



ROAD SAFETY AUDIT

US-31 (REYNOLDS RD
TO SULLIVAN RD)

CITIES OF INTERLOCHEN AND GRAWN,
MICHIGAN

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1.0 Introduction

Road Safety Audits (RSAs) help promote road safety by identifying safety issues during the planning, design, and implementation stages, promoting awareness of safe design practices, integrating multimodal safety concerns, and considering human factors. Over the past decade, the Michigan Department of Transportation (MDOT) has been at the forefront of incorporating RSAs into the project life cycle.

Cincar Consulting Group, LLC (C2G) was brought on to facilitate a safety review of the US-31 corridor from Reynolds Road to Sullivan Road in the cities of Interlochen and Grawn, Michigan. This section of corridor is currently slated for redesign to include a center left-turn lane and guardrail improvements. MDOT Road Safety Audits follow the 8-step process outlined by the Federal Highway Administration (FHWA) in **Figure 1**. Each audit is broken down into smaller steps based on responsibility and project timeline.

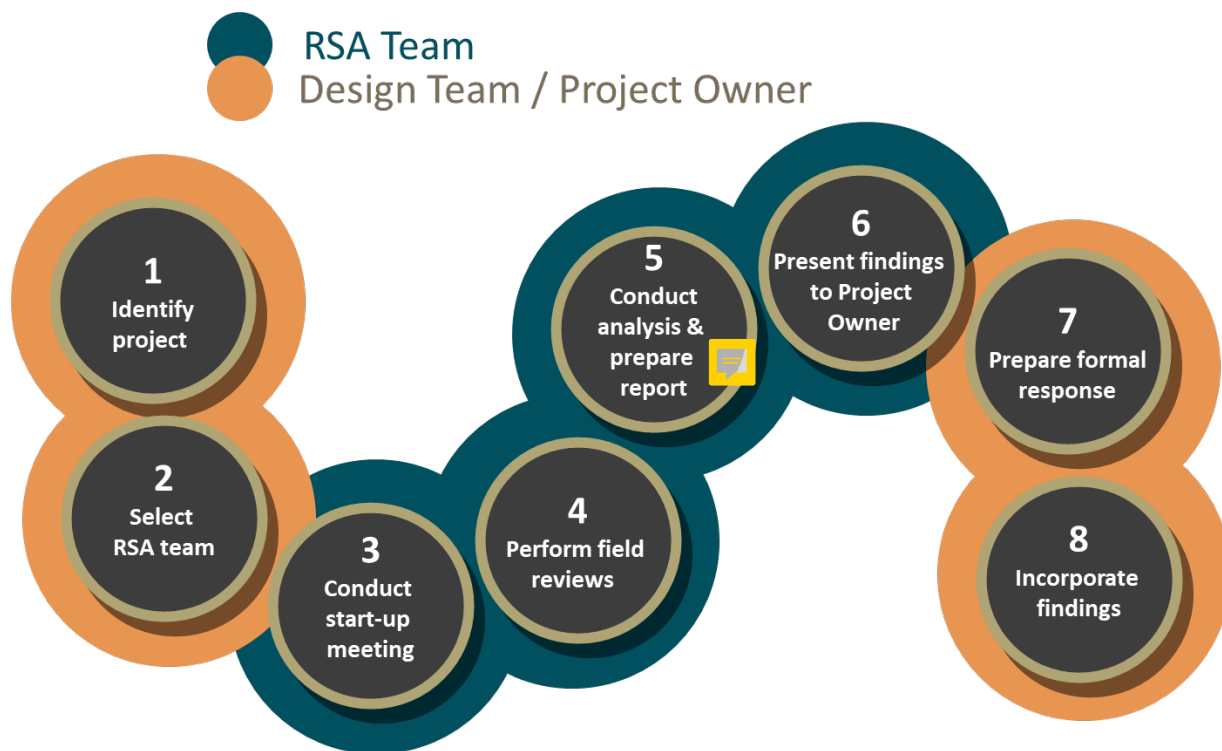


Figure 1: FHWA Road Safety Audit Process

RSAs are a proactive approach to address the safety of all road users by identifying safety issues and developing potential mitigation measures to be incorporated into the future design. Because the review is performed by an “independent and multi-disciplinary team” a wider range of recommendations can be achieved than through a standard crash analysis and design approach. An RSA also establishes connections with local engineers, planners, first responders, and maintenance staff to hear their experiences firsthand, opening the lines of communication with stakeholders.

The following report will detail the:

- RSA process and team
- Existing conditions, crash analysis, and field observations
- Geometric, operational, road user, and environmental safety issues identified within the project area
- Potential recommendations developed to reduce frequency and severity of crashes

1.1 Project Background

The objective of the study was to review the corridor for any safety issues that could be mitigated in the future design project. The project limits are shown in **Figure 2**. US-31 is a minor arterial linking Benzie County on the west to the cities of Interlochen and Grawn and eventually to Traverse City. J Maddie Parkway/Long Lake Road splits the corridor with about 10,862 AADT (2020) from Reynolds Road to J Maddie Parkway/Long Lake Road and 14,730 AADT (2020) from J Maddie Parkway/Long Lake Road to Sullivan Road. The project limits are about 8.39 miles in length.

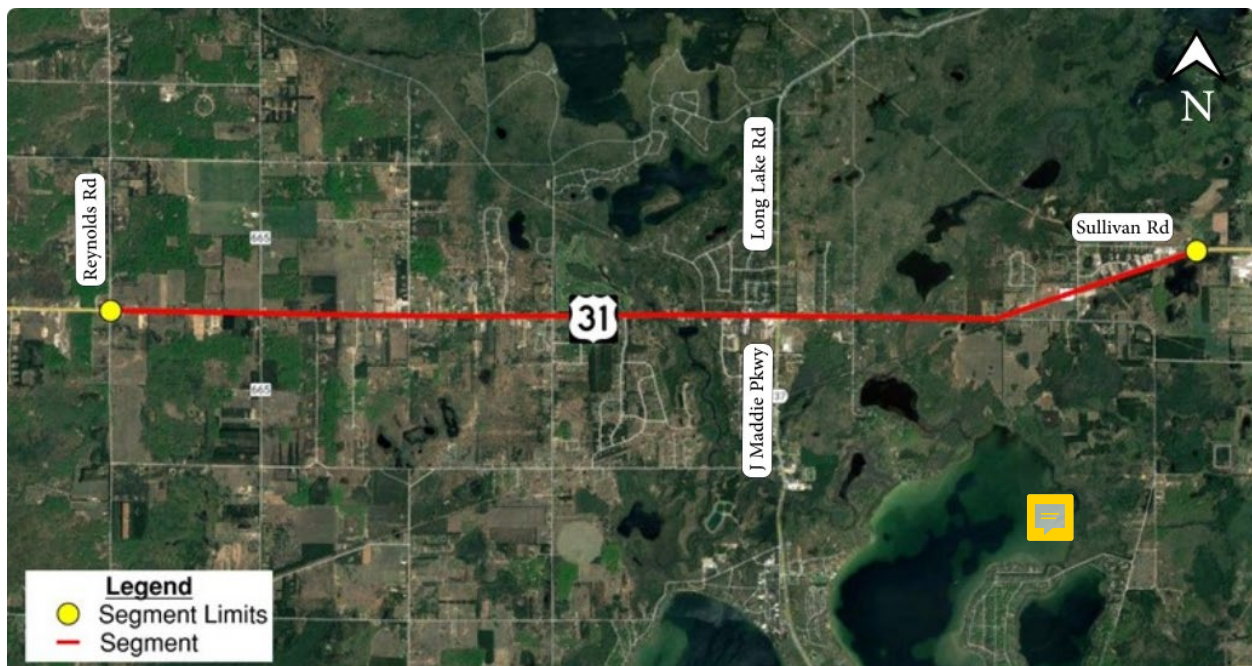


Figure 2: US-31 Road Safety Audit Limits

2.0 Road Safety Audit (RSA)

A Road Safety Audit (RSA) is a formal safety performance examination of an existing or future road or intersection by an independent and multidisciplinary team. The US-31 RSA followed the FHWA eight-step process. **Table 1** details key dates and information relating to the RSA process. Meeting minutes including a detailed list of attendees from the Kick-Off meeting and Preliminary Findings meeting are included in Appendix A.

Table 1: US-31 RSA Outline

Location	US-31 (Reynolds Rd to Sullivan Rd)
Project Owner	MDOT, North Region, and Traverse City TSC
Project Stage	Existing Roadway (future geometric changes)
Kick-Off Meeting	July 19, 2022 (MS Teams)
Attendees	MDOT C2G HNTB Inland Twp Interlochen Fine Arts Grand Traverse County Road Commission Green Lake Twp Community Stakeholders/Cycling Advocate
Field Review	July 20 - 21, 2022
Preliminary Findings Meeting	August 2, 2022 (MS Teams)
Attendees	MDOT C2G HNTB BATA Inland Township TART Trails RS Engineering (Designer) Michigan State Police

2.1 RSA Team

The RSA team was selected by MDOT (project owner) to represent a team (**Table 2**) that is:

- Independent: the views of the team members have no prior affiliation with the project
- Multi-disciplinary: team members bring forth different skillset and perspectives
- Experienced in performing RSAs

Table 2: US-31 RSA Team Members

Team Member	Organization	Role
Lauren Warren, PE, PTOE, PMP	C2G	Lead Facilitator
Skyler Waaso, PE, PTOE	HNTB	Traffic & Safety
John Engle, PE	MDOT	Traffic Operations
Michelle Eno	MDOT	Traffic & Safety
Cory Gardner, PE	MDOT	Operations (Design/Geometrics)

2.2 RSA Data Reviewed

The RSA Team was provided with the following documentation at the beginning of the project to aid in the review:

- **Traffic Counts:** Traffic counts were obtained using the MDOT Annual Average Daily Traffic (AADT) map interface (Highway Performance Monitoring System).
- **Crash Data:** the previous five years of crash data (2017-2021) were analyzed using data from the MDOT Safety Management Analysis Database. UD-10's for injury and fatal crashes were reviewed.
- **Supplemental Information:**
 - Aerial imagery
 - Signal operations
 - Background information on the project
 - Design Scoping Document
 - J Maddie Parkway future plans
- **Field Review:** A field review was conducted by two members of the RSA team on July 20-21, 2022. Video footage and photographs of the site were taken and distributed to the remaining team members who did not conduct an in-person review due to COVID-19 travel restrictions. A third team member performed an independent field review on July 12, 2022. Google Earth imagery was also used by virtual team members to supplement the review process.

2.3 RSA Analysis Process

After the project was identified and the existing information was inventoried, the RSA team conducted their safety analysis (Step 5). The team first identified the safety issues, then prioritized them, and finally estimated the frequency, severity, and risk associated with each safety issue.

2.3.1 Identify and Prioritize

A thorough review of the data listed in Section 2.2 was performed to identify any trends that are present. During the field review, the team referenced the GORE (geometrics, operations, roadway users, and environment) to help identify and begin to prioritize safety issues. It is important to keep in mind that the RSA team performed the review to the best of their skillset and ability within the timeframe and constraints given.

2.3.2 Estimate Risk

Each safety issue identified is assigned a crash frequency (**Table 3**) and crash severity (**Table 4**) rating using the FHWA guidance outlined. Once the crash frequency and severity associated with a safety issue were assigned, the values were placed into the Crash Risk Assessment matrix

(Table 5) and a risk factor was estimated. A risk factor that identifies as A has the lowest risk priority and F has the highest risk priority.

Table 3: Estimating Crash Frequency

Estimated		Frequency Rating
Exposure	Probability	
Medium → High	High	Frequent
Low → High	Medium → High	Occasional
Low → Medium	Low	Rare

Items considered when assigning crash frequency include volume, geometrics, congestion, environment, and road user characteristics.

Table 4: Estimating Crash Severity

Typical Collisions Expected	Expected Collision Severity	Severity Rating
High speeds or heavy vehicles, pedestrians, or bicycles	Probable fatality or incapacitating injury	High
Medium to high speed; head-on, crossing, or off-road collisions	Moderate to severe injury	Moderate
Medium to low speeds; left-turn and right-turn collisions	Minor to moderate injury	Low
Low to medium speeds; rear-end or sideswipe collisions	Property damage only	Negligible

Items considered when assigning crash severity include speed, crash types, vulnerability of road users, and vehicle composition.

Table 5: Crash Risk Assessment

Crash Frequency	Crash Severity			
	Negligible	Low	Moderate	High
Frequent	C	D	E	F
Occasional	B	C	D	E
Rare	A	B	C	D

A = lowest priority, F = highest priority

By identifying risk factors for each safety issue, the RSA team was able to prioritize the safety issues from highest to lowest priority. The final stage was to develop potential mitigations that would enhance safety within the project area. Recommendations made through an RSA process should be realistic, constructive, appropriate for the stage of the project, and for all road users. Identified safety issues, associated risks, and recommendations for this project are presented in Section 5.0.

3.0 Corridor Characteristics

3.1 Project Location

The project segment is approximate 8.39 miles between Reynolds Rd and Sullivan Rd in Grawn and Interlochen County (**Figure 2**). US-31 is a two-lane section, with one lane in each direction, continuous center rumble strips for the majority of the corridor, shoulder rumble strips between Betsie River Rd and Gonder Rd, and a wide shoulder throughout the length of the corridor. Several driveways also exist throughout the length of the corridor. There is only one signalized intersection at J Maddie Pkwy that is present along the corridor and advanced warning flashers have been installed. Numerous stop-controlled access points exist along the corridor and some are heavily skewed. An ITS tower between Betsie River and Round Lake Rd was observed to monitor weather conditions along US-31. **Figure 3** shows some of the existing roadway characteristics. The US-31 corridor has a posted speed limit of 55 MPH.



Figure 3: US-31 Existing Roadway Characteristics

There is one signalized intersection and 19 unsignalized intersections within the project limits. The following list goes from West to East:

- **At US-31 and Reynolds Road:** WB US-31 has one through lane and a dedicated right-turn lane, while EB US-31 has one through lane. Left turns from EWB US-31 to Reynolds Road are permitted. The wider outside shoulder on US-31 begins just west of Reynolds Road. The NB and SB approach of Reynolds Road has one through/left/right-turn lane. These approaches are marked with dual stop signs and delineated posts on the right-side stop. Also, one streetlight is located in the SE quadrant of the intersection.
- **At US-31 and Lake Ann Road/Bendon Road:** EWB US-31 has one through lane and a dedicated right-turn lane in each direction. Left turns from EWB US-31 to Lake Ann Road/Bendon Road are permitted. SB Lake Ann Road has one through/left/right-turn lane. Similarly, NB Bendon Road has one through/left/right-turn lane. Both approaches are marked with dual stop signs. Also, one streetlight is located in the SE quadrant of the intersection.
- **At US-31 and Blackford Boulevard:** EWB US-31 has one through lane in each direction. Left turns from WB US-31 to Blackford Blvd are permitted. NB Blackford Blvd has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on Blackford Blvd is 25 MPH.
- **At US-31 and Betsie River Road:** EWB US-31 has one through lane in each direction. NSB Betsie River Rd has one through/left/right-turn lane. Both approaches of Betsie River Rd are marked with a stop sign. There is an ITS device in front of Precision Concrete (East of Betsie River Rd) which also includes an ESS (icing) roadway sensor. Also, shoulder rumble strips start from the SE leg of the intersection.
- **At US-31 and Round Lake Road:** WB US-31 has one through lane and a dedicated right-turn lane, while EB US-31 has one through lane. Left turns from EB US-31 to Round Lake Rd are permitted. SB Round Lake Rd has one left/right-turn lane and is separated by a concrete median. This approach is marked with a stop sign.
- **At US-31 and Gonder Road:** EWB US-31 has one through lane in each direction. Left turns from EWB US-31 to Gonder Road are permitted. NSB Gonder Road has one through/left/right-turn lane. Both approaches at Gonder Road are marked with a stop sign. One streetlight is located in the SE leg of the intersection. Also, shoulder rumble strips end before the SW leg of the intersection.
- **At US-31 and Morgan Run Drive:** EWB US-31 has one through lane in each direction. Left turns from WB US-31 to Morgan Run Dr are permitted. NB Morgan Run Dr has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on Morgan Run Dr is 25 MPH.
- **At US-31 and Lake N Drive:** EWB US-31 has one through lane in each direction. Left turns from WB US-31 to Lake N Drive are permitted. NB Lake N Drive has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on Lake N Drive is 25 MPH. One streetlight is located in the SE leg of the intersection.

- **At US-31 and Melody Lane:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to Melody Ln are permitted. SB Melody Ln has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on Melody Ln is 25 MPH. One streetlight is located in the NE leg of the intersection.
- **At US-31 and Griner Parkway:** EWB US-31 has one through lane in each direction. Left turns from WB US-31 to Griner Pkwy are permitted. NB Griner Pkwy has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on Griner Pkwy is 25 MPH.
- **At US-31 and Kozy Court:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to Kozy Ct are permitted. SB Melody Ln has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on Kozy Ct is 25 MPH.
- **At US-31 and J Maddie Parkway (M-137):** EWB US-31 has a one-through lane and a dedicated left-turn and right-turn lane. Advance warning signs/flashers are provided to the east and west of the intersection, warning travelers of the signal downstream. NSB J Maddie Pkwy (M-137) has one through/right-turn lane and a dedicated left-turn lane. The posted speed limit on J Maddie Pkwy (M-137) is 45 MPH.
- **At US-31 and White Oak Lane:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to White Oak Ln are permitted. SB White Oak Ln has one left/right-turn lane. This approach is marked with a stop sign. The posted speed limit on White Oak Ln is 25 MPH.
- **At US-31 and Tonawanda Road:** EWB US-31 has one through lane in each direction. Left turns from EWB US-31 to Tonawanda Road are permitted. NSB Tonawanda Road has one through/left/right-turn lane. Both approaches at Tonawanda Road are marked with a stop sign. A streetlight is in the diagonal span.
- **At US-31 and Ellis Lake Road:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to Ellis Lake Rd are permitted. SB Ellis Lake Rd has one left/right-turn lane. This approach is marked with a stop sign.
- **At US-31 and E Duck Lake Rd:** EWB US-31 has one through lane in each direction. Left turns from WB US-31 to E Duck Lake Rd are permitted. SEB E Duck Lake Rd has one left/right-turn lane. This approach is marked with a stop sign. There is a severe skew on the E Duck Lake Rd approach. A streetlight is in the diagonal span.
- **At US-31 and Fairfield Drive:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to Fairfield Dr are permitted. SB Fairfield Dr has one left/right-turn lane. This approach is marked with a stop sign.
- **At US-31 and Pine Tree Road:** EWB US-31 has one through lane in each direction. Left turns from EWB US-31 to Pine Tree Rd are permitted. NSB Pine Tree Rd has one through/left/right-turn lane. Both approaches at Pine Tree Rd are marked with a stop sign. A streetlight is in the diagonal span.
- **At US-31 and Scotchwood Lane:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to Scotchwood Ln are permitted. SB Scotchwood Ln has one left/right-turn lane. This approach is marked with a stop sign.

- **At US-31 and Sullivan Road:** EWB US-31 has one through lane in each direction. Left turns from EB US-31 to Sullivan Rd are permitted. SB Sullivan Rd has one left/right-turn lane. This approach is marked with a stop sign. Severe skew at Sullivan Rd approach. A streetlight is in the diagonal span.

3.1.1 Field Observations

Observations of the site were conducted on July 20-21, 2022, by two RSA team members. A third team member performed a field review on July 12, 2022. The corridor was visited during the AM, off-peak, and PM hours operational hours. These timelines included site reviews during lighted and dark conditions. Team members obtained videos and photographs while driving and walking the site. Key corridor observations included:

- Heavy EB movement in the AM and heavy WB movement in the PM
- Traffic operations and left turns at the signal at J Maddie Parkway
- Frequent number of cross streets (stop controlled) some at a skew with decreased visibility
- Center rumble strips and wide paved/gravel shoulder
- Misuse of shoulder, bypass lanes, and right-turn lanes by vehicles trying to pass a left-turning vehicle
- Vertical sight distance issues due to crest/sag curves
- Heavy trucking presence due to plant on the west end of the corridor

3.2 Roadway Users

The primary mode of travel throughout the corridor is passenger vehicles. The corridor has an approximate AADT of 10,862 vehicles (west of J Maddie Pkwy) and 14,730 vehicles (east of J Maddie Pkwy). Additional modes of travel include cycling. See **Figure 4** pictures for roadway users. A local transit route uses US-31 with a stop in the SW parking lot at J Maddie Pkwy. Several cyclists were observed utilizing the shoulders and crossing at intersections.

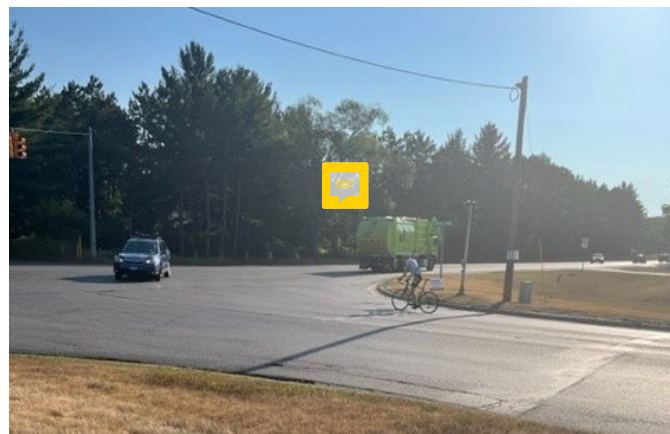
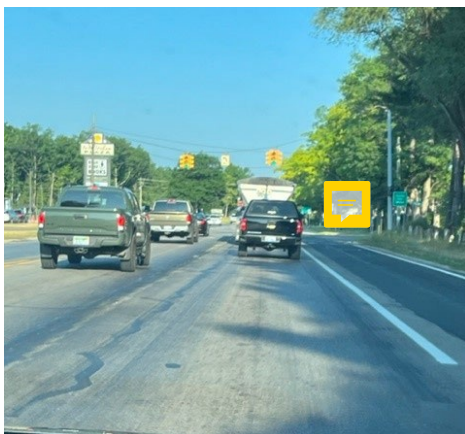


Figure 4: Roadway Users

3.3 Crash Analysis

A crash analysis of US-31 between Reynolds Road and Sullivan Road was performed for a five-year period ranging from January 1, 2017, to December 31, 2021.

There were 230 crashes during the analysis period, of which 46% (106 total) were rear-end collisions, 11% (25 total) were angle crashes, and 6% (13 total) were sideswipe same-direction crashes. The remainder of the crashes consisted of single motor vehicle, head-on, sideswipe opposite direction, head-on, and other crashes.

Crash types are summarized in **Figure 5**. The proportion of rear-end straight crashes is similar to other Grand Traverse County US-Route crash averages.

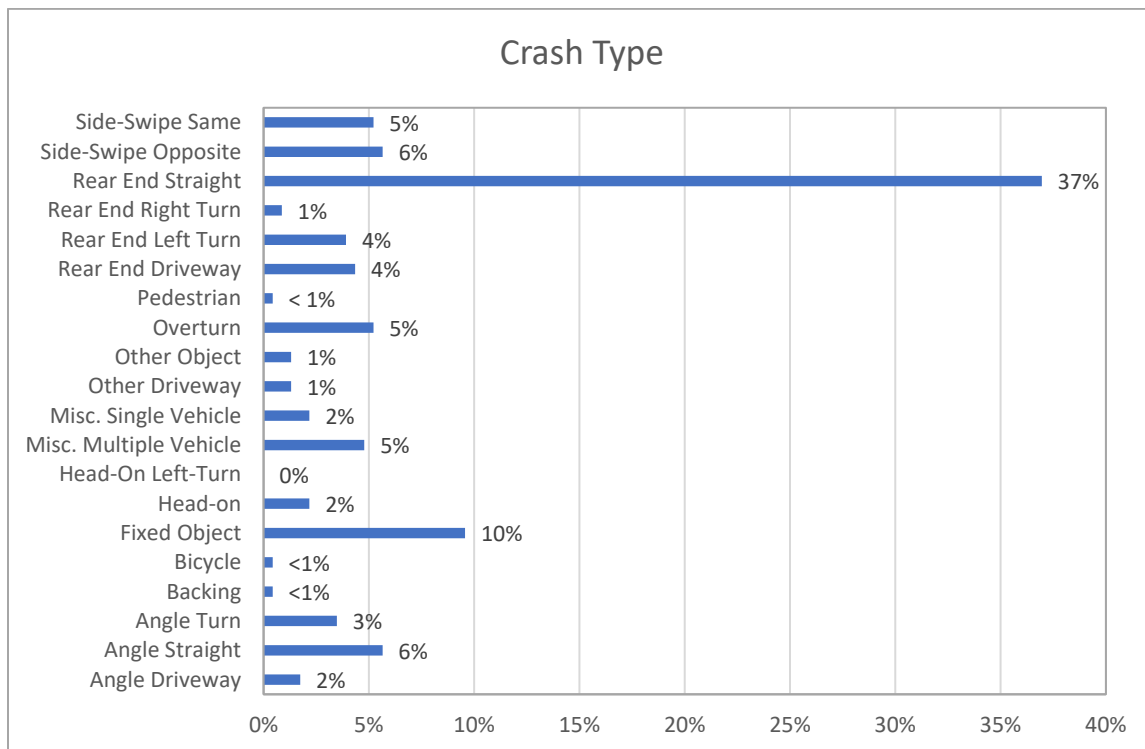


Figure 5: Crash Type

3.3.1 Crash Characteristics

Out of the 230 total crashes, 66 crashes (29%) resulted in some type of injury. Four crashes (2%) resulted in Fatal (Type K) injuries and six crashes (3%) resulted in Type A injuries. A breakdown of crashes by severity is shown in **Figure 6**. The proportion of Fatal (Type K), Type A, and Type B injuries is approximately 7% higher when compared to other Grand Traverse County US-Route averages. The proportion of Type C injuries is approximately 4% higher and the proportion of crashes with some type of injury is approximately 11% higher when compared to other Grand Traverse County US-Route crash averages.

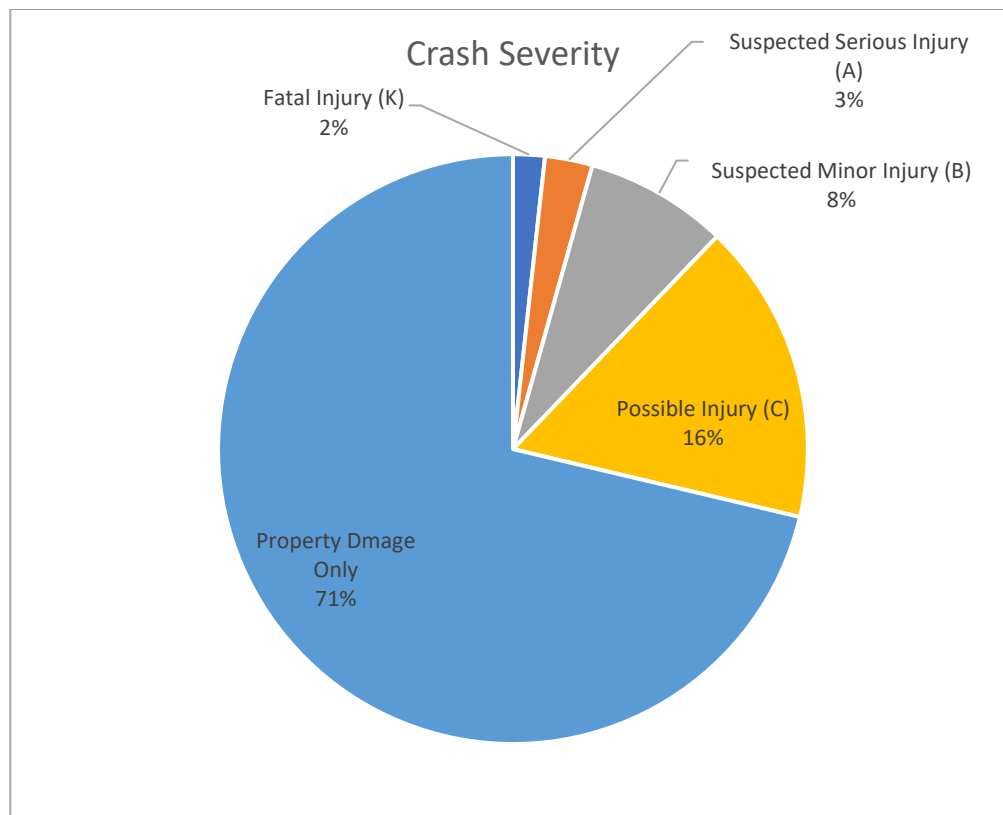


Figure 6: Crash Severity

3.3.2 Crash Trends

To better understand crash trends, the crash data was further broken down into relevant categories such as time of day, roadway conditions, and lighting conditions. Understanding crash trends allows for appropriate mitigation measures to be recommended.

The varying roadway and lighting conditions at the time of a crash are shown in **Figure 7**. The proportion of crashes occurring in dry roadway conditions is approximately 6% lower when compared to other Grand Traverse County US-Route crash averages. The proportion of crashes occurring in icy road conditions is approximately 10% higher when compared to other Grand Traverse County US-Route crash averages. The proportion of crashes occurring during daylight along US-31 is similar to other Grand Traverse County US-Routes crash averages.

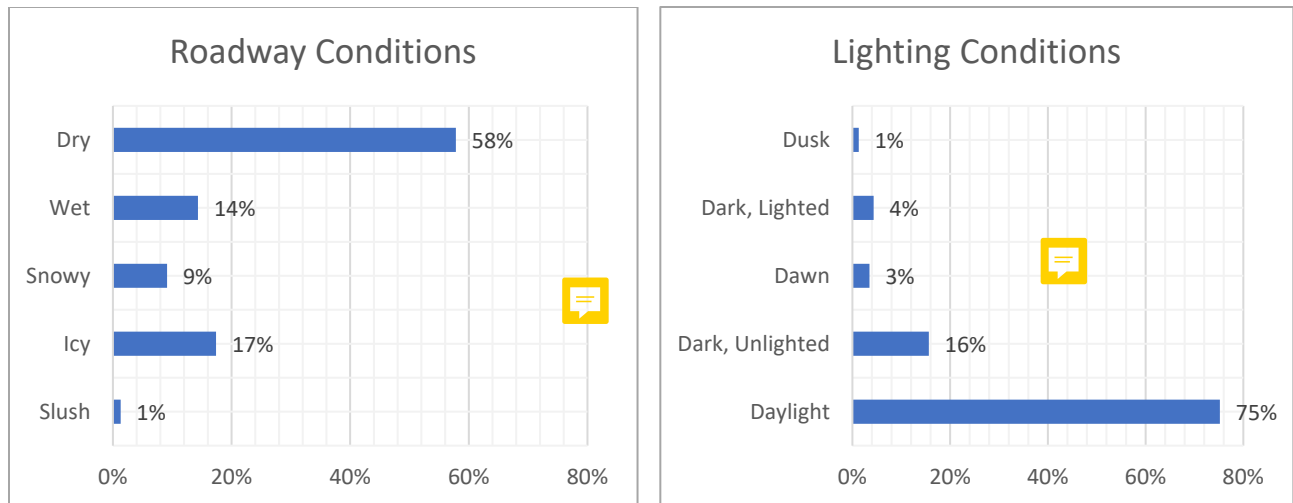


Figure 7: Crashes by Roadway and Lighting Conditions

The crashes along US-31 were broken down by month and are displayed in **Figure 8**. The highest proportion of crashes occurred in January and December. The proportion of crashes in January is approximately 4.4% higher when compared to Grand Traverse County monthly percentages for the same five-year time period.

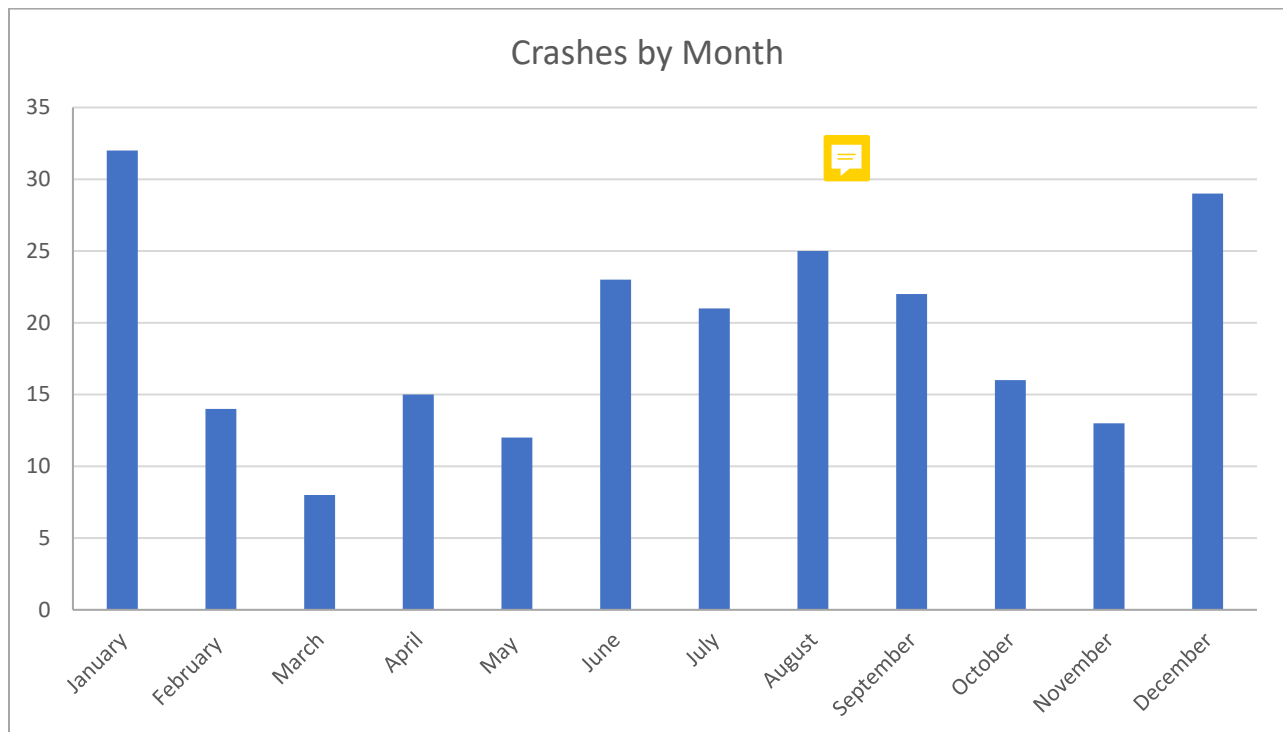


Figure 8: Crashes by Month

The crashes along the US-31 corridor were broken down by hour of the day and are shown in **Figure 9**. The highest proportion of crashes along the corridor occur during the midday and PM peak periods from 11:00 AM to 2:00 PM and 4:00 PM to 7:00 PM.

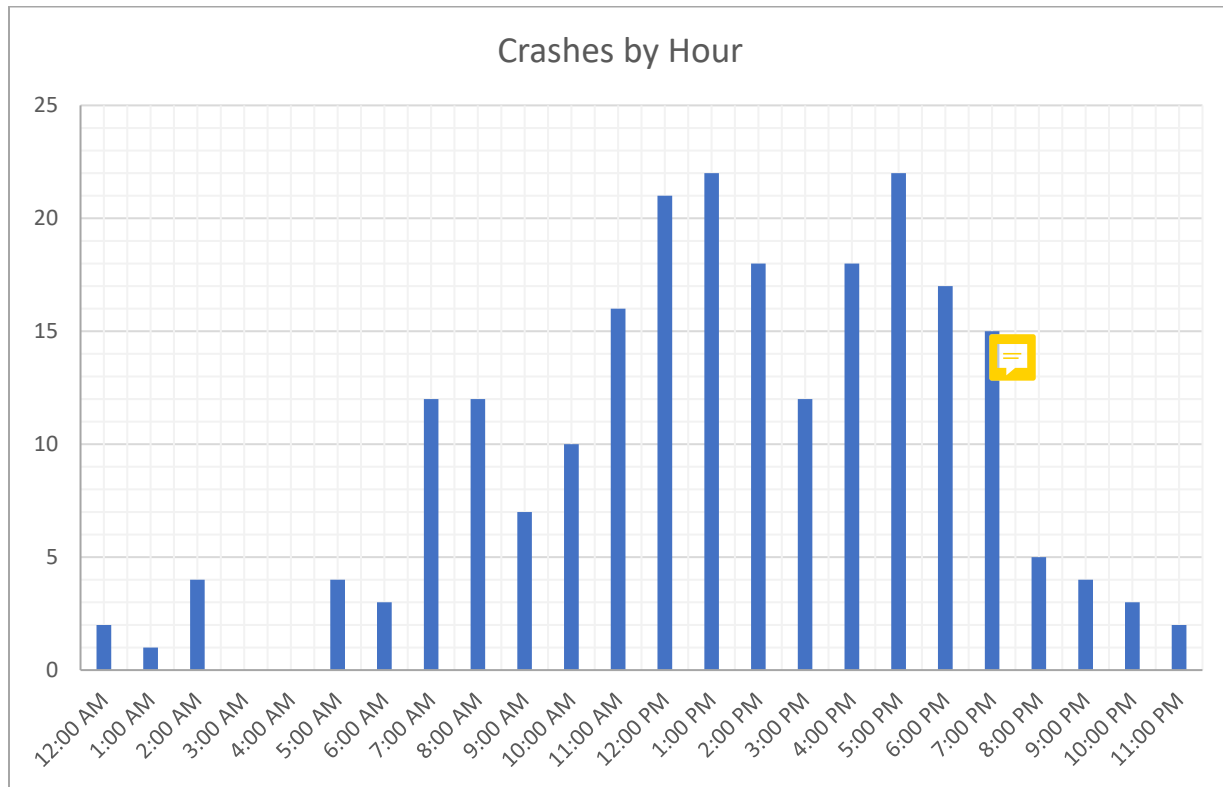





Figure 9: Crashes by Hour

4.0 Existing Safety Measures

The RSA Team noted several positive safety measures currently present along the project corridor that are intended to enhance the overall safety of both motorized and non-motorized travelers.

Existing Safety Measures	
<p>Center rumble strips (side rumbles between Betsie River Rd and Gonder Rd)</p> <p>Corridor pavement markings visible</p>	
<p>Local intersections</p> <ul style="list-style-type: none"> • Streetlights • Advanced signage • Dual stop signs with reflectors 	

Existing Safety Measures	
<p>Advanced warning flashers at J Maddie Pkwy and Fire Station (pre-empt)</p>	
<p>ESS – ITS tower to monitor weather conditions. Two pavement pucks present.</p>	

5.0 Safety Issues and Recommendations

The following section details the safety risks identified by the RSA team after performing their review, as well as the RSA Risk Priority Ranking. Risks are presented in order from highest (Risk Rating F) to lowest (Risk Rating A). Recommendations presented include both short and long-term mitigations and a range of investment levels. It will be up to the project owner to prioritize which mitigations are implemented based on each of these factors.

5.1 Issue #1 - Corridor Wide

SAFETY ISSUES

The US-31 corridor runs east/west which creates sun glare/blind in the morning and evening hours of travel. There is only one lane in each direction with no passing lanes. Crossroads and driveways are spaced throughout the corridor, which results in left-turn movements. The lack of turn lanes has resulted in a higher percentage of rear-end crashes, vehicles passing on the right (gravel shoulder), and using the existing right-turn only lanes as by-pass lanes. Queuing was also noticeable on EB US-31 at Tonawanda Rd. The lack of available gaps eastbound during the AM and westbound during the PM is causing drivers to be more aggressive in completing turning movements.

Gravel shoulders are present along the corridor. A height difference between the pavement and the gravel shoulder was noticed as well as highly varied slopes. Both traits could decrease the driver's ability to recover if they run off the road. Several cyclists along the corridor were observed utilizing gravel shoulders. An example of this can be seen in **Figure 10**.



Figure 10: Corridor Wide Examples

RISK RATING

Due to the corridor-wide nature of these safety issues the RSA team members assigned crash frequency as **frequent**. The crash types associated with left turns are typically angle and rear-end. Crashes affiliated with this safety issue tend to involve motor vehicles and thus assigned a **moderate** severity. The final risk rating is E.

Crash Frequency	Crash Severity
Frequent	Moderate
	E



RECOMMENDATIONS

- **Install a center left-turn lane:** MDOT has already identified this improvement and it is programmed for inclusion in the upcoming years.
- **Install right-turn lanes to proper standards and flares:** if right-turn-only lanes are included along the corridor it would encourage proper standards to be followed which could increase driver compliance to use these lanes correctly.
- **Provide paved shoulders with rumble/mumble strips:** paved shoulders would eliminate the height difference between the mainline and shoulder and create standard slopes. The paved shoulders would provide a better surface for cyclists and also create a buffer between vehicles and cyclists.
- **Fill gravel to match pavement height:** if the shoulders remain unpaved, gravel should be filled to the pavement height and maintained to improve safety.

5.2 Issue #2 – Vertical / Horizontal Curves

SAFETY ISSUES

Horizontal and vertical curves are present along the corridor that create poor sight distance, leading to misjudged gaps in traffic flows. Several noticeable locations along US-31 include:

- **Golf Course / Lakes Drive:** a vertical curve is present and leads to drivers not being able to see while turning from WB US-31 onto Lakes Drive. Additionally, the upwards slope while traveling WB creates varied speeds while approaching the Golf Course driveway. An example of this can be seen on the left of **Figure 11**. Drivers were seen taking small gaps from these access points.
- **Tonawanda Road:** a sag/crest curve is just to the east of J Maddie Parkway. Drivers traveling EB come over the curve and sometimes do not have proper site distance to stop if a queue is occurring on EB US-31 at Tonawanda.
- **Duck Lake Road:** this roadway connects to US-31 on the outer part of a horizontal curve creating a skew. During the field visits, drivers were observed exiting US-31 EB at a high rate of speed and either utilizing the wide gravel shoulder or entering the oncoming WB lane on Duck Lake Road. An example of this can be seen on the right of **Figure 11**. The skew connection also makes it difficult to make turns onto WB US-31 from Duck Lake Road. A near miss was observed at this intersection.

- Sullivan Road: also connects to US-31 in a horizontal curve. Due to the lower volume along this roadway not as many crashes were recorded at the intersection.



Figure 11: Vertical/Horizontal Curve Examples

RISK RATING

Due to the higher traffic volumes on Duck Lake Road and the behaviors that were observed, the RSA team members assigned the crash frequency as **occasional**. The crash types associated with curves include angle and rear-end crashes combined with increased speed and were thus assigned a **high** severity. The final risk rating is E.

Crash Frequency	Crash Severity
Occasional	High
	E

RECOMMENDATIONS

- **Proper design standards for curves:** As the corridor undergoes a redesign, an evaluation of the sight distance should be performed. Where possible, the redesign should work to reduce the number of sag curves and improve the sight distance.
- **Redesign Duck Lake Road approach:** Redesign the approach to “T-in” to US-31. This would eliminate the sweeping right-turn movement and could improve sight distance for entering WB. A second option could be to cul-de-sac this end and have drivers use Pine Tree Road. Pine Tree Road crosses US-31 on a straight section that is relatively flat.

Pine Tree is a local roadway and may need minor improvements to handle additional traffic.

- **Redesign Sullivan Road approach:** Redesign the approach to “T-in” to US-31. A second option could be to cul-de-sac this end and have drivers use Pine Tree Road. Pine Tree Road crosses US-31 on a straight section that is relatively flat. Business access needs to be maintained and may not be feasible due to developments planned on the north side.



Figure 12: Cul-de-sac Option at Duck Lake Road and Sullivan Road

5.3 Issue # 3 – US-31 at J Maddie Parkway / Long Lake Road

SAFETY ISSUES

The US-31 at J Maddy Parkway intersection is the only signalized intersection within the study area corridor limits. The signalized intersection contains several safety concerns.

The overgrown vegetation in the northeastern quadrant restricts sight distance posing a risk for turning vehicles. Vehicles were observed traveling through the intersection during yellow and all-red signal time to complete their movements. It was observed that some of the northbound and southbound left turners had to wait two signal cycles before completing the left-turn due to the lack of available gaps in opposing traffic. Vehicles, including asphalt trucks, were observed traveling through the intersection at high speeds. The pavement markings within the intersection were also worn and difficult to detect and the intersection does not currently include crosswalks or ramps for pedestrians. **Figure 13** illustrates some of these issues such as the overgrown vegetation and lack of crosswalk and ramp features at the intersection.



Figure 13: Safety issues at US-31 and J Maddy Parkway

RISK RATING

Upon review of the data and observations the RSA team members assigned the crash frequency as **occasional**. The crash type prevalent at this intersection are rear-end crashes. The number of crashes in this area as well as the potential for crashes to involve vulnerable road users (pedestrians and bicycles) are the reasons for assigning a high crash severity. The final risk rating is E.

Crash Frequency	Crash Severity
Occasional	High
	E

RECOMMENDATIONS

- **Improve visibility of the clear zone/ROW in all quadrants:** It is recommended that vegetation be removed in all quadrants to improve visibility for both drivers and allow adequate space for pedestrians.
- **Enhance pavement markings** to facilitate a clear path for pedestrians crossing each approach at the intersection. This could reduce the number of pedestrians crossing at unmarked locations.
- **Address access management of existing and future driveways near the intersection:** It is recommended to follow an access management plan when access requests are submitted for new or existing developments. Proper access management will help to minimize the number of conflict points near the intersection.
- **Enhance traffic signal:** The signal at the intersection could be modernized to a box span to provide good visibility to the signal heads. Backplates could also be incorporated to provide enhanced visibility of the signal heads. Clearance intervals and current cycle lengths can be evaluated to determine any necessary adjustments. Also, a left-turn phasing warrant analysis can be completed to determine any changes to the left-turn phasing on all four approaches.

- **Consider a roundabout:** The installation of a roundabout would be useful in reducing the travel speed on approaches to the intersection as well as the adjacent corridor. However, the number of lanes would need to be evaluated along with incorporation of proper pedestrian facilities, signage, and pedestrian refuge, to ensure safe access to the intersection for all users. A layout of a potential roundabout design is shown in **Figure 14**.

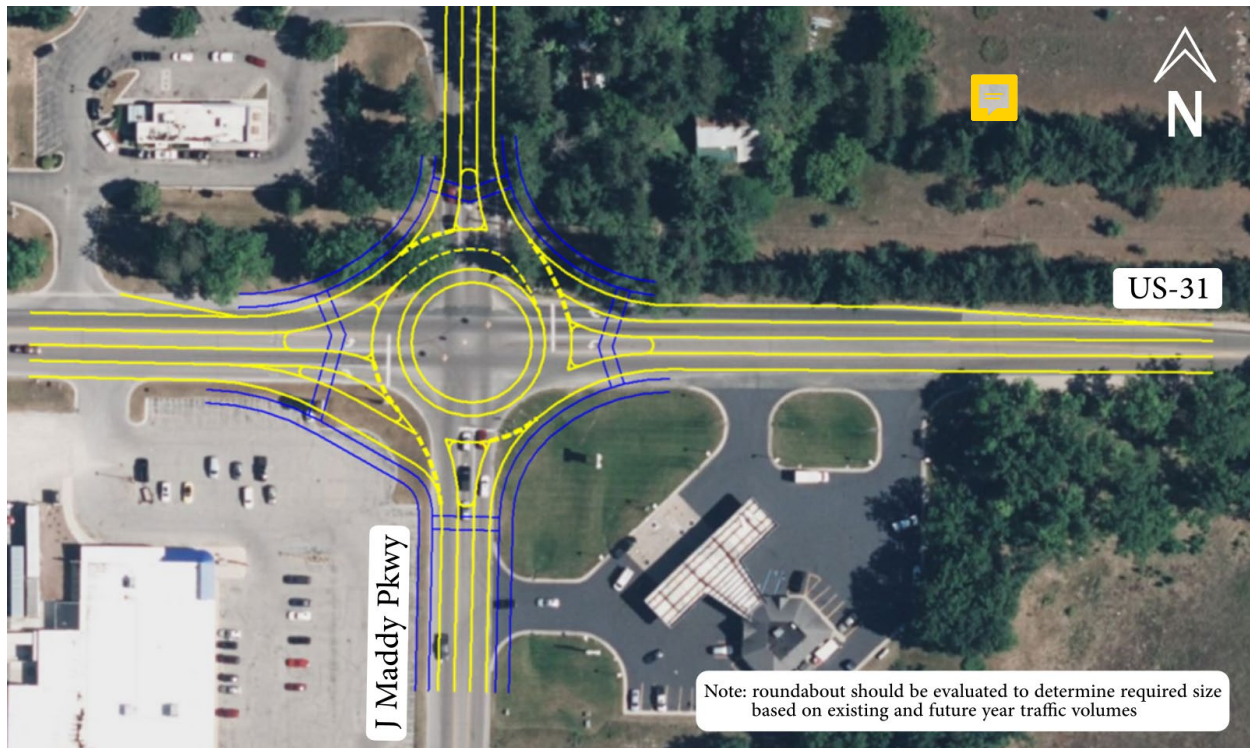


Figure 14: Roundabout layout at US-31 and J Maddy Pkwy

5.4 Issue # 4 – Winter/Icy Conditions

SAFETY ISSUES

The icy roadway conditions during the winter months pose safety concerns along the US-31 corridor. An existing ITS Environmental Sensor Station (ESS) site that monitors the weather conditions has two pucks in the roadway, where both are located on US-31 between Betsie River Road and Gonder Road. Large trees on the southside of US-31 shade the roadway and may contribute to the ice not melting on the roadway. The highest number of crashes associated with icy, wet, and snowy roadway conditions are located a half mile to the west and a half mile to the east of the US-31 and J Maddy Parkway intersection.



Figure 15: Existing ITS sensor (puck) along US-31

RISK RATING

Upon review of the data and observations the RSA team members assigned the crash frequency as **occasional**. Crashes associated with roadway conditions were higher at the US-31 at J Maddy Parkway intersection, but no other high concentration locations were identified from the crash analysis. The final risk rating is D.

Crash Frequency	Crash Severity
Occasional	Moderate
	D

RECOMMENDATIONS

- **ITS ESS Site and advanced warning signs:** Utilize the existing two sensors and add advanced warning signs (LED border or flasher) to alert drivers of the downstream roadway conditions
- **Clear pine trees** in the area to eliminate or reduce the shaded area along the roadway
- **Add delineators** on shoulders to prevent vehicles from veering off the roadway

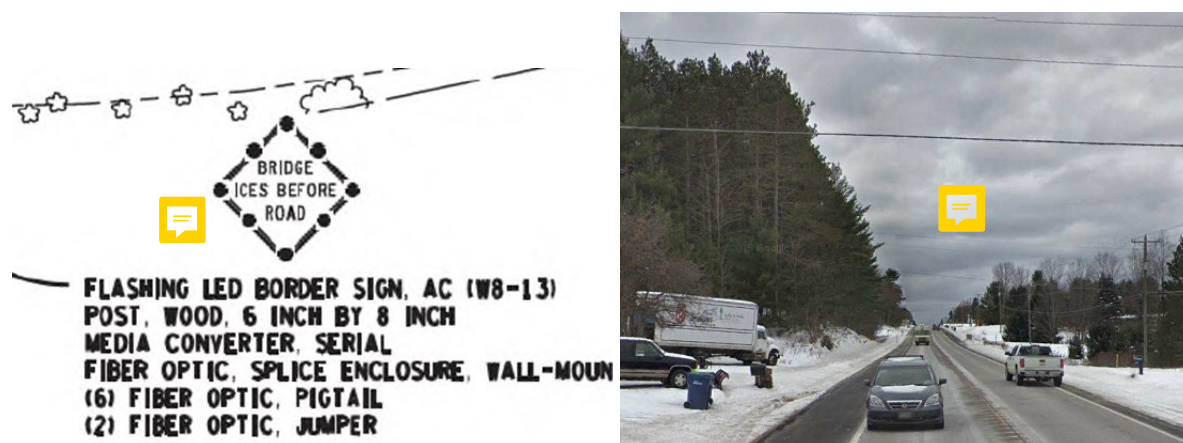


Figure 16: Advanced Warning Flasher with LED border sign

5.5 Other Issues and Recommendations

Additional concerns were noted during the field review but were not given priority ranking. They are documented here for further consideration:

1. Enhance lighting to cover the entire intersection and approaches, especially on the proposed widened US-31 corridor
2. Increase street name sizes for enhanced visibility for drivers
3. Develop a Corridor Access Plan with MDOT and the local communities in order to accommodate the needs of new developments and the fire station relocation
4. Consider future construction and necessary accommodations along J Maddy Parkway as it relates to the proposed non-motorized path (J Maddy Parkway & Karlin Road DDA Trail)

6.0 Safety Analysis

The Highway Safety Manual (HSM) introduces a science-based technical approach to incorporating safety into traditional roadway planning and safety analyses. The first edition of the HSM (2010) provides the best information and tools in a useful form to facilitate roadway planning, design, operations, and maintenance decisions based on precise consideration of their safety consequences. The primary focus of the HSM is the introduction and development of analytical tools for predicting the impact of transportation project and program decisions on road safety.

The HSM Analysis spreadsheet provided and maintained by MDOT was utilized for this analysis as it predicts the number of crashes to be proportionally increased or decreased based on calibrated conditions in Michigan. The Urban & Suburban Segments model was used for this analysis. Crash Modification Factors (CMF) were applied as necessary for the base conditions and proposed alternatives.

6.1 Base Conditions

For this analysis, crash data from 2017 to 2021 were evaluated for US-31 between Reynolds Road and Sullivan Road. The following provides some of the more common traits and characteristics identified for these segments:

Roadway Type	Minor Arterial
Segment Length	8.39 miles
AADT	10,862 from Reynolds Road to M-137 14,730 from M-137 to Sullivan Road
Commercial Vehicles	4%
On-Street Parking	No Parking; 0% coverage
Lighting	Present

6.2 After Conditions with Recommendations

Due to the existing limitations in the HSM methodology and the recommendations identified to address concerns in the study area, not all suggested treatments could be evaluated.

Recommendations included in the HSM Calculation are provided in **Table 6** and a summary of results are provided in **Table 7**. If all corridor-wide treatments are implemented, the annual number of crashes is expected to decrease by approximately 42% for the US-31 segment from Reynolds Road to J Maddy Parkway and decrease by approximately 37.5% for the US-31 segment from J Maddy Parkway to Sullivan Road.

Table 6. HSM Crash Reduction Factors

Treatment	Source	Est. Crash Reduction
Add a two-way left-turn lane (corridor-wide)	MDOT HSM Spreadsheet	Built-in
Rumble strips on shoulders	CMF 6679	7%

Table 7. HSM Results

Segment	Length	AADT	Average Crashes per Year	
			Existing	Alternative
US-31 from Reynolds Road to J Maddy Parkway	4.4	10,862	19	11
US -31 from J Maddy Parkway to Sullivan Road	2.9	14,730	16	10

Some other treatments have a quantifiable impact on specific crash types or locations. These are summarized in **Table 8**. Since these were not corridor-wide improvements, they were not incorporated into the HSM calculation. Other recommendations not listed here may not be quantifiable but nevertheless are expected to have a positive impact on corridor safety.

Table 8. Other Crash Reduction Factors

Treatment	Source	Est. Crash Reduction	Applicable Crashes
Improve Access Management	MDOT TOR Spreadsheet	15%	Driveway applicable crashes
Box Span Signal Upgrade from Diagonal Span (US-31 at J Maddy Parkway)	MDOT TOR Spreadsheet	10%	All applicable crashes+
Signal Optimization & Timing Updates (US-31 at J Maddy Parkway)	MDOT TOR Spreadsheet	10%	All applicable crashes+
Install Backplates at the signalized intersection (US-31 at J Maddy Parkway)	MDOT TOR Spreadsheet	15%	All applicable crashes
Install a Roundabout (US-31 and J Maddy Parkway)	MDOT TOR Spreadsheet	78%	Fatal and A-Injury reduction
		57%	Minor Crash reduction
Remove Trees from roadway shoulder (US-31 between Betsie River Rd and Gonder Rd)	MDOT TOR Spreadsheet	75%	Fixed-object applicable crashes
Add Shoulder Delineators	CMF 9728	10%	Run off road
Enhance Lighting (unsignalized intersections)	CMF 11026	32.1%	All crashes
Increase Street Name Sizes	MDOT TOR Spreadsheet	30%	Angle, Rear-end crashes

+ All Applicable Crashes – Rear End, Angle Crashes, Sideswipe Same. The crashes should occur at the signal that is being upgraded. Does not include driveway and animal involved crashes.

7.0 Summary

The objective of the study was to perform a formal safety review (RSA) of the US-31 corridor from Reynolds Road to Sullivan Road for any safety issues that could be mitigated in a future design project. US-31 is a minor arterial linking Benzie County on the west to the cities of Interlochen and Grawn and eventually to Traverse City. J Maddie Parkway/Long Lake Road splits the corridor with about 10,862 AADT (2020) from Reynolds Road to J Maddie Parkway/Long Lake Road and 14,730 AADT (2020) from J Maddie Parkway/Long Lake Road to Sullivan Road. The project limits are about 8.39 miles in length.

A crash analysis was performed for a five-year period ranging from 2017 to 2021 to review for applicable trends and a field visit was conducted. Below is a summary of the safety issues observed and voiced by community members, the RSA risk rating, and the potential countermeasures identified.

A variety of short-term and long-term recommendations with a range of cost implications has been presented. Issues are linked to the discussion sections above. It is up to the Project Owner to determine which recommendations to implement and how to fund.

Table 9: Summary of Recommendations

Safety Issue	Risk Rating	Identified Countermeasures
Issue #1 - Corridor Wide <ul style="list-style-type: none"> Lack of left-turn lanes High percentage of rear-end crashes Vehicles passing on the right either using gravel shoulder or right-turn only lanes East/west corridor gets sun glare 	E	<ul style="list-style-type: none"> Install left turn lane Install right-turn lanes to standard Paved shoulders with rumble/mumble strips Gravel filled to match pavement height
Issue #2 – Vertical / Horizontal Curves <ul style="list-style-type: none"> Golf Course and Lakes Drive interaction due to curve Tonawanda sag/crest curve Duck Lake Road and Sullivan Road connect on horizontal curve 	E	<ul style="list-style-type: none"> Improve sight distance by reducing number or severity of vertical curves T-in Duck Lake and Sullivan Rd or consider cul-de-sac
Issue # 3 – US-31 at J Maddie Parkway / Long Lake Road <ul style="list-style-type: none"> Overgrown vegetation in NE quad restricting sight distance Vehicles using yellow/all red to complete movements Ped lights/buttons but no crosswalks or ramps (cyclists observed) Worn pavement markings within intersection 	E	<ul style="list-style-type: none"> Improve clear zone/ROW in all quadrants Enhance pavement markings Enhance crosswalks Provide access management of existing and future driveways within intersection Evaluate need for signal improvements: <ul style="list-style-type: none"> Evaluate clearance intervals and cycle length Perform left-turn warrant analysis Modernize to box span

Safety Issue	Risk Rating	Identified Countermeasures
<ul style="list-style-type: none"> High speeds through intersection (asphalt trucks) Access points within intersection 		<ul style="list-style-type: none"> Add backplates to gain visibility Improve crosswalk markings and addition of refuge ramps Assess roundabout: <ul style="list-style-type: none"> Evaluate number of lanes needed Incorporate proper pedestrian facilities, signage, and refuges Assess if it reduces travel speed on approaches / adjacent corridor
Issue # 4 – Winter/Icy Conditions <ul style="list-style-type: none"> High percentage of weather-related crashes Large trees shade the roadway not allowing melt US-31 at J Maddy Pkwy (½ mile on either side of the intersection) 	D	<ul style="list-style-type: none"> ITS ESS Site: <ul style="list-style-type: none"> Consider relocating pucks to capture shaded area. Add advanced warning signs (LED border or flasher) for drivers. Clear pine trees in area to eliminate/reduce shaded area (ROW/private owner) Provide delineators on shoulders
Other Issues and Recommendations		<ul style="list-style-type: none"> Enhance lighting to cover entire intersection/approaches (newly widened roadway) Increase street name sizes Develop a Corridor Access Plan – MDOT/Local Community J Maddie Pkwy path - consider future construction / accommodations