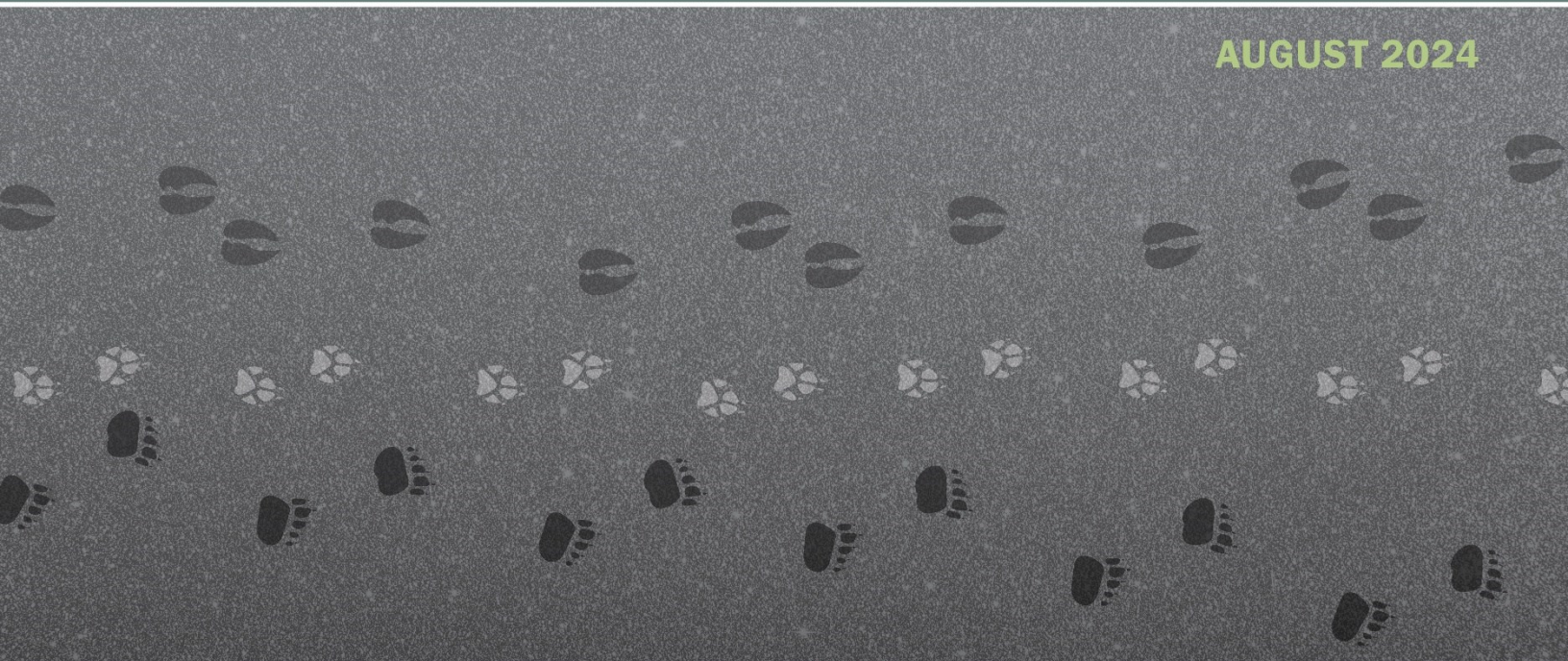




# U.S. 36 Wildlife Crossing Assessment, Prioritization, & Cost Estimation Study

AUGUST 2024





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# 1. Executive Summary

## 1.1 Background

Boulder County, including the Parks and Open Space (BCPOS) Department and Public Works Department, is pursuing the implementation of wildlife crossing structures on US Highway 36 (US 36), between Boulder and Lyons, and specifically between Left Hand Canyon Drive and State Highway (SH) 66. BCPOS funded this study and is primarily referenced in this report. In the last ten years, Colorado Department of Transportation (CDOT), Colorado Parks and Wildlife (CPW), and Colorado State Patrol (CSP) have recorded 263 wildlife-vehicle collisions (WVCs) resulting in 282 animal deaths. Many WVCs are not reported so the actual number of WVCs is likely much higher. These crashes are traumatic and represent a cost to society through property damage, injuries, and the value of wildlife. Additionally, the highway divides the wildlife habitat, disrupting migration patterns and resulting in genetic isolation. BCPOS staff are aware of these issues and have taken several important steps to understand the problem and implement solutions:

- BCPOS staff have been carefully tracking deer and elk movement patterns for many years, working closely with CPW district wildlife managers and area biologists. CPW has collected several years of elk collar data which have provided a clear understanding of elk movement patterns in the area.
- BCPOS has vetted the concept of wildlife crossings through the 2020 Red Hill Elk Management Plan (Boulder County, 2020a). This plan was created in full collaboration with CPW, as it established a hunting program on Open Space that commenced in 2020, and is revisited annually to review hunt objectives, but also includes review of establishing safe passage of elk across US 36.
- BCPOS has held several public meetings, developed a webpage and short survey, and showcased this corridor via webinar participation. The education initiative has just begun and BCPOS will be connecting with interested parties in the months and years to come.

The issue of this problematic stretch of US 36 has also been highlighted by the Boulder County 2020 Transportation Master Plan Update, which conducted a comprehensive analysis of WVCs in all of Boulder County. The results show that 40 percent of all WVCs in the entirety of Boulder County occur in this stretch (Boulder County, 2020b).

In 2022, CDOT completed the Eastern Slope and Plains Wildlife Prioritization Study (ESPWPS) to identify the stretches of highway in eastern Colorado that have the highest number of WVCs (Kintsch et al. 2022). This stretch of US 36 is ranked in the top 5 percent of segments needing mitigative actions, and in fact, based on the study's modeling inputs, this stretch received the highest score in CDOT Region 4. The ESPWPS results were the final catalyst for BCPOS to move forward with pursuing an analysis of the corridor for crossing location considerations, prioritizations, strategies, and cost estimates.

With these supporting documents and past efforts, Boulder County is committed to addressing the known safety issues in the corridor. This conceptual analysis report is the first step, and future

success in constructing wildlife crossings will require further analysis and design. Proceeding with this project requires close collaboration with the integral agencies of CDOT and CPW. Also, with Boulder County, the federal agencies at Table Mountain, Town of Lyons, City of Boulder, landowners and public citizens, and to initiate new partnerships with other entities and agencies.

## 1.2 Screening and Prioritization of Wildlife Crossings

A list of potential wildlife crossing locations within the project corridor was developed based on the recommendations in the ESPWPS, site reconnaissance and BCPOS and CPW staff knowledge. The list of potential crossing locations included underpasses at existing drainageways and overpasses at locations where US 36 is depressed in the existing topography. In all, 14 potential wildlife crossing locations were evaluated and screened. The screening criteria included WVC and collar data, site feasibility, right-of-way (ROW)/leveraging investments, and environmental clearances.

The screening yielded the following locations that were advanced for further evaluation and prioritization:

- Overpass at milepost (MP) 22.4
- Overpass at MP 24.6
- Overpass at MP 26.4

The prioritization process involved a quantitative comparison of the three screened locations to prioritize them. The prioritization criteria included WVCs, connectivity, cost, benefit/cost, and environmental permitting. Table 1 below summarizes the results of the prioritization process:

**Table 1. Summary of Prioritization Results**

Crossing MP	Type	Cost	Rank
22.4	Overpass	\$18.67M	3
24.6 <sup>1</sup>	Overpass	\$16.39M	1
26.4	Overpass	\$16.17M	2

<sup>1</sup>An underpass at **MP 25.0** was also identified as an option, with some caveats described later in the document. This underpass should be analyzed in greater depth as a potential alternative to the overpass at MP 24.6.

## 1.3 Fencing Strategies

The study included recommendations for wildlife fencing along US 36 and for the larger area east of US 36 bounded by Saint Vrain Creek, Left Hand Creek at SH 119, and US 36. Wildlife fencing is recommended on both sides of US 36 from Left Hand Creek to Saint Vrain Creek. In the larger area east of US 36, wildlife fencing is recommended on 55<sup>th</sup> Street east of Table Mountain and on SH 119 from Niwot Road to Airport Road. In addition to the fencing, a wildlife detection



zone is recommended on Nelson Road on the straightaway between Triple Creek Ranch and North 51st Street, where most elk crossings occur.

## 1.4 Accommodations for Small Species

While the focus of this study was to identify and prioritize locations for ungulate crossings, this study also includes a list of potential modifications to existing drainage structures to make them more conducive for use as wildlife crossings for small species. The potential modifications include herptile barrier, small animal jump outs, turnarounds, guide walls, lighting grates, catwalks, backfilling culverts and adding vegetation.

## 1.5 Implementation

Recognizing that the funding to build all the improvements will not likely be available at once, this study recommends a phase implementation strategy, outlined in Table 2 below. This strategy is only one possibility; the actual phasing will depend on available funding.

**Table 2. Summary of Phased Implementation**

Order of Priority	Description	Itemized Cost	Total Cost
Phase 1	Fencing along US 36	\$11,982,000	\$28,718,000
	Overpass at MP 24.6 (if underpass at 25.0 screened out)	\$15,386,000	
	Improve existing drainage culverts to accommodate smaller species	\$1,350,000	
Phase 2	Fencing along SH 119 from Niwot Road to Airport Road	\$3,778,000	\$8,611,000
	Wildlife detection zone on Nelson Road	\$813,000	
	Fencing along 55 <sup>th</sup> Street and Plateau Road	\$4,020,000	
Phase 3	Overpass at MP 26.4	\$15,173,000	\$32,540,000
	Overpass at MP 22.4	\$17,367,000	

## 2. Introduction

Colorado experiences nearly 6,800 reported wildlife-vehicle collisions (WVCs) annually (CDOT, 2023). Many WVCs are not reported, with some studies suggesting that unreported WVCs may be as high as 40% locally (Kintsch et al. 2021; Olson 2013). Across the United States, 1 – 2 million WVCs are estimated to occur each year (Conover et al. 1995; IIHS 2018; State Farm 2021). Nationwide, these WVCs are responsible for costs exceeding 10 billion dollars annually (Huijser et al. 2007; adjusted for inflation to 2021 dollars). Additionally, there are unquantified costs as roadways fragment wildlife habitats, serving as barriers to wildlife access of food, shelter, and mating opportunities, resulting in degradation of the ecological system.

In recognition of the need to enhance wildlife connectivity, reduce wildlife mortality, and protect drivers and their property, BCPOS is undertaking the US 36 Wildlife Crossings Project (Project). The Project's primary objectives are to implement wildlife crossing concepts along US 36 between Nelson Road and SH 66 (hereafter referred to as "project corridor") and to develop a strategy for facilitating the movement of wildlife in the larger area bounded by Saint Vrain Creek, Left Hand Creek at SH 119, and US 36 (hereafter referred to as "area of interest"). The project corridor has a high number of WVCs relative to the surrounding region and has been identified as a prioritized corridor by CDOT and CPW for the implementation of wildlife crossing systems (Kintsch et al. 2022).

Boulder County, with input from stakeholders including CPW, CDOT, and public citizens, has developed this Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study (Study) to screen and prioritize wildlife crossing concepts in the project corridor and area of interest, and provide cost estimates for these prioritized concepts. This Study will address implementation strategies, including potential application for the Federal Highway Administration (FHWA) Wildlife Crossings Pilot Program (WCPP) funds made available by the Infrastructure Bill.

### 2.1 Study Goals and Content

The goals of this Study are to 1) assess and prioritize wildlife crossing concepts in the project corridor, 2) provide cost estimates including contingencies for recommended priority crossing locations and supporting infrastructure, and 3) assess strategies to facilitate the safe passage of wildlife in the greater area of interest. This report has been prepared to:

- Document how this Study and the analysis were developed based on the best available information for the project corridor.
- Describe how wildlife mitigation options and systems were developed, screened, and prioritized.
- Describe how wildlife movement strategies in the area of interest (east of US 36) were developed.
- Discuss mitigation strategies for smaller to medium-sized wildlife, such as retrofitting existing culverts, in addition to developing strategies for large animal crossings, such as elk and deer.

- Provide cost estimates including contingencies for the recommended wildlife crossing concepts.
- Offer potential strategies to implement these projects.

## 2.2 Project Location

The project corridor and area of interest are shown in Figures 1 and 2. West of US 36, forested mountains and montane slopes host a rich biodiversity of plants and fungi including rare plant species, mule deer, elk, and black bear, as well as numerous mesocarnivores and smaller mammals. Most of the lands west of the highway are County-owned open space or conservation easements. Private ownership is more prevalent east of US 36, although Boulder County has several land holdings in this area. The area of interest includes native shortgrass prairie, wetlands, agriculture, and human development among the foothills of the Rocky Mountains.

Several streams and ditches occur along and surrounding the corridor, including Left Hand Creek, Saint Vrain Creek, Lykins Gulch, Lake Ditch, Boulder Feeder Canal, and numerous dry and intermittent tributaries to these streams.

The land surrounding the project corridor includes sensitive ecological features such as habitat for the federally listed Preble's meadow jumping mouse; nesting habitat for golden eagles and other raptors; riparian habitats and wetlands; rare and native vegetation communities; and wildlife movement, foraging, and/or breeding habitat for species such as elk, mule deer, bobcats, mountain lions, and black bear. These sensitive ecological resources are further discussed in Chapter 3.



Figure 1. Project Location

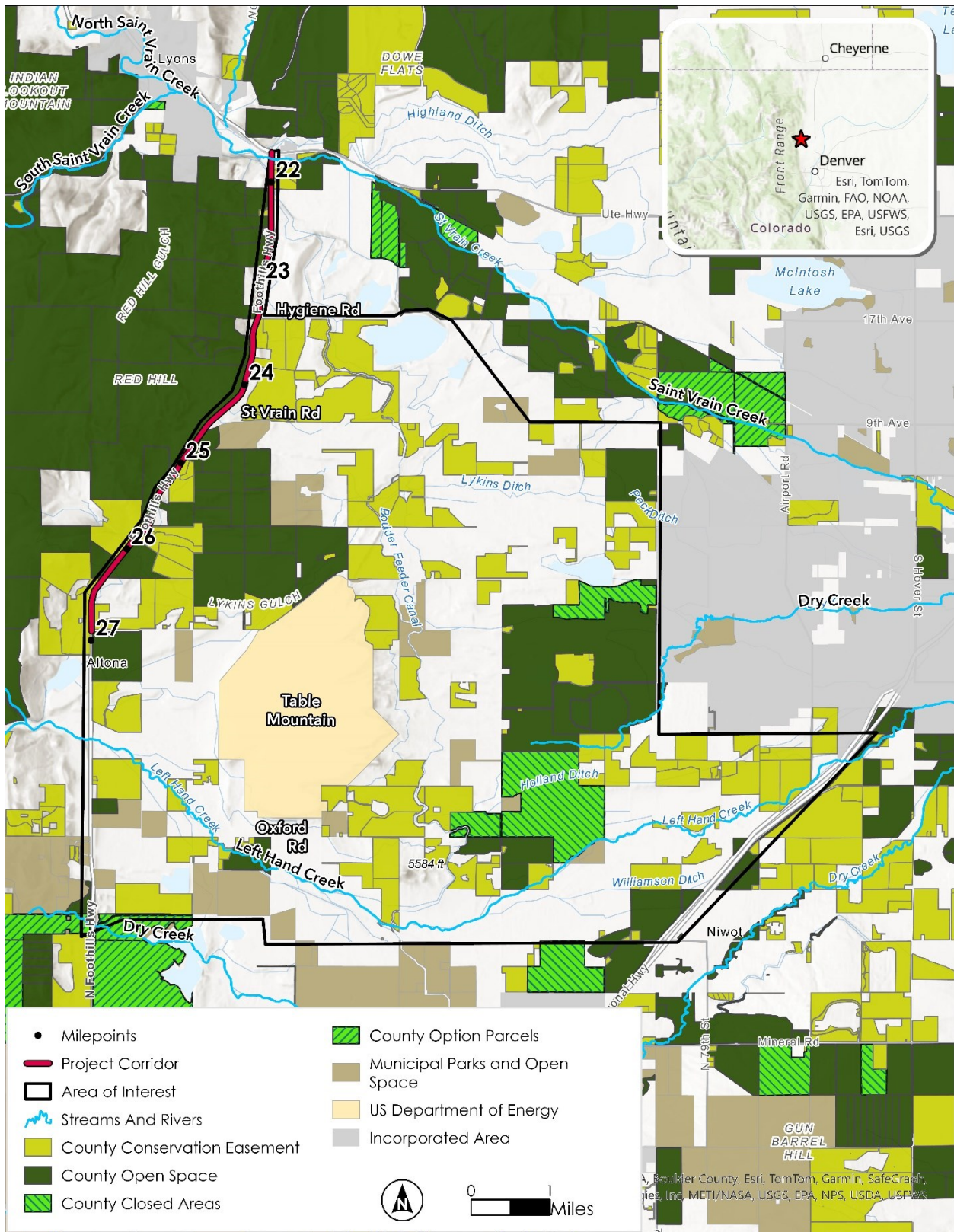
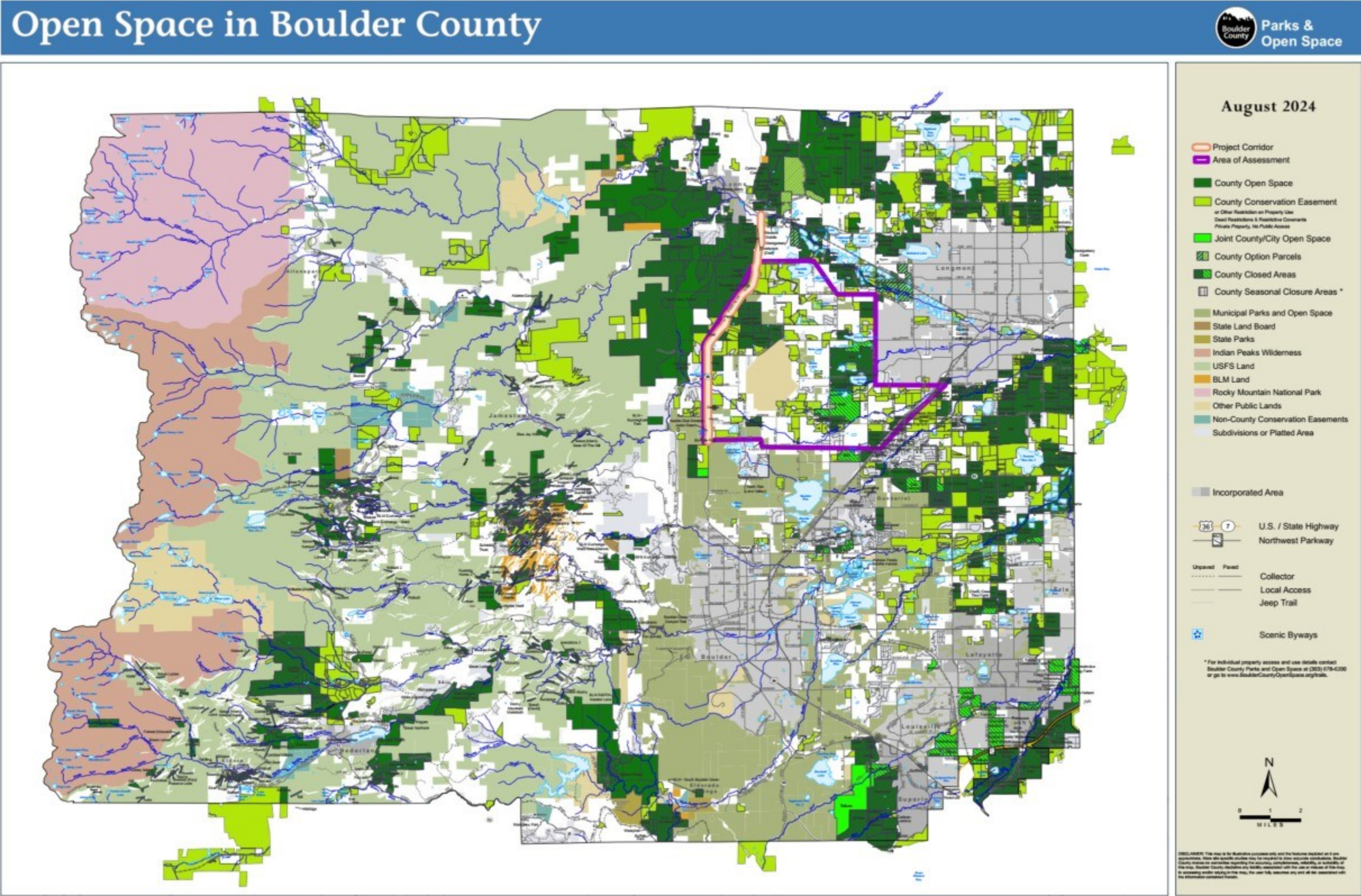




Figure 2. Open Space in Boulder County





## 2.3 Need for Wildlife Crossing Mitigation

US 36 between Nelson Road and Saint Vrain Road has been ranked by CPW and CDOT in their Colorado ESPWPS as being in the top 5 percent of highways in CDOT Regions 1, 2 and 4, in need of mitigative actions to address WVCs. This corridor actually received the highest scoring in all of CDOT's highways in Region 4, based on the ESPWPS's modeling process. The modeling done for the analysis included vehicle collisions as a percentage of the focus species populations (elk, deer, pronghorn, lynx bighorn), migration routes, winter concentration areas, traffic volumes and speed (current and predicted), distance from suburban housing density, and of course collision rates overall (Kintsch et al. 2022). For context, CDOT is responsible for about 6,500 highway lane miles in Region 4 alone, which provides context on this corridor's importance in comparative terms.

CDOT, CPW, and CSP wildlife mortality data for this corridor from 2014 through 2023 documents that 263 animals were hit and killed, including 3 bears, 120 deer, 130 elk, 2 lions, and 27 smaller animals including species such as badgers, snakes, bobcats, prairie dogs, and foxes. These numbers underrepresent the true number of mortalities, as many WVCs are not reported if no vehicle damage or human injuries occur. The human cost of wildlife collisions is significant as well. Each accident typically costs drivers \$11,100 in property damages, and injuries cost drivers \$101,000 on average (Kintsch et al., 2022).

The presence of wildlife habitat along the project corridor including the Red Hill elk herd (see Chapter 2.6.2) in combination with characteristics of the roadway such as high traffic speeds and volumes have created conditions conducive to these high WVCs. Additionally, WVCs along the project corridor have increased within the last five years (CDOT, 2024a); and, with continued population growth resulting in increases in annual daily traffic along US 36, the number of WVCs is anticipated to continue to rise. Previous efforts to reduce WVCs along the corridor, such as the implementation of yellow wildlife crossing caution signs, reflectors, and a pilot program to reduce nighttime speeds, have been largely unsuccessful, resulting in the need to implement new solutions to reduce WVCs along the corridor and provide safe passage for wildlife.

Using study results focused on deer, road permeability to deer crossings is generally related to the traffic volume (Seiler, 2003):

- 3,000 vehicles/day = frequent road crossings but fewer collisions
- 3,000 – 10,000 vehicles/day = road crossings but significant collisions
- 10,000+ vehicles/day = the road essentially becomes a wall/habitat edge with little to no permeability

Traffic volumes along US 36 between Broadway and SH 66 are as shown in Table 3, below. These traffic volumes are anticipated to increase, bolstering the need for a crossing. Note that average daily traffic numbers along US 36 between Broadway and Nelson Road would indicate little to no permeability for deer, elk, or other wildlife species, and that average daily traffic numbers between Nelson Road and SH 66 would indicate road crossings with significant collisions.



**Table 3. Average Daily Traffic on US 36 between Broadway and SH 66, from CDOT Online Transportation Information System (2022)**

Begin	End	Average Daily Traffic
Broadway	Neva Road	14,000
Neva Road	Left Hand Canyon Drive	12,000
Left Hand Canyon Drive	Nelson Road	10,000
Nelson Road	SH 66	9,000

Source: CDOT Online Transportation Information System Database

## 2.4 Wildlife Crossing Mitigation Concepts

Several different wildlife crossing mitigation concepts that are effective in promoting the safe passage of wildlife across roadways were considered for implementation within the project corridor. The term “wildlife crossing system” generally describes the mitigation concept of utilizing a variety of structural and non-structural measures that work in combination to enhance safe passage of wildlife across roadways. The mitigation concepts assessed for the project corridor during screening are:

- Underpasses.** Underpasses are structures that provide passage for wildlife underneath a roadway. They are typically built in the form of a bridge or arched culvert with natural bottom and can be used in level, sloped, or raised topography (FHWA, 2011). Depending on the size and design of the structure, underpasses can be effectively used by deer, elk, bears, mountain lions, bobcats, coyotes, and a variety of other species. A minimum height of 13 feet and width of 32 feet are recommended to accommodate large mammals such as elk (FHWA, 2011). Subsequent research and monitoring on structure use by elk has shown a preference of a minimum of 15 feet to accommodate elk passage (Basting, 2023).
- Overpasses.** Overpasses are structures that provide passage for wildlife over a roadway and are generally considered one of the most effective mitigation concepts for promoting the safe passage of wildlife and reconnecting fragmented habitat (USFS, 2021). A large overpass that is specifically designed for wildlife and built with adequate vegetative cover is highly effective and utilized by large ungulates and mammals. A width of 165 to 230 feet is recommended to accommodate large mammals (FHWA, 2011). Many species, such as mountain lions, bears, and smaller species will be hesitant to use overpasses unless adequate cover is provided. As with underpasses, spacing between overpasses will depend on local conditions.
- Retrofitting Existing Structures.** Retrofitting existing drainage structures can be an effective and cost-efficient strategy to provide or enhance wildlife crossing opportunities for small to medium-sized animals. Common retrofits are detailed in Chapter 6 and include herptile barriers, small animal jump outs, turnarounds, guide walls, lighting grates, catwalks, backfilling a portion of the culvert, and adding vegetation and/or brush windrows.

- **Fencing and Deer Guards.** Wildlife exclusion fencing and deer guards are designed to help keep wildlife away from roadways and can be used to guide animals to crossing area(s). Deer guards are like cattle guards, installed at highway accesses, but wider in the travel direction, as deer and elk can jump the narrower cattle guards. When used in conjunction with underpasses and overpasses, fencing and deer guards can help direct wildlife to the wildlife crossing structures and increase their overall effectiveness. Wildlife fencing over 5 km (3 miles) is preferable to shorter, discontinuous fencing when installed in conjunction with wildlife crossings (Huijser et al., 2016). In order to be effective, wildlife fencing must be installed with wildlife escape ramps to allow animals that get trapped on the roadway side of the fence to jump out to the safe side. There is not a standard for the spacing of wildlife escape ramps, but typically they are spaced two per side per mile.
- **Roadway Signage, Including Speed Limits** There are many different types of roadway signage that can be used as wildlife mitigation concepts. Some signage is designed to actively alert travelers to potential wildlife crossings, such as wildlife warning signals or variable message signs, while some signs passively mitigate the potential risk of WVCs, such as speed limit changes and roadside reflectors.
- **Public Information and Policy.** Part of effective wildlife mitigation involves efforts that include the community in which the mitigation is being implemented. Utilizing public meetings, brochures, websites, and other outreach approaches are effective methods of educating the public about wildlife mitigation.

The ideal spacing of wildlife crossings on a landscape is influenced by many factors, including terrain, human activity and development, habitat types and connectivity, and climate. In general, previous large projects have spaced wildlife crossings between 0.9 and 3.8 miles apart, averaging 1.2 miles between crossings (FHWA, 2011).

## 2.5 Local, State and Federal Policy Actions

Recent local, state, and federal policies promoting investments, research, and directives related to wildlife conservation have provided momentum to expand the network of wildlife crossings in the state (Table 4).

**Table 4. Local, State, and Federal Policy Actions**

Year	Policy Action
2017 & 2018	The US Department of Interior issued <b>Order No. 3356 Hunting, Fishing, Recreational Shooting, and Wildlife Conservation Opportunities and Coordination with States, Tribes, and Territories (2017)</b> and <b>Order No. 3362 Subject: Improving Habitat Quality in Western Big-Game Winter Range and Migration Corridors (2018)</b> which direct federal land managers to work with states to protect big game species and their habitat within the region.
2019	Governor Polis signed Executive Order D-2019-011, Conserving <b>Colorado's Big Game Winter Range and Migration Corridors</b> .  The CPW Commission adopted a resolution reaffirming the Governor's Executive Order and supporting the federal funding opportunity. CPW and CDOT signed a memorandum of understanding for collaboration in mitigating WVCs, identifying

Year	Policy Action
	priority big game highway crossings in the state, and participation in and support of the multi-stakeholder Colorado Wildlife-Transportation Alliance (CWTA).  The Colorado Legislature showed support in advancing wildlife corridor conservation and habitat connectivity with the development of a bipartisan Colorado Habitat Connectivity Senate Joint Resolution 21-021 that unanimously passed through both chambers of the Legislature and was enacted in June 2019.
2020	CPW completed the Big Game Winter Range and Migration Corridor Status Report addressing current population status, known threats to seasonal big game habitat and migration corridors, and identifying data and information gaps.
2021	The Colorado Department of Natural Resources produced a Policy Report identifying potential policy, regulatory, and legislative opportunities to ensure the ongoing conservation of seasonal big game habitat and migration corridors. The Infrastructure Investment and Jobs Act was signed, which includes a 5-year pilot program of \$350 million to construct wildlife road crossings.
2022	Governor Polis signed <b>Senate Bill 22-151, Safe Crossings for Colorado Wildlife and Motorists</b> on June 1, 2022. The bill created a dedicated wildlife mitigation fund for Colorado and allocated \$5 million to the fund in the first year and an additional \$500,000 in 2023.

## 2.6 Project Background

Boulder County has, for many years, been focused on strategies for reducing vehicle related wildlife mortality. Previous studies and/or plans that have created an impetus for this screening and prioritization study along US 36 include the ESPWPS, BCPOS Red Hill Elk management Plan, and the Vision Zero Plan as outlined in the Boulder County Transportation Master Plan 2020 Update.

### 2.6.1 Eastern Slope and Plains Wildlife Prioritization Study

The ESPWPS was a collaborative effort between CDOT and CPW to prioritize wildlife-highway conflict areas and mitigation needs in the central and eastern portions of the state to determine where targeted mitigation could have the greatest impact on reducing WVCs. In April 2022, CDOT and CPW released the ESPWPS, which included tools to guide mitigation implementation in the highest priority segments (Kintsch et al. 2022). The ESPWPS produced the following tools:

- A list of the top five percent of priority segments for CDOT Regions 1, 2, and 4 to highlight the highway segments in each region where investments in wildlife crossing systems would have the greatest benefits for wildlife and motorists. The ESPWPS identified US 36 between MPs 24.3 to 26.9 (Saint Vrain Road to Nelson Road) as a top five percent priority segment for CDOT Regions 1, 2, and 4 and the highest ranked, in terms of scoring inputs, segment for CDOT Region 4.
- Wildlife-highway mitigation recommendations for the top five percent of priority highway segments in CDOT Regions 1, 2, and 4. The ESPWPS identified seven mitigation recommendations (potential projects) for the project corridor. Each of the ESPWPS



mitigation recommendations were evaluated in this Study, plus additional areas based on BCPOS staff knowledge of animal movement patterns.

## **2.6.2 Boulder County Red Hill Elk Management Plan**

The Red Hill elk herd, a sub-herd of the Saint Vrain elk herd, has been closely monitored by CPW and BCPOS since the late 1990s. The initial study from 1997 to 2005 documented the herd's migratory patterns, where most of the herd migrated to high elevation meadows and wetlands between Niwot Ridge and Saint Vrain Mountain for summer calving, before returning to lower elevations such as Heil Valley Ranch and Red Hill for the rut and to over-winter. This period also marked the transition of Heil Valley Ranch from a working ranch to a County open space property, leading to significant changes in elk distribution due to increased human recreational activity and decreased hunting pressure.

As trails were created on these new open space properties, the elk adjusted their use areas to avoid regions with high human visitation. They began to utilize more secluded areas closed to the public, such as the hogbacks adjacent to US 36 and regions west of the main recreational trailed areas within the property. The further establishment of an extensive trail loop on the north end of the property, and within a previously heavily used area by elk, further pushed the elk to more remote areas. Between 2005 and 2020, BCPOS acquired additional land along the hogbacks, creating a natural sanctuary that is largely devoid of people and hunting activities, thus providing a safer habitat for the elk.

A radio-collar study initiated in 2017 by CPW and BCPOS, identified significant changes to elk distribution in the area, including the emergence of a resident elk herd in the area south of Saint Vrain Road and east of US 36. This resident herd, which did not exhibit the migratory behavior typical of this herd, grew significantly in size. From July 2018 to June 2019, the number of resident elk increased from approximately 48 to 108 individuals. This initial population growth, attributed to successful calf recruitment in 2018 and 2019, as well as possible immigration of adult elk from the migratory herd, indicated a robust and expanding resident population. Today, it is estimated that the resident herd in this area is somewhere between 100-125 individuals.

The areas east of US 36, comprising a mix of development, irrigated fields, and native shortgrass prairie, provide essential resources for the elk, such as forage, cover, and shade. The relatively quiet environment of the 1,700-acre Department of Commerce Table Mountain research facility, with restricted access and minimal human disturbance, also offers a favorable habitat to support a year-round herd. Each year in October, the number of elk in this area swells to well over 300 individuals with the addition of the migratory herd arriving on their winter range and joining the resident herd.

In 2020, BCPOS implemented a comprehensive management plan to address the growing population of non-migratory elk in the Red Hill herd (Boulder County, 2020a). The plan includes both short-term and long-term approaches aimed at mitigating impacts to natural resources, local agriculture, and highway safety. In the short term, BCPOS manages a controlled public harvest program of the resident elk herd, helps facilitate hazing on agricultural properties, and coordinates hunting access with adjacent landowners and county agricultural tenants. The long-term strategy involves reducing the size of the summer elk population, improving habitat, and facilitating safe elk movement across US 36 through the potential construction of wildlife crossings.

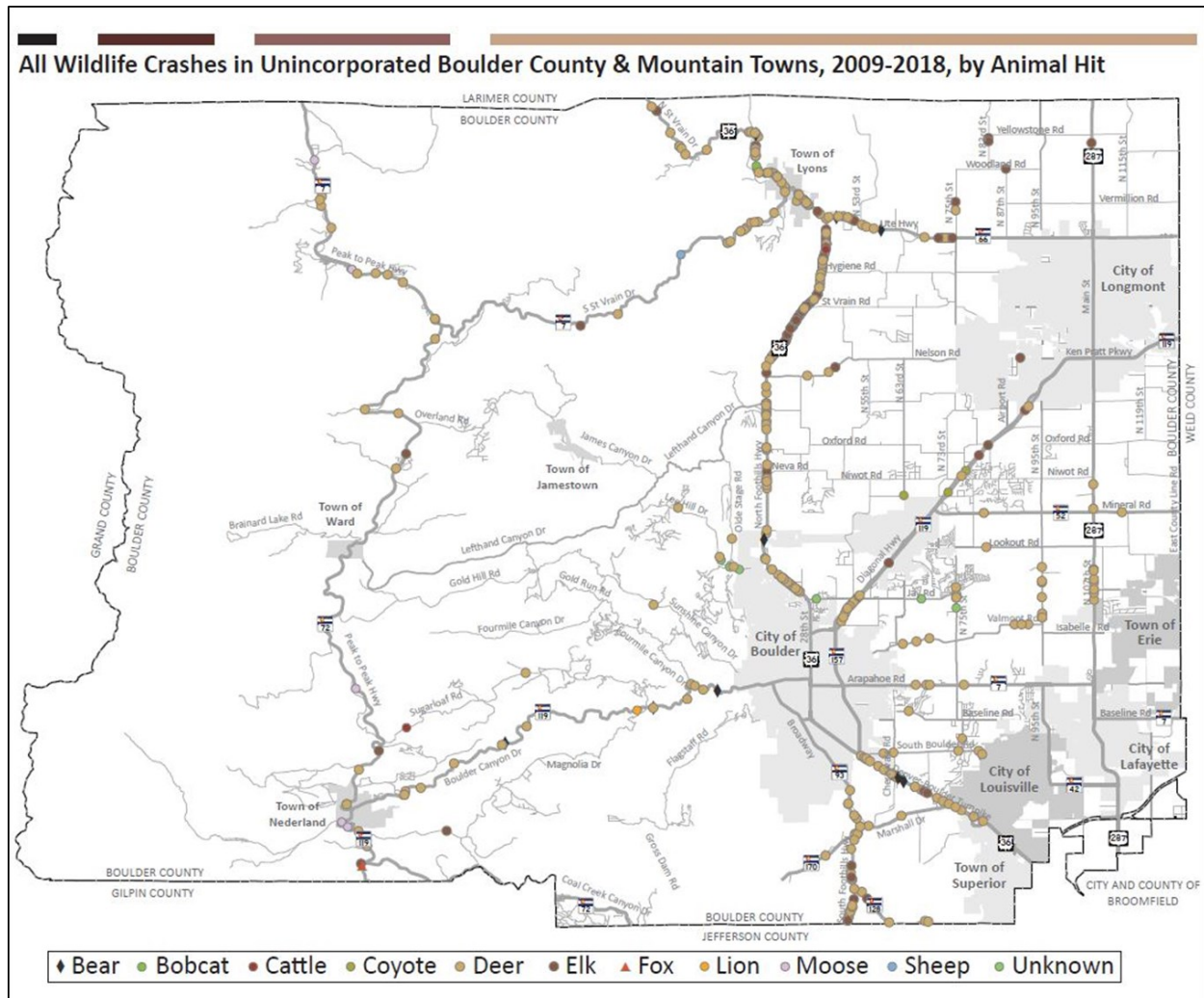
Currently, the public harvest program ([Red Hill Elk Herd Management - Boulder County](#)) targets the rapid growth of the resident sub-herd, and aims to minimize elk-human conflicts, including damage to agricultural properties and private land infrastructure. This program is modeled after the successful public harvest program at Ron Stewart Preserve at Rabbit Mountain, involving controlled, antlerless-only elk hunting through a public lottery system. BCPOS has enacted strict safety measures, including a shooting proficiency test and mandatory hunter orientation to participate. Monitoring, data collection, and analysis are conducted to measure progress and adapt the management plan as needed. Methods used for data collection include annually consistent ground counts, remote camera arrays, and unmanned aerial system (UAS) surveying.

BCPOS is continuing to conduct habitat and biodiversity assessments to support the evaluation of wildlife overpasses/underpasses to facilitate safe elk movement across US 36. With these measures, the Red Hill Elk Management Plan hopes to achieve a sustainable balance among the resident elk population and landowners, while reducing the risk of WVCs.

### **2.6.3 Boulder County Transportation Master Plan Update**

Boulder County completed an update to its Transportation Master Plan (TMP) in 2020. The Boulder County TMP establishes, as one of its six primary goals, to “Minimize Environmental Impacts”, including “land and wildlife habitat fragmentation” (Boulder County, 2020b). The updated TMP provides the framework for the County’s Vision Zero Plan, which has as its objective to eliminate major injuries and fatalities from WVCs in unincorporated Boulder County by 2035. US 36 between Boulder and Lyons was identified as a top priority in the plan based on traffic crash data from 2009 to 2018. The data showed that 40 percent of crashes related to wildlife strikes occurred in the US 36 corridor, which provides a comparative context for all roads in Boulder County overall.

**Figure 3. Wildlife Crashes in Boulder County**



## 3. EXISTING CONDITIONS

### 3.1 Data Collection

To support the screening and prioritization process, existing data pertaining to wildlife habitat and range; key environmental considerations; land use; and infrastructure were collected and analyzed from the following data sources:

- **CDOT WVC Data.** CDOT provided WVC data from the CSP collected from 2005 to 2024 documenting known WVCs along US 36 between MPs 21 and 27 (CDOT, 2024a).
- **Colorado Natural Heritage Program Colorado Conservation Data Explorer (CODEX).** Data from the CODEX was used to determine sensitive species known to occur within a half mile of the area of interest (CNHP, 2024).
- **CPW's Species Activity Mapping (SAM) Data.** SAM data is readily available data that displays wildlife habitat for a variety of species, including but not limited to overall, summer, breeding, winter and winter concentrations ranges within Colorado (CPW, 2023).
- **Boulder County GIS Data.** Boulder County's public GIS data were used to identify existing and proposed developments along the project corridor; parks and recreational resources, US 36 ROW; and land ownership (Boulder County, 2024a).
- **CPW Elk Collar Data.** In collaboration with CPW, Boulder County has an extensive monitoring and management program for the Red Hill elk herd. CPW made collar data available to develop an elk crossing density map, which was used in this Study to inform where WVCs were likely to occur along the project corridor (Boulder County, 2024b).
- **Boulder County Comprehensive Plan (BCCP) Data.** The BCCP was developed so that future land use decisions impacting land in the County could be decided upon in a consistent, considered approach. Spatial data from the BCCP were used to assess existing environmental conditions along the corridor including critical wildlife habitats and migration corridors, Preble's meadow jumping mouse conservation areas, rare plant areas, and wetland and riparian areas (Boulder County, 2020c)
- **US Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI).** The USFWS NWI was used to identify wetlands and riverine systems within and near the project corridor (USFWS, 2024a).
- **USFWS Information Planning and Consultation System (IPaC).** The IPaC was used to identify threatened and endangered species with the potential to occur within the project corridor (USFWS, 2024b).
- **Office of Archaeology and Historic Preservation (OAHP) COMPASS Database.** The OAHP COMPASS database was used to identify previously identified historic and archaeological resources within a half mile of the project corridor (OAHP, 2024).

- **CDOT Online Transportation Information System (OTIS).** The CDOT OTIS database was evaluated to identify the locations of drainage systems (i.e., concrete box culverts, corrugated metal pipes) and bridges in the project corridor (CDOT, 2024b).
- **North Foothills Bikeway Feasibility Study Data.** GIS data with the preliminary designs for the North Foothills Bikeway Feasibility Study, including ROW data, was evaluated (Otak, 2024).

## 3.2 Wildlife

### 3.2.1 Wildlife Habitat and Range

#### 3.2.1.1 Large Mammals

Ungulates and other large mammals known to occur near the project corridor include elk, mule deer, white-tailed deer, black bear, and mountain lion. CPW Species Area Mapping (SAM) data were evaluated to identify habitat for these species within a half mile of the project corridor (Figures 4 – 7). Based on CPW SAM data, within a half mile of the project corridor there is summer range, winter range, severe winter range, concentration areas, winter concentration areas, and resident populations for elk and mule deer; production areas (areas female occupy seasonal for calving), migration patterns and corridors for elk; winter range and concentration areas for white-tailed deer; fall concentration for black bear; and mountain lion peripheral range. Black bears are generally present in the wooded areas along Left Hand Creek, while mountain lions utilize various habitats in the region, including shrublands. Human conflict zones with black bears and mountain lions have been mapped along the corridor.



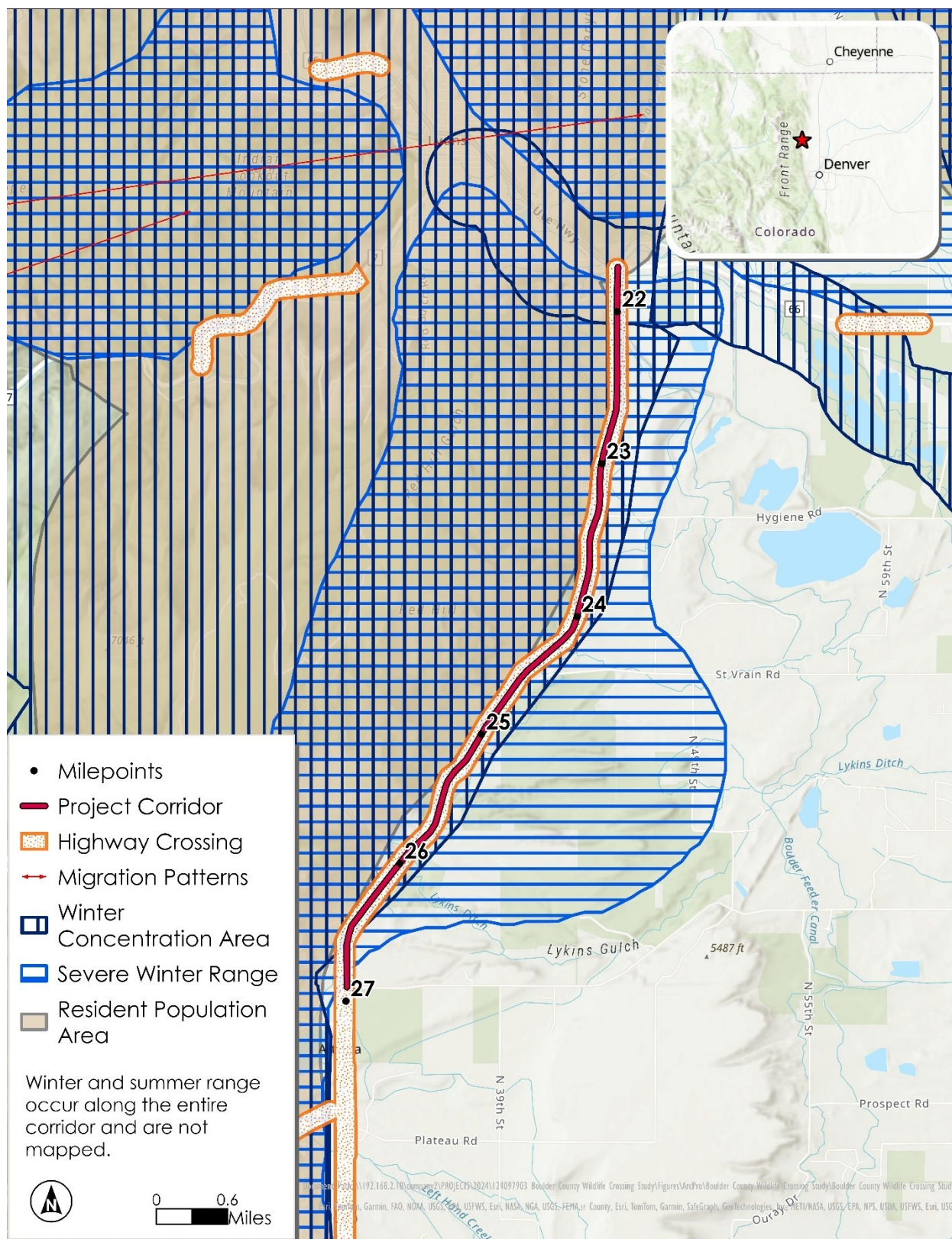
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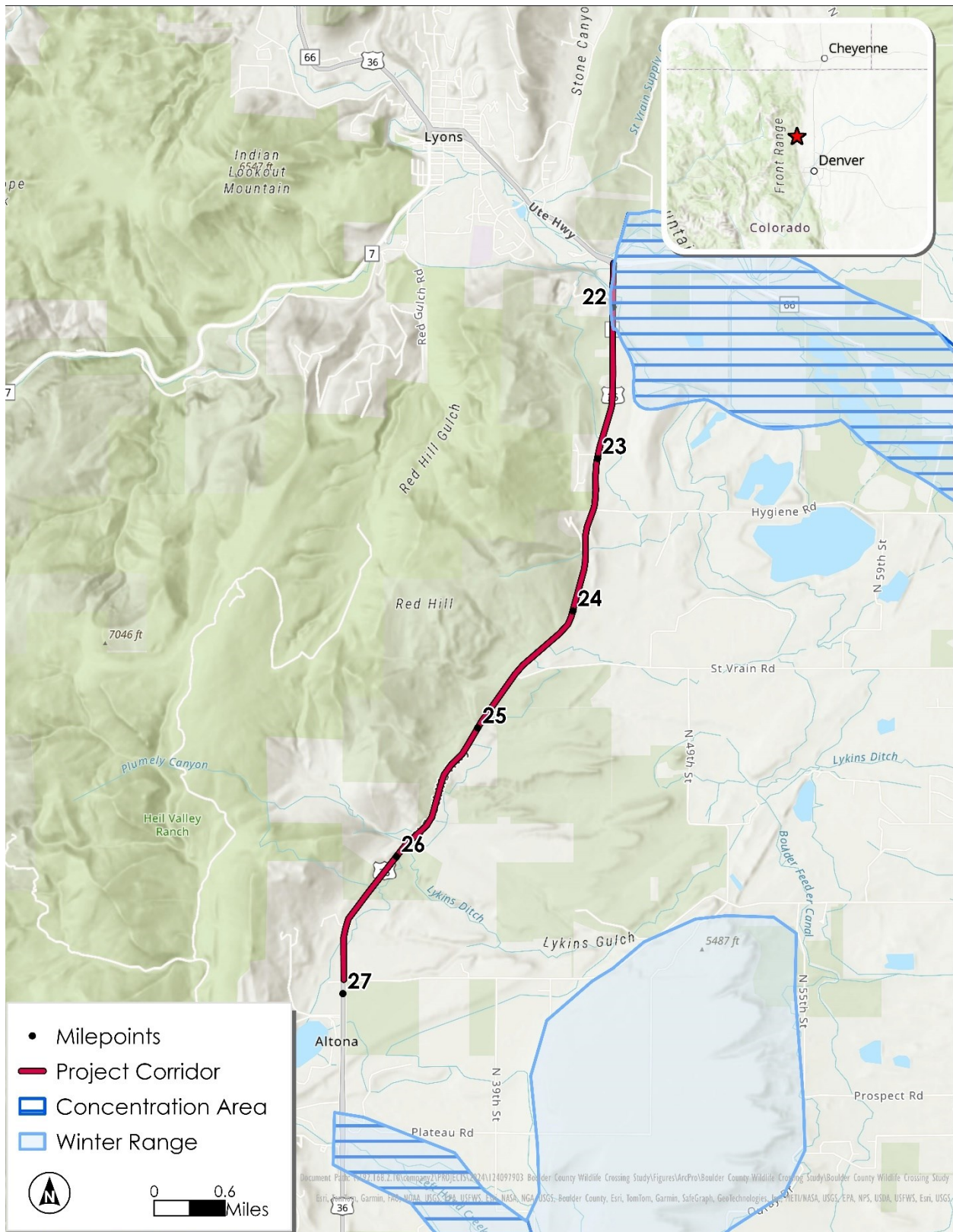


**Figure 6. Mule Deer Habitat and Range**





**Figure 7. White-tailed Deer Habitat and Range**



### **3.2.1.2 Other Species**

The area surrounding the project corridor provides a variety of habitat types for many other species of wildlife. Grasslands, shrublands, irrigated agricultural fields, forested areas, wetlands, streams, and riparian areas provide habitat for the life histories of a broad variety of animal species. Through the course of daily and seasonal movement patterns, these species travel across roads and may be injured or killed through vehicle collisions.

Common small and medium mammals in the area include coyotes, red and gray foxes, black-tailed prairie dogs, raccoons, ground squirrels, bobcats, and rabbits. Less frequently observed mammalian species include federally threatened Preble's meadow jumping mice, river otters, badgers and beavers.

Over 400 species of birds are known to occur in Boulder County (Boulder County Audubon Society, 2024). Bald and golden eagles, red-tailed hawks, Swainson's hawks, American kestrels, osprey, barn owls, burrowing owls, and great horned owls are species of raptors that nest in the areas surrounding the project corridor. Potential nest sites for these species include trees, cliffs, open spaces, and human-made buildings such as bridges and barns. Waterfowl, wading birds, shorebirds, songbirds, and corvids, also occur.

Herptiles (reptiles and amphibians) are also common along the project corridor. Upland areas, particularly grasslands and shrublands with a sufficient prey base, provide habitat for reptiles such as bull snakes, prairie rattlesnakes, fence lizards, and toads. Riparian and wetland areas provide habitat for species that rely on water for their life histories, such as garter snakes, snapping turtles, chorus frogs, and tiger salamanders.

## **3.2.2 Wildlife Crossing Hotspots**

Factors that drive wildlife to cross US 36 are likely diversity in habitats (i.e., different habitat conditions that provide food, water, and sanctuary) as well as mating and rearing opportunities. There are ecosystem types (e.g., grasslands, shrublands, agricultural fields, forested areas, riparian areas, etc.) along both sides of the corridor that provide foraging, mating, and rearing habitat for ungulates, bears, and lions, as well as a broad variety of smaller to medium-sized mammals, birds, and herptiles. Mule deer, for example, may cross US 36 to occupy their severe winter range habitat east of the highway when pushed to by weather conditions. Certain species that cross US 36 concentrate their movements along topographical depressions or water related drainages, as these systems provide wildlife with better overall cover. Also, many species are more active during twilight (i.e., dawn and dusk) and nighttime hours, making it difficult for drivers traveling at high speeds to see wildlife on or near the roadway.

Based on CDOT's WVC data from 2005 to 2024, WVCs are generally highest between MP 24.5 and 26.5, and about 44 percent of the WVCs are elk, 41 percent are deer, and 1 percent are black bear. CDOT's WVC data for elk is generally consistent with the CPW/Boulder County elk collar data, which shows the highest crossing densities spanning an approximate 0.5-mile segment centered near MP 25. Wildlife crossing locations that occurred near WVC hotspots and high-density wildlife crossing locations were considered more favorably during the screening and prioritization process, as discussed in Chapters 4 and 8.



### 3.3 Environment

Other key environmental resources considered during the screening process included:

- **Aquatic Resources.** USFWS NWI data identified 16 riverine features (stream and ditch segments) and 20 potential wetlands within the project corridor ROW. There are likely other wetlands that are not mapped by NWI that occur within drainages and other depressional areas along the project corridor. Some of these features may be jurisdictional waters of the US (WOTUS). If a WOTUS will be impacted, a US Army Corps of Engineers permit and mitigation for impacts may be required. As of May 2024, the state of Colorado affords additional legislative protection to wetlands and streams under House Bill 24-1379.
- **Cultural Resources.** The OAHN COMPASS database search indicated that within a half mile of the project corridor there are at least 30 cultural resources listed in the National Register of Historic Places. In addition, there are likely potentially eligible historic resources (i.e., structures over 50 years old) in the area that have not yet been evaluated. Proposed wildlife crossing strategies will have to go through consultation, and potentially mitigation if historic or archaeological resources are present.
- **Threatened and Endangered Species.** Based on the IPaC database search and habitat observed during review of aerial imagery, the Preble's meadow jumping mouse (threatened), tricolored bat (proposed endangered), monarch butterfly (candidate species for federal listing), and Ute ladies'-tresses orchid (threatened) have the potential to occur along the project corridor. Although the Ute ladies'-tresses orchid was listed in the IPaC database, the species is unlikely to occur in the corridor as habitat is marginal. Preble's meadow jumping mouse Habitat Conservation Areas have been mapped along most of the riparian areas of the project corridor in the BCCP, Environmental Resources Element (Boulder County, 2020b). Proposed wildlife mitigation strategies that have the potential to impact these species may need to go through consultation with the USFWS, and conservation measures may need to be developed and applied to avoid impacts to species and remain in compliance with the federal Endangered Species Act.
- **Sensitive Species Habitat.** The BCCP's Environmental Resources Element outlines landscape designations to define and highlight high value natural areas in Boulder County. The designations in the US 36 corridor include Environmental Conservation Areas, Natural Areas, Significant Natural Communities, Critical Wildlife Habitat, Rare Plant Areas, and High Biodiversity Areas. Environmental Conservation Areas are defined in the BCCP's Environmental Resources Element as the largest remaining relatively natural or restorable forests, shrublands, grasslands, and agricultural landscapes in Boulder County. Natural Areas are defined as areas especially unique and important to the natural heritage of the county that typifies native vegetation and associated biological and geological features. Significant Natural Communities are areas that are recognized by the presence of a critical plant association that is limited in its distribution and occurrence. Critical Wildlife Habitats are defined as areas of unique habitat which have a crucial role in sustaining populations of native wildlife and in perpetuating the diversity of native species in the county. Rare Plant Areas represent significant riparian and rare plant sites which should be conserved and preserved to ensure ecological processes and function. High

Biodiversity Areas are areas with a concentration of rare environmental resources that represent the greatest opportunities for preserving specific aspects of Boulder County's natural heritage. (BOCO 2020b). Additionally, BCPOS has designated closed areas for wildlife through the North Foothills Open Space Management Plan (Boulder County, 1996). These closures encompass the west side of US 36 from approximately Nelson Road to Highland Drive.

The above resources do not pose fatal flaws. However, the presence of the above resources may, depending on impacts, require additional consultation, permitting, and mitigation, and therefore require planning and analysis when implementing certain wildlife crossing concepts.

### **3.4 Land Use**

Land ownership information was accessed through publicly available Boulder County GIS data. The land adjacent to the west of the project corridor is primarily County-owned, while the land adjacent to the east is mixed ownership (County-owned, private and County Conservation Easements; Figure 8). Placing a wildlife crossing where the adjacent land on both sides is designated open space helps ensure that the habitat surrounding the wildlife crossing will remain open indefinitely into the future. Additionally, there are many Boulder County conservation easements east of the corridor which will remain undeveloped. Potential wildlife crossing strategies that would require easements or additional transportation ROW that would need to be acquired from private properties could be more difficult to implement than those that would occur within transportation ROW or County-owned land, as they would require negotiation with the property owner and additional cost to buy any ROW or conservation easements needed to implement the crossing. Land ownership considerations during the screening process are discussed further in Chapter 4.

Map of the Front Range area in Colorado, showing the Project Corridor (red line) and various land management areas. The map includes an inset map of Colorado with a star marking the Front Range area. The legend identifies symbols for Milepoints, Drainage Structures, Lake Ditch, Project Corridor, County Conservation Easement, County Open Space, County Option Parcels, Municipal Parks and Open Space, US Forest Service, Bureau of Land Management, US Department of Energy, and Incorporated Area. The map also shows major roads like Highway 36, Hygiene Rd, St Vrain Rd, Nelson Rd, and Plateau Rd, and geographical features like Indian Lookout Mountain, Red Hill, and Table Mountain.

## 3.5 Existing and Proposed Transportation-Related Infrastructure

Existing conditions pertaining to infrastructure and how they impacted the screening and prioritization process are discussed below.

### 3.5.1 US 36

US 36 between Nelson Road and SH 66 generally consists of a single vehicular travel lane in both directions and shoulders with turn-lanes at the intersections with SH 66, Hygiene Road, Saint Vrain Road, and Nelson Road. US 36 between Nelson Road and SH 66 has portions that occur within cuts (i.e., favorable for overpasses), fills (i.e., favorable for underpasses), and both flat and high-gradient topography. The topography surrounding US 36 was considered during the screening process and is further discussed in Chapter 4.

**Photo 1. View of US 36 near MP 25.5**



### 3.5.2 Lake Ditch

Lake Ditch meanders along the east side of US 36 from roughly MP 24.5 to 26.5 (Figure 8). At some areas of the project corridor, the ditch and its associated infrastructure (e.g., access roads) are close enough to the highway so that it would pose challenges to the construction feasibility of proposed underpasses and/or overpasses. Considerations of Lake Ditch and other ditch features during the screening processes are further discussed in Chapter 4.



**Photo 2. View of Lake Ditch near MP 24.5**



### **3.5.3 Existing Drainage Structures**

Drainage structures (e.g., concrete box culverts, corrugated metal pipes) were identified in the CDOT OTIS database and are shown in Figure 8. Currently, there are few structures along the project corridor large enough to be used by ungulates. Some medium-to-small sized culverts in the area may provide safe passage for bears and smaller mammals (e.g., coyotes, rabbits, mice). Although bears are large mammals, they frequently use smaller structures for passage; however, there is a size limit where small culverts are not usable by bears. These existing structures may be cleaned and integrated with wildlife fencing to increase usage by bears and smaller mammals or upsized to increase usage by ungulates. Chapter 4 screens the existing drainage structures and provides recommendations for which to upsize for use by ungulates.

**Photo 3. View of Existing Drainage Structures near MP 25.5 (Left), MP 26.8 (Middle), and MP 24.4 (Right)**



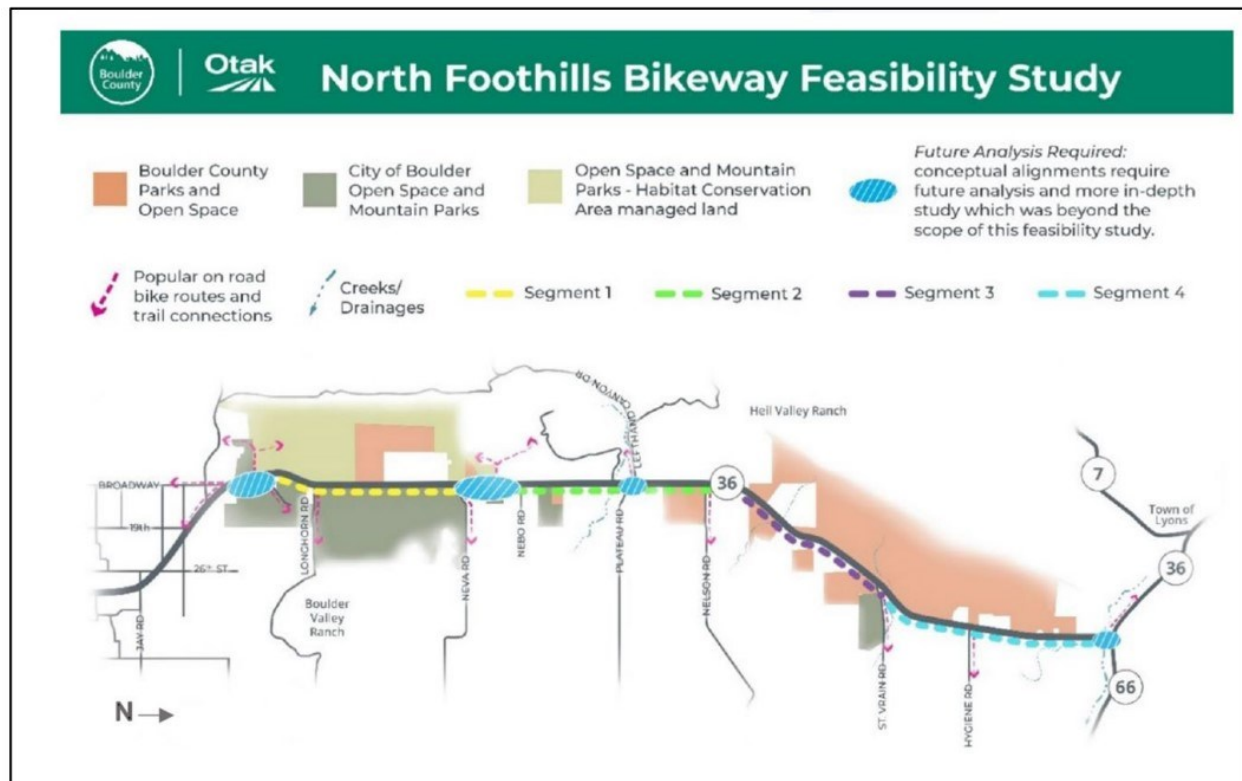
### **3.5.4 North Foothills Bikeway Feasibility Study**

Boulder County's Transportation Planning Division, in collaboration with CDOT, BCPOS, the City of Boulder, and the Town of Lyons, is conducting the North Foothills Bikeway Feasibility Study. The purpose of the North Foothills Bikeway Feasibility Study is to determine the feasibility of constructing a bikeway separated from motorized vehicle traffic along US 36 between the City of Boulder and the Town of Lyons. The proposed bikeway would be located mainly within the ROW on the east side of US 36. This Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study is coordinating closely with the North Foothills Bikeway Feasibility Study to ensure that the proposed



bikeway is incorporated into decision-making during the screening and prioritization process, including constructability and cost estimates. The lengths of the proposed underpasses and/or overpasses would, for example, need to be extended (i.e., increased cost) to include the proposed bikeway. The cost to accommodate the future bikeway has been included separately in the cost estimates in Chapter 7.

**Photo 4. North Foothills Bikeway Project Location and Segment Map**



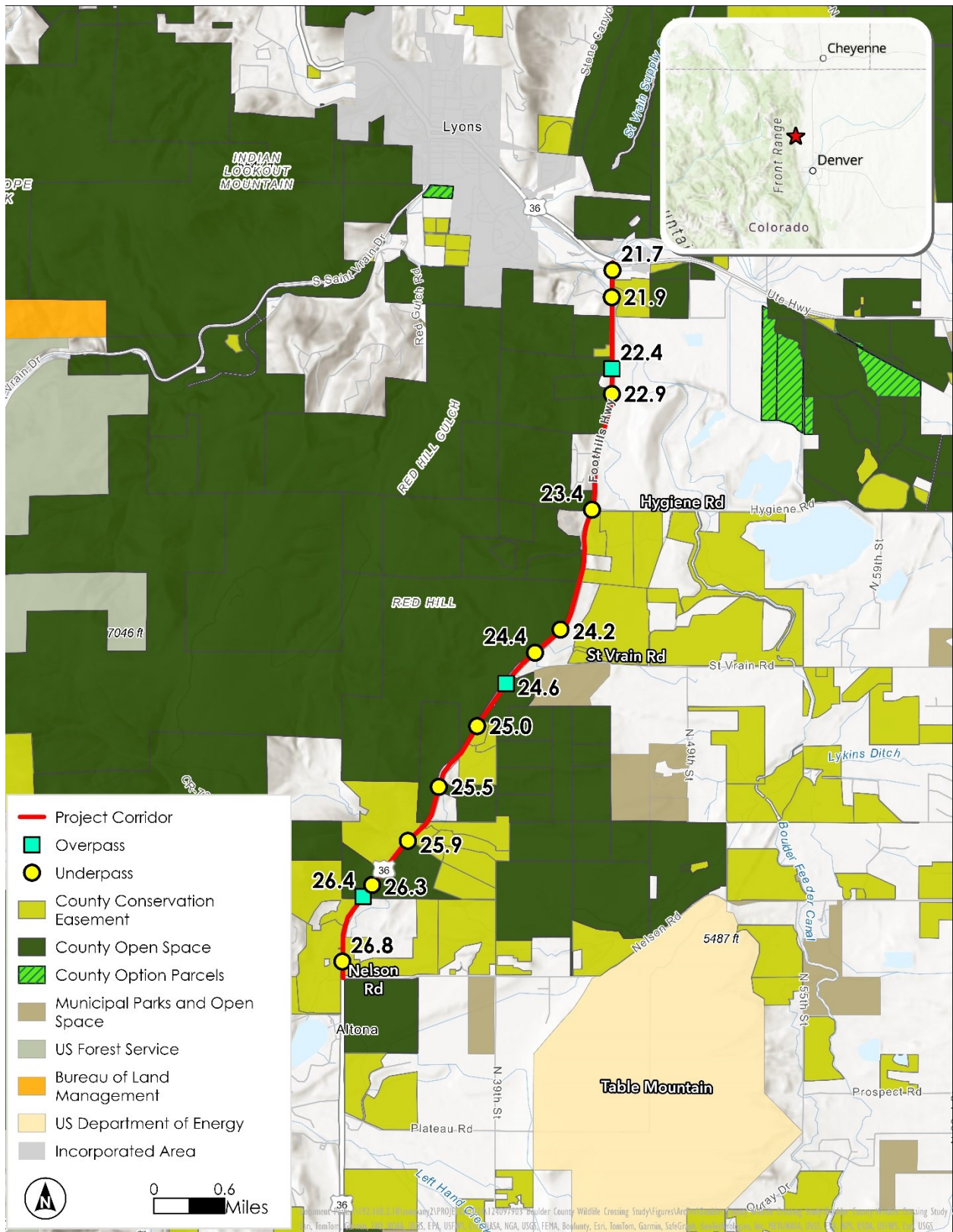
## **4. IDENTIFICATION AND SCREENING OF POTENTIAL WILDLIFE CROSSING LOCATIONS AND TYPES**

### **4.1 Identification of Potential Wildlife Crossing Locations**

The screening and prioritization process is focused on wildlife crossing structures for elk, as they are the largest species in the area. Wildlife crossings that accommodate elk will also be used by deer, carnivores and smaller species if structures like shrubs, ground cover, branches and other similar features are added. Accommodations for smaller species are covered in more detail in Chapter 6.

A list of potential wildlife crossing locations within the project corridor was developed based on the recommendations in the ESPWPS, site reconnaissance conducted by the design team, and BCPOS and CPW staff knowledge. The list of potential crossing locations includes underpasses at existing drainageways and overpasses at locations where US 36 is depressed in the existing topography. Other mitigation options, such as fencing and deer guards, were not assessed in this initial screening; however, they will be considered as part of any concept advanced for implementation. Figure 9 shows all the potential locations for wildlife crossings that were evaluated.

### Figure 9. Evaluated Crossings



## 4.2 Screening Methodology

The goal of the screening process is to qualitatively evaluate the potential crossings, and screen them down to a smaller number that will then be prioritized. Each proposed wildlife crossing location was screened based on the following criteria: WVCs and collared elk movement data, site feasibility, ROW/leveraging investments, and environmental clearances, with each criteria receiving a score of 1, 2, or 3, with the higher scores being more favorable. Spacing was also considered but not as part of the screening matrix.

Weights were assigned to each of the screening criteria based on the importance of each criterion regarding the project goals of effectively reducing WVCs while maintaining connectivity. The weighted score for each wildlife crossing location was calculated by multiplying the score for each criterion by its weight, and then adding up the products.

### WVCs and Movement Data

WVC data was supplemented by collar data and the knowledge of BCPOS and CPW staff. A 0.5-mile moving average of the WVCs was used to smooth out spikes at each milepost caused by rounding during data collection. The scoring considers only elk because deer WVCs are fairly uniform across the entire corridor with moderate increases at the same locations where the elk have increases. See Appendix B for details about the WVC data and analysis.

- **3** = Elk WVC moving average greater than 5, or high collar data.
- **2** = Elk WVC moving average is 2, 3, or 4.
- **1** = Elk WVC moving average is 0 or 1.
  - Weight = **3**. Reducing WVCs while maintaining connectivity is the main goal of this effort, so this criterion is weighted heavily.

### Site Feasibility

The terrain and built features at a particular location may or may not be conducive to the construction of a wildlife crossing. For example, if US 36 is in a cut, then a wildlife overpass would fit well in that terrain. As another example, if there is a nearby irrigation ditch, it may conflict with an elk underpass.

- **3** = Wildlife crossing structure fits within the topography and site constraints with no obvious complications.
- **2** = There are possible complications with irrigation infrastructure or the topography.
- **1** = Wildlife crossing structure is not feasible on the site.
  - Weight = **2**. This criterion represents cost and likelihood of impacts to the surrounding area. If a proposed wildlife crossing does not fit well with the existing topography, it would be expensive and cause a large disturbance to the surrounding area.



## **ROW/Leveraging Investments**

BCPOS owns a considerable amount of the land immediately to the west of US 36 through this corridor, and a considerable amount immediately to the east. Placing a wildlife crossing where the adjacent land on both sides is designated open space helps ensure that the habitat surrounding the wildlife crossing will remain open indefinitely into the future. Additionally, there are many Boulder County conservation easements east of the corridor which will also remain undeveloped.

- **3** = Both sides of US 36 are designated open space.
- **2** = One side of US 36 is designated open space.
- **1** = Neither side of US 36 is designated open space.
  - Weight = **3**. If Boulder County owns the land on both sides of US 36 at a proposed wildlife crossing location, it is doubly beneficial because 1) no ROW purchase is required for construction, and 2) the surrounding habitat will remain useable by the wildlife.

## **Environmental Clearances**

Environmental resources, if present, would need to be permitted and mitigated during design. While the permitting process is well-known and certainly surmountable, it is better to plan improvements to avoid environmental resources altogether, if possible. To this end, the presence of potential waters of the US (wetlands/waters), threatened and endangered species habitat, and cultural resources were evaluated for each potential wildlife crossing structure location using the BCCP, USFWS IPaC Database, USFWS NWI, and the OAHP COMPASS Database.

Note that all locations evaluated during the screening process occur along a portion of the US 36 highway which is potentially historic (US 36 5BL.7529.6) and may require consultation, permitting, and/or mitigation. As this would affect each location equally, this segment of highway as a cultural resource was not considered during the screening process.

- **3** = None of the environmental categories (wetlands/waters, threatened and endangered species habitat, and cultural resources [excluding US 36 5BL.7529.6] are present).
- **2** = One or two of the environmental categories are present.
- **1** = At least three environmental categories are present.
  - Weight = **1**. Since the environmental clearance process is a surmountable obstacle and would only involve extra effort during design, this criterion is not weighted.

## **Spacing**

There are no specific guidelines for the spacing of wildlife crossings. The FHWA Wildlife Crossing Structure Handbook provides examples of roadways where the crossings are spaced from 0.9 to 3.8 miles apart, averaging about 1.2 miles apart. The appropriate spacing depends on

topography, species, adjacent land management, and the larger, regional corridor network. Spacing was not scored in the screening matrix. Instead, the spacing was determined based on wildlife movements, site conditions, and the results of the other criteria in the screening matrix.

## 4.3 Screening Results

The left columns of the matrix indicate the milepost (MP) where the potential crossing is located and a short description of the crossing; the middle portion of the matrix shows the criteria with the ratings (1, 2 or 3). The column labeled "Notes on Criteria" gives specific data for each of criteria, explaining why they were scored as they were. The rightmost column indicates which crossings were recommended to be advanced for further analysis and offers information about why they were advanced or screened out.

**Table 5. Screening Matrix**

MP of Crossing	Crossing Type	WVC & Collar Data (Weight = 3)	Site Feasibility (Weight = 2)	ROW/ Leveraging Investments (Weight = 3)	Environmental Clearances (Weight = 1)	Score	Weighted Score	Notes on Criteria	Advance for Further Evaluation as an Elk Crossing?
21.7	Underpass. Existing bridge over St Vrain River	1	3	1	1	6	13	WVCs: Moving average = 1 elk, 0 deer. 11 prairie dogs Site feasibility: Ungulates can cross under the existing bridge on the south riverbank. ROW/Leveraging investments: Private on both sides Environmental Clearances: Potential <b>Preble's meadow</b> jumping mouse (PMJM) habitat. Likely wetlands/waters. Eligible property (5BL.13120) to the east of proposed crossing.	No. This may be a good location to end the wildlife fencing, but no further analysis of the existing bridge will be done for prioritization.
21.9	Underpass 5.5x5.5 concrete box culvert (CBC) and 6x3.5 CBC	1	1	1	1	4	9	WVCs: Moving average = 1 elk, 2 deer Site feasibility: The site is very complicated due to the ditches, ditch access roads, and gates ROW/Leveraging investments: The ditches are owned by the Northern Colorado Water Conservancy District. Nearby land is private. Environmental Clearances: Potential <b>PMJM habitat</b> . Likely <b>wetlands/waters</b> . No cultural resources beyond US 36 5BL.7529.6.	No. The ditches and access roads make the location infeasible and there are very few WVCs
22.4	Overpass	1	3	2	2	8	17	WVCs: Moving average = 1 elk, 3 deer Site feasibility: The terrain on both sides is very flat so an overpass is feasible ROW/Leveraging investments: West - BCPOS; East - Cemex Environmental Clearances: Potential PMJM habitat. No wetlands/waters. Property to west of crossing is potentially eligible.	Yes. This location provides good spacing and has the highest weighted score compared to the other nearby locations.
22.9	Underpass. Replace existing 48" CMP drainage culvert	1	2	2	2	7	15	WVCs: Moving average = 1 elk, 2 deer Site feasibility: US 36 is on about 12 feet of embankment. The area could be dug out and graded to drain to accommodate an elk crossing, but the grading would be extensive. ROW/Leveraging investments: West - BCPOS. East - Private Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. No cultural resources beyond US 36 5BL.7529.6.	No. The overpass to the north is more favorable. This is an existing drainage crossing 4 feet in diameter. The area to the east used to be a stock pond until the flood in 2013 changed the hydrology of the Ledge Ditch; now the area is vegetated.
23.4	Underpass. Replace existing 48" CMP drainage culvert	1	2	2	3	8	16	WVCs: Moving average = 1 elk, 3 deer Site feasibility: Not enough vertical clearance for an ungulate crossing ROW/Leveraging investments: City of Boulder owns west side. Private on the east. Environmental Clearances: None beyond US 36 5BL.7529.6.	No. This is an existing drainage culvert just south of Hygiene Road. A wildlife crossing here would be difficult to construct due to its proximity to the intersection.
24.2	Underpass. Replace existing 6x7 CBC	1	1	2	2	6	13	WVCs: Moving average = 2 elk, 4 deer Site feasibility: House, driveway, and steep grade on the east side ROW/Leveraging investments: Public to west. Private to east Environmental Clearances: No threatened or endangered species habitat. Likely wetlands/waters. Potentially eligible sites (5BL.6584 and 5BL.12988 are currently field not eligible) are located to the southeast and to the west of the crossing.	No. There is a steep grade, driveway, and house to the east.

MP of Crossing	Crossing Type	WVC & Collar Data (Weight = 3)	Site Feasibility (Weight = 2)	ROW/ Leveraging Investments (Weight = 3)	Environmental Clearances (Weight = 1)	Score	Weighted Score	Notes on Criteria	Advance for Further Evaluation as an Elk Crossing?
24.4	Underpass. Replace existing 48" CMP drainage culvert	2	2	2	1	7	17	WVCs: Moving average = 2 elk, 4 deer Site feasibility: Animals have to cross Saint Vrain Road to get to Table Mountain. Irrigation ditch may be in the way ROW/Leveraging investments: Public to west. Private to east Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. Potentially eligible ditch (5BL.6934) to the southwest and northwest of the crossing.	No. The drainage ditch to the west would make construction of an underpass complicated. Wildlife would have to cross Saint Vrain Road to get to Table Mountain.
24.6	Overpass	3	3	3	2	11	26	WVCs: Moving average = 3 elk, 2 deer. Highest collar data on the corridor Site feasibility: Good for overpass. US 36 is in a cut and the area around the cut is flat, making a good landing area for the overpass. ROW/Leveraging investments: County property on both sides, but additional coordination needed with owner to southeast. Environmental Clearances: Potential PMJM habitat. No wetlands/waters. No cultural resources beyond US 36 5BL.7529.6.	Yes. This is a favored location based on topography, ownership, collar data. Highest collar data on the corridor. Boulder County owns both sides at this location; there is private property to the southeast. Scenic impacts would be limited except for drivers. This location and 25.0 will be compared to each other, and only one will be implemented. See paragraph below
25.0	Underpass. Replace existing drainage culvert	3	2	2	1	8	20	WVCs: Moving average = 6 elk, 3 deer Site feasibility: 19' between US 36 surface and top of irrigation ditch limits the structure type options ROW/Leveraging investments: Private land with a conservation easement on east side, east of fence. West is open space. Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. Potentially eligible ditch (5BL.6934) to the southwest and northwest of the crossing.	No. This location may be a feasible alternative to 24.6. See paragraph above.
25.5	Underpass. Replace existing 6x7 CBC	2	2	2	2	8	18	WVCs: Moving average = 3 elk, 1 deer Site feasibility: 21' between US 36 and top of irrigation ditch leaves 6' structure depth ROW/Leveraging Investments: Public to west. Private to east Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. No cultural resources beyond US 36 5BL.7529.6.	No. This box culvert goes public to private. Improvements should be considered.
25.9	Underpass. Replace existing 6x7 CBC	2	2	3	1	8	20	WVCs: Moving average = 3 elk, 1 deer Site feasibility: 3' structure depth is not likely possible ROW/Leveraging Investments: West side is conservation easement. County open space east side Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. Three potentially eligible resources (5BL.7610 and 5BL.898 which are currently field not eligible and 5BL.897 currently field needs data) to west of crossing.	No. Boulder County land on the east is a 330' wide corridor between two private properties. Lake Ditch is close on the east side.
26.3	Underpass. Replace existing drainage culvert	3	3	3	2	11	26	WVCs: Moving average = 6 elk, 4 deer Site feasibility: Good. The ditch is far below US 36, so no issues. ROW/Leveraging Investments: BCPOS both sides Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. No cultural resources beyond US 36 5BL.7529.6.	No. This is an existing drainage crossing that would need to be excavated deeper to accommodate an elk crossing. This may be a backup if a crossing at 26.4 proves to be infeasible after further analysis.



MP of Crossing	Crossing Type	WVC & Collar Data (Weight = 3)	Site Feasibility (Weight = 2)	ROW/ Leveraging Investments (Weight = 3)	Environmental Clearances (Weight = 1)	Score	Weighted Score	Notes on Criteria	Advance for Further Evaluation as an Elk Crossing?
26.4	Overpass	3	3	3	3	12	27	WVCs: Moving average = 5 elk, 4 deer Site feasibility: US 36 is in a cut and the area around the cut is flat, making a good landing area for the wildlife overpass ROW/Leveraging Investments: BCPOS on both sides. This site is at the southern limit of BCPOS. Environmental Clearances: None beyond US 36 5BL.7529.6.	Yes. Elk cross often here. High WVC area because of site distance issues. This is near the southern limit of BCPOS land, so the crossing must be far enough north to avoid private property.
26.8	Underpass. Replace existing 6x7 CBC	1	1	3	1	6	15	WVCs: Moving average = 0 elk, 1 deer Site feasibility: The existing structure height is the maximum possible. Not enough vertical difference to accommodate ungulate crossing. ROW/Leveraging Investments: Conservation easements on both sides. Environmental Clearances: Potential PMJM habitat. Likely wetlands/waters. Potentially eligible property to southwest of crossing.	No. Difficult to modify existing structure. Typically, 14 to 15 feet height is desired for ungulates.

As a result of screening, three potential wildlife crossings (overpasses at MP 22.4, 24.6, 26.4) were advanced for high-level conceptual design and to be prioritized for implementation. The proposed wildlife crossings will be spaced about 2 miles apart. The results of the screening are the same whether the raw scores or weighted scores are used.

The underpass at MP 25.0 was screened out at this stage for two reasons: 1) the land to the east of US 36 is privately owned (although there is a conservation easement), and 2) the Lake Ditch is close to US 36 both horizontally and vertically; given the approximate nature of the LIDAR survey and conceptual design, it is difficult to determine with certainty if there would in fact be enough vertical clearance. During final design, the underpass at MP 25.0 should be analyzed in greater depth as a potential alternative to the overpass at MP 24.6 because if it is feasible, it would cost about half as much as the overpass at MP 24.6 because the structure is about half as big.

Figure 10 below shows the three screened wildlife overpasses, as well as existing drainage structures that could be modified to serve as wildlife crossings for smaller species. See Chapter 6 for more detail about modifying existing structures.

This map illustrates the proposed project corridor through the Front Range National Antiquities Act area. The corridor is shown as a red line with various elevation points marked along it. The map includes a legend for land ownership types, an inset map of Colorado, and a scale bar.

**Legend:**

- Project Corridor (Red line)
- Overpass to Advance (Cyan square)
- Existing Drainage Structure (Red X)
- County Conservation Easement (Yellow)
- County Open Space (Dark Green)
- County Option Parcels (Green with diagonal lines)
- Municipal Parks and Open Space (Brown)
- Incorporated Area (Grey)
- US Forest Service (Light Green)
- Bureau of Land Management (Orange)
- US Department of Energy (Light Orange)

**Inset Map:** Shows the location of the project area within Colorado, with Denver and Cheyenne marked.

**Elevation Points (feet):**

- 21.9
- 22.4
- 22.9
- 23.4
- 24.2
- 24.4
- 24.6
- 25.0
- 25.5
- 25.9
- 26.3
- 26.4
- 26.8

**Geographic Features:**

- Indian Lookout Mountain
- Red Hill
- Table Mountain
- St. Vrain Rd
- Hygiene Rd
- Nelson Rd
- Plateau Rd
- Prospect Rd
- Lykins Ditch
- Table Mountain

**Scale:** 0 to 0.6 Miles



## **5. FENCING STRATEGIES AND OTHER MITIGATION EAST OF US 36**

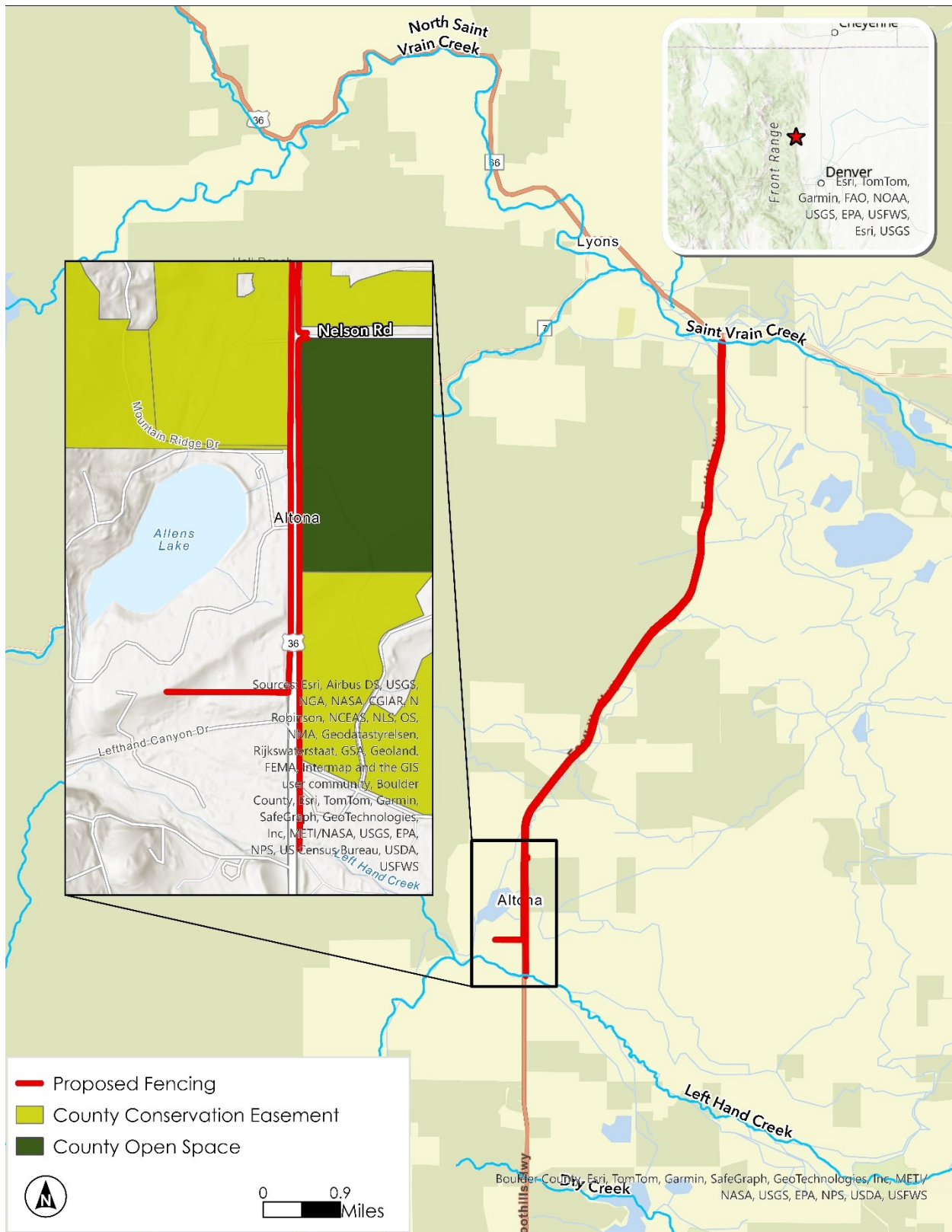
A key objective of this Study is to develop strategies to facilitate the movement of wildlife in the area of interest (i.e., the area generally bounded by Saint Vrain Creek, Left Hand Creek at SH 119, and US 36) to minimize human-wildlife conflict in the region. BCPOS, CPW, Benesch, and Pinyon Environmental, Inc. conducted desktop reviews of aerial imagery, wildlife movement, existing infrastructure, and land ownership; and site visits of the area to develop fencing strategies and other wildlife mitigation concepts in this region. Note that the fencing strategies along North 55<sup>th</sup> Street (Chapter 5.2.1) and SH 119 (Chapter 5.3) will be fine-tuned and further assessed in the future.

### **5.1 US 36 Fencing**

Wildlife exclusion fencing with jump outs and deer guards are proposed along both sides of US 36 to help keep wildlife away from the highway and guide animals to crossing areas (Figure 11). Fencing would tie into existing drainage structures, which would promote the utilization of these structures as highway crossings by small to medium-sized wildlife. Deer guards would be installed at intersections and driveways along both sides of the highway.

The proposed fencing along both sides of the highway would terminate at the north end at Saint Vrain Creek. It is presumed that wildlife at the north end of the fencing would utilize the existing bridge over Saint Vrain Creek to cross under the highway rather than crossing the creek to the north. On the east side of the highway, the fencing would jut-out about 120 feet on the north and south sides of Nelson Road, and a deer guard would be installed on Nelson Road at the east-end of the fencing. The proposed fencing would terminate at the south end east of US 36 at Left Hand Creek, facilitating the movement of wildlife to cross under the highway at the bridge. The proposed fencing west of US 36 on the southern end would jut out about a third of a mile to the west to facilitate movement away from the highway and away from the residential areas along and south of Left Hand Canyon Drive.

**Figure 11. Proposed Fencing along US 36**



## **5.2 East of US 36**

### **5.2.1 Nelson Road and North 55<sup>th</sup> Street**

The installation of roadway signage (“wildlife detection zone”; Figure 12) and/or a wildlife detection zone are proposed for the straightaway of Nelson Road between Triple Creek Ranch and North 51st Street, where the majority of elk crossings occur. Elk collar data show high use of elk along this stretch of Nelson Road and relatively few elk west of the identified crossing area. Along the portion of Nelson Road that begins to curve west of North 51st Street, existing fences discourage elk from crossing Nelson Road. An eight-foot-tall bison fence borders the Strear property, a Boulder County conservation easement, along the east side of North 51st Street and the north side of Nelson Road to the Boulder Feeder Canal, which serves as the eastern edge of the property (Figure 12). This fence prevents elk from crossing North 51st Street in these areas. A steep grade and guard rails on the north side of Nelson Road near Black Cat Organic Farm, as well as internal fences and human activity on the farm, may also act as a barrier to crossing in the curve west of North 51st Street.

A wildlife detection zone consists of radar detectors, or thermal and color cameras to detect wildlife near the highway. The detection system is connected to a central control system that analyzes the detection data from all sensors. When a large animal is detected, the control system activates a series of warning signs that advise motorists of the presence of animals.

South of Nelson Road, wildlife movement strategies should focus on reducing elk-human conflict with private landowners east of North 55th Street/Ouray Drive. Installation of wildlife fencing is proposed along the west side of North 55th Street/Ouray Drive to the northern boundary of the Sunny Acres Non-Urban Planned Unit Development (NUPUD) conservation easement. To deter elk from circumnavigating the fence, the fence would cross Ouray Drive and line the northern border of the Sunny Acres property, terminating at the Boulder Feeder Canal. Residential development and fences along Boulder Hills Drive discourage elk from crossing into the development to travel north. Wildlife fencing would extend along the south side of Plateau Road to North 63rd Street to prevent northward travel to the private properties east of North 55th Street.



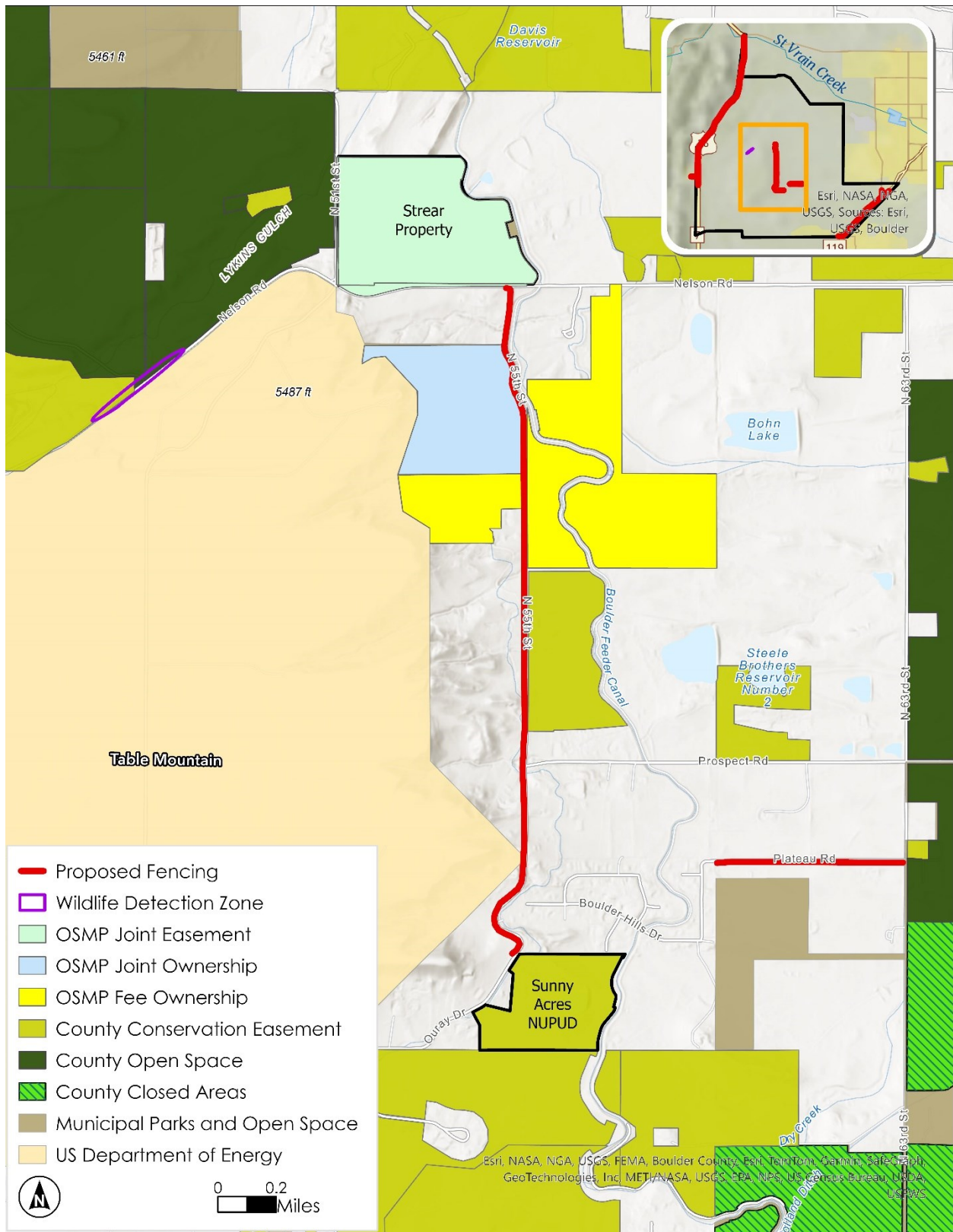
**Photo 5. Example of a Wildlife Detection Zone**



### **5.2.2 Table Mountain**

Table Mountain (as shown in Figure 12) represents an area of high use and high-quality habitat for elk east of US 36, due to topography, vegetation, and seclusion. The majority of Table Mountain is under federal ownership and an intergovernmental agreement (IGA) will be necessary to ensure the long-term success of this project. Collar data and local observations suggest that Table Mountain hosts both resident elk and large segments of the migratory herd throughout the winter months and acts as a travel corridor for elk moving from the north to the south and vice versa. Human-wildlife conflicts have occurred with property owners to the east of North 55th Street; therefore, it is a priority to deter elk from the area east of North 55th Street and west of North 63rd Street. The fencing locations and the implementation of a wildlife detection zone described above (Chapter 5.2.1) should effectively mitigate elk from traveling into this human-wildlife conflict zone, while still facilitating north to south elk movement.

**Figure 12. Nelson Road and North 55th Street**



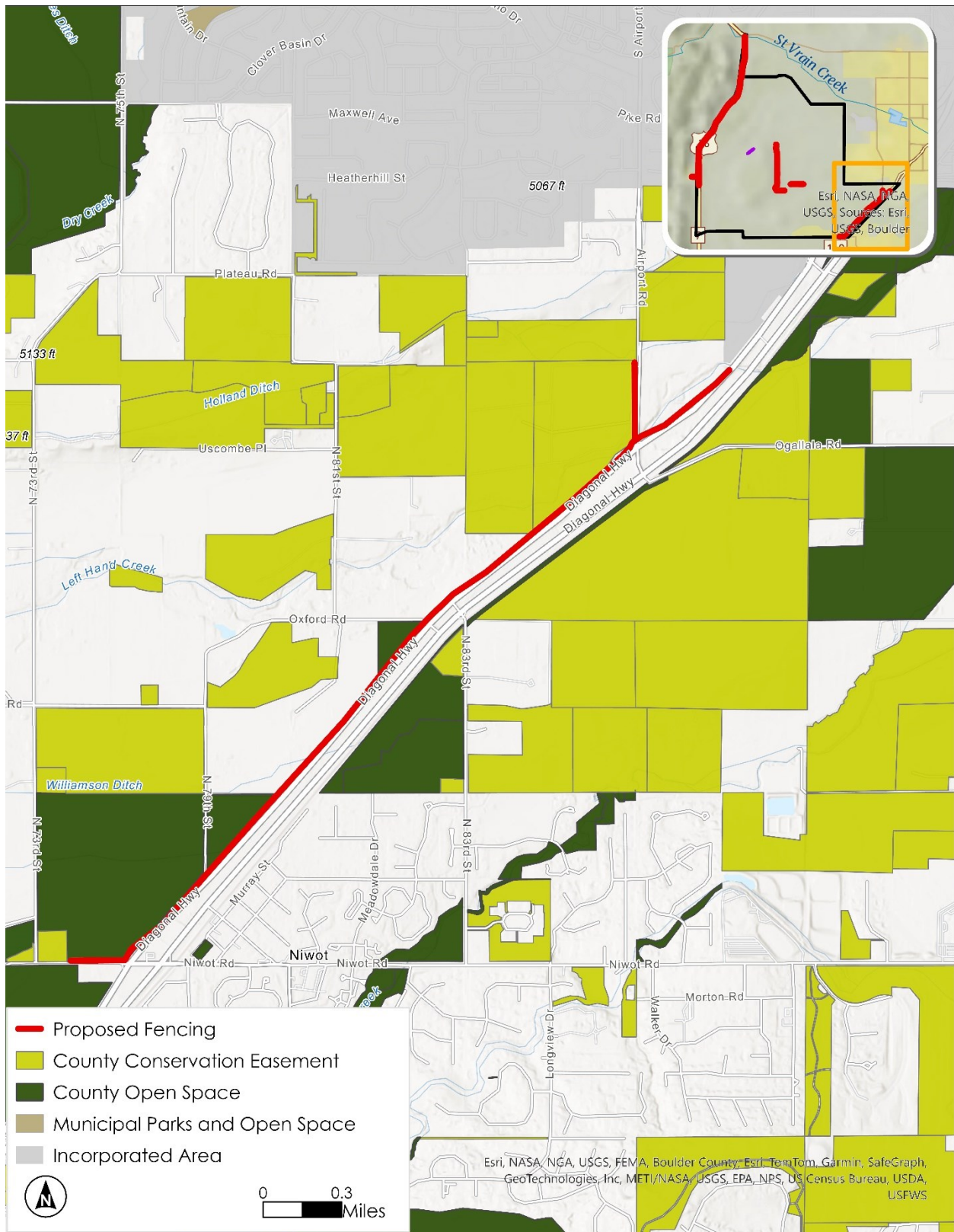
## 5.3 State Highway 119

White-tailed deer, elk and occasionally black bear are the primary cause of WVCs at SH 119 ("Diagonal Highway" in Figure 13) in the area of interest. The goal in this area is to prevent crossings from occurring on SH 119. The installation of fencing on the west side of SH 119 would prevent wildlife from crossing the highway. Fencing on portions of the east side of SH 119 will be considered in permeable areas as well, but are not detailed in this study. The west side fence would terminate at Niwot Road to the south and at Left Hand Creek to the north, with portions extending along Niwot Creek and Airport Road to stop wildlife from circumventing the fence. The three existing bridges over Left Hand Creek at Airport Road and SH 119 provide potential crossing opportunities for elk and other wildlife. During a site visit, deer, raccoon, and other small mammal tracks were observed in a vector that suggests wildlife are already using this as movement corridor. With minor improvements to the corridor, namely the removal of a barbed wire fence and human trash, this could be a highly effective corridor for white-tailed deer, elk and small mammals.

While Boulder County's 2015 - 2020 collar data shows elk regularly using land to the west of Airport Road and north of SH 119, they rarely crossed SH 119. Recently, however, surveys and observations suggest that elk are moving into this area more frequently throughout the year and are trying to cross the highway to access the agricultural fields to the east. This has led to several serious accidents involving elk over the past few years along this stretch of highway. It should be noted that elk movements are dynamic and change on a yearly basis due to shifts in land use, climate, and vegetation, creating a challenge for projects like this; closing one area to elk may motivate elk to forage in a new area. One of the goals with this project is to be predictive in how wildlife may respond to fencing on the landscape. While installing fencing along SH 119 would certainly reduce WVCs from white-tailed deer and elk, it will also deter elk from seeking new areas to forage across SH 119.



**Figure 13. State Highway 119**



## 6. SMALL TO MEDIUM SIZED WILDLIFE CROSSING CONCEPTS

### 6.1 Small Animal Species

As previously described in Chapter 3.2, the area surrounding the project corridor provides a variety of habitat types for many other species of wildlife. Common small and medium mammals in the area include coyotes, red and gray foxes, black-tailed prairie dogs, raccoons, ground squirrels, badgers, and beavers. Less frequently observed mammalian species include federally threatened Preble's meadow jumping mice, river otters, and bobcats.

Common small and medium mammals in the area include coyotes, red and gray foxes, black-tailed prairie dogs, raccoons, ground squirrels, bobcats, and rabbits. Less frequently observed mammalian species include federally threatened Preble's meadow jumping mice, river otters, badgers and beavers.

While the primary purpose of the project is to mitigate WVCs associated with ungulates, opportunities exist in the corridor to help mitigate WVCs for smaller species and promote their movement and survival.

### 6.2 Existing Drainage Structures

There are a variety of existing drainage structures in the corridor. Table 6 below summarizes the ones that are 48 inches and larger, as determined from the CDOT OTIS database, along US 36 from SH 66 to Left Hand Creek. Each location provides an opportunity for a small animal enhancement, though modifications to culverts associated with irrigation ditches may not be allowed by the ditch company due to concerns about efficient water conveyance.

**Table 6. Existing Drainage Structures 48 Inches and Larger**

Milepost	Structure ID	Type <sup>1</sup>	Facility
21.8	D-15-I	Bridge (115' span)	Saint Vrain Creek
21.9	036B021930BR	CBC (6' x 3.5')	Swede Ditch
21.9	036B021950BR	CBC (5.5' x 5.5')	Boulder Feeder Canal
22.9	036B022870BR	CMP (48")	South Ledge Ditch
23.4	036B023360BR	CMP (48")	Drainage
23.6	036B023610BR	CBC (6' x 7')	Drainage
24.2	036B024180BR	CBC (6' x 7')	Drainage
24.4	036B024380BR	CMP (48")	Drainage
25.5	036B025450BR	CBC (6' x 7')	Drainage
25.9	036B025880BR	CBC (6' x 7')	Drainage: Lykins Gulch
26.7	036B026660BR	CMP (58" x 36" arch)	Lake Ditch
26.8	036B026800BR	CBC (6' x 7')	Drainage
27.9	D-15-BT	Bridge (150' span)	Left Hand Creek

<sup>1</sup>CBC = Concrete Box Culvert. CMP = Corrugated Metal Pipe.

## 6.3 Potential Enhancements

The section below presents several ideas of enhancements to existing culverts to make them function better as wildlife crossings for small animals, along with associated costs. This is intended to provide a potential menu of small animal enhancements, and additional study, coordination and design would be required for any being deployed in the project corridor. If an existing crossing is intended to be used as a wildlife crossing, the wildlife fencing must tie into its wingwalls, or pass over the structure to allow animals to go through the structure without leaving gaps in the fencing.

**Herptile Barrier:** Mesh or solid plastic about 36 inches high added to other, taller fencing or installed by itself to provide a barrier to small herptiles, either to exclude them or direct them to a crossing structure. Additional information: <https://snakefencing.com/>. Approximate Cost: **\$25 per linear foot**

**Example of a Herptile Barrier**



**Small Animal Jump Outs:** These would be installed in conjunction with the herptile barrier. They are similar to escape ramps for ungulates but smaller, allowing small animals that get trapped on the roadway side of the fence to jump out. Documentation shows them to be effective. Additional information: <https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/final-caltrans-usgs-report-herproadresearch-rev.pdf>. Approximate Cost: **\$500**

**Example of a Small Animal Jump Out**



**Turnarounds:** This would also be installed in conjunction with herptile barrier. Turnarounds involve adding blocks along fences near crossings to encourage animals to turn around back toward the crossing. Documentation shows them to be effective. Additional information: <https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/final-caltrans-usgs-report-herproadresearch-rev.pdf>. Approximate Cost: **\$250**

**Example of a Turnaround**



**Guide Walls:** Angled concrete or wooden walls that promote funneling smaller animals into a culvert. The walls are offset a few feet away from the culvert and are around 6 inches to 1 foot tall. Additional information: <https://storymaps.arcgis.com/stories/84e9c986d22e4864b4c3b78660ca442e>. Approximate Cost: **Nominal to \$250 if constructed from wood**

**Example of Guide Walls**



**Lighting Grate:** Grates added to the pavement surface above the culvert to allow light, moisture and air circulation into the culverts, making it more likely animals may use it by reducing the tunnel effect. These are like drainage grates but could be smaller. The grates should be installed to avoid the typical wheel paths of the traffic above (such as in the shoulder, on the centerline stripe, or exactly in the middle of the lane). Additional information: [https://files.ontario.ca/bmp\\_herp\\_2016\\_final\\_final\\_resized.pdf](https://files.ontario.ca/bmp_herp_2016_final_final_resized.pdf). Approximate Cost: **\$10,000/grate**



### Example of a Lighting Grate



**Catwalks:** An elevated ledge or walkway ("catwalk") through a culvert. The catwalk should be high enough to be above the normal water elevation and have ramps at the culvert ends to allow animals to get up to it. The catwalks can be cast into the side of new concrete culverts or added to existing culverts with metal grating or lumber. The width of the catwalk will depend on the species targeted. If a catwalk were to be installed in a culvert conveying irrigation, it would need to be coordinated with the owner of the irrigation ditch. Additional information: <https://www.codot.gov/programs/research/reports/2007/smallmammal.pdf>. Approximate Cost: **\$100/linear foot**. Culverts along US 36 are in the range of 100 feet long, so this would cost around \$10,000 per culvert

### Example of a Catwalk



**Backfilling a portion of the culvert:** Soil or smooth rocks may be used. Hydraulic requirements may preclude this option in some culverts. Backfilling a portion of the culvert serves two functions. 1) It makes the opening smaller to match the dimensions of smaller animals. 2) It creates a natural bottom. Additional information: [https://files.ontario.ca/bmp\\_herp\\_2016\\_final\\_final\\_resized.pdf](https://files.ontario.ca/bmp_herp_2016_final_final_resized.pdf). Approximate Cost: **\$2500 or more, depending on the size of the culvert.**

### Example of Backfill



**Adding Vegetation:** Some research suggests simply adding vegetation of any kind to the bottom of a culvert and near the entrance to a culvert would make it more likely for small animals to cross. Lighting grates must be added to support vegetation in culverts. Specific plants can be selected to entice a particular species to use the crossing, or to repel certain species to keep them away from the roadway. This tactic of repelling is mentioned in literature but is unconventional and untested. Additional information: [https://files.ontario.ca/bmp\\_herp\\_2016\\_final\\_final\\_resized.pdf](https://files.ontario.ca/bmp_herp_2016_final_final_resized.pdf). Approximate Cost: **\$5000 or more depending on types and quantities of plants.**

### Example of Vegetation



**Vegetation and Brush Windrows on an Ungulate Overpass:** To make an overpass attractive to smaller species, add shrubs, trees, and grass to the top. Tunnels made of sticks can be built to provide shelter for smaller species. Additional information: [https://files.ontario.ca/bmp\\_herp\\_2016\\_final\\_final\\_resized.pdf](https://files.ontario.ca/bmp_herp_2016_final_final_resized.pdf). Approximate Cost: **\$1000 per tree; \$150 per shrub; \$30/linear foot brush windrow**

### Example of Vegetation and Brush Windrows



## 6.4 Recommended Small Animal Crossing Upgrades

Table 7 below summarizes the quantities that were made in estimating the potential costs of upgrades at each existing culvert. See Appendix A for more detailed information on the quantities and costs.

**Table 7. Assumptions of Quantities for Small Animal Upgrades**

Upgrade	Abbreviation	Assumptions for quantities, if used
Herptile Barrier	HB	400 feet per location
Small Animal Jump Outs	SAJ	4 per location
Turnarounds	T	4 per location
Guide walls	G	2 per location
Lighting Grates	LG	2 per location
Catwalks	C	Structure lengths were measured from aerial imagery
Backfilling Culvert	BC	1 per location
Adding Vegetation	V	2 per location

Based on the target species and feasibility of upgrades at each culvert site, Table 8 shows the small animal upgrades that are recommended at existing culverts. The approximate costs provided for each upgrade do not include temporary easements that may be required for construction. Costs for structures associated with irrigation company ditches assume the ditch company allows the upgrade and additional permit or agreement costs are not included. The approximate costs include contingencies and maintenance.

**Table 8. Recommended Small Animal Upgrades and Costs**

Culvert Milepost	Culvert Info	Recommended Upgrades	Approximate Cost
21.9 (1)	6' x 3.5' Irrigation	HB, SAJ, T, LG, C	\$140,000
21.9 (2)	5.5' x 5.5' Irrigation	HB, SAJ, T, LG, C,	\$138,000

Culvert Milepost	Culvert Info	Recommended Upgrades	Approximate Cost
22.9	48" CMP Irrigation	HB, SAJ, T, G, C, V	\$115,000
23.4	48" CMP Drainage	HB, SAJ, T, G, C, V	\$140,000
23.6	6' x 7' CBC Drainage	HB, SAJ, T, G, LG, BC, V	\$151,000
24.2	6' x 7' CBC Drainage	HB, SAJ, T, G, LG, BC, V	\$151,000
24.4	48" CMP Drainage	HB, SAJ, T, G, C	\$82,000
25.5	6' x 7' CBC Drainage	HB, SAJ, T, G, LG, BC, V	\$151,000
25.9	6' x 7' CBC Drainage	HB, SAJ, T, G, LG, BC, V	\$151,000
26.7	4.83' x 3' Irrigation	HB, C	\$66,000
26.8	6' x 7' CBC Drainage	HB, SAJ, T, G, LG, BC, V	\$151,000

In addition to the upgrades recommended above, replacing an existing culvert with a larger one may make it more attractive for use as a crossing for deer or other species. Replacing an existing culvert with a 100-foot-long 10-foot by 10-foot concrete box culvert would cost approximately \$1,771,000, which includes contingencies and maintenance.

## 6.5 Additional Resources

Resources related to small animal crossings in addition to the ones shown above:

- [Cost Effective Wildlife Crossing Structures, FHWA/NC/2009-26](#)
- [Pairing long-term population monitoring and wildlife crossing structure interaction data to evaluate road mitigation effectiveness](#)
- [Washington County Reptile Crossing, Mn/DOT](#)
- [Monkton, VT Wildlife Crossing](#)



## 7. OPINION OF PROBABLE COSTS

### 7.1 Crossing Locations Analyzed

As a result of the screening in Chapter 4, three potential wildlife crossings (overpasses at MP 22.4, 24.6, 26.4) were advanced for high-level conceptual design and to be prioritized for implementation. The crossing locations and types are summarized in Table 9 below and shown in Figure 14 on the next page.

**Table 9. List of Crossings Advanced**

Crossing MP	Description of Crossing
22.4	Overpass
24.6	Overpass
26.4	Overpass

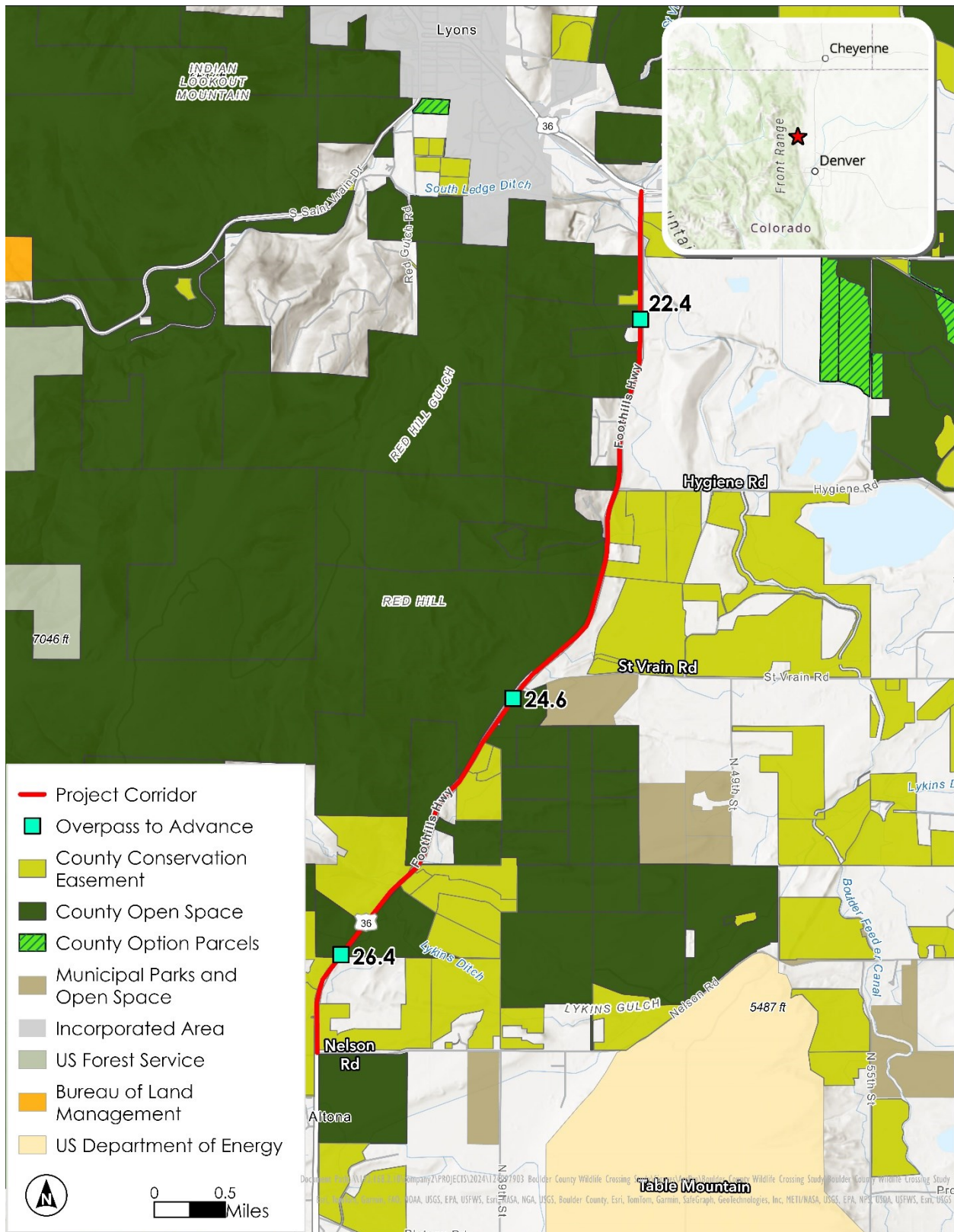
The proposed overpasses are assumed to be hourglass-shaped, like the image below, with a 210-foot-wide throat that constricts down to 165 feet at the middle. Alternatively, the overpass could have straight wingwalls instead of curved, or the entire structure could be a constant width. The exact structure shape will be evaluated during final design. 3H:1V slopes were assumed for the approaches to the overpasses.

For each of the three wildlife crossings, the structure, earthwork, and pavement work were drawn and modeled in conceptual Civil 3D models using aerial imagery and existing terrain data from the Denver Regional Council of Governments.

**Photo 6. Example of hourglass-shaped overpass**



**Figure 14. Proposed Wildlife Crossings Used for Prioritization**



## 7.2 Fencing East of US 36

The wildlife movement strategies east of US 36 discussed in Chapter 5 include fencing and associated items along US 36 and for an area between US 36 and SH 119. An opinion of probable costs was developed that includes the items to implement that plan, including:

- Wildlife fence along US 36, 55th Street, Plateau Road, east of Ouray Drive, SH 119, and Airport Road
- Deer guards at driveways and public roads, and escape ramps
- Wildlife detection zone on Nelson Road west of 51st Street

### 7.2.1 Items in opinions of probable costs

The opinions of probable costs were calculated in an Excel spreadsheet. The spreadsheet categorizes the costs into “hard” and “soft” costs that are totaled. This method of developing conceptual cost estimates is standard practice.

- Hard costs are associated with calculatable quantities that have a unit cost applied to them. Unit costs are based on recent CDOT cost data. Hard cost items include:
  - Earthwork, pavement, and guardrail
  - Overpass/underpass structures, headwalls, wingwalls, and bikeway structures
  - Wildlife fencing on both sides of US 36, deer guards at driveways, and escape ramps, assumed two per side per mile
- Soft costs are estimated as percentages of the hard costs, with the percentages adjusted based on the nature of the project. Items calculated this way include:
  - A contingency to account for unknown site and design conditions
  - Clearing and grubbing, removals, and drainage
  - Signing and pavement marking
  - Landscaping, aesthetics, and lighting
  - Traffic control and mobilization

The total of the above costs represents the estimated 2024 construction bid cost for the location. To determine an overall program cost for the location, additional items are added to the total of bid items:

- Design engineering and construction engineering/inspection, based on a percentage of the construction bid cost
- Permitting
- Property acquisitions, whether ROW needed for a crossing or a permanent easement for fencing

- Inflation is then applied to an assumed construction year of 2027
- After-construction ongoing costs are also added, including two rounds of structure rehabilitation for the crossings, 1,000 feet of fence replacement, deer guard replacements, and maintenance for the wildlife detection zone

## 7.3 Summarized Costs

The detailed cost estimating spreadsheets are included in Appendix A. Table 10 below summarizes the opinions of probable costs for the four crossing locations and the fencing east of US 36.

**Table 10. Opinion of Probable Project Costs by Location**

Crossing Location	2027 Project Cost	2027 Project Cost + Ongoing Costs
22.4 Overpass	\$17,367,000	\$18,367,000
24.6 Overpass	\$15,386,000	\$16,386,000
26.4 Overpass	\$15,173,000	\$16,173,000
Fencing along US 36	\$11,982,000	\$12,620,500
Fencing areas east of US 36	\$8,727,000	\$9,128,000

Modifying existing culverts to better serve as wildlife crossings for smaller species is not included in these cost estimates; that is covered separately in Chapter 6.



## 8. PRIORITIZATION

The goal of this step in the process is to prioritize the potential projects such that the most effective and beneficial projects will be built first. The approach and results are described below.

### 8.1 Prioritization Criteria

Each of the three wildlife crossing locations (overpasses at MP 22.4, 24.6, and 26.4) advanced to this step will be compared with each other in a matrix using the following criteria: WVCs, connectivity, cost, benefit/cost ratio, environmental permitting, and leveraging investments.

Because the goal of these proposed wildlife crossings is to reduce WVCs and improve connectivity in the most cost-effective way, weighting factors were added to WVCs, connectivity, cost, and benefit/cost ratio so that these factors influence the ranking more than the other factors.

- **WVCs (Weighting factor = 3).** The number of WVCs within the limits of evaluation.
  - **3** = 135 WVCs
  - **2** = 73 or 74 WVCs
  - **1** = Not used
- **Connectivity (Weighting factor = 2).** The connectivity is measured based on the heat map of the collar data collected by BCPOS.
  - **3** = High
  - **2** = Medium
  - **1** = Low
- **Cost (Weighting factor = 2).** Refer to Chapter 7 for more detail about the cost estimates. A conceptual model was developed in Civil 3D using Denver Regional Council of Governments LIDAR data as a base. Major items such as earthwork, pavement, structures, and fencing were calculated from a preliminary Civil 3D design model. Other quantities were accounted for as percentages of the major items. The costs below are 2027 project costs.
  - **3** = Under \$17 million
  - **2** = Over \$17 million
  - **1** = Not used
- **Benefit/Cost (Weighting factor = 2).** The monetary benefit of a wildlife crossing project is the savings due to reduced WVCs. To calculate the value of the benefits, two elements were considered: 1) the human costs, which are property damage, injuries, and fatalities, and 2) the estimated value of wildlife to society. The value of the benefits is divided by the 2027 project cost to get a benefit/cost ratio.

- **3** = Benefit/cost over 0.30
- **2** = Benefit/cost is less than 0.30
- **1** = Not used
- **Environmental permitting.** Based on field reconnaissance and resource database searches, potential to impact wetlands, cultural resources, and sensitive habitats were evaluated. This was based on presence and proximity to the potential crossing; quantitative impact analysis was not completed as a part of this study.
  - **3** = No environmental resources at the crossing location
  - **2** = One or two environmental resources at the crossing location
  - **1** = More than two environmental resources at the crossing location
- **Leveraging Investments.** BCPOS owns much land immediately to the west of US 36 through this corridor, and a few parcels immediately to the east. Placing a wildlife crossing where the adjacent land on both sides is designated open space helps ensure that the habitat surrounding the wildlife crossing will remain open indefinitely into the future.
  - **3** = The crossing location has open space on both sides of US 36
  - **2** = The crossing location has open space on one side of US 36
  - **1** = The crossing location has private property on both sides of US 36

## 8.2 Evaluation of Criteria

### 8.2.1 WVCs

The CPW/CDOT Maintenance Staff roadkill data and CSP data from 2014 – 2023 were used to assess the historic WVCs. Table 11 below summarizes the data in terms of crash type: property damage only (PDO), injury, or fatality. If the crash type was not documented (which is all the CPW/CDOT data), it was assumed to be PDO. No fatalities were documented for the project corridor. Table 12 summarizes the WVC data according to the species.

**Table 11. Summary of WVCs by PDO/Injury/Fatality**

Crossing MP	PDO	Injury	Total
22.4	23 (CSP) 40 (CPW/CDOT) <b>Total = 63</b>	4	<b>67</b>
24.6	54 (CSP) 61 (CPW/CDOT) <b>Total = 115</b>	12	<b>127</b>
26.4	25 (CSP) 38 (CPW/CDOT) <b>Total = 63</b>	6	<b>69</b>

Crossing MP	PDO	Injury	Total
<b>Totals</b>	102 (CSP) 139 (CPW/CDOT) <b>Total = 241</b>	22	<b>263</b>

**Table 12. Summary of WVCs by Wildlife Species**

Crossing MP	Deer	Elk	Bear	Lion	Other	Total
22.4	17 (CSP) 21 (CPW/ CDOT) Total = 38	8 (CSP) 12 (CPW/ CDOT) Total = 20	0 (CSP) 0 (CPW/ CDOT) Total = 0	1 (CSP) 1 (CPW/ CDOT) <b>Total = 2</b>	1 (CSP) 12 (CPW/ CDOT) Total = 13	73
24.6	26 (CSP) 23 (CPW/ CDOT) Total = 49	39 (CSP) 31 (CPW/ CDOT) Total = 70	1 (CSP) 2 (CPW/ CDOT) Total = 3	0 (CSP) 0 (CPW/ CDOT) <b>Total = 0</b>	0 (CSP) 13 (CPW/ CDOT) Total = 13	135
26.4	18 (CSP) 15 (CPW/ CDOT) Total = 33	13 (CSP) 27 (CPW/ CDOT) Total = 40	0 (CSP) 0 (CPW/ CDOT) Total = 0	0 (CSP) 0 (CPW/ CDOT) Total = 0	0 (CSP) 1 (CPW/ CDOT) Total = 1	74
Totals	61 (CSP) 59 (CPW/ CDOT) Total = 120	60 (CSP) 70 (CPW/ CDOT) Total = 130	1 (CSP) 2 (CPW/ CDOT) Total = 3	1 (CSP) 1 (CPW/ CDOT) Total = 2	1 (CSP) 26 (CPW/ CDOT) Total = 27	282

Overall, the number of elk and deer WVCs are close to equal, and the number of WVCs near MP 24.6 is almost double that of the other MPs.

## 8.2.2 Connectivity

Figure 15 shows the relative density of elk crossing US 36 based on collar data collected by BCPOS. The darker colors indicate a greater number of elk crossing US 36. Clearly the highest density of elk crossing US 36 is near MP 25 with the density dissipating for a mile or so north and south of there. The crossings are rated in Table 13, below.

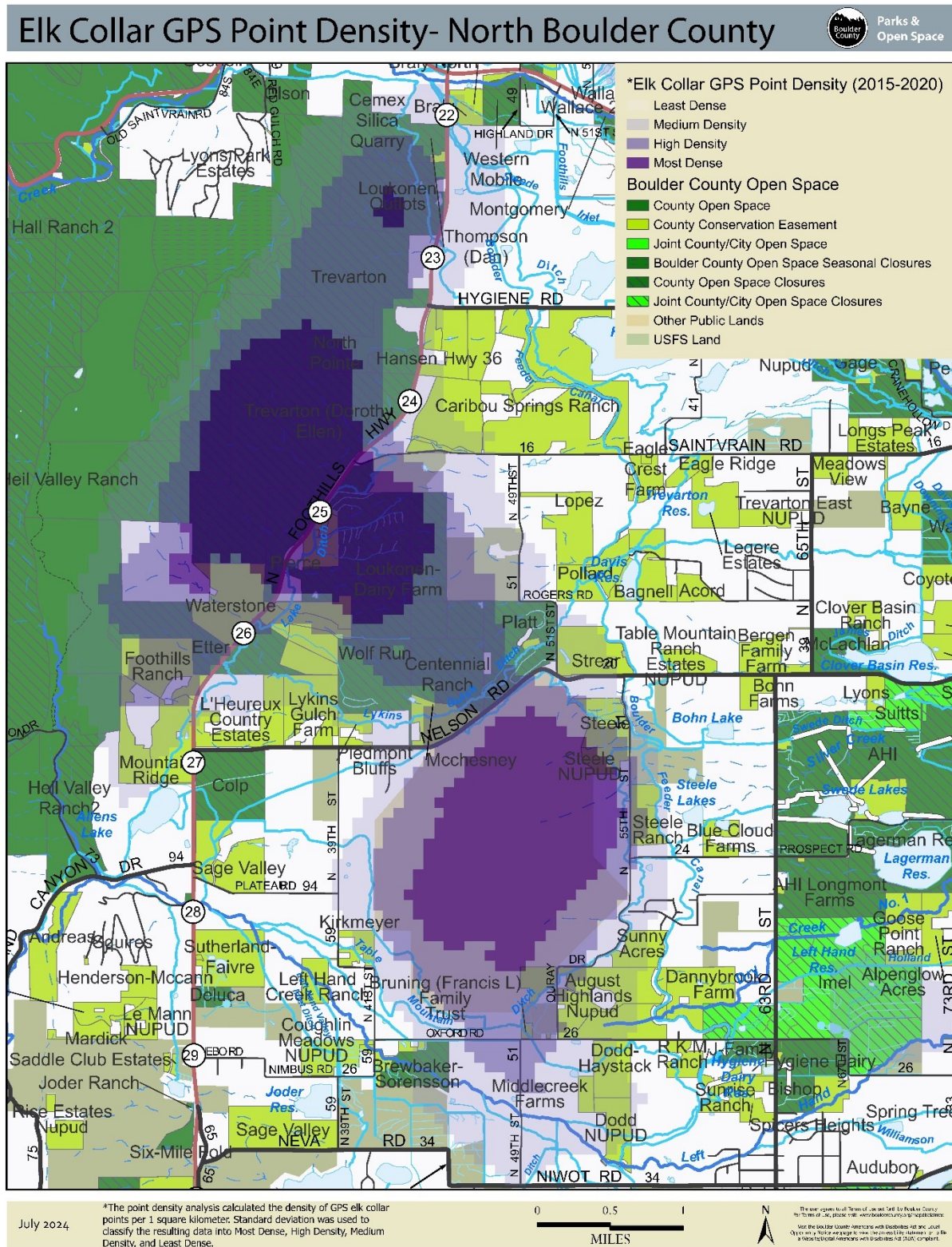
**Table 13. Ranking of Connectivity**

Crossing MP	Density of Elk Crossing	Score
22.4	Low	1
24.6	High	3
26.4	Medium	2

The collar data matches the WVC data very closely in that there is a high concentration around MP 25. However, the WVC data is recorded with the mileposts often rounded, so it is difficult to distinguish between a concentration at milepost 24.6 versus 25.0, whereas the collar data lends itself better to a more precise analysis.



Figure 15. Elk Movement Density Map



### 8.2.3 Cost

See Chapter 7 for a detailed explanation of how the OPCCs are calculated. Table 14 below summarizes the cost estimates for each wildlife crossing structure, along with the fence and its appurtenances for each segment, along with engineering, permitting, property acquisition, inflation, and maintenance.

**Table 14. Cost Summary**

Crossing MP	Description of Crossing	2027 Project Cost Estimate
22.4	Overpass	\$17,367,000
24.6	Overpass	\$15,386,000
26.4	Overpass	\$15,173,000

The terrain around MP 22.4 is level, whereas the other two overpasses are located where US 36 is in a cut. Therefore, the overpass at MP 22.4 requires more embankment material than the other two, which increases its cost. Overpass dimensions are around 165 by 70 feet, which is in accordance with FHWA guidelines.

### 8.2.4 Benefit/Cost

The monetary benefit of a wildlife crossing project results from the savings due to the reduced WVCs. Two elements were considered in the calculation of benefits: 1) human cost, which includes property damage, injury, or fatality, and 2) the value of wildlife.

The goal of the benefit/cost analysis in this study is to compare the potential projects to each other, so anything that would affect all the projects the same, such as inflation, depreciation, and traffic growth, was disregarded. The benefit calculations assume the following:

- A 20-year lifespan. This is an arbitrary number, and only for the purpose of comparing the wildlife crossing locations to each other.
- The number of future WVCs was calculated by taking the yearly average from 2008 to 2023 from about a mile in either direction of each crossing and multiplying by the life span.
- Elk are valued at \$2,537 each and other species are valued at \$2,178 each, based on the ESPWPS.
- The cost of crashes is valued according to the CDOT Traffic & Safety Engineering Branch, 2023.
  - PDO = \$11,100
  - Injury = \$101,800
  - Fatality = \$1,820,600

The benefit/cost ratio is simply the estimated benefit divided by the 2027 project cost estimate. The projects with high benefit/cost ratios offer the best benefit to reduce WVCs relative to their

cost. Table 15 summarizes the results to indicate how the groups were ranked in the prioritization matrix.

**Table 15. Benefit/Cost Summary**

Crossing MP	Description of Crossing	Estimate of Benefit	2027 Project Cost Estimate	Benefit/Cost
22.4	Overpass	\$2,488,900.00	\$17,367,000	0.14
24.6	Overpass	\$5,578,000.00	\$15,386,000	0.36
26.4	Overpass	\$2,967,000.00	\$15,173,000	0.20

Using this simplified method of calculating benefits, none of the structures have a benefit/cost ratio greater than one. However, not all the benefits are calculated, such as residual value of the structure, user delay costs, inflation, and others. If these benefits are considered, then the benefit/cost ratio would increase. Again, the purpose of this benefit calculation is to simply compare these structures to each other.

## 8.2.5 Environmental Permitting

Environmental resources were identified based on a site reconnaissance visit and reviews of resource database searches and aerial imagery. As described in Chapter 4, a score of 2 in Table 16 indicates that one or two of the three environmental categories assessed in this study (wetlands/waters, threatened and endangered species habitat, or a cultural resource) have the potential to be impacted by constructing the crossing and may require consultation, permitting, and/or mitigation. The environmental data presented in this study are preliminary and will need to be verified as part of future National Environmental Policy Act (NEPA) studies that will be required to implement any mitigation concept.

**Table 16. Environmental Resources**

Crossing MP	Environmental Concerns	Matrix Score
22.4	Potential PMJM habitat Potential historic property to the west of the crossing	2
24.6	Potential PMJM habitat	2
26.4	None	3

## 8.2.6 Leveraging Investments (ROW)

Table 17 indicates whether there is designated open space at one or both sides of US 36 at each wildlife crossing location.

**Table 17. Open Space Adjacent to Wildlife Crossing Location**

Crossing MP	Open Space	Matrix Score
22.4	West is BCPOS. East is private	2

Crossing MP	Open Space	Matrix Score
24.6	Both sides BCPOS open space.	3
26.4	Both sides BCPOS open space	3

## 8.3 Prioritization Matrix

The potential projects were scored and then ranked according to the methods described in the *Prioritization Criteria* and *Evaluation of Criteria* sections above in this Chapter. The projects were ranked 1 through 3, with 1 being the most favorable.

**Table 18. Prioritization Matrix**

Crossing MP	WVCs	Connectivity	Cost	Benefit/Cost	Environmental Permitting	Leveraging Investments (ROW)
<b>Weight</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>
22.4	2	1	2	2	2	2
24.6	3	3	3	3	2	3
26.4	2	2	3	2	3	3

Crossing MP	Score	Weighted Score	Benefit / Cost Ratio	Cost <sup>1</sup>	Rank
22.4	11	22	0.14	\$18.67M	3
24.6	17	35	0.34	\$16.39M	1
26.4	15	29	0.18	\$16.17M	2

<sup>1</sup>Includes Maintenance

## 8.4 Summary

Provided below is a summary of the prioritization results for each of the three wildlife crossing locations shown in Figure 14.

### 8.4.1 MP 22.4

The overpass at MP 22.4 ranked last for three important reasons: 1) there are not many elk in the segment, according to the WVC and collar data, 2) the structure would cost more than the others because more embankment material would be required due to the flat terrain, and 3) the land on the east side of US 36 is privately owned.

### 8.4.2 MP 24.6

This crossing is ranked first because it has the most WVCs, low cost (slightly higher than MP 26.4) and the highest benefit/cost ratio. Based on the collar data and information from CPW and



BCPOS staff, this area has the highest concentration of wildlife crossings in the project corridor. As mentioned at the end of Chapter 4, a more detailed investigation of the underpass at MP 25.0 should be done during final design to understand the conditions of the conservation easement and, to confirm the vertical clearance between the Lake Ditch, the elk underpass and US 36 with better topographic survey and a more detailed structure analysis.

The overpass would be about 400 feet south of the St. Vrain intersection. The design team checked the intersection sight distance at St. Vrain Road to make sure that the walls of the structure would not block the sight distance for drivers stopped at St. Vrain Road, turning onto US 36, and found that there is adequate sight distance.

The images below are conceptual renderings of the overpass at MP 24.6. There will be a berm or opaque fence in the final design.

**Photo 7. View of MP 24.6**



**Photo 8. Conceptual Renderings of the Overpass at MP 24.6**



#### **8.4.3 MP 26.4**

The overpass at MP 26.4 was ranked 2nd. It costs approximately the same as the overpass at MP 24.6, but the benefit is much lower because the number of WVCs in this segment is much lower. It ranks above the crossing at MP 22.4 because the land on both sides of MP 26.4 is open space and it has fewer potential environmental resources than MP 22.4.



**Photo 9. View of MP 26.4**



## 9. IMPLEMENTATION

Future funding availability and timing will have a substantial impact on what improvements are implemented, and the outline presented below provides one example of how all the improvements described in this report could be implemented. These ideas are not intended to prescribe which exact combinations of improvements to make but are intended to illustrate implementation concepts. The costs below all represent the 2027 project costs, which include the construction, design, and inflation to 2027.

The minimum baseline project that BCPOS would implement consists of the following elements:

- Fencing along US 36 from Left Hand Canyon Drive to SH 66 (with deer guards and escape ramps). **Cost: \$11,982,000**
- Wildlife crossing at MP 24.6. **Cost: \$15,386,000**
- Improvements to existing drainage culverts to better accommodate small species. **Cost: \$1,350,000**

The above project would eliminate most of the WVCs on US 36 while still maintaining reasonable connectivity. By greatly reducing the WVCs, this project would help protect human and animal life and would reduce the costs associated with property damage due to WVCs. The next phase of implementation would include the area east of US 36, in order of priority:

- Fencing along SH 119 from Niwot Road to Airport Road. This is the highest priority of all the fencing east of US 36 because it would reduce WVCs on SH 119, thus reducing the risk to human life and well-being. **Cost: \$3,778,000**
- Wildlife detection zone on Nelson Road, just west of 55<sup>th</sup> Street. This project is important because it would help reduce the risk of WVCs on Nelson Road. **Cost: \$813,000**
- The fencing along 55<sup>th</sup> Street and Plateau Road. This fencing would help protect property and crops from damage caused by elk. **Cost: \$4,020,000**

With all the fencing in place to the east of US 36, the next phase is to install the remaining wildlife crossings on US 36, in order of priority:

- Overpass at MP 26.4, which was ranked next after the crossing at MP 24.6. **Cost: \$15,173,000**
- Overpass at MP 22.4. **Cost: \$17,367,000**

### 9.1 Funding and Partnerships

The need for wildlife crossings has become more of a priority for local, state, and federal agencies over the past decade. As such, there are numerous grant opportunities that vary in funding availability and selection criteria.



A project-specific schedule for planning, design, and construction must be developed as each phase of the plan is implemented. The concepts presented in this report have been developed only to a conceptual level, so the final design must still be completed. Further advancing the designs, conducting environmental surveys, and obtaining environmental clearances may be advantageous in the pursuit of grants.

Given the high costs, uncertainty of timing, and variety of options in the order of implementation, it is anticipated that all the fencing and wildlife crossings in this report will be implemented over the course of several years, and more than one funding source will be needed to implement everything described in this study. There are many opportunities for funding, such as federal grants, state grants, and legislated funding.

As mentioned, future efforts to bring these project components to the construction phase will require further analysis and design. Proceeding with this project requires close collaboration with the integral agencies of CDOT and CPW. Also, with Boulder County, the federal agencies at Table Mountain, Town of Lyons, City of Boulder, landowners and public citizens, and to initiate new partnerships with other entities and agencies.

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## Appendix A. Cost Estimates



**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - MP 22.4 Overpass Only**



Prepared On: 6/27/2024

Project Description  
Overpass at Mile Post 22.4.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
203-00060	Embankment Material (Complete In Place)	CY	24,804	\$50	\$1,240,213	
606-00302	Guardrail Type 3 (31 Inch MGS)	LF	1,000	\$42	\$42,000	
606-02005	End Anchorage (Flared)	EACH	4	\$5,000	\$20,000	
607-11350	Fence Deer	LF		\$25	\$0	
607-60002	Game Ramp	EACH		\$15,000	\$0	
611-00021	20 Foot Deer Guard	EACH		\$75,000	\$0	
611-00029	28 Ft Deer Guard	EACH		\$90,000	\$0	
	Overpass Structure	SF	11,880	\$400	\$4,752,000	
601-07000	Concrete Retaining Wall	SF	1,925	\$90	\$173,250	
603-71612	16 x 12 Foot Concrete Box Culvert	LF	185	\$2,500	\$462,500	
608-00020	Concrete Bikeway	SY	247	\$90	\$22,200	
				<i>Bikeway Subtotal</i>	\$657,950	
<b>Total of Quantity Items</b>					<b>\$6,712,163</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$1,006,824	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		3%	\$ 231,570	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		2%	\$ 154,380	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		10%	\$ 771,899	(E)
601	Structure Aesthetics			1%	\$ 77,190	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 231,570	(G)
613	Lighting			1%	\$ 77,190	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 77,190	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 771,899	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 540,329	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$10,653,000</b>	(L)
	Force Account	10% of (L)		10%	\$ 1,065,300	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$11,719,000</b>	(N)
	Construction Engineering/Inspection	15% of (K+L)		15%	\$1,757,745	(O)
	Design Engineering	12% of (K+L)		12%	\$1,406,196	(P)
	Permitting				\$45,000	(Q)
	Property Acquisition	SF	37000	\$2	\$74,000	(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 15,002,000</b>	
		Annual Inflation		5%		
		Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 17,367,000</b>	
	Ongoing Maintenance - Fence Replacement	50' / year, 20 years		\$38	\$0	
	Ongoing Maintenance - Guard Replacements	3 over 20 years		\$112,500	\$0	
	Maintenance - Assumed 2 structure rehabs		2	\$500,000	\$1,000,000	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 18,367,000</b>	

**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - MP 24.6 Overpass Only**



Prepared On:

6/27/2024

Project Description  
Overpass at Mile Post 24.6.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
203-00060	Embankment Material (Complete In Place)	CY	11,544	\$50	\$577,224	
606-00302	Guardrail Type 3 (31 Inch MGS)	LF	1,000	\$42	\$42,000	
606-02005	End Anchorage (Flared)	EACH	4	\$5,000	\$20,000	
607-11350	Fence Deer	LF		\$25	\$0	
607-60002	Game Ramp	EACH		\$15,000	\$0	
611-00021	20 Foot Deer Guard	EACH		\$75,000	\$0	
611-00028	28 Foot Cattle Guard	EACH		\$90,000	\$0	
	Overpass Structure	SF	11,880	\$400	\$4,752,000	
601-07000	Concrete Retaining Wall	SF	235	\$90	\$21,150	
603-71612	16 x 12 Foot Concrete Box Culvert	LF	215	\$2,500	\$537,500	
608-00020	Concrete Bikeway	SY	287	\$90	\$25,800	
			<i>Bikeway Subtotal</i>	<i>\$584,450</i>		
<b>Total of Quantity Items</b>					<b>\$5,975,674</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$896,351	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		3%	\$ 206,161	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		2%	\$ 137,441	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		10%	\$ 687,203	(E)
601	Structure Aesthetics			1%	\$ 68,720	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 206,161	(G)
613	Lighting			1%	\$ 68,720	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 68,720	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 687,203	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 481,042	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$9,484,000</b>	(L)
	Force Account	10% of (L)		10%	\$ 948,400	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$10,433,000</b>	(N)
	Construction Engineering/Inspection	15% of (K+L)		15%	\$1,564,860	(O)
	Design Engineering	12% of (K+L)		12%	\$1,251,888	(P)
	Permitting				\$41,000	(Q)
	Property Acquisition	SF				(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 13,291,000</b>	
		Annual Inflation		5%		
		Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 15,386,000</b>	
	Ongoing Maintenance - Fence Replacement	50' / year, 20 years		\$38	\$0	
	Ongoing Maintenance - Guard Replacements	3 over 20 years		\$112,500	\$0	
	Maintenance - Assumed 2 structure rehabs		2	\$500,000	\$1,000,000	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 16,386,000</b>	

**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - MP 26.4 Overpass Only**



Prepared On: 6/27/2024

Project Description  
Overpass at Mile Post 26.4.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
203-00060	Embankment Material (Complete In Place)	CY	15,316	\$50	\$765,818	
606-00302	Guardrail Type 3 (31 Inch MGS)	LF	1,000	\$42	\$42,000	
606-02005	End Anchorage (Flared)	EACH	4	\$5,000	\$20,000	
607-11350	Fence Deer	LF		\$25	\$0	
607-60002	Game Ramp	EACH		\$15,000	\$0	
611-00021	20 Foot Deer Guard	EACH		\$75,000	\$0	
611-00029	28 Ft Deer Guard	EACH		\$90,000	\$0	
	Overpass Structure	SF	11,880	\$400	\$4,752,000	
601-07000	Concrete Retaining Wall	SF	935	\$90	\$84,150	
603-71612	16 x 12 Foot Concrete Box Culvert	LF	175	\$2,500	\$437,500	
608-00020	Concrete Bikeway	SY	233	\$90	\$21,000	
			<i>Bikeway Subtotal</i>	<i>\$542,650</i>		
<b>Total of Quantity Items</b>					<b>\$6,122,468</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$918,370	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		3%	\$ 211,225	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		2%	\$ 140,817	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		5%	\$ 352,042	(E)
601	Structure Aesthetics			1%	\$ 70,408	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 211,225	(G)
613	Lighting			1%	\$ 70,408	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 70,408	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 704,084	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 492,859	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$9,365,000</b>	(L)
	Force Account	10% of (L)		10%	\$ 936,500	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$10,302,000</b>	(N)
	Construction Engineering/Inspection	15% of (K+L)		15%	\$1,545,225	(O)
	Design Engineering	12% of (K+L)		12%	\$1,236,180	(P)
	Permitting				\$23,000	(Q)
	Property Acquisition	SF				(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 13,107,000</b>	
		Annual Inflation		5%		
		Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 15,173,000</b>	
	Ongoing Maintenance - Fence Replacement	50' / year, 20 years		\$38	\$0	
	Ongoing Maintenance - Guard Replacements	3 over 20 years		\$112,500	\$0	
	Maintenance - Assumed 2 structure rehabs		2	\$500,000	\$1,000,000	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 16,173,000</b>	

**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - US 36 Fence Only**



Prepared On: 6/27/2024

**Project Description**

Wildlife fencing from Saint Vrain Creek bridge to Left Hand Creek bridge (both sides). Escape ramps each side (2 per mile).  
Deer guards at all driveways and public roads.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
607-11350	Fence Deer	LF	64,086	\$25	\$1,602,150	
607-60002	Game Ramp	EACH	24	\$15,000	\$364,125	
611-00021	20 Foot Deer Guard	EACH	34	\$75,000	\$2,550,000	
611-00029	28 Ft Deer Guard	EACH	5	\$90,000	\$450,000	
<b>Total of Quantity Items</b>					<b>\$4,966,275</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$744,941	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		4%	\$ 228,449	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		4%	\$ 228,449	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		6%	\$ 342,673	(E)
601	Structure Aesthetics			0%	\$ -	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 171,336	(G)
613	Lighting			0%	\$ -	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 57,112	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 571,122	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 399,785	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$7,711,000</b>	(L)
	Force Account	10% of (L)		10%	\$ 771,100	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$8,483,000</b>	(N)
	Construction Engineering/Inspection	15% of (K+L)		10%	\$848,210	(O)
	Design Engineering	12% of (K+L)		12%	\$1,017,852	(P)
	Permitting					(Q)
	Property Acquisition	SF			\$0	(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 10,350,000</b>	
	Annual Inflation			5%		
	Construction Year			2027		
<b>2027 Total Project Cost</b>					<b>\$ 11,982,000</b>	
	Ongoing Maintenance - Fence Replacement	100' / year, 20 years	2,000	\$38	\$76,000	
	Ongoing Maintenance - Guard Replacements	5 over 20 years	5	\$112,500	\$562,500	
					\$0	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 12,620,500</b>	



**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - Fencing and Improvements East of US 36**



Prepared On: 6/25/2024

**Project Description**

Deer fence along: 1) west side of 55th St from Ouray to Nelson; 2) south side of Plateau Rd west of 63rd; 3) overland from Ouray Dr to Boulder Feeder Canal; 4) north side of CO119 from Niwot to Left Hand Creek; 5) west side of Airport Rd from 119 to 2nd driveway. 20' deer guard at each driveway. 28' deer guard across public roads. Wildlife detection warning system on Nelson Road west of 51st.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
607-11350	Fence Deer	LF	28,169	\$25	\$704,225	
607-60002	Game Ramp	EACH	11	\$15,000	\$165,000	
611-00021	20 Foot Deer Guard	EACH	24	\$75,000	\$1,800,000	
611-00029	28 Ft Deer Guard	EACH	7	\$90,000	\$630,000	
613-05151	Wildlife Detection System	EACH	1	\$100,000	\$100,000	
<b>Total of Quantity Items</b>					<b>\$3,399,225</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$509,884	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		4%	\$ 156,364	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		4%	\$ 156,364	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		6%	\$ 234,547	(E)
601	Structure Aesthetics			0%	\$ -	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 117,273	(G)
613	Lighting			0%	\$ -	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 39,091	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 390,911	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 273,638	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$5,277,297</b>	(L)
	Force Account	10% of (L)		10%	\$ 527,730	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$5,805,027</b>	(N)
	Construction Engineering/Inspection	10% of (K+L)		10%	\$580,503	(O)
	Design Engineering	12% of (K+L)		12%	\$696,603	(P)
	Permitting					(Q)
	Permanent Easements	SF	30000	\$3	\$90,000	(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 7,172,133</b>	
		Annual Inflation		5%		
		Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 8,247,953</b>	
	Ongoing Maintenance - Fence Replacement	50' / year, 20 years	1,000	\$38	\$38,000	
	Ongoing Maintenance - Guard Replacements	3 over 20 years	3	\$112,500	\$337,500	
	Ongoing Maintenance - Detection System		5	\$5,000	\$25,000	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 8,648,453</b>	

**Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study**

US 36 Wildlife Crossings Project  
Boulder, Colorado

**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - Fencing Along 55th St / Plateau Rd**



Prepared On: 6/25/2024

**Project Description**

Deer fence along: 1) west side of 55th St from Ouray to Nelson; 2) south side of Plateau Rd west of 63rd; 3) overland from Ouray Dr to Boulder Feeder Canal. 20' deer guard at each driveway. 28' deer guard across public roads.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
607-11350	Fence Deer	LF	13,777	\$25	\$344,425	
607-60002	Game Ramp	EACH	5	\$15,000	\$75,000	
611-00021	20 Foot Deer Guard	EACH	15	\$75,000	\$1,125,000	
611-00029	28 Ft Deer Guard	EACH	1	\$90,000	\$90,000	
613-05151	Wildlife Detection System	EACH		\$100,000	\$0	
<b>Total of Quantity Items</b>					<b>\$1,634,425</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$245,164	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		4%	\$ 75,184	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		4%	\$ 75,184	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		6%	\$ 112,775	(E)
601	Structure Aesthetics			0%	\$ -	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 56,388	(G)
613	Lighting			0%	\$ -	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 18,796	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 187,959	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 131,571	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$2,537,446</b>	(L)
	Force Account	10% of (L)		10%	\$ 253,745	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$2,791,191</b>	(N)
	Construction Engineering/Inspection	10% of (K+L)		10%	\$279,119	(O)
	Design Engineering	12% of (K+L)		12%	\$334,943	(P)
	Permitting					(Q)
	Permanent Easements	SF	30000	\$3	\$90,000	(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 3,495,253</b>	
		Annual Inflation		5%		
		Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 4,019,541</b>	
	Ongoing Maintenance - Fence Replacement	25' / year, 20 years	500	\$38	\$19,000	
	Ongoing Maintenance - Guard Replacements	1 over 20 years	1	\$112,500	\$112,500	
	Ongoing Maintenance - Detection System			\$5,000	\$0	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 4,151,041</b>	

**Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study**

US 36 Wildlife Crossings Project  
Boulder, Colorado

**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - Fencing Along CO 119 Only**



Prepared On: 6/27/2024

**Project Description**

Deer fence along: 1) north side of CO119 from Niwot to Left Hand Creek; 2) west side of Airport Rd from 119 to 2nd driveway.  
 20' deer guard at each driveway. 28' deer guard across public roads.

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost	
<b>Roadway Items</b>						
607-11350	Fence Deer	LF	15,068	\$25	\$376,700	
607-60002	Game Ramp	EACH	6	\$15,000	\$90,000	
611-00021	20 Foot Deer Guard	EACH	10	\$75,000	\$750,000	
611-00029	28 Ft Deer Guard	EACH	4	\$90,000	\$360,000	
613-05151	Wildlife Detection System	EACH		\$100,000	\$0	
<b>Total of Quantity Items</b>					<b>\$1,576,700</b>	(A)
		<b>% Range</b>		<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)		15%	\$236,505	(B)
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%		4%	\$ 72,528	(C)
202	Removals	(0-10%) of (A+B) Default = 8%		4%	\$ 72,528	(D)
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%		6%	\$ 108,792	(E)
601	Structure Aesthetics			0%	\$ -	(F)
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%		3%	\$ 54,396	(G)
613	Lighting			0%	\$ -	(H)
614	Signing and Striping	(1-5%) of (A+B) Default = 5%		1%	\$ 18,132	(I)
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%		10%	\$ 181,321	(J)
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%		7%	\$ 126,924	(K)
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$2,447,826</b>	(L)
	Force Account	10% of (L)		10%	\$ 244,783	(M)
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$2,692,609</b>	(N)
	Construction Engineering/Inspection	10% of (K+L)		10%	\$269,261	(O)
	Design Engineering	12% of (K+L)		12%	\$323,113	(P)
	Permitting					(Q)
	Permanent Easements	SF			\$0	(R)
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 3,284,983</b>	
		Annual Inflation		5%		
		Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 3,777,730</b>	
	Ongoing Maintenance - Fence Replacement	25' / year, 20 years	500	\$38	\$19,000	
	Ongoing Maintenance - Guard Replacements	2 over 20 years	2	\$112,500	\$225,000	
	Ongoing Maintenance - Detection System				\$0	
<b>Total Construction + Ongoing Costs</b>					<b>\$ 4,021,730</b>	

**Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study**

US 36 Wildlife Crossings Project  
 Boulder, Colorado

**Boulder County**  
**US 36 Wildlife Crossings Study**  
**Cost Estimate - Small Animal Enhancements**



Prepared On: 8/16/2024

Project Description  
Improvements to drainage culverts to accommodate crossing by smaller species

Item No.	Quantity Items	Units	Quantity	Unit Cost	Cost
<b>Roadway Items</b>					
	Herpitle Barrier	LF	4,000	\$25	\$100,000
	Small Animal Jumpouts	EACH	36	\$500	\$18,000
	Turnarounds	EACH	36	\$250	\$9,000
	Guidewalls	EACH	16	\$250	\$4,000
	Lighting Grates	EACH	14	\$10,000	\$140,000
	Catwalks	LF	835	\$100	\$83,500
	Backfilling Culvert	EACH	5	\$2,500	\$12,500
	Adding Vegetation	EACH	14	\$5,000	\$70,000
<b>Total of Quantity Items</b>					<b>\$437,000</b>
		<b>% Range</b>	<b>% Used</b>	<b>Cost</b>	
	Contingencies	(15% - 30%) of (A)	15%		\$65,550
201	Clearing and Grubbing	(3-10%) of (A+B) Default = 6%	2%	\$	10,051
202	Removals	(0-10%) of (A+B) Default = 8%	2%	\$	10,051
208	SWMP/Landscape Restoration	(0-10%) of (A+B) Default = 4%	10%	\$	50,255
601	Structure Aesthetics		0%	\$	-
603	Drainage/Utilities	(3-10%) of (A+B) Default = 6%	3%	\$	15,077
613	Lighting		0%	\$	-
614	Signing and Striping	(1-5%) of (A+B) Default = 5%	1%	\$	5,026
630	Construction Signing & Traffic Control	5 to 25% of (A+B) Default = 20%	10%	\$	50,255
626	Mobilization	(4 to 10%) of (A) through (I) Default = 7%	7%	\$	35,179
<b>Total of Construction Bid Items (A+B+C+D+E+F+G+H+I+J+K)</b>					<b>\$679,000</b>
	Force Account	10% of (L)	10%	\$	67,900
<b>Subtotal of Construction Cost (L+M)</b>					<b>\$747,000</b>
	Construction Engineering/Inspection	15% of (K+L)	15%		\$112,035
	Design Engineering	12% of (K+L)	12%		\$89,628
	Permitting				
	Property Acquisition	SF			
<b>2024 Total Project Cost (N+O+P+Q+R)</b>					<b>\$ 949,000</b>
	Annual Inflation		5%		
	Construction Year		2027		
<b>2027 Total Project Cost</b>					<b>\$ 1,099,000</b>
	Ongoing Maintenance - Fence Replacement	250' / year, 20 years	5,000	\$38	\$190,000
	Ongoing Maintenance - Catwalk Replacements	50' / year, 20 years	1,000	\$150	\$150,000
<b>Total Construction + Ongoing Costs</b>					<b>\$ 1,439,000</b>

CBC 6x3.5 Irrig	CBC 5.5x5.5 Irrig	CMP 48" Irrig	48" Drainage	CBC 6x7 Drainage	CBC 6x7 Drainage	48" Drainage	CBC 6x7 Drainage	CBC 6x7 Drainage	Elliptical pipe 4.83x3 Irrig	CBC 6x7 Drainage
21.9	21.9	22.9	23.4	23.6	24.2	24.4	25.5	25.9	26.7	26.8
200	200	400	400	400	400	400	400	400	400	400
2	2	4	4	4	4	4	4	4	0	4
2	2	4	4	4	4	4	4	4	0	4
0	0	2	2	2	2	2	2	2	0	2
2	2	0	0	2	2	0	2	2	0	2
160	155	115	190			115			100	
0	0	0	0	1	1	0	1	1	0	1
0	0	2	2	2	2		2	2	0	2
\$42,500	\$42,000	\$35,000	\$42,500	\$46,000	\$46,000	\$25,000	\$46,000	\$46,000	\$20,000	\$46,000 Base Cost
(A) \$139,948.51	\$138,302.06	\$115,251.72	\$139,948.51	\$151,473.68	\$151,473.68	\$82,322.65	\$151,473.68	\$151,473.68	\$65,858.12	\$151,473.68 Cost Plus Contingencies
\$140,000.00	\$138,000.00	\$115,000.00	\$140,000.00	\$151,000.00	\$151,000.00	\$82,000.00	\$151,000.00	\$151,000.00	\$66,000.00	\$151,000.00 Rounded Cost

The table above summarizes the quantities of each upgrade assumed at each existing culvert. The top rows provide information about the type of structure, size, it use, and the milepost. The numbers in each column indicate the quantity of each item in the table to the left. For example, there is a 6x3.5' concrete box culvert, used for irrigation, at MP 21.9. For that structure, we assume 200 feet of herpitle barrier, 2 small animal jumpouts, 2 turnarounds, 2 lighting grates, and 160 feet of catwalk. Those quantities were multiplied by the unit costs in the table to the left. The total is the Base Cost. All the contingencies were added to the Base Cost to get the Cost Plus Contingencies, which was rounded to get the Rounded Cost



## Appendix B. WVC Analysis

## WVC and Carcass Data

WVC data from 2014 to 2023 between MP 21.6 (SH 66) and MP 27.0 (Nelson Road) was obtained from two sources: CPW carcass data, and CSP crash data (**Table B-1**). There were two instances of duplicate data among the two datasets, which were resolved prior to analysis.

**Table B-1. WVC and Carcass Data**

MP	Elk	Deer	Bird	Raccoon	Skunk	Cat	Prairie Dog	Lion	Cattle	Rabbit	Unknown	Bear	Fox	Non-Ungulates	Total
21.6	0	2	0	0	0	0	0	0	0	0	1	0	0	1	3
21.7	1	0	0	0	0	0	11	0	0	0	1	0	0	12	13
21.8	0	2	0	0	0	0	0	0	0	1	0	0	0	1	3
21.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	2	6	0	3	0	0	0	1	0	0	0	0	0	4	12
22.1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3
22.2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	4
22.3	0	3	0	0	0	0	0	0	0	0	2	0	0	2	5
22.4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
22.5	3	1	0	0	0	0	0	1	0	0	0	0	0	1	5
22.6	1	2	0	1	0	0	0	0	0	0	0	0	0	1	4
22.7	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
22.8	0	2	0	0	0	0	0	0	0	0	2	0	0	2	4
22.9	5	1	0	0	0	0	0	0	0	0	0	0	0	0	6
23	4	10	0	0	0	0	0	0	0	0	1	0	0	1	15
23.1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
23.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
23.4	0	4	0	0	0	0	0	0	0	0	2	0	0	2	6
23.5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3

MP	Elk	Deer	Bird	Raccoon	Skunk	Cat	Prairie Dog	Lion	Cattle	Rabbit	Unknown	Bear	Fox	Non-Ungulates	Total
23.6	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
23.7	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
23.8	1	3	0	0	0	0	0	0	0	0	0	0	0	0	4
23.9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
24	7	13	0	0	0	0	0	0	0	0	1	0	0	1	21
24.1	2	2	0	0	0	0	0	0	0	0	0	2	0	2	6
24.2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3
24.3	1	0	0	0	0	0	0	0	0	0	0	1	0	1	2
24.4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
24.5	11	2	0	1	0	0	0	0	0	0	0	0	0	1	14
24.6	2	3	0	0	0	0	0	0	0	0	0	0	0	0	5
24.7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3
24.8	3	1	0	0	0	0	0	0	0	0	0	0	0	0	4
24.9	7	1	0	0	0	0	0	0	0	0	0	0	0	0	8
25	18	7	0	1	0	0	0	0	0	0	4	0	2	7	32
25.1	5	4	0	0	0	0	0	0	0	0	0	0	0	0	9
25.2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
25.3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
25.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.5	6	2	0	0	0	0	0	0	0	0	3	0	0	3	11
25.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.7	4	1	0	0	0	0	0	0	0	0	0	0	0	0	5
25.8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3
25.9	5	3	0	0	0	0	0	0	0	0	0	0	0	0	8

#### Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study

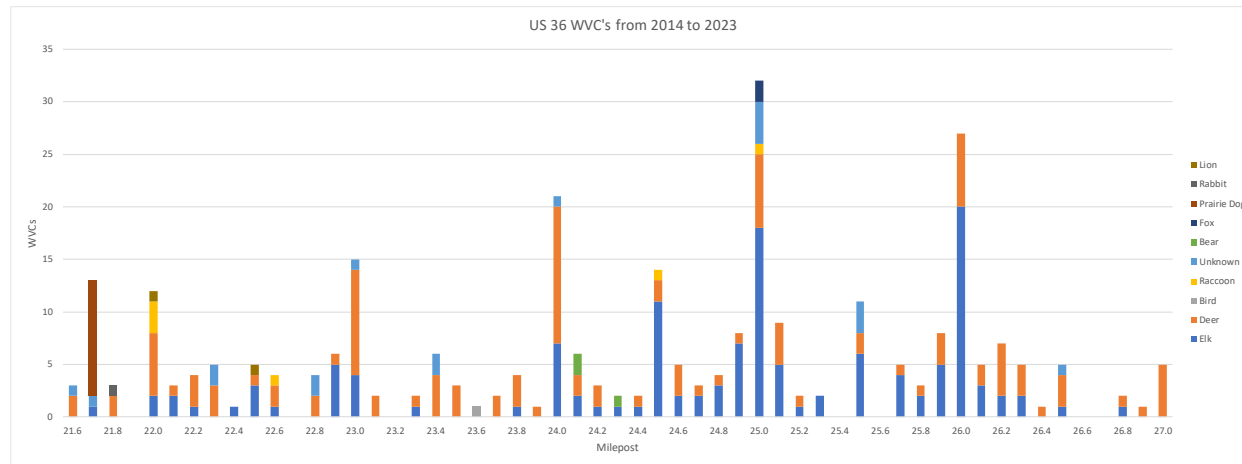
US 36 Wildlife Crossings Project  
Boulder, Colorado

MP	Elk	Deer	Bird	Raccoon	Skunk	Cat	Prairie Dog	Lion	Cattle	Rabbit	Unknown	Bear	Fox	Non-Ungulates	Total
26	20	7	0	0	0	0	0	0	0	0	0	0	0	0	27
26.1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	5
26.2	2	5	0	0	0	0	0	0	0	0	0	0	0	0	7
26.3	2	3	0	0	0	0	0	0	0	0	0	0	0	0	5
26.4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
26.5	1	3	0	0	0	0	0	0	0	0	1	0	0	1	5
26.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
26.9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
27	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5
Total	131	122	1	6	0	0	11	2	1	1	18	3	2		298



Plotting the raw data produced the chart below in **Figure B-1**.

**Figure B-16. U.S. 36 WVCs from 2014 to 2023**

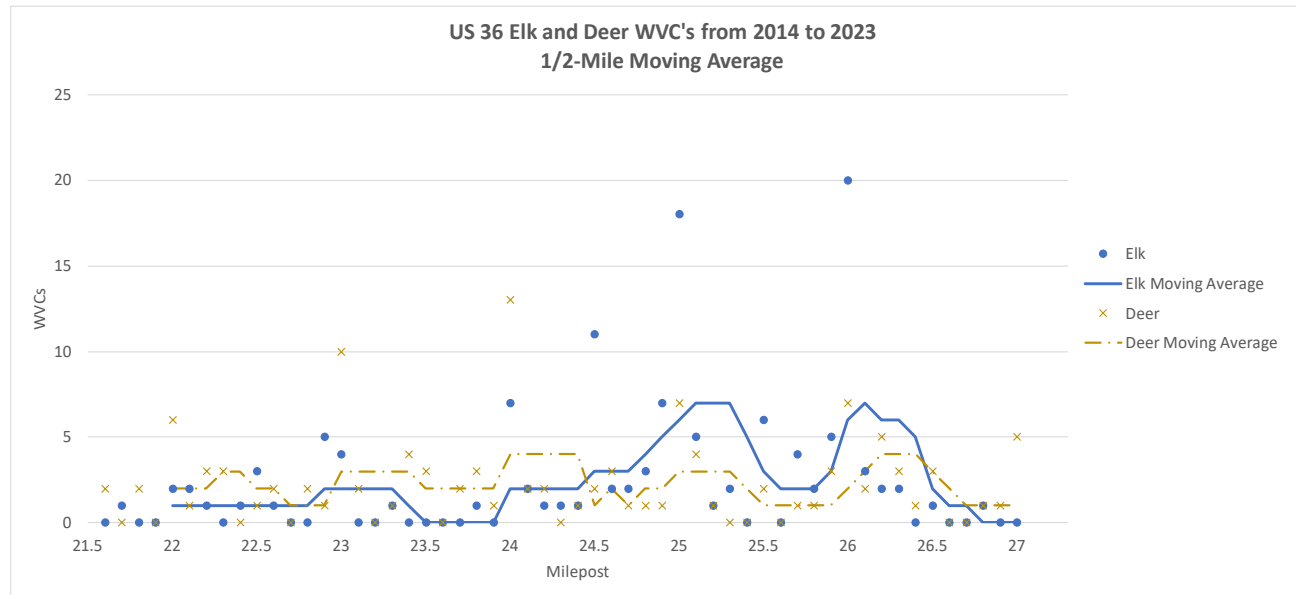


A few features to note in the data:

- The non-ungulate species include raccoon, skunk, cat, prairie dog (11 prairie dog WVCs at MP 21.7), rabbit, mountain lion, and a bird.
- The spikes at each milepost are most likely attributed to rounding when the data was collected.
- The deer WVCs are more uniformly spread throughout the corridor, whereas the elk have significant bumps around MP 25 and MP 26.

To spread out the spikes at each milepost, the design team used a moving average, taking the average of the next half-mile of WVCs, which spreads the spikes into the next half-mile. The results of the moving average are shown in **Figure B-2** below.

**Figure B-17. U.S. 36 Elk and Deer WVCs from 2014 to 2023 1.2-Mile Moving Average**



## Appendix C. Criteria Memos

# Memorandum

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**TO:** Benesch: John Sabo, Matt Salek  
Pinyon: Pam Wegener, Amy Kennedy, Heather Coates  
Boulder County Parks & Open Space: Susan Spaulding, D'Ann Lambert, Sharla Benjamin

**FROM:** JJ Wierema

**SUBJECT:** **US 36 Wildlife Crossing Study - Draft Screening Criteria**

**DATE:** **4/29/2024**

The goal of this study is to develop a list of prioritized projects and concept designs to reduce wildlife-vehicle collisions on US 36, focused on the area between Nelson Road and Hygiene Road (about 3.6 miles). Beyond those limits, we are considering a wildlife crossing about  $\frac{3}{4}$  miles north of Hygiene Road, which may be a good location to terminate the wildlife fencing; we are also considering continuing the wildlife fence as far south as Left Hand Canyon Drive. To methodically evaluate many viable solutions, we will evaluate potential project ideas in two stages: 1) screening, and 2) prioritization.

This memo outlines potential screening criteria and recommends which criteria to use for this study. The criteria come from various sources, and the recommendations to include them are based on our team's past experience with similar studies.

## Screening

We will consider wildlife underpasses at existing drainageways, overpasses in areas where US 36 is in a cut section, and wildlife crossings at locations where there is a high number of wildlife/vehicle collisions (WVC's). The designs will be very high-level, developed sufficiently to qualitatively evaluate them per the selection criteria. The goal of this process is to refine the list of potential projects down to a smaller number, which will be agreed upon by Boulder County Parks & Open Space and the design team.

Anything that would be the same for all the locations, such as the future bikeway or traffic control, that would be ranked the same for all locations in a screening matrix, will not be used as screening criteria. However, these things will be considered in the cost estimates after the screening.

**Table C-1. Screening Criteria**

Criteria	Source of Criteria	Recommended by Benesch /Pinyon for screening	Comments
WVC's and movement data	Wildlife Crossing Pilot Program (WCPP)	X	
Connectivity	WCPP		Any crossings we propose will improve connectivity.

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4/29/2024 | **US 36 Wildlife Crossing Study – Screening Criteria**

## **Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study**

US 36 Wildlife Crossings Project  
Boulder, Colorado



Criteria	Source of Criteria	Recommended by Benesch /Pinyon for screening	Comments
Leveraging investments	WCPP	Possibly. Evaluate after mapping is complete	If the land adjacent to the proposed crossing location is Boulder County Open Space land, then the habitat will remain undisturbed long-term, and ROW or easements required to build the crossing will be at no-cost.
Economic Development and Visitation Opportunities	WCPP		Any crossings we propose will enhance economic development and visitation opportunities because this is the main route from Denver to Estes Park and Rocky Mountain National Park. We are making that route safer.
Innovation	WCPP		Not affected by which crossings we screen.
Education and Outreach	WCPP		Not affected by which crossings we screen.
Monitoring and Research	WCPP		Boulder County has the infrastructure in place to monitor wildlife cameras, which can be installed at any crossing location.
Survival of Species	WCPP	Possibly. Depends on T&E data	Any crossing we propose will promote the survival of the species. We may be able to score better in grant applications if we can mention that we are enhancing the survival of T&E species.
Spacing	WVC Reduction Study: Best Practices Manual and FHWA Wildlife Crossing Structure Handbook	X	Both design guides evaluated 8 corridors that have existing large mammal crossings. The average spacing of the crossings is about 1.3 miles. The spacing ranges between one every 0.5 miles to one every 3.8 miles. BCPOS and the design team will collaboratively determine the appropriate spacing for this corridor.
Environmental clearances and permitting	Used on a past project (Raton Pass) by the design team	Possibly. Evaluate after desktop environmental survey and site visit	The effort for any crossing location will be similar. However, there are some significant waterways where there may be wetlands that could require mitigation or additional permitting.
Qualitative Cost	Used on Raton Pass		The cost is entirely associated with the site feasibility, so this is a redundant criterion.

Criteria	Source of Criteria	Recommended by Benesch /Pinyon for screening	Comments
Site feasibility	Used on Raton Pass	X	This is a judgement call by the design team as to how well the location would accommodate a wildlife crossing compared to the other possible locations.
Constructability	Used on Raton Pass		The constructability is entirely associated with the site feasibility, so this is a redundant criterion.
ROW impacts	Used on Raton Pass	X	Depending on the sentiments of the adjacent landowners, acquiring right-of-way can be challenging and could potentially kill the project.
Likelihood of animal use	Used on Raton Pass		This criterion is going to be highly correlated to WVCs and movement data.
Maintenance access	Used on Raton Pass		This criterion is related to ROW impacts and site feasibility.



# benesch

## Meeting Minutes

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**TO:** Benesch: John Sabo, Matt Salek  
Pinyon: Pam Wegener, Amy Kennedy, Heather Coates  
Boulder County Parks & Open Space: Susan Spaulding, D'Ann Lambert, Sharla Benjamin

**FROM:** JJ Wierema

**SUBJECT:** **US 36 Wildlife Crossing Study - Draft Prioritization Criteria**

**DATE:** **6/5/2024**

The following wildlife crossings (based predominately on elk movement data and WVC info) came out of the screening process:

1. Overpass at MP 22.4
2. Overpass at MP 24.6
3. Underpass at 25.0, which would be in addition to selected overpasses, or as a back up.
4. Overpass at MP 26.4

In addition to the wildlife crossings, fencing, deer guards, escape ramps, and modifying existing drainage structures to better accommodate smaller species will be part of any project. Those elements will be considered separately.

Ideally, all the wildlife crossings could be built at one time, *along with all the fencing* and accommodations for smaller species. However, it is likely that the project will be built in phases as funding is available. To identify which of the crossings above are highest priority, we will evaluate them in a prioritization matrix, which will quantitatively compare them to each other. The purpose of this memo is to outline potential prioritization criteria and recommend which criteria to use for this study. The criteria come from various sources, and the recommendations to include them are based on our team's experience with similar studies.

**Table C-2. Prioritization Criteria**

Criteria	Source of Criteria	Recommended by Benesch /Pinyon for screening	Comments
WVC's	Wildlife Crossing Pilot Program (WCPP)	X	Measured by CSP and CPW data
Connectivity	WCPP	X	Measured by collar data
Leveraging investments	WCPP	X	Boulder County owns open space on one or both sides of US 36. This would differentiate the crossing at 22.4, which has BCPOS land on only one side

Criteria	Source of Criteria	Recommended by Benesch /Pinyon for screening	Comments
Economic Development	WCPP		Any crossings we propose will enhance economic development. It is the main route from Denver to Estes Park and Rocky Mountain National Park. It also is the main route between Lyons and Boulder and will increase working commuter safety.
Innovation	WCPP	Possibly?	Not affected by which crossings we build first.
Education and Outreach/Visitation Opportunities	WCPP		
Monitoring and Research	WCPP	Possibly?	Boulder County has the infrastructure in place to monitor wildlife cameras, which can be installed at any crossing location. This could factor into the crossing at 22.4, which we'd need to get permission to monitor.
Survival of Species	WCPP	Possibly	The WCPP clarifies that this is survival of federally listed species.
Cost	Used on a past project (Raton Pass) by the design team	X	
Benefit/Cost	Used on a Raton Pass	X	The benefits include savings in reduced crashes, accounting for the cost of damage or human injury, and the monetary value of the wildlife to society.
Environment	Used on a Raton Pass	Possibly	Consider the effort required to do the environmental clearance. The crossing at 22.4 is in the PMJM management area. The crossing at 24.6 is also PMJM based on trapping history.
Disruption to Traffic	Used on a Raton Pass		All would be approximately the same
ROW impacts	Used on a Raton Pass		This is the same as leveraging existing investments



Criteria	Source of Criteria	Recommended by Benesch /Pinyon for screening	Comments
Compatibility with Development	Used on a Raton Pass		This is the same as leveraging existing investments
Maintenance access	Used on a Raton Pass		If a maintenance access road must be built, it would be indirectly measured in the cost

## Appendix D. Site Visit Notes

## Meeting Minutes

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Project Name: BCPOS – US 36 Wildlife Study  
Project Number: Benesch 152367.01  
Date of Meeting: May 2, 2024  
Time of Meeting: 8:30 to 2:00  
Meeting Location: On site – US 26 from Nelson Road to Hygiene Road  
Regarding: Site Reconnaissance  
Attendees: Benesch: JJ Wierema, John Sabo  
Pinyon: Amy Kennedy, Heather Coates  
Boulder County Parks & Open Space: Susan Spaulding, Sharla Benjamin, Jonathan DeCoste  
Colorado Parks & Wildlife: Ben Kraft, Joe Padia  
CDOT Region 4: Anne Hoffman

The group met at the corner of Nelson Road and US 36, conducted a safety briefing, and then drove north on US 36 through the entire project corridor to about a mile past Hygiene Road. From there, we visited several sites, traveling southward. We stopped at all the sites recommended in the ESPWPS and a few others. At each site, we photographed the area and documented the existing conditions.

### **Milepost 22.9 (about ¾ mile north of Hygiene Road)**

This site is not on the ESPWPS, but Jon said that he is aware of many elk WVCs here. There is an existing culvert, approximately 5-foot diameter, with about 5 feet of fill above it. The area could potentially be dug out enough to accommodate an elk crossing.

**Photo D-10. Milepost 22.9**



There is a stock pond on the west, and Jon said there used to be one on the east, but it is dry now.



**Milepost 24.4 (1000 feet north of St. Vrain Road)**

This site was identified in the ESPWPS. At this location, the irrigation ditch is on the west side of US 36. The interaction between the drainage and irrigation ditch is complicated. A pipe crosses under the irrigation ditch to convey the drainage, and then another pipe carries the drainage under US 36. This drainage pipe could be expanded to accommodate an elk underpass.

**Photo D-11. Milepost 24.4**



Jon mentioned that there are many elk WVCs in this location. He also mentioned that a crossing here could be less favorable, as it would direct wildlife into an area where they would still have to cross St. Vrain Road to get to Table Mountain.

**Milepost 24.6 (about 450 feet south of St. Vrain Road)**

**Photo D-12. Milepost 24.6**





This site was not identified in the ESPWPS. Jon, Joe, and Ben all agreed that more elk cross here than at MP 24.4. Both resident and migratory elk herds utilize this area. Because of the flat topography on either side of US 36, they have a better line of sight to Table Mountain, which is where they want to graze. Elk cross US 36 back and forth daily here, especially during the winter and spring. Joe prefers a crossing here rather than the drainageway because at this location, the elk do not have to cross St. Vrain Road to get to Table Mountain.

US 36 is in a cut at this location, so a wildlife overpass would fit well here. The topography is flat to the east and west of US 36 here at the top of the roadway cut. The irrigation ditch is far from US 36 and would not interfere with the crossing.

#### **Milepost 25.0 (about 0.4 miles south of St. Vrain Road)**

A drainage culvert crosses under US 36 here. There is over 20 feet of cover. This location is identified in the ESPWPS.

Red Hill is to the west. Ben said that elk and deer cross here every evening from west to east. Deer carcasses were on the ground to the west of this culvert.

**Photo D-13. Milepost 25.0**



The irrigation ditch to the east is about 30 feet down vertically from the roadway surface and the culvert is further down below the ditch. The floor of the wildlife underpass would have to be above the elevation of the ditch.

### **Milepost 25.5**

This location was identified in the ESPWPS. There is an existing 8-foot-tall concrete box culvert here, which has approximately 8 to 10 feet of cover. This box culvert could be expanded to serve as an elk underpass.

**Photo D-14. Milepost 25.5**



The irrigation ditch to the east may be at a higher elevation than the floor of the elk underpass. Further investigation would be needed to determine how the irrigation ditch and wildlife underpass would interact.

### **Milepost 26.3 (about 0.6 miles north of Nelson Road)**

This location was identified in the ESPWPS. There is about 20 feet of fill here, and it may be possible to install an elk underpass.

There is an overhead power line to the east.

### **Milepost 26.4 (about ½ mile north of Nelson Road)**

This location was not identified in the ESPWPS. US 36 is in a cut here, and this is at the southern limit of Boulder County Parks and Open Space property to the east, so it may be a good location for an overpass.



**Photo D-15. Milepost 26.4**



**Photo D-16. Milepost 26.4**





**Milepost 26.8 (about 0.1 mile north of Nelson Road)**

The ESPWPS says that this existing underpass does not have enough cover and cannot feasibly be modified to have more height. The gate can be removed, and wildlife fence can be tied to this structure to serve as a crossing for smaller species and bears.

Jon mentioned that elk do not cross here very often.

**Photo D-17. Milepost 26.8**

**Left Hand Canyon Drive**

The group stopped here because this is potentially a good southern limit for the wildlife fencing. There are houses along the north side of Left Hand Canyon Drive, and the fence could potentially wrap toward the west behind the houses.

Jon said the area behind the houses is owned by the Left Hand Water District.

The above constitutes our understanding of the issues discussed and the conclusions reached. If there are any misunderstandings or omissions, please forward comments/corrections within five business days to the undersigned.

Respectfully submitted,



JJ Wierema, P.E.



## Meeting Minutes

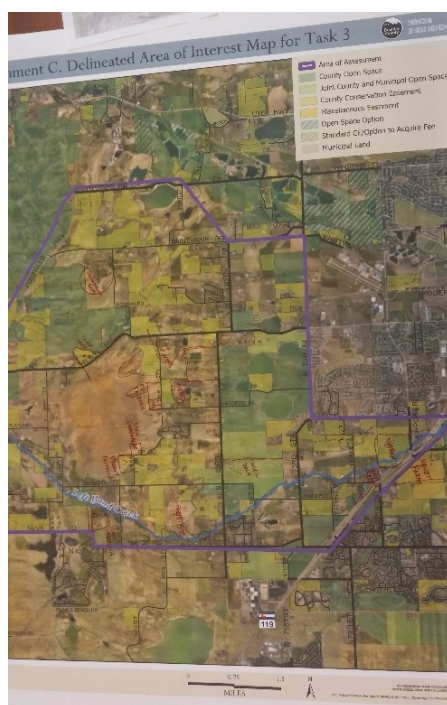
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Project Name: BCPOS – US 36 Wildlife Study  
Project Number: Benesch 152367.01  
Date of Meeting: May 22, 2024  
Time of Meeting: 9:00 to 2:00  
Meeting Location: In Boulder County Parks and Opens Space office, and on site east of US 36 between Nelson Road and SH 119  
  
Regarding: Site Reconnaissance – Fencing Strategies  
Attendees: Benesch: JJ Wierema  
Pinyon: Becky Burink, Dylan Baldassari  
Boulder County Parks & Open Space: Susan Spaulding, Sharla Benjamin, Jonathan DeCoste  
Colorado Parks & Wildlife: Joe Padia

The group met in the office and discussed the elk movements in the area east of US 36. Joe noted several landowners who have complained about elk causing damage to their properties, and marked up a map with several landowner names, approximately outlining their property boundaries.

Joe mentioned that there are two groups of elk: there is a group that migrates back and forth across US 36, and a group that stays to the east of US 36. The resident herd damages crops and property. The county has been issuing hunting vouchers to several property owners in the area in an effort to get the resident herd to migrate, and to reduce its population to a more manageable number.

**Photo D-18. Area of Interest**



## **Nelson Road**

We stopped on Nelson Road, about 0.6 miles west of N 51st Street at an access road. Jon said that the elk cross Nelson Road going from Red Mountain to Table Mountain and back. There is a location just east of this access road where a wildlife underpass may be feasible (shown in the photo), as Nelson Road is on an embankment. To the north of this location is open space; to the south is federal property.

We also discussed the possibility of other non-structural methods to reduce WVCs, including a wildlife detection zone with flashing signs, changing the landscaping to lower speeds.

CPW is working on a MOU with Table Mountain, which includes wildlife fencing. If Table Mountain were to place continuous wildlife fencing along the south side of Nelson Road, then any wildlife crossings the county builds on Nelson Road in this stretch would be ineffective.

The curves on Nelson Road, west of N 51<sup>st</sup> St, have high WVCs because drivers travel at high speeds and there is limited sight distance. Fencing along Nelson Road from US 36 to N 51<sup>st</sup> Street would help reduce the WVCs.

**Photo D-19. Nelson Road**



## **Around Table Mountain**

Jon said that elk come down from the southeast corner of Table Mountain to the north of Oxford Road. The area is shown in the photo to the right.

Jon said that elk spend time near Left Hand Creek to the west of Table Mountain during the summer.

Fencing along the east side of Table Mountain may help to keep elk out of crops and private properties where they are unwelcome.

Jon said that about 120 elk spend winters on the Imel property, which is east of N 63<sup>rd</sup> St between Oxford Rd and Plateau Rd. Elk calve in Left Hand Creek to the southeast of the Imel property.

**Photo D-20. Table Mountain Area**



### **Along SH 119**

The number of deer and elk WVCs on SH 119 has been increasing over the last several years. In general, the east side of SH 119 is private agricultural land and residential, not county-owned open space.

The group agreed that fencing along the west side of SH 119 from Niwot Rd to Left Hand Creek just east of Airport Rd would be a good strategy to prevent WVCs on SH 119. This would allow wildlife to use the Left Hand Creek bridges as a way to cross SH 119.

We walked along Left Hand Creek where it crosses under SH 119 and Airport Road. There is an electric fence crossing Left Hand Creek, just east of Airport Road, as shown in the photo. Its purpose appears to be to restrict wildlife movement through the creek bed, which conflicts with the idea of allowing wildlife to use the bridges as crossings.

**Photo D-21. Left Hand Creek under State Highway 119 and Airport road**



### **Office Debriefing**

We reconvened at the Boulder County Parks and Open Space office to discuss the overall fencing strategy.

Fence along both sides of Nelson Road, from US 36 east to N 51<sup>st</sup> St. The fence on the north side could be behind the homes along Nelson Road. Install a non-structural wildlife crossing on Nelson Road, near where we stopped, about half a mile west of N 51<sup>st</sup> St.

Fence along the east side of Table Mountain, west of N 55th St between Nelson Road and Prospect. A few options were discussed here, listed in order of preference:

1. Put the fence behind the houses, on Table Mountain Property. This will require a MOU with Table Mountain.
2. Put the fence right on the western property line of the private properties.
3. Put the fence along the frontage of N 55<sup>th</sup> St on County ROW.

Fence along the west side of SH 119 from Niwot Rd to Left Hand Creek/Airport Road.

#### **Action Items**

**Table D-1. Action Items**

Item	Responsibility	Due Date
Benesch and Pinyon will develop the fencing plan and we will schedule another site visit to vet the plan and resolve any questions.	Benesch/Pinyon	6/6

The above constitutes our understanding of the issues discussed and the conclusions reached. If there are any misunderstandings or omissions, please forward comments/corrections within five business days to the undersigned.

Respectfully submitted,



JJ Wierema, P.E.