Improving transportation safety on Indian Reservations

Safety Toolkit

Wyoming Technology Transfer Center (WYT^2/LTAP)

Abstract

Transportation safety is a crucial issue for Indian Reservations as well as all other communities throughout the country. The *Improving transportation safety on Indian Reservations-Safety Toolkit* presents a five step safety improvement program process in determining high risk road segments and their corresponding countermeasures on Indian Reservations. The five steps are: Crash data Analysis, Level I field evaluation, combined ranking to identify potential high-risk locations based on steps 1 and 2, Level II field evaluation to identify countermeasures, and Benefit-cost analysis. Intended for low cost safety improvements, each step in the Toolkit includes a set of tools, field and professional examples and useful resources to implement the steps. The methodology provides flexibility for the Tribes to utilize the process the way they consider best to address. It has been implemented on several Indian reservations and has great success to reduce the high number of fatal crashes prevalent in the reservations' roadways.

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Introduction

Background

Over the past several years there has been a steady decline in fatal crash rates across the United States, yet transportation related mortality rates continue to increase on tribal lands. The Centers for Disease Control (CDC) reported that motor vehicle crashes are the leading cause of unintentional injury for Native American/Alaska Natives (AI/AN) ages 1 to 44. Compounding poor road conditions with the nature of rural roadways and risky driving behaviors, such as speeding and impaired driving, significantly increases the chances of fatal and serious crash rates on their roadways.

Numerous agencies and research projects are seeking to address the causes and solutions to this disparity in crash, injury, and death rates, but data collection and analysis practices in AI/AN areas hinder efforts to identify priority areas. Data collection and analysis are affected by variations in training, data processing capabilities, and jurisdictional authority, among other factors. Without a good understanding of where, when, and why crashes are occurring among the populations suffering the highest injury and fatality rates, traffic safety professionals will continue to struggle to improve safety in the areas where these crashes are occurring.

Determining high-risk rural road segments and their corresponding safety countermeasures is one of the most efficient and cost-effective ways to improve roadway safety. To help counties identify high-risk rural locations and develop a strategy to obtain funding to reduce crashes on the riskiest segments, the WYT^2/LTAP developed the Wyoming Rural Road Safety Program (WRRSP), which was funded by the Mountain-Plains Consortium (MPC) and WYDOT in cooperation with the FHWA. As a derivative of the WRRSP, the University of Wyoming developed a methodology for tribal communities to identify low-cost safety improvements on their roadways. The WYT^2/LTAP was directed by WYDOT to develop this methodology so that Tribes could successfully apply for Highway Safety Improvement Program funds for their rural roads. Such methodology resulted in implementing a low cost safety improvement program that should help in reducing the high crash rates on Indian reservations. Since Indian reservation roads are similar to rural local roads, modifying the WRRSP to fit the needs of Indian reservations provides Indian Nations with the opportunity to identify low cost safety improvements and then apply for and allocate funding for these improvements. This methodology also provides a tool for Indian Nations across the country to be able to utilize funds for safety improvements on their roadway systems.

What is in the Toolkit?

The toolkit is a step by step approach for the Tribes to utilize in prioritizing safety improvements. For each step in the process, this Toolkit provides an overview and application of the step, guidance related to applying the step, field and professional example of the step and a summary of resources that offer more information about the step.

As in the WRRSP methodology, crash data is analyzed and a ranking is established based on the high crash locations. From this ranking, a list of roadways is proposed for field evaluation. From the field evaluation, a ranking of the conditions of the roadway is developed. The two rankings are combined to provide a list of proposed roadways considered for safety improvements. Another field evaluation is performed to identify safety improvements. Cost estimates are developed and a benefit-cost analysis is performed. The combination of historical crash data and field evaluations provides a substantive basis for identifying high risk locations. The benefit-cost analysis gives the Tribes a measure to prioritize the projects.

More detail is provided in the following descriptions. Additional processes within the methodology are intended to give the Tribes the ability to make changes and identify other factors involved in the high-risk locations such as behavioral factors.

Why use the Toolkit?

This Toolkit is intended for low-cost safety improvements but other improvements can be identified and presented to the Tribes for consideration for other funding opportunities. The methodology provides flexibility for the Tribes to utilize the results the way they consider best to address.

How and when to use the Toolkit

In this toolkit, the methodology from the WRRSP is used as a template to develop the program for Indian reservations. Depending on available data, preference by the Tribes, and other factors this process has been altered to meet the needs of the Tribes. Part of this process includes looking at trends in crash data and developing a systemic approach. A combination of data driven, field verification and trend analysis is utilized. The proposed five-step procedure is as follows:

1. Crash data analysis.
2. Level I field evaluation.
3. Combined ranking to identify potential high-risk locations based on steps 1 and 2.
4. Level II field evaluation to identify countermeasures.
5. Benefit-cost analysis.

Figure 1 shows the sequence of the steps whereas detailed procedure is demonstrated in Figure 2. This section briefly describes each step and the context for when it should be used. More information covering guidance for conducting a given step or source of relevant resources are available in the respective chapter of this Toolkit.

Figure 1. Safety Improvement Program Procedure

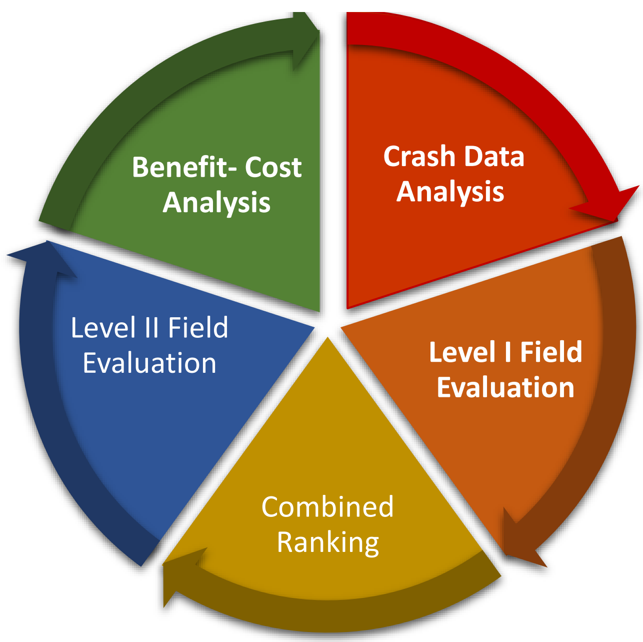
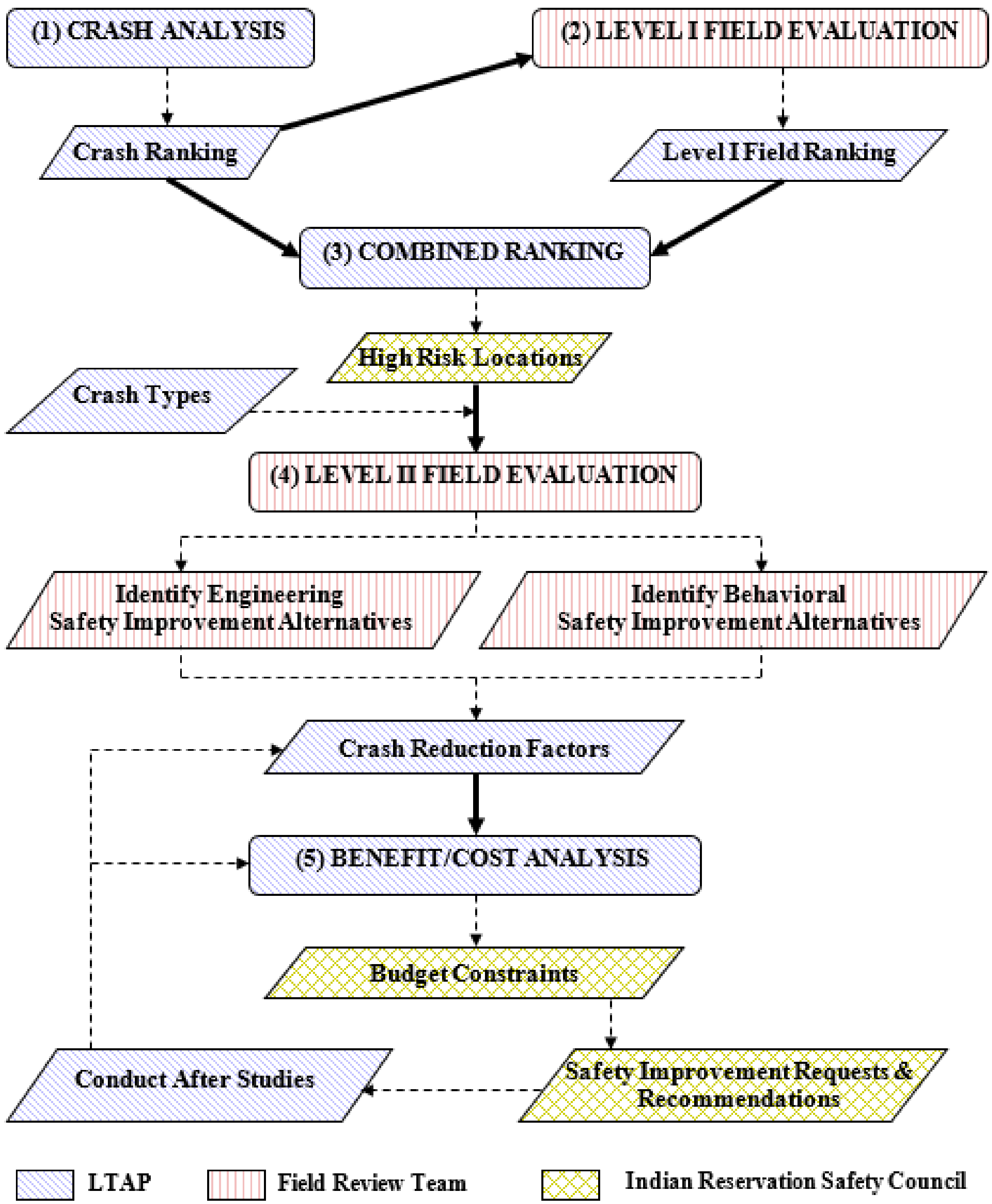


Figure 2. Safety Improvement Program Procedure



Step 1. Compile Data and Crash Data Analysis

The first step in conducting a safety evaluation is compiling the available data and determining high-risk crash locations. Crash data, traffic volumes and roadway characteristics data are used for analysis. The analysis should be performed for a recent period of time. Five to ten years provides enough data to identify trends or hotspots depending on the state and volume of traffic experienced on the local tribal roads.

When to do this Step

There are usually two circumstances requiring crash data to be compiled and analyzed: 1) agency staff or the public are concerned about crashes at a particular location; or 2) agency staff want to collaborate the recorded crash data and first-hand knowledge of the Tribes regarding crashes intended to better understand the factors contributing to high risk crash locations.

Step 2. Level I Field Evaluation

This step in the safety evaluation is a systematic way to determine the high-risk rural locations and then provide a ranking of the roadway conditions. It is conducted using the same method at each location so the results can be compared and prioritized. The roadways are reviewed at one-mile segments and each segment is rated from 0 to 10, with 0 being the worst and 10 the best. All segments should begin with a 5 rating as the average. These ratings are applied to five categories which are described in a relevant chapter (Chapter 2).

When to do this Step

Level I field evaluation is an effective way to identify the most accident prone sites for safety improvements. As soon as the crash data analysis, especially the crash ranking, is completed, the level I field evaluation can be put into effect. It is essential every segment of the roadway network be evaluated by the same evaluation team in order to ensure consistency between different segments of the roadways.

Step 3. Combined Ranking

In this step, crash locations are narrowed down to a list of high priority locations for implementing countermeasures. Two rankings, crash ranking and Level I rankings are combined by sorting each route and adding respective ranks to the respective segment. After the ranks are tabulated, the segments are again sorted from smallest to largest to determine which segments are in need of immediate countermeasures.

When do to this step

Due to funding and resource constraints, narrowing to high crash locations is helpful to implement the countermeasures. As soon as the crash data analysis and level I field evaluation are completed, combined ranking can be performed.

Step 4. Level II Field Evaluation

Once the Tribes have identified their priority sites, a Level II evaluation is performed on each of the routes selected. This step will identify potential countermeasures to address the identified safety concerns. It is suggested that the evaluation team performing the Level I field evaluation is that same team that performs the Level II field evaluation for maintaining consistency. In this step, additional data such as speed, congestion Levels, traffic counts, review of behavioral factors, and other casual factors that may influence the judgement of safety countermeasures may need to be collected .

When do to this step

Once the high risk locations are determined from combined ranking, the countermeasures can be selected for improvements. In order to maximize resources, the Level I field evaluation may be performed at the same time as the Level II field evaluation.

Step 5. Benefit Cost Analysis

Economic analysis provides crucial information for the decision makers to prioritize projects and select appropriate safety countermeasures that can achieve best economic effectiveness.
Based on the selected countermeasures and associated costs, benefit-cost analysis is performed for each project. This is calculated as the net present dollar value of benefits and is provided as a cost estimate for the Tribes. If the project is set up for each road, then all the improvements identified for that road are included in the estimate. Construction costs, environmental costs, planning and design costs, and ongoing maintenance costs are estimated for the safety improvements. This analysis also considers the service life of the countermeasure.

When do to this step?

This step is required when more than one countermeasure has been identified for a site or when funds are insufficient. Once the countermeasures are selected, the anticipated benefit and cost of the implementation can be evaluated.

Evaluate Effectiveness

Another critical component in the process of identifying safety improvement is the evaluation of the effectiveness of those improvements. The effectiveness of the safety countermeasures cannot be assessed immediately after implementation. After two or three years, enough data needed to be collected to determine the number of crashes, serious injuries, and fatalities have occurred since implementation of the countermeasure, and then compare it with the same types of data from before implementation.

When do to this step?

The evaluation of effectiveness of the countermeasures can be conducted two to three years after its implementation.

Chapter 1. Compile Data and Crash Data Analysis

Overview

The first step in conducting a safety evaluation is compiling the available data and determining high-risk crash locations. Crash data, traffic volumes and roadway characteristics are the most common types of quantitative data used for analysis. All states have some form of crash data analysis capabilities. The data is maintained by either the state Department of Transportation, law enforcement, Tribal governments, or possibly some other state agency or consultant. The use of crash data to improve the safety of Tribal roadways needs to be understood by Tribal governments. Performing a crash analysis can take on many forms and provides decision makers critical information on what improvements or programs should be initiated.

The type of safety evaluation that will be conducted and its level of complexity will vary depending on the quantity and quality of the available data. It is possible to perform a valuable safety analysis with limited amounts of data.

In addition to data, documents and other readily available resources along with information and assistance from a variety of organizations and agencies can be referenced and enlisted as support for crash data analysis.

This section provides information about:

- Anecdotal data;
- Quantitative data, including crash data, traffic volumes and roadway characteristics;
- Data from existing resources and documents ; and
- Organizations and agencies that can provide additional safety analysis support.

Compiling the available data is the first step in conducting a crash data analysis. Many factors will affect a crash analysis. These factors may include influences such as the standardization of reporting methods, the type of crash data, how accessible the crash data is, and how complete a crash data set may be. This section will teach users how to perform a complete crash analysis, as well as provide guidance in minimizing the effects of the factors on the process.

Communications among agencies needs to be established and a more formal understanding between the Tribes and the state are necessary to provide a complete data analysis.

Data Examples

Anecdotal Data

Anecdotal data is collected in an informal way which includes phone calls from tribal members, community member survey results, local staff and police knowledge, etc. These cover a range of perspectives about potential safety issues as well as prospective countermeasures. This data includes issues such as speeding, limited sight distance, lack of signage, high-risk locations during extreme weather conditions, and roadway segments that frequently experience a high number of crashes. This data can be particularly useful in incorporating first-hand knowledge of the Tribes regarding crashes.

Quantitative Data

Quantitative data includes information from police reports, crash data, traffic volume data and roadway characteristics.

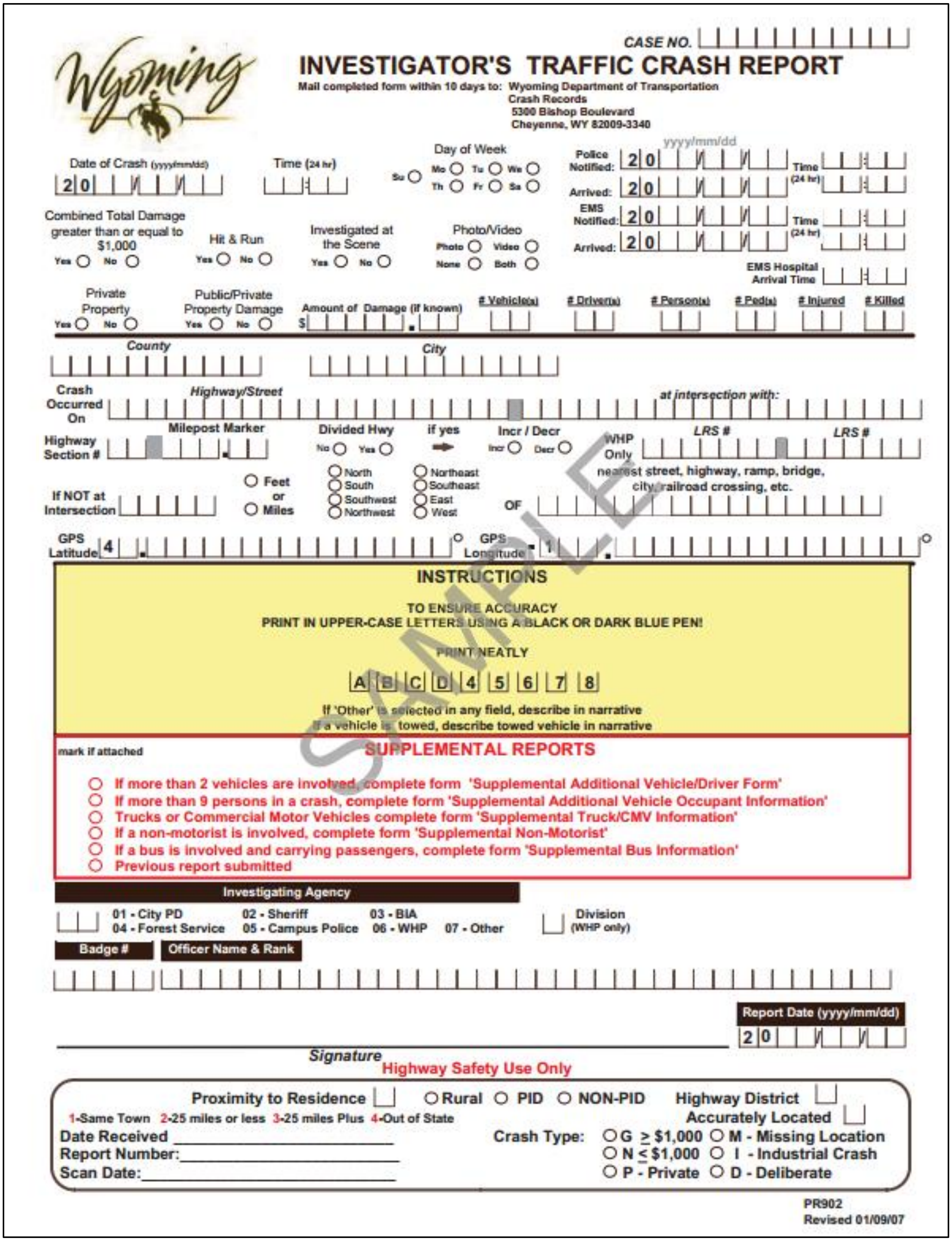
Crash Data

Crash data can be collected from various sources such as local and state crash databases, as well as local police crash reports and the National Highway Traffic Safety Administration (NHTSA), and Fatal Analysis Recording System (FARS).

Local, Tribal, and State Crash Data. Local law enforcement agencies should keep records of all crashes their officers have recorded. These crash reports are recorded on crash forms that are uniform across the state, but often differ between states. An example of this form is presented in Figure 3. Most crash reports include a key that describes the meaning of codes used in the initial form. An example of this key is presented in Figure 4. There is usually a key for driver information, vehicle information, vehicle occupant information and base information (shown in Figure 4).

As sovereign nations, the Tribes are not obligated to submit their crash reports to the state agency. Many times, they are hesitant to provide detailed information to outside agencies not understanding or knowing how that information will be used. The Tribes need to be assured that the data collection is essential to improving traffic safety and that the information would not be used to adversely impact the tribe or the individual driver involved in a crash. These vary among the Tribal administrations and there exists conflict between the state and BIA requirements. They also follow different crash reporting and investigation protocols. If the state has an electronic reporting system, the Tribal law enforcement needs to have the same system as well as training on the use of it.

Figure 3. Example Crash Report Form from Wyoming



CASE NO.

Wyoming

INVESTIGATOR'S TRAFFIC CRASH REPORT

Mail completed form within 10 days to: Wyoming Department of Transportation
Crash Records
5300 Bishop Boulevard
Cheyenne, WY 82009-3340

Date of Crash (yyyy/mm/dd) 2 0
Time (24 hr)
Day of Week: Su ○ Mo ○ Tu ○ We ○ Th ○ Fr ○ Sa ○

yyyy/mm/dd
Police Notified: 2 0 — Time (24 hr)
Arrived: 2 0
EMS Notified: 2 0 — Time (24 hr)
Arrived: 2 0
EMS Hospital Arrival Time

Combined Total Damage greater than or equal to $1,000: Yes ○ No ○
Hit & Run: Yes ○ No ○
Investigated at the Scene: Yes ○ No ○
Photo/Video: Photo ○ Video ○ None ○ Both ○

Private Property: Yes ○ No ○
Public/Private Property Damage: Yes ○ No ○
Amount of Damage (if known) $
Vehicle(s) — # Driver(s) — # Person(s) — # Ped(s) — # Injured — # Killed

County — City

Crash Occurred On — Highway/Street — at intersection with:

Highway Section # — Milepost Marker — Divided Hwy: No ○ Yes ○ — if yes — Incr / Decr: Incr ○ Decr ○ — WHP Only — LRS # — LRS #

If NOT at Intersection — ○ Feet or ○ Miles — ○ North ○ South ○ Southwest ○ Northwest — ○ Northeast ○ Southeast ○ East ○ West — OF — nearest street, highway, ramp, bridge, city, railroad crossing, etc.

GPS Latitude 4 — GPS Longitude 1

INSTRUCTIONS

TO ENSURE ACCURACY
PRINT IN UPPER-CASE LETTERS USING A BLACK OR DARK BLUE PEN!

PRINT NEATLY

A B C D 4 5 6 7 8

If 'Other' is selected in any field, describe in narrative
If a vehicle is towed, describe towed vehicle in narrative

mark if attached

SUPPLEMENTAL REPORTS

- ○ If more than 2 vehicles are involved, complete form 'Supplemental Additional Vehicle/Driver Form'
- ○ If more than 9 persons in a crash, complete form 'Supplemental Additional Vehicle Occupant Information'
- ○ Trucks or Commercial Motor Vehicles complete form 'Supplemental Truck/CMV Information'
- ○ If a non-motorist is involved, complete form 'Supplemental Non-Motorist'
- ○ If a bus is involved and carrying passengers, complete form 'Supplemental Bus Information'
- ○ Previous report submitted

Investigating Agency
01 - City PD 02 - Sheriff 03 - BIA
04 - Forest Service 05 - Campus Police 06 - WHP 07 - Other
Division (WHP only)

Badge # — Officer Name & Rank

Report Date (yyyy/mm/dd) 2 0

Signature

Highway Safety Use Only

Proximity to Residence — ○ Rural ○ PID ○ NON-PID — Highway District
1-Same Town 2-25 miles or less 3-25 miles Plus 4-Out of State — Accurately Located
Date Received ____
Report Number: ____
Scan Date: ____

Crash Type: ○ G ≥ $1,000 ○ M - Missing Location
○ N ≤ $1,000 ○ I - Industrial Crash
○ P - Private ○ D - Deliberate

PR902
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SAMPLE

Figure 4. Example Key for Crash Report Form in Wyoming

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Base Information

FIRST HARMFUL EVENT

Non - Collision:
01 - Overturn/Rollover
02 - Fire/Explosion
03 - Immersion
04 - Jackknife
05 - Cargo/Equipment Loss or Shift
06 - Fell/Jumped from a motor vehicle
07 - Thrown or Falling Object
08 - Carbon Monoxide (CO) Poisoning
09 - Injuries by being thrown against part of the vehicle
10 - Other Non-Collision (Motorcycle Loss of Control)

Collision w/ Person, MV, or Non-Fixed Object:
11 - Pedestrian
12 - Motor Vehicle in Transport on Roadway
13 - Motor Vehicle on OTHER Roadway
14 - Parked Motor Vehicle
15 - Railway Vehicle
16 - Pedacycle
17 - Work Zone/Maintenance Equipment
18 - Work Zone Channeling Device
19 - Object Set in Motion by Another Vehicle
20 - Other NON-Fixed Object

Animals:
21 - Horse
22 - Cow
23 - Pig
24 - Sheep
25 - Other Domestic (Dog, Llama, etc)
26 - Elk
27 - Deer
28 - Moose
29 - Antelope
30 - Buffalo
31 - Other Wild (Bear, Coyote, Eagle)

Collision w/ Fixed Object
32 - Guardrail End
33 - Guardrail Face
34 - Impact Attenuator/Crash Cushion
35 - Bridge Pier or Support
36 - Bridge Overhead Structure
37 - Bridge Rail
38 - Concrete Traffic Barrier/Jersey Barrier
39 - Other Traffic Barrier (Includes temporary)
40 - Utility Pole/Light Support
41 - Traffic Signal Support
42 - Overhead Traffic Sign
43 - Sign Support Single Post
44 - Sign Support Multiple Post
45 - Other Traffic Sign Support
46 - Barricade
47 - Tree/Shrubbery
48 - Cut Slope
49 - Road Approach
50 - Rock, Boulder, Rock Slide
51 - End of Drainage Pipe/Structure/Culvert
52 - Building or Other Structure Wall
53 - Fence (Including Post)
54 - Raised Median or Curb
55 - Delineator Post
56 - Earth Embankment/Berm
57 - Ditch
58 - Snow Embankment
59 - Mail Box
60 - Tunnel
61 - Cattle Guard
62 - Fixed Object Other

99 -Unknown

Location of FHE
01 - On Roadway
02 - Off Roadway
03 - Shoulder
04 - Median
05 - On OTHER Roadway
06 - Outside of ROW
07 - Gore
08 - Separator
09 - In Parking Lane/Zone
10 - Tunnel
11 - Bridge
12 - Port of Entry
13 - Rest Area
99 - Unknown

Weather 1st choice 2nd choice
01 - Clear
02 - Raining
03 - Snowing
04 - Fog
05 - Blowing Dust/Sand/Dirt
06 - Severe Wind Only
07 - Blizzard
08 - Sleet/Hail/Freezing Rain
09 - Blowing Snow
10 - Cloudy,Overcast
11 - Smoke
12 - Other
99 - Unknown

Road 1st choice 2nd choice
01 - Dry
02 - Wet
03 - Ice/Frost
04 - Snow
05 - Mud/Dirt/Gravel
06 - Slush
07 - Oil/Fuel
08 - Sand on Dry Pavement
09 - Sand on Icy Road
10 - Water standing/Running
11 - Other
99 - Unknown

Lighting
01 - Daylight
02 - Darkness Unlighted
03 - Darkness Lighted
04 - Dawn
05 - Dusk
06 - Other
99 - Unknown

School Bus Related
01 - No
02 - Yes, Directly Involved
03 - Yes, Indirectly Involved

Road Circumstance choose up to 3 — 1st choice 2nd choice 3rd choice
01 - None
02 - Road Surface Condition
03 - Debris, lose material on the surface
04 - Ruts, Holes, Bumps
05 - Work Zone/Construction Zone
06 - Worn or Polished Surface
07 - Obstruction in Roadway
08 - Traffic Control Device Missing
09 - Traffic Control Device Inoperative
10 - Traffic Control Device Obscured
11 - Shoulders (None, Low, Soft, High)
12 - Non - Highway Work
13 - Reduced Road Width
14 - Lane Markings Missing or Faded
15 - Obstructed by a Previous Crash
16 - Other
99 - Unknown

Environmental Circumstance choose up to 3 — 1st choice 2nd choice 3rd choice
01 - Weather Conditions
02 - Visual Obstruction Buildings
03 - Visual Obstruction Other Vehicle
04 - Visual Obstruction Vegetation
05 - Visual Obstruction Hillcrest
06 - Visual Obstruction Embankment-Snow, Rock,etc
07 - Other Physical Obstruction
08 - Glare (Sun or Headlight)
09 - Animals in Roadway
10 - Other
11 - None
99 - Unknown

Work Zone Related
01 - Yes 02 - No 99 - Unknown

Work Zone Workers Present

Work Zone Location
01 - Before the First Warning Sign
02 - Advance Warning Area
03 - Transition Area
04 - Activity Area
05 - Termination Area
99 - Unknown

Type of Work Zone
01 - Lane Closure
02 - Lane Shift or Crossover
03 - Work on Shoulder/Median
04 - Intermittent or Moving Work
05 - Other
99 - Unknown

Manner of Collision *see below
01 - Not a Collision w/2 Vehicles in Transport
02 - Rear End (Front to Rear)
03 - Head On (Front to Front)
04 - Angle Same Direction (Front to Side)
05 - Angle Right (Front to Side, Includes Broadside)
06 - Angle Direction not Specified
07 - Sideswipe Same Direction (Passing)
08 - Sideswipe Opposite Direction (Meeting)
09 - Rear to Side (Normally Backing)
10 - Rear to Rear (Normally Backing)
11 - Rear to Front (Normally Backing)
12 - Other
99 - Unknown

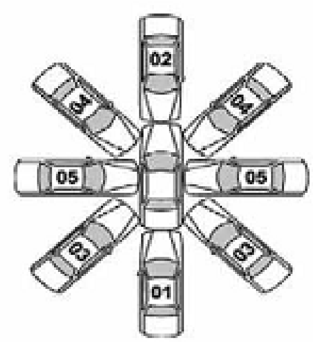
Direction of Force
01 - Opposing (Opposite Direction within 15 degrees)
02 - Angle (force exceeds 15 degrees)
03 - Same (same direction within 15 degrees)
04 - Meeting (glancing collision from opposite direction)
05 - Passing (glancing collision from same direction)
99 - Unknown

Relation to Junction

Non-Interchange Area
01 - Non-Junction
02 - Intersection
03 - Intersection Related
04 - Driveway Related
05 - Entrance/Exit Ramp
06 - Railway Grade Crossing
07 - Crossover Related
08 - Business Entrance
09 - Alley
10 - Other Non-Interchange (ie. Bike, Snowmobile Trail, School Xing)
99 - Unknown (describe in narrative)

Interchange Area
12 - Thru Roadway
13 - Intersection
14 - Intersection Related
15 - Ramp
16 - Other Parts (Gore)
99 - Unknown Interchange

Type of Intersection
01 - Not an Intersection
02 - Four (4) -Way Intersection
03 - T Intersection
04 - Y Intersection
05 - Five (5) Point or more
06 - Intersection as part of an Interchange
07 - Roundabout
99 - Unknown



Manner of Collision CLARIFICATION
01 - Rear End (Front-to-Rear)
02 - Head-on (Front-to-Front)
03 - Angle (Front-to-Side), Same Direction
04 - Angle (Front-to-Side), Opposing Direction
05 - Angle (Front-to-Side), Right Angle/Broadside

Regardless of the differences in crash reporting and forms, crash reports from all states generally contain data related to:

- Crash date, time and location.
- Drivers and passenger information -
    - Age, impairment, and gender
- Severity of crashes -
    - Critical, Serious or Property Damage Only (PDO)
- Road conditions at the time of the crash.
- Weather conditions at the time of the crash.
- Lighting conditions.
- Type of crash.
- Safety device use.
- Speed.

Some states' DOTs collect and maintain crash data for all public roads. In other states, the state police maintain a comparable data system. These databases can generate reports by analyzing summary crash data. For example, Wyoming uses the Critical Analysis Reporting Environment (CARE) package. The CARE package includes different types of information, specifically the information mentioned above. Users can extract crash reports for any road in Wyoming, over any period. Many states also publish summary crash reports that can be useful to understand crash trends and provide contact information for data requests or support e.g. an Oregon Department of Transportation annual crash report.

Staff in the traffic engineering or safety division of the DOT or Local Technical Assistance Program (LTAP)/Tribal Assistance Program (TTAP) can provide guidance on requesting crash data. Typically, these staff study both engineering and behavioral-related (behavioral including seat belts, driving under the influence of alcohol or drugs, texting/cell phone usage) crash issues and are therefore good resources for data analysis assistance and information about safety-related activities at the DOT. Due to processing and reporting issues, crash data summaries are often not available until six to nine months after the end of a given calendar year.

NHTSA Fatal Analysis Recording System. NHTSA Fatal Analysis Report System (FARS) database provides yearly crash data regarding motor vehicle crashes with fatal injuries. FARS is an on line database which can be queried to learn about fatal crashes in any jurisdiction from 1975 to the present.

Traffic Volume Data

Traffic volume data are essential for traffic operations analysis, transportation planning activities, and analysis of traffic patterns. These data can also be used in combination with crash data to calculate crash rates. Calculating crash rates is important because the number of crashes at a given location depends not only on roadway characteristics and driver behavior, but also on the volume of traffic or exposure. Crash rates can be used as a tool to compare accident prone sites with comparable traffic volume and roadway characteristics.

The types of traffic volume information that contribute to safety analysis include:

- **Average Annual Daily Traffic (AADT).** Total volume of vehicle traffic of a highway or road for a year divided by 365 days. If AADT is not available, Average Daily Traffic (ADT) can be used to estimate AADT.

- **Vehicle Miles Traveled (VMT).** VMT is defined as a measurement of miles traveled by vehicles within a specified region for a specified time period. It is calculated by multiplying traffic volume on a road segment by the segment length.

- **Major and Minor Street AADT.** (or ADT) or total entering volume (TEV) for intersections. Intersection TEV is the sum of the traffic entering the intersection at all approaches.

Traffic volumes of a road segment depend on the type of roadway facility, the season, day of week, and the level of development. Some agencies may collect and record traffic volume data for local roads through their public works, engineering, planning, or traffic engineering department. State DOTs typically collect and record traffic volume data on state owned roads (and in some cases non state owned roads as well). When none if these sources are available or attainable, the handbook of Simplified Practice for Traffic Studies can be used as a guideline of collecting traffic volume data.

Roadway Characteristics Data

Many analysis tools use roadway characteristics data as an element of the analysis, including roadway classification, roadway segment characteristics and intersection characteristics. While many analysis guides will suggest gathering this information before a network evaluation, many of these characteristics will be logged in Step 2 of this toolkit.

Data from Existing Plans, Documents, or Other Agencies

Alongside crash data, traffic volume data, and roadway geometrics data, statewide safety policies and planning documents also may contain information to Tribal practitioners studying safety. An example of these resources is a:

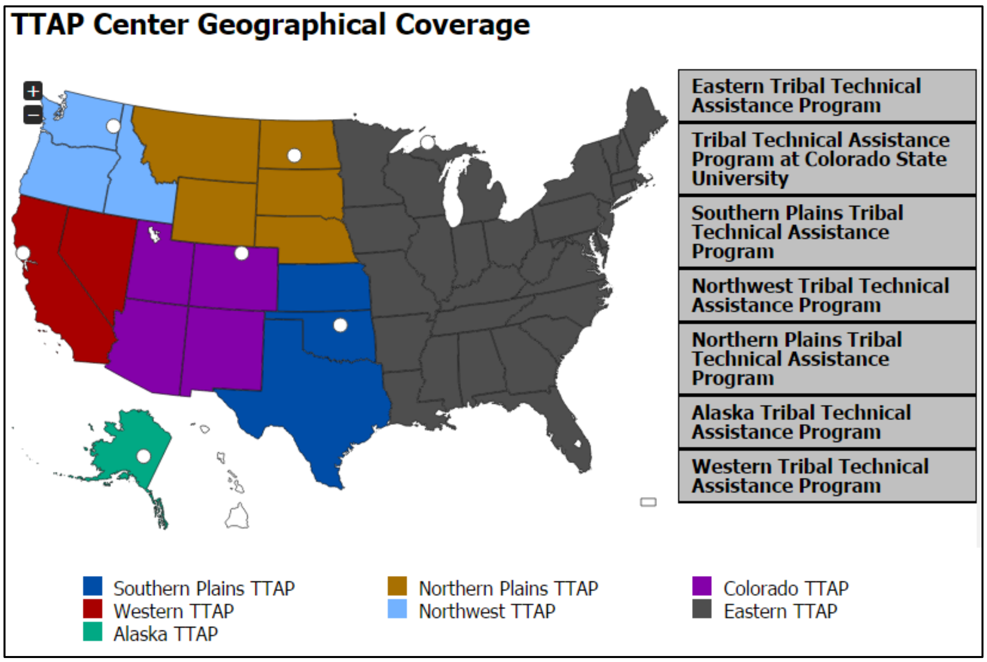
- **Strategic Highway Safety Plan (SHSP).** Every state is required to have a SHSP that provides a systematic approach to reducing fatal and serious injury crashes on all public transportation facilities. These plans generally have a statewide scope, thus they may not provide practitioners with localized data; however, they highlight areas and strategies statewide that provide valuable information about the most important safety issues from the state's perspective. Your state's DOT should be able to provide you with this information. More information about SHSPs is available on the Federal Highway Administration website: http://safety.fhwa.dot.gov/hsip/shsp/. This site will also provide links to all state SHSPs.

- **Other Resources.** Usually, state DOTs have Tribal Government Liaison staff that are in charge of working with sovereign nations on transportation issues. These staff provide an easy access point for Tribal governments communicating with the state DOT or local agencies in the area.

Many organizations provide training, information, contacts, or analysis support such as:

- **LTAP/TTAP.** Local Technical Assistance Programs (LTAP) and Tribal Technical Assistance Programs (TTAP) centers provide support to every state. Seven regional TTAP centers provide assistance to Tribal governments by region across the country. Every state including Puerto Rico has a LTAP center charged with helping local and Tribal agencies with transportation problems through training and technical support. Current TTAP centers are shown in Figure 5. FHWA will be replacing these centers with a national center in the near future.

Figure 5. Location of TTAP Centers



- **State DOT Local Office.** State DOTs provide assistance to some form of local assistance program or office. Staff in these offices help local agencies in solving transportation-related problems and may administer Federal and state funds for local agencies. Staff in these offices understand project-funding opportunities with their excellent knowledge and experience. They can also make connections to key people within the DOT.

- **State Highway Safety Office.** Every state and territory has a Highway Safety Office (HSO). Most of the SHSOs are situated within their state's Department of Transportation. Representatives from the HSO have a great knowledge about critical behavioral safety issues (behavioral safety issues include impaired driving, occupant protection, distracted driving, and driving while drowsy in the state. They can give access to crash data as well as information about effective behavioral countermeasures and grant funding opportunities.

- **The Governor's Highway Safety Association (GHSA).** It is a national advocacy and leadership organization that serves the Highway Safety Offices. The GHSA web site http://www.GHSA.org comprises plenty of information about behavioral safety issues, programs, funding sources, and a variety of other safety resources.

- **FHWA State and Division Offices.** Each state has an FHWA Division Office. Staff from FHWA Division Offices provide assistance on a vast range of transportation planning and engineering topics, comprising roadway safety. Division Office staff can help in providing information about best practices appropriate to local and Tribal roads and solutions to specific safety issues.

- **National Association of County Engineers.** The National Association of County Engineers (NACE) is an association for practitioners liable for county roads and bridges. Advocacy, networking opportunities, training support, and many other resources for county/parish engineers, transportation directors, highway superintendents, road supervisors, and highway administrators is provided by this organization. The organization helps to get connected with other professionals working on transportation safety issues as well as on-line resources on a variety of transportation topics, including roadway safety. The URL of the website is http://www.countyengineers.org.

- **American Public Works Association.** The American Public Works Association (APWA) provides educational and networking opportunities to public works personnel to grow in their professionalism and directly impact the quality of life in all the communities they serve. APWA (http://www.apwa.net) provides assistance to staff in learning more about managing transportation and road safety in their community.

Application of the Crash Data Analysis

*If five to ten years of crash history is not attainable, **three years of crash data** may be considered for an analysis. Many times, Tribes will only be able to use as much information they can find; which will often be limited and gaps will be found in the data. Some data is better than no data.*

Crash data must be acquired that represents an extended and recent period. It is typical to use five to ten years, because this provides enough data to identify hot spot locations. Crash rates can be difficult to justify and occasionally cannot be considered quantifiable because of the lack of data and challenges in updating and maintaining correct crash reports. Accurate and complete crash data can be confidently used to develop safety models that can provide specific information on problem areas, causal factors, and behavioral factors involved and how they affect the seriousness of the crash. Trends are easily identified when the data is complete. Having accurate locations is significant and can be incorporated into a geographical information system (GIS) that could be connected to roadway inventories. This would provide more specific information on roadway geometrics and pavement conditions that can be included in the analysis of crashes. After acquiring all of the necessary data, the analysis and subsequent ranking proceeds using the crash data.

Why Analyze Crash Data?

The purpose of analyzing crash information is to determine the factors that may be common across a number of crashes. Patterns can be identified by summarizing data by factors that may be contributing to the safety issue. The crash history obtained will provide the basis for initial ranking of the sites. Based on the number of crashes for a given hotspot, the highest number would receive the highest rank. If traffic volume is available, these crashes can be converted to a crash rate, which provides for a more accurate assessment of high crash occurrence.

CRASH HOT SPOT

A crash hot spot is a segment that contains a number of crashes per specific length. Usually this includes a number of crashes per a one-mile segment.

Calculating a Crash Rate

A crash rate can be calculated to obtain either a crash rate by vehicle miles traveled or a crash rate by route length. The crash rate by vehicle miles traveled can be calculated if estimated traffic volumes for a particular roadway (AADT) have been obtained. If this information is not attainable, the crash rate by route length can be used. Two examples are provided below:

Example 1. Crash Rate by Vehicle Miles Traveled. Table 1 presents a scenario where two roadways have the same number of crashes but different traffic volumes.

Table 1. Example of Crash Rate Calculation by Vehicle Miles Traveled

Roadway	Total # of Crashes	Traffic Volume (AADT)	Years of Data	Length of Segment (miles)	Crash Rate
Route A	10	250	5	12	182.6
Route B	10	500	5	12	91.3

Equation 1 can be used to calculate the crash rate by vehicle miles traveled on a roadway, where:

$$R = \frac{C * 100{,}000{,}000}{V * 365 * N * L} \qquad \textbf{Equation 1.}$$

- R = Roadway crash for the road segment expressed as **crashes per 100 million vehicle-miles of travel**
- C = Total number of roadway crashes in the study period (obtained from crash data)
- V = Traffic volumes using Average Annual Daily Traffic (AADT) volumes
- N = Number of years of data
- L = Length of the roadway segment in miles

Route A has experienced 182.6 crashes per 100 million vehicle-miles traveled on that roadway, Route B has experienced 91.3 crashes per 100 million vehicle miles traveled. Though both routes have the same number of crashes, Route A is more susceptible to crashes based on the exposure. This means a practitioner could consider Route A as a more promising candidate for a safety treatment than Route B due to its higher crash rate.

Example 2. Crash Rate by Route Length. Table 2 presents a scenario where two roadways have the same number of crashes but different roadway lengths and traffic volume data is not available.

Table 2. Example of Crash Rate Calculation by Route Length

Roadway	Total # of Crashes	Years of Data	Length of Segment (miles)	Crashes per Mile
Route A	8	5	8	0.20
Route B	8	5	12	0.13

Equation 2 can be used to calculate the crashes per mile per year where:

$$R = \frac{C}{N * L} \qquad \textbf{Equation 2.}$$

- R = Crashes per mile for the road segment expressed as **crashes per each one mile of roadway per year**
- C = Total number of crashes in the study period
- N = Number of years of data
- L = Length of roadway segment in miles

In this example, Route A has experienced 0.20 crashes per roadway mile. Route B has experienced 0.13 crashes per mile of roadway. In this case, even though both routes have the same number of crashes, Route A may be more susceptible to future crashes, considering for a more promising candidate for safety treatments.

Other Factors

Beside the total number of crashes and crash rate, several other factors are analyzed to determine causal effects and severity to identify ways to reduce fatal and serious injury crashes. The following criteria are considered for this analysis:

- Severity of crashes – Critical, Serious or Property Damage Only (PDO).
- Road conditions.
- Lighting conditions.
- First harmful event.
- Driver's gender.
- Driver's age.
- Alcohol-drug related crashes.
- Safety device use.
- Speed.

The first four criteria above identify physical aspects of the crashes along with the severity. The crash severity of each crash should be categorized into three separate categories: 1) Critical, 2) Serious, and 3) Property Damage Only. Each category includes the KABCO injury scale Levels as follows:

CRASH SEVERITY KABCO SYSTEM

Crash Severity: The KABCO scale is used to classify crashes by injury severity. The letters represent injury Levels as follows:

K – fatal injury;
A – incapacitating injury;
B - non-incapacitating injury;
C – possible injury;
O – no injury; and
PDO – property damage only crash

- Critical Injuries – fatal and incapacitating injuries
- Serious Injuries – non-incapacitating injuries, and possible injuries
- PDO – no injuries, or property damage crashes only

These will provide a basis for determining high-risk locations. Based on direction from the Tribes, several factors are being analyzed that are behavioral in nature. The last five criteria are intended more for the behavioral analysis of the crash data. Behavioral improvements will be reviewed along with physical improvements. Crash rates can and should be generated for this information using the examples in the previous section. For example, the number of critical crashes can be calculated into a number of crashes per one mile of roadway per year. This information should be plotted into graphs presenting visual information of valuable trends.

Generation of Hotspots

The crash analysis includes the number of crashes per one-mile segments, which are known as hotspots. Each segment is ranked from the largest number of crashes per hotspot to the least number of crashes. Based on this ranking, the top high crash routes are selected and proposed for a Level I Field Evaluation (Step 2) as the Tribes determine.

A route may appear several times at different milepost segments and some segments may contain the same number of crashes. These are ranked accordingly and the crash rank value assigned would be the same. The next lower number of crashes segment would be assigned the rank value that corresponds to the line number. An example of ranking the segments according to crash number is located in Table 3.

Table 3. Example of Crash Ranking

Line Number	Route	Mile Post	Number of Crashes	Crash Rank
1	C	2	15	1
2	A	4	14	2
3	D	3	14	2
4	A	6	12	4
5	B	10	9	5

Once the segments have been ranked, then the top routes are selected. The top 15 to 25 routes should be selected for the Level I Evaluation (Step 2) as determined by the Tribes.

Professional Examples

Wind River Indian Reservation (WRIR) Implementation

This methodology was implemented on the Wind River Indian Reservation (WRIR) county and Indian Reservation roads (IRRs). This example can assist your Tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe.

The analysis and subsequent ranking were conducted using the above described crash analysis. The crash analysis database only produced crash locations on county roads on the reservation. A discrepancy exists with the ability of the system to identify IRR crash locations because of state inventory does not include them yet. The inventory is what links the crash data to a location. This was brought to the attention of the Tribal transportation personnel and discussions concluded to proceed with the county roads and IRR roads simultaneously to try to reconcile later.

The road segments were then sorted by the highest number of crashes per one-mile segment. Ranking was assigned starting at the number one (1). Progressing through the list, equal scores received equal rank. However, the next rank number would be associated with the total number of segments ranked so far. The ranking can be observed in Table 5.

The top 24 roads were then selected for Level I field evaluation and included roads that had three (3) or more crashes per one-mile segment. Seventeen Mile Road has some of the highest number of crashes per mile but was removed from the ranking since a TIGER grant roadway improvement construction project for this road had only recently been approved and was about to start construction. The roads ranked by crash rate are listed in Table 4.

As an example, Table 4 presents the actual crash information regarding a completed analysis on the Wind River Indian Reservation county road high crash locations. Table 4 includes all routes included in the crash analysis. It presents information regarding: the roadway name, the total number of crashes on the roadway, the maximum number of crashes in a one mile segment (max hot spot), the total number of fatalities and injuries on each road, the length of the study area, and the number of crashes per roadway mile per one year. It also provides an initial ranking of the roadways based on the maximum number of crashes in a one-mile hot spot.

Table 5 presents the actual country road crash rankings generated from the one-mile hot spot crash information. It can be seen that one-mile segments from the same roadway appear more than once. This scenario summarizes a real analysis which may bear a resemblance when implementing this program on another reservation.

Table 4. County Road High Risk Crash Locations on the WRIR.

Rank	WYDOT Route	County Route	Road Name	Total Crashes	Max Hot Spot	Fatalities	Injuries	Length (miles)	Crash Rate/Mile
2	ML5827	334	Seventeen Mile	105	12	11	84	13	8.1
4	ML5813	320	Burma	45	9	1	27	9	5
11	ML5848	367	Pingetzer	5	5	0	5	1	5
3	ML5849	385	Eight Mile	48	12	1	17	10	4.8
7	ML5828	335	Ethete	40	8	2	26	10	4
6	ML5837	346	South Fork	18	9	0	20	5	3.6
16	ML5902	480	Kinnear Spur	7	4	0	2	2	3.5
5	ML5836	345	North Fork	19	6	1	20	6	3.2
10	ML5783	272	Hutchinson	6	5	0	1	2	3
1	ML5716	54	Riverview	67	18	3	32	23	2.9
12	ML5916	496	Zuber	5	4	0	1	2	2.5
14	ML5844	360	Country Acres	5	4	0	6	2	2.5
24	ML5697	12	Williams	5	3	0	4	2	2.5
8	ML5807	315	Paradise Valley	22	6	0	8	11	2
13	ML5838	347	Trout Creek	8	4	1	5	4	2
17	ML5784	273	Cliff Drive	4	4	0	0	2	2
18	ML5825	333	Elkhorn Drive	4	4	0	2	2	2
15	ML5891	463	Peterson	6	4	0	0	4	1.5
19	ML5876	430	Bass Lake	18	3	1	4	12	1.5
20	ML5822	300	East Pavillion	6	3	0	2	5	1.2
23	ML5831	339	Two Valley	7	3	0	8	6	1.2
9	ML5875	428	North Pavillion	7	5	0	3	7	1
22	ML5823	331	Buckhorn Flats	5	3	0	1	7	0.7
21	ML6216	1	Owl Creek	7	3	0	4	15	0.5

Table 5. County Road Crash Ranking on the WRIR.

Row No.	County Route	IRR Route	Road Name	Beg MP	End MP	Total Crashes	Crash Rank
1	54	169	Riverview Road	2.01	3	18	1
2	54	169	Riverview Road	7.01	8	12	2
3	385	385	Eight Mile Road	5.01	6	12	2
4	54	169	Riverview Road	4.01	5	9	4
5	320	132	Burma Road	0	1	9	4
6	346	72	South Fork Road	0	1	9	4
7	320	132	Burma Road	5.01	6	8	7
8	335	52	Ethete Road	0	1	8	7
9	385	385	Eight Mile Road	1.01	2	8	7
10	385	385	Eight Mile Road	4.01	5	8	7
11	320	132	Burma Road	1.01	2	7	11
12	320	132	Burma Road	4.01	5	7	11
13	335	52	Ethete Road	1.01	2	7	11
14	54	169	Riverview Road	3.01	4	6	14
15	54	169	Riverview Road	6.01	7	6	14
16	315	315	Paradise Valley Road	4.01	5	6	14
17	320	132	Burma Road	3.01	4	6	14
18	335	52	Ethete Road	5.01	6	6	14
19	345	B029	North Fork Road	3.01	4	6	14
20	385	385	Eight Mile Road	2.01	3	6	14
21	54	169	Riverview Road	5.01	6	5	21
22	272	141	Hutchinson Road	0	1	5	21
23	345	B029	North Fork Road	2.01	3	5	21
24	346	72	South Fork Road	2.01	3	5	21
25	367	367	Pingetzer Road	0	1	5	21
26	12	CO12	Williams Road	1.01	2	4	26
27	54	169	Riverview Road	1.01	2	4	26
28	320	132	Burma Road	2.01	3	4	26
29	335	52	Ethete Road	3.01	4	4	26
30	335	52	Ethete Road	4.01	5	4	26
31	335	52	Ethete Road	6.01	7	4	26
32	345	B029	North Fork Road	1.01	2	4	26
33	360	162	Country Acres Road	1.01	2	4	26
34	385	385	Eight Mile Road	7.01	8	4	26
35	480	170	Kinnear Spur Road	1.01	2	4	26
36	496	-	Zuber Road	0	1	4	26
37	273	-	Cliff Drive	0	1	3	37
38	315	315	Paradise Valley Road	0	1	3	37
39	333	333	Elkhorn Drive	0	1	3	37

Sisseton Wahpeton Oyate (SWO) Implementation

Due to the success of the Wind River Indian Reservation implementation of the safety improvement program, tribes across the country became interested in implementing their own program. WYT^2/LTAP and the Northern Plains Tribal Technical Assistance Program (NPTTAP) collaborated to develop a regional implementation for the Northern Plains. The methodology was implemented on the Sisseton Wahpeton Oyate Reservation roads. This example can assist your Tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe.

The analysis of crash data is the first step in the roadway safety program methodology. Safety goals and strategies are driven by data that documents the safety problems. Many factors must be reviewed to determine appropriate safety measures considering the four E's of safety (engineering, enforcement, education, and emergency response).

The analysis and subsequent ranking proceeded using the crash analysis described in this chapter. An initial ranking was performed based on GIS maps with the crashes overlaid on the roadways. Initial data did not include all milepost locations. Once the Level I field evaluation was completed, the crash rankings mileposts were revised to match the Level I mileposts. Table 6 is the preliminary crash ranking. The road segments were then sorted by the highest number of crashes per segment. Ranking was assigned starting at the number one (1). Progressing through the list, equal scores received equal rank.

Table 6. County Road Crash Ranking on the SWO Reservation

Highway	Functional Class	No. Crashes	Length (mi)	Crashes/Mile	Crash Rank
446 Ave	Rural Major Collector	9	2	5	1
459 Ave	Rural Major Collector	27	7	3.9	2
473 Ave	Rural Major Collector	3	1	3	3
455 Ave	Rural Major Collector	42	16	2.6	4
456 Ave	Rural Local Road	3	1.5	2.0	5
107 St	Rural Major Collector	6	3	2	6
164 St	Rural Major Collector	5	2.5	2	6
446A Ave	Rural Major Collector	8	4	2	6
465 Ave	Rural Major Collector	4	2	2	6
446 Ave	Rural Major Collector	16	9	1.8	10
122 St	Rural Minor Collector	3	1.7	1.8	10
447 Ave	Rural Major Collector	5	3	2	12
127 St	Rural Major Collector	32	20	1.6	13
118 St	Rural Local Road	6	4	1.5	14
445 Ave	Rural Major Collector	3	2	1.5	14
455 Ave	Rural Major Collector	19	13	1.5	14
144 St	Rural Minor Collector	7	5	1.4	17
BIA 7	Rural Major Collector	17	13	1.3	18
463 Ave	Rural Local Road	5	4	1.3	28
448 Ave	Rural Major Collector	5	4	1.3	18
122 St	Rural Minor Collector	10	10	1	21
149 St	Rural Major Collector	5	5	1	21
454 Ave	Rural Major Collector	13	13	1	21
BIA 3	Rural Major Collector	4	4	1	21
Lohre Rd	Rural Major Collector	4	4	1	21
462 Ave	Rural Major Collector	8	9	0.9	26
473 Ave	Rural Major Collector	6	7	0.9	26
County Rd 10	Rural Major Collector	5	6	0.8	28
142 St	Rural Local Road	4	5	0.8	28
446 Ave	Rural Major Collector	12	15	0.8	28
458 Ave	Rural Minor Collector	11	15	0.7	31
118 St	Rural Local Road	2	3	0.7	31
Lake Rd	Rural Major Collector	7	11	0.6	33
101 St	Rural Minor Collector	16	29	0.6	33
457 Ave	Rural Local Road	5	19	0.3	35

Chapter 2. Level I Field Evaluation

Overview

With the crash analysis output from **Step 1**, a Level I field evaluation is performed on the selected routes of the network that are identified as high-risk locations. A "network" refers to the collection -of roads under the jurisdiction of an agency. A Level I field evaluation is conducted using the same method at each location so the results can be compared and prioritized. It is anticipated that Tribal leaders and any transportation supervisors within the community will be performing the Level I field evaluation. The WYT[2]/LTAP Center can provide training on Level I field evaluations if needed. Once the evaluations have been completed, the field ranking can be obtained from the Level I field evaluation.

This step in the safety evaluation is a systematic way to determine the high-risk rural locations and then provide a ranking of the roadway conditions.

In addition to data, documents, and other readily available resources, assistance from a variety of organizations and agencies can be referenced as support for a Level I evaluation.

Level I Field Evaluation Review Team

The evaluating team should consist of at least three individuals. A team of tribal members and potential transportation experts such as LTAP, TTAP and/or the transportation department within the reservation should perform this evaluation. This team should be selected by the Tribes.

An example of a Level I field evaluation team could be as follows:

- One member from Tribal leadership
- One Tribal transportation member
- One BIA engineering consultant

At least one individual is needed to record data.

The Tribal personnel are essential in providing the site expertise because they have first-hand knowledge of the problem areas. Each individual should be present during the entire evaluation. It is essential every segment of the roadway network be evaluated by the same evaluation team. If there are inconsistencies between the evaluation team, there could be discrepancies between different segments of the roadways. By performing all roads together with the same individuals, relative results would be produced, which are sufficient to providing a field verification of crash results.

Application of a Level I Field Evaluation

Evaluation of Roadway Segments

The Tribes can perform the Level I field evaluation on shorter segments with a high number of crashes or on the whole length of the selected roads. On certain roads, for example, if most of the crashes occurred in short concentrated segments, only these segments need to be evaluated. If crashes were scattered throughout the entire length of the road, the whole length of the road should be evaluated. Five categories are used in the Level I field evaluation. The road should be evaluated in the field and analyzed for each single-mile segment. Each single-mile segment will be given a score of 0 to 10 for each of the 5 categories, with 0 being the most dangerous and 10 being the least dangerous. All segments should begin with a rating of five (5) as the average.

Categories of Evaluation

The ratings applied to the five categories are as follows:

- **General Category.** The general category covers the geometrics and condition of the roadway. Conditions such as sharp horizontal curves, poor sight distance at vertical curves, and poor pavement quality is looked at for this rating.
- **Intersections.** The presence of intersections, the number and sight visibility of them are rated.
- **Signage and Pavement Markings.** The condition or existence of pavement markings and signs are rated.
- **Fixed Objects and Clear Zones.** The presence of fixed objects and condition of the clear zone are rated.
- **Shoulder and Right-of-Way.** The quality of the shoulder treatment and adequacy of the right-of-way are rated.

A spreadsheet is the easiest way to rate the segments of roadway. Each roadway should have its own spreadsheet for scoring and should provide a designated row, or line, for each mile segment to be evaluated. There should be seven total columns per row, such as a column for the designated one-mile segment, each of the five categories, and a column for the final segment score. Figure 1 presents an example of the scoring spreadsheet. The following discuss in more detail what an evaluator may observe in each of the five categories.

1. General:
    - Presence of sharp horizontal or vertical curves.
    - Poor visibility that could result in safety problems.
    - Pavement defects that could result in safety problems.
    - Ponding or sheet flow areas that could result in safety problems.
    - Presence of loose aggregate/gravel that could cause safety problems.

2. Intersection and Rail Road Crossings:
    - Intersections free of sight restrictions that could result in safety problems.

- Intersections free of abrupt changes in grade or conditions.
- Presence of advanced warning signs when intersection traffic control sight restrictions exist.
- Presence of railroad crossing signs at RR crossing approach.
- Presence of railroad advanced warning signs when crossing sight restrictions exist.
- Vegetation and other obstructions restricting sight distance at railroad crossing.
- Roadway approach grade at railroad crossing Level enough to prevent snagging.

3. Signage and Pavement Markings:
   - Signing present at needed locations to improve safety.
   - Presence of advanced warning signage at needed locations to improve safety.
   - Presence of unnecessary signage that may cause a safety problem.
   - Effective signage for existing conditions.
   - Presence of visible pavement markings.
   - Presence of ineffective pavement markings for present conditions.
   - Presence of old or faded pavement markings affecting the safety of the roadway.
   - Presence of needed delineators.
   - Presence of improper or unsuitable delineators.

4. Fixed Objects and Clear Zone:
   - Clear zones free of hazards, non-traversable side slopes without safety barriers.
   - Presence of narrow bridges or cattle guards.
   - Presence of culverts with inadequate extensions.

5. Shoulder and right-of-way:
   - Standard shoulder width.
   - Slope greater than 3:1.
   - Presence of hazards along shoulder.
   - High rollover potential.

Figure 6 presents an example of the scoring spreadsheet. Looking at the example given in Figure 6, generally the condition was about average but where there was not a shoulder present, therefore a below average rating of two (2) was assigned. For a team of evaluators, either discussion could be ensued to determine one score or each member could score independently. Then these scores would be averaged for each segment of each roadway. Maintaining the same team throughout the evaluation period would ensure consistency in results.

An example of recording an observation while active in the Level I Field Evaluation would be:

"Noting that an advanced warning sign is needed for an upcoming curve. Note the type of the sign, and the mile-marker of the location that the sign should be placed."

When in the field, be sure and take notes regarding any issues or any countermeasures needed you may observe. It is recommended to take note of any precise improvements needed while present in the Level I Field

Evaluation, as this can serve as a more feasible approach to prepare for Step 4 (Level II Field Evaluation).

This review process is repeated for each segment of each roadway that is selected from the crash ranking. Field decisions are made by review team members to reduce the length evaluated based on knowledge of recent or upcoming construction and maintenance that would address safety issues. Looking at the hotspots in the context of the entire roadway is a practical approach to address roadway safety improvements. For example, if the field evaluation reveals that the roadway is in poor condition, pavement markings are missing, or shoulders are narrow, the improvement would not only be applied to the hotspot but to the entire portion of the roadway.

Once the Level I field evaluations are completed, every segment receives a total score summed up from the score of each category. The maximum segment score a one-mile segment could receive is 50. Each segment that was evaluated is provided a rank from lowest score to the highest score. Similar to the crash ranking, a Level 1 rank is assigned to each segment. Again, if two scores are the same, they will receive the same rank. The following rank value would correspond to the line number. The segment with the highest risk is considered to have the lowest rank.

The segments are now ready for the combined ranking (**Step 3**).

Figure 6. Example of a Level I Field Evaluation Scoring Spreadsheet

Level I Field Evaluation	Evaluator:						Date:	Page of
Notes:							Road Name:	Road Length: 6.0 miles
							Road No.: A	Road Surface: Asphalt
							Road Class:	Speed Limit:
Mile Post	**General**	**Intersections / RR Crossings**	**Signage /Pavement Markings**	**Fixed Objects/ Clear Zones**	**Shoulder / ROW**	**Segment Score**		
0.0 - 1.0	5	7	4	7	2	25	No shoulder	
1.1 - 2.0	5	7	4	7	2	25		
2.1 - 3.0	6	7	4	2	2	21	Power pole in clear zone	
3.1 - 4.0	6	6	5	7	2	26		
4.1 - 5.0	5	7	5	7	2	26		
5.1 - 6.0	6	7	5	7	2	27		

Table 7 presents an example of ranking the Level 1 scores.

Table 7. Example of Level I Ranking

Line Number	Route	Mile Post	Level 1 Score	Level 1 Rank
1	A	2	20	1
2	B	4	24	2
3	A	3	25	3
4	C	6	25	3
5	C	10	27	5

In the Field Examples

Figure 7 presents a Level 1 field example displaying a main intersection with a railroad crossing. When providing a Level I field evaluation score, this intersection may receive a nine in the General and Fixed Object/Clear Zone category, as it is in respectable shape relative to these categories. This roadway may receive a score of four in the Signage and Pavement Marking category, due to the faded pavement markings. Even though there are not any pavement markings designating a shoulder, the roadway is wide with no presence of hazards along the shoulder. Thus, this could receive a score of eight in the ROW/Shoulder category. It may also receive a score of three in the Intersection/RR crossings since an advanced railroad crossing warning sign is not present. The total segment score of this intersection would be 33.

Figure 7. Field Example 1

Figure 8 shows another field example of an adequate roadway with minimal shoulder width. Overall, this roadway is in good condition, thus it may receive a score of nine in the General category. This roadway may receive a score of four in the Signage and Pavement Marking category due to the faded pavement markings. It may also receive a score of five in the ROW/Shoulder category as it has a minimal shoulder width.

Figure 8. Field Example 2

Figure 9 presents a roadway that may receive a score of three in the ROW/Shoulder category for the absence of an adequate shoulder. It may also receive a score of five in the Signage and Pavement Marking category because of the poor visibility of an advisory speed limit and reduced speed ahead sign. It also has a faded centerline. However, it may be given a score of nine in the other three categories due to the satisfactory conditions in terms of these categories.

Figure 9. Field Example 3

Figure 10 depicts another real life example of comparatively good roadway. It may receive a score of eight in the ROW/Shoulder category due to an adequate shoulder width. This roadway has good sight distance, pavement markings, a large clear zone and adequate roadway infrastructure. Thus, it may be given a score of eight or nine in each of the other four categories.

Figure 10. Field Example 4

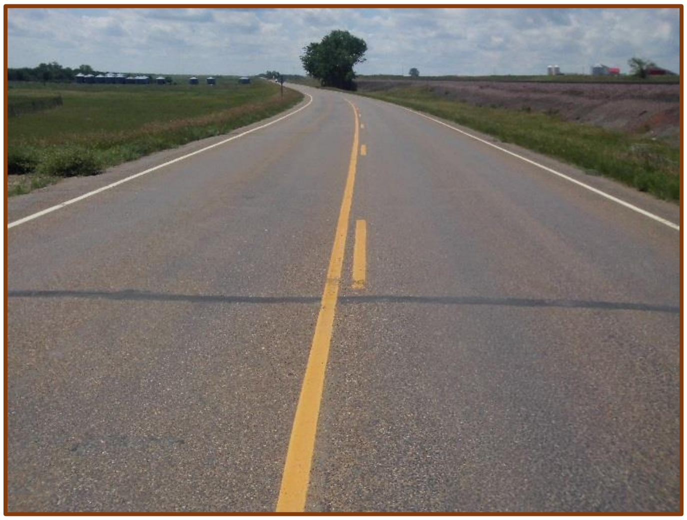


Figure 11 presents another real life example displaying a roadway with a very small shoulder. When providing a Level I field evaluation score, it may receive a score of four in the ROW/Shoulder category due to its width. However, since the roadway seems to be in adequate shape, it may get a score of nine in all other categories.

Figure 11: Field Example 5

Figure 12 shows an example of a gravel road. When providing a Level I field evaluation score, this roadway may receive a score of seven in the General category, due to the presence of loose aggregate/gravel potentially causing a safety hazard. It may get a score of nine in all other categories.

Figure 12. Field Example 6

Figure 13 also depicts another real life example of a gravel road. When providing a Level I field evaluation score, this roadway may receive a score of three in the General category, due to the presence of loose aggregate/gravel significantly affecting the safety of the roadway. It may receive a score of nine in each of the other four categories.

Figure 13. Field Example 7

A gravel road with a culvert crossing depicted in Figure 14 may receive a score of four in the Clear Zone/Fixed Object category due to narrow bridge with damaged guardrail. It may also receive a score of seven in the General category due to loose aggregates. However, since this roadway seems to be in good shape in terms of the other three categories, it may receive a score of eight or nine.

Figure 14. Field Example 8

Figure 15 displays a field example of a roadway with a sharp horizontal curve. An advanced warning sign is not present on this road. Poor visibility due to presence of vegetation may also contribute to safety issues. In a Level I field evaluation, this roadway may receive a score of four in the Signage and Pavement Marking category. However, it may receive a score of eight or nine in the other categories of a Level I field evaluation.

Figure 15. Field Example 10

Figure 16 shows a roadway with serious pavement surface distress. When providing a Level I field evaluation, it may receive a score of one in the General category due to significant potholes in the roadway, and a score of four in the Pavement Marking category due to missing edge line markings. However, it may get an eight or nine in the other categories.

Figure 16. Field Example 11

Figure 17 depicts real life example of a gravel road in poor condition. When providing Level I field evaluation, it may receive a score of one in the General category due to gravel defects and ponding or sheet flow areas that could result in safety problems. Nevertheless, it may receive a score of eight or nine in the other categories.

Figure 17. Field Example 12

Professional Examples

Wind River Indian Reservation (WRIR) Implementation

This methodology was implemented on the Wind River Indian Reservation (WRIR) county and Indian Reservation roads (IRRs). This example can assist your Tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe.

An example of the spreadsheets developed for each roadway can be observed in Figure 18. This process is very subjective. The evaluating team consisted of three individuals. One member from WYT^2/LTAP, one Tribal transportation member, and one BIA engineering consultant comprised the team that was selected by the Tribes. Each individual evaluated each roadway and the values were combined and averaged. By performing all roads together with the same individuals, relative results were produced that were sufficient to providing a field verification of crash results.

This process was repeated for each segment of each roadway that was selected from the crash ranking. See WRIR example in Chapter 1. Each roadway ranged from one mile to up to 23 miles long. Field decisions were made by WRIR team members to reduce the length evaluated based on knowledge of recent or upcoming construction and maintenance that would address safety issues.

Once evaluation of all the roads was complete, the segment scores were tabulated. The combined score for each segment was assigned and the segments were sorted from lowest to highest score. From this, ranking was assigned starting at the number one. Progressing through the list, equal scores received equal rank. The next rank number would then be that associated with the total number of segments ranked so far. Table 8 provides as an example and summarizes the Level I ranking for this case study.

Figure 18. Example of a Level I Field Evaluation for the WRIR on Ethete Rd.

WRIR Level I Field Evaluation	Evaluator: LTAP & WRIR	Date: 6/5/12	Page: of
Notes: Combined data. a lot of pedestrian, a lot of entrances, school, no pvmt markings, no delineators, no intersection signage, open ditch.		Road Name: Ethete Road	Road Length:
		Road No.: ML5828 (Co. Rt. 335)	Road Surface:
		Road Class:	Speed Limit:

Mile Post	General	Intersections / RR Crossings	Signage / Pavement Markings	Fixed Objects/ Clear Zones	Shoulder / ROW	Segment Score	Comments
0.0 - 1.0	8	6	7	8	8	37	wide shoulders, reconstructed 5 yrs ago
1.01 - 2.0	8	8	8	8	8	40	1 fatality crossing centerline
2.01 - 3.0	8	8	8	8	8	40	
3.01 - 4.0	8	8	8	8	8	40	
4.01 - 5.0	8	8	8	8	8	40	
5.01 - 6.0	7	4	3	3	3	20	Section evaluated from 5.6 - 6.0 only. First .6 new construction.
6.01 - 7.0	6	6	5	5	4	26	busy int no signs
7.01 - 8.0	5	6	2	6	2	21	90 turns, wrong speed warning sign, drop off at curve
8.01 - 9.0	5	7	2	4	3	21	2 sharp curves
9.01 - 10.0	7	7	5	5	3	27	fairly straight, no shoulders, some drop off
10.01 - 10.5	7	7	6	7	3	30	
							verify mile mark direction

WRIR Segment Score	WRIR Segment Score	Average
47	44	43
48	45	44
48	45	44
48	45	44
48	44	44
23	16	20
25	20	24
20	20	20
24	21	22
24	22	24
24	23	26

Table 8. Level I Evaluation Ranking on the WRIR Local Roadways

Row No.	County Route	Road Name	Beg MP	End MP	Total Crashes	Level I Score	Level I Rank
1	273	Cliff Drive	0.0	1.0	3	18	1
2	335	Ethete Road	5.01	6.0	6	20	2
3	335	Ethete Road	7.01	8.0	2	20	2
4	339	Two Valley Road	2.01	3.0	0	21	4
5	347	Trout Creek Road	3.01	4.0	2	21	4
6	335	Ethete Road	8.01	9.0	1	22	6
7	347	Trout Creek Road	0.0	1.0	1	23	7
8	347	Trout Creek Road	1.01	2.0	2	23	7
9	331	Buckhorn Flats Road	1.01	2.0	0	24	9
10	335	Ethete Road	6.01	7.0	4	24	9
11	335	Ethete Road	9.01	10.0	1	24	9
12	345	North Fork Road	5.01	6.0	1	24	9
13	346	South Fork Road	2.01	3.0	5	24	9
14	480	Kinnear Spur Road	0.0	1.0	3	24	9
15	345	North Fork Road	4.01	5.0	1	25	15
16	463	Peterson Road	0.0	1.0	2	25	15
17	463	Peterson Road	1.01	2.0	2	25	15
18	463	Peterson Road	2.01	3.0	1	25	15
19	480	Kinnear Spur Road	1.01	2.0	4	25	15
20	1	Owl Creek Road	2.01	3.0	0	26	20
21	1	Owl Creek Road	3.01	4.0	2	26	20
22	330	East Pavillion Road	1.01	2.0	2	26	20
23	339	Two Valley Road	4.01	5.0	2	26	20
24	345	North Fork Road	0.0	1.0	2	26	20
25	345	North Fork Road	2.01	3.0	5	26	20
26	346	South Fork Road	3.01	4.0	1	26	20
27	347	Trout Creek Road	2.01	3.0	3	26	20
28	1	Owl Creek Road	4.01	5.0	1	27	28
29	1	Owl Creek Road	5.01	6.0	2	27	28
30	1	Owl Creek Road	6.01	7.0	0	27	28
31	54	Riverview Road	6.01	7.0	6	27	28
32	272	Hutchinson Road	0.0	1.0	5	27	28
33	315	Paradise Valley Road	9.01	10.0	2	27	28
34	345	North Fork Road	1.01	2.0	4	27	28
35	367	Pingetzer Road	0.0	1.0	5	27	28
36	463	Peterson Road	3.01	4.0	1	27	28
37	54	Riverview Road	2.01	3.0	18	28	37
38	54	Riverview Road	5.01	6.0	5	28	37
39	339	Two Valley Road	0.0	1.0	1	28	37

Sisseton Wahpeton Oyate (SWO) Implementation

Due to the success of the Wind River Indian Reservation implementation of the safety improvement program, tribes across the country became interested in implementing their own program. WYT^2/LTAP and the Northern Plains Tribal Technical Assistance Program (NPTTAP) collaborated to develop a regional implementation for the Northern Plains. The methodology was implemented on the Sisseton Wahpeton Oyate Reservation roads. This example can assist your Tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe.

Refer to Chapter 1 for the previous step in this example. After consultation with the Tribe, 21 roads were selected to be evaluated. The evaluating team consisted of four individuals, SWO Transportation Safety Officer, WYT^2/LTAP, Northern Plains TTAP, and South Dakota LTAP.

Each roadway ranged from two mile to up to 18 miles long. Field decisions were made by SWO team members to reduce the length evaluated based on knowledge of recent or upcoming construction and maintenance that would address safety issues. Looking at the hotspots in the context of the entire roadway is a practical approach to address roadway safety improvements. For example, if the field evaluation reveals that the roadway is in poor condition, pavement markings are missing, or shoulders are narrow, the improvement would not only be applied to the hotspot but to the entire portion of the roadway.

Once evaluation of all the roads was complete, the segment scores were tabulated. The overall Level I score for each segment was assigned and the segments were sorted from lowest to highest score. From this, ranking was assigned starting at the number one (1). Progressing through the list, equal scores received equal rank. The next rank number would then be that associated with the total number of segments ranked so far. Table 9 summarizes the Level I ranking for the top 55 segments.

Table 9. Level I Evaluation Ranking on the SWO Local Roadways

Highway	Beg MP	End MP	Level I Score	Level I Rank	Highway	Beg MP	End MP	Level I Score	Level I Rank
456 Ave	1	2	7	1	118 St	2	3	21	28
446 Ave (S)	7	8	10	2	118 St	3	4	21	28
455 Ave (S)	0	1	12	3	Lake Rd	4	5	21	28
455 Ave (S)	11	12	14	4	455 Ave (S)	4	5	22	31
446 Ave (S)	6	7	16	5	455 Ave (S)	5	6	22	31
456 Ave	0	1	16	5	455 Ave (S)	7	8	22	31
456 Ave	2	3	16	5	459/458 Ave	1	2	22	31
456 Ave	3	4	16	5	Lake Rd	0	1	22	31
462 Ave	0	1	17	9	Lake Rd	1	2	22	31
459/458 Ave	0	1	18	10	Lake Rd	2	3	22	31
462 Ave	4	5	18	10	Lake Rd	3	4	22	31
123 St	0	1	19	12	Lake Rd	5	6	22	31
123 St	1	2	19	12	Lake Rd	6	7	22	31
123 St	2	3	19	12	Lake Rd	7	8	22	31
123 St	3	4	19	12	Lake Rd	8	9	22	31
123 St	4	5	19	12	Lake Rd	9	10	22	31
446A/446 Ave	0	1	19	12	Lake Rd	10	11	22	31
446A/446 Ave	1	2	19	12	Lake Rd	11	12	22	31
446A/446 Ave	2	3	19	12	118 St	0	1	23	46
446A/446 Ave	3	4	19	12	118 St	1	2	23	46
462 Ave	1	2	19	12	164 St	0	1	23	46
462 Ave	2	3	19	12	164 St	1	2	23	46
462 Ave	3	4	19	12	164 St	2	3	23	46
127 St	12	13	20	24	455 Ave (S)	6	7	23	46
127 St	13	14	20	24	455 Ave (S)	8	9	23	46
127 St	14	15	20	24	455 Ave (S)	9	10	23	46
127 St	15	16	20	24	455 Ave (S)	10	11	23	46
					Lohre Rd	8	9	23	46

Data from Existing Plans, Documents or Other Agencies

Safety policies and planning documents may contain information which would be helpful in Level I field evaluation. Examples of these documents are given below:

- **Safety Evaluation for Roadways (SAFER) Manual.** This manual was developed by the University of Wisconsin– Madison, Department of Engineering Professional Development with support from the Federal Highway Administration, the Wisconsin Department of Transportation, and UW–Extension. It is designed to provide background information and offer an approach for reviewing safety conditions on local roads and streets. It also helps local officials with setting priorities and planning for both immediate action and future improvements.

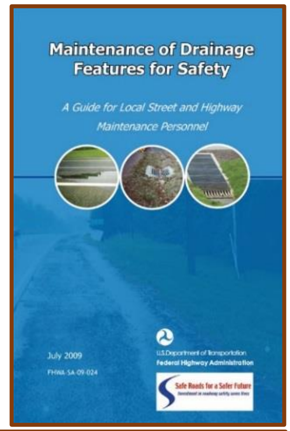
  The SAFER Manual provides a one to five rating scale to rate roads depending on the urgency of the corrective action that is necessary. The manual has over 100 photographs of common safety concerns on topics such as roadsides, intersections, rail crossings, geometric issues, singing and pavement markings, road maintenance and other special conditions. Electronic version of the SAFER Manual can be accessed at: https://localroads.wisc.edu/content/safety-evaluation-roadways-safer-manual.

- **FHWA Maintenance of Signs and Supports.** The FHWA prepared this guide in 2010. Sign principals, types of sign, installation of signs, signs location etc. are discussed in this guide to help local agency practitioners and maintenance staff . Section 8 discusses inspection methods and offers maintenance staff a sign inspection checklist that is very helpful for conducting routine inspection.
  An electronic copy of the manual is available here:
  https://safety.fhwa.dot.gov/local_rural/training/fhwasa09025.

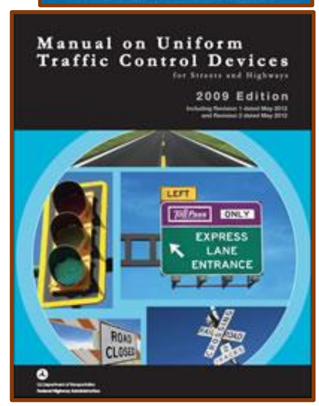
- **Vegetation Control for Safety.** This guide was made by FHWA in 2008. It aids local agency maintenance staff in identifying locations where vegetation control is essential to enhance traffic and pedestrian safety. The main goals of vegetation control include:
  - Keeping signs visible to drivers.
  - Keeping road users (vehicles, bicycles and pedestrians) visible to drivers.
  - Improving visibility of livestock and wildlife near the road.
  - Helping pedestrians and bicyclists see motor vehicles.
  - Keeping sidewalks and pedestrian paths clear and free from overhanging vegetation.
  - Removing trees close to the roadway which could result in a severe crash if hit.
  - Improving winter road maintenance in snow and ice areas.
  - Helping drainage systems function as designed.
  - Preserving pavements through daylighting and root system control.

Electronic copy of the manual can be accessed at the link: https://safety.fhwa.dot.gov/local_rural/training/fhwasa07018/.

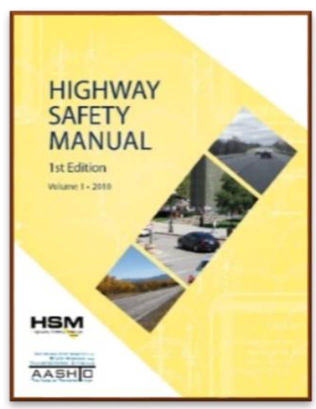
- **Maintenance of Drainage Features for Safety.** This guide was published in 2009 to assist local maintenance staff in understanding the importance of maintaining and upgrading drainage features on their road system and the potential impacts to road safety. A way to recognize drainage problems and a way to correct drainage features are given in this document to guide the maintenance staff. A field inspection check list with conditions indicative of a drainage problem is also provided on the guide. An electronic copy of the manual is available here: https://safety.fhwa.dot.gov/local_rural/training/fhwasa09024/



- **Manual on Uniform Traffic Control Devices (MUTCD).** The MUTCD administered by the FHWA since 1971, is an assemblage of national standards for all traffic control devices, including road markings, highway signs, and traffic signals. It is updated periodically to accommodate the nation's changing transportation needs and address new safety technologies, traffic control tools and traffic management techniques. The most current edition of the MUTCD is from 2009.
  An electronic copy of the manual is available here: https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm.



- **AASHTO Highway Safety Manual.** AASHTO published the first edition of Highway Safety Manual (HSM) in 2010. The manual consists of four major sections: fundamentals, roadway safety management, predictive method and crash modification factors. Crash frequency and equivalent property damage only methods are explained in Chapter 4: crash frequency.
  An electronic copy of the manual is available here: http://www.highwaysafetymanual.org/Pages/default.aspx.



- **FHWA Roadway Departure Safety: A Manual for local Rural Road Owners.** FHWA prepared this manual to provide local practitioners information on identifying locations with historical or potential rural roadway departures crashes and countermeasures to address these locations. The manual also explicates how crash rates can be effective in comparing different network segments and can account for the Level of exposure.
  An electronic copy of the manual can be found in the following link: https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/fhwasa1109.pdf.

- **FHWA Intersection Safety. A Manual for Local Rural Road Owners.** This manual provide information on effectively identifying intersection safety issues in local areas. It also helps in choosing the countermeasures that address them, and evaluating the benefits of these countermeasures. It was also developed by the FHWA.
  An electronic copy of the manual is available here:
  https://safety.fhwa.dot.gov/local_rural/training/fhwasa1108/fhwasa1108.pdf

- **Road Safety Information Analysis: A Manual for Local Rural Road Owners.** FHWA developed this manual to provide information on crash data collection and analysis techniques specifically applicable to local and tribal practitioners with limited resources. Usage of crash rate to compare relative safety to other similar roadways, segments or intersections in the jurisdiction, region and state is also given in this manual.
  Virtual copy of the manual can be reached at:
  https://safety.fhwa.dot.gov/local_rural/training/fhwasaxx1210/lrro_data.pdf.

- **FHWA Systematic Safety Project Selection Tool.** The Systematic Safety Project Selection Tool guidebook developed by FHWA offers practitioners a step by step process for conducting systematic safety planning, considered for balancing investments in spot specific and systematic safety improvements and analytical techniques for quantifying the benefits of a systematic safety program. In the systematic safety approach, crashes are evaluated to identify road characteristics, including road width, shoulder width, and sight distance that are present at a large number of crash sites across the road network. Then countermeasures are identified and implemented to address these common risk factors.
  An electronic copy of the manual is available here:
  https://safety.fhwa.dot.gov/systemic/fhwasa13019/sspst.pdf.

Chapter 3. Combined Ranking

Overview

The results of a combined ranking between the crash ranking and the Level I ranking provides a list of high priority locations. Though every identified high crash location should be considered for determining countermeasures, it may not be possible to take care of all locations due to funding and resource constraints. In this step, the two rankings, crash ranking and Level I rankings are combined by sorting each route and adding respective ranks to the respective segment. After the ranks were tabulated, the segments were again sorted from smallest to largest to determine which segments are in need of immediate countermeasures.
This section shows the methodology and example of a combined ranking provided for:

- Selecting the roads that would be evaluated for safety improvements.
- Allocating funds on the roadway segments that are considered the most hazardous.
- Integrating a particular hazardous site into the upcoming maintenance plans or construction projects.
- Reducing fatalities or serious injuries by taking the necessary steps.

Application of the Combined Ranking

Combining the Ranking

The third step in the safety evaluation process is to combine the crash ranking with the Level I rankings. Crash ranking (**Step 1**) and Level I rankings (**Step 2**) are tabulated and combined to develop a final ranking for the Level II field evaluation. To determine the final rankings, the numerical values of the crash rank and the Level 1 rank are added together. The newly tabulated segments contain information on the road name or number, beginning mile post, ending mile post, crash ranking, Level 1 ranking and finally the combined ranking. Table 10 provides an example of how the crash rank and Level I rank are combined.

The segments are then sorted by the combined rank value, smallest to largest. The segments with the smallest numbers are considered the most hazardous. From these segments, the roads with the smallest combined ranking value are considered for Level II field evaluation for determining countermeasures. Although other segments of the same road may have a much lower rank, each road is looked at in its entirety for safety improvements. Ten to fifteen roads should be selected for the Level II evaluation. Table 11 depicts an example of routes selected from the combined ranking.

Table 10. Example of Combining Crash Rank and Level I Rank

Route	Beg MP	End MP	Total Crashes	Crash Rank	Level I Rank	Combined Rank
A	0	1	2	14	15	29
A	1.01	2	4	12	10	22
A	2.01	3	2	14	13	27
A	3.01	4	14	2	1	3
A	4.01	5	12	4	3	7
B	0	1	14	2	2	4
B	1.01	2	8	6	12	18
B	2.01	3	9	5	2	7
C	0	1	9	8	9	17
C	1.01	2	15	1	3	4
D	0	1	3	10	11	21
D	1.01	2	11	2	5	7
E	0	1	1	20	6	26
E	1.01	2	4	8	4	12

Table 11. Example of Top Five Roads Selected from Combined Ranking

Route	Total Crashes	Crash Rank	Level I Rank	Combined Rank
A	14	2	1	3
C	15	1	3	4
D	14	2	5	7
B	9	5	2	7
E	4	8	4	12

The rankings along with the selected roads are provided for review and approval to proceed with the Level II evaluation. The Tribes have the option of including more sites or adjusting the rankings based on their insights.

Professional Examples

Wind River Indian Reservation (WRIR) Implementation

Referring to the example of crash ranking and Level I evaluation on Wind River Indian Reservation, combined ranking of the previous two steps were performed. With a list of all the segments ranked by highest number crashes and lowest Level I score, the two rankings were combined. This was done by sorting each route and adding the respective ranks for the respective segment.

Once these were all totaled, then the segments were sorted from smallest to largest combined rank value. The road segments with the lowest score were used to select the roads that would be evaluated for safety improvements. Table 12 is a list of the top twelve roads with their respective combined ranking.

It displays a list of the top twelve roads with their respective combined ranking and presents information regarding: the roadway name, beginning mile post, end mile post, crash rank, Level I ranking and combined ranking. The road segments with the lowest rank were used to select the roads that would be evaluated for safety improvements.

Table 12. Combined Ranking of the Top 12 Roads on the WRIR.

County Route	Road Name	Beg MP	End MP	Crash Rank	Level 1 Rank	Combined Rank
335	Ethete Road	5.01	6.0	14	2	16
346	South Fork Road	2.01	3.0	21	9	30
54	Riverview Road	2.01	3.0	1	37	38
273	Cliff Drive	0.0	1.0	37	1	38
345	North Fork Road	2.01	3.0	21	20	41
480	Kinnear Spur Road	1.01	2.0	26	15	41
272	Hutchinson Road	0.0	1.0	21	28	49
367	Pingetzer Road	0.0	1.0	21	28	49
347	Trout Creek Road	3.01	4.0	47	4	51
320	Burma Road	0.0	1.0	4	50	54
463	Peterson Road	0.0	1.0	47	15	62
385	Eight Mile Road	1.01	2.0	7	57	64

When comparing the combined ranking, crash rankings and the Level I rankings, it can be deceiving as to which highways should take priority to ensure improvement. When observing the crash rankings, one would conclude that county route 54 is the most hazardous one that needs immediate countermeasures. However, when observing the combined rankings, one would conclude that county route 335 should be considered as the most hazardous road.

Sisseton Wahpeton Oyate (SWO) Implementation

Referring to the example of crash ranking and Level I evaluation on the Sisseton Wahpeton Oyate Reservation the two rankings were combined. The crash rankings were first redone matching the one-mile segments to the Level I one-mile segments for each route. Then the respective ranks for the respective segments were added.

Once these were all totaled, then the segments were sorted from smallest to largest combined rank value. The road segments with the lowest score were used to select the roads that would be evaluated for safety improvements. Table 13 is an example of the combined rank that was performed in this safety evaluation. Table 13 presents information regarding the top two roadways with the highest Level 1 rank within the SWO Reservation.

Table 13. Combined Ranking of the Top Segments on the SWO.

Highway	Beg MP	End MP	Total Crashes	Crash Rank	Level I Score	Level I Rank	Combined Rank
101 St	0	1	2	37	33	188	225
101 St	1	2	1	85	33	188	273
101 St	2	3	0	128	33	188	316
101 St	3	4	0	128	33	188	316
101 St	4	5	0	128	32	177	305
101 St	5	6	0	128	32	177	305
101 St	6	7	1	85	32	177	262
101 St	7	8	0	128	32	177	305
101 St	8	9	2	37	32	177	214
101 St	9	10	2	37	32	177	214
101 St	10	11	0	128	26	77	205
101 St	11	12	0	128	26	77	205
101 St	12	13	0	128	26	77	205
101 St	13	14	2	37	26	77	114
101 St	14	15	0	128	26	77	205
101 St	15	16	0	128	26	77	205
101 St	16	17	0	128	26	77	205
101 St	17	18	0	128	26	77	205
118 St	0	1	0	128	23	46	174
118 St	1	2	0	128	23	46	174
118 St	2	3	2	37	21	28	65
118 St	3	4	3	17	21	28	45

Chapter 4. Level II Field Evaluation

Overview

After the priority sites have been identified by the Tribes through **Step 2** and **Step 3**, the next step is to perform a Level II Field Evaluation. This step will identify potential countermeasures to address the identified safety concerns. It is suggested that the evaluation team performing the Level I field evaluation is that same team that performs the Level II field evaluation for maintaining consistency. In order to maximize resources the Level I field evaluation may be performed at the same time as the Level II field evaluation. The WYT^2/LTAP Center can also provide assistance on a Level II field evaluation if needed.

A Level II Field Evaluation **may be performed at the same time** as a Level I Field Evaluation in order to maximize time and resources.

In this step, additional data such as speed, congestion Levels, traffic counts, review of behavioral factors, and other casual factors that may influence the judgement of safety countermeasures may need to be collected. Single or multiple countermeasures can be implemented on one or multiple locations depending on needs, budgets, and local priorities. Relevant documents, other readily available resources, assistance from a variety of organizations and agencies can be referenced as support for a Level II evaluation.

Application of a Level II Field Evaluation

Performing a Level II Field Evaluation

If access to traffic-volume collection equipment is not accessible, this step can be considered optional. Contact your local DOT, TTAP, or LTAP center for assistance. They may be able to supply previously collected AADT information.

A Level II field evaluation is aimed at identifying causative factors on each road section and selecting corresponding countermeasures. It will be performed on roadways that are identified as high risk locations based on the combined rankings from **Step 3**. Crash records contain the crash information (e.g. run off road crash, animal related crash, etc). The crash records associated with these high-risk locations will be helpful to identify causative factors and select appropriate safety countermeasures. As an example, if most of the crashes are animal related at one road segment, installing animal fence at this segment might be helpful to reduce the number of crashes.

Level II field evaluation consists of three major steps:

- Collect traffic volumes on the selected roads for seven days.

- Review the list of safety issues to look for as described in the following section.
- Perform Level II field evaluation for each high-risk road, using the Level II field evaluation form shown in Figure 19 and Figure 20.

General guidelines are provided in the following sections to help in performing a Level II field evaluation. An example of performing Level II field evaluations are presented in this chapter. Once the Tribes have identified their priority sites, an evaluation team performs the Level II field evaluation on each of the selected routes. Further data may need to be collected for the next Levels of the safety improvement program. Such data could include speeds, congestion Levels, traffic counts, review of behavioral factors, and other casual factors that may influence the judgement of safety countermeasures.

Some typical countermeasures that are considered low cost safety improvements include the installation of advanced warning signs, chevrons at curves, delineators and pavement markings. Other countermeasures that may require design that is more intensive would be culvert-widening, installation of guardrail, and flashing warning beacons. Countermeasures should be considered based on the types of crashes and their frequency at the locations. Each route is re-evaluated, and proposed countermeasures are finally identified.

A collaborative exercise is essential that entails making decisions as a team on what can and should be done for the various locations. A spreadsheet for each road should be developed to record all possible improvements identified. As each road is driven and possible improvements are identified, these are recorded on the spreadsheet. Figure 19 and Figure 20 present an example of a Level II field evaluation form. Not every column or row will be filled with information; the goal of this spreadsheet is to take note of safety hazards observed in the field, thus safety hazards will vary throughout different locations.

Performing a Level II Field Evaluation at the Same Time as a Level I Field Evaluation

In order to maximize time, resources, and keep the evaluators consistent, it may be in the best interest of the reservation to conclude a Level I field evaluation with the Level II field evaluation. This would require the team to perform the steps described in this chapter at the same time they are performing the steps in **Chapter 2**.

This may sound confusing considering the purpose of **Chapter 3**, but occasionally tribes may find that they would like to identify countermeasures for all roadways involved in the safety evaluation, and not just the segments or roadways that appeared on the combined ranking analysis. This decision can be made at the discretion of the tribes. It will directly apply to a situation where every road should be reviewed and considered for countermeasure implementation. This can be called a systematic approach where the team of evaluators provide the numerical ratings as described in **Chapter 2**, and take notes of desired countermeasures to improve the safety hazard at the same time. Both processes should be followed as described in each Chapter; however, they are performed simultaneously and **Step 3** will be performed after both the Level I and Level II field evaluations.

Figure 19. Level II Field Evaluation Form (Example)

Level II Field Evaluation	Evaluator:	Date:	Page:
Notes:			
	Road Name:	Road Length:	
	Road No.:	Road Surface:	
	Road Class:	Speed Limit:	

Condition #	Locations	Horizontal Middle Ordinate (M)	Horizontal Degree of Curvature (D)	Horizontal Curve Stopping Sight Dist.	Vertical Curve: Crest or Sag	Vertical Curve Stopping Sight Dist.	Steep Slope	Intersection Stopping Sight Dist.	Signs	Pavement Markings	Delineators	Roadway Width	Shoulder Width	Bridge Width	Fixed Objects in ROW	Fencing	Cattle Guard
#1																	
#2																	
#3																	
#4																	
#5																	
#6																	
#7																	
#8																	
#9																	
#10																	

Immediate Safety Improvements:

Low-Cost Safety Improvements:

High-Cost Safety Improvements:

Figure 20. Completed Level II Field Evaluation Form (Example)

Level II Field Evaluation	**Evaluator: F. Jones**	**Date: 7/22/07**	**Page: 1 of 1**
Notes:	**Road Name: Test**	**Mile Post: 1.00 to 2.00**	
	Road No.: 401	**Road Surface: Asphalt**	
	Road Class: Minor Collector	**Speed Limit: 55**	

Condition #	Locations	Horizontal Middle Ordinate (M)	Horizontal Degree of Curvature (D)	Horizontal Curve Stopping Sight Dist.	Vertical Curve: Crest or Sag	Vertical Curve Stopping Sight Dist.	Steep Slope	Intersection Stopping Sight Dist.	Signs	Pavement Markings	Delineators	Roadway Width	Shoulder Width	Bridge Width	Fixed Objects in ROW	Fencing	Cattle Guard
#1	1.0 - 2.0									Needed	Needed					Needed	
#2	1.2								2								
#3	1.25						2										
#4	1.5	4	18d15'		Crest	350'			4								
#5	1.7	9	40d00'						2								
#6																	
#7																	
#8																	
#9																	
#10																	

Immediate Safety Improvements: 1.2 - Minor horizontal curve, Check placement and retroreflection of curve sign and/or add MPH curve sign W13-5,
install Do Not Pass sign R4-1 on both ends of curve.
1.25 - Minor steep foreslope, Install additional delineator posts, install guardrail.
1.5 - Vertical and horizontal curve, stopping sight distance is 350', Install Curve sign W1-2 or MPH curve sign W13-15. Install Do Not Pass Sign R4-1 on both ends.
1.7 - Minor horizontal curve, Install curve signs W1-2, or MPH sign W13-15 on both ends.

Low-Cost Safety Improvements: 1.0 to 2.0 - Install pavement markings, replace broken and missing delineator posts.

High-Cost Safety Improvements: 1.2 - Improve alignment.
1.25 - Extend culvert, fill and flatten foreslope.
1.5 - Improve alignment.
1.7 - Improve alignment.

In the Field

Safety Issues to Look For

The following examples describe what safety issues an evaluator may observe when performing a Level II field evaluation.

A. Roadside Features

a) Are clear zones free of hazards and non-traversable side slopes without safety barriers?
b) Are the clear zones free of nonconforming and/or dangerous obstructions that are not properly shielded?

B. Road Surface-Pavement Condition

a) Is the pavement free of defects that could result in safety problems (e.g., loss of steering control)?
b) Are changes in surface type (e.g., pavement ends or begins) free of poor transitions?
c) Is the pavement free of locations that appear to have inadequate skid resistance that could result in safety problems, particularly on curves, steep grades, and approaches to intersections?
d) Is the pavement free of areas where ponding or sheet flow of water may occur resulting in safety problems?
e) Is the pavement free of loose aggregate/gravel, which may cause safety problems?

C. Road Surface-Pavement Markings

a) Is the road free of locations with pavement marking safety deficiencies?
b) Is the road free of pavement markings that are not effective for the conditions present?
c) Is the road free of old pavement markings that affect the safety of the roadway?

D. Road Surface-Unpaved Roads

a) Is the road surface free of defects that could result in safety problems (e.g., loss of steering control)?
b) Is the road surface free of areas where ponding or sheet flow of water may occur resulting in safety problems?
c) Is the road surface free of loose gravel or fines that may cause safety problems (control, visibility, etc.)?
d) Are changes in surface type (e.g., pavement ends or begins) free of drop-offs or poor transitions?

E. Signing and Delineation

a) Is the road free of locations where signing is needed to improve safety?
b) Are existing regulatory, warning, and directory signs conspicuous?
c) Is the road free of locations with improper signing which may cause safety problems?
d) Is the road free of unnecessary signing which may cause safety problems?
e) Are signs effective for existing conditions?
f) Can signs be read at a safe distance?

g) Is the road free of signing that impairs safe sight distances?
h) Is the road free of locations with improper or unsuitable delineation (post delineators, chevrons, and object markers)?

F. Intersections and Approaches

a) Are intersections free of sight restrictions that could result in safety problems?
b) Are intersections free of abrupt changes in elevation or surface condition?
c) Are advance warning signs installed when intersection traffic control cannot be seen a safe distance ahead of the intersection?

G. Special Road Users, Railroad Crossings, Consistency

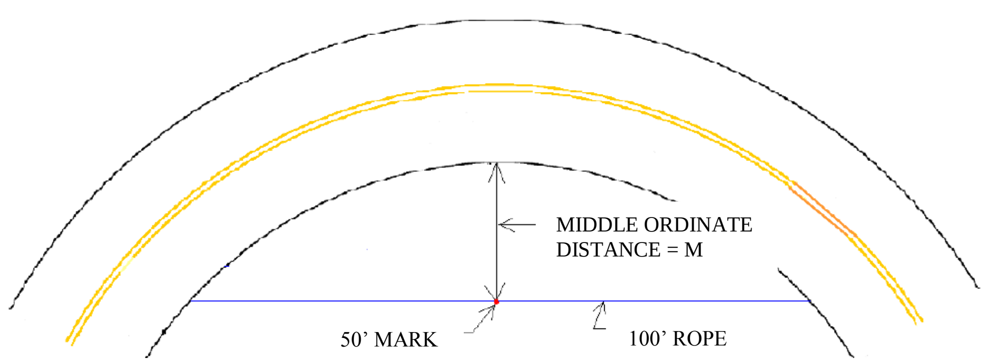
a) Are travel paths and crossing points for pedestrians and cyclists properly signed and/or marked?
b) Are bus stops and mail boxes safely located with adequate clearance and visibility from the traffic lane?
c) Is appropriate advance signing provided for bus stops and refuge areas?
d) Are railroad crossing (cross bucks) signs used on each approach at railroad crossings?
e) Are railroad advance warning signs used at railroad crossing approaches?
f) Are railroad crossings free of vegetation and other obstructions that have the potential to restrict sight distance?
g) Are roadway approach grades to railroad crossings flat enough to prevent vehicle snagging?
h) Is the road section free of inconsistencies that could result in safety problems?

Guidelines for a Level II Field Evaluation

The following instructions are helpful when conducting the Level II field evaluations where horizontal curves, vertical curves, and other components may be a safety concern.

Horizontal Curve Evaluation. The WYT2/LTAP Center developed a simple procedure to measure a curve's radius in the field. As shown in Figure 21, use a 100-foot rope having a mark at 50 foot. Lay it on the shoulder of the road, pulling tight. At the 50-foot mark, measure the distance from the rope to the shoulder of the road. This measurement will give you the middle ordinate of the curve.

Figure 21. Measuring to Find Radius of Horizontal Curve



Use Figure 22 to find the radius and degree of curvature of the curve that corresponds to the measured middle ordinate.

Figure 22. Table of Radius and Degree of Curvature

M	Radius	Degree of Curvature	M	Radius	Degree of Curvature
0.5	2500	2°15'	10.5	124	46°
0.75	1667	3°30'	11	119	48°
1	1251	4°30'	11.5	114	50°
1.5	834	6°45'	12	110	52°
2	626	9°15'	12.5	106	54°
2.5	501	11°30'	13	103	55°45'
3	418	13°45'	13.5	99	57°45'
3.5	359	16°	14	96	59°30'
4	315	18°15'	14.5	93	61°15'
4.5	280	20°30'	15	91	63°
5	253	22°45'	15.5	88	64°45'
5.5	230	25°	16	86	66°30'
6	211	27°	16.5	84	68°15'
6.5	196	29°15'	17	82	69°45'
7	182	31°30'	17.5	80	71°30'
7.5	170	33°30'	18	78	73°
8	160	35°45'	18.5	77	74°30'
8.5	151	37°45'	19	75	76°
9	143	40°	19.5	74	77°30'
9.5	136	42°	20	73	79°
10	130	44°			

Compare the measured radius and degree of curvature to the minimum requirements out of the county fund manual. These requirements are summarized in Figure 23. As an alternative, counties can use the minimum requirements from the AASHTO policy on Geometric Design of Highways and Streets or the AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads.

Figure 23. Geometric Design Criteria

GEOMETRIC DESIGN CRITERIA FOR RRR PROJECTS COUNTY ROAD FUND MANUAL MARCH, 2000				
CURRENT ADT	0 - 400	400 - 750		>750
Lane Width[1]	10[2]	10[3]		11
Shoulder Width	2	2		2
Bridges Min. Width	Traveled way + 2 ft (each side)	Traveled way + 2 ft (each side)		Traveled way + 2 ft (each side)
	DESIGN SPEED (MPH)			
	20	30	40	50
Maximum Degree of Curvature (D)	49° 15'	21°	11° 15'	6° 45'

NOTES:

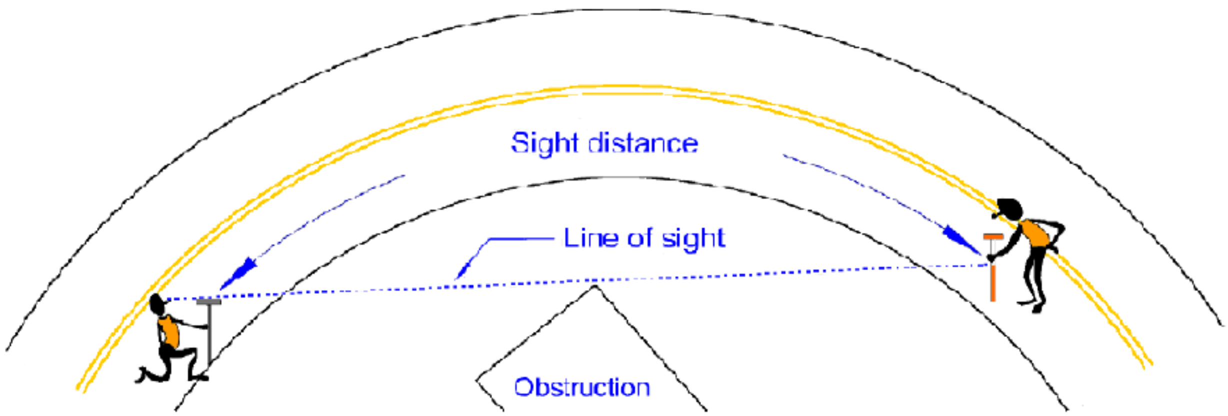
(1) Minimum desirable lane width is 11 feet. If feasible, 12 feet is preferable.

(2) 9' Lane width is allowable if the ADT is less than 100.

(3) Where truck volumes exceed 15%, minimums of 11 foot lanes are to be used.

Horizontal Curve Stopping Sight Distance. Measure the stop sight distance. As shown in Figure 24, stopping sight distance on all horizontal curves are measured along the travel path of the vehicle using a driver's eye height of 42 inches, looking at an object 24 inches high. To measure sight distance, kneel and use a 42-inch sighting stick to get your eyes at the proper height. Have an assistant move a 24-inch target stick until you cannot see the target. Measure the distance between the two to get the stopping sight distance.

Figure 24. Measuring Stopping Sight Distance for Horizontal Curves



Use the Table in Figure 25 to determine if the stopping sight distance is acceptable for the speed limit and traffic volumes.

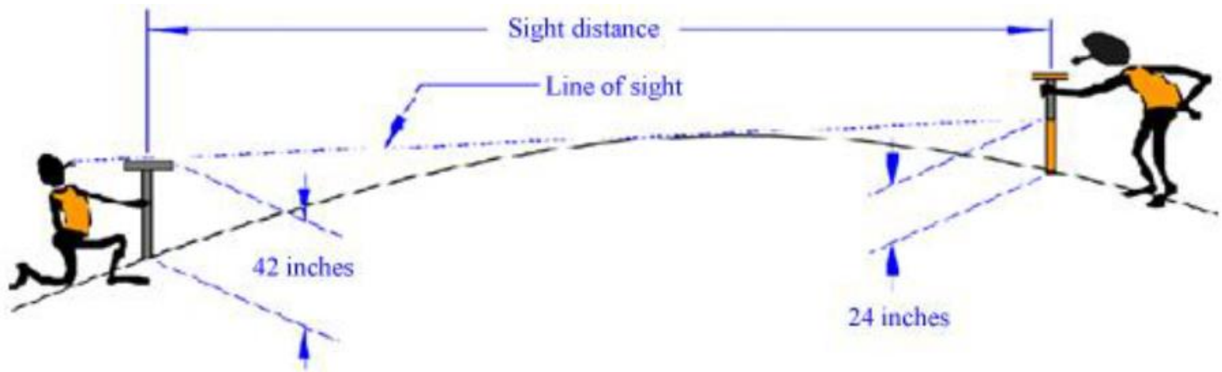
Figure 25. Stopping Sight Distance Form

Traffic speed[1], mph	Stopping Sight Distance, feet				
	0-100 veh/day	100-250 veh/day: Lower risk locations[2]	100-250 veh/day: Higher risk locations[2]	250-400 veh/day	>400 veh/day
25	115	115	125	125	155
30	135	135	165	165	200
35	170	170	205	205	250
40	215	215	250	250	305
45	260	260	300	300	360
50	310	310	350	350	425
55	365	365	405	405	495
60	435	435	470	470	570

[1]Choose a speed that includes most traffic on the road. If you know it, use the 85th percentile speed. This is the speed that 85% of traffic is not exceeding, and 15% is exceeding.
[2]Higher risk locations include features like intersections, narrow bridges, railroad grade crossings, sharp curves or steep downgrades. Lower risk locations are areas without such features
Based on AASHTO Geometric Design of Very Low-Volume Local Roads and "Green Book".

Vertical Curve Stopping Sight Distance. Measure stopping sight distance. As shown in Figure 26, stopping sight distance on all vertical curves are measured along the travel path of the vehicle using a driver's eye height of 42 inches, looking at an object 24 inches high. To measure sight distance, kneel and use a 42-inch sighting stick to get your eyes at the proper height. Have an assistant move a 24-inch target stick until you cannot see the target. Measure the distance between the two to get the stopping sight distance.

Figure 26. Measuring Stopping Sight Distance for a Vertical Curve



Use the stopping sight distance in Figure 25 to determine if the measured stopping sight distance is acceptable given the speed limit and traffic volumes.

Steep Slope. Determine if the fore-slope exceed maximum allowed per the AASHTO policy on Geometric Design of Highways and Streets or the AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads.

Intersections. Determine if safety improvements are needed at intersections.

Signs Needed. Are signs needed? Determine if existing signs meet the MUTCD requirements. Also determine if additional signs are needed.

Pavement Markings. Are pavement markings needed? Determine if existing pavement markings meet the MUTCD requirements. Also determine if additional pavement markings are needed.

Delineators. Are delineators needed? Determine if existing delineators meet the MUTCD requirements. Also determine if additional delineators are needed.

Fencing. Is fencing needed? Determine if existing fencing meets the MUTCD requirements. Also determine if additional fencing is needed.

Fixed objects in ROW. Determine if clear zones and ROWs free of hazardous objects, and if there are nonconforming and/or dangerous objects that are not properly shielded in the clears zones and ROWs.

Bridge. Determine if the bridge is narrower than the width of the road.

Cattle Guard. Determine if the cattle guard is narrower than the width of the road.

Shoulder. Determine if the shoulder needs to be wider and verify if it has a steep drop off.

In the Field Examples

The following figures present examples that may be similar to what would be observed and noted in an actual Level II field evaluation.

Figure 27. Field Example 1

- Add object marker OM-3C on power poles.
- Add intersection-warning sign W2-4.
- Need winding road W1-5 sign.

W1-5

W2-4

OM-3C

Figure 28. Field Example 2

- Install object markers OM-3C on utility poles.
- Install intersection sign W2-1.
- Install stop ahead sign W3-1.

OM-3C

W2-1

W3-1

Figure 29. Field Example 3

- Vertical edge drop off
- Apply filled and compacted shoulder material.

Figure 30. Field Example 4

- Replace stop ahead sign with a W3-1.

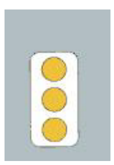
W3-1

Figure 31. Field Example 5

- Install chevrons W1-8 on curve.
- Install post delineators.
- If possible, install guardrail.
- Install curve W1-2 and advisory speed sign W13-1.

W1-8

Post Delineator



W1-2

W13-1

Figure 32. Field Example 6

- Install delineators.
- Apply centerline and edge line markings.

Figure 33. Field Example 7

- Replace 12-foot cattle guard with a 24-foot cattle guard.

Figure 34. Field Example 8

- Sight distance obstructed by row of tress, cut trees if possible.
- Install intersection sign W2-1, and advisory speed sign W13-1 if many intersection related crashes.

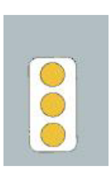
Figure 35. Field Example 9

- Flatten fore slope to 3-1.

Figure 36. Field Example 10

- Install curve sign W1-1 with a speed reduction sign W13-1.
- Cut trees if possible, if not install delineators.
- Install intersection sign W2-4.
- Install object markers OM-3C on trees.

OM-3C



Post Delineator

W2-4

W1-1

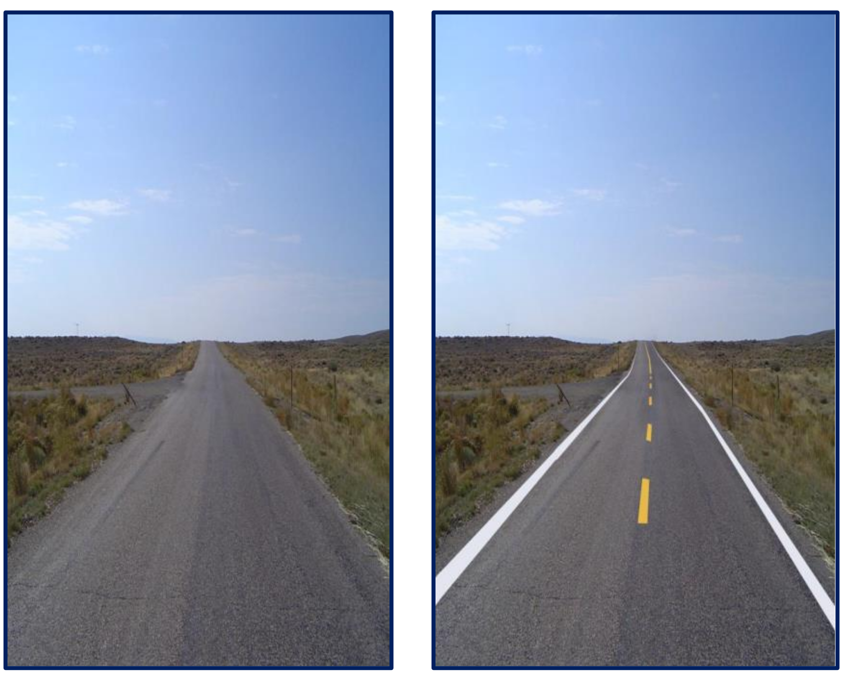
W13-1

Figure 37. Field Example 11

- Cut back slope if possible and install curve sign W1-2.

W1-2

Figure 38. Field Example 12



- Install stop sign R1-1 and stop ahead sign W3-1.
- Install delineators.
- Install intersections sign W2-2.
- Apply centerline and edge line markings.

Delineator Post

W2-2

R1-1

W3-1

Figure 39. Field Example 13

- Install more delineators.
- Extend culvert and provide fill material.

Figure 40. Field Example 14

- Install a winding road W1-5 sign.

Figure 41. Field Example 15

- Install a curve ahead sign W1-2.

Figure 42. Field Example 16

- Install a left arrow sign W1-6.

Professional Examples

Wind River Indian Reservation (WRIR) Implementation

This methodology was implemented on the Wind River Indian Reservation (WRIR) county and Indian Reservation roads (IRR) (see the example of previous steps). This example can assist your Tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe.

After Level I field evaluation and the combined ranking, a Level II field evaluation was executed in Wind River Indian Reservation. Twelve roads were selected by the team from the 24 based on the combined ranking to be evaluated for countermeasures. WRIR transportation reviewed the list and agreed to proceed with the Level II evaluation of these roads. At this time, the WRIR transportation director requested that 16 IRR roads be evaluated as well for safety improvements. These roads were identified by WRIR as having several crashes and known fatalities. Like many common scenarios on tribal lands, the crash data did not provide locations for the crashes on these 16 additional roads so they were not included in steps 1 through 3, but did identify that the crashes had occurred on IRR roads. Therefore, a similar evaluation was proposed for the 16 IRR roads identified by the WRIR transportation.

Each selected road was reviewed as a whole, with the hot spots identified. Many of the countermeasures are site specific and would be applied to these hot spot locations. Other countermeasures would include pavement markings, vegetation clearing or other improvements that would be applied to an entire portion of roadway. Based on the Level I evaluation and crash data, countermeasures were identified for each road. This exercise involved making decisions as a team, discussing what can and should be done for the various locations.

A spreadsheet was set up for each roadway that included standard countermeasures, typically signs, and was broken in the tenth of a mile segments. As each road was driven and possible improvements were identified, these were recorded on the spreadsheet. A spreadsheet for each road was created and all possible improvements identified. This was accomplished for each of the 12 county roads and the 16 IRR roads. Figure 43 presents an actual spreadsheet that was used in this study to identify countermeasures on one of the 16 IRR.

Many of the countermeasures included pavement marking and signage. Several roads were narrow with no shoulder and steep slopes. Future long-term improvements would include rebuilding these roads. These types of projects would require acquiring right-of-way and major reconstruction. These types of improvements are not within the scope of the High Risk Rural Road Program designed to provide funding for low cost improvements. However, several were noted and were provided to the tribes for future consideration and pursuit of other funding sources.

Figure 43. Example of a Level II Field Evaluation Spreadsheet for a Ethete Road on the WRIR

Wind River Indian Reservation | **County:** Fremont | **Road Name**: Ethete Road | **County Route:** 335 | **IRR Route:** 52 | **Date:** 7/5/12

Road Class: Rural Collector | **ADT:** | **85th Speed:** | **Road Surface:** Asphalt 0.0 to 10.5 Gravel/natural earth to

LOCATION	PAVEMENT MARKINGS	STOP R1-1	STOP AHEAD W3-1	CURVE LT W1-1 (90°)	CURVE RT W1-1 (90°)	CURVE LT W1-2	CURVE RT W1-2	CHEVRON W1-8	WINDING ROAD W1-5	INTERSECTION W2-1	INTERSECTION W2-2 (T)	PAVEMENT ENDS W8-3	OBJECT MARKER OM-3	SPEED LIMIT 20 R2-1	SPEED LIMIT 35 W13-1	ARROW W1-6	ROAD NARROWS W5-1	OPEN RANGE	SHOULDER DROP OFF W8-9A	COMMENTS
0.0 - 5.6																				Speed and Safety Study
5.6 - 10.5																				Speed and Safety Study
5.61R																				Congested Area Sign
5.6 - 7.0																				Clear Vegitation
5.8R																				School sign
6.1 L																				School sign
5.8R																				School Flashers
6.1 L																				School Flashers
6.0																				Crosswalk at school
6.5R										1										
6.6L										1										
7.4R					1															Replace existing
7.5-7.7								5												Both Directions
7.8L				1																Replace Existing
7.9R					1															Replace Existing
8.0 - 8.2								5												Both directions
8.1L				1																Replace Existing
8.0R																				Extend Culvert south end
8.8R							1													Replace Existing
8.9-9.1								5												Both directions
9.2L						1														Replace Existing
9.6R											1									
9.8L											1									
10.3R										1										Replace existing
10.4R			1																	Replace existing
10.3	1																			Rumble Strips for Stop
0.0-10.5																				Long Term - Wedge Shoulders
TOTAL		0	1	2	2	1	1	15	0	3	2	0	0	0	0	0	0	0	0	
TOTAL SIGNS =			27																	

Sisseton Wahpeton Oyate (SWO) Implementation

As previously stated, WYT^2/LTAP and the Northern Plains Tribal Technical Assistance Program (NPTTAP) collaborated to develop a regional implementation for the Northern Plains. The methodology was implemented on the Sisseton Wahpeton Oyate Reservation roads. This example can assist your tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe. If the full example of the safety implementation on this reservation is desired for any extra assistance, please contact the Wyoming LTAP center.

Referring to the example provided in the previous chapters, a Level II field evaluation was executed on the Sisseton Wahpeton Oyate Indian Reservation. This evaluation was performed at the same time as the Level I field evaluation to maximize resources. The team discussed countermeasures with the understanding that further investigation would be needed. From the combined rankings, the hot spot locations were reviewed for most severe crashes at those locations, roadway geometrics, and other unique conditions to identify appropriate countermeasures. Thirteen roads were identified for recommended safety improvements. The countermeasures are identified for the given roadway segments in Table 14.

Table 14. Proposed Safety Improvements for SRST

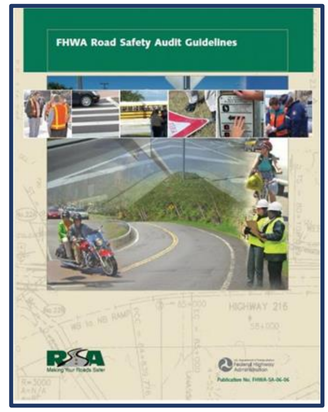
Highway	Beg MP	End MP	Most Severe Crash	Road Geometry	Prevalent crashes	Recommended Countermeasure
118 St	1	4	Injury	Level, Gravel	Overturn/ Rollover	Speed Study for compliance and possibly reduced speed
123 St	0	5	Injury	Level, Gravel, 55 MPH	Overturn/ Rollover, Roadside	Speed Study for compliance and possibly reduced speed
127 St	0	16	Injury	Straight & curves, no shoulder	Overturn/ Rollover, Animal, Intersections	Rumble Strip/Stripe, Intersection Ahead Signs at cross streets,
164 St	0	3	Injury	Straight, narrow shoulder	Intersection	Intersection ahead/stop ahead, proper stop signage, transverse Rumble Strip, intersection study
445 Ave	0	6	Fatal	Curves, rough pavement	Roadside	Curve warning signs w/chevrons. Replace right angle curve sign at T-int. Surface treat or overlay
446 Ave (S)	0	7	Fatal	Curves, narrow shoulder	Overturn/ Rollover, Roadside	Rumble stripe, Chevrons in curves
446A/ 446 Ave	0	4	Injury	Curves, entrances	Overturn/ Rollover, Roadside	Speed Study for compliance and possibly reduced speed in high density driveway areas, Chevrons in curves, Rumble Strip/Stripe
455 Ave (N)	5	18	Injury	Straight, No shoulders	Animal, Roadside, collisions	Edgeline, Rumble Strip/Stripe, Safety wedge
455 Ave (S)	0	12	Injury	Straight, No shoulders	Overturn/ Rollover, Roadside, Animal	Replace Guardrail, Remove objects in clear zone, Install intersection ahead signs, Edgeline and centerline
456 Ave	0	2	Fatal	Level, Gravel, rough	Overturn/ Rollover	Increase maintenance, Speed study for possible reduced speed
459/458 Ave	0	9	Fatal*	Straight & curves, no shoulder, good recovery slopes	Overturn/ Rollover, Roadside, Animal	Rumble Strip/Stripe, Safety wedge, Delineators in curve,
462 Ave	0	9	Injury	Straight, No shoulder	Overturn/ Rollover	Edgeline, Rumble Strip/Stripe, Safety wedge
Lake Rd	0	12	Fatal	Curves, narrow shoulders	Overturn/ Rollover, Roadside	Edgeline & Centerline, Clear vegetation in ROW, Replace Guardrail

Data from Existing Plans, Documents or Other Agencies

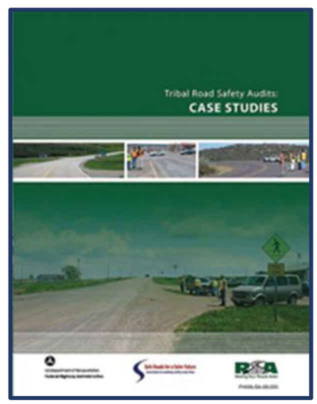
Safety policies and planning documents may contain information that would be helpful in performing a Level II field evaluation. Examples of these documents are given below:

- **FHWA Office of Safety Web site.** The site provides information about the benefits of an RSA, legal topics related to implementing an RSA; and Steps to conduct an RSA, Training etc. information are provided on the website at: http://safety.fhwa.dot.gov/rsa/.

- **FHWA Road Safety Audit Guidelines.** This publication provides background information on RSAs, the steps in the RSA process, and the RSA tools. The background chapters describe issues that should be considered prior to RSA implementation, such as project selection, and costs and benefits. The guidelines details an eight-step process to conducting an RSA. Electronic copy of the guideline can be accesses at http://safety.fhwa.dot.gov/rsa/guidelines/documents/fhwa_sa_06_06.pdf.

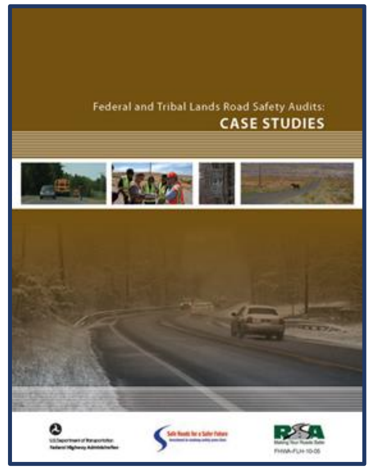


- **Road Safety Audits and Road Safety Audit Reviews.** The National Highway Institute offers a course on Road Safety Audits (RSA) and Road Safety Audit Reviews (RSAR). The Course teaches how to improve transportation safety by applying a new, proactive approach to reduce accidents and their severity: Road Safety Audits (RSA) and Road Safety Audit Reviews (RSAR). This course also includes RSA definition and history, stages and how to conduct a RSA, and legal considerations.



- **FHWA Tribal Road Safety Audit Case Studies.** This document assists tribal governments with examples and advice that can help them in implementing RSAs in their own jurisdictions. It also offers background information on the RSA process and the implementation of this process specifically on Tribal lands. Key factors and lessons learned in conducting a successful RSA on Tribal lands are summarized based on four case studies in this document. Detailed cases study background information, safety issues, and findings are provided in the document's appendix. The document is available at the following link: https://safety.fhwa.dot.gov/rsa/tribal_rsa_studies/tribal_rsa_studies.pdf .

FHWA Federal and Tribal Lands Road Safety Audits, Case Studies. This document was published by FHWA in 2009 for Federal Land Management Agencies (FLMA) and Tribal agencies that want to implement RSAs. The document describes background on the RSA process and conducting RSAs on Federal and Tribal lands. It consists of six Federal and Tribal lands RSA case studies and two additional RSAs on Federal lands conducted by the Western and Eastern Federal Lands Division Offices. Each case study includes photographs, a project description, a summary of key findings, and lessons learned. The document can be accessed at the following link: https://ntl.bts.gov/lib/35000/35700/35777/trsa-case-studies-2.pdf. The document can be ordered in hard copy at the FHWA report center: http://www.fhwa.dot.gov/research/library/reportsources.cfm. Report Number: FHWA-FLH-10-05.



- **FHWA Local Rural Road Safety Audit Guidelines and Case Studies.** This document describes the usefulness of RSA in improving the safety performance of local rural roads. It provides 12 RSA case studies focused on county roads, township roads, intersections, and railroad crossings. For each case study, the document contains photographs, project descriptions, summary of key findings, lessons learned, and the follow-up actions that were taken to improve safety. The document's appendices include detailed case study information and a safety issues review list for practitioners to consider when doing a road safety field-review.

- **Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes**. This toolbox provides crash reduction effectiveness information for three types of pedestrian safety countermeasures – signalization (i.e., pedestrian signal phasing), geometric (i.e., pedestrian overpass or raised median), and operational (i.e., signs and markings). For each countermeasure, the toolbox assigned Crash Reduction Factors (CRF). The toolbox can be accessed at the following link: http://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_tctpepc/ped_tctpepc.pdf.

- **Pedestrian Safety in Native America.** This FHWA report investigate data from multiple national sources to classify crash patterns among Native American communities. The report gives examples of countermeasures, including education-based, media-based, and

law enforcement-based interventions as well as child education and pedestrian facility improvements. The report also demonstrates four successful Tribal safety intervention programs and their crash reductions after implementation. The document can be accessed at the following link: http://katana.hsrc.unc.edu/cms/downloads/Peds_Safety_in_Native_America.pdf.
Hard copy of the report can also be ordered from the FHWA report center: http://www.fhwa.dot.gov/research/library/reportsources.cfm.
Report Number: FHWA-SA-04-007.

- **NCHRP 500 Reports.** The NCHRP 500 Reports assist local practitioners in reducing injuries and fatalities in targeted areas. Each publication addresses a specific type of crash or contributing factor:

    - Volume 01. A Guide for Addressing Aggressive-Driving Collisions;
    - Volume 02. A Guide for Addressing Collisions Involving Unlicensed Drivers and Drivers with Suspended or Revoked Licenses;
    - Volume 03. A Guide for Addressing Collisions with Trees in Hazardous Locations;
    - Volume 05. A Guide for Addressing Unsignalized Intersection Collisions
    - Volume 04. A Guide for Addressing Head-On Collisions;
    - Volume 06. A Guide for Addressing Run-Off-Road Collisions;
    - Volume 07. A Guide for Reducing Collisions on Horizontal Curves;
    - Volume 08. A Guide for Reducing Collisions Involving Utility Poles;
    - Volume 09. A Guide for Reducing Collisions Involving Older Drivers;
    - Volume 10. A Guide for Reducing Collisions Involving Pedestrians;
    - Volume 11. A Guide for Increasing Seat Belt Use;
    - Volume 12. A Guide for Reducing Collisions at Signalized Intersections
    - Volume 13. A Guide for Reducing Collisions Involving Heavy Trucks;
    - Volume 14. Reducing Crashes Involving Drowsy and Distracted Drivers;
    - Volume 15. A Guide for Enhancing Rural Emergency Medical Services;
    - Volume 16. A Guide for Reducing Crashes Involving Alcohol;
    - Volume 17. A Guide for Reducing Work Zone Collisions;
    - Volume 18. A Guide for Reducing Collisions Involving Bicycles;
    - Volume 19. A Guide for Reducing Collisions Involving Young Drivers;
    - Volume 20. A Guide for Reducing Collisions Head-on Crashes on Freeways;
    - Volume 21. Safety Data and Analysis in Developing Emphasis Area Plans;
    - Volume 22. A Guide for Addressing Collisions Involving Motorcycles; and
    - Volume 23. A Guide for Reducing Speed-Related Crashes

The reports also provide links to information on agencies or organizations currently implementing the strategy. Electronic copy of NCHRP 500 Reports can be accessed with this site: http://www.trb.org/Main/Blurbs/152868.aspx. Hard copy of the reports can also be found at the TRB Book Store: http://books.trbbookstore.org/. Book Code: NR500A (for Volume 01) to NR500Y (for Volume 23).

- **Vegetation Control for Safety.** The FHWA published this guide in 2008 to help local agency maintenance staff with determining locations where vegetation control can be improved to enhance traffic and pedestrian safety. This document serves staff with specific items to check, and safe ways to mow, cut brush, and control roadside vegetation.
  Manual can be accessed with the link:
  http://safety.fhwa.dot.gov/local_rural/training/fhwasa07018/vegetationfv1108.pdf.

- **Maintenance of Drainage Features for Safety.** This guide assists local maintenance staff to understand the importance of maintaining and upgrading drainage features on their road system and the potential impacts to road safety. The document helps staff to recognize drainage problems and how to correct drainage features. An electronic copy of the manual can be accessed: http://safety.fhwa.dot.gov/local_rural/training/fhwasa09024/. The manual is FHWA Report Number: FHWA-SA-09-024.

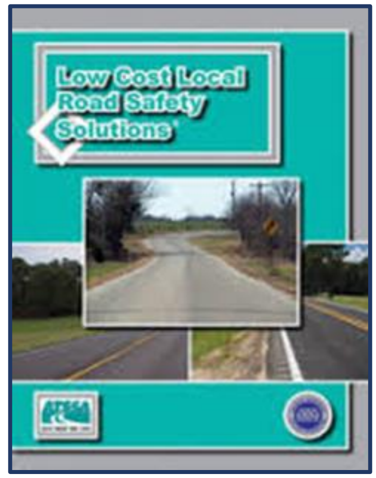
- **Guardrail Repair.** The FHWA published this guide in 2008 to serve practitioners with up-to-date information on how to repair W-Beam guardrails. The manual also helps to identify the extent of guardrail damage to assess its continued safety performance. An electronic copy of the manual can be accessed at: http://safety.fhwa.dot.gov/local_rural/training/fhwasa08002/. The manual is FHWA Report Number: FHWA-SA-08-002.

- **Intersection Safety: A Manual for Local Rural Road Owners.** The manual determines countermeasures and specifies the intersection types where each countermeasure is effective. This manual can be downloaded from the link:http://safety.fhwa.dot.gov/local_rural/training/fhwasa1108/fhwasa1108.pdf. The manual is FHWA Report Number: FHWA-SA-11-08.

- **Guidelines for Selection of Speed Reduction Treatments at High Speed Intersections.** This report demonstrates how practitioners could evaluate and select speed reduction treatments for intersections with approach speeds of 45 miles per hour or greater. The report provides a summary of various speed reduction treatments, and a step-by-step process of using intersection information (i.e., roadway features and speed data) to select the appropriate treatments to achieve speed reduction objectives. It focused on physical treatments (geometry, signing, striping), rather than on enforcement.

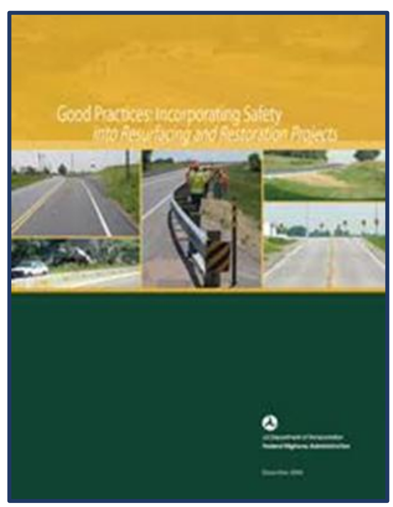
  This manual can be downloaded from the following link:
  http://docs.mvrpc.org/safety/Low_Cost_Local_Roadway_Safety_Solutions.pdf. The reports can be ordered in hard copy at the TRB Book Store: http://books.trbbookstore.org/. Book Code: NR613.

- **Roadway Departure Safety – A Manual for Local Road Owners.** FHWA published this manual to serve local practitioners with information to determine locations with historical or potential rural roadway departure crashes, and countermeasures to address these locations. It provides information on the procedures and processes to improve safety by reducing the potential for roadway departure crashes.
  Electronic copy of the manual can be found at:
  https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/fhwasa1109.pdf. It can be ordered in hard copy at the FHWA report center:
  http://www.fhwa.dot.gov/research/library/reportsources.cfm.
  Report Number: FHWA-SA-11-09.



- **Low Cost Local Road Safety Solutions.** This ATSSA publication serves users with information on 16 proven low-cost countermeasures, focusing on traffic control devices such as signing and pavement marking. For each countermeasure, the publication provides an overview of the countermeasure, its crash reduction effectiveness, and the relevant reference and countermeasure applications that prove the countermeasure's effectiveness. This report can be downloaded at no expense from the following link: http://docs.mvrpc.org/safety/Low_Cost_Local_Roadway_Safety_Solutions.pdf.

- **Good Practices: Incorporating Safety into Resurfacing and Restoration Projects.** This FHWA reports serve as users guidance on how to make sure safety improvements are included in resurfacing and restoration projects. The document determines a set of common issues and success factors in agencies across six states.
  This report can be accessed from the link:
  http://safety.fhwa.dot.gov/roadway_dept/strat_approach/fhwasa07001/fhwasa07001.pdf. The report can be ordered in hard copy at the FHWA report center:
  http://www.fhwa.dot.gov/research/library/reportsources.cfm.
  Report Number: FHWA-SA-07-001.



Chapter 5. Benefit-Cost Ratio Analysis

Overview

This chapter introduces the basic steps of performing the economic analysis to evaluate the cost effectiveness of safety countermeasures. Economic analysis is the fifth step in this toolkit and it provides crucial information for the decision makers to prioritize projects and select appropriate safety countermeasures that can achieve best economic effectiveness. This chapter will describe how to calculate a benefit cost ratio (BCR) as the economic criterion to evaluate the economic effectiveness. It will also introduce Excel worksheets designed for this safety study to calculate the BCR.

In a benefit-cost analysis, the safety benefits are converted to an estimated dollar value of fatalities, injuries, and property damage avoided over the service life of the treatment.

Based on the selected countermeasures and associated costs, a benefit-cost analysis is performed for each project. This is calculated as the net present dollar value of benefits and is provided as a cost estimate for the tribes. If the project is set up for each road, then all the improvements identified for that road are included in the estimate. This provides the tribes information on the most effective safety improvements. Construction costs, environmental costs, planning and design costs, and ongoing maintenance costs are estimated for the safety improvements. This analysis also considers the service life of the countermeasure.

Application of the Benefit-Cost Analysis

It is important to note that one reason rural roads have higher fatality rates than urban roads is because rural roads are less likely to have adequate safety features. Most of rural roads were constructed a long time ago with narrow lanes, limited shoulders, excessive curves and steep slopes. As a result, they often lack consistent design features, such as lane widths, curves, shoulders and clearance zones along roadways.

Fatalities on non-interstate rural roadways are more likely to occur than on all other routes once a vehicle has left the roadway. Because a high number of fatalities occurring on Tribal lands are linked to vehicles departing from the roadway, the examples discussed in this chapter will be aimed at keeping vehicles from leaving the roadway or reducing the consequences of a vehicle leaving the roadway. All the candidate countermeasures for rural roads and associated crash reduction factors (CRF) for a project like this are listed in Table 15. The selected countermeasures have relative low cost and short timeframe for implementation. If a tribe needs other types of countermeasures not listed in this table, they can refer to the FHWA's full list.

Table 15. Countermeasures and Respective CRF's used for Safety Improvements

Countermeasures	Crash Type	Crash Reduction Factors			Service Life
		Fatal	Injury	PDO	
Install guide signs (general)	All	15%	15%	15%	5
Install advance warning signs	All	40%	40%	40%	5
Install chevron signs on horizontal curves	All	35%	35%	35%	5
Install curve advance warning signs	All	30%	30%	30%	5
Install delineators (general)	All	11%	11%	11%	4
Install delineators (on bridges)	All	40%	40%	40%	4
Install edgelines, centerlines and delineators	All	0%	45%	0%	4
Install centerline markings	All	33%	33%	33%	2
Improve sight distance to intersection	All	56%	37%	0%	15
Flatten crest vertical curve	All	20%	20%	20%	15
Flatten horizontal curve	All	39%	39%	39%	15
Improve horizontal and vertical alignments	All	58%	58%	58%	15
Flatten side slopes	All	43%	43%	43%	15
Install guardrail (at bridge)	All	22%	22%	22%	10
Install guardrail (at embankment)	All	0%	42%	0%	10
Install guardrail (outside curves)	All	63%	63%	0%	10
Improve guardrail	All	9%	9%	9%	10
Improve superelevation	All	40%	40%	40%	15
Widen bridge	All	45%	45%	45%	15
Install shoulder	All	9%	9%	9%	5
Pave shoulder	All	15%	15%	15%	5
Install transverse rumble strips on approaches	All	35%	35%	35%	3
Improve pavement friction	All	13%	13%	13%	5
Install animal fencing	Animal	80%	80%	80%	10
Install snow fencing	Snow	53%	53%	53%	10

Components of the Benefit Cost Analysis

Anticipated Benefits

The anticipated benefit of a safety countermeasure is the costs saved which is due to the reduction in traffic crashes. The saved costs are determined by applying the Crash Reduction Factor (CRF) to the number of expected crashes that occur at each severity Level at the analysis site. The anticipated benefits can be expressed as the number of crashes saved or converted to a monetary value by using crash cost. In this safety improvement program, the benefits of the countermeasures are converted to the monetary value as:

Anticipated Benefits = Expected PDO crashes* CRF_{PDO}*Crash $Cost_{PDO}$+ Expected Injury crashes*CRF_{Injury} *Crash $Cost_{Injury}$ + Expected Fatal crashes *CRF_{Fatal} +Crash $Cost_{Fatal}$

Where: CRF_{PDO} is the crash reduction factor of reducing PDO crashes.
CRF_{Injury} is the crash reduction factor of reducing Injury crashes.
CRF_{Fatal} is the crash reduction factor of reducing Fatal crashes.

What is a Crash Reduction Factor?

Benefits of a safety project are measured by the percent reduction in the number and severity of crashes. The crash reduction factor (CRF) is an estimate of the percentage reduction that might be expected after implementing a given countermeasure. A CRF should be regarded as a generic estimate of the effectiveness of a countermeasure. This estimate is a useful guide, but it is necessary to apply engineering judgment and to consider site-specific environmental, traffic volume, traffic mix, geometric, and operational conditions, which will affect the safety impact of a countermeasure.

The crash reduction factor is an estimate of the percentage reduction that might be expected after implementing a given countermeasure.

It is recommended by the FHWA that if crash reduction factors are not available in a local agency, they may be obtained from the State DOT or from existing literature. However, FHWA also warned that although hundreds of the CRF tables can be found in highway safety literature, a great majority of them are dubious values due to poor experimental designs and evaluation methods. Therefore, practitioners must ensure that a countermeasure applies to the particular conditions under consideration.

When using CRFs to calculate expected benefits from implementation of combined safety countermeasures, it is important to calculate the combined CRF. The combined CRF should not be simply combined in additive fashion. As an example, and referring to Table 15, if a project will install both guide signs and delineators to address a safety concern, the percentage reduction of the combined CRFs for fatalities should not simply be 11%+15% = 26%. Instead, according to the FHWA, the combined CRFs are calculated in a multiplicative approach as:

$$CRF_{combined} = 1- [(1-CRF_1)*(1-CRF_2)*(1-CRF_3)]$$

Where: $CRF_{combined}$ is the combined crash reduction factor.

CRF_1, CRF_2, CRF_3 are the individual reduction factors from different countermeasures.

Using Table 15, the combined CRFs of installing guide signs and delineators should be calculated as 1-(1-11%)*(1-15%) = 24.35%.

Crash Cost

Table 16 shows the estimated cost of calculating the anticipated benefits in this safety study. These estimates were based on a survey conducted by AASHTO in 2007. This survey identified the crash cost used by different highway agencies in the U.S. The crash cost values presented in Table 16 are the averages of the crash costs from different highway agencies. These values were used as the default crash cost estimates for this improvement program.

Table 16. Crash Costs

Crash Severity Level	Fatal	Injury	PDO
Crash Cost	$2,500,000	$60,000	$6,000

Cost of Countermeasures

Several factors affect the cost of the countermeasures. These factors are: initial implementation costs, operation and maintenance costs, service life, and salvage value.

Initial Cost. According to the FHWA, the initial implementation costs include right-of-way acquisition, construction, site preparation, equipment, design, traffic maintenance, administration and any other aspects of implementation. The costs of countermeasures are difficult to be estimated and they vary due to several factors, such as project scope, location and time. They can be estimated from the results of recently completed similar projects or by the experts who have been involved in similar projects. In this program, the cost of each countermeasure is not provided. The tribes are encouraged to estimate their own cost values according to their specific situations.

The Operation and Maintenance Cost. The operation and maintenance costs are the differences in cost to operate and maintain the facilities before and after the safety improvement is implemented. In some cases, operating or maintenance costs of new countermeasures may be lower than the original projects. This will result in a negative value of operating maintenance cost and it would be subtracted from the initial implementation costs. As an example, if a road currently has low visibility signs and the safety countermeasure to address safety concern on this road is to replace the old signs with high visibility signs. Furthermore, the maintenance costs of the new signs are lower than the original signs. In this case, the operation and maintenance costs are the differences in the cost of maintaining new signs minus the cost of maintaining old signs. The differences result in negative value and they should be subtracted from the initial costs.

This program is aiming at providing the general guidelines to the tribes. Incorporating operating and maintenance costs will add complexities to the implementation of this safety program. Therefore, the operation and maintenance cost was not included when calculating the cost of the countermeasures.

Service Life and Salvage Value. The service life represents the time-period that the countermeasure can effectively perform its intended function. The service life of each selected countermeasure for this safety project is listed in Table 15. Values from “Illinois DOT Safety Engineering Policy Memorandum” and the “Kentucky Transportation Center Development of Procedures for Identifying High-Crash Locations and Prioritizing Safety Improvements” were used as references. In cases where no service life information is available, the default value of ten years will be used. In this safety program, the salvage values of most countermeasures are negligible and they are set to zero.

Interest Rate. To simplify calculating the cost, the interest rate is assumed to equal to the inflation rate. For example, the cost of installing an advanced warning sign is \$500 at year 2016, and assuming both interest and inflation rates are 4%. If the service life of the sign is two years, then cost of the sign at year 2018 will be $\$500*(1+4\%)^2 = \$540.8$. Considering the inflation rate, the equivalent present cost at 2016 will be $\$540.8/(1+4\%)^2 = \$500$.

Calculating the Benefit/Cost Ratio (BCR)

An Example of Calculating BCR

In this safety program, the BCR method is employed for performing benefit cost analysis. The BCR method uses a benefit to cost ratio to compare the effectiveness of various safety improvements. If a safety countermeasure is economically justifiable, its BCR should be larger than one, which means this countermeasure has greater return than its associated cost. The equation of calculating BCR is:

BCR = Present value of benefits/ Present value of costs

An example of calculating BCR will be helpful to understand this method more thoroughly. If improving guardrail is selected as a countermeasure for a specific road segment, the crash reduction factors (Table 15) for all Levels of crash severity is 9 percent. The estimated cost of each Level of severity of crashes can be obtained from Table 16. Supposing that the cost of improving guardrail is \$50,000 and on this road segment, during the past 10 years, there were three fatalities, two injuries and 10 PDOs, the BCR on this road segment is:

Benefit: 3 x 2,500,000 x 0.09 + 2 x 60,000 x 0.09 + 10 x 6,000 x 0.09 **= \$691,200**

Cost of the countermeasures: \$50,000

$$\frac{\mathbf{B}}{\mathbf{C}} = \frac{\$691{,}200}{\$50{,}000} = \mathbf{1.82}$$

In this example, the B/C ratio is greater than one and it implies that the selected countermeasure on this segment is economic applausive. The BCRs of other countermeasures are calculated in the same way.

To compare the economic effectiveness among mutually exclusive countermeasures, a common used method is the incremental benefit cost ratio. It is not proper to simply calculate the BCR of each alternative and choose the one with the highest value. The result may be misleading. As an example, there are four mutual exclusive alternative countermeasures to address safety concerns at one location. The cost, benefit and BCR of each alternative are shown in Table 17. It is clear from the table that B has the highest BCR. However, it should not be simply concluded that B is best alternative.

Table 17. An Example of Performing Incremental BCR

	A	B	C	D
Cost	4005	2010	6002	1060
Benefit	7310	4750	8630	1440
B/C	1.83	2.36	1.44	1.36

To perform the incremental BCR analysis, first it is necessary to arrange the alternatives in ascending order of investment as shown in Table 18.

Table 18. An Example of Performing Incremental BCR Step 1

	D	B	A	C
Cost	1060	2010	4005	6002
Benefit	1440	4750	7310	8630
B/C	1.36	2.36	1.83	1.44

Then, comparing the incremental BCR between different countermeasures as show in Table 19. If the change in B (ΔB) divided by the change in C (ΔC) is greater than one, it represents a desirable increment of investment.

Table 19. An Example of Performing Incremental BCR Step 2

	Increment B-D	Increment A-B	Increment C-A
ΔCost	950	1995	1997
ΔBenefit	3310	2560	1320
ΔB/C	3.48	1.28	0.66

From Table 19, it is clear that the increment C-A is not as attractive as the ΔB/ΔC of 0.66. Therefore, C is eliminated from the selection. Comparing B with D, B is more attractive. Comparing A with B, the incremental BCR is greater than one. Finally, we can conclude that A is the best alternative. Although B has the highest BCR among the alternatives, it is not the best alternative.

An Example of Using Excel to Calculate BCR

The Wyoming Technology Transfer Center developed simple Excel worksheets to calculate the shown in Figure 44.

Contact the WYT2/LTAP Center for access to a similar spreadsheet.

Figure 44. Excel Screenshot of General and Site Information

BCRs for all proposed countermeasures. The following steps illustrate how to use the worksheets to calculate BCR on a BIA Route 1 on the Fort Peck Reservation:

Step 1. Input the general and site information into the table

General Information		Site Information	
Analyst	Trenna T.	Facility	
Agency/Company	WYTT	Road	BIA Route 1
Project	FPIR	Analysis Time Period	2005 to 2014
Date Performed	8/8/2016	Analysis Year	2016
		Segment Length (mi.)	78

Step 2. Input the following items into the table shown in Figure 45 for each road segment:

- Road number.
- The number of crashes that occurred in 10 years.
- The corresponding number of the countermeasures (table within Figure 46) will be used on this road segment. As an example, on this road segment, five countermeasures: "install advance warning signs", "install chevron signs on horizontal curves", "install delineators", "install centerline markings" and "improve guardrail" are evaluated. The corresponding numbers "2", "3", "5", "8", and "17" should be inputted in column A, B, C, D, and E respectively.

Figure 45. Benefit to Cost Analysis Input Menu

	Number of Crashes			Countermeasures				
Road Segment	*Fatal*	*Injury*	*PDO*	*A*	*B*	*C*	*D*	*E*
BIA Route 1	5	32	7	2	3	5	8	17

Step 3. Input the costs of the countermeasures in Figure 46 (in this example, $9,000 for installing advance warning signs, $6,900 for installing chevrons, $234,000 for installing delineators on a 78 mile roadway, $5,400 for painting a centerline, and $18,000 for improving guardrail).

After all the information is in, the worksheet will automatically calculate the benefit and the BCR value for each countermeasure and the combined BCR if both "2", "3", "5", "8", and "17" are implemented Figure 47.

Generally, the higher the BCR value, the more the cost effectiveness of the countermeasures. It is beneficial to look at the BCR for each countermeasure separately when determining which countermeasure should be implemented first. When budgets are strict, not all countermeasures may be able to be implemented at once. The individual BCRs can influence a decision as to which ones will be the most cost effective. In Figure 47 there is a column called "Combined". This is the combined BCRs of all countermeasures for that specific roadway and it is useful when comparing one roadway against another. A higher combined BCR will prioritize that roadway above the others when deciding which roadways and countermeasures to focus on.

Figure 46. Crash Cost Input Menu

	Countermeasures	Crash Type	Crash Reduction Factors			Cost	Service Life
			Fatal	Injury	PDO		
1	Install guide signs (general)	All	15%	15%	15%		5
2	Install advance warning signs (positive guidance)	All	40%	40%	40%	$9,000	5
3	Install chevron signs on horizontal curves	All	35%	35%	35%	$6,900	5
4	Install curve advance warning signs	All	30%	30%	30%		5
5	Install delineators (general)	All	11%	11%	11%	$234,000	4
6	Install delineators (on bridges)	All	40%	40%	40%		4
7	Install edgelines, centerlines and delineators	All	0%	45%	0%		4
8	Install centerline markings	All	33%	33%	33%	$5,400	2
9	Improve sight distance to intersection	All	56%	37%	0%		15
10	Flatten crest vertical curve	All	20%	20%	20%		15
11	Flatten horizontal curve	All	39%	39%	39%		15
12	Improve horizontal and vertical alignments	All	58%	58%	58%		15
13	Flatten side slopes	All	43%	43%	43%		15
14	Install guardrail (at bridge)	All	22%	22%	22%		10
15	Install guardrail (at embankment)	All	0%	42%	0%		10
16	Install guardrail (outside curves)	All	63%	63%	0%		10
17	Improve guardrail	All	9%	9%	9%	$18,000	10
18	Improve superevlevation	All	40%	40%	40%		15
19	Widen bridge	All	45%	45%	45%		15
20	Install shoulder	All	9%	9%	9%		5
21	Pave shoulder	All	15%	15%	15%		5
22	Install transverse rumble strips on approaches	All	35%	35%	35%		3
23	Improve pavement friction	All	13%	13%	13%		5
24	Install Rumble Strip	All	32%	32%	32%		10
25	Speed Study	All	10%	10%	10%		10

Figure 47. An Example of Calculating B/C Ratio

	Calculation					
	Countermeasures					
	A	*B*	*C*	*D*	*E*	Combined
Cost	$18,000.00	$13,800.00	$585,000.00	$27,000.00	$18,000.00	$661,800.00
Benefit	$5,784,800.00	$5,061,700.00	$1,590,820.00	$4,772,460.00	$1,301,580.00	$11,401,452.21
B/C Ratio	321.38	366.79	2.72	176.76	72.31	17.23

Professional Example

Wind River Indian Reservation (WRIR) Implementation

This methodology was implemented on the Wind River Indian Reservation (WRIR) County and Indian Reservation roads (IRR) (see the example of previous steps). This example can assist your Tribe with the methodology when implementing this safety improvement program. Modifications and the applicability can be altered to meet the unique needs of the tribe.

After Level I field evaluation and the combined ranking, a Level II field evaluation was executed in Wind River Indian Reservation. Twelve roads were selected by the team from the 24 based on the combined ranking to be evaluated for countermeasures. WRIR transportation reviewed the list and agreed to proceed with the Level II evaluation of these roads.

The ratio of benefit to cost was then calculated. Values less than 1.0 would indicate that there is no benefit in the improvement and the project should be eliminated. None of the roads fell into this category. The roads had a ratio ranging from 2.0 to as high as 399.46. These higher values were surprising since typically benefit-cost ratios are usually between one and one-hundred. A closer look at the roads over 100 reveals that many of the improvements are very low cost but the benefit of the lives saved and injuries prevented is extremely significant. See Table 20 for these results.

Table 20. WRIR Benefit-Cost Analysis Results on Twelve County Roads

Road	Benefit	Cost	B/C Ratio
Eight Mile Road	$2,962,691	$7,417	399.46
Riverview Road	$7,155,772	$44,360	161.31
Ethete Road	$2,657,358	$27,017	98.36
North Fork Road	$3,585,894	$36,863	97.28
Trout Creek Road	$2,421,742	$30,900	78.37
Burma Road	$1,262,850	$16,640	75.89
South Fork Road	$1,117,816	$31,600	35.37
Pingetzer Road	$145,392	$7,750	18.76
Hutchinson Road	$57,600	$3,400	16.94
Kinnear Spur Road	$130,447	$8,100	16.10
Cliff Road	$14,281	$5,600	2.55
Peterson Road	$29,137	$14,600	2.00

Conclusions

The safety Toolkit provides five step methodology to serve the tribes with the opportunity to identify low cost safety improvements and allocate funding for these improvements. The goal of the safety improvement program process is to serve Tribes in determining high crash risk locations and identifying the potential low cost countermeasures. It provides information about many resources useful in conducting the methodology and step by step examples of how to do so.

The safety improvement program process can be utilized as a step-by-step process (from Step 1 through Step 5) or as a guideline to implement one or more individual steps as deemed necessary for a particular area. The Toolkit describes each step elaborately in its respective chapter, namely how or when the step might be accomplished, field examples, professional examples implemented on WRIR and Sisseton Wahpeton Oyate, and resources for learning more about the steps. The first step in conducting a safety evaluation is compiling the available data and determining high-risk crash locations. After compiling and analyzing available crash data from various sources, a ranking is established based on the high crash locations. From this ranking, a list of roadways is proposed for field evaluation. Each roadway is provided with a score by the field review team based on five categories: General Category, Intersections, Signage and Pavement Marking, Fixed Objects and Clear Zones, Shoulder and Right of Way. After that, each segment is provided with a ranking from lowest score to the highest score. Field Evaluation Review Team should be consistent throughout the whole process in order to avoid discrepancy between different road segments. These two rankings are then combined to provide a list of proposed roadways considered for safety improvements. To determine the final rankings, the numerical values of the crash ranking and the Level 1 ranking are added together. A Level II field evaluation is aimed at identifying causative factors on each road section and selecting corresponding countermeasures. The team performing the Level I field evaluation would be the same team that performs the Level II field evaluation for maintaining consistency. Additional data such as speed, congestion levels, traffic counts, review of behavioral factors, and other casual factors that may influence the judgement of safety countermeasures might be required in this step. Economic analysis is the fifth step in this toolkit and it provides crucial information for the decision makers to prioritize projects and select appropriate safety countermeasures that can achieve the best economic effectiveness.

Successful implementation in Wind River Indian Reservation and Sisseton Wahpeton Oyate (SWO) Indian Reservation described in the professional examples section reflects the adaptability of the five step process in different Indian reservation areas. Strong cooperation and collaboration among the various stakeholders and tribal members accelerated the success of the program in WRIR and SWO. High benefit cost ratio of the countermeasures implemented in WRIR indicate that small improvements on these rural roads have a significant impact on the number of fatal and serious injury crashes, proving the effectiveness of the low cost countermeasures.

This toolkit provides a methodology which is flexible enough to be implemented in different tribal areas. This methodology has been implemented in several Indian reservations and has shown great promise to reduce the high number of fatal crashes prevalent on the reservations roadways.