US 93 Post-Construction Wildlife-Vehicle Collision and Wildlife Crossing Monitoring and Research

PROPOSAL

by

Marcel P. Huijser[1], Rob Ament[1], Whisper Camel[2] & Dale Becker[2]

[1]Western Transportation Institute, and
Department of Ecology at
Montana State University – Bozeman

[2]The Confederated Salish and Kootenai Tribes of the Flathead Nation
Tribal Natural Resources Department
Polson

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1. INTRODUCTION

The US Highway 93 (US 93) reconstruction project on the Flathead Indian Reservation in northwest Montana represents one of the most extensive wildlife-sensitive highway design efforts in North America. The reconstruction of the 56 mile (90 km) long road section includes the installation of 42 fish- and wildlife crossing structures and approximately 16.6 miles (26.7 km) of wildlife exclusion fencing. The mitigation measures are aimed at improving safety for the traveling public through reducing wildlife-vehicle collisions and allowing wildlife to continue to move across the landscape and the road. Other examples of relatively long road sections in North America with a high concentration of wildlife crossing structures and wildlife fencing are I-75 (alligator alley) in south Florida (24 crossing structures over 40 mi; Foster & Humphrey, 1995, the Trans-Canada Highway in Banff National Park in Alberta, Canada (24 crossing structures over 28 mi (phase 1, 2 and 3A); Clevenger et al., 2002), State Route 260 in Arizona (17 crossing structures over 19 mi; Dodd et al., 2006), and I-90 at Snoqualmie Pass East in Washington State (about 30 crossing structures planned over 15 mi; WSDOT, 2007). Both the road length and number of wildlife crossing structures of US 93 on the Flathead Indian Reservation makes it the most extensive mitigation project of its kind in North America to date. If the section of US 93 south (south of Missoula, Bitterroot valley) is included, the mitigation measures along US 93 are even more substantial.

The magnitude of the US 93 reconstruction project and associated mitigation measures provide an unprecedented opportunity to evaluate to what extent these mitigation measures help improve safety through a reduction in wildlife-vehicle collisions, maintain habitat connectivity for wildlife (especially deer and black bear), and what the monetary costs and benefits are for the mitigation measures. In addition, the landscape along US93 is heavily influenced by human use. This is in contrast to the more natural vegetation along most of the other road sections that have large scale wildlife mitigation in North America. As the roads with most wildlife-vehicle collisions are in rural areas, the results from the US 93 project are expected to be of great interest to agencies throughout North America (Huijser et al., 2008).

In 2002, prior to US 93's reconstruction, the Western Transportation Institute at Montana State University-Bozeman (WTI-MSU) was funded by the Federal Highway Administration (FHWA) and the Montana Department of Transportation (MDT) to initiate a before-after field study to assess the effectiveness of the wildlife mitigation measures and to document events and decisions that shaped the process of planning and designing the mitigation measures. Preconstruction field data collection efforts were completed in the fall of 2005 and a final report on the preconstruction monitoring findings was published in January 2007 (Hardy et al., 2007). While the preconstruction monitoring and research efforts (Hardy et al., 2007) are valuable on their own, their main purpose is to provide a reference for a before-after comparison with the post-construction data.

This document details a post-construction monitoring and research plan with the objective of performing the post-construction monitoring and conducting the before-after comparisons. This document has been prepared by a partnership of WTI and the Confederated Salish & Kootenai Tribes (CSKT) (see Appendix A), in close cooperation with MDT and FHWA. The post-construction monitoring and research plan has the following components that are discussed in separate chapters of this document:

- The objectives of the evaluation study and the definitions of "effectiveness" for assessing the performance of the mitigation measures;
- Methods for the terrestrial post-construction monitoring and research efforts; and
- Schedule, deliverables and budget for the primary monitoring and research plan.

Consistent with the direction provided by MDT, the project is centered on three main subjects:

- Improvement in human safety through a reduction in wildlife-vehicle collisions;
- Maintaining habitat connectivity for wildlife (especially for deer (white-tailed deer [*Odocoileus virginianus*] and mule deer [*Odocoileus hemionus*] combined) and black bear (*Ursus americanus*) through the use of the wildlife crossing structures; and
- A cost-benefit analyses for the mitigation measures.

Proposed Length of the Monitoring and Research Project

Based on discussion with MDT and FHWA, the project will cover a period of 5.5 years and will start on 1 January 2010 and end on 30 June 2015. However, the data that will be reported on in the final report will run from May 2008 through December 2014. The data collected between May 2008 through 31 December 2009 were collected by WTI-MSU and CSKT outside of the current work scope, but will be combined with the data that will be collected between 2010 and 2014 for the deliverables of the current project. Thus the reporting will include four years of data for each of the three main study areas (Evaro, Ravalli Hills, Ravalli Curves) as well as the more isolated crossing structures (10 of the 26 isolated structures, see later).

Table 1: Number of years that data will be available for for the different road sections with continuous fencing. Note that the time periods relate to data collection only, excluding preparations, and data analyses and reporting.

Year	Evaro	Ravalli Curves	Ravalli Hill	Isolates structures
2008		Since May	Since May	*[1]
2009		X	X	*[1]
2010		X	X	Start in May
2011	Start in January	X	X	X
2012	X	End in May	End in May	X
2013	X			X
2014	End in December			End in May
2015				
Total	4 years	4 years	4 years	4 years

*[1] = some isolated structures were monitored in 2008 and 2009 already by CSKT.

2. EVALUATION STUDY OBJECTIVES AND DEFINITIONS OF EFFECTIVENESS

This post-construction monitoring and research plan builds on the objectives and approach established in the preconstruction study (Hardy et al., 2007). This chapter reviews these objectives and defines the measures of effectiveness to provide a framework for the development of the post-construction monitoring and research plan.

The goals of the evaluation study are to investigate the "effectiveness" of the wildlife crossing structures and wildlife fencing and to identify best management practices and further research that may benefit future wildlife-vehicle collision reduction and wildlife crossing mitigation projects. Specific objectives of the pre- and post-construction monitoring and research efforts are to:

- Identify and quantify the effects of the US 93 wildlife crossing structures and wildlife fencing on:
  - Driver safety and wildlife-vehicle collisions; and
  - Wildlife movements across the highway;
- Evaluate whether these effects meet "desired" safety or biological "Measures of Effectiveness (MOEs)"; and
- Establish guidance for future wildlife crossing structure and wildlife fencing projects.

A "before-after" approach was adopted during the development of the preconstruction monitoring and research plan (Hardy et al., 2007). This set the framework for the post-construction monitoring and research efforts. While all wildlife species are of interest, the data collection efforts primarily focus on deer species (white-tailed deer [*Odocoileus virginianus*] and mule deer [*Odocoileus hemionus*] combined) and black bear (*Ursus americanus)* (Hardy et al., 2007).

All reported deer- and black bear-vehicle collisions (DVCs and BVCs, respectively) along the 56 miles of the US 93 reconstruction project between Evaro, at the southern boundary of the reservation, and Polson, to the north (Figure 1) will be compared before and after the installation of the mitigation measures. Changes in the frequency and location of DVCs and BVCs will be used to evaluate the effect of the wildlife crossing structures and wildlife exclusion fencing on safety for the traveling public. In addition, changes in the number of road-killed deer and black bear are also of interest from a conservation perspective.

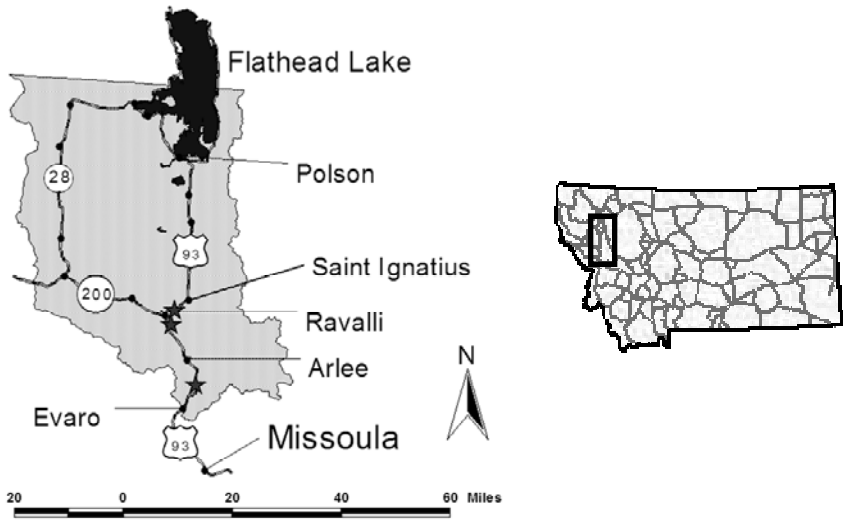

Figure 1: The Flathead Indian Reservation in Montana including major highways. The US 93 reconstruction effort and wildlife-vehicle collision study area traverses 56 miles from Evaro to Polson. Stars represent three areas where the longest stretches of wildlife fencing with crossing structures have been or will be constructed and where deer and black bear crossing rates have been (preconstruction) and will be (post-construction) estimated or measured.

Potential changes in deer and black bear movements between both sides of the highway before and after the reconstruction project will be assessed in the Evaro (north of Evaro), Ravalli Curves (south of Ravalli) and Ravalli Hill (north of Ravalli) areas (Figure 1). These three areas have or will have the longest sections of wildlife exclusion fencing with crossing structures (Hardy et al., 2007). In these three areas and for three seasons preceding the reconstruction, sand track beds were installed and monitored for potential wildlife crossings at random locations immediately parallel to the highway (Hardy et al., 2007) (Figures 2, 3 and 4). Observations of wildlife tracks, especially of deer and black bear, in the sand beds provided a sample of how many wildlife movements occurred across the highway. The sand tracking beds covered approximately 30% of the road length in the three areas (Evaro, Ravalli Curves and Ravalli Hill) (Hardy et al., 2007). This sample was extrapolated to estimate the total number of deer and black bear movements across the highway in the three areas (Evaro, Ravalli Curves and Ravalli Hill) (Hardy et al., 2007). After the installation of the wildlife crossing structures and wildlife fencing has been completed, deer and black bear can theoretically only cross the highway at the crossing structures (the desired outcome) or at the ends of the wildlife fencing (an undesired outcome). By comparing the preconstruction crossing estimates with the post-construction crossing measurements, the effect of the mitigation measures on deer and black bear movements between both sides of the highway can be evaluated (Hardy et al., 2007).

Figure 2: A tracking bed along US 93, in the Evaro road section on the Flathead Indian Reservation in Montana (Photo: Marcel Huijser, WTI).

Figure 3: Deer track on one of the sand tracking beds along US 93 (Photo: Marcel Huijser, WTI).

Figure 4: Black bear track on one of the sand tracking beds along US 93 (Photo: Amanda Hardy, WTI).

For black bears, collision and carcass data will not only be obtained from MDT through crash (Montana Highway Patrol (MHP)) and carcass databases that they manage, but also from Montana Fish, Wildlife and Parks (MTFWP).

During the preconstruction monitoring and research, efforts were made to quantify factors other than road reconstruction and the mitigation measures that could affect the number of deer-vehicle collisions (DVCs) and deer-highway crossings. Deer pellet count data (Figures 5 and 6) were collected to establish an index of local deer population trends. Furthermore, traffic data were collected to relate animal movements to traffic volume. By repeating these additional data collection efforts after construction, researchers will be able to better interpret to what extent changes in DVCs and deer-highway crossings may be attributed to the mitigation measures rather than potential changes in population size or traffic volume.

Figure 5: Deer pellet groups were surveyed along transects perpendicular to US 93 (Photo: Marcel Huijser, WTI).

Figure 6: A deer pellet group (Photo: Marcel Huijser, WTI).

Measures of Effectiveness

The primary goal of the wildlife-vehicle collision and wildlife crossing evaluation monitoring and research is to measure whether the mitigation measures are "effective". *Effectiveness* typically is defined by an individual or an agency as a "desired outcome" that relates to values associated with biological, social/cultural, economic, political, safety, and/or other particular interests. This section outlines the considerations for and definitions of measures and thresholds of effectiveness adopted by CSKT, MDT and FHWA. These definitions of effectiveness will be used to conclude whether the wildlife-vehicle collision and wildlife crossing mitigation measures are "effective."

Considerations when Defining Measures of Effectiveness

While the terms "effect" and "effectiveness" are similar, they are not synonymous. "Effects" are detected when measuring changes in particular parameters of interest before and after a change in a system (e.g., a change in wildlife-vehicle collisions or wildlife crossings after the installation of wildlife crossing structures and wildlife fencing). "Effectiveness" is based on whether the measured effects achieve "desired outcomes" that relate to values or to deeper understanding of the impact that a given effect may have on a larger system. In essence, effects are measured, often in a quantitative manner, whereas "effectiveness" applies judgments to the measured effects allowing one to make statements about whether the change in the system (e.g. the installation of the mitigation measures) achieved the desired outcome.

Definitions of effectiveness may reflect subjective values, target values in management plans, and/or scientific evidence regarding how effects may impact a given system, whether that system relates to transportation safety, ecological processes, economic returns, or any other area of interest upon which "desired outcomes" were defined. Recognizing that different viewpoints and values can be equally valid, the raw results, with no judgments of the outcome, are usually presented to allow independent assessments of effectiveness based on individual values and opinions.

For example, a statistically-detected effect of a reduction in deer-vehicle collisions by 10% may be considered ineffective by agencies if the desired outcome was to reduce DVCs by 50% for safety and economic reasons. At the same time, some may consider any reduction in DVCs as effective if they highly prize the value of the animals and/or human safety risks. Further, a statistically-detectable effect may or may not be biologically significant; e.g., a 50% reduction in vehicle collisions with a large and rare species may be considered effective by some for various (safety, economics, cultural) reasons, but it is possible that such a reduction may have little or no effect on the population viability of that species if, in fact, the population is threatened and ultimately any non-natural mortality may reduce the long-term sustainability of the population. Conversely, it is possible to have biologically significant effects and related changes within the population of interest that are not statistically detectable.

Many factors influence whether existing effects can be detected. With large sample sizes, it is more likely that small effects, if present, will indeed be detected through the use of statistics, but depending on the variables concerned, a small effect may not be biologically meaningful. On the other hand, in cases with small sample sizes (i.e., rare or elusive species), a statistically significant effect may only be detected if the effect is very large and consistent, and a statistically insignificant change may be biologically significant (Taylor & Gerodette, 1993).

No matter what effect may be measured, especially in ecological field studies, it cannot be considered “proof” of a simple “cause and effect” relationship (Neter et al., 1996). Other variables such as changes in the population size, unusual weather events, increases in traffic volumes or changes in vehicle speed need to be assessed to understand how these factors may contribute to observed changes in the response variable. In the case of the US 93 evaluation, routine evaluation of the parameters of interest along with potential confounding variables will allow for better interpretation of how the mitigation measures may influence local deer and black bear populations over time.

Numerous considerations were taken into account for establishing the measures of effectiveness and the thresholds of change that will be used to judge the performance of the wildlife mitigation measures along US 93. It should be noted that considerations brought forth in this chapter are not a complete analysis of issues that may be considered when defining desired outcomes and effectiveness. Other wildlife mitigation evaluation studies may opt to consider other parameters, values, desired outcomes and systems of interest depending on management objectives, public values, and parameters that can be measured in the field. Few studies have applied Measures of Effectiveness (MOEs); it is our hope that this effort serves as an example that may encourage others to adopt such *a priori* definitions of success. The remainder of this chapter describes the factors considered by CSKT, MDT and FHWA when they established the measures of effectiveness for the US 93 mitigation measures.

Parameters: Based on Evaluation Objectives

Parameters used to investigate the effects and effectiveness of the mitigation measures on US 93 were derived from the objectives (see earlier in this chapter) and the species of main interest: deer (white-tailed deer and mule deer combined) and black bear. The proposed monitoring and research (see next chapter) is largely based on the following parameters:

a) Standardized numbers/rates of deer-vehicle collisions (DVCs);

b) Standardized numbers/rates of bear-vehicle collisions (BVCs);

c) Standardized numbers/rates of successful deer-highway crossings (DHCs); and

d) Standardized numbers/rates of successful bear-highway crossings (BHCs).

The effect of the parameters will be measured by comparing their values before and after installation of the mitigation measures (Hardy et al., 2007). In addition to the parameters described above, there are confounding variables that will be taken into consideration. The following sections discuss the parameters in greater detail and describe the thresholds for “effectiveness” that the three agencies (CSKT, MDT, FHWA) agreed upon.

Effectiveness Thresholds: Statistical, Management & Biological Considerations

A decrease in the numbers of deer- and bear-vehicle collisions, and an increase or no change in the numbers of highway crossings made by deer and bear may be generally considered “desired outcomes” for the mitigation efforts. Beyond generalities, the three agencies (CSKT, MDT, FHWA) agreed on *a priori* definitions of effectiveness. These definitions will be used to conclude whether the mitigation measures are “effective” and achieved the “desired outcomes”.

Statistical considerations and biological, safety, and economic implications of the threshold values for the MOEs are described below.

Effectiveness thresholds relate to desired levels or degrees of change in the parameters of interest. For any given measure (e.g., DVCs), it is possible to have two different desired effectiveness threshold values relating to *management objectives* or *biological objectives*; e.g., management may aim for a 50% reduction in DVCs to meet safety management objectives, while a 25% reduction in DVCs may be considered biologically effective for maintaining a healthy deer population that can sustain hunting by CSKT members. The three agencies adopted a combination of safety and biologically based parameters and values for a comprehensive assessment of the mitigation from these two different perspectives. Effectiveness thresholds, whether related to management or biological outcomes, are based on a synthesis of the following considerations:

- Statistical limitations: Statistical power quantifies the percent change in a particular measure that can be statistically detected when comparing pre- and post-construction data, if such a change indeed occurs. For example, if a threshold of desired reduction in DVCs is established at 25% (whether related to biological or management objectives), but power analyses show that only changes greater than 40% can be quantitatively detected, then 25% reduction is unlikely to be demonstrated, even if the effect is really there. In this example "not being able to demonstrate an effect" only means that the effect was 40% or less; it is not proof that there was no effect.
- Management considerations: Here, management thresholds of effectiveness relate to safety and economics.
- Biological considerations: In many cases, there is insufficient information to state if and by how much wildlife-vehicle collisions and wildlife crossings influence the population survival probability for wildlife, including deer and black bear. Population viability modeling may be a useful tool to project how various scenarios of changes in vehicle-related wildlife mortality and wildlife movements across the highway might influence the long-term sustainability of the population in question. However, population viability parameters and analyses are not included in the MOEs or primary monitoring and research because of the magnitude of such efforts. Nonetheless, such parameters and analyses are mentioned when this tool may be considered helpful, and some of the management MOEs are based on what could be considered biologically meaningful.

Effectiveness Thresholds for Deer-Vehicle Collisions

From 2002-2005, the average annual number of reported deer-vehicle collisions (DVCs) that occurred along the entire 52.6 mile study area (mile markers 6.0-58.6) was 90 (95% C.I. = 82, 98), or an average of 1.7 deer killed per mile per year (95% C.I. = 1.6, 1.9) (Figure 7). These levels of DVC mortalities are not considered a substantial threat to the long-term viability of local deer populations along the US 93 corridor, which are numerous enough to sustain additional losses, for example through hunting. Therefore, "biological effectiveness" of reducing DVCs can be inferred if any reduction in DVCs is observed (assuming deer are able to continue to cross the highway). Beyond biological interests, statistical, economic and safety factors discussed below are helpful for considering more specific, quantitative threshold representing other meaningful desired outcomes.

Figure 7: Road-killed mule deer in the Ravalli Curves area along US 93 on the Flathead Indian Reservation, Montana (Photo: Marcel Huijser, WTI).

Based on a power analysis, given the variability in the preconstruction (2002—2005) DVC data, a 25% decline in DVCs across the entire study area would be detectable after 4 years of post-construction study (22% after 5 years). Therefore, based on statistical considerations, the smallest percent reduction in DVCs that can be used to define effectiveness must be no less than a 25% reduction in DVCs after 4 years of post-construction monitoring.

Different magnitudes of DVC reductions can be translated into economic savings (due to fewer collisions, injuries, loss of the deer as a resource, etc.) that can be compared to the cost of implementing the mitigation measures over different lengths of time. Using the preconstruction average of 90 DVCs occurring in the study area per year, annual savings (in millions of dollars) were calculated for a range of DVCs reductions (35% to 100%) at varying times post-construction (Table 2; see pages 84-87 of Hardy et al., 2007 for details and sources used to derive estimated costs). This analysis related to expenses associated with DVCs. Larger mammals such as elk and moose incur greater expenses per collision and if collisions with those species are prevented, a smaller reduction in collisions would pay for the expense of the mitigation measures, or the savings would outweigh the costs sooner than reported in Table 2.

Table 2: Reduction in DVCs and corresponding savings in millions of dollars considering an average of 90 deer killed in the study area yearly and the average cost of 1 collision being $7,890 (Huijser et al., 2006). Grey shaded areas represent savings exceeding $10 million in construction costs for mitigation measures.

% Reduction in DVCs	# Fewer DVCs	SAVINGS (millions of US dollars)									
		After 1 year	After 5 years	After 10 years	After 15 years	After 20 years	After 25 years	After 30 yrs	After 35 yrs	After 40 yrs	After 45 years
35%	31.5	$0.25	$1.24	$2.49	$3.73	$4.97	$6.21	$7.46	$8.70	$9.94	$11.18
40%	36	$0.28	$1.42	$2.84	$4.26	$5.68	$7.10	$8.52	$9.94	$11.36	$12.78
45%	40.5	$0.32	$1.60	$3.20	$4.79	$6.39	$7.99	$9.59	$11.18	$12.78	$14.38
50%	45	$0.36	$1.78	$3.55	$5.33	$7.10	$8.88	$10.65	$12.43	$14.20	$15.98
55%	49.5	$0.39	$1.95	$3.91	$5.86	$7.81	$9.76	$11.72	$13.67	$15.62	$17.57
60%	54	$0.43	$2.13	$4.26	$6.39	$8.52	$10.65	$12.78	$14.91	$17.04	$19.17
65%	58.5	$0.46	$2.31	$4.62	$6.92	$9.23	$11.54	$13.85	$16.15	$18.46	$20.77
70%	63	$0.50	$2.49	$4.97	$7.46	$9.94	$12.43	$14.91	$17.40	$19.88	$22.37
75%	67.5	$0.53	$2.66	$5.33	$7.99	$10.65	$13.31	$15.98	$18.64	$21.30	$23.97
80%	72	$0.57	$2.84	$5.68	$8.52	$11.36	$14.20	$17.04	$19.88	$22.72	$25.56
85%	76.5	$0.60	$3.02	$6.04	$9.05	$12.07	$15.09	$18.11	$21.13	$24.14	$27.16
90%	81	$0.64	$3.20	$6.39	$9.59	$12.78	$15.98	$19.17	$22.37	$25.56	$28.76
95%	85.5	$0.67	$3.37	$6.75	$10.12	$13.49	$16.86	$20.24	$23.61	$26.98	$30.36
100%	90	$0.71	$3.55	$7.10	$10.65	$14.20	$17.75	$21.30	$24.85	$28.40	$31.95

A 35% reduction in DVCs results in 31.5 fewer DVCs annually, amounting to an annual $250,000 savings to the traveling public and society (Table 2). Over the long term (45 years), this annual savings will offset the $10 million investment in the mitigation measures (Note: wildlife crossing structures are designed to last approximately 75 years while fencing is estimated to last 25 years). Other wildlife fencing and crossing studies have published reductions in ungulate-vehicle collisions ranging from 79-99% (87% on average) for large ungulates (Huijser et al., 2007); however, expecting this level of DVC reduction for the entire length of US 93 on the Flathead Reservation is incorrect. The authors of this proposal estimate the potential reduction in collisions with large animals to be around 26%. This estimate is based on the simplistic assumption that collisions with large animals are homogenously distributed along the 56 mi long road section, the fact that only approximately 30% (16.6 mi out of 56 mi) of the 56 mi long road section will be fenced and that the mitigation measures in these fenced areas may be 87% effective in reducing collisions with large animals. However, the sections that have fencing will have more gaps in the fence to accommodate driveways and highway access points than has typically been the case in other studies. This may result in a reduced effectiveness of the mitigation measures. On the other hand, one may expect that the mitigation measures are located where deer (and other animals) crossed the road more frequently or were killed by vehicles more frequently than the average location along the 56 mi long road section.

Based on these considerations, **the agencies adopted the following *management MOE* thresholds: if DVCs are reduced by at least 25% across the entire 56 mi long road section (fenced and unfenced road sections combined) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently improved road safety along the entire corridor with regard to DVCs.**

Additional threshold: if DVCs are reduced by at least 50% in all areas with fencing on both sides of the road (however short these sections might be) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently improved road safety along the mitigated road sections with regard to DVCs.

Additional threshold: if DVCs are reduced by at least 70% in the three areas with relatively long sections with more or less contiguous fencing (Evaro, Ravalli Curves and Ravalli Hill) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently improved road safety along these three road sections with regard to DVCs.

Note: data from road sections that may not have been reconstructed yet will be excluded from the analyses described above.

Effectiveness Thresholds for Bear-Vehicle Collisions

Given that BVCs are relatively rare compared to DVCs, the economic and safety significance of BVCs is comparatively less than DVCs (not to discount the economic and safety impacts of BVCs that do occur); however, even the rare occurrences of BVCs may have a biologically significant effect on the black bear population in the area along the US 93 corridor.

From 1995-2005, a total of 32 BVCs over the entire US 93 study area were reported (Table 3) and the mean number of BVCs per year was 2.9 (95% CI = 2, 4.1). Narrowing the dataset to the four years immediately prior to reconstruction (2002-2005), the mean annual number of reported BVC was 5 BVCs a year (95% CI = 3, 7.7). Because of high variability of the data and the relatively short duration of the post construction research, only very large and unrealistic reductions in black bear mortality can be statistically detected. The agencies decided to use only the "more intensive monitoring" years (2002, 2003) that were associated with a black bear study (McCoy, 2005) as a reference (8.5 BVCs on average).

Since we may only expect a reduction of 26% in road killed large mammals along the entire corridor (see earlier), the large variability in the annual BVC data, and the 4 year study period, the study cannot conclude whether BVCs have been reduced along the entire corridor. **Therefore the agencies adopted a management MOE for BVCs that is not based on statistics: if BVCs are reduced by at least 50% in the three areas with relatively long sections with more or less contiguous fencing (Evaro, Ravalli Curves and Ravalli Hill) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently benefitted the black bear population along US 93.**

Table 3: Number of reported BVCs on US 93 on the Flathead Indian Reservation from 1995 through 2005. Note: Higher numbers reported in 2002 and 2003 are likely due to focused monitoring and research efforts to document these incidents associated with a separate black bear study. Source: MDT, MHP, and MTFWP data records.

Year	Bears Killed	Year	Bears Killed
1995	1	2001	1
1996	0	2002	8
1997	1	2003	9
1998	4	2004	2
1999	2	2005	1
2000	3	-	-

Effectiveness Thresholds for Deer- and Bear-Highway Crossings

Healthy, sustainable wildlife populations need individuals to move across the landscape to find food, water, shelter, mates, to escape predators and natural disasters, and disperse from kin and colonize or re-colonize other areas. The main purpose of the wildlife crossing structures along US 93 is to accommodate such wildlife movements under and over the road.

Unfortunately, currently there are no data on how much wildlife movement across US 93 is required to warrant the long-term sustainability of healthy wildlife populations. Such data may be obtained through population viability modeling, and/or in combination with extensive field studies which are not within the scope of this project. However, it is possible to measure wildlife movements, including those of deer and black bear, through the crossing structures, and to select defensible thresholds of potential changes in highway crossing rates before and after the installation measures.

Two other approaches for assessing the effectiveness of the wildlife crossing structures across the highway are summarized below. These approaches are outlined in terms of whether they relate to management and biological evaluations.

Biologically based management MOEs:

> *Pre- versus post-construction crossing comparison* of the total estimated crossings in the three areas with extensive wildlife fencing (Evaro, Ravalli Curves, Ravalli Hill). The estimated number of deer and black bear crossings preconstruction (see Hardy et al., 2007) is compared to the number of post-construction crossings observed through the structures and around the ends of these segments of extensive fencing (this relates directly to the study objectives);

Safety based management MOEs:

> *Total number of passages through the crossing structures* representing potential collisions avoided given that the animal opted to use the below- or above-grade passage rather than crossing at-grade (outside of the fenced areas) where conflicts between vehicles and animals could occur.

Power analyses to estimate detectable differences between estimated preconstruction deer and bear crossing rates and post-construction counts of deer and bear passages through the crossing structures installed in the Evaro, Ravalli Curves, Ravalli Hill areas indicated that a 80% or greater change in deer-highway crossings (DHC) rates could be detected after 4 years of post-construction monitoring in these three study areas combined. For black bears, a 410% change in bear-highway crossings (BHCs) could potentially be detected after 4 years of post-construction study across the three study areas combined. This analysis is based on a two-sided test, recognizing that wildlife crossings could either increase due to the presence of safe crossing structures or decrease if deer and black bear do not use them, have trouble locating them, or have to learn that using the crossing structures is safe. It is unlikely that such large magnitudes of change in DHC and BHC rates will indeed occur. These statistical limitations prompted the agencies to adopt benchmarks that related to other management and biological interests, albeit using less quantitatively rigorous techniques.

Although quantitatively less rigorous, one could compare the actual number of post-construction DHCs and BHCs observed during the same months preconstruction crossings were monitored (June-October) to the average of the three years of preconstruction estimated crossings rates pooled across the three study areas, with a lower bound of effectiveness set at 1 or 2 standard deviations (SD) below the mean (1 SD covers approximately 67% of the variation amongst the averaged values while 2 SD roughly corresponds to 96% of variation amongst the averaged values). The drawback of this approach is that each annual preconstruction crossing estimate for each study area has its own inherent variability and sampling error that may not be adequately represented when summed for each year and averaged across the three years. The advantage of this approach is that it provides target values that management could use to evaluate the effectiveness of the wildlife crossing structures.

In 2003, 2004 and 2005, total DHCs across the three study areas combined were estimated at 1932, 1521 and 1743, respectively; these annual averages were not statistically different from year to year ($P>0.1$; Hardy et al., 2007). The average of those values is 1732 (SD = 168). Based on these values, and after taking other confounding variables into account, **the agencies adopted the following thresholds for maintaining or increasing DHCs:**

1. **If <1396 (corresponding to the overall preconstruction DHC average minus 2 SD) post-construction DHCs per year (yearly average over a 4 year period) are observed between June and October, across the three study areas combined, the mitigation is considered to have reduced deer movements across the road and is considered ineffective in terms of a management goal to maintain such movements;**
2. **If 1396-2068 (corresponding to the overall preconstruction DHC average plus and minus 2 SD) post-construction DHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in similar number of deer movements across the road and is considered effective in terms of a management goal to maintaining such movements;**
3. **If >2068 (corresponding to the overall preconstruction DHC average plus 2 SD) post-construction DHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in an increase in deer movements across the road and is considered effective in terms of a management goal to increasing such movements.**

Total BHCs combined across all three study areas were estimated at 129, 165 and 33 in 2003, 2004 and 2005, respectively (Hardy et al., 2007). BHCs were statistically significantly lower in 2005 than in 2003 or 2004 ($P<0.01$). The average of the annual estimated BHCs values pooled across the three study areas is 109 (SD = 56). With high variability observed in these data, 2 SD below the mean drops below zero, indicating that if no BHCs occur, it may just be representative of the natural variation in the system; alternatively, the biological consequences of no BHCs may create real problems for the long-term viability of the black bear population. To err on the side of caution, in the case of BHCs, the bounds of effectiveness for management objectives were set at 1 SD from the mean. Based on these values, and after taking other confounding variables into account, **the agencies adopted the following thresholds for maintaining or increasing BHCs:**

1. **If <53 (corresponding to the overall preconstruction BHC average minus 1 SD) post-construction BHCs per year (yearly average over a 4 year period) are observed between June and October, across the three study areas combined, the mitigation is considered to have reduced black bear movements across the road and is considered ineffective in terms of a management goal to maintain such movements;**
2. **If 53-165 (corresponding to the overall preconstruction BHC average plus and minus 1 SD) post-construction BHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in similar number of black bear movements across the road and is considered effective in terms of a management goal to maintaining such movements;**
3. **If >165 (corresponding to the overall preconstruction BHC average plus 1 SD) post-construction BHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in an increase in black bear movements across the road and is considered effective in terms of a management goal to increasing such movements.**
4. The simplest approach considers each deer and bear (for that matter, any animal) passage under or over the road a successful avoidance of a potential collision. Without knowing what the animal-vehicle encounter to animal-vehicle collision ratio may be, it is difficult to designate a meaningful number of below- or above-grade animal crossings that would effectively translate into reduced collisions, reduced economic impact and increased safety. Using this approach, the following management threshold of "effectiveness" was adopted by the agencies: **if at least 1299 (75% of 1732) DHC and 82 (75% of 109) BHCs are observed moving through the crossing structures across the three study areas combined annually (yearly average over a 4 year period), driver safety is considered to have sufficiently increased as a result of the presence and use of the crossing structures.**

Other Considerations

This study is not conducted in a laboratory where confounding variables can be controlled. Interpretations of effects and determinations of effectiveness need to take confounding variables into account (e.g., increases or decreases in the deer or black bear population, changes in traffic volumes and speeds, changes in land use, extreme weather or fires, changes in hunting practices or intensity, etc.). This project includes measuring potential (substantial) changes in the deer population, and traffic volume and speed, and describing potential substantial changes in land use, extreme weather or fires, changes in hunting practices or intensity, etc. It is not within the scope of this project to measure potential changes in the black bear population though. It may be appropriate to reconsider the thresholds, or have a correction factor, for the MOEs for influences beyond the mitigation measures themselves.

The MOEs suggested in this manuscript refer specifically to the objectives of the evaluation study, with a few additional approaches offered to supplement these MOEs. However, the MOEs described in this chapter do not cover all of the objectives of the evaluation study. Therefore the monitoring and research plan (see next two chapters) is based on a combination of the MOEs and the objectives of the evaluation study.

Summary of MOEs

The final MOEs and thresholds of change for defining effectiveness are compiled in Table 4. Supporting information is detailed above and in the preconstruction final report (Hardy et al., 2007).

Conclusions

The previous sections described the thresholds for the effectiveness of the wildlife fencing and wildlife crossing structures along US 93. This approach, rarely applied in previous evaluation studies for wildlife mitigation measures, will help draw conclusions from the data and ensures that the three agencies use the same parameters and similar wording when describing the conclusions of the monitoring and research efforts.

Selecting quantitative parameters that measure the effect of the mitigation measures was a relatively straight forward process that followed from the objectives of the project. The process of designating levels of change (thresholds) that signify “effectiveness” for those parameters was less straight-forward and required that agencies carefully assess the statistical, management and biological considerations. The CSKT, MDT and FHWA agreed on the thresholds described in Table 4.

Table 4. Measures of effectiveness and thresholds for management and biological definitions of "effectiveness" as agreed upon by the three agencies.

<table>
<tr><th rowspan="2"></th><th colspan="4">Measures</th></tr>
<tr><th>Deer-vehicle collisions (DVC)</th><th>Black bear vehicle collisions (BVC)</th><th>Deer Crossings in the Evaro, Ravalli Curves and Ravalli Hill areas combined over 2003-2005</th><th>Bear Crossings in the Evaro, Ravalli Curves and Ravalli Hill areas combined over 2003-2005</th></tr>
<tr><th rowspan="6">Thresholds for Defining Effectiveness</th><td rowspan="3">Safety based management MOE: If greater than 25% reduction in DVCs using 4 years of post-construction monitoring data, the mitigation measures are considered effective in reducing DVCs (or 50% or 70% reduction in selected areas)</td><td rowspan="3">Biologically based management MOE: if BVCs are reduced by at least 50% in the three areas with continuous fencing (Evaro, Ravalli Curves and Ravalli Hill), using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently benefitted the black bear population along US 93</td><td colspan="2">Pre-post Crossings Comparison</td></tr>
<tr><td>Biologically based management MOE: If <1396 DHCs are observed in the three areas combined, annually, mitigation is ineffective in maintaining habitat connectivity for deer</td><td>Biologically based management MOE: If <53 BHCs are observed in the three areas combined, annually, mitigation is ineffective in maintaining habitat connectivity for black bear</td></tr>
<tr><td>Biologically based management MOE: If 1396-2068 DHCs are observed in the three areas combined, annually, mitigation is maintaining habitat connectivity for deer</td><td>Biologically based management MOE: If 53-165 BHCs are observed in the three areas combined, annually, mitigation is maintaining habitat connectivity for black bear</td></tr>
<tr><td colspan="2" rowspan="3"></td><td>Biologically based management MOE: If >2068 DHCs are observed in the three areas combined, annually, mitigation is improving habitat connectivity for deer</td><td>Biologically based management MOE: If >165 BHCs are observed in the three areas combined, annually, mitigation is improving habitat connectivity for black bear</td></tr>
<tr><td colspan="2">Crossing Structure Passages as Avoided Collisions</td></tr>
<tr><td colspan="2">Safety based management MOE: If >1299 DHCs and >82 BHCs post-construction crossings through the structures are observed annually in the three areas with continuous fencing (Evaro, Ravalli Curves and Ravalli Hill), using 4 years of post-construction monitoring data, the mitigation measures are considered effective in terms potential collisions that were avoided</td></tr>
</table>

3. POST-CONSTRUCTION MONITORING AND RESEARCH PLAN

Post-construction data collection protocols and analytical methods described below are based on the objectives of the study, the measures of effectiveness (see previous chapter) and the comparability of the preconstruction and post-construction data. Standardized field methods developed during preconstruction monitoring, documented in the "US 93 Preconstruction Field Methods Handbook" (Hardy & Huijser, 2007), will be applied.

The tasks for the monitoring and research are described below. The tasks are described with regard to:

- Data collection methods, including sampling schedules to attain appropriate sample sizes;
- Analytical approaches to investigate effects and effectiveness; and
- Organization and scheduling considerations.

The schedule, deliverables, budget per task and total budget are summarized in Chapter 4.

Task 1: Deer- and Black Bear-Vehicle Collisions (Safety)

Preconstruction animal-vehicle collision (AVC) data were obtained from MDT's Traffic Safety Bureau, including AVC reports from the Montana Highway Patrol (MHP) and carcass removal reports from MDT's Maintenance Division. Although there are recognized limitations to using these data, they were consistently collected over the years immediately prior to reconstruction, they did not require research staff to spend substantial time collecting data, they did not expose research staff to additional traffic safety risks, and MDT and MHP made these data readily available for the purposes of this study. Additional data on black bear road mortality were obtained from Montana Fish, Wildlife and Parks and through the investigation of reports of possible road-killed black bear. The same sources for deer- and bear-vehicle collisions will be used for the post-construction monitoring and research.

Data Collection Methods

To assess potential changes in deer- and bear-vehicle collisions (DVCs and BVCs, respectively), WTI will request MHP accident reports and MDT carcass removal reports from US 93 between Evaro and Polson. In addition, WTI will request bear road mortality data from Montana Fish, Wildlife, and Parks. To better ensure consistency of carcass reporting efforts over the duration of the study, WTI would like to work with the MDT Maintenance Division to encourage the maintenance crews working along US 93 between Evaro and Polson to report these data *with similar effort as has been applied since 2002*. WTI proposes to request AVC data from MDT annually. Once the data have been obtained, WTI will analyze and report annually.

Analysis

Each year of post-construction data will be merged with the previous years of post-construction data and compared to the preconstruction dataset. The data will be analyzed in terms of the following pre- and post-construction comparisons:

1. The number of DVC and BVC occurrences. This relates to the following MOEs:

   If DVCs are reduced by at least 25% across the entire 56 mi long road section (fenced and unfenced road sections combined) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently improved road safety along the entire corridor with regard to DVCs.

   Additional threshold: if DVCs are reduced by at least 50% in all areas with fencing on both sides of the road (however short these sections might be) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently improved road safety along the mitigated road sections with regard to DVCs.

   Additional threshold: if DVCs are reduced by at least 70% in the three areas with relatively long sections with more or less contiguous fencing (Evaro, Ravalli Curves and Ravalli Hill) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently improved road safety along these three road sections with regard to DVCs.

   If BVCs are reduced by at least 50% in the three areas with relatively long sections with more or less contiguous fencing (Evaro, Ravalli Curves and Ravalli Hill) using 4 years of post-construction monitoring data, the mitigation measures are considered to have sufficiently benefitted the black bear population along US 93.

2. Spatial distribution of deer-vehicle collisions relative to areas within and outside wildlife exclusion fencing, as well as at fence ends and fence gaps, with or without swing gates or deer grades.

   These results are of specific interest for other multifunctional landscapes where shorter sections of wildlife fencing and gaps for access roads are typical.

Organization and Scheduling

WTI will be the primary organization responsible for Task 1.

The data collection for this task is ongoing and is conducted by MHP, MDT and Montana Fish, Wildlife and Parks.

WTI will request the data from the abovementioned organizations on a yearly basis. WTI will request the data for the previous calendar year to be delivered by 1 March. For example, data from 2009 (and previous years) are requested to be received by 1 March 2010.

Task 2: Wildlife Use of Underpasses and Effectiveness of Associated Mitigation Measures (Conservation and Safety)

Hardy et al. (2007) reported on the preconstruction results of the tracking bed study aimed at estimating the preconstruction highway crossings of deer and black bear in three study areas: Evaro, Ravalli Curves and Ravalli Hill. For a valid comparison, the post construction monitoring and research follows the methods described by Hardy et al. (2007).

Data Collection Methods

The post construction monitoring and research will focus on measuring the following:

a. Digital photo cameras at all crossing structures (n=16) in the Evaro (n=6), Ravalli Curves (n=9) and Ravalli Hill areas (n=2), and at a selection of the isolated crossing structures (n=10). Typically, one camera (Reconyx) will be installed at a crossing structure. However, at larger bridges and the overpass, two or more cameras will be installed in order to cover the width of the crossing structure. Tree stems, stumps, dead trees and/or branches, or rocks may be used at some of the crossing structures to encourage larger sized animals to walk in front of the cameras rather than behind the cameras and to encourage use by small mammals, reptiles and amphibians. The cameras will have additional protection against theft and vandalism (e.g. metal box or metal ring, cable and lock). Vandalized or stolen cameras will be replaced as the budget allows (a total of 26 replacement cameras are scheduled, but some funds may have to go to e.g. replacement batteries, memory cards and protective equipment instead). Should the theft or vandalism be at a substantial scale, or should all replacement cameras have been deployed already, the project partners (MDT/CSKT/WTI) will have to reconsider the methods and the associated budget. The memory card of the cameras will be exchanged at least once per month, and batteries will be replaced as necessary. The crossing structures that will have 2 or more cameras are at Evaro (railroad: 3 (long range) overpass: 4 (long range)) and Ravalli Curves (spanned bridge Spring Creek (Figure 8): 2 (long range); spanned bridge Jocko side channel: 2 (long range)). Twenty-four cameras will be in operation in the crossing structures in the three fenced areas (11 in Evaro, 11 in Ravalli Curves, 2 in Ravalli Hill), plus 10 in the isolated structures, for a total of 34 cameras.

Figure 8: Extended bridge across spring creek in the Ravalli Curves area along US Highway 93 on the Flathead Indian Reservation, Montana (Photo: Marcel Huijser, WTI).

b. Tracking beds (sand and 1/8 volume crushed gravel; similar to the preconstruction monitoring and research, see Hardy & Huijser, 2007)) will be installed outside 4-5 selected crossing structures (including the following four structures: RC396, RC427, RC432 and RH 459 (see Appendix B for full name and locations)) to allow for a translation of the post construction camera data to the preconstruction tracking data. These underpasses receive relatively high use by deer and/or black bear, providing a relatively large sample size with minimal effort. The tracking beds will be monitored for 1 year to cover different environmental conditions (two checks per week (3 or 4 day intervals) between 1 May and 31 October; not in winter (frozen). Annual weed control on these 4-5 tracking beds is required.

c. Digital photo cameras (Reconyx) will be installed at fence gaps with a wildlife guard (n=15) in the Evaro (n=3) and Ravalli Curves (n=12) areas and at the 4 fence ends (n=12) in each of the three areas. Vandalized or stolen cameras will be replaced as the budget allows (see earlier). Should the theft or vandalism be at a substantial scale, or should all replacement cameras have been deployed already (see earlier), the project partners (MDT/CSKT/WTI) will reconsider the methods and the associated budget.

d. Tracking beds (sand and 1/8 volume crushed gravel; similar to the preconstruction monitoring and research, see Hardy & Huijser, 2007) were installed at the top and bottom of all wildlife jump-outs (n=29) in the Ravalli Curves (n=25) and Ravalli Hill areas (n=4) in 2008. The tracking beds will be monitored in 2010 and 2011. The tracking beds will be monitored once per week between 1 May and 31

October; not in winter (frozen). Annual weed control on these tracking beds is required. These tracking beds are needed to document potential intrusions of larger animals (especially deer and black bear) in the fenced areas (Ravalli Curves, Ravalli Hill). More importantly, they are aimed at documenting the use of the jump-outs and how their height may influence their use. The latter is especially relevant since the purpose of the jump-outs is to allow animals to escape from the right-of-way while minimizing the number of animals trying to enter the right-of-way. The tracking beds will provide an indication of how much individual jump-outs are being used.

e. One digital photo camera (Reconyx) will be installed at one people access point in the Ravalli Curves area (north of Spring Creek). This site is monitored to evaluate to what extent it is a barrier for ungulates (especially deer).

f. Annual deer pellet group counts will be conducted at the same locations (in Evaro, Ravalli Curves, and Ravalli Hill) as described by Hardy and Huijser (2007). The pellet group counts allow the researchers to detect substantial changes in the size of the deer population along US 93 which would influence the use of the crossing structures.

Analysis

The cameras inside the underpasses and on the one overpass in the Evaro, Ravalli Curves, and Ravalli Hill areas are expected to capture all (or nearly all) of the deer and bear movements through the crossing structures. This information, in combination with data of wildlife crossing at the end of the fences, at the gaps in the fence and at the jump-outs in the Ravalli Curves and Ravalli Hill areas will serve as a relative measurement for intrusions into the road corridor and movements around the road sections that are fenced.

Total crossings measured through the cameras in the underpasses and one overpass will be compared to the estimated total preconstruction crossings extrapolated across the stretches of roads that will have contiguous fencing installed (Evaro, Ravalli Curves and Ravalli Hill).

Photo monitoring is advantageous because species identification is more reliable than based on tracks only, and they are more cost-effective than tracking under most conditions (Ford et al., 2009).

Track beds outside crossing structures will provide data that are comparable to the preconstruction track bed data because the exposed track beds are subject to environmental conditions that may cause tracks to be erased before they are recorded. Thus, the tracking beds outside the crossing structures will be constructed and monitored in a manner that is similar to that of the preconstruction tracking beds.

The analyses will focus on evaluating the following MOEs for deer and black bear highway crossings:

Conservation (Deer):

1. *If <1396 (corresponding to the overall preconstruction DHC average minus 2 SD) post-construction DHCs per year (yearly average over a 4 year period) are observed between June and October, across the three study areas combined, the mitigation is considered to*

have reduced deer movements across the road and is considered ineffective in terms of a management goal to maintain such movements;

2. *If 1396-2068 (corresponding to the overall preconstruction DHC average plus and minus 2 SD) post-construction DHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in similar number of deer movements across the road and is considered effective in terms of a management goal to maintaining such movements;*
3. *If >2068 (corresponding to the overall preconstruction DHC average plus 2 SD) post-construction DHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in an increase in deer movements across the road and is considered effective in terms of a management goal to increasing such movements.*

Conservation (Black bear):

1. *If <53 (corresponding to the overall preconstruction BHC average minus 1 SD) post-construction BHCs per year (yearly average over a 4 year period) are observed between June and October, across the three study areas combined, the mitigation is considered to have reduced black bear movements across the road and is considered ineffective in terms of a management goal to maintain such movements;*
2. *If 53-165 (corresponding to the overall preconstruction BHC average plus and minus 1 SD) post-construction BHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in similar number of black bear movements across the road and is considered effective in terms of a management goal to maintaining such movements;*
3. *If >165 (corresponding to the overall preconstruction BHC average plus 1 SD) post-construction BHCs per year (yearly average over a 4 year period) are observed between June and October, across the three areas combined, the mitigation is considered to have resulted in an increase in black bear movements across the road and is considered effective in terms of a management goal to increasing such movements.*

Safety (Deer and Black bear):

If at least 1299 (75% of 1732) DHC and 82 (75% of 109) BHCs are observed moving through the crossing structures across the three study areas combined annually (yearly average over a 4 year period), driver safety is considered to have sufficiently increased as a result of the presence and use of the crossing structures.

It is recognized that phased highway segment reconstruction resulted in the completion of the Ravalli Curves and Ravalli Hill areas in 2006 while the Evaro area will not be completed until summer 2010. Therefore, when crossing data is collected, the deer and black bear in the Ravalli area will have had 2 years to adapt to the wildlife fencing and the wildlife crossing structures whereas these mitigation measures will be less than 1 year old new in the Evaro area when the research starts there. Because of the resulting potential variation in the data, the data from Evaro and the Ravalli areas will be analyzed for potential differences before pooling. The analysis may provide insight into whether wildlife species' familiarity with wildlife crossing structures and wildlife fencing increases the use of the wildlife crossing structures.

Organization and Scheduling

WTI will be the primary organization responsible for Task 2. Field work assistance and other tasks will be provided by CSKT.

Lake County Weed Control is envisioned to conduct the herbicide applications for the tracking beds.

The cameras will be installed shortly after the start of the project (goal: May 2010 at the latest for the Ravalli Curves and Ravalli Hill areas and ten isolated crossing structures, and January 2011 in the Evaro area. Note that the structures in the Ravalli Curves and Ravalli Hill section will be monitored through tracking beds until cameras have been installed. Note that the camera attachments in the Evaro area may have to be installed by September/October 2010 at the latest because of how the temperature may affect installation).

Task 3 Cost-Benefit Analyses

Data Collection Methods

For this task all the actual costs associated with the design, construction, and maintenance of all mitigation measures along the entire 56 mi long road section (or the sections that have been completed and as far as data are available) will be requested from MDT. WTI will then conduct a cost-benefit analyses similar to that by (Huijser et al., 2009), using updated cost estimates for ungulate-vehicle collisions, and actual cost data for the design, implementation and maintenance of the mitigation measures along US 93. The cost-benefit analyses will show if and to what extend the mitigation measures are generating benefits in excess of costs.

Analysis

The analysis is focused on providing information with regard to the costs and benefits of the mitigation measures along the 56 mi long section of US 93.

Organization and Scheduling

WTI will be the primary responsible organization for Task 3.

The data will be collected on an ongoing basis from MDT (through 31 December 2014).

4. POST-CONSTRUCTION MONITORING AND RESEARCH SCHEDULE, DELIVERABLES, BUDGET, AND EXPECTATIONS FOR MDT, CSKT, AND OTHERS

Schedule

The project is proposed to have 4 years of data collection (see Table 1). The project will run for a total of 5.5 years though and start on 1 January 2010 and end on 30 June 2015 (Table 5). The data included in the final report will be from May 2008 through 31 December 2014 (see Table 1).

Table 5: Schedule.

Task	2010	2011	2012	2013	2014	2015
1. Deer and black bear vehicle collisions	X	X	X	X	X	X
2. Wildlife use of underpasses	X	X	X	X	X	X
3. Cost-benefit analyses	X	X	X	X	X	X

Deliverables

WTI will provide quarterly reports to MDT, starting 31 March 2010 for the duration of the project.

WTI will provide yearly draft interim reports on 30 June 2010, 2011, 2012, 2013, and 2014. Following MDT review (comments back to WTI by 31 July), WTI will deliver the final annual interim reports by 31 August of each year.

The final draft report will be delivered 31 March 2015 (MDT provides comments by 30 April 2015), and WTI will deliver the final report by 30 June 2015. A draft of the project summary report (i.e. a document consisting of about 4 pages) will be delivered 30 April 2015 (MDT provides comments by 31 May 2015), and WTI will deliver the final project summary report by 30 June 2015.

The interim and final reports will be delivered in electronic format (MS Word and PDF format) only.

Table 6 summarizes the deliverables and delivery dates for the individual products. In addition, there will be **quarterly reports** on the status of the terrestrial monitoring and research. The final report and the project summary report, integrating the results of the separate tasks is scheduled to be completed by 30 June 2015.

Table 6: Deliverables terrestrial monitoring and research.

Deliverable	Date
Draft interim report for 2009 and earlier	30-Jun-2010
Comments MDT	31 Jul-2010
Final interim report for 2009 and earlier	31-Aug-2010
Draft Interim report for 2010 and earlier	30-Jun-2011
Comments MDT	31 Jul-2011
Final interim report for 2010 and earlier	31-Aug-2011
Draft interim report for 2011 and earlier	30-Jun-2012
Comments MDT	31 Jul-2012
Final interim report for 2011 and earlier	31-Aug-2012
Draft interim report for 2012 and earlier	30-Jun-2013
Comments MDT	31 Jul-2013
Final interim report for 2012 and earlier	31-Aug-2013
Draft interim report for 2013 and earlier	30-Jun-2014
Comments MDT	31 Jul-2014
Final interim report for 2013 and earlier	31-Aug-2014
Draft final report	31-Mar-2015
Comments MDT	30-Apr-2015
Final report	30-Jun-2015
Draft project summary report	30-Apr-2015
Comments MDT	31-May-2015
Final project summary report	30-Jun-2015

Budget

The total budget for the project is shown in Tables 7, 8, and 9 (Table 7: MDT budget by state fiscal year, Table 8: MDT budget by federal fiscal year, Table 9: WTI UTC budget by federal fiscal year). Funding for this project consists of $250,000 from the WTI University Transportation Center (UTC) program, matched by $500,000 from MDT, for a total budget of $750,000. Note that the funding from the WTI UTC program is contingent on the existence and scale of a UTC program at WTI at the time of the project initiation and for the duration of the project (through 30 June 2015). Level of effort by team member and task is summarized in Table 10 and 11.

Table 7: Monitoring and Research Budget for MDT (20% IDC) per state fiscal year (1 July through 30 June).

	FY0910	FY1011	FY1112	FY1213	FY1314	FY1415
Principal investigator (WTI)	$10,899	$22,888	$24,033	$25,234	$26,496	$69,552
Support staff (WTI)	$10,183	$5,204	$5,464	$5,737	$6,024	$22,829
Subcontract CSKT	$18,742	$39,129	$32,419	$24,341	$25,559	$23,920
Travel	$1,860	$3,906	$4,101	$4,306	$4,522	$4,748
Meetings/conference	$0	$0	$0	$0	$0	$2,000
Weed spraying	$1,500	$2,000	$1,500	$1,575	$1,654	$0
Minor equipment (tools, IT, software)	$2,000	$1,000	$1,050	$1,103	$1,158	$1,216
Subtotal	$45,183	$74,127	$68,568	$62,297	$65,412	$124,264
IDC	$9,037	$8,251	$7,230	$7,591	$7,971	$20,069
Total	$54,220	$82,378	$75,797	$69,888	$73,383	$144,333
Grand total	$500,000					

Table 8: Monitoring and Research Budget for MDT (20% IDC) per federal fiscal year (1 October through 30 September)

	FY0910	FY1011	FY1112	FY1213	FY1314	FY1415
Principal investigator (WTI)	$16,349	$22,888	$24,033	$25,234	$26,496	$62,597
Support staff (WTI)	$10,183	$5,204	$5,464	$5,737	$6,024	$23,421
Subcontract CSKT	$28,112	$39,129	$27,542	$24,341	$25,559	$20,832
Travel	$2,790	$3,906	$4,101	$4,306	$4,522	$3,561
Meetings/conference	$0	$0	$0	$0	$0	$2,000
Weed spraying	$1,500	$2,000	$1,500	$1,575	$1,654	$0
Minor equipment (tools, IT, software)	$2,000	$1,000	$1,050	$1,103	$1,158	$1,216
Subtotal	$60,934	$74,127	$63,690	$62,297	$65,412	$113,626
IDC	$11,564	$7,000	$7,230	$7,591	$7,971	$18,559
Total	$72,498	$81,127	$70,920	$69,888	$73,383	$132,185
Grand total	$500,000					

Table 9: Monitoring and Research Budget for WTI-MSU (41.5% IDC) per federal fiscal year (1 October through 30 September).

	FY0910	FY1011	FY1112	FY1213	FY1314	FY1415
Principal investigator (WTI)	$16,349	$22,888	$24,033	$0	$0	$22,096
Cameras and associated equipment	$55,000	$8,800	$7,700	$0	$11,119	$0
Traffic counters	$1,500	$1,500	$500	$1,736	$500	$0
Conference	$2,200	$1,575	$1,654	$1,736	$1,823	$0
Subtotal	$75,049	$34,763	$33,886	$3,473	$13,442	$22,096
IDC (41.5%)	$24,361	$14,427	$14,063	$928	$5,579	$9,170
Total	$99,409	$49,190	$47,949	$3,165	$19,021	$31,266
Grand total	$250,000					

Table 10: Level of Effort (hours) by team member and task for MDT funds per state fiscal year (1 July through 30 June).

	Task 1	Task 2	Task 3	Total
Marcel Huijser	1070	1165	677	2912
Rob Ament	0	0	280	280
Tony Clevenger	80	80	0	160
Ben Dorsey	160	160	0	320
Statistician	56	62	0	118
Jeralyn Brodowy	64	0	0	64
Carol Diffendaffer	88	0	0	88
Neil Hetherington	80	0	0	80
Whisper Camel	0	2340	0	2340
Stephanie Gillen	0	1560	0	1560
Total				7922

Table 11: Level of Effort (hours) by team member and task for UTC funds per federal fiscal year (1 October through 30 September).

	Task 1	Task 2	Task 3	Total
Marcel Huijser	0	1474	0	1474

Expectations

The expectations for MDT, CSKT and others are summarized in table 12, 13 and 14.

Table 12: Expectations for MDT.

1. Continue to collect carcass data with consistent search and reporting effort.
2. Allow the research to take place within the right-of-way of US 93 for the duration of the project and beyond, should additional funding from other sources allow for longer term research.
3. Dump sand at 4 underpasses for tracking beds outside 4 underpasses. WTI will distribute the sand on the actual tracking beds.
4. Install tracking bed on center of the wildlife overpass.
5. Install tracking beds on top and bottom of all the jump-outs in the Evaro section that has continuous fencing.
6. Assist with/allow installation of wildlife cameras at underpasses, overpass, wildlife guards and potentially fence ends and in right-of-way of US 93.
7. Provide crash and carcass the data for US 93 for the previous calendar year by 1 March. For example, data from 2009 (and previous years) are requested to be received by 1 March 2010.
8. Provide actual cost data for the design, implementation and maintenance of the mitigation measures along US 93 as available when requested.
9. Should major vandalism or theft occur with essential research equipment (e.g. cameras), WTI and MDT will have to reconsider the research methods, associated budgets and if and how to proceed with the project.

Table 13: Expectations for CSKT (outside the subcontract to WTI-MSU).

1. Allow the research to take place (i.e. provide permits) within the right-of-way of US 93 and on lands adjacent to the road (as far as these are under Tribal management) for the duration of the project and beyond, should additional funding from other sources allow for longer term research.

Table 14: Expectations for Others.

1. Montana Highway Patrol will continue to collect crash data with consistent search and reporting effort.
2. Montana Fish, Wildlife, and Parks will provide bear-vehicle collision data for US 93.
3. Landowners/users along US 93 will allow for research (e.g. deer pellet group counts, cameras or other equipment) to take place on their land adjacent to US 93. If no permission can be obtained in certain locations, no data will be collected from those lands.

5. STAFF

The WTI-CSKT team consists of the Western Transportation Institute, the Ecology Department at Montana State University, and the Confederated Salish and Kootenai Tribes.

The principal investigator for this project will be Marcel Huijser, a road ecologist at WTI. Another key team member is Whisper Camel, a wildlife biologist with the Confederate Salish-Kootenai Tribes who will be responsible for the work done by the Confederate Salish-Kootenai Tribes. Profiles of these key team members are provided below. In addition, profiles of support staff are provided.

Key Staff

Marcel Huijser, Research Ecologist

Marcel Huijser received his M.S. in population ecology (1992) and his Ph.D. in road ecology (2000) at Wageningen University in Wageningen, The Netherlands. He studied plant-herbivore interactions in wetlands for the Dutch Ministry of Transport, Public Works and Water Management (1992-1995), hedgehog traffic victims and mitigation strategies in an anthropogenic landscape for the Dutch Society for the Study and Conservation of Mammals (1995-1999), and multifunctional land use issues on agricultural lands for the Research Institute for Animal Husbandry at Wageningen University and Research Centre (1999-2002). Currently Marcel works on wildlife-transportation issues for the Western Transportation Institute at Montana State University (2002-present). In this position he is responsible for a series of completed and ongoing highway wildlife mitigation projects. These efforts include leading research into the development, reliability and effectiveness of animal detection systems and a congressional report on the wildlife-vehicle collision reduction strategies. He is a member of the Transportation Research Board (TRB) Committee on Ecology and Transportation and co-chairs the TRB Subcommittee on Animal-Vehicle Collisions. Marcel Huijser will serve as the principal investigator for the project.

Whisper Camel, Tribal Wildlife Biologist

Whisper Camel received her B.S. in Wildlife Biology (2003) from the University of Montana, Missoula, MT, and her M.S. in Fish and Wildlife Management (2007) from Montana State University, Bozeman, MT. Her master’s project was part of US 93 pre-construction wildlife monitoring efforts. Her studies focused on which land cover variables were associated with deer crossings across the highway and deer-vehicle collision locations (Camel, 2007). She was also involved in the animal tracking and deer pellet group studies headed by The Western Transportation Institute in conjunction with US 93 pre-construction wildlife monitoring. She currently works for the Confederated Salish and Kootenai Tribes Wildlife Management Program as a Wildlife Biologist. Main work focus includes US 93 re-construction consultation, monitoring wildlife mitigation effectiveness, and wetland mitigation projects. Her duties include consultation and implementation. Whisper will be involved with field work, data analyses and reporting. In addition, she will serve as the lead for the efforts conducted by the Confederated Salish and Kootenai Tribes.

Supporting Staff

Stephanie A. Gillin, CSKT Wildlife Biologist

Stephanie Gillin has been a professional Wildlife Biologist for eight years with the Confederated Salish and Kootenai Tribal Wildlife Program, with an additional four years of Wildlife Biologist trainee experience. Her professional experience includes; Big game aerial flight surveys, Chronic Wasting Disease surveillance testing on the Flathead Indian Reservation, special permit hunt coordinator, water fowl brood and pair counts, land management of wildlife mitigation properties, student and community outreach liaison, and numerous wildlife monitoring projects. Stephanie received her B.S. in Wildlife Biology from the University of Montana. She is a member of the Native American Wildlife Society and The Wildlife Society. She is an enrolled member of the Confederated Salish & Kootenai Tribes. Stephanie will be involved with field work, data analyses and reporting.

Tony Clevenger

Tony Clevenger has carried out research during the last 12 years assessing the performance of mitigation measures designed to reduce habitat fragmentation on the Trans-Canada Highway (TCH) in Banff National Park, Alberta. Since 2002, he has been a research wildlife biologist for the Western Transportation Institute (WTI) at Montana State University. Tony is currently a member of the U.S. National Academy of Sciences Committee on Effects of Highways on Natural Communities and Ecosystems. Since 1986, he has published over 40 articles in peer-reviewed scientific journals and has co-authored three books including, Road Ecology: Science and Solutions (Island Press, 2003). Tony will advise on the research strategies related to US 93.

Rob Ament

Rob Ament, M.Sc., Biological Sciences, is the Road Ecology Program Manager at the Western Transportation Institute at Montana State University. He has more than 25 years of experience in field ecology, natural resource management, environmental policy and organizational development. He manages nine road ecologists with over 20 active research projects throughout North America, three of which he is the principal investigator. Rob will manage the partnership of funders related to US 93.

Ben Dorsey

Ben Dorsey is a former WTI research associate working for Dr. Tony Clevenger conducting research for the Banff Wildlife Crossings Project along the TransCanada Highway in Alberta, Canada. He currently is pursuing a M.Sc. degree at Montana State University, studying the impacts of the Canadian Pacific Railroad on large mammals. His career has focused on developing tools and applications for collecting and analyzing spatial data. He has worked as a GIS specialist and Wildlife technician in Yellowstone, Kalaupapa, and Banff National Parks. Ben will provide assistance with regard to information technologies and spatial analyses for the project.

Other Staff

A statistician will be consulted for certain aspects of the data analyses. In addition, WTI's business manager (Jeralyn Brodowy) will assist with the contracting process and Carol Diffendaffer and Neil Hetherington with editing and graphics.

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7. APPENDIX A: PARTNERSHIP CSKT

THE CONFEDERATED SALISH AND KOOTENAI TRIBES
OF THE FLATHEAD NATION
P.O. BOX 278
Pablo, Montana 59855
(406) 275-2700
FAX (406) 275-2806
www.cskt.org

Joseph E. Dupuis - Executive Secretary
Vern L. Clairmont - Executive Treasurer
Leon Bourdon - Sergeant-at-arms

TRIBAL COUNCIL MEMBERS:
James Steele, Jr. - Chairman
Carole Lankford - Vice Chair
Lloyd D. Irvine - Secretary
Ron Trahan - Treasurer
Joe Durglo
Mike Kenmille
Steve Lozar
Jim Malatare
Reuben A. Mathias
Sonny Morigeau

November 1, 2007

Mr. Jim Lynch, Director
Montana Department of Transportation
2701 Prospect Avenue
P. O. Box 201001
Helena, Montana 59620-1001

Dear Mr. Lynch:

In December of 2000, the Confederated Salish and Kootenai Tribes, the Federal Highway Administration and the Montana Department of Transportation signed a historic agreement regarding the reconstruction of a fifty-seven mile segment of U. S. Highway 93 located on the Flathead Indian Reservation. This unique agreement between the three governments incorporated a wide array of new concepts in highway design and construction that stressed safety of the people who use the highway, acknowledged and respected the cultural and historical values of the Tribes, attempted to better fit the highway to the landscape, and prioritized identification and mitigation of ecological impacts.

A facet of both the public safety and the ecological concerns related to the highway reconstruction project was an effort to maintain habitat connectivity across the right-of-way and simultaneously reduce the level of vehicle-wildlife collisions. In and effort to reduce the level of this particular impact, professional engineers and wildlife biologists of the three governments worked cooperatively to develop designs and construct a series of wildlife crossing structures.

Prior to construction, the Western Transportation Institute was contracted to conduct a pre-construction monitoring project to assess wildlife crossing at selected locations at which wildlife crossing structures would be placed. The results of the pre-construction project provided an excellent baseline to use in further evaluating the use of the crossing structures and the ultimate success of their construction.

This letter is in reference to a proposal for funding to conduct post-construction monitoring of wildlife use of several of the crossing structures. The Western

Transportation Institute has worked closely with the Tribal Wildlife Management Program to develop an in-depth proposal to conduct this monitoring project jointly, along with other research partners. This project, when completed, will allow for direct comparison of the pre-construction and post-construction research.

The Confederated Salish and Kootenai Tribes strongly support this proposal as an excellent method to evaluate wildlife use of the crossing structures and the benefits of their construction. The Tribes strongly encourage serious consideration of the proposal and the funding request that it entails. The crossing designs incorporated in the U. S. Highway 93 reconstruction project will provide a template for use in guiding other highway construction projects here in Montana and elsewhere. Completion of the pre-construction and post-construction monitoring studies will also provide a clear and complete evaluation of the success of these designs.

If you have any further questions regarding the Tribes' support of this proposal, please contact Mr. Dale Becker, the Tribal Wildlife Program Manager at (406) 883-2888.

Sincerely,
Confederated Salish and Kootenai Tribes

James Steele, Jr., Chairman
Tribal Council

8. APPENDIX B: NAMES CROSSING STRUCTURES (WILDLIFE AND FOR OTHER PURPOSES)

#	Station	Crossing Name	Type	Size	Complete
1	132+87.6	Frog Creek Fish Crossing	Corr Metal pipe or concrete box culvert	7x5	2009
2	148+02.3	North Evaro	Corr Metal pipe or concrete box culvert	12 x 22	2009
3	163+05	Rail Link	Multi span bridge (existing)	n/a	2009
4	168+62.5	Finely Creek #1	Corr Metal pipe or concrete box culvert	12x22	2009
5	172+45.1	Finely Creek #2	Corr Metal pipe or concrete box culvert	12x22	2009
6	173+40	Evaro Overpass	Wildlife Overpass	49wx197L	2009
7	176+39.2	Finely Creek #3	Corr Metal pipe or concrete box culvert	12x22	2009
8	181+21.3	Finely Creek #4	Corr Metal pipe or concrete box culvert	12x22	2009
9	198+40	Schley Creek	Corr Metal pipe or concrete box culvert	12x22	2009
10	204+09	East Fork Finley Creek	Corr Metal pipe or concrete box culvert	12x22	2009
11		Agency Creek	concrete box culvert		2009
12	310+00	Jocko Crossing 1	concrete box culvert	5x7	2006
13	310+50	Jocko Crossing 2	concrete box culvert	5x7	2006
14	311+10	Jocko Crossing 3	concrete box culvert	5x7	2006
15	312+00	Jocko River	Open Span Bridge	15x395	2006
16	377+00	Schall Flats #1 (RC377)	concrete box culvert	6x4	2006
17	381+00	Jocko/Spring Creek (RC381)	Open Span Bridge	10x100	2006
18	396+09	Ravalli Curves #1 (RC396)	Corr Metal arch culvert	12x22	2006
19	405+20	Ravalli Curves #2 (RC406)	Corr Metal arch culvert	12x22	2006
20	424+60	Jocko Side Channel (RC422)	Open Span Bridge	12x100	2006
21	426+00	Ravalli Curves #3 (RC426)	concrete box culvert	6x4	2006
22	427+00	Ravalli Curves #4 (RC427)	concrete box culvert	6x4	2006
23	429+40	Ravalli Curves #5 (RC431)	concrete box culvert	6x4	2006
24	431+23	Copper Creek (RC432)	Corr Metal arch culvert	12x24	2006
25	463+71	Ravalli Hill #1 (RH463)	Corr Metal arch culvert	17x24	2006
26	459+46.8	Ravalli Hill #2 (RH459)	Corr Metal arch culvert	17x24	2006
27	498+55.7	Pistol Creek #1	Corr Metal arch culvert	17x24	2006
28	501+63	Pistol Creek #2	Corr Metal arch culvert	17x24	2006
29	517+84.7	Sabine Creek Fish Crossing	Corr Metal arch culvert	24x13	2006
30	528+90	Mission Creek Crossing	Open Span Bridge	16x131	2006
31	544+43.2	Mission Stockpass	concrete box culvert	6x4	2006
31	550+56.6	Post Creek #1	Corr Metal arch culvert	24x15.5	2006
32	555+06	Post Creek #2	Corr Metal arch culvert	24x15.5	2006
33	559+98.4	Post Creek #3	Corr Metal arch culvert	24x13	2006
34	561+83.1	Post Creek #4	Corr Metal arch culvert	6x4	2006
35	565+56.6	Post Creek #5	Corr Metal arch culvert	8x8	2006
36	592+12.2	Post Creek #6	Plastic coated corr metal culvert	6x4	2006
37	597+55.5	Post Creek #7	Plastic coated corr metal culvert	6x4	2006
38	774+00	Spring Cr 1	Conspan Arches	9x28	2008
39	782+20	Ronan Stockpass	cement culvert	10x14	2008
40	783+65	Spring Cr 2	Conspan Arches	9x28	2008
41	809+50	Mud Creek	Conspan Arches NB &SB	14x43	2008
42	871+00	Bike Passage	cement culvert	10x14	2008
43	917+00	Polson Hill	SSPP Conc.footers/Divided lanes	12x22	2006