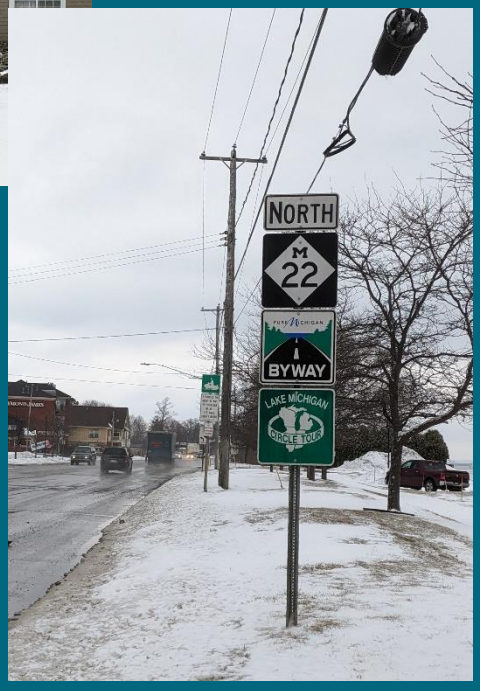
Road Safety Audit Report

M-22/M-72
Traverse City, Grand Traverse/Leelanau Counties

Michigan Department of Transportation
MDOT Job No. 204066

April 2022



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1.0 Introduction

The State of Michigan, through the Governor's Traffic Safety Advisory Commissions, has created a plan to help improve the traffic safety culture through the Strategic Highway Safety Plan and the Toward Zero Deaths statewide campaign. As part of the implementation of these plans, Road Safety Audits (RSA) are utilized to formally examine the safety performance of an existing or future road or intersection by an independent, multi-disciplinary team. The goal of an RSA is to answer the following questions:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

This RSA was requested by the Michigan Department of Transportation (MDOT) Traverse City Transportation Service Center (TSC). This segment of M-22/M-72 from 500 feet west of US-31 to 1,200 feet north of M-72 is planned for reconstruction. The RSA is intended to provide MDOT and the consultant designer with an independent review of safety concerns and design elements that may be considered to enhance safety with this project, or in the future. The subject roadway segment, intersections, and approximate limits that were investigated for this RSA are described in Table 1. The RSA study area is shown on Figure 1.

Table 1– M-22/M-72 RSA Segments and Intersections

Section/Intersection	Length (mi +/-)	Cross Section / Configuration	Speed Limit (mph)	Additional Information
M-22 North of M-72 to project limits	0.23	3 Lane w/ Center Left Turn Lane	40	Leelanau County
M-22 at M-72 Intersection	n/a	Signalized T-intersection	40 (M-22) 35 (M-72)	Bay Street intersects M-72 approx. 65' west of M-22
M-22 between M-72 and Pedestrian Mid-Block Crossing	0.28	4-Lane Boulevard	35	12' wide median
Signalized Mid-Block Pedestrian Crossing Near Elmwood Ave	n/a	HAWK Signal	35	Pushbutton actuation / TART Trail
M-22/M-72 between Pedestrian HAWK to project limits near US-31	0.21	4-Lane Boulevard	35	12' wide median
M-22/M-72 at US-31 Intersection (outside project limits)	n/a	Signalized T-intersection	40 (M-22) 30 (US-31)	Bay Street intersects US-31 approx. 65' west of M-22

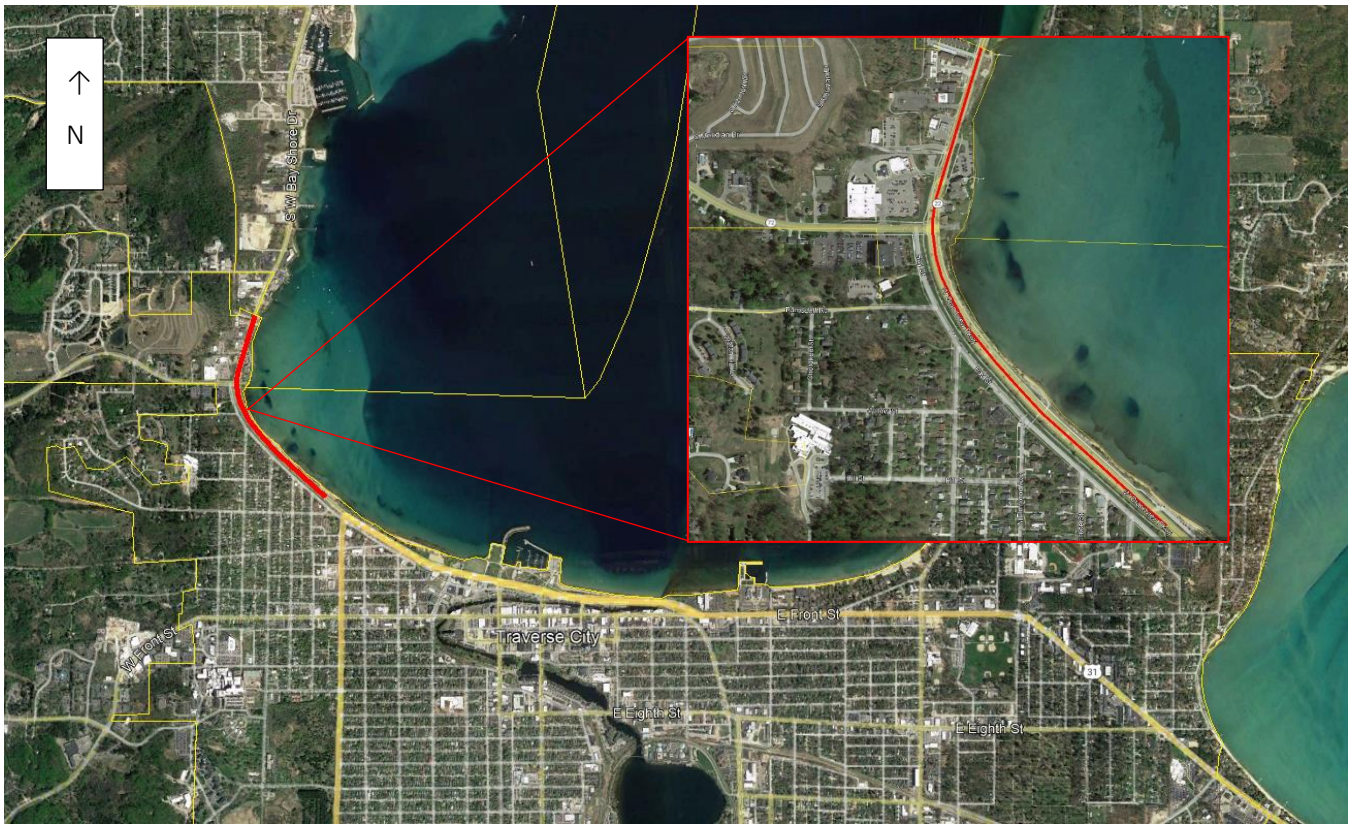

Figure 1 – RSA Study Area

Historically, RSAs have been performed in-person with all RSA Team members and stakeholders present on-location. In the wake of the COVID-19 pandemic and social distancing practices, MDOT has been conducting RSAs in a more virtual manner. Fishbeck staff visited the site in-person to record photos, video, and observations that were shared with the RSA Team. Other RSA Team members visited the site independently, and/or reviewed available aerial imagery and the photos/videos provided by Fishbeck. The RSA Team met via conference calls to review all site notes and observations to develop a consensus as to the safety concerns and relative mitigation measures included in this report.

2.0 Road Safety Audit

2.1 RSA Team

The RSA Team was comprised of representatives from across the state and led by members of Fishbeck. The team consisted of an experienced group of individuals possessing a diverse range of expertise including, geometrics, operations, and safety. The RSA Team included the following individuals:

- Mark Fisher, MDOT Lansing Geometrics
- Tom Anderson, MDOT Huron TSC
- Marc Fredrickson, MDOT Muskegon TSC
- TJ Likens, Fishbeck RSA Team Leader
- Greg Hickey, Fishbeck RSA Engineer
- Kyle Reidsma, Fishbeck QA/QC Manager

2.2 RSA Overview

An RSA is a proactive, formal safety performance examination of an existing (or future) transportation facility by an unbiased, multidisciplinary team. An RSA considers the safety of all users, examines the interaction between facility and user, identifies risks to the users, and suggests safety improvement measures. An RSA is not a check of adherence to published standards and specifications. RSAs involve field investigations as well as review of available plans and data. The goal is to suggest measures with the potential to improve overall safety performance of the facility for all road users and to reduce protentional crash severity.

The study limits on M-22/M-72 were selected by MDOT based on current project programming practices. The RSA was conducted in a manner consistent with the Federal Highway Administration (FHWA) *Road Safety Audit Guidelines* adopted by MDOT. The assessment took place in March 2022 with reporting completed in April 2022 according to the following schedule.

Table 2 – RSA Schedule

Milestone	Date(s)
Fishbeck Field Review	March 2-3, 2022
Kick-Off Meeting	March 7, 2022
RSA Team Field Reviews	March 7-10, 202
RSA Team Conference Call	March 11, 2022
RSA Findings Presentation	March 14, 2022
Draft RSA Findings Report	April 8, 2022
Final RSA Findings Report	April 28, 2022

Information utilized by the RSA Team throughout the assessment's duration included:

- Aerial imagery;
- Traffic volume data;
- Crash data and safety studies;
- Available roadway plans;
- Adjacent lane use information; and
- Known safety concerns from stakeholder input.

2.3 Fishbeck Field Review

An in-person field investigation was performed by Fishbeck staff on Wednesday, March 2 and Thursday, March 3, 2022. On March 2, daytime, p.m. peak, and nighttime reviews were completed, with a.m. peak reviews completed on March 3. Weather conditions were relativity clear and cold with light snowfall in the afternoon of March 2. The site visit was documented with digital imagery and video recordings supplemented with both audible commentary and written notes/sketches. Additionally, Fishbeck staff drove the segment multiple times during daylight and nighttime/evening hours, and each drive was video recorded with audible commentary.

The videos, photos, and notes were shared with other members of the RSA Team. The RSA Team members from MDOT visited the site independently and/or reviewed the observations recorded by Fishbeck in order to identify potential safety concerns on their own. RSA Team members provided notes and observations via email that were compiled by Fishbeck. The RSA Team discussed these observations on a subsequent conference call.

2.4 Kick-Off Meeting

A virtual kick-off meeting was held the afternoon of March 7, 2022. In attendance were all members of the RSA Team, representatives from MDOT Traverse TSC, MDOT North Region, City of Traverse City, Grand Traverse County, and Leelanau County, as well as other local stakeholders. The purpose of this meeting was to provide an overview of the RSA process, a brief recounting of the field visit, and a review of the current M-22/M-72 facilities.

The kick-off meeting was facilitated by Fishbeck with input from MDOT and the RSA Team. All attendees were encouraged to provide background information to the RSA Team relevant to the project study area including anecdotal knowledge, personal observations, and a history of the study roadway and surrounding area. Key information provided included:

- MDOT plans to reconstruct the study section of M-22/M-72 and has recently selected a design consultant.
- There is a significant pedestrian and bicyclist presence along the corridor related to summer tourism and the Traverse Area Recreation Trail (TART) which runs parallel with M-22/M-72.
- Bay Street runs parallel to M-22/M-72 approximately 65 feet south/west of the studied roadway segment. This proximity causes conflict and motorist confusion at the Bay Street intersections with M-72 and US-31.
- MDOT will be collecting volume data at the M-22/M-72 intersection in the spring of 2022 to further evaluate operations and potential intersection reconfiguration concepts.
- There were comments regarding the use of the high-intensity activated crosswalk (HAWK) signalized mid-block pedestrian crossing near Elmwood Avenue. Stakeholders had observed “near-misses” caused by improper signal usage and crossing without activating the signal. For example, some vehicles would stop at the crosswalk absent of a signal indication to allow waiting pedestrians to cross. This would block pedestrians from the view of trailing vehicles, which would maneuver around the stopped vehicle and accelerate through the crosswalk when the HAWK was not activated properly, or if motorists ignored the signal.
- Similar issues with pedestrian safety were noted at the M-72 intersection, where vehicles would execute a right turn on a red signal indication with pedestrians utilizing the crosswalks under a protected walk phase. This is a legal maneuver, but the complexity of movements can draw attention away from pedestrians crossing or waiting to cross.
- Large, multi-axled gravel haulers utilize M-72 as an east-west corridor and would frequently travel through the M-22/M-72 intersection.
- Concern over vehicular speeds along the roadway corridor were expressed. The desire was stated to reduce existing speed limits and/or implement design features to induce lower average speeds.

- It was noted that the presence of the Grand Traverse Bay along the eastern edge of M-22/M-72 provides a significant distraction to all road users. This is especially prevalent during tourism seasons.
- Beyond the northern M-22/M-72 RSA study limit, M-22 is currently being redesigned and will be reconstructed. The redesign includes the construction of curb and gutter along each side of the roadway and non-motorized improvements along the corridor. This will eliminate the wide paved shoulder on the bay side of that segment of M-22.
- The northern area of the study limits handles a significant amount of surface run-off, and drainage improvements have been made in this area that should be reviewed during roadway design. Recent improvements have limited drainage spread into the travelled way.
- Traffic signals at M-72 and US-31 have recently been upgraded to operate on an adaptive system with additional cameras and sensors to detect and respond to demand fluctuations.

2.5 RSA Team Conference Call

A virtual conference call was facilitated by Fishbeck with members of the RSA Team on March 11, 2022. Fishbeck presented an overview of field observations, photos, and videos and these items were discussed amongst the team. Safety concerns along the corridor were identified and the RSA Team discussed relative risk factors and potential options to improve safety at these locations. The team identified ten specific safety concerns that are outlined in greater detail in subsequent sections of this report, along with general improvements that could enhance safety for the study corridor. Overall, two key findings emerged:

- Pedestrian/bicycle safety is a recurring concern. At several locations interactions between vehicles and non-motorized traffic present exposure for crash occurrence that is likely to result in severe outcome.
- The offset of Bay Street at the M-22/M-72 intersection creates complicated operations that have an adverse impact on safety. The same is true at US-31; however, the M-22/US-31 and US-31/Bay Street intersections are outside the limits of the current project.

Observation of a.m. and p.m. peak period traffic operations indicated that the traffic signals at M-72 and US-31 adequately process peak period demands, although movements at the adjacent Bay Street intersections experienced longer delays and queues and caused turbulence to/from M-22/M-72/US-31. The adaptive signal system processes vehicle queues every cycle and operations appear generally acceptable. The RSA Team and project stakeholders concurred that vehicular and non-motorized volumes are higher during the peak summer tourism season. Unfamiliar drivers may also be more readily confused, adding to delays and conflicts. Therefore, the RSA Team expects that vehicle delays and queues would be longer during the summer than observed for this RSA.

2.6 RSA Findings Presentation

A virtual findings meeting was held the afternoon of March 14, 2022. Attendance was similar to the kick-off meeting, including all members of the RSA Team, representatives from MDOT Traverse TSC, MDOT North Region, City of Traverse City, Grand Traverse County, and Leelanau County, as well as other local stakeholders. The purpose of this meeting was to communicate the key safety-related findings by the RSA Team and review potential safety improvement measures with MDOT and project stakeholders. During the course of the findings meeting, there were discussions to elaborate on the observations and findings of the RSA Team as well as reflect relevant information back to the RSA Team from MDOT and stakeholders. The information, observations, and findings presented at this meeting are further documented in this report.

3.0 Study Area Characteristics, Operations, and Safety

The project section of M-22/M-72 is a minor arterial with a posted speed limit of 35 miles per hour (mph) between US-31 and M-72 and a posted speed limit of 40 mph north of M-72. M-22/M-72 generally traverses southeast to northwest through the RSA study area, following the shoreline immediately adjacent to west arm of the Grand Traverse Bay (Lake Michigan). The studied segment is located within Traverse City, Grand Traverse and Leelanau Counties, Michigan.

M-22 overall serves as a minor arterial that runs along the Leelanau peninsula, connecting with US-31 in Traverse City and north of Manistee. Traverse City and the surrounding region experience a significant influx of seasonal residents and tourists during the warmer summer months. M-22/M-72 is a heavily travelled roadway which facilitates a significant portion of the tourism related traffic volumes in and through Traverse City. Primary adjacent land uses are residential, commercial, and recreational with beach parking and access near the M-22/M-72 and US-31 intersection. The Average Daily Traffic (ADT) volume on M-22/M-72 is approximately 28,500 vehicles per day between US-31 and M-72. North of M-72 the ADT is approximately 23,500. Commercial (heavy vehicle) traffic comprises approximately 2% of the AADT. These data were reported by MDOT in Traffic Analysis Request (TAR) #3483 dated February 2, 2022.

From US-31 to M-72, M-22/M-72 is a divided boulevard with a narrow (12-foot) median and two lanes in each direction. Pedestrian facilities run parallel on both sides of the roadway, including the TART trail. This roadway section has an enclosed drainage system with curb and gutter on the outside and median. There are three bidirectional median breaks within this section of the boulevard. North of M-72, M-22 narrows to have a three-lane section with one lane in each direction and a center lane for left turns. The west side of M-22 north of M-72 has curb and gutter, while the east side has a 12-foot wide paved shoulder with open drainage. The TART trail runs along the west side of M-22, with portions maintained as a wide paved area immediately behind the curb. On the east side, the sidewalk terminates and gaps out to the north along the bay. Grades are relatively flat along the study corridor.

3.1 Crash Statistics

Crash data from two previous studies of M-22/M-72 from east of US-31 to north of M-72 were provided by MDOT. Crash history was compiled in these studies by MDOT between January 1, 2013 and December 31, 2020 (overlapping data from 2016). These data extend slightly beyond the limits of this RSA; however, provide an indication of prevailing crash types along the corridor. Animal crashes were excluded from these data.

Crash data provided by MDOT indicate that the predominant crash types on the corridor are rear-end and sideswipe (same direction) crashes. This correlates with anecdotal knowledge of vehicle delays and congestion on the corridor, especially as experienced during the peak summer months. As shown on Figure 2, other crash types each comprise 2% to 7% of the overall crash history.

Crashes involving a pedestrian/bicycle as well as all serious injury crashes were further evaluated by Fishbeck. Crash data from 2013 thru 2020 (excluding animal crashes) were obtained from Michigan Traffic Crash Facts, which references the Michigan State Police database. During this period, three crashes involving a bicycle and one involving a pedestrian occurred, resulting in one A-level serious injury, one B-level minor injury, one C-level possible injury, and one property damage only (PDO) crash. In addition to the bicycle crash that resulted in A-level injury, one vehicle head-on left-turn crash occurred at the US-31 intersection that resulted in A-level injury. The US-31 intersection is outside the limits of this RSA; however, the crash is noteworthy. Zero fatalities have been recorded on this corridor. Approximately 89% of all crashes resulted in PDO severity.

Two of the four pedestrian/bicycle crashes occurred at mid-block marked pedestrian crossings in July 2017 and July 2018. Both crashes involved a truck stopping for a bicycle crossing M-22/M-72, blocking view of the

crosswalk, and a driver in the other lane continuing through the crosswalk, striking the cyclist. One crash resulted in the cyclist being propelled and crashing to the pavement, incurring several broken bones and internal injury according to the police report. An MDOT press release indicates that the existing HAWK signalized crossing of M-22/M-72 near Elmwood Avenue was installed in 2019. Installation of the HAWK signalized crossing of M-22/M-72 can be expected to provide significant safety enhancement as compared to the previous marked/signed crossings.

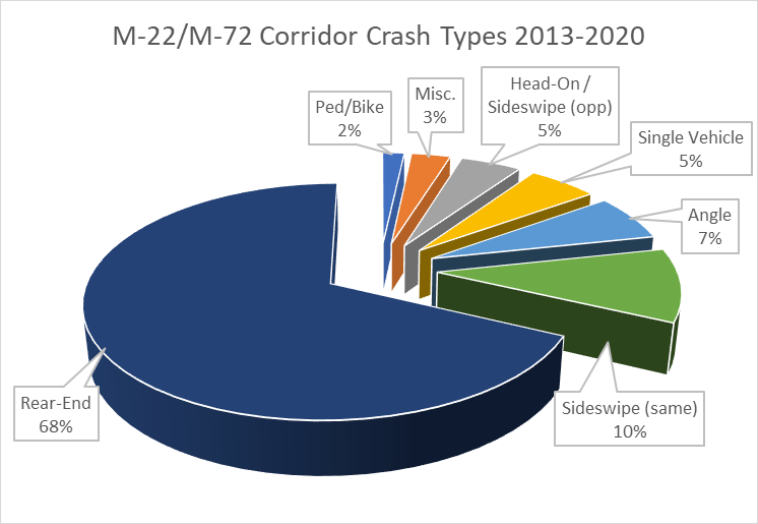

Figure 2 – M-22/M-72 Corridor Crash History by Type

Historical crashes at the M-22/M-72 intersection were also evaluated in greater detail, including those occurring in the vicinity of Bay Street. During the 2013-2020 timeframe, 157 total crashes were recorded in this area with zero fatal or A-level serious injury crashes. Similar to the overall study corridor, the predominant crash types at this intersection are rear-end and sideswipe (same direction) crashes. This correlates with anecdotal knowledge of vehicle delays and congestion, especially as experienced during the peak summer months. Angle, head-on (left-turn), and sideswipe (opposite) crashes comprise approximately 14% of crash occurrence at this location. The recent signal modernization can be expected to provide safety enhancement by reducing delays and queues which may encourage risky maneuvers. Additionally, improved left-turn operation can be expected to reduce angle and head-on (left-turn) crash occurrence, which tend to result in more severe outcomes.

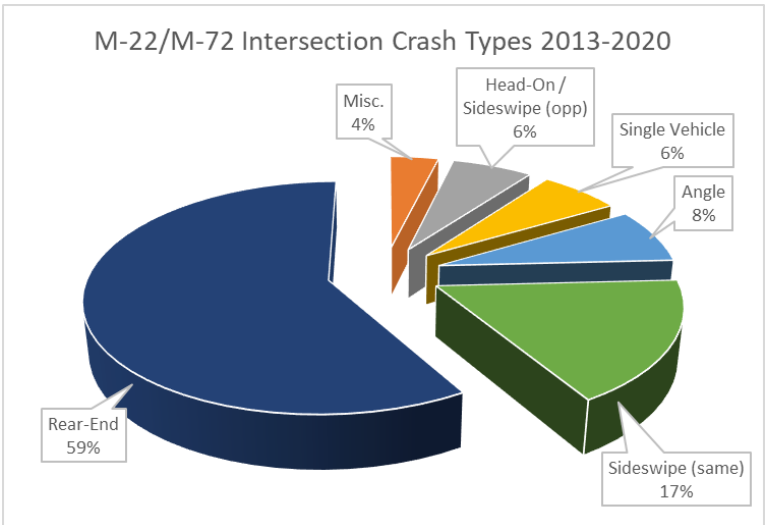

Figure 3 – M-22/M-72 Intersection Crash History by Type

4.0 Safety Benefit and Performance

This report provides information on issues identified by the RSA Team and deemed relevant to the stated goal of identifying opportunities to improve road safety within the study area. Opportunities to improve safety on M-22/M-72 are outlined herein based on observations and expertise of the RSA Team. Where appropriate, an assessment of road user safety risk and suggestions for improvement are included. A draft of this report was prepared by the consultant team and circulated among all RSA Team members for review prior to being finalized. The findings of this report were developed based on discussions throughout the RSA process and consensus by all RSA Team members. Upon acceptance, MDOT will prepare a formal Owner's Response which will also be appended to the report.

The suggestions and illustrations (e.g. exhibits and photographs) should not be viewed as design or operational recommendations. They are intended to be illustrative of existing issues and potential solutions to identified safety issues and are presented for consideration only. Based on the information provided in this report and other potential considerations, some suggestions may be rejected via a formal Owner's Response. Depending on the complexity of an accepted suggestion, subsequent tasks may include the completion of detailed engineering studies, further benefit-cost assessments, identification of funding, environmental studies, detailed design, and ultimately construction.

4.1 Estimating Benefits

For comparative purposes, where possible, a benefit-to-cost ratio has been calculated for the safety improvements that have been suggested for consideration. This ratio compares the net annual benefits resulting from an individual improvement to the annual installation cost over the expected service life of the improvement. A five-step process was utilized to determine this ratio as follows:

1. Estimate the expected crash frequency at each location of interest.
2. Estimate the change in crashes by severity for each suggested safety improvement.
3. Estimate the net benefit resulting from the change in crashes.
4. Estimate cost for installation of each suggested safety improvement.
5. Calculate the annual benefit-to-cost ratio.

The Highway Safety Manual (HSM) provides a structured methodology to estimate expected crash frequency and severity for facilities with known characteristics. The HSM was referenced to determine average expected crash frequencies based on statistics for similar facilities as well as available crash history. To estimate the expected crash frequency at each location of interest, Chapter 12 (Predictive Methods for Urban and Suburban Arterials) of the HSM was referenced.

Once average crash frequency was estimated, methodologies presented in Chapter 13 (Roadway Segments) and Chapter 14 (Intersections) of the HSM were referenced to estimate the change in crashes resulting from each safety improvement based on relevant Crash Modification Factors (CMF). CMFs quantify the change in expected average crash frequency by implementing a particular improvement. After the change in crashes was determined for each safety improvement, traffic crash costs by casualty/severity were used to estimate the resultant net benefit. Crash costs were determined based on data published by MDOT.

Cost estimates were developed on generalized order of magnitude basis and not actual unit pricing. Finally, an annual benefit-to-cost ratio was calculated for relevant suggestions and can be used to evaluate treatment options at locations identified by this RSA. Benefit-costs should not be referenced on an absolute basis to select nor disqualify any potential treatment. Rather, this information can be compared to draw conclusions for the relative efficacy of treatment options as well as order of magnitude cost considerations for short and long-term improvements.

4.2 Safety Performance

The application of HSM methodologies is being advanced nationally and in the State of Michigan through the development of various spreadsheets and software. For the analysis of M-22/M-72, the HSM analysis spreadsheet developed by MDOT was utilized. HSM analysis of urban/suburban arterials requires the overall roadway be broken down into homogeneous segments and individual intersections. As defined above, the study portion of M-22/M-72 has two distinct cross sections; the three-lane section north of M-72 and the four-lane boulevard between the M-72 intersection and US-31. Within the study limits, the M-22/M-72 intersection was identified to have particular safety concerns and was analyzed separately.

HSM analysis of M-22/M-72 was completed for the individual segments and intersection within the approximately 0.75-mile study limits. Crash data were reviewed to determine the number of crashes that occurred along project segments, and which crashes were related to the subject intersection. Crash history was also disaggregated by single vehicle and multi-vehicle types to correspond with the HSM predictive calculations. Historical crash occurrence was compared to HSM crash predictions to determine the current safety performance of the facility.

On average, the project segments of M-22/M-72 experience 30 total crashes per year, comprised of 2 single-vehicle and 28 multi-vehicle crashes. The intersection of M-22 and M-72 experiences an average of 20 crashes per year, which are all multi-vehicle crashes. There is likely some overlap in the number of reported crashes between each segment and intersection per the published crash data; however, these averages provide a reasonable estimate of annual crash occurrence for the purpose of evaluating safety performance of the facility.

HSM analysis indicates that the study segments of M-22/M-72 are performing in a manner reasonably consistent with crash expectation for the characteristics of the facility. At the intersection of M-22 and M-72, crashes are occurring with a slightly higher rate than expected. The results of this HSM review indicate that safety treatments focused on the intersection of M-22 and M-72 intersection would have a more significant impact on safety performance than those focused on the M-22/M-72 corridor. That stated, the opportunity to reduce vehicle-pedestrian/bicycle safety is a recurring concern throughout the project limits. At several locations interactions between vehicles and non-motorized traffic present exposure for crash occurrence that is likely to result in severe outcome.

5.0 Assessment Findings and Suggestions

The findings and suggestions of this RSA were developed by the RSA Team based on office reviews, field reviews, collaborative discussions, and via the drafting and review of this report. Each safety concern is outlined with a summary of relevant observations, an analysis of the associated risk, and a detailed list of suggestions intended to address each concern. These suggestions are based on the RSA Team's knowledge and understanding of current best practices and applicable safety enhancement treatments.

Each list of suggested safety concerns provided in the following subsections is presented according to location and risk categorization. A safety concern that has the potential to result in crashes that could have a generally high severity (potential to result in death or incapacitating injury) on a more frequent basis may be categorized as an "E or F" (highest relative risk). On the contrary, a safety concern that has the potential to result in crashes that would have a generally low severity (property damage only) on a less frequent basis may be categorized as an "A or B" (lowest relative risk). The relative risk factor matrix is illustrated on Figure 4 below.

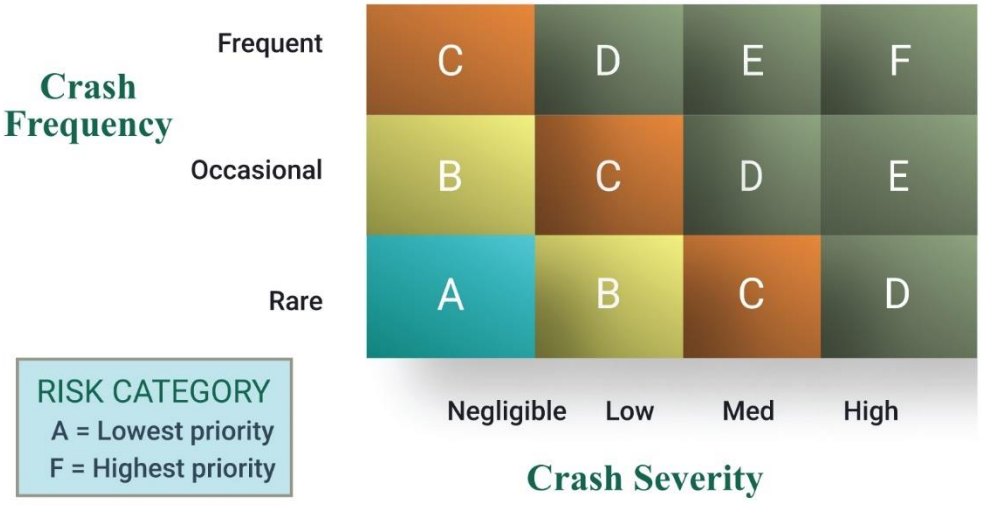

Figure 4 – RSA Relative Risk Factor Matrix

Safety concerns identified by the RSA Team are outlined in the following subsections from northwest to southeast along the M-22/M-72 study corridor. Safety concerns are presented with suggested improvement measures, which are generally listed in order of greatest intensity (i.e. requires reconstruction) to less invasive, lower cost treatments (i.e. signing and marking). These suggestions are presented independent of explicit costs, feasibility of installation, and benefit-cost analyses; however, higher risk ratings have the potential to result in more severe crashes with a greater frequency of occurrence and may justify higher priority for improvement.

The effectiveness of lower-level (lower cost and easier implementation) treatments should be monitored, especially with respect to their ability to reduce the occurrence of severe crashes. If a particular treatment does not result in a measurable safety improvement, higher-level, more intense (greater cost and more complex implementation) treatments (or a combination thereof) may then be considered. Given the planned reconstruction of this corridor, several of these suggested safety treatments could be implemented directly into the proposed project.

6.0 M-22 North of M-72

6.1 Safety Concern: Pedestrian Facilities

Observations: Existing sidewalk runs along the east (bay) side of M-22 from M-72 to approximately 700 feet north of the intersection, across from the Holiday gas station. The sidewalk on the east side is terminated at a curb cut along M-22. There is no marked or signed pedestrian crossing where the sidewalk ends; although a small STOP sign and an ADA detectable warning surface have been installed facing pedestrians on the sidewalk approach to M-22. There is signage on the east side of the M-22/M-72 intersection indicating that the sidewalk ends ahead for NB pedestrians, and to cross to the west side at the signalized intersection; however, context of the sign is not clear, and the sign is somewhat misleading as the sidewalk visibly continues north from the intersection. The existing sidewalk terminus at an unmarked crossing of M-22 presents significant pedestrian safety concern.

There is also no receiving curb cut/ramp on the west side of M-22 at the Holiday gas station. Additionally, sidewalk (paved area) on the west side of M-22 in front of Harrington's restaurant runs immediately adjacent to the back of curb, providing no buffer to the travelled way. When the sidewalk is at the back of curb, MDOT would typically require a 6-foot sidewalk to provide additional buffer from the road. The existing sidewalk width here appears less than 6-feet. The sidewalk in front of Harrington's also does not connect to the adjacent property to the north. There is a worn path indicating pedestrian usage in the approximately 15' sidewalk gap.

Lastly, there is a sandy area with a fire pit on the east side across from the condominium development at the northern City limits. This area is signed as MDOT property but is evidenced to be used for recreation. Pedestrians can be expected to cross M-22 at night between the condos and beach/fire pit.

Risk Analysis: Gaps in the non-motorized network and absence of marked/signed crossings of M-22 may lead to vehicle-pedestrian crashes with severe outcome. This concern is exacerbated during nighttime conditions when visibility is reduced (lighting improvements are discussed in a subsequent section).

Frequency	Severity	Grade
Occasional	High	E

Table 3 – Relative Risk Analysis of Safety Concern 6.1

Suggestions: Gaps in the existing non-motorized network should be closed. This may require shore stabilization along the bay to provide adequate space for continuous sidewalk/path; however, curbing the east side of M-22 and eliminating the wide paved shoulder may mitigate this impact. If sidewalk on the east side cannot be continued to the north, the sidewalk should be terminated into the commercial building, not into an unmarked crossing of M-22. Pedestrian refuge islands (permanent or seasonal) and a marked/signed crossing should be considered on this 3-lane section to connect land uses that would generate pedestrian activity across M-22.

Priority for Consideration: High

Figure 5 – Sidewalk Ends into M-22 (left) Firepit in MDOT ROW (right)

6.2 Safety Concern: Vehicle Speeds

Observations: The posted speed limit on M-22 north of M-72 increases from 35 mph to 40 mph. During site observations, speeds were not measured; however, the RSA Team observed speeds that appeared to be between 40 and 45 mph. Stakeholder input and anecdotal knowledge indicate that northbound drivers often accelerate north of the M-72 intersection, and that southbound traffic retains higher speeds approaching M-72 from the north even as the speed limit is reduced. Observed speeds may be relative to lower traffic volumes during the off-peak season but are always of concern. During the peak summer months, vehicular congestion and pedestrian activity are higher and increased speeds would adversely impact both vehicular and pedestrian safety. During winter months, higher speeds can result in loss of control and roadway departure.

Risk Analysis: Vehicle speeds have a significant impact on the severity of injury in a vehicle-pedestrian crash. Higher speed differential can also result in rear-end crashes resulting in a more severe outcome. Roadway departure concerns are also outlined in a subsequent section; whereby higher vehicle speeds would increase the potential for loss of control.

Frequency	Severity	Grade
Occasional	Medium	D

Table 4 – Relative Risk Analysis of Safety Concern 6.2

Suggestions:

1. Current and future design efforts for M-22 north of M-72 may consider modifying the design speed; however, this is unlikely given the function and classification of the facility. Narrowing of the roadway to replace wide paved shoulder with curb and gutter may have a positive impact to reduce vehicle speeds. Narrowing of the roadway via modification of the median immediately north of M-72 is also discussed in following sections.
2. Dynamic speed signs to display the speed limit in contrast to actual vehicle speeds may also encourage speed reduction, in combination with focused speed enforcement.

Priority for Consideration: Moderate

Figure 6 – M-22 Posted Speed (left) Dynamic Speed Sign (right)

6.3 Safety Concern: Lighting

Observations: South of M-72, the corridor has regularly spaced lighting located in the median that casts light directly on both bounds of M-22/M-72. This light also spreads to provide moderate visibility along the non-motorized facilities on both sides of the roadway, in combination with supplemental lighting of the TART trail. Immediately north of M-72, there is a gap in street lighting where visibility is significantly reduced. Lighting is installed approximately 500 feet north of the intersection and some ambient light is cast from the Holiday fuel station and other commercial uses to the north.

The dark space immediately north of the M-22/M-72 intersection is of particular concern. As described in the following section, there is a NB lane drop transitioning from the 4-lane boulevard to the 3-lane section of M-22. Darkness in this area limits visibility of the small median island and ability for drivers to perceive the travel lane. Additionally, visibility of pedestrian activity in this area is limited.

Risk Analysis: Inability to perceive the transition between the 4-lane boulevard and 3-lane section may result in sideswipe crashes. Single vehicle fixed object crashes may also result from limited conspicuity of the small median island north of M-72 in both the NB and SB directions. Both of these vehicle crash types are likely result in property damage only severity. Pedestrian activity in this area would correlate to a higher risk factor that is addressed in the previous section on pedestrian facilities.

Frequency	Severity	Grade
Occasional	Low	C

Table 5 – Relative Risk Analysis of Safety Concern 6.3

Suggestions:

1. Install additional lighting immediately north of the M-22/M-72 intersection.
2. Install delineators, refresh pavement markings, and/or paint the island curb to increase visibility for proper lane use and fixed object location.

Priority for Consideration: Moderate

Figure 7 – Dark Area (left) Narrow Median (right)

6.4 Safety Concern: Roadway Departure

Observations: Along the east (bay) side of M-22 north of M-72, the distance between the travelled way and the shoreline varies. North of the existing office/commercial uses located just north of M-72, the shoreline is very close to the roadway at some points. Given the changing roadway alignment, lane transitions, lighting needs, vehicle speeds, and winter weather conditions, this proximity is of concern for lane departure crashes. A NB lane departure crash could result in a vehicle leaving the roadway and not being able to recover on the roadside slope before hitting large rocks or entering the water.

Risk Analysis: This safety concern is related to single-vehicle crashes when a vehicle departs the roadway. The roadside slope is not considered to be steep enough to result in overturn crashes (except in the case of reckless speed); however, fixed object crashes into large rock or entering the water have the potential to result in injury.

Frequency	Severity	Grade
Rare	Medium	B

Table 6 – Relative Risk Analysis of Safety Concern 6.4

Suggestions:

1. Eliminate the wide shoulder on the east (bay) side of M-22 north of M-72. Install curb and gutter. Narrowing the roadway may have a positive impact to reducing vehicle speeds and better delineate the travelled way.
2. Install guardrail if roadside slopes cannot be mitigated and/or where the distance from the travelled way to the rocks/water cannot be increased.
3. Install reflective delineators and refresh pavement markings to highlight the edge of the roadway.

Priority for Consideration: Moderate

Figure 8 – Buffer to Rock/Water Looking N (left) Looking S (right)

7.0 M-22 at M-72 Intersection

7.1 Safety Concern: Non-Motorized Crossings

Observations: The TART trail runs along the west side of M-22/M-72 from the HAWK signalized crossing near Elmwood Avenue thru the M-22/M-72 intersection. This intersection is signalized with pedestrian countdown signals to provide protected pedestrian crossing, including on the west leg where the TART trail crosses M-72.

As further described in the subsequent section, turning movement complexity at this intersection is increased due to the proximity of Bay Street to M-22/M-72. Drivers must observe, perceive, and navigate several conflict points when turning between M-22 and M-72. Drivers may not perceive pedestrians while attention is drawn to the number of vehicular conflict points, despite the pedestrian crossing signals. There is a dynamic "No Turn on Red" case sign that is activated for SB right turns to M-72 during the NB left-turn phase to WB M-72; however, there is no additional notification or protection to mitigate vehicle-pedestrian conflicts.

Stakeholder input and anecdotal knowledge indicate that cyclists on the TART trail tend to ride thru this crossing. A walking/running pedestrian may have greater ability to stop, wait, or maneuver to have a "near miss" as opposed to a pedestrian-vehicle crash. Cyclists approaching the intersection at higher speeds would also be less likely to be observed by a turning vehicle and are therefore more likely to be struck while crossing M-72.

Risk Analysis: One recent vehicle-pedestrian crash was recorded in December 2020 when a NB left-turn vehicle rolled over a pedestrian's foot in the crosswalk. The pedestrian was reportedly crossing on a walk signal with the vehicle turning left on a permissive flashing yellow arrow. Although this conflict resulted in only minor injury, this conflict point has the potential to result in vehicle-pedestrian/cyclist crashes that result in a severe outcome.

Frequency	Severity	Grade
Occasional	High	E

Table 7 – Relative Risk Analysis of Safety Concern 7.1

Suggestions:

1. Install permanent "No Turn on Red" signage on right-turn movements that conflict with pedestrian crossings, particularly on the SB approach of M-22 conflicting with the TART crossing.
2. Install a "Turning Vehicles Yield to Pedestrians" sign to notify turning vehicles to yield to crossing pedestrians, particularly in association with the NB permissive left-turn flashing yellow arrow.
3. Install a Leading Pedestrian Interval (LPI) to allow pedestrians/cyclists to enter the crosswalk during the all-red phase, prior to any vehicular movements. LPI can be considered for all crosswalks or installed specifically for the TART crossing the west leg of M-72. An LPI would slightly decrease vehicular green time when a pedestrian call is placed; however, the potential safety benefit may outweigh this minor operational impact.

Priority for Consideration: High

Figure 9 – TART Trail M-72 Crossing (left) Yield to Pedestrian Sign (right)

7.2 Safety Concern: Bay Street Offset

Observations: Bay Street runs parallel with M-22/M-72 within the project limits between M-72 and US-31. Bay Street intersects M-72 at a T-intersection approximately 65 feet west of M-22 where Bay Street is stop-controlled and EB M-72 traffic operates under signalized control. Turning movements between Bay Street and M-22/M-72 are complex and field observations indicate continuous vehicular conflicts. There are advanced signal heads and an advanced stop bar on EB M-72 at Bay Street approaching M-22. These advanced measures provide temporary gaps in the EB M-72 queue to allow vehicles to turn to/from Bay Street.

The most frequent turning maneuver observed at this location was from SB M-22 to EB Bay Street. Bay Street provides the first entry point to the local Traverse City street network for traffic arriving from the north. This "S" turn maneuver requires drivers to observe, perceive, and react to multiple conflict points, including the TART trail crossing of M-72. Although the advanced signal heads provide a gap to allow movements from Bay Street to M-72, vehicles are often queued EB on M-72 to turn right onto M-22/M-72.

Risk Analysis: As described in the previous section, vehicle-pedestrian crashes present the highest risk related to the complexity of turning movements at this location. Conflicting movements may result in angle crashes which tend to result in more severe outcomes; however, speeds and therefore severity risk at this location are lower due to turning movements and recurring congestion. Similarly, lower speed rear-end and sideswipe crashes are likely to occur due to the stated complexity and number of conflict points.

Frequency	Severity	Grade
Occasional	Medium	D

Table 8 – Relative Risk Analysis of Safety Concern 7.2

Suggestions:

WSP conducted an alternatives evaluation ranging from limiting turning movements at Bay Street, to widening the M-22/M-72 median to provide indirect left-turns and eliminate left-turns at M-22/M-72 signal, to reconstructing the M-22/M-72 intersection as a roundabout. The pros of these concepts include the elimination of conflict points; however, right-of way constraints and operational impacts at this intersection and other locations on the corridor must be investigated further. An additional alternative was discussed by the RSA Team that would cul-de-sac Bay Street and provide access via a new mid-block intersection near Elmwood Avenue, which could be tied in with the signalized HAWK crossing.

At a minimum, the RSA Team suggests that left-turn restrictions to/from Bay Street at M-72 and the potential impacts be investigated. This would require a physical channelizing island and regulatory signs. The RSA Team and stakeholders also discussed concerns relative to TART trail crossing safety with a roundabout at this location. WSP operational reviews indicated a roundabout would need to have multiple lanes; therefore, additional safety measures should be considered for the TART trail crossing if a roundabout is selected as the preferred alternative.

Priority for Consideration: Moderate

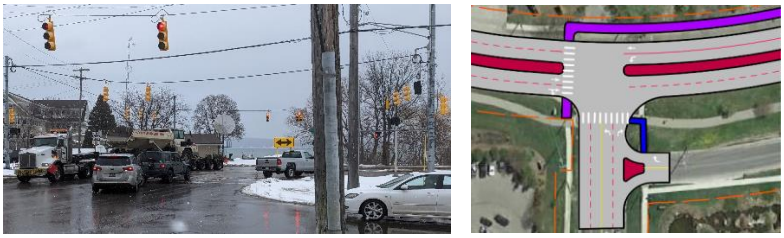

Figure 10 – EB M-72 at Bay Street/M-22 Conflicts (left) WSP Turn Restriction Concept (right)

7.3 Safety Concern: NB Median Lane Drop

Observations: Southeast of the M-72 intersection M-22/M-72 has two lanes in each direction with a narrow boulevard median. Travelling NB approaching the M-22/M-72 intersection, the median lane becomes a dedicated left-turn only lane to WB M-72 and the outside lane continues NB thru the intersection. On the receiving north leg of M-22, NB thru traffic enters a wide paved area separated from SB traffic by a short and narrow median. There is enough pavement on the receiving lane for two vehicles to traverse NB thru the intersection and may be perceived as a thru lane by NB vehicles in the median lane.

Vehicles were observed making last-minute lane changes or travelling thru the intersection from the median lane despite lane control signs, pavement markings, and upstream route/guide signage. The RSA Team reviewed upstream lane use and route/guide signage on NB M-22/M-72 to determine if drivers are being informed of the downstream lane drop prior to arriving at the M-22/M-72 intersection. There is existing signing, approximately 150' from the intersection, and pavement markings indicating that the median lane becomes a left-turn lane. Additionally, there are lane use signs for M-72 (left lane) and M-22 (right lane) approximately 1600' in advance of the M-22/M-72 intersection. The RSA Team identified significant upstream signage, which should be adequate to communicate proper lane selection and positioning in advance of the decision point. Future design should review the location and spacing of these signs with respect to the HAWK crossing; however, additional signage is therefore not recommended as a mitigation measure for this issue.

Risk Analysis: Vehicles travelling NB thru the intersection from the median lane may sideswipe vehicles in the outside lane. Vehicles stopping or abruptly maneuvering from the median lane to the outside lane may cause rear-end collisions. These crash types typically result in property damage only.

Frequency	Severity	Grade
Occasional	Low	C

Table 9 – Relative Risk Analysis of Safety Concern 7.3

Suggestions:

1. Narrow the receiving lane to eliminate the perception that two NB lanes are carried thru the intersection.
2. Create a more deliberate and conspicuous median that is longer and wider than existing. Redevelopment of the parcel(s) and access reconfiguration on the east side of M-22/M-72 at this intersection should be considered that would narrow the travelled way without limiting property access.
3. Offset the NB left-turn lane to the median and add hatching between lanes to more clearly separate the NB left-turn movement from the NB thru lane.

Priority for Consideration: Moderate

Figure 11 – NB Lane Drop Guide (left) and Lane Use (right) Signage

8.0 Midblock HAWK Crossing near Elmwood Avenue

8.1 Safety Concern: Signal Visibility

Observations: At this location, a mid-block pedestrian crossing facilitates connection for the TART trail. Southeast of this crossing, the TART trail runs parallel with M-22/M-72 on both sides of the roadway. On the bay side the TART connects to beach and a public parking area at the southeast limits of this RSA near US-31. To the northwest, the TART trail runs only on the west/City side; therefore, non-motorized traffic continuing on the TART trail must cross M-22/M-72 at this midblock crossing.

The HAWK signal heads are fairly visible during daylight; however, drivers do not always expect an operating signal at a mid-block location. At nighttime, the signal heads are less visible and the crossing is not conspicuous. There is street lighting in the median along M-22/M-72 including a streetlight within 50 feet of the crosswalk. Unless activated by a pedestrian, the signal is dark during daylight and nighttime hours. Upstream pedestrian crossing warning signs are in place on the outside of each bound, but they are slightly worn and the retro-reflectivity appears to be faded. Investigation of historical press releases indicates that the HAWK signal was installed in 2019. The previously existing crossing and warning signage may have been retained/salvaged. Special emphasis crosswalk markings are in place at the crosswalk providing greater visibility to motorists.

Risk Analysis: The historical crash data review as outlined in a previous section indicates that two crashes occurred at mid-block marked pedestrian crossings in July 2017 and July 2018. Both crashes involved a truck stopping for a bicycle crossing M-22/M-72, blocking view of the crosswalk, and a driver in the other lane continuing thru the crosswalk, striking the cyclist. Although HAWK installation is a significant safety improvement as compared to the previous marked/signed crossing, visibility of the relatively new HAWK signal and upstream warning can be improved to mitigate the potential for a severe vehicle-pedestrian/cyclist crash.

Frequency	Severity	Grade
Occasional	High	E

Table 10 – Relative Risk Analysis of Safety Concern 8.1

Suggestions:

1. Install retroreflective backplates on the HAWK signals to increase visibility and enhance conspicuity of the crossing location for approaching vehicles.
2. Replace existing pedestrian crossing advanced warning signs with new signs and include vertical reflective strips on the sign posts. Install complementary left-side warning signs on the median.

Priority for Consideration: High

Figure 12 – HAWK Signal Visibility and Signage Day (left) Night (right)

8.2 Safety Concern: Nighttime Crossing Visibility

Observations: As described in the previous section, this mid-block pedestrian crossing facilitates connection for the TART trail. The crossing is fairly visible during daylight; however, at night the crossing is less conspicuous. The lighted "STOP on Red" case sign above the crosswalk does enhance nighttime recognition that something is ahead, although the message is difficult to decipher while travelling at posted speed.

Lighting is consistent along the boulevard section of the study area, and there is a light pole immediately north of the HAWK crossing that provides positive lighting onto the crosswalk. The light cast from this pole also creates a glare that inhibits visibility of the signal heads, particularly in the NB direction where the light is immediately behind the signal heads. The sidewalk approaches to the crosswalk are not as visible, especially on the darker bay side. There is a bench and lighted area on the bay side just to the north of the crossing, but this light does not cast sufficiently onto the crossing approach.

Risk Analysis:

Vehicle speeds have a significant impact on the severity of injury in a vehicle-pedestrian crash. Enhancing nighttime visibility of both the crosswalk and TART trail approaches to M-22/M-72 would give drivers improved perception when a pedestrian/cyclist is present. This recognition may reduce vehicle speeds through the crosswalk and reduce driver reaction times even if the HAWK signal has not been activated. Visibility of a pedestrian/cyclist before they enter the travelled way would reduce the potential for a severe outcome crash.

Frequency	Severity	Grade
Occasional	High	E

Table 11 – Relative Risk Analysis of Safety Concern 8.2

Suggestions:

1. Install additional lighting to increase nighttime visibility of pedestrians/bicyclists waiting to enter the roadway at the crosswalk approaches to M-22/M-72. This may include relocation of the existing bench/lighted area on the bay side.
2. When this roadway is reconstructed, review the location of the existing light pole immediately north of the crossing. Install lighting that casts onto the roadway and crosswalk but does not inhibit visibility of the signal heads. Signal backplates suggested in the prior section may also partially mitigate this issue.
3. Consider alternative lighting for the crosswalk including overhead crosswalk case sign options or relocating lighting at this location to the outside of the roadway to cast on the crosswalk and each approach.

Priority for Consideration: High

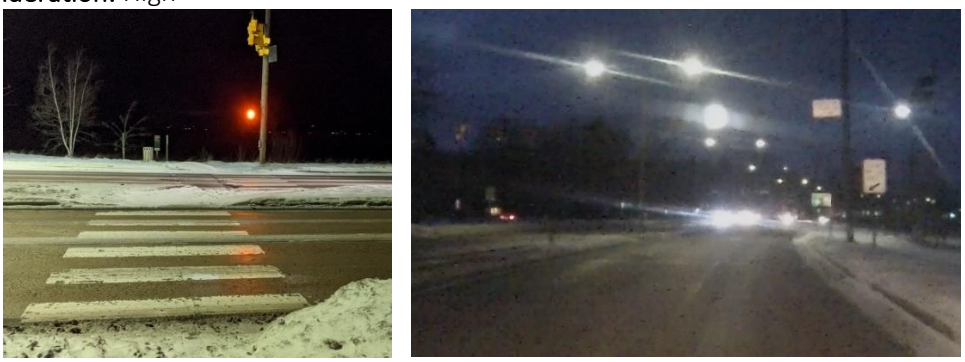

Figure 13 – Night HAWK Crosswalk Visibility (left) NB Light Glare at HAWK (right)

8.3 Safety Concern: HAWK Crossing Operation

Observations: When the HAWK signal was installed in 2019, the previous marked/signed mid-block crossing configuration was apparently maintained. When this roadway is reconstructed, the configuration of this crosswalk may be modified to improve operations, in combination with conspicuity and lighting items identified in previous sections. Even if visibility is improved, stakeholder input indicated that pedestrian/cyclists do not always stop to activate the HAWK signal.

The sidewalk in the median currently runs at a diagonal and crossing each bound of M-22/M-72 is offset by approximately 15 feet. This offset can provide safety benefit for pedestrians at unsignalized locations. The offset forces pedestrian/cyclists in the median to face toward the direction of conflicting traffic and heightens awareness to pause before crossing the next bound. With the HAWK signal installation, this offset may actually impact pedestrian safety adversely. The HAWK signal is timed to cross both bounds of M-22/M-72 and this diagonal median crossing requires additional time to navigate, with no pushbuttons in the narrow median. Pedestrians with a disability may have difficulty perceiving the offset. Winter maintenance may also be more difficult and snow in the median may inhibit pedestrian ability to perceive the crossing alignment.

Risk Analysis: Vehicle-pedestrian/bicycle crashes have the potential to result in severe outcome. Confusion while crossing both bounds of M-22/M-72 can result in pedestrians within the travelled way after the expiration of the HAWK signal indication and resumption of vehicular movements. Not activating the HAWK signal negates the safety benefit of recently upgrading this crossing.

Frequency	Severity	Grade
Occasional	High	E

Table 12 – Relative Risk Analysis of Safety Concern 8.3

Suggestions:

1. Reconfigure the crosswalk to have a direct alignment thru the median and crossing both bounds, eliminating the offset.
2. Install alternative signage (i.e. R10-3 or R10-3a) on the pushbutton pedestal to heighten the message to pedestrians to activate the HAWK signal.
3. Install passive pedestrian detection at the crossing to activate the HAWK signal.

Priority for Consideration: Moderate

Figure 14 – HAWK Crossing Offset (left) Pushbutton and Sign (right)

9.0 Overall M-22/M-72 Corridor

9.1 Safety Concern: Sign Retro-reflectivity

Observations: Sign retro-reflectivity was not measured; however, the general observation by the RSA Team along the corridor was that sign visibility could be improved, especially at night. Some signs appeared faded and given the complexity of vehicular and non-motorized movements along this corridor, the importance of these messages is heightened. Although the RSA Team is not aware of the installation timeline and age of signage along this corridor, weather conditions along the bay may contribute to premature degradation of sign quality.

Risk Analysis: Inability of drivers to see and respond to designed signage and messaging may result in otherwise avoidable crash occurrence. Crash risk for vehicle-pedestrian crashes is covered in previous sections of this report. The risk rating shown below is relative to vehicle crashes, most notably rear-end and sideswipe crashes that may occur as a result of lane change maneuvers.

Frequency	Severity	Grade
Infrequent	Medium	C

Table 13 – Relative Risk Analysis of Safety Concern 9.1

Suggestions:

1. Replace all corridor signage. The messages on current signing are appropriate; however, the visibility can be improved.
2. Install vertical reflective strips on the sign support posts where messaging is particularly important.

Priority for Consideration: Moderate

Figure 15 – Corridor Signage N of M-72 (left) NW of US-31 (right)

9.2 Additional Observations

Observations: The RSA Team identified some other minor observations that did not stand out as significant safety concerns or that are outside the project limits, but that were noteworthy for this report:

- Three bidirectional median breaks exist in the M-22/M-72 median between the M-72 and US-31 intersections. While the two northern crossovers were not identified to serve a specific need for local traffic movements, the crossover between Elmwood Avenue and Spruce Street can serve traffic leaving the West End Beach parking lot (on the east side of EB M-22/M-72 near Wayne Street).
- The West End Beach public parking lot is located at the south end of the project limits. The northern portion of this parking lot has been eroded into the bay and temporary barricades are in place.
- Sidewalk connectivity is gapped between the south side and north side of the West End Beach parking lot; whereas curbcuts and ramps on each end of the lot direct non-motorized traffic into the parking lot. There are no detectable warning surfaces on the sidewalk ramps on either end of the parking lot. The TART trail mixes with vehicular traffic within the parking lot to provide connectivity on the bayside portion of the trail.
- The M-22/M-72 and US-31 intersection is outside of the limits of this RSA study; however, similar observations were made at this intersection as documented in this report for the M-22/M-72 intersection.

Risk Analysis:

- The median is narrow and the rear-end of a vehicle attempting to use the bi-directional crossovers would be exposed to thru traffic, resulting in potential rear-end crashes.
- Loss of parking at the public park may result in addition movements to/from M-22/M-72 therefore increasing the risk for angle crash occurrence.
- Mixing non-motorized traffic and vehicular traffic within the parking lot presents safety concerns.
- The same concerns outlined in this report at the M-22/M-72 intersection for both pedestrian and vehicular safety exist at the M-22/M-72 and US-31 intersection.

Frequency	Severity	Grade
Rare	Medium	B

Table 14 – Relative Risk Analysis of Safety Concern 8.3

Suggestions:

1. Close the bidirectional median breaks on M-22/M-72 within the study limits.
2. Stabilize the shoreline and restore the West End Beach public parking lot near US-31.
3. Modify the West End Beach parking lot to eliminate the utilizing the parking lot as a portion of the TART trail.
4. Investigate the operational and safety issues relative to Bay Street documented at the M-22/M-72 intersection relative to the US-31 intersection.

Priority for Consideration: Low

Figure 16 – Median Crossover (left) US-31/Bay Street Conflicts (right)

10.0 HSM & Benefit-Cost Analysis

There were several possible safety improvements suggested by the RSA Team relative to each project segment and intersection location. Each of these treatments was categorized based on the targeted crash type, type of improvement, and relative level of cost (low, medium, high). Degree of improvement was generalized as follows, with cost based on high-level estimates and relative order of magnitude:

- Reconstruction: Substantial change to the cross section of the roadway including narrowing, widening, and alignment change ($1M per lane mile).
- Install Pathway/Sidewalk: For this project, non-motorized improvements include construction of the actual pathway as well as slope stabilization considerations along the bay ($500K per path mile).
- Modify Curb: Reconfigure specific areas of curb to narrow road width, improve intersection geometry, alter/close median crossovers, improve median islands, and manage access ($50K per location).
- Lighting Installation: Install supplemental downward or infill lighting ($25K per location).
- Signs & Markings/Signal Operations: Enhance existing signage, install more visible/durable markings, enhance pedestrian crossings, install delineators, and/or modify signal operations ($5-25K per location).

Table 15 – Safety Treatments and Order of Magnitude Costs

Improvement	Targeted Crashes	Type of Improvement	Priority	Cost Level	Relative Cost
North of M-72					
Narrow Roadway	Rear-End/Sideswipe	Reconstruction	Moderate	High	$500,000
Close Non-Motorized Gaps	Pedestrian	Pathway/Walk	High	High	$150,000
Pedestrian Refuge Islands	Pedestrian	Modify Curb	High	Medium	$100,000
Guardrail	Single-Vehicle	Modify Curb	Moderate	Medium	$50,000
Lighting Improvements	Rear-End/Sideswipe	Lighting	Moderate	Medium	$25,000
Pedestrian Crossing(s)	Pedestrian	Sign & Marking	High	Low	$10,000
Dynamic Speed Signs	Rear-End/Single-Vehicle	Sign & Marking	Moderate	Low	$10,000
Delineators/Markings	Rear-End/Sideswipe	Sign & Marking	Moderate	Low	$10,000
M-22 at M-72 Intersection					
Restrict Turn Movements	Angle	Reconstruction	Moderate	High	$500,000
Widen North Median	Rear-End/Sideswipe	Reconstruction	Moderate	Medium	$100,000
Offset Left-Turn Lane	Rear-End/Sideswipe	Reconstruction	Moderate	Medium	$50,000
Leading Pedestrian Interval	Pedestrian	Signal Ops	High	Low	$5,000
No-Turn-on-Red/Yield	Pedestrian	Sign & Marking	High	Low	$5,000
Midblock HAWK Crossing					
Reconfigure Crosswalk	Pedestrian	Reconstruction	Moderate	Medium	$50,000
Lighting Improvements	Pedestrian	Lighting	Moderate	Medium	$25,000
Passive Ped Detection	Pedestrian	Signal Ops	Moderate	Low	$25,000
Crosswalk Case Signs	Pedestrian	Sign & Marking	High	Low	$10,000
Signal Backplates	Pedestrian	Sign & Marking	High	Low	$5,000
Upstream Signage	Pedestrian	Sign & Marking	High	Low	$5,000
Crosswalk Signage	Pedestrian	Sign & Marking	Moderate	Low	$5,000
Overall M-22/M-72 Corridor					
Improve Shoreline Parking	Angle	Reconstruction	Low	High	$200,000
Close Median Breaks	Angle	Reconstruction	Low	Medium	$100,000
Refresh Corridor Signage	Rear-End/Sideswipe	Sign & Marking	Moderate	Low	$25,000

10.1 HSM Crash Modification Factors

The observations of the RSA Team indicate two key areas subject to improvement:

- Pedestrian/bicycle safety is a recurring concern. At several locations interactions between vehicles and non-motorized traffic present exposure for crash occurrence that is likely to result in severe outcome.
- The offset of Bay Street at the M-22/M-72 intersection creates complicated operations that have an adverse impact on safety.

HSM analyses indicate there is a statistical opportunity to reduce crashes at the intersection of M-22 and M-72. Along the overall M-22/M-72 corridor, vehicular crash occurrence is relatively consistent with statistical crash expectation for a facility of this type. That stated, the opportunity to reduce vehicle-pedestrian/bicycle safety is a recurring concern throughout the project limits. At several locations interactions between vehicles and non-motorized traffic present exposure for crash occurrence that is likely to result in severe outcome.

In order to provide perspective as to the most impactful treatments for this corridor, the potential benefit of roadway and intersection improvements to reduce crash occurrence was evaluated based on HSM methodologies and related to order of magnitude cost estimates. CMFs were identified through the Crash Modification Clearinghouse, which is maintained by FHWA. Due to the emerging nature of predictive crash analyses, not all CMFs fit exactly to the subject roadway segment or intersection; however, candidate CMFs provide insight as to the relative crash reduction potential of a given treatment. CMFs were selected that have at a 4 or 5-star rating applicable to the proposed safety improvement measure. The following present the key findings and relative crash reduction expectancy for each portion of the facility:

M-22 North of M-72

In addition to pedestrian safety, the key recommendation on this segment of the project is narrowing the travelled way to reduce rear-end/sideswipe as well as single vehicle crash potential. A CMF of 0.89 (11% reduction) is expected if curb and gutter are installed on M-22 north of M-72, which would narrow the travelled way and provide a more conspicuous travel lane, particularly for NB vehicles.

M-22 and M-72 Intersection

Turning movements at this intersection and the offset to Bay Street are not directly addressed by the HSM or the CMF Clearinghouse; however, eliminating offset/corner clearance of driveways at a signalized intersection are reported to have a CMF of 0.82 (18% reduction). Eliminating left-turns to/from Bay Street adjacent to the M-22/M-72 intersection can be reasonably expected to have a similar impact on crash occurrence. As previously stated, restricted traffic movements at this location may have an adverse impact on other intersections (i.e. M-22/M-72 and US-31) and should be further evaluated.

M-22/M-72 from M-72 to US-31

On the boulevard segment of this project, signing upgrades are the primary recommended improvement developed by the RSA Team, in addition to recommendations specific to closing median breaks and the HAWK signalized crossing near Elmwood Avenue. The HSM and CMF Clearinghouse do not specifically address signage upgrades or retro-reflectivity of signs; however, improvement of delineation (markings and signs) generally provides a CMF of 0.80 to 0.90 (10-20% reduction). Corridor signing improvements are expected to have the greatest benefit of informing drivers of downstream signalized intersections (i.e. at M-72 and at US-31) and the mid-block HAWK crossing that are captured by other CMFs.

10.2 Benefit-Cost Analysis

The order of magnitude cost estimates outlined above are specific to the safety improvements suggested by the RSA Team and may not be equal to actual construction costs. This is especially true for reconstruction of the overall facility, which may require material, drainage, right-of-way, and maintenance of traffic costs that are unrelated to the subject safety treatments. That stated, a comparison of the relative costs and benefit to reduce crash occurrence do provide valuable information for decision making for the range of low to high-cost improvements presented herein.

Benefit that would be achieved by crash reduction was measured based on monetary values published by MDOT and methodology published by FHWA. Crashes result in both tangible and intangible consequences. While economic costs can be measured directly, intangible impacts such as physical and emotional suffering are monetized by quality-adjusted life years (QALY). The lost quality of life due to death or injury is quantified in the referenced sources and included in comprehensive costs referenced for this benefit-cost analysis.

Annual benefits due to crash reductions were compared to annualized treatment costs in order to develop generalized benefit-cost ratios. Probable crash reductions were estimated based on HSM predictive values as described in the previous section. The five key tiers of improvements (reconstruction, install pathway/sidewalk, curb modifications, lighting installation, and sign/marking upgrades) are intended to improve the safety reliability of the facility for vehicular traffic; however, the most significant benefit is related to mitigating the potential for vehicle-pedestrian/bicycle crashes that may result in a severe injury or fatal outcome.

Crash benefit was calculated by applying the CMFs described above to the historical annual crash occurrence and cost per crash. Project costs were calculated based on the order of magnitude costs outlined above, not actual design quantities. The most intense mitigation measures were assumed for this analysis and are estimated to cost $500,000 per treatment with an expected service life of 20 years. These measures include narrowing M-22 north of M-72 and reconfiguring the M-22/M-72 intersection to restrict turning movements at Bay Street. As described above, the benefits of general corridor improvements (i.e. signing upgrades) are expected to be realized at the HAWK crossing and M-22/M-72 intersection; therefore, benefit/cost is captured at those specific locations.

Preventing future vehicle-pedestrian/bicycle crashes that may result in a severe A-level injury or fatal outcome provides the highest level of benefit, regardless of cost. Results of this analysis also indicate that both reconstructive efforts recommended by the RSA Team would have a positive benefit/cost impact; whereby the annual benefit is greater than the average cost. Lower cost items are also expected to have a positive benefit; however, these measures are expected to provide the greatest benefit towards the stated safety concerns.

Table 16 – Benefit/Cost Analysis

Location	Treatment	Annual Benefit	Annual Cost	B/C Ratio
N of M-72	Narrow Roadway	$37,300	$25,000	1.49
M-22/M-72	Restrict Bay Street	$39,700		1.59
Corridor	*Most significant benefit is realized at the M-22/M-72 intersection and HAWK crossing*			
Pedestrian/Bike	**Treatment**	**Annual Benefit**	**Annual Cost**	**B/C Ratio**
A-Level	Various	$27,680	$25,000	1.11
Fatal	Various	$282,000		11.28

11.0 Conclusions

This assessment has been prepared to assist MDOT and local stakeholders in the identification and actualization of opportunities to improve safety within the study area. The suggestions contained in this report are for consideration only and are not intended to serve as design or operational requirements. Where feasible, the safety recommendations outlined herein should be considered in the design plans for the upcoming reconstruction of M-22/M-72. The RSA Team suggests that MDOT consider making incremental improvements if lesser measures prove ineffective towards reducing the crash risk identified herein.

Overall, the RSA Team agreed that the study area has existing safety-related treatments that are consistent with the needs of the facility users and best practices. While this report identifies potential areas for safety improvement, crash occurrence on the corridor is similar to crash expectancy for facilities with similar characteristics. The greatest areas for safety improvement identified by the RSA Team are:

- Pedestrian/bicycle safety is a recurring concern. At several locations interactions between vehicles and non-motorized traffic present exposure for crash occurrence that is likely to result in severe outcome.
- The offset of Bay Street at the M-22/M-72 intersection creates complicated operations that have an adverse impact on safety.

Each of the specific concerns identified by the RSA Team are outlined below based on the safety risk and relative priority.

Table 17 – Safety Concern Priority Summary

Safety Concern	Location	Report Section	Priority	Risk Grade
Pedestrian Facilities	North of M-72	6.1	High	E
Non-Motorized Crossings	M-22/M-72 Intersection	7.1	High	E
HAWK Signal Visibility	Near Elmwood Avenue	8.1	High	E
HAWK Nighttime Visibility	Near Elmwood Avenue	8.2	High	E
HAWK Operation	Near Elmwood Avenue	8.3	Moderate	E
Vehicle Speeds	North of M-72	6.2	Moderate	D
Bay Street Offset	M-22/M-72 Intersection	7.2	Moderate	D
Lighting	North of M-72	6.3	Moderate	C
NB Median Lane Drop	M-22/M-72 Intersection	7.3	Moderate	C
Overall Corridor	Sign Retro-Reflectivity	9.1	Moderate	C
Roadway Departure	North of M-72	6.4	Moderate	B
Additional Observations	Various	9.2	Low	B

This report does not preclude the identification of additional issues pertaining to safety by MDOT with the emergence of new issues over time. The findings, conclusions, and suggestions outlined in this report were developed based on consensus by the RSA Team and are not necessarily those of MDOT or other stakeholders.

The FHWA RSA process recommends that MDOT review this report, document their responses to the issues identified herein in a formal response, and track their progress towards the implantation of safety improvements prompted by this assessment. Relevant information referenced in this RSA are submitted to MDOT with this report to the MDOT Project-Wise folder associated with this project, including:

- Traffic volume, crash, and project data provided by MDOT;
- Field photos and videos captured by Fishbeck;
- Crash data collected and reviewed by Fishbeck;
- HSM References; and
- Calculation spreadsheets and notes.