Ontario

MINISTRY OF TRANSPORTATION

Appendices

Preliminary Design and Class Environmental Assessment
Highway 148 (Pembroke to Greenwood Road) County of Renfrew

IBI

TRANSPORTATION ENVIRONMENTAL STUDY REPORT

Preliminary Design and Class Environmental Assessment
Highway 148 (Pembroke to Greenwood Road)
County of Renfrew

G.W.P. 214-00-00

Class Environmental Assessment for Provincial Transportation Facilities - “Group B” Project

JUNE 2018

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Ontario

Final Report

Highway 148 Traffic Operations and Safety Review - Existing Conditions

IBI

Prepared for MTO Eastern Region
by IBI Group

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1 Introduction

This section provides the context for the analysis presented throughout the report, including background, scope of analysis, and a description of the study area.

1.1 Background

As part of an environmental assessment (EA) study of Highway 148, IBI Group was tasked with assessing the operational and safety performance of the Highway 148 corridor between the Ontario/Quebec border to the east and the City of Pembroke to the west. The project corridor is approximately 5 km in length.

This study involves reviewing the existing traffic operations and historical safety performance of the highway for the purposes of identifying existing issues and proposing measures to mitigate these issues and to accommodate future traffic growth.

1.2 Scope

The intent of this report is to present the results of the Existing Conditions assessment. The Highway 148 operational and safety assessment includes the following lines of analysis:

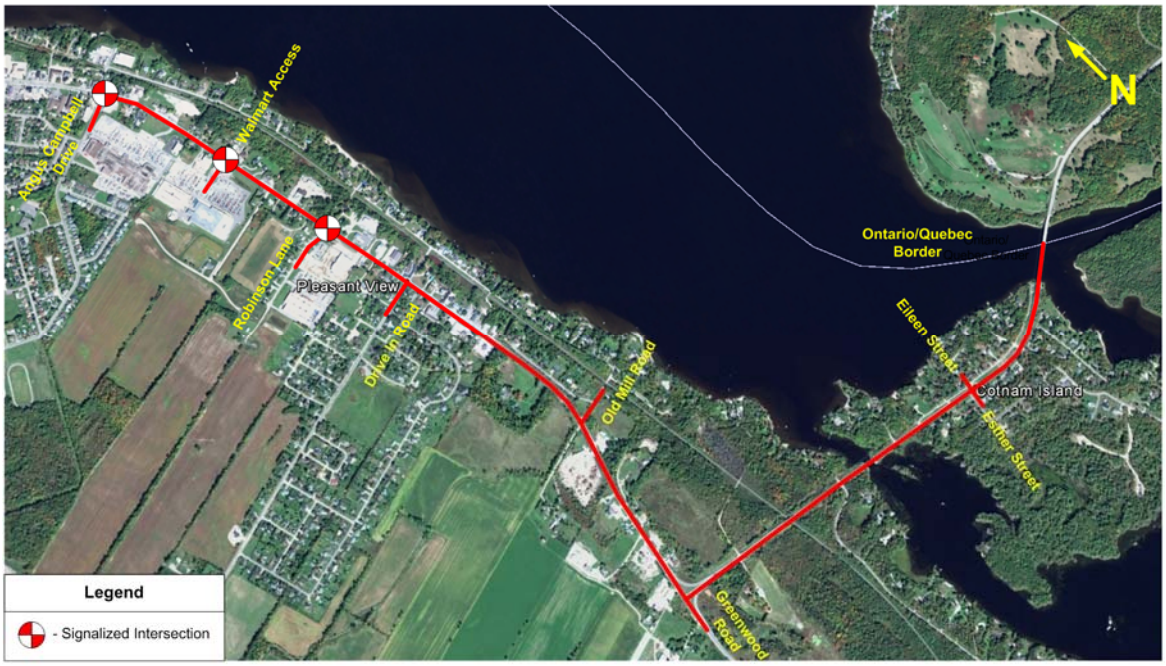
- Traffic Operations Review – Synchro 7.0 traffic assessment and traffic signal warrant assessment of the urban section. Side road volume review of the rural section; and
- Collision Assessment – Overall collision analysis, spatial assessment, collision diagrams, over-representation analysis, and predictive collision analysis.

1.3 Study Area

The Highway 148 corridor is composed of two distinct operating environments which are categorized as rural and urban. The urbanized section of Highway 148 is west of the intersection of Highway 148 at Greenwood Road (County Road 40) and has several signalized intersections/accesses. There are also many residential and commercial driveways with direct access to Highway 148. East of the Greenwood Road intersection is the rural section of Highway 148, where adjacent land uses largely access Highway 148 via intersecting service roads. It should be noted that Highway 148 is generally assumed to travel east-west, and intersecting roads run north-south. The study area is illustrated in **Exhibit 1-1**. Many driveways and accesses intersect Highway 148; however, the major intersections within the study area include the following:

- Highway 148 at Esther Street/Eileen Street - Unsignalized;
- Highway 148 at Greenwood Road (County Road 40) - Unsignalized;
- Highway 148 at Old Mill Road – Unsignalized;
- Highway 148 at Drive in Road – Unsignalized;
- Highway 148 at Robinson Lane – Signalized;
- Highway 148 at Walmart Access – Signalized; and
- Highway 148 at Angus Campbell Drive – Signalized.

Exhibit 1-1: Study Area Map



2 Existing Conditions Analysis

This section discusses the methodology and results of the 2015 existing conditions operational and safety analysis.

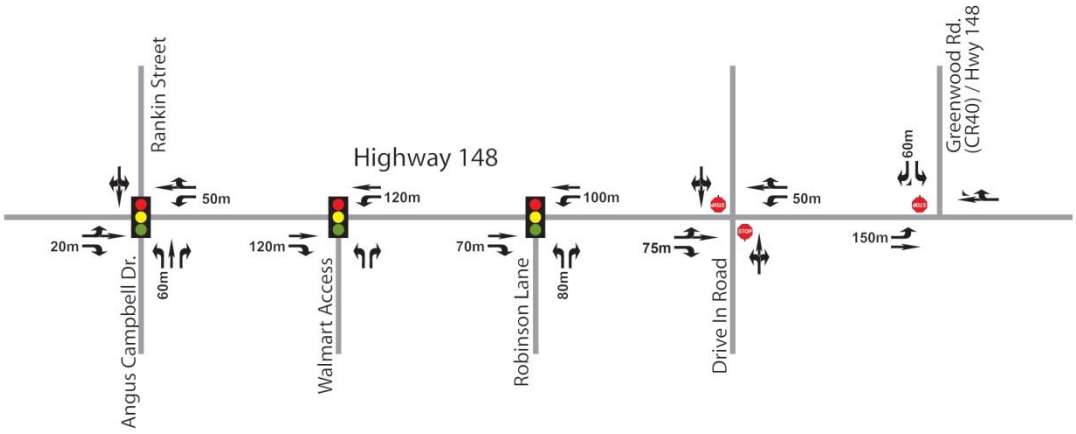
2.1 Operational Analysis

A review of existing traffic operations has been conducted for the major intersections within the study area. The review was conducted utilizing turning movement count (TMC) data provided by MTO for the following intersections:

- Angus Campbell Drive (August 2012);
- Walmart Access (August 2012);
- Robinson Lane (February 2015);
- Drive In Road (August 2012); and
- Greenwood Road (August 2012).

The turning movement counts are available in **Appendix A**. The lane configurations at each intersection are indicated in **Exhibit 2-1**.

Exhibit 2-1: Existing Lane Configurations



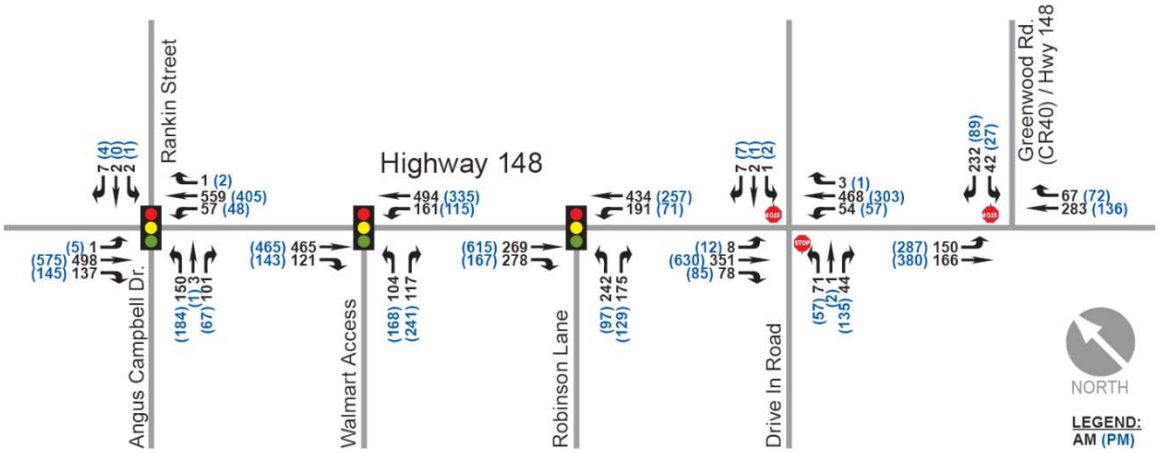
2.1.1 Existing (2015) Traffic Volumes

Representative 2015 traffic volumes have been derived by the application of the following adjustment factors to the volumes from the 2012 turning movement counts:

- Seasonal Adjustment Factor: The TMC data was recorded in August 2012. In order to account for variations in traffic volumes at different times of the year, the TMC volumes have been revised by applying a seasonal adjustment factor. MTO has classified traffic patterns on Highway 148 as Intermediate Commuter and prescribed a seasonal adjustment factor of 1.1 to traffic volumes in August for this pattern type. The adjusted traffic volumes have been obtained by dividing the recorded 2012 traffic volumes by the seasonal adjustment factor.
- Traffic Growth Factor: Based on a review of historical traffic volume data along the Highway 148 corridor, MTO has recommended that a 1.0 % annual traffic growth rate be applied in the derivation of future traffic growth projections along Highway 148.
- Commercial Development Traffic Adjustment: The traffic volumes along the corridor were then adjusted based on the 2015 TMC recorded at Robinson Lane to account for additional traffic generated by the Laurentian Square commercial development, which opened after the 2012 counts were conducted.

The existing (2015) traffic volumes for the weekday morning and afternoon peak hours are indicated in **Exhibit 2-2**.

Exhibit 2-2: 2015 Traffic Volumes



2.1.2 Intersection Capacity Analysis

Intersection capacity analysis of the study area intersections was conducted using Synchro 7.0 analysis software package which employs the Highway Capacity Manual 2000 (HCM) methodology. The criteria for identifying critical intersections are as follows:

- Overall intersection LOS E or F for all intersections – average control delay per vehicle greater than 55 seconds and 35 seconds for signalized and unsignalized intersections, respectively; and
- An overall intersection V/C ratio of 0.90 or greater.

The criteria for identifying critical movements are as follows:

- Average control delay is greater than 55 seconds;
- A V/C ratio of 1.00 or greater for an exclusive movement;
- The available storage space for an exclusive movement is exceeded by the estimated 95th percentile queue length;
- An existing access is blocked by the estimated 95th percentile queue length for an individual movement; and
- Exclusive turning lanes are inaccessible because of queue lengths in adjacent through lanes.

Exhibit 2-3 presents a summary of the 2015 Existing Conditions traffic operations. As noted above, Highway 148 is considered oriented in an east-west direction while the side roads are considered north-south in the analysis. Detailed output from the Synchro analysis is provided in **Appendix B**.

The results of the analysis indicate that the major intersections along Highway 148 are currently operating at acceptable levels of service during the weekday morning and afternoon peak hours. However, vehicle queues in the eastbound and westbound through lanes at the Angus Campbell Drive intersection are shown to periodically block the adjacent right turn and left turn lanes during the morning peak hour. Similarly, the queue in the eastbound through lane at the Robinson Lane intersection extends beyond the adjacent auxiliary right turn lane during the afternoon peak hour.

Exhibit 2-3: Intersection Capacity Analysis – Existing (2015) Traffic

INTERSECTION	TRAFFIC CONTROL	PEAK HOUR	OVERALL DELAY (S)	OVERALL LOS	CRITICAL MOVEMENT				
					MOVEMENT	DELAY (S)	LOS	V/C RATIO	95TH QUEUE (M)
Angus Campbell Drive	Signals	AM	13.0	B	EBTL	15.9	B	0.66	79.0
					WBTR	8.1	A	0.54	65.4
		PM	15.3	B	EBTL	18.9	B	0.75	104.3
Walmart Access	Signals	AM	10.7	B	-	-	-	-	-
		PM	14.1	B	-	-	-	-	-
Robinson Lane	Signals	AM	12.9	B	-	-	-	-	-
		PM	11.2	B	EBT	11.8	B	0.67	#103.6
Drive In Road	Stop	AM	3.6	-	-	-	-	-	-
		PM	7.0	-	-	-	-	-	-
Greenwood Road (County Road 40)	Stop	AM	5.3	-	-	-	-	-	-
		PM	4.1	-	-	-	-	-	-

2.1.3 Traffic Control Signal Warrant Assessment

Traffic control signal warrant analysis has been conducted for the following unsignalized intersections based on the 2012 TMC data provided:

- Drive In Road (County Road 29)
- Greenwood Road (County Road 40)

The OTM Book 12 methodology assesses the warrant of a traffic signal at an intersection based on factors including existing vehicular volume, collision history, pedestrian volumes and projected future vehicular volumes. From the OTM Book 12 methodology, the following Justifications are applicable for the study intersections:

- Justification 1 – Minimum Vehicular Volume;
- Justification 2 – Delay to Cross Traffic;
- Justification 3 – Volume/Delay Combination; and
- Justification 5 – Collision Experience.

Justification 1 considers traffic signals for the purposes of mitigating the cumulative delay produced by large volumes of intersecting traffic. Justification 1A accounts for the lowest total traffic for all intersection approaches while Justification 1B accounts for the lowest volume on the minor road. The predetermined minimum volume thresholds for both Justifications 1A and 1B must be 100% fulfilled for signals to be justified. Under the event that the thresholds are not met but are at least 80% fulfilled, Justification 3 may be applied.

Justification 2 considers traffic signals where main road traffic volumes are excessive to the point that minor road vehicles suffer significant delays or hazards in entering the intersection. Similar to Justification 1, both Justification 2A and 2B minimum volume thresholds must reach 100% compliance for signals to be justified. Justification 3 may be applied if Justifications 2A and 2B both exceed 80% compliance but do not reach the 100% threshold.

Justification 3 considers traffic signals for applications where both the volumes and delays evaluated under Justifications 1 and 2 are approaching the 100% threshold but do not meet the

requirements. For signals to be warranted under Justification 3, all four Justifications 1A, 1B, 2A and 2B must meet their respective minimum volume thresholds to a compliance of 80%.

Justification 5 considers traffic signals for the purposes of improving intersection safety where an unsignalized intersection has an unusually high collision history. According to Justification 5, traffic signals are warranted if the following two conditions are met:

- Fifteen (15) or more reportable collisions are susceptible to correction with signalization over a 36 month period. Collisions susceptible to correction include: angle and turning movement collisions; and
- Less restrictive methods of correction have failed to reduce collision frequency. Less restrictive methods include: implementation of warning signs, flashing beacons or geometric/visibility improvements, etc.

Justification 4 – Minimum Four Hour Vehicle Volume is not applicable since the OTM Book 12 states that it must not be applied in combination with other traffic control signal justifications. Additionally, Book 12 states that the MTO does not consider Justification 4 for the purposes of warranting signals.

Justification 6 – Pedestrian Volume and Delay is not applicable due to the absence of significant pedestrian volumes within the study corridor.

Justification 7 – Projected Volumes is not applicable given that the scope of the current analysis is limited to existing conditions.

Copies of the traffic signal warrants calculation sheets are provided in **Appendix C**.

2.1.3.1 Highway 148/Greenwood Road (County Road 40)

The results of the signal warrant analysis for the Greenwood Road intersection are presented in **Exhibit 2-4**.

Exhibit 2-4: Traffic Signal Warrant Analysis – Highway 148/Greenwood Road

JUSTIFICATION		RURAL (FREE FLOW)		
		COMPLIANCE	SIGNAL JUSTIFIED?	
			YES	NO
1. Minimum Vehicular Volume	Total Volume	99%		✓
	Crossing Volume	19%		
2. Delay to Cross Traffic	Main Road	98%		✓
	Crossing Road	69%		
3. Combination	Justification 1	19%		✓
	Justification 2	69%		
5. Collision Experience		20%		✓

The results of the analysis indicate that traffic signals are not currently warranted at the Greenwood Road (County Road 40) intersection.

2.1.3.2 Highway 148/Drive In Road

The results of the signal warrant for the Drive In Road intersection are presented in **Exhibit 2-5**. The warrant analysis was conducted for both restricted flow and free flow conditions given that the intersection is located at the fringe between urban and rural conditions along Highway 148.

Exhibit 2-5: Traffic Signal Warrant Analysis – Highway 148/Drive In Road

JUSTIFICATION		URBAN (RESTRICTED FLOW)			RURAL (FREE FLOW)		
		COMPLIANCE	SIGNAL JUSTIFIED?		COMPLIANCE	SIGNAL JUSTIFIED?	
			YES	NO		YES	NO
1. Minimum Vehicular Volume	Total Volume	100%		✓	100%		✓
	Crossing Volume	78%			93%		
2. Delay to Cross Traffic	Main Road	99%		✓	100%		✓
	Crossing Road	77%			99%		
3. Combination	Justification 1	78%		✓	93%	✓	
	Justification 2	77%			99%		
5. Collision Experience		13%		✓	13%		✓

The results of the traffic control signal warrants analysis indicate the following:

- If considered free flow (rural) conditions, Justification1 is satisfied to 93% and Justification 2 is satisfied to 99%. Therefore, traffic signals are warranted based on Justification 3—the Combination warrant—which is met if both Justification 1 and Justification 2 are satisfied to 80% or more.
- If considered restricted flow (urban) conditions, Justification 1 is satisfied to 78% and Justification 2 is satisfied to 77%, which falls just below the requirements to satisfy Justification 3.This suggests that the intersection can be expected to meet the minimum signal warrants for restricted flow conditions under Justification 3 in the near future.

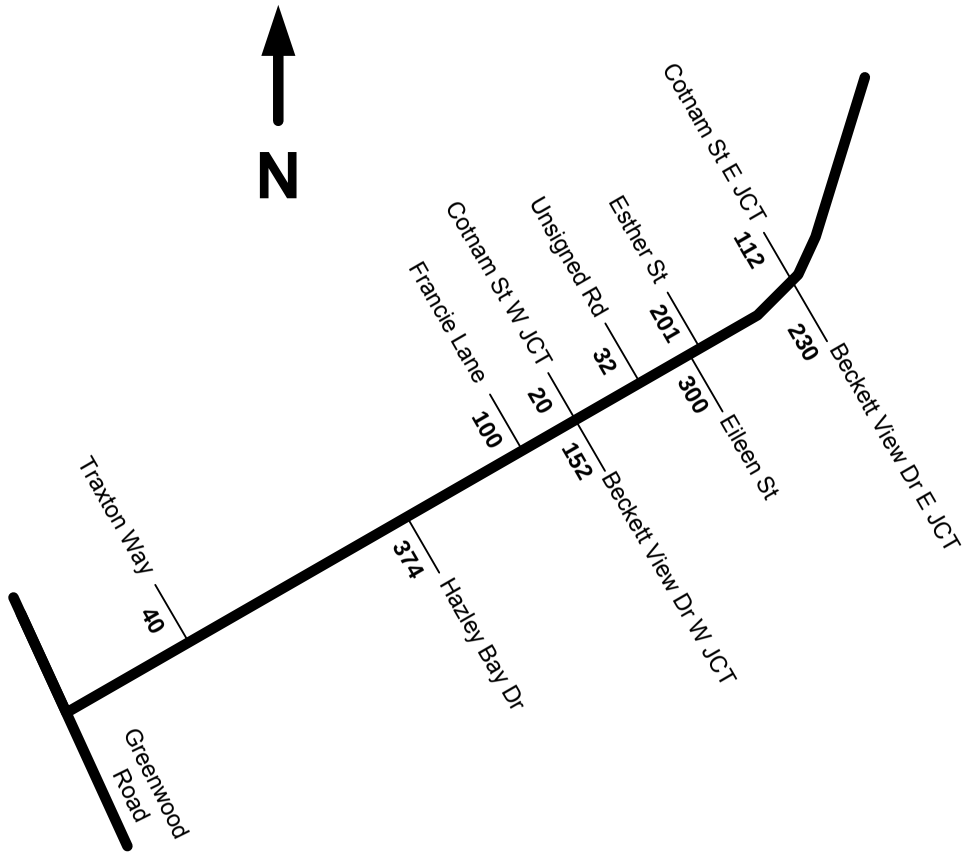
2.2 Rural Section Side Road Volume Review

Bi-directional side road data was collected from October 24, 2013 to October 30, 2013 at the following side roads:

- Beckett View Drive E JCT – South approach;
- Beckett View Drive W JCT – South approach;
- Cotnam Street E JCT – North approach;
- Cotnam Street W JCT – North approach;
- Eileen Street – North approach;
- Esther Street – South approach;
- Unsigned Road – North approach;
- Francie Lane – North approach;
- Hazley Bay Drive – South approach; and
- Traxton Way – North approach.

The Average Daily Traffic (ADT) volumes for each side road are summarized in **Exhibit 2-6**.

Exhibit 2-6: Side Road ADT Summary



Based on the surrounding land uses, it was noted that the following side roads have a significantly higher number of trips than expected:

- Beckett View Drive E JCT;
- Francie Lane; and
- Hazley Bay Drive.

Based on the reported volumes, it would appear that there could be some operational and safety benefit to consolidating some of the crossing roads along this section of the highway to reduce the number of conflict points and allow for better right-of-way control.

2.3 Safety Analysis

This section of the report presents the study corridor existing conditions collision assessment analysis results. IBI reviewed the provided historical collision data (5 years from January 1, 2007 to December 31, 2011) for the purposes of identifying collision trends and over-representations at study intersections and midblock segments. The analysis includes a spatial assessment of the corridor collisions, collision diagrams depicting hot spots, over-representation analysis, and predictive collision analysis. The predictive method was used to compare the number of observed collisions to those predicted by Safety Performance Functions (SPFs) and Collision Modification Factors (CMFs).

2.3.1 Overall Collision Analysis

This section of the report presents the results of the overall collision analysis. As displayed in **Exhibit 2-7**, a total of 44 collisions were reported for the corridor over the five-year analysis period from January 1, 2007 through December 31, 2011. In general, there are approximately 5-10 collisions observed per year with the exception of 2009 when 15 collisions were observed. It is speculated that the 2009 spike in collision frequency occurred due to the natural fluctuation of collisions year to year considering that no external factors were observed that could have lead to the increased collision frequency. The majority of these collisions occurred during the day with clear environmental conditions and a dry road surface.

Exhibit 2-7: Five Year Collision Distribution

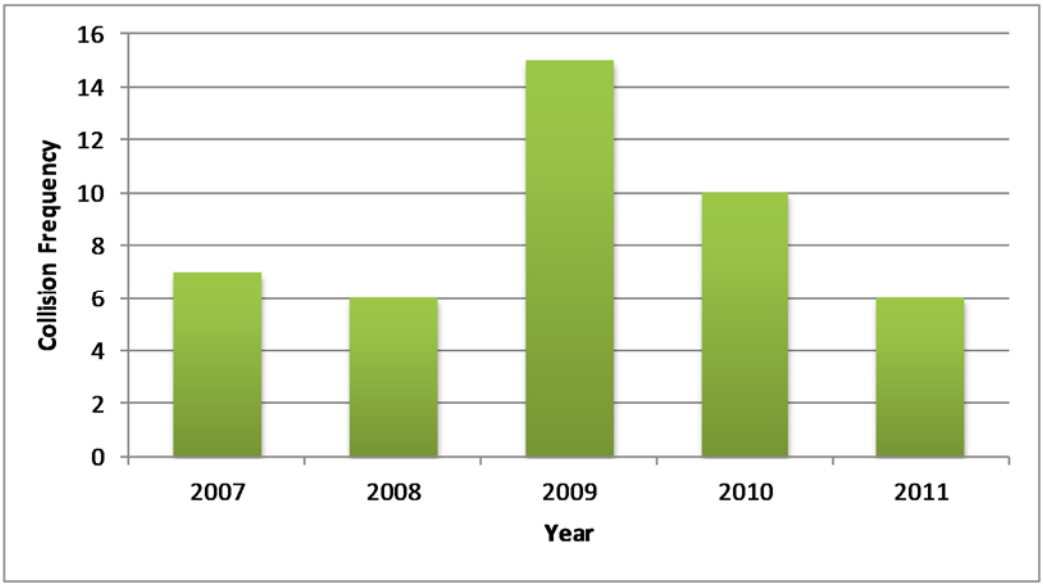


Exhibit 2-8 presents the distribution of collisions by initial impact type. The dominant initial impact type along the corridor is rear-end collisions (41%). Of the 18 observed rear-end collisions, 16 occurred within the urbanized section of the study corridor. It is anticipated that the high concentration of intersections and private driveways accessing Highway 148 plays a significant factor in these rear-end collisions. With only one lane per direction, vehicles turning at an intersection or private driveway are required to slow down/stop within the travel lane.

Single vehicle collisions represented the second most common initial impact type (32%). The single vehicle collisions consisted of a combination of wild animal strikes and loss-of-control incidents, the latter of which appear to have been influenced by wet road surface conditions and driver impairment.

Exhibit 2-8: Collision Distribution by Initial Impact Type

ANGLE	APPROACH	REAR END	SINGLE VEHICLE	TURNING
1	2	18	14	9

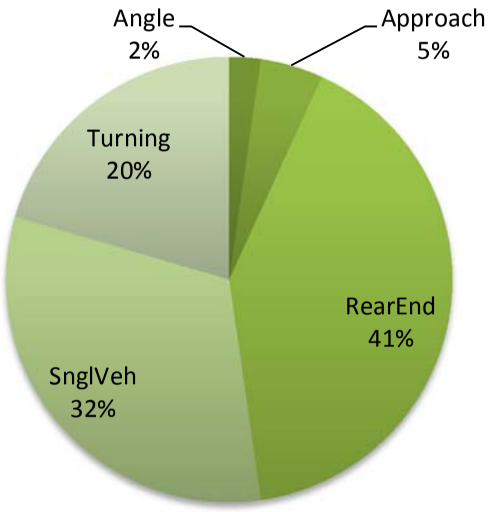
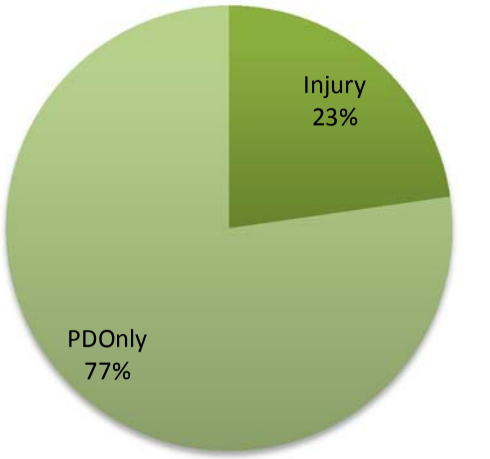


Exhibit 2-9 presents the distribution of collisions by severity. As anticipated, the majority of collisions involved property damage only (77%) with only minimal injury (23%) and fatal (0%) collisions. Half of the injury collisions occurred in the 700m section of Highway 148 between Daily Street and Robinson Lane, this area is where the urban are becomes more pronounced and the driveway density is much higher than the section to the east, it may be that higher turning movement concentrations coupled with higher operating speeds, through this transition area, are contributing to a concentration of more severe collisions.

Exhibit 2-9: Collision Distribution by Severity

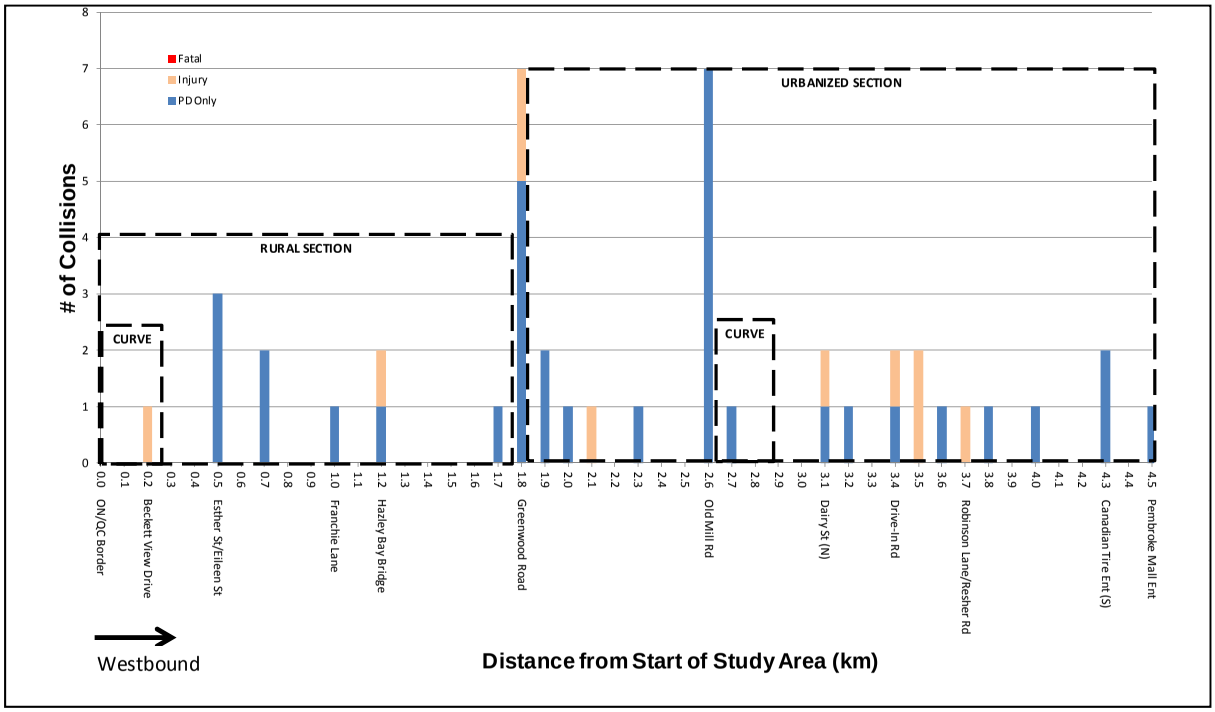
PDONLY	INJURY	FATAL
34	10	0



2.3.2 Spatial Assessment

The collisions along the corridor were plotted every 100 m to identify problem areas, and are presented in **Exhibit 2-10**. The actual number of collisions associated with intersections may be higher than what is shown in **Exhibit 2-10**, as some intersection-related collisions occur 100 m before or after the intersection itself.

Exhibit 2-10: Highway 148 Collision Distribution



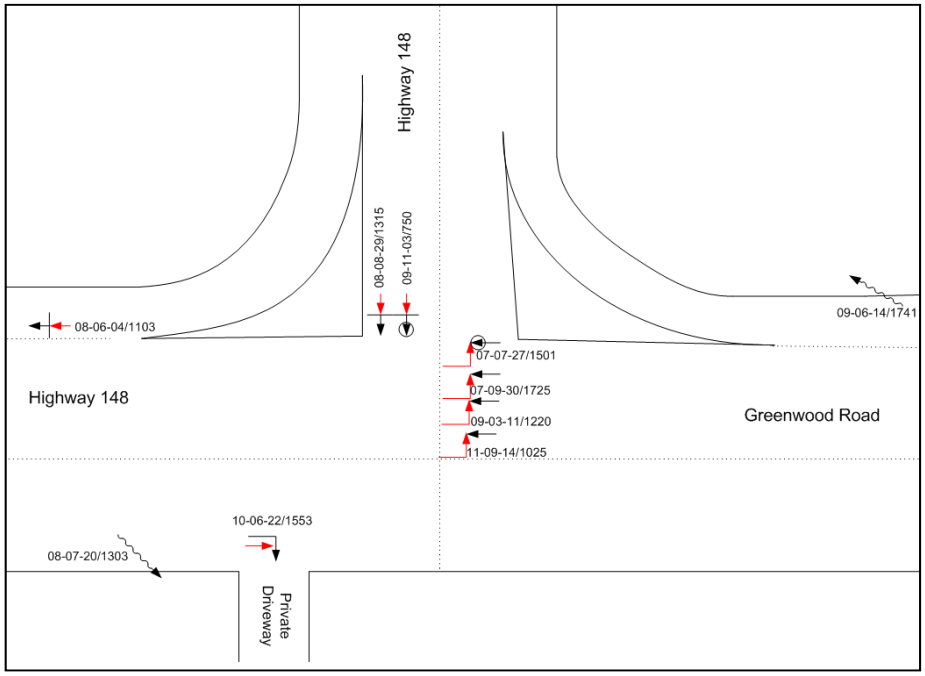
The collision spatial assessment shows that:

- There are concentrations of collisions at the intersections at Greenwood Road and Old Mill Road;
- Collisions occur more frequently in the urbanized section than in the rural section;
- The number of collisions along curved sections does not appear to be significantly different in comparison to other sections of the mainline; and
- A majority of injury collisions occur within the urbanized section (between Daily Street and Robinson Lane). No collisions involved pedestrians.

2.3.3 Collision Diagrams

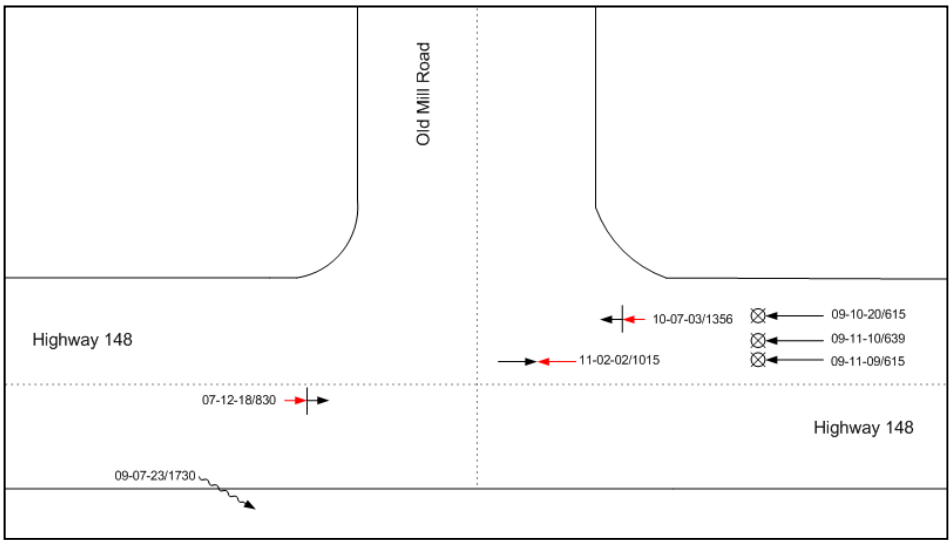
Collisions at the intersections at Greenwood Road (**Exhibit 2-11**) and Old Mill Road (**Exhibit 2-12**) were further investigated to identify trends related to the collision severity or initial impact type.

Exhibit 2-11: Collision Diagram of Greenwood Road



At the Greenwood Road intersection, there have been ten reported collisions during the analysis period, five of which have been turning collisions. Four of five turning collisions are due to eastbound left-turning drivers failing to yield or making improper left-turns. It is not expected that the road geometry or sightlines played a factor in these collisions as the approaches to the intersection are straight and level. Aside from the turning collisions, the intersection does not appear to have any significant collision trends.

Exhibit 2-12: Collision Diagram of Old Mill Road



At the Old Mill Road intersection, there have been seven collisions reported during the analysis period. Of those collisions, four have been single vehicle collisions, three of which involved wild animal strikes. An aerial image of the intersection is shown in **Exhibit 2-13**.

Exhibit 2-13: Aerial Image of Intersection at Old Mill Road

Based on the vegetation around the intersection, it is likely that the wild animal collisions occurred just east of the intersection, where animals would cross from the field south of Highway 148 to the small wooded area north of Highway 148, or vice versa (as depicted by the red arrow). The wild animal collisions occurred during October and November, which is consistent with wild animal the timing of deer moving to wintering areas. Improvements can be made to the intersection to reduce the number of these collisions such as:

- Implementing additional lighting around the intersection to improve visibility;
- Removing roadside foliage to improve visibility and sightlines; and
- Posting animal crossing warning signs.

It should be noted that the only wild animal collisions reported along the corridor were at this intersection. Aside from the wild animal collisions, the intersection does not appear to have any significant collision trends.

2.3.4 Over-Representation Analysis

An Over-Representation (OR) analysis was performed to determine if any of the collision attributes of the corridor are statistically higher (over-represented) based on a chi-square distribution, in comparison to the aggregate provincial highways data. The OR analysis is performed on a corridor level as opposed to an intersection level, as the Provincial distributions of collision attributes do not exist for intersections alone. The collision attributes that are over-represented along the corridor are summarized in **Exhibit 2-14**.

Exhibit 2-14: Over-Representation Analysis Summary

		# OF TOTAL	% OF TOTAL	% PROVINCIAL HIGHWAYS
Road Location	Intersection Related	16	36.4%	11.3%
Initial Impact Type	Rear-end	18	40.9%	14.2%
	Turning	9	20.5%	7.3%
Environment Conditions	Rain	10	22.7%	8.1%
Driver Action (All Drivers)	Following Close	13	17.1%	5.8%
Vehicle Maneuver (All Vehicles)	Merging	3	3.9%	0.4%

The analysis results show that rear-end and turning collisions were over-represented. The driver action of "Following Close" related to rear-end collisions is also are over-represented. The over representation of these collision attributes may be the due to the high density of driveways and intersections along the corridor, especially within the urbanized section, when compared with typical highway segments. Driveways and intersections provide opportunities for rear-end and turning collisions as:

- Vehicles slowing to turn into a driveway or at an intersection can be rear-ended by drivers that are following closely or are inattentive; and
- Vehicles turning into a driveway or at an intersection can collide with other vehicles if the turning driver fails to yield or makes an improper turn.

The OR analysis shows that collisions under "rainy" environmental and "wet" road conditions were over-represented. A review of the collision data found that:

- A majority of the collisions resulted in property damage only; and
- There were no identifiable trends in collision location, type of initial impact, or driver actions resulting in collisions.

Despite the lack of identifiable trends in collisions, an investigation into the road drainage may provide further insight into such collisions. Improving the road drainage may help reduce the number of collisions that occur due to "wet" road conditions (i.e., when drivers lose control of their vehicles).

Collisions where the vehicle maneuver was coded as "merging" were found to be over-represented. All of the collisions involving "merging" vehicles, totalling two, were related to the Greenwood Road intersection. One collision was a rear-end collision, where a westbound vehicle exiting the channelized right-turn failed to yield, while the other was a driver who lost control of their vehicle entering the channelized right-turn from Greenwood Road. The collision data did not show identifiable trends, and it is likely that the collisions are only over-represented due to the small number of total collisions along the corridor.

2.3.5 Predictive Collision Analysis

This section discusses the methodology and results of the intersection and mainline predictive collision analysis.

2.3.5.1 Intersection Collision Analysis

The predictive collision analysis at intersections was conducted by applying the Highway Safety Manual's (HSM) Predictive Method with SPFs provided by the MTO. All SPFs provided by the MTO follow the functional form:

$$Predicted\ Number\ of\ Collisions = e^{a} * \left[\left(\frac{AADT_{min}}{1000} \right)^{b_1} * \left(\frac{AADT_{maj}}{1000} \right)^{b_2} * e^{\left(\frac{b_3 * AADT_{min}}{1000} + b_4 * \left(\frac{AADT_{min}}{1000} \right)^2 \right)} \right]$$

Safety Performance Functions (SPFs) used for safety analyses require Average Annual Daily Traffic (AADT) volumes for major and minor approaches instead of peak hour TMCs. AADTs for the major approaches of the intersection were calculated by averaging the AADTs from the two sections (Ontario Provincial Highways Traffic Volumes) adjacent to the intersection. AADTs for the minor approaches of the intersection were obtained one of two ways:

- Calculated by taking the total passenger car equivalents over the eight hour count period and multiplying by two. Heavy vehicles/trucks were considered to be two passenger car equivalents to account for the varying proportions of heavy vehicles/trucks at intersections; or
- Taken from automatic traffic recorders (ATR). It should be noted that ATR counts provided only Average Daily Traffic (ADT) counts.

The minor approach ADTs or AADTs were then factored by the seasonal adjustment factor, shown in

Exhibit 2-15, to account for the month that the data was collected. Minor approach volumes were adjusted to their respective 2007 to 2011 volumes assuming varying growth rates, depending on their purpose. It should be noted that vehicles using channelized right-turns were excluded from AADT calculations.

Exhibit 2-15: Seasonal Adjustment Factors

INTERSECTION	COLLECTION DATE	ROAD CLASSIFICATION	SEASONAL ADJUSTMENT FACTOR
Old Mill Road*	Oct-13	2013	0.9
Drive In Road^	Aug-12	2012	1.1
Robinson Lane^	Aug-12	2012	1.1
Walmart Access^	Aug-12	2012	1.1
Beckett View Drive / Cotnam E JCT*	Oct-13	2013	0.9
Esther Street / Eileen Street*	Oct-13	2013	0.9

IC - Intermediate Commuter CTR – Commuter Tourist Recreation

* - Minor approach growth rate of 1.0% per year

^ - Minor approach growth rate of 0.5% per year

CMFs were used to adjust the number of predicted collisions generated by SPFs and to account for site conditions that differ significantly from the base conditions in which the SPFs were developed. CMFs, summarized in **Exhibit 2-16**, are based on different intersection properties, which include: control method (signalized or stop controlled), driveway density, horizontal curves, and intersection lighting.

Exhibit 2-16: Intersection CMFs

INTERSECTION	CMF	FACTOR	MTO SPF
Greenwood Road	Left Turn	0.56	Unsignalized 3-leg Arterial and Collector
	Right Turn	0.86	
	Lighting	0.90	
Old Mill Rd	Lighting	0.90	Unsignalized 3-leg Arterial and Collector
Drive In Road	Left Turn	0.72	Unsignalized 4-leg Arterial
	Right Turn	0.86	
	Lighting	0.90	
Robinson Lane	Left Turn	0.67	Signalized 3-leg Arterial Rural and Collector
	Right Turn	0.96	
Walmart Access	Right Turn	0.96	Signalized 3-leg Arterial Rural and Collector
Beckett View Drive / Cotnam E JCT	Right Turn	0.86	Unsignalized 4-leg Collector
Esther Street / Eileen Street	Lighting	0.90	Unsignalized 4-leg Collector

Using the SPFs, CMFs, and historical collision data, the number of excess collisions at each intersection was calculated. The excess number of collisions is an indicator of an intersection's safety performance. If the excess number of collisions is greater than zero, the intersection has more collisions than the SPFs would predict, given its geometric and operating conditions. If the value of excess collisions is less than zero, the intersection has fewer collisions than were predicted by the SPFs. The numbers of excess collisions at each intersection are summarized in **Exhibit 2-17**.

Exhibit 2-17: Intersection Excess Collisions

	EXCESS COLLISIONS		
INTERSECTION	F+I	PDO	ALL
Greenwood Road	0.37	2.69	3.06
Drive In Road	0.02	0.02	0.04
Robinson Lane	-0.13	-2.69	-2.82
Walmart Access	-2.07	-6.76	-8.84
Beckett View Drive / Cotnam E JCT	0.10	-0.54	-0.44
Esther Street / Eileen Street	-0.24	-0.01	-0.25

Generally, the intersections performed as or better than predicted by the SPFs. The intersection at Greenwood Road was the only one found to have a significant number of excess collisions, which consist mostly of the left-turn collisions. Based on the Ontario Traffic Manual Book 12 traffic signal warrants, traffic control signals are not justified at this time due to low minor street volumes. Similarly, implementation of a roundabout at the intersection is not expected to be an economically viable solution given the low number of excess collisions most of which are of low severity.

2.3.5.2 Mainline Collision Analysis

To assess the safety performance of mainline sections, the Highway Safety Manual's (HSM) predictive method was applied using the Safety Performance Functions (SPFs) available in the MTO publication "Operational Performance Assessment of Highway and Freeway Sections" dated April 2009. The SPFs take the general form of:

$$Collisions/km/year = \alpha(AADT)^{\beta}$$

Where α = and β are coefficients depending the type of roadway and collision severity.

For collision analysis along the mainline, the corridor was divided into segments based on: AADT data, intersections, and horizontal curvature. The segments analyzed are summarized in **Exhibit 2-18**.

Exhibit 2-18: Mainline Collision Analysis Segments

SEGMENT	FROM	LHRS	OFFSET	TO	LHRS	OFFSET	LENGTH (km)
1	Curve 1 Start	46250	0.00	Beckett View Drive / Cotnam E JCT / Curve 1 End	46250	0.22	0.22
2	Beckett View Drive / Cotnam E JCT / Curve 1 End	46250	0.22	Eileen Street / Esther Street	46250	0.47	0.25
3	Eileen Street / Esther Street	46250	0.47	Bridge	46250	1.00	0.53
4	Bridge	46250	1.00	Greenwood Road	46261	0.00	0.80
5	Greenwood Road	46261	0.00	Old Mill Road / Curve 2 Start	46261	0.76	0.76
6	Old Mill Road / Curve 2 Start	46261	0.76	Curve 2 End	46261	0.99	0.23
7	Curve 2 End	46261	0.99	Drive In Road	46261	1.62	0.63
8	Drive In Road	46261	1.62	Robinson Lane	46261	2.00	0.38
9	Robinson Lane	46261	2.00	Walmart Access	46261	2.48	0.48
10	Walmart Access	46261	2.48	End of Analysis Section	46261	2.70	0.22

The CMFs for each segment are summarized in **Exhibit 2-19**. Driveway density CMFs are a function of AADT, which differ for each analysis year. In the analysis, driveway density CMFs are applied to their respective year.

Exhibit 2-19: Mainline Collision CMFs

SEGMENT	YEAR	CMF	
		DRIVEWAY DENSITY	HORIZONTAL CURVE
1	2007	1.00	1.23
2	2007	1.00	-
3	2007	1.14	-
4	2007	1.00	-
5	2007	1.20	-
	2008	1.20	
	2009	1.19	
	2010	1.19	
	2011	1.18	
6	2007	1.02	1.15
7	2007	1.41	-
	2008	1.40	
	2009	1.39	
	2010	1.38	
	2011	1.37	
8	2007	1.40	-
	2008	1.39	
	2009	1.38	
	2010	1.37	
	2011	1.36	
9	2007	1.24	-
	2008	1.24	
	2009	1.23	
	2010	1.22	
	2011	1.22	
10	2007	1.22	-
	2008	1.22	
	2009	1.21	
	2010	1.21	
	2011	1.20	

Using the SPFs, CMFs, and historical collision data, the numbers of excess collisions of each segment was calculated and are summarized in **Exhibit 2-20**.

Exhibit 2-20: Mainline Segment Excess Collisions

SEGMENT	EXCESS COLLISIONS				
	F	I	F+I	PDO	ALL
1	0.00	-0.02	-0.02	-0.20	-0.22
2	0.00	-0.01	-0.02	-0.18	-0.19
3	-0.01	-0.08	-0.09	0.40	0.31
4	-0.02	-0.13	-0.16	-2.08	-2.23
5	-0.03	-0.20	-0.23	-2.07	-2.30
6	0.00	-0.04	-0.05	-0.19	-0.24
7	-0.03	-0.18	-0.21	-1.93	-2.14
8	-0.01	0.13	0.13	-0.93	-0.81
9	-0.02	-0.20	-0.21	-1.18	-1.40
10	0.00	-0.04	-0.05	-0.18	-0.23

Generally, the mainline segments of the highway performed as or better than predicted by the SPFs. Therefore, there are no safety performance issues that are significantly different than expected.

3 Conclusions

Based on the preceding sections, the following conclusions regarding the existing conditions were made:

Operational Analysis

- Intersections in the urban section of the corridor are operating at an acceptable level of service. However, vehicle queues in the through lanes along Highway 148 periodically block access to adjacent turning lanes at the Angus Campbell Drive and Robinson Lane intersections during the peak hours;
- At the Drive In Road intersection, signals are warranted under rural conditions, but not under urban conditions. However, under urban conditions, signals are close to being warranted and it can be expected that the warrant will be met within the near future; and
- Based on the surrounding land uses, side road volume data at the intersections at Hazley Bay Drive, Beckett View Drive E JCT, and Francie Lane were higher than expected, and there may be some operational and safety benefits to consolidating several of the crossing roadways to create fewer conflict points.

Safety Analysis

- There are approximately 5-10 collisions per year with an apparently anomalous spike of 15 collisions in 2009. Rear end collisions (41%) and single vehicle collisions (32%) were the two most common initial impact types.
- Collisions occur more frequently in the urbanized section than in the rural section;
- The number of collisions along curved sections does not appear to be significantly different in comparison to other sections of the mainline;
- A majority of injury collisions occur within the urbanized section;

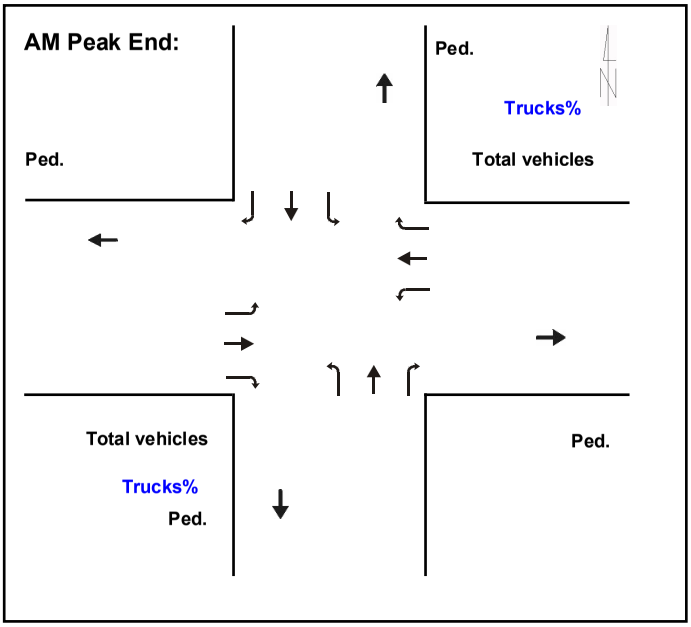
- There are a significant number of turning collisions at the Greenwood Road intersection. However, traffic signals are not currently warranted based on volumes, delay, or collision experience;
- Wild animal collisions at the Old Mill Road intersection are likely related to animals crossing between the field south of Highway 148 and the small wooded area north of Highway 148. Improvements could be made to the intersection to reduce the likelihood of these collisions, such as vegetation trimming, fencing, lighting, and posting warning signs;
- The OR analysis found that rear-end and turning collisions were over-represented, as well as the related driver action of “Following Close”. The over representation of these collisions and may be the due to the high density of driveways and intersections along the corridor, especially within the urbanized section;
- The OR analysis shows that collisions under “rainy” environmental and “wet” road conditions were over-represented. There were no identifiable trends in collision location, type of initial impact, or driver actions resulting in collisions. An investigation into the road drainage may provide further insight into such collisions; and
- With the exception of the Greenwood Road intersection, the study area intersections and mainline did not show any locations with significant excess collision frequencies over the analysis period.

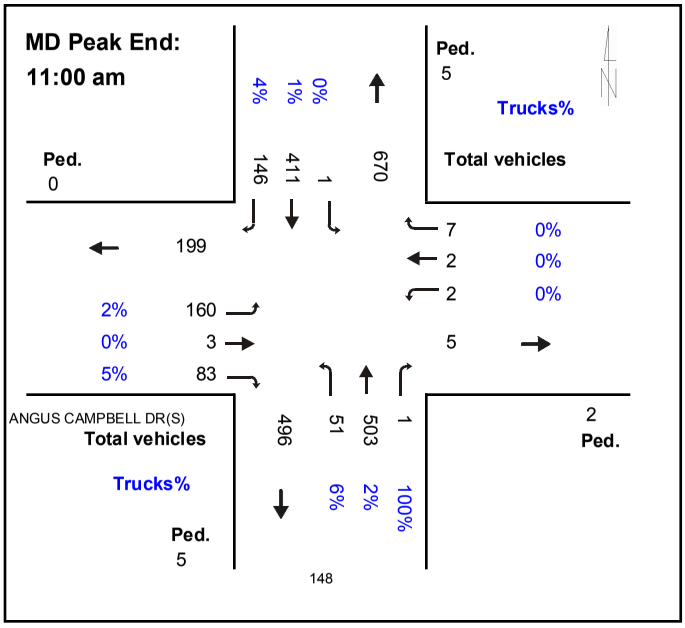
Appendix A: Turning Movement Counts

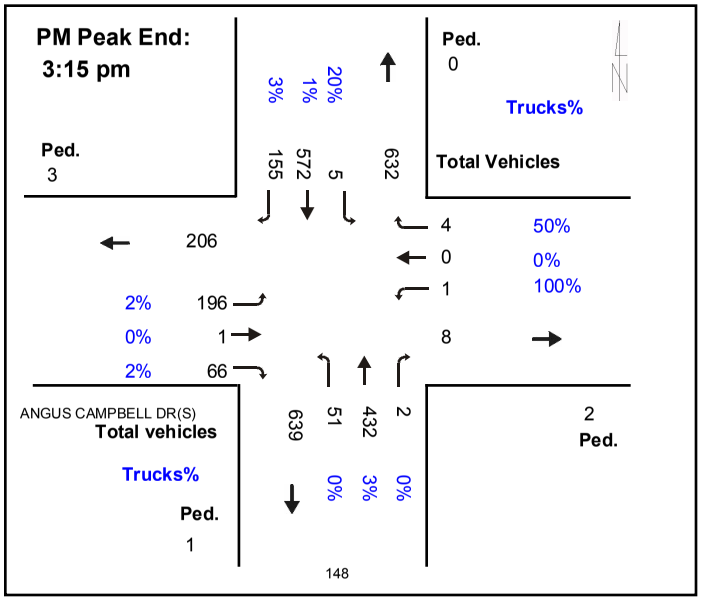
HWY 148 @ ANGUS CAMPBELL DR(S)

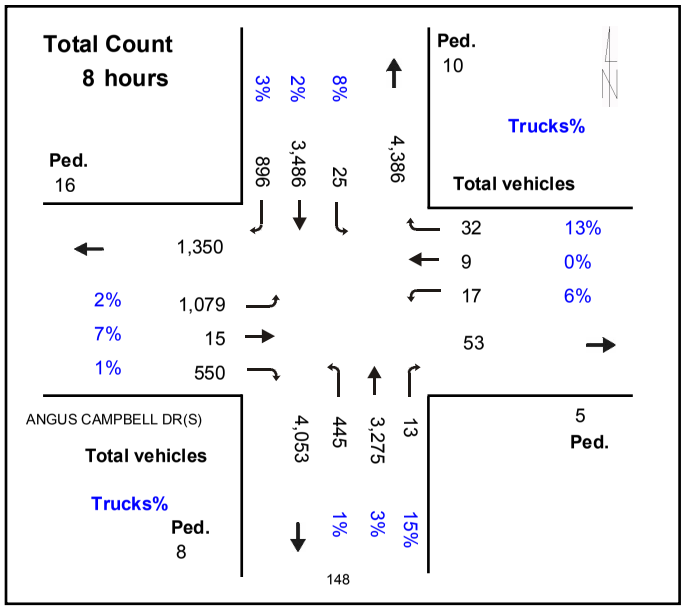
Eastern

Intersection ID:462610307 **Count Day: Monday** **Count Date: 13-Aug-2012**









15 MIN REPORT

Intersection ID:462610307 **HWY 148 @ ANGUS CAMPBELL DR(S)** **Municipality: Eastern** **Date: 13-Aug-2012**

	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																									
14:15	0	130	56	0	0	1	0	1	1	0	1	1	2	0	0	0	0	0	0	0	10	123	1	0	3	0	0	0	0	0	50	0	16	1	1	0	0	0	0	0	398
14:30	0	129	39	1	3	0	0	0	1	0	0	0	1	0	0	2	0	0	0	0	11	97	1	0	0	0	0	1	0	0	41	0	15	1	0	0	0	0	0	3	346
14:45	2	146	39	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	8	96	0	0	3	0	0	2	0	0	47	0	14	0	0	0	0	0	0	0	360
15:00	1	127	34	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	15	104	1	0	3	0	0	0	0	0	63	1	10	0	0	0	0	0	0	0	362
15:15	1	165	39	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	123	0	0	2	0	0	1	0	1	42	0	26	2	0	0	0	0	1	0	423
15:30	3	107	22	0	1	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	13	99	1	0	4	0	0	0	0	0	33	0	16	1	0	0	0	0	0	0	304
15:45	1	163	31	0	2	0	0	1	0	1	0	0	2	0	0	0	0	0	0	0	22	91	0	0	1	0	0	0	0	0	38	1	26	0	0	0	0	0	0	0	380
16:00	0	115	33	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	102	0	0	3	0	0	1	0	0	45	1	15	0	0	0	0	0	0	0	340
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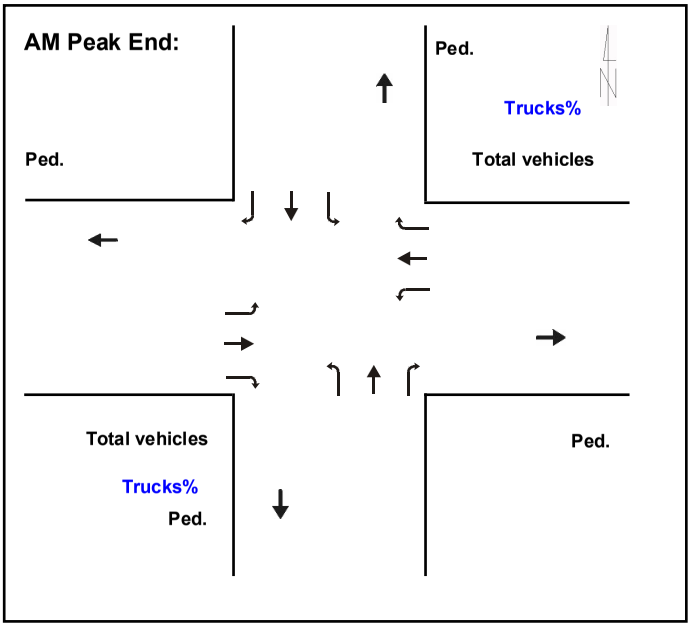
17:00	1	121	25	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	24	79	0	0	0	0	0	0	0	0	18	0	20	0	0	0	0	0	0	1	292
17:15	1	169	27	0	7	0	0	3	0	0	0	0	6	0	0	1	0	0	0	0	15	79	0	0	2	0	0	0	0	0	25	1	20	0	0	1	0	0	0	0	357
17:30	2	141	27	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	14	63	0	0	1	0	0	0	0	0	38	1	22	0	0	0	0	0	0	0	311
17:45	2	137	32	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	20	76	0	1	1	0	0	1	0	0	39	1	16	0	0	0	0	0	0	1	329
18:00	0	113	25	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	10	78	0	0	0	0	0	1	0	0	32	0	15	0	0	0	0	0	0	0	277
Period2																																									
7:15	1	29	12	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	6	69	3	0	7	0	0	1	0	1	8	0	4	1	0	0	0	0	0	0	147
7:30	1	39	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	80	0	0	3	0	0	0	0	0	12	0	9	1	0	0	0	0	0	0	161
7:45	1	51	11	0	6	1	0	1	1	0	2	0	1	0	0	0	0	0	0	0	8	104	0	0	1	0	0	1	0	0	6	1	9	0	0	0	0	0	0	0	205
8:00	0	46	8	0	2	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	10	129	1	0	5	0	0	1	0	0	18	1	11	0	0	0	1	0	0	0	236
8:15	0	58	12	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	16	100	1	0	4	0	0	0	0	0	15	0	9	0	0	0	0	0	0	0	217
8:30	0	57	16	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	10	110	0	1	2	0	0	1	0	0	16	0	11	0	0	0	0	0	0	1	229
8:45	0	75	12	1	2	0	0	2	0	0	0	1	1	0	0	1	0	0	0	0	13	123	0	0	2	0	0	1	0	0	21	0	15	1	0	0	0	0	0	0	271
9:00	0	71	30	0	3	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	12	110	0	1	1	0	0	1	0	0	30	0	12	2	0	0	0	0	0	0	276
9:15	1	87	27	0	3	0	0	2	0	3	2	0	0	0	0	0	0	0	0	0	10	85	0	0	6	0	0	2	0	0	26	0	16	0	0	0	0	0	0	2	272
9:30	0	83	31	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	108	1	0	2	0	0	0	0	0	25	0	15	0	0	1	0	0	0	3	284
9:45	0	99	27	0	3	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	10	84	0	0	2	0	0	2	0	0	29	0	13	1	0	0	0	0	0	0	273
10:00	2	104	35	0	1	2	0	0	0	0	2	1	0	1	0	0	0	0	0	0	16	130	1	0	1	0	0	0	0	0	39	1	23	2	0	0	0	0	0	0	361
10:15	1	78	42	0	0	1	0	1	2	3	1	0	1	0	0	0	0	0	0	1	11	122	0	1	1	0	0	1	0	1	33	2	19	0	0	1	0	0	0	0	323
10:30	0	101	34	0	2	0	0	1	0	2	1	1	0	0	0	0	0	0	0	1	11	117	0	0	1	0	0	0	0	2	37	0	14	2	0	1	0	0	0	0	328
10:45	0	109	36	0	1	1	0	0	0	0	0	1	3	0	0	0	0	0	0	0	15	122	0	0	1	0	1	0	0	0	46	0	22	0	0	0	0	0	1	0	359
11:00	0	117	28	0	1	2	0	0	0	0	0	0	3	0	0	0	0	0	0	0	11	131	0	0	5	1	1	2	0	2	41	1	24	1	0	0	0	0	1	0	372

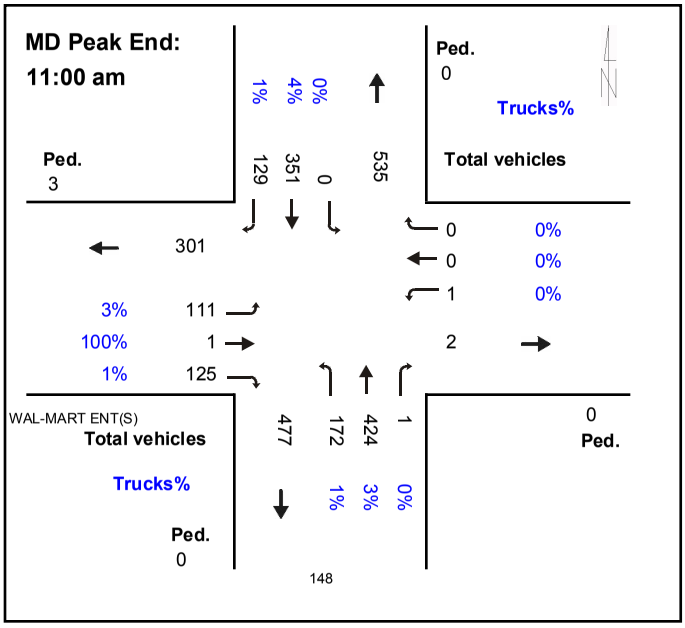
Ontario

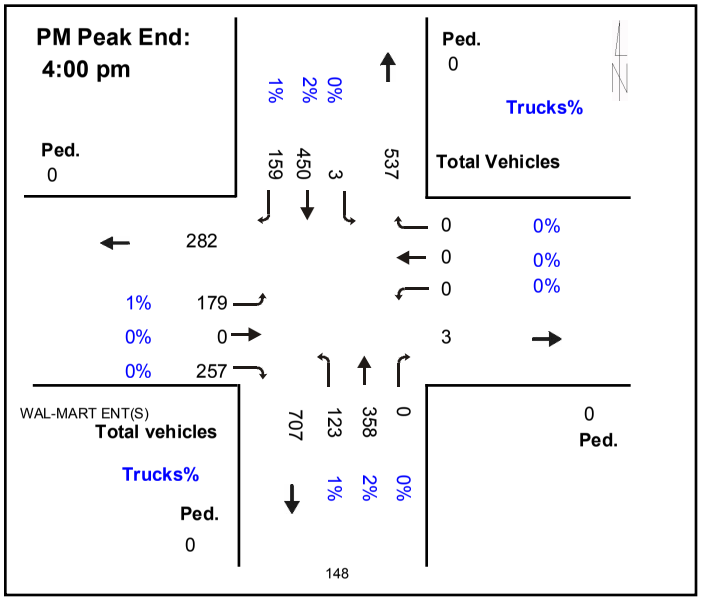
HWY 148 @ WAL-MART ENT(S)

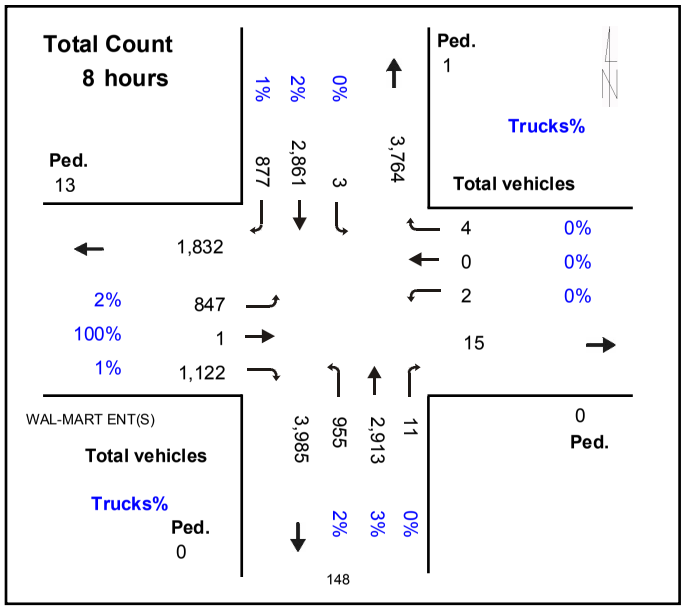
Eastern

Intersection ID:462610248 **Count Day: Tuesday** **Count Date: 14-Aug-2012**









15 MIN REPORT

Intersection ID:462610248 **HWY 148 @ WAL-MART ENT(S)** **Municipality: Eastern** **Date: 14-Aug-2012**

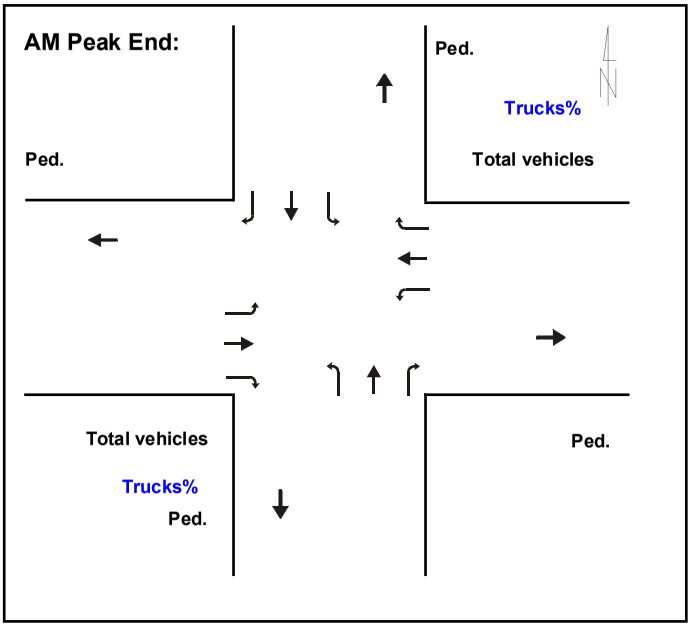
	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																									
14:15	0	106	42	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	39	73	3	0	0	0	1	1	0	0	39	0	63	1	0	0	0	0	0	0	370
14:30	0	103	38	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	38	84	0	0	2	0	0	0	0	0	33	0	49	0	0	0	0	0	0	0	350
14:45	0	102	40	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	40	86	1	1	0	0	0	0	0	0	37	0	49	0	0	0	0	0	0	1	361
15:00	0	102	35	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	97	5	0	1	0	0	0	0	0	45	0	43	2	0	1	0	0	1	0	374
15:15	1	91	44	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	78	0	0	2	0	0	0	0	0	55	0	60	0	0	0	0	0	0	0	370
15:30	1	101	34	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	91	0	0	0	0	0	0	0	0	34	0	65	0	0	0	0	0	0	0	355
15:45	0	129	41	0	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	23	91	0	0	2	0	0	1	0	0	49	0	59	0	0	0	0	0	0	0	400
16:00	1	122	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	92	0	1	1	0	0	0	0	0	40	0	73	1	0	0	0	0	0	0	404
16:15	0	129	31	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	24	73	0	0	2	0	0	0	0	0	34	0	65	1	0	1	0	0	0	1	363
16:30	0	142	29	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	66	0	1	4	0	0	0	0	0	31	0	57	0	0	0	0	0	0	0	358
16:45	0	138	36	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	77	0	0	0	0	0	0	0	0	31	0	63	1	0	0	0	0	0	0	382
17:00	0	149	26	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	85	0	0	3	0	0	0	0	0	37	0	54	1	0	0	0	0	0	0	393
17:15	0	143	35	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	42	76	0	0	2	0	0	0	0	0	36	0	53	0	0	0	0	0	0	0	389
17:30	0	111	34	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	78	0	2	0	0	0	0	0	0	34	0	41	0	0	0	0	0	0	0	323
17:45	0	127	28	0	3	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	26	53	0	0	1	0	0	0	0	0	30	0	49	0	0	0	1	0	0	0	320
18:00	0	96	34	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	61	0	0	3	0	1	0	0	0	37	0	39	0	0	1	0	0	0	0	299
Period2																																									
7:15	0	28	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	66	0	2	1	0	1	1	0	0	5	0	7	0	0	0	0	0	0	0	122
7:30	0	33	4	0	3	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	10	86	1	0	2	0	0	1	0	0	4	0	3	0	0	1	0	0	0	1	151
7:45	0	29	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	96	0	1	4	0	0	0	0	0	9	0	6	0	0	0	0	0	1	0	174
8:00	0	44	15	0	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18	124	0	1	2	0	0	0	0	0	4	0	3	2	0	1	0	0	0	0	219
8:15	0	45	15	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	98	0	1	4	0	0	0	0	0	6	0	7	2	0	0	0	0	0	1	193
8:30	0	41	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	26	112	0	1	2	0	0	3	0	0	7	0	7	0	0	0	0	0	0	0	214
8:45	0	48	14	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	23	109	0	2	0	0	0	0	0	0	11	0	9	0	0	0	0	0	0	0	220
9:00	0	54	12	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	17	122	0	2	2	0	0	0	0	0	7	0	9	1	0	0	0	0	0	1	230
9:15	0	52	12	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	28	86	0	1	1	0	0	1	0	0	12	0	13	0	0	1	0	0	0	0	209
9:30	0	53	21	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	80	0	0	6	0	0	1	0	0	13	0	14	0	0	0	0	0	0	1	225
9:45	0	66	26	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	91	0	1	2	0	0	2	0	0	22	0	10	0	0	1	0	0	0	0	255
10:00	0	70	32	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	20	94	0	1	3	0	0	1	0	0	19	0	17	2	0	1	0	0	0	4	269
10:15	0	86	27	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	46	102	1	0	1	0	0	1	0	0	24	0	31	0	0	0	0	0	0	0	324
10:30	0	82	29	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	49	106	0	0	5	0	0	0	0	0	18	0	32	1	0	0	0	0	0	0	325
10:45	0	83	37	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	37	107	0	0	2	0	0	2	0	0	35	0	30	1	0	0	0	1	0	3	340
11:00	0	87	35	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	39	96	0	1	0	0	0	2	0	0	31	0	31	0	0	0	1	0	1	0	329

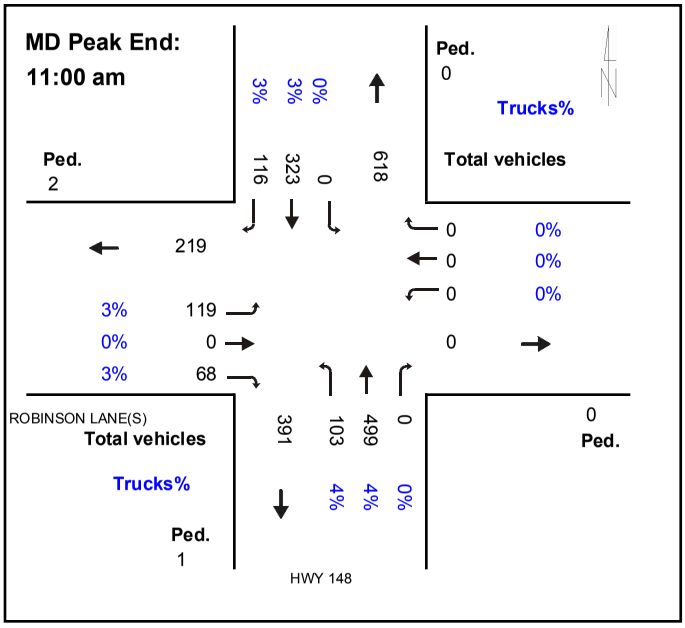
Ontario

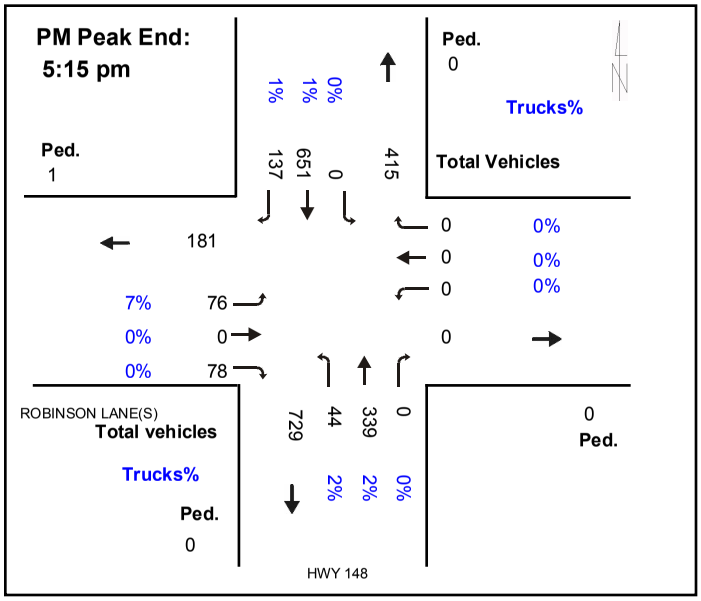
HWY 148 @ ROBINSON LANE(S)

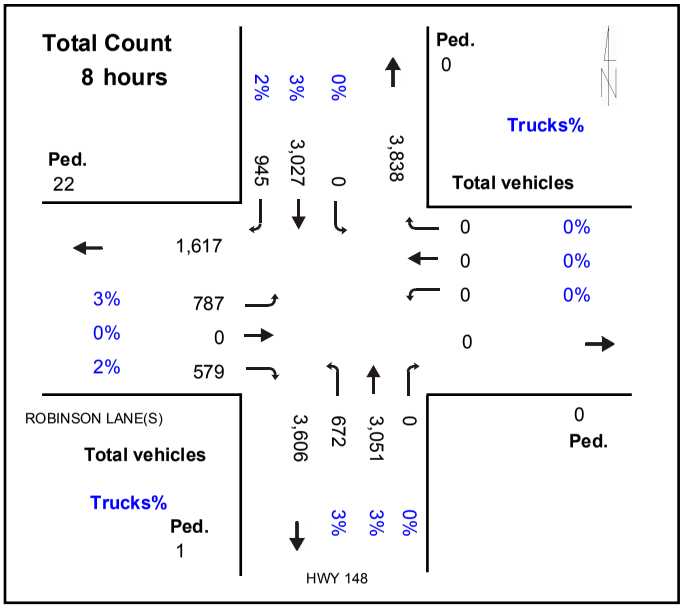
Eastern

Intersection ID:462610200 **Count Day: Monday** **Count Date: 13-Aug-2012**









15 MIN REPORT

Intersection ID:462610200 **HWY 148 @ ROBINSON LANE(S)** **Municipality: Eastern** **Date: 13-Aug-2012**

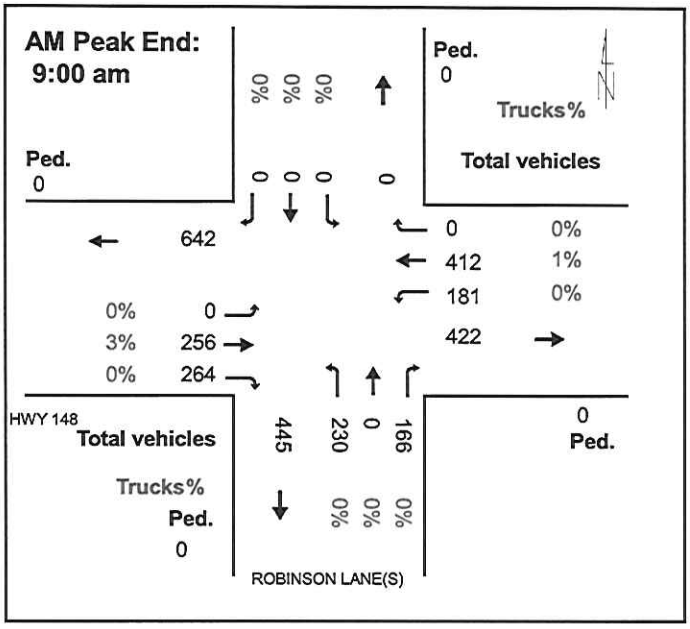
	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																								
14:15	0	88	32	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	16	65	0	0	2	0	0	0	0	0	32	0	16	0	0	0	0	0	0	0	254
14:30	0	118	27	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	73	0	0	0	0	0	0	0	0	15	0	8	0	0	0	0	0	0	0	251
14:45	0	110	28	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	75	0	0	3	0	1	2	0	0	26	0	16	0	0	0	0	0	0	2	282
15:00	0	120	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	80	0	1	3	0	0	0	0	0	24	0	17	1	0	0	0	0	0	0	297
15:15	0	119	48	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	15	104	0	0	3	0	0	1	0	0	26	0	24	0	0	0	0	0	0	2	347
15:30	0	98	31	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	12	85	0	0	2	0	0	0	0	0	30	0	26	0	0	0	0	0	0	0	287
15:45	0	138	35	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	9	90	0	0	2	0	0	0	0	0	32	0	24	0	0	0	0	0	0	0	333
16:00	0	120	39	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	87	0	1	2	0	0	1	0	0	27	0	16	0	0	1	0	0	0	0	306
16:15	0	149	40	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	12	65	0	4	1	0	0	0	0	0	20	0	25	0	0	0	0	0	0	0	318
16:30	0	159	35	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	78	0	0	2	0	0	0	0	0	19	0	20	0	0	0	0	0	0	0	325
16:45	0	179	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	86	0	0	1	0	1	0	0	0	25	0	16	4	0	0	0	0	0	0	359
17:00	0	139	36	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	92	0	0	1	0	0	1	0	0	16	0	22	0	0	0	0	0	0	1	318
17:15	0	166	28	0	5	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	12	77	0	0	1	0	0	0	0	0	11	0	20	1	0	0	0	0	0	0	324
17:30	0	160	32	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	13	64	0	0	0	0	0	1	0	0	19	0	14	0	0	0	0	0	0	6	311
17:45	0	143	23	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	9	89	0	0	2	0	0	1	0	0	12	0	21	0	0	0	0	0	0	1	304
18:00	0	106	27	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	70	0	0	1	0	0	1	0	0	10	0	12	0	0	0	0	0	0	0	233
Period2																																								
7:15	0	31	15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	16	49	0	3	3	0	0	2	0	0	10	0	12	1	0	0	0	0	1	6	150
7:30	0	30	16	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	85	0	1	0	0	0	0	0	0	15	0	19	3	0	1	0	0	0	0	208
7:45	0	26	24	0	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	22	95	0	0	3	0	0	1	0	0	22	0	17	0	0	1	0	0	0	0	216
8:00	0	36	19	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	33	121	0	1	5	0	0	0	0	0	34	0	17	0	0	0	1	0	0	0	272
8:15	0	45	15	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	34	97	0	0	5	0	0	0	0	0	33	0	18	0	0	2	0	0	0	0	254
8:30	0	38	19	0	4	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	36	108	0	1	2	0	0	1	0	0	32	0	14	2	0	0	0	0	0	0	260
8:45	0	40	30	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	29	120	0	0	1	0	0	1	0	0	25	0	17	1	0	0	0	0	0	0	267
9:00	0	51	22	0	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	33	116	0	1	2	0	0	1	0	0	29	0	13	0	0	0	0	0	0	0	273
9:15	0	54	35	0	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	24	98	0	0	4	0	0	3	0	0	26	0	13	2	0	2	0	0	1	0	267
9:30	0	47	22	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	108	0	0	2	0	0	0	0	0	21	0	22	0	0	1	0	0	0	1	251
9:45	0	62	36	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	34	95	0	1	2	0	0	1	0	0	27	0	28	2	0	0	0	0	0	0	292
10:00	0	64	35	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	104	0	0	3	0	0	0	0	0	32	0	14	0	0	0	0	0	0	1	294
10:15	0	54	23	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18	109	0	2	2	0	0	2	0	0	25	0	23	0	0	0	0	0	0	2	263
10:30	0	64	32	0	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	32	84	0	0	1	0	1	2	0	1	37	0	10	1	0	1	0	0	0	0	271
10:45	0	96	27	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	24	129	0	0	4	0	0	0	0	0	26	0	14	1	0	1	0	0	0	0	326
11:00	0	98	30	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	25	156	0	1	7	0	0	3	0	0	28	0	19	1	0	0	0	0	0	0	371

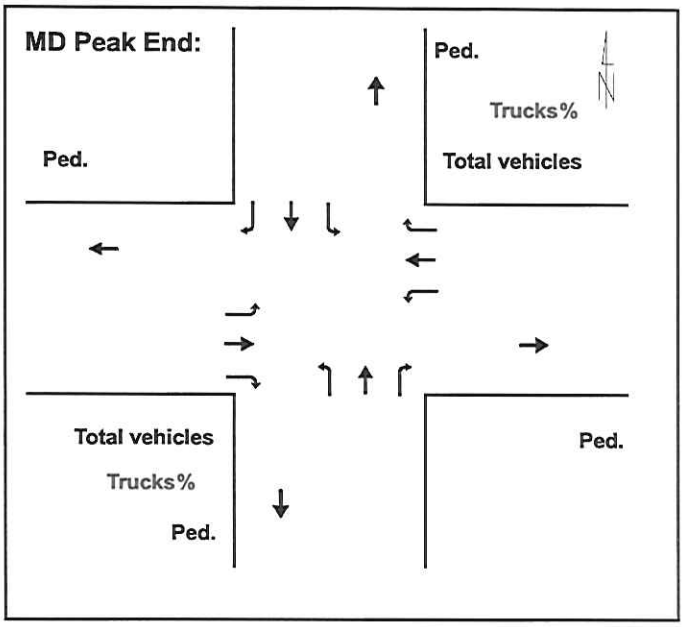
Ontario

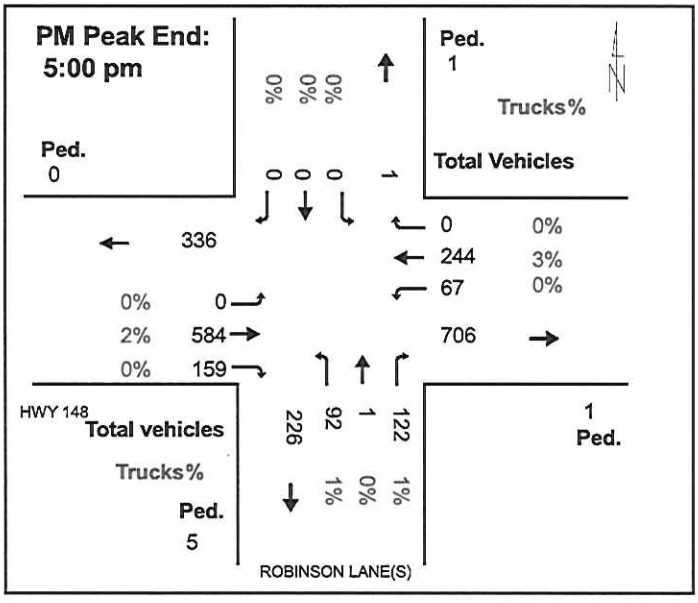
HWY 148 @ ROBINSON LANE(S)

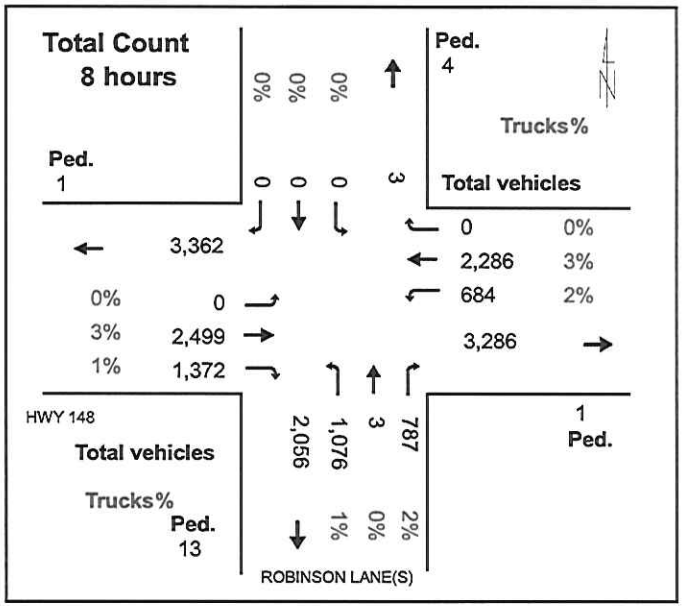
Eastern

Intersection ID:462610200 | **Count Day: Tuesday** | **Count Date: 24-Feb-2015**









15 MIN REPORT

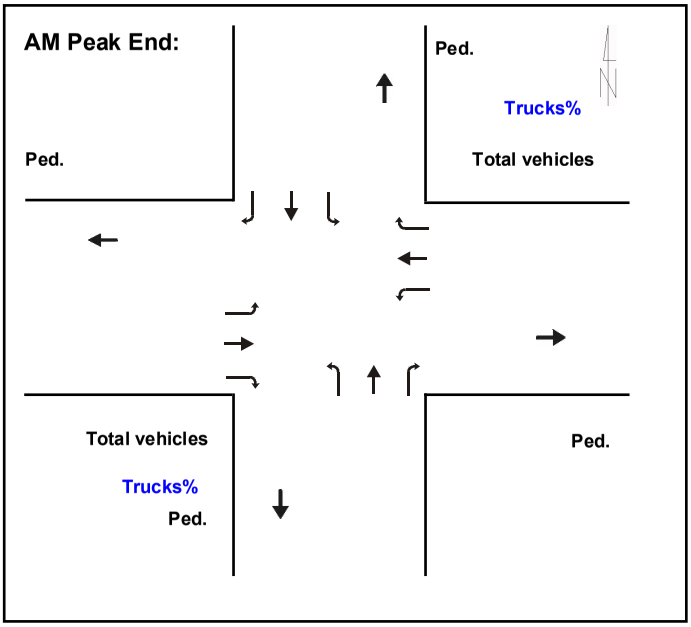
Intersection ID:462610200 **HWY 148 @ ROBINSON LANE(S)** **Municipality: Eastern** **Date: 24-Feb-2015**

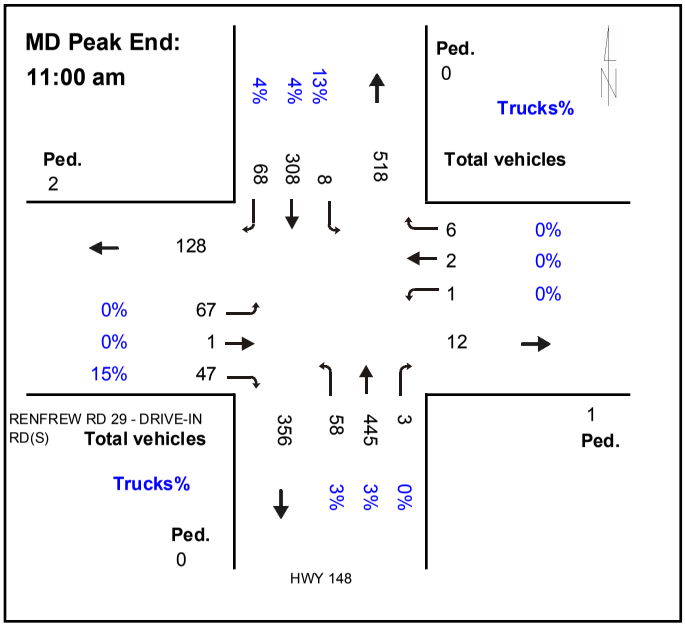
	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																								
13:15	0	0	0	0	0	0	0	0	0	0	17	54	0	0	2	0	0	1	0	0	34	0	16	0	0	0	0	0	0	0	0	85	47	0	0	1	0	3	0	0	260
13:30	0	0	0	0	0	0	0	0	0	0	20	61	0	0	0	0	0	3	0	0	38	0	24	0	0	1	1	0	0	0	0	79	42	0	0	1	0	0	0	0	270
13:45	0	0	0	0	0	0	0	0	0	0	25	72	0	0	0	0	0	2	0	0	29	0	28	0	0	0	0	0	0	0	0	73	47	0	0	0	0	0	0	0	276
14:00	0	0	0	0	0	0	0	0	0	0	11	73	0	0	0	0	0	1	0	0	31	0	18	0	0	1	0	0	0	2	0	84	38	0	2	0	0	1	0	0	262
14:15	0	0	0	0	0	0	0	0	0	0	15	59	0	0	0	0	2	1	0	0	25	0	25	1	0	0	0	0	0	0	0	64	44	0	1	1	0	1	0	0	239
14:30	0	0	0	0	0	0	0	0	0	0	12	62	0	0	0	0	0	1	0	0	29	0	18	0	0	0	1	0	0	0	0	85	51	0	0	1	0	0	0	0	260
14:45	0	0	0	0	0	0	0	0	0	0	22	57	0	1	1	0	0	2	0	0	34	0	27	1	0	0	0	0	0	0	0	98	45	0	1	0	0	0	0	0	289
15:00	0	0	0	0	0	0	0	0	0	0	9	58	0	0	0	0	1	3	0	0	36	0	22	2	0	1	0	0	0	0	0	108	37	0	2	2	0	0	2	0	283
15:15	0	0	0	0	0	0	0	0	0	0	21	55	0	0	0	0	0	0	0	0	22	0	25	1	0	0	0	0	2	0	0	81	38	0	0	0	0	4	0	0	249
15:30	0	0	0	0	0	0	0	0	0	0	20	43	0	1	1	0	1	0	0	0	42	0	33	0	0	0	0	0	0	0	0	76	35	0	0	0	0	0	0	0	252
15:45	0	0	0	0	0	0	0	0	0	0	10	56	0	1	1	0	0	1	0	0	31	0	21	0	0	0	0	0	0	0	0	110	50	0	1	0	0	8	0	0	290
16:00	0	0	0	0	0	0	0	0	0	1	12	66	0	0	0	0	0	0	0	0	34	1	30	0	0	1	0	0	1	0	0	105	45	0	0	0	0	4	0	1	301
16:15	0	0	0	0	0	0	0	0	0	0	12	62	0	2	0	0	0	1	0	0	22	0	26	0	0	0	0	0	0	0	0	139	37	0	0	0	0	0	0	0	301
16:30	0	0	0	0	0	0	0	0	0	0	23	58	0	0	2	0	0	1	0	0	25	0	40	1	0	1	0	0	0	0	0	121	38	0	0	0	0	3	0	0	313
16:45	0	0	0	0	0	0	0	0	0	1	19	57	0	0	1	0	0	1	0	0	23	1	32	0	0	0	0	0	0	0	0	137	39	0	0	0	0	2	0	0	313
17:00	0	0	0	0	0	0	0	0	0	0	10	60	0	1	0	0	0	1	0	1	21	0	23	0	0	0	0	0	0	5	0	177	45	0	2	0	0	3	0	0	349
Period2																																								
8:15	0	0	0	0	0	0	0	0	0	0	63	118	0	0	0	0	0	0	0	0	64	0	87	0	0	0	0	0	0	0	0	98	103	0	2	0	0	0	0	0	535
8:30	0	0	0	0	0	0	0	0	0	0	61	119	0	0	0	0	0	0	0	0	117	0	51	0	0	0	0	0	0	0	0	85	114	0	0	0	0	0	0	0	547
8:45	0	0	0	0	0	0	0	0	0	0	16	44	0	0	1	0	0	1	0	0	24	0	10	1	0	0	0	0	0	0	0	18	20	0	0	0	0	0	0	0	135
9:00	0	0	0	0	0	0	0	0	0	0	41	126	0	0	2	0	0	1	0	0	24	0	18	0	0	0	0	0	0	0	0	48	27	0	2	0	0	3	0	0	292
9:15	0	0	0	0	0	0	0	0	0	0	20	83	0	0	1	0	0	2	0	0	28	0	14	0	0	0	0	0	1	0	0	32	16	0	2	0	0	1	0	0	200
9:30	0	0	0	0	0	0	0	0	0	0	14	88	0	0	2	0	1	3	0	0	24	0	23	0	0	0	0	0	0	5	0	39	41	0	1	0	0	0	0	0	241
9:45	0	0	0	0	0	0	0	0	0	1	26	77	0	0	1	0	0	1	0	0	29	0	22	0	0	0	0	0	0	0	0	40	31	0	3	0	0	3	0	0	234
10:00	0	0	0	0	0	0	0	0	0	0	27	87	0	0	1	0	0	2	0	0	38	0	18	0	0	0	1	0	0	0	0	43	42	0	3	0	0	0	0	0	262
10:15	0	0	0	0	0	0	0	0	0	0	25	77	0	2	1	0	0	2	0	0	27	0	15	0	0	0	0	0	0	0	0	34	43	0	0	1	0	1	0	0	228
10:30	0	0	0	0	0	0	0	0	0	0	20	49	0	0	0	0	1	1	0	0	37	0	15	1	0	0	0	0	1	0	0	35	24	0	1	0	0	3	1	0	189
10:45	0	0	0	0	0	0	0	0	0	0	24	78	0	0	0	0	0	1	0	0	27	0	17	1	0	0	0	0	0	0	0	47	34	0	0	0	0	0	0	0	229
11:00	0	0	0	0	0	0	0	0	0	0	16	86	0	0	1	0	1	2	0	0	28	0	19	0	0	0	1	0	0	1	0	56	34	0	2	0	0	0	2	0	249
11:15	0	0	0	0	0	0	0	0	0	0	16	62	0	1	1	0	0	1	0	0	24	0	11	1	0	1	0	0	0	0	0	53	27	0	0	0	0	0	0	0	198
11:30	0	0	0	0	0	0	0	0	0	1	16	61	0	0	2	0	1	0	0	0	30	1	18	1	0	0	0	0	0	0	0	67	32	0	2	2	0	2	0	0	236
11:45	0	0	0	0	0	0	0	0	0	0	8	50	0	0	0	0	0	2	0	0	28	0	12	1	0	1	0	0	0	0	0	56	47	0	2	0	0	1	0	0	208
12:00	0	0	0	0	0	0	0	0	0	0	16	66	0	0	1	0	0	2	0	0	35	0	17	0	0	0	0	0	0	0	0	53	43	0	0	1	0	1	1	0	236

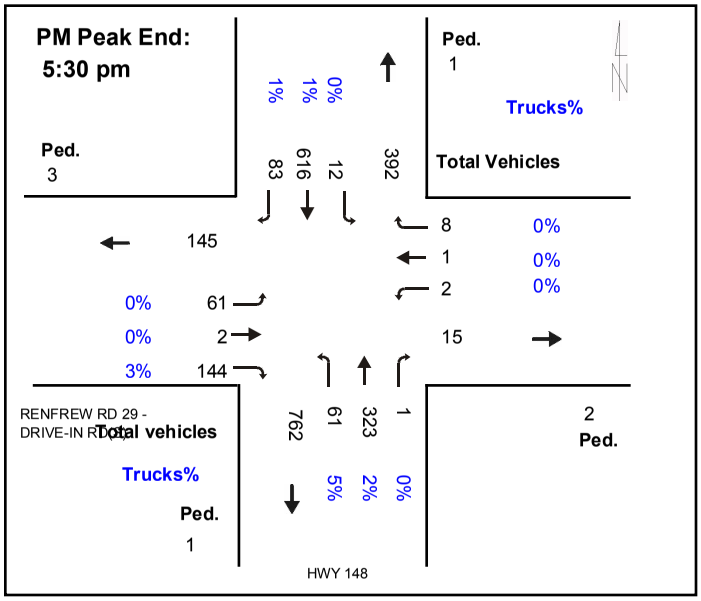
HWY 148 @ RENFREW RD 29 - DRIVE-IN RD(S)

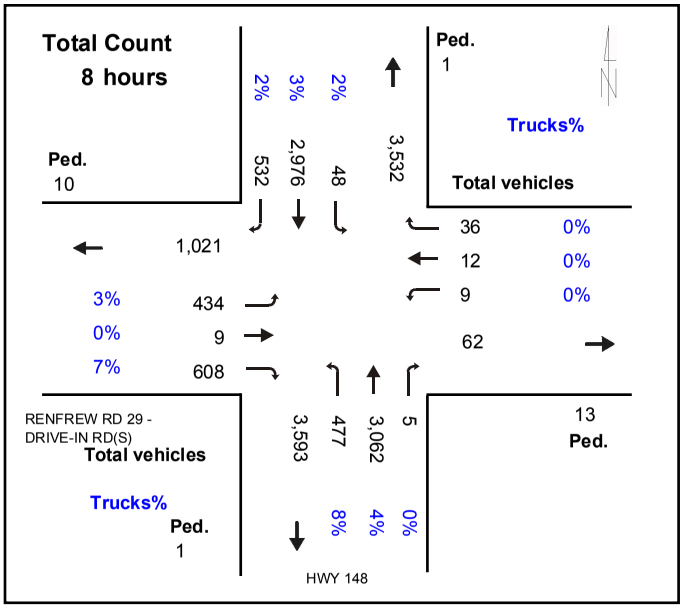
Eastern

Intersection ID:462610162 **Count Day: Tuesday** **Count Date: 14-Aug-2012**









15 MIN REPORT

Intersection ID:462610162 **HWY 148 @ RENFREW RD 29 - DRIVE-IN RD(S)** **Municipality: Eastern** **Date: 14-Aug-2012**

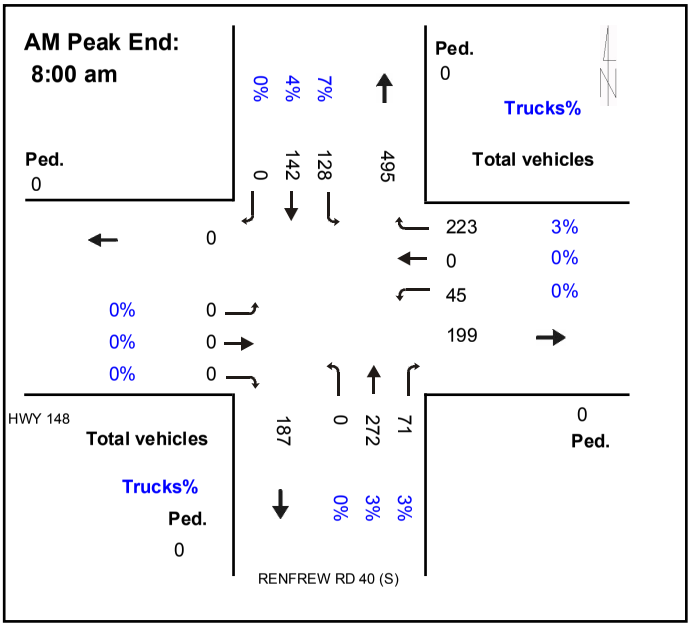
	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																								
14:15	1	105	18	0	2	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	14	80	0	0	2	0	0	3	0	0	14	0	18	0	0	0	0	0	0	0	260
14:30	1	119	20	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	13	86	0	1	3	0	0	0	0	0	11	1	15	2	0	4	0	0	0	0	280
14:45	0	128	18	0	6	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	15	104	0	1	2	0	0	1	0	0	14	0	15	0	0	0	0	0	0	1	309
15:00	1	111	18	0	5	0	0	1	1	0	0	2	2	0	0	0	0	0	0	0	8	88	1	2	6	0	0	0	0	0	10	1	18	1	0	0	0	0	0	0	276
15:15	3	108	33	0	3	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	15	79	0	1	3	0	2	0	0	0	16	0	26	0	0	1	0	0	0	0	295
15:30	3	115	25	0	4	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	15	82	0	0	1	0	0	1	0	0	9	1	19	0	0	2	0	0	0	0	279
15:45	1	139	19	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18	87	0	2	3	0	0	0	0	0	9	0	40	2	0	4	0	0	0	0	330
16:00	0	143	30	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	88	0	3	5	0	0	0	0	0	16	0	24	0	0	0	0	0	0	2	324
16:15	3	157	27	0	2	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	18	74	0	1	2	0	1	0	0	0	6	1	31	0	0	3	0	0	0	0	329
16:30	2	108	15	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	7	55	0	3	5	0	0	0	0	0	20	0	30	0	0	1	0	0	0	0	248
16:45	2	128	11	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	8	77	0	1	0	0	0	0	0	0	15	1	35	0	0	2	0	0	0	0	285
17:00	1	165	23	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	18	86	0	0	4	0	0	0	0	0	11	1	43	0	0	0	0	0	1	3	361
17:15	5	181	31	0	1	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	20	72	1	1	2	0	0	0	0	1	13	0	27	0	0	1	0	0	0	0	359
17:30	4	135	17	0	3	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	12	80	0	1	2	0	0	0	0	0	22	0	35	0	0	0	0	0	0	0	316
17:45	1	137	23	0	2	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	8	69	0	0	1	0	0	0	0	0	6	0	29	0	0	2	0	0	1	0	282
18:00	3	120	17	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	14	62	0	1	2	0	0	1	0	0	12	0	16	0	0	1	0	0	0	1	252
Period2																																								
7:15	0	24	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	17	69	0	3	2	0	0	3	0	0	10	0	8	0	0	0	0	0	0	0	152
7:30	2	28	5	0	4	0	0	1	0	0	1	0	2	0	0	0	0	0	0	0	15	77	0	0	3	0	0	0	0	0	11	0	7	0	0	0	0	0	0	0	156
7:45	0	34	13	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	19	114	0	0	7	0	0	0	0	0	14	0	5	0	0	0	0	0	0	1	210
8:00	0	42	9	0	1	1	0	1	0	0	0	2	2	0	0	0	0	0	0	0	20	114	0	1	1	0	0	0	0	0	29	1	7	1	0	1	0	0	0	0	233
8:15	2	37	4	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	12	116	0	0	4	0	0	0	0	0	11	0	8	0	0	0	0	0	1	0	200
8:30	1	28	17	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	111	0	0	2	0	0	0	0	0	7	1	11	0	0	2	0	0	1	0	191
8:45	0	39	6	0	2	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	13	117	0	1	2	0	0	0	0	0	13	0	8	2	0	1	0	0	0	0	207
9:00	1	34	10	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	15	122	0	2	4	0	0	0	0	0	9	0	12	0	0	1	0	0	0	0	213
9:15	0	48	9	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	2	14	96	0	0	5	0	0	1	0	0	10	0	9	1	0	1	0	0	0	0	201
9:30	1	53	12	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	20	104	0	2	4	0	0	1	0	0	15	0	6	1	0	2	0	0	0	0	223
9:45	2	69	8	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11	99	0	4	2	0	1	3	0	0	12	0	6	0	0	2	0	0	0	0	222
10:00	0	53	6	0	5	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	6	113	0	3	2	0	0	1	0	0	11	0	15	1	0	2	0	0	1	0	223
10:15	3	65	16	0	2	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	20	101	0	2	1	0	0	1	0	0	15	0	10	0	0	2	0	0	0	1	242
10:30	0	74	15	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	11	116	0	0	4	0	0	0	0	0	15	0	8	0	0	4	0	0	0	1	253
10:45	3	79	19	0	4	1	0	0	0	0	1	0	3	0	0	0	0	0	0	0	8	124	2	0	4	0	0	1	0	0	23	0	8	0	0	0	0	0	0	0	280
11:00	1	77	15	1	2	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	17	91	1	0	0	0	0	2	0	0	14	1	14	0	0	1	0	0	0	0	242

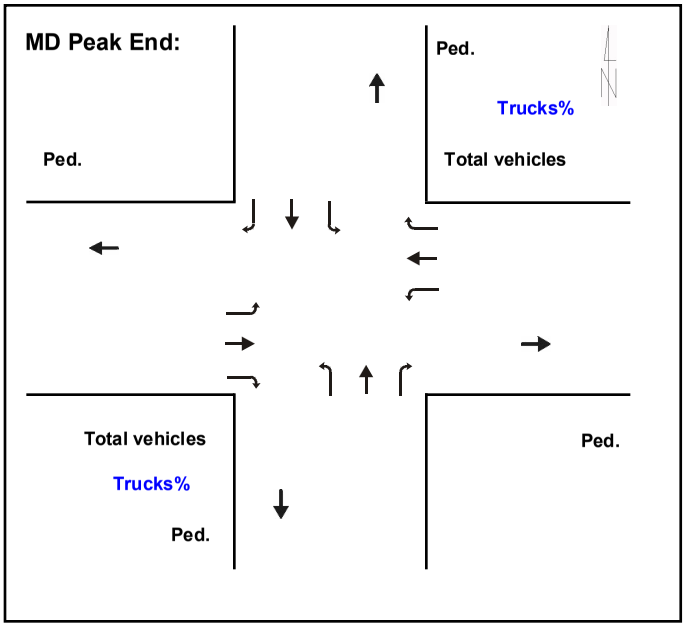
Ontario

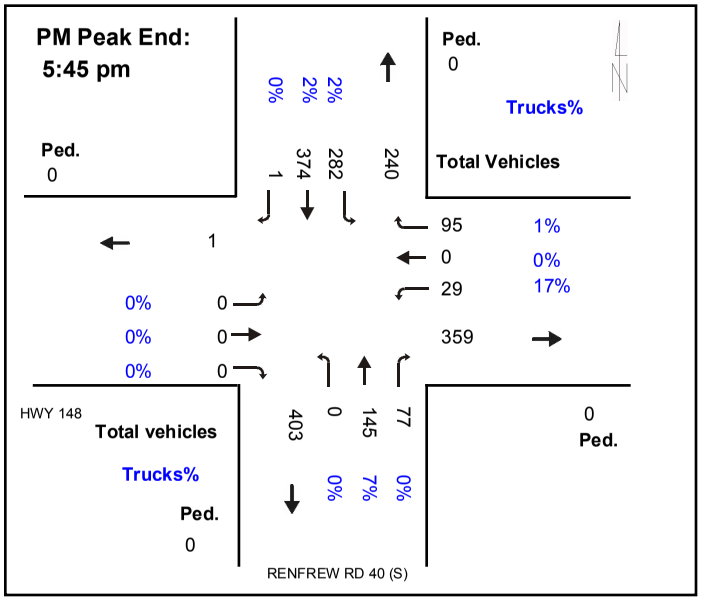
HWY 148 @ RENFREW RD 40 (S)

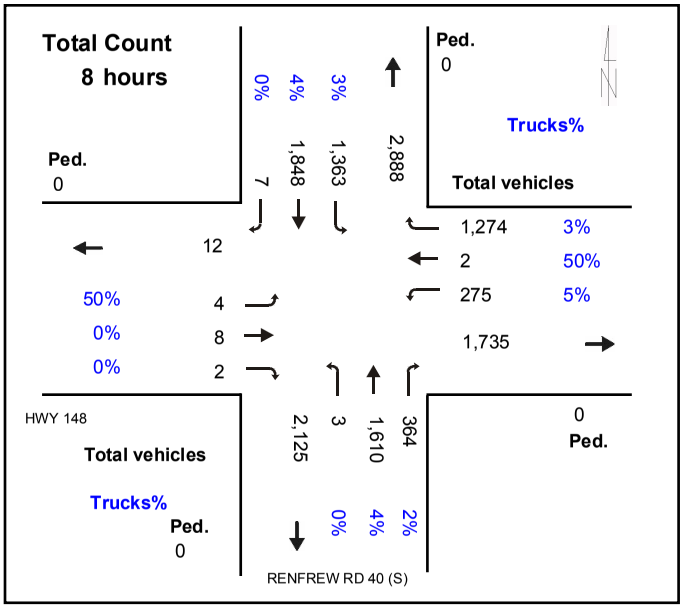
Eastern

Intersection ID:462610000 **Count Day: Monday** **Count Date: 20-Aug-2012**









15 MIN REPORT

Intersection ID:462610000 **HWY 148 @ RENFREW RD 40 (S)** **Municipality: Eastern** **Date: 20-Aug-2012**

	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																								
14:15	16	26	0	1	0	0	0	0	0	0	5	0	23	0	0	3	0	0	0	0	0	26	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	106
14:30	65	78	0	1	1	0	0	2	0	0	9	0	45	0	0	1	1	0	0	0	0	61	10	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	276
14:45	42	78	0	0	3	0	0	2	0	0	10	0	37	2	0	0	0	0	0	0	0	37	12	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	228
15:00	52	50	0	0	2	0	0	0	0	0	8	0	40	0	0	0	0	0	0	0	0	50	6	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	212
15:15	63	66	0	1	3	0	0	1	0	0	6	0	35	0	0	0	0	0	0	0	0	40	6	0	1	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	225
15:30	57	67	0	1	1	0	0	0	0	0	16	0	48	1	0	3	0	0	1	0	0	46	6	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	251
15:45	51	62	0	0	1	0	0	1	0	0	5	0	16	0	0	0	0	0	0	0	3	33	9	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	183
16:00	79	95	1	0	2	0	0	2	0	0	6	0	22	0	0	0	0	0	0	0	0	42	21	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	274
16:15	59	45	0	0	0	0	0	0	0	0	6	0	29	0	0	0	0	0	0	0	0	35	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	184
16:30	72	68	1	0	4	0	1	0	0	0	11	0	23	2	0	0	0	0	0	0	0	37	18	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238
16:45	78	93	0	3	4	0	0	0	0	0	4	0	34	1	0	0	0	0	0	0	0	36	14	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	268
17:00	60	79	0	0	0	0	0	0	0	0	7	0	22	0	0	0	0	0	0	0	0	38	21	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230
17:15	68	84	1	2	2	0	0	0	0	0	7	0	22	0	0	0	0	0	1	0	0	23	15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	226
17:30	74	105	0	0	2	0	0	0	0	0	14	0	24	1	0	0	0	0	0	0	0	34	23	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	278
17:45	75	99	0	3	2	0	0	1	0	0	0	0	26	0	0	0	0	0	0	0	0	40	18	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	269
18:00	59	73	0	2	2	0	1	0	0	0	16	0	19	1	0	1	0	0	0	0	0	28	16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	219
Period2																																									
7:15	44	29	0	3	2	0	0	0	0	0	12	0	30	0	0	0	0	0	0	0	0	55	30	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	209
7:30	28	32	0	1	0	0	0	0	0	0	3	0	70	0	0	3	0	0	0	0	0	50	30	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	220
7:45	30	42	0	0	2	0	2	0	0	0	13	0	63	0	0	0	0	0	1	0	0	73	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	233
8:00	17	33	0	3	1	0	0	1	0	0	17	0	54	0	0	2	0	0	0	0	0	86	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	219
8:15	12	29	0	1	3	0	0	0	0	0	5	0	54	0	0	2	0	0	0	0	0	56	2	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	167
8:30	6	30	1	1	1	0	0	1	0	0	6	1	44	0	1	0	0	0	0	0	0	63	5	0	1	0	0	0	1	0	1	7	0	0	0	0	0	0	0	0	170
8:45	20	25	0	0	4	0	0	0	0	0	6	0	55	0	0	0	1	0	0	0	0	56	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	176
9:00	22	31	1	1	2	0	0	0	0	0	8	0	44	1	0	0	0	0	0	0	0	71	11	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	196
9:15	14	28	0	0	1	0	0	0	0	0	14	0	51	0	0	0	0	0	1	0	0	42	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	155
9:30	20	43	1	1	2	0	0	3	0	0	7	0	51	0	0	2	0	0	0	0	0	45	4	0	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	183
9:45	22	24	0	0	1	0	1	0	0	0	7	0	50	0	0	0	0	0	0	0	0	43	7	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	158
10:00	16	55	0	1	4	0	0	0	0	0	8	0	41	0	0	0	0	0	0	0	0	57	4	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	189
10:15	17	48	0	1	0	0	0	1	0	0	5	0	41	1	0	1	0	0	0	0	0	37	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159
10:30	26	43	0	0	2	0	0	2	0	0	6	0	47	0	0	2	0	0	0	0	0	61	10	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	201
10:45	30	55	0	2	3	0	2	1	0	0	15	0	42	0	0	2	0	0	2	0	0	65	7	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	230
11:00	30	53	1	2	3	0	1	2	0	0	0	0	40	1	0	3	0	0	1	0	0	73	13	0	2	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	228

Appendix B: Synchro Analysis Output

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	498	137	57	559	1	153	0	101	2	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.91	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1865	1585	1772	1865		1772		1585		1690	
Flt Permitted		1.00	1.00	0.28	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1864	1585	531	1865		1400		1585		1690	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1	524	144	60	588	1	161	0	106	2	2	7
RTOR Reduction (vph)	0	0	39	0	0	0	0	0	82	0	5	0
Lane Group Flow (vph)	0	525	105	60	589	0	161	0	24	0	6	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		25.4	25.4	34.9	34.9		13.4		13.4		13.4	
Effective Green, g (s)		25.4	25.4	34.9	34.9		13.4		13.4		13.4	
Actuated g/C Ratio		0.42	0.42	0.58	0.58		0.22		0.22		0.22	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		791	673	444	1088		313		355		378	
v/s Ratio Prot				0.01	c0.32							
v/s Ratio Perm		c0.28	0.07	0.06			c0.12		0.01		0.00	
v/c Ratio		0.66	0.16	0.14	0.54		0.51		0.07		0.01	
Uniform Delay, d1		13.8	10.6	6.5	7.6		20.3		18.3		18.1	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		2.1	0.1	0.1	0.6		1.4		0.1		0.0	
Delay (s)		15.9	10.7	6.6	8.1		21.8		18.4		18.1	
Level of Service		B	B	A	A		C		B		B	
Approach Delay (s)		14.8			8.0			20.4			18.1	
Approach LOS		B			A			C			B	

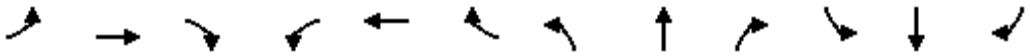
Intersection Summary			
HCM 2000 Control Delay	13.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	59.8	Sum of lost time (s)	14.5
Intersection Capacity Utilization	70.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	465	121	161	494	104	117
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.34	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	637	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	489	127	169	520	109	123
RTOR Reduction (vph)	0	61	0	0	0	107
Lane Group Flow (vph)	489	66	169	520	109	16
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	31.9	31.9	41.0	41.0	8.1	8.1
Effective Green, g (s)	31.9	31.9	41.0	41.0	8.1	8.1
Actuated g/C Ratio	0.52	0.52	0.67	0.67	0.13	0.13
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	965	820	471	1241	233	208
v/s Ratio Prot	c0.26		0.02	c0.28	c0.06	
v/s Ratio Perm		0.04	0.22			0.01
v/c Ratio	0.51	0.08	0.36	0.42	0.47	0.08
Uniform Delay, d1	9.7	7.5	5.1	4.8	24.8	23.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.9	0.2	0.5	1.0	1.5	0.2
Delay (s)	11.6	7.7	5.6	5.8	26.2	23.6
Level of Service	B	A	A	A	C	C
Approach Delay (s)	10.8			5.8	24.9	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	10.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	61.6	Sum of lost time (s)	19.0
Intersection Capacity Utilization	57.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	269	278	191	434	242	175
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.51	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	951	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	283	293	201	457	255	184
RTOR Reduction (vph)	0	187	0	0	0	140
Lane Group Flow (vph)	283	106	201	457	255	44
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	20.5	20.5	30.4	30.4	13.5	13.5
Effective Green, g (s)	20.5	20.5	30.4	30.4	13.5	13.5
Actuated g/C Ratio	0.36	0.36	0.54	0.54	0.24	0.24
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	674	573	609	999	421	377
v/s Ratio Prot	0.15		0.04	c0.25	c0.14	
v/s Ratio Perm		0.07	0.14			0.03
v/c Ratio	0.42	0.18	0.33	0.46	0.61	0.12
Uniform Delay, d1	13.6	12.4	7.0	8.1	19.2	16.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.4	0.2	0.3	0.3	2.5	0.1
Delay (s)	14.0	12.5	7.3	8.4	21.7	17.1
Level of Service	B	B	A	A	C	B
Approach Delay (s)	13.3			8.1	19.8	
Approach LOS	B			A	B	

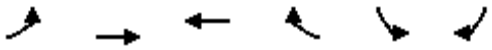
Intersection Summary			
HCM 2000 Control Delay	12.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	56.7	Sum of lost time (s)	15.8
Intersection Capacity Utilization	54.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	8	351	78	54	468	3	71	1	44	1	2	7
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	8	369	82	57	493	3	75	1	46	1	2	7
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		387										
pX, platoon unblocked												
vC, conflicting volume	496			452			1001	996	369	1041	1076	494
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	496			452			1001	996	369	1041	1076	494
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			95			64	100	93	99	99	99
cM capacity (veh/h)	1063			1104			206	229	674	184	205	573

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	378	82	57	496	122	11
Volume Left	8	0	57	0	75	1
Volume Right	0	82	0	3	46	7
cSH	1063	1700	1104	1700	280	365
Volume to Capacity	0.01	0.05	0.05	0.29	0.44	0.03
Queue Length 95th (m)	0.2	0.0	1.1	0.0	14.7	0.6
Control Delay (s)	0.3	0.0	8.4	0.0	27.4	15.2
Lane LOS	A		A		D	C
Approach Delay (s)	0.2		0.9		27.4	15.2
Approach LOS					D	C

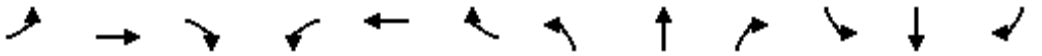
Intersection Summary				
Average Delay	3.6			
Intersection Capacity Utilization	64.9%	ICU Level of Service	C	
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	150	166	283	67	42	232
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	158	175	298	71	44	244
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	298				824	333
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	298				824	333
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	87				85	65
cM capacity (veh/h)	1258				299	706

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	158	175	368	288
Volume Left	158	0	0	44
Volume Right	0	0	71	244
cSH	1258	1700	1700	834
Volume to Capacity	0.13	0.10	0.22	0.35
Queue Length 95th (m)	3.0	0.0	0.0	10.9
Control Delay (s)	8.3	0.0	0.0	13.7
Lane LOS	A			B
Approach Delay (s)	3.9		0.0	13.7
Approach LOS				B

Intersection Summary			
Average Delay	5.3		
Intersection Capacity Utilization	40.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	575	145	48	405	2	185	0	67	1	0	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.89	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1864	1585	1772	1864		1772		1585		1647	
Flt Permitted		1.00	1.00	0.22	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1859	1585	408	1864		1407		1585		1647	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	5	605	153	51	426	2	195	0	71	1	0	4
RTOR Reduction (vph)	0	0	35	0	0	0	0	0	54	0	4	0
Lane Group Flow (vph)	0	610	118	51	428	0	195	0	17	0	1	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		28.6	28.6	38.1	38.1		15.4		15.4		15.4	
Effective Green, g (s)		28.6	28.6	38.1	38.1		15.4		15.4		15.4	
Actuated g/C Ratio		0.44	0.44	0.59	0.59		0.24		0.24		0.24	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		817	697	375	1092		333		375		390	
v/s Ratio Prot				0.01	c0.23							
v/s Ratio Perm		c0.33	0.07	0.07			c0.14		0.01		0.00	
v/c Ratio		0.75	0.17	0.14	0.39		0.59		0.04		0.00	
Uniform Delay, d1		15.2	11.0	7.7	7.2		22.0		19.1		18.9	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		3.7	0.1	0.2	0.2		2.6		0.0		0.0	
Delay (s)		18.9	11.1	7.9	7.5		24.6		19.2		18.9	
Level of Service		B	B	A	A		C		B		B	
Approach Delay (s)		17.4			7.5			23.1			18.9	
Approach LOS		B			A			C			B	

Intersection Summary			
HCM 2000 Control Delay	15.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	65.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	465	143	115	335	168	241
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.32	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	591	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	489	151	121	353	177	254
RTOR Reduction (vph)	0	79	0	0	0	206
Lane Group Flow (vph)	489	72	121	353	177	48
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	30.9	30.9	40.2	40.2	12.2	12.2
Effective Green, g (s)	30.9	30.9	40.2	40.2	12.2	12.2
Actuated g/C Ratio	0.48	0.48	0.62	0.62	0.19	0.19
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	887	754	417	1155	333	297
v/s Ratio Prot	c0.26		0.01	c0.19	c0.10	
v/s Ratio Perm		0.05	0.17			0.03
v/c Ratio	0.55	0.10	0.29	0.31	0.53	0.16
Uniform Delay, d1	12.1	9.3	6.5	5.8	23.8	22.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.5	0.3	0.4	0.7	1.6	0.3
Delay (s)	14.5	9.6	6.9	6.5	25.4	22.3
Level of Service	B	A	A	A	C	C
Approach Delay (s)	13.4			6.6	23.6	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	14.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	64.9	Sum of lost time (s)	19.0
Intersection Capacity Utilization	56.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

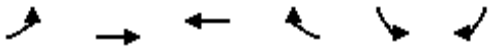
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	615	167	71	257	97	129
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.27	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	503	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	647	176	75	271	102	136
RTOR Reduction (vph)	0	84	0	0	0	117
Lane Group Flow (vph)	647	92	75	271	102	19
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	29.6	29.6	36.1	36.1	8.0	8.0
Effective Green, g (s)	29.6	29.6	36.1	36.1	8.0	8.0
Actuated g/C Ratio	0.52	0.52	0.63	0.63	0.14	0.14
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	970	824	397	1183	249	222
v/s Ratio Prot	c0.35		0.01	c0.15	c0.06	
v/s Ratio Perm		0.06	0.11			0.01
v/c Ratio	0.67	0.11	0.19	0.23	0.41	0.09
Uniform Delay, d1	10.0	7.0	5.3	4.4	22.3	21.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.7	0.1	0.2	0.1	1.1	0.2
Delay (s)	11.8	7.0	5.5	4.5	23.4	21.4
Level of Service	B	A	A	A	C	C
Approach Delay (s)	10.8			4.8	22.3	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	11.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	56.9	Sum of lost time (s)	15.8
Intersection Capacity Utilization	58.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	12	630	85	57	303	1	57	2	135	2	1	7
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	13	663	89	60	319	1	60	2	142	2	1	7
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		387										
pX, platoon unblocked				0.79			0.79	0.79	0.79	0.79	0.79	
vC, conflicting volume	320			753			1135	1128	663	1271	1217	319
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	320			549			1036	1027	435	1209	1140	319
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			92			60	99	71	97	99	99
cM capacity (veh/h)	1234			798			151	168	486	82	144	719

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	676	89	60	320	204	11
Volume Left	13	0	60	0	60	2
Volume Right	0	89	0	1	142	7
cSH	1234	1700	798	1700	291	243
Volume to Capacity	0.01	0.05	0.08	0.19	0.70	0.04
Queue Length 95th (m)	0.2	0.0	1.7	0.0	34.1	0.9
Control Delay (s)	0.3	0.0	9.9	0.0	42.0	20.5
Lane LOS	A		A		E	C
Approach Delay (s)	0.2		1.6		42.0	20.5
Approach LOS					E	C

Intersection Summary				
Average Delay	7.0			
Intersection Capacity Utilization	72.1%	ICU Level of Service	C	
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	287	380	136	72	27	89
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	302	400	143	76	28	94
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	143				1185	181
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	143				1185	181
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	79				83	89
cM capacity (veh/h)	1433				164	859

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	302	400	219	122
Volume Left	302	0	0	28
Volume Right	0	0	76	94
cSH	1433	1700	1700	704
Volume to Capacity	0.21	0.24	0.13	0.17
Queue Length 95th (m)	5.6	0.0	0.0	4.4
Control Delay (s)	8.2	0.0	0.0	14.8
Lane LOS	A			B
Approach Delay (s)	3.5		0.0	14.8
Approach LOS				B

Intersection Summary			
Average Delay	4.1		
Intersection Capacity Utilization	40.8%	ICU Level of Service	A
Analysis Period (min)	15		

Appendix C: Traffic Signal Warrants

Input Data Sheet

Analysis Sheet | Results Sheet | Proposed Collision

GO TO Justification:

What are the intersecting roadways? Highway 148/Greenwood Road (County Road 40)

What is the direction of the Main Road street? East-West

When was the data collected? 2012-08-20

Justification 1 - 4: Volume Warrants

a.- Number of lanes on the Main Road? 1

b.- Number of lanes on the Minor Road? 1

c.- How many approaches? 3

d.- What is the operating environment? Rural

Population < 10,000 AND Speed >= 70 km/hr

e.- What is the eight hour vehicle volume at the intersection? (Please fill in table below)

Hour Ending	Main Eastbound Approach			Minor Northbound Approach			Main Westbound Approach			Minor Southbound Approach			Pedestrians Crossing Main Road
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
8:00	128	142	0	0	0	0	0	272	0	45	0	0	
9:00	63	126	0	0	0	0	0	257	0	27	0	0	
10:00	75	161	0	0	0	0	0	194	0	36	0	0	
11:00	111	213	0	0	0	0	0	245	0	28	0	0	
15:00	177	242	0	0	0	0	0	185	0	35	0	0	
16:00	252	301	0	0	0	0	0	172	0	34	0	0	
17:00	273	293	0	0	0	0	0	152	0	31	0	0	
18:00	284	370	0	0	0	0	0	133	0	39	0	0	
Total	**1,363**	**1,848**	**0**	**0**	**0**	**0**	**0**	**1,610**	**0**	**275**	**0**	**0**	**0**

Justification 5: Collision Experience

Preceding Months	Number of Collisions*
1-12	1
13-24	1
25-36	1

* Include only collisions that are susceptable to correction through the installation of traffic signal control

Justification 6: Pedestrian Volume

a.- Please fill in table below summarizing total pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Factored 8 hour pedestrian volume	0		0		0		0		
% Assigned to crossing rate	100%		50%		0%		0%		
Net 8 Hour Pedestrian Volume at Crossing									0
Net 8 Hour Vehicular Volume on Street Being Crossed									6,411

b.- Please fill in table below summarizing delay to pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Total 8 hour pedestrians delayed greater than 10 seconds	0	0	0	0	0	0	0	0	
Factored volume of total pedestrians	0		0		0		0		
Factored volume of delayed pedestrians	0		0		0		0		
% Assigned to Crossing Rate	100%		50%		0%		0%		
Net 8 Hour Volume of Total Pedestrians									0
Net 8 Hour Volume of Delayed Pedestrians									0

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148/Greenwood Road (County Road 40) Count Date: 2012-08-20

Justification 1: Minimum Vehicle Volumes

Free Flow Rural Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☑	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
1A	480	720	600	900	587	473	466	597	639	759	749	826		
	COMPLIANCE %				100	99	97	100	100	100	100	100	796	99
1B	180	255	180	255	45	27	36	28	35	34	31	39		
	COMPLIANCE %				25	15	20	16	19	19	17	22	153	19
Free Flow Signal Justification 1:					Both 1A and 1B 100% Fulfilled each of 8 hours — Yes ☐ No ☑ Lesser of 1A or 1B at least 80% fulfilled each of 8 hours — Yes ☐ No ☑									

Justification 2: Delay to Cross Traffic

Free Flow Rural Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☑	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
2A	480	720	600	900	542	446	430	569	604	725	718	787		
	COMPLIANCE %				100	93	90	100	100	100	100	100	783	98
2B	50	75	50	75	45	27	36	28	35	34	31	39		
	COMPLIANCE %				90	54	72	56	70	68	62	78	550	69
Free Flow Signal Justification 2:					Both 2A and 2B 100% fulfilled each of 8 hours — Yes ☐ No ☑ Lesser of 2A or 2B at least 80% fulfilled each of 8 hours — Yes ☐ No ☑									

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicle Volume	YES ☐	NO ☑	YES ☐	NO ☑
Justification 2	Delay Cross Traffic	YES ☐	NO ☑		NOT JUSTIFIED

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main) X	Heaviest Minor Approach Y (actual)	Required Value Y (warrant threshold)	Average % Compliance	Overall % Compliance
Justification 4	15:00	604	35	244	14 %	17 %
	16:00	725	34	198	17 %	
	17:00	718	31	200	15 %	
	18:00	787	39	176	22 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148/Greenwood Road (County Road 40) Count Date: 2012-08-20

Justification 5: Collision Experience

Justification	Preceding Months	% Fulfillment	Overall % Compliance
Justification 5	1-12	20 %	20 %
	13-24	20 %	
	25-36	20 %	

Justification 6: Pedestrian Volume

Pedestrian Volume Analysis

8 Hour Vehicular Volume V_8		Net 8 Hour Pedestrian Volume				
		< 200	200 - 275	276 - 475	476 - 1000	>1000
Justification 6A	< 1440					
	1440 - 2600					
	2601 - 7000	Not Justified				
	> 7000					

Pedestrian Delay Analysis

Net Total 8 Hour Volume of Total Pedestrians		Net Total 8 Hour Volume of Delayed Pedestrians		
		< 75	75 - 130	> 130
Justification 6B	< 200	Not Justified		
	200 - 300			
	> 300			

Results Sheet

Input Sheet | Analysis Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148/Greenwood Road (County Road 40) Count Date: 2012-08-20

Summary Results

Justification			Compliance		Signal Justified? YES	Signal Justified? NO
1. Minimum Vehicular Volume	A	Total Volume	99	%	☐	☑
	B	Crossing Volume	19	%		
2. Delay to Cross Traffic	A	Main Road	98	%	☐	☑
	B	Crossing Road	69	%		
3. Combination	A	Justificaton 1	19	%	☐	☑
	B	Justification 2	69	%		
4. 4-Hr Volume			17	%	☐	☑
5. Collision Experience			20	%	☐	☑
6. Pedestrians	A	Volume	Justification not met		☐	☑
	B	Delay	Justification not met			

Input Data Sheet

Analysis Sheet | Results Sheet | Proposed Collision

GO TO Justification:

What are the intersecting roadways? Highway 148 & Drive-In Road

What is the direction of the Main Road street? North-South

When was the data collected? 2012

Justification 1 - 4: Volume Warrants

a.- Number of lanes on the Main Road? 1

b.- Number of lanes on the Minor Road? 1

c.- How many approaches? 4

d.- What is the operating environment? Urban

Population >= 10,000 **AND** **Speed < 70 km/hr**

e.- What is the eight hour vehicle volume at the intersection? (Please fill in table below)

Hour Ending	Main Northbound Approach			Minor Eastbound Approach			Main Southbound Approach			Minor Westbound Approach			Pedestrians Crossing Main Road
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
8:00	75	390	0	65	1	28	2	137	39	1	3	4	0
9:00	50	478	0	42	1	45	4	149	37	1	0	3	0
10:00	61	431	0	51	0	44	3	234	36	0	2	5	0
11:00	58	445	3	67	1	47	8	308	68	1	2	6	0
15:00	54	375	1	52	2	70	3	483	76	0	3	5	0
16:00	65	349	0	52	1	116	7	520	111	0	0	3	0
17:00	57	303	0	52	3	146	8	563	76	4	2	5	1
18:00	57	291	1	53	0	112	13	582	89	2	0	5	1
Total	**477**	**3,062**	**5**	**434**	**9**	**608**	**48**	**2,976**	**532**	**9**	**12**	**36**	**2**

Justification 5: Collision Experience

Preceding Months	Number of Collisions*
1-12	0
13-24	0
25-36	2

***** Include only collisions that are susceptable to correction through the installation of traffic signal control

Justification 6: Pedestrian Volume

a.- Please fill in table below summarizing total pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Factored 8 hour pedestrian volume	0		0		0		0		
% Assigned to crossing rate	100%		100%		100%		100%		
Net 8 Hour Pedestrian Volume at Crossing									2
Net 8 Hour Vehicular Volume on Street Being Crossed									7,100

b.- Please fill in table below summarizing delay to pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Total 8 hour pedestrians delayed greater than 10 seconds	0	0	0	0	0	0	0	0	
Factored volume of total pedestrians	0		0		0		0		
Factored volume of delayed pedestrians	0		0		0		0		
% Assigned to Crossing Rate	100%		100%		100%		100%		
Net 8 Hour Volume of Total Pedestrians									2
Net 8 Hour Volume of Delayed Pedestrians									7,100

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 1: Minimum Vehicle Volumes

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☑	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
1A	480	720	600	900	745	810	867	1,014	1,124	1,224	1,219	1,205		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
1B	120	170	120	170	102	92	102	124	132	172	212	172		
	COMPLIANCE %				60	54	60	73	78	100	100	100	625	78
Restricted Flow Signal Justification 1:					Both 1A and 1B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 1A or 1B at least 80% fulfilled each of 8 hours					Yes ☐		No ☑		

Justification 2: Delay to Cross Traffic

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☑	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
2A	480	720	600	900	643	718	765	890	992	1,052	1,007	1,033		
	COMPLIANCE %				89	100	100	100	100	100	100	100	789	99
2B	50	75	50	75	69	44	53	70	55	53	60	56		
	COMPLIANCE %				92	59	71	93	73	71	80	75	613	77
Restricted Flow Signal Justification 2:					Both 2A and 2B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 2A or 2B at least 80% fulfilled each of 8 hours					Yes ☐		No ☑		

Justification 3: Combination

Combination Justification 1 and 2

	Justification Satisfied 80% or More			Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☐	NO ☑	YES ☐	NO ☑
Justification 2	Delay Cross Traffic	YES ☐	NO ☑		NOT JUSTIFIED

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main)	Heaviest Minor Approach	Required Value	Average % Compliance	Overall % Compliance
		X	Y (actual)	Y (warrant threshold)		
Justification 4	16:00	1,052	169	92	100 %	100 %
	17:00	1,007	201	101	100 %	
	18:00	1,033	165	96	100 %	
	15:00	992	124	104	100 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 5: Collision Experience

Justification	Preceding Months	% Fulfillment	Overall % Compliance
Justification 5	1-12	0 %	13 %
	13-24	0 %	
	25-36	40 %	

Justification 6: Pedestrian Volume

Pedestrian Volume Analysis

8 Hour Vehicular Volume V_8		Net 8 Hour Pedestrian Volume				
		< 200	200 - 275	276 - 475	476 - 1000	>1000
Justification 6A	< 1440					
	1440 - 2600					
	2601 - 7000					
	> 7000	Not Justified				Justified

Pedestrian Delay Analysis

Net Total 8 Hour Volume of Total Pedestrians		Net Total 8 Hour Volume of Delayed Pedestrians		
		< 75	75 - 130	> 130
Justification 6B	< 200			Not Justified
	200 - 300			
	> 300			

A	Volume	Justification not met
B	Delay	Justification not met

Results Sheet

Input Sheet | Analysis Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Summary Results

Justification			Compliance		Signal Justified? YES	Signal Justified? NO
1. Minimum Vehicular Volume	A	Total Volume	100	%	☐	☑
	B	Crossing Volume	78	%		
2. Delay to Cross Traffic	A	Main Road	99	%	☐	☑
	B	Crossing Road	77	%		
3. Combination	A	Justificaton 1	78	%	☐	☑
	B	Justification 2	77	%		
4. 4-Hr Volume			100	%	☑	☐
5. Collision Experience			13	%	☐	☑
6. Pedestrians	A	Volume	Justification not met		☐	☑
	B	Delay	Justification not met			

Input Data Sheet

Analysis Sheet | Results Sheet | Proposed Collision

GO TO Justification:

What are the intersecting roadways? Highway 148 & Drive-In Road

What is the direction of the Main Road street? North-South

When was the data collected? 2012

Justification 1 - 4: Volume Warrants

a.- Number of lanes on the Main Road? 1

b.- Number of lanes on the Minor Road? 1

c.- How many approaches? 4

d.- What is the operating environment? Rural

Population < 10,000 AND Speed >= 70 km/hr

e.- What is the eight hour vehicle volume at the intersection? (Please fill in table below)

Hour Ending	Main Northbound Approach			Minor Eastbound Approach			Main Southbound Approach			Minor Westbound Approach			Pedestrians Crossing Main Road
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
8:00	75	390	0	65	1	28	2	137	39	1	3	4	0
9:00	50	478	0	42	1	45	4	149	37	1	0	3	0
10:00	61	431	0	51	0	44	3	234	36	0	2	5	0
11:00	58	445	3	67	1	47	8	308	68	1	2	6	0
15:00	54	375	1	52	2	70	3	483	76	0	3	5	0
16:00	65	349	0	52	1	116	7	520	111	0	0	3	0
17:00	57	303	0	52	3	146	8	563	76	4	2	5	1
18:00	57	291	1	53	0	112	13	582	89	2	0	5	1
Total	**477**	**3,062**	**5**	**434**	**9**	**608**	**48**	**2,976**	**532**	**9**	**12**	**36**	**2**

Justification 5: Collision Experience

Preceding Months	Number of Collisions*
1-12	0
13-24	0
25-36	2

* Include only collisions that are susceptable to correction through the installation of traffic signal control

Justification 6: Pedestrian Volume

a.- Please fill in table below summarizing total pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Factored 8 hour pedestrian volume	0		0		0		0		
% Assigned to crossing rate	100%		100%		100%		100%		
Net 8 Hour Pedestrian Volume at Crossing									2
Net 8 Hour Vehicular Volume on Street Being Crossed									7,100

b.- Please fill in table below summarizing delay to pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Total 8 hour pedestrians delayed greater than 10 seconds	0	0	0	0	0	0	0	0	
Factored volume of total pedestrians	0		0		0		0		
Factored volume of delayed pedestrians	0		0		0		0		
% Assigned to Crossing Rate	100%		100%		100%		100%		
Net 8 Hour Volume of Total Pedestrians									2
Net 8 Hour Volume of Delayed Pedestrians									7,100

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 1: Minimum Vehicle Volumes

Free Flow Rural Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☑	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
1A	480	720	600	900	745	810	867	1,014	1,124	1,224	1,219	1,205		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
1B	120	170	120	170	102	92	102	124	132	172	212	172		
	COMPLIANCE %				85	77	85	100	100	100	100	100	747	93
Free Flow Signal Justification 1:					Both 1A and 1B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 1A or 1B at least 80% fulfilled each of 8 hours					Yes ☑		No ☐		

Justification 2: Delay to Cross Traffic

Free Flow Rural Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☑	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
2A	480	720	600	900	643	718	765	890	992	1,052	1,007	1,033		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
2B	50	75	50	75	69	44	53	70	55	53	60	56		
	COMPLIANCE %				100	88	100	100	100	100	100	100	788	99
Free Flow Signal Justification 2:					Both 2A and 2B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 2A or 2B at least 80% fulfilled each of 8 hours					Yes ☑		No ☐		

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☑	NO ☐	YES ☑	NO ☐
Justification 2	Delay Cross Traffic	YES ☑	NO ☐	JUSTIFIED	

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main)	Heaviest Minor Approach	Required Value	Average % Compliance	Overall % Compliance
		X	Y (actual)	Y (warrant threshold)		
Justification 4	16:00	1,052	169	106	100 %	100 %
	17:00	1,007	201	115	100 %	
	18:00	1,033	165	110	100 %	
	15:00	992	124	119	100 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 5: Collision Experience

Justification	Preceding Months	% Fulfillment	Overall % Compliance
Justification 5	1-12	0 %	13 %
	13-24	0 %	
	25-36	40 %	

Justification 6: Pedestrian Volume

Pedestrian Volume Analysis

8 Hour Vehicular Volume V_8		Net 8 Hour Pedestrian Volume				
		< 200	200 - 275	276 - 475	476 - 1000	>1000
Justification 6A	< 1440					
	1440 - 2600					
	2601 - 7000					
	> 7000	Not Justified				Justified

Pedestrian Delay Analysis

Net Total 8 Hour Volume of Total Pedestrians		Net Total 8 Hour Volume of Delayed Pedestrians		
		< 75	75 - 130	> 130
Justification 6B	< 200			Not Justified
	200 - 300			
	> 300			

A	Volume	Justification not met
B	Delay	Justification not met

Results Sheet

Input Sheet | Analysis Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Summary Results

Justification			Compliance		Signal Justified? YES	Signal Justified? NO
1. Minimum Vehicular Volume	A	Total Volume	100	%	☐	☑
	B	Crossing Volume	93	%		
2. Delay to Cross Traffic	A	Main Road	100	%	☐	☑
	B	Crossing Road	99	%		
3. Combination	A	Justificaton 1	93	%	☑	☐
	B	Justification 2	99	%		
4. 4-Hr Volume			100	%	☑	☐
5. Collision Experience			13	%	☐	☑
6. Pedestrians	A	Volume	Justification not met		☐	☑
	B	Delay	Justification not met			

Appendix B2 – Traffic Operations and Safety Review – Future Conditions

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Memorandum

To/Attention	Chris Belanger Project Manager, MTO	**Date**	October 31, 2017
From	Matt Colwill/Justin Date	**Project No**	37432
cc			
Subject	Highway 148 Traffic Operations and Safety Review - Future Conditions Analysis		

The following is a summary of the review of future traffic operations and safety along Highway 148 between Pembroke and the Quebec Border.

Intersection Capacity Analysis

Future traffic volumes at the 5-year (2019), 10-year (2024) and 20-year (2034) horizons have been derived for the study area intersections by the following steps:

- Applied seasonal adjustment factors to the turning movement count data recorded in 2012 and 2015 (Robinson Lane);
- Distributed additional commercial traffic recorded on Robinson Lane (February 2015) to adjacent intersections along the corridor;
- Applied a 1% annual traffic growth rate to the turning movement count volumes; and
- Added site generated traffic from the proposed subdivision on Traxton Way (obtained from the Traffic Impact Study prepared by GHD Inc.).

Intersection capacity analysis of the study area intersections was conducted using Synchro 7 software which employs the Highway Capacity Manual (HCM) 2000 methodology. The criteria for identifying critical intersections are as follows:

- Overall intersection LOS E or F for all intersections – average control delay per vehicle greater than 55 seconds and 35 seconds for signalized and unsignalized intersections, respectively; and
- An overall intersection V/C ratio of 0.90 or greater.

The criteria for identifying critical movements are as follows:

- Average control delay is greater than 55 seconds;
- A V/C ratio of 1.00 or greater for an exclusive movement;
- The available storage space for an exclusive movement is exceeded by the estimated 95th percentile queue length;
- An existing access is blocked by the estimated 95th percentile queue length for an individual movement; and

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- Exclusive turning lanes are inaccessible because of queue lengths in adjacent through lanes.

For the purpose of the analysis, Highway 148 is considered oriented in an east-west direction while the side roads are considered north-south. The Drive In road intersection was identified as meeting the minimum warrants for traffic signals in the review of existing traffic operations. As such, for the analysis of future conditions, the intersection has been analyzed with traffic signals in place and with auxiliary left-turn lanes on each approach.

Future (2019) Traffic – Urban Section

Exhibit 1 presents the projected peak hour traffic volumes at the 5-year horizon, 2019 and a summary of the results of the intersection capacity analysis is presented in **Exhibit 2**.

Exhibit 1: Future (2019) Traffic

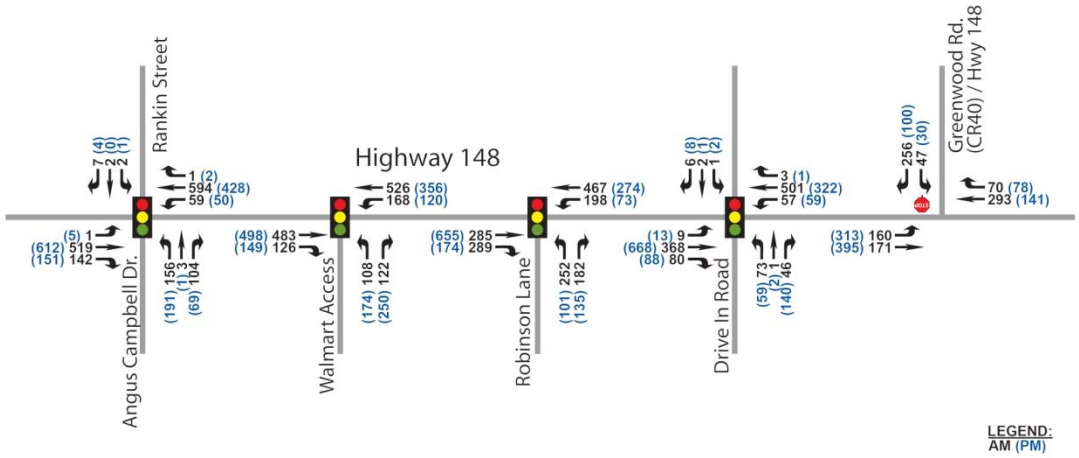

Exhibit 2: Intersection Capacity Analysis – Future (2019) Traffic

INTERSECTION	TRAFFIC CONTROL	PEAK HOUR	OVERALL DELAY (s)	OVERALL LOS	CRITICAL MOVEMENT				
					MOVEMENT	DELAY (s)	LOS	V/C RATIO	95TH QUEUE (m)
Angus Campbell Drive	Signals	AM	13.4	B	EBT	16.4	B	0.68	84.9
					WBT	8.6	A	0.57	72.8
		PM	15.9	B	EBT	23.8	C	0.77	116.1
Walmart Access	Signals	AM	10.9	B	-	-	-	-	-
		PM	14.5	B	-	-	-	-	-
Robinson Lane	Signals	AM	13.1	B	-	-	-	-	-
		PM	11.7	B	EBT	12.5	B	0.7	114.9
Drive In Road	Signals	AM	6.2	A	-	-	-	-	-
		PM	8.2	A	EBT	7.0	A	0.61	63.8
Greenwood Road (County Road 40)	Stop	AM	5.8	-	-	-	-	-	-
		PM	4.4	-	-	-	-	-	-

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The results of the analysis indicate that all of the study area intersections within the urban section of Highway 148 are expected to operate at acceptable levels of service under 2019 traffic conditions. The queue length (95th %) on the eastbound through movement at the Angus Campbell Drive intersection is projected to be approximately 85 m and 116 m during the weekday morning and afternoon peak hours, respectively. The adjacent right-turn lane on the eastbound approach has a storage length of approximately 20 m and may be periodically inaccessible due to the queue in the through lane. Similarly, the projected queue in the westbound through lane is indicated to extend beyond the 50 m storage length of the adjacent westbound left-turn lane in the morning peak hour.

It is also projected that the queues in the eastbound through lanes at the Robinson Lane and Drive In Road intersections will periodically extend beyond the adjacent eastbound right-turn lanes during the afternoon peak hour, thereby blocking right-turning vehicles.

Opportunities to extend the existing auxiliary turning lanes at these intersections will be investigated further during the development of design options in the study.

Future (2024) Traffic – Urban Section

Exhibit 3 presents the projected peak hour traffic volumes at the 10-year horizon, 2024 and a summary of the results of the intersection capacity analysis is presented in **Exhibit 4**.

Exhibit 3: Future (2024) Traffic

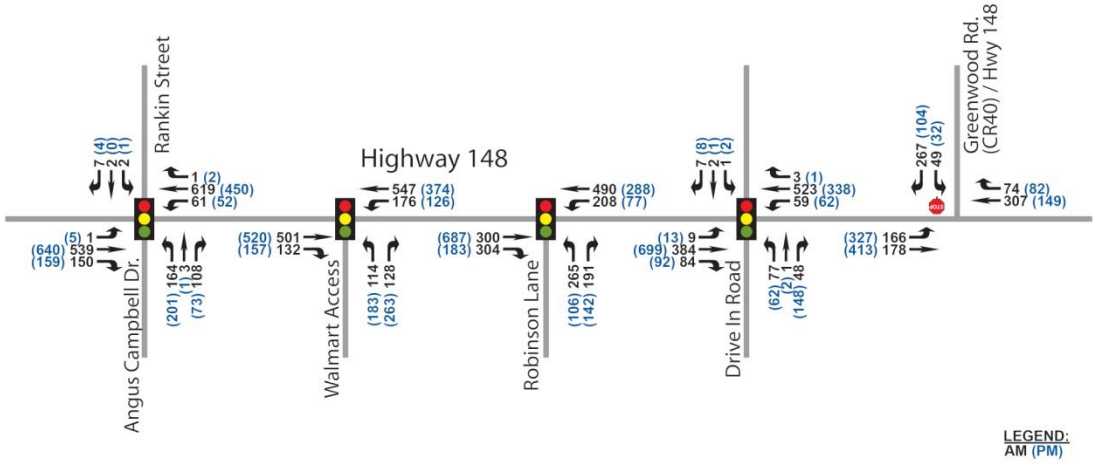

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Exhibit 4: Intersection Capacity Analysis – Future (2024) Traffic

INTERSECTION	TRAFFIC CONTROL	PEAK HOUR	OVERALL DELAY (s)	OVERALL LOS	CRITICAL MOVEMENT				
					MOVEMENT	DELAY (s)	LOS	V/C RATIO	95TH QUEUE (m)
Angus Campbell Drive	Signals	AM	14.0	B	EBT	17.4	B	0.71	91.2
					WBT	9.2	A	0.60	79.8
		PM	16.7	B	EBT	20.9	C	0.79	131.2
Walmart Access	Signals	AM	11.6	B	-	-	-	-	-
		PM	15.4	B	-	-	-	-	-
Robinson Lane	Signals	AM	13.5	B	-	-	-	-	-
		PM	14.7	B	EBT	18.1	B	0.80	124.5
Drive In Road	Signals	AM	6.4	A	-	-	-	-	-
		PM	8.0	A	EBT	7.6	A	0.66	69.0
Greenwood Road (County Road 40)	Stop	AM	6.0	-	-	-	-	-	-
		PM	4.6	-	-	-	-	-	-

The results of the analysis indicate that the intersections are expected to continue to operate at acceptable levels of service at the 2024 horizon year. There are no new critical movements identified in the analysis but the queues in the previously identified critical movements will increase under these traffic conditions.

Future (2034) Traffic – Urban Section

Exhibit 5 presents the projected peak hour traffic volumes at the 20-year horizon, 2024 and a summary of the results of the intersection capacity analysis is presented in **Exhibit 6**.

Exhibit 5: Future (2034) Traffic

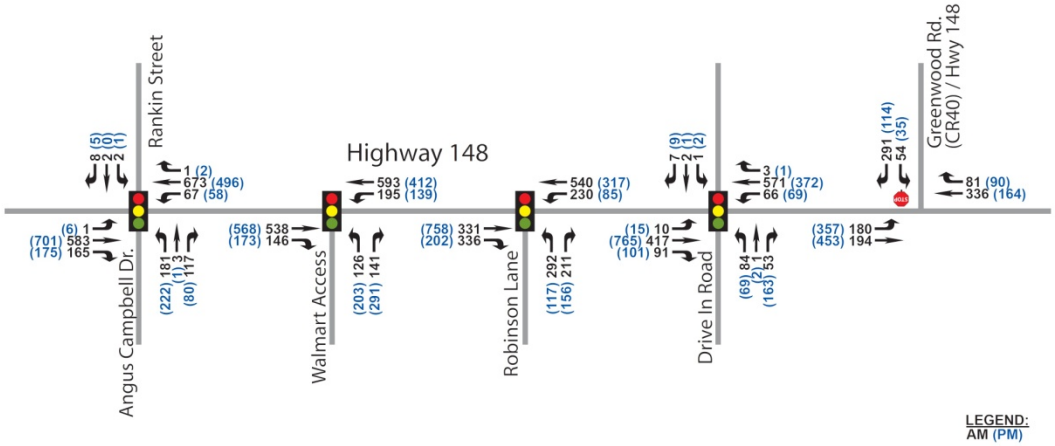

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Exhibit 6: Intersection Capacity Analysis – Future (2034) Traffic

INTERSECTION	TRAFFIC CONTROL	PEAK HOUR	OVERALL DELAY (s)	OVERALL LOS	CRITICAL MOVEMENT				
					MOVEMENT	DELAY (s)	LOS	V/C RATIO	95TH QUEUE (m)
Angus Campbell Drive	Signals	AM	15.3	B	EBT	18.9	B	0.74	107.3
					WBT	10.2	B	0.64	96.5
		PM	18.2	B	EBT	22.1	C	0.81	162.3
Walmart Access	Signals	AM	13.5	B	-	-	-	-	-
		PM	16.0	B	-	-	-	-	-
Robinson Lane	Signals	AM	14.3	B	-	-	-	-	-
		PM	17.5	B	EBT	23.9	C	0.88	145.7
Drive In Road	Signals	AM	6.6	A	-	-	-	-	-
		PM	8.8	A	EBT	8.4	A	0.71	90.0
Greenwood Road (County Road 40)	Stop	AM	6.5	-	-	-	-	-	-
		PM	5.1	-	-	-	-	-	-

The results of the analysis indicate that the intersections are expected to continue to operate at acceptable levels of service at the 2034 horizon year. There are no new critical movements identified in the analysis but the queues in the previously identified critical movements will increase under these traffic conditions.

Traffic Control Signal Warrant Assessment – Projected Volumes

Traffic control signal warrant analysis has been conducted for the Highway 148/Greenwood Road (County Road 40) intersection under 2034 traffic conditions.

For this exercise, eight-hour projections for the 2034 horizon year have been derived by including the morning and afternoon peak hour volumes and then applying the average of the two peak volumes to the other six hours.

The OTM Book 12 methodology has been applied for the following justifications:

- Justification 1 – Minimum Vehicular Volume
- Justification 2 – Delay to Cross Traffic
- Justification 3 – Volume/Delay Combination

Justification 1 considers traffic signals for the purposes of mitigating the cumulative delay produced by large volumes of intersecting traffic. Justification 1A accounts for the lowest total traffic for all intersection approaches while Justification 1B accounts for the lowest volume on the minor road. The predetermined minimum volume thresholds for both Justifications 1A and 1B must be 100% fulfilled for signals to be justified. Under the event that the thresholds are not met but are at least 80% fulfilled, Justification 3 may be applied.

Justification 2 considers traffic signals where main road traffic volumes are excessive to the point that minor road vehicles suffer significant delays or hazards in entering the intersection.

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Similar to Justification 1, both Justification 2A and 2B minimum volume thresholds must reach 100% compliance for signals to be justified. Justification 3 may be applied if Justifications 2A and 2B both exceed 80% compliance but do not reach the 100% threshold.

Justification 3 considers traffic signals for applications where both the volumes and delays evaluated under Justifications 1 and 2 are approaching the 100% threshold but do not meet the requirements. For signals to be warranted under Justification 3, all four Justifications 1A, 1B, 2A and 2B must meet their respective minimum volume thresholds to a compliance of 80%.

The results of the warrant analysis are presented in **Exhibit 7**. The intersection does not meet the minimum warrant for traffic signals under 2034 traffic conditions.

Exhibit 7: Traffic Control Signal Warrant Analysis – Highway 148/Greenwood Road – 2034 Traffic

JUSTIFICATION		RURAL (FREE FLOW)		
		COMPLIANCE	SIGNAL JUSTIFIED?	
			YES	NO
1. Minimum Vehicular Volume	Total Volume	100%		✓
	Crossing Volume	25%		
2. Delay to Cross Traffic	Main Road	100%		✓
	Crossing Road	88%		
3. Combination	Justification 1	25%		✓
	Justification 2	88%		

Roundabout Warrant Assessment – Projected Volumes

Although traffic signals at the Greenwood Road intersection are not warranted in the future horizons, a roundabout assessment was completed for the purposes of exploring additional alternatives. The roundabout assessment was conducted under 2034 future conditions to capture the conditions with highest traffic volumes. The Highway Capacity Manual 2010 methodology was used for calculating the V/C ratios for each approach.

The presented v/c ratios (**Exhibit 8**) are calculated for conditions with one entering lane per approach and one circulating lane.

Exhibit 8: Roundabout Assessment – Highway 148/Greenwood Road

AM PEAK			
APPROACH	EASTBOUND	WESTBOUND	SOUTHBOUND
Entering Volume (PCE/h)	381	442	355
Circulating Volume (PCE/h)	56	184	356
Single Lane V/C Ratio	0.36	0.47	0.45

PM PEAK			
APPROACH	EASTBOUND	WESTBOUND	SOUTHBOUND
Entering Volume (PCE/h)	264	867	158
Circulating Volume (PCE/h)	37	382	171
Single Lane V/C Ratio	0.80	0.34	0.17

The Greenwood intersection would operate acceptably as a one entering per lane approach and one circulating lane roundabout, given that the maximum v/c ratio of any movement is 0.80 in either peak hour.

Future Traffic – Rural Section

A potential design alternative to improve operations of the rural section of Highway 148 is to consolidate the driveways between the Pembroke Allumette Bridge and the Ontario/Quebec Border Bridge, which would reduce the number of direct accesses to Highway 148. The design alternative would include consolidating all driveways to a four-leg intersection at Esther Street / Eileen Street. Service roads would be needed to be extended. The potential design alternative was further evaluated to determine if left-turn lanes or signalization would be required in the 2034 horizon.

Another potential design alternative within the rural section is the proposed subdivision on Traxton Way. As the development would include additional left-turning traffic, a left-turn lane warrant assessment was undertaken.

Left-turn Lane Warrant Assessment

Left-turn lane warrants were completed for consolidated Esther Street / Eileen Street intersection and the Traxton Way intersection with development volumes. Left-turn lane warrant assessments were completed using the methodology presented within the Ministry of Transportation Ontario's (MTO) "Geometric Design Standards for Ontario Highways" manual (1994). The figures within the manual are intended to assess the need for left-turn lanes for free flow conditions. The following data is required to complete the left turn lane warrant analysis:

- Design Speed – posted speed limit (km/h);
- Advancing Volume – Sum of all traffic volumes in the direction of the potential left-turn lane (vehicles per hour);
- Opposing Volume – Sum of all traffic volumes in the direction opposite to the potential left-turn lane (vehicles per hour);
- Left-Turn Percentage – Percentage of advancing volume making a left-turn (%); and
- Left-Turn Truck Percentage – Percentage of left-turning traffic that is trucks (%).

The following assumptions were made when calculating the turning volumes (based on bi-directional side road counts):

- During the AM peak hour, approximately 30% of side road traffic were inbound (towards residences);
- During the PM peak hour, approximately 70% of side road traffic were inbound; and
- Inbound vehicles were split evenly between the eastbound and westbound direction.

The 2034 horizon year left-turn lane warrant results for the consolidated Esther Street/ Eileen Street intersection are presented in **Exhibit 9**. Under 2034 traffic conditions, auxiliary left-turn lanes are warranted on the eastbound and westbound approaches to the consolidated intersection.

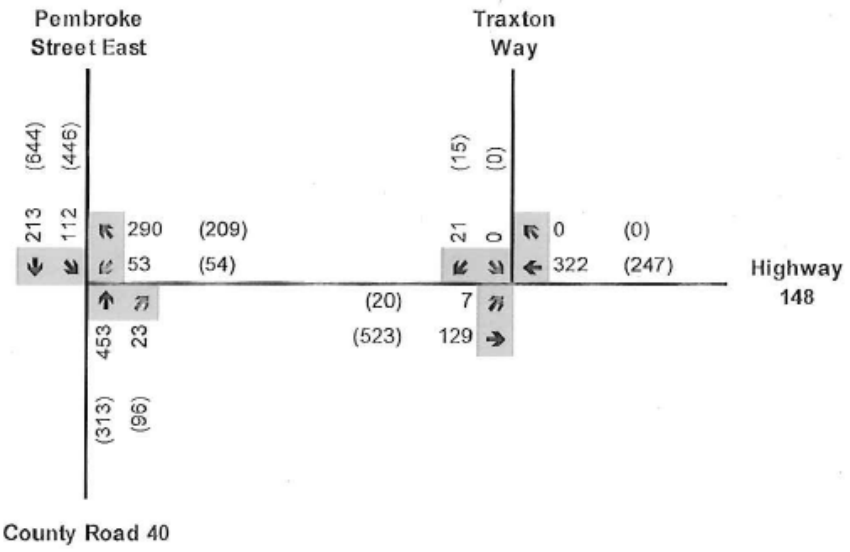
Chris Belanger
Project Manager, MTO – October 31, 2017

Exhibit 9: 2034 Esther Street / Eileen Street Left-Turn Lane Warrant Data

TERM	EASTBOUND LEFT		WESTBOUND LEFT	
	AM PEAK	PM PEAK	AM PEAK	PM PEAK
Design Speed (kph)	100	100	100	100
Advancing Volume (vph)	217	607	534	304
Opposing Volume (vph)	534	304	217	607
Left Turn Volume	14	52	17	60
Left Turn Percent (%)	6%	9%	3%	20%
Left Turn Truck Percent (%)	0%	0%	0%	0%
Warrant Result	**No**	**Yes**	**Yes**	**Yes**

The volumes of the Traxton Way development in the 2026 future horizon, estimated by GHD Inc., are summarized in **Exhibit 10**.

Exhibit 10: Traxton Way Future Total 2026 Traffic Volumes



Due to the low left-turning volumes, a left-turn lane at the Traxton Way intersection is not warranted.

Traffic Control Signal Warrant Assessment

Traffic control signal warrant analysis was conducted for the consolidated Eileen Street / Esther Street intersection under 2034 traffic conditions. The results of the warrant analysis are presented in Exhibit 11. The intersection does not meet the minimum warrant for traffic signals under 2034 traffic conditions.

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Project Manager, MTO – October 31, 2017

Exhibit 11: Traffic Control Signal Warrant Analysis – Consolidated Eileen Street / Esther Street Intersection

JUSTIFICATION		RURAL (FREE FLOW)		
		COMPLIANCE	SIGNAL JUSTIFIED?	
			YES	NO
1. Minimum Vehicular Volume	Total Volume	97%		✓
	Crossing Volume	45%		
2. Delay to Cross Traffic	Main Road	91%		✓
	Crossing Road	54%		
3. Combination	Justification 1	45%		✓
	Justification 2	54%		

Intersection Safety Analysis

The Intersection Safety Analysis section presents the methodology and results of the predictive future "Do Nothing" intersection collision analysis.

Excess collisions calculated in the existing conditions analysis were used to create calibration factors that were in turn, used to adjust the number of predicted collisions in future horizons on an intersection-by-intersection basis. The factors were applied in a manner similar to CMFs to account for the historical safety performance. The historical calibration factors are summarized in **Exhibit 12**.

Exhibit 12: Intersection Historical Calibration Factors

INTERSECTION	CALIBRATION FACTOR	
	F+I	PDO
Greenwood Road	1.13	1.50
Old Mill Rd	0.90	1.39
Drive In Road	0.94	0.88
Robinson Lane	0.97	0.70
Walmart Access	0.71	0.54
Beckett View Drive / Cotnam E JCT	1.05	0.91
Esther Street / Eileen Street	0.92	1.00

To establish the volumes used for analysis in future horizons, a 1.0% per annum growth rate (prescribed by the MTO) was applied to traffic volumes along Highway 148 for all horizon years. The same side street growth rates used in the existing conditions analysis were applied (1.0% and 0.5% per annum for intersections within the Urban and Rural section, respectively). The number of predicted and expected (predicted factored by historical calibration factors) collisions at intersections under the "Do Nothing" scenario was calculated by applying grown volumes to the SPFs and CMFs used in the existing conditions analysis. The number of excess collisions at each intersection was determined (number of expected collisions less the number of predicted collisions). The excess number of collisions is an indicator of an intersection's safety performance. If the excess number of collisions is greater than zero, the intersection has more collisions than the SPFs would predict, given its geometric and operating conditions.

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The excess collisions were then converted to a net present value (NPV) collision cost. The estimated societal costs for each of the collision severity types are summarized in **Exhibit 13**. The SPFs provided by the MTO only predict collisions as either "Fatal and Injury" or "Property Damage Only". Therefore, it was assumed that 1% of future fatal and injury collisions would be fatalities to establish a weighted F+I collision cost.

Exhibit 13: Combined Societal Costs of Traffic Collisions in Ontario

COLLISION COSTS	
Fatal	$1,582,000
Injury	$59,000
PDOnly	$8,000

The net present value of the collisions is calculated by:

1. Multiplying the predicted number of collisions by the associated societal cost; and
2. Discounting all future year collision costs to the base year (2014) using a rate of return of 4%.

Based on the analysis, the intersections at Greenwood Road and Beckett View Drive/Cotnam E JCT are the only intersections expected to have a positive NPV of excess collisions in the future horizons. The NPV collision costs for these intersections are summarized in **Exhibit 14**.

Exhibit 14: Future Intersection Collisions Costs (NPV) – "Do Nothing" Scenario

INTERSECTION	5-YEAR HORIZON			10-YEAR HORIZON			20-YEAR HORIZON		
	F+I	PDO	ALL	F+I	PDO	ALL	F+I	PDO	ALL
Greenwood Road	**$7,300**	**$6,800**	**$14,100**	**$14,900**	**$14,100**	**$29,000**	**$31,500**	**$29,900**	**$61,400**
Old Mill Rd	-$6,700	**$6,100**	-$600	-$13,500	**$12,400**	-$1,200	-$27,600	**$25,300**	-$2,200
Drive In Road	-$11,200	-$3,800	-$15,000	-$23,500	-$8,200	-$31,700	-$52,600	-$18,400	-$71,000
Robinson Lane	-$2,800	-$11,200	-$14,000	-$5,700	-$23,000	-$28,500	-$11,400	-$47,700	-$59,200
Walmart Access	-$64,300	-$36,000	-$100,400	-$129,800	-$73,100	-$202,900	-$264,000	-$149,600	-$413,600
Beckett View Drive / Cotnam E JCT	**$1,800**	-$1,200	**$600**	**$3,800**	-$2,400	**$1,400**	**$7,900**	-$5,000	**$2,900**
Esther Street / Eileen Street	-$4,900	$0	-$4,900	-$9,900	$0	-$10,000	-$20,900	$0	-$20,900

The collision trends for intersections with excess collisions, consistent with those observed in the existing conditions, include:

- Greenwood Road – Concentration of turning collisions, which are primarily due to eastbound left-turning vehicles failing to yield or making improper turns; and
- Old Mill Road – Concentration of wild animal collisions.

It is expected in the future horizons that Greenwood Road will have an excess collision cost of approximately $61,400 over the 20-year horizon. Based on the moderate value of the excess collisions at the Greenwood Road intersection, there may not be an economic justification for converting the intersection to a roundabout. However, a roundabout may still be considered for other reasons, such as acting as a speed management feature and serving as a gateway to the urban area.

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At Old Mill Road, low-cost improvements to reduce wild animal collisions (e.g., lighting, signage, foliage clearing) may be economically feasible improvements proportional to the cost of excess property damage collisions over the 20-year horizon.

The value of the excess fatal and injury collisions at the Beckett View Drive / Cotnam E JCT intersection is low in all horizon years. Therefore, economically justified opportunities for safety improvement are limited; however, there may be some low-cost measures (e.g., improved positive guidance/signage) that could be applied to the intersection.

The consolidation of the driveways in the rural area into one four-leg intersection (Esther Street / Eileen Street) would be expected to concentrate collisions at the new intersection, due to increased turning movement volumes. Given that the intersections did not experience excess collisions during the existing conditions, there are no historical issues that warrant mitigation.

Mainline Safety Analysis

The Mainline Safety Analysis presents the methodology and results of the predictive future "Do Nothing" mainline collision analysis.

Similar to the intersection safety analysis, historic calibration factors (**Exhibit 15**) were also applied to the mainline analysis.

Exhibit 15: Mainline Historical Calibration Factors

SECTION	HISTORICAL CALIBRATION FACTOR		
	I	F+I	PDO
1	0.99	0.99	0.96
2	0.99	0.99	0.96
3	0.98	0.98	1.04
4	1.00	1.00	0.92
5	0.97	0.97	0.89
6	0.98	0.98	0.97
7	0.98	0.97	0.89
8	1.03	1.03	0.92
9	0.96	0.96	0.91
10	0.98	0.98	0.98

Volumes used in analysis were established by applying a growth rate of 1.0% per annum was to traffic volumes along Highway 148 for all horizon years. The number of predicted and expected collisions were calculated for each mainline section and then converted to a net present value (**Exhibit 16**).

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Exhibit 16: Future Mainline Collisions Costs (NPV) – "Do Nothing" Scenario

SECTION	SECTION LENGTH (km)	5-YEAR HORIZON			10-YEAR HORIZON			20-YEAR HORIZON		
		F+I	PDO	Total	F+I	PDO	Total	F+I	PDO	Total
1	0.22	-$700	-$400	-$1,100	-$1,500	-$800	-$2,300	-$3,100	-$1,600	-$4,700
2	0.25	-$600	-$300	-$1,000	-$1,300	-$700	-$2,000	-$2,700	-$1,300	-$4,000
3	0.53	-$3,700	**$900**	-$2,800	-$7,400	**$1,700**	-$5,700	-$15,300	**$3,500**	-$11,800
4	0.80	-$3,000	-$2,200	-$5,200	-$6,100	-$4,500	-$10,600	-$12,700	-$9,200	-$21,800
5	0.76	-$15,300	-$5,500	-$20,800	-$31,000	-$11,100	-$42,100	-$63,200	-$22,500	-$85,800
6	0.23	-$2,000	-$400	-$2,400	-$4,100	-$700	-$4,800	-$8,500	-$1,500	-$10,000
7	0.63	-$13,900	-$5,000	-$18,900	-$28,000	-$9,900	-$37,900	-$56,500	-$20,000	-$76,500
8	0.38	-$200	-$2,400	-$2,600	-$500	-$4,800	-$5,300	-$1,000	-$9,600	-$10,500
9	0.48	-$10,300	-$3,100	-$13,400	-$20,700	-$6,200	-$26,900	-$41,900	-$12,400	-$54,200
10	0.22	-$2,200	-$400	-$2,500	-$4,300	-$800	-$5,100	-$8,700	-$1,600	-$10,300

It was found that sections generally had a negative NPV of excess total collisions in the future horizons. However, Section 3 is expected to have a small value of excess property damage only collisions cost in all future horizons. Given the small NPV of excess collisions, economically viable options for safety improvements are limited. As historical collision data shows that the collisions within the section were speed related, some low-cost measures (e.g., reducing speed by narrowing lane widths through restriping) could be applied to the section. It should be noted that consolidation of driveways would reduce the potential of future driveway related collisions within the section.

Conclusions

Based on the future "Do Nothing" scenario analysis, it can be concluded that:

- In all future horizon years, intersections will generally operate acceptably. However, eastbound and westbound through movement queues at the Angus Campbell Drive intersection will prevent vehicles from accessing the adjacent turn lanes during peak hours. Similarly, the eastbound through queues will occasionally block right-turn lanes at the Drive in Road and Robinson Lane intersections during the PM peak hour;
- Signalization of the Highway 148 at Greenwood Road intersection is not justified in any future horizon year;
- If the Highway 148 at Greenwood Road intersection were converted to a roundabout:
    - The intersection would operate adequately as a one lane entering per approach and one lane circulating roundabout; and
    - The collisions savings would likely be less than the cost of construction.

- If the driveways in between the Pembroke Allumette Bridge and the Ontario/Quebec Border Bridge (rural section) are consolidated into one four leg intersection at the Eileen Street / Esther Street location:
    - Left-turn lanes would be warranted based on the current turning movement assumptions;
    - Signalization of the intersection would not be warranted; and
    - As a result of higher turning volumes, the number of collisions in the future would be expected to increase, and safety performance should be monitored.
- An eastbound left-turn lane at the Traxton Way would is not required to accommodate the proposed adjacent development due to low turning volumes;
- Based on the low value of the excess collisions at the Greenwood Road intersection, there may not be an economic justification for converting the intersection to a roundabout. However, a roundabout may still be considered for other reasons, such as acting as a speed management feature and serving as a gateway to the urban area.
- Low-cost improvements to reduce wild animal collisions (e.g., lighting, signage, foliage clearing) may be economically feasible improvements given the cost of excess property damage collisions over the 20-year horizon.
- The consolidation of the driveways in the rural area into one four-leg intersection (Esther Street / Eileen Street) is expected to increase the number of collisions at the intersection, due to increased turning movement volumes. As the intersection did not experience excess collisions during the existing conditions, there are no historical issues that warrant mitigation;
- Although there is a positive NPV collision cost at the Beckett View Drive / Cotnam E JCT intersection in future horizons, opportunities for economically viable safety improvements are limited due to the low number/value of excess collisions; and
- Section 3 is expected to have a small value (NPV) of excess property damage only collisions cost in all future horizons. The small NPV of excess collisions limits options for economically feasible safety improvements, However, the collisions, which in the historical collision data are speed related, could be treated by low-cost measures (e.g., reducing speed by narrowing lane widths through restriping). It should be noted that consolidation of driveways would reduce the potential of future driveway related collisions within the section.

Future Design Considerations

Based on the results of the analysis of future traffic operations and safety performance of the Highway 148 study corridor, the following improvements are recommended for further review and evaluation:

- Implement a two-way left-turn centre lane within the urban section;
- Signalize the Highway 148/Drive In Road intersection;

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- Convert the current rail overpass to either an at-grade or grade-separated crossing, which would accommodate active and recreational modes of transportation (e.g., walking, biking, and snowmobiles, etc.);
- Consolidate driveways along the rural section of Highway 148 between the Pembroke Allumette Bridge and the Ontario/Quebec Border Bridge to reduce the number of direct accesses onto the Highway; and

Appendix: Synchro Analysis Output

2019 Traffic

2024 Traffic

2034 Traffic

2019 Traffic

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	519	142	59	594	1	159	0	104	2	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.91	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1865	1585	1772	1865		1772		1585		1690	
Flt Permitted		1.00	1.00	0.27	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1864	1585	501	1865		1400		1585		1690	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1	546	149	62	625	1	167	0	109	2	2	7
RTOR Reduction (vph)	0	0	39	0	0	0	0	0	84	0	5	0
Lane Group Flow (vph)	0	547	110	62	626	0	167	0	25	0	6	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		26.3	26.3	35.8	35.8		13.8		13.8		13.8	
Effective Green, g (s)		26.3	26.3	35.8	35.8		13.8		13.8		13.8	
Actuated g/C Ratio		0.43	0.43	0.59	0.59		0.23		0.23		0.23	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		802	682	428	1092		316		357		381	
v/s Ratio Prot				0.02	c0.34							
v/s Ratio Perm		c0.29	0.07	0.07			c0.12		0.02		0.00	
v/c Ratio		0.68	0.16	0.14	0.57		0.53		0.07		0.01	
Uniform Delay, d1		14.0	10.7	6.7	7.9		20.8		18.6		18.4	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		2.4	0.1	0.2	0.7		1.6		0.1		0.0	
Delay (s)		16.4	10.8	6.9	8.6		22.4		18.7		18.4	
Level of Service		B	B	A	A		C		B		B	
Approach Delay (s)		15.2			8.5			20.9			18.4	
Approach LOS		B			A			C			B	

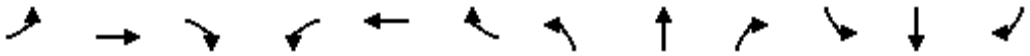
Intersection Summary			
HCM 2000 Control Delay	13.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	61.1	Sum of lost time (s)	14.5
Intersection Capacity Utilization	72.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	483	126	168	526	108	122
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.33	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	611	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	508	133	177	554	114	128
RTOR Reduction (vph)	0	64	0	0	0	111
Lane Group Flow (vph)	508	69	177	554	114	17
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	31.9	31.9	41.0	41.0	8.2	8.2
Effective Green, g (s)	31.9	31.9	41.0	41.0	8.2	8.2
Actuated g/C Ratio	0.52	0.52	0.66	0.66	0.13	0.13
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	964	819	454	1239	235	210
v/s Ratio Prot	c0.27		0.02	c0.30	c0.06	
v/s Ratio Perm		0.04	0.24			0.01
v/c Ratio	0.53	0.08	0.39	0.45	0.49	0.08
Uniform Delay, d1	9.9	7.5	5.3	4.9	24.8	23.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.1	0.2	0.6	1.2	1.6	0.2
Delay (s)	12.0	7.7	5.9	6.1	26.4	23.6
Level of Service	B	A	A	A	C	C
Approach Delay (s)	11.1			6.1	24.9	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	10.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	61.7	Sum of lost time (s)	19.0
Intersection Capacity Utilization	58.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	285	289	198	467	252	182
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.49	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	913	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	300	304	208	492	265	192
RTOR Reduction (vph)	0	194	0	0	0	146
Lane Group Flow (vph)	300	110	208	492	265	46
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	20.6	20.6	30.5	30.5	13.7	13.7
Effective Green, g (s)	20.6	20.6	30.5	30.5	13.7	13.7
Actuated g/C Ratio	0.36	0.36	0.54	0.54	0.24	0.24
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	674	572	592	997	425	380
v/s Ratio Prot	0.16		0.04	c0.26	c0.15	
v/s Ratio Perm		0.07	0.15			0.03
v/c Ratio	0.45	0.19	0.35	0.49	0.62	0.12
Uniform Delay, d1	13.9	12.5	7.1	8.4	19.3	16.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.2	0.4	0.4	2.8	0.1
Delay (s)	14.3	12.7	7.5	8.8	22.2	17.1
Level of Service	B	B	A	A	C	B
Approach Delay (s)	13.5			8.4	20.0	
Approach LOS	B			A	C	

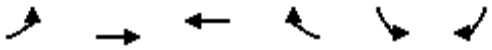
Intersection Summary			
HCM 2000 Control Delay	13.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	57.0	Sum of lost time (s)	15.8
Intersection Capacity Utilization	55.6%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	9	368	80	57	501	3	73	1	46	1	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.88	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1591		1772	1648	
Flt Permitted	0.45	1.00	1.00	0.53	1.00		0.85	1.00		0.85	1.00	
Satd. Flow (perm)	834	1865	1585	994	1864		1587	1591		1587	1648	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	9	387	84	60	527	3	77	1	48	1	2	7
RTOR Reduction (vph)	0	0	35	0	0	0	0	42	0	0	6	0
Lane Group Flow (vph)	9	387	49	60	530	0	77	7	0	1	3	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	22.9	22.9	22.9	22.9	22.9		4.7	4.7		4.7	4.7	
Effective Green, g (s)	22.9	22.9	22.9	22.9	22.9		4.7	4.7		4.7	4.7	
Actuated g/C Ratio	0.58	0.58	0.58	0.58	0.58		0.12	0.12		0.12	0.12	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	482	1078	916	574	1077		188	188		188	195	
v/s Ratio Prot		0.21			c0.28			0.00			0.00	
v/s Ratio Perm	0.01		0.03	0.06			c0.05			0.00		
v/c Ratio	0.02	0.36	0.05	0.10	0.49		0.41	0.04		0.01	0.01	
Uniform Delay, d1	3.6	4.4	3.6	3.7	4.9		16.2	15.4		15.4	15.4	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.2	0.0	0.1	0.4		1.5	0.1		0.0	0.0	
Delay (s)	3.6	4.6	3.7	3.8	5.3		17.6	15.5		15.4	15.4	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		4.5			5.1			16.8			15.4	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	6.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.48		
Actuated Cycle Length (s)	39.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	55.6%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	160	171	293	70	47	256
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	168	180	308	74	49	269
Pedestrians			3			
Lane Width (m)			3.7			
Walking Speed (m/s)			1.2			
Percent Blockage			0			
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	308				865	345
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	308				865	345
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	86				82	61
cM capacity (veh/h)	1246				278	695

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	168	180	382	319
Volume Left	168	0	0	49
Volume Right	0	0	74	269
cSH	1246	1700	1700	823
Volume to Capacity	0.14	0.11	0.22	0.39
Queue Length 95th (m)	3.3	0.0	0.0	12.9
Control Delay (s)	8.3	0.0	0.0	14.5
Lane LOS	A			B
Approach Delay (s)	4.0		0.0	14.5
Approach LOS				B

Intersection Summary			
Average Delay	5.8		
Intersection Capacity Utilization	42.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	612	151	50	428	2	192	0	69	1	0	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.89	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1864	1585	1772	1864		1772		1585		1647	
Flt Permitted		1.00	1.00	0.20	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1859	1585	370	1864		1407		1585		1647	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	5	644	159	53	451	2	202	0	73	1	0	4
RTOR Reduction (vph)	0	0	34	0	0	0	0	0	56	0	4	0
Lane Group Flow (vph)	0	649	125	53	453	0	202	0	17	0	1	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		30.9	30.9	40.4	40.4		15.9		15.9		15.9	
Effective Green, g (s)		30.9	30.9	40.4	40.4		15.9		15.9		15.9	
Actuated g/C Ratio		0.46	0.46	0.60	0.60		0.23		0.23		0.23	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		847	722	354	1110		329		371		386	
v/s Ratio Prot				0.01	c0.24							
v/s Ratio Perm		c0.35	0.08	0.07			c0.14		0.01		0.00	
v/c Ratio		0.77	0.17	0.15	0.41		0.61		0.05		0.00	
Uniform Delay, d1		15.4	10.9	8.2	7.3		23.2		20.1		19.9	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		4.2	0.1	0.2	0.2		3.4		0.1		0.0	
Delay (s)		19.6	11.0	8.4	7.6		26.6		20.1		19.9	
Level of Service		B	B	A	A		C		C		B	
Approach Delay (s)		17.9			7.7			24.9			19.9	
Approach LOS		B			A			C			B	

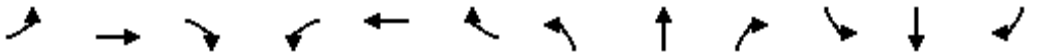
Intersection Summary			
HCM 2000 Control Delay	15.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	67.8	Sum of lost time (s)	14.5
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	498	149	120	356	174	250
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.29	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	541	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	524	157	126	375	183	263
RTOR Reduction (vph)	0	82	0	0	0	213
Lane Group Flow (vph)	524	75	126	375	183	50
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	30.9	30.9	40.2	40.2	12.3	12.3
Effective Green, g (s)	30.9	30.9	40.2	40.2	12.3	12.3
Actuated g/C Ratio	0.48	0.48	0.62	0.62	0.19	0.19
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	886	753	387	1153	335	299
v/s Ratio Prot	c0.28		0.01	c0.20	c0.10	
v/s Ratio Perm		0.05	0.19			0.03
v/c Ratio	0.59	0.10	0.33	0.33	0.55	0.17
Uniform Delay, d1	12.4	9.4	6.9	5.9	23.8	22.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.9	0.3	0.5	0.8	1.8	0.3
Delay (s)	15.3	9.6	7.4	6.7	25.6	22.3
Level of Service	B	A	A	A	C	C
Approach Delay (s)	14.0			6.9	23.7	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	14.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	65.0	Sum of lost time (s)	19.0
Intersection Capacity Utilization	58.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

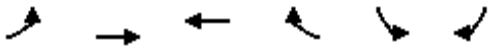
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	655	174	73	274	101	135
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.24	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	454	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	689	183	77	288	106	142
RTOR Reduction (vph)	0	86	0	0	0	122
Lane Group Flow (vph)	689	97	77	288	106	20
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	30.6	30.6	37.2	37.2	8.0	8.0
Effective Green, g (s)	30.6	30.6	37.2	37.2	8.0	8.0
Actuated g/C Ratio	0.53	0.53	0.64	0.64	0.14	0.14
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	983	836	372	1196	244	218
v/s Ratio Prot	c0.37		0.01	c0.15	c0.06	
v/s Ratio Perm		0.06	0.12			0.01
v/c Ratio	0.70	0.12	0.21	0.24	0.43	0.09
Uniform Delay, d1	10.3	6.9	5.6	4.4	22.9	21.8
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.3	0.1	0.3	0.1	1.2	0.2
Delay (s)	12.5	7.0	5.9	4.5	24.2	22.0
Level of Service	B	A	A	A	C	C
Approach Delay (s)	11.4			4.8	22.9	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	11.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	58.0	Sum of lost time (s)	15.8
Intersection Capacity Utilization	60.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	13	668	88	59	322	1	59	2	140	2	1	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.87	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1589		1772	1616	
Flt Permitted	0.56	1.00	1.00	0.31	1.00		0.75	1.00		0.66	1.00	
Satd. Flow (perm)	1038	1865	1585	587	1864		1402	1589		1235	1616	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	14	703	93	62	339	1	62	2	147	2	1	8
RTOR Reduction (vph)	0	0	31	0	0	0	0	78	0	0	7	0
Lane Group Flow (vph)	14	703	62	62	340	0	62	71	0	2	2	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	32.7	32.7	32.7	32.7	32.7		8.0	8.0		8.0	8.0	
Effective Green, g (s)	32.7	32.7	32.7	32.7	32.7		8.0	8.0		8.0	8.0	
Actuated g/C Ratio	0.62	0.62	0.62	0.62	0.62		0.15	0.15		0.15	0.15	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	644	1157	983	364	1156		212	241		187	245	
v/s Ratio Prot		c0.38			0.18			c0.04			0.00	
v/s Ratio Perm	0.01		0.04	0.11			0.04			0.00		
v/c Ratio	0.02	0.61	0.06	0.17	0.29		0.29	0.29		0.01	0.01	
Uniform Delay, d1	3.8	6.1	4.0	4.2	4.6		19.8	19.8		19.0	19.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.9	0.0	0.2	0.1		0.8	0.7		0.0	0.0	
Delay (s)	3.9	7.0	4.0	4.5	4.8		20.6	20.5		19.0	19.0	
Level of Service	A	A	A	A	A		C	C		B	B	
Approach Delay (s)		6.6			4.7			20.6			19.0	
Approach LOS		A			A			C			B	

Intersection Summary			
HCM 2000 Control Delay	8.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	52.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	63.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	313	395	141	78	30	100
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	329	416	148	82	32	105
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	148				1264	189
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	148				1264	189
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	77				78	88
cM capacity (veh/h)	1427				143	850

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	329	416	231	137
Volume Left	329	0	0	32
Volume Right	0	0	82	105
cSH	1427	1700	1700	620
Volume to Capacity	0.23	0.24	0.14	0.22
Queue Length 95th (m)	6.3	0.0	0.0	5.9
Control Delay (s)	8.3	0.0	0.0	16.1
Lane LOS	A			C
Approach Delay (s)	3.7		0.0	16.1
Approach LOS				C

Intersection Summary			
Average Delay	4.4		
Intersection Capacity Utilization	42.9%	ICU Level of Service	A
Analysis Period (min)	15		

2024 Traffic

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	539	150	61	619	1	167	0	108	2	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.91	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1865	1585	1772	1865		1772		1585		1690	
Flt Permitted		1.00	1.00	0.25	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1864	1585	464	1865		1400		1585		1690	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1	567	158	64	652	1	176	0	114	2	2	7
RTOR Reduction (vph)	0	0	39	0	0	0	0	0	88	0	5	0
Lane Group Flow (vph)	0	568	119	64	653	0	176	0	26	0	6	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		26.8	26.8	36.4	36.4		14.4		14.4		14.4	
Effective Green, g (s)		26.8	26.8	36.4	36.4		14.4		14.4		14.4	
Actuated g/C Ratio		0.43	0.43	0.58	0.58		0.23		0.23		0.23	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		801	681	409	1089		323		366		390	
v/s Ratio Prot				0.02	c0.35							
v/s Ratio Perm		c0.30	0.07	0.07			c0.13		0.02		0.00	
v/c Ratio		0.71	0.17	0.16	0.60		0.54		0.07		0.01	
Uniform Delay, d1		14.6	10.9	7.1	8.3		21.1		18.7		18.5	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		2.9	0.1	0.2	0.9		1.9		0.1		0.0	
Delay (s)		17.4	11.1	7.3	9.2		22.9		18.8		18.5	
Level of Service		B	B	A	A		C		B		B	
Approach Delay (s)		16.1			9.0			21.3			18.5	
Approach LOS		B			A			C			B	

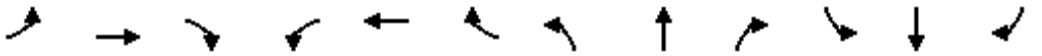
Intersection Summary			
HCM 2000 Control Delay	14.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	62.3	Sum of lost time (s)	14.5
Intersection Capacity Utilization	74.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	501	132	176	547	114	128
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.30	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	555	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	527	139	185	576	120	135
RTOR Reduction (vph)	0	71	0	0	0	116
Lane Group Flow (vph)	527	68	185	576	120	19
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	29.4	29.4	39.5	39.5	8.3	8.3
Effective Green, g (s)	29.4	29.4	39.5	39.5	8.3	8.3
Actuated g/C Ratio	0.49	0.49	0.66	0.66	0.14	0.14
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	909	772	436	1221	243	218
v/s Ratio Prot	c0.28		0.03	c0.31	c0.07	
v/s Ratio Perm		0.04	0.25			0.01
v/c Ratio	0.58	0.09	0.42	0.47	0.49	0.09
Uniform Delay, d1	11.0	8.3	5.8	5.2	24.1	22.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.7	0.2	0.7	1.3	1.6	0.2
Delay (s)	13.7	8.5	6.5	6.5	25.6	22.9
Level of Service	B	A	A	A	C	C
Approach Delay (s)	12.6			6.5	24.2	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	11.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	60.3	Sum of lost time (s)	19.0
Intersection Capacity Utilization	60.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

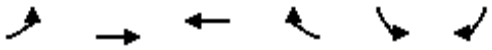
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	300	304	208	490	265	191
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.47	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	877	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	316	320	219	516	279	201
RTOR Reduction (vph)	0	204	0	0	0	152
Lane Group Flow (vph)	316	116	219	516	279	49
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	20.8	20.8	30.7	30.7	14.0	14.0
Effective Green, g (s)	20.8	20.8	30.7	30.7	14.0	14.0
Actuated g/C Ratio	0.36	0.36	0.53	0.53	0.24	0.24
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	674	573	575	995	431	385
v/s Ratio Prot	0.17		0.05	c0.28	c0.16	
v/s Ratio Perm		0.07	0.16			0.03
v/c Ratio	0.47	0.20	0.38	0.52	0.65	0.13
Uniform Delay, d1	14.1	12.6	7.3	8.6	19.5	17.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	0.2	0.4	0.5	3.3	0.1
Delay (s)	14.6	12.8	7.7	9.1	22.9	17.1
Level of Service	B	B	A	A	C	B
Approach Delay (s)	13.7			8.7	20.5	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	13.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	57.5	Sum of lost time (s)	15.8
Intersection Capacity Utilization	56.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	9	384	84	59	523	3	77	1	48	1	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	0.95	0.95	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.88	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1683	1772	1585	1772	1864		1772	1591		1772	1648	
Flt Permitted	0.43	1.00	1.00	0.51	1.00		0.83	1.00		0.83	1.00	
Satd. Flow (perm)	757	1770	1585	959	1864		1554	1591		1554	1648	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	9	404	88	62	551	3	81	1	51	1	2	7
RTOR Reduction (vph)	0	0	37	0	0	0	0	45	0	0	6	0
Lane Group Flow (vph)	8	405	51	62	554	0	81	7	0	1	3	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	22.8	22.8	22.8	22.8	22.8		4.8	4.8		4.8	4.8	
Effective Green, g (s)	22.8	22.8	22.8	22.8	22.8		4.8	4.8		4.8	4.8	
Actuated g/C Ratio	0.58	0.58	0.58	0.58	0.58		0.12	0.12		0.12	0.12	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	435	1019	912	552	1073		188	192		188	199	
v/s Ratio Prot					c0.30			0.00			0.00	
v/s Ratio Perm	0.01	0.23	0.03	0.06			c0.05			0.00		
v/c Ratio	0.02	0.40	0.06	0.11	0.52		0.43	0.04		0.01	0.01	
Uniform Delay, d1	3.6	4.6	3.7	3.8	5.1		16.1	15.4		15.3	15.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.3	0.0	0.1	0.4		1.6	0.1		0.0	0.0	
Delay (s)	3.6	4.9	3.7	3.9	5.5		17.7	15.4		15.3	15.3	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		4.7			5.3			16.8			15.3	
Approach LOS		A			A			B			B	

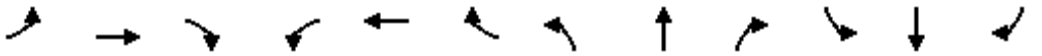
Intersection Summary			
HCM 2000 Control Delay	6.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	39.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	166	178	307	74	49	267
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	175	187	323	78	52	281
Pedestrians			3			
Lane Width (m)			3.7			
Walking Speed (m/s)			1.2			
Percent Blockage			0			
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	323				902	362
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	323				902	362
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	86				80	59
cM capacity (veh/h)	1231				263	680

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	175	187	401	333
Volume Left	175	0	0	52
Volume Right	0	0	78	281
cSH	1231	1700	1700	805
Volume to Capacity	0.14	0.11	0.24	0.41
Queue Length 95th (m)	3.5	0.0	0.0	14.3
Control Delay (s)	8.4	0.0	0.0	15.2
Lane LOS	A			C
Approach Delay (s)	4.1		0.0	15.2
Approach LOS				C

Intersection Summary			
Average Delay	6.0		
Intersection Capacity Utilization	43.9%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	640	159	52	450	2	202	0	73	1	0	4
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.89	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1864	1585	1772	1864		1772		1585		1647	
Flt Permitted		1.00	1.00	0.18	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1859	1585	335	1864		1407		1585		1647	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	5	674	167	55	474	2	213	0	77	1	0	4
RTOR Reduction (vph)	0	0	34	0	0	0	0	0	59	0	4	0
Lane Group Flow (vph)	0	679	133	55	476	0	213	0	18	0	1	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		32.4	32.4	42.0	42.0		16.5		16.5		16.5	
Effective Green, g (s)		32.4	32.4	42.0	42.0		16.5		16.5		16.5	
Actuated g/C Ratio		0.46	0.46	0.60	0.60		0.24		0.24		0.24	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		860	733	336	1118		331		373		388	
v/s Ratio Prot				0.02	c0.26							
v/s Ratio Perm		c0.37	0.08	0.08			c0.15		0.01		0.00	
v/c Ratio		0.79	0.18	0.16	0.43		0.64		0.05		0.00	
Uniform Delay, d1		15.9	11.0	8.8	7.5		24.1		20.7		20.5	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		4.9	0.1	0.2	0.3		4.2		0.1		0.0	
Delay (s)		20.8	11.1	9.0	7.8		28.3		20.7		20.5	
Level of Service		C	B	A	A		C		C		C	
Approach Delay (s)		18.9			7.9			26.3			20.5	
Approach LOS		B			A			C			C	

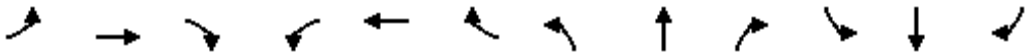
Intersection Summary			
HCM 2000 Control Delay	16.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	69.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	520	157	126	374	183	263
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.27	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	505	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	547	165	133	394	193	277
RTOR Reduction (vph)	0	87	0	0	0	223
Lane Group Flow (vph)	547	78	133	394	193	54
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	31.0	31.0	40.3	40.3	12.8	12.8
Effective Green, g (s)	31.0	31.0	40.3	40.3	12.8	12.8
Actuated g/C Ratio	0.47	0.47	0.61	0.61	0.20	0.20
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	881	749	364	1145	345	309
v/s Ratio Prot	c0.29		0.02	c0.21	c0.11	
v/s Ratio Perm		0.05	0.21			0.03
v/c Ratio	0.62	0.10	0.37	0.34	0.56	0.17
Uniform Delay, d1	12.9	9.6	7.4	6.2	23.9	22.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.3	0.3	0.6	0.8	2.0	0.3
Delay (s)	16.2	9.9	8.0	7.0	25.8	22.3
Level of Service	B	A	A	A	C	C
Approach Delay (s)	14.7			7.3	23.7	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	14.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	65.6	Sum of lost time (s)	19.0
Intersection Capacity Utilization	60.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

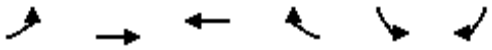
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	687	183	77	288	106	142
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.18	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	342	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	723	193	81	303	112	149
RTOR Reduction (vph)	0	99	0	0	0	123
Lane Group Flow (vph)	723	94	81	303	112	26
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	30.0	30.0	38.2	38.2	10.6	10.6
Effective Green, g (s)	30.0	30.0	38.2	38.2	10.6	10.6
Actuated g/C Ratio	0.49	0.49	0.62	0.62	0.17	0.17
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	908	771	332	1156	304	272
v/s Ratio Prot	c0.39		0.02	c0.16	c0.06	
v/s Ratio Perm		0.06	0.13			0.02
v/c Ratio	0.80	0.12	0.24	0.26	0.37	0.09
Uniform Delay, d1	13.2	8.6	7.5	5.3	22.5	21.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.9	0.1	0.4	0.1	0.8	0.2
Delay (s)	18.1	8.7	7.8	5.4	23.3	21.6
Level of Service	B	A	A	A	C	C
Approach Delay (s)	16.1			5.9	22.3	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	14.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	61.6	Sum of lost time (s)	15.8
Intersection Capacity Utilization	62.8%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	13	699	92	62	338	1	62	2	148	2	1	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.87	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1589		1772	1616	
Flt Permitted	0.55	1.00	1.00	0.29	1.00		0.75	1.00		0.66	1.00	
Satd. Flow (perm)	1022	1865	1585	543	1864		1402	1589		1225	1616	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	14	736	97	65	356	1	65	2	156	2	1	8
RTOR Reduction (vph)	0	0	39	0	0	0	0	135	0	0	7	0
Lane Group Flow (vph)	14	736	58	65	357	0	65	23	0	2	2	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	26.8	26.8	26.8	26.8	26.8		6.2	6.2		6.2	6.2	
Effective Green, g (s)	26.8	26.8	26.8	26.8	26.8		6.2	6.2		6.2	6.2	
Actuated g/C Ratio	0.60	0.60	0.60	0.60	0.60		0.14	0.14		0.14	0.14	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	608	1110	943	323	1110		193	218		168	222	
v/s Ratio Prot		c0.39			0.19			0.01			0.00	
v/s Ratio Perm	0.01		0.04	0.12			c0.05			0.00		
v/c Ratio	0.02	0.66	0.06	0.20	0.32		0.34	0.11		0.01	0.01	
Uniform Delay, d1	3.7	6.1	3.8	4.2	4.6		17.5	17.0		16.8	16.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	1.5	0.0	0.3	0.2		1.0	0.2		0.0	0.0	
Delay (s)	3.7	7.6	3.8	4.5	4.7		18.6	17.2		16.8	16.8	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		7.1			4.7			17.6			16.8	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.0	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	45.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	65.3%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

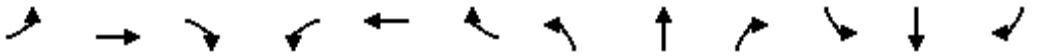


Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	327	413	149	82	32	104
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	344	435	157	86	34	109
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	157				1323	200
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	157				1323	200
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	76				74	87
cM capacity (veh/h)	1417				130	838

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	344	435	243	143
Volume Left	344	0	0	34
Volume Right	0	0	86	109
cSH	1417	1700	1700	552
Volume to Capacity	0.24	0.26	0.14	0.26
Queue Length 95th (m)	6.7	0.0	0.0	7.2
Control Delay (s)	8.4	0.0	0.0	17.5
Lane LOS	A			C
Approach Delay (s)	3.7		0.0	17.5
Approach LOS				C

Intersection Summary			
Average Delay	4.6		
Intersection Capacity Utilization	44.3%	ICU Level of Service	A
Analysis Period (min)	15		

2034 Traffic



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	1	583	165	67	673	1	184	0	117	2	2	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.91	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1865	1585	1772	1865		1772		1585		1683	
Flt Permitted		1.00	1.00	0.22	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1864	1585	404	1865		1398		1585		1683	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1	614	174	71	708	1	194	0	123	2	2	8
RTOR Reduction (vph)	0	0	39	0	0	0	0	0	94	0	6	0
Lane Group Flow (vph)	0	615	135	71	709	0	194	0	29	0	6	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		29.2	29.2	38.9	38.9		15.5		15.5		15.5	
Effective Green, g (s)		29.2	29.2	38.9	38.9		15.5		15.5		15.5	
Actuated g/C Ratio		0.44	0.44	0.59	0.59		0.24		0.24		0.24	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		825	702	377	1100		328		372		395	
v/s Ratio Prot				0.02	c0.38							
v/s Ratio Perm		c0.33	0.09	0.09			c0.14		0.02		0.00	
v/c Ratio		0.75	0.19	0.19	0.64		0.59		0.08		0.01	
Uniform Delay, d1		15.3	11.2	7.9	8.9		22.4		19.6		19.3	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		3.7	0.1	0.2	1.3		2.8		0.1		0.0	
Delay (s)		18.9	11.3	8.1	10.2		25.2		19.7		19.4	
Level of Service		B	B	A	B		C		B		B	
Approach Delay (s)		17.3			10.0			23.1			19.4	
Approach LOS		B			B			C			B	

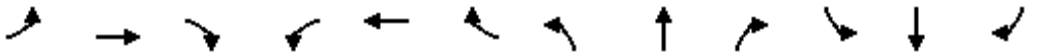
Intersection Summary			
HCM 2000 Control Delay	15.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	65.9	Sum of lost time (s)	14.5
Intersection Capacity Utilization	80.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	538	146	195	593	126	141
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.25	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	469	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	566	154	205	624	133	148
RTOR Reduction (vph)	0	83	0	0	0	122
Lane Group Flow (vph)	566	71	205	624	133	26
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	28.8	28.8	38.8	38.8	11.0	11.0
Effective Green, g (s)	28.8	28.8	38.8	38.8	11.0	11.0
Actuated g/C Ratio	0.46	0.46	0.62	0.62	0.18	0.18
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	862	732	365	1161	312	279
v/s Ratio Prot	c0.30		0.03	c0.33	c0.08	
v/s Ratio Perm		0.04	0.32			0.02
v/c Ratio	0.66	0.10	0.56	0.54	0.43	0.09
Uniform Delay, d1	12.9	9.4	7.6	6.7	22.8	21.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.9	0.3	2.0	1.8	0.9	0.1
Delay (s)	16.8	9.7	9.6	8.4	23.8	21.6
Level of Service	B	A	A	A	C	C
Approach Delay (s)	15.3			8.7	22.6	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	13.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	62.3	Sum of lost time (s)	19.0
Intersection Capacity Utilization	63.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	331	336	230	540	292	211
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.43	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	807	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	348	354	242	568	307	222
RTOR Reduction (vph)	0	226	0	0	0	167
Lane Group Flow (vph)	348	128	242	568	307	55
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	21.3	21.3	31.3	31.3	14.6	14.6
Effective Green, g (s)	21.3	21.3	31.3	31.3	14.6	14.6
Actuated g/C Ratio	0.36	0.36	0.53	0.53	0.25	0.25
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	676	575	545	994	440	394
v/s Ratio Prot	0.19		0.05	c0.30	c0.17	
v/s Ratio Perm		0.08	0.18			0.03
v/c Ratio	0.51	0.22	0.44	0.57	0.70	0.14
Uniform Delay, d1	14.7	13.0	7.7	9.2	20.0	17.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.2	0.6	0.8	4.8	0.2
Delay (s)	15.3	13.2	8.3	10.0	24.8	17.3
Level of Service	B	B	A	A	C	B
Approach Delay (s)	14.2			9.5	21.7	
Approach LOS	B			A	C	

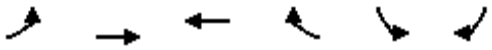
Intersection Summary			
HCM 2000 Control Delay	14.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	58.7	Sum of lost time (s)	15.8
Intersection Capacity Utilization	60.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	417	91	66	571	3	84	1	53	1	2	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.88	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1590		1772	1641	
Flt Permitted	0.39	1.00	1.00	0.51	1.00		0.80	1.00		0.80	1.00	
Satd. Flow (perm)	724	1865	1585	947	1864		1492	1590		1492	1641	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	11	439	96	69	601	3	88	1	56	1	2	8
RTOR Reduction (vph)	0	0	40	0	0	0	0	49	0	0	7	0
Lane Group Flow (vph)	11	439	56	69	604	0	88	8	0	1	3	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	23.4	23.4	23.4	23.4	23.4		5.0	5.0		5.0	5.0	
Effective Green, g (s)	23.4	23.4	23.4	23.4	23.4		5.0	5.0		5.0	5.0	
Actuated g/C Ratio	0.58	0.58	0.58	0.58	0.58		0.12	0.12		0.12	0.12	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	419	1080	918	548	1079		184	196		184	203	
v/s Ratio Prot		0.24			c0.32			0.00			0.00	
v/s Ratio Perm	0.02		0.04	0.07			c0.06			0.00		
v/c Ratio	0.03	0.41	0.06	0.13	0.56		0.48	0.04		0.01	0.01	
Uniform Delay, d1	3.6	4.7	3.7	3.9	5.3		16.5	15.6		15.5	15.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.3	0.0	0.1	0.6		2.0	0.1		0.0	0.0	
Delay (s)	3.7	4.9	3.7	4.0	5.9		18.4	15.7		15.5	15.6	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		4.7			5.7			17.4			15.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	6.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	40.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	59.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	180	194	336	81	54	291
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	189	204	354	85	57	306
Pedestrians			3			
Lane Width (m)			3.7			
Walking Speed (m/s)			1.2			
Percent Blockage			0			
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	354				982	396
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	354				982	396
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	84				75	53
cM capacity (veh/h)	1200				231	651

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	189	204	439	363
Volume Left	189	0	0	57
Volume Right	0	0	85	306
cSH	1200	1700	1700	772
Volume to Capacity	0.16	0.12	0.26	0.47
Queue Length 95th (m)	3.9	0.0	0.0	17.8
Control Delay (s)	8.6	0.0	0.0	17.0
Lane LOS	A			C
Approach Delay (s)	4.1		0.0	17.0
Approach LOS				C

Intersection Summary			
Average Delay	6.5		
Intersection Capacity Utilization	47.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	6	701	175	58	496	2	223	0	80	1	0	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Lane Util. Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Frt		1.00	0.85	1.00	1.00		1.00		0.85		0.89	
Flt Protected		1.00	1.00	0.95	1.00		0.95		1.00		0.99	
Satd. Flow (prot)		1864	1585	1772	1864		1772		1585		1642	
Flt Permitted		1.00	1.00	0.15	1.00		0.75		1.00		0.99	
Satd. Flow (perm)		1858	1585	285	1864		1406		1585		1642	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	738	184	61	522	2	235	0	84	1	0	5
RTOR Reduction (vph)	0	0	32	0	0	0	0	0	65	0	5	0
Lane Group Flow (vph)	0	744	152	61	524	0	235	0	19	0	1	0
Turn Type	Perm	NA	Perm	pm+pt	NA		Perm		Perm	Perm	NA	
Protected Phases		2		1	6						4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)		37.4	37.4	47.0	47.0		17.6		17.6		17.6	
Effective Green, g (s)		37.4	37.4	47.0	47.0		17.6		17.6		17.6	
Actuated g/C Ratio		0.49	0.49	0.62	0.62		0.23		0.23		0.23	
Clearance Time (s)		6.0	6.0	3.0	6.0		5.5		5.5		5.5	
Vehicle Extension (s)		3.0	3.0	3.0	3.0		3.0		3.0		3.0	
Lane Grp Cap (vph)		913	778	304	1151		325		366		379	
v/s Ratio Prot				0.02	c0.28							
v/s Ratio Perm		c0.40	0.10	0.11			c0.17		0.01		0.00	
v/c Ratio		0.81	0.20	0.20	0.46		0.72		0.05		0.00	
Uniform Delay, d1		16.4	10.9	10.0	7.7		27.0		22.8		22.5	
Progression Factor		1.00	1.00	1.00	1.00		1.00		1.00		1.00	
Incremental Delay, d2		5.7	0.1	0.3	0.3		7.7		0.1		0.0	
Delay (s)		22.1	11.0	10.3	8.0		34.7		22.8		22.5	
Level of Service		C	B	B	A		C		C		C	
Approach Delay (s)		19.9			8.3			31.6			22.5	
Approach LOS		B			A			C			C	

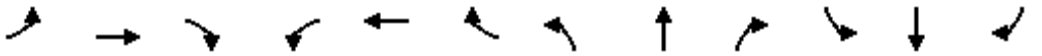
Intersection Summary			
HCM 2000 Control Delay	18.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	76.1	Sum of lost time (s)	14.5
Intersection Capacity Utilization	75.6%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	568	173	139	412	203	291
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.23	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	429	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	598	182	146	434	214	306
RTOR Reduction (vph)	0	97	0	0	0	209
Lane Group Flow (vph)	598	85	146	434	214	97
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	31.0	31.0	40.3	40.3	13.4	13.4
Effective Green, g (s)	31.0	31.0	40.3	40.3	13.4	13.4
Actuated g/C Ratio	0.47	0.47	0.61	0.61	0.20	0.20
Clearance Time (s)	6.2	6.2	6.5	6.2	6.3	6.3
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	873	742	317	1135	358	320
v/s Ratio Prot	c0.32		0.02	c0.23	c0.12	
v/s Ratio Perm		0.05	0.26			0.06
v/c Ratio	0.68	0.11	0.46	0.38	0.60	0.30
Uniform Delay, d1	13.8	9.9	8.4	6.6	24.0	22.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.4	0.3	1.1	1.0	2.7	0.5
Delay (s)	18.1	10.2	9.5	7.6	26.6	23.0
Level of Service	B	B	A	A	C	C
Approach Delay (s)	16.3			8.1	24.5	
Approach LOS	B			A	C	

Intersection Summary			
HCM 2000 Control Delay	16.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	66.2	Sum of lost time (s)	19.0
Intersection Capacity Utilization	64.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	758	202	85	317	117	156
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	1.00	1.00	0.95	1.00	0.95	1.00
Satd. Flow (prot)	1865	1585	1772	1865	1772	1585
Flt Permitted	1.00	1.00	0.13	1.00	0.95	1.00
Satd. Flow (perm)	1865	1585	236	1865	1772	1585
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	798	213	89	334	123	164
RTOR Reduction (vph)	0	109	0	0	0	136
Lane Group Flow (vph)	798	104	89	334	123	28
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases		2	6			8
Actuated Green, G (s)	30.3	30.3	38.6	38.6	10.8	10.8
Effective Green, g (s)	30.3	30.3	38.6	38.6	10.8	10.8
Actuated g/C Ratio	0.49	0.49	0.62	0.62	0.17	0.17
Clearance Time (s)	6.7	6.7	3.0	6.7	6.1	6.1
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	908	772	277	1157	307	275
v/s Ratio Prot	c0.43		c0.03	0.18	c0.07	
v/s Ratio Perm		0.07	0.17			0.02
v/c Ratio	0.88	0.13	0.32	0.29	0.40	0.10
Uniform Delay, d1	14.3	8.8	9.1	5.5	22.8	21.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	9.7	0.1	0.7	0.1	0.9	0.2
Delay (s)	24.0	8.8	9.7	5.6	23.7	21.8
Level of Service	C	A	A	A	C	C
Approach Delay (s)	20.8			6.5	22.6	
Approach LOS	C			A	C	

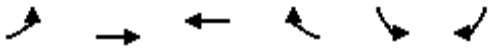
Intersection Summary			
HCM 2000 Control Delay	17.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	62.2	Sum of lost time (s)	15.8
Intersection Capacity Utilization	66.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	765	101	69	372	1	69	2	163	2	1	9
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.86	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1589		1772	1613	
Flt Permitted	0.53	1.00	1.00	0.25	1.00		0.75	1.00		0.65	1.00	
Satd. Flow (perm)	988	1865	1585	464	1864		1401	1589		1207	1613	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	805	106	73	392	1	73	2	172	2	1	9
RTOR Reduction (vph)	0	0	41	0	0	0	0	112	0	0	8	0
Lane Group Flow (vph)	16	805	65	73	393	0	73	62	0	2	2	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	29.0	29.0	29.0	29.0	29.0		6.6	6.6		6.6	6.6	
Effective Green, g (s)	29.0	29.0	29.0	29.0	29.0		6.6	6.6		6.6	6.6	
Actuated g/C Ratio	0.61	0.61	0.61	0.61	0.61		0.14	0.14		0.14	0.14	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	601	1136	965	282	1135		194	220		167	223	
v/s Ratio Prot		c0.43			0.21			0.04			0.00	
v/s Ratio Perm	0.02		0.04	0.16			c0.05			0.00		
v/c Ratio	0.03	0.71	0.07	0.26	0.35		0.38	0.28		0.01	0.01	
Uniform Delay, d1	3.7	6.4	3.8	4.3	4.6		18.6	18.4		17.7	17.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	2.0	0.0	0.5	0.2		1.2	0.7		0.0	0.0	
Delay (s)	3.7	8.4	3.8	4.8	4.8		19.9	19.1		17.7	17.7	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		7.8			4.8			19.3			17.7	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	47.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	357	453	164	90	35	114
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	376	477	173	95	37	120
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						9
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	173				1448	220
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	173				1448	220
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	73				65	85
cM capacity (veh/h)	1398				105	817

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	376	477	267	157
Volume Left	376	0	0	37
Volume Right	0	0	95	120
cSH	1398	1700	1700	448
Volume to Capacity	0.27	0.28	0.16	0.35
Queue Length 95th (m)	7.7	0.0	0.0	10.9
Control Delay (s)	8.5	0.0	0.0	21.1
Lane LOS	A			C
Approach Delay (s)	3.8		0.0	21.1
Approach LOS				C

Intersection Summary			
Average Delay	5.1		
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		

Appendix B3 – Two Way Left Turn Lane (Technical Memo)

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Memorandum

To/Attention	Chris Belanger Project Manager, MTO	**Date**	December 4, 2017
From	Justin Date	**Project No**	37432
cc	Allan Ortlieb		
Subject	Highway 148, Pembroke to Quebec Border Preliminary Design and Class EA Study Assessment of Two-Way Left-Turn Lane Option—Angus Campbell Drive to Dairy Road		

Introduction

This memorandum provides a summary of the evaluation of a centre Two-Way Left-Turn Lane (TWLTL) proposed for the section of Highway 148 between Angus Campbell Drive and Dairy Road. A TWLTL is a continuous paved centre lane on an undivided road that provides deceleration and storage area for left-turning vehicles in either direction. This type of lane is intended to reduce the frequency of collisions involving left-turning turning vehicles at locations where the frequency and spacing of access driveways and side roads make it difficult to introduce separate unidirectional left-turn lanes. The use of TWLTLs has been shown to be effective in reducing rear-end collisions involving vehicles stopping or slowing to turn left in the through lane because these vehicles are removed from the primary travel lane while drivers wait for an acceptable gap in the opposing traffic stream to make the turn. They have also been found to reduce the frequency of head-on collisions along undivided roads by providing a buffer between the opposing travel lanes.

Existing Conditions

Highway Conditions

The section of Highway 148 between Angus Campbell Drive and Drive In Road is 1.76 km in length and consists of two travel lanes approximately 3.75 m wide with auxiliary turning lanes provided at the major intersections at Angus Campbell Drive, the Walmart Access, Robinson Lane and Drive In Road. This section of Highway 148 is considered to be more urban than the rest of the highway and is characterized by lower posted speed limits, higher traffic volumes, increased access density and numerous commercial properties fronting the highway. The posted speed limit is 50 km/h for the section from Angus Campbell Drive to just west of Robinson Lane and 60 km/h from Robinson Lane to 145 m east of Dairy Road.

The road cross-section along the corridor transitions from rural with paved shoulders and ditches to a more urban cross-section with concrete curbs and a closed drainage system between the Walmart Access and Angus Campbell Drive. West of Angus Campbell Drive, Highway 148 becomes Pembroke Street East, a municipal road under the jurisdiction of the Town of

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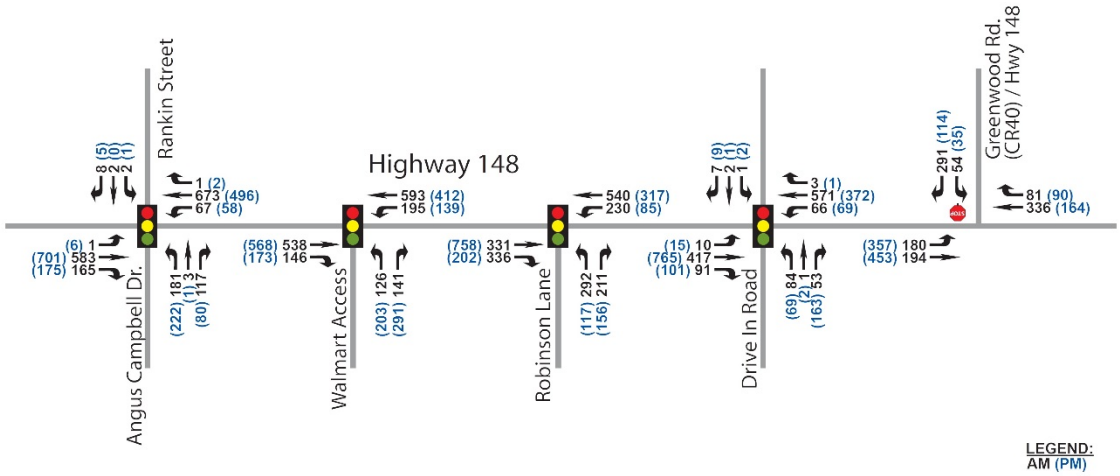
Pembroke. There is an existing TWLTL median lane in the section of Pembroke Street East from approximately 150 m west of Angus Campbell Drive to Belmont Avenue.

Traffic Volumes

The section of Highway 148 between Greenwood Road and Angus Campbell Drive has a historical Annual Average Daily Traffic (AADT) volume of approximately 11,000 vehicles with a truck percentage of 1.5%.

Projected 2034 peak hour traffic volumes along this section of Highway 148 are indicated in Exhibit 1 below.

Exhibit 1: Future (2034) Traffic Volumes



Traffic Speeds

MTO carried out speed surveys along Highway 148 in 2014. The following 85th percentile vehicular speeds were recorded along the section under consideration for TWLTL:

- Between Walmart Access and Robinson Lane: 73–81 km/h
- Dairy Road: 84 km/h

Access Management

The land use on either side of the highway is a mix of low-density residential and commercial. The commercial properties range from small-scale, single-unit businesses to large-format retail developments and a shopping centre.

The large-format retail developments (Home Depot, Walmart) and the Pembroke Mall are located on the south side of the highway and have been designed with some access management features. The primary access/egress points to these developments are located at major signalized intersections at Angus Campbell Drive, the Walmart Access and Robinson Lane where there are auxiliary lanes provided for turning vehicles. Secondary access driveways have been designed with turn restrictions and are limited to either right-in only or right-in/right-

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out only movements. Access to the other commercial and residential properties along the highway is unrestricted and MTO access management standards for maximum access density and driveway spacing are exceeded throughout the corridor.

Table 1 indicates the number of access driveways and the corresponding access density between the major intersections along this section of Highway 148.

Table 1: Existing Access Density

HIGHWAY 148	DISTANCE (Available for LT Lane)	ACCESS DRIVEWAYS[1]	ACCESS DENSITY (Access connections per km)
Angus Campbell Drive to Walmart Access	543 m	16	30
Walmart Access to Robinson Lane	437 m	17	39
Robinson Lane to Drive In Road	348 m	17	49
Drive In Road to Dairy Road	317 m	13	41
TOTAL	**1,645 m**	**63**	**38**

1. Right-In/Right-Out and Right-In Only access driveways are not included in the total.

Collision Analysis

An assessment of recorded collision data (5 years) along the corridor identified that rear-end collisions was the dominant collision type along Highway 148 and accounted for 41% of all collisions recorded along the highway during the period analyzed. Of the 18 recorded rear-end collisions, 16 occurred within the more urban section of the corridor between Greenwood Road and Angus Campbell Drive. It is considered that the high concentration of intersections and private driveways accessing Highway 148 is a significant factor contributing to these rear-end collisions. With only one lane in each direction, left-turning vehicles have to slow down/stop within the travel lane to make the manoeuvre and can be rear-ended by other drivers who are inattentive or following too closely.

Justification

Literature Review

A review of available literature has provided limited information on the criteria or requirements for justifying the introduction of Two-Way Left-Turn Lanes. The complexity and number of factors to be considered at any specific site make it difficult to establish a set of firm limiting conditions for the effective operation of TWLTLs. The following is a summary of the literature review.

The *Geometric Design Standards for Ontario Highways (MTO)*[1] includes a policy statement on appropriate lane widths to be used in the design of TWLTLs but does not include criteria or guidance on the conditions for which they should be considered.

The *Geometric Design Guide for Canadian Roads*[2] by the Transportation Association of Canada (TAC) indicates that TWLTLs may be appropriate under the following general conditions:

- Arterial roadways with reasonably straight and flat alignments;

- Commercial strip or industrial development on both sides of the roadway with numerous access driveways; and
- Operating speeds < 70 km/h

In Texas[3], the following criteria are used for considering the potential use of a continuous TWLTL on a suburban roadway:

- Minimum future ADT volume of 3,000 vehicles per day for an existing two-lane suburban roadway; and
- Side road plus driveway density of 6 or more entrances per km

When both conditions are met, the use of a TWTL should be considered.

In Illinois[4], the following TWLTL guidelines are used for two-lane roadways:

- Only provide in areas with a high number of existing driveways per km (20-55 driveways total per km) on both sides of the street;
- Traffic volumes between 5,000 and 14,000 ADT; and
- Design speeds < 70 km/h

Advantages and Disadvantages of Two-Way Left-Turn Lanes

Table 2 summarizes some of the advantages and disadvantages of TWLTLs on two-lane roads.

Table 2: Advantages and Disadvantages of TWLTLs

ADVANTAGES	DISADVANTAGES
Reduces the frequency of collisions involving left-turning vehicles, particularly rear-end collisions.	Left-turn paths are not clearly defined and turning conflicts can occur.
Reduces the frequency of head-on collisions by providing a buffer between opposing directions of travel.	Limited to tangent alignments with good sight distance.
Improves the operational efficiency of the corridor by reducing delays due to left-turning vehicles in the though lane.	Operation may not be clearly understood by the unfamiliar driver.
Well-suited to corridors with frequent low to medium volume driveways	May be prone to improper use eg. through vehicles using the TWLTL as a passing lane to overtake slower vehicles.
Provides a lane for emergency vehicles to bypass through traffic.	From an access management perspective, TWLTLs increase rather than control access opportunities.

Operational Effectiveness

Most of the available information on the operational and safety benefits of TWLTLs has been based on studies conducted on multi-lane highways with either a 5-lane cross-section or 4-lane to 3-lane conversion (road diet) examples. However, the information available on TWLTLs on two-lane highways does point to clear benefits from these facilities.

The publication *Low-Cost methods for improving Traffic Operations on Two Lane Roads*[5] by the Federal Highway Administration (FHWA) presents a model that can be used to predict the amount of delay reduced by a TWLTL on a two-lane highway in a rural or urban fringe area, represented by the following equation:

$$DR = -6.87 + 0.058V$$

Where,

$D = Delay\ reduction\ (seconds\ per\ left\text{-}turning\ vehicle)$

$V = Opposing\ Volume\ (Veh/h)$

Based on the above, the introduction of a TWLTL could be expected to reduce the delay per left-turning vehicles by up to 49 seconds during the heaviest peak hours of travel along this section of Highway 148.

The publication *Safety Evaluation of Installing Center Two-Way Left-Turn Lanes on Two-Lane Roads* (FHWA)[6] indicates that rear-end collisions can be reduced by approximately 36% for rural installations based on an analysis of representative sites in the US, but the results of the study also indicate a much lower safety effectiveness in urban settings. The report recommends that additional research is required to determine the factors that impact the safety effectiveness of TWLTLs in urban environments, such as intersection spacing and driveway density. While the safety benefits of TWLTLs in urban locations may be lower than for rural installations, there is still considered to be a benefit associated with the introduction of TWLTLs at locations where the existing rate of rear-end collisions is high.

Justification Review

Based on the above, the section of Highway 148 under consideration meets the general criteria for daily traffic volumes, access density and land use conditions used for justifying the implementation of a TWLTL. However, current operating speeds along the corridor are higher than the recommended 70 km/h maximum. In particular, the section between Drive in Road and Dairy Road is located just to the west of the 80 km/h posted speed zone and as a result experiences 85th percentile speeds of 84 km/h. As such, a TWLTL is not recommended for the section of the highway between Drive In Road and Dairy Road.

A TWLTL is recommended for the section of Highway 148 between Angus Campbell Drive and Drive In Road but consideration should be given to reducing the posted speed limit from 60 km/h to 50 km/h in the section from west of Robinson lane to Drive In Road if a centre TWLTL is implemented. This speed limit reduction would also be appropriate if this section of the highway is fully urbanized.

Design Criteria

MTO design standards specify a desirable lane width of 4.0 m for continuous TWLTLs. The TWLTL should be delineated according to the pavement marking details provided in Ontario Traffic Manual (OTM) Book 11 and indicated in Exhibit 2 below.

The TWLTL design guidelines in OTM Book 11 recommend terminating the TWLTL on the approach to major intersections in order to provide a designated left-turn lane. The designated left-turn lane should be designed to provide sufficient storage for left-turning vehicles plus additional length to allow for deceleration on the approach to the lane. This treatment reduces the effective length of the TWLTL between major intersections. The recommended storage

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length should be based on the projected 95th percentile queue length for the left-turn movement. OTM Book 11 specifies a minimum storage length of 20 m with an additional length for the designated left-turn lane calculated by the following equation:

$$L = \frac{S \times W}{1.6}$$

$$Where, S = speed\ (km/h), W = lane\ width\ (m)$$

Exhibit 2: Delineation of Two-Way Left-Turn Lane (OTM Book 11)

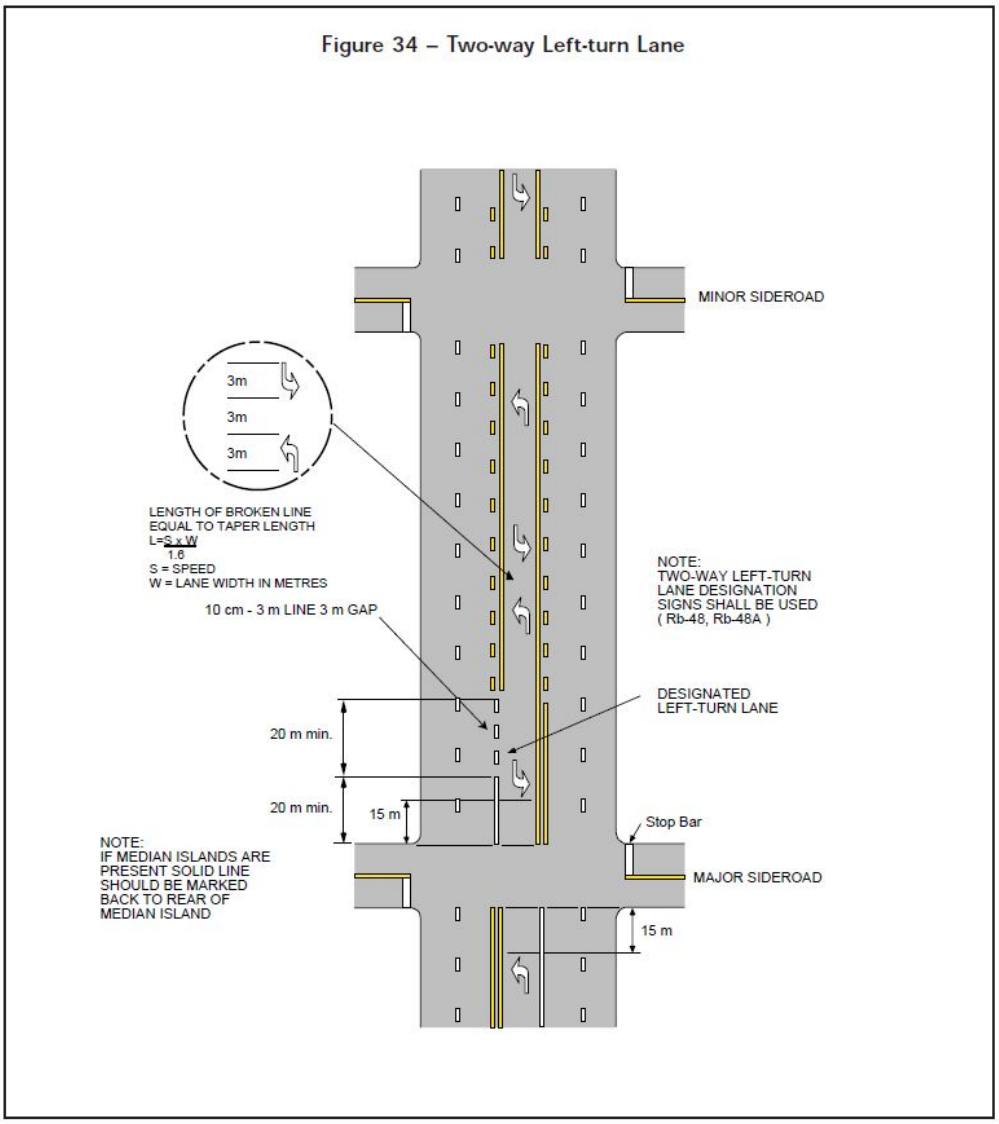

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Table 3 provides a summary of the designated left-turn lane requirements for the urban section of Highway 148 based on the OTM Book 11 guidelines.

Table 3: Designated left-turn lane requirements—OTM Book 11

INTERSECTION	APPROACH	QUEUE LENGTH[1]		STORAGE LENGTH	POSTED SPEED	DESIGN SPEED	ADDITIONAL LENGTH
		AM	PM				
Angus Campbell Drive	WBL	8 m	7 m	20 m	50 km/h	70 km/h	175 m
Walmart Access	WBL	17 m	15 m	20 m	50 km/h	70 km/h	175 m
Robinson Lane	WBL	21 m	7 m	25 m	60 km/h	80 km/h	200 m
Drive In Road	EBL	2 m	2 m	20 m	60 km/h	80 km/h	200 m

1. Projected 95th percentile queues at 2034 horizon year.

Table 4 indicates the effective length of TWLTL that can be achieved between the major intersections considering the standard designated left-turn lane requirements above.

Table 4: Effective Length of TWLTL—OTM Book 11

SECTION	DISTANCE (Stop-bar to Stop-bar)	DESIGNATED LT LANE LENGTH	TWLTL LENGTH	TOTAL ACCESS DRIVEWAYS	ACCESS DRIVEWAYS IN TWLTL SECTION
Angus Campbell to Walmart Access	543 m	195 m	348 m	16	7
Walmart Access to Robinson Lane	437 m	195 m	242 m	17	11
Robinson Lane to Drive In Road	348 m	225 m + 220 m	-97 m	17	Unable to provide TWLTL

The effective length of TWLTL that can be achieved between the major intersections is significantly reduced by the requirement to provide designated left-turn lanes at the approaches to these intersections. With this arrangement, only 7 (or 44%) of the 16 driveways in the section between Angus Campbell Drive and the Walmart Access could potentially be served by the TWLTL. Similarly, 11(or 65%) of the 17 driveways in the section between the Walmart Access and Robinson Lane could be effectively served by the TWLTL. For the section between Robinson lane and Drive In Road, there is insufficient distance between the intersections to effectively provide both designated left-turn lanes and the TWLTL. The additional length requirement specified in the OTM would appear to be excessive in this case given the increasingly urban nature of this section of Highway 148.

Given the constraints related to intersection spacing and access needs along this section of the corridor, consideration should be given to reducing the designated left-turn lane length requirements at the major intersections in order to maximize the effectiveness of the TWLTL. The deceleration length for left-turning vehicles in this case is different from the approach taper requirements for conventional auxiliary left–turn lanes where the approach taper is typically used to shift the through lanes laterally to the right to provide width for the left-turn lane. Therefore, it is recommended that the length of the designated left-turn lanes be comprised of the required storage length plus the estimated braking distance for the design speed. For a design speed of 70 km/h, the calculated braking distance on wet pavements is 60 m (Table C2-1 MTO Design Standards).

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Table 5 provides the proposed reduced requirements for designated left-turn lanes at the major intersections based on the above.

Table 5: Effective Length of TWLTL—Reduced Designated Left-Turn Lane Design

SECTION	DISTANCE (Stop-bar to Stop-bar)	DESIGNATED LT LANE LENGTH	TWLTL LENGTH	TOTAL ACCESS DRIVEWAYS	ACCESS DRIVEWAYS IN TWLTL SECTION
Angus Campbell to Walmart Access	543 m	80 m	463 m	16	11
Walmart Access to Robinson Lane	437 m	80 m	357 m	17	15
Robinson Lane to Drive In Road	348 m	85 m + 80 m	183 m	17	8

With the adjusted design requirements, the effective length of the TWLTL is increased to allow 11 (69%) of the 16 total driveways between Angus Campbell Drive and the Walmart Access, 15 (88%) of the 17 driveways between the Walmart Access and Robinson Lane, and 8 (47%) of the 17 driveways between Robinson Lane and Drive In Road, to be served by the TWLTL.

Conclusions and Recommendations

From a traffic operations and safety perspective, a TWLTL is recommended as an appropriate and justifiable measure to accommodate access to the numerous driveways along the section of Highway 148 between Angus Campbell Drive and Drive In Road, for the following reasons:

- Existing ADT of 11,000 vehicles is within the generally accepted range of 3,000 to 14,000 vehicles for TWLTL.
- Existing access density of 38 access connections per km meets the criteria of 20–55 total access connections per km.
- It will reduce the frequency of collisions involving left-turning vehicles, particularly rear-end collisions.
- It will improve the operational efficiency of the corridor by reducing delays caused by left-turning vehicles in the through lanes.
- It provides continuity with the existing section of TWLTL provided along Pembroke Road East.

A TWLTL is not recommended between Drive In Road and Dairy Road due to the high operating speeds along this section of the highway.

The TWLTL between Angus Campbell Drive and Drive In Road should be designed to be 4.0 m wide and delineated according to the layout indicated in OTM Book 11. Given the constraints along the corridor and in order to maximize the effectiveness of the TWLTL, it is recommended that designated left-turn lanes at intersections be designed to accommodate the vehicle storage length plus the required braking distance for the design speed. In this regard, consideration should be given to reducing the 60 km/h posted speed limit to 50 km/h in the section from Drive In Road to just west of Robinson Lane.

It should be noted that from an access management perspective, TWLTLs increase rather than control access possibilities. As such, a TWLTL should be considered as an interim measure to

accommodate the many access driveways along the corridor today. As new developments are proposed there will be opportunities to introduce access management measures in line with the MTO Access Management Guidelines. The ongoing need for TWLTLs will have to be reviewed in relation to future development applications. There is the potential for sections of the TWLTL to be converted to designated left-turn configuration if deemed appropriate.

References

1. Ministry of Transportation of Ontario (MTO). *Geometric Design Guide for Ontario Highways*. Ontario: MTO, 1985.
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3. Texas Transportation Institute. *NCHRP Web-Only Document 193: Development of Left-Turn Lane Warrants for Unsignalized Intersections*. Texas: NCHRP, 2010.
4. Illinois Department of Transportation. *Bureau of Design and Environment Manual*. Illinois: Illinois DOT, 2015.
5. Harwood, D. W. and Hoban, C. J. *Low-Cost Methods for Improving Traffic Operations on Two-Lane Roads*. Virginia: Federal Highway Administration (FHWA), 1987.
6. Federal Highway Administration (FHWA). *Safety Evaluation of Installing Center Two-Way Left-Turn Lanes on Two-Lane Roads*. Washington, DC: FHWA, 2008.

Appendix B4 – Drive In Road Intersection Review (Interim Report)

Ontario

Interim Report
4013-0034

Highway 148 and Drive In Road Intersection Review

IBI

Prepared for MTO Eastern Region
by IBI Group
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1 Introduction

This report provides a summary of the review of the Highway 148/Drive In Road intersection undertaken as part of the Highway 148 Preliminary Design and Class Environmental Assessment (EA) Study.

Highway 148 is a two-lane provincial King's highway that connects the City of Pembroke with the Ontario-Quebec provincial border. Highway 148 is considered an east-west highway by MTO and so for the purpose of the EA Study, the Highway 148 approaches at intersections are referred to as east and west while side streets are considered north-south. The western terminus of the highway is located approximately 160 m to the west of Angus Campbell Drive at the City of Pembroke boundary, while the eastern terminus is at the Ontario-Quebec provincial border. The highway is separated into two distinct sections:

1. The 1.8 km long section between Greenwood Road (Renfrew County Road 40) and the interprovincial border, which is generally rural in nature and has a posted speed limit of 80 km/h and Annual Average Daily Traffic (AADT) of 5,500 vehicles.
2. The 3.2 km section from Greenwood Road to Angus Campbell Drive, which transitions from a rural to an urban cross-section on the approach to the Pembroke boundary. This section of the highway has an AADT of 11,000 vehicles and is characterized by increased commercial activity and numerous entrances onto the highway from private residential and commercial properties. The posted speed limit is reduced from 80 km/h to 60 km/h between Renfrew County Road 40 and Drive In Road (Renfrew County Road 29).

Drive In Road is a two-lane road which intersects with Highway 148 at a location approximately 1.6 km west of the Highway 148/County Road 40 intersection. The intersection is indicated on Exhibit 1 below. The section of Drive In Road to the south of Highway 148 has a posted speed limit of 60 km/h and forms part of Renfrew County Road 29 with MacKay Street and Town Line Road. The section of Drive In Road to the north of Highway 148 is a local municipal road which connects to Burns Drive—a residential street which runs roughly parallel to the banks of the Ottawa River.

The Highway 148/Drive In Road intersection is currently unsignalized with stop control on the Drive In Road approaches. An auxiliary left-turn lane on the westbound approach and a right-turn lane on the eastbound approach are provided at the intersection.

MTO has received complaints from the public and local municipalities in recent years regarding delays and safety concerns at the intersection, particularly for vehicles attempting to enter the intersection from the south on Drive In Road.

The review has sought to achieve the following objectives:

- To develop and evaluate traffic control options for the intersection;
- select the preferred form of traffic control; and
- determine the property requirements to support future modifications at the intersection.

Exhibit 1: Key Plan

2 Collision Records

Collision records for the Highway 148/Drive In Road intersection have been reviewed for the six-year period from January 7, 2007 to December 31, 2012. During this period there were two reported collisions at the intersection. Of these collisions, one involved a left-turning vehicle (westbound-Highway 148) failing to yield which resulted in injuries. The other was a rear-end collision (westbound on Highway 148) involving three vehicles which resulted in property damage only.

Details of the collision records are provided in Appendix A.

3 Traffic Volumes

3.1 Existing (2015) Traffic

Existing peak hour traffic volumes at the Highway 148/Drive In Road intersection have been based on turning movement count (TMC) volumes recorded at the intersection on August 14, 2012. Representative 2015 traffic volumes have been derived by first applying a 1% annual traffic growth rate to the peak hour volumes recorded in 2012. The 1% growth rate was established by MTO staff for use in this study through a review of historic automatic traffic recorder data for the corridor. The traffic volumes were then adjusted based on a 2015 TMC recorded at Robinson Lane to account for additional traffic generated by the nearby Laurentian Square commercial development, which was built after the 2012 count was conducted.

Exhibit 2 presents the existing (2015) traffic volumes for the weekday morning and afternoon peak hours.

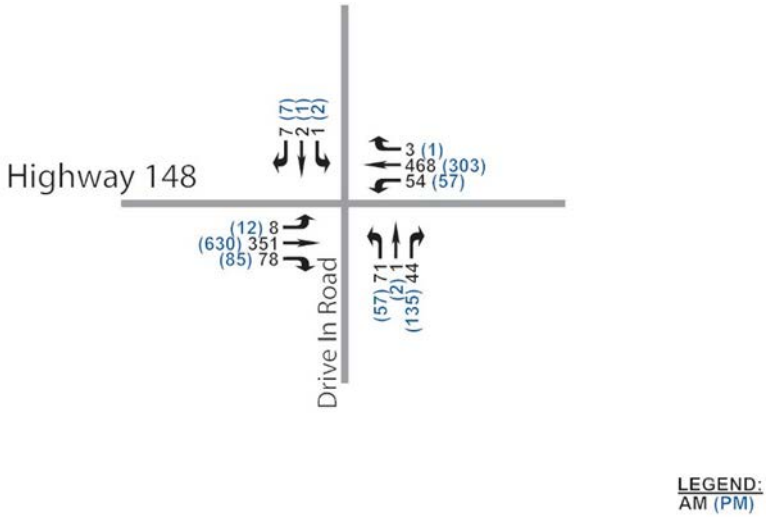


Exhibit 2: Existing (2015) Traffic

A copy of the 2012 TMC is provided in **Appendix B**.

3.2 Future (2035) Traffic

Future traffic volumes at the Highway 148/Drive In Road intersection have been derived for the 2035 study horizon year by the application of the 1% annual traffic growth rate to the 2015 traffic volumes indicated above.

Exhibit 3 presents the future (2035) traffic volumes for the weekday morning and afternoon peak hours.

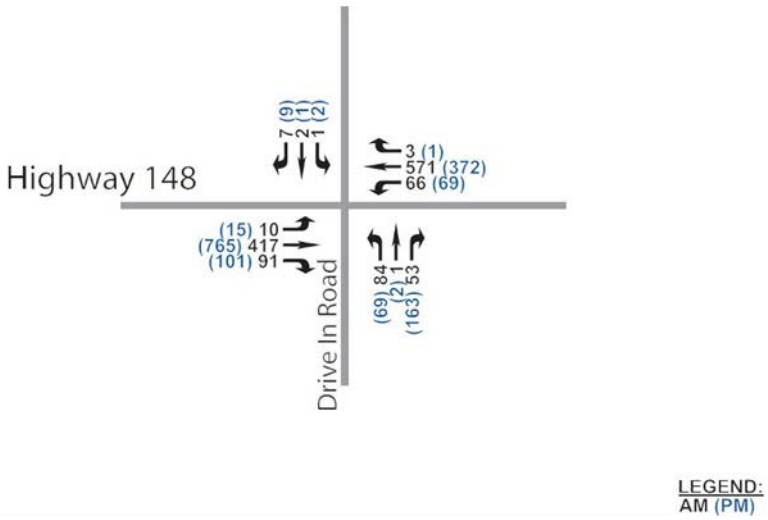


Exhibit 3: Future (2035) Traffic

4 Traffic Control Review

4.1 Traffic Control Alternatives

The following traffic control options have been proposed for consideration at the intersection:

- Option 1: Do Nothing (i.e. Two-Way Stop Control)
- Option 2: All-Way Stop Control
- Option 3a: Traffic Signals—Existing lane configuration
- Option 3b: Traffic Signals—Auxiliary left-turn lanes on all approaches
- Option 3c: Traffic Signals—Auxiliary right-turn lane on northbound approach
- Option 4: Roundabout

The analysis of the intersection with traffic signals has considered three options for the lane configurations (Options 3a–3c) as indicated in Exhibit 4 below.

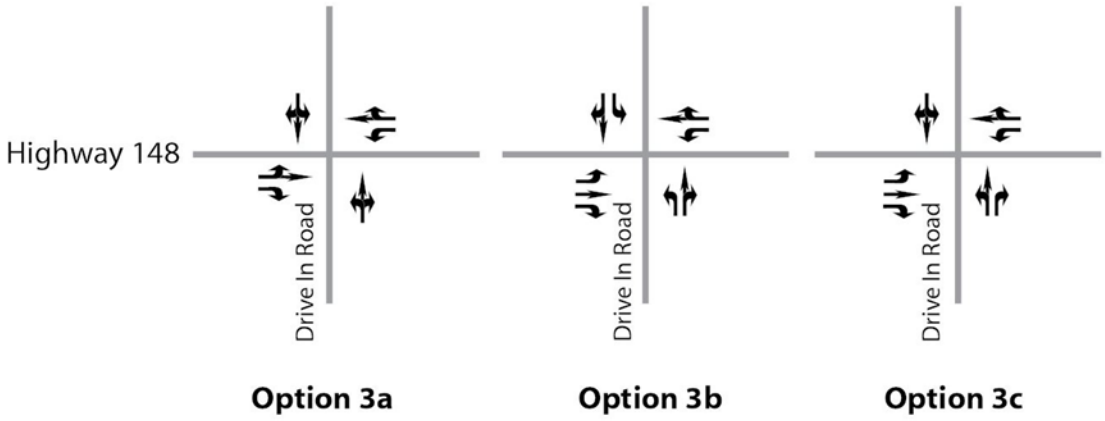


Exhibit 4: Signalized Intersection Lane Configuration Options

The analysis of the roundabout option has considered a single-lane roundabout. A conceptual plan of the roundabout is indicated on Exhibit 5.

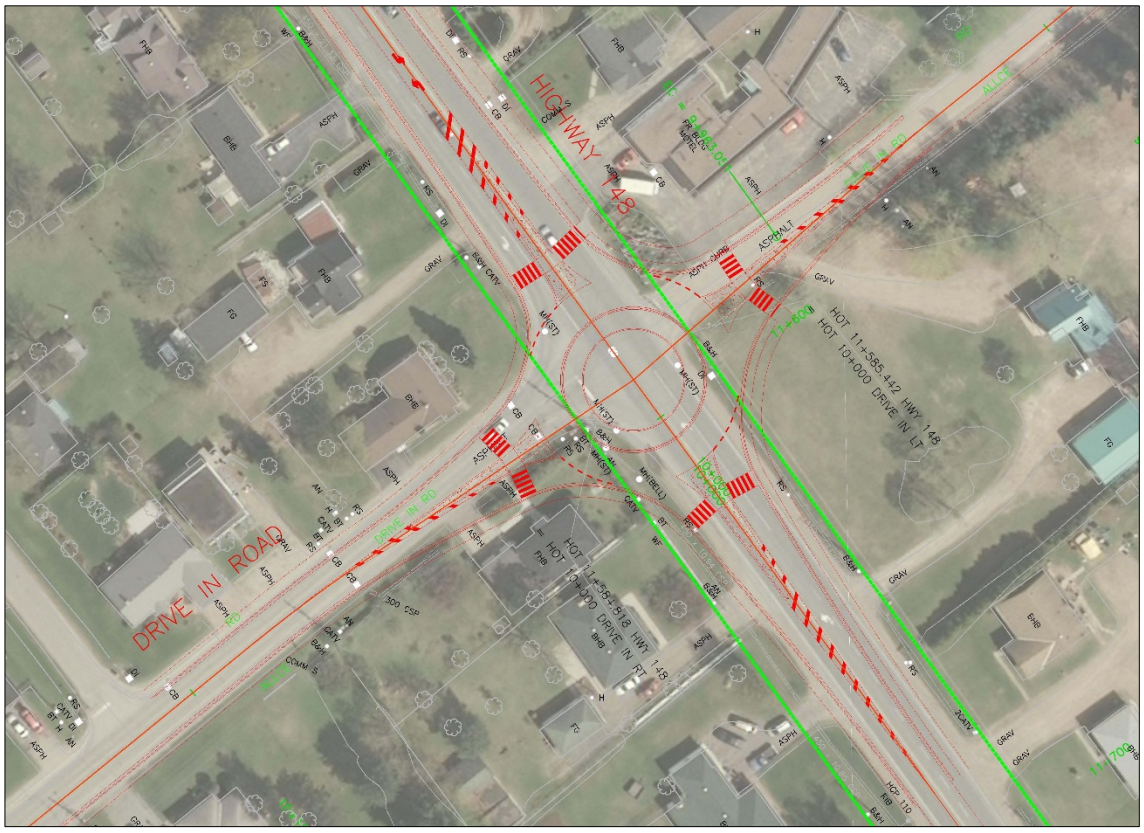


Exhibit 5: Conceptual Design of Roundabout Option

4.2 Intersection Capacity Analysis

Intersection capacity analysis of the Highway 148/Drive In Road intersection has been undertaken for the options listed above. The analysis has been based on the Highway Capacity Manual (HCM) methodology using Synchro Version 9 Software for the stop control and traffic signals options and SIDRA Version 6 software for the roundabout option.

The results of the intersection capacity analysis are summarized in **Table 1**.

Table 1: Intersection Capacity Analysis

TRAFFIC CONDITION	OPTION/ TRAFFIC CONTROL	PEAK HOUR	AVERAGE DELAY (s)	OVERALL LOS	CRITICAL MOVEMENT				
					MOVEMENT	DELAY (s)	LOS	V/C RATIO	95TH QUEUE (m)
2015 Traffic	Option 1 – TWSC	AM	3.6	-	-	-	-	-	-
		PM	7.0	-	NB	42.0	E	0.70	34.1
	Option 2 – AWSC	AM	16.7	C	-	-	-	-	-
		PM	35.5	E	EBTL	58.7	F	1.00	-
	Option 3a – Signals (Ex.Config.)	AM	6.4	A	-	-	-	-	-
		PM	8.2	A	EBTL	7.7	A	0.65	#69.0
	Option 3b – Signals (Auxiliary LT Lanes)	AM	6.1	A	-	-	-	-	-
		PM	7.6	A	-	-	-	-	-
	Option 3c – Signals (Auxiliary RT lane)	AM	6.2	A	-	-	-	-	-
		PM	7.6	A	-	-	-	-	-
	Option 4 – Roundabout	AM	9.7	A	-	-	-	-	-
		PM	14.4	B	-	-	-	-	-
2035 Traffic	Option 1 – TWSC	AM	6.7	-	NBL	56.7	F	0.71	31.8
		PM	41.5	-	NBL	271.9	F	1.43	106.8
	Option 2 – AWSC	AM	31.8	D	WB	46.0	E	-	-
		PM	38.3	E	EBTL	60.6	F	-	-
	Option 3a – Signals (Ex.Config.)	AM	7.4	A	-	-	-	-	-
		PM	11.1	B	EBTL	11.9	B	0.77	#126.1
	Option 3b – Signals (Auxiliary LT Lanes)	AM	6.6	A	-	-	-	-	-
		PM	8.8	A	EBT	8.4	A	0.71	#90.0
	Option 3c – Signals (Auxiliary RT lane)	AM	7.2	A	-	-	-	-	-
		PM	8.8	A	EBT	8.4	A	0.71	#89.2
	Option 4 – Roundabout	AM	12.7	B	-	-	-	-	-
		PM	26.6	D	EB	37.2	E	0.95	177.9

The results of the intersection capacity analysis indicate that the northbound approach on Drive In Road is currently operating at Level of Service (LOS) D during the morning peak hour and at LOS E during the afternoon peak hour. The operating condition at the intersection would deteriorate to LOS F during both peak hours under 2035 traffic conditions with the “Do Nothing” scenario (Option 1).

With All-Way Stop Control in place (Option 2), the intersection would operate at an overall LOS E during the afternoon peak hour under both existing and 2035 traffic conditions. The critical movement during the afternoon peak hour is the eastbound approach which would operate above capacity (LOS F).

Introducing traffic control signals at the intersection will significantly improve the operating condition of the intersection for all of the lane configurations considered (Options 3a – 3c) with Option 3c resulting in the shortest projected queue length on the eastbound approach.

A single-lane roundabout (Option 4) at the intersection would operate at acceptable levels of service for the overall intersection during both peak hours, but the eastbound approach would operate at LOS E in the afternoon peak hour at the 2035 horizon year, resulting in a significant queue length (177 m on the eastbound approach).

Detailed output for Synchro and SIDRA of the intersection capacity analysis is provided in Appendix C.

4.3 Traffic Control Signal Warrants

An analysis of traffic control signal justification has been carried out for the Highway 148/Drive In Road intersection using the eight-hour TMC data recorded in 2012. The analysis has followed the justification methodology prescribed in the Ontario Traffic Manual, Book 12 (March 2012) and has been conducted for both restricted flow and free flow traffic conditions, given that the intersection is located at the fringe between rural and urban conditions along Highway 148.

The results of the analysis are summarized in Table 2 below.

Table 2: Traffic Control Signal Warrants – Results

JUSTIFICATION		URBAN (RESTRICTED FLOW)			RURAL (FREE FLOW)		
		COMPLIANCE	SIGNAL JUSTIFIED?		COMPLIANCE	SIGNAL JUSTIFIED?	
			YES	NO		YES	NO
1. Minimum Vehicular Volume	Total Volume	100%		✓	100%		✓
	Crossing Volume	78%			93%		
2. Delay to Cross Traffic	Main Road	99%		✓	100%		✓
	Crossing Road	77%			99%		
3. Combination	Justification 1	78%		✓	93%	✓	
	Justification 2	77%			99%		
5. Collision Experience		13%		✓	13%		✓

The results of the traffic control signal warrants analysis indicate the following:

- If considered free flow (rural) conditions, Justification1 is satisfied to 93% and Justification 2 is satisfied to 99%. Therefore, traffic signals are warranted based on Justification 3—the Combination warrant—which is met if both Justification 1 and Justification 2 are satisfied to 80% or more. Traffic signals are also warranted based on Justification 4, the warrant for four-hour vehicle volumes.
- If considered restricted flow (urban) conditions, Justification 1 is satisfied to 78% and Justification 2 is satisfied to 77%, which falls just below the requirements to satisfy Justification 3, but meets the requirements of Justification 4 to 100%.This suggests that the intersection can be expected to meet the minimum signal warrants for restricted flow conditions under Justification 3 in the near future.

Details of the traffic Signal Warrants analysis are provided in Appendix D.

4.4 All-Way Traffic Control Warrants

An analysis of all-way stop control (AWSC) justification has been carried out based on the warrants procedure in the Ontario Traffic Manual – Book 5.

The OTM Book 5 justification procedure for AWSC consists of a traffic volume warrant and a warrant based on collision history.

The AWSC volume warrant is based on the following criteria:

All-way stop control may be considered on major roads where the following conditions are met:

- *The total vehicle volume on all intersection approaches exceeds 500 vehicles per hour for each of any eight hours of the day;*
- *The combined vehicular and pedestrian volume on the minor street exceeds 200 units per hour (all vehicles plus pedestrians wishing to enter the intersection) for each of the same eight hours, with an average delay to traffic on the minor street (either vehicles or pedestrians wishing to enter the intersection) of greater than 30 seconds; and*
- *The volume split does not exceed 70/30. Volume on the major street is defined as vehicles only. Volume on the minor street includes all vehicles plus any pedestrians wishing to cross the major roadway.*

The AWSC volume warrant was checked for existing and projected traffic volumes and indicates the following:

- The total vehicle volume on all intersection approaches exceeds 500 vehicles per hour for the eight hours of data reviewed;
- The combined vehicular and pedestrian volume on minor streets does not exceed 200 units per hour in most cases; and
- The volume split exceeds 70/30 for all hours. Over 85% of all traffic passing through the intersection travels along the major street.

Based on the volumes criteria, all-way stop control at the Drive-in Road intersection is not warranted.

The AWSC collision warrant is defined as follows:

For the purposes of this warrant, a high accident frequency is an average of four collisions per year over a three-year period. Only those accidents susceptible to relief through multi-way stop control must be considered (i.e., right angle and turning type collisions). Included in this warrant are those locations where visibility problems exist which limit the safe approach speed to less than 15 km/h, thereby creating an unreasonable accident potential. Special advance warning or overhead flashing lights may be necessary to augment the control if vertical or horizontal alignment is a factor.

Historical collision records for the five-year period between January 1, 2007 and December 31, 2011 were reviewed and indicate that there were only two recorded collisions at the intersection, both of which occurred in 2009. The two collisions consisted of a rear-end collision and a turning collision. Based on the above, all-way stop control is not warranted.

4.5 Evaluation of Traffic Control Alternatives

An evaluation of the four major alternatives for traffic control was carried out based on the results of the analysis. A summary of the evaluation is provided in Table 3 below.

Table 3: Evaluation of Traffic Control Alternatives

TRAFFIC CONTROL ALTERNATIVE / DISCUSSION	RECOMMENDATION
1. Do Nothing The Drive In Road intersection is currently operating at close to its theoretical capacity during the afternoon peak hour and the Ministry's minimum warrants for traffic signals are met. Maintaining the existing configuration and intersection control would result in significant delays to side street traffic with the anticipated growth in traffic along the corridor.	Not carried forward.
2. All-Way Stop Control Introducing AWSC would result in a worsening of the overall operating condition of the intersection with increased average vehicular delays. In addition, the minimum warrants for AWSC are not met based on collision history or existing and projected traffic volumes. AWSC is also not recommended on roads with multi-lane approaches where a stopped vehicle on the right will obscure the stop sign. Furthermore, AWSC intersections are not typically encountered on provincial King's Highways. As such, drivers not familiar with the area would not expect to encounter this type of traffic control on Highway 148 which could lead to non-compliance at the stop signs.	Not carried forward.
3. Traffic Control Signals Traffic signals are justified at the intersection based on the Ministry's minimum warrants. The intersection is projected to continue to operate at acceptable levels of service at the 2034 horizon year of the study with traffic signals in place. Option 3c is the preferred lane configuration for the signalized intersection. An auxiliary left-turn lane is recommended on the eastbound approach to the intersection to oppose the existing westbound left-turn lane. An auxiliary right-turn lane is proposed on the northbound approach which will require widening along the east side of Drive In Road. This widening can be accommodated within the Ministry-owned property at 127 Drive In Road. Some additional property will be required on the other three corners to accommodate traffic signal plant and to provide adequate daylight triangles.	**Carried forward.**
4. Roundabout A single-lane roundabout would operate at an overall acceptable level of service at the study horizon year but would result in an increase in delays to traffic on the Highway 148 approaches to the intersection. A larger area of property would be required on the northeast and northwest quadrants of the intersections than what would be required for traffic signals. The existing grade of the southbound approach to the intersection is 10%. Roundabouts are generally not recommended on crest vertical curves with approach roadways that have grades steeper than 4%, as a driver's sightline may be compromised. In addition, a roundabout at this location may create driver-expectancy issues as the other major intersections in the urban section are signalized.	Not carried forward

Based on the evaluation undertaken, traffic control signals is the recommended traffic control alternative for the Drive In Road intersection.

5 Intersection Design

5.1 Drive in Road – South Approach

The existing intersection is significantly constrained by adjacent properties and utilities. The requirement for daylighting triangles at the intersection in conjunction with signalization will impact properties adjacent to the intersection, particularly on the south leg of the intersection. To assess the potential impacts on the south approach, the following design options were considered:

- **Option A** – Hold the existing centreline and widen the approach on Drive-In Road to accommodate a shared through-left lane and an auxiliary right-turn lane on the south approach.
- **Option B** – Hold the north curb line on Drive In Road and shift the centreline approximately 1.625 m east and widen the approach to accommodate a shared through-left lane and an auxiliary right-turn lane.
- **Option C** – Shift the centreline by a minimum of 3.0 m south, thereby increasing the boulevard width on the west side and widen the approach to accommodate a shared through-left lane and an auxiliary right-turn lane.

Option A includes efforts to maintain House #127 (on the east side) but would require buy-out of House #128 on the west side.

Option B is intended to reduce impacts to properties on the west side by holding the existing west curb line while still providing for a two lane approach. Widening would occur on the east side limiting the impact to the House #127 property which is now owned by MTO.

Option C recognizes House #127 as a buy-out and shifts the centreline further to the east to minimize impacts to properties to the west. Given that neighbouring properties on the east side are set further back from the existing ROW, this option can be more easily accommodated.

Table 4 provides a summary of the evaluation of the three options with discussion on the potential impacts.

Option B has been carried forward as the preferred option for the design of the northbound approach to the intersection as it provides sufficient pavement width to accommodate the recommended lane configuration while minimizing the impact to House #128 on the west side of Drive In Road and allowing for House # 127 tor remain if required.

A preliminary plan of the signalized intersection is indicated on **Exhibit 6** below.

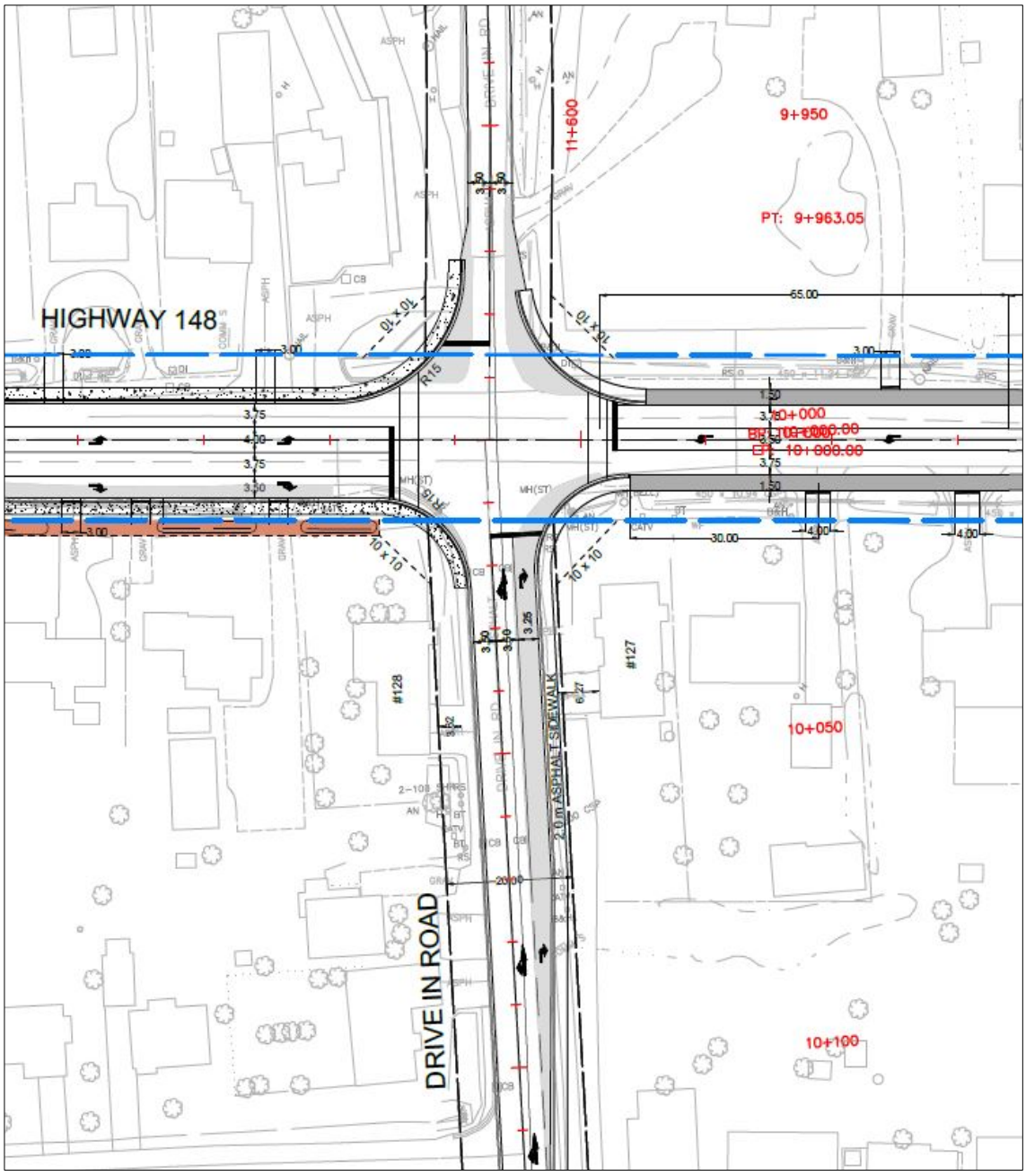


Exhibit 6: Functional Design of Highway 148/Drive In Road Intersection

Table 4: Evaluation of Design Alternatives – South Approach

OPTION	DISCUSSION REGARDING PROPERTY IMPACTS	RECOMMENDATION
Existing Conditions *(For Information purposes only)*	• Existing Drive-In Road (CR 29) ROW width = 20 m • Existing 6.5 m pavement (excluding mountable curb) • House #128 (west side) is located 1 m beyond ROW limit; offset approx. 5 m beyond asphalt sidewalk. • House #127 (east side) is located 6 m beyond ROW Limit; offset approx. 10.5 m beyond asphalt sidewalk. • Distance between houses = approx. 27 m	N/A
Option A - Hold existing centreline and widen approach on Drive-In Road to 2 lanes	• Provide 10.25m pavement width (add exclusive northbound right turn lane on Drive-In Road) • Requires buy-out of House #128 on west side (offset reduced from 5 m to 2.9 m; insufficient to accommodate parked vehicle in front of garage). • Maintain House #127 on east side (offset reduced from 10.5 m to 7.9 m) and property significantly impacted given 10 m x 10 m daylighting requirement and tree loss along Highway 148 and Drive-In Road. • Maintain existing hydro line on east side of Drive-In Road but modify at intersection to accommodate pavement widening and traffic signal poles	• **Not Carried Forward** • Requires removal of both Houses #127 and #128
Option B - Shift centreline approx.1.875 m east (hold west curb line) and widen approach on Drive-In Road to 2 lanes	• Provide 10.25 m pavement width (add exclusive northbound right turn lane on Drive-In Road • Maintain House #128 on west side. Hold existing curb line on west side of roadway (i.e. maintain 5 m offset from sidewalk to face of bldg, House #128). • Maintain House #127 on east side (offset reduced from 10.5 m to 6.3 m); however significantly impacted with10 m x 10 m daylighting and tree loss/ clearing. • Maintain hydro line on east side of Drive-In Road within easement beyond ROW.	• **Carry Forward**
Option C - Shift centreline minimum 2.875 m east (increase boulevard on west side) and widen approach on Drive-In Road to 2 lanes	• Provide 10.25 m pavement width (add exclusive northbound right turn lane on Drive-In Road) • Maintain House #128 on west side. Shift the west curb line easterly, increasing the offset to the building from 5 m to minimum 6 m to accommodate vehicle parking). • Offset to House #127 reduced from 10.5 m to 5.75 m • Hydro line on east side of Drive-In Road requires relocation	• **Not Carried Forward** • Requires removal of House #127

5.2 Drive In Road – North Approach

The section of Drive In Road north of Highway 148 is classified as a local road and provides a connection to Burns Drive, a private roadway serving the single family residences to the north. Peak hour traffic volumes are low, with less than 25 vehicles (two-way) travelling along the roadway during the weekday peak hours. This corresponds to an AADT of less than 400 vehicles.

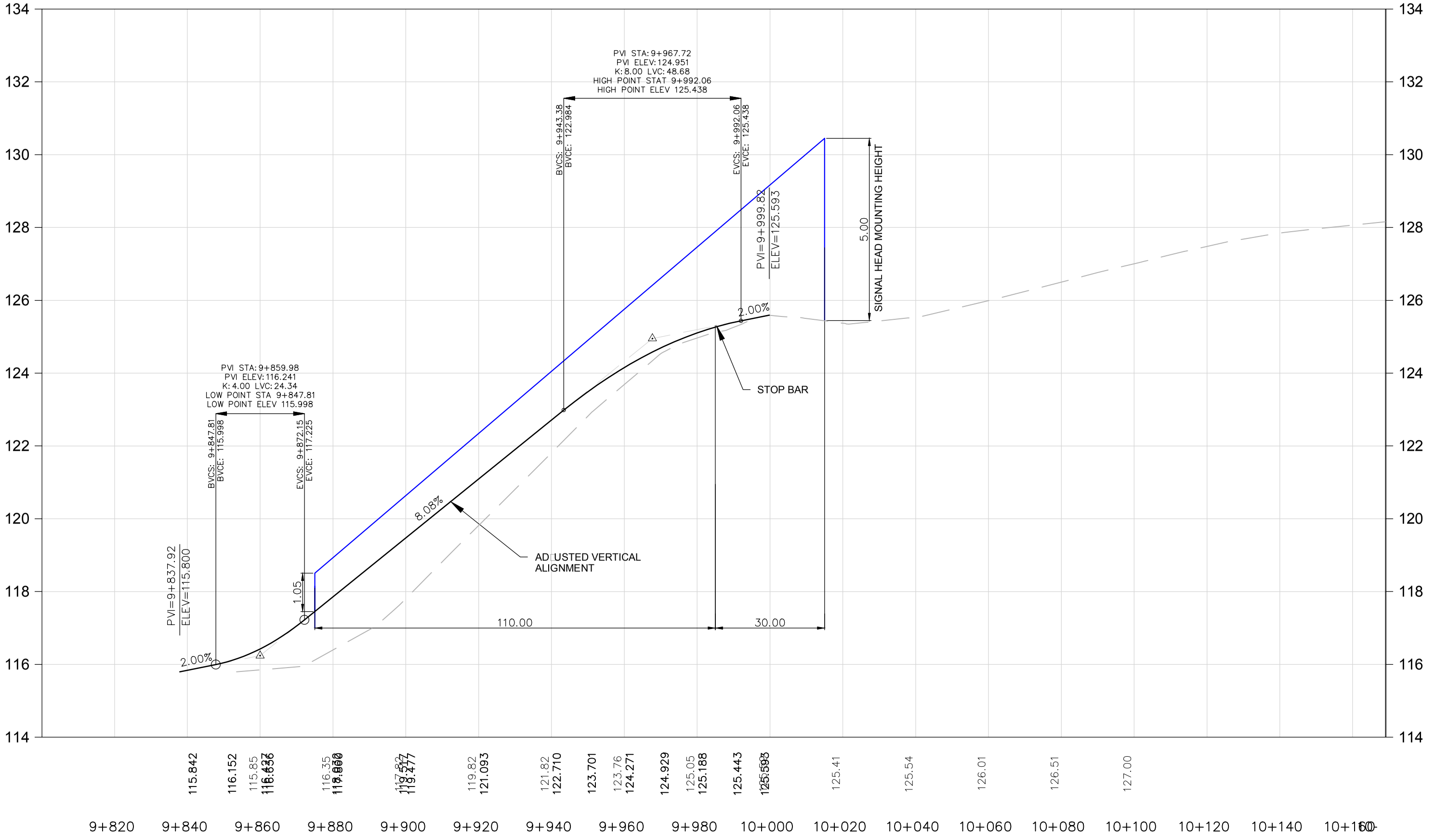
The north approach to the highway has an existing upgrade of 10% which is considered acceptable for the class of roadway and the volume of traffic it accommodates.

As indicated on Exhibit 5 above, the vertical alignment of the approach to Highway 148 includes a crest curve with an approximate K value of 5, which corresponds to a design speed of approximately 42 km/h.

The feasibility of adjusting the grade of the north approach was reviewed and it has been determined that the grade could be reduced to 8% without significantly impacting the elevations of the CPR corridor or Burns Drive to the north. This adjustment to the vertical alignment also allows for an improved K value of 8 for the crest curve on the approach to the Highway 148 which corresponds to a design speed of 50 km/h. However, raising the profile of Drive In Road at this location will result in impacts to adjacent properties as the cross-section is modified. **Exhibit 7** presents details of the adjusted profile of the modified approach. **Exhibit 8** indicates the approximate limits of excavation and potential property impacts of the modified approach.

Based on the review above, an adjustment of the existing vertical alignment of Drive In Road is not recommended for the following reasons:

- The existing (10%) grade is considered acceptable for the class of roadway and traffic volumes.
- The existing approach would meet the minimum signal visibility distance for a design speed of 60 km/h. (Lower operating speeds are anticipated given the steep upgrade on the approach).
- Adjusting the vertical alignment (to 8%) would only provide a marginal improvement to crest curvature and stopping sight distance—50 km/h design speed from 42 km/h existing.
- In addition to the increased capital cost, the adjustment to the vertical alignment on Drive In Road would result in impacts to property, vegetation and utilities.



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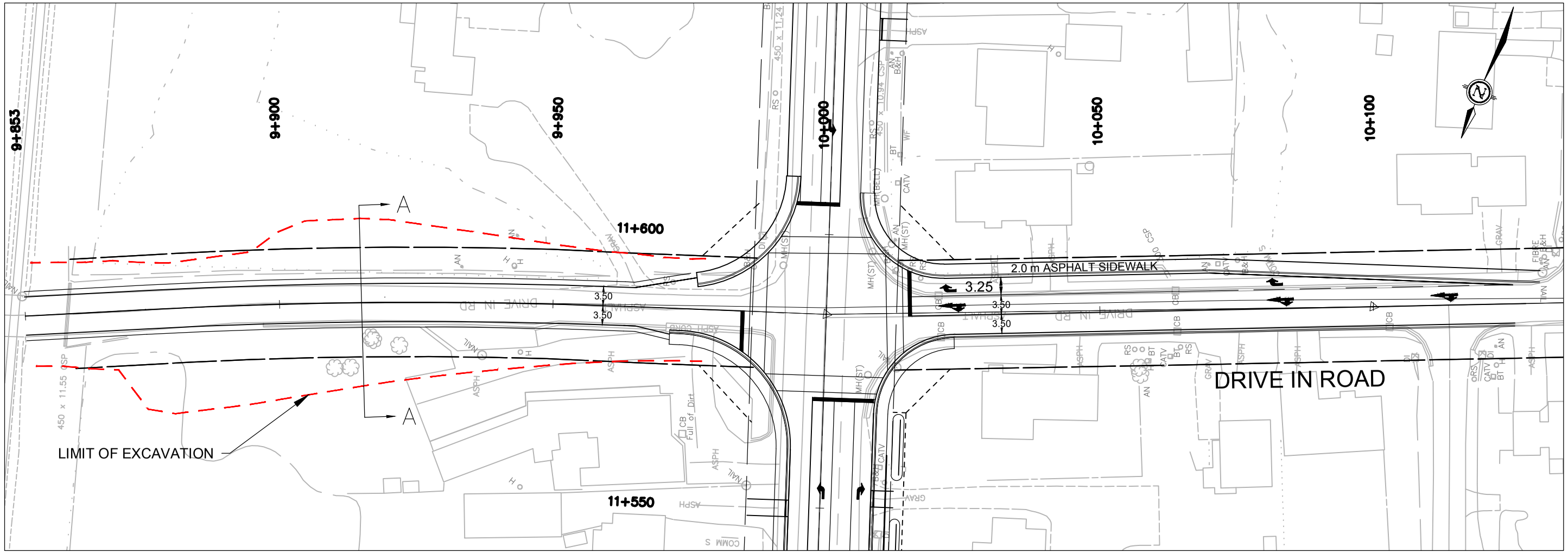
SCALE:
HOR −10m 0 10 20 30m
VER −1m 0 1 2 3m

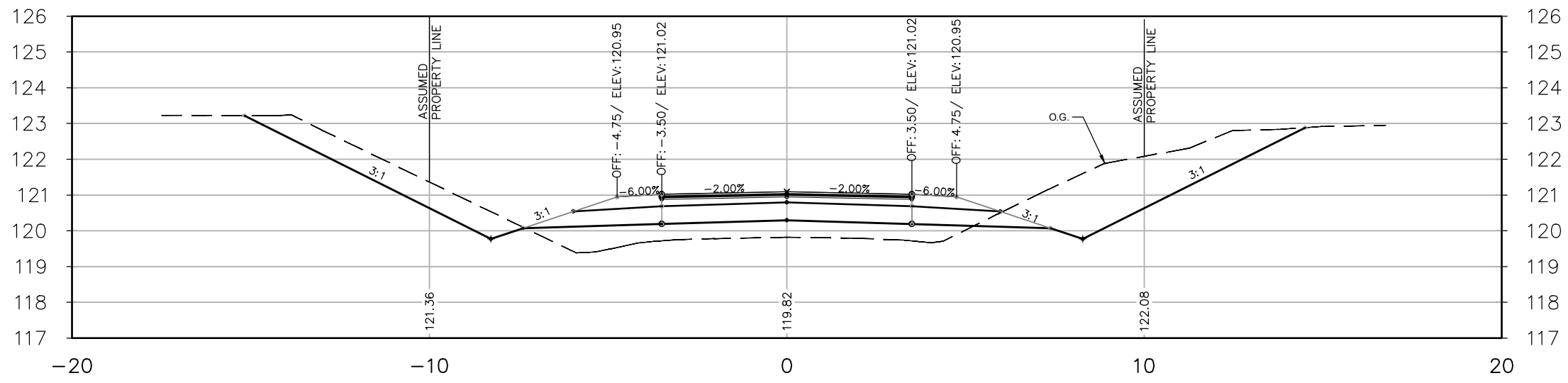
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

HIGHWAY 148 DRIVE IN ROAD INTERSECTION
ADJUSTED VERTICAL ALIGNMENT
NORTH APPROACH

SHEET 7

37432-Hwy148: Hwy17 EA 5.9 Drawing: 59civil layout: 37431-Drive In Signal Sigth.dwg
August 24, 2016





DRIVE IN ROAD TYPICAL SECTION (A-A)

SCALE 1:150

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Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com

Ontario

SCALE:

HOR 0 15 30 Meter

4013-E-0034

HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

HIGHWAY 148 DRIVE IN ROAD INTERSECTION

ADJUSTED VERTICAL ALIGNMENT-NORTH APPROACH PLAN AND CROSS-SECTION

SHEET 8

37432-Hwy148 Hwy17 EA 5.9 Drawing 59civil layout 37431-Drive In Signal Sigth.dwg
August 24, 2016

5.3 Sight Distance Review

A review of sight distances at the signalized intersection has been undertaken based on the standards outlined in the Ontario Traffic Manual (OTM) Book 12 and the Geometric Design Standards for Ontario Highways (GDSOH).

5.3.1 Signal Visibility Distance

Traffic signal heads for the intersection should be positioned to ensure that minimum sight distances are provided on each approach to allow an approaching vehicle sufficient distance to consider the decision to proceed through the intersection or to stop.

In particular, the signal visibility distance was reviewed for the existing 10% grade on the north approach to the intersection on Drive In Road.

The review indicates that the proposed traffic signal will be visible for a minimum distance of 110 m from the stop bar, which satisfies the OTM requirement for an 85th percentile speed of 60 km/h (Table 25). This is considered to be acceptable given that operating speeds are expected to be lower than 60 km/h due to the steep upgrade of the north approach.

Exhibit 9 illustrates the signal visibility distance that can be achieved along Drive In Road on the north approach to the intersection.

5.3.2 Sight Distance and Visibility Triangle

Sight line and property requirements to allow sufficient distance for a driver on the highway to react in case a driver on the side road violates the red signal phase were reviewed. The dimensions of the sight visibility triangles have been derived based on information provided in Figure E3-3 and Table E3-3 of the GDSOH, as follows:

- Highway 148 Design Speed = 80 km/h (60 km/h posted speed limit)
- Highway 148 approach distance, a = 65 m
- Drive In Road Design Speed = 30 km/h (assumed)
- Drive In Road approach distance, b = 25 m

The required visibility triangles for the intersection are indicated on **Exhibit 10**.

5.3.3 Turning Movement Sight Distance

Vehicles at the stop bars on Drive In Road must have sufficient sight distance to approaching vehicles on Highway 148 to allow for safe right turn movements on to the highway during the red signal phase. The sight distance should provide sufficient time for the turning vehicles to attain the assumed operating speed of the highway before being overtaken by an approaching vehicle travelling in the same direction at the design speed.

For a design speed of 80 km/h on Highway 148, the sight distance requirement for right-turns from the Drive In Road approaches is 275 m based on the requirements indicated in Figure E3-6 of the GDSOH. This sight distance requirement can be achieved at the intersection provided that adequate daylighting can be maintained, as indicated on **Exhibit 11**.

PVI STA: 9+972.26
PVI ELEV: 125.044
K: 5.00 LVC: 40.02
HIGH POINT STAT 9+992.27
HIGH POINT ELEV 125.443

BVCS: 9+952.25
BVCE: 123.044

EVCS: 9+992.27
EVCE: 125.443

PVI=10+000.00
ELEV=127.240

PVI=9+999.82
ELEV=125.593

15.50%

1.99%

5.00

SIGNAL HEAD MOUNTING HEIGHT

STOP BAR

PVI STA: 9+882.14
PVI ELEV: 116.034
K: 4.00 LVC: 36.72
LOW POINT STA 9+863.77
LOW POINT ELEV 115.884

BVCS: 9+863.77
BVCE: 115.884

EVCS: 9+900.50
EVCE: 117.870

10.00%

PVI=9+853.49
ELEV=115.800

EXISTING GRADE

1.05

0.82%

110.00

30.00

134 132 130 128 126 124 122 120 118 116 114

115.800	115.85	115.884	116.35	116.445	117.820	119.82	119.819	121.82	121.819	123.044	123.76	123.758	124.644	125.05	125.048	125.443	125.593	125.594	125.526	125.480	125.41	125.414	125.54	125.541	125.675	126.01	126.014	126.51	126.509	127.00	127.005	127.240
9+820	9+840	9+860	9+880	9+900	9+920	9+940	9+960	9+980	10+000	10+020	10+040	10+060	10+080	10+100	10+120	10+140	10+160															

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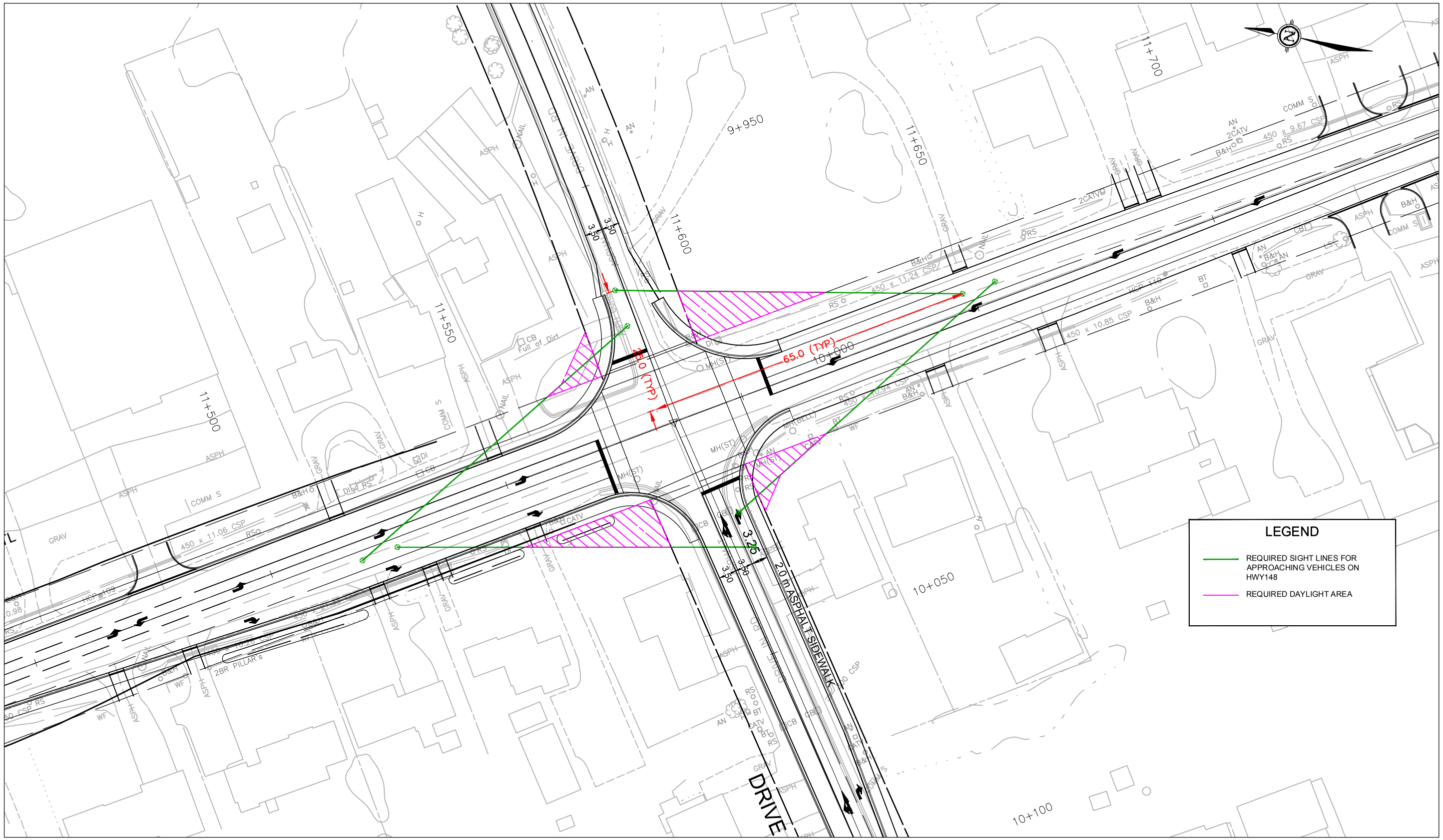
SCALE:
HOR −10m 0 10 20 30m
VER −1m 0 1 2 3m

4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

DRIVE IN ROAD
EXISTING VERTICAL ALIGNMENT
SIGNAL VISIBILITY DISTANCE - NORTH APPROACH

SHEET 9

37432-Hwy148 \Hwy17 EA 5.9 Drawing \58civil layout \37431-Drive In Signal Sigth.dwg
Augu 1 24 2016



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4013-E-0034

HIGHWAY 148

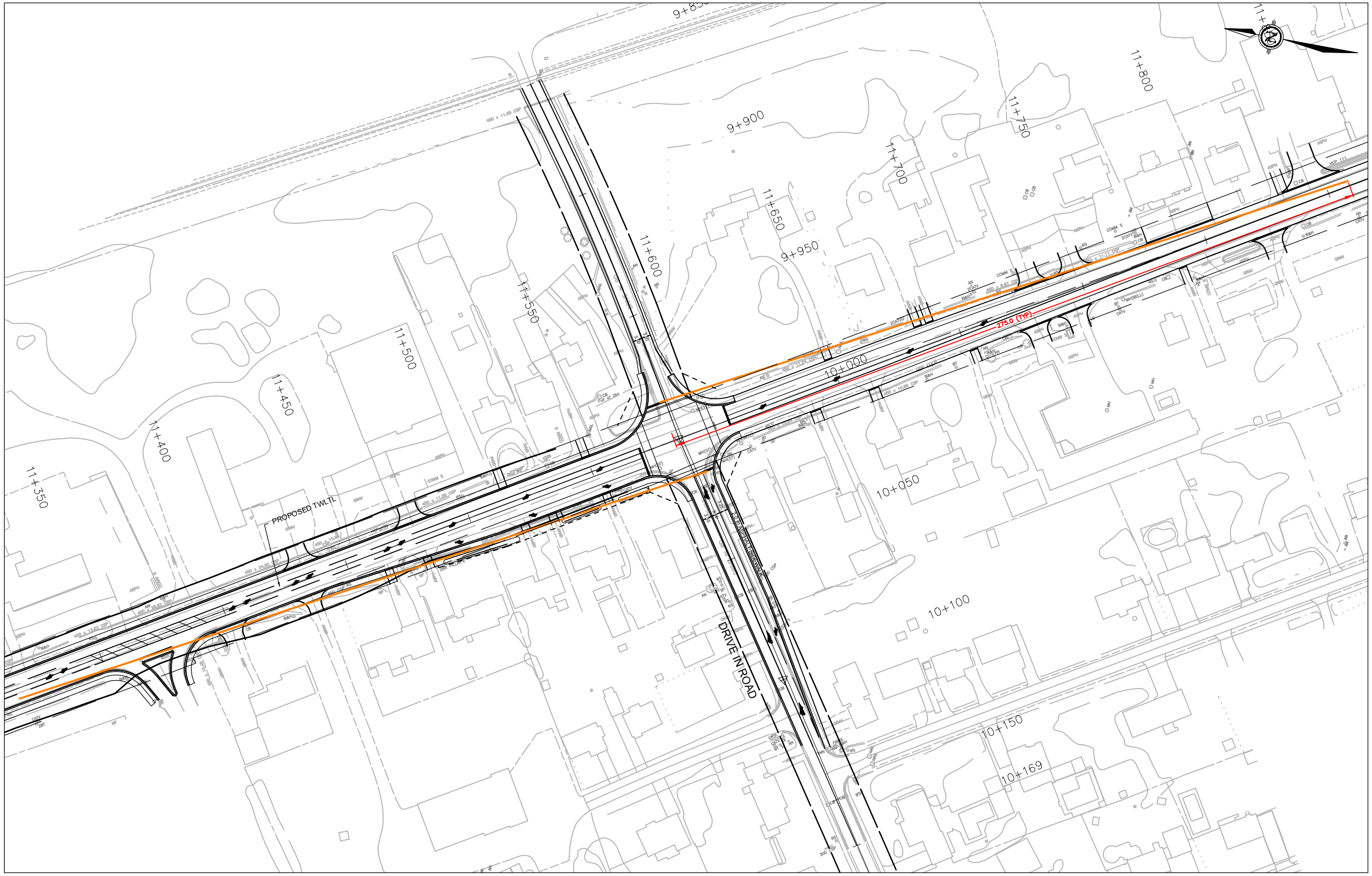
PRELIMINARY DESIGN AND CLASS EA STUDY

HIGHWAY 148 DRIVE IN ROAD INTERSECTION

SIGHT DISTANCES AND VISIBILITY TRIANGLES FOR HWY 148 APPROACHES

SHEET 10

37432-Hwy148 Hwy17 EA 5.9 Drawing\59civil\layout\37431-Drive In Signal Sigth.dwg
August 24, 2016



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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

DRIVE IN ROAD

RIGHT TURN SIGHT DISTANCES

SHEET 11

□37432-Hwy148: Hwy17 EA 5.9 Drawing: 59civil layout: 37431-Drive In Signal Sigth.dwg

Augu 1 24, 2016

6 Conclusions

Based on the above, the main findings and conclusions of the Highway 148/ Drive In Road review are as follows:

- Traffic signals are justified at the Highway 148/Drive In Road intersection based on existing traffic volumes.
- Traffic signals are the preferred traffic control measure for the intersection.
- The following modifications to the intersection are recommended with the introduction of traffic signals:
  - An auxiliary right-turn lane on the northbound approach (south leg) on Drive In Road.
  - An auxiliary left-turn lane on the eastbound approach on Highway 148.
- Widening of Drive In Road to accommodate traffic signals at Highway 148 should hold the west curb line to minimize impacts to the properties on the west side. It is recommended that the centreline on the south leg of the intersection on Drive In Road be shifted approximately 1.875 m to the east and that the approach be widened to 10.25 m to accommodate the auxiliary right-turn lane.
- The required signal visibility distances can be met on the north approach without adjustment to the existing (10%) grade.
- Property acquisition will be required for daylighting triangles to achieve adequate sight distances.

Appendix A – Collision Records

Highway 148 Collisions - LHRS 46250 o/s 0.0 to LHRS 46261 o/s 3.2 January 1st 2007 to December 31st 2012

LHRS	Offset	MFSER	Year	Month	Day	Time	Day of Wk	Light	Env	Rd Surf	Acc Type	Fatal	Class	Veh #	Dir	Location Des	Veh Type	DrMan	DrAct	DrCond	Event 1	Event 2	Event 3
46261	1.6	90481491	2009	7	23	1314	Thu	Daylight	Rain	Wet	Turning	0	PDOnly	1	W	IntSectRel	Passenger Van	Turn Left	Fail to Yield	Normal	Other motor veh.	& -	&--
46261	1.6	90481491	2009	7	23	1314	Thu	Daylight	Rain	Wet	Turning	0	PDOnly	2	W	IntSectRel	Auto+Stn Wagon	Gng Ahead	Driving properly	Normal	Other motor veh.	& -	&--
46261	1.6	90780246	2009	10	10	1510	Sat	Daylight	Clear	Dry	RearEnd	0	Injury	1	W	AtIntSect	Passenger Van	Slwg/Stpg	Following Close	Normal	Other motor veh.	& -	&--
46261	1.6	90780246	2009	10	10	1510	Sat	Daylight	Clear	Dry	RearEnd	0	Injury	2	W	AtIntSect	Auto+Stn Wagon	Slwg/Stpg	Driving properly	Normal	Other motor veh.	& Other motor veh.	&--
46261	1.6	90780246	2009	10	10	1510	Sat	Daylight	Clear	Dry	RearEnd	0	Injury	3	W	AtIntSect	Auto+Stn Wagon	Slwg/Stpg	Driving properly	Normal	Other motor veh.	& -	&--

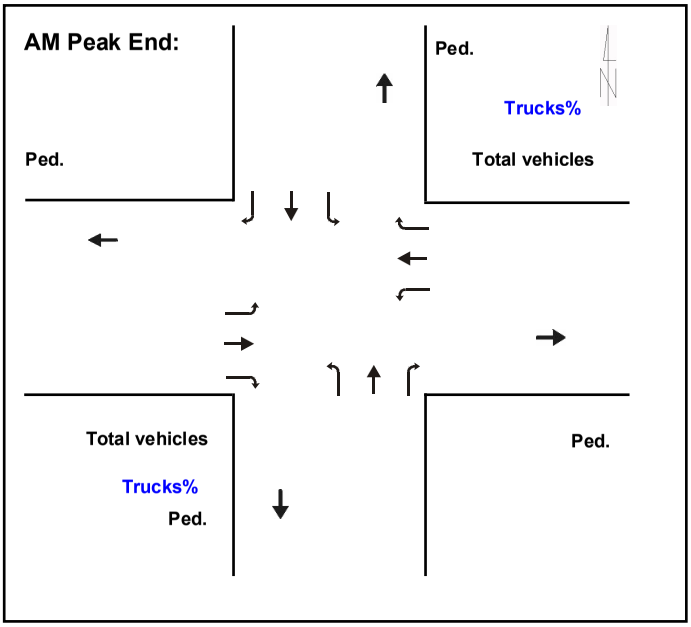
20722	Red Bold	=	Fatal
Dawn Artificial	Pink Background	=	Dawn
Dark	Dark Blue Background	=	Dark / night
Snow	Light Blue Background	=	Winter conditions
20722	Yellow Background	=	Animal Wild Collision
Fatigue	Light Green Background	=	Fatigue driver condition
Dusk	Dark Grey	=	Dusk light condition
PrvDrv	Lime Green	=	Private drive related collision
Impair Drugs	Light rose Background	=	Drugs or alcohol impairment driver condition
OvrPass	Bright Green Background	=	Overpass related collision

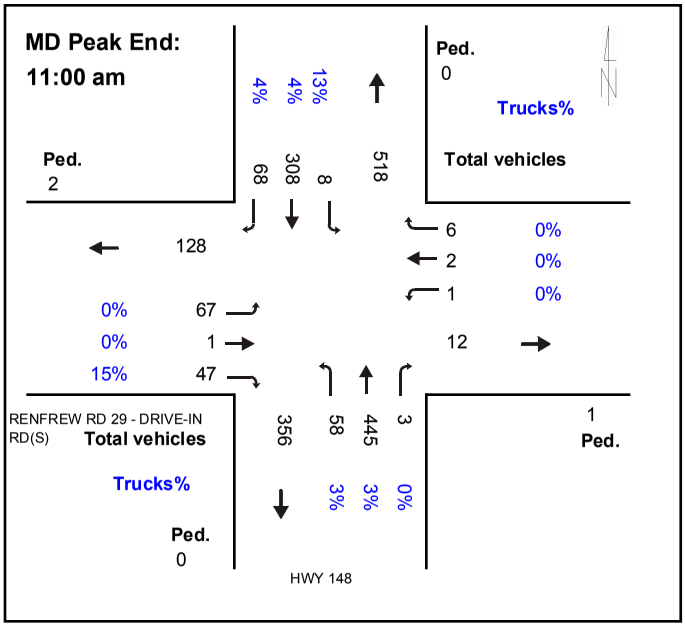
Appendix B – Traffic Data

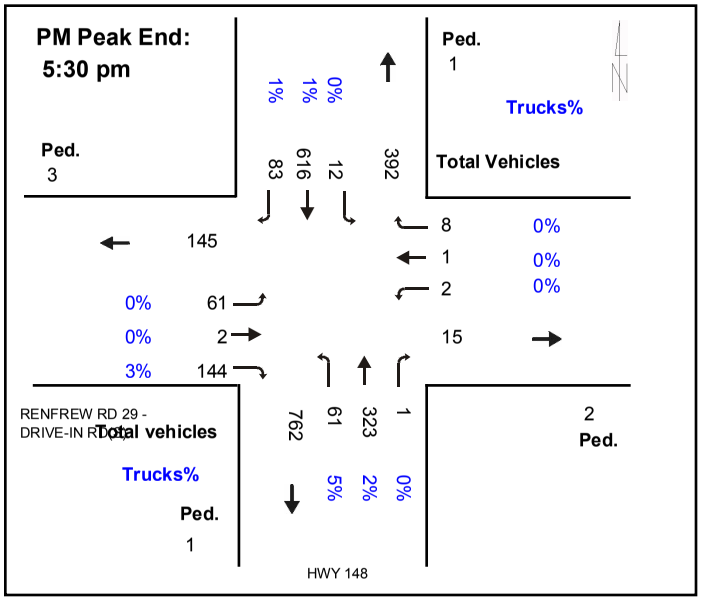
HWY 148 @ RENFREW RD 29 - DRIVE-IN RD(S)

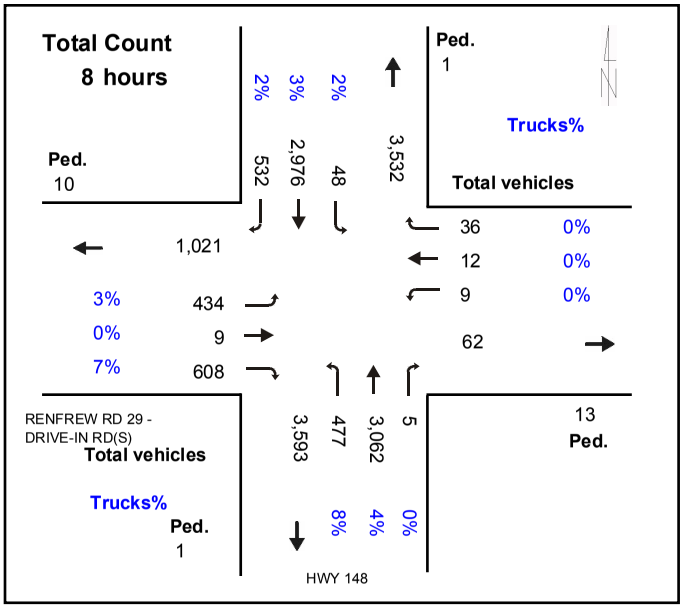
Eastern

Intersection ID:462610162 **Count Day: Tuesday** **Count Date: 14-Aug-2012**







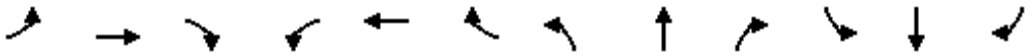


15 MIN REPORT

Intersection ID:462610162 **HWY 148 @ RENFREW RD 29 - DRIVE-IN RD(S)** **Municipality: Eastern** **Date: 14-Aug-2012**

	NORTH APPROACH										EAST APPROACH										SOUTH APPROACH										WEST APPROACH										
Time	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Cars			Trucks			Heavies			Ped	Total
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		Left	Thru	Right	Left	Thru	Right	Left	Thru	Right		
Period1																																								
14:15	1	105	18	0	2	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	14	80	0	0	2	0	0	3	0	0	14	0	18	0	0	0	0	0	0	0	260
14:30	1	119	20	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	13	86	0	1	3	0	0	0	0	0	11	1	15	2	0	4	0	0	0	0	280
14:45	0	128	18	0	6	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	15	104	0	1	2	0	0	1	0	0	14	0	15	0	0	0	0	0	0	1	309
15:00	1	111	18	0	5	0	0	1	1	0	0	2	2	0	0	0	0	0	0	0	8	88	1	2	6	0	0	0	0	0	10	1	18	1	0	0	0	0	0	0	276
15:15	3	108	33	0	3	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	15	79	0	1	3	0	2	0	0	0	16	0	26	0	0	1	0	0	0	0	295
15:30	3	115	25	0	4	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	15	82	0	0	1	0	0	1	0	0	9	1	19	0	0	2	0	0	0	0	279
15:45	1	139	19	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18	87	0	2	3	0	0	0	0	0	9	0	40	2	0	4	0	0	0	0	330
16:00	0	143	30	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	88	0	3	5	0	0	0	0	0	16	0	24	0	0	0	0	0	0	2	324
16:15	3	157	27	0	2	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	18	74	0	1	2	0	1	0	0	0	6	1	31	0	0	3	0	0	0	0	329
16:30	2	108	15	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	7	55	0	3	5	0	0	0	0	0	20	0	30	0	0	1	0	0	0	0	248
16:45	2	128	11	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	8	77	0	1	0	0	0	0	0	0	15	1	35	0	0	2	0	0	0	0	285
17:00	1	165	23	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	18	86	0	0	4	0	0	0	0	0	11	1	43	0	0	0	0	0	1	3	361
17:15	5	181	31	0	1	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	20	72	1	1	2	0	0	0	0	1	13	0	27	0	0	1	0	0	0	0	359
17:30	4	135	17	0	3	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	12	80	0	1	2	0	0	0	0	0	22	0	35	0	0	0	0	0	0	0	316
17:45	1	137	23	0	2	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	8	69	0	0	1	0	0	0	0	0	6	0	29	0	0	2	0	0	1	0	282
18:00	3	120	17	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	14	62	0	1	2	0	0	1	0	0	12	0	16	0	0	1	0	0	0	1	252
Period2																																								
7:15	0	24	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	17	69	0	3	2	0	0	3	0	0	10	0	8	0	0	0	0	0	0	0	152
7:30	2	28	5	0	4	0	0	1	0	0	1	0	2	0	0	0	0	0	0	0	15	77	0	0	3	0	0	0	0	0	11	0	7	0	0	0	0	0	0	0	156
7:45	0	34	13	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	19	114	0	0	7	0	0	0	0	0	14	0	5	0	0	0	0	0	0	1	210
8:00	0	42	9	0	1	1	0	1	0	0	0	2	2	0	0	0	0	0	0	0	20	114	0	1	1	0	0	0	0	0	29	1	7	1	0	1	0	0	0	0	233
8:15	2	37	4	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	12	116	0	0	4	0	0	0	0	0	11	0	8	0	0	0	0	0	1	0	200
8:30	1	28	17	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	111	0	0	2	0	0	0	0	0	7	1	11	0	0	2	0	0	1	0	191
8:45	0	39	6	0	2	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	13	117	0	1	2	0	0	0	0	0	13	0	8	2	0	1	0	0	0	0	207
9:00	1	34	10	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	15	122	0	2	4	0	0	0	0	0	9	0	12	0	0	1	0	0	0	0	213
9:15	0	48	9	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	2	14	96	0	0	5	0	0	1	0	0	10	0	9	1	0	1	0	0	0	0	201
9:30	1	53	12	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	20	104	0	2	4	0	0	1	0	0	15	0	6	1	0	2	0	0	0	0	223
9:45	2	69	8	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11	99	0	4	2	0	1	3	0	0	12	0	6	0	0	2	0	0	0	0	222
10:00	0	53	6	0	5	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	6	113	0	3	2	0	0	1	0	0	11	0	15	1	0	2	0	0	1	0	223
10:15	3	65	16	0	2	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	20	101	0	2	1	0	0	1	0	0	15	0	10	0	0	2	0	0	0	1	242
10:30	0	74	15	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	11	116	0	0	4	0	0	0	0	0	15	0	8	0	0	4	0	0	0	1	253
10:45	3	79	19	0	4	1	0	0	0	0	1	0	3	0	0	0	0	0	0	0	8	124	2	0	4	0	0	1	0	0	23	0	8	0	0	0	0	0	0	0	280
11:00	1	77	15	1	2	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	17	91	1	0	0	0	0	2	0	0	14	1	14	0	0	1	0	0	0	0	242

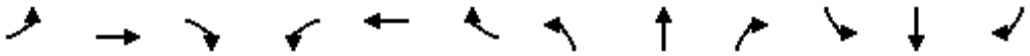
Appendix C – Intersection Capacity Analysis



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	8	351	78	54	468	3	71	1	44	1	2	7
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	8	369	82	57	493	3	75	1	46	1	2	7
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		387										
pX, platoon unblocked												
vC, conflicting volume	496			452			1001	996	369	1041	1076	494
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	496			452			1001	996	369	1041	1076	494
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			95			64	100	93	99	99	99
cM capacity (veh/h)	1063			1104			206	229	674	184	205	573

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	378	82	57	496	122	11
Volume Left	8	0	57	0	75	1
Volume Right	0	82	0	3	46	7
cSH	1063	1700	1104	1700	280	365
Volume to Capacity	0.01	0.05	0.05	0.29	0.44	0.03
Queue Length 95th (m)	0.2	0.0	1.1	0.0	14.7	0.6
Control Delay (s)	0.3	0.0	8.4	0.0	27.4	15.2
Lane LOS	A		A		D	C
Approach Delay (s)	0.2		0.9		27.4	15.2
Approach LOS					D	C

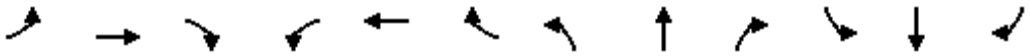
Intersection Summary				
Average Delay	3.6			
Intersection Capacity Utilization	64.9%	ICU Level of Service	C	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	8	351	78	54	468	3	71	1	44	1	2	7
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	8	369	82	57	493	3	75	1	46	1	2	7

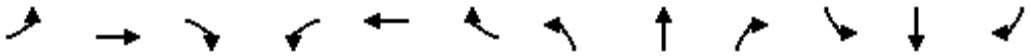
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total (vph)	378	82	57	496	122	11
Volume Left (vph)	8	0	57	0	75	1
Volume Right (vph)	0	82	0	3	46	7
Hadj (s)	0.06	-0.65	0.55	0.05	-0.05	-0.35
Departure Headway (s)	5.6	4.9	6.0	5.5	6.2	6.2
Degree Utilization, x	0.59	0.11	0.09	0.75	0.21	0.02
Capacity (veh/h)	623	709	580	642	533	496
Control Delay (s)	15.0	7.3	8.4	22.1	10.8	9.3
Approach Delay (s)	13.6		20.7		10.8	9.3
Approach LOS	B		C		B	A

Intersection Summary				
Delay	16.7			
Level of Service	C			
Intersection Capacity Utilization	64.9%	ICU Level of Service	C	
Analysis Period (min)	15			



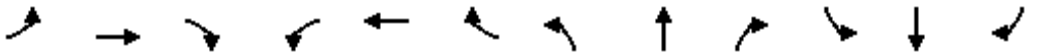
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	351	78	54	468	3	71	1	44	1	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	1.00			0.95			0.91	
Flt Protected		1.00	1.00	0.95	1.00			0.97			1.00	
Satd. Flow (prot)		1863	1585	1772	1863			1717			1680	
Flt Permitted		0.99	1.00	0.54	1.00			0.81			0.95	
Satd. Flow (perm)		1843	1585	1003	1863			1428			1598	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	8	369	82	57	493	3	75	1	46	1	2	7
RTOR Reduction (vph)	0	0	36	0	0	0	0	40	0	0	6	0
Lane Group Flow (vph)	0	377	46	57	496	0	0	82	0	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		21.6	21.6	21.6	21.6			4.8			4.8	
Effective Green, g (s)		21.6	21.6	21.6	21.6			4.8			4.8	
Actuated g/C Ratio		0.56	0.56	0.56	0.56			0.12			0.12	
Clearance Time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		1036	891	564	1047			178			199	
v/s Ratio Prot					c0.27							
v/s Ratio Perm		0.20	0.03	0.06				c0.06			0.00	
v/c Ratio		0.36	0.05	0.10	0.47			0.46			0.02	
Uniform Delay, d1		4.6	3.8	3.9	5.0			15.6			14.7	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		0.2	0.0	0.1	0.3			1.9			0.0	
Delay (s)		4.8	3.8	4.0	5.3			17.5			14.8	
Level of Service		A	A	A	A			B			B	
Approach Delay (s)		4.7			5.2			17.5			14.8	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	6.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	38.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	351	78	54	468	3	71	1	44	1	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.88	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1863		1772	1591		1772	1648	
Flt Permitted	0.47	1.00	1.00	0.54	1.00		0.87	1.00		0.87	1.00	
Satd. Flow (perm)	886	1865	1585	1010	1863		1622	1591		1622	1648	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	8	369	82	57	493	3	75	1	46	1	2	7
RTOR Reduction (vph)	0	0	36	0	0	0	0	40	0	0	6	0
Lane Group Flow (vph)	8	369	46	57	496	0	75	7	0	1	3	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	21.7	21.7	21.7	21.7	21.7		4.6	4.6		4.6	4.6	
Effective Green, g (s)	21.7	21.7	21.7	21.7	21.7		4.6	4.6		4.6	4.6	
Actuated g/C Ratio	0.57	0.57	0.57	0.57	0.57		0.12	0.12		0.12	0.12	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	501	1056	898	572	1055		194	191		194	197	
v/s Ratio Prot		0.20			c0.27			0.00			0.00	
v/s Ratio Perm	0.01		0.03	0.06			c0.05			0.00		
v/c Ratio	0.02	0.35	0.05	0.10	0.47		0.39	0.03		0.01	0.01	
Uniform Delay, d1	3.6	4.5	3.7	3.8	4.9		15.5	14.9		14.8	14.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.2	0.0	0.1	0.3		1.3	0.1		0.0	0.0	
Delay (s)	3.6	4.7	3.7	3.9	5.2		16.8	15.0		14.8	14.9	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		4.5			5.1			16.1			14.9	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	6.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.45		
Actuated Cycle Length (s)	38.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	53.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	351	78	54	468	3	71	1	44	1	2	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Frt	1.00	1.00	0.85	1.00	1.00			1.00	0.85		0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00			0.95	1.00		1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1863			1777	1585		1680	
Flt Permitted	0.47	1.00	1.00	0.54	1.00			0.85	1.00		0.95	
Satd. Flow (perm)	884	1865	1585	1010	1863			1577	1585		1610	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	8	369	82	57	493	3	75	1	46	1	2	7
RTOR Reduction (vph)	0	0	36	0	0	0	0	0	40	0	6	0
Lane Group Flow (vph)	8	369	46	57	496	0	0	76	6	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)	21.6	21.6	21.6	21.6	21.6			4.7	4.7		4.7	
Effective Green, g (s)	21.6	21.6	21.6	21.6	21.6			4.7	4.7		4.7	
Actuated g/C Ratio	0.56	0.56	0.56	0.56	0.56			0.12	0.12		0.12	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)	498	1051	893	569	1050			193	194		197	
v/s Ratio Prot		0.20			c0.27							
v/s Ratio Perm	0.01		0.03	0.06				c0.05	0.00		0.00	
v/c Ratio	0.02	0.35	0.05	0.10	0.47			0.39	0.03		0.02	
Uniform Delay, d1	3.7	4.5	3.8	3.9	5.0			15.5	14.8		14.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2	0.0	0.2	0.0	0.1	0.3			1.3	0.1		0.0	
Delay (s)	3.7	4.7	3.8	3.9	5.3			16.8	14.9		14.8	
Level of Service	A	A	A	A	A			B	B		B	
Approach Delay (s)		4.6			5.2			16.1			14.8	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	6.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	38.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	53.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

LANE SUMMARY

Site: Highway 148/Drive In Road Roundabout - 2015 - AM

Highway 148/Drive In Road Roundabout
2015 Traffic - AM Peak Hour
Roundabout

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Drive In Road													
Lane 1[d]	126	3.0	732	0.172	100	6.8	LOS A	0.6	4.8	Full	500	0.0	0.0
Approach	126	3.0		0.172		6.8	LOS A	0.6	4.8				
East: Highway 148													
Lane 1[d]	571	3.0	1002	0.570	100	11.1	LOS B	3.7	29.1	Full	500	0.0	0.0
Approach	571	3.0		0.570		11.1	LOS B	3.7	29.1				
North: Drive In Road													
Lane 1[d]	11	3.0	564	0.019	100	6.6	LOS A	0.1	0.5	Full	500	0.0	0.0
Approach	11	3.0		0.019		6.6	LOS A	0.1	0.5				
West: Highway 148													
Lane 1[d]	475	3.0	1028	0.462	100	8.8	LOS A	2.6	20.2	Full	500	0.0	0.0
Approach	475	3.0		0.462		8.8	LOS A	2.6	20.2				
Intersection	1183	3.0		0.570		9.7	LOS A	3.7	29.1				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

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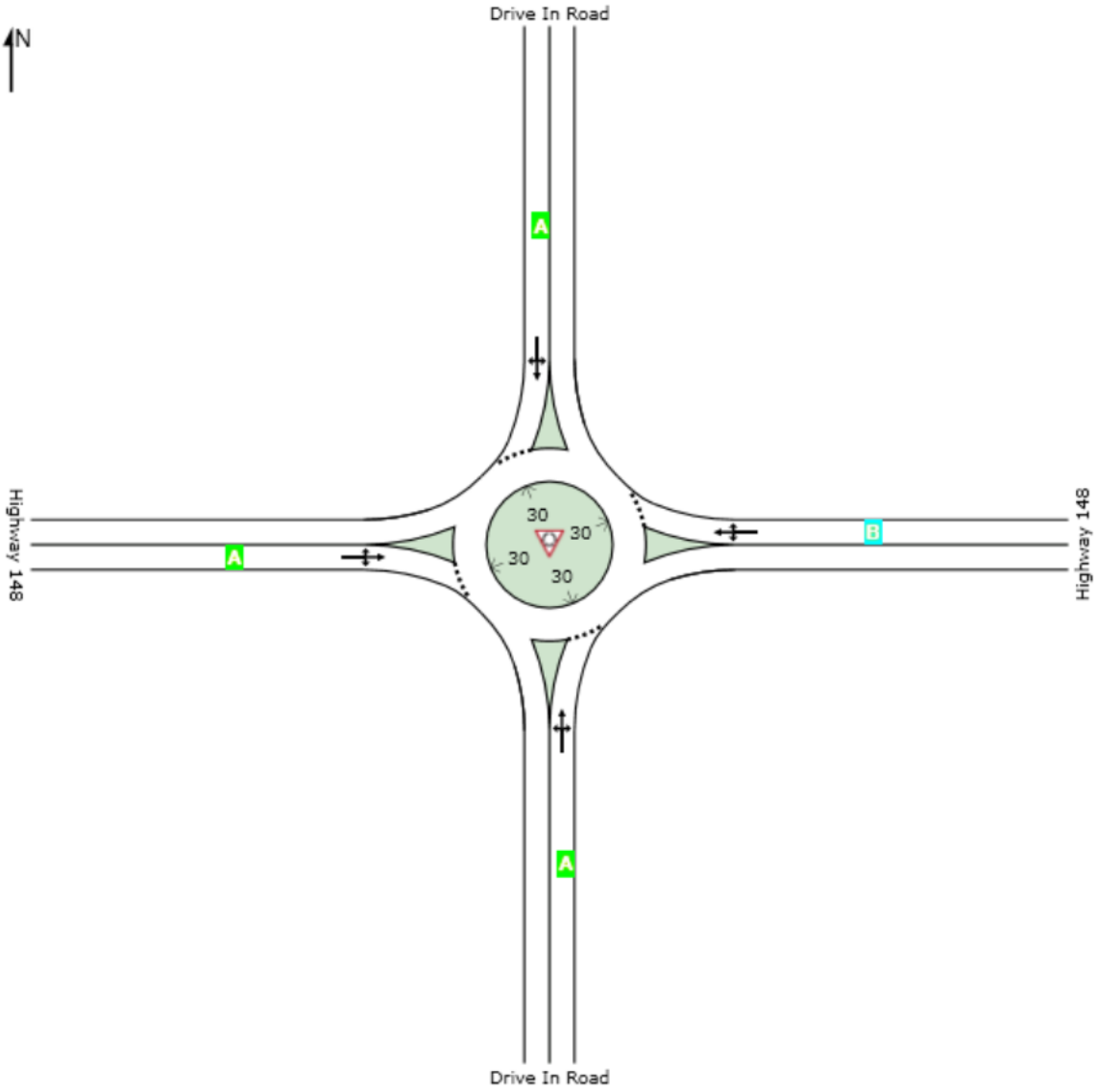
LEVEL OF SERVICE

Site: Highway 148/Drive In Road Roundabout - 2015 - AM

Highway 148/Drive In Road Roundabout
2015 Traffic - AM Peak Hour
Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	A	B	A	A	A



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
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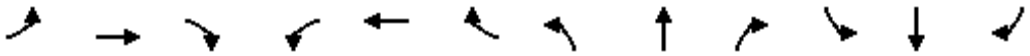
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	12	630	85	57	303	1	57	2	135	2	1	7
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	13	663	89	60	319	1	60	2	142	2	1	7
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		387										
pX, platoon unblocked				0.79			0.79	0.79	0.79	0.79	0.79	
vC, conflicting volume	320			753			1135	1128	663	1271	1217	319
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	320			549			1036	1027	435	1209	1140	319
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			92			60	99	71	97	99	99
cM capacity (veh/h)	1234			798			151	168	486	82	144	719

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	676	89	60	320	204	11
Volume Left	13	0	60	0	60	2
Volume Right	0	89	0	1	142	7
cSH	1234	1700	798	1700	291	243
Volume to Capacity	0.01	0.05	0.08	0.19	0.70	0.04
Queue Length 95th (m)	0.2	0.0	1.7	0.0	34.1	0.9
Control Delay (s)	0.3	0.0	9.9	0.0	42.0	20.5
Lane LOS	A		A		E	C
Approach Delay (s)	0.2		1.6		42.0	20.5
Approach LOS					E	C

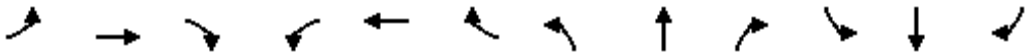
Intersection Summary				
Average Delay	7.0			
Intersection Capacity Utilization	72.1%	ICU Level of Service	C	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	12	630	85	57	303	1	57	2	135	2	1	7
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	13	663	89	60	319	1	60	2	142	2	1	7

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total (vph)	676	89	60	320	204	11
Volume Left (vph)	13	0	60	0	60	2
Volume Right (vph)	0	89	0	1	142	7
Hadj (s)	0.06	-0.65	0.55	0.05	-0.31	-0.33
Departure Headway (s)	5.8	5.1	6.6	6.1	6.2	6.8
Degree Utilization, x	1.00	0.13	0.11	0.54	0.35	0.02
Capacity (veh/h)	676	695	530	580	565	478
Control Delay (s)	58.7	7.6	9.2	14.8	12.4	9.9
Approach Delay (s)	52.7		13.9		12.4	9.9
Approach LOS	F		B		B	A

Intersection Summary				
Delay	35.5			
Level of Service	E			
Intersection Capacity Utilization	72.1%	ICU Level of Service	C	
Analysis Period (min)	15			



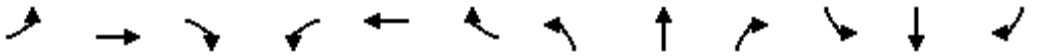
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	12	630	85	57	303	1	57	2	135	2	1	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	1.00			0.91			0.91	
Flt Protected		1.00	1.00	0.95	1.00			0.99			0.99	
Satd. Flow (prot)		1863	1585	1772	1864			1665			1672	
Flt Permitted		0.99	1.00	0.32	1.00			0.90			0.91	
Satd. Flow (perm)		1850	1585	600	1864			1516			1544	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	13	663	89	60	319	1	60	2	142	2	1	7
RTOR Reduction (vph)	0	0	39	0	0	0	0	121	0	0	6	0
Lane Group Flow (vph)	0	676	50	60	320	0	0	83	0	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		24.0	24.0	24.0	24.0			6.4			6.4	
Effective Green, g (s)		24.0	24.0	24.0	24.0			6.4			6.4	
Actuated g/C Ratio		0.57	0.57	0.57	0.57			0.15			0.15	
Clearance Time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		1047	897	339	1055			228			233	
v/s Ratio Prot					0.17							
v/s Ratio Perm		c0.37	0.03	0.10				c0.06			0.00	
v/c Ratio		0.65	0.06	0.18	0.30			0.37			0.02	
Uniform Delay, d1		6.3	4.1	4.4	4.8			16.2			15.3	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		1.4	0.0	0.3	0.2			1.0			0.0	
Delay (s)		7.7	4.1	4.7	5.0			17.2			15.4	
Level of Service		A	A	A	A			B			B	
Approach Delay (s)		7.3			4.9			17.2			15.4	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	42.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	75.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	12	630	85	57	303	1	57	2	135	2	1	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.87	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1589		1772	1620	
Flt Permitted	0.57	1.00	1.00	0.34	1.00		0.75	1.00		0.68	1.00	
Satd. Flow (perm)	1057	1865	1585	630	1864		1403	1589		1265	1620	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	13	663	89	60	319	1	60	2	142	2	1	7
RTOR Reduction (vph)	0	0	38	0	0	0	0	122	0	0	6	0
Lane Group Flow (vph)	13	663	51	60	320	0	60	22	0	2	2	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	24.4	24.4	24.4	24.4	24.4		5.9	5.9		5.9	5.9	
Effective Green, g (s)	24.4	24.4	24.4	24.4	24.4		5.9	5.9		5.9	5.9	
Actuated g/C Ratio	0.58	0.58	0.58	0.58	0.58		0.14	0.14		0.14	0.14	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	609	1075	914	363	1075		195	221		176	225	
v/s Ratio Prot		c0.36			0.17			0.01			0.00	
v/s Ratio Perm	0.01		0.03	0.10			c0.04			0.00		
v/c Ratio	0.02	0.62	0.06	0.17	0.30		0.31	0.10		0.01	0.01	
Uniform Delay, d1	3.8	5.9	3.9	4.2	4.6		16.4	15.9		15.7	15.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	1.1	0.0	0.2	0.2		0.9	0.2		0.0	0.0	
Delay (s)	3.8	6.9	3.9	4.4	4.7		17.3	16.1		15.7	15.7	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		6.5			4.7			16.4			15.7	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	7.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	42.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	61.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	12	630	85	57	303	1	57	2	135	2	1	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Frt	1.00	1.00	0.85	1.00	1.00			1.00	0.85		0.91	
Flt Protected	0.95	1.00	1.00	0.95	1.00			0.95	1.00		0.99	
Satd. Flow (prot)	1772	1865	1585	1772	1864			1779	1585		1672	
Flt Permitted	0.57	1.00	1.00	0.34	1.00			0.73	1.00		0.91	
Satd. Flow (perm)	1057	1865	1585	630	1864			1354	1585		1544	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	13	663	89	60	319	1	60	2	142	2	1	7
RTOR Reduction (vph)	0	0	37	0	0	0	0	0	122	0	6	0
Lane Group Flow (vph)	13	663	52	60	320	0	0	62	20	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)	25.1	25.1	25.1	25.1	25.1			6.1	6.1		6.1	
Effective Green, g (s)	25.1	25.1	25.1	25.1	25.1			6.1	6.1		6.1	
Actuated g/C Ratio	0.58	0.58	0.58	0.58	0.58			0.14	0.14		0.14	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)	614	1083	920	366	1083			191	223		218	
v/s Ratio Prot		c0.36			0.17							
v/s Ratio Perm	0.01		0.03	0.10				c0.05	0.01		0.00	
v/c Ratio	0.02	0.61	0.06	0.16	0.30			0.32	0.09		0.02	
Uniform Delay, d1	3.8	5.9	3.9	4.2	4.6			16.7	16.1		16.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2	0.0	1.0	0.0	0.2	0.2			1.0	0.2		0.0	
Delay (s)	3.9	6.9	3.9	4.4	4.7			17.7	16.3		16.0	
Level of Service	A	A	A	A	A			B	B		B	
Approach Delay (s)		6.5			4.7			16.7			16.0	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	7.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.56		
Actuated Cycle Length (s)	43.2	Sum of lost time (s)	12.0
Intersection Capacity Utilization	61.4%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

LANE SUMMARY

Site: Highway 148/Drive In Road Roundabout - 2015 - PM

Highway 148/Drive In Road Roundabout
2015 Traffic - PM Peak Hour
Roundabout

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Drive In Road													
Lane 1[d]	211	3.0	533	0.396	100	13.1	LOS B	1.6	12.7	Full	500	0.0	0.0
Approach	211	3.0		0.396		13.1	LOS B	1.6	12.7				
East: Highway 148													
Lane 1[d]	392	3.0	1012	0.388	100	7.7	LOS A	1.9	15.1	Full	500	0.0	0.0
Approach	392	3.0		0.388		7.7	LOS A	1.9	15.1				
North: Drive In Road													
Lane 1[d]	11	3.0	687	0.016	100	5.4	LOS A	0.1	0.4	Full	500	0.0	0.0
Approach	11	3.0		0.016		5.4	LOS A	0.1	0.4				
West: Highway 148													
Lane 1[d]	790	3.0	1024	0.771	100	18.1	LOS C	8.3	65.0	Full	500	0.0	0.0
Approach	790	3.0		0.771		18.1	LOS C	8.3	65.0				
Intersection	1404	3.0		0.771		14.4	LOS B	8.3	65.0				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

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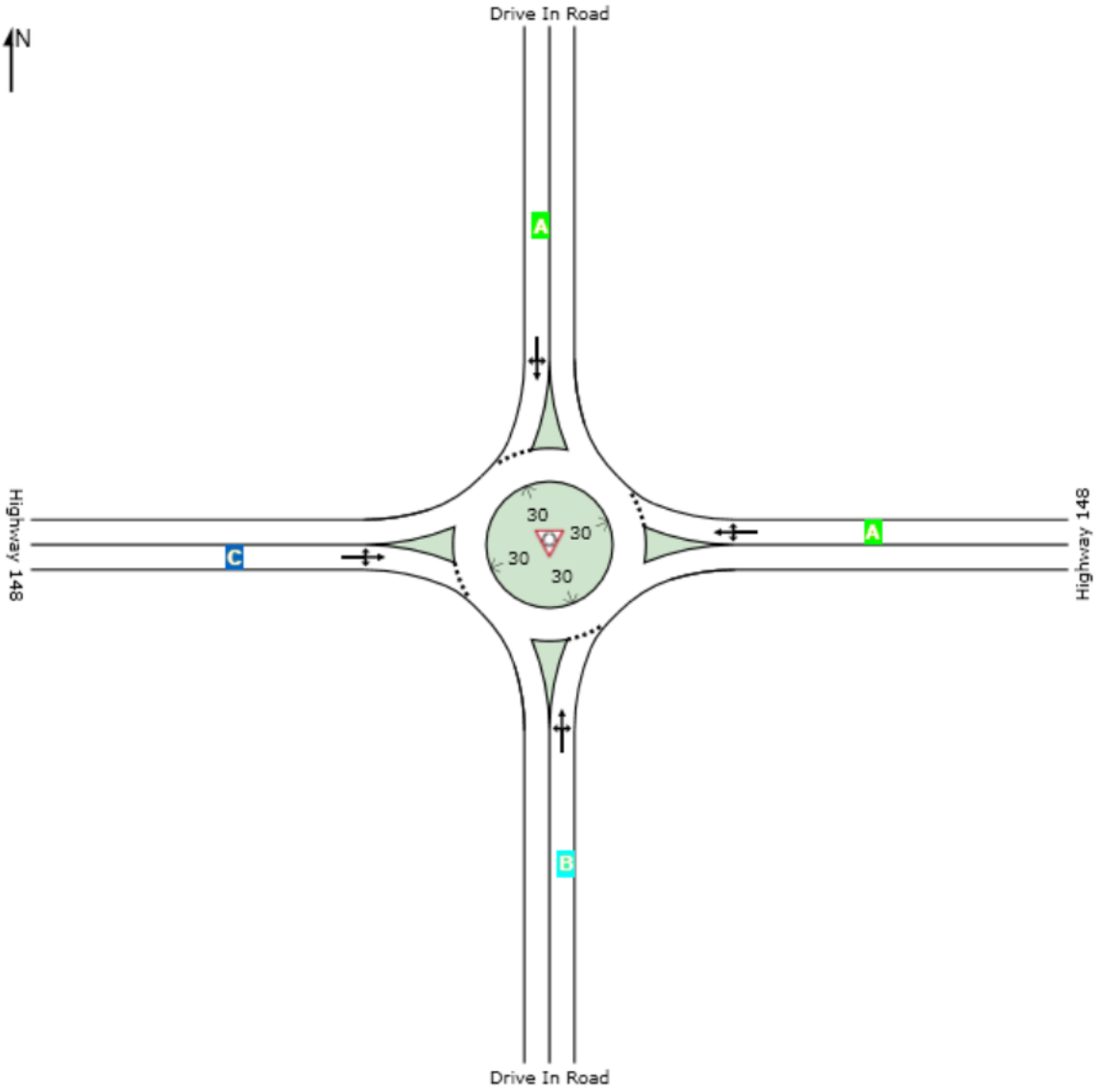
LEVEL OF SERVICE

Site: Highway 148/Drive In Road Roundabout - 2015 - PM

Highway 148/Drive In Road Roundabout
2015 Traffic - PM Peak Hour
Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	B	A	A	C	B



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

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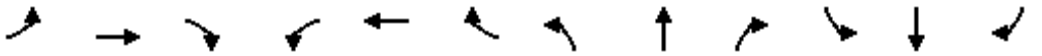
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	10	417	91	66	571	3	84	1	53	1	2	8
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	11	439	96	69	601	3	88	1	56	1	2	8
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		387										
pX, platoon unblocked				0.99			0.99	0.99	0.99	0.99	0.99	
vC, conflicting volume	604			535			1209	1203	439	1258	1297	603
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	604			522			1206	1199	424	1255	1295	603
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			93			39	99	91	99	99	98
cM capacity (veh/h)	969			1026			144	168	619	124	147	497

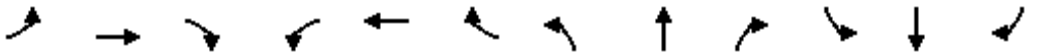
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	449	96	69	604	145	12
Volume Left	11	0	69	0	88	1
Volume Right	0	96	0	3	56	8
cSH	969	1700	1026	1700	205	292
Volume to Capacity	0.01	0.06	0.07	0.36	0.71	0.04
Queue Length 95th (m)	0.2	0.0	1.5	0.0	31.8	0.9
Control Delay (s)	0.3	0.0	8.8	0.0	56.7	17.9
Lane LOS	A		A		F	C
Approach Delay (s)	0.3		0.9		56.7	17.9
Approach LOS					F	C

Intersection Summary				
Average Delay	6.7			
Intersection Capacity Utilization	76.1%	ICU Level of Service	D	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	417	91	66	571	3	84	1	53	1	2	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	1.00			0.95			0.90	
Flt Protected		1.00	1.00	0.95	1.00			0.97			1.00	
Satd. Flow (prot)		1863	1585	1772	1864			1716			1674	
Flt Permitted		0.98	1.00	0.50	1.00			0.81			0.95	
Satd. Flow (perm)		1834	1585	926	1864			1429			1601	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	11	439	96	69	601	3	88	1	56	1	2	8
RTOR Reduction (vph)	0	0	42	0	0	0	0	47	0	0	7	0
Lane Group Flow (vph)	0	450	54	69	604	0	0	98	0	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		24.7	24.7	24.7	24.7			6.9			6.9	
Effective Green, g (s)		24.7	24.7	24.7	24.7			6.9			6.9	
Actuated g/C Ratio		0.57	0.57	0.57	0.57			0.16			0.16	
Clearance Time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		1038	897	524	1055			226			253	
v/s Ratio Prot					c0.32							
v/s Ratio Perm		0.25	0.03	0.07				c0.07			0.00	
v/c Ratio		0.43	0.06	0.13	0.57			0.43			0.02	
Uniform Delay, d1		5.4	4.2	4.4	6.1			16.6			15.5	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		0.3	0.0	0.1	0.8			1.3			0.0	
Delay (s)		5.7	4.3	4.5	6.8			17.9			15.5	
Level of Service		A	A	A	A			B			B	
Approach Delay (s)		5.5			6.6			17.9			15.5	
Approach LOS		A			A			B			B	

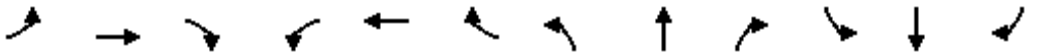
Intersection Summary			
HCM 2000 Control Delay	7.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	43.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	417	91	66	571	3	84	1	53	1	2	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.88	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1590		1772	1641	
Flt Permitted	0.39	1.00	1.00	0.51	1.00		0.80	1.00		0.80	1.00	
Satd. Flow (perm)	724	1865	1585	947	1864		1492	1590		1492	1641	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	11	439	96	69	601	3	88	1	56	1	2	8
RTOR Reduction (vph)	0	0	40	0	0	0	0	49	0	0	7	0
Lane Group Flow (vph)	11	439	56	69	604	0	88	8	0	1	3	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	23.4	23.4	23.4	23.4	23.4		5.0	5.0		5.0	5.0	
Effective Green, g (s)	23.4	23.4	23.4	23.4	23.4		5.0	5.0		5.0	5.0	
Actuated g/C Ratio	0.58	0.58	0.58	0.58	0.58		0.12	0.12		0.12	0.12	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	419	1080	918	548	1079		184	196		184	203	
v/s Ratio Prot		0.24			c0.32			0.00			0.00	
v/s Ratio Perm	0.02		0.04	0.07			c0.06			0.00		
v/c Ratio	0.03	0.41	0.06	0.13	0.56		0.48	0.04		0.01	0.01	
Uniform Delay, d1	3.6	4.7	3.7	3.9	5.3		16.5	15.6		15.5	15.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.3	0.0	0.1	0.6		2.0	0.1		0.0	0.0	
Delay (s)	3.7	4.9	3.7	4.0	5.9		18.4	15.7		15.5	15.6	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		4.7			5.7			17.4			15.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	6.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	40.4	Sum of lost time (s)	12.0
Intersection Capacity Utilization	59.9%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	417	91	66	571	3	84	1	53	1	2	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Frt	1.00	1.00	0.85	1.00	1.00			1.00	0.85		0.90	
Flt Protected	0.95	1.00	1.00	0.95	1.00			0.95	1.00		1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864			1777	1585		1674	
Flt Permitted	0.37	1.00	1.00	0.51	1.00			0.72	1.00		0.96	
Satd. Flow (perm)	699	1865	1585	945	1864			1345	1585		1612	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	11	439	96	69	601	3	88	1	56	1	2	8
RTOR Reduction (vph)	0	0	41	0	0	0	0	0	47	0	7	0
Lane Group Flow (vph)	11	439	55	69	604	0	0	89	9	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)	24.9	24.9	24.9	24.9	24.9			6.8	6.8		6.8	
Effective Green, g (s)	24.9	24.9	24.9	24.9	24.9			6.8	6.8		6.8	
Actuated g/C Ratio	0.57	0.57	0.57	0.57	0.57			0.16	0.16		0.16	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)	398	1062	903	538	1062			209	246		250	
v/s Ratio Prot		0.24			c0.32							
v/s Ratio Perm	0.02		0.03	0.07				c0.07	0.01		0.00	
v/c Ratio	0.03	0.41	0.06	0.13	0.57			0.43	0.04		0.02	
Uniform Delay, d1	4.1	5.3	4.2	4.4	6.0			16.7	15.7		15.6	
Progression Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2	0.0	0.3	0.0	0.1	0.7			1.4	0.1		0.0	
Delay (s)	4.1	5.6	4.2	4.5	6.7			18.1	15.7		15.6	
Level of Service	A	A	A	A	A			B	B		B	
Approach Delay (s)		5.3			6.5			17.2			15.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	7.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	43.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	59.9%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

LANE SUMMARY

Site: Highway 148/Drive In Road Roundabout - 2034 - AM

Highway 148/Drive In Road Roundabout
2034 Traffic - AM Peak Hour
Roundabout

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Drive In Road													
Lane 1[d]	150	3.0	678	0.221	100	7.9	LOS A	0.8	6.2	Full	500	0.0	0.0
Approach	150	3.0		0.221		7.9	LOS A	0.8	6.2				
East: Highway 148													
Lane 1[d]	696	3.0	985	0.706	100	15.5	LOS C	6.0	46.5	Full	500	0.0	0.0
Approach	696	3.0		0.706		15.5	LOS C	6.0	46.5				
North: Drive In Road													
Lane 1[d]	11	3.0	489	0.022	100	7.6	LOS A	0.1	0.5	Full	500	0.0	0.0
Approach	11	3.0		0.022		7.6	LOS A	0.1	0.5				
West: Highway 148													
Lane 1[d]	563	3.0	1014	0.555	100	10.7	LOS B	3.6	28.0	Full	500	0.0	0.0
Approach	563	3.0		0.555		10.7	LOS B	3.6	28.0				
Intersection	1420	3.0		0.706		12.7	LOS B	6.0	46.5				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

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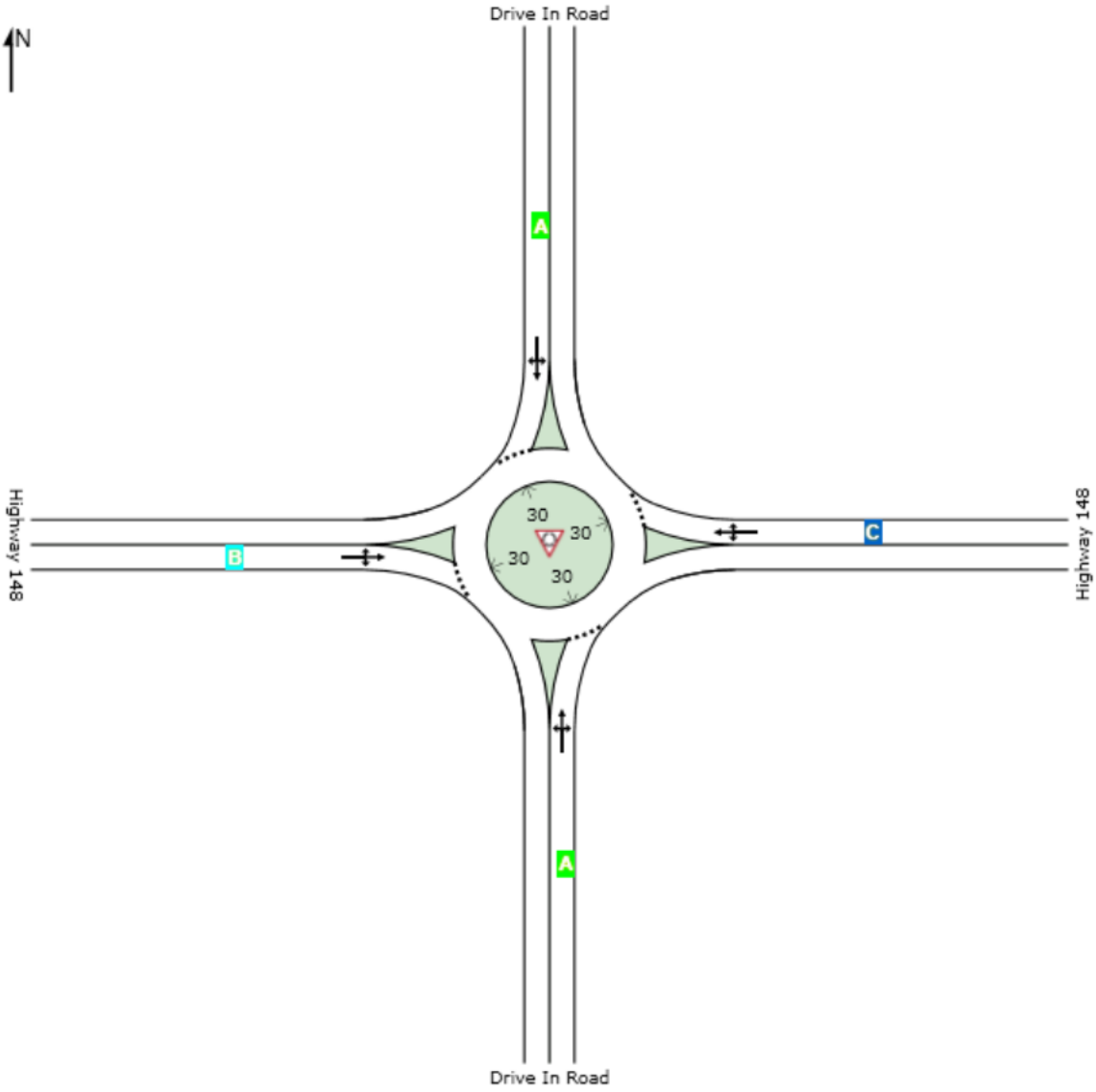
LEVEL OF SERVICE

Site: Highway 148/Drive In Road Roundabout - 2034 - AM

Highway 148/Drive In Road Roundabout
2034 Traffic - AM Peak Hour
Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	A	C	A	B	B

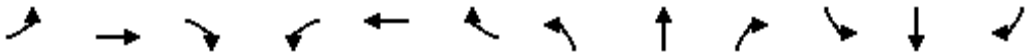


Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	15	765	101	69	372	1	69	2	163	2	1	9
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	16	805	106	73	392	1	73	2	172	2	1	9
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		387										
pX, platoon unblocked				0.62			0.62	0.62	0.62	0.62	0.62	
vC, conflicting volume	393			912			1384	1375	805	1547	1481	392
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	393			556			1313	1299	385	1575	1469	392
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			88			1	98	58	93	98	99
cM capacity (veh/h)	1160			629			74	87	412	28	69	654

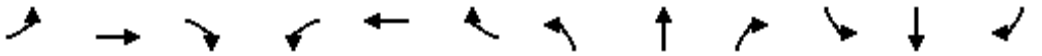
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	821	106	73	393	246	13
Volume Left	16	0	73	0	73	2
Volume Right	0	106	0	1	172	9
cSH	1160	1700	629	1700	173	122
Volume to Capacity	0.01	0.06	0.12	0.23	1.43	0.10
Queue Length 95th (m)	0.3	0.0	2.7	0.0	106.8	2.4
Control Delay (s)	0.4	0.0	11.5	0.0	271.9	37.9
Lane LOS	A		B		F	E
Approach Delay (s)	0.3		1.8		271.9	37.9
Approach LOS					F	E

Intersection Summary				
Average Delay	41.5			
Intersection Capacity Utilization	84.6%	ICU Level of Service	E	
Analysis Period (min)	15			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	765	101	69	372	1	69	2	163	2	1	9
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Lane Util. Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Frt		1.00	0.85	1.00	1.00			0.91			0.90	
Flt Protected		1.00	1.00	0.95	1.00			0.99			0.99	
Satd. Flow (prot)		1863	1585	1772	1864			1665			1662	
Flt Permitted		0.99	1.00	0.21	1.00			0.90			0.94	
Satd. Flow (perm)		1847	1585	388	1864			1514			1580	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	805	106	73	392	1	73	2	172	2	1	9
RTOR Reduction (vph)	0	0	45	0	0	0	0	105	0	0	7	0
Lane Group Flow (vph)	0	821	61	73	393	0	0	142	0	0	5	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)		29.7	29.7	29.7	29.7			9.9			9.9	
Effective Green, g (s)		29.7	29.7	29.7	29.7			9.9			9.9	
Actuated g/C Ratio		0.58	0.58	0.58	0.58			0.19			0.19	
Clearance Time (s)		6.0	6.0	6.0	6.0			6.0			6.0	
Vehicle Extension (s)		3.0	3.0	3.0	3.0			3.0			3.0	
Lane Grp Cap (vph)		1063	912	223	1072			290			303	
v/s Ratio Prot					0.21							
v/s Ratio Perm		c0.44	0.04	0.19				c0.09			0.00	
v/c Ratio		0.77	0.07	0.33	0.37			0.49			0.02	
Uniform Delay, d1		8.4	4.8	5.7	5.9			18.6			16.9	
Progression Factor		1.00	1.00	1.00	1.00			1.00			1.00	
Incremental Delay, d2		3.5	0.0	0.9	0.2			1.3			0.0	
Delay (s)		11.9	4.9	6.6	6.1			19.9			16.9	
Level of Service		B	A	A	A			B			B	
Approach Delay (s)		11.1			6.2			19.9			16.9	
Approach LOS		B			A			B			B	

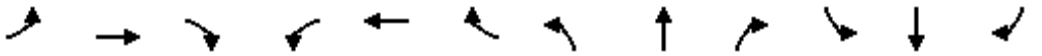
Intersection Summary			
HCM 2000 Control Delay	11.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	51.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	88.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	765	101	69	372	1	69	2	163	2	1	9
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.86	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1772	1865	1585	1772	1864		1772	1589		1772	1613	
Flt Permitted	0.53	1.00	1.00	0.25	1.00		0.75	1.00		0.65	1.00	
Satd. Flow (perm)	988	1865	1585	464	1864		1401	1589		1207	1613	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	805	106	73	392	1	73	2	172	2	1	9
RTOR Reduction (vph)	0	0	41	0	0	0	0	112	0	0	8	0
Lane Group Flow (vph)	16	805	65	73	393	0	73	62	0	2	2	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8			4		
Actuated Green, G (s)	29.0	29.0	29.0	29.0	29.0		6.6	6.6		6.6	6.6	
Effective Green, g (s)	29.0	29.0	29.0	29.0	29.0		6.6	6.6		6.6	6.6	
Actuated g/C Ratio	0.61	0.61	0.61	0.61	0.61		0.14	0.14		0.14	0.14	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	601	1136	965	282	1135		194	220		167	223	
v/s Ratio Prot		c0.43			0.21			0.04			0.00	
v/s Ratio Perm	0.02		0.04	0.16			c0.05			0.00		
v/c Ratio	0.03	0.71	0.07	0.26	0.35		0.38	0.28		0.01	0.01	
Uniform Delay, d1	3.7	6.4	3.8	4.3	4.6		18.6	18.4		17.7	17.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	2.0	0.0	0.5	0.2		1.2	0.7		0.0	0.0	
Delay (s)	3.7	8.4	3.8	4.8	4.8		19.9	19.1		17.7	17.7	
Level of Service	A	A	A	A	A		B	B		B	B	
Approach Delay (s)		7.8			4.8			19.3			17.7	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	47.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	765	101	69	372	1	69	2	163	2	1	9
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Frt	1.00	1.00	0.85	1.00	1.00			1.00	0.85		0.90	
Flt Protected	0.95	1.00	1.00	0.95	1.00			0.95	1.00		0.99	
Satd. Flow (prot)	1772	1865	1585	1772	1864			1779	1585		1662	
Flt Permitted	0.53	1.00	1.00	0.25	1.00			0.72	1.00		0.93	
Satd. Flow (perm)	988	1865	1585	466	1864			1349	1585		1551	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	805	106	73	392	1	73	2	172	2	1	9
RTOR Reduction (vph)	0	0	41	0	0	0	0	0	112	0	8	0
Lane Group Flow (vph)	16	805	65	73	393	0	0	75	60	0	4	0
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2		2	6			8		8	4		
Actuated Green, G (s)	29.2	29.2	29.2	29.2	29.2			6.6	6.6		6.6	
Effective Green, g (s)	29.2	29.2	29.2	29.2	29.2			6.6	6.6		6.6	
Actuated g/C Ratio	0.61	0.61	0.61	0.61	0.61			0.14	0.14		0.14	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0			6.0	6.0		6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)	603	1139	968	284	1138			186	218		214	
v/s Ratio Prot		c0.43			0.21							
v/s Ratio Perm	0.02		0.04	0.16				c0.06	0.04		0.00	
v/c Ratio	0.03	0.71	0.07	0.26	0.35			0.40	0.27		0.02	
Uniform Delay, d1	3.7	6.4	3.8	4.3	4.6			18.8	18.5		17.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2	0.0	2.0	0.0	0.5	0.2			1.4	0.7		0.0	
Delay (s)	3.7	8.4	3.8	4.8	4.8			20.2	19.1		17.8	
Level of Service	A	A	A	A	A			C	B		B	
Approach Delay (s)		7.8			4.8			19.5			17.8	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	47.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

LANE SUMMARY

Site: Highway 148/Drive In Road Roundabout - 2034 - PM

Highway 148/Drive In Road Roundabout
2034 Traffic - PM Peak Hour
Roundabout

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Drive In Road													
Lane 1[d]	254	3.0	456	0.557	100	20.2	LOS C	2.6	20.6	Full	500	0.0	0.0
Approach	254	3.0		0.557		20.2	LOS C	2.6	20.6				
East: Highway 148													
Lane 1[d]	480	3.0	995	0.483	100	9.4	LOS A	2.7	21.3	Full	500	0.0	0.0
Approach	480	3.0		0.483		9.4	LOS A	2.7	21.3				
North: Drive In Road													
Lane 1[d]	13	3.0	619	0.021	100	6.0	LOS A	0.1	0.5	Full	500	0.0	0.0
Approach	13	3.0		0.021		6.0	LOS A	0.1	0.5				
West: Highway 148													
Lane 1[d]	958	3.0	1011	0.948	100	37.2	LOS E	22.8	177.9	Full	500	0.0	0.0
Approach	958	3.0		0.948		37.2	LOS E	22.8	177.9				
Intersection	1705	3.0		0.948		26.6	LOS D	22.8	177.9				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

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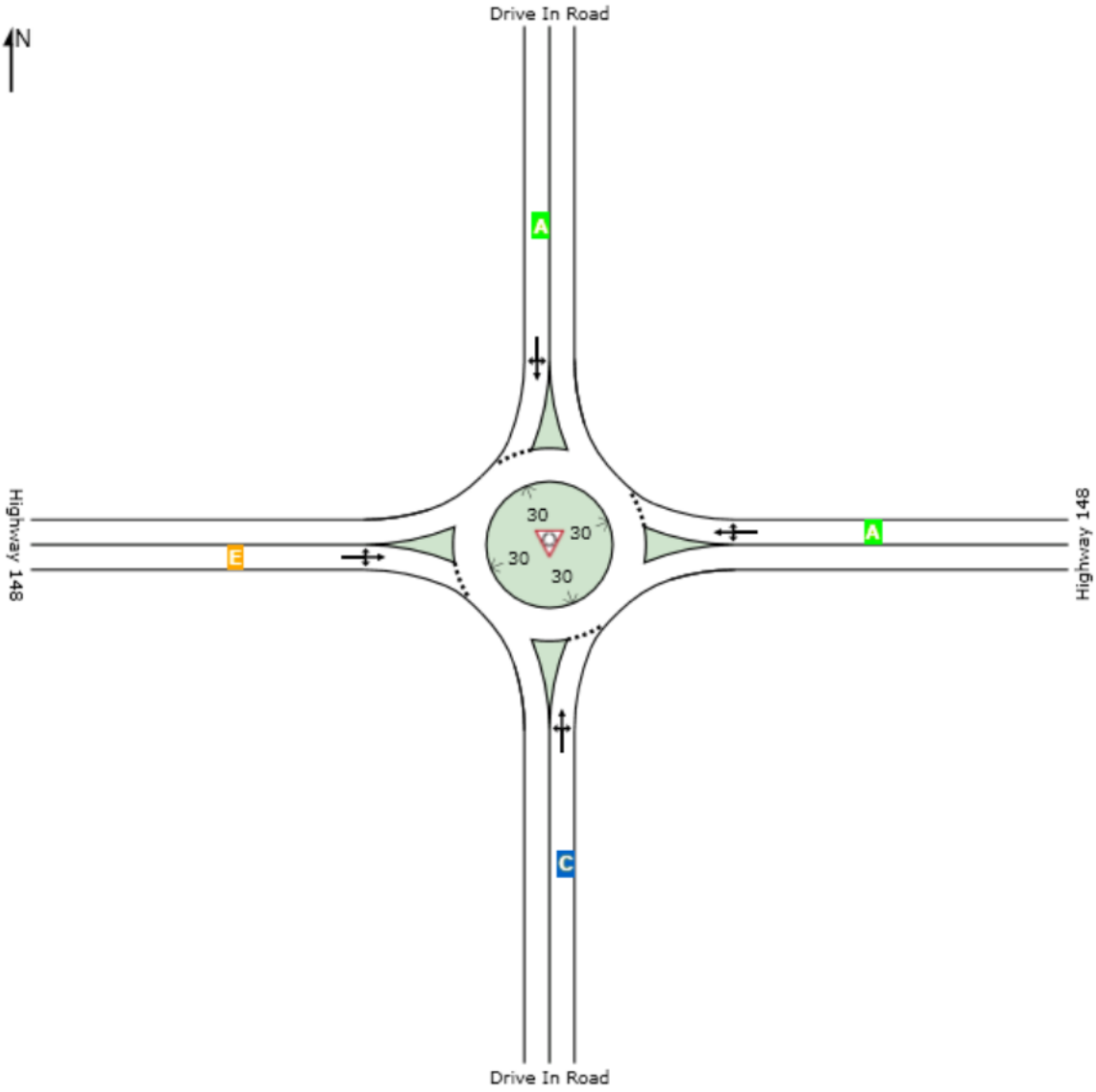
LEVEL OF SERVICE

Site: Highway 148/Drive In Road Roundabout - 2034 - PM

Highway 148/Drive In Road Roundabout
2034 Traffic - PM Peak Hour
Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	C	A	A	E	D



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Appendix D – Traffic Signal Warrants

Input Data Sheet

Analysis Sheet | Results Sheet | Proposed Collision

GO TO Justification:

What are the intersecting roadways? Highway 148 & Drive-In Road

What is the direction of the Main Road street? North-South

When was the data collected? 2012

Justification 1 - 4: Volume Warrants

a.- Number of lanes on the Main Road? 1

b.- Number of lanes on the Minor Road? 1

c.- How many approaches? 4

d.- What is the operating environment? Urban

Population >= 10,000 **AND** **Speed < 70 km/hr**

e.- What is the eight hour vehicle volume at the intersection? (Please fill in table below)

Hour Ending	Main Northbound Approach			Minor Eastbound Approach			Main Southbound Approach			Minor Westbound Approach			Pedestrians Crossing Main Road
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
8:00	75	390	0	65	1	28	2	137	39	1	3	4	0
9:00	50	478	0	42	1	45	4	149	37	1	0	3	0
10:00	61	431	0	51	0	44	3	234	36	0	2	5	0
11:00	58	445	3	67	1	47	8	308	68	1	2	6	0
15:00	54	375	1	52	2	70	3	483	76	0	3	5	0
16:00	65	349	0	52	1	116	7	520	111	0	0	3	0
17:00	57	303	0	52	3	146	8	563	76	4	2	5	1
18:00	57	291	1	53	0	112	13	582	89	2	0	5	1
Total	**477**	**3,062**	**5**	**434**	**9**	**608**	**48**	**2,976**	**532**	**9**	**12**	**36**	**2**

Justification 5: Collision Experience

Preceding Months	Number of Collisions*
1-12	0
13-24	0
25-36	2

***** Include only collisions that are susceptable to correction through the installation of traffic signal control

Justification 6: Pedestrian Volume

a.- Please fill in table below summarizing total pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Factored 8 hour pedestrian volume	0		0		0		0		
% Assigned to crossing rate	100%		100%		100%		100%		
Net 8 Hour Pedestrian Volume at Crossing									2
Net 8 Hour Vehicular Volume on Street Being Crossed									7,100

b.- Please fill in table below summarizing delay to pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Total 8 hour pedestrians delayed greater than 10 seconds	0	0	0	0	0	0	0	0	
Factored volume of total pedestrians	0		0		0		0		
Factored volume of delayed pedestrians	0		0		0		0		
% Assigned to Crossing Rate	100%		100%		100%		100%		
Net 8 Hour Volume of Total Pedestrians									2
Net 8 Hour Volume of Delayed Pedestrians									7,100

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 1: Minimum Vehicle Volumes

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☑	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
1A	480	720	600	900	745	810	867	1,014	1,124	1,224	1,219	1,205		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
1B	120	170	120	170	102	92	102	124	132	172	212	172		
	COMPLIANCE %				60	54	60	73	78	100	100	100	625	78
Restricted Flow Signal Justification 1:					Both 1A and 1B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 1A or 1B at least 80% fulfilled each of 8 hours					Yes ☐		No ☑		

Justification 2: Delay to Cross Traffic

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☑	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
2A	480	720	600	900	643	718	765	890	992	1,052	1,007	1,033		
	COMPLIANCE %				89	100	100	100	100	100	100	100	789	99
2B	50	75	50	75	69	44	53	70	55	53	60	56		
	COMPLIANCE %				92	59	71	93	73	71	80	75	613	77
Restricted Flow Signal Justification 2:					Both 2A and 2B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 2A or 2B at least 80% fulfilled each of 8 hours					Yes ☐		No ☑		

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☐	NO ☑	YES ☐	NO ☑
Justification 2	Delay Cross Traffic	YES ☐	NO ☑		NOT JUSTIFIED

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main)	Heaviest Minor Approach	Required Value	Average % Compliance	Overall % Compliance
		X	Y (actual)	Y (warrant threshold)		
Justification 4	16:00	1,052	169	92	100 %	100 %
	17:00	1,007	201	101	100 %	
	18:00	1,033	165	96	100 %	
	15:00	992	124	104	100 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 5: Collision Experience

Justification	Preceding Months	% Fulfillment	Overall % Compliance
Justification 5	1-12	0 %	13 %
	13-24	0 %	
	25-36	40 %	

Justification 6: Pedestrian Volume

Pedestrian Volume Analysis

8 Hour Vehicular Volume V_8		Net 8 Hour Pedestrian Volume				
		< 200	200 - 275	276 - 475	476 - 1000	>1000
Justification 6A	< 1440					
	1440 - 2600					
	2601 - 7000					
	> 7000	Not Justified				Justified

Pedestrian Delay Analysis

Net Total 8 Hour Volume of Total Pedestrians		Net Total 8 Hour Volume of Delayed Pedestrians		
		< 75	75 - 130	> 130
Justification 6B	< 200			Not Justified
	200 - 300			
	> 300			

A Volume	Justification not met
B Delay	Justification not met

Results Sheet

Input Sheet | Analysis Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Summary Results

Justification			Compliance		Signal Justified? YES	Signal Justified? NO
1. Minimum Vehicular Volume	A	Total Volume	100	%	☐	☑
	B	Crossing Volume	78	%		
2. Delay to Cross Traffic	A	Main Road	99	%	☐	☑
	B	Crossing Road	77	%		
3. Combination	A	Justificaton 1	78	%	☐	☑
	B	Justification 2	77	%		
4. 4-Hr Volume			100	%	☑	☐
5. Collision Experience			13	%	☐	☑
6. Pedestrians	A	Volume	Justification not met		☐	☑
	B	Delay	Justification not met			

Input Data Sheet

Analysis Sheet | Results Sheet | Proposed Collision | GO TO Justification:

What are the intersecting roadways? Highway 148 & Drive-In Road

What is the direction of the Main Road street? North-South

When was the data collected? 2012

Justification 1 - 4: Volume Warrants

a.- Number of lanes on the Main Road? 1

b.- Number of lanes on the Minor Road? 1

c.- How many approaches? 4

d.- What is the operating environment? Rural

Population < 10,000 AND Speed >= 70 km/hr

e.- What is the eight hour vehicle volume at the intersection? (Please fill in table below)

Hour Ending	Main Northbound Approach			Minor Eastbound Approach			Main Southbound Approach			Minor Westbound Approach			Pedestrians Crossing Main Road
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
8:00	75	390	0	65	1	28	2	137	39	1	3	4	0
9:00	50	478	0	42	1	45	4	149	37	1	0	3	0
10:00	61	431	0	51	0	44	3	234	36	0	2	5	0
11:00	58	445	3	67	1	47	8	308	68	1	2	6	0
15:00	54	375	1	52	2	70	3	483	76	0	3	5	0
16:00	65	349	0	52	1	116	7	520	111	0	0	3	0
17:00	57	303	0	52	3	146	8	563	76	4	2	5	1
18:00	57	291	1	53	0	112	13	582	89	2	0	5	1
Total	**477**	**3,062**	**5**	**434**	**9**	**608**	**48**	**2,976**	**532**	**9**	**12**	**36**	**2**

Justification 5: Collision Experience

Preceding Months	Number of Collisions*
1-12	0
13-24	0
25-36	2

* Include only collisions that are susceptable to correction through the installation of traffic signal control

Justification 6: Pedestrian Volume

a.- Please fill in table below summarizing total pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Factored 8 hour pedestrian volume	0		0		0		0		
% Assigned to crossing rate	100%		100%		100%		100%		
Net 8 Hour Pedestrian Volume at Crossing									2
Net 8 Hour Vehicular Volume on Street Being Crossed									7,100

b.- Please fill in table below summarizing delay to pedestrians crossing major roadway at the intersection or in proximity to the intersection (zones). Please reference Section 4.8 of the Manual for further explanation and graphical representation.

	Zone 1		Zone 2		Zone 3 (if needed)		Zone 4 (if needed)		Total
	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	Assisted	Unassisted	
Total 8 hour pedestrian volume	0	0	0	0	0	0	0	0	
Total 8 hour pedestrians delayed greater than 10 seconds	0	0	0	0	0	0	0	0	
Factored volume of total pedestrians	0		0		0		0		
Factored volume of delayed pedestrians	0		0		0		0		
% Assigned to Crossing Rate	100%		100%		100%		100%		
Net 8 Hour Volume of Total Pedestrians									2
Net 8 Hour Volume of Delayed Pedestrians									7,100

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 1: Minimum Vehicle Volumes

Free Flow Rural Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☑	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
1A	480	720	600	900	745	810	867	1,014	1,124	1,224	1,219	1,205		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
1B	120	170	120	170	102	92	102	124	132	172	212	172		
	COMPLIANCE %				85	77	85	100	100	100	100	100	747	93
Free Flow Signal Justification 1:					Both 1A and 1B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 1A or 1B at least 80% fulfilled each of 8 hours					Yes ☑		No ☐		

Justification 2: Delay to Cross Traffic

Free Flow Rural Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☑	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐	8:00	9:00	10:00	11:00	15:00	16:00	17:00	18:00		
2A	480	720	600	900	643	718	765	890	992	1,052	1,007	1,033		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
2B	50	75	50	75	69	44	53	70	55	53	60	56		
	COMPLIANCE %				100	88	100	100	100	100	100	100	788	99
Free Flow Signal Justification 2:					Both 2A and 2B 100% Fullfilled each of 8 hours					Yes ☐		No ☑		
					Lesser of 2A or 2B at least 80% fulfilled each of 8 hours					Yes ☑		No ☐		

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☑	NO ☐	YES ☑	NO ☐
Justification 2	Delay Cross Traffic	YES ☑	NO ☐	JUSTIFIED	

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main)	Heaviest Minor Approach	Required Value	Average % Compliance	Overall % Compliance
		X	Y (actual)	Y (warrant threshold)		
Justification 4	16:00	1,052	169	106	100 %	100 %
	17:00	1,007	201	115	100 %	
	18:00	1,033	165	110	100 %	
	15:00	992	124	119	100 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Justification 5: Collision Experience

Justification	Preceding Months	% Fulfillment	Overall % Compliance
Justification 5	1-12	0 %	13 %
	13-24	0 %	
	25-36	40 %	

Justification 6: Pedestrian Volume

Pedestrian Volume Analysis

8 Hour Vehicular Volume V_8		Net 8 Hour Pedestrian Volume				
		< 200	200 - 275	276 - 475	476 - 1000	>1000
Justification 6A	< 1440					
	1440 - 2600					
	2601 - 7000					
	> 7000	Not Justified				Justified

Pedestrian Delay Analysis

Net Total 8 Hour Volume of Total Pedestrians		Net Total 8 Hour Volume of Delayed Pedestrians		
		< 75	75 - 130	> 130
Justification 6B	< 200			Not Justified
	200 - 300			
	> 300			

A Volume	Justification not met
B Delay	Justification not met

Results Sheet

Input Sheet | Analysis Sheet | Proposed Collision

GO TO Justification:

Intersection: Highway 148 & Drive-In Road Count Date: 2012

Summary Results

Justification			Compliance		Signal Justified? YES	Signal Justified? NO
1. Minimum Vehicular Volume	A	Total Volume	100	%	☐	☑
	B	Crossing Volume	93	%		
2. Delay to Cross Traffic	A	Main Road	100	%	☐	☑
	B	Crossing Road	99	%		
3. Combination	A	Justificaton 1	93	%	☑	☐
	B	Justification 2	99	%		
4. 4-Hr Volume			100	%	☑	☐
5. Collision Experience			13	%	☐	☑
6. Pedestrians	A	Volume	Justification not met		☐	☑
	B	Delay	Justification not met			

Appendix B5 – Greenwood Road Intersection (Technical Memo)

IBI GROUP
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Memorandum

To/Attention	Allan Ortlieb	**Date**	January 28, 2016 *(Revision 1)*
From	Stephan Schmidle	**Project No**	24RX14.0333
cc	Chris Belanger, MTO Project Manager		
Subject	Design Alternative for the Intersection of Highway 148 and Greenwood Road		

The objective of this memorandum is to evaluate design alternatives for the intersection of Highway 148 and Greenwood Road as part of the planned pavement rehabilitation for Highway 148.

1.0 Existing Conditions

1.1 Intersection Configuration

The intersection is an unsignalized “T” connecting Greenwood Road and Highway 148 with the east intersection leg the minor approach (Exhibit 2). Both highways have rural cross-sections with unpaved shoulders. The posted speed on both highways is 80 km/h, implying a design speed of 100 km/h. Both right turns are channelized with curve radii of 70 metres and 46 metres for the WBR and NBR movements, respectively.

The intersection does not fully comply with the Geometric Design Standards for Ontario Highways in several regards:

- The acceleration lane (upon exiting the WBR right-turn channelization) is designed as a direct taper. However, for a design speed of 100 km/h a parallel lane is required. The taper length is 152 metres, which is less than the acceleration length of 210 metres required for highway volumes with less than 400 vehicles per hour (Table E8-3).
- There are no pavement markings at the acceleration lane as required by Ontario Traffic Manual (OTM) Book 11, Figure 14. (Note that provision of traffic signage, i.e. yield signs. is not required, as the taper length exceeds the minimum required by OTM Book 5, table 2.)
- The southbound left-turn lane has a total length of 197 metres, but a total length of 260 metres is required. Exhibit 1 compares the original design, the existing conditions and GDSOH requirements.

The exhibit shows that the existing taper length of the SBL lane is less than the original design length. Presumably the taper length was reduced in the field to accommodate nearby commercial driveways.

IBI Group is a group of firms providing professional services and is affiliated with IBI Group Architects

Exhibit 1: Design of the southbound left-turn lane

DESIGN ELEMENT	1974 DESIGN	EXISTING CONDITIONS (APPROXIMATELY)	GDSOH REQUIREMENTS
Taper	136 metres	75 metres	160 metres
Parallel lane (to crossing-road CL)	123 metres	122 metres	100 metres
Offset to crossing-road CL			15 metres
Minimum storage (collision warrant)			15 metres
Parallel lane			70 metres
Total	259 metres	197 metres	260 metres

1.2 Nearby Driveways

Exhibit 2 shows that there are several commercial and residential driveways in the vicinity of the intersection. Several changes have occurred since the ortho photos were taken in 2008. Between April 2010 and September 2013 the following took place:

- Mike's Ultramar gas station at 1409 Pembroke Street East was closed;
- A large residential building was constructed at 1423 Pembroke Street East;
- The self-storage business at 2651 Greenwood Road was expanded; and
- A small fast-food operation opened on the property of the Esso gas station (1412 Pembroke Street East).

Several observations may be made with respect to these driveways.

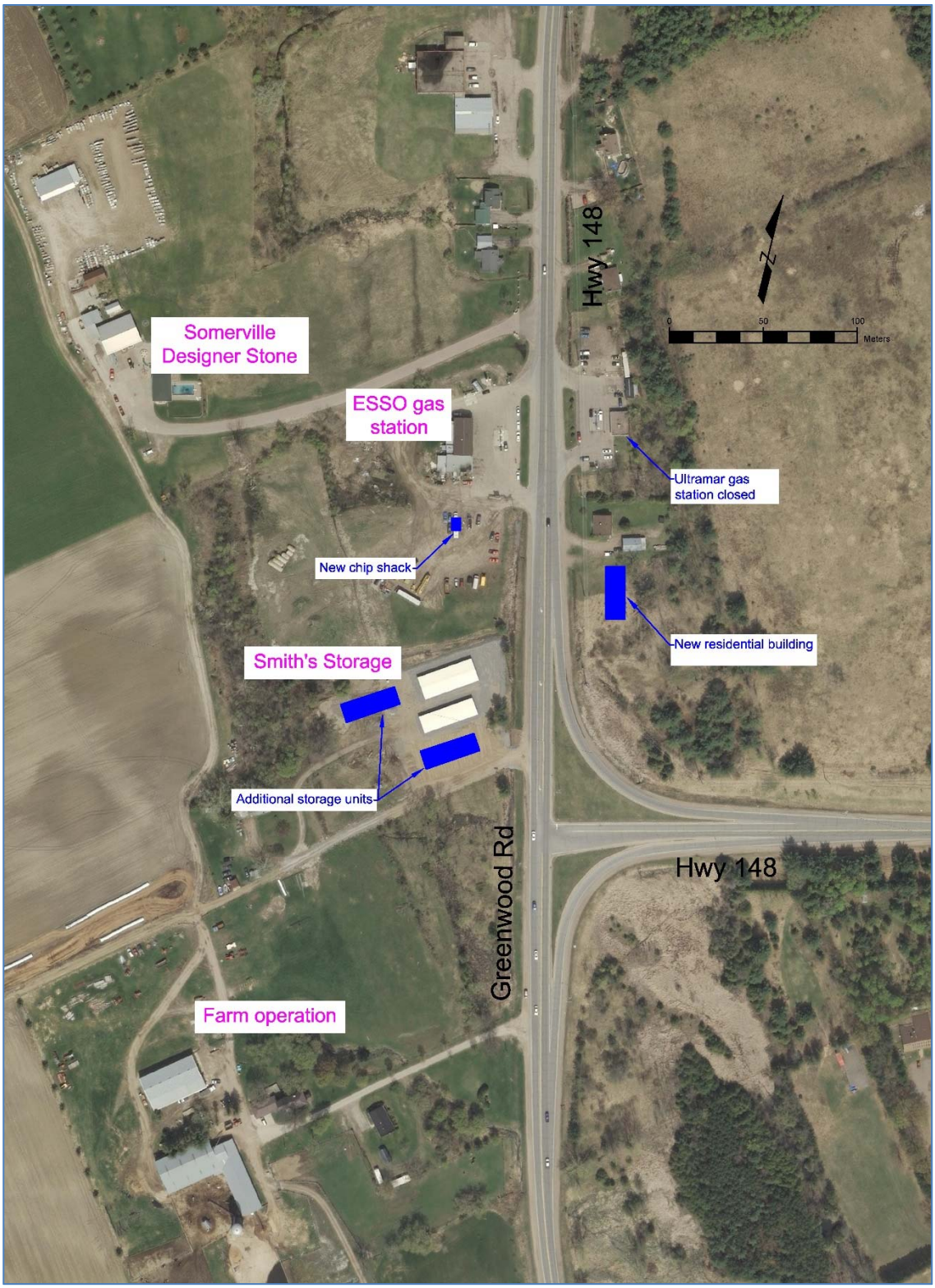
There are two residential driveways on the acceleration taper of the WBR channelization. The driveways are located at the end of the taper, which potentially increases the complexity and number of decisions to be made by drivers attempting to merge into the traffic stream on Highway 148.

The driveway of the self-storage business is located within the north intersection approach. This is unusual and consequently drivers and violates driver expectancy.

In many cases, drivers coming from Quebec and residents living on Cotnam Islands or along Hazley Bay Drive used the Ultramar gas station to purchase gas prior to entering Pembroke. With the closure of the Ultramar gas station, we understand that some of these drivers are now choosing to access the Esso gas station. In doing so, these vehicles tend to slow down (and potentially stop) immediately upon merging onto Highway 148, introducing a conflict with northbound traffic on Highway 148.

Allan Ortlieb – January 28, 2016_rev1

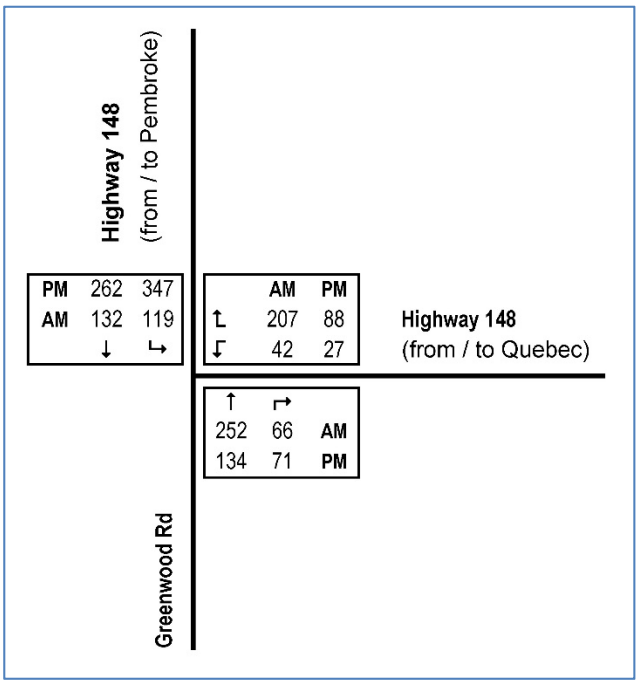
Exhibit 2: Existing conditions



1.3 Traffic Conditions

The intersection operates well under existing and future traffic conditions. Exhibit 2 summarizes existing traffic volumes.

Exhibit 3: Traffic volumes at the intersection (existing conditions, peak periods)



1.4 Traffic Safety

a) Concerns Raised by Residents

We were advised that there have been a number of “near collisions” at Esso’s south driveway due to vehicles exiting the WBR channel and stopping at the driveway to let SBT vehicles pass. It is possible that these incidents are related to the closure of the Ultramar gas station (as discussed above). In addition, residents reported that the SBL movement is sometimes difficult due to a lack of gaps in the northbound traffic stream.

b) Collision Analysis

As part of the operational analysis of the highway corridor, IBI Group conducted a collision analysis for the intersection (“Highway 148 Traffic Operations and Safety Review”, Draft Report). Collision data was available for 5 years from January 2007 to December 2011. During that period a total of 10 collisions occurred at the intersection (Exhibit 4), eight of which resulted in property damage only. The remaining two collisions also resulted in non-fatal injuries. The collisions can be classified as shown in Exhibit 5.

Based on the predictive methods of the Highway Safety Manual the number of collisions are higher than what would be predicted for this intersection configuration (Exhibit 6).

Allan Ortlieb – January 28, 2016_rev1

Exhibit 4: Collision diagram for the intersection (2007 – 2011)

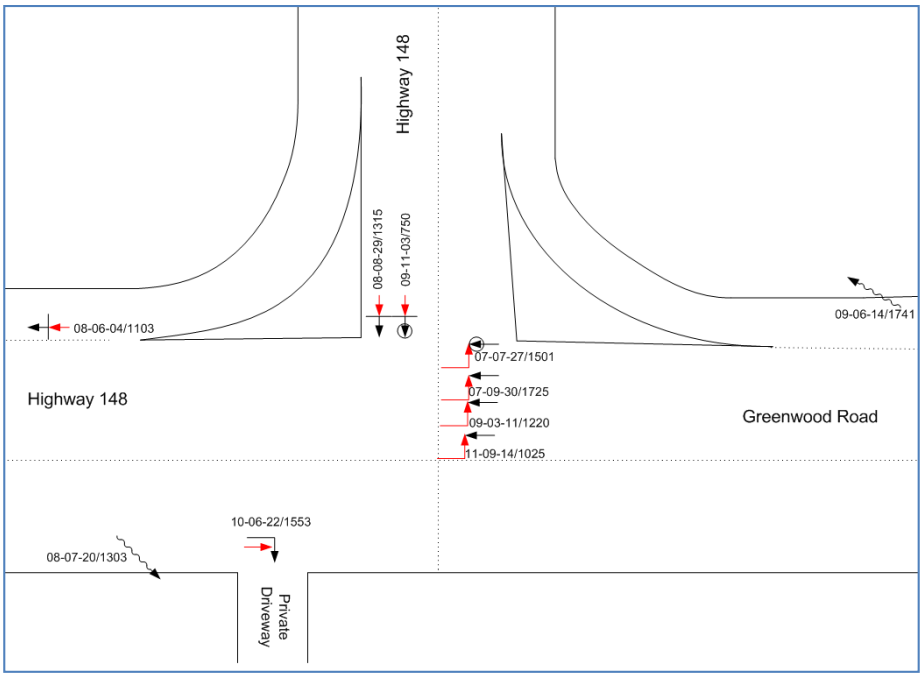


Exhibit 5: Collision types (2007 – 2011)

COLLISION TYPE	LOCATION	NO. OF INCIDENTS
Rear-ending	Stop-controlled minor intersection approach	2
	WBR acceleration taper	1
	SBT vehicle colliding with vehicle at the driveway of the self-storage business	1
Single vehicle leaving roadway	NBR deceleration taper	1
	SBT traffic lane	1
SBL turning vehicle colliding with NBT vehicle	SBL traffic lane	4
Total		10

Exhibit 6: Predictive collision analysis (2007 – 2011)

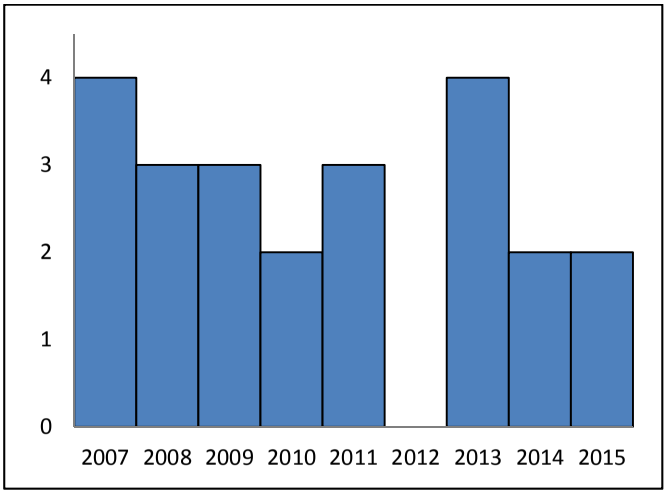
COLLISIONS	FATAL AND NON-FATAL INJURIES	PROPERTY DAMAGE ONLY	TOTAL
Observed	2	8	10
Predicted	0.72	1.61	2.33
Expected	1.09	4.30	5.39
Excess	0.37	2.69	3.06

Recent Collision Experience

The above collision analysis only considered collisions between 2007 and 2011, and therefore likely did not fully capture potential traffic-safety effects relating to the closure of the Ultramar gas station. Based on additional collision data received from MTO, it was determined that in total 23 collisions were recorded in the vicinity of the intersection between 2007 and 2015, i.e. an average of 2.55 collisions per year. Exhibit 7 illustrates a year-on-year variability of the number of collisions. Based on the collision records, it is difficult to identify only those related to vehicles exiting the WBR channel and turning into the Esso driveway, but it appears that of the 23 collisions only three can potentially be linked to the Esso driveway, one each in 2008, 2014 and 2015.

Therefore, the concern raised by residents regarding conflicts between vehicles turning into the Esso station and the through volumes along Highway 148, do not appear to be reflected in the in the collision data available.

Exhibit 7: Collision experience in the vicinity of the intersection, 2007 – 2015



2.0 Potential Design Alternatives

As part of the planned pavement rehabilitation, modifications of the existing intersection configuration should be considered to mitigate the above geometric deficiencies and safety concerns. Beyond the “do nothing” alternative the following alternatives are technically feasible:

- Modify the WBR channelization;
- Remove WBR channelization;
- Signalize intersection;
- Convert intersection to roundabout; and
- Modify commercial access configurations.

In addition, minor improvements at the intersection may be considered, including provision of pavement markings for the WBR channelization and provision of additional signage (“hidden driveways ahead”).

Option 1 - Provide Pavement Markings for the WBR Channelization

The following pavement markings, which are specified in OTM Book 11 (Figure 14) for demarcation of acceleration tapers at channelized intersections are presently not provided:

- Continuity line between the gore and the end of the taper: 3-3-3, 20 cm, white.
- Edge line from 100 metres in advance of taper start to 30 metres beyond the taper end: solid, 20 cm, white.

These pavement markings will be beneficial as they inform merging drivers that they do not have the right of way.

Option 2- Provide Additional Signage

Warning signs at the beginning of the WBR curve should be considered to warn drivers of driveways within the taper. However, in compliance with OTM Book 6 hidden intersection signage (Wa-13A and Wa-18t) should not be used for this purpose.

Option 3 - Modify the WBR Channelization

a) Upgrade taper to speed-change lane

Replacing the existing direct acceleration taper on Highway 148 with a speed-change lane will upgrade the right turn to current standards and drivers more time to accelerate to highway operating speeds prior to merging into the NBT lane. However, extending the speed-change lane will also increase the number of private driveways located within the auxiliary lane. It is also unclear whether this modification will alter behaviour of drivers attempting to enter the Esso gas station.

Our preliminary review indicates that the speed-change lane will not require additional property.

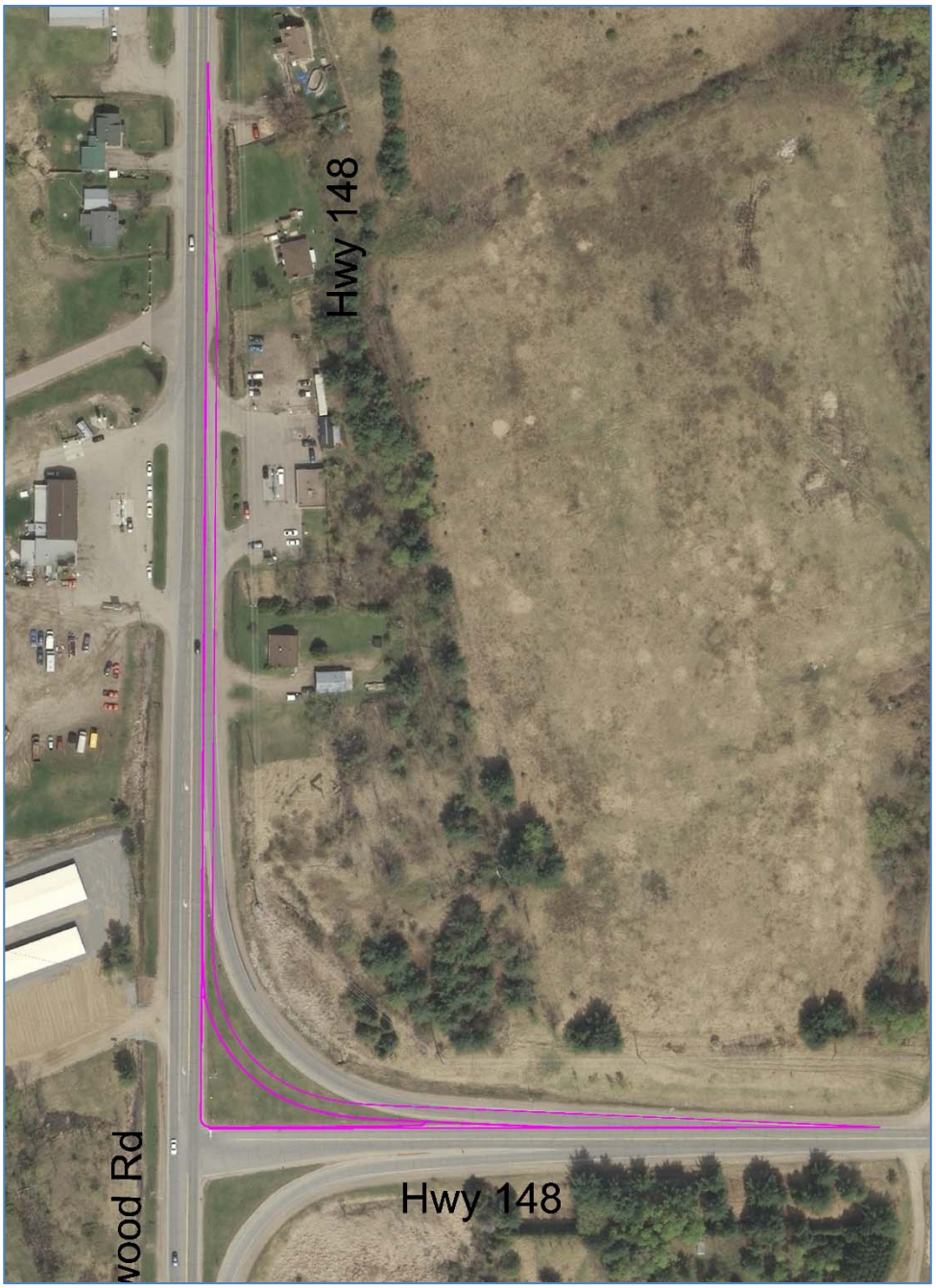
b) Reduce the curve radius

The existing curve radius of the WBR channelization is 70 metres. Tightening the curve will have several benefits:

- The distance between the start of the speed-change lane and the first residential driveway is increased.
- The design speed for the right turn is reduced which may reduce the risk of collisions at driveways located on the speed-change lane. For instance, the design speed of a channel with radius of 45 metres is 40 km/h. The existing channel has a design speed of approximately 47 km/h.
- The distance between the gore and the Esso driveway is increased, which will force merging drivers attempting to access the gas station to “establish themselves” as drivers on Highway 148 before stopping at the driveway. It will also provide NBT drivers a potential “slip-around”, by using the speed-change lane to overtake stopped vehicles on the right.

Exhibit 8 shows a potential channel configuration with speed-change lane and a curve radius of 45 metres.

Exhibit 8: Provision of speed-change lane with reduced curve radius

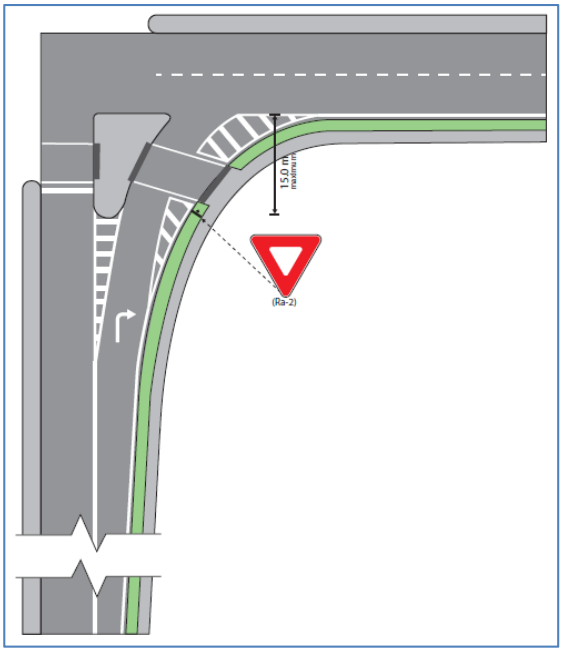


c) Smart Channel

The existing channel could also be replaced with a so-called “smart channel”, which does not provide an acceleration taper or lane. Exhibit 9 shows this channel type. However, this type of channel is more appropriate for low-speed urban conditions and particularly at signalized intersections. At the Greenwood intersection it would not be possible to eliminate situations where a WBL vehicle may obstruct intersection sightlines for a WBR vehicle (or vice versa).

Also note that the horizontal curvature of Greenwood Road south of the intersection will limit intersection sight distance to approximately 275 metres, which is less than the sight distance of 375 metres required by the WBR movement (i.e. vehicle turning right with another vehicle approaching in the travel direction). While it may be acceptable to compromise this sight distance at intersections with low traffic volumes at either the minor or major intersection approach, reduced sight distances at the Greenwood intersection are likely to create additional traffic-safety concerns.

Exhibit 9: Smart channel



Source: OTM, Book 15 (draft 2014), Fig. 50

d) Remove WBR Channelization

Alternatively the WBR channel could be removed, thereby changing the WBR movement to stop control. This will increase delays to WBR motorists, but eliminates concerns with respect to the traffic safety at the Esso gas station.

The preferred design will be a combined left/right-turn lane, due to safety concerns for exclusive left- and right-turn lanes at minor approaches of unsignalized intersections. Based on existing traffic volumes, operational it is anticipated that this configuration will operate satisfactorily (i.e. Level of Service of C or better). However, the sight-distance constraints discussed above would also apply to this configuration. In addition, provision of a combined WBLR lane entails the risk that a future increase in westbound traffic volumes could necessitate further intersection improvements, e.g., signalization.

e) Modify the Southbound Left-turn Lane

Exhibit 1 showed that the existing SBL lane, and particularly the taper length, is substandard. The taper length was probably reduced during construction to avoid overlapping with the Esso and Ultramar driveways. However, since no rear-ending collisions were reported between SBL and SBT vehicles, increasing the length of the SBL taper does not appear necessary.

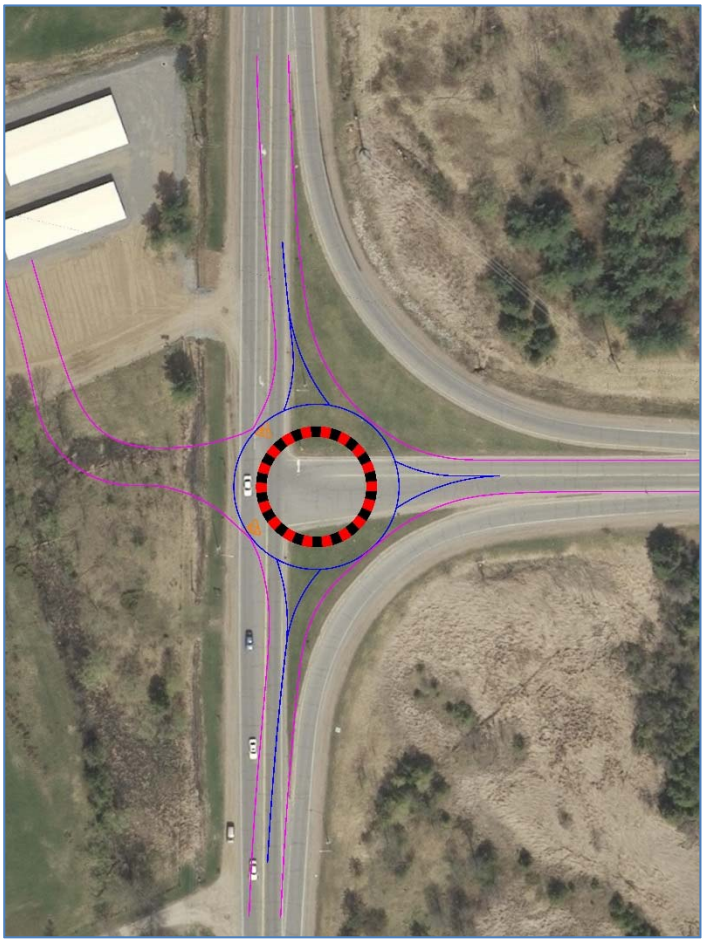
f) Signalize Intersection

Signalization of the intersection would be expected to mitigate collisions due to an SBL turning vehicle colliding with an NBT vehicle. In addition, safety concerns with respect to the Esso gas station would be eliminated, if the WBR channelization were removed as part of the signalization. However, signalization is not warranted (OTM Book 12).

g) Convert Intersection to Roundabout

Replacing the intersection with a roundabout would also eliminate safety concerns with respect to the Esso gas station and collisions of SBL vehicles with NBT vehicles. The roundabout would be expected to operate well. Implementation of the roundabout would require no additional property, except for realigning the driveway of the self-storage business toward the intersection. Exhibit 10 shows a concept design for the roundabout. However, we understand that MTO's policy is to consider roundabouts only at intersections where signalization is warranted.

Exhibit 10: Concept design for roundabout



h) Modify Commercial Access Configuration

There are several opportunities for modifying the commercial driveways to mitigate safety concerns.

Implement Raised Median at the North Intersection Approach

A raised median in the north intersection approach would prevent WBR drivers from entering the Esso driveway. However, this would create adverse business impacts for the Esso gas station. In addition, it is likely that drivers would then make U-turns at the northern limit of the median to access the gas station, thereby creating additional safety concerns.

Provide a Left-turn Lane at the Esso Driveway

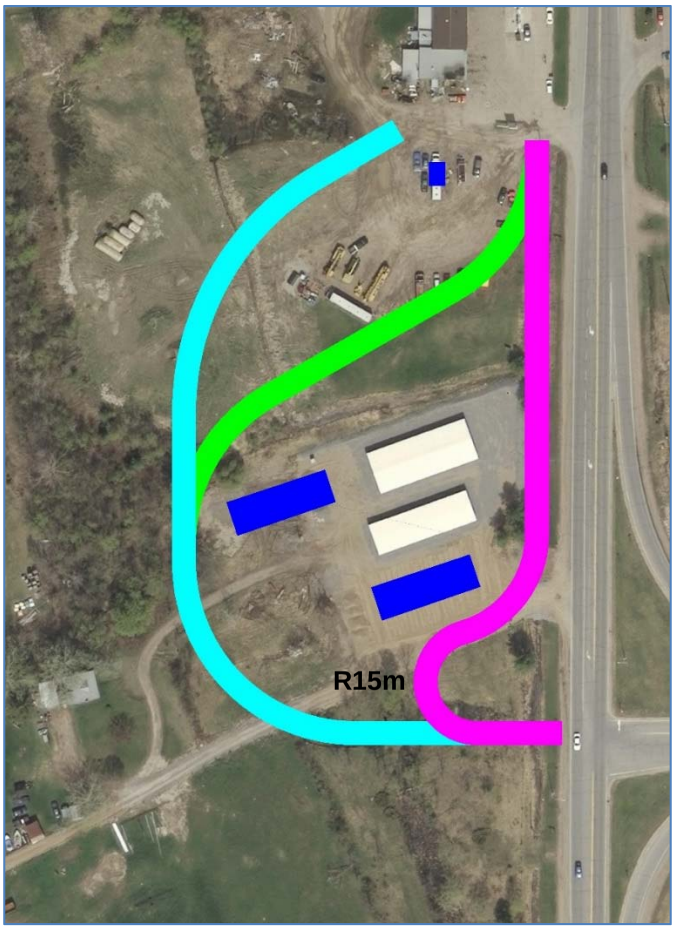
A NBL turn lane at the Esso driveway could be provided, which would reduce the risk that drivers stop in the NBT lane. However, this treatment would require shortening the existing SBL intersection turn lane, which is already substandard.

Relocate the Esso Driveways

Opportunities for relocating the Esso driveways are limited. Alternatives are (a) the existing Somerville Designer Stone driveway; and (b) a new driveway at the intersection, which would also serve the self-storage business. Exhibit 11 shows several potential alignments for a new Esso driveway. The exhibit indicates that a new driveway would require purchase of additional property and may also entail impacts to the natural environment.

Note that the magenta alignment would require very small curve radii of approximately 15 metres. This alignment would therefore be difficult for larger trucks. We would anticipate significant objections to any driveway relocations by the operator of the gas station. A new driveway would potentially interfere with operations of the self-storage business as well.

Exhibit 11: Potential alignments for a new Esso driveway



Improvements for the Driveway of the Self-storage Business

As noted above, it would be desirable to incorporate the driveway of the self-storage business with the intersection. In addition, a right-turn taper into the development may be considered.

3.0 Assessment of Alternatives

3.1 Initial Screening

Several design alternatives for the intersection can be screened out without a detailed evaluation (Exhibit 12).

Exhibit 12: Screening of alternatives

DESIGN ALTERNATIVE	REASONS FOR ELIMINATION
Signalize intersection	Signalization warrants of OTM Book 12 are not met.
Convert intersection to roundabout	MTO's policy is to consider roundabouts only at intersections for which signalization is warranted.
Lengthen the southbound left-turn lane	Increasing the taper length would result in overlap with the Esso gas station. Based on the collision data, lengthening of the taper is not expected to provide significant safety improvements.
Shorten the southbound left-turn lane to provide an NBL turn lane at the Esso gas station	Existing SBL taper length is already below GDSOH requirements.
Provide a raised median at the north intersection approach	Adverse business impacts for the Esso gas station and potential for creating unsafe traffic conditions due to U-turns.
Modify access configuration for Esso gas station	Purchase of additional property would be required. Adverse business impacts for Esso and potentially the self-storage business.
Implement a "smart channel" for the WBR movement	This treatment is untested for high-speed roadways. There are significant intersection sight-distance concerns.

3.2 Detailed Evaluation

The design alternatives for the intersection that were not screened are:

- Do nothing, i.e. retain the existing intersection layout;
- Maintain the WBR channelization, but provide an acceleration lane and/or reduce the curve radius; and
- Remove the WBR channelization and convert the WBR movement to stop-control.

Exhibit 13 provides an evaluation of these (main) design alternatives, reducing the WBR channelization from R=70m to R=45m is preferred, in conjunction with providing a parallel acceleration lane of 235m, based on a 100km/h.

In addition, the following measures should be considered: (a) provision of pavement markings for the WBR channelization and signage ("hidden driveways ahead") if channelization is maintained; and (b) relocation driveway of the self-storage business toward the intersection.

Exhibit 13: Evaluation matrix for main design alternatives

CRITERIA	DO NOTHING	REDUCE RADIUS OF WBR CHANNEL AND PROVIDE STANDARD ACELERATION LNAE	REMOVE WBR CHANNEL
Intersection operations and safety	*Negative:* No improvements to intersection safety.	*Positive:* Reduced turn speed for WBR vehicles may reduce collision risk. Increases decision time for drivers to merge. *Negative:* Does not reduce collisions between SBL and NBR vehicles.	*Negative:* Increased delay for WBR drivers. *Negative:* Does not reduce collisions between SBL and NBR vehicles. *Negative:* Intersection sight distance concerns for the WBR movement. *Negative:* Risk that further intersection upgrades may be required in the future.
Driveway safety	*Negative:* No improvements to driveway safety.	*Positive:* Reduces collision risk at the private driveway at the end of the existing taper. *Positive:* Mitigates (but does not fully eliminate) concerns regarding drivers at the Esso driveway stopping immediately upon entering Highway 148. *Negative:* Increases the number of driveways on the auxiliary lane	*Positive:* Eliminates situations where drivers at the Esso driveway stop immediately upon entering Highway 148.
Cost	None	Medium	Low
Property impacts	None	None	None
Business impacts	None	None	None
Impacts to natural environment	None	Additional green space can be provided adjacent to the channel.	Additional green space can be provided adjacent to the channel.
Compliance with design standards	Not compliant due to absence of acceleration lane.	No impact with respect to design compliance.	Yes
RANKING	NOT PREFERRED	ACCEPTABLE	NOT PREFERRED

4.0 Conclusion

This memorandum has provided an evaluation of the design alternatives for the intersection of Highway 148 and Greenwood Road within the context of the planned pavement rehabilitation for Highway 148. One of the main concerns expressed by residents, relates to the WBR turn channel and failure of this traffic to yield to traffic travelling northbound on Highway 148. A second concern is the potential relates to vehicles turning left into the Esso gas station, even though the analysis of available collision data could not substantiate a significant problem.

To address these concerns, it is recommended to reduce the curve radius of the WBR intersection channel from R=70m to R=45m. It is also recommended to improve traffic signage at the end of the WBR channel (e.g., provision of yield signs) and to provide pavement markings to separate the WBT lane and the WBR acceleration taper. This treatment is expected somewhat mitigate operational and safety concerns associated with vehicles merging to quickly into the Highway 148 northbound lane, as well as increase the distance between the bullnose and the entrance to the Esso station. Signalization or conversion of the intersection to a roundabout could provide additional safety benefits, however neither of these treatments are currently warranted.

Appendix C – Fish and Fish Habitat Assessment

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May 23, 2017

Marianne Alden-Radue, Environmental Planner
IBI Group
410 Albert Street, Suite 101
Waterloo ON N2L 3V3

Dear Marianne:

Re: Total Project Management (TPM) for Preliminary Design of Highway 148, Pembroke to Greenwood Road, Township of Laurentian Valley - G.W.P. *214-00-00*
Draft Fish and Fish Habitat Impact Assessment Technical Memorandum

1.0 Introduction

The Ministry of Transportation of Ontario (MTO) has retained IBI Group to complete the Total Project Management (TPM) for Preliminary Design on Highway 148 from Pembroke to Greenwood Road, Township of Laurentian Valley, G.W.P: 214-00-00, Contract Number: 4013-0034. This memorandum summarizes the fish and fish habitat conditions and impact assessment within this study area, from west of Angus Campbell Drive to Greenwood Road (Highway 40), presented in **Figure 1**.

The proposed road improvements to Highway 148 within the study limits consists of the following:

- Construction of concrete sidewalks;
- Construction of paved shoulders;
- Profile adjustments (asphalt padding or re-grading of granular sub-base);
- Road widening /full depth reconstruction; and
- Property acquisitions.

This preliminary design study is following the planning process for Group "B" projects under the *Class Environmental Assessment for Provincial Transportation Facilities* (MTO 2000), which is approved under the Ontario *Environmental Assessment Act.* IBI Group is managing the study on behalf of MTO. LGL Limited is providing natural sciences services with regards to aquatic habitat/fisheries on behalf of IBI. The fisheries assessment for this preliminary design study was undertaken in accordance with the MTO *Environmental Guide for Fish and Fish Habitat* (2009) and the PILOT *MTO/DFO/OMNR Protocol for Protecting Fish and Fish Habitat on Provincial Transportation Undertakings* (2016a). The purpose of this report is to document the existing conditions and assess any potential impacts to fish and fish habitat within the study area.

Five culvert crossings that either support or have the potential to support fish or fish habitat are found in the study area. These culverts are labelled C1 – C5 and are described in more detail in the sections below.

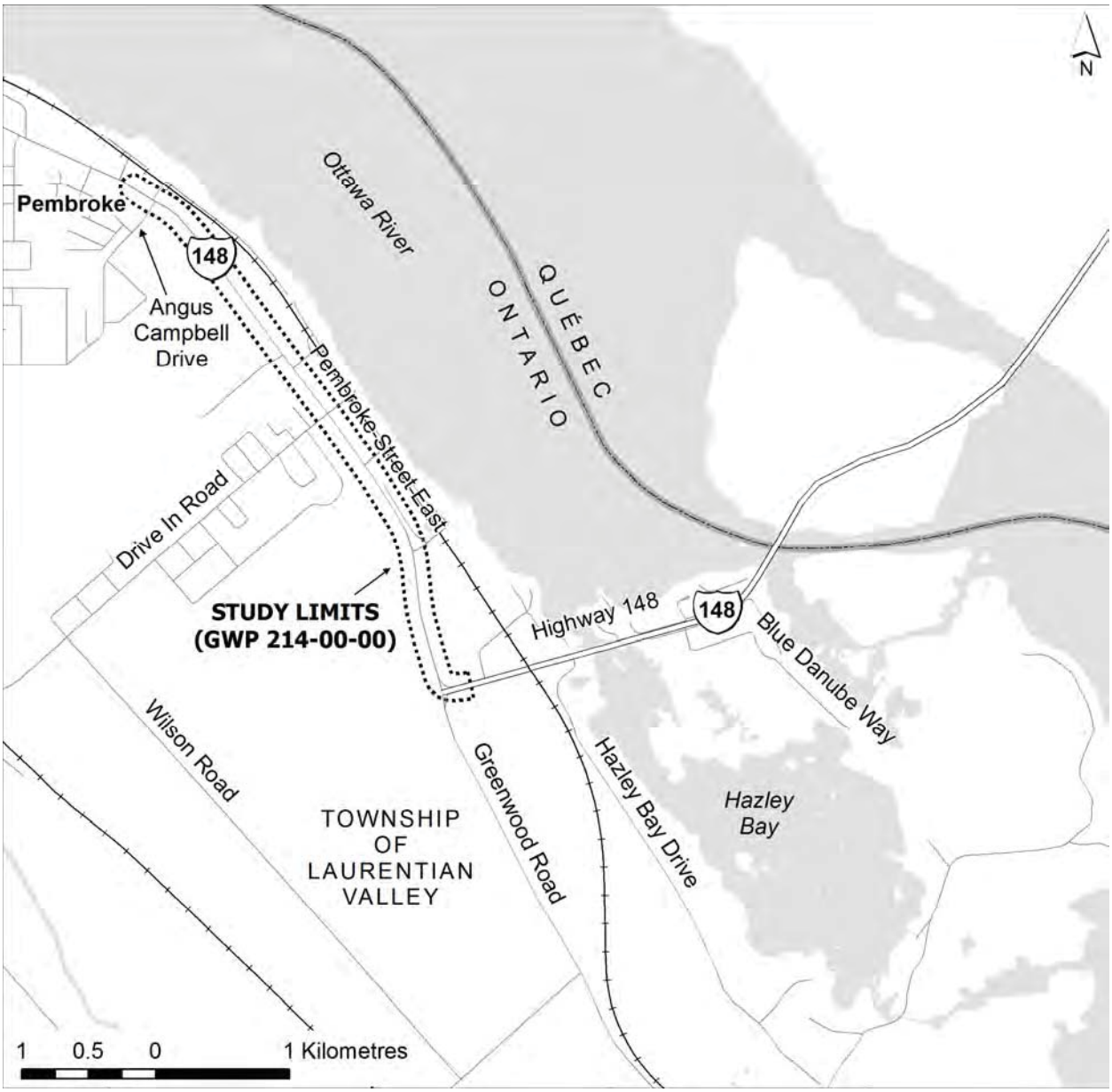

FIGURE 1. HIGHWAY 148 FROM PEMBROKE TO GREENWOOD ROAD KEY PLAN

2.0 Constraints and Opportunities Map

The purpose of the constraints and opportunities map is to show biological and physical constraints (i.e. fish and fish habitat) to highway development. The study area was reviewed to identify opportunities and constraints using the criteria outlined in the MTO *Environmental Guide for Fish and Fish Habitat* (2009). See **Figure 2** for a constraints/opportunities map of the study area and **Table 1** for the location of the culvert crossings.

LEGEND

- Study Limits
- Watercourse
- Flow Direction
- Permanent flow warmwater - C2,C3,C4,C5
- Intermittent flow warmwater - C1

Data Sources: LGL Limited field Surveys, Ministry of Natural Resources and Forestry.

200 100 0 200 Metres

N

FISHERIES CONSTRAINT AND OPPORTUNITIES

LGL LIMITED
environmental research associates

Project:	TA8489	**Figure:**	2
Date:	May, 2017	**Prepared By:**	MWF
Scale:	1 : 11,000	**Checked By:**	JC

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TABLE 1/TEMPLATE 10.1. LOCATION OF WORK TABLE

Waterbody	Highway	Municipality	Location of Stream (GPS Coordinates)
C1 (11+176)	Highway 148	Laurentian Valley	45°48.99, 77° 4.56
C2 (12+331)	Highway 148	Laurentian Valley	45°48.48, 77° 4.03
C3 (12+584)	Highway 148	Laurentian Valley	45°48.34, 77° 4.01
C4 (13+078)	Highway 148	Laurentian Valley	45°48.08, 77° 3.93
C5 (10+051)	Highway 148	Laurentian Valley	45°48.04, 77° 3.87

3.0 Background Data Collection

The following data sources relevant to fish and fish habitat within the study area were reviewed:

- DFO. 2014/2015. *Email Correspondence with Dave Balint, DFO SAR Coordinator*
- DFO. June 2, 2015. Phone Correspondence with Rick Kiriluk, Fish Biologist - Triage Unit.
- MNRF. 2014. *Natural Heritage Information Centre*.
- MNRF. 2015. *Response to Data Request from OMNR Pembroke District (M. Lyons). March 6, 2015. Further information pending (i.e. fisheries sensitivity).*
- McIntosh Perry. December 2010. *Fish and Fish Habitat Existing Conditions Report Rehabilitation of Hazley Bay Bridge and Cross Culvert Replacement Highway 148, from the Quebec Border approximately 5 km to the Pembroke City Limits. Final Report.*

Background information was collected from a number of data sources and through correspondence with the MNRF Pembroke Office and DFO. The study area is located within the Pembroke District of the MNRF. In accordance with the MTO Fisheries Protocol, a project notification letter was sent to the MNRF – Pembroke Office on January 5, 2015 to request information with regards to the thermal regime, fish habitat, fish communities, fisheries management considerations, fisheries sensitivity, in-water timing windows for construction and presence of aquatic SAR. The MNRF provided a formal response to the information request on March 6, 2015.

In December 2010, McIntosh Perry completed a Fish and Fish Habitat Existing Conditions Report for Rehabilitation of Hazley Bay Bridge and Cross Culvert Replacement on Highway 148, from the Quebec Border for approximately 5 km to the Pembroke City Limits. In this report they identified numerous fish species present in the study area. A summary of the fish species reported in this document is provided in **Table 2**.

4.0 Field Investigations

The existing conditions information was collected during field investigations in the fall of 2014 on November 26 and in spring 2015 on June 2 by LGL fisheries staff. The determination of direct fish habitat use based on fish sampling has been taken from the McIntosh Perry Report.

5.0 Existing Fish and Fish Habitat Conditions

5.1 Fish and Fish Habitat in the Study Area

Aquatic habitat within the study area is described in detail in the following sections and is summarized in **Table 2**.

Crossing C1 (11+176)
This is an un-named tributary of the Ottawa River. The structure at this crossing is an open bottom concrete culvert that is 1.22 X 0.90 m in size and 31.2 m in length. Flow direction is from west to east toward the Ottawa River. The McIntosh Perry reports intermittent flow with no fish captured during sampling activities. However this crossing should be considered indirect fish habitat with a contributing function to downstream fish habitat. For the location of this culvert crossing and those below refer to **Figure 2**.

Crossing C2 (12+331)
This is an un-named tributary of the Ottawa River. The structure at this crossing is an open bottom concrete culvert that is 2.4 X 1.5 m in size and 28.5 m in length. Flow direction is from south to north toward the Ottawa River. The McIntosh Perry reports permanent flow and an associated warmwater forage fish community at this crossing consisting of White Sucker (*Catostomus commersoni*) and Central Mudminnow.

Crossing C3 (12+584)
This is an un-named tributary of the Ottawa River. The structure at this crossing is a concrete box culvert that is 0.91 X 0.61 m in size and 23.2 m in length. Flow direction is from south to north toward the Ottawa River. The McIntosh Perry reports permanent flow and an associated warmwater forage fish community at this crossing consisting of Brassy Minnow (*Hybognathus hankinsoni*), Creek Chub (*Semotilus atromaculatus*) and Brook Stickleback.

Crossing C4 (13+078)
This is an un-named tributary of the Ottawa River. The structure at this crossing is a 900 mm diameter HDPE that is 34.25 m in length. Flow direction is from south to north toward the Ottawa River. The McIntosh Perry reports permanent flow and an associated warmwater forage fish community at this crossing consisting of Brook Stickleback and Central Mudminnow.

Crossing C5 (10+051)
This is an un-named tributary of the Ottawa River. The structure at this crossing is an open bottom concrete culvert that is 1.87 X 1.1 m in size and 46.46 m in length. Flow direction is from north to south. The McIntosh Perry reports permanent flow and an associated warmwater forage fish community at this crossing consisting of Brook Stickleback (*Culaea inconstans*) and Central Mudminnow (*Umbra limi*).

TABLE 2/TEMPLATE 10.2
EXISTING FISH AND FISH HABITAT EXISTING CONDITIONS SUMMARY

GWP or Project Name	Waterbody	Latitude	Longitude	Flow	Thermal Regime	Fish Habitat	*Fish Species Present	Substrate Type	Vegetation	Constraints and Opportunity	Important, Exceptional Fish Habitat	Species at Risk / Critical Habitat Present	**In-water Works Timing Window
Description	Name of waterbody and crossing #/station			Ephemeral, Intermittent, Permanent	Warm, Cool, Cold	CRA fishery*, supports CRA fishery, not fish habitat	Indicate if the information is from background secondary source data (indicate source) or if obtained through field investigations	E.g. Boulder, cobble, rubble, gravel, sand, muck, etc.	Riparian & In-Stream** species	E.g. Perched culvert, eroding bank, fish passage barrier, undersized CSP	E.g. Ground water upwelling, spawning areas, refugia, migratory routes	Indicate/describe the species at risk and/or critical habitat present	Timing window for when in-water work can occur
	C1 (11+176)	45°48.99	77° 4.56	Intermittent	Warm	No	None	Gravel, sand	Woodland, shrub thicket	-	-	-	Unknown sensitivity (TBD)
	C2 (12+331)	45°48.48	77° 4.03	Permanent	Warm	Yes	White Sucker, Central Mudminnow	Muck	Phragmites	-	-	-	Unknown sensitivity (TBD)
	C3 (12+584)	45°48.34	77° 4.01	Permanent	Warm	Yes	Brassy Minnow, Brook Stickleback, Creek Chub	Clay, muck	Shrub thicket, cattails	-	-	-	Unknown sensitivity (TBD)
	C4 (13+078)	45°48.08	77° 3.93	Permanent	Warm	Yes	Brook Stickleback, Central Mudminnow	Clay, muck	Woodland, cattails	-	-	-	Unknown sensitivity (TBD)
	C5 (10+051)	45°48.04	77° 3.87	Permanent	Warm	Yes	Brook Stickleback, Central Mudminnow	Silt, sand	Woodland, shrub thicket, cattails	-	-	-	Unknown sensitivity (TBD)

*Based on McIntosh Perry Report (2010)

** MNR Correspondence, Pembroke District Office received March 6, 2015

5.2 Aquatic Species at Risk

No species at risk have been identified through background data review in any of the watercourses within the study area (11+176 (C1), 12+331 (C2), 12+584 (C3), 13+078 (C4) and (10+051 (C5)).

5.3 Critical Fish Habitat

No critical habitat was identified within any of the watercourses (11+176 (C1), 12+331 (C2), 12+584 (C3), 13+078 (C4) and 10+051 (C5)) in the study area.

5.4 Thermal Regime

Watercourses 12+331 (C2), 12+584 (C3), 13+078 (C4) and (10+051 (C5) in the study area support a warmwater fish community with a typical in-water works timing window of July 1 – March 31. This timing window is to be confirmed with MNRF. The watercourse at 11+176 (C1) should be managed similar to the watercourses above, despite the indirect fish habitat function.

6.0 Impact Assessment

Appendix B (attached) presents the New Construction design drawings outlining the proposed improvements produced by IBI Group. These improvements will not affect fish and fish habitat in the study area. The proposed work will all be outside of the watercourse crossing areas where work is proposed. However, mitigation measures are proposed below to prevent negative effects to fish and fish habitat. The impacts and mitigation are addressed in the sections below.

7.0 Mitigation Measures

To mitigate for the harmful alteration of fish habitat, the measures identified below will be implemented pre-, during and post-construction at the locations where work is proposed in the vicinity of culverts C1 – C5.

7.1 Soil Disturbance and Erosion and Sediment Control

The Highway 148 improvements have the potential to suspend soil particles, resulting in the impairment of surface water quality. An increase in runoff may promote erosion downstream thus impairing water quality with sediments. Water quality treatment must be provided to maintain the existing quality of surface water within the study limits.

Standard erosion and sedimentation control measures must be followed during construction in the vicinity of culverts C1 – C5 in the study area, in accordance with Ontario Provincial Standard Specification (OPSS) 805 (Construction Specification for Temporary Erosion and Sediment Control Measures) to cover the installation, maintenance, monitoring and removal of the temporary erosion and sediment control measures and the removal of sediment accumulated by the control measures. The following temporary erosion and sedimentation control measures will be implemented:

- the extent and duration that soils are exposed to the elements will be kept to the minimum area and time necessary to perform the work;
- areas of riparian disturbances will be minimized and existing riparian vegetation will be retained, where feasible;

- seed and mulch, tackifier, and/or erosion control blanket will be provided in areas of soil disturbance to provide adequate slope protection and long-term slope stabilization;
- fiber roll flow check dams (will be placed at regular intervals in roadside ditches down-gradient from areas of soil disturbance to trap suspended sediments and reduce the erosive force of runoff; and
- monitoring and maintenance of erosion and sedimentation control measures will take place during construction to ensure their effectiveness.

These environmental protection measures will be implemented prior to construction commencement/any soil disturbance and will remain in place until construction is complete and soils have been re-stabilized. This will greatly reduce the potential for soil erosion and impairment of surface water quality and fish habitat.

7.2 Contamination of Surface Water from Other Sources/Best Management Practices

There is also the potential for contamination of surface water from sources other than sediment (i.e. spills or other materials/equipment). Best management/construction practices and control of all construction operations will be implemented during construction to reduce the potential for spills or other materials/equipment from entering the watercourses within the study area. The following measures will be employed:

- storage, stockpiling and staging areas will be delineated prior to construction and inspected in accordance with the current *MTO Construction Administration and Inspection Task Manual;*
- in accordance with NSSP 0800A001 (Operational Constraint – Environmental - Watercourse/Fisheries Protection - General), construction material, excess material, construction debris, and empty containers will be stored away from the Hazley Bay Bridge and culverts C1 – C5 in the study area;
- in accordance with NSSP 0800A001 (Operational Constraint – Environmental - Watercourse/Fisheries Protection - General), equipment refueling, maintenance and washing activities will be conducted at a pre-determined site located at an adequate distance (minimum 30 m) from culverts C1 – C5 in the study area to prevent the entry of petroleum, oil or lubricants (POL) or other deleterious substances (including any debris, waste, rubble or concrete material), or their release to the environment. Any material which inadvertently enters the watercourses will be removed by the Contractor in a manner satisfactory to the Contract Administrator; and,
- all spills that could potentially cause damage to the environment should be reported to the Spills Action Centre of the Ministry of Environment and Climate Change (MOECC) and to Fisheries and Oceans Canada (DFO). In the event of a spill, containment and clean-up will be completed quickly and effectively.

These environmental protection measures will greatly reduce the potential for surface water contamination from spills of POL and from other materials/equipment from entering the watercourses within the study area, and will provide a contingency in the event of an unforeseen event.

8.0 Scale of Negative Residual Effects

The proposed work in the study area within the vicinity of culverts C1 to C5 qualify either as routine MTO works (as per Table 2 of MTO/DFO/MNRF Protocol) or the works are greater than 30 m from a watercourse. The proposed work will include: construction of concrete sidewalks; construction of paved shoulders; profile adjustments (asphalt padding or re-grading of granular sub-base); and road widening /full depth reconstruction. These works are similar to milling or resurfacing identified in the routine MTO works table.

No negative residual effects are anticipated as a result of these activities, provided that the mitigation measures described above are implemented.

9.0 Analysis of Fish and Fish Habitat Sensitivity

The watercourse crossings at culverts C2 – C5 directly support tolerant forage fish species and culvert C1 supports indirect fish habitat; therefore all of these crossings should have a low sensitivity ranking.

10.0 Categorization of Risk

The proposed work in the study area within the vicinity of culverts C1 to C5 qualify either as routine MTO works (as per Table 2) or the works are greater than 30 m from a watercourse. All of the watercourse crossings in the study area have a low sensitivity ranking based on their fish communities. As such, there is little to no risk to fish or fish habitat at these watercourse locations.

11.0 Conclusions

The work proposed in the vicinity of the Hazley Bay Bridge will have a low-medium level of risk to fish and fish habitat based on a low scale of negative effects and a high sensitivity of fish habitat. The work proposed in the vicinity of this structure will not impact fish or fish habitat or SAR or their habitat. The mitigation measures identified in this memorandum will ensure that no negative impacts will occur.

No impacts are expected to culverts C1 – C5, and especially at culverts C2 – C5 which directly support fish or fish habitat. The works within 30 m of each of these culverts is considered routine MTO works.

Should you have any questions regarding the existing conditions information provided in this technical memorandum, please feel free to contact me.

Yours truly,

LGL Limited, environmental research associates

Joseph Cavallo, B.Sc.
Senior Fisheries Biologist/Fisheries Assessment Specialist

APPENDIX B
IBI GROUP RECOMMENDED PLANS

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

HIGHWAY 148

RANKIN ST

ANGUS CAMPBELL DRIVE

PROPOSED TWLTL

EXTENSION OF RIGHT-TURN LANE

9+880 9+900 9+920 9+940 9+960 9+980 10+000 10+020 10+040 10+060 10+080 10+100 10+120 10+200 10+300

CONC BLK APARTMENTS

MTL CLAD BLDG

CONC BLK BLDG

FR BLDG RETIREMENT HOME

BR BLDG APARTMENTS

FR BLDG MOTEL

BR CHURCH

NOT SURE AB

J:\37432-Hwy148_Hwy17_EA\5.9 Drawings\59civil\layouts\37431-Hwy 148 layouts.dwg

February 24, 2017

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Ontario

SCALE:

HOR 10m 0 10 20 30m

4013-E-0034

HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 1

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

10+400 10+500 10+600 10+700

PROPOSED TWLTL

HWY 148

HIGHWAY 148

CLOSE ACCESS

SHOPPING ACCESS

WALMART ACCESS

CONC BLK RESTAURANT

CONC BLK LCBO

CONC BLK TD BANK

CONC BLK REITMANS

OT SURE ABOUT C/L.

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 2

J:\37432-Hwy148_Hwy17_EA\5.9 Drawings\59civil\layouts\37431-Hwy 148 layouts.dwg

February 24, 2017

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

PROPOSED TWLTL

HIGHWAY 148

HWY 148

10+800

10+900

11+000

11+100

CLOSE ACCESS

70m TAPER

EXTENSION OF EXISTING RIGHT-TURN LANE

CONC BLK BOSTON PIZZA

MTL CLAD BLDG

CONC BLK HARRINGTON

PEMBROKE PENTECOSTAL CEMETARY IRON FENCE

CONC BLK G

BHB

600 x 14.78 CSP

450 x 22.01 CSP

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 3

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

RESMER ROAD

HIGHWAY 148

ROBINSON LANE

PROPOSED TWLTL

PROPOSED TWLTL

100m PARALLEL LANE

CLOSE ACCESS

11+200

11+300

11+400

11+500

10+020

10+040

10+060

10+080

10+100

10+120

BHB

FG

FH

CONC BLK BLDG

MTL CLAD BLDG

STUCCO BLDG WINNERS

CONC BLK BLDG TIM HORTONS

FHB

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 4

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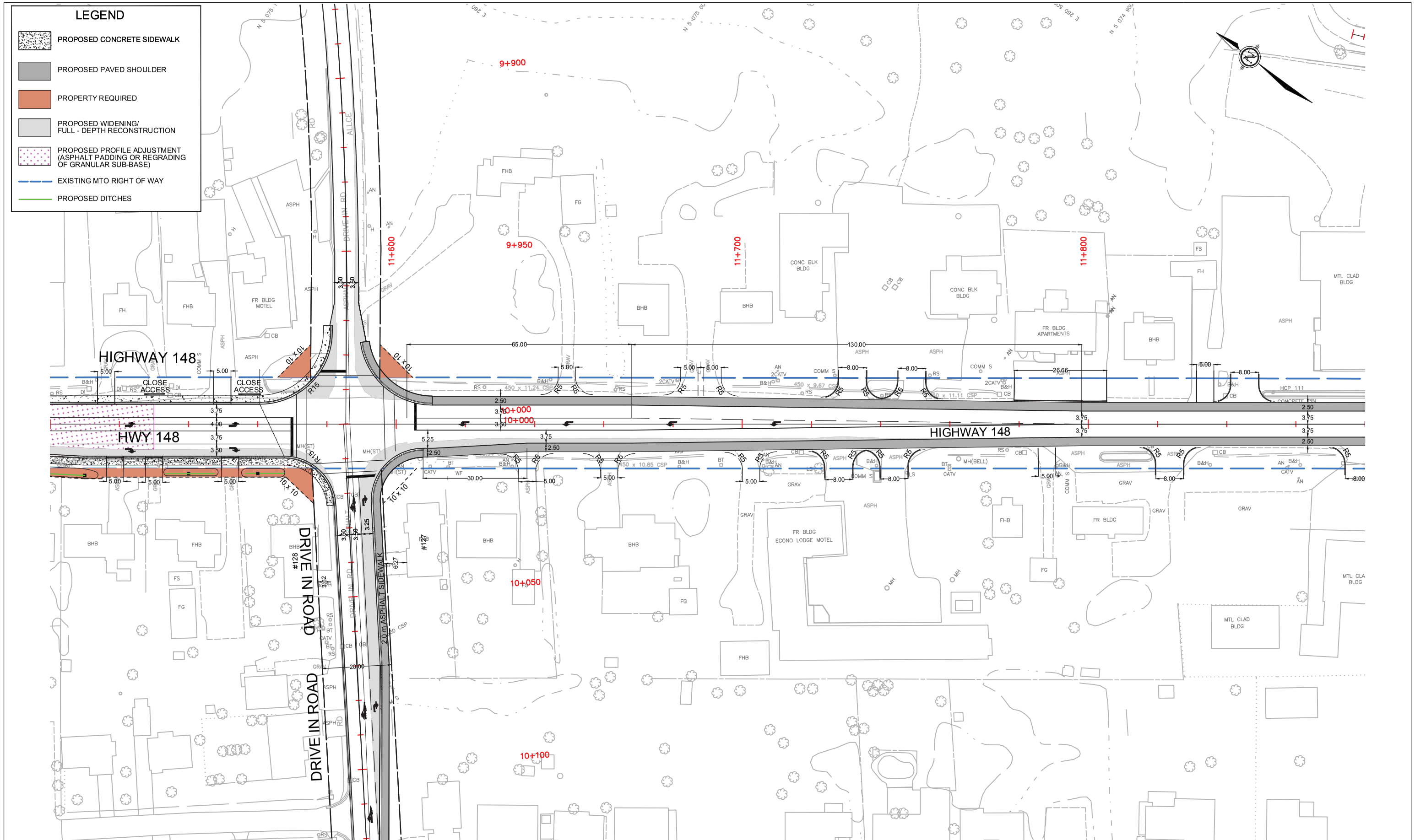

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET

5

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

DAIRY RD

HIGHWAY 148

9+920
9+940
9+960
9+980
10+000
11+900
12+000
12+100
12+200

CLOSE ACCESS

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 6

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February 24, 2017

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

OLD MILL RD

HIGHWAY 148

9+920 9+940 9+960 9+980 10+000 12+300 12+400 12+500 12+600

N 5 074 300 N 5 074 200

600 x 14.73 CSP 900 x 18.05 CSP 2400 x 1200 x 28.59 RIB 450 x 10.95 CSP 900 x 22.04 CSP 800 x 600 x 23.19 NRPD

HCP 113 RIB HCP 114 RIB

R15 R5 R2 8.00 5.00 3.50

MTL CLAD BLDG FHB BHB FG GRAV COMM S

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 7

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

12+700 12+800 12+900 13+000

80.00 m TAPER

160.00 m LEFT-TURN TAPER

HIGHWAY 148

HCM 00820030003

HCP 115 CONCRETE PIN

MTL CLAD BLDG WINMAR

MTL CLAD BLDG

CONC BLK BLDG

5 STONE PILLARS

450 x 11.94 CSP

450 x 10.90 CSP

450 CSP

450 x 10.82 CSP

450 x 9.25 CSP

450 x 9.02 CSP

600 CSP

N 5 074

N 5 073 900

N 5 073 700

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 8

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

PROPOSED ACCELERATION LANE

REDUCE RADIUS OF RAMP TO 45m SPIRAL PARAMETER = 40

2.5 m PAVED SHOULDER

2.5 m PAVED SHOULDER

150.00 m RIGHT-TURN LANE

85.00 m LEFT-TURN LANE

HIGHWAY 148

HIGHWAY 148

TRAXTON WAY

13+000

13+100

13+300

13+400

10+000

10+050

10+100

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 9

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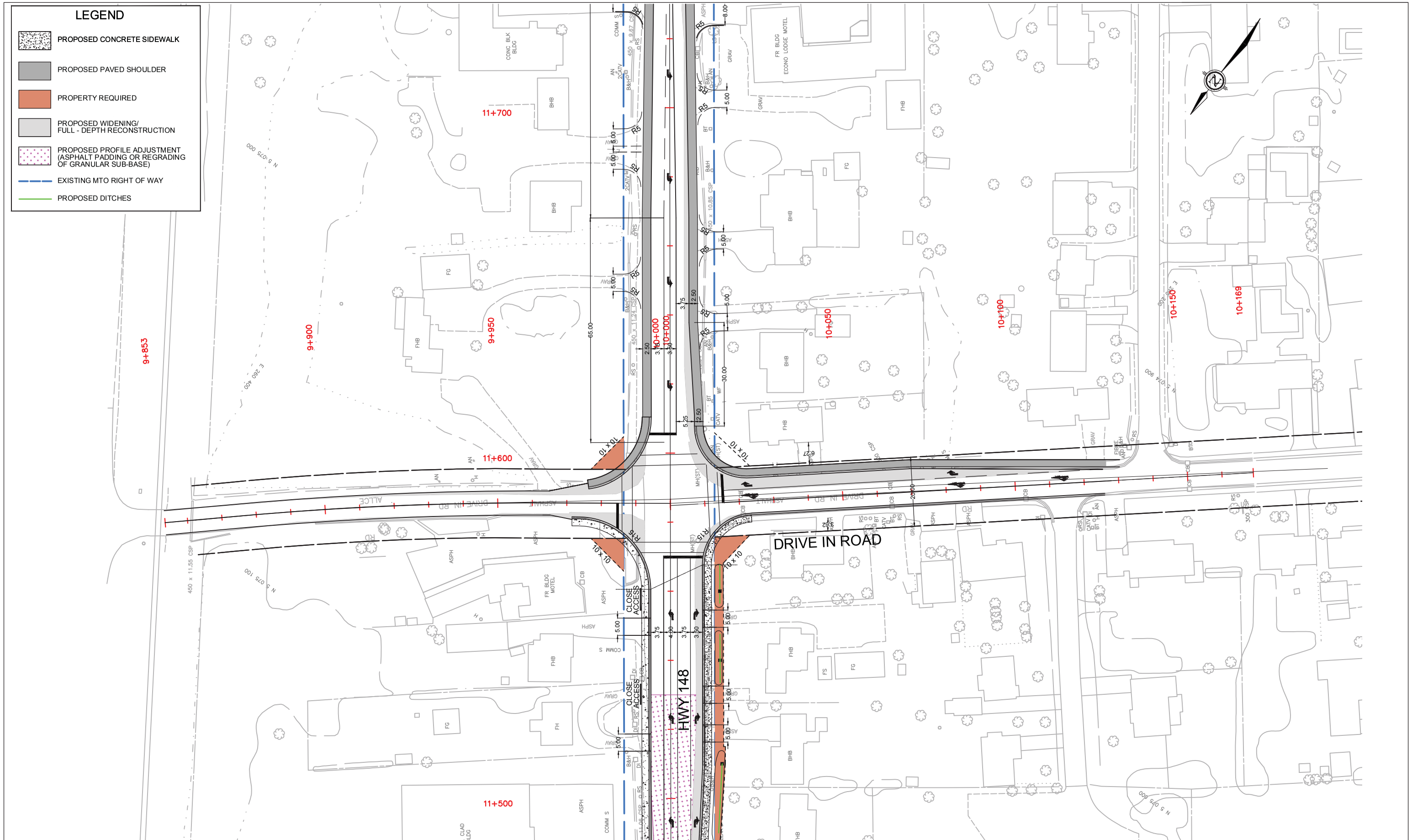

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PRELIMINARY DESIGN AND CLASS EA STUDY

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PRELIMINARY

SHEET
15

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February 24, 2017

LEGEND

- PROPOSED CONCRETE SIDEWALK
- PROPOSED PAVED SHOULDER
- PROPERTY REQUIRED
- PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
- PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
- EXISTING MTO RIGHT OF WAY
- PROPOSED DITCHES

2.5 m PAVED SHOULDER

2.5 m PAVED SHOULDER

PROPOSED ACCELERATION LANE

155.00 m

80.00 m TAPER

150.00 m RIGHT-TURN LANE

160.00 m LEFT-TURN TAPER

85.00 m LEFT-TURN LANE

2.5 m PAVED SHOULDER

HIGHWAY 148

HIGHWAY 148

HIGHWAY 148

GREENWOOD ROAD

12+900

13+000

13+100

13+200

13+300

10+000

10+050

10+100

10+150

J:\37432-Hwy148_Hwy17_EA\5.9 Drawings\56civil\layouts\37431-Hwy 148 layouts.dwg

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VER 1m 0 1 2 3m

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

RECOMMENDED PLAN

PRELIMINARY

SHEET 16

Appendix D – Terrestrial Assessment

HIGHWAY 148 (PEMBROKE TO GREENWOOD ROAD ROAD IMPROVEMENTS - PRELIMINARY DESIGN (GWP 214-00-00) TOWNSHIP OF LAURENTIAN VALLEY, COUNTY OF RENFREW

NATURAL ENVIRONMENT – TERRESTRIAL REPORT

Prepared for:	IBI Group
Submitted by:	Niblett Environmental Associates Inc.
File:	PN 15-013
Date:	August 2017

Niblett Environmental Associates Inc.
Biological Consultants

August 31, 2017 PN 15-013

Marianne Alden-Radue RPP
Environmental Planner

IBI GROUP
410 Albert Street, Suite 101
Waterloo ON N2L 3V3

RE: HIGHWAY 148 (PEMBROKE TO GREENWOOD ROAD)
ROAD IMPROVEMENTS - PRELIMINARY DESIGN (GWP 214-00-00)
TOWNSHIP OF LAURENTIAN VALLEY, COUNTY OF RENFREW

NATURAL ENVIRONMENT – TERRESTRIAL REPORT

Dear Ms. Alden-Radue:

We are pleased to submit our Natural Environment Terrestrial Report with regards to the proposed short term improvement works as part of the Preliminary Design for Highway 148.

If you have any questions or comments we would be pleased to provide additional assistance as needed.

Sincerely,

Chris Ellingwood
President and Sr. Terrestrial/Wetland Biologist

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ACKNOWLEDGEMENT

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Ernie Silhanek, Terrestrial and Wetland Biologist
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Will Pridham, GIS and Graphics Specialist

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PRELIMINARY DESIGN FOR HIGHWAY 148 SHORT TERM IMPROVEMENTS (PEMBROKE TO GREENWOOD ROAD) TOWNSHIP OF LAURENTIAN VALLEY, COUNTY OF RENFREW

NATURAL ENVIRONMENT - TERRESTRIAL REPORT

1.0 Introduction

1.1 Background

Niblett Environmental Associates Inc. (NEA) was retained by the IBI Group to complete the Natural Environment Terrestrial Report component of the Preliminary Design and Environmental Assessment Study for the Highway 148 Improvements. This document is one component of the Environmental Assessment (EA) process and will be included within the final Transportation Environmental Study Report submitted by IBI Group.

The Ministry of Transportation has initiated a Preliminary Design and Environmental Assessment Study for Highway 148 corridor short-term improvements for the section of roadway between Pembroke and Greenwood Road. This study was undertaken in order to fulfill the requirements of a Group 'B' project under the Class Environmental Assessment for Provincial Transportation Facilities (2000).

1.2 Study Scope

The Terrestrial Report documents the existing conditions of the terrestrial habitat, urban natural heritage features and wetlands. Significant natural features and linkages within the study area including Species at Risk and other Areas of Interest are identified.

1.3 Study Area Property Description

Highway 148 is a minor collector highway, connecting Pembroke to the Quebec border at L'Isle-aux-Allumettes and to the Quebec Route 148, a distance of approximately 5 km (Bevers, 2010). The study area is located within the Township of Laurentian Valley starting at the City of Pembroke limits west of Angus Campbell Drive and south to Greenwood

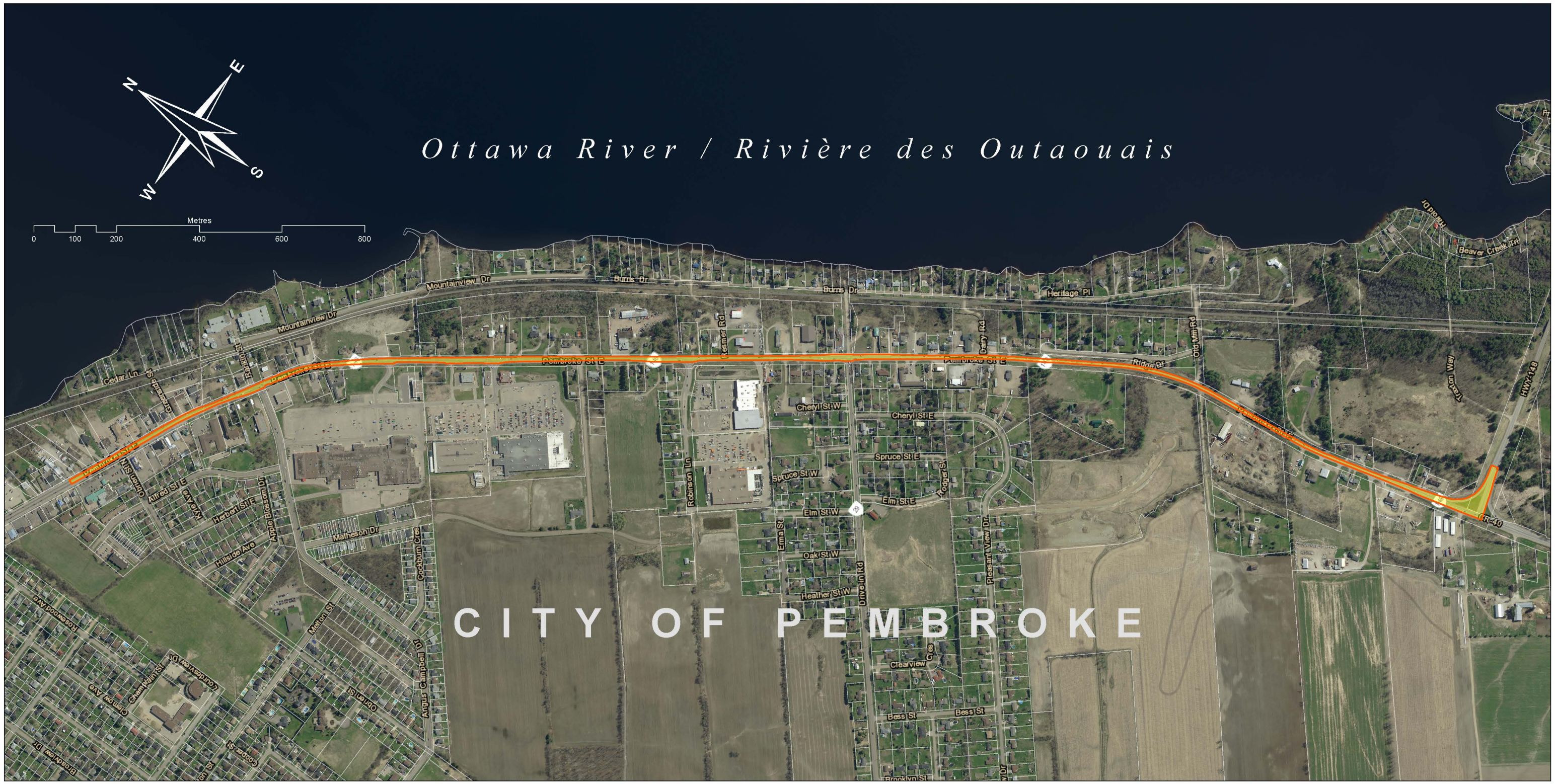
Road.(Figure 1). The project limits are restricted to the highway right-of-way (ROW) and those lands directly adjacent to the highway, typically within the 50m ROW corridor.

1.4 General Description of Natural Environment

As the study area is a linear corridor, a number of different environments were encountered along the approximate 3.2 km length of Highway 148. The study area is comprised comprised of a variety of commercial properties and residential dwellings.

For the most part, the highway traverses a landscape that is generally flat to gently rolling and is largely dominated by agricultural lands, woodlands, wetlands and open fields/grasslands. The focus of this report is on those wetland communities which are designated as provincially significant (PSW), woodlands and adjacent grassland communities where possible Species at Risk habitat occur.

There are no Life Science or Earth Science Areas of Natural and Scientific Interest (ANSI's), Environmentally Significant Areas (ESA's) or other designations on or within 120 m of the road allowance and project limits.



LEGEND

- Assessment Parcel
- Study Area (Hwy 148) Pt 1

Composite imagery acquired in 2014 as part of the DRAPE initiative.

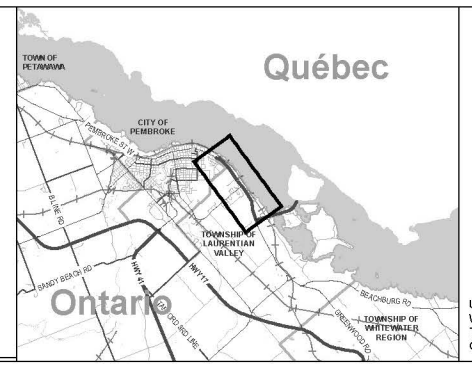


FIGURE 1: STUDY AREA

Highway 148
County of Pembroke
Pembroke District

UTM Zone 18
WKID: 26918 Authority: EPSG
Transverse Mercator
GCS North American 1983, ESRI ArcGIS 10.1

Map was produced by NEA under public license from Ontario Ministry of Natural Resources. Copyright (c) Queens Printer 2016.

REVISIONS

NO	BY	DATE	DESCRIPTION
4	W.P.	22/06/2017	Updated study areas and aerials.

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PROJECT NO: PN15-013
REVISION NO.: RV-04
PROJECT: Highway 148 & 7
CLIENT: Insert client here

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2.0 Study Methodology

2.1 General Methodology

Our approach to the preparation of the Terrestrial Report consisted of three distinct phases.

In the first phase we collected and reviewed available information on the site including previously completed reports, Existing Environmental Conditions Report Rehabilitation of Hazley Bay Bridge by McIntosh Perry (2011), Fish and Fish Habitat Impact Assessment Report Hwy 148 by McIntosh Perry, (2011), recent and historical aerial photographs, key natural features GIS mapping, Official Plan schedules of the Township of Laurentian Valley and the Ministry of Natural Resources and Forestry (MNRF). Literature reviewed also included MNRF NHIC database and local natural area reports. Also reviewed were MTO Contract Drawings: 2011-4051, 1965-0135; the Original Construction Drawings provided by the Ministry of Transportation (MTO), MTO Class Environmental Assessment for Provincial Transportation Facilities (2000), Species At Risk screening by McIntosh Perry (2014) and minutes from project meetings.

Other information that is readily available for the site were reviewed which include: key natural heritage features from MNRF GIS data layers (2008-2011), MNRF 'Make-a-map Natural Heritage Features' mapping, Township of Laurentian Valley's Official Plans schedules and other correspondence or files. In addition to information available from MNRF and the municipality, several additional sources were reviewed to complete the literature review. These sources included the Ontario Breeding Bird Atlas data (both Cadman, 1987 and 2001-2005 field data), Ontario Herpetofaunal Atlas (Oldman et al., 2000) and the Ontario Mammal Atlas (Dobbyn, 1994). This information was reviewed for identifying potential species in the study area including Species at Risk.

Based on the literature and mapping we determined that habitats and sections of the study area that would require more detailed field investigations and specialized targeted surveys. The areas of particular focus were delineated on the latest aerial photography available as a preliminary natural heritage review.

Our second phase consisted of site visits by our terrestrial and wetland biologists to confirm the data collected in the literature review and collect site specific information. Surveys included site visits that encompass bird surveys, amphibian surveys, Ecological Land Classification (ELC) mapping, vegetation community boundaries, wildlife corridors and linkages and presence of significant species including Species at Risk. Detailed inventories

were completed for the entire length of the study area (3.2 km) on December 8th, 2014 and on April 30th and June 2nd, 2015.

The third and final phase consisted of preparing the Natural Environment Terrestrial Report as part of the provincial Class Environmental Assessment (CEA) process. The report is a compilation and analysis of the background literature and field data and an assessment of constraints and sensitive areas including vegetation communities, woodlands, sensitive species and habitats and Species at Risk on or adjacent to the study site.

2.2 Detailed Approach

2.2.1 Vegetation

Individual trees along the highway were identified and all vegetation communities within the study area were visited and species composition of dominant species determined. Community type criteria followed MNR's Ecological Land Classification for Southern Ontario (ELC) program, First approximation (Lee et al., 1998) and were determined to the Vegetation Type level. Detailed plant inventories of each community were conducted. Field survey dates were performed on December 8th, 2014.

Photographs and/or specimens were taken of plants requiring verification of identification.

National, provincial and regional significance of species and communities was determined from accepted status lists and published reference lists such as SARA (2017), Ontario Endangered Species Act (June 30th, 2007), COSEWIC (2017), COSSARO (2017), Cuddy (1991) and Brunton (2005).

2.2.2 Birds

Area searches and incidental observations were conducted within the study site. Data from the Ontario Breeding Bird Atlas (2001-2005) was compiled. Breeding bird survey/meadowlark surveys were conducted on April 30th, 2015 to document early migrants, resident birds and early nesting species. Targeted eastern meadowlark/bobolink surveys were conducted on June 2nd, 2015. The remaining field investigations were conducted outside of breeding bird season. Due to the timing of the project however any evidence of nesting (old nests) and/or habitat was documented and only incidental observations of resident bird species was noted.

Significance on a national, provincial or regional level was based on COSEWIC (2017), SARO (2017), ESA (2007) and SARA (2017).

2.2.3 Amphibians

Targeted spring surveys for breeding amphibians were completed in the evening of April 30, 2015 to document any calling breeding frogs. Surveys were focused in the wetland areas associated with the PSW located adjacent to the highway. The survey locations were selected based on GIS mapping, aerial photography and our fall field surveys. These stations were visited only once due to the fact that amphibians were generally only heard at distances greater than 75 m from the roadway, well outside the highway right-of-way boundaries.

In one case, however, a single individual spring peeper was heard calling approximately 7 m from the station located in the wetland area on the west side of Hwy 148 at the junction of County Road 40.

Due to the volume of traffic generated noise and the fact that the majority of the frogs were calling beyond the project limits, additional surveys were not conducted.

Surveys were completed at least 30 minutes after sunset and completed by midnight. Field conditions were recorded upon arrival (cloud cover, temperature, wind, precipitation). Observations at each station would sustain for 3 minutes where Call level codes were recorded. Due to the heavy traffic associated with highway vehicular use during the surveys, noise conditions obstructed hearing amphibian calls for the required 3 minute period. This was mitigated by remaining at the station for much longer periods of time in order to ascertain the calling code (i.e. the number of individuals) in the area of the station. Protocol from Environment Canada's Marsh Monitoring Program (BSC, 2008) was utilized using associated call level codes:

Code 1: Calls not simultaneous, number of individuals can be accurately counted
Code 2: Some calls simultaneous, number of individuals can be reliably estimated
Code 3: Full chorus, calls continuous and overlapping, number of individuals cannot be reliably estimated.

Whether the species were located within or outside of 100 meters of the survey station was recorded.

2.2.4 Reptiles

Incidental observations of reptilian species could not be made during the December field investigation however anecdotal evidence such as previous attempts by turtles to nest along the shoulders of the highway (predated nests with egg shells or old excavation holes) was searched for. During the spring and summer site visits, shoulders of the roadway near wetlands, creek crossings and ponded areas were checked for nesting attempts or sightings of adult females. The June mortality surveys were conducted by driving the road searching for turtle remains.

2.2.5 Mammals

Incidental observations of mammals were made during the site visits. Observations included direct sightings and indirect evidence such as calls, scat, browse, burrows, tracks, dens, trails and nests. The occurrence of linkages and corridors within the area were assessed based on field work and existing literature.

Significance on a national, provincial or regional level was based on COSEWIC (2017), COSSARO (2017), SARA (2017) and MNR (1993 and 2000).

2.2.6 Species At Risk

The Ontario Endangered Species Act places the onus on proponents to determine if Species at Risk are present or absent on a property through targeted in-season field surveys by a qualified biologist. The background review and screening of the study area identified a few potential federal or provincial Species at Risk. Based on the rural location and habitat present, the presence of barn swallows, bank swallows, eastern meadowlark and bobolink may find suitable habitat adjacent to the study area (within 30 m).

Based on the habitat found in the study area, it was determined that there was no suitable breeding habitat present for eastern whip-poor-will therefore no evening surveys were conducted. This was also confirmed as no whip-poor-will birds were heard during the evening frog surveys. Although these surveys were conducted on April 30th, 2015 and this time frame is early for breeding pairs of whip-poor-will, birds would have been calling as they migrated through the area. This was not the case as no birds were heard.

Targeted surveys were completed for the presence of barn swallows and bank swallows. This included checking culverts for nest sites and open areas for foraging birds.

Targeted surveys were conducted for eastern meadowlark and bobolink in suitable habitat. This included detailed scans of the open fields for suitable habitat for grassland bird species.

3.0 Resource Inventory

3.1 Vegetation

As this is a linear corridor, a number of individual specimen tree and shrub species were identified along the route as well as larger vegetated communities. Fourteen (14) vegetation communities have been delineated within the study area. A total of 52 plant species were recorded.

Only dominant tree and shrub species found in the vegetation communities were documented in order to obtain the most suitable ELC code. In some cases, ELC codes were not applicable to all communities along the route.

Many of the small woodland communities adjacent to the highway were considered an isolated feature on the landscape as there is no connectivity to other features in the larger countryside. This was especially true for the section of Highway 148 from the city limits south to Greenwood Road. This section of 148 was lined with numerous commercial and residential properties on both sides of the highway The functions of the small sporadic woodlands in the residential and commercial lined areas of the highway would be limited as a result of the location and lack of connectivity. As such the main function would be as wildlife habitat for typical urban wildlife species and a limited bird community.

The size and shape of some of the woodlands does not provide for interior bird habitat. Interior forest habitat applies to woodlands that are large enough to support interior bird species and have woodland that is greater than 100 metres from the edges.

The grassy areas found within the right-of-way, adjacent to the highway were all included as one community. Road and highway right of ways (ROW's), are disturbed sites and typically have a variety of common successional weed species growing that are able to tolerate the conditions associated with being adjacent to transportation routes.

Community locations described below are based on MTO benchmarks and survey station markers as provided on the survey plate No. 71-17/5-O to No. 71-62/11-0. Community locations are shown in Figures 2 A to 2C.

A search for butternut trees, a provincially endangered species, was conducted however none were found.

All images are taken from Google Earth - Street View (Oct, 2012) unless otherwise stated.

LEGEND

- STN-2 Breeding Bird Point Count Station Label
- STN-2 Marsh Monitoring Station Label
- LABEL Vegetation Community Label
- Marsh Monitoring (MMP) Station
- Breeding Bird Point Count Station
- Watercourse
- Owner Parcel
- Vegetation Community
- Study Limit

Composite imagery acquired in 2014. Town of Pemroke. 30 cm Resolution.

ELC TYPES (1ST APPROXIMATION)

CODE	TYPE DESCRIPTION
NO CODE	No applicable ELC code.

FIGURE 2A: NATURAL AREAS

Highway 148, City of Pembroke
County of Pemroke
Pembroke District

MTM 9
WKID: 32189 Authority: EPSG
Transverse Mercator
GCS North American 1983, ESRI ArcGIS 10.1

Map was produced by
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REVISIONS

NO	BY	DATE	DESCRIPTION
1	W.P.	16/11/2015	Initial map creation.

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PROJECT NO: PN15-013
REVISION NO.: RV-01
PROJECT: Highway 148 & 17 EA
CLIENT: N/A

SCALE: 1:3,000 CENTIMETERS

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LEGEND

- STN-2 Breeding Bird Point Count Station Label
- STN-2 Marsh Monitoring Station Label
- LABEL Vegetation Community Label
- Marsh Monitoring (MMP) Station
- Breeding Bird Point Count Station
- Watercourse
- Owner Parcel
- Vegetation Community
- Study Limit

DWG name, DD-MM-YYYY. Version. Organization.
Composite imagery acquired in 2014. Town of Pembroke. 30 cm Resolution.

ELC TYPES (1ST APPROXIMATION)

CODE	TYPE DESCRIPTION
NO CODE	No applicable ELC code.
CUP3-2	White pine coniferous plantation
FOD8-1	Fresh-moist poplar deciduous forest
MAS2-1	Cattail mineral shallow marsh
MAS2-9	Forb mineral shallow marsh

FIGURE 2B: NATURAL AREAS

Highway 148, City of Pembroke
County of Pemroke
Pembroke District

MTM 9
WKID: 32189 Authority: EPSG
Transverse Mercator
GCS North American 1983, ESRI ArcGIS 10.1

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REVISIONS

NO	BY	DATE	DESCRIPTION
1	W.P.	16/11/2015	Initial map creation.

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PROJECT NO: PN15-013
REVISION NO.: RV-01
PROJECT: Highway 148 & 17 EA
CLIENT: N/A

SCALE: 1:3,000 CENTIMETERS

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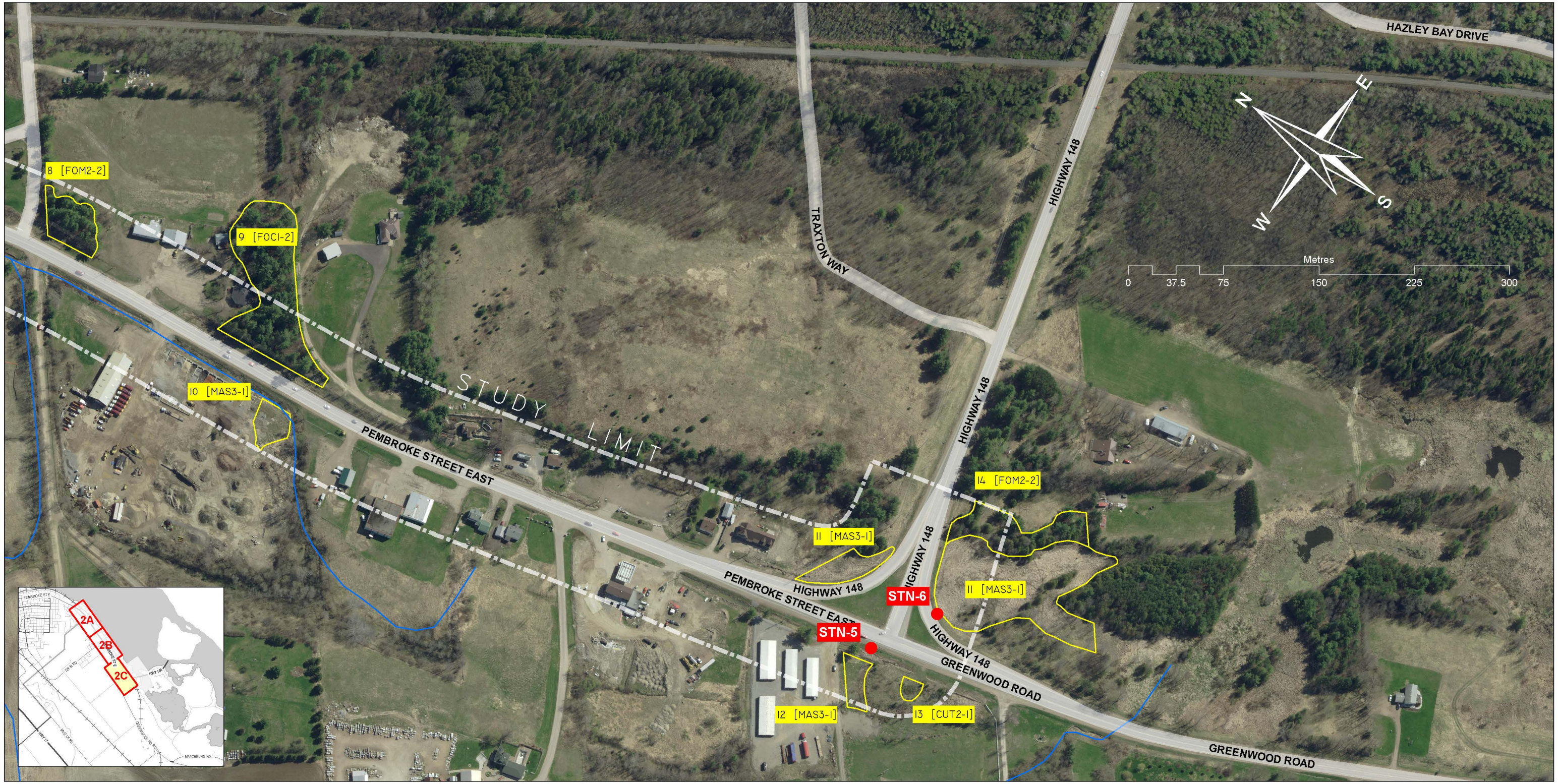

LEGEND

- STN-2 Breeding Bird Point Count Station Label
- STN-2 Marsh Monitoring Station Label
- LABEL Vegetation Community Label
- Marsh Monitoring (MMP) Station
- Breeding Bird Point Count Station
- Watercourse
- Owner Parcel
- Vegetation Community
- Study Limit

Composite imagery acquired in 2014, City of Pembroke, 30 cm Resolution.

ELC TYPES (1ST APPROXIMATION)

CODE	TYPE DESCRIPTION
NO CODE	No applicable ELC code.
CUT2-1	Common juniper cultural alvar thicket
FOC1-2	Dry-fresh white pine-red pine-coniferous forest
FOC4-1	Fresh-moist white cedar coniferous forest
FOD3-1	Dry-fresh poplar deciduous forest
FOD7-1	Fresh-moist white elm lowland deciduous forest
FOM2-2	Dry-fresh white pine-sugar maple mixed forest
FOM5-2	Dry-fresh poplar mixed forest
MAM3-9	Rush grass organic shallow marsh
MAS3-1	Cattail organic shallow marsh
SWD2-1	Black ash mineral deciduous swamp
SWD3-2	Silver maple mineral deciduous swamp

FIGURE 2C: NATURAL AREAS

Highway 148, City of Pembroke
County of Pemroke
Pembroke District

UTM Zone 18
WKID: 26918 Authority: EPSG
Transverse Mercator
GCS North American 1983, ESRI ArcGIS 10.1

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REVISIONS

NO	BY	DATE	DESCRIPTION
1	W.P.	16/11/2015	Initial map creation.
2	W.P.	22/06/2017	Initial map creation.

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PROJECT NO: PN15-013
REVISION NO.: RV-02
PROJECT: Highway 148 & 17 EA
CLIENT: N/A

SCALE: 1:3,000 CENTIMETERS

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Community 1: Manitoba Maple Woodland Cluster (ELC code: no applicable ELC Code)

Location: 10+000 – 10+035 (NNE side of highway)

Community 1 located on the northeast side of the highway, at the City limits of Pembroke (Figure 2A). It consisted of a small natural area, adjacent the highway contained of a couple of large Manitoba maple (*Acer negundo*) trees with a small natural understory area of a few stems of tartarian honeysuckle (*Lonicera tatarica*) and ground cover containing typical successional weed species including motherwort (*Leonurus cardiaca*), common mullein (*Verbascum thapsus*), bitter nightshade (*Solanum dulcamara*), bouncing bet (*Saponaria officinalis*) and awnless brome grass (*Bromus inermis spp. inermis*).

Photo 1: Manitoba Maple cluster; view looking north. (Photo Date: December 8th, 2014)

Community 2: Manitoba Maple Woodland (no applicable ELC code)

Location: 11+120 – 11+170 (NNE side of highway)

This community was located on the northeast side of the highway, just west of the Robinson Lane intersection (Figure 2A). A watercourse traversed the area, flowing in a northerly direction and was dominated by Manitoba maple with a few red pine trees (*Pinus resinosa*), Norway maple (*Acer platanoides*) and American elm (*Ulmus americana*) as associates. It appears as though the red pine were planted specimen trees found growing in the upland areas while the Manitoba maple dominated the valley associated with the creek. Other species found included staghorn sumac (*Rhus typhina*), prickly gooseberry (*Ribes cynosbati*), wild red raspberry (*Rubus idaeus*) and wild grape (*Vitis riparia*). Herbaceous plants found included common ragweed (*Ambrosia artemisiifolia L.*), common evening primrose (*Oenothera biennis*), Kentucky blue grass (*Poa pratensis*), awnless brome grass, New England aster (*Symphyotrichum novae-angliae*), and Canada goldenrod (*Solidago canadenisis*).

Photo 2: View looking southeast; Community 2.

Community 3: White Pine Coniferous Plantation (ELC code: CUP3-2)

Location: 12+030 – 12+075 (South West side of highway)

Community 3 was identified as being on the western side of the highway, at the entrance to a farm residence (Figure 2B). This area contained planted tree species consisting mostly of eastern white pine (*Pinus strobus*). Other species included Manitoba maple, sugar maple (*Acer saccharum ssp. saccharum*) and white birch (*Betula papyrifera*). Herbaceous plants consisted of calico aster (*Symphyatrichum lateriflorum*), New England aster and awnless brome grass.

Photo 3: White pine plantation; view looking south.

Community 4: Cattail Mineral Shallow Marsh (ELC code: MAS 2-1)

Location: 12+075– 12+180 (NE side of Hwy.)

This community was located adjacent the highway (Figure 2B) and was dominated by common cattail and narrow-leaved cattail (*Typha latifolia; T. angustifolia*). A few shrubs were found growing in the ditch including pussy willow (*Salix discolor*) and slender willow (*Salix petiolaris*). Herbaceous plants consisted of purple loosestrife (*Lythrum salicaria*), Canada bluejoint grass (*Calamagrostis canadensis*) and New England aster.

Photo 4: View of community 4; east side of highway.

Community 5: Forb Mineral Shallow Marsh (ELC code: MAS 2-9)

Location: 12+135 – 12+205 (SW side of Hwy.)

Located on the opposite side of the highway from Community 4 (Figure 2B), this ditch contained a variety of young trees and shrubs including Manitoba maple, green ash (*Fraxinus pensylvanica*) and slender willow. Herbaceous plants included common cattail, common evening primrose, common milkweed (*Asclepias syriaca*), tall goldenrod (*Solidago altissima*), orchard grass (*Dactylis glomerata*) and awnless brome grass.

Photo 5: View of community 5; west side of highway.

Community 6: Fresh – Moist Poplar Deciduous Forest (ELC code: FOD 8-1)

Location: 12+265 – 12+305 (SW side of Hwy.)

This deciduous woodlot located along the west side of the highway contained Manitoba maple, trembling aspen (*Populus tremuloides*), sugar maple, American elm and a few saplings of eastern white pine (as seen in the foreground of Photo 6) along with staghorn sumac (Figure 2B).

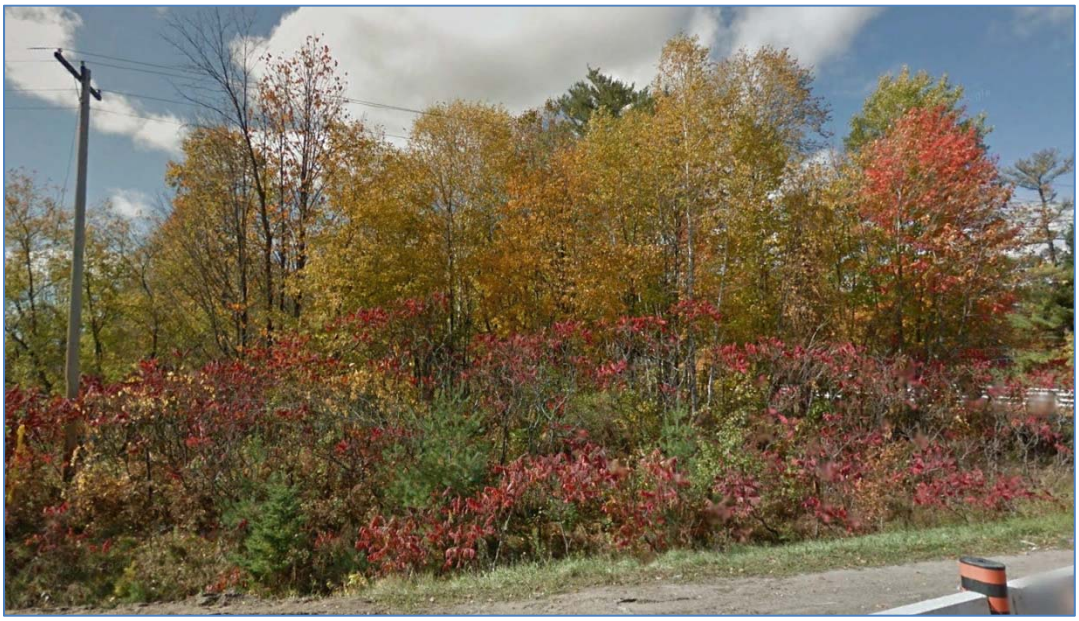

Photo 6: View looking west at Community 6.

Community 7: Disturbed area (new culvert) (no applicable ELC code)

Location: 12+325 – 12+360 (NE side of Hwy.)

This community was located on the east side of the highway where in fall of 2012, a new concrete box culvert was installed under the roadway (Photo 7)(Figure 2B). Since that time, the invasive species common reed (*Phragmites australis*) has proceeded to grow in the disturbed site. Other species found immediately adjacent to this area included Canada bluejoint grass, common cattail, New England aster, common ragweed, viper's bugloss (*Echium vulgare*), Queen-Anne's lace (*Daucus carota*) and white sweet-clover (*Melilotus alba*).

Photo 7: View looking east; new culvert seen in bottom centre of photo.

Photo 8: Same view two years later showing phragmites dominated area. (Photo date: Dec. 8, 2014)

Community 8: Dry – Fresh White Pine – Sugar Maple Mixed Forest (ELC code: FOM 2-2)

Location: 12+435 – 12+495 (East side of Hwy.)

This mixed forest community was located on the east side of the highway (Figure 2C) and was dominated by eastern white pine and sugar maple with associates of trembling aspen, Manitoba maple, American elm and white ash (*Fraxinus americana*). Herbaceous plants included awnless brome grass, New England aster and tall goldenrod.

Photo 9: View looking east.

Community 9: Dry – Fresh White Pine Coniferous Forest (ELC code: FOC 1-2)

Location: 12+590 – 12+695 (East side of Hwy.)

This coniferous forest also located on the east side of the highway was dominated by eastern white pine with associates of white spruce (*Picea glauca*), sugar maple, American elm and green ash (Figure 2C). Staghorn sumac was found growing along the outer edges of the woodlot as well as tall goldenrod, awnless brome grass and New England aster.

During field investigations, there appeared to be a distinct wildlife crossing point at this location as was evident by a trail with numerous tracks that lead from this woodlot and crossed the highway to the west, into Community 10 (a marsh community).

Photo 10: View looking north.

Community 10: Cattail Organic Shallow Marsh (ELC code: MAS 3-1)

Location: 12+695 – 12+710 (West side of Hwy.)

Located on the opposite side of Community 9, this small wetland pocket consisted mainly of common and narrow-leaved cattail (Figure 2C). The surrounding slopes of the community consisted of crack willow (*Salix fragilis*), American elm and balsam poplar (*Populus balsamifera*). Other species within the wetland included slender willow, tall goldenrod and awnless brome grass.

Numerous wildlife tracks were observed on the snow covered ponded areas of the wetland providing further evidence of the wildlife traffic at this location.

Photo 11: View looking WSW. (Photo date: Dec. 8, 2014)

Community 11: Cattail Organic Shallow Marsh (ELC code: MAS 3-1)

Location: North and South side of the highway at the Hwy 148 and County Rd 40 junction. (Approx. - 10+030 – 10+060 N side; 10+040 – 10+080 S side)

The cattail marsh located on the northeast corner of this intersection was connected via a culvert to the large marsh area, south of the highway (Figure 2C). This wetland is part of the Hazley Bay/Lisk Bay provincially significant wetland complex. The marsh was dominated by common cattail and narrow-leaved cattail. Other species found on the peripheral edge included slender willow, Manitoba maple and American elm.

Photo 12: View looking northwest at northeast corner of Hwy 148/Cty Rd 40 intersection.

Photo 13: View looking south at cattail marsh – part of Hazley Bay/Lisk Bay PSW.

Community 12: Cattail Organic Shallow Marsh (ELC code: MAS 3-1)

Location: 13+175 – 13+215 (West side of Hwy.)

Located along the west side of the highway, this wetland community was associated with the ditch adjacent the roadway and was dominated by common cattail and narrow-leaved cattail (Figure 2C). Other species found included American elm, white spruce, crack willow and slender willow.

Photo 14: Marsh community on west side of highway at Hwy 148/Cty Rd. 40 intersection.

Community 13: Common Juniper Cultural Alvar Thicket (ELC code: CUT 2-1)

Location: 13+210 – 13+230 (West side of Hwy.)

Just south of the marsh Community (13) was an upland area dominated by common juniper (*Juniperus communis*) (Figure 2C). This area also contained staghorn sumac, American elm, eastern white pine and awnless brome grass.

Photo 15: View looking west at common juniper community.

Community 14: Dry – Fresh White Pine – Sugar Maple Mixed Forest (ELC code: FOM 2-2)

Location: (Approx. - 10+130 – 10+230; South side of Highway)

Located east of the Highway 148/Cty Rd. 40 intersection, on the south side, this community is dominated by eastern white pine and sugar maple (Figure 2C). Only a portion of this community was identified in the study area. Other trees found growing here included white spruce, balsam poplar and eastern white cedar (*Thuja occidentalis*).

Photo 16: View looking South at Community 14.

3.2 Mammals and Herpetozoa

Amphibian surveys were conducted on April 30th, 2015 in the wetland areas located adjacent to the highway. Results of the amphibian surveys conducted are shown in Table 1 below.

Table 1: Amphibian Survey Results for Study Area

Survey Type	Date Conducted	Results		
		Location	Species	Observations
Amphibian Surveys	April 30, 2015	STA 13+200 West side - Station 5	SPPE	Call Index 1 – 3 individuals; <7m
		STA 10+050 South side – Station 6	SPPE	Call Index 2 – 6 individuals; 110 m
NOTE: These are the only locations along the Highway 148 corridor to the County Road 40 junction where amphibians were surveyed due to suitable habitat availability. * SPPE = spring peeper, -no constraint to construction but silt fence adjacent to these vernal pools/wetlands required				

No nesting sites (predated, attempts or egg shell fragments) were found during any of the field surveys. Additional turtle nesting surveys were also conducted on June 2nd, 2015 at the peak of the nesting season. This included surveying the gravel shoulders of the entire length of the study area from the City limits of Pembroke to Greenwood Road. No turtle nesting sites or attempts at nesting were discovered nor were any adult females observed, on either side of the highway corridor's entire length.

No mammals were observed although numerous tracks were identified during the December field surveys and included those of red squirrel (*Tamiasciurus hudsonicus*), meadow vole (*Microtus pennsylvanicus*), raccoon (*Procyon lotor*) and red fox (*Vulpes vulpes*).

A road mortality survey was conducted on June 2nd, 2015 and found evidence of one mammal species a black squirrel (*Sciurus carolinensis*), a melanistic variety of the eastern gray, on the west shoulder of Highway 148 at STA 12+245.

3.3 Birds

A total of nine (9) bird species were identified within the study area, which included black capped chickadee (*Poecile atricapillus*), ruffed grouse (*Bonasa umbellus*), rock pigeon (*Columbia livia*), blue jay (*Cyanocitta cristata*), American crow (*Corvus brachyrhynchos*), common raven (*Corvus corax*), red-breasted nuthatch (*Sitta canadensis*), European starling (*Sturnus vulgaris*), and pine siskin (*Carduelis pinus*) (Appendix II). These birds are common birds for the area.

Conducting surveys along the road allowance was difficult due to heavy traffic and high noise levels. This limits the observer from hearing birds.

Potential habitat does exist within the study area for bird nesting, particularly with bobolink and eastern meadowlark in the few open field habitats, as well as barn swallows as they typically nest in man-made structures and have been recorded to nest under bridges.

Due to trespass issues on properties adjacent to the highway, transect surveys following the standard MNRF protocol for surveying eastern meadowlark and bobolink were not conducted; as a result, only point count surveys were conducted in areas of suitable habitat for these grassland bird species and only from the road allowance. Results of the targeted point count surveys for eastern meadowlark and bobolink, conducted on June 2nd, 2015, are outlined in Table 2 below.

Table 2: Eastern Meadowlark / Bobolink Survey Results for Study Area

Meadowlark/bobolink surveys (point count)	June 2, 2015	STA 12+125	EAME BOBO	None observed or heard
NOTE: This is the only location where suitable habitat had the potential to support EAME (Eastern meadowlark), BOBO (bobolink). * BARS = barn swallow				

No structures or bridges were identified in the study area could provide potential habitat for barn swallow nesting.

4.0 Resource Significance

4.1 Vegetation

A review of the list of plants observed by NEA found that none were significant on a national or provincial level (COSWEWIC, 2017; COSSARO, 2017; SARA, 2017)(Appendix I).

No significant vegetation communities were found in the area. No endangered vegetation species were found including butternuts on site.

4.2 Natural Features

No Areas of Natural and Scientific Interest (ANSI's) or significant valleylands, significant woodlands or environmentally significant areas were found in the study area. A review of the natural features in the study area can be found below.

4.2.1 Significant Wetlands

There was one provincially significant wetlands (PSW) located in the section of Highway 148 from the Pembroke City limits to Greenwood Road. This was identified as the Hazley Bay/Lisk Bay wetland complex. Wetland Evaluation System for Southern Ontario that scores wetlands based on numerous criteria. The designation of PSW is an MNRF status that affords protection of these wetlands under the Provincial Policy Statement (Gov. of Ont. April 30, 2014).

4.2.2 Unevaluated Wetlands

MNRF mapping for this area had categorized a few wetlands as "unevaluated". One was located on the west side of Greenwood Road. NEA staff also observed and documented a few wetland communities along the highway, not documented by MNRF, that were associated with a watercourse and/or part of the ditches found adjacent to the highway.

4.2.3 Species at Risk

Several Significant Species were identified within the general area of the project by MNRF as previously identified in the Existing Environmental Conditions Report Rehabilitation of Hazley Bay Bridge by McIntosh Perry (2011) and a Species at Risk screening by McIntosh Perry (2014). These reports identified several potential Species at Risk.

A Species at Risk and property information request was sent to the MNRF in Pembroke, dated January 8th, 2015. NEA received a response from Mary Lyons, District Planner with MNRF, on January 20th, 2015. She suggested that the SAR information provided in the McIntosh Perry documents related to the rehabilitation of the Hazley Bay bridge be used as SAR screening information for the EA.

A literature review and a review of the study area and the known records for SAR has identified four bird species (barn swallow, bank swallow, eastern meadowlark and bobolink) as well as four turtle species as having the potential to be on site (map, stink pot, Blanding's and snapping turtle). NEA confirmed through our literature review that these are the only species of wildlife (birds, mammals, reptiles, amphibians) to have potential suitable habitat on this site.

Targeted surveys for Species at Risk were conducted on June 2nd, 2015, specifically in the ROW's (for eastern meadowlark, bobolink and barn swallow), and areas adjacent wetlands (for turtle species). No bridges were identified in this part of the study area that could potentially provide barn swallow nesting opportunities.

The April 30th and June 2nd, 2015 field investigation was within the breeding bird period for meadowlarks, bobolink and barn swallows that return by late March or early April in Eastern Ontario. No structures were identified that would provide opportunity for barn swallow nesting.

A review of the NHIC natural areas geographic query found no Earth Science ANSI's or Environmentally Significant Areas (ESA's) within or adjacent to the study area.

4.3 Birds

A review of the list of breeding bird species recorded for the study area (Appendix II) found that none were considered significant nationally or provincially. No regionally rare species were identified during field investigations. One bird was identified as being area sensitive, red-breasted nuthatch (*Sitta canadensis*). Area sensitive is defined as a wildlife species that requires contiguous areas of suitable habitat in order to sustain their population numbers.

A review of the Ontario Breeding Bird Atlas data (BSC, 2001-2005) generated for the 10 x 10 km squares (18UR3) that contained the study area found ten species that are considered significant on a national and/or provincial level (Table 3). The species were common nighthawk (*Chordeiles minor*), chimney swift (*Chaetura pelagica*), red-headed woodpecker (*Melanerpes erythrocephalus*), eastern wood-pewee (*Contopus virens*), loggerhead shrike

(*Lanius ludovicianus*), bank swallow (*Riparia riparia*), barn swallow (*Hirundo rustica*), wood thrush (*Hylocichla mustelina*), bobolink (*Dolichonyx oryzivorus*) and eastern meadowlark (*Sturnella magna*).

Table 3 identifies the current status of each species, the typical habitat preferences and if there was suitable habitat within the study area or observations during our surveys.

Table 3. Nationally and Provincially Significant Bird Species identified within the OBBA 10km by 10km square containing the study area.

Common Name	National Status*	Provincial Status*	Habitat Characteristics	Habitat Found On Subject Property	Recorded During Field Visit
Common nighthawk	THR	THR	Prefers open ground; clearings in dense forests; ploughed fields; gravel beaches or barren areas with rocky soils; open woodlands; flat gravel roofs.	Foraging habitats over urban and rural area along route. No nest sites within ROW or roosting sites.	No
Chimney swift	THR	THR	Commonly found in urban areas near buildings; nests in hollow trees, crevices of rock cliffs, chimneys; highly gregarious; feeds over open water.	No nesting sites within ROW.	No
Red-headed woodpecker	THR	SC	Open, deciduous forest with little understory; fields or pasture lands with scattered large trees; wooded swamps; orchards, small woodlots or forest edges; groves of dead or dying trees	Possible habitat exists in woodlands north and south of Highway corridor	No
Eastern wood-pewee	THR	SC	Inhabits deciduous, mixed woods or pine plantations	Yes - in adjacent mixed or deciduous forests outside road allowance	No

Loggerhead shrike	END	END	Prefers a mixture of grasslands and pastures with low trees and shrubs	No – no suitable nesting habitat found within ROW or in study area	No
Bank swallow	THR	THR	Nests in colonies in streamside banks	No – no suitable nesting habitat found within ROW or in study area	No
Barn Swallows	THR	THR	Prefers farmlands or rural areas; cliffs, caves, rock niches; buildings or other man-made structures for nesting; open country near body of water.	No. Foraging habitat exists No nests were observed in any of the culverts crossing along the highway	No
Wood thrush	THR	SC	Breeds in deciduous and mixed forests in areas with large trees, moderate understory abundant in leaf litter and shade present.	Yes - in adjacent mixed and deciduous forests outside of ROW.	No
Bobolink	THR	THR	Prefers large, open expansive grasslands with dense ground cover; hayfields, meadows or fallow fields; marshes; requires tracts of grassland >50 ha.	Suitable habitat exists in hayfields adjacent to ROW within the study area.	No
Eastern Meadowlark	THR	THR	Prefers open, grassy meadows, farmland, pastures, hayfields or grasslands with elevated singing perches; cultivated land and weedy areas with trees; old orchards with adjacent, open grassy areas > 10 ha.	Suitable habitat exists adjacent to the study area in hay fields – outside ROW	No

* National Status Codes: Species of Concern (SC), Threatened Species (THR), Not At Risk (NAR) (COSEWIC, 2017)
*Provincial Status Codes: Species of Concern (SC), Threatened Species (THR), Not At Risk (NAR) (COSSARO, 2017)

4.4 Mammals and Herpetozoa

A literature review found that there were no provincially (COSSARO, 2017) or federally (COSEWIC, 2017, SARA, 2017) significant herpetozoa or mammal species observed in the study area at the time of the field visit.

No evidence of snapping turtle existed on any roadsides adjacent to any wetland communities. There was no evidence of nesting attempts identified along any of the roadside shoulders or area adjacent the bridge. No suitable habitat for nesting turtles existed in this portion of the study area.

4.5 Significant Species and Habitats

Several Significant Species were identified within the general area of the project by the Ministry of Natural Resources and Forestry. Information obtained in the review of the McIntosh Perry report (2011) cited four potential Species at Risk: northern map turtle, eastern small myotis, barn swallow and snapping turtle (Table 4). NHIC identified five significant species within the 1km by 1km square containing the study area (bobolink, lake sturgeon, snapping turtle, butternut and chimney swift). None of the species listed below were identified during field surveys.

Table 4: Species at Risk identified by NHIC and/or McIntosh Perry in the general area of the study area

Common Name	Scientific Name	National Status	Provincial Status	Habitat Present in ROW (Y/N)
**Barn Swallow	*Hirundo rustica*	THR	THR	No. Details in table 3.
*Bobolink	*Dolichonyx oryzivorus*	THR	THR	No. Details in table 3
*Chimney Swift	*Chaetura pelagica*	THR	THR	No. Details in table 3
**Eastern small footed myotis	*Myotis leibii*		END	No. Possible habitat in Adjacent Woodlands outside ROW
*(**)Snapping turtle	*Chelydra serpentina*	SC	SC	No.

**Northern Map Turtle	*Graptemys geographica*	SC	SC	No.
*Lake Sturgeon	*Acipenser fulvescens*	THR	SC	None in the ROW
*Butternut	*Juglans cinerea*	END	END	None identified in ROW

*NHIC listed species. **Species identified in the McIntosh Perry Report.

5.0 Project Description

The Ministry of Transportation has initiated a Preliminary Design and Environmental Assessment Study for Highway 148 corridor improvements for the section of roadway between Pembroke city limits and Greenwood Road.

An alternative was chosen and a preliminary design (IBI Group, Feb 24, 2017) was provided to NEA.

6.0 Impacts

6.1 Wetlands and Vegetation Communities

Table 5 below identifies vegetation communities which may require mitigation measures during the construction phase of the highway improvements.

Table 5: Community Locations (STA marker), Vegetation Types and Environmental Concerns in Study Area

STA marker	Location on Highway	Community Type	Environmental Concerns
10+000 – 10+035	NNE side	Manitoba Maple woodland – No applicable ELC Code	Root damage to adjacent trees; nesting birds
11+120 – 11+170	NNE side	Manitoba Maple woodland – No applicable ELC Code	Root damage to adjacent trees; nesting birds
12+075 – 12+180	NE side	Wetland – MAS2-1	nesting attempts on shoulders of the road by turtles
12+325 – 12+360	NE side	New culvert – disturbed area No applicable ELC Code	nesting attempts on shoulders of the road by turtles

12+435 – 12+495	E side	Woodland – FOM2-2	Root damage to adjacent trees; nesting birds
12+590 – 12+695	E side	Woodland – FOC1-2	Root damage to adjacent trees; nesting birds

ELC codes given to communities are based on initial observations during 2014 and 2015 field investigations. Natural environment concerns have been identified based on the presence or potential presence of sensitive habitat and or SAR within the study area.

Description of the ELC codes is provided in Table 6 below.

Table 6: ELC Code Descriptions

ELC Code	Description
FOC1-2	Dry – Fresh White Pine – Red Pine Coniferous Forest
FOM2-2	Dry – Fresh White Pine – Sugar Maple Mixed Forest
FOD8-1	Fresh – Moist Poplar Deciduous Forest
CUP3-2	White Pine Coniferous Plantation
CUT2-1	Common Juniper Cultural Alvar Thicket
MAS2-1	Cattail Mineral Shallow Marsh
MAS2-9	Forb Mineral Shallow Marsh
MAS3-1	Cattail Organic Shallow Marsh

6.2 Unevaluated Wetlands/Provincially Significant Hazley Bay/Lisk Bay Wetland Complex

A number of wetland communities were observed along the Highway 148 corridor. Two small wetland communities requiring mitigation techniques on the northerly section of Highway 148 are located at Station markers 12+075 – 12+180, on the North-East side and at markers 12+325 – 12+360 also found on the North-East side where a new culvert was previously installed in 2012. Mitigation measures would include installing silt fencing adjacent the construction envelope to protect from sediment entering the wetlands. If any portion of this wetland is required to be removed, then 1:1 compensation will be required elsewhere in the general area.

A small wetland connected to the Hazley Bay/Lisk Bay Wetland Complex was identified on the south side of Highway 148 at the sharp bend of the highway at Greenwood Road at marker 10+050. Construction will occur within 30 meters of the PSW. The proposed road widening will extend almost to the PSW boundary. Potential impacts that may be associated with the road widening at this location include potential sedimentation entering the wetland,

disruption to wildlife habitat including amphibians and mammals using this area for habitat and contamination. The removal of vegetation directly adjacent the wetland and the extension of the road to this location will increase the deleterious substances entering into the wetland (i.e. Road salts, car oils or gasoline). These may have long lasting effects on the wetland without mitigation in place. NEA recommends the installation of silt fencing along the construction envelope prior to the commencement of construction. If any upland still exists between the construction envelope and the PSW a screen of cedars is recommended to help buffer the wetland from the highway.

6.3 Species at Risk

No Species at Risk or their habitats were identified during field surveys within this portion of the study area.

7.0 Mitigation Measures

1) Tree clearing for project be conducted outside of Breeding Bird Season (April 15th-August 15th). If necessary in season, a bird biologist can check trees for presence of active nests, prior to cutting.

2) Sediment fencing should be installed prior to construction along all wetlands and natural features in order to prevent sediment from entering these areas.

3) Wetland compensation of 1:1 in the general area of the project should be utilized when removal of wetland is required.

4) When construction is occurring within 30 meters of a PSW a screen of cedars should be planted along the wetland edge to increase the integrity of the buffer.

5) A restoration plan should be implemented for construction areas occurring directly adjacent/within unevaluated wetland.

6) A monitoring program should be implemented to ensure that the mitigation measures are installed, maintained and functioning as intended.

8.0 Conclusions

Based on our site visit and review of the construction drawings, the woodland communities identified adjacent to the highway (specifically those north of Greenwood Road) have limited functions and will remain predominantly outside of the construction envelope for the proposed highway improvement works. Field investigations identified several sensitive areas, species and their habitats which exist within the study area and may be considered a constraint during construction or require mitigation.

Highway Improvements along the Highway 148 stretch to Greenwood Road will have an overall negative low significant impact on the adjacent terrestrial vegetation communities and wetland habitats locally and cumulatively.

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APPENDIX I
PLANT SPECIES BY COMMUNITY

Appendix I - A Plant Distribution By Community

Families and genera for the plant species found in this appendix are listed in taxonomic order. The species are listed alphabetically within each genus.

Three standard reference works were used for the botanical nomenclature and taxonomy (Newmaster et. al., 1998; Gleason and Cronquist 1991; Voss 1980; 1985). Other published works for botanical names included; ferns (Cody and Britton 1989); grasses (Dore and McNeill 1980); orchids (Whiting and Catling 1986); shrubs (Soper and Heimburger 1982) and trees (Farrar 1995).

Community 1 **ComID:** 2869 **ELC Code:** None Applicable

Common Name	*Scientific Name*	Remarks
PINK FAMILY	*CARYOPHYLLACEAE*	
bouncing bet	*Saponaria officinalis*	
BUCKWHEAT FAMILY	*POLYGONACEAE*	
curled dock	*Rumex crispus*	
EVENING PRIMROSE FAMILY	*ONAGRACEAE*	
common evening primrose	*Oenothera biennis*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	
NIGHTSHADE FAMILY	*SOLANACEAE*	
bitter nightshade	*Solanum dulcamara*	
MINT FAMILY	*LAMIACEAE*	
motherwort	*Leonurus cardiaca*	
FIGWORT FAMILY	*SCROPHULARIACEAE*	
common mullein	*Verbascum thapsus*	
HONEYSUCKLE FAMILY	*CAPRIFOLIACEAE*	
tartarian honeysuckle	*Lonicera tatarica*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	

Plant Species Per Community 9

Community 2 **ComID:** 2870 **ELC Code:** None Applicable

Common Name	*Scientific Name*	Remarks
PINE FAMILY	*PINACEAE*	
red pine	*Pinus resinosa*	

ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
PINK FAMILY	*CARYOPHYLLACEAE*	
bouncing bet	*Saponaria officinalis*	
GOOSEBERRY FAMILY	*GROSSULARIACEAE*	
prickly gooseberry	*Ribes cynosbati*	
ROSE FAMILY	*ROSACEAE*	
wild red raspberry	*Rubus idaeus*	
EVENING PRIMROSE FAMILY	*ONAGRACEAE*	
common evening primrose	*Oenothera biennis*	
GRAPE FAMILY	*VITACEAE*	
Virginia creeper	*Parthenocissus inserta*	
wild grape	*Vitis riparia*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	
Norway maple	*Acer platanoides*	
CASHEW FAMILY	*ANACARDIACEAE*	
staghorn sumac	*Rhus typhina*	
CARROT FAMILY	*APIACEAE*	
Queen-Anne's lace	*Daucus carota*	
NIGHTSHADE FAMILY	*SOLANACEAE*	
bitter nightshade	*Solanum dulcamara*	
ASTER FAMILY	*ASTERACEAE*	
common ragweed	*Ambrosia artemisiifolia L.*	
Canada goldenrod	*Solidago canadensis*	
New England aster	*Symphyotrichum novae- angliae*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	
Kentucky blue grass	*Poa pratensis*	

Plant Species Per Community 18

Community 3 **ComID:** 2871 **ELC Code:** CUP3-2

Common Name	***Scientific Name***	**Remarks**
PINE FAMILY	*PINACEAE*	
eastern white pine	*Pinus strobus*	
BIRCH FAMILY	*BETULACEAE*	
white birch	*Betula papyrifera*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	
sugar maple	*Acer saccharum ssp.saccharum*	
ASTER FAMILY	*ASTERACEAE*	
calico aster	*Symphyotrichum lateriflorum var.laterifl*	
New England aster	*Symphyotrichum novae- angliae*	

GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	

Plant Species Per Community 7

Community 4

ComID: 2872 **ELC Code:** MAS2-1

Common Name	*Scientific Name*	Remarks
WILLOW FAMILY	*SALICACEAE*	
pussy willow	*Salix discolor*	
slender willow	*Salix petiolaris*	
LOOSESTRIFE FAMILY	*LYTHRACEAE*	
purple loosestrife	*Lythrum salicaria*	
ASTER FAMILY	*ASTERACEAE*	
New England aster	*Symphyotrichum novae- angliae*	
GRASS FAMILY	*POACEAE*	
Canada bluejoint grass	*Calamagrostis canadensis*	
CATTAIL FAMILY	*TYPHACEAE*	
narrow-leaved cattail	*Typha angustifolia*	
common cattail	*Typha latifolia*	

Plant Species Per Community 7

Community 5

ComID: 2873 **ELC Code:** MAS2-9

Common Name	*Scientific Name*	Remarks
WILLOW FAMILY	*SALICACEAE*	
slender willow	*Salix petiolaris*	
EVENING PRIMROSE FAMILY	*ONAGRACEAE*	
common evening primrose	*Oenothera biennis*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	
MILKWEED FAMILY	*ASCLEPIADACEAE*	
common milkweed	*Asclepias syriaca*	
OLIVE FAMILY	*OLEACEAE*	
green ash	*Fraxinus pennsylvanica var. subintegerr*	
ASTER FAMILY	*ASTERACEAE*	
tall goldenrod	*Solidago altissima*	
field sow thistle	*Sonchus arvensis ssp.arvensis*	
calico aster	*Symphyotrichum lateriflorum var.laterifl*	
GRASS FAMILY	*POACEAE*	
poverty grass	*Aristida dichotoma*	
awnless brome grass	*Bromus inermis ssp.inermis*	
orchard grass	*Dactylis glomerata*	
CATTAIL FAMILY	*TYPHACEAE*	
common cattail	*Typha latifolia*	

Plant Species Per Community 12

Community 6 **ComID:** 2874 **ELC Code:** FOD8-1

Common Name	*Scientific Name*	Remarks
PINE FAMILY	*PINACEAE*	
white spruce	*Picea glauca*	
eastern white pine	*Pinus strobus*	
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
BIRCH FAMILY	*BETULACEAE*	
white birch	*Betula papyrifera*	
WILLOW FAMILY	*SALICACEAE*	
trembling aspen	*Populus tremuloides*	
DOGWOOD FAMILY	*CORNACEAE*	
red-osier dogwood	*Cornus stolonifera*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	
sugar maple	*Acer saccharum ssp.saccharum*	
CASHEW FAMILY	*ANACARDIACEAE*	
staghorn sumac	*Rhus typhina*	
CARROT FAMILY	*APIACEAE*	
Queen-Anne's lace	*Daucus carota*	
BORAGE FAMILY	*BORAGINACEAE*	
Viper's bugloss	*Echium vulgare*	
ASTER FAMILY	*ASTERACEAE*	
common burdock	*Arctium minus*	
New England aster	*Symphyotrichum novae- angliae*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	
CATTAIL FAMILY	*TYPHACEAE*	
common cattail	*Typha latifolia*	

Plant Species Per Community 15

Community 7 **ComID:** 2875 **ELC Code:**

Common Name	*Scientific Name*	Remarks
WILLOW FAMILY	*SALICACEAE*	
crack willow	*Salix fragilis*	
PEA FAMILY	*FABACEAE*	
white sweet-clover	*Melilotus alba*	
white clover	*Trifolium repens*	
CARROT FAMILY	*APIACEAE*	
Queen-Anne's lace	*Daucus carota*	

BORAGE FAMILY	*BORAGINACEAE*	
Viper's bugloss	*Echium vulgare*	
ASTER FAMILY	*ASTERACEAE*	
common ragweed	*Ambrosia artemisiifolia L.*	
common burdock	*Arctium minus*	
chicory	*Cichorium intybus*	
New England aster	*Symphyotrichum novae- angliae*	
GRASS FAMILY	*POACEAE*	
Canada bluejoint grass	*Calamagrostis canadensis*	
common reed	*Phragmites australis*	
CATTAIL FAMILY	*TYPHACEAE*	
common cattail	*Typha latifolia*	

Plant Species Per Community 12

Community 8 **ComID:** 2876 **ELC Code:** FOM2-2

Common Name	***Scientific Name***	**Remarks**
PINE FAMILY	*PINACEAE*	
eastern white pine	*Pinus strobus*	
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
WILLOW FAMILY	*SALICACEAE*	
trembling aspen	*Populus tremuloides*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	
sugar maple	*Acer saccharum ssp.saccharum*	
OLIVE FAMILY	*OLEACEAE*	
white ash	*Fraxinus americana*	
ASTER FAMILY	*ASTERACEAE*	
tall goldenrod	*Solidago altissima*	
New England aster	*Symphyotrichum novae- angliae*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	

Plant Species Per Community 9

Community 9 **ComID:** 2877 **ELC Code:** FOC1-2

Common Name	***Scientific Name***	**Remarks**
PINE FAMILY	*PINACEAE*	
white spruce	*Picea glauca*	
eastern white pine	*Pinus strobus*	
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	

MAPLE FAMILY	*ACERACEAE*	
sugar maple	*Acer saccharum ssp.saccharum*	
CASHEW FAMILY	*ANACARDIACEAE*	
staghorn sumac	*Rhus typhina*	
OLIVE FAMILY	*OLEACEAE*	
green ash	*Fraxinus pennsylvanica var. subintegerr*	
ASTER FAMILY	*ASTERACEAE*	
tall goldenrod	*Solidago altissima*	
New England aster	*Symphyotrichum novae- angliae*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	

Plant Species Per Community 9

Community 10

ComID: 2878

ELC Code: MAS3-1

Common Name	*Scientific Name*	Remarks
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
WILLOW FAMILY	*SALICACEAE*	
balsam poplar	*Populus balsamifera*	
crack willow	*Salix fragilis*	
slender willow	*Salix petiolaris*	
ASTER FAMILY	*ASTERACEAE*	
tall goldenrod	*Solidago altissima*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	
CATTAIL FAMILY	*TYPHACEAE*	
narrow-leaved cattail	*Typha angustifolia*	
common cattail	*Typha latifolia*	

Plant Species Per Community 8

Community 11

ComID: 2879

ELC Code: MAS3-1

Common Name	*Scientific Name*	Remarks
PINE FAMILY	*PINACEAE*	
white spruce	*Picea glauca*	
eastern white pine	*Pinus strobus*	
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
WILLOW FAMILY	*SALICACEAE*	
slender willow	*Salix petiolaris*	
MAPLE FAMILY	*ACERACEAE*	
Manitoba maple	*Acer negundo*	

MILKWEED FAMILY	*ASCLEPIADACEAE*	
common milkweed	*Asclepias syriaca*	
ASTER FAMILY	*ASTERACEAE*	
tall goldenrod	*Solidago altissima*	
CATTAIL FAMILY	*TYPHACEAE*	
narrow-leaved cattail	*Typha angustifolia*	
common cattail	*Typha latifolia*	

Plant Species Per Community 9

Community 12

ComID: 2880

ELC Code: MAS3-1

Common Name	*Scientific Name*	Remarks
PINE FAMILY	*PINACEAE*	
white spruce	*Picea glauca*	
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
WILLOW FAMILY	*SALICACEAE*	
crack willow	*Salix fragilis*	
slender willow	*Salix petiolaris*	
CATTAIL FAMILY	*TYPHACEAE*	
narrow-leaved cattail	*Typha angustifolia*	
common cattail	*Typha latifolia*	

Plant Species Per Community 6

Community 13

ComID: 2881

ELC Code: CUT2-1

Common Name	*Scientific Name*	Remarks
PINE FAMILY	*PINACEAE*	
eastern white pine	*Pinus strobus*	
CYPRESS FAMILY	*CUPRESSACEAE*	
common juniper	*Juniperus communis var. depressa*	
ELM FAMILY	*ULMACEAE*	
American elm	*Ulmus americana*	
CASHEW FAMILY	*ANACARDIACEAE*	
staghorn sumac	*Rhus typhina*	
GRASS FAMILY	*POACEAE*	
awnless brome grass	*Bromus inermis ssp.inermis*	

Plant Species Per Community 5

Community 14 **ComID:** 3498 **ELC Code:** FOM2-2

Common Name	*Scientific Name*	Remarks
PINE FAMILY	*PINACEAE*	
white spruce	*Picea glauca*	
eastern white pine	*Pinus strobus*	
CYPRESS FAMILY	*CUPRESSACEAE*	
eastern white cedar	*Thuja occidentalis*	
WILLOW FAMILY	*SALICACEAE*	
balsam poplar	*Populus balsamifera*	
MAPLE FAMILY	*ACERACEAE*	
sugar maple	*Acer saccharum ssp.saccharum*	

Plant Species Per Community 5

Total Number of Plant Species 52

APPENDIX II
PROJECT BIRD STATUS LIST

APPENDIX II Bird Status Report

Bird species observed by NEA are listed in the order followed the American Ornithologists' Union (AOU) Check-list of North American birds (7th edition, 1999, 47th Supplement). Common and scientific nomenclature are based on those used by AOU. Breeding status and breeding evidence code are listed when observed. Any significant status for a species on national and provincial lists is displayed as well as those from relevant regional lists.

List Status :

END - endangered	A wildlife species facing imminent extirpation or extinction.
END-R -endangered regulated	A wildlife species facing imminent extirpation or extinction in Ontario which has been regulated under Ontario's Endangered Species Act (ESA).
THR - threatened	A wildlife species likely to become endangered if limiting factors are not reversed.
SC - special concern	A wildlife species that may become threatened or an endangered species because of a combination of biological characteristics and identified threats.
YES - Area Sensitive	A wildlife species that requires large areas of suitable habitat in order to sustain their population numbers.

*** Other status levels are not displayed**

List Sources:

COSEWIC	The Committee on the Status of Endangered Wildlife in Canada, May 2016.
COSSARO	The Committee on the Status of Species at Risk in Ontario, June 2016.
SARA	Species At Risk Act, Schedule 1, Government of Canada, 2016.
Area Sensitive	Significant Wildlife Technical Guide, Appendix C, OMNR, Oct. 2000
Region 6	Southern Ontario Wetland Evaluation Appendix 11B, Version 3.2, March 2013

Breeding Status: (Observed By NEA)

B -species observed in breeding season in suitable habitat with some evidence of breeding (confirmed, probable or possible as per Ontario Breeding Bird Atlas, 2002).

F -species observed in breeding season but no evidence of breeding or suitable nest sites available on the study site (includes flyovers, migrants and foraging colonial breeders).

M -species observed outside of breeding season for that species and in area outside of the known

Breeding Evidence Code: (Observed By NEA)

OBSERVED

X -species observed in its breeding season (no evidence of breeding).

POSSIBLE BREEDING

H -species observed in its breeding season in suitable nesting habitat

S -singing male present, or breeding calls heard, in its breeding season in suitable nesting habitat

PROBABLE BREEDING

P -pair observed in their breeding season in suitable nesting habitat

T -permanent territory presumed through registration of territorial song on at least 2days, a week or more apart, at the same place

D -courtship or display between a male and a female or 2 males, including courtship feeding or copulation

V -visiting probable nest site

A -agitated behaviour or anxiety calls of an adult

B -brood patch on adult female or cloacal protuberance on adult male

N -nest-building or excavation of nest hole

CONFIRMED BREEDING

DD -distraction display or injury feigning

NU -used nest or egg shell found (occupied or laid within the period of study)

FY -recently fledged young or downy young, including young incapable of sustained flight

AE -adults leaving or entering nest site in circumstances indicating occupied nest

FS -adult carrying fecal sac

CF -adult carrying food for young

NE -nest containing eggs

NY -nest with young seen or heard

SOURCE: Ontario Breeding Bird Atlas March 2001

AOU Code	Common Name	Scientific Name	Observed Breeding Status	Breed Evidence Code				Area Sensitive	Region 6		
RUGR	Ruffed Grouse	*Bonasa umbellus*	B	None				No			
ROPI	Rock Pigeon	*Columbia livia*	B	None				No			
BLJY	Blue Jay	*Cyanocitta cristata*	B	None				No			
AMCR	American Crow	*Corvus brachyrhynchos*	B	None				No			
CORA	Common Raven	*Corvus corax*	B	None				No			
BCCH	Black-capped Chickadee	*Poecile atricapillus*	B	None				No			
RBNU	Red-breasted Nuthatch	*Sitta canadensis*	B	None				Yes			
EUST	European Starling	*Sturnus vulgaris*	B	None				No			
PISI	Pine Siskin	*Carduelis pinus*	B	None				No			
TOTAL SPECIES OBSERVED:	9	**BREEDING SPECIES OBSERVED:**	**9**		**0**	**0**	**0**	**1**	**0**	**0**	**0**

Appendix E – Stage 1 Archaeological Assessment

STAGE 1 ARCHAEOLOGICAL ASSESSMENT
HIGHWAY 148 (GWP 214-00-00) ANGUS CAMPBELL DRIVE TO GREENWOOD ROAD
PROVINCIAL TRANSPORTATION FACILITIES
CLASS ENVIRONMENTAL ASSESSMENT
TOWNSHIP OF LAURENTIAN VALLEY (FORMER TOWNSHIP OF PEMBROKE)
COUNTY OF RENFREW, ONTARIO

SUMMARY OF REPORT PREVIOUSLY PREPARED AND SUBMITTED UNDER PIF P392-0155-2015

Prepared for:

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26 May 2017

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Stage 1 Archaeological Assessment
Highway 148 (GWP 214-00-00) Angus Campbell Drive to Greenwood Road
Provincial Transportation Facilities
Class Environmental Assessment
Former Township of Pembroke, County of Renfrew
Township of Laurentian Valley, Ontario

EXECUTIVE SUMMARY

Archaeological Services Inc. was contracted by IBI Group on behalf of the Ministry of Transportation to conduct a Stage 1 Archaeological Assessment for the Highway 148 Provincial Transportation Facilities Class Environmental Assessment (EA). ASI (2016) completed the Stage 1 report (PIF# P392-0155-2015) was submitted to MTCS and accepted into the provincial register on May 30, 2016. The Highway 148 project will identify current and future needs of this road network. Recommendations shall be provided to correct identified deficiencies and to further enhance highway operation and safety.

The overall study area is being split into two sections: Highway 148 from Angus Campbell Drive to Greenwood Road (GWP 214-00-00) and Highway 148 from Greenwood Road east to the Quebec border (GWP 239-00-00). This report summarizes the previous Stage 1 findings (ASI 2016) for the section of Highway 148 from Angus Campbell Drive to Greenwood Road. This report is for IBI Group's records only, and no additional archaeological assessment has been undertaken for this summary report.

The Stage 1 background study determined that one previously registered archaeological site is located within one kilometre of the study area. A review of the geography and history of the study area suggested that the study area has potential for the identification of Indigenous and Euro-Canadian archaeological resources, depending on the condition of soils within the study area. The Stage 1 property inspection determined that while the majority of the study area has been previously disturbed by construction of the existing ROW and adjacent developments, some lands are considered to retain archaeological potential.

In light of these results, ASI makes the following recommendations:

1. Parts of the Highway 148 study area are considered to retain archaeological potential. These lands require Stage 2 property assessment by test pit survey at five metre intervals and pedestrian survey at five metre intervals, where appropriate, prior to any proposed impacts;

2. The majority of the Highway 148 study area has been documented to be disturbed during construction of the existing ROW and adjacent development. Some lands were documented to be within low and wet conditions. These lands do not require further archaeological assessment;

ASI

3. The Pembroke Pentecostal Cemetery is located within the Highway 148 study area. The cemetery lands should be avoided by the Highway 148 detailed design. A Cemetery Investigation is required in the ROW lands adjacent to the cemetery to confirm the presence or absence of unmarked graves within the study area, prior to any proposed impacts. This entails the controlled mechanical removal of topsoil under the supervision of a licensed archaeologist. The exposed subsoil will then be shovel-shined and thoroughly examined for the presence of burial shafts; and,

4. Should the proposed work extend beyond the current Highway 148 study area then further Stage 1 assessment should be conducted to determine the archaeological potential of the surrounding lands.

PROJECT PERSONNEL

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1.0 PROJECT CONTEXT

Archaeological Services Inc. (ASI) was contracted by IBI Group on behalf of the Ministry of Transportation to conduct a Stage 1 Archaeological Assessment for the Highway 148 Provincial Transportation Facilities Class Environmental Assessment (EA). ASI (2016) completed the Stage 1 report (PIF# P392-0155-2015) which was submitted to MTCS and accepted into the provincial register on May 30, 2016. The Highway 148 project will identify current and future needs of this road network. Recommendations shall be provided to correct identified deficiencies and to further enhance highway operation and safety.

The overall study area has been split into two sections during detailed design: Highway 148 from Angus Campbell Drive to Greenwood Road (GWP 214-00-00) and Highway 148 from Greenwood Road east to the Quebec border (GWP 239-00-00). This report summarizes the previous Stage 1 findings (ASI 2016) for the section of Highway 148 from Angus Campbell Drive to Greenwood Road (Figure 1). This report is for IBI Group's records only, and no additional archaeological assessment has been undertaken.

The 2011 *Standards and Guidelines for Consultant Archaeologists (*S & G*)*, administered by the Ministry of Tourism, Culture and Sport (MTCS), Section 1, discusses the objectives of a Stage 1 archaeological assessment as follows:

- To provide information about the geography, history, previous archaeological fieldwork and current land condition of the study area;
- To evaluate in detail the archaeological potential of the study area which can be used, if necessary, to support recommendations for Stage 2 archaeological assessment for all or parts of the property; and,
- To recommend appropriate strategies for Stage 2 archaeological assessment, if necessary.

This report describes the Stage 1 archaeological assessment that was conducted for this project and is organized as follows: Section 1.0 summarizes the background study that was conducted to provide the archaeological and historical context for the project study area; Section 2.0 analyses the characteristics of the project study area and evaluates its archaeological potential; Section 3.0 provides recommendations for the next assessment steps; and the remaining sections contain other report information that is required by the S & G, e.g., advice on compliance with legislation, works cited, mapping and photo-documentation.

1.1 Development Context

All work has been undertaken as required by the *Environmental Assessment Act*, RSO (1990) and regulations made under the Act, and are therefore subject to all associated legislation. This project is being conducted under the Class Environmental Assessment (EA) for Provincial Transportation Facilities process (1999).

All activities carried out during this assessment were completed in accordance with the MTO document *Class Environmental Assessment for Provincial Transportation Facilities* (1999, as amended in 2000), the *Ontario Heritage Act* (2005), and the S & G.
Permission to carry out all activities necessary for the completion of the assessment was granted by IBI Group on January 23, 2015 and May 9, 2017.

1.2 Historical Context

The purpose of this section, according to the S & G, Section 7.5.7, Standard 1, is to describe the past and present land use and the settlement history and any other relevant historical information gathered through the Stage 1 background research. First, a summary is presented of the current understanding of the Indigenous land use of the study area. This is followed by a review of the historical Euro-Canadian settlement history.

1.2.1 Indigenous Land Use and Settlement

Eastern Ontario has been occupied by human populations since the retreat of the Laurentide glacier, approximately 10,500-10,000 BP (Karrow and Warner 1990: Fig. 2.9, 2.11). Populations at this time would have been highly mobile, inhabiting a boreal-parkland similar to the modern sub-arctic. The first populations of the Ottawa Valley may have occupied the shore-zone of the former Champlain Sea. By approximately 10,000 BP, the environment had progressively warmed and populations now occupied less extensive territories (Ellis and Deller 1990: 62-63).

By 10,000 BP, the ice margin had retreated northward from Georgian Bay and the pro-glacial Lake Algonquin was drained through the North Bay outlet (Karrow and Warner 1990: Fig. 2.9). From approximately 10,000-5,500 BP, the Great Lakes basins experienced low-water levels and so it is likely that many sites that would have been located on those former shorelines are now submerged. From approximately 10,000 to 8,000 BP, eastern Ontario was occupied by populations whose subsistence seems to have been focused within the boreal forest environment (Wright 2001: 101, 105, 106). Groups may have had seasonal prolonged residency at fords to take advantage of migrating animal herds, made vulnerable by the crossing, but otherwise likely subsisted at large in the forest environment (Wright 2001: 112, 113).

By approximately 8,000 BP, subsistence is believed to have shifted to an increased reliance on aquatic resources, likely anadromous fish. This is indicated by evidence from isotopic analysis of bone samples from the Wapekeka Burial site (dated to approximately 7,000 BP) (Wright 2001: 125). Comparative evidence from the O.S.A Lake site near Georgian Bay allows some speculation that contact existed between populations in north-central Ontario and those in southern Ontario (Wright 2001: 123). Such communication networks certainly extended into eastern Ontario as well.

By approximately 6,000 BP evidence exists for the highly specialized production of ground-stone and native copper artifacts. This is coupled with evidence for population growth and extensive exchange networks (Ellis *et al.* 1990: 88, 90). Material culture is indicative of influences from populations in the St. Lawrence basin of southeastern Ontario and southern Quebec. Evidence of this is found at the large burial and habitation sites of Allumette Island-1 and Morrison's Island-6 exhibit evidence of this influence (Ellis *et al.* 1990: 90) and is indicative of connection between the populations in the Ottawa Valley and those in the St. Lawrence basin. Trapping and fishing appear to have been a main-stay of subsistence. The combined habitation-burial sites are suggestive of decreased mobility (Ellis *et al*. 1990: 91). This use of the Ottawa River Valley as a special place for burial should be seen as deliberate and reflective of the cosmology of these people as well as indicative of shared meaning across the community (Brown 1995: 13; Holloway and Hubbard 2001: 74; Parker Pearson 1999: 141).

Little is known about subsequent occupation of the Upper Ottawa Valley until approximately 2,200 BP. Between approximately 4,800 through 4,000 BP, evidence exist in southern Ontario for infrastructure such as fish weirs as well as established cemeteries (Ellis *et al*. 1990; Ellis *et al.* 2009). Evidence from the McIntyre site on Rice Lake is indicative that populations in eastern Ontario had greater variability in their diet, and began inhabiting larger sites with overall greater cultural complexity (Ellis *et al.* 1990: 120). At this time period, the Great Lakes watershed was experiencing the Nipissing high-water phase. Ca. 5,000 BP, isostatic rebound of the continent caused the Lake Huron basin to flood in-land as far as Lake Nipissing (though the exact strandline is debated). This isostatic rebound also affected the watershed boundaries causing the upper Great Lakes to drain through the modern St. Clair River drainage rather than its previous drainage down the Ottawa River (Jackson *et al.* 2000). This drastic change to the waterways of Ontario certainly had profound implications for the human geography of the entire Great Lakes basin.

Between approximately 3,000 through 2,500 BP, populations continued a semi-permanent existence and exploited seasonally available resources, and harvesting spawning fish continued to be an important part of their subsistence. Evidence still exists for extensive and complex exchange networks (Spence *et al.* 1990: 136, 138). Evidence for contacts with populations in New York State and New England has been found at the Morrison's Island-2 site on the Ottawa River Valley. The Morrison's Island-2 site demonstrates the continuation of this mortuary landscape as well as provides evidence for elaborate burial customs (Spence *et al.* 1990: 140). The presence of red ochre at this site is specifically implicit of ceremonialism.

By approximately 2,500 BP, evidence exists for macro-band camps, focussing on the seasonal exploitation of resources such as spawning fish and wild rice. Bands likely retreated to interior camps during the winter (Spence *et al.* 1990: 155, 164).

By approximately 1,000 BP until approximately 300 BP, archaeological evidence indicates lifeways similar to those of the historically described Indigenous groups. Populations in central-eastern Ontario were Algonquian speaking peoples who were in contact with Iroquoian speaking peoples to the south. This is hinted at by some analogous material culture between the two groups during this time (Fox 1990: 183). Such contact is consistent with evidence dating to approximately 3,000 BP and extensively documented in historical accounts of the seventeenth century.

The study area is located within the territory of the *Kichespirini* Algonquin Nation, who primarily occupied Morrison's Island. The Kichespirini were the most powerful of the Algonquin Nations during the sixteenth century and the most commercially oriented. The Algonquins were primarily hunter-fishers. While this was of dire economic importance, protocol was strictly guided by Algonquin cosmology and understanding of the spiritualism in the natural world. Some Algonquins also practiced limited horticulture on lots cleared by slash-and-burn and adopted new European cultivars (e.g. the pea) very early on (Day and Trigger 1978:795; Whiteduck 2002). Control of the waterways was also an important facet of the Algonquins' economy, as sovereignty and tolls were exacted for right-of-passage. Such tolls may be seen as comparable to modern day visas and/or tariffs, and were important elements of the Algonquins' place and position in the geo-political world of the seventeenth century (Whiteduck 2002). The Kichespirini used their position on Morrison's Island to control traffic along the Ottawa River. The Algonquins had largely dispersed from the Ottawa Valley and its tributaries between 1650 and 1675, but they continued to use it for hunting. The Kichespirini are recorded, however, to have held their position on Morrison's Island in 1650 with a force of 400 warriors (Day and Trigger 1978).

In the early seventeenth century, the Algonquin were the primary intermediary in the flow of European objects into Huron controlled territory located between Georgian Bay and Lake Superior (Day and

Trigger 1978: 793). Control of the waterways was also an important facet of the Algonquin economy, as sovereignty and tolls were exacted for right-of-passage. Such tolls may be seen as comparable to modern day visas and/or tariffs, and were important elements of the Algonquins' place and position in the geo-political world of the seventeenth century (Whiteduck 2002). In 1646, war broke out between the Five Nations Iroquois and the Algonquins, ultimately leading to their dispersal from the Ottawa Valley between 1650 and 1675 (Day and Trigger 1978: 794), however, they continued to use the Upper Ottawa Valley for hunting and fishing.

During the beginning of the second half of the seventeenth century, eastern Ontario was used by the Five Nations Iroquois as a hinterland for the fur trade (Trigger 1978: Figure 1e) but were pushed out of the Lake Ontario north-shore region in the latter decade of the nineteenth century by Ojibwa bands moving south (Rogers 1978: 761). Ojibwa occupation of eastern Ontario is unclear as the Upper Ottawa Valley continued to be used by the Algonquin for hunting and the Ottawa River continued to be inhabited by the Algonquins into the twentieth century (Day and Trigger 1978: 795). The Algonquins are documented by the eighteenth century, to have considered early-on the need for conservation. This realisation was brought to the fore-front by the extirpation of the vast majority of wild-life from eastern Ontario by the logging industry, which crippled the hunting-based economy of the Algonquins (Whiteduck 2002). The study area is located within the parcel of the Williams Treaty of 1923 between the His Majesty the King and the Mississauga Indians of Rice Lake, Mud Lake, Scugog Lake and Alderville (Cloutier 1957). The Algonquin still regard territories south of the Ottawa River as theirs (Day and Trigger 1978: 795).

1.2.2 Historic Euro-Canadian Land Use: Township Survey and Settlement

Historically, the study area is located in part of Lots 11-24, Concession 2 in the Former Township of Pembroke, County of Renfrew.

The S & G stipulates that areas of early Euro-Canadian settlement (pioneer homesteads, isolated cabins, farmstead complexes), early wharf or dock complexes, pioneer churches and early cemeteries, are considered to have archaeological potential. Early historical transportation routes (trails, passes, roads, railways, portage routes), properties listed on a municipal register or designated under the *Ontario Heritage Act* or a federal, provincial, or municipal historic landmark or site are also considered to have archaeological potential.

For the Euro-Canadian period, the majority of early nineteenth century farmsteads (i.e., those which are arguably the most potentially significant resources and whose locations are rarely recorded on nineteenth century maps) are likely to be located in proximity to water. The development of the network of concession roads and railroads through the course of the nineteenth century frequently influenced the siting of farmsteads and businesses. Accordingly, undisturbed lands within 100 m of an early settlement road are also considered to have potential for the presence of Euro-Canadian archaeological sites.

The first Europeans to arrive in the area were missionaries and transient traders from France, who were conducted into the region by Indigenous allies and set up missions at strategic locations along the well-traveled lake and river routes. These occupations occurred at sites that afforded both natural landfalls and convenient access, by means of the various waterways and overland trails. The study area is situated on the Ottawa River, which was part of the main route to the interior of North America from the French settlements at Quebec and Trois-Rivière. The Ottawa River route was highly travelled into the nineteenth century.

Pembroke Township

The Township of Pembroke is the smallest in Renfrew County and is situated adjacent to the Ottawa River. The Township was partitioned in 1835 from the area of Westmeath. The Township is named for the Earl of Pembroke (Mika and Mika 1981: 185).

Pembroke

Pembroke was first settled in 1828 by Col. Peter White who built a cabin at the mouth of the Muskrat River. In 1831, the first mill was constructed. The settlement slowly expanded with the first school being constructed in 1836 and the post office being established in 1846. By 1887 the town had a population of 4,500 people with a range of industries as well as seven churches, the Presbyterian, Methodist and Catholic churched being the most prominent buildings. Pembroke was the first town in Canada to have electric lights and, in 1884, to sell it commercially (Mika and Mika 1981: 185-187).

1.2.3 Historic Map Review

The 1863 *Map of the Counties of Lanark and Renfrew* was reviewed for this Stage 1 archaeological assessment. The map did not appear to indicate any historic features within the study area, however it may portray features in proximity to it. The print quality and map scale, however, are both inadequate for the purposes of an effective map review.

The 1881 *Illustrated Atlas of Renfrew County* was examined to determine the presence of historic features within the study area during the nineteenth century. The map indicates lots, geographic township outlines, transportation routes, water bodies and settlement communities as well as schools and churches, however, lot tenure or historic features such as farmhouses are not indicated. A historic schoolhouse is indicates in proximity to the study area. The historic mapping also indicates that Pembroke Street/Old Highway 17 (possibly by a different alignment) is a historic plank road (Figure 2). Transportation and communication networks are important because they serve to integrate social and economic activities between disparate settlement centres. As these settlements grew and traffic increased between them, toll gates, taverns, hotels and other services for travelers were established where major transportation routes were crossed. Early overland routes followed the natural topography, avoiding swamps or rocky outcrops.

No other relevant historic map was identified in the course of the background research.

1.2.4 Summary of Historical Context

The background research demonstrated that the study area retains potential for the recovery of Indigenous archaeological resources. The study area lands are situated within the traditional territory of the *Kichespirini* Nation of the Algonquin. During the second half of the seventeenth century, the study area may have been utilised by the Five Nations Iroquois for resource extraction. By the late seventeenth century, Algonquin resource extraction is documented in the Upper Ottawa River and occupation is known into the twentieth century.

The background research demonstrates that the study area is situated within the former Township of Pembroke. The study area is situated in proximity to the Ottawa River. The Ottawa River was a vital waterway for the fur trade from the seventeenth to nineteenth century as well as since the earliest human occupation of the Ottawa Valley.

1.3 Archaeological Context

This section provides background research pertaining to previous archaeological fieldwork conducted within and in the vicinity of the study area, its environmental characteristics (including drainage, soils or surficial geology and topography, etc.), and current land use and field conditions. Three sources of information were consulted to provide information about previous archaeological research in the study area; the site record forms for registered sites housed at the MTCS; published and unpublished documentary sources; and the files of ASI.

1.3.1 Current Land Use and Field Conditions

The study area predominantly consists of the Highway 148 right-of-way (ROW) from Angus Campbell Drive to the intersection at Greenwood Road. The study area is situated within the suburban area between the City of Pembroke and the community of Pleasant View and beyond Pleasant View within a mixed low density residential and commercial-industrial area. The study area is located between the rural agricultural lands of the Ottawa Valley and the Ottawa River. The study area includes public ROW which has been significantly graded as well as adjacent lands which are primarily developed but some can be considered to have relatively undisturbed frontages.

1.3.2 Geography

In addition to the known archaeological sites and historic features, the state of the natural environment is an important indicator of archaeological potential. Accordingly, a description of the study area geography, physiography and soils is provided below.

The S & G, Section 1.3.1, stipulates that primary water sources (lakes, rivers, streams, creeks, etc.), secondary water sources (intermittent streams and creeks, springs, marshes, swamps, etc.), ancient water sources (glacial lake shorelines indicated by the presence of raised sand or gravel beach ridges, relic river or stream channels indicated by clear dip or swale in the topography, shorelines of drained lakes or marshes, cobble beaches, etc.), as well as accessible or inaccessible shorelines (high bluffs, swamp or marsh fields by the edge of a lake, sandbars stretching into marsh, etc.) are characteristics that indicate archaeological potential.

Water has been identified as the major determinant of site selection and the presence of potable water is the single most important resource necessary for any extended human occupation or settlement. Since water sources have remained relatively stable in Ontario since 5,000 BP (Karrow and Warner 1990: Figure 2.16), proximity to water can be regarded as a useful index for the evaluation of archaeological site potential. Indeed, distance from water has been one of the most commonly used variables for predictive modeling of site location.

The S & G, Section 1.3.1, also lists other geographic characteristics that can indicate archaeological potential including: elevated topography (eskers, drumlins, large knolls, plateaux), pockets of well-drained sandy soil, especially near areas of heavy soil or rocky ground, distinctive land formations that might have been special or spiritual places, such as waterfalls, rock outcrops, caverns, mounds, and promontories and their bases. Physical indicators of use may be present, such as burials, structures, offerings, rock paintings or carvings. Resource areas, including; food or medicinal plants (migratory routes, spawning areas) are also considered characteristics that indicate archaeological potential.

The study area is situated within the Petawawa Sand Plain and the Ottawa Valley Clay Plains physiographic regions in sand plain and clay plain (Chapman and Putnam 1984). The Petawawa Sand Plain is a sand plain on the Ontario side of the Ottawa River which is interrupted by several outcrops of Precambrian rock. The Plain extends from Petawawa to south of Pembroke and covers an area of approximately 337 km^2. The sand plain was formed as a delta in the Champlain Sea by the Petawawa, Barrow, Indian and Ottawa Rivers during the Fossmill stage of Lake Algonquin (Chapman and Putnam 1984: 210).

The Ottawa Valley clay between Pembroke and Hawksbury consist of clay plains interrupted by ridges of rock or sand (Chapman and Putnam 1984:205). The region divides into two parts, above and below Ottawa, which each section having its own distinctive traits. The upper section is characterized by a broad valley with the Laurentian uplands rising on both sides (Chapman and Putnam 1984:205). The Quebec side of the valley features a steep slope with a sharp rise of approximately 183 m, while the Ontario side is gradually sloping with some prominent scarps.

Sand plains and clay plains are glaciolacustrine features which are products of the Late Wisconsian glacial stage (ca. 25,000-10,000 BP). Sand plains are formed in shallow waters and beach ridges mark the former shorelines. Clay plains are formed when glacial melt waters pond between ice margins, high ground or flood basins. Clay plains are formed in deep water by sediment sorting (Karrow and Warner 1990: 5).

Figure 3 illustrates the surficial geology of the study area. The study area is underlain by deposits of sand, clay, and diamicton (poorly sorted sediments typically of glacial origin). The study area also includes a number of fluvial terraces. Sand deposits consist of late Pleistocene alluvial deposits and include deposits of clay, silt gravel and may contain organic remains. Clay deposits consist of massive to well-laminated fine-textured glaciomarine deposits and include deposits of silt and minor deposits of sand and gravel. Diamicton deposits consist of stone-poor sandy silt to silty sand-textured till on Paleozoic terrain (OGS 2010).

Soils within the study area include Uplands loamy sand, Renfrew sand complex, Rubicon sandy loam and Ste. Rosalie clay (Dept. of Agriculture 1964). For detailed soil descriptions see Appendix A.

The study area is located adjacent to the Ottawa River. The Ottawa River drains an area of 1,463 km^2 and extends 1,271 km from source to mouth. The Ottawa River was of key importance as a transportation route from the seventeenth through to the nineteenth century as well as since the earliest human occupation of the Ottawa Valley. In latter days, this importance shifted more towards the timber trade (Chapman and Putnam 1984: 110). The Ottawa River has been nominated as a Canadian Heritage River (CHRS 2011).

The study area is located at the delta of the former glacial Ottawa River and the Champlain Sea. The Champlain Sea was a large inland arm of the Atlantic Ocean stretching inland as far as modern day Kingston and Pembroke. The Champlain Sea formed at approximately 13,000 BP when an ice barrier at located at modern day Quebec City melted and the inland glacial Lake Candona was flooded by the Goldthwait Sea. The Champlain Sea persisted until approximately 10,600 BP when due to isostatic rebound of the continent it receded to the modern Lake Champlain and the extinct Lampsilis Lake (Pintal 2012: 221; Robinson 2012: 197). The geography of the Champlain Sea strand is difficult to determine precisely. The sea levels in Quebec have been reconstructed at approximately 175 m above sea level (a.s.l.) (Karrow 2006) however in parts of New York State and Vermont State, Champlain Sea strands

have been documented at elevations of approximately 91 m a.s.l. (Chapman 1937; Rayburn 2004) and approximately 107 m a.s.l. (Springston and DeSimone 2007).

Algonquin cosmology understood that the natural world was filled with spirits or Manitous. Such Manitous were found in the rivers, and maintaining their benevolence was of regular importance while travelling through the country. Manitous could be identified at places with 'power' and may especially be found at places such as waterfalls, caves or canyons which are prone to reverberation, echo, or other noise (Whiteduck 2002).

1.3.3 Previous Archaeological Research

In Ontario, information concerning archaeological sites is stored in the Ontario Archaeological Sites Database (OASD) maintained by the MTCS. This database contains archaeological sites registered within the Borden system. Under the Borden system, Canada has been divided into grid blocks based on latitude and longitude. A Borden block is approximately 13 kilometres east to west, and approximately 18.5 kilometres north to south. Each Borden block is referenced by a four-letter designator, and sites within a block are numbered sequentially as they are found. The study area under review is located in Borden block *BkGg*.

According to the OASD, one previously registered archaeological sites are located within one kilometre of the study area (MTCS 2015a); this site is located within 300 m of the study area. Site detailed are outlined in Table 1.

Table 1: Details of previously registered archaeological sites registered within one kilometre of the study area

Borden #	Site Name	Cultural Affiliation	Site Type	Researcher
BkGg-23	Pembroke PCP – Boat Structure	Euro-Canadian (1870-1880)*	Wreck	Adams HCI 2003

* - Dates based on MTCS 2015b
Adams HCI – Adams Heritage Consulting Inc.

According to the background research, one previous archaeological assessment has been conducted within 50 m of the study area (Stantec Consulting Ltd. 2011). This report is reviewed below.

Stantec Consulting Ltd. (2011) conducted a Stage 1 archaeological assessment of proposed Highway 148 Road Improvements under the project direction of David McLeod (CIF P200-013-2010). The Stage 1 background research determined that the study area retained potential for archaeological resources. This study area includes some lands within the current Highway 148 study area, along the Highway 148 ROW from Spring Street to the Quebec Border. Results of site reconnaissance conducted for this assessment are not discussed. The print quality and map scale of the assessment results were both inadequate for the purposes of commenting on archaeological potential.

1.3.4 Summary of Archaeological Context

The background research and historic mapping demonstrates that the study area is located in the Former Township of Pembroke, County of Renfrew. The study area is located in proximity to the Ottawa River as well as the former tidal foreshore of the Champlain Sea. The study area includes elevated terrain and well-drained sandy soils. The study area is also located in proximity to a previously registered

archaeological site. These criteria indicate that the study area has potential for the recovery of Indigenous and Euro-Canadian archaeological resources.

2.0 FIELD METHODS (PROPERTY INSPECTION)

The Stage 1 property inspection was conducted under the field direction of Peter Carruthers (P163), of ASI, on June 5, 2015, in order to gain first-hand knowledge of the geography, topography, and current conditions and to evaluate and map archaeological potential of the study area. It was a visual inspection only and did not include excavation or collection of archaeological resources.

The Stage 1 property inspection adhered to the S & G, Section 1.2, Standards 1-6, which are discussed below. The entire property and its periphery must be inspected. The inspection may be either systematic or random. Coverage must be sufficient to identify the presence or absence of any features of archaeological potential. The inspection must be conducted when weather conditions permit good visibility of land features. Natural landforms and watercourses are to be confirmed if previously identified. Additional features such as elevated topography, relic water channels, glacial shorelines, well-drained soils within heavy soils and slightly elevated areas within low and wet areas should be identified and documented, if present. Features affecting assessment strategies should be identified and documented such as woodlots, bogs or other permanently wet areas, areas of steeper grade than indicated on topographic mapping, areas of overgrown vegetation, areas of heavy soil, and recent land disturbance such as grading, fill deposits and vegetation clearing. The inspection should also identify and document structures and built features that will affect assessment strategies, such as heritage structures or landscapes, cairns, monuments or plaques, and cemeteries.

Weather conditions for the inspection were overcast with a temperature of approximately 17° C. Previously identified features of archaeological potential were examined; additional features of archaeological potential not visible on mapping were identified and documented as well as any features that could affect assessment strategies. Field observations are compiled onto the maps of the study area in Section 7.0 (Figures 4-5) and associated photography is presented in Section 8.0 (Plates 1-33).

3.0 ANALYSIS AND CONCLUSIONS

The historical and archaeological contexts were analyzed to help determine the archaeological potential of the study area. A summary of the archaeological potential of the study area is presented in Section 2.1 of this report.

3.1 Analysis of Archaeological Potential

The S & G, Section 1.3.1, lists criteria indicative of archaeological potential. The study area meets the following criteria indicative of archaeological potential:

- Water source: primary, secondary, or past water source (e.g. Ottawa River; Champlain Sea)
- Well-drained soils (e.g. Uplands loamy sand)
- Elevated terrain (e.g. fluvial terraces; moraine)
- Previously registered archaeological site (Pembroke PCP Boat Structure *BkGg-23*)
- Early transportation route (Pembroke Street)

These criteria are indicative of potential for the identification of Indigenous and Euro-Canadian archaeological resources within the study area.

3.2 Analysis of Property Inspection Results

The majority of the study area has been documented to be previously disturbed by the construction/ grading activities associated with the existing Highway 148 ROW and adjacent developments (Figures 4-5: areas marked in yellow). Other lands were documented to be within low and wet conditions (Figure 5: area marked in blue). These lands do not retain archaeological potential and therefore do not require further archaeological assessment.

Some parts of the study area are considered to retain archaeological potential. These lands should be subject to test pit survey at five-metre intervals and pedestrian survey at five metre intervals, where appropriate on account of their property conditions, in accordance with the S & G, Section 2.1.2, Standard 1.a, c, e and f (Figures 4-5: areas marked in green and orange, respectively). This assessment should be completed prior to any proposed impacts by the project.

The property inspection documented that the Pembroke Pentecostal Cemetery is located within the study area (Figures 5 and 6: area marked in dark orange; Plate 27). The cemetery lands should be avoided by the detailed design for the Highway 148 improvements. Because of the effects of development and road widening during the course of the twentieth century, the modern physical boundaries of a cemetery are not always a reliable indicator of its actual extent. There is potential for the presence of unmarked graves beyond the limits of the cemetery. Accordingly any construction work adjacent to a known cemetery must be preceded by a Stage 3 Cemetery Investigation (Figures 5 and 6: area marked in hatching). This entails the controlled removal of topsoil by Gradall (or smaller machine if required) under the supervision of a licensed archaeologist. The exposed subsoil will then be shovel-shined and thoroughly examined for the presence of burial shafts. This work will be done in accordance with the S & G and the regulations under the *Funeral, Burial and Cremation Services Act*.

3.3 Conclusions

The Stage 1 background study determined that one previously registered archaeological site is located within one kilometre of the study area. A review of the geography and history of the study area suggested that the study area has potential for the identification of Indigenous and Euro-Canadian archaeological resources, depending on the condition of soils within the study area. The Stage 1 property inspection determined that while the majority of the study area has been previously disturbed by construction of the existing ROW and adjacent developments, some lands are considered to retain archaeological potential.

4.0 RECOMMENDATIONS

In light of the results of this assessment, ASI makes the following recommendations:

1. Parts of the Highway 148 study area are considered to retain archaeological potential. These lands require Stage 2 property assessment by test pit survey at five metre intervals and pedestrian survey at five metre intervals (Figures 4-5: areas marked in green and orange, respectively), where appropriate, prior to any proposed impacts;

2. The majority of the Highway 148 study area has been documented to be disturbed during construction of the existing ROW and adjacent development (Figures 4-5: areas marked in yellow). Some lands were documented to be within low and wet conditions (Figure 5: area marked in blue). These lands do not require further archaeological assessment;

3. The Pembroke Pentecostal Cemetery is located within the Highway 148 study area. The cemetery lands should be avoided by the Highway 148 detailed design (Figures 4: area marked in dark orange). A Cemetery Investigation is required in the ROW lands adjacent to the cemetery to confirm the presence or absence of unmarked graves within the study area, prior to any proposed impacts (Figures 4: area marked in hatching). This entails the controlled mechanical removal of topsoil under the supervision of a licensed archaeologist. The exposed subsoil will then be shovel-shined and thoroughly examined for the presence of burial shafts; and,

4. Should the proposed work extend beyond the current Highway 148 study area then further Stage 1 assessment should be conducted to determine the archaeological potential of the surrounding lands.

Notwithstanding the results and recommendations presented in this study, ASI notes that no archaeological assessment, no matter how thorough or carefully completed, can necessarily predict, account for, or identify every form of isolated or deeply buried archaeological deposit. In the event that archaeological remains are found during subsequent construction activities, the consultant archaeologist, approval authority, and the Cultural Programs Unit of the MTCS should be immediately notified.

5.0 ADVICE ON COMPLIANCE WITH LEGISLATION

ASI advises compliance with the following legislation:

- This report is submitted to the Minister of Tourism, Culture and Sport as a condition of licensing in accordance with Part VI of the *Ontario Heritage Act*, RSO 1990, c 0.18. The report is reviewed to ensure that it complies with the standards and guidelines that are issued by the Minister, and that the archaeological field work and report recommendations ensure the conservation, preservation and protection of the cultural heritage of Ontario. When all matters relating to archaeological sites within the study area of a development proposal have been addressed to the satisfaction of the Ministry of Tourism, Culture and Sport, a letter will be issued by the ministry stating that there are no further concerns with regard to alterations to archaeological sites by the proposed development.

- It is an offence under Sections 48 and 69 of the *Ontario Heritage Act* for any party other than a licensed archaeologist to make any alteration to a known archaeological site or to remove any artifact or other physical evidence of past human use or activity from the site, until such time as a licensed archaeologist has completed archaeological field work on the site, submitted a report to the Minister stating that the site has no further cultural heritage value or interest, and the report has been filed in the Ontario Public Register of Archaeology Reports referred to in Section 65.1 of the *Ontario Heritage Act.*

- Should previously undocumented archaeological resources be discovered, they may be a new archaeological site and therefore subject to Section 48 (1) of the *Ontario Heritage Act*. The proponent or person discovering the archaeological resources must cease alteration of the site immediately and engage a licensed consultant archaeologist to carry out archaeological fieldwork, in compliance with sec. 48 (1) of the *Ontario Heritage Act*.

- The *Cemeteries Act*, R.S.O. 1990 c. C.4 and the *Funeral, Burial and Cremation Services Act*, 2002, S.O. 2002, c.33 (when proclaimed in force) require that any person discovering human remains must notify the police or coroner and the Registrar of Cemeteries at the Ministry of Consumer Services.

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7.0 MAPS

Study Area

Archaeological Services Inc.
528 Bathurst St.
Toronto, Ontario
Canada, M5S 2P9
T 416-966-1069
F 416-966-9723
info@iASI.to/www.iASI.to

BASE:

(c) OpenStreetMap and contributors,
Creative Commons-Share Alike
License (CC-BY-SA)

0 1
Kilometers

ASI PROJECT NO.: 14EA-201
DATE: Feb 2, 2015
DRAWN BY: BW
FILE: 14EA200_fig1

Figure 1: Highway 148 (GWP 214-00-00) Angus Campbell Drive to Greenwood Road Study Area Location

Archaeological Services Inc.
528 Bathurst St.
Toronto, Ontario
Canada, M5S 2P9
T 416-966-1069
F 416-966-9723
info@iASI.to/www.iASI.to

BASE: (c) OpenStreetMap and contributors, Creative Commons-Share Alike License (CC-BY-SA)

1881 Map of the County of Renfrew

0 0.75
Kilometers

ASI PROJECT NO.: 14EA-201
DATE: Feb 2, 2015

DRAWN BY: BW
FILE: 14EA201_fig2_Hist

Figure 2: Highway 148 (GWP 214-00-00) Angus Campbell Drive to Greenwood Road Study Area Overlaid on 1881 Map of Township of Pembroke

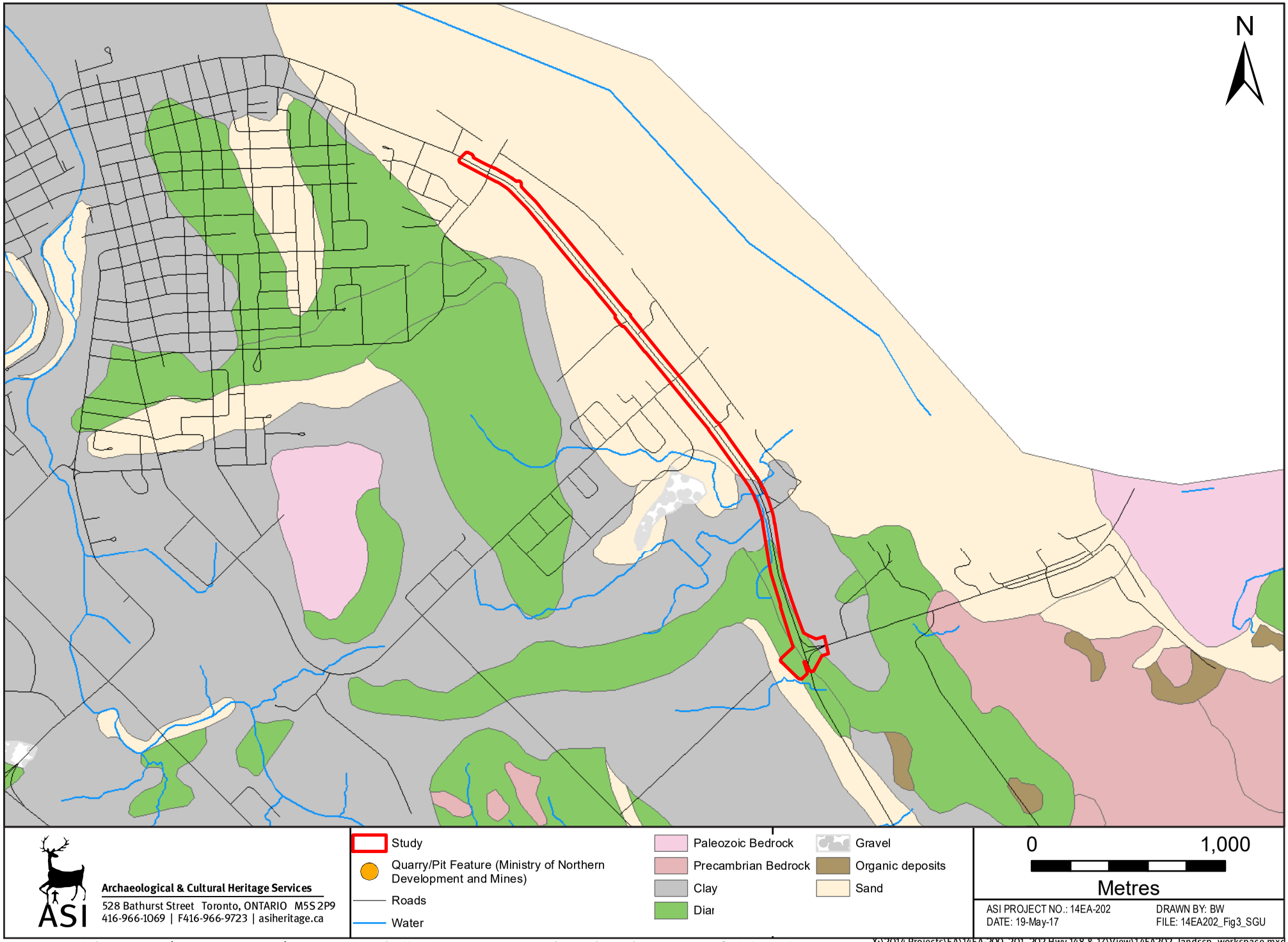

Figure 3: Highway 148 (GWP 214-00-00) Angus Campbell Drive to Greenwood Road Study Area - Surficial Geology

Study Area

Archaeological Potential (Req. Stage 2 test-pit survey at 5 m intervals)

Cemetery (Protection and Avoidance)

Disturbed: No Potential

Requires Cemetery Investigation

Photo Plate and Orientation

Recommended Plan

Roads

BASE:

Ortho
Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250

Metres

ASI PROJECT NO.: 14EA-200
DATE: 19-May-17

DRAWN BY: BW
FILE: 14EA200_Fig4_S1

Archaeological & Cultural Heritage Services
528 Bathurst Street Toronto, ONTARIO M5S 2P9
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Figure 4: Highway 148 (GWP 214-00-00) Angus Campbell Drive to Greenwood Road Study Area - Property Inspection Results (Sheet 1)

Study Area

Archaeological Potential (Req. Stage 2 test-pit survey at 5 m intervals)

Archaeological Potential (Req. Stage 2 pedestrian survey at 5 m intervals)

Disturbed: No Potential

Low and Wet: No Potential

Photo Plate and Orientation

Recommended Plan

Roads

BASE:

Ortho
Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250

Metres

ASI PROJECT NO.: 14EA-200
DATE: 19-May-17

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FILE: 14EA200_Fig5_S2

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Figure 5: Highway 148 (GWP 214-00-00) Angus Campbell Drive to Greenwood Road Study Area - Property Inspection Results (Sheet 2)

8.0 IMAGES

Plate 1: View southeast of study area. Highway 148 ROW is disturbed. No potential. Some lands beyond ROW Require Stage 2 test-pit survey at 5m intervals.

Plate 2: View southeast of Highway 148 ROW. ROW is disturbed. No potential.

Plate 3: View east of study area. Highway 148 ROW is disturbed. No potential.

Plate 4: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 5: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 6: View northeast of study area. Highway 148 ROW and some lands beyond are disturbed. Some lands beyond ROW require Stage 2 test-pit survey.

Plate 7: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 8: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 9: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 10: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 11: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 12: View NNE of study area. Highway 148 ROW and land beyond is disturbed. No potential.

Plate 13: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 14: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 15: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 16: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 17: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 18: View southeast of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 19: View NNW of study area. Highway 148 ROW has been filled; lands beyond are disturbed. No potential.

Plate 20: View south of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 21: View northwest of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 22: View SSE of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 23: View north of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 24: View south of study area. Highway 148 ROW and lands beyond are disturbed. No potential.

Plate 25: View east of study area. Highway 148 ROW is disturbed. No potential. Lands beyond retain potential. Require Stage 2 test-pit survey at five metre intervals.

Plate 26: View southwest of study area. Highway 148 ROW is disturbed. Some lands beyond ROW are low and wet. No potential. Some lands beyond retain potential. Require Stage 2 test-pit survey at five metre intervals.

Plate 27: Northeast view of Pembroke Pentecostal Cemetery. Cemetery lands should be avoided from impact. Surrounding lands require Cemetery Investigation.

Plate 28: Northeast view of study area. Highway 148 ROW and lands beyond are disturbed with no archaeological potential.

Plate 29: South view of study area. Highway 148 ROW and lands beyond are graded and disturbed. No archaeological potential.

Plate 30: Southeast view of study area. Highway 148 ROW and lands beyond are disturbed with no archaeological potential.

Plate 31: Northwest view of study area. Highway 148 ROW is deeply disturbed with no archaeological potential.

Plate 32: South view of study area. Highway 148 ROW and lands beyond are graded and disturbed with no archaeological potential.

Plate 33: Southeast view of study area. Highway 148 ROW and lands beyond are graded and disturbed with no archaeological potential.

9.0 APPENDIX A: DETAILED SOIL DESCRIPTIONS

Uplands loamy sand is a well-drained sandy soil which tends to run parallel to the Ottawa River. These deposits were laid down as a delta in a glacial lake which extended southward down the Ottawa Valley. This soil is found on level or gently undulating topography. These soils are derived from eroded Precambrian shield. Subsoil has concentrations of iron and organic material. Uplands loamy sand has been documented to retain the following profile (Gillespie *et al*. 1964:41, 42, 56):

Horizon	Colour	Texture/structure	Profile depth
Ae	White (10YR 8/1)	Sand; single grain structure, loose consistency	0-5 cm
Bfh1	Very dark grayish brown (10YR 3/2)	Sandy loam; granular structure; friable	5-15 cm
Bfh2	Dark yellowish brown (10YR 4/4)	Sandy loam; granular structure; very friable	15-28 cm
BC	Yellowish brown (10YR 5/6)	Sand; single grain structure; loose consistency	28-43 cm
C	Pale brown (10YR 6/3)	Sand	43+ cm

Renfrew sand complex consists of Renfrew clay with sand deposited over top. The depth of sand varies greatly from 15-91 cm. The sand deposits are typically Uplands sandy loam. Renfrew clay typically is found on flat topography which is in some areas incised by stream channels. The clay was deposited by a glacial lake basin in the Ottawa River extending from Arnprior to deep River. The clay is calcareous however free lime is not commonly occurring in the upper reaches of the soil. This soil is imperfectly drained. The Ap horizon has a poor organic content. Renfrew clay has been documented to retain the following profile (Gillespie *et al.* 1964:31, 32, 34, 53):

Horizon	Colour	Texture/structure	Profile depth
Ah	Grayish brown (10YR 5/2)	Clay; subangular blocky and platy structure; friable consistency; stonefree	0-4 cm
Ae	Gray (10YR 6/1)	Clay; platy and subangular blocky structure; friable consistency; weak to moderate mottling	4-10 cm
AB	Light brownish gray (10YR 6/2)	Clay; medium blocky structure; firm consistency; mottled	10-18 cm
Btg	Grayish brown (10YR 5/2)	Clay; prismatic structure breaking to blocky; hard consistency; clay skins on aggregate faces; mottled	18-28 cm
BCg	Grayish brown (10YR 5/2)	Clay; medium blocky structure; hard consistency; mottled	28-48 cm
C	Gray (10YR 5/1)	Clay; amorphous; plastic consistency; stonefree	48+ cm

Rubicon sandy loam as part of a delta deposited from a glacial river into a lake basin which stretched southward from Pembroke down the Ottawa River valley. This oil is imperfectly drained and underlain by glacial lake clay. Mottling is present on account of a high water table in the spring and autumn. The soil is derived from Precambrian bedrock. The Ae horizon is typically only found in uncultivated areas. Rubicon sandy loam has been documented to retain the following profile (Gillespie *et al*. 1964:36, 54).

Horizon	Colour	Texture/structure	Profile depth
Ae	Gray (10YR 6/1)	Sand; single grain structure; loose	0-5 cm
Bhf	Dark reddish brown (5YR	Loamy sand; granular structure; friable	5-10 cm

Horizon	Colour	Texture/structure	Profile depth
	2/2)		
Bfhg	Strong brown (7.5YR 5/8)	Loamy sand; granular structure; friable; some dark dusky red ortstein nodules; mottled	10-25 cm
Bfg1	Yellowish brown (10YR 5/6)	Sand; single grain; low contrasting mottling	25-46 cm
Bfg2	Olive (5Y 5/3)	Sand; single grain; loose; low contrast mottling	46-61 cm
C	Light gray (5Y 6/1)	Sand	61+ cm

Ste. Rosalie clay is a poorly drained soil that is found in the Ottawa River valley and throughout the lowland areas of the bordering areas. The soil is typically found in flat topography. Ponding is common in the spring and summer following heavy rains. Ste. Rosalie clay has been documented to retain the following profile (Gillespie *et al.* 1964:37, 38)

Horizon	Colour	Texture/structure	Profile depth
AP	Very dark gray (10YR 3/1)	Clay; coarse subangular blocky structure; firm consistency	0-13 cm
Cmg	Olive-gray (5Y 4/2)	Clay; amorphous; plastic consistency; strong mottling	13-46 cm
C	Olive-gray (5Y 4/2)	Clay; amorphous; plastic consistency	46+ cm

Appendix F – Cultural Heritage Resource Assessment

CULTURAL HERITAGE RESOURCE ASSESSMENT:
BUILT HERITAGE RESOURCES AND CULTURAL HERITAGE LANDSCAPES

EXISTING CONDITIONS – IMPACT ASSESSMENT

HIGHWAY 148, ANGUS CAMPBELL DRIVE TO GREENWOOD ROAD
CITY OF PEMBROKE, ONTARIO

Prepared for:

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ASI File: 14EA-201

June 2017

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CULTURAL HERITAGE RESOURCE ASSESSMENT:
BUILT HERITAGE RESOURCES AND CULTURAL HERITAGE LANDSCAPES

EXISTING CONDITIONS – IMPACT ASSESSMENT

HIGHWAY 148, ANGUS CAMPBELL DRIVE TO GREENWOOD ROAD
CITY OF PEMBROKE, ONTARIO

EXECUTIVE SUMMARY

ASI was contracted by IBI Group (Toronto) to conduct a Cultural Heritage Resource Assessment as part of the Highway 148 Provincial Transportation Facilities Class Environmental Assessment (EA) (Part A of the project). The project includes Preliminary Design and Environmental Assessment and will identify the current and future road network.

The overall study area includes two sections: Highway 148 from Angus Campbell Drive to Greenwood Road (GWP 214-00-00) and Highway 148 from Greenwood Road east to the Quebec border (GWP 239-00-00). This report consists of the Cultural Heritage Resource Assessment for the section of Highway 148 from Angus Campbell Drive to Greenwood Road.

The background research, data collection, and field review conducted for the study area determined that 11 cultural heritage resources are located within or adjacent to the Highway 148 from Angus Campbell Drive to Greenwood Road study area. Based on the results of the assessment, the following recommendations have been developed:

1. Construction activities and staging should be suitably planned and undertaken to avoid impacts to identified cultural heritage resources;

2. CHL 4, CHL 5, and CHL 6 will be impacted through minor property acquisition and removal of small portions of their landscape adjacent to the Highway 148 right-of-way (ROW). As such, post-construction landscaping should reflect the pre-construction condition of the resource; and

3. Should future work require an expansion of the study area then a qualified heritage consultant should be contacted in order to confirm the impacts of the proposed work on potential heritage resources.

PROJECT PERSONNEL

Senior Project Manager:	Annie Veilleux, MA, CAHP Cultural Heritage Specialist Manager, Cultural Heritage Division
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1.0 INTRODUCTION

ASI was contracted by IBI Group (Toronto) to conduct a Cultural Heritage Resource Assessment as part of the Highway 148 Provincial Transportation Facilities Class Environmental Assessment (EA) (Part A of the project). The project includes Preliminary Design and Environmental Assessment and will identify the current and future road network.

The overall study area includes two sections: Highway 148 from Angus Campbell Drive to Greenwood Road (GWP 214-00-00) and Highway 148 from Greenwood Road east to the Quebec border (GWP 239-00-00). This report consists of the Cultural Heritage Resource Assessment for the section of Highway 148 from Angus Campbell Drive to Greenwood Road (Figure 1).

The purpose of this report is to present a built heritage and cultural landscape inventory of cultural heritage resources, identify existing conditions of the Highway 148 from Angus Campbell Drive to Greenwood Road study area, identify impacts to cultural heritage resources, and propose appropriate mitigation measures. The research carried out for this CHRA was conducted under the senior project management of Annie Veilleux and project management of Joel Konrad, both of ASI.

Figure 1: Location of the study area
Base Map:©OpenStreetMap and contributors, Creative Commons-Share Alike License (CC-BY-SA)

2.0 BUILT HERITAGE RESOURCE AND CULTURAL HERITAGE LANDSCAPE ASSESSMENT CONTEXT

2.1 Legislation and Policy Context

This cultural heritage assessment considers cultural heritage resources in the context of improvements to specified areas, pursuant to the *Environmental Assessment Act* (1990). This assessment addresses above ground cultural heritage resources over 40 years old. Use of a 40 year old threshold is a guiding principle when conducting a preliminary identification of cultural heritage resources (Ministry of Transportation 2006; Ministry of Transportation 2007; Ontario Realty Corporation 2007). While identification of a resource that is 40 years old or older does not confer outright heritage significance, this threshold provides a means to collect information about resources that may retain heritage value. Similarly, if a resource is slightly younger than 40 years old, this does not preclude the resource from retaining heritage value.

For the purposes of this assessment, the term cultural heritage resources was used to describe both cultural heritage landscapes and built heritage resources. A cultural landscape is perceived as a collection of individual built heritage resources and other related features that together form farm complexes, roadscapes and nucleated settlements. Built heritage resources are typically individual buildings or structures that may be associated with a variety of human activities, such as historical settlement and patterns of architectural development.

The analysis throughout the study process addresses cultural heritage resources under various pieces of legislation and their supporting guidelines. Under the *Environmental Assessment Act* (1990) environment is defined in Subsection 1(c) to include:

- Cultural conditions that influence the life of man or a community, and;
- Any building, structure, machine, or other device or thing made by man.

The Ministry of Tourism, Culture and Sport is charged under Section 2 of the *Ontario Heritage Act* with the responsibility to determine policies, priorities and programs for the conservation, protection and preservation of the heritage of Ontario and has published two guidelines to assist in assessing cultural heritage resources as part of an environmental assessment: *Guideline for Preparing the Cultural Heritage Resource Component of Environmental Assessments* (1992), and *Guidelines on the Man-Made Heritage Component of Environmental Assessments* (1981). Accordingly, both guidelines have been utilized in this assessment process.

The *Guidelines on the Man-Made Heritage Component of Environmental Assessments* (Section 1.0) states the following:

> When speaking of man-made heritage we are concerned with the works of man and the effects of his activities in the environment rather than with movable human artifacts or those environments that are natural and completely undisturbed by man.

In addition, environment may be interpreted to include the combination and interrelationships of human artifacts with all other aspects of the physical environment, as well as with the social, economic and cultural conditions that influence the life of the people and communities in Ontario. The *Guidelines on the Man-Made Heritage Component of Environmental Assessments* distinguish between two basic ways

of visually experiencing this heritage in the environment, namely as cultural heritage landscapes and as cultural features.

Within this document, cultural heritage landscapes are defined as the following (Section 1.0):

> The use and physical appearance of the land as we see it now is a result of man's activities over time in modifying pristine landscapes for his own purposes. A cultural landscape is perceived as a collection of individual man-made features into a whole. Urban cultural landscapes are sometimes given special names such as townscapes or streetscapes that describe various scales of perception from the general scene to the particular view. Cultural landscapes in the countryside are viewed in or adjacent to natural undisturbed landscapes, or waterscapes, and include such land uses as agriculture, mining, forestry, recreation, and transportation. Like urban cultural landscapes, they too may be perceived at various scales: as a large area of homogeneous character; or as an intermediate sized area of homogeneous character or a collection of settings such as a group of farms; or as a discrete example of specific landscape character such as a single farm, or an individual village or hamlet.

A cultural feature is defined as the following (Section 1.0):

> …an individual part of a cultural landscape that may be focused upon as part of a broader scene, or viewed independently. The term refers to any man-made or modified object in or on the land or underwater, such as buildings of various types, street furniture, engineering works, plantings and landscaping, archaeological sites, or a collection of such objects seen as a group because of close physical or social relationships.

The Minister of Tourism, Culture, and Sport has also published *Standards and Guidelines for Conservation of Provincial Heritage Properties* (April 2010; Standards and Guidelines hereafter). These Standards and Guidelines apply to properties the Government of Ontario owns or controls that have cultural heritage value or interest. They are mandatory for ministries and prescribed public bodies and have the authority of a Management Board or Cabinet directive. Prescribed public bodies include:

- Agricultural Research Institute of Ontario
- Hydro One Inc.
- Liquor Control Board of Ontario
- McMichael Canadian Art Collection
- Metrolinx
- The Niagara Parks Commission.
- Ontario Heritage Trust
- Ontario Infrastructure Projects Corporation
- Ontario Lottery and Gaming Corporation
- Ontario Power Generation Inc.
- Ontario Realty Corporation
- Royal Botanical Gardens
- Toronto Area Transit Operating Authority
- St. Lawrence Parks Commission

The Standards and Guidelines provide a series of definitions considered during the course of the assessment:

A provincial heritage property is defined as the following (14):

> Provincial heritage property means real property, including buildings and structures on the property, that has cultural heritage value or interest and that is owned by the Crown in right of Ontario or by a prescribed public body; or that is occupied by a ministry or a prescribed public body if the terms of the occupancy agreement are such that the ministry or public body is entitled to make the alterations to the property that may be required under these heritage standards and guidelines.

A provincial heritage property of provincial significance is defined as the following (14):

> Provincial heritage property that has been evaluated using the criteria found in Ontario Heritage Act O.Reg. 10/06 and has been found to have cultural heritage value or interest of provincial significance.

A built heritage resource is defined as the following (13):

> …one or more significant buildings (including fixtures or equipment located in or forming part of a building), structures, earthworks, monuments, installations, or remains associated with architectural, cultural, social, political, economic, or military history and identified as being important to a community. For the purposes of these Standards and Guidelines, "structures" does not include roadways in the provincial highway network and in-use electrical or telecommunications transmission towers.

A cultural heritage landscape is defined as the following (13):

> … a defined geographical area that human activity has modified and that has cultural heritage value. Such an area involves one or more groupings of individual heritage features, such as structures, spaces, archaeological sites, and natural elements, which together form a significant type of heritage form distinct from that of its constituent elements or parts. Heritage conservation districts designated under the Ontario Heritage Act, villages, parks, gardens, battlefields, mainstreets and neighbourhoods, cemeteries, trails, and industrial complexes of cultural heritage value are some examples.

Additionally, the *Planning Act* (1990) and related *Provincial Policy Statement* (*PPS*), which was updated in 2014, make a number of provisions relating to heritage conservation. One of the general purposes of the *Planning Act* is to integrate matters of provincial interest in provincial and municipal planning decisions. In order to inform all those involved in planning activities of the scope of these matters of provincial interest, Section 2 of the *Planning Act* provides an extensive listing. These matters of provincial interest shall be regarded when certain authorities, including the council of a municipality, carry out their responsibilities under the *Act*. One of these provincial interests is directly concerned with:

> 2.(d) the conservation of features of significant architectural, cultural, historical, archaeological or scientific interest

Part 4.7 of the *PPS* states that:

> The official plan is the most important vehicle for implementation of this Provincial Policy Statement. Comprehensive, integrated and long-term planning is best achieved through official plans.
>
> Official plans shall identify provincial interests and set out appropriate land use designations and policies. To determine the significance of some natural heritage features and other resources, evaluation may be required.
>
> Official plans should also coordinate cross-boundary matters to complement the actions of other planning authorities and promote mutually beneficial solutions. Official plans shall provide clear, reasonable and attainable policies to protect provincial interests and direct development to suitable areas.
>
> In order to protect provincial interests, planning authorities shall keep their official plans up-to-date with this Provincial Policy Statement. The policies of this Provincial Policy Statement continue to apply after adoption and approval of an official plan.

Those policies of particular relevance for the conservation of heritage features are contained in Section 2-Wise Use and Management of Resources, wherein Subsection 2.6 - Cultural Heritage and Archaeological Resources, makes the following provisions:

> 2.6.1 Significant built heritage resources and significant cultural heritage landscapes shall be conserved.

A number of definitions that have specific meanings for use in a policy context accompany the policy statement. These definitions include built heritage resources and cultural heritage landscapes.

A *built heritage resource* is defined as: "a building, structure, monument, installation or any manufactured remnant that contributes to a property's cultural heritage value or interest as identified by a community, including an Aboriginal community" (PPS 2014).

A *cultural heritage landscape* is defined as "a defined geographical area that may have been modified by human activity and is identified as having cultural heritage value or interest by a community, including an Aboriginal community. The area may involve features such as structures, spaces, archaeological sites or natural elements that are valued together for their interrelationship, meaning or association" (PPS 2014). Examples may include, but are not limited to farmscapes, historic settlements, parks, gardens, battlefields, mainstreets and neighbourhoods, cemeteries, trailways, and industrial complexes of cultural heritage value.

In addition, significance is also more generally defined. It is assigned a specific meaning according to the subject matter or policy context, such as wetlands or ecologically important areas. With regard to cultural heritage and archaeology resources, resources of significance are those that are valued for the important contribution they make to our understanding of the history of a place, an event, or a people (*PPS* 2014).

Criteria for determining significance for the resources are recommended by the Province, but municipal approaches that achieve or exceed the same objective may also be used. While some significant resources may already be identified and inventoried by official sources, the significance of others can only be determined after evaluation (*PPS* 2014).

Accordingly, the foregoing guidelines and relevant policy statement were used to guide the scope and methodology of the cultural heritage assessment.

2.2 Municipal Policies

The City of Pembroke's Official Plan (Section 3.6, 2008 consolidation) sets out a number of general policies with regard to cultural heritage resources:

1. Significant built heritage resources and significant cultural heritage landscapes shall be conserved.

2. Require that, in any proposed plan of subdivision, and prior to the undertaking of any public work, private development, consent or zoning by-law amendment, consideration be given to the possible effects and impacts of such works or development on cultural heritage resources and, where identified, such impacts are appropriately mitigated.

2.3 Data Collection

In the course of the cultural heritage assessment, all potentially affected cultural heritage resources are subject to inventory. Short form names are usually applied to each resource type, (e.g. barn, residence). Generally, when conducting a preliminary identification of cultural heritage resources, three stages of research and data collection are undertaken to appropriately establish the potential for and existence of cultural heritage resources in a particular geographic area.

Background historic research, which includes consultation of primary and secondary source research and historic mapping, is undertaken to identify early settlement patterns and broad agents or themes of change in a study area. This stage in the data collection process enables the researcher to determine the presence of sensitive heritage areas that correspond to nineteenth and twentieth-century settlement and development patterns. To augment data collected during this stage of the research process, federal, provincial, and municipal databases and/or agencies are consulted to obtain information about specific properties that have been previously identified and/or designated as retaining cultural heritage value. Typically, resources identified during these stages of the research process are reflective of particular architectural styles, associated with an important person, place, or event, and contribute to the contextual facets of a particular place, neighborhood, or intersection.

A field review is then undertaken to confirm the location and condition of previously identified cultural heritage resources. The field review is also utilised to identify cultural heritage resources that have not been previously identified on federal, provincial, or municipal databases.

Several investigative criteria are utilised during the field review to appropriately identify new cultural heritage resources. These investigative criteria are derived from provincial guidelines, definitions, and past experience. During the course of the environmental assessment, a built structure or landscape is identified as a cultural heritage resource if it is considered to be 40 years or older, and if the resource satisfies at least one of the following criteria:

Design/Physical Value:

- It is a rare, unique, representative or early example of a style, type, expression, material or construction method.
- It displays a high degree of craftsmanship or artistic merit.
- It demonstrates a high degree of technical or scientific achievement.
- The site and/or structure retains original stylistic features and has not been irreversibly altered so as to destroy its integrity.
- It demonstrates a high degree of excellence or creative, technical or scientific achievement at a provincial level in a given period.

Historical/Associative Value:

- It has a direct association with a theme, event, belief, person, activity, organization, or institution that is significant to: the City of Pembroke the Province of Ontario; or Canada.
- It yields, or has the potential to yield, information that contributes to an understanding of the history of the: the City of Pembroke the Province of Ontario; or Canada.
- It demonstrates or reflects the work or ideas of an architect, artist builder, designer, or theorist who is significant to: the City of Pembroke; the Province of Ontario; or Canada.
- It represents or demonstrates a theme or pattern in Ontario's history.
- It demonstrates an uncommon, rare or unique aspect of Ontario's cultural heritage.
- It has a strong or special association with the entire province or with a community that is found in more than one part of the province. The association exists for historic, social, or cultural reasons or because of traditional use.
- It has a strong or special association with the life or work of a person, group or organization of importance to the province or with an event of importance to the province.

Contextual Value:

- It is important in defining, maintaining, or supporting the character of an area.
- It is physically, functionally, visually, or historically linked to its surroundings.
- It is a landmark.
- It illustrates a significant phase in the development of the community or a major change or turning point in the community's history.
- The landscape contains a structure other than a building (fencing, culvert, public art, statue, etc.) that is associated with the history or daily life of that area or region.
- There is evidence of previous historic and/or existing agricultural practices (e.g. terracing, deforestation, complex water canalization, apple orchards, vineyards, etc.)
- It is of aesthetic, visual or contextual important to the province.

If a resource meets one of these criteria it will be identified as a cultural heritage resource and is subject to further research where appropriate and when feasible. Typically, detailed archival research, permission to enter lands containing heritage resources, and consultation is required to determine the specific heritage significance of the identified cultural heritage resource.

When identifying cultural heritage landscapes, the following categories are typically utilized for the purposes of the classification during the field review:

Farm complexes:	comprise two or more buildings, one of which must be a farmhouse or barn, and may include a tree-lined drive, tree windbreaks, fences, domestic gardens and small orchards.

Roadscapes:	generally two-lanes in width with absence of shoulders or narrow shoulders only, ditches, tree lines, bridges, culverts and other associated features.
Waterscapes:	waterway features that contribute to the overall character of the cultural heritage landscape, usually in relation to their influence on historic development and settlement patterns.
Railscapes:	active or inactive railway lines or railway rights of way and associated features.
Historical settlements:	groupings of two or more structures with a commonly applied name.
Streetscapes:	generally consists of a paved road found in a more urban setting, and may include a series of houses that would have been built in the same time period.
Historical agricultural landscapes:	generally comprises a historically rooted settlement and farming pattern that reflects a recognizable arrangement of fields within a lot and may have associated agricultural outbuildings, structures, and vegetative elements such as tree rows.
Cemeteries:	land used for the burial of human remains.

Results of the desktop data collection and field review are contained in Sections 3.0, while Sections 4.0 and 5.0 contain conclusions and recommendations with respect to potential impacts of the undertaking on identified cultural heritage resources.

3.0 HISTORICAL BACKGROUND

3.1 Introduction

This section provides a brief summary of historical research and a description of identified above ground cultural heritage resources that may be impacted by the proposed road improvements. A review of available primary and secondary source material was undertaken to produce a contextual overview of the study area, including a general description of Euro-Canadian settlement and land use. Historically, the study area is located in the road allowance between the following lots and concessions:

Township of Pembroke, Renfrew County

- Lots 11-24, Concession II

3.2 Landscape and Physiography

The study area is located adjacent to the Ottawa River. The Ottawa River drains an area of 14,630,000 hectares and extends 1,271 kilometres from source to mouth. The Ottawa River was of key importance as a transportation route from the seventeenth through to the nineteenth century as well as since the earliest

human occupation of the Ottawa Valley. In latter days, this importance shifted more towards the timber trade (Chapman and Putnam 1984: 110).

West of the study area, at approximately Petawawa, the Ottawa River begins to widen and continues to broaden around Allumette Island. In this area, the landscape of the Ottawa River transitions from forest to agricultural lands (Haxton and Chubbick 2002), land uses supported by the Petawawa Sand Plain and the Ottawa Valley Clay Plains physiographic regions (Chapman and Putnam 1984). The Petawawa Sand Plain on the Ontario side of the Ottawa River is interrupted by several outcrops of Precambrian rock. The Plain extends from Petawawa to south of Pembroke and covers an area of approximately 337 km^2. The sand plain was formed as a delta in the Champlain Sea by the Petawawa, Barrow, Indian and Ottawa Rivers during the Fossmill stage of Lake Algonquin (Chapman and Putnam 1984: 210).

The river continues eastward, in a series of lake like stretches, punctuated by rapids at Ile du Grand Calumet, which marks another transition in the landscape with the adjacent forest cover becoming more "deciduous in composition… dominated by maples, beech, birch, and oak", defining features of the Upper St. Lawrence Section of the Great Lakes-St. Lawrence Forest Region (Haxton and Chubbick 2002:43).

3.3 Township Survey and Settlement

3.3.1 Pembroke Township

Historically, the study area is located within Pembroke Township, Renfrew County. The Township was partitioned in 1835 from the area of Westmeath and was named for the Earl of Pembroke (Mika and Mika 1977: 185). The Township of Pembroke is depicted on historic mapping as consisting of one settlement centre. This settlement was first known as Miramichi, then beginning in 1846, its name changed a series of times, from Campbelltown, Lowertown, Moffat, Sydenham, and then finally to Pembroke in 1857.

Nineteenth-century settlement in Pembroke was linked with the lumbering industry given its location at the confluence of the Muskrat and Ottawa rivers. It was first settled in 1828 by Col. Peter White who built a cabin at the mouth of the Muskrat River. In 1831, the first mill was constructed. The settlement slowly expanded with the first school being constructed in 1836 and the post office being established in 1846. In 1875, the Canada Central Railway, established in 1861, opened a line linking Renfrew and Pembroke (Andreae 1997). By 1887 the town had a population of 4,500 people with a range of industries as well as seven churches, the Presbyterian, Methodist and Catholic churches being the most prominent buildings. Pembroke was the first town in Canada to have electric lights and, in 1884, to sell it commercially (Mika and Mika 1977: 185-187).

In 1877 Pembroke was incorporated as a Town, and in 1971 the municipality was granted City status (City of Pembroke n.d.). Today, Pembroke has a population of approximately 14,800.

3.4 Review of Historic Mapping

Both the 1863 *Map of the Counties of Lanark and Renfrew* by Walling, the earliest available map of the area[1], and the 1881 *Map of the County of Renfrew* (Figure 2) were reviewed to determine the potential for the presence of nineteenth-century cultural heritage resources within the study area (Table 1). It should be noted, however, that not all features of interest were mapped systematically in the Ontario series of historical atlases, given that they were financed by subscription, and subscribers were given preference with regard to the level of detail provided on the maps. Moreover, not every feature of interest would have been within the scope of the atlases. Historically, the study area is located in the former Township of Pembroke, Renfrew County. The 1863 map depicts a number of properties within the study area including on Lots 10 (Jourdan), 12 (Martin) and 13 (Fraser) (Stantec 2011a). Landowners are not identified on the 1881 map.

The 1863 map shows that the route of the northwest part of Highway 148 is a historically surveyed road. The section that currently leads onto Cotnam Island is not shown on this map. The 1881 map shows a similar landscape, with the addition of the now disused Canadian Pacific Railway (originally operated by the Canada Central Railway) which runs between Highway 148 and the Ottawa River until it is crossed by the road at the CPR Bridge. A review of historic topographic maps from the twentieth century show that development along the corridor progressed in stages, with buildings introduced along the north side of Highway 148 in the early twentieth, with few changes occurring to circa 1950 (Figure 3). A review of mapping from 1975 shows that during the third quarter of the century, residential development accelerated along the corridor with the south side of the highway distinguished by residential buildings constructed during this time period.

Highway 148 was established in 1983 when Highway 62, a historically surveyed thoroughfare, was renumbered as part of the Ontario highway system. This highway is 5.0 km long. Pembroke is the only community located along this provincial highway (Bevers 2015).

[1] While a copy of the 1863 map could not be procured at this stage, part of the map appears in *Stage 1 Archaeological Assessment Hwy 148 Road Improvements, Pembroke Ontario*. Property owners identified on that partial map are identified in Table 1.

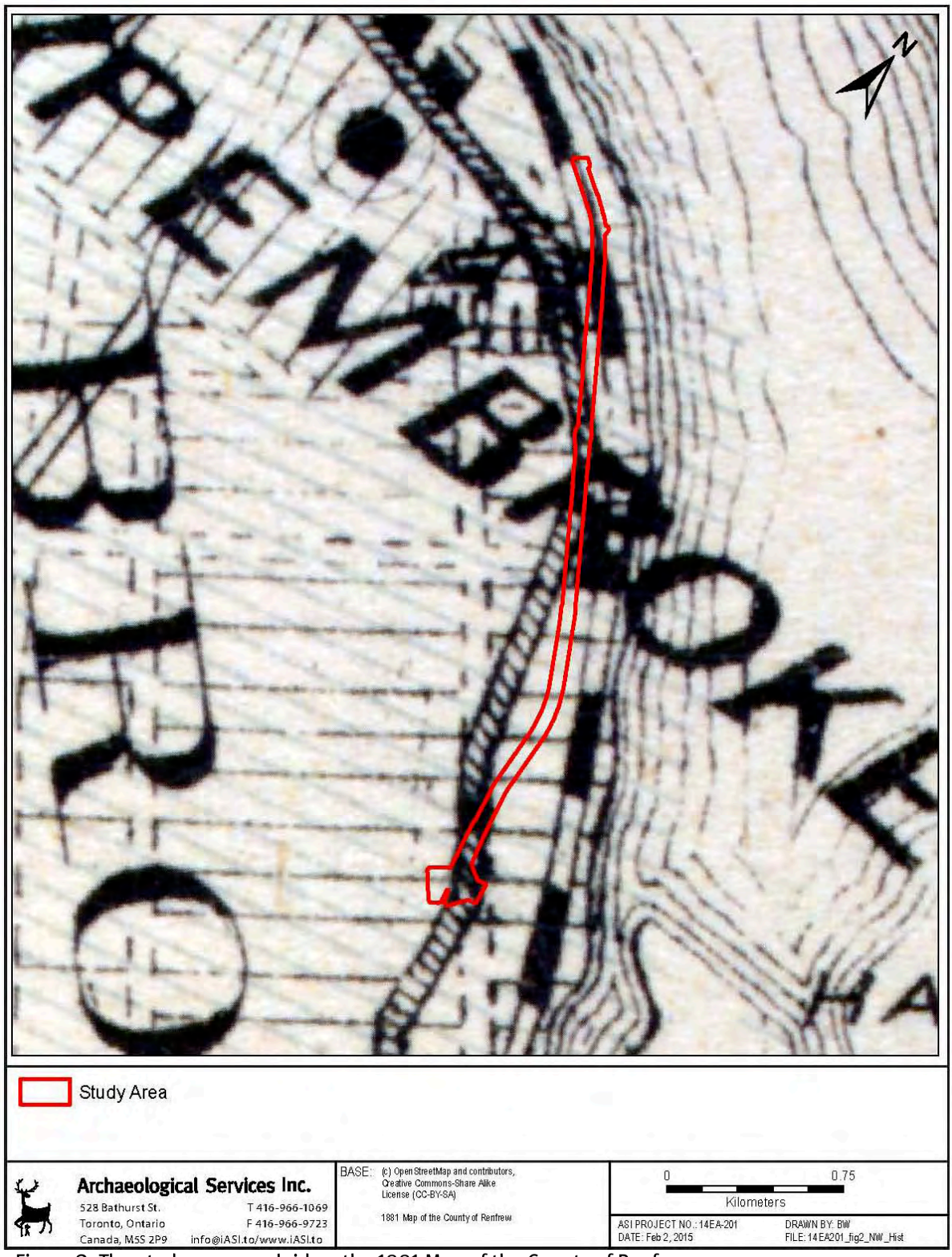

Figure 2: The study area overlaid on the 1881 Map of the County of Renfrew
Base Map: Renfrew Supplement in *Illustrated atlas of the Dominion of Canada.* Toronto : H. Belden & Co., 1881

Table 1: Highway 148 Provincial Transportation Facilities Class EA – Nineteenth-century property owner(s) and historical features(s)

Con #	Lot #	1863 Property Owner(s)	1863 Historical Feature(s)
II	12	McLaughlin	N/A
	13	A. Martin	Homestead
	14	P. Fraser	Homestead
	15	Richard Fraser	N/A
	16	N/A	N/A
	17	J. McKewen	N/A
	18	L. Jones	N/A
	19	N/A	N/A
	20	N/A	N/A
	21	N/A	N/A
	22	N/A	N/A
	23	N/A	N/A
	24	N/A	N/A

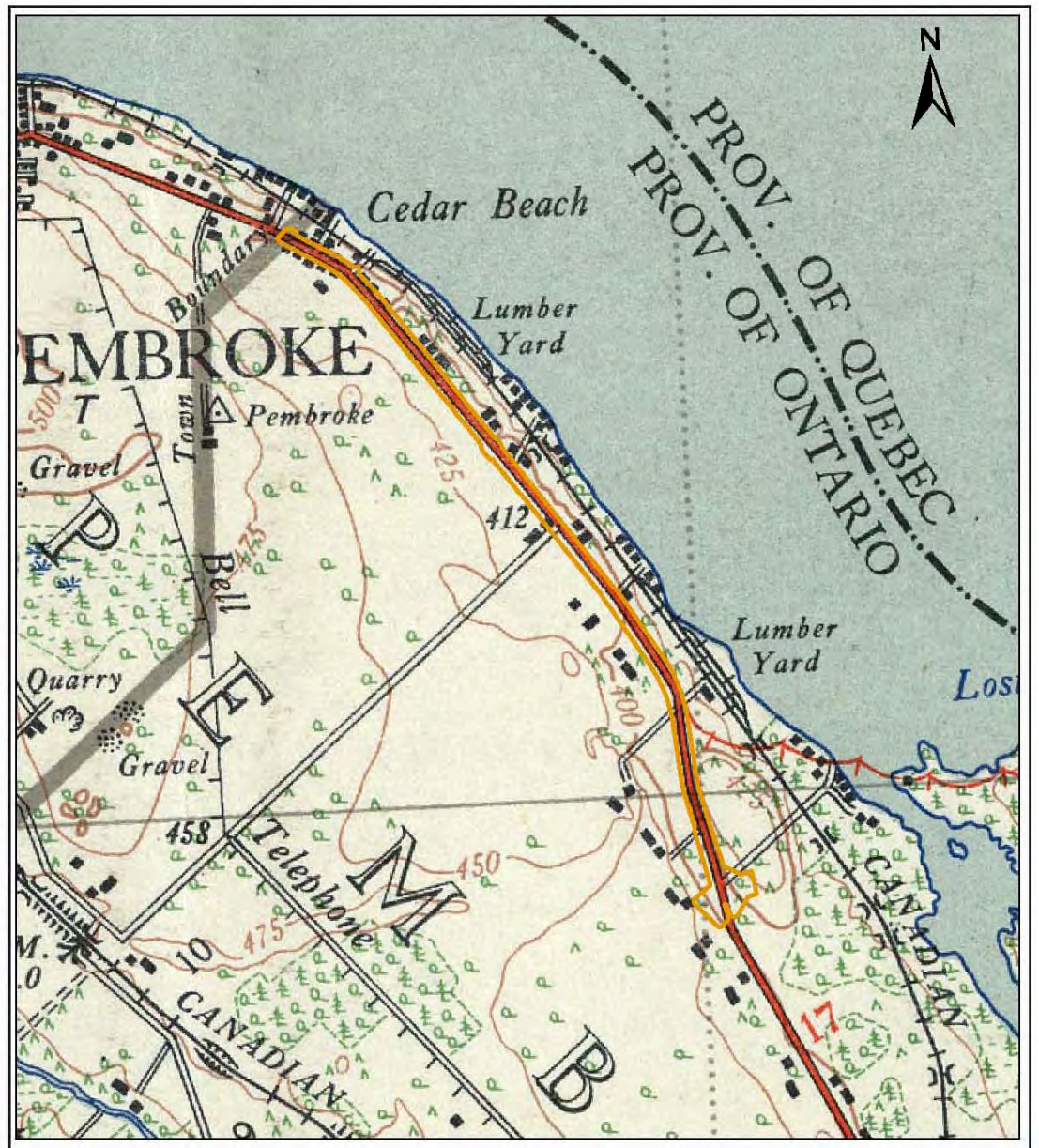

Figure 3: Historic topographic maps showing location of study area.
Base: Pembroke Sheet. 31/F-14, 1936

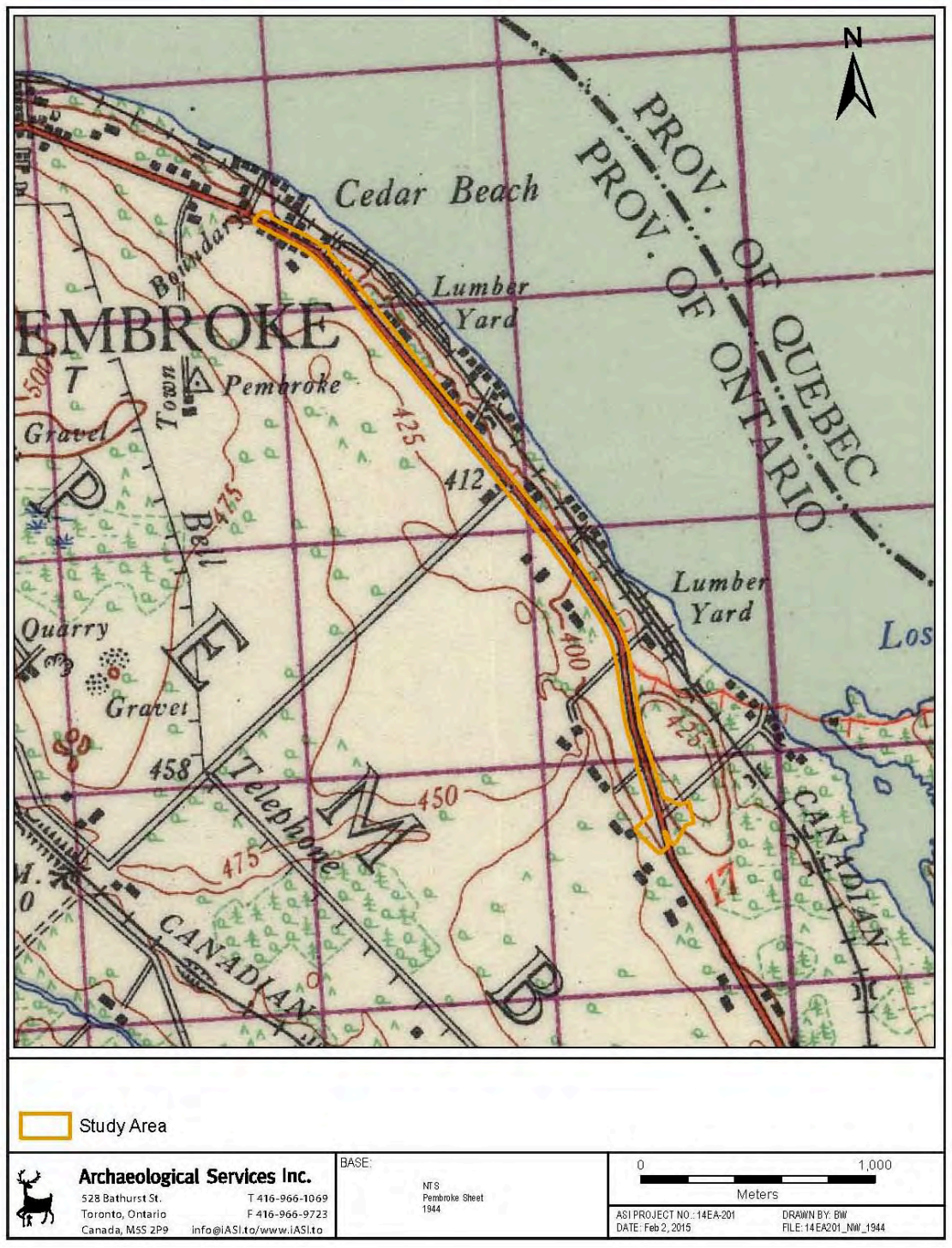

Figure 4: Historic topographic maps showing location of study area.
Base: Pembroke Sheet. 31/F-14, 1948

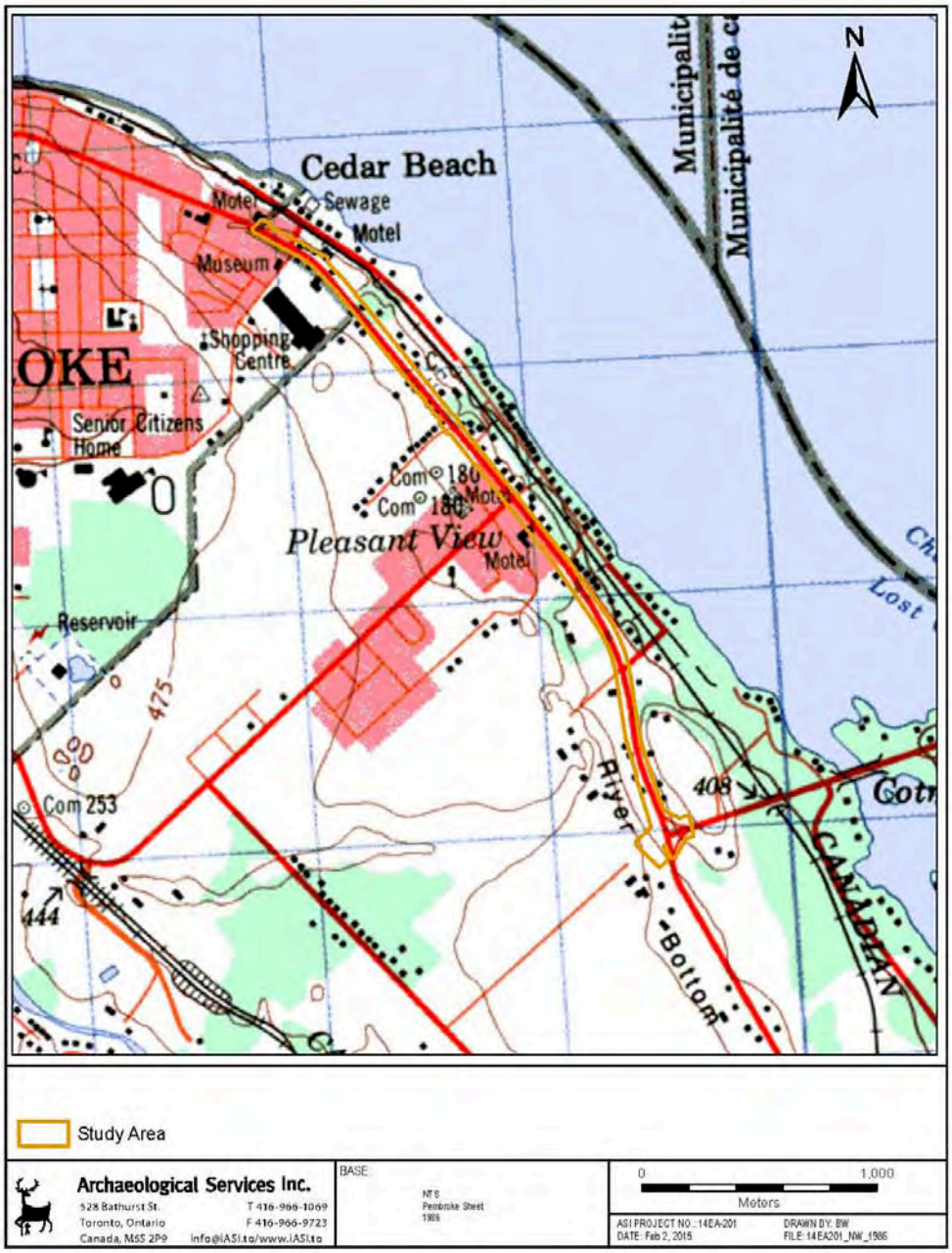

Figure 5: Historic topographic maps showing location of study area.
Base: Pembroke Sheet. 31/F-14, 1986

4.0 BUILT HERITAGE RESOURCE AND CULTURAL HERITAGE LANDSCAPE ASSESSMENT

Data collection examining previously identified cultural heritage resources within the study area was first undertaken through a review of information publically available on the City of Pembroke website. While the City of Pembroke does not provide an inventory of heritage properties on their website, the City's planning department was contacted directly in order to identify any potential heritage concerns within or

adjacent to the study area.[2] The Manager of Planning and Building confirmed that the City has designated four properties under the *Ontario Heritage Act*. However, these properties are neither located within nor adjacent to the study area. Additionally, this correspondence also confirmed that the City of Pembroke does not maintain a list or inventory of non-designated properties located in the municipality.

The *Canadian Register of Historic Places* (available online), the *Cultural Heritage Evaluation Report, CPR and Hazley Bay Bridges* (Stantec 2011b) and the *Stage 1 Archaeological Assessment Hwy 148 Road Improvements, Pembroke Ontario* (Stantec 2011a), were also reviewed to identify any previously identified heritage properties within or adjacent to the study area. While a review of this information did not yield any previously identified cultural heritage resources, the document *A Cultural Framework for the City of Pembroke and the County of Renfrew* identifies a total of 273 cultural heritage assets within the region of which 44 are classed as 'Built Heritage Properties' (Millier Dickinson Blais 2012:13). A review of the Ottawa Valley Culture map confirmed that cultural facilities and spaces located within the study area include the Champlain Trail Museum and Pioneer Village located at the intersection of Angus Campbell Drive and Highway 148. This facility also functions as a Doors Open venue and provides space for the Ottawa Valley Heritage Society.

A review of *The Canadian Heritage Rivers System* identifies the Ottawa River as a heritage waterway, and thus the river is nationally designated for its natural, cultural, and recreational values.

A field review was undertaken by Peter Carruthers, ASI, on 5 June, 2015, to document the existing conditions of the study area. The field review was preceded by a review of available, current and historic, aerial photographs and maps (including online sources such as Bing and Google maps). These large-scale maps were reviewed for any potential cultural heritage resources which may be extant in the study area. The existing conditions of the study area are described below. Identified cultural heritage resources are discussed in Section 4.2 and are mapped in Section 9.0 (Figures 6 and 7) of this report. Plate locations and directions are also mapped on Figures 6 and 7.

4.1 Angus Campbell Drive to Greenwood Road – Existing Conditions

The study area is composed of a two lane roadway, established since the nineteenth century, and which provides east-west access in and out of Pembroke. Highway 148 was formally established in 1983 when Highway 62/Highway 17, a historically surveyed thoroughfare was renumbered. Today, the local road is identified on various local maps as Pembroke Street East. The road right-of-way features a relatively consistent cross-section throughout the study area, characterized by narrow gravel shoulders, turning lanes at controlled intersections, and a range of commercial, retail, and residential land uses on either side of the road right-of-way (Plates 1 – 3).

The study corridor has maintained its visual function as a historic thoroughfare through the retention of a series of buildings and landscape features. The Champlain Trail Museum and Pioneer Village, including its commemorative signage, installations, and buildings anchor the north end of the corridor (Plate 4). In places, nineteenth-century residential structures and landscape features, such as a cemetery and remnant agricultural complexes, also frame the road right-of-way, communicating its function as a historic line of communication and transport (Plate 5 - 7). Interspersed throughout are various groupings of: mid twentieth-century residential structures (Plate 8); and relatively recent retail land uses, such as Home Depot and Walmart, which tend to characterize historic thoroughfares, turned highway corridors, located

[2] Contact occurred via telephone in January 2015.

at the peripheries of historic settlement centres (Plate 9). A review of historic topographic maps also reinforces this characterization of the study area, showing the gradual filling in of the Highway 148 right-of-way in the post 1950 period with residential buildings in the Pleasant View area and on-going building development around historic thoroughfares such as Old Mill Road and Traxton Way.

Also extant throughout the corridor, on the east side of the road-right-of way, is a visible vegetative corridor in the background, marking the western limits of the former rail right-of-way established in 1875 (Plate 10). This vegetative corridor continues uninterrupted along the east side of the corridor, with the exception of parcels containing and adjacent to the 'New Start Restaurant' which provides views to the Ottawa River from the Highway 148 road right-of-way (Plates 11 – 12).

Plate 1: View south, from south of Angus Campbell Drive, showing residential land use and right-of-way cross-section.

Plate 2: View south looking towards commercial centre located east of Angus Campbell Drive.

Plate 3: View east, from south of Drive In Road, showing typical mid twentieth-century retail business within the study area.

Plate 4: View to Champlain Trail Museum and Pioneer Village property, showing road signage and interpretative mural on building elevation.

Plate 5: View of east side of Highway 148, showing typical nineteenth-century residential land use and remnant agricultural landscape.

Plate 6: View of Pentecostal cemetery, located on Highway 148.

Plate 7: View south, from south of Dairy Road showing typical early twentieth-century agricultural landscape.

Plate 8: View of grouping of mid-twentieth-century residential buildings located near Robinson Lane.

Plate 9: View of typical retail development along highway corridors, taken from near Resmer Road.

Plate 10: View of former rail right-of-way and adjacent vegetative corridors.

Plate 11: View east showing interruption along vegetative corridor adjacent to former rail right-of-way.

Plate 12: View east showing vacant parcel and views towards Ottawa River.

4.2 Angus Campbell Driver to Greenwood Road – Identified Cultural Heritage Resources

Based on the results of the background research and field review, four built heritage resources (BHR) and seven cultural heritage landscapes (CHL) were identified within and/or adjacent to the Highway 148 study area (Table 2). A detailed inventory of these cultural heritage resources is presented in Section 7.0 and mapping of these features is provided in Section 8.0 of this report.

Table 2: Summary of built heritage resources (BHR) and cultural heritage landscapes (CHL) in the study area

Resource	Type	Address/Location	Recognition
BHR 1	Residence/Commercial	1027 Pembroke Street East	Identified during field review
BHR 2	Residence	1028 Pembroke Street East	Identified during field review
BHR 3	Residence	1173 Pembroke Street East	Identified during field review
BHR 4	Commercial	1227 Pembroke Street East	Identified during field review
CHL 1	Museum	1022 Pembroke Street East	Identified during field review
CHL 2	Residential Complex	No Address; Located between 1105 and 1065 Pembroke Street East	Identified during field review
CHL 3	Cemetery	1135 Pembroke Street East	Identified during field review
CHL 4	Residential Complex	1145 Pembroke Street East	Identified during field review
CHL 5	Residential Complex	1124 Pembroke Street East	Identified during field review
CHL 6	Residential Complex	1211 Pembroke Street East	Identified during field review
CHL 7	Agricultural Complex	1244 Pembroke Street East	Identified during field review

4.3 Screening for Potential Impacts

To assess the potential impacts of the undertaking, identified cultural heritage resources are considered against a range of possible impacts as outlined in the document entitled *Screening for Impacts to Built Heritage and Cultural Heritage Landscapes* (MTC November 2010) which include:

- Destruction, removal or relocation of any, or part of any, significant heritage attribute or feature (III.1).
- Alteration which means a change in any manner and includes restoration, renovation, repair or disturbance (III.2).
- Shadows created that alter the appearance of a heritage attribute or change the exposure or visibility of a natural feature or plantings, such as a garden (III.3).
- Isolation of a heritage attribute from its surrounding environment, context, or a significant relationship (III.4).
- Direct or indirect obstruction of significant views or vistas from, within, or to a built or natural heritage feature (III.5).
- A change in land use such as rezoning a battlefield from open space to residential use, allowing new development or site alteration to fill in the formerly open spaces (III.6).
- Soil disturbance such as a change in grade, or an alteration of the drainage pattern, or excavation, etc (III.7).

A number of additional factors are also considered when evaluating potential impacts on identified cultural heritage resources. These are outlined in a document set out by the Ministry of Culture and Communications (now Ministry of Tourism, Culture and Sport) and the Ministry of the Environment entitled *Guideline for Preparing the Cultural Heritage Resource Component of Environmental Assessments* (October 1992) and include:

- Magnitude: the amount of physical alteration or destruction which can be expected;
- Severity: the irreversibility or reversibility of an impact;
- Duration: the length of time an adverse impact persists;
- Frequency: the number of times an impact can be expected;
- Range: the spatial distribution, widespread or site specific, of an adverse impact; and
- Diversity: the number of different kinds of activities to affect a heritage resource.

For the purposes of evaluating potential impacts of development and site alteration, MTC (2010) defines "adjacent" as: "contiguous properties as well as properties that are separated from a heritage property by narrow strip of land used as a public or private road, highway, street, lane, trail, right-of-way, walkway, green space, park, and/or easement or as otherwise defined in the municipal official plan."

Various works associated with infrastructure improvements have the potential to affect cultural heritage resources in a variety of ways, and as such, appropriate mitigation measures for the undertaking need to be considered. Where any above-ground cultural heritage resources are identified, which may be affected by direct or indirect impacts, appropriate mitigation measures are recommended. This may include completing a heritage impact assessment or documentation report, or employing suitable measures such as landscaping, buffering or other forms of mitigation, where appropriate. In this regard, provincial guidelines should be consulted for advice and further heritage assessment work should be undertaken as necessary.

4.3.1 Description of Development

The identified preferred alignment from Angus Campbell Drive to Greenwood Road includes the following components (See Section 10 for Recommended Plan Drawings):

- Expansion or repaving of the existing Highway 148 from Angus Campbell Drive to Greenwood Road, and will specifically consist of:
  - Construction of concrete sidewalks along Highway 148 from north of Angus Campbell Drive to Drive In Road;
  - Paved shoulder from Drive In Road to Greenwood Road;
  - Profile adjustment at various points between Angus Campbell Drive and Drive In Road;
  - Ditches dug at various points between Angus Campbell Drive and Drive In Road; and
  - Road widening between Robinson Lane and Drive in Road and at the intersection of Highway 148 and Greenwood Road.

The potential impacts and recommended mitigation measures of the Highway 148 preferred alignment are outlined in Table 3:

Table 3: Potential Impacts and Proposed Mitigation Measures for the Preferred Alternative

Resource	Potential Impact(s) – Highway 148 from Angus Campbell Drive to Greenwood Road	Recommended Mitigation Measures
BHR 1	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to BHR.
BHR 2	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to BHR.
BHR 3	• Impacts limited to MTO ROW	• Ensure constriction and staging activities are planned to avoid impacts to BHR.
BHR 4	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to BHR.
CHL 1	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to CHL.
CHL 2	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to CHL.
CHL 3	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to CHL.
CHL 4	• Alteration (III.2) due to removal of agricultural landscape features and construction of roadway; and, • Soil disturbance (III.7) due to grading.	• As impacts are minimal and will not impact substantial features of the landscape, no property specific heritage impact assessment is recommended; • Post-construction landscaping should reflect the pre-construction condition of the resource; and • Should additional land be required on this property a resource specific heritage impact assessment should be completed.

Resource	Potential Impact(s) – Highway 148 from Angus Campbell Drive to Greenwood Road	Recommended Mitigation Measures
CHL 5	• Alteration (III.2) due to removal of agricultural landscape features and construction of roadway; and, • Soil disturbance (III.7) due to grading.	• As impacts are minimal and will not impact substantial features of the landscape, no property specific heritage impact assessment is recommended; • Post-construction landscaping should reflect the pre-construction condition of the resource; and • Should additional land be required on this property a resource specific heritage impact assessment should be completed.
CHL 6	• Alteration (III.2) due to removal of agricultural landscape features and construction of roadway; and, • Soil disturbance (III.7) due to grading.	• As impacts are minimal and will not impact substantial features of the landscape, no property specific heritage impact assessment is recommended; • Post-construction landscaping should reflect the pre-construction condition of the resource; and • Should additional land be required on this property a resource specific heritage impact assessment should be completed.
CHL 7	• Impacts limited to MTO ROW	• Ensure construction and staging activities are planned to avoid impacts to CHL.

5.0 CONCLUSIONS

The results of background historical research and a review of secondary source material, including historical mapping, revealed that the study area forms part of a historically surveyed thoroughfare that was developed with buildings and associated land uses, beginning in the first half of the nineteenth century. Because this portion of Highway 148 lies at the periphery of the historic core of Pembroke, subsequent development of buildings and commercial enterprises was slow to progress through the late nineteenth century and through the twentieth century. Accordingly, the study area is characterized by its historic function as an early transportation route located at the edge of a major settlement centre and adjacent to the Ottawa River.

Key Findings

- A total of 11 cultural heritage resources were identified within and/or adjacent to the Highway 148 study area, including four built heritage resources and seven cultural heritage landscapes;

- All of these resources were identified based on field survey and subsequent research and analysis activities;

- Of the 11 cultural heritage resources, three are residential buildings (BHR 1 – BHR 3); one is a commercial building (BHR 4); one is a museum, featuring the former Lowertown School (CHL 1); four are residential complexes (CHL 2, CHL 4 – CHL 6); one is a cemetery (CHL 3); and one is an agricultural complex (CHL 7).

- Identified cultural heritage resources are historically, architecturally, and contextually associated with mid-nineteenth-century to mid-twentieth century settlement patterns, agricultural land uses, and social and community activities associated with the Town of Pembroke and the Ottawa River.

6.0 RECOMMENDATIONS

The background research, data collection, and field review conducted for the study area determined that 11 cultural heritage resources are located within or adjacent to the Highway 148 from Angus Campbell Drive to Greenwood Road study area. Based on the results of the assessment, the following recommendations have been developed:

1. Construction activities and staging should be suitably planned and undertaken to avoid impacts to identified cultural heritage resources;

2. CHL 4, CHL 5, and CHL 6 will be impacted through minor property acquisition and removal of small portions of their landscape adjacent to the Highway 148 ROW. As such, post-construction landscaping should reflect the pre-construction condition of the resource; and

3. Should future work require an expansion of the study area then a qualified heritage consultant should be contacted in order to confirm the impacts of the proposed work on potential heritage resources.

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8.0 CULTURAL HERITAGE RESOURCE INVENTORY

Table 4: Inventory of Cultural heritage resources (CHR) in the study area

Resource	Type	Address/Location	Recognition	Description	Photos
BHR 1	Residence/Commercial	1027 Pembroke Street East	Identified during field review	Historical: - Likely built during the last quarter of the nineteenth century, corresponding with expansion of settlement activities along the periphery of Pembroke. Design: - One-and-a-half storey residence in the Ontario Gothic style which was popular during the mid to late nineteenth-century. - Traditional stylistic and material elements associated with the style, include central dormer with arched window, brick veneer exterior, field stone foundations, symmetrical façade with 12 over 12 windows with brick voussoirs. - Rear addition, clad in red brick veneer, likely corresponding to an original summer kitchen accretion. Context: - Contributes to the historic character of the Highway 148 corridor, communicating this right-of-way's antecedents in the nineteenth century.	 View of north and west elevation of subject residential structure.
BHR 2	Residence	1028 Pembroke Street East	Identified during field review	Historical: - Likely built during first quarter of the twentieth century, corresponding to expansion of settlement activities along the periphery of Pembroke. Design: - One-storey residence in the 'Ontario Cottage's style. - Traditional stylistic and material elements associated with the style, include hipped roof, central dormer, symmetrical front faced and six over six sash windows. Context: - Contributes to the historic character of the Highway 148 corridor, communicating this right-of-way's antecedents in the nineteenth century.	 View northwest towards eastern and southern elevations of subject residence.

Resource	Type	Address/Location	Recognition	Description	Photos
BHR 3	Residence	1173 Pembroke Street East	Identified during field review	Historical: - Based on a review of historic topographic mapping, this structure likely dates to the ealy twenteith century and is associated with settlement expansion activities along the periphery of Pembroke. Design: - The residential strucutre features two-and-a-half storey massing, hipped roof, '4-square' footprint and internal layout, and symmetrical fenestration on the front elevation. - The structure's '4 square' layout, brick materials, and massing are typical features of early-twentieth-century farmhouse construction. Context: - The subject residential building, combined with its scale, building footrpint, increased setback in relation to adjacent structures, and relationship to Resmer Road, a circulation route that appears since at least 1934, and crossing the rail right-of-way, contributes to the corridor's function and character as a historically-surveyed thoroughfare featuring a range of land uses.	 View east to western elevation of subject residence.
BHR 4	Commercial	1227 Pembroke Street East	Identified during field review	Historical: - Based on a review of historic topographic mapping, this structure likely dates to the ealy twenteith century and is associated with settlement expansion activities along the periphery of Pembroke. Design: - This commerical structure features typical and utilitarian features common among commericial buildings constructed during the first half of the twentieth century. - Features reflective of the structure's construction date include brick veneer, poured concrete slab foundation; and wooden window sill and lintels.	

Resource	Type	Address/Location	Recognition	Description	Photos
CHL 1	Museum	1022 Pembroke Street East	Identified during field review	Historical: - The museum was officially opened at the current site in 1958, originally contained within the Lowertown schoolhouse which was constructed on the lot in 1838. - The museum became the meeting place for members of the Ottawa valley Historical Society, a group that began to convene in 1955, dedicated to preserving the history of the area. - Over time, the museum operations and the Ottawa Valley Historical Society expanded operations through donation of various historically-significant structures from other places and communities, such as reconstruction of a log home on the property, originally located in Rankin, and relocation of a church on to the property in 1997. The subject church was constructed in 1879 and was originally located in Micksburg, a small community southwest of the study area. Design: - The subject property contains various institutional structures that demonstrate historic construction methods and use of materials. Context: - The subject property anchors the Highway 148 corridor as a historically-surveyed thoroughfare. The retention of the Lowertown schoolhouse, plus introduction of other historically-significant structures, as well as interpretative murals and signage establish a strong community-based, cultural presence along the corridor. - The property's affiliation with the Ottawa Valley Historical society, and its collection of structures from nearby cross-roads communities, such as Rankin and Micksburg, also contribute to the function and character of the Highway corridor as a route associated with the broader settlement patterns of the Ottawa Valley.	 View of Lowertown schoolhouse, constructed 1838. View of Micksburg United Church located on the museum grounds.

Resource	Type	Address/Location	Recognition	Description	Photos
CHL 2	Residential Complex	No Address; Located between 1105 and 1065 Pembroke Street East	Identified during field review	Historical: - A feature in this location is illustrated as early as ca. 1930 on historic topographic maps and given the style and massing of the residential strucutre, it is likely that it dates to the last quarter of the ninteenth-century and is therefore associated with expansion of settlement activities along the Highway 148 corridor. Design: - The residential structure features one-and-a-half storey massing and central dormer on front and rear elevations, features typicaly of the Ontario Gothic style. - The structure also appears to feature a a side accretion with gabled dormers on the front elevation. Context: - The property features the primary residential structure that appears to date the late ninteenth century, a range of small outbuildings or ancillary structures as illustrated on 2014 aerial mapping, and groupings of mature vegetation such as cedar plantings at the entrace to the property and mostly deciduous trees north and east of the residential structure.	 View southwest from the north side of Glendale Avenue towards York Road.
CHL 3	Cemetery	1135 Pembroke Street East	Identified during field review	Historical: - Based on a review of markers within the cemetery, it appears that it has been in use since ca. 1940. It is also likely that establishment of this cemetery relates to the operation of the Pembroke Pentecostal Tabernacle, a congegation that was formally establihsed in 1924. Design: - The cemetery follows a typical layout common to small burial grounds associated with congregations in smaller communities. The property is clearly marked by cast-iron fencing and prominent signage on its western property line. - Plantings within the grounds do not appear to be follow a clearl landscape design intent. Context: - The prominent signage and clear views of the parcel that clearly communicate its function as a burial ground contribute to the character and visual experience of this portion of the Highway 148 corridor as a historically surveyed thoroughfare associated temporally and functionally with land uses in Pembroke, as well as surrounding communities.	 View east toward Pembroke Pentecostal Cemetery

Resource	Type	Address/Location	Recognition	Description	Photos
CHL 4	Residential Complex	1145 Pembroke Street East	Identified during field review	Historical: - Based on a review of historic topographic mapping, this structure likely dates to the mid twenteith century and is associated with settlement expansion activities along the periphery of Pembroke. Design: - The residential strucutre features one-and-a-half storey massing and a cross-gable roof line. The footprint of the structure, combined with symmetrical fenestration, and front-facing gable roof-line on the front elevation, and entablature around the front entrance doorway suggests an early twentieth century construction date. Context: - The subject structure, combined with its scale, building footrpint, modest set back, aligned with other earlier twentieth century structures along this portion of the study area, and the property's retention of a relatively large lot extending to the rail right-of-way and retentention of vegetation and treed areas along the eastern property line and south of the residence contribute to the corridor's character as an evolved mixed use corridor.	 View southeast towards subject residence.
CHL 5	Residential Complex	1124 Pembroke Street East	Identified during field review	Historical: - Based on a review of historic topographic mapping, this structure likely dates to the mid twenteith century and is associated with settlement expansion activities along the periphery of Pembroke. Design: - The residential strucutre features one-and-a-half storey massing and symmetrical façade is typical of novice or resident built housing during the early twentieth century. A review of historical topographic mapping indicates that between 1934 and 1950, one structure appeared in this general location and given the absence of other buildings in the vicinity, it's likely this building was built by a land-owner. Context: - The subject structure, combined with its scale, building footrpint, slightly increased setback in relation to adjacent structures, and retention of relatively large lot extending westward and bearing evidence of agricultural land uses contributes to the corridor's function and character as a historically-surveyed thoroughfare featuring a range of land uses.	 View northwest towards eastern elevation of subject residence.

Resource	Type	Address/Location	Recognition	Description	Photos
CHL 6	Residential Complex	1211 Pembroke Street East	Identified during field review	Historical: - Based on a review of historic topographic mapping, this structure likely dates to the early twenteith century and is associated with settlement expansion activities along the periphery of Pembroke. Design: - The residential strucutre features a steeply-pitched gable roof, internal chimney; symmetrical fenestration and a side accretion. - The layout and massing of the structure is typical of early twentieth-century residential construction trends in towns and vilages. Context: - The subject structure, combined with its scale, building footrpint, increased setback in relation to adjacent structures, and retention of a large lot size in comparison to other adjacent subdivided lots contributes to the corridor's function and character as a historically-surveyed thoroughfare featuring a range of land uses.	 View southeast towards primary residential building.

Resource	Type	Address/Location	Recognition	Description	Photos
CHL 7	Agricultural Complex	1244 Pembroke Street East	Identified during field review	Historical: - Based on a review of historic topographic mapping, this structure likely dates to the early twenteith century and is associated with settlement expansion activities along the periphery of Pembroke. Design: - The residential strucutre features massing typical of early twentieth-century farmhouse design. - The residential sructure is set in a '4 square' layout, feating a hopped roof, central hipped former; brick veneer; veranda on front elevation, spanning width of the western elevation; and a rear accreation with internal chimney. - The parcel size, limits, arrangement and setback of buildings, as well as open space patterns are typical and consistent with a lot that has been actively farmed for over a century. Context: - The subject structure, combined with its scale, building footprint, setback, relationship to on-site agricutlural buildings, on site land uses which appear to include animal husbandry; and retention of mature vegetation surrounding the residential structure contribute to the corridor's function and character as a historically-surveyed thoroughfare, associated with early settlement activities.	 View southwest towards primary residential building and agricultural landscape. Detail of primary residence.

9.0 CULTURAL HERITAGE RESOURCE LOCATION MAPPING

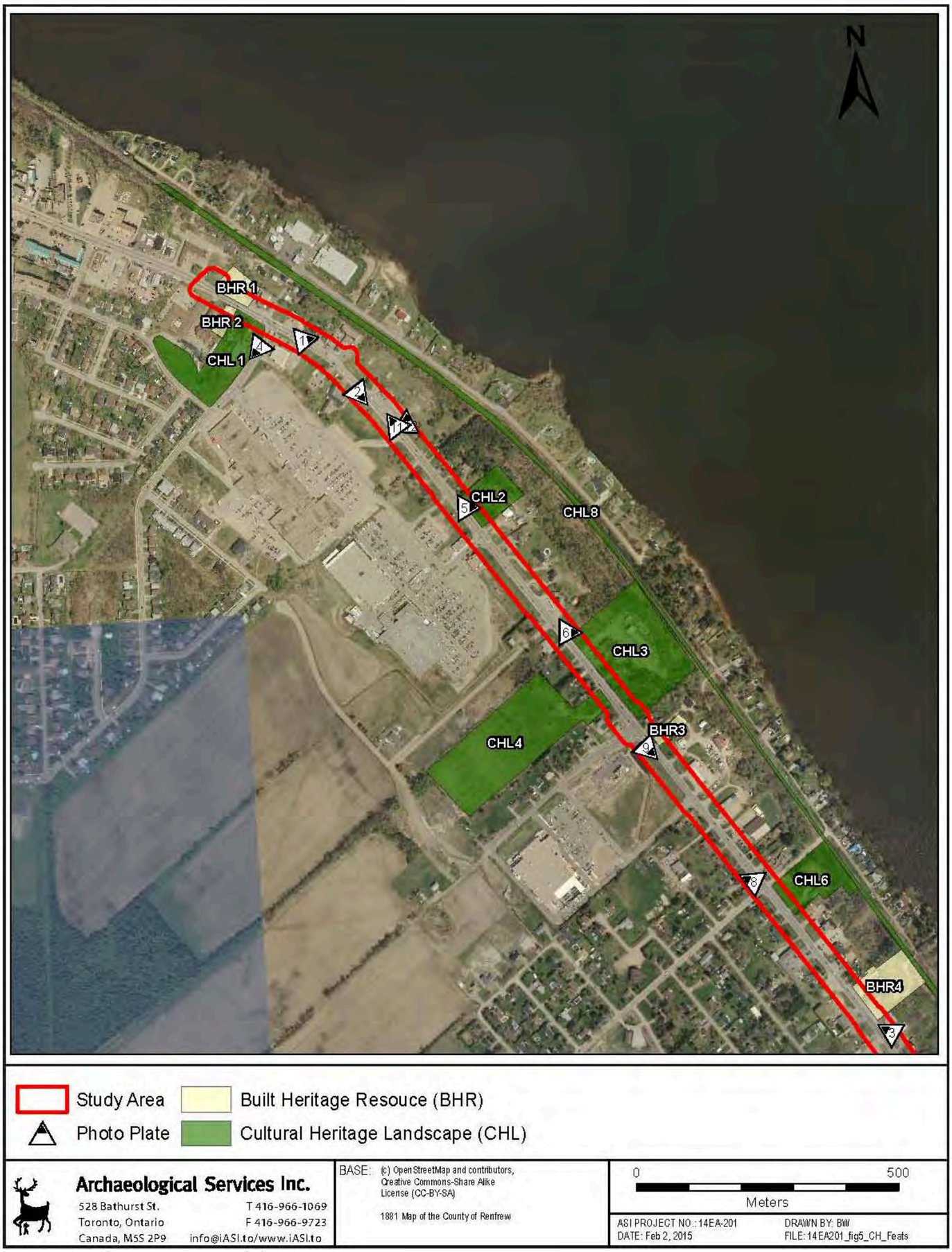
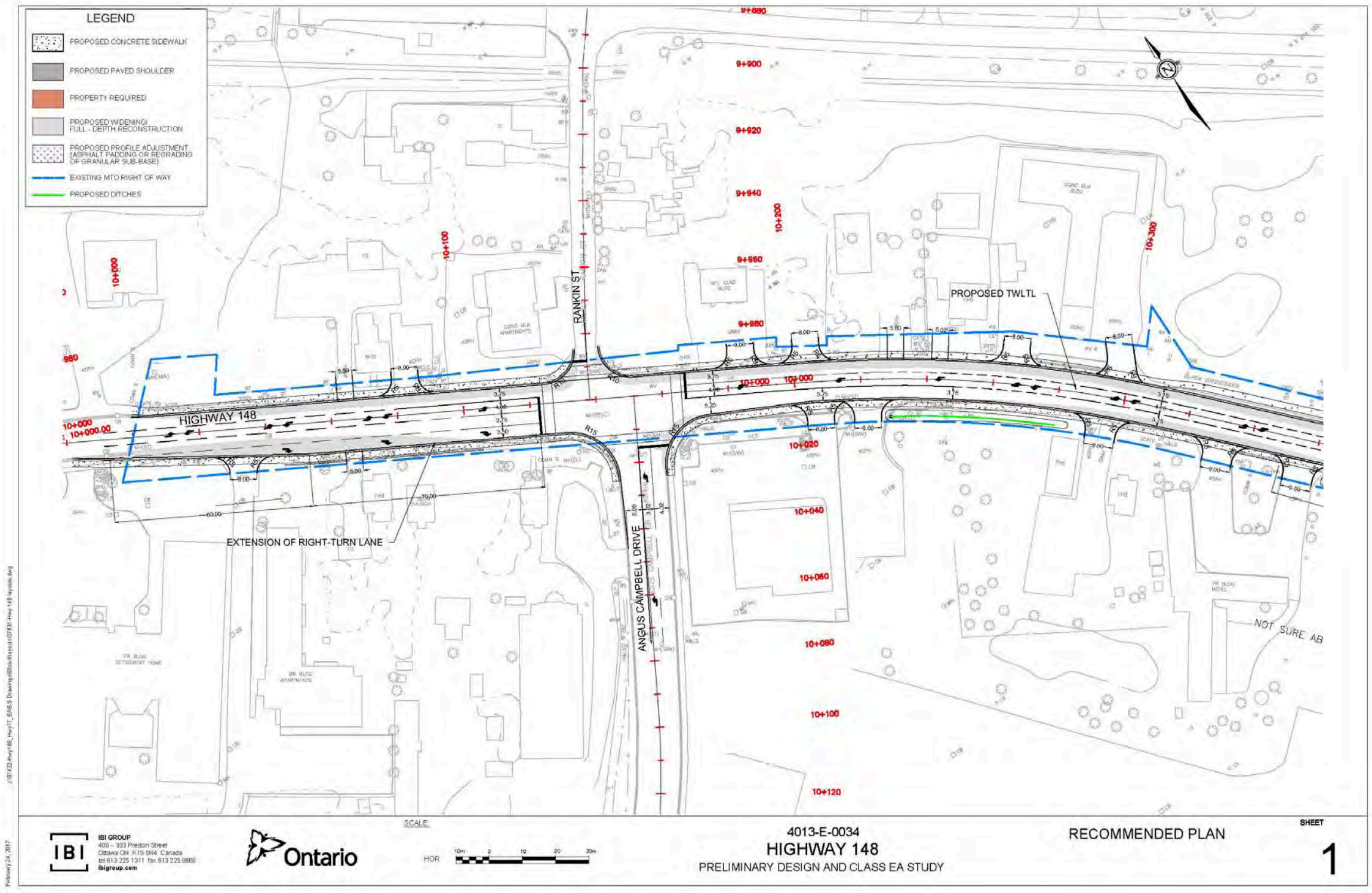
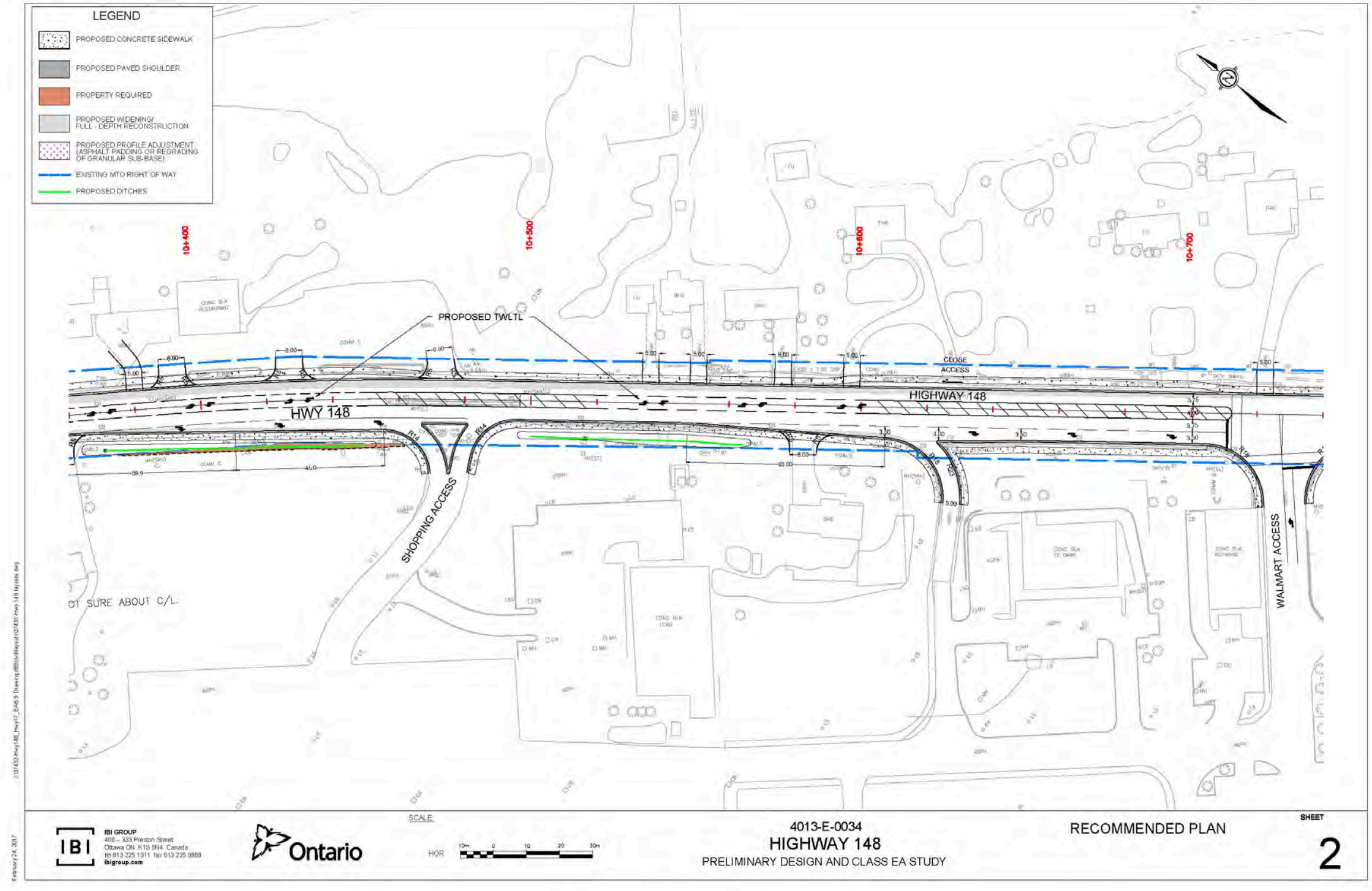


Figure 6: Cultural heritage resources and photo locations

Figure 7: Cultural heritage resource locations

10.0 RECOMMENDED PLAN DRAWINGS

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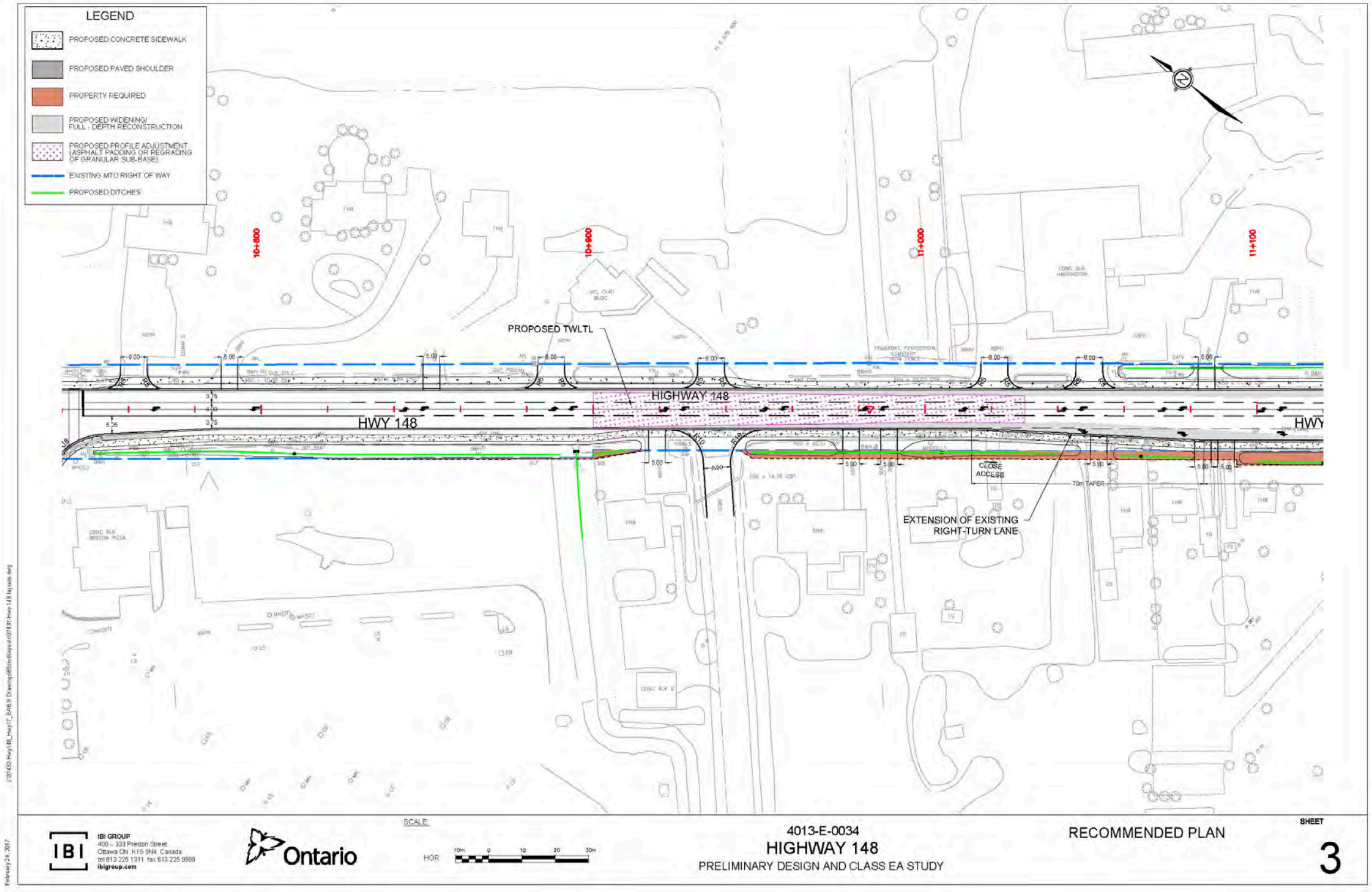
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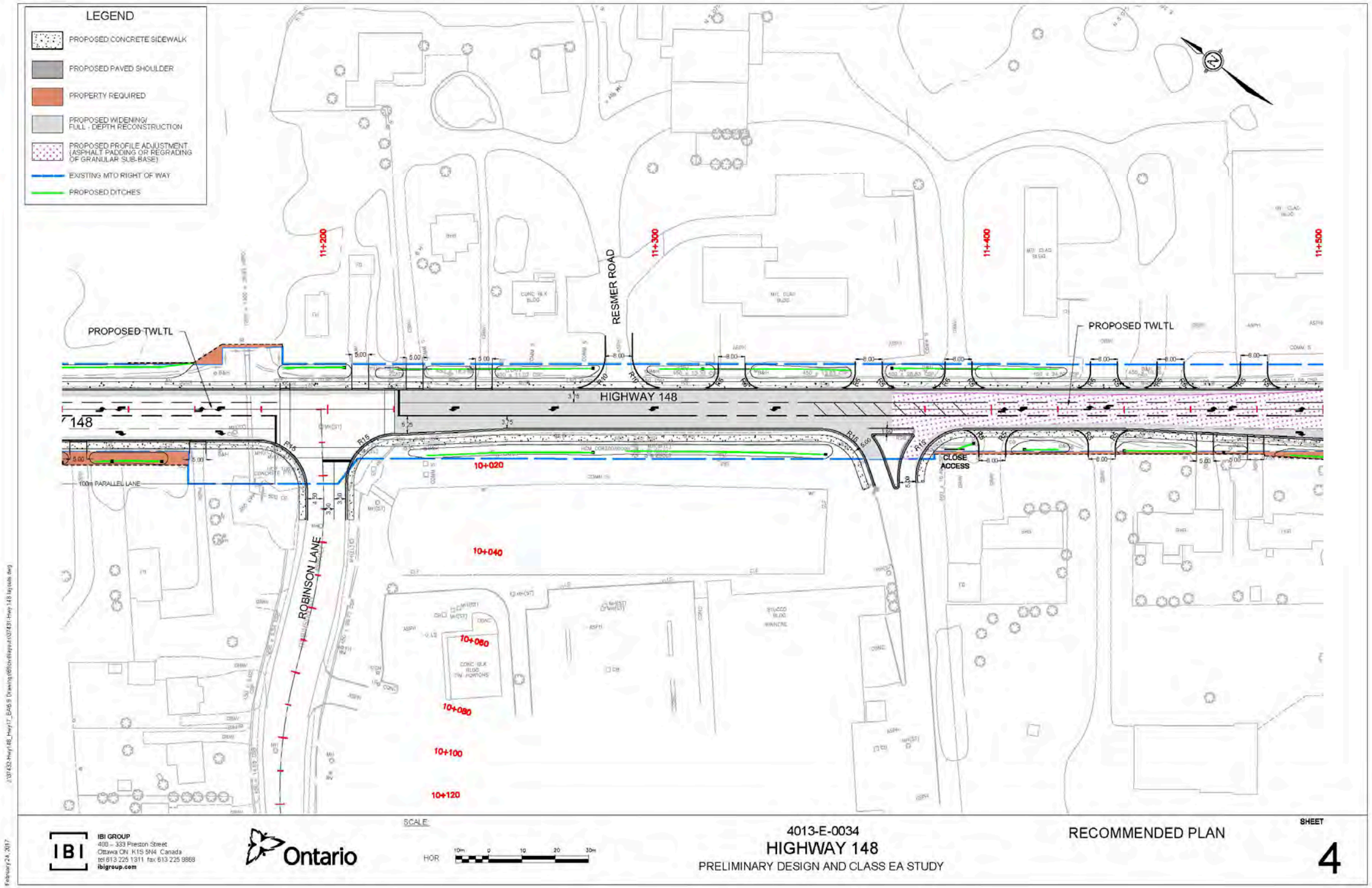
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EXISTING MTO RIGHT OF WAY
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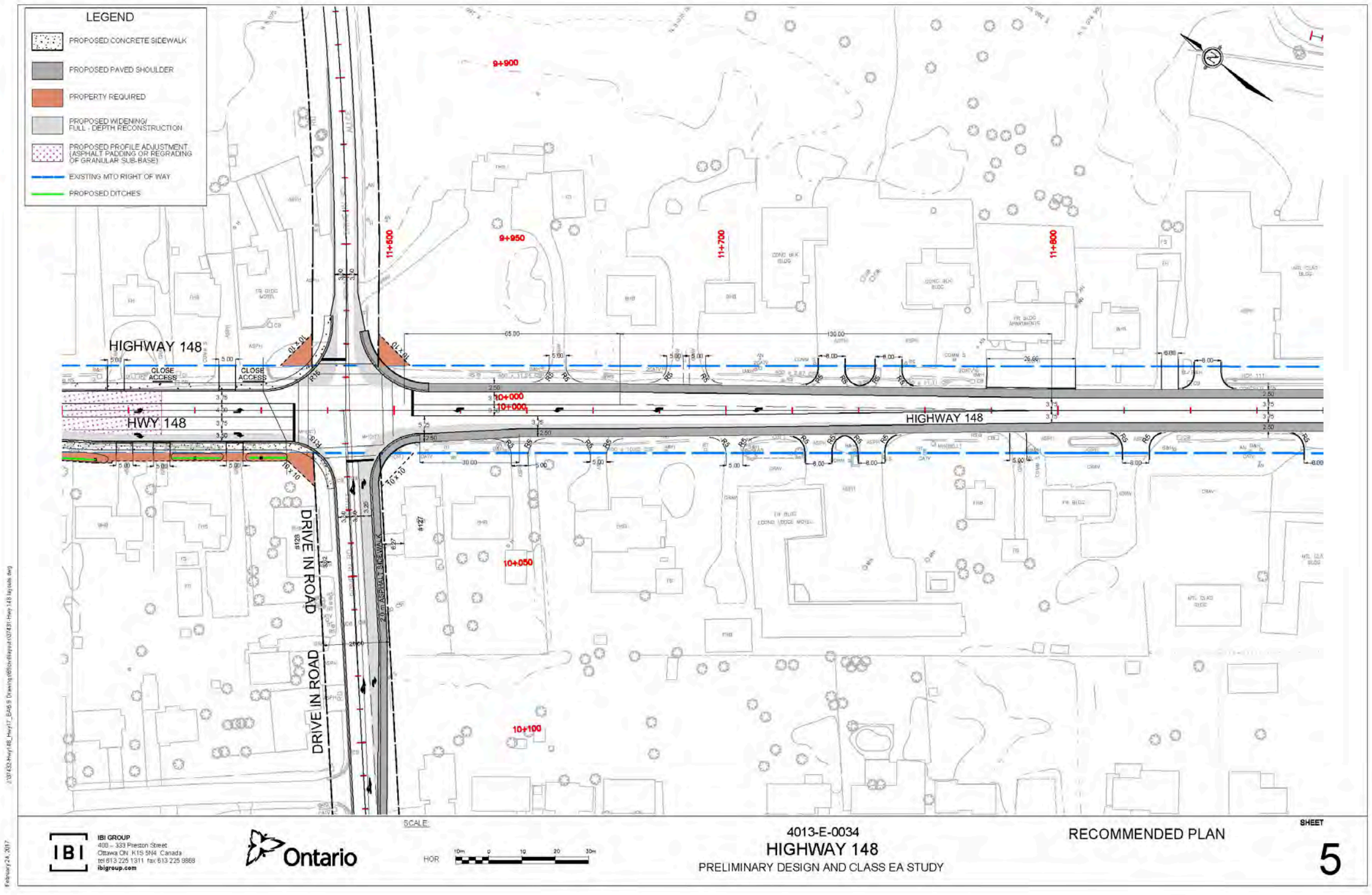
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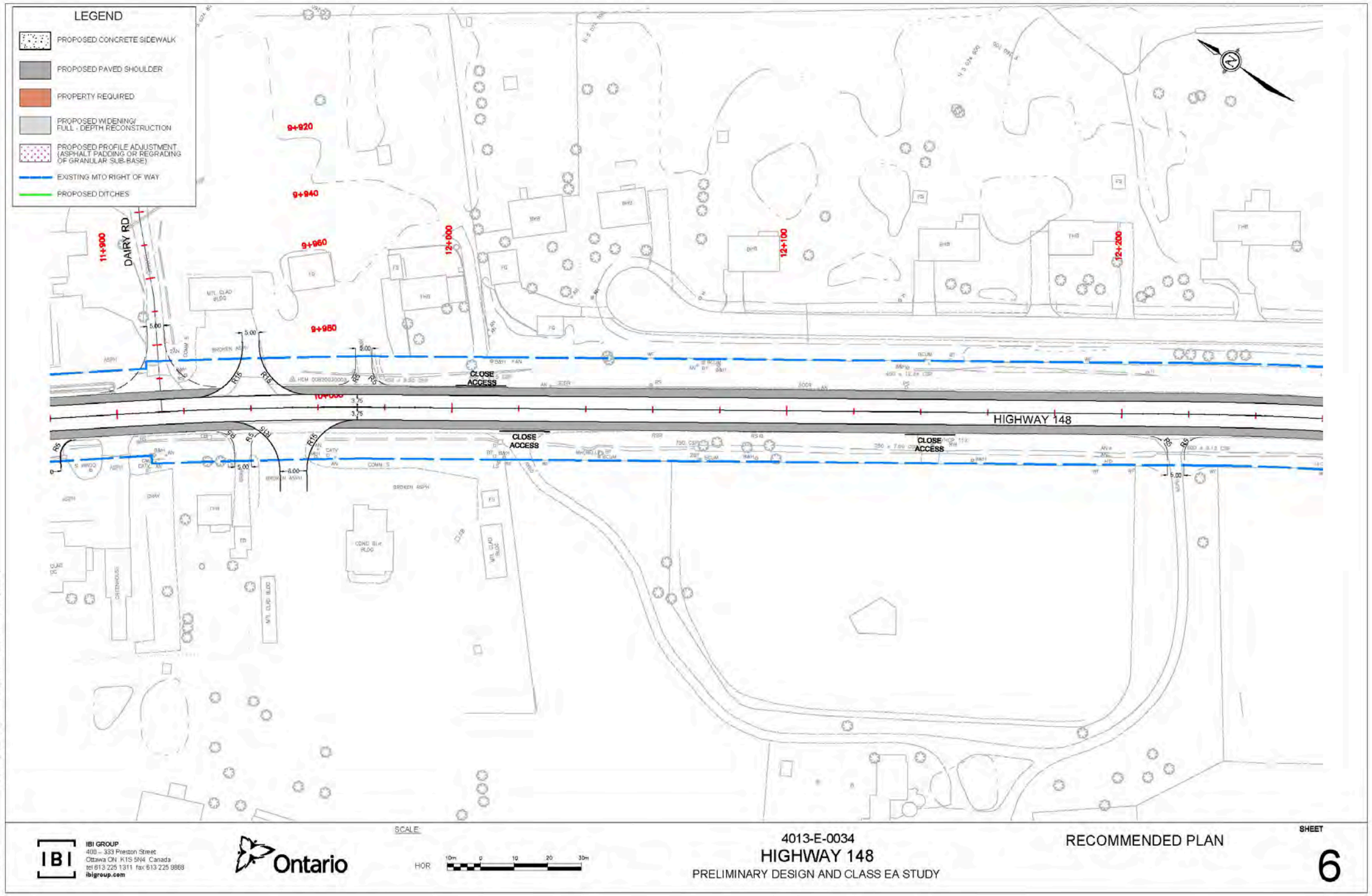
PROPOSED PAVED SHOULDER
PROPERTY REQUIRED
PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
HIGHWAY 148
HWY 148
CLOSE ACCESS
CLOSE ACCESS
DRIVE IN ROAD
DRIVE IN ROAD
9+900
9+950
10+000
10+050
10+100
11+600
11+700
11+800
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
HOR
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
5

ASI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PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
DAIRY RD
HIGHWAY 148
CLOSE ACCESS
CLOSE ACCESS
CLOSE ACCESS
9+920
9+940
9+960
9+980
10+000
11+900
12+000
12+100
12+200
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
HOR
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
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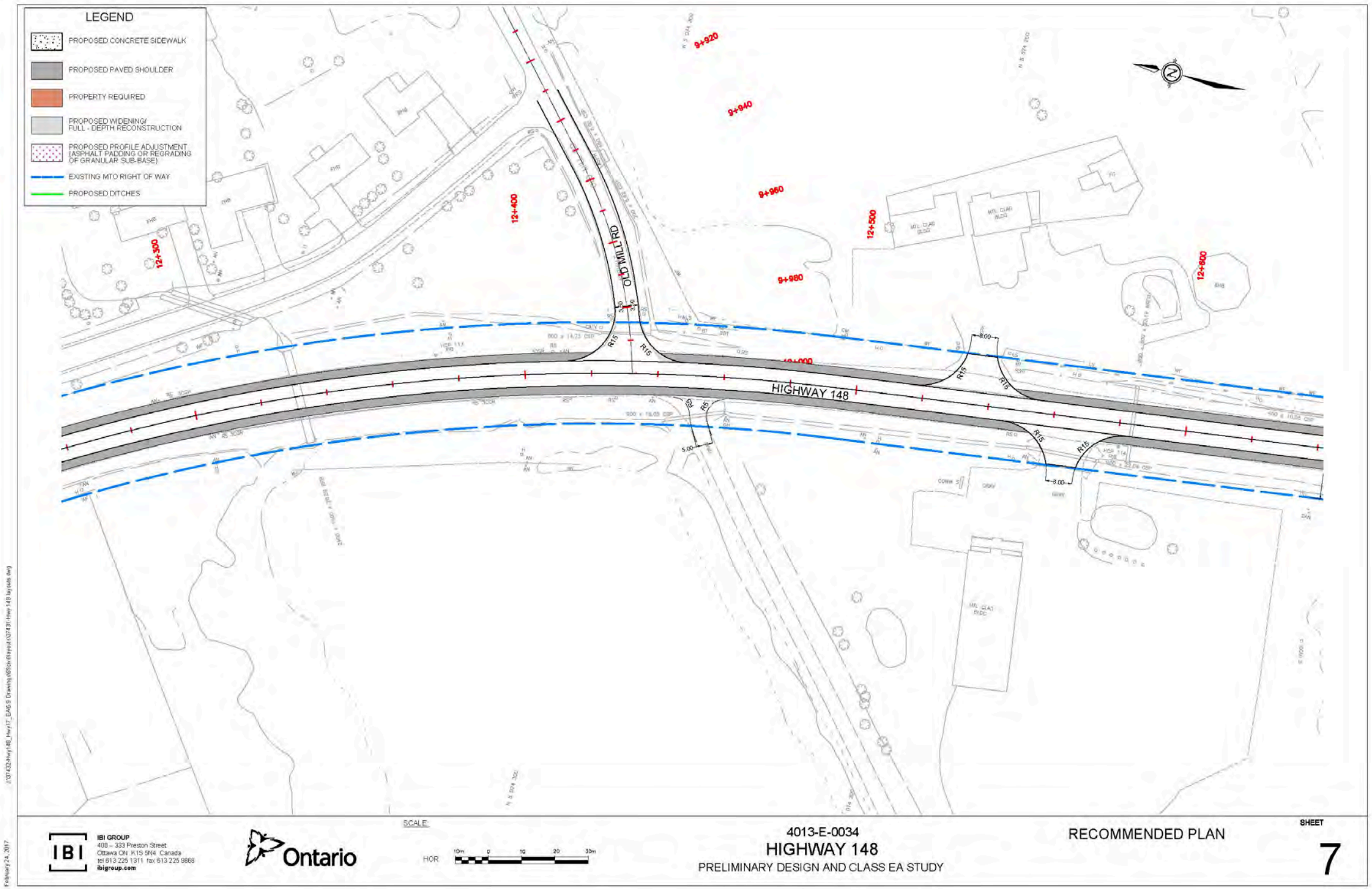
6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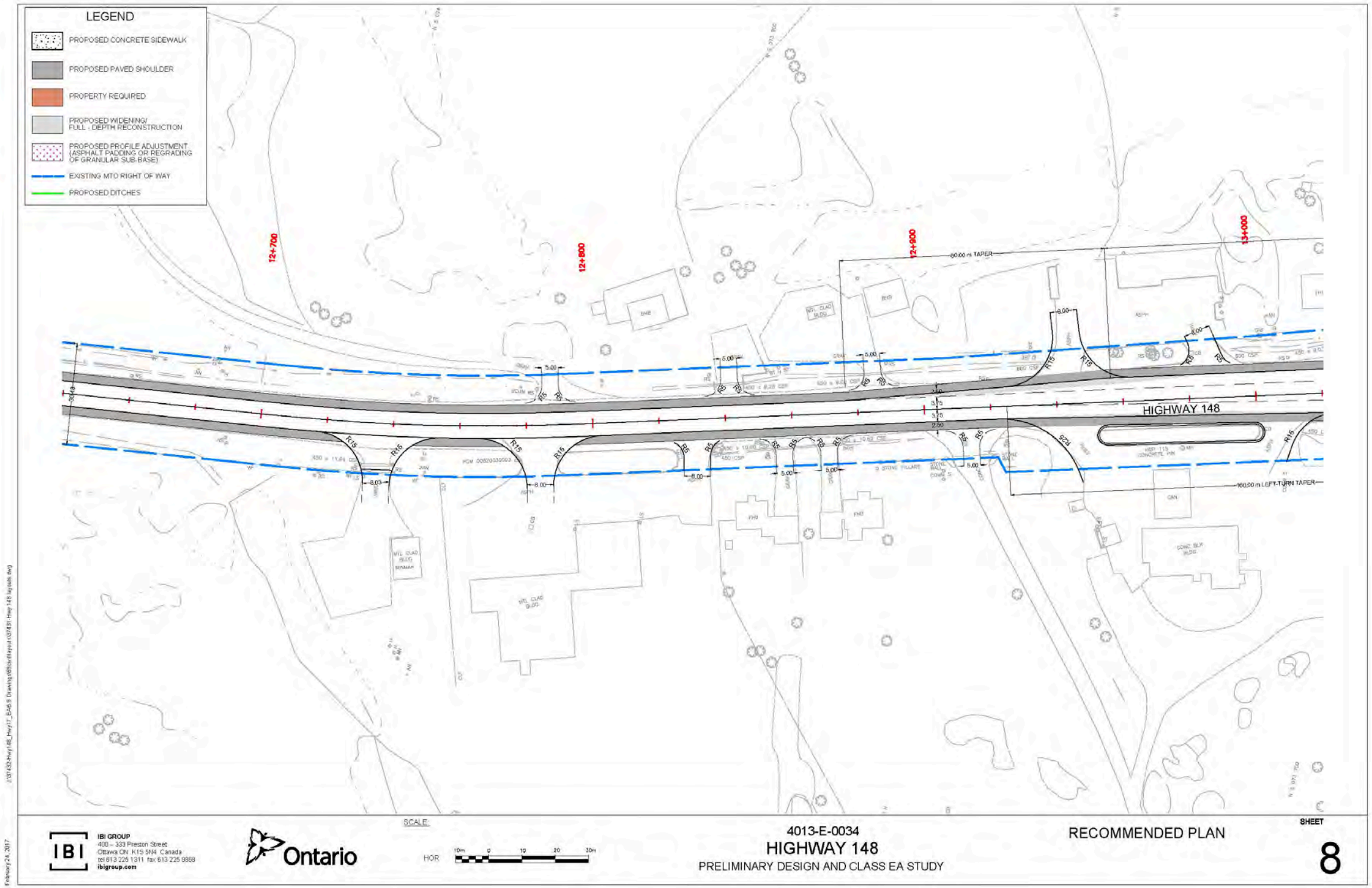
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
OLD MILL RD
HIGHWAY 148
9+920
9+940
9+960
9+980
10+000
12+400
12+500
12+600
12+300
R15
R16
8.00
5.00
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
HOR
10m 0 10 20 30m
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
7
February 24, 2017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PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
12+700
12+800
12+900
13+000
HIGHWAY 148
160.00 m LEFT-TURN TAPER
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
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HIGHWAY 148
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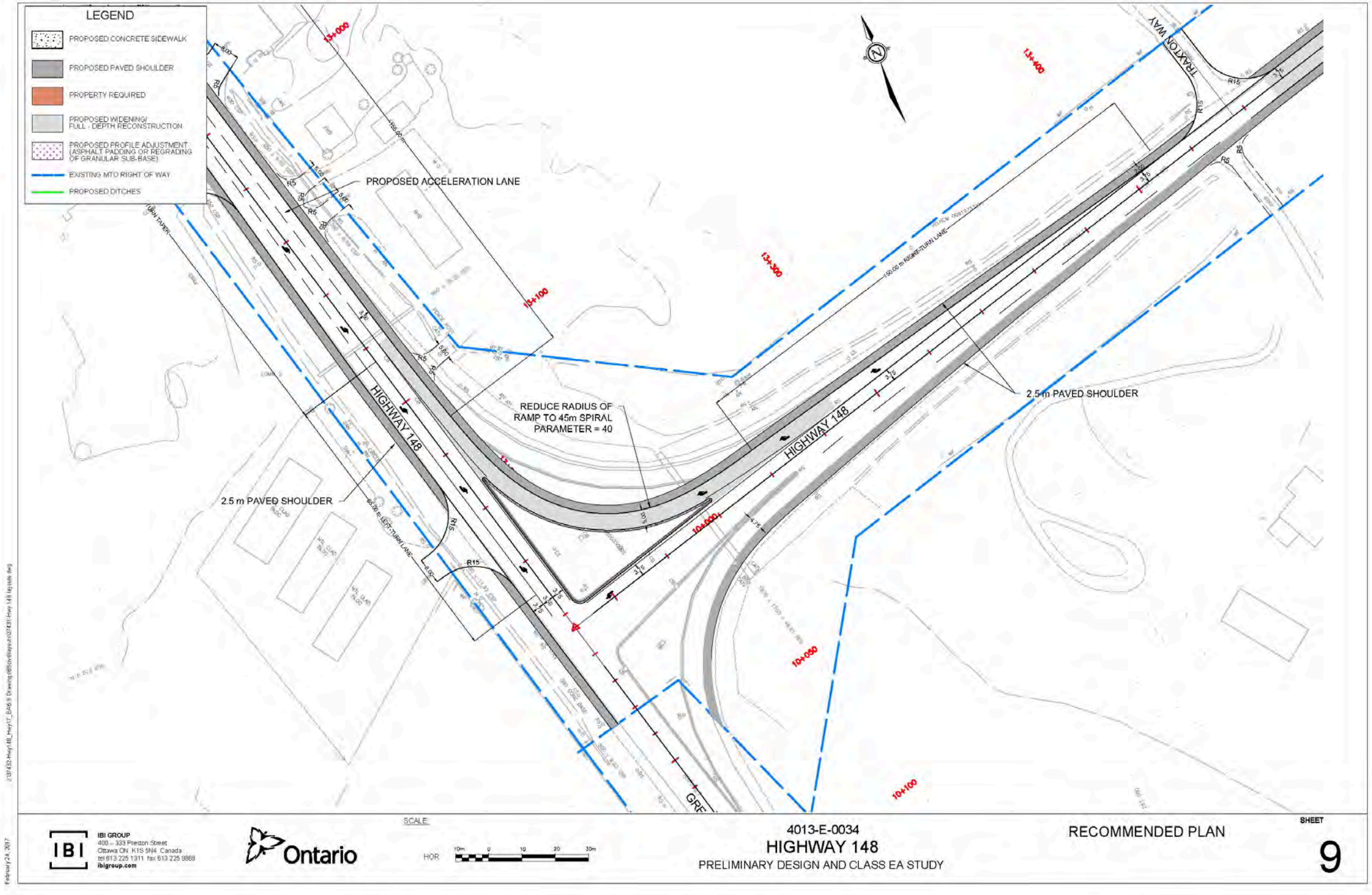
8
February 24, 2017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EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
PROPOSED ACCELERATION LANE
REDUCE RADIUS OF RAMP TO 45m SPIRAL PARAMETER = 40
2.5 m PAVED SHOULDER
2.5 m PAVED SHOULDER
HIGHWAY 148
HIGHWAY 148
TRAXTON WAY
13+000
13+100
13+200
13+300
13+400
10+000
10+050
10+100
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
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4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
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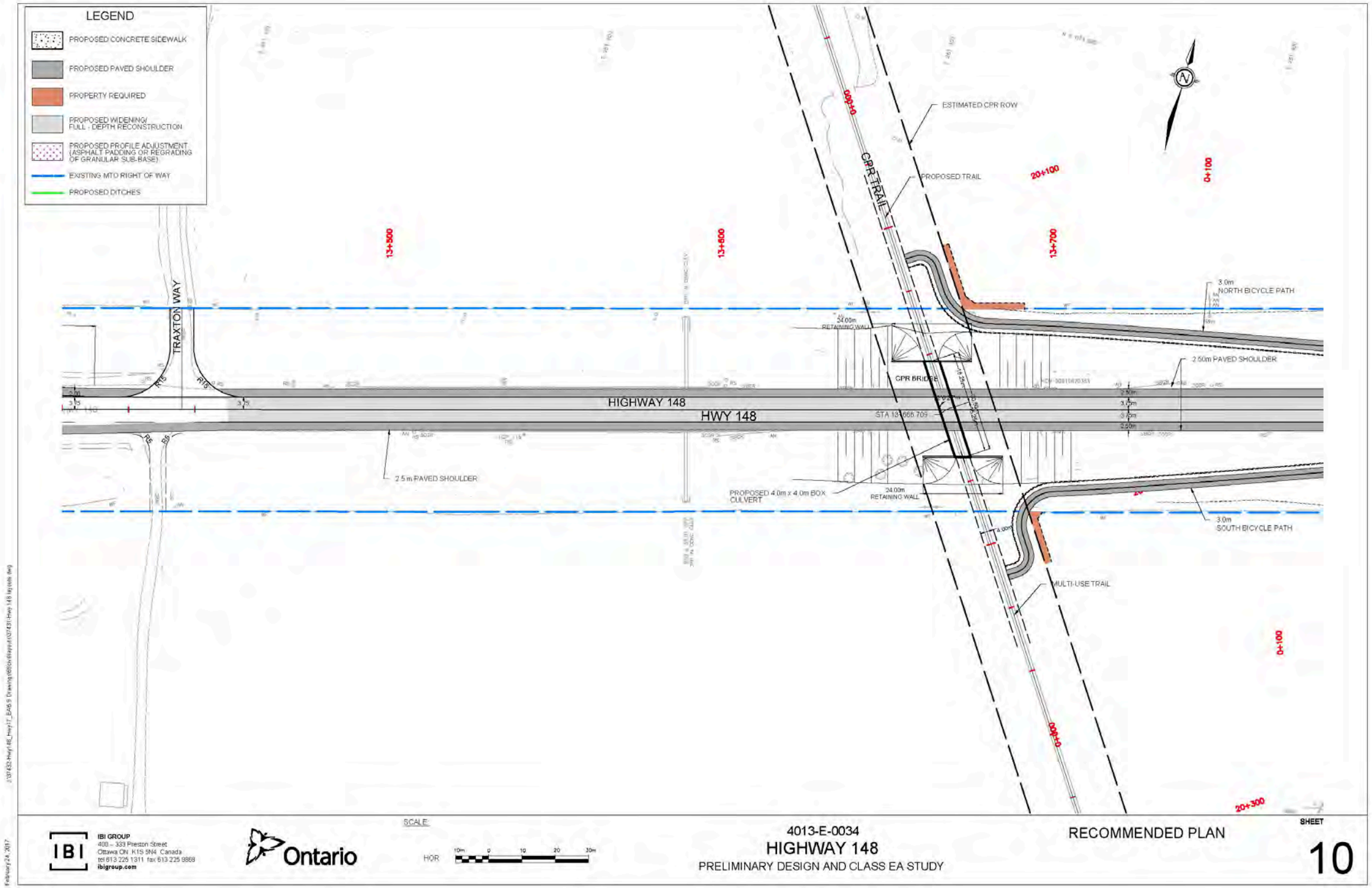
LEGEND
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PROPOSED PAVED SHOULDER
PROPERTY REQUIRED
PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
ESTIMATED CPR ROW
PROPOSED TRAIL
CPR TRAIL
TRAXTON WAY
HIGHWAY 148
HWY 148
CPR BRIDGE
24.00m RETAINING WALL
3.0m NORTH BICYCLE PATH
2.50m PAVED SHOULDER
2.5 m PAVED SHOULDER
PROPOSED 4.0m x 4.0m BOX CULVERT
3.0m SOUTH BICYCLE PATH
MULTI-USE TRAIL
13+500
13+600
13+700
20+100
0+100
0+200
20+300
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
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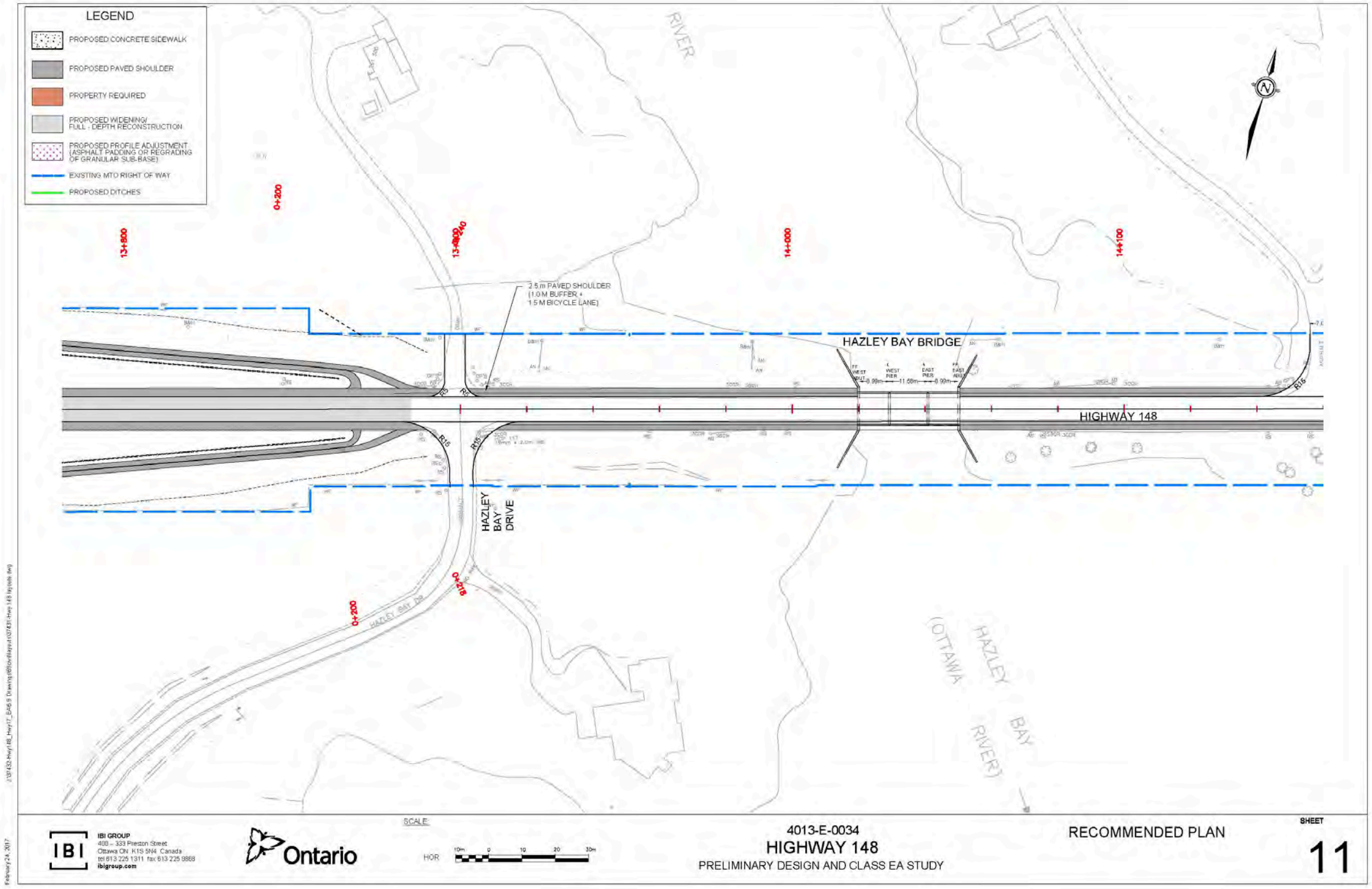
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
10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PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
RIVER
0+200
13+800
13+900
14+000
14+100
2.5 m PAVED SHOULDER (1.0 M BUFFER + 1.5 M BICYCLE LANE)
HAZLEY BAY BRIDGE
HIGHWAY 148
HAZLEY BAY DRIVE
0+200
0+218
HAZLEY BAY (OTTAWA RIVER)
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
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4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
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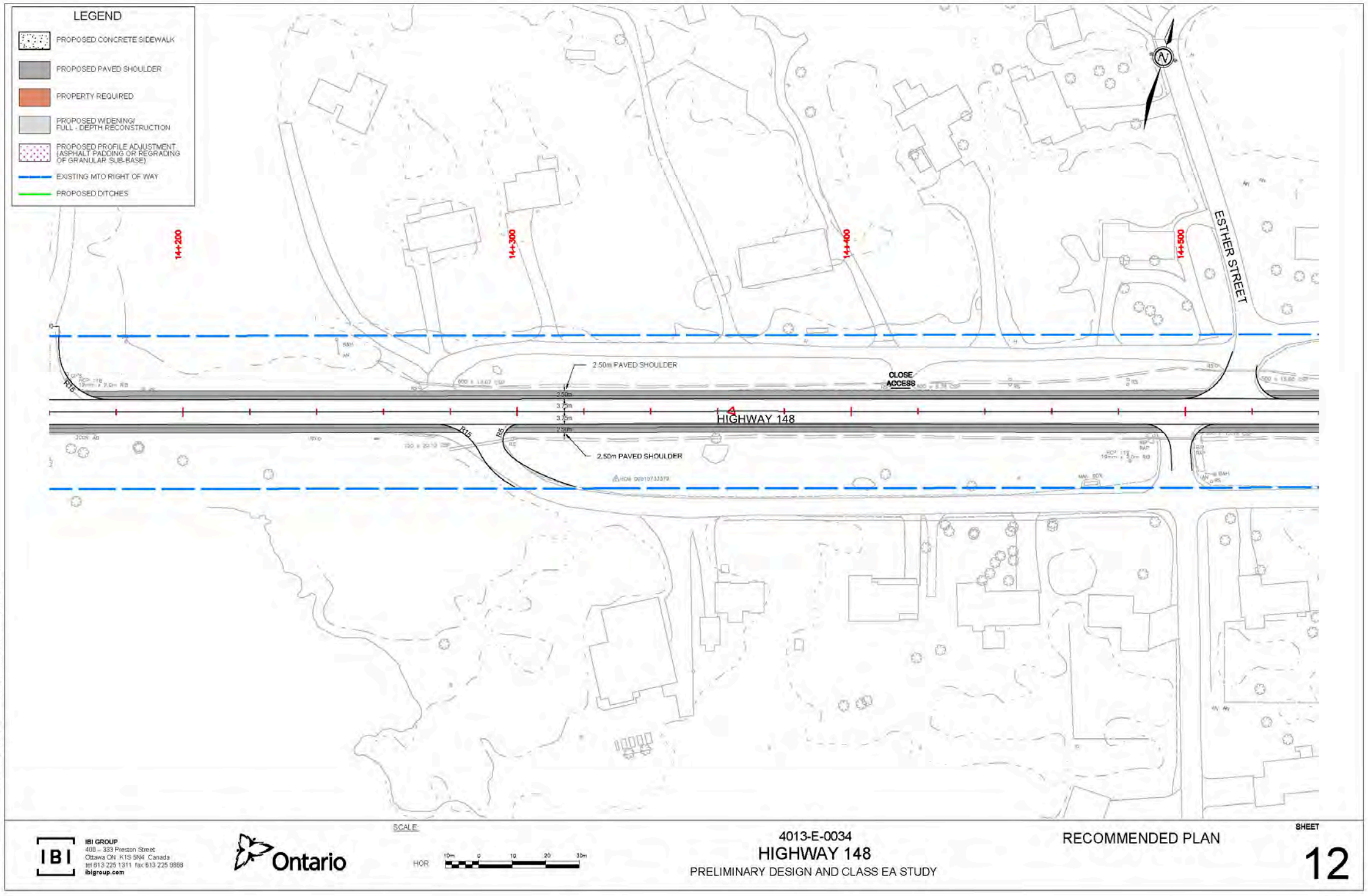
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PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
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EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
14+200
14+300
14+400
14+500
ESTHER STREET
2.50m PAVED SHOULDER
CLOSE ACCESS
HIGHWAY 148
2.50m PAVED SHOULDER
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
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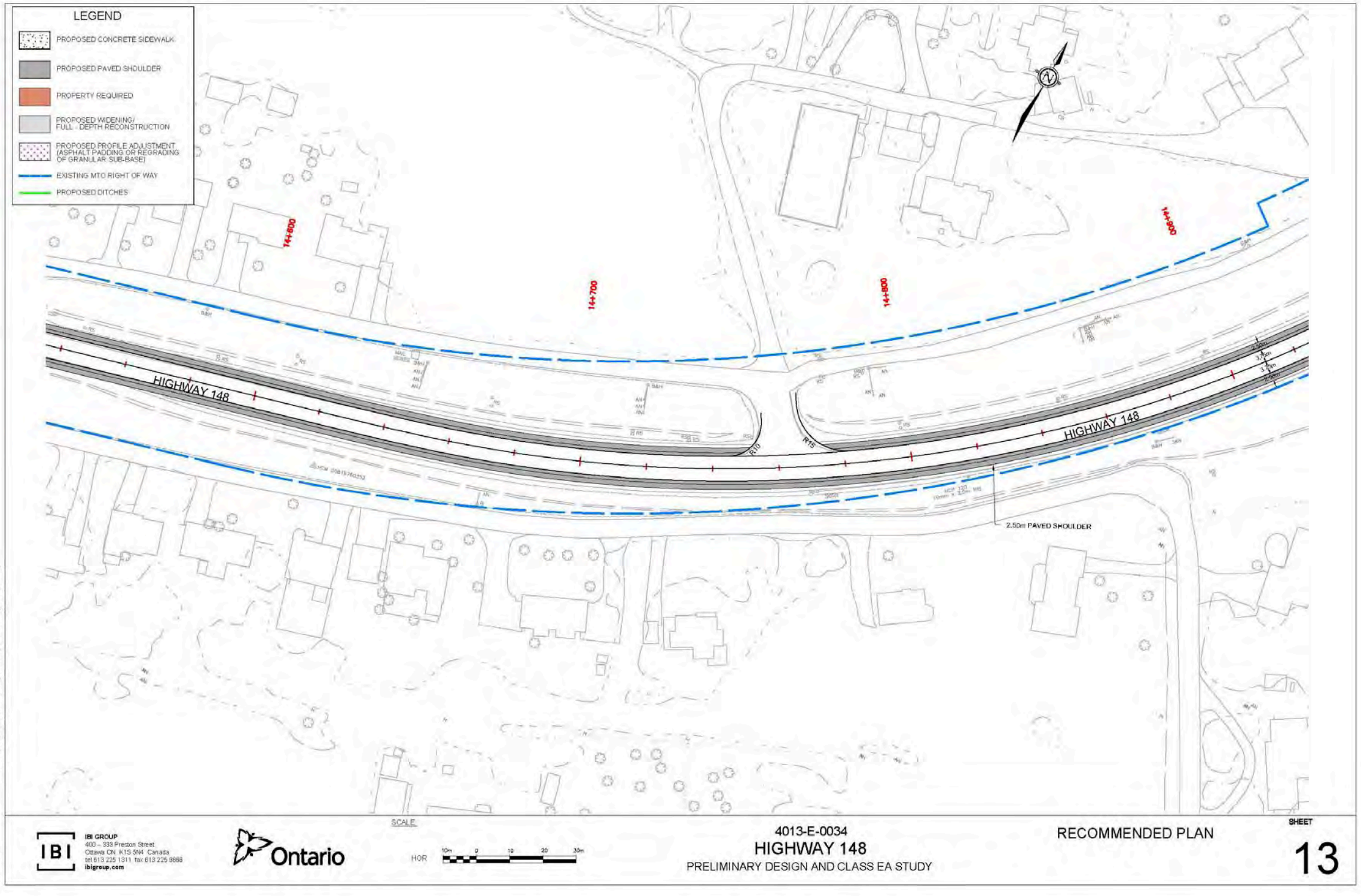
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EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
14+800
14+700
14+800
14+900
HIGHWAY 148
HIGHWAY 148
2.50m PAVED SHOULDER
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 8668
ibigroup.com
Ontario
SCALE
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10m 0 10 20 30m
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
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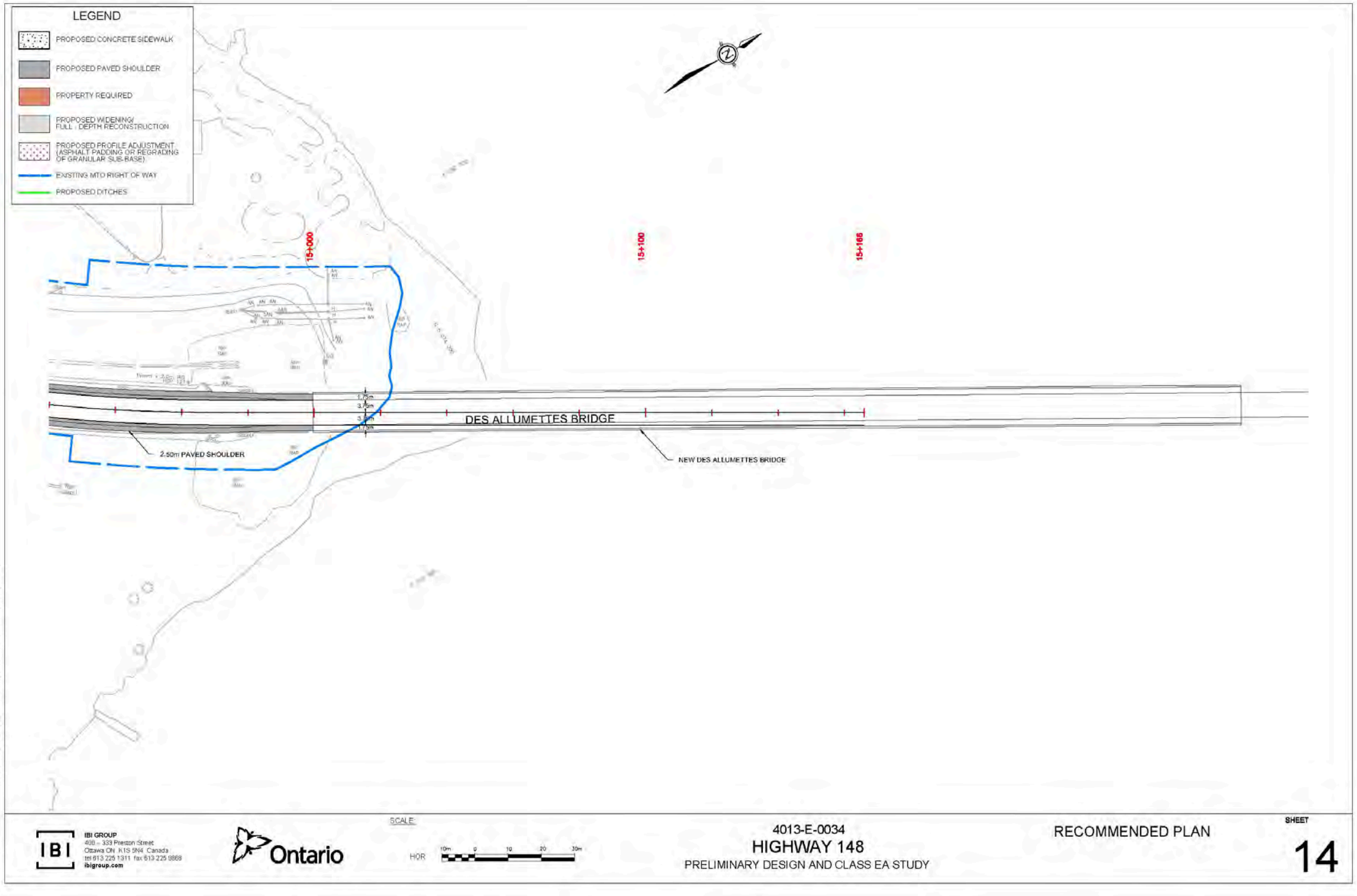
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EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
15+000
15+100
15+166
DES ALLUMETTES BRIDGE
2.50m PAVED SHOULDER
NEW DES ALLUMETTES BRIDGE
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE:
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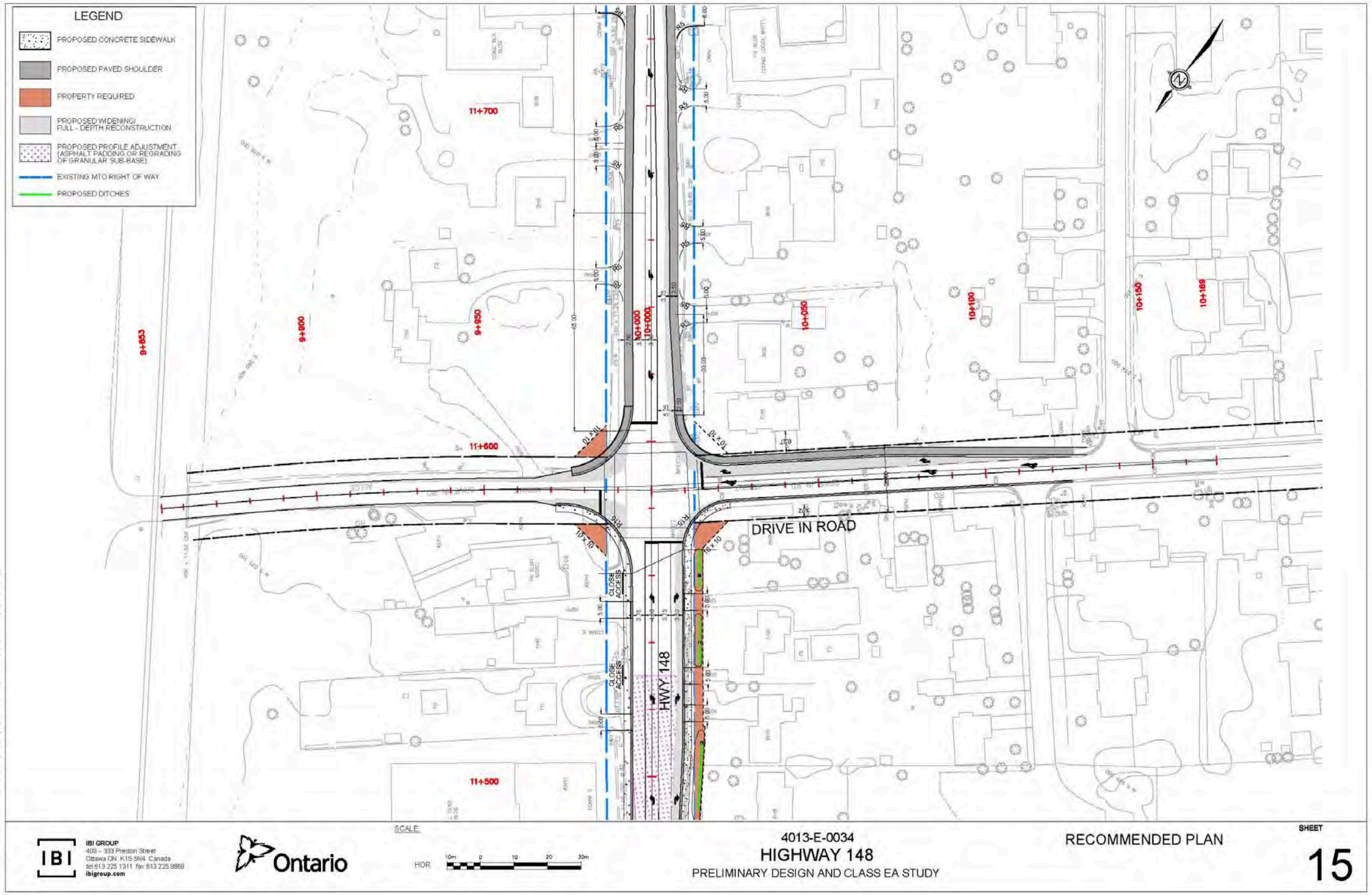
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
14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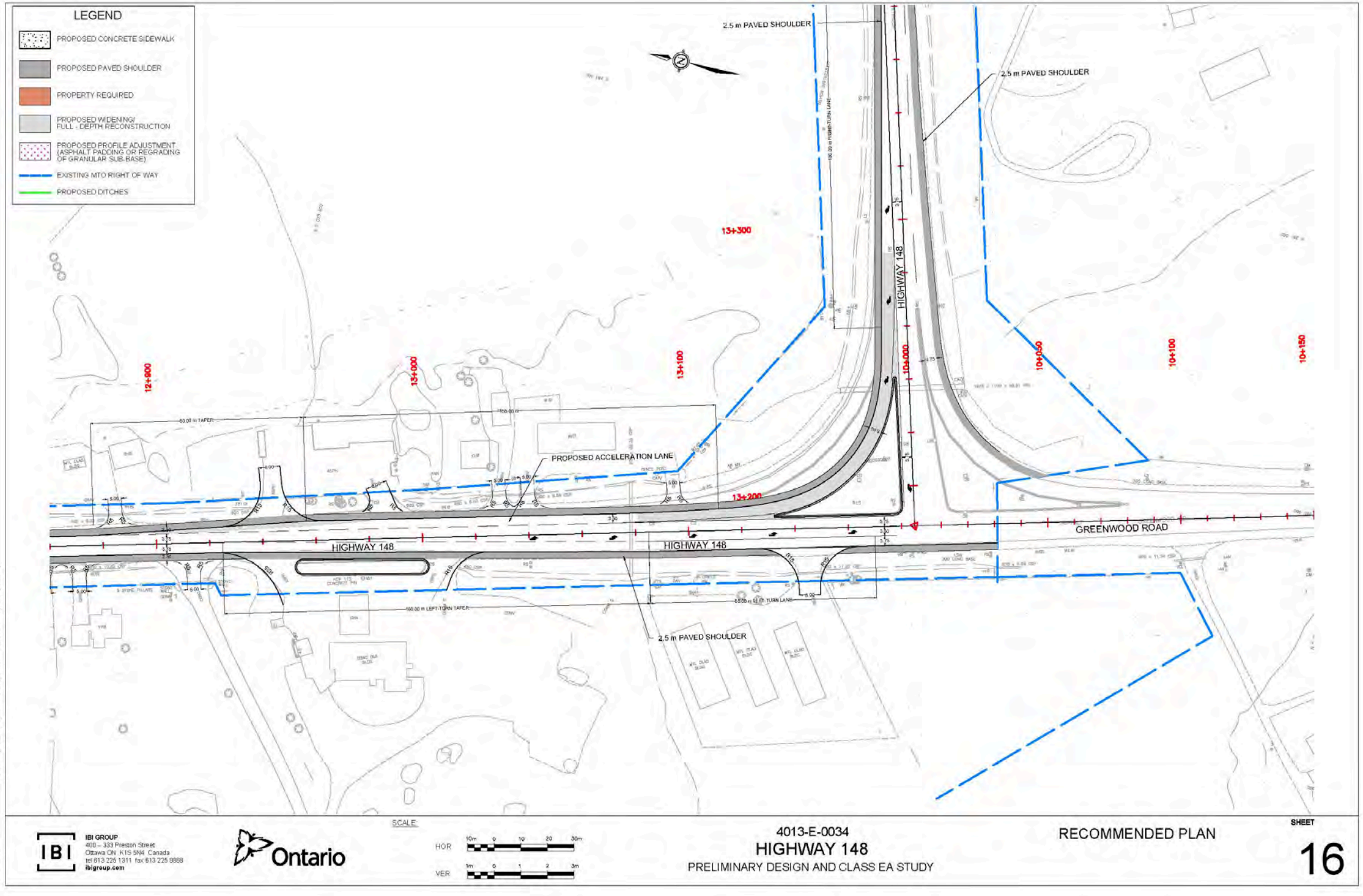
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
11+700
11+600
11+500
9+853
9+800
9+850
10+000
10+000A
10+050
10+100
10+150
10+188
DRIVE IN ROAD
HWY 148
CLOSE
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE
HOR
10m 0 10 20 30m
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
15
February 24, 2017


LEGEND
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PROPOSED PAVED SHOULDER
PROPERTY REQUIRED
PROPOSED WIDENING/ FULL - DEPTH RECONSTRUCTION
PROPOSED PROFILE ADJUSTMENT (ASPHALT PADDING OR REGRADING OF GRANULAR SUB-BASE)
EXISTING MTO RIGHT OF WAY
PROPOSED DITCHES
2.5 m PAVED SHOULDER
2.5 m PAVED SHOULDER
HIGHWAY 148
12+900
13+000
13+100
13+200
13+300
10+000
10+050
10+100
10+150
PROPOSED ACCELERATION LANE
60.00 m TAPER
HIGHWAY 148
HIGHWAY 148
GREENWOOD ROAD
100.00 m LEFT-TURN TAPER
2.5 m PAVED SHOULDER
IBI GROUP
400 – 333 Preston Street
Ottawa ON K1S 5N4 Canada
tel 613 225 1311 fax 613 225 9868
ibigroup.com
Ontario
SCALE
HOR
VER
4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY
RECOMMENDED PLAN
SHEET
16
February 24, 2017

Appendix G – Contamination and Waste Assessment

February 2016

FINAL REPORT

Contamination Overview Study Highway 148 from the Pembroke Connecting Link to the Quebec Border, Pembroke, Ontario, G.W.P. #214-00-00 & 4091-13-00

Submitted to:
IBI Group
100 - 175 Galaxy Blvd
Toronto, ON
M9W 0C9

Attn.: Mr. Allan Ortlieb

REPORT

Report Number: 1407554

Distribution:

1 e-copy - IBI Group
1 e-copy - Golder Associates Ltd.

Golder Associates

Executive Summary

Golder Associates Ltd. ("Golder Associates") was retained by IBI Group ("IBI") on behalf of the Ministry of Transportation ("MTO") to carry out a Contamination Overview Study ("COS") of Highway 148 from the Pembroke Connecting Link to Quebec border in Pembroke, Ontario. It is Golder Associates' understanding that the COS is required as part of the Preliminary Design and Environmental Impact Assessment carried out for Highway 148, from the Pembroke connecting link to Quebec border. For the purpose of the COS, the study area includes the existing HWY 148 Right-of-Way ("ROW") from Angus Campbell Avenue to the Quebec border, and the adjacent properties within 100 metres from the both sides of the ROW. The approximate total length of the section of HWY 148 included in this study is 5.0 km.

The objective of the COS was to identify potentially contaminating properties/activities within the study area which represent an issue of potential environmental concern (i.e., are characterized by possible soil and/or groundwater contamination) and thus have the potential to affect the proposed construction within the HWY 148 ROW.

In order to assess historical and current land uses and to identify properties with the potential to have impacted the subsurface at the study area, a review of an EcoLog ERIS report and aerial photographs for the study area was completed. In addition, a "drive-by" and walkthrough visual reconnaissance of the study area was conducted.

For the purpose of describing relative locations in this COS report, the following 3 sections along HWY 148 were defined:

- Section 1 – the section of the HWY 148 between Angus Campbell Drive and Route 29 (see Figure 2A);
- Section 2 – the section of the HWY 148 between Route 29 and Greenwood Road (see Figure 2B); and,
- Section 3 – the section of HWY 148 between Greenwood Road and the Quebec border (see Figure 2C).

Based on the findings of the COS assessment conducted on the study area, several issues of potential environmental concern having high potential for subsurface impacts on the HWY 148 ROW were identified for Sections 1 and 2 of HWY 148. These included:

- Former and current presence of retail fuel outlets on adjacent lands north and south of HWY 148 including: 1) former Irving Oil at 1034 Pembroke Street East, 2) former Ultramar gas station at 1409 Pembroke Street East, and 3) current ESSO gas station at 1400 Pembroke Street East.
- Presence of a hazardous waste generator on adjacent land north of HWY 148: Oil Changers (previously Sunoco Inc.) at 1043 Pembroke Street East.
- Reported spill on HWY 148: 500 L of diesel spilled on HWY 148 at Greenwood Road in 2007.

Based on the above, it is recommended that a subsurface investigation be carried out along Sections 1 and 2 of the HWY 148 at the areas located in close proximity to the above identified issues of potential environmental concern due to the potential for subsurface impacts to be encountered to construction of the highway improvements.

Additionally, the quality and source of fill material along HWY 148 is unknown. An assessment of the quality of the fill would be required, where encountered, as part of the proposed construction activities prior to the reuse of any excavated and/or excess fill material. Similarly, there is the potential for soil and groundwater along the HWY 148 ROW to be impacted with sodium and chloride as a result of highway de-icing activities. Excess soil generated during construction should be assessed for salt-related impacts before being reused off-site. Similarly, the quality of water generated during any construction dewatering activities should be assessed prior to being discharged to the environment.

No issues of potential environmental concern were identified within the study area for Section 3 of the HWY 148.

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APPENDICES

APPENDIX A
Ecolog ERIS Report

APPENDIX B
Site Photographs

1.0 INTRODUCTION

Golder Associates Ltd. ("Golder Associates") was retained by IBI Group ("IBI") on behalf of the Ministry of Transportation ("MTO") to carry out a Contamination Overview Study ("COS") of Highway 148 from the Pembroke Connecting Link to Quebec border in Pembroke, Ontario. It is Golder Associates' understanding that the COS is required as part of the Preliminary Design and Environmental Impact Assessment carried out for Highway 148, from the Pembroke connecting link to Quebec border. For the purpose of the COS, the study area includes the HWY 148 Right-of-Way ("ROW") from Angus Campbell Avenue to the Quebec border and the adjacent properties within 100 metres from the both sides of the ROW. The approximate total length of the section of HWY 148 included in this study is 5.0 km as shown on the Key Plan, Figure 1 and Site Plan, Figure 2.

The objective of the COS was to identify potentially contaminating properties/activities within the study area which represent an issue of potential environmental concern (i.e., are characterized by possible soil and/or groundwater contamination) and thus have the potential to affect the proposed construction within the HWY 148 ROW.

For the purpose of describing relative locations in this report, the following sections along HWY 148 were defined:

- Section 1 – the section of the HWY 148 between Angus Campbell Drive and Route 29 (see Figure 2A);
- Section 2 – the section of the HWY 148 between Route 29 and Greenwood Road (see Figure 2B); and,
- Section 3 – the section of HWY 148 between Greenwood Road and the Quebec border (see Figure 2C).

The locations of the Sections along HWY 148 are shown on Figure 2.

The MTO has retained IBI to carry out the preliminary design and Environmental Impact Assessment under a total project management ("TPM") agreement (G.W.P. 214-00-00, 4091-13-00). Golder Associates was retained by IBI to complete the COS component of this project. This COS is based on our proposal dated July 15, 2014.

1.1 Scope of Work

The COS scope of work included the following:

- Review of the background information for the study area including "Standards Select" Ecolog ERIS report and aerial photographs;
- Correspondence with Technical Standards and Safety Authority ("TSSA"); and,
- A "drive-by" and walkthrough reconnaissance of the study area.

Details of the information reviewed and study area reconnaissance findings are provided in Sections 3 and 4 of this report. Section 5 discusses the findings of this report. Study limitations and appropriate uses of this report are given in Section 6.

The scope of this COS assessment is sufficient only to identify potential environmental issues within the study area which are obvious from a preliminary visual examination of surface features or from reviewed sources of information. No soil, water, liquid, gas, product or chemical sampling and testing on or in the vicinity of the study area was conducted as part of this assessment. This assessment included a cursory overview, via a "drive-by"

and walkthrough reconnaissance of the study area, and does not constitute a complete assessment of these lands. Private properties located within the study area were assessed from publicly accessible lands.

2.0 INFORMATION REVIEW

In order to assess historical and current land uses and to identify properties with the potential to have impacted the study area, a preliminary review of the information from the following sources was conducted:

- Standard Select EcoLog ERIS report;
- Aerial Photographs obtained from LGI Copy Service Canada ("LGI"); and,
- "Drive-by" and walkthrough reconnaissance of the study area.

Table 1 in Section 4 of the report provides a summary of the study area reconnaissance observations and list the properties identified as having the potential to impact the subsurface along the HWY 148 ROW. Figure 2 (Site Plan) shows the three sections along HWY 148. Figures 2A, 2B and 2C show the land use within the study area and location of properties identified to represent an issue of potential environmental concern for Sections 1, 2 and 3, respectively.

2.1 Environmental Database Review

Golder Associates retained EcoLog Environmental Risk Information Services Ltd. ("EcoLog ERIS") to conduct a search of the following eight selected federal, provincial and private sector databases for information on the properties located within the study area (100 metres from both sides of the ROW):

- Inventory of Coal Gasification Plants and Coal Tar Sites;
- Ontario Regulation 347 Waste Generators Summary;
- TSSA Incidents;
- Record of Site Condition;
- Ontario Spills;
- Anderson's Storage Tanks;
- Waste Disposal Sites - MOE CA Inventory; and,
- Waste Disposal Sites - MOE 1991 Historical Approval Inventory.

Notable results of Golder Associates' review of the EcoLog ERIS report are provided in Table 1 in Section 4 of the report. A copy of the EcoLog ERIS report is included in Appendix A.

2.2 Aerial Photographs

Aerial photographs for the study area for the years 1950, 1970 and 1993 were obtained from LGI. The review of the 1950 aerial photograph indicated that the lands adjacent to Sections 1 and 2 of HWY 148 were partially developed with what appear to be residential and farm structures and the lands adjacent to Section 3 of HWY 148

were undeveloped vegetated lands. The review of 1970 aerial photograph indicated that the lands along Sections 1 and 2 of HWY 148 are mixture of residential and commercial buildings and green spaces and that the lands along Section 3 are mainly occupied by vegetated and forested lands with some residential dwellings. In 1993 aerial photograph, the adjacent lands along HWY 148 appear similar to the present and include residential and commercial type buildings. No evidence of landfill sites was noted on any of the aerial photographs.

A review of the aerial photographs did not identify any obvious issues of potential environmental concern for the study area, however, it should be noted that due to the scales of the aerial photographs (1:35,000, 1:40,000 and 1:50,000) available for the study area, no specific details regarding the historical land uses of the properties located within the study area could be observed.

2.3 Technical Standards and Safety Authority Correspondence

The Technical Standards and Safety Authority ("TSSA") was contacted via e-mail to determine if any underground storage tanks (USTs) were registered on selected addresses along HWY 148 and the ROW.

Ms. Sarah Quibell at TSSA responded via email on June 8, 2015 and indicated that the TSSA has the following records:

- 1034 Pembroke Street East, Pembroke has record of 4 expired USTs.
- 1043 Pembroke Street East, Pembroke has record of an expired self-serve gas station.
- 1409 Pembroke Street East, Pembroke has record of 2 expired USTs and an active cylinder exchange facility.

3.0 STUDY AREA DESCRIPTION

Study Area Limits

The COS study area consists of the Highway 148 ROW and adjacent properties within 100 m from both sides of the ROW between Angus Campbell Drive and the Quebec border, in the Pembroke, Ontario, as illustrated on Figures 2, 2A, 2B and 2C.

For the purpose of the COS study, the following 3 sections along HWY 148 were defined:

- Section 1 - section of the HWY 148 between Angus Campbell Drive and Route 29 (see Figure 2A). Lands within Section 1 of the study area generally consist of commercial and residential properties and some green spaces;
- Section 2 - the section of HWY 148 between Greenwood Road and the Quebec border (see Figure 2B). Lands within Section 2 of the study area consist of commercial, residential and light industrial properties and some green spaces; and,
- Section 3 – the section of HWY 148 between Greenwood Road and the Quebec border (see Figure 2C). Lands within Section 3 of the study area generally consist of green spaces and residential houses.

The locations of the Sections along HWY 148 are shown on Figure 2.

For the purpose of describing relative locations in this COS report, it is assumed that Sections 1 and 2 of HWY 148 have east-west direction and Section 3 has north-south direction.

Topography and Drainage

Section 1

Topography in Section 1 of the study area is uneven with elevations varying from approximately 123 metres above sea level ("mASL") within the west portion, 126.74 mASL in the central part to 125.50 mASL in the east portion of the Section 1 (based on the drawings provided by IBI).

Section 2

Topography in Section 2 of the study area is uneven with elevations varying from approximately 125.5 mASL at the east portion dropping, 118.2 mASL in the central portion to approximately 122 mASL at the west portion of Section 2 (based on the drawings provided by IBI).

Section 3

Topography in Section 3 of the study area is uneven with an elevation varying from approximately 122 mASL in the south part, 115 mASL in the central part to 128 mASL at the north (end) part of Section 3 at the Quebec border (based on the drawings provided by IBI). Ottawa River crosses Section 3 of the study area.

In general, the regional groundwater flow direction is expected to be towards Ottawa River located north of Sections 1 and 2 and crossing Section 3 of the study area. The shallow groundwater with the study area would follow the topography of the area. It should be noted that the local groundwater flow may be influenced by underground utilities (i.e., service trenches) and building structures.

According to Ontario Ministry of Northern Development and Mines maps, the surficial geology within the study area consists of older alluvial deposits comprised of clay, silt, sand, gravel, may contain organic remains.

The bedrock within the study area is reported to consist of limestone, dolostone, shale, arkose, and sandstone and tectonite unit.

4.0 STUDY AREA RECONNAISSANCE

A visual field reconnaissance of the study area was conducted on May 27, 2015 to assess the current land usage in the study area and associated potential for subsurface environmental contamination. This assessment included a cursory overview, via a "drive-by" or walkthrough field reconnaissance of the study area, and does not constitute a complete assessment of these lands.

The following land uses within the study area was observed by Sections:

- Section 1 (between Angus Campbell Drive and Route 29) – the land use was in general commercial and residential and included the following:
  - Pembroke Mall and small commercial plaza (Bulk Barn and Wave Optical), museum, church, residential apartment building and Wizzard Den (1035 Pembroke Street East). These properties are generally located at and near the intersection of HWY 148 and Angus Campbell Drive;
  - Insurance company (1041 Pembroke Street East), Oil Changers and Beer Brewery (1043 Pembroke Street East);
  - Residential properties, Travellers Inn, restaurants, LCBO, retail stores, Boston Pizza;
  - Farm house with farm equipment yard (1105 Pembroke Street East);

- Irvcon Ltd. and Harrington Mechanical – roofing, plumbing, heating contractor (1145 Pembroke Street East);
- Pembroke Cemetery (1135 Pembroke Street East), retail plaza (Winners, Tim Horton's, Home Depot), Mattress Factory Outlet, M&R Feeds, Pet Nutrition and Fencing, land care landscaping;
- Motel, Physio Valley, Oak Furniture and Mattress Show Room, Renfrew County Board of Education Plant Department (1202 Pembroke Street East).

- Section 2 (between Route 29 and the HWY 148 at Greenwood Road) – the land use is commercial, residential and light industrial and included the following:
  - Canadian Red Cross (1217 Pembroke Street East), Exit Ottawa Valley Realty, Econolodge motel;
  - Peter's Electronic Repair (1224 Pembroke Street East);
  - Garden Centre, Thom Transit Ltd (1227 Pembroke Street East), JVO Satellite Inc., Flea Market;
  - Residential houses and green spaces;
  - Heavy Equipment Rental and Valley Contracting (1310 Pembroke Street East) - two fuel aboveground storage tanks (ASTs), various heavy equipment machinery and aggregates were noted in the yard of the property. There is on site machinery and equipment fuelling at this property.
  - Winmar Property Restoration (1366 Pembroke Street East) consisting of a small building and a yard - one fuel AST was noted installed on gravel surface at this property;
  - Valley Compressor (1376 Pembroke Street East) – an office building and Maintenance / shipping / receiving building was noted on this property;
  - Vacant property with gravel surface (1409 Pembroke Street East). Seven monitoring wells finished with stick up casing and a number of metal and plastic drums were noted on this property. In addition, 3 monitoring wells were observed on the adjacent residential property located west of the vacant property and one flush mount monitoring well was noted on the HWY 148 ROW. Based on Ecolog ERIS report, this property was previously occupied by an Ultramar gas station. The observed drums are most likely associated with soil cuttings and purged water generated during the drilling and sampling of the boreholes and monitoring wells.
  - ESSO gas station (1400 Pembroke Street East), machinery and equipment storage yard just east of the gas station, and Smith's storage (1444B/A Pembroke Street East). A flush mount monitoring well was observed on the HWY 148 ROW, just south of the ESSO gas station and across the former Ultramar property.
- Section 3 (between HWY 148 at Greenwood Road and the Quebec border) - the land use was observed to be parkland and residential. Ottawa River is located on both sides of HWY148.

During the site visit, no staining or distressed vegetation, which might indicate the presence of subsurface impact, were observed within the study area.

A summary of the findings of the field reconnaissance is presented in Table 1 below. A photographic record of the reconnaissance is provided in Appendix B. Land use and locations of notable observations are shown on Figures 2A, 2B and 2C of this report.

Table 1: Summary of Issues of Potential Environmental Concern and Field Reconnaissance Observations

ID on Figures 2A, 2B and 2C	Property/Activity of Potential Environmental Concern	Location	Comments/observations from the site visit	Potential for Subsurface impacts to HWY 148 and ROW (1)	Information Sources
Section 1 – refer to Figure 2A					
1	Former presence of a gasoline station "Irving Oil" and associated four former USTs	1034 Pembroke Street East, at the southeast intersection of HWY 148 and Angus Campbell Drive	The Ecolog ERIS report listed Irving Oil as hazardous waste generator in 2004 and as a gasoline gas station. A strip mall plaza (Bulk Barn and Wave Optical) is currently located at this location.	High	Ecolog ERIS report, TSSA, site visit
2	60 L of diesel spilled on parking lot at Pembroke Street East and Angus Campbell Drive in 2005.	Parking lot at Pembroke Street East and Angus Campbell Drive, adjacent and south of the HWY 148	The Ecolog ERIS report indicated that environmental impact due to the spill is not anticipated. During the site visit no evidence of stressed vegetation or staining was noted in the area of reported spill. In addition, the area was redeveloped with the current plaza sometime after 2005.	Low	Ecolog ERIS report, site visit
3	Oil Changers, former self-served gas station	1043 Pembroke Street East, adjacent and north of HWY 148	The property was previously occupied by Sunoco Inc. which was a registered hazardous waste generator for light fuels for years 2002, 2003 and 2004. According to TSSA, the address was also occupied by a former gas station. Currently this address is occupied by Oil Changers.	High	Ecolog ERIS report, TSSA, site visit

ID on Figures 2A, 2B and 2C	Property/Activity of Potential Environmental Concern	Location	Comments/observations from the site visit	Potential for Subsurface impacts to HWY 148 and ROW (1)	Information Sources
4	Irvcon Ltd. and Harrington Mechanical (roofing, plumbing, heating contractor)	1145 Pembroke Street East, adjacent and north of HWY 148	The Irvcon Ltd. is registered hazardous waste generator for aromatic solvents, light fuels, aliphatic solvents, petroleum distillates, waste oils and lubricants from 1993 to present. There were no spill records reported in the Ecolog ERIS report for this property.	Low	Ecolog ERIS report, site visit
Section 2- refer to Figure 2B					
5	Unknown quantity of furnace oil spilled to ground in 1996 at a private residence	1221 Pembroke Street East, adjacent and north of HWY 148	The Ecolog ERIS report indicated that the spill occurred after the tank fell over due to an error and that environmental impact due to the spill is possible.	Low	Ecolog ERIS report
6	Thom Transit Ltd. (urban transit system company)	1227 Pembroke Street East, adjacent and north of HWY 148	Thom Transit is a registered hazardous waste generator for waste oils and lubricants. No evidence of AST or underground storage tanks (UST) was noted on this property from publically accessible areas.	Low	Ecolog ERIS report, site visit
7	Heavy Equipment Rental and Valley Contracting (snow removal, sand, topsoil, excavating, landscaping, gravel and heavy equipment rental)	1310 Pembroke Street East, adjacent and south of HWY 148	Two fuel ASTs, various heavy equipment machinery and aggregates were noted on the yard of the property. There is on site equipment fuelling at this property. This address or company was not listed as a hazardous waste generator and there were no spill records reported in the Ecolog ERIS report.	Low	Site visit

ID on Figures 2A, 2B and 2C	Property/Activity of Potential Environmental Concern	Location	Comments/observations from the site visit	Potential for Subsurface impacts to HWY 148 and ROW (1)	Information Sources
8	Valley Compressor (industrial machinery equipment and supplies wholesaler-distributors)	1376 Pembroke Street East, adjacent and south of HWY 148	This address was listed as a hazardous waste generator under 659273 Ontario Inc. for waste oils and lubricants since 2005 until present. During the site visit it was observed that there is an office building and maintenance/shipping/receiving building.	Low	Ecolog ERIS report, site visit
9	Former Ultramar gas station with associated two former USTs	1409 Pembroke Street East, adjacent and north of HWY 148	This property was noted to be vacant land with seven monitoring wells and a number of drums suspected to contain soil cuttings and purged water generated during the subsurface investigation carried out on the property. In addition, 3 monitoring wells were noted on the adjacent residential property. Based on Ecolog ERIS report, the property was previously occupied by Ultramar gas station and convenience store and Ultramar was a registered hazardous waste generator for light fuels between 2006 until 2014.	High	Ecolog ERIS report, TSSA, site visit
10	ESSO gas station	1400 Pembroke Street East, adjacent and south of HWY 148	ESSO retail fuel outlet is located immediately south of HWY 148, across the former Ultramar gas station located at 1409 Pembroke Street East. A flush mount monitoring well was observed on the ROW just south of ESSO gas station,	High	Site visit

ID on Figures 2A, 2B and 2C	Property/Activity of Potential Environmental Concern	Location	Comments/observations from the site visit	Potential for Subsurface impacts to HWY 148 and ROW (1)	Information Sources
11	500 L of diesel reportedly spilled on HWY 148 at Greenwood Road in 2007	On HWY 148 at Greenwood Road	The Ecolog ERIS report indicated that the diesel spilled due to transport accident and that environmental impact due to the spill is possible.	High	Ecolog ERIS
Section 3 – Refer to Figure 2C No issues of potential environmental concern were identified					

Note: (1)-High potential for subsurface impacts – assigned to former or current activities associated with retail fuel outlets, underground storage tanks (USTs), spills with anticipated environmental impacts, large scale facility listed as hazardous waste generators, automotive services, or dry cleaning facilities located within the study area and adjacent to the ROW. Low potential for subsurface impacts - assigned to former or current activities associated with printing, photographic operations, light industrial facilities, small quantities spills with no anticipated impacts to the environment, small hazardous waste generators located adjacent to the ROW or activities with high potential for subsurface impacts, however, located down-gradient and at a distance more than 50 m from the ROW.

5.0 KEY FINDINGS AND CONCLUSIONS

Based on the findings of the COS assessment conducted on the study area, several issues of potential environmental concern having a high potential for subsurface impacts on the HWY 148 ROW were identified for Sections 1 and 2 of HWY 148. These included:

- Former and current presence of retail fuel outlets on adjacent lands north and south of HWY 148 including: 1) former Irving Oil at 1034 Pembroke Street East, 2) former Ultramar gas station at 1409 Pembroke Street East, and 3) current ESSO gas station at 1400 Pembroke Street East.
- Presence of a hazardous waste generator on adjacent land north of HWY 148: Oil Changers (previously Sunoco Inc.) at 1043 Pembroke Street East.
- Reported spill on HWY 148: 500 L of diesel spilled on HWY 148 at Greenwood Road in 2007.

Based on the above, it is recommended that a subsurface investigation be carried out along Sections 1 and 2 of the HWY 148 at the areas located in close proximity to the above identified issues of potential environmental concern due to the potential for subsurface impacts to be encountered to construction of the highway improvements.

Additionally, the quality and source of fill material along HWY 148 is unknown. An assessment of the quality of the fill would be required, where encountered, as part of the proposed construction activities prior to the reuse of any excavated and/or excess fill material. Similarly, there is the potential for soil and groundwater along the HWY 148 ROW to be impacted with sodium and chloride as a result of highway de-icing activities. Excess soil generated during construction should be assessed for salt-related impacts before being reused off-site. Similarly, the quality of water generated during any construction dewatering activities should be assessed prior to being discharged to the environment.

No issues of potential environmental concern were identified within the study area for Section 3 of the HWY 148.

6.0 LIMITATIONS AND USE

This report was prepared for the exclusive use of MTO and IBI. This report is based on data and information collected during the Contamination Overview Study of the study area conducted by Golder Associates Ltd. and is based solely on site conditions encountered at the time of the site visit on May 27, 2015 supplemented by limited historical information and geological data obtained by Golder Associates, as described in this report.

This report has been prepared as part of environmental due diligence activities associated with proposed construction activities in the study area and is not intended to be used as supporting documentation for a Record of Site Condition under Ontario Regulation 153/04, as amended. If a Record of Site Condition is required for the properties within the study area and this report is to be used as part of the supporting documentation, it must be reviewed and updated by Golder Associates Ltd. Additional environmental site assessment activities would be required to comply with Ontario Regulation 153/04, as amended.

In evaluating the site, Golder Associates Ltd. has relied in good faith on information provided by others. We accept no responsibility for any deficiency, misstatements or inaccuracies contained in this report as a result of omission, misinterpretations or fraudulent acts of the persons interviewed. Golder Associates Ltd. accepts no responsibility for any reduction in property value, either real or perceived, as a result of the reporting of factual information herein.

It should be noted that the results of an investigation of this nature should, in no way, be construed as a warranty that the site is free from any and all contamination from past or current practices. This assessment was carried out using existing historical information as available from various agencies and no assurance is made regarding the accuracy or completeness of this information. No sampling of soil, groundwater, air emissions or gas was conducted.

Report Signature Page

GOLDER ASSOCIATES LTD.

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Environmental Engineer

Sherry Eaton, M.Sc., P.Geo., PMP
Associate

PROFESSIONAL GEOSCIENTIST
SHERRY L. EATON
PRACTISING MEMBER
1173
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ONTARIO

MS/SE:ca;kc

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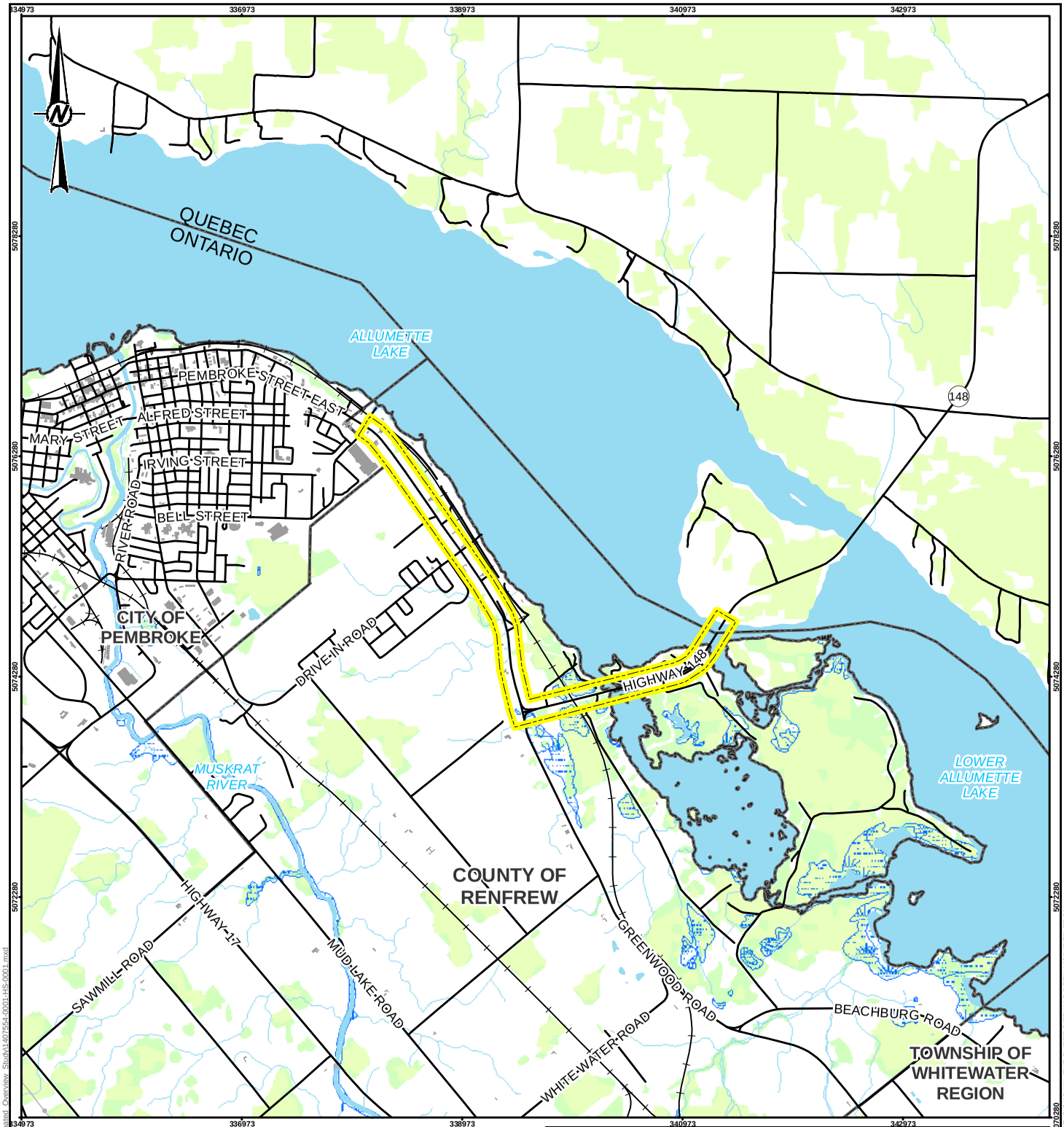
n:\active_2014\1182 - edd\1407554 ibi prelim design hwy 148\reports\final\1407554 rpt feb. 2016 cos hwy 148 pembroke (final).docx



LEGEND

- RAILWAY
- ROAD
- UTILITY LINE
- WATERCOURSE
- APPROXIMATE SITE BOUNDARY
- BUILIDING
- MUNICIPAL BOUNDARY
- WATERBODY
- WETLAND
- WOODED AREA

0 1,000 2,000

1:50,000 METRES

REFERENCE(S)

BASE DATA - MNR LIO, OBTAINED 2015, CANVEC, V10
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
IBI GROUP

PROJECT
CONTAMINATION OVERVIEW STUDY, HIGHWAY 148 FROM PEMBROKE CONNECTING LINK TO THE QUEBEC BORDER, PEMBROKE, ONTARIO

TITLE
KEY PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-03
DESIGNED	JT
PREPARED	JB
REVIEWED	MS
APPROVED	SE

PROJECT NO. 1407554 | CONTROL | REV. | FIGURE 1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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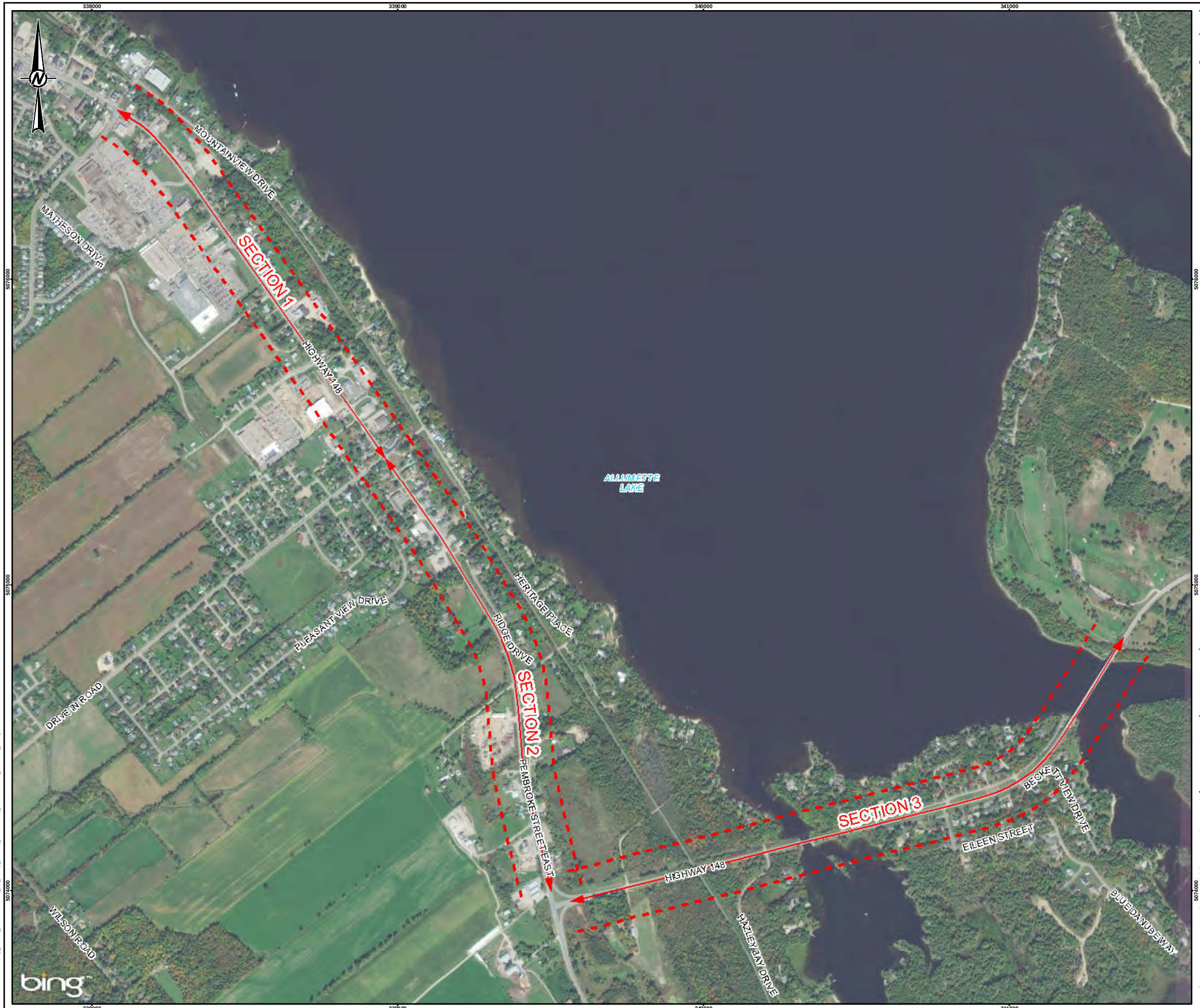

LEGEND

- HIGHWAY 148
- STUDY AREA (100m BUFFER FROM BOTH SIDES OF HWY 148 RIGHT OF WAY (ROW))

0 500 1,000

1:12,500 Metres

NOTE(S)

1. SECTIONS 1, 2, AND 3 DEFINED FOR THE PURPOSE OF THE CONTAMINATION OVERVIEW STUDY (COS).
2. ALL LOCATIONS ARE APPROXIMATE.
3. BASE DRAWINGS 37432_HWY148-PLAN&PROFILE-A_2015-05-15.PDF AND 37432_HWY148-PLAN&PROFILE-B_2015-05-15.PDF PROVIDED BY IBI GROUP.

REFERENCE(S)

BASE DATA - ATLAS OF CANADA, NATURAL RESOURCES CANADA, 2011. MNR LIO, OBTAINED 2015 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015
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PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
IBI GROUP

PROJECT
CONTAMINATION OVERVIEW STUDY, HIGHWAY 148 FROM PEMBROKE CONNECTING LINK TO THE QUEBEC BORDER, PEMBROKE, ONTARIO

TITLE
STUDY AREA PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-05
DESIGNED	JB
PREPARED	JB
REVIEWED	MS
APPROVED	SE

PROJECT NO. 1407554 | CONTROL | REV. | FIGURE **2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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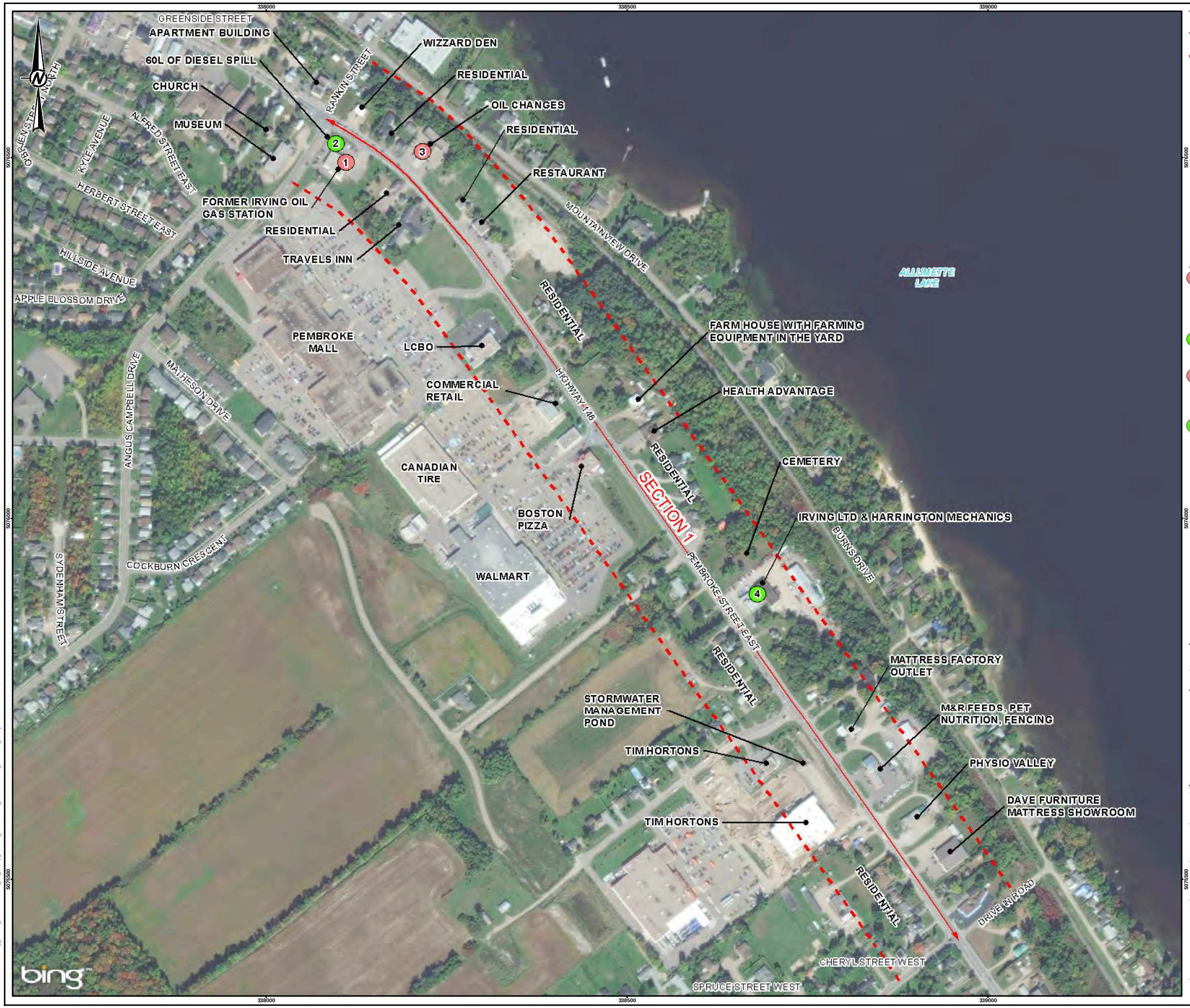

LEGEND

- HIGHWAY 148
- STUDY AREA (100m BUFFER FROM BOTH SIDES OF HWY 148 RIGHT OF WAY (ROW))
- 1 ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN WITH HIGH POTENTIAL FOR SUBSURFACE IMPACTS ON HWY 148 AND ROW
- 2 ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN WITH LOW POTENTIAL FOR SUBSURFACE IMPACTS ON HWY 148 AND ROW

ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN (SECTION 1):

1. FORMER PRESENCE OF A GASOLINE STATION "IRVING OIL" AT 1034 PEMBROKE STREET EAST, AT THE SOUTHEAST INTERSECTION OF HWY 148 AND ANGUS CAMPBELL DRIVE. CURRENTLY OCCUPIED BY BULK BARN AND WAVE OPTICAL.

2. 60 L OF DIESEL SPILLED ON PARKING LOT AT PEMBROKE STREET EAST AND ANGUS CAMPBELL DRIVE IN 2005.

3. OIL CHANGERS (1043 PEMBROKE STREET EAST), PREVIOUSLY OCCUPIED BY SUNOCO INC. WHICH WAS A REGISTERED HAZARDOUS WASTE GENERATOR FOR LIGHT FUELS

4. IRVCON LTD. AND HARRINGTON MECHANICAL WHICH IS REGISTERED HAZARDOUS WASTE GENERATOR (1145 PEMBROKE STREET EAST)

0 200 400

1:5,250 Metres

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE.
2. BASE DRAWINGS 37432_HWY148-PLAN&PROFILE-A_2015-05-15.PDF AND 37432_HWY148-PLAN&PROFILE-B_2015-05-15.PDF PROVIDED BY IBI GROUP.

REFERENCE(S)

BASE DATA - ATLAS OF CANADA, NATURAL RESOURCES CANADA, 2011. MNR LIO, OBTAINED 2015 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015
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PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
IBI GROUP

PROJECT
CONTAMINATION OVERVIEW STUDY, HIGHWAY 148 FROM PEMBROKE CONNECTING LINK TO THE QUEBEC BORDER, PEMBROKE, ONTARIO

TITLE
STUDY AREA PLAN SECTION 1

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-04
DESIGNED	JB
PREPARED	JB
REVIEWED	MS
APPROVED	SE

PROJECT NO. 1407554 | CONTROL | REV. | FIGURE **2A**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

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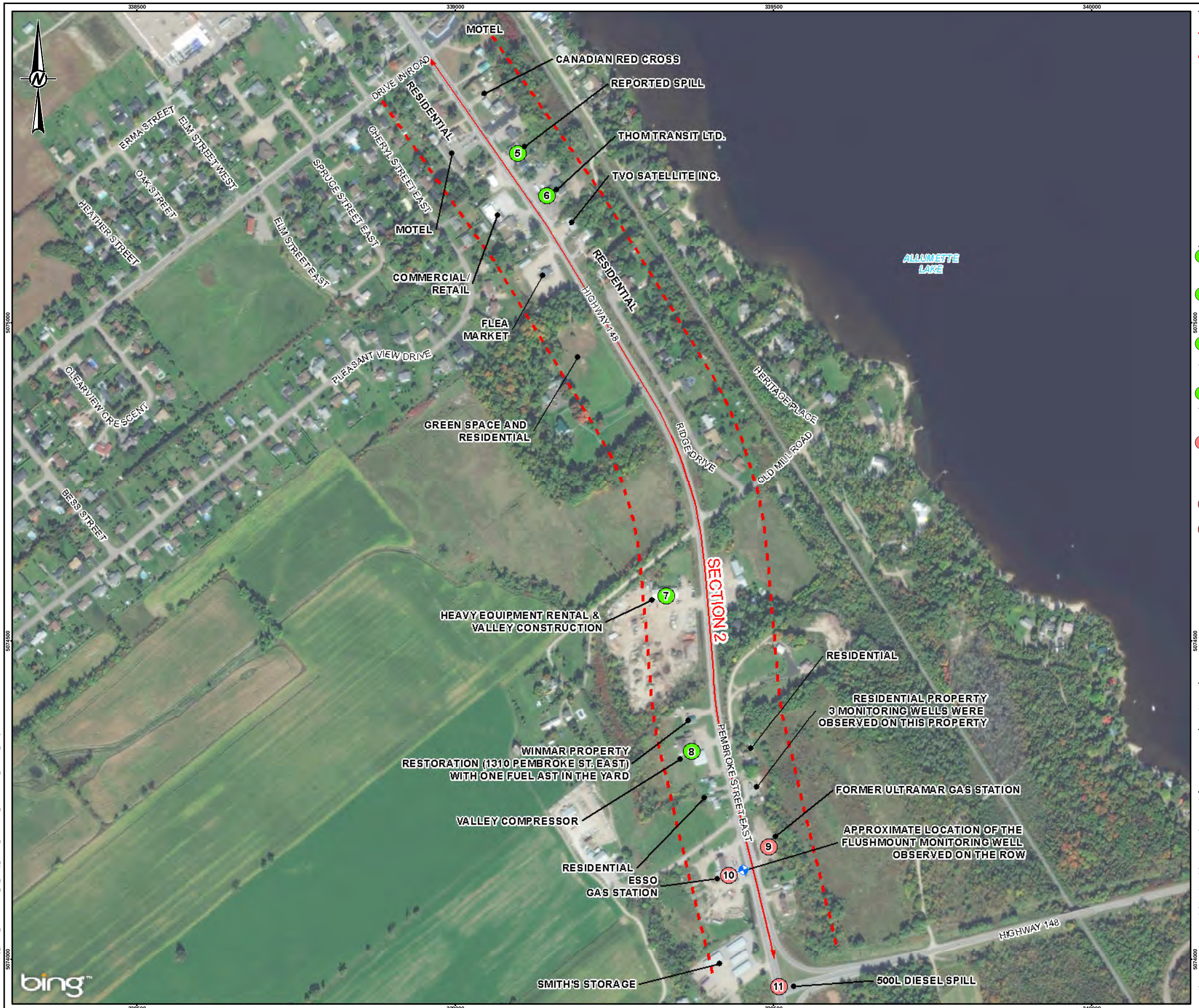

LEGEND

- HIGHWAY 148
- STUDY AREA (100m BUFFER FROM BOTH SIDES OF HWY 148 RIGHT OF WAY (ROW))
- 9 ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN WITH HIGH POTENTIAL FOR SUBSURFACE IMPACTS ON HWY 148 AND ROW
- 8 ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN WITH LOW POTENTIAL FOR SUBSURFACE IMPACTS ON HWY 148 AND ROW

ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN (SECTION 2):

5. UNKNOWN QUANTITY OF FURNACE OIL SPILLED TO GROUND IN 1996 AT A PRIVATE RESIDENCE (1221 PEMBROKE STREET EAST).

6. THOM TRANSIT LTD., URBAN TRANSIT SYSTEM COMPANY REGISTERED AS HAZARDOUS WASTE GENERATOR FOR WASTE OILS AND LUBRICANTS (1227 PEMBROKE STREET EAST).

7. HEAVY EQUIPMENT RENTAL AND VALLEY CONTRACTING (1310 PEMBROKE STREET EAST), TWO FUEL ABOVEGROUND STORAGE TANKS (ASTS) WERE NOTED ON THE PROPERTY.

8. VALLEY COMPRESSOR (INDUSTRIAL MACHINERY EQUIPMENT AND SUPPLIES WHOLESALER-DISTRIBUTORS) IS REGISTERED AS A HAZARDOUS WASTE GENERATOR (1376 PEMBROKE STREET EAST).

9. FORMER ULTRAMAR GAS STATION (1409 PEMBROKE STREET EAST), CURRENTLY VACANT PROPERTY. A NUMBER OF MONITORING WELLS AND DRUMS SUSPECTED TO CONTAIN SOIL CUTTINGS AND PURGED WATER WERE NOTED ON THE PROPERTY.

10. ESSO GAS STATION.

11. 500 L OF DIESEL REPORTEDLY SPILLED ON HWY 148 AT GREENWOOD ROAD IN 2007 DUE TO TRANSPORT ACCIDENT.

0 200 400
1:6,000 Metres

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE.
2. BASE DRAWINGS 37432_HWY148-PLAN&PROFILE-A_2015-05-15.PDF AND 37432_HWY148-PLAN&PROFILE-B_2015-05-15.PDF PROVIDED BY IBI GROUP.

REFERENCE(S)
BASE DATA - ATLAS OF CANADA, NATURAL RESOURCES CANADA, 2011. MNR LIO, OBTAINED 2015 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015
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PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
IBI GROUP

PROJECT
CONTAMINATION OVERVIEW STUDY, HIGHWAY 148 FROM PEMBROKE CONNECTING LINK TO THE QUEBEC BORDER, PEMBROKE, ONTARIO

TITLE
STUDY AREA PLAN
SECTION 2

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-05
DESIGNED	JB
PREPARED	JB
REVIEWED	MS
APPROVED	SE

PROJECT NO. 1407554 | CONTROL | REV. | FIGURE **2B**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: S:\Clients\MTO\Hwy_148\99_PRO\31407554_IBI_Group_ESA\40_PROD\0001_Contaminated_Overview_Study\1407554-0001-HS-0004.mxd

LEGEND

- HIGHWAY 148
- STUDY AREA (100m BUFFER FROM BOTH SIDES OF HWY 148 RIGHT OF WAY (ROW))
- 11 ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN WITH HIGH POTENTIAL FOR SUBSURFACE IMPACTS ON HWY 148 AND ROW

ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN (SECTION 3):

NO ISSUES OF POTENTIAL ENVIRONMENTAL CONCERN WERE IDENTIFIED WITHIN SECTION 3 OF THE STUDY AREA.

ISSUE #11 BELOW IS PART OF SECTION 2 OF THE STUDY AREA

11 500 L OF DIESEL REPORTEDLY SPILLED ON HWY 148 AT GREENWOOD ROAD IN 2007 DUE TO TRANSPORT ACCIDENT.

0 200 400

1:7,000 Metres

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE.
2. BASE DRAWINGS 37432_HWY148-PLAN&PROFILE-A_2015-05-15.PDF AND 37432_HWY148-PLAN&PROFILE-B_2015-05-15.PDF PROVIDED BY IBI GROUP.

REFERENCE(S)

BASE DATA - ATLAS OF CANADA, NATURAL RESOURCES CANADA, 2011. MNR LIO, OBTAINED 2015 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015
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PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18N

CLIENT
IBI GROUP

PROJECT
CONTAMINATION OVERVIEW STUDY, HIGHWAY 148 FROM PEMBROKE CONNECTING LINK TO THE QUEBEC BORDER, PEMBROKE, ONTARIO

TITLE
STUDY AREA PLAN
SECTION 3

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-05
DESIGNED	JB
PREPARED	JB
REVIEWED	MS
APPROVED	SE

PROJECT NO. 1407554 | CONTROL | REV. | FIGURE **2C**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

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APPENDIX A

Ecolog ERIS Report

ENVIRONMENTAL RISK INFORMATION SERVICE

DATABASE REPORT

Project Property:	*1407554* *Moffat Street* *Pembroke ON*
P.O. Number	
Report Type:	*Quote - Custom-Build Your Own Report*
Order #:	*20150506101*
Requested by:	*Golder Associates Ltd.*
Date:	*May 13, 2015*

Ecolog ERIS Ltd.
Environmental Risk Information Service Ltd. (ERIS)
A division of Glacier Media Inc.
P: 1.866.517.5204
E: info@erisinfo.com

www.erisinfo.com

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Aerial....11
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Executive Summary

Property Information:

Project Property:	*1407554* *Moffat Street Pembroke ON*
P.O. Number:	

Order Information:

Order No.:	*20150506101*
Date Requested:	*13/05/2015*
Requested by:	*Golder Associates Ltd.*
Report Type:	*Quote - Custom-Build Your Own Report*

Additional Products:

Executive Summary: Report Summary

Database	Name	Searched	Project Property	Boundary to 0.10km	Total
AAGR	Abandoned Aggregate Inventory	N	-	-	-
AGR	Aggregate Inventory	N	-	-	-
AMIS	Abandoned Mine Information System	N	-	-	-
ANDR	Anderson's Waste Disposal Sites	N	-	-	-
AUWR	Automobile Wrecking & Supplies	N	-	-	-
BORE	Borehole	N	-	-	-
CA	Certificates of Approval	N	-	-	-
CFOT	Commercial Fuel Oil Tanks	N	-	-	-
CHEM	Chemical Register	N	-	-	-
COAL	Inventory of Coal Gasification Plants and Coal Tar Sites	Y	0	0	0
CONV	Compliance and Convictions	N	-	-	-
CPU	Certificates of Property Use	N	-	-	-
DRL	Drill Hole Database	N	-	-	-
EASR	Environmental Activity and Sector Registry	N	-	-	-
EBR	Environmental Registry	N	-	-	-
ECA	Environmental Compliance Approval	N	-	-	-
EEM	Environmental Effects Monitoring	N	-	-	-
EHS	ERIS Historical Searches	N	-	-	-
EIIS	Environmental Issues Inventory System	N	-	-	-
EXP	List of TSSA Expired Facilities	N	-	-	-
FCON	Federal Convictions	N	-	-	-
FCS	Contaminated Sites on Federal Land	N	-	-	-
FOFT	Fisheries & Oceans Fuel Tanks	N	-	-	-
FST	Fuel Storage Tank	N	-	-	-
FSTH	Fuel Storage Tank - Historic	N	-	-	-
GEN	Ontario Regulation 347 Waste Generators Summary	Y	0	26	26
HINC	TSSA Historic Incidents	N	-	-	-
IAFT	Indian & Northern Affairs Fuel Tanks	N	-	-	-
INC	TSSA Incidents	Y	0	1	1
LIMO	Landfill Inventory Management Ontario	N	-	-	-
MINE	Canadian Mine Locations	N	-	-	-
MNR	Mineral Occurrences	N	-	-	-
NATE	National Analysis of Trends in Emergencies System (NATES)	N	-	-	-
NCPL	Non-Compliance Reports	N	-	-	-
NDFT	National Defence & Canadian Forces Fuel Tanks	N	-	-	-
NDSP	National Defence & Canadian Forces Spills	N	-	-	-
NDWD	National Defence & Canadian Forces Waste Disposal Sites	N	-	-	-

Database	Name	Searched	Project Property	Boundary to 0.10km	Total
NEES	National Environmental Emergencies System (NEES)	N	-	-	-
NPCB	National PCB Inventory	N	-	-	-
NPRI	National Pollutant Release Inventory	N	-	-	-
OGW	Oil and Gas Wells	N	-	-	-
OOGW	Ontario Oil and Gas Wells	N	-	-	-
OPCB	Inventory of PCB Storage Sites	N	-	-	-
ORD	Orders	N	-	-	-
PAP	Canadian Pulp and Paper	N	-	-	-
PCFT	Parks Canada Fuel Storage Tanks	N	-	-	-
PES	Pesticide Register	N	-	-	-
PINC	TSSA Pipeline Incidents	N	-	-	-
PRT	Private and Retail Fuel Storage Tanks	N	-	-	-
PTTW	Permit to Take Water	N	-	-	-
REC	Ontario Regulation 347 Waste Receivers Summary	N	-	-	-
RSC	Record of Site Condition	Y	0	0	0
RST	Retail Fuel Storage Tanks	N	-	-	-
SCT	Scott's Manufacturing Directory	N	-	-	-
SPL	Ontario Spills	Y	0	4	4
SRDS	Wastewater Discharger Registration Database	N	-	-	-
TANK	Anderson's Storage Tanks	Y	0	0	0
TCFT	Transport Canada Fuel Storage Tanks	N	-	-	-
VAR	TSSA Variances for Abandonment of Underground Storage Tanks	N	-	-	-
WDS	Waste Disposal Sites - MOE CA Inventory	Y	0	0	0
WDSH	Waste Disposal Sites - MOE 1991 Historical Approval Inventory	Y	0	0	0
WWIS	Water Well Information System	N	-	-	-
	Total:		0	31	31

Executive Summary: Site Report Summary - Project Property

Map Key	DB	Company/Site Name	Address	Dir/Dist m	Elev diff m	Page Number

No records found in the selected databases for the project property.

Executive Summary: Site Report Summary - Surrounding *Properties*

Map Key	DB	Company/Site Name	Address	Dir/Dist m	Elev diff m	Page Number
1	SPL	COULES FUELS	1240 PEMBROKE STREET TANK TRUCK (CARGO) PEMBROKE CITY ON	NW/60.2	124.65	12
2	GEN	THOM TRANSIT LTD.	1227 PEMBROKE STREET EAST PEMBROKE ON K8A 7R8	NNW/67.2	121.00	12
3	SPL	PRIVATE RESIDENCE	1221 PEMBROKE ST. EAST FURNACE OIL TANK STAFFORD AND PEMBROKE TOWNSHIPS ON	NNW/39.3	121.98	12
4	INC		1218 Pembroke Street East, Pembroke ON	NW/49.8	124.00	13
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON	S/90.3	127.03	13
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	S/90.3	127.03	14
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	S/90.3	127.03	14
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	S/90.3	127.03	14
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	S/90.3	127.03	14
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	S/90.3	127.03	14
5	GEN	659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	S/90.3	127.03	15
6	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	SSE/40.1	129.00	15
6	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON	SSE/40.1	129.00	15
6	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	SSE/40.1	129.00	15
6	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	SSE/40.1	129.00	16
6	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 7R8	SSE/40.1	129.00	16

Map Key	DB	Company/Site Name	Address	Dir/Dist m	Elev diff m	Page Number
6	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	SSE/40.1	129.00	16
7	GEN	Ultramar Ltd.	1409 Pembroke Street East Pembroke ON	SSE/50.0	129.00	16
8	SPL	Hwy. 148 & Greenwood Rd. just south of Pembroke<UNOFFICIAL>	Hwy. 148 & Greenwood Rd. <UNOFFICIAL> Pembroke ON	SSE/1.1	128.00	16
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON	NNW/98.0	121.00	17
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	NNW/98.0	121.00	17
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	NNW/98.0	121.00	18
9	GEN	IRVCON LIMITED	1145 PEMBROKE STREET EAST PEMBROKE ON K8A 7R4	NNW/98.0	121.00	18
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	NNW/98.0	121.00	18
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	NNW/98.0	121.00	19
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	NNW/98.0	121.00	19
9	GEN	IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	NNW/98.0	121.00	19
10	GEN	THE FORZANI GROUP	1100 Pembroke Street East, UNIT 503 Pembroke ON K8A 6Y7	NW/9.0	125.96	20
11	GEN	SUNOCO INC.	1043 PEMBROKE STREET EAST PEMBROKE ON K8A 6Z3	NNW/45.2	120.77	20
12	GEN	IRVING OIL	1034 PEMBROKE STREET PEMBROKE ON K8A 6X7	NW/39.7	122.00	20
13	SPL	McBurney Transport Limited<UNOFFICIAL>	Parking lot at Pembroke Street East and Angus Campbell Drive<UNOFFICIAL> Pembroke ON	NW/11.6	121.00	20

Executive Summary: Summary By Data Source

GEN - Ontario Regulation 347 Waste Generators Summary

A search of the GEN database, dated 1986-Apr 2014 has found that there are 26 GEN site(s) within approximately 0.10 kilometers of the project property.

Site	Address	Distance m	Map Key
THOM TRANSIT LTD.	1227 PEMBROKE STREET EAST PEMBROKE ON K8A 7R8	67.2	2
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON	90.3	5
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	90.3	5
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	90.3	5
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	90.3	5
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	90.3	5
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	90.3	5
659273 Ont Inc	1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	90.3	5
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	40.1	6
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON	40.1	6
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	40.1	6
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	40.1	6
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 7R8	40.1	6
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON K8A 6W2	40.1	6
Ultramar Ltd.	1409 Pembroke Street East Pembroke ON	50.0	7
IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	98.0	9
IRVCON LIMITED	1145 Pembroke St East Pembroke ON	98.0	9
IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	98.0	9
IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	98.0	9

Site	Address	Distance m	Map Key
IRVCON LIMITED	1145 PEMBROKE STREET EAST PEMBROKE ON K8A 7R4	98.0	9
IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	98.0	9
IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	98.0	9
IRVCON LIMITED	1145 Pembroke St East Pembroke ON K8A 7R4	98.0	9
THE FORZANI GROUP	1100 Pembroke Street East, UNIT 503 Pembroke ON K8A 6Y7	9.0	10
SUNOCO INC.	1043 PEMBROKE STREET EAST PEMBROKE ON K8A 6Z3	45.2	11
IRVING OIL	1034 PEMBROKE STREET PEMBROKE ON K8A 6X7	39.7	12

INC - TSSA Incidents

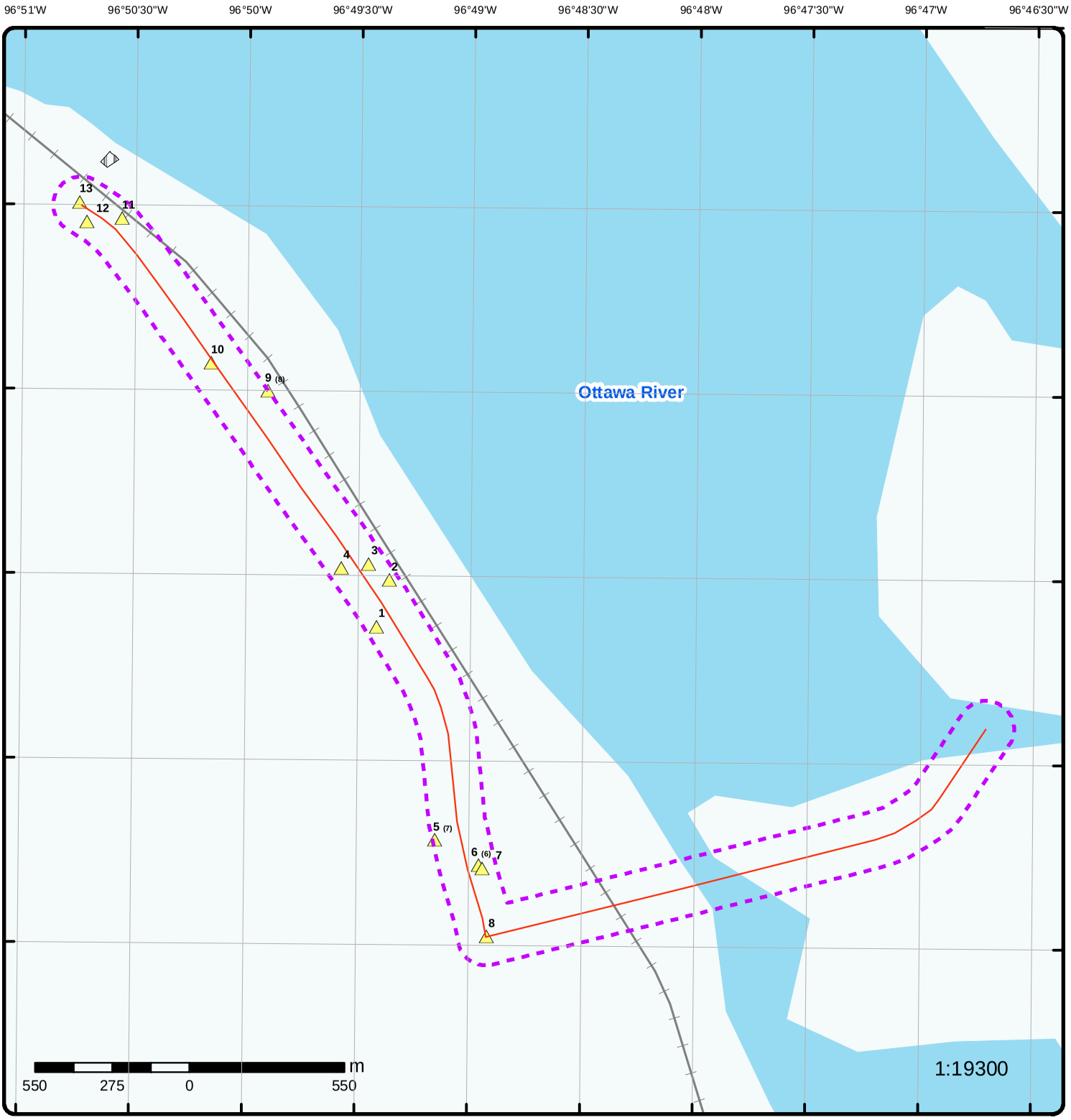
A search of the INC database, dated June 2009-2014 has found that there are 1 INC site(s) within approximately 0.10 kilometers of the project property.

Site	Address	Distance m	Map Key
	1218 Pembroke Street East, Pembroke ON	49.8	4

SPL - Ontario Spills

A search of the SPL database, dated 1988-Feb 2014 has found that there are 4 SPL site(s) within approximately 0.10 kilometers of the project property.

Site	Address	Distance m	Map Key
COULES FUELS	1240 PEMBROKE STREET TANK TRUCK (CARGO) PEMBROKE CITY ON	60.2	1
PRIVATE RESIDENCE	1221 PEMBROKE ST. EAST FURNACE OIL TANK STAFFORD AND PEMBROKE TOWNSHIPS ON	39.3	3
Hwy. 148 & Greenwood Rd. just south of Pembroke<UNOFFICIAL>	Hwy. 148 & Greenwood Rd. <UNOFFICIAL> Pembroke ON	1.1	8
McBurney Transport Limited<UNOFFICIAL>	Parking lot at Pembroke Street East and Angus Campbell Drive<UNOFFICIAL> Pembroke ON	11.6	13



Map

Order No: 20150506101

Address: Moffat Street, Pembroke, ON

- Project Property
- Buffer Outline
- Eris Sites with Higher Elevation
- Eris Sites with Same Elevation
- Eris Sites with Lower Elevation
- Eris Sites with Unknown Elevation
- Industrial and Resource - Regions
- Main Line
- Sidetrack
- Transit Line
- Abandoned Line
- National Park
- Provincial or Territorial Park
- Other Park
- Golf Course or Driving Range
- Park or Sports Field
- Other Recreation Area

Source: © 2014 DMTI Spatial Inc.

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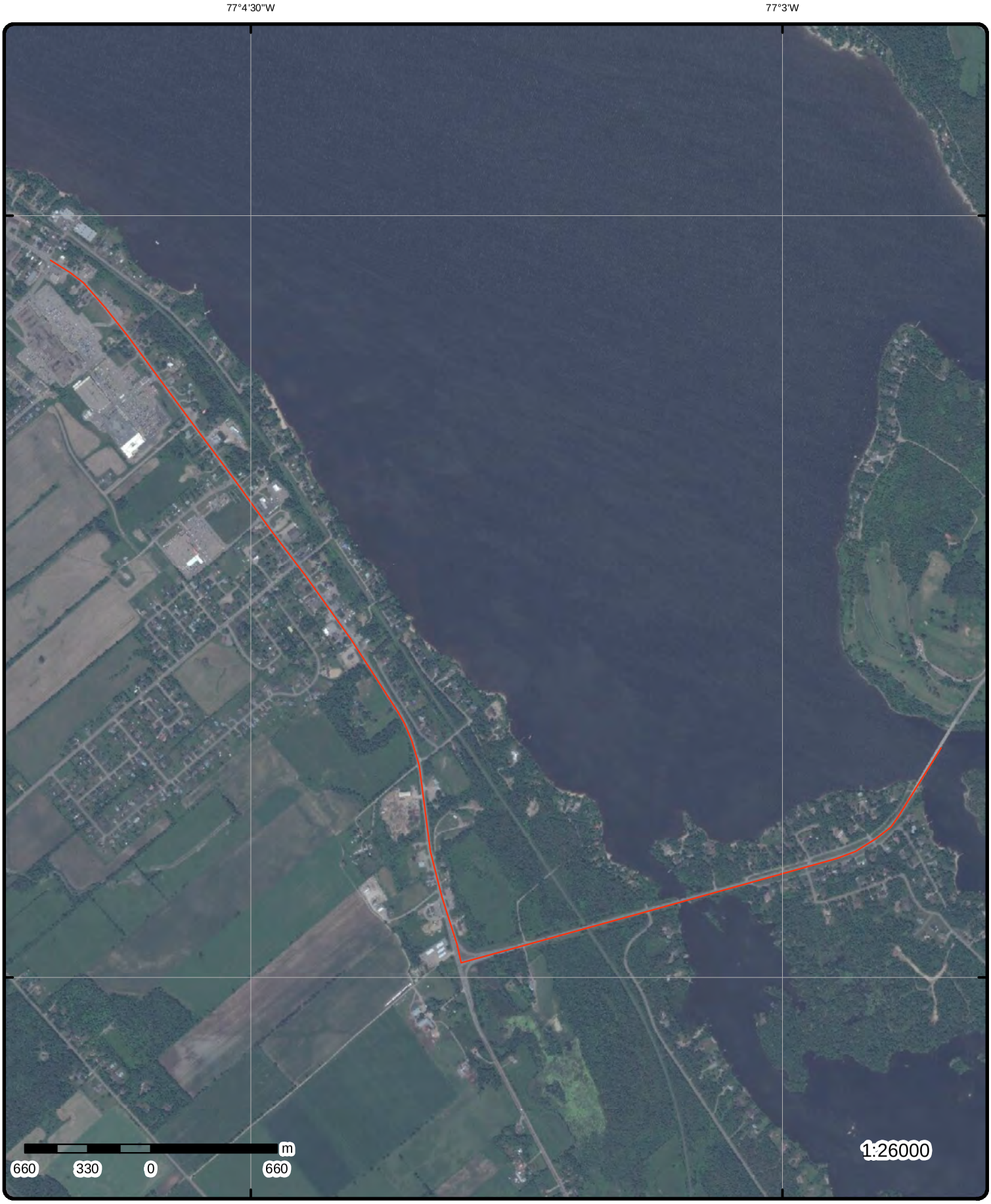

Aerial

Order No: 20150506101

Address: Moffat Street, Pembroke, ON

Source: ESRI World Imagery, Updated October 2014

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Detail Report

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
1	1 of 1	NW/60.2	124.6	COULES FUELS 1240 PEMBROKE STREET TANK TRUCK (CARGO) PEMBROKE CITY ON	SPL

Ref No.: 83322
Incident Dt: //
MOE Reported Dt: 3/29/1993
Contaminant Name:
Contaminant Quantity:
Incident Summary: COULES FUELS: 10-25 L FURNACE OIL TO GROUND DURING DELIVERY.
Incident Cause: CONTAINER OVERFLOW
Incident Reason: EQUIPMENT FAILURE
Nature of Impact: Soil contamination
Receiving Medium: LAND
Environmental Impact: CONFIRMED

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
2	1 of 1	NNW/67.2	121.0	THOM TRANSIT LTD. 1227 PEMBROKE STREET EAST PEMBROKE ON K8A 7R8	GEN

Generator #: ON2437700
Approval Yrs: 98,99,00,01
SIC Code: 4571
SIC Description: URBAN TRANSIT SYS.

--- Details ---
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
3	1 of 1	NNW/39.3	122.0	PRIVATE RESIDENCE 1221 PEMBROKE ST. EAST FURNACE OIL TANK STAFFORD AND PEMBROKE TOWNSHIPS ON	SPL

Ref No.: 125389
Incident Dt: 4/20/1996
MOE Reported Dt: 4/23/1996
Contaminant Name:
Contaminant Quantity:
Incident Summary: PRIVATE RESIDENCE:UNK QUA FURNACE OIL TO GRD AFTER TANK FELL OVER.
Incident Cause: OTHER CONTAINER LEAK
Incident Reason: ERROR
Nature of Impact: Soil contamination
Receiving Medium: LAND
Environmental Impact: POSSIBLE

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
4	1 of 1	NW/49.8	124.0	1218 Pembroke Street East, Pembroke ON	INC

Incident ID:	3028774
Incident Number:	871246
SR Type:	FS-Perform L1 Incident Insp
Status Code:	Causal Analysis Complete
Summary:	1218 Pembroke Street East, Pembroke - Fire
Drainage System:	
Sub Surface Contam.:	
Aff. Prop. Use Water:	
Contam. Migrated:	
Contact Natural Env.:	
Near Body of Water:	
Approx. Quant. Rel.:	
Equipment Model:	1F
Serial No:	53115
Residential App. Type:	
Commercial App. Type:	Boiler
Industrial App. Type:	
Institutional App. Type:	
Venting Type:	Forced Draft (e.g., Combustion Air Blower)
Vent Connector Mater.:	C Vent (e.g., Single Wall Vent)
Vent Chimney Mater.:	Liner - Aluminum
Notes:	Owner failing to properly light pilot light.
Pipeline Type:	
Pipeline Involved:	
Pipe Material:	
Depth Ground Cover:	
Regulator Location:	
Regulator Type:	
Operation Pressure:	
Pipeline Notes:	Owner failed to propely light boiler after the appliance did not work. Failed to call contractor. Location is a Hotel.
Liquid Prop Make:	
Liquid Prop Model:	
Liquid Prop Serial No:	
Equipment Type:	
Cylinder Capacity:	
Cylinder Capac. Units:	
Cylinder Material Type:	
Tank Capacity:	
Tank Material Type:	
Tank Storage Type:	
Tank Location Type:	
Pump Flow Rate Capac.:	
Liquid Prop Notes:	

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
5	1 of 7	S/90.3	127.0	659273 Ont Inc 1376 Pembroke St. East RR # 1 Pembroke ON	GEN

Generator #:	ON9651018
Approval Yrs:	2013
SIC Code:	417230
SIC Description:	INDUSTRIAL MACHINERY, EQUIPMENT AND SUPPLIES WHOLESALER-DISTRIBUTORS
--- Details ---	
Waste Code:	252
Waste Description:	WASTE OILS & LUBRICANTS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
5	2 of 7	S/90.3	127.0	659273 Ont Inc 1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	GEN

Generator #: ON9651018
Approval Yrs: 2012
SIC Code: 417230
SIC Description: Industrial Machinery Equipment and Supplies Wholesaler-Distributors

--- Details ---
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
5	3 of 7	S/90.3	127.0	659273 Ont Inc 1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	GEN

Generator #: ON9651018
Approval Yrs: 2009
SIC Code: 417230
SIC Description: Industrial Machinery Equipment and Supplies Wholesaler-Distributors

--- Details ---
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
5	4 of 7	S/90.3	127.0	659273 Ont Inc 1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	GEN

Generator #: ON9651018
Approval Yrs: 2010
SIC Code: 417230
SIC Description: Industrial Machinery Equipment and Supplies Wholesaler-Distributors

--- Details ---
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
5	5 of 7	S/90.3	127.0	659273 Ont Inc 1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	GEN

Generator #: ON9651018
Approval Yrs: 05,06,07,08
SIC Code: 417230
SIC Description: Industrial Machinery Equipment and Supplies Wholesaler-Distributors

--- Details ---
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
5	6 of 7	S/90.3	127.0	659273 Ont Inc 1376 Pembroke St. East RR # 1 Pembroke ON K8A 6W2	GEN

Generator #: ON9651018

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB

Approval Yrs: 2011
SIC Code: 417230
SIC Description: Industrial Machinery Equipment and Supplies Wholesaler-Distributors

--- Details ---
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

---

5 | **7 of 7** | **S/90.3** | **127.0** | **659273 Ont Inc**
1376 Pembroke St. East RR # 1
Pembroke ON K8A 6W2 | **GEN**

Generator #: ON9651018
Approval Yrs: As of April 2014
SIC Code:
SIC Description:

--- Details ---
Waste Code: 252
Waste Description: Waste crankcase oils and lubricants

---

6 | **1 of 6** | **SSE/40.1** | **129.0** | **Ultramar Ltd.**
1409 Pembroke Street East
Pembroke ON K8A 6W2 | **GEN**

Generator #: ON8418436
Approval Yrs: 2011
SIC Code: 447110
SIC Description: Gasoline Stations with Convenience Stores

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS

---

6 | **2 of 6** | **SSE/40.1** | **129.0** | **Ultramar Ltd.**
1409 Pembroke Street East
Pembroke ON | **GEN**

Generator #: ON8418436
Approval Yrs: 06,07,08
SIC Code: 447110
SIC Description: Gasoline Stations with Convenience Stores

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS

---

6 | **3 of 6** | **SSE/40.1** | **129.0** | **Ultramar Ltd.**
1409 Pembroke Street East
Pembroke ON K8A 6W2 | **GEN**

Generator #: ON8418436
Approval Yrs: 2009
SIC Code: 447110
SIC Description: Gasoline Stations with Convenience Stores

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
6	4 of 6	SSE/40.1	129.0	Ultramar Ltd. 1409 Pembroke Street East Pembroke ON K8A 6W2	GEN

Generator #: ON8418436
Approval Yrs: 2012
SIC Code: 447110
SIC Description: Gasoline Stations with Convenience Stores

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
6	5 of 6	SSE/40.1	129.0	Ultramar Ltd. 1409 Pembroke Street East Pembroke ON K8A 7R8	GEN

Generator #: ON8418436
Approval Yrs: As of April 2014
SIC Code:
SIC Description:

--- Details ---
Waste Code: 221
Waste Description: Light fuels

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
6	6 of 6	SSE/40.1	129.0	Ultramar Ltd. 1409 Pembroke Street East Pembroke ON K8A 6W2	GEN

Generator #: ON8418436
Approval Yrs: 2010
SIC Code: 447110
SIC Description: Gasoline Stations with Convenience Stores

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
7	1 of 1	SSE/50.0	129.0	Ultramar Ltd. 1409 Pembroke Street East Pembroke ON	GEN

Generator #: ON8418436
Approval Yrs: 2013
SIC Code: 447110
SIC Description:

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
8	1 of 1	SSE/1.1	128.0	Hwy. 148 & Greenwood Rd. just south of Pembroke<UNOFFICIAL> Hwy. 148 & Greenwood Rd. <UNOFFICIAL> Pembroke ON	SPL

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB

Ref No.: 7150-75E3D3
Incident Dt:
MOE Reported Dt: 7/23/2007
Contaminant Name: DIESEL FUEL
Contaminant Quantity: 500 L
Incident Summary: Transport (NOS) - 500 L of diesel to hwy.
Incident Cause: Other Transport Accident
Incident Reason: Unknown - Reason not determined
Nature of Impact: Soil Contamination
Receiving Medium: Land
Environmental Impact: Possible

9	1 of 8	NNW/98.0	121.0	**IRVCON LIMITED** **1145 Pembroke St East** **Pembroke ON**	GEN

Generator #: ON1754200
Approval Yrs: 2013
SIC Code: 238160, 238220
SIC Description: ROOFING CONTRACTORS, PLUMBING, HEATING AND AIR-CONDITIONING CONTRACTORS

--- Details ---
Waste Code: 211
Waste Description: AROMATIC SOLVENTS
+
Waste Code: 221
Waste Description: LIGHT FUELS
+
Waste Code: 212
Waste Description: ALIPHATIC SOLVENTS
+
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS
+
Waste Code: 213
Waste Description: PETROLEUM DISTILLATES

9	2 of 8	NNW/98.0	121.0	**IRVCON LIMITED** **1145 Pembroke St East** **Pembroke ON K8A 7R4**	GEN

Generator #: ON1754200
Approval Yrs: As of April 2014
SIC Code:
SIC Description:

--- Details ---
Waste Code: 211
Waste Description: Aromatic solvents and residues
+
Waste Code: 212
Waste Description: Aliphatic solvents and residues
+
Waste Code: 213
Waste Description: Petroleum distillates
+
Waste Code: 252
Waste Description: Waste crankcase oils and lubricants
+

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB

Waste Code: 221
Waste Description: Light fuels

---

9 **3 of 8** **NNW/98.0** **121.0** **IRVCON LIMITED** **GEN**
1145 Pembroke St East
Pembroke ON K8A 7R4

Generator #: ON1754200
Approval Yrs: 2012
SIC Code: 238160, 238220
SIC Description: Roofing Contractors, Plumbing Heating and Air-Conditioning Contractors

--- Details ---
Waste Code: 213
Waste Description: PETROLEUM DISTILLATES
+
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS
+
Waste Code: 221
Waste Description: LIGHT FUELS
+
Waste Code: 211
Waste Description: AROMATIC SOLVENTS
+
Waste Code: 212
Waste Description: ALIPHATIC SOLVENTS

---

9 **4 of 8** **NNW/98.0** **121.0** **IRVCON LIMITED** **GEN**
1145 PEMBROKE STREET EAST
PEMBROKE ON K8A 7R4

Generator #: ON1754200
Approval Yrs: 93,94,95,96,97,98,99,00,01,02,03,04,05,06
SIC Code: 4236
SIC Description: SHEET METAL & ROOF.

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS
+
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

---

9 **5 of 8** **NNW/98.0** **121.0** **IRVCON LIMITED** **GEN**
1145 Pembroke St East
Pembroke ON K8A 7R4

Generator #: ON1754200
Approval Yrs: 2009
SIC Code: 238160, 238220
SIC Description: Roofing Contractors, Plumbing Heating and Air-Conditioning Contractors

--- Details ---
Waste Code: 212
Waste Description: ALIPHATIC SOLVENTS
+
Waste Code: 221
Waste Description: LIGHT FUELS
+

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
Waste Code:		252			
Waste Description:		WASTE OILS & LUBRICANTS			

9 **6 of 8** **NNW/98.0** **121.0** **IRVCON LIMITED** **GEN**
1145 Pembroke St East
Pembroke ON K8A 7R4

Generator #: ON1754200
Approval Yrs: 07,08
SIC Code: 238160 238220
SIC Description: Roofing Contractors, Plumbing Heating and Air-Conditioning Contractors

--- Details ---
Waste Code: 212
Waste Description: ALIPHATIC SOLVENTS
+
Waste Code: 221
Waste Description: LIGHT FUELS
+
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

9 **7 of 8** **NNW/98.0** **121.0** **IRVCON LIMITED** **GEN**
1145 Pembroke St East
Pembroke ON K8A 7R4

Generator #: ON1754200
Approval Yrs: 2010
SIC Code: 238160, 238220
SIC Description: Roofing Contractors, Plumbing Heating and Air-Conditioning Contractors

--- Details ---
Waste Code: 221
Waste Description: LIGHT FUELS
+
Waste Code: 212
Waste Description: ALIPHATIC SOLVENTS
+
Waste Code: 213
Waste Description: PETROLEUM DISTILLATES
+
Waste Code: 211
Waste Description: AROMATIC SOLVENTS
+
Waste Code: 252
Waste Description: WASTE OILS & LUBRICANTS

9 **8 of 8** **NNW/98.0** **121.0** **IRVCON LIMITED** **GEN**
1145 Pembroke St East
Pembroke ON K8A 7R4

Generator #: ON1754200
Approval Yrs: 2011
SIC Code: 238160, 238220
SIC Description: Roofing Contractors, Plumbing Heating and Air-Conditioning Contractors

--- Details ---
Waste Code: 211
Waste Description: AROMATIC SOLVENTS
+

Map Key	Number of Records	Direction/ Distance m	Elevation m	Site	DB
Waste Code:		212			
Waste Description:		ALIPHATIC SOLVENTS			
+					
Waste Code:		213			
Waste Description:		PETROLEUM DISTILLATES			
+					
Waste Code:		221			
Waste Description:		LIGHT FUELS			
+					
Waste Code:		252			
Waste Description:		WASTE OILS & LUBRICANTS			
10	**1 of 1**	**NW/9.0**	**126.0**	***THE FORZANI GROUP*** ***1100 Pembroke Street East, UNIT 503*** ***Pembroke ON K8A 6Y7***	**GEN**
Generator #:		ON4766642			
Approval Yrs:		2011			
SIC Code:		451110			
SIC Description:					
11	**1 of 1**	**NNW/45.2**	**120.8**	***SUNOCO INC.*** ***1043 PEMBROKE STREET EAST*** ***PEMBROKE ON K8A 6Z3***	**GEN**
Generator #:		ON2153982			
Approval Yrs:		02,03,04			
SIC Code:					
SIC Description:					
--- Details ---					
Waste Code:		221			
Waste Description:		LIGHT FUELS			
12	**1 of 1**	**NW/39.7**	**122.0**	***IRVING OIL*** ***1034 PEMBROKE STREET*** ***PEMBROKE ON K8A 6X7***	**GEN**
Generator #:		ON2551595			
Approval Yrs:		04			
SIC Code:		447190			
SIC Description:		Other Gasoline Stations			
13	**1 of 1**	**NW/11.6**	**121.0**	***McBurney Transport Limited<UNOFFICIAL>*** ***Parking lot at Pembroke Street East and Angus Campbell Drive<UNOFFICIAL>*** ***Pembroke ON***	**SPL**
Ref No.:		1703-6HJ4L2			
Incident Dt:		10/25/2005			
MOE Reported Dt:		10/25/2005			
Contaminant Name:		DIESEL FUEL			
Contaminant Quantity:					
Incident Summary:		McBurn's Transport: 60 L diesel to parking lot			
Incident Cause:		Pipe Or Hose Leak			
Incident Reason:		Debris on Road			

Nature of Impact:
Receiving Medium: Land
Environmental Impact: Not Anticipated

Unplottable Summary

DB	Company Name/Site Name	Address	City	Postal
SPL	PRIVATE OWNER	PEMBROKE ST E. AT CANADA TIRE GAS BAR	PEMBROKE CITY ON	
SPL	TRANSPORT TRUCK	WEST END MALL, PEMBROKE ST W	PEMBROKE CITY ON	
SPL	The Corporation of the City of Pembroke	Pembroke St W	Pembroke ON	
SPL	SUNOCO	SUNOCO STATION ON PEMBROKE ST. E.	PEMBROKE CITY ON	
SPL	City of Pembroke<UNOFFICIAL>	Rankin Road	Laurentian Valley ON	
SPL		STORM SEWER ON PEMBROKE STREET<UNOFFICIAL>	Pembroke ON	
SPL	UNKNOWN	PEMBROKE STREET	PEMBROKE ON	
SPL	Section 21<UNOFFICIAL>	Greenwood Rd and Hwy 148	Pembroke ON	
SPL	IRVING OIL		PEMBROKE CITY ON	

Unplottable Report

Site: ***PRIVATE OWNER***
PEMBROKE ST E. AT CANADA TIRE GAS BAR PEMBROKE CITY ON

Database: ***SPL***

Ref No.:	44132
Incident Dt:	12/1/1990
MOE Reported Dt:	12/1/1990
Contaminant Name:	
Contaminant Quantity:	
Incident Summary:	125 LTR GASOLINE TO ROAD FROM RUPTURED CAR TANK. FD WASHED TO DITCH.
Incident Cause:	OTHER CONTAINER LEAK
Incident Reason:	DAMAGE BY MOVING EQUIPMENT
Nature of Impact:	Soil contamination
Receiving Medium:	LAND
Environmental Impact:	POSSIBLE

Site: ***TRANSPORT TRUCK***
WEST END MALL, PEMBROKE ST W PEMBROKE CITY ON

Database: ***SPL***

Ref No.:	155449
Incident Dt:	5/8/1998
MOE Reported Dt:	5/8/1998
Contaminant Name:	
Contaminant Quantity:	
Incident Summary:	TRANSPORT TRUCK - 40 L HYDRAULIC FLUID TO GR.
Incident Cause:	PIPE/HOSE LEAK
Incident Reason:	WELD/SEAM FAILURE
Nature of Impact:	
Receiving Medium:	LAND
Environmental Impact:	NOT ANTICIPATED

Site: ***The Corporation of the City of Pembroke***
Pembroke St W Pembroke ON

Database: ***SPL***

Ref No.:	8243-5X5K6K
Incident Dt:	3/16/2004
MOE Reported Dt:	3/16/2004
Contaminant Name:	SEWAGE,RAW UNCHLORINATED
Contaminant Quantity:	
Incident Summary:	Tipped over Port-a-potty in Pembroke
Incident Cause:	Other Discharges
Incident Reason:	Negligence (Apparent) - Caused by lack of diligence
Nature of Impact:	Human Health/Safety
Receiving Medium:	Water
Environmental Impact:	Possible

Site: ***SUNOCO***
SUNOCO STATION ON PEMBROKE ST. E. PEMBROKE CITY ON

Database: ***SPL***

Ref No.:	48960

Incident Dt:	4/11/1991
MOE Reported Dt:	4/11/1991
Contaminant Name:	
Contaminant Quantity:	
Incident Summary:	SUNOCO: 20 L GASOLINE TO PAVEMENT AT SERVICE STN.
Incident Cause:	PIPE/HOSE LEAK
Incident Reason:	EQUIPMENT FAILURE
Nature of Impact:	
Receiving Medium:	LAND
Environmental Impact:	NOT ANTICIPATED

Site: ***City of Pembroke<UNOFFICIAL>***
Rankin Road Laurentian Valley ON

Database: ***SPL***

Ref No.:	0731-6U9QZT
Incident Dt:	10/4/2006
MOE Reported Dt:	10/4/2006
Contaminant Name:	SLUDGE (N.O.S.)
Contaminant Quantity:	500 L
Incident Summary:	Pembroke: 1/2 m 3 dried sludge to rd, cleaned.
Incident Cause:	Other Discharges
Incident Reason:	Other - Reason not otherwise defined
Nature of Impact:	Surface Water Pollution
Receiving Medium:	Water
Environmental Impact:	Not Anticipated

Site:
STORM SEWER ON PEMBROKE STREET<UNOFFICIAL> Pembroke ON

Database: ***SPL***

Ref No.:	5350-5UMUA4
Incident Dt:	12/27/2003
MOE Reported Dt:	12/27/2003
Contaminant Name:	DIESEL FUEL
Contaminant Quantity:	
Incident Summary:	Source Ukn-Ukn Qty Diesel to Storm Sewer
Incident Cause:	
Incident Reason:	
Nature of Impact:	
Receiving Medium:	Water
Environmental Impact:	Not Anticipated

Site: ***UNKNOWN***
PEMBROKE STREET PEMBROKE ON

Database: ***SPL***

Ref No.:	189810
Incident Dt:	11/3/2000
MOE Reported Dt:	11/3/2000
Contaminant Name:	
Contaminant Quantity:	
Incident Summary:	UNKNOWN:DIESEL OR FUEL OIL FROM UNKNOWN TRUCK ONTO STREET, FD, WORKS
Incident Cause:	UNKNOWN
Incident Reason:	UNKNOWN
Nature of Impact:	Water course or lake
Receiving Medium:	LAND
Environmental Impact:	POSSIBLE

Site: ***Section 21<UNOFFICIAL>***
Greenwood Rd and Hwy 148 Pembroke ON

Database: ***SPL***

Ref No.:	4868-9BBM8C
Incident Dt:	2013/09/07
MOE Reported Dt:	2013/09/07
Contaminant Name:	DIESEL FUEL
Contaminant Quantity:	15 L
Incident Summary:	Single MVA- 15L gasoline to wet ditch
Incident Cause:	Collision/Accident
Incident Reason:	Road Conditions
Nature of Impact:	Soil Contamination
Receiving Medium:	
Environmental Impact:	Not Anticipated

Site: ***IRVING OIL***
PEMBROKE CITY ON

Database: ***SPL***

Ref No.:	109570
Incident Dt:	1/27/1995
MOE Reported Dt:	1/27/1995
Contaminant Name:	
Contaminant Quantity:	
Incident Summary:	IRVING OIL: 40L GASOLINE TO CEMENT PAD ON PREMISESCONTAINED AND CLEANED UP
Incident Cause:	VALVE/FITTING LEAK OR FAILURE
Incident Reason:	EQUIPMENT FAILURE
Nature of Impact:	
Receiving Medium:	LAND
Environmental Impact:	NOT ANTICIPATED

Appendix: Database Descriptions

Ecolog Environmental Risk Information Services Ltd can search the following databases. The extent of Historical information varies with each database and current information is determined by what is publicly available to Ecolog ERIS at the time of update. ***Note:*** *Databases denoted with " * " indicates that the database will no longer be updated. See the individual database description for more information.*

Abandoned Aggregate Inventory: Provincial AAGR

The MAAP Program maintains a database of all abandoned pits and quarries. Please note that the database is only referenced by lot and concession and city/town location. The database provides information regarding the location, type, size, land use, status and general comments.*

Government Publication Date: Sept 2002*

Aggregate Inventory: Provincial AGR

The Ontario Ministry of Natural Resources maintains a database of all active pits and quarries. The database provides information regarding the registered owner/operator, location name, operation type, approval type, and maximum annual tonnage.

Government Publication Date: Up to Aug 2012

Abandoned Mine Information System: Provincial AMIS

The Abandoned Mines Information System contains data on known abandoned and inactive mines located on both Crown and privately held lands. The information was provided by the Ministry of Northern Development and Mines (MNDM), with the following disclaimer: "the database provided has been compiled from various sources, and the Ministry of Northern Development and Mines makes no representation and takes no responsibility that such information is accurate, current or complete". Reported information includes official mine name, status, background information, mine start/end date, primary commodity, mine features, hazards and remediation.

Government Publication Date: 1800-Jan 2014

Anderson's Waste Disposal Sites: Private ANDR

The information provided in this database was collected by examining various historical documents which aimed to characterize the likely position of former waste disposal sites from 1860 to present. The research initiative behind the creation of this database was to identify those sites that are missing from the Ontario MOE Waste Disposal Site Inventory, as well as to provide revisions and corrections to the positions and descriptions of sites currently listed in the MOE inventory. In addition to historic waste disposal facilities, the database also identifies certain auto wreckers and scrap yards that have been extrapolated from documentary sources. Please note that the data is not warranted to be complete, exhaustive or authoritive. The information was collected for research purposes only.

Government Publication Date: 1860s-Present

Automobile Wrecking & Supplies: Private AUWR

This database provides an inventory of all known locations that are involved in the scrap metal, automobile wrecking/recycling, and automobile parts & supplies industry. Information is provided on the company name, location and business type.

Government Publication Date: 2001-Jul 2014

Borehole: Provincial BORE

A borehole is the generalized term for any narrow shaft drilled in the ground, either vertically or horizontally. The information here includes geotechnical investigations or environmental site assessments, mineral exploration, or as a pilot hole for installing piers or underground utilities. Information is from many sources such as the Ministry of Transportation (MTO) boreholes from engineering reports and projects from the 1950 to 1990's in Southern Ontario. Boreholes from the Ontario Geological Survey (OGS) including The Urban Geology Analysis Information System (UGAIS) and the York Peel Durham Toronto (YPDT) database of the Conservation Authority Moraine Coalition. This database will include fields such as location, stratigraphy, depth, elevation, year drilled, etc. For all water well data or oil and gas well data for Ontario please refer to WWIS and OOGW.

Government Publication Date: 1875-Jul 2014

Certificates of Approval: Provincial CA

This database contains the following types of approvals: Air & Noise, Industrial Sewage, Municipal & Private Sewage, Waste Management Systems and Renewable Energy Approvals. The MOE in Ontario states that any facility that releases emissions to the atmosphere, discharges contaminants to ground or surface water, provides potable water supplies, or stores, transports or disposes of waste, must have a Certificate of Approval before it can operate lawfully. Fields include approval number, business name, address, approval date, approval type and status. This database will no longer be updated, as CofA's have been replaced by either Environmental Activity and Sector Registry (EASR) or Environmental Compliance Approval (ECA). Please refer to those individual databases for any information after Oct.31, 2011.

Government Publication Date: 1985-Oct 30, 2011*

Commercial Fuel Oil Tanks: Provincial CFOT

Since May 2002, Ontario developed a new act where it became mandatory for fuel oil tanks to be registered with Technical Standards & Safety Authority (TSSA). This data would include all commercial underground fuel oil tanks in Ontario with fields such as location, registration number, tank material, age of tank and tank size.

Government Publication Date: 1948-2014

Chemical Register: Private CHEM

This database includes information from both a one time study conducted in 1992 and private source and is a listing of facilities that manufacture or distribute chemicals. The production of these chemical substances may involve one or more chemical reactions and/or chemical separation processes (i.e. fractionation, solvent extraction, crystallization, etc.).

Government Publication Date: 1992, 1999-Jul 2014

Inventory of Coal Gasification Plants and Coal Tar Sites: Provincial COAL

This inventory includes both the "Inventory of Coal Gasification Plant Waste Sites in Ontario-April 1987" and the Inventory of Industrial Sites Producing or Using Coal Tar and Related Tars in Ontario-November 1988) collected by the MOE. It identifies industrial sites that produced and continue to produce or use coal tar and other related tars. Detailed information is available and includes: facility type, size, land use, information on adjoining properties, soil condition, site operators/occupants, site description, potential environmental impacts and historic maps available. This was a one-time inventory.*

Government Publication Date: Apr 1987 and Nov 1988*

Compliance and Convictions: Provincial CONV

This database summarizes the fines and convictions handed down by the Ontario courts beginning in 1989. Companies and individuals named here have been found guilty of environmental offenses in Ontario courts of law.

Government Publication Date: 1989-Feb 2014

Certificates of Property Use: Provincial CPU

This is a subset taken from Ontario's Environmental Registry (EBR) database. It will include all CPU's on the registry such as (EPA s. 168.6) - Certificate of Property Use.

Government Publication Date: 1994-Apr 2015

Drill Hole Database: Provincial DRL

The Ontario Drill Hole Database contains information on more than 113,000 percussion, overburden, sonic and diamond drill holes from assessment files on record with the department of Mines and Minerals. Please note that limited data is available for southern Ontario, as it was the last area to be completed. The database was created when surveys submitted to the Ministry were converted in the Assessment File Research Image Database (AFRI) project. However, the degree of accuracy (coordinates) as to the exact location of drill holes is dependent upon the source document submitted to the MNDM. Levels of accuracy used to locate holes are: centering on the mining claim; a sketch of the mining claim; a 1:50,000 map; a detailed company map; or from submitted a "Report of Work".

Government Publication Date: 1886-Jan 2014

Environmental Activity and Sector Registry: Provincial EASR

On October 31, 2011, a smarter, faster environmental approvals system came into effect in Ontario. The EASR allows businesses to register certain activities with the ministry, rather than apply for an approval. The registry is available for common systems and processes, to which preset rules of operation can be applied. The EASR is currently available for: heating systems, standby power systems and automotive refinishing. Businesses whose activities aren't subject to the EASR may apply for an ECA (Environmental Compliance Approval), Please see our ECA database.

Government Publication Date: Oct 31 2011-Apr 2015

Environmental Registry: Provincial EBR

The Environmental Registry lists proposals, decisions and exceptions regarding policies, Acts, instruments, or regulations that could significantly affect the environment. Through the Registry, thirteen provincial ministries notify the public of upcoming proposals and invite their comments. For example, if a local business is requesting a permit, license, or certificate of approval to release substances into the air or water; these are notified on the registry. Data includes: Approval for discharge into the natural environment other than water (i.e. Air) - EPA s. 9, Approval for sewage works - OWRA s. 53(1), and EPA s. 27 - Approval for a waste disposal site. For information regarding Permit to Take Water (PTTW), Certificate of Property Use (CPU) and (ORD) Orders please refer to those individual databases.

Government Publication Date: 1994-Apr 2015

Environmental Compliance Approval: Provincial ECA

On October 31, 2011, a smarter, faster environmental approvals system came into effect in Ontario. In the past, a business had to apply for multiple approvals (known as certificates of approval) for individual processes and pieces of equipment. Today, a business either registers itself, or applies for a single approval, depending on the types of activities it conducts. Businesses whose activities aren't subject to the EASR may apply for an ECA. A single ECA addresses all of a business's emissions, discharges and wastes. Separate approvals for air, noise and waste are no longer required. This database will also include Renewable Energy Approvals. For CofA's prior to Nov 1st, 2011, please refer to the CA database. For all Waste Disposal Sites please refer to the WDS database.

Government Publication Date: Oct 31, 2011-Apr 2015

Environmental Effects Monitoring: Federal EEM

The Environmental Effects Monitoring program assesses the effects of effluent from industrial or other sources on fish, fish habitat and human usage of fisheries resources. Since 1992, pulp and paper mills have been required to conduct EEM studies under the Pulp and Paper Effluent Regulations. This database provides information on the mill name, geographical location and sub-lethal toxicity data.

Government Publication Date: 1992-2007*

ERIS Historical Searches: Private EHS

EcoLog ERIS has compiled a database of all environmental risk reports completed since March 1999. Available fields for this database include: site location, date of report, type of report, and search radius. As per all other databases, the ERIS database can be referenced on both the map and "Statistical Profile" page.

Government Publication Date: 1999-Aug 2014

Environmental Issues Inventory System: Federal EIIS

The Environmental Issues Inventory System was developed through the implementation of the Environmental Issues and Remediation Plan. This plan was established to determine the location and severity of contaminated sites on inhabited First Nation reserves, and where necessary, to remediate those that posed a risk to health and safety; and to prevent future environmental problems. The EIIS provides information on the reserve under investigation, inventory number, name of site, environmental issue, site action (Remediation, Site Assessment), and date investigation completed.

Government Publication Date: 1992-2001*

List of TSSA Expired Facilities: Provincial EXP

This is a list of all expired facilities that fall under the TSSA (TSSA Act & Safety Regulations), including the six regulations that exist under the Fuels Safety Division. It will include facilities such as private fuel outlets, bulk plants, fuel oil tanks, gasoline stations, marinas, propane filling stations, liquid fuel tanks, piping systems, etc. These tanks have been removed and automatically fall under the expired facilities inventory held by TSSA.

Government Publication Date: Current to Nov 2014

Federal Convictions: Federal FCON

Environment Canada maintains a database referred to as the "Environmental Registry" that details prosecutions under the Canadian Environmental Protection Act (CEPA) and the Fisheries Act (FA). Information is provided on the company name, location, charge date, offence and penalty.

Government Publication Date: 1988-Jun 2007*

Contaminated Sites on Federal Land: Federal FCS

The Federal Contaminated Sites Inventory includes information on all known federal contaminated sites under the custodianship of departments, agencies and consolidated Crown corporations as well as those that are being or have been investigated to determine whether they have contamination arising from past use that could pose a risk to human health or the environment. The inventory also includes non-federal contaminated sites for which the Government of Canada has accepted some or all financial responsibility. It does not include sites where contamination has been caused by, and which are under the control of, enterprise Crown corporations, private individuals, firms or other levels of government.

Government Publication Date: June 2000-Apr 2015

Fisheries & Oceans Fuel Tanks: Federal FOFT

Fisheries & Oceans Canada maintains an inventory of all aboveground & underground fuel storage tanks located on Fisheries & Oceans property or controlled by DFO. Our inventory provides information on the site name, location, tank owner, tank operator, facility type, storage tank location, tank contents & capacity, and date of tank installation.

Government Publication Date: 1964-Sept 2003

Fuel Storage Tank: Provincial FST

The Technical Standards & Safety Authority (TSSA), under the Technical Standards & Safety Act of 2000 maintains a database of registered private and retail fuel storage tanks in Ontario with fields such as location, tank status, license date, tank type, tank capacity, fuel type, installation year and facility type.

Government Publication Date: 2010-Nov 2014

Fuel Storage Tank - Historic: Provincial FSTH

The Technical Standards & Safety Authority (TSSA), under the Technical Standards & Safety Act of 2000 maintains a database of registered private and retail fuel storage tanks in Ontario with fields such as location, tank status, license date, tank type, tank capacity, fuel type, installation year and facility type.

Government Publication Date: Pre-Jan 2010*

Ontario Regulation 347 Waste Generators Summary: Provincial GEN

Regulation 347 of the Ontario EPA defines a waste generation site as any site, equipment and/or operation involved in the production, collection, handling and/or storage of regulated wastes. A generator of regulated waste is required to register the waste generation site and each waste produced, collected, handled, or stored at the site. This database contains the registration number, company name and address of registered generators including the types of hazardous wastes generated. It includes data on waste generating facilities such as: drycleaners, waste treatment and disposal facilities, machine shops, electric power distribution etc. This information is a summary of all years from 1986 including the most currently available data. Some records may contain, within the company name, the phrase "See & Use..." followed by a series of letters and numbers. This occurs when one company is amalgamated with or taken over by another registered company. The number listed as "See & Use", refers to the new ownership and the other identification number refers to the original ownership. This phrase serves as a link between the 2 companies until operations have been fully transferred.

Government Publication Date: 1986-Apr 2014

TSSA Historic Incidents: Provincial HINC

This database will cover all incidences recorded by TSSA with their older system, before they moved to their new management system. TSSA's Fuels Safety Program administers the Technical Standards & Safety Act 2000, providing fuel-related safety services associated with the safe transportation, storage, handling and use of fuels such as gasoline, diesel, propane, natural gas and hydrogen. Under this Act, TSSA regulates fuel suppliers, storage facilities, transport trucks, pipelines, contractors and equipment or appliances that use fuels. The TSSA works to protect the public, the environment and property from fuel-related hazards such as spills, fires and explosions. This database will include spills and leaks from pipelines, diesel, fuel oil, gasoline, natural gas, propane and hydrogen recorded by the TSSA.

Government Publication Date: 2006-June 2009*

Indian & Northern Affairs Fuel Tanks: Federal IAFT

The Department of Indian & Northern Affairs Canada (INAC) maintains an inventory of all aboveground & underground fuel storage tanks located on both federal and crown land. Our inventory provides information on the reserve name, location, facility type, site/facility name, tank type, material & ID number, tank contents & capacity, and date of tank installation.

Government Publication Date: 1950-Aug 2003*

TSSA Incidents: Provincial INC

TSSA's Fuels Safety Program administers the Technical Standards & Safety Act 2000, providing fuel-related safety services associated with the safe transportation, storage, handling and use of fuels such as gasoline, diesel, propane, natural gas and hydrogen. Under this Act, TSSA regulates fuel suppliers, storage facilities, transport trucks, pipelines, contractors and equipment or appliances that use fuels. Includes incidents from fuel-related hazards such as spills, fires and explosions. This database will include spills and leaks from diesel, fuel oil, gasoline, natural gas, propane and hydrogen recorded by the TSSA.

Government Publication Date: June 2009-2014

Landfill Inventory Management Ontario: Provincial LIMO

The Landfill Inventory Management Ontario (LIMO) database is updated every year, as the ministry compiles new and updated information. The inventory will include small and large landfills. Additionally, each year the ministry will request operators of the larger landfills complete a landfill data collection form that will be used to update LIMO and will include the following information from the previous operating year. This will include additional information such as estimated amount of total waste received, landfill capacity, estimated total remaining landfill capacity, fill rates, engineering designs, reporting and monitoring details, size of location, service area, approved waste types, leachate of site treatment, contaminant attenuation zone and more. The small landfills will include information such as site owner, site location and certificate of approval # and status.

Government Publication Date: 2012

Canadian Mine Locations: Private MINE

This information is collected from the Canadian & American Mines Handbook. The Mines database is a national database that provides over 290 listings on mines (listed as public companies) dealing primarily with precious metals and hard rocks. Listed are mines that are currently in operation, closed, suspended, or are still being developed (advanced projects). Their locations are provided as geographic coordinates (x, y and/or longitude, latitude). As of 2002, data pertaining to Canadian smelters and refineries has been appended to this database.

Government Publication Date: 1998-2009*

Mineral Occurrences: Provincial MNR

In the early 70's, the Ministry of Northern Development and Mines created an inventory of approximately 19,000 mineral occurrences in Ontario, in regard to metallic and industrial minerals, as well as some information on building stones and aggregate deposits. Please note that the "Horizontal Positional Accuracy" is approximately +/- 200 m. Many reference elements for each record were derived from field sketches using pace or chain/tape measurements against claim posts or topographic features in the area. The primary limiting factor for the level of positional accuracy is the scale of the source material. The testing of horizontal accuracy of the source materials was accomplished by comparing the planimetric (X and Y) coordinates of that point with the coordinates of the same point as defined from a source of higher accuracy.

Government Publication Date: 1846-Apr 2013

National Analysis of Trends in Emergencies System (NATES): Federal NATE

In 1974 Environment Canada established the National Analysis of Trends in Emergencies System (NATES) database, for the voluntary reporting of significant spill incidents. The data was to be used to assist in directing the work of the emergencies program. NATES ran from 1974 to 1994. Extensive information is available within this database including company names, place where the spill occurred, date of spill, cause, reason and source of spill, damage incurred, and amount, concentration, and volume of materials released.

Government Publication Date: 1974-1994*

Non-Compliance Reports: Provincial NCPL

The Ministry of the Environment provides information about non-compliant discharges of contaminants to air and water that exceed legal allowable limits, from regulated industrial and municipal facilities. A reported non-compliance failure may be in regard to a Control Order, Certificate of Approval, Sectoral Regulation or specific regulation/act.

Government Publication Date: 1994-2012

National Defence & Canadian Forces Fuel Tanks: Federal NDFT

The Department of National Defence and the Canadian Forces maintains an inventory of all aboveground & underground fuel storage tanks located on DND lands. Our inventory provides information on the base name, location, tank type & capacity, tank contents, tank class, date of tank installation, date tank last used, and status of tank as of May 2001. This database will no longer be updated due to the new National Security protocols which have prohibited any release of this database.

Government Publication Date: Up to May 2001*

National Defence & Canadian Forces Spills: Federal NDSP

The Department of National Defence and the Canadian Forces maintains an inventory of spills to land and water. All spill sites have been classified under the "Transportation of Dangerous Goods Act - 1992". Our inventory provides information on the facility name, location, spill ID #, spill date, type of spill, as well as the quantity of substance spilled & recovered.

Government Publication Date: Mar 1999-Aug 2010

National Defence & Canadian Forces Waste Disposal Sites: Federal NDWD

The Department of National Defence and the Canadian Forces maintains an inventory of waste disposal sites located on DND lands. Where available, our inventory provides information on the base name, location, type of waste received, area of site, depth of site, year site opened/closed and status.

Government Publication Date: 2001-Apr 2007*

National Environmental Emergencies System (NEES): Federal NEES

In 2000, the Emergencies program implemented NEES, a reporting system for spills of hazardous substances. For the most part, this system only captured data from the Atlantic Provinces, some from Quebec and Ontario and a portion from British Columbia. Data for Alberta, Saskatchewan, Manitoba and the Territories was not captured. However, NEES is also a repository for all previous Environment Canada spill datasets. NEES is composed of the historic datasets ' or Trends ' which dates from approximately 1974 to present. NEES Trends is a compilation of historic databases, which were merged and includes data from NATES (National Analysis of Trends in Emergencies System), ARTS (Atlantic Regional Trends System), and NEES. In 2001, the Emergencies Program determined that variations in reporting regimes and requirements between federal and provincial agencies made national spill reporting and trend analysis difficult to achieve. As a consequence, the department has focused efforts on capturing data on spills of substances which fall under its legislative authority only (CEPA and FA). As such, the NEES database will be decommissioned in December 2004.

Government Publication Date: 1974-2003*

National PCB Inventory: Federal NPCB

Environment Canada's National PCB inventory includes information on in-use PCB containing equipment in Canada including federal, provincial and private facilities. All federal out-of-service PCB containing equipment and all PCB waste owned by the federal government or by federally regulated industries such as airlines, railway companies, broadcasting companies, telephone and telecommunications companies, pipeline companies, etc. are also listed. Although it is not Environment Canada's mandate to collect data on non-federal PCB waste, the National PCB inventory includes some information on provincial and private PCB waste and storage sites. Some addresses provided may be Head Office addresses and are not necessarily the location of where the waste is being used or stored.

Government Publication Date: 1988-2008*

National Pollutant Release Inventory: Federal NPRI

Environment Canada has defined the National Pollutant Release Inventory ("NPRI") as a federal government initiative designed to collect comprehensive national data regarding releases to air, water, or land, and waste transfers for recycling for more than 300 listed substances.

Government Publication Date: 1993-2013

Oil and Gas Wells: Private OGW

The Nickle's Energy Group (publisher of the Daily Oil Bulletin) collects information on drilling activity including operator and well statistics. The well information database includes name, location, class, status and depth. The main Nickle's database is updated on a daily basis, however, this database is updated on a monthly basis. More information is available at www.nickles.com.

Government Publication Date: 1988-Mar 2015

Ontario Oil and Gas Wells: Provincial OOGW

In 1998, the MNR handed over to the Ontario Oil, Gas and Salt Resources Corporation, the responsibility of maintaining a database of oil and gas wells drilled in Ontario. The OGSR Library has over 20,000+ wells in their database. Information available for all wells in the ERIS database include well owner/operator, location, permit issue date, well cap date, licence no., status, depth and the primary target (rock unit) of the well being drilled. All geology/stratigraphy table information, plus all water table information is also provide for each well record.

Government Publication Date: 1800-2013

Inventory of PCB Storage Sites: Provincial OPCB

The Ontario Ministry of Environment, Waste Management Branch, maintains an inventory of PCB storage sites within the province. Ontario Regulation 11/82 (Waste Management - PCB) and Regulation 347 (Generator Waste Management) under the Ontario EPA requires the registration of inactive PCB storage equipment and/or disposal sites of PCB waste with the Ontario Ministry of Environment. This database contains information on: 1) waste quantities; 2) major and minor sites storing liquid or solid waste; and 3) a waste storage inventory.

Government Publication Date: 1987-Oct 2004

Orders: Provincial ORD

This is a subset taken from Ontario's Environmental Registry (EBR) database. It will include all Orders on the registry such as (EPA s. 17) - Order for remedial work, (EPA s. 18) - Order for preventative measures, (EPA s. 43) - Order for removal of waste and restoration of site, (EPA s. 44) - Order for conformity with Act for waste disposal sites, (EPA s. 136) - Order for performance of environmental measures.

Government Publication Date: 1994-Apr 2015

Canadian Pulp and Paper: Private PAP

This information is part of the Pulp and Paper Canada Directory. The Directory provides a comprehensive listing of the locations of pulp and paper mills and the products that they produce.

Government Publication Date: 1999, 2002, 2004, 2005, 2009

Parks Canada Fuel Storage Tanks: Federal PCFT

Canadian Heritage maintains an inventory of all known fuel storage tanks operated by Parks Canada, in both National Parks and at National Historic Sites. The database details information on site name, location, tank install/removal date, capacity, fuel type, facility type, tank design and owner/operator.

Government Publication Date: 1920-Jan 2005*

Pesticide Register: Provincial PES

The Ontario Ministry of Environment maintains a database of all manufacturers and vendors of registered pesticides.

Government Publication Date: 1988-Jun 2013

TSSA Pipeline Incidents: Provincial PINC

TSSA's Fuels Safety Program administers the Technical Standards & Safety Act 2000, providing fuel-related safety services associated with the safe transportation, storage, handling and use of fuels such as gasoline, diesel, propane, natural gas and hydrogen. Under this Act, TSSA regulates fuel suppliers, storage facilities, transport trucks, pipelines, contractors and equipment or appliances that use fuels. This database will include spills, strike and leaks from recorded by the TSSA.

Government Publication Date: June 2009-2014

Private and Retail Fuel Storage Tanks: Provincial PRT

The Fuels Safety Branch of the Ontario Ministry of Consumer and Commercial Relations maintained a database of all registered private fuel storage tanks and licensed retail fuel outlets. This database includes an inventory of locations that have gasoline, oil, waste oil, natural gas and/or propane storage tanks on their property. The MCCR no longer collects this information. This information is now collected by the Technical Standards and Safety Authority (TSSA).

Government Publication Date: 1989-1996*

Permit to Take Water: Provincial PTTW

This is a subset taken from Ontario's Environmental Registry (EBR) database. It will include all PTTW's on the registry such as OWRA s. 34 - Permit to take water.

Government Publication Date: 1994-Apr 2015

Ontario Regulation 347 Waste Receivers Summary: Provincial REC

Part V of the Ontario Environmental Protection Act ("EPA") regulates the disposal of regulated waste through an operating waste management system or a waste disposal site operated or used pursuant to the terms and conditions of a Certificate of Approval or a Provisional Certificate of Approval. Regulation 347 of the Ontario EPA defines a waste receiving site as any site or facility to which waste is transferred by a waste carrier. A receiver of regulated waste is required to register the waste receiving facility. This database represents registered receivers of regulated wastes, identified by registration number, company name and address, and includes receivers of waste such as: landfills, incinerators, transfer stations, PCB storage sites, sludge farms and water pollution control plants. This information is a summary of all years from 1986 including the most currently available data.

Government Publication Date: 1986-2013

Record of Site Condition: Provincial RSC

The Record of Site Condition (RSC) is part of the Ministry of the Environment's Brownfields Environmental Site Registry. Protection from environmental cleanup orders for property owners is contingent upon documentation known as a record of site condition (RSC) being filed in the Environmental Site Registry. In order to file an RSC, the property must have been properly assessed and shown to meet the soil, sediment and groundwater standards appropriate for the use (such as residential) proposed to take place on the property. The Record of Site Condition Regulation (O. Reg. 153/04) details requirements related to site assessment and clean up.
RSCs filed after July 1, 2011 will also be included as part of the new (O.Reg. 511/09).

Government Publication Date: 1997-Sept 2001, Oct 2004-Mar 2015

Retail Fuel Storage Tanks: Private RST

This database includes an inventory of retail fuel outlet locations (including marinas) that have on their property gasoline, oil, waste oil, natural gas and / or propane storage tanks.

Government Publication Date: 1999-Jul 2014

Scott's Manufacturing Directory: Private SCT

Scott's Directories is a data bank containing information on over 200,000 manufacturers across Canada. Even though Scott's listings are voluntary, it is the most comprehensive database of Canadian manufacturers available. Information concerning a company's address, plant size, and main products are included in this database.

Government Publication Date: 1992-Mar 2011

Ontario Spills: Provincial SPL

This database identifies information such as location (approximate), type and quantity of contaminant, date of spill, environmental impact, cause, nature of impact, etc. Information from 1988-2002 was part of the ORIS (Occurrence Reporting Information System). The SAC (Spills Action Centre) handles all spills reported in Ontario. Regulations for spills in Ontario are part of the MOE's Environmental Protection Act, Part X.

Government Publication Date: 1988-Feb 2014

Wastewater Discharger Registration Database: Provincial SRDS

Information under this heading is combination of the following 2 programs. The Municipal/Industrial Strategy for Abatement (MISA) division of the Ontario Ministry of Environment maintained a database of all direct dischargers of toxic pollutants within nine sectors including: Electric Power Generation; Mining; Petroleum Refining; Organic Chemicals; Inorganic Chemicals; Pulp & Paper; Metal Casting; Iron & Steel; and Quarries. All sampling information is now collected and stored within the Sample Result Data Store (SRDS).

Government Publication Date: 1990-2011

Anderson's Storage Tanks: Private TANK

The information provided in this database was collected by examining various historical documents, which identified the location of former storage tanks, containing substances such as fuel, water, gas, oil, and other various types of miscellaneous products. Information is available in regard to business operating at tank site, tank location, permit year, permit & installation type, no. of tanks installed & configuration and tank capacity. Data contained within this database pertains only to the city of Toronto and is not warranted to be complete, exhaustive or authoritative. The information was collected for research purposes only.

Government Publication Date: 1915-1953*

Transport Canada Fuel Storage Tanks: Federal TCFT

List of fuel storage tanks currently or previously owned or operated by Transport Canada. This inventory also includes tanks on The Pickering Lands, which refers to 7,530 hectares (18,600 acres) of land in Pickering, Markham, and Uxbridge owned by the Government of Canada since 1972; properties on this land has been leased by the government since 1975, and falls under the Site Management Policy of Transport Canada, but is administered by Public Works and Government Services Canada. This inventory provides information on the site name, location, tank age, capacity and fuel type.

Government Publication Date: 1970-Mar 2007

TSSA Variances for Abandonment of Underground Storage Tanks: Provincial VAR

The TSSA, Under the Liquid Fuels Handling Code and the Fuel Oil Code, all underground storage tanks must be removed within two years of disuse. If removal of a tank is not feasible, you may apply to seek a variance from this code requirement. This is a list of all variances granted for abandoned tanks.

Government Publication Date: Current to Nov 2014

Waste Disposal Sites - MOE CA Inventory: Provincial WDS

The Ontario Ministry of Environment, Waste Management Branch, maintains an inventory of known open (active or inactive) and closed disposal sites in the Province of Ontario. Active sites maintain a Certificate of Approval, are approved to receive and are receiving waste. Inactive sites maintain Certificate(s) of Approval but are not receiving waste. Closed sites are not receiving waste. The data contained within this database was compiled from the MOE's Certificate of Approval database. Locations of these sites may be cross-referenced to the Anderson database described under ERIS's Private Source Database section, by the CA number. All new Environmental Compliance Approvals handed out after Oct 31, 2011 for Waste Disposal Sites will still be found in this database.

Government Publication Date: 1970-Apr 2015

Waste Disposal Sites - MOE 1991 Historical Approval Inventory: Provincial WDSH

In June 1991, the Ontario Ministry of Environment, Waste Management Branch, published the "June 1991 Waste Disposal Site Inventory", of all known active and closed waste disposal sites as of October 30st, 1990. For each "active" site as of October 31st 1990, information is provided on site location, site/CA number, waste type, site status and site classification. For each "closed" site as of October 31st 1990, information is provided on site location, site/CA number, closure date and site classification. Locations of these sites may be cross-referenced to the Anderson database described under ERIS's Private Source Database section, by the CA number.

Government Publication Date: Up to Oct 1990*

Water Well Information System: Provincial WWIS

This database describes locations and characteristics of water wells found within Ontario in accordance with Regulation 903. It includes such information as coordinates, construction date, well depth, primary and secondary use, pump rate, static water level, well status, etc. Also included are detailed stratigraphy information, approximate depth to bedrock and the approximate depth to the water table.

Government Publication Date: 1955-Mar 2014

Definitions

Database Descriptions: This section provides a detailed explanation for each database including: source, information available, time coverage, and acronyms used. They are listed in alphabetic order.

Detail Report: This is the section of the report which provides the most detail for each individual record. Records are summarized by location, starting with the project property followed by records in closest proximity.

Distance: The distance value is the distance between plotted points, not necessarily the distance between the sites' boundaries". All values are an approximation.

Direction: The direction value is the compass direction of the site in respect to the project property and/or center point of the report.

Elevation: The elevation value is taken from the location at which the records for the site address have been plotted. All values are an approximation. Source: Google Elevation API.

Executive Summary: This portion of the report is divided into 3 sections:

'Report Summary'- Displays a chart indicating how many records fall on the project property and, within the report search radii.

'Site Report Summary'-Project Property'- This section lists all the records which fall on the project property. For more details, see the 'Detail Report' section.

'Site Report Summary-Surrounding Properties'- This section summarizes all records on adjacent properties, listing them in order of proximity from the project property. For more details, see the 'Detail Report' section.

Map Key: The map key number is assigned according to closest proximity from the project property. Map Key numbers always start at #1. The project property will always have a map key of '1' if records are available. If there is a number in brackets beside the main number, this will indicate the number of records on that specific property. If there is no number in brackets, there is only one record for that property.

The symbol and colour used indicates 'elevation': the red inverted triangle will dictate 'ERIS Sites with Lower Elevation', the yellow triangle will dictate 'ERIS Sites with Higher Elevation' and the orange square will dictate 'ERIS Sites with Same Elevation.'

Unplottables: These are records that could not be mapped due to various reasons, including limited geographic information. These records may or may not be in your study area, and were included as reference.

APPENDIX B

Site Photographs

Photograph 1: View of the intersection of HWY 148 with Angus Campbell Drive (west end of Section 1).

Photograph 2: View of the location where the former Irving Oil was located, 1034 Pembroke Street East (currently occupied by Bulk Barn and Wave Optical).

Photograph 3: View of Oil Changers (1043 Pembroke Street East) on the north side of HWY 148.

Photograph 4: View of Irvcon Ltd. and Harrington Mechanical (1145 Pembroke Street East) on the north side of HWY 148.

Photograph 5: General view of Section 1 of HWY 148 looking west.

Photograph 6: View of the intersection of HWY 148 and Robinson Lane.

Photograph 7: View of HWY 148 between Route 29 (Drive in Road) and Erma Street looking west

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Photograph 9: View Section 2 of HWY 148 looking west.

Photograph 10: View of Heavy Equipment Rental and Valley Contracting and the two fuel ASTs observed on the property (1310 Pembroke Street East).

Photograph 11: View of the Winmar Property Restoration (1366 Pembroke Street East) and the fuel AST noted on this property.

Photograph 12: View of the Valley Compressor (1376 Pembroke Street East) on the south side of HWY 148.

Photograph 13: View of ESSO gas station on the south side of HWY 148.

Photograph 14: View of the vacant property previously occupied by Ultramar gas station (1409 Pembroke Street East).

Photograph 15: View of the drums suspected to be filled with soil cuttings and purged water noted on the former Ultramar gas station property (1409 Pembroke Street East).

Photograph 16: View of some of the monitoring wells observed on the former Ultramar gas station property and on the adjacent residential property.

Photograph 17: View of the flush mount monitoring well observed on the HWY 148 ROW along ESSO gas station and across the former Ultramar gas station.

Photograph 18: View of the east end of Section 2 of HWY 148 at Greenwood Road where HWY 148 extends to Quebec border.

Photograph 19: View of the south part of Section 3 of HWY 148 extending to Quebec border looking north.

Photograph 20: View of the central part of Section 3 of HWY 148 looking south.

Photograph 21: View of Section 3 of HWY 148 and surrounding lands looking south.

Photograph 22: View of the north part of Section 3 of HWY 148 looking north.

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Appendix H – Drainage and Stormwater Management

Ontario

HIGHWAY 148 IMPROVEMENTS
PEMBROKE TO QUEBEC BORDER
GWP-214-00-00 & GWP-239-00-00

DRAINAGE DESIGN AND STORMWATER MANAGEMENT REPORT

Prepared for Ministry of Transportation Ontario
by IBI Group

November 2017

IBI

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1. INTRODUCTION

1.1 Background

IBI group has been retained by the Ministry of Transportation, Eastern Region to prepare the Preliminary Design and Environmental Assessment (EA) Study of Highway 148 improvements from northwest of Angus Campbell Drive in Pembroke to Quebec Border (approximately 5 km). The project location is shown on **Figure 1**.

The study includes a review existing and future highway needs, and recommendations for operational and safety improvements. Based on the findings of the study, it is proposed to rehabilitate the existing pavement throughout the study limits, including consideration of urban versus rural treatment, widening to accommodate auxiliary lanes, intersection improvements, paved shoulders, entrance modifications/removals. In addition, the study will determine the most appropriate strategy for the rehabilitation/replacement, or removal the CPR structure (Site number 29-038) over the abandoned railway line taking into account the County of Renfrew plans for a trail on the abandoned rail network that crosses under Highway 148. The Hazley Bay Structure(Site number 29-039) has also been included in this study to determine the most appropriate strategy for accommodating Active Transportation at this location if it is determined active transportation is feasible and safe along this section of Hwy 148.

The project is divided into two contracts, from the west project limit (10+000) to west of Greenwood Road (13+180) is covered under the contract GWP 214-00-00 and from west of Greenwood Road to the Quebec border (15+020) is covered under the contract GWP 239-00-00.

This Stormwater Management (SWM) report is a supporting document to the Environmental Assessment Study and covers both projects. The objective of this report (SWM) is to verify and summarize the recommended drainage and stormwater management strategy and identify any deficiencies and/or opportunities for improvements that exist within the study limit. Also the goal is to mitigate the possible impacts of the proposed improvements to Hwy 148 on receiving drainage systems.

1.2 Existing Drainage Infrastructure

As part of Highway 148 Class EA, the following drainage components were identified:

- There are seven (7) centreline culverts; two RFO (reinforced open bottom), two NRF (non-reinforced closed bottom), one 900mm HDPE and one 900mm HDPE liner crossings convey external flows across Highway 148. The other culvert was listed as buried on the base plans supplied by MTO. All sideroad/entrance culverts are approximately 900 mm in diameter.

- The existing road side ditches provide water quality/quantity control to Highway 148 runoff before discharging to receiving systems.

- Most of the watercourses convey flow through estate/residential/commercial areas located adjacent to Highway 148 in City of Pembroke. Some pockets of rural or agricultural areas are also located at the north project limit near Quebec border.

- There are four low points located at Highway 148 within the study limit which provide overland flow route to major system runoff.

- There are no storm water management facilities adjacent to the project corridor.
- Highway runoff from Angus Campbell Drive to approximately 200 m east of City of Pembroke Limits is currently conveyed by storm sewers.
- It is assumed Highway 148, between Drive-in-Road (RD Allce) and Dairy Road, has a closed drainage system due to presence of roadside catch basins and manholes. However, in the absence of information, location of the storm sewer could not be identified.

1.3 Proposed Roadway Improvements

As part of the overall improvements to Highway 148, the following specific upgrades and modifications will be undertaken:

Roadway Improvements

- Urbanize Highway 148 between Angus Campbell Drive and Drive-In Road, including pavement widening to accommodate a continuous Two-Way Left-Turn Lane (TWLTL). Protect for new sidewalk on both sides of Highway 148.
- Install traffic signals at Drive-In Road.
- Maintain a 2 lane rural cross-section between Drive-In Road and the Inter-provincial Bridge, Rehabilitate the existing pavement and provide 2.5 m wide paved shoulders.
- Replace the former CPR bridge with a trail culvert. Lower the Highway 148 profile (+1 m) from Traxton Way to Hazley Bay Drive. Protect for active transportation pathway connections from Highway 148 to the proposed CPR trail.
- Reduce the westbound right turn channelization and extend the acceleration lane at the Greenwood Road intersection (entering Pembroke).
- Incorporate entrance modifications/removals with the study limits in accordance with MTO access management principles.

Drainage improvements

- Install a new drainage system where proposed storm sewers will be placed at multiple locations and tie into the existing system;
- Upsizing the existing system where there is a capacity restraint of the existing sewers;
- Catch basins will be provided as required on both sides of Highway 148 to collect runoff from the roadway corridor;
- Oil Grit Separators will be installed before storm sewer outfalls to receiving watercourse in order to provide runoff water quality control;
- Rehabilitation and/or replacement of the existing storm sewer where applicable to improve the hydraulic capacity;
- Existing roadside ditches will continue to provide quality and quantity controls to runoff water resulting from roadway and paved shoulder areas;
- Rehabilitation and/or replacement of the existing cross drainage culverts to enhance hydraulic and structural capacity; and,
- Erosion and sediment control measures will be installed prior to construction.

1.4 Review of Background Documents

A brief summary of the reports reviewed as part of this drainage study, is provided below:

1. "Contract Drawings, Contract No. 2011 – 4051, WP No. 240-00-01, Eastern Region",Ministry of Transportation, Ontario, November 2011.

2. "Final Drainage Study Report, Highway 148 Centreline Culverts, WP 4007-10-00 and Hazley Bay Structure, WP 240-00-01", McIntosh Perry, June 15, 2011.

3. "Culvert Inspection, Highway 148, From Pembroke city limits to the Quebec Border, WP 4007-10-00", McIntosh Perry, June 2011.

4. "Sewer CCTV Inspection Report, Highway 148, Pembroke, Ontario," Clean Water Works Inc., October 14, 2015.

4. "Fish and Fish Habitat Impact Assessment Report, Highway 148, Hazley Bay Bridge, Site 23-039, Structure Rehabilitation, G.W.p.4046-10-00", McIntosh Perry, March, 2011

5. Engineering Plates, W.P.No. 71-17, Ministry of Transportation.

6. Engineering Plates W.P.No. 71-62, Ministry of Transportation.

7. Proposed Retail Commercial Development, Part of lot 23 and 24, Concession II, F.A.L., Township of Pembroke, Drawing 1 to Drawing 3, Janota Patrick & Associates Ltd., March.

1.5 Study Approach

The tasks completed in the preparation of this Stormwater Management Report are summarized as follows:

- Collected and reviewed all relevant background information for the study area;
- Reviewed record drawings to identify drainage features within and adjacent to Highway 148 right-of-way;
- Completed hydrologic modeling to quantify flow contributions to and from highway 148 right-of-way for water course crossings;
- Review the hydraulic performance of existing culverts that were assessed under EA Study;
- Investigated the potential water quality control measures to mitigate negative impacts of proposed improvements on the receiving drainage systems;
- Prepared storm sewer systems layout to convey roadway runoff;

- Recommended mitigation measures to offset negative impacts of the project to the terrestrial and aquatic features in the study area;
- Proposed an erosion and sediment control plan to detail the requirements of sediment control during the construction phase of the project;
- Liaised with external agencies; and
- Prepared a detailed Drainage and Stormwater Management Report.

Ministry of Transportation Ontario
HIGHWAY 148 IMPROVEMENTS
PEMBROKE TO QUEBEC BORDER
GWP-214-00-00 & GWP-239-00-00

DRAWING NAME: J:\24RX14.0333_MTO-TPM-HWY 148 PEMBROKE TO QUEBEC BORDE\5.9 DRAWING\59CIVIL\DRAINAGE\HWY 148-KEY PLAN.DWG MODIFIED: Feb. 27, 2015 6:08 PM

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Client: MINISTRY OF TRANSPORTATION
Project: HWY 148 FROM PEMBROKE TO QUEBEC BORDER
Drawing Title: KEYPLAN
Project No.: 24RX14.0333
Drawing No.: FIGURE-1

LEGEND
PROJECT LIMITS

2. SITE DESCRIPTION

2.1 Study Area

Highway 148 begins at the Pembroke boundary (from the outskirts of Pembroke), approximately 60 m northwest of Angus Campbell Drive. From there, the route travels southeast through the urban-rural fringe of the City, passing east of two large shopping complexes. After passing west of the community of Pleasant View, the route enters a rural area and curves south alongside farmland. Highway 148 continues east, crossing the Ottawa Valley Railway and the entrance to Hazley Bay before entering the community of Cotnam Island. The highway curves northeast and crosses the Ottawa River, entering Quebec midspan. The Township of Laurentian Valley is located within the County of Renfrew and surrounds the City of Pembroke and is south of the Town of Petawawa.

Highway 148 from Pembroke to Quebec Border generally features a two lane rural paved highway with wide shoulders. Grassy ditches exist on both sides of the right-of-way in rural areas. Highway 148 follows generally flat topography which gradually sloped towards south-east direction.

The landscape on either side of Highway 148 near City of Pembroke is generally characterized by commercial and residential complexes. Other than the City area, there exist forests and meadows. Small pockets of commercial, residential and agricultural uses are scattered in between forests and meadows.

In terms of watercourses, the study area falls within the Ottawa River Watershed. The river rises from its source in Lake Capimitchigama, in the Laurentian Mountains of central Quebec, and flows west to Lake Timiskaming. From there its route has been used to define the interprovincial border with Ontario. The Ottawa River drains into the Lake of Two Mountains and the St. Lawrence River at Montreal. The river is 1,271 kilometers in length; it drains an area of 146,300 km^2. The study corridor of Highway 148 is located close proximity of the west side of Ottawa River.

2.2 Existing Drainage Conditions

There are 8 watercourse crossings within the study limits. The general slope of Highway 148, within the project limits, is towards south-east direction, with four low points (sag) at the road. Roadside ditching has been used at most of the locations to direct drainage to nearest watercourse. The EA report has identified a total of 7 culverts which act as cross-drainage structures within the study corridor. The location of culverts is shown in **Figure 2**.

Within the study area, Highway 148 is a two lane, rural highway, approximately 8 to 10 meters wide with shoulders varying in width between 1.3 meters to 3.8 meters. The road is urbanaized on both sides in the City of Pembroke and stormwater is managed through storm sewer system. Other than the City area, the stormwater is managed through roadside ditches/swales. There are no pedestrian sidewalks on the road. In rural areas, roadside ditches/swales run along each side of the road and range from 5-8 metres in width and 0.2 to 0.5 metres in depth. Corrugated steel pipe (CSP) culverts of varying diameters and lengths convey stormwater under driveways and street entrances on both sides of the road.

The location of the crossings and drainage catchments are illustrated on **Figure 2**. The transverse drainage culverts/structures are labelled as C1 through C7 on **Drawing SWM-01**, numbered from west to east along Highway 148. **Table 1** provides details of the transverse drainage culverts/structures.

A review of available topographic and Ontario base mapping was undertaken to determine drainage boundaries. Based on this assessment, and the combining of the drainage boundaries used in the information provided by the Ministry of Transportation, delineations of drainage areas have been made to establish drainage boundaries. **Figure 2** shows location of sub-catchments and associated drainage areas.

2.3 Existing Drainage Elements

2.3.1 CULVERTS

Currently, there are a total seven (7) cross drainage culverts located within the study area and are detailed as follows:

Concrete Culverts

Four Concrete culverts currently exist under Highway 148. The span of these culverts ranges from 0.91 to 2.4 m and height from 0.9 to 1.5 m.

Pipe Culverts

There are two HDPE culverts of 900mm diameter located underneath the Highway 148.

Table 1 presents a summary of all culvert crossings.

Table 1 - Summary of Existing Culverts / Crossings

Crossing / Culvert	Location	Area	Type	Existing Size (Dia.)/(spanxrise)	Existing Length
		ha		(mm)	(m)
C1	11+176	30.31	RFO	1.22 m X 0.90 m	31.2
C2	12+331	315.90	NRF Box	2.4 m X 1.5 m	28.5
C3	12+584	1.48	Conc. Box	0.91 m X 0.61 m	23.3
C4	13+078	7.51	HDPE	900 mm	34.25
C5	13+237	8.23	RFO	1.87 m X 1.1 m	46.46
C6	13+588	16.22	HDPE (lined)	900 mm	55.28
C7	13+790	3.73	Unknown	Unknown	Unknown

Note: 1. Refer Figure 2 for crossing/culvert location.

The culvert at Station 10+606 illustrated on the MTO's base plan is buried. Based on the plan, the culvert is located approximately 600m east of the intersection of Highway 148 and Renfrew Road 40, 125m east of the CPR Rail Line and is located within east approach fill for the CPR overpass. A possible soil movement on side slopes on the north east side of the CPR approach fill was observed. It is recommended to investigate soil movement in this area.

2.3.2 STORM SEWERS

Under existing conditions, runoff from Highway 148 and the areas adjacent to the Highway within City of Pembroke limit are primarily collected by catchbasins and conveyed and discharged to outfalls through a storm sewer system. The location of existing storm sewers including outlet points are shown on **Drawing SWM-01.** The storm sewer and catch-basin locations were established from as-built drawings and site inspections.

The design flows for 10-year event were computed by Rational Method using City of Ottawa IDF curves with 10 minute inlet time. The IDF curves at Petawawa Nat Forestry also investigated and found that the City of Ottawa IDF curves provide higher rainfall intensity values. The result of detailed hydraulic assessment of the existing storm sewer are provided in **Appendix C**. The existing mainline sewers are sufficient hydraulically to convey roadway runoffs.

A field investigation with CCTV inspection was conducted by Clean Water Works Inc. in October, 2015, to assess physical condition of the existing storm sewers. The CCTV study found that largely, the existing sewer is in good condition. A detailed sewer inspection report with field observations along with photographs were provided. **Appendix D** provides a summary of existing condition assessment and recommendations for improvements of the inspected pipes.

2.3.3 DRAINAGE DITCHES

V-shaped/flat bottom roadside ditches currently exist on both sides of the Highway 148, at locations where the road runs through the rural or forest areas. The width of drainage ditches varies from 5-8 meters and depth varies from 0.2 to 0.5 meters.

2.4 Existing Landuse, Soils and Physiography

The present Highway 148 study corridor is located within the Township of Laurentian Valley in the County of Renfrew. The land use within the study area consists of forested areas, residential dwellings and commercial use, as well as some areas of agriculture.

The study area lies on the southern edge of the Boreal Shield region of Ontario. This ecozone is characterized by thin soils; rock outcroppings are numerous. According to Agriculture Canada's Soil Survey Report No. 37 (1964), soil conditions in the area of the identified culverts consist of Uplands Loamy sand and rubicon Sandy Loam. The Uplands Series is considered to have good drainage according to the Soil Survey, while the Rubicon Series has imperfect drainage. The Topography within the study area is generally gently to moderately sloping towards the Ottawa River.

3. DRAINAGE AND STORMWATER MANAGEMENT ISSUES

In general, Highway 148 presently has a rural cross-section throughout the entire length, except in the vicinity of City of Pembroke. The road cross section in the city area is urban in nature and stormwater is managed through storm sewer system. In other areas, stormwater is managed through roadside ditches. Under the EA study of Highway 148 Improvements; existing and future highway needs, safety improvements, necessity of pavement rehabilitation were reviewed.

With the increase growth of urbanization, it is necessary to assess the performance of the present storm sewers and to provide recommendations for any necessary improvements. The culverts identified in the study corridor were assessed for their proper functioning.

At present, road shoulders are being shared by pedestrians, which is a major safety concern. Feasibility of providing sidewalks especially within residential/commercial areas should be determined. However, addition of sidewalks may cause flow barrier to some roadside ditches or result in relocation of ditches. Alternative drainage options or incorporation of curb gutter system will be investigation.

The future highway needs may result in an increase in pavement areas within the study corridor. Water quality control will be required for all new additional paved areas.

Under any future improvements, best efforts will be made to maintain the grassed boulevard and drainage swales that presently exist. In addition, the various stormwater management measures such as providing sump for all new catchbasins and permeable paving (low impact development techniques) on sidewalks, creating more green space within the Right of Way should be considered.

For major system runoff; it is expected that the quantity of runoff from the improved section of the roads will not result in a significant increase in runoff, and as such, specific techniques to reduce the quantity and rate of runoff may not be considered warranted. This is due to the fact that the peak flows generated from the upstream catchments are much greater than the peak flows generated from smaller roadway paved areas, which occur earlier. Due to this lagging effect a small increase in the peak flow generated by the roadway does not result in an appreciable increase in the peak flow of the overall hydrograph.

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Client	MINISTRY OF TRANSPORTATION
Project	HWY 148 FROM PEMBROKE TO QUEBEC BORDER
Drawing Title	CATCHMENT AREA
Project No.	24RX14.0333
Drawing No.	FIGURE-2

LEGEND

- 1 / 61.67ha — CATCHMENT ID / CATCHMENT AREA
- CATCHMENT AREA
- EXISTING CULVERT
- OVERLAND FLOW ARROW

MODIFIED: Nov. 24, 2017 9:59 AM
DRAWING NAME: J:\24RX14.0333_MTO-TPM-HWY 148 PEMBROKE TO QUEBEC BORDE\5.9 DRAWING\S9CIVIL\DRAINAGE\FIGURE 2\HWY 148-FIGURE-2-NEW-REV02.DWG

4. DESIGN CRITERIA

In conformance with MTO's current policies and guidelines, the following design criteria have been adopted in the development of drainage and stormwater management strategies for this project.

Culverts

According to the MTO's Highway Drainage Design and standards (January 2008), the following criterion were applied to evaluate hydraulic performance of the existing culverts.

Design Flow

Section WC-1 of the Highway Drainage Design Standards states that for centreline culverts/structure with a span less than 6 m, a 25-year design flow should be applied for Rural Arterial and collector road.

On Regulated Watercourses the Regulatory Flow shall be calculated in all cases where Floodline Mapping is available, where there is a potential risk to public safety, or where there is potential damage to adjacent properties.

The Drainage Design Standards also recommend that provision be made to consider the extra requirements to ensure the highway is traversable during Regulatory Storm conditions (WC-1, Section 1.1.3). The MTO drainage standards state that use of the Regulatory Flow to size crossings in order to prevent overtopping should be justified on a cost/benefit basis. For this site, 100-year storm was considered to be the regulatory flow.

Check Flow

MTO's Drainage Design Standard WC-7 states that the check flow shall not exceed the elevation of the edge of the travelled road. Check flow is determined as 115% of the 100-year design flow for rural arterial (WC-1). The check flow water level is analysed for the design of culverts.

Flood Depth clearance

In accordance with WC-7, Section 3.5 of the Drainage Design Standards, the maximum allowable water depth during the design flood is that which creates a headwater (HW) to diameter (D) ratio (HW/D) of 1.5 at the culvert inlet, if the culverts rise is less than 3.0 m.

The provision of vertical clearance is typically related to scour and debris. There is no clearance requirement for closed-footing culverts (box) and open-footing culverts with non-erodible bottom. For open-footing culverts with-erodible bottom, the requirement is a minimum of 0.30 m vertical clearance from the design flood.

Freeboard

For spans classified as a structure under MTO Guidelines, in accordance with WC-2 of the Highway Drainage Design Standards the minimum freeboard measured vertically from the edge of the travelling lanes to the high water level for the design flood is 1.0 m.

Clause 1-10.8.2 of the CHBDC recommends a freeboard of 1.0 metre "….from the edge of through traffic lanes to the design high-water level ….." for the design storm. This freeboard is a recommended value although it is recognized that, due to site-specific considerations, it is not always feasible to provide this value.

Roadside Ditches

The standard SD-9 identifies the minimum design requirement of Roadside Ditches for the conveyance of flow. Roadside Ditches shall be designed to convey both the Minor System Design Flow and the Major System Design Flow, as defined in Standard SD-1.

The maximum depth of flow in the Roadside Ditch associated with the Minor System Design Flow shall be 1.0 m. There is no maximum depth of flow in the Roadside Ditch associated with the Major System Design Flow. For the Major System Design Flow, the design of the roadside ditch shall ensure that Design Flow will not spread onto either the shoulder or the travel lane.

The minimum freeboard to the top of Sub-Grade shall be 0.3 meters for the Minor System Design Flow. There is no minimum freeboard associated with the Major System Design Flow.

Flow Spread

The standard SD-3 identifies that the Maximum Depth of flooding at the lowest edge of the travel lanes shall not exceed 25 mm. The Maximum Lateral Spread Distance for a two lane roadway shall be such that the minimum width of the Open Roadway is 3.5 meters.

The Maximum Lateral Spread Distance for a roadway with two lanes in each direction shall be such that a minimum of one lane remains open in each direction.

The Maximum Lateral Spread Distance for a roadway with more than two lanes in each direction shall be such that a minimum of two lanes remains open in each direction.

Storm Sewer System

- Minor drainage system to be sized to convey runoff from a 10 year storm.

Major System Drainage

- Major system flows (i.e. storms in excess of a 10 year event) to be conveyed overland to receiving drainage watercourses.

Water Quality

- Oil/Grit separators are to be designed according to the Ministry of the Environment (MOE) 'Enhanced' Level Of Protection (i.e. 80 percent long-term suspended solid removal);

- Grass Swales are to be designed to meet the following MOE criteria for quality control:

Minimum length of swale:	60 m
Allowable velocity (25 mm Chicago Storm):	0.5 m/s
Minimum bottom width of swale:	0.75 m
Maximum Drainage Area:	2 ha

MTO's Criteria for quality control require the following:

a.	Minimum length of swale:	40 m
b.	Minimum bottom width of swale:	1.0 m

Scouring/Armouring

According to WC-3, Sub-section 3.2.1, depending on the existing condition, erosion protection at the downstream end is required if the outlet velocity exceeds 1.5 m/s.

IDF Curves

The City of Ottawa IDF curves are used in this study. The IDF curves at Petawawa Nat Forestry also investigated and found that the City of Ottawa IDF curves provide higher rainfall intensity values.

5. HYDROTECHNICAL ASSESSMENTS

5.1 Hydrologic assessment

Hydrologic analyses were conducted for EA study to evaluate the performance of existing culverts for conveyance of external runoff across the Highway 148 according to current design standards.

5.1.1 EXISTING CONDITION

Hydrologic data for the existing conditions are summarized in **Table 2**. Additional details are given in **Appendix A**.

The drainage catchments for the existing conditions were defined using the available topographic mapping for the project. For areas extending beyond the survey coverage, 1:10 000 OBM mapping was used. The catchment boundaries are shown on **Figure 2**.

The soils are relatively uniform in the area generally consisting of Sandy Loam. Detailed calculations of CN and Tc/Tp values for the existing conditions are given in **Appendix A.**

Hydrologic Analysis

The culverts drainage areas were delineated based on topographic information and the OBM available through the MNR website. The proportion of detention/storage area to the total area for each site is taken into consideration. The **Figure 2** illustrates the drainage area for each site.

Based on the size, location and features of the watershed, the Northern Ontario Hydrology Method, Modified Index Flood Method and Unified Ontario Flood Method were used to determine the peak flows for all seven sites. The Rational Method was used to verify the methods listed above.

Rational Method

The Rational Method is based on a runoff coefficient, the time of concentration for runoff to become fully established in the drainage area, and rainfall intensity-duration-frequency (IDF) curves. The soil type inferred for this area is a sandy loam over bedrock and land use is primarily wooded with some wetland areas. A peaking factor was also applied to the results of the Rational Method to account for natural attenuation in wetland areas.

MTO Northern Ontario Method

The methodology was developed for MTO to provide flow rates across streams with small to medium watershed areas in northern Ontario. This method is based on flood quantities estimated using probalistic and statistical methods with data from 15 stream gauge stations across the northern Ontario.

MTO Modified Index Flood Method

The Modified Index Flood Method was originally developed by the U.S. Geological Service and modified for MTO in 1986 to reflect Ontario conditions. In 1996, the accuracy of the method was evaluated by comparing flow estimates from the method to flows obtained from Ontario flood frequency analyses on 49 representative gauged watersheds. This method is recommended for medium to large watersheds.

Unified Ontario Flood Method (UOFM)

A new method for calculating the design instantaneous flow rate has been developed through a research project with the University of Toronto. This method provides a new approach to calculating the design flow rates based on up to date stream flow and rainfall information from Water Survey of Canada (2014). As MTO updated the IDF curves to provide values that reflect the most up to date Environment Canada rainfall data. This work supports MTO's approach to adaption to climate change and replaced the current methods included in the MTO Drainage Manual. The new UOFM method shall be used in the design of ministry water crossing infrastructure when accurate flow data are not available and when the watershed conditions meet the limitations of this method.

The detailed calculations and representative outputs are given in **Appendix A.** The computed flows for all frequencies of storms for the existing condition are summarized in **Table 2**.

Table 2 – Existing Culvert Design Flows

Crossing / Culvert	Station	Area	Flow						Check Flood
			2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	115% of 100 yr
		ha	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
C1	11+176	30.31	0.45	0.67	0.81	0.99	1.13	1.26	1.45
C2	12+331	315.90	2.61	3.87	4.70	5.74	6.53	7.31	8.41
C3	12+584	1.48	0.07	0.09	0.11	0.14	0.17	0.20	0.23
C4	13+078	7.51	0.12	0.17	0.20	0.25	0.28	0.32	0.36
C5	13+237	8.23	0.17	0.26	0.31	0.38	0.44	0.49	0.56
C6	13+588	16.22	0.18	0.25	0.28	0.37	0.45	0.52	0.60
C7	13+790	3.73	0.04	0.05	0.06	0.08	0.10	0.12	0.13

Note: 1. Refer to **Appendix A** for details.

5.2 Hydraulic Assessment

5.2.1 EXISTING CULVERTS

Method

Culvert inverts and lengths were established from as-built drawings, survey, culvert inspection reports and topography of the roadway. Some of this information is to be supplemented by field inspections to verify culvert inverts and sedimentation in some locations.

The peak flows were computed with the methods discussed in Section 5.1.1 and the maximum flow value of all four methods was used as the design flow. The design flows are provided in **Table 2**.

The CulvertMaster model was used for the hydraulic analysis at all locations. Tailwater elevations for the CulvertMaster analyses were calculated by the model based on the downstream channel slopes and geometries. The tailwater elevation for each culvert analysis is documented in the CulvertMaster outputs in **Appendix B**. The existing condition drainage map including the location of culverts is presented in **Drawing SWM -01** at the back of the report.

The criteria for culvert design on Highway 148 are:

- Design capacity (with nominal clearance) for the 25-year design flow;

- The minimum freeboard measured vertically from the edge of the travelling lanes to the high water level for the design flood is 1.0 m;
- No flooding/overtopping of the highway for 115% of the 100-year flow; and
- No increase in upstream flood elevations.

Results of Analysis

The results of the hydraulic analysis for the existing culverts are summarized in **Table 3**. The computed 25-year freeboard (i.e. distance between the upstream water elevation and the highway profile elevation) is adequate for all culverts for the present condition. All other cross-drainage culverts have sufficient capacity to convey the 115% of 100 year design storm without overtopping the road.

Drainage Study by MPCE for Highway 148 Centreline Culverts

Based on the field investigations, hydrologic and hydraulic analyses conducted by MPCE, the following recommendations and remedial actions were proposes for each of the culvert:

Culvert at 11+176

Place rip-rap throughout the entire length of the culvert. Rip-rap consisting of two layers of 200mm nominal diameter stones to extend 4.5m downstream of the outlet end.

Culvert at 12+331

Remove and replace the existing 1830 mm X 1220 mm non-rigid open bottom concrete box culvert with a 2400 mm X 1500 mm closed bottom concrete box culvert. Construct the concrete box culvert 0.3m below the existing inverts. Place native substrate throughout the entire length of the culvert. Rip-rap consisting of two layers of 300mm nominal diameter stones to extend to 4.8m downstream of the outlet end

Culvert at 12+584

Upstream and downstream ditch clean-out is required.

Culvert at 13+078

Remove and replace existing 900mm culvert. Upstream and downstream ditch clean-out is required

Culvert at 13+588

Line the existing concrete box culvert with a 900mm HDPE

The Culvert at Station 13+790, illustrated on the base plan supplied by MTO, is buried. The contributing drainage area to the culvert and peak flow rates are calculated for the culvert. The existing topography indicated that this culvert was functioning as an equalization culvert between the upstream and downstream water elevations. Since the culvert has been plugged at both ends, it is recommended to open both ends of the culvert and assess the physical condition.

5.2.2 HAZLEY BAY STRUCTURE

With the recent rehabilitation to the bridge structure (WP 240-00-01, Contract 2011-4051), all the existing deck drains were removed. Therefore, no stormwater directly discharge to the Ottawa River. The removal of deck drains allowed the stormwater to traverse the curb and gutter system and to infiltrate into the recently built constricted channels consisting of rip-rap strategically placed downstream of the curb and gutter system including the well vegetated side slope providing some level of quality control. This treatment train provides significant improvement compared to the previous condition in terms of the runoff quality discharging from the structure before reaching the Ottawa River.

Table 3 – Hydraulic Assessment of Existing Culverts

Crossing / Structure	Station	Drainage Area (ha)	Type	U/S Invert (m)	D/S Invert (m)	Length (m)	Dimension (mm)		Flow (m^3/s)		Tailwater Elev (m)	Spill Elev. (m)	Design Headwater Elev. (m)		Headwater Depth/ Culvert Height (HW/D)	Freeboard from Spill Point (m)		Check		
							Span	Rise/ Dia.	25 yr	115% of 100 yr			25 yr	115% of 100 yr	25 yr	25 yr	115% of 100 yr	HW/D<1.5	Freeboard>1.0 m	WL<Edge of Travelled Lane
																		25 yr	25 yr	115% of 100 yr
C1	11+176	30.31	RFO	121.8	121.5	31.2	1220	910	0.99	1.45	122.38	126.00	122.54	122.77	0.80	3.46	3.23	Yes	Yes	Yes
C2	12+331	315.90	NRF Box	114.08	113.98	28.5	2440	1520	5.74	8.41	115.88	118.23	116.12	116.39	1.34	2.11	1.84	Yes	Yes	Yes
C3	12+584	1.48	Conc. Box	117.39	117.38	23.2	910	610	0.14	0.23	117.92	119.90	117.93	117.94	0.88	1.97	1.96	Yes	Yes	Yes
C4	13+078	7.51	HDPE	118.77	118.65	34.25		900	0.25	0.36	119.25	121.30	119.29	119.33	0.56	2.01	1.97	Yes	Yes	Yes
C5	13+237	8.23	RFO	119.31	119.27	46.46	1830	1220	0.38	0.56	120.41	121.40	120.41	120.41	0.90	0.99	0.99	Yes	No	Yes
C6	13+588	16.22	HDPE (Lined)	116.07	116.05	55.28		900	0.37	0.60	116.68	124.80	116.74	116.83	0.74	8.06	7.97	Yes	Yes	Yes
C7	13+790	3.73	-	-	-	-	-	-	0.08	0.13	-	-	-	-	-	-	-	-	-	-

Note 1: The maximum of 4 methods was selected as the design flow value (Rational, Northern Ontario Hydrology, Modified Index Flood and Unified Ontario Flood)

C1, C2, C4, C5 - flows were maximum in Northern Ontario Hydrology Method
C3, C6, C7 - flows were maximum in Rational Method
The culvert C7 is buried

6. DRAINAGE AND SWM PLAN

6.1 Highway Drainage

The recommended option considers fully urbanizing the section between Dairy Road and Angus Campbell Drive with centre two-way left-turn lane (TWLT), cycle tracks and sidewalks in the boulevard on both sides. This will require widening of ROW from 26m to 30m.

The roadway design is illustrated on **Drawing SWM-02**.

The quantity of runoff resulting from major storms within the urban section will be conveyed to two existing low points as overland flow. The general direction of roadway overland flow is shown on **Drawing SWM-02.** The minor drainage system at urban sections will be conveyed by storm sewers. The existing storm sewers are capable of accommodating proposed condition flows generated within the right-of way. The proposed storm drainage system configuration is shown on **Drawing SWM-02.** All storm sewers will be designed to meet the MTO Standards and provided sufficient capacity to convey the 10-year storm event. The sewer design sheets provided in **Appendix C** demonstrate that the minor flow increases in proposed condition are insignificant and the existing storm lines will continue to hold future flows.

The existing catch basins and manholes will need to be replaced/relocated as required to account for the proposed road widening and improvements. At few locations where currently there are no existing storm sewers, new storm sewers are proposed to safely convey the proposed roadway runoff during the design storm.

It is anticipated that the quantity of runoff from the improved section of the roadway will not result in a significant increase in post condition flow, and as such, specific techniques to reduce the quantity and rate of runoff are not considered warranted. This is due to the fact that the peak flows generated from the upstream rural catchments are much greater than the peak flows generated from smaller roadway paved areas, which occur earlier. Due to this lagging effect a small increase in the peak flow generated by the roadway does not result in an appreciable increase in the peak flow of the overall hydrograph.

The preferred option from Dairy Road to the Quebec Border maintains the existing rural cross-section with buffered paved shoulders. Therefore, there will not be any change in the existing drainage strategy and roadway runoff will continue to be conveyed by roadside ditches. The existing roadside ditches will continue to provide water quantity and quality controls.

The paved roadway areas will require water quality treatment to control the amount of pollutants draining to the receiving drainage systems.

The list of stormwater management measures that may be considered include:

1. Water Quality Inlets (Oil/Grit Separators)

2. Enhanced Grassed Swales

3. Infiltration Facilities

Each of these types of SWM measures was reviewed for application to this project.

6.1.1 "DO NOTHING" ALTERNATIVE

If nothing is done to mitigate these effects, the receiving watercourses may be negatively impacted with the potential of reduced stream water quality, in-stream erosion and degraded aquatic habitat. Since there are potential negative consequences associated with the "Do Nothing" alternative, it cannot be considered as a reasonable or acceptable course of action. Hence, some form of mitigation measures must be undertaken to manage the stormwater runoff from the proposed roadway improvement.

6.1.2 WATER QUALITY INLETS (OIL/GRIT SEPARATORS)

Water quality inlets, also known as oil/grit separators (OGS), combine storage chambers for sediment trapping and oil separation with drainage inlets or inflow sewers for intercepting or receiving roadway stormwater runoff. Oil/grit separators are capable of removing up to 80% of the sediment load when properly applied as a source control for small areas. This type of SWMP was considered feasible for this project.

6.1.3 ENHANCES GRASSED SWALES

Enhanced grassed swales are formed by widening the roadway ditches and install small porous check dams to retard the stormwater flow. The check dams slow down and detain the flow, increasing the degree of sedimentation and infiltration process. The ditch also provide additional storage capacity for flow retention and sediment accumulation. Due to the limited storage capacity in the ditches, the degree of flow control may be small; however, they are more effective at controlling runoff from smaller and more frequent storm events, which result in some erosion control benefit. Enhance grassed ditches can be created with relatively minor modifications to the standard ditches in a rural roadway section. Since there are existing roadside ditches located within the road right-of-way limits of the rural segment of the Highway 148, this option was considered to be a feasible water quality and quantity control measures.

6.1.4 INFILTRATION FACILITIES

Infiltration facilities capture runoff for infiltration to groundwater. This reduces the rates of runoff to the receiving streams and provides a high level of treatment through the capture of both particulate and dissolved constituents. These types of facilities reduce water temperature impacts and enhance stream base flows through groundwater recharge. Since the volume of runoff to the receiving streams is reduced, these facilities also contribute to controlling downstream erosion and peak flow rates.

The disadvantage of these types of facilities is that they tend to become clogged by sediment wash-off from the roadway. As a result, the maintenance of an infiltration facility may be more frequent and more costly than other types of stormwater management. A second disadvantage is the need to protect the groundwater from contamination from chlorides and other constituents of road runoff. For these reasons, infiltration facilities were not considered for further review.

6.2 Preferred SWM Measures

The proposed drainage plan is shown on **Drawing SWM-02** where new catch basins/manholes and storm sewers are recommended. Water quality control is required for all paved areas associated with the proposed improvement of Highway 148, according to MOECC and MTO Criteria.

A number of stormwater quality control practices were reviewed and assessed for their applicability on this project. After considering the site conditions, it was determined that two possible SWM measures were applicable for use, namely Oil/grit Seperator system and roadside grassed swale.

In general, stormwater from the urbanized section between Dairy Road and Angus Campbell Drive will be treated by Oil Grit Seperator (OGS) units before discharging to the receiving drainage systems.

A total of four (4) OGS units have been proposed within the study corridor of Highway 148. The proposed OGS locations are shown on Drawing **SWM-02**. The OGS units will be designed to provide Enhanced Level (80% SS removal) of protection. The sizing of OGS units will be performed during detail design stage.

The rural section of Highway 148 from Dairy Road to the Quebec Border maintains the existing roadside ditches. Therefore, there will not be any change in the existing drainage strategy and roadway runoff will continue to be conveyed by roadside ditches. The existing roadside ditches will continue to provide stormwater quality controls.

7. EROSION AND SEDIMENT CONTROL

7.1 Introduction

If uncontrolled, the construction activity associated with Highway 148 improvements could result in increased rates of erosion and sedimentation within and adjacent to the site area. Erosion, for the purposes of this discussion, is described as the process whereby soil particles are detached from an exposed surface and transported by water, wind or some other agent. Sedimentation is defined as the deposition of (eroded) particles at a "downstream" point, typically a watercourse. The potential environmental impacts from increased erosion and sedimentation include: degradation of water quality; destruction of fisheries habitat; and, increased flooding potential.

Erosion and sedimentation processes are typically accelerated due to construction activities. Literature indicates that construction activities can increase erosion and sedimentation rates by 2 to 3 orders of magnitude over that expected from a natural forested area. Erosion and sedimentation control are therefore an integral and important component in the design and construction of any project.

7.2 Erosion and Sediment Control Measures

To minimize the potential environmental impacts, the following erosion and sedimentation control practices will serve to guide the design and implementation phase of the Erosion and Sedimentation Control Plan:

- Limit size of disturbed area,
- Limit duration of soil exposure,
- Retain existing vegetation where feasible,
- Limit slope, length and gradient of disturbed areas,

- Preserve overland sheet flow and micro-drainage (avoid concentrated channel flow),
- Break and redirect flows to lower gradients,
- Design and implement staged stripping,
- Prevent disturbance of previously stripped and stabilized parcels, and
- Stabilize stripped parcels with temporary vegetative controls.

Appropriate permanent/temporary erosion control measures to be considered in the design and implementation of the Erosion and Sedimentation Control Plan are:

Hydroseeding/Seed and Bonded Fibre Matrix - One step application of seed and hydraulic slurry with adhesive binder (provides permanent stabilization for moderate to steep slopes).

Seed and Straw Mulch - Alternative two step application that will be applied to provide permanent/temporary vegetative stabilization of disturbed areas.

Mulch (straw, wood etc.) - Used to provide temporary erosion protection of exposed slopes during over-wintering and for disturbed areas inactive for greater than 45 days.

Sod - Utilized to provide quick permanent stabilization of disturbed areas. Applications include lateral ditches with gradients <5% and slopes with steep to moderate grades (i.e. 3% to 5%).

Erosion Control Blanket - Applied as temporary/permanent erosion protection for slopes greater than 2:1 or as a ditch liner. For permanent applications, seed will be applied prior to installation.

Aggregate Stone - Appropriate material, such as rip rap will be used to provide immediate permanent erosion protection of lateral ditches >5% gradient; and along chute/spillways. Geotextile fabric will be applied prior to placement of any aggregate material.permanent/

7.3 Sediment Control

The following elements should be included in the sediment control plan:

- Provision of a series of temporary interceptor/conveyor ditches to direct runoff to the siltation/watercourses;
- Provision of rock or flow checks within drainage swales/ditches; and
- Placement of a series of silt control fencing for the interception of sheet flow drainage.

All sediment control measures should not be removed until final stabilization of the site. In addition, any accumulated sediment shall be removed, as part of a maintenance program, from all control measures when accumulation reaches 50% of the height or volume of the control structure.

Environmental Inspection Process - As a component of erosion and sedimentation control, environmental inspections of the construction site will be conducted. Environmental inspections will be conducted to assess the performance of erosion and sedimentation control measures and

identify any required maintenance. The frequent inspections will also permit the identification of localized erosion and sedimentation control issues that require site specific attention.

Implementation and Recommendation - A 200 m standby supply of prefabricated silt fence barrier, in addition to silt fence requirements, shall be maintained at the construction site prior to commencement of grading operations and throughout the duration of the contract.

Where interceptor ditches and/or subsurface drains are specified, they shall be constructed prior to commencement of any related cut or fill activities.

Cut and fill earth slopes and ditches, shall be treated with the specified cover material (seed and mulch, seed and erosion control blanket, seed and sod, rip rap, etc.) within 45 days from the commencement of the cut, fill or ditching operation. Commencement of a cut, fill or ditching operation shall be considered to have occurred when the original stabilizing cover has been removed, including grubbing, or has been covered with fill material.

Run-off from the site and stockpiles shall be controlled to the extent possible to minimize sediment entry to the adjacent watercourses.

Where dewatering is required, and where culverts are cleaned by hydraulic means, the effluent shall be discharged in a manner that prevents the entry of sediments to watercourses, or scouring and erosion at the outlet.

All erosion and sediment control measures will be clearly stated in the contract drawings and documents.

8. CONCLUSIONS AND RECOMMANDATIONS

This report documents the drainage and stormwater management aspects associated with the Highway 148 roadway improvements. It outlines the proposed stormwater management strategy adopted for this project. Hydrologic and hydraulic analyses were undertaken to determine the design features of all required drainage elements. A detail layout of the features of the recommended stormwater management system is provided. Erosion and sediment control plan of the development have been outlined and guidelines for the preparation of an erosion and sediment control plan prescribed.

Recommendation of this study are as follows:

- The existing storm sewer system underneath Highway 148 will continue to convey flows across the Highway.
- Install a new drainage system where proposed storm sewers will be placed at multiple locations and tie into the existing system;
- All existing culverts meet the current design standards/criteria. All cross-drainage culverts have sufficient capacity to convey the 115% of 100 year design storm without overtopping the road.
- New catch basins will be installed at the urban section on both sides of Highway to collect runoff generated from the paved areas.

- Install four (04) Oil/Grit Separators (OGS) units within the study corridor of Highway 148 to provide water quality control of the runoff generated from paved areas.
- The existing road side ditches east of Drive-In Road will continue to provide water quality/quantity control to Highway 148 runoff before discharging to receiving systems.
- There are four low points located on Highway 148 which provide overland flow route to major system runoff.
- Sediment and erosion control measures will be installed prior to construction.
- Inspections are recommended to be conducted during all stages of construction to assess the performance of erosion and sedimentation control measures.
- There are no stormwater management facilities adjacent to the project corridor.

APPENDIX A

Hydrologic Input Parameters and Flow Calculations

Table 1: Catchment Parameters

Culvert No.	Station	Drainage Area	Drainage Area	Percent of Wetland	Soil Type	Land Use	Composite Values of Parameters		
							Runoff Coefficient	SCS Curve No.	Initial Abstraction
		A	A				C	CN	I_a
		ha	km^3	%					mm
C1	11+176	30.31	0.30	0.00	Sandy Loam	Range, Grass, Woods	0.23	69.01	3.36
C2	12+331	315.90	3.16	0.04	Sandy Loam	Range, Grass, Woods	0.17	67.40	3.47
C3	12+584	1.48	0.01	0.00	Sandy Loam	Grass, Woods	0.25	72.19	2.86
C4	13+078	7.51	0.08	1.88	Sandy Loam	Range	0.11	59.32	4.91
C5	13+237	8.23	0.08	0.00	Sandy Loam	Grass, Woods	0.13	70.78	2.58
C6	13+588	16.22	0.16	5.80	Sandy Loam	Range, Woods	0.13	56.15	5.74
C7	13+790	3.73	0.04	29.49	Sandy Loam	Grass, Woods	0.07	48.64	6.37

Note 1: Run-off coefficient. C is from Design Chart 1.07 (p-22)
Note 2: SCS Curve No. CN is from Design Chart 1.09 (p-26)

Culvert No.	Area (ha)							Runoff Coefficient, C							SCS Curve No., CN							Initial Abstraction (mm)						
	Agriculture	Range	Woods	Wetland	Bare Rock	Grass	Impervious	Agriculture	Range	Woods	Wetland	Bare Rock	Grass	Impervious	Agriculture	Range	Woods	Wetland	Bare Rock	Grass	Impervious	Agriculture	Range	Woods	Wetland	Bare Rock	Grass	Impervious
C1	0.00	17.21	0.60	0.00	0.00	7.40	5.10	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00
C2	0.00	142.38	26.10	0.12	0.00	116.80	30.50	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00
C3	0.00	0.00	0.38	0.00	0.00	0.80	0.30	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00
C4	0.00	7.24	0.00	0.14	0.00	0.00	0.13	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00
C5	0.00	0.00	1.49	0.00	0.00	6.23	0.51	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00
C6	0.00	9.29	5.24	0.94	0.00	0.00	0.75	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00
C7	0.00	0.00	2.20	1.10	0.00	0.43	0.00	0.22	0.10	0.08	0.05	0.40	0.08	0.90	70.00	59.00	48.00	40.00	89.00	74.00	98.00	4.00	5.00	8.00	10.00	0.00	1.50	0.00

Table 2: Hydrologic Assessment of Culverts at Highway 148 (Rational Method)

Culvert No.	Station	Drainage Area	Catchment Length	Water shed U/s Elev.	Water shed D/s Elev.	Slope	Time of Conc.	Time of Conc.	2 Year Storm		5 Year Storm		10 Year Storm		25 Year Storm		50 Year Storm		100 Year Storm		Adjusted Flow						CHK Flood
									Intensity	Flow	Intensity	Flow	Intensity	Flow	Intensity	Flow	Intensity	Flow	Intensity	Flow	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	
		A	L			S	T_c	T_c	I_2	Q	I_5	Q	I_{10}	Q	I_{25}	Q	I_{50}	Q	I_{100}	Q	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	$115\%Q_{100}$
		ha	m	m	m	%	min	hr	mm/hr	cms	mm/hr	cms	mm/hr	cms	mm/hr	cms	mm/hr	cms	mm/hr	cms	cms	cms	cms	cms	cms	cms	cms
C1	11+176	30.31	1600	130	122	0.50	143	2.38	12.7	0.249	17.4	0.339	19.4	0.379	23.2	0.499	26.0	0.609	28.7	0.701	0.249	0.339	0.379	0.499	0.609	0.701	0.81
C2	12+331	315.90	3222	145	114	0.96	165	2.75	11.4	2.214	15.5	3.016	17.3	3.372	20.7	4.433	23.2	5.411	25.6	6.233	2.037	2.775	3.102	4.078	4.978	5.734	6.59
C3	12+584	1.48	90	130	122	8.89	13	0.21	67.4	0.069	92.1	0.094	105.7	0.108	126.3	0.142	141.4	0.173	156.3	0.199	0.069	0.094	0.108	0.142	0.173	0.199	0.23
C4	13+078	7.51	585	130	119	1.88	56	0.94	25.7	0.119	35.1	0.162	39.6	0.183	47.4	0.241	53.0	0.294	58.6	0.339	0.089	0.121	0.137	0.180	0.219	0.252	0.29
C5	13+237	8.23	480	130	120	2.08	49	0.82	28.3	0.144	38.6	0.196	43.7	0.222	52.2	0.291	58.4	0.355	64.6	0.409	0.144	0.196	0.222	0.291	0.355	0.409	0.47
C6	13+588	16.22	500	130	116	2.80	46	0.76	29.9	0.299	40.8	0.408	46.2	0.462	55.2	0.607	61.8	0.741	68.3	0.854	0.182	0.249	0.282	0.370	0.452	0.521	0.60
C7	13+790	3.73	240	115	112	1.25	41	0.69	32.1	0.074	43.8	0.101	49.7	0.114	59.4	0.150	66.5	0.183	73.5	0.211	0.041	0.055	0.063	0.083	0.101	0.116	0.13

Note 1: Q = 0.0028*A*C*I

Note 2: I = a/(T_c+b)^c

Note 3: For storms having return period of more than 10 years increase the runoff coefficient © as follows to a maximum value of 0.95

Note 4: Reduction factor K_s is from Design Chart 1.06

Note 5: Use Airport Equation to calculate Time of Concentration (T_c) for C < 0.40, and Bransby-Williams Equation for C > 0.40

Ottawa IDF Parameters:

Return Period	a	b	c
2 yr	733	6.2	0.81
5 yr	998	6.1	0.81
10 yr	1174	6.0	0.82
25 yr	1403	6.0	0.82
50 yr	1570	6.0	0.82
100 yr	1736	6.0	0.82

25 yr, add 10% 50 yr, add 20% 100 yr, add 25%

Runoff Coefficient:

Culv No.	Runoff Coefficient, C					
	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
C1	0.23	0.23	0.23	*0.25*	0.27	0.29
C2	0.22	0.22	0.22	0.24	0.26	0.28
C3	0.25	0.25	0.25	0.27	0.30	0.31
C4	0.22	0.22	0.22	0.24	0.26	0.28
C5	0.22	0.22	0.22	0.24	0.26	0.28
C6	0.22	0.22	0.22	0.24	0.26	0.28
C7	0.22	0.22	0.22	0.24	0.26	0.28

Reduction factor, K_s:

Culv No.	Percent of Lake and Wetlands	Curve	K_s
	%		
C1	0.00	None	1.000
C2	0.04	A	0.920
C3	*0.00*	None	1.000
C4	1.88	C	0.745
C5	*0.00*	None	1.000
C6	5.80	C	0.610
C7	29.49	B	0.55

Airport Equation:

$$t_c = \frac{3.26 \times (1.1 - C) \times L^{0.5}}{S_w^{0.33}}$$

where:

C = rational method runoff coefficient

L = length of overland flow, m

S = surface slope, %

Table 3

Hydrologic Assessment of Culverts at Highway 148 (Northern Ontario Hydrology Method)

Culvert No.	Station	Drainage Area	Wetaland Area	Area Ratio	Mean Annual Discharge	Coefficient of Discharge	Coefficient of Skew	Peaking Factor	Frequency Factor						Maximum Daily Discharge						Maximum Instantaneous Discharge						CHK Flood
									2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	
		A	A_d	Ad/A	Q_m	C_v	C_s	P_f	K	K	K	K	K	K	Q_t	Q_t	Q_t	Q_t	Q_t	Q_t	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	$115\%Q_{100}$
		km^2	km^2		cms	-	-	-	-	-	-	-	-	-	cms	cms	cms	cms	cms	cms	cms	cms	cms	cms	cms	cms	cms
C1	11+176	0.30	0.000	0.0000	0.05	0.50	1.21	10.22	-0.16	0.72	1.30	2.04	2.59	3.14	0.044	0.065	0.079	0.097	0.110	0.124	0.451	0.667	0.810	0.992	1.128	1.263	1.45
C2	12+331	3.16	0.001	0.0004	0.57	0.50	1.21	4.94	-0.16	0.72	1.30	2.04	2.59	3.14	0.529	0.783	0.950	1.163	1.322	1.481	2.612	3.865	4.691	5.745	6.529	7.312	8.41
C3	12+584	0.01	0.000	0.0000	0.00	0.50	1.21	28.34	-0.16	0.72	1.30	2.04	2.59	3.14	0.002	0.003	0.003	0.004	0.004	0.005	0.051	0.075	0.092	0.112	0.127	0.143	0.16
C4	13+078	0.08	0.001	0.0188	0.01	0.48	1.14	11.87	-0.16	0.72	1.30	2.04	2.59	3.14	0.010	0.014	0.017	0.021	0.024	0.027	0.115	0.168	0.203	0.248	0.281	0.315	0.36
C5	13+237	0.08	0.000	0.0000	0.01	0.50	1.21	15.74	-0.16	0.72	1.30	2.04	2.59	3.14	0.011	0.016	0.020	0.024	0.028	0.031	0.174	0.258	0.313	0.384	0.436	0.489	0.56
C6	13+588	0.16	0.009	0.0580	0.02	0.45	0.99	5.07	-0.13	0.77	1.33	1.99	2.46	2.90	0.021	0.029	0.035	0.041	0.046	0.050	0.104	0.149	0.177	0.210	0.233	0.255	0.29
C7	13+790	0.04	0.011	0.2973	0.002	0.26	0.10	1.09	-0.09	0.81	1.34	1.93	2.32	2.67	0.002	0.003	0.003	0.004	0.004	0.004	0.003	0.003	0.004	0.004	0.004	0.005	0.01

Note 1: $Q_m=0.170*A^{1.06}*(1-A_d/A)^{2.07}$ $C_v=0.502*(1-A_d/A)^{1.85}$ $C_s=2.52+[3.73*(1-A_d/A)]$ $P_f=1.0+6.0*A^{(-0.36)}*e^{[-18*(A_d/A)]}$ $Q_t=Qm*(1+k*C_v)$ $Q=Qt*P_f$

Note 2: Frequency factor k is from Design Chart 1.2

Ref: Chapter 8, Part 3, MTO Drainage Management Manual, 1997

Table 4

Hydrologic Assessment of Culverts at Highway 148 (MTO Modified Index Flood Method)

Culvert No.	Station	Drainage Area	Storage Area from Lakes & Swamps	Storage Percent	Warershed Base Class		Watershed Class	Class Coefficient	25 Year Flow	Peak Flow						CHK Flood
										2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	
		A	A_d		WCb	WCa	WC	C	Q_{25}	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}	$115\%Q_{100}$
		km^2	km^2	%	-	-	-	-	cms	cms	cms	cms	cms	cms	cms	cms
C1	11+176	0.30	0.000	0.000	7.20	0.00	7.20	1.39	0.56	0.30	0.39	0.47	0.56	0.63	0.70	0.81
C2	12+331	3.16	0.001	0.032	7.20	0.00	7.20	1.39	3.29	1.77	2.30	2.76	3.29	3.68	4.11	4.73
C3	12+584	0.01	0.000	0.000	7.20	0.00	7.20	1.39	0.06	0.03	0.04	0.05	0.06	0.07	0.07	0.08
C4	13+078	0.08	0.001	1.877	6.98	0.00	6.98	1.29	0.19	0.10	0.13	0.16	0.19	0.21	0.23	0.27
C5	13+237	0.08	0.000	0.000	7.20	0.00	7.20	1.39	0.21	0.12	0.15	0.18	0.21	0.24	0.27	0.31
C6	13+588	0.16	0.009	5.795	6.45	0.00	6.45	1.07	0.27	0.15	0.19	0.23	0.27	0.31	0.34	0.39
C7	13+790	0.04	0.011	29.491	3.30	0.00	3.30	0.35	0.03	0.02	0.02	0.02	0.03	0.03	0.04	0.04

Note 1: Watershed Base Class, WCb is from Design Chart 1.16

Note 2: Storage Adjustment, Wca

A. Storage mostly in upper basin	Adjust=	0.5
B. Storage evenly distributed in basin	Adjust=	0.0
C. Storage mostly in lower basin	Adjust=	-0.5
D. Storage evenly distributed in basin	Adjust=	0.0

Note 3: Class Coefficient, C is from Design Chart 1.15

Note 4: 25 Year Flow, Q25 = C*A^0.75

Note 5: Frequency Conversion Factor , is from Chart H5-9

Frequency Conversion Factor					
2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
0.54	0.7	0.84	1	1.12	1.25

Ref: Chapter 8, Part 3, MTO Drainage Management Manual, 1997

Table 5: Hydrologic Assessment of Culverts at Highway 148 (MTO Unified Ontario Flood Method)

Coefficients of the Regression Model and Output Summary:

T	x	a	b	c	Adjusted R^2	Standard error (log units)
Boreal Shield						
2	-10.870	0.839	-4.633	3.583	0.965	0.159
10	-8.583	0.795	-4.522	2.917	0.954	0.174
25	-7.834	0.779	-4.510	2.703	0.947	0.183
50	-7.371	0.769	-4.520	2.572	0.942	0.189
100	-6.967	0.759	-4.541	2.457	0.937	0.195

Range of Quantile Estimates:

T	Standard error (log units)	Range of Quantiles	
		Lower Limit	Upper Limit
Boreal Shield			
2	0.159	-31%	44%
10	0.174	-33%	49%
25	0.183	-34%	52%
50	0.189	-35%	55%
100	0.195	-36%	57%

$Q_{UOFM} = K_r * A^a * Li^b * P^c$ $K_r = 10^x$ (x = value of constant obtained from the output of stepwise regression)

Culvert No.	Station	Drainage Area (A)	Areas of Lakes and Wetlands	Lake Attenuation Index (LI)	Mean Annual Precipitation (p)	Design/Lower/Upper Ranges	2-Year Flow	10-Year Flow	25-Year Flow	50-Year Flow	100-Year Flow	CHK Flood (115% Q_{100})
		$(km)^2$	$(km)^2$		(mm)							
C1	11+176	0.303	0	1	840	Q_{uofm}	0.149	0.343	0.464	0.564	0.667	0.767
						Lower Limit of U_{uofm}	0.103	0.230	0.306	0.367	0.427	0.491
						Upper Limit of U_{uofm}	0.214	0.511	0.705	0.875	1.048	1.205
C2	12+331	3.159	0.0012	1.0003	840	Q_{uofm}	1.062	2.206	2.876	3.417	3.948	4.540
						Lower Limit of U_{uofm}	0.733	1.478	1.898	2.221	2.527	2.906
						Upper Limit of U_{uofm}	1.529	3.286	4.371	5.296	6.198	7.128
C3	12+584	0.01	0	1	840	Q_{uofm}	0.012	0.031	0.044	0.055	0.067	0.078
						Lower Limit of U_{uofm}	0.008	0.021	0.029	0.036	0.043	0.050
						Upper Limit of U_{uofm}	0.017	0.046	0.067	0.086	0.106	0.122
C4	13+078	0.08	0.141	2.8774	840	Q_{uofm}	0.046	0.113	0.156	0.193	0.232	0.266
						Lower Limit of U_{uofm}	0.032	0.076	0.103	0.125	0.148	0.170
						Upper Limit of U_{uofm}	0.066	0.168	0.238	0.299	0.363	0.418
C5	13+237	0.08	0	1	840	Q_{uofm}	0.050	0.122	0.168	0.207	0.248	0.285
						Lower Limit of U_{uofm}	0.034	0.081	0.111	0.135	0.159	0.183
						Upper Limit of U_{uofm}	0.072	0.181	0.255	0.321	0.390	0.448
C6	13+588	0.16	0.00939	1.0578	840	Q_{uofm}	0.068	0.162	0.221	0.271	0.322	0.370
						Lower Limit of U_{uofm}	0.047	0.108	0.146	0.176	0.206	0.237
						Upper Limit of U_{uofm}	0.098	0.241	0.336	0.419	0.505	0.581
C7	13+790	0.04	0.0302	1.8096	840	Q_{uofm}	0.002	0.004	0.006	0.008	0.009	0.011
						Lower Limit of U_{uofm}	0.001	0.003	0.004	0.005	0.006	0.007
						Upper Limit of U_{uofm}	0.002	0.007	0.010	0.012	0.014	0.017

Table 6.a: Peak Flows - Centreline Culvert at 11+176 (C1)

Method Used	Drainage Area (ha)	Peak Flows (m^3/sec)			CHK Flood
		Q_{25}	Q_{50}	Q_{100}	115%Q_{100}
Rational Method	30.31	0.499	0.609	0.701	0.810
Northern Ontario Hydrology Method		0.992	1.128	1.263	1.45
Modified Index Flood Method		0.56	0.63	0.70	0.81
Unified Ontario Flood Method		0.464	0.564	0.667	0.767

Table 6.b: Peak Flows - Centreline Culvert at 12+331 (C2)

Method Used	Drainage Area (ha)				CHK Flood
		Q_{25}	Q_{50}	Q_{100}	115%Q_{100}
Rational Method	315.90	4.078	4.978	5.734	6.59
Northern Ontario Hydrology Method		5.745	6.529	7.31	8.41
Modified Index Flood Method		3.29	3.68	4.11	4.73
Unified Ontario Flood Method		2.88	3.42	3.95	4.54

Table 6.c: Peak Flows - Centreline Culvert at 12+584 (C3)

Method Used	Drainage Area (ha)				CHK Flood
		Q_{25}	Q_{50}	Q_{100}	115%Q_{100}
Rational Method	1.48	0.142	0.173	0.199	0.229
Northern Ontario Hydrology Method		0.112	0.127	0.143	0.164
Modified Index Flood Method		0.059	0.066	0.074	0.085
Unified Ontario Flood Method		0.044	0.055	0.067	0.078

Table 6.d: Peak Flows - Centreline Culvert at 13+078 (C4)

Method Used	Drainage Area (ha)				CHK Flood
		Q_{25}	Q_{50}	Q_{100}	115%Q_{100}
Rational Method	7.51	0.180	0.219	0.252	0.290
Northern Ontario Hydrology Method		0.248	0.281	0.315	0.362
Modified Index Flood Method		0.185	0.207	0.231	0.266
Unified Ontario Flood Method		0.156	0.193	0.232	0.266

Table 6.e: Peak Flows - Centreline Culvert at 13+237 (C5)

Method Used	Drainage Area (ha)				CHK Flood
		Q_{25}	Q_{50}	Q_{100}	$115\%Q_{100}$
Rational Method	8.23	0.291	0.355	0.409	0.471
Northern Ontario Hydrology Method		0.384	0.436	0.489	0.562
Modified Index Flood Method		0.214	0.239	0.267	0.307
Unified Ontario Flood Method		0.168	0.207	0.248	0.285

Table 6.f: Peak Flows - Centreline Culvert at 13+588 (C6)

Method Used	Drainage Area (ha)				CHK Flood
		Q_{25}	Q_{50}	Q_{100}	$115\%Q_{100}$
Rational Method	16.22	0.370	0.452	0.521	0.599
Northern Ontario Hydrology Method		0.210	0.233	0.255	0.293
Modified Index Flood Method		0.273	0.306	0.342	0.393
Unified Ontario Flood Method		0.221	0.271	0.322	0.370

Table 6.g: Peak Flows - Centreline Culvert at 13+790 (C7)

Method Used	Drainage Area (ha)				CHK Flood
		Q_{25}	Q_{50}	Q_{100}	$115\%Q_{100}$
Rational Method	3.73	0.083	0.101	0.116	0.134
Northern Ontario Hydrology Method		0.004	0.004	0.005	0.005
Modified Index Flood Method		0.030	0.033	0.037	0.043
Unified Ontario Flood Method		0.006	0.008	0.009	0.011

APPENDIX B

Culvert Master Output

Culvert Design Report
Station 13+237- Ex <revised dec 16>

Peak Discharge Method: User-Specified					
Design Discharge	0.3840	m3/s	Check Discharge	0.5620	m3/s

Grades Model: Inverts					
Invert Upstream	119.31	m	Invert Downstream	119.27	m
Length	46.46	m	Slope	0.000861	m/m
Drop	0.04	m			

Headwater Model: Maximum Allowable HW		
Headwater Elevation	121.40	m

Tailwater Conditions: Constant Tailwater		
Tailwater Elevation	120.41	m

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1830 x 1220 mm Box	0.3840 m3/s	120.41 m	0.18 m/s
	Trial-2	1-1830 x 1220 mm Box	0.5620 m3/s	120.41 m	0.27 m/s

Culvert Design Report
Station 13+237- Ex <revised dec 16>

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	121.40	m	Storm Event	Design	
Computed Headwater Elevation	120.41	m	Discharge	0.3840	m3/s
Headwater Depth/Height	0.90		Tailwater Elevation	120.41	m
Inlet Control HW Elev.	120.41	m	Control Type	Outlet Control	
Outlet Control HW Elev.	120.41	m			

Grades					
Upstream Invert	119.31	m	Downstream Invert	119.27	m
Length	46.46	m	Constructed Slope	0.000861	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	1.14	m
Slope Type	Mild		Normal Depth	0.27	m
Flow Regime	Subcritical		Critical Depth	0.17	m
Velocity Downstream	0.18	m/s	Critical Slope	0.003770	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.83	m
Section Size	1830 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	120.41	m	Upstream Velocity Head	0.00	m
Ke	0.20		Entrance Loss	0.00	m

Inlet Control Properties					
Inlet Control HW Elev.	120.41	m	Flow Control	Unsubmerged	
Inlet Type	90° headwall w 45° bevels		Area Full	2.2	m2
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

Culvert Design Report
Station 13+237- Ex <revised dec 16>

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	121.40	m	Storm Event	Check	
Computed Headwater Elevation	120.41	m	Discharge	0.5620	m3/s
Headwater Depth/Height	0.90		Tailwater Elevation	120.41	m
Inlet Control HW Elev.	120.41	m	Control Type	Outlet Control	
Outlet Control HW Elev.	120.41	m			

Grades					
Upstream Invert	119.31	m	Downstream Invert	119.27	m
Length	46.46	m	Constructed Slope	0.000861	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	1.14	m
Slope Type	Mild		Normal Depth	0.34	m
Flow Regime	Subcritical		Critical Depth	0.21	m
Velocity Downstream	0.27	m/s	Critical Slope	0.003669	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.83	m
Section Size	1830 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	120.41	m	Upstream Velocity Head	0.00	m
Ke	0.70		Entrance Loss	0.00	m

Inlet Control Properties					
Inlet Control HW Elev.	120.41	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	2.2	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 13+588- Ex <revised Dec 16>

Peak Discharge Method: User-Specified					
Design Discharge	0.3700	m3/s	Check Discharge	0.5990	m3/s

Grades Model: Inverts					
Invert Upstream	116.07	m	Invert Downstream	116.05	m
Length	55.28	m	Slope	0.000362	m/m
Drop	0.02	m			

Headwater Model: Maximum Allowable HW		
Headwater Elevation	124.80	m

Tailwater Conditions: Constant Tailwater		
Tailwater Elevation	116.68	m

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-900 mm Circular	0.3700 m3/s	116.74 m	0.77 m/s
	Trial-2	1-900 mm Circular	0.5990 m3/s	116.83 m	1.24 m/s

Culvert Design Report
Station 13+588- Ex <revised Dec 16>

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	124.80	m	Storm Event	Design	
Computed Headwater Elevation	116.74	m	Discharge	0.3700	m3/s
Headwater Depth/Height	0.74		Tailwater Elevation	116.68	m
Inlet Control HW Elev.	116.68	m	Control Type	Outlet Control	
Outlet Control HW Elev.	116.74	m			

Grades					
Upstream Invert	116.07	m	Downstream Invert	116.05	m
Length	55.28	m	Constructed Slope	0.000362	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.63	m
Slope Type	Mild		Normal Depth	0.71	m
Flow Regime	Subcritical		Critical Depth	0.35	m
Velocity Downstream	0.77	m/s	Critical Slope	0.003374	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	116.74	m	Upstream Velocity Head	0.03	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	116.68	m	Flow Control	Unsubmerged	
Inlet Type	Beveled ring, 33.7° bevels		Area Full	0.7	m2
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Culvert Design Report
Station 13+588- Ex <revised Dec 16>

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	124.80	m	Storm Event	Check	
Computed Headwater Elevation	116.83	m	Discharge	0.5990	m3/s
Headwater Depth/Height	0.84		Tailwater Elevation	116.68	m
Inlet Control HW Elev.	116.70	m	Control Type	Outlet Control	
Outlet Control HW Elev.	116.83	m			

Grades					
Upstream Invert	116.07	m	Downstream Invert	116.05	m
Length	55.28	m	Constructed Slope	0.000362	m/m

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.63	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.45	m
Velocity Downstream	1.24	m/s	Critical Slope	0.003604	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	116.83	m	Upstream Velocity Head	0.07	m
Ke	0.20		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	116.70	m	Flow Control	Unsubmerged	
Inlet Type	Beveled ring, 33.7° bevels		Area Full	0.7	m2
K	0.00180		HDS 5 Chart	3	
M	2.50000		HDS 5 Scale	B	
C	0.02430		Equation Form	1	
Y	0.83000				

Culvert Design Report
Station 11+176- Ex <revised nov 17>

Peak Discharge Method: User-Specified					
Design Discharge	0.9920	m3/s	Check Discharge	1.4500	m3/s

Grades Model: Inverts					
Invert Upstream	121.80	m	Invert Downstream	121.50	m
Length	31.20	m	Slope	0.009615	m/m
Drop	0.30	m			

Headwater Model: Maximum Allowable HW		
Headwater Elevation	126.00	m

Tailwater Conditions: Constant Tailwater		
Tailwater Elevation	122.38	m

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-1220 x 910 mm Box	0.9920 m3/s	122.54 m	0.93 m/s
	Trial-2	1-1220 x 910 mm Box	1.4500 m3/s	122.77 m	1.36 m/s

Culvert Design Report
Station 11+176- Ex <revised nov 17>

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	126.00	m	Storm Event	Design	
Computed Headwater Elevation	122.54	m	Discharge	0.9920	m3/s
Headwater Depth/Height	0.80		Tailwater Elevation	122.38	m
Inlet Control HW Elev.	122.49	m	Control Type	Outlet Control	
Outlet Control HW Elev.	122.54	m			

Grades					
Upstream Invert	121.80	m	Downstream Invert	121.50	m
Length	31.20	m	Constructed Slope	0.009615	m/m

Hydraulic Profile					
Profile	S1		Depth, Downstream	0.88	m
Slope Type	Steep		Normal Depth	0.31	m
Flow Regime	Subcritical		Critical Depth	0.41	m
Velocity Downstream	0.93	m/s	Critical Slope	0.004423	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.22	m
Section Size	1220 x 910 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	122.54	m	Upstream Velocity Head	0.12	m
Ke	0.70		Entrance Loss	0.08	m

Inlet Control Properties					
Inlet Control HW Elev.	122.49	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	1.1	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 11+176- Ex <revised nov 17>

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	126.00	m	Storm Event	Check	
Computed Headwater Elevation	122.77	m	Discharge	1.4500	m3/s
Headwater Depth/Height	1.06		Tailwater Elevation	122.38	m
Inlet Control HW Elev.	122.69	m	Control Type	Entrance Control	
Outlet Control HW Elev.	122.77	m			

Grades					
Upstream Invert	121.80	m	Downstream Invert	121.50	m
Length	31.20	m	Constructed Slope	0.009615	m/m

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	0.88	m
Slope Type	Steep		Normal Depth	0.40	m
Flow Regime	N/A		Critical Depth	0.52	m
Velocity Downstream	1.36	m/s	Critical Slope	0.004702	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	1.22	m
Section Size	1220 x 910 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	122.77	m	Upstream Velocity Head	0.26	m
Ke	0.70		Entrance Loss	0.18	m

Inlet Control Properties					
Inlet Control HW Elev.	122.69	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	1.1	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 12+331 - Ex <revised nov 17>

Peak Discharge Method: User-Specified			
Design Discharge	5.7400 m3/s	Check Discharge	8.4100 m3/s

Grades Model: Inverts			
Invert Upstream	114.08 m	Invert Downstream	113.98 m
Length	28.50 m	Slope	0.003509 m/m
Drop	0.10 m		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	118.23 m

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	115.88 m

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-2440 x 1520 mm Box	5.7400 m3/s	116.12 m	1.54 m/s
	Trial-2	1-2440 x 1520 mm Box	8.4100 m3/s	116.39 m	2.26 m/s

Culvert Design Report
Station 12+331 - Ex <revised nov 17>

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	118.23	m	Storm Event	Design	
Computed Headwater Elevation	116.12	m	Discharge	5.7400	m3/s
Headwater Depth/Height	1.34		Tailwater Elevation	115.88	m
Inlet Control HW Elev.	115.88	m	Control Type	Outlet Control	
Outlet Control HW Elev.	116.12	m			

Grades					
Upstream Invert	114.08	m	Downstream Invert	113.98	m
Length	28.50	m	Constructed Slope	0.003509	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	1.90	m
Slope Type	N/A		Normal Depth	0.83	m
Flow Regime	N/A		Critical Depth	0.83	m
Velocity Downstream	1.54	m/s	Critical Slope	0.003521	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1520 mm		Rise	1.52	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	116.12	m	Upstream Velocity Head	0.12	m
Ke	0.70		Entrance Loss	0.09	m

Inlet Control Properties					
Inlet Control HW Elev.	115.88	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	3.7	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 12+331 - Ex <revised nov 17>

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	118.23	m	Storm Event	Check	
Computed Headwater Elevation	116.39	m	Discharge	8.4100	m3/s
Headwater Depth/Height	1.52		Tailwater Elevation	115.88	m
Inlet Control HW Elev.	115.91	m	Control Type	Outlet Control	
Outlet Control HW Elev.	116.39	m			

Grades					
Upstream Invert	114.08	m	Downstream Invert	113.98	m
Length	28.50	m	Constructed Slope	0.003509	m/m

Hydraulic Profile					
Profile	PressureProfile		Depth, Downstream	1.90	m
Slope Type	N/A		Normal Depth	1.09	m
Flow Regime	N/A		Critical Depth	1.07	m
Velocity Downstream	2.26	m/s	Critical Slope	0.003750	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1520 mm		Rise	1.52	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	116.39	m	Upstream Velocity Head	0.26	m
Ke	0.70		Entrance Loss	0.18	m

Inlet Control Properties					
Inlet Control HW Elev.	115.91	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	3.7	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 12+584 - Ex <revsied 2016>

Peak Discharge Method: User-Specified			
Design Discharge	0.1420 m3/s	Check Discharge	0.2290 m3/s
Grades Model: Inverts			
Invert Upstream	117.39 m	Invert Downstream	117.38 m
Length	23.20 m	Slope	0.000431 m/m
Drop	0.01 m		
Headwater Model: Maximum Allowable HW			
Headwater Elevation	119.90 m		
Tailwater Conditions: Constant Tailwater			
Tailwater Elevation	117.92 m		

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-910 x 610 mm Box	0.1420 m3/s	117.93 m	0.29 m/s
	Trial-2	1-910 x 610 mm Box	0.2290 m3/s	117.94 m	0.46 m/s

Culvert Design Report
Station 12+584 - Ex <revsied 2016>

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	119.90	m	Storm Event	Design	
Computed Headwater Elevation	117.93	m	Discharge	0.1420	m3/s
Headwater Depth/Height	0.88		Tailwater Elevation	117.92	m
Inlet Control HW Elev.	117.92	m	Control Type	Outlet Control	
Outlet Control HW Elev.	117.93	m			

Grades					
Upstream Invert	117.39	m	Downstream Invert	117.38	m
Length	23.20	m	Constructed Slope	0.000431	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.54	m
Slope Type	Mild		Normal Depth	0.30	m
Flow Regime	Subcritical		Critical Depth	0.13	m
Velocity Downstream	0.29	m/s	Critical Slope	0.004562	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	0.91	m
Section Size	910 x 610 mm		Rise	0.61	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	117.93	m	Upstream Velocity Head	0.00	m
Ke	0.70		Entrance Loss	0.00	m

Inlet Control Properties					
Inlet Control HW Elev.	117.92	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	0.6	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 12+584 - Ex <revsied 2016>

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	119.90	m	Storm Event	Check	
Computed Headwater Elevation	117.94	m	Discharge	0.2290	m3/s
Headwater Depth/Height	0.91		Tailwater Elevation	117.92	m
Inlet Control HW Elev.	117.92	m	Control Type	Outlet Control	
Outlet Control HW Elev.	117.94	m			

Grades					
Upstream Invert	117.39	m	Downstream Invert	117.38	m
Length	23.20	m	Constructed Slope	0.000431	m/m

Hydraulic Profile					
Profile	M1		Depth, Downstream	0.54	m
Slope Type	Mild		Normal Depth	0.43	m
Flow Regime	Subcritical		Critical Depth	0.19	m
Velocity Downstream	0.46	m/s	Critical Slope	0.004576	m/m

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	0.91	m
Section Size	910 x 610 mm		Rise	0.61	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	117.94	m	Upstream Velocity Head	0.01	m
Ke	0.70		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	117.92	m	Flow Control	Unsubmerged	
Inlet Type	0° wingwall flares		Area Full	0.6	m2
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Design Report
Station 13+078 - Ex <revised 2016>

Peak Discharge Method: User-Specified					
Design Discharge	0.2480	m3/s	Check Discharge	0.3620	m3/s

Grades Model: Inverts					
Invert Upstream	118.77	m	Invert Downstream	118.65	m
Length	34.25	m	Slope	0.003504	m/m
Drop	0.12	m			

Headwater Model: Maximum Allowable HW	
Headwater Elevation	121.30

Tailwater Conditions: Constant Tailwater		
Tailwater Elevation	119.25	m

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-900 mm Circular	0.2480 m3/s	119.29 m	0.55 m/s
	Trial-2	1-900 mm Circular	0.3620 m3/s	119.33 m	0.80 m/s

Culvert Design Report
Station 13+078 - Ex <revised 2016>

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	121.30	m	Storm Event	Design	
Computed Headwater Elevation	119.29	m	Discharge	0.2480	m3/s
Headwater Depth/Height	0.56		Tailwater Elevation	119.25	m
Inlet Control HW Elev.	119.25	m	Control Type	Outlet Control	
Outlet Control HW Elev.	119.29	m			

Grades					
Upstream Invert	118.77	m	Downstream Invert	118.65	m
Length	34.25	m	Constructed Slope	0.003504	m/m

Hydraulic Profile					
Profile	S1		Depth, Downstream	0.60	m
Slope Type	Steep		Normal Depth	0.28	m
Flow Regime	Subcritical		Critical Depth	0.28	m
Velocity Downstream	0.55	m/s	Critical Slope	0.003318	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	119.29	m	Upstream Velocity Head	0.03	m
Ke	0.50		Entrance Loss	0.01	m

Inlet Control Properties					
Inlet Control HW Elev.	119.25	m	Flow Control	Unsubmerged	
Inlet Type	Square edge w/headwall		Area Full	0.7	m2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Design Report
Station 13+078 - Ex <revised 2016>

Design:Trial-2

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	121.30	m	Storm Event	Check	
Computed Headwater Elevation	119.33	m	Discharge	0.3620	m3/s
Headwater Depth/Height	0.61		Tailwater Elevation	119.25	m
Inlet Control HW Elev.	119.25	m	Control Type	Outlet Control	
Outlet Control HW Elev.	119.33	m			

Grades					
Upstream Invert	118.77	m	Downstream Invert	118.65	m
Length	34.25	m	Constructed Slope	0.003504	m/m

Hydraulic Profile					
Profile	S1		Depth, Downstream	0.60	m
Slope Type	Steep		Normal Depth	0.34	m
Flow Regime	Subcritical		Critical Depth	0.35	m
Velocity Downstream	0.80	m/s	Critical Slope	0.003369	m/m

Section					
Section Shape	Circular		Mannings Coefficient	0.012	
Section Material	Corrugated HDPE (Smooth Interior)		Span	0.91	m
Section Size	900 mm		Rise	0.91	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	119.33	m	Upstream Velocity Head	0.06	m
Ke	0.50		Entrance Loss	0.03	m

Inlet Control Properties					
Inlet Control HW Elev.	119.25	m	Flow Control	Unsubmerged	
Inlet Type	Square edge w/headwall		Area Full	0.7	m2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

APPENDIX C

Storm Sewer Analysiss

Project Name: HWY 148

Project Number: 24RX14.0333

Date /Rev March 03, 2015

Initial Time of Concentration: 10 min

IDF Used: City of Ottawa

Rainfall Intensity: I = A/(T + B)^C (T in min)

Storm Return Period (years) = 10

Where
A = 1174.184
B = 6.014
C = 0.816

Location								Design Flow					Sewer Characteristics								Sewer Verification			
			Subareas				Total			Time	Rain	Peak						Cap						
Catchment	From	To	for C=				Area	Indiv.	Acc	of Conc.	fall	flow	Length	Pipe	Pipe	n	Slope	full	Vel.	Travel	q/Q	Cv	Cap	Pipe volume
	MH	MH	0.90	0.75	0.50	0.25		AC	AC	Sewer	I	q		Dia	Type			Q	V	Time		(1)	ok	
			(ha)	(ha)			(ha)	(ha)	(ha)	(min)	(mm/h)	(L/s)	(m)	(mm)			%	(L/s)	(m/s)	(min)		(m/s)		m3
1	MH1	MH2		0.200	0.660		0.860	0.480	0.480	10.00	122.14	163.0	22.0	800	Conc	0.013	0.50	935.0	1.86	0.29	0.17	1.26	0.00	11.053
2	MH2	MH3		0.320			0.320	0.240	0.720	10.29	120.37	240.9	71.0	800	Conc	0.013	0.50	935.0	1.86	0.64	0.26	1.48	0.00	35.670
5				0.790				0.593																
	MH3	MH6	0.000	9.780	0.660		10.440	7.665	7.665	13.02	106.08	2260.4	144.0	1400	Conc	0.013	0.50	4158.5	2.70	0.89	0.54	2.70	0.00	221.558
																								314.436
6	MH11	MH12		11.190			11.190	8.393	8.393	23.00	75.21	1754.7	143.0	1200	Conc	0.013	0.50	2756.8	2.44	0.94	0.64	2.54	0.00	161.647
7	MH12	MH13		0.590			0.590	0.443	8.836	23.94	73.27	1799.9	151.0	1200	Conc	0.013	0.50	2756.8	2.44	1.03	0.65	2.54	0	170.690
8	MH15	MH16		0.120			0.120	0.090	0.090	10.00	122.14	30.6	10.0	300	Conc	0.013	0.50	68.4	0.97	0.18	0.45	0.93	0	0.707
9	MH16	MH17		0.320	0.300		0.620	0.390	0.480	10.18	121.04	161.5	85.0	450	Conc	0.013	0.50	201.6	1.27	1.12	0.80	1.40	0	13.512
10	MH17	MH18		0.330			0.330	0.248	0.728	11.30	114.63	232.0	25.0	500	Conc	0.013	0.50	267.0	1.36	0.31	0.87	1.52	0	4.906
11	MH18	MH13		0.440			0.440	0.330	1.058	11.60	113.00	332.3	35.0	700	Conc	0.013	0.50	654.9	1.70	0.34	0.51	1.70	0	13.463
12				0.690				0.518																
13				0.900				0.675																
	MH13	MH19	0.000	14.580	0.300		14.880	11.085	11.085	24.97	71.28	2196.5	90.0	1000	Conc	0.013	1.00	2397.6	3.05	0.44	0.92	3.45	0	70.650
																								435.575
	NOTE: THE STORM SEWER WAS INSTALLED IN 1999 YEAR AS PER CONTRACT DWG.98191																							

APPENDIX D

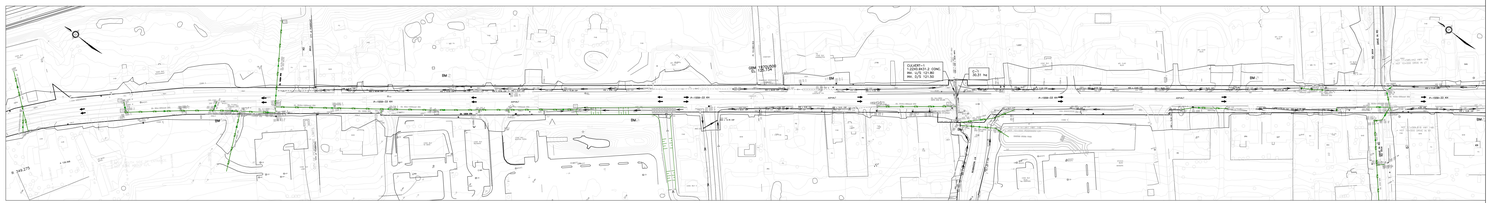
CCTV Inspection Summary

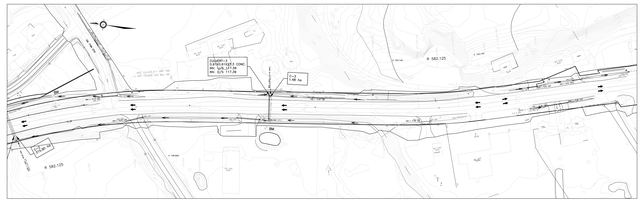
CCTV Inspection Summary and Recommendations

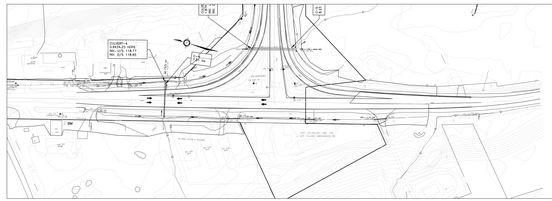
Sewer Segment	Flow Direction	Location	Observations	Recommendations
MH6 – MH6A	MH6 to MH6A	Pembroke Street	In good conditions	No improvement required
CBMH1022 – MH6A	CBMH1022 to MH6A	Pembroke Street	Partially blocked (50%) by settled gravel deposition, abandoned survey	Need to clean-up
CBMH1 – MH6A	CBMH1 to MH6A	Pembroke Street	Surface corrosion of metal pipe with hole soil visible	Need the pipe replacement
MH3 – CBMH1	MH3 – CBMH1	Pembroke Street	In good condition	No improvement required
MH5 – MH4	MH4 – MH5	Angus Campbell Drive	Found attached encrustation deposits	Need pipe clean-up and repair
MH5 – MH3	MH5 – MH3	Angus Campbell Drive	Found attached encrustation deposits	Need pipe clean-up and repair
MH2 – MH3	MH2 – MH3	Pembroke Street	Found settled gravel deposits and attached encrustation deposits	Need Pipe clean-up and repair
MH1 – MH2	MH1 – MH2	Pembroke Street	In good condition	No improvement required
CBMH2 - OUTLET	CBMH2 - Outlet	Pembroke Street	Observed obstacle within structure and abandoned survey	Need to clean-up the pipe
CB15 – CB16	CB15 – CB16	Highway 148	Found fine settled deposits	Need to clean-up
CB16 – CB17	CB16 – CB17	Highway 148	Found fine settled deposited and blocked by debris, abandoned survey	Need to clean-up and pipe repair
CB17 – CB17A	CB17 – CB17A	Highway 148	Found fine settled deposits	Need to clean-up
CB17A – MH18	CB17A – MH18	Highway 148	Found fine settled deposits	Need to clean-up
CB13B – MH19	CB13B – MH19	Highway 148	In good condition	No improvement required
CB13A – CB13B	CB13A – CB13B	Highway 148	In good condition	No improvement required
CBMH1102 – CB13B	CBMH1102 – CB13B	Highway 148	In good condition	No improvement required

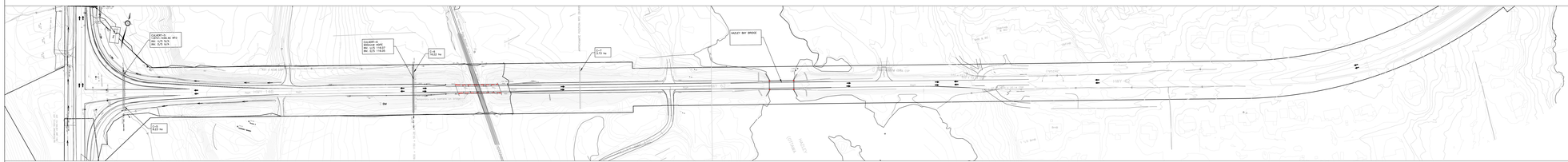
Sewer Segment	Flow Direction	Location	Observations	Recommendations
CBMH1106 – CBMH1102	CBMH1106 – CBMH1102	Highway 148	Surface reinforcement exposed at one location	Need surface repair
CB11 – CBMH1106	CB11 – CBMH1106	Highway 148	Found longitudinal crack at one location	Need Repair
MH30 – MH31	MH30 – MH31	Highway 148	In good condition	No improvement required
MHST01 – MHST02	MHST01 – MHST02	Highway 148	In good condition	No Improvement required
MHST03 – MHST02	MHST03 – MHST02	Highway 148	Found fine settled deposits (40%)	Need cleaning to remove the deposits
MHST02 – CBMH01	MHST02 – CBMH01	Highway 148	Found settled gravel deposits and tree roots at joints	Need cleanup and repair
CB04 – MHST03	CB04 – MHST03	Highway 148	Abandoned survey due to buried catch basin concrete top	Need cleanup
CBMH01 – CBMH02	CBMH01 – CBMH02	Highway 148	In good condition	No improvement required
CBMH02 – CBMH03	CBMH02 – CBMH03	Highway 148	Found settled gravel and rock deposits, surface spalling and longitudinal cracks	Need cleanup and sewer main repair
CB02 – CBMH03	CB02 – CBMH03	Highway 148	Found fine settled deposits and broken joint with visible soil	Need replacement
CB03 – CBMH05	CB03 – CBMH05	Highway 148	Found settled fine deposits (90%) and abandoned survey due to debris	Need cleanup/replacement
CB01 – CB04	CB01 – CB04	Highway 148	In good condition	No improvement required
CB06 - Outlet	CB06 - Outlet	Highway 148	Found settled fine deposits and abandoned survey due to debris	Need clean-up to remove deposits and debris
CBMH03 – CBMH04	CBMH03 – CBMH04	Highway 148	Found settled fine deposits	Need Clean-up

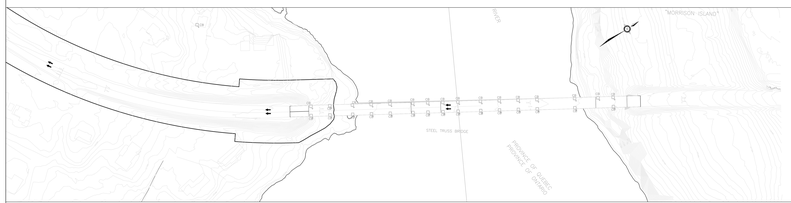
Sewer Segment	Flow Direction	Location	Observations	Recommendations
CBMH04 – CBMH03 R	CBMH04 – CBMH03 R	Highway 148	Found settled fine deposits and abandoned survey due to buried structure	Need clean-up and remove the obstruction
CBMH04 – CBMH05	CBMH04 – CBMH05	Highway 148	Found settled gravel at one location	Need clean-up
CBMH05 – CBMH06	CBMH05 – CBMH06	Highway 148	In good condition	No Improvement required
DICB01 – DIMH01	DICB01 – DIMH01	Highway 148	Found settled fine deposits and surface corrosion on metal pipe	Need clean-up and metal pipe rehabilitation
DICB02 – MHST03	DICB02 – MHST03	Highway 148	Found settled fine deposits and abandoned survey due to debris	Need clean-up to remove debris
DICB03- Main	DICB03- Main	Highway 148	In good condition	No improvement required
DIMH01 – CB01	DIMH01 – CB01	Highway 148	Found settled fine deposits and abandoned survey due to debris	Need clean-up and remove debris
INLET – CBMH2	INLET – CBMH2	Pembroke Street	Abandoned survey due to rocks	Need to remove the obstruction
MH18 – CB13A	MH18 – CB13A	Highway 148	Found one break-in intruding pipe	
MH31 - TEE	MH31 - TEE	Highway 148	In good condition	No improvement required











LEGEND

OVERLAND FLOW ARROW

EXISTING DITCH FLOW

EXISTING STORM SEWER

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Client

MINISTRY OF TRANSPORTATION

Project

HWY 148 FROM PEMBROKE TO QUEBEC BORDER

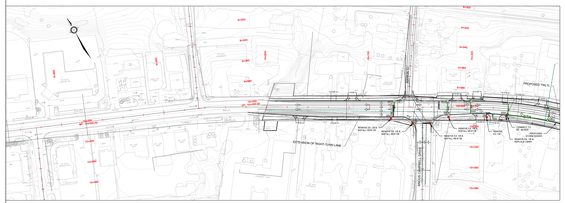
Drawing Title

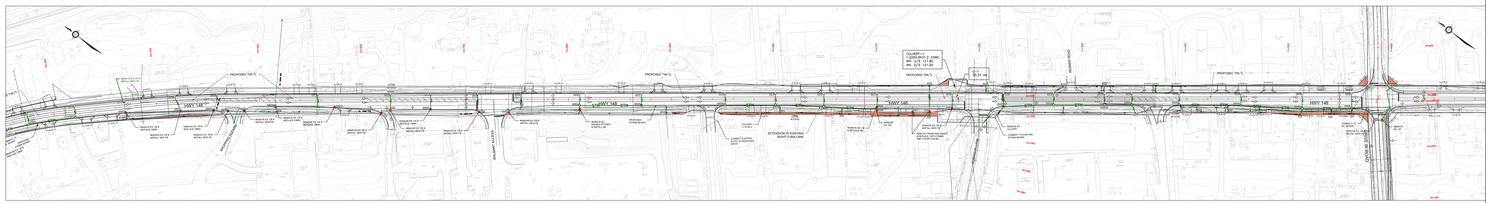
EXISTING DRAINAGE PLAN

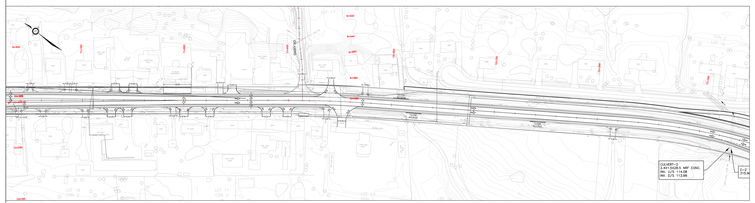
Check Scale (may be photo-reduced)

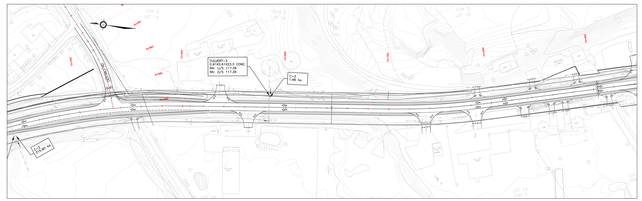
SCALE = 1:1000

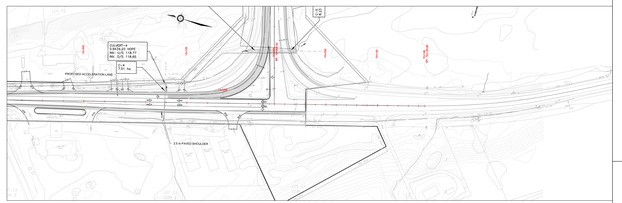
Project No.	Drawing No.
24RX14.0333	SWM-01

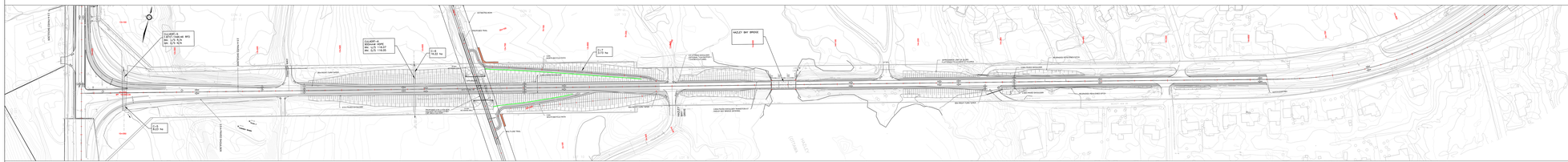


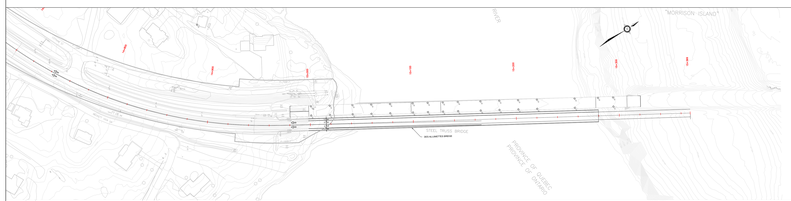












LEGEND

- OVERLAND FLOW
- EXISTING SEWER
- PROPOSED SEWER
- CATCH BASIN
- DOUBLE CATCH BASIN
- CATCH BASIN MANHOLE
- DOUBLE CATCH BASIN MANHOLE
- OIL AND GRIT SEPARATOR
- DITCH INLET
- MANHOLE

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Client

MINISTRY OF TRANSPORTATION

Project

HWY 148 FROM PEMBROKE TO QUEBEC BORDER

Drawing Title

PROPOSED DRAINAGE PLAN

Check Scale (may be photo-reduced)

SCALE = 1:1000

Project No.	Drawing No.
24RX14.0333	SWM-02

Appendix I – Composite Utility Plan

LEGEND

- GAS LINE
- SANITARY
- STORM
- WATER
- BELL
- CABLE
- EXISTING MTO RIGHT OF WAY
- RELOCATE HYDRO POLE
- RELOCATE UTILITY PEDESTAL
- RELOCATE UTILITY MAINTENANCE HOLE
- RELOCATE U/G UTILITY

HIGHWAY 148

RANKIN ST

ANGUS CAMPBELL DRIVE

HOT 10+000 HWY 148 AHEAD
= PEMBROKE CONN LINK BACK

9+880 9+900 9+920 9+940 9+960 9+980 10+000 10+020 10+040 10+060 10+080 10+100 10+120 10+200 10+300

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Ontario

SCALE:
HOR 10m 0 10 20 30m

4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN
STA. 10□000 TO STA. 10□360

SHEET
1

October 21, 2016

□37432-Hwy148 I:\Hwy17 EA\5.9 Drawing \59civil layout \37431-Hwy 148 Utility Impact Sheet .dwg

LEGEND

- GAS LINE
- SANITARY
- STORM
- WATER
- BELL
- CABLE
- EXISTING MTO RIGHT OF WAY
- RELOCATE HYDRO POLE
- RELOCATE UTILITY PEDESTAL
- RELOCATE UTILITY MAINTENANCE HOLE
- RELOCATE U/G UTILITY

10+400

10+500

10+600

10+700

HIGHWAY 148

WALMART ACCESS

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

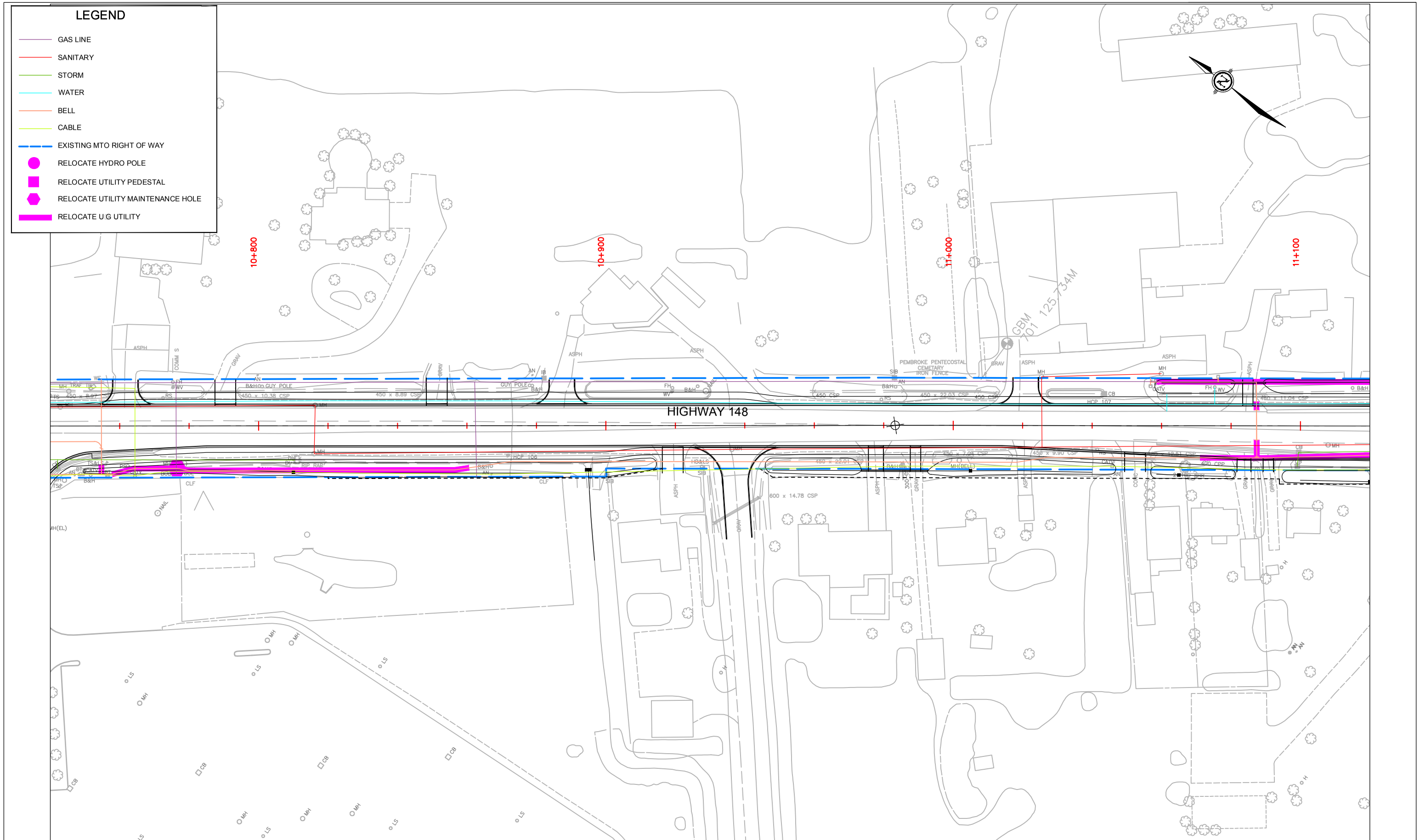
UTILITY IMPACT PLAN

STA. 10□360 TO STA. 10□740

SHEET 2

□37432-Hwy148 \Hwy17 EA 5.9 Drawing \58civil layout \37431-Hwy 148 Utility Impact sheet \.dwg

October 21, 2016



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SCALE:

HOR 10m 0 10 20 30m

4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN

STA. 10□740 TO STA. 11□120

SHEET
3

□:37432-Hwy148□Hwy17□EA 5.9 Drawing□59civil layout□37431-Hwy 148 Utility Impact □heet□.dwg

October 21□2016

LEGEND

- GAS LINE
- SANITARY
- STORM
- WATER
- BELL
- CABLE
- EXISTING MTO RIGHT OF WAY
- RELOCATE HYDRO POLE
- RELOCATE UTILITY PEDESTAL
- RELOCATE UTILITY MAINTENANCE HOLE
- RELOCATE U/G UTILITY

11+200
11+300
11+400
11+500
RESMER ROAD
HIGHWAY 148
10+000
10+020
10+040
10+060
10+080
10+100
10+120
ROBINSON LANE

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SCALE:
HOR 10m 0 10 20 30m

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HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN
STA. 11+120 TO STA. 11+500

SHEET
4

October 21, 2016
□:37432-Hwy148 Hwy17 EA 5.9 Drawing 59civil layout □37431-Hwy 148 Utility Impact □heet□.dwg

LEGEND

- GAS LINE
- SANITARY
- STORM
- WATER
- BELL
- CABLE
- EXISTING MTO RIGHT OF WAY
- RELOCATE HYDRO POLE
- RELOCATE UTILITY PEDESTAL
- RELOCATE UTILITY MAINTENANCE HOLE
- RELOCATE U\G UTILITY

HIGHWAY 148

HIGHWAY 148

DRIVE IN ROAD

9+900
9+950
10+000
10+050
10+100
11+600
11+700
11+800

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Ontario

SCALE:
HOR 10m 0 10 20 30m

4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN
STA. 11□500 TO STA. 11□880

SHEET
5

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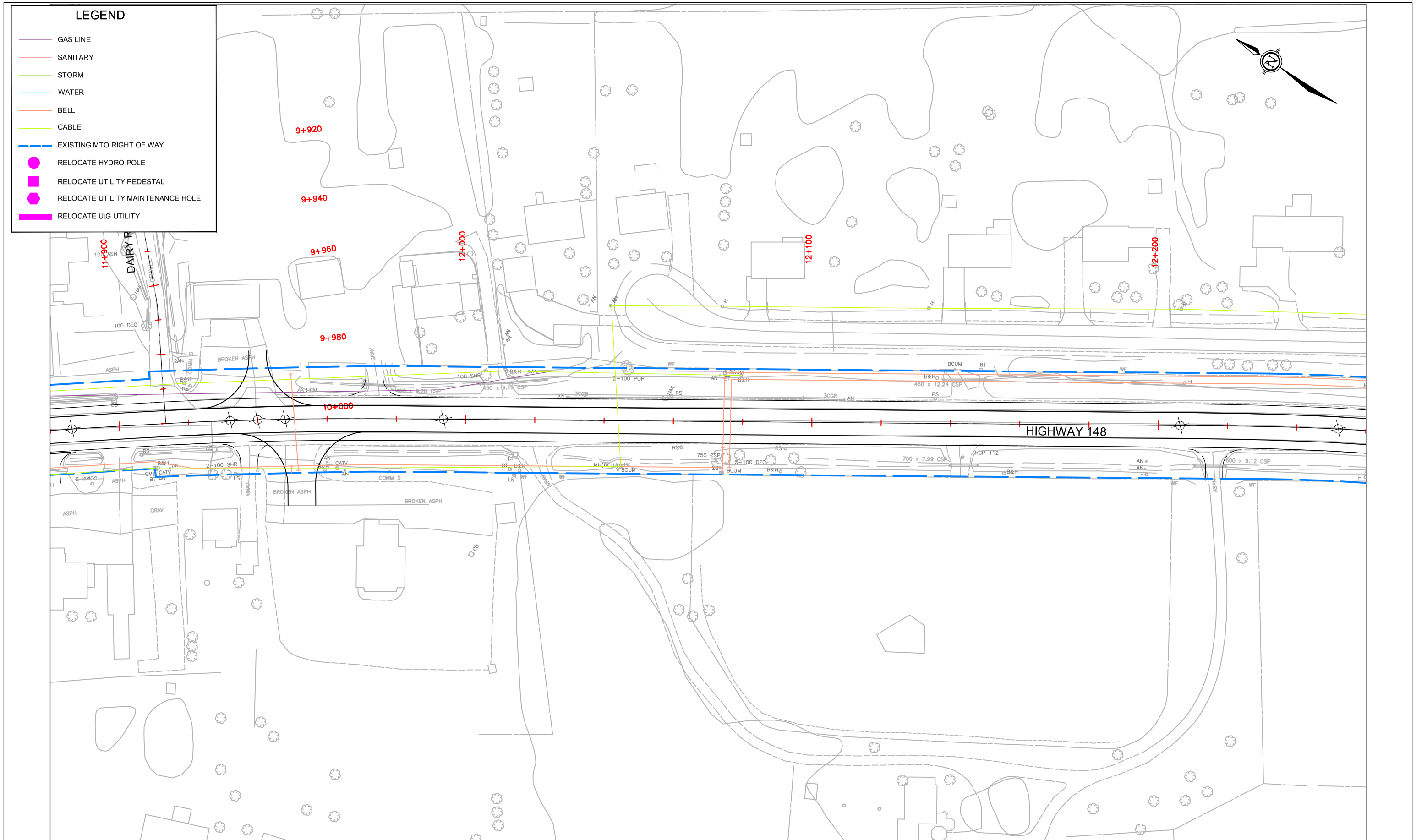
October 21, 2016



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Ontario

SCALE:

HOR 10m 0 10 20 30m

4013-E-0034
HIGHWAY 148
PRELIMINARY DESIGN AND CLASS EA STUDY

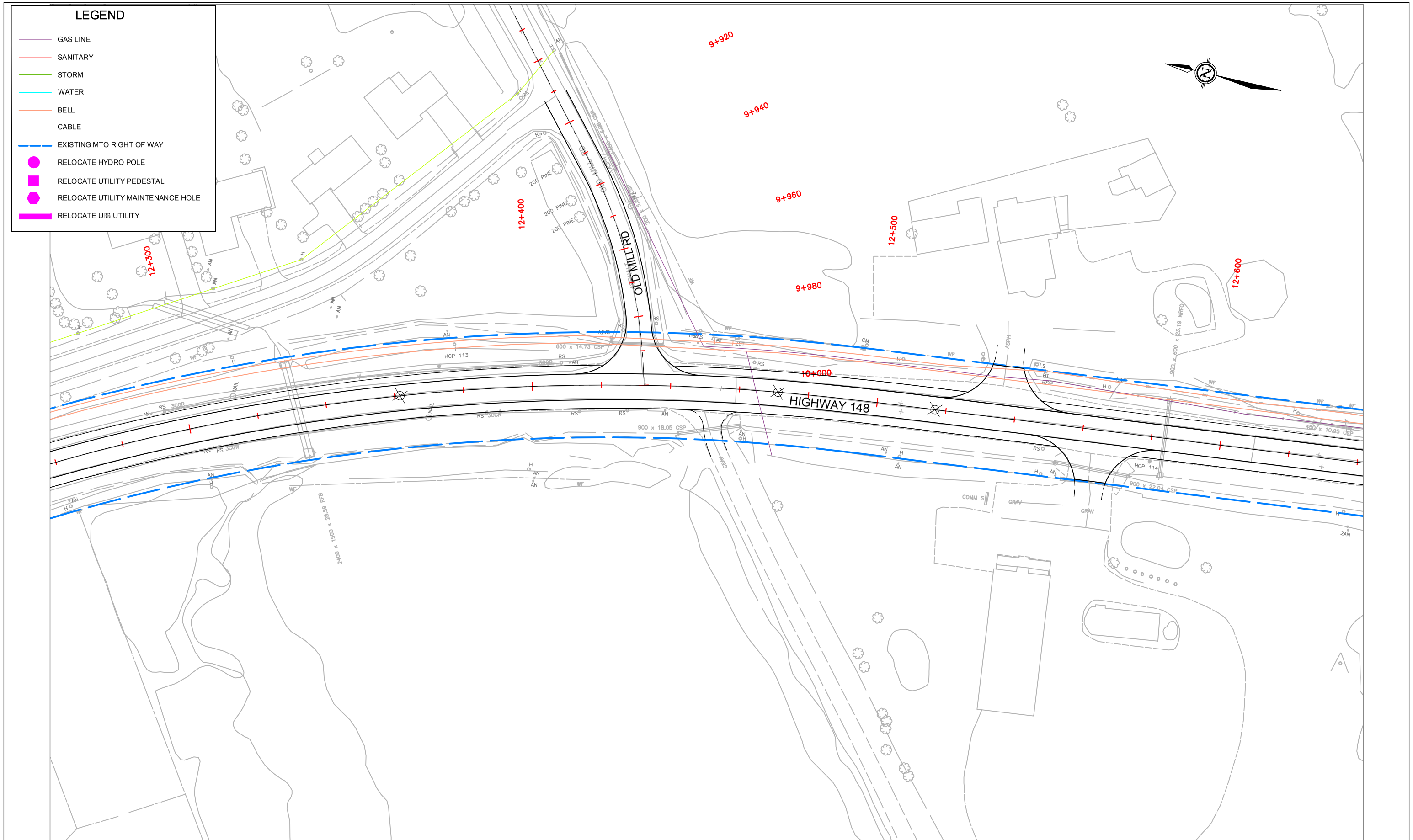
UTILITY IMPACT PLAN

STA. 11□880 TO STA. 12□260

SHEET
6

October 21, 2016

□:37432-Hwy148□Hwy17□EA 5.9 Drawing□59civil layout□37431-Hwy 148 Utility Impact □heet□.dwg



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Ontario

SCALE:

HOR 10m 0 10 20 30m

4013-E-0034

HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN

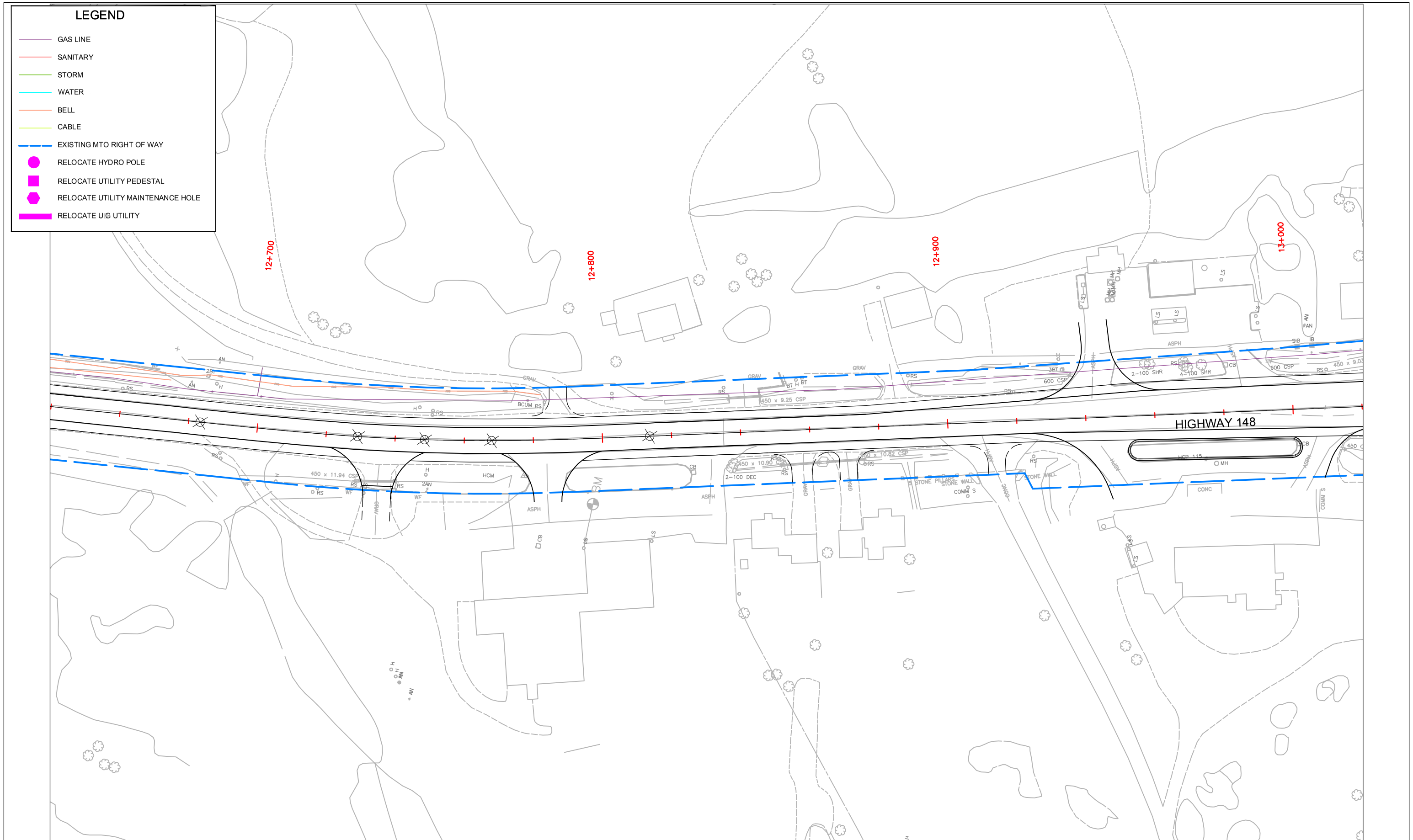
STA. 12□260 TO STA. 12□640

SHEET

7

October 21, 2016

□:37432-Hwy148□Hwy17□EA 5.9 Drawing□59civil layout□37431-Hwy 148 Utility Impact □heet□.dwg



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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN

STA. 12□640 TO STA. 13□020

SHEET

8

October 21, 2016

□:37432-Hwy148□Hwy17□EA 5.9 Drawing□59civil layout□37431-Hwy 148 Utility Impact □heet□.dwg

LEGEND

- GAS LINE
- SANITARY
- STORM
- WATER
- BELL
- CABLE
- EXISTING MTO RIGHT OF WAY
- RELOCATE HYDRO POLE
- RELOCATE UTILITY PEDESTAL
- RELOCATE UTILITY MAINTENANCE HOLE
- RELOCATE U/G UTILITY

HIGHWAY 148

TRAXTON WAY

13+000
13+100
13+200
13+300
13+400
10+000
BP: 10+000.00
10+050
10+100

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HIGHWAY 148

PRELIMINARY DESIGN AND CLASS EA STUDY

UTILITY IMPACT PLAN

STA. 13□020 TO STA. 13□400

SHEET 9

□:37432-Hwy148 Hwy17 EA 5.9 Drawing□59civil layout□37431-Hwy 148 Utility Impact □heet□.dwg

October 21, 2016