Tribal Road Safety Audits:
CASE STUDIES

U.S.Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

RSA
Making Your Roads Safer

FHWA-SA-08-005

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Road Safety Audits (RSAs) are an effective tool for proactively improving the future safety performance of a road project during the planning and design stages, and for identifying safety issues in existing transportation facilities. To demonstrate the usefulness and effectiveness of RSAs for tribal road agencies, the Federal Highway Administration (FHWA) Office of Safety and Office of Federal Lands sponsored a series of four tribal RSAs.

The results of the tribal RSAs have been compiled in this case studies document. Each case study includes photographs, a project description, a summary of key findings, and the lessons learned. The aim of this document is to provide tribal governments with examples and advice that can assist them in implementing RSAs in their own jurisdictions.</td></tr>
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PREFACE

Road Safety Audits (RSAs) are an effective tool for proactively improving the future safety performance of a road project during the planning and design stages, and for identifying safety issues in existing transportation facilities. Additional information and resources on RSAs are available on the web at *http://safety.fhwa.dot.gov/rsa*.

Information for the case studies reported in this document was gathered during a series of four RSAs conducted throughout the United States in 2005 and 2006, involving tribal transportation agencies of the Standing Rock Sioux, Santa Clara Pueblo, Jemez Pueblo, and Navajo Nation. The Federal Highway Administration (FHWA) and the authors greatly appreciate the cooperation of these tribes, as well as other participating agencies such as the Bureau of Indian Affairs (BIA) and state departments of transportation (DOTs), for their willing and enthusiastic participation in this FHWA-sponsored RSA series.

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Background

Road Safety Audits (RSAs) are an effective tool for proactively improving the future safety performance of a road project during the planning and design stages, and for identifying safety issues in existing transportation facilities.

The Federal Highway Administration (FHWA) Office of Safety and FHWA Office of Federal Lands commissioned a series of four tribal road safety audits (RSAs) as part of a Task Order under FHWA Contracts DTFH61-05-D-00024 and DTFH61-03-D-00105. FHWA wanted to demonstrate the usefulness and effectiveness of RSAs for tribal road agencies. The RSAs were conducted by Opus Hamilton Consultants Ltd. and Vanasse Hangen Brustlin, Inc.

The results of the RSAs have been compiled in this case studies document. Each case study includes photographs, a project description, a summary of key findings, and the lessons learned. The aim of this document is to provide tribal governments with examples and advice that can assist them in implementing RSAs in their own jurisdictions.

What is an RSA?

A Road Safety Audit (RSA) is a formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team.

Compromises and constraints among the competing interests that typically drive a road project (such as cost, right of way, environment, topographic and geotechnical conditions, socioeconomic issues, and capacity/efficiency) are a normal part of the planning and design process. The design team has the responsibility of integrating these competing interests to arrive at a design that accommodates these interests in as balanced and effective a manner as possible. RSAs, conducted by a team that is independent of the design, enhance safety by explicitly and exclusively identifying the safety implications of project decisions. By focusing on safety, RSAs make sure that safety does not “fall through the cracks.”

The RSAs followed the procedures outlined in the *FHWA Road Safety Audit Guidelines* document (Publication Number FHWA-SA-06-06). The procedures involve an eight-step RSA process discussed later in this case study document.

The multidisciplinary RSA team is typically composed of at least three members having a background in road safety, traffic operations, and/or road design, and members from other areas such as maintenance, human factors, enforcement, and first responders. Members of the RSA team are independent of the operations of the road or the design of the project being audited. The RSA team's independence assures two things: that there is no potential conflict of interest or defensiveness, and the project is reviewed with "fresh eyes."

RSAs can be done at any stage in a project's life:

- A *pre-construction RSA (planning and design stages)* examines a road before it is built, at the planning/feasibility stage or the design (preliminary or detailed design) stage. An RSA at this stage identifies potential safety issues before crashes occur. The earlier a pre-construction RSA is conducted, the more potential it has to efficiently remedy possible safety concerns.
- *Construction RSAs (work zone, changes in design during construction, and pre-opening)* examine temporary traffic management plans associated with construction or other roadwork, and changes in design during construction. RSAs at this stage can also be conducted when construction is completed but before the roadway is opened to traffic.
- A *post-construction or operational RSA (existing road)* examines a road that is operating, and is usually conducted to address a demonstrated crash problem.

The FHWA Tribal RSA Case Study Program

The four RSAs conducted in this case study program are summarized in Table 1.

TABLE 1 CASE STUDY RSAs

FACILITY OWNER	RSA SITES	RSA STAGE
Standing Rock Sioux Tribe, North Dakota and South Dakota	▪ two-lane rural roads (paved and gravel), including state highways ▪ unsignalized intersections	existing roads
Santa Clara Pueblo, New Mexico	▪ two-lane state highway ▪ signalized and unsignalized intersections	planning stage and existing roads
Jemez Pueblo, New Mexico	▪ two-lane state highway ▪ unsignalized intersections	existing roads
Navajo Nation Reserve, Arizona	▪ two-lane rural roads ▪ signalized and unsignalized intersections	existing roads

All participating tribal transportation agencies volunteered to be involved in this RSA program. Involvement in the case study program required the agency to nominate the sites for the RSA project; provide the RSA team with the materials (such as volume and crash data) on which the RSA would be based; participate in the start-up and preliminary findings meetings; and contribute at least one tribal staff member to participate on the RSA team. The RSA teams were led by two experienced and independent consultants.

Information on each of these RSAs, including background, a summary of RSA issues, and a list of suggested improvements, is included in the Appendix.

THE RSA PROCESS

Eight Steps of an RSA

The eight steps of an RSA are shown in Figure 1, and are discussed below with reference to the case studies.

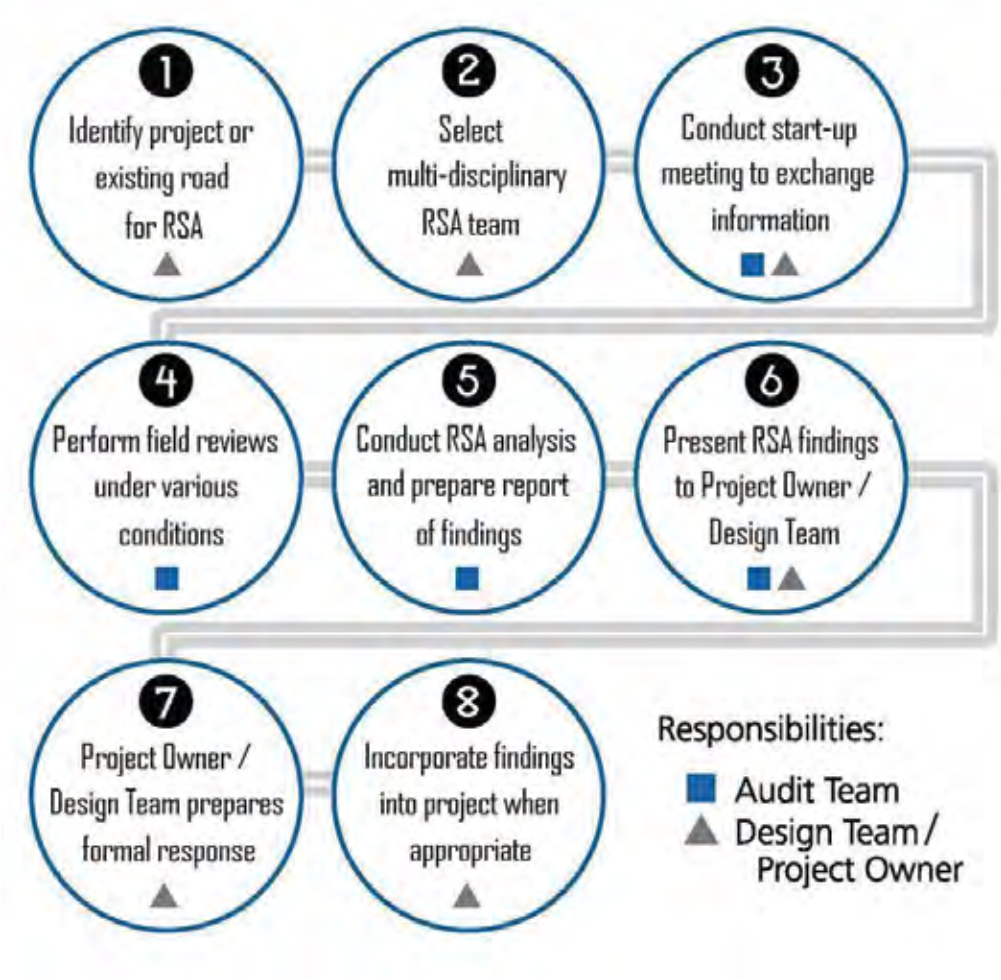


FIGURE 1 RSA PROCESS

RSA projects and the **RSA team** (Steps 1 and 2) were pre-selected in this FHWA case studies project. RSA teams were interdisciplinary, including engineering and enforcement staff. A pavement specialist was included in the case of the Standing Rock Sioux RSA.

All meetings and site visits for the RSAs in the case studies project were conducted over three days. The RSAs typically began with a **start-up meeting** (Step 3) attended by the Project Owner (hereafter referred to as the Owner), the Design Team (Santa Clara Pueblo only), and the RSA team:

- The Owner described the tribe's and other users' concerns regarding the roads to be audited, why the sites had been chosen for an RSA, and any constraints or limitations. Typically, the reasons for the RSA site selection centered on high-profile crashes or public safety concerns.
- For the Santa Clara Pueblo RSA, which included a planning-stage RSA, the Design Team representative then described the future road design, including its constraints and challenges.
- The multidisciplinary RSA team then described the RSA process. This included an overview of the RSA process with examples of safety issues that are typically encountered and mitigation measures to address them.

FIGURE 2
START-UP MEETING

FIGURE 3
FIELD REVIEW

Following the start-up meeting and a preliminary review of the design or site documentation provided by the Owner and Design Team, the RSA team conducted a **field review** (Step 4). The purpose of the field review was to observe the ambient conditions in which the proposed design would operate (for the planning-stage RSA), or to observe geometric and operating conditions (for the RSAs of existing roads). The RSA team observed

road user characteristics (such as typical speeds and traffic mix), surrounding land uses (including traffic and pedestrian generators), and link points to the adjacent transportation network. Field reviews were conducted by the RSA team under a variety of environmental conditions (such as daytime and night-time) and operational conditions (such as peak and non-peak times).

The team conducted the **RSA analysis** (Step 5) in a setting in which all team members reviewed available background information (such as traffic volumes and collision data). The RSA analysis methodology involved a systematic review of features at the RSA sites, including road geometry, sight distances, clear zones, drainage, signing, lighting, and barriers. Human factors issues were also considered by the RSA team, including road and intersection "readability," sign location and sequencing, and older-driver limitations. On the basis of this review, the RSA team identified and prioritized safety issues, features that could contribute to a higher frequency and/or severity of crashes. For each safety issue, the RSA team generated a list of possible ways to mitigate the crash potential.

At the end of the analysis session, the Owner, Design Team (Santa Clara Pueblo only), and RSA team reconvened for a **preliminary findings meeting** (Step 6). Presenting the preliminary findings verbally in a meeting gave the Owner and Design Team the opportunity to ask questions and seek clarification on the RSA findings, and also provided a useful forum for the Owner and Design Team to suggest additional or alternative mitigation measures in conjunction with the RSA team. The discussion provided practical information that was subsequently used to write the RSA report.

FIGURE 4
RSA ANALYSIS SESSION

FIGURE 5
PRELIMINARY FINDINGS MEETING

In the weeks following the on-site portion of the RSA, the RSA team wrote and issued the **RSA report** (also part of Step 6) to the Owner documenting the results of the RSA. The main contents of the RSA report were a prioritized listing and description of the safety issues identified (illustrated using photographs taken during the site visit), with suggestions for improvements.

The Owner and Design Team were encouraged to write a brief **response letter** (Step 7) containing a point-by-point response to each of the safety issues identified in the RSA report. The response letter identifies the action(s) to be taken, or explains why no action would be taken. The formal response letter is an important "closure" document for the RSA. As a final step, the Owner and Design Team were encouraged to use the RSA findings to identify and implement safety improvements as and when policy, manpower, and funding permit (Step 8).

Prioritization of Issues

Where reliable crash data were not available (or where a design was being audited), a prioritization framework was applied in both the RSA analysis and presentation of findings. The likely *frequency* and *severity* of crashes associated with each safety issue were qualitatively estimated, based on team members' experience and expectations. Expected crash *frequency* (Table 2) was qualitatively estimated on the basis of expected exposure (how many road users would likely be exposed to the identified safety issue?) and probability (how likely was it that a collision would result from the identified issue?). Expected crash *severity* (Table 3) was qualitatively estimated on the basis of factors such as anticipated speeds, expected collision types, and the likelihood that vulnerable road users would be exposed. These two risk elements (frequency and severity) were then combined to obtain a qualitative risk assessment on the basis of the matrix shown in Table 4. Consequently, each safety issue was prioritized on the basis of a ranking between A (lowest risk and lowest priority) and F (highest risk and highest priority). It should be stressed that this prioritization method was qualitative, based on the expectations and judgment of the RSA team members, and was employed to help the Owner and Design Team prioritize the multiple issues identified in the RSA.

For each safety issue identified, possible mitigation measures were suggested. The suggestions focused on measures that could be cost-effectively implemented within likely budget limitations.

TABLE 2 FREQUENCY RATING

ESTIMATED		EXPECTED CRASH FREQUENCY (per RSA item)	FREQUENCY RATING
EXPOSURE	PROBABILITY		
high	high	10 or more crashes per year	*Frequent*
medium	high		
high	medium	1 to 9 crashes per year	*Occasional*
medium	medium		
low	high		
high	low	less than 1 crash per year, but more than 1 crash every 5 years	*Infrequent*
low	medium		
medium	low	less than 1 crash every 5 years	*Rare*
low	low		

TABLE 3 SEVERITY RATING

TYPICAL CRASHES EXPECTED (per RSA item)	EXPECTED CRASH SEVERITY	SEVERITY RATING
crashes involving high speeds or heavy vehicles, pedestrians, or bicycles	probable fatality or incapacitating injury	*Extreme*
crashes involving medium to high speed; head-on, crossing, or off-road crashes	moderate to severe injury	*High*
crashes involving medium to low speeds; left-turn and right-turn crashes	minor to moderate injury	*Moderate*
crashes involving low to medium speeds; rear-end or sideswipe crashes	property damage only or minor injury	*Low*

TABLE 4 CRASH RISK ASSESSMENT

FREQUENCY RATING	SEVERITY RATING			
	Low	*Moderate*	*High*	*Extreme*
Frequent	**C**	**D**	**E**	**F**
Occasional	**B**	**C**	**D**	**E**
Infrequent	**A**	**B**	**C**	**D**
Rare	**A**	**A**	**B**	**C**

Crash Risk Ratings: **A**: *lowest risk level* **B**: *low risk level* **C**: *moderate-low risk level* **D**: *moderate-high risk level* **E**: *high risk level* **F**: *highest risk level*

RSAs: COSTS AND BENEFITS

RSA Costs

Three main factors contribute to the cost of an RSA:

- RSA team costs.
- Design team and owner costs.
- Costs of design changes or enhancements.

The *RSA team costs* reflect the size of the team and the time required for the RSA, which in turn are dependent on the complexity of the RSA project. For the RSAs in this case studies project, the following cost components are noted:

- RSA teams were composed of between five and ten persons in this case studies project, but these teams were large since the RSAs served as training exercises for tribal and state engineering staff. Without the need for training, the RSA teams would more typically have been composed of three persons.
- Opening and closing meetings, site visits, and RSA analysis sessions were conducted in a three-day period for each RSA.
- Prior to and following the on-site portion of the RSA, the time required for analysis (such as analysis of collision records, and research on applicable design standards or mitigation measures) and writing the RSA report ranged between about 30 to 40 man-hours.

For this case studies project, additional RSA team costs were incurred in travel for experienced RSA team leaders. However, typical RSAs would employ local team members, and consequently entail only minor travel costs.

The *design team and owner costs* reflect the time required for staff to attend the start-up and preliminary findings meetings, and to subsequently read the RSA report and respond to its findings. In addition, staff time is required to compile project or site materials for the RSA team.

The final cost component is that resulting from *design changes or enhancements,* which reflect the number and complexity of the issues identified during the RSA. Suggested

design changes and enhancements, listed in the Appendix (Tables A.1 through A.4) for each of the RSAs conducted for this case studies project, have focused on low-cost improvements or countermeasures where possible. Suggested improvements for the RSAs focused on improved signing and pavement markings, minor or moderate geometric changes (such as added auxiliary lanes at intersections), gateway treatments, and barrier improvements.

RSA Benefits

The primary benefits of RSAs are to be found in reduced crash costs as road safety is improved. The costs of automotive crashes are estimated by the US Department of Transportation[1] as:

- $3,000,000 for a traffic fatality.
- $2,290,000 for a critical injury.
- $565,000 for a severe injury.
- $175,000 for a serious injury.
- $45,000 for a moderate injury.
- $6,000 for a minor injury.

Other benefits of RSAs include reduced life-cycle project costs as crashes are reduced, and the development of good safety engineering and design practices, including integration of multimodal safety concerns and consideration of human factors in the design, operations, and maintenance of roads.

It is difficult to quantify the benefits of design-stage RSAs, since they aim to prevent crashes from occurring on new or improved facilities that have no crash record. However, when compared with the high cost of motor-vehicle injuries discussed above, the moderate cost of a design-stage RSA suggests that changes implemented from an RSA only need to prevent a few moderate- or high-severity crashes for an RSA to be cost effective.

The benefits of RSAs on existing roads can be more easily quantified, since pre-and post-improvement collision histories are available. As an example, the Road Improvement

1 *Intersection Safety Issue Brief No. 15 ("Road Safety Audits: An Emerging and Effective Tool for Improved Safety"), issued April 2004 by Federal Highway Administration and Institute of Transportation Engineers.*

Demonstration Project conducted by AAA Michigan in Detroit and Grand Rapids (MI), which is based on RSAs of existing high-crash urban intersections and implementation of low-cost safety measures at them, has demonstrated a benefit-cost ratio of 16:1. Another example of data on the quantitative safety benefit of RSAs conducted on existing roads comes from the New York DOT, which reports a 20 to 40 percent reduction in crashes at more than 300 high-crash locations that had received surface improvements and had been treated with other low-cost safety improvements suggested by RSAs.

The South Carolina DOT RSA program has reported a positive impact on safety. Early results from four separate RSAs, following one year of results, are promising. One site, implementing four of eight suggested improvements, saw total crashes decrease 12.5 percent, resulting in an economic savings of $40,000. A second site had a 15.8 percent increase in crashes after only two of the thirteen suggestions for improvements were incorporated. A third site, implementing all nine suggested improvements, saw a reduction of 60 percent in fatalities, resulting in an economic savings of $3,660,000. Finally, a fourth location, implementing 25 of the 37 suggested safety improvements, had a 23.4 percent reduction in crashes, resulting in an economic savings of $147,000.

The most objective and most often-cited study of the benefits of RSAs, conducted in Surrey County, United Kingdom, compared fatal and injury crash reductions at 19 audited highway projects to those at 19 highway projects for which RSAs were not conducted. It found that, while the average yearly fatal and injury crash frequency at the RSA sites had dropped by 1.25 crashes per year (an average reduction from 2.08 to 0.83 crashes per year), the average yearly fatal and injury crash frequency at the sites that were not audited had dropped by only 0.26 crashes per year (an average reduction from 2.6 to 2.34 crashes per year). This suggests that RSAs of highway projects make them almost five times more effective in reducing fatal and injury crashes.

Other major studies from the United Kingdom, Denmark, New Zealand, and Jordan quantify the benefits of RSAs in different ways. However, all report that RSAs are relatively inexpensive to conduct and are highly cost effective in identifying safety enhancements.

THE FHWA CASE STUDIES: PROMOTING THE ACCEPTANCE OF RSAs

The RSAs in this case studies project have been well received by all participating agencies. Characteristics of the FHWA RSAs that have promoted their acceptance by the participating agencies are generally those that are aimed at making the RSA as useful and "user-friendly" as possible.

Key Factors for Success

1. Identify candidate funding sources for suggested improvements

All of the tribal RSAs included suggestions for improvements to address safety issues. An important consideration in identifying and implementing road safety improvements is funding. The federal government provides funding assistance for eligible activities through legislative formulas and discretionary authority, including some funding programs based on 80/20 (federal/local) matches. The RSA team can obtain up-to-date information on funding opportunities by referring to the following resources and visiting the following websites:

- *Tribal Highway Safety Improvement Implementation Guide (http://www.fhwa.dot.gov/hep/tribaltrans/saf_guide.htm*).
- *Tribal Transportation Funding Resources (http://www.fhwa.dot.gov/hep/tribaltrans/ttfundresource.pdf).*
- FHWA Discretionary Programs website *(http://www.fhwa.dot.gov/discretionary/proginfo.cfm).*
- FTA Grants/Grants Programs website *(http://www.fta.dot.gov/funding/grants_financing_36.html).*

The *Tribal Highway Safety Improvement Implementation Guide* advises that the implementation plan for a tribal highway safety improvement project (THSIP) or highway safety project will depend greatly on which funding sources the tribes pursue, since each source has different program eligibility requirements. Some of the important government traffic safety-funding sources include:

- *FHWA funds* administered by the state, include the Highway Safety Improvement Program (HSIP) and Surface Transportation Program (STP).
- *Transportation Enhancement Funds* for projects involving pedestrian facilities and scenic highways.
- *National Highway Traffic Safety Administration (NHTSA)* funds administered by the state Highway Safety Office and the BIA Highway Safety Office, including the *State and Community Highway Safety Grants Program.*
- *Safe Routes to School (SRTS) Program.*
- *Scenic Byway Funds.*
- *Indian Reservation Roads (IRR) Program,* jointly administered by BIA Division of Transportation and the Federal Lands Highway Office and funded by FHWA.
- The Indian Health Service *Injury Prevention Program* for basic and advanced injury prevention projects, and for building tribal capacity for preventing any type of injury problem facing a tribal government.
- *Public Lands Highways Discretionary Program*.

Additional sources specific to each state may be available from the state department of transportation.

2. *Preliminary RSA results (findings and suggestions) have been presented to the Owner twice, verbally and in a draft written form, to provide the Owner and Design Team with the opportunity for input and review before the results are documented in the final report.*

Since RSA reports may become public documents and/or may be used to justify funding requests, transportation agencies may be sensitive to their contents and the way in which the RSA results are presented. To address an agency's concerns and provide it with an opportunity for input, the RSA team first discusses the RSA results in the preliminary findings meeting. In this discussion, the design team and the Owner have the opportunity to identify potentially sensitive safety issues or alternative suggestions to those that have been identified by the RSA team. In practice, the safety issues identified by the RSA team in the tribal RSA have been consistently accepted as valid, and no agency has attempted to discourage their inclusion in the RSA report. In contrast, the RSA team's suggestions for improvements have been discussed at some length.

After discussion in the preliminary findings meeting, a final set of suggestions can be identified and incorporated in the RSA report. A draft version of the RSA report is provided to the Owner for review. The Owner or Design Team can suggest clarifications or provide additional information that can be incorporated in the final RSA report. In practice, of the four RSA reports completed to date in this tribal case studies project, only minor changes to two drafts have been requested.

By discussing RSA findings in the preliminary findings meeting and issuing a draft version of the report, the RSA team, Design Team, and Owner can work together to ensure that potentially sensitive issues are appropriately presented, and that findings are presented in a way that will facilitate funding applications. It remains the responsibility of the RSA team to ensure that, while the Owner's concerns are adequately addressed, the final RSA report is an objective and accurate reflection of its findings, and that the integrity and independence of the RSA process are maintained.

3. For RSAs at an early design stage, the RSA team has provided guidance on possible low-cost improvements that could be implemented as interim measures to decrease interim crash risks.

One of the RSAs in this pilot series was conducted at the start of the planning process for highway upgrades, when construction was not expected to start for another two years. The RSA team examined safety issues and suggested safety improvements that could be implemented in the short-term and medium-term (before substantial upgrades to the corridor were completed), as well as the long-term (implemented as part of the corridor upgrades).

4. The safety benefits of a project have been identified as part of the RSA process and report.

As part of the RSA process, the team identified measures already in place (prior to the RSA) that improve the safety of road users, such as continuous sidewalk networks, shoulder rumble strips, nighttime lighting at isolated rural intersections, targeted traffic enforcement, and institutional measures that provide ongoing support for transportation safety initiatives. Acknowledging safety measures that have already been implemented puts the RSA findings in an appropriate context, and acknowledges the efforts already done by the road agency to improve the safety of road users.

5. RSA teams have been composed of a multidisciplinary group of experienced professionals.

The core disciplines on an RSA team are traffic operations, geometric design, and road safety. Beyond these core requirements, all of the RSA teams in this case studies project have included members who have brought a range of backgrounds and specialties to the RSA, including:

- *Specialist expertise:* The RSA of tribal roads on the Standing Rock Sioux reservation included a pavement management expert to advise on maintenance issues associated with pavement deterioration in the harsh Plains environment.
- *Enforcement:* The RSA teams included traffic enforcement officers where possible, and consulted with enforcement staff where their full-time participation on the RSA team was not feasible. Enforcement staff contribute knowledge regarding local driver behavior and road safety history, and can advise concerning the expected effectiveness of suggested improvements that rely on driver behavior to be effective.
- *Road agency staff:* RSA teams included members from the tribal road agency, BIA engineering staff, state DOTs, and FHWA field safety staff. These team members provided first-hand knowledge of local policies, practices, constraints, and resources.

In this series of pilot RSAs, RSA team members were recruited from the tribe, BIA, state DOTs, and FHWA. Tribes considering their own RSAs may consider these agencies, as well as staff from other tribes with whom they establish a reciprocal relationship, when looking to staff RSA teams. When staffing a team, the RSA team leader should remember that the RSA team should be independent of the project or site being audited, as far as possible. While consultation with local involved staff is necessary to gain an adequate understanding of the project or site, the RSA team should be made up of members who have little or no prior involvement with the specific project or site.

6. RSA reports have been brief.

The RSA report is concise, and focuses on describing safety issues and suggested mitigation. Graphics and photographs were used as extensively as possible. The reports included:

- *Background,* providing a brief summary of the road or project being audited.
- *RSA team and process,* including a listing of the RSA team members, the design or as-built drawings used, site visit dates, and a description of the prioritization method used.
- *Site observations* made during site visits, including photographs.
- *Safety benefits of the proposed improvements,* describing elements of the project that are expected to effectively address existing safety issues or otherwise enhance road safety.
- *RSA findings,* a listing of safety issues and suggested mitigation, usually one or two pages each. A two-page example is shown in Figure 6. A safety issue has been identified in a single sentence at the top of the page. A description (with photos) of the safety issue follows, describing the nature of the safety concern and how it may contribute to collisions. Prioritization of the safety issue follows, using the prioritization matrix described earlier, and ways to address the safety issue are suggested.

Lessons Learned

Over the course of the tribal RSA case studies project, the RSA teams have identified six key elements that can help to make an RSA successful.

1. *The RSA team must acquire a clear understanding of the project background and constraints.*

At the RSA start-up meeting, a frank discussion of the constraints and challenges encountered in the design of the project, or operation of existing road, is critical to the success of the RSA. It is crucial that the RSA team understand the trade-offs and compromises that were a part of the design process or the form of the present road. Knowledge of these constraints helps the RSA team to identify mitigation measures that are practical and reasonable.

identification of safety issue (one sentence)

expanded description of safety issue (with photos)

risk rating (to help prioritize issues)

suggestions for improvements to address safety issues

Road Safety Audit
NM4 in the Pueblo of Jemez
Safety Issue 6: Roadside Hazards

Safety Issue 6: Unshielded roadside hazards are present off the highway.

Safety Issue Description: A roadside clear zone of about 17 feet (for a *design* speed of 50 mph and design ADT of 1,500 to 6,000 vehicles) is desirable to reduce the risks associated with leaving the travel lanes. The clear zone should be free of fixed-object hazards, and should not have unrecoverable (between 1:3 and 1:4) or critical (steeper than 1:3) side-slopes.

Hazards including steep embankments, culvert headwalls, and other drainage structures were observed in the clear zone along NM4. These hazards are shown at right. The risk of an off-road collision is increased in some areas by poor shoulder conditions (Issue 5 above) that would limit the ability of a driver to recover control of a vehicle that has left the travel lane.

It is noted that the culvert headwalls on the west side of NM4 in the Red Rocks area have been designed to be crashworthy, reducing the risk to errant vehicles.

Arroyo embankment and culvert headwall adjacent to NM4 in the residential area. The RSA Team members are standing on the narrow shoulder adjacent to this embankment and headwall.

Looking north from Traging Post Road. A roadside embankment is present on the west side of NM4. Drivers leaving the roadway would be unable to recover control of their vehicle on this steep embankment.

Red Rocks area. The drainage inlet the driveway beyond the gas station sign is a roadside hazard. The near inlet (visible at bottom foreground) has been designed to be crashworthy.

Expected Crash Types: off-road crashes

Expected Frequency: infrequent

Expected Severity: high moderate

Risk Rating: C (moderate-low risk level)

Suggestions:

Install roadside barriers to prevent drivers from leaving travel lanes. Where hazards are present within the clear zone, roadside guardrail may be considered. Guardrails should be of an appropriate length and have adequate end treatments.

Provide crashworthy barrier for drainage inlets: At the Red Rocks area, the risk associated with unprotected drainage inlets may be reduced by extending the crashworthy treatment already introduced at some inlets to all inlets in the clear zone.

FIGURE 6 EXAMPLE DISCUSSION OF AN RSA SAFETY ISSUE

2. Recurring concerns identified in multiple tribal RSAs may reflect safety issues typical of tribal transportation environments.

RSA teams identified the following issues on at least three of the four tribal RSAs conducted in this series, suggesting that RSA teams may expect to encounter these issues during tribal RSAs:

SAFETY ISSUE	Standing Rock Sioux	Santa Clara Pueblo	Jemez Pueblo	Navajo Nation
pedestrian safety, including the safety of children walking to and from school and school-bus stops	✓	✓	✓	✓
worn, damaged, or confusing signs and pavement markings		✓	✓	✓
hazardous roadside conditions		✓	✓	✓
limited road maintenance	✓		✓	✓

With regard to maintenance of tribal roads, this activity has historically been funded through a range of sources, including federal and state funding sources. Funding for maintenance has typically been constrained by limited overall budgets, and by funding categories that exclude maintenance. At the same time, tribal road agencies are often responsible for an extensive network of rural roads that connect a widely-dispersed population, and that must be maintained in a harsh environment that can cause rapid pavement deterioration. As a result, road maintenance was observed to be problematical in three of the four tribal RSAs. Poor pavement conditions could result in cracked, worn, and rutted pavements, which can affect driver control and accelerate the deterioration of pavement markings.

A recognition on the part of the RSA team that the issues listed above will often be significant in tribal RSAs may help the RSA team leader to recruit appropriate expertise to address these issues. For example, the RSA team on the Standing Rock Sioux RSA included a pavement specialist from the nearby state university, who contributed his expertise to the audit team.

3. *The involvement of multiple road agencies in the design, operation, and maintenance of roads on tribal lands can present a challenge, and can also help promote a successful RSA outcome.*

Most of the roads audited in this series of RSAs were under the joint jurisdiction of two or three road agencies at different levels, including:

- The tribal transportation agency.
- The Bureau of Indian Affairs.
- One or more state Departments of Transportation.

Although relations between the representatives from these agencies ranged from civil to friendly on all RSAs conducted in this series, these multiple layers can result in a large and unwieldy RSA team, and may result in conflict between members of the team. At the same time, the involvement of multiple agencies was a distinct advantage in some tribal RSAs where participants were able to call upon resources within multiple agencies to make the RSA outcome as successful as possible.

4. The RSA team and Design Team need to work in a cooperative fashion to achieve a successful RSA result. It is important to maintain an atmosphere of cooperation among all participants in the RSA process – the Design Team, RSA team, and the Owner.

The RSA team should be consistently positive and constructive when dealing with the Design Team. Many problems can be avoided if the RSA team maintains effective communication with the Design Team during the RSA (including the opportunities presented in the start-up and preliminary findings meetings) to understand why roadway elements were designed as they were, and whether mitigation measures identified by the RSA team are feasible and practical. This consultation also gives the Design Team a “heads-up” regarding the issues identified during the RSA, as well as some input into possible solutions, both of which can reduce apprehension (and therefore defensiveness) concerning the RSA findings.

The cooperation of the Design Team is vital to the success of the RSA. An RSA is not a critical review of the design team’s work, but rather a supportive review of the design with a focus on how safety can be further incorporated into it. Cooperation between the RSA team and Design Team usually results in a productive RSA, since the RSA team will fully understand the design issues and challenges (as explained by the Design Team), and

suggested mitigation measures (as discussed in advance with the Design Team) will be practical and reasonable.

Support from the Owner is vital to the success of individual RSAs and the RSA program as a whole. It is essential that the Owner commit the necessary time within the project schedule for conducting the RSA and incorporating any improvements resulting from it, as well as the staff to represent the Owner in the RSA process (primarily the start-up and preliminary findings meetings).

5. A "local champion" can greatly help to facilitate the establishment of RSAs.

Wilson and Lipinski[2] noted in their recent synthesis of RSA practices in the United States that the introduction of RSAs or an RSA program can face opposition based on liability concerns, the anticipated costs of the RSA or of implementing suggested changes, and commitment of staff resources. To help overcome this resistance, a "local champion" who understands the purposes and procedures of an RSA, and who is willing and able to promote RSAs on at least a trial basis, is desirable. Thus, measures to introduce RSAs to a core of senior transportation professionals can help to promote their wider acceptance. "Local champions" have been found within tribal road agencies, state DOTs, and FHWA field offices.

6. The RSA field review should be scheduled during regular recurring traffic conditions.

Where possible, the RSA team should visit the project site when traffic conditions are typical or representative. For example, the RSA on the Standing Rock Sioux reservation included the highway adjacent to a reservation high school, where recurring congestion from arriving and departing school buses was a reported issue. The RSA team scheduled site visits during the school year, coinciding with the start and end of the school day, and consequently was able to observe the congested conditions. In contrast, the RSAs on the Jemez and Santa Clara Pueblos were conducted in late October, well after the end of the summer tourist season. Consequently, the RSA teams were not able to observe tourist traffic associated with the scenic and cultural attractions on the Pueblo lands. Although this did not significantly affect the RSA findings, scheduling the field review to observe regularly recurring traffic conditions is preferable, since it allows the RSA team to see how these traffic conditions and road user behavior may affect safety.

2 Eugene Wilson and Martin Lipinski. *NCHRP Synthesis 336: Road Safety Audits, A Synthesis of Highway Practice* (National Cooperative Highway Research Program, TRB, 2004)

CONCLUSION

The tribal RSA case studies project sponsored by the FHWA Office of Safety has been well received by the participating tribal transportation agencies. The case studies project has exposed tribal governments to the concepts and practices of an RSA, and provided the opportunity for tribal staff members to participate on the RSA team as part of the process. This case studies document has summarized the results of each RSA, with the intent of providing tribal governments with examples and advice to assist them in implementing RSAs in their own jurisdictions.

APPENDIX A

CASE STUDY RSAs

RSA NUMBER 1

STANDING ROCK SIOUX TRIBE (NORTH AND SOUTH DAKOTA): RSA OF RESERVATION ROADS

Roads: existing two-lane rural tribal roads

RSA Sites:	• paved and gravel roadways (including state secondary highways under state DOT jurisdiction) in rural and low-density urbanized environments • one small bridge
Environment:	☑ **urban/urbanized** ☐ suburban ☑ **rural**
Owners:	Standing Rock Sioux Tribe, Bureau of Indian Affairs (BIA), North Dakota DOT, South Dakota DOT

Road Safety Audit

Date of RSA:	22-24 May 2005
RSA Stage(s):	☐ planning/design stage ☑ **RSA of existing roads**
RSA team:	staff from the Standing Rock Sioux Tribe, Federal Highway Administration (North Dakota and South Dakota field offices), North Dakota DOT, South Dakota DOT, Bureau of Indian Affairs, North Dakota State University, Northern Plains TTAP, and Opus Hamilton

BACKGROUND:

The Standing Rock Sioux Tribe (SRST) reservation in North and South Dakota extends over 2.3 million acres, with an extensive rural road network of BIA, county, and state roads. The reservation roads connect the reservation's communities to each other and to the tribal administrative center in Fort Yates, ND. They also serve through traffic, and provide access to the Tribe's two casinos.

At the time of the RSA, the Standing Rock Sioux Tribe was actively pursuing improvements to transportation infrastructure on the reservation. Under the SRST Transportation Department, the Tribe had embarked on a long-range, multi-million-dollar program to upgrade community transportation facilities, using an innovative financing scheme involving government, tribal, and borrowed funds.

The Tribe maintained its extensive road network using its own funds as well as funding from sources such as the BIA. Maintenance of tribal roads was a sensitive topic, since funding for maintenance involved an extensive government allocation effort that limited the amounts available to reservations. At the same time, road maintenance was viewed as an important responsibility that directly affected tribal efforts to build a cohesive reservation community and promote economic activity. Maintenance of the roads on the SRST reservation was a challenge due to their extent (connecting a population of about 9,000

spread over 850,000 acres) and the impacts of the Northern Plains environment (winter road conditions, frost damage, and variations in the underlying water table). Although the SRST reported that it fully utilized available government funds and its own funds, the RSA team observed multiple maintenance-related issues on reservation roads, which are summarized as Issue 1 in Table A.1.

Roads studied during this RSA included ND 24 and Highway 1806 (part of BIA 3), US 12, and community access roads. Typical reservation roadways are shown in Figure A.1. The RSA team drove these roads to identify safety issues associated with road geometry, traffic operations, and maintenance. Although bridge inspection is not a usual part of the RSA process, the RSA team was asked to observe possible maintenance issues associated with a bridge on BIA 3 at Four-Mile Creek. RSA findings associated with the bridge were included in the RSA report.

BIA 3 at intersection with ND 24 south of Fort Yates, ND

BIA 3 / Hwy 1806 in Kenel, SD

US 12 at Grand River Casino (left), near Mobridge, SD

BIA 44 west of Mahto, SD

FIGURE A.1 VIEWS OF RSA SITES (STANDING ROCK SIOUX TRIBE RSA)

KEY RSA FINDINGS AND SUGGESTIONS:

The key findings and suggestions of the RSA are summarized in Table A.1.

TABLE A.1 SUMMARY OF SELECTED SAFETY ISSUES AND SUGGESTIONS: STANDING ROCK SIOUX TRIBE RSA

SELECTED SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
1	*Road Maintenance:* Limited maintenance on reservation roads contributes to poor pavement conditions and concern regarding bridge stability.	B to D	• control cracking with sawcut and fill • accommodate future overlays • bridge inspection and repair
2	*Access to Grand River Casino:* Drivers turning into and out of the Grand River Casino may interfere with crossing, opposing, and following traffic on US12.	D	• speed reduction • improved signing • westbound left turn bay • access relocation
3	*BIA 31 and ND 24 (School Frontage):* Driver workload is potentially high near the intersection of BIA 31 and ND 24, which accommodates local, school, and through traffic.	B to D	• no-passing zone • crosswalk maintenance • enhanced signing • turning lanes on ND24 • improved lighting • access consolidation • urban cross section
4	*BIA 3 and Highway 1806 (Kenel):* Vehicle and pedestrian traffic may interfere with through traffic on BIA 3 through Kenel.	B to D	• marked crosswalk • regrading • urban cross section • relocation of grocery store
5	*Hwy 1806 and US 12 (Jed's Landing):* Driver workload is potentially high at the intersection, which accommodates high turning volumes and high speeds.	C	• speed reduction • review of turning lanes
6	*BIA 3 and ND 24:* Left-turning vehicles may obstruct through vehicles at highway intersection on a horizontal curve.	A	• left turn bay

KEY LESSONS LEARNED:

This large RSA team effectively combined members from a wide range of disciplines and jurisdictions, and included experts with relevant specialist knowledge. The core disciplines that must be represented on any RSA team are traffic operations, geometric design, and road safety. Beyond these core requirements, the Standing Rock RSA team included members with a range of backgrounds and specialties, including team members from the Standing Rock Sioux tribe, two state DOTs having highways traversing the reservation, two state FHWA field offices, the Bureau of Indian Affairs, the Northern Plains Tribal Transportation Assistance Program (TTAP) program, and North Dakota State University. The RSA team members contributed a wealth of knowledge and expertise in topics as diverse as pedestrian safety, pavement maintenance, and tribal policies, practices, and conditions.

See also the discussion of “Key Factors for Success” and “Lessons Learned” in the main text.

RSA NUMBER 2

SANTA CLARA PUEBLO: RSA OF STATE HIGHWAY NM 30 THROUGH THE PUEBLO

Road: existing two-lane rural tribal road

RSA Sites:	• paved two-lane roadway with paved shoulders in an urbanized environment: ◆ auxiliary turning lanes at some major intersections ◆ short four-lane segment at recently upgraded intersection • one signalized intersection
Project Environment:	☑ **urban/urbanized** ☐ suburban ☐ rural
Project Owner:	Santa Clara Pueblo and New Mexico Department of Transportation

Road Safety Audit

Date of RSA:	24-25 October 2006
RSA Stage(s):	☑ **planning/design stage** ☑ **In-service audit**
RSA team:	staff from Santa Clara Pueblo, Bureau of Indian Affairs (BIA) Southwest Regional Office, New Mexico DOT (District 5), Federal Highway Administration, Gannett Fleming West Consultants, Opus Hamilton, VHB

BACKGROUND:

The Santa Clara Pueblo in New Mexico is home to approximately 11,000 residents. State Highway 30 (NM 30), which runs through the Pueblo, has an estimated AADT of 9,000 vehicles, reflecting use by:

- Residents of the Pueblo for travel within Pueblo lands, as well as travel to neighboring communities.
- Visitors to the Pueblo and its attractions, including the Black Mesa Golf Club, scenic Santa Clara Canyon, and historic Puye Cliff Dwellings.
- Through traffic on NM 30, including commuters travelling between Los Alamos (an employment center south of the Pueblo) and Espanola (a residential area north of the Pueblo).

The highway accommodates a substantial truck volume, estimated at 16 percent of AADT. Posted speed limits along the audit segment vary from 45 to 60 mph, with a 15 mph speed limit posted at a school crosswalk for two hours on school days. Two views of NM 30 are shown in Figure A.2.

The main residential area of the Pueblo is divided by the NM 30, which separates the historic center of the Pueblo on the east side of the highway from more recently-developed residential areas on the west side. The Pueblo's transportation agency has very effectively limited vehicle access to the highway by designating a limited number

of access points and restricting, where possible, direct driveway access. Similarly, it encourages pedestrians to cross the highway in a safe manner by providing a marked school crosswalk that is regularly supervised by tribal enforcement officers.

At the time of the RSA, NM DOT was conducting a study of the NM 30 corridor to identify the need for upgrades. The DOT had committed approximately $8 million to implement NM 30 upgrades, starting in 2008. The RSA was conducted with a view to identify safety issues that could be addressed by the planned upgrades.

Looking south along NM 30 toward a signed and marked school zone crosswalk near the Pueblo's main residential area.

Looking north along NM 30 toward a recently improved intersection adjacent to a convenience store/gas station. The full traffic signal was in place, but not operational, at the time of the audit.

FIGURE A.2 VIEWS OF RSA SITE (THE SANTA CLARA PUEBLO)

KEY RSA FINDINGS AND SUGGESTIONS:

The key findings and suggestions of the RSA are summarized in Table A.2. Where appropriate, the suggestions were divided into:

- Short-term (could be implemented prior to the anticipated opening of scenic and historic areas the following spring).
- Medium-term (could be implemented in the interim period before substantial upgrades to the corridor were started).
- Long-term (could be implemented as part of the corridor upgrades that were scheduled to start in two years).

TABLE A.2 SUMMARY OF RSA SAFETY ISSUES AND SUGGESTIONS: SANTA CLARA PUEBLO RSA

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
1	*Pedestrian Facilities:* • Vehicles on the shoulder, an absence of night-time lighting, and the possibility of accelerating vehicles, increase the risk of collision for pedestrians crossing NM30 in the school crosswalk. • Pedestrian connections are non-continuous.	D	• school crosswalk: ◆ paint advance yield lines ◆ provide flexible delineator posts on shoulders ◆ provide overhead lighting • install additional crossing facilities at signalized intersection • provide grade-separated crossings • plan and provide a continuous pedestrian network • consider urban cross-section (long-term)
2	*Narrow Shoulder and Auxiliary Lanes:* • Discontinuous shoulders may increase the risk of collisions. • Narrow 10-foot lanes may increase the risk of off-road or sideswipe collisions.	C	• enhance signing and delineation • include a pavement fillet to limit pavement edge drop-offs • re-stripe lanes • widen cross-section • plan and provide a continuous pedestrian network
3	*Signal Operation at Puye Cliffs Access Road:* Drivers turning from the Puye Cliffs access road may require a full signal to safely turn left onto NM30.	C	• review the need for a full signal • review merge operation and safety • change lane configuration • provide signing
4	*Signing and Pavement Markings:* An absence of warning signs and pavement markings may increase the collision risk at merge areas.	B	• post advance signing before end of bypass lanes • review taper lengths • review need for or location of “Pass With Care” sign • paint centerlines on intersecting residential streets • plan and provide guide signing for Puye Cliffs Visitor Center • provide temporary signing for start of signal operation • provide lane use signing

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
5	*Lighting:* The absence of overhead lighting limits the visibility and conspicuousness of unsignalized intersections and the school crosswalk.	B	• install lighting at signed entrances to Pueblo • install lighting at school crosswalk
6	*Roadside Hazard:* Two signal poles are located within the clear zone at a signalized intersection.	C	• provide a roadside barrier
7	*Speed Limits:* • Frequent speed limit changes may result in unintentional violations and differential speeds. • Speeds limits may be high adjacent to the main residential area.	C	• review speed limits

KEY LESSONS LEARNED:

Conducting the RSA at the start of the parallel corridor upgrade study provided an opportunity for enhanced safety input to the corridor study. In addition to the issue-specific suggestions listed in Table A.2, the RSA team discussed longer-term suggestions to improve safety along NM 30. In particular, the RSA team recognized that the growth of the Pueblo's main residential area had generated a need to examine whether the current rural configuration and high speeds along NM 30 were still appropriate. Specifically, the RSA team suggested that NM DOT and the Pueblo consider converting the high-speed, two-lane rural highway cross-section into a four-lane urban cross-section through all or part of the Pueblo. The urban cross-section could enhance vehicle and pedestrian safety by reducing through speeds, providing facilities to better accommodate drivers turning into and out of the Pueblo's residential areas, and providing safer opportunities for pedestrians crossing the highway. In addition, since NM DOT and Pueblo staff often cited excessive speed as an issue along NM 30 (and a review of the highway collision history supported this view), the RSA Team suggested that a formal speed study could be considered as a supplement to the NM 30 corridor upgrade study.

See also the discussion of "Key Factors for Success" and "Lessons Learned" in the main text.

RSA NUMBER 3

THE JEMEZ PUEBLO: RSA OF STATE HIGHWAY NM 4 THROUGH THE PUEBLO

Road: existing two-lane rural tribal road

RSA Sites:	• paved two-lane highway (rural cross-section) through the main residential area of the Pueblo • several intersections with STOP control on minor road • high pedestrian volumes walking along and crossing the highway
Project Environment:	☑ **urban/urbanized** ☐ suburban ☐ rural
Project Owner:	Pueblo of Jemez and the New Mexico DOT

Road Safety Audit

Date of RSA:	26-27 October 2006
RSA Stage(s):	☐ planning/design stage ☑ **RSA of existing roads**
RSA team:	staff from Pueblo of Jemez, BIA Southwest Regional Office, New Mexico DOT (District 6), Federal Highway Administration, VHB, and Opus Hamilton Consultants

BACKGROUND:

The Jemez Pueblo, the only remaining village of the Towa-speaking Pueblos in New Mexico, is home to approximately 2,000 residents. State Highway 4 (NM 4), a minor arterial, runs through the main village area. In 2003, the highway had an estimated workweek AADT of 3,000 vehicles (rising to 5,700 over the Memorial Day weekend), reflecting use by:

- Residents of the Pueblo for travel within the Pueblo, as well as travel to neighboring communities such as Jemez Springs and Bernalillo.
- Visitors to the Pueblo and surrounding areas, including the tribe's Walatowa Visitors Center and the Red Rocks Recreation Area.
- Through traffic on NM 4, which is part of the Jemez Mountain Trail National Scenic Byway (established 1998) and provides access to the Valles Caldera National Preserve (established 2000).

Two views of NM 4 are shown in Figure A.3.

Looking north along NM 4 at the entrance to the Pueblo of Jemez. NM 4 is predominantly a two-lane rural road with wide shoulders, with a speed limit of 30 mph along this segment.

Looking north along NM 4 at the Red Rocks recreational area. Roadside land uses include the commercial area (service station and Walatowa Visitors Center) visible at left, and the recreational area (where small-scale vending takes place during the summer) at right. The speed limit along this segment of the highway is 50 mph.

FIGURE A.3 VIEWS OF RSA SITE (THE JEMEZ PUEBLO)

KEY RSA FINDINGS AND SUGGESTIONS:

The key findings and suggestions of the RSA are summarized in Table A.3.

TABLE A.3 SUMMARY OF RSA SAFETY ISSUES AND SUGGESTIONS: JEMEZ PUEBLO RSA

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
1	*Frequent Uncontrolled Accesses:* Uncontrolled access to properties adjacent to NM 4 increases the risk of conflicts and collisions.	D	• support for realignment of NM 4 • pilot application of access management measures • development of access management policy • intersection lighting

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
2	*Pedestrian Safety:* Pedestrians walking along NM 4 have no dedicated pedestrian facilities.	D	• network of continuous off-road paths • improved visibility at school bus stops • lighting in areas of potential vehicle/ pedestrian conflicts • marked pedestrian crossings • reduced speed limit (Red Rocks recreational area) • access management plan
3	*Signing, Pavement Markings, and Delineation:* Missing signs, pavement markings, or delineation may limit driver guidance and increase the risk of collision. Excessive signing may distract drivers.	C	• comprehensive signing review • improved pavement markings
4	*Speed:* Speeds above the posted speed limit increase the risk and potential severity of crashes on NM 4.	E	• gateway treatment • speed display signs • consistent speed limit (Red Rock recreational area) • pavement word markings • review of need for transitional speed zone
5	*Deterioration of Shoulder:* Shoulder conditions may deteriorate as a result of surface drainage flows and traffic.	C	• shoulder stabilization • curb and gutter
6	*Roadside Hazards:* Unshielded roadside hazards are present off the highway.	C	• roadside barriers • crashworthy drainage inlets
7	*Intersection with Bear Canyon Road:* Limited sight distances, especially at night, increase the risk of collision at this intersection.	C	• improved signing and pavement markings • lighting • transverse rumble strips • pedestrian improvements
8	*School Bus Operations:* School buses do not consistently operate their flashing lights when picking up and dropping off students.	D	• clarification of policy • lighting at school bus stops

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
9	*Animals on the Highway:* Animals on the highway pose a crash risk.	C	• lighting • cattle guards • resolve conflicts between "open range" concept and requirements to keep cattle off the highway

KEY LESSONS LEARNED:

Cultural traditions can conflict with road safety initiatives. The RSA Team noted in its report that the Pueblo of Jemez has been supportive of efforts (like the Scenic Byways designation of NM 4) to increase tourism, preserve the environment, and improve economic development in the region. At the same time, to protect and preserve its spiritual and cultural practices, the tribe has also insisted that all recommendations for roadway improvements should consider impacts on the culture and traditional lifestyle of its members. Two examples illustrate this lesson:

- Improved night-time lighting was identified in the RSA report as one of several measures that could address pedestrian safety. Pueblo representatives were supportive of the idea, but noted that, since night-time lighting conflicts with traditional/cultural activities near the center of the community, controls that allow for manually turning street lights on or off as needed were preferred.
- Over half of all reported collisions along NM 4 in the Jemez Pueblo involved animals (primarily cattle) on the highway. Although the RSA team noted that the most effective and practical long-term measure to address livestock collisions was to install and maintain fencing to keep livestock off the road, there was extended discussion regarding whether some or all of the Pueblo lands are "open range", which would imply that it is the responsibility of road users to drive with caution and avoid livestock on the road. The RSA team suggested that efforts should be undertaken to clarify and resolve potentially conflicting laws and customs regarding the movement of livestock over public roads, with the goal of protecting road users (including both local traffic and through traffic) and livestock.

See also the discussion of "Key Factors for Success" and "Lessons Learned" in the main text.

RSA NUMBER 4

NAVAJO NATION: RSA OF HIGHWAY N-12

Road: existing two-lane rural tribal road	
RSA Sites:	• two segments in rural areas having a two-lane rural cross-section with paved shoulders • one segment in an urbanized area having a five-lane cross-section with paved shoulders or curb-and-gutter • two signalized intersections (urbanized area)
Project Environment:	☑ **urban/urbanized** ☐ suburban ☑ **rural**
Project Owner:	Navajo Nation and the Bureau of Indian Affairs

Road Safety Audit	
Date of RSA:	1-3 November 2006
RSA Stage(s):	☐ planning/design stage ☑ **RSA of existing roads**
RSA team:	staff from Navajo DOT, BIA, Arizona DOT, Federal Highway Administration, Navajo Police, and Opus Hamilton

BACKGROUND:

Highway N-12 is a rural minor arterial providing access to the Navajo capital at Window Rock, AZ. The highway, which is under the jurisdiction of the BIA, intersects I-40 near Lupton, AZ, and continues northward to US 191, passing through three states (Arizona, New Mexico, and Utah). This RSA has focused on the portion of N-12 north of Highway 264 between Window Rock and Fort Defiance, and also included two smaller sites south of Highway 264.

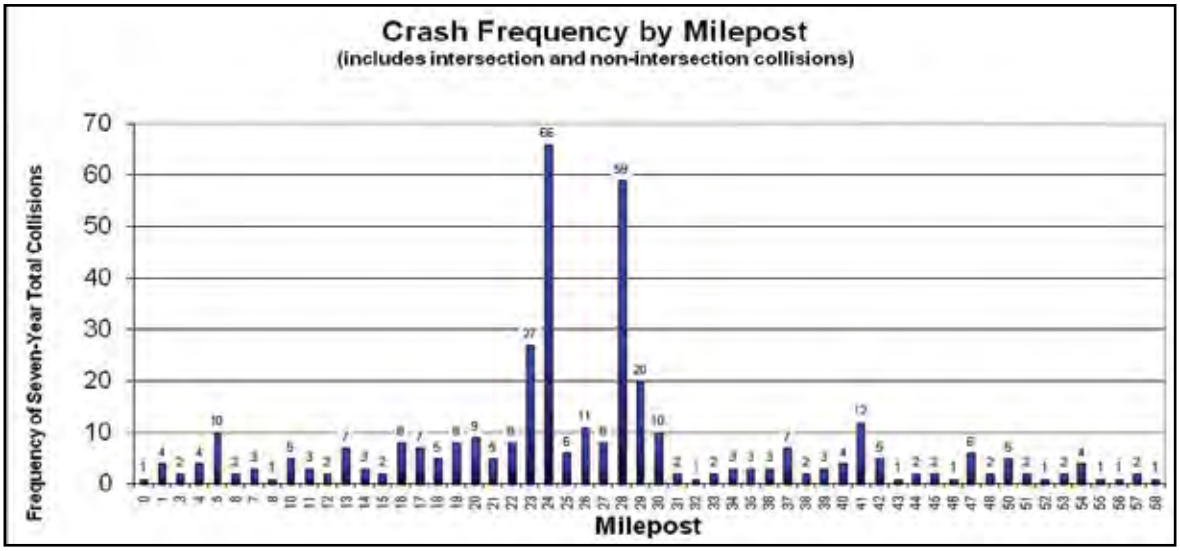
On the segment between Window Rock and Fort Defiance, Highway N-12 has an AADT ranging between 14,000 and 24,000 vehicles, reflecting use by:

- Residents of the Navajo Nation reservation, especially employees and visitors associated with the tribal government, which is centered in Window Rock.
- Residents and visitors to commercial establishments in Window Rock.
- Visitor and long-distance traffic on N-12.

The highway accommodates a substantial truck volume. Speed limits along the audit segments vary from 35 to 55 mph. Two views of N-12 are shown in Figure A.4.

Seven years (1999 through 2005) of collision summaries along N-12 were reviewed as part of this RSA. Over seven years, a total of 386 collisions were reported along N-12. Annual collision frequency peaked in 2002 with 60 reported collisions, and declined each

subsequent year to a low of 21 reported collisions in 2005. Figure A.5 shows the spatial distribution of collisions along the entire highway segment from MP 0.0 to MP 58.5. Peaks are evident around MP 23/24 and MP 28/29, which correspond to the Window Rock and Fort Defiance areas.



NOTE: *Shows collision locations reported on N-12 over seven years (1999 through 2005). Distribution is shown in one-mile segments, so (for example) all collisions at MP 24.0 through 24.9 are shown at "MP24" in the chart.*

FIGURE A.4 COLLISIONS ALONG HIGHWAY N-12

Looking north along N-12 at the intersection with N-110 (near Fort Defiance). A 62-foot urban cross-section is provided, consisting of two through lanes in each direction, with curb and gutter and turn lanes (or a raised median) at intersections.

Looking south along N-12 at audit site south of Highway 264. The cross-section is a two-lane rural road with wide paved shoulders.

FIGURE A.5 VIEWS OF RSA SITE (NAVAJO NATION)

KEY RSA FINDINGS AND SUGGESTIONS:

The key findings and suggestions of the RSA are summarized in Table A.4.

TABLE A.4 SUMMARY OF SELECTED SAFETY ISSUES AND SUGGESTIONS: NAVAJO NATION RSA

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
1	*Signing and Pavement Marking:* Worn or missing signs and pavement markings may limit driver guidance, especially at night.	D	• policy measures • measures to improve visibility and reduce maintenance requirements
2	*Pedestrian Facilities:* The design and maintenance of some pedestrian facilities may limit their usefulness. Pedestrians who are unable or unwilling to use pedestrian facilities may use the roadway instead, where they are exposed to vehicle traffic.	D	• maintenance schedule review • completion of pedestrian networks with sidewalk segments and marked crosswalks (where currently missing) • removal of obstructions in sidewalk
3	*Poor Pavement Conditions:* Cracked, worn, rutted, and dusty/muddy pavement may reduce driver control (especially for motorcyclists), particularly on N-12 between N-110 and Hwy 264.	C	• pavement repair and rehabilitation
4	*Intersection of N-12 and N-100 (Window Rock):* • Peak period left-turn volumes exceed the capacity of the left turn lanes. • Access to the residential area interferes with operations at the N-12/N-100 intersection. • Fixed-object hazards are located in the right-turn channelizing island. • Laning on the east exit leg is not clear.	C	• extend left turn lane to accommodate peak demand • revise signal operation to clear queue • introduce staggered work hours to reduce peak volumes • reconfigure intersection to four legs • relocate signal controller box • clarify laning requirements on eastbound exit leg

SAFETY ISSUE (Number and Description)		RISK RATING	SUGGESTIONS
5	*Intersection of N-12 and N-110 (Fort Defiance):* • The intersection configuration and conspicuousness may be limited. • Movements at driveways near the intersection may contribute to conflicts. • A fixed-object hazard is located close to travel lanes. • Laning on the east exit leg is not clear.	C	• improve signing and pavement markings • upgrade the signal display • review opportunities for access management • upgrade the east exit leg
6	*N-12 near St Michael's School (between MP22 and MP23):* • Horizontal and vertical curves limit sight distance on the approaches to the school driveway. • Roadside hazards may increase the potential risk and severity of an off-road collision.	C	• improve signing around the school driveway • increase the length of the guardrail • improve curve delineation
7	*S-curve on N-12 between MP13 and MP14:* • A steep roadside slope may increase the potential risk and severity of an off-road collision. • Drivers may be unprepared for vehicles pulling into or out of a school bus stop.	C	• install rumble strips • improve signing • increase length of guardrail

KEY LESSONS LEARNED:

See the discussion of "Key Factors for Success" and "Lessons Learned" in the main text.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