Manitoba Transportation and Infrastructure

IN-SERVICE ROAD SAFETY REVIEW – PTH 1 AND PTH 5 INTERSECTION

EXECUTIVE SUMMARY REPORT

DECEMBER 2023

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1 INTRODUCTION

At the request of Manitoba Transportation and Infrastructure (MTI), WSP Canada Inc. (WSP) has conducted an in-service road safety review (ISRSR) for the two-way stop-controlled intersection of PTH 1 and PTH 5 located near Carberry, Manitoba. The layout of the intersection is displayed in **Figure 1** below.

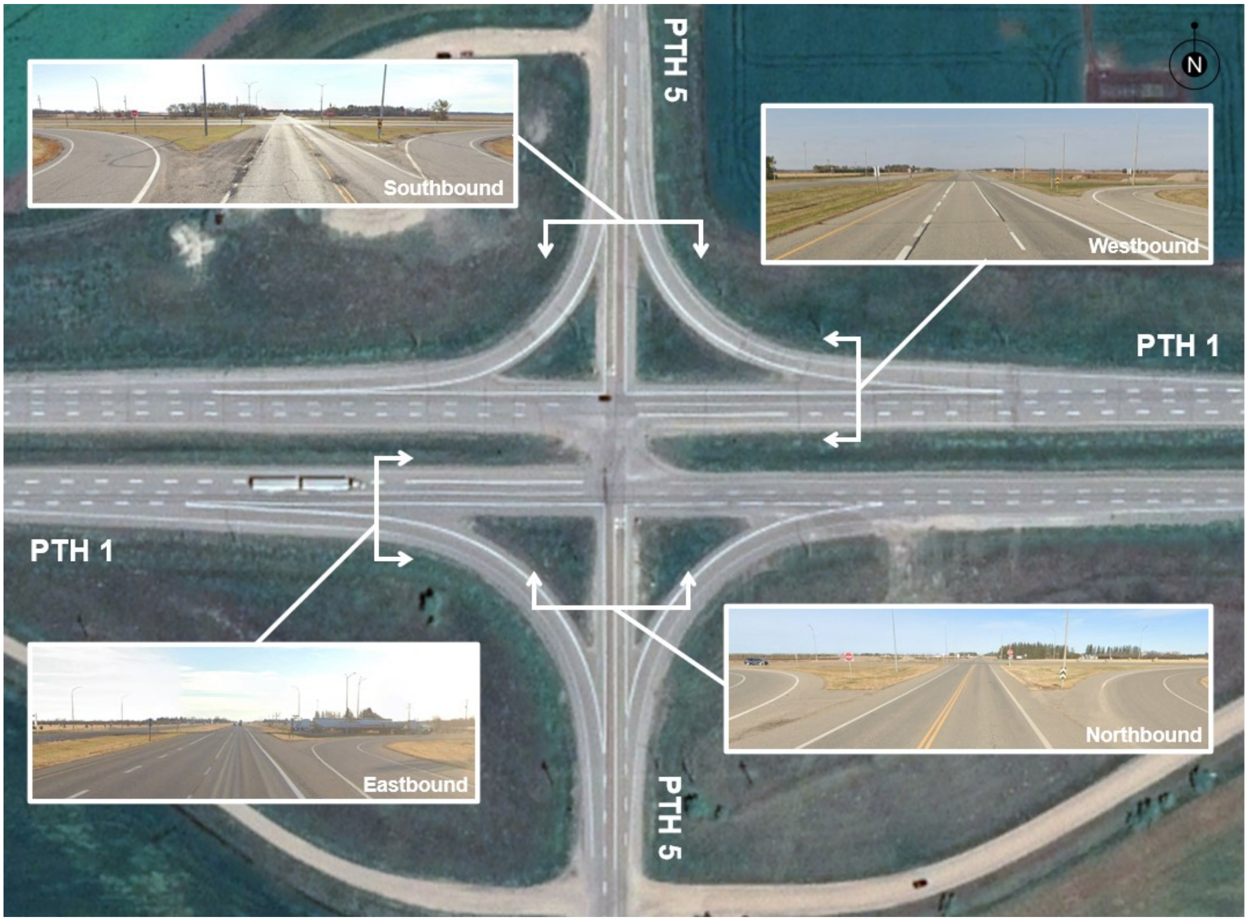


Figure 1: PTH 1 and PTH 5 Intersection

The purpose of the ISRSR was to identify safety performance issues associated with the intersection and to suggest potential safety enhancements for consideration by MTI. The ISRSR was conducted in accordance with the Transportation Association of Canada (TAC) Canadian Guide to In-service Road Safety Reviews and was an independent and formal process conducted by a multidisciplinary team who, based on their experience and expertise, provided opinions on safety issues from the perspective of all road users.

ISRSRs are separate from the design process. ISRSRs are not intended to identify one single safety solution for an intersection or roadway segment. Rather, the ISRSR typically identifies several potential countermeasures for further consideration by the road agency. These countermeasures will include short-term recommendations (such as sign upgrades or reapplication of pavement markings) to long-term recommendations (such as intersection reconfiguration or interchange construction).

It is important to note that multiple longer term safety options may be identified for consideration that are alternatives (i.e., traffic signals, roundabout, or other treatment). Where the recommendations for long-term options are identified, a functional design is needed to evaluate the options and identify the optimal solution. The evaluation of options in a functional design will consider safety and operational issues as well as other items such as cost, environmental implications, drainage, land acquisition and construction traffic management requirements. At the conclusion of the functional design, the optimal treatment will be identified, and the project can proceed to the detailed design phase and subsequent construction.

Note: While this ISRSR was initiated as a result of a fatal collision that occurred on June 15th, 2023, this review did not examine the details of this incident, as it is part of an ongoing RCMP investigation.

2 METHODOLOGY

In carrying out this work, an assessment of the existing road safety performance of the study area was conducted using a “lines-of-evidence” approach, followed by a risk-level evaluation.

The lines-of-evidence approach involved examining the safety performance of the study area using a range of tools and techniques, each of which were assessed first individually, and then as a whole. This included six distinct examination methods as illustrated in **Figure 2**:. Findings from a synthesis of the lines-of-evidence and risk-level evaluation were then used to identify priority road safety issues and opportunities for road safety improvement. Each step in this framework is described in further detail in the following sections.

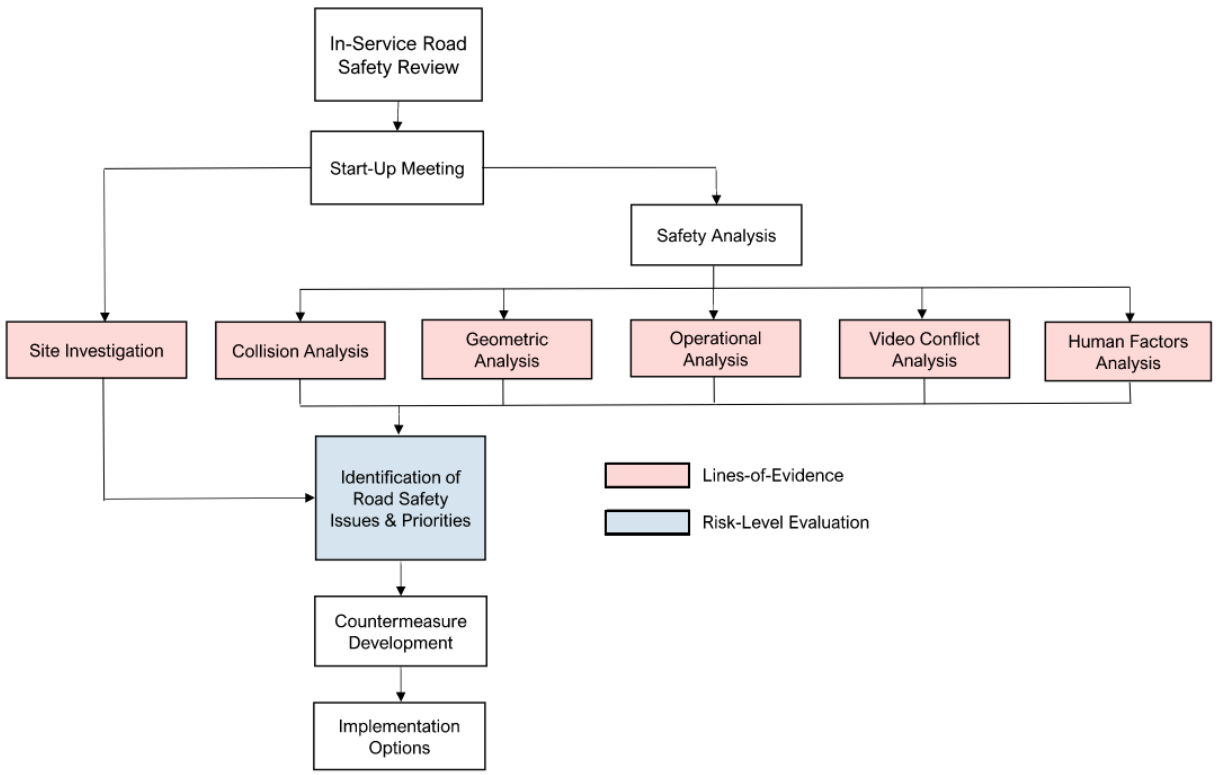


Figure 2: Study Methodology

START-UP MEETING

A virtual project start-up meeting was held between key members of the road safety team and MTI representatives. Key background information related to the study area was obtained during the meeting.

SITE INVESTIGATION

The site investigation was an important element of the ISRSR as it provided the team with an opportunity to observe in-service conditions in the field, and to collect information on road safety and operational characteristics of the facility including how drivers interact with the infrastructure and each other.

The site investigation team was multidisciplinary and included road safety, traffic engineering, geometric design, and human factors experts. The site was examined based on the needs of all relevant users and modes (vehicular traffic, heavy trucks, buses, pedestrians, and bicycles). The site investigation examined the facility during the morning and afternoon peak traffic periods and during day and night conditions.

SAFETY ANALYSIS

The safety analysis was a critical component of the audit process and involved problem definition and assessment. Historical collision data provided the primary foundation for this analysis. However, traffic and geometric characteristics as well as human factors considerations were also reviewed. A description of each component of the safety analysis process is provided below.

- **Collision Analysis:** Using the most recent ten years of reported collision data provided by MTI, an analysis of collision patterns and trends was conducted to develop a clear understanding of the road safety performance characteristics on the facility.
- **Geometric Analysis:** A review of geometric design elements was conducted based on the TAC Geometric Design Guide for Canadian Roads and local design standards. The focus of this review was to identify any correlations that may exist between infrastructure characteristics and collision occurrence.
- **Operational Analysis:** A traffic operational analysis was undertaken to identify operational issues that may be contributing to collision risk at the intersection. In addition, an assessment of vehicle speeds on PTH 1 and PTH 5 approaching the intersection was conducted to determine if the current posted speed limits are appropriate for the conditions present.
- **Video Conflict Analysis:** A traffic conflict analysis was conducted using video recordings collected from several locations at the intersection. This analysis examined near miss events between road users to gain an understanding of the probable causes of potential collisions.

The results from this analysis provided useful information on near-misses, stop-sign compliance, and traffic volume data.

- **Human Factors Analysis:** An analysis of human factors was conducted to identify possible human factors issues at the intersection. Elements examined included driver workload, visual complexity, sign and pavement marking effectiveness, factors influencing speed selection, gap search and manoeuvre distance, and decision point spacing.

IDENTIFICATION OF ROAD SAFETY ISSUES AND PRIORITIES

Findings from the site investigation and the safety analysis were used to identify road safety issues and develop a list of priorities for road safety improvements.

COUNTERMEASURE DEVELOPMENT

Using the prioritized list of road safety and operational issues, the road safety team identified potential countermeasures. As part of this task, estimates of countermeasure effectiveness were provided where possible. High-level qualitative cost-estimates were also prepared for each countermeasure.

IMPLEMENTATION OPTIONS

Using the results from the countermeasure development task discussed above, short, medium, and long-term implementation options focused on improving road safety and traffic operations at the intersection were developed. Maintenance issues and “watch list” items were also identified.

3 SAFETY ISSUES AND COUNTERMEASURES

The road safety issues identified were prioritized using both a lines-of-evidence approach and risk-level evaluation approach:

— The **lines-of-evidence approach** examined the findings from each of the individual analyses to identify where lines of evidence overlap and point to a common conclusion regarding a particular issue at the intersection.

— A **risk-level evaluation approach** was also applied to the road safety issues identified to assess the frequency with which the specific issue is likely to cause a collision and the severity of the collision that would result from the issue. Using these two rating criteria, each issue was then assigned a level of risk of Low, Medium, High and Very High.

The lines-of-evidence approach and risk-level evaluation approach led to the identification of each issue as high, medium or low in priority. Using the prioritized list of road safety issues, the road safety team identified potential countermeasures to address the concerns identified. As part of this task, estimates of countermeasure effectiveness and cost effectiveness were provided and used to identify a prioritized list of countermeasures. Implementation options were also developed based on the time and level of development needed to implement the countermeasure. The following implementation criteria were applied:

— **Short-term options**: These items include low and moderate-cost countermeasures that can be implemented with little project development effort.

— **Medium-term options**: These items include countermeasures that will require project development effort but should be considered in the near future.

— **Long-term options**: These items include countermeasures that will require significant planning and analysis due to their cost and potential impacts on surrounding communities and developments. These items should be considered as alternatives for further review as part of future highway rehabilitation.

— **Maintenance items**: These items include countermeasures that should be addressed as part of routine maintenance activities on the highway.

— **Watch list items**: Due to the low cost-effectiveness associated with the selected countermeasures, some road safety issues have been placed on a “watch list”. These issues should be monitored on an ongoing basis for changes in safety performance that might trigger reconsideration of the need to invest in mitigation.

The prioritized list of road safety issues, countermeasures, implementation options, and relative cost estimates are summarized in the following sections.

3.1 SHORT-TERM OPTIONS AND MAINTENANCE ITEMS

Short-term options and maintenance items are summarized in **Table 1**, including their relative priority, implementation options and relative cost.

Table 1: Short-Term Options and Maintenance Items

<table>
<tr><th>PRIORITY LEVEL</th><th>ROAD SAFETY ISSUE</th><th>COUNTERMEASURE</th><th>IMPLEMENTATION OPTIONS</th><th>RELATIVE COST</th></tr>
<tr><td rowspan="3">High Priority</td><td>PTH 5 rumble strips condition: The transverse rumble strips on both PTH 5 approaches to the intersection are worn in the wheel paths and this impacts their effectiveness.</td><td>The condition and design of the rumble strips should be reviewed and repaired/adjusted as necessary.[1]</td><td>Short-term</td><td>Low</td></tr>
<tr><td rowspan="2">Intersection conspicuity: On PTH 1, there is little contrast between the mainline lanes and the intersection. Advanced warning of the approaching intersection is limited.</td><td>Install the Concealed or Unexpected Intersection sign (WA-11).[1, 2]</td><td>Short-term</td><td>Low</td></tr>
<tr><td>Install a Dynamic Advance Intersection Warning System.[2]</td><td>Short-term</td><td>Moderate</td></tr>
<tr><td rowspan="4">Medium Priority</td><td>Signage specific for median acceleration lanes: The effectiveness of the advanced signage for the northbound to westbound median left-turn acceleration lane is limited.</td><td>Provide signage specific for median acceleration, designed with input from a human factors expert.</td><td>Short-term</td><td>Low</td></tr>
<tr><td>Median yield sign location: The yield signs in the median are located at an increased offset from the travel path. This may reduce their effectiveness.</td><td>Review the locations of yield signs to reduce the lateral offset.</td><td>Short-term</td><td>Low</td></tr>
<tr><td rowspan="2">Trucks stopping in prohibited locations: Trucks are violating the existing “No stopping” signs at the intersection.</td><td>Engage with the Manitoba Trucking Association and local trucking operations.</td><td>Short-term</td><td>Low</td></tr>
<tr><td>Enforcement of the "no stopping" signage.</td><td>Short-term</td><td>Low</td></tr>
</table>

PRIORITY LEVEL	ROAD SAFETY ISSUE	COUNTERMEASURE	IMPLEMENTATION OPTIONS	RELATIVE COST
	Eastbound median left-turn acceleration lane: There is no eastbound median left-turn acceleration lane.	Provide southbound to eastbound median acceleration lane.	Short-term	Moderate
	PTH 1 speed compliance confirmation: The 100 km/h speed reduction zones are long with no additional enforcement.	Conduct a follow-up speed study on PTH 1.	Short-term	Moderate
	Limited intersection illumination: Conspicuity of the intersection and the PTH 1 left-turn lanes is limited at night.	Re-evaluate intersection illumination and enhance where necessary.	Short-term	Moderate
	Headlight glare: Some headlight glare was observed from opposing traffic on both PTH 1 and PTH 5 approaches to the intersection. Of particular concern is glare for the PTH 5 traffic that is using the median cross-over as it may impact driver perception of traffic conditions.			
	PTH 1 solid line pavement markings between the mainline travel lanes: The solid line pavement markings on PTH 1 between the mainline travel lanes in advance of the intersection are short.	Extend solid line pavement markings.	Maintenance	Low
	PTH 1 delineation of westbound median left-turn acceleration lane: The westbound median left-turn acceleration lane is currently delineated with dashed lines, which may	Provide solid line pavement markings to delineate acceleration lane from mainline travel lanes.	Maintenance	Low

PRIORITY LEVEL	ROAD SAFETY ISSUE	COUNTERMEASURE	IMPLEMENTATION OPTIONS	RELATIVE COST
	encourage drivers to merge directly into the high-speed mainline lane.			
Low Priority	**Right turns from PTH 5 (yield sign controlled):** The right-turn acceleration lane geometry (in both eastbound and westbound direction) suggests to drivers that they should merge into traffic, while the yield signs suggests that drivers should yield to traffic.	Review for compliance with the provincial standard requirements.	Short-term	Low
	PTH 1 left-turn deceleration lane delineation pavement markings: The solid line pavement markings on PTH 1 between the mainline travel lanes and the left-turn lanes in advance of the intersection are short.	Extend solid line pavement markings.	Maintenance	Low
	Warning signage: No Divided Highway Ahead Warning Sign (WA-34) is provided on the PTH 5 northbound approach.	Provide the necessary signage to provide consistency.	Maintenance	Low
	Guide signage: Guide signage on the eastbound and westbound approaches to the intersection are not consistent.	Provide the necessary signage to provide consistency.	Maintenance	Low
	Pavement markings condition: In general, line painting is deteriorated.	Reapply line painting and pavement markings.	Maintenance	Low
	Signage condition: Some signs on the approaches to the intersection were	Review signage for deterioration and reflectivity.[1]	Maintenance	Low

PRIORITY LEVEL	ROAD SAFETY ISSUE	COUNTERMEASURE	IMPLEMENTATION OPTIONS	RELATIVE COST
	deteriorated, damaged, or exhibited low reflectivity at night.			
	Non-breakaway signage posts: Several signs located within the intersection clear zone are mounted on a single 6x4 in (15x10cm) wooden post that are not equipped with shear holes.	Provide shear holes as necessary in sign posts.	Maintenance	Low
	Pavement condition: Pavement cracking and discontinuities within the intersection may impact drainage and lead to further deterioration.	Assess to determine if patch repairs, rehabilitation, or replacement is warranted.	Maintenance	Low
	PTH 5 shoulder conditions: The shoulders on PTH 5 are deteriorated and may affect drainage and vehicle stability.	Grade existing shoulders to ensure smooth surface.	Maintenance	Low
	Illumination maintenance: A light bulb on the double davit in the northwest corner of the intersection is not working.	Replace bulbs as necessary.	Maintenance	Low

[1] It is our understanding that MTI has implemented these countermeasures since the site investigation.

[2] Either the Concealed or Unexpected Intersection sign (WA-11) or a Dynamic Advance Intersection Warning System should be installed (not both).

In summary:

- **Short-term:** The short-term options included both low-cost and moderate-cost options.
  - Short-term, low-cost options included countermeasures that addressed issues related to signage application and compliance.
  - Short-term, moderate-cost options addressed issues related to intersection conspicuity and speed differentials and included the installation of a Dynamic Advance Intersection Warning System, provision of a southbound to eastbound median acceleration lane, conducting a follow-up speed study, and enhancing illumination.

— **Maintenance:** All maintenance items identified were considered to be low-cost. Maintenance items addressed issues related to pavement marking, signage, pavement, shoulder, and illumination conditions.

3.2 MEDIUM-TERM AND LONG-TERM OPTIONS

Medium-term and long-term options are summarized in **Table 2**, including their relative priority, implementation options and relative cost.

Table 2: Medium-Term and Long-Term Options

PRIORITY LEVEL	ROAD SAFETY ISSUE	COUNTERMEASURE	IMPLEMENTATION OPTIONS	RELATIVE COST
High Priority	**Median operations:** The narrow median width limits the available storage and refuge area. The median is often occupied by several vehicles at the same time, and different driver behaviors were observed.	Implement an alternative intersection configuration.	Medium-term	High
		Provide a grade-separation (interchange).	Long-term	High
	Left Turns from PTH 1: The negative offset of the PTH 1 left-turn lanes can create sightline obstructions.	Implement an alternative intersection configuration.	Medium-term	High
	Limited positive guidance in the median: No positive guidance is provided in the median to help drivers position their vehicles and navigate through the median.	Implement an alternative intersection configuration.	Medium-term	High
Medium Priority	**PTH 5 stop sign compliance:** The results of the video analysis suggest a reduced level of compliance with the Stop signs on PTH 5, particularly for the southbound left turn movement.	Implement an alternative intersection configuration.	Medium-term	High
	Absence of eastbound median left-turn acceleration lane: There is no eastbound median left-turn acceleration lane for vehicles turning left from PTH 5.	Implement an alternative intersection configuration.	Medium-term	High
	Median yield sign location: The yield signs in the median are located at an increased	Implement an alternative intersection configuration.	Medium-term	High

PRIORITY LEVEL	ROAD SAFETY ISSUE	COUNTERMEASURE	IMPLEMENTATION OPTIONS	RELATIVE COST
	offset from the travel path. This may reduce their effectiveness.			
	A-pillar obstruction: The vehicle A-pillars can obstruct the sightlines to approaching vehicles on PTH 1. This is a particular problem when looking to the right when making a left turn.	Implement an alternative intersection configuration.	Medium-term	High

In summary:

- **Medium-term:** The medium-term options included countermeasures that were all considered to be moderate cost. The medium-term options addressed common issues associated with two-way stop-controlled intersections on divided highways including median operations, stop-sign compliance, and speed differentials between turning movements and mainline traffic. Alternative intersection configurations were identified as a potential countermeasure for all medium-term options; however, require further evaluation and development through a functional design study. Additional details on possible types of alternative intersection configurations are provided below.
- **Long-term:** One long-term option, the provision of a grade-separated interchange, was identified to address common issues associated with two-way stop-controlled intersections on divided highways. A grade-separated interchange is a high-cost option and requires further evaluation and development through a functional design study. Additional details on the grade-separated interchange option are provided below.

The following sections provide additional information on the medium-term and long-term options that should be considered for further evaluation and development through a functional planning and design study. The functional planning and design study would address other considerations such as environmental constraints, drainage, land acquisition (as may be required), funding requirements, and construction traffic management requirements.

INTERSECTION MEDIAN WIDENING

Intersection median widening was identified as a possible alternative intersection configuration (medium-term option); however, this option may require significant changes to the highway alignment. Literature indicates that in general, four-legged, two-way-stop-controlled intersections on rural expressways are safer if the median is wider, and this is most likely due to the fact that wider medians allow for two-stage gap selection (i.e., minor road left-turning or crossing vehicles can safely stop in the median area to evaluate the adequacy of the gap in expressway traffic coming from the right, thereby reducing the relative crash risk associated with these manoeuvres). In addition to providing the benefits of extra median storage for large vehicles, this treatment can also help emphasize the presence of the intersection, encourage more consistent left-turn behavior in the median, and provide opportunity for enhanced delineation and better positive guidance within the median. If widened enough to accommodate storage of the design vehicle, stop control can be considered in the median.

ROUNDABOUT

A roundabout was identified as a possible alternative intersection configuration (medium-term option). A roundabout can provide significant road safety benefits due to its characteristic low-speed operations and reduced vehicle conflicts and collision severity. When compared to a stop-controlled intersection, the majority of conflict points that are eliminated are crossing type conflicts occurring at the median crossovers that in general result in higher severity outcomes. Roundabout conflicts are generally low-speed, sideswipe collisions that result in low severity outcomes.

However, the application of a roundabout in a high-speed rural environment and the isolated nature of this intersection can raise concern regarding driver expectation. As such, careful consideration of a system of speed management measures focused on reducing vehicle approach speeds for a significant distance would be required as part of this option. These speed management measures can include advanced warning provisions, speed feedback signs, the application of peripheral pavement markings, and the introduction of alignment shifts using long splitter islands. The operational characteristics of long combination vehicles would also need to be considered.

To help quantify the relative change in road safety performance associated with changing the existing stop-controlled intersection to a multi-lane roundabout, an analysis was conducted using safety performance functions (SPFs) from the Federal Highway Administration (FHWA) Highway Safety Manual (HSM) to estimate the expected collision frequency for the existing stop-controlled configuration, and using Collision Modification Factors (CMFs) from both the FHWA HSM and the TAC Roundabout Design Guide to estimate the expected collision frequency for a multilane roundabout configuration. These CMFs suggest a 44% reduction in total collisions and an 82% reduction in fatal and injury collisions. **Table 3** presents the findings from this review.

Table 3: Annual Expected Collision Frequency for the Installation of a Roundabout

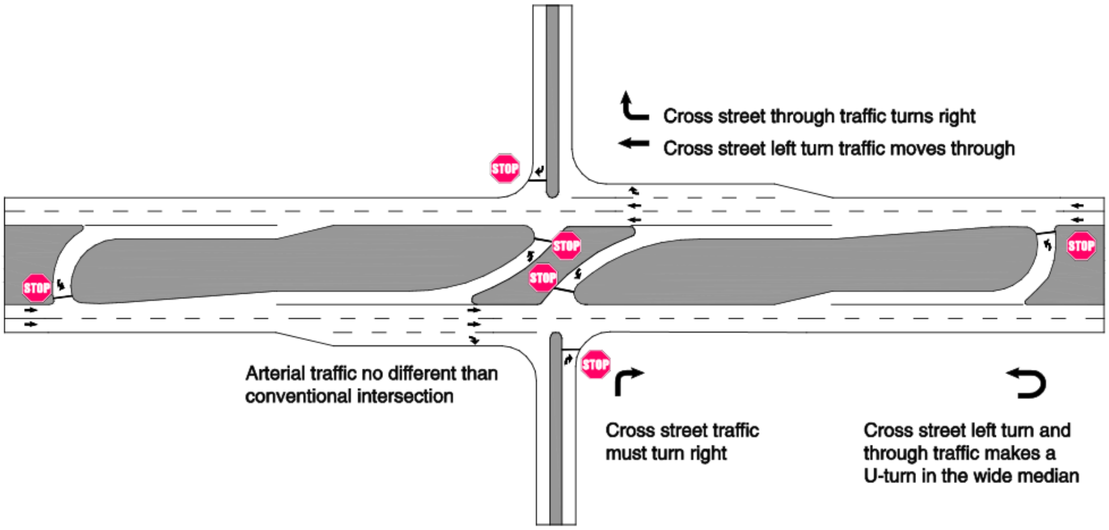
INTERSECTION CONFIGURATION	ANNUAL EXPECTED COLLISION FREQUENCY		
	PROPERTY DAMAGE ONLY COLLISIONS	FATAL AND INJURY COLLISIONS	TOTAL COLLISIONS
Existing Stop-Control	1.58	1.63	3.21
Roundabout Intersection – HSM CMFs	1.51	0.29	1.80

As shown in the table, the installation of a multilane roundabout is expected to result in lower total, PDO and fatal and injury annual expected collision frequencies when compared to the existing stop-control configuration.

In addition to the analysis above, safety performance functions (SPFs) specific to estimating roundabout related collisions were reviewed from the National Cooperative Highway Research Program (NCHRP) Report No. 888. These SPFs suggest that a similar trend in reducing fatal and injury collisions is expected when converting the existing stop-controlled intersection to a multilane roundabout.

RESTRICTED CROSSING U-TURN (RCUT)

A stop-controlled or yield-controlled RCUT intersection can be used as a safety treatment at isolated intersections on four-lane divided highways in rural areas. There are known safety benefits associated with this type of intersection. The RCUT intersection, also known as a J-Turn or Superstreet, differs from a conventional intersection by eliminating the left-turn and through movements from crossroad approaches. To accommodate these movements, the RCUT intersection requires drivers to turn right onto the main road and then make a U-turn maneuver at a one-way median opening located downstream of the intersection. On the major road approaches, the left turns are typically accommodated similar to left turns at conventional intersections. **Figure 3** illustrates the movements at an RCUT intersection.



Source: FHWA Restricted Crossing U-Turn Intersection Informational Guide (August 2014)

Figure 3: Rural Stop Controlled RCUT Configuration

Due to the significant truck volumes on both PTH 1 and PTH 5, the application of this configuration would require careful consideration. Of particular concern is providing adequate gap search and maneuver distance between the main intersection and the upstream U-turn provisions to ensure heavy trucks have sufficient distance to merge onto the highway, make the necessary lane change maneuvers, and decelerate into the U-turn. If the median width is less than adequate for larger vehicle U-turns, additional pavement can be added at the far side of the U-turn crossover in the form of “loons” to accommodate this movement as shown in **Figure 4** below. These would need to be sized to accommodate the required design vehicle.

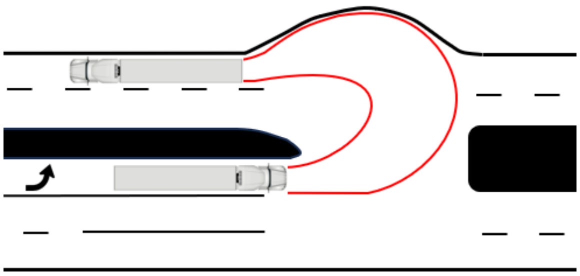
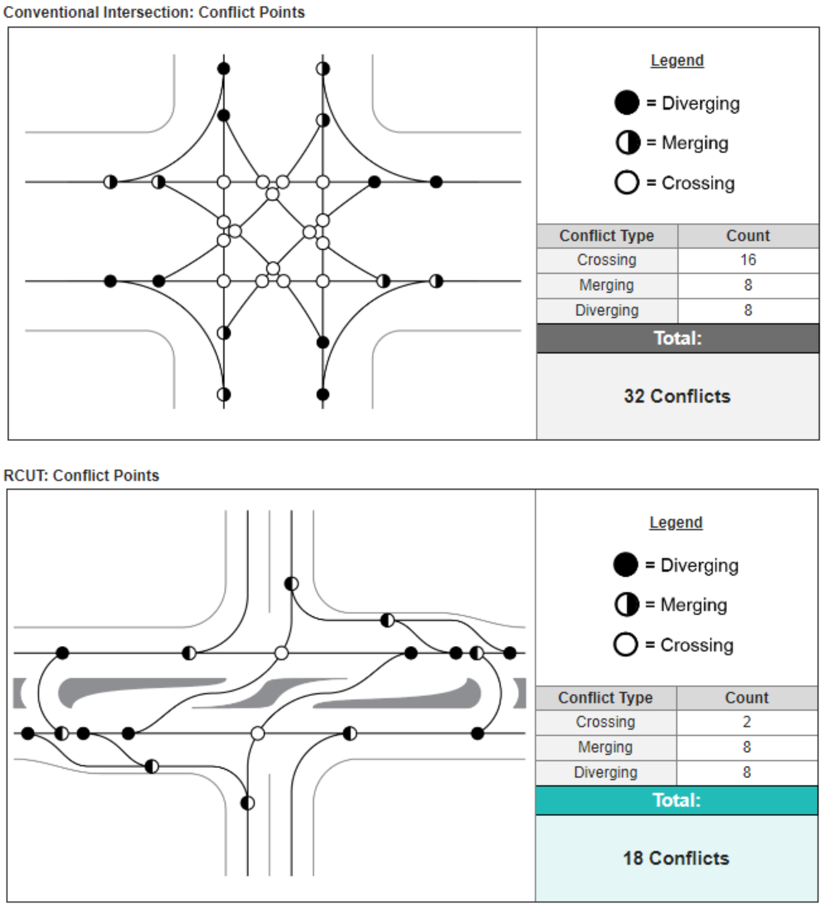


Figure 4: Example of a Truck Turning Loon

By restricting several movements at the main crossing intersection, RCUT intersections reduce vehicular intersection conflict points from 32 (stop-controlled intersection) to 18 (RCUT intersection). The majority of the reduced conflict points are crossing type conflicts occurring at the median crossovers that in general result in higher severity outcomes. Conflict points are also spread out which allows drivers to make decisions for each conflict individually, lowering driver workload and risk of error. The difference in number of conflicts is shown in **Figure 5**.



Source: Virginia Department of Transportation

Figure 5: Conventional intersection and RCUT intersection conflict points

A study of the safety performance of RCUT intersections conducted by Missouri Department of Transportation found the RCUT design resulted in a 34.8% reduction in total collisions and a 53.7% reduction in fatal and injury collisions. These expected reductions were used to help quantify the relative change in road safety performance associated with changing the existing stop-controlled intersection to a RCUT intersection. **Table 4** presents the findings from this review.

Table 4: Annual Expected Collision Frequency for the Installation of a RCUT Intersection

INTERSECTION CONFIGURATION	ANNUAL EXPECTED COLLISION FREQUENCY		
	PROPERTY DAMAGE ONLY COLLISIONS	FATAL AND INJURY COLLISIONS	TOTAL COLLISIONS
Existing Stop-Control	1.58	1.63	3.21
RCUT Intersection	1.35	0.75	2.10

The key findings from this analysis indicate that an RCUT intersection would result in lower total, PDO, and fatal and injury annual expected collision frequencies when compared to the existing stop-controlled intersection.

GRADE-SEPARATED INTERCHANGE

Grade separation can be achieved by either overpass or underpass and there are a variety of interchange types (i.e., Diamond, Parclo, etc.) to consider based on site conditions and operational requirements. Jurisdictions considering new interchanges generally must consider a variety of factors including highway classification, operational capacity, collision frequency and severity, site topography, road-user benefits, relative priority across the transportation network, funding, and other considerations. For these reasons, a functional design study is typically conducted to explore and evaluate options before selecting a preferred option to develop to a detailed design and eventual construction.

Research shows that converting an at-grade intersection to a grade-separated interchange may reduce all collisions by 42% and fatal and injury collisions by 57% (CMF Clearinghouse: Elvik, R. and Erke, A., 2007). These expected reductions were used to help quantify the relative change in road safety performance associated with changing the existing stop-controlled intersection to a grade-separated interchange. **Table 5** presents the findings from this review.

Table 5: Annual Expected Collision Frequency for the Installation of an Interchange

INTERSECTION CONFIGURATION	ANNUAL EXPECTED COLLISION FREQUENCY		
	PROPERTY DAMAGE ONLY COLLISIONS	FATAL AND INJURY COLLISIONS	TOTAL COLLISIONS
Existing Stop-Control	1.58	1.63	3.21
Grade-Separated Interchange	1.16	0.70	1.86

The key findings from this analysis indicate that a grade-separated interchange would result in lower total, PDO, and fatal and injury annual expected collision frequencies when compared to the existing stop-controlled intersection.

SUMMARY OF MEDIUM-TERM AND LONG-TERM OPTIONS

Table 6 summarizes the potential benefits and drawbacks of the medium-term (alternative intersection configuration) and long-term (grade-separated interchange) options.

Table 6: Medium-Term and Long-Term Options – Potential Benefits and Drawbacks

OPTIONS	POTENTIAL BENEFITS	POTENTIAL DRAWBACKS
Median Widening at Intersection (Medium-Term)	- Medium-term implementation. - Moderate cost. - Minor road left-turning or crossing vehicles including trucks can safely stop in the median area to allow two-stage gap selection. - Allows for enhanced delineation and positive guidance which encourages more consistent driver behavior in the intersection.	- Requires significant changes to highway alignment. - May impact drainage, utilities, property, etc. (to be determined during functional design stage).
Roundabout (Medium-Term)	- Medium-term implementation. - Moderate cost. - Increases safety due to its low-speed operations and reduced vehicle conflicts. - Safety analyses indicated a significant reduction in fatal and injury collision frequency is expected when converting the existing stop-controlled intersection to a roundabout.	- The application of a roundabout in a high-speed rural environment and the isolated nature of this intersection can raise concern regarding driver expectation. Careful consideration of a system of speed management measures focused on reducing vehicle approach speeds would be required. - The operational characteristics of long combination vehicles would also need to be considered.
Restricted Crossing U-Turn (Medium-Term)	- Medium-term implementation. - Moderate cost. - By restricting several movements at the main intersection, RCUT intersections reduce vehicular intersection conflict points from 32 to 18. - The majority of the conflict points that are eliminated are crossing type conflicts that result in higher severity outcomes. - Safety analyses indicated a significant reduction in fatal and injury collision frequency is expected when converting the existing stop-controlled intersection to an RCUT intersection.	- Provides a less direct route for left-turn and through movements, as drivers are required to turn right onto the main road and then make a U-turn maneuver at a one-way median opening located downstream of the intersection. - Due to the significant truck volumes on both PTH 1 and PTH 5, the application of this configuration would require careful consideration.
Grade-Separated Interchange (Long-Term)	- Research shows that converting an at-grade intersection to a grade-separated interchange may reduce all collisions by 42% and fatal / injury collisions by 57%.	- Long-term implementation. - High cost.

3.3 WATCH LIST ITEMS

The watch list of items that should be considered in conjunction with the medium-term and long-term options during the functional planning and design phase, or as part of other systemic planning studies, are summarized in **Table 7**, including their relative priority, implementation options and relative cost.

Table 7: Watch List Items

PRIORITY LEVEL	ROAD SAFETY ISSUE	COUNTERMEASURE	IMPLEMENTATION OPTIONS	RELATIVE COST
Medium Priority	**PTH 1 right-turn deceleration lane length:** The length of the right-turn deceleration lanes is short.	Extend speed-change lanes as part of any future highway rehabilitation such as installation of alternative intersection design or an interchange.	Watch List	Moderate
	PTH 1 right-turn acceleration lane length: The length of the right-turn acceleration lanes is short.			
	PTH 5 speed reduction zone: Posted speed on PTH 5 is 100 km/h and no speed reduction zone is provided on the approaches to the stop-controlled intersection.	Consider for further review a speed reduction on PTH 5 as part of MTI's initiative to develop systemic response plans for intersections.	Watch List	Moderate
Low Priority	**PTH 1 left-turn deceleration lane length:** The length of the left turn deceleration lanes from PTH 1 is short.	Extend speed-change lanes as part of any future highway rehabilitation such as installation of alternative intersection design or an interchange.	Watch List	Moderate
	Proximity of service roads: There is a potential for vehicle queues on PTH 5 to extend into the service road intersections. The right-turn merge tapers from PTH 1 extend through the service road intersections.	Realignment of the service roads to increase the separation between the intersections.	Watch List	Moderate
	PTH 5 shoulder width: Portions of the PTH 5 shoulder are narrow and a 0.8m partially paved shoulder is not provided.	Provision of paved shoulders on PTH 5 following MTI standards.	Watch List	Moderate

In summary, the watch list items were all considered to be moderate-cost and should be considered as part of any future highway rehabilitation, such as the implementation of an alternative intersection configuration or grade-separated interchange. Watch list items addressed speed-change lane length, speed zone application, realignment of service roads, and the provision of paved shoulders on PTH 5.

3.4 OTHER OPTIONS CONSIDERED

Traffic signals at the intersection and a speed limit reduction on PTH 1 were also considered as potential countermeasures, however, have not been included in the short list of countermeasures for consideration for the PTH 1 and PTH 5 intersection for the reasons identified below.

TRAFFIC SIGNALS

Consideration was given to traffic signals as a potential countermeasure. A traffic signal could provide some operational benefits when properly applied; however, the isolated nature of the study area intersection raises concern regarding the presence of speed adapted drivers, the potential for signal violations, and the risk of high-speed rear-end collisions.

Based on relevant North American road safety research, the provision of isolated traffic signals on high-speed facilities such as PTH 1 can result in increased total collision frequency, as well as fatal and injury collision frequency.

Table 8 presents the results of quantitative road safety analysis conducted using the methodologies outlined in the American Association of State Highway and Transportation Officials (AASHTO) HSM. In this analysis, Safety Performance Factors (SPFs) from the HSM were applied to estimate the expected change in annual collision frequency associated with changing the existing stop-controlled intersection to a traffic signal. The results of this analysis indicate that installing a traffic signal at this location would result in a significant increase in total collisions annually.

Table 8: Annual Expected Collision Frequency for the Installation of a Traffic Signal

INTERSECTION CONFIGURATION	ANNUAL EXPECTED COLLISION FREQUENCY		
	PROPERTY DAMAGE ONLY COLLISIONS	FATAL AND INJURY COLLISIONS	TOTAL COLLISIONS
Existing Stop-Control	1.58	1.63	3.21
Signalized Intersection	4.66	3.70	8.36

Based on the above, a traffic signal is not included on the short list of countermeasures considered for implementation at this location.

PTH 1 SPEED LIMIT REDUCTION

Concern has been raised regarding the appropriateness of the 100 km/h posted speed limit in the vicinity of this intersection and the need to further reduce the mainline speed limit. Research indicates that simply reducing the speed limit to less then 100 km/h on a high-speed facility can create other challenges. These include the following:

- Localized speed reduction zones on high-speed freeways are contrary to driver expectation. As a result, driver compliance to the to the localized speed reduction will likely be poor.
- The highway appearance within the localized speed reduction zone would still be consistent with other portions of the highway posted at 110 km/h located upstream and downstream of the intersection, and there would be no visual cues (other than the speed limit signage) of the need to change driving behavior. This would contribute to poor compliance with the reduced speed limit.
- Drivers would likely have been driving at high speed for long periods of time. As a result, they will be speed adapted. Speed adaptation is a driver's underestimation of their actual speed after transitioning from a higher speed-limit facility or highway section.

Poor compliance with the reduced speed limit may contribute to increased speed differentials and an increased risk of collision. Based on the concerns outlined in the points above, the adoption of a reduced speed limit (less then 100 km/h) on the PTH 1 approaches to the intersection is not recommended as a standalone treatment.

4 CONCLUSION AND RECOMMENDATIONS

This report summarises findings from the ISRSR conducted for the intersection of PTH 1 and PTH 5 in accordance with the TAC Canadian Guide to In-service Road Safety Reviews. In conducting this review, a lines-of-evidence approach and risk-based evaluation were applied to identify a prioritized list of road safety issues.

Using this prioritized list of road safety issues, and results from a cost-effectiveness assessment of potential countermeasures, short, medium and long-term implementation options were developed based on the time and level of development needed for countermeasure implementation.

As noted earlier in this report, an ISRSR is separate from the design process and is not intended to identify one single safety solution for an intersection or roadway segment. Rather, an ISRSR typically identifies a number of potential countermeasures for further consideration by the road agency, ranging from shorter-term countermeasures (such as sign upgrades, reapplication of pavement markings, and enhanced illumination), to medium- and longer-term countermeasures (such as modifying traffic control or reconstructing and reconfiguring an intersection).

It is recommended that the short-term countermeasures and maintenance items, generally consisting of low and moderate cost countermeasures that can be implemented with little project development effort, be implemented right away.

It is recommended that the medium-term and long-term countermeasures identified in **Section 3.2** undergo further evaluation and development through a functional design study to select the most appropriate option from a safety perspective, as well as address other considerations such as environmental constraints, drainage, land acquisition, and construction traffic management requirements. It is recognized that the ultimate solution will also need to consider department priorities and budget requirements.