Blackfeet Animal-Vehicle Collision Reduction Master Plan:

Enhancing Safety and Connectivity for People and Animals

By:

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A report prepared for the

Blackfeet Nation Fish and Wildlife Department

24 Starr School Rd, Browning, MT 59417

November 26, 2019

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Suggested Citation:

Fairbank, E.R., Callahan, A.R., Creech, T., Huijser, M.P., and Ament, R. 2019. Blackfeet Nation Animal-Vehicle Collision Reduction Master Plan. Center for Large Landscape Conservation, Bozeman, MT.

ACKNOWLEDGEMENTS

The authors of this report would like to thank the Federal Highway Administration Tribal Transportation Program (FHWA-TTP) for funding this project. We also thank the Blackfeet Nation Fish and Wildlife Department and the Blackfeet Nation Lands Department and their staff for providing data and other information critical to this effort. We would like to further recognize Cassie Powell from the Blackfeet Nation Fish and Wildlife office for her continued support and coordination throughout the course of this work. In addition, we would like to thank our tribal liaison, Ardis Dayrider, as well as Brandon Kittson (recently graduated from Salish Kootenai College) and Tabitha Graves (United States Geologic Survey) for sharing the data collected for Mr. Kittson's student thesis. Another big thank you to our Technical Advisory Team, and to Jacob Levitus for helping out with various aspects of this project, and for the photo used on the cover.

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EXECUTIVE SUMMARY

The U.S. has an estimated 1-2 million animal-vehicle collisions (AVCs) occur each year at an estimated cost of $8.4 billion annually (Huijser et al. 2008; Sullivan 2011). Crashes resulting in human injuries and fatalities have been documented to be higher for Native Americans than for any other groups in the U.S. (Shinstine et al., 2015). Tribal transportation stakeholders recognize that there are many factors that make addressing highway safety difficult for tribes including: lack of resources, lack of crash data, poor data accuracy, and the challenges of working across jurisdictional lines with state, local, and federal agencies (Shinstine et al., 2015).

From 1996-2012, the Blackfeet Tribe Motor Vehicle Crash Site Identification Project identified 385 collisions that involved domestic (n=291) and wild (n=94) animals, ranking them as the third and fourth most common causes, respectively, of motor vehicle crashes on the Blackfeet Reservation. In addition to the human costs associated with AVCs, roads and traffic are also a serious concern for wildlife habitat connectivity and biological conservation.

This project represents the first Reservation-wide AVC study, which identifies, prioritizes, and proposes mitigation measures for road stretches with the highest incidence of AVCs. In addition to crash and carcass data (i.e. animal mortality data), the resulting AVC Reduction Master Plan also incorporates animal movement data and connectivity modeling output to identify areas on the Reservation with the greatest conservation value, where preserving connectivity across roads is critical for wildlife, and where wildlife are most likely cross roads and encounter vehicle traffic on a regular basis.

Our initial screening of Reservation roads identified 42 mile segments as having high value across prioritization characteristics or exceptionally high value for any single characteristics. These segments were clustered in 15 distinct stretches of road that ranged in length from 1 to 5 miles. Many stretches included road segments that were identified as high priority based on multiple characteristics. The majority of the priority stretches occurred along US 89 and US 2, the two roads with the highest traffic volumes within the Reservation.

A Technical Advisory Team made up of local and regional wildlife and transportation agency staff, and road ecology experts visited each of the 15 priority stretches and developed the site-specific mitigation recommendations contained in this report. The researchers also present recommendations to address livestock AVCs on off-system routes, which were not prioritized in the analysis due to the lack of available data, but which were repeatedly brought up as high risk areas in our public meetings. In addition, we present a cost-benefit analysis, potential funding sources for implementing the recommended mitigation measures, as well as identifying policy and enforcement challenges and solutions for addressing livestock AVCs.

The final AVC Reduction Master Plan provides direction and is intended to serve as a blueprint for the Blackfeet Nation, which may then propose specific collision-reducing mitigation projects for further development, design, and construction.

1. INTRODUCTION

1.1. Background

Vehicle collisions with large animals are a frequent occurrence in many parts of the world (Farrell and Tappe 2007; Grilo et al. 2018; Jeganathan et al. 2018) and can result in animal mortality, property damage, and human injuries or fatalities (Bissonette et al. 2008; Huijser et al. 2008). In the United States, animal-vehicle collisions (AVCs) and associated human fatalities have increased by at least 50 percent since 1990. The U.S. has an estimated 1-2 million AVCs occur each year at an estimated cost of $8.4 billion annually (Huijser et al. 2008; Sullivan 2011).

Crashes resulting in human injuries and fatalities have been documented to be higher for Native Americans than for any other groups in the U.S. (Shinstine et al., 2015). Tribal transportation stakeholders recognize that there are many factors that make addressing highway safety difficult for tribes including: lack of resources, lack of crash data, poor data accuracy, and the challenges of working across jurisdictional lines with state, local, and federal agencies (Shinstine et al., 2015).

From 1996-2012, the Blackfeet Tribe Motor Vehicle Crash Site Identification Project identified 385 collisions that involved domestic (n=291) and wild (n=94) animals, ranking them as the third and fourth most common causes, respectively, of motor vehicle crashes on the Blackfeet Reservation. Collisions with domestic animals (n=3) ranked as the third highest cause of human fatality-related crashes, and collisions with domestic (n=113) and wild animals (n=20) ranked as the third and seventh highest causes of human injury-related crashes on the Reservation during the same period. These data do not include unreported collisions.

In addition to the human costs associated with AVCs, roads and traffic are also a serious concern for wildlife habitat connectivity and biological conservation. The Blackfeet Nation is located in northern Montana east of Glacier National Park along the Canadian border and supports a high diversity of wildlife species, partly due to its location in the transition zone between the Northern Great Plains and the Rocky Mountains and relatively abrupt elevation changes (Blackfeet CEDS, 2018). The Reservation provides a variety of wildlife habitats, including conifer forests of various ages, extensive aspen stands interspersed with meadows and riparian areas, prairie potholes, native grasslands, and agricultural crop land. It is home to moose, elk, grizzly bear, black bear, mule deer, swift fox, and many other species (Blackfeet CEDS, 2018). In addition to addressing the human safety concerns associated with AVCs, this project also seeks to identify areas where the road network intersects critical corridors that provide habitat connectivity for the Blackfeet Nation’s diverse wildlife, which are culturally, spiritually, and economically important to the people of the Blackfeet Nation (Blackfeet CEDS, 2018).

1.2. Differences in AVCs: Livestock vs Wildlife

Much of what is known about AVCs comes from the scientific discipline of road ecology, which has developed rapidly over the past several decades and seeks to understand and mitigate the impacts of roads on ecological systems (Spellerberg 1998; Forman et al. 2003; Van der ree et al.

2015). Most road ecology research focuses on vehicle collisions with wildlife species, especially large ungulates such as whitetail deer, mule deer, elk, and moose, which account for the vast majority of AVCs in North America (Huijser et al. 2008). Collisions with domestic livestock (e.g., cattle, horses, and sheep) are typically not differentiated from collisions with wildlife in data collection systems used by transportation departments, law enforcement agencies, natural resource agencies, and motor vehicle insurance companies. In most scientific analyses, collisions with domestic animals are either lumped together with collisions involving wildlife or are excluded altogether. This lack of differentiation between domestic animal-vehicle collisions (DAVCs) and wildlife-vehicle collisions (WVCs) is also common among traffic safety studies conducted by transportation agencies and public health researchers, and limits our understanding of where, when, and how frequently DAVCs occur, and whether these patterns differ from those for WVCs.

Recent research by the Center for Large Landscape Conservation and the Western Transportation Institute at Montana State University (Creech et al. *in Press*) indicates that DAVCs and WVCs in Montana differ with respect to timing, location, and frequency. WVCs exhibit two diel peaks (dawn and dusk) versus only one prominent peak (late evening/early night) for DAVCs. Statewide, DAVCs are over-represented relative to WVCs in most eastern Montana counties and are under-represented in most western Montana counties. At finer spatial scale (i.e., 1-mile road segments), WVC and DAVC hotpots do not show strong overlap in many areas. Perhaps most relevant to this study, the Blackfeet Reservation is a major outlier with respect to the proportion of AVCs involving domestic animals; *while DAVCs account for only 7 percent of AVCs statewide, they account for 59 percent of AVCs on the Blackfeet Reservation* (Creech et al. *in press*) These findings suggest that DAVCs warrant greater attention on the Reservation and may represent a high priority for management and mitigation measures. In addition to being relatively common on the Reservation, DAVCs are more dangerous to motorists on a per-collision basis than WVCs.

For these reasons, we treat DAVCs and WVCs independently in this report. This is critical because DAVC and WVC hotspots may occur in different locations along the Reservation's road network, and the most appropriate mitigation measures for DAVC hotspots may differ from those for WVC hotspots. We take these distinctions into account in our site-specific recommendations.

1.3. Project Goal and Tasks

Although there is interest in the Blackfeet community in reducing collisions between motorists and animals, there is currently no Reservation-wide assessment of the highest-priority road stretches to mitigate for high rates of AVCs. Without such a priority list, it is difficult to determine the best locations to invest scarce tribal transportation safety dollars to help reduce AVCs on the Reservation. The Animal-Vehicle Collision Reduction Project described in this report seeks to fill that gap by developing the first Reservation-wide Animal-Vehicle Collision Reduction Master Plan, which identifies, prioritizes, and proposes mitigation measures for road stretches with the highest incidence of AVCs. This report also incorporates animal movement data and connectivity modeling output to identify areas on the Reservation with the greatest conservation value, where preserving connectivity across roads is critical for wildlife, and where wildlife are most likely cross roads and encounter vehicle traffic on a regular basis.

The final ***Animal-Vehicle Collision Reduction Master Plan*** provides direction and serves as a blueprint for the Blackfeet Nation, which may then propose specific collision-reducing mitigation projects for further development, design, and construction. The tribe's consultation with local, state, and federal agencies, as well as with tribal members and local citizens, and other interested stakeholders was critical during plan development. The plan also considers and incorporates all wildlife and road safety data and information that was available at the time of its development. Finally, the plan also draws on (1) traditional ecological knowledge collected and compiled through public meetings and a mapping exercise, and (2) results of a field evaluation of priority road stretches conducted by a Technical Advisory Team of researchers, tribal, state, and local biologists, engineers, and transportation experts.

Project Tasks included:

1. Gathering and synthesizing existing AVC data
2. Holding a public meeting and conducting a mapping exercise to get feedback from community members on AVC locations and animal movement data
3. Identifying priority road stretches for implementing mitigation
4. Conducting field evaluation of priority road stretches
5. Recommending site-specific mitigation measures to reduce collisions
6. Conducting cost-benefit analysis for mitigation measures
7. Identifying potential funding sources for implementing mitigation measures

2. METHODOLOGY

2.1. Study area

The study focused on a subset of roads within the Blackfeet Reservation for which adequate data were available for identifying high-priority mitigation sites. We included all roads maintained by the Montana Department of Transportation (MDT), often referred to as "On-System" routes. We also included several paved "Off-System" routes identified as problematic for AVCs in initial scoping discussions with tribal members. A full list of study roads and their characteristics can be found in Table 1. When identifying priority locations for mitigation, we used mile segments – i.e., segments of road between consecutive mile markers – as our spatial unit of analysis. Most of the study roads had physical reference markers (i.e., roadside mile posts) that we used to define mile segments. However, some Off-System roads either lacked physical reference markers or we were unable to obtain geographic coordinates for reference markers because those roads were inaccessible at the time of the analysis (Table 1); in these cases, we created virtual reference markers in a Geographic Information System (GIS) at one-mile increments. *It is important to note that results for these roads do not align with any existing physical markers, and coordinates of virtual markers must be used to locate mile segments along these roads.*

Table 1. Description of roads included in Blackfeet AVC reduction study.

Road name	Length within Reservation (miles)	Reference markers[1]
US Highway 89	75.0	Physical
US Highway 2	49.0	Physical
Montana Highway 464 (Duck Lake Road)	33.6	Physical
Heart Butte Road	31.3	Physical
Montana Highway 213 (Chalk Butte Rd)	29.7	Physical
Montana Highway 358 (Cutbank-Valier Highway)	20.4	Physical
Montana Highway 444 (Meriwether Road)	19.8	Physical
Starr School Road	13.4	Physical
Birch Creek Road	12.5	Virtual
Badger Creek Road	12.0	Physical
Montana Highway 49 (Looking Glass Road)	11.7	Virtual
Montana Highway 17 (Chief Mountain International Highway)	10.7	Virtual
Many Glacier Road	4.8	Virtual

[1] "Physical" reference markers are those for which a roadside marker is physically present. "Virtual" reference markers were created in a GIS for roads that lacked physical markers for the purposes of this study only.

2.2. Data sources

We acquired a diversity of data sets to inform our analyses of AVC risk on the Blackfeet Reservation. These data sets could be roughly classified into five categories: (1) law enforcement records from AVCs; (2) records of animal carcasses observed along roads; (3) observations of live animals on or near roads; (4) observations of animal trails along roads; and (5) other ecological data such as wildlife telemetry locations, habitat models, and connectivity models. In addition to standard data sources used in AVC research (e.g., natural resource agency records, transportation department records, scientific publications), we solicited information from local residents on locations of animal-vehicle conflict along Reservation roads. This "traditional ecological knowledge" (TEK) shared by residents largely fell into the aforementioned categories (carcass, live animal observations, and wildlife habitat observations) and was based on both long-term experiences and recollection of individual events.

Data sources varied with respect to temporal extent, spatial extent, locational accuracy, and number of observations. Information on these and other characteristics is provided for each data set in Table 2. Below, we briefly describe the data sets in each of the aforementioned categories. All data labelled as Traditional Ecological Knowledge (TEK) was collected during a public meeting, held at the Blackfeet Community College in spring of 2019, where the researchers conducted a community mapping exercise. During this mapping exercise residents and members of the local community were asked to identify points on large maps of the Reservation where they are seeing animals (alive or dead) on or near roads. We had over 160 data points collected through the community mapping exercise, which was extremely informative particularly for off-system routes (not maintained by MDT) where there was very little available data on AVCs aside from the Montana Highway Patrol crash records.

Crash data: We obtained Montana Highway Patrol (MHP) records for crashes occurring from 2008-2017 within the Reservation via a data request submitted to MDT. These records included the date, time, location, and animal type (domestic versus wildlife) of all AVCs to which MHP responded. We calculated the number of recorded wildlife crashes and the number of recorded domestic animal crashes within each road mile segment as metrics of AVC risk.

Carcass data: We obtained data on animal carcasses observed along Reservation roads from five sources: (1) MDT maintenance personnel records from 2008-2017, which only covered On-System routes that MDT is responsible for maintaining; these records may also be biased by spatially inconsistent sampling effort; (2) records of wildlife and domestic animal carcasses removed from roads by Blackfeet Fish & Wildlife Department (BFWD) game wardens from 2014-2018; (3) records of livestock carcasses removed from roads by Blackfeet Lands Department (BLD) staff in 2018, typically in response to reports from local residents; (4) information on carcasses observed by local residents (i.e., TEK); (5) Records of wildlife carcasses recorded by Blackfeet agency personnel using the Tribal Roadkill Observation and Data System (ROaDS) smart phone application in 2018-2019 (though some technical difficulties reduced the number of data collectors that were able to contribute).

Live animal observations: We obtained records of observations of live animals on or near roads from four sources: (1) BFWD records of live wildlife observations from 2014-2018; (2) BLD observations of live livestock from 2018; (3) information on live wildlife or livestock observed by local residents (TEK); (4) observations of live wildlife and domestic animals recorded by Blackfeet agency personnel using the Tribal ROaDS smart phone application in 2018-2019 (though some technical difficulties reduced the number of data collectors that were able to contribute).

Animal trails: Data from transect surveys for animals trails along portions of Chief Mountain International Highway and US 89 were provided by Brandon Kittson, a Blackfeet tribal member and recent Salish Kootenai College graduate. Mr. Kittson collected these data as part of his undergraduate thesis (Kittson 2019). In addition, we supplemented these data with a small number of animal trail observations made along U.S. Highway 2 west of the town of East Glacier by Becca Holdhusen using a similar methodology. Animal trails data did not distinguish between trails made by domestic animals and those made by wildlife.

Other ecological data: We obtained telemetry data from BFWD for eight grizzly bears outfitted with GPS collars from 2016-2018 and used telemetry locations to infer locations of road crossings. We converted locations into movement paths by assuming straight-line travel between consecutive telemetry fixes, limiting our analysis to fixes separated by less than eight hours to minimize potential deviation from assumed straight-line paths. We then determined where these inferred movement paths intersected the road network (i.e., approximate locations of grizzly bear crossings).

We used geospatial data from Krosby et al. (2018) on riparian climate corridors to determine where roads intersect riparian zones that are likely to facilitate climate-induced species range shifts. This data set included a resiliency index for each riparian zone based on its ability to facilitate range shifts and serve as a climate micro-refugium, which was estimated based on the temperature gradient along its length and its degree of canopy cover, solar insolation, and human modification.

We used geospatial data from Dickson et al. (2016) on ecological connectivity to determine where roads intersect major dispersal corridors. This data set was the product of a Circuitscape analysis of species-neutral connectivity among large protected areas within the western U.S., and it generated a connectivity value for each landscape pixel reflecting its estimated contribution to West-wide connectivity. Movement was assumed to be more difficult through areas with more rugged topography and higher degree of human modification.

Finally, we received information from local residents (TEK) through the community mapping exercise regarding the presence of wildlife habitat along the road network. Observations were classified as pertaining to movement habitat, denning/nesting habitat, or general habitat.

Table 2. Description of data sets used in analysis.

Data set	Description	Sampling period	Spatial extent	Sample size[1]	Precision[2]
MDT wildlife carcasses	Carcasses of wildlife recorded by Montana Dept. of Transportation maintenance personnel	2008-2017	On-system routes	142	Good
MDT domestic animal carcasses	Carcasses of domestic animals recorded by Montana Dept. of Transportation maintenance personnel	2008-2017	On-system routes	69	Good

Data set	Description	Sampling period	Spatial extent	Sample size[1]	Precision[2]
MHP wildlife crashes	Records of vehicle collisions with wildlife from Montana Highway Patrol	2008-2017	All study roads	131	Good
MHP domestic animal crashes	Records of vehicle collisions with domestic animals from Montana Highway Patrol	2008-2017	All study roads	181	Good
BFWD wildlife carcasses	Records of wildlife carcasses reported to Blackfeet Fish & Wildlife Dept.	2014-2018	All study roads	14	Moderate
BFWD domestic animal carcasses	Records of domestic animal carcasses reported to Blackfeet Fish & Wildlife Dept.	2014-2018	All study roads	9	Moderate
BFWD wildlife alive on road	Records of live wildlife on or near roads reported to Blackfeet Fish & Wildlife Dept.	2008-2009, 2015-2018	All study roads	6	Moderate
BLD domestic animals alive on road	Records of live domestic animals on or near roads reported to Blackfeet Lands Dept.	2018	All study roads	171	Moderate
BLD domestic animal carcasses	Records of domestic animal carcasses reported to Blackfeet Lands Dept.	2018	All study roads	31	Moderate
Grizzly bear telemetry	GPS collar locations from telemetry study of 8 grizzly bears	2016-2018	All study roads	341[3]	Poor[4]
Animal trail surveys	Records of animal trails observed along portions of US 89, MT 17, and US 2 during surveys conducted primarily for Brandon Kittson's undergraduate thesis research	2016 (US 2 data); 2017 (MT 17 and US 89 data)	MT 17; US 89 (MP8-31); US 2 (East Glacier to western boundary)	349	Good
TEK - wildlife carcasses	Locations of wildlife carcasses/AVCs as identified by tribal members and local residents	Not specified	All study roads	16	Poor
TEK - domestic animal carcasses	Locations of domestic animal carcasses/AVCs as identified by tribal members and local residents	Not specified	All study roads	32	Poor
TEK - domestic animals alive on road	Locations of domestic animal carcasses/AVCs as identified by tribal members and local residents	Not specified	All study roads	146	Poor
TEK - wildlife alive on road	Locations of wildlife sightings on/near roads as identified by	Not specified	All study roads	101	Poor

Data set	Description	Sampling period	Spatial extent	Sample size[1]	Precision[2]
	tribal members and local residents				
TEK - wildlife habitat	Locations of wildlife movement corridors, general habitat, and denning/nesting habitat as identified by tribal members and local residents	Not specified	All study roads	43	Poor
Ecological connectivity	Estimated value for facilitating ecological flows (e.g., wildlife movement) between protected areas in the western U.S., from Dickson et. (2016)	NA	Reservation-wide	NA	Moderate[5]
Riparian climate corridors	Estimated value of riparian corridors for facilitating climate-induced species range shifts, from Krosby et al. (2018)	NA	Reservation-wide	NA	Moderate[5]
ROaDS app wildlife carcasses	Records of wildlife carcasses submitted by local residents using the Tribal ROaDS smart phone application	2019	All study roads	5	Good
ROaDS app wildlife alive on road	Records of live wildlife on or near roads submitted by local residents using the Tribal ROaDS smart phone application	2019	All study roads	16	Good
ROaDS app domestic animals alive on road	Records of live domestic animals on or near roads submitted by local residents using the Tribal ROaDS smart phone application	2019	All study roads	44	Good

[1] Sample size is the total number of observations (e.g., carcasses, crashes, live animal sightings) along study roads. Note that observations spanning multiple mile segments were counted once for each 1-mile road segment within the indicated stretch of road.
[2] A rough categorical estimate of locational error associated with data set. **Good:** location recorded at time of observation with GPS coordinates. **Moderate:** location recorded at time of observation with road reference marker to nearest mile or with detailed location description based on local landmarks. **Poor:** location estimated based on memory of past events.
[3] Number of grizzly bear road crossings inferred from ~11,000 telemetry locations.
[4] Although raw grizzly bear data include precise GPS coordinates, this data set was considered to be of poor precision because the analysis used inferred locations of road crossings between consecutive animal relocations up to 8 hours apart, which were estimated with potentially large error based on assumption of straight-line travel.
[5] Data set consists of connectivity model output rather than locations of specific events, and was assigned to the moderate precision category based on the spatial resolution of the model.

2.3. Indices of road segment importance

We used each of the data sets described above to generate a road mile segment-level index of importance as a potential mitigation location. Data of the same type but from different sources (e.g., MDT carcass data and BLD carcass data) were analyzed separately but used the same index. Indices were calculated for data types as follows:

Crash data: We calculated the number of recorded wildlife crashes or domestic animal crashes within each road mile segment as an index of AVC risk.

Carcass data: We calculated the number of recorded wildlife carcasses or domestic animal carcasses within each road mile segment as an index of AVC risk. In rare cases where a record indicated multiple carcasses observed at a particular location and time, we treated each carcass as an independent observation.

Live animal observations: We calculated the number of recorded wildlife observations or domestic animal observations within each road mile segment as an index of animal use intensity. Many live animal observation records indicated that multiple animals were observed simultaneously (e.g., a herd of cattle crossing a road); we treated these as a single observation rather than independent observations for each individual animal.

Animal trails: We calculated the number of recorded animal trails along each road mile segment as an index of animal use intensity. We were not able to distinguish between trails created by wildlife versus domestic animals.

Other ecological data: We calculated the number of grizzly bear paths intersecting each road mile segment (i.e., number of inferred road crossings by bears) as an index of grizzly bear road use. We calculated the maximum resiliency index value from Krosby et al. (2018) of any riparian zones intersecting each road mile segment as an index of potential importance for climate change adaptation. We calculated the maximum connectivity value from Dickson et al. (2016) of the landscape pixels overlapping each road mile segment as an index of importance for general connectivity. We calculated the number of habitat observations by local residents per road mile segment as an index of wildlife habitat presence.

Records from some data sets (e.g., live animal observations, habitat observations) contained locational information that spanned multiple road mile segments. For instance, a herd of cows may have been recorded between mile markers 10 and 13 along a road. In such cases, we attributed the record individually to each road mile segment contained within the reported segment of road.

Most of our indices were based on counts of events (i.e., crashes, carcasses, live animals) observed within road mile segments. However, distances between consecutive physical reference markers were not always 1 mile along study roads (mean=0.98; range=0.14-2.42 miles), which could lead to biased comparisons among road mile segments of different lengths. To adjust for this bias, we divided the count within each road mile segment by the length of the segment, such that index values were expressed as counts per mile within each segment, regardless of its actual length. This procedure was applied to all datasets except the riparian climate corridor and ecological connectivity datasets, for which indices were not based on counts per linear unit and thus did not require this bias correction.

Many of our data sets contained records with unknown spatial precision or with significant locational error; for instance, locations of live animal observations or carcasses were often recorded only to the nearest mile marker, and in some cases only a description of a nearby landmark was provided. To account for this spatial uncertainty, we applied a moving window approach to most of our data sets, in which the index value for each road segment was recalculated as the mean of the values for that segment and its two neighboring segments. This smoothing function resulted in a more realistic representation of spatial uncertainty and minimized any effect of observations occurring at segment boundaries. Only the data sets based on ecological models (riparian climate corridors, ecological connectivity) were exempted from this procedure because they were not derived from error-prone observations of events.

2.4. Initial screening of priority road segments

We used the segment-level indices derived from data sets described above to identify an initial set of high-priority road segments for possible mitigation measures. This screening approach was necessary to narrow the scope of the subsequent field evaluation to a reasonably small set of sites to visit. We developed seven prioritization characteristics representing different reasons for considering a segment to be an important mitigation target: 1) wildlife-vehicle collision risk, 2) domestic animal vehicle-collision risk, 3) total AVC risk, 4) live wildlife on/near roads, 5) live domestic animals on/near roads, 6) all live animals on/near roads, and 7) regional conservation value. Characteristics are described in more detail in Table 3. Each characteristic was informed by a different subset of the 21 available data sets (Table 4).

Table 3. Description of prioritization characteristics.

Characteristic	Description	Evaluation method
WVC risk	Frequency of collisions with wildlife	Data analysis
DAVC risk	Frequency of collisions with domestic animals	Data analysis
Total AVC risk	Frequency of collisions with all animals	Data analysis
Live wildlife on/near roads	Intensity of wildlife use of roads and roadside environments	Data analysis
Live domestic animals on/near roads	Intensity of domestic animal use of roads and roadside environments	Data analysis
All animals on/near roads	Intensity of all animal use of roads and roadside environments	Data analysis
Regional conservation value	Contribution to regional conservation (if mitigated) by serving as a movement corridor or high-quality wildlife habitat at the regional scale	Data analysis
Local conservation value	Contribution to regional conservation (if mitigated) by serving as a movement corridor or high-quality wildlife habitat at the local scale	Field
Mitigation options	Type and engineering feasibility of mitigation measures that could be implemented	Field
Barrier effect	Degree of negative impact on wildlife movement potential due to high traffic volume or non-wildlife-friendly fencing	Field

Characteristic	Description	Evaluation method
Land security	Presence/absence of “secured” land (e.g., state, federal, private conservation easement) on both sides of road to allow for effective crossing structures	Field
Vulnerability	Potential for future increase in AVC risk or negative impact to wildlife due to increased speed limit, traffic volume, road width, or number of lanes	Field

[1] Characteristics evaluated using data analysis were assigned continuous values. Characteristics evaluated in the field were assigned to categories.

Table 4. Data sets used to calculate segment-level importance index for each prioritization characteristic. An "X" indicates that the data set in that row was included in calculations for the characteristic in that column.

Data set	WVC risk	DAVC risk	Total AVC risk	Live wildlife on/near road	Live domestic animals on/ near road	All live animals on/ near road	Regional conservation value
Animal trails along roads[1]							
Blackfeet F&W domestic animal carcasses		X	X				
Blackfeet F&W wildlife carcasses	X		X				
Blackfeet F&W wildlife alive on/near road				X		X	
Blackfeet Lands Dept. domestic animal carcasses		X	X				
Blackfeet Lands Dept. domestic animals alive on/near road					X	X	
Ecological connectivity among protected areas							X
Grizzly bear telemetry inferred road crossings							X
MDT domestic animal carcasses		X	X				
MDT wildlife carcasses	X		X				
MHP domestic animal crashes		X	X				
MHP wildlife crashes	X		X				
Riparian climate corridors							X
Traditional ecological knowledge - domestic animal carcasses		X	X				
Traditional ecological knowledge - wildlife carcasses	X		X				
Traditional ecological knowledge - wildlife habitat							X
Traditional ecological knowledge - domestic animals alive on/near road					X	X	

Data set	WVC risk	DAVC risk	Total AVC risk	Live wildlife on/near road	Live domestic animals on/ near road	All live animals on/ near road	Regional conservation value
Traditional ecological knowledge - wildlife alive on/near road				X		X	
Tribal ROaDS smart phone application - wildlife carcasses	X		X				
Tribal ROaDS smart phone application - domestic animals alive on/near road					X	X	
Tribal ROaDS smart phone application - wildlife alive on/near road				X		X	

[1] Data set has limited spatial coverage and it is not clear whether animal trails should be considered evidence of AVC risk, potential wildlife crossings, or both. Accordingly, we used it to confirm priority locations suggested by other data sets, and not as part of our initial site selection process.

Table 5. Characteristics of individual road mile segments within priority stretches. An "X" indicates that the segment in that row was considered high priority for the characteristic in that column.

			PRIORITY CHARACTERISTIC							
Priority stretch ID	**Route name**	**Reference marker (start of mile segment)**	**Composite**	**Regional conservation value**	**WVC risk**	**DAVC risk**	**Total AVC risk**	**Live wildlife on/near road**	**Live domestic animals on/near road**	**All animals on/near road**
1	Heart Butte Rd	14		X						
	Heart Butte Rd	15		X						
2	MT 49 (Lookingglass Rd)	2		X						
3	Rte 358 (Cutbank-Valier Hwy)	16		X						
4	Rte 464 (Duck Lake Rd)	31	X			X				

			PRIORITY CHARACTERISTIC							
Priority stretch ID	**Route name**	**Reference marker (start of mile segment)**	**Composite**	**Regional conservation value**	**WVC risk**	**DAVC risk**	**Total AVC risk**	**Live wildlife on/near road**	**Live domestic animals on/near road**	**All animals on/near road**
	Rte 464 (Duck Lake Rd)	32	X			X				
	Rte 464 (Duck Lake Rd)	33	X	X		X				
5	US 2	206	X		X		X			
	US 2	207	X	X	X		X			
	US 2	208	X		X		X			
	US 2	209	X	X						
	US 2	210		X						
6	US 2	245						X		
	US 2	246						X		
	US 2	247	X		X		X	X		
	US 2	248	X		X		X			
	US 2	249	X		X		X			
7	US 2	254	X		X		X	X		
8	US 89	10						X		
	US 89	11	X					X		
9	US 89	22						X		
	US 89	23	X					X		X
	US 89	24	X					X		X
	US 89	25	X			X		X		
	US 89	26	X			X				
10	US 89	30				X				
11	US 89	35	X						X	
	US 89	36	X		X					
	US 89	37	X							

			PRIORITY CHARACTERISTIC							
Priority stretch ID	**Route name**	**Reference marker (start of mile segment)**	**Composite**	**Regional conservation value**	**WVC risk**	**DAVC risk**	**Total AVC risk**	**Live wildlife on/near road**	**Live domestic animals on/near road**	**All animals on/near road**
	US 89	38	X	X						
12	US 89	43	X		X		X			
	US 89	44	X		X		X			
13	US 89	85		X						
14	US 89	94				X			X	X
	US 89	95	X			X	X		X	X
	US 89	96	X			X			X	X
	US 89	97	X			X			X	X
	US 89	98							X	
15	US 89	101							X	X
	US 89	102							X	X
	US 89	103							X	X
	US 89	104							X	X

Establishing a segment-level importance index for each prioritization characteristic required combining results across the multiple datasets associated with that characteristic. We first rescaled index values for all data sets to range between 0 and 1 to allow valid comparisons across data sets. We then implemented a weighted averaging approach in which the contribution of each data set to the overall importance index for a given characteristic was a function of that data set's sample size (e.g., number of crashes or carcasses included in data set) and spatial precision (categorized as "good", "moderate", or "poor"; see Table 2 for category descriptions). Initial weights were calculated as the proportion of the total sample size (i.e., sum of sample sizes across all data sets included in characteristic) comprised by each individual data set. We then modified these initial weights by multiplying them by 1, 0.75, and 0.5 for data sets with good, moderate, and poor precision, respectively; this down-weighted the contribution of data sets in which we had less confidence because locations were recorded with greater potential spatial error. We rescaled the modified weights to sum to 1, then calculated the weighted mean of segment-level indices for data sets included in a characteristic as an overall segment-level priority index for that characteristic.

If data were missing for a data set in a given road segment (e.g., for data sets that did not include sampling of all study roads), then that data set was assigned a weight of 0 for that segment and weights for the remaining data sets were rescaled proportionally to sum to 1. We modified our weighting method slightly for the regional conservation value characteristic because sample sizes for some data sets included in this characteristic could not be defined (e.g., connectivity models); for this characteristic, we assumed that all data sets had the same sample size.

To identify high-priority sites for field evaluation, we calculated the unweighted mean of each segment's index values across all seven prioritization characteristics as a composite index. We then selected the 25 segments with the highest composite index value as high-priority segments. This approach tends to select segments with high index values across multiple characteristics, but may overlook segments that are extremely important for a single characteristic despite having lower composite index values. To capture these outliers, we added any segment that ranked within the top 10 among all segments for any characteristic to our list of priority sites if it had not already been selected based on composite index value.

Many of the 1-mile road segments on our priority sites list were spatially adjacent and formed continuous, multi-segment stretches of road. We considered adjacent 1-mile segments (forming stretches up to 5 miles in length) as a single priority stretch for field evaluation, but used finer-scale, 1-mile segment-level data to help select locations for mitigation within priority stretches (Table 5). In total, our analysis identified the top 15 priority stretches in which to conduct field evaluations for potential mitigation measures (Table 6, Figure 1).

Table 6. Priority road stretches selected for further field investigation, with priority characteristics for each stretch based on data analysis.

Route name	Priority stretch ID	Start reference marker	End reference marker	Priorities within stretch[1]
Heart Butte Rd	1	14	16	RCV
MT 49 (Lookingglass Rd)	2	2	3	RCV
Rte 358 (Cutbank-Valier Hwy)	3	16	17	RCV

Rte 464 (Duck Lake Rd)	4	31	34	COMP, DAVC, RCV
US 2	5	206	211	COMP, RCV, TAVC, WVC
US 2	6	245	250	COMP, TAVC, WLO, WVC
US 2	7	254	255	COMP, TAVC, WLO, WVC
US 89	8	10	12	COMP, WLO
US 89	9	22	27	COMP, DAVC, TLO, WLO
US 89	10	30	31	DAVC
US 89	11	35	39	COMP, DALO, RCV, WVC
US 89	12	43	45	COMP, TAVC, WVC
US 89	13	85	86	RCV
US 89	14	94	99	COMP, DALO, DAVC, TAVC, TLO
US 89	15	101	105	DALO, TLO

[1] Characteristics for which at least one road mile segment within the priority stretch was considered high priority. COMP = composite index (weighted mean of all characteristics); DAVC = domestic animal-vehicle collision risk; DALO = live domestic animal on/near road; TALO = total live animals on/near road; TAVC = total animal-vehicle collision risk; RCV = regional conservation value; WLO = live wildlife on/near road; WVC = wildlife-vehicle collision risk.

2.5. Field evaluation

Priority stretches were visited in the field on June 4th and 5th, 2019, and evaluated for potential mitigation measures. The authors of this report and an interdisciplinary Technical Advisory Team of biologists, transportation ecologists, and engineers drove each priority stretch, looking for the most suitable locations within each stretch to further evaluate for potential mitigation measures. Our Technical Advisory Team included the following individuals:

- Blackfeet Nation Fish and Wildlife Department (BFWD) - Dustin Weatherwax
- Western Transportation Institute, Montana State Univ. (WTI) - Marcel Huijser
- Center for Large Landscape Conservation – Rob Ament, Renee Callahan, and Liz Fairbank
- Montana Department of Transportation (MDT) - Paul Sturm and Steve Prinzing
- U.S. Fish and Wildlife Service (USFWS) - Mark McGrath
- Federal Lands Highways (FLH) - Matt Hinshaw

To assist in ranking sites for mitigation priority, we developed a field evaluation matrix. The matrix was used to evaluate each site by assigning a subjective score from 1 (low priority) to 5 (high priority) for each of the following 12 criteria:

1. **Wildlife-vehicle collision risk:** Frequency of collisions with wildlife
2. **Domestic animal vehicle-collision risk:** Frequency of collisions with domestic animals
3. **Total AVC risk:** Frequency of collisions with all animals
4. **Live wildlife on/near roads:** Intensity of wildlife use of roads and roadside environments
5. **Live domestic animals on/near roads:** Intensity of domestic animals use of roads and roadside environments
6. **All live animals on/near roads:** Intensity of all animal use of roads and roadside environments
7. **Regional conservation value:** Contribution to regional conservation (if mitigated) by serving as a movement corridor or high-quality wildlife habitat at the regional scale
8. **Local conservation value:** Contribution to regional conservation (if mitigated) by serving as a movement corridor or high-quality wildlife habitat at the local scale
9. **Mitigation options:** Type and engineering feasibility of mitigation measures that could be implemented
10. **Barrier effect:** Degree of negative impact on wildlife movement potential due to high traffic volume or non-wildlife-friendly fencing

11. **Land security:** Presence/absence of “secured” land (e.g., state, federal, private conservation easement) on both sides of road to allow for effective crossing structures
12. **Vulnerability:** Potential for future increase in AVC risk or negative impact to wildlife due to increased speed limit, traffic volume, road width, or number of lanes

Criteria 1-7 were scored before the field evaluation based on data analysis (and confirmed or adjusted by local and regional experts during the field evaluation), while criteria 8-12 were scored in the field by the researchers and the Technical Advisory Team. At the end of the field evaluation, each site was assigned an overall score (from 1 to 5) based on the average from each of the 12 evaluation criteria.

For scoring the criteria based on data analysis (see 1-7 above), the researchers used categories based on the mean percentiles for each priority stretch to give a score from 1 (low priority) to 5 (high priority). The scoring categories for the criteria based on data analysis are described in Table 7 below.

Table 7. The categories used to score the criteria based on data analysis.

Score	Percentile Categories	Description
5	95-100%	The 5% of stretches with the highest index values
4	75-94.9%	The next 20% of stretches with the highest index values
3	50-74.9%	The next 25% of stretches with the highest index values
2	25-49.9%	The next 25% of stretches with the highest index values
1	<24.9%	The 25% of stretches with the lowest index values

For scoring criteria (8-12) based on the field evaluation, the researchers and team of experts ranked each criteria with a score from 1 (low priority) to 5 (high priority). While many of these scores are based on expert opinion from the Technical Advisory Team, for land security we specifically describe what each score means:

1. Housing or industrial/commercial development on both sides of site
2. Housing or industrial/commercial development on one side of site, privately owned open space on other side (with unsecured easements)
3. Privately owned open space lands on both sides, but without conservation easements
4. Public lands (federal, state, or tribal) or private land with a conservation easement on one side of the site, open space on other side (without conservation easements)
5. Public lands (federal, state, or tribal) or private lands with a conservation easement on both sides

3. RESULTS: PRIORITY ROAD SEGMENTS FOR FURTHER EVALUATION

Our initial screening of potential priority sites identified 42 mile segments as having high value across prioritization characteristics or exceptionally high value for any single characteristics (Table 5, Fig. 1). These segments were clustered in 15 distinct stretches of road that ranged in length from 1 to 5 miles (Table 6). Many stretches included road segments that were identified as high priority based on multiple characteristics. The majority of the priority stretches occurred along US 89 and US 2, the two roads with the highest traffic volumes within the Reservation.

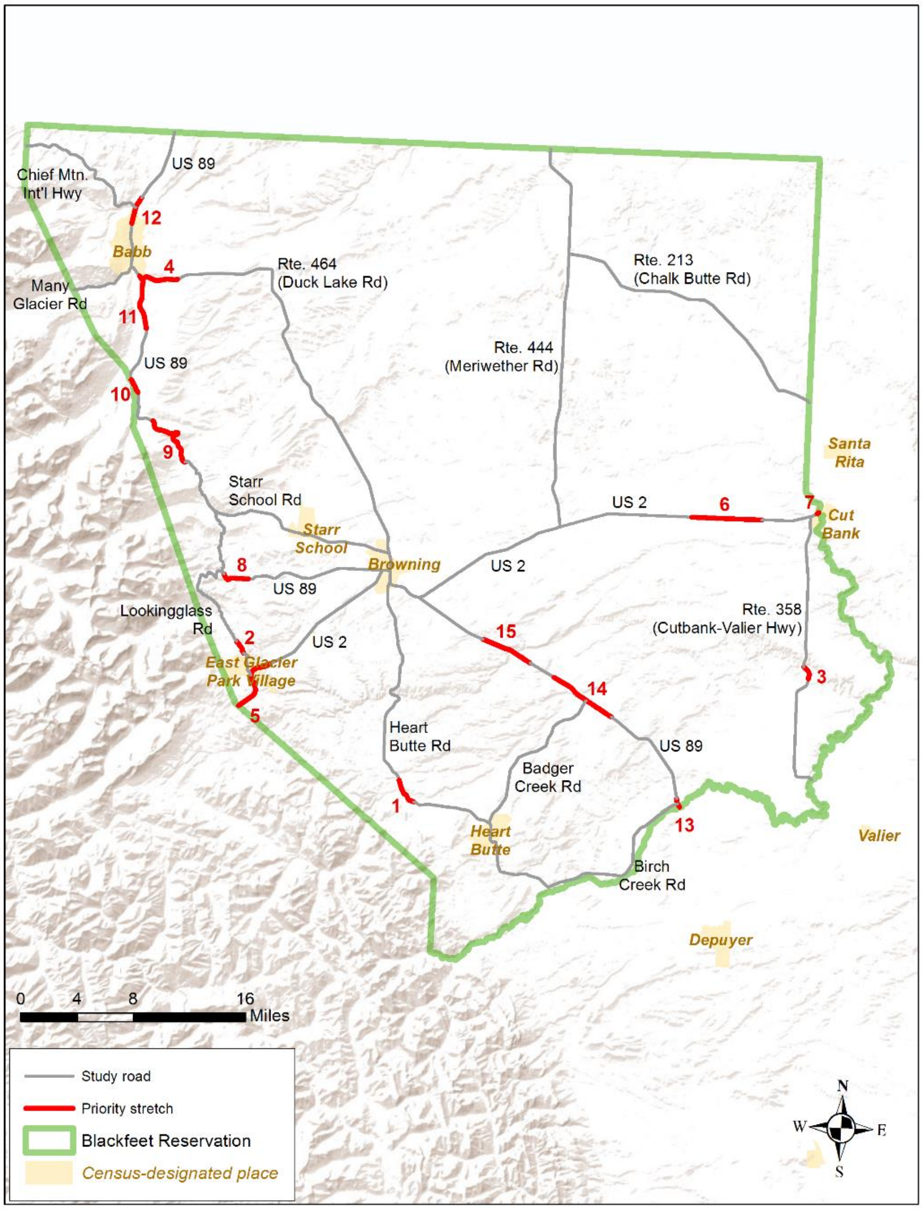


Figure 1: Map of the 15 highest priority road stretches on the Blackfeet Reservation.

4. FIELD EVALUATION AND MITIGATION RECOMMENDATIONS

The Technical Advisory Team visited each of the 15 priority road stretches in the field on June 4 and 5, 2019. Each site was evaluated using the Site Visit Matrix and was given a priority ranking (from 1 to 14 [with one tie], where 1 is the highest priority) based on AVC risk, conservation value, mitigation options, barrier effect of the road corridor and its vulnerability to future change, and land security. Many of the priority stretches included existing infrastructure that could be used to facilitate animal movements, such as a bridge spanning a riparian corridor. This existing infrastructure was evaluated in terms of (1) current ability to function as a wildlife crossing, and (2) potential for retrofitting to improve its ability to provide safe road crossing opportunities for large animals.

Most roads on the Blackfeet Reservation experience relatively low traffic volumes at present, but there are many factors that may precipitate an increase in traffic volumes in the near future, including: increased tourism and visitation to Glacier National Park, which can be accessed via two entrances on the Blackfeet Reservation; increased natural resource use, such as oil and gas extraction, gravel mining, forestry, and wind energy development; human population growth; and the prospect of creating a Blackfeet National Park with free-roaming bison on the western side of the Reservation. These factors have the potential to spur on infrastructure development, including new road construction and increasing traffic volumes on existing roads (Blackfeet CEDS, 2018).

Current traffic volumes may not pose a significant barrier effect to wildlife movement or a significant source of wildlife mortality on roads, but increases in traffic volumes in the near future may result in more conflict between wildlife and vehicles. Studies of traffic volume on US Highway 2 during two earlier periods (1999-2001 and 2012-2013) indicate that traffic volumes have increased substantially over the last 2 decades along the southern boundary of Glacier National Park – an increase of 54% at mile marker 184 and 19% at mile marker 202 were documented (Waller and Miller 2015). Thus, while our recommendations are conservative and generally do not include extensive construction of wildlife crossing structures and wildlife-proof fencing, more extensive mitigation measures (e.g., a series of overpasses, underpasses, and wildlife-proof fencing) may become necessary to mitigate habitat fragmentation and conserve wildlife populations within the Reservation's unique and diverse landscape if traffic volumes continue to increase.

Studies in the region have found that roads can become an absolute barrier to wildlife movements at different thresholds for different species. A study of US Highway 2 immediately west of the Blackfeet Reservation found that traffic volumes significantly impacted grizzly bear movements and that increases in traffic have continued to sever bear movement across the highway (Waller and Miller 2015). Waller and Miller (2015) used 100 vehicles per hour as the threshold at which grizzlies were no longer able to get across the highway, although lower traffic volumes are known to create avoidance in grizzlies (Waller and Servheen 2005, Waller and Miller 2015). Similarly, a study in Wyoming found that traffic volumes of greater than 120 vehicles per hour created an absolute barrier for mule deer (Riginos et al., 2019).

Another issue that may create a need for mitigation measures in the future is the reintroduction and geographic expansion of bison within the Reservation. The Blackfeet Nation is currently working to bring free-roaming wild bison back to the Reservation through its Iinnii Initiative Program. This could have serious implications for conflict between animals and traffic, and for the safety of motorists. The addition of a wild bison population on the landscape will likely require a shift in management of animal-road conflict, and it will likely require mitigation measures such as wildlife-proof fencing in combination with crossing structures – such as overpasses and underpasses – to allow bison and other animals to move freely across the landscape while keeping people and animals safe.

The following site-specific recommendations are based on current conditions within the Reservation:

4.1. Recommendations for Priority Road Stretches

- **STRETCH 1:** ***Heart Butte Road MP 14-16. Average Daily Traffic=1,294 vehicles.***

  Priority Rank: 11

- This site was identified as a regional and local conservation priority, which was confirmed by BFWD Acting Director Dustin Weatherwax[1]. He noted that the entire Badger Creek drainage is an important movement corridor for a variety of wildlife species and provides connectivity from the alpine and forest environments of the west side of the Reservation to the shortgrass prairie environments in the east, as well as providing riparian vegetation for forage.
- We evaluated the bridge over Badger Creek in the center of the stretch at MP 15. This bridge provides useable below-grade passage for a variety of wildlife species even during peak flow. This terrestrial passage is much larger throughout the rest of the year.
- Bridge GPS coordinates (latitude/longitude decimal degrees, WGS84 datum): 48.327712, -112.974275
- Allotted Tribal Lands exist on both sides of the stretch; this is open space with little chance of development.
- This site is a **low priority for mitigation** because traffic volumes here are very low (primarily local traffic traveling between the community of Heart Butte and Browning), the barrier effect is low, and the bridge that is currently in place should be functioning well for providing connectivity along the riparian corridor for animal movements.
- Recommended Mitigation Actions: None at this time.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
2	3	3	4	3	3	5	5	5	1	3	1	3.16

[1] For purposes of this section, we will use institutional titles and affiliations in effect as of June 4-5, 2019, the date of the site visits/field evaluations.

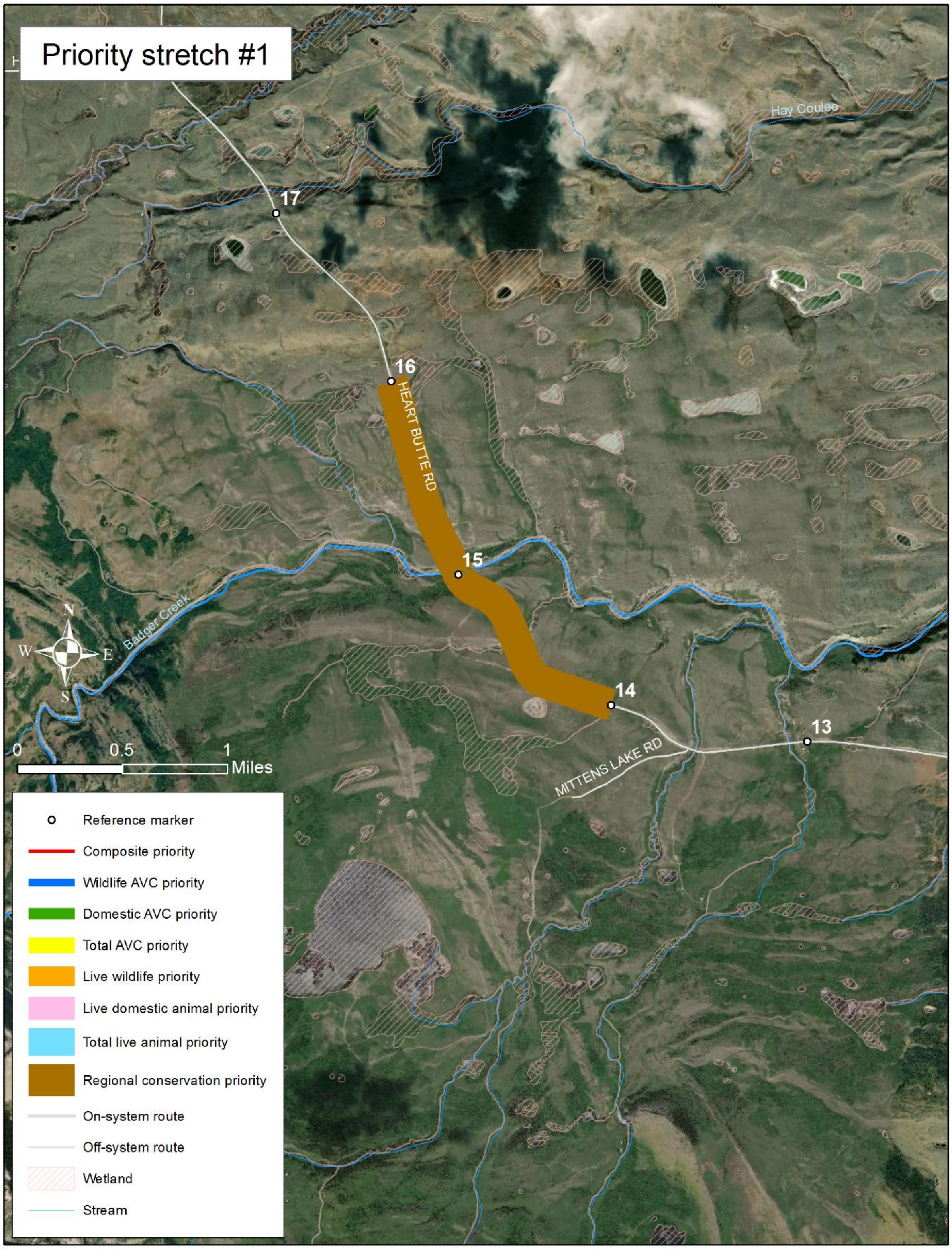


Figure 2: Map of Stretch 1.

- **STRETCH 2:** ***Looking Glass Rd (MT49). Average Daily Traffic=2,251 vehicles.***

  Priority Rank: 10.

  - This site was identified as a regional and local conservation priority based on data analysis, which was confirmed by BFWD Acting Director Dustin Weatherwax. He noted that this area is *extremely important* for wildlife and that the Two Medicine River drainage on the Reservation is a very important movement corridor for a variety of wildlife species. The Two Medicine River drainage provides connectivity from the alpine and forest environments of the west side of the Reservation to the shortgrass prairie environments in the east, as well as providing riparian vegetation for forage. This particular location is less than 2 miles from the eastern border of Glacier National Park and sits right at the transition zone between forest and grassland.
  - We evaluated the bridge over the Two Medicine River in the center of this 1-mile stretch. Unfortunately, there is no good terrestrial passage for wildlife under this bridge because steep banks covered in boulders extend right to the water's edge. Terrestrial animals, especially ungulates, are likely currently forced to cross the road at-grade to move along the riparian corridor.
  - Bridge GPS coordinates: 48.470363, -113.236818
  - Private (fee) land that currently consists of open space surrounds the stretch. This could be a potential area to work on getting a conservation easement to ensure that the land retains its value for wildlife and habitat connectivity. In addition, the Blackfeet Nation is currently working on developing the first Tribal National Park, which would border Glacier National Park on the west side of the Reservation. This area would be a part of the proposed park.
  - <u>Recommended Mitigation Actions</u>: Improve terrestrial passage underneath the bridge. This would likely require additional bridge length because the current structure of the bridge leaves little room outside of the river for animal movements. Adding to the bridge length should be considered when the aging bridge is replaced, and could be considered as a stand-alone project. Night-time road closures (excepting local residents and emergency services) may also be appropriate in this section, especially if the bridge is not retrofitted to include terrestrial passage. This would be even more critical if Looking Glass Road were to become a park road, ensuring that even if traffic volumes/visitation were to increase significantly after the formation of the park, animals would still be able to cross safely after dark.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
2	3	2	4	3	4	5	5	5	1	3	1*	3.16

* The vulnerability score could be impacted by the formation of the national park. MDT does not currently project an increase in traffic volumes on this stretch (hence the score of 1), however

their projection does not include the potential for this area to become a park and see substantial increases in visitation, recreational use, camping, etc.

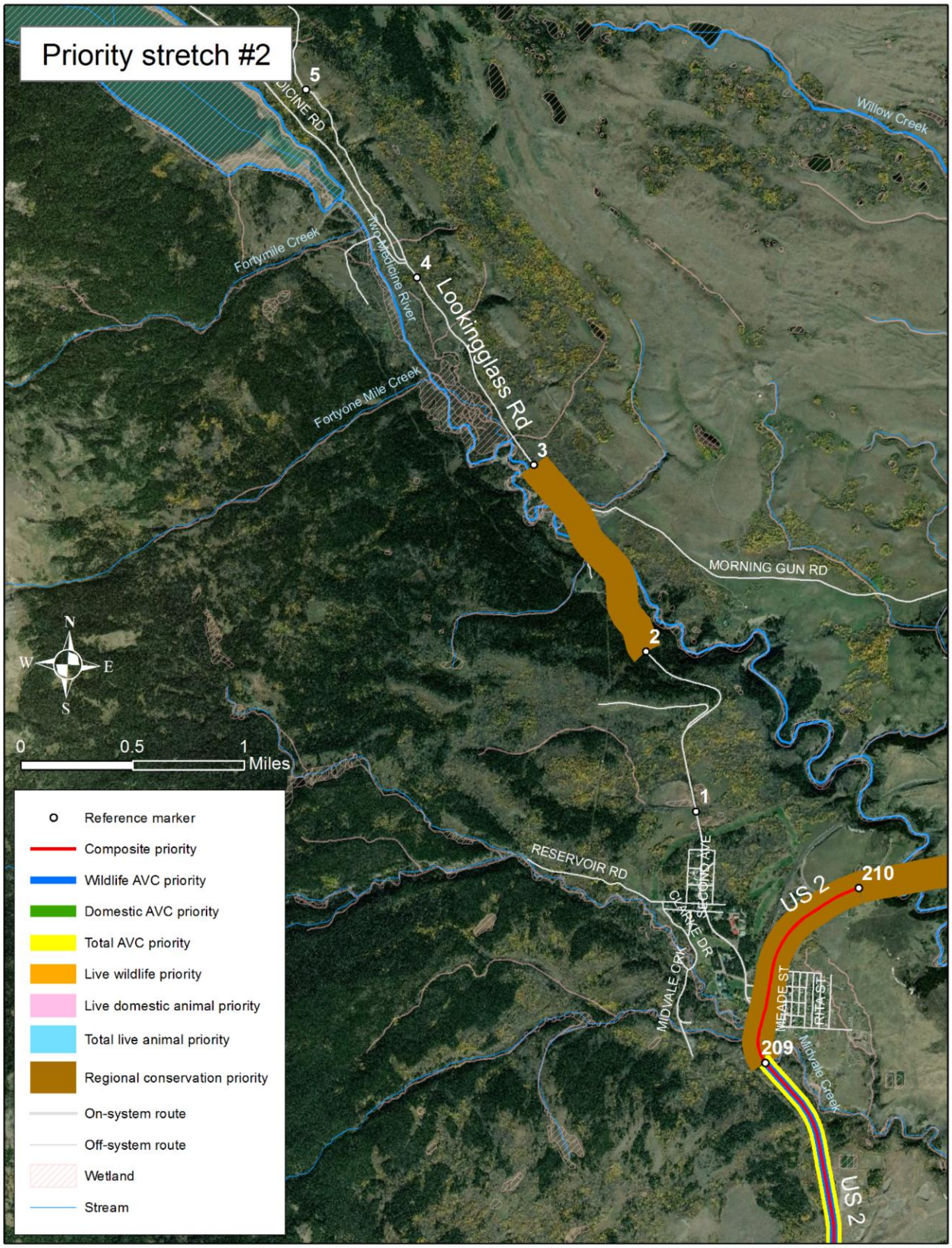


Figure 3: Map of Stretch 2.

- **STRETCH 3:** ***Route 358 (Cutbank-Valier Highway) MP 16. Average Daily Traffic=734 vehicles.***

Priority Rank: 12

- This site was identified as a regional and local conservation priority based on data analysis, which was confirmed by BFWD Acting Director Dustin Weatherwax. He noted that the Two Medicine River drainage on the Reservation is a very important movement corridor for a variety of wildlife species. In this area, on the eastern side of the Reservation, the Two Medicine River drainage provides diverse riparian vegetation for wildlife forage, in contrast with the surrounding high plains.
- We evaluated the bridge over the Two Medicine River around MP 16.8. This bridge provides safe terrestrial passage for animal movements below grade.
- Bridge GPS coordinates: 48.470363, -113.236818
- Private (fee) land that currently consists of open space surrounding the stretch.
- Recommended Mitigation Actions: None at this time due to very low traffic volume, low AVC rate, and little expectation for this to change. The bridge currently provides for wildlife connectivity across the road corridor.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
4	2	3	4	2	2	5	5	5	1	3	1	3.08

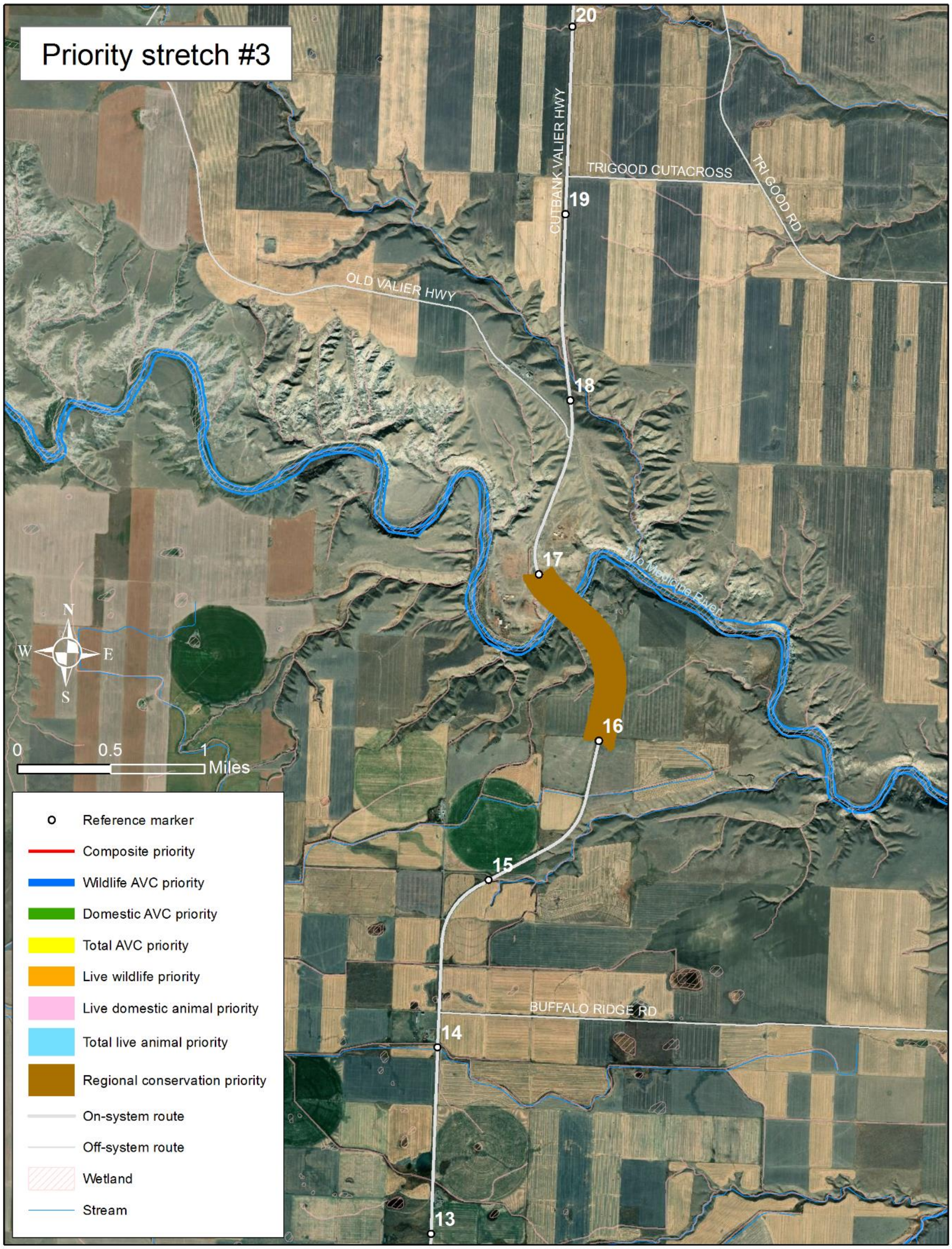


Figure 4: Map of Stretch 3.

- **STRETCH 4:** ***Duck Lake Rd (Route 464) MP 31-33. Average Daily Traffic=451 vehicles.***

Priority Rank: 7

- This site was identified as a regional and local conservation priority and a domestic AVC priority based on data analysis. BFWD Acting Director Dustin Weatherwax confirmed that this area is very important for grizzly bears including sows and cubs based on GPS collar data.
- Data collected by Brandon Kittson, a student at Confederated Salish Kootenai College, found 10 animal trails within 1.2 miles of this priority stretch.
- The stretch is located in the northwest section of the Reservation. The landscape in this area is primarily forested and located between Duck Lake and Lower Saint Mary Lake and includes networks of streams, wetlands, and riparian habitat.
- MDT recently installed over 7 miles of new right-of-way (ROW) livestock fencing and cattle guards in this area, which should solve the issue of domestic AVCs. Unfortunately, the fencing that was installed is not wildlife-friendly (4-strand barbed-wire, top strand ~48” tall, bottom strand ~12” off the ground). BFWD personnel noted that this type of fencing is particularly problematic for moose calves who are often entangled in this type of fencing; in fact, two such events were reported during the week of our site visits, the first week in June.
- <u>Recommended Mitigation Actions:</u> Retrofit fencing to be wildlife-friendly. There are also two sites within this stretch that could be good locations for underpasses in high-fill areas (where the road bed has been raised and sits on fill dirt). The best location is a ravine around MP 32.75 (coordinates: 48.844583, -113.399861) where the road is already constructed on deep fill. MDT Engineer Steve Prinzing noted that building a concrete box culvert would be the easiest option here in terms of engineering; however, due to the fact that one of the target species for use of the crossing would be grizzly bear sows and cubs, a larger structure such as an open-span bridge would be required to ensure their passage (Ford et al. 2017).

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
3	5	4	4	2	3	5	4	4	2	4	1	3.42

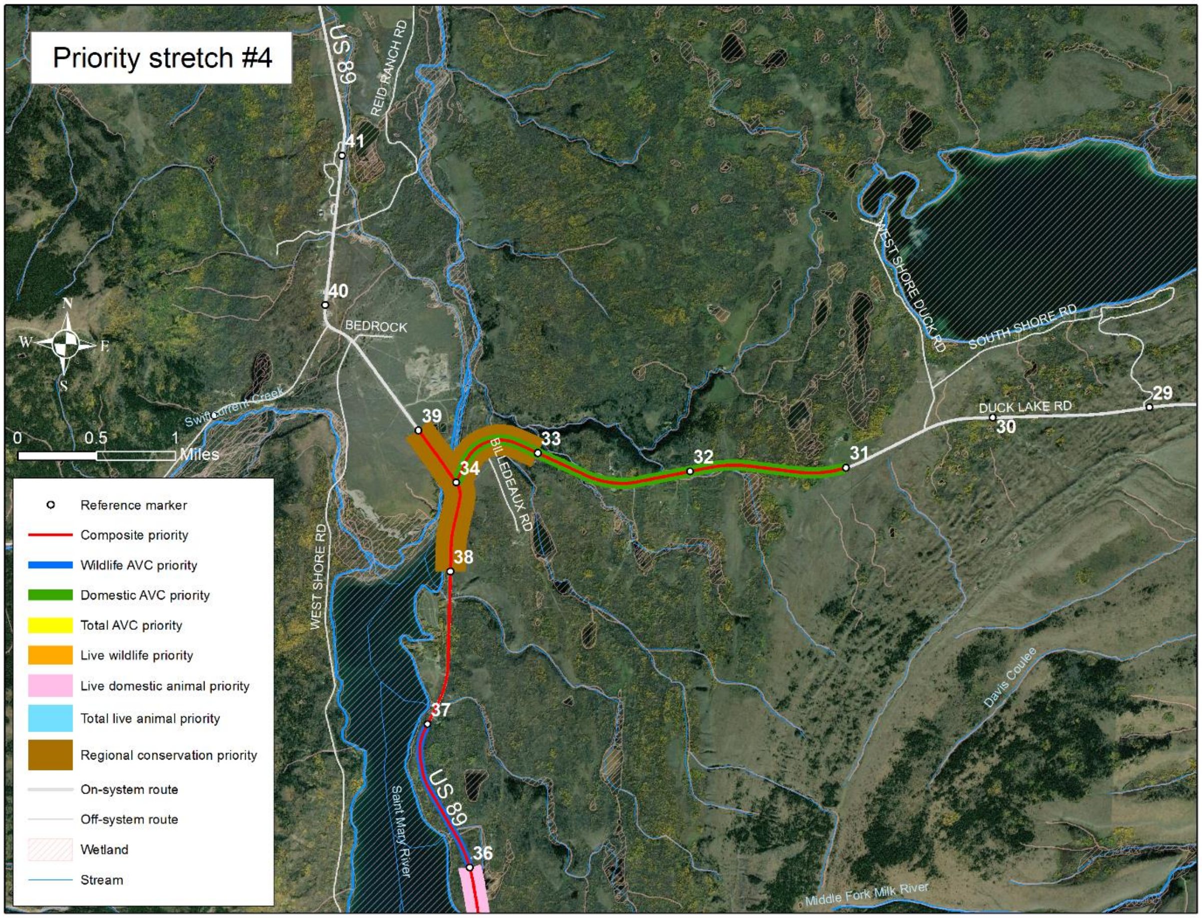


Figure 5: Map of Stretch 4.

- **STRETCH 5:** ***Highway 2 MP 206-210. Bordering Glacier National Park. Average Daily Traffic=2774 vehicles.***

Priority Rank: 1

- This site was identified as a regional and local conservation priority and a wildlife and domestic AVC priority based on data analysis. BFWD confirmed that this area is very important for a variety of wildlife species including elk, moose, grizzly bear, and lynx, among others. The streams and wetlands occurring directly adjacent to the road in many places in this area are prime habitat for moose.
- BFWD note that both moose and grizzly bears have been killed by vehicles on this stretch in recent years, and that young moose have become entangled in the barbed-wire livestock fencing.
- This stretch is on the western side of the Reservation directly adjacent to Glacier National Park. The stretch extends east from the park boundary, through wetlands with meandering streams, and has several creek and river crossings, including a large bridge across the Two Medicine River. The stretch also runs through the town of East Glacier.

- Land ownership in this area is primarily private “fee” land, with a few small blocks of allotted and tribal land. Conservation easements would likely need to be secured to move forward with any substantial mitigation efforts in the area.
- The Burlington Northern Santa Fe (BNSF) railroad tracks also run in parallel to the road along this stretch. These railroad tracks have been a substantial source of mortality for grizzlies and other animals, with three grizzly bears (a sow with two cubs) killed on the tracks adjacent to this road stretch during the summer of 2019, and another in the fall. The railroad also increases the barrier effect of the road corridor. *It is critical that any mitigation actions in this area consider both the road and the railroad*.
- <u>Recommended Mitigation Actions:</u> In order to address both the habitat connectivity and safety concerns, a combination of overpass(es), underpasses, and wildlife-proof fencing are recommended along this stretch of road. A proposed overpass location based on engineering feasibility due to the road already being cut in to the hillside is at 48.420883, -113.213878. This road overpass could be coupled with an overpass across the adjacent low-volume access road and railroad tracks, although this is outside of the scope of this road study and would require a partnership with the railroad and other private landowners to address this issue. Because this area is of critical importance for wildlife habitat and connectivity for many species, both underpasses and overpasses should be considered to accommodate species-specific preferences. Partnership with the railroad and close monitoring of this stretch of road and railroad, both pre- and post-mitigation action, is highly recommended.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
5	4	5	3	4	4	5	5	4.5	3	3	2	3.96

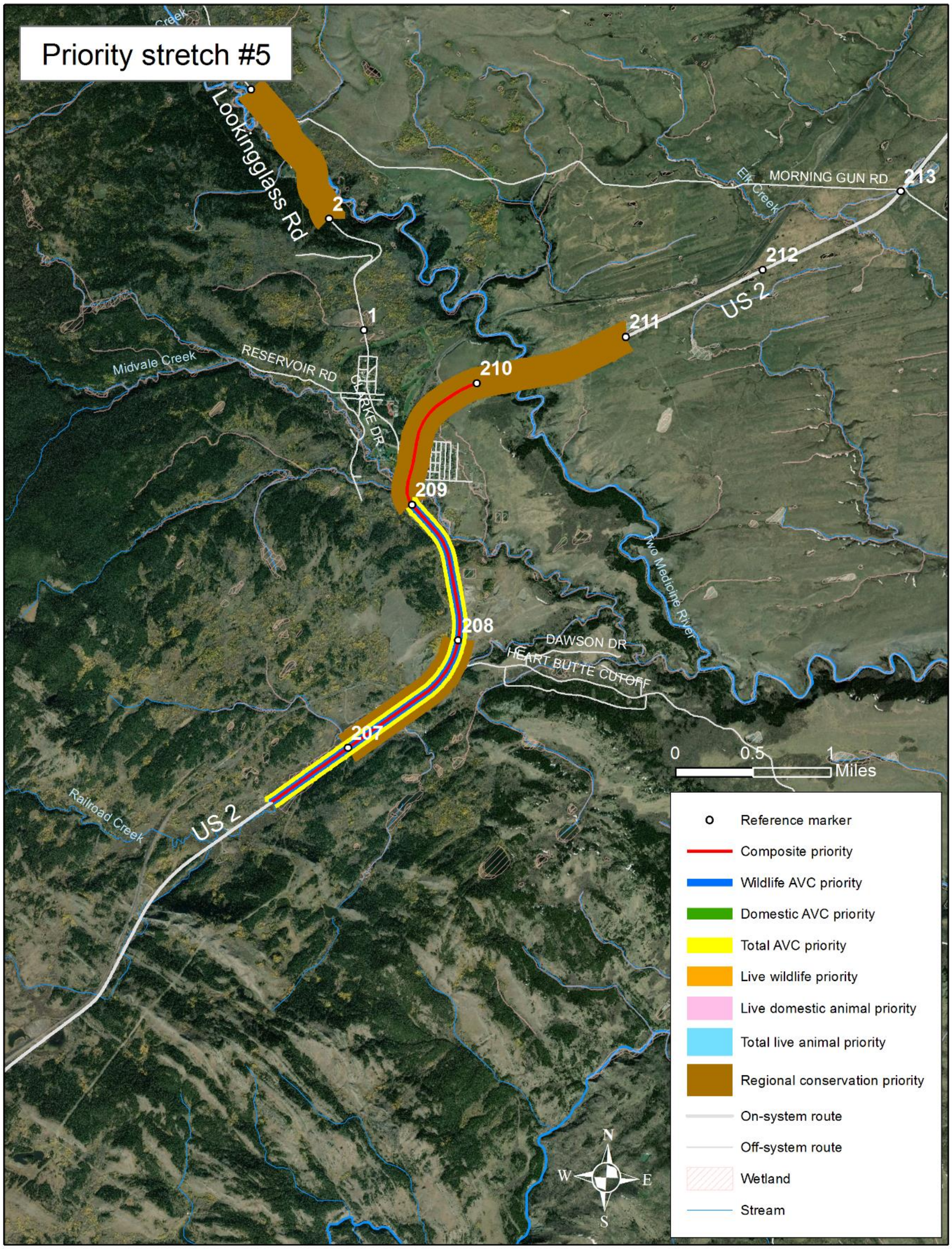


Figure 6: Map of Stretch 5.

➢ **STRETCH 6: *Highway 2 MP 245-249. Average Daily Traffic=2288 vehicles.***

Priority Rank: 14

- This site was identified as a priority due to high AVC risk, primarily with livestock and deer.
- Due to the presence of unsecured (no conservation easement), developed agricultural land on both sides of the road and topography that would lend itself to construction of overpasses, we concluded there were no technically feasible mitigation options here and thus declined to further evaluate this site. We do recommend that wildlife-friendly livestock fencing be implemented throughout this priority stretch.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
5	4	5	4	2	3	1	2	2	2	3	1	2.83

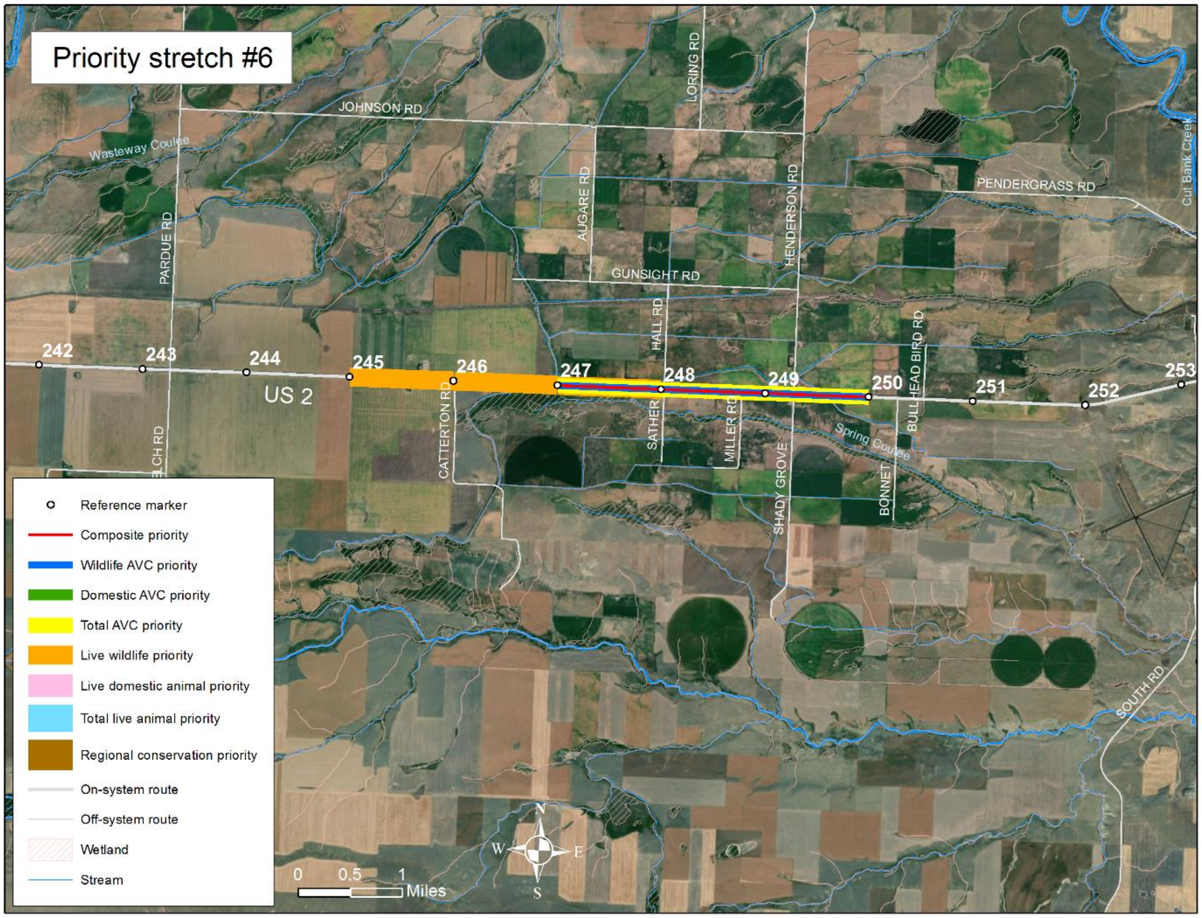


Figure 7: Map of Stretch 6.

- **STRETCH 7:** ***Highway 2 MP 254. Average Daily Traffic=4033 vehicles.***

Priority Rank: 2

- This site was identified as a priority due to high AVC risk, especially with mule deer, and it is also of high local conservation value according to data analysis.
- The stretch is located just east of the town of Cut Bank along Cut Bank Creek.
- Land adjacent to the stretch is all private (fee) land with some vulnerability to development. This area is used as a fishing/boating access point.
- The bridge over Cut Bank Creek currently provides passage for wildlife beneath the road. There is some room for improving terrestrial pathways below the bridge, but it currently seems to be functioning well for wildlife passage.
- Bridge GPS coordinates: 48.633865, -112.346938
- Recommended Mitigation Actions: In order to address the WVC risk, we recommend constructing wing fencing to guide animals to cross at the bridge and keep them off the road. Specifically, we propose that wing fencing be constructed to and be tied into the cliffs on the east side of the bridge (48.636093, -112.344001), closest to Cut Bank, and extend out to the access road on the west side of the bridge (48.632981, -112.349255). **This site is a high priority due to the relatively easy, low-cost options to reduce AVCs.**

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
5	4	5	5	2	4	2	5	5	3	3	4	3.92

Figure 8: Map of Stretch 7.

- **STRETCH 8:** ***Highway 89 MP 10-11. West of Browning. Average Daily Traffic=499 vehicles.***

Priority Rank: 5 (tie with Site 14)

- This site was identified as a priority due to high AVC risk and local conservation value. BFWD note that this area is important for a variety of species including grizzly bear and moose.
- 26 animal trails were recorded in 1.25 miles within this priority road stretch (Kittson 2019).
- The stretch was under construction during the site visits as part of the Highway 89 reconstruction process. Unfortunately, no improvements for wildlife were included in the reconstruction project in this stretch, and the new ROW fencing that is being installed here is not wildlife-friendly.
- There is currently a small culvert running under the road (48.540784, -113.254031) to accommodate water flow from a tributary of South Fork Cutbank Creek, but the culvert is not suitable for use by large mammals.

- This area is within proposed bison range, and a bison fence was visible along some of the stretch.
- This area is also within the area proposed for the Blackfeet National Park.
- Recommended Mitigation Actions: An overpass in combination with wildlife exclusion fencing would be the ideal mitigation option in this area due to the target species (such as moose and grizzly bears, which prefer overpasses) and the fact that the road itself was recently reconstructed and is not topographically suited to accommodate large underpasses without significant changes to the road bed. The approximate location of the proposed overpass (48.540709, -113.256202) is at a large road-cut where the topography creates natural high points on either side of the road, especially on the north side of the highway, which could accommodate this type of structure with minimal fill.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
4	3	4	5	2	4	3	4	5	3	4	1	3.5

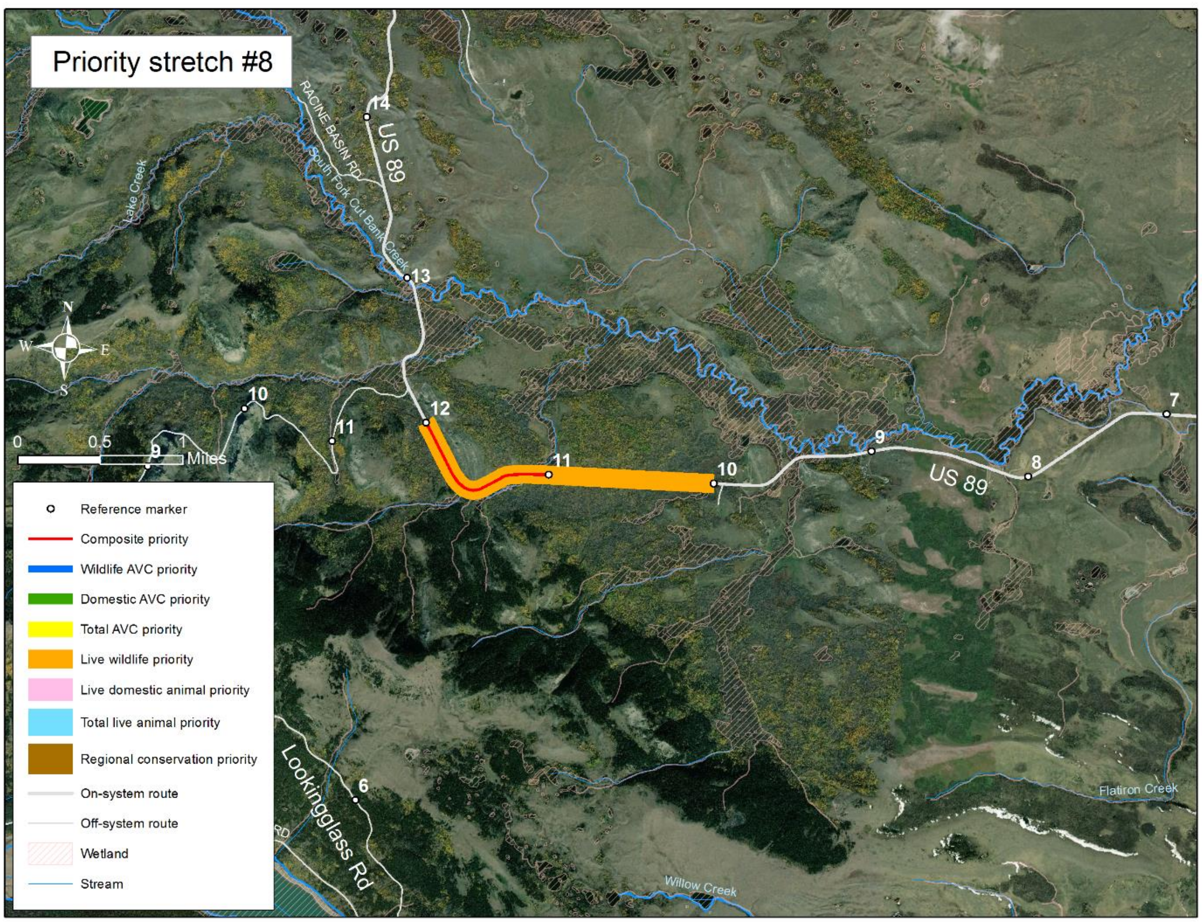


Figure 9: Map of Stretch 8.

- **STRETCH 9:** ***Highway 89 MP 22-26. North of Browning. Average Daily Traffic=620 vehicles.***

Priority Rank: 8

- This site was identified as a priority due to live animal movements, wildlife and domestic animal collision risk, and local conservation value. BFWD note that this is core habitat for moose, grizzly bears, and wolves.
- 75 animal trails were detected within this priority road stretch; these trails were concentrated around road mile 23 (Kittson 2019).
- This area is part of the Highway 89 reconstruction project. It was in the ROW phase during our site visits and is slated to be completed in 2021. The reconstruction project includes installation of ROW fencing (not wildlife-friendly) and cattle guards, as well as adding in 6-ft shoulders and straightening of some sharp curves. These road improvements will effectively increase the design speed of the road, even if the posted speed limit remains the same.
- Land ownership is primarily tribal, with a few areas of private (both fee and allotted).
- This stretch is within the area proposed for the Blackfeet National Park.
- Recommended Mitigation Actions: There are few mitigation options in this road stretch due to the topography and road design. We recommend that any fencing in this area be wildlife-friendly to accommodate passage by moose (especially juveniles), who are known to become entangled in the type of fencing currently proposed to be built in this road stretch. In addition, if this area does become part of the Blackfeet National Park, and if WVCs continue to increase in this area, we propose night-time road closures (with the exception of local residents and emergency vehicles) to ensure that wildlife is given the opportunity to safely move across the road during at least part of each day.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
3	3	4	5	4	5	4	5	1	1	4	1	3.33

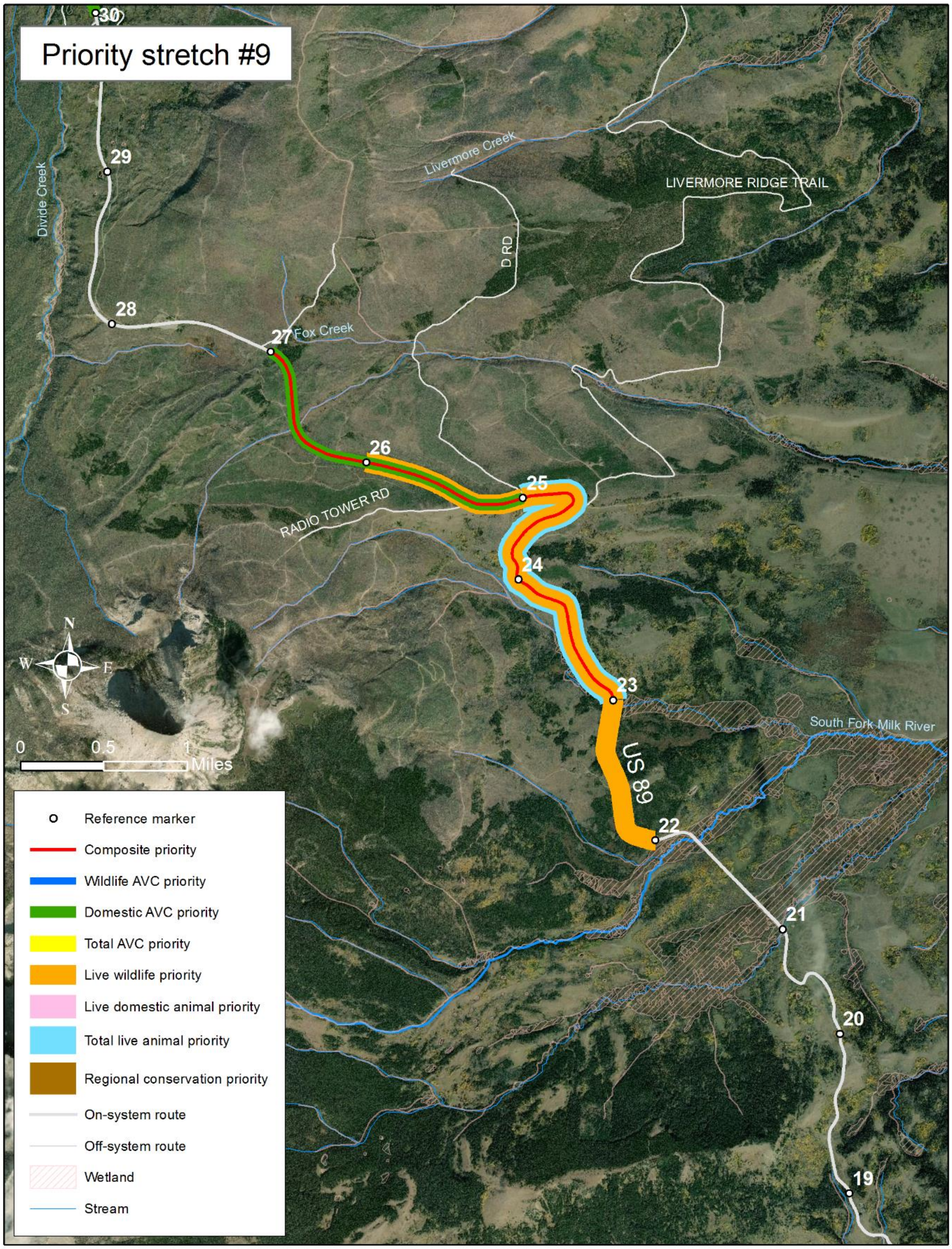


Figure 10: Map of Stretch 9.

- **STRETCH 10: *Highway 89 MP 30-31. North of Browning. Average Daily Traffic=733 vehicles.***

Priority Rank: 13

- This site was identified as a priority due to collisions with livestock.
- Land ownership in the area is private (fee) land on both sides of the stretch.
- Recommended Mitigation Actions: Install wildlife-friendly ROW fencing.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
3	5	4	3	3	2	4	4	5	1	2	1	3.08

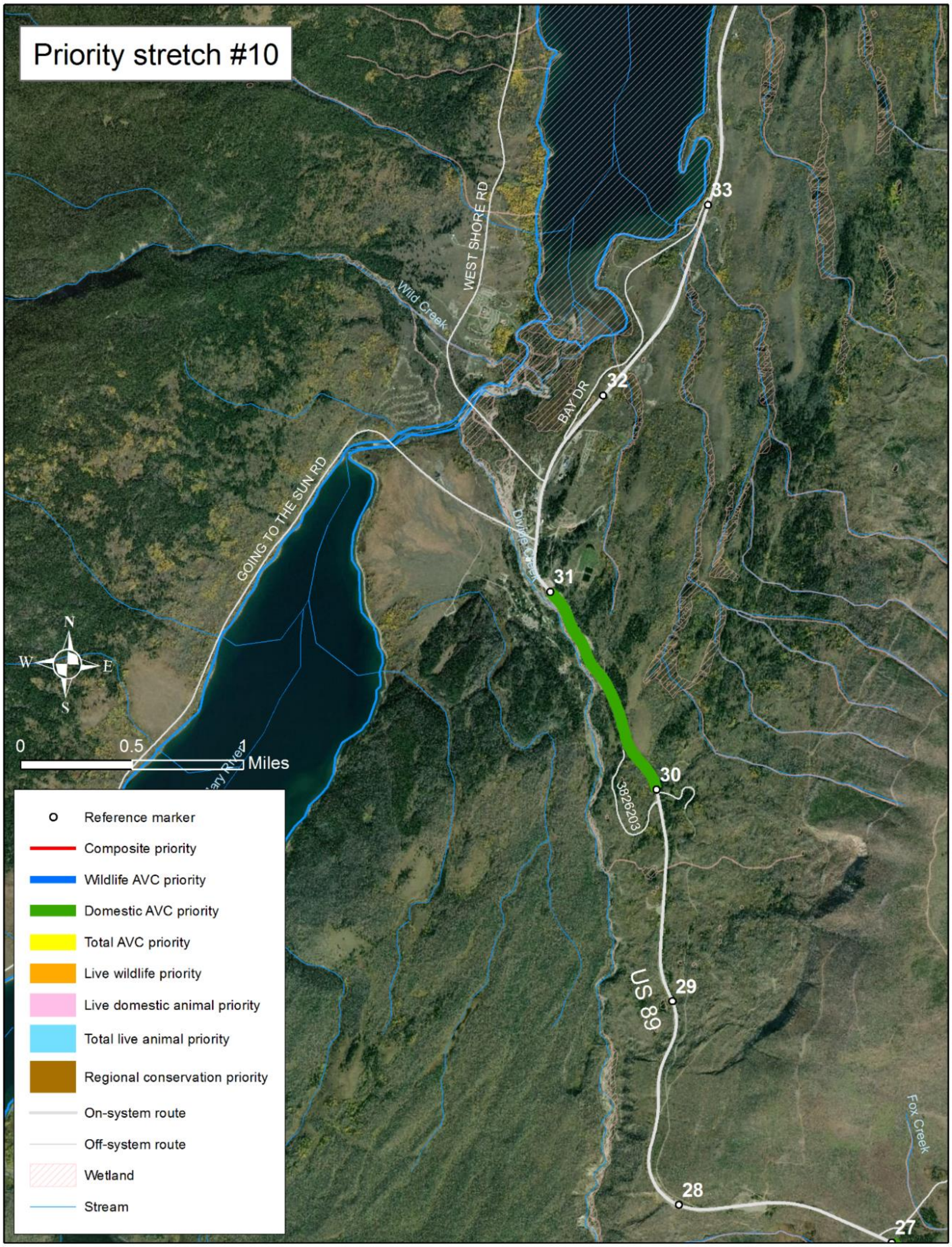


Figure 11: Map of Stretch 10.

➢ **STRETCH 11:** ***Highway 89 MP 35-38. North of Browning. Average Daily Traffic=1054.***

Priority Rank: 4

- This site was identified as a priority due to its regional conservation value and overall AVC risk. BFWD note that this is an important elk movement corridor that crosses the road at the north end of Lower Saint Mary Lake.
- Land ownership is primarily tribal public land with a few parcels of private (fee and allotted) land on the east side of the road.
- There is an existing bridge across the Saint Mary River that provides some opportunity for terrestrial passage on the west side of the river, although steep banks and dense vegetation along the east bank make terrestrial passage a challenge.
- Recommended Mitigation Actions: We recommend improving terrestrial passage under the bridge at the Saint Mary River around MP38.7 (48.843886, -113.417817). This will not require any major changes, only leveling and removal of dense woody shrubs, and could be completed by seasonal trail crews that the Blackfeet Nation employs. In addition, we recommend that variable message signs (VMSs) be placed north of the bridge visible to both directions of traffic during spring and fall elk migrations to warn drivers of wildlife on the road. To address the livestock collision risk further south in this stretch (MP35-36), we recommend construction of wildlife-friendly ROW fencing. It is imperative that this fencing is wildlife-friendly in order to not impede wildlife movements between the lake and the surrounding hills.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
5	4	5	3	4	4	4	2	5	3	4	1	3.66

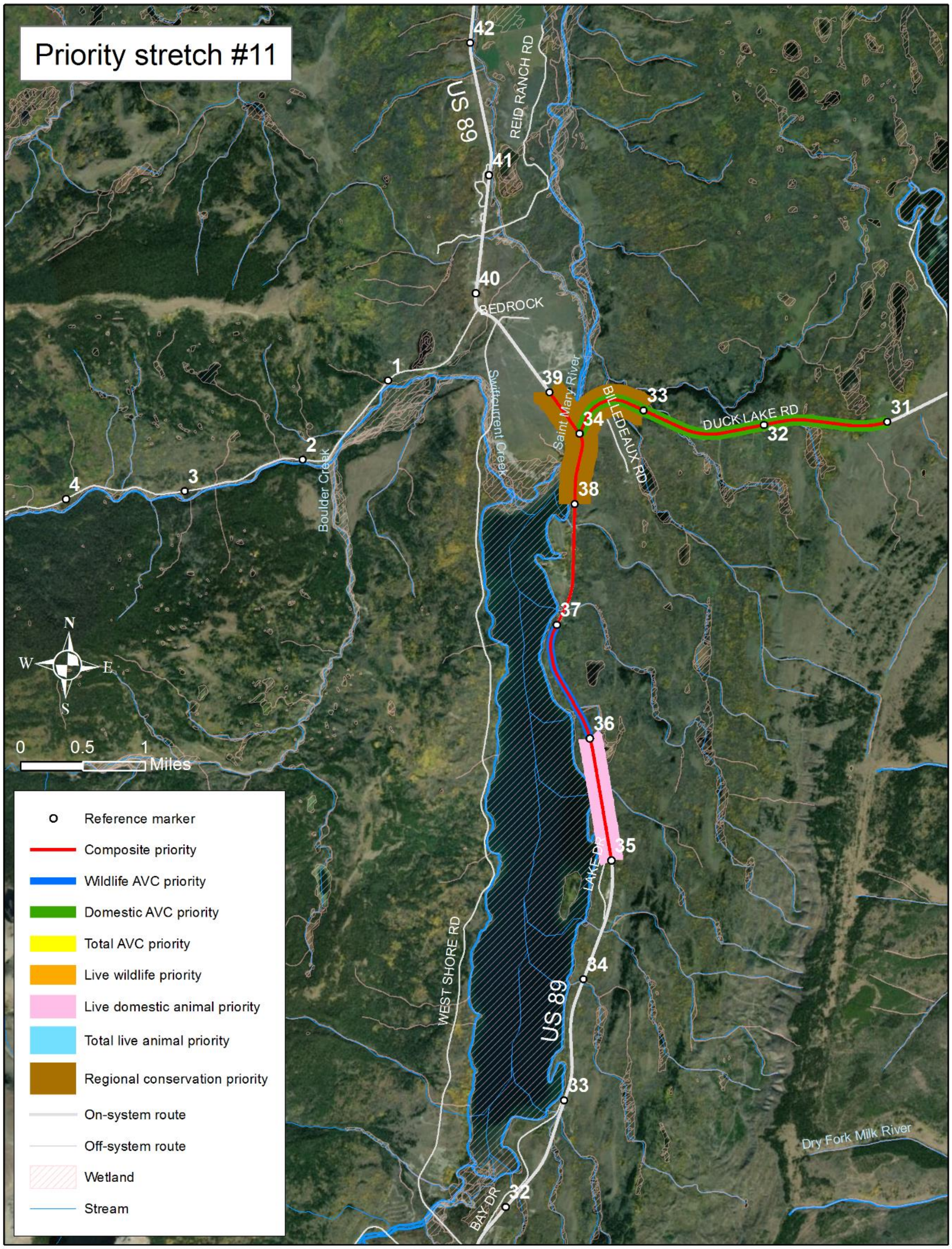


Figure 12: Map of Stretch 11.

- **STRETCH 12: *Highway 89 MP 43-44. North of Babb. Average Daily Traffic=1600 vehicles.***

Priority Rank: 3

- This site was identified as a priority due to high WVC risk. It also has high local conservation value due to its location within the Kennedy Creek drainage, a tributary to the Saint Mary River. BFWD note that this is a heavy movement area for moose and other wildlife moving between the mountains to the west and the Saint Mary River and wetlands/ponds to the east.
- Land ownership adjacent to this road stretch is primarily public (tribal/federal), with a few parcels of private (fee and allotted) lands.
- There is an existing bridge over Kennedy Creek around MP 43.8 (48.914321, -113.434992) with potential for terrestrial wildlife passage. Unfortunately, there is currently a steep line of boulders that spans from the sides of the bridge all the way to the water, restricting terrestrial passage beneath the bridge, especially for ungulates. MDT staff note that this could be fixed relatively easily (from an engineering perspective) with a retrofit to create a walkway for wildlife.
- <u>Recommended Mitigation Actions</u>: To allow for wildlife to safely pass beneath the bridge at Kennedy Creek, we propose retrofitting the boulder rip-rap to create a walkway for terrestrial wildlife passage. It will be critical to place this walkway where there will be sufficient vertical clearance (at least 4 meters) to allow for moose to pass safely under the bridge. We also recommend wildlife-proof fencing to guide animals to the bridge underpass once a walkway has been installed. Due to the short length of the associated wildlife-proof fencing, we also recommend fence end treatments to keep wildlife from entering the fenced road stretch.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
5	5	5	4	2	3	4	5	5	1	5	1	3.75

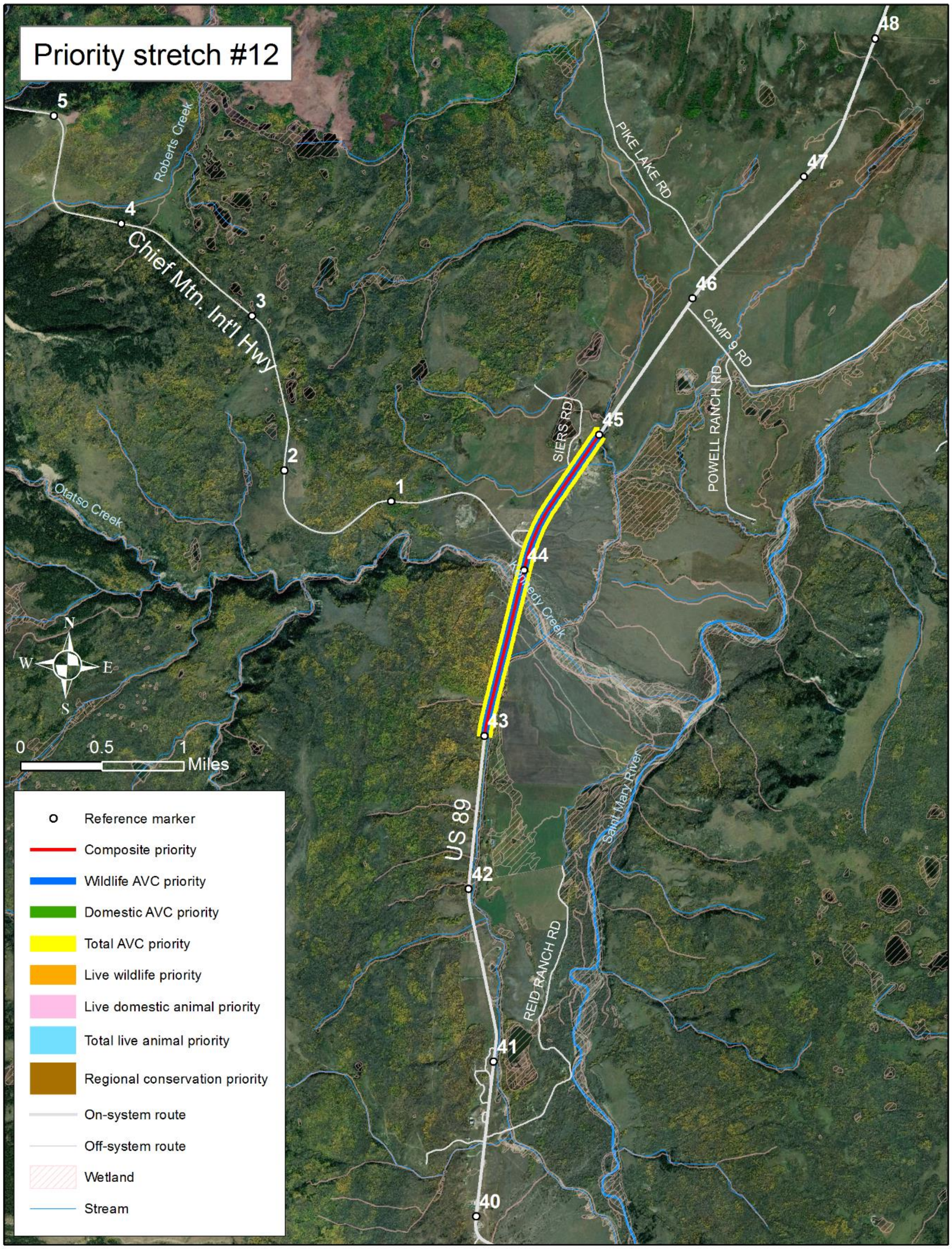


Figure 13: Map of Stretch 12.

➢ **STRETCH 13:** ***Highway 89 MP 85. Along southern border of the Blackfeet Reservation. Average Daily Traffic=708 vehicles.***

Priority Rank: 6

- This site was identified as a regional conservation priority. It is located in the Birch Creek drainage along the southern border of the Reservation and is an important movement corridor for wildlife.
- Land ownership adjacent to this road stretch is primarily private (allotted) open space.
- There is an existing bridge over Birch Creek around MP 85 (48.326226, -112.547655) that has high potential for use by wildlife but is currently outfitted with boulders down to the water's edge. Terrestrial passage for wildlife should be improved for the existing bridge to be functional as a wildlife crossing.
- Recommended Mitigation Actions: To allow for wildlife passage beneath the bridge at Birch Creek, we recommend that a terrestrial walkway be created. In addition, we recommend that wildlife-proof wing fencing be constructed on both sides of the road to guide wildlife towards the safe crossing opportunity. This wing fencing should extend from the bridge to Birch Creek Road (48.327762, -112.549217) to the north, and to Robare Lane and the edge of the riparian tree line to the south (48.322992, -112.544446).

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
4	3	4	3	4	3	5	5	5	1	3	1	3.42

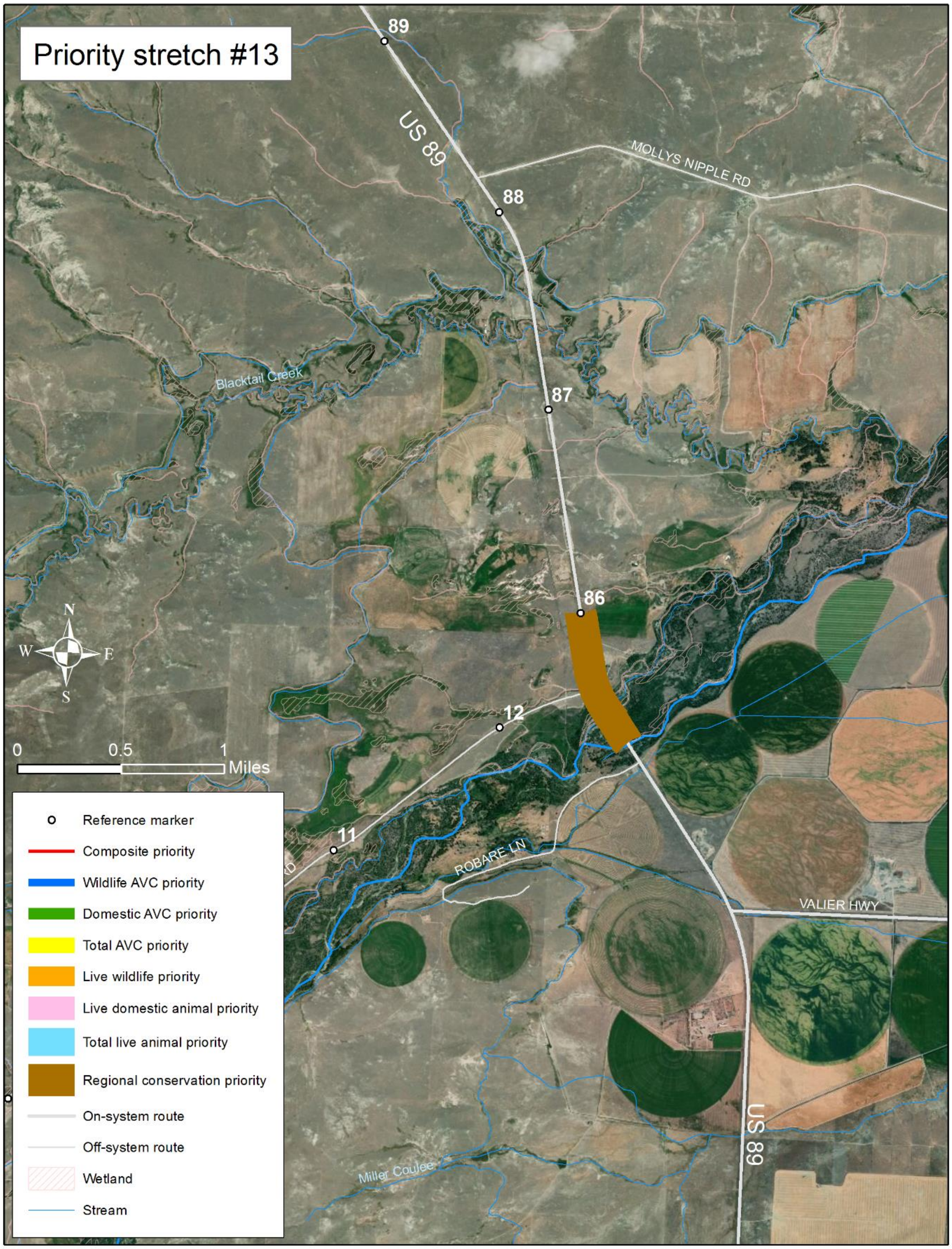


Figure 14: Map of Stretch 13.

- **STRETCH 14:** ***Highway 89 MP 94-99. Average Daily Traffic=873.***

Priority Rank: 5 (tie with Site 8)

- This site was identified as a priority due to AVC risk and local conservation value, as the Badger Creek Drainage provides important wildlife habitat.
- Land ownership adjacent to this stretch of road is primarily private (fee and allotted) open space.
- There is an existing bridge over Badger Creek around MP 96.6 (48.433981, -112.704732) that currently provides good terrestrial passage for wildlife.
- MDT is in the process of replacing the ROW fencing along this road stretch, which should address the safety issue of livestock on the road.
- <u>Recommended Mitigation Actions</u>: None at this time. Because (1) MDT is already addressing the safety issue of livestock on the road with new ROW fencing (although we recommend that all future ROW fence be wildlife-friendly), and (2) the bridge is currently providing habitat connectivity for wildlife, we concluded that the issues identified at the site are already being addressed and thus proposed no further action.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
3	5	4	3	5	5	3	4	5	1	3	1	3.5

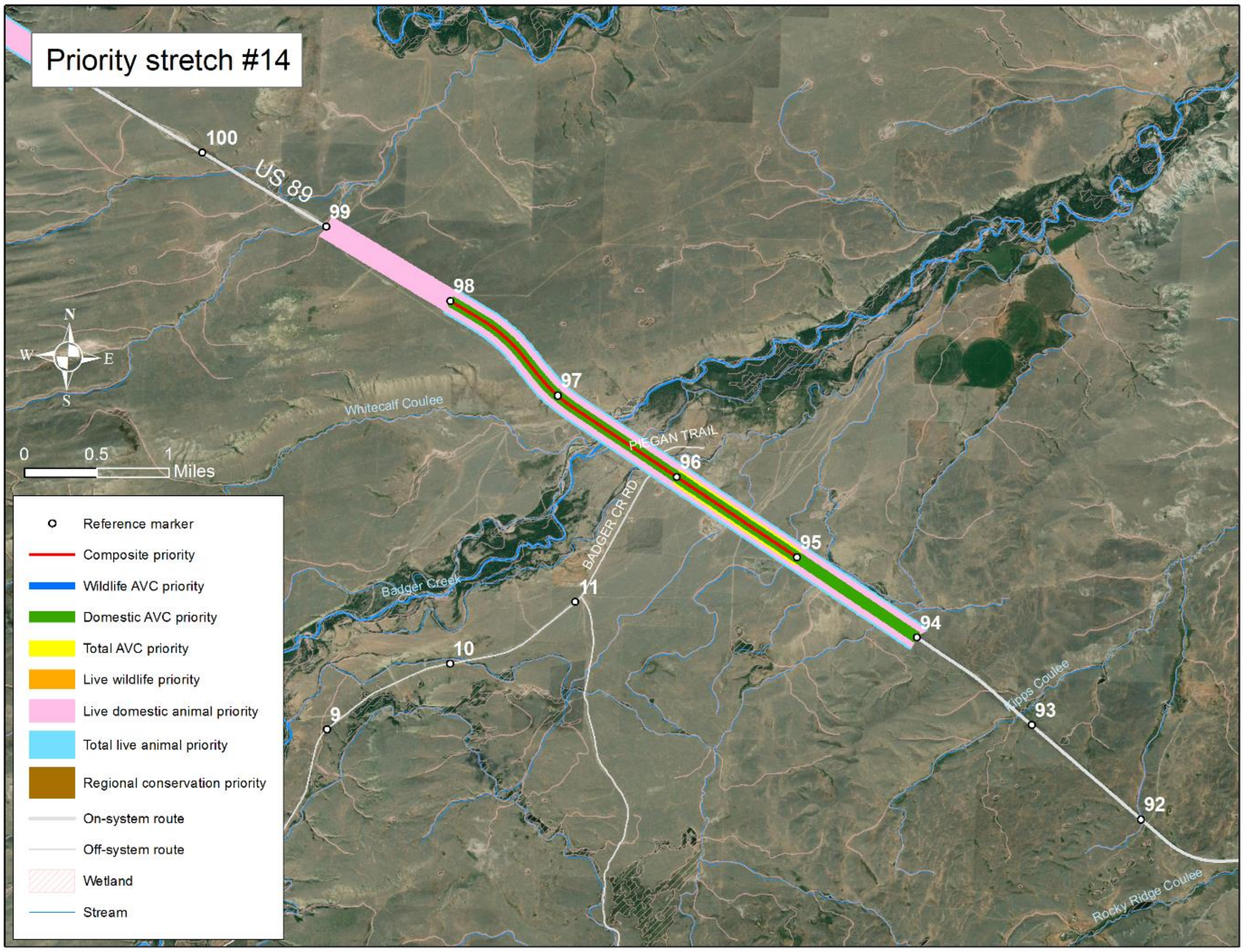


Figure 15: Map of Stretch 14.

➢ **STRETCH 15:** ***Highway 89 MP 101-104. Average Daily Traffic=873 vehicles.***

Priority Rank: 9

- This site was identified as a priority due to high AVC risk and local conservation value, as the Two Medicine River drainage provides important wildlife habitat.
- Land ownership adjacent to this stretch of road is private (fee and allotted) open space.
- There is an existing bridge over the Two Medicine River around MP102.1 (48.472968, -112.801713) that provides some terrestrial passage, but this could be improved.
- Because MDT replaced the ROW fencing along this stretch within the past 5 years, we concluded that the issue of livestock on the road had been solved so long as it is maintained.
- Recommended Mitigation Actions: We recommend that terrestrial passage be improved under the bridge at Two Medicine River. Because the ROW fencing was recently replaced, the AVC risk associated with livestock on the road is likely resolved if maintained.

WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnerability	AVG Score
3	3	3	3	5	5	2	5	5	1	3	1	3.25

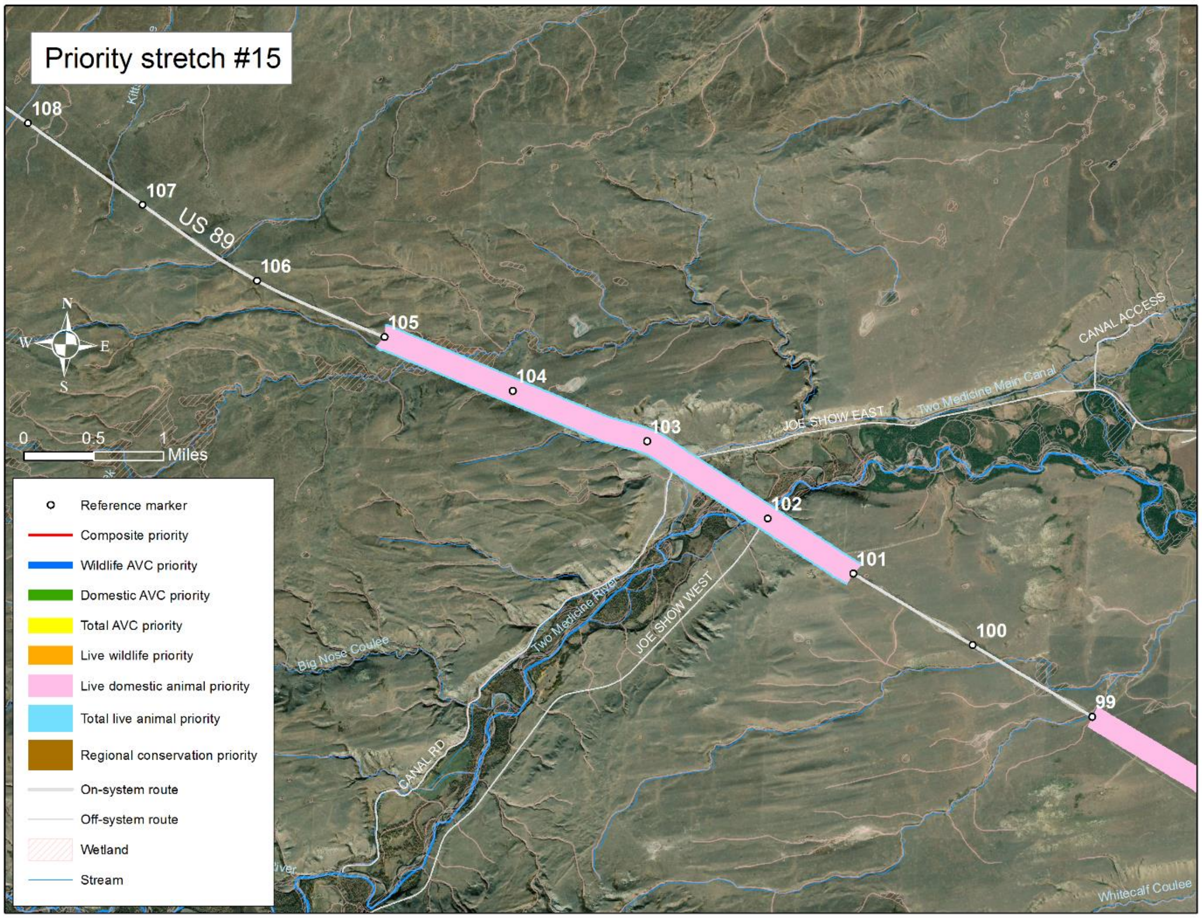


Figure 16: Map of Stretch 15.

Table 8. Overall scores and rankings for all 15 priority road stretches.

Stretch ID	WVC Risk	DAVC Risk	Total AVC Risk	Live Wildlife on/near rd	Live dom. on/near rd	All animals on/near rd	Reg. cons. value	Local cons. value	Mitigation options	Barrier effect	Land Security	Vulnera -bility	AVG Score	Priority Rank
1	2	3	3	4	3	3	5	5	5	1	3	1	3.16	11
2	2	3	2	4	3	4	5	5	5	1	3	1	3.16	10
3	4	2	3	4	2	2	5	5	5	1	3	1	3.08	12
4	3	5	4	4	2	3	5	4	4	2	4	1	3.42	7
5	5	4	5	3	4	4	5	5	4.5	3	3	2	3.96	1*
6	5	4	5	4	2	3	1	2	2	2	3	1	2.83	14
7	5	4	5	5	2	4	2	5	5	3	3	4	3.92	2*
8	4	3	4	5	2	4	3	4	5	3	4	1	3.5	5
9	3	3	4	5	4	5	4	5	1	1	4	1	3.33	8
10	3	5	4	3	3	2	4	4	5	1	2	1	3.08	13
11	5	4	5	3	4	4	4	2	5	3	4	1	3.66	4*
12	5	5	5	4	2	3	4	5	5	1	5	1	3.75	3*
13	4	3	4	3	4	3	5	5	5	1	3	1	3.42	6
14	3	5	4	3	5	5	3	4	5	1	3	1	3.5	5*
15	3	3	3	3	5	5	2	5	5	1	3	1	3.25	9

*Denotes a site that is in the Top Five Priority Road Stretches

4.2. Additional Recommendations for Off-System Routes:

In addition to the site-specific recommendations for the 15 priority sites outlined above, we concluded it was necessary to address AVC issues associated with several of the Off-System routes (routes not maintained by MDT) for which very few data were available, thereby precluding a robust analysis. Throughout the course of the project, several Off-System routes were repeatedly brought up for discussion as being serious safety concerns, especially for livestock-vehicle collisions. Although these routes were not identified as priorities based on our data analysis (likely due to lack of available data), we concluded that it was appropriate and necessary to recognize the community's identification of these routes as serious problem areas for human safety risk due to livestock on roads and to provide recommendations to mitigate this risk.

The Off-System routes that were identified as problematic through local knowledge and anecdotal evidence (shared at the public meetings and through conversations on-the-ground) are Heart Butte Road, Badger Creek Road, Birch Creek Road, and Starr School Road. In order to keep livestock off of these routes while maintaining connectivity for wildlife, we recommend that wildlife-friendly livestock fencing (along with gates and cattle guards at access points) be installed along the ROW. With the help of the Blackfeet Nation's seasonal Piikani Lands Crew, a division of Montana Conservation Corps (MCC) this could be an effective and low-cost solution to improve the safety of these roads for both people and animals. In addition, we recommend that tribal agencies (e.g., BFWD, BLD) begin collecting and sharing data on where livestock are gaining access to the roads and working with landowners and transportation staff from the road's jurisdiction (tribal, BIA, county, etc.) to ensure ROW fences are properly maintained to exclude livestock from the road. In portions of the Reservation that are "open range" (either officially or in practice), we recommend that signage be deployed to warn visitors, who may not be familiar with the area or with the concept of open range, that there may be loose livestock on the roads.

4.3. Enforcement of existing Tribal Mandates on Livestock Tresspass:

There are currently two Tribal Resolutions (313-2007; 38-2015A) and one Tribal Ordinance (19-A) that seek to address the issue of livestock on roads. Ordinance 19A and Resolution 313-2007 both state that livestock are prohibited from "trespassing" on highway rights-of-way, and trespassing animals will be removed and impounded, and their owners subjected to penalties, including fines. These regulations (and their amendments) set forth well-defined procedures for who is the party responsible for responding to these "trespassing" livestock, and the appropriate remedies for such trespass, including impoundment, penalties, and possible sale at auction, it is clear, however, by reading these documents, and consulting with the public and some of the responsible agencies that there has been a long-standing and ongoing dearth of effective enforcement.

Indeed, the express terms of Resolution 38-2015 acknowledge this deficiency:

> ***"The provisions of the Blackfeet Tribal Resolution No. 313-2007 have not been adequately and routinely enforced by the appropriate tribal officials and programs, and it would be in the best interests of the safety of the public travelling through the***

Blackfeet Indian Reservation for the provisions of this Resolution to be actively enforced."

We propose that the agencies responsible for responding to livestock on roads and enforcing the Ordinance 19A, including the Montana Department or Transportation and Montana Justice Department for non-Indian livestock owners; and Blackfeet Law Enforcement, Blackfeet Stock Inspectors, Blackfeet Fish and Wildlife, and Blackfeet Lands Department for tribal livestock owners (Tribal Resolutions 38-2015A and 38-2015) conduct a meeting and develop an Action Plan and Task Force to address the continued threat of trespassing livestock. More robust enforcement of these regulations is essential to improving safety on Reservation roads, as fatalities and injuries involving crashes with domestic animals have continued to occur despite Ordinance 19A's passage in July 1973.

In addition, Resolution 38-2015A requests that, pursuant to sections 60-7-101, 102, and 103 of the Montana Code Annotated, the State fence its rights-of-way in designated "high hazard areas". We recommend that a similar regulation be crafted and adopted for all roads on the Reservation. In addition to more rigorous enforcement and construction of fencing by MDT in high-hazard areas, we further encourage consideration of a default presumption that, absent specific reasons for overcoming the presumption, wildlife-friendly livestock fencing will be installed in order to reduce the negative impact of livestock fencing on wildlife movements.

4.4. Renderings: Examples of Recommended Mitigation Measures

4.4.1. Rendering of Bridge Modification

This rendering provides a visual representation of a modified bridge over the Two Medicine River on Looking Glass Road (Site 2) that includes a walkway to allow large wildlife to pass safely under the bridge instead of having to cross at-grade on the road surface.

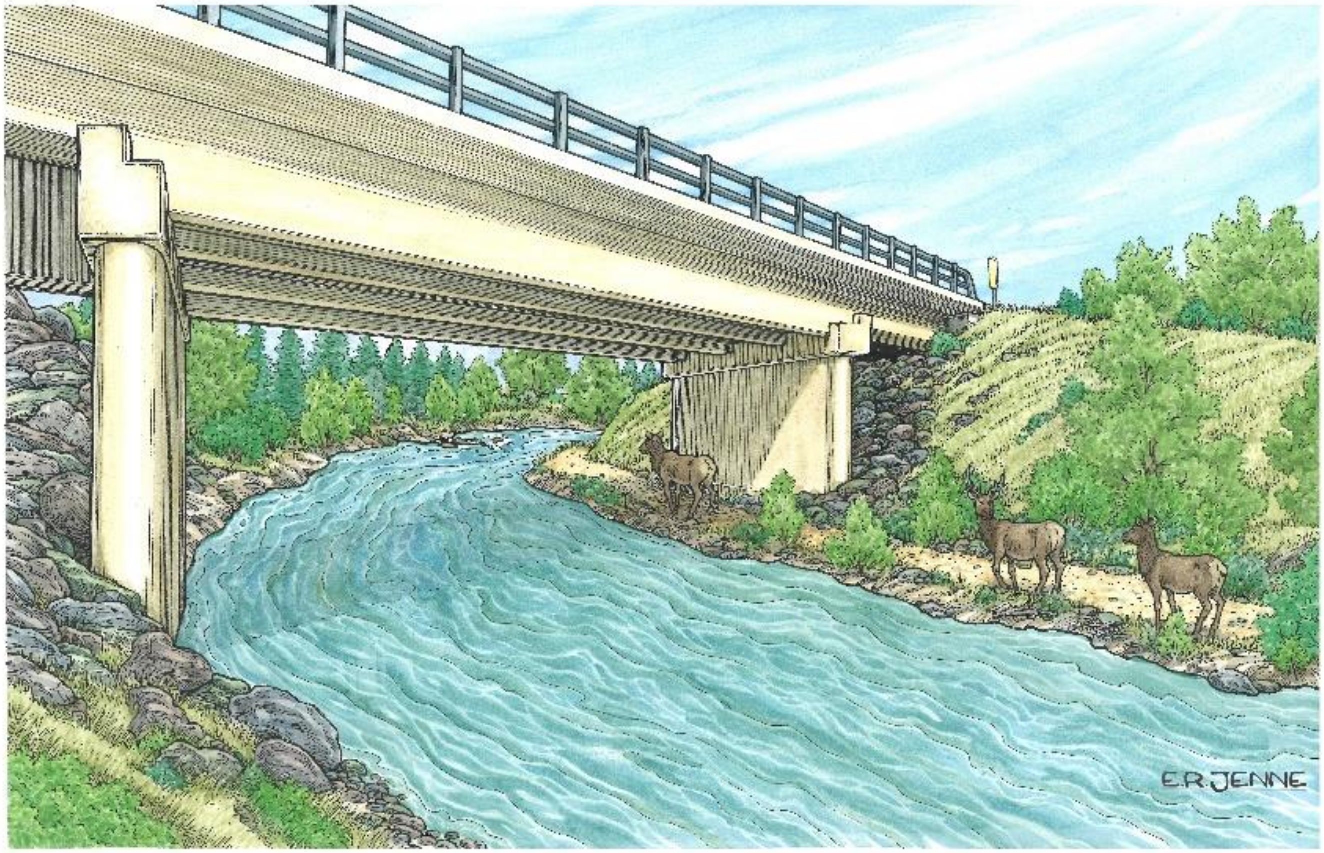


Figure 17: Rendering of a recommended bridge modification to include a walkway for safe wildlife passage. The existing bridge has no space beneath it to allow animals to walk under the bridge, which forces animals moving along the riparian corridor to cross the road at-grade. Artist rendering by Ed Jenne.

4.4.2. Rendering of a new wildlife underpass

This rendering provides a visual representation of a proposed new wildlife underpass that would be suitable for large wildlife such as elk, moose, and grizzly bear family groups. This proposed crossing structure is on Duck Lake Road (Stretch 4) where the road is built up on deep fill, and thus building a span bridge (as pictured) could likely be readily accommodated by removing existing fill.

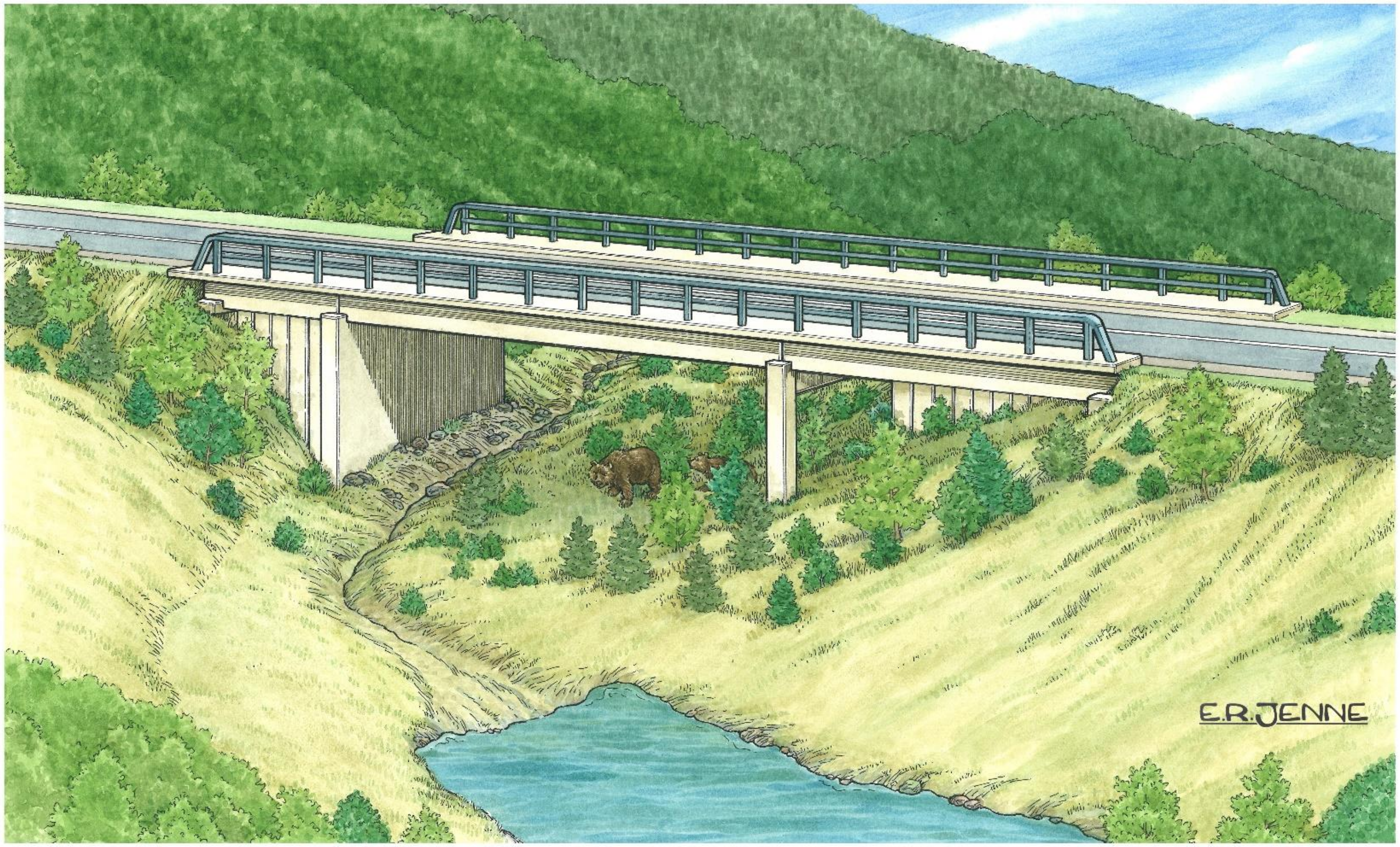


Figure 18: Rendering of a new wildlife underpass. Artist rendering by Ed Jenne.

4.4.3. Rendering of a new wildlife overpass

This rendering provides a visual representation of a wildlife overpass proposed on Hwy 89 (Stretch 8). This location was chosen due to its topography, with the existing deep road-cut allowing for construction of the overpass while requiring minimal fill on one side of the road. This area is currently adjacent to bison range and will likely be used by wild bison once their population is established.

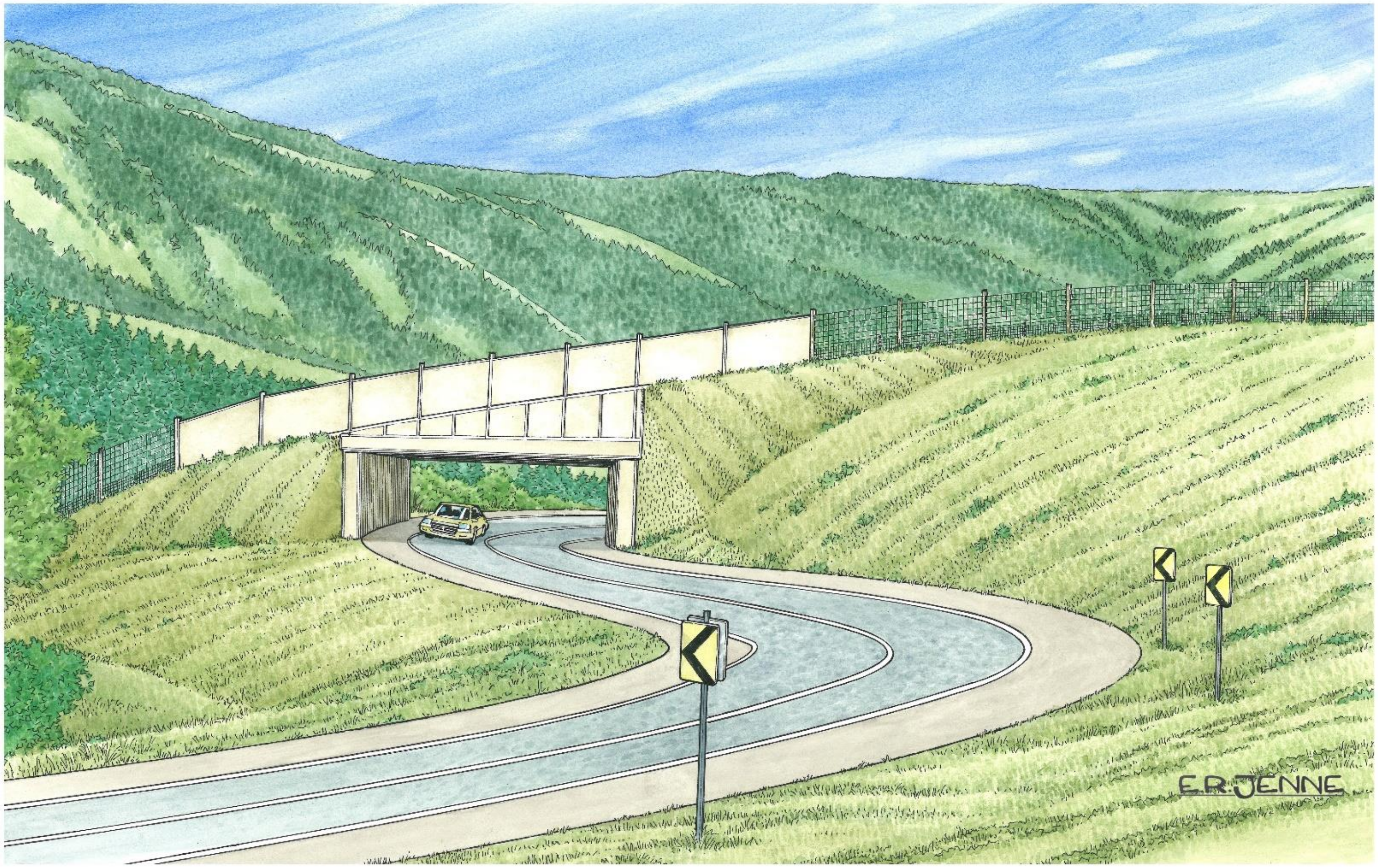


Figure 19: Rendering of Proposed Overpass on Highway 89 (Stretch 8). Artist rendering by Ed Jenne.

5. DIRECT MONETARY COSTS OF ANIMAL-VEHICLE COLLISIONS

5.1. Introduction

In a 2008 Report to Congress, Huijser et al. summarize the costs associated with wildlife-vehicle collisions for common ungulates in the United States (deer, elk, and moose), which make up over 90% of all WVCs in North America (Huijser et al., 2008). This model takes into account the following criteria on a per collision basis: vehicle repair costs, human injuries, human fatalities, towing, accident attendance and investigation, hunting value of the animal, and carcass removal and disposal (Huijser et al., 2008). These costs are summarized in Table 9 below.

This model is mostly based on human safety parameters. Parameters and economic values associated with biological conservation, tourism and recreation, and the cultural and spiritual value of wildlife are not included in this model. Therefore, the model is limited to assessing the costs of collisions through the lens of human safety.

Table 9. Summary of costs associated with a WVC for deer, elk, and moose (summarized from Huijser et al., 2008).

Description	**Deer**	**Elk**	**Moose**
Vehicle repair costs per collision	$1,840	$3,000	$4,000
Human injuries per collision	$2,702	$5,403	$10, 807
Human fatalities per collision	$1,671	$6,683	$13,366
Towing, accident attendance and investigation	$125	$375	$500
Hunting value of the animal per collision	$2,000	$3,000	$2,000
Carcass removal and disposal per collision	$50	$100	$100
TOTAL:	$8,388	$18,561	$30,773

*Costs are in 2007 U.S. dollars and have likely increased since that time due to inflation.

Methods

We used 10 years of data from two sources for the AVC economic cost analyses:

- Animal-vehicle crash data recorded by MHP (2008 through 2017). This data set includes a description of the animals involved in each crash, but the description is limited to “wild” (typically large wild ungulates) or “domestic” (typically cattle or horses).

- Carcass removal data recorded by MDT maintenance personnel (2008 through 2017). This data set also includes a description of the animals involved in each crash, but the description is typically to the species level for wild species (e.g. deer, elk, black bear, moose, pronghorn, grizzly bear, “other wild species”) or “domestic” (typically cattle or horses).

It is important to note that we were only able to use two out of the five data sets that included reports on crashes and carcasses for this analysis. Crashes and carcasses recorded by BFWD, BLD, and from the community mapping exercise were not reported with the necessary spatial and temporal accuracy or consistency to be included in this analysis. While these data sources were still helpful for other aspects of our analysis (e.g., identifying high priority road stretches for further examination), we hope that one of the outcomes of this study will be improved data collection standards and sharing of data among the various jurisdictions and agencies in the region that are collecting this type of data.

In addition to the fact that that we were only able to use a fraction of the available data for this portion of the study, we also know that crashes and carcasses are generally underreported, perhaps by as much as 70-85% (Huijser et al., 2008). A 2018 study in Idaho used a conservative correction factor of 50% underreporting for their economic analysis (Seidler et al., 2018; Conover et al., 1995). Underreporting may have various causes, including infrequent carcass checks, poor visibility of the carcass from the road, mutilation of the carcass by traffic to the point that the species can no longer be identified or that little to none of the carcass remains, decomposition, and removal by humans or scavengers (Huijser et al., 2008). In addition, drivers may be less likely to report an accident with an animal if they are out of compliance with law enforcement for any reason, or if they are in a remote place where they may have to wait for a long period of time for a law enforcement responder to arrive at the scene. For this analysis, we chose not to adjust cost estimates using a correction factor because the appropriate value for that correction factor is highly uncertain; however, readers should bear in mind when interpreting results of the economic analysis that our reported cost estimates likely account for only a fraction of the AVCs occurring on the Reservation.

For each of the 15 priority road stretches, we counted the numbers of wildlife crashes, wildlife carcasses, domestic animal crashes, and domestic animal carcasses within the stretch. We divided these counts by the total length of the stretch and then by the number of years of data (n=10) to convert counts to per-mile-per-year rates for each of the four categories (Table 10). We then multiplied these rates by per-animal collision costs from Huisjer et al. (2008) to estimate the total cost of AVCs per year per mile within each priority stretch (Table 11). We assumed that wild animal collisions had the same per-animal costs as those calculated for deer collisions because the vast majority of wildlife AVCs on the Reservation involve deer. We assumed that domestic collisions had the same per-animal costs as those calculated for moose collisions because (1) cost estimates for domestic animal collisions were unavailable and (2) horse and cattle, which account for most domestic animal collisions on the Reservation, are most similar in body mass to moose.

Table 10. Rates of AVCs per mile per year within priority road stretches.

Stretch number	Stretch description	Domestic animal crash rate per mile per year	Wildlife crash rate per mile per year	Domestic animal carcass rate per mile per year	Wildlife carcass rate per mile per year
1	Heart Butte Rd, RM14-16	0.100	0.000	NA*	NA*
2	Lookinglass Rd, RM2-3	0.000	0.000	NA*	NA*
3	Cutbank-Valier Hwy, RM16-17	0.000	0.000	0.000	0.289
4	Duck Lake Rd, RM31-34	0.261	0.037	0.261	0.037
5	US2, Reservation boundary to RM211	0.131	0.240	0.044	0.328
6	US2, RM245-250	0.180	0.240	0.040	0.400
7	US2, RM254 to Reservation boundary	0.000	0.713	0.713	1.425
8	US89, RM10-12	0.100	0.150	0.000	0.050
9	US89, RM22-27	0.141	0.060	0.141	0.040
10	US89, RM30-31	0.098	0.000	0.000	0.000
11	US89, RM35-39	0.101	0.378	0.050	0.101
12	US89, RM43-45	0.200	0.499	0.150	0.200
13	US89, Reservation boundary to RM86	0.000	0.295	0.000	0.148
14	US89, RM94-99	0.420	0.020	0.080	0.060
15	US89, RM101-105	0.000	0.079	0.026	0.026

*NA indicates that these priority stretches are located along "Off-System" routes that are not included in MDT's carcass collection efforts and are therefore effectively unsampled.

The costs associated with the implementation of different types and combinations of mitigation measures can vary, but we provide the best available estimates in Table 11. We have included one mitigation measure for domestic species (wildlife-friendly livestock fences), and three different types and combinations of mitigation measures for large wild animal species (Table 11). The costs estimates are all based on a 75-year long life expectancy of crossing structures and a 3% discount rate (see Huijser et al., 2009) for details.

Table 11. Costs per mile per year of mitigation measure discussed in this study.

Measures	**Costs (US$ per mile per year)**
Wildlife friendly livestock fence	$2,550 (2019 US$)*1
Wildlife fence, under pass (once every 2 km), jump-outs	$18,123 (2007 US$)*2
Wildlife fence, under- and overpass (underpass once every 2 km, overpass once every 24 km), jump-outs	$24,230 (2007 US$)*2
Wildlife fence, gap (once every 2 km), animal detection system in gap, jump-outs	$28,150 (2007 US$)*2

*1 Based on Huijser et al., (2016): Installation $9/m in 2006 US$, $18,000/km (both sides hwy) in 2006 US$, $22,848/km (both sides hwy) in 2019 US$, $36,762/mi (both sides hwy) in 2019 US$, based on 25 year life span, $500 maintenance per year, $10,000 removal costs, and 3% discount rate, the annual costs are $2,550/mile/year.
*2 See Huijser et al., 2009 for cost calculations.

In addition to the cost analysis presented in this chapter, the study authors also estimated costs at a finer spatial scale (0.1-mile segments) for the entire study road network. These results can be found in Appendix B.

Results

Estimates of total AVC costs (including domestic animal and wildlife collisions recorded in crash and carcass records) per mile per year within priority stretches ranged from $0 to $39,874. For most priority stretches, costs associated with domestic animal collisions exceeded costs associated with wildlife collisions. Estimated AVC costs in some priority stretches were very low because these stretches were initially identified as priorities based on factors other than human safety risk, such as wildlife connectivity value.

We reiterate that the data used to conduct the analysis likely represent only a fraction of the actual AVCs on the reservation, and therefore the cost estimates presented in Table 11 should be interpreted as minimum estimates; true costs are likely to be several times greater. In addition, these costs do not take into account the values associated with biological conservation, tourism and recreation, or the cultural and spiritual value of wildlife.

Table 12. Costs of AVCs per mile per year within the 15 priority road stretches.

Stretch number	Stretch description	Cost per mile per year of domestic animal crashes	Cost per mile per year of wildlife crashes	Cost per mile per year of domestic animal carcasses	Cost per mile per year of wildlife carcasses	Total cost of all AVCs per mile per year *
1	Heart Butte Rd, RM14-16	$ 3,077.30	$ 0	NA	NA	$ 3,077.30
2	Lookinglass Rd, RM2-3	$ 0	$ 0	NA	NA	$ 0
3	Cutbank-Valier Hwy, RM16-17	$ 0	$ 0	$ 0	$ 2,424.13	$ 2,424.13
4	Duck Lake Rd, RM31-34	$ 8,031.75	$ 310.36	$ 8,031.75	$ 310.36	$ 16,684.22
5	US2, Reservation boundary to RM211	$ 4,031.26	$ 2,013.12	$ 1,354.01	$ 2,751.26	$ 10,149.66
6	US2, RM245-250	$ 5,539.14	$ 2,013.12	$ 1,230.92	$ 3,355.20	$ 12,138.38
7	US2, RM254 to Reservation boundary	$ 0	$ 5,980.64	$ 21,941.15	$ 11,952.90	$ 39,874.69
8	US89, RM10-12	$ 3,077.30	$ 1,258.20	$ 0	$ 419.40	$ 4,754.90

9	US89, RM22-27	$ 4,338.99	$ 503.28	$ 4,338.99	$ 335.52	$ 9,516.79
10	US89, RM30-31	$ 3,015.75	$ 0	$ 0	$ 0	$ 3,015.75
11	US89, RM35-39	$ 3,108.07	$ 3,170.66	$ 1,538.65	$ 847.19	$ 8,664.58
12	US89, RM43-45	$ 6,154.60	$ 4,185.61	$ 4,615.95	$ 1,677.60	$ 16,633.76
13	US89, Reservation boundary to RM86	$ 0	$ 2,474.46	$ 0	$ 1,241.42	$ 3,715.88
14	US89, RM94-99	$ 12,924.66	$ 167.76	$ 2,461.84	$ 503.28	$ 16,057.54
15	US89, RM101-105	$ 0	$ 662.65	$ 800.10	$ 218.09	$ 1,680.84

*Possibility of duplicates between reported crashes and carcasses. NA for some fields is due to the fact that these priority stretches are on “Off-System” routes that are not included in MDT’s carcass collection efforts.

Discussion

Cost estimates for AVCs within priority stretches will be a useful tool for transportation managers who need to justify their decisions to implement mitigation measures with economic evaluations. These are conservative estimates of costs using cost values from 2007 (with the exception of the livestock fencing costs which are in 2019 dollars) and do not include a correction factor for likely underreporting. Collisions with domestic animals on the Reservation could be mitigated with the construction of wildlife-friendly livestock fencing, which costs an estimated $2,550 per mile per year to build and maintain (Table 11) (Huijser et al., 2016). For the vast majority of the priority road stretches identified in this study, the cost threshold for constructing wildlife-friendly livestock fencing is met or exceeded (Table 12). This means that constructing wildlife-friendly livestock fencing to reduce the number of collisions with livestock would actually save money compared to doing nothing. In addition, retrofitting existing bridges to include safe passage routes for wildlife beneath the road surface and constructing wing fencing to guide animals toward safe crossing opportunities could be done at a relatively low cost (far less than the values for constructing new crossing structures and fencing described in Table 11) and could improve wildlife habitat connectivity and reduce AVCs. These types of mitigation options would pay for themselves just in terms of human safety parameters outlined above well within their lifetime. For more extensive mitigation measures such as constructing new wildlife crossing structures with fencing (as described in Table 11), an underreporting correction factor and/or other values such as tourism and recreation, cultural and spiritual value of wildlife to the community would need to be included to meet the cost-benefit thresholds (Table 11, Appendix B).

6. POTENTIAL FUNDING SOURCES

6.1. Introduction

There are a variety of potential sources of funding that support transportation infrastructure and related mitigation measures aimed at reducing the number of AVCs and maintaining or improving habitat connectivity on Blackfeet tribal lands. Most familiar are the traditional transportation programs authorized under the two most recent transportation bills - *Moving Ahead for Progress in the 21st Century Act* (MAP-21), Public Law No. 112-141 (2012), as modified by the *Fixing America's Surface Transportation Act* (FAST Act), Public Law No. 114-94, 23 USC § 101 *et seq*. (2015). In addition to these, there are other federal, state, and private funding sources potentially available to the Blackfeet Nation and its partners to support implementation of the site-specific mitigation measures recommended in this report, including construction of wildlife crossing structures, deployment of seasonal VMSs, and livestock fencing construction and repair projects.

In addition to direct funding programs, numerous communities have explored, and in many cases successfully employed, public-private partnerships to reduce AVCs on local roadways and in some instances achieve other common goals such as the protection of threatened or endangered species, restoring or improving adjacent habitat and functioning ecosystems, and reducing the effects of motorist collisions on rural communities and their residents, for which the loss of a functioning vehicle too often impacts their ability to commute to jobs or secure access to other critical community services. Public-private partnerships consisting of a wide-ranging spectrum of interested stakeholders have the additional benefit of potentially providing additional non-federal funds, or "matching" funds that are typically required by federal transportation programs.

Such benefits reach well beyond the realm of transportation safety, thereby providing tribal members and community residents with the opportunity to develop new partnerships that have the ability and capacity to tap additional resources. Indeed, as described below, many successful partnerships focusing on the mitigation of highways to protect wildlife and motorists have sought to access the broadest variety of funding opportunities, including a mix of federal, tribal, state, and local funding opportunities as well as private funding from charitable foundations, non-profit organizations, corporations and/or individuals. Since many federal and state grant programs include restrictions on the use of private funding for mitigation and infrastructure, assembling a diverse array of partners who are able to use private funds for other activities related to the mitigation, such as monitoring, research, and outreach, is often quite useful. Thus, a diverse partnership can collectively raise funds for different facets of the overall mitigation project.

Lastly, although not a direct source of funding, the FAST Act authorizes MDT to develop programmatic mitigation plans to address the potential environmental impacts of future transportation projects (23 U.S.C. § 169). These plans may be developed on a regional, ecosystem, watershed, or statewide scale and may encompass multiple environmental resources within a defined geographic area or may focus on a specific resource, such as aquatic resources, parkland, or wildlife habitat. Overall, such plans help ensure a more systematic approach to highway planning and projects, rather than simply constructing individual projects on a "one-off' basis. If desired, the Blackfeet Nation could work with MDT to assess the propriety of including the recommended mitigation measures from this AVC study in the state's long-range transportation planning and short-term programmed highway safety improvement projects, as warranted.

6.2.Transportation Funding Sources

The FAST Act carried forward and re-authorized funding of more than $300 billion per year for federal fiscal years 2015 through 2019 for a variety of surface transportation programs originally enacted in MAP-21 for federal fiscal years 2015 through 2019. It is a remarkable transportation law that explicitly makes available funding for projects aimed at reducing the number of motorist collisions involving wildlife or maintaining or improving ecological connectivity. As described below, these provisions include five programs that authorize tribal, federal, state, and local transportation officials to spend money on projects aimed at reducing AVCs and re-weaving habitat severed by roads (Callahan and Ament 2015).

6.2.1. Federal and Tribal Transportation Program

The FAST Act authorizes funding for three federal and tribal programs: the Tribal Transportation Program, the Federal Lands Transportation Program and the Federal Lands Access Program, (23 U.S.C. §§ 201-204).

6.2.1.1. Tribal Transportation Program

The Tribal Transportation Program (TTP) is the largest source of federal funding for projects involving tribal transportation facilities. Under the FAST Act, the program receives about $450 million/year to provide access to basic community services to enhance the quality of life on tribal lands. Funding from this program can be used to pay for environmental mitigation in or adjacent to tribal land (I) to improve public safety and reduce vehicle-caused wildlife mortality while maintaining habitat connectivity; and (II) to mitigate the damage to wildlife, aquatic organism passage, habitat, and ecosystem connectivity, including the costs of constructing, maintaining, replacing, or removing culverts and bridges, as appropriate.

6.2.1.2. Federal Lands Transportation Program

The FAST Act also provides approximately $350-$375 million per year for the Federal Lands Transportation Program (FLTP). Eligible projects include facilities on Federal Lands such as national parks, national forests, and wildlife refuges. The National Park Service gets the largest share of funding at $268 million in the first year up to $300 million in FY 2020, while the U.S. Fish and Wildlife Service ($30 million per year) and the U.S. Forest Service ($15 million in FY 2016 increasing to $19 million in FY 2020) receive smaller allotments. The remaining funds are competitively apportioned to the Bureau of Land Management, Army Corps of Engineers, and other federal agencies, depending on their needs.

Similar to the TTP, funding may be used to pay for environmental mitigation in or adjacent to Federal land open to the public (I) to improve public safety and reduce vehicle-caused wildlife mortality while maintaining habitat connectivity; and (II) to mitigate damage to wildlife, aquatic organism passage, habitat, and ecosystem connectivity, including costs to construct, maintain, replace, or remove culverts and bridges. In contrast to TTP and the Federal Lands Access Program, there is a cap of $10,000,000 per fiscal year for eligible FLTP activities aimed at reducing wildlife mortality (FAST Act § 1119(1)(B), 23 U.S.C. § 203(a)(1)(D)). Although tribal transportation facilities are not eligible for direct FLTP funding, it may be possible to defray the costs of tribal mitigation measures by bundling those projects with adjacent FLTP projects to take advantage of economies of scale and scope, thereby lowering overall costs for both projects (https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/project_bundling.cfm). The FLTP would also allow the Blackfeet Nation to explore cooperating with adjacent federal land management agencies, including Glacier National Park, on wildlife infrastructure and related mitigation measures of mutual interest.

6.2.1.3. Federal Lands Access Program

The Federal Lands Access Program (FLAP) complements the Federal Lands Transportation Program and other Federal transportation programs, such as the Defense Access Roads program and the Forest Development Roads and Trails program, by providing about $250 million per year in funding for projects to improve transportation facilities that provide access to, are adjacent to, or are located within Federal lands. FLAP also supplements State and local resources for public roads, transit systems, and other transportation facilities, with a preference for projects that provide access to high-use Federal recreation sites and economic generators, as identified by Federal land managers. FLAP funding can be used to pay for environmental mitigation to improve public safety and reduce AVCs while maintaining habitat connectivity. Many of the roads that are prioritized for wildlife crossings on Blackfeet Nation lands also provide access roads to nearby federal lands and thus can readily be shown to be important economic generators, given the high levels of tourism in Glacier National Park and nearby federal lands.

6.2.2. Montana Transportation Programs and Funding

The FAST Act provides federal funding for state projects to reduce AVCs under two programs: the Surface Transportation Block Grant Program (23 U.S.C. § 133(b) (15)), and the Highway Safety Improvement Program (23 U.S.C. § 148).

6.2.2.1. Surface Transportation Block Grant Program

This program provides over $10 billion per year in flexible funding for state and local governments to fund surface transportation projects on federal-aid highways. Under the FAST Act, this new Block Grant program subsumed what had previously been a separate program for activities identified as “transportation alternatives,” and replaced it with an annual set-aside of $835 to $850 million for similar projects under the Block Grant. Among other things, eligible projects include activities to reduce vehicle-caused wildlife mortality or restore and maintain connectivity among terrestrial or aquatic habitats.

6.2.2.2. Highway Safety Improvement Program

The FAST Act allocates over $2 billion each year to reduce traffic fatalities and serious injuries on all public roads, including non-State-owned public roads and roads on tribal lands. The Highway Safety Improvement Program (HSIP) requires states to use these funds for safety projects consistent with the state’s highway safety plan. Eligible highway safety improvement projects include the addition or retrofitting of structures or other measures to eliminate or reduce crashes involving vehicles and wildlife. Unlike the other FAST Act programs, projects aimed solely at improving or maintaining habitat connectivity (as opposed to those that have the twin goals of reducing AVCs while improving connectivity) are not eligible for HSIP funds.

Moreover, HSIP funds are typically allocated based on crash rate and crash severity prioritization through cost-benefit analyses. As a result, measures aimed at mitigating high rates of AVCs compete with all other crash types for funding.

6.2.2.3. BUILD Discretionary Grants

The *Better Utilizing Investments to Leverage Development* (BUILD) grant is a discretionary funding program run by the U.S. DOT. Formerly known as the *Transportation Investment Generating Economic Recovery*, or TIGER grant, the program was originally administered by the FHWA as part of the *American Recovery and Reinvestment Act of 2009*, 2009, Pub. L. No. 111-5, 123 Stat. 115 (2009 ("ARRA"). Since its inception in 2010, the program has awarded more than $7 billion in capital investment funds for surface transportation infrastructure over 10 rounds (USDOT 2019).

The Consolidated Appropriations Act, 2019 (Pub. L. 116–6, February 15, 2019) appropriated $900 million in funding for competitive surface transportation infrastructure investments including but not limited to roadway, bridge, or railway projects likely to have a significant local or regional impact. As described in this year's 2019 Notice Of Funding Opportunities (NOFO) for the BUILD grants, the Secretary of Transportation earmarked 50% of the funds for improved access to reliable, safe, and affordable transportation for rural communities, including projects that address public health and safety (USDOT 2019). Although not explicitly identified as eligible, projects to reduce AVCs such as the priorities identified in this report would appear to clearly meet the required touchstone of improving public health and safety. In addition to increased safety, other relevant grant selection criteria include projects that improve quality of life, promote innovation, and involve a diverse range of partners. The maximum funding award for the 2019 NOFO is $25 million per project, with a limit of no more than $90 million per state (USDOT 2019).

If the NOFO does not result in the award of all available funds, the U.S. DOT may publish additional grant proposal solicitations. Moreover, because BUILD funds must be appropriated annually by Congress, it remains unclear how this program will fare in the future. Nonetheless, to the extent Congress continues to fund the BUILD program, it remains a potential source of significant funding to deploy wildlife infrastructure including the measures recommended in this report. At the same time, BUILD is a highly competitive program and, although we are aware of multiple proposals having been submitted during past funding rounds, we are unaware of a successful application for wildlife infrastructure or related mitigation measures.

6.2.2.4. Eco-Logical Competitive Grants

Eco-Logical is a nine-step, voluntary framework for federal, state, tribal, and local partners to collaborate, share data, and identify and prioritize areas of ecological significance during infrastructure planning, design, review, and construction (USDOT 2006). Transportation planners and other decision-makers are free to use the Eco-Logical framework in its entirety, or to "pick and choose" those elements deemed most beneficial, based upon the task at hand. At its core, Eco-Logical seeks to pave the way for ensuring that transportation planning and projects consider wildlife and their ecosystems. In the past, the needs for Eco-Logical research were incorporated into the Strategic Highway Research Program (SHRP 2) and included, among other resources, funding for an Implementation Assistance Program (IAP). Launched in 2013, the IAP provided more than $130 million in funding and technical assistance to more than 430 projects in all 50 states, the District of Columbia, and Puerto Rico via seven rounds of SHRP2. Although the IAP is now closed, the SHRP2 website indicates the potential for "limited future opportunities for assistance on a case-by-case basis, as needs arise and funding permits." The site also references other potential opportunities to access funding aimed at promoting technology and innovation including *Every Day Counts*, *AASHTO's Innovation Initiative*, the *Accelerated Innovation Deployment Demonstration*, and *the State Transportation Innovation Councils Incentive Program*. For more information on IAP's status and potential opportunities to partner with MDT or federal land managers to employ the Eco-Logical process and potentially qualify for financial and technical assistance, visit: https://www.fhwa.dot.gov/goshrp2/ImplementationAssistance/FAQ.

6.3. Non-Transportation Funding Sources

In addition to transportation funding sources, there are a variety of other potential non-transportation funding sources, including federal and state wildlife grant programs.

6.3.1. Federal Non-Transportation Programs

6.3.1.1. USFWS Tribal Wildlife Grant Program

Since 2003, the U.S. Fish and Wildlife Service (FWS) has administered a competitive Tribal Wildlife Grant program that has provided over $60 million to tribal conservation initiatives spearheaded by more than 300 tribes (USFWS 2015). The goal of the program, which is open to federally-recognized tribes such as the Blackfeet, is "to provide a funding opportunity for tribal governments to develop and implement programs that benefit native species and their habitats, including those of cultural importance to Native Americans and those that are not hunted or fished" (USFWS 2015).

Grants may be used to provide funding and technical assistance to tribes, including conservation planning and management, habitat conservation, preservation, mapping, and management; laboratory and field research; field and population surveys, research, mapping, and monitoring; and public outreach and education, and may be used to pay for salaries, equipment, consultants, acquisitions, and travel (USFWS 2015). Grant proposals should highlight where the proposed project will address one or more of the following FWS priorities: Land Conservation Cooperatives, Threatened or Endangered Species, enhanced ability to engage in Consultation with Tribal Governments, Adaptation to Climate Change, America's Great Outdoors, and Youth in Nature (USFWS 2015). Because the recommended crossings and other mitigation measures have the potential to conserve and provide safe passage for game species, non-game species, and species of cultural significance, they are likely to align well with the goals of the Tribal Wildlife Grant program.

6.3.1.2. DOI Secretarial Order 3362: NFWF Grant Program

In 2018, the U.S. Department of Interior (DOI) issued a Secretarial Order aimed at *Improving Habitat Quality in Western Big-Game Winter Range and Migration Corridors* in 11 Western states, including Montana. Among other things, the Order asked state wildlife agencies to identify threats to priority wildlife corridors for big-game species such as elk, mule deer, and pronghorn (DOI 2018). A review of those state agency plans reveals that the single barrier identified by all 11 states is roads (*id*).

In an effort to address the identified barriers, a public-private partnership among the DOI, the National Fish and Wildlife Foundation (NFWF), and ConocoPhillips issued a request for proposals aimed at advancing the Order's goal of "Working cooperatively with private landowners and State highway departments to achieve permissive fencing measures, including potentially modifying (via smooth wire), removing (if no longer necessary), or seasonally adapting (seasonal lay down) fencing if proven to impede movement of big game through migration corridors" (DOI 2018). In addition, the Order authorizes use of "other proven actions necessary to conserve and/or restore the vital big-game winter range and migration corridors across the West" (DOI 2018).

In May of this year, the DOI, NFWF and Conoco-Phillips partnership awarded $2.1 million in funding to six states, involving one state DOT-tribal partnership and two fencing projects:

- "In Colorado, the state Department of Transportation will work with the Southern Ute Tribe and Colorado Parks and Wildlife to install wildlife fencing to direct mule deer, elk, and other wildlife to an either an overpass or underpass on U.S. Highway 160 between Durango and Pagosa Springs. This project will increase connectivity and maintain a significant corridor for the respective deer and elk herds while reducing mortality for these species and improving motorist safety (DOI 2019)."
- "In Montana, the Ranchers Stewardship Alliance, Inc. will work with a wide range of partners and in a completely voluntary manner with private landowners to improve or modify fencing in corridor areas (DOI 2019)."

Eligible applicants include tribal, federal, state, local, and municipal governments and non-profit organizations, and the press release suggests that this is the first of at least one more funding rounds. If a second solicitation is issued, it could be a great match for mitigation recommendations to replace existing 4-strand barbed wire with wildlife-friendly fencing and other wildlife-friendly measures to mitigate the harmful effects of roads on wildlife movement and migration. For more information on the program, please visit https://www.nfwf.org/westernmigrations.

6.3.1.3. State Non-Transportation Programs

In addition to direct federal sources, the Montana Department of Fish Wildlife and Parks (FWP) also receives federal grant funds through the State Wildlife Grant program that could potentially be indirectly tapped for wildlife infrastructure and related mitigation measures on Blackfeet tribal lands. The State Wildlife Grant program provides Federal funds to State fish and wildlife agencies to develop and implement programs that benefit wildlife and their habitats, including species that are not hunted or fished. Funds may be used for conservation needs identified in the state's State Wildlife Action Plan (SWAP), including habitat loss and fragmentation and stress due to changing climatic conditions. All three needs could be improved by deploying wildlife infrastructure to reduce AVCs and increase ecological connectivity. To view Montana's SWAP, visit: http://fwp.mt.gov/fishAndWildlife/conservationInAction/actionPlan.html.

6.4.Private Philanthropy

In addition to federal, tribal, and state funding opportunities, partnerships or coalitions consisting of public agencies and private partners are increasingly being used to develop innovative funding support to deploy wildlife crossing infrastructure and related mitigation measures, typically either to accelerate an existing project or to raise the priority of a project that wouldn't otherwise be prioritized but for the availability of private funding to leverage public dollars.

According to the National Philanthropic Trust, Americans made over $425 billion in charitable donations during 2018, a 0.7% increase compared to 2017 (NPT 2019). That same year, individuals were the largest source of charitable giving, donating over $290 billion (68% of total giving) (*id*.). Charitable foundation increased 7.3% to $75.86 billion, while corporate giving rose 5.4$ to $20 billion (*id.*). Local organizations and residents in Montana have a long history of philanthropy, and support many efforts throughout the state and in particular near revered public lands such as Glacier National Park, including environmental and animal projects and programs.

6.4.1. Charitable Foundations

Conserving wildlife and improving human safety have the potential to garner philanthropic support, particularly if wildlife crossing projects are developed with a variety of goals including preservation of iconic, charismatic carnivores such as the bison, grizzly bear, mountain lion, and wolverines as well as ungulates such as mule deer, moose, elk, and pronghorn. Projects are usually most successful when there are multiple partners involved. Such a partnership can often benefit from having a non-profit organization (with Internal Revenue Service 501c3 status) that can receive tax-deductible contributions for the project. While transportation infrastructure is generally financed through a combination of local, state, or federal funding, private foundation philanthropy can increase funding efficiency by helping to leverage or match public funds for research, education, and outreach efforts. Most private philanthropy is focused on granting to non-profit organizations; therefore, for the recommended wildlife crossings and other mitigation measures to maximize their ability to benefit from private philanthropy, it would be beneficial to explore partnering with non-profit organizations.

6.4.2. Corporate Philanthropy

American corporations have a long history of philanthropy and often give directly through their community programs (where their employees are located) or have created their own foundations. Depending on the company, they may also have employee contribution programs that they match. Other ways that local corporations could support tribal wildlife crossing projects would be by making in-kind gifts and/or to providing volunteers for the projects.

For example, the Burlington North Santa Fe's main vehicle for charitable giving is the BNSF Railway Foundation, which is committed to helping improve the quality of life for communities within the 28 states in which it operates. According to its website, the Foundation is "focused on making a difference in the communities where our employees live, work and volunteer," including in Montana (http://www.bnsffoundation.org/). Exploring the availability of BNSF Railway Foundation funding and partnership opportunities would seem particularly appropriate for the #1 priority site (segment 5), which recommends consideration of BNSF's railway tracks, in conjunction with any planned measures to mitigate the adjacent roadway.

Priority wildlife crossing projects could thus be eligible to receive support from a variety of such charitable corporate foundations and volunteer programs.

6.4.3. Organizations and Individuals

There may be many organizations and individuals that the Blackfeet Nation find are eager to help build and maintain wildlife crossing projects. Some organizations may be more aligned than others, such as environmental or fish and wildlife conservation groups. For example, various coalitions of wildlife, governmental, and non-profit conservation groups have begun to work on raising the profile of the issue of motorist crashes with wildlife, as evidenced by Montana's inaugural Wildlife and Transportation Summit, which occurred December 4-5, 2018 (MDT 2019). Co-hosted by MDT, FWP and an informal coalition of organizations and individuals known as Montanans for Safe Wildlife Passage (MSWP), the Summit was attended by Governor Steve Bullock and his Natural Resource Advisor Patrick Holmes along with about 80 staffers from MDT and FWP plus another 70 or more interested stakeholders from across the state. In addition to donating in-kind time and raising private funds to pay for the hard costs of the Summit, MSWP and its member groups have expressed an interest in helping implement on-the-ground solutions to reducing motorist crashes involving wildlife (MDT 2019).

In addition to MSWP, there are likely countless other potential non-profit partners that would likely be interested in teaming with the Blackfeet to help fund and construct wildlife crossing projects, depending on the location, the species of concern, and other aspects of individual mitigation projects. The likelihood that organizations and or individuals would like to engage with the Blackfeet will become evident once implementation plans are developed.

6.5. Special Purpose Taxes

States and, in some cases, local jurisdictions also have the authority to authorize funding or impose special taxes to support implementation of recommended wildlife infrastructure and related mitigation measures.

For example, Teton County, Wyoming, just approved including on the fall 2019 county ballot an initiative proposing a $10 million Special Purpose Excise Tax (SPET) to support construction of priority wildlife crossing structures identified in the county-wide Wildlife Crossing Master Plan (Teton County 2018).

In addition, Pima County, Arizona, has used a portion of its local sales tax revenues to fund wildlife crossings in the county. Citizens of Pima County successfully sought to create a Regional Transportation Authority (RTA) to address regional transportation planning and funding (Campbell and Kennedy 2010). The RTA was approved by voters and funded by a 0.5% sales tax for 20 years. As a result, a portion of the tax revenue, $45M, has been set aside to protect and enhance wildlife connectivity across the county's road system. It allows for funding of design and construction of wildlife crossings for future road projects and retrofitting of existing highways. One such project to tap these funds built an overpass and underpass for wildlife crossings for State Route 77 north of Tucson, AZ (Figure 22). Nationally, this is the first sales tax increase approved by citizens to help reduce wildlife-highway conflicts and improve connectivity.

> Unlike other similar AVC assessments, the current report is unique in that it is on behalf of a sovereign tribe. As such, it bears noting that the Supreme Court has recognized that tribes have inherent authority to impose taxes under certain circumstances:
>
> > "The power to tax transactions occurring on [tribal] trust lands and significantly involving a tribe or its members is a fundamental attribute of sovereignty which the tribes retain unless divested of it by federal law or necessary implication of their dependent status." (Merrion v. Jicarilla Apache Tribe 1980)

Although such funds do not currently exist, the Blackfeet Nation thus could explore its authority to institute a tax aimed at funding the costs of wildlife crossing implementation projects. (*See, e.g.*, *Merrion v. Jicarilla Apache Tribe*, 617 F.2d 537, 544 (10th Cir. 1980) ("[W]e conclude that the Tribe has the inherent power to levy a privilege tax on the occupation of severing oil and gas from reservation land even though the tax falls on nonmembers."). *But see Atkinson Trading Co., Inc. v. Shirley*, 532 U.S. 653 (2001) (finding that the Navajo lacked authority to impose a tax on non-member hotel guests where the hotel, despite being within reservation boundaries, was located on non-tribal land held in fee by a non-member).)

Figure 20: Wildlife underpass on State Route 77, Pima County, Arizona. Photo credit: Rob Ament

6.6.Summary

There are a variety of transportation and non-transportation program funds that may provide support for the wildlife infrastructure and related mitigation measures recommended in this report. To the extent that the Blackfeet Nation would like to maximize the potential to draw from the complete spectrum of resources, a key first step would be to explore the potential for one or more public-private partnerships aimed at implementing the recommended measures described in this plan. Many highway mitigation projects in the U.S. have succeeded by creating similar opportunities that allow a variety of interested stakeholders including government agencies, non-profit organizations, and individuals to contribute to their success. Such projects have relied on many different people, organizations, and funds to be brought together for the common goals of making our roads safer for people and wildlife while at the same time maintaining or improving habitat connectivity.

7. APPENDIX A

Mitigation Measures

This appendix provides information about the mitigation measures that have been recommended in this report. This appendix has been adapted from Ament et al. 2014.

7.1. BACKGROUND:

Road ecologists and transportation engineers at the Western Transportation Institute – Montana State University (WTI), along with partners including staff from the Center for Large Landscape Conservation (CLLC) have produced several key publications that evaluate, discuss and/or review the wildlife mitigation measures recommended in this report as well as other road ecology concepts covered in this report. WTI and CLLC researchers involved in this study were also coauthors of many of the documents below and we derive the recommendations in this Appendix and throughout this report from these documents, among many others:

National Guidelines and Manuals

- A handbook for the design and evaluation of wildlife crossing structures (Clevenger and Huijser 2011)
- A report to the U.S. Congress on the causes of and solutions to wildlife-vehicle collisions (Huijser et al. 2008)
- A best practices manual for reducing wildlife-vehicle collisions (Huijser et al. 2008)

Journal Articles

- Cost-benefits analyses of wildlife mitigation measures (Huijser et al. 2009)
- Differences in spatiotemporal patterns of vehicle collisions with wildlife and livestock. Journal of Environmental Management (Creech et al, 2019)
- Effectiveness of short sections of wildlife fencing and crossing structures along highways in reducing wildlife–vehicle collisions and providing safe crossing opportunities for large mammals (Huijser et al. 2016)

Highway Studies

- Teton County Wildlife Crossings Master Plan (Huijser et al. 2018)
- US 93 North post-construction wildlife-vehicle collision and wildlife crossing monitoring on the Flathead Indian Reservation between Evaro and Polson, Montana (Huijser et al. 2016)
- Highway mitigation for wildlife in northwest Montana (Ament et al. 2014)
- Trans-Canada Highway Wildlife and Monitoring Research, Final Report (Clevenger and Barrueto 2014)

This appendix only briefly summarizes the mitigation measures recommended in this study (excluding wildlife-friendly livestock fence to reduce collisions with livestock).

7.2. INTRODUCTION

The authors consider separating wildlife from traffic with wildlife fencing, in combination with wildlife underpasses and overpasses, to be the best long-term mitigation option to promote connectivity and reduce mortality of wildlife on highways. Evaluations of this mitigation approach demonstrate high levels of effectiveness in promoting connectivity and decreasing mortality.

7.3. MITIGATION MEASURES:

7.3.1. Wildlife Fencing

On average, an 87 percent reduction in wildlife-vehicle collisions can be expected from fencing when combined with overpasses or underpasses (Huijser et al. 2008). Because fencing itself creates a barrier, it is not a solution to wildlife connectivity, but rather is intended to guide animals to crossing structures. Most fencing is constructed at a height of 2.4 meters (8 feet). Wire mesh fence with an opening size of 10.2 centimeters (4 inches) deters most medium- to large-sized animals from passing through the fence. Wildlife fencing is typically placed at the edge of the ROW, or at least outside the clear zone of the highway, so it does not interfere with operations such as snow plowing.

Fencing should include escape ramps, which allow wildlife trapped on the highway side of a fence to jump to safety outside the fenced section. The height of the jump out should be approximately 1.2-1.8 meters (4-6 feet) above the outside surface so that wildlife are deterred from jumping up and entering the roadway.

7.3.2. Wildlife Overpasses

Wildlife overpasses are perhaps the most iconic of all the wildlife mitigation measures due to their size and visibility to motorists and the public. They are designed to allow movement of large animals, but by including additional design elements they can also pass small- and medium-sized mammals, as well as amphibians, reptiles, semi-arboreal, and/or semi-aquatic species. Some species, such as elk, moose, pronghorn, and grizzly bears have a strong preference for overpasses, and overpasses may be needed to pass family groups of species such as grizzly bears, which prefer large, open structures such as overpasses or larger span bridge underpasses (Clevenger and Barrueto, 2014; Ford et al. 2017; Sawyer et al. 2016).

7.3.3. Wildlife Underpasses

Wildlife underpasses are designed to allow wildlife to cross safely under the road. When designed for large mammals, they can also successfully allow passage of smaller species. Designing the structure and its approaches with cover can help many smaller species feel secure in its use. Underpasses can also be adapted for amphibian, semi-aquatic, and semi-arboreal species, as well as facilitating aquatic connectivity when placed in riparian areas. There are many types of underpass structures, including concrete open-span bridges, concrete bottomless arches, corrugated steel arches, and box culverts. All of these allow for the natural substrate to be continued from outside to within the crossing structure. Recommended dimensions depend on the target species for which the underpass is designed.

Underpasses can accommodate water flow, such as rivers or streams, along with wildlife movement. Often bridges or culverts that are required to span water bodies can be designed even wider/longer to accommodate terrestrial habitat. Since they are generally located in riparian habitats, frequently used for wildlife movements, these types of underpasses support the movement of both aquatic and terrestrial species.

7.3.4. Warning Signs and Variable Message Signs

Wildlife warning signs along highways are perhaps the most commonly applied wildlife mitigation measure to reduce WVCs. They are intended to alert drivers of likely presence of wildlife on or near the road, these signs seek to make drivers more alert, reduce their speed, or both. Driver awareness and response may be influenced by the type of warning sign. It appears that larger, non-standard signs are more effective than standard signs at influencing driver behavior, however these measures likely do not increase connectivity for wildlife.

Static warning signs have been shown to be ineffective. If used, signage should only be used seasonally and/or should have more visibility than typical signs. Messages displayed on VMSs are designed to attract the attention of the driver and invoke a response to a greater extent than standard wildlife warning signs. Wildlife advisory messages posted on portable VMSs have been found to reduce vehicle speeds. VMSs appear to have potential to reduce wildlife–vehicle collisions, but additional studies are needed to better evaluate their effectiveness.

8. APPENDIX B- COST-BENEFIT ANALYSIS FOR ALL ROADS INCLUDED IN THE STUDY

8.1. Introduction

This chapter contains cost estimates of large animal-vehicle collisions and potential future mitigation measures on the Blackfeet Indian Reservation. The cost estimates for large animal-vehicle collisions are largely based on the cost-benefit model developed by Huijser et al. (2009). This model is mostly based on human safety parameters; parameters and economic values associated with biological conservation are not included in this model. Therefore, the model is limited in nature. We encourage readers of this report to consider the results of this analysis during the decision process on whether mitigation measures should be implemented, but the outcomes of the analyses should not be used as a litmus test for implementing mitigation.

8.2. Methods

The researchers used two datasets for the economic analyses:

- Large mammal-vehicle crash data recorded by MHP (10 years: 2008 through 2017). This data set includes a description of the animals involved in each crash, but the description is limited to “wild” (typically large wild ungulates) or “domestic” (typically cattle or horses). The researchers assigned each large animal crash record to the nearest 0.1 mi marker along the different highway sections on the Reservation.
- Carcass removal data recorded by MDT maintenance personnel (10 years: 2008 through 2017). This data set also includes a description of the animals involved in each crash, but the description is typically to the species level for wild species (e.g. “deer”, elk, black bear, moose, pronghorn, grizzly bear, “other wild species”) or “domestic” (typically cattle or horses). The researchers assigned each large animal carcass record to the nearest 0.1 mi marker along the different highway sections on the Reservation.

These two data sets (crash data and carcass removal data) are described and summarized in further detail in the following sections. Note that in this chapter the term “collisions” refers to both crashes and carcasses.

For this chapter, we did not investigate temporal trends (changes in the number of crashes or carcasses over time). However, we did conduct spatial analyses to determine (1) where docrashes or carcasses occur in the highest or lowest concentrations, and (2) what are the economic costs associated with collisions and potential future mitigation measures along different road sections? For a correct interpretation of “peaks” (i.e., road segments with the highest costs associated with AVCs) and “valleys” (i.e., segments with the lowest costs), a consistent search and reporting effort is required for all the road sections involved. There were 14 road sections included in the cost-benefit analyses for crash data, but only 7 road sections had consistent search and reporting effort by MDT for carcass removal data (Table 1). We conducted separate analyses of crash data and carcass removal data rather than combining the two data sources and attempting to remove potential duplicate observations.

Severe underreporting of animal-vehicle crashes and animal carcasses is suspected along Reservation roads. Underreporting occurs when the true number of crashes or carcasses is higher than the reported number. Underreporting results in lower peaks and lower valleys. This is especially relevant in the context of cost-benefit analyses, as underreporting of crashes and carcasses makes it less likely that thresholds are met or exceeded above which the implementation of mitigation measures is economically advantageous.

Table 1. Road sections included ("yes") and excluded ("no") in the cost-benefit analyses based on large animal crash data and large animal carcass data.

Road section #	Road section	Crash data	Carcass data
1	US Hwy 2	Yes	Yes
2	US Hwy 89 (south of Browning)	Yes	Yes
3	US Hwy 89 (north of Browning)	Yes	Yes
4	MT Hwy 213 (Chalk Butte Rd)	Yes	Yes
5	MT Hwy 358 (Cutbank – Valier Hwy)	Yes	Yes
6	Meriwether Rd	Yes	Yes
7	MT Hwy 464 (Duck Lake Rd)	Yes	Yes
8	Heart Butte Rd	Yes	No
9	Birch Creek Rd	Yes	No
10	MT Hwy 17 (Chief Mountain International Hwy)	Yes	No
11	Many Glacier Rd	Yes	No
12	MT Hwy 49 (Lookingglass Rd)	Yes	No
13	Starr School Rd	Yes	No
14	Badger Creek Rd	Yes	No

The researchers conducted separate analyses for "wild" and "domestic" species because the nature of the problems and the associated mitigation measures are not necessarily the same. Large wild animal-vehicle collisions pose both a human safety and a habitat connectivity issue, and at a bare minimum, a road should not be turned into an absolute barrier through wildlife fences without safe crossing opportunities. While animal detection systems do allow animals to cross roads, animals have to cross on the pavement and the barrier effect of roads and traffic remains unaddressed. Wildlife crossing structures (underpasses and overpasses) make it easier for wildlife to access the other side of the highway, allowing for an improvement of habitat connectivity compared to an unmitigated highway (Huijser et al., 2016). On the other hand, collisions with large domestic species (e.g. horses and cattle) are largely a human safety issue, and habitat connectivity is not necessarily an issue. The livestock owners can still periodically move livestock from one side of a road to the other side of the road rather than allowing the animals to cross between the two sides of the road at will with the associated risk of collisions.

Huijser et al. (2009) reported the costs associated with deer, elk, and moose vehicle collisions, but not with other species. When using species-specific MDT carcass records to estimate costs associated with WVCs, we used animal body size and weight to identify the most relevant cost category from Huijser et al. (2009). Carcasses of mule deer, white-tailed deer, pronghorn, black bear, and grizzly bear were assigned to the “deer cost category”, elk carcasses were assigned to the “elk cost category”; and moose carcasses were assigned to the “moose cost category.” Domestic animal carcasses were assigned to the “moose cost category.” The MHP crash data only indicated whether the species involved was “wild” or “domestic”, and we therefore assigned “wild” (mostly deer) crash records to the “deer cost category” and “domestic” (mostly cattle and horses) crash records to the “moose cost category.”

We calculated the costs associated with crashes and carcasses of domestic species and wild species per mile per year for each 0.1 mi road segment (moving average). We compared these with the costs associated with the implementation of different types and combinations of mitigation measures, which are the economic thresholds above which implementing mitigation measures is cost-effective. Results are displayed as figures (one per road) showing the estimated AVC costs (y-axis values) for all 0.1-mile segments along the road (x-axis values), with economic thresholds displayed as horizontal lines to illustrate where AVC costs exceed mitigation costs. We included one mitigation measure for domestic species (wildlife-friendly livestock fences), and four different types and combinations of mitigation measures for large wild animal species (Table 2). The costs estimates are all based on a 75-year long period, the expected lifespan of a crossing structure, and a 3% discount rate (see Huijser et al., 2009) for details.

Table 2. The measures evaluated in the cost-benefit analyses for large domestic species and large wild species and their associated costs per mile per year.

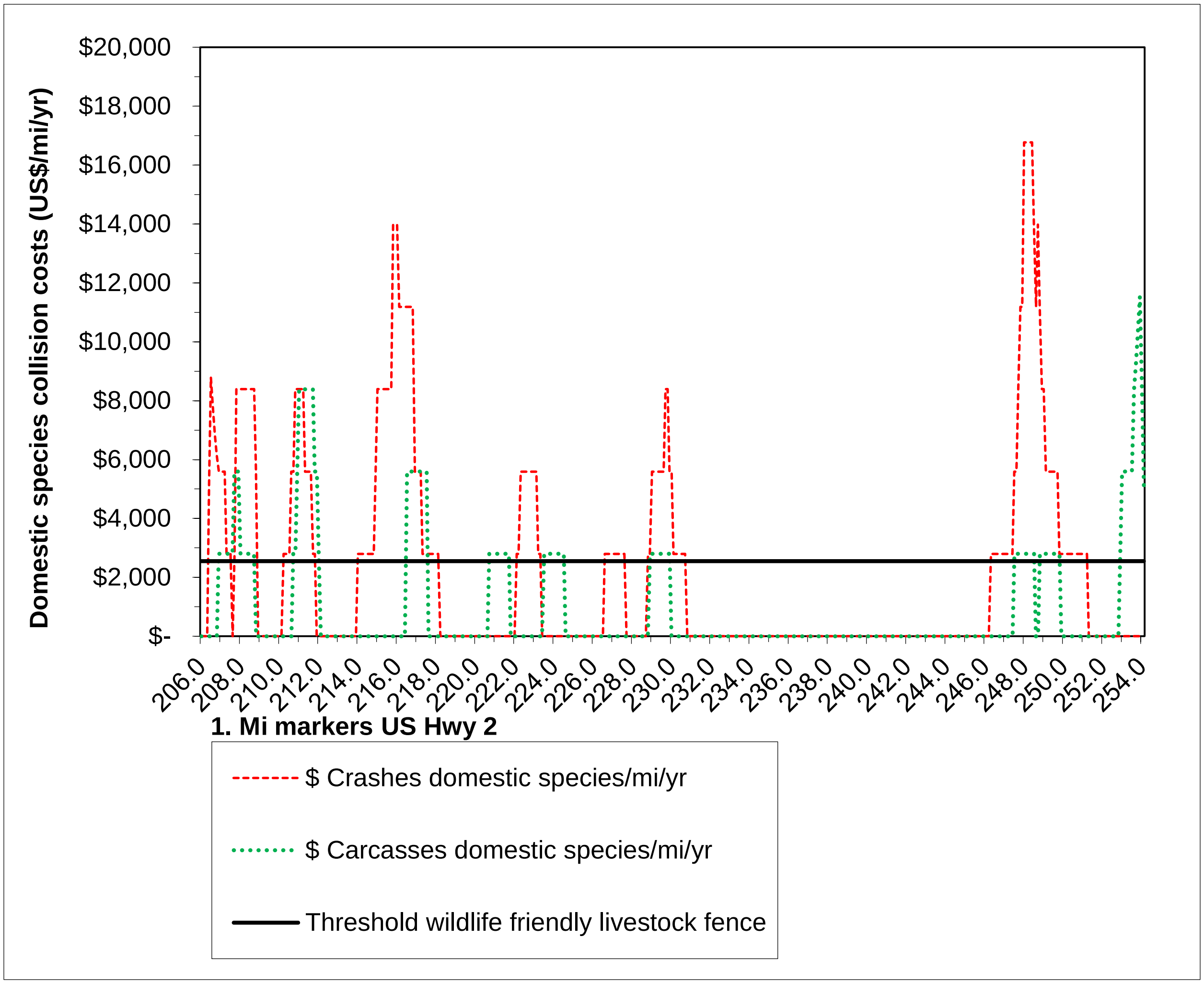
Measures	Analyses for large domestic species	Analyses for large wild species	Costs (US$ per mile per year)
Wildlife friendly livestock fence	Yes	No	$2,550 (2019 US$)[*1]
Wildlife fence, under pass (once every 2 km), jump-outs	No	Yes	$18,123 (2007 US$)[*2]
Wildlife fence, under- and overpass (underpass once every 2 km, overpass once every 24 km), jump-outs	No	Yes	$24,230 (2007 US$)[*2]
Wildlife fence, gap (once every 2 km), animal detection system in gap, jump-outs	No	Yes	$28,150 (2007 US$)[*2]
Animal detection system (not combined with a wildlife fence)	No	Yes	$37,014 (2007 US$)[*2]

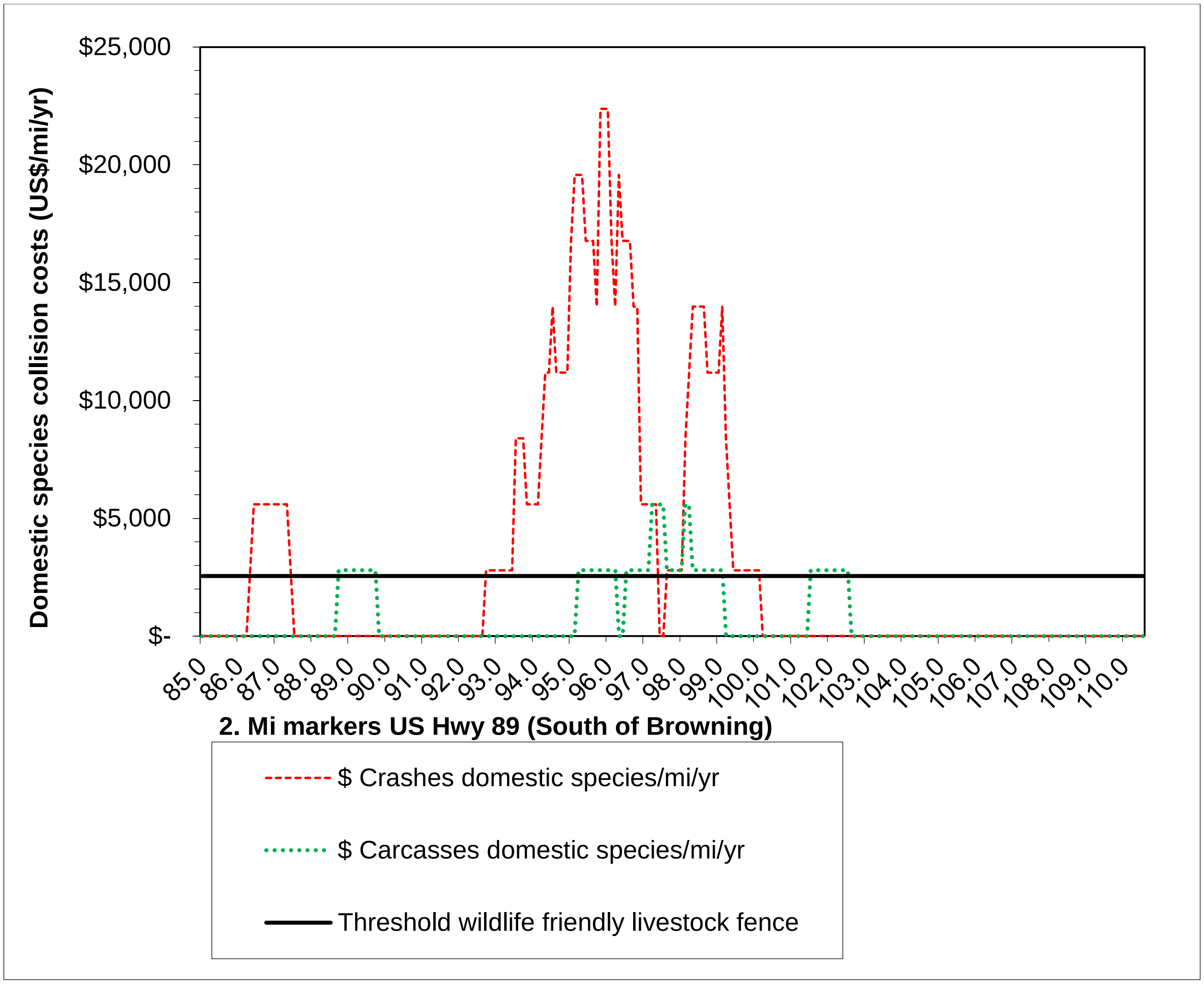
[*1] Based on Huijser et al., (2016): Installation $9/m in 2006 US$, $18,000/km (both sides hwy) in 2006 US$, $22,848/km (both sides hwy) in 2019 US$, $36,762/mi (both sides hwy) in 2019 US$, based on 25 year life span, $500 maintenance per year, $10,000 removal costs, and 3% discount rate, the annual costs are $2,550/mile/year.
[*2] See Huijser et al., 2009 for cost calculations.

8.3. Results

Domestic species

The following figures show the costs associated with collisions with large domestic species (for both crash and carcass removal data), and the economic threshold for cost-effective implementation of wildlife-friendly livestock fences, for each of the 14 road sections listed in Table 1. The costs associated with large domestic species-vehicle collisions are higher than the costs associated with wildlife-friendly livestock fences along many of the road sections.





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Domestic species collision costs (US$/mi/yr)
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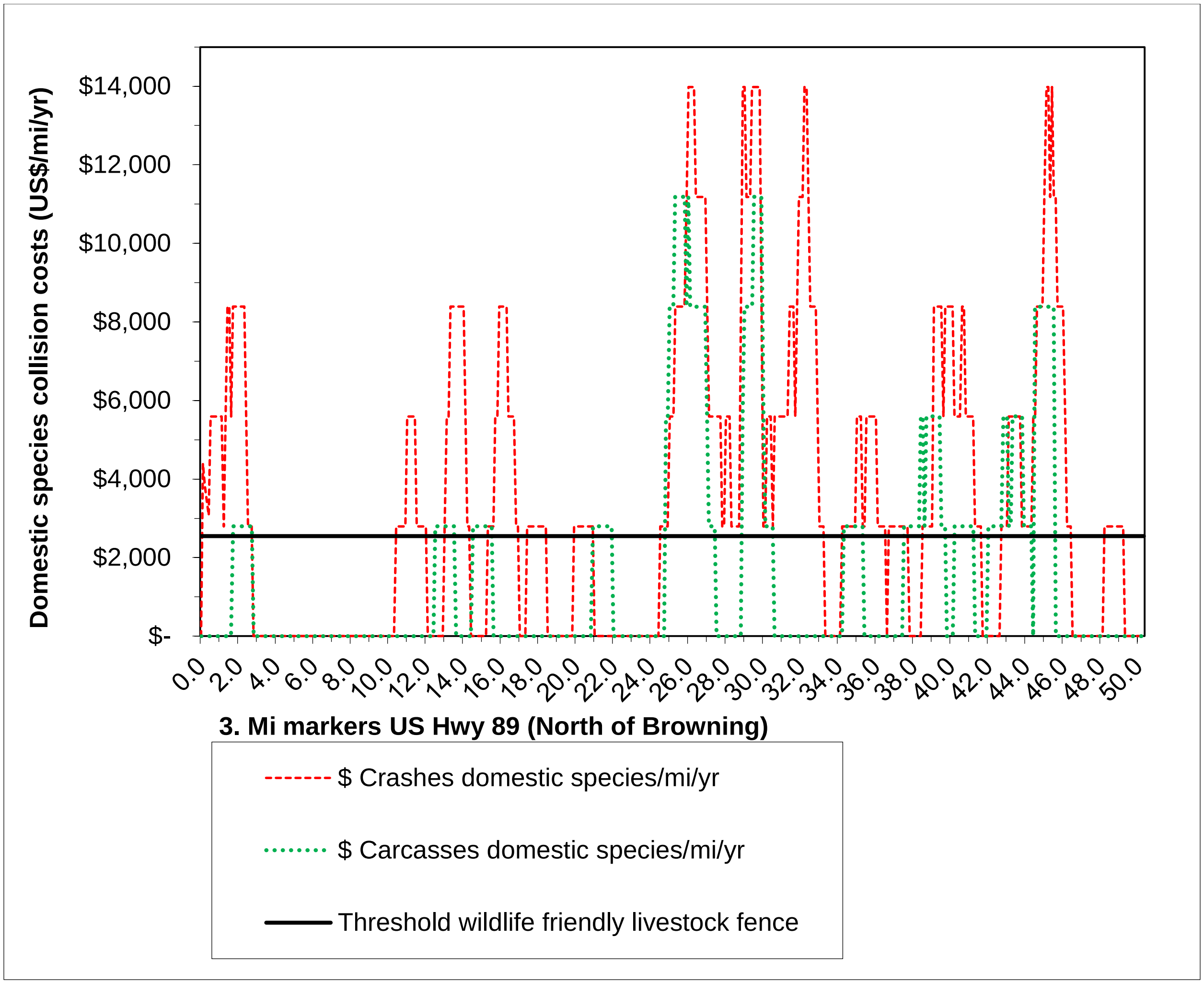
2. Mi markers US Hwy 89 (South of Browning)
$ Crashes domestic species/mi/yr
$ Carcasses domestic species/mi/yr
Threshold wildlife friendly livestock fence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$ Crashes domestic species/mi/yr
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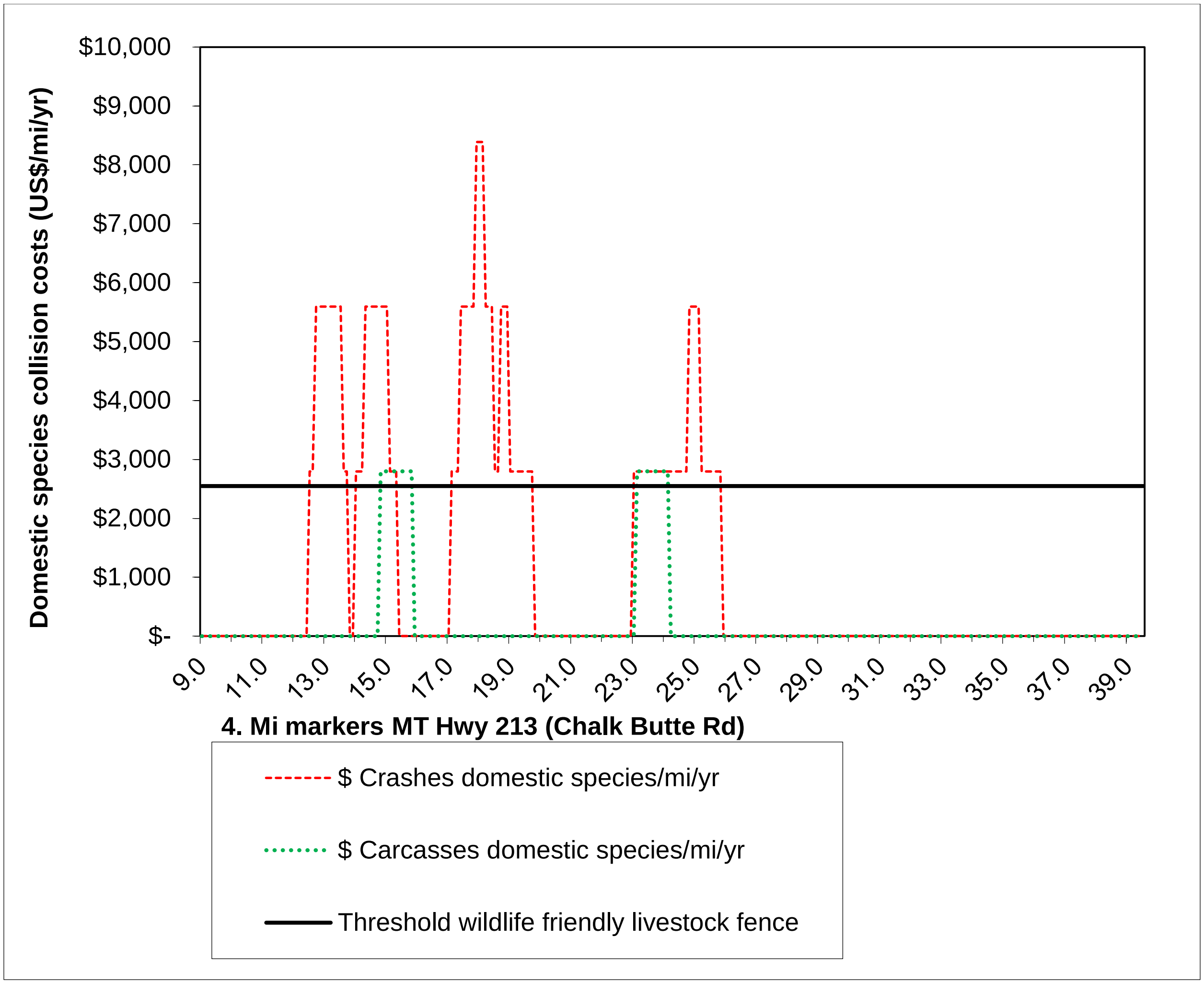
Threshold wildlife friendly livestock fence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4. Mi markers MT Hwy 213 (Chalk Butte Rd)
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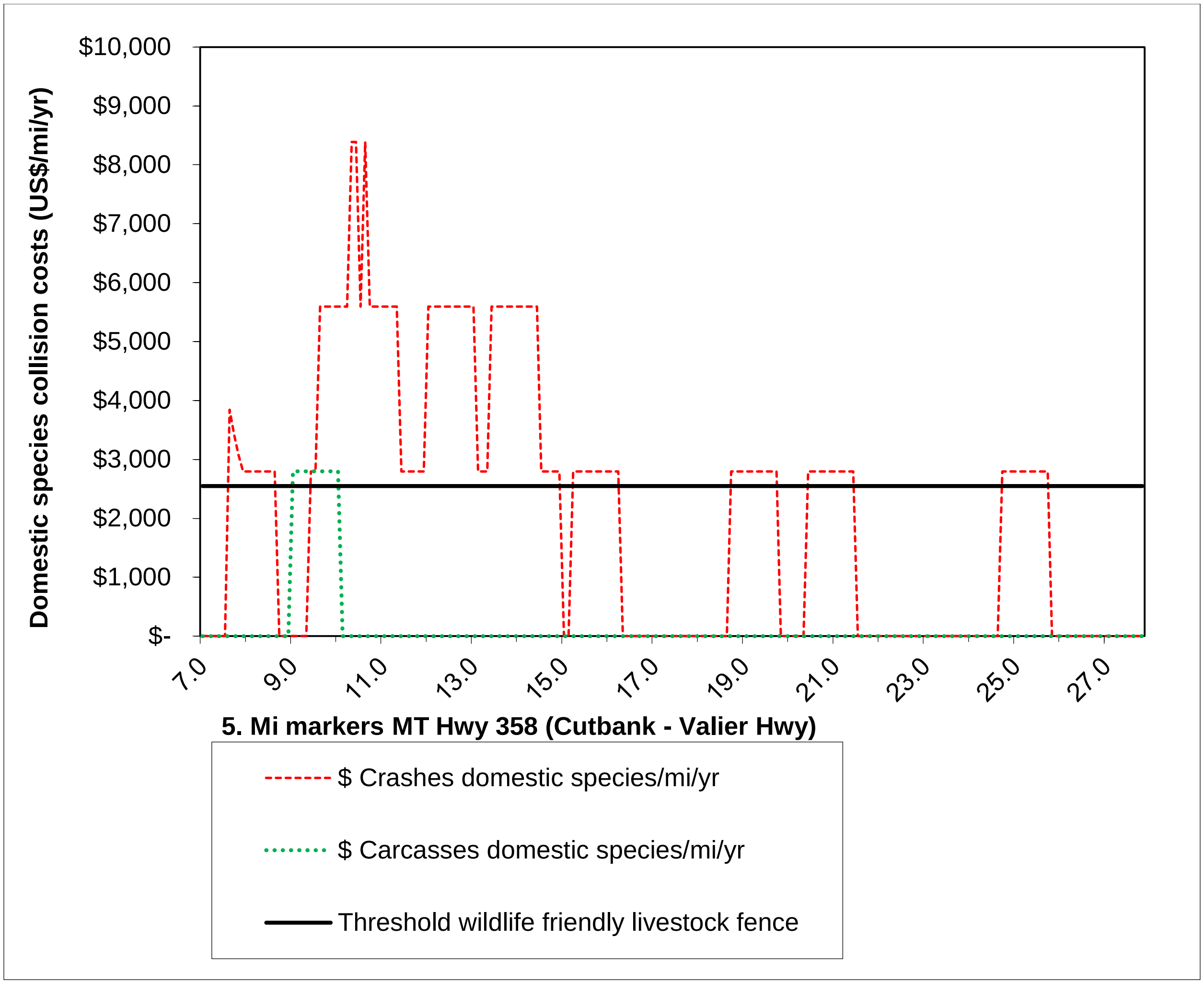
Threshold wildlife friendly livestock fence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$ Crashes domestic species/mi/yr
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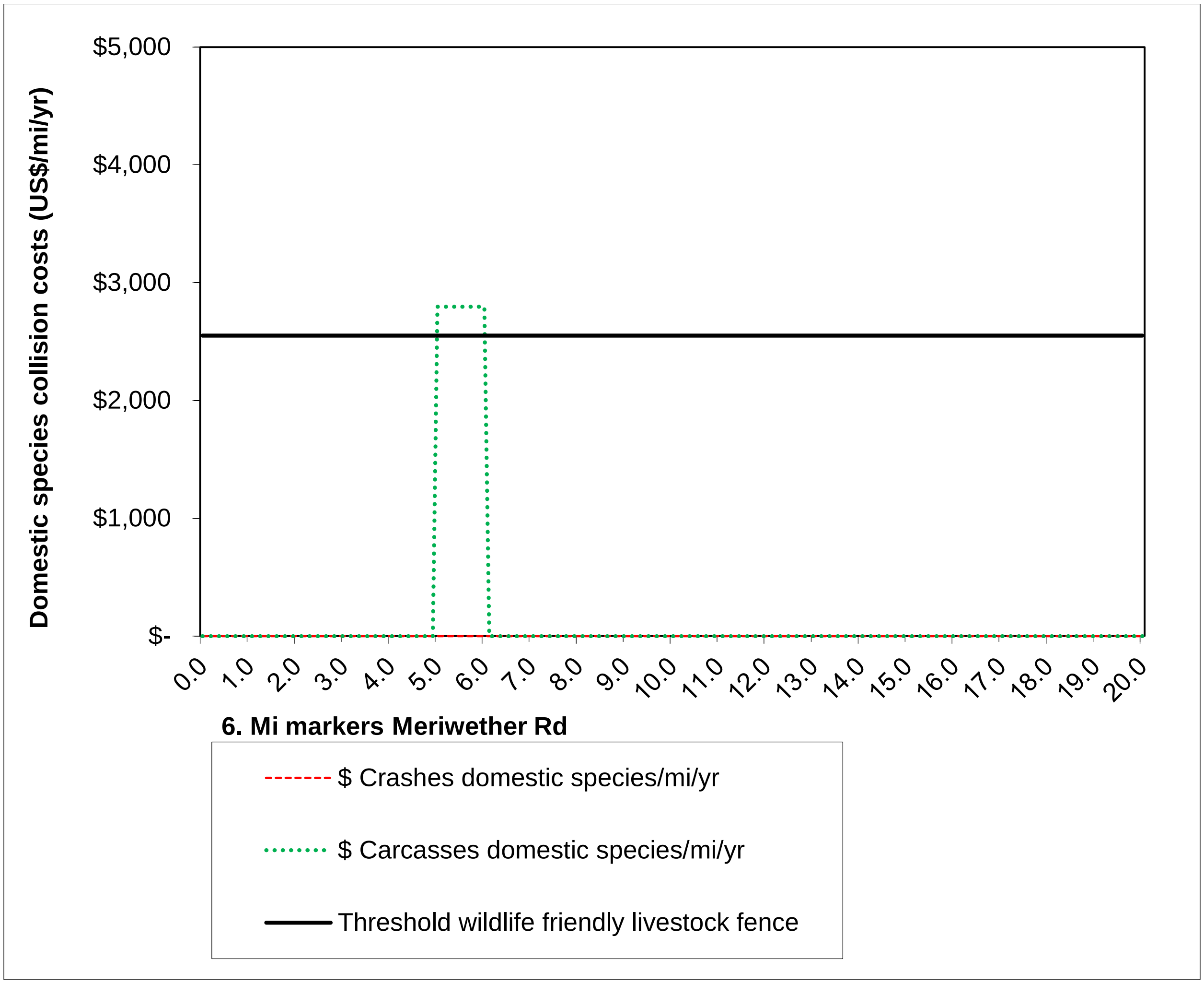
Threshold wildlife friendly livestock fence



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6. Mi markers Meriwether Rd
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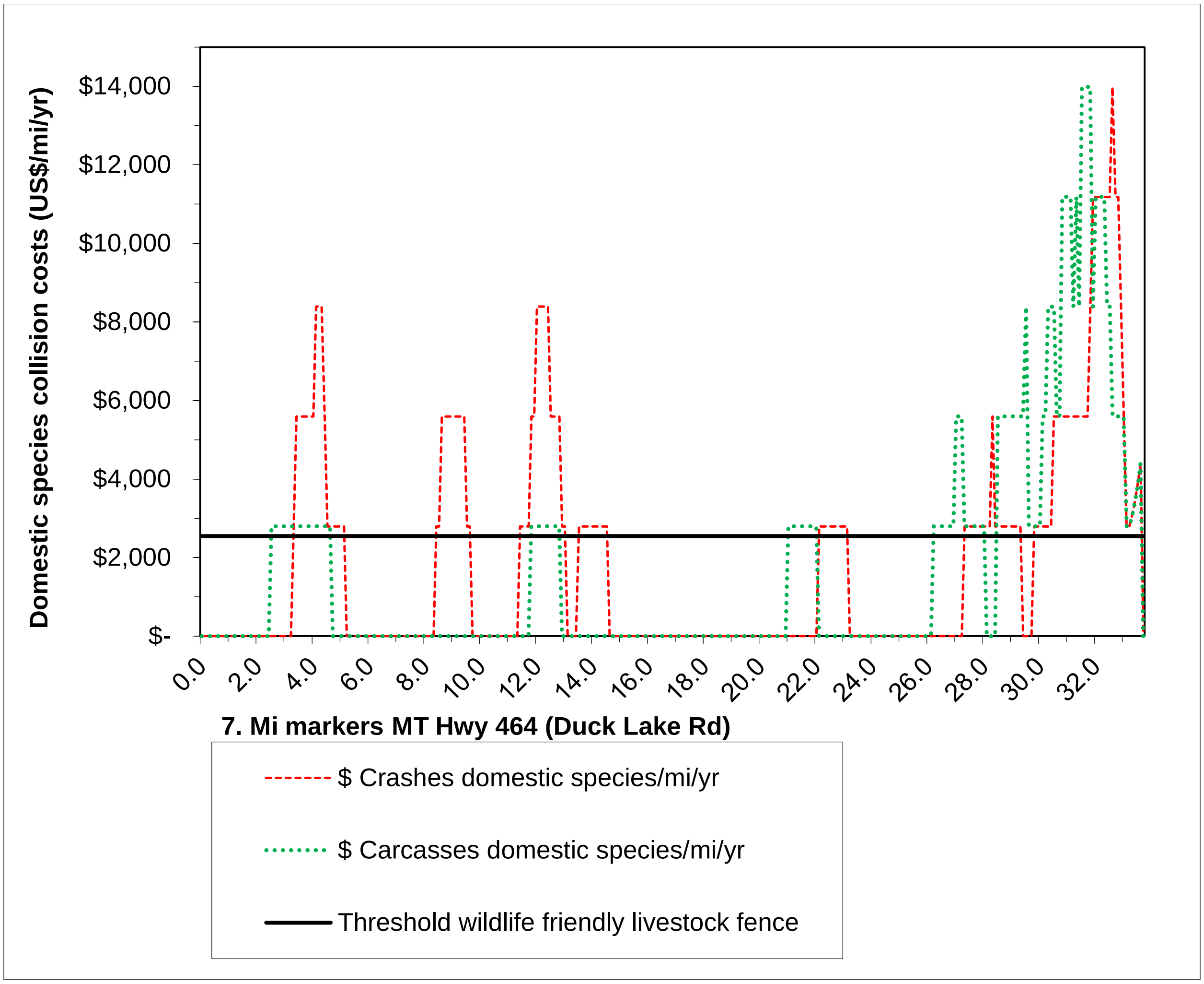
$ Carcasses domestic species/mi/yr
Threshold wildlife friendly livestock fence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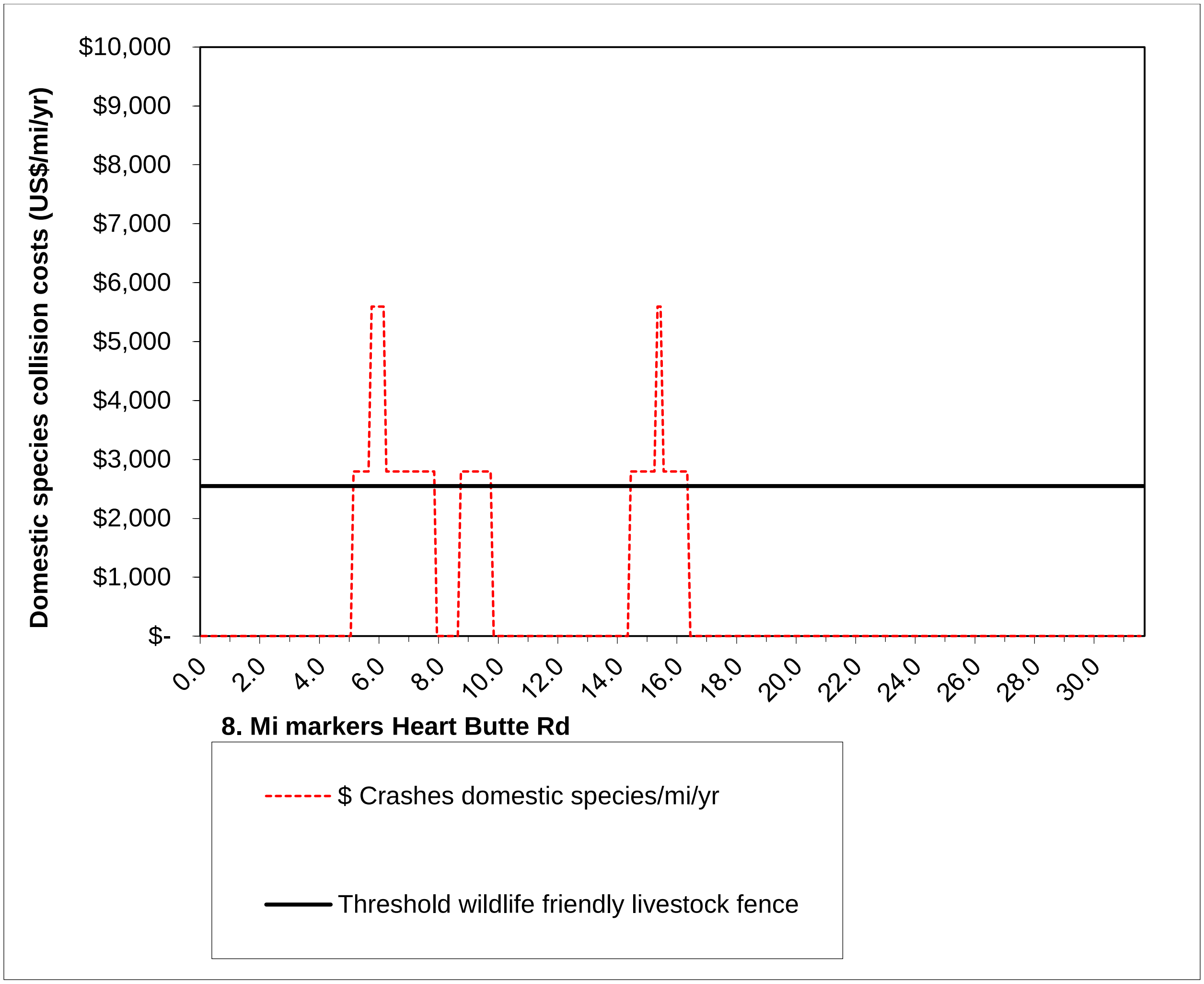
$ Crashes domestic species/mi/yr
$ Carcasses domestic species/mi/yr
Threshold wildlife friendly livestock fence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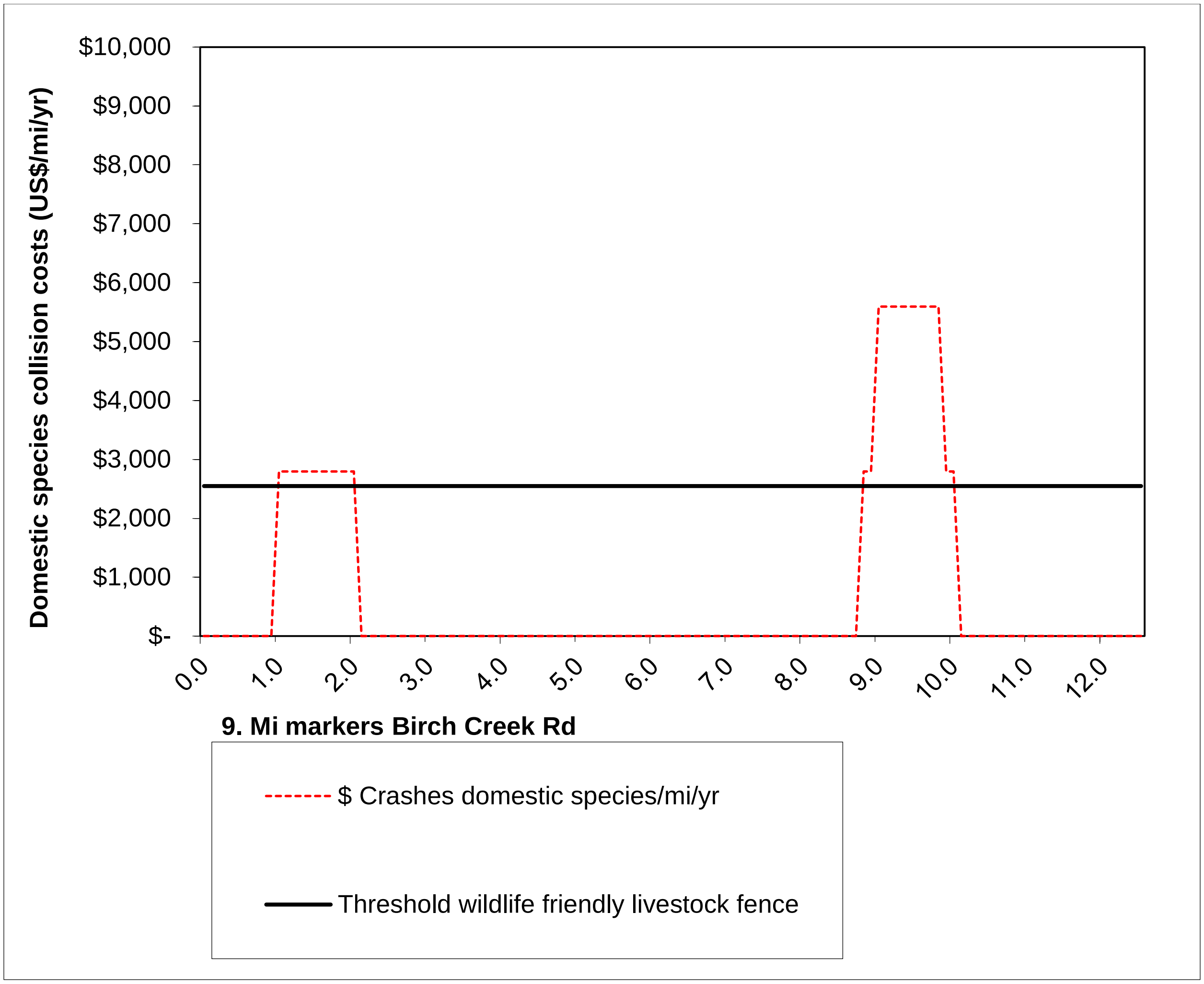
8. Mi markers Heart Butte Rd
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence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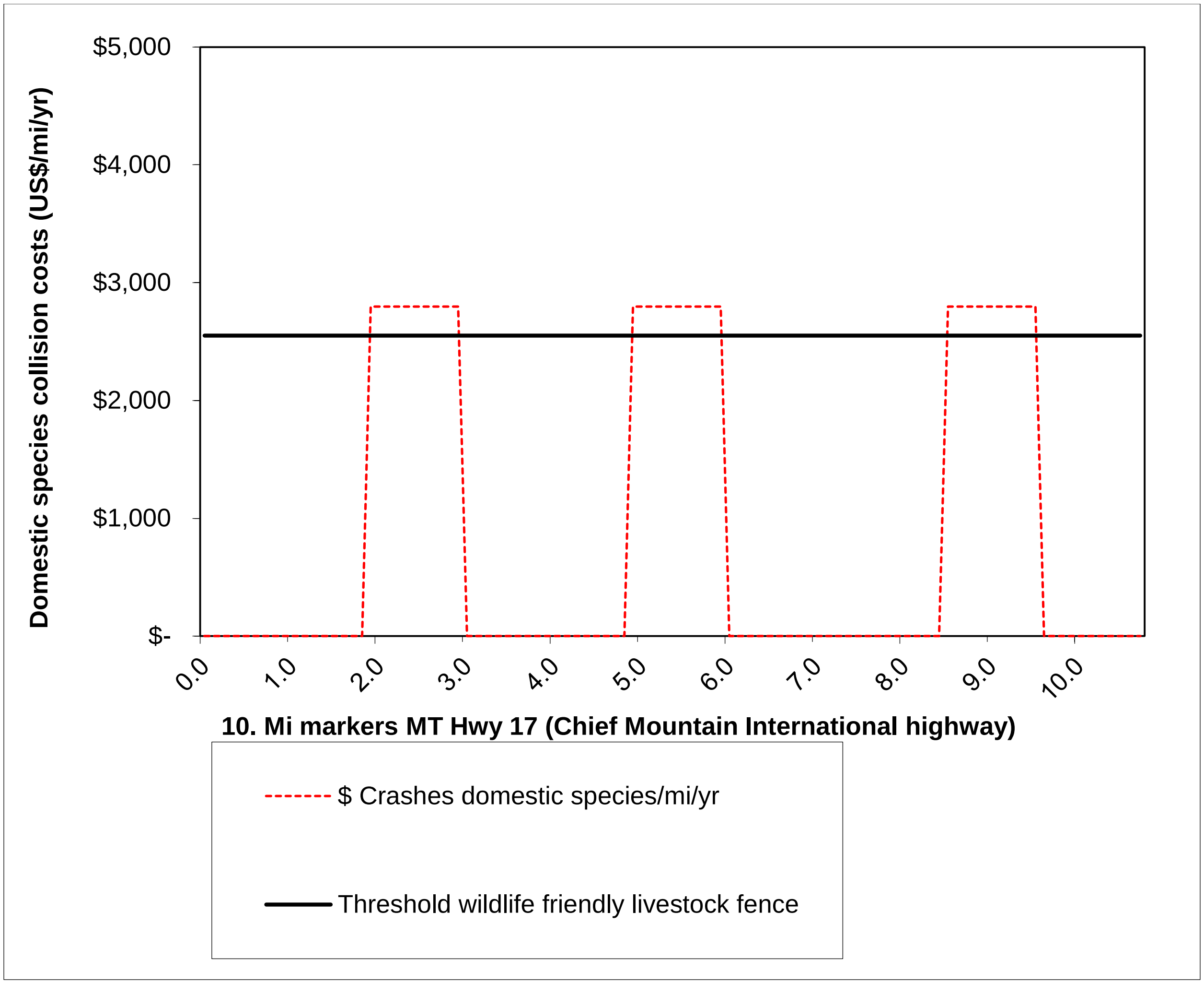
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence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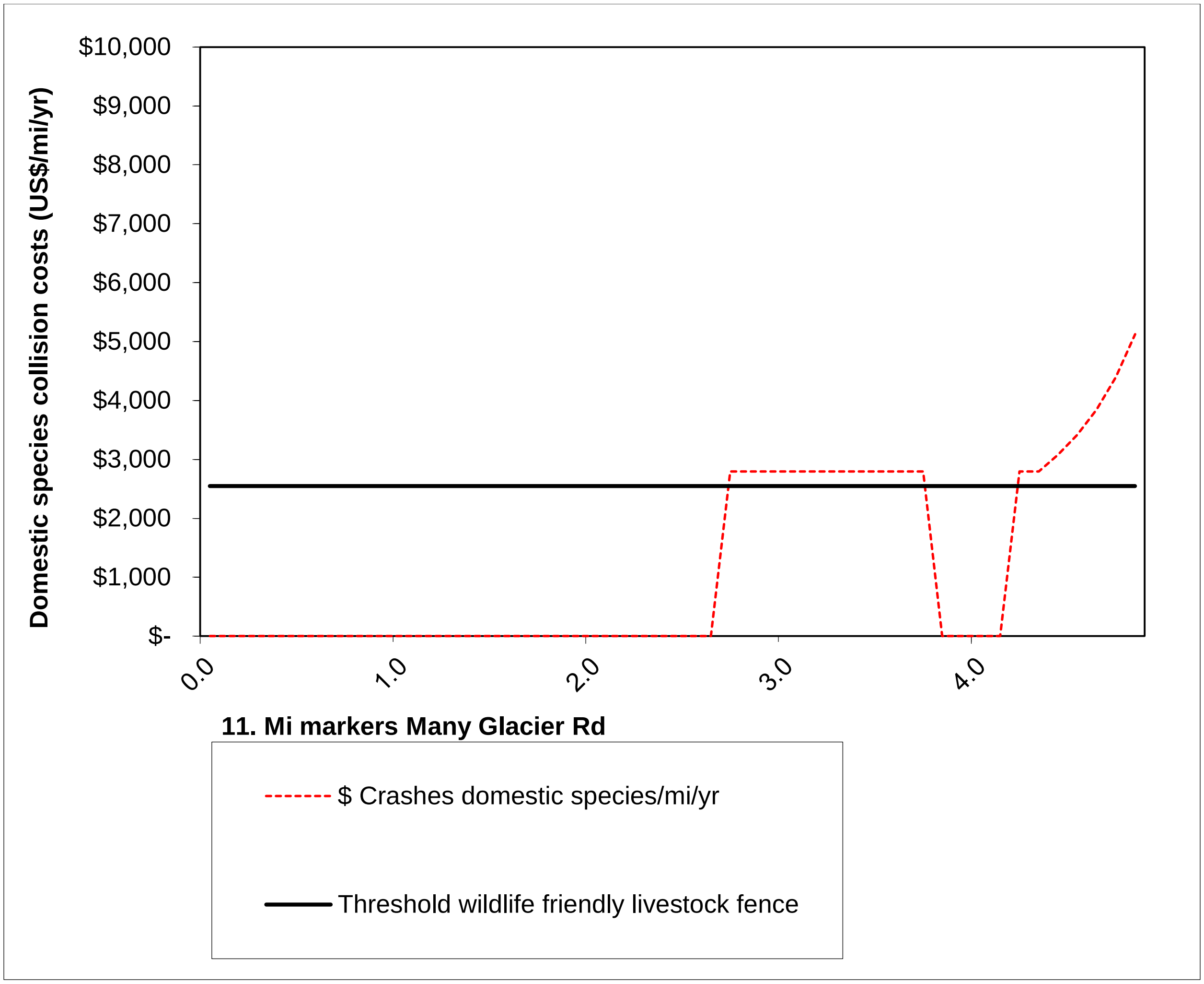
10. Mi markers MT Hwy 17 (Chief Mountain International highway)
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence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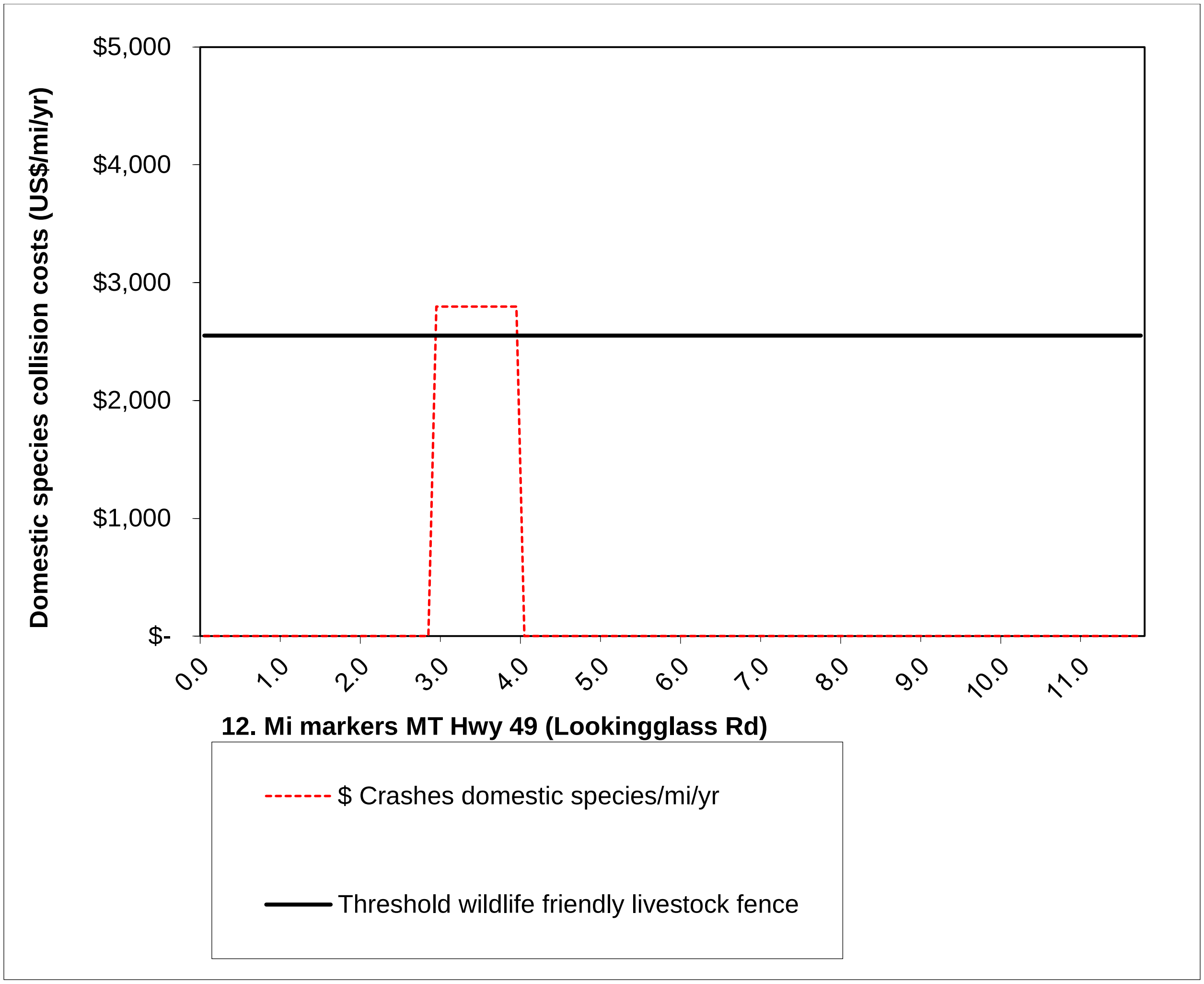
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence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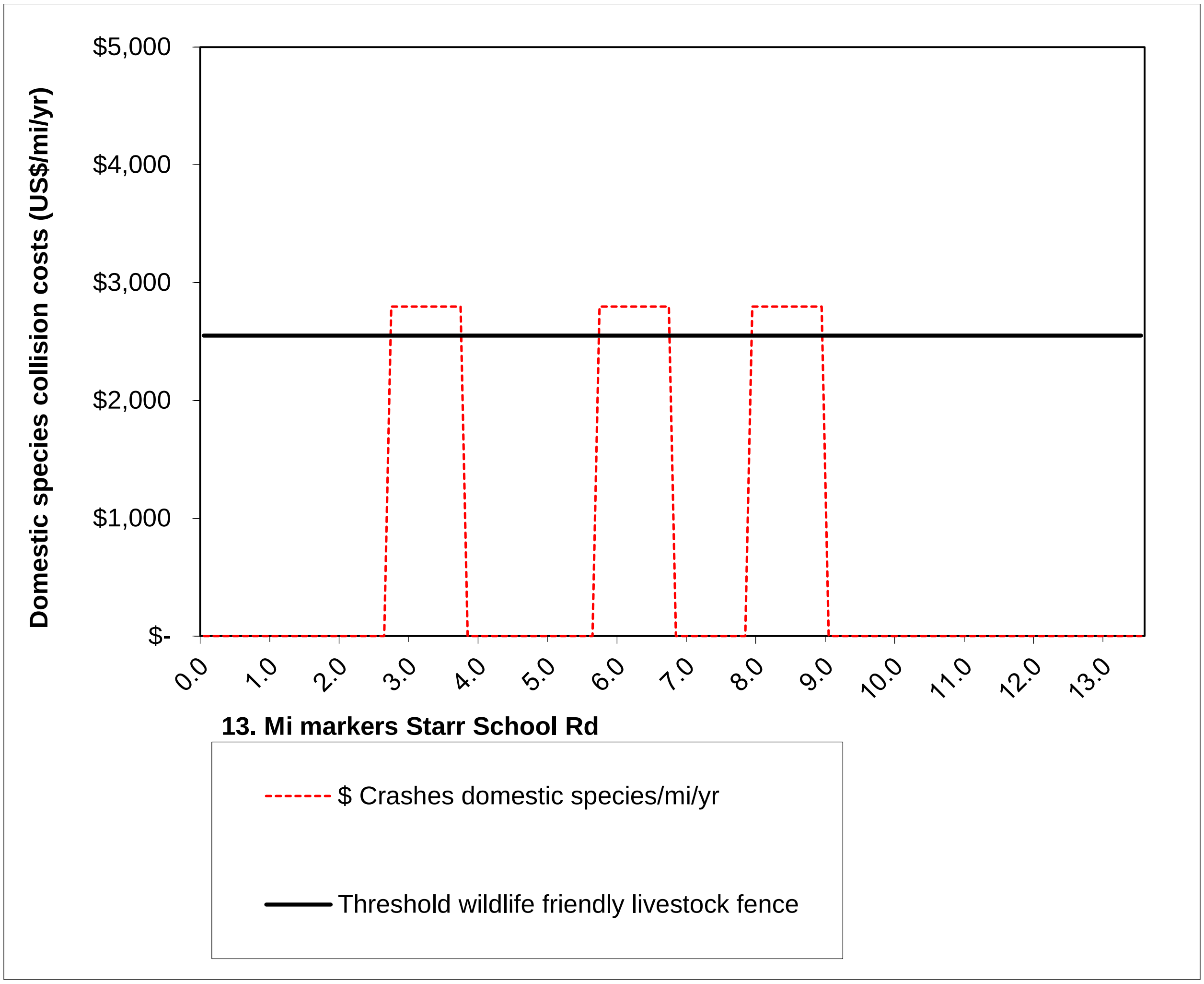
12. Mi markers MT Hwy 49 (Lookingglass Rd)
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence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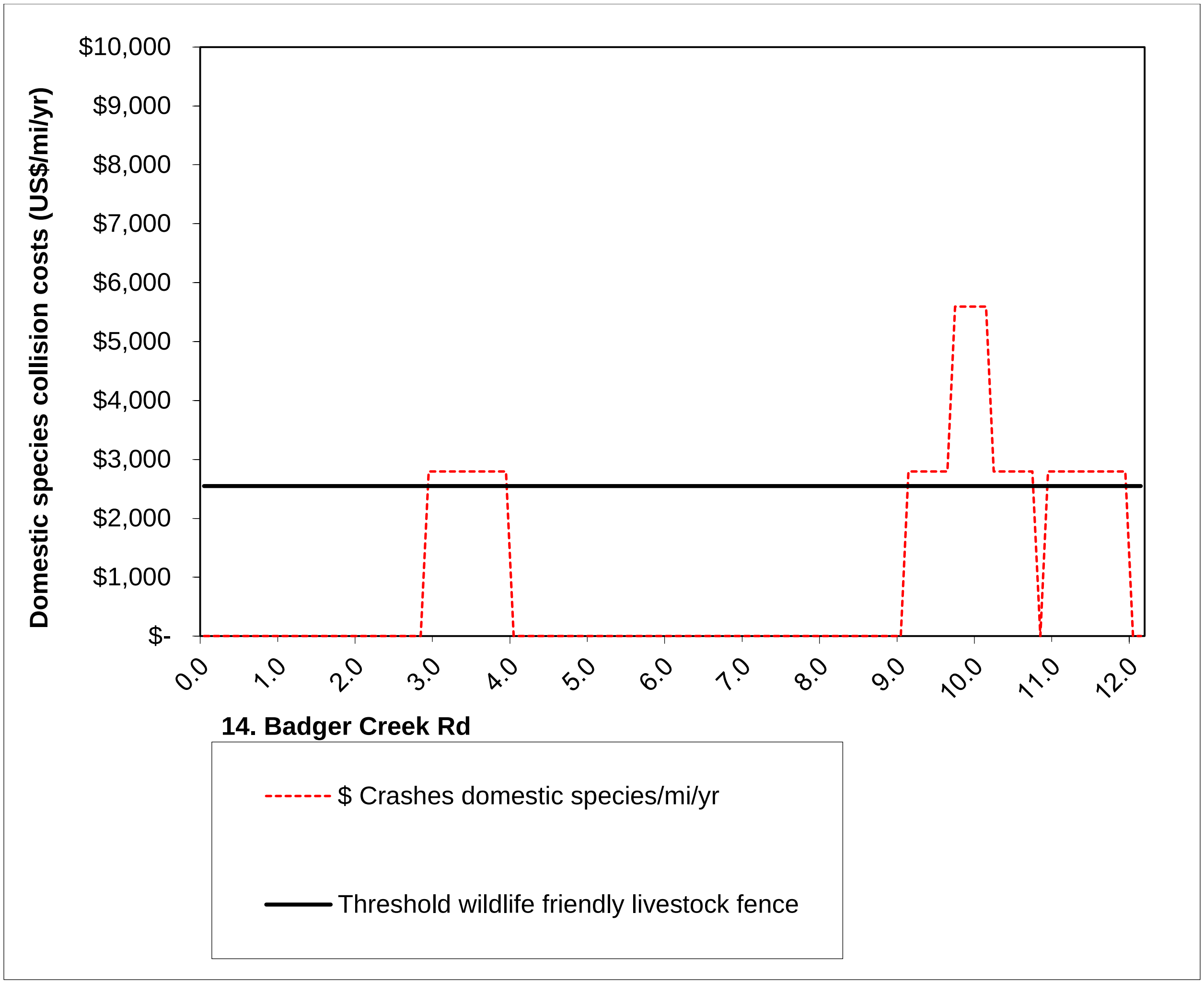
13. Mi markers Starr School Rd
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence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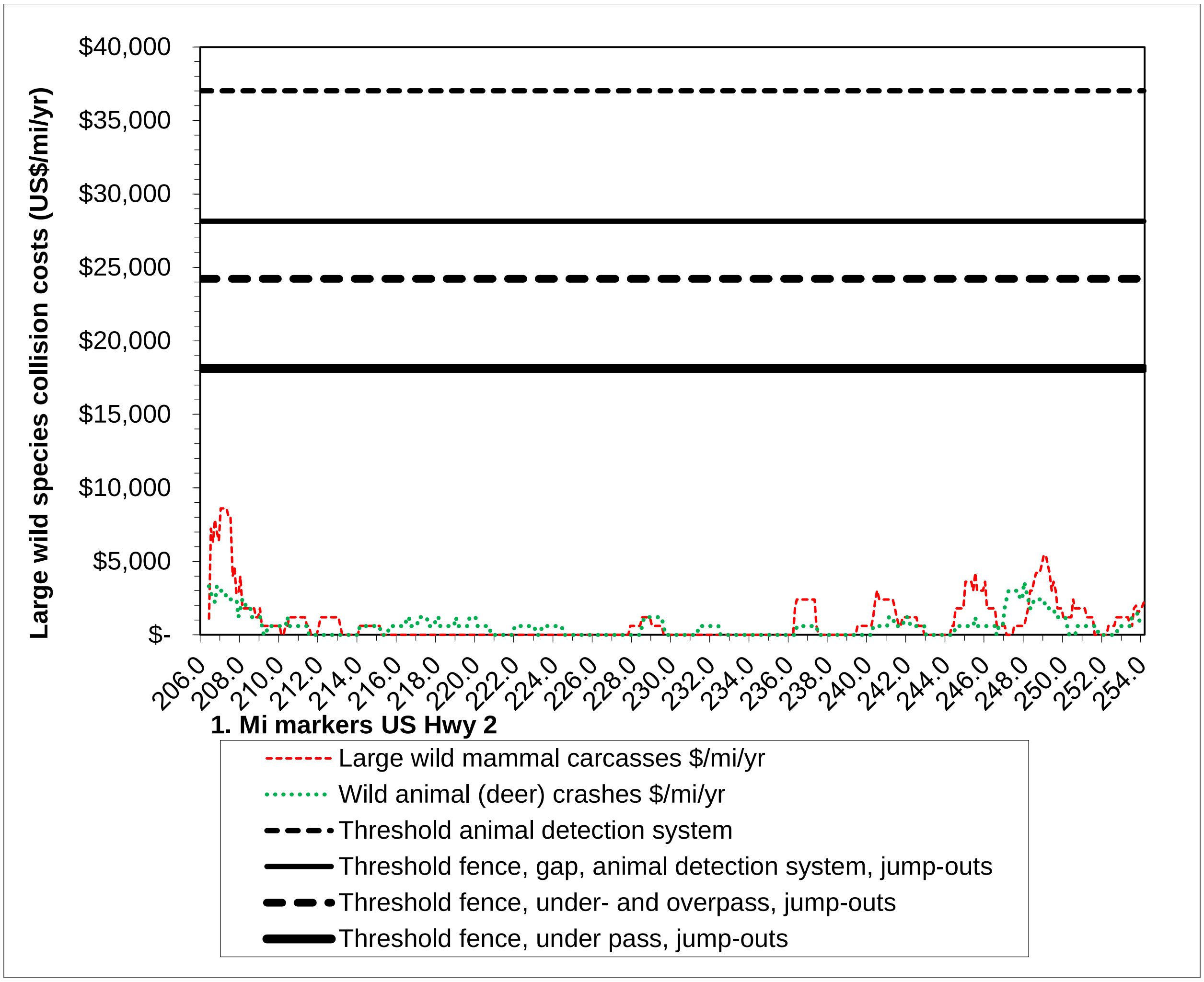
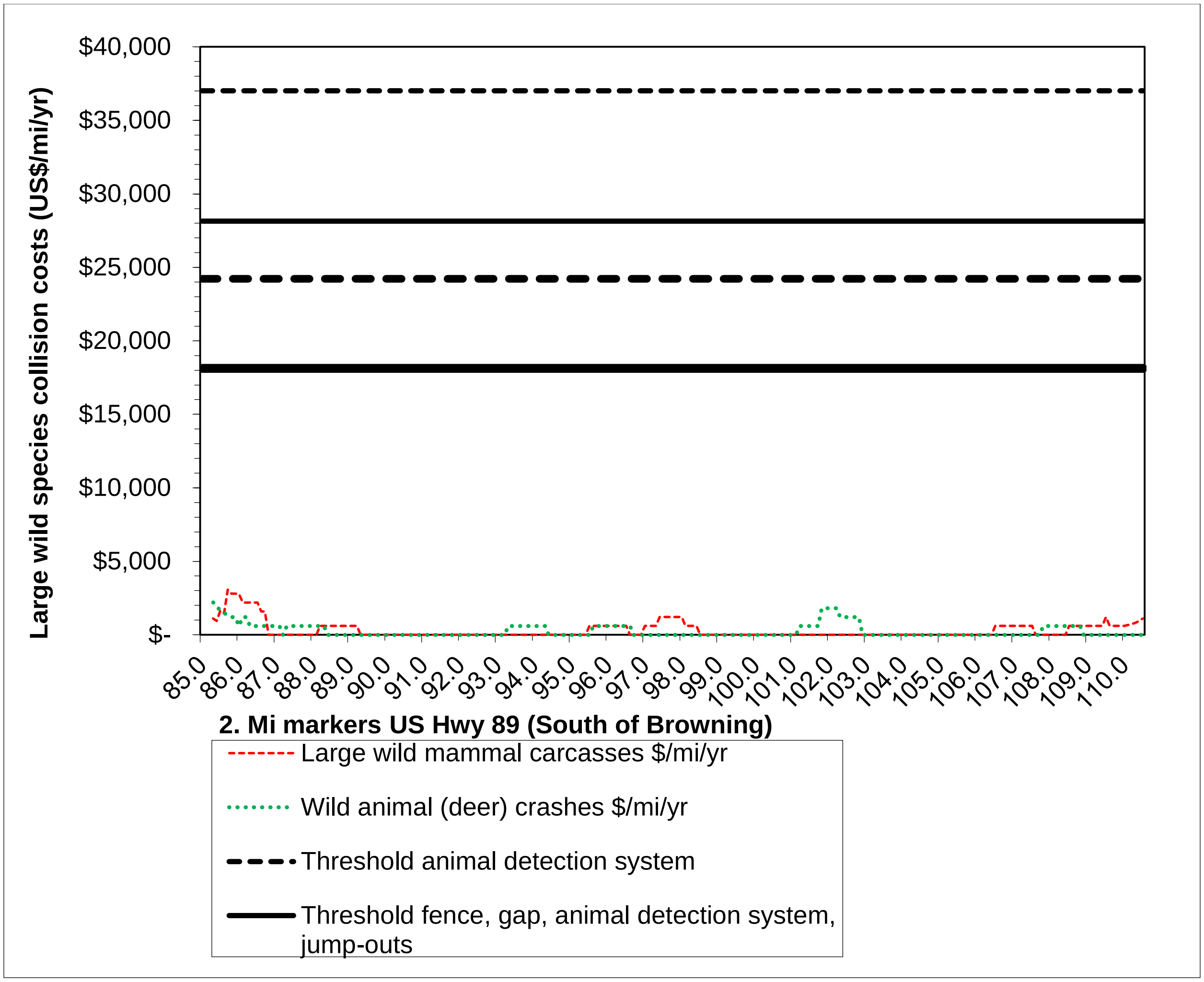
$ Crashes domestic species/mi/yr
Threshold wildlife friendly livestock fence

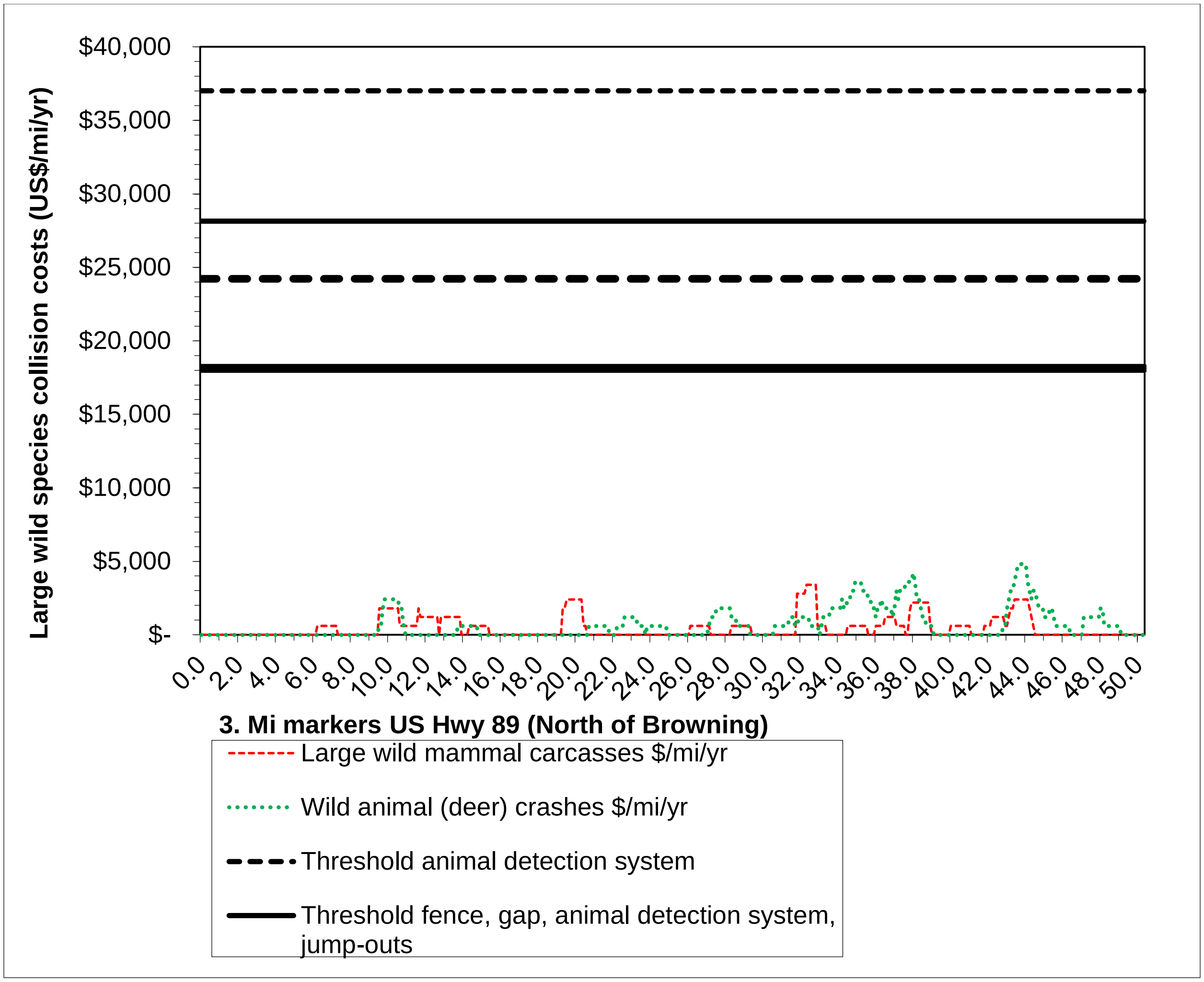
Large wild animal species

The following figures show the costs associated with collisions with large wild animal species (for both crash and carcass removal data), and the economic thresholds for cost-effective implementation of four different types and combinations of mitigation measures, for each of the 14 road sections listed in Table 1. The costs associated with large wild animal species-vehicle collisions were always lower than the costs associated with the four different types and combinations of mitigation measures.

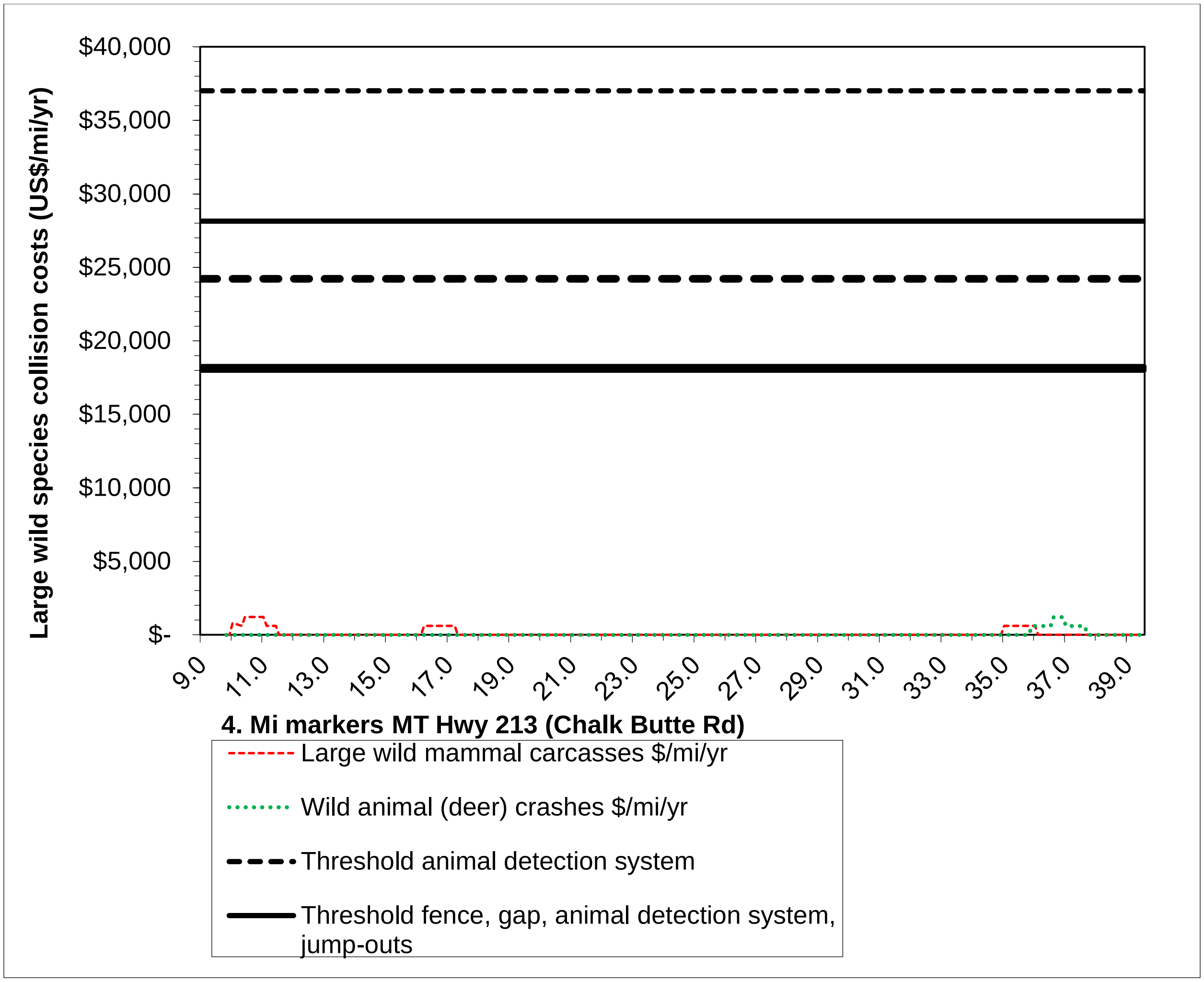


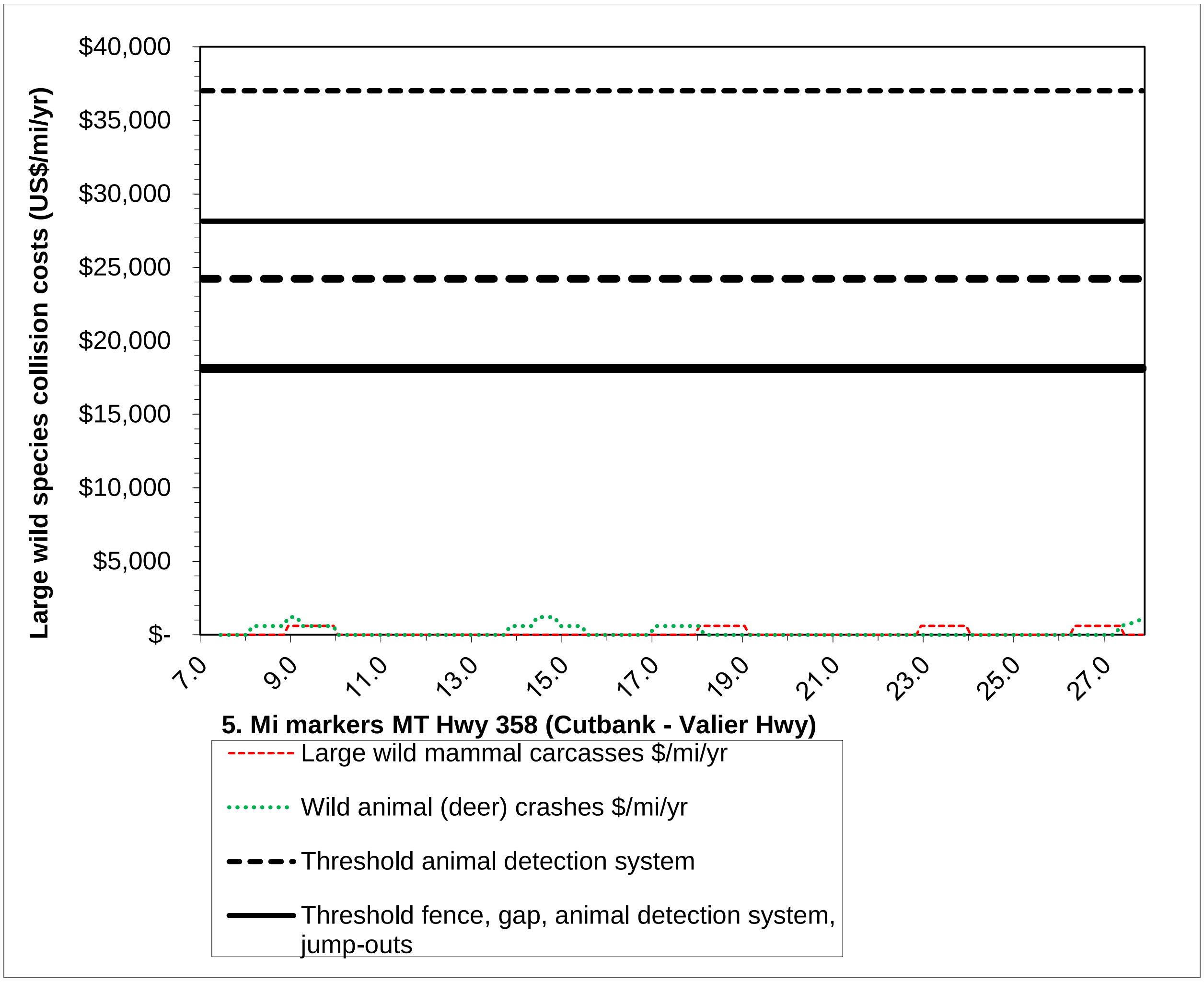


$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
Large wild species collision costs (US$/mi/yr)
85.0
86.0
87.0
88.0
89.0
90.0
91.0
92.0
93.0
94.0
95.0
96.0
97.0
98.0
99.0
100.0
101.0
102.0
103.0
104.0
105.0
106.0
107.0
108.0
109.0
110.0
2. Mi markers US Hwy 89 (South of Browning)
Large wild mammal carcasses $/mi/yr
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs

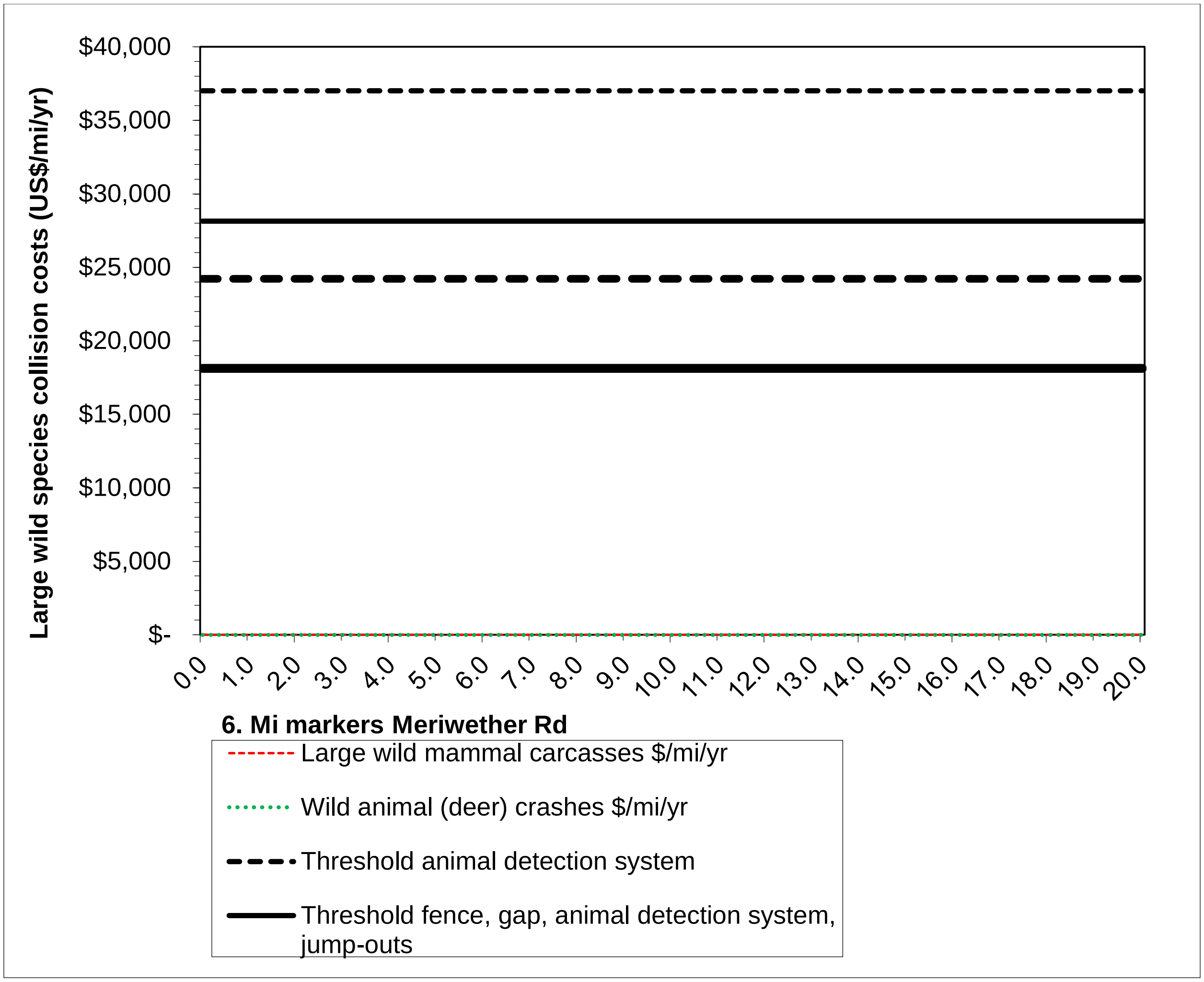


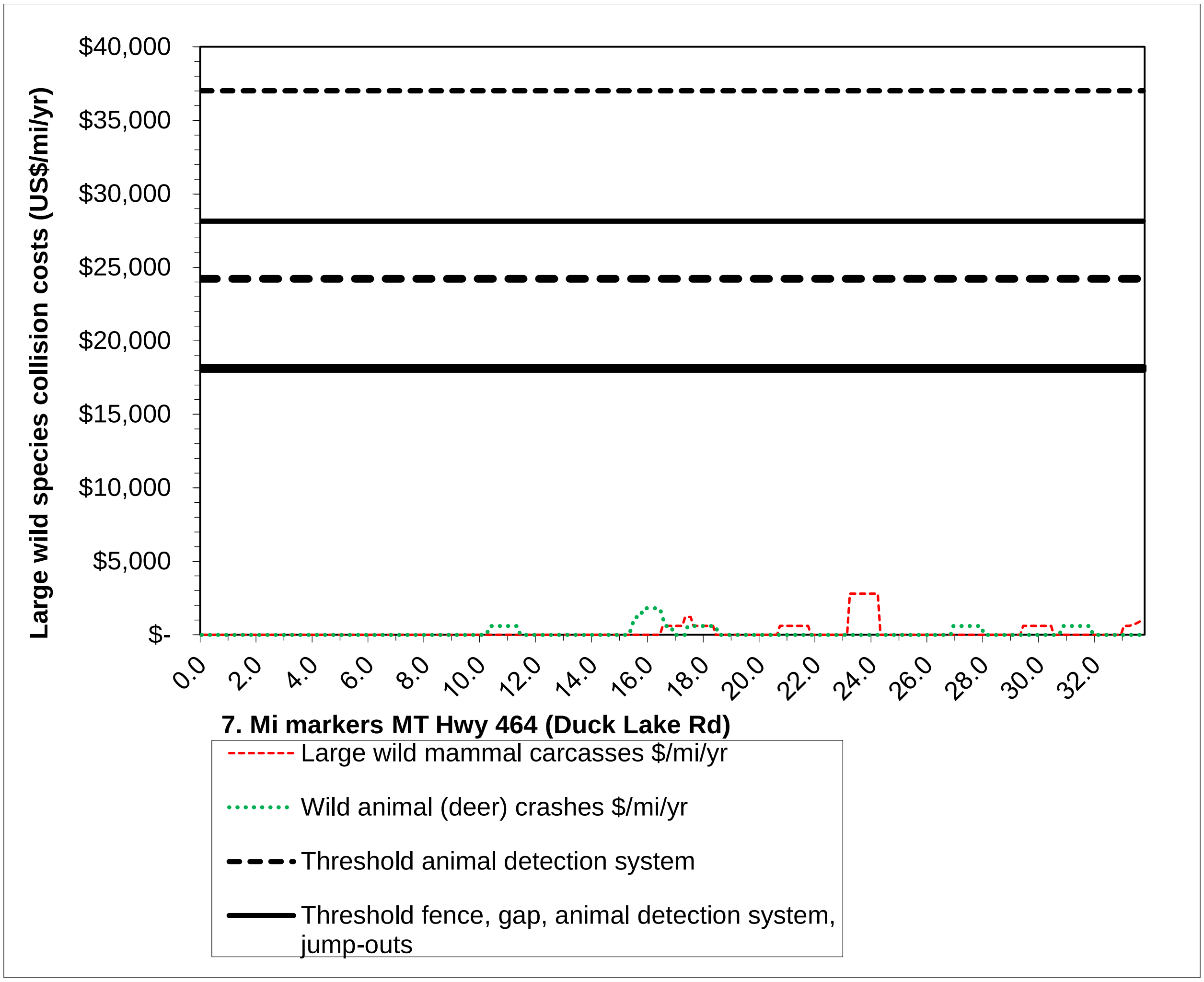
Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0 50.0
3. Mi markers US Hwy 89 (North of Browning)
Large wild mammal carcasses $/mi/yr
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs

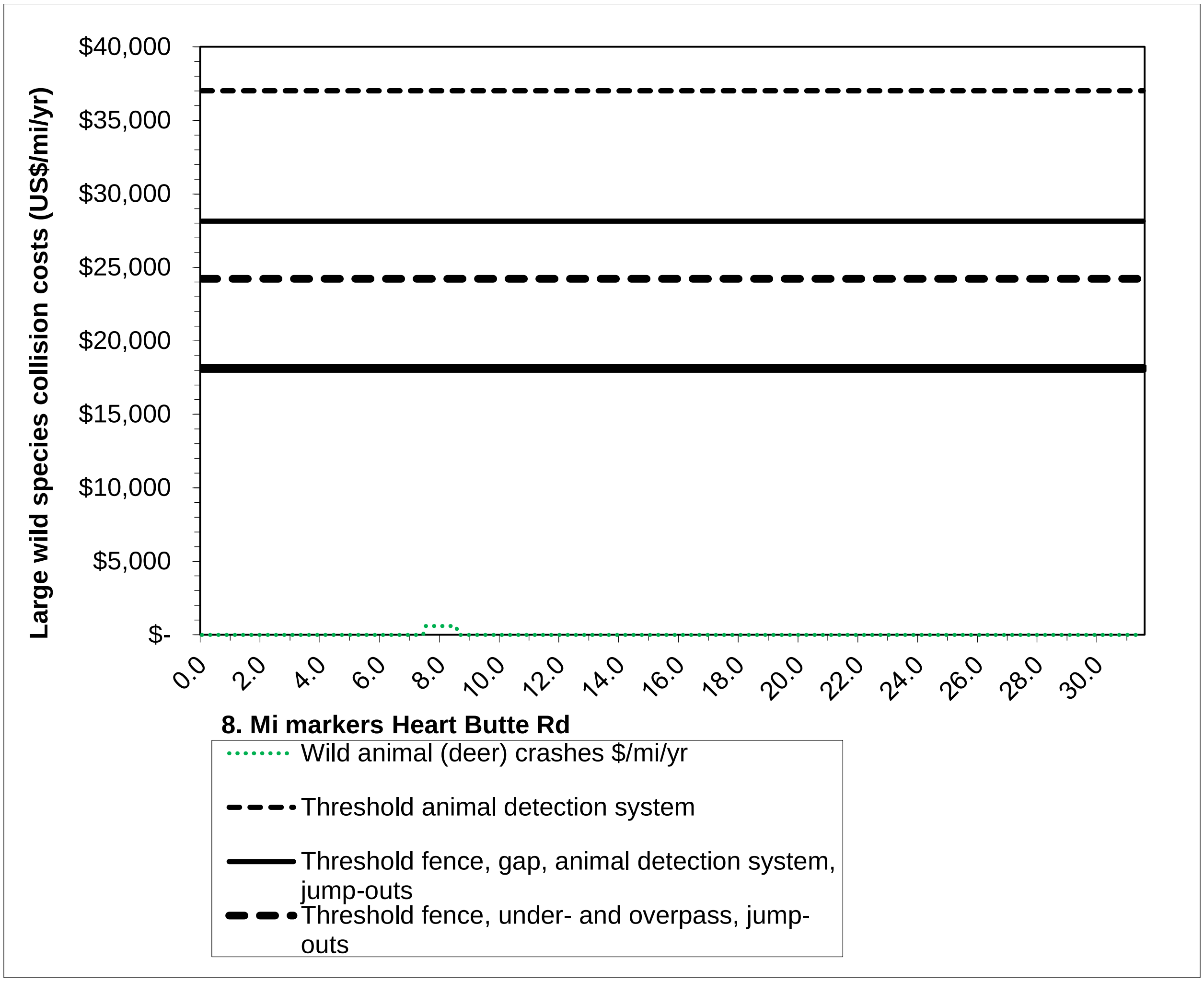

Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
27.0
29.0
31.0
33.0
35.0
37.0
39.0
4. Mi markers MT Hwy 213 (Chalk Butte Rd)
Large wild mammal carcasses $/mi/yr
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs

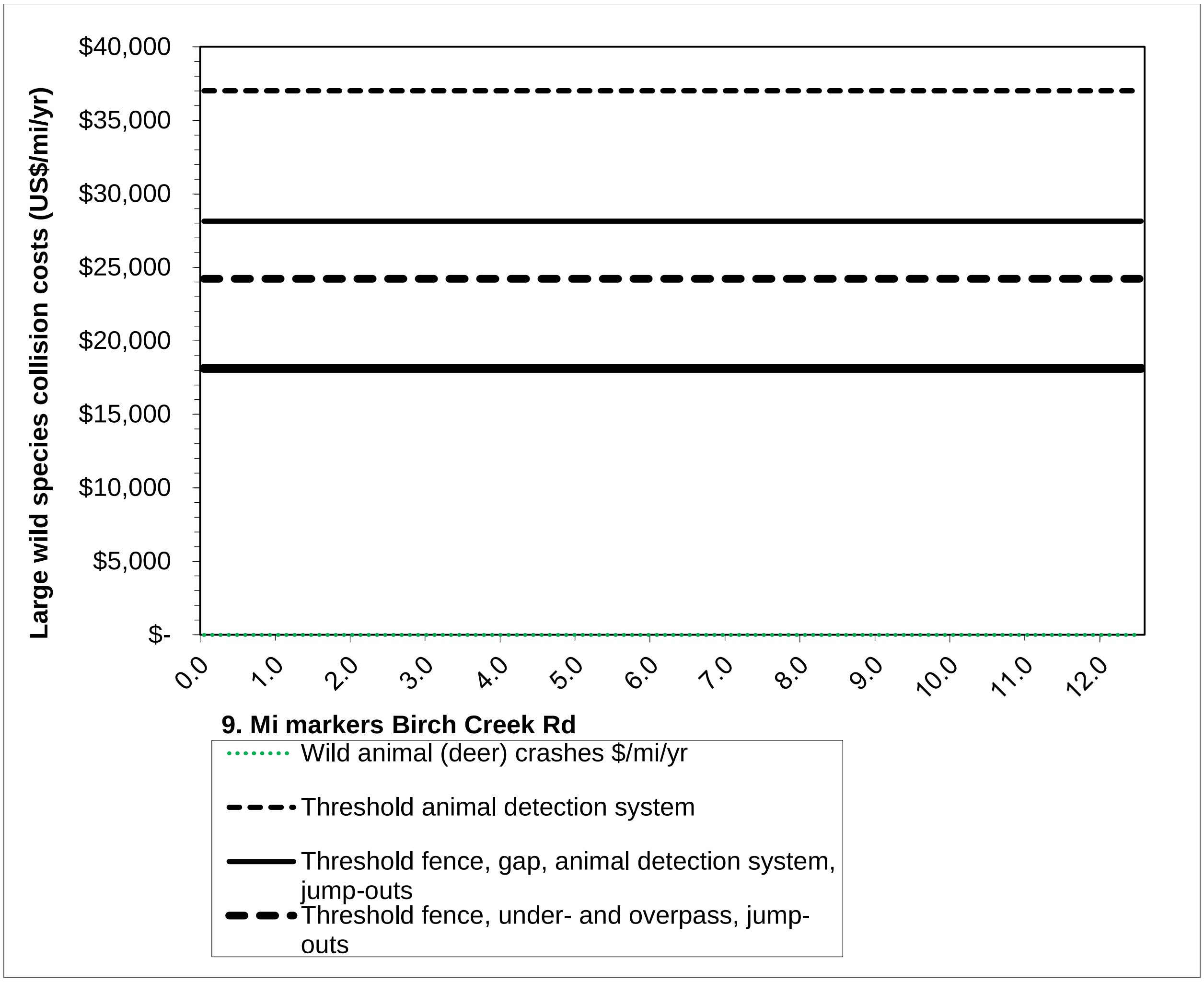


Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
7.0
9.0
11.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0
27.0
5. Mi markers MT Hwy 358 (Cutbank - Valier Hwy)
Large wild mammal carcasses $/mi/yr
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs

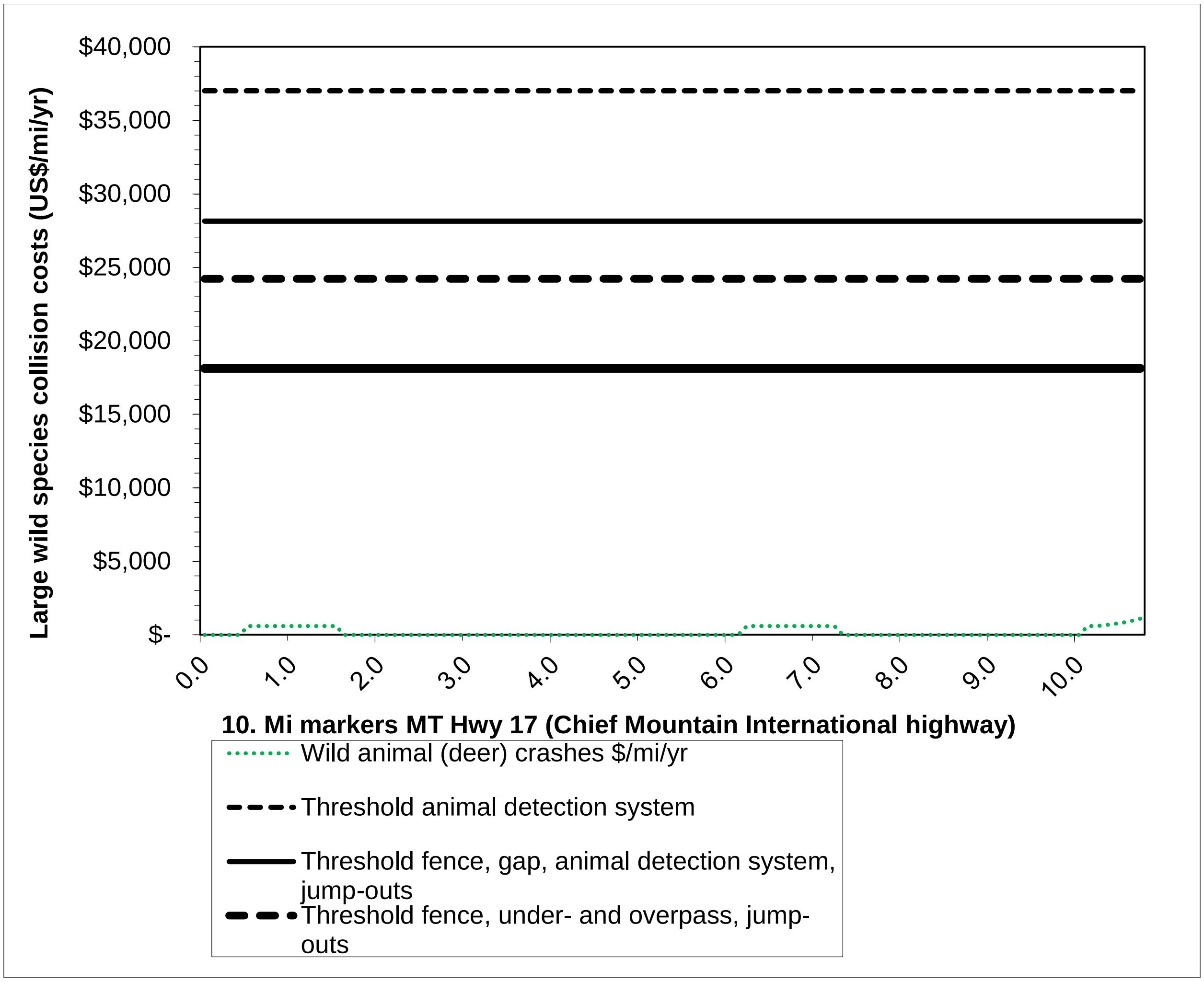

Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
6. Mi markers Meriwether Rd
Large wild mammal carcasses $/mi/yr
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs


Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
32.0
7. Mi markers MT Hwy 464 (Duck Lake Rd)
Large wild mammal carcasses $/mi/yr
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs


$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
Large wild species collision costs (US$/mi/yr)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
8. Mi markers Heart Butte Rd
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs
Threshold fence, under- and overpass, jump-outs



Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
9. Mi markers Birch Creek Rd
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs
Threshold fence, under- and overpass, jump-outs


Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0
1.0
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4.0
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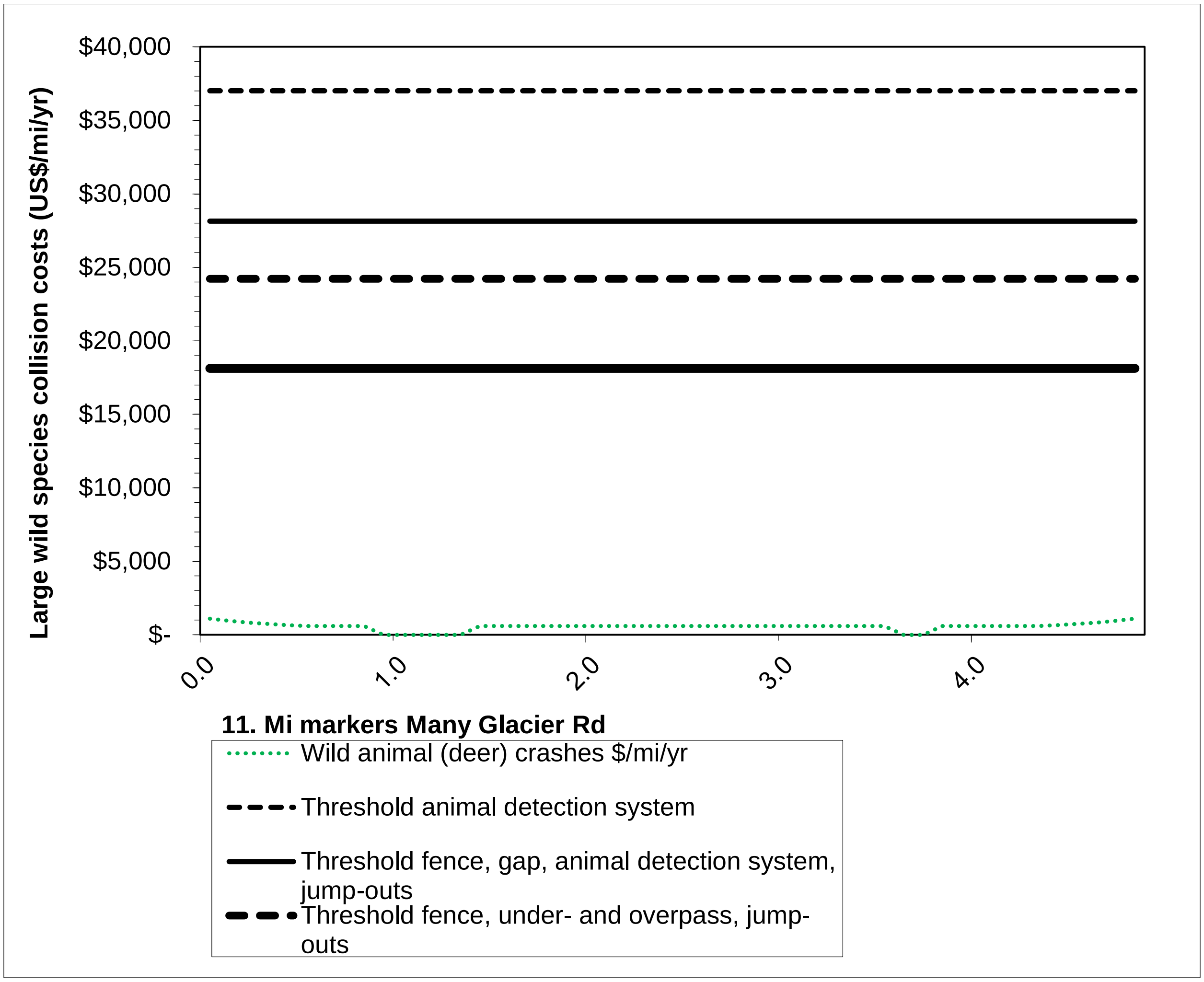
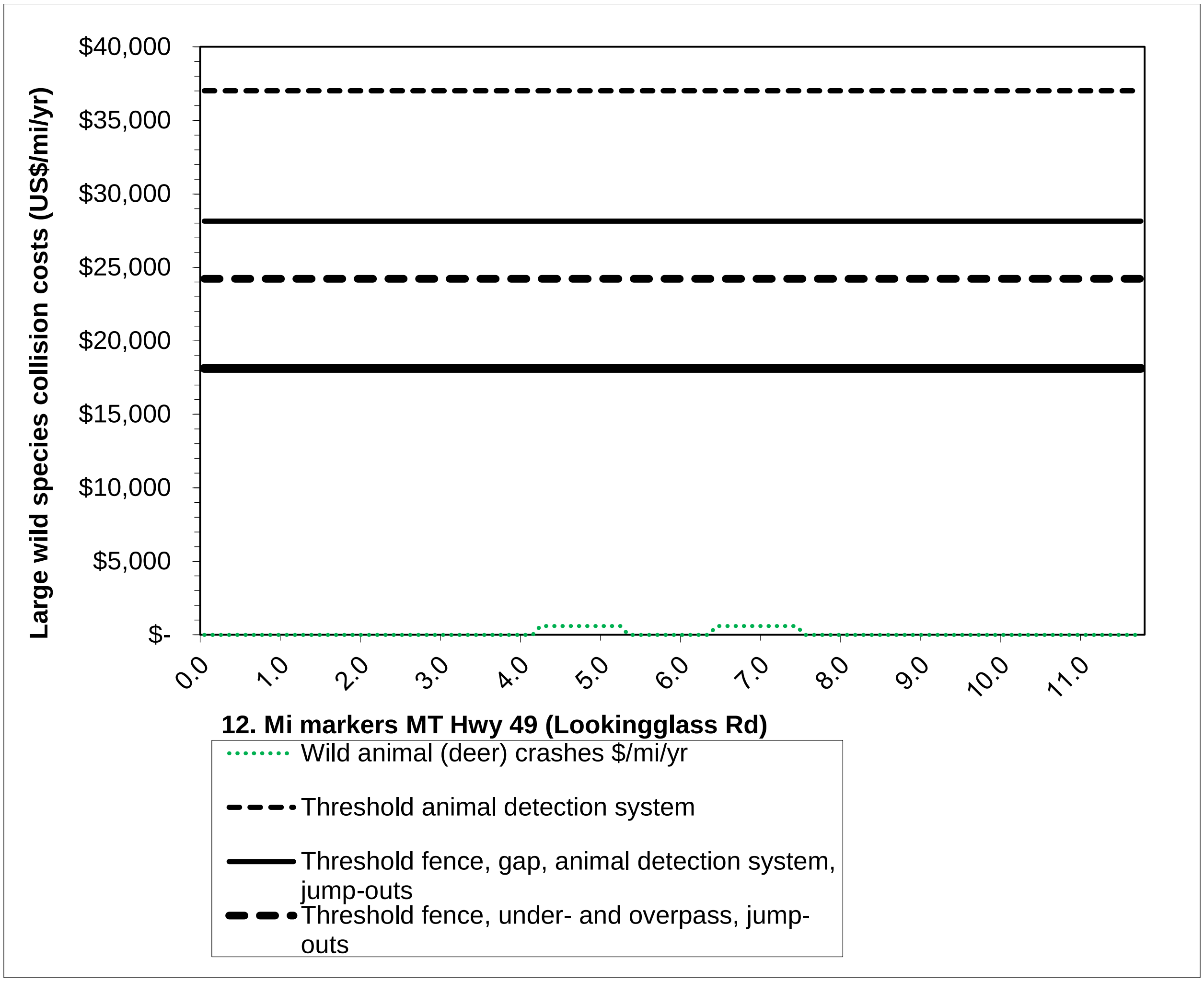
6.0
7.0
8.0
9.0
10.0
10. Mi markers MT Hwy 17 (Chief Mountain International highway)
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs
Threshold fence, under- and overpass, jump-outs


Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0
1.0
2.0
3.0
4.0
11. Mi markers Many Glacier Rd
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs
Threshold fence, under- and overpass, jump-outs


Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0
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4.0
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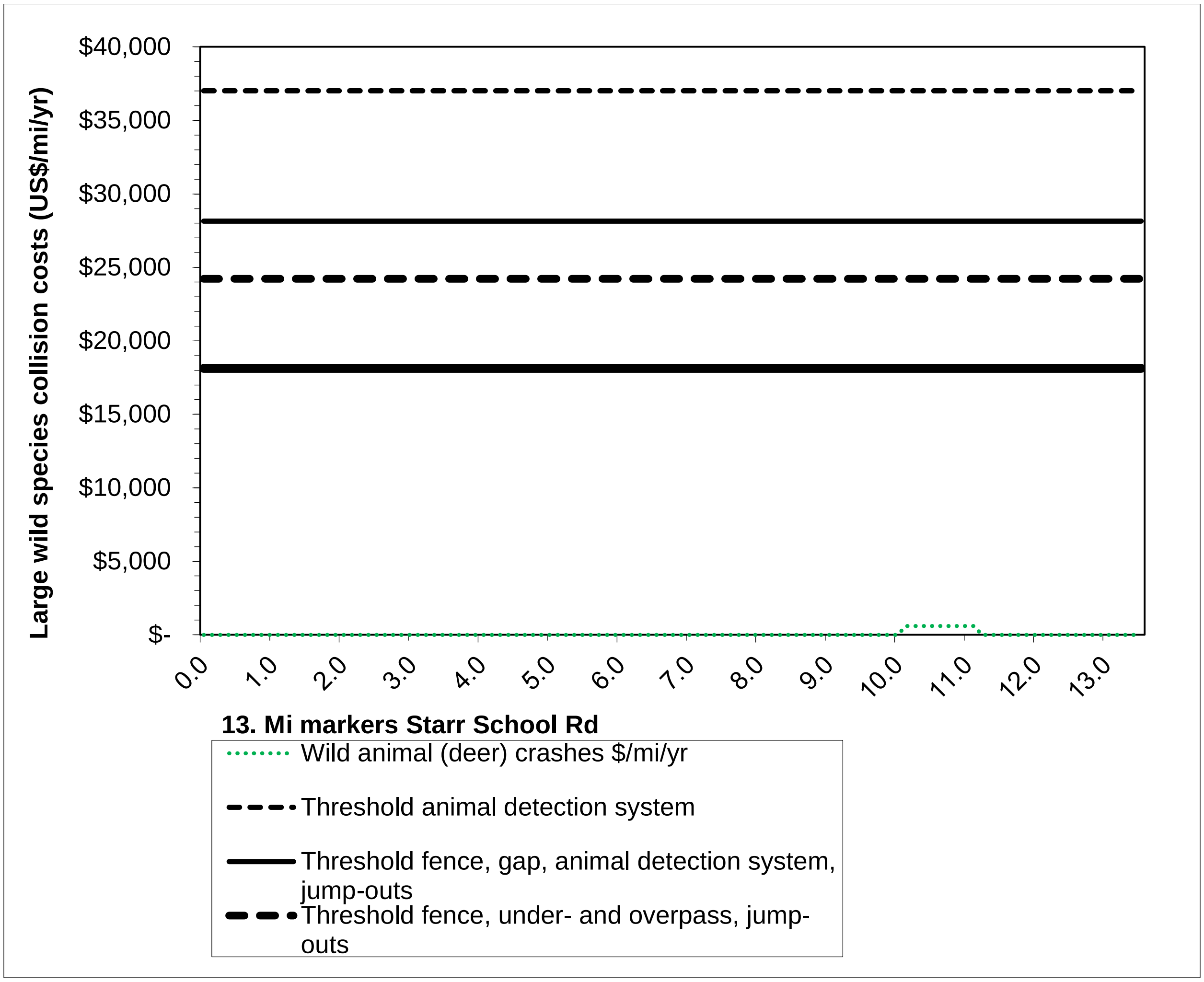
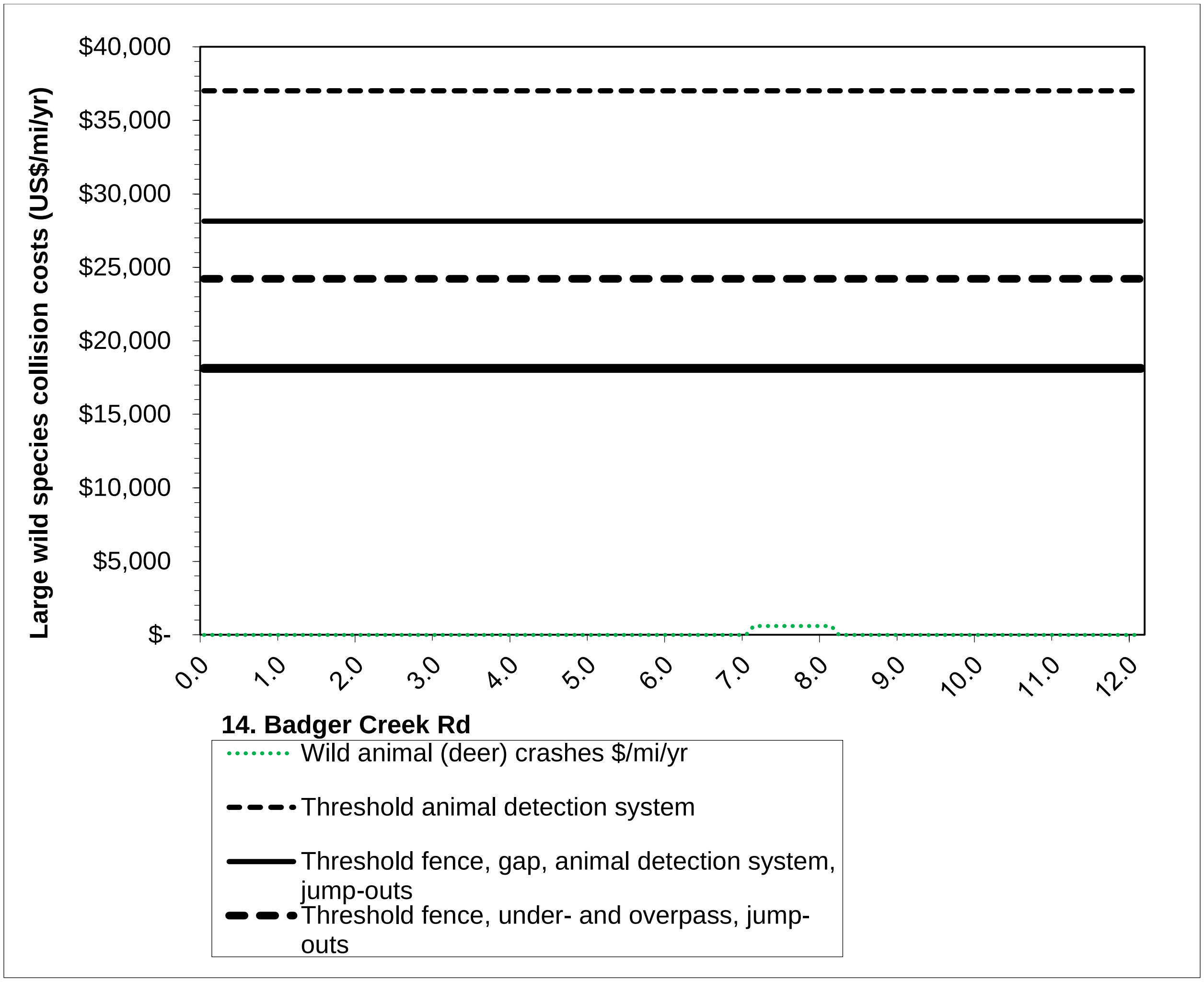
6.0
7.0
8.0
9.0
10.0
11.0
12. Mi markers MT Hwy 49 (Lookingglass Rd)
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs
Threshold fence, under- and overpass, jump-outs


Large wild species collision costs (US$/mi/yr)
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0
13. Mi markers Starr School Rd
Wild animal (deer) crashes $/mi/yr
Threshold animal detection system
Threshold fence, gap, animal detection system, jump-outs
Threshold fence, under- and overpass, jump-outs



8.4. Discussion

Large domestic species

Based on the cost-benefit analyses and costs associated with human safety, it is economically advantageous to implement wildlife-friendly livestock fences along most highway sections on the Reservation. Of course, the effectiveness depends on not only a correct design and careful construction process, but also on fence maintenance and diligence in closing gates at access points. Standard ROW or livestock fences along roads can be a barrier to wildlife, may injure animals because of barbed wires, and may result in animals dying because they become entangled in the wires. Therefore, we suggest implementing wildlife-friendly ROW or livestock fences rather than standard fence designs.

Large wild animal species

The costs associated with vehicle collisions involving large wild animal species were always lower than the costs associated with the four different types and combinations of mitigation measures. This contrasts with the results of cost-benefit analyses from most other regional AVC studies (e.g., Teton County Wildlife Crossings Master Plan), which identified road segments where the economic thresholds were met or exceeded. Potential explanations for the relatively low number of large wildlife-vehicle crashes or large wild mammal carcasses include (1) suspected severe underreporting of these crashes and carcasses, and (2) the generally low traffic volume of the roads analyzed. Regardless, the fact that the economic thresholds for the mitigation measures were not met does not necessarily mean that it makes no economic sense to implement mitigation measures because:

1. The number of wildlife-vehicle collisions is likely severely underreported on the Blackfeet Indian Reservation. The true number of collisions with large wild animal species may be high enough to meet or exceed the economic thresholds for the different mitigation measures.
2. The number of collisions with large domestic species (e.g. horses, cattle) would also decrease if wildlife fences were constructed. In this context, it is defensible to add the costs associated with large domestic animal-vehicle collisions to those for large wild mammal species and re-evaluate whether the thresholds for the mitigation measures aimed at large wild animal species are met.
3. The economic model of Huijser et al. (2009) is largely based on parameters associated with human safety, and parameters based on biological conservation are lacking. For example, grizzly bears or wolves that are hit are likely to have a very high economic value associated with biological conservation, and these values are not included in the economic model. Cultural, spiritual, and recreational values of wildlife are also not considered in this model. The current economic model is limited, and the outcomes should not be used as a litmus test for implementing mitigation measures.

Nonetheless, based on the current data, the implementation of mitigation measures aimed at reducing collisions with large wild animal species and aimed at providing safe crossing opportunities cannot be justified solely through economic parameters associated with human safety. The economic justification for such measures is at least partially dependent on the economic values associated with biological conservation, and the cultural, spiritual, and recreational value of wildlife.

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See, e.g., *Merrion v. Jicarilla Apache Tribe*, 617 F.2d 537, 544 (10th Cir. 1980) ("[W]e conclude that the Tribe has the inherent power to levy a privilege tax on the occupation of severing oil and gas from reservation land even though the tax falls on nonmembers."). *But see Atkinson Trading Co., Inc. v. Shirley*, 532 U.S. 653 (2001) (finding that the Navajo lacked authority to impose a tax on non-member hotel guests where the hotel, despite being within reservation boundaries, was located on non-tribal land held in fee by a non-member).

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