SANDERSON STEWART

ACTIVITY 112 – PRELIMINARY TRAFFIC INTERIM IMPROVEMENTS REPORT UPDATE

FOR

SF 119-Int Imp-N Grass Range

HSIP-STPHS 14(36) UPN 7848000

PREPARED FOR:

MONTANA DEPARTMENT OF TRANSPORTATION
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TABLE OF CONTENTS

INTRODUCTION 1
PROJECT BACKGROUND 1
UPDATED HISTORICAL CRASH ANALYSIS 1
Previous Crash History Analyses 1
Current Crash History Analysis 2
LITERATURE REVIEW 4
Signage Improvements 5
Transverse (In-Lane) Rumble Strips 5
All-Way Stop Control Conversion 6
Intelligent Transportation Systems 6
MONTANA CASE STUDIES 7
Red Horn Site Intersection[2] 7
Valier Site Intersection[3] 8
Bowman's Corner Intersection[4] 8
Canyon Ferry Site[5] 8
Dern & Springcreek Site[6] 9
Fairfield Site[7] 9
MITIGATION ALTERNATIVES 12
Mainline Speed Reduction 12
All-Way Stop Control 12
Advanced Intersection Warning System 13
Traffic Signal 13
Roundabout 14
SUMMARY AND RECOMMENDATIONS 14

LIST OF TABLES

TABLE 1. CRASH DATA SUMMARY 4
TABLE 2. SIGNAGE IMPROVEMENT DETAILS 5
TABLE 3. MONTANA CASE STUDY ANALYSIS 10

LIST OF FIGURES

FIGURE 1. MONTANA CASE STUDY LOCATIONS 11
FIGURE 2. SECONDARY DESIGN RECOMMENDATION 16

INTRODUCTION

This report summarizes the findings for the Activity 112 – Preliminary Traffic – Interim Improvements Study for the SF 119 – Int Imp – N Grass Range, HSIP – STPHS 14(36) – Control No. 7848000 (Grass Range) project. The recommended mitigation alternatives provided herein are intended to achieve a balance of safety, mobility, and fiduciary responsibility through the implementation of geometric and/or traffic control improvements as an interim solution leading up to the eventual installation of a roundabout at the intersection. The recommendations were developed based on Sanderson Stewart's understanding of the project objectives and in accordance with Montana Department of Transportation (MDT) design standards, the Manual On Uniform Traffic Control Devices (MUTCD), AASHTO and other applicable design and analysis resources.

PROJECT BACKGROUND

The Grass Range project was originally nominated by MDT as a safety improvement project in response to high historical crash frequency and severity rates for the intersection of US Highway 87 (US 87)/Montana Highway 19 (MT 19) and Montana Highway 200 (MT 200). Previous attempts to mitigate the crash problem, including installation of overhead flashers, in-lane rumble strips (on the stop-controlled approaches), and oversized stop signs, had seemingly been unsuccessful in solving the crash problem. Sanderson Stewart was hired by MDT as a design consultant for the project in 2013. The initial project scope consisted primarily of an Activity 112 – Preliminary Traffic Report, the intent of which was to evaluate existing operational and safety conditions and make recommendations for a mitigation solution. A public meeting was held on January 14, 2014 and the Activity 112 submittal was made in February 19, 2014. The report considered a variety of improvements options and ultimately recommended construction of a roundabout to mitigate the crash problem at the intersection. MDT concurred with that assessment, and the project then proceeded through the design and right-of-way (R/W) phases; necessary R/W was secured and the bid package assembled and advertised.

Sanderson Stewart completed the design of the project late in 2016. The project bidding commenced in the spring of 2017. However, a group of people that opposed the project, including several Montana legislators, requested that an additional public informational meeting be held. MDT agreed and a second public informational meeting was held on January 18, 2017 in Lewistown. Over 100 people attended the meeting, many of them speaking out in opposition to the project for a variety of reasons. A short time later, the decision was made to delay construction of the roundabout and instead pursue the evaluation of alternate improvements to reassess whether the roundabout is the most appropriate intersection treatment and determine if an interim solution could be implemented that would improve safety until the roundabout (if still the most appropriate solution) can be constructed in the future. This report documents the research, analysis, and findings from that evaluation effort.

UPDATED HISTORICAL CRASH ANALYSIS

As a part of the original Activity 112 – Preliminary Traffic Report, Sanderson Stewart analyzed crash data for the 10-year time-period from January 1, 2003 to December 31, 2012. The findings from that analysis are summarized in the following pages. Through this current study, Sanderson Stewart was tasked with re-evaluating crash history for the intersection over a longer period of time to look for trends that might help with identifying an interim improvement solution and if the roundabout is still the most appropriate solution. That analysis and the resulting conclusions are also summarized in the follow paragraphs.

Previous Crash History Analyses

Prior to Sanderson Stewart's original crash analysis for the Activity 112 – Preliminary Traffic Report, MDT had taken a look at crash history for the time period from 2003 to 2009. Based on that evaluation, MDT concluded the primary cause for crashes was a failure of eastbound and westbound (minor approach) vehicles to yield to the northbound and southbound (major approach) vehicles. MDT determined that a roundabout would be the best mitigation alternative and calculated a 4.57 benefit-to-cost ratio based on an estimated $1,972,290.00 project cost. Those conclusions led MDT to allocate safety funding and develop a project to more formally evaluate the intersection.

Sanderson Stewart's original Activity 112 crash analysis found that nine crashes were reported within the study area (intersection junction of US 87, MT 19, and MT 200) during the 10-year analysis period. Incidentally, a tenth, fatal crash occurred in August 2013, at which time the original Activity 112 – Preliminary Traffic study effort was under way. No pedestrian-related crashes were reported, which is not unexpected since there are no pedestrian facilities in the area. Eight of the ten reported crashes (including the fatal crash from 2013) involved two or more vehicles, while the other two crashes were classified as run-off-the-road collisions. All eight of the multiple-vehicle crashes were classified as right-angle crashes. Four fatalities (three fatal crashes) and ten injuries were reported as a result of the ten reported crashes.

A further evaluation into the cause of the right-angle crashes (through a review of the crash reports) revealed that four of the five non-fatal, right-angle crashes could be described as "near-misses," as they exhibited similar speeds and impact locations to the three fatal crashes. Research into the police reports showed that in most cases, as was consistent with MDT's original findings, vehicles on the minor approaches did not completely stop prior to entering the intersection, but usually slowed before crossing. This pattern of non-compliance at the minor approach stop signs may be attributable to driver familiarity with the intersection in combination with the low traffic volumes on the major intersection approach. Numerous attendees at the public informational meeting held January 14, 2014 confirmed that this pattern of non-compliance was common-place, with people regularly ignoring the stop signs partially or completely, particularly at night. The attendees also noted that this pattern of non-compliance and the resulting crash trend has been a problem for more than ten years.

There are many factors that could contribute to a pattern of non-compliance at stop-controlled intersections. In this case however, the most significant factor is likely driver behavior. MDT previously tried to address the non-compliance issue through installation of in-lane, transverse rumble strips, advanced warning signage, oversized stop signs, and overhead flashers at the intersection. Those measures would typically be more than adequate for providing notice to drivers that they are approaching a stop-controlled intersection.

Motorists misjudging gaps in traffic based on their personal gap acceptance criteria could also be a contributing factor due to the rapid arrival of northbound and southbound vehicles which may be approaching at speeds in excess of the posted 70 MPH speed limit. Four of the crashes involved drivers over the age of 80. Cognitive impairment may have been a factor for those crashes.

A few of the crashes involved out-of-state drivers. It is possible that unfamiliarity with the intersection may have been a factor since the drivers would have travelled a considerable unimpeded distance (Lewistown to the west, Roundup to the south, Winnett to the East, and Malta to the North, which are 23 to 112 miles) prior to encountering this stop-controlled intersection. However, as was previously stated, the in-lane rumble strips, advanced warning signage and overhead flashers should have provided enough warning about the need to stop at the intersection regardless of the rural location or unfamiliarity factors.

Current Crash History Analysis

Historical crash data for the current study was obtained from MDT for the most recent available 15-year period from January 1, 2002 to December 31, 2016. In total, nineteen crashes were reported within the study area (intersection junction of US 87, MT 19, and MT 200) during the analysis period. Once again, no pedestrian crashes were reported. Ten of the crashes involved two or more vehicles, all of them being classified as right-angle collisions. The remaining crashes consisted of one roll-over, four animal collisions, and four run-off-the-road collisions. Four fatalities (three fatal crashes), four incapacitating injuries, and twelve non-incapacitating injuries were reported in the nineteen reported crashes.

The crashes were spread fairly evenly through months of the year and days of the week, revealing no particular seasonal trends. Sixteen of the crashes occurred during clear or cloudy weather conditions and thirteen of the crashes occurred on dry road conditions, so weather and roadway characteristics are not primary controlling factors in the right-angle collisions. Fifteen of the nineteen crash also occurred during daylight hours (6:00 am – 6:00 pm), so darkness was not a factor in the majority of right-angle collisions.

A closer look at the cause of the right-angle crashes (crash reports) revealed that all ten involved drivers who either did not completely stop prior to entering the intersection or that stopped and then proceeded when they should have yielded the right-of-way. In a couple of the crash reports, the offending driver noted they did not see the opposing vehicle or believed they had enough time to complete their traffic maneuver. In general, it seems that the trends for this analysis period are consistent with what was found in previous studies. Based on the historical crash evaluations from previous studies and this current effort, there may be several different factors contributing to the right-angle crash trend at the Grass Range project intersection. Table 1 on page 4 summarizes both the original period (discussed in this section) and the new study period.

Table 1: Crash Data Summaries

Month	Crashes	%
January	2	10.5%
February	1	5.3%
March	4	21.1%
April	1	5.3%
May	0	0.0%
June	0	0.0%
July	2	10.5%
August	5	26.3%
September	0	0.0%
October	2	10.5%
November	2	10.5%
December	0	0.0%
Totals	19	100.0%

Day	Crashes	%
Sunday	3	15.8%
Monday	3	15.8%
Tuesday	5	26.3%
Wednesday	0	0.0%
Thursday	1	5.3%
Friday	2	10.5%
Saturday	5	26.3%
Totals	19	100.0%

Weather	Crashes	%
Clear	10	52.6%
Cloudy	6	31.6%
Snow	0	0.0%
Sleet	0	0.0%
Rain	1	5.3%
Windy	0	0.0%
Blowing Snow	2	10.5%
Totals	19	100.0%

Note: Crash data summarized from 1/1/02 through 12/31/16

Road Conditions	Crashes	%
Dry	13	68.4%
Wet	1	5.3%
Ice	3	15.8%
Snow/Slush	2	10.5%
Totals	19	100.0%

Year	Crashes	%
2002	1	5.3%
2003	1	5.3%
2004	2	10.5%
2005	2	10.5%
2006	1	5.3%
2007	2	10.5%
2008	1	5.3%
2009	0	0.0%
2010	1	5.3%
2011	1	5.3%
2012	2	10.5%
2013	3	15.8%
2014	1	5.3%
2015	1	5.3%
2016	0	0.0%
Totals	19	100.0%

Crash Severity	Crashes	%
Fatal	4	21.1%
Injury Crash	4	21.1%
Possible Injury	2	10.5%
Prop. Damage Only	9	47.4%
Totals	19	100.0%

Horiz. Align.	Crashes	%
Straight	19	100.0%
Curve	0	0.0%
Totals	19	100.0%

Collision Type	Crashes	%
Roll Over	1	5.3%
Rear End	0	0.0%
Wild Animal	4	21.1%
Right Angle	10	52.6%
Run-Off	0	0.0%
Fixed Object	4	21.1%
Left Turn SD	0	0.0%
Totals	19	100.0%

Vehicle Type	Crashes	%
Passenger Car	9	30.0%
Pickup Truck	10	33.3%
SUV	4	13.3%
Mid-size Car	2	6.7%
Truck/Tractor	2	6.7%
Large Car	3	10.0%
Totals	30	100.0%

Light Conditions	Crashes	%
Dawn	0	0.0%
Daylight	14	73.7%
Dark-Lighted	1	5.3%
Dark-Not Lighted	3	15.8%
Dusk	1	5.3%
Totals	19	100.0%

Time of Day	Crashes	%
Before 6:00 am	0	0.0%
6:00 am - 9:00 am	3	15.8%
9:00 am- 12:00 pm	4	21.1%
12:00 pm - 3:00 pm	4	21.1%
3:00 pm - 6:00 pm	4	21.1%
6:00 pm - 9:00 pm	3	15.8%
After 9:00 pm	1	5.3%
Totals	19	100.0%

LITERATURE REVIEW

Sanderson Stewart performed a literature review for the purpose of investigating strategies that have been utilized around the United States to reduce the frequency and severity of crashes at rural intersections. The mitigation alternatives investigated ideally fit in existing right-of-way and therefore alternatives such as offset intersections and grade separation options were not evaluated. The results of this research and several of the most viable strategies are discussed in detail in the following sections of the report, with before and after crash analysis results where that information was available.

Signage Improvements

In May 2009, the Federal Highway Administration (FHWA) published a report called "Low-Cost Safety Enhancements for Stop Controlled and Signalized Intersections." A link to that report is provided below.

https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa09020/fhwasa09020.pdf

The report discussed multiple mitigation alternatives to reduce the frequency of crashes at minor approach, two-way stop-controlled intersections. The most basic alternatives improved the signage and pavement markings at the intersections. For that strategy, the report recommended doubling up (left and right) oversized advanced intersection warning signs with street name plaques listing the cross street at the intersection. It also recommended doubling up (right and left) oversized advanced "Stop Ahead" intersection warning signs and oversized stop signs on the stop-controlled approaches. According to this report, these minor improvements can reduce the frequency of crashes by up to 40 percent. The cost to implement these improvements ranges from $5,000 to $8,000.

The Oregon Department of Transportation published a similar document entitled "Basic Intersection Upgrades." That study again focused on signage improvements that were very similar to the FHWA study. Below is a link to that document.

https://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/pdf/Int_Upgrades.pdf

The report goes into more detail about cost for each of these types of improvements and provides before and after data in regard to crash frequency reductions. The table below summaries their findings:

Table 2: Signage Improvement Details

Oregon Department of Transportation Basic Intersection Upgrades			
Improvement	Overall Crash Reduction	Right Angle Crash Reduction	Cost
Intersection Warning Signs (both sides) with a Street Name Plaque on the Through Approach	22%	35%	$600 - $800 per sign
Stop Ahead Signs (both sides) on the Stop Approach	N/A	35%	$500 - $700 per sign
Double Stop Signs (both sides) on the Stop Approach	11%	55%	$500 - $700 per sign
Oversized Stop Signs	19%	N/A	$500 - $700 per sign

MDT has already implemented advanced stop ahead warning signs and oversized stop signs on the stop-controlled intersection approaches at the Grass Range intersection. Those improvements have not lessened the frequency or severity of crashes at the intersection. Some of the other signing-related strategies (doubled up stop and intersection warning signs, etc.) have not yet been tried at the Grass Range intersection.

Transverse (In-Lane) Rumble Strips

In areas where noise is not a concern, transverse, in-lane rumble strips can be utilized to warn drivers of an impending hazard or change in traffic control. The rumble strips provide both an audible and vibratory alert to the driver, just as they do when applied along roadway shoulders. The previously-referenced FWHA study reported that transverse rumble strips across stop-controlled approach lanes in rural areas can reduce the frequency of crashes by 28 percent. The cost to install these devices can range from $3,000 to $10,000.

Transverse rumble strips have already been installed on both the east and west minor approaches to the Grass Range intersection. There is no indication that the modifications reduced crash frequency or severity. This implies to the author that drivers are knowingly ignoring the traffic control requirements at the intersection based on anticipated lack of conflicting major approach traffic.

All-Way Stop Control Conversion

Conversion of intersections from two-way stop control to all-way stop control has been shown through numerous studies to be an effective strategy for reducing frequency, and particularly crash severity at both urban and rural intersections. "Evaluation of the Conversion from Two-Way Stop Sign Control to All-Way Stop Sign Control at 53 Locations in North Carolina," by Simpson and Hummer, provides an in-depth look at safety benefits, cost and ease of implementation of all-way stop control for sites in urban, suburban and rural locations with varying speed conditions. The study results showed that such conversion brought about great reductions in the occurrence of total crashes, injury crashes and front-end (right-angle) crashes; the recommended crash reduction percentages for those three categories were 68 percent, 77 percent and 75 percent, respectively. Simpson and Hummer also specifically looked at the relationship between speed limits and crash reductions, concluding that conversion to all-way stop control was especially effective for higher-speed, rural locations.

https://www.researchgate.net/publication/233300336_Evaluation_of_the_Conversion_from_Two-Way_Stop_Sign_Control_to_All-Way_Stop_Sign_Control_at_53_Locations_in_North_Carolina

Previous to the Simpson and Hummer study, "The Safety Effect of Conversion to All-Way Stop Control," by Lovell and Hauer (1986), looked at ten low-volume, high-speed rural intersection conversion sites in Michigan. Based on two- and three-year before and after periods, that study showed a 53 percent reduction in total crashes, a 65 percent reduction in right-angle crashes, and a 61 percent reduction in injury crashes.

More recently, a preliminary safety evaluation of all-way stop control was conducted by the NCDOT Safety Evaluation Group in October of 2008 for eighteen intersection sites that had at least three years of after period crash data. That study showed reductions of 67 percent, 79 percent, and 82 percent for total, frontal impact and injury crashes at a mixture of urban, suburban and rural intersections without flashing beacons. At intersections with flashing beacons, the results were very similar at 76 percent, 80 percent and 83 percent reductions, respectively.

Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) have been used by many states and jurisdictions throughout the country for traffic safety enhancement. ITS is a general term that describes the use of information systems to improve safety and efficiency for the transport of people and goods. Relative to the specific safety problem (right-angle crash trend) that has been identified for the Grass Range intersection, there is an ITS application that has been utilized in various similar locations around the country to promote reductions in crash frequency and severity. The general strategy is as follows: A sensor is placed on the minor, stop-controlled intersection approach well in advance of the intersection. When a minor approach vehicle trips the sensor, a warning sign(s) becomes illuminated on the mainline approaches to the intersection to inform those drivers that there may be vehicle entering the traveled way from the minor approach. The reverse can also be implemented; instead of placing the sensor on the minor approach, it is placed on the major approach. This illuminates a sign on the minor approach letting drivers approaching the intersection know that there is mainline traffic approaching the intersection. Either, or both, methods can be implemented; the intent being to raise awareness about potential conflicts at the intersection.

The Federal Highway Administration produced a report called "Stop-Controlled Intersection Safety Through Route Activated Warning System" This report examined the use of a Through Route Activated Warning System. This technology tends to be implemented in areas with limited sight distance and/or a history of crashes. Detectors are placed on the stop controlled approach. As a vehicle enters the intersection from the minor approach, LED beacons placed along the through highway are illuminated, informing drivers that a vehicle is entering the intersection. Either diamond or rectangular shaped warning signs can be used with dual flashers. Text on the sign can read "Vehicles Entering when Flashing" or "Watch for Entering Traffic when Flashing." Implementing the Through Route Activated Warning System is a relatively inexpensive alternative with a cost between $15,000 and $35,000. The states that have implemented the system have reported back that the system is reliable and requires minimal maintenance. Also, unsolicited feedback from the public has been positive. The Federal Highway Administration performed a before and after crash analysis in two states (Missouri and North Carolina) and found that there was a 51 percent reduction in crashes and a 77 percent reduction in severe angle crashes as a result of implementing a Through Route Activated Warning System.

https://safety.fhwa.dot.gov/intersection/conventional/unsignalized/fhwasa11023/index.cfm

The Minnesota Department of Transportation (MnDOT) published a similar report entitled "MnDOT RICWS Safety" in June 2015 that analyzed the effectiveness of advanced warning systems. Twenty-nine Rural Intersection Collision Warning Systems (RICWS) were installed in Minnesota in 2014. MnDOT picked the intersections to study based on previous crash data and intersection characteristics. Because many of these intersections did not experience a high number of crashes individually (two crashes per year or less), all the data from the before/after study was combined to increase sample size for the crash data set. The before crash study was conducted for three years prior to RICWS installation, and the after crash study was only based on nine months of data ending on March 31, 2015. To account for the shorter after study period, crashes were annualized. The findings of the study showed a 22 percent decrease in annualized crash frequency, 24 percent decrease in overall crash rate, 30 percent decrease in fatal crashes, and a 62 percent decrease in severe (fatal + serious injury) crashes. This study also looked at the traffic volumes entering the intersection. It was found that the less busy an intersection was the more effective the RICWS was. At intersections with a twelve MEV (million entering vehicles) or fewer, crash rates and frequency dropped by 73 percent.

http://www.dot.state.mn.us/its/projects/2011-2015/rural-intersect-conflict-warn-system/documents/d3ricwssafety.pdf

MONTANA CASE STUDIES

MDT has also been proactive in the use of ITS to promote safety at rural intersections with high crash rates and high severity crash rates. The following section of this report describes a handful of case study locations in Montana where improvements have been made for the specific purpose of reducing crash rate and severity. The subject intersections have been improved using mitigation methods such as ITS or roundabouts. Sanderson Stewart has analyzed the crash data for these intersections and the results are summarized below. Figure 1 shows the location of each of these intersection as well as the Grass Range project.

Red Horn Site Intersection[2]

The Red Horn Site is the intersection of Highway 93 (N-5) and Dublin Gulch/Red Horn Road between St. Ignatius and Ronan. The intersection was on the 1991 HSIP list and brought before the MDT Safety Engineering Section. The intersection was put on the HSIP list again in 1993 and 1994, but as before, no recommendations were made. Yet again, the intersection was put on the HSIP list in 1996. At that time the Safety Engineering Section recommended the installation of a left-turn bay. A benefit/cost analysis yielded a score of greater than 1.0. In 2004, the left turn bay was constructed. In 2001, the intersection was again placed on the HSIP list, but again, no countermeasures could be identified. The intersection appeared again on the 2011/2012 HSIP list. The Safety Engineering Section recommended a ITS system that became operational on October 26, 2016. This ITS system included dual W26-3/W26-4 (Traffic Crossing/Traffic Turn) sign clusters with a flasher on both the north and south approaches and R1-1 sign (Stop Sign) with two beacon flashers on the east and west approaches. All the flashers are activated with radar detectors on the east and west approaches. As this project was constructed recently, there has been no before/after study conducted for this intersection.

Valier Site Intersection[3]

The Valier Site is the junction between Highway 44 (P-44) and Highway 91 between Valier and Conrad. The intersection was bought to the Safety Engineering Section in 2010 per a request from a Montana Highway Patrol Trooper and the Cascade County Deputy County Attorney. The Safety Engineering Section reviewed crash data for the intersection for a 10-year period (January 1, 2000 to December 31, 2010). After the review, it was recommended that the intersection implement new signing and refresh the existing transverse rumble strips. In August 2011, during an on-site field review, Great Falls District personnel expressed the need for an ITS-based intersection warning system to augment the other improvements. On August 15, 2016, these improvements were installed and became operational. Because these improvements were installed so recently there is no before/after study. This ITS system included a single W26-2/W26-3 (Caution/Traffic Crossing) sign cluster with beacon flasher on both the east and west approaches and dual R1-1/W4-4p (Stop/Cross traffic does not stop) sign clusters with two beacon flashers on both the north and south approaches. All of the flashers are activated with loop detection on the north and south approaches.

Bowman's Corner Intersection[4]

Bowman's corner intersection is the junction between Highway 200 (N-24) and Highway 287 (P-3) in Lewis and Clark County. The Great Falls district requested that the intersection be brought to the attention of the Safety Engineering Sections in 2010. The Safety Engineering Section personnel reviewed crash data for an 11-year period (January 1, 2001 to December 31, 2011). The Safety Engineering Section proposed two alternatives to mitigate the crash problem. The first alternative was to install a roundabout, and the second was to install an active ITS intersection warning system. This ITS systems included dual R1-1 (Stop) signs with two beacon flashers on both the north and south minor approaches. The beacon flashers are activated with loop detection on the north and south approaches. Based on a benefit cost analysis, the intersection warning system was chosen as the preferred alternative. It was installed and became operational on March 31, 2012. A before and after crash data analysis was performed to evaluate effectiveness of the installation. There were four crashes reported at the intersection during the 58-month pre-installation study period (May 1, 2007 to February 29, 2012). Of those four crashes, three were right-angle collision with one resulting in a fatality. After the installation of the ITS warning system, between March 1, 2012 and December 31, 2016, three crashes were reported during what was also a 58-month analysis period. Although the number of crashes only reduced from 4 to 3, only one of the after period crashes was a right-angle collision, and none of the after-period crashes resulted in a fatality. Although it appears the frequency and severity of crashes has reduced, the small sample size does not allow for concrete conclusions. This warning system would appear to have reduced the severity of crashes as well as the frequency of crashes.

Canyon Ferry Site[5]

The Canyon Ferry site is located at the junction of Canyon Ferry Road and Lake Helena Drive in Helena. Prior to the construction of safety-related improvements, the intersection was two-way stop controlled and was prone to right-angle collision crashes. A roundabout was constructed and operational by January 2009 to mitigate the numerous accidents that occurred at this intersection. The crash history for the intersection was documented for 8 years before and after the roundabout was implemented. From January 1, 2001 to December 31, 2008 there were 26 total crashes. Of those 26 crashes, there were 17 right-angle collisions, resulting in 3 fatalities (2 fatal crashes). Since the roundabout was constructed (the study period was between January 1, 2009 and December 31, 2016) there have only been 8 total crashes, all of which resulted in property damage only.

Dern and Springcreek Site[6]

The Dern and Springcreek site is at the intersection of Highway 2 (N-1) with West Spring Creek Road and Dern Road, west of Kalispell. This intersection was brought to the attention of the Safety Engineering Section, because of a historically high crash frequency. MDT identified three potential mitigation measures. It was decided that an ITS system would be implemented as part of an interim project. The ITS system was installed and became operational on December 19, 2014. This ITS system included dual W26-2/W26-3 (Caution/Traffic Crossing) sign cluster with flasher on both the major east and west approaches and dual (both sides of road) R1-1/W4-4p (Stop/Cross traffic does not stop) sign clusters with two beacon flashers on both the north and south minor approaches. All the flashers are activated with loop detection on the east and west approaches. A pre-installation study was done on the intersection between December 18, 2012 and December 18, 2014. During that two-year period, nine crashes were reported, five of which were right-angle collisions. The nine crashes resulted in five injuries and no fatalities. A post-installation study was performed between December 19, 2014 and December 19, 2016. The total number of crashes during that two-year period was five, with only three being right-angle collisions. Those five crashes resulted in three injuries and no fatalities. Based on that limited sample size, it would appear that the ITS system reduced the frequency and severity of crashes at the intersection. A roundabout design is still deemed to be the long-term solution to the safety problem.

Fairfield Site[7]

The Fairfield site is the intersection of Highway 89 (P-3), State Secondary 431 (S-431) and State Secondary 565 (S-565) near Fairfield. The intersection was first brought before the Safety Engineering Sections in 2002 via a site study request. Crash data was analyzed from January 1, 1992 to October 1, 2002. No feasible countermeasures were recommended at the end of the study. The intersection was then added to the HSIP list in 2006 and 2008, but remained unchanged. However, when it was added to the 2010/2011 HSIP list, the Safety Engineering Section recommended installation of an ITS system. This ITS system included a single W26-2/W26-3 (Caution/Traffic Crossing) sign cluster with a beacon flasher on both the east and west major approaches and dual R1-1 (Stop) signs with two flashers on both the north and south minor approaches. All of the flashers are activated with loop detection on the north and south minor approaches. A benefit/cost analysis was completed and yielded a b/c ratio greater than 1.0. The system became operational on July 11, 2014. The intersection was added to the 2012/2013 HSIP list, but no action was taken because of the recently installed ITS system. A before and after study was conducted on the intersection. Between August 1, 2004 and July 31, 2014 there were a total of 11 crashes. Of the eleven crashes, seven were right-angle collision resulting in one fatality and four injuries. Since the installation of the ITS system (August 1, 2014 to December 31, 2016) there has only been one crash. The crash was a right-angle collision that resulted in injuries. While it would appear that the ITS system decreased the severity and frequency of crashes at this intersection, it should be noted that the study period post-construction is shorter than the pre-construction study period.

MDT provided before and after crash data for four of the six projects and detailed crash reports for two. Table 3 summarizes the Montana case studies before and after detailed crash data.

Table 3: Montana Case Study Analysis

		Bowman's Corner (ITS)	Fairfield (ITS)	Dern (ITS)	Canyon Ferry (Roundabout)	Grass Range (Project Site)
Before Mitigation	Crash Rate	2.11	1.74	1.27	2.13	2.94
	Severity Index	5.00	4.18	3.22	2.46	3.11
	Severity Rate	10.54	7.28	4.09	5.25	9.13
	FTY+DTC/YR	--	0.80	1.50	--	--
After Mitigation	Crash Rate	1.58	1.06	0.70	0.66	--
	Severity Index	1.67	3.00	1.80	1.00	--
	Severity Rate	2.63	3.17	1.27	0.66	--
	FTY+DTC/YR	--	0.67	1.00	--	--
Before/After Comparison	+/- Crash Rate	-0.53 (-25.0%)	-0.69 (-39.4%)	-0.56 (-44.4%)	-1.48 (-69.2%)	--
	+/- Severity Index	-3.33 (-66.7%)	-1.18 (-28.3%)	-1.42 (-44.1%)	-1.46 (-59.4%)	--
	+/- Severity Rate	-7.90 (-75.0%)	-4.12 (-56.5%)	-2.82 (-69.0%)	-4.59 (-87.5%)	--
	+/- FTY+DTC/YR	--	-0.13 (-16.7%)	-0.50 (-33.3%)	--	--

Crash Rates, Severity Indexes, and Severity Rates are calculated based on traffic volumes, crash data, and length of analysis time period. The three sites with ITS features show a before and after approximate reduction in crash rates of 25 to 45 percent, a reduction of severity index of 28 to 67 percent, and a reduction of severity rate of 56 to 75 percent. The single site with a roundabout design shows an approximate reduction in crash rate of 70 percent, a reduction of severity index of 60 percent, and a reduction of severity rate of 88 percent. These metrics demonstrate the benefits of both ITS features and roundabout designs to reduce both crash rates and crash severity at intersections with a documented right-angle crash trend.

Referring to the Grass Range crash analysis, no single factor was concluded to be the cause of the right-angle crashes trend. It was noted that several different factors are likely contributing but the documented cause is simply vehicles that fail to yield right-of-way and vehicles that disobeyed traffic control (FTY+DTC), which are involved in the crash trend. Included in the FTY+DTC subgroup for this before/after analysis are vehicles that experienced high severity right-angle crashes as well as "near miss" vehicles that demonstrated similar driving characteristics but luckily only experienced low severity right-angle crashes. The Fairfield and Dern sites were reviewed for FTY+DTC crashes before and after the ITS mitigation. The Fairfield site shows an approximate 17 percent reduction of FTY+DTC crashes per year after the ITS mitigation. The Dern site shows an approximate 33.3 percent reduction of FTY+DTC crashes per year after the ITS mitigation. Both sites; however, continued to experience similar FTY+DTC crashes after the ITS mitigation features were implemented at a reduced rate.

Figure 1: Montana Case Study Locations

MITIGATION ALTERNATIVES

Based on a detailed review of research and empirical data from the literature review effort and the Montana case studies, Sanderson Stewart developed a list of viable mitigation alternatives for interim safety improvements at the Grass Range intersection. The following paragraphs discuss each of those alternatives, listing pros and cons relative to safety, operations, cost and ease of implementation.

Mainline Speed Reduction

The detailed analysis of the crash history for the Grass Range intersection conducted by Sanderson Stewart showed that the majority of crashes appear to happen as a result of minor approach drivers misjudging gaps or completely missing vehicles in the high-speed mainline traffic stream. Given that sight distance exceeds requirements in both directions along the mainline from both minor approaches, the misjudging of gap availability is most likely a function of the high mainline speeds. If travel speeds on the uncontrolled mainline approaches at the intersection were substantially reduced, the gaps for minor approach movements would be lengthened, and motorists on the minor approaches would most likely easier to judge as well. In addition, the lowering of speeds for mainline vehicles should reduce crash severity to some extent.

The problem with artificially lowering speed limits is that it can be difficult to gain compliance from drivers unless the driving environment is also changed to encourage compliance. An effective way to affect that change would be to change the physical characteristics of the roadway through implementing vertical curb or other vertical features such as flexible delineators to constrict the vehicle space and make it less comfortable to drive at speeds faster than the new posted speed limit. However, those types of changes can be complicated, require provisions for oversized/overweight vehicles (common at this intersection) and be expensive, particularly in a rural, high-speed highway environment such as this one.

The most-effective way to encourage compliance is through strict law enforcement of the speed limit; to do so would require dedicated manpower allocation of local or State law enforcement entities. Automated speed enforcement would seem to be an excellent consideration for this location if a speed limit reduction was implemented, but automated ticketing is currently not legal in Montana.

Estimated Cost Range - $3,000 (signage only) to $1,000,000 (substantial geometric improvements)

All-Way Stop Control

As was discussed in the literature review section of this report, the conversion from two-way stop control to all-way stop control has been shown to be effective in reducing the frequency and severity of crashes in urban, suburban and rural environments. The requirement that all vehicles stop at an intersection virtually eliminates the possibility of a high-speed collision, except when a driver completely disregards the traffic control. The primary downside for conversion to all-way stop control is that mainline vehicles would be required to stop, thereby introducing delay associated with slowing down, stopping and having to accelerate back to normal highway operating speeds. The delay would be particularly impactful for the trucking industry, because heavy vehicles take longer to slow down, stop and then accelerate back to operating speed. The introduction of this delay for mainline traffic at the Grass Range intersection was a concern for some of those in attendance at the public informational meeting held in Lewistown and who opposed the installation of a roundabout. Total intersection delay associated with an all-way stop will be higher than that for the roundabout that was designed due to the mandatory (enforceable by law) requirement to come to a full stop, whereas complete stops at the roundabout will only be occasional when there are one or more conflicting vehicles circulating in front of the approach. The stop and start maneuvers would also increase fuel consumption and vehicle emissions, though on a relatively small scale given the low traffic demand at the intersection. From a safety perspective, the major concern would be drivers on the mainline not realizing that there was a stop condition requirement coming up and failing to comply with the stop at high speed and colliding with other vehicles at the intersection causing a crash. However, if all-way stop control were implemented, multiple, redundant advanced warning features are recommended to warn drivers, including in-lane transverse rumble strips, advanced warning signs, conversion of the overhead flasher to all red beacons, and a progressively-reduced speed limit leading into the intersection. These features will provide notice to drivers that an all-way stop condition is in place at the upcoming intersection.

Estimated Cost - $100,000 (transverse rumble strips, overhead flasher upgrades, etc.)

Advanced Intersection Warning System

As was discussed in both the literature review and Montana case study sections of this report, the implementation of an ITS-based advanced intersection warning system has been shown to be effective in reducing the frequency and severity of crashes in rural environments, and specifically in Montana. The systems investigated included radar or loop detection systems that activate flashers on warning and stop signs. These ITS features help to notify both minor approach and/or mainline vehicles of approaching vehicles from adjacent approaches. Such notifications would ideally promote an increase in driver awareness and compliance with traffic control. The primary downside for implementation of an advanced intersection warning system would be a possible increase in non-compliance of the traffic control when the flashers are not activated. Traffic delay at the intersection would approximate the existing two-way stop control. From a safety perspective, it has been documented in both the literature review and Montana case studies that advanced intersection warning systems can reduce crash frequency and severity of right-angle crash trends at two-way stop controlled intersections. However, as documented in Table 3, the Montana case study analysis showed the right-angle crashes still occur, but less frequently than before installation of the ITS features.

Estimated Cost - $150,000 (signage, flashers, detection sensor, electrical, etc.)

Traffic Signal

The original Activity 112 – Preliminary Traffic Report for the Grass Range project evaluated a traffic signal as a mitigation option for addressing the crash history problem at the intersection. It was determined that none of the traffic volume-based Manual on Uniform Traffic Control Devices (MUTCD) traffic signal warrants (including the Crash Experience warrant) would be satisfied even for a 20-year future projection of traffic for the intersection. MDT's general policy is that a traffic signal cannot be installed without at least one MUTCD traffic signal warrant being met. Also, traffic signals in high-speed rural corridors can be subject to crash frequency and severity problems as well, particularly in low-volume applications. Red light-running is a concern in this rural low-volume environment, and judging available gaps would still be a concern for right-turn-on-red movements unless a reduced speed limit was introduced in conjunction with the traffic signal. With those factors considered, a traffic signal was eliminated as a viable option in the original traffic report and due to the MDT policy pertaining to traffic signal warrants. In the years since the original study was completed, nothing has changed to support the implementation of a traffic signal. That being the case, a traffic signal is still not considered to be a viable alternative.

Estimated Cost Range - $150,000 (span wire signal) to $400,000 (pole-based signal with actuation capabilities)

Roundabout

A single-lane roundabout was also evaluated as a potential mitigation alternative through the original study and was ultimately recommended as the preferred alternative, primarily because single-lane roundabouts have an excellent track record for virtually eliminating severe crashes, while moving traffic efficiently and limiting control delay since vehicles are only required to stop on a roundabout approach if they must yield to vehicles circulating in front of their approach. Compared to an all-way stop, a roundabout reduces overall vehicle delay with the yield control. The entering geometrics of a roundabout require a reduction in speed to maneuver the traffic calming geometrics. The Montana case study that implemented a roundabout witnessed the greatest reduction in crash rate and severity. It did not witness similar right-angle crash trends after the roundabout was implemented. Operationally, the roundabout alternative that has been designed will introduce motorist delay and require traffic control to accommodate the negotiation of some (as permitted by MDT) oversized/overweight vehicles through the intersection. These delays are anticipated to be brief and somewhat infrequent. From a safety perspective, the roundabout alternative is the only option to both reduce crash rates and severity as well as ideally remove the right-angle crash trend from future events. Additionally, the roundabout alternative is the only mitigation alternative listed to reduce the number of vehicle conflict points.

Estimated Cost Range - $3,500,000 to $4,000,000 (based on current approved design)

SUMMARY AND RECOMMENDATIONS

In response to the January 18, 2017 public meeting held in Lewistown and general opposition to the roundabout project by local legislators, MDT made the decision to delay construction of the roundabout at the Grass Range intersection and perform the study presented in this document. The scope of this study was to evaluate both permanent design alternatives (to the roundabout) and interim improvement alternatives that could be implemented immediately to improve safety until the roundabout or another permanent solution (that would be identified by this study) can be constructed. This study provided a project background summary, a review of original and updated crash data, literature review of appropriate design alternatives, a Montana case study summary of six similar intersections, and provided a synopsis of the evaluation of an array of mitigation alternatives.

Through the review of the updated crash data, the right-angle crash trend noted in the original crash analysis continues to be the primary accident trend. The combination of high speeds and the disregard for traffic control/failure to yield right-of-way, and unexplainable driver behavior has continued to cause severe crashes at the project intersection. Coincidentally, another injury, right-angle crash occurred at the project intersection as this report was being finalized. This crash on May 2, 2017 occurred during daylight hours, with dry road conditions, without any perceived drug or alcohol influence, and it involved one vehicle failing to yield the right-of-way to another vehicle, consistent with the historical trend. Fortunately, only one person sustained injuries of the five people involved, which included three young children. This latest incident exemplifies the need for a design alternative at the intersection that will increase safety immediately.

The Literature Review section of this report evaluated design alternatives and described several design features of varying cost and safety implications that have been implemented around the country. A few of the alternatives have already been in use at the project intersection including transverse rumble strips, oversized signs, and overhead flashers. Through the Montana case study review, six intersections of similar traffic speeds, traffic control, crash trends, and geometrics were studied to determine their effectiveness at improving safety. The two mitigation alternatives that have been implemented at those locations include an ITS-based advanced intersection warning system and a roundabout. Both mitigation strategies have shown a reduction in crash rates and crash severities compared to their previous form of two-way stop control, although before and after crash history sample sizes are relatively small from a statistical standpoint. The roundabout case study was found to have the greatest reduction in crash rates and severity and therefore has the greatest potential as a long-term safety improvement.

Through the analysis of this report and the engineering judgment of its authors, the roundabout is still the most appropriate long-term mitigation solution for improving safety and efficiently metering traffic through the Grass Range intersection. MDT's Vision Zero initiative's goal is to ultimately reach zero deaths and zero injuries on Montana highways. The combination of previously implemented transverse rumble strips, oversize signs, overhead flashers, and the long history of severe crashes due to high speeds leaves little margin to implement a less proven design option. Referencing the timing of the latest project intersection crash, time is very much of the essence to prevent future crashes. It is recommended that if the roundabout design cannot be built and operating within the 2017 calendar year, that an interim alternative be strongly considered.

Secondary to the roundabout, an all-way stop alternative should be considered. The primary goal of the all-way stop alternative is to reduce vehicles speeds and crash severities. The alternative should include speed reduction down to 45 mph for all approaches, include speed reduction signs (W3-5) with solar-powered flashers, and perpetuate the oversized signs, transverse rumble strips, and update the intersection overhead flashers for all four approaches. It is recommended that if this secondary alternative is implemented for long-term, periodic follow-up analysis should be conducted. Figure 2 details the secondary alternative design.

Recommendations included in this report are to achieve a balance of safety and mobility through Sanderson Stewart's understanding of the project objectives, professional opinion and position of staff, and in accordance with MDT design standards, the Manual On Uniform Traffic Control Devices (MUTCD), AASHTO, and other design resources.

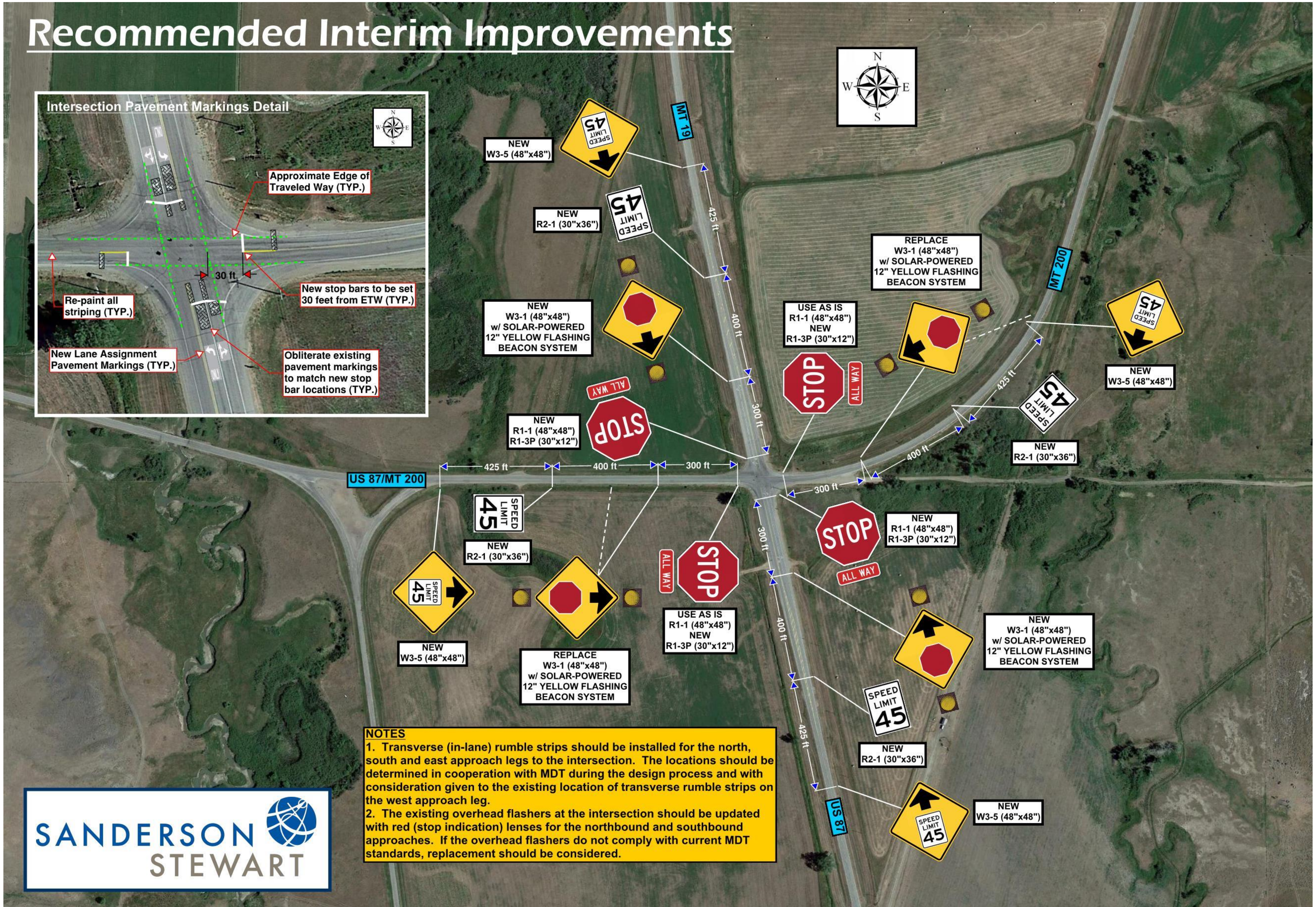

Figure 2: Secondary Design Recommendation