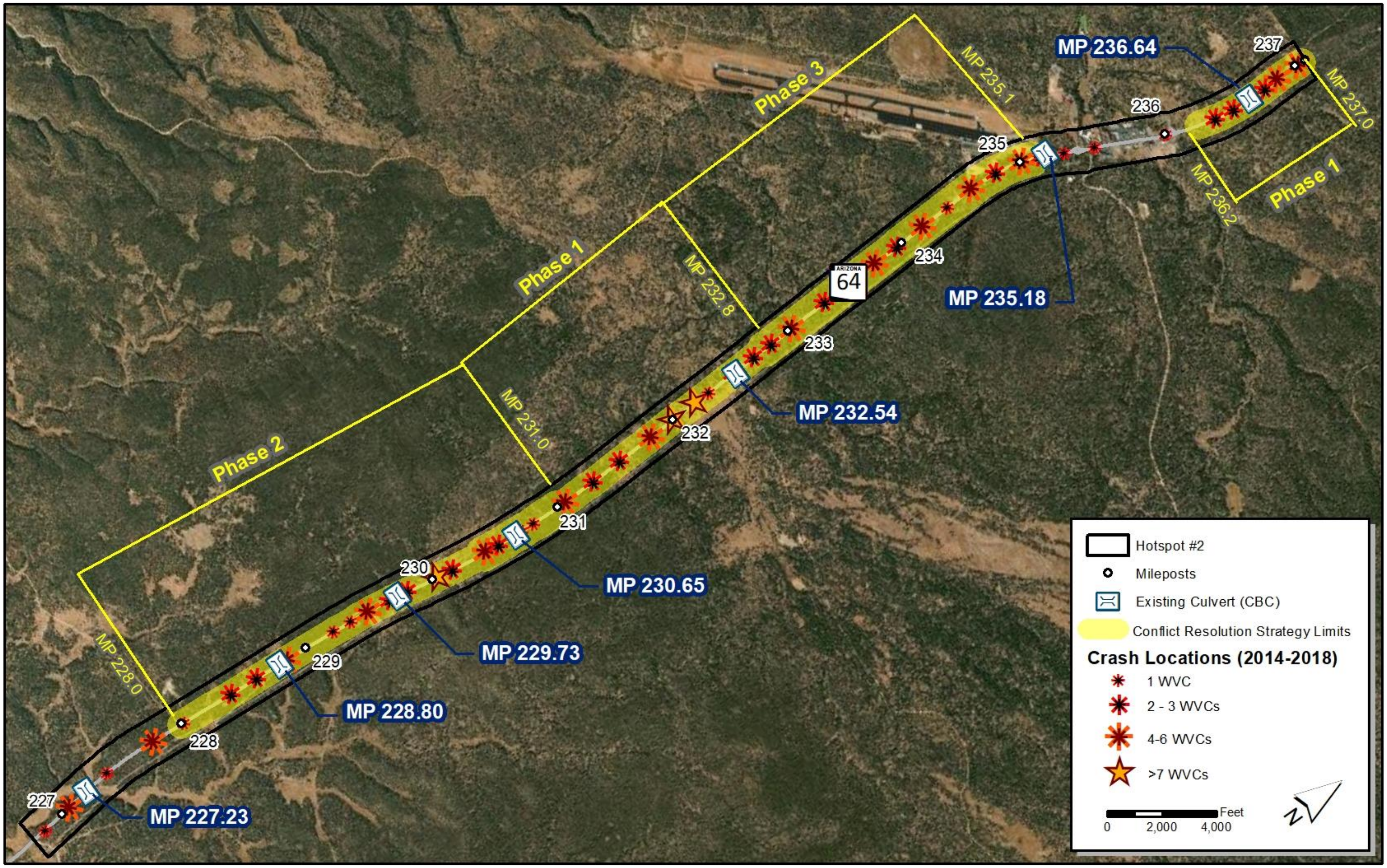


*Figure 3- 20. WVC locations that occurred along the SR 64 Hotspot #2 between 2014-2018, existing drainage structures, and conflict resolution strategy limits and phases.*

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## MULE DEER MIGRATION CORRIDOR

While mule deer along SR 64 are resident, a good portion of the mule deer population along Hotspot #2 was discovered to be migratory. These deer summer near the San Francisco Peaks and migrate over 50 miles to winter south of the Grand Canyon along SR 64. First documented by deer instrumented with GPS telemetry collars in 2008 (Dodd et al. 2012), further collaring by AGFD in 2019 confirmed the same migration pattern. Under the 2018 U. S. Department of Interior Secretarial Order 3362, an interagency Corridor Mapping Team used AGFD telemetry data to quantify the mule deer migration corridor between San Francisco Peaks summer range and winter range along Hotspot #2, as well as stopover concentration areas adjacent to the highway (Figure 3-21; Kauffman et al. 2020). These deer corridors overlap much of Hotspot #2 (Figure 3-21).

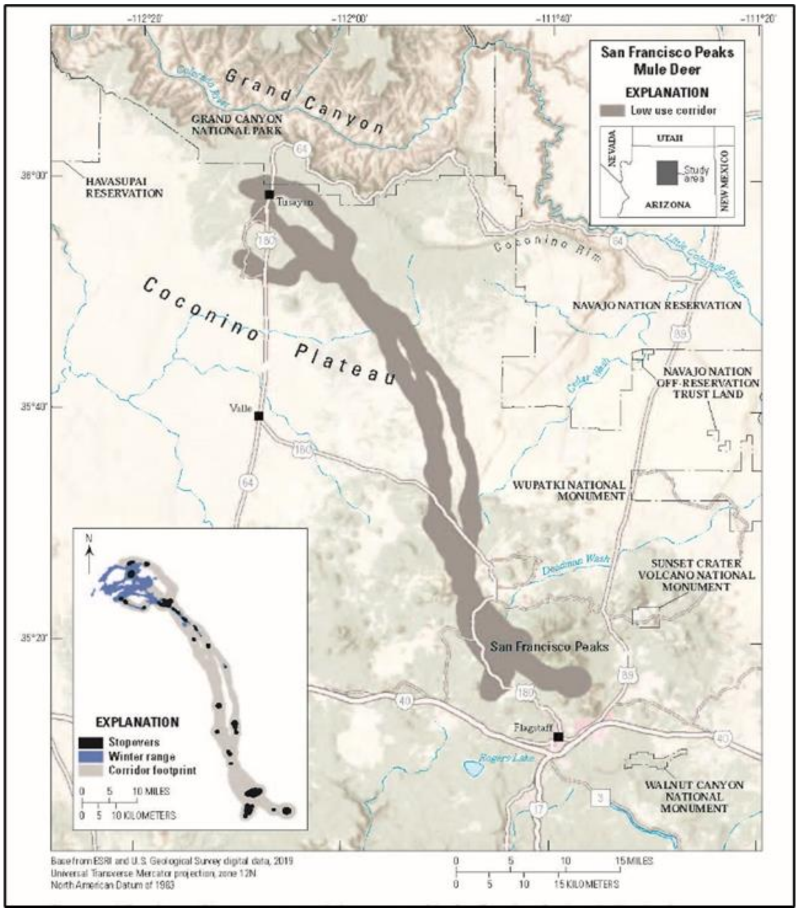


*Figure 3- 21. Mapped San Francisco Peaks mule deer migration corridor determined from AGFD GPS-telemetry studies along SR 64 (Kauffman et al. 2020). The red box corresponds to Hotspot #2.*

### CONFLICT RESOLUTION STRATEGY

A Wildlife Accident Reduction Study (ADOT Project No. 064 CN 185 H5386 01C) for SR 64 was commissioned by ADOT to pursue development of a proactive assessment of WVCs and potential mitigation measures to reduce WVCs along 50 miles (185.5–235.4). This study recommended four underpasses and an overpass along the stretch that corresponds to Hotspot #2 be integrated into future highway reconstruction (ADOT 2006). This study recognized the need to conduct further field evaluation and monitoring to determine the best locations for wildlife passage structures and fencing needed to funnel animals to structures. As such, AGFD was commissioned to do a follow-up assessment of WVC patterns and conduct a GPS telemetry-based elk, mule deer, and pronghorn movements assessment.

AGFD's recommendation for passage structures for the hotspot concurred with the original ADOT study, though AGFD recommend a fifth underpass (Figure 3-22; Dodd et al. 2012). Unfortunately, the highway grade at these five sites, all with existing CBC, will change considerably with future highway reconstruction; as such, installation of strategic drop-in underpasses to address short-term conflicts is not an option. However, the recommended overpass at MP 234.4 (Figure 3-22) could be implemented as a drop-in, stand-alone structure.

The portion of the hotspot south of Tusayan (MP 227-235) that is the focus of our resolution strategy accounts for the largest portion of WVCs (84%), and averages 2.9 WVCs/mile/year. By comparison, the short 0.7-mile section at the northern end of Tusayan south of the Grand Canyon NP boundary (MP 236.4-237.1) averages 59% higher incidence of WVCs; 4.6 WVCs/mile/year (Figure 3-22).

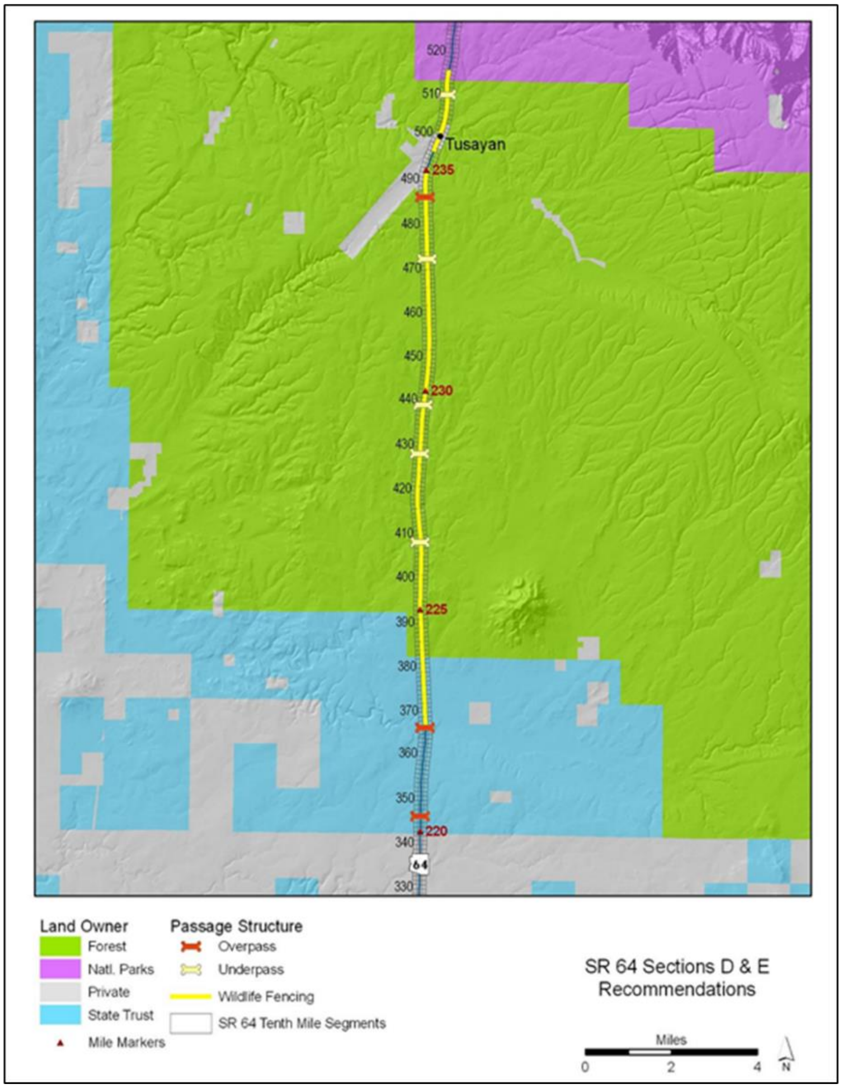


*Figure 3- 22. Wildlife passage structures (yellow underpass/red overpass) and extent of wildlife fencing recommended in the AGFD wildlife movements study and design concept report (Dodd et al. 2012) corresponding to SR 64 Hotspot #2.*

## EXISTING DRAINAGE STRUCTURES

To evaluate drainage structures along SR 64 that could be employed as part of a retrofitting strategy to resolve wildlife-vehicle conflicts, we assessed the location and dimensions of seven structures (all CBC) for potential suitability as wildlife passage structures (Table 3-10, Figure 3-20). All seven CBC had the same dimensions and thus openness index, 0.32, which is considered marginal for elk and mule deer (Figure 3-23); Gordon and Anderson (2003) recommended a minimum index of 0.8 for mule deer. Thus, there is limited opportunity to retrofit existing CBC as the cornerstone of a short-term resolution strategy for SR 64.

*Table 3- 10. Existing drainage structures located along the SR 64 Hotspot #2.*

| MP | Structure | No. barrels | Width (ft) | Height (ft) | Openness index* |
|---|---|---|---|---|---|
| 227.23 | CBC | 1 | 6 | 7 | 0.32 |
| 228.80 | CBC | 1 | 6 | 7 | 0.32 |
| 229.73 | CBC | 1 | 6 | 7 | 0.32 |
| 230.65 | CBC | 1 | 6 | 7 | 0.32 |
| 232.54 | CBC | 2 | 6 | 7 | 0.32 |
| 235.18 | CBC | 1 | 6 | 7 | 0.32 |
| 236.64 | CBC | 1 | 6 | 7 | 0.32 |
| *Width × Height / Length (all assumed to be 40'; index calculation uses metric units) | | | | | |

FIELD REVIEW

We conducted a field review of the hotspot on 18-March-2021. Even this early into the tourist season the daytime traffic levels were very high (Figure 3-16). We reviewed several of the existing CBC, confirming that they are marginal in accommodating deer and especially elk passage, though we did see evidence of deer having crossed through one structure. At several of the CBC, barbed-wire fence at the mouths of structures blocks/limits deer access (Figure 3-23). We noted several elk carcasses along the roadway from recent WVCs.

*Figure 3- 23. Existing CBC along SR 64 Hotspot #2, one a 2-barrel structure (MP 232.5; left) and the other a single-barrel CBC like all other structures (right), with fencing at the mouth that limits wildlife access to and through the already marginal structure.*

We focused our efforts on addressing a multi-faceted conflict resolution strategy that combines wildlife fencing (and attention to potential end-runs at fence termini) and an experimental application of open-road radar detection systems. We also assessed the potential for a drop-in overpass at MP 234.4 as a resolution element; a large cut slope on the west side of SR 64 makes an overpass attractive but the terrain to the east is below road grade and would require extensive filling to create a suitable approach slope, necessitating work beyond the ADOT right-of-way. As such, we eliminated an overpass from consideration as a short-term resolution strategy, but suitable for a long-term strategy or deferring this until reconstruction is pursued.

## RECOMMENDED CONFLICT RESOLUTION STRATEGY ACTIONS

In the absence of suitable existing drainage structures for retrofitting, our recommended strategy for addressing wildlife-vehicle conflicts on the portion of SR 64 Hotspot #2 south of Tusayan centers on a combination of wildlife fencing and the application of open-road radar animal detection technology integrated with motorist alert signage. Such animal detection technology is particularly applicable to SR 64 due to its rapidly declining traffic volume in the evening through early morning hours (Figure 3-20). To address the high-incidence collision zone north of Tusayan, we recommend implementation of a nonstructural Wildlife Collision Avoidance Zone to modify motorist behavior and increase awareness.

### *OPEN-ROAD RADAR ANIMAL DETECTION TECHNOLOGY*

Open-road radar animal detection systems integrated with triggered motorist alert signage have proven successful in preventing WVCs (e.g., British Columbia, Canada). These systems employ 360-degree rotational Frequency Modulated Continuous Wave radar detection unit(s) integrated with two types of alert signage: 1) static gateway signs as motorists approach the WVC avoidance zone, and 2) hybrid static/dynamic (Blank-Out) "slow down" message signs (Figure 3-24) at intermediate locations along the zone that are triggered when animals are detected (Figure 3-24 and Figure 3-25). The number and spacing of intermediate signs are tied to posted speed and detection zone length; radar detection can be effective up to three miles on roadway stretches with direct line-of-sight (a critical consideration).

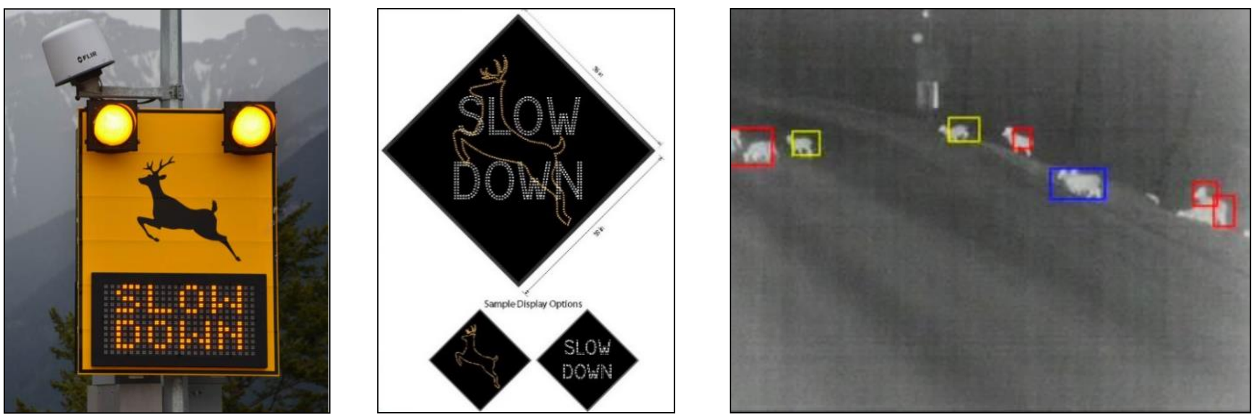


*Figure 3- 24. Pole-mounted variable message sign and radar unit for open-road radar detection system (left), static/dynamic Blank-Out message sign display options (center), and ITS-integrated detection of animals approaching and crossing a highway (right; photos courtesy Crosstek Wildlife Solutions).*

Crosstek Wildlife Solutions LLC (currently responsible for the SR 260 crosswalk with its animal detection system) is the proprietary vendor of open-road radar animal detection systems (ORAD™) in the US. Their ORAD™ systems have successfully integrated Intelligent Transportation System (ITS) components with high-performance security technologies for application in highway-wildlife conflict resolution (Figure 3-24 and Figure 3-25). For each mile of ORAD™ application on SR 64, four static/dynamic Blank-Out signs are recommended.

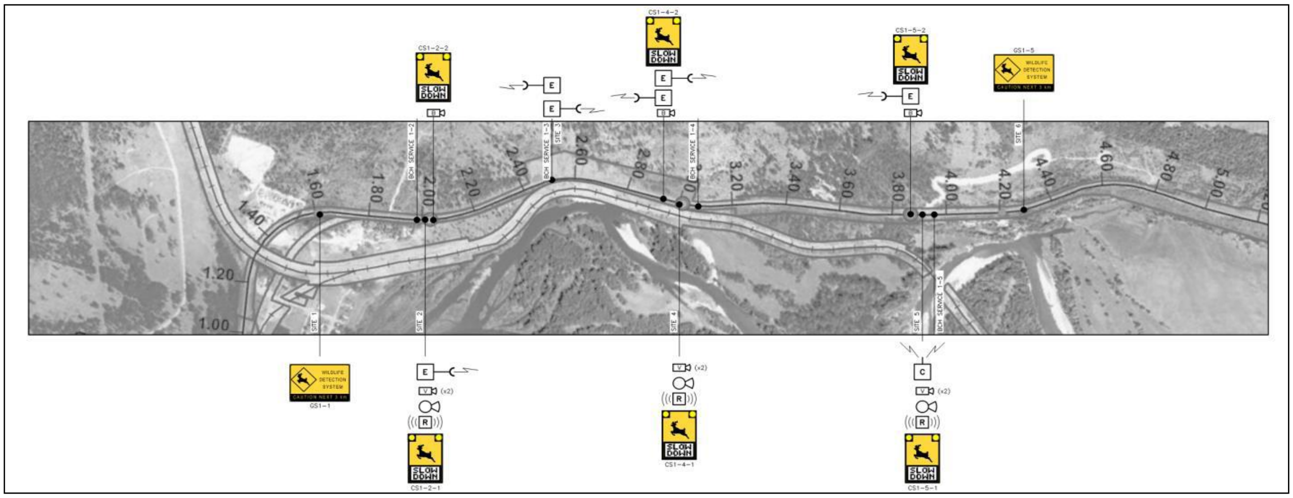


*Figure 3- 25. Schematic of the layout of a radar-based animal detection system and motorist alert gateway and triggered intermediate static/dynamic signage along a British Columbia highway (Source: PBX Engineering, Vancouver, BC).*

### *GENERAL STRATEGY APPROACH*

#### *SOUTH OF TUSAYAN SECTION*

Our conflict resolution strategy for SR 64 proposes phased implementation of two radar detection systems along highly suitable highway sections (Figure 3-26): 1) a 2.4-mile section (MP 228.0-230.4) coinciding with the southern mule deer corridor (Figure 3-21), and 2) a 1.8-mile section (MP 231.0-232.8) coinciding with the highest WVC incidence MP.

*Figure 3- 26. Stretches of SR 64 where open-road radar animal detection systems are appropriate for use: MP 228.0-230.4 (2.4 miles; left) and MP 231.0-232.8 (1.8 miles; right).*

Under our recommended immediate-term phase, one experimental ORAD™ system and signage would be implemented for formal evaluation. Under our short- and intermediate-term phases, wildlife fencing would be erected along two stretches of SR 64 where line-of-sight is limited, fencing to the stretches with good line-of-sight visibility suited for open-road radar detection systems. A total of 2.9 miles of SR 64 would be fenced (5.8 miles total fencing); combined, fencing and open-road radar detection systems would address 7.1 miles of the hotspot accounting for 85% of all WVCs. Open-road radar animal detection systems would also be able to detect animals making end runs around the fence termini, triggering signage to alert approaching motorists.

#### *NORTH OF TUSAYAN SECTION*

For the short, 0.7-mile section of the hotspot just south of the Grand Canyon NP boundary with the highest WVC incidence/mile, we recommend that ADOT consider a combination of measures to create an experimental Wildlife Collision Prevention Zone. This zone is intended to modify motorist behavior with reduced speed and increased awareness to improve the likelihood of avoiding WVCs. While erecting wildlife fence or installing an open-road radar detection system are also options here, both would cost approximately $400,000. A Wildlife Collision Prevention Zone would be considerably more cost effective (<$50,000) and with the highway's tourist-dominated traffic, it should be quite effective.

### *IMMEDIATE-TERM PROJECT RECOMMENDATIONS*

#### *SOUTH OF TUSAYAN SECTION*

This phase would implement only the northern ORAD™ system and integrated signage. It would cover 1.8 miles, encompassing the highest WVC-incidence MP (232) along the entire hotspot (Figure 3-27), and would address 28% of all hotspot WVC. This phase is intended to allow for the experimental evaluation of the technology before further investment in fencing and other elements were made. The components of this phase (Table 3-11, Figure 3-27) include:

- Installation of an experimental ORAD™ system at MP 232.1 which will offer coverage of at least 0.9 mile in each direction along the 1.8-mile section between MP 231.0 and MP 232.8; static gateway signs should be erected at the end of this coverage zone (Figure 3-27).
- This detection system should be integrated with six static/dynamic Blank-Out message signs spaced along the stretch to alert motorists to the presence of animals.
- As we anticipate this experimental application of an open-road radar animal detection system will be the state's first, we urge ADOT to support a minimum one-year formal monitoring/research study to evaluate the efficacy and reliability of the technology as well as a comparison of before- and after-mitigation WVC incidence. The outcome of this monitoring will inform ADOT on its next phase of WVC conflict resolution on SR 64 and other highways. During this evaluation, Crosstek could train ADOT staff on system operation.
- This phase would eliminate an average of eight WVCs/year, five associated with elk and three associated with mule deer. Using average cost figures from Huijser et al. (2009*a*) for WVCs involving mule deer ($6,617) and elk ($17,483), this strategy would accrue an annual benefit of $107,266, with a project cost:benefit break-even point of just 1.1 years for a lease option (purchase if effective to be done under Short-term Phase).

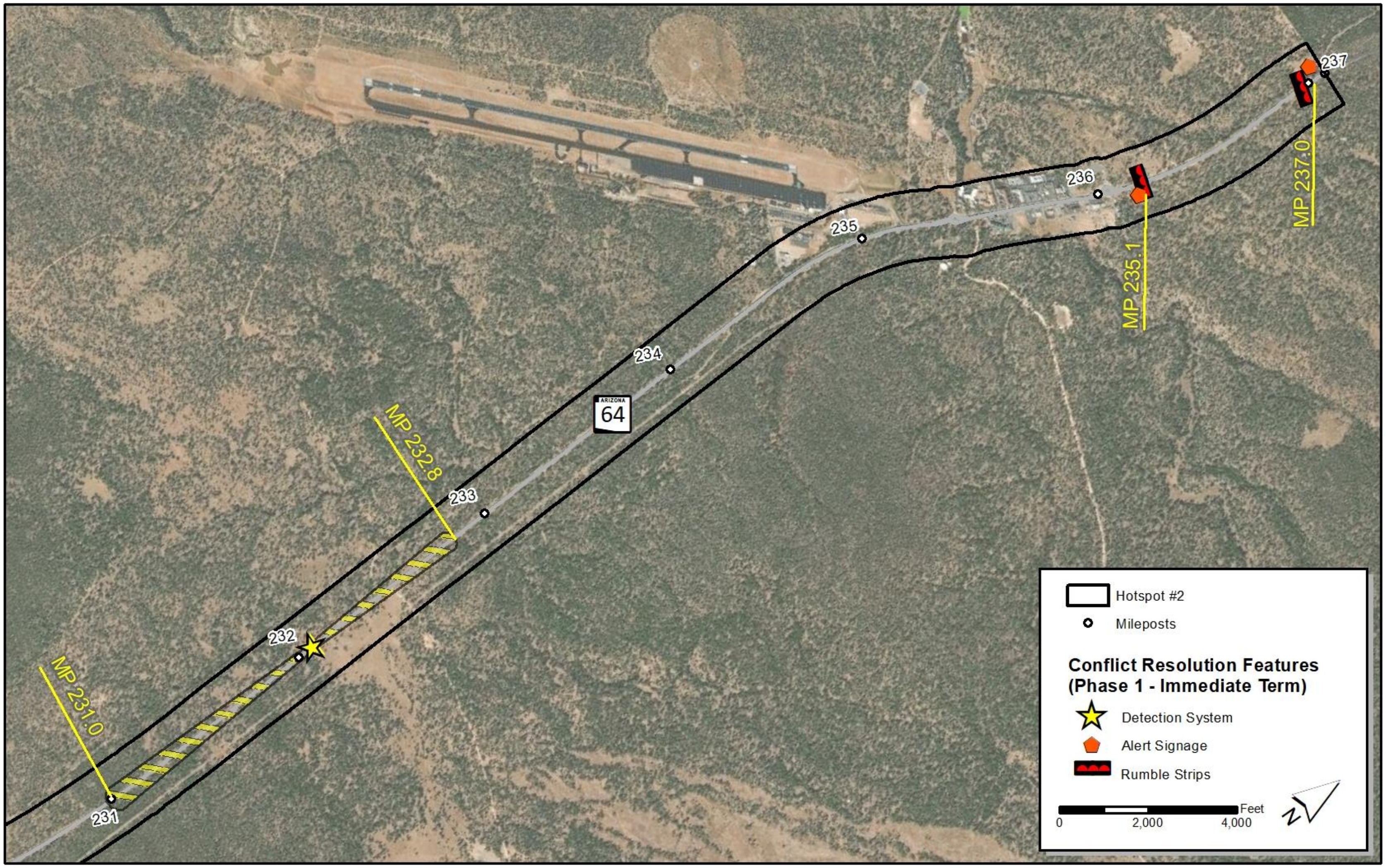


*Figure 3- 27. SR 64 Hotspot #2 wildlife-vehicle conflict resolution Phase 1 immediate-term project involving an experimental open-road radar animal detection system and a Wildlife Collision Prevention Zone with special signage, rumble strips and reduced posted speed north of Tusayan.*

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Crosstek Wildlife Solutions LLC offers multiple purchase options for their ORAD™ animal detection and integrated signage system:

1) Purchase of a permanent ORAD™ integrated system including planning, design, electrical infrastructure installation (Phase 1), and radar and signage installation (Phase 2). The estimated ORAD™ system cost with six Blank-out message signs is $595,000 - $655,000. We are hesitant to recommend a permanent system with the potential for future reconstruction of SR 64 which would likely necessitate removal of much of the electrical infrastructure associated with such a system.
2) Purchase of a Mobile Autonomous Radar Unit (estimated cost $250,000) and six mobile Blank-Out message signs ($25,000 each) is estimated to cost $400,000.
3) Lease of a Mobile Autonomous Radar Unit and six Blank-Out message signs for 6-12 months, estimated at $10,000/month including setup and operation by the vendor. This approach would allow ADOT to formally evaluate ORAD™ for one year; Crosstek has indicated that half the lease payment ($60,000) would apply toward subsequent purchase.

In evaluating ORAD™ procurement options, it is important to stress that a system replaces the need to erect (and maintain) wildlife fence, which in this case would be 3.6 miles of fence (estimated cost $568,800), three pair of escape jumps (6 total; $66,000), and two cattle guard grate extension units ($60,000), totaling $694,800. Further, without suitable existing drainage structures for retrofitting, fencing would necessitate an at-grade crosswalk with animal detection system to allow wildlife passage, costing another approximately $150,000 and bringing total cost to $844,800. Thus, the ORAD™ radar system and signage is actually a lower cost option than the wildlife fence and crosswalk that it replaces. A radar system is also preferred in this instance as it would better provide for unimpeded wildlife passage within an important deer corridor.

For this initial experimental phase, we recommend that ADOT lease a mobile ORAD™ system for a year ($10,000/month). If proven effective, we recommend that ADOT immediately purchase the system (as well as a second for the next phase if pursued).

*NORTH OF TUSAYAN SECTION*

The components of the recommended experimental Wildlife Collision Prevention Zone option include:

- Erect innovative motorist alert signage like that used in other states and Canada to highlight WVC hotspots (Figure 3-28); install gateway signs at the entry points to the high-incidence WVC zone between MP 236.2 (north of the roundabout) and MP 237.1 (Figure 3-27). The signage should be as large as possible and preferably be LED-enhanced for nighttime impact.
- Cut transverse rumble strips into the pavement at the approaches to the *Wildlife Collision Prevention Zone* in conjunction with the signage to maximize impact in raising motorist WVC risk awareness/alertness, and


*Figure 3- 28. Conceptual layout for motorist alert signs at the approaches to a designated Wildlife Collision Prevention Zone; the signs should be LED-enhanced for maximum nighttime impact.*

thus wildlife avoidance response (Figure 3-27).

- Maintain the posted speed limit in Tusayan of 35 mph throughout the zone. This will dramatically increase motorist response time and distance to allow motorists to avoid WVC or reduce the damage from WVC. New 35 mph signs should be installed near the zone ends. Narrow the travel lanes through the zone with paint restriping to create the perception on the part of motorists that the road is narrower thus promoting lower speeds.
- Narrow the travel lanes through the zone with paint restriping to create the perception on the part of motorists that the road is narrower thus promoting lower speeds.

*SHORT-TERM PROJECT RECOMMENDATIONS*

Our recommended second phase would address the southern 3-mile stretch of SR 64 that accounts for another 30% of WVCs (Figure 3-17) with a combination of fencing and a second open-road radar animal detection system to be pursued after the first ORAD™ system has proven successful in reducing WVCs. The components of this phase (Table 3-11, Figure 3-29) include:

- Erect wildlife fence extending 0.6 mile (1.2 miles total) along SR 64 between MP 230.4 and MP 231.0. Both fence termination points would fall within open-road radar coverage which would address any potential fence end-runs that occur (Figure 3-29). Even though existing CBC structures are marginal for deer passage, fencing nonetheless should be tied into the MP 230 CBC abutments and have barbed-wire fencing moved to the ROW (with PVC on the top stands) to promote passage by deer and other species.
- This short stretch of wildlife fencing would necessitate only installation of a single set of escape ramps (2 total), with no lateral roads requiring cattle guards or gates (Figure 3-29).
- Install an open-road radar animal detection system at approximately MP 229.2 which will offer coverage of at least 1.2 mile in each direction along the SR 64 section between MP 228.0 and MP 230.4 (Figure 3-29); static gateway signs should be erected at the ends of this coverage zone. This detection system should be integrated with eight static/dynamic Blank-Out message signs spaced along the stretch to alert motorists to animals.

As this phase is predicated on Phase 1 being successful, we recommend that ADOT consider the purchase of the second Mobile ORAD™ system. Again, concerns for future highway reconstruction preclude us from recommending a permanent ORAD ™ system.

- This phase would cost $995,600 including the first ORAD™ system, and would eliminate an average of 17 WVCs/year, 11 associated with elk and six associated with mule deer. Using average cost figures from Huijser et al. (2009*a*) for WVC, this strategy would accrue an annual benefit of $232,015, with a project cost:benefit break-even point of approximately 4.3 years.

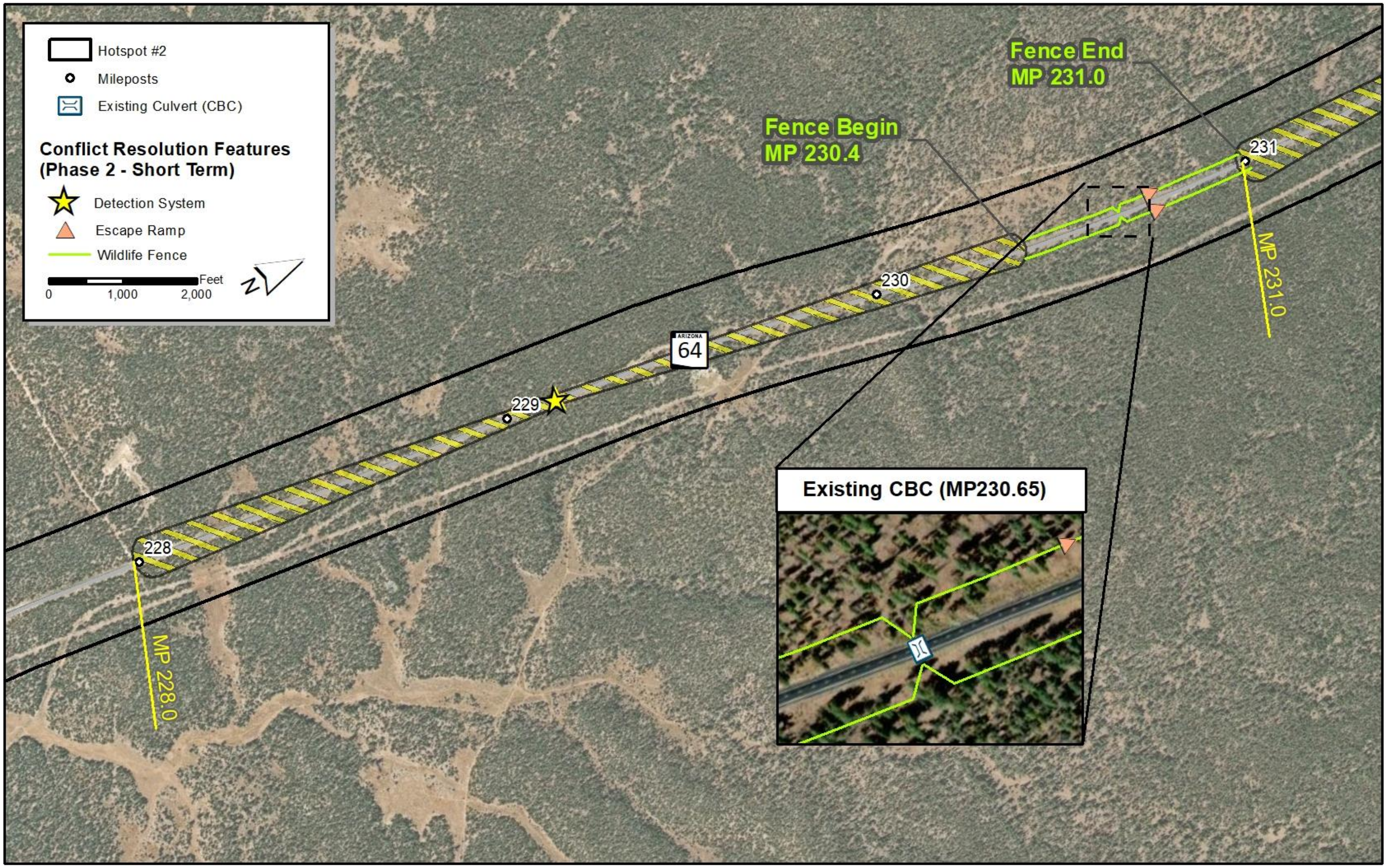


*Figure 3- 29. SR 64 Hotspot #2 wildlife-vehicle conflict resolution Phase 2 short-term project for a second experimental open-road radar animal detection system and wildlife fencing linking it to the Phase 1 experimental open-road radar detection system.*

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### *INTERMEDIATE-TERM PROJECT RECOMMENDATIONS*

This phase would address another 2.3 miles of SR 64 north to Tusayan that accounts for another 20% of all hotspot WVCs, employing wildlife fencing and associated measures which add considerable cost. The components of this phase (Table 3-11) include:

Erect wildlife fence extending 2.3 miles (4.6 miles total) along SR 64 between MP 232.8 and MP 235.1. On the south end, we recommend terminating the fence at the beginning of the stretch with excellent line-of-sight visibility with the first ORAD™ system and signage to alert motorists to end-runs. The northern fence terminus would be just south of the north entrance to Grand Canyon Airport (Figure 3-30 and Figure 3-31), where visibility is good and the highway transitions into a reduced posted speed zone (35 mph) approaching Tusayan. We recommend motorist alert signage, preferably flashing or LED-enhanced signs at the approaches to the fence terminus to alert motorists to potential crossing animals.

*Figure 3- 30. Recommended northern wildlife fence termination point before the north entrance into the airport and highway transition into Tusayan.*

- Wildlife fencing necessitates the installation of a double-wide cattle guard on the south airport entrance road and cattle guard extension grates on two other roads (Figure 3-31). Also, four pairs of evenly spaced escape ramps (8 total) will be needed along the fenced stretch to provide a means for animals to escape from the fenced corridor (Figure 3-31).
- This phase would eliminate an average of six WVCs/year, four associated with elk and two associated with mule deer. Using average cost figures from Huijser et al. (2009*a*) for WVCs this strategy would accrue an annual benefit of $83,166, with a project cost:benefit break-even point of approximately 11.6 years.

### *LONG-TERM PROJECT (DROP-IN PASSAGE STRUCTURE)*

The reconstruction of SR 64 within Hotspot #2 is likely to alter the road grade and/or alignment in places, especially the low spots in the highway where existing drainage structures and many of the AGFD-recommended new underpasses are located. Thus, there is limited potential for replacing drainage structure CBC with drop-in underpasses. However, the proposed overpass at MP 234.4 would provide for improved grade-separated passage at the northern end of the hotspot (Figure 3-31). We estimate that a single-span, 100-ft wide overpass here will cost $2.5 million, especially with the filling entailed on the east side of SR 64 to create approach slopes.

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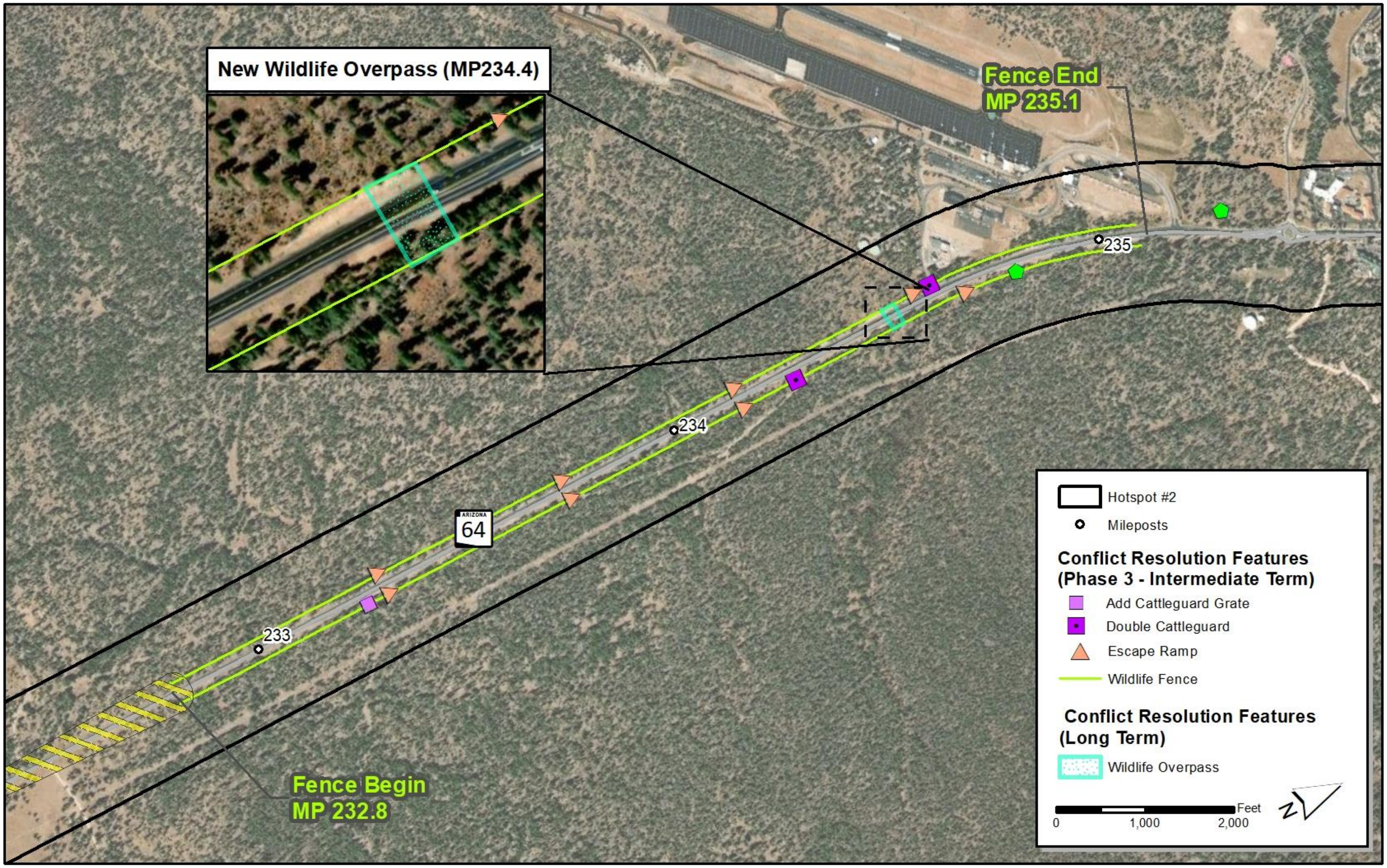


*Figure 3- 31. SR 64 Hotspot #2 wildlife-vehicle conflict resolution Phase 3 intermediate-term project for wildlife fencing and associated measures and long-term installation of a drop-in wildlife overpass integrated with the wildlife fencing.*

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*Table 3- 11. SR 64 Hotspot #2 resolution strategy components and estimated costs to address wildlife-vehicle conflicts associated with recommended immediate-, short-, intermediate- and long-term projects.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Immediate-Term Projects** | | | | |
| **South of Tusayan Section (Mobile ORAD™ Radar System option lease or purchase)** | | | | |
| Mobile ORAD™ radar unit and 6 Blank-Out signs (Lease) | Months | 12 | $10,000 | $120,000 ($60,000 applied to purchase) |
| **North of Tusayan Section (*Wildlife Accident Prevention Zone*)** | | | | |
| Gateway motorist alert signage | Each | 2 | $10,000 | $20,000 |
| Speed limit signs | Each | 2 | $2,000 | $4,000 |
| Transverse rumble strips | Each | 2 | $10,000 | $20,000 |
| **Total (North of Tusayan)** | | | | **$44,000** |
| **Short-Term Project (Mobile ORAD™ Radar Systems purchase and wildlife fencing)** | | | | |
| Wildlife fence | Miles | 1.2 | $158,000 | $189,600 |
| Escape ramps | Each | 2 | $11,000 | $22,000 |
| Mobile ORAD™ radar unit and 8 Blank-Out signs (new) | Each | 1 | $450,000 | $450,000 |
| Mobile ORAD™ radar unit and 6 Blank-Out signs (existing) | Each | 1 | $340,000 w/ lease credit | $340,000 |
| **Total** | | | | **$1,001,600** |
| **Intermediate-Term Project (Wildlife fencing)** | | | | |
| Wildlife fence | Miles | 4.6 | $158,000 | $726,800 |
| Escape ramps | Each | 6 | $11,000 | $48,000 |
| Cattle guard grates | Each | 6 | $30,000 | $180,000 |
| Alert signage – north fence end | Each | 2 | $4,000 | $8,000 |
| **Total** | | | | **$980,800** |
| **Long-term Project (Drop-in overpass)** | | | | |
| Drop-in overpass | Each | 1 | $2,500,000 | $2,500,000 |

## ENVIRONMENTAL OVERVIEW

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Early coordination with Grand Canyon National Park, local businesses in Tusayan, and Grand Canyon National Park Airport should be anticipated for the projects in Hotspot #2. Pending the outcome of coordination as well as technical studies and approvals, the anticipated impacts of this undertaking are expected to be beneath the threshold of significant. Construction of the proposed Immediate-Term and Short-Term projects will be confined to the existing ADOT easement through Kaibab National Forest. Likewise, the proposed Intermediate-Term project will be confined to the existing ADOT ROW through privately owned lands and easement through Kaibab National Forest. If NEPA is required for the proposed Immediate-, Short-, and Intermediate-Term projects, these projects are anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: “Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way.” For the Long-Term project, construction of an overpass may require a TCE from Kaibab National Forest. If NEPA is required and a TCE is needed for the proposed Long Term project, then the project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) under C-list (c)23(i): “Federally funded project that received less than $5,000,000…” rather than C-list (c)22: “Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way.”.

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of all the proposed projects, and surveys are recommended to reassess the current location of cultural sites and determine their NRHP eligibility. A hazardous materials assessment should be performed for all proposed projects to address any potential hazardous material concerns. Additionally, hazardous materials testing will be required for the Short-Term project because the proposed fencing will tie into existing structures, and for the Intermediate Term project because existing cattleguards will be impacted. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. None of the proposed projects are located within currently designated or proposed critical habitat for any species. For the Short-Term project, wildlife fencing will tie into the existing culvert at MP 230.65 which may provide habitat to roosting bats or nesting birds federally protected by the MBTA. Further investigation of this structure will be necessary during the environmental clearance of the Short-Term project, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required for any of the projects.

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## HOTSPOT #4: INTERSTATE 40 (MP 195.5-199.5)

*Figure 3- 32. The Rio de Flag bridges on I-40 (MP 197.5) under which the Rio de Flag flows.*

The 4-mile I-40 Hotspot #4 falls within the city limits of Flagstaff and has the distinction of having the highest AADT of any hotspot in the state. This divided 4-lane stretch of highway crosses through urbanized areas to the north with residential and commercial/ business uses. The southern side is dominated by forested habitats which abut Walnut Canyon; the Rio de Flag flows under the interstate at MP 197.5 (Figure 3-32) and feeds lush riparian habitats that attract wildlife (Figure 3-34). The hotspot's high traffic volume coupled with the prevalence of human development presents challenges to the resolution of wildlife vehicle conflicts, though the Rio de Flag bridges (Figure 3-32) offer potential retrofitting opportunities (Gagnon et al. 2012).

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 47

**WVCs/mile/year:** 2.26

**WVC percentage of all crashes:** 8.9%

**2018 WVC species composition** (9 WVC)**:** Mule deer – 75% Elk – 25%

**AADT:** 48,105 vehicles/day

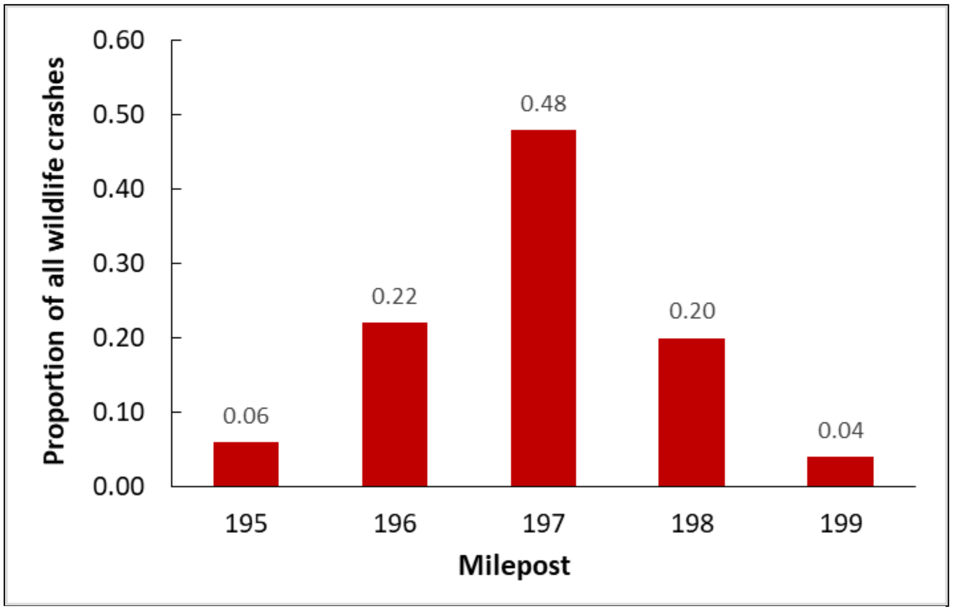


*Figure 3- 33. Proportion of all I-40 Hotspot #4 WVC by milepost (2014-2018).*

The proportion of all WVC which occurred by MP ranges from 0.04-0.48 (Figure 3-33); MP 197 alone accounts for 48% of all WVC and along with the adjacent mileposts (196 and 198), accounts for 90% (Figure 3-33 and Figure 3-34).

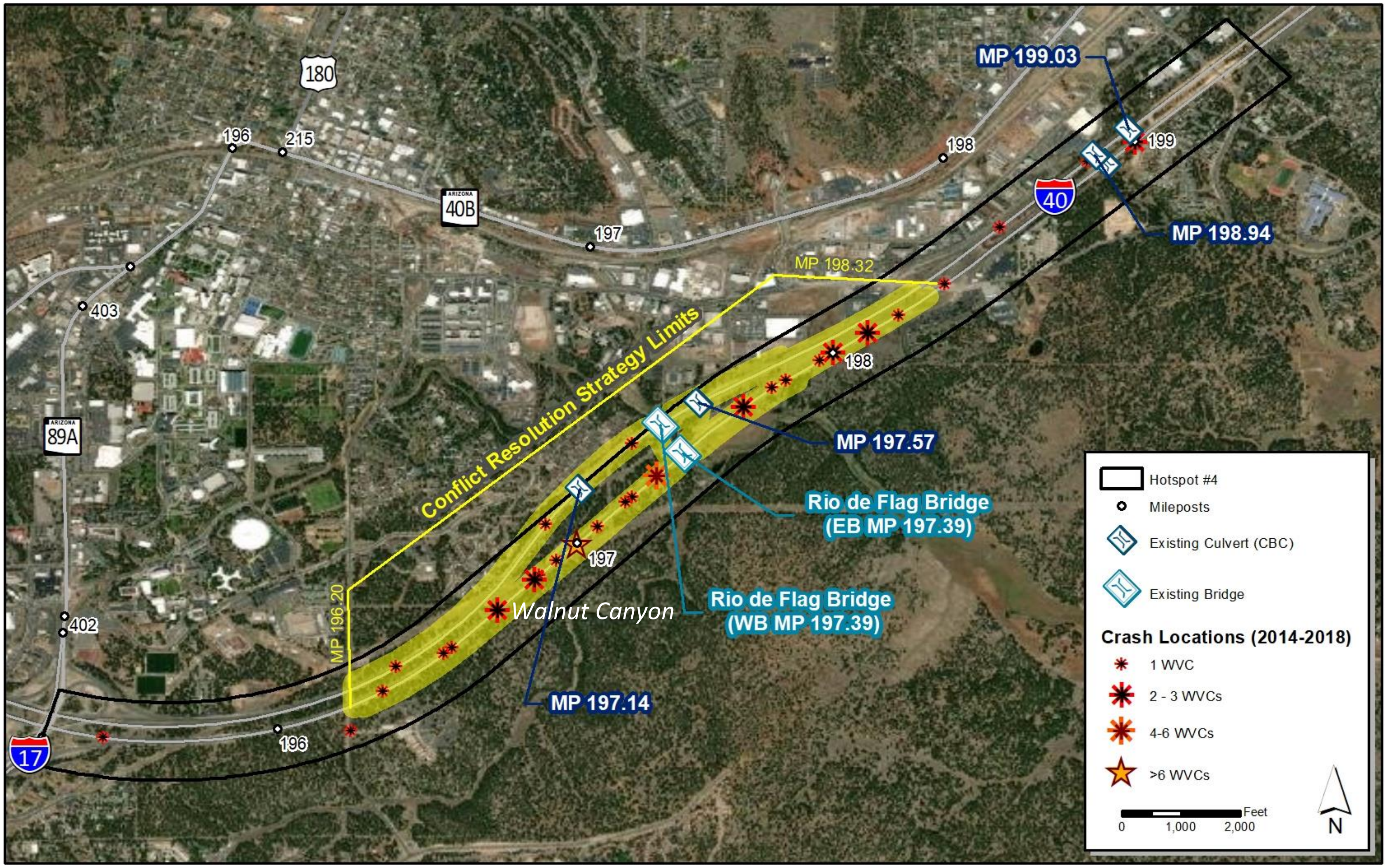


*Figure 3- 34. The I-40 Hotspot #4 located in Flagstaff showing WVC locations occurring between 2014-2018, existing drainage structures, the Rio de Flag bridges, and the portion of the hotspot addressed with our conflict resolution strategy. Note I-40's proximity to the undeveloped forested area abutting Walnut Canyon area to the south and lush riparian habitats along the Rio de Flag.*

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I-40 WVC incidence exhibited a seasonal peak extending from June through November which accounted for 70% of crashes; the spring months (Feb-May) accounted for just 9% (Figure 3-35).

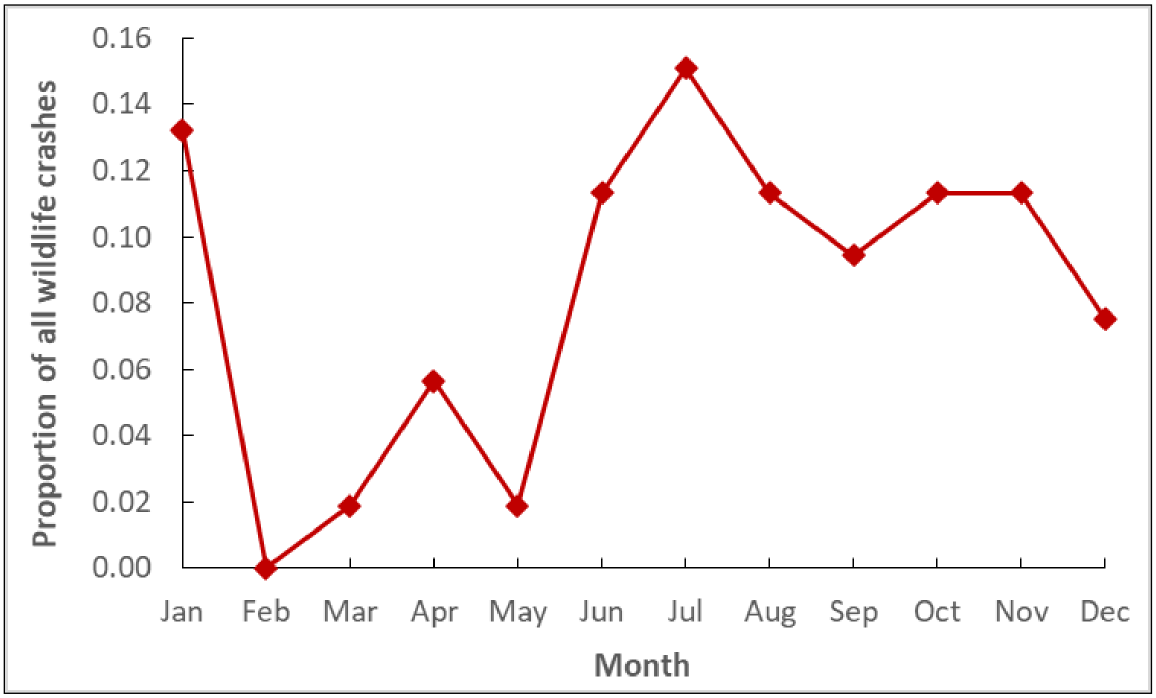


*Figure 3- 35. Monthly proportion of all WVCs that occurred along I-40 (2014-2018).*

#### CONFLICT RESOLUTION STRATEGY

As part of its evaluation of the long-range reconstruction of I-40 to address traffic volume and highway safety issues, ADOT commissioned a Wildlife Accident Reduction Study (WARS). This project (ADOT Project No. 040 CN 183 H7586 01L; Federal Project No. NH-040-C (211) S; Stanley Consultants, Inc. 2013) was intended to address reconstruction between Bellemont and Winona.

AGFD was commissioned to assess WVCs and elk movements (GPS telemetry) and develop recommendations for incorporation into a design concept report (DCR) for a 55 stretch of I-40 (Gagnon et al. 2012). Hotspot #4 largely corresponds to their Urban section (Figure 3-36), with a single wildlife passage structure; the existing bridges over Rio de Flag at MP 197.5 (Figure 3-36). They concluded that there were no other feasible sites for passage structures, which our assessment of existing drainage structures confirmed. Their compilation of elk GPS locations (Figure 3-37) shows a concentration of elk to the south side of I-40 along the hotspot on either side of the Rio de Flag; I-40 is a barrier which deters most incursions onto I-40 due to high traffic volume, but the concentrated proximity of elk nonetheless should be cause for concern without adequate fencing. Without funnel fencing, the bridges are ineffective as passage structures.

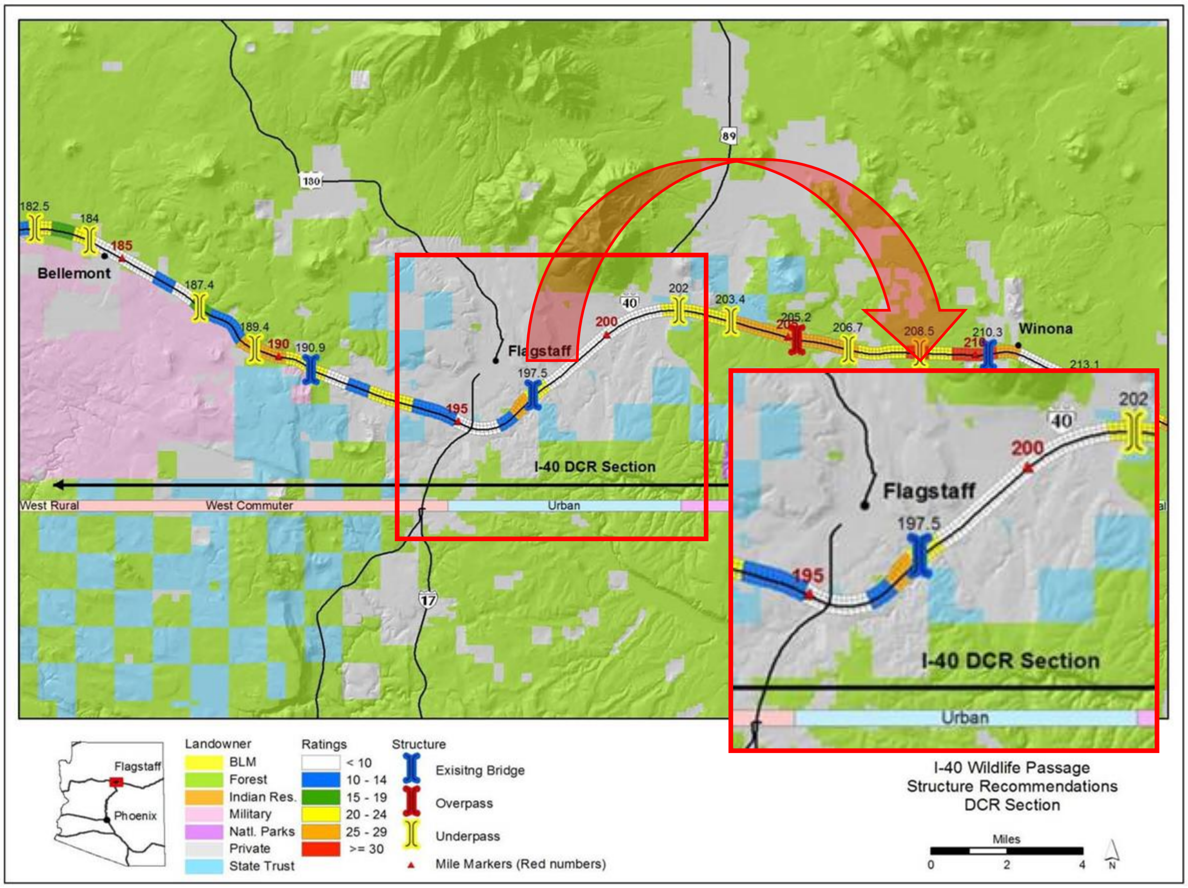


*Figure 3- 36. Wildlife passage structures (yellow underpass/red overpass) recommended in the AGFD wildlife movements study and design concept report for I-40 (Gagnon et al. 2012), with an enlarged inset of their Urban Section corresponding to Hotspot #4 and showing the Rio de Flag bridges location.*

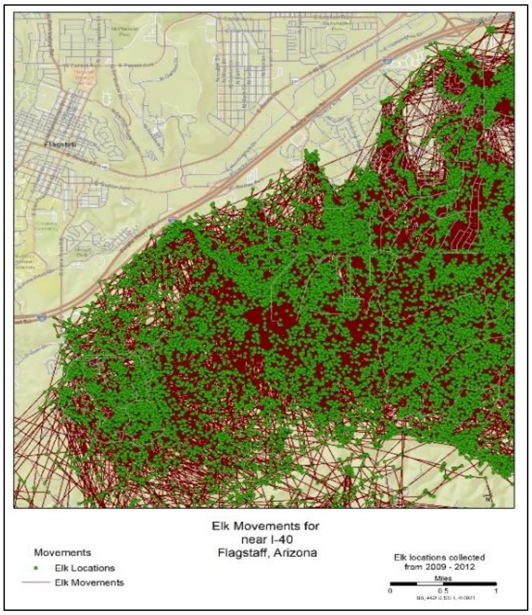


*Figure 3- 37. Compilation of GPS locations from elk collared along I-40 from 2009-2012, showing a concentration along the south side of I-40 within Hotspot #4 (Map courtesy AGFD).*

EXISTING DRAINAGE STRUCTURES

We found that only one set of existing drainage structures (of 4 sites) is paired on both sets of I-40 lanes to potentially provide wildlife passage across I-40 (Table 3-12). Except for the large WB lane structure at MP 197.6, all other individual CBC are too small and far too long (>170 feet) to be suitable for passage (openness indices ≤0.11; Table 3-12). The structure at MP 197.6 through which a gated water treatment facility access road passes has a higher degree of openness (0.58; Figure 3-38) though still considered marginal for deer and elk passage (Gordon and Anderson 2003).


*Figure 3- 38. The large access road concrete box culvert under the WB lanes of I-40 located at MP 197.6, looking south.*

*Table 3- 12. Existing drainage (access) structures located along I-40 Hotspot #4, most only spanning the west-bound (WB) lanes.*

| MP | Structure | No. barrels | Width (ft) | Height (ft) | Length (ft) | Openness index* |
|---|---|---|---|---|---|---|
| 197.14 (WB only) | CBC | 1 | 6 | 7 | 170 | 0.07 |
| 197.57 (WB only) | CBC | 1 | 15 | 14 | 110 | 0.58 |
| 198.94 | CBC | 1 | 8 | 8 | 170 (WB)<br>200 (EB) | 0.09<br>0.10 |
| 199.03 (WB only) | CBC | 2 | 10 | 8 | 220 | 0.11 |

*Width × Height / Length (metric units)

FIELD REVIEW FINDINGS

While the MP 197.6 structure is marginal as a passage structure (Figure 3-38), we nonetheless realized during our 19-March-2021 field review that it can play an integral role in a conflict resolution strategy which revolves around retrofitting the Rio de Flag bridges at MP 197.5 as a wildlife underpass. Accommodating wildlife passage under the WB I-40 lanes via the MP 197.6 CBC with wildlife fencing will avoid the need for two sets of double-wide cattle guards on the access road, one north of I-40 and another where the road enters the median near the Rio de Flag (see Figure 3-39).

We found that the 2.1-mile stretch with the highest-WVC incidence between Lone Tree Road and Butler Avenue (MP 196.2-198.3; Figure 3-34) is predominately fenced with 42" game (ROW) fence, whereas adjacent stretches are fenced with 6-foot-high chain-link fence including the eastern portion of the hotspot beyond MP 197.9. This partly explains why deer and elk are accessing the interstate and causing WVCs. While the concentrated elk use documented by AGFD abutting the south side of I-40 (Figure 3-37) could be diminished by future development, we noted considerable fresh elk signs on the north side of I-40 within the ROW as well.

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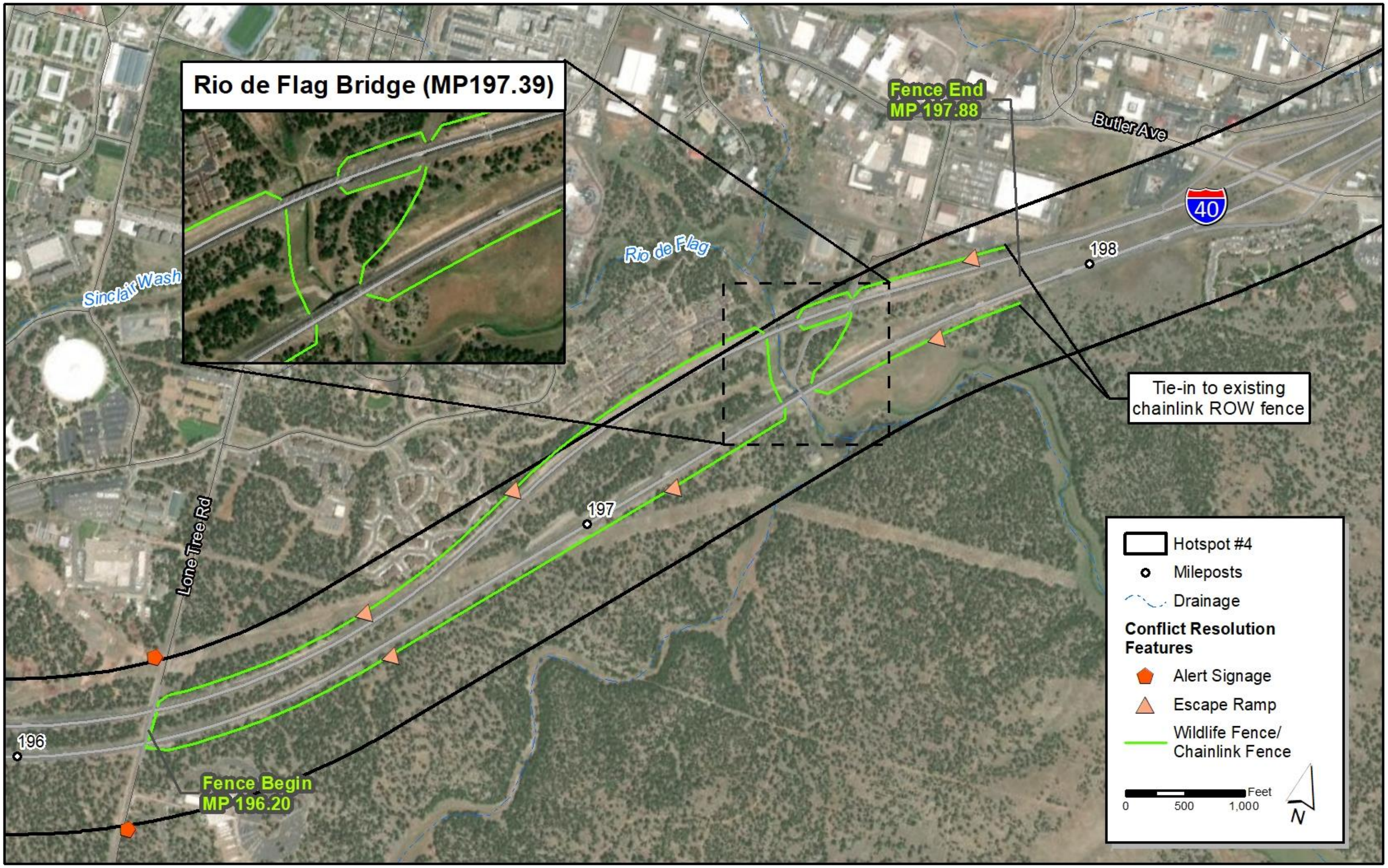


*Figure 3- 39. Wildlife-vehicle conflict resolution strategy for I-40 Hotspot #4 including retrofitting of the Rio de Flag bridges and MP 197.6 road access culvert (insert) with wildlife (or chain-link) fencing and escape ramps.*

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RECOMMENDED CONFLICT STRATEGY ACTIONS AND COSTS (RETROFITTING WITH WILDLIFE FENCE)

Our strategy for addressing wildlife-vehicle conflicts on the I-40 Hotspot #4 entails the retrofitting of the existing Rio de Flag bridges and Lone Tree Road underpass fence and escape ramps. This strategy addresses WVC along the 2-mile highest-incidence stretch accounting for 85% of the hotspot WVCs. The components (and estimated costs; Table 3-13) of this retrofitting strategy include the following (Figure 3-39):

- We recommend fencing 1.7 miles of the I-40 corridor from MP 196.2 and MP 197.9 up to the point where chain-link fencing exists (totaling 3.4 miles of fence), between the Rio de Flag bridges, and integrating the MP 197.6 access road culvert (Figure 3-39). Fencing can be accomplished preferably with wildlife fence or chain-link fence if it better meets ADOT's safety needs. The western terminus should be at the Lone Tree Road underpass abutments (with fencing between the bridges). Fencing should be flared toward the ROW from the abutments to provide for a less abrupt approach by animals to the bridges (Figure 3-39); from the bridges to the Rio de Flag is 1.3 miles. The eastern fence terminus should be integrated with the western side of the Butler Avenue traffic interchange, 0.8 miles east of the Rio de Flag bridges.
- To address the funneling of wildlife to the Lone Tree Road bridges where potential passage is limited by high side slopes and a paved urban trail (which wildlife will likely use; Figure 3-40) we recommend two actions.

*Figure 3- 40. The steep eastern bridge side slopes at the WB I-40 Lone Tree Road underpass with an adjacent urban trail (left) which limit wildlife passage through the structure. Passage could be enhanced if the side slopes were partially excavated to resemble the western side slopes (right) where animals could more readily pass under the bridges (right).*

First, alert signage (preferably flashing or LED-enhanced) should be erected to advise motorists and cyclists of the anticipated increased presence of wildlife (Figure 3-39); animals are already being funneled to the western bridge abutments by chain-link fencing to the west.

Second, animal passage atop the eastern side slopes (especially for mule deer) could be enhanced considerably if the slopes were partially excavated to create a 4-6-foot-high flattened area (like the western side slopes), provided such can be done without compromising bridge integrity

(Figure 3-40). Also, leveling the existing berm between the bridges would enhance passage. These actions will require close coordination between ADOT and the City of Flagstaff.

- Wildlife fencing necessitates the installation of evenly spaced paired wildlife escape ramps at three sites along I-40 (6 total), with two pairs located west of the Rio de Flag bridges and one pair to the east (Figure 3-39).

This retrofitting strategy to address WVCs along the western three miles of the I-40 hotspot is estimated to cost $613,200, or $360,705/mile (Table 3-13). This strategy will eliminate an average of eight WVCs/year, six associated with mule deer and two associated with elk. Using average cost figures from Huijser et al. (2009*a*) for WVC involving mule deer ($6,617) and elk ($17,483), our retrofit strategy would accrue an annual benefit of $74,668, with a project cost:benefit break-even point of approximately 8.2 years.

Fencing the I-40 ROW along this stretch currently without chain-link fence would also enhance human/pedestrian safety, especially given the proximity of the Arizona Trail which traverses the north side of I-40 east of the Rio de Flag.

*Table 3- 13. I-40 hotspot retrofitting strategy components and estimated costs to address wildlife-vehicle conflicts.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| Wildlife fence | Miles | 3.4 | $158,000 | $537,200 |
| Escape ramps | Each | 6 | $11,000 | $66,000 |
| Alert signage | Each | 2 | $5,000 | $10,000 |
| **All components** | | | | **$613,200** |

#### ENVIRONMENTAL OVERVIEW

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Pending the outcome of technical studies and approvals, the anticipated impacts of this undertaking are expected to be beneath the threshold of significant. Construction of the proposed fencing retrofit project will be confined to the existing ADOT ROW through privately owned lands where there is low risk of environmental impacts. If NEPA is required, this project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: "Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way." Similarly, if the project is federally funded, then a Section 4(f) analysis will be required due to the projects proximity to the Arizona Trail and Flagstaff Urban Trail System.

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources within the ROW have already been mitigated and the proposed fencing retrofit project would follow the appropriate Section 106 procedures. Hazardous materials testing will be required because the proposed fencing will tie into existing structures, and a hazardous materials assessment should be performed for the project area to address any potential hazardous material concerns. During the environmental clearance process the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project area. However, the proposed project is not currently located within designated or proposed critical habitat for any species. Existing structures impacted by the proposed project may provide habitat to roosting bats or nesting birds federally protected by the MBTA. Further investigation of these structures will be necessary during the environmental clearance, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed project are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required.

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Gagnon, J. W., S. Sprague, N. L. Dodd, C. Loberger, R. E. Nelson, S. Boe, and R. E. Schweinsburg. 2012. Elk movements associated with Interstate 40 for Design Concept Study and Environmental Assessment: I-40 Bellemont to Winona. ADOT Roadway Predesign, Phoenix.

Gordon, K. M., and S. H. Anderson. 2003. Mule deer use of underpasses in western and southeastern Wyoming. *In* 2003 Proceedings of the International Conference on Ecology and Transportation, Center for Transportation and the Environment, North Carolina State University, Raleigh.

Huijser, M. P., Duffield, J. W., Clevenger, A. P., Ament, R. J., & McGowen, P. T. 2009*a*. Cost–benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada; a decision support tool. *Ecology and Society, 14*, 15−41.

Stanley Consultants, Inc. 2013. Wildlife Accident Reduction Study; 1-40 Bellemont to Winona MP 183.0-214.0. ADOT Project No. 040 CN 183 H7586 01L and Federal Project No. NH-040-C (211) S. Stanley Consultants, Inc., Phoenix.

## HOTSPOT #4 (TIE): SR 77 NORTH OF SHOW LOW – SHUMWAY AREA (MP 349.2-356.4)

The SR 77 Hotspot #4 is located just south of Taylor. This hotspot is a mix of 4-lane (MP 249.2-251.6) and 2-lane (MP 251.6-254.8) roadway, with passing lane sections in each direction (NB – 254.8-255.3; SB 255.3-256.4). SR 77 is traveled by residents, commuters to/from Holbrook (county seat), tourists, and commercial vehicles. Wildlife-vehicle conflicts are strongly influenced by the juxtaposition of wooded Sitgreaves National Forest to the west (south of MP 354) and Silver and Show Low creeks and associated extensive lush riparian areas on private lands near the community of Shumway (Figure 3-41 and Figure 3-42). The northern two miles cross through open grassland habitats. There are four well-traveled intersecting roads (Lone Pine, White Mountain Lake, Shumway, and Taylor Farms roads) and numerous private driveways and access roads, which complicate the consideration of wildlife fencing. Also complicating the resolution of WVC is concern over the appropriateness of directing wildlife via passage structures and fencing into private land riparian habitats and irrigated pasture.

*Figure 3- 41. Juxtaposition of riparian habitat (Silver Creek) and pasture lands on private lands to the east of SR 77 (left) and wooded national forest lands to the west of the highway (right).*

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 79

**WVCs/mile/year:** 2.26

**WVC percentage of all crashes:** 69.3%

**2018 WVC species composition** (29 WVC)**:** Elk – 60% Mule deer – 40%

**AADT:** 9,034 vehicles/day

The proportion of all WVC which occurred by MP varied from 0-0.40 (Figure 3-43) with MP 351 alone accounting for 40% of WVC, and three MP (MP 351-352 and 354) accounting for 82% of all (Figure 3-42). MP 351 and 352 abut Silver Creek and MP 354 crosses Show Low Creek (Figure 3-42).

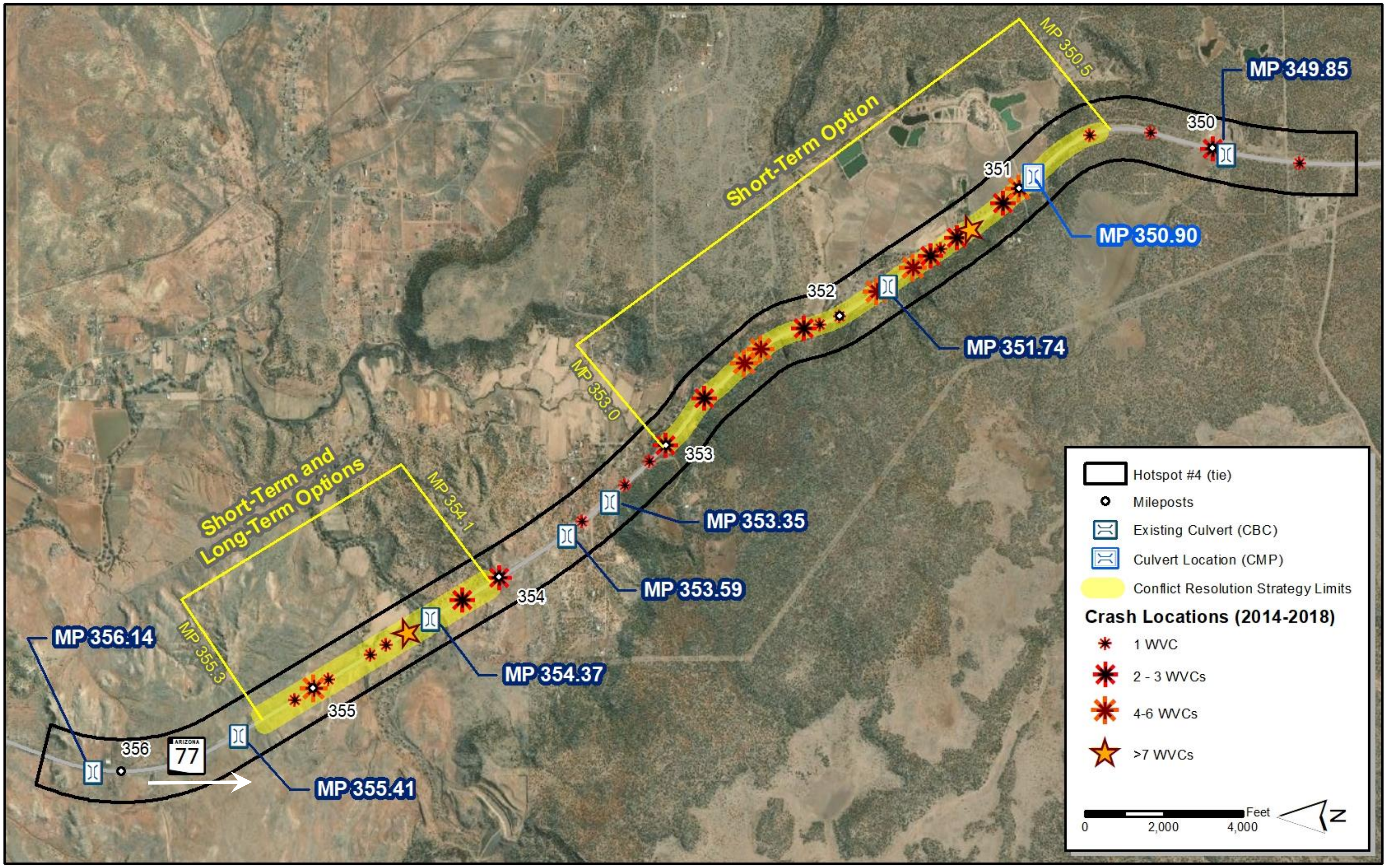


*Figure 3- 42. The SR 77 Hotspot #4 located near the community of Shumway, showing WVC locations occurring between 2014-2018, existing drainage structures, and short-term conflict resolution option sections.*

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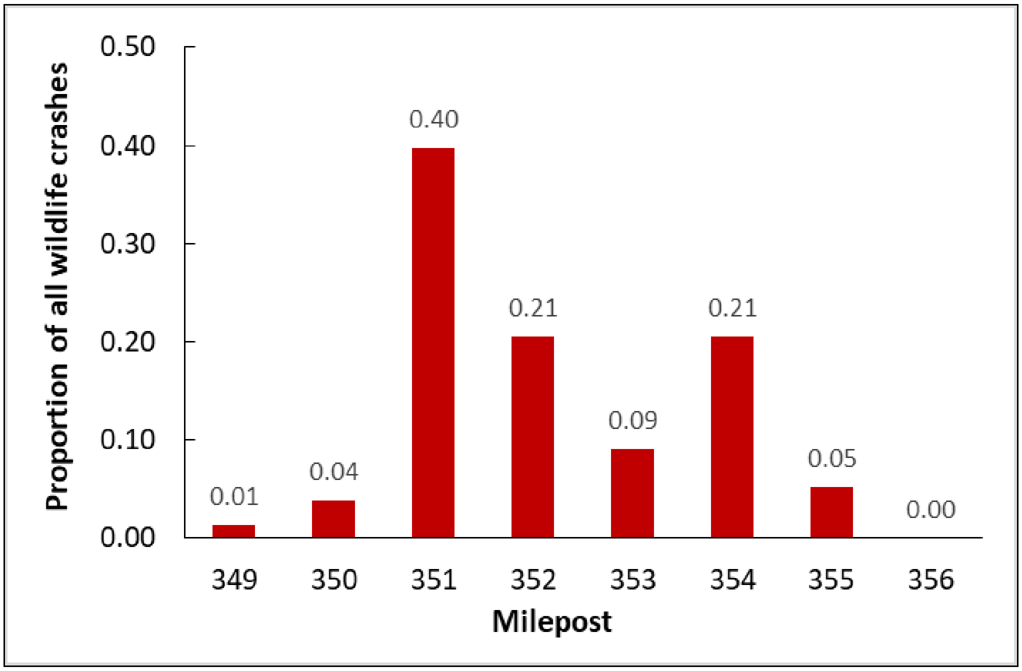


*Figure 3- 43. Proportion of all SR 77 Hotspot #4 WVCs by milepost (2014-2018).*

SR 77 WVC incidence exhibited monthly variation though seasonal trends were not readily apparent (Figure 3-44). The peak month for WVCs was June, typically one of the driest and hottest when animals likely were seeking water and forage along Silver and Show Low creek riparian habitats. Overall, the summer months (Jun-Aug) accounted for 33% of WVCs while spring and winter accounted for the lowest, 20% and 21%, respectively.

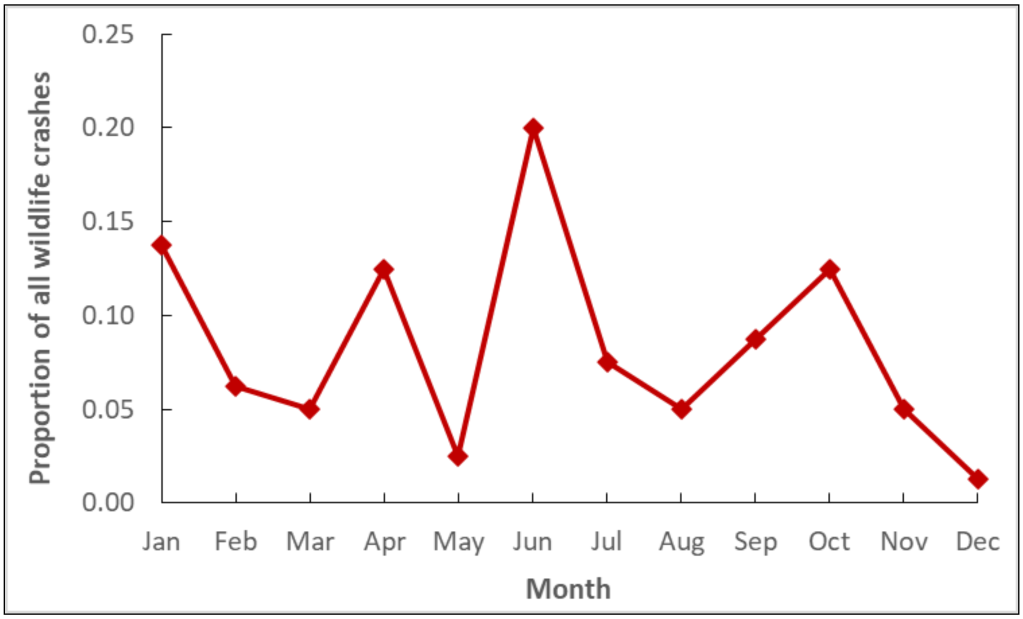


*Figure 3- 44. Monthly proportion of all WVCs that occurred along SR 77 Hotspot #4 (2014-2018).*

EXISTING DRAINAGE STRUCTURES

To evaluate drainage structures along SR 77 that could be employed as part of a retrofitting strategy to resolve wildlife-vehicle conflicts, we assessed the location and dimensions of eight structures for potential suitability as wildlife passage structures (Table 3-14, Figure 3-42). Seven structures are CBC with one large, long CMP with a concrete bottom (Table 3-14, Figure 3-45). Reflective of the width of the roadway (length of the CBC) and the relatively small dimensions of the structures, all but one of the structures' openness indices were ≤0.25; the CBC where Show Low Creek crosses SR 77 (Figure 3-46) has an index of 0.29 due to its shorter length, but still marginal for passage (Gordon and Anderson 2003). Thus, strategies to retrofit existing CBC as passage structures are limited, at best due to drainage structure unsuitability as passages.

*Table 3- 14. Existing drainage structures along SR 77 and their dimensions and openness indices.*

| MP | Structure Type | No. barrels | Width (ft) | Height (ft) | Length (ft) | Openness index* |
|---|---|---|---|---|---|---|
| 349.85 | CBC[1] | 1 | 6 | 8 | 102 | 0.14 |
| 350.90 | CMP[2] | 1 | 8-ft diameter | | 220 | |
| 351.74 | CBC | 1 | 6 | 7 | 95 | 0.13 |
| 353.35 | CBC | 1 | 10 | 8 | 114 | 0.21 |
| 353.59 | CBC | 1 | 10 | 8 | 129 | 0.19 |
| 354.37 | CBC | 3 | 10 | 8 | 84 | 0.29 |
| 355.40 | CBC | 1 | 6 | 7 | 102 | 0.13 |
| 356.14 | CBC | 1 | 6 | 7 | 97 | 0.13 |

*Width × Height / Length (metric units) [1]Concrete box culvert [2]Corrugated metal pipe

*Figure 3- 45. SR 77 Hotspot #4 drainage structures including large, corrugated metal pipe (MP 350.9; left), and CBC at MP 351.74 (center) and MP 353.35 (right). All are marginal for wildlife passage (see Table 3-14 for dimensions).*

**CONFLICT RESOLUTION STRATEGY**

Underscoring the challenging nature of resolving wildlife-vehicle conflicts on SR 77 Hotspot #4, ADOT engaged consultants in 2012 to develop a preferred alternative for widening the highway between MP 342.2 to 357.4, as part of ADOT Project No. 077 NA 342 H8140 01L. AGFD was engaged to conduct an extensive field review and provided recommendations to ADOT (in a June 7, 2012 letter) for addressing WVCs and connectivity. It is unknown what the status of this project is, as it is not included in the current

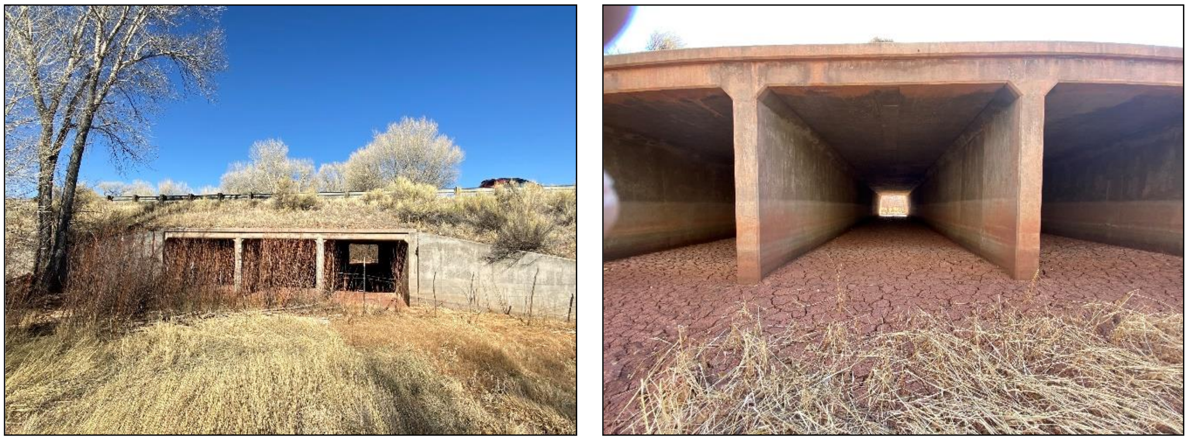

*Figure 3- 46. Three-barrel CBC drainage structure where Show Low Creek crosses SR 77 (MP 354.4), the most suitable of any structures along Hotspot #4 for wildlife passage.*

STIP. Regardless, AGFD recognized that there are limited opportunities for resolution short of reconstruction and did recommend new wildlife passage structures along the hotspot at several locations: a potential overpass at MP 350.5-7, an underpass at MP 351.7 (with existing CBC), and an underpass at 354.4 (with existing Show Low Creek CBC). We question the wisdom of constructing a wildlife underpass between MP 351 and 353 due to the conflict of funneling wildlife onto private lands to the east of SR 77, where elk-proof fence has already been erected to protect a plant nursery (Figure 3-47). Funneling wildlife to this area could result in private landowner conflicts and likely would result in the erection of additional elk-proof fence, negating efforts to promote wildlife passage.

*Figure 3- 47. Private lands east of SR 77 in the vicinity of the existing CBC at MP 351.7, where 8-foot elk fence has been erected just off the highway ROW to protect a plant nursery on private lands.*

FIELD REVIEW FINDINGS

In addition to confirming the critical juxtaposition of National Forest and private lands harboring riparian and irrigated pasture lands that draw wildlife and account for the spike in WVCs between MP 351 and 353 (Figure 3-41), we too, found that there was a suitable overpass site at MP 350.2 with Apache-Sitgreaves National Forest land on each side of the highway that is highly suitable for an overpass (Figure 3-48). An overpass here could avoid funneling wildlife directly onto private lands. While an overpass at this location would promote landscape-level connectivity, it is unlikely that wildlife movement near this location is driven by landscape movements versus wildlife use of lush private lands. Thus, a drop-in overpass at this location is not considered a priority as it relates to resolving conflicts along Hotspot #4.

Much of the peak 1.5-mile WVC stretch along the hotspot between MP 351.2 and 352.7 accounting for 60% of all WVCs is 2-lane roadway with curves where the highway is at its closest to Silver Creek in the vicinity of the community of Shumway (Figure 3-42). Line-of-sight visibility is not sufficient for full coverage associated with an open-road radar detection system.

*Figure 3- 48. Suitable site for a drop-in overpass at SR 77 MP 350.2 where the highway has already been widened to 4 lanes.*

The other peak WVC stretch along SR 77 at MP 354 coincides with where Show Low Creek intersects the highway (Figure 3-49), accounting for 20% of all WVCs. The habitat on either side of the creek is open, sparsely wooded grassland constituting marginal mule deer and elk habitat. The existing CBC at Show Low Creek (MP 354.4; Figure 3-46) is the largest of all existing structures but still marginal for wildlife use, especially by elk. This WVC peak could easily be addressed with wildlife fencing to retrofit the structure at Show Low Creek were it suitable for wildlife passage; efforts to retrofit the existing structure could force animals to the fence termini and create WVC end-runs. As such, this site would be ideal for a drop-in underpass to promote passage and the resolution of WVC issues along this stretch. This site could support a 32-foot wide × 11-foot-high precast concrete arch underpass, which would have an openness index of 1.3 without altering the highway grade/profile.

*Figure 3- 49. The location along SR 77 where Show Low Creek intercepts the highway, surrounded by relatively open grassland habitats.*

RECOMMENDED CONFLICT RESOLUTION STRATEGY ACTIONS

Due to the challenges of resolving wildlife-vehicle conflicts along the hotspot due to the prevalence of private lands and coupled with the lack of options for retrofitting of existing structures, resolution options on Hotspot #4 are limited. However, with nearly 60% of all WVCs occurring within a limited 1.5-mile stretch adjacent to private lands and Silver Creek, along which the posted speed is 65 mph, we believe that a nonstructural approach (Wildlife Accident Prevention Zone) is the most viable option to address conflicts. For the limited 1-mile stretch near Show Low Creek, a similar nonstructural approach or even just enhanced signage (flashing LED) would alert motorists to the increased risk of WVC and improve reaction time to avoid collisions; a longer-term option here is to install a drop-in underpass at Show Low Creek and erect wildlife fencing.

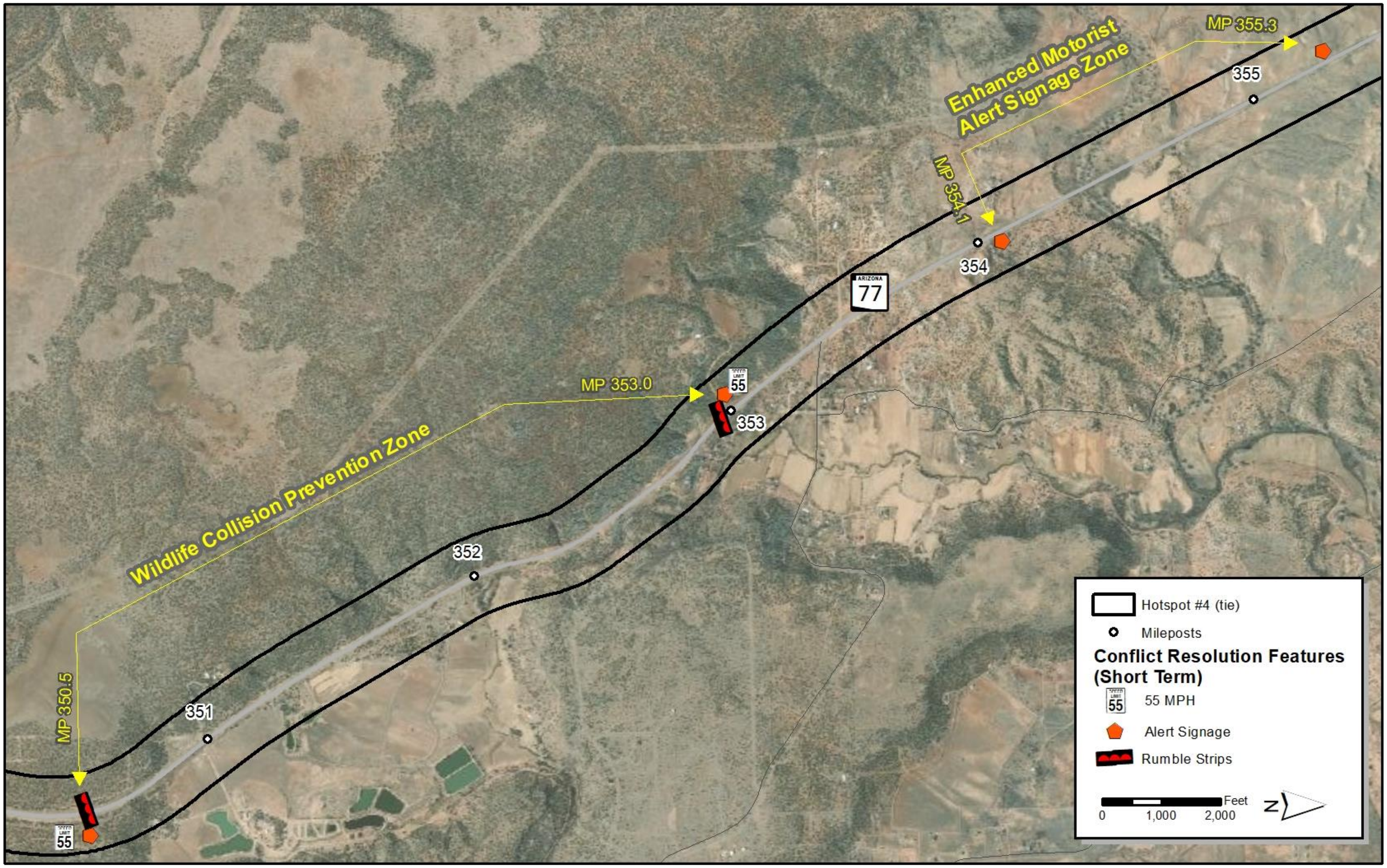


*Figure 3- 50. SR 77 Hotspot #4 short-term wildlife-vehicle conflict resolution strategy with a Wildlife Collision Prevention Zone and a section with enhanced motorist alert signage.*

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### *SHORT-TERM STRATEGY OPTIONS*

We recommend two short-term nonstructural options for ADOT consideration along the SR 77 Hotspot #4 which revolve around modifying motorist behavior (Figure 3-50, Table 3-15).

#### *WILDLIFE COLLISION PREVENTION ZONE: SIGNAGE, TRAFFIC CALMING, AND SPEED REDUCTION*

We recommend that ADOT consider options to alter motorist behavior within the limited 2.5-mile stretch adjacent to Silver Creek; this nonstructural option would be cost effective and readily implementable. It includes a combination of measures to create an experimental Wildlife Collision Prevention Zone along the stretch where WVCs account for 60% of all WVCs. The components of this option include.

- Erect innovative motorist alert signage like that used in other states and Canada to highlight WVC hotspots (Figure 3-50 and Figure 3-51); install gateway signs at the entry points to the high-incidence WVC zone between MP 350.5 and MP 353.0. The signage should be as large as possible and preferably be LED-enhanced for nighttime impact.
- Cut transverse rumble strips into the pavement at the approaches to the *Wildlife Collision Prevention Zone* in conjunction with the signage to maximize impact in raising motorist WVC risk awareness/alertness, and thus wildlife avoidance response (Figure 3-50). Ideally, additional rumble strips (1-2) should be installed at intermediate points along the zone to maintain driver awareness though the zone.
- Reduce the posted speed limit throughout the zone from 65 to 55 mph. This will increase response time and distance to allow motorists to avoid WVCs or reduce the damage from WVCs, especially through the curvy section between MP 352 and MP 353.
- Narrow the travel lanes through the zone with paint restriping to create the perception on the part of motorists that the road is narrower thus promoting lower speeds.


*Figure 3- 51. Conceptual layout for motorist alert signs at the approaches to a designated Wildlife Collision Prevention Zone; the signs should be LED-enhanced for maximum nighttime impact.*

#### *ENHANCED MOTORIST ALERT SIGNAGE*

For the limited 1-mile stretch around Show Low Creek with good line-of-sight visibility (Figure 3-49), we recommend the installation of enhanced motorist alert signage (Figure 3-52).

- Erect enhanced motorist alert signage with flashing LED lights (Figure 3-52) at MP 354.1 (crest of the hill overlooking Show Low Creek) and MP 355.3 (Figure 3-50).

*Figure 3- 52. Solar-powered sign with LED flashers at a high-incidence bison collision zone in Yellowstone National Park. Such signage is effective at nighttime hours when most WVCs occur.*

*LONG-TERM STRATEGY OPTION*

The concentrated nature of WVCs along the Show Low Creek corridor points to the need for enhanced grade-separated passage opportunities which will also allow for effective resolution of WVC concerns.

*Figure 3- 53. Installation of a drop-in precast arch wildlife underpass along SR 86 with similar dimensions to that recommended for SR 77.*

- Replace the existing Show Low Creek 3-barrel CBC (MP 354.4) with a drop-in precast concrete arch wildlife underpass (Figure 3-53 and Figure 3-54). This site can support an 11-foot-high underpass without altering the existing highway profile. With a width of 32-feet wide; this structure would improve the openness index 4.5-fold. A drop-in underpass could be constructed with limited disruption to traffic and could be expedited with express foundations. The estimated cost of an underpass would be $1.2 million (Table 3-15).
- Along with a drop-in underpass, wildlife fence should be erected along 1.2 miles of SR 77 between MP 354.1 to MP 355.3 (Figure 3-54).
- The erection of wildlife fencing along this stretch will necessitate the installation of two pairs of (4 total) wildlife escape ramps and three cattle guard extension grates (Figure 3-54).
- Static motorist alert signs should be installed at the approaches to the fence termini (MP 354.0 and MP 355.4) to alert motorists to the potential for animals crossing the highway (Figure 3-54).

**ENVIRONMENTAL OVERVIEW**

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Construction of the proposed Short Term (A) project will be confined to the existing ADOT ROW through private land and easement through ASLD lands and Apache-Sitgreaves National Forest, and the Short Term (B) and Long-Term projects will be confined to the existing ADOT ROW through private land and easement through ASLD land. The proposed Long-Term project entails a drop-in precast arch and it is assumed that no new ROW or TCEs will be needed for installation of this structure. Therefore, if NEPA is required for any of the proposed projects, they are anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: "Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way."

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of all the proposed projects. For the Short-Term projects it is recommended that these known cultural sites be avoided, though reassessment may be needed to determine the avoidance limits. For the Long-Term project survey is recommended to reassess the current location of cultural sites and determine their NRHP eligibility. A hazardous materials assessment should be performed for all proposed projects to address

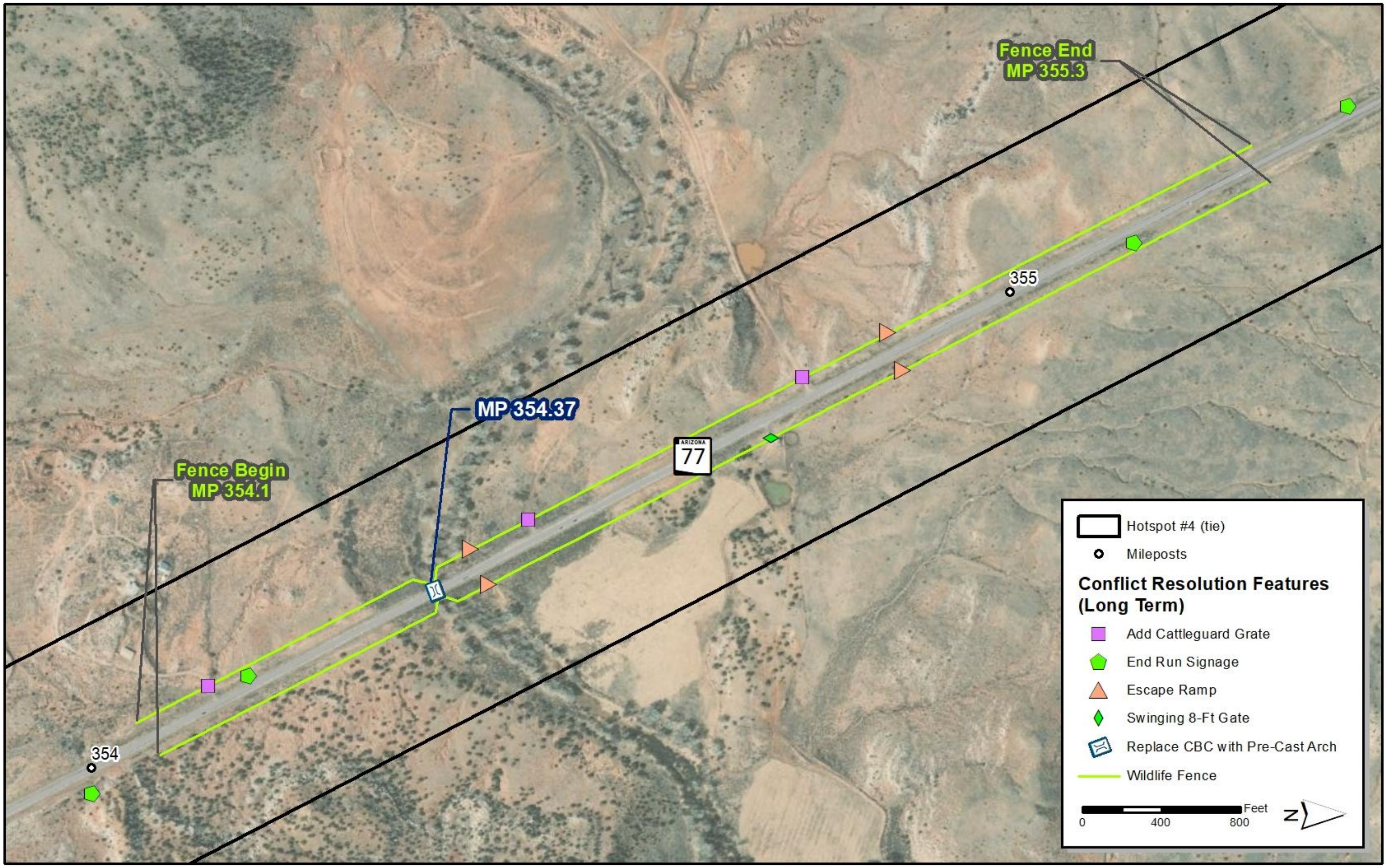


*Figure 3- 54. SR 77 Hotspot #4 long-term wildlife-vehicle conflict resolution strategy including a drop-in wildlife underpass and wildlife fencing and associated measures (cattle guards, escape ramps, alert signage).*

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*Table 3- 15. SR 77 Hotspot #4 resolution strategy components and estimated costs to address wildlife-vehicle conflicts associated with short- and long-term projects.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Short-Term Projects** | | | | |
| **Silver Creek Section (*Wildlife Collision Prevention Zone*)** | | | | |
| Motorist alert signage | Each | 2 | $10,000 | $20,000 |
| Speed limit signs | Each | 2 | $2,000 | $4,000 |
| Transverse rumble strips | Each | 2 | $10,000 | $20,000 |
| **Show Low Creek Section (Enhanced Motorist Alert Signage)** | | | | |
| Enhanced motorist alert signs | Each | 2 | $5,000 | $10,000 |
| **Short-Term Total** | | | | **$54,000** |
| **Long-Term Project (Drop-in underpass and wildlife fencing)** | | | | |
| Precast Arch Underpass | Each | 1 | $1,200,000 | $1,200,000 |
| Wildlife fence | Miles | 2.4 | $158,000 | $379,200 |
| Escape ramps | Each | 4 | $11,000 | $44,000 |
| Cattle guard grates | Each | 3 | $30,000 | $90,000 |
| Alert signage at fence ends | Each | 2 | $4,000 | $8,000 |
| **Long-Term Total** | | | | **$1,721,200** |

any potential hazardous material concerns. Additionally, hazardous materials testing will be required for the Long-Term project because of impacts to existing structures and cattleguards. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. None of the proposed projects are located within currently designated or proposed critical habitat for any species.

The Long-Term project will impact an existing culvert at MP 354.37 which may provide habitat to roosting bats or nesting birds federally protected by the MBTA. Further investigation of this structure will be necessary during the project environmental clearance, and avoidance or species exclusion mitigations may be warranted. Additionally, the existing culvert at MP 354.37 conveys flow from an unnamed ephemeral tributary to Silver Creek. Jurisdictional status of this unnamed ephemeral tributary will need to be determined as part of the environmental clearance to identify whether the proposed Long-Term project will impact WOTUS and therefore require a CWA Section 404 permit and Section 401 water quality certification.

Gordon, K. M., and S. H. Anderson. 2003. Mule deer use of underpasses in western and southeastern Wyoming. *In* 2003 Proceedings of the International Conference on Ecology and Transportation, Center for Transportation and the Environment, North Carolina State University, Raleigh.

## HOTSPOT #6: STATE ROUTE 260 - HEBER TO SHOW LOW (MP 309.0-339.0)

The 30-mile SR 260 Hotspot #6 is the longest modeled hotspot in the state, stretching from just east of Heber (Overgaard) to Show Low. It is one of the main highway corridors between Phoenix and the White Mountains. Much of the hotspot traverses the area burned by the 2002 Rodeo-Chediski Fire that consumed 468,638-acres of Ponderosa pine and juniper woodland forests, enhancing mule deer and elk foraging habitat adjacent to the highway. As a result, the deer population has increased 5-fold in the area (Gagnon et al. 2017), as have WVCs (Figure 3-55). Adding to the wildlife-vehicle conflict where 70% of all accidents involve WVCs, the highway traverses the transition zone between summer and winter ranges to which deer and elk move seasonally. Several ephemeral drainages also serve as wildlife movement corridors.

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 338

**WVCs/mile/year:** 2.25

**WVC percentage of all crashes:** 70.4%

**2018 WVC species composition** (67 WVC)**:** Mule deer – 51% Elk – 48% Black bear – 1%

**AADT:** 13,436 vehicles/day

Since the Rodeo-Chediski Fire burned in 2002, SR 260 WVC incidence has increased over 3-fold from an average of 27.8 WVCs/year between 2003-2008 to 88.3 WVCs/year between 2016-2018 (Figure 3-55). This underscores the urgent need to develop and implement strategies, short of full highway reconstruction to mitigate the impact of increasing WVCs.

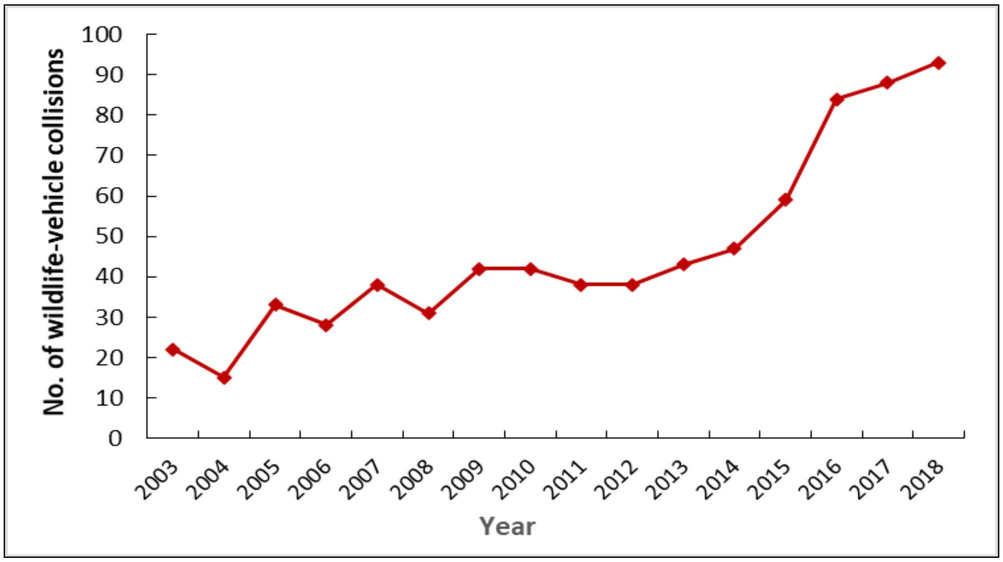


*Figure 3- 55. Annual incidence of WVCs along SR 260 Hotspot #6 (2003-2018).*

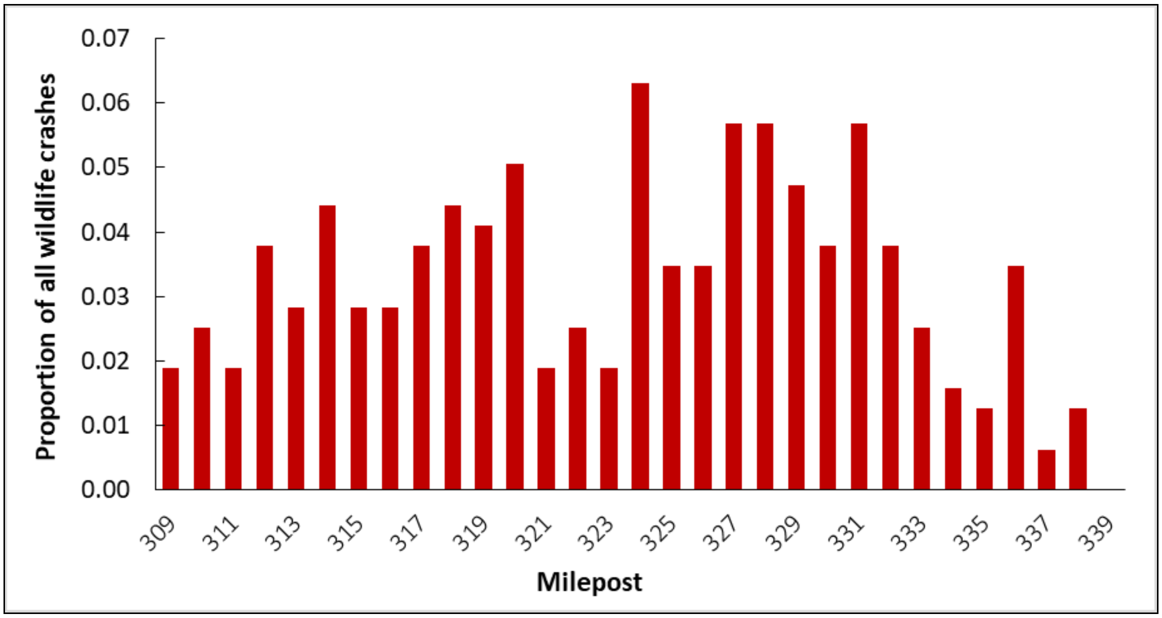


*Figure 3- 56. Proportion of all SR 260 Hotspot #6 WVC by milepost (2014-2018).*

With an average proportion of all hotspot WVCs per mile section (MP) of 3%, over half the MP exhibited average or higher proportion of WVCs, reflecting the relatively even distribution across the hotspot. The proportion of all WVCs by MP ranged from 0-0.06 (Figures 3-56 and 3-58).

SR 260 WVC incidence exhibited bimodal seasonal peaks in June, the hottest and driest month and October (Figure 3-57); each month accounted for 14% of crashes; the spring months (Feb-May) had the lowest WVC incidence, accounting for just 21% of all WVCs (Figure 3-57).

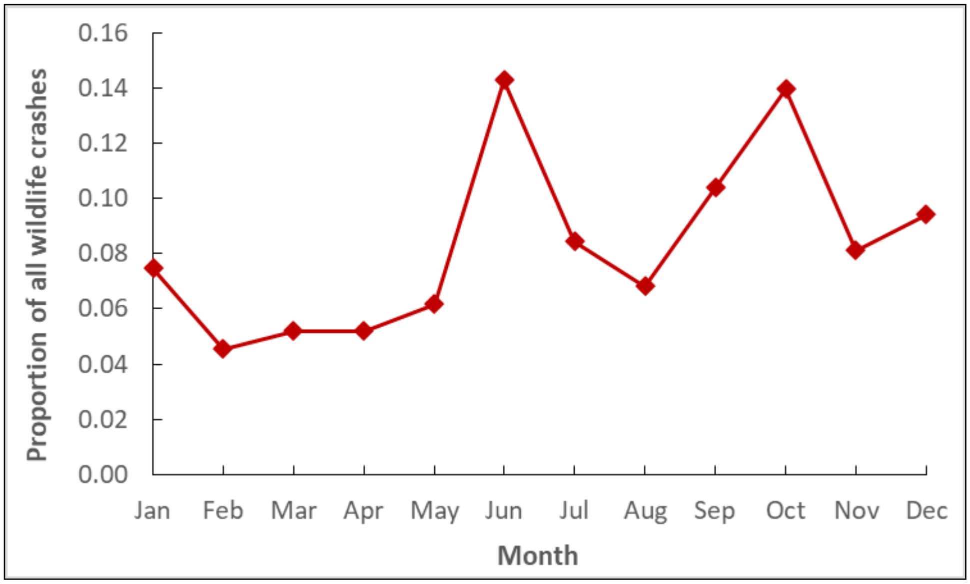


*Figure 3- 57. Monthly proportion of all WVCs that occurred along SR 260. Hotspot #6 (2014-2018).*

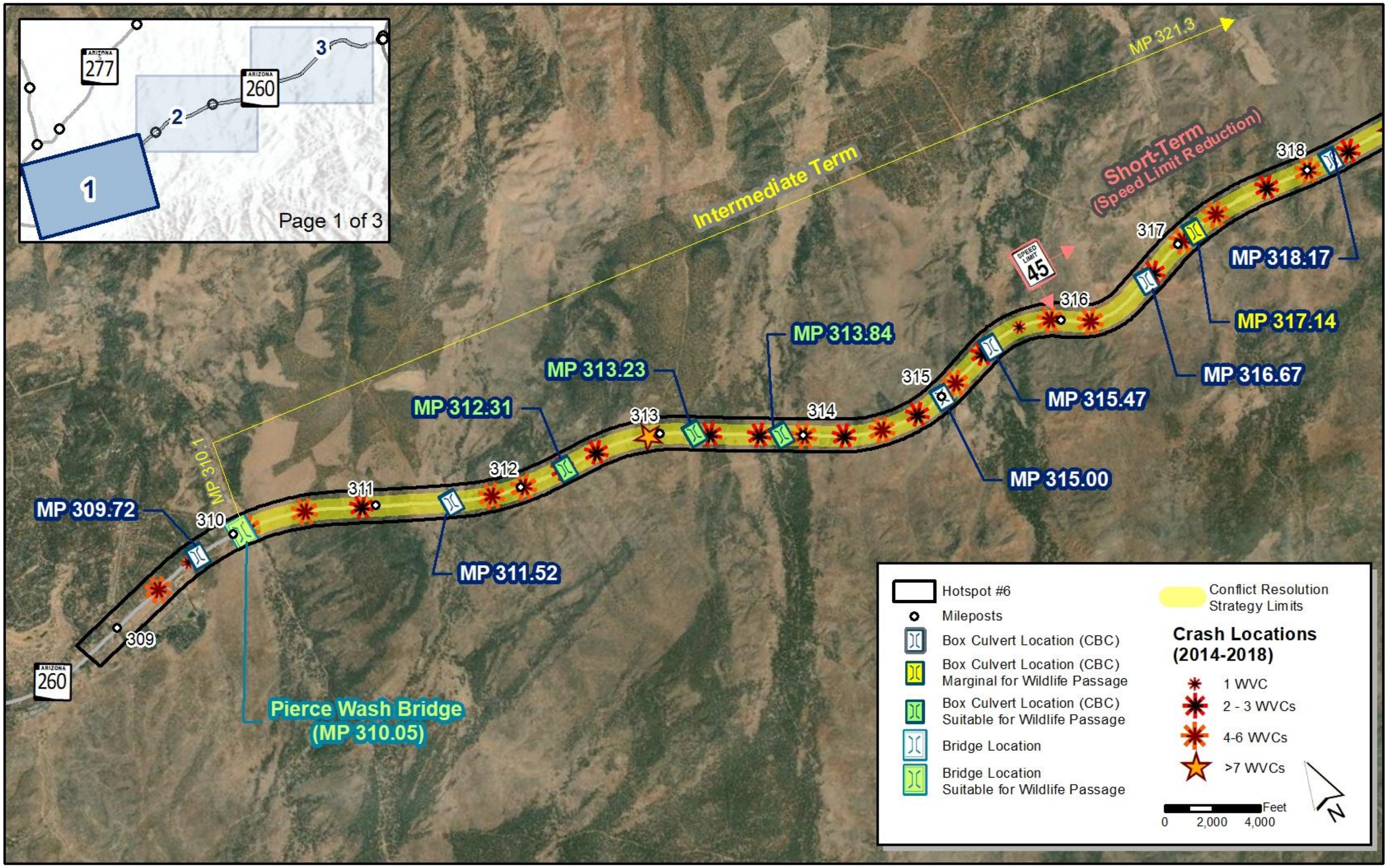


*Figure 3- 58 (1 of 3). WVC locations that occurred along the western portion of SR 260 Hotspot #6 between 2014-2018, existing drainage structures and bridges including those suitable for wildlife passage, and conflict resolution strategy limits and projects.*

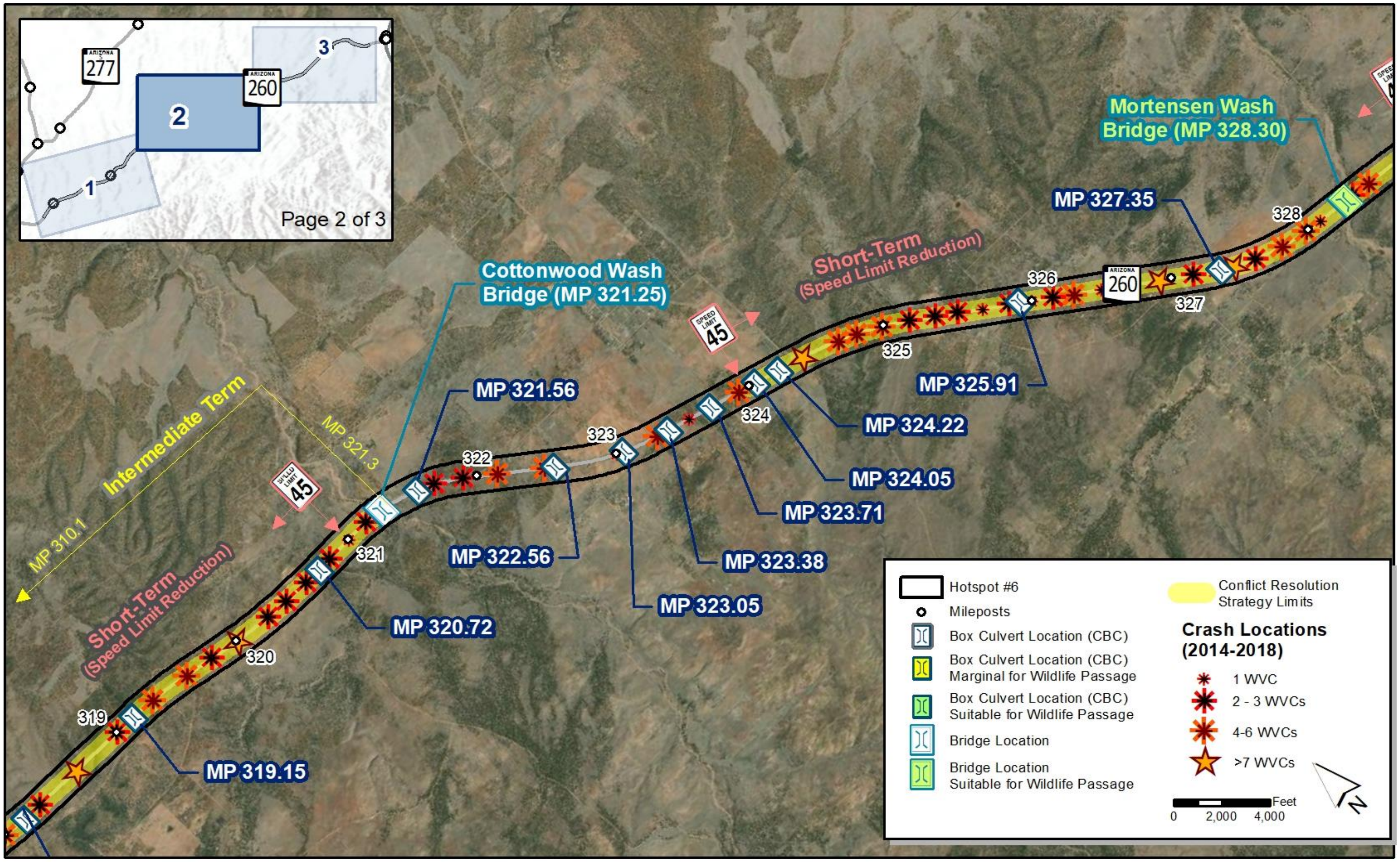


*Figure 3-58 (2 of 3). WVC locations that occurred along the central portion of SR 260 Hotspot #6 between 2014-2018, existing drainage structures and bridges including those suitable for wildlife passage, and conflict resolution strategy limits and projects.*

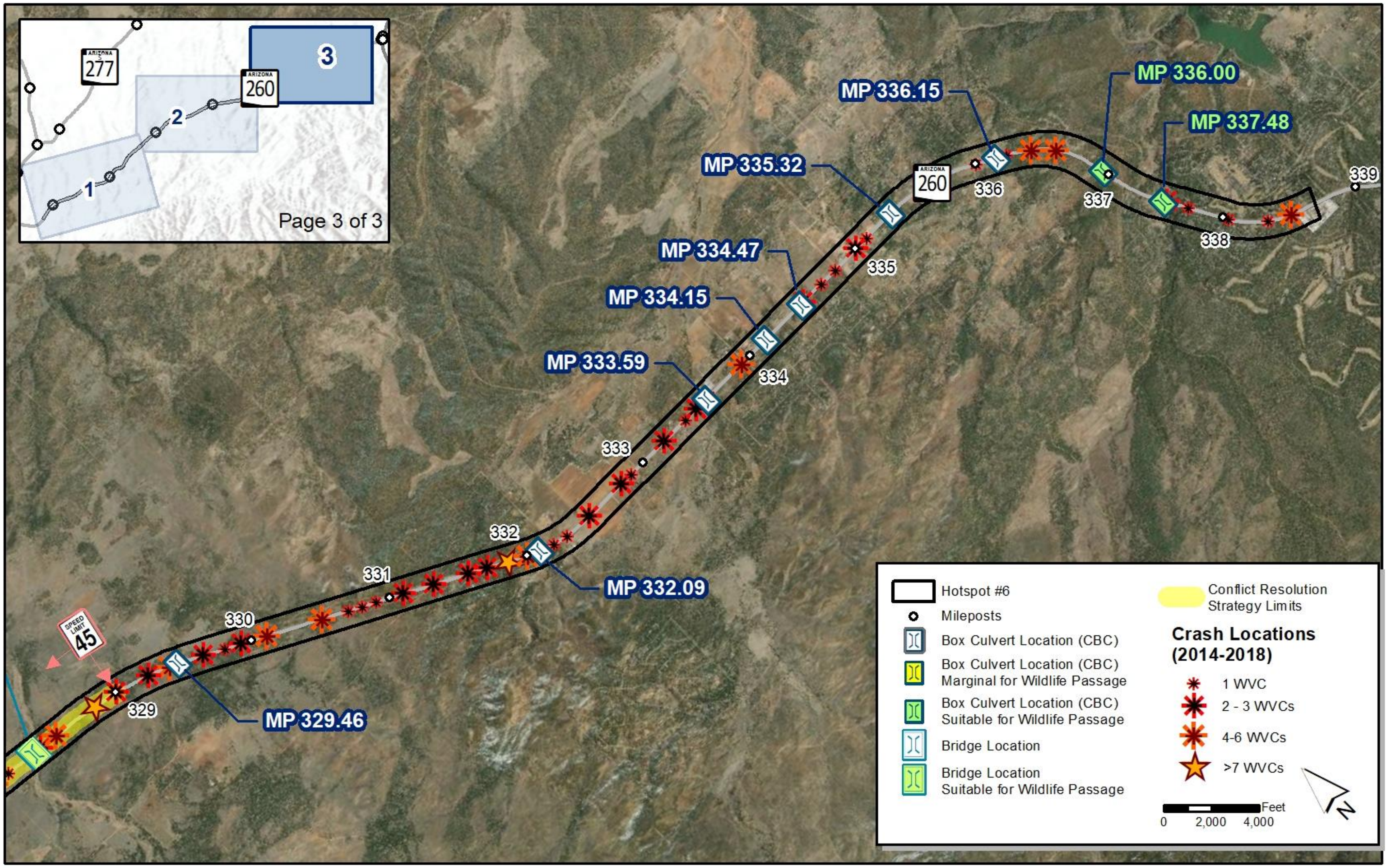


*Figure 3-58 (3 of 3). WVC locations that occurred along the eastern portion of SR 260 Hotspot #6 between 2014-2018, existing drainage structures and bridges including those suitable for wildlife passage, and conflict resolution strategy limits and projects.*

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### CONFLICT RESOLUTION STRATEGY

To address WVC safety and traffic concerns, ADOT pursued a Design Concept Report (Project No. 260 NA 309 H7254 01L; ADOT 2014*b*) for reconstruction of SR 260 from Overgaard to Show Low. A Technical Advisory Committee compiled a list of 16 possible locations for wildlife passage structures based on historic WVC data, topography, existing drainage structures; it narrowed the list to nine preliminary locations based on cost, feasibility, and spacing (ADOT 2014*b*). The TAC also recommended a site-specific elk and deer movement study to validate recommendations to reduce WVCs and promote permeability. ADOT commissioned AGFD to assess WVC patterns and elk and mule deer movements with GPS telemetry. AGFD's study stretched 60 miles from MP 280 to MP 340, encompassing the entirety of Hotspot #6.

Gagnon et al.'s (2017) recommendations for the hotspot included seven to eight underpasses and two to three overpasses (an alternative for either was identified at one site; Table 3-16, Figure 3-59); these recommendations were incorporated into ADOT (2014) as Appendix H. These recommended 10 passage structure locations would provide for average spacing of 3.0 miles. Wildlife fencing was recommended between MP 309.5 and 333.6 (Figure 3-59). Of the eight existing structures, three bridges are very suitable to accommodate wildlife passage (openness indices >3.5) with retrofitting, while a fourth (Decker Wash CBC) is marginal but would likely accommodate deer passage with fencing (Figure 3-60).

*Table 3- 16. SR 260 Hotspot #6 wildlife passage structure locations recommended by Gagnon et al. (2017) by type, dimensions, openness indices, and passage suitability (Figure 3-59).*

| MP | Geographic feature | Structure type | Existing structure | Suitable for passage | Largest cell dimensions | | | Openness Index* |
|---|---|---|---|---|---|---|---|---|
| | | | | | Width (ft) | Height (ft) | Length (ft) | |
| 310.1 | Pierce Wash | Underpass | Yes | Yes | 27 | 15 | 35 | 3.53 |
| 312.3 | Unnamed wash | Underpass | Yes | No | 10 | 10 | 122 | 0.25 |
| 313.8 | Decker Wash | Underpass | Yes | Yes | 10 | 12 | 76 | 0.48 |
| 315.5 | Cut slope | Overpass | No | N/A | | | | |
| 318.2 | Bagnal Wash | Underpass | Yes | No | 8 | 10 | 139 | 0.18 |
| 319.3 | Cut slope | Overpass | No | N/A | | | | |
| 321.3 | Cottonwood Wash | Underpass | Yes | Yes | 60 | 9 | 38 | 4.33 |
| 324.6 or 325.9 | Cut slope | Overpass | No | N/A | | | | |
| | Unnamed wash | Underpass | Yes | No | 8-ft CMP** | | 254 | 0.03 |
| 328.3 | Mortensen Wash | Underpass | Yes | Yes | 80 | 15 | 40 | 9.14 |
| 329.5 | Colbath Wash | Underpass | Yes | No | 8-ft CMP** | | 254 | 0.03 |

*Width × Height / Length (metric values) **Corrugated metal pipe

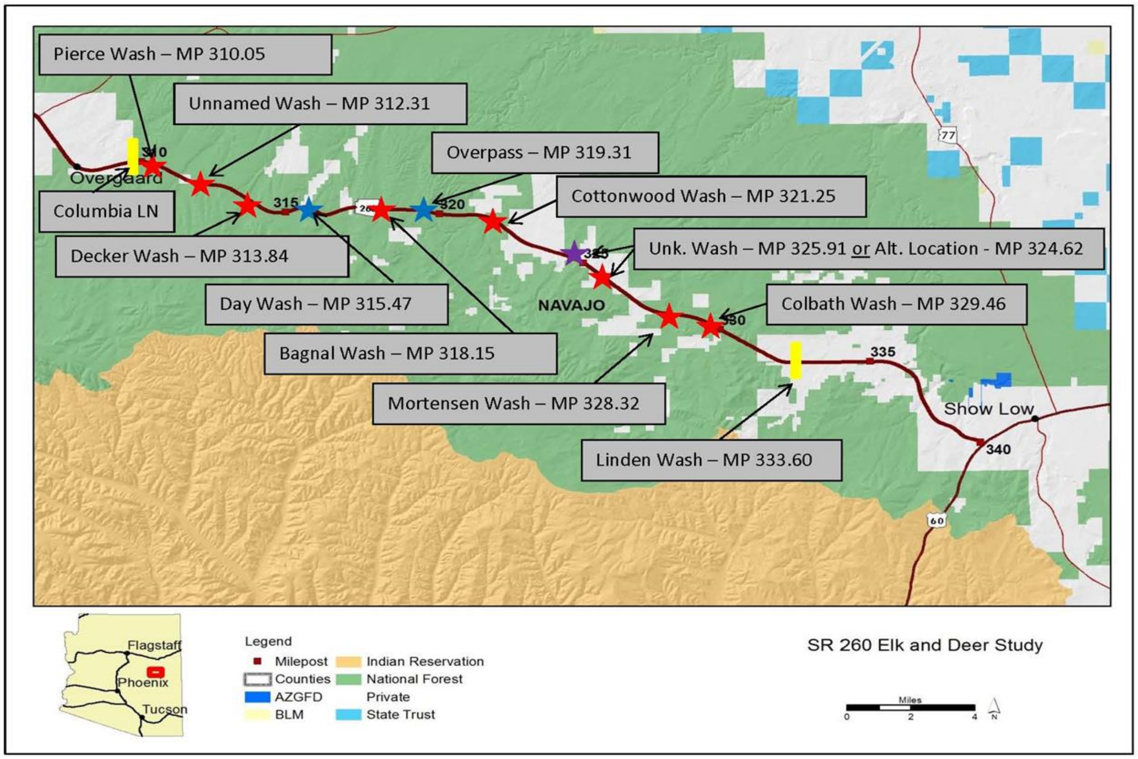


*Figure 3- 59. Wildlife passage structures (red underpasses/blue overpass) and the ends of wildlife fencing (yellow bars) recommended for SR 260 Hotspot #6 (Gagnon et al. 2017).*


*Figure 3- 60. Existing SR 260 structures suitable for wildlife passage: Pierce (A), Decker (B), Cottonwood (C), and Mortensen (D) wash bridges (from Gagnon et al. 2017).*

EXISTING DRAINAGE STRUCTURES

In addition to the existing structures in Table 3-16, we evaluated the potential for retrofitting 24 existing drainage structures, all concrete box culverts (CBC) spread across the hotspot. Reflective of the width of the roadway (length of the culverts) and their relatively small dimensions, most openness indices are low (≤0.30: Table 3-17). However, there are three structure openness indices >0.35, two which are relatively short that could be suitable for wildlife passage with fencing, especially for mule deer (Table 3-17).

*Table 3- 17. Existing concrete box culvert structures along SR 260 Hotspot #6 by number of barrels, dimensions, and openness indices, and whether they may be suitable for wildlife passage with retrofitting.*

| MP | Structure type | No. barrels | Width (ft) | Height (ft) | Length (ft) | Openness index* | Suitable for Passage |
|---|---|---|---|---|---|---|---|
| 309.7 | CBC | 2 | 8 | 7 | 52 | 0.33 | No |
| 311.5 | CBC | 6 | 10 | 8 | 77 | 0.32 | No |
| 313.2 | CBC | 1 | 10 | 8 | 62 | 0.39 | Yes |
| 315.0 | CBC | 1 | 10 | 6 | 83 | 0.22 | No |
| 315.5 | CBC | 4 | 10 | 8 | 108 | 0.23 | No |
| 316.7 | CBC | 2 | 8 | 7 | 135 | 0.13 | No |
| 317.1 | CBC | 2 | 12 | 12 | 127 | 0.35 | Marginal |
| 319.2 | CBC | 1 | 10 | 8 | 91 | 0.27 | No |
| 320.7 | CBC | 1 | 10 | 8 | 85 | 0.29 | No |
| 321.6 | CBC | 1 | 10 | 8 | 85 | 0.29 | No |
| 322.6 | CBC | 1 | 10 | 8 | 86 | 0.28 | No |
| 323.1 | CBC | 1 | 10 | 8 | 86 | 0.28 | No |
| 323.4 | CBC | 1 | 10 | 8 | 84 | 0.29 | No |
| 323.7 | CBC | 1 | 10 | 8 | 84 | 0.29 | No |
| 324.0 | CBC | 1 | 10 | 8 | 85 | 0.29 | No |
| 324.2 | CBC | 3 | 10 | 5 | 98 | 0.16 | No |
| 327.4 | CBC | 1 | 10 | 8 | 88 | 0.28 | No |
| 333.6 | CBC | 3 | 10 | 8 | 97 | 0.25 | No |
| 334.1 | CBC | 1 | 6 | 7 | 57 | 0.22 | No |
| 334.5 | CBC | 1 | 8 | 5 | 92 | 0.13 | No |
| 335.3 | CBC | 1 | 6 | 4 | 131 | 0.06 | No |
| 336.1 | CBC | 2 | 10 | 8 | 68 | 0.36 | Yes |
| 337.0 | CBC | 1 | 10 | 8 | 72 | 0.34 | No |
| 337.5 | CBC | 2 | 12 | 12 | 112 | 0.39 | Yes |

PAST HOTSPOT WILDLIFE-VEHICLE CONFLICT RESOLUTION EFFORTS

The difficulty in addressing the wildlife-vehicle conflicts associated with increasing WVCs along Hotspot #6 following the Rodeo-Chediski Fire were recognized soon after the fire, when ADOT had secured potential Federal Emergency Management Agency funding to erect wildlife fencing to prevent what was then anticipated to be an increase in post-fire WVCs. ADOT evaluated options for fencing in 2003, which was deemed questionable without adequate means to accommodate passage and could create a barrier to ungulate movement between summer and winter ranges. As an alternative, SWAREFLEX reflectors (Figure 3-61) were installed along a 7-mile stretch between MP 312-319; the reflectors project a “visual fence” that animals perceive as a barrier when vehicles pass at nighttime. However, a 10-year comparison of WVC incidence for the treated section and adjacent similar (burned) untreated sections was done in 2014. It found that WVC were statistically higher in the treated versus untreated sections, and that WVC incidence increased steadily over the 10-year period (as reflected in Figure 3-55).

*Figure 3- 61. SWAREFLEX wildlife warning reflectors along Hotspot #6, showing the installation location adjacent to the roadway to limit snowplow damage (left) and a closeup of a reflector mounted on a delineator post (right).*

The same challenges to finding resolution of WVC conflicts faced in 2003 remain today. With just a total of six existing, potentially suitable structures that could be integrated into retrofit fencing options in 30 miles (Table 3-16 and Table 3-17) average passage structure spacing would be five miles, double the desired spacing. Add to this the highway stretches crossing through human development around Clay Springs to Pinedale (MP 322-327) and Linden to Show Low (MP 332-339), each with numerous driveways and side roads necessitating dozens of cattle guards if fencing were erected.

Even the best case, least-developed 11.2-mile section of the hotspot with half the existing potentially suitable structures between MP 310.1-321.3 (Pierce Wash to Cottonwood Wash; average spacing 5.6 miles) would necessitate a minimum of 16 cattle guard grates and 15 gates costing $500,000, 36 escape ramps at $270,000, and nearly $3,000,000 for wildlife fence. To provide even a reasonable level of average spacing (3 miles), two of the AGFD-recommended drop-in overpasses are needed, costing approximately $2,250,000 each. The total cost to address 42% of the hotspot’s WVC would cost over $8.2 million; fencing alone would cost $3.7 million.

Applications of animal detection technology are limited along the hotspot due to its extensive length, relatively uniform WVC distribution, and winding and undulating nature of the highway, though there likely are stretches where line-of-sight visibility approaches two miles. While we recommended *Wildlife Collision Reduction Zones* for other highway hotspots (SR 64, SR 77, US 89), these applications are limited to peak WVC areas less than 2.5 miles in length. Modifying motorist behavior over a near-continuous 30-mile hotspot is unrealistic and unlikely to sustain driver alertness.

## EXPERIMENTAL DUSK/NIGHTTIME SPEED REDUCTION

Increased motorist alertness can reduce vehicle stopping distances by as much as 68 feet at 55 mph, enough to avoid or reduce the severity of WVCs (Huijser et al., 2009*b*). The risk of WVCs increases exponentially with increasing vehicular speed (Kloden et al. 1997). Increasing motorist alertness and vehicular speed can result in meaningful reductions in WVC incidence (Huijser et al. 2009*b*). According to Gagnon et al. (2017), over 80% of SR 260 WVCs occurred during the 13-hour dusk/nighttime period (18:00-06:00 hours) compared to less than 20% during the 11-hour daytime period (07:00-17:00 hours; Figure 3-62). According to the Federal Highway Administration (FHWA; 2012), nighttime speed limits can be established on highways where safety issues require a lower speed than those set for daytime. This includes *"….roads crossing the routes and movement patterns of large-sized, nocturnal wildlife*." As such, we surmised that a reduced posted speed limit for the 13-hour dusk/nighttime period could reduce SR 260 WVC incidence.

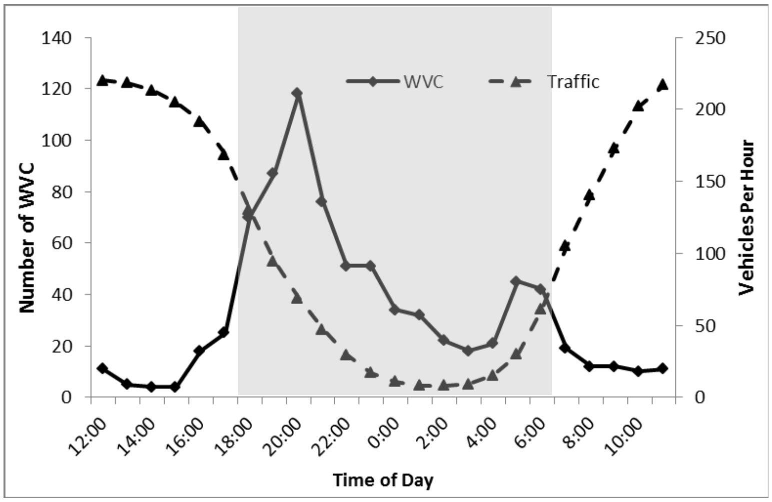


*Figure 3- 62. Incidence of WVCs on the Hotspot #6 portion of SR 260 (solid line) and traffic volume (dashed line) by hour (from Gagnon et al. 2017). The shaded 13-hour dusk/nighttime period accounting for over 80% of WVCs has been added.*

However, in Wyoming, Riginos et al. (2019) evaluated nighttime speed reduction to reduce WVC incidence on high-speed rural 2-lane highways, finding it ineffective in reducing WVCs and motorist speeds (from the daytime 70 mph to nighttime 55 mph); study sections averaged approximately 10 miles. While recommending against this approach to reducing WVC on similar highways, they did acknowledge that the use of electronic digital signage could be more effective than the stacked daytime/nighttime speed limit static signs (Figure 3-63) that they hypothesized might have been confusing to motorists. Further, they made the caveat that If a project's objective is to obtain more data on the possible


*Figure 3- 63. Static stacked daytime/ nighttime speed limit signs.*

benefits of reduced speed limits where crossing structures are not possible and enhanced (e.g., digital) seasonal signage is used, further applications could be justified.

As such, we propose that an experimental application of reduced speed limit zones be implemented and evaluated, employing these elements: 1) electronic digital variable speed limit signs (Figure 3-64) along two 5-mile peak WVC stretches that combined account for 45% of all hotspot WVCs, and 2) initially limiting nighttime speed limits to the peak 5-month period (June-October) accounting for 55% of all collisions and the highest traffic volume.


*Figure 3- 64. Electronic variable speed limit sign to establish dusk/nighttime speed limits; signs can be solar powered (from Solar Traffic Systems, Inc.)*

## RECOMMENDED CONFLICT RESOLUTION PROJECTS

We propose two wildlife-vehicle conflict resolution project packages for ADOT consideration: 1) an experimental nonstructural project establishing seasonal differential daytime and dusk/nighttime speed limits, and 2) a structural/fencing project with wildlife fencing of the most suitable portion of the hotspot and construction of two drop-in overpasses.

### *SHORT-TERM EXPERIMENTAL PROJECT (SEASONAL DUSK/NIGHTTIME SPEED LIMIT REDUCTION)*

- We recommend the installation of gateway signs (Figure 3-65) at each end of the hotspot (e.g., MP 309.5 and MP 337.5) to alert that the entire 28 mile-section is a wildlife corridor (Figure 3-58). We recognize such signage is not place- or time-specific yet it provides an introductory alert to motorists that will be followed with place-specific alerts and measures as they enter peak WVC zones.
- Implement two 5-mile seasonal speed reduction zones within peak WVC sections (Figure 3-58):
    - MP 316.0 - MP 321.0 (20% of all WVC)
    - MP 324.0 - MP 329.0 (25% of all WVC)
- Erect fold-down gateway information signs Figure 3-66) in advance of the speed-reduction zones to be opened from June 1st to October 31st each year.
- Within these zones, install at least four new electronic digital variable speed limit signs (Figure 3-64), one each at the ends of the speed reduction zones and two in the center (Figure 3-58).
- Narrow the travel lanes through the zone with paint restriping to create the perception on the part of motorists that the road is narrower thus promoting lower speeds.


*Figure 3- 65. Conceptual motorist alert gateway sign for hotspot end points.*


*Figure 3- 66. Conceptual seasonal fold-down motorist alert gateway sign for speed reduction zones.*

- Monitor the effectiveness of the speed reduction signage for a period of two years to decide whether to keep signage in place, expand to other peak sections, or to discontinue the experimental project.

*INTERMEDIATE-TERM PROJECT (WILDLIFE FENCING AND DROP-IN OVERPASS)*

- We recommend fencing an 11.2-mile section (MP 310.1-MP 321.3; Figure 3-67, Table 3-18) of the hotspot with wildlife fence to funnel wildlife to three existing potentially suitable passage structures (Pierce, Decker, and Cottonwood wash bridges). Fencing this stretch would address 42% of all hotspot WVC.
- As this fence linking existing passage structures would result in an excessive average passage spacing of 5.6 miles, we recommend the installation of two drop-in overpasses at MP315.5 and MP 319.3 (Figure 3-67, Table 3-18), as recommended by Gagnon et al. (2017); this would improve average spacing to 3.0 miles. Overpasses would need to be designed at the locations to ensure there is no conflict with future highway reconstruction.
- The erection of wildlife fence along 11.2 miles of Hotspot #6 would necessitate at least 18 pairs (36 total) of evenly spaced escape ramps, and 16 cattle guard grates and 15 gates at existing lateral access points (Table 3-18).
- At the fence ends which tie into bridge abutments, we recommend that enhanced motorist alert signage (flashing LED) be erected at the approaches to fence termini (Figure 3-67, Table 3-19) to alert motorists to the increased potential for crossing animals.

**ENVIRONMENTAL OVERVIEW**

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Construction of the proposed Short-Term project will be confined to the existing ADOT ROW through private land and easement through Apache-Sitgreaves National Forest. If NEPA is required for the proposed Short-Term project, this project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: “Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way.” The proposed Intermediate Term project recommends two overpass structures which may require TCEs from Apache-Sitgreaves National Forest. If NEPA is required and TCEs are needed for the proposed overpasses, then the Intermediate project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)23(i): “Federally funded project that received less than $5,000,000…” rather than C-list (c)22: “Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way.”

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of both proposed projects. For the Short-Term project it is recommended that these known cultural sites be avoided, though reassessment may be needed to determine the avoidance limits. For the Intermediate Term project survey is recommended to reassess the current location of cultural sites and determine their NRHP eligibility. A hazardous materials assessment should be performed for both proposed projects to address any potential hazardous material concerns. Additionally, hazardous materials testing will be required for the Intermediate Term project because of impacts to existing structures and cattleguards.

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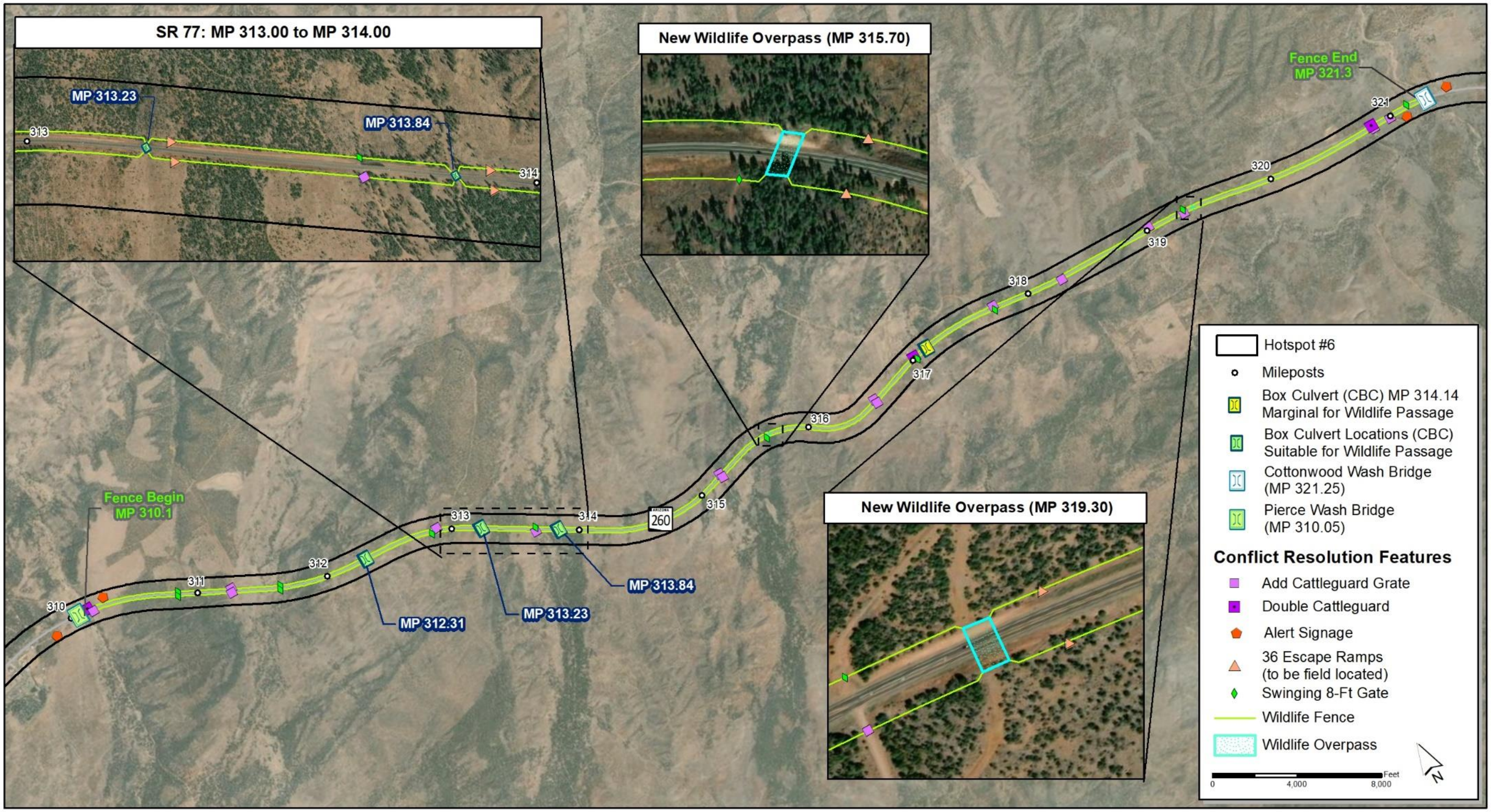


*Figure 3- 67. SR 260 Hotspot #6 intermediate-term structural/wildlife fencing conflict resolution project including 2 drop-in wildlife overpasses and wildlife fencing (with associated escape ramps, cattle guard grates, and gates) linking them to suitable existing bridges, with motorist alert signage at fence termini.*

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*Table 3- 18. SR 260 Hotspot #6 conflict resolution strategy estimated costs by proposed conflict resolution projects.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Short-Term Project (Seasonal Dusk/Nighttime Speed Limit Zones)** | | | | |
| Electronic digital variable speed limit signs | Each | 8 | $4,500 | $36,000 |
| Gateway motorist alert signage | Each | 6 | $10,000 | $60,000 |
| **Total** | | | | **$96,000** |
| **Intermediate-Term Project (Drop-In Overpasses and Wildlife Fencing)** | | | | |
| Precast concrete overpasses | Each | 2 | $2,500,000 | $5,000,000 |
| Wildlife fence | Miles | 22.4 | $158,000 | $3,539,200 |
| Escape ramps | Each | 36 | $11,000 | $396,000 |
| Cattle guard extension grates | Each | 4 | $30,000 | $120,000 |
| Double-wide gates | Each | 4 | $2,500 | $10,000 |
| Enhanced alert signage | Each | 4 | $4,000 | $16,000 |
| **Total** | | | | **$9,081,200** |

During the environmental clearance process for both proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. Neither of the proposed projects are located within currently designated or proposed critical habitat for any species. For the Intermediate Term project, wildlife fencing will tie into several existing structures which may provide habitat to roosting bats or nesting birds that are federally protected by the MBTA. Further investigation will be necessary during the environmental clearance, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required for either of the projects.

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## HOTSPOT #7: INTERSTATE 17 (MP 321.0-338.2)

Hotspot #7 spans a 17.2-mile stretch of I-17 south of Flagstaff, the main transportation corridor between Phoenix and northern Arizona. This portion of I-17 has been addressed by a Wildlife Accident Reduction/Initial Design Concept Report (IDCR; Stanley Consultants 2011) and a follow-up wildlife movements and wildlife DCR (Gagnon et al. 2013), both commissioned by ADOT. These efforts form the basis for our conflict resolution strategy.

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 187

**WVCs/mile/year:** 2.17

**WVC percentage of all crashes:** 26.8%

**2018 WVC species composition** (27 WVC)**:** Elk - 52% Mule deer – 44% Black bear – 4%

**AADT:** 31,544 vehicles/day

The proportion of all WVCs that occurred by MP within the hotspot ranged from 0-0.12 (Figure 3-68 and Figure 3-69). WVC peaks generally correspond to meadow/riparian habitats (Gagnon et al. 2013).

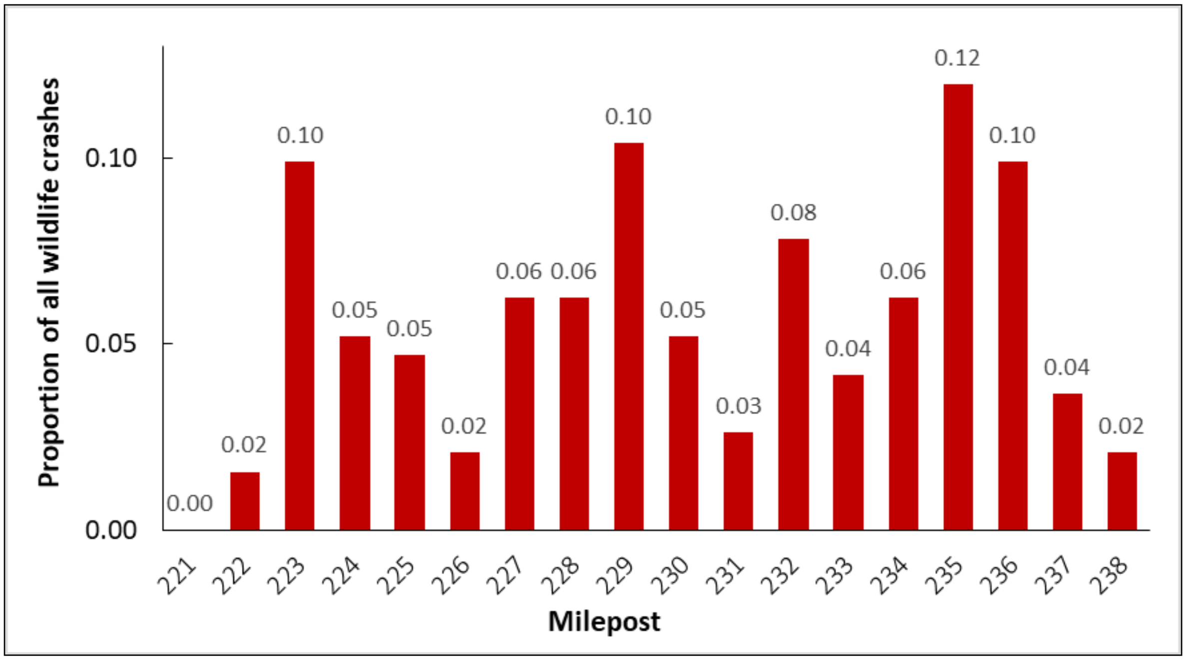


*Figure 3- 68. Proportion of all I-17 Hotspot #7 WVCs by milepost (2014-2018).*

I-17 WVC incidence varied by season, with a marked peak in June, the driest and warmest month (Figure 3-70). The 4-month (late-spring and summer) period between May and August accounted for 59% of all collisions, while the 4-month (winter and early-spring) period between December and March accounted for only 12% of all WVC (Figure 3-70).

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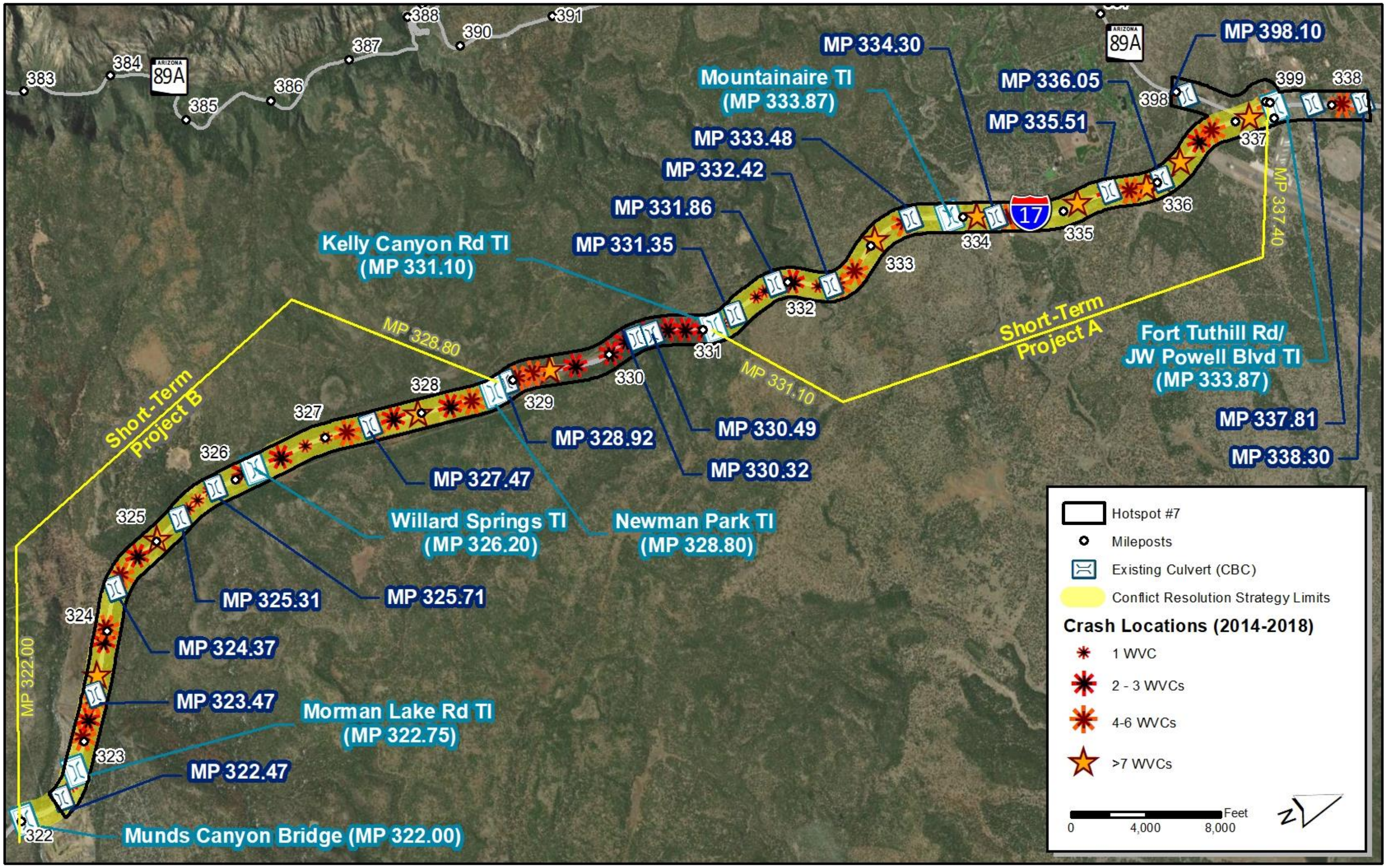


*Figure 3- 69. I-17 Hotspot #7 showing WVC locations occurring between 2014-2018, existing drainage structures, and the portion of the hotspot addressed with a conflict resolution projects.*

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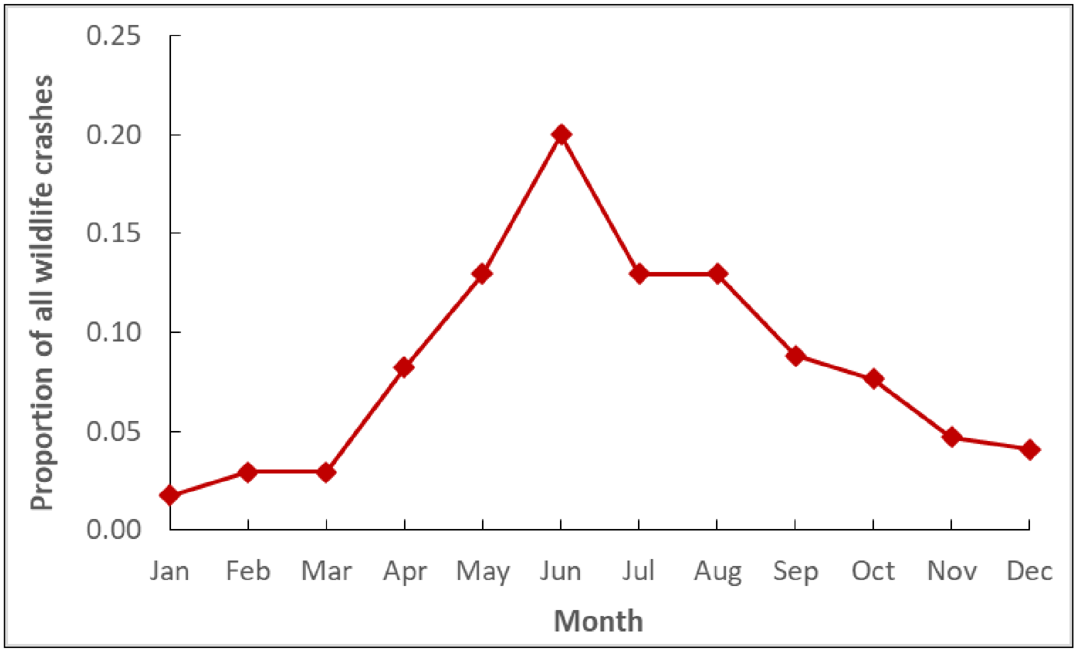


*Figure 3- 70. Monthly proportion of all WVCs that occurred along I-17 (2014-2018).*

PRIOR EFFORTS TO IDENTIFY AND RESOLVE WILDLIFE-VEHICLE CONFLICT

*INITIAL DCR AND WILDLIFE MOVEMENT STUDY AND WILDLIFE DCR STUDIES*

As part of its evaluation of the long-range reconstruction of the northern portion of I-17 to address traffic volume and highway safety issues, ADOT commissioned the development of a Wildlife Accident Reduction Study (WARS). This project (ADOT Project No. 17 YV 298 H6960 01L; Federal Project No. NH-017-B [AUC]; Stanley Consultants, Inc. 2011) was intended to address planned I-17 reconstruction between SR 179 and the I-40 junction. This WARS analyzed WVC data, and along with other information evaluated 22 potential wildlife passage structure sites for inclusion in future I-17 reconstruction; these were then addressed in a Draft Environmental Assessment (ADOT 2011). ADOT commissioned AGFD to conduct a follow-up assessment of WVC patterns and elk movements and crossing patterns (GPS telemetry) to develop data-driven mitigation recommendations (Gagnon et al. 2013). This study spanned I-17 MP 294–340, encompassing the entirety of Hotspot #7 (Figure 3-71).

Within the Hotspot #7 portion of I-17, Gagnon et al. (2013) and the Location/DCR study (Stanley Consultants 2011) had full concurrence in their recommendations for wildlife passage structures (Table 3-19). Both recommended eight underpasses and two overpasses (Table 3-19, Figure 3-71), yielding an average passage structure spacing of 1.7 miles.

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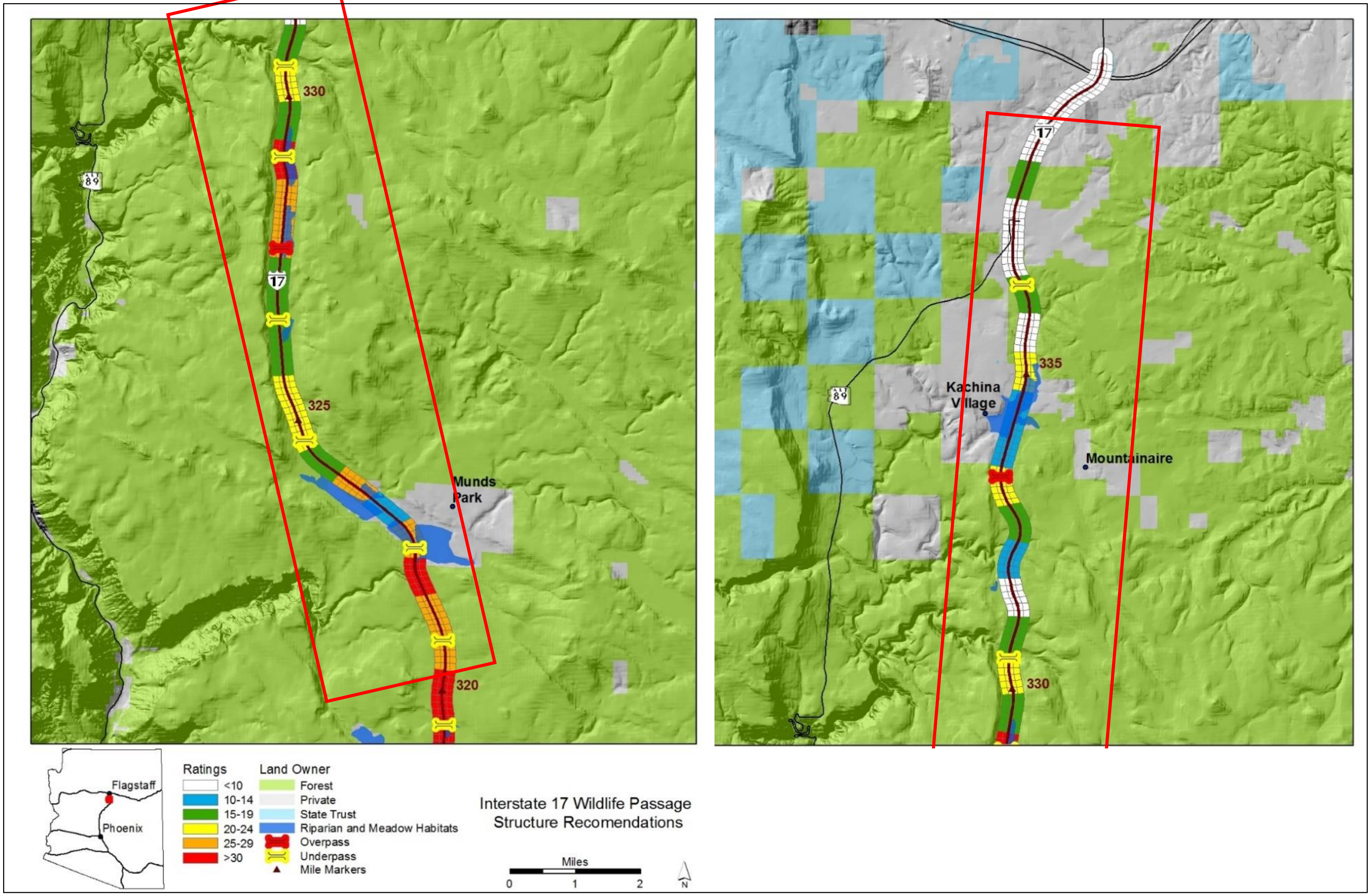


*Figure 3- 71. Wildlife passage structures (yellow underpasses/red overpass) recommended in the wildlife DCR (Gagnon et al. 2013) for I-17, including for Hotspot #7 (red box) with the southern (left) and northern (right) portions.*

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*Table 3- 19. Wildlife passage structure locations and types within I-17 Hotspot #6 recommended by Gagnon et al. (2013) and Stanley Consultants (2011).*

| MP | Passage structure type | | Passage structure location and comments |
|---|---|---|---|
| | Underpass | Overpass | |
| 322.0 | X | | Munds Canyon Bridge – modified bridges |
| 324.4 | X | | Munds Ranch Rd – new bridges |
| 326.3 | X | | Willard Springs TI – widen existing bridges |
| 327.4 | | X | Willard Springs Meadow |
| 328.8 | X | | Newman Park TI – new bridges |
| 330.3 | X | | James Canyon – new underpass |
| 332.2 | X | | Kelly Canyon – new bridges |
| 333.1 | | X | South of Kachina Village; very high priority |
| 336.1 | X | | Old Munds Highway – new bridges |

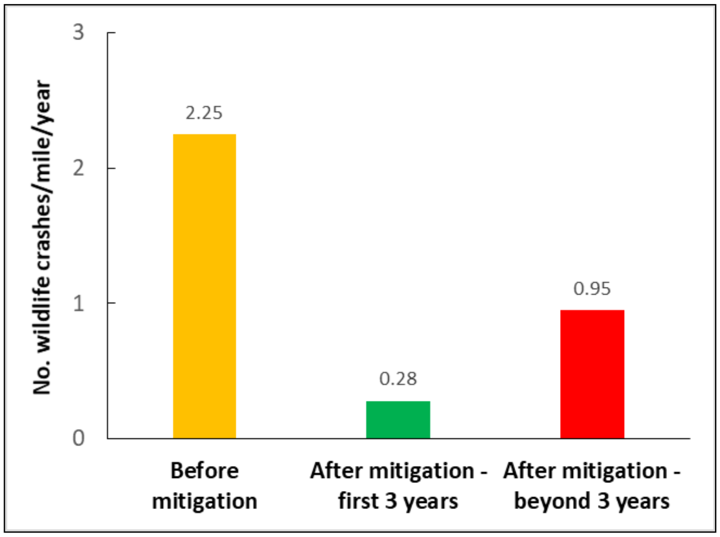
### *MUNDS CANYON ENHANCEMENT PROJECT*

The northern extent of the Munds Canyon Enhancement Project partially overlaps the hotspot (MP 316.8-322.7). This project was completed in late-2011 and entailed retrofitting existing ROW fence to block elk passage across I-17 (smaller species including deer could still access the highway), funneling animals toward the large Munds Canyon and Woods Canyon bridges to enhance their functionality for wildlife passage. In addition, two traffic interchanges were linked with fencing and retrofitted to serve as dual-use passage structures. Three large box culverts also provided passage for wildlife. A total of 11.6 miles of the highway received fencing treatments: 8.4 miles of ROW fence was raised to 8-feet by retrofitting and 3.2 miles of new 8-feet barbed-wire fence was erected.

Post-fencing camera monitoring recorded a 217 percent increase in wildlife use of the two bridges over two years demonstrating that retrofit fencing increased functionality of bridges as underpasses (Gagnon et al. 2015). Elk-vehicle collisions declined by 97 percent and economic benefits associated with reduced collisions (Huijser et al. 2009*a*) exceeded total project costs in just four years.

After-mitigation performance of this project found that while WVCs declined 87 percent in the first 3 years after implementation, its effectiveness declined thereafter, with only a 56% reduction in WVCs (Figure 3-72). This disparity in effectiveness reflects the aging of the retrofit fencing and the inadequacy of its design (versus that of a more durable wildlife fence standard) in withstanding pressures exerted by elk and winter snow loads, coupled with breaches in fencing and other measures (e.g., escape ramps). This results in a need for increased maintenance efforts. This application and several others on SR 260 have shown that elk retrofit fence is only a short-term alternative to wildlife fence. We have addressed the upgrade/replacement of elk retrofit fence in our strategy recommendations.

*Figure 3- 72. Comparison of before- and after-wildlife mitigation project WVC incidence (no./mile/year) the I-17 Munds Canyon Enhancement Project, with after-mitigation WVC incidence shown separately by the first three years after mitigation and beyond three years.*




### *PURSUIT OF STAND-ALONE/DROP-IN WILDLIFE OVERPASS PROJECTS*

Since 2014, ADOT, AGFD, and the Coconino NF have been working together to pursue stand-alone/drop-in overpass construction projects for Hotspot #7, consistent with the IDCR and Wildlife DCR utilizing Hazard Elimination System and other funding. These efforts have focused on pursuing avenues to implement the two wildlife DCR recommended overpasses at MP 333.1 and MP 327.4 (Gagnon et al. 2013). This culminated with ADOT's Northcentral District identifying the overpasses as high-ranking modernization projects on ADOT's Planning to Programming (P2P) list, as they ranked #2 and #4 for District modernization projects. At the statewide level after applying ADOT's P2P scorecard, these projects ranked as the #9 and #10 priorities among all modernization projects. The District included a budget for each overpass of $3.9 million dollars.

*Figure 3- 73. Precast concrete arch overpass installation along I-80 in Nevada (NDOT) (photo).*

Along existing highways, drop-in overpass installations are increasingly being implemented across the western US, including along busy interstate highways (Figure 3-73). Precast concrete (and metal-plate) arch designs allow for cost-effective and rapid installation with minimal traffic disruption.

For the two proposed I-17 overpasses, twin-arch structures set between cut-slope sections are proposed (Figure 3-74), with widths of 75 to 100 feet; locating the structures on cut-slope sections will minimize the amount of fill needed for approach slopes, as well as the extent of side walls.

*Figure 3- 74. Rendering of the proposed I-17 wildlife overpass located at MP 333.1 (Courtesy of Contech Engineered Solutions).*

AGFD has committed to helping fund overpass construction and has identified them as a priority in its action plan for implementing Interior Secretarial Order 3362 which focuses on conserving priority wildlife winter range, stopover areas, and migration corridors. Under Secretarial Order 3362, an interagency Corridor Mapping Team used AGFD GPS telemetry data to quantify the I-17 elk migration corridor which overlaps Hotspot #7, as well as winter range and stopover areas adjacent to the highway (Figure 3-75; Kauffman et al. 2020). Identification of this wildlife corridor and prioritization by AGFD should enhance the likelihood of future Federal funding and grants (e.g., National Fish and Wildlife Foundation) for projects to enhance corridors.

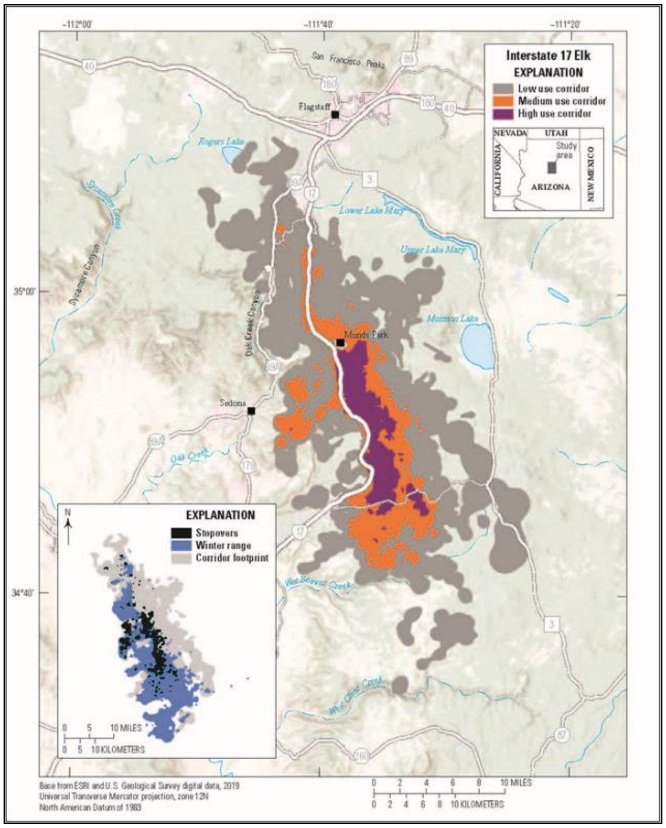



*Figure 3- 75. Mapped I-17 elk migration corridor which overlaps much of Hotspot #7, determined from AGFD GPS-telemetry studies (Kauffman et al. 2020).*

## CONFLICT RESOLUTION STRATEGY AND PROJECTS

As there are relatively few options for retrofitting of exisitng structures, Hotspot #7 conflict resolution strategies center upon the installation of two drop-in wildlife overpasses. Construction of these overpasses can be accomplished independently in a phased manner or jointly, with willdife fencing erected along I-17 linking the overpasses to traffic interchanges and potentially suitable drainage/access structures where animals can pass under I-17.

### EXISTING DRAINAGE STRUCTURES

To evaluate drainage structures along I-17 that could be employed as part of a retrofitting strategy to resolve wildlife-vehicle conflicts, we assessed the location and dimensions of 16 structures, all CBC for potential suitability as wildlife passage structures (Table 3-20, Figure 3-69). Reflective of the width of the roadway (length of the CBC) and the relatively small dimensions of the structures, all but two CBC's openness indices were ≤0.20. The large single-barrel CBC through which access roads pass at MP 324.4 and MP 336.0 (Old Munds Highway) had indices >0.42; while marginal for wildlife passage (Gordon and Anderson 2003), especially by elk, these structures hold potential for integration into retrofitting and drop-in overpass strategies.

*Table 3- 20. Existing drainage structures along I-17 and their dimensions and openness indices.*

| MP | Structure type | No. barrels | Width (ft) | Height (ft) | Length (ft) | Openness index* |
|---|---|---|---|---|---|---|
| 323.4 | CBC | 2 | 11 | 11 | 212 | 0.17 |
| 324.4 | CBC | 1 | 15 | 16 | 175 | 0.42 |
| 325.3 | CBC | 1 | 11 | 9 | 193 | 0.16 |
| 325.8 | CBC | 1 | 10 | 8 | 246 | 0.10 |
| 327.5 | CBC | 1 | 10 | 8 | 170 | 0.14 |
| 328.9 | CBC | 1 | 10 | 8 | 229 | 0.11 |
| 330.3 | CBC | 2 | 10 | 8 | 232 | 0.11 |
| 330.5 | CBC | 3 | 10 | 8 | 285 | 0.09 |
| 331.4 | CBC | 1 | 10 | 8 | 269 | 0.09 |
| 331.9 | CBC | 1 | 10 | 8 | 175 | 0.14 |
| 332.4 | CBC | 1 | 10 | 8 | 221 | 0.11 |
| 333.5 | CBC | 1 | 10 | 8 | 230 | 0.11 |
| 334.3 | CBC | 3 | 9 | 7 | 200 | 0.10 |
| 335.5 | CBC | 2 | 7 | 6 | 277 | 0.05 |
| 336.0 | CBC | 1 | 15 | 16 | 167 | 0.44 |
| 337.8 | CBC | 2 | 10 | 10 | 306 | 0.10 |

*Width × Height / Length (metric values)

### *SHORT-TERM PROJECT A (DROP-IN OVERPASS AND RETROFIT FENCING)*

This project implements the priority drop-in overpass to provide suitable wildlife passage across I-17, integrated with wildlife fencing to funnel animals to the overpass and other structures and to reduce WVCs; this phase will address 43% of the hotspot's WVCs (Figure 3-76, Table 3-21).

- Construct a drop-in precast concrete double-arch overpass at MP 333.3, fit between existing cut slopes to minimize the amount of approach slope material (Figure 3-74 and Figure 3-76). This proposed overpass will be approximately 210 feet long with 78-foot span arches; width will be 80-150 feet; most similar overpasses implemented in the western US have been 200-feet wide though Gagnon et al. (2017) found that 50-foot overpasses on US 93 were effective for desert bighorn sheep. The ADOT Northcentral District estimated the cost of an overpass here at $3.9 million (Table 3-21).
- Wildlife Fencing should be erected along I-17 between MP 331.1 to MP 337.4, or 6.3 miles (12.6 miles total; Figure 3-76, Table 3-21). This fencing will link the overpass to the Kelly Canyon TI (MP 331.1) to the south, and the Mountainaire TI (MP 333.0), John Wesley Powell TI (MP 337.4), and the Old Munds Highway CBC at MP 336.1 all to the north. Gagnon et al. (2017) found that the Schnebly Hill TI retrofitted as a dual-use underpass and the Fox Ranch Road TI retrofitted as a dual-use overpass on the Munds Canyon Enhancement Project received minimal wildlife use; as such, only the Old Munds Highway CBC will accommodate wildlife passage in addition to the overpass.
- Wildlife fencing necessitates the implementation of approximately 18 pairs of escape ramps (36 total) and six cattle guard extension grates (4 alone at the Mountainaire TI) at traffic interchanges (Figure 3-76, Table 3-21).
- At the fence ends which tie into traffic interchange abutments to seal off the fenced corridor, wildlife-run effects could still occur. To address this issue, we recommend that enhanced motorist alert signage (flashing LED) be erected at the approaches to fence termini (Figure 3-76) to alert motorists to the increased potential for crossing animals.

With wildlife passage provided at the proposed overpass and the large Old Munds Highway culvert, the average spacing between structures along the stretch recommended for fencing is 2.1 miles.

The total estimated cost for this project is just over $6 million (Table 3-21). In addressing 45% of the hotspot's WVCs, this phase would eliminate 16 WVCs/year, of which eight would be elk and seven would be mule deer (2 black bear). Using average cost figures from Huijser et al. (2009*a*) for WVCs involving elk ($17,483) and mule deer ($6,617), this phase would accrue an annual benefit of $186,183/year, with a cost:benefit break-even point of approximately 32.6 years.

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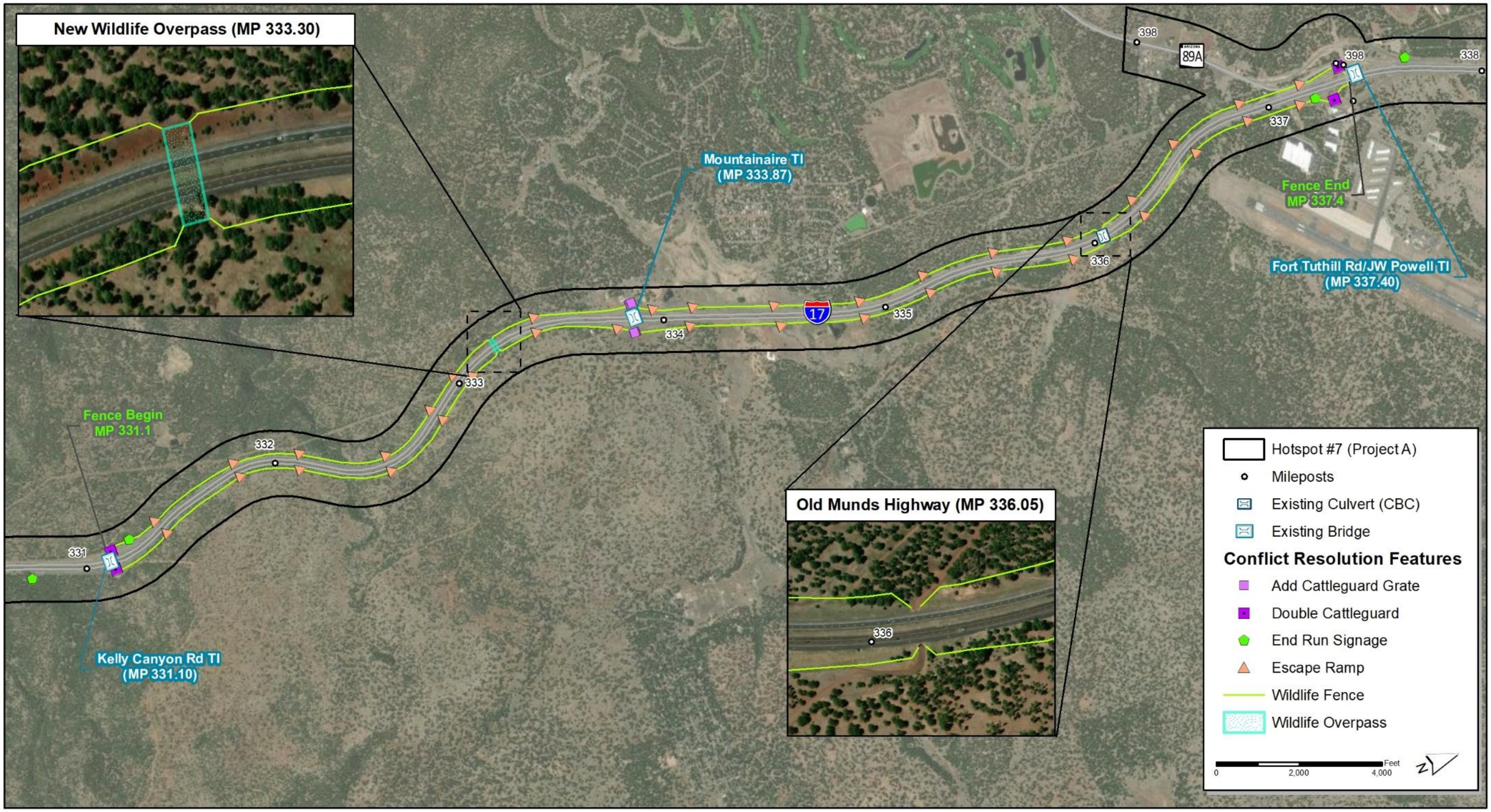


*Figure 3- 76. Short-term wildlife-vehicle conflict resolution Project A including a drop-in wildlife overpass at MP 333.3 and wildlife fencing and associated measures (cattle guards, escape ramps, alert signage) linking the overpass to the large culvert at the Old Munds Highway (see insets).*

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### *SHORT-TERM PROJECT B (DROP-IN OVERPASS AND RETROFIT FENCING)*

This project implements a second, southern drop-in overpass to provide suitable wildlife passage across I-17, integrated with wildlife fencing to funnel animals to the overpass and the large marginal CBC at MP 324.4 and to reduce WVCs (Figure 3-77, Table 3-21). This project will address another 30% of the hotspot's WVCs.

- Construct a drop-in precast concrete double-arch overpass at MP 327.4 fit between existing cut slopes to minimize the amount of approach slope material (Figure 3-77). This proposed overpass will be approximately 250 feet long with 78-foot span arches; with similar dimensions to the overpass at MP 333.1. The ADOT Northcentral District has estimated the cost of an overpass here at $3.9 million (Table 3-21).
- Wildlife Fencing should be erected along I-17 between MP 322.0 to MP 328.8, or 6.8 miles (12.0 miles total; Figure 3-77, Table 3-21). This fencing will link the overpass to the Munds Canyon (MP 322.0) and Willard Springs (MP 326.2) TI and the large access road culvert (324.4) to the south, and the Newman Park TI (MP 328.0) to the north. The large access road CBC will provide for passage across I-17 in addition to the overpass along this phase.
- Wildlife fencing necessitates the implementation of approximately 17 pairs (34 total) of escape ramps, four cattle guard extension grates at TI, and four double gates at the decommissioned rest area at MP 324.0 for maintenance access (Figure 3-77, Table 3-21).
- At the fence ends which tie into traffic interchange abutments to seal off the fenced corridor, wildlife-run effects could still occur. To address this issue, we recommend that enhanced motorist alert signage (flashing LED) be erected at the approaches to fence termini (Figure 3-77) to alert motorists to the increased potential for crossing animals.

With wildlife passage provided at the proposed overpass and the large CBC at MP 324.4, average spacing between structures along the stretch recommended for fencing is 2.0 miles.

In addressing 35% of the hotspot's WVCs, this project would result in the elimination of 14 WVCs/year, of which seven would be elk and six would be mule deer. Using average cost figures from Huijser et al. (2009*a*) for WVCs involving elk ($17,483) and mule deer ($6,617), this phase would accrue an annual benefit of $162,083/year, with a project cost:benefit break-even point of approximately 38.2 years.

### *INTERMEDIATE-TERM PROJECT (MUNDS CANYON ELK RETROFIT FENCING UPGRADE)*

To proactively address the inadequate long-term design of elk retrofit fencing (versus that of more durable wildlife fence standard) before further potential degradation occurs (such as that along SR 260), we recommend that fencing along the Munds Canyon Enhancement Project stretch be upgraded to a wildlife fence standard. As this fence was better constructed and is newer than that along SR 260, we anticipate that much of the existing fence infrastructure can be integrated into the wildlife fence standard, thus reducing costs.

- Upgrade 11.6 miles of elk retrofit fence to a wildlife fence standard, including installing mesh wire that will limit passage for most wildlife species.
- As part of the fence upgrade, existing rock-gabion basket escape ramps should be rehabilitated to address maintenance issues (Figure 3-78).

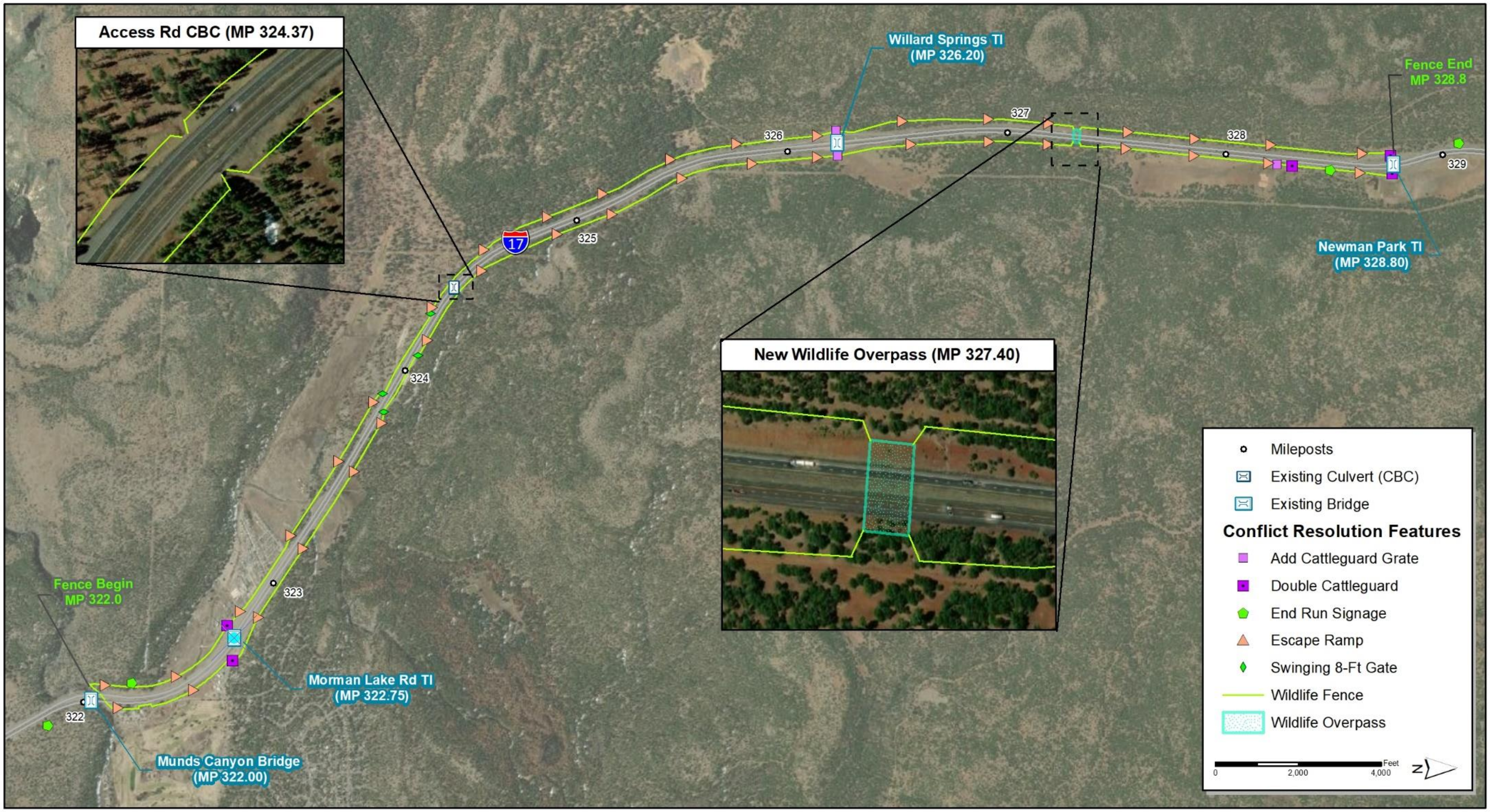


*Figure 3- 77. Short-term wildlife-vehicle conflict resolution Project B including a drop-in wildlife overpass at MP 327.4 and wildlife fencing and associated measures (cattle guards, gates, escape ramps, alert signage) linking the overpass to the large access road culvert at MP 324.4 (see insets).*

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*Figure 3- 78. I-17 rock-gabion basket escape ramp which has been subject to settling of baskets and loss of fill material from behind the baskets (despite an erosion cloth barrier).*

*Table 3- 21. I-17 Hotspot #7 conflict resolution strategy estimated costs by proposed projects.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Short-Term Project A (Drop-In Overpass MP 337.and Retrofit Fencing)** | | | | |
| Precast concrete overpass (MP 333.1) | Each | 1 | $3,900,000 | $3,900,000 |
| Wildlife fence | Miles | 12.6 | $158,000 | $1,990,800 |
| Escape ramps | Each | 36 | $11,000 | $396,000 |
| Cattle guard extension grates | Each | 4 | $30,000 | $120,000 |
| Enhanced alert signage | Each | 4 | $4,000 | $16,000 |
| **Total** | | | | **$6,422,800** |
| **Short-Term Project B (Drop-In Overpass and Retrofit Fencing)** | | | | |
| Precast concrete overpass (MP 327.4) | Each | 1 | $3,900,000 | $3,900,000 |
| Wildlife fence | Miles | 13.6 | $158,000 | $2,148,800 |
| Escape ramps | Each | 34 | $11,000 | $374,000 |
| Cattle guard extension grates | Each | 4 | $30,000 | $120,000 |
| Double-wide gates | Each | 4 | $2,500 | $10,000 |
| Enhanced alert signage | Each | 4 | $4,000 | $16,000 |
| **Total** | | | | **$6,568,800** |
| **Intermediate-Term Project (Munds Canyon Elk Retrofit Fencing Upgrade/Replacement)** | | | | |
| Elk retrofit fence upgrade | Miles | 11.6 | $105,000 | $1,218,000 |
| Escape ramp rehabilitation | Each | 6 | $5,000 | $30,000 |
| **Total** | | | | **$1,248,000** |

## ENVIRONMENTAL OVERVIEW

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Construction of the proposed Intermediate-Term project will be confined to the existing ADOT ROW through private land and easement through Coconino National Forest. If NEPA is required for the proposed Immediate-Term project, this project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: “Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way.” The proposed Short-Term projects entail overpass structures which may require TCEs from Coconino National Forest. If NEPA is required and TCEs are needed for the proposed Short-Term projects, then the projects are anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)23(i): “Federally funded project that received less than $5,000,000…” rather than C-list (c)22: “Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way.”

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of both proposed projects. For the Short-Term projects survey is recommended to reassess the current location of cultural sites and determine their NRHP eligibility. For the Intermediate-Term project, it is recommended that these known cultural sites be avoided, though reassessment may be needed to determine the avoidance limits. Hazardous materials testing will be required for all the proposed projects because the proposed fencing will tie into existing structures and cattleguards. Additionally, a hazardous materials assessment should be performed for the project area to address any potential hazardous material concerns. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. None of the proposed projects are located within currently designated or proposed critical habitat for any species. Though the effects of noise from each of the proposed projects to the Mexican spotted owl (*Strix occidentalis lucida*) should be evaluated in the respective biological documents due to the proximity of suitable habitat. Wildlife fencing will tie into several existing structures which may provide habitat to roosting bats or nesting birds that are federally protected by the MBTA. Further investigation of structures throughout both project areas will be necessary during their respective environmental clearances, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required for any of the projects.

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## HOTSPOT #10: STATE ROUTE 260 – PAYSON TO STAR VALLEY (MP 252.5-255.5)

Hotspot #10 spans a section of SR 260 east of Payson approaching the Town of Star Valley. Our statewide hotspot analysis identified a large section of highway from MP 250.0 to MP 260.0. However, final design for the reconstruction of the Lion Springs Section between MP 256.0 and MP 260.2 is currently underway and should be completed by early 2022; currently, the design includes a wildlife overpass, two underpasses, and wildlife fencing; as such, this stretch was excluded from this analysis and strategy development.

*Figure 3- 79. Typical stretch of SR 260 Hotspot #10 between Payson and Star Valley.*

### HOTSPOT OVERVIEW (STAR VALLEY PORTION ONLY)

**Total WVCs (2014-2018):** 42

**WVCs/mile/year:** 2.80

**WVC percentage of all crashes:** 20.1% (for entire hotspot)

**2018 WVC species composition (10 WVC):** Elk – 90% Mule deer – 10%

**AADT:** 23,094 vehicles/day

The Star Valley portion of the hotspot accounts for 58% of all WVCs within the entire hotspot including the Lion Springs Section. Alone, the 3-mile Payson-Star Valley portion of the hotspot with WVCs (MP 253-255) has an incidence of 2.80 WVCs/mile/year that would make it the second-ranked hotspot in the state. Much of the hotspot traverses mixed forest and chaparral on both sides of the highway, of which most of the frontage on both sides is largely undeveloped (Figure 3-79 and Figure 3-80). There are numerous driveways and lateral roads that limit WVC resolution options (e.g., fencing). Two golf courses adjacent to MP 254 contribute to wildlife-vehicle conflicts. The entire hotspot is 4-lane roadway (Figure 3-77) posted for 55 mph with a transition to 45 mph in Payson and 35 mph in Star Valley.

The proportion of all WVCs that occurred by MP within the hotspot ranged from 0-0.38 (Figure 3-80 and Figure 3-81), with no WVCs occurring at MP 252 within Payson. All WVCs in MP 255 occurred on the half-mile stretch before entering Star Valley, thus making this the highest incidence section of the hotspot (Figure 3-81).

While April exhibited the highest proportion of WVCs (17%) and December the lowest (2%), seven months exhibited greater than the average proportion of WVCs (8.3%) spread across the entire year (Figure 3-82). The April peak may reflect the period when migratory elk are moving from winter range south of Star Valley to summer range atop the Mogollon Rim.

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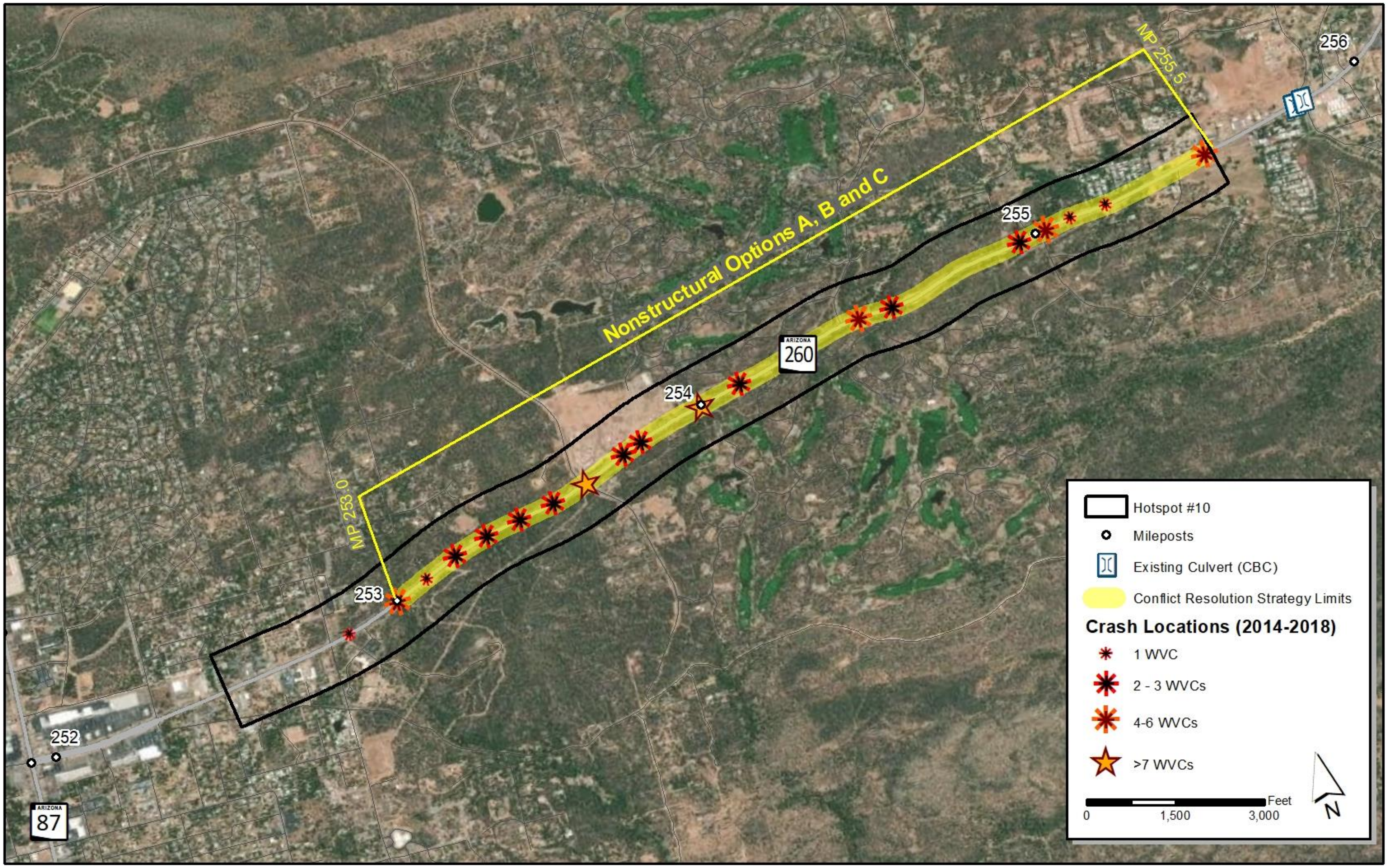


*Figure 3- 80. WVC locations that occurred along the SR 260 Hotspot #10 between 2014-2018, and conflict resolution strategy limits for three resolution options.*

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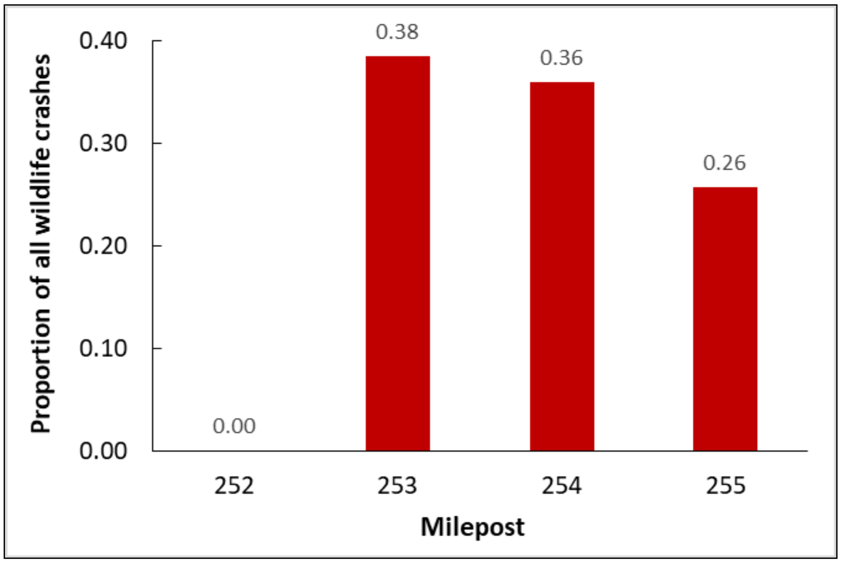


*Figure 3- 81. Proportion of all SR 260 Hotspot #10 (Star Valley portion) WVCs by milepost (2014-2018); all WVCs in MP 355 occurred between MP 255.0-255.5.*

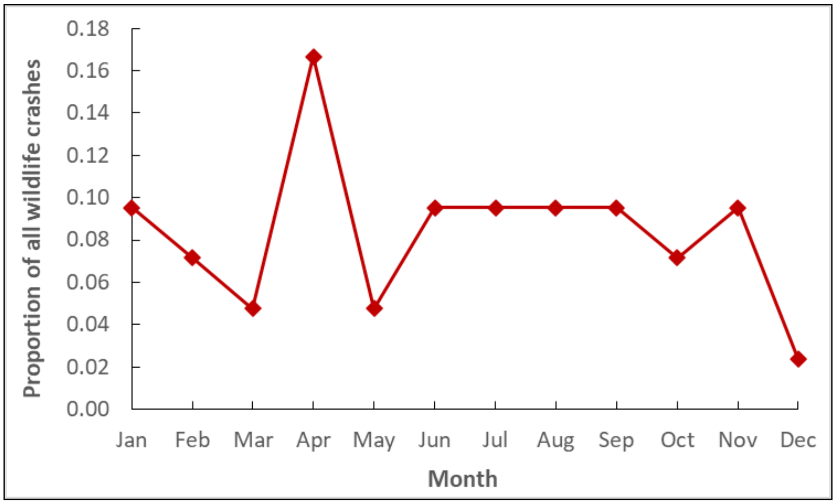


*Figure 3- 82. Proportion of all SR 260 Hotspot #10 WVCs by month (2014-2018).*

### CONFLICT RESOLUTION STRATEGY

Assessments of WVCs along MP 254 which were done as part of the *Sayer v. State of Arizona* case showed an interesting trend since 1994 when golf courses were built at Chaparral Pines and The Rim Club (Table 3-22). From 1994-1998, largely before they were built, WVCs averaged just 0.8/year along the MP. In the five years (1999-2003) after the both courses opened, average WVCs increased 6-fold (Table 3-22). After The Rim Club's course was fenced n 2004, average 2004-2008 WVCs dropped 42% to 2.8/year, the same as our assessment. The proportion of all WVCs within the hotspot by MP has also shifted over time; between 1990-2003, MP 254 accounted for 61% of WVCs whereas it dropped to 36% during our assessment (Figure 3-81); this suggests that fencing of The Rim Club's course may have altered elk movement patterns across the hotspot. Regardless, the trends for MP 254 and the rest of the hotspot suggest that the incidence of WVCs will remain an issue into the future.

Opportunities to address the wildlife-vehicle conflicts on Hotspot #10 are limited. There are no suitable existing structures along the hotspot to support a retrofit fencing strategy. The curvy nature of the roadway precludes consideration of technology-based strategies such as open-road radar detection systems. As such, the only viable option for this hotspot is a nonstructural project along 2.5 miles to alert motorists to the risk of WVCs and to modify behavior in terms of reduced speed and increased response time (Table 2). We offer three nonstructural options that have also been recommended on other highways.

*Table 3- 22. Average annual incidence of wildlife-vehicle collisions and on State Route 260 Milepost 254, 1994–2018.*

| 5-year period | Status with golf courses/fencing | Average WVC/year |
|---|---|---|
| 1994-1998 | Chaparral Pines golf course opened in 1997 | 0.8 |
| 1999-2003 | The Rim Club course opened in 1999 | 4.8 |
| 2004-2008 | The Rim Club fenced in 2004 | 2.8 |
| 2014-2018 | Chaparral Pines fenced in 2017 | 2.8 |

### *NONSTRUCTURAL OPTION A – EXPERIMENTAL WILDLIFE COLLISION PREVENTION ZONE*

This option includes considering a combination of measures to create an experimental *Wildlife Collision Prevention Zone* along the 2.5-mile hotspot that would address where 100% of all accidents occur.

- Erect innovative motorist alert signage like that used in other states and Canada to highlight WVC hotspots (Figure 3-83); install gateway signs at the entry points to the high-incidence WVC zone between MP 253.0 and MP 255.5 (Figure 3-84). The signage should be as large as possible and preferably be LED-enhanced for nighttime impact.
- Cut transverse rumble strips into the pavement at the approaches to the *Wildlife Collision Prevention Zone* in conjunction with the signage to maximize impact in raising motorist WVC risk awareness/alertness, and thus wildlife avoidance response (Figure 3-84). Ideally, additional rumble strips should be cut half-way through the zone to maintain driver awareness.


*Figure 3- 83. Conceptual motorist alert signs at the approaches to a designated Wildlife Collision Prevention Zone; the signs should be LED-enhanced for maximum nighttime impact.*

- Reduce the posted speed limit throughout the zone from 55 to 45 mph; from the west, the posted speed (45 mph) on the east side of Payson would be maintained, and the posted speed in Star Valley (35 mph) would increase to 45 mph versus 55 mph. This will increase response time and distance to allow motorists to avoid WVCs or reduce the damage from WVCs. We also recommend installing signs on either side of Tyler Parkway to alert traffic turning onto SR 260.

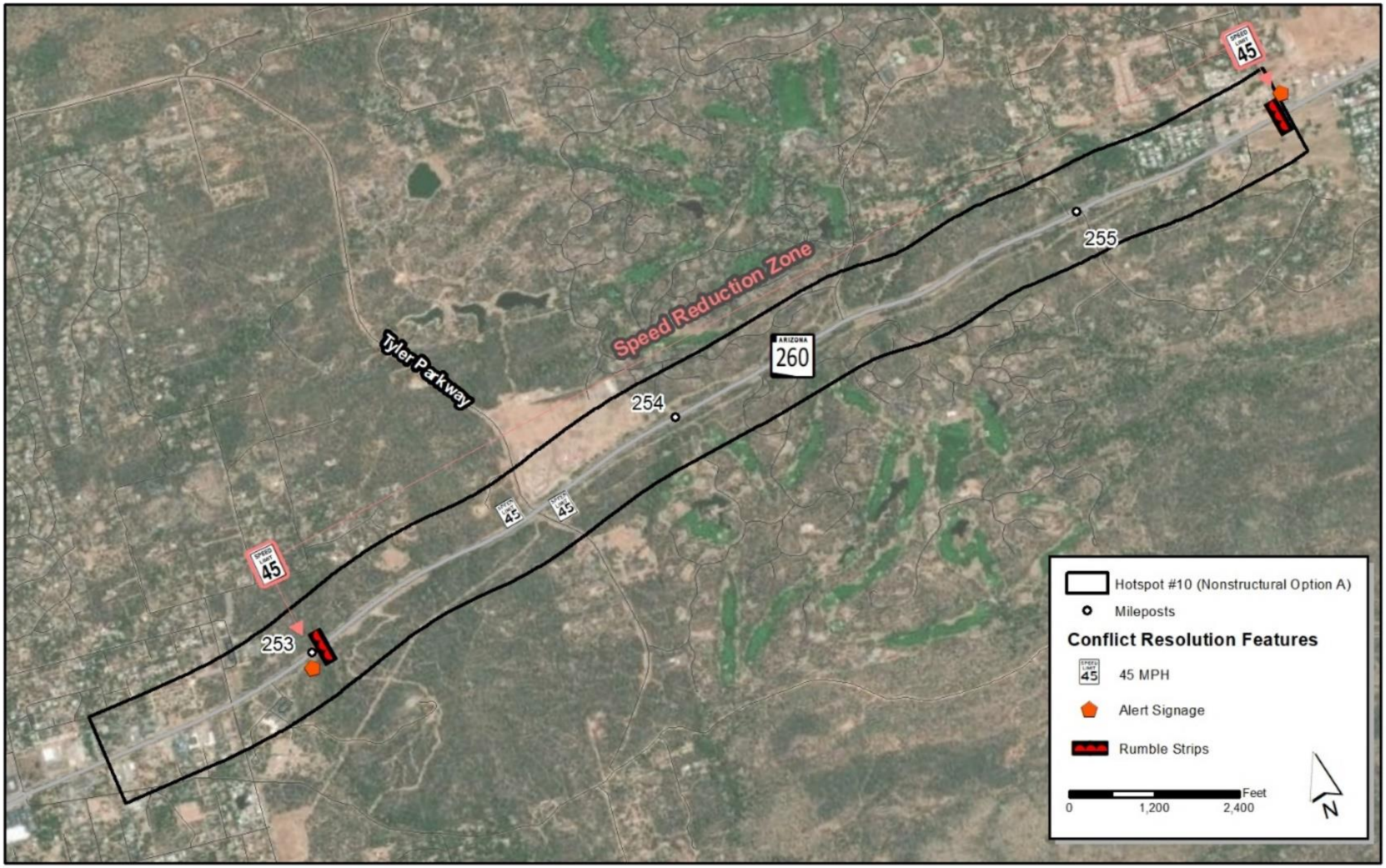


*Figure 3- 84. SR 260 Hotspot #10 wildlife-vehicle conflict resolution Option A for an experimental Wildlife Collision Prevention Zone with special signage, rumble strips and reduced posted speed limit between Payson and Star Valley.*

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- Narrow the travel lanes through the zone with paint restriping to create the perception on the part of motorists that the road is narrower thus promoting lower speeds.

### *NONSTRUCTURAL OPTION B – EXPERIMENTAL SEASONAL DUSK/NIGHTTIME SPEED REDUCTION ZONE*

This option would only reduce the posted speed at dusk-nighttime (18:00-06:00 hours) when the vast majority of WVCs occur on SR 260 (Dodd et al. 2007).

- Implement a 2.5-mile seasonal speed reduction zone between MP 253.0 and MP 255.5 (Figure 3-88).
- Erect fold-down gateway information signs (Figure 3-88 and Figure 3-85) in advance of the speed-reduction zone to be opened during from April 1st to October 31st each year, the period which accounts for two-thirds of all hotspot WVC.
- Within the zone, install at least three pairs of new electronic digital variable speed limit signs (Figure 3-86), one each at the end of the speed reduction zone and one in the center of the hotspot to catch traffic turning onto Tyler Parkway and heading east (Figure 3-88). These signs need to be programmed during the seasonal period to switch from 55 mph to 45 mph between the hours of 18:00-06:00 in April, 19:00-06:000 hours from May-September, and 18:00-0:600 hours during October.


*Figure 3- 85. Conceptual fold-down seasonal motorist alert signs at the approaches to a speed reduction zone; signs should be LED-enhanced for maximum nighttime impact.*


*Figure 3- 86. Electronic variable speed limit sign establishing dusk and nighttime speed limits; signs can be solar powered (from Solar Traffic Systems, Inc.).*

### *NONSTRUCTURAL OPTION C – ENHANCED MOTORIST ALERT SIGNAGE*

At a minimum to more effectively alert motorists to the potential risk of WVCs along the 2.5-mile zone between MP 253.0 and MP 255.5, we offer this option.

- Erect enhanced motorist alert signage with flashing LED lights (Figure 3-87) at the approaches to the zone at MP 252.9 and MP 255.6 and a pair of signs at the midpoint of the zone at MP 254.3 (Figure 3-89).

*Figure 3- 87. Solar-powered motorist alert sign with LED flashers at a high-incidence bison collision zone in Yellowstone National Park. Such signage is especially effective at nighttime hours when many WVCs occur.*

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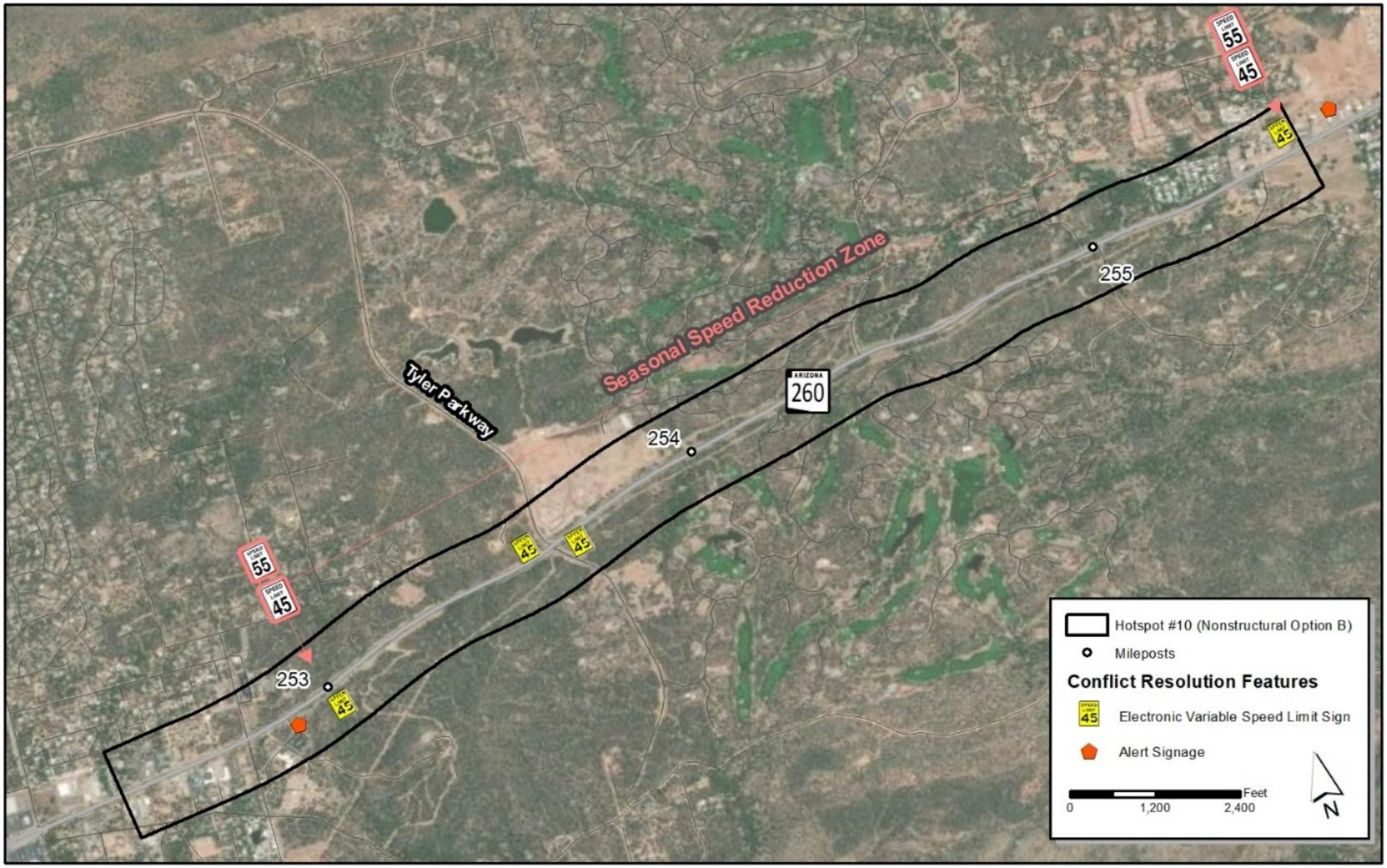


*Figure 3- 88. SR 260 Hotspot #10 wildlife-vehicle conflict resolution Option B for an experimental seasonal dusk/nighttime speed reduction zone between Payson and Star Valley, with electronic variable speed limit signs and alert signage.*

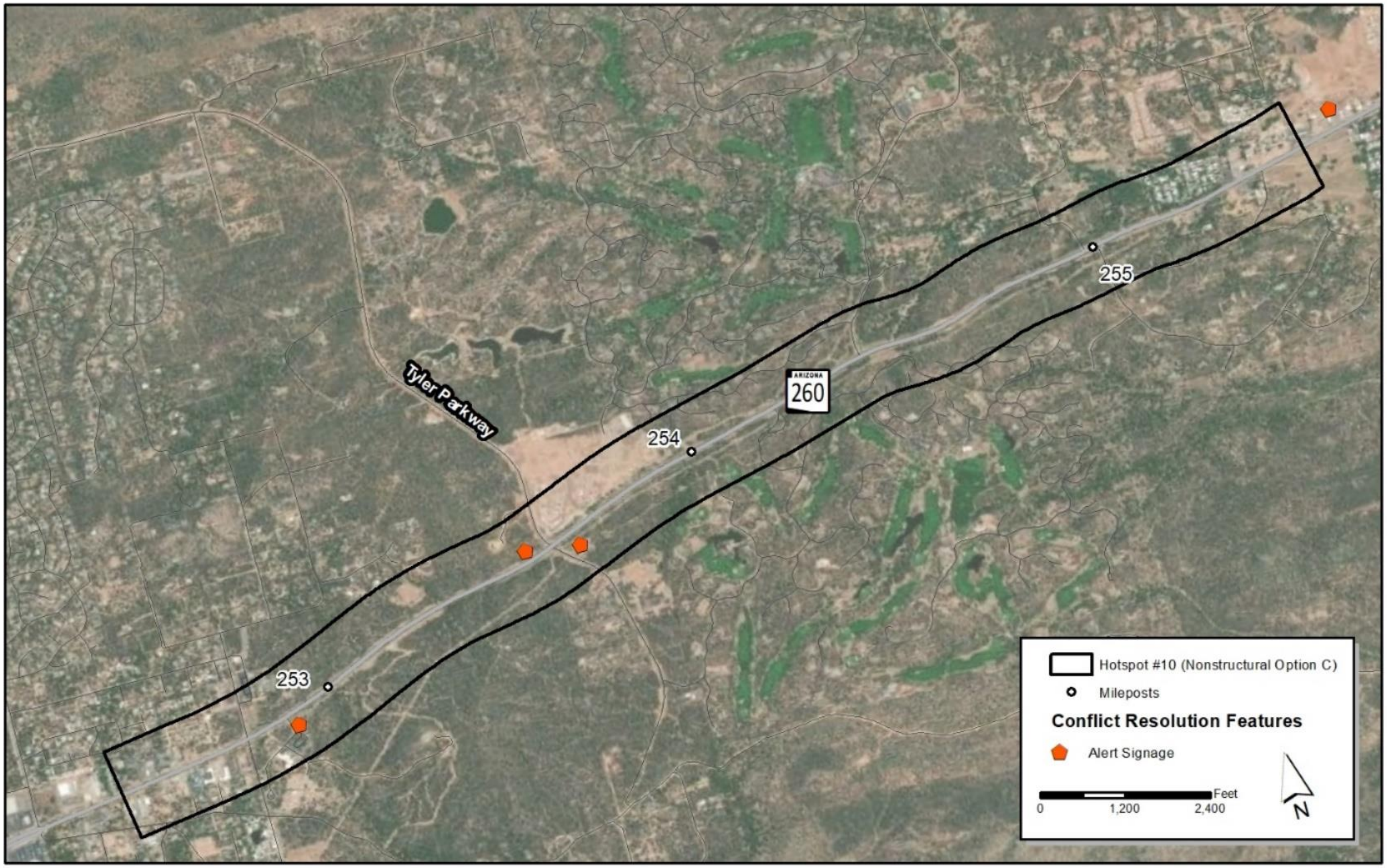


*Figure 3- 89. SR 260 Hotspot #10 wildlife-vehicle conflict resolution Option C for enhanced motorist alert signage between Payson and Star Valley.*

*Table 3- 23. SR 260 Hotspot #10 wildlife-vehicle conflict resolution option components and estimated costs to address wildlife-vehicle conflicts associated with three options.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Option A (*Wildlife Collision Prevention Zone*)** | | | | |
| Gateway motorist alert signage | Each | 2 | $10,000 | $20,000 |
| Speed limit signs | Each | 4 | $2,000 | $8,000 |
| Transverse rumble strips | Each | 2 | $10,000 | $20,000 |
| **Option A Total** | | | | **$48,000** |
| **Option B (Seasonal Dusk/Nighttime Speed Reduction Zone)** | | | | |
| Electronic digital variable speed limit signs | Each | 12 | $4,500 | $54,000 |
| Gateway motorist alert signage | Each | 2 | $10,000 | $20,000 |
| **Option B Total** | | | | **$74,000** |
| **Option C (Enhanced Motorist Alert Signage)** | | | | |
| Enhanced motorist alert signs | Each | 4 | $5,000 | $20,000 |
| **Option C Total** | | | | **$20,000** |

### ENVIRONMENTAL OVERVIEW

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Construction of the proposed projects will be confined to the ADOT ROW through privately owned lands. If NEPA is required, this project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: "Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way." Similarly, if the projects are federally funded, then a Section 4(f) analysis should be considered due to the projects proximity to golf courses.

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of the proposed projects, and it is recommended that these known cultural sites be avoided, though reassessment may be needed to determine the avoidance limits. A hazardous materials assessment should be performed for all the proposed projects to address any potential hazardous material concerns. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. None of the proposed projects are located within currently designated or proposed critical habitat for any species. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required.

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Dodd, N. L., J. W. Gagnon, S. Boe, A. Manzo, and R. E. Schweinsburg. 2007. Evaluation of measures to minimize wildlife-vehicle collisions and maintain wildlife permeability across highways – State Route 260, Arizona. Arizona Transportation Research Center Publication SPR 540, Phoenix.

## HOTSPOT #15: STATE ROUTE 260 – LITTLE GREEN VALLEY AND KOHLS RANCH SECTIONS (MP 264.5-268.4)

SR 260 Hotspot #15 is unique among statewide hotspots in that it falls within two previously mitigated sections of highway with wildlife underpasses (2) and large bridges (2): Little Green Valley (LGV) and Kohls Ranch (KR) sections. Here, short-term elk retrofit fencing was used to funnel animals to underpasses and prevent WVCs; its condition since has deteriorated. This retrofit fencing should be replaced with more durable wildlife fence.

### HOTSPOT OVERVIEW

**Total WVCs** (2014-2018)**:** 57

**WVCs/mile/year:** 2.92

**WVC percentage of all crashes:** 50.7%

**2018 WVC species composition** (20 WVC)**:** Elk – 65% Mule deer – 20% Black bear – 10% Mountain lion – 5%

**AADT:** 9,793 vehicles/day

### HISTORY AND BACKGROUND

As phased reconstruction of five SR 260 sections began in 2000 (Table 3-24, Figure 3-90), limited wildlife fencing was erected. Research found WVCs on the first section, Preacher Canyon, increased 21% over before-construction levels (Gagnon et al. 2018). On the next section, Christopher Creek, elk WVCs increased 171% after reconstruction. As the project was still active, ROW fence was retrofitted in 2004, raising the fence from 3.5 to eight feet. This fence was effective in the short term, reducing WVCs 88% (Dodd et al. 2007). Over time however, fence condition deteriorated, and new wildlife fence was installed along the entire section in 2012.

On the third section, KR, retrofit fencing was used in 2006 to raise existing ROW fence. With the 2012 reconstruction of LGV Section, wildlife fencing was erected along 0.7 miles associated with an underpass (Table 3-24). Elsewhere, new ROW fencing was retrofitted when constructed. KR Section retrofit fencing has not held up well over time due to wear and tear, persistent efforts by elk to breach the fence, and snow loading (Figure 3-91). Elk, deer, and other species can crawl under the fence and well-established trails are now commonplace. Despite continual maintenance, this design has proven inadequate as a long-term alternative to wildlife fence. While the LGV Section fence remains in better condition due to its more recent and integrated implementation, it too, is increasingly showing the same problems (Figure 3-91).

Due to deteriorating condition of retrofit fencing on the KR and LGV sections, its effectiveness in preventing WVC (and funneling animals to underpasses) has declined over time to the point that WVC incidence is now 42% higher than the before-mitigation levels (Figure 3-92).

The proportion of all WVC which occurred by MP (excluding MP 263) on the LGV and KR sections of the hotspot ranged from 0.09-0.28 (Figure 3-93); the LGV section accounted for 37% of WVC and the KR Section 63% (Figure 3-93), though their average WVC incidence where retrofit fence exists is comparable: 2.1 versus 2.4 WVC/mile/year for LGV and KR, respectively.

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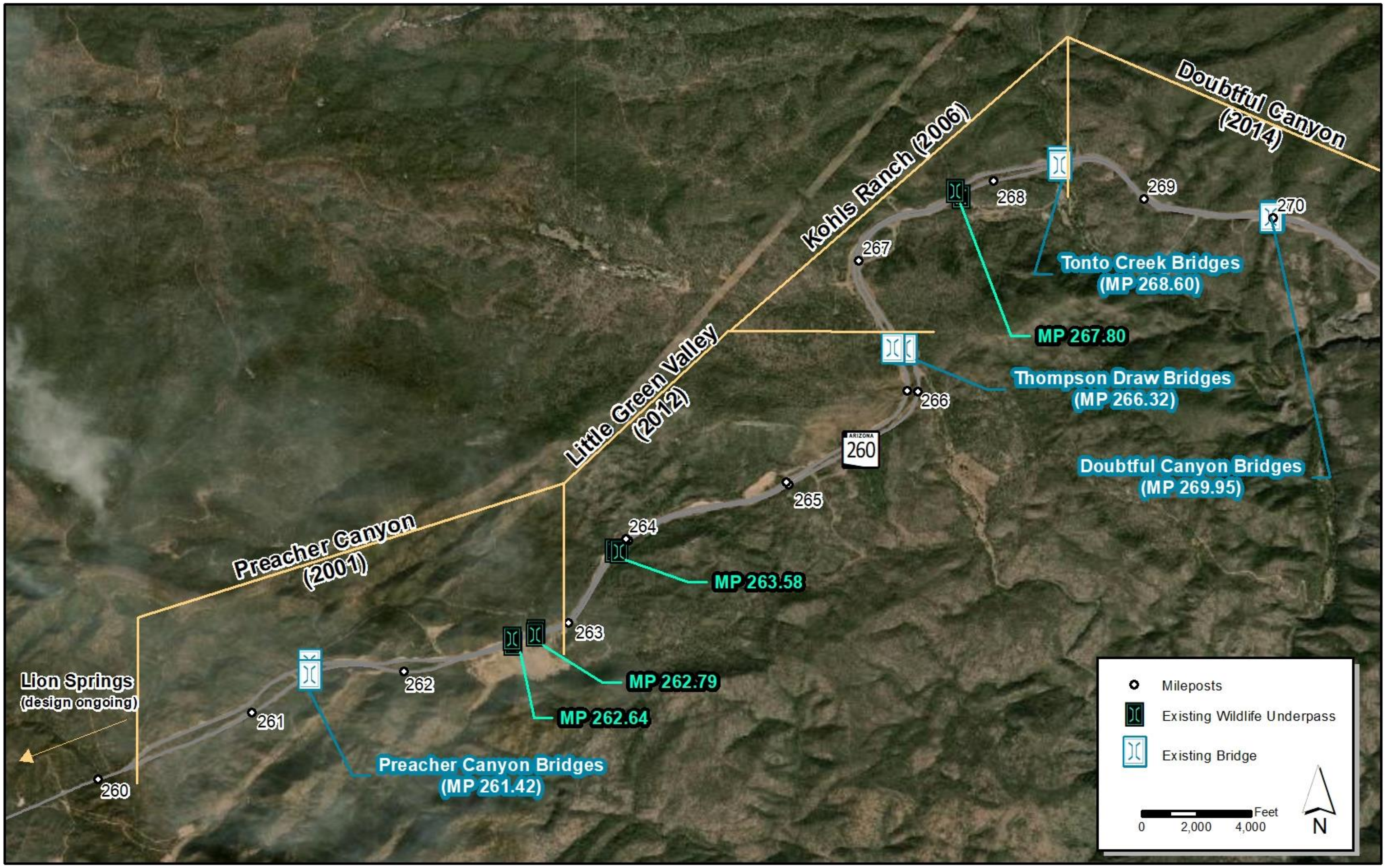


*Figure 3- 90. SR 260 reconstruction sections and year completed, with wildlife underpasses and bridges; not shown is the Christopher Creek Section (2004) located east of the Doubtful Canyon Section.*

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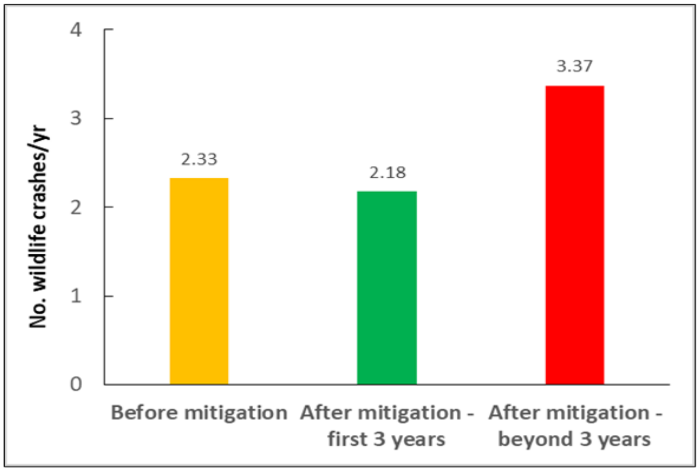
*Table 3- 24. SR 260 reconstruction sections with the types of fence used, current condition, and priority for replacement with new wildlife fence.*

| Section (year) | MP range | Miles | Fence type | Condition | Refence priority |
|---|---|---|---|---|---|
| Preacher Canyon (2001) | 260.2-261.4 | 1.2 | Retrofit electric | Good* | Low-Moderate |
| | 261.4-262.6 | 1.2 | Retrofit barbed wire | Good* | Low-Moderate |
| | 262.6-263.1 | 0.5 | Wildlife fence | Fair | Moderate |
| Little Green Valley (2012) | 263.1-264.5 | 1.4 | Wildlife fence | Good | N/A |
| | 264.5-266.3 | 1.8 | Retrofit barbed wire | Poor | Very high |
| Kohls Ranch (2006) | 266.3-268.4 | 2.1 | Retrofit barbed wire | Very poor | Very high |
| Doubtful Canyon (2014) | 268.5-271.0 | 2.5 | Wildlife fence | Good | N/A |

*Currently being maintained by vendor (will cease with Lion Springs Section reconstruction)

*Figure 3- 91. Kohls Ranch section retrofit fence (left) where elk have created a "hole" in the strands though which they walk; note the smooth, bottom strand allowing animals to crawl under the fence (left), also prevalent on the Little Green Valley Section fence (right).*

*Figure 3- 92. Comparison of WVC incidence on the SR 260 Little Green Valley and Kohls Ranch sections along Hotspot #15, before wildlife mitigations were done, the first three years after retrofit fencing, and beyond three years.*



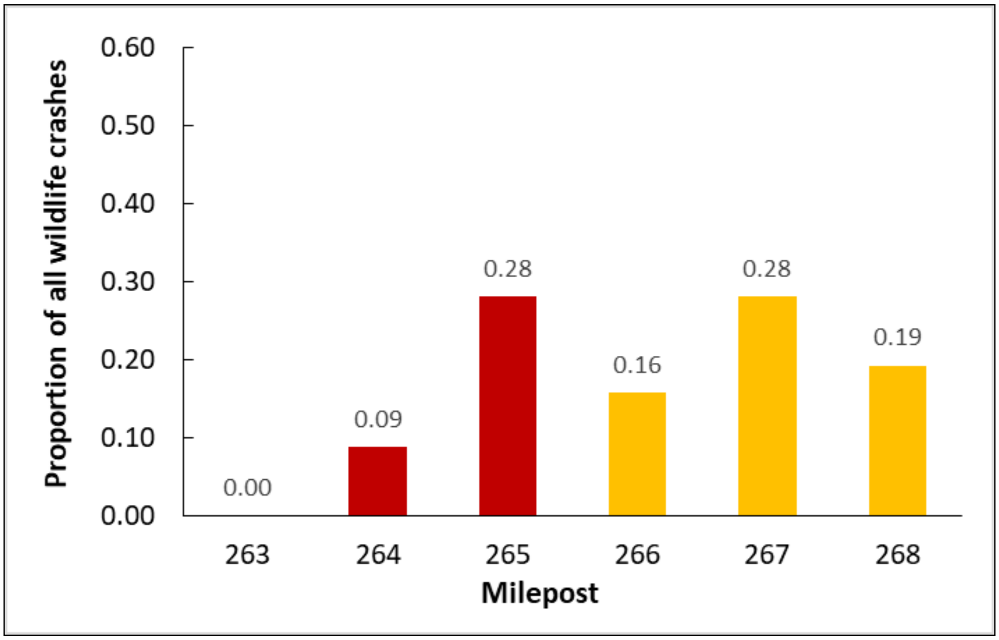



*Figure 3- 93. Proportion of all SR 260 Hotspot #15 WVCs on the Little Green Valley (red bars) and Kohls Ranch (gold bars) sections by milepost (2014-2018); note MP 263 had no WVCs as it was fenced with wildlife fence while the rest of the hotspot was fenced with retrofitted ROW fence.*

Our statewide hotspot analysis also identified a portion of the Doubtful Canyon Section (Table 3-24), the last one reconstructed in 2014 as being within Hotspot #15; this section was fenced with wildlife fence. Our summer 2020 field review found that recent WVCs occurred at fence breaks or breach points (e.g., flapper gates in drainages). Thus, this section's WVCs can be addressed with maintenance and WVC incidence is not due to poor fence design. Thus, we have excluded this 2.5-mile section from our analysis and strategy development (Table 3-24).

The Preacher Canyon Section was not identified as a hotspot in the statewide analysis as its fencing is currently performing well in reducing WVC incidence. However, 2.4 miles of retrofit fencing is currently being maintained by the vendor (Crosstek Wildlife Solutions, LLC) that installed the wildlife crosswalk project in 2006, including a stretch with electrified fence which was recently replaced (Table 3-24). Design of the adjacent Lion Springs Section where the crosswalk is located is ongoing and when implemented (2021 or 2022 bid advertisement) the crosswalk will be removed; after that, vendor maintenance will cease. Given the long-term track record of retrofit fencing on SR 260 and I-17, proactive upgrade/replacement of this fence may be warranted though it is not an immediate priority. Also, the easternmost 0.2-mile stretch of wildlife fence on the north side of the highway has suffered from considerable treefall damage and should have new woven wire strung.

OTHER ISSUES CONTRIBUTING TO WILDLIFE-VEHICLE CONFLICTS

In addition to the deteriorating condition of elk retrofit fence on the hotspot, two other factors contribute to the current high incidence of WVCs on the Kohls Ranch hotspot: improperly designed/installed double-wide cattle guards on LGV Section and insufficient escape ramps along both LGV and KR sections.

On the LGV Section, two sets of double-wide (side-by-side) cattle guards were installed on access roads so that there is an island between each set of grates such that animals can jump over each set of grates independent of the other (Figure 3-94). How many of the WVC are occurring due to these cattle guards versus elk retrofit fencing is unknown, and the most expedient approach to rectifying the situation is unclear, short of moving one set of the cribs and grates. If the elk retrofit fence is replaced on this section and WVCs persist, then corrective action will be apparent and can be addressed.

*Figure 3- 94. Improperly designed/ installed double-wide cattle guards on the SR 260 Little Green Valley Section that may be contributing to WVCs.*

The other issue contributing to the high incidence of WVCs on the Kohls Ranch hotspot associated with retrofitting of ROW fence is the absence of escape ramps on the LGV and KR sections outside of underpass locations, though two jump-outs were built into the wildlife fencing between the Thompson Draw bridge. As such, a 3.5-mile stretch has no escape measures other than the two jump-outs which Gagnon et al. (2020) found to be largely ineffective. This situation exacerbates the encroachment of elk and other species into the highway corridor, trapping them without options for escape. With a general target of having one escape ramp every half mile (Gagnon et al. 2020), our hotspot resolution strategy which revolves around upgrading retrofit fence to wildlife fence also needs to address the lack of escape ramps across most of the hotspot.

RECOMMENDED CONFLICT RESOLUTION STRATEGY (RETROFIT FENCE UPGRADING/REPLACEMENT)

Our short-term strategy focus and highest priority for action is the LGV and KR sections of SR 260 Hotspot #15. This stretch was previously mitigated to address WVC incidence and connectivity, both which are diminished due to the deteriorating condition of elk retrofit fence, similar to a northern California highway with underpasses and fencing with deferred maintenance (Caldwell and Klip 2021). Thus, our strategy focuses on upgrading/replacing elk retrofit fence with wildlife fence. Some corner and in-line fence support buttressing and use of 10-foot T-posts was done when the ROW fence was raised during retrofitting. As such, upgrading the retrofit fence to a wildlife fence standard will be less costly than new construction, though additional corner supports and buttressing may be necessary. With the condition of the LGV Section fence in better condition than the KR Section fence, the existing barbed-wire strands may be able to be integrated with the woven wire used with wildlife fencing. In places, the existing fence on the KR Section may need to be removed entirely.

We also address the long-term fence upgrading/replacement on the Preacher Canyon Section, a lower priority as the fence is largely in good condition and functional; the exception is the easternmost 0.2-mile of the section which was heavily impacted by treefall which compromised the integrity of the wildlife fence. With the programmed reconstruction of the Lion Springs Section and removal of the wildlife crosswalk, resulting in a stop to the contractor-conducted maintenance of the section's elk retrofit fence, we recommend proactive consideration of upgrading/replacing the section's retrofit fencing and the treefall-impacted wildlife fence.

### *SHORT-TERM RESOLUTION STRATEGY*

The components of our short-term conflict resolution strategy include (Table 3-25; Figure 3-95):

- The upgrade/replacement of 3.9 miles of elk retrofit fencing on the SR 260 LGV and KR sections, between MP 264.5 and MP 268.4 to a wildlife fence standard, totaling 7.8 miles along both sides of SR 260 (Figure 3-95). Much of the existing fence infrastructure can be used or integrated into the wildlife fence to reduce upgrade/replacement costs.
- Along with fence upgrade/replacement, we recommend that a minimum of six pairs of evenly spaced (≈0.6 mile) escape ramps (12 total) be installed along the SR 260 hotspot (Figure 3-95), four on the LGV Section (MP 264.5-266.3) including a pair near the Thompson Draw bridge, and two on the KR Section between the Thompson Draw bridge and the Tonto Creek bridge (MP 268.6).
- When the LGV and KR fence is upgraded/replaced, we recommend replacing the woven wire along the easternmost 0.2-mile section of Preacher Canyon Section wildlife fence (north side of the highway only) where it ties into the LGV wildlife fence (Figure 3-95).

### *LONG-TERM RESOLUTION STRATEGY*

- With the programmed reconstruction of the Lion Springs Section which will include wildlife fence, vendor-conducted maintenance of the Preacher Canyon Section elk retrofit fence between MP 260.2 and MP 262.6 will cease. We recommend that ADOT proactively upgrade/replace this fence with wildlife fence. Consideration should be given to including this upgrade/replacement as part of the Lion Springs Section reconstruction.
- Once the LGV Section elk-retrofit fence is upgraded/replaced, monitoring of WVCs should be done to ascertain WVC incidence; continued WVCs in the vicinity of the paved access roads with improperly designed/installed double-wide cattle guards may necessitate further action on ADOT's part (e.g., installation of an electrified mat).

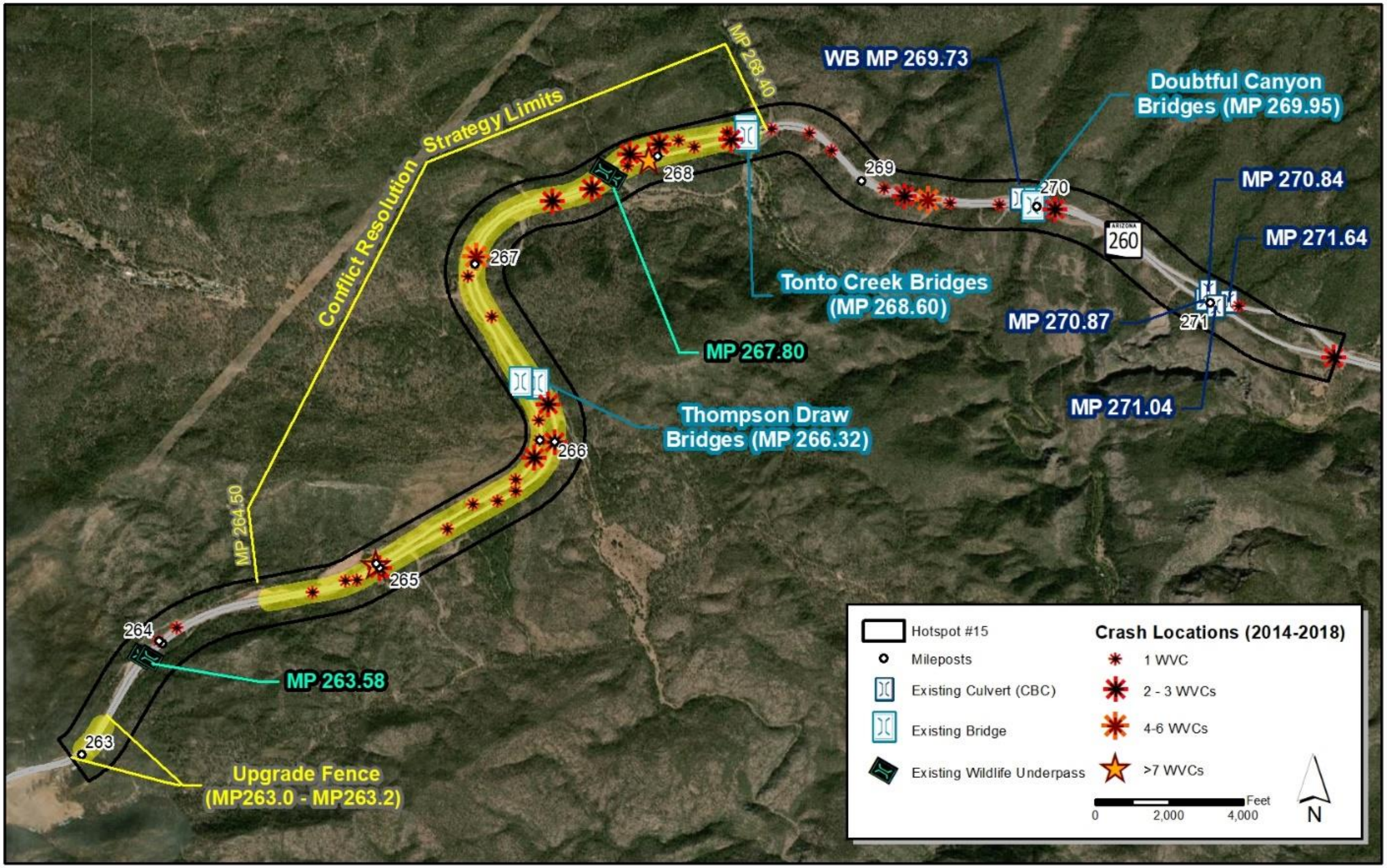



*Figure 3- 95. State Route 260 Kohls Ranch Hotshot #15 showing the Little Green Valley, Kohls Ranch, and a portion of the Doubtful Canyon sections, with fence types, condition, and replacement priority. Also shown are wildlife underpasses and bridges.*

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*Table 3- 25. SR 260 Hotspot #15 highest priority retrofitting strategy components and estimated costs to address wildlife-vehicle conflicts.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Short-Term Resolution Strategy (Little Green Valley and Kohls Ranch Sections)** | | | | |
| Wildlife fence | Miles | 8.0* | $130,000 | $1,040,000 |
| Escape ramps | Each | 12 | $11,000 | $132,000 |
| **Total** | | | | **$1,172,000** |
| **Long-Term Resolution Strategy (Lion Springs Section)** | | | | |
| Wildlife fence | Miles | 4.8 | $130,000 | $624,000 |
| **Total** | | | | **$624,000** |

*Includes 0.2 mile for the Preacher Canyon Section

The retrofitting strategy to address WVC along 3.9 miles of the hotspot is estimated to cost $1,172,000, or just over $293,000/mile (Table 3-25). This strategy would eliminate an average of 11.4 WVC/year, 65% involving elk and 20% involving mule deer (bears and lions could still climb over fences). Using average cost figures from Huijser et al. (2009*a*) for WVC involving elk ($17,483) and mule deer ($6,617), the SR 260 Kohls Ranch hotspot strategy would accrue an annual benefit of $144,636, with a project cost:benefit break-even point of 8.1 years.

### ENVIRONMENTAL OVERVIEW

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Construction of the proposed fencing retrofit project will be confined to the existing ADOT easement through Tonto National Forest. An Environmental Impact Statement (EIS) was completed for this corridor in 2000; however, the proposed projects were not evaluated as part of the preferred alternative. Therefore, if NEPA is required, this project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: "Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way."

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of both proposed projects, and it is recommended that these known cultural sites be avoided, though reassessment may be needed to determine the avoidance limits. Hazardous materials testing will be required for both proposed projects because the proposed fencing will tie into existing structures and cattleguards, and a hazardous materials assessment should be performed for the project area to address any potential hazardous material concerns. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. Neither of the proposed projects are located within currently designated or proposed critical habitat for any species. Though the effects of noise from the proposed project to the Mexican spotted owl (*Strix occidentalis lucida*) should be evaluated in the biological document due to the proximity of suitable habitat. Additionally, wildlife fencing will tie into several existing structures which may provide habitat to roosting bats or nesting birds that are federally protected by the MBTA. Further investigation of structures throughout both project areas will be necessary during their respective environmental clearances, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required for either project.

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## HOTSPOT #21: INTERSTATE 40 × STATE ROUTE 64 (SR 64 PORTION ONLY) (MP 185.5-195.5)

Hotspot #21 spans a portion of I-40 on each of its junctions with SR 64, and a 10-mile stretch of SR 64. This assessment and WVC resolution strategy focuses on the SR 64 portion due to the availability of retrofitting options identified in an AGFD wildlife movements and design concept report commissioned by ADOT (Dodd et al. 2012). SR 64 accounts for 82% of all WVCs for the entire hotspot.

### HOTSPOT OVERVIEW (SR 64 PORTION)

**Total WVCs** (2014-2018)**:** 84

**WVCs/mile/year:** 1.68

**WVC percentage of all crashes:** 40.1%

**2018 WVC species composition** (11 WVC)**:** Elk – 100%

**AADT:** 18,967 vehicles/day

The proportion of all WVCs that occurred by MP within the hotspot ranged from 0-0.15 (Figure 3-96 and Figure 3-97). Half the hotspot between MP 186-190 accounted for two-thirds of all WVCs (Figure 3-96).

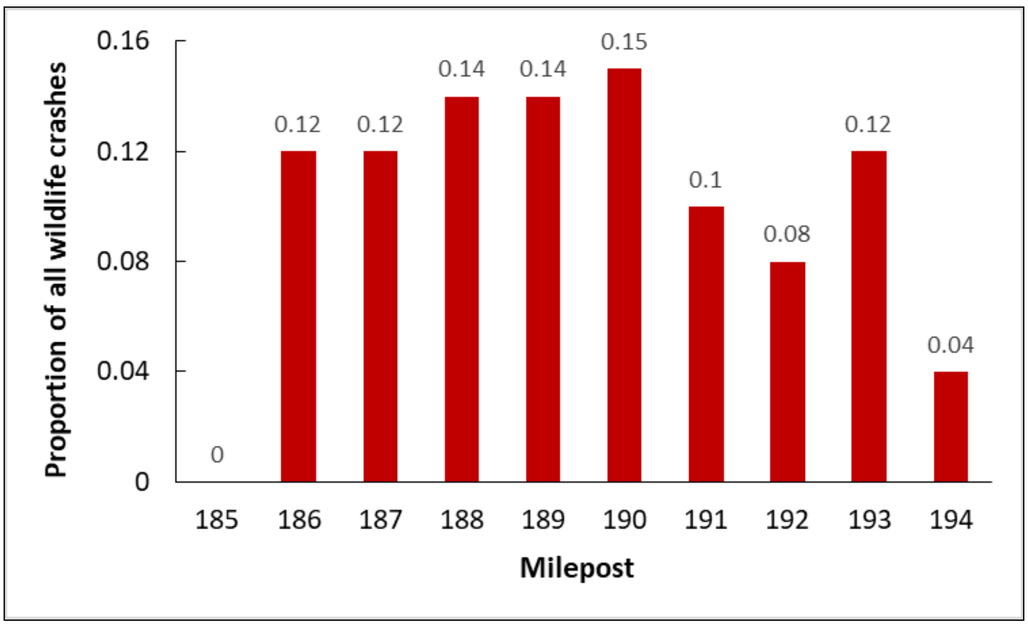


*Figure 3- 96. Proportion of all SR 64 Hotspot #21 WVCs by milepost (2014-2018).*

SR 64 WVC incidence varied by season, with the 5-month period between May and September accounting for 61% of WVCs (Figure 3-98). While this period is the peak of the tourist season for visiting the Grand Canyon National Park, other factors such as water and forage availability likely also influence WVC incidence. The lowest incidence of WVCs occurred during the winter and spring months (February to April) accounting for only 6% of WVCs (Figure 3-98).

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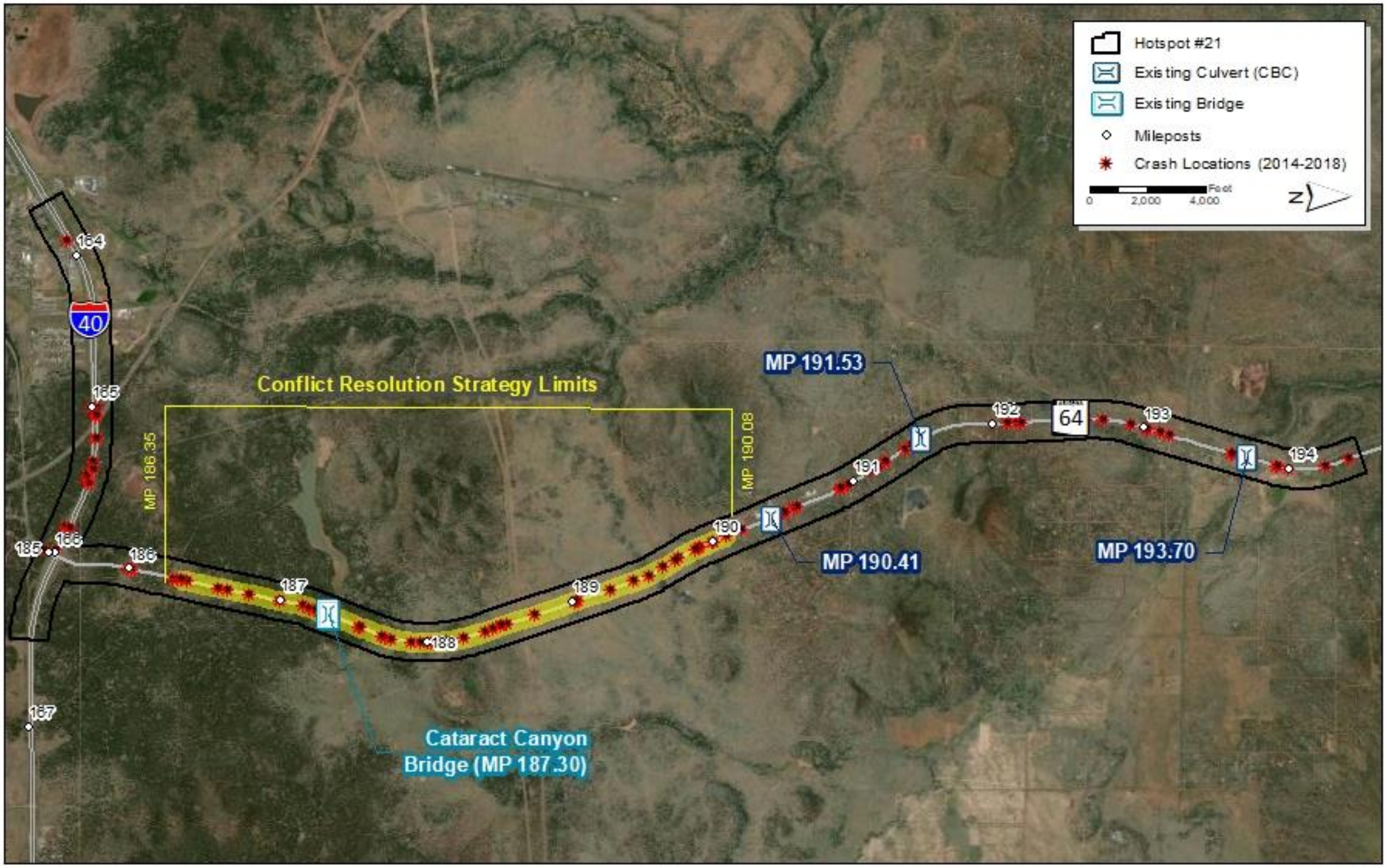


*Figure 3- 97. The SR 64 portion of Hotspot #21 located north of the I-40 × SR 64 junction, showing WVC locations occurring between 2014-2018, existing drainage structures, the Cataract Canyon bridge, and the portion of the hotspot addressed with a conflict resolution strategy.*

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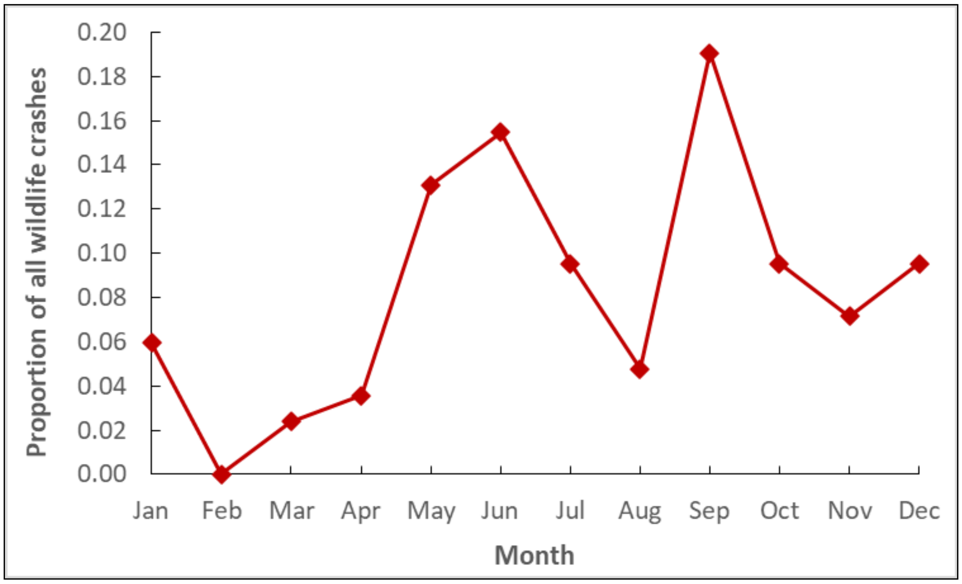


*Figure 3- 98. Monthly proportion of all WVCs that occurred along SR 64 (2014-2018).*

### CONFLICT RESOLUTION STRATEGY

A Wildlife Accident Reduction Study (ADOT Project No. 064 CN 185 H5386 01C; ADOT 2006) for SR 64 was commissioned by ADOT to pursue development of a proactive assessment of WVCs and potential mitigation measures to reduce WVCs along 50 miles (185.5–235.4). This study recognized the need to conduct further field evaluation and monitoring to determine the best locations for wildlife passage structures and fencing needed to funnel animals to structures. As such, AGFD was commissioned to do a follow-up assessment of WVC patterns and conduct a GPS telemetry-based elk, mule deer, and pronghorn movements assessment.

Strategies to resolve wildlife-vehicle conflicts within the SR 64 portion of Hotspot #21 center on retrofitting anchored by the presence of the 104-foot long and 44-foot-wide Cataract Canyon bridge located at MP 187.3 (Figure 3-99). The bridge with its four 26-ft wide × 16-ft high cells is suitable for wildlife passage as each cell has an openness index (width × height/length) of 2.88.

AGFD's recommendations focused on the same 5-mile stretch accounting for two-thirds of WVCs. Retrofitting of the Cataract Canyon bridge (MP 187.3) was central to their proposed strategy for this stretch of SR 64 (Figure 3-98) even though they recorded limited use by approaching elk and mule deer in the absence of wildlife fencing. Dodd et al. (2012) also recommended construction of a new overpass at MP 189.2, linked by wildlife fencing along 4.1 miles of the highway (MP 186.0-190.1) to the Kaibab NF boundary (Figure 3-100). The proposed overpass at MP 189.2 would address elk and mule deer WVCs while also facilitating pronghorn passage across SR 64 which was shown to be a severe barrier to passage of this species.

*Figure 3- 99. SR 64 Cataract Canyon bridge located at MP 187.3 (left) and an individual barrel (right) suitable for accommodating elk and mule deer passage with wildlife fencing.*

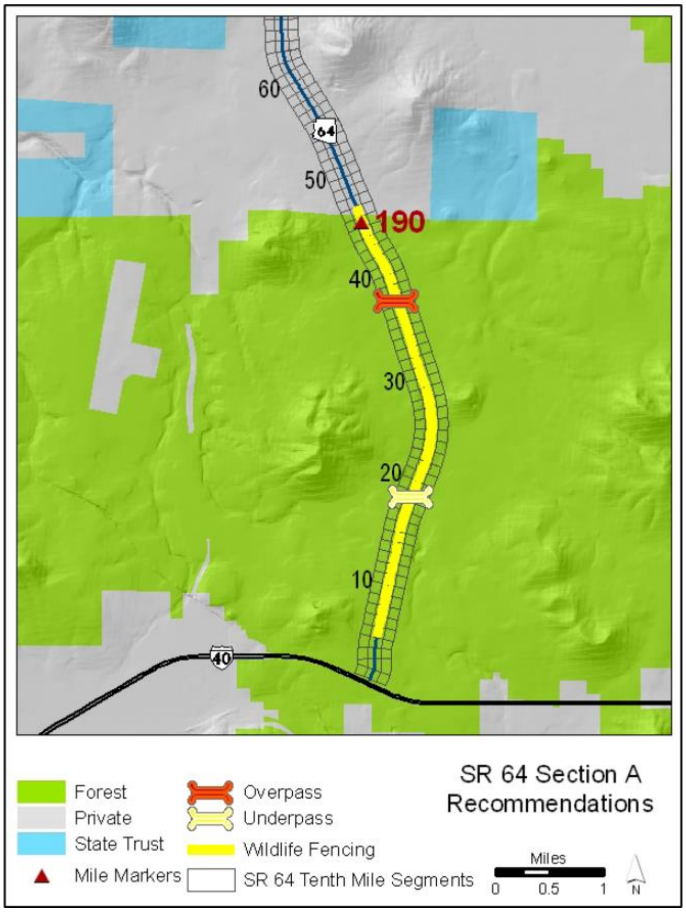


*Figure 3- 100. Wildlife passage structures (yellow underpass/red overpass) and extent of wildlife fencing (yellow highlighting) recommended in the AGFD wildlife movements study and design concept report (Dodd et al. 2012) for the SR 64 portion of Hotspot #21.*

EXISTING DRAINAGE STRUCTURES

In addition to the Cataract Canyon bridge, there are three other existing drainage structures located along the length of the hotspot, all concrete box culverts (CBC; Table 3-26, Figure 3-97).

Of the existing CBC, only the 5-barrel structure with 10-ft wide × 7-ft high cells located at MP 193.7 could potentially be suitable as a passage structure for elk and deer, though it still exhibits a marginal openness index (0.54) as Gordon and Anderson (2003) recommended a minimum index of 0.8 for mule deer. Further, extending wildlife fence to this structure from the Cataract Canyon bridge would require over 12 miles of fencing (both sides of SR 64), much which would pass adjacent to private lands and development. Thus, existing CBC do not appear conducive to inclusion into a retrofitting option for SR 64 Hotspot #21.

*Table 3- 26. Existing drainage structures located along the SR 64 portion of Hotspot #21.*

| MP | Structure | No. barrels | Width (ft) | Height (ft) | Openness index* |
|---|---|---|---|---|---|
| 190.41 | CBC | 1 | 6 | 3 | 0.14 |
| 191.53 | CBC | 1 | 6 | 7 | 0.32 |
| 193.70 | CBC | 5 | 10 | 7 | 0.54 |

*Width × Height / Length (metric units)   (Lengths all assumed to be 40')

FIELD REVIEW

We conducted a field review of the hotspot on 18-March-2021. This review focused on determining wildlife fence termination points on either side of the Cataract Canyon bridge that will minimize the potential for wildlife end-run effects. Our recommended fence termination points correspond to those recommended by AGFD (Dodd et al. 2012); our recommended 4.1-mile extent of fencing addresses over half the WVCs for the entire 10-mile hotspot.

*SOUTHERN FENCE TERMINUS:* This fence terminus is located at MP 186.3 just north of the junction with the road to Kaibab Lake; this location encompasses nearly all recorded WVCs between I-40 and the Cataract Canyon bridge. The site coincides with a forest opening that provides good motorist visibility for animals crossing at the end of the fence; it is also located at the transition to a reduced vehicular speed transition area north of I-40.

*NORTHERN FENCE TERMINUS:* Our recommended fence termination extends the fence to MP 190.1 as SR 64 enters development in the community of Red Lake; this terminus coincides with a commercial business to the west with existing fencing that extends to the highway ROW and thus would help deter an end run from occurring.

RECOMMENDED CONFLICT RESOLUTION STRATEGY (RETROFITTING WITH WILDLIFE FENCE, WITH A STRUCTURAL OPTION)

Our preliminary strategy for resolving wildlife-vehicle conflicts on the SR 64 portion of Hotspot #21 entails the retrofitting of the existing Cataract Canyon bridge with wildlife fencing and associated components (e.g., escape ramps, cattle guard extensions, gates) and installation of motorist alert signage at the fence termini. A longer-term structural option for a drop-in wildlife overpass is also provided.

***SHORT-TERM RESOLUTION STRATEGY***

The components of our recommended short-term retrofitting-based conflict resolution strategy include (Table 3-27; Figure 3-101):

- Fencing 3.75 miles of the SR 64 corridor with wildlife fence between MP 186.3 and MP 190.1, with 1.0 mile south of the Cataract Canyon bridge (MP 187.3) and 2.8 miles to the north, totaling 7.5 miles of wildlife fence (Figure 3-101).
- Fencing necessitates the installation of three cattle guard extension grates to create double (side-by-side) wildlife guards at side roads with existing single-wide cattle guards and one new double-wide cattle guard installation. Also, up to six 8-foot-high swinging gates at lateral access roads

may be required depending on ADOT's and the Kaibab National Forest's determination of necessity for small lateral roads; two are required in wildlife fencing at the Cataract Canyon bridge for ADOT maintenance access (Figure 3-99).

- We recommend six pairs of evenly spaced (0.6 mi) wildlife escape ramps to be installed along SR 64 (12 total), with one pair south of the Cataract Canyon bridge and five pairs to the north (Figure 3-101).
- Motorist alert signage (preferably flashing/LED-enhanced) at the approaches to the wildlife fencing to alert motorists to the potential for encountering animals crossing the roadway (Figure 3-101).

*Table 3- 27. SR 64 Hotspot #21 short- and long-term resolution strategy components and estimated costs to address wildlife-vehicle conflicts.*

| Project component | Units | No. units | Estimated unit cost | Total estimated cost |
|---|---|---|---|---|
| **Short-Term Strategy (Retrofitting Cataract Canyon Bridge)** | | | | |
| Wildlife fence | Miles | 7.5 | $158,000 | $1,185,000 |
| Escape ramps | Each | 12 | $11,000 | $132,000 |
| Cattle guards | Each | 5 | $30,000 | $150,000 |
| Swinging 8-ft gates | Each | 6 | $1,500 | $9,000 |
| Alert signage | Each | 4 | $4,000 | $16,000 |
| **All components** | | | | **$1,492,000** |
| **Long-Term Strategy (Drop-In Overpass)** | | | | |
| Drop-in overpass | Each | 1 | $2,500,000 | $2,500,000 |

The retrofitting strategy to address WVC along 3.75 miles of the hotspot is estimated to cost $1,492,000, or $398,000/mile (Table 3-27). This strategy would eliminate an average of 8.7 WVC/year, all associated with elk. Using average cost figures from Huijser et al. (2009*a*) for WVC involving elk ($17,483), the SR 64 retrofit strategy would accrue an annual benefit of $152,000, with a project cost:benefit break-even point of 9.8 years.

### *LONG-TERM STRUCTURAL MITIGATION OPTION*

We recommend consideration of a drop-in overpass structure at MP 189.2 (Figure 3-101), as recommended by Dodd et al. (2012) to improve passage spacing, minimize the northern end-run effect and potential WVCs, and promote pronghorn (as well as elk, deer, and other species') connectivity. An overpass employing a prefabricated design is estimated to cost $2.5 million including structure, installation, earthwork, and mobilization (Table 3-27).

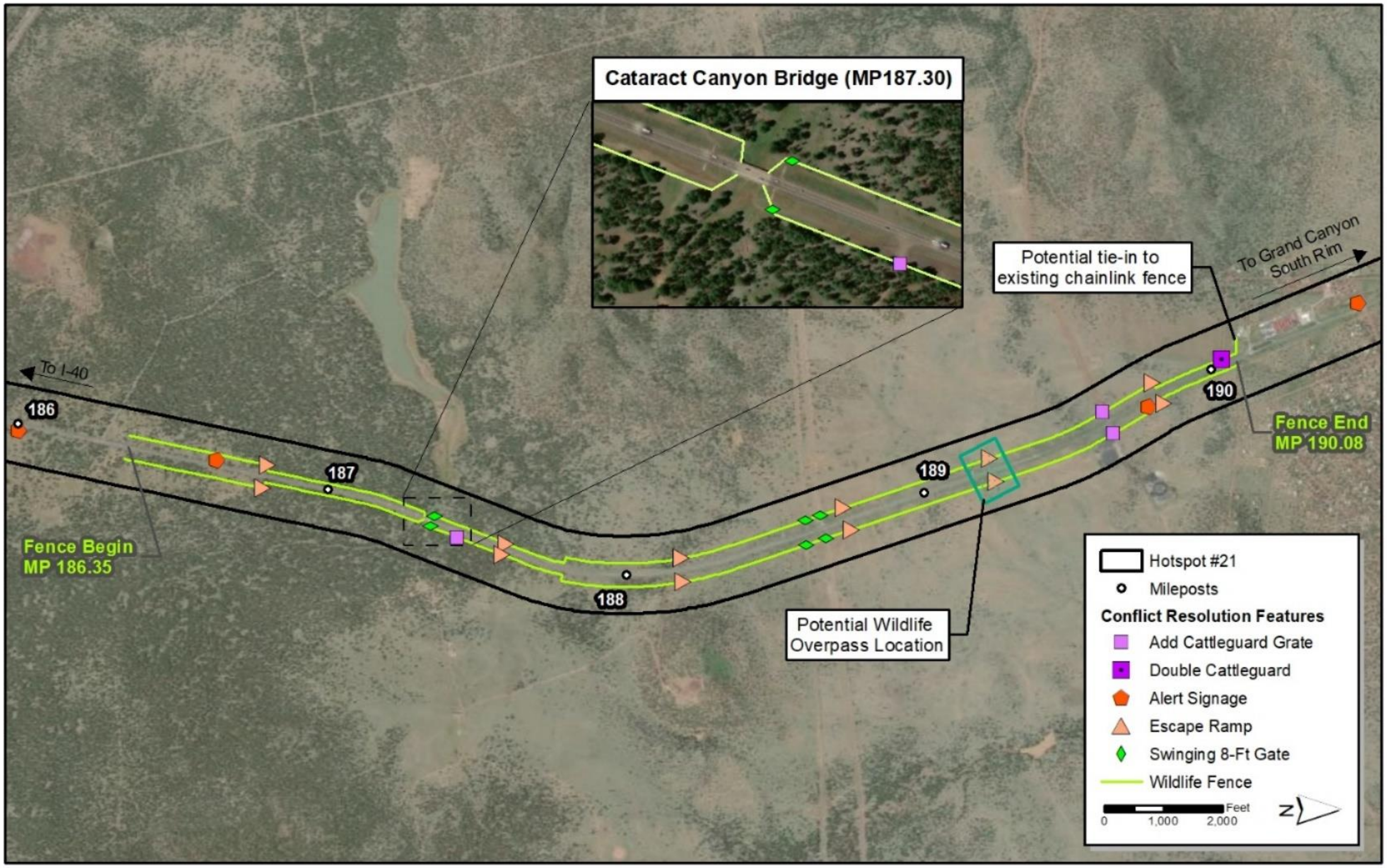


*Figure 3- 101. Short-term wildlife-vehicle conflict resolution strategy for SR 64 Hotspot #21 including retrofitting of the Cataract Canyon bridge (insert) with wildlife fencing and associated measures (cattle guards, gates, escape ramps). Also shown is the location of the proposed overpass for long-term implementation.*

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## ENVIRONMENTAL OVERVIEW

The environmental requirements for this project will be applicable to ADOT District permit requirements and may require compliance with NEPA if a federal nexus is identified. Overall environmental requirements will be discussed with the ADOT District during final design to determine if a categorical exclusion or condensed clearance memo will be required. Pending the outcome of technical studies and approvals, the anticipated impacts of this undertaking are expected to be beneath the threshold of significant. Construction of the proposed Short-term project will primarily occur within existing ADOT ROW through private land and existing easement through ASLD lands and Kaibab National Forest. However, the recommended fence terminus at the north end of the proposed Short-term project would tie-in to a private landowner's fence. At a minimum, early coordination with private landowners at the northern terminus of the fence should be anticipated though some TCE or ROW acquisition may be needed. For the Long-term project, construction of an overpass may require a TCE from Kaibab National Forest. If NEPA is required for the proposed Short-Term project and no TCE or new ROW is needed, the project is anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) as C-list (c)22: "Projects, as defined in 23 U.S.C. 101, that would take place entirely within the existing operational right-of-way." If NEPA is required for the Long-term project, or a TCE or new ROW is needed and NEPA is required for the Short-term project, then the projects are anticipated to be cleared under ADOT CE Assignment (23 U.S.C 326) under C-list (c)23(i): "Federally funded project that received less than $5,000,000…".

The environmental clearance effort would be led by ADOT EP and would include cultural, hazardous material, biological and surface waters review. Cultural resources are known in the vicinity of all the proposed projects. For the Short-Term project, it is recommended that these known cultural sites be avoided, though reassessment may be needed to determine the avoidance limits. For the Long-term project, survey is recommended to reassess the current location of cultural sites and determine their NRHP eligibility. A hazardous materials assessment should be performed for all the proposed projects to address any potential hazardous material concerns. Additionally, hazardous materials testing will be required for the Short-Term project because of impacts to existing structures and cattleguards. During the environmental clearance process for each of the proposed projects the IPaC and AGFD Review Tool will be reviewed to identify species federally protected under the ESA and sensitive species known to occur in the project areas. None of the proposed projects are located within currently designated or proposed critical habitat for any species. For the Short-term project, wildlife fencing will tie into the existing Cataract Canyon Bridge (MP 187.3) which may provide habitat to roosting bats or nesting birds that are federally protected by the MBTA. Further investigation of this structure will be necessary during the environmental clearance of the Short-Term project, and avoidance or species exclusion mitigations may be warranted. Impacts to WOTUS from the proposed projects are not anticipated, thus a CWA Section 404 permit or Section 401 water quality certification will not be required for either project.

## REFERENCES

Arizona Department of Transportation (ADOT). 2006. Final wildlife accident reduction study, State Route 64: I-40 to Moqui, Williams–Grand Canyon–Cameron Highway. Project No. 064 CN 185 H5386 01C. Phoenix: Arizona Department of Transportation.

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# CHAPTER 4 – FUTURE CONDITIONS

Future conditions in Arizona that may affect the interplay of transportation and wildlife include changes in climate, increases in human population, listings of endangered and threatened species, new models of transportation planning, and new resources for funding. As we attempt to forecast future conditions for the 5-10-20 year planning horizon, it is difficult to speculate as little information is currently known in Arizona regarding wildlife under current conditions. As an example, any wildlife-vehicle conflicts with threatened or endangered species and special status species is not readily available as these data are not readily captured in the ACIS database or a statewide carcass database. Databases are currently being built, but this emphasizes the importance that ADOT continues to maintain a strong relationship with their planning partners including AGFD so they can address and better forecast these types of issues. Below we outline certain areas that may be considered.

## BIG GAME CONSIDERATIONS

Ungulate wildlife in Arizona including bighorn sheep, pronghorn, mule deer, elk, white-tailed deer will be better studied and understood in the future with continued research. Data supporting calving/fawning areas, winter ranges, movement corridors and habitat blocks are known for certain species but are not readily available for all species and are not available throughout all locations within the state. The continued partnership of ADOT and AGFD will be as important as ever as new projects are planned. As has been highlighted previously the importance of studies prior to new construction showing movement patterns and habitat blocks is important. In locating the future I-11, these types of studies should occur prior to construction so potential wildlife conflicts can best be mitigated.

### CLIMATE CHANGE

ADOT assisted FHWA in the development of a Climate Change Adaptation Guide (FHWA-HOP-15-026). This guidance document serves as a starting point for integrating programmatic resilience into operations and maintenance activities. Maintenance programs are noted to be vulnerable to natural hazards, extreme weather and climate impacts. In March 2020, ADOT published a pilot study on *Asset Management, Extreme Weather, and Proxy Indicators Pilot Project*. This project highlights that transportation infrastructure is a complex system of assets required to deliver multiple services and functions. With fiscal constraints, and the fact that retrofitting to address the impacts of extreme weather and climate risk continues to be cost prohibitive, this study set out to look at new and novel approaches to long term planning, asset management, project development, engineering design and lifecycle planning. Although this report did not specifically address wildlife or fencing, this concept of asset management techniques identifying risks to the integrated system can consider the impacts of wildlife to the roadway system. The project team would encourage ADOT to use this same approach to consider the impacts of wildlife and the safety risk to the travelling public and the financial impacts to the state due to loss of wildlife.

These effects are further compounded by the fact that climate change has the potential to impact wildlife and ecological concerns. Not a lot of information is available in the State of Arizona on future trends for wildlife. ADOT, AGFD and their planning partners/stakeholders should continue to identify issues of concern that the State should be considering in their long-term planning efforts.

Increasingly frequent and destructive extreme weather events, including heavy precipitation, are occurring around the world (Intergovernmental Panel on Climate Change 2014). Such extreme precipitation events impact transportation infrastructure, damaging and even washing out bridges and culverts which are unable to accommodate infrequent extreme flows. In addition to impacting both road and environmental integrity, damaged infrastructure disrupts commerce and results in repair and maintenance costs (National Cooperative Highway Research Program [NCHRP] 2014).

To address increasing climate unpredictability and infrastructure resilience to extreme precipitation events, and to reduce long-term maintenance costs, consideration should be given to increasing culvert and even bridge sizes, at relatively low to moderate additional cost (NCHRP 2014). Upgrading/oversizing culverts, if adequate openness is achieved can also benefit a wide range of wildlife species by improving their suitability for passage, thus creating cost-effective dual-function structures.

## PROJECTED WILDLIFE-VEHICLE CONFLICT

As described earlier, we found a strong linear association between Arizona's estimated population between 2003-2018 and the incidence of wildlife-related crashes (*r* = 0.916; Figure 4-1); this association alone explains 84% of the variation in wildlife-related crashes. We used the regression equation for this association to project the incidence of future crashes as Arizona's population continues to grow. For the projections, we assumed that the annual population growth would be at the same average rate as for the 2003-2018 period, or 1.88%, from which we calculated future projects for 5-year increments through 2051 (Figure 4-1). These projections assume that no additional wildlife-vehicle conflict mitigations would be implemented.

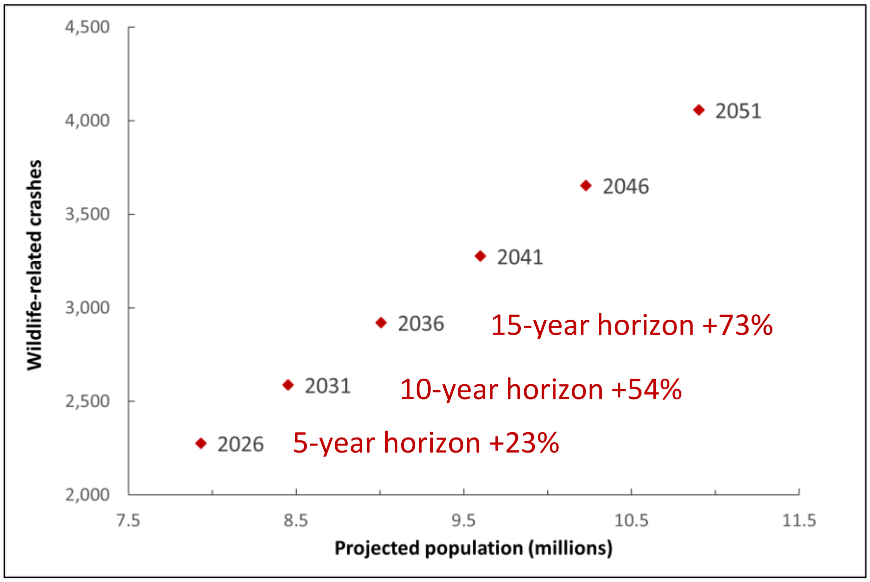


*Figure 4- 1. Five-year increment projections in future wildlife-related crash incidence from the linear regression equation between crashes and Arizona's population between 2003-2018.*

Future projections of wildlife-related crash incidence for the 5-year increments were calculated from the regression equation:

$$\textit{Wildlife crashes} = -2{,}483.1266 + (0.0006 \times \textit{Population})$$

Our projections show that over the next five years (2026), annual wildlife crashes would increase 23% (392 crashes) over the 2018 level (1,684 crashes; Figure 4-1). Our ten-year projection (2031) is for a 54%

increase in the annual incidence of wildlife crashes (to 2,588) over the 2018 level (Figure 4-1). And out 15 years, in 2036 when Arizona's population is projected to first top nine million residents, crashes are projected to increase 73% over 2018, to an annual level of 2,921 crashes (Figure 4-1). Along with the increased wildlife-vehicle conflicts is the potential for ecological factors to become a bigger issue for ADOT including potential future species listings. Without accurate data showing the impacts of collisions on threatened and endangered species and special status species, there is always the risk of increased mitigation costs. A proactive approach that conducts special planning studies to investigate some of these potential impacts may be warranted.

Associated with the future potential increases in WVCs, the associated barrier effect would also be expected to worsen across Arizona's highways, as suggested by models of the relationship between highway traffic volume and highway permeability (Mueller and Berthoud 1997; Seiler 2003). Thus, habitats and populations could become increasingly fragmented and subject to genetic isolation, reducing long-term population viability for the most sensitive species such as pronghorn, bighorn sheep, and others. These impacts could impact the significant nature-based ecotourism and recreational sectors (e.g., wildlife viewing, hunting) across Arizona.

## SUMMARY OF FUTURE CONDITIONAL NEEDS AND RISKS

The RFP requested how and when these conditional needs and risks be addressed. This section highlights some general thoughts to consider.

### NEEDS SHOULD BE ADDRESSED PROACTIVELY NOW, IN THE P2P PLANNING PROCESS, AND WITH EVERY ITERATION OF THE STIP AND LONG-RANGE TRANSPORTATION PLANS

The needs of wildlife, both vertebrates and invertebrates to move freely between habitats in the face of roads, traffic, and habitat fragmentation that comes with the building of new roads must be considered more than ever in the future. These needs should be considered annually within the P2P planning process. Wildlife needs should be addressed at all levels in ADOT and within all appropriate planning processes. Partnerships with land management, resource agencies, MPOs and COGs should continue to be emphasized.

Wildlife and overall ecosystem processes will need to be considered in all functions and divisions within ADOT.

### NEEDS SHOULD BE ADDRESSED WITHIN MOST DIVISIONS WITHIN ADOT AND WITH PLANNING PARTNERS

This includes Maintenance and Operations. Maintenance staff will need continued guidance and education for mowing regimes that promote connectivity for monarch butterflies and pollinators. They will need to continue to monitor and repair wildlife exclusion fences, from elk fences to tortoise fences. Culverts that are expected to pass wildlife, such as tortoises, snakes, small mammals, should be cleared out every year.

Maintenance staff that maintain wildlife fencing should be consulted early in planning to identify challenges and successes in maintaining wildlife fencing. Lessons learned should be shared with the designers. ADOT may want to consider a statewide fencing contract or evaluation process (asset management) to focus on the maintenance of the fencing assets put in place to account for wildlife-vehicle conflicts.

Traffic Safety engineers and other personnel should be looking at the transportation related aspects of wildlife-vehicle conflict that could help determine what the hotspots are and how to plan for funding future projects that help reduce wildlife-vehicle conflicts.

**RISK FACTORS TO CONSIDER**

Changes in land use, lawsuits, land ownership, funding availability for wildlife mitigation, and climate change induced conditions affecting wildlife.

Lawsuits for serious injuries and fatalities will continue to occur in Arizona. It is by having a strategic plan and a proactive approach to mitigate these effects that ADOT can successfully defend these types of lawsuits.

Climate change also effects ecosystems and wildlife. With the anticipated drier and hotter climate of Arizona in future years, wildlife, pollinators, and even plants will need to migrate north, up in latitude, restrict their ranges to the more moist and cooler areas, and overall adapt in ways that will bring them in conflict with roads.

As has been highlighted in this report funding of future wildlife mitigation efforts may be partially or wholly dependent on outside funding sources. ADOT should consider looking into alternative funding sources, including partnerships, grants (wildlife, natural disaster, hazard mitigation, FEMA, FHWA, DOT, pilot studies), executive/secretarial orders. Funding should be considered for planning studies to address all of the above.

# CHAPTER 5 – STATEWIDE LIST OF WILDLIFE CROSSING NEEDS

The hotspot analysis did little to identify problem areas for animals that are not as numerous in Arizona as mule deer or elk, nor are large enough to cause serious damage to a vehicle or driver. The research team brought together transportation related data and ecological related data to score each of the 51 hotspots based on other factors, to more fully inform ADOT and its agency partners as to what other challenges and potential solutions exist in those hotspots. The factors or variables had points to score and to help with prioritizing the original 51 hotspots based on different priorities for ADOT and its partners. All these data and point scoring were placed in an Excel spreadsheet named the "Master Matrix." The inputted variable can be changed and ranked differently so that their importance can be lowered or elevated in the scores for any of the rankings at a later time.

The transportation data included: points for rank in wildlife-vehicle collision priorities; points for fatal accidents due to wildlife-vehicle collisions in the hotspots; points for serious injury crashes from wildlife collisions; points for percentage of all crashes that were wildlife related; and points for the Average Annual Daily Traffic (ADDT). Each one of these variables was calculated in a tab in the spreadsheet, and only the final points scores are presented in the Matrix tab. The Transportation Score reflects scores for the fatal and injury crashes, percentage of crashes that are wildlife-related, and traffic volume. It DOES NOT include values for hotspot scores- the goal was to rank hotspots solely by other factors to see how the 51 hotspots ranked for these alone.

The ecological data tallied for each hotspots' ecological score included points for: if the hotspot intersected or was adjacent to a state wildlife linkage, county wildlife linkage, and local linkage; if the hotspot was in critical habitat of threatened or endangered species; if there was desert tortoise presence or habitat; if there was pronghorn presence or a migration linkage in the hotspot; bighorn sheep presence; known white-tailed deer distribution; elk migration linkage; and for mule deer linkage presence. The points were more heavily weighted to species important to ADOT operations that were not represented in the crash hotspots. These were the Sonoran and Mojave Desert tortoises, pronghorn, bighorn, white-tailed deer, elk linkages, and mule deer linkages. Each one of these variables was calculated in a tab in the spreadsheet, and only the final points scores are presented in the Matrix tab. The points were added for all these ecological factors, and each WVC hotspot was then ranked according to ecological variables. The scores for the species of interest always remained the same in various weightings. However, when linkages were the focus, linkage scores went from a range of 0- 3 points, to 0 - 71 points. When the analysis was species focused, the linkage scores were reduced to 0-3 points. The ranking of the hotspots with this species focus is presented in the tab "Tally of the 3 Ranks." When Linkages were more highly weighted over species scores, the results are presented in the tab, "TALLY OF 3 RANKS - LINKAGES HIG."

The 51 original hotspots were then ranked based on these transportation and ecological data. Below the top 10 hotspots are presented for different ways to rank the data. Table 5-1 presents the top 10 hotspots when solely ecological data are tallied, and the scores for species are weighted higher than scores for linkages. Table 5-2 presents the top 10 hotspots when only ecological data are considered and linkages are weighted more heavily than species' presence. Table 5-3 presents the top 10 hotspots when only transportation data are considered. This ignores the rank for the number of wildlife-vehicle crashes per mile per year, and only considers the transportation factors presented above. Finally, in Table 5-4, the ecological data with a linkage focus was combined with transportation data to rank the top 10 hotspots based on these multiple factors.

The ADOT district where each hotspot resides is also presented, and the rows for the hotspots are color coded according to ADOT district for ease of viewing. Color key: Blue = Northcentral District, Tan = Northwest District, Yellow = Southcentral District, Green =Northeast District, Brown = Southwestern District.

These Top 10 lists are potential project locations for future wildlife mitigation to reduce the hazards of wildlife-vehicle collisions and to promote wildlife connectivity. The exact locations by mile posts and maps of these areas are presented in earlier sections of the report. The reader is advised to look for hotspots that consistently rank in several of these Top 10 lists. These hotspots are then important for multiple divisions within ADOT for achieving various goals of less crashes, safer roads, and the protection of listed species, wildlife linkages, wildlife migration corridors, and compliance with environmental regulations.

*Table 5- 1. Top 10 List of hotspots based on ecological score with a species focus. (Blue= Northcentral District, Tan = Northwest District, Green = Northeast District).*

| Rank | Hotspot name | WVC Hotspot score |
|---|---|---|
| 1 | SR 89 A Forest Highlands | 39 |
| 2 | I-40 Pine Springs | 18 |
| 3 | I-17 Rattlesnake Canyon to South of Munds Park | 19 |
| 4 | I-40 West Flagstaff to Williams | 16 |
| 5 | SR 69 N Spring Valley | 41 |
| 6 | I-40-SR 64 North of Williams | 21 |
| 7 | US 89 North of Flagstaff | 1 |
| 7 (tie) | I-17 Munds Park to Flagstaff Pulliam Airport | 7 |
| 9 | SR 73/SR 260 South of Show Low | 22 |
| 9 (tie) | US 60 East of Show Low | 22 |

*Table 5- 2. Top 10 List of Hotspots based on an ecological score with linkages focus. (Blue Northcentral District, Tan = Northwest District).*

| Rank | Hotspot name | WVC Hotspot score |
|---|---|---|
| 1 | SR 89 A Forest Highlands | 39 |
| 2 | I-17 Rattlesnake Canyon to South of Munds Park | 19 |
| 3 | I-40 West Flagstaff to Williams | 16 |
| 4 | SR 69 N Spring Valley | 41 |
| 5 | US 89 North of Flagstaff | 1 |
| 5 (tie) | I-17 Munds Park to Flagstaff Pulliam Airport | 7 |
| 7 | US 89 Sunset Crater Volcano NM | 8 |
| 7 (tie) | US 180 Kaibab National Forest - Ebert Mountain | 43 |
| 9 | SR 64 South Rim Grand Canyon | 2 |
| 10 | I-40 Pine Springs | 18 |
| 10 (tie) | SR 69 Prescott | 3 |
| 10 (tie) | I-40 East Flagstaff Wildcat Hill 40 | 14 |
| 10 (tie) | I-17 South of Munds Park | 34 |
| 10 (tie) | SR 64 South Rim Grand Canyon- Red Horse Wash | 37 |

*Table 5- 3. Top 10 List of Hotspots based on transportation score and no rank for hotspot. (Blue Northcentral District, Yellow = Southcentral District, Green =Northeast District, Brown = Southwestern District).*

| Rank | Hotspot name | WVC Hotspot score |
|---|---|---|
| 1 | I-19 Tumacacori | 43 |
| 2 | US 60 East of Show Low - Bell | 43 |
| 3 | SR 64 South Rim Grand Canyon | 2 |
| 4 | US 95 North Yuma | 28 |
| 5 | SR 260 Payson – Kohls Ranch | 15 |
| 6 | SR 77 North of Show Low | 4 |
| 7 | SR 260 Heber to Show Low | 6 |
| 8 | SR 64 South Rim Grand Canyon- Red Horse Wash | 37 |
| 8 (tie) | SR 64 South Rim Grand Canyon - Desert View | 37 |
| 10 | SR 90 Sierra Vista | 29 |
| 10 (tie) | SR 87 NW Boundary of Mogollon Rim | 34 |

*Table 5- 4. Top 10 List of Hotspots based on combined transportation and ecological ranks with a linkages focus and no scoring for hotspot rank. (Blue Northcentral District, Brown = Southwestern District).*

| Rank | Hotspot name | WVC Hotspot score |
|---|---|---|
| 1 | SR 64 South Rim Grand Canyon | 2 |
| 2 | SR 64 South Rim Grand Canyon- Red Horse Wash | 37 |
| 3 | US 89 North of Flagstaff | 1 |
| 4 | I-40 West Flagstaff to Williams | 16 |
| 4 (tie) | I-17 Rattlesnake Canyon to South of Munds Park | 19 |
| 6 | US 95 North Yuma | 28 |
| 7 | SR 87 NW Boundary of Mogollon Rim | 34 |
| 8 | I-17 Munds Park to Flagstaff Pulliam Airport | 7 |
| 9 | SR 260 Payson – Kohls Ranch | 15 |
| 10 | US 89 Sunset Crater Volcano NM | 8 |

# CONCLUSION

Wildlife-vehicle conflicts on Arizona's highways are a significant and growing issue. ADOT and its partners have been national leaders the past two decades in addressing conflicts related to WVC and highway barrier effects. Most projects where wildlife-vehicle conflicts have been addressed in the past were associated with major highway construction/reconstruction, for which ADOT funding outside urban areas has declined. At the same time, wildlife-vehicle conflicts are increasing due to Arizona's growing population and associated travel on rural highways. This study represents a proactive commitment on ADOT's part to assess, identify, and prioritize highway stretches where WVC present highway safety concerns. Further, this study has attempted to provide ADOT options short of full highway reconstruction to address conflicts with a range of project strategies and options while recognizing that reconstruction projects still represent the most comprehensive approach to resolving the full range of wildlife-vehicle conflicts.

Conflict resolution strategies and proposed projects for the nine of our identified (of 51 statewide) priority hotspots run the gamut from relatively low-cost motorist alert signage to retrofit wildlife fencing to link existing suitable structures to new drop-in passage structures. Whereas costly wildlife passage structures and fencing options intended to modify wildlife behavior were predominately applied in the past, several identified hotspots fall within semiurban settings or rural highway stretches where opportunities for structural mitigations are limited. In these cases, a range of measures and projects intended to modify motorist behavior have been developed including comprehensive strategies to slow motorists and increase awareness of WVC risk; some of these strategies incorporate new technologies such as wildlife radar detection systems and integrated alert signage; enhanced speed reduction efforts could increase effectiveness of such measures. We appreciate ADOT's willingness to consider these nontraditional WVC-mitigation approaches, along with a commitment to formally evaluating their effectiveness including engaging the Arizona Transportation Research Center. We also urge ADOT to utilize FHWA grant programs and protocols to fund and evaluate these new and innovative technologies (https://cms7.fhwa.dot.gov/research/technology-innovation-deployment/grant-programs).

We believe that ADOT will be better positioned to pursue and obtain funding from variety of sources to pursue implementation of wildlife-vehicle conflict resolution projects; ADOT's efforts to research and develop crash modification factors for WVC mitigation projects could help make these project more competitive in the pursuit of funding. The development of strategies and projects to address wildlife-vehicle conflicts on the state's many other WVC hotspots will better allow for the integration of wildlife needs into ADOT District maintenance and construction projects of opportunity as well as better informing the statewide P2P process.

Lastly, ADOT's ACIS database is a valuable planning and monitoring resource. Even still, we identified several limitations with WVC tracking in the ACIS. The 2017 WVC reporting change where all animal records were combined versus tracking crashes involving wildlife, livestock, and other animals separately severely limits the ability to parcel out WVC; we recommend that reporting be changed to the pre-2017 protocol. Other improvements to the form could facilitate more accurate evaluation and mitigation efforts including adding wildlife species to WVC reports. There is important information regarding WVC and associated injuries and deaths that is being missed with "First Harmful Event" tracking; improved capability in tracking WVC with other harmful events would help capture underreported injury- and death-related information and thus make mitigation projects more competitive for funding.

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# APPENDIX A. OPTIMIZED HOTSPOT ANALYSIS METHODS

## INTRODUCTION

The hotspot analysis was a state-wide analysis of the reported crashes with wildlife on ADOT administered roads, based on crashes per mile. This report details how the research team modeled the data with different choices of the variables important to the hotspot modeling process.

## OBJECTIVES OF HOTSPOT ANALYSIS TASK

The primary goal of this task was to identify priority wildlife-vehicle collision hotspots across Arizona to assist ADOT in prioritizing significant problem stretches of highway for wildlife conflict with large animals, such as ungulates and large carnivores. These hotspots are largely the identification of areas where mule deer and elk collisions are reported to occur.

## METHODS

This methods section is presented in two parts. The first sub-section, "GIS Actions," details how the GIS Analyst worked with the crash data and roads data to input into the model using the Getis-Ord Optimized Hot Spot Analysis tool (OHSA), and model instructions adapted to fit the Arizona data. The OHSA allows the analyst to adapt model parameters to ensure proper values are used given the spatial distribution of the occurrence data. The tool also enables the analyst to select the most appropriate aggregation method, that is, the method by which the points or occurrences may be counted or summarized, for a given area. The ability to summarize data within a given aggregation area is the differentiating feature from the standard Hot Spot Analysis (Getis-Ord Gi*) tool available in ArcGIS (Cramer and McGinty 2018).

Subsection, "Important Variables and Top Selections" details how the research team in conjunction with the panel selected the values for five top variables important to the hotspot modeling.

## GIS ACTIONS

### DATA RECEIVED FROM ADOT

Two key data components needed for the hotspot analysis are the simplified statewide system shapefile and crash data both of which was received from ADOT. The crash data were received in two sets which was determined by the change of the data collection log for the data in 2017. Crash data from 2003 to 2016 were delivered in a single file with unified formatting. Crash data from 2017 and 2018 were delivered separately with different data fields than the previous 14 years of data. The crash data were manually merged into a singular file for the purposes of the OHSA in conjunction with ADOT to ensure the data set was inclusive of the most up to date data. Because of the differences in reporting for the crash data sets, we were able to only identify the species of wildlife in the crash data for 2017 and 2018. Out of the 28,045 crash incidents reported in the data from 2003-2018, 474 crashes were still missing coordinate information and could not be plotted in GIS. Initially, from the full data range of 2003-2018, two data ranges were under consideration for the crash data: a ten-year data set from 2009 through 2018 and a five-year data set from 2014 through 2018. While providing a larger sample size for the purposes of the Optimized Hot Spot Analysis, the ten-year dataset was not reflective of already implemented wildlife mitigation projects on the state highway system. As a result, the five-year data set was chosen to more accurately reflect existing conditions.

### REFINING THE PYTHON CODE FOR ARIZONA ROADWAYS

Python code developed under another state hotspot analysis of animal crash data (Cramer and McGinty 2018) was adapted for this project. To do this, the Python code had to be adjusted in a series of runs to calibrate the model to best suit ADOT statewide facilities. Due to the complexity of the ADOT state system file received, the shapefile needed to be slightly simplified using the *Generalize* function of GIS to reduce the number of vertices and ultimately glitches in the buffer output of the code. This function was added as a precursor to the rest of the code with an input tolerance value of 1 foot. This input was chosen to ensure the line did not shift more than 1 foot from the original alignment. The resultant generalized state system file was then input into the rest of the Python script which was utilized to splice the statewide system highway line file into one-mile increments with a 200 meter width. Even with the generalized state system file, the buffer output from the code still contained 50 glitches that were rectified manually. Following the correction of the 50 segments, Hotspots analyses of the wildlife-vehicle crash data in Arizona were performed using the Esri® ArcGIS 10.5.1 Getis-Ord Gi* statistic tool called Optimized Hot Spot Analysis (OHSA) (http://desktop.arcgis.com/en/arcmap/latest/tools/spatial-statistics-toolbox/optimized-hot-spot-analysis.htm). These methods are applicable with versions 10.4 and greater of Esri ArcGIS.

### RANKING

The resultant OHSA shapefile segments were aggregated into hotspots based on the crash data using the 90%, 95%, and 99% confidence intervals as well as only the 95% and 99% confidence intervals. The *Dissolve* geoprocessing function was utilized to merge the individual confidence interval segments into one fluid hotspot. The generalized state system line file was aggregated into a single attribute using the *Dissolve* function and merging the multi-lines into a single line attribute. This was done to ensure the file had as few individual features as possible for an accurate calculation of the length. The resultant dissolved statewide line file was cut to the lengths of aggregated hotspot file using the *Clip* geoprocessing tool in GIS. The lengths of the resultant lines from the *Clip* were calculated and then spatially joined to the aggregated hotspot shapefile. Following this the crashes were spatially joined to the aggregated hotspot shapefile to calculate the number of crashes per hotspot. The crash totals in each hotspot were normalized by the length of the hotspot. The resultant crashes per mile were then sorted from largest to smallest and a rank assigned to each hotspot in ascending order.

## IMPORTANT VARIABLES AND THE TOP SELECTIONS

The research team worked on mapping hotspots during July and August, 2020. In August and September 2020, the research team conferred with the agency advisory panel members on the five most important variables of the crash analysis: (1) the length of the road segment, (2) the width of the road segment, (3) search distance, (4) the years of crash data, and (5) inclusion of confidence intervals.  The reasoning for the selection of the final variables is presented below.

### SEGMENT LENGTH

The length of the road segments does not affect the hotspot analysis, since the analysis was performed on crash data, but rather how the crash points are placed in the "bins" or segments the roads are partitioned into. When the road segment is small, such as 0.25 of a mile, the analysis produces many, (hundreds) of small hotspots across the state. When the size of the segment is over 1 mile, the runs of the model produce hotspots that can be off from the actual crash locations. It is in the range of 0.5-mile to 1 mile segments we find the best match of hotspots with the crash data. The hotspot analysis was performed with 0.5-mile and one-mile crash segments. The one-mile segments allowed some of the smaller 0.5-mile segments to merge. This produced a map that: 1) merged some of the many hotspots in the Flagstaff area, allowing for other areas of the state to have representation in the top 25 hotspots; and 2) gave reasonably long lengths of road that could be compared to upcoming ADOT projects. The one-mile length of road segment was chosen as the size for the master map. The 0.5-mile segment results were laid over the one-mile-long segment results, to show the hotspots within the hotspots (super-hotspots). This allows ADOT and other personnel to identify the top hotspot problem areas in the state, and then the most intense crash areas within those hotspot areas.

The research team also presented preliminary results to the Technical Advisory Committee or TAC and demonstrated that there were several hotspots just one mile in length. The team asked if this was a problem and if these shorter sections should be dropped out. Multiple panel members agreed that one mile hotspot segments provided some utility in planning, programming, and actual projects for ADOT. These one-mile segments were left in the top 25 hotspots.

### SEGMENT OR BUFFER WIDTH

The width of each road segment is important as well, because OHSA looks outward from the road segment under analysis, to the distance selected for the segment width. This is very important to gauge with respect to the state roads under consideration: too small a width, and the model does not include opposing lanes of interstates; too wide a width, and the model is analyzing crashes in nearby roads rather than the road under consideration. The research team worked with the model iterations with 200 feet wide segments, and 200 meters (656 feet) wide segments. The smaller number resulted in hotspots that did not encompass opposing lanes of interstates 40 and 17. The larger number did have some hotspots that included nearby service roads on interstates. The larger number produced much more accurate results with respect to interstates, including opposing lanes, and it was the 200-meter width that was chosen.

### ANALYSIS BUFFER OR SEARCH DISTANCE OR DISTANCE BAND

The analysis buffer or search distance or distance band is the instruction to the model to tell it how many miles out from a crash point should the model look to identify hotspots. The search distances typical of this state highway OHSA analysis are 0.5-mile, 1-mile, 2-miles, and 5-miles. The longer the distance out, such as the 2-mile and 5-mile lengths, the more the hotspots from those iterations are not centered on the crash data points hotspots. It is typically the 0.5-mile and one-mile search distances that work with crash data along highways. Our team chose one-mile search distance as the optimum length. This allowed the model to go out one neighboring segment to look for aggregations of the crash data.

### CONFIDENCE INTERVAL

The Getis-Ord OHSA modeling is a statistically sound method to determine aggregation of points at 90, 95, and the 99 percent confidence intervals. The higher the confidence interval value, the more certain the results are to be considered priority hotspots. Typically modeling results are presented for at a minimum, the 99 percent confidence interval, with 95 percent confidence intervals often added to provide a richer result presentation. The model runs were examined for how inclusion of the 90 percent confidence interval affected the results. The researchers saw patterns that when the 90 percent confidence interval segments were included with the 95 percent and 99 percent confidence interval hotspot segments, these lower ranked hotspots acted as connectors between the higher ranked hotspots. This was important to help create one long hotspot as a priority rather than three individual hotspots that were nearby but broken up without the 90 percent confidence interval segments. This was important for a statewide study because Flagstaff had so many of the state's top hotspots, shorter segments there "bumped off" hotspots in other areas of the state from the state's top 25 priority hotspots. It was decided to include the 90 percent confidence intervals to help demonstrate the breadth of hotspots across the state.

### YEARS OF DATA

The research team modeled 10 years of animal-vehicle collision crash data, and five years of data. The results were examined, in conjunction with the TAC. It was decided that 10 years of data analysis identified several areas that have already had wildlife crossing structures and wildlife fence placed at these hotspots. This is because some time during the 10 years of data, these projects were completed. As with concerns with confidence intervals, the researchers did not want to present top priority hotspots that had already been addressed and wanted to keep those mitigated areas from "bumping off" other hotspots on the top 25 list. The team and panel decided on analyzing the past five years of crash data to identify new, more recent problem areas or continuous hotspot areas that hadn't yet been addressed.

The final values for each of these five variables that were used for the final, master animal-vehicle crash hotspot analysis are presented below in Table A-1.

*Table A- 1. Final Variable Values Used in the Master Top 25 Animal-Vehicle Crash Hotspots in Arizona.*

| Segment Length | Buffer Width | OHSA Analysis Buffer | Crash Data Year Range | Confidence Intervals |
|---|---|---|---|---|
| 1 mile (5,280 ft) | 200 meter (656.168 ft) | 1 mile (1609 m) | 5 Year (2014-2018) | 90, 95, and 99 |

## RESULTS

### OVERALL HOTSPOTS

There were 51 hotspots identified in the final, master run of the hotspots analysis. The number of 1-mile road segments in each of the three confidence intervals is presented, along with the number of total hotspots for the 95-99 confidence intervals, and the 90-95-99 confidence intervals, Table A-2.

*Table A- 2. Numbers of Resulting 1-Mile Segments, and Number of Hotspots under 95-99, and then 90-95-99 Confidence Intervals.*

| # of 90% Interval 1-Mile Segments | # of 95% Interval 1-Mile Segments | # of 99% Interval 1-Mile Segments | # of Hotspots with 95+99% Intervals | # of Hotspots with 90+95+99% Intervals |
|---|---|---|---|---|
| 21 | 43 | 231 | 44 | 51 |

Multiple runs of the model with slight adjustments to different variables resulted in many of the hotspots remaining in the top 25 list. Some, such as Hotspots 1 and 2, remained in their position under all the different scenarios of model run, building greater confidence in the results. See below for a comparison of hotspots with 95-99 confidence intervals compared to 90-95-99 confidence intervals.

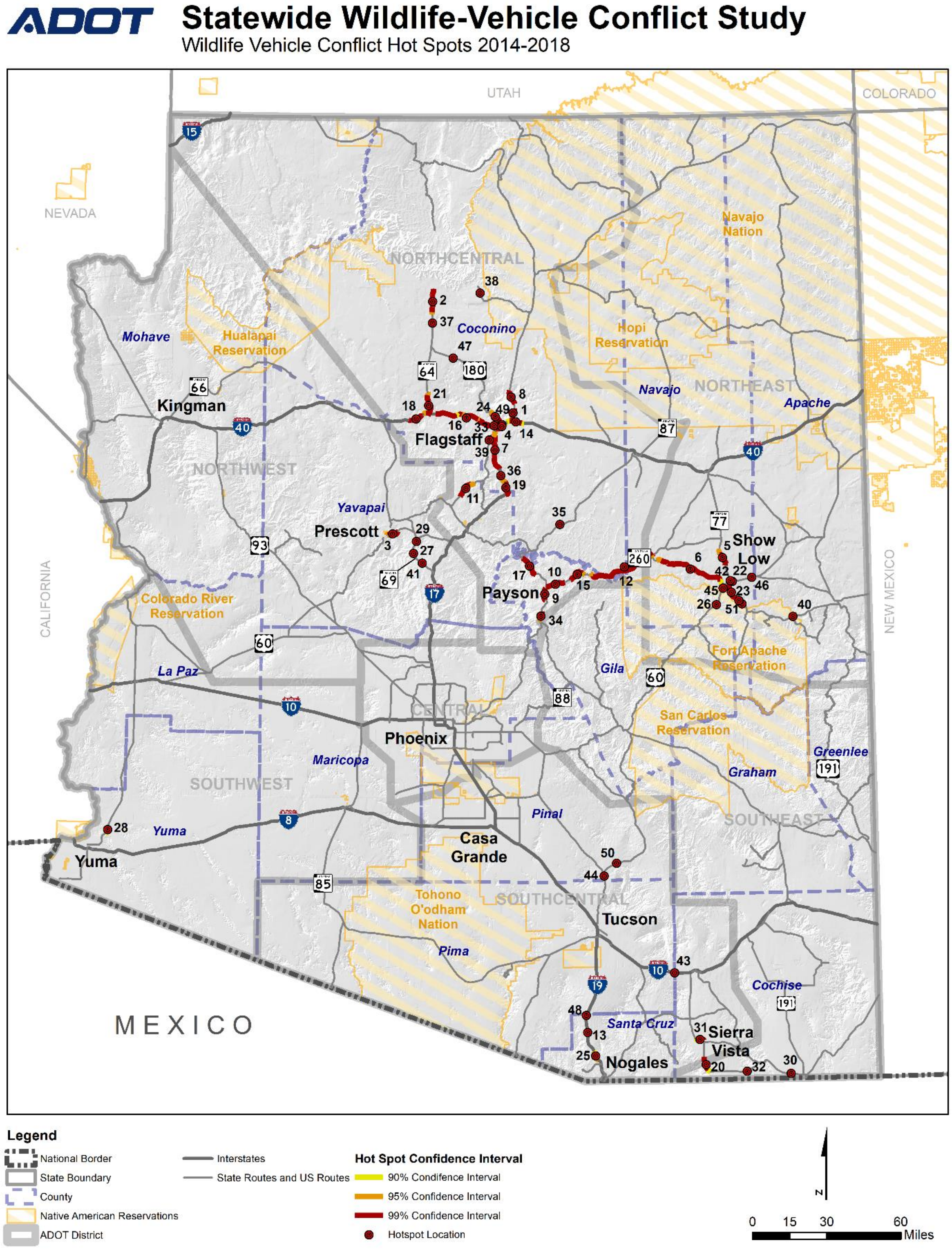



*Figure A- 1. Arizona Wildlife-Vehicle Reported Crash Top 51 Hotspots 2014-2018.*

## COMPARISONS OF HOTSPOTS WITH DIFFERENT CONFIDENCE INTERVALS

*Table A- 3. 5 year 2014 to 2018, 95 percent to 99 percent interval.*

| Rank | Name | Route # | Length (mi) | # of Crashes | Crashes per Mile | Annual Avg. Crashes per Mile |
|---|---|---|---|---|---|---|
| 1 | See results section | U 089 | 4.000001431 | 79 | 19.75 | 3.95 |
| 2 | | S 064 | 10.38741302 | 141 | 13.57 | 2.71 |
| 3 | | S 069 | 5.575406171 | 75 | 13.45 | 2.69 |
| 4 | | S 260 | 29.00001144 | 330 | 11.38 | 2.28 |
| 5 | | I 040 | 9.000003815 | 102 | 11.33 | 2.27 |
| 6 | | I 040 | 4.161973462 | 47 | 11.29 | 2.26 |
| 7 | | S 077 | 7.000002861 | 79 | 11.29 | 2.26 |
| 8 | | I 040 | 5.522597473 | 61 | 11.05 | 2.21 |
| 9 | | I 017 | 17.2147333 | 187 | 10.86 | 2.17 |
| 10 | | U 089 | 6.000002384 | 65 | 10.83 | 2.17 |
| 11 | | S 087 | 5.000001907 | 53 | 10.60 | 2.12 |
| 12 | | S 260 | 8.21584972 | 87 | 10.59 | 2.12 |
| 13 | | S 089A | 8.000002861 | 82 | 10.25 | 2.05 |
| 14 | | S 260 | 33.00001323 | 336 | 10.18 | 2.04 |
| 15 | | I 019 | 1.000000477 | 10 | 10.00 | 2.00 |
| 16 | | S 092 | 6.000002384 | 59 | 9.83 | 1.97 |
| 17 | | S 090 | 2.000000715 | 19 | 9.50 | 1.90 |
| 18 | | S 260 | 8.000002861 | 75 | 9.37 | 1.87 |
| 19 | | S 087 | 9.000003815 | 84 | 9.33 | 1.87 |
| 20 | | I 040 | 6.277752556 | 58 | 9.24 | 1.85 |
| 21 | | I 017 | 8.000002861 | 73 | 9.12 | 1.82 |
| 22 | | I 019 | 1.000000358 | 9 | 9.00 | 1.80 |
| 23 | | I 040/S 064 | 12.00000431 | 103 | 8.58 | 1.72 |
| 24 | | U 095 | 2.000000715 | 17 | 8.50 | 1.70 |
| 25 | | I 040 | 16.52928945 | 137 | 8.29 | 1.66 |

*Table A- 4. 5 year 2014 to 2018, 90 percent to 99 percent interval.*

| Rank | Name | Route # | Length (mi) | # of Crashes | Crashes per Mile | Annual Avg. Crashes per Mile |
|---|---|---|---|---|---|---|
| 1 | U 089 | | 4.000001431 | 79 | 19.75 | 3.95 |
| 2 | S 064 | | 10.38741302 | 141 | 13.57 | 2.71 |
| 3 | S 069 | | 5.575406171 | 75 | 13.45 | 2.69 |
| 4 | I 040 | | 4.161973462 | 47 | 11.29 | 2.26 |
| 5 | S 077 | | 7.000002861 | 79 | 11.29 | 2.26 |
| 6 | S 260 | | 30.00001144 | 338 | 11.27 | 2.25 |
| 7 | I 017 | | 17.2147333 | 187 | 10.86 | 2.17 |
| 8 | U 089 | | 6.000002384 | 65 | 10.83 | 2.17 |
| 9 | S 087 | | 5.000001907 | 53 | 10.60 | 2.12 |
| 10 | S 260 | | 8.21584972 | 87 | 10.59 | 2.12 |
| 11 | S 089A | | 8.000002861 | 82 | 10.25 | 2.05 |
| 12 | S 260 | | 33.00001323 | 336 | 10.18 | 2.04 |
| 13 | I 019 | | 1.000000477 | 10 | 10.00 | 2.00 |
| 14 | I 040 | | 7.687787261 | 73 | 9.50 | 1.90 |
| 15 | S 260 | | 8.000002861 | 75 | 9.37 | 1.87 |
| 16 | I 040 | | 26.52929422 | 248 | 9.35 | 1.87 |
| 17 | S 087 | | 9.000003815 | 84 | 9.33 | 1.87 |
| 18 | I 040 | | 6.277752556 | 58 | 9.24 | 1.85 |
| 19 | I 017 | | 8.000002861 | 73 | 9.12 | 1.82 |
| 20 | S 092 | | 7.000002861 | 63 | 9.00 | 1.80 |
| 21 | I 040/S 064 | | 12.00000431 | 103 | 8.58 | 1.72 |
| 22 | U 060 | | 1.000000358 | 8 | 8.00 | 1.60 |
| 23 | S 073 | | 7.000002861 | 56 | 8.00 | 1.60 |
| 24 | U 180 | | 6.000002384 | 47 | 7.83 | 1.57 |
| 25 | I 019 | | 4.000001431 | 30 | 7.50 | 1.50 |

# APPENDIX B. DATA SOURCES USED IN THIS STUDY

| **Layer Name** | **Description Name** |
|---|---|
| OwnerMaint | ADOT Statewide System |
| ArizonaStateSystem | Simplified ADOT Statewide System |
| District | ADOT Districts |
| Mileposts_All | Mileposts |
| Underpass_Overpass | Underpasses and overpasses |
| tl_2018_us_aiannh_SW_AZ | Native American Reservations |
| tl_2018_us_county_AZ_Counties | Arizona Counties |
| Box_Culvert_Locations_CBC | Box Culverts |
| Critical_Habitat_June2020 | Critical Habitat |
| FiveYR2021_2025Linear | ADOT 5 year STIP |
| FiveYR2021_2025Point | ADOT 5 year STIP |
| **Annual Average Daily Traffic (AADT)** | |
| 2005-2018 | AADT and Year |
| **Wildlife Mitigation Projects** | |
| Access_Control | Access Control |
| Crossing_Approach | Crossing Approach |
| Elk_Rock | Elk Rock |
| Escape_Ramps | Escape Ramps |
| Fence_Break | Fence Break |
| Fence_Crossings | Fence Crossings |
| Fence_Jump | Fence Jump |
| Oneway_Gate | One way Gate |
| Reptile_Fencing | Reptile Fencing |
| Sware_Flex_Relectors | Sware Flex Reflectors |
| Unregulate_Fencing | Unregulated Fencing |
| Wildlife_Overpass | Wildlife Overpass |
| Wildlife_Underpass | Wildlife Underpass |
| **Wildlife Linkage Study** | |

| Layer Name | Description Name |
|---|---|
| CAP | Central Arizona Project Linkage |
| Habitat_Blocks | Habitat Blocks |
| PLZ_across_HB | Potential linkages zones across habitat blocks |
| Potential_Linkage_Zones | Potential Linkage Zones |
| **County Linkages** | |
| CountyStakeholderAssessments_AGFD_2009_2013 | County Wildlife Linkages |
| DetailedLinkageDesigns_AGFD_2012_2013 | Local Wildlife Linkage Designs |
| **Wildlife Distribution Models** | |
| BighornSheep | Bighorn Sheep Wildlife Distribution Model |
| Pronghorn | Pronghorn Wildlife Distribution Model |
| Elk | Elk Rock |
| WhitetailedDeer | White-tailed Deer Wildlife Distribution Model |
| MuleDeer | Mule Deer Wildlife Distribution Model |
| **Desert Tortoise Data** | |
| hdms_tortoise_tortdb_hwy_20200923 | Unverified Tortoise Occurrence Database pre-2016 |
| hdms_tortoise_pod_hwy_20200923 | Unverified Tortoise Occurrence Database post-2016 |
| hdms_tort_eos_hwy_20200923 | Verified Tortoise Occurrence Database |
| **Western Migrations Winter Range Data** | |
| PR_AZ_SouthInterstate40_Routes_Ver1_2019 | Pronghorn Routes South of I-40 |
| PR_AZ_SouthInterstate40_Corridors_Ver1_2019 | Pronghorn Corridors South of I-40 |
| PR_AZ_SouthInterstate40_AnnualRange_Ver1_2019 | Pronghorn Annual Range South of I-40 |
| PR_AZ_NorthI40_Corridors_Ver1_2020 | Pronghorn Routes North of I-40 |
| MD_AZ_SanFranciscoPeaks_Routes_Ver1_2019 | Mule Deer Routes San Francisco Peaks |
| MD_AZ_SanFranciscoPeaks_WinterRange_Ver1_2019 | Mule Deer Winter Range San Francisco Peaks |
| MD_AZ_SanFranciscoPeaks_Stopovers_Ver1_2019 | Mule Deer Stopovers San Francisco Peaks |
| MD_AZ_SanFranciscoPeaks_Corridors_Ver1_2019 | Mule Deer Corridors San Francisco Peaks |
| MD_AZ_KaibabNorth_Routes_Ver1_2019 | Mule Deer Routes Kaibab North |
| MD_AZ_KaibabNorth_WinterRange_Ver1_2019 | Mule Deer Winter Range Kaibab North |
| MD_AZ_KaibabNorth_Corridors_Ver1_2019 | Mule Deer Corridors Kaibab North |

| Layer Name | Description Name |
| --- | --- |
| MD_AZ_KaibabNorth_Stopovers_Ver1_2019 | Mule Deer Stopovers Kaibab North |
| ELK_AZ_NorthI40_Routes_Ver1_2020 | Elk Routes North of I-40 |
| ELK_AZ_NorthI40_WinterRange_Ver1_2020 | Elk Winter Range North of I-40 |
| ELK_AZ_NorthI40_Corridors_Ver1_2020 | Elk Corridors North of I-40 |
| ELK_AZ_NorthI40_Stopovers_Ver1_2020 | Elk StopoversNorth of I-40 |
| Elk_AZ_Interstate17_Routes_Ver1_2019 | Elk Routes I-17 |
| Elk_AZ_Interstate17_WinterRange_Ver1_2019 | Elk Winter Range I-17 |
| Elk_AZ_Interstate17_Stopovers_Ver1_2019 | Elk Stopovers I-17 |
| Elk_AZ_Interstate17_Corridors_Ver1_2019 | Elk Corridors I-17 |

# APPENDIX C. OVERVIEW OF PRIORITIZATION MATRIX

The Master Matrix Excel spreadsheet is a prioritization matrix to help determine the top road segments on Arizona DOT (ADOT) highways where there are conflicts with animals and specifically wildlife. The leading method to the prioritization was to identify road segments that were hotspots for reported crashes with wildlife (WVC). These 51 hotspots were then prioritized based on their rank for number of reported crashes per mile. When hotspots had the same score for crashes per mile when carried out to only 2 decimal places, these hotspots were given the same rank. The next hotspot was then given the score of what it would be if there were no ties. These hotspots were largely where mule deer and elk were reported to be involved in crashes. The hotspot analysis did little to identify problem areas for animals that are not as numerous in Arizona or are not large enough to cause serious damage to a vehicle or driver.

The research team brought together transportation related data and ecological related data to then score each of the 51 hotspots based on other factors, to more fully inform ADOT and its agency partners as to what other challenges and potential solutions exist in those hotspots. The factors or variables had points to score and to help with prioritizing based on different priorities for ADOT and its partners. Any variable can be changed so that their importance can be lowered or elevated in the scores for any of the rankings.

The transportation data included: points for rank in wildlife-vehicle collision priorities; points for fatal accidents due to wildlife-vehicle collisions in the hotspots; points for serious injury crashes from wildlife collisions; points for percentage of all crashes that were wildlife related; and points for the Average Annual Daily Traffic (AADT). Each one of these variables was calculated in a tab in the spreadsheet, and only the final points scores are presented in the Matrix. The Transportation Score reflects scores for the fatal and injury crashes, percentage of crashes that are wildlife-related, and traffic volume. It DOES NOT include values for hotspot scores- the goal was to rank hotspots solely by other factors to see how the 51 hotspots ranked for these alone.

The ecological data tallied for each hotspots' ecological score included points for: if the hotspot intersected or was adjacent to a state wildlife linkage, county wildlife linkage, and local linkage; if the hotspot was in critical habitat of threatened or endangered species; if there was desert tortoise presence or habitat; if there was pronghorn presence or a migration linkage in the hotspot; bighorn sheep presence; known white-tailed deer distribution; elk migration linkage; and for mule deer linkage presence. The points were more heavily weighted to species important to ADOT operations that were not represented in the crash hotspots. These were the Sonoran and Mojave Desert tortoises, pronghorn, bighorn, white-tailed deer, elk linkages, and mule deer linkages. Each one of these variables was calculated in a tab in the spreadsheet, and only the final points scores are presented in the Matrix. The points were added for all these ecological factors, and each WVC hotspot was then ranked according to ecological variables. The scores for the species of interest always remained the same in various weightings. However, when linkages were the focus, linkage scores went from a range of 0-3 points, to 0 - 71 points. When the analysis was species focused, the linkage scores were reduced to 0 - 3 points. The ranking of the hotspots with this species focus is presented in the tab "Tally of the 3 Ranks." When Linkages were more highly weighted over species scores, the results are presented in the tab, "TALLY OF 3 RANKS - LINKAGES HIG."

The ADOT district where each hotspot resides is also presented, and the rows for the hotspots are color coded according to ADOT district for ease of viewing. Color key: Blue = Northcentral District, Tan = Northwest District, Yellow = Southcentral District, Green =Northeast District, Brown = Southwestern District.

## TRANSPORTATION FACTORS

### FATALITY SCORE

Justification for using fatal collisions: Traffic Safety is interested in all fatal crash locations and how the areas can be improved. This factor in WVC hotspots can help secure safety funding for mitigation solutions.

### SERIOUS INJURY

Justification for using serious injury collisions: Traffic Safety is interested in all serious injury crash locations and how the areas can be improved. This factor in WVC hotspots can help secure safety funding for mitigation solutions.

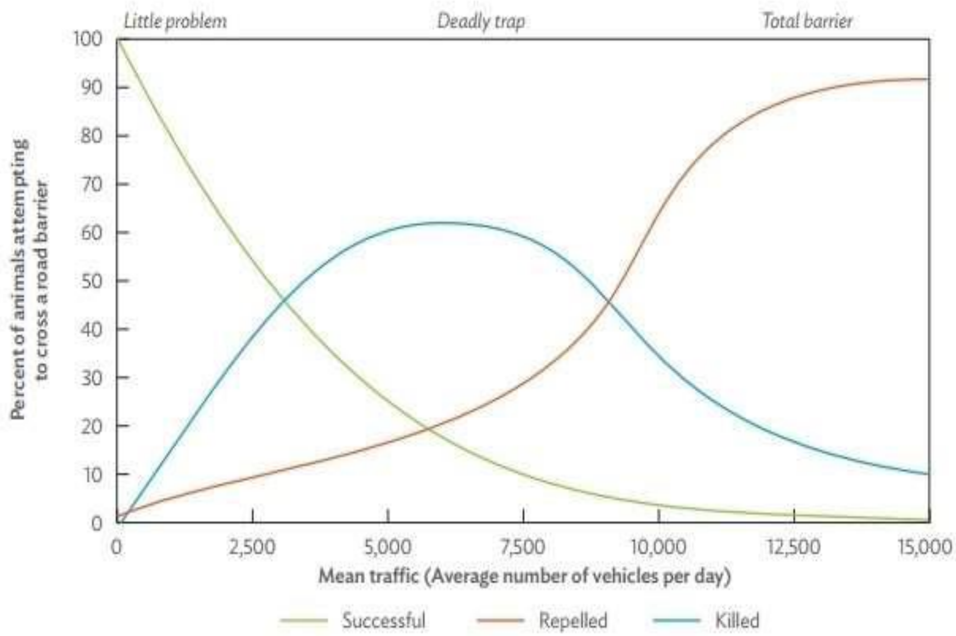
### AVERAGE ANNUAL DAILY TRAFFIC – AADT

The AADT was translated into one of four classes of values (see Table C-1).
Justification: These classes are based on the effect traffic volume has on wildlife - specifically large ungulates, abilities to cross roads safely. See the file: "Statewide WVC AADT Relationships.pdf" for an in depth explanation. Also see Charry and Jones (2009).

*Table C- 1. Points assigned to represent barrier effect threshold ranges.*

| Points Score | AADT Values and Reasons for Thresholds |
|---|---|
| 0 | < 2,000 – low volume: low-moderate lethality, minimal barrier effect, moderate-high WVC |
| 3 | 2,000-7,500 – medium volume: moderate-high lethality, increasing barrier effect; high WVC |
| 5 | 7,501-15,000 – high volume; high lethality; near-total barrier, moderate-high WVC |
| 7 | > 15,000 – extreme high volume; very high lethality, near-total barrier, low-moderate WVC |

*Figure C- 1. Relationship between traffic volume and the barrier effect with animal crossings (Seiler, 2003).*




## PERCENTAGE OF TOTAL CRASHES THAT ARE ANIMAL-RELATED

Justification: The percentage of crashes in a hotspot that are animal related can be another important factor for ADOT to consider providing mitigation in the hotspot. In some instances, hotspots ranked much lower actually have a greater problem of wildlife-vehicle collisions than some of the top ranked hotspots when looking at these percentages.

Methods: Crash data plotted in ArcGIS, by GPS coordinates, clipped files to only wildlife-vehicle crashes, spatial join with the individual hotspots to aggregate the total per hotspot. Percentage of crashes that were animal-related were multiplied by 0.10 to bring the value down to a single digit number. This made the variable weighted comparably similar to the other transportation factors which were also all single digits. If the percentages were left as they were, this variable would outweigh the others and the rankings would be skewed more heavily to the areas with higher animal-crash percentages. If this is the goal of another iteration of the matrix, this can be done easily by eliminating this factor in column H of the prioritization matrix, and just taking the column G value for this factor.

## ECOLOGICAL FACTORS

### LINKAGES

Three types of wildlife linkages were referenced for this scoring: State, County, and detailed Local Linkages. These were taken from the following GIS data sets.

*Table C- 2. Linkage data sets.*

| Name of Linkage Source | GIS File Used | Data Description |
|---|---|---|
| Central Arizona Project Linkage | CAP | |
| Potential Linkage Zones across Habitat Blocks | PLZ_across_HB | |
| Potential Linkage Zones | Potential_Linkage_Zones | State Plan focused on fracture zones |
| County Wildlife Linkages | CountyStakeholderAssessments_ AGFD_2009_2013 | This GIS dataset represents areas identified as important for wildlife movement and landscape connectivity in counties throughout Arizona. Data was generated from stakeholder input at workshops. This multi-agency, multi-disciplinary effort was undertaken to encourage biologists and non-biologists alike to incorporate information about wildlife linkages and strategies for their conservation into transportation corridor and project planning as well as other community projects and land-use decisions. The workshops provided a forum for stakeholders to learn more about wildlife connectivity, outline the general locations of wildlife linkages on large maps, and provide descriptive information about each linkage on datasheets. The linkages were then further refined to eliminate redundancy in the data. This dataset corresponds to and was used to help AZGFD create the County Wildlife Connectivity Assessment Reports on Stakeholder Input available at http://www.azgfd.gov/wildlife/planning. This dataset is updated with additional county information as it becomes available. |
| Local Linkage Designs | DetailedLinkageDesigns_ AGFD_2012_2013 | Linkage designs were created based on methodology from Arizona Missing Linkages 2007 and 2008 reports to AGFD, available at www.corridordesign.org. These linkages should be used in combination with the County Wildlife Linkage datasets and reports, the Arizona Wildlife Linkages Assessment, and Detailed Connectivity reports. Additional connectivity datasets may be available through AZGFD. |

When linkage scoring was more important than species presence or habitat scoring, the points for linkages were as follows:

Scoring was based on the following points for linkages:

1. Ecological - Is it in a statewide wildlife linkage? If yes, then 40 points, if no, 0 points.
2. Ecological - Is it in county Linkage analysis? If yes then 30 points, if no then 0 points.
3. Ecological - Is it in Local Linkage analysis? If yes then 1 point, if no then 0 points

Scores for Hotspot bisecting or adjacent to State, County, and Other linkages: Sum values for all three. Range = 0 – 71.

The original Score for Hotspot bisecting State, County, and Other linkages under a Species Focused Ecological Ranking gave one point for each of the 3 types of linkages, and summed those scores, with top score =3, low score = 0.

## CRITICAL HABITAT

This score was for hotspot being in Threatened/ Endangered Wildlife Critical Habitat. The GIS layer used was: Critical_Habitat_June2020

Justification: Critical habitat represents habitat areas important to threatened and endangered species of wildlife, as mapped and approved by the US Fish and Wildlife Service. The identification of these species' habitats in hotspots is an important factor for ADOT to consider in future transportation mitigation.

The scoring was simply based on the equation: Ecological - Is the Hotspot in critical habitat of a wildlife species? Y=1, N=0.

The scoring for the critical habitat was multiplied by 10 to give it a bit greater weight than simply a 1. Score for hotspot being in critical habitat. 1=10 points. Range= 0-10.

## TORTOISE

Data on Sonoran and Mojave Tortoise locations were used to assess where a hotspot might also be near these animals known and predicted habitats. Score for Tortoise presence and suitable habitat: (1 point if within 2 miles of ADOT system x 10) + (1 point if within Suitable habitat area x 10) , max score =20.

Justification: Tortoises are not a species represented in the crash database. They are typically not found where the more numerous ungulate species reside - such as the mountains and foothills where mule deer, elk, black bear, and sometimes white-tailed deer reside. As a result, the hotspots do not address their presence well. The scoring here is an effort to elevate hotspot where there are definite desert tortoises (Column E), and where there is suitable tortoise habitat (Column F). The total points for areas with tortoises can be up to 20.

*Table C- 3. Tortoise map sources.*

| Name of Tortoise Map Source | GIS File Used | Data Description |
|---|---|---|
| Verified Tortoise Occurrence Database | hdms_tort_eos_ hwy_20200923 | Subset of Element Occurrence records (EO Reps) in the Heritage Data Management System (HDMS) of the Arizona Game and Fish Department for Sonoran and Mohave Desert Tortoise within 2 miles of State Highways. These data do not include any records for tribal lands. These data were buffered to one square mile due to land ownership issues, but are within 2miles of USFS lands. EOs are population based polygons. There is a single record per species per location and it may include multiple observations at the same place over time. This is what the field definitions are for. |
| 2016 SWAP SDT Model | rep_goagso1.tif | This raster file represents areas suitable habitat for Sonoran Desert Tortoise from the AGFD 2016 Statewide Action Plan. |

Scoring
If desert tortoise present, within 2 miles of ADOT highway near hotspot? Presence =1 (hwy Data)
Ecological - Is the hotspot in suitable habitat for Desert Tortoise? Suitable habitat = 1
Rating on Tortoise presence and suitable habitat: (Column E  x 10) + (Column F x 10)
Range = 0 – 20 points.

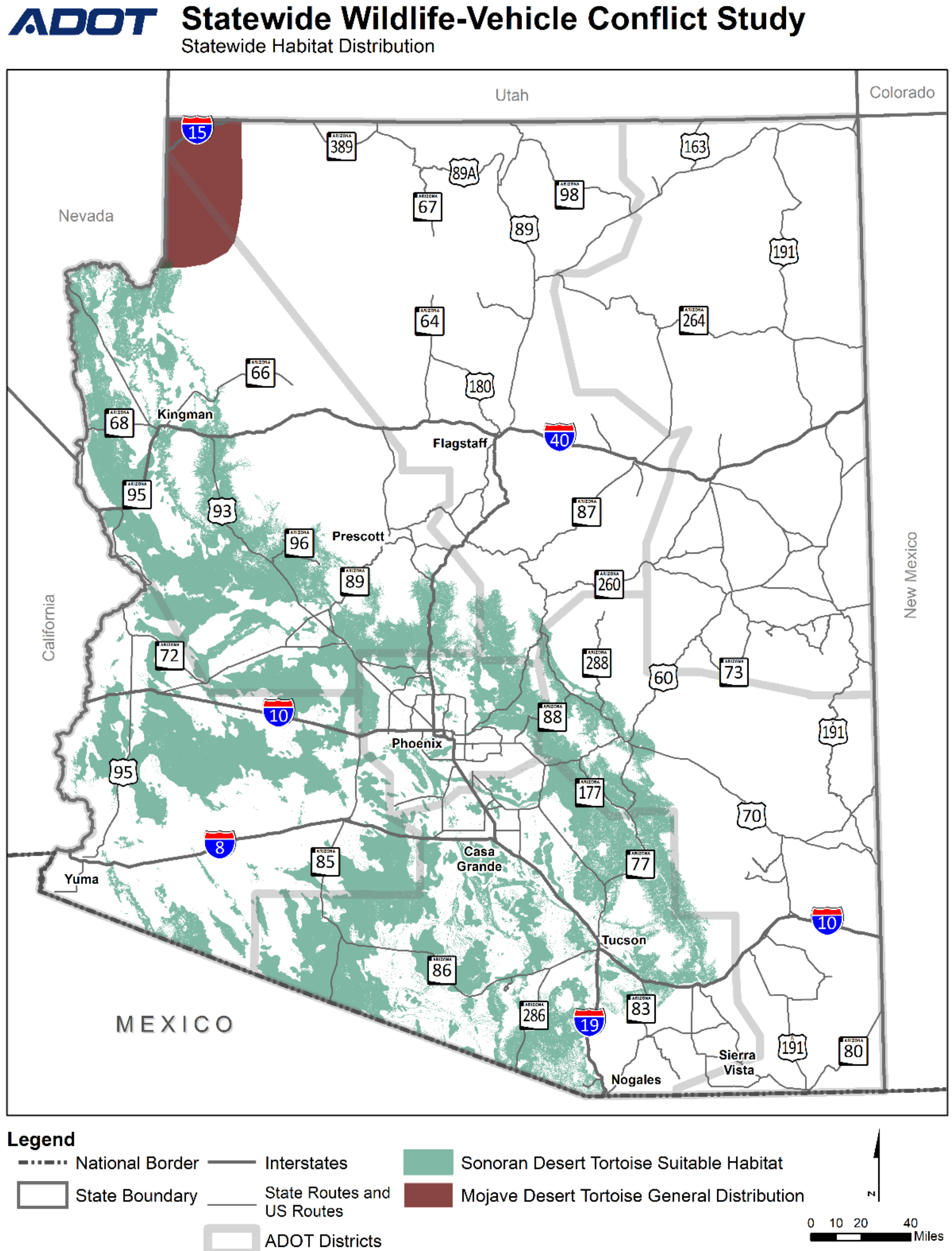



*Figure C- 2. Tortoise Habitat Map.*

## PRONGHORN

Justification: Pronghorn are not well represented in the crash database. This is due in part to their reluctance to jump fences and cross highways. Therefore, highways are virtual barriers to pronghorn movement, and to get an understanding of where those areas are, crash data will not be as helpful as identifying pronghorn habitat. In this scoring, we evaluated hotspots for their presence inside pronghorn habitat, and where they bisect mapped pronghorn migration linkages. The 30 points given to this species' presence was an effort to elevate hotspots with pronghorn nearby.

The Pronghorn Wildlife Distribution Model was used to determine if the hotspot was bisecting or near pronghorn habitat.

Score for Presence of Pronghorn (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts). Range of points = 0 – 40.

Table below presents the GIS layers used to make these values.

*Table C- 4. Pronghorn Migration and Range Data Sources*

| Western Migration and Range Data | Pronghorn Data | Area of Interest |
|---|---|---|
| PR_AZ_SouthInterstate40 _Routes_Ver1_2019 | Pronghorn Routes South of I-40 | South I-40 between Flagstaff and Williams |
| PR_AZ_SouthInterstate40 _Corridors_Ver1_2019 | Pronghorn Corridors South of I-40 | South I-40 between Flagstaff and Williams |
| PR_AZ_SouthInterstate40 _AnnualRange_Ver1_2019 | Pronghorn Annual Range South of I-40 | South I-40 between Flagstaff and Williams |
| PR_AZ_NorthI40_Corridors _Ver1_2020 | Pronghorn Routes North of I-40 | North I-40 between Flagstaff and Williams |

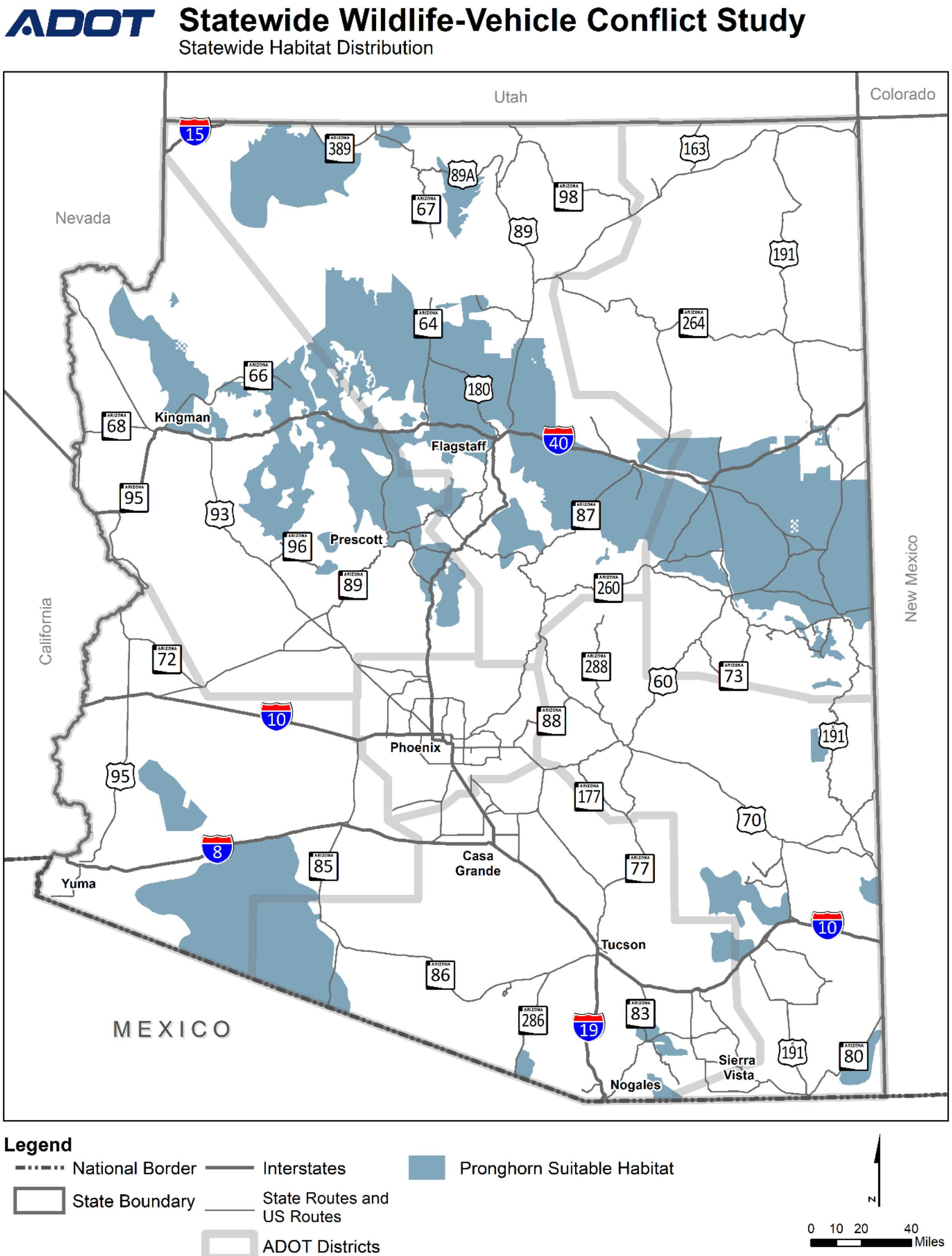



*Figure C- 3. Pronghorn Habitat Map.*

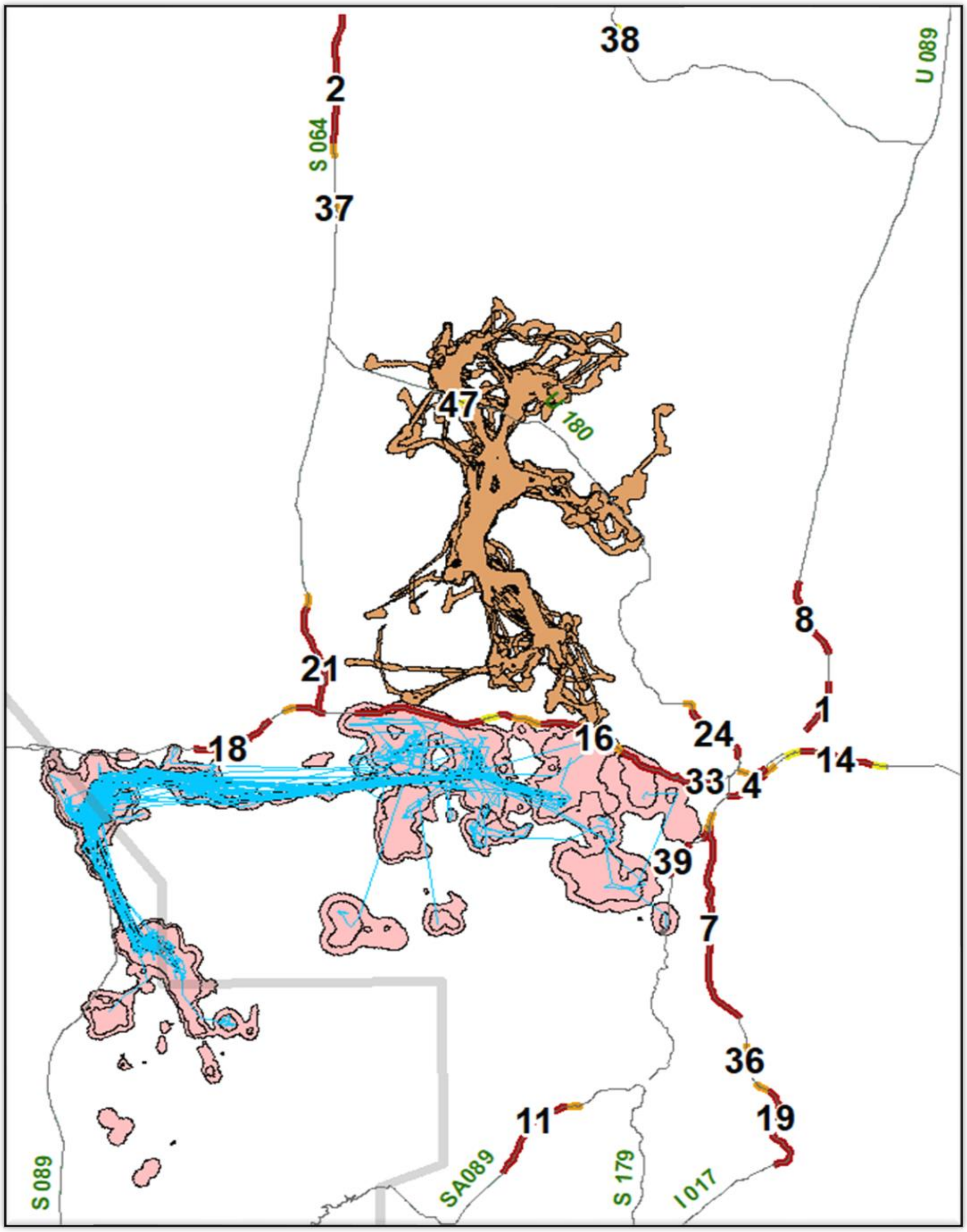



*Figure C- 4. Pronghorn range data.*

## BIGHORN SHEEP

Justification: Bighorn are rarely represented in the crash data, yet vehicle collisions are an important and concerning source of mortality for herds across Arizona. This scoring was an effort to elevate areas where hotspots are in bighorn habitat. The 30 points given for bighorn habitat was a way to help elevate areas where these animals reside. Only one hotspot was in bighorn habitat, near Yuma.

The Bighorn Sheep Wildlife Distribution Model was used to determine if bighorn were nearby. The GIS file was: BighornSheep.

The simple question was asked: Is the Hot Spot in Bighorn habitat? If yes then 1, if no then 0. Then this score was multiplied by 30 to give final points.

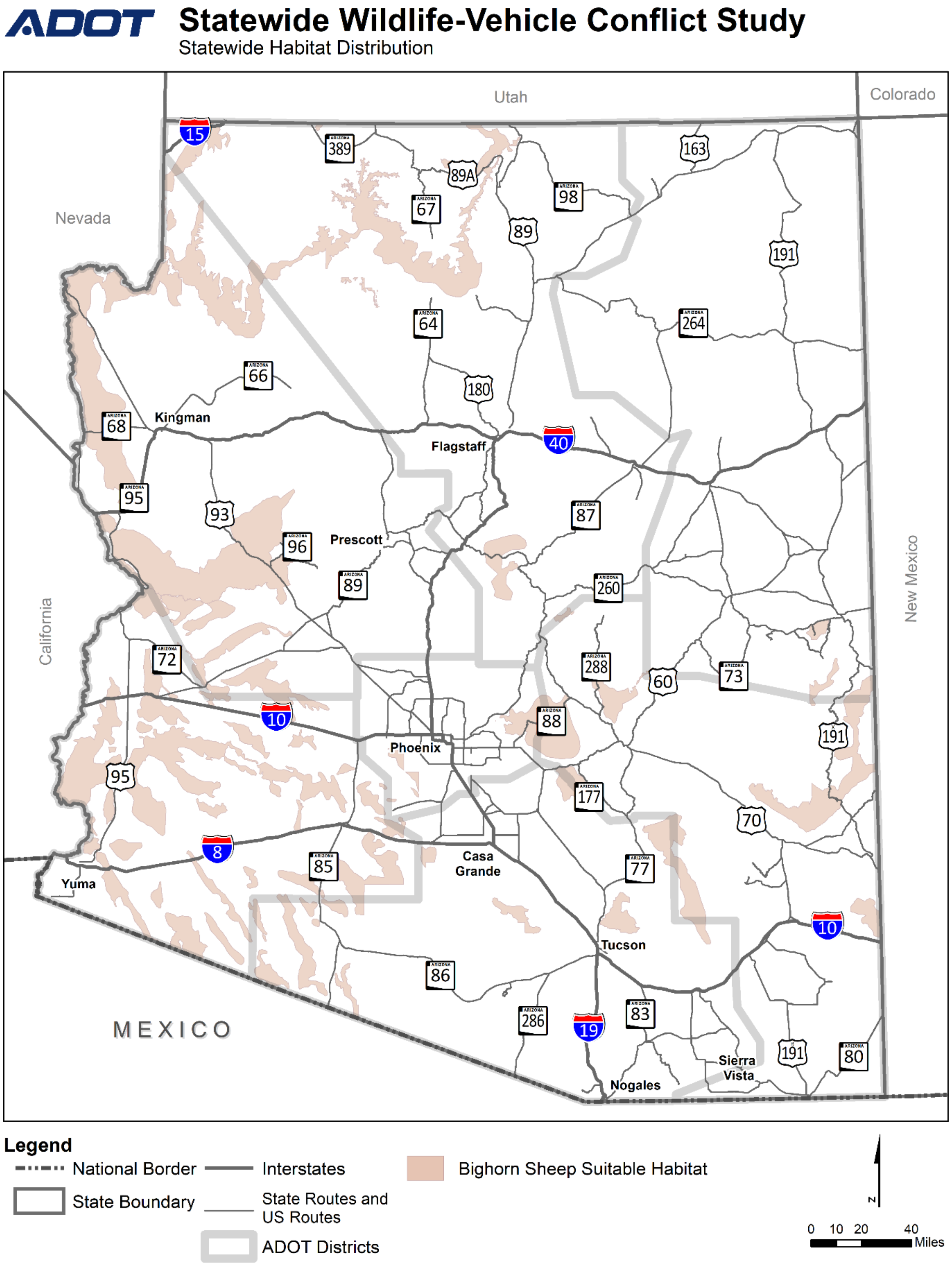



*Figure C- 5. Bighorn Sheep Habitat Map.*

## WHITE-TAILED DEER

Justification: White-tailed deer were selected to represent areas that may not have been ranked high because they are not home to mule deer and elk. The white-tailed deer was selected to try and get better ecological representation of the Southeastern Arizona Sky Islands area. The team initially thought black bear would be a surrogate for the Southeast, but its wide distribution in the mountains of central and northern Arizona did not lend it to helping to elevate the value of hotspots in the southeastern corner of the state. The white-tailed deer rating of 15 points for its presence was meant to give greater weight to hotspots in their habitat. Since they are a fairly numerous species compared to bighorn sheep, and are almost certainly better represented in the crash database than pronghorn, it was given less points than these 2 other species that also were not well represented in the crash database. However, our efforts failed to add points to the two hotspots in the southeastern corner of the state.

The White-tailed Deer Wildlife Distribution Model results, in the GIS file, WhitetailedDeer, was used to determine if the hotspot was in white-tailed deer habitat. If the hotspot was in or adjacent to this species' habitat, it received a score of 15. Otherwise the score was 0 for white-tailed deer.

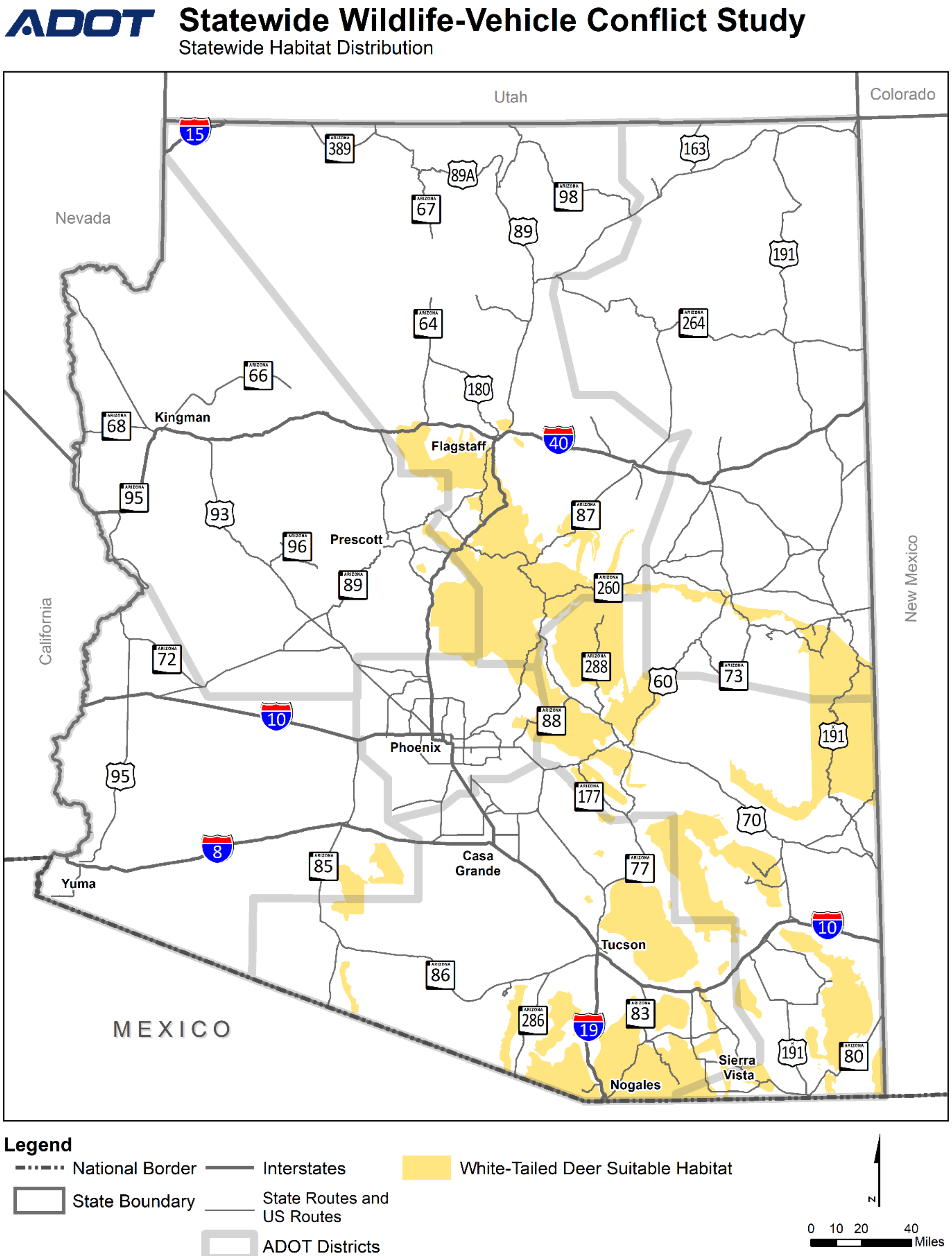



*Figure C- 6. White-Tailed Deer Habitat Map.*

## ELK

Justification: Elk were well represented in the crash data, and the WVC hotspots appear to have well represented problem areas with this species in habitat that is bisected by roads. However, the team wanted to acknowledge the importance of elk migration linkages and give these areas added value, thus the scoring. The total of 5 points is low, which is an effort to help this evaluation to elevate species not well represented in the crash data and hotspots.

The following GIS files were used to determine if the hotspot was in elk migration areas. If a hotspot was in one of these elk migration areas, it received 5 points.

*Table C- 5. Elk Migration and Range Data Sources*

| Western Migration and Range Data | Locations |
|---|---|
| ELK_AZ_NorthI40_Routes_Ver1_2020 | Elk Routes North of I-40 |
| ELK_AZ_NorthI40_WinterRange_Ver1_2020 | Elk Winter Range North of I-40 |
| ELK_AZ_NorthI40_Corridors_Ver1_2020 | Elk Corridors North of I-40 |
| ELK_AZ_NorthI40_Stopovers_Ver1_2020 | Elk StopoversNorth of I-40 |
| Elk_AZ_Interstate17_Routes_Ver1_2019 | Elk Routes I-17 |
| Elk_AZ_Interstate17_WinterRange_Ver1_2019 | Elk Winter Range I-17 |
| Elk_AZ_Interstate17_Stopovers_Ver1_2019 | Elk Stopovers I-17 |
| Elk_AZ_Interstate17_Corridors_Ver1_2019 | Elk Corridors I-17 |

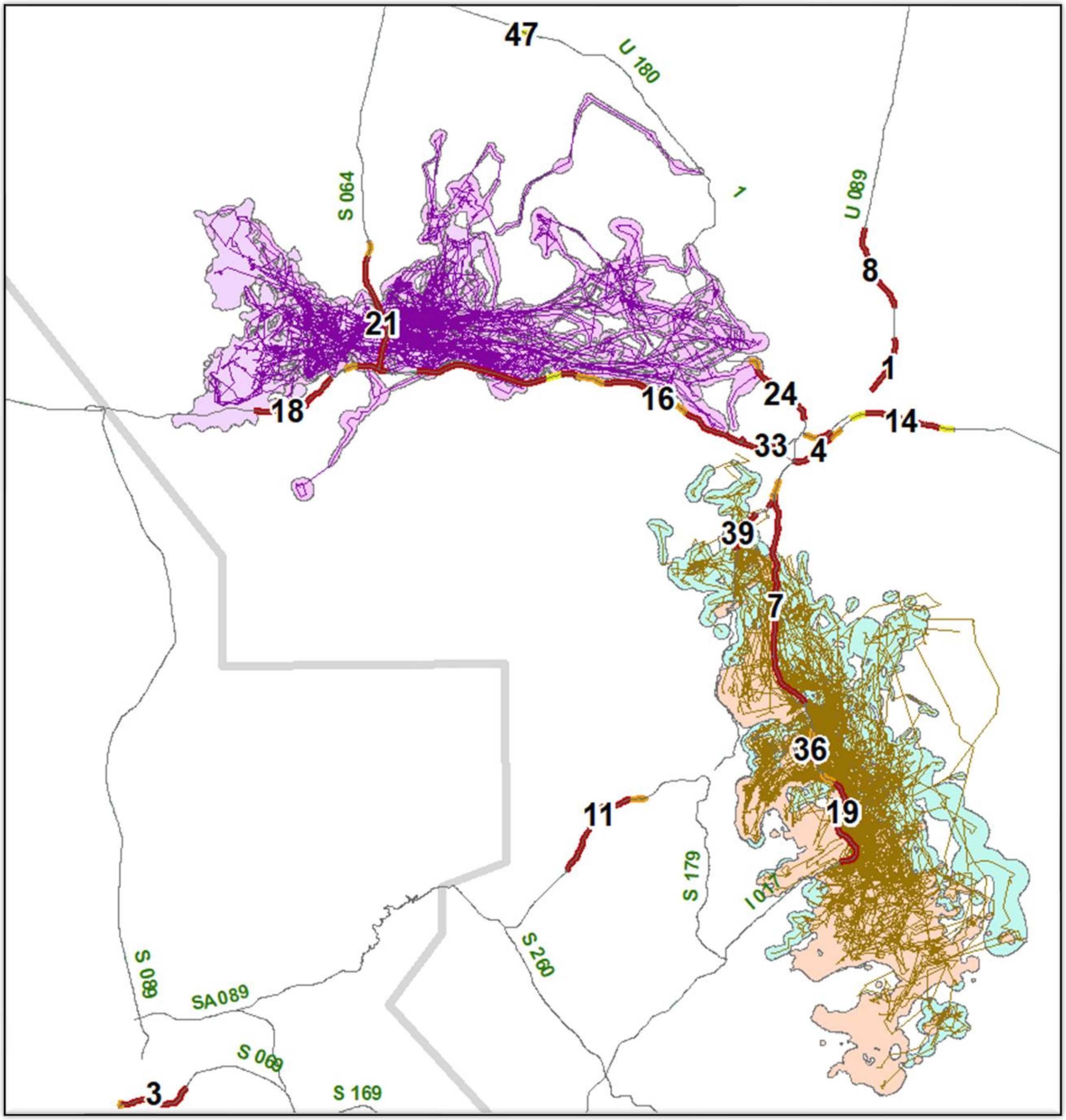



*Figure C- 7. Elk Range Data.*

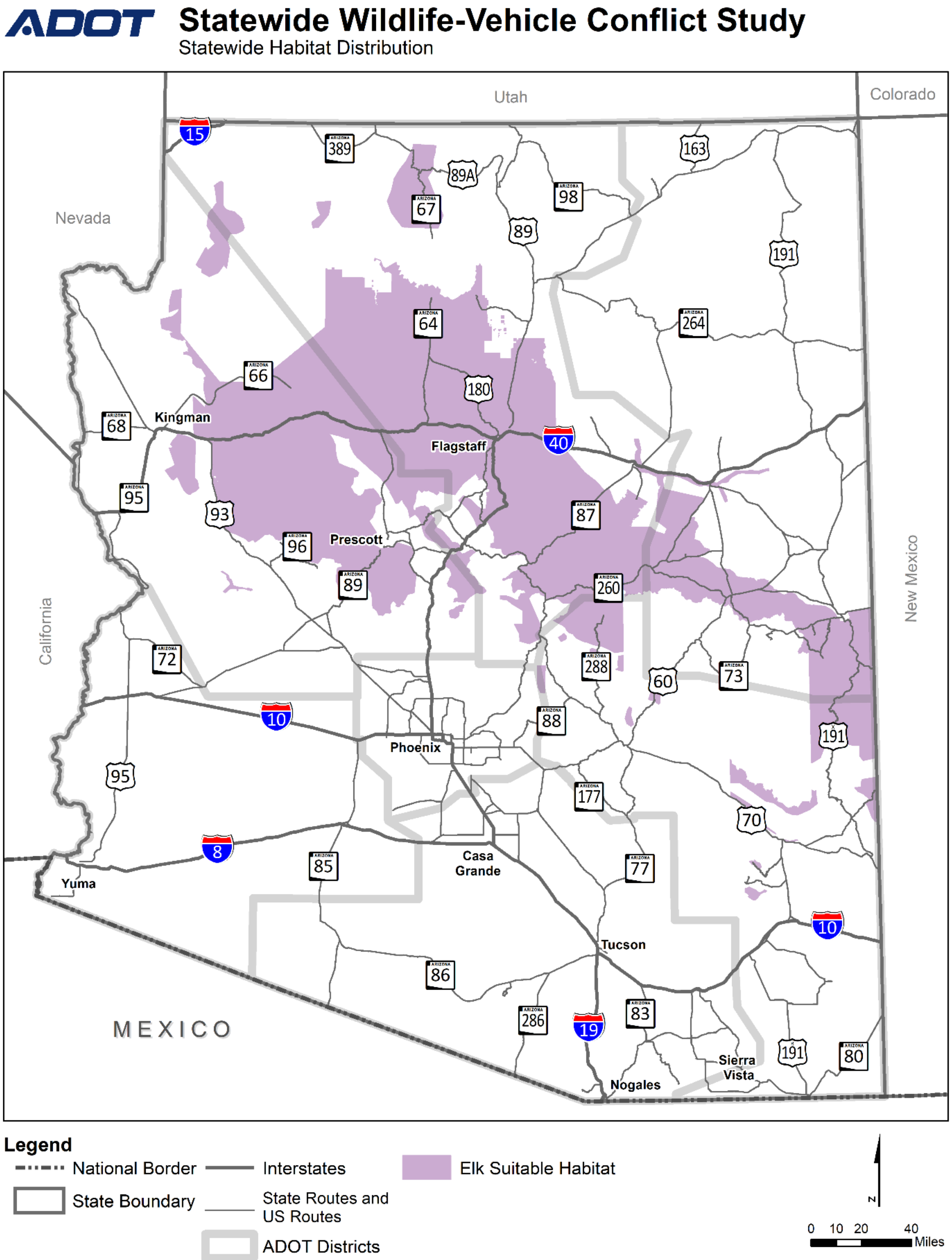



*Figure C- 8. Elk Habitat.*

### MULE DEER

Justification: Mule deer were well represented in the crash data and in the crash hotspots. However, the team wanted to acknowledge and include value of the importance of mule deer migration linkages, and thus gave these areas an extra 5 points.

The following GIS files were used to determine if the hotspot was in mule deer migration areas. If a hotspot was in one of these mule migration areas, it received 5 points.

*Table C- 6. Mule Deer Migration and Range Data*

| Western Migration and Range Data | Locations |
|---|---|
| MD_AZ_SanFranciscoPeaks_Routes_Ver1_2019 | Mule Deer Routes San Francisco Peaks |
| MD_AZ_SanFranciscoPeaks_WinterRange_Ver1_2019 | Mule Deer Winter Range San Francisco Peaks |
| MD_AZ_SanFranciscoPeaks_Stopovers_Ver1_2019 | Mule Deer Stopovers San Francisco Peaks |
| MD_AZ_SanFranciscoPeaks_Corridors_Ver1_2019 | Mule Deer Corridors San Francisco Peaks |
| MD_AZ_KaibabNorth_Routes_Ver1_2019 | Mule Deer Routes Kaibab North |
| MD_AZ_KaibabNorth_WinterRange_Ver1_2019 | Mule Deer Winter Range Kaibab North |
| MD_AZ_KaibabNorth_Corridors_Ver1_2019 | Mule Deer Corridors Kaibab North |
| MD_AZ_KaibabNorth_Stopovers_Ver1_2019 | Mule Deer Stopovers Kaibab North |

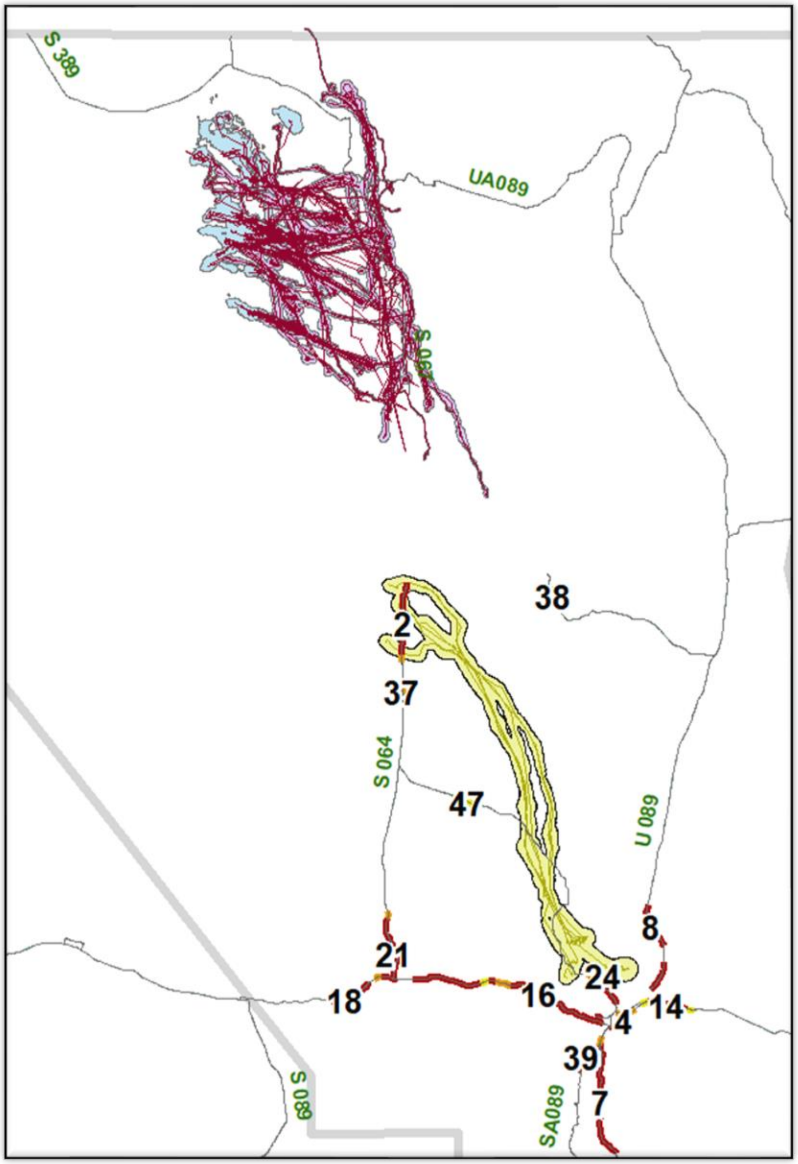



*Figure C- 9. Mule Deer Range Data.*

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*Table C-7. Overview of how the 51 hotspots were evaluated with respect to transportation factors.*

| WVC Crash Hotspot Rank | Name | Fatality score = (fatalities / miles of hotspot) x 10 | Serious Injury Score = (injuries / miles of hotspot) x 10 | Percentage of All Crashes that are WVC in Hotspot (Percentage x 0.1 to bring numbers down to single and low double digits) | AADT = Five Point Classes: 0 < 2,000 AADT; 3 = 2,000-7,500; 5 = 7,501-15,000; 7 > 15,000 | SCORE = Fatalities + Injuries + %WVC x .1 + AADT (*Higher Numbers are Higher Priority*) | Transportation Rank (*Lower Numbers are Higher Rank*) |
|---|---|---|---|---|---|---|---|
| 1 | US 89 North of Flagstaff | | | 4.14 | 7 | 11.14 | 16 |
| 2 | SR 64 South Rim Grand Canyon | 0.96 | 1.92 | 6.44 | 5 | 14.32 | 3 |
| 3 | SR 69 Prescott | | | 1.02 | 7 | 8.02 | 40 |
| 4 | I-40 Flagstaff from I-17 to Walnut Canyon | | | 0.89 | 7 | 7.89 | 43 |
| 4 | SR 77 North of Show Low | | 1.43 | 6.93 | 5 | 13.36 | 6 |
| 6 | SR 260 Heber to Show Low | | 1.00 | 7.04 | 5 | 13.04 | 7 |
| 7 | I-17 Munds Park to Flagstaff Pulliam Airport | | 0.58 | 2.68 | 7 | 10.26 | 23 |
| 8 | US 89 Sunset Crater Volcano NM | | | 4.82 | 5 | 9.82 | 26 |
| 9 | SR 87 South Payson | 2.00 | | 2.09 | 7 | 11.09 | 17 |
| 10 | SR 260 East of Payson | 1.22 | 2.43 | 2.01 | 7 | 12.66 | 11 |
| 11 | SR 89A Page Springs North to Sedona | | | 3.48 | 5 | 8.48 | 37 |
| 12 | SR 260/SR 277 Mountain Meadow to Heber | | 0.61 | 4.47 | 5 | 10.08 | 24 |

| WVC Crash Hotspot Rank | Name | Fatality score = (fatalities / miles of hotspot) x 10 | Serious Injury Score = (injuries / miles of hotspot) x 10 | Percentage of All Crashes that are WVC in Hotspot (Percentage x 0.1 to bring numbers down to single and low double digits) | AADT = Five Point Classes: 0 < 2,000 AADT; 3 = 2,000-7,500; 5 = 7,501-15,000; 7 > 15,000 | SCORE = Fatalities + Injuries + %WVC x .1 + AADT (*Higher Numbers are Higher Priority*) | Transportation Rank *(Lower Numbers are Higher Rank*) |
|---|---|---|---|---|---|---|---|
| 13 | I-19 Rio Rico Northeast | | | 5.26 | 7 | 12.26 | 13 |
| 14 | I-40 East Flagstaff Wildcat Hill | | | 2.36 | 7 | 9.36 | 30 |
| 15 | SR 260 Payson – Kohls Ranch | | 3.75 | 5.07 | 5 | 13.82 | 5 |
| 16 | I-40 West Flagstaff to Williams | 0.38 | 0.75 | 2.71 | 7 | 10.84 | 20 |
| 17 | SR 87/SR 260 NW Payson | | 1.11 | 4.69 | 3 | 8.80 | 34 |
| 18 | I-40 Pine Springs | | | 2.65 | 7 | 9.65 | 28 |
| 19 | I-17 Rattlesnake Canyon to South of Munds Park | | 1.25 | 2.36 | 7 | 10.61 | 21 |
| 20 | SR 92 North of Mexican Border-Nicksville | | | 4.81 | 5 | 9.81 | 27 |
| 21 | I-40-SR 64 North of Williams | | | 4.01 | 7 | 11.01 | 19 |
| 22 | SR 73 / SR 260 South of Show Low | | | 1.04 | 7 | 8.04 | 39 |
| 22 | US 60 East of Show Low | | | 4.21 | 5 | 9.21 | 31 |
| 24 | US 180 North Flagstaff | | | 2.98 | 5 | 7.98 | 41 |
| 25 | US 60 Forest Dale Canyon South of Show Low | | | 8.33 | 3 | 11.33 | 15 |

| WVC Crash Hotspot Rank | Name | Fatality score = (fatalities / miles of hotspot) x 10 | Serious Injury Score = (injuries / miles of hotspot) x 10 | Percentage of All Crashes that are WVC in Hotspot (Percentage x 0.1 to bring numbers down to single and low double digits) | AADT = Five Point Classes: 0 < 2,000 AADT; 3 = 2,000-7,500; 5 = 7,501-15,000; 7 > 15,000 | SCORE = Fatalities + Injuries + %WVC x .1 + AADT (*Higher Numbers are Higher Priority*) | Transportation Rank *(Lower Numbers are Higher Rank*) |
|---|---|---|---|---|---|---|---|
| 25 | SR 69 Poland Junction | | | 5.17 | 7 | 12.17 | 14 |
| 25 | I-19 North of Nogales | | | 2.00 | 7 | 9.00 | 33 |
| 28 | US 95 North Yuma | | 3.33 | 5.79 | 5 | 14.12 | 4 |
| 29 | I-40 Business Loop into W Flagstaff - West Historic Rte 66 | | | 1.23 | 5 | 6.23 | 49 |
| 29 | SR 69 Humboldt | | | 2.19 | 7 | 9.19 | 32 |
| 29 | SR 90 Sierra Vista | | 3.33 | 2.39 | 7 | 12.72 | 10 |
| 29 | SR 92 Naco - Mexico Border | | | 7.00 | 3 | 10.00 | 25 |
| 29 | SR 80 West of Douglas - Mexico Border | | | 7.50 | 3 | 10.50 | 22 |
| 34 | I-17 South of Munds Park | | | 2.55 | 7 | 9.55 | 29 |
| 34 | SR 87 NW Boundary of Mogollon Rim | 5.00 | | 7.65 | 0 | 12.65 | 12 |
| 34 | SR 87 Deer Creek Village | | | 6.05 | 5 | 11.05 | 18 |
| 37 | SR 64 South Rim Grand Canyon- Red Horse Wash | | | 10.00 | 3 | 13.00 | 8 |
| 37 | SR 64 South Rim Grand Canyon - Desert View | | | 10.00 | 3 | 13.00 | 8 |
| 39 | SR 89 A Forest Highlands | | | 4.47 | 3 | 7.47 | 44 |

| WVC Crash Hotspot Rank | Name | Fatality score = (fatalities / miles of hotspot) x 10 | Serious Injury Score = (injuries / miles of hotspot) x 10 | Percentage of All Crashes that are WVC in Hotspot (Percentage x 0.1 to bring numbers down to single and low double digits) | AADT = Five Point Classes: 0 < 2,000 AADT; 3 = 2,000-7,500; 5 = 7,501-15,000; 7 > 15,000 | SCORE = Fatalities + Injuries + %WVC x .1 + AADT (*Higher Numbers are Higher Priority*) | Transportation Rank (*Lower Numbers are Higher Rank*) |
|---|---|---|---|---|---|---|---|
| 40 | SR 260 / US 60 Show Low | | | 7.24 | 0 | 7.24 | 46 |
| 41 | SR 69 N Spring Valley | | | 2.38 | 5 | 7.38 | 45 |
| 42 | SR 77 Downtown Show Low | | | 1.09 | 5 | 6.09 | 50 |
| 43 | US 180 Kaibab National Forest - Ebert Mountain | | | 6.67 | 0 | 6.67 | 48 |
| 43 | US 60 Apache Reservation Boundary - Show Low | | | 5.71 | 3 | 8.71 | 35 |
| 43 | US 60 East of Show Low - Bell | | 10.00 | 4.44 | 3 | 17.44 | 2 |
| 43 | I-10 West of Benson | | | 1.43 | 7 | 8.43 | 38 |
| 43 | I-19 Tumacacori | | 10.00 | 2.86 | 7 | 19.86 | 1 |
| 43 | SR 77 Catalina | | | 3.64 | 5 | 8.64 | 36 |
| 49 | I-40 Entrance Ramp East Flagstaff | | | 0.10 | 7 | 7.10 | 47 |
| 50 | SR 77 Biosphere 2 | | | 3.00 | 3 | 6.00 | 51 |
| 51 | SR 260 South of Show Low | | | 0.91 | 7 | 7.91 | 42 |

*Table C- 8. Overview of how the 51 hotspots were evaluated with respect to ecological factors.*

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | US 89 North of Flagstaff | 70 | | | 30 | | 15 | | | 115 | 5 |
| 2 | SR 64 South Rim Grand Canyon | 70 | | | 30 | | | | 5 | 105 | 9 |
| 3 | SR 69 Prescott | 70 | | | 30 | | | | | 100 | 10 |
| 4 | I-40 Flagstaff from I-17 to Walnut Canyon | 70 | | | | | | | | 70 | 20 |
| 4 | SR 77 North of Show Low | 30 | | | 30 | | | | | 60 | 28 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | SR 260 Heber to Show Low | 0 | | | | | 15 | | | 15 | 45 |
| 7 | I-17 Munds Park to Flagstaff Pulliam Airport | 70 | 10 | | 30 | | | 5 | | 115 | 5 |
| 8 | US 89 Sunset Crater Volcano NM | 70 | 10 | | 30 | | | | | 110 | 7 |
| 9 | SR 87 South Payson | 0 | | | | | 15 | | | 15 | 45 |
| 10 | SR 260 East of Payson | 0 | | | | | 15 | | | 15 | 45 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | SR 89A Page Springs North to Sedona | 70 | 10 | | | | 15 | | | 95 | 15 |
| 12 | SR 260/SR 277 Mountain Meadow to Heber | 30 | 10 | | | | 15 | | | 55 | 31 |
| 13 | I-19 Rio Rico Northeast | 40 | 10 | 10 | | | | | | 60 | 28 |
| 14 | I-40 East Flagstaff Wildcat Hill | 70 | | | 30 | | | | | 100 | 10 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | SR 260 Payson – Kohls Ranch | 40 | 10 | | | | 15 | | | 65 | 26 |
| 16 | I-40 West Flagstaff to Williams | 71 | 10 | | 40 | | | 5 | | 126 | 3 |
| 17 | SR 87/SR 260 NW Payson | 40 | 10 | | | | 15 | | | 65 | 26 |
| 18 | I-40 Pine Springs | 30 | 10 | | 40 | | 15 | 5 | | 100 | 10 |
| 19 | I-17 Rattlesnake Canyon to South of Munds Park | 70 | 10 | | 30 | | 15 | 5 | | 130 | 2 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | SR 92 North of Mexican Border-Nicksville | 0 | 10 | | | | 15 | | | 25 | 43 |
| 21 | I-40-SR 64 North of Williams | 30 | | | 30 | | 15 | 5 | | 80 | 18 |
| 22 | SR 73 / SR 260 South of Show Low | 0 | | | 30 | | 15 | | | 45 | 36 |
| 22 | US 60 East of Show Low | 0 | | | 30 | | 15 | | | 45 | 36 |
| 24 | US 180 North Flagstaff | 71 | 10 | | | | | 5 | 5 | 91 | 17 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | US 60 Forest Dale Canyon South of Show Low | 40 | | | | | | | | 40 | 38 |
| 25 | SR 69 Poland Junction | 40 | | | 30 | | | | | 70 | 20 |
| 25 | I-19 North of Nogales | 0 | 10 | 10 | | | 15 | | | 35 | 40 |
| 28 | US 95 North Yuma | 40 | | | | 30 | | | | 70 | 20 |
| 29 | I-40 Business Loop into W Flagstaff -West Historic Rte 66 | 40 | | | 30 | | | | | 70 | 20 |

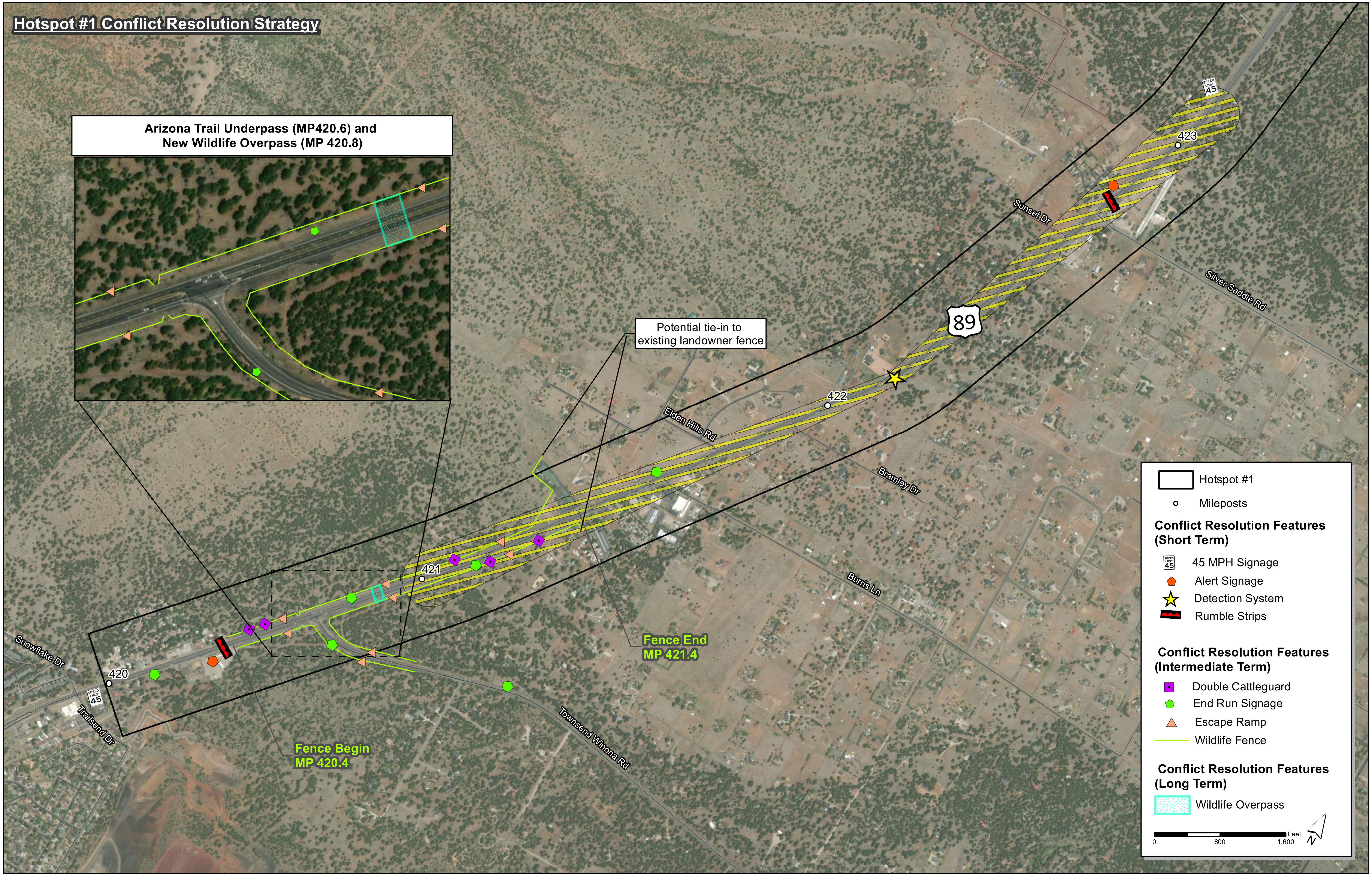
| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | SR 69 Humboldt | 40 | | | 30 | | | | | 70 | 20 |
| 29 | SR 90 Sierra Vista | 40 | | | | | 15 | | | 55 | 31 |
| 29 | SR 92 Naco - Mexico Border | 0 | | | | | | | | 0 | 50 |
| 29 | SR 80 West of Douglas - Mexico Border | 0 | | | | | | | | 0 | 50 |
| 34 | I-17 South of Munds Park | 70 | 10 | | | | 15 | 5 | | 100 | 10 |
| 34 | SR 87 NW Boundary of Mogollon Rim | 70 | 10 | | | | 15 | | | 95 | 15 |
| 34 | SR 87 Deer Creek Village | 0 | | 10 | | | 15 | | | 25 | 43 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | SR 64 South Rim Grand Canyon-Red Horse Wash | 70 | | | 30 | | | | | 100 | 10 |
| 37 | SR 64 South Rim Grand Canyon - Desert View | 30 | | | 30 | | | | | 60 | 28 |
| 39 | SR 89 A Forest Highlands | 71 | 10 | | 40 | | 15 | 5 | | 141 | 1 |
| 40 | SR 260 / US 60 Show Low | 40 | | | 30 | | | | | 70 | 20 |
| 41 | SR 69 N Spring Valley | 70 | | 10 | 30 | | 15 | | | 125 | 4 |
| 42 | SR 77 Downtown Show Low | | | | 30 | | | | | 30 | 41 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 43 | US 180 Kaibab National Forest - Ebert Mountain | 70 | | | 40 | | | | | 110 | 7 |
| 43 | US 60 Apache Reservation Boundary - Show Low | | | | | | 15 | | | 15 | 45 |
| 43 | US 60 East of Show Low - Bell | | | | 30 | | | | | 30 | 41 |
| 43 | I-10 West of Benson | 40 | | 10 | | | | | | 50 | 35 |
| 43 | I-19 Tumacacori | 31 | | 20 | | | | | | 51 | 34 |
| 43 | SR 77 Catalina | 70 | | 10 | | | | | | 80 | 18 |

| WVC Crash Hotspot Rank | Name | Linkage Focus Scoring Score for Hotspot bisecting State, County, and Other linkages: *Scoring = 40 points for state linkage; 30 points in county linkage; 1 point for local linkages. Max score = 71* | Score for Hotspot being in Threatened/ Endangered Wildlife Critical Habitat *Scoring = 0 if not in habitat, 10 points for being in habitat of any of these species. Max score = 10* | Score for Tortoise presence and suitable habitat *Scoring = (Miles of Tortoise presence x 10) + (Suitable habitat x 10) , max score =20* | Score for Presence of Pronghorn *Scoring = (30 pts) + if hotspot is in Pronghorn Migration Linkage (10 pts), max score = 40* | Score for Presence of Bighorn Habitat *Scoring = 30 pts if in habitat, max score = 30* | Score for White-tailed Deer if in WTD distribution map? *Scoring = 15 pts for yes, if no = 0 points, max score = 15* | Score for elk if in elk migrations map? *Scoring = 5 for yes, if no = 0 points, max score = 5* | Score for if the Hotspot intersects a Mule Deer Migration Linkage *Scoring = 5 for yes, 0=no, max score =5* | Linkage Focused Score Wildlife-Ecological Variable Scores Summed | Linkage Focused Ecological Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | I-40 Entrance Ramp East Flagstaff | 40 | | | | | | | | 40 | 38 |
| 50 | SR 77 Biosphere 2 | 30 | | 10 | | | 15 | | | 55 | 31 |
| 51 | SR 260 South of Show Low | | | | | | 15 | | | 15 | 45 |

# APPENDIX D. HOTSPOT CONFLICT RESOLUTION STRATEGIES AND FEATURES

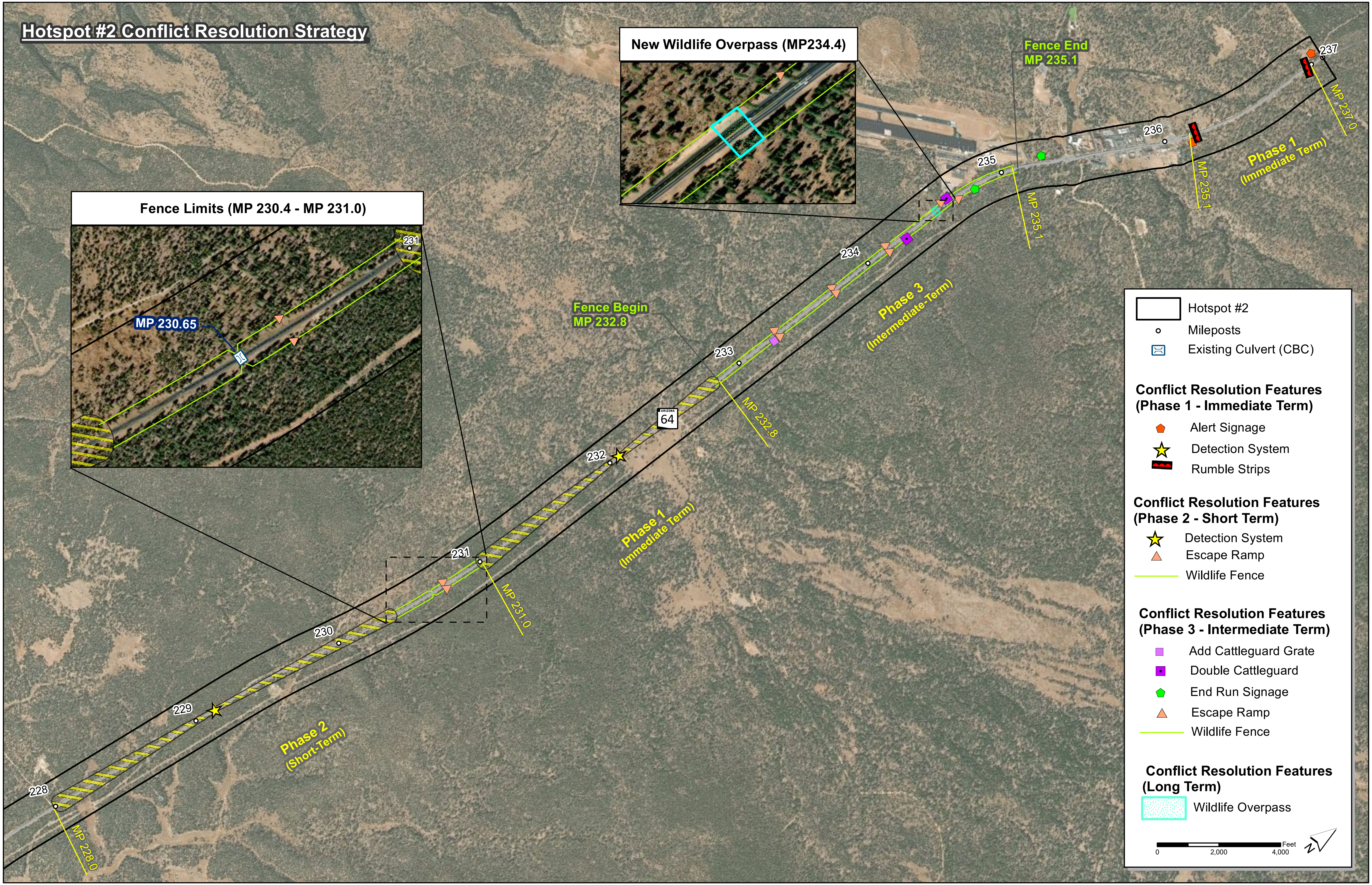

Hotspot #1 Conflict Resolution Strategy
Arizona Trail Underpass (MP420.6) and
New Wildlife Overpass (MP 420.8)
Potential tie-in to
existing landowner fence
Fence End
MP 421.4
Fence Begin
MP 420.4
420
421
422
423
89
Sunset Dr
Silver Saddle Rd
Elden Hills Rd
Bramley Dr
Burris Ln
Townsend Winona Rd
Snowflake Dr
Trailsend Dr
Hotspot #1
Mileposts
Conflict Resolution Features
(Short Term)
45 MPH Signage
Alert Signage
Detection System
Rumble Strips
Conflict Resolution Features
(Intermediate Term)
Double Cattleguard
End Run Signage
Escape Ramp
Wildlife Fence
Conflict Resolution Features
(Long Term)
Wildlife Overpass
Feet
0
800
1,600

## Hotspot #1 Conflict Resolution Features

US Highway 89 (US89) Hotspot #1 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed Short-Term, Intermediate Term, and Long-Term projects resolution features.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Short-Term Project** | | | | |
| US89 | 419.95 | Point | Speed Limit Signage | 2 |
| US89 | 423.15 | Point | Speed Limit Signage | |
| US89 | 420.36 | Point | Motorist Alert Signage | 2 |
| US89 | 422.80 | Point | Motorist Alert Signage | |
| US89 | 420.36 | Point | Rumble Strips | 2 |
| US89 | 422.80 | Point | Rumble Strips | |
| US89 | 422.17 | Point | ORAD™ Radar Detection Unit | 1 |
| US89 | 420.95 - 423.95 | Polygon | ORAD™ Radar Detection Distance | |
| **Intermediate Term** | | | | |
| US89 | 421.28 | Point | Double Cattleguard | 5 |
| US89 | 421.15 | Point | Double Cattleguard | |
| US89 | 421.08 | Point | Double Cattleguard | |
| US89 | 420.52 | Point | Double Cattleguard | |
| US89 | 420.47 | Point | Double Cattleguard | |
| Townsend Winona Road | N/A* | Point | End Run Signage | 6 |
| Townsend Winona Road | N/A | Point | End Run Signage | |
| US89 | 420.74 | Point | End Run Signage | |
| US89 | 421.12 | Point | End Run Signage | |
| US89 | 420.23 | Point | End Run Signage | |
| US89 | 421.60 | Point | End Run Signage | |
| US89 | 421.20 | Point | Escape Ramp[1] | 8 |
| US89 | 421.20 | Point | Escape Ramp[1] | |
| Townsend Winona Road | N/A | Point | Escape Ramp[1] | |
| Townsend Winona Road | N/A | Point | Escape Ramp[1] | |
| US89 | 420.82 | Point | Escape Ramp[1] | |
| US89 | 420.55 | Point | Escape Ramp[1] | |
| US89 | 420.55 | Point | Escape Ramp[1] | |
| US89 | 420.82 | Point | Escape Ramp[1] | |
| US89 | 421.38 | Line | Wildlife Fence (60 LF*) – Potential connection to adjacent landowners existing chain link fence | 11,951 LF |
| US89 | 421.38 | Line | Wildlife Fence (1,095 LF) – Potential connection to adjacent landowners existing chain link fence | |
| US89 | 420.60 | Line | Wildlife Fence (115 LF) – Connection to Arizona Trail metal pipe arch culvert | |
| US89 | 420.40 - 421.40 | Line | Wildlife Fence (10,682 LF) – ROW* Fence[2] | |
| **Long Term** | | | | |
| US89 | 420.80 | Polygon | Wildlife Overpass | 1 |

Notes:
[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.
[2] Fence ends should be field determined to avoid blocking businesses.
* Definitions: CBC = concrete box culvert; LF = linear feet; N/A = not applicable; ROW = right-of-way


Hotspot #2 Conflict Resolution Strategy
New Wildlife Overpass (MP234.4)
Fence Limits (MP 230.4 - MP 231.0)
MP 230.65
Fence End
MP 235.1
Fence Begin
MP 232.8
228
229
230
231
232
233
234
235
236
237
64
MP 228.0
MP 231.0
MP 232.8
MP 235.1
MP 237.0
Phase 1
(Immediate Term)
Phase 2
(Short-Term)
Phase 3
(Intermediate-Term)
Hotspot #2
Mileposts
Existing Culvert (CBC)
Conflict Resolution Features
(Phase 1 - Immediate Term)
Alert Signage
Detection System
Rumble Strips
Conflict Resolution Features
(Phase 2 - Short Term)
Detection System
Escape Ramp
Wildlife Fence
Conflict Resolution Features
(Phase 3 - Intermediate Term)
Add Cattleguard Grate
Double Cattleguard
End Run Signage
Escape Ramp
Wildlife Fence
Conflict Resolution Features
(Long Term)
Wildlife Overpass
Feet
0
2,000
4,000
N

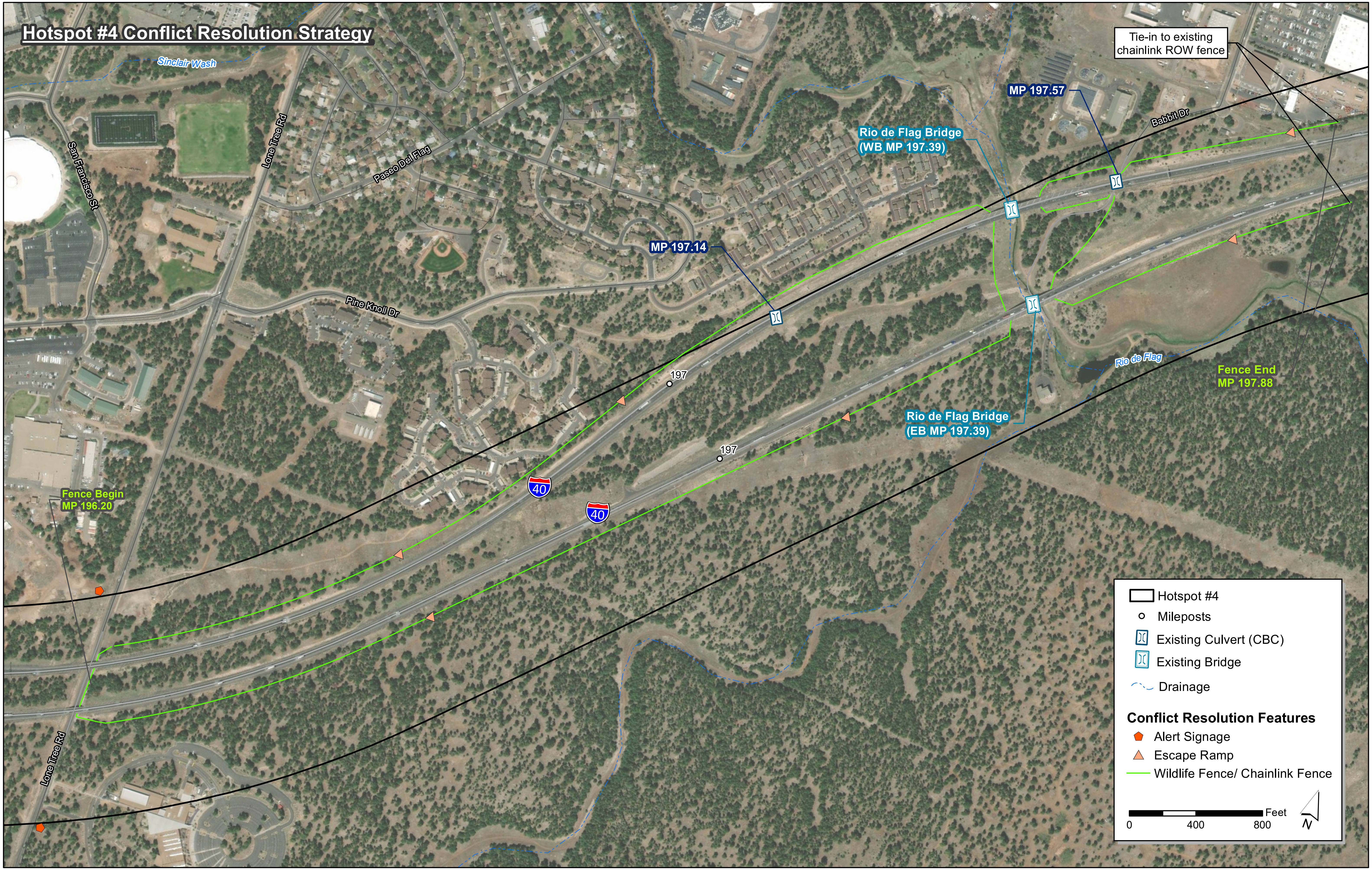
## Hotspot #2 Conflict Resolution Features

State Route 64 (SR64) Hotspot #2 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed projects (i.e. Phase 1 - Immediate Term, Phase 2 - Short-Term, Phase 3 - Intermediate Term, and Long-Term) resolution features.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Phase 1: Immediate Term Project (MP 231.0 – MP 232.8 and MP 236.2 – MP 237.0)** | | | | |
| SR64 | 237.00 | Point | Motorist Alert Signage | 2 |
| SR64 | 236.20 | Point | Motorist Alert Signage | |
| SR64 | 237.00 | Point | Rumble Strips | 2 |
| SR64 | 236.20 | Point | Rumble Strips | |
| SR64 | 232.10 | Point | ORAD™ Radar Detection Unit | 1 |
| SR64 | 231.00 - 232.80 | Polygon | ORAD™ Radar Detection Distance | |
| **Phase 2: Short Term Project (MP 228.0 – MP 231.0)** | | | | |
| SR64 | 230.75 | Point | Escape Ramp[1] | 2 |
| SR64 | 230.75 | Point | Escape Ramp[1] | |
| SR64 | 229.15 | Point | ORAD™ Radar Detection Unit | 1 |
| SR64 | 228.00 - 230.4 | Polygon | ORAD™ Radar Detection Distance | |
| SR64 | 230.65 | Line | Wildlife Fence (340 LF*) – Connection to CBC* at MP 230.65 | 6,623 LF |
| SR64 | 230.40 - 231.0 | Line | Wildlife Fence (6,283 LF) – ROW* Fence | |
| **Phase 3: Intermediate Term Project (MP 232.8 – MP 235.1)** | | | | |
| SR64 | 233.25 | Point | Add Grate to Existing Cattleguard | 1 |
| SR64 | 234.65 | Point | Double Cattleguard | 2 |
| SR64 | 234.28 | Point | Double Cattleguard | |
| SR64 | 234.80 | Point | End Run Signage | 2 |
| SR64 | 235.25 | Point | End Run Signage | |
| SR64 | 234.59 | Point | Escape Ramp[1] | 8 |
| SR64 | 234.68 | Point | Escape Ramp[1] | |
| SR64 | 234.15 | Point | Escape Ramp[1] | |
| SR64 | 234.15 | Point | Escape Ramp[1] | |
| SR64 | 233.70 | Point | Escape Ramp[1] | |
| SR64 | 233.70 | Point | Escape Ramp[1] | |
| SR64 | 233.30 | Point | Escape Ramp[1] | |
| SR64 | 233.30 | Point | Escape Ramp[1] | |
| SR64 | 232.80 - 235.10 | Line | Wildlife Fence – ROW Fence | 24,024 LF |
| **Long Term** | | | | |
| SR64 | 234.40 | Polygon | Wildlife Overpass | 1 |

Notes:
[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.
* Definitions: CBC = concrete box culvert; LF = linear feet; ROW = right-of-way

# Hotspot #4 Conflict Resolution Strategy



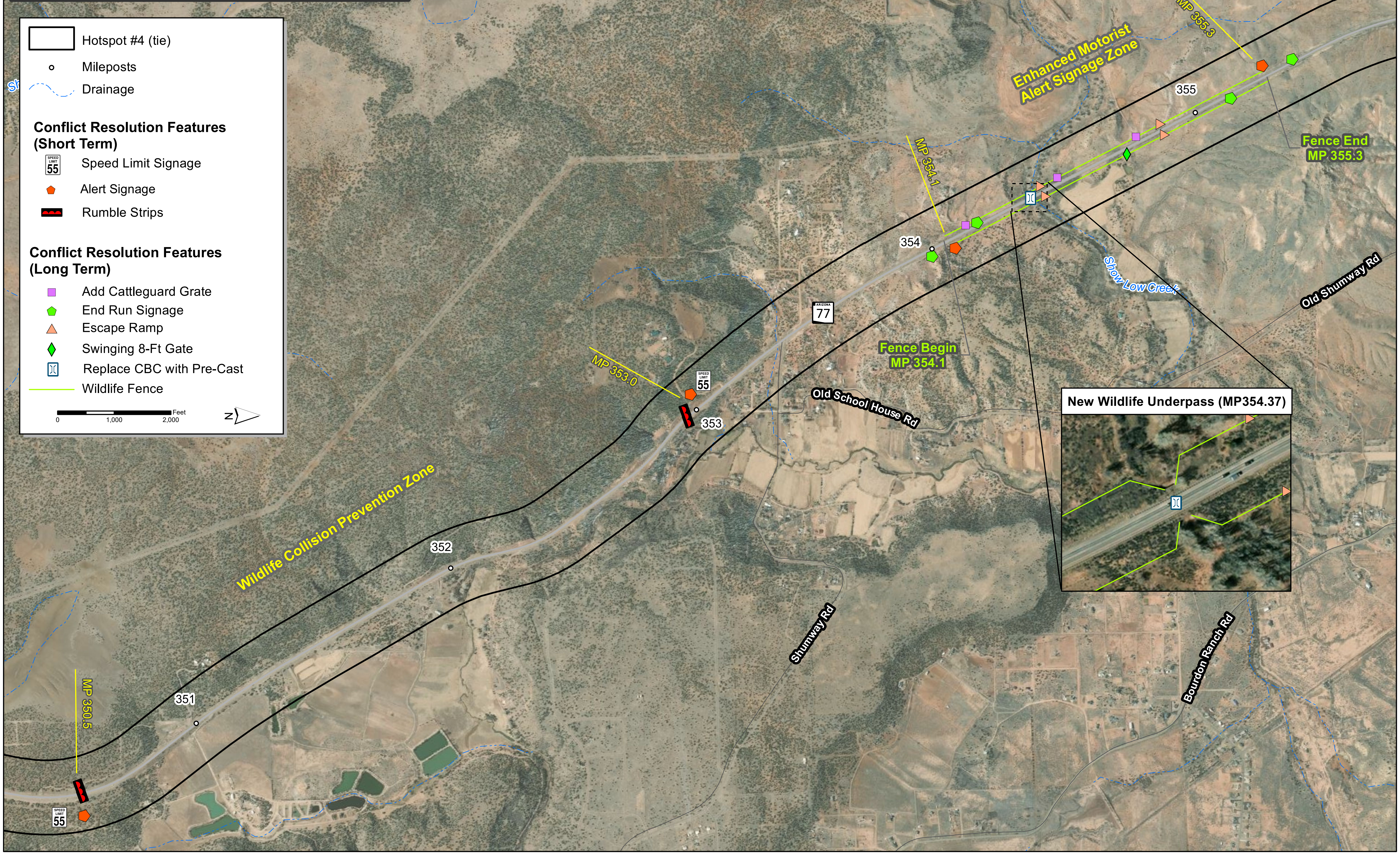
## Hotspot #4 Conflict Resolution Features

Interstate 40 (I-40) Hotspot #4 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed project features.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| Lone Tree Road | N/A* | Point | Motorist Alert Signage | 2 |
| Lone Tree Road | N/A | Point | Motorist Alert Signage | |
| I-40 | 197.82 | Point | Escape Ramp[1] | 6 |
| I-40 | 197.74 | Point | Escape Ramp[1] | |
| I-40 | 196.63 | Point | Escape Ramp[1] | |
| I-40 | 196.63 | Point | Escape Ramp[1] | |
| I-40 | 196.96 | Point | Escape Ramp[1] | |
| I-40 | 197.14 | Point | Escape Ramp[1] | |
| I-40 | 196.20 | Line | Wildlife Fence or Chain link Fence (573 LF*) – Connection to Lone Tree Road Bridge[2] | 18,071 LF |
| I-40 | 197.57 | Line | Wildlife Fence or Chain link Fence (1,381 LF) – Connection to westbound CBC* at MP 197.57[3] | |
| I-40 | 197.39 | Line | Wildlife Fence or Chain link Fence (841 LF) – Connection to Rio De Flag Bridge | |
| I-40 | 196.20-197.88 | Line | Wildlife Fence or Chain link Fence (15,277 LF) – ROW* Fence[4] | |

Notes:
[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.
[2] Angle the eastbound right-of-way fence connection
[3] Fenced island to allow multi-use path through median with no cattleguard crossings.
[4] Tie into existing chain link right-of-way fence at MP 197.88.
* Definitions: CBC = concrete box culvert; LF = linear feet; N/A = not applicable; ROW = right-of-way

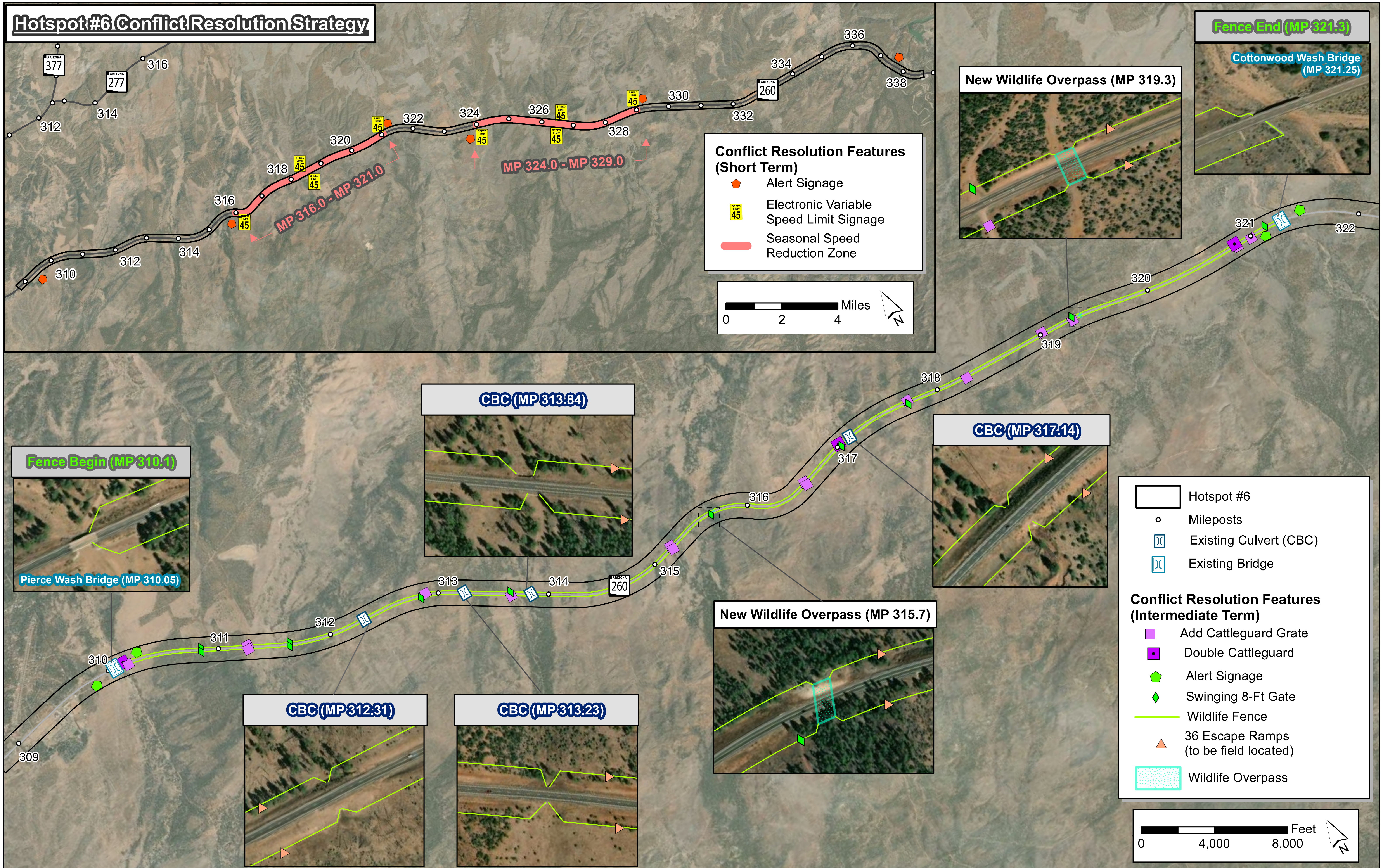
# Hotspot #4 (tie) Conflict Resolution Strategy



## Hotspot #4 (tie) Conflict Resolution Features

State Route 77 Hotspot #4(tie) wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with proposed Short-Term and Long-Term Projects.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Short-Term Project** | | | | |
| SR77 | 353.00 | Point | Speed Limit Signage | 2 |
| SR77 | 350.50 | Point | Speed Limit Signage | |
| SR77 | 350.50 | Point | Motorist Alert Signage | 4 |
| SR77 | 353.00 | Point | Motorist Alert Signage | |
| SR77 | 355.30 | Point | Motorist Alert Signage | |
| SR77 | 354.10 | Point | Motorist Alert Signage | |
| SR77 | 350.50 | Point | Rumble Strips | 2 |
| SR77 | 353.00 | Point | Rumble Strips | |
| SR77 | 354.10 -355.3 0 | Line | Enhanced Motorist Alert Signage Zone | |
| SR77 | 350.50 - 353.00 | Line | Wildlife Collision Prevention Zone | |
| **Long-Term Project** | | | | |
| SR77 | 354.13 | Point | Add Grate to Existing Cattleguard | 3 |
| SR77 | 354.48 | Point | Add Grate to Existing Cattleguard | |
| SR77 | 354.78 | Point | Add Grate to Existing Cattleguard | |
| SR77 | 354.00 | Point | End Run Signage | 4 |
| SR77 | 354.20 | Point | End Run Signage | |
| SR77 | 355.10 | Point | End Run Signage | |
| SR77 | 355.40 | Point | End Run Signage | |
| SR77 | 354.11 | Point | Escape Ramp | 4 |
| SR77 | 354.11 | Point | Escape Ramp | |
| SR77 | 354.86 | Point | Escape Ramp | |
| SR77 | 354.86 | Point | Escape Ramp | |
| SR77 | 354.72 | Point | Swinging 8-Ft Gate | 1 |
| SR77 | 354.37 | Line | Wildlife Fence (303 Lin. Ft.) - Connection to New Arch at MP 354.36 | 12,714 Lin. Ft. |
| SR77 | 354.10 - 355.30 | Line | Wildlife Fence (12,411 Lin. Ft.) - ROW Fence | |



Hotspot #6 Conflict Resolution Strategy
MP 316.0 - MP 321.0
MP 324.0 - MP 329.0
Conflict Resolution Features (Short Term)
Alert Signage
Electronic Variable Speed Limit Signage
Seasonal Speed Reduction Zone
Miles
0 2 4
New Wildlife Overpass (MP 319.3)
Fence End (MP 321.3)
Cottonwood Wash Bridge (MP 321.25)
CBC (MP 313.84)
CBC (MP 317.14)
Fence Begin (MP 310.1)
Pierce Wash Bridge (MP 310.05)
New Wildlife Overpass (MP 315.7)
CBC (MP 312.31)
CBC (MP 313.23)
Hotspot #6
Mileposts
Existing Culvert (CBC)
Existing Bridge
Conflict Resolution Features (Intermediate Term)
Add Cattleguard Grate
Double Cattleguard
Alert Signage
Swinging 8-Ft Gate
Wildlife Fence
36 Escape Ramps (to be field located)
Wildlife Overpass
Feet
0 4,000 8,000

## Hotspot #6 Conflict Resolution Features

State Route 260 (SR260) Hotspot #6 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed Short-Term and Intermediate Term projects.

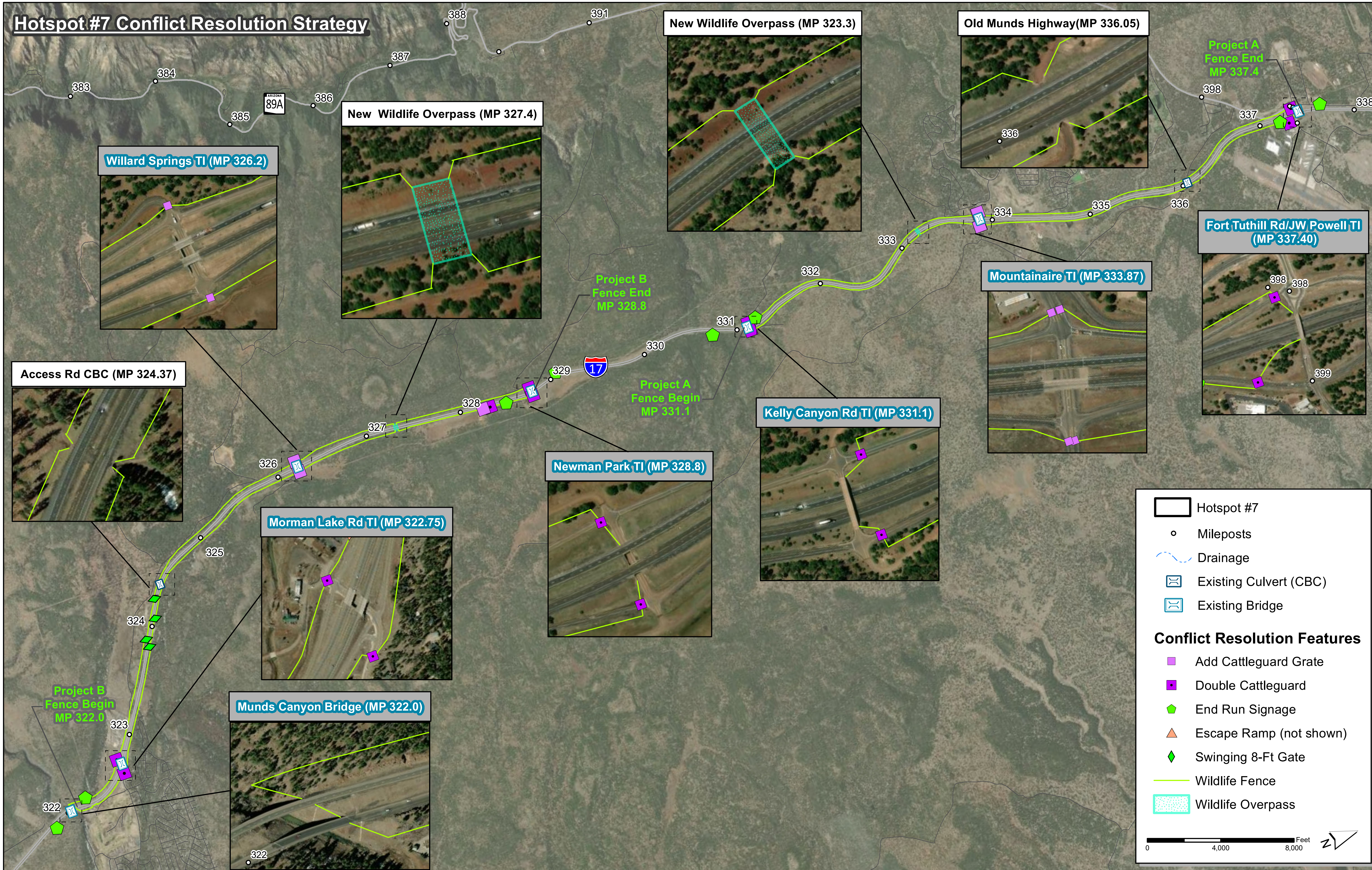
| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Short-Term Project** | | | | |
| SR260 | 309.50 | Point | Motorist Alert Signage | 6 |
| SR260 | 315.75 | Point | Motorist Alert Signage | |
| SR260 | 321.25 | Point | Motorist Alert Signage | |
| SR260 | 323.75 | Point | Motorist Alert Signage | |
| SR260 | 329.25 | Point | Motorist Alert Signage | |
| SR260 | 337.50 | Point | Motorist Alert Signage | |
| SR260 | 316.00 | Point | Electronic Variable Speed Limit Signage | 8 |
| SR260 | 318.50 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 318.50 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 321.00 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 324.00 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 326.50 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 326.50 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 329.00 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 316.00 - 321.00 | Line | Seasonal Speed Reduction Zone | 2 |
| SR260 | 324.00 - 329.00 | Line | Seasonal Speed Reduction Zone | |
| **Intermediate Term Project** | | | | |
| SR260 | 310.17 | Point | Add Grate to Existing Cattleguard | 15 |
| SR260 | 311.26 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 311.26 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 312.89 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 313.76 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 315.21 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 315.21 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 316.58 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 316.58 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 317.72 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 318.27 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 319.30 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 319.02 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 320.85 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 321.00 | Point | Add Grate to Existing Cattleguard | |
| SR260 | 310.15 | Point | Double Cattleguard | 3 |
| SR260 | 317.03 | Point | Double Cattleguard | |
| SR260 | 320.85 | Point | Double Cattleguard | |

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Intermediate Term Project (continued)** | | | | |
| SR260 | 309.90 | Point | End Run Signage | 4 |
| SR260 | 310.30 | Point | End Run Signage | |
| SR260 | 321.08 | Point | End Run Signage | |
| SR260 | 321.44 | Point | End Run Signage | |
| SR 260 | N/A* | Point | Escape Ramp[1] | 36 |
| SR260 | 310.85 | Point | Swinging 8-Ft Gate | 11 |
| SR260 | 310.85 | Point | Swinging 8-Ft Gate | |
| SR260 | 311.64 | Point | Swinging 8-Ft Gate | |
| SR260 | 311.64 | Point | Swinging 8-Ft Gate | |
| SR260 | 312.86 | Point | Swinging 8-Ft Gate | |
| SR260 | 313.76 | Point | Swinging 8-Ft Gate | |
| SR260 | 315.65 | Point | Swinging 8-Ft Gate | |
| SR260 | 317.03 | Point | Swinging 8-Ft Gate | |
| SR260 | 317.72 | Point | Swinging 8-Ft Gate | |
| SR260 | 319.30 | Point | Swinging 8-Ft Gate | |
| SR260 | 321.14 | Point | Swinging 8-Ft Gate | |
| SR260 | 310.10 | Line | Wildlife Fence (205 LF*) – Connection to Pierce Wash Bridge | 118,694 LF |
| SR260 | 312.31 | Line | Wildlife Fence (217 LF) – Connection to CBC* | |
| SR260 | 313.84 | Line | Wildlife Fence (321 LF) – Connection to CBC | |
| SR260 | 313.23 | Line | Wildlife Fence (337 LF) – Connection to CBC | |
| SR260 | 315.70 | Line | Wildlife Fence (128 LF) – Connection new wildlife overpass | |
| SR260 | 317.14 | Line | Wildlife Fence (198 LF) – Connection to CBC | |
| SR260 | 319.30 | Line | Wildlife Fence (112 LF) – Connection new wildlife overpass | |
| SR260 | 321.30 | Line | Wildlife Fence (205 LF) – Connection to Cottonwood Wash Bridge | |
| SR260 | 310.10 - 321.30 | Line | Wildlife Fence (116,943 LF) – ROW* Fence | |
| SR260 | 315.7 | Polygon | Wildlife Overpass | 2 |
| SR260 | 319.3 | Polygon | Wildlife Overpass | |

Notes:

[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.

* Definitions: CBC = concrete box culvert; LF = linear feet; N/A = not applicable; ROW = right-of-way



Hotspot #7 Conflict Resolution Strategy
New Wildlife Overpass (MP 323.3)
Old Munds Highway(MP 336.05)
Project A Fence End MP 337.4
New Wildlife Overpass (MP 327.4)
Willard Springs TI (MP 326.2)
Project B Fence End MP 328.8
Access Rd CBC (MP 324.37)
Project A Fence Begin MP 331.1
Mountainaire TI (MP 333.87)
Fort Tuthill Rd/JW Powell TI (MP 337.40)
Kelly Canyon Rd TI (MP 331.1)
Newman Park TI (MP 328.8)
Morman Lake Rd TI (MP 322.75)
Project B Fence Begin MP 322.0
Munds Canyon Bridge (MP 322.0)
89A
17
Hotspot #7
Mileposts
Drainage
Existing Culvert (CBC)
Existing Bridge
Conflict Resolution Features
Add Cattleguard Grate
Double Cattleguard
End Run Signage
Escape Ramp (not shown)
Swinging 8-Ft Gate
Wildlife Fence
Wildlife Overpass
Feet
0
4,000
8,000

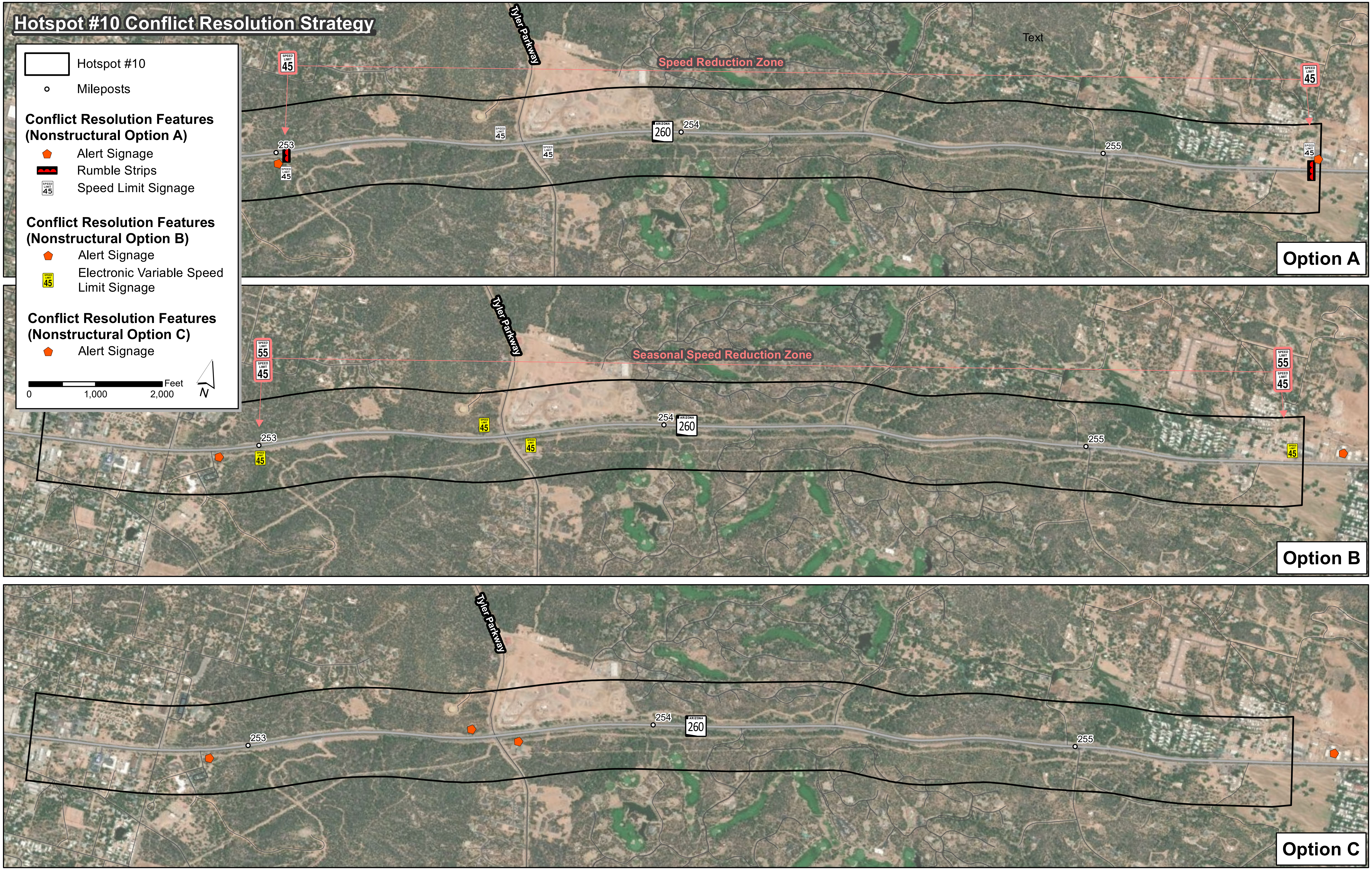
## Hotspot #7 Conflict Resolution Features

Interstate 17 (I-17) Hotspot #7 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed Short-Term projects.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Short Term Project A (MP 331.1 – MP 337.4)** | | | | |
| I-17 | 333.87 | Point | Add Grate to Existing Cattleguard | 4 |
| I-17 | 331.10 | Point | Double Cattleguard | 2 |
| I-17 | 337.40 | Point | Double Cattleguard | 2 |
| I-17 | 330.75 | Point | End Run Signage | 4 |
| I-17 | 331.25 | Point | End Run Signage | |
| I-17 | 337.25 | Point | End Run Signage | |
| I-17 | 337.65 | Point | End Run Signage | |
| I-17 | N/A* | Point | Escape Ramp[1] | 36 |
| I-17 | 331.10 | Line | Wildlife Fence (387 LF*) – Connection to Kelly Canyon Road TI* | 66,503 LF |
| I-17 | 333.30 | Line | Wildlife Fence (205 LF) – Connection to new wildlife overpass | |
| I-17 | 336.05 | Line | Wildlife Fence (396 LF) – Connection to Old Munds Highway CBC* | |
| I-17 | 337.4 | Line | Wildlife Fence (799 LF) – Connection to Fort Tuthill Road/JW Powell Boulevard TI | |
| I-17 | 331.10 - 337.40 | Line | Wildlife Fence (64,716 LF) – ROW* Fence | |
| I-17 | 333.3 | Polygon | Wildlife Overpass | 1 |
| **Short Term Project B (MP 322.0 – MP 328.8)** | | | | |
| I-17 | 326.20 | Point | Add Grate to Existing Cattleguard | 3 |
| I-17 | 326.20 | Point | Add Grate to Existing Cattleguard | |
| I-17 | 328.23 | Point | Add Grate to Existing Cattleguard | |
| I-17 | 322.63 | Point | Double Cattleguard | 5 |
| I-17 | 322.63 | Point | Double Cattleguard | |
| I-17 | 328.31 | Point | Double Cattleguard | |
| I-17 | 328.80 | Point | Double Cattleguard | |
| I-17 | 328.80 | Point | Double Cattleguard | |
| I-17 | 321.75 | Point | End Run Signage | 4 |
| I-17 | 322.25 | Point | End Run Signage | |
| I-17 | 328.50 | Point | End Run Signage | |
| I-17 | 329.10 | Point | End Run Signage | |
| I-17 | N/A | Point | Escape Ramp[1] | 40 |
| I-17 | 323.82 | Point | Swinging 8-Ft Gate | 4 |
| I-17 | 323.88 | Point | Swinging 8-Ft Gate | |
| I-17 | 324.07 | Point | Swinging 8-Ft Gate | |
| I-17 | 324.24 | Point | Swinging 8-Ft Gate | |
| I-17 | 324.37 | Line | Wildlife Fence (220 LF) – Connection to CBC | 72,147 LF |
| I-17 | 327.4 | Line | Wildlife Fence (294 LF) – Connection to new wildlife overpass | |
| I-17 | 328.8 | Line | Wildlife Fence (320 LF) – Connection to Newman Park TI | |
| I-17 | 322.00 - 328.80 | Line | Wildlife Fence (71,313 LF) – ROW* Fence | |
| I-17 | 327.4 | Polygon | Wildlife Overpass | 1 |

Notes:
[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.
* Definitions: CBC = concrete box culvert; LF = linear feet; N/A = not applicable; ROW = right-of-way; TI = traffic interchange

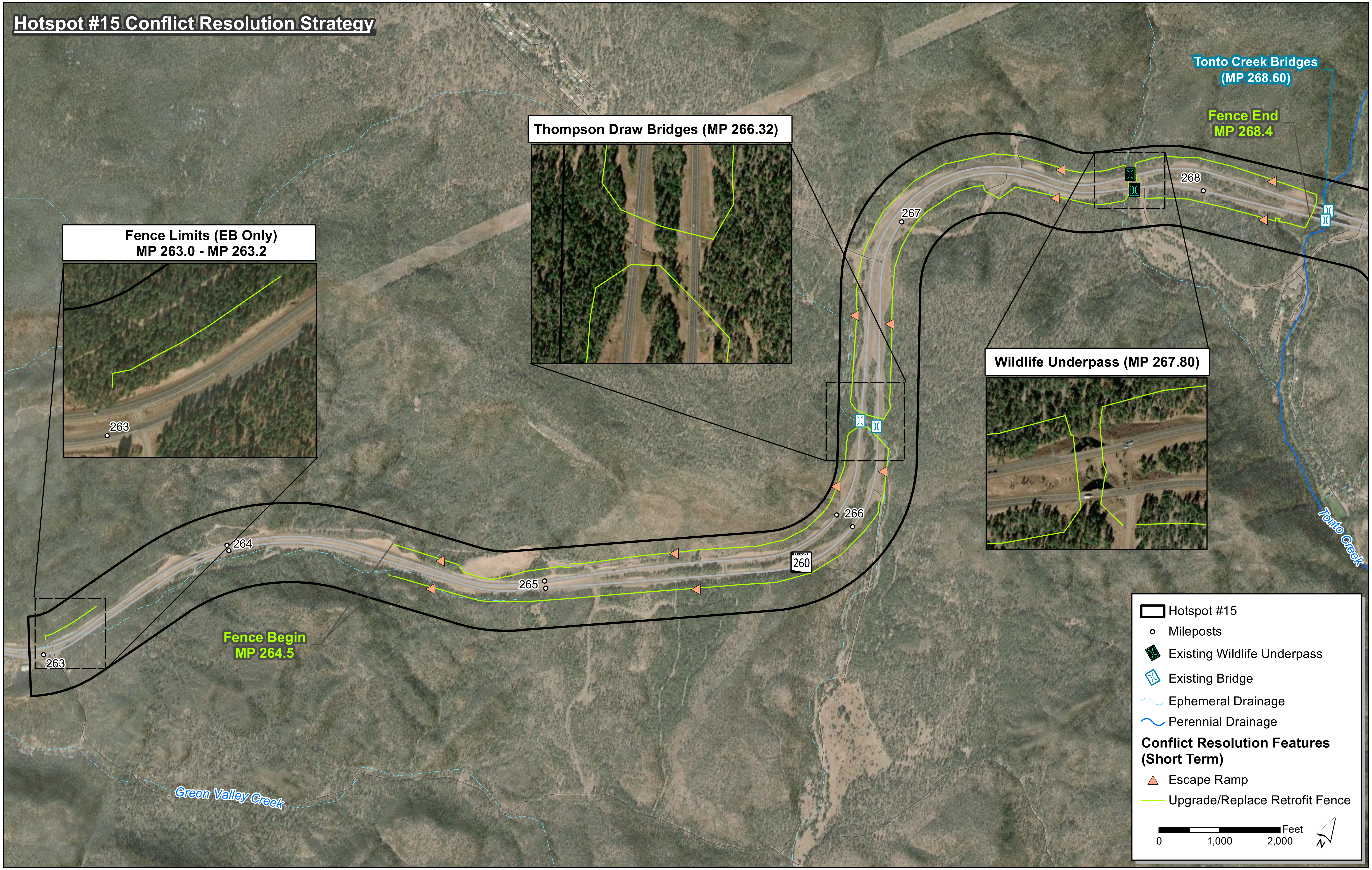
# Hotspot #10 Conflict Resolution Strategy



## Hotspot #10 Conflict Resolution Features

State Route 260 (SR260) Hotspot #10 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the 3 proposed nonstructural project options.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Option A (Wildlife Collision Prevention Zone)** | | | | |
| SR260 | 253.00 | Point | Gateway Motorist Alert Signage | 2 |
| SR260 | 255.50 | Point | Gateway Motorist Alert Signage | |
| SR260 | 253.00 | Point | Speed Limit Signage | 4 |
| SR260 | 253.55 | Point | Speed Limit Signage | |
| SR260 | 253.65 | Point | Speed Limit Signage | |
| SR260 | 255.50 | Point | Speed Limit Signage | |
| SR260 | 253.00 | Point | Transverse Rumble Strips | 2 |
| SR260 | 255.50 | Point | Transverse Rumble Strips | |
| **Option B (Seasonal Dusk/Nighttime Speed Reduction Zone)** | | | | |
| SR260 | 252.90 | Point | Gateway Motorist Alert Signage | 2 |
| SR260 | 255.60 | Point | Gateway Motorist Alert Signage | |
| SR260 | 253.00 | Point | Electronic Variable Speed Limit Signage | 4 |
| SR260 | 253.55 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 253.65 | Point | Electronic Variable Speed Limit Signage | |
| SR260 | 255.50 | Point | Electronic Variable Speed Limit Signage | |
| **Option C (Enhanced Motorist Alert Signage)** | | | | |
| SR260 | 252.90 | Point | Enhanced Motorist Alert Signage | 4 |
| SR260 | 253.55 | Point | Enhanced Motorist Alert Signage | |
| SR260 | 253.65 | Point | Enhanced Motorist Alert Signage | |
| SR260 | 255.60 | Point | Enhanced Motorist Alert Signage | |



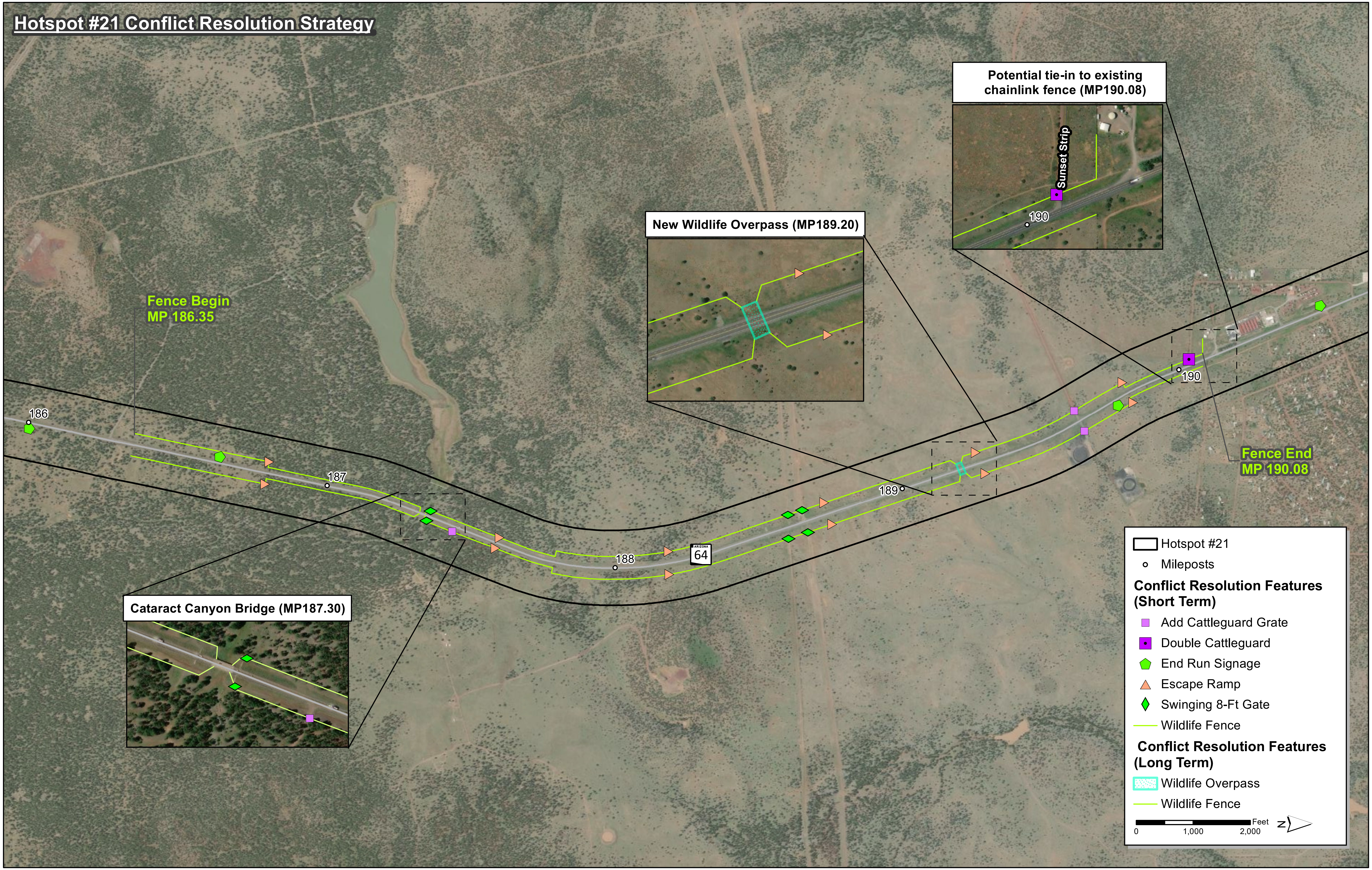
Hotspot #15 Conflict Resolution Strategy
Thompson Draw Bridges (MP 266.32)
Fence Limits (EB Only)
MP 263.0 - MP 263.2
263
Wildlife Underpass (MP 267.80)
Tonto Creek Bridges
(MP 268.60)
Fence End
MP 268.4
268
267
266
265
264
263
260
Fence Begin
MP 264.5
Green Valley Creek
Tonto Creek
Hotspot #15
Mileposts
Existing Wildlife Underpass
Existing Bridge
Ephemeral Drainage
Perennial Drainage
Conflict Resolution Features (Short Term)
Escape Ramp
Upgrade/Replace Retrofit Fence
0
1,000
2,000
Feet
N

## Hotspot #15 Conflict Resolution Features

State Route 260 (SR260) Hotspot #15 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed Short-Term project.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| SR260 | 264.65 | Point | Escape Ramp[1] | 12 |
| SR260 | 264.65 | Point | Escape Ramp[1] | |
| SR260 | 265.40 | Point | Escape Ramp[1] | |
| SR260 | 265.46 | Point | Escape Ramp[1] | |
| SR260 | 266.05 | Point | Escape Ramp[1] | |
| SR260 | 266.15 | Point | Escape Ramp[1] | |
| SR260 | 266.68 | Point | Escape Ramp[1] | |
| SR260 | 266.68 | Point | Escape Ramp[1] | |
| SR260 | 267.55 | Point | Escape Ramp[1] | |
| SR260 | 267.55 | Point | Escape Ramp[1] | |
| SR260 | 268.20 | Point | Escape Ramp[1] | |
| SR260 | 268.20 | Point | Escape Ramp[1] | |
| SR260 | 263.0-263.2 | Line | Upgrade and/or Replace Wildlife Fence (1,049 LF*) – EB* ROW* Fence[2] | 43,486 LF |
| SR260 | 264.5-268.4 | Line | Wildlife Fence or Chain link Fence (42,437 LF) – ROW Fence[2] | |

Notes:
[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.
[2] Existing fence is elk retrofit fencing.
* Definitions: EB = eastbound; LF = linear feet; ROW = right-of-way



Hotspot #21 Conflict Resolution Strategy
Potential tie-in to existing chainlink fence (MP190.08)
Sunset Strip
190
New Wildlife Overpass (MP189.20)
Fence Begin MP 186.35
186
187
188
64
189
190
Fence End MP 190.08
Cataract Canyon Bridge (MP187.30)
Hotspot #21
Mileposts
Conflict Resolution Features (Short Term)
Add Cattleguard Grate
Double Cattleguard
End Run Signage
Escape Ramp
Swinging 8-Ft Gate
Wildlife Fence
Conflict Resolution Features (Long Term)
Wildlife Overpass
Wildlife Fence
0
1,000
2,000
Feet
N

## Hotspot #21 Conflict Resolution Features

State Route 64 (SR64) Hotspot #21 wildlife-vehicle conflict resolution strategy components and estimated milepost (MP) locations associated with the proposed Short-Term and Long-Term projects.

| Route | Milepost Limits | GIS Feature Type | Resolution Component Type | Resolution Component Totals by Type |
|---|---|---|---|---|
| **Short Term Project** | | | | |
| SR64 | 187.44 | Point | Add Grate to Existing Cattleguard | 3 |
| SR64 | 189.63 | Point | Add Grate to Existing Cattleguard | |
| SR64 | 189.63 | Point | Add Grate to Existing Cattleguard | |
| SR64 | 190.04 | Point | Double Cattleguard | 1 |
| SR64 | 186.00 | Point | End Run Signage | 4 |
| SR64 | 186.65 | Point | End Run Signage | |
| SR64 | 189.76 | Point | End Run Signage | |
| SR64 | 190.50 | Point | End Run Signage | |
| SR64 | 186.80 | Point | Escape Ramp[1] | 12 |
| SR64 | 186.80 | Point | Escape Ramp[1] | |
| SR64 | 187.60 | Point | Escape Ramp[1] | |
| SR64 | 187.60 | Point | Escape Ramp[1] | |
| SR64 | 188.15 | Point | Escape Ramp[1] | |
| SR64 | 188.15 | Point | Escape Ramp[1] | |
| SR64 | 188.75 | Point | Escape Ramp[1] | |
| SR64 | 188.75 | Point | Escape Ramp[1] | |
| SR64 | 189.25 | Point | Escape Ramp[1] | |
| SR64 | 189.25 | Point | Escape Ramp[1] | |
| SR64 | 189.82 | Point | Escape Ramp[1] | |
| SR64 | 189.82 | Point | Escape Ramp[1] | |
| SR64 | 187.35 | Point | Swinging 8-Ft Gate | 6 |
| SR64 | 187.35 | Point | Swinging 8-Ft Gate | |
| SR64 | 188.60 | Point | Swinging 8-Ft Gate | |
| SR64 | 188.60 | Point | Swinging 8-Ft Gate | |
| SR64 | 188.66 | Point | Swinging 8-Ft Gate | |
| SR64 | 188.66 | Point | Swinging 8-Ft Gate | |
| SR64 | 187.3 | Line | Wildlife Fence (368 LF*) – Connection to Cataract Canyon Bridge | 39,865 LF |
| SR64 | 190.08 | Line | Wildlife Fence (266 LF) – Potential connection to adjacent landowners existing chain link fence | |
| SR64 | 186.35 - 190.08 | Line | Wildlife Fence (39,231 LF) – ROW* Fence | |
| **Long Term Project** | | | | |
| SR64 | 189.2 | Line | Wildlife Fence – Connection to new wildlife overpass | 464 LF |
| SR64 | 198.2 | Polygon | Wildlife Overpass | 1 |

Notes:
[1] Escape ramps locations have been estimated and are not the exact suggested location. Escape ramps should be field located based on surrounding topography and habitat conditions.
* Definitions: LF = linear feet; ROW = right-of-way