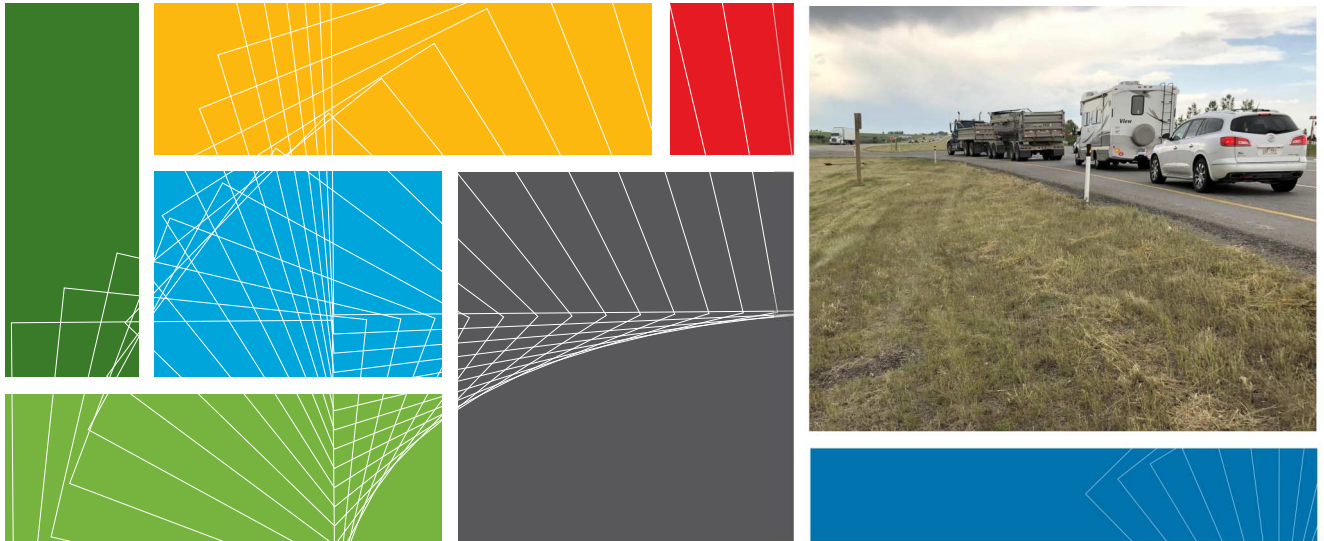


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Alberta Transportation

Final

Highway 2 at Township Road 210 Safety Review

July 2019





Corporate Authorization

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Steven Dudley, P.Eng.
Transportation Engineer

Stephen Burnell, P.Eng., PTOE
Senior Transportation Engineer



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1.0 Introduction

Alberta Transportation (AT) retained ISL Engineering and Land Services Ltd. (ISL) to undertake a safety review of the intersection of Highway 2:12 at Township Road 210 (TR210) located in the Municipal District (MD) of Foothills. TR210 is the second intersection north of the Highway 7 interchange on Highway 2 and provides an alternate route to the town of Okotoks, which is located approximately 3.2 km to the west.

The purpose of this safety review is to identify existing issues that affect the overall safety and traffic operations of the intersection, and to identify counter measures to mitigate the identified issues.

1.1 Scope of Work

ISL confirmed the scope of work with AT staff in an email dated Wednesday, June 12, 2018. The agreed-upon scope of work for the safety review included the following:

- Collect data (as-built drawings, traffic counts, collision info, etc.).
- Retrieve and review as-built drawings (ISL did not receive as-built drawings for this intersection).
- Assess the data and existing conditions.
- Develop sketches.
- Develop a report for the safety review.

1.2 Study Methodology

This review includes a systematic review of the functional, traffic, collision, operational and geometric characteristics of the intersection. The review considers the guidelines and procedures provided in the following AT, Transport Canada (TC) and Transportation Association of Canada (TAC) manuals:

- “Canadian Guide to In-Service Road Safety Reviews” (TAC, 2003) - IRSR
- “Rural Intersection Safety Handbook” (TC, 2006); and
- “Methods of Reducing Collisions on Alberta Roads” (AT, 2010) – MORCAR.

ISL considered the following relevant guidelines as part of this study:

- “Highway Geometric Design Guide” (AT, 1999) - HGDG
- “Roadside Design Manual” (AT, 2007) - RDM
- “Highway Lighting Guide” (AT, 2003)
- “Highway Pavement Marking Guide” (AT, 2003)
- “Manual of Uniform Traffic Control Devices for Canada” (TAC, 1998) - MUTCDC
- “Geometric Design Guide for Canadian Roads” (TAC, 2017) - GDG
- “Illumination of Isolated Rural Intersections” (TAC, 2001)
- “Traffic Signal Warrant Handbook” (TAC, 2007)

2.0 Site Characteristics

2.1 Background Information

ISL obtained background information about the study intersection including the following:

- Information from the AT website including, but not limited to:
 - Design guidelines/bulletins
 - Turning Movement Summary Diagrams (Appendix A)
 - Directional Traffic Count Summaries (Appendix A)
 - Traffic control and sign information
- Information from the Transportation Infrastructure Management System (TIMS) including:
 - roadway classification, linear referencing information, geometric information, and collision data from AT Maps
 - Reports generated from the Network Expansion Support System (NESS) (Appendix B)

2.2 Roadway Classification

Highway 2

Highway 2:12, also referred to as the Queen Elizabeth II Highway, is a rural four-lane divided highway that forms a part of the CANAMEX north-south trade corridor. It has a Level 1 Service Classification and a Freeway/Expressway Functional Classification. At the study location, Highway 2 is oriented northwest-southeast and has a 110 km/h posted speed limit. Although Highway 2 predominantly has a four-lane cross section, the highway segment within the study area provides five (5) through lanes: three (3) northbound and two (2) southbound. Highway 2 is designated as a Long Combination Vehicle (LCV) route. For simplicity in discussing Highway 2 approaches:

- the northwest approach is referred to as the north approach; and
- the southeast approach is referred to as the south approach.

The Highway 2:12 at TR210 intersection is shown in Figure 1.

Township Road 210

TR210, also known as 338th Avenue East, intersects Highway 2 and forms intersection number 19291. Both TR210 approaches are stop-controlled.

West of Highway 2, TR210 is a paved rural two-lane undivided roadway that is primarily oriented east-west and has an 80 km/h posted speed limit.

East of Highway 2, TR210 is a paved rural two-lane undivided roadway with a statutory 80 km/h speed limit. TR210 intersects with RR291 in a “T” configuration centred approximately 74 m east of the northbound Highway 2 centreline.



Figure 1: Highway 2:12 at TR210 Intersection

Range Road 291

RR291, also known as 64th Street East, is a paved rural two-lane undivided roadway. RR291 intersects with TR210 east of Highway 2, is oriented north-south and has a statutory 80 km/h speed limit.

1064 Drive E

1064th Drive E is a paved rural two-lane undivided roadway. 1064th Drive E intersects with TR210 approximately 46 m west of southbound Highway 2 centreline, is oriented north-south and has a posted 80 km/h speed limit.

2.3 Traffic Volumes

Traffic characteristics for the TR210 intersection are presented in Figure 2 and include:

- Annual Average Daily Traffic (AADT);
- percent trucks (including RVs and buses); and
- AM and PM 100th highest hour turning movement estimates.

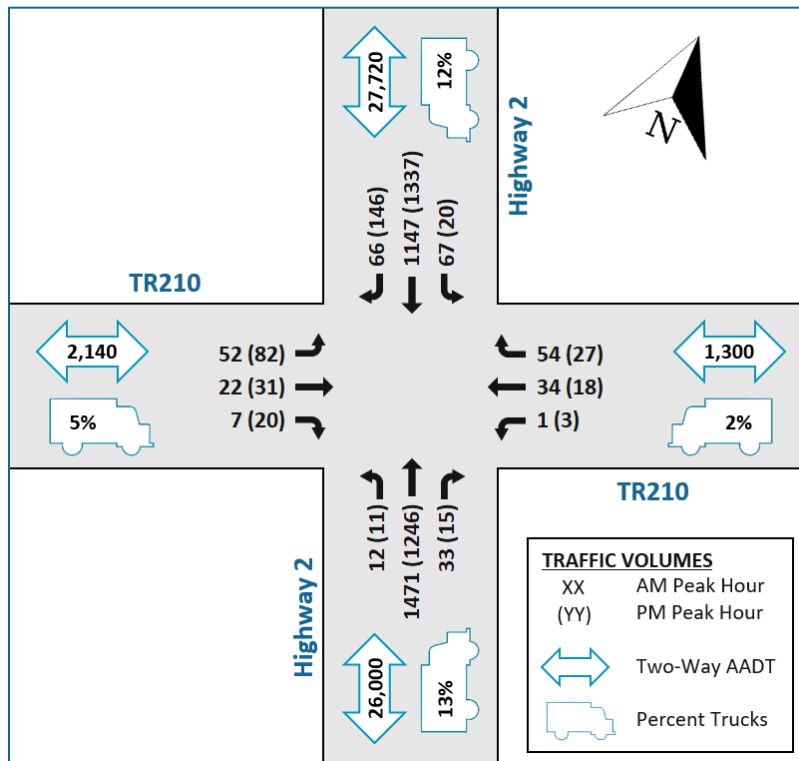


Figure 2: 2018 Traffic Characteristics

The traffic characteristics and patterns illustrate the following:

- The Highway 2 two-way AADT is approximately 27,000, including significant truck traffic (12% to 13%).
- West of Highway 2, TR210 has a two-way AADT of 2,140 and 5% truck traffic.
- East of Highway 2, TR210 has a two-way AADT of 1,300 and 2% truck traffic.
- Highway 2 northbound and southbound through traffic are the dominant movements in both the AM and PM peak hours.
- Major turning movements at the intersection consist of southbound right and left turns, northbound right turns, eastbound left turns, and westbound right turns.
- Westbound left turns are minimal in both peak hours.
- Highway 2 has a 56% northbound / 44% southbound directional split in the AM peak hour, and a 48% northbound / 52% southbound directional split in the PM peak hour.
- The AM Peak hour is 11:00 a.m. to noon.
- The morning peak period for minor approach turning movements is 7:00 to 8:00 a.m., which is four (4) hours earlier than the AM Peak hour. In the 2018 raw count data, the volume of eastbound left turns in the 7:00 to 8:00 a.m. hour is approximately three (3) times what it is in the AM peak hour.
- The PM Peak hour is 3:45 p.m. to 4:45 p.m. and corresponds with the afternoon peak period for the minor approach turning movements.



Table 1 provides the growth rates reported in TIMS NESS (ATR Number 60021260). ISL used historical Highway 2 AADT at the Highway 7 / Highway 547 interchange (obtained from “Alberta Highways 1 to 986 Traffic Volume History (1962 - 2017)”) to check the growth rates provided in NESS. The NESS and calculated five-year growth rates are similar while the calculated ten-year and twenty-year growth rates are higher than the rates provided from NESS.

Table 1: Historical Growth Rates for Highway 2

Growth Rate (Method)	Growth Rates (%)		
	5 Year	10 Year	20 Year
TIMS NESS (Linear Regression)	3.85	2.97	2.98
TIMS NESS (Two-Point)	4.27	2.56	2.76
Calculated (Two-Point from AADT)	3.57	4.41	5.18

3.0 Collision Analysis

Collision information for the period of 2012 to 2016 was obtained for the TR210 TIMS intersection polygon, which extends 140 m to the south and 147 m to the north. From 2012 to 2016, a total of 32 collisions were recorded, which corresponds to an intersection collision rate of 66.5 collisions per hundred million entering vehicles (100MEV), a rate that is just below AT’s threshold for special monitoring sites (69.8 collisions per 100MEV). Intersection collision rates and provincial thresholds for special monitoring sites are summarized in Table 2.

Table 2: Intersection Collision Rates, 2012 to 2016 (Source: TIMS NESS)

Collision Statistic	Actual Value for Intersection	Special Monitoring Threshold	Exceeds Threshold?
Total Rate (Collisions/100MEV)	66.5	69.8	No
Non-animal Rate (Collisions/100MEV)	66.5	69.6	No
5-Year Collision Cost (Million Dollars)	1.101	1.752	No

The spatial distribution of collisions are provided in Figure 3.

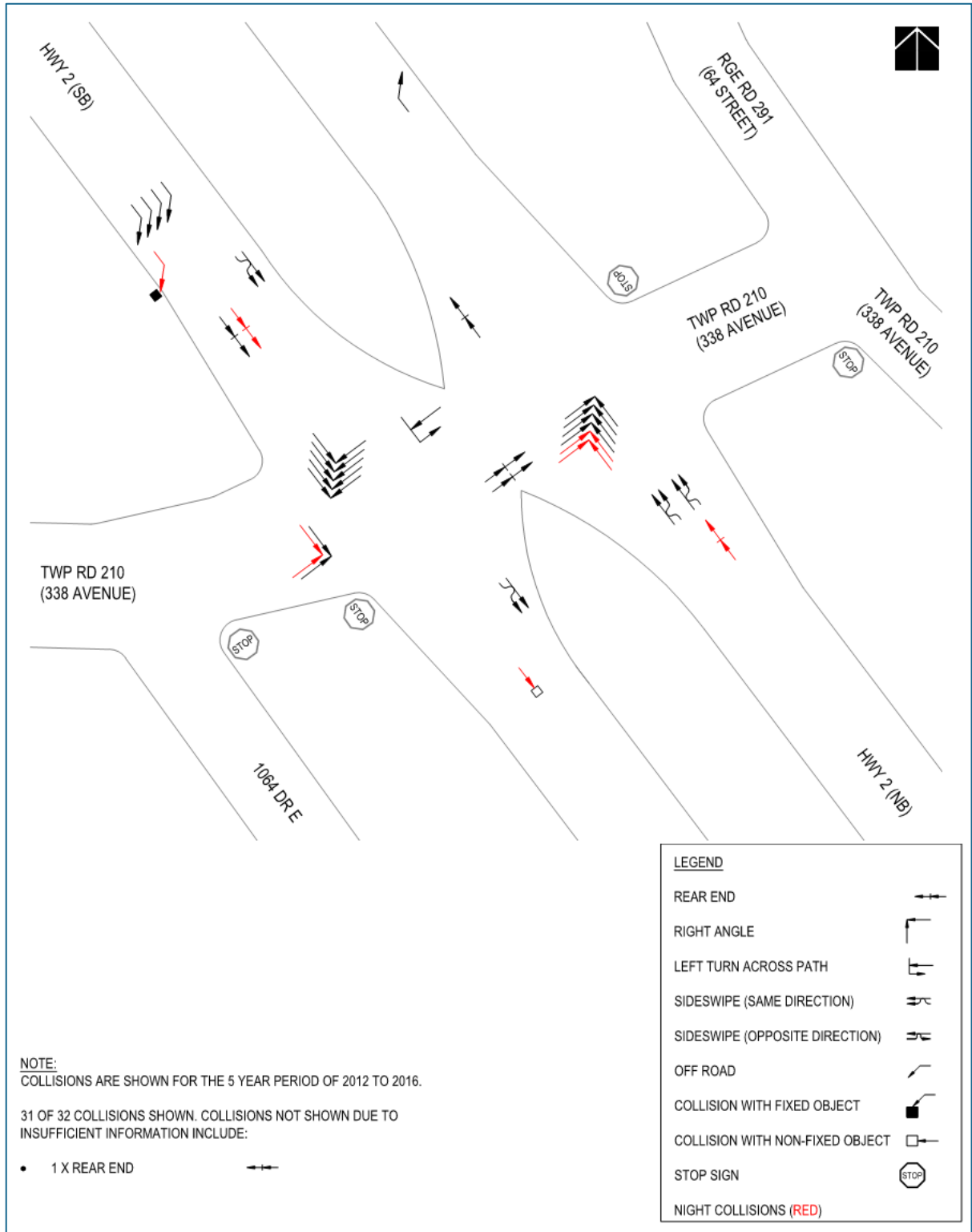


Figure 3: Collision Diagram

3.1 Collision Types and Severity

Figure 4 provides a summary of collisions by type and severity.

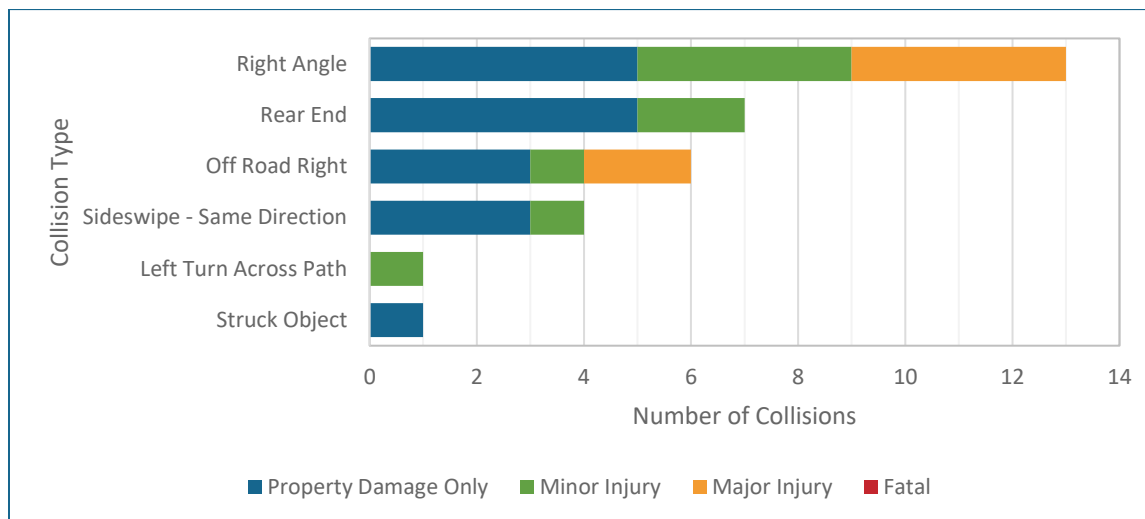


Figure 4: Summary of Collisions by Types and Severity (2012 to 2016)

The following observations are related to the type and severity of collisions at the study intersection:

- The prevalent collision types are “Right Angle” (40.6% of collisions) and “Rear End” (21.9% of collisions).
- Broken down by severity, the intersection experienced six (6) major injury, nine (9) minor injury, and 17 property damage only (PDO) collisions.
- Over half (61.5%) of the “Right Angle” collisions were major or minor injury severity.
- There were no fatal collisions at the intersection.
- There were no animal collisions at the intersection.

3.2 Temporal Collision Patterns

Figure 5, Figure 6 and Figure 7 provide the temporal distributions of collisions by year, month and time of day.

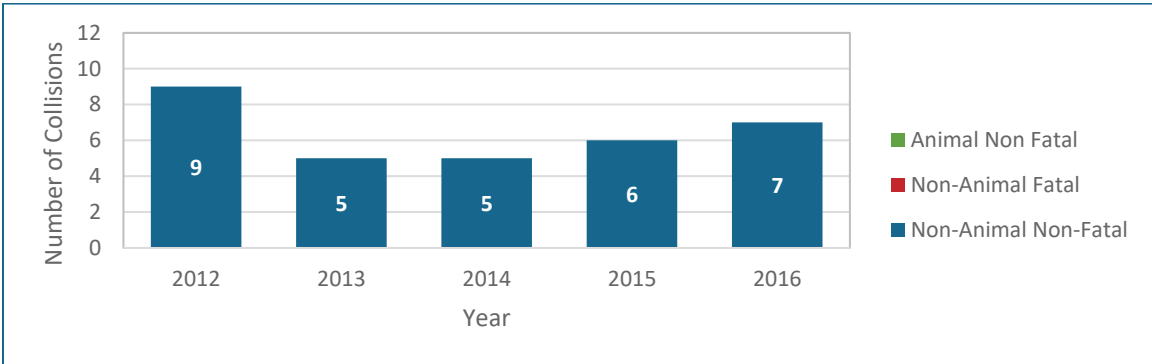


Figure 5: Distribution of Collisions by Year (2012 to 2016)

The distribution of collisions by year reveals the following patterns:

- The annual number of collisions ranged from five (5) to nine (9) collisions per year, with the highest number occurring in 2012.

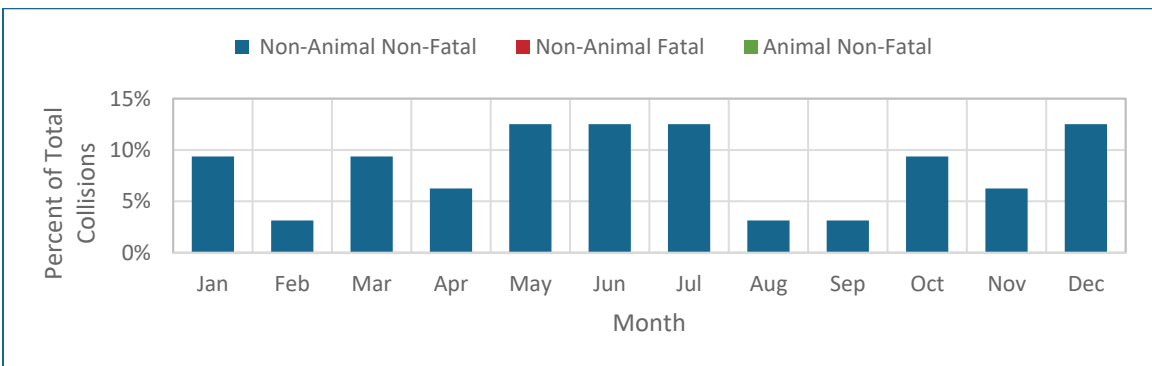


Figure 6: Distribution of Collisions by Month (2012 to 2016)

The distribution of collisions by month reveals the following patterns:

- Collisions occurred in every month of the year.
- The highest number of collisions occurred in May, June, July and December.

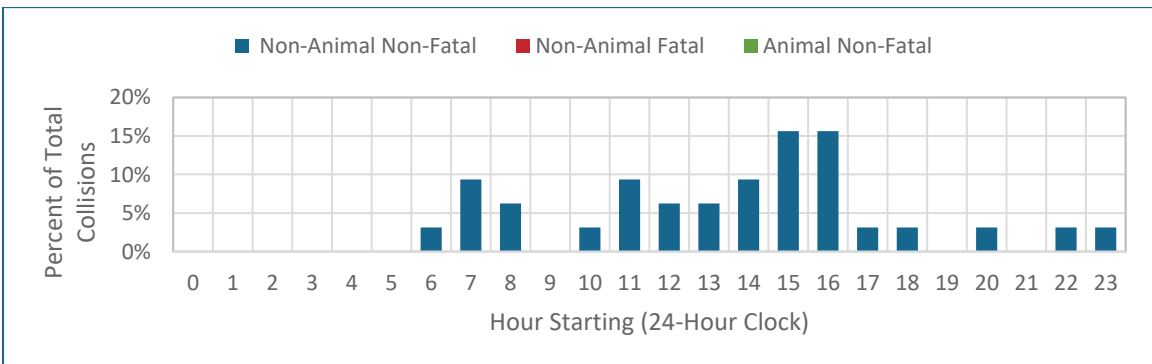


Figure 7: Distribution of Collisions by Time of Day (2012 to 2016)

The distribution of collisions by time of day reveals the following patterns:

- 87.5% of collisions occurred over the 12-hour period of 6 a.m. to 6 p.m.
- The collision distribution has one (1) large peak and two (2) smaller peaks. The large peak is in the period of 2 to 5 p.m. The smaller peaks are in the 7 a.m. hour and 11 a.m. hour.
- Periods with higher collisions correlate to periods with higher minor approach turning movements.

3.3 Environmental, Lighting and Surface Conditions

Table 3 provides a summary of collisions related to lighting, environmental and surface conditions.

Table 3: Lighting, Environmental and Surface Conditions for Collisions (2012 to 2016)

Condition	Non-Animal		Animal		Total	
	Number	Percent	Number	Percent	Number	Percent
Lighting Condition						
Darkness	7	21.9%	0	--	7	21.9%
Daylight	25	78.1%	0	--	25	78.1%
Total	32	100%	0	--	32	100%
Environmental Condition						
Clear	24	75.0%	0	--	24	75.0%
Fog/Smoke/Smog/Dust	1	3.1%	0	--	1	3.1%
Hail/Sleet	1	3.1%	0	--	1	3.1%
Raining	1	3.1%	0	--	1	3.1%
Snow	4	12.5%	0	--	4	12.5%
Unknown/Unspecified	1	3.1%	0	--	1	3.1%
Total	32	100%	0	--	32	100%
Surface Conditions						
Dry	19	59.4%	0	--	19	59.4%
Slush/Snow/Ice	7	21.9%	0	--	7	21.9%
Wet	5	15.6%	0	--	5	15.6%
Unknown/Unspecified	1	3.1%	0	--	1	3.1%
Total	32	100%	0	--	32	100%

Reviewing the lighting, environmental and surface conditions reveals the following patterns:

- The majority of collisions occurred in daylight conditions.
- The majority of collisions occurred in clear conditions.
- The majority of collisions occurred with dry surface conditions, however, slush/snow/ice or wet surface conditions were present for over a third of collisions.

3.4 Collision Characteristics

Collision characteristics include:

- **Right Angle Collision:** Thirteen (13) “Right Angle” collisions (four (4) major injury, four (4) minor injury, and five (5) PDO) involved a vehicle on the minor approach proceeding into the



intersection unsafely and colliding with a Highway 2 vehicle. The following items were noted in the review of “Right Angle” collisions:

- The percent “Right Angle” collisions involving northbound vehicles (54%) is similar to those involving southbound vehicles (46%).
- Eleven (11) collisions involved vehicles departing from the median.
- Two (2) collisions involved vehicles departing a stop-controlled minor approach. Stop sign awareness/compliance was not identified as a factor in either of them.
- Two (2) collisions that were coded as “Right Angle” involved eastbound left turn vehicles, suggesting that the collisions could actually be “Rear End” or “Sideswipe – Same Direction” collisions.
- Five (5) collisions (38%) occurred in the two-hour period of 3:00 p.m. to 5:00 p.m.
- Four (4) collisions occurred with wet surface conditions and one (1) with slush/ice/snow.
- Three (3) of the collisions occurred in darkness.
- One (1) collision identified that an eastbound vehicle attempted to cross southbound and northbound Highway 2 in a single uninterrupted movement.
- Driver error appears to be a factor in many of the “Right Angle” collisions. For example, in one collision, a vehicle crossing Highway 2 collided with the trailer of a southbound vehicle. In another, a vehicle was travelling without headlights/running lights after dark and was not visible to the other vehicle involved in the collision.
- **Rear End Collision:** Seven (7) collisions (two (2) minor injury, and five (5) PDO “Rear End”) involved a vehicle colliding with a preceding vehicle. The following items were noted in the review of “Rear End” collisions:
 - Two (2) collisions occurred between eastbound vehicles in the median opening. Slush/snow/ice surface conditions were present for one of the collisions.
 - One (1) collision occurred after an eastbound left turn vehicle stopped suddenly after entering Highway 2 and was rear-ended.
 - One (1) collision was a multi-vehicle event involving three (3) southbound vehicles. Slush/snow/ice surface conditions were present.
 - One (1) collision occurred on TR210 outside of the intersection and involved a vehicle backing into another during a hailstorm. Before the collision occurred, both vehicles had pulled to the road shoulder seeking protection from nearby trees. This collision had insufficient information to locate it on the collision diagram.
 - One (1) collision involved a vehicle being struck from behind after stopping to help a person on the side of northbound Highway 2. Slush/snow/ice surface conditions were present.
 - One (1) collision involved a vehicle intentionally rear-ending another vehicle.
- **Sideswipe Collisions:** Four (4) collisions (one (1) minor injury and three (3) PDO “Sideswipe Same Direction”) involved a vehicle swiping the side of another vehicle. The following items were noted in the review of “Sideswipe Same Direction” collisions:
 - Two (2) collisions occurred in clear dry conditions.
 - Two (2) collisions occurred in winter months (November and March). Slush/snow/ice surface conditions were present
 - In one (1) collision, a southbound vehicle sideswiped an adjacent southbound vehicle, crossed the median, and then struck a northbound vehicle.

- **Offroad Collisions:** Six (6) collisions (two (2) major injury, one (1) minor injury and three (3) PDO “Off Road Right”) involved a vehicle losing control and leaving the roadway. The following items were noted in the review of “Off Road” collisions:
 - Three (3) collisions occurred due to vehicle mechanical failures. In one, the front right tire blew. In the second, the vehicle, a motorcycle, experienced a wheel wobble. In the third, the welds broke on the rear axles of a flat bed trailer. All three collisions resulted in the vehicle losing control.
 - One (1) collision occurred due to a driver experiencing a medical emergency.
 - One (1) collision occurred due to a vehicle hitting a patch of ice, causing the vehicle to spin out and go into the ditch.
 - One (1) collision indicated that a vehicle pulling a trailer lost control and spun out. Conditions were clear and dry.
- **Struck Object:** One (1) collision (PDO “Struck Object”) occurred when a tire from a transport truck struck the front end of the following vehicle.
- **Left Turn Across Path:** One (1) collision (minor injury “Left Turn Across Path”) involved a westbound vehicle colliding with a southbound left turn vehicle in the median opening.



4.0 Site Visit

ISL completed site visits on Wednesday, July 18, 2018 between the hours of 9 a.m. and 6 p.m. Site visits included

- site drive-through in daylight;
- observations of site conditions; and
- observations of traffic operations.

Weather conditions during the site visit included a partially overcast sky, a moderate amount of wind and a late afternoon thunderstorm. Pavement surfaces were dry for most of the site visit. Site photographs are provided in Appendix C.

4.1 Drive-Through Observations

South Approach (Northbound Travel)

- **Sight Lines and Intersection Awareness:** Northbound drivers ascend a hill and travel a crest curve in advance of the intersection. The intersection is visible south of the intersection and before turn lane tapers are visible. Vehicles stopped on the median and east approaches are visible to approaching highway drivers. An advance Local Road Name sign and Tourist Oriented Directional signage enhance driver recognition of the intersection.
- **Northbound Right Turn:** No issues were identified for this movement.
- **Northbound Through Movement:** No issues were identified for this movement.
- **Northbound Left Turn to Median:** The deceleration lane is relatively short and has limited storage for northbound left turn vehicles.

North Approach (Southbound Travel)

- **Sight Lines and Intersection Awareness:** The north approach is relatively flat in advance of the intersection. The intersection is visible in advance of the turn lane tapers. Vehicles stopped on the median and west approaches are visible to approaching highway drivers. An advance Local Road Name sign and Tourist Oriented Directional signage enhance driver recognition of the intersection.
- **Southbound Right Turn:** The shoulder width for the southbound right turn lane is narrow.
- **Southbound Through Movement:** No issues were identified for this movement.
- **Southbound Left Turn to Median:** The deceleration lane is relatively short and has limited storage for southbound left turn vehicles.

West Approach (Eastbound Travel)

- **Sight Lines and Intersection Awareness:** Eastbound drivers travel a reverse curve in advance of the intersection. Sight lines are satisfactory and the intersection is visible well in advance. Junction, Divided Highway, and Route Marker signage provide advance warning of the intersection. Transverse rumble strips, Stop Ahead sign, STOP AHEAD word marking, and an oversize Stop sign with a flashing red light provide advance warning of the stop condition.
- **Eastbound Right Turn:** No issues were identified for this movement.

- **Eastbound Crossing to Median:**

- It can be challenging to find a sufficient gap to cross the four (4) southbound lanes (i.e., two (2) through lanes, a right turn lane and left turn lane).
- Visibility of southbound vehicles can be obstructed by vehicles in the right turn deceleration lane.

East Approach (Westbound Travel)

- **Sight Lines and Intersection Awareness:** Sight lines approaching the intersection from the east are satisfactory. Drivers on the east approach are aware of the Highway 2 intersection, as the TR210/RR291 intersection is located only 74 m to the east. South and east of the TR210/RR291 intersection, a Divided Highway sign provides TR210 drivers with advance warning of the intersection. An oversized Stop sign with a flashing red light provide advance warning of the stop condition at Highway 2.
- **Westbound Right Turn:** No issues were identified for this movement.
- **Westbound Crossing to Median:**
 - It can be challenging to find a sufficient gap to cross the five (5) northbound lanes (i.e., three (3) through lanes, a right turn lane and left turn lane).
 - Visibility of northbound vehicles can be obstructed by vehicles in the right turn deceleration lane.
- **Road Ban:** At the time of the site visit, a 90% road ban was in effect for TR210 and a 75% road ban was in effect for RR291.

Highway 2 Median Opening (Eastbound Travel)

- There are no markings or signs to guide drivers through the median opening.
- It can be challenging to find a sufficient gap to cross the five (5) northbound lanes (i.e., three (3) through lanes, a right turn lane and left turn lane).
- Visibility of northbound vehicles can be obstructed by vehicles in the left turn deceleration lane. This sight line issue is exacerbated when vehicles in the left turn deceleration lane queue before entering the median opening or are trucks.
- When left turn and through vehicles are queued side-by-side in the median opening, there is potential for visibility of northbound vehicles on the highway to be obstructed by the eastbound through vehicle.
- There is no left turn acceleration lane. Safe entry into the highway requires selection of a gap sufficiently large to accelerate before being overtaken by through highway traffic.

Highway 2 Median Opening (Westbound Travel)

- There are no markings or signs to guide drivers through the median opening.
- Visibility of southbound vehicles can be obstructed by vehicles in the left turn deceleration lane. This sight line issue is exacerbated when vehicles in the left turn deceleration lane queue before entering the median opening or are trucks.
 - When left turn and through vehicles are queued side-by-side in the median opening, there is potential for visibility of southbound vehicles on the highway to be obstructed by the westbound through vehicle.



- There is no left turn acceleration lane. Safe entry into the highway requires selection of a gap sufficiently large to accelerate before being overtaken by through highway traffic.

4.2 Traffic Control Devices

Figure 8 identifies the existing signage and pavement markings observed at the intersection during the site visit. The following comments relate to site visit observations at the intersection:

General

- Some of the wood sign posts located within the clear zone did not have holes drilled into the post to complete the breakaway feature.
- Rural Address signs (i.e. Street Name signs) were located in the northwest and southeast quadrants of the intersection and were in good condition.

South Approach (Northbound Travel)

- The Wrong Way sign on the median side of the northbound lanes was bent. The sign was still legible.
- The One Way sign on the median side of the northbound lanes was knocked over.
- The One Way sign on the outside edge of the northbound lanes was bent. The sign was still legible.
- Pavement markings for the northbound lanes of Highway 2 were in good condition.
- Centreline and shoulder rumble strips terminated in advance of the tapers and were in good condition.

North Approach (Southbound Travel)

- Pavement markings for the southbound lanes of Highway 2 were in good condition.
- In the southbound right turn lane, portions of the edge line were worn away.
- The southbound right turn deceleration lane had three (3) right turn arrows. Two (2) of the arrows were recently refreshed and the other was faded. Drawing TCS-C-510.2 of the “Highway Pavement Marking Guide” indicates that there should be two (2) right turn arrows spaced 100 m apart. The faded right turn arrow is not likely to cause driver confusion.
- A delineator guide post by the southbound left turn lane was knocked out of the ground.
- A delineator guide post by the southbound right turn radius was bent over / flattened.
- Centreline and shoulder rumble strips terminated in advance of the tapers and were in good condition.

West Approach (Eastbound Travel)

- The eastbound Stop sign was oversize (1,200 mm by 1,200 mm) and supplemented with a flashing red light. The Stop sign was installed on a double-wide wood post that appeared to have been installed recently.
- The stop line and Stop word marking were in acceptable condition.
- The edge line along the eastbound right turn radius was worn.
- The STOP AHEAD word marking was in excellent condition.

- The Divided Highway sign had minor damage (scratches). The sign was still legible.
- The Junction sign had moderate damage (bent Highway 2 route marker, scratches, fading symbols). The sign was still legible.
- The Maximum 80 km/h Speed sign had minor damage (fading, delamination). The sign was still legible.
- Three (3) signs (Checkerboard Right, Reverse Curve, Bidirectional Checkerboard) were installed in the ditch on short posts and the bottom of each sign was just above the road surface.
- The transverse rumble strips in advance of the Stop sign were worn in the wheel paths.
- Neither centreline nor shoulder rumble strips were identified for this approach.

East Approach (Westbound Travel)

- The westbound Stop sign was oversize (1,200 mm by 1,200 mm) and supplemented with a flashing red light. The Stop sign was installed on a double-wide wood post that appeared to have been installed recently.
- The stop line and Stop word marking were in good condition.
- The edge line along the westbound right turn radius was worn.
- Rumble strips were not identified for this approach.

1064 Drive E

- The regular size Stop sign (600 mm x 600 mm) was bent and had minor damage (scratches) to the sign face. The sign was still legible.
- The Stop Ahead sign was damaged (faded symbols). The stop symbol was severely faded.



4.3 Illumination

The study intersection was not currently illuminated.

4.4 General Observations

- **Median Opening Operations:**
 - During the peak hour, there are few gaps available to cross Highway 2. With limited gaps available, vehicles queue in the median opening and on the stop-controlled approaches and may wait a significant amount of time for an acceptable gap.
 - Even when there is a sufficient gap, a left turn or through vehicle on a stop-controlled approach may not be able to cross to enter the median opening because of the number of vehicles already in the median and the limited space available for storage of additional vehicles.
 - The median opening experienced significant congestion during the PM peak hour. Vehicles entering the median opening were observed queueing side-by-side or pulling in at an angle behind a vehicle stopped in the median to fit in the available space. Up to three (3) passenger vehicles were observed stacking in the median opening when entering vehicles pulled in at an angle behind other stacked vehicles.
 - Due to the volume of conflicting movements in the median opening, highway left turn vehicles stop in the left turn deceleration lane and wait for conflicting vehicles to clear before entering the median opening.
- **Left Turn Vehicle Behavior:** Left turn vehicles were observed entering and travelling through the median opening along different paths. When left turn vehicles from opposite directions entered the median opening together, they were observed turning in front of one another (simultaneous left turns) or behind each other (i.e., interlocking left turns) as illustrated in Figure 9.
 - Simultaneous left turns may conflict with traffic from the minor approach entering the median opening.
 - Interlocking left turns may result in left turn queues blocking the completion of through or left turn movements from the median opening.
- **Queue Lengths:** Vehicle queues observed at the intersection were as high as:
 - Nine (9) eastbound vehicles, including one (1) truck towing a trailer, on the stop-controlled west approach.
 - Four (4) northbound vehicles, including three (3) trucks towing trailers, in the northbound left turn deceleration lane.
 - Three (3) southbound vehicles in the Highway 2 southbound left turn deceleration lane.
- **Truck Volumes High During Site Visit:** On the day of the site visit, a significant number of trucks, including numerous dump trucks towing pup trailers, were observed completing the northbound left turn and eastbound right turn movements. The traffic count data indicates that there would be less trucks completing these movements than what was observed, suggesting that the observed truck volumes, or the original traffic count, may not be representative of normal traffic conditions.

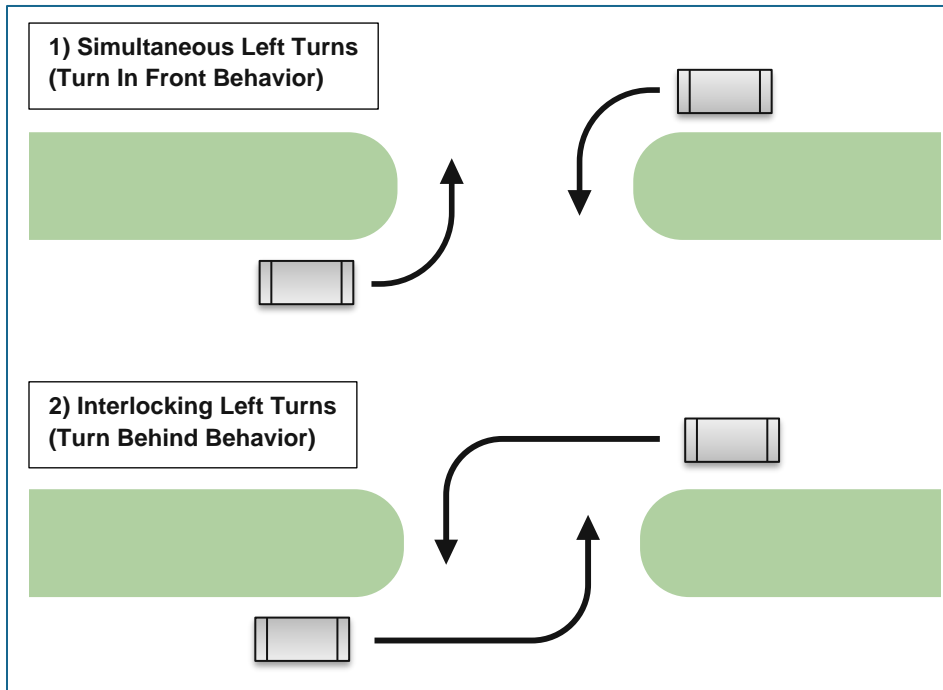


Figure 9: Opposing Left Turn Behavior (Source: Adapted from NCHRP Report 650)

- **Southbound Right Turn Deceleration Lane:** It appears that the length of the southbound right turn lane was recently extended using the existing paved shoulder. As no pavement widening occurred, the deceleration lane shoulder is narrow (less than 0.3 m).
- **Pavement Condition:**
 - Pavement deterioration is evident on the south edge of the west approach and the adjacent area appears to be heavily travelled. At this location, the edge of lane coincides with the edge of asphalt.
 - Tire tracks and pavement deterioration were observed along the south edge of the median opening west of the bullet nose.
- **Memorial Marker:** A memorial marker for a 2011 fatal collision is located on the northeast corner of the intersection, just north of the Stop sign.



5.0 Operational Analysis

5.1 Traffic Operations

The Highway Capacity Manual (HCM) provides a methodology for assessing intersection traffic operations. The quality of intersection traffic operations are commonly reported in terms of level of service (LOS) and intersection capacity.

The LOS is based on average total delay per vehicle, and ranges from LOS of 'A' (free flow) to LOS of 'F' (very congested). For rural areas, a LOS of 'C' is generally considered as an acceptable standard for operations, and a LOS of 'D' may be accepted when limited to low-volume movements. When intersection operations are below the accepted standard, intersection improvements may be required. LOS criteria for unsignalized intersections are shown in Table 4.

Table 4: LOS Criteria for Unsignalized Intersections

Level of Service (LOS)	Control Delay per Vehicle (sec)
A	≤ 10.0
B	> 10.0 and ≤ 15.0
C	> 15.0 and ≤ 25.0
D	> 25.0 and ≤ 35.0
E	> 35.0 and ≤ 50.0
F	> 50.0

The capacity of a controlled intersection approach is based on the distribution of gaps in the major road traffic flow; driver judgement in selecting a gap through which to execute the desired maneuver; and the follow-up time required by each driver in a queue. The volume-to-capacity (V/C) ratio is a ratio of the traffic flow for a given lane group to the capacity. A V/C ratio of 1.0 indicates that the flow rate equals the capacity. A V/C ratio of 0.85 or less for all intersection movements is a generally accepted standard for peak hour operations. The HCM 2010 indicates that any traffic movement with a V/C ratio of 1.0 or greater is considered to have a LOS of 'F' regardless of delay.

Characteristics for the study intersection were coded into Trafficware Synchro 9 software with the following adjustments and parameters:

- All turning movement volumes lower than 10 vehicles were increased to 10 vehicles.
- The percent heavy vehicles for each turning movement were based on AADT values. Percentages less than 2% were increased to 2%.
- Calculated peak hour factor (PHF) values from the raw traffic count data were used.

The HCM 2010 two-way stop control (TWSC) procedure utilized by Synchro is incapable of analyzing this intersection due to the magnitude of the traffic volumes and the number of lanes. The procedure uses a gap-acceptance model that considers the size and distribution (availability) of gaps on the major road, the usefulness of gaps to drivers on the minor approaches, and the relative priority of the various movements at the intersection. Stop-controlled movements are

assigned a lower priority than movements from the major road. When the volume of major road movements are high, there is minimal opportunity for the stop-controlled movements to accept gaps resulting in the stop-controlled movements having little or no capacity. Based on the 100th highest hour traffic volumes, an insufficient number of gaps are available to accommodate the volume of stop-controlled movements and therefore, the Synchro HCM 2010 analysis does not provide results for crossing or turning movements from the stop-controlled approaches.

5.2 Traffic Control Devices

Stop Sign and Stop Line Placement

The current usage and placement of Stop signs, stop lines, and Stop Line signs were reviewed and compared against the AT guidelines. Table 5 provides a summary of the review.

Table 5: Stop Sign, Stop Line, and Stop Line Sign Review

Item	Alberta Transportation Guideline	West Approach	East Approach
Stop Sign Placement <i>(from edge of intersecting road)</i>	2.0 m Min. (<i>Design Bulletin #82/2014</i>) 15.0 m Max. (<i>Design Bulletin #82/2014</i>) ≤ 5.0 m Preferred. (<i>2012 Recommended Practice</i>)	~5.6 m	~11.0 m
Stop Line Placement	4.7 m or 4.9 m from nearest lane line <i>(Design Bulletin #56/2007)</i> or 1.2 m to 10 m from edge of intersecting roadway. (<i>2013 Recommended Practice</i>)	~11.2 m from nearest lane line	~4.7 m from nearest lane line
Stop Line Sign	Consider when Stop sign is ≥ 15 m from stop line.	Not Present, Not Warranted	Not Present, Not Warranted

The existing placement of Stop signs and stop lines meet AT guidelines. It is noted that the eastbound stop line is perpendicular to the TR210 centreline and therefore the separation from the stop line to the nearest Highway 2 lane line increases at the south end of the stop line; in contrast, the stop line for the east approach is installed parallel to Highway 2. The larger setback for the west stop line may impact sightlines for drivers relative to southbound vehicles and create potential for southbound right turn vehicles to block sightlines to the southbound through lanes..

Spacing and Placement of Other Signs

The spacing and placement of other signs were reviewed against the following AT guidelines:

- Recommended Practices for Traffic Controls
- Typical Signage Drawings
- Highway Guide and Information Sign Manual
- “Design Bulletin #82/2014”, Longitudinal Sign Placement at Highway Intersections

**South Approach:**

- The One Way and Do Not Enter signage are located at approximately 12 m and 31 m from the intersection. Drawing TCS-A4-430G indicates they should be 7 m and 27 m from the intersection. Consideration should be given to adjusting the location of the One Way signs as the current sign placement may impact their effectiveness. Sign adjustment should be considered with the next overlay or sign maintenance activity.
- The Wrong Way signs are correctly located at approximately 75 m from the intersection.

North Approach:

- The One Way and Do Not Enter signage are located at approximately 21 m and 40 m from the intersection. Drawing TCS-A4-430G indicates they should be 7 m and 27 m from the intersection. Consideration should be given to adjusting the location of both the One way and Do Not Enter signs as the current sign placement may impact their effectiveness. Sign adjustment should be considered with the next overlay or sign maintenance activity.
- The Wrong Way signs are correctly located at approximately 75 m from the intersection.

West Approach:

- The Route Marker Cluster is 60 m west of the intersecting road. Drawing TCS-A4-430B indicates it should be 80 m from the intersecting road. (*TCS-A4-430B is used for the west approach as the speed through the reverse curve in advance of the intersection is expected to be 70 km/h or lower*)
- The Stop Ahead sign is 120 m west of the intersecting road. Drawing TCS-A4-430B does not include a Stop Ahead sign, and TCS-A4-430C, for speeds greater than 70 km/h, indicates it should be 250 m from the intersecting road. TAC guidelines indicate warning signs should be located a minimum of 50 m and a maximum of 150 m in advance of the corresponding condition. Based on the expected reduced speed through the reverse curve, the current location of the Stop Ahead sign is considered to be suitable.
- The Junction sign and Rumble Strips signs are located at 298 m, and 512 m, respectively, west of Highway 2. Drawing TCS-A4-430C indicates that the signs should be in the reverse order and spaced at 450 m and 400 m, respectively.
- Sign adjustment should be considered with the next overlay or sign maintenance activity. Any adjustments to sign locations should consider that a minimum of 50 m should be provided between signs.

East Approach:

- A Divided Highway sign is provided on westbound TR210, however, a Divided Highway sign is not provided on southbound RR291. Providing a Divided Highway sign on southbound RR291 in advance of the TR210/RR291 intersection should be considered.

1064th Drive E:

- The Bidirectional Checkerboard sign at TR210 is offset left-of-centre for approaching drivers and lower than typical due to placement in the ditch. 1064th Drive E is a low volume roadway and the sign is visible in the current location. If this sign is included in a future maintenance activity, it should be repositioned eastward and installed on a taller post.

Additional Traffic Controls for Stop-Controlled Approaches

AT specifies a four-level system of traffic control devices that can be implemented as safety measures to improve intersection recognition and stop sign compliance at rural stop-controlled approaches (“2011 Recommended Practice, Safety Measures at Rural Stop-Controlled

Intersections”). The warrant is sequential and requires that a preceding level of the warrant is met before considering the next level.

From 2012 to 2016, two (2) collisions involved vehicles departing a stop-controlled approach and neither indicated that the vehicle on the minor approach failed to stop. For the purposes of this analysis, none of the collisions are considered Stop sign violations. The warrant results are shown in Table 6.

For both approaches, existing traffic control devices exceed what is identified by the warrant. All of the traffic control devices identified in the warrant are already in place on the west approach, and all except the Stop Ahead sign and STOP AHEAD word marking are in place on the east approach.

Advance Intersection Signage and Road Name Signs

The following AT guidelines describe the use of Rural Address signs (i.e., road name signs for rural roadways) and advance road name signs.

- “2003 Recommended Practice for Rural Address Signs”
- “2008 Recommended Practice for Local Road Name Signs”

Rural Address signs assist emergency personnel and motorists in wayfinding by providing them with a reference to the grid road system. Typical rural address signs are shown in Figure 10.



Figure 10: Typical Rural Address Signs

Although Rural Address signs provide a means for motorists to positively identify an intersection, they may not be suitable to make wayfinding decisions in advance of the intersection due to their small size and placement at the intersection. Advance Township/Range Road signs or Local Road Name signs assist motorists to make appropriate wayfinding decisions in advance of the intersection, and may be placed in addition to, or in lieu of, the Rural Address sign. These signs are beneficial at night where an intersection may be challenging to recognize and identify. A typical Advance Township/Range Road sign is shown in Figure 11.



Figure 11: Typical Advance Township/Range Road Sign

It is noted that the MD of Foothills uses a street/avenue grid that aligns with the City of Calgary’s grid, and therefore, rural address signage provides the name of the street/avenue rather than the township/range road.



Table 6: Warrants for Additional Traffic Control Devices at Stop-Controlled Intersections

	Traffic Control Device	Warrant	Approach	
			West	East
1	Oversize Stop Sign (900 mm)	<u>One</u> of the following conditions present:		
		1. Major intersection on two-lane or four-lane highway.	✓	✓
		2. ≥ three (3) collisions involving Stop sign violations over five (5) year period.		
		3. Low visibility/sight line restrictions on stop-controlled approach.		
		4. Complex visual environment.		
		5. Complex and frequent turning maneuvers.		
		Warrant Met	Yes	Yes
	Oversize Stop Sign (1200 mm or 1500 mm)	<u>Both</u> of the following conditions present:		
		1. ≥ three (3) collisions involving Stop sign violations over five (5) year period.		
		2. Other measures (e.g. improving sight lines, 900 mm Stop sign) proven ineffective.	?	?
Warrant Met		No	No	
2	Stop Ahead Sign	<u>One</u> of the following conditions present:		
		1. Low visibility/sight line restrictions on stop-controlled approach.		
		2. Rapid change in roadway alignment.	✓	
		3. Complex visual environment.		
		4. Existing oversize stop sign has proven ineffective.	?	?
		Warrant Met	Yes	No
3	STOP Word Marking	<u>All</u> of the following conditions met:		
		1. ≥ three (3) collisions involving Stop sign violations over five (5) year period.		
		2. Approaching roadway posted at ≥ 80 km/h.	✓	*
		3. Approach traffic volume > 500 vehicles per day.	✓	*
		4. Other measures ineffective in preventing failing-to-stop collisions.	?	?
	Warrant Met	No	No	
	STOP AHEAD Word Marking	<u>All</u> of the following conditions met:		
		1. STOP word marking present/warranted.	*	*
		2. Stop Ahead sign present/warranted.	*	
	Warrant Met	*	No	
4	Flashing Red Light	<u>All</u> of the following conditions met:		
		1. ≥ three (3) collisions involving Stop sign violations over five (5) year period.		
		2. Approaching roadway posted at ≥ 80 km/h.	*	*
		3. Approach traffic volume > 500 vehicles per day.	*	*
		4. Other measures ineffective in preventing failing-to-stop collisions.	?	?
Warrant Met	No	No		

* indicates that a condition is met but not considered due to the sequential nature of the warrant.

? indicates insufficient information available to determine whether condition is met or not.

At the study intersection, there are advance Local Road Name signs on both the northbound and southbound approaches. Rural Address signs (i.e., road name sign) are in the northwest and southeast quadrants of the intersection.

5.3 Traffic Signal Warrant

Traffic signal warrant analysis was undertaken by applying the warrant procedure described in the TAC “Traffic Signal Warrant Handbook”, which uses a point system to determine the need for signalization. In this warrant system, a cumulative score of 100 points is considered the minimum value required to warrant a traffic signal.

Typically, the hourly volumes for the peak six (6) hours of the day are totaled and averaged for use in the traffic signal warrant. For the study intersection, design hour volumes (i.e., 100th highest hour) were available for AM and PM peak periods and therefore, a factor was developed from the raw traffic count to create an estimate of the total six-hour peak based on the AM and PM 100th highest hours. The factor was developed by summing the three (3) highest AM hourly volumes and the three (3) highest PM hourly volumes, and then dividing by the sum of the highest AM and the highest PM hour. The resulting factor is 2.78. The sum of the AM and PM 100th highest hours was adjusted with this factor to provide the six hour total for the traffic signal warrant.

A traffic signal is warranted based on the results of the warrant (187 points). The completed warrant sheet is provided in Appendix E.



6.0 Geometric Analysis

6.1 Roadway Alignment

Roadway characteristics, including traffic volumes and flow characteristics, speed limits, vehicle mix and adjacent land uses, indicate that Highway 2 functions as a rural divided freeway / expressway, and that TR210 functions as a rural collector roadway to the west of Highway 2 and as a rural local roadway east of Highway 2. Design designations for the roadways appear to be:

- **Highway 2:** RFD-516.6/12.4-130
- **TR210 to the West of Highway 2:** RCU-209.4-90
- **TR210 to the East of Highway 2:** RLU-210-90
- **RR291:** RLU-208-90
- **1064th Drive E:** RLU-209-90

Roadway alignment elements were reviewed against design standards provided in Table A-10-1a of the HGDG. Highway 2 geometric characteristics were obtained from AT Maps.

Highway 2 Northbound Lanes

The northbound lanes of Highway 2 are tangent through the study area with no horizontal curvature. No geometric issues were identified for the horizontal alignment.

In the direction of travel (south to north), the vertical profile includes:

- Crest curve (km 20.887 to 21.170, K value of 77). With this K value, the curve is sufficient for a 110 km/h design speed, but not for a 120 km/h or 130 km/h design speed. Although the curve is substandard for a 130 km/h design speed, intersection sight distances are met (see Section 6.4).
- Uphill tangent (km 21.170 to 21.588; 0.6% grade) through the intersection (km 21.448).
- Crest curve (km 21.588 to 21.683; K value of 158).
- Flat tangent (km 21.683 to 21.749; 0.0% grade).
- Sag curve (km 21.749 to 22.099; K value of 144).

As the through road, Highway 2 has a grade line that carries through the intersection unaffected by the intersecting roads.

Highway 2 Southbound Lanes

The southbound lanes of Highway 2 are tangent through the study area with no horizontal curvature. No geometric issues were identified for the horizontal alignment.

In the direction of travel (north to south), the vertical profile includes:

- Sag curve (km 22.052 to 21.834; K value of 116).
- Downhill tangent (km 21.834 to 21.295; -0.4% grade) through the intersection (km 21.448).
- Crest curve (km 21.295 to 20.933; K value of 133).

As the through road, Highway 2 has a grade line that carries through the intersection unaffected by the intersecting roads. No geometric issues were identified for the southbound vertical alignment.

West Approach (TR210)

Alignment elements for the west approach are:

- The horizontal alignment approaching the intersection consists of two (2) curves that are used to align RR210 with the intersection followed by a tangent approximately 30 m in length.
 - The radius of the first curve on approach to the intersection is approximately 150 m. Based on minimum radius formula provided in the HGDG and a maximum superelevation of 0.06 m/m, the maximum safe travel speed around the curve would be 63 km/h, which is less than the 80 km/h speed limit. If the superelevation is less than 0.06 m/m, the safe speed would be less than 63 km/h.
 - The first curve and second curve are separated by a tangent of approximately 30 m.
 - The radius of the second curve on approach to the intersection is approximately 100 m. Based on minimum radius formula provided in the HGDG, and a maximum superelevation of 0.06 m/m, the maximum safe travel speed around the curve would be 53 km/h, which is less than the 80 km/h speed limit. If the superelevation is less than 0.06 m/m, the safe speed would be less than 53 km/h.
 - Based on the “2003 Recommended Practice for Reverse Turn and Reverse Curve Signs”, the MUTCDC, and the minimum radius analysis provided above, a Reverse Turn sign with an Advisory Speed tab is suggested to be installed in advance of the first curve.
- The vertical alignment is relatively flat.

East Approach (TR210)

Alignment elements for the east approach from Highway 2 to RR291 are:

- The horizontal alignment is straight.
- The vertical alignment is relatively flat.
- The alignment of the east approach appears to meet applicable design standards.

Alignment elements for TR210 south and east of the TR210 / RR291 intersection are:

- There is a horizontal curve approximately 90 m south and east of the TR210/RR291 intersection.
- The vertical alignment is relatively flat with a slight downhill grade on approach to the TR210/RR291 intersection.
- Based on visual observations, the alignment appears suitable for its current function.

Range Road 291

Alignment elements for RR291 are:

- There is a horizontal curve approximately 70 m north of the TR210/RR291 intersection.
- The vertical alignment is relatively flat.
- Based on visual observations, the alignment appears suitable for its current function.



1064th Drive E

Alignment elements for 1064th Drive E are:

- The horizontal alignment is straight.
- The vertical alignment is relatively flat.
- Based on visual observations, the alignment appears suitable for its current function.

6.2 Cross Section Elements

Highway 2 Northbound Lanes

The typical cross section for northbound Highway 2 is approximately 16.6 m consisting of a 2.5 m inner shoulder, three (3) 3.7 m travel lanes and a 3.0 m outer shoulder. Northbound Highway 2 is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes are relatively flat and appear to be appropriate for the roadway classification.

Median Width

The typical median width, shoulder line to shoulder line between northbound and southbound Highway 2, is approximately 32.0 m.

Highway 2 Southbound Lanes

The typical cross section for northbound Highway 2 is approximately 12.4 m consisting of a 2.0 m inner shoulder, two (2) 3.7 m travel lanes and a 3.0 m outer shoulder. Northbound Highway 2 is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes are relatively flat and appear to be appropriate for the roadway classification.

West Approach (TR210)

TR210 has a typical cross section of approximately 9.4 m consisting of a 3.7 m travel lane and 1.0 m shoulder in each direction. Figure A-7-1b of the HGDG suggests that an 11.0 m cross section would be more appropriate for the current AADT. The roadway is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

East Approach (TR210)

TR210 has a typical cross section of approximately 10.0 m consisting of a 5.0 m travel lane in each direction until the TR210/RR291 intersection. The paved roadway width for TR210 appears to be appropriate for current traffic volumes.

South and east of the TR210/RR291 intersection, TR210 has a typical cross section of approximately 8.6 m consisting of a 4.3 m travel lane in each direction.

TR210 is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

Range Road 291

RR291 has a typical cross section of approximately 8.0 m consisting of a 4.0 m travel lane in each direction. The roadway is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

1064th Drive E

Near TR204, 1064th Drive E has a typical cross section of approximately 9.0 m consisting of a 4.5 m travel lane in each direction. Approximately 80 m south of TR210, 1064th Drive E narrows down to an approximate cross section of 7.0 m. The roadway is crowned and appears to have adequate cross slope to shed water away from the road surface. Side slopes appear to be appropriate for the roadway classification.

6.3 Intersection Elements

Existing Lane Configuration

Deceleration lanes and/or tapers are provided for left and right turn movements from Highway 2. Acceleration tapers are provided for the eastbound and westbound right turn movements. Through and left turn movements from the minor approaches must complete a two-stage maneuver to cross or enter the highway.

Angle of Intersection

The intersection angle for this location is approximately 77° and the intersection forms a left hand forward (LFH) intersection. As per Section D.3.2 of the HGDG, the minimum allowable intersection angle is 70° and the minimum desirable intersection angle is 80°. The intersection angle meets AT guidelines and realignment is not required.

Median Opening

A bullet nose median opening is used at the intersection, which is consistent with Section D.8.5 of the HGDG that indicates bullet nose median openings should be used on all openings where conditions for a semi-circular or flat nose median opening are not met. This type of median opening permits simultaneous left turn movements for trucks from each direction on the highway, as well as turns from the minor approaches.

As a record drawing was not available, the geometric parameters for this median opening were approximated from an airphoto of the intersection:

- 75.0 m radius for turnout curve at the median edge (R1).
- 5.8 m radius at the tip of the bullet nose (R2).
- 22.0 m median opening width (L).
- 49.8 m offset from centre of intersection to the start of R1 (b).
- 28.7 m median width from edge of northbound left turn lane to edge of the nearest southbound through lane (M).

The geometric parameters suggest that the control radius at the sharpest portion of turn (R_c) is approximately 25 m, which is suitable for the maximum turning template of the WB-23 (25 m long Super B-Train) design vehicle and all shorter truck-trailer combinations.



The median design appears to meet AT guidelines, however, a bullet-nose median opening presents unique challenges as described below.

- There are no markings or signs to guide drivers through the median.
- The Alberta “Use of Highway and Rules of the Road Regulation” and “Driver’s Guide to Operation, Safety and Licensing, Cars and Light Trucks” do not provide clear guidance on left turns through a median opening on a divided highway. This potentially leads to driver confusion as to what path they should take through the median opening.
- Considering a left turn from a divided highway to be a movement from a one-way road onto a two-way road, the driver is legally required to enter the two-way road on the right side of the centreline. The geometric layout of a bullet-nose median opening encourages left turn vehicles to make simultaneous left turns (turn-in-front behavior) and enter the median opening on the left side of centre.
- When a highway left turn vehicle enters the median opening at the same time as an opposing through or left turn vehicle from the minor approach, it is expected that the highway left turn vehicle has the right of way as the minor approach vehicle movement is controlled by a Stop sign. Vehicles departing the stop-controlled approach to enter the median opening, however, are considering the provision of a suitable gap in the adjacent highway lanes to complete a safe, staged crossing and are not typically checking for the presence of highway left turn vehicles on the far side of the median before crossing to the median. The highway left turn vehicle, if not directed by a traffic control device (pavement marking) to the right side of the median centreline, may potentially utilize the same space in the median as the vehicle entering from the minor approach.
- The potential for driver confusion in the median opening increases with higher traffic volumes because there is a greater probability of conflicting movements occurring at the same time and there are more things requiring the driver’s attention.

The collision information identified one (1) collision (minor injury “Left Turn Across Path”) in the median between a vehicle turning left from the highway and a vehicle entering the median from a minor approach and supports the observation that there is potential for confusion in the median opening.

Left Turn Lane Warrant

The left turn warrant considers the operational and safety impacts of left turning vehicles on the highway. The interference caused by a standing left turn vehicle can reduce capacity and create a safety hazard. The left turn lane warrant analysis was completed using the methodology described in Section D.8.6 of the HGDG. Table 7 provides results of the left turn warrants and the worksheets are included in Appendix E.

A left turn treatment with 15 m of storage is warranted for the northbound direction. A left turn treatment with 30 m of storage is warranted for the southbound direction.

Table 7: Warrant for Exclusive (Parallel) Left Turn Lane

Period	Volumes			HGDC Chart	Warrant Met?	Storage	
	V _L	V _O	T			S (m)	S _T (m)
Northbound							
AM	12	1,280	0%	Figure D-8.6C	Yes	15	0
PM	11	1,503	0%	Figure D-8.6C	Yes	15	0
Southbound							
AM	67	1,516	0%	Figure D-8.6C	Yes	30*	N/A
PM	20	1,272	0%	Figure D-8.6C	No	N/A	N/A

V_L = Volume Left Turns; V_O = Volume Opposing; T = Percent Trucks in V_L; S = Storage; S_T = Storage for Trucks (HGDC Table D.7.6a)
 * The opposing volume for the southbound left turn movement was adjusted as there are three (3) opposing through lanes and HGDC Figure D-8.6c is based on a left turn with only two (2) opposing through lanes. The adjusted opposing volume only considers volumes from the two (2) right-most opposing through lanes plus the opposing left and right turns. A 40 / 35 / 25 split (right to left) was assumed for lane utilization for the northbound through lanes. Further evaluation may be required to confirm southbound left turn storage requirements.

Right Turn Lane Warrant

To warrant an exclusive right turn lane on a divided highway facility, the right turn volume must be greater than 360 vehicles per day. Results of the left turn lane warrant are provided in Table 8.

Table 8: Warrant for Exclusive (Parallel) Right Turn Lane

Direction	Volumes		Warrant Met?
	Daily Right Turn	Threshold	
Northbound	100	≥ 360	No
Southbound	740	≥ 360	Yes

An exclusive right turn treatment is warranted for the southbound direction.

Median Acceleration Lane Warrant

AT recently released Design Bulletin #100/2019 Median Acceleration Lane Design Guidelines which identify installation conditions (warrants). Median acceleration lanes (MALs) may be considered where the first two conditions plus any of the last three conditions exist:

1. There is left turning traffic from the minor road merging with high-speed divided highway through traffic.
2. There are limited gaps available in the major road traffic stream.
3. There is a significant collision history of sideswipe or rear end type crashes.
4. There is insufficient intersection sight distance at the intersections for some of the design vehicles making the left turn off the minor roadway.
5. There are enough large vehicles originating on the minor roadway for it to be an operational concern for the major road.

The first two conditions are met for both northbound and southbound Highway 2. The collision history indicates a combined total of four (4) “Rear End” or “Sideswipe” collisions in the southbound lanes, and a total of four (4) “Rear End” or “Sideswipe” collisions in the northbound lanes. Additionally, two (2) collisions that were coded as “Right Angle” involved eastbound left turn vehicles, suggesting that the collisions could actually be “Rear End” or “Sideswipe – Same



Direction” collisions. The drive through observations identified potential sight line limitations for left turns from the median onto both northbound and southbound Highway 2, albeit the sight limitations are dynamic restrictions as they are related to other vehicles in the median opening or vehicles approaching the median opening in the left turn deceleration lane. The sight distance review related to static sight obstructions, provided in Section 6.4, indicates sight distance appears to be adequate for all approaches and departures at the intersection. For the review of MALs, the dynamic sight constraints are considered to be relevant. As the first two conditions and two (2) of the last three (3) conditions in the warrant are met, MALs should be considered.

Turn Lane Geometry

The existing acceleration and deceleration lanes were checked against the applicable design standards provided in Section D.8 of the HGDG.

For new construction, acceleration and deceleration lanes should consist of a 3.5 m lane and 1.5 m shoulder while a 3.0 m lane and 0.3 m shoulder may be acceptable for twinning projects on existing pavement. The length of the southbound right turn deceleration lane appears to have been extended using the existing paved shoulder and may have inadequate lane and shoulder width to meet minimum AT standards. All of the other deceleration and acceleration lanes and shoulders appear to meet AT’s minimum standards.

Generally, an 87.5 m (25:1) lane taper is sufficient for low-volume turning movements. Higher-volume turn movements may warrant a taper and a parallel lane. Standard taper and parallel lengths for various design speeds are given in Table D.8.4 of the HGDG and are generally applicable where the highway has a high level of service (i.e., LOS of “A”). Where the highway operates with a LOS lower than “A”, it is desirable that the parallel lane length be sufficient for all deceleration to take place in the auxiliary lane. Adjustments to the parallel deceleration lane length may be required for additional storage, for the effect of trucks on storage requirements, and for the effect of grade on deceleration (HGDG Table D.6.2.6).

In Alberta, the level of service for a typical four-lane divided highway is “A” in the design hour unless the AADT exceeds 17,000. Southbound Highway 2 is expected to have a LOS lower than “A” as the two-way AADT exceeds 17,000 and there are two (2) northbound through lanes making it desirable, but not required, for all deceleration to take place in the auxiliary lane. In contrast, it is expected that northbound Highway 2 has a higher level of service as having three (3) through lanes would provide additional capacity and make it less necessary for deceleration to take place completely in the auxiliary lane.

Beyond the intersection, an acceleration lane is typically provided to facilitate right turns from the minor approach. Generally, the acceleration lane is similar in design to the deceleration lane preceding the intersection that facilitates right turns from the highway. Adjustments to the acceleration lane length may be required for the effect of grade on acceleration (HGDG Table No. 2, Figure D-6.3.4).

In Table 9, warranted auxiliary lane lengths (minimum and desirable, where applicable) are shown side-by-side with as-built auxiliary lane lengths.

Table 9: Auxiliary Lane Geometry

Direction	Lane	Lane Length		Sufficient?
		Warranted (130 km/h Design Speed)	As-built Length	
Deceleration Lanes				
Northbound	Left Turn	110 m Parallel (min.) 140 m Taper	~50 m Parallel ~87.5 m Taper	No
	Right Turn	87.5 m Taper	~140 m Taper	Exceeds
Southbound	Left Turn	110 m Parallel (min.) 215 m Parallel (des.) 140 m Taper	~30 m Parallel ~87.5 m Taper	No
	Right Turn	110 m Parallel (min.) 215 m Parallel (des.) 140 m Taper	~110 m Parallel ~140 m Taper	Yes
Acceleration Lanes				
Eastbound	Left Turn	610 m (min.) 695 m (des.)	~75 m Radius	No
	Right Turn	110 m Parallel (min.) 140 m Taper	~87.5 m Taper	No
Westbound	Left Turn	610 m (min.) 695 m (des.)	~75 m Radius	No
	Right Turn	87.5 m Taper	~140 m Taper	Exceeds

min. = minimum; des. = desirable

The geometry of each right turn deceleration lane appears to meet or exceed current AT standards with exception of the shoulder width for the southbound right turn deceleration lane. Both the northbound and southbound left turn deceleration lane appear to have insufficient length, as does the acceleration lane for the westbound right turn.

Although MALs may be warranted as an interim safety improvement it is expected that MALs will not be a suitable upgrade for this location as:

- The operational analysis indicates that the existing all-turns TWSC intersection is no longer sufficient to provide adequate traffic operations.
- Potential improvement strategies (i.e., median closure or traffic signal) do not benefit from the provision of MALs.

6.4 Sight Distance

Stopping Sight Distance

Adequate sight distances are critical for safe traffic operations. The minimum sight distance required at each point on the highway is stopping sight distance (SSD), which is the sight distance available on the roadway that allows a driver travelling at an assumed running speed (based on the design speed) to stop before reaching a stationary object in its path.

SSD may be inadequate when drivers must make complex or instantaneous decisions, when information is difficult to perceive, or when unexpected or unusual maneuvers are required. In



such situations, it is beneficial to provide drivers with decision sight distance, a longer sight distance that provides drivers more time to react. The study intersection is rural and has a relatively simple layout, requiring drivers to make relatively few decisions or maneuvers. For this intersection, minimum SSD is expected to be adequate.

This intersection was reviewed using minimum SSD values from Table B.2.3 of the HGDG, which are based on:

- A perception reaction time of 2.5 s;
- Typical friction factors;
- An eye height of 1.05 m; and
- An object height of 0.38 m.

Available SSD was reviewed for each approach. Table 10 provides minimum SSD values (from Table B.2.3 of the HGDG) side-by-side with available sight distances.

Table 10: Stopping Sight Distances

Approach	Design Speed (km/h)	Minimum Stopping SD (HGDG Table B.2.3) (m)	Available SD (m)	Sufficient?
North	130	275	> 275	Yes
South	130	275	> 275	Yes
East	90*	170	>74	Yes*
West	90	170	> 170	Yes

* The available sight distance is sufficient to provide SSD for a speed of 55 km/h. Although the east approach has a statutory 80 km/h speed limit, vehicles travel much slower than 80 km/h because they first slow to negotiate the RR291 intersection (estimated speed of ~14 km/h for right turns, ~24 km/h for left turns) before proceeding the ~60 m to the Highway 2 intersection suggesting that the available sight distance is adequate.

Minimum visibility triangles for stop-controlled approaches were checked using Figure D-4.2.1 of the HGDG and a design speed of 130 km/h for the major road. The minimum visibility triangles were determined to be clear for both minor approaches.

Intersection Sight Distance

Intersection sight distance (ISD) is defined as the sight distance available from a point where vehicles are required to stop on the intersecting road, while drivers are looking left and right along the major roadway, before entering the intersection. ISD is adequate when it allows design vehicles to safely make all maneuvers without significantly affecting vehicles travelling on the major roadway.

Intersection sight distances are summarized in Table 11. Required crossing sight distance values are based on Section D.4.2.2.1 of the HGDG and are larger for crossing northbound Highway 2 due to the additional crossing width associated with a third through lane on the highway. Sight distances for left turns are from Figure D-4.2.2.2 of the HGDG. Available sight distance was estimated using time-based measurements and an estimated vehicle speed of 120 km/h,.

Table 11: Sight Distances for Vehicles Departing from Minor Approach or Median

Crossing or Entering	Design Vehicle on Minor Road	Required ISD (m)		Available ISD (m)	Sufficient?
		Crossing	Left Turn		
Hwy 2 NB	WB-23	500*	500*	> 500	Yes
	SU	444	385	> 500	Yes
	P	314	255	> 500	Yes
Hwy 2 SB	WB-23	500*	500*	> 500	Yes
	SU	412	385	> 500	Yes
	P	303	255	> 500	Yes

Note: Figure D-4.2.2.2 of the HGDC indicates the usefulness of sight distances in excess of 500 m has been debated. Therefore, 500 m was selected as the maximum applicable sight distance requirement.

Sight distance appears to be adequate for all approaches and departures at this intersection.

6.5 Access Management and Intersection Spacing

6.5.1 Highway 2

Access Management

With a Freeway/Expressway Functional Classification, Highway 2 is a strategically important corridor that requires a high level of access management. In the study area, Highway 2 currently functions as an expressway with a mix of interchanges and at-grade intersections. Ultimately, Highway 2 will evolve into a freeway with access only permitted via grade-separated interchanges. Table I.5 of the HGDC identifies the following access management guidelines for public roads intersecting an Expressway/Future Freeway:

- Minimum spacing of 1.6 km is required.
- Existing intersections may remain on temporary basis only if minimum spacing attained. Non-conforming accesses are to be removed when upgrading of highway occurs.
- New accesses not permitted unless minimum spacing is attained.
- Service interchanges are normally spaced up to 16 km apart in a rural environment.

Planning Studies

ISL did not receive or find any studies identifying future plans for this section of the Highway 2 corridor.

Intersection Spacing

Junctions on Highway 2 are listed in Table 12 along with their existing configuration and spacing.



Table 12: Highway 2 Accesses

Access Type (Intersection Type)	Intersecting Road	Intersection Number	km	Distance to Last Access (km)	
				Access	Public Road
Highway (interchange)	Hwy 7 / Hwy 547	1664	15.377	6.932	6.932
Municipal Road (at-grade)	TR204	1277	17.677	2.300	2.300
Municipal Road (at-grade)	TR210 (Study Intersection)	19291	21.448	3.771	3.771
Municipal Road (at-grade)	TR212	1200	25.465	4.017	4.017
Highway (interchange)	Hwy 2A / Hwy 522	34	28.669	3.204	3.204

The existing intersection spacing on Highway 2 exceeds the minimum spacing requirement of 1.6 km for an Expressway/Future Freeway.

6.5.2 Township Road 210

Access Management

Chapter I (Access Management Guidelines) of the HGDG does not indicate the minimum offset for a private access from an expressway, however, it is expected that it would not be less than the minimum offset for a private access from a major two lane highway, which is 50 m. An offset of 400 m or greater is desirable for a major access (i.e. public roadway, multi-parcel residential, commercial, or industrial).

Frontage Service Roads

Frontage service roads are public roads that are adjacent to and generally parallel to major roads such as freeways, expressways and major arterials. RR291 intersects with TR210 east of Highway 2, and 1064th Drive E intersects with TR210 west of Highway 2. Near the intersection, RR291 and 1064th Drive E are both similar to a frontage service road. The HGDG provides the following guidance regarding highway to service road intersection spacing:

- Section D.3.6 indicates that the minimum offset distance between the highway and service road intersections is the length of the design vehicle plus a 3.0 m buffer to the edge of travel lane on each end of the design vehicle. For a WB-21 or WB-23, the required offset distance, including buffers at each end, is 31 m. For a WB-36, the required offset distance including buffers at each end is 44 m.
- Figure 9.1f indicates the distance from the centreline of the service road intersection to the centreline of the intersection with the nearside highway lanes is 46 m, which could be considered the minimum.

Intersection Spacing

Accesses on TR210 are listed in Table 13 along with their existing configuration and spacing from the study intersection.

Table 13: Township Road 210 Intersections and Accesses

Intersection / Access Type	Intersecting Road	From Study Intersection	
		Spacing*	Direction
Residential (at-grade)	--	445	West
Commercial (at-grade)	--	200	West
Municipal Road (at-grade)	1064 th Dr E	46	West
Municipal Road (at-grade)	RR291	74	East

Note: Spacing is the centreline to centreline distance between intersecting roads, and is measured from the centreline of the nearside highway lanes when measured from Highway 2.

Considering Table 13 the following conclusions can be made;

- The location of the residential access in relation to Highway 2 is acceptable as it exceeds the 50 m minimum offset for a private access.
- The location of the commercial access in relation to Highway 2 is less than desirable for a major access, however, it is at a larger offset than required for a private access. With low traffic volumes at the access, the existing offset does not currently appear to be a safety issue.
- The location of the 1064th Drive E service road in relation to Highway 2 just meets the 46 m spacing shown for an at-grade intersection in Figure 9.1f of the HGDG and provides enough space to store a WB-21 or WB-23. The spacing does not need to be sufficient to store a WB-36 as 1064th Drive E only provides access to rural residential properties and will not be used regularly by large trucks.
- The location of the RR291 service road in relation to Highway 2 exceeds the 46 m spacing shown for an at-grade intersection in Figure 9.1f of the HGDG and has adequate space to store a WB-21, WB-23 or WB-36.

6.6 Illumination Warrant and Analysis

Illumination requirements were considered for the study intersection using guidelines contained in the AT “Highway Lighting Guide” and the TAC guideline “Illumination of Isolated Rural Intersections”.

The TAC Warrant for Illumination of Isolated Rural Intersections was used to evaluate the intersection. The warrant considers the geometric, operational, environmental and safety characteristics of the intersection. Nighttime collisions are considered in the safety portion of the warrant. For unsignalized intersections, the following point system is used to determine if illumination is warranted:

- Full illumination is warranted for a score of greater than 240 points;
- Partial and/or delineation lighting is warranted for a score of between 120 and 240 points; and
- Lighting is not warranted for a score of less than 120 points.

Partial lighting refers to the illumination of key decision areas on the approach to an intersection; delineation lighting refers to “sentry” lighting that marks an intersection location for approaching traffic and illuminates vehicles or pedestrians on the cross street.



For the safety portion of the warrant, five (5) nighttime collisions occurred over the past three (3) years, however, three (3) of the collisions are considered attributable to factors unrelated to inadequate lighting, including:

- One (1) “Off Road Right” collision that occurred due to a tire blow out.
- One (1) “Rear End” collision that involved a vehicle intentionally rear-ending another vehicle.
- One (1) “Struck Object” collision that occurred when a tire flew from a transport truck striking the front end of the following vehicle.

The safety portion of the warrant was completed for two (2) scenarios: the first considers collision frequency rounded up to 1.0 (for two (2) nighttime collision over a three year period); the second considers collision frequency rounded up to 2.0 (for all five (5) nighttime collisions over a three year period). Results of the illumination warrant analysis are provided in Table 14 and warrant worksheets are included in Appendix E.

Table 14: Illumination Warrant for Existing Conditions

Scenario	Warrant Points	Lighting Warranted	Upgrades Required?
Collision Frequency of 1.0	236	Delineation Lighting	Yes
Collision Frequency of 2.0	266	Full Illumination	Yes

For the first scenario, delineation lighting is warranted, however, the 236 points is just four (4) points shy of warranting full illumination and does not include any points for the environmental portion of the warrant. If the nearby commercial developments have illumination sufficient to interfere with nighttime visibility of the roadway, the point value would increase five (5) points and full illumination would be warranted.

For the second scenario, the warrant point value exceeds 240 and full illumination is warranted.

7.0 Traffic Conflicts

During the intersection review, close attention was paid to traffic operations and potential conflicts at the intersection. The following potential conflicts were identified:

- During the peak hour, there are few sufficient gaps available to cross Highway 2. Sometimes, an acceptable gap is available however the median opening already has queued vehicles and there is insufficient space to accept any additional vehicles. The challenge finding safe gaps in the Highway 2 traffic stream results in queue formation on stop-controlled approaches and in the median. The queue is related to a poor level of service and delays on the stop-controlled approaches and in the median. **Potential for “Rear End” collisions as vehicles approach the end of queue. Potential for driver frustration and risk taking due to delay.**
- Due to operational and geometric conditions (i.e., high traffic volumes, large crossing distance), it may be challenging for a vehicle crossing Highway 2 to judge safe gaps for a crossing maneuver. **Potential for “Right Angle” collision between Highway 2 vehicle and westbound/eastbound vehicle attempting crossing maneuver.**
- For a vehicle on a stop-controlled approach, visibility of oncoming highway vehicles may be blocked by other highway vehicles, including those in the adjacent right turn deceleration lane. **Potential for “Right Angle” collisions as sight lines for drivers on the stop-controlled approach are temporarily blocked and drivers may be unable to adequately judge gaps.**
- For a vehicle in the median opening, visibility of oncoming highway vehicles can be obstructed by highway left turn vehicles that are queued in a left turn deceleration lane waiting for vehicles in the median opening to clear. **Potential for “Right Angle” collisions between Highway 2 through vehicle and vehicle crossing the highway from the median. Potential for “Rear End” or “Sideswipe – Same Direction” collision between a Highway 2 through vehicle and a left turn vehicle entering Highway 2 from the median opening. In both cases, sight lines for drivers in the median opening are temporarily blocked and drivers may be unable to adequately judge gaps.**
- Traffic conflicts may occur when multiple vehicles enter or occupy the median opening simultaneously, such as:
 - When a highway left turn vehicle enters the median opening at the same time as an opposing highway left turn vehicle, drivers may be unsure of whether to turn in front of or behind one another. **Potential for “Left Turn Across Path”, “Head On” or “Sideswipe – Opposite Direction” collision between opposite left turn vehicles.**
 - When a highway left turn vehicle enters the median opening at the same time as an opposing through or left turn vehicle from the stop-controlled approach, the highway left turn may enter the median opening on the left side of centre and potentially try to utilize the same space as the vehicle entering from the minor approach. **Potential for “Head On” or “Sideswipe – Opposite Direction” collision between left turn vehicle from the highway and vehicle entering median from stop-controlled approach.**
 - When a minor approach left turn vehicle and through vehicle are queued side-by-side in the median opening, there is potential for visibility of oncoming highway vehicles to be obstructed by the through vehicle. **Potential for “Rear End” collisions as sight lines for drivers of left turn vehicles are temporarily blocked and drivers may be unable to adequately judge gaps to enter the highway. Potential for “Sideswipe – Same**



Direction” or “Off-Road” collision if a higher speed vehicle on the highway attempts evasive maneuver.

- The lengths of the northbound and southbound left turn deceleration lanes are insufficient to provide space for left turn vehicle storage. Left turn vehicles queued in the deceleration lane reduce the length available for deceleration and can result in excessive deceleration in the adjacent Highway 2 through lane and a large speed differential between left turn and through vehicles on Highway 2. There is potential for the queue length to encroach into the adjacent Highway 2 through lane. ***Potential for “Rear End” collision as a left turn vehicle from Highway 2 approaches the end of queue in the left turn lane. Potential for “Rear End” or “Sideswipe – Same Direction” collision as a through vehicle on Highway 2 does not recognize that a left turn vehicle is decelerating in the through lanes of the highway and travelling significantly slower. Potential for “Off Road Left” collision as a left turn or through vehicle from Highway 2 avoids hitting a slower moving/stopped left turn vehicle.***
- There is no acceleration lane for westbound or eastbound left turn vehicles. Left turn vehicles from the median must complete most of their acceleration in the left through lane of the highway. ***Potential for “Rear End” collisions if the vehicle in the left highway lane does not recognize that a vehicle has just completed the left turn and is travelling significantly slower. Potential for “Sideswipe – Same Direction” or “Off-Road” collision if higher speed vehicle attempts evasive maneuver.***
- Due to the narrow shoulder for the southbound right deceleration lane, southbound right turn vehicles have a greater risk of leaving the paved road surface. ***Potential for “Off Road Right” collision for southbound right turn vehicle that departs their lane.***
- Based on the wear on the south edge of the west approach, it appears that eastbound right turn vehicles use the shoulder to bypass adjacent vehicles queued at the Stop sign. While bypassing queued vehicles, the right turn vehicle is not in a defined travel lane and can violate driver expectations. There is potential for vehicles in the defined travel lane to shift to the right into the path of a vehicle travelling at a higher rate of speed on the shoulder. ***Potential for “Rear End” collision or “Sideswipe – Same Direction” collision between vehicles respecting the defined travel lane and vehicles utilizing the shoulder to bypass queued traffic. Potential for “Turn Across Path” conflict if right turn driver in defined travel lane fails to recognize a vehicle approaching from behind on the shoulder.***

8.0 Identified Safety Issues

Based on the collision analysis, site visit, geometric analysis, operational analysis and observed traffic conflicts, the following safety issues are identified:

- **Inadequate Level of Traffic Control:** Both the HCM 2010 TWSC procedure and the traffic signal warrant suggest that an all-turns TWSC intersection is no longer sufficient.
- **Lack of Adequate Crossing Opportunities:** During the peak hour, there are few sufficient gaps available to cross Highway 2. Sometimes, an acceptable gap is available to cross to the median, however, the median may not have sufficient capacity to receive any additional vehicles.
- **Challenging Gap Selection:** Drivers on the stop-controlled approaches and in the median opening have difficulty selecting safe gaps to cross the highway, especially to cross the three (3) through lanes of northbound Highway 2.
- **Blocked Sight Lines:** The following sight line issues were identified:
 - When a minor approach left turn vehicle and through vehicle are queued side-by-side in the median opening, there is potential for visibility of oncoming highway vehicles to be obstructed by the adjacent through vehicle.
 - Vehicles slowing or queued in the left turn deceleration lanes may block sight lines for vehicles turning left or crossing from the median.
 - For a vehicle on a stop-controlled approach, visibility of oncoming highway traffic may be obstructed by a vehicle in the adjacent right turn deceleration lane, the sight line issue can be mitigated if drivers wait for the deceleration lane to clear.
 - For a vehicle on a stop-controlled approach, visibility of faster oncoming highway traffic can be obstructed by closer, slower highway vehicles and make it difficult to select a safe gap. At this intersection, the potential for this to occur is higher for a vehicle crossing northbound Highway 2 than southbound Highway 2 as there is an additional through lane in the northbound direction.
- **Inadequate Deceleration Lanes:** The length of the northbound and southbound left turn deceleration lanes are inadequate to satisfy vehicle deceleration and storage requirements.
- **Challenges with Bullet-Nose Median Opening:** Bullet-nose median openings present unique challenges for drivers including:
 - There are no markings or signs to guide drivers through the median.
 - The Alberta “Use of Highway and Rules of the Road Regulation” and the Alberta Drivers Handbook do not provide clear guidance on left turns through a median opening on a divided highway. This potentially leads to driver confusion as to what path they should take through the median opening.
 - When highway left turn vehicles enter the median opening at the same time as opposing through or left turn vehicles from the stop-controlled approach, the highway left turn vehicle may enter the median opening on the left side of centre and potentially try to utilize the same space as the vehicle entering from the minor approach.
 - The potential for driver confusion in the median opening increases with higher traffic volumes because there is a greater probability of conflicting movements occurring at the same time and there are more things requiring the driver’s attention.



- **Speed Differential for Median Left Turns:** There is a significant speed differential between left turn vehicles departing the median opening and through vehicles on Highway 2.
- **Narrow Shoulder for Southbound Right Turn:** The shoulder for the southbound right turn deceleration lane appears to be less than AT's minimum standard, and may result in an increased risk of vehicles leaving the asphalt surface.
- **Eastbound Right Turn on Shoulder:** Eastbound right turn vehicles can violate driver expectancy if they depart the defined travel lane to pass queued vehicles on the unpaved shoulder.
- **Pavement Deterioration:** Traffic usage has resulted in gravel/soil loss, exposed edge of pavement, and pavement deterioration on the TR210 south shoulder and on the south edge of the median opening.
- **West Approach Alignment:** Some horizontal alignment elements of the west approach do not appear to meet applicable design standards for the 80 km/h speed limit. It is recommended that a Reverse Turn Sign with an Advisory Speed tab be installed in advance of the first curve on approach to the intersection.
- **Lack of Illumination:** The intersection is not presently illuminated. Full illumination is recommended for this intersection. Illumination will assist drivers identify the intersection location at night. Street light poles may also assist drivers with daytime recognition of the intersection.

8.1 Signage and Rumble Strip Deficiencies

The following signage deficiencies were identified. The majority of the deficiencies are not urgently in need of repair, however, if not addressed, further deterioration could lead to the sign(s) and/or rumble strips becoming inoperative and/or impact safe operation of the intersection:

- **Incomplete Breakaway Features:** Some of the wood sign posts located within the clearzone did not have holes drilled into the post to complete the breakaway feature.
- **Sign Spacing and Placement:**
 - The One Way signs on the south approach were located too far from the intersection. Consideration should be given to adjusting their location to be 7 m from the intersection as the current placement may impact their effectiveness.
 - The One Way and Do Not Enter signs on the north approach were located too far from the intersection. Consideration should be given to adjusting the location of both signs so that they are 7 m and 27 m, respectively, from the intersection as the current placement may impact their effectiveness.
 - The Junction sign and Rumble Strips signs are located at 298 m, and 512 m, respectively, west of Highway 2. Drawing TCS-A4-430C indicates that the signs should be in the reverse order and spaced at 450 m and 400 m, respectively.
 - A Divided Highway sign is provided on westbound TR210 south and east of the TR210 / RR 291 intersection, however, a Divided Highway sign is not provided on southbound RR291. Providing a Divided Highway sign on southbound RR291 in advance of the TR210/RR291 intersection should be considered.
 - The Bidirectional Checkerboard sign at the TR210 / 1064th Drive E intersection is offset left-of-centre for approaching drivers and lower than typical due to placement in the ditch.

1064th Drive E is a low volume roadway and the sign is visible in the current location. If this sign is included in a future maintenance activity, it should be repositioned eastward and installed on a taller post

- Sign adjustment should be considered with the next overlay or sign maintenance activity. Any adjustments to sign locations should consider that a minimum of 50 m should be provided between signs.
- **Misaligned and/or Damaged Signage:**
 - The Wrong Way sign on the median side of northbound Highway 2 was bent.
 - The One Way sign on the median side of the northbound Highway 2 was knocked down.
 - The One Way sign on the outside edge of the northbound Highway 2 was bent.
 - Delineator guide posts located by the southbound left turn lane and the southbound right turn radius were missing, damaged or bent.
 - The Divided Highway sign on the west approach had minor damage (scratches). The sign was still legible.
 - The Junction sign on the west approach had moderate damage (bent Highway 2 route marker, scratches and scrapes, fading symbols). The sign was still legible.
 - The Maximum 80 km/h Speed sign on the west approach had minor damage (fading, delamination). The sign was still legible.
 - Some signs on the west approach (Checkerboard Right, Reverse Curve, Bidirectional Checkerboard) were installed on short posts resulting in the bottom edge of the sign being less than 1 m above the road surface.
 - The Stop sign on the 1064 Drive E approach to TR210 was bent and had minor damage (scratches) to the sign face. The sign was still legible.
 - The Stop Ahead sign on 1064 Drive E was damaged (severely faded stop symbol).
- **Rumble Strips:**
 - The transverse rumble strips in advance of the eastbound Stop sign were worn in the wheel paths. Consideration should be given to re-milling the rumble strips if an overlay is not planned for the near future.

It is recognized that AT completes ongoing maintenance of signs and rumble strips and that some of the identified deficiencies may have been resolved as part of the maintenance program following completion of the site inspection.

8.2 Pavement Marking Deficiencies

The majority of the pavement marking deficiencies are not urgently in need of repair, however, further deterioration could lead to pavement markings becoming inoperative and/or impact safe operation of the intersection:

- The edge line along the eastbound right turn radius was worn.
- The edge line along the westbound right turn radius was worn.

It is recognized that AT completes ongoing maintenance of pavement markings and that these pavement markings may have been repainted as part of the maintenance program following completion of the site inspection.



9.0 Improvement Strategies

The review of improvement strategies considered, among other things, the NCHRP Report 650, “Median Intersection Design for Rural High-Speed Divided Highways”, which provides a table of potential rural expressway intersection safety improvements. These improvements are categorized into three fundamental types:

1. **Conflict-point reduction** treatments aim to reduce the number of conflict points or to replace conflict points associated with the greatest crash risk (e.g., crossing path) with less risky conflict points (e.g., merge and diverge).
2. **Gap selection aids** are meant to help the minor road drivers determine whether a gap is safe to accept and could include measures that help minor road drivers better see and anticipate the speed of oncoming traffic.
3. **Intersection recognition devices** are intended to help approaching drivers become more aware of the intersection so that they might be better prepared to react accordingly, and can be divided into two (2) categories: those for drivers on the minor road, and those for drivers on the major road.

Potential safety improvement options are listed in Table 15 and highlighted as follows:

- Green highlighting identifies potential solutions to address known safety issues.
- Yellow highlighting identifies options that are considered viable components if included with one of the green options.
- Red highlighting identifies options that are not considered suitable strategies for addressing the safety issues identified at the Highway 2 / TR210 intersection.

The options highlighted in green are discussed further in the following sections.

Table 15: Potential Rural Expressway Intersection Safety Treatments

Category	Subcategory	Treatment	Discussion
1. Conflict Point Management Strategies	1. Removal / Reduction Through Access Control	1. Conversion of entire expressway corridor to freeway	This is the ultimate plan for the Highway 2 corridor and resolves the safety issues identified for the TR210 intersection, however, this is not an interim solution.
		2. Isolated conversion to grade separation or interchange	Given the proximity of the intersection to the existing Highway 7 / Highway 547 and Highway 2A / Highway 522 interchanges, conversion of the intersection to an interchange is not expected to be a viable option.
		3. Close low-volume minor road intersections and use frontage roads	Total closure of the TR210 intersection is expected to be part of the ultimate plan to convert the expressway corridor to freeway, however, total closure may not be an acceptable interim solution.
		4. Close median crossovers (right-in, right-out access only)	Closure of the TR210 median opening is a viable option. Although median closure would result in additional trip lengths for some movements, prohibited movements can be re-routed to make use of the Highway 2 interchanges at Highway 7 / Highway 547 and Highway 2A / Highway 522. Options for median closure include: 1. Minor Approach Turn Restrictions – use channelization to restrict minor approach left and through movements. Provide channelization to allow unrestricted Highway 2 left turns. 2. Full Median Closure – full median closure to prohibit Highway 2 left turns and minor approach left and through movements.
		5. Convert four-legged intersection into "T" intersection, or initially construct "T" intersections instead of four-legged intersections * Use a "one-quadrant interchange" design (if necessary)	This is not considered a viable option as "T" intersection(s) on Highway 2 do not address the primary safety issues. Gap selection would still be a challenge for vehicles entering or departing Highway 2 at TR210.
	2. Replacement of High-Risk Conflict Points	1. J-turn intersections (indirect minor road crossing and left-turns)	A J-turn intersection is not considered a feasible option as the median is not wide enough for a median U-turn lane and large distances would be required for weaving on northbound Highway 2.
		2. Offset "T" intersections (indirect minor road crossing)	This is not considered a viable option as "T" intersection(s) on Highway 2 do not address the primary safety issues. Gap selection would still be a challenge for vehicles entering or departing Highway 2 at TR210 and large distances would be required for weaving on Highway 2.
		3. Jughandle intersections (indirect left-turns)	Jughandles would be required for both northbound and southbound left turns resulting in three intersections replacing the existing intersection. A jug handle intersection would not meet the 1.6 km intersection spacing requirement for Highway 2. Jughandles are typically implemented at signalized intersections to reduce the number of required phases and improve the intersection level of service. The basic implementation of a traffic signal at TR210 would be sufficient to resolve the identified issues.
		4. Other indirect left-turn treatments (Michigan lefts)	Michigan left turn intersections require traffic signal control to allow the minor road through traffic to travel straight through the intersection. They are typically used to reduce phases at signalized urban and suburban intersections to improve operation and level of service. Determined to be inappropriate for Highway 2 / TR210 based on continued through movements from the minor road, and that a traffic signal without the Michigan left turn modifications would likely perform acceptably.
		5. Expressway semi-roundabout intersection (ES-RI)	Semi-roundabout intersections were determined to be inappropriate based on the required speed reduction for implementation of a roundabout style intersection plus significant reconstruction of the Highway 2 approaches, which would be throwaway for the ultimate Highway 2 corridor.
	3. Relocation or Control	1. Provide left/right turn lanes or increase their length	Right and left turn deceleration lanes are provided for both directions on Highway 2 at the intersection. Consideration should be given to widening the shoulder on the southbound right turn lane. If an option is chosen that maintains the median opening, the northbound and southbound left turn lanes and tapers may require lengthening.
		2. Provide free right turn ramps for exiting expressway traffic	Considering the right turn volumes and conflicting through volumes, it is not expected that a free right turn with a lane away would be beneficial for either direction.
		3. Minimize median opening length	Reducing the median opening length is not recommended. The existing median opening length meets AT guidelines and is required to accommodate left turn truck movements.
		4. Signalization	The TAC traffic signal warrant is met. Traffic signals control conflict points by alternately assigning right of way to conflicting movements and provide gaps for vehicles to complete movements through the intersection. Installation of a traffic signal would require a speed limit reduction to 80 km/h on Highway 2.
2. Gap Selection Aids	1. Vehicle Detection (Intersection Sight Distance Enhancements)	1. Provide clear sight triangles	N/A – Sight triangles are adequate.
		2. Modify horizontal/vertical alignments on intersection approaches	N/A – Horizontal and vertical alignments are satisfactory.



Category	Subcategory	Treatment	Discussion
		3. Realign skewed intersections to reduce or eliminate skew	N/A – Angle of intersection (~77°) is not ideal, however, it does meet AT minimum requirements.
		4. Move minor road stop line as close to expressway as possible	Existing stop line placement meets AT guidelines, however, sight lines for eastbound drivers could be improved by moving the eastbound stop line closer to Highway 2.
		5. Provide offset right turn lanes	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		6. Provide offset left turn lanes	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
	2. Judging Arrival Time	1. Intersection decision support system (IDS) or other dynamic device	N/A
		2. Roadside markers/poles (static markers at a fixed distance)	Not considered due to potential for driver misunderstanding.
	3. Merging / Crossing Aids	1. Provide left turn acceleration lanes (MALs) for merging traffic	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		2. Provide right turn acceleration lanes for merging traffic	A simple taper design is provided for acceleration for the westbound and eastbound right turns, however, the eastbound right turn acceleration lane should be extended to meet AT guidelines. Acceleration lane improvements could be considered with other improvements.
	----- (Promoting Two-Stage Gap Selection)	3. Expressway speed zoning/enforcement near intersections	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations. If a traffic signal is considered, a reduced speed limit on Highway 2 would be required.
		4. Widen median to provide for adequate vehicle storage	N/A – The median is wide enough to provide adequate vehicle storage for two-stage gap selection.
		5. Add centerline, yield/stop bars, and other signage in the median	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		6. Extend left edge lines of expressway across median opening	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		7. Public education campaign teaching two-stage gap selection	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
3. Intersection Recognition Devices	1. Intersection Treatments	1. Provide overhead control beacon reinforcing two-way stop control	N/A – Based on site observations and collision reports, drivers on the minor approaches recognize the intersection and traffic controls.
		2. Provide intersection lighting	The warrant for full illumination is almost met. If the intersection is signalized, full illumination will be required.
	2. All Approaches	1. Enhanced (overhead/larger/flashing) intersection approach signage	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
	3. Expressway Approaches	1. Provide diagrammatic freeway-style intersection guide signs	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		2. Provide Dynamic WATCH FOR ENTERING TRAFFIC WHEN FLASHING Signs	A dynamic traffic warning system could reduce the speed of Highway 2 vehicles, when activated, resulting in reduced collisions and/or reduced collision severity. A dynamic traffic warning system would not be expected to improve the LOS during peak periods. Intersection Conflict Warning Systems (ICWS) provide dynamic signs, variable message signs and flashers tied to detection systems to provide active warning to traffic on the major road, minor road or both roads at the intersection. There could be benefits realized from the implementation of a system to warn drivers of other traffic at the intersection. Implementation of ICWS on high volume roadways is not beneficial as the reduced traffic gaps result in continuous activation of the system.
		3. Use of a variable median width (wider in intersection vicinity)	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
		4. Change median type in vicinity of intersection	N/A – An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations.
	4. Minor Road Approaches	1. Use STOP-AHEAD pavement marking and in-lane rumble strips	N/A – Stop sign compliance does not appear to be an issue at this location. STOP AHEAD pavement marking and rumble strips already in place for the west approach.
		2. Provide a stop bar (or a wider one)	N/A – Stop bars currently in place and recognized.
		3. Provide divisional/splitter island at mouth of intersection	An all-turns TWSC intersection is no longer sufficient to provide adequate safety/traffic operations. Provision of a divisional/splitter island could be incorporated into a right-in, right-out configuration and/or with a partial median closure.
		4. Provide signage/markings for prevention of wrong-way entry	N/A – Wrong way signage currently in place.

Note: Items highlighted in green are discussed further as potential countermeasures.

Ultimately full closure of the Highway 2 / TR210 intersection would provide the greatest operational and safety benefit to this section of Highway 2. The existing road network on the west side of Highway 2 provides access to interchanges at Highway 7 / Highway 547 (south of Okotoks) and Highway 2A / Highway 522 (north of Okotoks) through Okotoks. On the east side of Highway 2, local road access is only available to the interchange at Highway 2A / Highway 522 (north of Okotoks). It is expected that the adjacent communities and residents would expect upgrades to the service road network to improve access to these interchanges in the event of access restrictions or closures to Highway 2.

The following sections identify options to improve safety for the intersection of Highway 2 and TR210. Note that the improvements and cost estimates do not consider the potential of throwaway costs at the point of implementation of the ultimate improvements. It is recommended that a more thorough review of the proposed improvements be undertaken prior to design of any interim improvement to minimize throwaway, and to consider the benefit of the options relative to the timing of the ultimate improvements.

It is recognized that some of the suggested improvements may divert traffic to other at-grade intersections, and if similar improvements are not considered at those locations, there is the potential that safety and operational issues may be exacerbated. For example, access restrictions at TR210 could potentially divert some traffic movements to TR204 or TR212. The resolution of operational and safety issues at TR210 may require the implementation of similar or alternate measures at adjacent intersections. Ultimately, all of these at-grade accesses would be closed when Highway 2 is upgraded to a freeway. It is expected that implementation of short-term improvements would need to consider improvements and or development of sections of the service road network to provide access north and south to the Highway 7 / Highway 547 and Highway 2A / Highway 522 interchanges. This level of review would be better suited to a functional planning study than a site-specific safety review.

Discussions of specific improvements at the TR210 intersection consider that traffic will be redirected, when necessary, to the interchanges and that alternative route options related to short cutting or U-turns at existing at-grade intersections would be addressed with similar improvements or closure.

The selection and discussion of safety improvement strategies eliminated options that were felt to have significantly higher cost, have potential to result in greater throwaway, and/or not provide a significant advantage over a more economical and efficient solution.

9.1 Signage, Pavement Markings and Rumble Strips

Some actions could be taken to address deficiencies with signs, pavement markings and rumble strips, however, it is expected that they would have a negligible effect on the majority of the collisions occurring at this intersection. These improvements include:

- Repair/replace bent and/or damaged signs and sign posts.
- Complete the breakaway features on sign posts.
- Adjust the placement and spacing of signs to follow "Design Bulletin #82/2014".
- Re-mill the rumble strips on the west approach if an overlay is not planned for the near future.



- Move the eastbound stop line on the west approach closer to Highway 2. (a swept path analysis may be required)
- Install a Reverse Turn sign with an Advisory Speed tab in advance of the reverse curve on the west approach (TR210).

If the intersection is maintained open, the repair of these identified deficiencies could be considered with future maintenance activities or included with other intersection improvements.

9.2 Intersection Conflict Warning System for Highway 2

Dynamic signage could be provided on Highway 2 in advance of the intersection to advise Highway 2 drivers that vehicles are present at the TR210 stop bars. For the purpose of this review the dynamic signage is considered to include a static overhead sign supplemented with flashing beacons. The static sign would provide a “Vehicles Entering When Flashing” message. Loops, radar or video detection equipment would be installed for the TR210 approaches to identify vehicles at the stop bar. Pros and cons are discussed in Table 16

Table 16 Pros and Cons – Intersection Conflict Warning System for Highway 2

Pros	Cons
<ul style="list-style-type: none"> • Intersection warning device. • Activated when vehicles present on TR210 approach. • Increase intersection awareness • Prepare approaching drivers to slow down and/or complete evasive maneuvers. • Heightened awareness and potentially reduced perception/reaction time for Highway 2 drivers. • Approaching vehicles may reduce speed when system is active. • Potential reduction in right angle and rear end collisions. • Reduced collision severity for slower moving vehicles on Highway 2. • Potential to install with solar powered flashers and radio communication between the controller and the flashers. • Could be combined with a Traffic Approaching System on TR210. (additional cost) 	<ul style="list-style-type: none"> • Medium implementation cost. • Highway 2 drivers may not recognize flashing beacons or adjust speed / driving behaviour when beacons flashing. • No warrant system to determine when or where a Traffic Entering System should be installed. • Video cameras may not be suitable detection devices if there are visibility issues (fog) on Highway 2. • If system control is completed with relays and/or simple detection control, the system reliability may be reduced resulting in increased down time. • Failed detection would result in continuously flashing beacons. • If beacons are flashing and approaching Highway 2 traffic does not see vehicles on the TR210 approaches, there is potential that local drivers may ignore the system. • When the flashing beacons are not activated, Highway 2 drivers may have a heightened perceived sense of security and increase their speed believing that no traffic is present at the intersection. • In a power outage, the flashers would not activate, however, drivers are expected to be aware of their driving environment and recognize vehicles at the TR210 intersection approaches.

Intersection Conflict Warning System for Highway 2 Estimated Cost: \$250,000

9.3 Intersection Conflict Warning System for TR210

A Traffic Approaching System could be provided on the TR210 approaches to advise drivers that vehicles are approaching on Highway 2. For the purpose of this review, a variable message sign (VMS) or electronic sign would be side mounted and supplemented with a “When Flashing” tab and flashing beacons. The VMS or electronic sign would provide a “Traffic Approaching” message when vehicles are detected on Highway 2 by loops, radar or video detection equipment. To minimize confusion, the electronic signs would be blank when there are no identified approaching vehicles on Highway 1. Pros and cons are discussed in Table 17.

Table 17: Pros and Cons – Intersection Conflict Warning System for TR210

Pros	Cons
<ul style="list-style-type: none"> • Intersection warning device • Activated when vehicles approaching on Highway 2. • Assist drivers to choose appropriate gaps for crossing and turn movements. • Potential reduction in right angle and rear end collisions. • Potential to install with solar powered detection and radio communication between the controller and detection devices. • Could be combined with a Traffic Entering System on Highway 2. (additional cost) 	<ul style="list-style-type: none"> • Medium implementation cost. • No warrant system to determine when or where Traffic Approaching System should be installed. • Challenging to locate signs within the drivers cone of vision at the stop bar locations on the stop controlled TR210 and median approaches. It is expected that the signs would have to be placed on the far sides of the Highway 2 lanes. Signs for vehicles in the median opening could be blocked by right and left turning vehicles from Highway 2. • Collision severity might not be reduced as system does not provide the potential to alter travel speeds on Highway 2 unless combined with a Traffic Entering System on Highway 2. • Video cameras may not be suitable detection devices if there are visibility issues at the intersection. • If system control is completed with relays and/or simple detection control, the system reliability may be reduced resulting in increased down time. Operational / equipment redundancy should be considered in the system design. • Potential for drivers to become reliant on the system. In the event of system failure or power outage, the system would be inoperable and drivers not knowing the system has malfunctioned





	<p>might continue to follow the direction of the system and assume there is no approaching traffic. An uninterruptible power supply (UPS) would maintain operation of the system for a period of time but would not continue operation for extended power outages or other types of system failure.</p> <ul style="list-style-type: none"> • System may not properly report gaps related to very high speed vehicles on Highway 2. • Failed detection would result in continuously flashing beacons. Continuously flashing beacons could confuse drivers who rely on the system and increase delay on the TR210 approaches. • Potential exposure to legal liability in the event that a driver follows the direction of the system and is involved in a collision.
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Intersection Conflict Warning System for TR210 Estimated Cost: \$200,000 (**NOT RECOMMENDED**)

ISL does not recommend implementation of a Intersection Conflict Warning System for TR210 based on the high traffic volumes on Highway 2 resulting in reducing potential for the system to identify suitable gaps, the risk associated with drivers becoming reliant on the system to make decisions to enter the intersection and the potential for system malfunction and/or power outage.

9.4 Movement Restrictions

9.4.1 Minor Approach Turn Restrictions

This option would restrict left turn and through movements on the TR210 approaches and allow unrestricted movement of the left turns from Highway 2. Turn restrictions could be accomplished by either of the following treatments separately, or by a combination of both treatments:

- Develop divisional islands on the minor approaches to restrict left turn and through movements from the minor approaches while continuing to allow left turns from Highway 2 (Figure 12).
- Convert the existing median opening to a directional median opening that allows left turns from Highway 2 while restricting minor approach left turn and through movements (Figure 13).

The result of both of these options is that the minor approaches would operate as right-in, right-out and the left turns from Highway 2 would continue to be allowed. With no conflicting movements in the median opening, an additional 15 to 20 m would be available for left turn vehicle storage, however, to meet AT guidelines, the parallel lane lengths would need to be extended by 65 m for the southbound left turn lane and 45 m for the northbound left turn lane.



Figure 12: Turn Restrictions Using Divisional Island on Minor Approaches



Figure 13: Turn Restrictions Using Directional Median Opening

Restricted movements could be re-routed as follows:

- Eastbound left turns (up to 82 vehicles in the peak hour) would use Highway 2A and the Highway 2A / Highway 522 interchange as an alternate route to reach their destination. For this movement, the proposed turn restrictions would not result in significant additional trip length.
- Eastbound through movements (up to 31 vehicles in the peak hour) would first complete a right turn and head south to the Highway 7 / Highway 547 interchange, cross the interchange, head north on Highway 2, and then make a right turn at TR210. For this movement, the proposed turn restrictions would result in additional trip length of approximately 13.5 km. Alternately, this movement could use the local road network and Highway 2A to travel to the Highway 2A / Highway 522 interchange, and then cross Highway 2 to access the acreage residential areas on the east side of Highway 2.
- Westbound left turns (up to 3 vehicles in the peak hour) would complete a right turn and head north to the Highway 2A / Highway 522 interchange, cross the interchange, and then head south on Highway 2. For this movement, the proposed turn restrictions would result in additional trip length of approximately 14.9 km.
- Westbound through movements (up to 34 vehicles in the peak hour) would complete a right turn and head north to the Highway 2A / Highway 522 interchange and then use Highway 2A to reach their destination. For this movement, the proposed turn restrictions would result in additional trip length of approximately 18.2 km.

Synchro analysis results based on the HCM 2010 TWSC procedure are shown in Table 18 and Table 19. Synchro reports are provided in Appendix D.

Table 18:: AM Peak Hour Synchro Results – Minor Approach Turn Restrictions

Performance Measure	Northbound			Southbound			Eastbound	Westbound
	L	T	R	L	T	R	R	R
LOS	B	--	--	E	--	--	C*	C*
Delay (s)	14.9	--	--	42.7	--	--	16.5	23.3
V/C	0.06	--	--	0.52	--	--	0.05	0.32
95% Queue (veh)	0.2	--	--	2.6	--	--	0.2	1.3
Intersection LOS / Delay (s)	A / 2.1							

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

Table 19: PM Peak Hour Synchro Results – Minor Approach Turn Restrictions

Performance Measure	Northbound			Southbound			Eastbound	Westbound
	L	T	R	L	T	R	R	R
LOS	B	--	--	C	--	--	C*	C*
Delay (s)	14.8	--	--	22.6	--	--	16.8	18.4
V/C	0.05	--	--	0.14	--	--	0.13	0.19
95% Queue (veh)	0.1	--	--	0.5	--	--	0.4	0.7
Intersection LOS / Delay (s)	A / 0.9							

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

All movements operate at LOS of 'C' or better except for the southbound left turn. Although Synchro indicates the southbound left turn operates at an unacceptable LOS of 'E' in the AM peak hour, restricting the minor approach left turn and through movements may be a viable interim improvement option when the following is considered:

- Under existing conditions, left turns from the highway experience appreciable delay related to the significant volume of conflicting movements in the median opening.
- Restricting minor approach left turn and through movements removes all conflicting traffic flows in the median opening and simplifies the task of completing a highway left turn.
- Without conflicting vehicles in the median opening, the Highway 2 left turn vehicles are able to immediately enter the median opening, choose a gap and cross to TR210.

When Highway 2 traffic volumes reach a point where highway left turns no longer have a sufficient number of safe gaps, highway left turns could be restricted by fully closing the median opening. Based on current traffic volumes, the southbound left turn would operate at a LOS "E", however, less than a 6% increase in northbound traffic volumes would result in a LOS "F" suggesting a potential lifespan of three (3) to five (5) years.

Considering the illumination warrant for this improvement, the warrant score and associated lighting recommendation is dependent on whether the channelization is painted or raised. Results for the illumination warrant are provided in Table 20 and warrant worksheets are included in Appendix E. A collision frequency of 1.0 was used in each scenario. A collision frequency of 2.0 would result in an additional 30 points.



Table 20: Illumination Warrant – Minor Approach Turn Restrictions

Scenario	Warrant Points	Lighting Warranted	Upgrades Required?
Painted Channelization	201	Delineation Lighting	Yes
Raised Channelization	261	Full Illumination	Yes

With painted channelization, delineation lighting is warranted. With raised channelization, full illumination is warranted.

Estimated costs are provided in Table 21. Other improvements that can be paired with the primary improvements are shaded in grey.

Table 21: Estimated Costs – Minor Approach Turn Restrictions

Improvement	Option	Cost
Divisional Islands on Minor Approaches	Painted Channelization	\$10,000
	Raised Channelization	\$180,000
Directional Median Opening	Painted Channelization	\$15,000
	Raised Channelization	\$190,000
Intersection Lighting (<i>required with raised channelization options</i>)	Full Illumination	\$420,000
Extend Northbound Left Deceleration Lane	Minimum Length	\$110,000
Extend Southbound Left Deceleration Lane	Minimum Length	\$150,000
	Desirable Length	\$240,000
Improve Southbound Right Turn Lane	Widen Shoulder	\$120,000
	Desirable Length	\$210,000
Extend Eastbound Right Turn Acceleration Lane	Minimum Length	\$130,000

* Minimum and desirable lengths for turn lane improvements are provided in Table 9 and have been adjusted to account for the 15 to 20 m of additional storage available in the median opening. The desirable length for a deceleration lane allows for all deceleration to take place in the auxiliary lane.

At a minimum, this option requires either divisional islands on the minor approaches or a directional median opening. To discourage restricted movements, raised divisional islands should be installed on either the minor approaches or as part of a directional median opening. The minimum cost for implementing this option is estimated to be in the range of \$600,000, which would include raised divisional islands on the minor approaches and full illumination. An additional \$260,000 would be necessary to complete improvements for the left turn lane storage and tapers.

Pros and cons for minor approach turn restrictions are discussed in Table 22.

Table 22: Pros and Cons – Minor Approach Turn Restrictions

Pros	Cons
<ul style="list-style-type: none"> • Reduced conflicting traffic movements in the median. • Simplified driving task for highway left turns. • Reduces crossing conflicts. • Reduces merge/diverge conflicts. • Reduced “Right Angle” and “Rear End” collisions. • Maintains free flow movement for north-south traffic on Highway 2 (~93% of total entering traffic). • Aligns well with the ultimate plan to close the intersection and develop Highway 2 into a freeway facility. • Provides additional storage space for left turn movements. 	<ul style="list-style-type: none"> • Eliminates minor approach left turn and through movements. • Additional travel distance and time for restricted/re-routed movements. • Roadway hazards introduced with raised channelization. • Medium implementation cost. • Collision statistics included 11 “Right Angle” collisions related to vehicles travelling from the median opening and interacting with Highway 2 through vehicles. Maintaining the median open for left turns from Highway 2 could result in further right angle collisions related to vehicles crossing from the median opening to TR210. • Drivers on the TR210 approaches with a desire to cross or make a left turn may complete a right turn and then an illegal U-turn at an emergency / maintenance median crossover. • Drivers on Highway 2 with a desire to make a left turn onto TR210 might complete an illegal U-turn at an emergency / maintenance median crossover to access the right in. • Increased enforcement may be required at the emergency / maintenance median crossovers. • Maintenance crossovers adjacent to the interchanges may need to be closed to direct traffic to the interchange to complete a U-turn. This will increase travel times for maintenance vehicles.

9.4.2 Full Median Closure

This option would restrict left turns on Highway 2 approaches as well as left turn and through movements on the TR210 approaches. Turn restrictions would be accomplished with complete closure of the median opening, and a painted right-in, right-out divisional island on the minor approaches. A sketch of the full median closure option is provided in Figure 14.

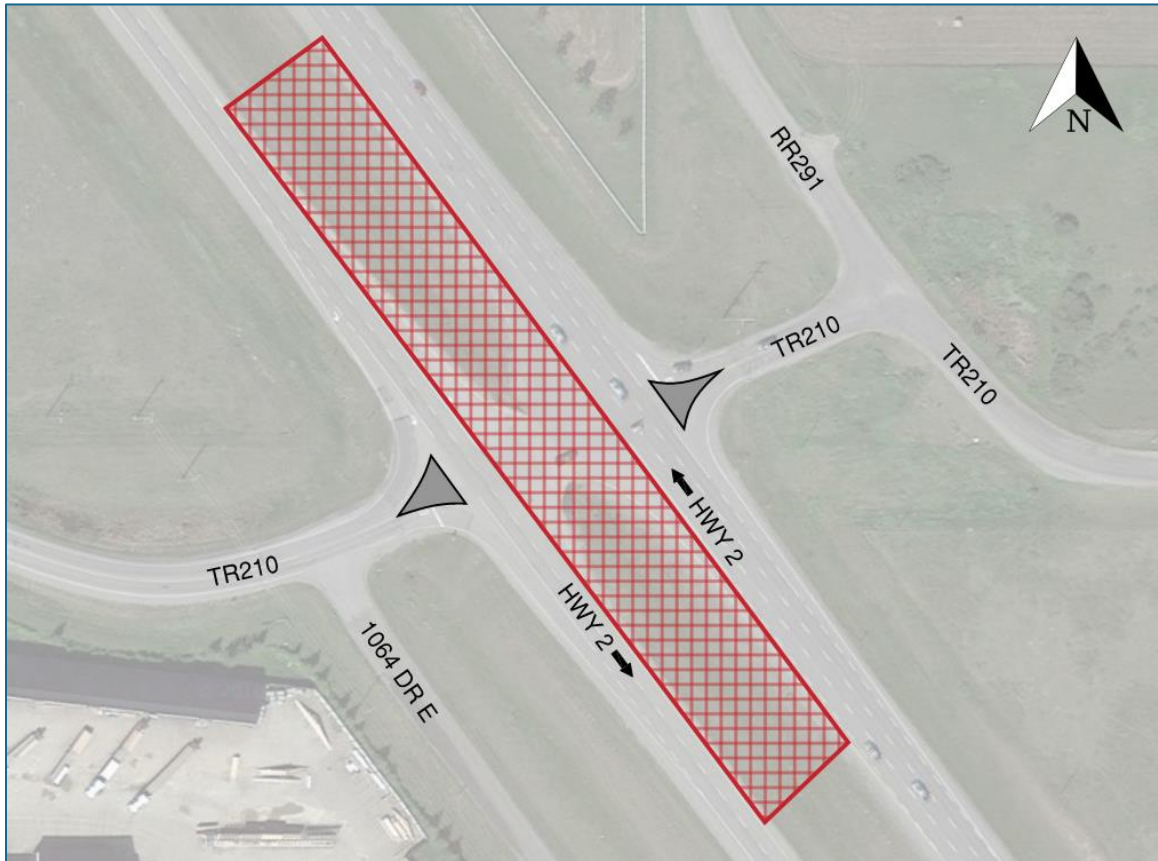


Figure 14: Full Median Closure

Minor approach left turn and through movements could be re-routed in the same way described for the Minor Approach Turn Restrictions option. Highway left turns could be re-routed as follows:

- Northbound left turns (up to 12 vehicles in peak hour) would use the Highway 7 / Highway 547 interchange, Highway 2A and the local road network as an alternate route to their destination. For this movement, closure of the median opening would not significantly add to the overall trip distance, however, the trip duration may increase due to a lower average travel speed.
- Southbound left turns (up to 67 vehicles in peak hour) would use the Highway 2A / Highway 552 interchange, Highway 522 and the local road network (RR290 or RR291) as an alternate route to their destination. For this movement, closure of the median would not significantly add to the overall trip distance, however, the trip duration may increase due to a lower average travel speed.

Synchro analysis results for the HCM 2010 TWSC procedure are shown in Table 23 and Table 24. Synchro reports are provided in Appendix D.

Table 23: AM Peak Hour Synchro Results – Full Median Closure

Performance Measure	Northbound		Southbound		Eastbound	Westbound
	T	R	T	R	R	R
LOS	--	--	--	--	C*	C*
Delay (s)	--	--	--	--	16.5	23.3
V/C	--	--	--	--	0.05	0.32
95% Queue (veh)	--	--	--	--	0.2	1.3
Intersection LOS / Delay (s)	A / 0.7					

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

Table 24: PM Peak Hour Synchro Results – Full Median Closure

Performance Measure	Northbound		Southbound		Eastbound	Westbound
	T	R	T	R	R	R
LOS	--	--	--	--	C*	C*
Delay (s)	--	--	--	--	16.8	18.4
V/C	--	--	--	--	0.13	0.19
95% Queue (veh)	--	--	--	--	0.4	0.7
Intersection LOS / Delay (s)	A / 0.6					

* The minor approaches were considered to be Yield controlled for this analysis. If the right turns were considered to be free flow, the LOS would increase to "A"

All movements except for the eastbound right movement operate at LOS 'C' or better. The overall LOS is improved compared to the Minor Approach Turn Restrictions option.

Implementation of a median closure would eliminate the need for illumination as each minor approach would be restricted to right-in, right-out and would only connect with a one-way direction of Highway 2. Considering the potential warrant points, delineation lighting is only required where it is desirable to illuminate pedestrians or cross street traffic and neither of these conditions would be present for the right-in, right-out intersections.

Estimated costs are provided in Table 25. Other improvements that can be paired with the primary improvements are shaded in grey.

Table 25: Estimated Costs – Full Median Closure

Improvement	Option	Cost
Full Closure of the Median Opening	N/A	\$130,000
Improve Southbound Right Turn Lane	Widen Shoulder	\$120,000
	Desirable Length	\$210,000
Extend Eastbound Right Turn Acceleration Lane	Minimum Length	\$140,000

* Minimum and desirable lengths for turn lane improvements are provided in Table 9. The desirable length for a deceleration lanes allows for all deceleration to take place in the auxiliary lane

As described above, turn restrictions would be accomplished with complete closure of the median opening and painted islands on the minor approaches to direct traffic. The cost for these improvements is estimated to be in the range of \$130,000.



Pros and cons for full median closure are discussed in Table 26.

Table 26: Pros and Cons – Full Median Closure

Pros	Cons
<ul style="list-style-type: none"> • Eliminates all crossing conflict. • Reduces merge/diverge conflicts. • Eliminates “Right Angle” collisions. • Reduces “Rear End” collisions. • Reduced collision severity. • Aligns well with the ultimate plan to close the intersection and develop Highway 2 into a freeway facility. • Basic implementation has relatively low implementation cost. 	<ul style="list-style-type: none"> • Eliminates left turns from Highway 2. • Eliminates minor approach left turn and through movements. • Additional travel distance and time for restricted/re-routed movements. • Drivers on the TR210 approaches with a desire to cross or make a left turn may complete a right turn and then an illegal U-turn at an emergency / maintenance median crossover. • Drivers on Highway 2 with a desire to make a left turn onto TR210 might complete an illegal U-turn at an emergency / maintenance median crossover to access the right in. • Increased enforcement may be required at the emergency / maintenance median crossovers. • Maintenance crossovers adjacent to the interchanges may need to be closed to direct traffic to the interchange to complete a U-turn. This will increase travel times for maintenance vehicles.

9.5 Traffic Signal

A traffic signal is potentially a cost-effective short-term solution to resolve conflicts and congestion at the intersection. The following enhancements are required with a traffic signal:

- Full illumination of the intersection.
- Reduced speed limit of 80 km/h on Highway 2.
- Advance warning flashers.

Synchro analysis results for a traffic signal are shown in Table 27 and Table 28. Synchro reports are provided in Appendix D.

Table 27: AM Peak Hour Synchro Results – Traffic Signal

Performance Measure	Northbound			Southbound			Eastbound	Westbound
	L	T	R	L	T	R	LTR	LTR
LOS	A	B	A	A	B	A	D	C
Delay (s)	5.2	13.0	0.1	9.4	14.0	0.8	48.3	32.7
V/C	0.10	0.58	0.06	0.39	0.70	0.09	0.60	0.59
95% Queue (m)	1.8	79.3	0.0	7.0	104.7	0.0	24.9	18.6
Intersection LOS / Delay (s)	B / 14.6							

Table 28: PM Peak Hour Synchro Results – Traffic Signal

Performance Measure	Northbound			Southbound			Eastbound	Westbound
	L	T	R	L	T	R	LTR	LTR
LOS	A	B	A	A	B	A	D	C
Delay (s)	6.7	13.5	0.1	7.0	16.6	2.4	52.5	21.6
V/C	0.08	0.53	0.02	0.13	0.72	0.18	0.77	0.31
95% Queue (m)	2.3	74.6	0.0	3.4	134.9	7.2	44.2	17.6
Intersection LOS / Delay (s)	B / 16.6							

All movements operate well with acceptable LOS, however, in both the AM and PM peak hours, the eastbound left/through/right movement has a LOS of 'D', which is the maximum acceptable threshold for AT.

The estimated costs for a traffic signal with full illumination and advanced warning flashers is in the range of \$800,000.

Pros and cons for a traffic signal are discussed in Table 29.



Table 29: Pros and Cons – Traffic Signal

Pros	Cons
<ul style="list-style-type: none"> • Alternately assigns right of way between conflicting movements. • Does not restrict any traffic movements. • Reduced collision severity due to lower speed and potential protected left turns. • Reduced sight distance requirements. • Reduced deceleration / acceleration lane length requirements. • Traffic signal and advance warning flashers work as an intersection recognition device for Highway 2 drivers. 	<ul style="list-style-type: none"> • Does not meet the intent of a freeway / expressway roadway classification. • Drivers may not expect to encounter a traffic signal on a freeway / expressway, especially in a rural area. • Improved operation may result in increased minor approach traffic volumes. • Implementation of traffic signal could make future closure of the intersection more difficult due to public expectations. • “Rear End”, “Sideswipe” and “Fixed Object” collisions may increase. • Safety implications related to potential red light running. • Introduction of fixed hazards (poles) within the clear zone. • Speed limit reduction to 80 km/h. • Medium implementation cost.

9.6 Summary

The most prevalent type of collision at the TR210 intersection are “Right Angle” collisions involving a vehicle departing the median and these collisions are distributed almost equally between northbound and southbound Highway 2. The collision information suggests that most drivers are stopping before crossing the highway but are proceeding when it is unsafe. This suggests sight line issues and/or challenging gap selection.

An Intersection Conflict Warning System for Highway 2 could be considered as a short term measure to advise drivers on Highway 2 of potential vehicles entering from TR210. The warning system could increase driver awareness and potentially result in vehicles slowing as they approach the intersection with the result that collision severity could be decreased.

Ultimately, the development of Highway 2 to a freeway will resolve the safety issues identified at this intersection. In the meantime, there are several options that can be considered to reduce conflicts and improve safety at the intersection. These options include a traffic signal, partial median closure, and full median closure. These options resolve identified safety and operational issues at the TR210 intersection, however, they have the potential to introduce new operational and safety issues on the Highway 2 corridor and at adjacent at-grade intersections. Specifically, the partial and full median closure options may require implementation of similar measures at adjacent intersections as well as other steps to eliminate the potential for illegal use of adjacent median crossovers for U-turns.

A traffic signal could provide satisfactory traffic operations and safety for the intersection, however, a traffic signal is not necessarily the best solution for a freeway or a remote high-volume section of highway. Although there are traffic signals on the highway just south of Calgary, they

are a significant distance north of TR210 and drivers are not typically expecting a speed zone reduction or a traffic signal while travelling in a freeway environment. Implementation of a traffic signal could impact highway efficiency and increase “Rear End”, “Side Swipe” and “Fixed Object” collisions. A traffic signal at this location could potentially draw more traffic to the intersection and make future closure of the intersection more difficult. The unexpected speed reduction for Highway 2 drivers could introduce a continued enforcement issue. From the perspective of Highway 2 users, there are better options to improve safety on this stretch of Highway 2 as there are alternate local road connections for the adjacent developed areas. For these reasons, a traffic signal is not recommended at the TR210 intersection.

Restricting minor road left turn and through movements is a viable short-term solution that AT could consider to improve safety and traffic operations. This option is relatively inexpensive and imposes less turn restrictions than full closure of the median, however, gap selection would continue to be a challenge for highway left turns and severe “Right Angle” collisions could still occur. This option may also attract illegal U-turns to the intersection if similar measures are implemented at adjacent at-grade intersections. When Highway 2 traffic volumes reach a point where highway left turns no longer have a sufficient number of safe gaps, highway left turns could be restricted by fully closing the median opening. Based on a review of traffic volumes, it is expected that left turns from Highway 2 could be allowed for three (3) to five (5) years before the southbound left turn movement has a LOS “F”.

Full closure of the median opening appears to offer the most significant safety benefit, has relatively low implementation costs, and aligns best with the ultimate plan to develop the corridor to a freeway. This option would eliminate all crossing conflicts and “Right Angle” collisions, and would significantly reduce the number of conflict points. This option is considered a viable medium to long-term solution and includes improvements related to the ultimate closure of the TR210 intersection approaches (to be implemented when required). Steps will need to be considered to eliminate potential for illegal U-turns at adjacent median crossovers.

ISL recommends that AT initiate full closure of the median opening including, but not limited, to the following:

- Improvements / upgrades required for closure of the median opening.
- Improvements / upgrades required for the TR210 approaches.
- Improvements / upgrades required for deceleration and acceleration lanes.
- Improvements / upgrades required to eliminate potential for illegal U-turns at adjacent median crossovers.
- Public consultation as necessary for the next steps of safety improvements.



Appendix A
Traffic Data



Turning Movement Summary Diagram

North On 2			
Vehicle Type	Vol	%	
A: Passenger Vehicle	24426	88.1	
B: Recreational Vehicle	405	1.5	
C: Bus	12	0.0	
D: Single Unit Truck	777	2.8	
E: Tractor Trailer Unit	2100	7.6	
ASDT	31500	AAADT	27720

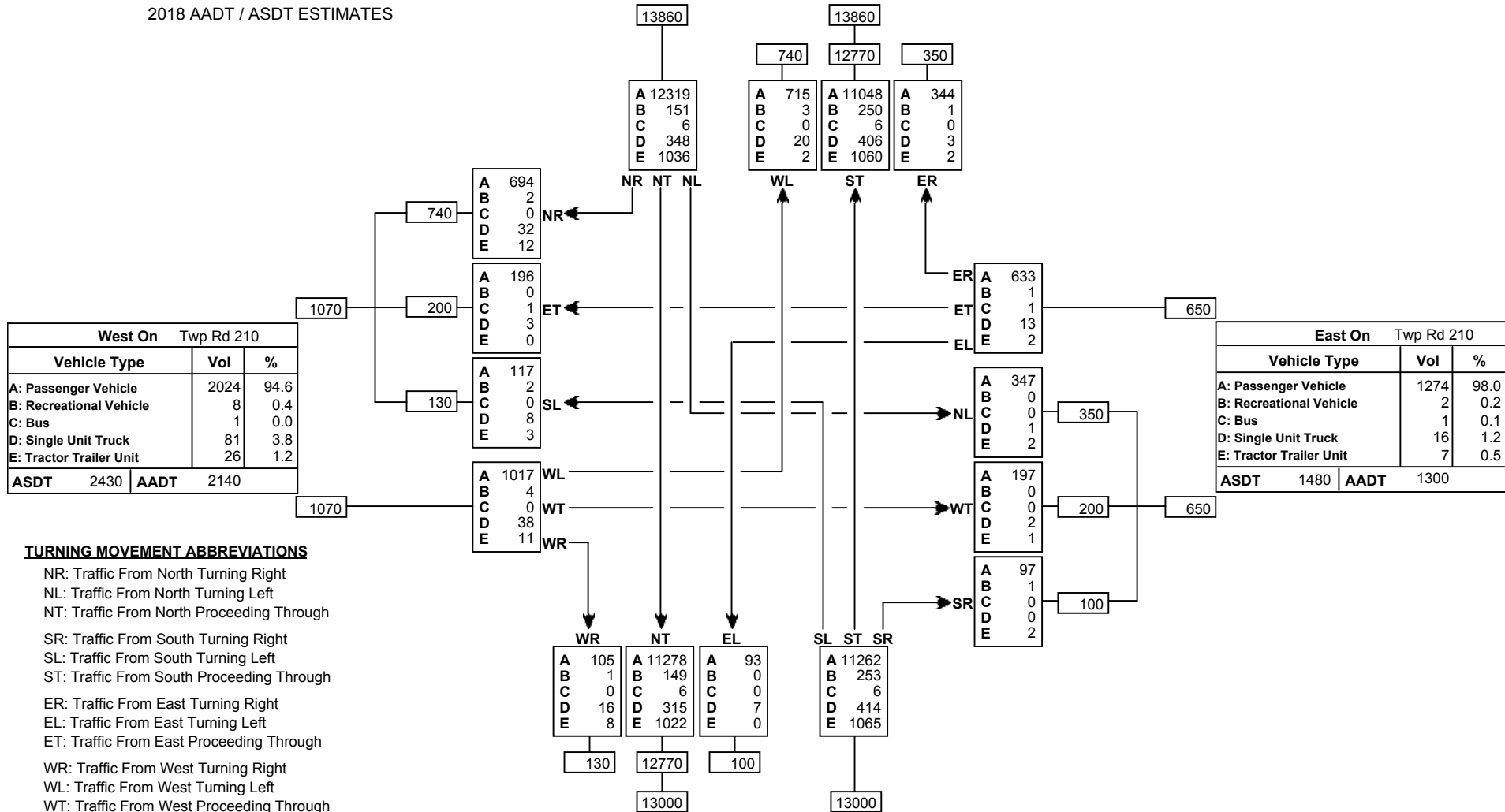
ISL Engineering and Land Services Ltd.

Reference No.: 1000591

Intersection of:

2 & TWP RD 210 (338 AVE E)

2018 AADT / ASDT ESTIMATES



South On 2			
Vehicle Type	Vol	%	
A: Passenger Vehicle	22738	87.5	
B: Recreational Vehicle	403	1.6	
C: Bus	12	0.0	
D: Single Unit Truck	752	2.9	
E: Tractor Trailer Unit	2095	8.1	
ASDT	29550	AAADT	26000

Turning Movement Summary Diagram

North On 2		
Vehicle Type	Vol	%
A: Passenger Vehicle	2373	83.1
B: Recreational Vehicle	65	2.3
C: Bus	1	0.0
D: Single Unit Truck	113	4.0
E: Tractor Trailer Unit	305	10.7
Total	2857	

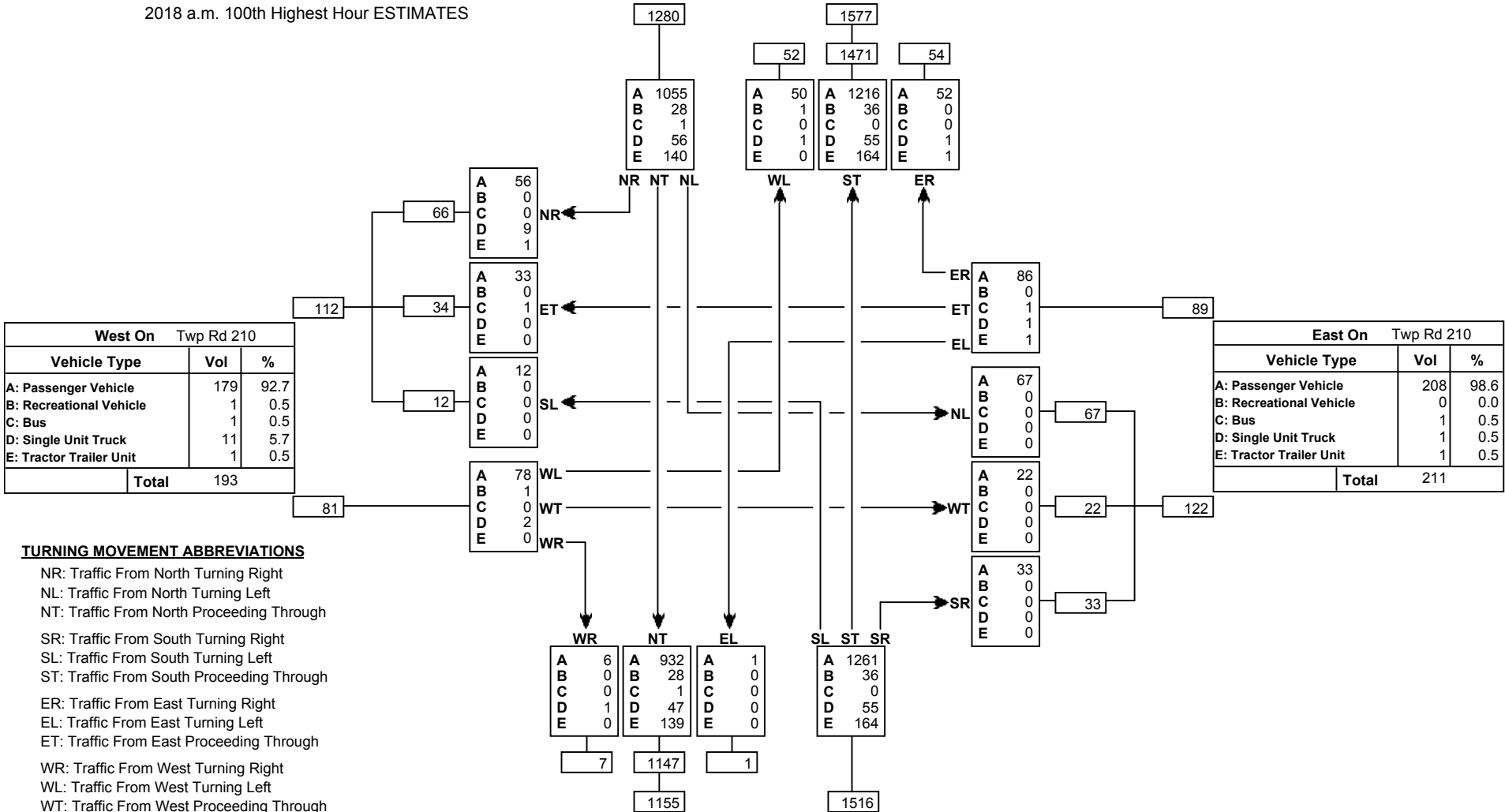
ISL Engineering and Land Services Ltd.

Reference No.: 1000591

Intersection of:

2 & TWP RD 210 (338 AVE E)

2018 a.m. 100th Highest Hour ESTIMATES



West On Twp Rd 210		
Vehicle Type	Vol	%
A: Passenger Vehicle	179	92.7
B: Recreational Vehicle	1	0.5
C: Bus	1	0.5
D: Single Unit Truck	11	5.7
E: Tractor Trailer Unit	1	0.5
Total	193	

East On Twp Rd 210		
Vehicle Type	Vol	%
A: Passenger Vehicle	208	98.6
B: Recreational Vehicle	0	0.0
C: Bus	1	0.5
D: Single Unit Truck	1	0.5
E: Tractor Trailer Unit	1	0.5
Total	211	

TURNING MOVEMENT ABBREVIATIONS

- NR: Traffic From North Turning Right
- NL: Traffic From North Turning Left
- NT: Traffic From North Proceeding Through
- SR: Traffic From South Turning Right
- SL: Traffic From South Turning Left
- ST: Traffic From South Proceeding Through
- ER: Traffic From East Turning Right
- EL: Traffic From East Turning Left
- ET: Traffic From East Proceeding Through
- WR: Traffic From West Turning Right
- WL: Traffic From West Turning Left
- WT: Traffic From West Proceeding Through

South On 2		
Vehicle Type	Vol	%
A: Passenger Vehicle	2200	82.4
B: Recreational Vehicle	64	2.4
C: Bus	1	0.0
D: Single Unit Truck	103	3.9
E: Tractor Trailer Unit	303	11.3
Total	2671	

Turning Movement Summary Diagram

North On 2		
Vehicle Type	Vol	%
A: Passenger Vehicle	2608	91.3
B: Recreational Vehicle	30	1.0
C: Bus	1	0.0
D: Single Unit Truck	76	2.7
E: Tractor Trailer Unit	143	5.0
Total	2858	

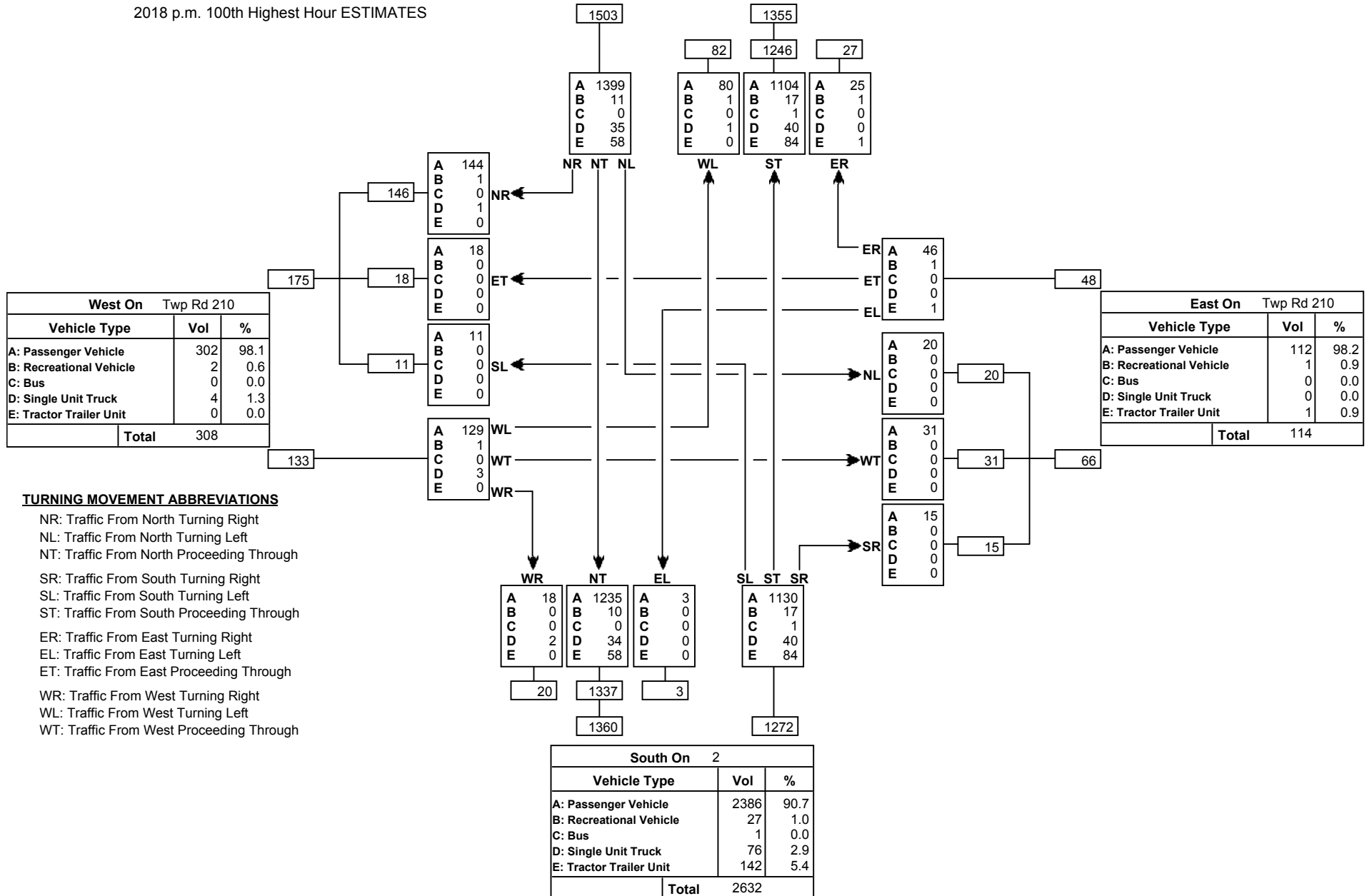
ISL Engineering and Land Services Ltd.

Reference No.: 1000591

Intersection of:

2 & TWP RD 210 (338 AVE E)

2018 p.m. 100th Highest Hour ESTIMATES





Appendix B
NESS Report



Report Notes

Report Name	Hwy 2 and TR 210 Safety
Segments	ALL
Collision Year Range	2012-2016
LRS Provided to Create the Report	Not provided
Intersections Provided to Create the Report	19291-HIGHWAY 2:12 AND TOWNSHIP ROAD 210

Report Contents

Intersection Summary Report

Width Safety Report

Intersection Report

Horizontal Curve Report

Vertical Curve Report

Collision Summary

Traffic Growth

INT Collision History

INT Collision Direction

Intersection Summary Report

LRS	Intersection Site #	Description	Type
2:12 R1 21.448	19291	HIGHWAY 2:12 AND TOWNSHIP ROAD 210	AG

Width Safety Report

Report Notes

Number of results found 2

Collision Cost in \$/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * \$9,120,367) + (sum of collisions involving a serious injury * \$66,744) + (sum of collisions involving a minor injury * \$66,744) + (sum of the property damage only collisions * \$5,851)/km

LRS	Len	Existing			Collision Frequency				Total Rate			Non Animal Rate			Collision Cost (M)			Safety	Region
		WAADT	Width	Paved Y/N	Total	Fatal	Injury	Non Animal	Actual	BM	Δ	Actual	BM	Δ	Actual	BM	Δ	Issues	
2:12 L1 19.960 - 27.778	7.818	27,740	11.80	Y	59	0	17	42	31.6	52.6	21.0	22.5	49.8	27.3	0.177	0.794	0.617	Ne	1
2:12 R1 19.480 - 28.676	9.196	27,722	16.50	Y	99	0	24	75	45.1	45.8	0.7	34.2	38.7	4.5	0.222	1.010	0.788	Ne	1

Intersection Report

Report Notes

- Number of results found 1
- The number of collisions in this report are collisions at and near the intersection and are collisions within the intersection polygon in TIMS
- For details on individual collisions, see the "Collision Details" section within Excel report
- The Signalization Work Activity Trigger is Traffic Score (TS) > 79 or TS >= 60 with 5 or more angle collisions
- Interchange Trigger - Signalization trigger met on Level 1 divided highway with 100+ km/h, or left turn volume >= 700 vehicles per hour
- Collision Cost in \$ (M) over 5 years
- Collision Rate in C/100MEV
- Intersection collision rate is calculated as (sum of intersection collisions over 5 years * 100 Mil) / (sum of AADT entering over 5 years * 365.25)
- Collision cost is calculated as (sum of collisions involving a fatality * \$9,120,367) + (sum of collisions involving a serious injury * \$66,744) + (sum of collisions involving a minor injury * \$66,744) + (sum of the property damage only collisions * \$5,851)
- Va, Vo and VI in VPH
- LT & RT Length in m
- Pk = Peak Hour
- Year LT = Scheduled Year of Left Turn Lane Construction
- Year LTR = Scheduled Year of Left Turn Lane Reconstruction
- Year RT = Scheduled Year of Right Turn Lane Construction
- Year RTR = Scheduled Year of Right Turn Lane Reconstruction

<p>INT #:19291 LRS: 2:12 R1 21.448 Location: HIGHWAY 2:12 AND TOWNSHIP ROAD 210</p> <p>Lv 2 Work Activity Summary Lv 3 Work Activity Summary</p>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td colspan="7" style="text-align: center;"><u>Major Road Details</u></td> <td colspan="4" style="text-align: right;">TMD Ref:</td> <td style="text-align: right;">Veh/day</td> <td style="text-align: right;">Growth</td> </tr> <tr> <td colspan="3">Int. Type: AG</td> <td colspan="4">Posted Speed: 110</td> <td colspan="4">Maj Rd: 2-EB/WB</td> <td style="text-align: right;">27,740</td> <td style="text-align: right;">1.9%</td> </tr> <tr> <td colspan="3">Service Class: LV 1</td> <td colspan="4">Lit: N Sig: N Div: Y Radius:</td> <td colspan="4">Min Rd:</td> <td></td> <td></td> </tr> <tr> <td colspan="7" style="text-align: center;"><u>Collision Frequency</u></td> <td colspan="4" style="text-align: center;"><u>Collision Rate</u></td> <td colspan="2" style="text-align: center;"><u>Collision Cost</u></td> </tr> <tr> <td colspan="2" style="text-align: center;"><u>Total</u></td> <td colspan="2" style="text-align: center;"><u>Fatal</u></td> <td colspan="2" style="text-align: center;"><u>Inj</u></td> <td colspan="2" style="text-align: center;"><u>Non-An</u></td> <td colspan="2" style="text-align: center;"><u>Total</u></td> <td colspan="2" style="text-align: center;"><u>BM</u></td> <td colspan="2" style="text-align: center;"><u>Cost (in \$M)</u></td> <td colspan="2" style="text-align: center;"><u>BM</u></td> </tr> <tr> <td colspan="2" style="text-align: center;">32</td> <td colspan="2" style="text-align: center;">0</td> <td colspan="2" style="text-align: center;">15</td> <td colspan="2" style="text-align: center;">32</td> <td colspan="2" style="text-align: center;">66.5</td> <td colspan="2" style="text-align: center;">69.8</td> <td colspan="2" style="text-align: center;">66.5</td> <td colspan="2" style="text-align: center;">69.6</td> <td colspan="2" style="text-align: center;">1.101</td> <td colspan="2" style="text-align: center;">1.752</td> </tr> <tr> <td><u>Approach</u></td> <td><u>LT Lane</u></td> <td><u>LT Len</u></td> <td><u>LT BM</u></td> <td><u>RT Lane</u></td> <td><u>RT Len</u></td> <td><u>RT BM</u></td> <td><u>Chan</u></td> <td><u>Yr LT</u></td> <td><u>Vo</u></td> <td><u>VI</u></td> <td><u>BM</u></td> <td><u>Va</u></td> <td><u>Undiv BM</u></td> <td><u>Pk</u></td> <td><u>Yr RT</u></td> <td><u>RT AADT</u></td> <td><u>Yr Chan</u></td> <td colspan="2"></td> </tr> <tr> <td>2-EB</td> <td>Y</td> <td style="color: red;">88</td> <td>210</td> <td>Y</td> <td style="color: red;">98</td> <td>210</td> <td>N</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td colspan="2"></td> </tr> <tr> <td>2-WB</td> <td>Y</td> <td style="color: red;">85</td> <td>210</td> <td>Y</td> <td style="color: red;">108</td> <td>210</td> <td>N</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td colspan="2"></td> </tr> <tr> <td><u>Yr Signal</u></td> <td colspan="2"><u>TS</u></td> <td><u>Ang. Coll</u></td> <td colspan="3"><u>Yr IC</u></td> <td><u>TS</u></td> <td><u>LT vph</u></td> <td><u>Yr Light.</u></td> <td><u>Day</u></td> <td><u>Night</u></td> <td><u>N/D Col%</u></td> <td><u>Near VC</u></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td></td> <td colspan="2"></td> <td style="text-align: center;">13</td> <td colspan="3"></td> <td></td> <td></td> <td></td> <td style="text-align: center;">25</td> <td style="text-align: center;">7</td> <td style="text-align: center;">28.00</td> <td style="text-align: center;">Y</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> </table>	<u>Major Road Details</u>							TMD Ref:				Veh/day	Growth	Int. Type: AG			Posted Speed: 110				Maj Rd: 2-EB/WB				27,740	1.9%	Service Class: LV 1			Lit: N Sig: N Div: Y Radius:				Min Rd:						<u>Collision Frequency</u>							<u>Collision Rate</u>				<u>Collision Cost</u>		<u>Total</u>		<u>Fatal</u>		<u>Inj</u>		<u>Non-An</u>		<u>Total</u>		<u>BM</u>		<u>Cost (in \$M)</u>		<u>BM</u>		32		0		15		32		66.5		69.8		66.5		69.6		1.101		1.752		<u>Approach</u>	<u>LT Lane</u>	<u>LT Len</u>	<u>LT BM</u>	<u>RT Lane</u>	<u>RT Len</u>	<u>RT BM</u>	<u>Chan</u>	<u>Yr LT</u>	<u>Vo</u>	<u>VI</u>	<u>BM</u>	<u>Va</u>	<u>Undiv BM</u>	<u>Pk</u>	<u>Yr RT</u>	<u>RT AADT</u>	<u>Yr Chan</u>			2-EB	Y	88	210	Y	98	210	N													2-WB	Y	85	210	Y	108	210	N													<u>Yr Signal</u>	<u>TS</u>		<u>Ang. Coll</u>	<u>Yr IC</u>			<u>TS</u>	<u>LT vph</u>	<u>Yr Light.</u>	<u>Day</u>	<u>Night</u>	<u>N/D Col%</u>	<u>Near VC</u>										13							25	7	28.00	Y						
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Horizontal Curve Report

Report Notes

Number of results found 0

Collision Cost in \$/km (M) over 5 years

Collision Rate in C/100MVKM

Collision rate is calculated as (sum total collisions over 5 years * 100 Mil) / (sum of AADT history for the same 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * \$9,120,367) + (sum of collisions involving a serious injury * \$66,744) + (sum of collisions involving a minor injury * \$66,744) + (sum of the property damage only collisions * \$5,851)/km

e in %

Deflection Angle in degrees

LRS	Len	Exist WAADT	Geometric Analysis						Collision Frequency				Safety Analysis				Work Activity Year		Region
			Type	Actual	BM	Δ	Defl Angle	Int On Curve	Total	Fatal	Injury	Non Animal	Type	Actual	BM	Δ	Safety Assess	Recon	
No data found																			

Vertical Curve Report

Report Notes

Number of results found 0

Gradient in %

Collision Rate in C/100MVKM

Collision rate is calculated as (sum segment collisions over 5 years * 100 Mil) / (sum of AADT 5 years * 365.25 * length (km))

Collision cost is calculated as (sum of collisions involving a fatality * \$9,120,367) + (sum of collisions involving a serious injury * \$66,744) + (sum of collisions involving a minor injury * \$66,744) + (sum of the property damage only collisions * \$5,851)/km

LRS	Len	Existing WAADT	Type	Grad	K-Value					Running Speed			Total Collision Rate		WA Year	Heavy Truck %	Region
					k	3R4R BM	Δ	NC BM	Δ	Estimated	Design	Δ	H Curve	INT			
2:12 L1 21.295 - 21.834	0.539		TAN	0.40													1
2:12 R1 19.694 - 24.117	4.423															13.3	1
2:12 R1 21.170 - 21.588	0.418		TAN	0.60													1
2:12 R1 21.588 - 21.683	0.095		CREST		158												1

Collision Summary

Report Notes

For details on individual collisions, see 'Collision Details' section within the Collision Summary worksheet in the Excel version of this report

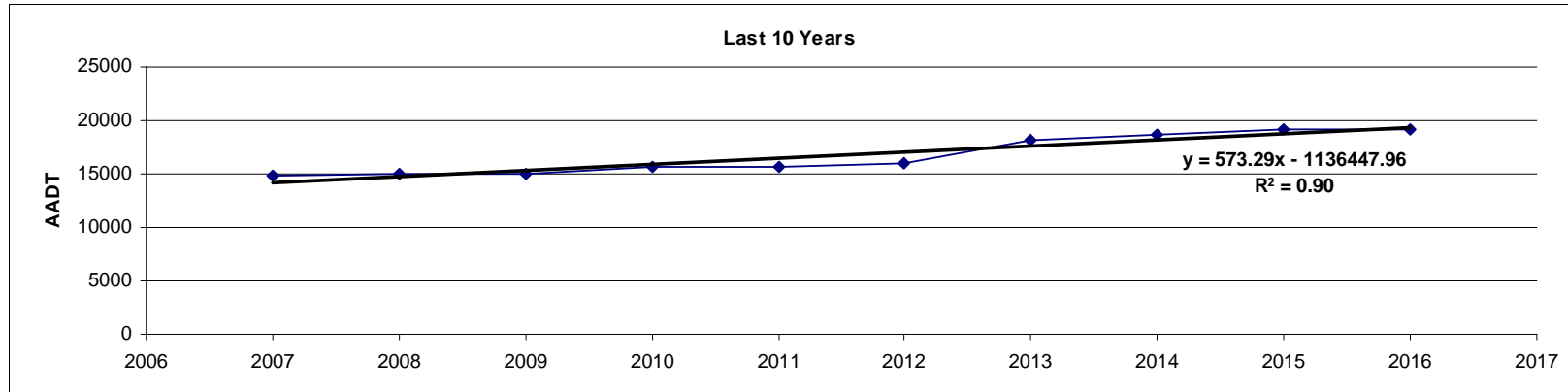
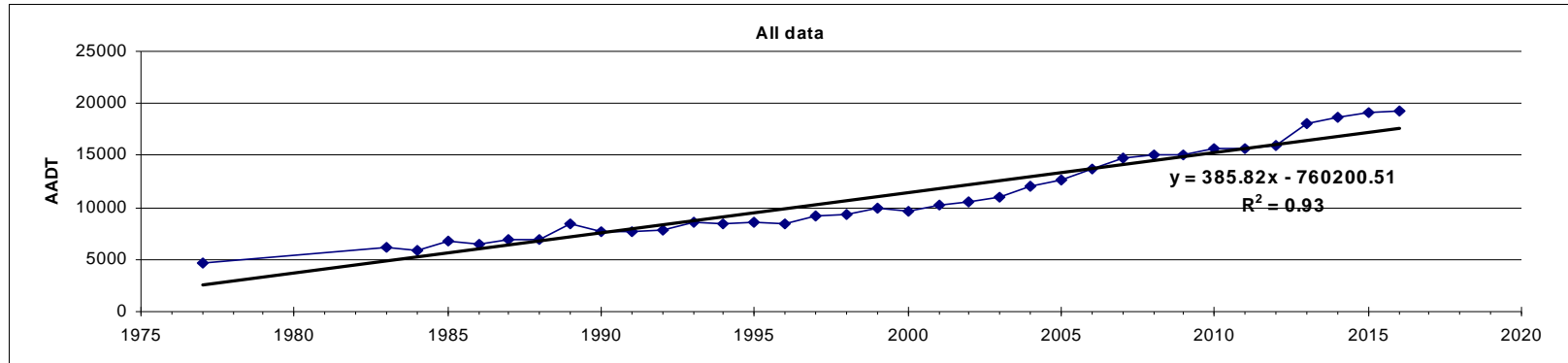
Event	Total				Roadway				Intersection			
	Fatal	Injury	Property Damage Only	Total	Fatal	Injury	Property Damage Only	Total	Fatal	Injury	Property Damage Only	Total
BACKING	0	0	0	0	0	0	0	0	0	0	0	0
HEAD ON	0	0	0	0	0	0	0	0	0	0	0	0
LEFT TURN - ACROSS PATH	0	1	0	1	0	0	0	0	0	1	0	1
OFF ROAD LEFT	0	0	0	0	0	0	0	0	0	0	0	0
OFF ROAD RIGHT	0	3	3	6	0	0	0	0	0	3	3	6
OTHER	0	0	0	0	0	0	0	0	0	0	0	0
PASSING - LEFT TURN	0	0	0	0	0	0	0	0	0	0	0	0
PASSING - RIGHT TURN	0	0	0	0	0	0	0	0	0	0	0	0
REAR END	0	2	5	7	0	0	0	0	0	2	5	7
RIGHT ANGLE	0	8	5	13	0	0	0	0	0	8	5	13
SIDESWIPE - OPPOSITE DIRECTION	0	0	0	0	0	0	0	0	0	0	0	0
SIDESWIPE SAME DIRECTION	0	1	3	4	0	0	0	0	0	1	3	4
STRUCK OBJECT	0	0	1	1	0	0	0	0	0	0	1	1
UNKNOWN	0	0	0	0	0	0	0	0	0	0	0	0
ANIMAL	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	15	17	32	0	0	0	0	0	15	17	32

Traffic Growth

Table of ATR's included within the report by location

Hwy	CS	Label	From	To	ATR #
2	12	L1	19.600	28.669	60021260

ATR NUMBER: 60021260 2:12:L1 km 11.185 4.3 KM S 2 & 7 & 547 ALDERSYDE



Growth rate	Since	Two points	Diff to historical	linear regression	Diff to historical	r square	Year	AADT	ASDT	% diff
Historical:	1977	1.94		2.19		0.929	2016	19,247	21,424	11.3
20 yrs:	1997	2.76	0.82	2.98	0.79	0.974	2015	19,150	21,207	10.7
10 yrs:	2007	2.56	0.62	2.97	0.78	0.902	2014	18,607	20,422	9.8
5 yrs:	2012	4.27	2.33	3.85	1.66	0.806	2013	18,114	20,731	14.4
							2012	15,963	17,775	11.4
							2011	15,697	17,531	11.7
							2010	15,664	17,245	10.1
							2009	15,030	16,947	12.8
							2008	14,987	16,485	10
							2007	14,808	16,247	9.7

Other Calculation	Two points	Diff to historical	linear regression	Diff to historical	r square
Start yr:					
End yr:					
# yr:					

INT Collision History

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Report Notes

Number of results found

1

This Section includes details on the collision history for selected intersections.

**TIMS Network Expansion Support System (NESS)
TIMS Geometric Report**

INT # **19291-1** INT type AT GRADE - TYPE UNKNOWN Region: SOUTHERN REGION INT Effective Date: 01-Oct-00
 Location: **HIGHWAY 2:12 AND TOWNSHIP ROAD 210** Classification: LV 1 Signalized: N Last paved yr: 2012 Divided: Y
 Posted speed: 110 Lit: N Last paved road name: 2 TM number:

NESS Safety Calculations (2012 - 2016)

	Actual	BM	Deltas
Total rate:	66.473	69.8	3.3
Non animal rate:	66.473	69.6	3.1
Collision cost (\$ x M):	1.101	1.752	0.651

Total (ani + non ani)	Non-animal	2012	2013	2014	2015	2016
# Daytime: 25	Daytime	8	4	3	3	7
# Nighttime: 7	Nighttime	1	1	2	3	
	Unknown					

Modify Outliners for Non Animal Collision						
	2012	2013	2014	2015	2016	
F and Maj Inj.	1	1	0	2	2	
Min. Inj.	1.3	1	1	2	2.3	
Non ani	9	5	5	6	7	

Three Similar Collisions Over Five Yrs Period

(excluding off road and animal collision)

Year: 2016
 Prim. evt.: REAR END (7), RIGHT ANGLE (13),
 SIDESWIPE:SAME DIR. (4).

Collision Frequency Over Last 15 Yrs

Severity - non ani.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Last 5 yrs
FATAL					1					1						0
MAJOR	1		1	1			2	2		3	1	1		2	2	6
MINOR	2		1	1	3			1			2	1	1	2	3	9
PDO	1	1	1	1	1	1		2	2	5	6	3	4	2	2	17
TOTAL	4	1	3	3	5	3	0	5	2	9	9	5	5	6	7	32
TOTAL-non ani.	4	1	3	3	5	3	0	5	2	9	9	5	5	6	7	32

Collision Summary Last 5 Yrs (2012 - 2016)

(Non animal collisions)

Month	Freq	Hour	AM	PM	Weekday	Freq
Jan:	3	0:		2	Mon:	6
Feb:	1	1:		2	Tue:	6
Mar:	3	2:		3	Wed:	4
Apr:	2	3:		5	Thu:	3
May:	4	4:		5	Fri:	6
Jun:	4	5:		1	Sat:	4
Jul:	4	6:	1	1	Sun:	3
Aug:	1	7:	3		unknown:	
Sep:	1	8:	2	1		
Oct:	3	9:				
Nov:	2	10:	1	1		
Dec:	4	11:	3	1		
unknown:		unknown:				

Collision event	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Last 5 yrs
ANIMAL																0
BACKING																0
HEAD ON																0
LEFT TURN:ACROSS PATH					1				1			1				1
OFF ROAD LEFT					1											0
OFF ROAD RIGHT											1			3	2	6
OTHER																0
PASSING:LEFT TURN																0
PASSING:RIGHT TURN																0
PEDESTRIAN																0
REAR END					1	1		1	4		1	3	1	2		7
RIGHT ANGLE	4	1	3	1	4	2		4	1	5	6	2	1	2	2	13
SIDESWIPE:OPP DIR																0
SIDESWIPE:SAME DIR											2	1		1		4
STRUCK OBJECT													1			1
UNKNOWN																0

INT polygon yr: 31-Mar-2017

*The number of collision in this report are collisions at and near the intersection and is calculated using intersection polygon in TIMS.
 *Cost of PDO collision had increased from \$1,000 to \$2,000 in 2011

INT Collision Direction

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Report Notes

Number of results found

1

This Section contains information about the direction of collisions occurring at selected intersections.

INT #: 19291 LOCATION: HIGHWAY 2:12 AND TOWNSHIP ROAD 210

2012 - 2016 Collision Objects: Vehicle 1 and 2 Travel Direction Summary

All non animal:	NB	NE	EB	SE	SB	SW	WB	NW	U
FATAL									
MAJOR		4		4				2	
MINOR	1	2	2	5	1		2	4	
PDO	5	3	3	10		3	4	2	
Total	6	9	5	19	1	3	2	10	2

Right angle	NB	NE	EB	SE	SB	SW	WB	NW	U
FATAL									
MAJOR		4		3				1	
MINOR	1	2	1		1		1	2	
PDO	1	1	1	3		3		1	
Total	2	7	2	6	1	3	1	4	0

Left turn across path	NB	NE	EB	SE	SB	SW	WB	NW	U
FATAL									
MAJOR									
MINOR			1				1		
PDO									
Total	0	0	1	0	0	0	1	0	0

Rear end	NB	NE	EB	SE	SB	SW	WB	NW	U
FATAL									
MAJOR									
MINOR				2				2	
PDO	2	2	2	2				2	
Total	2	2	2	4	0	0	0	2	2

Other collisions	NB	NE	EB	SE	SB	SW	WB	NW	U
BACKING	0	0	0	0	0	0	0	0	0
HEAD ON	0	0	0	0	0	0	0	0	0
OFF ROAD LEFT	0	0	0	0	0	0	0	0	0
OFF ROAD RIGHT	0	0	0	5	0	0	0	1	0
OTHER	0	0	0	0	0	0	0	0	0
PASSING:LEFT TURN	0	0	0	0	0	0	0	0	0
PASSING:RIGHT TURN	0	0	0	0	0	0	0	0	0
PEDESTRIAN	0	0	0	0	0	0	0	0	0
SIDESWIPE:OPP DIR	0	0	0	0	0	0	0	0	0
SIDESWIPE:SAME DIR	2	0	0	3	0	0	0	3	0
STRUCK OBJECT	0	0	0	1	0	0	0	0	0
UNKNOWN	0	0	0	0	0	0	0	0	0

Collision with no dir. data # coll

*U: unknown direction



Appendix C
Site Photographs





Advance Local Road Name sign on the north approach.



View of the start of the north approach right turn lane.



Looking north from the north approach right turn lane.

It appears that the length of the southbound right turn lane may have been extended recently using the existing paved shoulder.



Looking toward the intersection from the north approach right turn lane.



Looking toward the intersection from the north approach right turn lane.



Looking north from the north approach right turn lane.

Note that the painted lines from the prior right turn lane configuration were partially visible.



Looking north from the north approach right turn lane.

Note that the shoulder for the deceleration lane appears to be narrow (less than 0.3 m).



Looking north at a truck travelling in the north approach right turn lane.



Looking toward the intersection from the north approach left turn lane.



Looking north from the north approach left turn lane.



Looking north from the median opening.



Looking south from the median opening.



Looking toward the intersection from the south approach right turn lane.



Looking south from the south approach right turn lane.



Looking toward the intersection from the south approach right turn lane.



Looking south from the south approach left turn lane.



Looking toward the intersection from the south approach left turn lane.



At this moment, three (3) vehicles were queued in the northbound left turn lane.



Looking toward the intersection from the west approach.



Transverse rumble strips on the west approach are worn in the wheel paths.



Looking toward the intersection from the Stop Ahead sign and word marking on the west approach.



Looking west from the Reverse Curve sign on the west approach.



Looking toward the intersection from the TR210 / 1064th Drive E intersection.



Looking toward the intersection from the west approach.

Pavement deterioration was evident on the south edge of the west approach and the adjacent area appeared to be heavily travelled.



Looking toward the intersection from the west approach.



View west of the TR210 and 1064th Drive E intersection.

The south edge of TR210 appeared to be heavily travelled from 1064th Drive E to Highway 2.



Pavement deterioration on the south edge of the west approach.



The Stop sign and flashing red light on the west approach.



The double-wide post for the Stop sign and flashing red light on the west approach.

The post appeared to have been installed recently.



View to the north from the eastbound stop line.



View to the south from the eastbound right turn radius.



View of a vehicle stopped on the west approach.

Note that the vehicle on the west approach had pulled forward past the stop line.



View of a vehicle stopped on the west approach.

Note that the vehicle on the west approach had pulled forward past the stop line.



Looking south on
1064th Drive E.



Looking north toward
the TR210 / 1064th
Drive E intersection.



View of Stop sign on
south approach of the
TR210 / 1064th
Drive E intersection.



Looking south at the TR210 / RR291 intersection and west approach from RR291.



Looking north on RR291.



Looking west toward Highway 2 from the Divided Highway sign on the west approach.



Looking north at the TR210 / RR291 intersection.



Looking east toward the TR210 / RR291 intersection on the east approach.



Looking east toward the TR210 / RR291 intersection and the curve on TR210.



Looking toward the intersection from the east approach.



The Stop sign and flashing red light on the east approach.



The double-wide post for the Stop sign and flashing red light on the east approach.

The post appear to have been installed recently.



View to the south from the westbound stop line.



View to the north from the westbound right turn radius.



Looking towards the intersection from the northeast corner of the intersection.

At this moment, the queue length for the northbound left turn lane included four (4) vehicles including three (3) trucks.

During the site visit, a high volume of trucks were observed turning at the intersection.



Looking towards the intersection from the northeast corner of the intersection.

At this moment, the queue length on the west approach included seven (7) vehicles.



Looking towards the intersection from the northeast corner of the intersection.

At this moment, the queue length for the southbound left turn lane included two (2) vehicles.



Looking towards the intersection from the northeast corner of the intersection.

At this moment, four (4) vehicles simultaneously occupy the median opening while a queued southbound left turn vehicle waits for the median opening to clear.



Looking north at the median opening.

At this moment, some vehicles had pulled in to the median opening at an angle to fit in the available space.



Looking north at the median opening.

Side-by-side queuing was observed in the median opening.



Looking north at the median opening.

Deterioration was evident on the south edge of pavement in the median opening.



The One Way sign in the median beside the northbound left turn lane was knocked over.



A delineator guide post beside the southbound left turn lane was knocked out of the ground.



A delineator guide post beside the southbound right turn radius was bent over / flattened.



A memorial marker for a 2011 fatal collision is located on the northeast corner of the intersection, just north of the Stop sign.



Appendix D
Operational Analysis



Intersection												
Int Delay, s/veh	1.2											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕		↕	↑↑↑	↕	↕	↑↑	↕
Traffic Vol, veh/h	52	22	10	10	34	54	12	1471	33	67	1147	66
Future Vol, veh/h	52	22	10	10	34	54	12	1471	33	67	1147	66
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	10	-	10	10	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	70	58	88	58	60	50	94	58	68	79	70
Heavy Vehicles, %	3	2	19	7	2	2	10	13	3	1	12	6
Mvmt Flow	57	31	17	11	59	90	24	1565	57	99	1452	94

Due to an error, reported storage lengths are 10 times larger than those entered into Synchro

Major/Minor	Minor2		Minor1		Major1		Major2					
Conflicting Flow All	2354	3320	726	2553	3357	783	1546	0	0	1622	0	0
Stage 1	1650	1650	-	1613	1613	-	-	-	-	-	-	-
Stage 2	704	1670	-	940	1744	-	-	-	-	-	-	-
Critical Hdwy	7.01	6.54	7.28	7.09	6.54	7.14	4.3	-	-	5.32	-	-
Critical Hdwy Stg 1	6.56	5.54	-	7.44	5.54	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.76	5.54	-	6.64	5.54	-	-	-	-	-	-	-
Follow-up Hdwy	3.68	4.02	3.49	3.72	4.02	3.92	2.3	-	-	3.11	-	-
Pot Cap-1 Maneuver	~ 26	~ 8	331	18	~ 8	289	389	-	-	196	-	-
Stage 1	100	155	-	71	161	-	-	-	-	-	-	-
Stage 2	366	151	-	267	139	-	-	-	-	-	-	-
Platoon blocked, %								-	-	-	-	-
Mov Cap-1 Maneuver	-	~ 4	331	-	~ 4	289	389	-	-	196	-	-
Mov Cap-2 Maneuver	-	~ 4	-	-	~ 4	-	-	-	-	-	-	-
Stage 1	94	77	-	67	151	-	-	-	-	-	-	-
Stage 2	145	142	-	74	69	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s			0.2	2.4
HCM LOS	-	-		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1WBLn1	SBL	SBT	SBR
Capacity (veh/h)	389	-	-	-	196	-	-
HCM Lane V/C Ratio	0.062	-	-	-	0.503	-	-
HCM Control Delay (s)	14.9	-	-	-	40.6	-	-
HCM Lane LOS	B	-	-	-	E	-	-
HCM 95th %tile Q(veh)	0.2	-	-	-	2.5	-	-

Notes
~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

Intersection												
Int Delay, s/veh	0.3											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕		↕	↑↑↑	↕	↕	↑↑	↕
Traffic Vol, veh/h	82	31	20	10	18	27	11	1246	15	20	1337	146
Future Vol, veh/h	82	31	20	10	18	27	11	1246	15	20	1337	146
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	10	-	10	10	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	74	75	45	38	80	64	63	90	71	61	98	82
Heavy Vehicles, %	3	2	19	7	2	2	10	13	3	2	12	6
Mvmt Flow	111	41	44	26	23	42	17	1384	21	33	1364	178

Due to an error, reported storage lengths are 10 times larger than those entered into Synchro

Major/Minor	Minor2		Minor1		Major1		Major2					
Conflicting Flow All	2029	2869	682	2187	3026	692	1542	0	0	1405	0	0
Stage 1	1430	1430	-	1418	1418	-	-	-	-	-	-	-
Stage 2	599	1439	-	769	1608	-	-	-	-	-	-	-
Critical Hdwy	7.01	6.54	7.28	7.09	6.54	7.14	4.3	-	-	5.34	-	-
Critical Hdwy Stg 1	6.56	5.54	-	7.44	5.54	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.76	5.54	-	6.64	5.54	-	-	-	-	-	-	-
Follow-up Hdwy	3.68	4.02	3.49	3.72	4.02	3.92	2.3	-	-	3.12	-	-
Pot Cap-1 Maneuver	~ 45	~ 16	355	33	~ 13	331	390	-	-	248	-	-
Stage 1	137	199	-	98	201	-	-	-	-	-	-	-
Stage 2	425	197	-	340	162	-	-	-	-	-	-	-
Platoon blocked, %								-	-	-	-	-
Mov Cap-1 Maneuver	-	~ 13	355	-	~ 11	331	390	-	-	248	-	-
Mov Cap-2 Maneuver	-	~ 13	-	-	~ 11	-	-	-	-	-	-	-
Stage 1	131	173	-	94	192	-	-	-	-	-	-	-
Stage 2	313	188	-	196	140	-	-	-	-	-	-	-

Approach	EB		WB		NB		SB	
HCM Control Delay, s						0.2		0.5
HCM LOS	-		-					

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1WBLn1	SBL	SBT	SBR
Capacity (veh/h)	390	-	-	-	248	-	-
HCM Lane V/C Ratio	0.045	-	-	-	0.132	-	-
HCM Control Delay (s)	14.7	-	-	-	21.7	-	-
HCM Lane LOS	B	-	-	-	C	-	-
HCM 95th %tile Q(veh)	0.1	-	-	-	0.5	-	-

Notes
 ~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

Intersection												
Int Delay, s/veh	2.1											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↗			↗	↘	↗↗↗	↗	↘	↗↗	↗
Traffic Vol, veh/h	0	0	10	0	0	72	12	1471	55	67	1148	66
Future Vol, veh/h	0	0	10	0	0	72	12	1471	55	67	1148	66
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	0	-	-	0	10	-	10	10	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	58	88	88	79	50	94	75	68	79	70
Heavy Vehicles, %	0	0	19	0	0	3	10	13	2	2	12	6
Mvmt Flow	0	0	17	0	0	91	24	1565	73	99	1453	94

Due to an error, reported storage lengths are 10 times larger than those entered into Synchro

Major/Minor	Minor2	Minor1	Major1	Major2
Conflicting Flow All	-	-	727	-
Stage 1	-	-	-	-
Stage 2	-	-	-	-
Critical Hdwy	-	-	7.28	-
Critical Hdwy Stg 1	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-
Follow-up Hdwy	-	-	3.49	-
Pot Cap-1 Maneuver	0	0	330	0
Stage 1	0	0	-	0
Stage 2	0	0	-	0
Platoon blocked, %	-	-	-	-
Mov Cap-1 Maneuver	-	-	330	-
Mov Cap-2 Maneuver	-	-	-	-
Stage 1	-	-	-	-
Stage 2	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	16.5	23.3	0.2	2.6
HCM LOS	C	C		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	388	-	-	330	287	190	-	-
HCM Lane V/C Ratio	0.062	-	-	0.052	0.318	0.519	-	-
HCM Control Delay (s)	14.9	-	-	16.5	23.3	42.7	-	-
HCM Lane LOS	B	-	-	C	C	E	-	-
HCM 95th %tile Q(veh)	0.2	-	-	0.2	1.3	2.6	-	-

Intersection												
Int Delay, s/veh	0.9											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↗			↗	↘	↗↗↗	↘	↘	↗↗	↘
Traffic Vol, veh/h	0	0	20	0	0	39	11	1246	46	20	1340	146
Future Vol, veh/h	0	0	20	0	0	39	11	1246	46	20	1340	146
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	0	-	-	0	10	-	10	10	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	45	88	88	64	63	90	73	61	97	82
Heavy Vehicles, %	0	0	19	0	0	3	10	13	2	2	12	6
Mvmt Flow	0	0	44	0	0	61	17	1384	63	33	1381	178

Due to an error, reported storage lengths are 10 times larger than those entered into Synchro

Major/Minor	Minor2		Minor1		Major1		Major2					
Conflicting Flow All	-	-	691	-	-	692	1559	0	0	1447	0	0
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.28	-	-	7.16	4.3	-	-	5.34	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.49	-	-	3.93	2.3	-	-	3.12	-	-
Pot Cap-1 Maneuver	0	0	350	0	0	330	384	-	-	237	-	-
Stage 1	0	0	-	0	0	-	-	-	-	-	-	-
Stage 2	0	0	-	0	0	-	-	-	-	-	-	-
Platoon blocked, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	-	350	-	-	330	384	-	-	237	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-

Approach	EB		WB		NB		SB	
HCM Control Delay, s	16.8		18.4		0.2		0.5	
HCM LOS	C		C					

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	384	-	-	350	330	237	-	-
HCM Lane V/C Ratio	0.045	-	-	0.127	0.185	0.138	-	-
HCM Control Delay (s)	14.8	-	-	16.8	18.4	22.6	-	-
HCM Lane LOS	B	-	-	C	C	C	-	-
HCM 95th %tile Q(veh)	0.1	-	-	0.4	0.7	0.5	-	-

Intersection												
Int Delay, s/veh	0.7											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↗			↗		↗↗↗	↗		↗↗	↗
Traffic Vol, veh/h	0	0	10	0	0	72	0	1471	55	0	1148	66
Future Vol, veh/h	0	0	10	0	0	72	0	1471	55	0	1148	66
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	0	-	-	0	-	-	10	-	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	58	88	88	79	88	94	75	88	79	70
Heavy Vehicles, %	0	0	19	0	0	3	2	13	2	2	12	6
Mvmt Flow	0	0	17	0	0	91	0	1565	73	0	1453	94

Due to an error, reported storage lengths are 10 times larger than those entered into Synchro

Major/Minor	Minor2		Minor1		Major1		Major2					
Conflicting Flow All	-	-	727	-	-	783	-	0	0	-	-	0
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.28	-	-	7.16	-	-	-	-	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.49	-	-	3.93	-	-	-	-	-	-
Pot Cap-1 Maneuver	0	0	330	0	0	287	0	-	-	0	-	-
Stage 1	0	0	-	0	0	-	0	-	-	0	-	-
Stage 2	0	0	-	0	0	-	0	-	-	0	-	-
Platoon blocked, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	-	330	-	-	287	-	-	-	-	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-	-	-	-	-

Approach	EB		WB		NB		SB	
HCM Control Delay, s	16.5		23.3		0		0	
HCM LOS	C		C					

Minor Lane/Major Mvmt	NBT	NBR	EBLn1	WBLn1	SBT	SBR
Capacity (veh/h)	-	-	330	287	-	-
HCM Lane V/C Ratio	-	-	0.052	0.318	-	-
HCM Control Delay (s)	-	-	16.5	23.3	-	-
HCM Lane LOS	-	-	C	C	-	-
HCM 95th %tile Q(veh)	-	-	0.2	1.3	-	-

Intersection												
Int Delay, s/veh	0.6											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↗			↗		↑↑↑	↗		↑↑	↗
Traffic Vol, veh/h	0	0	20	0	0	39	0	1246	46	0	1340	146
Future Vol, veh/h	0	0	20	0	0	39	0	1246	46	0	1340	146
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	Yield	-	-	Yield	-	-	None	-	-	None
Storage Length	-	-	0	-	-	0	-	-	10	-	-	1100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	88	88	45	88	88	64	88	90	73	88	97	82
Heavy Vehicles, %	0	0	19	0	0	3	2	13	2	2	12	6
Mvmt Flow	0	0	44	0	0	61	0	1384	63	0	1381	178

Due to an error, reported storage lengths are 10 times larger than those entered into Synchro





















Major/Minor	Minor2		Minor1		Major1		Major2	
Conflicting Flow All	-	-	691	-	-	692	-	0
Stage 1	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-
Critical Hdwy	-	-	7.28	-	-	7.16	-	-
Critical Hdwy Stg 1	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	-	-	-	-	-
Follow-up Hdwy	-	-	3.49	-	-	3.93	-	-
Pot Cap-1 Maneuver	0	0	350	0	0	330	0	-
Stage 1	0	0	-	0	0	-	0	-
Stage 2	0	0	-	0	0	-	0	-
Platoon blocked, %	-	-	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	-	350	-	-	330	-	-
Mov Cap-2 Maneuver	-	-	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	16.8	18.4	0	0
HCM LOS	C	C		

Minor Lane/Major Mvmt	NBT	NBR	EBLn1WBLn1	SBT	SBR
Capacity (veh/h)	-	-	350	330	-
HCM Lane V/C Ratio	-	-	0.127	0.185	-
HCM Control Delay (s)	-	-	16.8	18.4	-
HCM Lane LOS	-	-	C	C	-
HCM 95th %tile Q(veh)	-	-	0.4	0.7	-

Lanes, Volumes, Timings
3: Hwy 2 & TR210

AM Traffic Signal
01-07-2019

												
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	52	22	10	10	34	54	12	1471	33	67	1147	66
Future Volume (vph)	52	22	10	10	34	54	12	1471	33	67	1147	66
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		15.0	0.0		0.0	50.0		1.0	50.0		110.0
Storage Lanes	0		0	0		0	1		1	1		1
Taper Length (m)	7.5			7.5			30.0			30.0		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	1.00	1.00	0.95	1.00
Frt		0.978			0.924				0.850			0.850
Flt Protected		0.974			0.997		0.950			0.950		
Satd. Flow (prot)	0	1719	0	0	1710	0	1641	4590	1568	1770	3223	1524
Flt Permitted		0.725			0.968		0.125			0.115		
Satd. Flow (perm)	0	1279	0	0	1661	0	216	4590	1568	214	3223	1524
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		9			60				139			139
Link Speed (k/h)		80			80			110			110	
Link Distance (m)		443.3			118.4			628.3			632.6	
Travel Time (s)		19.9			5.3			20.6			20.7	
Peak Hour Factor	0.92	0.70	0.58	0.88	0.58	0.60	0.50	0.94	0.58	0.68	0.79	0.70
Heavy Vehicles (%)	3%	2%	19%	7%	2%	2%	10%	13%	3%	2%	12%	6%
Adj. Flow (vph)	57	31	17	11	59	90	24	1565	57	99	1452	94
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	105	0	0	160	0	24	1565	57	99	1452	94
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		0.0			0.0			32.0			32.0	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.8			4.8			4.8			4.8	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Turn Type	Perm	NA		Perm	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2		2	6		6
Detector Phase	4	4		8	8		5	2	2	1	6	6
Switch Phase												
Minimum Initial (s)	10.0	10.0		10.0	10.0		5.0	20.0	20.0	5.0	20.0	20.0
Minimum Split (s)	18.5	18.5		18.5	18.5		11.0	26.5	26.5	11.0	26.5	26.5
Total Split (s)	21.0	21.0		21.0	21.0		12.0	57.0	57.0	12.0	57.0	57.0
Total Split (%)	23.3%	23.3%		23.3%	23.3%		13.3%	63.3%	63.3%	13.3%	63.3%	63.3%
Maximum Green (s)	12.5	12.5		12.5	12.5		6.0	50.5	50.5	6.0	50.5	50.5
Yellow Time (s)	5.0	5.0		5.5	5.5		5.0	5.0	5.0	5.0	5.0	5.0
All-Red Time (s)	3.5	3.5		3.0	3.0		1.0	1.5	1.5	1.0	1.5	1.5
Lost Time Adjust (s)		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)		8.5			8.5		6.0	6.5	6.5	6.0	6.5	6.5
Lead/Lag							Lead	Lag	Lag	Lead	Lag	Lag
Lead-Lag Optimize?							Yes	Yes	Yes	Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Recall Mode	None	None		None	None		None	Max	Max	None	Max	Max

Lanes, Volumes, Timings
3: Hwy 2 & TR210

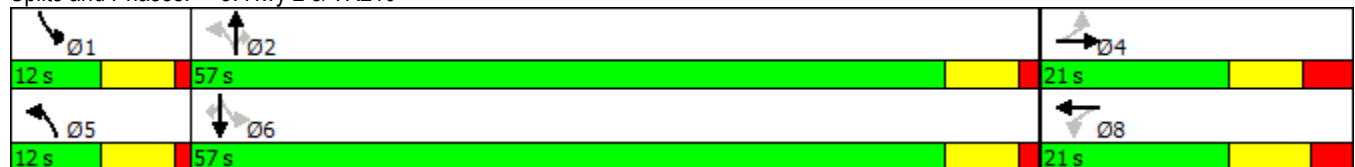
AM Traffic Signal
01-07-2019

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Act Effct Green (s)		11.4			11.4		55.8	50.7	50.7	58.2	55.4	55.4
Actuated g/C Ratio		0.13			0.13		0.65	0.59	0.59	0.67	0.64	0.64
v/c Ratio		0.60			0.59		0.10	0.58	0.06	0.39	0.70	0.09
Control Delay		48.3			32.7		5.2	13.0	0.1	9.4	14.0	0.8
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		48.3			32.7		5.2	13.0	0.1	9.4	14.0	0.8
LOS		D			C		A	B	A	A	B	A
Approach Delay		48.3			32.7			12.5			12.9	
Approach LOS		D			C			B			B	
Queue Length 50th (m)		16.5			16.9		1.1	63.6	0.0	4.8	64.7	0.0
Queue Length 95th (m)		24.9			18.6		1.8	79.3	0.0	7.0	104.7	0.0
Internal Link Dist (m)		419.3			94.4			604.3			608.6	
Turn Bay Length (m)							50.0		1.0	50.0		110.0
Base Capacity (vph)		193			292		238	2692	977	252	2065	1026
Starvation Cap Reductn		0			0		0	0	0	0	0	0
Spillback Cap Reductn		0			0		0	0	0	0	0	0
Storage Cap Reductn		0			0		0	0	0	0	0	0
Reduced v/c Ratio		0.54			0.55		0.10	0.58	0.06	0.39	0.70	0.09

Intersection Summary





















Area Type:	Other
Cycle Length:	90
Actuated Cycle Length:	86.5
Natural Cycle:	70
Control Type:	Semi Act-Uncoord
Maximum v/c Ratio:	0.70
Intersection Signal Delay:	14.6
Intersection LOS:	B
Intersection Capacity Utilization:	64.7%
ICU Level of Service:	C
Analysis Period (min):	15

Splits and Phases: 3: Hwy 2 & TR210



Lanes, Volumes, Timings
3: Hwy 2 & TR210

PM Traffic Signal
01-07-2019

												
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	82	31	20	10	18	27	11	1246	15	20	1337	146
Future Volume (vph)	82	31	20	10	18	27	11	1246	15	20	1337	146
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0		15.0	0.0		0.0	50.0		1.0	50.0		110.0
Storage Lanes	0		0	0		0	1		1	1		1
Taper Length (m)	7.5			7.5			30.0			30.0		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	1.00	1.00	0.95	1.00
Frt		0.970			0.938				0.850			0.850
Flt Protected		0.972			0.986		0.950			0.950		
Satd. Flow (prot)	0	1684	0	0	1699	0	1641	4590	1568	1770	3223	1524
Flt Permitted		0.774			0.846		0.126			0.147		
Satd. Flow (perm)	0	1341	0	0	1458	0	218	4590	1568	274	3223	1524
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		14			42				139			178
Link Speed (k/h)		80			80			110			110	
Link Distance (m)		443.3			118.4			628.3			632.6	
Travel Time (s)		19.9			5.3			20.6			20.7	
Peak Hour Factor	0.74	0.75	0.45	0.38	0.80	0.64	0.63	0.90	0.71	0.61	0.98	0.82
Heavy Vehicles (%)	3%	2%	19%	7%	2%	2%	10%	13%	3%	2%	12%	6%
Adj. Flow (vph)	111	41	44	26	23	42	17	1384	21	33	1364	178
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	196	0	0	91	0	17	1384	21	33	1364	178
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(m)		0.0			0.0			32.0			32.0	
Link Offset(m)		0.0			0.0			0.0			0.0	
Crosswalk Width(m)		4.8			4.8			4.8			4.8	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (k/h)	25		15	25		15	25		15	25		15
Turn Type	Perm	NA		Perm	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2		2	6		6
Detector Phase	4	4		8	8		5	2	2	1	6	6
Switch Phase												
Minimum Initial (s)	10.0	10.0		10.0	10.0		5.0	20.0	20.0	5.0	20.0	20.0
Minimum Split (s)	18.5	18.5		18.5	18.5		11.0	26.5	26.5	11.0	26.5	26.5
Total Split (s)	26.0	26.0		26.0	26.0		11.0	53.0	53.0	11.0	53.0	53.0
Total Split (%)	28.9%	28.9%		28.9%	28.9%		12.2%	58.9%	58.9%	12.2%	58.9%	58.9%
Maximum Green (s)	17.5	17.5		17.5	17.5		5.0	46.5	46.5	5.0	46.5	46.5
Yellow Time (s)	5.0	5.0		5.5	5.5		5.0	5.0	5.0	5.0	5.0	5.0
All-Red Time (s)	3.5	3.5		3.0	3.0		1.0	1.5	1.5	1.0	1.5	1.5
Lost Time Adjust (s)		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)		8.5			8.5		6.0	6.5	6.5	6.0	6.5	6.5
Lead/Lag							Lead	Lag	Lag	Lead	Lag	Lag
Lead-Lag Optimize?							Yes	Yes	Yes	Yes	Yes	Yes
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Recall Mode	None	None		None	None		None	Max	Max	None	Max	Max

Lanes, Volumes, Timings
3: Hwy 2 & TR210

PM Traffic Signal
01-07-2019

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Act Effect Green (s)		15.0			15.0		50.3	47.0	47.0	51.4	49.0	49.0
Actuated g/C Ratio		0.18			0.18		0.60	0.56	0.56	0.62	0.59	0.59
v/c Ratio		0.77			0.31		0.08	0.53	0.02	0.13	0.72	0.18
Control Delay		52.5			21.6		6.7	13.5	0.1	7.0	16.6	2.4
Queue Delay		0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		52.5			21.6		6.7	13.5	0.1	7.0	16.6	2.4
LOS		D			C		A	B	A	A	B	A
Approach Delay		52.5			21.6			13.3			14.8	
Approach LOS		D			C			B			B	
Queue Length 50th (m)		31.3			7.5		1.0	60.4	0.0	2.0	73.4	0.0
Queue Length 95th (m)		44.2			17.6		2.3	74.6	0.0	3.4	134.9	7.2
Internal Link Dist (m)		419.3			94.4			604.3			608.6	
Turn Bay Length (m)							50.0		1.0	50.0		110.0
Base Capacity (vph)		295			342		218	2589	945	259	1897	970
Starvation Cap Reductn		0			0		0	0	0	0	0	0
Spillback Cap Reductn		0			0		0	0	0	0	0	0
Storage Cap Reductn		0			0		0	0	0	0	0	0
Reduced v/c Ratio		0.66			0.27		0.08	0.53	0.02	0.13	0.72	0.18

Intersection Summary

Area Type: Other
 Cycle Length: 90
 Actuated Cycle Length: 83.3
 Natural Cycle: 75
 Control Type: Semi Act-Uncoord
 Maximum v/c Ratio: 0.77
 Intersection Signal Delay: 16.6
 Intersection Capacity Utilization 63.5%
 Analysis Period (min) 15

Intersection LOS: B
 ICU Level of Service B

Splits and Phases: 3: Hwy 2 & TR210





Appendix E
Warrants





Alberta Transportation - Traffic Signal Warrant Analysis

Main Street (name)	Highway 2	Direction (EW or NS)	NS
Side Street (name)	TR210	Direction (EW or NS)	EW
Quadrant / Int #	19291	Comments	6-Hour Peak: 2.78 x (AM + PM DHV)
for Warrant Calculation Results, please hit 'Page Down'	CHECK SHEET		

Road Authority:	Alberta Transportation
City:	3.2 km E of Okotoks, AB
Analysis Date:	2018 Nov 28, Wed
Count Date:	2018 100th Highest Hour
Date Entry Format:	(yyyy-mm-dd)

Lane Configuration		Excl LT	Th & LT	Through	Th+RT+LT	Th & RT	Excl RT	UpStream Signal (m)	# of Thru Lanes
Highway 2	NB	1		3			1	9,999	3
Highway 2	SB	1		2			1	9,999	2
TR210	WB				1				
TR210	EB				1				

Are the TR210 WB right turns significantly impeded by through movements? (y/n) **y**
 Are the TR210 EB right turns significantly impeded by through movements? (y/n) **y**

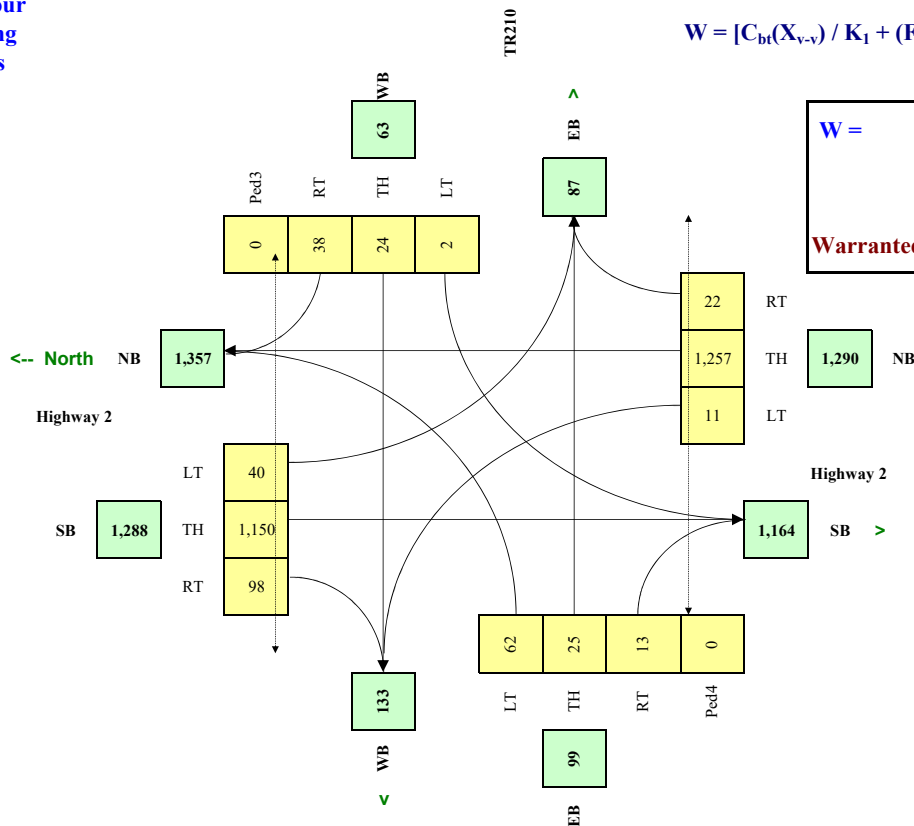
Demographics		
Elem. School/Mobility Challenged	(y/n)	n
Senior's Complex	(y/n)	n
Pathway to School	(y/n)	n
Metro Area Population	(#)	28,900
Central Business District	(y/n)	n

Other input		Speed (Km/h)	Truck %	Bus Rt (y/n)	Median (m)
Highway 2	NS	110	13.0%	n	32.0
TR210	EW		5.0%	n	

Traffic Input	Set Peak Hours												Ped1	Ped2	Ped3	Ped4	
	NB			SB			WB			EB			NS	NS	EW	EW	
	LT	Th	RT	LT	Th	RT	LT	Th	RT	LT	Th	RT	W Side	E Side	N Side	S Side	
press 'Set Peak Hours' Button to set the peak hour periods																	
	64	7544	133	242	6897	589	11	144	225	372	147	75	0	0	0	0	
Total (6-hour peak)	64	7,544	133	242	6,897	589	11	144	225	372	147	75	0	0	0	0	
Average (6-hour peak)	11	1,257	22	40	1,150	98	2	24	38	62	25	13	0	0	0	0	

Average 6-hour Peak Turning Movements

$$W = [C_{bt}(X_{v-v}) / K_1 + (F(X_{v-p}) L) / K_2] \times C_i$$



W =	187	187	0
		<i>Veh</i>	<i>Ped</i>

Warranted

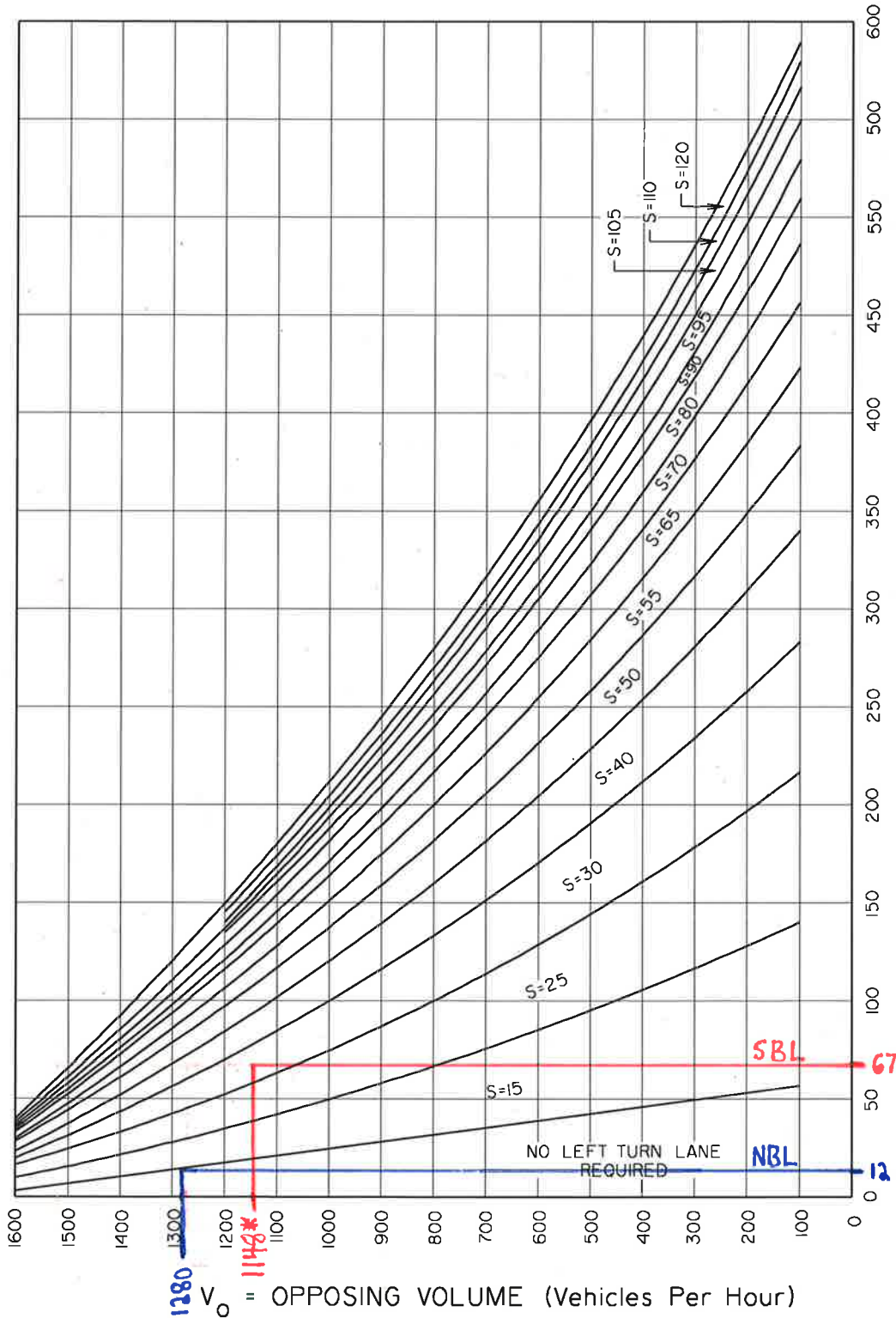
RESET SHEET

Hwy 2 at TR210

AM 100th Highest Hour Traffic Volumes (2018)

Analysis Date: Apr 4, 2019

FIGURE D-8.6c WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR FOUR-LANE DIVIDED HIGHWAYS

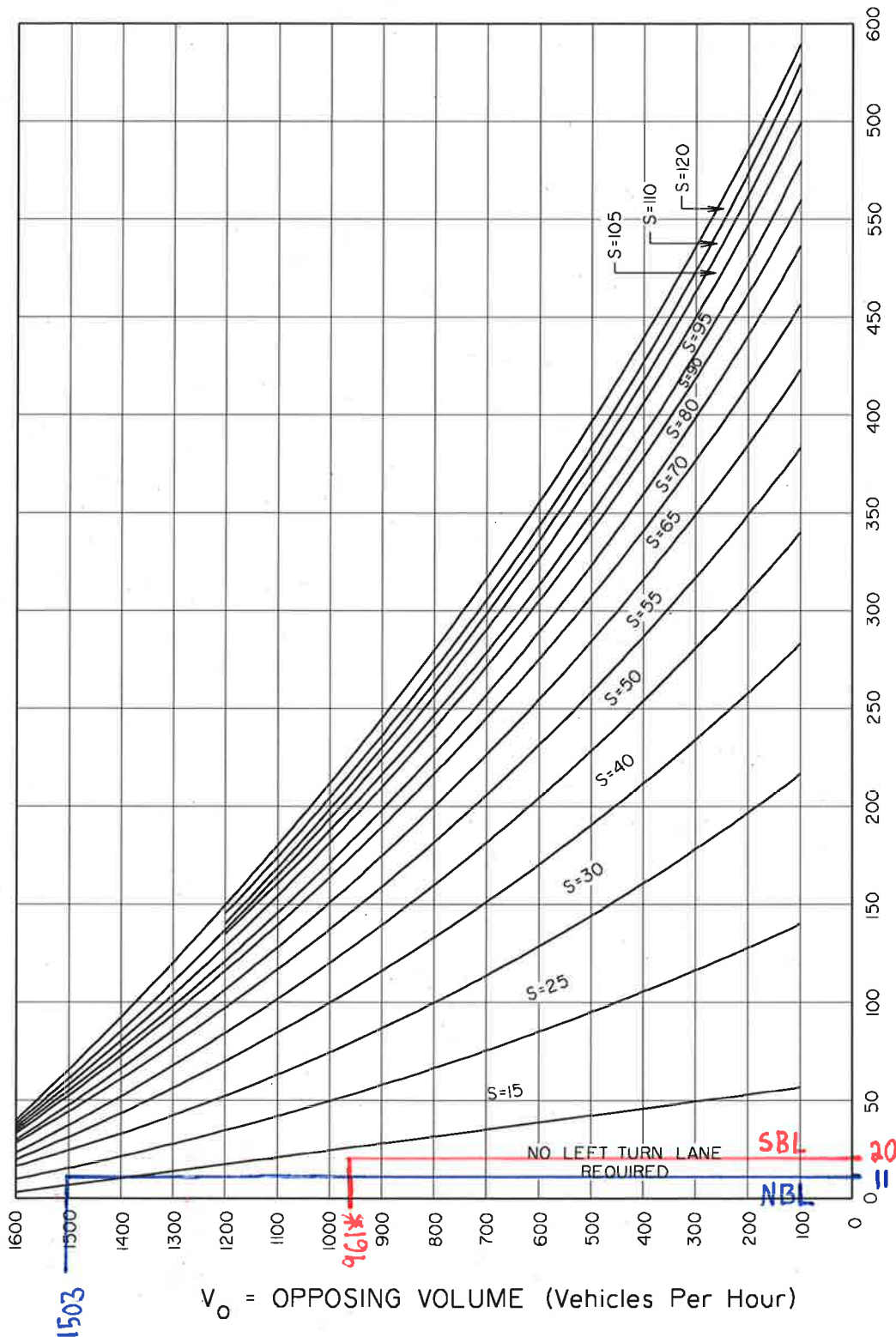


* Adjusted opposing volume for SBL as the left turns cross 3 lanes and the chart is based on left turns crossing 2 lanes. Adjusted opposing volume to only include through volumes from the 2 right-most through lanes plus the left and right turns. Assumed a 40/35/25 split (right to left) for lane utilization. $V_o = 12 + 1471(0.40 + 0.35) + 33 = 1148$

1148

Hwy 2 at TR210
PM 100th Highest Hour Traffic Volumes (2018)
Analysis Date: Apr 4, 2019

FIGURE D-8.6c WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR FOUR-LANE DIVIDED HIGHWAYS



* Adjusted opposing volume for SBL in same manner as described for AM 100th Highest Hour analysis.

$$V_o = 11 + 12.46(0.40 + 0.35) + 15 = 961$$

Illumination of Isolated Rural Intersections

LIGHTING WARRANT SPREADSHEET

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Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 210	Minor Road
Okotoks, AB	City/Town

Date	January 8, 2019
Other	Existing Conditions Scenario: Collision Frequency of 1.0

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	3		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	15
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	100			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
	Posted Speed Category =	0				
	Posted Speed Category =	0				
	Posted Speed Category =	C	4			
	Posted Speed Category =	0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	80	1	5		OK	5
Downhill Approach Grade (x.x%)	0.4	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
Geometric Factors Subtotal						46

OPERATIONAL FACTORS

Is the intersection signalized ? (Y / N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	27720	4	10		OK	40
AADT on Minor Road (2-way)	2140	4	20	Either Use the two AADT inputs OR the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	80
Signalization Warrant	Descriptive	0	30		OK	0
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
Operational Factors Subtotal						175

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
Environmental Factor Subtotal						0

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter either the annual frequency (See Table 1(C), note #4) OR the number of collisions / MEV	OK	15
OR				(Unused values should be set to Zero)		
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0		OK	0
Is the average ratio of all night to day collisions >= 1.5 (Y/N)	n	0			OK	
Collision History Subtotal						15

Check Intersection Signalization:
Intersection is not Signalized

ILLUMINATION WARRANTED
DELINEATION LIGHTING TO ILLUMINATE PEDESTRIANS OR
CROSS STREET TRAFFIC

SUMMARY

Geometric Factors Subtotal	46
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	15

TOTAL POINTS **236**

Illumination of Isolated Rural Intersections

LIGHTING WARRANT SPREADSHEET

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Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 210	Minor Road
Okotoks, AB	City/Town

Date	January 8, 2019
Other	Existing Conditions Scenario: Collision Frequency of 2.0

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	3		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	15
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	100			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
	Posted Speed Category =	0				
	Posted Speed Category =	0				
	Posted Speed Category =	C	4			
	Posted Speed Category =	0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	80	1	5		OK	5
Downhill Approach Grade (x.x%)	0.4	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
Geometric Factors Subtotal						46

OPERATIONAL FACTORS

Is the intersection signalized? (Y / N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	27720	4	10		OK	40
AADT on Minor Road (2-way)	2140	4	20	Either Use the two AADT inputs OR the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	80
Signalization Warrant	Descriptive	0	30		OK	0
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
Operational Factors Subtotal						175

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
Environmental Factor Subtotal						0

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	2.0	3	15	Enter either the annual frequency (See Table 1(C), note #4) OR the number of collisions / MEV	OK	45
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0	(Unused values should be set to Zero)	OK	0
Is the average ratio of all night to day collisions >= 1.5 (Y/N)	n	0			OK	
Collision History Subtotal						45

Check Intersection Signalization:
Intersection is not Signalized

FULL ILLUMINATION WARRANTED

SUMMARY

Geometric Factors Subtotal	46
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	45

TOTAL POINTS **266**

HIGHWAY 2 & TWP RD 210 Existing Conditions

TABLE 1(A) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: GEOMETRIC FACTORS

Classification Factor	Rating					Weight		Score (Rating x Weight)
	0	1	2	3	4			
channelization	none	right and/or left turn lanes on minor approach only	right turn lane(s) only on major leg(s)	left turn lane(s) on major leg(s)	left and right turn lanes on all legs	raised and operating speed less than 70 km/h on at least one channelized approach OR	15	
				raised and operating speed 70 km/h or more on at least one channelized approach OR		20		
				painted only		5		
approach sight distance on the most constrained approach (relative to recommended minimum intersection sight distance)	100% or more	75% - 99%	50% - 74%	25% - 49%	<25%	10		
horizontal curvature (radius) at or immediately before intersection on any leg for posted speed limit of:								
110 km/h	tangent	>1,800m	1,150 to 1,800m	750 to 1,150m	<750m			
90 or 100 km/h	tangent	>1,400m	950 to 1,400m	600 to 950m	<600m			
70 or 80 km/h	tangent	>950m	550 to 950m	340 to 550m	<340m			
60 km/h	tangent	>575m	320 to 575m	190 to 320m	<190m	5		
angle of intersection OR offset intersection	90° angle	80° or 100° angle	--	70° or 110° angle	<70° or >110° OR offset intersection	5		
downhill approach grades at or immediately before intersection on any leg	<3.0%	3.1 to 3.9% and meets design guidelines for type and speed of road	4.0 to 4.9% and meets design guidelines for type and speed of road	5.0 to 7.0% and meets design guidelines for type and speed of road	>7.0% OR exceeds maximum gradient for the type and speed of road	3		
number of legs	--	3	4	5	6 or more	3		
SUBTOTAL (Geometric Factors)								

TABLE 1(B) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: OPERATIONAL FACTORS

Classification Factor	Rating					Weight	Score (Rating x Weight)
	0	1	2	3	4		
IF THE INTERSECTION IS SIGNALIZED, ILLUMINATION IS WARRANTED.							
IF THE INTERSECTION IS NOT SIGNALIZED, points should be calculated on the basis of <i>either</i> the AADT factor <i>or</i> the signalization warrant factor:							
either							
AADT (2-way) ¹ :							
on major road and	<1,000	1,000 to 2,000	2,000 to 3,000	3,000 to 5,000	>5,000	10	
on minor road	<500	500 to 1,000	1,000 to 1,500	1,500 to 2,000	>2,000	20	
or							
signalization warrant ¹	intersection not signalized and volume-based signal warrant is less than 20% satisfied	intersection not signalized and volume-based warrant is 20% to 40% satisfied	intersection not signalized and volume-based warrant is 40% to 60% satisfied	intersection not signalized and volume-based warrant is 60% to 80% satisfied	intersection not signalized and volume-based warrant is over 80% satisfied	30	
regular night-time hourly pedestrian volume ²	no pedestrians	up to 10	10 to 30	30 to 50	over 50	10	
intersecting roadway classifications	no primary road involved	primary/rural major, primary/rural minor, or primary/designated community access	primary/secondary	primary/primary	intersection includes divided highway	5	
operating speed or posted speed limit on major road ³	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
operating speed or posted speed limit on minor road ³	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
SUBTOTAL (Operational Factors) ¹							

- NOTES**
1. If the intersection is not signalized, the user should choose *EITHER* the AADT factor *OR* the signalization warrant factor. The points from either factor, but not both factors, may be used in the warrant points calculation.
 2. The number of certain types of vulnerable pedestrians should be factored to reflect their increased need for visibility. The number of child pedestrians (ages 12 and under) should be multiplied by 2, and the number of senior pedestrians (ages 65 and over) should be multiplied by 1.5.
 3. 85th percentile night-time speed should be used if available. Otherwise, the posted speed limit may be used.

TABLE 1(C) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: ENVIRONMENTAL AND COLLISION FACTORS

Classification Factor	Rating					Weight	Score (Rating x Weight)
	0	1	2	3	4		
ENVIRONMENTAL FACTOR							
lighted development within 150m radius of intersection	--	in one quadrant	in two quadrants	in three quadrants	in four quadrants	5	
SUBTOTAL (Environmental Factors)							
COLLISION HISTORY							
average annual night-time collision frequency ⁴ or rate over last 3 years (only collisions potentially attributable to inadequate lighting)	0 collisions per year	Scenario Collision Frequency of 1.0 1 collision per year	--	Scenario Collision Frequency of 2.0 2 collisions per year	3 or more per year OR at least 1.5 collisions per million entering vehicles per year <i>and</i> an average ratio of all night to day collisions of at least 1.5.	1 or 2 collisions per year	15
						3 or more collisions per year OR rate ≥ 1.5 collisions/MEV	30
SUBTOTAL (Collision History)							
Geometric Factors Subtotal (Table 1(A))							
Operational Factors Subtotal (Table 1(B))							
Environmental Factors Subtotal (Table 1(C))							
Collision History Subtotal (Table 1(C))							
TOTAL POINTS							

NOTE: 4. reported collisions, rounded to nearest whole number

Illumination of Isolated Rural Intersections

LIGHTING WARRANT SPREADSHEET

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Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 210	Minor Road
Okotoks, AB	City/Town

Date	January 8, 2019
Other	Minor Approach Turn Restrictions Option Scenario: Painted Channelization

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	4		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	20
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	100			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
	Posted Speed Category =	0				
	Posted Speed Category =	0				
	Posted Speed Category =	C	4			
	Posted Speed Category =	0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	80	1	5		OK	5
Downhill Approach Grade (x.x%)	0.4	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
Geometric Factors Subtotal						51

OPERATIONAL FACTORS

Is the intersection signalized ? (Y / N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	27280	4	10		OK	40
AADT on Minor Road (2-way)	1200	2	20	Either Use the two AADT inputs OR the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	40
Signalization Warrant	Descriptive	0	30		OK	0
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
Operational Factors Subtotal						135

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
Environmental Factor Subtotal						0

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter either the annual frequency (See Table 1(C), note #4) OR the number of collisions / MEV	OK	15
OR				(Unused values should be set to Zero)		
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0		OK	0
Is the average ratio of all night to day collisions >= 1.5 (Y/N)	n	0			OK	
Collision History Subtotal						15

Check Intersection Signalization:
Intersection is not Signalized

ILLUMINATION WARRANTED
DELINEATION LIGHTING TO ILLUMINATE PEDESTRIANS OR
CROSS STREET TRAFFIC

SUMMARY

Geometric Factors Subtotal	51
Operational Factor Subtotal	135
Environmental Factor Subtotal	0
Collision History Subtotal	15

TOTAL POINTS **201**

Illumination of Isolated Rural Intersections

LIGHTING WARRANT SPREADSHEET

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Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 210	Minor Road
Okotoks, AB	City/Town

Date	January 8, 2019
Other	Minor Approach Turn Restrictions Option Scenario: Raised Channelization

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	4		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	y				OK	
Highest operating speed on raised, channelized approach (km/h)	80		20		OK	
Channelization Factor					OK	80
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	100			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
	Posted Speed Category =	0				
	Posted Speed Category =	0				
	Posted Speed Category =	C	4			
	Posted Speed Category =	0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	80	1	5		OK	5
Downhill Approach Grade (x.x%)	0.4	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
Geometric Factors Subtotal						111

OPERATIONAL FACTORS

Is the intersection signalized ? (Y / N)	n			Calculate the Signalization Warrant Factor		
AADT on Major Road (2-way)	27280	4	10		OK	40
AADT on Minor Road (2-way)	1200	2	20	Either Use the two AADT inputs OR the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	40
Signalization Warrant	Descriptive	0	30		OK	0
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
Operational Factors Subtotal						135

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
Environmental Factor Subtotal						0

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter either the annual frequency (See Table 1(C), note #4) OR the number of collisions / MEV	OK	15
OR				(Unused values should be set to Zero)		
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0		OK	0
Is the average ratio of all night to day collisions >= 1.5 (Y/N)	n	0			OK	
Collision History Subtotal						15

Check Intersection Signalization:
Intersection is not Signalized

FULL ILLUMINATION WARRANTED

SUMMARY

Geometric Factors Subtotal	111
Operational Factor Subtotal	135
Environmental Factor Subtotal	0
Collision History Subtotal	15

TOTAL POINTS **261**

HIGHWAY 2 & TWP RD 210 Minor Approach Turn Restrictions Option

February 2001

TABLE 1(A) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: GEOMETRIC FACTORS

Classification Factor	Rating					Weight		Score (Rating x Weight)
	0	1	2	3	4			
channelization	none	right and/or left turn lanes on minor approach only	right turn lane(s) only on major leg(s)	left turn lane(s) on major leg(s)	left and right turn lanes on all legs	raised and operating speed less than 70 km/h on at least one channelized approach OR	15	Scenario: Raised Channelization
						raised and operating speed 70 km/h or more on at least one channelized approach OR	20	
						painted only	5	
approach sight distance on the most constrained approach (relative to recommended minimum intersection sight distance)	100% or more	75% - 99%	50% - 74%	25% - 49%	<25%	10		
horizontal curvature (radius) at or immediately before intersection on any leg for posted speed limit of:								
110 km/h	tangent	>1,800m	1,150 to 1,800m	750 to 1,150m	<750m			
90 or 100 km/h	tangent	>1,400m	950 to 1,400m	600 to 950m	<600m			
70 or 80 km/h	tangent	>950m	550 to 950m	340 to 550m	<340m			
60 km/h	tangent	>575m	320 to 575m	190 to 320m	<190m	5		
angle of intersection OR offset intersection	90° angle	80° or 100° angle	--	70° or 110° angle	<70° or >110° OR offset intersection	5		
downhill approach grades at or immediately before intersection on any leg	<3.0%	3.1 to 3.9% and meets design guidelines for type and speed of road	4.0 to 4.9% and meets design guidelines for type and speed of road	5.0 to 7.0% and meets design guidelines for type and speed of road	>7.0% OR exceeds maximum gradient for the type and speed of road	3		
number of legs	--	3	4	5	6 or more	3		
SUBTOTAL (Geometric Factors)								

ILLUMINATION OF ISOLATED RURAL INTERSECTIONS



TABLE 1(B) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: OPERATIONAL FACTORS

Classification Factor	Rating					Weight	Score (Rating x Weight)
	0	1	2	3	4		
IF THE INTERSECTION IS SIGNALIZED, ILLUMINATION IS WARRANTED.							
IF THE INTERSECTION IS NOT SIGNALIZED, points should be calculated on the basis of <i>either</i> the AADT factor <i>or</i> the signalization warrant factor:							
either							
AADT (2-way) ¹ :							
on major road and	<1,000	1,000 to 2,000	2,000 to 3,000	3,000 to 5,000	>5,000	10	
on minor road	<500	500 to 1,000	1,000 to 1,500	1,500 to 2,000	>2,000	20	
or							
signalization warrant ¹	intersection not signalized and volume-based signal warrant is less than 20% satisfied	intersection not signalized and volume-based warrant is 20% to 40% satisfied	intersection not signalized and volume-based warrant is 40% to 60% satisfied	intersection not signalized and volume-based warrant is 60% to 80% satisfied	intersection not signalized and volume-based warrant is over 80% satisfied	30	
regular night-time hourly pedestrian volume ²	no pedestrians	up to 10	10 to 30	30 to 50	over 50	10	
intersecting roadway classifications	no primary road involved	primary/rural major, primary/rural minor, or primary/designated community access	primary/secondary	primary/primary	intersection includes divided highway	5	
operating speed or posted speed limit on major road ³	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
operating speed or posted speed limit on minor road ³	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5	
SUBTOTAL (Operational Factors) ¹							

- NOTES**
1. If the intersection is not signalized, the user should choose *EITHER* the AADT factor *OR* the signalization warrant factor. The points from either factor, but not both factors, may be used in the warrant points calculation.
 2. The number of certain types of vulnerable pedestrians should be factored to reflect their increased need for visibility. The number of child pedestrians (ages 12 and under) should be multiplied by 2, and the number of senior pedestrians (ages 65 and over) should be multiplied by 1.5.
 3. 85th percentile night-time speed should be used if available. Otherwise, the posted speed limit may be used.

TABLE 1(C) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: ENVIRONMENTAL AND COLLISION FACTORS

Classification Factor	Rating					Weight	Score (Rating x Weight)
	0	1	2	3	4		
ENVIRONMENTAL FACTOR							
lighted development within 150m radius of intersection	--	in one quadrant	in two quadrants	in three quadrants	in four quadrants	5	
SUBTOTAL (Environmental Factors)							
COLLISION HISTORY							
average annual night-time collision frequency ⁴ or rate over last 3 years (only collisions potentially attributable to inadequate lighting)	0 collisions per year	1 collision per year	--	2 collisions per year	3 or more per year OR at least 1.5 collisions per million entering vehicles per year <i>and</i> an average ratio of all night to day collisions of at least 1.5.	1 or 2 collisions per year	15
						3 or more collisions per year OR rate ≥ 1.5 collisions/MEV	30
SUBTOTAL (Collision History)							
Geometric Factors Subtotal (Table 1(A))							
Operational Factors Subtotal (Table 1(B))							
Environmental Factors Subtotal (Table 1(C))							
Collision History Subtotal (Table 1(C))							
TOTAL POINTS							

NOTE: 4. reported collisions, rounded to nearest whole number

Illumination of Isolated Rural Intersections

LIGHTING WARRANT SPREADSHEET

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Please enter information in the cells with yellow background

INTERSECTION CHARACTERISTICS

Highway 2	Main Road
Township Road 210	Minor Road
Okotoks, AB	City/Town

Date January 8, 2019

Other Traffic Signal Option

GEOMETRIC FACTORS

	Value	Rating	Weight	Comments	Check	Score
Channelization Rating	Descriptive	3		Refer to Table 1(A) to determine rating value	OK	
Presence of raised channelization? (Y / N)	n				OK	
Highest operating speed on raised, channelized approach (km/h)	0		5		OK	
Channelization Factor					OK	15
Approach Sight Distance on most constrained approach (%)	100	0	10	Relative to the recommended minimum sight distance	OK	0
Posted Speed limit (in 10's of km/h)	80				OK	
Radius of Horizontal Curve (m)	100			Enter "T" for tangent (no horizontal curve at the intersection)	OK	
	Posted Speed Category =	0				
	Posted Speed Category =	0				
	Posted Speed Category =	C	4			
	Posted Speed Category =	0				
Horizontal Curvature Factor		4	5		OK	20
Angle of Intersection (10's of Degrees)	80	1	5		OK	5
Downhill Approach Grade (x.x%)	0.4	0	3	Rounded to nearest tenth of a percent	OK	0
Number of Intersection Legs	4	2	3	Number of legs = 3 or more	OK	6
Geometric Factors Subtotal						46

OPERATIONAL FACTORS

Is the intersection signalized ? (Y / N)	y			Illumination is Warranted		
AADT on Major Road (2-way)	27720	4	10		OK	40
AADT on Minor Road (2-way)	2140	4	20	Either Use the two AADT inputs OR the Descriptive Signalization Warrant (Unused values should be set to Zero) Refer to Table 1(B) for description and rating values for signalization warrant.	OK	80
Signalization Warrant	Descriptive	0	30		OK	0
Night-Time Hourly Pedestrian Volume	0	0	10	Refer to Table 1(B), note #2, to account for children and seniors	OK	0
Intersecting Roadway Classification	Descriptive	4	5	Refer to Table 1(B) for ratings.	OK	20
Operating Speed or Posted Speed on Major Road (km/h)	110	4	5	Refer to Table 1(B), note #3	OK	20
Operating Speed on Minor Road (km/h)	80	3	5	Refer to Table 1(B), note #3	OK	15
Operational Factors Subtotal						175

ENVIRONMENTAL FACTOR

Lighted Developments within 150 m radius of intersection	0	0	5	Maximum of 4 quadrants	OK	0
Environmental Factor Subtotal						0

COLLISION HISTORY

Average Annual night-time collision frequency due to inadequate lighting (collisions/yr, rounded to nearest whole #)	1.0	1	15	Enter either the annual frequency (See Table 1(C), note #4) OR the number of collisions / MEV	OK	15
OR				(Unused values should be set to Zero)		
Collision Rate over last 3 years, due to inadequate lighting (/MEV)	0	0	0		OK	0
Is the average ratio of all night to day collisions >= 1.5 (Y/N)	n	0			OK	
Collision History Subtotal						15

Check Intersection Signalization:
Intersection is Signalized

FULL ILLUMINATION WARRANTED

SUMMARY

Geometric Factors Subtotal	46
Operational Factor Subtotal	175
Environmental Factor Subtotal	0
Collision History Subtotal	15

TOTAL POINTS 236

HIGHWAY 2 & TWP RD 210 Traffic Signal Option

TABLE 1(A) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: GEOMETRIC FACTORS

Classification Factor	Rating					Weight		Score (Rating x Weight)
	0	1	2	3	4			
channelization	none	right and/or left turn lanes on minor approach only	right turn lane(s) only on major leg(s)	left turn lane(s) on major leg(s)	left and right turn lanes on all legs	raised and operating speed less than 70 km/h on at least one channelized approach OR	15	
				raised and operating speed 70 km/h or more on at least one channelized approach OR		20		
				painted only		5		
approach sight distance on the most constrained approach (relative to recommended minimum intersection sight distance)	100% or more	75% - 99%	50% - 74%	25% - 49%	<25%	10		
horizontal curvature (radius) at or immediately before intersection on any leg for posted speed limit of:								
110 km/h	tangent	>1,800m	1,150 to 1,800m	750 to 1,150m	<750m			
90 or 100 km/h	tangent	>1,400m	950 to 1,400m	600 to 950m	<600m			
70 or 80 km/h	tangent	>950m	550 to 950m	340 to 550m	<340m			
60 km/h	tangent	>575m	320 to 575m	190 to 320m	<190m	5		
angle of intersection OR offset intersection	90° angle	80° or 100° angle	--	70° or 110° angle	<70° or >110° OR offset intersection	5		
downhill approach grades at or immediately before intersection on any leg	<3.0%	3.1 to 3.9% and meets design guidelines for type and speed of road	4.0 to 4.9% and meets design guidelines for type and speed of road	5.0 to 7.0% and meets design guidelines for type and speed of road	>7.0% OR exceeds maximum gradient for the type and speed of road	3		
number of legs	--	3	4	5	6 or more	3		
SUBTOTAL (Geometric Factors)								

February 2001

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ILLUMINATION OF ISOLATED RURAL INTERSECTIONS



TABLE 1(B) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: OPERATIONAL FACTORS

Classification Factor	Rating					Weight	Score (Rating x Weight)	
	0	1	2	3	4			
IF THE INTERSECTION IS SIGNALIZED, ILLUMINATION IS WARRANTED.								
IF THE INTERSECTION IS NOT SIGNALIZED, points should be calculated on the basis of <i>either</i> the AADT factor <i>or</i> the signalization warrant factor:								
either								
AADT (2-way) ¹ :								
on major road and	<1,000	1,000 to 2,000	2,000 to 3,000	3,000 to 5,000	>5,000	10		
on minor road	<500	500 to 1,000	1,000 to 1,500	1,500 to 2,000	>2,000	20		
or								
signalization warrant ¹	intersection not signalized and volume-based signal warrant is less than 20% satisfied	intersection not signalized and volume-based warrant is 20% to 40% satisfied	intersection not signalized and volume-based warrant is 40% to 60% satisfied	intersection not signalized and volume-based warrant is 60% to 80% satisfied	intersection not signalized and volume-based warrant is over 80% satisfied	30		
regular night-time hourly pedestrian volume ²	no pedestrians	up to 10	10 to 30	30 to 50	over 50	10		
intersecting roadway classifications	no primary road involved	primary/rural major, primary/rural minor, or primary/designated community access	primary/secondary	primary/primary	intersection includes divided highway	5		
operating speed or posted speed limit on major road ³	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5		
operating speed or posted speed limit on minor road ³	50 km/h or less	60 km/h	70 km/h	80 km/h	90 km/h or over	5		
SUBTOTAL (Operational Factors) ¹								

- NOTES**
1. If the intersection is not signalized, the user should choose *EITHER* the AADT factor *OR* the signalization warrant factor. The points from either factor, but not both factors, may be used in the warrant points calculation.
 2. The number of certain types of vulnerable pedestrians should be factored to reflect their increased need for visibility. The number of child pedestrians (ages 12 and under) should be multiplied by 2, and the number of senior pedestrians (ages 65 and over) should be multiplied by 1.5.
 3. 85th percentile night-time speed should be used if available. Otherwise, the posted speed limit may be used.

TABLE 1(C) WARRANT FOR ILLUMINATION OF ISOLATED RURAL INTERSECTIONS: ENVIRONMENTAL AND COLLISION FACTORS

Classification Factor	Rating					Weight	Score (Rating x Weight)
	0	1	2	3	4		
ENVIRONMENTAL FACTOR							
lighted development within 150m radius of intersection	--	in one quadrant	in two quadrants	in three quadrants	in four quadrants	5	
SUBTOTAL (Environmental Factors)							
COLLISION HISTORY							
average annual night-time collision frequency ⁴ or rate over last 3 years (only collisions potentially attributable to inadequate lighting)	0 collisions per year	1 collision per year	--	2 collisions per year	3 or more per year OR at least 1.5 collisions per million entering vehicles per year <i>and</i> an average ratio of all night to day collisions of at least 1.5.	1 or 2 collisions per year	15
						3 or more collisions per year OR rate ≥ 1.5 collisions/MEV	30
SUBTOTAL (Collision History)							
Geometric Factors Subtotal (Table 1(A))							
Operational Factors Subtotal (Table 1(B))							
Environmental Factors Subtotal (Table 1(C))							
Collision History Subtotal (Table 1(C))							
TOTAL POINTS							

NOTE: 4. reported collisions, rounded to nearest whole number



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