



APPENDIX F

**Transportation Report, East Boundary Road Corridor
Protection Study, City of Cambridge (Region of
Waterloo, December 2018)**



Municipal Class Environmental Assessment

East Boundary Road Corridor Protection Study

City of Cambridge

TRANSPORTATION REPORT

December 2018

EXECUTIVE SUMMARY

The Region of Waterloo is undertaking the East Boundary Road Corridor Protection Study. The study follows the Environmental Assessment process and its purpose is to identify whether a new Regional road corridor should be constructed on the east side of Cambridge and, if so, where that corridor should be located. Various policies over the years have identified a high capacity road on the east side of Cambridge, and an east side road is consistent with current Regional policies including the Regional Official Plan (ROP) and the Transportation Master Plan (TMP). The Community Plan for the area approved by the City of Cambridge also includes the East Boundary Road.

There are three main north-south road corridors in Cambridge: Water Street/Hespeler Road, Franklin Boulevard and Townline Road. The two former corridors both traverse Cambridge from its southern extent to north of Highway 401, and each carry about 40,000 vehicles per day in their busiest sections. Townline Road does not extend as far south but does cross Highway 401, and carries more than 20,000 vehicles per day in its busiest section. While Townline Road generally operates well, both Water Street/Hespeler Road and Franklin Boulevard experience operational problems regularly.

Population and employment growth in southeast Cambridge is projected to be more than 10,000 people and 4,000 jobs in the long term. This growth will put increased pressure on the north-south transportation links described above. While the improvements to public transit outlined in the TMP are expected to accommodate much of this growth, traffic congestion on north-south screenlines is expected to worsen. This will cause delays for commuters, goods movement, transit vehicles and emergency vehicles.

A number of non-structural and other infrastructure-intensive alternatives have been examined in place of constructing a new road corridor. As noted above, public transit improvements will make a significant difference but are not expected to eliminate all problems. Improvements to other corridors, including Water Street/Hespeler Road and Franklin Boulevard, are already planned but further improvements would be impractical or cause negative community impacts. Finally, the Cheese Factory Road/Elgin Street/Conestoga Boulevard corridor is too discontinuous and residential in character to be a practical alternative.

Various alignments of the East Boundary Road have been tested to determine preferred alignments for accommodating regional and inter-regional traffic. The four routes were presented to the public at Public Consultation Centre 1 and are shown in Figure 1 below. Route A, the alignment currently in the ROP largely along Shellard Side Road, is the longest alignment and the furthest to the east, and is projected to carry the least traffic and provide the least relief to other Regional roads in Cambridge, notably Franklin Boulevard. Routes B and D are closer to Cambridge, are shorter, would carry the most traffic and would provide the most relief to other

Regional roads. Route B is also notable as being the further west and being able to provide the most direct access to planned residential developments in southeast Cambridge.

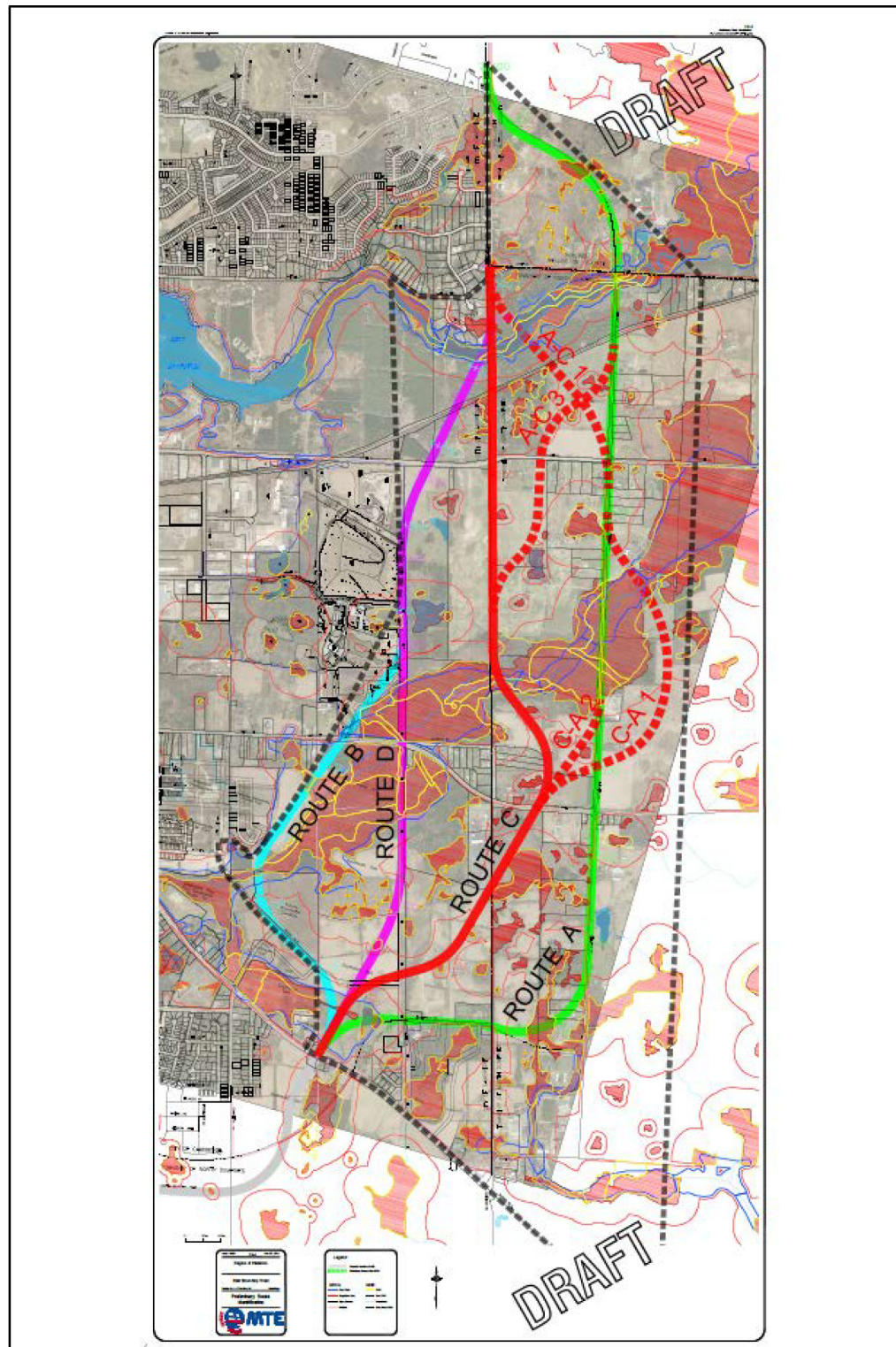


Figure 1: East Boundary Road routes (Public Consultation Centre 1).

Based on the contents of this report, the following scores are recommended for the transportation section of the criteria evaluation. Alternatives are ranked based on 8 being the least preferred and < being the most preferred.

An evaluation of the protection requirements for the crossing of the CP railway between Clyde Road and Avenue Road suggests that the minimum acceptable protection would be crossing signals and gates. However, the likely classification of the East Boundary Road as a Community Connector, the potential for the daily number of trains using the railway to increase, and the estimates of cross-product over 200,000 for Alignments B and D, suggest that a grade separated crossing may also be appropriate. Therefore, it is recommended that a grade separated crossing be considered when determining the preferred East Boundary Road alignment.

Turning movement projections arising out of the Regional transportation demand forecasting model determined that traffic signals or roundabouts would be warranted in the long term at the East Boundary Road intersections with Wesley Boulevard, Main Street, Clyde Road and Avenue Road/Gore Road. Roundabout screenings concluded that Intersection Control Studies should be done for all four intersections, which recommended that multi-lane roundabouts be constructed.

Table 1: Transportation evaluation results.

Evaluation Criteria	Route Alternative			
	A	B	C	D
Traffic	<ul style="list-style-type: none"> East Boundary Road carries 5,712 total traffic (lowest total amount). Dundas Street carries 10,456 total traffic (7.3% less than Do Nothing). Franklin Boulevard carries 18,324 total traffic (9.0% less than Do Nothing). Water Street carries 19,164 total traffic (1.2% less than Do Nothing). 	<ul style="list-style-type: none"> East Boundary Road carries 8,520 total traffic (second highest total amount). Dundas Street carries 10,113 total traffic (10.4% less than Do Nothing). Franklin Boulevard carries 17,175 total traffic (14.8% less than Do Nothing). Water Street carries 19,016 total traffic (2.0% less than Do Nothing). 	<ul style="list-style-type: none"> East Boundary Road carries 7,131 total traffic (second lowest total amount). Dundas Street carries 10,216 total traffic (9.5% less than Do Nothing). Franklin Boulevard carries 17,780 total traffic (11.7% less than Do Nothing). Water Street carries 19,053 total traffic (1.8% less than Do Nothing). 	<ul style="list-style-type: none"> East Boundary Road carries 8,588 total traffic (highest total amount). Dundas Street carries 9,782 total traffic (13.3% less than Do Nothing). Franklin Boulevard carries 17,260 total traffic (14.3% less than Do Nothing). Water Street carries 18,954 total traffic (2.3% less than Do Nothing).
	8	;	:	<
Active Transportation	Total length is 7,400 metres (24% longer than Route D).	Total length is 6,280 metres (5% longer than Route D).	Total length is 6,400 metres (7% longer than Route D).	Total length is 5,975 metres (shortest overall length).
	8	;	;	<
Public Transit	Longest total length, furthest away from existing and planned developments, little potentially developable lands to service.	Second shortest total length and close proximity to existing and planned developments.	Total length slightly longer than Route B, location is also further away from existing and planned developments, proximity to potentially developable lands but protected countryside along one side.	Shortest total length, further away from existing and planned developments, but close to potentially developable lands.
	8	<	:	;
Access to Developments	Furthest away from all existing and planned developments and very little access to potentially developable areas.	Closest to existing, planned and potential developments .	Would not provide access to existing or planned developments, could provide access to some potentially developable areas.	Further away from existing developments than Route B, but provides access to one planned development and a large amount of potentially developable lands.
	9	<	:	;
Overall	9	;	:	;

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1. INTRODUCTION

The Regional Transportation Master Plan (RTMP, 2010) identifies the East Boundary Road (EBR) for long-term road network improvements. The Regional Official Policies Plan (ROPP, 1995) and the Regional Official Plan (ROP, 2009) also identify this corridor.

The Region’s draft 2015 Transportation Capital Program includes total funding of \$490,000 in 2015 to continue the East Boundary Corridor Protection Study (project 7299). This study will establish the alignment of the future EBR. It will follow the Class Environmental Assessment (EA) process (Schedule “C”) for municipal road projects.

1.1. CAMBRIDGE AND INTER-REGIONAL TRANSPORTATION

Cambridge is located in the southeastern portion of the Region of Waterloo and is between Highways 401 and 403, as shown in Figure 1. There is significant inter-regional transportation demand between the Region of Waterloo, the Cities of Brantford and Hamilton, and Brant County. Both Highway 8 to Hamilton and Highway 24 to Brantford traverse Cambridge and pass through the downtown. Truck traffic is a particular concern because of narrow rights-of-way and proximity to residential areas and schools.

1.2. HISTORY OF EAST BOUNDARY ROAD

The initial concept was for a Highway 8 bypass and was first developed in 1966. It was part of a City of Galt plan for a ring road around the perimeter of the City. Responsibility for the boundary roads plan shifted to the Region of Waterloo (ROW) in 1988. The EBR was subsequently identified in the following Regional transportation planning policies:

- Cambridge Area Transportation Study (CATS) (1996)
- Regional Transportation Master Plan (RTMP) (1999)
- Cambridge Area Route Selection Study (CARSS) (2002)
- Detailed Transportation Network Review (DTNR) (2004)
- Regional Official Policies Plan (ROPP) (2004)
- Regional Transportation Master Plan (RTMP) (2010)
- Regional Official Plan (ROP) (2011)
- Cambridge Official Plan (2012)
- County of Wellington Official Plan (1999, revised 2015)

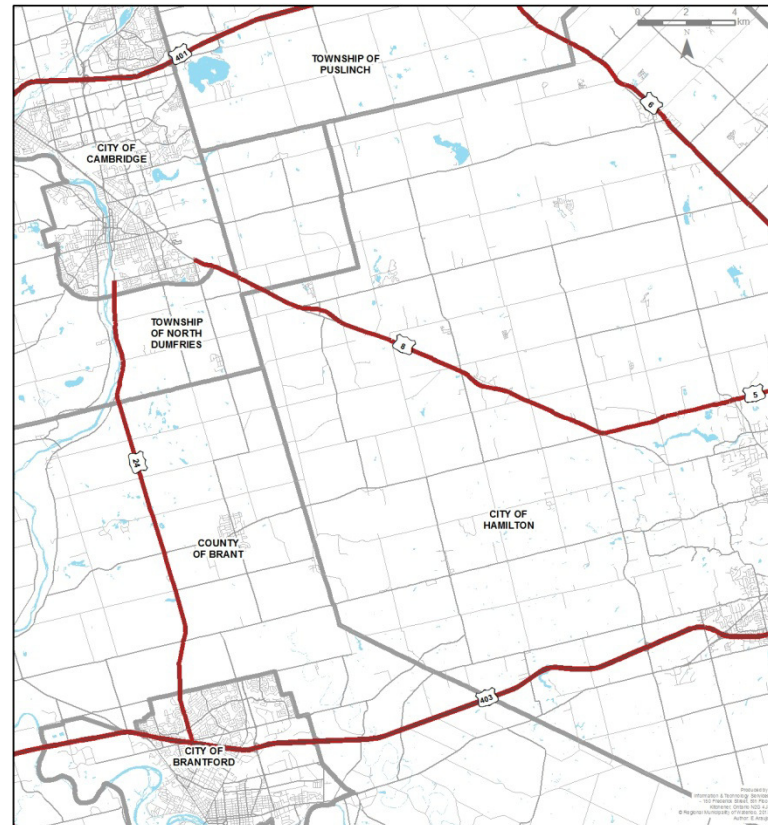


Figure 2: Cambridge and inter-regional transportation network

1.2.1. Cambridge Area Transportation Study (CATS)

CATS studied overall transportation needs in Cambridge. Among other findings, the study identified traffic capacity deficiencies in Galt, conflicts with heavy truck traffic, and north-south capacity deficiency within the commercial and industrial corridors south of Highway 401. The study revised the ring road concept and the new plan included an arterial corridor around the east, west, and south sides of the City of Cambridge, recommending the construction of the South Boundary Road and widening/realignment of Shellard Side Road to connect with a widened Townline Road. These routes would be along the alignment for the EBR in the ROP.

1.2.2. Regional Transportation Master Plan (RTMP)

While the 1999 RTMP did not specifically identify heavy truck traffic concerns in Galt, the findings with respect to north-south and east-west capacity deficiencies in Cambridge were consistent with CATS. The recommendations were also very similar: construct an arterial road alignment following the South Boundary Road between Water Street and Dundas Street, and an East Side Arterial along a widened Shellard Side Road to a widened Townline Road.

1.2.3. Cambridge Area Route Selection Study (CARSS)

The Region initiated a Class EA Study in the City of Cambridge in 2000, called the Cambridge Area Routes Selection Study (CARSS). Corridors considered during this study included:

- East Side Arterial Corridor near Townline Road and Shellard Road
- West Side Arterial Corridor extending west from Highway 24 at the southerly edge of Cambridge across the Grand River and north to Highway 401 near Highway 8
- East-West Arterial Corridor extending from Townline Road and Highway 401 west through the City of Cambridge and across the Grand River to the West Side Arterial (now formed in part by Can-Amara Parkway)
- South Boundary Road extending from Water Street (Highway 24) through to Dundas Street (Highway 8)

1.2.4. Detailed Transportation Network Review (DTNR)

The DTNR recommendations included the deletion of the West Side Arterial and any new bridge crossings of the Grand River from the Regional Official Policies Plan. The study also endorsed a list of transportation network improvements including the EBR to relieve traffic congestion on Hespeler Road and Franklin Boulevard.

1.2.5. Regional Transportation Master Plan (2010 Update)

The 2010 update to the RTMP identified PM peak hour north-south capacity deficiencies along Hespeler Road and Franklin Boulevard in multiple sections, and also identified daily capacity deficiencies along Hespeler Road. In addition to significant investments in public transit and the conversion of Franklin Boulevard to a roundabout corridor to increase operating efficiency, the RTMP also recommended construction of the South Boundary Road and EBR. The RTMP identified a number of infrastructure improvements for north-south travel within Cambridge. These included:

- widening of Townline Road in the 0-5 and 10-20 year horizons
- increasing capacity along Franklin Boulevard in the 0-5 year horizon
- identifying the need for a new East Boundary Road beyond 20 years

1.2.6. Transportation Master Plan (2018 Update)

Regional Council approved the 2018 TMP Update in June 2018. This study identified existing and new trends and their effects on Regional transportation needs to a horizon year of 2041. For the Regional roads program, this study largely confirmed the findings of the 2010 Update noted above, and confirmed the timing of the Townline Road widening (before 2031) and East Boundary Road construction (after 2031).

1.2.7. Regional Official Policies Plan (ROPP) and Regional Official Plan (ROP)

Schedule A of the ROP identifies a 50-metre allowance for a future East-South Arterial from Highway 24 to Can-Amara Parkway following the Shellard Side Road alignment. This East-South Arterial includes the South Boundary Road and the East Boundary Corridor. Map 9 of the ROPP and Map 5b of the ROP show this corridor graphically. Figure 2 shows the relevant portions of these maps.

With the EBR being identified as part of Cambridge’s transportation network for an extended period of time, the entire south part of Cambridge was planned and approved with the EBR assumed as a transportation improvement in the area for the future.

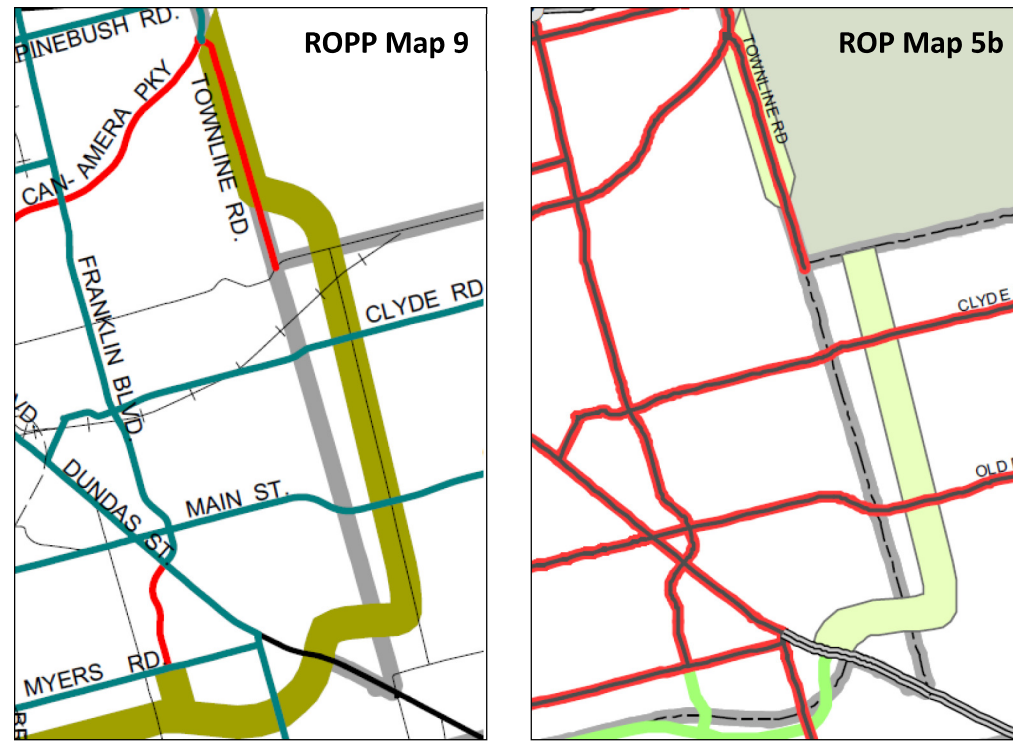


Figure 3: East Boundary Corridor in ROPP and ROP

1.2.8. City of Cambridge Official Plan

The Cambridge Official Plan identifies the alignment of the EBR shown in the ROPP and ROP as a “future conceptual transportation study area” from the RTMP in Map 7A. This continues planning for this area identified in previous studies such as the Southeast Galt Community Plan (1999).

1.2.9. County of Wellington Official Plan

The County of Wellington Official Plan identifies a proposed major roadway roughly aligning with the portion of the East Boundary Road shown to pass through the County in the ROPP in Schedule A7 (Puslinch), as shown in Figure 3 below. Wellington OP policies would govern such an alignment. Part 12 (Transportation) of the OP has a few policies relevant to this alignment:

- Section 12.1 (General) notes that the “County will co-operate with surrounding jurisdictions to develop a transportation system that recognizes the mobility of people within this area and their need for effective inter-regional transportation systems.” Similar language is also found within Section 2.5 (Our Neighbours).

- Section 12.5.2 (Major Roadways) provides general policies discussing the management of County roads, and would likely be the governing policies in the event that the EBR alignment passed through the County and became a County road for some of its length. These policies provide for access restrictions, also noting that an OP amendment would be required for a new major road.

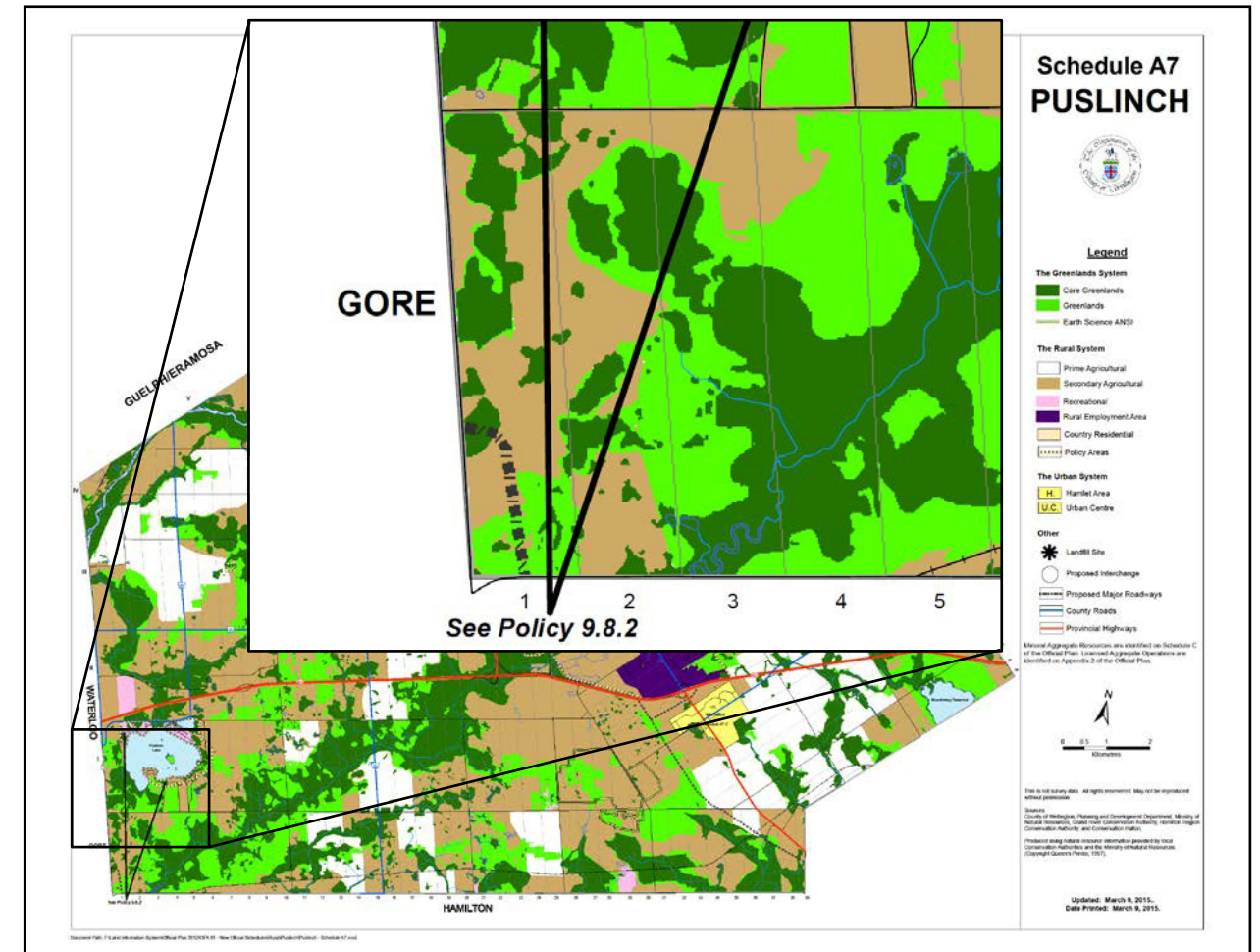


Figure 4: Wellington County Official Plan Schedule A7

It should be noted that other constraints identified in the Wellington County OP would also need to be investigated. The alignment shown in Figure 3 would pass through some areas identified as Secondary Agricultural, Greenlands and Core Greenlands. Section 4.3.2 (Secondary Agricultural Areas) denotes such lands as having agricultural capability and for which agriculture will continue to be the dominant use, but permitting other uses. Section 5.4 (Core Greenlands) identifies such lands as including provincially significant wetlands, all other wetlands, habitats for endangered or threatened species, fish habitats and hazardous lands. Similar designations of a less severe nature are attached to the Greenlands areas covered by Section 5.5. These issues would have to be reviewed during any study of the alignment of the road.

Schedule B7 (Well Head Protection Areas) of the County OP shows that the alignment would pass through areas of the Paris and Galt Moraine Policy Area and Well Head Protection Area 3. While the policies in Section 4.9.7 do not preclude roadways within the Paris and Galt Moraine policy areas, the importance of natural environmental protection and agricultural land uses is clearly established. While there are a significant number of policies governing land uses in Well Head Protection Areas (WHPAs), there are no policies strictly governing roads. It should be noted that WHPA 3 is the lowest category of potential risk in the County OP, and protection of the WHPA would in any event need to be studied as part of the ongoing natural environmental inventories being undertaken by others during this study.

1.3. DESCRIPTION OF EAST BOUNDARY CORRIDOR STUDY AREA

The study area for the East Boundary Road Corridor Protection Study extends from Dundas Street (Highway 8) to Avenue Road. The western limit is Franklin Boulevard and the eastern limit is 500 metres east of Shellard Road. Figure 4 shows the study area boundary.

Both the ROPP and the ROP show that East Boundary Corridor improvements may extend to Can-Amara Parkway.

1.4. OVERVIEW OF OTHER RELEVANT TRANSPORTATION STUDIES

1.4.1. MTO Highway 401 to Highway 24 By-Pass

The Ministry of Transportation of Ontario (MTO) has initiated an EA for Highway 24 between the City of Brantford and Highway 401. As one alternative, the MTO will be considering a by-pass around the City of Cambridge. This would connect Highway 24 to Highway 401. This project is currently “on hold.” Communicating regularly with MTO is part of the East Boundary Road process to avoid duplication of efforts.

1.4.2. South Boundary Road

The EA for the South Boundary Corridor and Franklin Boulevard Extension is complete. The ROW will begin construction of the first phase in 2017. This will connect Water Street to the Franklin Boulevard Extension at the south end of Cambridge.

1.4.3. Franklin Boulevard

The EA for Franklin Boulevard is complete. The ROW will reconstruct Franklin Boulevard starting in 2015. This will increase vehicle capacity through access control and roundabout installations.

1.4.4. Hespeler Road

The Rapid Transit EA identified Hespeler Road for improvements. These will improve transit service along the Hespeler Road corridor as part of implementing aBRT for 2015.

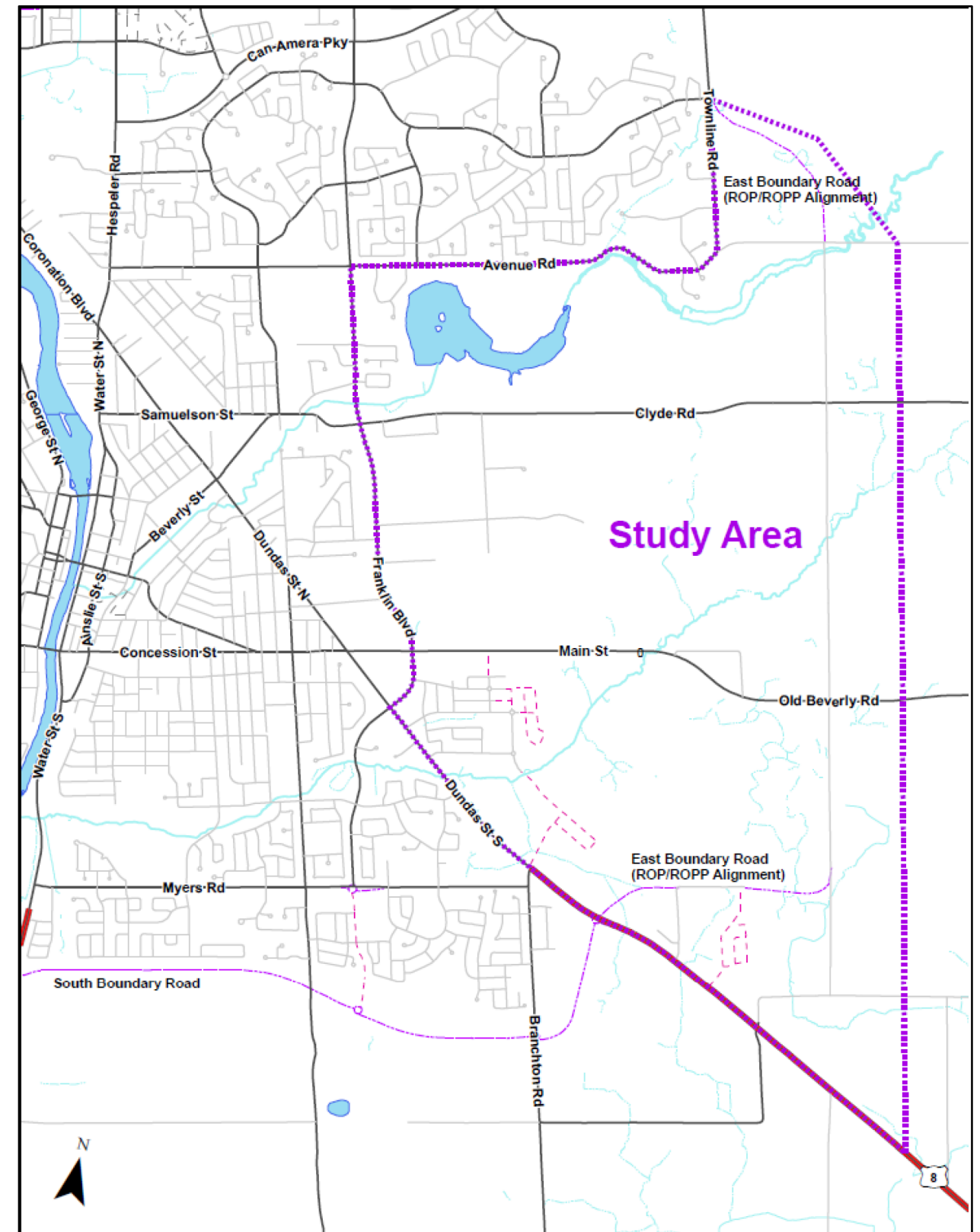


Figure 5: Study Area

1.5. REPORT OVERVIEW

Chapter 2 provides a brief primer on transportation analysis principles and methods.

Chapter 3 and Chapter 4 of this report review the existing and future traffic conditions for north-south travel in Cambridge. This evaluation reviews and confirms the need for long-term improvements for north-south travel in Cambridge. It also informs the problem statement.

Chapter 5, evaluates network alternatives. Each of these aims to solve the problem statement described in Section 4.4. The alternatives range from “Do Nothing” through non-structural improvements and several infrastructure intensive alternatives.

Chapter 6 builds on the finding in Chapter 5 that a new East Boundary Road is the preferred network alternative. This chapter evaluates several alignment alternatives against the transportation evaluation considerations that have been developed.

Chapters 7 and 8 provide conclusions and recommendations for selecting the preliminary preferred alignment, and Chapter 9 provides some next steps in the study.

2. TRANSPORTATION ANALYSIS PRIMER

Throughout this report, analysis will be performed and conclusions drawn about the operation of roads and intersections within the study area. This analysis makes use of industry standard performance measures. Summary tables for various scenarios, alternatives, or time horizons include these measures

- level of service (LOS) and delay
- volume to capacity ratio (v/c)
- queueing, or back of queue (BOQ), values

A description of each performance measurement is provided in the following few sections. Unfamiliar readers can reference these descriptions when interpreting analysis summary tables.

2.1. VOLUME TO CAPACITY RATIO (V/C)

In traffic analysis, “volume” represents the number of vehicles used in the analysis. Volumes are typically reported for one hour intervals i.e., 500 vehicles per hour (500 vph).

Capacity is the theoretical maximum number of vehicles that can travel on a given facility. Capacity can be calculated for an entire road or for an individual movement through an intersection. Capacities depend on a large number of factors including:

- the road itself
- the vehicle being used
- the drivers

The volume to capacity ratio represents how “full” a road or movement through an intersection is.

A v/c between 0.00 and 0.49 means that vehicles use less than half the capacity of the road. This is generally associated with good operating conditions. As the v/c approaches 1.00 traffic conditions worsen and at v/c = 1.00 the theoretical maximum number of vehicles is reached and operations are generally very poor.

When forecasting volumes, it is possible that an analysis will show a v/c of greater than 1.00. This indicates that more vehicles are expected than it is possible to serve.

A v/c greater than 1.00 is associated with very bad operations and extended traffic delays. When this happens, a road is often said to be “failing.”

2.2.LEVEL OF SERVICE (LOS) AND DELAY

Level of service attempts to describe the user experience on a transportation facility. The most common application of LOS is to driver experience.

Table 1 describes LOS for both signalized and unsignalized (i.e., stop controlled) intersections. As is shown in this table, each LOS is associated with a particular amount of delay. This value represents the delay each individual driver would experience on average.

As a qualitative measure, LOS cannot be calculated directly. As such, an industry standard relationship is used to compare delay and driver experience. Delay is a quantitative measurement commonly calculated in traffic analysis. Delay translates into a qualitative statement about the experience of driving on that road using the thresholds identified in Table 1.

Table 2: Vehicle Level of Service Definitions

LOS	Signalized Intersections		Unsignalized Intersections	
	Description	Delay	Description	Delay
A	Very seldom does a vehicle wait longer than one red light. The approach appears open, turns are easily made, and drivers have freedom of operation.	≤10 sec	Little or no traffic delay occurs. Approaches appear open, turning movements are easily made, and drivers have freedom of operation.	≤10 sec
B	An occasional green light is fully used and many greens approach full use. Many drivers begin to feel somewhat restricted within groups of vehicles approaching the intersection.	≤20 sec	Short traffic delays occur. Many drivers begin to feel somewhat restricted in terms of freedom of operation.	≤15 sec
C	Intersection operation is stable but often has fully used greens. Drivers feel more restricted and occasionally may wait more than one red light. Queues may develop behind turning vehicles.	≤35 sec	Average traffic delays occur. Operations are generally stable, but drivers emerging from the minor street may have trouble completing their movement. This may occasionally impact on the stability of flow on the major street.	≤25 sec
D	Drivers experience increasing restriction and instability of traffic flow. There are substantial delays to vehicles during short peaks within the peak hour, but there is enough time with lower demand to permit occasional clearing of queues and prevent excessive backups.	≤55 sec	Long traffic delays occur. Drivers emerging from minor streets experience significant restriction and frustration. Drivers on the major street will experience congestion and delay.	≤35 sec
E	The capacity of the road is reached. There are long queues of vehicles waiting upstream of the intersection and delays to vehicles may extend to several signal cycles.	≤80 sec	Very long traffic delays occur. Operations approach the capacity of the intersection.	≤50 sec
F	Vehicle demand exceeds the available capacity and delays extending through the peak hour are experienced.	>80 sec	Vehicle demand exceeds the available capacity. Very long traffic delays occur frequently.	>50 sec

2.3.QUEUEING

Queue values are the length of the 95th percentile queue or, back of the 95th percentile queue (BOQ). The 95th percentile queue usually represents a practical maximum queue length and

can assist in the design of roadway features such as turning lanes. Summary tables may give queue values with one of the three notes in Table 2. Analysis tables will repeat these notes, when needed, for ease of reference.

Acceptable queue lengths vary from location to location and depend more on the context of any given queue than on the length itself. For example, a 200 metre long queue at an off ramp on a four lane provincial highway may be frustrating but it is not likely to have severe impacts on other drivers. Conversely, the same 200 metre queue at an intersection in a busy downtown setting may back up through other intersections block driveways or turning vehicles and may cause cascading congestion issues that impact many other drivers throughout the area.

Because of the context sensitive nature of queue assessment interpretation may require more professional judgement than an assessment based on v/c or LOS. Issues one must consider include impacts to the broader network, operation of transit vehicles, and land access.

Table 3: Notes on Queueing Values

Note	Description
m	The length of the queue is metered by an upstream intersection. Due to operational restrictions at another intersection, the queue at this location is shorter than would otherwise be expected.
#	The 95th percentile volume, on which the 95th percentile queue is based, is greater than the available capacity. The queue length reported is the maximum after two signal cycles and should be adequate for design purposes.
~	This notation indicates that the 50th percentile volume is over capacity. Effectively this means that the average volume arriving will result in a queue that continuously lengthens until the volume arriving becomes consistently lower than the average peak volume. This situation represents a cascading congestion problem likely to have severe impacts on traffic operations.

2.4.SCREENLINES

Screenlines are commonly-used analysis tools to measure aggregate travel demand across an imaginary line or in/out of a cordoned area. Screenlines are often aligned with natural or artificial barriers in the environment such as rivers or railways. Comparing estimated demand from a tool such as a demand forecasting model against count data or surveys can be useful to calibrate a model, but screenlines are also useful for summarizing travel demand over large areas. The modelling in this study makes extensive use of screenlines.

3. EXISTING CONDITIONS

3.1. DESCRIPTION OF EXISTING NORTH-SOUTH CORRIDORS

Within Cambridge, there are three existing north-south corridors:

- Hespeler Road / Water Street (Highway 24)
- Franklin Boulevard
- Townline Road / Shellard Road

King Street / Coronation Boulevard / Dundas Street is another major corridor that serves north-south and, to some extent, east-west travel. Conestoga Boulevard, Cheese Factory Road, and Elgin Street form a continuous north-south corridor. However, the existing roads are discontinuous, and do not currently serve as a viable north-south travel alternative.

3.1.1. *Hespeler Road / Water Street (Highway 24)*

Through Cambridge the name, cross-section, and 2010 AADT of Highway 24 vary and are generally as follows:

- South Boundary Road to Ainslie Street North – Water Street, AADT = 11,000 to 20,000 vehicles, 2-lane cross-section
- Ainslie Street North to Dundas Street – Water Street, AADT = 30,000 to 38,000 vehicles, 4-lane cross-section
- Dundas Street to Dunbar Road – Hespeler Road, AADT = 32,000 to 35,000 vehicles, 4-lane cross-section
- Dunbar Road to Highway 401 – Hespeler Road, AADT = 31,000 to 41,000 vehicles, 6-lane cross-section

Exhibit 10 shows the number of lanes along this corridor for each road segment. Exhibit 5 shows 2011 AADT for this corridor.

3.1.2. *Franklin Boulevard*

Once construction is complete in 2016, Franklin Boulevard will extend from South Boundary Road over Highway 401 and into Hespeler. Currently Franklin Boulevard has the following characteristics:

- Myers Road to Dundas Street – AADT = 9,000 to 18,000 vehicles, 2-lane cross-section
- Dundas Street to Highway 401 – AADT = 20,000 to 41,000 vehicles, 4-lane cross-section

Exhibit 11 shows the number of lanes along this corridor for each road segment. Exhibit 6 shows 2011 AADT for this corridor.

Construction on this section will begin in 2014 to install 11 new roundabouts and other access management measures. This will improve the vehicle capacity of the road.

3.1.3. *Townline Road / Shellard Road*

Shellard Road extends from Morrison Road to Gore Road. About 750 metres west along Gore Road, Townline Road begins. Townline Road continues from there across Highway 401.

The corridor has a 2-lane cross-section until the intersection of Townline Road and Saginaw Parkway, where a 4-lane cross-section begins and continues north of Highway 401. Exhibit 12 shows the number of lanes along this corridor for each road segment.

Peak volumes occur on Townline Road near Highway 401 with an AADT of approximately 24,000 vehicles. Exhibit 7 shows 2011 AADT for this corridor.

3.1.4. *King Street / Coronation Boulevard / Dundas Street (Highway 8)*

This corridor extends from the southeast corner of Cambridge to the northwest. With the exception of a short stretch of 2-lane and 3-lane cross-section between Main Street and Beverly Street, this corridor has a 4-lane cross-section from Branchton Road to Preston.

Exhibit 13 shows the number of lanes along this corridor for each road segment. Exhibit 8 shows 2011 AADT for this corridor.

3.1.5. *Conestoga Boulevard / Elgin Street / Cheese Factory Road*

This corridor consists of City of Cambridge roads. Two major gaps in this corridor exist, one at Can-Am Parkway and the other at the CP Rail crossing just south of Samuelson Street. The entire corridor has a 2-lane cross-section. Exhibit 14 shows the number of lanes along this corridor for each road segment.

3.2. EXISTING LAND USE

The study area spans primarily residential, industrial, and open space lands. Figure 5 shows the land use in the study area and adjacent areas of Cambridge and North Dumfries.

Nine traffic analysis zones are adjacent to the study area and will have a direct impact on north-south travel in the corridor. Figure 6 shows these zones.

Exhibit 1 shows the population and employment estimates for these nine traffic zones.

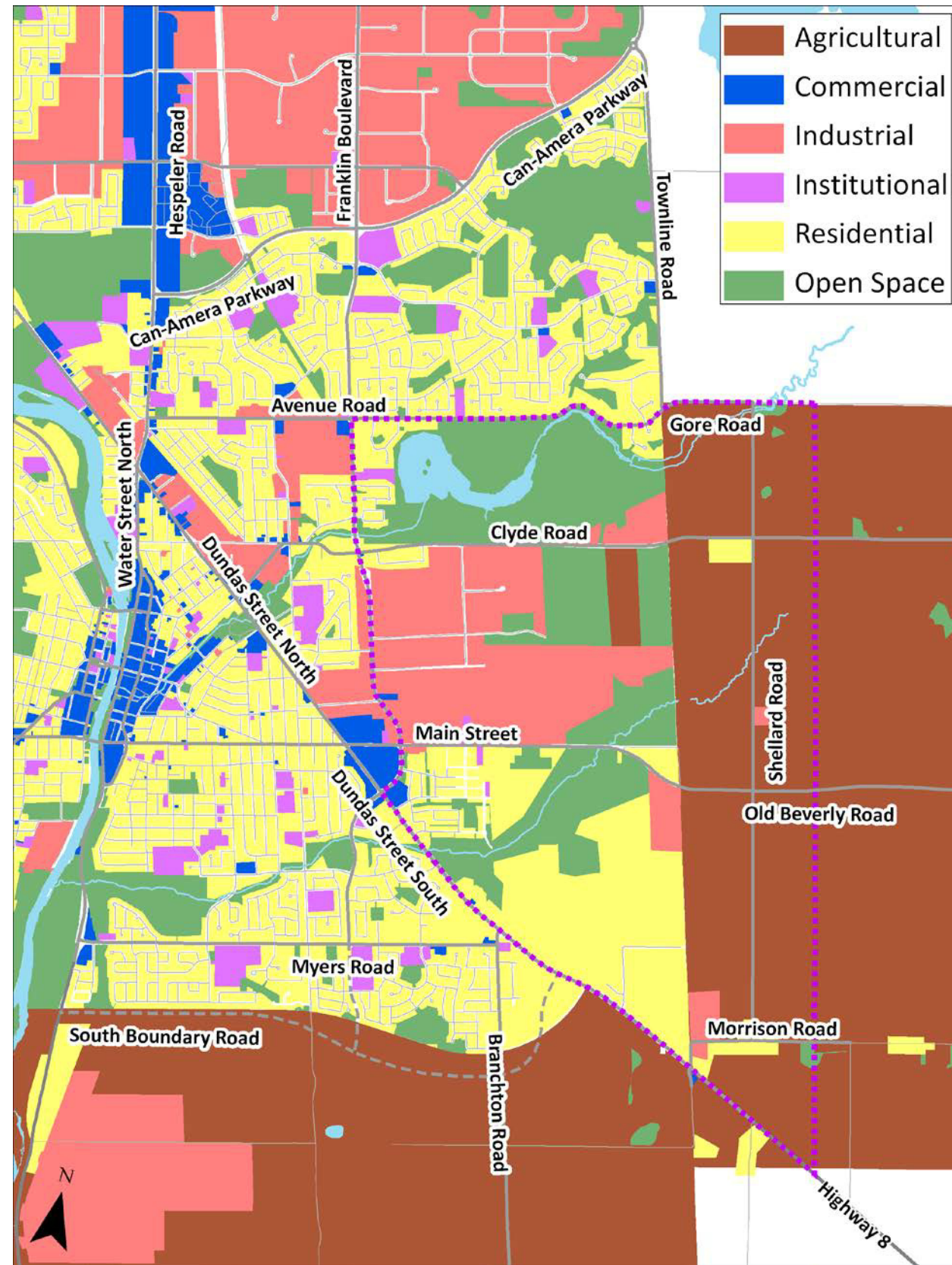


Figure 6: Existing Land Use

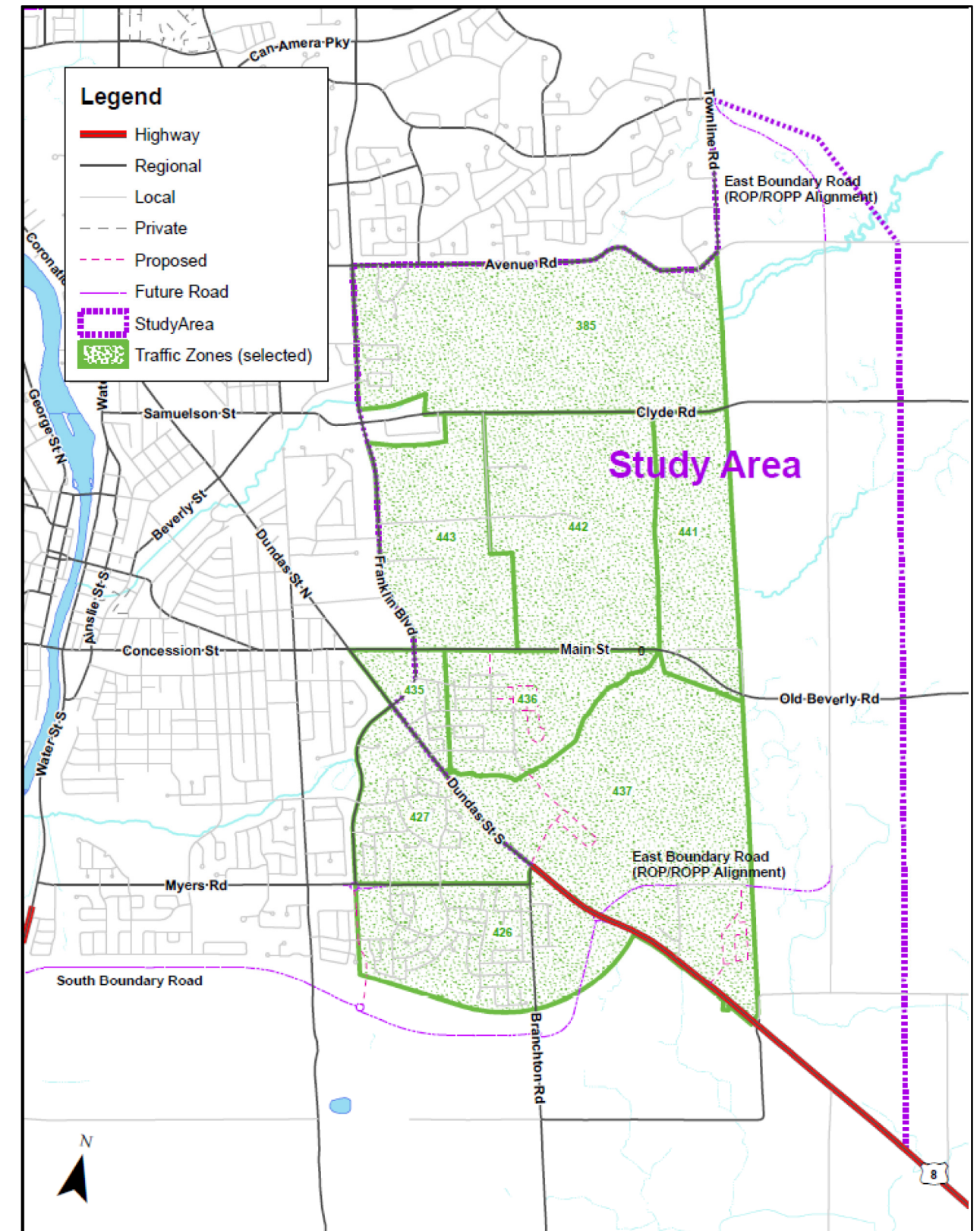


Figure 7: Traffic Analysis Zones

3.3. EXISTING TRAFFIC VOLUMES AND LEVELS OF SERVICE

3.3.1. Corridor Based Description of Existing Conditions

AADT

Exhibits 5 to 8 provide AADT values along the four regional corridors. The two primary corridors are Hespeler and Franklin. Each of these carries in excess of 40,000 vehicles per day. Volume in these corridors is concentrated near Can-Amara Parkway and Highway 401.

Townline Road near Highway 401 carries over 24,000 vehicles a day. Coronation Boulevard near Concession Road carries 27,000 vehicles a day.

2011 MODEL VOLUMES

Exhibits 15 to 19 provide peak hour volumes estimated by the 2011 travel-forecasting model.

These volumes demonstrate the expected northbound AM, southbound PM directionality of north-south travel in Cambridge. Peak volumes on Hespeler, Franklin, and Townline corridors occur near Can-Amara Parkway and Highway 401.

Exhibits 20 to 24 show the V/C along each of the five north-south corridors. These exhibits show that the Hespeler and Franklin corridors have v/c ratios consistent with experiencing operational problems in the peak direction.

The Elgin corridor shows localized high v/c ratios, and the Dundas corridor also has some locations between Concession Road and Elgin Street with high v/c ratios. Townline generally operates without difficulty.

3.3.2. Screenline Based Description of Existing Conditions

Four screenlines capture north-south travel in Cambridge. Figure 7 shows the location of these screenlines. Exhibit 2 lists each of the significant facilities that cross these screenlines.

Tables 3 and 4 show capacity, volume, and V/C values from the 2011 model for each screenline. This screenline analysis shows that the two more northern screenlines are at or are approaching capacity.

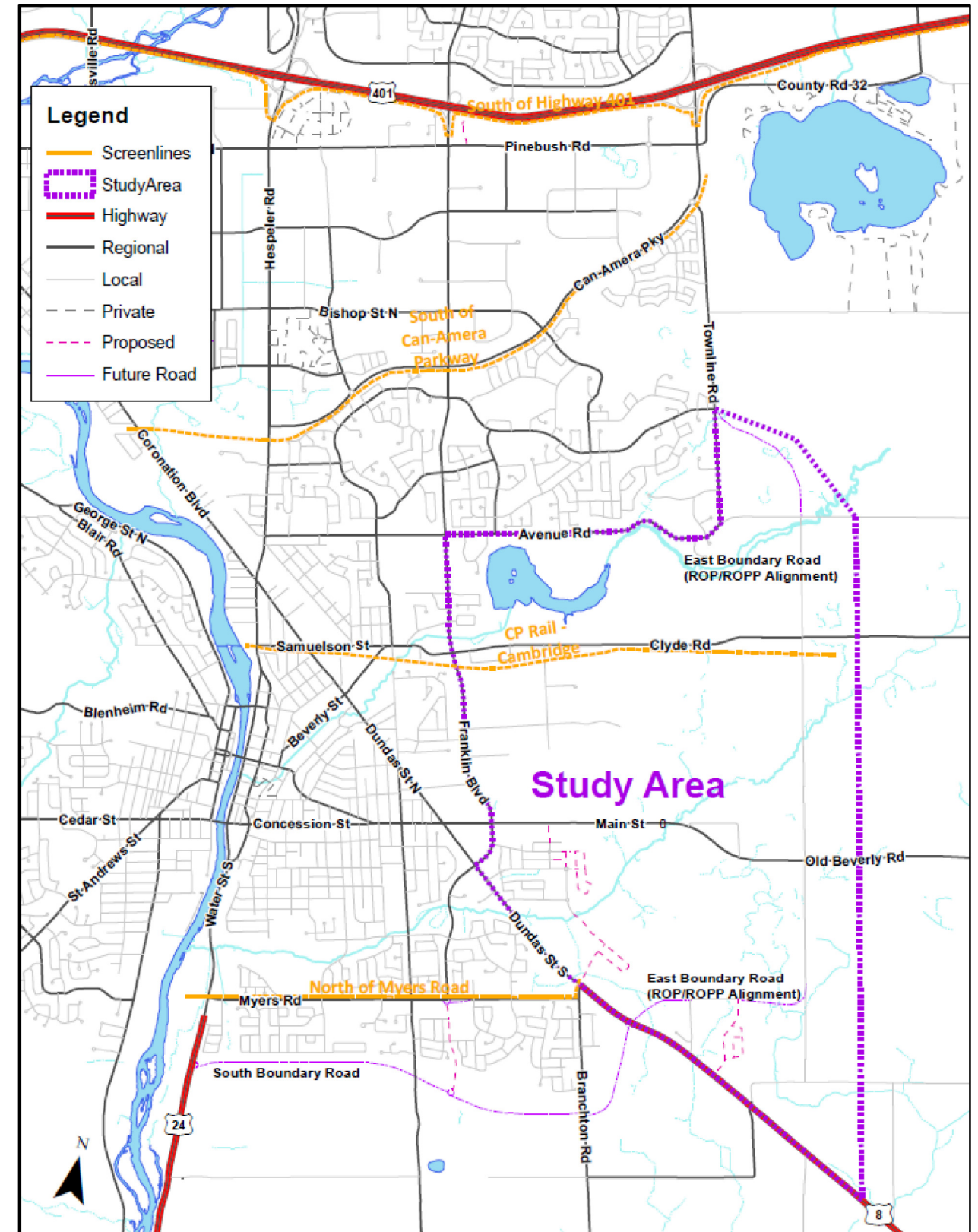


Figure 8: Screenlines

Table 4: 2011 AM Screenline Volumes

Screenline Name	Directional Lanes	Directional Capacity	Volume		V/C	
			SB	NB	SB	NB
North of Myers Road	7	5,000	1,055	1,969	0.21	0.39
CP Rail - Cambridge	8	6,550	2,221	4,448	0.34	0.68
South of Can-Amera Parkway	9	7,000	2,453	6,199	0.35	0.89
South of Highway 401	9	6,950	5,836	3,358	0.84	0.48

Table 5: 2011 PM Screenline Volumes

Screenline Name	Directional Lanes	Directional Capacity	Volume		V/C	
			SB	NB	SB	NB
North of Myers Road	7	5,000	1,970	1,327	0.39	0.27
CP Rail - Cambridge	8	6,550	4,996	2,804	0.76	0.43
South of Can-Amera Parkway	9	7,000	7,612	2,996	1.09	0.43
South of Highway 401	9	6,950	4,480	6,337	0.64	0.91

3.4. PUBLIC TRANSIT

Figure 8 shows the Grand River Transit routes that are operating within the study area. Given the nature of the area on the edge of the City, there are routes serving existing developments but no service in the outlying areas.

The main transit route serving a similar demand pattern to the EBR is Route 53 (Franklin Boulevard), which operates between Main Street and Bishop Street mostly along Franklin Boulevard. However, with only one bus every 30 minutes, this transit route cannot be expected to accommodate significant demand that would remove the need for improvements in the corridor.

The other significant current/planned transit service providing long-distance north-south travel in Cambridge is the recently started ION Bus Rapid Transit (BRT) service travelling along Ainslie/Water Street and Hespeler Road. While significant resources are being invested in this new service and efforts are being made to attract new users, this service will take some time to reach maturity and in any event is far away from the proposed EBR location.

Therefore, existing public transit has little effect on the amount of traffic travelling north/south parallel to the proposed corridor.

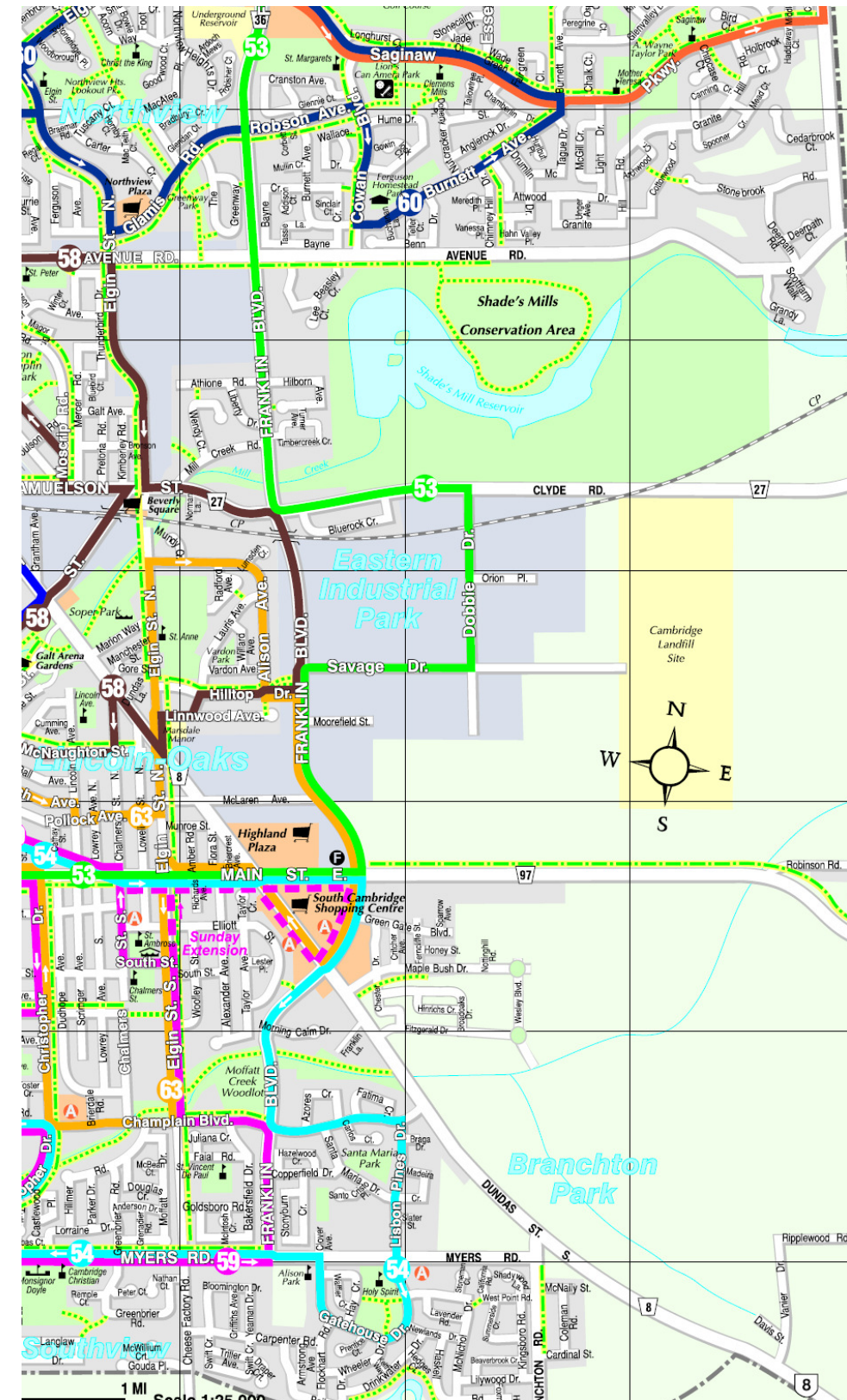


Figure 9: Transit Routes in Study Area

3.5. COMMERCIAL VEHICLE TRAFFIC

The three main Regional road corridors that serve similar demand patterns to the EBR (i.e. Hespeler Road/Water Street, Franklin Boulevard and Dundas Street) all carry significant numbers of commercial vehicles. Looking at all available traffic count data, the commercial vehicle percentages were determined and are reproduced in Table 5. With AADT on Hespeler Road about 40,000, the 5% of total traffic equates to about 2,000 trucks daily. Similarly for Franklin Boulevard with the same AADT, the roughly 7% of total traffic equates to almost 3,000 trucks daily. These represent a significant value to the local economy, and delays in these corridors carry real economic costs.

Table 6: Commercial Vehicle Percentages

Corridor	AM Peak Hour		PM Peak Hour		8-Hour Total	
	Trucks	Heavies	Trucks	Heavies	Trucks	Heavies
Hespeler/Water	2.7%	3.7%	1.2%	1.8%	2.2%	3.0%
Franklin	3.5%	3.6%	2.0%	2.0%	3.3%	3.7%
Dundas	1.8%	3.0%	0.8%	1.3%	1.5%	2.3%

3.6. RAIL TRAFFIC

The Canadian Pacific (CP) railway running generally parallel to Samuelson Street and Clyde Road carries freight rail traffic, but passenger service was discontinued some time ago. Crossings of Regional roads within the Cambridge City limits are generally grade separated, such as at Hespeler Road, Dundas Street, Beverly Street, and Franklin Boulevard, while crossings of Cambridge local roads are generally at-grade, such as Bond Street and Dobbie Drive. The Clyde Road, Shellard Side Road and Gore Road crossings are also at-grade.

The Region and the City of Cambridge are currently collaborating on a business case and feasibility study for the extension of GO Train service along the Milton Line to Cambridge. If this initiative is successful, trains would use this line and would increase the number of trains in the morning and afternoon peak periods.

4. FUTURE TRAFFIC CONDITIONS

4.1. FUTURE DEVELOPMENT

4.1.1. 2031 Horizon

The RTMP used a land use forecast for 2031 to determine transportation demand over the next 20 years. This forecast includes growth in the nine traffic analysis zones highlighted in Figure 6. Exhibit 1 shows growth in each zone. The total growth from 2011 to 2031 is:

- 11,092 additional residents
- 2,155 additional jobs

4.1.2. Mature State

Exhibit 1 shows growth assumed in the study area for the mature state. The mature state is defined more fully within the RTMP document, but corresponds to a future point where all currently designated lands are developed in accordance with current policies. These assumptions include the following growth on top of 2031 forecasts:

- 1,956 additional residents
- 1,944 additional jobs

When compared to 2011 land use estimates, this translates to:

- 13,048 additional residents
- 4,098 additional jobs

4.2. STUDY AREA TRANSPORTATION INFRASTRUCTURE IMPROVEMENTS

4.2.1. 2031 Horizon Model

The RTMP identifies several projects that directly contribute to north-south transportation capacity between 2011 and 2031. Other assessments have also identified transportation projects. Improvements include:

- Franklin Boulevard reconstruction between Myers Road and Highway 401
- Townline Road widening to four lanes between Can-Amara Parkway and Avenue Road (note that widening between Can-Amara Parkway and Saginaw Parkway has already been completed)
- Franklin Boulevard extension to South Boundary Road
- Hespeler Road improvements for aBRT

- Speedsville Road is widened to four lanes from Eagle Street to north of Highway 401

Exhibit 3 highlights how these changes affect each screenline. Exhibits 25 to 29 show the resulting road widths and capacity.

4.2.2. *Mature State Model*

The mature state network includes the following changes from 2031 that are generally associated with a full BRT along the Hespeler Road/Water Street corridor included in the Mature State model:

- Water Street is widened to four lanes between Myers Road and Ainslie Street
- Water Street from Ainslie Street to Dundas Street is only two lanes, not four as existing
- Beverly Street is widened to 4 lanes between Dundas Street and Samuelson Street
- Speedsville Road is not widened to four lanes from Eagle Street to north of Highway 401
- Hespeler Road from Dunbar Road to north of Highway 401 is only four lanes, not six as existing
- Franklin Boulevard capacity immediately north of Pinebush Road is 1100, not 750 as existing

Exhibit 4 highlights how these changes affect each screenline. Exhibits 40 to 44 show the resulting road widths and capacity.

4.3. FUTURE TRAFFIC VOLUMES AND LEVELS OF SERVICE

4.3.1. *Corridor Based Description of Future Conditions*

2031 HORIZON

Exhibits 30 to 34 give the corridor volumes forecast in the 2031 model. Exhibits 35 to 39 show the V/C for each corridor in the 2031 model.

As expected, volumes grow over the next 20 years. The peak direction flows continue to experience operational problems.

However, if the transit system develops as planned, it will capture much of the travel growth. In most cases, this reduction will return traffic volumes to near the level of 2011 traffic. The RTMP uses this scenario. Exhibits 30 to 39 demonstrate this scenario with 2031 RTMP PM peak hour values.

All corridors still demonstrate a modest increase in traffic and a corresponding reduction in the level of service. Additional north-south capacity between Samuelson Street / Clyde Road and Highway 401, or equivalent measures, may alleviate the forecast problems.

MATURE STATE

Exhibits 45 to 49 give the corridor volumes forecast in the Mature State model. Exhibits 50 to 54 show the V/C for each corridor in the Mature State model.

In the Mature State scenario, two major forces are evident:

- The large reduction in capacity on the Hespeler corridor results in a minor reduction in traffic on some sections of this corridor (other section remain stable or grow)
- The large increase in north-south travel, combined with the limited capacity on the Hespeler corridor, cause a very large increase in v/c ratio in all other corridors (with the exception of the Elgin corridor as it does not provide a continuous north-south connection)

In this model, traffic congestion affects the peak direction of all four continuous corridors. This congestion continues to be focused between Highway 401 and Can-Amara Parkway, suggesting the need for significant new north-south capacity between Concession Street / Main Street and Highway 401.

4.3.2. *Screenline Based Description of Future Conditions*

2031 HORIZON

Table 6 provides screenline volume, capacity, and V/C in the 2031 horizon assuming the improvements proposed in the RTMP. Screenlines highlighted in red are near capacity.

Improvements to north-south travel may be required based on the screenline assessment using RTMP assumptions. An improvement equivalent to one travel lane in each direction crossing Can-Amara Parkway would likely be sufficient to correct this screenline.

Table 7: 2031 RTMP PM Peak Hour Screenline Volumes

Screenline Name	Directional Lanes	Directional Capacity	Volume		V/C	
			SB	NB	SB	NB
North of Myers Road	8	6,450	2,877	1,907	0.45	0.30
CP Rail - Cambridge	8	6,950	5,886	3,068	0.85	0.44
South of Can-Amara Parkway	9	7,400	8,343	3,239	1.13	0.44
South of Highway 401	10	7,900	5,333	7,361	0.68	0.93

MATURE STATE

Table 7 provides screenline volume, capacity, and V/C for the Mature State. Three of the four screenlines are over capacity in the PM peak hour. New capacity is needed to address the screenline problems identified. Near the CP Rail and Highway 401 screenlines, one additional lane of capacity is likely sufficient. However, near Can-Amara Parkway, three additional lanes of capacity may be required in the peak direction.

Table 8: Mature State PM Screenline Volumes

Screenline Name	Directional Lanes	Directional Capacity	Volume		V/C	
			SB	NB	SB	NB
North of Myers Road	9	7,200	4,024	2,007	0.56	0.28
CP Rail - Cambridge	8	6,850	7,027	3,245	1.03	0.47
South of Can-Amera Parkway	9	7,400	10,565	3,190	1.43	0.43
South of Highway 401	8	6,750	6,481	7,461	0.93	1.11

4.4. PROBLEM STATEMENT

The following problem statement will guide the transportation evaluation of alternatives in the remainder of this report:

Regional transportation studies dating back to the 1960s have all identified a future need for an arterial road connection on the east side of Cambridge between the south end of the City to Highway 401. This arterial road has commonly been referred to as the “East Boundary Road.” Recent transportation demand modelling results have confirmed that an arterial road on the east side of Cambridge is needed to alleviate forecasted north-south roadway capacity deficiencies along Hespeler Road and Franklin Boulevard, improve access to the Regional road network for residents of the Southeast Galt Community area, and provide an alternative for goods movement to avoid traffic congestion in downtown Cambridge. Such a road could also accommodate alternative transportation, including dedicated walking and cycling facilities and public transit.

A route for an “East Boundary Road” needs to be confirmed to facilitate any proposed developments in the area to proceed and to protect the land for this future roadway. With the recent approval of the South Boundary Road between Highway 24 and Dundas Street south of Myers Road, and the upgrades to Townline Road south of Highway 401 completed, a route between Dundas Street in the south, to Townline Road in the north, must be identified for this Regional road.

5. TRANSPORTATION NETWORK ALTERNATIVES

The EA process requires explicit evaluation of both “alternatives to” (Phase 2) and “alternative methods” (Phase 3) of the undertaking. In other words, when determining how to address the problem or opportunity, various strategic alternatives must initially be evaluated in Phase 2. Once an overall approach has been chosen, then various alternative ways of implementing that approach must also be evaluated in Phase 3. The purpose of these multiple layers of evaluation is to determine the optimal solution that addresses the identified problem with a minimum disturbance to the surrounding environment.

The master planning process undertaken by the RTMP is intended to identify the overall problems facing the community and identify alternatives to on a broad system level. As noted earlier, the RTMP identified constructing the EBR as the preferred way to address long-term north-south transportation capacity deficiency in Cambridge. However, it is instructive to review these alternatives to confirm the RTMP findings.

5.1. ALTERNATIVE 1: DO NOTHING

The EA process explicitly requires consideration of the “Do Nothing” alternative, which represents the effect on the surrounding environment of choosing to not address the problem or opportunity. The 2031 and mature state transportation analysis presented in Section 4.3 describes the implications of the Do Nothing alternative on the other north-south roads in Cambridge. In practical terms, traffic conditions represented by those findings would result in delays to commuters, goods movement and potentially emergency vehicles. In turn, delays to goods movement would have a negative impact on the economy in Cambridge, particularly the manufacturing base along Franklin Boulevard that depends on timely shipments of parts and completed goods.

5.2. ALTERNATIVE 2: NON-STRUCTURAL IMPROVEMENTS

This alternative refers generally to using alternative modes to accommodate travel demands: public transit, cycling and walking. The RTMP considered these improvements as part of the overall system planning process, and included significant growth in PM peak hour mode share to about 20% overall for Cambridge by 2031 for these three modes. However, even with these improvements, the existing capacity deficiencies would not be addressed, and these would worsen significantly in the mature state. While non-structural improvements are a critical component of addressing long-term transportation needs in Cambridge, alone they are not sufficient to address all long-term needs.

5.3. ALTERNATIVE 3: IMPROVEMENTS TO FRANKLIN BOULEVARD

The Franklin Boulevard EA examined two main alternatives to addressing the long-term capacity deficiency along Franklin Boulevard: widening the road to six lanes or converting it to a roundabout corridor coupled with strong access controls. While widening the road to six lanes would have addressed the forecast capacity deficiencies, there was concern about poor traffic operations at the improved signalized intersections. Also, the widening would not address the other problems being experienced in the corridor, such as the lack of active transportation facilities and poor collision history. That study ultimately concluded that the roundabout corridor alternative was preferred, and construction will start in 2017.

The approved design for the road includes a centre median for access control, boulevard multi-use trails for active transportation on both sides, two travel lanes in each direction and two-/three-lane roundabouts at almost all intersections. Improving Franklin Boulevard to increase its capacity still further would require widening of the roadway. To retain the access control concept including the centre median, widening of the road would have to be done to the outsides. The designated road allowance specified in the ROP for Franklin Boulevard is between 30 and 36 metres, and it is unlikely that a six-lane roadway with a centre median and boulevard active transportation facilities on both sides could be accommodated within that allowance. Additionally, larger roundabouts at the intersections would require more private property to be acquired beyond the road allowance specified in the ROP. The cost of the current design for Franklin Boulevard is specified at \$50M in the draft 2015 TCP, and a wider road would cost significantly more. Finally, a new Environmental Assessment study would need to be completed prior to such a widening. Consequently, this alternative seems infeasible.

5.4. ALTERNATIVE 4: IMPROVEMENTS TO WATER STREET / HESPELER ROAD

As noted earlier, the Water Street/Hespeler Road corridor is the other north-south corridor showing future capacity deficiencies. The road is already six lanes wide between Eagle Street/Pinebush Road and Dunbar Road, south of which the road is four lanes wide. Two of these travel lanes have been removed in the mature state models to account for the extension of dedicated transit right-of-way to Cambridge. As shown in Exhibit 35, most of the forecast capacity deficiencies in this corridor would occur in the four-lane section between Dunbar Road and Ainslie Street. For some sections of this corridor, such as the section shown in Figure 9 below, adding additional lanes would require significant acquisitions of private property. While this would not necessarily render the alternative technically infeasible, the impacts to the social environment would be severe.



Figure 10: Water Street north of Dando Avenue (looking north)

5.5. ALTERNATIVE 5: IMPROVEMENTS TO ELGIN STREET CORRIDOR

Cheese Factory Road, Elgin Street and Conestoga Boulevard are City of Cambridge roads that are roughly parallel to Hespeler Road and Franklin Boulevard between the southern limit of Cambridge and Highway 401. As Cheese Factory Road continues into the Township of North Dumfries, this corridor can be viewed as being capable of providing a similar north-south corridor function as the East Boundary Road.

However, this corridor would be unsuitable for this purpose. As noted in Section 3.1.5, the corridor is discontinuous in two places: at Can-Amera Parkway and again at the CP Rail grade separation south of Samuelson Street. Figure 10 and Figure 11 show the discontinuities and the context of each area. South of the Can-Amera Parkway and Conestoga Boulevard intersection, the corridor becomes a City trail before intersecting with Elgin Street at a T-intersection. Elgin Street continues west/south as a residential collector road and only becomes a more suitable arterial-type roadway south of Avenue Road. Converting Elgin Street through this area into a facility capable of accommodating regional traffic would impose severe disruption to this residential area.

South of Samuelson Street, the corridor again becomes discontinuous where Elgin Street meets the CP Rail grade separation. The current structure is only wide enough to accommodate pedestrians and cyclists, and the trail also crosses a creek immediately south of the railway. Further south, Elgin Street again becomes a residential collector road with private residences fronting the street. Again, accommodating regional traffic along this portion of the road would impose severe disruption to the residential area, environmental disturbance to the creek, and entail significant expansion of the railway grade separation.



Figure 11: View of Elgin Street corridor from Can-Amera Parkway and Conestoga Boulevard intersection



Figure 12: North/south sides of Elgin Street CP Rail grade separation

Finally, it is also worth noting that the corridor ends at Pinebush Road just south of Highway 401. Were this corridor to begin accommodating inter-regional traffic, this traffic would have to turn onto Pinebush Road to join or cross the highway at the existing Hespeler Road, Franklin

Boulevard or Townline Road interchanges. This would add much more traffic to an already-busy Hespeler Road interchange, and also likely require widening of Pinebush Road to the east.

Consequently, the Cheese Factory Road/Elgin Street/Conestoga Boulevard corridor would not be a suitable alternative for addressing the identified problem.

5.6. ALTERNATIVE 6: CONSTRUCT NEW EAST BOUNDARY ROAD

The above sections outline the alternatives that were considered in place of constructing a new north-south corridor along the east side of Cambridge. Constructing this corridor would be more consistent with current Regional policies and would more effectively address the identified problem.

6. EAST BOUNDARY ROAD ALIGNMENT ALTERNATIVES

The East Boundary Road Corridor Protection Study is examining potential alignments of the roadway in an effort to reduce impacts to the natural and social environments. Since the Regional demand model assigns traffic to routes based on length, speed and traffic congestion along a route, it can also evaluate whether a proposed route will be more or less likely to accommodate traffic. This was used to review the different proposed corridor alignments for the transportation evaluation.

Four corridor alternatives, and various subalternatives, were presented to the public at the first Public Consultation Centre, and are shown in Figure 12. For the purposes of the transportation evaluation, the four main alternatives were compared, as well as the “Do Nothing” alternative, as follows:

- Route A (Shellard Side Road / ROP alignment)
- Route B (Southeast Galt Community alignment)
- Route C (Cambridge / North Dumfries boundary alignment)
- Route D (Hydro corridor alignment)

At the southern limit of the East Boundary Road, all of the alternatives would connect to the planned intersection of the South Boundary Road and Dundas Street. At the northern limit, Routes B, C and D would connect to Townline Road (widened to four lanes by 2031) at Avenue Road. Route A would follow the ROP alignment and connect to Townline Road around Saginaw Parkway, with a portion of the alignment travelling through the Township of Puslinch in Wellington County. The various subalternatives shown (e.g. A-C 1, etc.) were not evaluated, but are anticipated to perform within the range of the main alternatives identified above.

6.1. ASSIGNMENT RESULTS: DISCUSSION

Forecasts from the Regional transportation demand model for the 2031 PM peak hour are presented in Appendix B, and summarized in Figures 13 to 16. Some general observations are as follows:

1. The East Boundary Road is projected to carry significant traffic.
2. The East Boundary Road would provide significant relief to Dundas Street and Franklin Boulevard, but less significant relief to Water Street/Hespeler Road.
3. Routes B and D would carry the most traffic and provide the most relief to other Regional roads.
4. Route A would carry the least traffic and provide the least relief to other Regional roads.
5. Route B would provide more access to developments in Southeastern Cambridge.

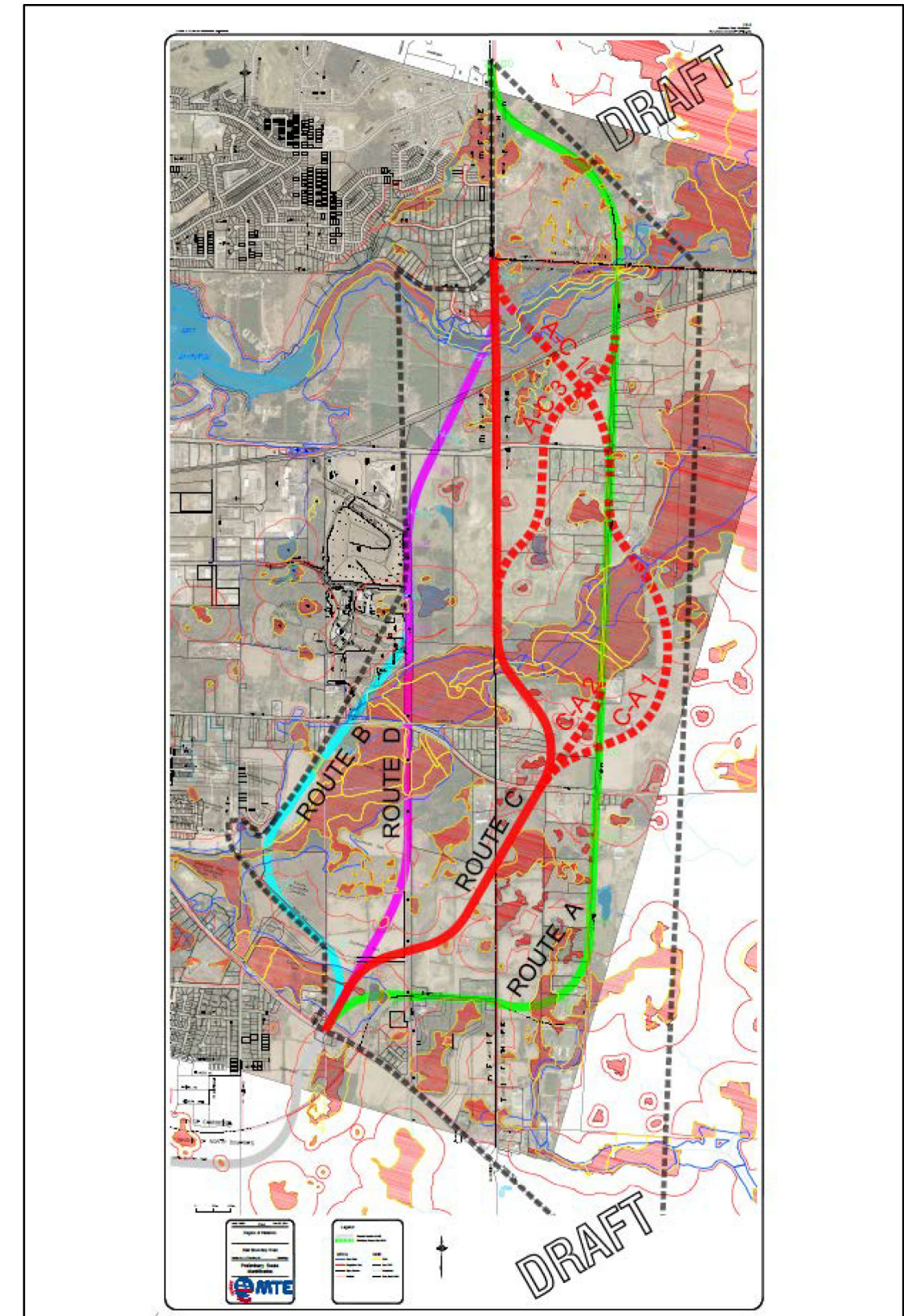


Figure 13: Preliminary EBR Corridor Alignments (PCC 1)

East Boundary Road

Alignment Alternative	Traffic						Total	% Less than Do Nothing
	NB/WB	v/c	% Less than Do Nothing	SB/EB	v/c	% Less than Do Nothing		
Total (all sections)								
A	938	N/A	N/A	4,774	N/A	N/A	5,712	N/A
B	1,562	N/A	N/A	6,957	N/A	N/A	8,520	N/A
C	1,327	N/A	N/A	5,804	N/A	N/A	7,131	N/A
D	1,726	N/A	N/A	6,862	N/A	N/A	8,588	N/A
North of Dundas Street								
A	82	0.04	N/A	85	0.04	N/A	167	N/A
B	135	0.06	N/A	305	0.14	N/A	440	N/A
C	158	0.07	N/A	159	0.07	N/A	317	N/A
D	191	0.09	N/A	297	0.14	N/A	488	N/A
South of Main Street								
A	126	0.06	N/A	179	0.08	N/A	305	N/A
B	197	0.09	N/A	598	0.27	N/A	795	N/A
C	181	0.08	N/A	340	0.15	N/A	521	N/A
D	211	0.10	N/A	483	0.22	N/A	694	N/A
North of Main Street								
A	147	0.07	N/A	800	0.36	N/A	946	N/A
B	246	0.11	N/A	1,138	0.52	N/A	1,384	N/A
C	198	0.09	N/A	985	0.45	N/A	1,184	N/A
D	261	0.12	N/A	1,147	0.52	N/A	1,408	N/A
South of Clyde Road								
A	147	0.07	N/A	808	0.37	N/A	955	N/A
B	246	0.11	N/A	1,138	0.52	N/A	1,384	N/A
C	194	0.09	N/A	996	0.45	N/A	1,190	N/A
D	261	0.12	N/A	1,147	0.52	N/A	1,408	N/A
Clyde Road to Avenue Road								
A	168	0.08	N/A	852	0.39	N/A	1,020	N/A
B	286	0.13	N/A	1,172	0.53	N/A	1,458	N/A
C	226	0.10	N/A	1,003	0.46	N/A	1,229	N/A
D	307	0.14	N/A	1,174	0.53	N/A	1,481	N/A
North of Avenue Road								
A	167	0.08	N/A	849	0.39	N/A	1,016	N/A
B	286	0.16	N/A	1,177	0.65	N/A	1,463	N/A
C	225	0.13	N/A	1,004	0.56	N/A	1,229	N/A
D	307	0.17	N/A	1,179	0.65	N/A	1,486	N/A
Can-Amara Parkway to Saginaw Parkway								
A	102	0.06	N/A	1,201	0.67	N/A	1,302	N/A
B	165	0.09	N/A	1,429	0.79	N/A	1,594	N/A
C	144	0.08	N/A	1,317	0.73	N/A	1,460	N/A
D	189	0.10	N/A	1,436	0.80	N/A	1,624	N/A

Figure 14: East Boundary Road 2031 PM Peak Hour Forecast Traffic

Dundas Street

Alignment Alternative	Traffic						Total	% Less than Do Nothing
	NB/WB	v/c	% Less than Do Nothing	SB/EB	v/c	% Less than Do Nothing		
Total (all sections)								
Do Nothing	4,718	N/A		6,565	N/A		11,283	
A	4,543	N/A	-3.7%	5,913	N/A	-9.9%	10,456	-7.3%
B	4,703	N/A	-0.3%	5,410	N/A	-17.6%	10,113	-10.4%
C	4,549	N/A	-3.6%	5,667	N/A	-13.7%	10,216	-9.5%
D	4,411	N/A	-6.5%	5,371	N/A	-18.2%	9,782	-13.3%
East of EBR/SBR								
Do Nothing	682	0.62		716	0.65		1,398	
A	637	0.58	-6.5%	657	0.60	-8.3%	1,294	-7.4%
B	673	0.61	-1.2%	724	0.66	1.2%	1,398	0.0%
C	673	0.61	-1.3%	700	0.64	-2.3%	1,373	-1.8%
D	673	0.61	-1.2%	728	0.66	1.6%	1,401	0.3%
EBR/SBR to Branchton Road								
Do Nothing	650	0.59		697	0.63		1,346	
A	631	0.57	-2.9%	640	0.58	-8.1%	1,271	-5.6%
B	753	0.68	15.9%	619	0.56	-11.1%	1,372	1.9%
C	612	0.56	-5.9%	639	0.58	-8.3%	1,250	-7.1%
D	597	0.54	-8.2%	568	0.52	-18.5%	1,164	-13.5%
Branchton Road to Champlain Boulevard								
Do Nothing	795	0.88		1,032	1.15		1,827	
A	741	0.82	-6.7%	986	1.10	-4.5%	1,727	-5.5%
B	747	0.83	-6.0%	822	0.91	-20.4%	1,570	-14.1%
C	738	0.82	-7.1%	909	1.01	-12.0%	1,647	-9.9%
D	702	0.78	-11.6%	807	0.90	-21.8%	1,510	-17.4%
Champlain Boulevard to Franklin Boulevard								
Do Nothing	804	0.45		1,326	0.74		2,130	
A	744	0.41	-7.4%	1,198	0.67	-9.7%	1,942	-8.8%
B	721	0.40	-10.3%	1,019	0.57	-23.2%	1,740	-18.3%
C	734	0.41	-8.7%	1,108	0.62	-16.4%	1,842	-13.5%
D	693	0.39	-13.8%	993	0.55	-25.1%	1,686	-20.8%
Franklin Boulevard to Main Street								
Do Nothing	675	0.38		1,041	0.58		1,717	
A	670	0.38	-0.8%	906	0.50	-13.0%	1,576	-8.2%
B	657	0.37	-2.7%	793	0.44	-23.9%	1,450	-15.6%
C	666	0.37	-1.4%	834	0.46	-20.0%	1,499	-12.7%
D	642	0.36	-4.9%	825	0.46	-20.7%	1,467	-14.5%
West of Main Street								
Do Nothing	512	0.68		783	1.04		1,295	
A	520	0.69	1.6%	676	0.90	-13.6%	1,196	-7.6%
B	550	0.73	7.4%	625	0.83	-20.1%	1,175	-9.3%
C	525	0.70	2.4%	653	0.87	-16.6%	1,177	-9.1%
D	519	0.69	1.4%	640	0.85	-18.3%	1,159	-10.5%
East of Beverly Street								
Do Nothing	600	0.80		970	1.29		1,570	
A	599	0.80	-0.2%	850	1.13	-12.4%	1,449	-7.8%
B	602	0.80	0.3%	808	1.08	-16.7%	1,410	-10.2%
C	602	0.80	0.2%	826	1.10	-14.9%	1,427	-9.1%
D	584	0.78	-2.7%	810	1.08	-16.5%	1,394	-11.2%

Figure 15: Dundas Street 2031 PM Peak Hour Forecast Traffic

Franklin Boulevard

Alignment Alternative	Traffic							
	NB/WB	v/c	% Less than Do Nothing	SB/EB	v/c	% Less than Do Nothing	Total	% Less than Do Nothing
Total (all sections)								
Do Nothing	5,410	N/A		14,738	N/A		20,148	
A	4,889	N/A	-9.6%	13,435	N/A	-8.8%	18,324	-9.0%
B	4,482	N/A	-17.2%	12,693	N/A	-13.9%	17,175	-14.8%
C	4,650	N/A	-14.0%	13,131	N/A	-10.9%	17,780	-11.7%
D	4,454	N/A	-17.7%	12,806	N/A	-13.1%	17,260	-14.3%
SBR to Myers Road								
Do Nothing	147	0.13		257	0.23		404	
A	113	0.10	-23.2%	241	0.22	-6.4%	353	-12.5%
B	102	0.09	-30.8%	252	0.23	-2.0%	354	-12.5%
C	105	0.10	-28.7%	255	0.23	-0.8%	360	-10.9%
D	99	0.09	-32.4%	257	0.23	-0.1%	356	-11.9%
Myers Road to Champlain Boulevard								
Do Nothing	287	0.13		651	0.30		938	
A	253	0.12	-12.2%	634	0.29	-2.6%	886	-5.6%
B	240	0.11	-16.5%	611	0.28	-6.2%	851	-9.3%
C	241	0.11	-16.2%	639	0.29	-1.8%	880	-6.2%
D	232	0.11	-19.5%	665	0.30	2.2%	897	-4.4%
South of Dundas Street								
Do Nothing	386	0.18		1,113	0.51		1,499	
A	349	0.16	-9.6%	1,102	0.50	-1.0%	1,451	-3.2%
B	329	0.15	-14.7%	1,059	0.48	-4.9%	1,388	-7.4%
C	327	0.15	-15.2%	1,095	0.50	-1.6%	1,422	-5.1%
D	317	0.15	-17.9%	1,124	0.51	1.0%	1,441	-3.9%
South of Main Street								
Do Nothing	649	0.30		1,793	0.82		2,442	
A	553	0.25	-14.9%	1,628	0.74	-9.2%	2,181	-10.7%
B	480	0.22	-26.0%	1,473	0.67	-17.8%	1,954	-20.0%
C	503	0.23	-22.5%	1,574	0.72	-12.2%	2,078	-14.9%
D	471	0.22	-27.4%	1,484	0.68	-17.3%	1,955	-20.0%
Savage Drive to Clyde Road								
Do Nothing	1,036	0.47		2,278	1.04		3,314	
A	906	0.41	-12.5%	1,906	0.87	-16.4%	2,812	-15.2%
B	803	0.37	-22.5%	1,694	0.77	-25.7%	2,497	-24.7%
C	855	0.39	-17.4%	1,795	0.82	-21.2%	2,650	-20.0%
D	808	0.37	-22.0%	1,678	0.77	-26.3%	2,486	-25.0%
South of Avenue Road								
Do Nothing	1,159	0.53		2,523	1.15		3,682	
A	1,037	0.47	-10.5%	2,088	0.95	-17.2%	3,125	-15.1%
B	932	0.43	-19.6%	1,906	0.87	-24.5%	2,838	-22.9%
C	985	0.45	-15.1%	2,009	0.92	-20.4%	2,993	-18.7%
D	935	0.43	-19.4%	1,901	0.87	-24.6%	2,836	-23.0%
Saginaw Parkway/Elgin Street to Can-Amara Parkway								
Do Nothing	1,015	0.47		3,438	1.57		4,453	
A	956	0.44	-5.8%	3,257	1.49	-5.3%	4,213	-5.4%
B	895	0.41	-11.8%	3,154	1.44	-8.3%	4,049	-9.1%
C	922	0.42	-9.2%	3,205	1.46	-6.8%	4,127	-7.3%
D	894	0.41	-11.9%	3,140	1.43	-8.7%	4,033	-9.4%
Can-Amara Parkway to Bishop Street								
Do Nothing	730	0.33		2,685	1.22		3,415	
A	724	0.33	-0.9%	2,579	1.17	-3.9%	3,303	-3.3%
B	700	0.32	-4.1%	2,545	1.16	-5.2%	3,245	-5.0%
C	712	0.33	-2.5%	2,559	1.17	-4.7%	3,270	-4.2%
D	699	0.32	-4.3%	2,557	1.16	-4.8%	3,256	-4.7%

Figure 16: Franklin Boulevard 2031 PM Peak Hour Forecast Traffic

Water Street/Hespeler Road

Alignment Alternative	Traffic							
	NB/WB	v/c	% Less than Do Nothing	SB/EB	v/c	% Less than Do Nothing	Total	% Less than Do Nothing
Total (all sections)								
Do Nothing	7,845	N/A		11,552	N/A		19,397	
A	7,937	N/A	1.2%	11,227	N/A	-2.8%	19,164	-1.2%
B	7,961	N/A	1.5%	11,055	N/A	-4.3%	19,016	-2.0%
C	7,930	N/A	1.1%	11,123	N/A	-3.7%	19,053	-1.8%
D	7,938	N/A	1.2%	11,017	N/A	-4.6%	18,954	-2.3%
South of SBR								
Do Nothing	707	0.64		895	0.81		1,602	
A	708	0.64	0.1%	903	0.82	0.9%	1,611	0.6%
B	708	0.64	0.2%	918	0.83	2.6%	1,626	1.5%
C	708	0.64	0.2%	912	0.83	1.9%	1,620	1.1%
D	709	0.64	0.2%	913	0.83	2.1%	1,622	1.3%
South of Myers Road								
Do Nothing	552	0.74		670	0.89		1,222	
A	553	0.74	0.2%	633	0.84	-5.5%	1,186	-3.0%
B	557	0.74	0.8%	602	0.80	-10.2%	1,159	-5.2%
C	551	0.74	-0.1%	614	0.82	-8.4%	1,165	-4.6%
D	552	0.74	0.0%	595	0.79	-11.2%	1,147	-6.1%
South of Ainslie Street								
Do Nothing	584	0.90		791	1.22		1,375	
A	584	0.90	0.1%	753	1.16	-4.8%	1,337	-2.7%
B	587	0.90	0.6%	729	1.12	-7.8%	1,317	-4.2%
C	582	0.90	-0.2%	739	1.14	-6.6%	1,321	-3.9%
D	583	0.90	-0.1%	723	1.11	-8.6%	1,306	-5.0%
South of Samuelson Street								
Do Nothing	981	0.66		1,926	1.29		2,907	
A	972	0.66	-0.9%	1,910	1.28	-0.9%	2,882	-0.9%
B	973	0.66	-0.8%	1,879	1.26	-2.4%	2,853	-1.9%
C	971	0.66	-1.0%	1,899	1.28	-1.4%	2,870	-1.3%
D	975	0.66	-0.6%	1,884	1.27	-2.2%	2,859	-1.7%
South of Coronation Boulevard/Dundas Street								
Do Nothing	949	0.64		1,811	1.22		2,760	
A	944	0.64	-0.4%	1,795	1.21	-0.9%	2,740	-0.7%
B	945	0.64	-0.4%	1,774	1.19	-2.1%	2,719	-1.5%
C	944	0.64	-0.5%	1,788	1.20	-1.3%	2,732	-1.0%
D	947	0.64	-0.2%	1,774	1.19	-2.0%	2,721	-1.4%
South of Avenue Road								
Do Nothing	1,088	0.74		1,705	1.15		2,793	
A	1,083	0.73	-0.4%	1,650	1.11	-3.2%	2,734	-2.1%
B	1,075	0.73	-1.3%	1,628	1.10	-4.5%	2,702	-3.3%
C	1,075	0.73	-1.3%	1,639	1.10	-3.9%	2,713	-2.9%
D	1,075	0.73	-1.2%	1,631	1.10	-4.4%	2,706	-3.1%
South of Can-Amara Parkway								
Do Nothing	772	0.53		2,344	1.58		3,116	
A	765	0.52	-0.9%	2,209	1.49	-5.8%	2,973	-4.6%
B	761	0.52	-1.4%	2,149	1.45	-8.3%	2,911	-6.6%
C	759	0.52	-1.7%	2,181	1.47	-6.9%	2,940	-5.6%
D	759	0.52	-1.7%	2,150	1.45	-8.3%	2,909	-6.6%
South of Pinebush Road/Eagle Street								
Do Nothing	2,212	0.99		1,410	0.63		3,622	
A	2,327	1.04	5.2%	1,375	0.61	-2.5%	3,702	2.2%
B	2,354	1.05	6.4%	1,376	0.61	-2.4%	3,730	3.0%
C	2,340	1.04	5.8%	1,351	0.60	-4.2%	3,692	1.9%
D	2,339	1.04	5.7%	1,346	0.60	-4.5%	3,685	1.7%

Figure 17: Water Street/Hespeler Road 2031 PM Peak Hour Forecast Traffic

The East Boundary Road would carry significant traffic by 2031, meaning that the road would be well used. While projected traffic is generally modest near the southern limit at Dundas Street, traffic volumes would be much higher close to Highway 401, and the road would be operating at 70-80% of its theoretical one-way design capacity for a four-lane roadway. In the PM peak hour, most traffic would be travelling southbound.

All alignments would provide significant relief to Dundas Street (South Boundary Road to Beverly Street), ranging from about 7% to about 13% less traffic overall, and more in the peak direction. Route D would provide the most relief for Dundas Street, while Route A would provide the least.

Similarly, all alignments would provide significant relief to Franklin Boulevard (South Boundary Road to Bishop Street), ranging from 9% to about 15% less traffic overall, and more in the peak direction. Route B would provide slightly more relief than alignment D, while Route A would provide the least. Also, relief for Franklin Boulevard would be more significant than for Dundas Street, both because it carries more traffic and because it is parallel to the East Boundary Road.

All alignments would provide minor relief to Water Street/Hespeler Road, ranging from about 1% to 2% less traffic overall, and more in the peak direction. It is worth noting that relief would be most pronounced outside of downtown Cambridge (i.e. south of Ainslie Street and north of Avenue Road). This is likely because travellers outside of the downtown area have more feasible routes available to them to reach their final destinations. Similar to above, Routes B and D would provide the most relief to Water Street/Hespeler Road, while Route A would provide the least.

Routes B and D would carry the highest traffic volumes and provide the most relief to other Regional roads. Route D is projected to carry higher traffic because it is the shortest alignment, providing the shortest travel times between other Regional roads. While Route B is also a relatively short route, the higher projected traffic volumes are also partly caused by its better accessibility, as it is the only alignment that could be connected to the residential developments around Green Gate Boulevard and Maple Bush Drive.

Conversely, Route A is projected to carry the least traffic volume, and provide the least relief to other Regional roads, of the tested alignments. The ROP alignment is significantly longer than the other routes and further away from major traffic generators.

6.2.ALIGNMENT CONSIDERATIONS: ACTIVE TRANSPORTATION

As a Regional road, the East Boundary Road would be designed as a multi-modal corridor able to accommodate multiple types of users. The road is intended to carry large volumes of car and truck traffic at high speeds, so active transportation would likely be provided a separated facility such as a boulevard multi-use trail.

Active transportation users travel much slower than vehicles, and as such the length of the corridor is much more relevant to their overall experience with the corridor. For this reason,

Route D, the shortest alternative, is more likely to accommodate higher numbers of utilitarian users than Route A, which is the longest. Table 8 below shows the total lengths of each route alternative (Highway 8/Dundas Street to Townline Road around Saginaw Parkway) and the increase in length over Route D.

Table 9: Lengths of East Boundary Corridor Route Alternatives

Route Alternative	Length (m)	% more than D
A	7,400	24%
B	6,280	5%
C	6,400	7%
D	5,975	

6.3.ALIGNMENT CONSIDERATIONS: PUBLIC TRANSIT ROUTING

As noted above, the East Boundary Road would be designed as a multi-modal transportation corridor, including potentially as a public transit route. Proximity to potential and planned developments, and overall length of the route, will determine how useful the road could be for public transit. Figure 18 below shows the different East Boundary Road alignments, planned developments, Provincially Significant Wetlands, and the Regional rural and protected countryside as defined in the ROP. Any area shown in white is a potential future development site. Route B, with its short total length and closest location to planned developments, could provide an excellent high-speed transit connection. Conversely, Route A is long, distant from planned developments, has protected countryside on both sides for much of its length, and therefore would be a poor routing choice for public transit. Route D is further from planned developments than Route B, but would have similar access to potentially developable area. Route C also has access to some potentially developable area, but less than B and D, and also would have protected countryside along one side for much of its length.

6.4.ALIGNMENT CONSIDERATIONS: ACCESS TO PLANNED DEVELOPMENTS

The East Boundary Road would be planned as a protected access roadway, meaning that the majority of nearby developments would not have direct accesses to it, and private driveways would generally be forbidden. Therefore, the degree of access provided to the road is governed more by how close it passes to nearby developments. As shown in Figure 17 below, Route A would provide the poorest connectivity to planned developments in southeast Cambridge, as the majority of the route would be far away from those developments. Conversely, Route B would provide the best access as it would pass through many of those developments. Routes C and D would provide good access for some developments, but would pass through fewer developments than Route B.

6.5. OVERALL EVALUATION

The overall evaluation is summarized in Table 9 below. From a transportation perspective and considering all evaluation criteria, Route B is the preferred route. Alternatives are ranked based on 8 being the least preferred and < being the most preferred.

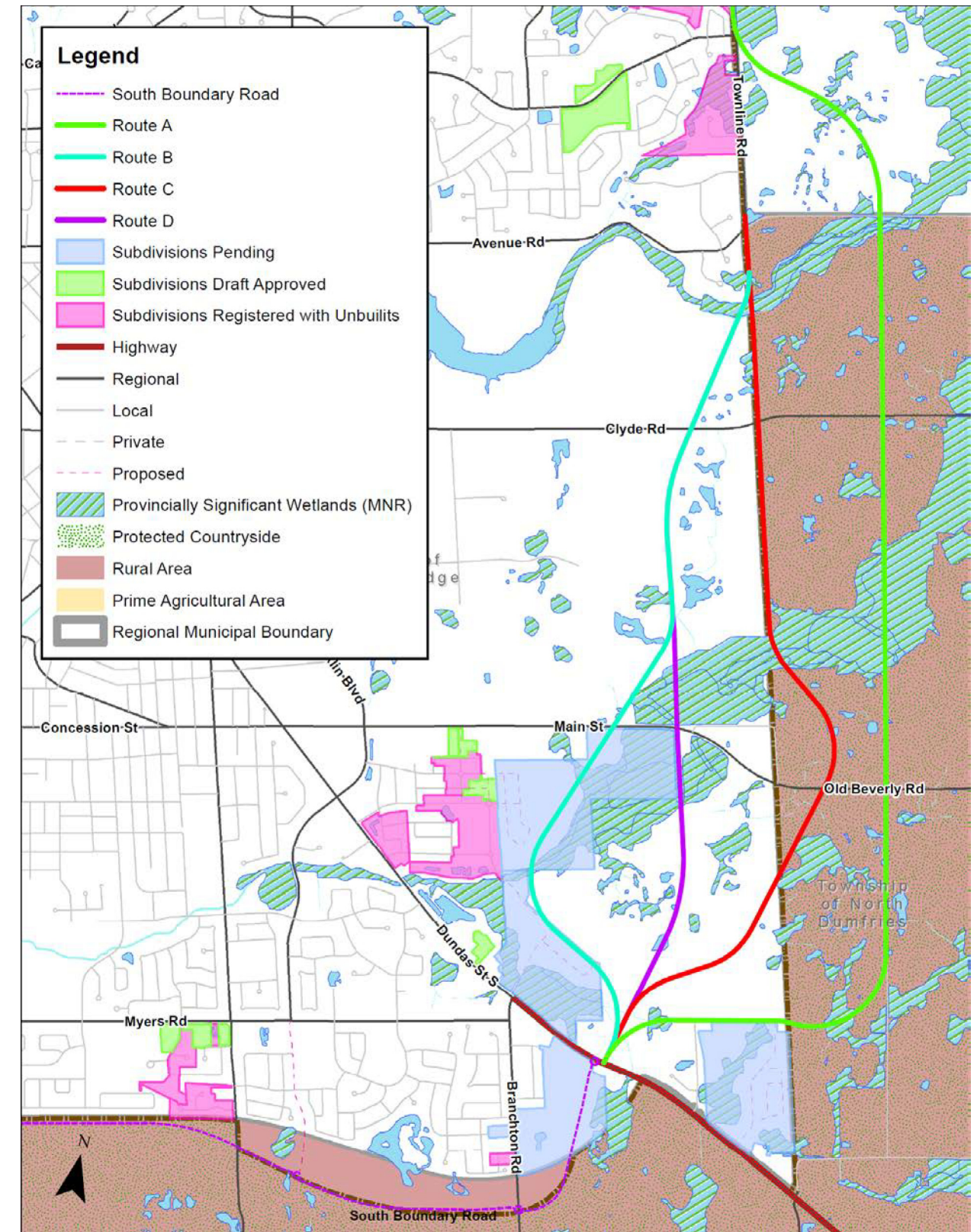


Figure 18: EBR Routes and Planned Developments

Table 10: Overall Transportation Evaluation Results

Evaluation Criteria	Route Alternative			
	A	B	C	D
Traffic	<ul style="list-style-type: none"> East Boundary Road carries 5,712 total traffic (lowest total amount). Dundas Street carries 10,456 total traffic (7.3% less than Do Nothing). Franklin Boulevard carries 18,324 total traffic (9.0% less than Do Nothing). Water Street carries 19,164 total traffic (1.2% less than Do Nothing). 	<ul style="list-style-type: none"> East Boundary Road carries 8,520 total traffic (second highest total amount). Dundas Street carries 10,113 total traffic (10.4% less than Do Nothing). Franklin Boulevard carries 17,175 total traffic (14.8% less than Do Nothing). Water Street carries 19,016 total traffic (2.0% less than Do Nothing). 	<ul style="list-style-type: none"> East Boundary Road carries 7,131 total traffic (second lowest total amount). Dundas Street carries 10,216 total traffic (9.5% less than Do Nothing). Franklin Boulevard carries 17,780 total traffic (11.7% less than Do Nothing). Water Street carries 19,053 total traffic (1.8% less than Do Nothing). 	<ul style="list-style-type: none"> East Boundary Road carries 8,588 total traffic (highest total amount). Dundas Street carries 9,782 total traffic (13.3% less than Do Nothing). Franklin Boulevard carries 17,260 total traffic (14.3% less than Do Nothing). Water Street carries 18,954 total traffic (2.3% less than Do Nothing).
	8	;	:	<
Active Transportation	Total length is 7,400 metres (24% longer than Route D).	Total length is 6,280 metres (5% longer than Route D).	Total length is 6,400 metres (7% longer than Route D).	Total length is 5,975 metres (shortest overall length).
	8	;	;	<
Public Transit	Longest total length, furthest away from existing and planned developments, little potentially developable lands to service.	Second shortest total length and close proximity to existing and planned developments.	Total length slightly longer than Route B, location is also further away from existing and planned developments, proximity to potentially developable lands but protected countryside along one side.	Shortest total length, further away from existing and planned developments, but close to potentially developable lands.
	8	<	:	;
Access to Developments	Furthest away from all existing and planned developments and very little access to potentially developable areas.	Closest to existing, planned and potential developments .	Would not provide access to existing or planned developments, could provide access to some potentially developable areas.	Further away from existing developments than Route B, but provides access to one planned development and a large amount of potentially developable lands.
	9	<	:	;
Overall	9	;	:	;

7. FUTURE TRAFFIC CONTROL

This section of the report outlines how turning movements at major proposed intersections were developed, and proposed traffic controls for those intersections. Additionally, preliminary recommendations of crossing protection at the intersection with the CP railway are provided.

7.1. TURNING MOVEMENT FORECASTS

As the East Boundary Road does not currently exist, turning movement forecasts were developed exclusively through the Regional transportation demand forecasting model for the four major intersections with Wesley Boulevard, Main Street, Clyde Road, and Avenue Road/Gore Road. These forecasts for the 2041 AM and PM peak hours are included in Figure 19 below. The 2041 AADT forecasts, used in the preliminary roundabout screenings and Intersection Control Studies, are included in Figure 20 below.

7.2. INTERSECTION TRAFFIC CONTROLS

7.2.1. Traffic Signal Warrants

The significant amount of development in the area, and the high capacity of the East Boundary Road, lead to high projected turning movements in the 2041 peak hours. Following Regional practice, traffic signal control warrants were carried out for these future intersections. It was determined that traffic signals will be warranted at the following intersections under 2041 traffic conditions:

- Wesley Boulevard & East Boundary Road
- Main Street & East Boundary Road
- Clyde Road & East Boundary Road
- Avenue Road/Gore Road & East Boundary Road/Townline Road

The traffic signal warrant spreadsheets are included in Appendix C.

7.2.2. Preliminary Roundabout Screenings

As the above locations will all be new intersections, in accordance with Regional practice preliminary roundabout screenings were performed. These screenings compared roundabouts with appropriate alternative forms of traffic control, in this case traffic control signals. The purpose of the screenings is to identify potential issues with constructing roundabouts, and determine whether more detailed Intersection Control Studies are necessary.

The preliminary roundabouts screenings for the above four intersections are included in Appendix D. In all cases, the screenings concluded that more detailed Intersection Control Studies would be required.

REGIONAL MUNICIPALITY OF WATERLOO
East Boundary Road (Avenue Road - Dundas Street South)
2041 AM and PM Peak Hour Volumes Forecast

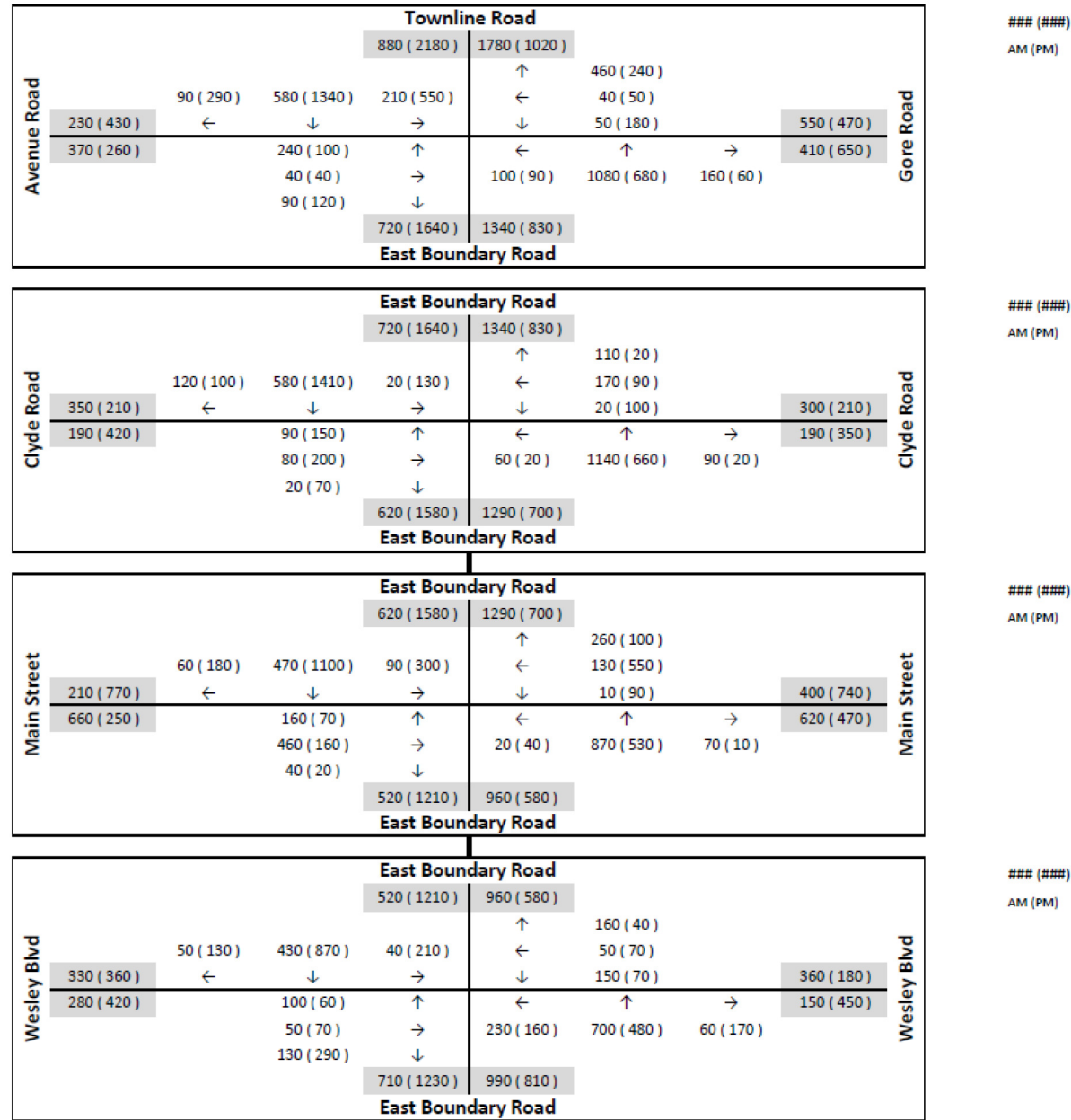


Figure 19: Turning Movement Forecasts (2041).

REGIONAL MUNICIPALITY OF WATERLOO
East Boundary Road (Avenue Road - Dundas Street South)
2041 AADT Forecast

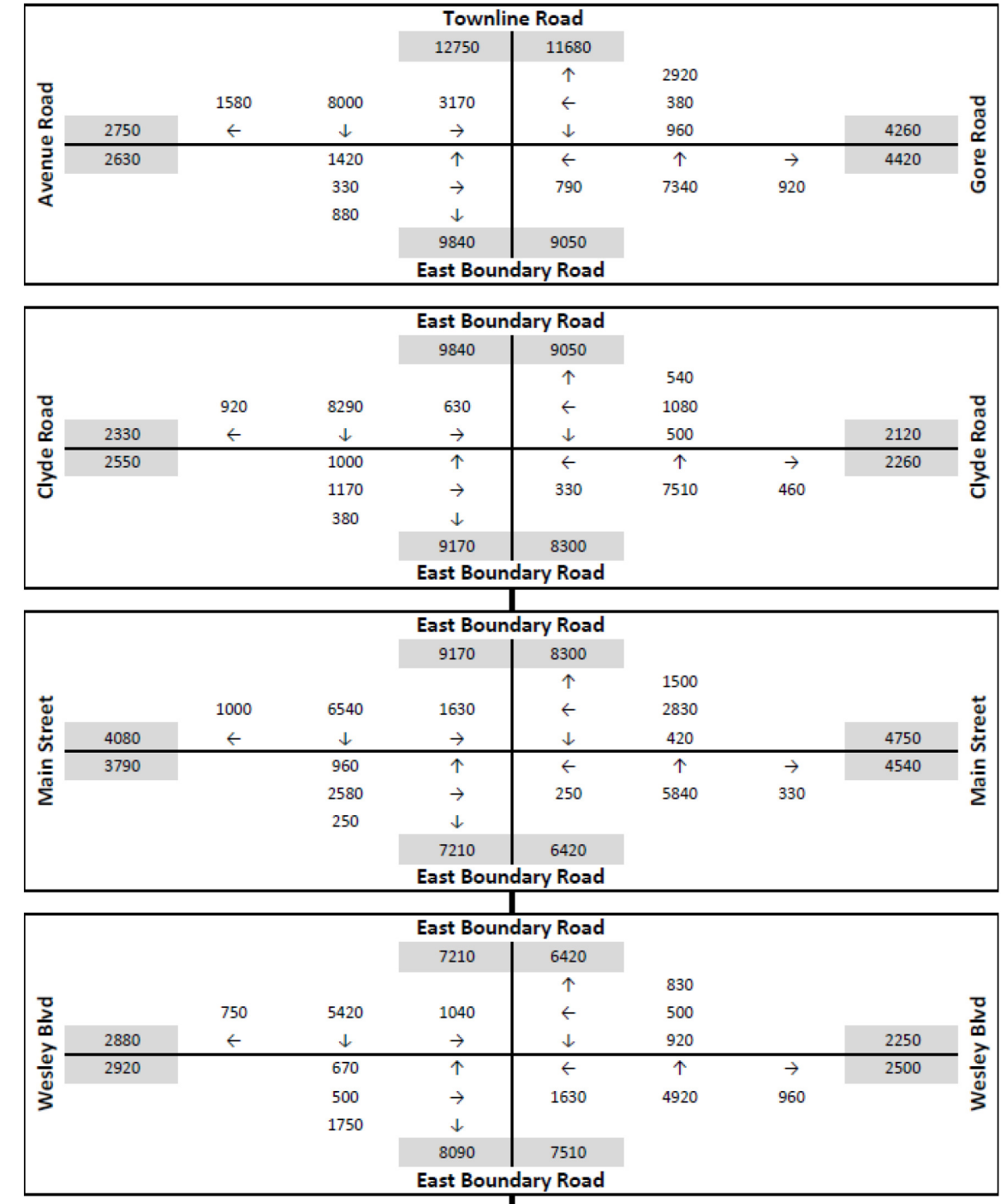


Figure 20: 2041 Turning Movement AADT Forecasts.

7.2.3. Intersection Control Studies

All four intersections were evaluated in one Intersection Control Study (ICS), which is included in Appendix E. The ICS includes forecast traffic operations, collision forecasts, functional designs, construction cost estimates, and 20-year lifecycle cost estimates, which consider capital costs and the societal cost of future predicted collisions.

The ICS concluded that multi-lane roundabouts would be the preferred form of traffic control at all four future East Boundary Road intersections with Wesley Boulevard, Main Street, Clyde Road, and Avenue Road/Gore Road. At the intersections with Avenue Road/Gore Road, and with Clyde Road, 20-year lifecycle cost estimates for both the traffic signal and roundabout control alternatives were essentially the same, with the roundabout additionally providing better peak hour traffic operations.

At the intersections with Main Street, and with Wesley Boulevard, while the traffic control signal alternative was projected to have a lower 20-year lifecycle cost, the roundabout alternatives were slightly more costly (about 20% more). The added benefit of being able to create a continuous roundabout corridor from the Avenue Road/Gore Road & East Boundary Road intersection in the northeast to Water Street & South Boundary Road intersection in the southwest, a total length of over ten kilometres, suggests that roundabouts are the preferred form of traffic control at these intersections as well.

7.3. CROSSING PROTECTION AT THE CP RAILWAY

The EBR crosses the main CP railway in the section between Avenue Road and Clyde Road. Correspondence with CPR staff indicates that there are currently 14 trains per day at this location with a maximum train speed of 60 miles per hour (about 100 kilometres per hour).

Guidelines for crossing protection at road/railway crossing locations recommend an escalating series of protective measures, from warning signs, to the addition of flashing lights, to descending barriers, and finally to full grade separation of the crossing. These measures are considered as the volume of trains and road vehicles increases, the operating speeds of trains and cars increases, and by the class of roadway crossing the railway. One measure that is frequently used is the cross-product (i.e. trains per day X road vehicles per day), with measures proposed as shown in Table 11 below.

Table 11: Road/Railway Crossing Protection

Cross-Product	Crossing Protection	Notes
> 1,000	Crossing signals	
> 50,000	Crossing signals with gates	Train speeds exceeding 50 mph
> 200,000	Grade separation	Preferred if over a major arterial

Based on an assumed ratio of 10% of PM peak hour traffic to AADT, forecast 2031 daily traffic for the different EBR alignments at their crossing locations can be estimated from the forecast peak hour traffic in Figure 14 as shown in Table 12 below.

Table 12: 2031 AADTs and Cross-Products at Crossing Location

EBR Alignment	2031 AADT	Cross-Products (14 trains)
A	10,200	143,000
B	14,580	204,000
C	12,290	172,000
D	14,810	207,000

Estimates of the 2031 cross-products for the various alignments would range from a low of about 143,000 (Alignment A) to a high of 207,000 (Alignment D). Given the operating speeds of trains on the railway and forecast cross-products in excess of 50,000 for any of the alignment alternatives, crossing signals with gates would be the minimum acceptable protection.

Although the Region does not designate its roadways as “arterials”, “collectors” and so on, it should be noted that the EBR would likely be classified as a Community Connector under the Region’s Context Sensitive Corridor Design Guidelines. This designation is most similar to a “major arterial” in use in many other jurisdictions. Furthermore, discussions involving the Region, the City of Cambridge and Metrolinx around extending GO Train service along the Milton Line, which uses this section of railway, have the potential to increase the number of trains per day. This would increase the cross-product estimates noted in Table 12 above.

Therefore, for the purposes of determining the preferred EBR alignment, it is recommended that a grade separation be considered.

8. CONCLUSIONS

Population and employment growth in southeast Cambridge is projected to be more than 10,000 people and 4,000 jobs in the long term. This growth will put increased pressure on the north-south transportation links described above. While the improvements to public transit outlined in the 2010 RTMP and the 2018 TMP Update are expected to accommodate much of this growth, traffic congestion on north-south screenlines is expected to worsen. This will cause delays for commuters, goods movement and emergency vehicles.

A number of non-structural and other infrastructure-intensive alternatives have been examined in place of constructing a new road corridor. As noted above, public transit improvements will make a significant difference but are not expected to eliminate all problems. Improvements to other corridors, including Water Street/Hespeler Road and Franklin Boulevard, are already planned but further improvements to these corridors would be impractical or cause severe impacts. Finally, the Cheese Factory Road/Elgin Street/Conestoga Boulevard corridor is too discontinuous and residential in character to be a practical alternative.

Various alignments of the East Boundary Road have been tested to determine preferred alignments for accommodating regional and inter-regional traffic. The four routes were presented to the public at Public Consultation Centre 1. Route A, the alignment currently in the ROP largely along Shellard Side Road, is the longest alignment and the furthest to the east, and is projected to carry the least traffic and provide the least relief to other Regional roads in Cambridge, notably Franklin Boulevard. Routes B and D are closer to Cambridge, are shorter, would carry the most traffic, and would provide the most relief to other Regional roads. Route B is also notable as being the furthest west and being able to provide the most direct access to planned residential developments in southeast Cambridge.

Reviews of 2041 peak hour turning movement projections determined that traffic control signals or roundabouts are warranted at these horizon years. Following Regional practice to complete preliminary roundabout screenings and more detailed Intersection Control Studies, roundabouts were determined to be the preferred form of traffic control. This is either because they are projected to have the same 20-year lifecycle cost, or because they will provide other benefits while being only slightly more expensive.

A review of the railway crossing determined that a grade separated crossing of the East Boundary Road would be appropriate.

9. RECOMMENDATIONS

Based on the contents of this report, the evaluation scores as presented in Table 9 are recommended to be carried forward to be compared against the other criteria categories.

The road cross section should be constructed to accommodate an ultimate four-lane width, as projected traffic volumes will eventually be too great for a two-lane facility.

The East Boundary Road intersections with Wesley Boulevard, Main Street, Clyde Road, and Avenue Road/Gore Road should be constructed as multi-lane roundabouts.

A grade separated crossing with the CP railway between Clyde Road and Avenue Road/Gore Road should be included in the preliminary design.

The East Boundary Road should be constructed to accommodate active transportation in separated facilities. As the road will likely have few intersections and other access points, boulevard multi-use trails would be the most appropriate facilities.

Appendix A: Exhibits

LAND USE BY TRAFFIC ANALYSIS ZONE

Exhibit 1: Traffic Analysis Zone Land Use Assumptions

TAZ	2011 Total Population	2011 Total Employment	2031 Total Population	2031 Total Employment	Mature State Total Population	Mature State Total Employment
385	744	94	932	80	1,215	68
426	3,667	396	4,245	427	4,334	283
427	2,605	97	3,599	162	3,954	209
435	333	570	742	624	748	602
436	436	46	3,087	200	3,446	235
437	159	51	5,528	998	6,349	1,510
441	80	5	986	178	1,027	217
442	19	1,096	19	1,187	20	1,743
443	12	1,669	9	2,324	11	3,256
<i>Total</i>	<i>8,056</i>	<i>4,025</i>	<i>19,148</i>	<i>6,180</i>	<i>21,104</i>	<i>8,123</i>
<i>Growth from 2011</i>			<i>11,092</i>	<i>2,155</i>	<i>13,048</i>	<i>4,098</i>
<i>Growth from 2031</i>					<i>1,956</i>	<i>1,944</i>

SCREENLINE FACILITIES

Exhibit 2: 2011 Model Screenline Facilities

Screenline Name	Directional Lanes	Directional Capacity
North of Myers Road		
Water Street	1	750
Christopher Drive	1	300
Elgin Street	1	300
Franklin Boulevard	1	750
Dundas Street	2	1,800
Shellard Side Road	1	1,100
<i>Total</i>	7	5,000
CP Rail - Cambridge		
Water Street	2	1,500
Dundas Street	2	1,500
Beverly Street	1	650
Franklin Boulevard	2	1,800
Shellard Side Road	1	1,100
<i>Total</i>	8	6,550
South of Can-Amera Parkway		
Coronation Boulevard	2	1,500
Hespeler Road	2	1,500
Franklin Boulevard	2	1,800
Burnett Avenue	1	400
Townline Rd	2	1,800
<i>Total</i>	9	7,000
South of Highway 401		
Speedsville Road	1	550
Hespeler Road	3	2,700
Smart Centre Ramp	1	400
Franklin Boulevard	2	1,500
Townline Road	2	1,800
<i>Total</i>	9	6,950

Exhibit 3: 2031 Model Screenline Facilities

Screenline Name	Directional Lanes	Directional Capacity
North of Myers Road		
Water Street	1	750
Christopher Drive	1	300
Elgin Street	1	300
Franklin Boulevard	2	2,200
Dundas Street	2	1,800
Shellard Side Road	1	1,100
<i>Total</i>	8	6,450
CP Rail - Cambridge		
Water Street	2	1,500
Dundas Street	2	1,500
Beverly Street	1	650
Franklin Boulevard	2	2,200
Shellard Side Road	1	1,100
<i>Total</i>	8	6,950
South of Can-Amera Parkway		
Coronation Boulevard	2	1,500
Hespeler Road	2	1,500
Franklin Boulevard	2	2,200
Burnett Avenue	1	400
Townline Rd	2	1,800
<i>Total</i>	9	7,400
South of Highway 401		
Speedsville Road	2	1,500
Hespeler Road	3	2,700
Smart Centre Ramp	1	400
Franklin Boulevard	2	1,500
Townline Road	2	1,800
<i>Total</i>	10	7,900

Exhibit 4: Mature State Model Screenline Facilities

Screenline Name	Directional Lanes	Directional Capacity
North of Myers Road		
Water Street	2	1,500
Christopher Drive	1	300
Elgin Street	1	300
Franklin Boulevard	2	2,200
Dundas Street	2	1,800
Shellard Side Road	1	1,100
<i>Total</i>	9	7,200
CP Rail - Cambridge		
Water Street	1	750
Dundas Street	2	1,500
Beverly Street	2	1,300
Franklin Boulevard	2	2,200
Shellard Side Road	1	1,100
<i>Total</i>	8	6,850
South of Can-Amera Parkway		
Coronation Boulevard	2	1,500
Hespeler Road	2	1,500
Franklin Boulevard	2	2,200
Burnett Avenue	1	400
Townline Rd	2	1,800
<i>Total</i>	9	7,400
South of Highway 401		
Speedsville Road	1	550
Hespeler Road	2	1,800
Smart Centre Ramp	1	400
Franklin Boulevard	2	2,200
Townline Road	2	1,800
<i>Total</i>	8	6,750

2011 AADT

2011 AADT	
Hespeler / Water	
401 EB Ramp	41328
Eagle / Pinebush	36551 32814
Langs / Sheldon	31302 32640 32640
Bishop	32776 34293
Dunbar	32572
Can-Amera	34428
Munch	32212 32019 31827
Avenue	33995
Dundas / Coronation	33833 30476
Samuelson	29897
Ainslie	11277 15202
Park Hill	11849 11849 11730
Dickson	11331
Main	13458 12904
Wellington	12104 8847
Concession	12687
Ainslie	19351 19351 19351 19351
Myers	20085
South Boundary	

Exhibit 5: Hespeler / Water Corridor – 2011 AADT

2011 AADT	
Franklin	
401 EB Ramp	25622
Pinebush	33542
Sheldon	34062
	33386
	29460
Bishop	27987
Can-Amera	40795
Elgin	32378
	32378
	33957
Avenue	37797
	28019
Clyde	32547
	28461
	30991
	28377
Main	22305
	19772
Franklin	17886
	14719
	9447
Myers	
South Boundary	

Exhibit 6: Franklin Corridor - 2011 AADT

2011 AADT	
Townline / Shellard	
401 EB Ramp	24162
Pinebush	
Can-Amera	21479
	13847
Avenue / Gore	6244
Clyde	
Main	
Morrison	

Exhibit 7: Townline / Shellard Corridor - 2011 AADT

2011 AADT	
King / Coronation / Dundas	
Bishop	19408
Concession	15028
	26940
	27761
	21555
	23790
	23790
Hespeler / Water	16072
	21344
Samuelson	17427
	19286
	21272
Beverly	17836
	16989
	16142
	12857
Elgin	10724
	11602
Main	12022
Franklin	12645
Champlain	11101
Branchton	
South Boundary	
Morrison	

Exhibit 8: King / Coronation / Dundas Corridor - 2011 AADT

City of Cambridge Roads – Not Compiled by Region

Exhibit 9: Conestoga / Elgin / Cheese Factory Corridor - 2011 AADT

2011 ROAD WIDTH AND CAPACITY

2011 Lanes				2011 Capacity			
Hespeler / Water				Hespeler / Water			
401 EB Ramp	3	3		401 EB Ramp	2700	2700	
Eagle / Pinebush	3	3		Eagle / Pinebush	2250	2250	
	3	3			2250	2250	
Langs / Sheldon	3	3		Langs / Sheldon	2250	2250	
	3	3			2250	2250	
	3	3			2250	2250	
Bishop	3	3		Bishop	2250	2250	
	3	3			2250	2250	
Dunbar	2	2		Dunbar	1500	1500	
	2	2			1500	1500	
Can-Amera	2	2		Can-Amera	1500	1500	
Munch	2	2		Munch	1500	1500	
	2	2			1500	1500	
	2	2			1500	1500	
Avenue	2	2		Avenue	1500	1500	
	2	2			1500	1500	
Dundas / Coronation	2	2		Dundas / Coronation	1500	1500	
	2	2			1500	1500	
Samuelson	2	2	Ainslie	Samuelson	1500	1500	Ainslie
Ainslie	2	0	1	Ainslie	1300	0	650
			2				1300
			1				650
Park Hill	1	1	1	Park Hill	650	650	650
	1	1	1		650	650	650
	1	1	1		650	650	650
Dickson	1	1	1	Dickson	650	650	650
Main	1	1	1	Main	650	650	650
	2	1	1		1300	650	650
Wellington			1	Wellington			650
			1				650
Concession	1	1	1	Concession	650	650	650
Ainslie	1	1		Ainslie	650	650	
	1	1			750	750	
	1	1			750	750	
	1	1			750	750	
Myers	1	1		Myers	1100	1100	
South Boundary	1	1		South Boundary	1100	1100	

Exhibit 10: Hespeler / Water Corridor - 2011 Road Width and Capacity

2011 Lanes		2011 Capacity	
Franklin		Franklin	
401 EB Ramp		401 EB Ramp	
2	2	1500	1500
Pinebush		Pinebush	
2	2	1800	1800
Sheldon		Sheldon	
2	2	1800	1800
2	2	1800	1800
2	2	1800	1800
Bishop		Bishop	
2	2	1800	1800
Can-Amera		Can-Amera	
2	2	1800	1800
Elgin		Elgin	
2	2	1800	1800
2	2	1800	1800
2	2	1800	1800
Avenue		Avenue	
2	2	1800	1800
2	2	1800	1800
Clyde		Clyde	
2	2	1800	1800
2	2	1800	1800
2	2	1800	1800
2	2	1800	1800
Main		Main	
2	2	1800	1800
2	2	1800	1800
Franklin		Franklin	
1	1	750	750
1	1	750	750
1	1	750	750
Myers		Myers	
2	2	1800	1800
South Boundary		South Boundary	

Exhibit 11: Franklin Corridor - 2011 Road Width and Capacity

2011 Lanes		2011 Capacity	
Townline / Shellard		Townline / Shellard	
401 EB Ramp		401 EB Ramp	
2	2	1800	1800
Pinebush		Pinebush	
2	2	1800	1800
2	2	1800	1800
Can-Amera		Can-Amera	
2	2	1800	1800
1	1	900	900
1	1	900	900
Avenue / Gore		Avenue / Gore	
1	1	1100	1100
Clyde		Clyde	
1	1	1100	1100
Main		Main	
1	1	1100	1100
Morrison		Morrison	

Exhibit 12: Townline / Shellard Corridor - 2011 Road Width and Capacity

2011 Lanes		2011 Capacity	
Coronation / Dundas		Coronation / Dundas	
Bishop		Bishop	
2	2	1300	1300
Concession		Concession	
2	2	1300	1300
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
Hespeler / Water		Hespeler / Water	
2	2	1500	1500
2	2	1500	1500
Samuelson		Samuelson	
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
Beverly		Beverly	
1	1	750	750
1	1	750	750
1	1	750	750
1	1	750	750
Elgin		Elgin	
2	1	1800	900
2	2	1800	1800
Main		Main	
2	2	1800	1800
Franklin		Franklin	
2	2	1800	1800
Champlain		Champlain	
2	2	1800	1800
Branchton		Branchton	
1	1	1100	1100
South Boundary		South Boundary	
1	1	1100	1100
1	1	1100	1100
Morrison		Morrison	
1	1	1100	1100

Exhibit 13: King / Coronation / Dundas Corridor - 2011 Road Width and Capacity

2011 Lanes		2011 Capacity	
Conestoga / Elgin / Cheese Factory			
Smartcentre		Smartcentre	
1	1	400	400
Pinebush		Pinebush	
1	1	650	650
1	1	650	650
Sheldon		Sheldon	
1	1	650	650
1	1	650	650
Bishop		Bishop	
1	1	650	650
Dunbar		Dunbar	
1	1	650	650
Can-Amera		Can-Amera	
****GAP****		****GAP****	
1	1	400	400
Munch		Munch	
1	1	400	400
Avenue		Avenue	
1	1	400	400
1	1	400	400
1	1	400	400
Samuelson		Samuelson	
****GAP****		****GAP****	
Alison		Alison	
1	1	300	300
Gore		Gore	
1	1	300	300
Dundas		Dundas	
1	1	300	300
Pollock		Pollock	
1	1	300	300
Main		Main	
1	1	300	300
1	1	300	300
1	1	300	300
1	1	300	300
Champlain		Champlain	
1	1	300	300
1	1	300	300
Myers		Myers	
1	1	400	400
South Boundary		South Boundary	

Exhibit 14: Conestoga / Elgin / Cheese Factory Corridor - 2011 Road Width and Capacity

2011 MODEL VOLUMES

2011 AM Volume				2011 PM Volume			
Hespeler / Water				Hespeler / Water			
401 EB Ramp				401 EB Ramp			
1821	1119			1322	2413		
Eagle / Pinebush				Eagle / Pinebush			
1657	896			1349	1975		
1286	1177			1664	1540		
Langs / Sheldon				Langs / Sheldon			
1140	1246			1643	1242		
1022	1326			1758	1148		
861	1509			2001	1016		
Bishop				Bishop			
893	1312			1562	1046		
512	1615			1860	585		
Dunbar				Dunbar			
514	1482			1602	686		
441	1591			1719	603		
Can-Amera				Can-Amera			
651	1954			2215	785		
Munch				Munch			
615	1619			1827	732		
642	1583			1782	763		
675	1587			1729	825		
Avenue				Avenue			
1076	1602			1682	1170		
Dundas / Coronation				Dundas / Coronation			
853	1415			1765	930		
853	1415			1765	930		
Samuelson		Ainslie		Samuelson		Ainslie	
867	1438			1844	960		
Ainslie				Ainslie			
716	0	150	1438	1452	0	392	960
		150	1438			392	960
Park Hill				Park Hill			
613	12	160	572	591	236	391	634
371	110	178	587	636	189	480	462
371	110	178	587	636	189	480	462
Dickson				Dickson			
371	109	178	568	636	106	480	442
Main				Main			
430	204	257	574	688	133	477	525
430	204	257	574	688	133	477	525
Wellington				Wellington			
		261	571			414	730
		57	844			683	325
Concession				Concession			
305	230	58	521	493	226	239	321
Ainslie				Ainslie			
362	751			731	547		
362	751			731	547		
362	751			731	547		
362	751			731	547		
Myers				Myers			
346	708			655	501		
South Boundary				South Boundary			
346	708			655	501		

Exhibit 15: Hespeler / Water Corridor - 2011 Model Volumes

2011 AM Volume		2011 PM Volume	
Franklin		Franklin	
401 EB Ramp	2108 1074	401 EB Ramp	1306 1532
Pinebush	1414 1145	Pinebush	1435 1087
Sheldon	1154 1678	Sheldon	1742 977
	1154 1678		1742 977
	980 1753		1849 737
Bishop	853 1993	Bishop	2172 635
Can-Amera	919 2305	Can-Amera	2764 860
Elgin	631 1974	Elgin	1938 769
	631 1974		1938 769
	866 1488		1701 846
Avenue	881 1501	Avenue	1625 925
	845 1409		1519 866
Clyde	805 1247	Clyde	1374 804
	616 1444		1558 584
	505 1270		1339 496
	430 1269		1335 424
Main	499 535	Main	1062 382
	333 546		1083 150
Franklin	121 743	Franklin	673 167
	102 647		579 144
	98 459		373 121
Myers	1179 1109	Myers	1240 1141
South Boundary		South Boundary	

Exhibit 16: Franklin Corridor - 2011 Model Volumes

2011 AM Volume		2011 PM Volume	
Townline / Shellard		Townline / Shellard	
401 EB Ramp	1007 641	401 EB Ramp	1114 1243
Pinebush	556 920	Pinebush	1465 727
	556 920		1465 727
Can-Amera	91 566	Can-Amera	943 69
	91 566		943 69
	57 372		494 87
Avenue / Gore	56 370	Avenue / Gore	459 99
Clyde	42 338	Clyde	431 90
Main	15 76	Main	12 52
Morrison		Morrison	

Exhibit 17: Townline / Shellard Corridor - 2011 Model Volumes

2011 AM Volume		2011 PM Volume	
Coronation / Dundas		Coronation / Dundas	
Bishop	498 542	Bishop	885 755
Concession	720 1006	Concession	1275 1084
	720 1006		1275 1084
	732 926		1164 1108
	681 1031		1285 1041
	620 1222		1551 1030
	620 1222		1551 1030
Hespeler / Water	655 1221	Hespeler / Water	1091 892
	315 1467		1257 674
Samuelson	250 1135	Samuelson	1031 555
	250 1135		1030 555
	250 1135		1030 555
Beverly	235 770	Beverly	825 499
	235 770		825 499
	224 499		761 425
	224 499		761 425
Elgin	179 529	Elgin	510 453
	145 604		598 395
Main	249 1054	Main	799 567
Franklin	451 846	Franklin	1172 514
Champlain	414 549	Champlain	661 468
Branchton	378 453	Branchton	514 463
South Boundary	378 453	South Boundary	514 463
	370 440		502 440
Morrison	377 502	Morrison	499 478

Exhibit 18: King / Coronation / Dundas Corridor - 2011 Model Volumes

2011 MODEL V/C

2011 AM Volume		2011 PM Volume	
Conestoga / Elgin / Cheese Factory		Conestoga / Elgin / Cheese Factory	
Smartcentre		Smartcentre	
74	489	654	96
Pinebush		Pinebush	
275	141	339	273
186	213	428	177
Sheldon		Sheldon	
207	251	458	160
41	401	654	13
Bishop		Bishop	
31	321	623	6
Dunbar		Dunbar	
63	473	766	23
Can-Amera		Can-Amera	
****GAP****		****GAP****	
158	103	179	200
Munch		Munch	
45	85	103	33
Avenue		Avenue	
124	78	261	87
124	78	261	87
124	78	261	87
Samuelson		Samuelson	
****GAP****		****GAP****	
Alison		Alison	
0	0	0	0
Gore		Gore	
52	300	35	213
Dundas		Dundas	
238	381	421	289
Pollock		Pollock	
169	262	294	218
Main		Main	
186	359	357	228
186	359	357	228
186	359	357	228
142	169	211	153
Champlain		Champlain	
109	81	115	99
109	81	115	99
Myers		Myers	
2	10	5	5
South Boundary		South Boundary	

Exhibit 19: Conestoga / Elgin / Cheese Factory Corridor - 2011 Model Volumes

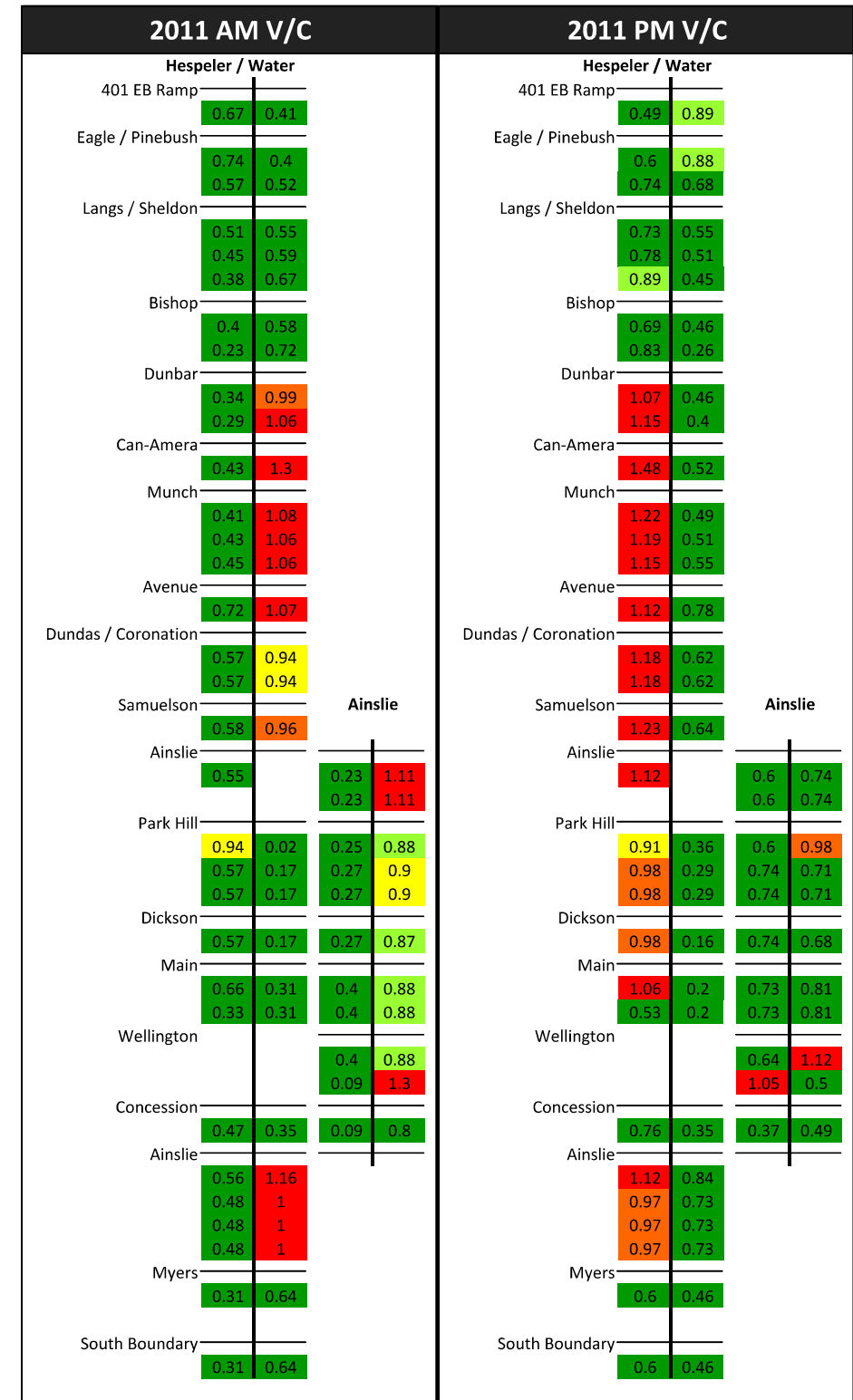


Exhibit 20: Hespeler / Water Corridor - 2011 Model V/C

2011 AM V/C		2011 PM V/C	
Franklin			
401 EB Ramp	1.41 0.72	0.87 1.02	
Pinebush	0.79 0.64	0.8 0.6	
Sheldon	0.64 0.93	0.97 0.54	
	0.64 0.93	0.97 0.54	
	0.54 0.97	1.03 0.41	
Bishop	0.47 1.11	1.21 0.35	
Can-Amera	0.51 1.28	1.54 0.48	
Elgin	0.35 1.1	1.08 0.43	
	0.35 1.1	1.08 0.43	
	0.48 0.83	0.95 0.47	
Avenue	0.49 0.83	0.9 0.51	
	0.47 0.78	0.84 0.48	
Clyde	0.45 0.69	0.76 0.45	
	0.34 0.8	0.87 0.32	
	0.28 0.71	0.74 0.28	
	0.24 0.71	0.74 0.24	
Main	0.28 0.3	0.59 0.21	
	0.19 0.3	0.6 0.08	
Franklin	0.16 0.99	0.9 0.22	
	0.14 0.86	0.77 0.19	
	0.13 0.61	0.5 0.16	
Myers	0.66 0.62	0.69 0.63	
South Boundary			

Exhibit 21: Franklin Corridor - 2011 Model V/C

2011 AM V/C		2011 PM V/C	
Townline / Shellard			
401 EB Ramp	0.56 0.36	0.62 0.69	
Pinebush	0.31 0.51	0.81 0.4	
	0.31 0.51	0.81 0.4	
Can-Amera	0.05 0.31	0.52 0.04	
	0.1 0.63	1.05 0.08	
	0.06 0.41	0.55 0.1	
Avenue / Gore	0.05 0.34	0.42 0.09	
Clyde	0.04 0.31	0.39 0.08	
Main	0.01 0.07	0.01 0.05	
Morrison			

Exhibit 22: Townline / Shellard Corridor - 2011 Model V/C

2011 AM V/C		2011 PM V/C	
Coronation / Dundas			
Bishop	0.38 0.42	0.68 0.58	
Concession	0.55 0.77	0.98 0.83	
	0.48 0.67	0.85 0.72	
	0.49 0.62	0.78 0.74	
	0.45 0.69	0.86 0.69	
	0.41 0.81	1.03 0.69	
	0.41 0.81	1.03 0.69	
Hespeler / Water	0.44 0.81	0.73 0.59	
	0.21 0.98	0.84 0.45	
Samuelson	0.17 0.76	0.69 0.37	
	0.17 0.76	0.69 0.37	
	0.17 0.76	0.69 0.37	
Beverly	0.31 1.03	1.1 0.67	
	0.31 1.03	1.1 0.67	
	0.3 0.67	1.01 0.57	
	0.3 0.67	1.01 0.57	
Elgin	0.1 0.59	0.28 0.5	
	0.08 0.34	0.33 0.22	
Main	0.14 0.59	0.44 0.32	
Franklin	0.25 0.47	0.65 0.29	
Champlain	0.23 0.31	0.37 0.26	
Branchton	0.34 0.41	0.47 0.42	
South Boundary	0.34 0.41	0.47 0.42	
	0.34 0.4	0.46 0.4	
Morrison	0.34 0.46	0.45 0.43	

Exhibit 23: King / Coronation / Dundas Corridor - 2011 Model V/C

2031 Lanes		2031 Capacity	
Franklin		Franklin	
401 EB Ramp		401 EB Ramp	
2	2	1500	1500
Pinebush		Pinebush	
2	2	2200	2200
Sheldon		Sheldon	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Bishop		Bishop	
2	2	2200	2200
Can-Amera		Can-Amera	
2	2	2200	2200
Elgin		Elgin	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Avenue		Avenue	
2	2	2200	2200
2	2	2200	2200
Clyde		Clyde	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Main		Main	
2	2	2200	2200
2	2	2200	2200
Franklin		Franklin	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Myers		Myers	
1	1	1100	1100
South Boundary		South Boundary	

Exhibit 26: Franklin Corridor - 2031 Road Width and Capacity

2031 Lanes		2031 Capacity	
Townline / Shellard		Townline / Shellard	
401 EB Ramp		401 EB Ramp	
2	2	1800	1800
Pinebush		Pinebush	
2	2	1800	1800
2	2	1800	1800
Can-Amera		Can-Amera	
2	2	1800	1800
2	2	1800	1800
2	2	1800	1800
Avenue / Gore		Avenue / Gore	
1	1	1100	1100
Clyde		Clyde	
1	1	1100	1100
Main		Main	
1	1	1100	1100
Morrison		Morrison	

Exhibit 27: Townline / Shellard Corridor - 2031 Road Width and Capacity

2031 Lanes		2031 Capacity	
King / Coronation / Dundas		King / Coronation / Dundas	
Bishop		Bishop	
2	2	1300	1300
Concession		Concession	
2	2	1300	1300
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
Hespeler / Water		Hespeler / Water	
2	2	1500	1500
2	2	1500	1500
Samuelson		Samuelson	
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
Beverly		Beverly	
1	1	750	750
1	1	750	750
1	1	750	750
1	1	750	750
Elgin		Elgin	
2	1	1800	900
2	2	1800	1800
Main		Main	
2	2	1800	1800
Franklin		Franklin	
2	2	1800	1800
Champlain		Champlain	
2	2	1800	1800
Branchton		Branchton	
1	1	1100	1100
South Boundary		South Boundary	
1	1	1100	1100
1	1	1100	1100
Morrison		Morrison	
1	1	1100	1100

Exhibit 28: King / Coronation / Dundas Corridor - 2031 Road Width and Capacity

2031 Lanes		2031 Capacity	
Conestoga / Elgin / Cheese Factory		Conestoga / Elgin / Cheese Factory	
Smartcentre	1 1	Smartcentre	400 400
Pinebush	1 1	Pinebush	650 650
Sheldon	1 1	Sheldon	650 650
Bishop	1 1	Bishop	650 650
Dunbar	1 1	Dunbar	650 650
Can-Amera	1 1	Can-Amera	650 650
****GAP****		****GAP****	
Munch	1 1	Munch	400 400
Avenue	1 1	Avenue	400 400
Samuelson	1 1	Samuelson	400 400
****GAP****		****GAP****	
Alison	1 1	Alison	300 300
Gore	1 1	Gore	300 300
Dundas	1 1	Dundas	300 300
Pollock	1 1	Pollock	300 300
Main	1 1	Main	300 300
Champlain	1 1	Champlain	300 300
Myers	1 1	Myers	400 400
South Boundary	1 1	South Boundary	400 400

Exhibit 29: Conestoga / Elgin / Cheese Factory Corridor – 2031 Road Width and Capacity

2031 MODEL VOLUMES

2031 AM Volume				2031 PM Volume				2031 RTMP PM Volume						
Hespeler / Water				Hespeler / Water				Hespeler / Water						
401 EB Ramp	2044	985		401 EB Ramp	1319	2703		401 EB Ramp	1303	2540				
Eagle / Pinebush	2123	855		Eagle / Pinebush	1429	2528		Eagle / Pinebush	1381	2308				
	1520	1261			1871	1847			1751	1681				
Langs / Sheldon	1386	1308		Langs / Sheldon	1817	1542		Langs / Sheldon	1717	1367				
	1227	1390			1933	1403			1808	1248				
	1022	1595			2198	1226			2039	1103				
Bishop	1089	1291		Bishop	1617	1270		Bishop	1527	1155				
	585	1666			2009	700			1824	677				
Dunbar	608	1551		Dunbar	1722	792		Dunbar	1635	756				
	470	1722			1900	640			1785	628				
Can-Amera	683	2105		Can-Amera	2322	802		Can-Amera	2238	775				
Munch	636	1706		Munch	1897	734		Munch	1840	718				
	662	1662			1847	768			1796	749				
	696	1644			1774	835			1728	816				
Avenue	1050	1670		Avenue	1717	1161		Avenue	1675	1110				
Dundas / Coronation	940	1560		Dundas / Coronation	1904	988		Dundas / Coronation	1821	945				
	940	1560			1904	988			1821	945				
Samuelson	952	1581	Ainslie	Samuelson	2038	1027	Ainslie	Samuelson	1933	974	Ainslie			
Ainslie	783	0	168	1581	Ainslie	1568	0	470	1027	Ainslie	1500	0	433	974
	0	0	168	1581		0	0	470	1027		0	0	433	974
Park Hill	657	129	214	563	Park Hill	570	330	467	708	Park Hill	577	313	433	657
	440	204	241	562		642	284	481	558		635	283	456	543
	440	204	241	562		642	284	481	558		635	283	456	543
Dickson	440	205	242	544	Dickson	642	146	481	530	Dickson	635	145	456	517
Main	461	290	298	551	Main	689	172	477	569	Main	683	175	450	557
	461	290	298	551		689	172	477	569		683	175	450	557
Wellington			299	523	Wellington			413	817	Wellington			381	769
			64	870				737	339				689	381
Concession	331	302	65	484	Concession	506	272	261	287	Concession	537	273	259	357
Ainslie	396	786			Ainslie	767	559			Ainslie	795	630		
	396	786				767	559				795	630		
	396	786				767	559				795	630		
	396	786				767	559				795	630		
Myers	371	663			Myers	566	495			Myers	647	585		
	371	663				566	495				647	585		
South Boundary	433	842			South Boundary	825	617			South Boundary	901	713		

Exhibit 30: Hespeler / Water Corridor - 2031 Model Volumes

2031 AM Volume		2031 PM Volume		2031 RTMP PM Volume	
Franklin		Franklin		Franklin	
401 EB Ramp	2156 1169	401 EB Ramp	1381 1591	401 EB Ramp	1314 1503
Pinebush	1545 1450	Pinebush	1763 1151	Pinebush	1725 1169
Sheldon	1273 2030	Sheldon	2168 985	Sheldon	2038 987
	1273 2030		2168 985		2038 987
	1089 2114		2284 778		2150 787
Bishop	958 2464	Bishop	2717 668	Bishop	2541 696
Can-Amera	1040 2841	Can-Amera	3398 991	Can-Amera	3284 951
Elgin	713 2490	Elgin	2513 905	Elgin	2429 861
	713 2490		2513 905		2429 861
	932 2033		2278 968		2184 920
Avenue	979 2079	Avenue	2241 1083	Avenue	2113 1031
	941 1989		2137 1041		2030 1007
Clyde	981 1907	Clyde	2067 1001	Clyde	1933 962
	698 2120		2300 730		2160 711
	607 1931		2045 653		1924 644
	535 1936		2048 595		1928 593
Main	601 1070	Main	1573 499	Main	1492 519
	435 1074		1612 285		1535 289
Franklin	151 1018	Franklin	1047 306	Franklin	866 299
	132 901		932 285		767 281
	130 655		622 253		519 259
Myers	38 170	Myers	216 119	Myers	223 125
South Boundary		South Boundary		South Boundary	

Exhibit 31: Franklin Corridor - 2031 Model Volumes

2031 AM Volume		2031 PM Volume		2031 RTMP PM Volume	
Townline / Shellard		Townline / Shellard		Townline / Shellard	
401 EB Ramp	1127 923	401 EB Ramp	1405 1362	401 EB Ramp	1473 1257
Pinebush	611 1317	Pinebush	1915 876	Pinebush	1897 764
	611 1317		1915 876		1897 764
Can-Amera	96 790	Can-Amera	1330 49	Can-Amera	1107 39
	96 790		1330 49		1107 39
	77 573		824 74		715 70
Avenue / Gore	82 556	Avenue / Gore	736 92	Avenue / Gore	676 86
Clyde	67 516	Clyde	694 86	Clyde	638 82
Main	35 151	Main	167 40	Main	65 35
Morrison		Morrison		Morrison	

Exhibit 32: Townline / Shellard Corridor - 2031 Model Volumes

2031 AM Volume		2031 PM Volume		2031 RTMP PM Volume	
King / Coronation / Dundas		King / Coronation / Dundas		King / Coronation / Dundas	
Bishop	598 649	Bishop	1038 862	Bishop	943 855
Concession	899 1219	Concession	1467 1300	Concession	1363 1291
	899 1219		1467 1300		1363 1291
	916 1114		1329 1331		1220 1321
	856 1222		1460 1260		1354 1252
	779 1407		1693 1206		1578 1214
	779 1407		1693 1206		1578 1214
Hespeler / Water	770 1398	Hespeler / Water	1193 1067	Hespeler / Water	1116 1062
	388 1648		1399 853		1301 868
Samuelson	319 1289	Samuelson	1121 726	Samuelson	1047 730
	319 1287		1117 726		1046 730
	319 1287		1117 726		1046 730
Beverly	297 920	Beverly	945 621	Beverly	916 663
	297 920		945 621		916 663
	295 715		905 628		875 648
	295 715		905 628		875 648
Elgin	294 767	Elgin	718 666	Elgin	687 692
	233 849		820 577		779 600
Main	374 1353	Main	1109 845	Main	1057 894
Franklin	658 1409	Franklin	1635 785	Franklin	1690 847
Champlain	673 1158	Champlain	1262 810	Champlain	1325 878
Branchton	665 1148	Branchton	1161 863	Branchton	1176 924
South Boundary	711 1178	South Boundary	1191 932	South Boundary	1214 985
	477 514		529 628		678 683
Morrison	447 592	Morrison	589 565	Morrison	673 651

Exhibit 33: King / Coronation / Dundas Corridor - 2031 Model Volumes

2031 AM Volume		2031 PM Volume		2031 RTMP PM Volume	
Conestoga / Elgin / Cheese Factory					
Smartcentre		Smartcentre		Smartcentre	
71	614	773	98	699	113
Pinebush		Pinebush		Pinebush	
365	138	398	399	388	358
270	213	488	295	477	265
Sheldon		Sheldon		Sheldon	
237	305	493	194	485	183
73	459	685	42	663	38
Bishop		Bishop		Bishop	
66	390	653	31	630	28
Dunbar		Dunbar		Dunbar	
170	561	871	95	816	166
Can-Amera		Can-Amera		Can-Amera	
****GAP****		****GAP****		****GAP****	
166	158	200	160	221	164
Munch		Munch		Munch	
45	124	150	33	139	36
Avenue		Avenue		Avenue	
128	81	345	76	300	77
128	81	345	76	300	77
128	81	345	76	300	77
Samuelson		Samuelson		Samuelson	
****GAP****		****GAP****		****GAP****	
Alison		Alison		Alison	
0	0	0	0	0	0
Gore		Gore		Gore	
45	286	30	203	17	202
Dundas		Dundas		Dundas	
227	396	418	294	401	283
Pollock		Pollock		Pollock	
141	271	290	219	277	217
Main		Main		Main	
188	354	353	205	350	192
188	354	353	205	350	192
188	354	353	205	350	192
143	147	174	130	177	120
Champlain		Champlain		Champlain	
105	71	88	67	99	64
105	71	88	67	99	64
Myers		Myers		Myers	
3	17	18	5	21	5
South Boundary		South Boundary		South Boundary	

Exhibit 34: Conestoga / Elgin / Cheese Factory Corridor – 2031 Model Volumes

2031 MODEL V/C

2031 AM V/C		2031 PM V/C		2031 RTMP PM V/C	
Hespeler / Water					
401 EB Ramp	0.76 0.36	401 EB Ramp	0.49 1	401 EB Ramp	0.48 0.94
Eagle / Pinebush	0.94 0.38	Eagle / Pinebush	0.64 1.12	Eagle / Pinebush	0.61 1.03
	0.68 0.56		0.83 0.82		0.78 0.75
Langs / Sheldon	0.62 0.58	Langs / Sheldon	0.81 0.69	Langs / Sheldon	0.76 0.61
	0.55 0.62		0.86 0.62		0.8 0.55
	0.45 0.71		0.98 0.54		0.91 0.49
Bishop	0.48 0.57	Bishop	0.72 0.56	Bishop	0.68 0.51
	0.26 0.74		0.89 0.31		0.81 0.3
Dunbar	0.41 1.03	Dunbar	1.15 0.53	Dunbar	1.09 0.5
	0.31 1.15		1.27 0.43		1.19 0.42
Can-Amera	0.46 1.4	Can-Amera	1.55 0.53	Can-Amera	1.49 0.52
Munch	0.42 1.14	Munch	1.26 0.49	Munch	1.23 0.48
	0.44 1.11		1.23 0.51		1.2 0.5
	0.46 1.1		1.18 0.56		1.15 0.54
Avenue	0.7 1.11	Avenue	1.14 0.77	Avenue	1.12 0.74
Dundas / Coronation	0.63 1.04	Dundas / Coronation	1.27 0.66	Dundas / Coronation	1.21 0.63
	0.63 1.04		1.27 0.66		1.21 0.63
Samuelson	0.63 1.05	Samuelson	1.36 0.68	Samuelson	1.29 0.65
Ainslie	0.6 0.26 1.22	Ainslie	1.21 0.72 0.79	Ainslie	1.15 0.67 0.75
	0.26 1.22		0.72 0.79		0.67 0.75
Park Hill	1.01 0.2 0.33 0.87	Park Hill	0.88 0.51 0.72 1.09	Park Hill	0.89 0.48 0.67 1.01
	0.68 0.31 0.37 0.86		0.99 0.44 0.74 0.86		0.98 0.44 0.7 0.84
	0.68 0.31 0.37 0.86		0.99 0.44 0.74 0.86		0.98 0.44 0.7 0.84
Dickson	0.68 0.32 0.37 0.84	Dickson	0.99 0.22 0.74 0.82	Dickson	0.98 0.22 0.7 0.8
Main	0.71 0.45 0.46 0.85	Main	1.06 0.26 0.73 0.88	Main	1.05 0.27 0.69 0.86
	0.35 0.45 0.46 0.85		0.53 0.26 0.73 0.88		0.53 0.27 0.69 0.86
Wellington	0.46 0.8	Wellington	0.64 1.26	Wellington	0.59 1.18
	0.1 1.34		1.13 0.52		1.06 0.59
Concession	0.51 0.46 0.1 0.74	Concession	0.78 0.42 0.4 0.44	Concession	0.83 0.42 0.4 0.55
Ainslie	0.61 1.21	Ainslie	1.18 0.86	Ainslie	1.22 0.97
	0.53 1.05		1.02 0.75		1.06 0.84
	0.53 1.05		1.02 0.75		1.06 0.84
	0.53 1.05		1.02 0.75		1.06 0.84
Myers	0.34 0.6	Myers	0.51 0.45	Myers	0.59 0.53
	0.34 0.6		0.51 0.45		0.59 0.53
South Boundary	0.39 0.77	South Boundary	0.75 0.56	South Boundary	0.82 0.65

Exhibit 35: Hespeler / Water Corridor - 2031 Model V/C

2031 AM V/C		2031 PM V/C		2031 RTMP PM V/C	
Franklin					
401 EB Ramp	1.44 0.78	0.92 1.06	0.88 1		
Pinebush	0.7 0.66	0.8 0.52	0.78 0.53		
Sheldon	0.58 0.92	0.99 0.45	0.93 0.45		
	0.58 0.92	0.99 0.45	0.93 0.45		
	0.5 0.96	1.04 0.35	0.98 0.36		
Bishop	0.44 1.12	1.24 0.3	1.16 0.32		
Can-Amera	0.47 1.29	1.54 0.45	1.49 0.43		
Elgin	0.32 1.13	1.14 0.41	1.1 0.39		
	0.32 1.13	1.14 0.41	1.1 0.39		
	0.42 0.92	1.04 0.44	0.99 0.42		
Avenue	0.45 0.95	1.02 0.49	0.96 0.47		
	0.43 0.9	0.97 0.47	0.92 0.46		
Clyde	0.45 0.87	0.94 0.46	0.88 0.44		
	0.32 0.96	1.05 0.33	0.98 0.32		
	0.28 0.88	0.93 0.3	0.87 0.29		
	0.24 0.88	0.93 0.27	0.88 0.27		
Main	0.27 0.49	0.72 0.23	0.68 0.24		
	0.2 0.49	0.73 0.13	0.7 0.13		
Franklin	0.07 0.46	0.48 0.14	0.39 0.14		
	0.06 0.41	0.42 0.13	0.35 0.13		
	0.06 0.3	0.28 0.12	0.24 0.12		
Myers	0.03 0.15	0.2 0.11	0.2 0.11		
South Boundary					

Exhibit 36: Franklin Corridor - 2031 Model V/C

2031 AM V/C		2031 PM V/C		2031 RTMP PM V/C	
Townline / Shellard					
401 EB Ramp	0.63 0.51	0.78 0.76	0.82 0.7		
Pinebush	0.34 0.73	1.06 0.49	1.05 0.42		
	0.34 0.73	1.06 0.49	1.05 0.42		
Can-Amera	0.05 0.44	0.74 0.03	0.62 0.02		
	0.05 0.44	0.74 0.03	0.62 0.02		
	0.04 0.32	0.46 0.04	0.4 0.04		
Avenue / Gore	0.07 0.51	0.67 0.08	0.61 0.08		
Clyde	0.06 0.47	0.63 0.08	0.58 0.07		
Main	0.03 0.14	0.15 0.04	0.06 0.03		
Morrison					

Exhibit 37: Townline / Shellard Corridor - 2031 Model V/C

2031 AM V/C		2031 PM V/C		2031 RTMP PM V/C	
King / Coronation / Dundas					
Bishop	0.46 0.5	0.8 0.66	0.73 0.66		
Concession	0.69 0.94	1.13 1	1.05 0.99		
	0.6 0.81	0.98 0.87	0.91 0.86		
	0.61 0.74	0.89 0.89	0.81 0.88		
	0.57 0.81	0.97 0.84	0.9 0.83		
	0.52 0.94	1.13 0.8	1.05 0.81		
Hespeler / Water	0.51 0.93	1.13 0.8	1.05 0.81		
	0.26 1.1	0.8 0.71	0.74 0.71		
Samuelson	0.21 0.86	0.93 0.57	0.87 0.58		
	0.21 0.86	0.75 0.48	0.7 0.49		
	0.21 0.86	0.74 0.48	0.7 0.49		
Beverly	0.4 1.23	1.26 0.83	1.22 0.88		
	0.4 1.23	1.26 0.83	1.22 0.88		
	0.39 0.95	1.21 0.84	1.17 0.86		
	0.39 0.95	1.21 0.84	1.17 0.86		
Elgin	0.16 0.85	0.4 0.74	0.38 0.77		
	0.13 0.47	0.46 0.32	0.43 0.33		
Main	0.21 0.75	0.62 0.47	0.59 0.5		
Franklin	0.37 0.78	0.91 0.44	0.94 0.47		
Champlain	0.37 0.64	0.7 0.45	0.74 0.49		
Branchton	0.6 1.04	1.06 0.78	1.07 0.84		
South Boundary	0.65 1.07	1.08 0.85	1.1 0.9		
	0.43 0.47	0.48 0.57	0.62 0.62		
Morrison	0.41 0.54	0.54 0.51	0.61 0.59		

Exhibit 38: King / Coronation / Dundas Corridor - 2031 Model V/C

2031 AM V/C	2031 PM V/C	2031 RTMP PM V/C
Conestoga / Elgin / Cheese Factory		
Smartcentre	Smartcentre	Smartcentre
0.18 1.54	1.93 0.25	1.75 0.28
Pinebush	Pinebush	Pinebush
0.56 0.21 0.42 0.33	0.61 0.61 0.75 0.45	0.6 0.55 0.73 0.41
Sheldon	Sheldon	Sheldon
0.36 0.47 0.11 0.71	0.76 0.3 1.05 0.06	0.75 0.28 1.02 0.06
Bishop	Bishop	Bishop
0.1 0.6	1 0.05	0.97 0.04
Dunbar	Dunbar	Dunbar
0.26 0.86	1.34 0.15	1.26 0.26
Can-Amera	Can-Amera	Can-Amera
****GAP****	****GAP****	****GAP****
0.42 0.4	0.5 0.4	0.55 0.41
Munch	Munch	Munch
0.11 0.31	0.38 0.08	0.35 0.09
Avenue	Avenue	Avenue
0.32 0.2 0.32 0.2 0.32 0.2	0.86 0.19 0.86 0.19 0.86 0.19	0.75 0.19 0.75 0.19 0.75 0.19
Samuelson	Samuelson	Samuelson
****GAP****	****GAP****	****GAP****
Alison	Alison	Alison
0 0	0 0	0 0
Gore	Gore	Gore
0.15 0.95	0.1 0.68	0.06 0.67
Dundas	Dundas	Dundas
0.76 1.32	1.39 0.98	1.34 0.94
Pollock	Pollock	Pollock
0.47 0.9	0.97 0.73	0.92 0.72
Main	Main	Main
0.63 1.18 0.63 1.18 0.63 1.18 0.48 0.49	1.18 0.68 1.18 0.68 1.18 0.68 0.58 0.43	1.17 0.64 1.17 0.64 1.17 0.64 0.59 0.4
Champlain	Champlain	Champlain
0.35 0.24 0.35 0.24	0.29 0.22 0.29 0.22	0.33 0.21 0.33 0.21
Myers	Myers	Myers
0.01 0.04	0.05 0.01	0.05 0.01
South Boundary	South Boundary	South Boundary

Exhibit 39: Conestoga / Elgin / Cheese Factory Corridor – 2031 Model V/C

MATURE STATE ROAD WIDTH AND CAPACITY

Mature State Lanes	Mature State Capacity
Hespeler / Water	
401 EB Ramp	401 EB Ramp
2 2	1800 1800
Eagle / Pinebush	Eagle / Pinebush
2 2	1500 1500
2 2	1500 1500
Langs / Sheldon	Langs / Sheldon
2 2	1500 1500
2 2	1500 1500
2 2	1500 1500
Bishop	Bishop
2 2	1500 1500
2 2	1500 1500
Dunbar	Dunbar
2 2	1500 1500
2 2	1500 1500
Can-Amera	Can-Amera
2 2	1500 1500
Munch	Munch
2 2	1500 1500
2 2	1500 1500
2 2	1500 1500
Avenue	Avenue
2 2	1500 1500
Dundas / Coronation	Dundas / Coronation
1 1	750 750
1 1	750 750
Samuelson	Samuelson
1 1	750 750
Ainslie	Ainslie
1 0	650 0
1 2	650 1700
1 2	650 1700
Park Hill	Park Hill
1 1	650 650
1 1	650 650
1 1	650 650
1 1	650 650
Dickson	Dickson
1 1	650 650
Main	Main
1 1	650 650
1 1	650 650
2 1	1300 650
1 1	650 650
1 1	650 650
Wellington	Wellington
1 1	650 650
1 1	650 850
Concession	Concession
1 1	650 650
2 2	1300 1300
2 2	1500 1500
2 2	1500 1500
2 2	1500 1500
Myers	Myers
1 1	1100 1100
South Boundary	South Boundary
1 1	1100 1100

Exhibit 40: Hespeler / Water Corridor - Mature State Road Width and Capacity

Mature State Lanes		Mature State Capacity	
Franklin		Franklin	
401 EB Ramp		401 EB Ramp	
2	0	1500	0
Pinebush		Pinebush	
2	2	2200	2200
Sheldon		Sheldon	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Bishop		Bishop	
2	2	2200	2200
Can-Amera		Can-Amera	
2	2	2200	2200
Elgin		Elgin	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Avenue		Avenue	
2	2	2200	2200
2	2	2200	2200
Clyde		Clyde	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Main		Main	
2	2	2200	2200
2	2	2200	2200
Franklin		Franklin	
2	2	2200	2200
2	2	2200	2200
2	2	2200	2200
Myers		Myers	
1	1	0	0
South Boundary		South Boundary	

Exhibit 41: Franklin Corridor - Mature State Road Width and Capacity

Mature State Lanes		Mature State Capacity	
Townline / Shellard		Townline / Shellard	
401 EB Ramp		401 EB Ramp	
2	2	1800	1800
Pinebush		Pinebush	
2	2	1800	1800
2	2	1800	1800
Can-Amera		Can-Amera	
2	2	1800	1800
2	2	1800	1800
2	2	1800	1800
Avenue / Gore		Avenue / Gore	
1	1	1100	1100
Clyde		Clyde	
1	1	1100	1100
Main		Main	
1	1	1100	1100
Morrison		Morrison	

Exhibit 42: Townline / Shellard Corridor - Mature State Road Width and Capacity

Mature State Lanes		Mature State Capacity	
King / Coronation / Dundas		King / Coronation / Dundas	
Bishop		Bishop	
2	2	1300	1300
Concession		Concession	
2	2	1300	1300
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
Hespeler / Water		Hespeler / Water	
2	2	1500	1500
2	2	1500	1500
Samuelson		Samuelson	
2	2	1500	1500
2	2	1500	1500
2	2	1500	1500
Beverly		Beverly	
1	1	750	750
1	1	750	750
1	1	750	750
1	1	750	750
Elgin		Elgin	
2	1	1800	900
2	2	1800	1800
Main		Main	
2	2	1800	1800
Franklin		Franklin	
2	2	1800	1800
Champlain		Champlain	
2	2	1800	1800
Branchton		Branchton	
1	1	1100	1100
South Boundary		South Boundary	
1	1	1100	1100
1	1	1100	1100
Morrison		Morrison	
1	1	1100	1100

Exhibit 43: King / Coronation / Dundas Corridor - Mature State Road Width and Capacity

MATURE STATE MODEL VOLUMES

Mature State Lanes		Mature State Capacity	
Conestoga / Elgin / Cheese Factory		Conestoga / Elgin / Cheese Factory	
Smartcentre		Smartcentre	
1	1	400	600
Pinebush		Pinebush	
1	1	650	650
1	1	650	650
Sheldon		Sheldon	
1	1	650	650
1	1	650	650
Bishop		Bishop	
1	1	650	650
Dunbar		Dunbar	
1	1	650	650
Can-Amera		Can-Amera	
****GAP****		****GAP****	
1	1	400	400
Munch		Munch	
1	1	400	400
Avenue		Avenue	
1	1	400	400
1	1	400	400
1	1	400	400
Samuelson		Samuelson	
****GAP****		****GAP****	
Alison		Alison	
1	1	300	300
Gore		Gore	
1	1	300	300
Dundas		Dundas	
1	1	300	400
Pollock		Pollock	
1	1	300	300
Main		Main	
1	1	300	300
1	1	300	300
1	1	300	300
1	1	300	300
Champlain		Champlain	
1	1	300	300
1	1	300	300
Myers		Myers	
1	1	300	300
South Boundary		South Boundary	

Exhibit 44: Conestoga / Elgin / Cheese Factory Corridor – Mature State Road Width and Capacity

Mature State AM Volume				Mature State PM Volume			
Hespeler / Water				Hespeler / Water			
401 EB Ramp		401 EB Ramp		401 EB Ramp		401 EB Ramp	
2653	1239	1380	2718	1380	2718	1380	2718
Eagle / Pinebush		Eagle / Pinebush		Eagle / Pinebush		Eagle / Pinebush	
2357	1015	1181	2347	1181	2347	1181	2347
1345	1693	1998	1333	1998	1333	1998	1333
Langs / Sheldon		Langs / Sheldon		Langs / Sheldon		Langs / Sheldon	
1481	1577	1689	1359	1689	1359	1689	1359
1173	1754	1946	1104	1946	1104	1946	1104
957	2008	2274	925	2274	925	2274	925
Bishop		Bishop		Bishop		Bishop	
1286	1492	1660	1186	1660	1186	1660	1186
668	1966	2272	611	2272	611	2272	611
Dunbar		Dunbar		Dunbar		Dunbar	
722	1833	2063	683	2063	683	2063	683
468	2176	2413	400	2413	400	2413	400
Can-Amera		Can-Amera		Can-Amera		Can-Amera	
622	2407	2578	612	2578	612	2578	612
Munch		Munch		Munch		Munch	
606	1914	2044	643	2044	643	2044	643
641	1862	1982	681	1982	681	1982	681
747	1782	1863	836	1863	836	1863	836
Avenue		Avenue		Avenue		Avenue	
1176	1697	1710	1135	1710	1135	1710	1135
Dundas / Coronation		Dundas / Coronation		Dundas / Coronation		Dundas / Coronation	
771	1123	1180	807	1180	807	1180	807
771	1123	1180	807	1180	807	1180	807
Samuelson		Samuelson		Samuelson		Samuelson	
862	1315	1402	902	1402	902	1402	902
Ainslie		Ainslie		Ainslie		Ainslie	
679	0	865	0	865	0	865	0
183	1315	538	902	538	902	538	902
183	1315	538	902	538	902	538	902
Park Hill		Park Hill		Park Hill		Park Hill	
529	254	619	354	619	354	619	354
529	427	627	388	627	388	627	388
529	427	627	388	627	388	627	388
Dickson		Dickson		Dickson		Dickson	
529	556	677	449	677	449	677	449
Main		Main		Main		Main	
551	546	716	448	716	448	716	448
551	546	716	448	716	448	716	448
Wellington		Wellington		Wellington		Wellington	
348	651	476	745	476	745	476	745
113	877	786	350	786	350	786	350
Concession		Concession		Concession		Concession	
528	652	724	618	724	618	724	618
76	533	363	303	363	303	363	303
Ainslie		Ainslie		Ainslie		Ainslie	
604	1185	1085	919	1085	919	1085	919
604	1185	1085	919	1085	919	1085	919
604	1185	1085	919	1085	919	1085	919
604	1185	1085	919	1085	919	1085	919
Myers		Myers		Myers		Myers	
566	810	721	824	721	824	721	824
South Boundary		South Boundary		South Boundary		South Boundary	
582	1086	1030	695	1030	695	1030	695

Exhibit 45: Hespeler / Water Corridor - Mature State Model Volumes

Mature State AM Volume		Mature State PM Volume	
Franklin		Franklin	
401 EB Ramp		401 EB Ramp	
2343	0	1734	0
Pinebush		Pinebush	
2076	2150	2039	1683
Sheldon		Sheldon	
1388	2348	2659	1260
1388	2348	2659	1260
1213	2441	2708	1060
Bishop		Bishop	
1025	2921	3113	778
Can-Amera		Can-Amera	
1143	3410	3809	1140
Elgin		Elgin	
1051	2808	3008	1138
1051	2808	3008	1138
1219	2574	2626	1308
Avenue		Avenue	
1241	2698	2824	1480
1192	2606	2684	1435
Clyde		Clyde	
1054	2299	2396	1173
703	2646	2783	786
634	2269	2499	644
562	2262	2500	571
Main		Main	
603	1270	1943	433
440	1276	1963	198
Franklin		Franklin	
172	1395	1651	194
168	1241	1497	167
144	899	1093	170
Myers		Myers	
0	0	0	0
South Boundary		South Boundary	

Exhibit 46: Franklin Corridor - Mature State Model Volumes

Mature State AM Volume		Mature State PM Volume	
Townline / Shellard		Townline / Shellard	
401 EB Ramp		401 EB Ramp	
1630	1348	1816	1854
Pinebush		Pinebush	
696	1912	2526	1040
696	1912	2526	1040
Can-Amera		Can-Amera	
80	1394	1976	34
80	1394	1976	34
68	901	1370	64
Avenue / Gore		Avenue / Gore	
82	840	1152	82
Clyde		Clyde	
68	777	1084	79
Main		Main	
28	319	388	36
Morrison		Morrison	

Exhibit 47: Townline / Shellard Corridor - Mature State Model Volumes

Mature State AM Volume		Mature State PM Volume	
King / Coronation / Dundas		King / Coronation / Dundas	
Bishop		Bishop	
569	888	1073	787
Concession		Concession	
801	1466	1661	1135
801	1466	1661	1135
823	1335	1563	1240
753	1427	1703	1181
693	1600	1909	1134
693	1600	1909	1134
Hespeler / Water		Hespeler / Water	
742	1818	1883	905
413	2076	2018	666
Samuelson		Samuelson	
388	1668	1701	603
391	1495	1514	603
391	1495	1514	603
Beverly		Beverly	
395	1067	1097	500
395	1067	1097	500
403	951	1046	614
403	951	1046	614
Elgin		Elgin	
364	963	841	608
328	1111	974	533
Main		Main	
460	1674	1233	829
Franklin		Franklin	
736	1563	1539	827
Champlain		Champlain	
809	1263	1324	790
Branchton		Branchton	
828	1250	1194	888
South Boundary		South Boundary	
927	1276	1230	1157
654	527	560	889
Morrison		Morrison	
524	684	680	660

Exhibit 48: King / Coronation / Dundas Corridor - Mature State Model Volumes

Mature State AM Volume		Mature State PM Volume	
Conestoga / Elgin / Cheese Factory		Conestoga / Elgin / Cheese Factory	
Smartcentre		Smartcentre	
100	0	6	4
Pinebush		Pinebush	
452	275	494	685
359	340	594	601
Sheldon		Sheldon	
242	544	675	233
72	692	873	85
Bishop		Bishop	
51	682	860	56
Dunbar		Dunbar	
146	711	973	322
Can-Amera		Can-Amera	
****GAP****		****GAP****	
121	88	164	81
Munch		Munch	
0	32	108	4
Avenue		Avenue	
7	68	220	1
7	68	220	1
7	68	220	1
Samuelson		Samuelson	
****GAP****		****GAP****	
Alison		Alison	
0	0	0	0
Gore		Gore	
53	191	68	98
Dundas		Dundas	
193	464	437	276
Pollock		Pollock	
160	334	284	205
Main		Main	
111	353	308	162
111	353	308	162
111	353	308	162
82	102	138	111
Champlain		Champlain	
72	62	86	74
72	62	86	74
Myers		Myers	
13	29	19	35
South Boundary		South Boundary	

Exhibit 49: Conestoga / Elgin / Cheese Factory Corridor – Mature State Model Volumes

MATURE STATE MODEL V/C

Mature State AM V/C		Mature State PM V/C	
Hespeler / Water		Hespeler / Water	
401 EB Ramp	1.47 0.69	401 EB Ramp	0.77 1.51
Eagle / Pinebush	1.57 0.68	Eagle / Pinebush	0.79 1.56
	0.9 1.13		1.33 0.89
Langs / Sheldon	0.99 1.05	Langs / Sheldon	1.13 0.91
	0.78 1.17		1.3 0.74
	0.64 1.34		1.52 0.62
Bishop	0.86 0.99	Bishop	1.11 0.79
	0.45 1.31		1.51 0.41
Dunbar	0.48 1.22	Dunbar	1.38 0.46
	0.31 1.45		1.61 0.27
Can-Amera	0.41 1.6	Can-Amera	1.72 0.41
Munch	0.4 1.28	Munch	1.36 0.43
	0.43 1.24		1.32 0.45
	0.5 1.19		1.24 0.56
Avenue	0.78 1.13	Avenue	1.14 0.76
Dundas / Coronation	1.03 1.5	Dundas / Coronation	1.57 1.08
	1.03 1.5		1.57 1.08
Samuelson	1.15 1.75	Samuelson	1.87 1.2
Ainslie	1.04	Ainslie	1.33
	0.28 0.77		0.83 0.53
	0.28 0.77		0.83 0.53
Park Hill	0.81 0.39	Park Hill	0.95 0.54
	0.81 0.66		0.75 1.15
	0.81 0.66		0.96 0.6
	0.57 0.94		0.91 0.97
	0.57 0.94		0.96 0.6
Dickson	0.81 0.86	Dickson	1.04 0.69
	0.45 0.96		0.9 0.97
Main	0.85 0.84	Main	1.1 0.69
	0.42 0.84		0.88 0.97
	0.5 0.96		0.55 0.69
	0.5 0.96		0.88 0.97
Wellington	0.54 1	Wellington	0.73 1.15
	0.17 1.03		1.21 0.41
Concession	0.81 1	Concession	1.11 0.95
	0.06 0.41		0.28 0.23
Ainslie	0.46 0.91	Ainslie	0.83 0.71
	0.4 0.79		0.72 0.61
	0.4 0.79		0.72 0.61
	0.4 0.79		0.72 0.61
Myers	0.51 0.74	Myers	0.66 0.75
South Boundary	0.53 0.99	South Boundary	0.94 0.63

Exhibit 50: Hespeler / Water Corridor - Mature State Model V/C

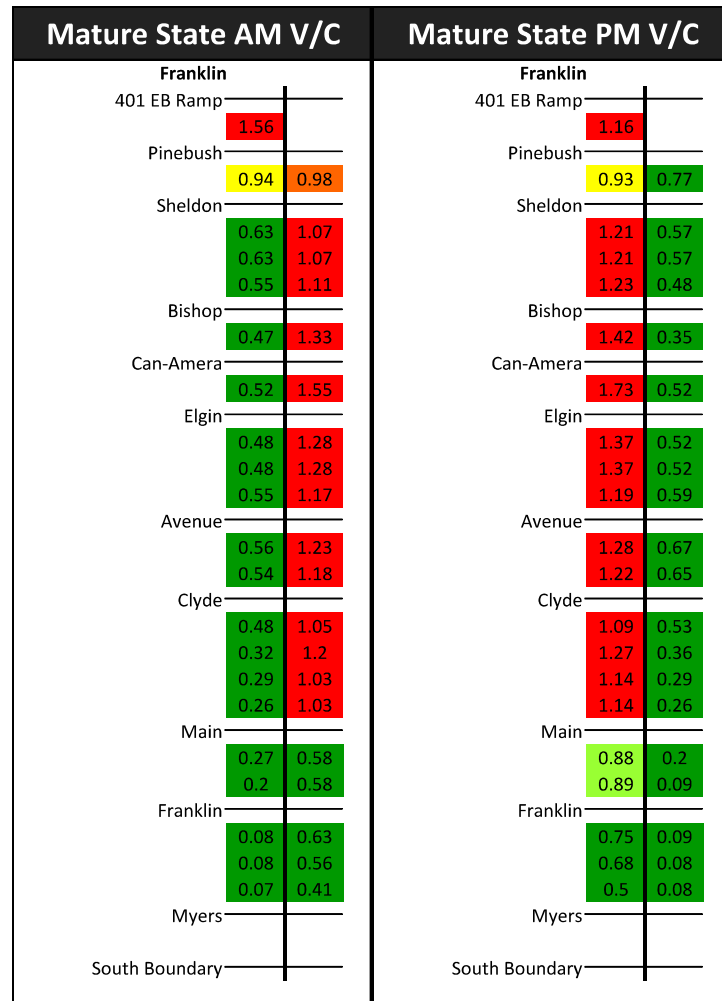


Exhibit 51: Franklin Corridor - Mature State Model V/C

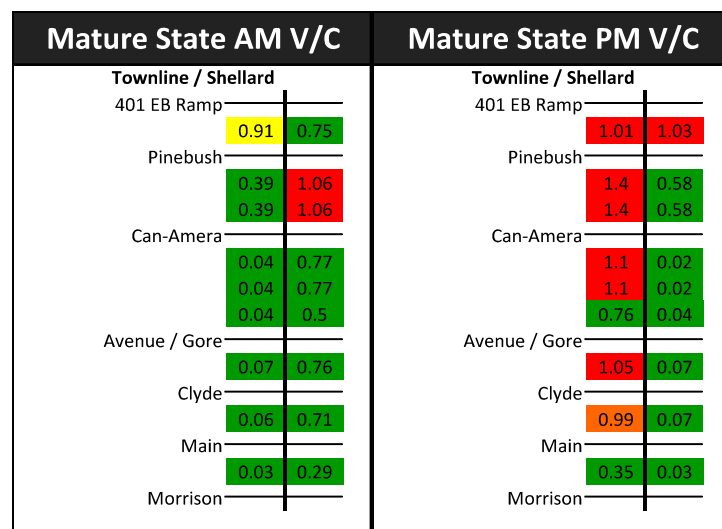


Exhibit 52: Townline / Shellard Corridor - Mature State Model V/C



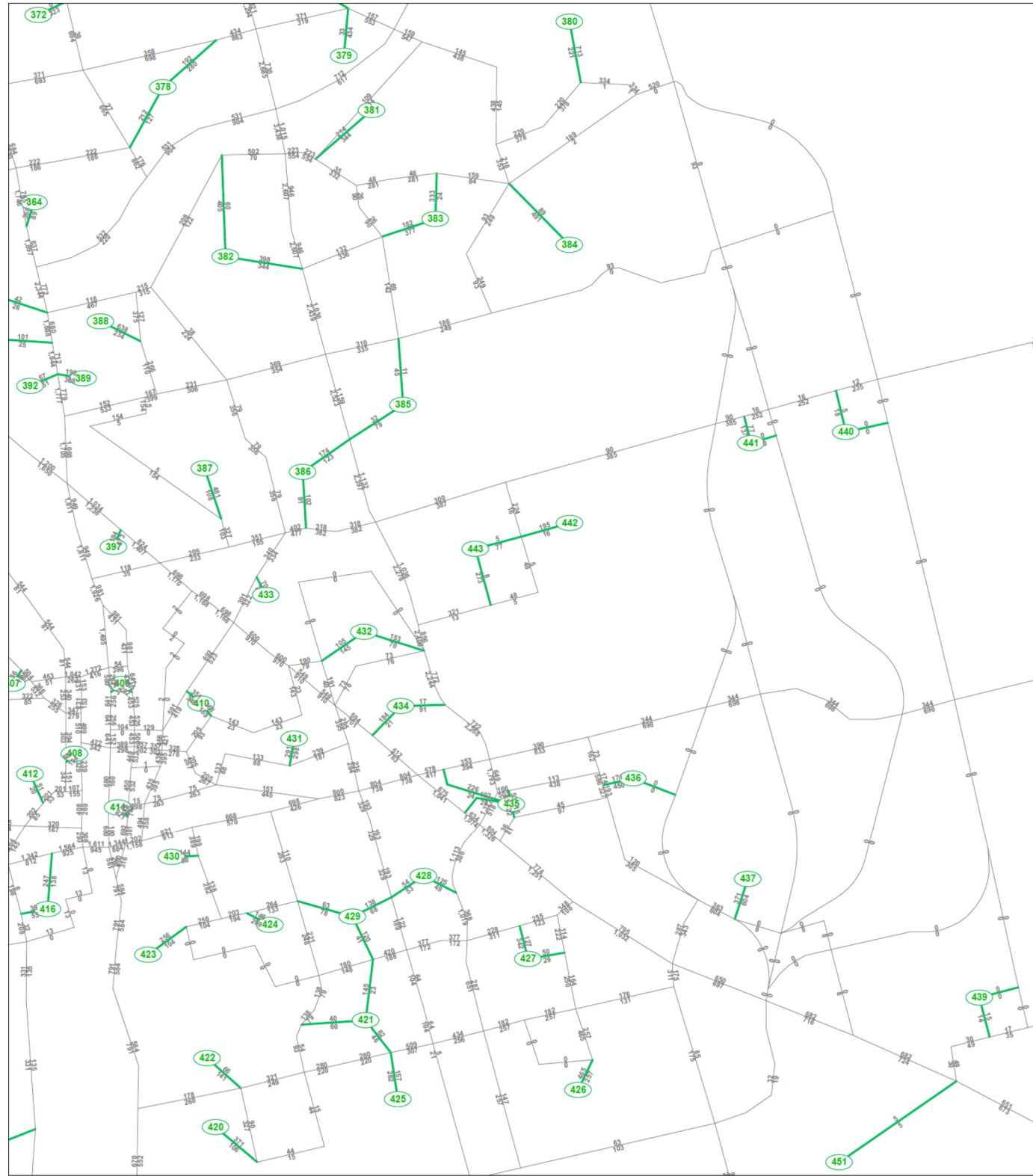
Exhibit 53: King / Coronation / Dundas Corridor - Mature State Model V/C

Mature State AM V/C		Mature State PM V/C	
Conestoga / Elgin / Cheese Factory		Conestoga / Elgin / Cheese Factory	
Smartcentre	0.25 0	Smartcentre	0.02 0.01
Pinebush	0.7 0.42 0.55 0.52	Pinebush	0.76 1.05 0.91 0.92
Sheldon	0.37 0.84 0.11 1.06	Sheldon	1.04 0.36 1.34 0.13
Bishop	0.08 1.05	Bishop	1.32 0.09
Dunbar	0.22 1.09	Dunbar	1.5 0.5
Can-Amera *****GAP*****	0.3 0.22	Can-Amera *****GAP*****	0.41 0.2
Munch	0 0.08	Munch	0.27 0.01
Avenue	0.02 0.17 0.02 0.17 0.02 0.17	Avenue	0.55 0 0.55 0 0.55 0
Samuelson *****GAP*****		Samuelson *****GAP*****	
Alison	0 0	Alison	0 0
Gore	0.18 0.64	Gore	0.23 0.33
Dundas	0.64 1.16	Dundas	1.46 0.69
Pollock	0.53 1.11	Pollock	0.95 0.68
Main	0.37 1.18 0.37 1.18 0.37 1.18 0.27 0.34	Main	1.03 0.54 1.03 0.54 1.03 0.54 0.46 0.37
Champlain	0.24 0.21 0.24 0.21	Champlain	0.29 0.25 0.29 0.25
Myers	0.04 0.1	Myers	0.06 0.12
South Boundary		South Boundary	

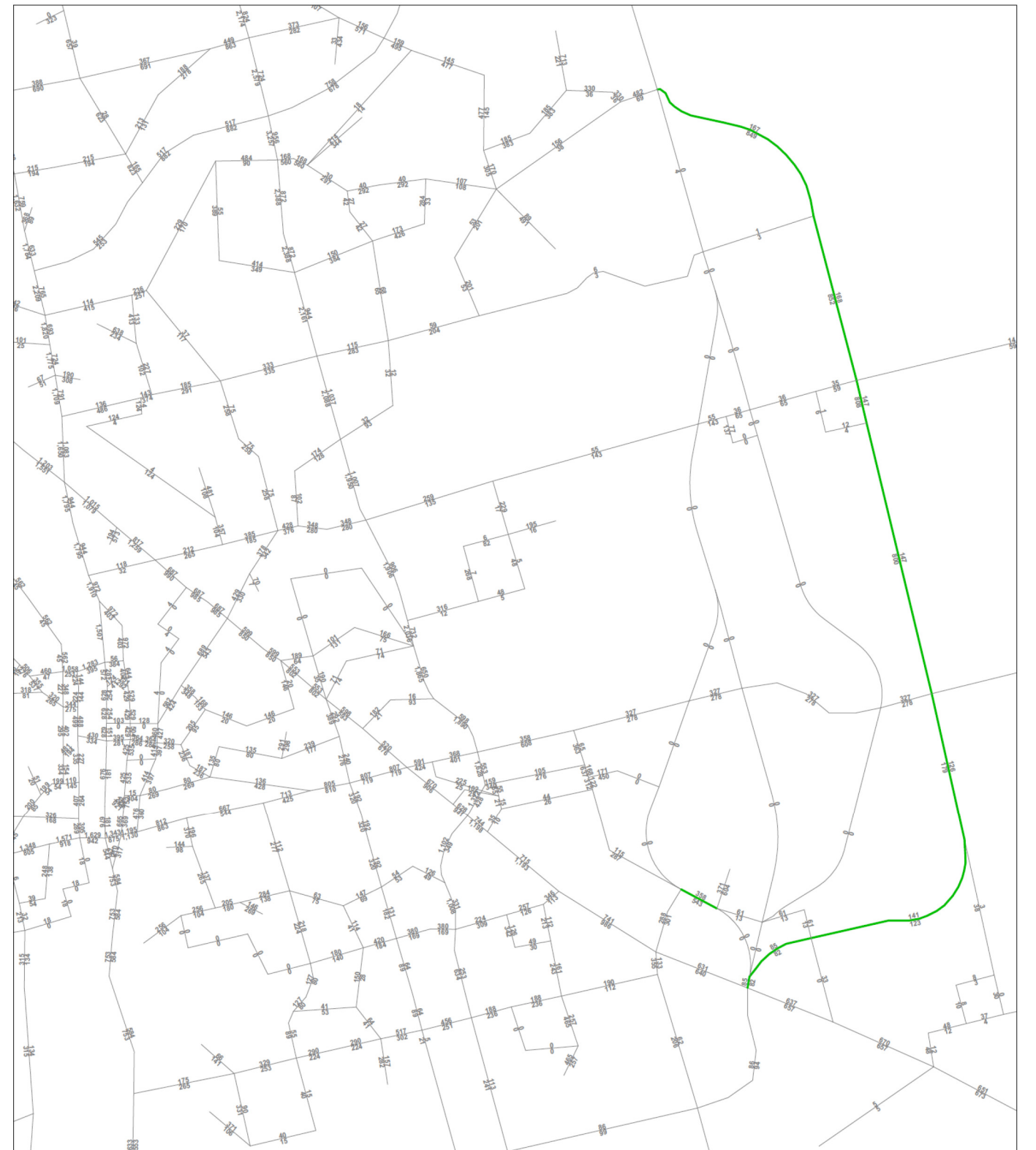
Appendix B: 2031 PM Peak Hour Model Assignments

Exhibit 54: Conestoga / Elgin / Cheese Factory Corridor – Mature State Model V/C

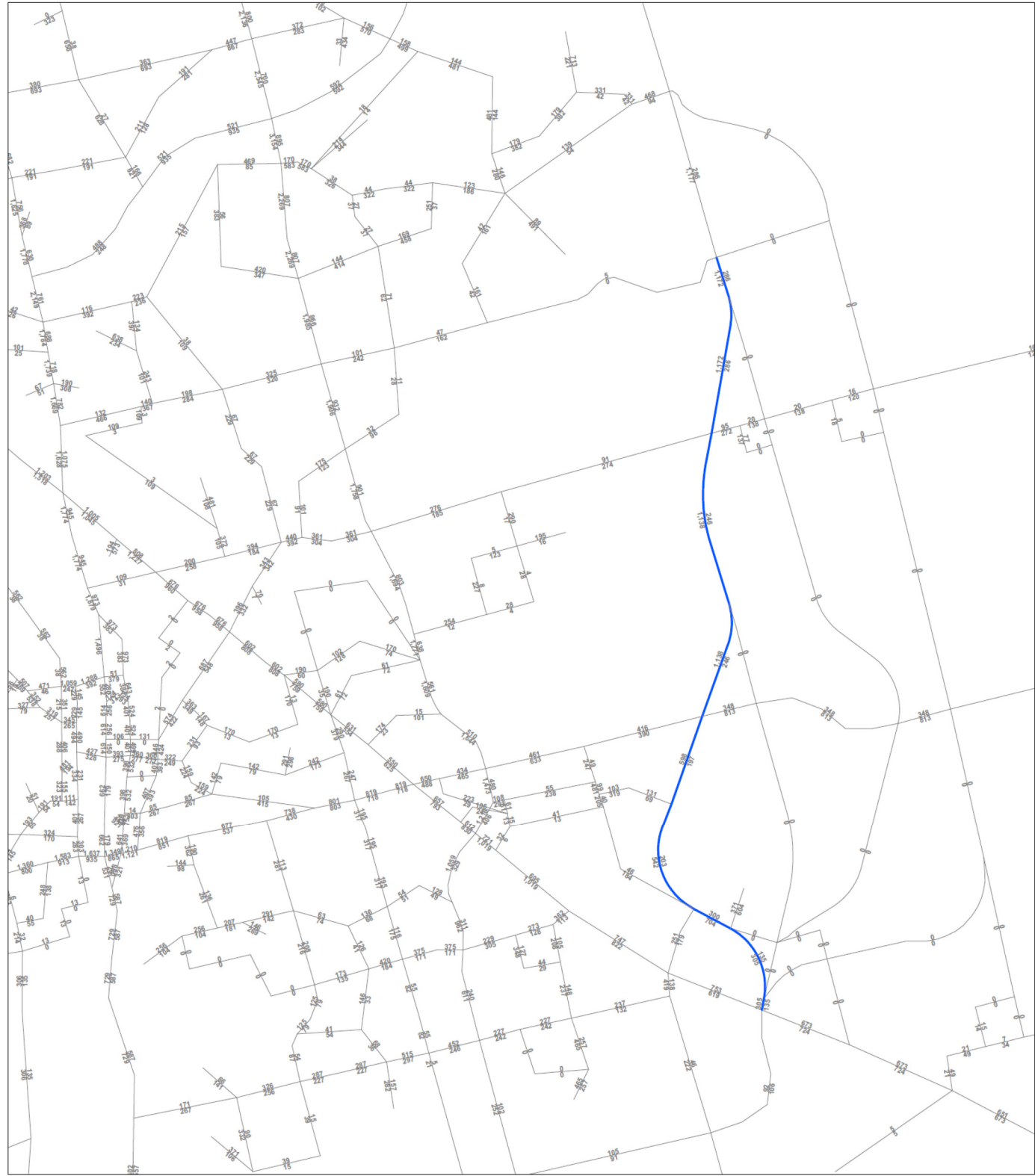
“Do Nothing” Alternative



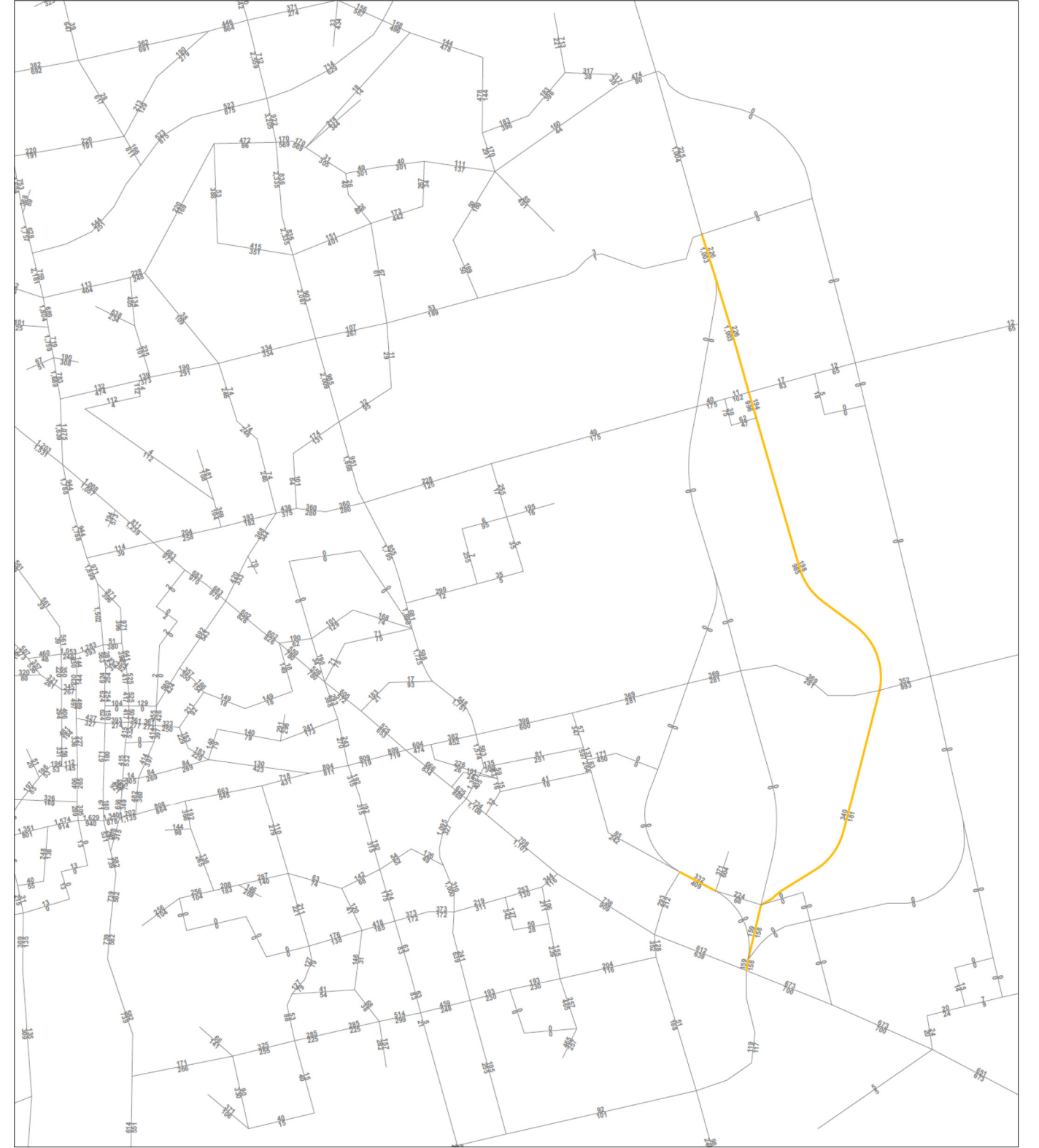
Route A



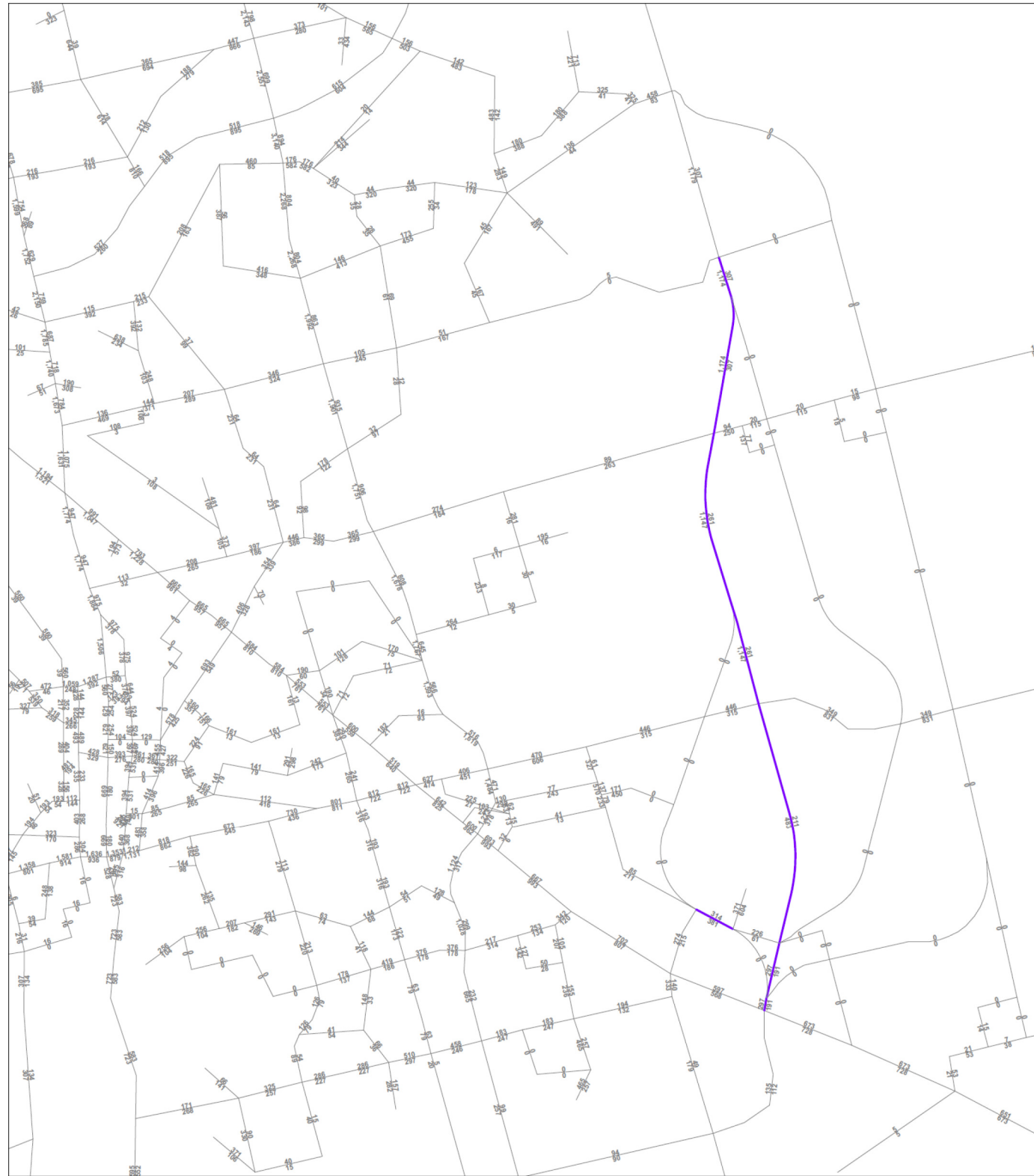
Route B



Route C




Route D



Appendix C: Traffic Signal Warrant Calculations

REGION OF WATERLOO TRAFFIC CONTROL SIGNAL WARRANT - STEP 1: VOLUME AND DELAY; FUTURE CONDITIONS



Intersection: **Eastboundary Rd at Wesley Blvd** Scenario: **2041 Total Traffic**
 Major Road: **Eastboundary Rd**

Approach Lanes: Major: 2, Minor: 1
 Flow Condition: Urban
 "T" Intersection: NO
 "New" / "Existing" Intersection: New
 Analysis Period: AM / PM Peak

JUSTIFICATION 7a - PEAK HOUR TRAFFIC VOLUME (TIS)

PERIOD	Eastboundary Rd						Wesley Blvd						Average Hourly Volume	
	Direction 1 NB			Direction 2 SB			Direction 1 EB			Direction 2 WB			All Appr	AHV
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT		
AM PEAK	190	400	270	290	180	50	100	50	130	240	90	460	All Appr	1348
PM PEAK	130	240	290	610	470	130	60	70	290	270	100	280	Minor Appr	535
													Major Appr	813
													Cross Minor	215

WARRANT 1: MINIMUM VEHICULAR VOLUME WARRANT 1 HAS BEEN SATISFIED: **YES**


1. MINIMUM VEHICULAR VOLUME	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow	Numerical	%	
A. Vehicle volume, all approaches (AHV)	480	720	600	900	1348	150%	150%
B. Vehicle volume, minor approach (AHV)	120	170	120	170	535	315%	

WARRANT 2: DELAY TO CROSS TRAFFIC WARRANT 2 HAS BEEN SATISFIED: **NO**

2. DELAY TO CROSS TRAFFIC	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow	Numerical	%	
A. Vehicle volume, major street (AHV)	480	720	600	900	813	90%	90%
B. Volume crossing from minor (AHV)	50	75	50	75	215	287%	

**STEP 1: VOLUME AND DELAY HAS BEEN SATISFIED FOR FUTURE CONDITIONS;
PROCEED TO STEP 2: GEOMETRIC/ENGINEERING REVIEW**

REGION OF WATERLOO TRAFFIC CONTROL SIGNAL WARRANT - STEP 1: VOLUME AND DELAY; FUTURE CONDITIONS



Intersection: **Eastboundary Rd at Main St** Scenario: **2041 Total Traffic**
 Major Road: **Eastboundary Rd**

Approach Lanes: Major: 2, Minor: 1
 Flow Condition: Urban
 "T" Intersection: NO
 "New" / "Existing" Intersection: New
 Analysis Period: AM / PM Peak

JUSTIFICATION 7a - PEAK HOUR TRAFFIC VOLUME (TIS)

PERIOD	Eastboundary Rd						Main St						Average Hourly Volume	
	Direction 1 NB			Direction 2 SB			Direction 1 EB			Direction 2 WB			All Appr	AHV
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT		
AM PEAK	20	870	70	90	470	60	160	460	40	10	130	260	All Appr	1448
PM PEAK	40	530	10	300	1100	180	70	160	20	90	550	100	Minor Appr	513
													Major Appr	935
													Cross Minor	253

WARRANT 1: MINIMUM VEHICULAR VOLUME WARRANT 1 HAS BEEN SATISFIED: **YES**

1. MINIMUM VEHICULAR VOLUME	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow	Numerical	%	
A. Vehicle volume, all approaches (AHV)	480	720	600	900	1448	161%	161%
B. Vehicle volume, minor approach (AHV)	120	170	120	170	513	301%	

WARRANT 2: DELAY TO CROSS TRAFFIC WARRANT 2 HAS BEEN SATISFIED: **NO**

2. DELAY TO CROSS TRAFFIC	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow	Numerical	%	
A. Vehicle volume, major street (AHV)	480	720	600	900	935	104%	104%
B. Volume crossing from minor (AHV)	50	75	50	75	253	337%	

**STEP 1: VOLUME AND DELAY HAS BEEN SATISFIED FOR FUTURE CONDITIONS;
PROCEED TO STEP 2: GEOMETRIC/ENGINEERING REVIEW**

REGION OF WATERLOO TRAFFIC CONTROL SIGNAL WARRANT - STEP 1: VOLUME AND DELAY; FUTURE CONDITIONS

Intersection: **Eastboundary Rd at Clyde Rd**

Major Road: **Eastboundary Rd**

Scenario: **2041 Total Traffic**

Flow Condition: **Urban**

"T" Intersection: **NO**

"New" / "Existing" Intersection: **New**

Analysis Period: **AM / PM Peak**

Approach Lanes: Major: **2**, Minor: **1**

JUSTIFICATION 7a - PEAK HOUR TRAFFIC VOLUME (TIS)

PERIOD	Eastboundary Rd						Clyde Rd						Average Hourly Volume	
	Direction 1 NB			Direction 2 SB			Direction 1 EB			Direction 2 WB				
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	All Appr	AHV
AM PEAK	60	1140	90	20	580	120	90	80	20	20	170	110	All Appr	1368
PM PEAK	20	660	20	130	1410	100	150	200	70	100	90	20	Minor Appr	280
													Major Appr	1088
													Cross Minor	160

WARRANT 1: MINIMUM VEHICULAR VOLUME WARRANT 1 HAS BEEN SATISFIED: **YES**

1. MINIMUM VEHICULAR VOLUME	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow			
	Numerical	%	Numerical	%			
A. Vehicle volume, all approaches (AHV)	480	720	600	900	1368	152%	152%
B. Vehicle volume, minor approach (AHV)	120	170	120	170	280	185%	

WARRANT 2: DELAY TO CROSS TRAFFIC WARRANT 2 HAS BEEN SATISFIED: **NO**

2. DELAY TO CROSS TRAFFIC	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow			
	Numerical	%	Numerical	%			
A. Vehicle volume, major street (AHV)	480	720	600	900	1088	121%	121%
B. Volume crossing from minor (AHV)	50	75	50	75	160	213%	

STEP 1: VOLUME AND DELAY HAS BEEN SATISFIED FOR FUTURE CONDITIONS;
PROCEED TO STEP 2: GEOMETRIC/ENGINEERING REVIEW

REGION OF WATERLOO TRAFFIC CONTROL SIGNAL WARRANT - STEP 1: VOLUME AND DELAY; FUTURE CONDITIONS

Intersection: **Townline Rd at Avenue Rd**

Major Road: **Townline Rd**

Scenario: **2041 Total Traffic**

Flow Condition: **Urban**

"T" Intersection: **NO**

"New" / "Existing" Intersection: **Existing**

Analysis Period: **AM / PM Peak**

Approach Lanes: Major: **2**, Minor: **1**

JUSTIFICATION 7a - PEAK HOUR TRAFFIC VOLUME (TIS)

PERIOD	Townline Rd						Avenue Rd						Average Hourly Volume	
	Direction 1 NB			Direction 2 SB			Direction 1 EB			Direction 2 WB				
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	All Appr	AHV
AM PEAK	100	1080	160	210	1340	290	240	40	90	50	40	460	All Appr	1720
PM PEAK	90	680	60	550	580	90	100	40	120	180	50	240	Minor Appr	413
													Major Appr	1308
													Cross Minor	165

WARRANT 1: MINIMUM VEHICULAR VOLUME WARRANT 1 HAS BEEN SATISFIED: **YES**

1. MINIMUM VEHICULAR VOLUME	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow			
	Numerical	%	Numerical	%			
A. Vehicle volume, all approaches (AHV)	480	720	600	900	1720	191%	191%
B. Vehicle volume, minor approach (AHV)	120	170	120	170	413	243%	

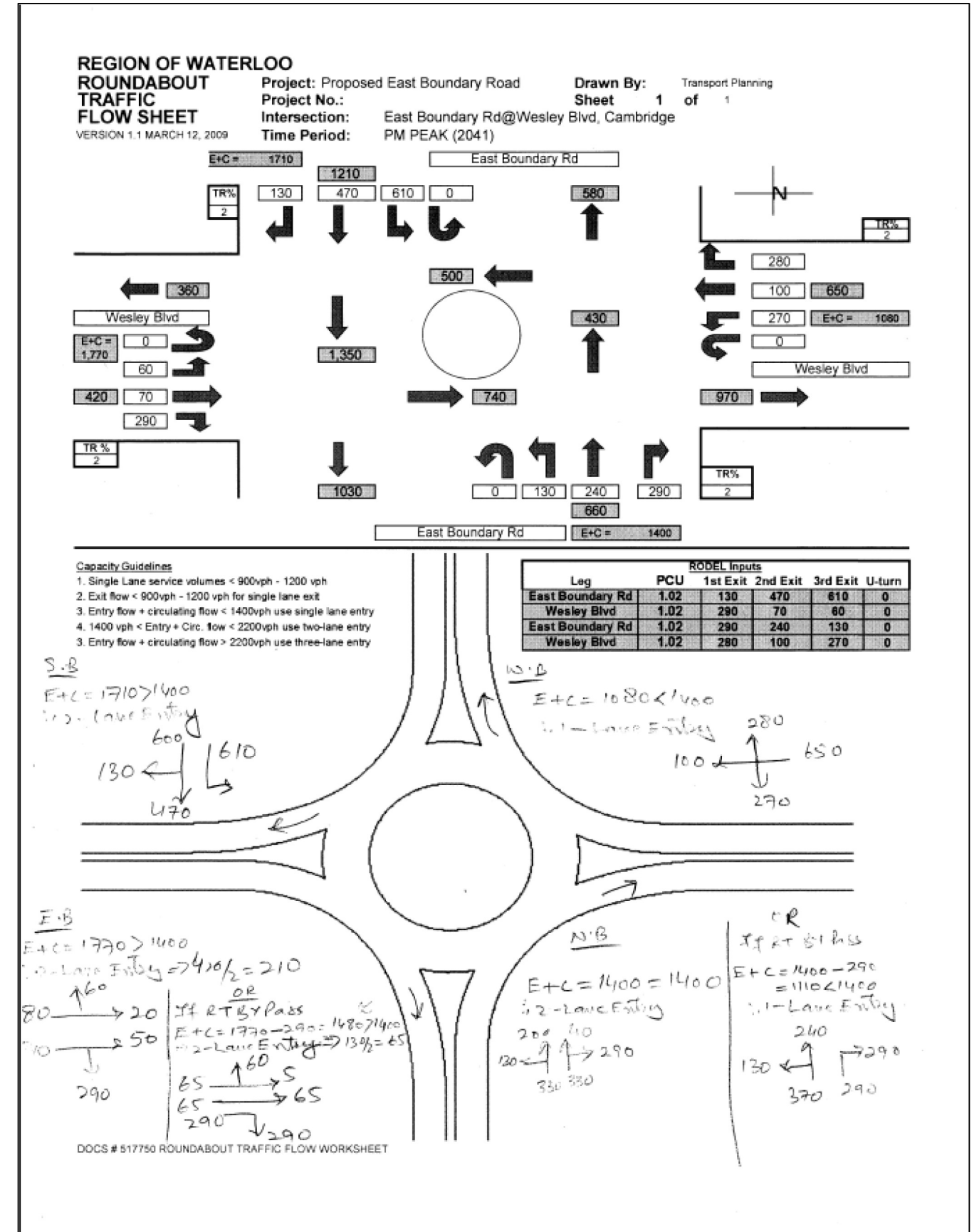
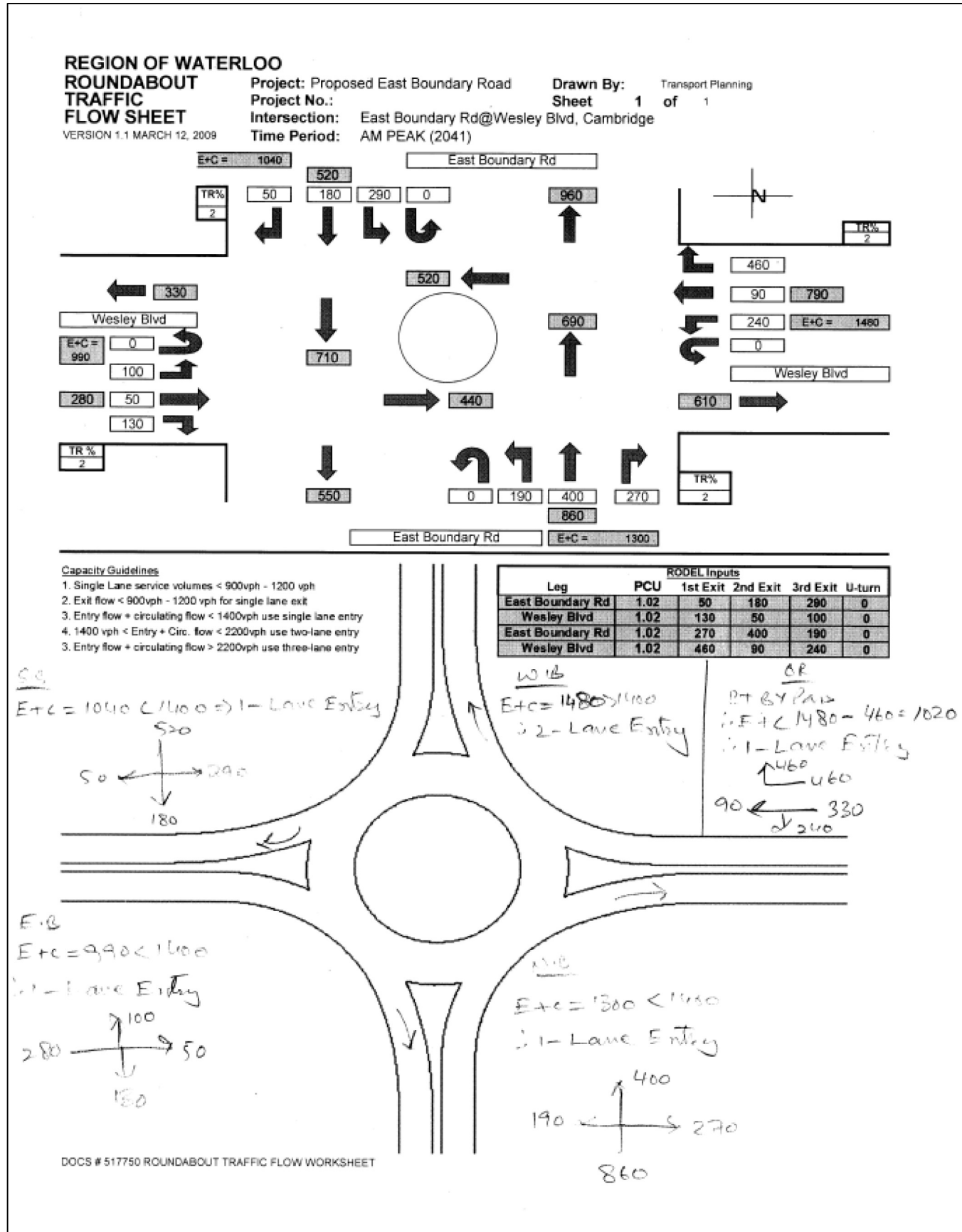
WARRANT 2: DELAY TO CROSS TRAFFIC WARRANT 2 HAS BEEN SATISFIED: **YES**

2. DELAY TO CROSS TRAFFIC	MINIMUM REQUIREMENTS				Compliance		
	1 lane		2 or more		Sectional		Entire %
	Free Flow	Rest Flow	Free Flow	Rest Flow			
	Numerical	%	Numerical	%			
A. Vehicle volume, major street (AHV)	480	720	600	900	1308	145%	145%
B. Volume crossing from minor (AHV)	50	75	50	75	165	220%	

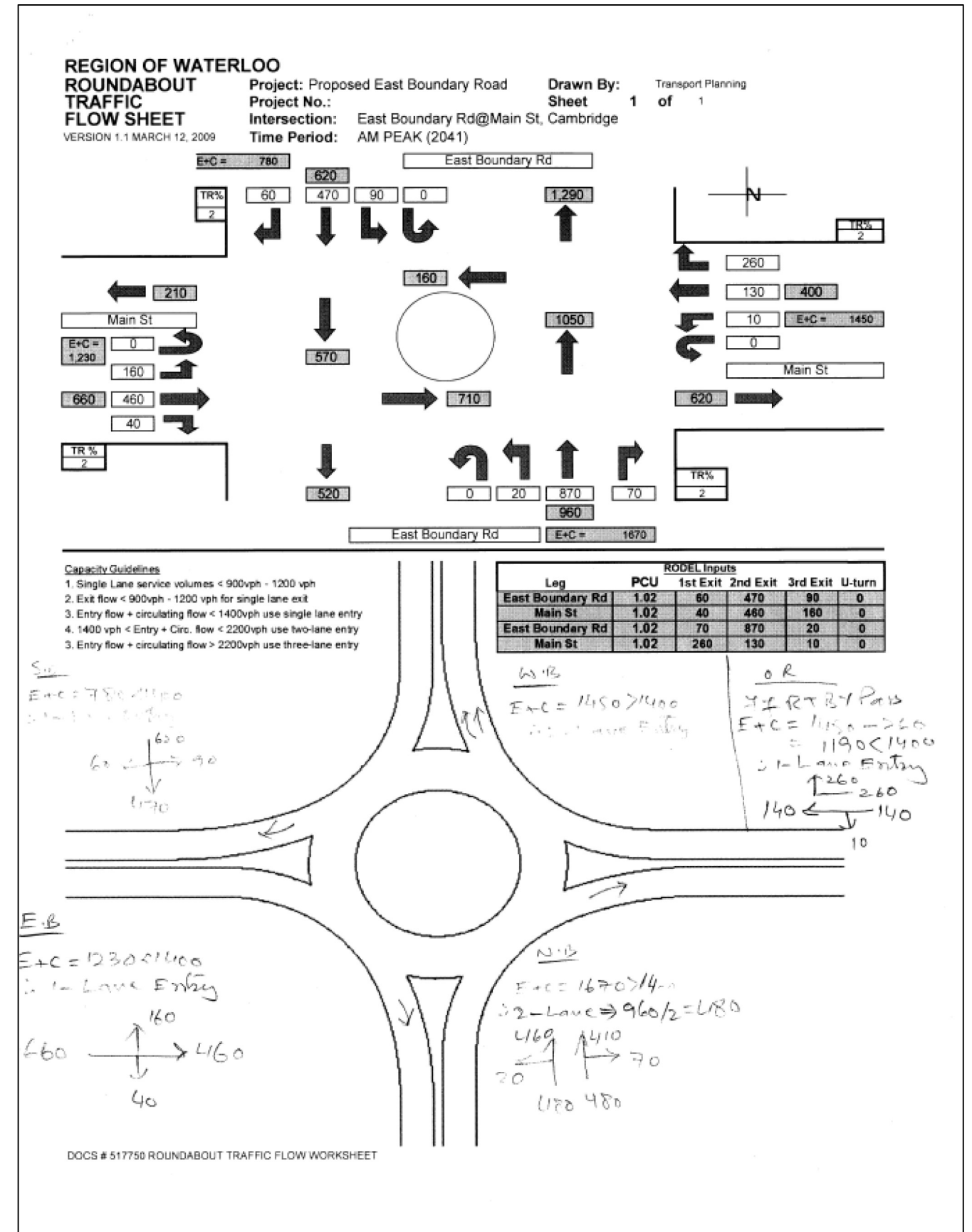
STEP 1: VOLUME AND DELAY HAS BEEN SATISFIED FOR FUTURE CONDITIONS;
PROCEED TO STEP 2: GEOMETRIC/ENGINEERING REVIEW

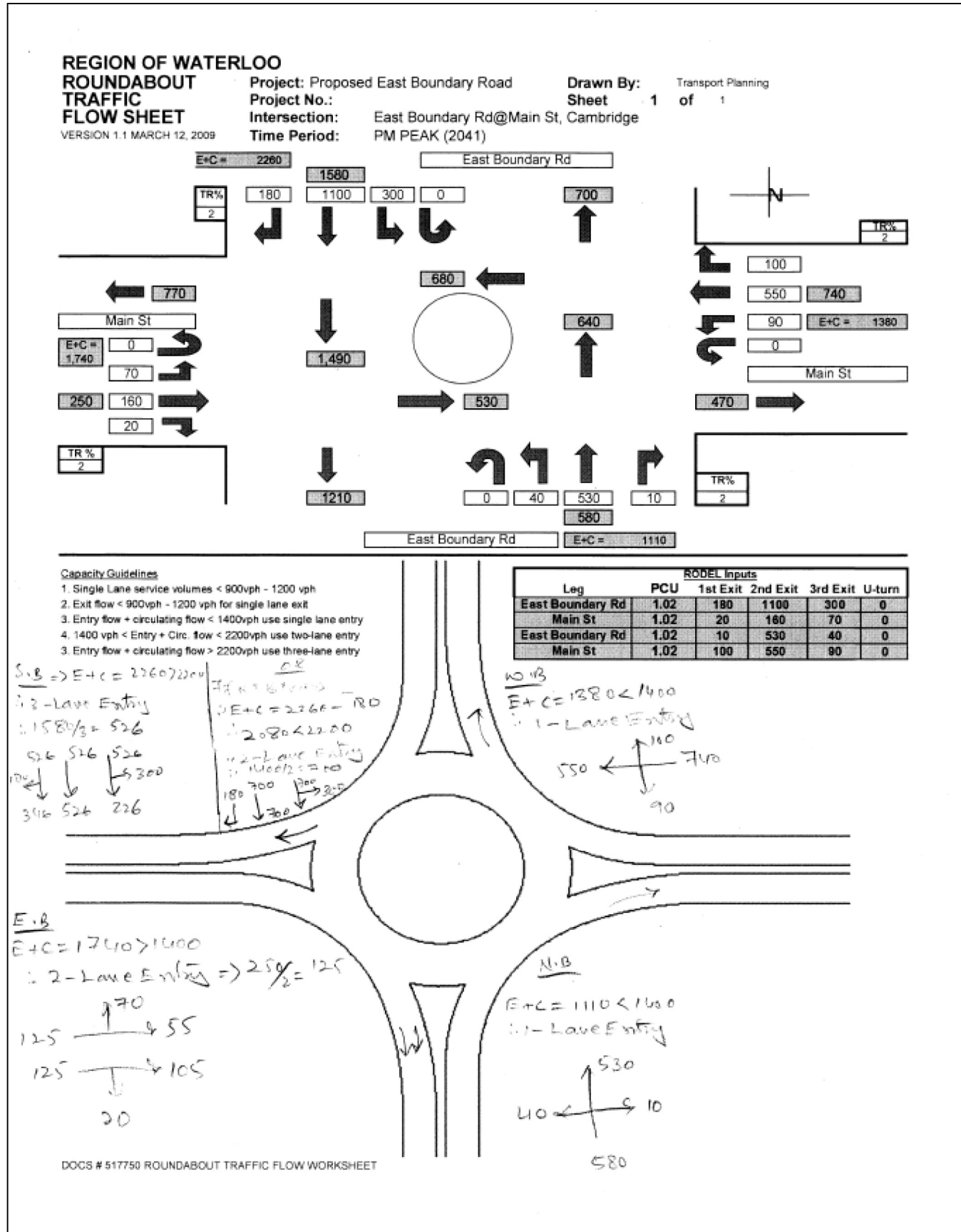
Appendix D: Preliminary Roundabout Screenings

Initial Roundabout Screening East Boundary Rd@Wesley Blvd , Cambridge - 2041 Forecast (Doc#2737246)	
Screening Question	Details
1. Project Name/File No	Proposed East Boundary Rd (Avenue Rd - Dundas St S), Cambridge
2. Intersection Location (Street/Road Names, distance from major intersection, etc.):	East Boundary Rd@Wesley Blvd St intersection will be a new intersection.
3. Brief Description of Intersection (Number of Legs, Lanes on each leg, total AADT, AADT on each road, etc.)	East Boundary Rd@Wesley Blvd intersection will be a new intersection. Estimated future AADTs and turning movements of this intersection are attached herewithin this initial roundabout screening.
4. What operational problems are being experienced at this location?	No operational problems identified. As it will be will be a new intersection.
5. Is it a new intersection or is it a retrofit of an existing intersection? If existing, what is the existing traffic control?	It will be will be a new intersection.
6. Is the intersection in the vicinity of a railroad crossing or another intersection? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem?	No.
7. Would the intersection be located within a coordinated signal system?	No.
8. Would the intersection be located on a Preferred Roundabout Corridor?	Yes. SBR has been approved with roundabouts and EBR is a continuation of the same corridor.
9. Is the intersection located within a corridor that is scheduled for improvements in the 10 Year Transportation Capital Program? What is the ultimate cross-section of the approach roads?	No.
10. What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed?	Not known. As it will be a new intersection.
11. Are persons with disabilities or horse and buggies frequent users of this intersection?	No known at this stage.
12. What traditional road improvements are proposed for this intersection? (eg. traffic signals, all-way stop, auxiliary lanes, etc.)	This is proposed to be a 4-legged intersection as a part of East Boundary Rd project.
13. If traffic control signals are being considered, are the traffic signal warrants met for the horizon year?	Yes.
14. What size of roundabout is being considered for this intersection? (eg. Single-lane, two-lane entry or three-lane entry?)	By utilising (2041) forecast volumes multi lane roundabout may be required such as 2 lane entry on major street with 1 lane entry on minor street.
Conclusions and Recommendation	
Roundabout is recommended as SBR has been already been approved with roundabouts and EBR is a continuation of the same corridor.	

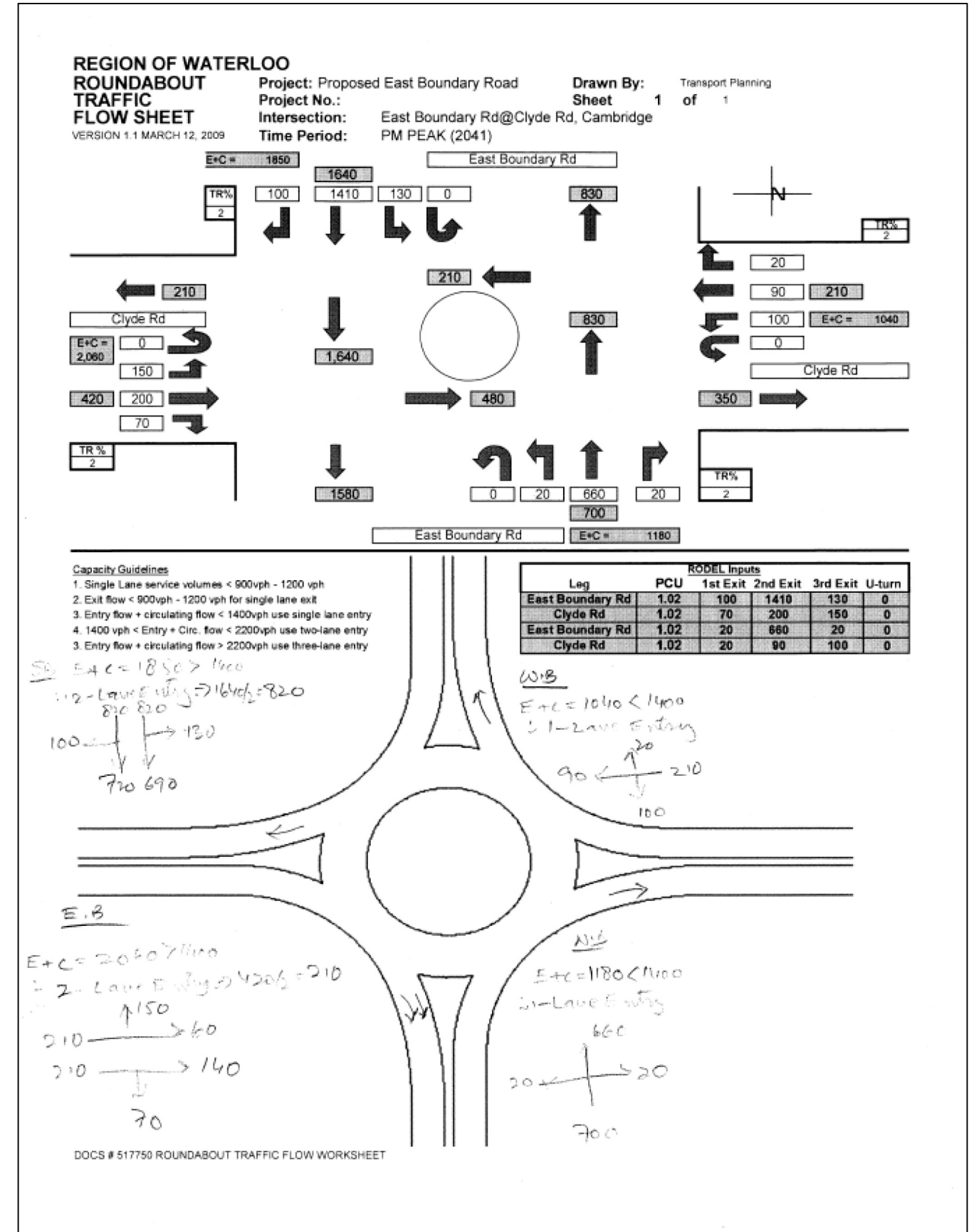
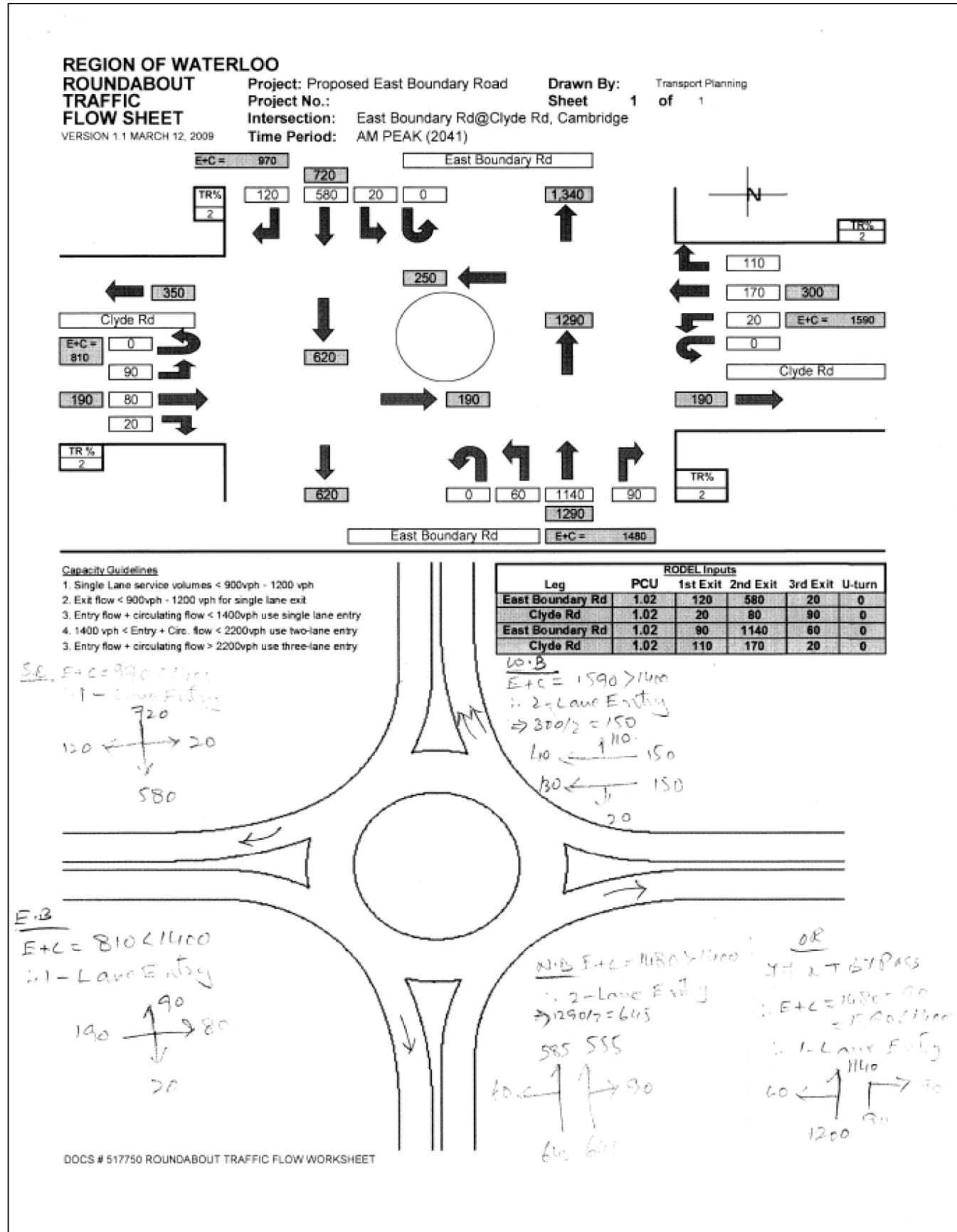


Initial Roundabout Screening East Boundary Rd@Main St , Cambridge - 2041 Forecast (Doc#2737244)	
Screening Question	Details
1. Project Name/File No	Proposed East Boundary Rd (Avenue Rd - Dundas St S), Cambridge
2. Intersection Location (Street/Road Names, distance from major intersection, etc.):	East Boundary Rd@Main St intersection will be a new intersection.
3. Brief Description of Intersection (Number of Legs, Lanes on each leg, total AADT, AADT on each road, etc.)	East Boundary Rd@Main Rd intersection will be a new intersection. And according to the TCP (2018) Main will have provision of cycling facilities 1070 Main St TO Franklin Blvd (Project No. 6565). Estimated future AADTs and turning movements of this intersection are attached herewithin this initial roundabout screening.
4. What operational problems are being experienced at this location?	No operational problems identified. As it will be a new intersection.
5. Is it a new intersection or is it a retrofit of an existing intersection? If existing, what is the existing traffic control?	It will be a new intersection.
6. Is the intersection in the vicinity of a railroad crossing or another intersection? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem?	No.
7. Would the intersection be located within a coordinated signal system?	No.
8. Would the intersection be located on a Preferred Roundabout Corridor?	Yes. SBR has been approved with roundabouts and EBR is a continuation of the same corridor.
9. Is the intersection located within a corridor that is scheduled for improvements in the 10 Year Transportation Capital Program? What is the ultimate cross-section of the approach roads?	No.
10. What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed?	Not known. As it will be a new intersection.
11. Are persons with disabilities or horse and buggies frequent users of this intersection?	No known at this stage.
12. What traditional road improvements are proposed for this intersection? (eg. traffic signals, all-way stop, auxiliary lanes, etc.)	This is proposed to be a 4-legged intersection as a part of East Boundary Rd project.
13. If traffic control signals are being considered, are the traffic signal warrants met for the horizon year?	Yes.
14. What size of roundabout is being considered for this intersection? (eg. Single-lane, two-lane entry or three-lane entry?)	By utilising (2041) forecast volumes multi lane roundabout may be required such as 2 lane entry on major street with 1 lane entry on minor street.
Conclusions and Recommendation	
Roundabout is recommended as SBR has been already been approved with roundabouts and EBR is a continuation of the same corridor.	

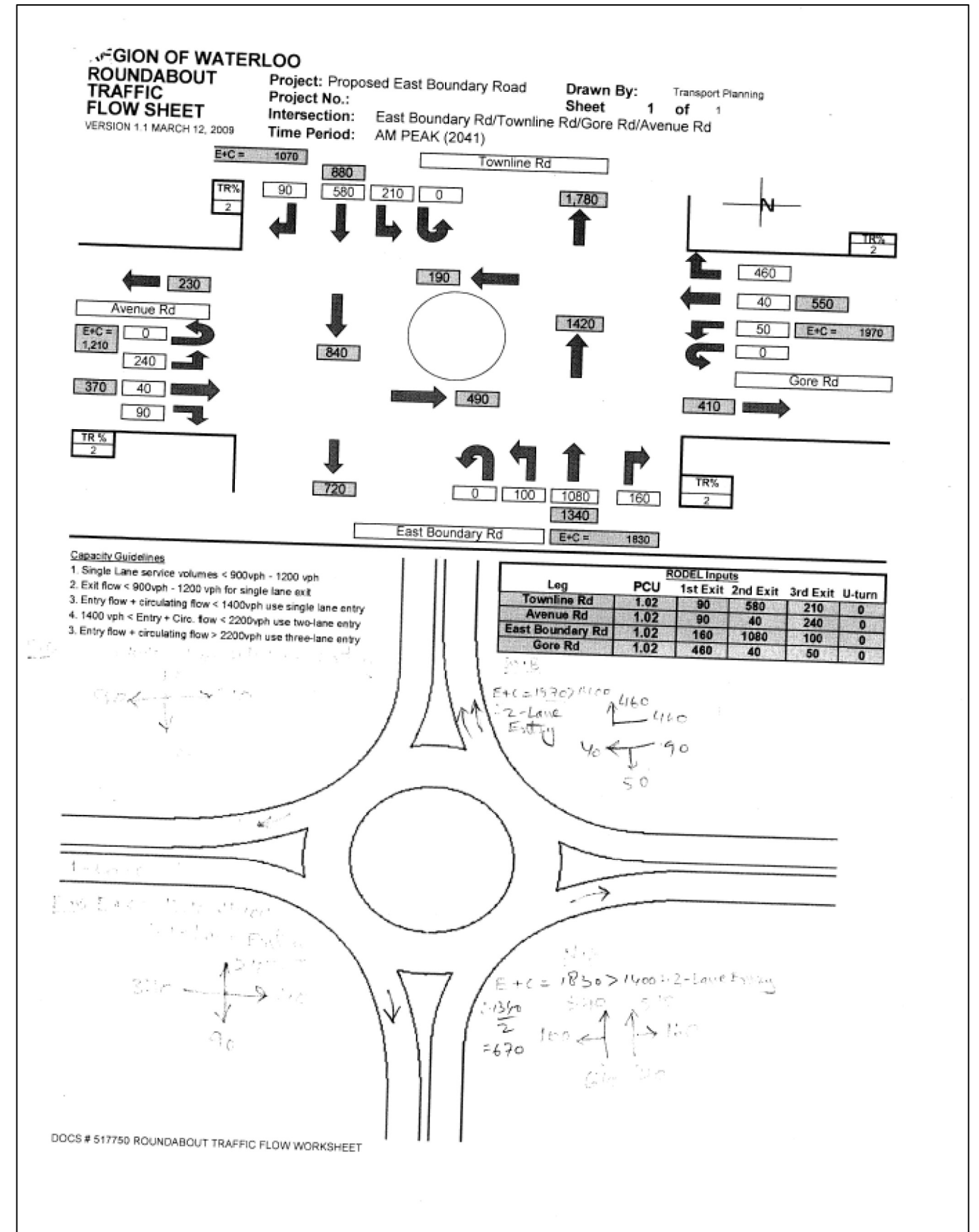


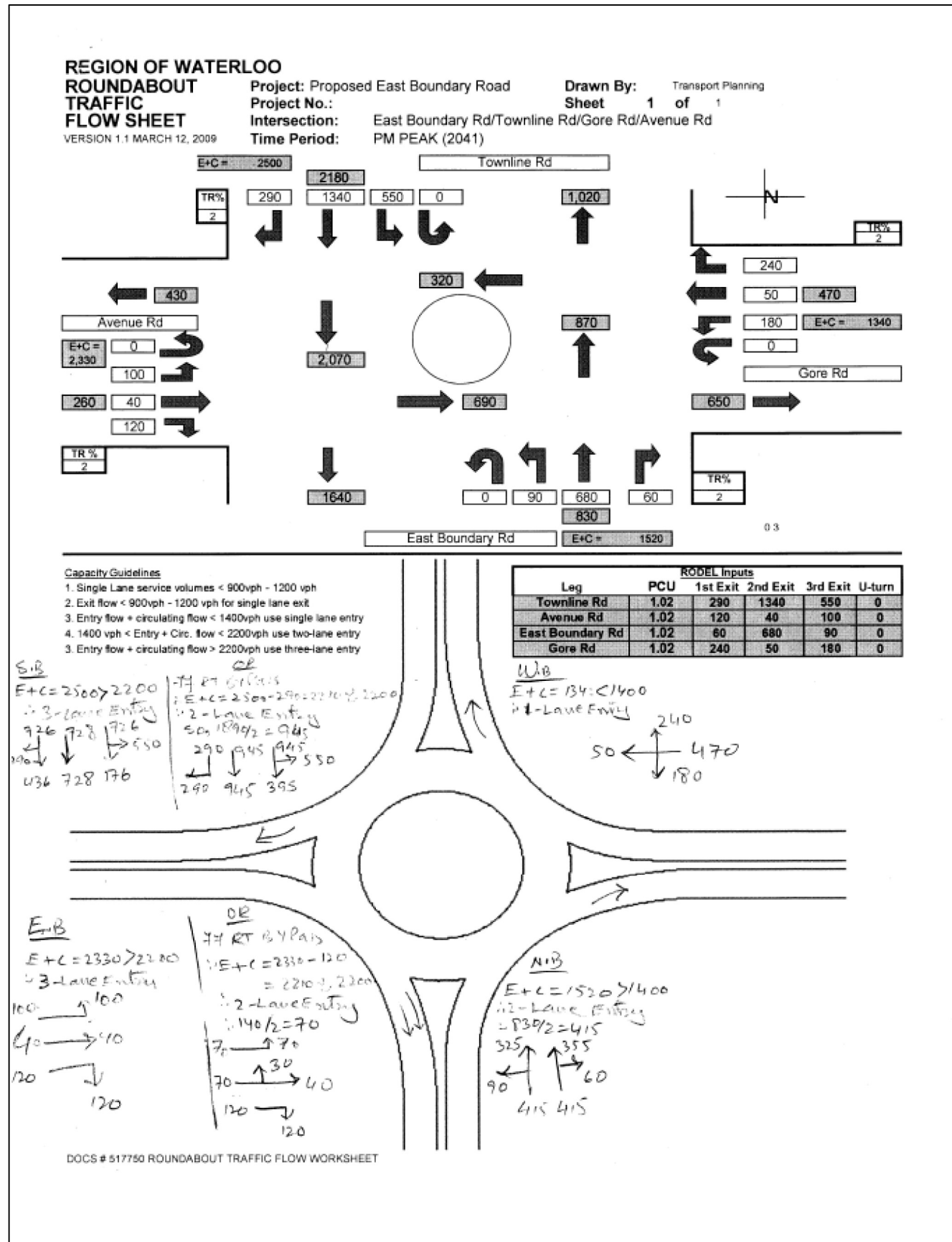


Initial Roundabout Screening East Boundary Rd@Clyde Rd, Cambridge - 2041 Forecast (Doc#2737240)	
Screening Question	Details
1. Project Name/File No	Proposed East Boundary Rd (Avenue Rd - Dundas St S), Cambridge
2. Intersection Location (Street/Road Names, distance from major intersection, etc.):	East Boundary Rd@Clyde Rd intersection will be a new intersection.
3. Brief Description of Intersection (Number of Legs, Lanes on each leg, total AADT, AADT on each road, etc.)	East Boundary Rd@Clyde Rd intersection will be a new intersection. And according to the TCP (2018) Clyde Rd will have provision of cycling facilities between Dobbie Rd and 940 m west of Village Rd (Project No. 5942). Estimated future AADTs and turning movements of this intersection are attached herewithin this initial roundabout screening.
4. What operational problems are being experienced at this location?	No operational problems identified. As it will be will be a new intersection.
5. Is it a new intersection or is it a retrofit of an existing intersection? If existing, what is the existing traffic control?	It will be will be a new intersection.
6. Is the intersection in the vicinity of a railroad crossing or another intersection? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem?	There is potentially be a rail crossing (CP) to the north of this intersection with approximate distance of 500m (distance could vary with the final alignment of proposed road). Please note; the type of railway crossing has not yet been determined. Based on forecast AADTs and current train traffic, the crossing would meet the 200,000 cross-product threshold for consideration of a grade separation.
7. Would the intersection be located within a coordinated signal system?	No.
8. Would the intersection be located on a Preferred Roundabout Corridor?	Yes. SBR has been approved with roundabouts and EBR is a continuation of the same corridor.
9. Is the intersection located within a corridor that is scheduled for improvements in the 10 Year Transportation Capital Program? What is the ultimate cross-section of the approach roads?	No.
10. What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed?	Not known. As it will be a new intersection.
11. Are persons with disabilities or horse and buggies frequent users of this intersection?	No known at this stage.
12. What traditional road improvements are proposed for this intersection? (eg. traffic signals, all-way stop, auxiliary lanes, etc.)	This is proposed to be a 4-legged intersection as a part of East Boundary Rd project.
13. If traffic control signals are being considered, are the traffic signal warrants met for the horizon year?	Yes.
14. What size of roundabout is being considered for this intersection? (eg. Single-lane, two-lane entry or three-lane entry?)	By utilising (2041) forecast volumes multi lane roundabout may be required such as 2 lane entry on major street with 1 lane entry on minor street.
Conclusions and Recommendation	
Roundabout is recommended as SBR has been already been approved with roundabouts and EBR is a continuation of the same corridor.	



Initial Roundabout Screening East Boundary Rd@Townline Rd/Gore Rd, Cambridge - 2041 Forecast (Doc#2737237)	
Screening Question	Details
1. Project Name/File No	Proposed East Boundary Rd (Avenue Rd - Dundas St S), Cambridge
2. Intersection Location (Street/Road Names, distance from major intersection, etc.):	Gore Rd/Townline Rd/Avenue Rd intersection is currently non-signalised (All-way Stop) T-intersection and proposed to be a 4-legged intersection with the addition of south leg as a part of East Boundary Rd project.
3. Brief Description of Intersection (Number of Legs, Lanes on each leg, total AADT, AADT on each road, etc.)	Townline Rd, Gore Rd and Avenue Rd has a two lane cross section. The on-road cycling facilities are provided at Townline Rd on both sides of the road. Estimated future AADTs and turning movements of this intersection are attached herewithin this initial roundabout screening.
4. What operational problems are being experienced at this location?	No operational problems identified. As it will be a retrofit of an existing intersection.
5. Is it a new intersection or is it a retrofit of an existing intersection? If existing, what is the existing traffic control?	It is a retrofit of an existing intersection with the addition of south leg as a part of East Boundary Rd project.
6. Is the intersection in the vicinity of a railroad crossing or another intersection? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem?	There is potentially be a rail crossing (CP) to the south of this intersection with approximate distance of 700m (distance could vary with the final alignment of proposed road). Please note; the type of railway crossing has not yet been determined. Based on forecast AADTs and current train traffic, the crossing would meet the 200,000 cross-product threshold for consideration of a grade separation.
7. Would the intersection be located within a coordinated signal system?	No.
8. Would the intersection be located on a Preferred Roundabout Corridor?	Yes. SBR has been approved with roundabouts and EBR is a continuation of the same corridor.
9. Is the intersection located within a corridor that is scheduled for improvements in the 10 Year Transportation Capital Program? What is the ultimate cross-section of the approach roads?	No.
10. What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed?	No collisions (2012 - 2016) noted at this intersection.
11. Are persons with disabilities or horse and buggies frequent users of this intersection?	No known at this stage.
12. What traditional road improvements are proposed for this intersection? (eg. traffic signals, all-way stop, auxiliary lanes, etc.)	This is proposed to be a 4-legged intersection with the addition of south leg as a part of East Boundary Rd project.
13. If traffic control signals are being considered, are the traffic signal warrants met for the horizon year?	Yes.
14. What size of roundabout is being considered for this intersection? (eg. Single-lane, two-lane entry or three-lane entry?)	By utilising (2041) forecast volumes multi lane roundabout may be required such as 2 lane entry on major street with 1 lane entry on minor street.
Conclusions and Recommendation	
Roundabout is recommended as SBR has been already been approved with roundabouts and EBR is a continuation of the same corridor.	





Appendix E: Intersection Control Study

The Region of Waterloo

Intersection Control Study

East Boundary Road at Avenue Road/Gore Road, Clyde Road,
Main Street and Wesley Boulevard

December 10, 2018

B000942

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The Region of Waterloo

Intersection Control Study

East Boundary Road at Avenue Road/Gore Road, Clyde Road,
Main Street and Wesley Boulevard

Project no B000942

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December 10, 2018

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1. Executive Summary

CIMA+ has undertaken an Intersection Control Study (ICS) for four locations along the future East Boundary Road (EBR) bordering the City of Cambridge and Township of North Dumfries in the Region of Waterloo, and Township of Puslinch in Wellington County. The locations are Avenue Road/Gore Road, Clyde Road, Main Street and Wesley Boulevard. They were subject to an initial roundabout pre-screening by the Region of Waterloo, which concluded they should proceed to an ICS.

The alternatives compared were future signalized intersections and multi-lane roundabouts. At Avenue Road/Gore Road no lands can currently be acquired on the northeast corner, within Wellington County. This meant that both conceptual designs have an interim configuration that matches to a two-lane road to the north. It is expected the necessary lands can be acquired to widen the north leg in the future, and ultimate configurations with additional lanes are reported in the capacity and safety analyses.

The interim versions, and the remaining concepts, are shown at the end of this report as Figures 2 to 9. A summary of the quantitative comparison is provided in Tables i and ii (where LOS is level of service).

Table i: Summary Evaluation – Avenue Rd./Gore Rd. and Clyde Rd

Evaluation Criteria	Avenue Rd./Gore Rd.		Clyde Rd.	
	Signals	Roundabout	Signals	Roundabout
2041 AM Peak Hour LOS	'C'	'A'	'B'	'A'
2041 PM Peak Hour LOS	'C'	'B'	'B'	'A'
Estimated Capital Cost (in thousands)	\$2,412	\$2,915	\$3,788	\$4,270
Estimated 20-Year Study Period Cost (PC, in thousands)	\$5,401	\$5,097	\$5,900	\$6,043

Table ii: Summary Evaluation – Main St. and Wesley Blvd.

Evaluation Criteria	Main St.		Wesley Blvd.	
	Signals	Roundabout	Signals	Roundabout
2041 AM Peak Hour LOS	'B'	'A'	'C'	'A'
2041 PM Peak Hour LOS	'B'	'B'	'D'	'A'
Estimated Capital Cost (in thousands)	\$4,433	\$5,215	\$3,709	\$3,968
Estimated 20-Year Study Period Cost (PC, in thousands)	\$6,648	\$7,779	\$5,492	\$6,634

Expressed as present costs, a roundabout is estimated to have a lower 20-year study period cost at Avenue Road/Gore Road by a margin of \$304,000 (which should not be considered significant given uncertainties associated with the traffic forecasts and safety performance methodology). A signalized intersection is estimated to have a lower 20-year study period cost by a margin of \$143,000 at Clyde Road (which should not be considered significant), a margin of \$1,131,000 at Main Street, and a margin of \$1,142,000 at Wesley Boulevard.

In general, the roundabout concepts (with the ultimate configuration at Avenue Road/Gore Road) are predicted to result in lower delays and queues during the 2041 peak hours than the signalized intersection concepts (with the ultimate configuration at Avenue Road/Gore Road). However generally favourable future peak hour operations for motorists can be expected with either alternative at all four locations.

A number of qualitative criteria were also discussed: in addition to peak hour traffic operations they include peak and off-peak vehicle noise, fuel consumption and emissions, aesthetics, public outreach, accessibility, pedestrian and cyclist security and comfort, pedestrian and cyclist safety, speed control, access management, truck accommodation and driver expectancy. Roundabouts have a number of advantages when considering these criteria. While collectively they should not be considered reason to overturn the results of the economic analysis, if the margin is close then they should be considered significant. This would make a roundabout preferred at Avenue Road/Gore Road, and at Clyde Road.

Historically, the Region may consider implementation of a roundabout if its 20-year study period cost is less than 1.5 times the cost of the signalized intersection alternative. This is the case at both Main Street and Wesley Boulevard (where a roundabout is 1.2 times the cost). Given this, the four roundabouts planned along South Boundary Road, and the two preferred as part of this study to the north, there are advantages to constructing roundabouts at Main Street and Wesley Boulevard as well.

2. Introduction

2.1 Purpose of this Report

The Region of Waterloo has requested an Intersection Control Study (ICS) for four locations along the future East Boundary Road (EBR) in southeast Cambridge: Avenue Road/Gore Road, Clyde Road, Main Street and Wesley Boulevard. This study compares signalized intersections and roundabouts at each location. The quantitative criteria used include:

- Peak hour operational performance for motorists
- Estimated construction costs
- Study period costs (which include motor vehicle collision and intersection maintenance costs).

A number of qualitative criteria were also discussed: environmental considerations, aesthetics, public outreach, accessibility, pedestrian and cyclist security and comfort, pedestrian and cyclist safety, speed control, access management, truck accommodation and driver expectancy.

2.2 Site Context

East Boundary Road will be a major north-south road connecting Avenue Road/Gore Road to the north at Townline Road, and Dundas Street (Highway 8) to the south at the termination of the planned South Boundary Road. It will accommodate future traffic growth and area development in southeast Cambridge, as well as offload traffic from parallel routes such as Water Street/Hespeler Road and Franklin Boulevard. East Boundary Road will have a four-lane urban cross section. Intersections will be widely spaced, so the posted speed limit will likely be above 60 km/h. There will be grade separations at Mill Creek, Moffat Creek and the Canadian Pacific (CP) Rail line. It is planned to be a multi-modal corridor, with bus transit service and a boulevard multi-use trail.

Avenue Road is an east-west road that runs between Hespeler Road to the west and Townline Road to the east. It has a two-lane rural section in the study area and a posted speed limit of 40 km/h. Gore Road continues east of Townline Road. It has a two-lane rural section and a posted speed limit of 60 km/h, and is under the jurisdiction of the County of Wellington.

Clyde Road (Regional Road 27) is an east-west road that runs between Elgin Street North to the west and Cooper Road to the east. It has a two-lane rural section in the study area and a posted speed limit of 50 km/h.

Main Street (Regional Road 97) is an east-west road that runs between Melville Street to the west and Shellard Side Road to the east. It has a two-lane rural section in the study area and a posted speed limit of 60 km/h.

Wesley Boulevard is residential collector road that currently runs north-south between Maple Bush Drive to the north and Fitzgerald Drive to the south. It will be extended to the south and east to form a 4-leg intersection with East Boundary Road.

Area land use is currently agricultural, and is planned to be primarily residential and mixed-use industrial. The site context and approximate alignment of East Boundary Road is shown in Figure 1.

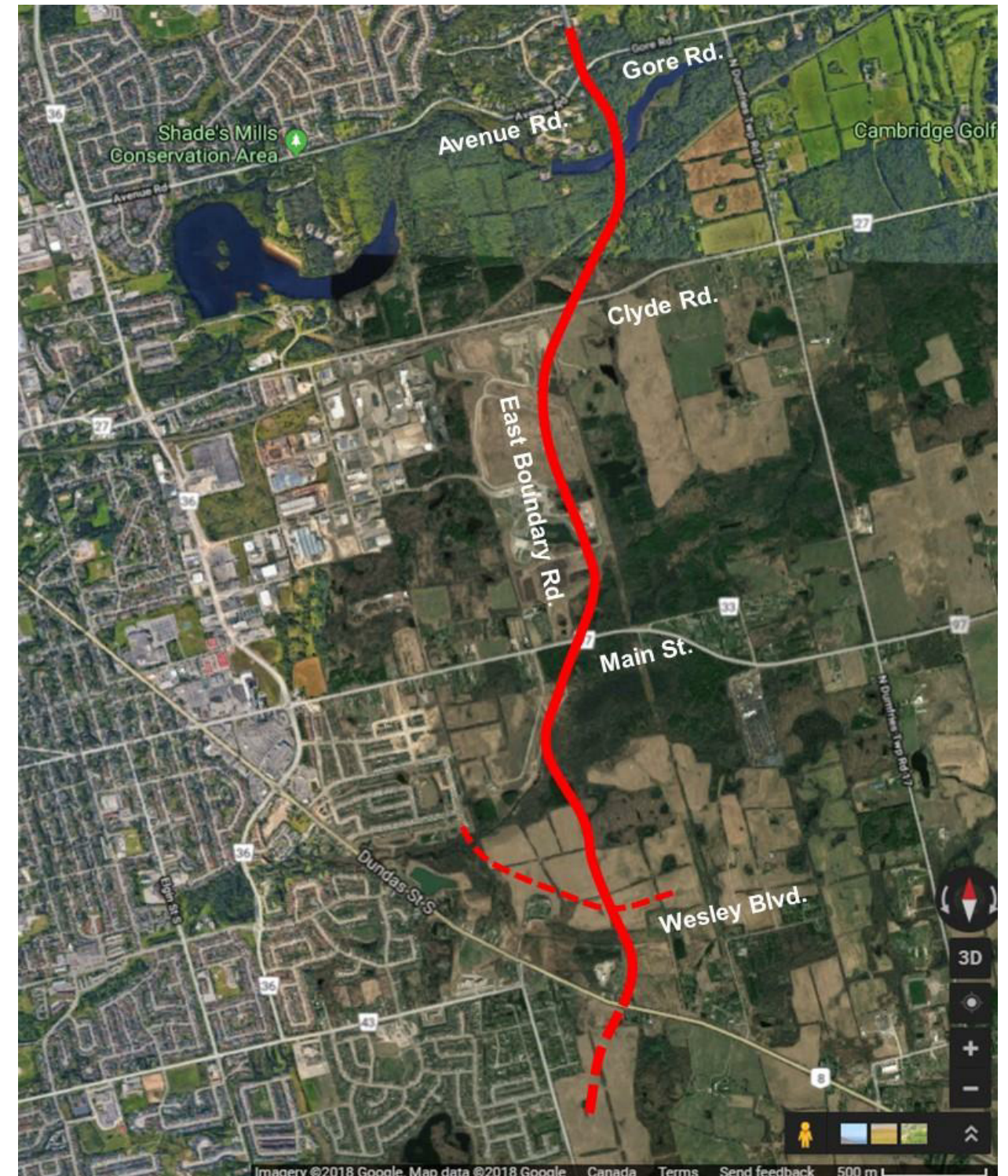


Figure 1: Future East Boundary Rd. Corridor

2.3 Intersection Alternatives

2.3.1 Signalized Intersections

Conceptual designs for the four intersections should they be under traffic signal control were developed such that a reasonable future peak hour level of service (LOS) for motorists could be achieved, but not result in excess off-peak capacity and poorer-than-necessary conditions for pedestrians and cyclists.

At Avenue Road/Gore Road a constraint was that no lands be acquired east of East Boundary Road and north of Gore Road, within Wellington County. This necessitated a conceptual design having an interim/ultimate lane configuration matching to a two-lane road to the north. The interim lane configuration is:

- Northbound and southbound – one left-turn and one through/right-turn lane.
- Eastbound and westbound – one left-turn, one through and one through/right-turn lane.

This configuration will not provide sufficient peak hour capacity for motorists by the horizon year of the project. It is expected that these lands can be acquired in the future and that the ultimate lane configuration will provide a future peak hour LOS for motorists similar to the other study area intersections. This ultimate configuration would need to have an additional through lane northbound, and additional through and left-turn lanes southbound. It is this configuration that is carried through in the following capacity and safety analyses.

At Clyde Road the lane configuration is:

- Northbound and southbound – one left-turn, one through and one through/right-turn lane.
- Eastbound and westbound – one left turn and one through/right-turn lane.

At Main Street the lane configuration is:

- All directions – one left-turn, one through and one through/right-turn lane.

At Wesley Boulevard the lane configuration is:

- Northbound, eastbound and westbound – one left-turn, one through and one through/right-turn lane.
- Southbound – two left-turn, one through and one through/right-turn lane.

The signalized intersection concepts are at the end of this report as Figures 2, 4, 6 and 8.

2.3.2 Roundabouts

The conceptual design for the roundabout at Avenue Road/Gore Road is also of an interim/ultimate configuration to avoid lands to the east. It has an inscribed circle diameter (ICD) of 60.5 metres and the following lane configuration:

- Northbound – two lanes, left/through and right.
- Southbound – one lane.
- Eastbound and westbound – one lane flaring to two, left/through and through/right.

As with the signalized intersection, this roundabout configuration will not provide sufficient peak hour capacity for motorists by the horizon year. It is expected that these lands can be acquired in the future and that the ultimate configuration will provide a future peak hour LOS for motorists similar to the other study area roundabouts. This ultimate configuration would need to have an additional through lane northbound, and two additional lanes southbound. It is this configuration that is carried through in the following capacity and safety analyses.

The roundabout alternatives at Clyde Road, Main Street and Wesley Boulevard have an ICD of 54 to 55 metres and the following lane configurations:

- Northbound and southbound– two lanes, left/through and through/right.
- Eastbound and westbound – one lane flaring to two, left/through and through/right.

These three roundabouts could have an initial configuration that retains the two-lane entries on East Boundary Road but has single-lane entries on the side streets. This is discussed in more detail in the following section.

The horizontal geometry for the roundabout concepts achieves appropriate speed control and accommodates a WB-20 design vehicle. The concepts are at the end of this report as Figures 3, 5, 7 and 9.

3. Performance Evaluation

3.1 Analysis Inputs

Forecast average annual daily traffic (AADT) and AM and PM peak hour turning movements for the 2041 horizon year were provided by the Region for incorporation into the following capacity and safety analyses.

3.2 Operational Performance Comparison

The signalized intersections were modelled using Synchro 9 under Highway Capacity Manual (HCM) 2000 methodology. The roundabouts were modelled using ARCADY 9 with a y-intercept adjustment of the capacity prediction of 5% downwards. A global 2% heavy vehicle percentage was assumed to apply to all movements. Predicted peak hour delay, 95th percentile queue and overall LOS results for the 2041 horizon year are summarized in Tables 1A and 1B. Synchro and ARCADY output sheets are provided in Appendix A.

Table 1A: Predicted 2041 Traffic Operations – Avenue Rd./Gore Rd. and Clyde Rd.

Measure and Direction		Avenue Rd./Gore Rd.		Clyde Rd.	
		Signals	Roundabout	Signals	Roundabout
AM Peak Hour	Delay				
	SB	22 s	2 s	11 s	3 s
	EB	43 s	4 s	20 s	3 s
	NB	35 s	4 s	13 s	5 s
	WB	31 s	13 s	23 s	6 s
	Queue				
	SB	61 m	<25 m	53 m	<25 m
	EB	77 m	<25 m	22 m	<25 m
	NB	158 m	<25 m	130 m	<25 m
	WB	38 m	39 m	47 m	<25 m
Overall LOS	'C'	'A'	'B'	'A'	
PM Peak Hour	Delay				
	SB	26 s	16 s	16 s	12 s
	EB	43 s	29 s	33 s	14 s
	NB	23 s	3 s	13 s	3 s
	WB	92 s	5 s	31 s	3 s
	Queue				
	SB	195 m	165 m	187 m	98 m
	EB	37 m	71 m	63 m	36 m
	NB	88 m	<25 m	58 m	<25 m
	WB	74 m	<25 m	32 m	<25 m
Overall LOS	'C'	'B'	'B'	'A'	

Table 2B: Predicted 2041 Traffic Operations – Main St. and Wesley Blvd.

Measure and Direction		Main St.		Wesley Blvd.	
		Signals	Roundabout	Signals	Roundabout
AM Peak Hour	Delay				
	SB	10 s	2 s	40 s	3 s
	EB	24 s	5 s	24 s	3 s
	NB	15 s	6 s	15 s	4 s
	WB	19 s	5 s	28 s	7 s
	Queue				
	SB	41 m	<25 m	46 m	<25 m
	EB	40 m	<25 m	20 m	<25 m
	NB	84 m	<25 m	41 m	<25 m
	WB	18 m	<25 m	50 m	<25 m
Overall LOS	'B'	'A'	'C'	'A'	
PM Peak Hour	Delay				
	SB	17 s	20 s	30 s	7 s
	EB	23 s	7 s	30 s	8 s
	NB	16 s	3 s	18 s	4 s
	WB	25 s	6 s	100 s	4 s
	Queue				
	SB	143 m	146 m	82 m	<25 m
	EB	23 m	<25 m	17 m	<25 m
	NB	48 m	<25 m	27 m	<25 m
	WB	59 m	<25 m	80 m	<25 m
Overall LOS	'B'	'B'	'D'	'A'	

Notes:

1. SB, EB, NB and WB are southbound, eastbound, northbound and westbound.
2. "Delay" is approach delay for a signalized intersection and average delay for a roundabout.
3. "Queue" corresponds to the longest 95th percentile queue per movement.

In general, the roundabout concepts as described in the preceding section (with the ultimate configuration at Avenue Road/Gore Road) are predicted to result in lower delays and queues during the 2041 peak hours than the signalized intersection concepts (with the ultimate configuration at Avenue Road/Gore Road) However generally favourable future peak hour operations for motorists can be expected with either alternative at all four locations.

The following results are predicted at the three southerly roundabouts if an initial configuration having single-lane entries on the side streets is still in place by the time the 2041 forecasts are realized:

- Clyde Road – V/C ratio of 1.64 eastbound during the PM peak hour.
- Main Street – V/C ratio of 0.94 westbound during the PM peak hour.

- Wesley Boulevard – V/C ratio of 1.04 westbound during the AM peak hour and 1.03 eastbound during the PM peak hour.

As mentioned in the preceding section the roundabout at Avenue Road/Gore Road would have an initial configuration with a single-lane entry southbound, rather than a three-lane entry. If the additional two lanes are not in place by the time the 2041 forecasts are realized then the predicted volume-to-capacity (v/c) ratio is 2.23 southbound during the PM peak hour. If two lanes are in place instead of three then the predicted v/c ratio is 1.15 southbound during the PM peak hour.

Depending on how quickly area growth results in traffic approaching the 2041 forecast levels, all four initial roundabout configurations should result in favourable peak and off-peak operations for motorists, and relatively low delays and queues for a number of years, before their ultimate counterparts need to be constructed.

3.3 Safety Performance Comparison

3.3.1 Future Safety Assessment

Future safety performance for motorists was predicted in accordance with the Intersection Control Studies Safety Assessment Methodology (HSM) spreadsheet (last revision March 2017) provided by Region Transportation Services. The spreadsheet uses a Safety Performance Function (SPF) for the prediction of collisions at signalized intersections based on Highway Safety Manual (HSM) methodology using AADT, calibrated using Region crash data at similar intersections. The model is based on multiple-vehicle collisions and has been assumed to apply to single-vehicle collisions as well.

For the roundabout alternative the spreadsheet draws upon an SPF based on a conflict model developed by the Region from current roundabout collision experience. Injury crashes are taken to be 10% of the total crashes, with all remaining collisions being property-damage-only (PDO). The model has the following form:

$$\text{Total crash frequency} = 0.0004 \times (\text{Total Daily Conflicts}) + 1.8122$$

The 2031 forecasts were assumed to be the 10-year horizon forecasts required for input into the spreadsheet. See Appendix B.

Predicted fatal, non-fatal injury, PDO and non-reportable (NR) crash frequencies are listed in Tables 2A and 2B, and are based on 2041 AADT. Note that the total conflicting volume by 2041 is predicted to be under 100,000 vehicles per day (vpd) at each location, which is considered an upper threshold for the Region roundabout safety model. Therefore a comparison using the intersection-level roundabout safety model in National Cooperative Highway Research Program (NCHRP) Report 572 was not undertaken.

Table 2A: Predicted 2041 Annual Crash Frequencies – Avenue Rd/Gore Rd and Clyde Rd

Collision Severity	Avenue Rd./Gore Rd.		Clyde Rd.	
	Signals	Roundabout	Signals	Roundabout
Fatal	0.01	-	0.01	-
Non-Fatal Injury	3.51	1.8	2.45	1.4
PDO and NR	6.28	16.1	4.48	13.0
Total	9.79	17.9	6.93	14.5

Table 2B: Predicted 2041 Annual Crash Frequencies – Main St. and Wesley Blvd.

Collision Severity	Main St.		Wesley Blvd.	
	Signals	Roundabout	Signals	Roundabout
Fatal	-	-	-	-
Non-Fatal Injury	2.57	2.1	2.04	2.2
PDO and NR	4.82	18.9	4.03	19.7
Total	7.39	21.0	6.08	21.9

3.3.2 Economic Analysis

Study period costs associated with motor vehicle collisions by severity were calculated as present costs (PC) using a 6% discount rate over 20 years and the formula:

$$PC = (\text{crash frequency})(\text{crash cost}) \left(\frac{1.06^{20} - 1}{(0.06)(1.06^{20})} \right)$$

Direct human capital crash costs from the Highway Safety Manual (HSM) Table 4A-1 were used, adjusted using the Consumers Price Index. They are \$1,656,000 per fatal, \$60,500 per non-fatal injury and \$5,000 per PDO collision.

The resulting 20-year study period collision costs are provided in Tables 3A and 3B.

Table 3A: Study Period Collision Costs, in thousands – Avenue Rd/Gore Rd and Clyde Rd

Collision Cost	Avenue Rd./Gore Rd.		Clyde Rd.	
	Signals	Roundabout	Signals	Roundabout
Fatal	\$133	-	\$95	-
Non-Fatal Injury	\$2,436	\$1,240	\$1,700	\$1,005
PDO and NR	\$360	\$922	\$257	\$748
Total	\$2,929	\$2,163	\$2,052	\$1,753

Table 3B: Study Period Collision Costs, in thousands – Main St. and Wesley Blvd.

Collision Cost	Main St.		Wesley Blvd.	
	Signals	Roundabout	Signals	Roundabout
Fatal	\$95	-	\$76	-
Non-Fatal Injury	\$1,783	\$1,459	\$1,416	\$1,517
PDO and NR	\$276	\$1,085	\$231	\$1,129
Total	\$2,155	\$2,544	\$1,723	\$2,646

A roundabout is predicted to result in a lower 20-year study period collision cost by a margin of \$766,000 at Avenue Road/Gore Road, and \$299,000 at Clyde Road. A signalized intersection is predicted to result in a lower 20-year study period collision cost by a margin of \$389,000 at Main Street, and \$923,000 at Wesley Boulevard.

It should be noted the Region roundabout safety model does not take lane configuration into account. All four initial roundabout configurations should result in lower collision frequencies compared to their ultimate counterparts, particularly those that have single-lane entries on the side streets.

It should also be noted that crash costs are mostly a societal cost, and if there are any savings associated with an alternative then only a small portion of that savings may return directly to the Region.

4. Evaluation of Alternatives

4.1 Cost Comparison

4.1.1 Construction and Property Costs

Estimated construction costs for the alternatives are as follows:

- Avenue Road/Gore Road – \$2,412,000 for the signalized intersection and \$2,915,000 for the roundabout (a difference of \$503,000).
- Clyde Road – \$3,788,000 for the signalized intersection and \$4,270,000 for the roundabout (a difference of \$482,000).
- Main Street – \$4,433,000 for the signalized intersection and \$5,215,000 for the roundabout (a difference of \$782,000).
- Wesley Boulevard – \$3,709,000 for the signalized intersection and \$3,968,000 for the roundabout (a difference of \$259,000).

Property acquisition was assumed at \$50 per square metre for agricultural land. The estimates include 15% for engineering, 15% for contingency, and 1.76% HST. Details are provided in Appendix C.

4.1.2 Study Period Costs

A comparison of overall capital and study period costs is shown in Tables 4A and 4B. As with the safety comparison a 6% discount rate over a 10-year study period was used for the present cost calculations. A cost of \$3,000 per year was assumed for annual traffic signal maintenance, with the assumption that a complete re-build would occur after 20 years. A cost of \$1,000 per year was assumed for landscaping maintenance at each a roundabout.

Table 4A: Total Study Period Costs, in thousands – Avenue Rd./Gore Rd. and Clyde Rd.

Cost	Avenue Rd./Gore Rd.		Clyde Rd.	
	Signals	Roundabout	Signals	Roundabout
Total Construction	\$2,412	\$2,915	\$3,788	\$4,270
Maintenance (PC)	\$60	\$20	\$60	\$20
Total Collision (PC)	\$2,929	\$2,162	\$2,052	\$1,753
Total Study Period Cost (PC)	\$5,401	\$5,097	\$5,900	\$6,043

A roundabout is estimated to have a lower 20-year study period cost at Avenue Road/Gore Road by a margin of \$304,000. Given the variability of traffic forecasts and the errors inherent in the safety analysis methodology, this margin should not be considered significant.

Table 4B: Total Study Period Costs, in thousands – Main St. and Wesley Blvd.

Cost	Main St.		Wesley Blvd.	
	Signals	Roundabout	Signals	Roundabout
Total Construction	\$4,433	\$5,215	\$3,709	\$3,968
Maintenance (PC)	\$60	\$20	\$60	\$20
Total Collision (PC)	\$2,155	\$2,544	\$1,723	\$2,646
Total Study Period Cost (PC)	\$6,648	\$7,779	\$5,492	\$6,634

A signalized intersection is estimated to have a lower 20-year study period cost by a margin of \$143,000 at Clyde Road (which should not be considered significant), a margin of \$1,131,000 at Main Street, and a margin of \$1,142,000 at Wesley Boulevard.

4.2 Corridor Considerations

A number of other criteria were considered but not compared through an economic evaluation. In addition to peak hour traffic operations they include peak and off-peak vehicle noise, fuel consumption and emissions, aesthetics, public outreach, accessibility, pedestrian and cyclist security and comfort, pedestrian and cyclist safety, speed control, access management, truck accommodation and driver expectancy. Table 5 summarizes qualitative comments associated with signalized intersections or roundabouts at individual locations along the corridor.

Table 5: Summary of Qualitative Evaluation

Evaluation Criteria		Signals	Roundabouts
Natural	Peak hour vehicle noise, fuel consumption and emissions	Relatively high, as a function of motor vehicle delays, start/stop cycles and idling.	Relatively moderate, or less than with signals due to generally lower delays and more uniform motor vehicle speeds.
	Off-peak vehicle noise, fuel consumption and emissions	Relatively moderate, as a function of motor vehicle delays, start/stop cycles and idling.	Relatively low. Although all traffic on East Boundary Rd. would need to slow to navigate the roundabouts, control delay on most approaches would be lower than with signals.
Social	Aesthetics	Continuous centre median provides an opportunity for streetscaping.	Continuous centre median provides an opportunity for streetscaping. More potential for decorative paving materials and landscaping at intersections because of roundabout central islands.
	Public Outreach	Status quo.	Would be included as part of the Region's ongoing roundabout outreach efforts.

Table 5: Summary of Qualitative Evaluation (cont'd)

Evaluation Criteria		Signals	Roundabouts
Social	Accessibility	Signalized intersections are considered accessible to persons with limited vision or mobility if standard curb ramps, tactile warning surface indicators and audible pedestrian signals are in place, and pedestrian Walk indications are sufficiently long for seniors.	Standard curb ramps and tactile warning surface indicators may be used, but multi-lane roundabouts are generally not considered accessible for persons with limited vision. This may be mitigated by the use of Level 2 Pedestrian Crossovers (PXO's) with actuated rectangular rapid flashing beacons (RRFB's). May require public consultation to determine if any specific accessibility concerns.
	Pedestrian Security and Comfort	Pedestrians crossing East Boundary Rd. may not be comfortable with long crossing distances at some locations (i.e. those having dual left turns) and minimum Walk intervals.	Pedestrians may not be comfortable with waiting for or creating a gap in traffic in order to cross. However traffic speeds are lower and crossing distances shorter than with signalized intersections, and pedestrians need to only look for oncoming traffic in one direction at a time. Pedestrian wait times would be lower, especially during congested conditions as they can cross between queued vehicles. Pedestrian travel distances are longer for through movements.
	Cyclist Security and Comfort	Cyclists on a multi-use path crossing the side streets can do so legally as pedestrians. Cyclists not likely to be on the road due to long intersection spacing and high motor vehicle speeds.	Cyclists on a multi-use path crossing the side streets can do so legally as pedestrians. Cyclists not likely to be on the road due to long intersection spacing and high motor vehicle speeds.
Operational	Pedestrian Safety	Status quo. Most collisions tend to involve motor vehicles turning left or right across the crosswalk when a pedestrian has the right-of-way.	Statistically pedestrians are on average 50% to 90% less likely to be involved in a collision at a roundabout. The variance is due to the design of pedestrian facilities, the speed of motor vehicle traffic, and the number of lanes in the roundabout. Any collisions that do occur should be less severe because of lower motor vehicle speeds, with the possible exception of those involving right-turning traffic.

Table 5: Summary of Qualitative Evaluation (cont'd)

Evaluation Criteria		Signals	Roundabouts
Operational	Cyclist Safety	Status quo. Most collisions tend to involve motor vehicles turning left or right when a cyclist is making a legal through movement.	Statistically cyclists are on average 10% to 30% less likely to be involved in a collision at a roundabout. The lower end of the range typically applies at multi-lane roundabouts. Any collisions that do occur should be less severe because of lower motor vehicle speeds, with the possible exception of those involving right-turning traffic.
	Speed Control	Motor vehicle speeds controlled only during red signal indication.	Motor vehicle speeds controlled at all times due to geometry of roundabout. This will influence speeds upstream and downstream of each roundabout, but not necessarily mid-block along East Boundary Rd.
	Access Management	Status quo.	Status quo, as East Boundary Rd. will have controlled access.
	Large Truck Accommodation	Large trucks may encroach on adjacent lanes as they make left or right turns.	Large trucks may encroach on adjacent lanes as they enter, circulate and exit each roundabout.
	Driver Expectancy	Status quo.	There are roundabouts planned on South Boundary Rd. and in place along Franklin Blvd. to the west.

4.3 Summary Evaluation

Tables 6A and 6B summarize findings in terms of future safety performance for motorists, capital costs, and 20-year study period costs with a safety performance assessment using the Region roundabout model.

Table 6A: Summary Evaluation – Avenue Rd./Gore Rd. and Clyde Rd

Evaluation Criteria	Avenue Rd./Gore Rd.		Clyde Rd.	
	Signals	Roundabout	Signals	Roundabout
2041 AM Peak Hour LOS	'C'	'A'	'B'	'A'
2041 PM Peak Hour LOS	'C'	'B'	'B'	'A'
Estimated Capital Cost (in thousands)	\$2,412	\$2,915	\$3,788	\$4,270
Estimated 20-Year Study Period Cost (PC, in thousands)	\$5,401	\$5,097	\$5,900	\$6,043

Table 6B: Summary Evaluation – Main St. and Wesley Blvd.

Evaluation Criteria	Main St.		Wesley Blvd.	
	Signals	Roundabout	Signals	Roundabout
2041 AM Peak Hour LOS	'B'	'A'	'C'	'A'
2041 PM Peak Hour LOS	'B'	'B'	'D'	'A'
Estimated Capital Cost (in thousands)	\$4,433	\$5,215	\$3,709	\$3,968
Estimated 20-Year Study Period Cost (PC, in thousands)	\$6,648	\$7,779	\$5,492	\$6,634

The only significant cost margins are at Main Street and Wesley Boulevard, where a signalized intersection is estimated to have a 20-year study period cost that is at least one million dollars less than a roundabout. At Avenue Road/Gore Road and Clyde Road the two alternatives are essentially equivalent in terms of costs.

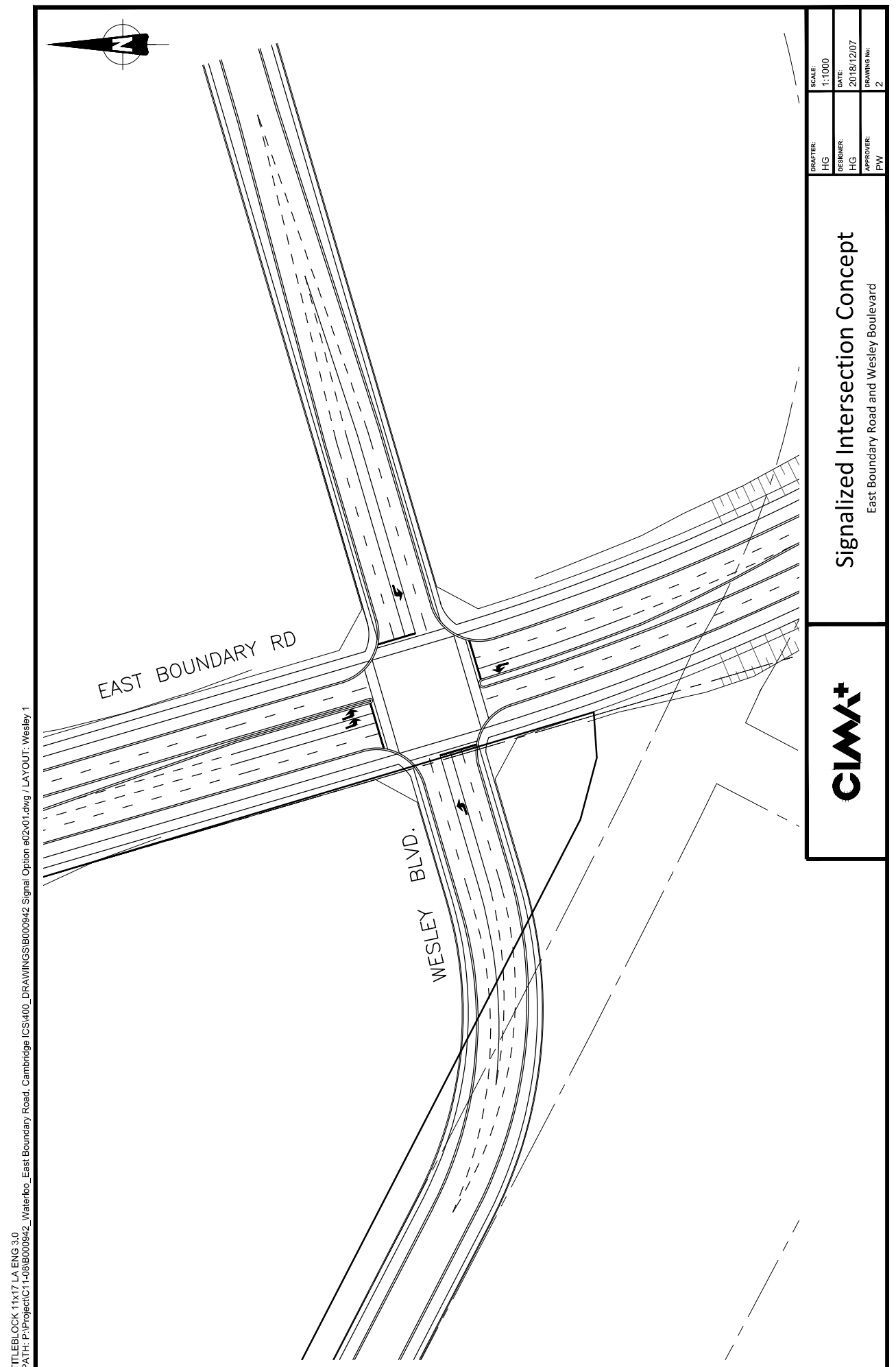
5. Conclusions

Expressed as present costs, a roundabout is estimated to have a lower 20-year study period cost at Avenue Road/Gore Road by a margin of \$304,000 (which should not be considered significant given uncertainties associated with the traffic forecasts and safety performance methodology). A signalized intersection is estimated to have a lower 20-year study period cost by a margin of \$143,000 at Clyde Road (which should not be considered significant), a margin of \$1,131,000 at Main Street, and a margin of \$1,142,000 at Wesley Boulevard.

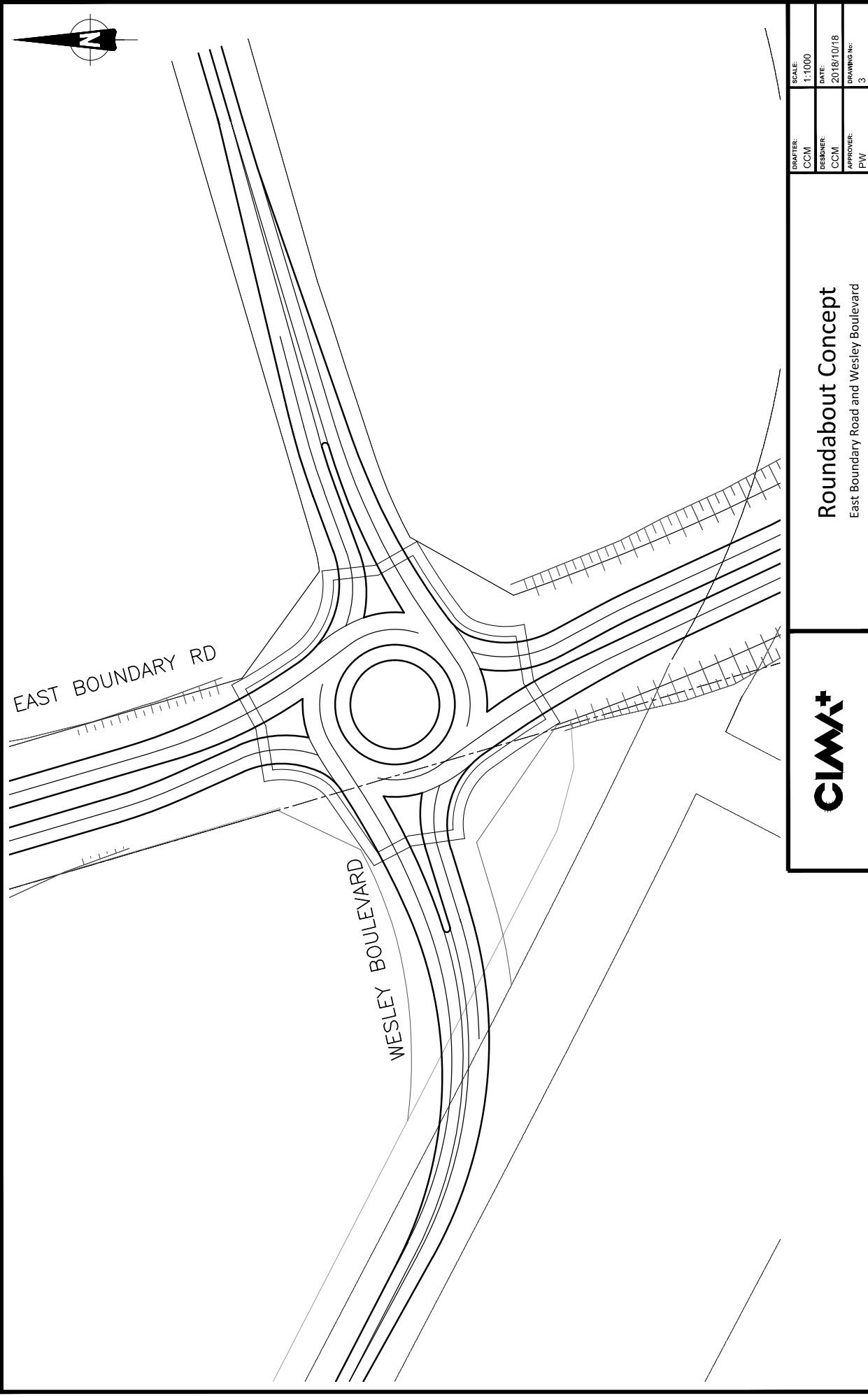
In general, the roundabout concepts (with the ultimate configuration at Avenue Road/Gore Road) are predicted to result in lower delays and queues during the 2041 peak hours than the signalized intersection concepts (with the ultimate configuration at Avenue Road/Gore Road). However generally favourable future peak hour operations for motorists can be expected with either alternative at all four locations.

A number of qualitative criteria were also discussed: in addition to peak hour traffic operations they include peak and off-peak vehicle noise, fuel consumption and emissions, aesthetics, public outreach, accessibility, pedestrian and cyclist security and comfort, pedestrian and cyclist safety, speed control, access management, truck accommodation and driver expectancy. Roundabouts have a number of advantages when considering these criteria. While collectively they should not be considered reason to overturn the results of the economic analysis, if the margin is close then they should be considered significant. This would make a roundabout preferred at Avenue Road/Gore Road, and at Clyde Road.

Historically, the Region may consider implementation of a roundabout if its 20-year study period cost is less than 1.5 times the cost of the signalized intersection alternative. This is the case at both Main Street and Wesley Boulevard (where a roundabout is 1.2 times the cost). Given this, the four roundabouts planned along South Boundary Road, and the two preferred as part of this study to the north, there are advantages to constructing roundabouts at Main Street and Wesley Boulevard as well.



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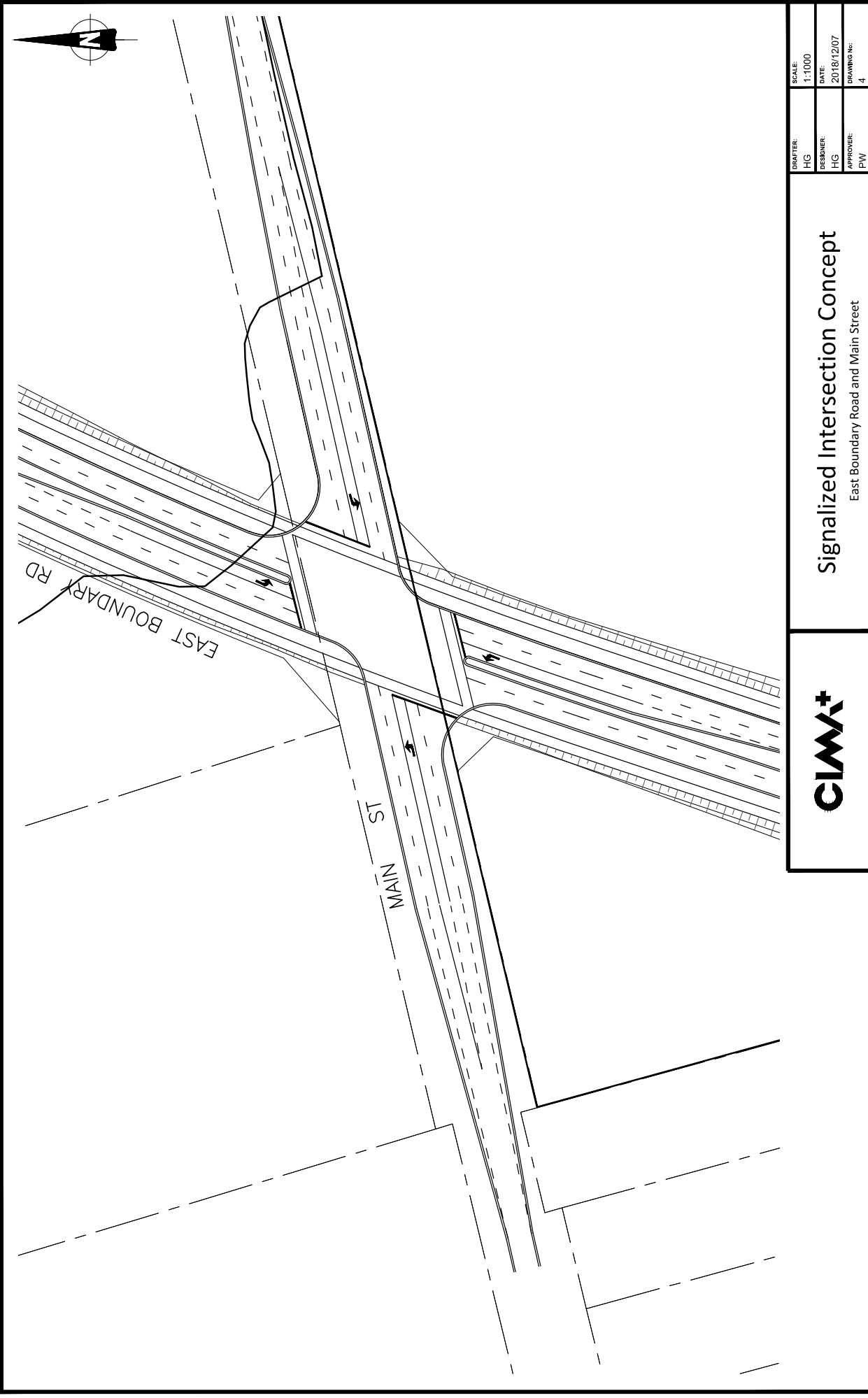


Roundabout Concept

East Boundary Road and Wesley Boulevard

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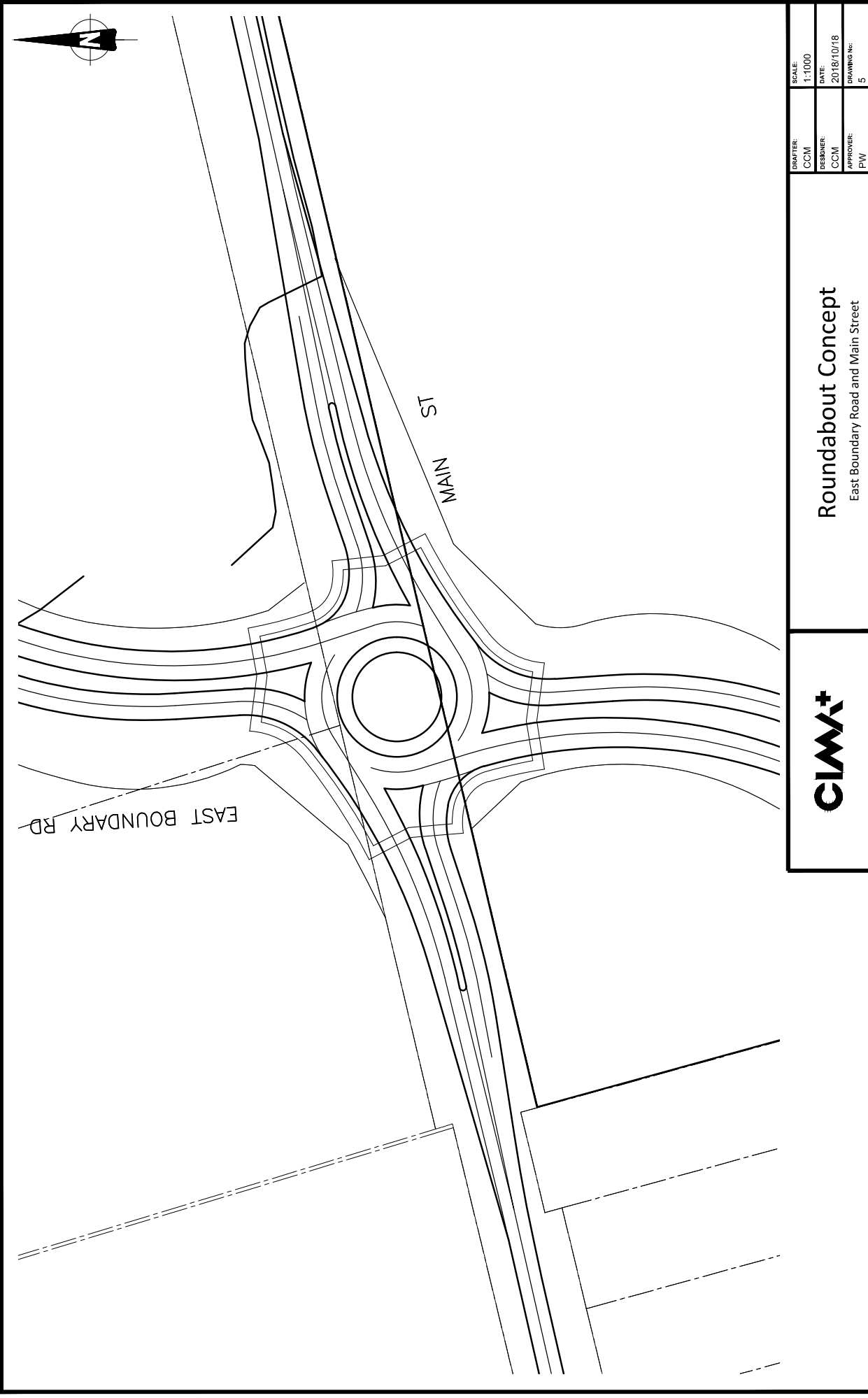


Signalized Intersection Concept

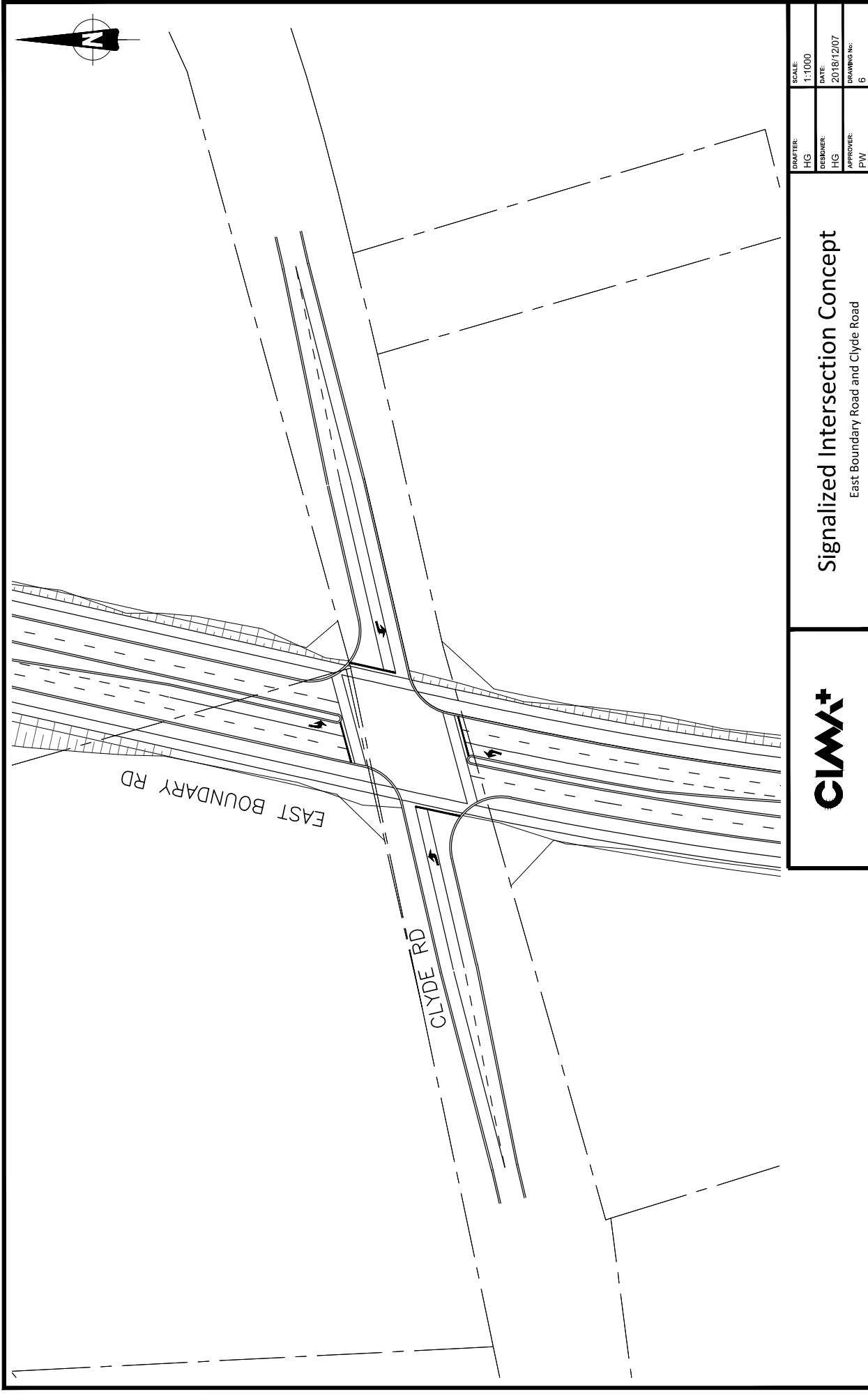
East Boundary Road and Main Street

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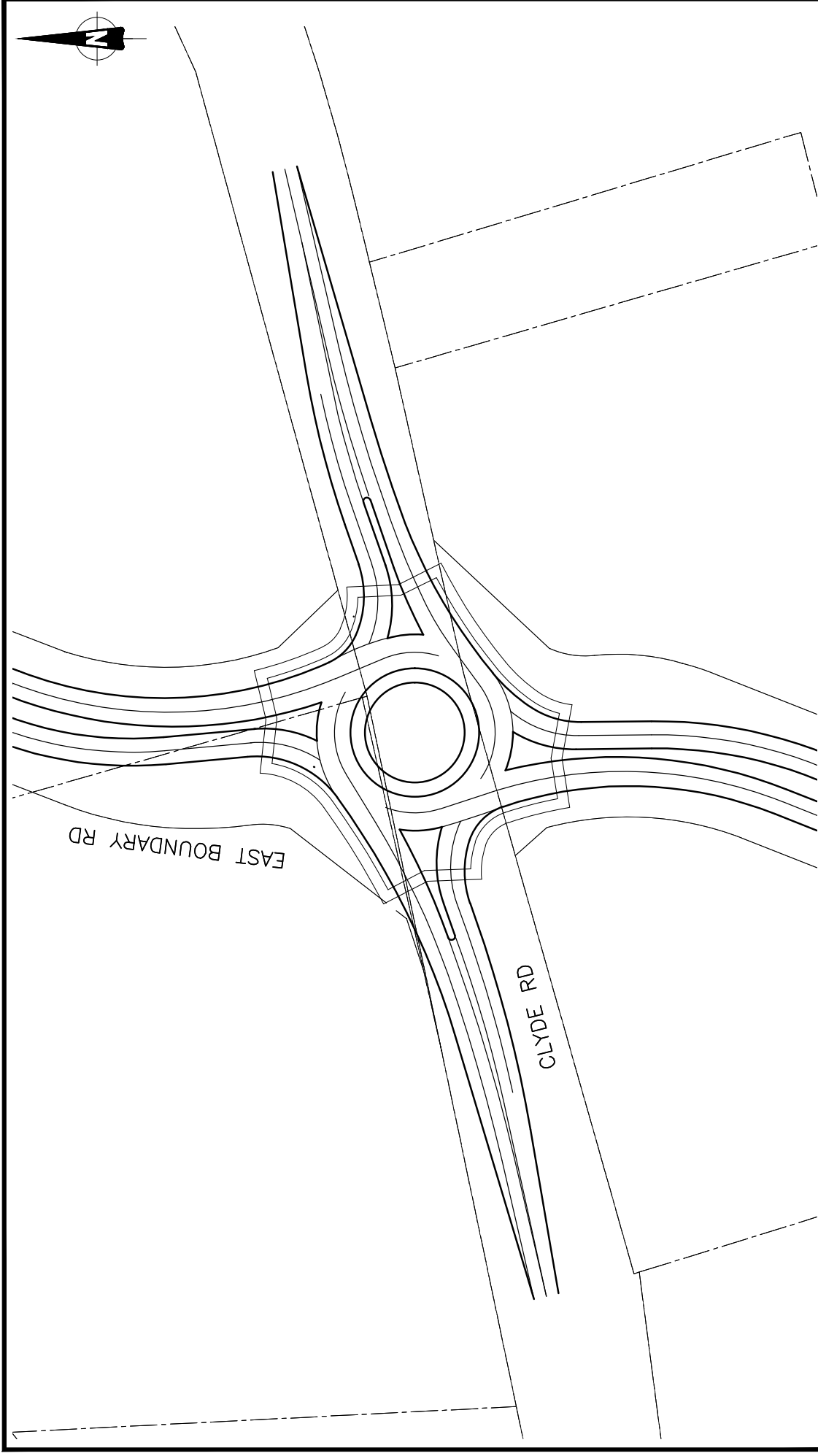
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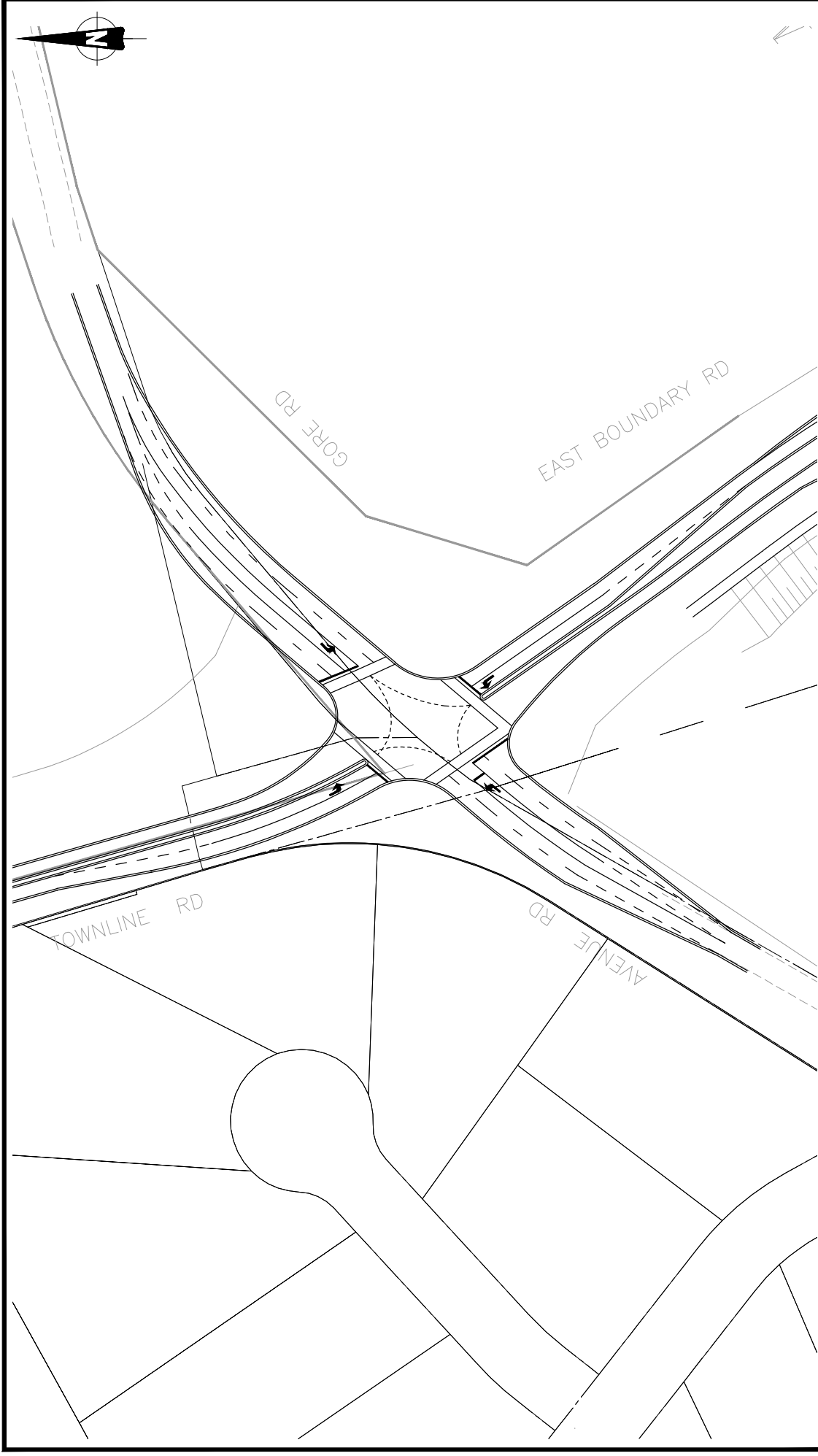


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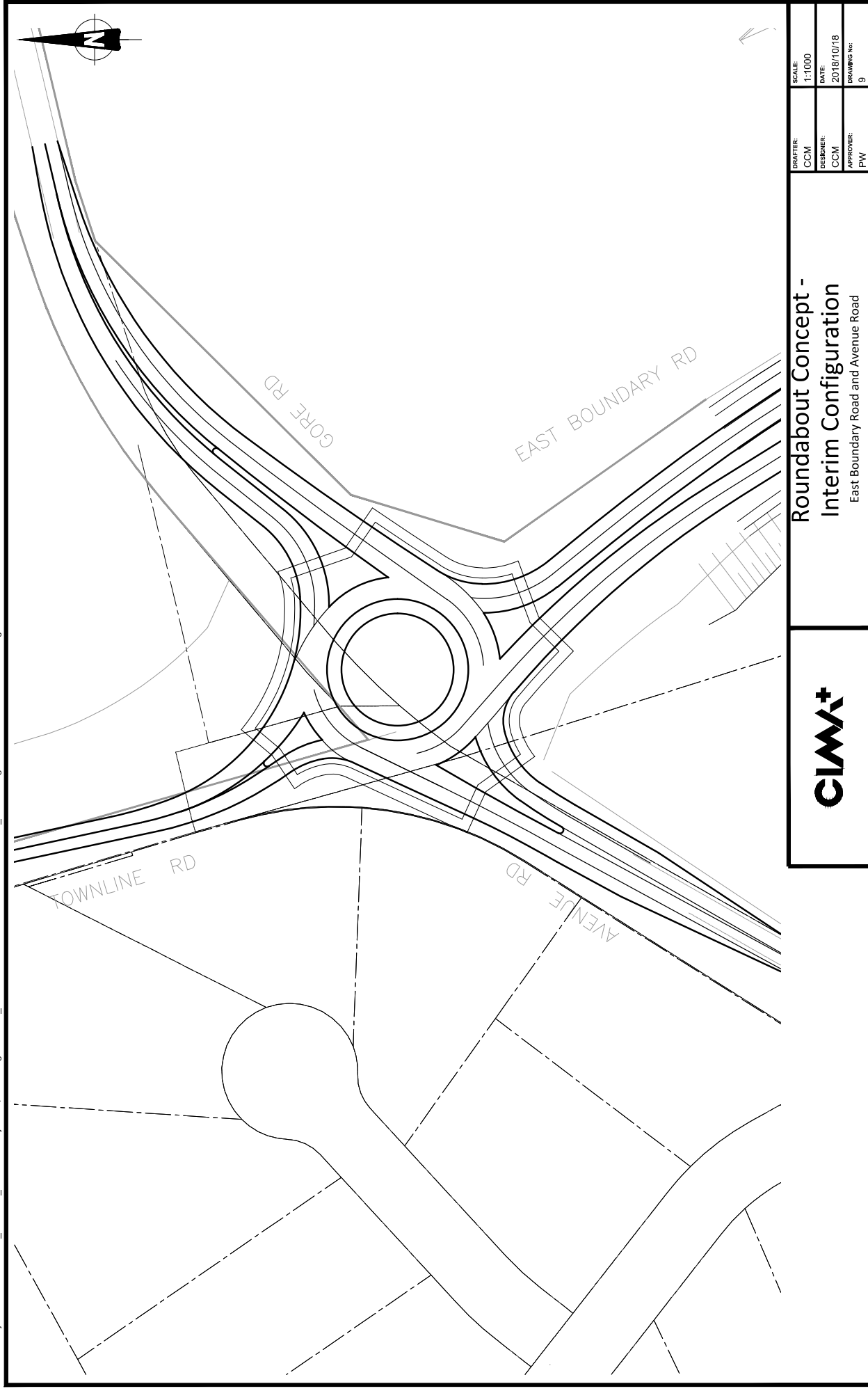
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A

Appendix A Capacity Analysis



Queues
9: East Boundary Road & Gore Road

2041 Scenario 2
Timing Plan: AM Peak

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	240	130	50	500	100	1240	210	670
v/c Ratio	0.90	0.15	0.25	0.99dr	0.26	0.94	0.61	0.46
Control Delay	68.5	9.6	28.0	21.1	10.6	37.2	42.4	17.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	68.5	9.6	28.0	21.1	10.6	37.2	42.4	17.4
Queue Length 50th (m)	~35.2	2.5	6.4	21.5	6.5	92.6	16.3	37.2
Queue Length 95th (m)	#77.3	9.2	15.1	37.5	15.8	#157.7	#30.9	61.2
Internal Link Dist (m)		244.9		898.9		902.1		236.9
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	266	1170	198	1147	415	1326	346	1457
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.90	0.11	0.25	0.44	0.24	0.94	0.61	0.46

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
- dr Defacto Right Lane. Recode with 1 though lane as a right lane.

HCM Signalized Intersection Capacity Analysis
9: East Boundary Road & Gore Road

2041 Scenario 2
Timing Plan: AM Peak

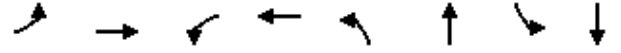
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔		↔	↔		↔	↔		↔	↔	↔
Traffic Volume (vph)	240	40	90	50	40	460	100	1080	160	210	580	90
Future Volume (vph)	240	40	90	50	40	460	100	1080	160	210	580	90
Ideal Flow (vphpl)	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		0.97	0.95	
Frt	1.00	0.90		1.00	0.86		1.00	0.98		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	2930		1635	2818		1635	3206		3172	3204	
Flt Permitted	0.44	1.00		0.44	1.00		0.34	1.00		0.95	1.00	
Satd. Flow (perm)	761	2930		755	2818		578	3206		3172	3204	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	240	40	90	50	40	460	100	1080	160	210	580	90
RTOR Reduction (vph)	0	67	0	0	167	0	0	12	0	0	12	0
Lane Group Flow (vph)	240	63	0	50	333	0	100	1228	0	210	658	0
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		Prot	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2					
Actuated Green, G (s)	20.8	18.8		13.9	13.9		37.1	30.9		6.5	33.2	
Effective Green, g (s)	20.8	20.8		13.9	15.9		37.1	32.9		8.5	35.2	
Actuated g/C Ratio	0.26	0.26		0.17	0.20		0.46	0.41		0.11	0.44	
Clearance Time (s)	4.0	6.0		4.0	6.0		4.0	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)	274	757		155	556		347	1310		334	1401	
v/s Ratio Prot	c0.08	0.02		0.01	c0.12		0.02	c0.38		c0.07	0.21	
v/s Ratio Perm	c0.15			0.05			0.11					
v/c Ratio	0.88	0.08		0.32	0.99dr		0.29	0.94		0.63	0.47	
Uniform Delay, d1	28.6	22.6		28.5	29.4		12.6	22.8		34.5	16.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	25.3	0.0		1.2	1.7		0.5	13.8		3.7	1.1	
Delay (s)	53.9	22.7		29.7	31.1		13.1	36.6		38.2	17.2	
Level of Service	D	C		C	C		B	D		D	B	
Approach Delay (s)		42.9			31.0			34.9			22.2	
Approach LOS		D			C			C			C	

Intersection Summary

- HCM 2000 Control Delay 31.6 HCM 2000 Level of Service C
- HCM 2000 Volume to Capacity ratio 0.85
- Actuated Cycle Length (s) 80.5 Sum of lost time (s) 16.0
- Intersection Capacity Utilization 88.6% ICU Level of Service E
- Analysis Period (min) 15
- dr Defacto Right Lane. Recode with 1 though lane as a right lane.
- c Critical Lane Group

Queues
9: East Boundary Road & Avenue Road/Gore Road

2041 Scenario 2
Timing Plan: PM Peak




Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	100	160	180	290	90	740	550	1630
v/c Ratio	0.53	0.38	0.95	0.55	0.47	0.55	0.72	0.84
Control Delay	53.9	16.0	100.7	13.8	24.5	24.5	41.1	22.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	53.9	16.0	100.7	13.8	24.5	24.5	41.1	22.0
Queue Length 50th (m)	20.0	4.0	~40.8	5.0	5.0	57.0	54.0	133.5
Queue Length 95th (m)	37.4	14.0	#74.2	17.9	18.8	88.1	72.2	#194.5
Internal Link Dist (m)		244.9		898.9		902.1		236.9
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	188	898	189	977	210	1350	935	1935
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.53	0.18	0.95	0.30	0.43	0.55	0.59	0.84

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
9: East Boundary Road & Avenue Road/Gore Road

2041 Scenario 2
Timing Plan: PM Peak



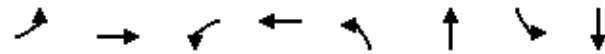
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↕		↔	↕		↔	↕		↔	↕	↔
Traffic Volume (vph)	100	40	120	180	50	240	90	680	60	550	1340	290
Future Volume (vph)	100	40	120	180	50	240	90	680	60	550	1340	290
Ideal Flow (vphpl)	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		0.97	0.95	
Flt	1.00	0.89		1.00	0.88		1.00	0.99		1.00	0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	2902		1635	2864		1635	3230		3172	3182	
Flt Permitted	1.00	1.00		1.00	1.00		0.10	1.00		0.95	1.00	
Satd. Flow (perm)	1721	2902		1721	2864		169	3230		3172	3182	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	100	40	120	180	50	240	90	680	60	550	1340	290
RTOR Reduction (vph)	0	107	0	0	214	0	0	5	0	0	12	0
Lane Group Flow (vph)	100	53	0	180	76	0	90	735	0	550	1618	0
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		Prot	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2					
Actuated Green, G (s)	11.0	9.0		9.0	9.0		46.8	40.7		22.0	58.6	
Effective Green, g (s)	11.0	11.0		9.0	11.0		46.8	42.7		24.0	60.6	
Actuated g/C Ratio	0.11	0.11		0.09	0.11		0.46	0.42		0.24	0.60	
Clearance Time (s)	4.0	6.0		4.0	6.0		4.0	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)	185	315		153	311		166	1364		752	1907	
v/s Ratio Prot	0.04	0.02		0.09	0.03		0.03	0.23		c0.17	c0.51	
v/s Ratio Perm	c0.02			c0.02			0.22					
v/c Ratio	0.54	0.17		1.18	0.24		0.54	0.54		0.73	0.85	
Uniform Delay, d1	41.9	40.9		46.1	41.2		17.1	21.8		35.6	16.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	3.2	0.3		128.1	0.4		3.6	1.5		3.7	4.9	
Delay (s)	45.1	41.2		174.1	41.7		20.7	23.4		39.3	21.4	
Level of Service	D	D		F	D		C	C		D	C	
Approach Delay (s)		42.7			92.4			23.1			25.9	
Approach LOS		D			F			C			C	

Intersection Summary

HCM 2000 Control Delay	34.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	101.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	85.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues
10: East Boundary Road & Clyde Road

2041
Timing Plan: AM Peak



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	90	100	20	280	60	1230	20	700
v/c Ratio	0.45	0.23	0.06	0.62	0.14	0.68	0.07	0.44
Control Delay	26.3	15.7	16.9	22.2	7.6	14.5	7.6	12.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.3	15.7	16.9	22.2	7.6	14.5	7.6	12.5
Queue Length 50th (m)	9.4	7.8	1.9	24.9	2.7	43.8	0.9	28.5
Queue Length 95th (m)	21.8	18.0	6.3	47.0	9.0	#130.3	4.2	52.9
Internal Link Dist (m)		445.8		940.5		1958.0		902.1
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	347	746	565	740	417	1819	268	1607
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.26	0.13	0.04	0.38	0.14	0.68	0.07	0.44

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
10: East Boundary Road & Clyde Road

2041
Timing Plan: AM Peak



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔		↔	↔		↔	↕		↔	↕	↔
Traffic Volume (vph)	90	80	20	20	170	110	60	1140	90	20	580	120
Future Volume (vph)	90	80	20	20	170	110	60	1140	90	20	580	120
Ideal Flow (vphpl)	1775	1650	1650	1775	1650	1650	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Flt	1.00	0.97		1.00	0.94		1.00	0.99		1.00	0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	1552		1635	1505		1635	3234		1635	3186	
Flt Permitted	0.43	1.00		0.69	1.00		0.31	1.00		0.15	1.00	
Satd. Flow (perm)	731	1552		1191	1505		528	3234		255	3186	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	90	80	20	20	170	110	60	1140	90	20	580	120
RTOR Reduction (vph)	0	14	0	0	37	0	0	6	0	0	19	0
Lane Group Flow (vph)	90	86	0	20	243	0	60	1224	0	20	681	0
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	14.7	14.7		14.7	14.7		35.1	31.9		30.5	29.6	
Effective Green, g (s)	16.7	16.7		16.7	16.7		35.1	33.9		30.5	31.6	
Actuated g/C Ratio	0.26	0.26		0.26	0.26		0.55	0.53		0.48	0.50	
Clearance Time (s)	6.0	6.0		6.0	6.0		4.0	6.0		4.0	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)	192	408		313	395		347	1726		142	1585	
v/s Ratio Prot		0.06			c0.16		c0.01	c0.38		0.00	0.21	
v/s Ratio Perm	0.12			0.02			0.09			0.07		
v/c Ratio	0.47	0.21		0.06	0.62		0.17	0.71		0.14	0.43	
Uniform Delay, d1	19.7	18.3		17.5	20.6		7.0	11.1		9.6	10.2	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.8	0.3		0.1	2.8		0.2	2.5		0.5	0.9	
Delay (s)	21.5	18.5		17.6	23.4		7.2	13.6		10.0	11.0	
Level of Service	C	B		B	C		A	B		B	B	
Approach Delay (s)		19.9			23.0			13.3			11.0	
Approach LOS		B			C			B			B	

Intersection Summary

HCM 2000 Control Delay	14.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	63.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.0%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues
10: East Boundary Road & Clyde Road

2041 Scenario 1
Timing Plan: PM Peak

	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	150	270	100	110	20	680	130	1510
v/c Ratio	0.52	0.68	0.61	0.28	0.10	0.41	0.29	0.77
Control Delay	32.9	34.7	44.2	23.1	7.8	14.3	8.2	18.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.9	34.7	44.2	23.1	7.8	14.3	8.2	18.0
Queue Length 50th (m)	21.1	36.8	14.4	12.7	1.0	34.3	7.1	73.8
Queue Length 95th (m)	39.4	62.9	31.8	26.1	4.2	57.8	17.4	#187.0
Internal Link Dist (m)		445.8		940.5		1958.0		902.1
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	405	544	227	547	207	1660	464	1969
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.37	0.50	0.44	0.20	0.10	0.41	0.28	0.77

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
10: East Boundary Road & Clyde Road

2041 Scenario 1
Timing Plan: PM Peak

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Movement												
Lane Configurations	↔	↔		↔	↔		↔	↕		↔	↕	↕
Traffic Volume (vph)	150	200	70	100	90	20	20	660	20	130	1410	100
Future Volume (vph)	150	200	70	100	90	20	20	660	20	130	1410	100
Ideal Flow (vphpl)	1775	1650	1650	1775	1650	1650	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95		1.00	0.95	
Flt	1.00	0.96		1.00	0.97		1.00	1.00		1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	1537		1635	1556		1635	3255		1635	3237	
Flt Permitted	0.68	1.00		0.38	1.00		0.10	1.00		0.31	1.00	
Satd. Flow (perm)	1172	1537		656	1556		170	3255		531	3237	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	150	200	70	100	90	20	20	660	20	130	1410	100
RTOR Reduction (vph)	0	15	0	0	10	0	0	2	0	0	5	0
Lane Group Flow (vph)	150	255	0	100	100	0	20	678	0	130	1505	0
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	18.2	18.2		18.2	18.2		44.2	42.0		53.6	47.4	
Effective Green, g (s)	20.2	20.2		20.2	20.2		44.2	44.0		53.6	49.4	
Actuated g/C Ratio	0.24	0.24		0.24	0.24		0.53	0.53		0.64	0.59	
Clearance Time (s)	6.0	6.0		6.0	6.0		4.0	6.0		4.0	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)	282	370		158	375		128	1709		439	1908	
v/s Ratio Prot		c0.17			0.06		0.00	0.21		c0.03	c0.47	
v/s Ratio Perm	0.13			0.15			0.08			0.16		
v/c Ratio	0.53	0.69		0.63	0.27		0.16	0.40		0.30	0.79	
Uniform Delay, d1	27.7	28.9		28.5	25.8		11.5	11.9		6.6	13.2	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.9	5.3		8.0	0.4		0.6	0.7		0.4	3.4	
Delay (s)	29.6	34.2		36.5	26.2		12.1	12.6		7.0	16.6	
Level of Service	C	C		D	C		B	B		A	B	
Approach Delay (s)		32.6			31.1			12.6			15.8	
Approach LOS		C			C			B			B	

Intersection Summary

HCM 2000 Control Delay	18.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	83.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	86.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues
7: East Boundary Road & Main Street

2041
Timing Plan: AM Peak

	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	160	500	10	390	20	940	90	530
v/c Ratio	0.68	0.51	0.05	0.37	0.04	0.63	0.30	0.30
Control Delay	35.7	20.2	16.5	8.4	8.2	17.7	10.4	9.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	35.7	20.2	16.5	8.4	8.2	17.7	10.4	9.9
Queue Length 50th (m)	18.3	27.4	0.9	8.1	1.0	48.4	4.6	15.3
Queue Length 95th (m)	38.2	40.3	4.0	17.5	4.5	83.6	13.3	40.8
Internal Link Dist (m)		721.0		663.6		2292.2		1958.0
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	348	1430	275	1424	482	1489	305	1776
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.46	0.35	0.04	0.27	0.04	0.63	0.30	0.30
Intersection Summary								

HCM Signalized Intersection Capacity Analysis
7: East Boundary Road & Main Street

2041
Timing Plan: AM Peak

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔		↔	↔		↔	↔		↔	↔	↔
Traffic Volume (vph)	160	460	40	10	130	260	20	870	70	90	470	60
Future Volume (vph)	160	460	40	10	130	260	20	870	70	90	470	60
Ideal Flow (vphpl)	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		1.00	0.95	
Frt	1.00	0.99		1.00	0.90		1.00	0.99		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	3230		1635	2943		1635	3233		1635	3214	
Flt Permitted	0.46	1.00		0.36	1.00		0.46	1.00		0.19	1.00	
Satd. Flow (perm)	792	3230		626	2943		783	3233		320	3214	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	160	460	40	10	130	260	20	870	70	90	470	60
RTOR Reduction (vph)	0	10	0	0	164	0	0	7	0	0	10	0
Lane Group Flow (vph)	160	490	0	10	226	0	20	933	0	90	520	0
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	17.4	17.4		17.4	17.4		31.2	30.2		38.2	33.7	
Effective Green, g (s)	19.4	19.4		19.4	19.4		31.2	32.2		38.2	35.7	
Actuated g/C Ratio	0.28	0.28		0.28	0.28		0.46	0.47		0.56	0.52	
Clearance Time (s)	6.0	6.0		6.0	6.0		4.0	6.0		4.0	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)	225	920		178	838		371	1528		266	1684	
v/s Ratio Prot		0.15			0.08		0.00	c0.29		c0.02	0.16	
v/s Ratio Perm	c0.20			0.02			0.02			0.17		
v/c Ratio	0.71	0.53		0.06	0.27		0.05	0.61		0.34	0.31	
Uniform Delay, d1	21.8	20.5		17.7	18.9		10.1	13.3		8.5	9.2	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	10.1	0.6		0.1	0.2		0.1	1.8		0.8	0.5	
Delay (s)	32.0	21.1		17.8	19.0		10.2	15.1		9.2	9.7	
Level of Service	C	C		B	B		B	B		A	A	
Approach Delay (s)		23.8			19.0			15.0			9.6	
Approach LOS		C			B			B			A	

Intersection Summary			
HCM 2000 Control Delay	16.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	68.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues
7: East Boundary Road & Main Street

2041 Scenario 1
Timing Plan: PM Peak

	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	70	180	90	650	40	540	300	1280
v/c Ratio	0.57	0.19	0.28	0.68	0.18	0.41	0.61	0.76
Control Delay	41.3	17.5	22.1	25.5	10.1	17.5	14.3	20.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	41.3	17.5	22.1	25.5	10.1	17.5	14.3	20.0
Queue Length 50th (m)	8.6	9.1	10.0	41.6	2.1	28.3	19.0	79.4
Queue Length 95th (m)	22.9	16.3	21.5	58.7	7.0	47.5	40.4	#143.0
Internal Link Dist (m)		721.0		663.6		2292.2		1958.0
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	161	1248	422	1247	218	1324	501	1684
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.43	0.14	0.21	0.52	0.18	0.41	0.60	0.76

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
7: East Boundary Road & Main Street

2041 Scenario 1
Timing Plan: PM Peak

	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔		↔	↔		↔	↔		↔	↔	↔
Traffic Volume (vph)	70	160	20	90	550	100	40	530	10	300	1100	180
Future Volume (vph)	70	160	20	90	550	100	40	530	10	300	1100	180
Ideal Flow (vphpl)	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		1.00	0.95	
Frt	1.00	0.98		1.00	0.98		1.00	1.00		1.00	0.98	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	3215		1635	3194		1635	3261		1635	3201	
Flt Permitted	0.24	1.00		0.64	1.00		0.14	1.00		0.34	1.00	
Satd. Flow (perm)	420	3215		1098	3194		234	3261		587	3201	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	70	160	20	90	550	100	40	530	10	300	1100	180
RTOR Reduction (vph)	0	13	0	0	21	0	0	2	0	0	14	0
Lane Group Flow (vph)	70	167	0	90	629	0	40	538	0	300	1266	0
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	19.4	19.4		19.4	19.4		32.6	29.4		43.3	36.1	
Effective Green, g (s)	21.4	21.4		21.4	21.4		32.6	31.4		43.3	38.1	
Actuated g/C Ratio	0.29	0.29		0.29	0.29		0.44	0.42		0.58	0.51	
Clearance Time (s)	6.0	6.0		6.0	6.0		4.0	6.0		4.0	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)	120	921		314	915		162	1370		479	1632	
v/s Ratio Prot		0.05			c0.20		0.01	0.17		c0.08	c0.40	
v/s Ratio Perm	0.17			0.08			0.10			0.28		
v/c Ratio	0.58	0.18		0.29	0.69		0.25	0.39		0.63	0.78	
Uniform Delay, d1	22.8	20.1		20.7	23.7		13.1	15.0		8.8	14.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	7.0	0.1		0.5	2.2		0.8	0.8		2.6	3.7	
Delay (s)	29.9	20.2		21.2	25.8		13.9	15.9		11.4	18.5	
Level of Service	C	C		C	C		B	B		B	B	
Approach Delay (s)		22.9			25.3			15.7			17.2	
Approach LOS		C			C			B			B	

Intersection Summary

HCM 2000 Control Delay	19.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	74.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues
2: East Boundary Road & Wesley Blvd

2041 Scenario 2
Timing Plan: AM Peak

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	100	180	240	550	190	670	290	230
v/c Ratio	0.42	0.29	0.75	0.60	0.33	0.48	0.91	0.17
Control Delay	23.1	9.7	37.6	9.8	10.0	11.7	65.6	10.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.1	9.7	37.6	9.8	10.0	11.7	65.6	10.7
Queue Length 50th (m)	9.8	3.0	26.0	8.4	10.8	21.4	20.1	7.5
Queue Length 95th (m)	20.3	10.8	#49.5	21.8	24.6	40.8	#46.1	16.0
Internal Link Dist (m)		463.8		443.1		393.6		2292.2
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	239	1257	318	1404	577	1387	320	1364
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.42	0.14	0.75	0.39	0.33	0.48	0.91	0.17

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
2: East Boundary Road & Wesley Blvd

2041 Scenario 2
Timing Plan: AM Peak

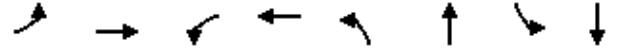
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↕		↔	↕		↔	↕		↔	↕	↔
Traffic Volume (vph)	100	50	130	240	90	460	190	400	270	290	180	50
Future Volume (vph)	100	50	130	240	90	460	190	400	270	290	180	50
Ideal Flow (vphpl)	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		0.97	0.95	
Frt	1.00	0.89		1.00	0.87		1.00	0.94		1.00	0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	2915		1635	2859		1635	3072		3172	3163	
Flt Permitted	0.36	1.00		0.58	1.00		0.61	1.00		0.95	1.00	
Satd. Flow (perm)	620	2915		999	2859		1047	3072		3172	3163	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	100	50	130	240	90	460	190	400	270	290	180	50
RTOR Reduction (vph)	0	106	0	0	332	0	0	123	0	0	27	0
Lane Group Flow (vph)	100	74	0	240	218	0	190	547	0	290	203	0
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		Prot	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2					
Actuated Green, G (s)	15.5	11.1		17.7	12.2		32.7	26.5		5.0	27.3	
Effective Green, g (s)	15.5	13.1		17.7	14.2		32.7	28.5		7.0	29.3	
Actuated g/C Ratio	0.22	0.19		0.25	0.20		0.47	0.41		0.10	0.42	
Clearance Time (s)	4.0	6.0		4.0	6.0		4.0	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)	200	544		302	579		540	1248		316	1322	
v/s Ratio Prot	0.03	0.03		c0.06	0.08		0.03	c0.18		c0.09	0.06	
v/s Ratio Perm	0.08			c0.14			0.13					
v/c Ratio	0.50	0.14		0.79	0.38		0.35	0.44		0.92	0.15	
Uniform Delay, d1	22.9	23.8		23.7	24.1		11.3	15.0		31.3	12.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	2.0	0.1		13.4	0.4		0.4	1.1		30.0	0.2	
Delay (s)	24.9	23.9		37.1	24.5		11.7	16.1		61.3	12.9	
Level of Service	C	C		D	C		B	B		E	B	
Approach Delay (s)		24.2			28.4			15.2			39.9	
Approach LOS		C			C			B			D	

Intersection Summary

HCM 2000 Control Delay	25.7	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	70.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues
2: East Boundary Road & Wesley Blvd

2041 Scenario 2
Timing Plan: PM Peak




Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	60	360	270	380	130	530	610	600
v/c Ratio	0.28	0.54	1.26	0.52	0.31	0.42	0.89	0.39
Control Delay	25.1	10.5	175.4	11.6	9.5	9.5	47.2	13.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.1	10.5	175.4	11.6	9.5	9.5	47.2	13.6
Queue Length 50th (m)	7.1	5.1	~41.3	7.3	6.9	13.1	46.8	26.7
Queue Length 95th (m)	16.1	17.0	#80.4	19.7	15.8	27.4	#82.4	45.4
Internal Link Dist (m)		463.8		443.1		393.6		2292.2
Turn Bay Length (m)	50.0		50.0		50.0		50.0	
Base Capacity (vph)	214	1213	215	1225	459	1266	688	1530
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.28	0.30	1.26	0.31	0.28	0.42	0.89	0.39

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
2: East Boundary Road & Wesley Blvd

2041 Scenario 2
Timing Plan: PM Peak



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↕		↔	↕		↔	↕		↔	↕	↔
Traffic Volume (vph)	60	70	290	270	100	280	130	240	290	610	470	130
Future Volume (vph)	60	70	290	270	100	280	130	240	290	610	470	130
Ideal Flow (vphpl)	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775	1775
Lane Width	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	0.95		0.97	0.95	
Frt	1.00	0.88		1.00	0.89		1.00	0.92		1.00	0.97	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1635	2875		1635	2908		1635	3001		3172	3163	
Flt Permitted	0.39	1.00		0.35	1.00		0.43	1.00		0.95	1.00	
Satd. Flow (perm)	675	2875		599	2908		732	3001		3172	3163	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	60	70	290	270	100	280	130	240	290	610	470	130
RTOR Reduction (vph)	0	245	0	0	232	0	0	187	0	0	23	0
Lane Group Flow (vph)	60	115	0	270	148	0	130	343	0	610	577	0
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		Prot	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2					
Actuated Green, G (s)	14.7	10.2		17.3	11.5		34.0	26.2		15.0	35.4	
Effective Green, g (s)	14.7	12.2		17.3	13.5		34.0	28.2		17.0	37.4	
Actuated g/C Ratio	0.19	0.15		0.22	0.17		0.43	0.36		0.21	0.47	
Clearance Time (s)	4.0	6.0		4.0	6.0		4.0	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)	179	442		206	495		403	1068		680	1493	
v/s Ratio Prot	0.02	0.04		c0.10	0.05		0.03	0.11		c0.19	c0.18	
v/s Ratio Perm	0.04			c0.19			0.11					
v/c Ratio	0.34	0.26		1.31	0.30		0.32	0.32		0.90	0.39	
Uniform Delay, d1	27.3	29.5		29.9	28.7		14.0	18.5		30.2	13.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.1	0.3		170.1	0.3		0.5	0.8		14.5	0.8	
Delay (s)	28.4	29.8		200.0	29.1		14.5	19.3		44.7	14.3	
Level of Service	C	C		F	C		B	B		D	B	
Approach Delay (s)		29.6			100.1			18.4			29.6	
Approach LOS		C			F			B			C	

Intersection Summary

HCM 2000 Control Delay	42.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	79.2	Sum of lost time (s)	16.0
Intersection Capacity Utilization	77.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Capacity Analysis Summary

90% y-Intercept Adjustment

Intersection	Horizon Year	Peak Hour	Int. LOS	Intersection Residual Capacity	Page
EBR and Avenue Road / Gore Road	2041	AM	A	5% [WB - Gore Rd]	A3
		PM	D	-5% [EB - Avenue Rd]	A3
EBR and Clyde Road		AM	A	32% [NB - EBR]	A5
		PM	B	4% [EB - Clyde Rd]	A5
EBR and Main Street		AM	A	26% [NB - EBR]	A7
		PM	C	-2% [SB - EBR]	A7
EBR and Wesley Boulevard		AM	A	26% [WB - Wesley Blvd]	A9
		PM	A	19% [SB - EBR]	A9

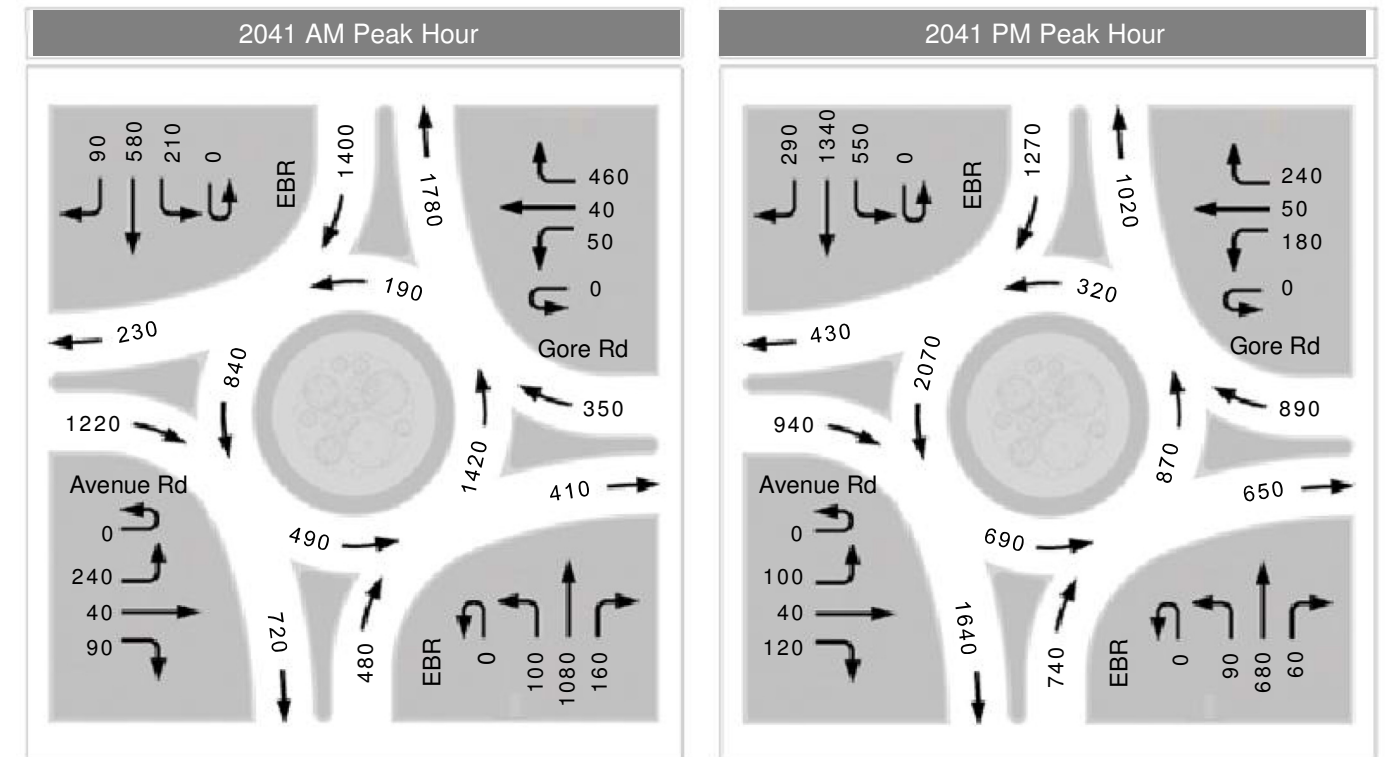
95% y-Intercept Adjustment

Intersection	Horizon Year	Peak Hour	Int. LOS	Intersection Residual Capacity	Page
EBR and Avenue Road / Gore Road	2041	AM	A	11% [WB - Gore Rd]	A3
		PM	B	1% [EB - Avenue Rd]	A3
EBR and Clyde Road		AM	A	40% [NB - EBR]	A5
		PM	A	10% [EB - Clyde Rd]	A5
EBR and Main Street		AM	A	33% [NB - EBR]	A7
		PM	B	4% [SB - EBR]	A7
EBR and Wesley Boulevard		AM	A	33% [WB - Wesley Blvd]	A9
		PM	A	26% [SB - EBR]	A9

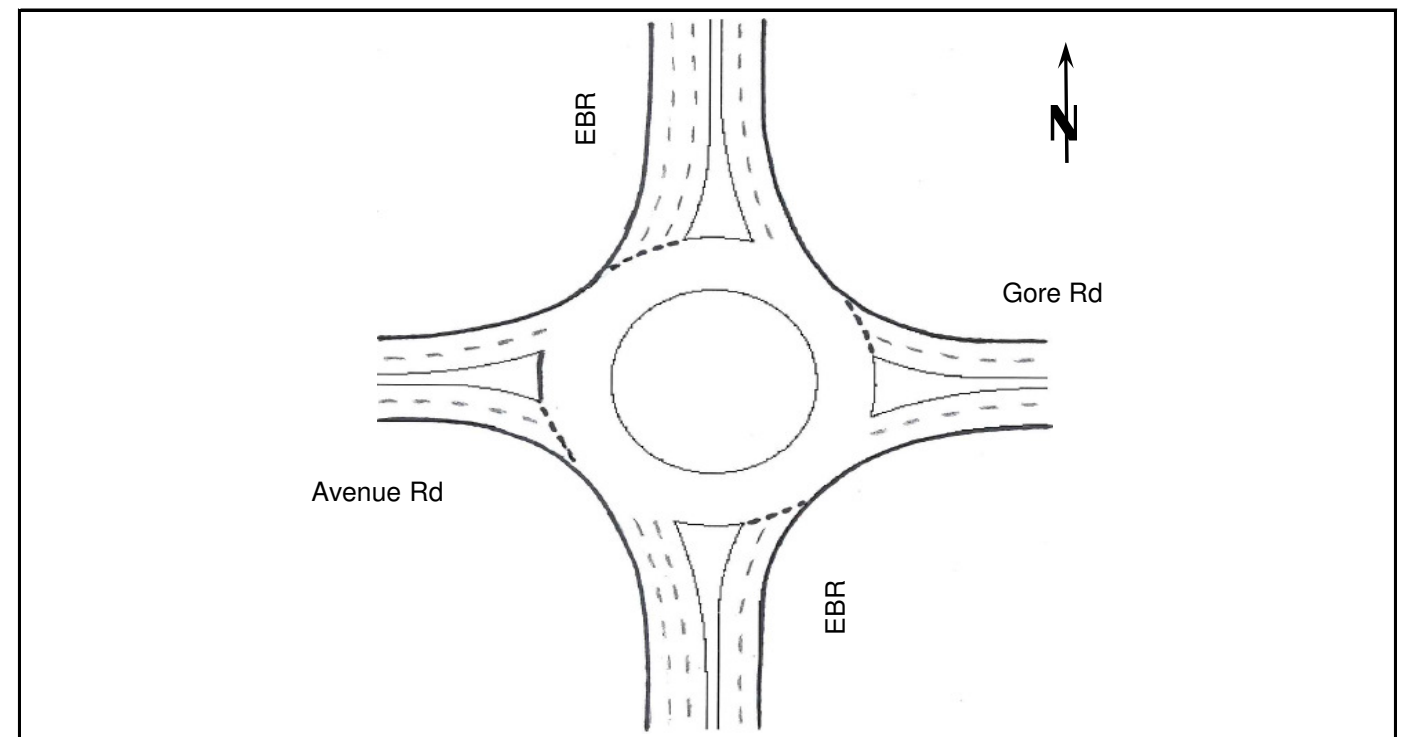
Notes

- All geometric parameters are measured to face of curb or, if no curb present, to edge of pavement.
- The ARCADY output is an aggregate output for each entry. It assumes that entering traffic is distributed evenly across the available lanes regardless of actual demand and lane configuration. If there are exclusive left-turn or right-turn lanes then actual delays and queues may be higher and capacity will need to be evaluated on a lane-by-lane basis.
- Results shown are the maximum values over all 15-minute time segments. Delay is the maximum value of average delay per arriving vehicle over all 15-minute time segments.
- Queue lengths are 95th percentile values based on an average vehicle length of 7 metres, and incorporate the storage effects of flared entries where applicable.
- Residual capacity is defined as the percent growth in traffic to reach level of service (LOS) 'E' as per Exhibit 17-2 of the Highway Capacity Manual (2010).
- The ARCADY output includes results with a y-intercept adjustment of the capacity equation to test for driver unfamiliarity with roundabouts or other factors.

Turning Movement Forecasts



Source: Region of Waterloo



Geometric Design Parameters

Conceptual Design Geometry

	Road Half Width, V (m)	Entry Width, E (m)	Eff. Flare Length, l' (m)	Entry Radius, R (m)	Inscribed Circle Dia, D (m)	Entry Angle, Ø (deg.)	Exit Only (T/F)	Right-Turn Bypass (T/F)
EBR SB	7.00	11.00	30	25	64	20	FALSE	FALSE
Avenue Rd EB	7.00	11.00	30	25	64	20	FALSE	FALSE
EBR NB	4.25	8.00	20	20	54	20	FALSE	FALSE
Gore Rd WB	4.25	8.00	20	20	54	20	FALSE	FALSE

Other Inputs

	Flare Storage (m)	Pedestrian Crossings	% Trucks	Flow Profile	Scaling Factor
EBR SB	15	0	2.0	ONE HOUR	1.00
Avenue Rd EB	10	0	2.0	ONE HOUR	1.00
EBR NB	15	0	2.0	ONE HOUR	1.00
Gore Rd WB	10	0	2.0	ONE HOUR	1.00

Capacity Analysis Results

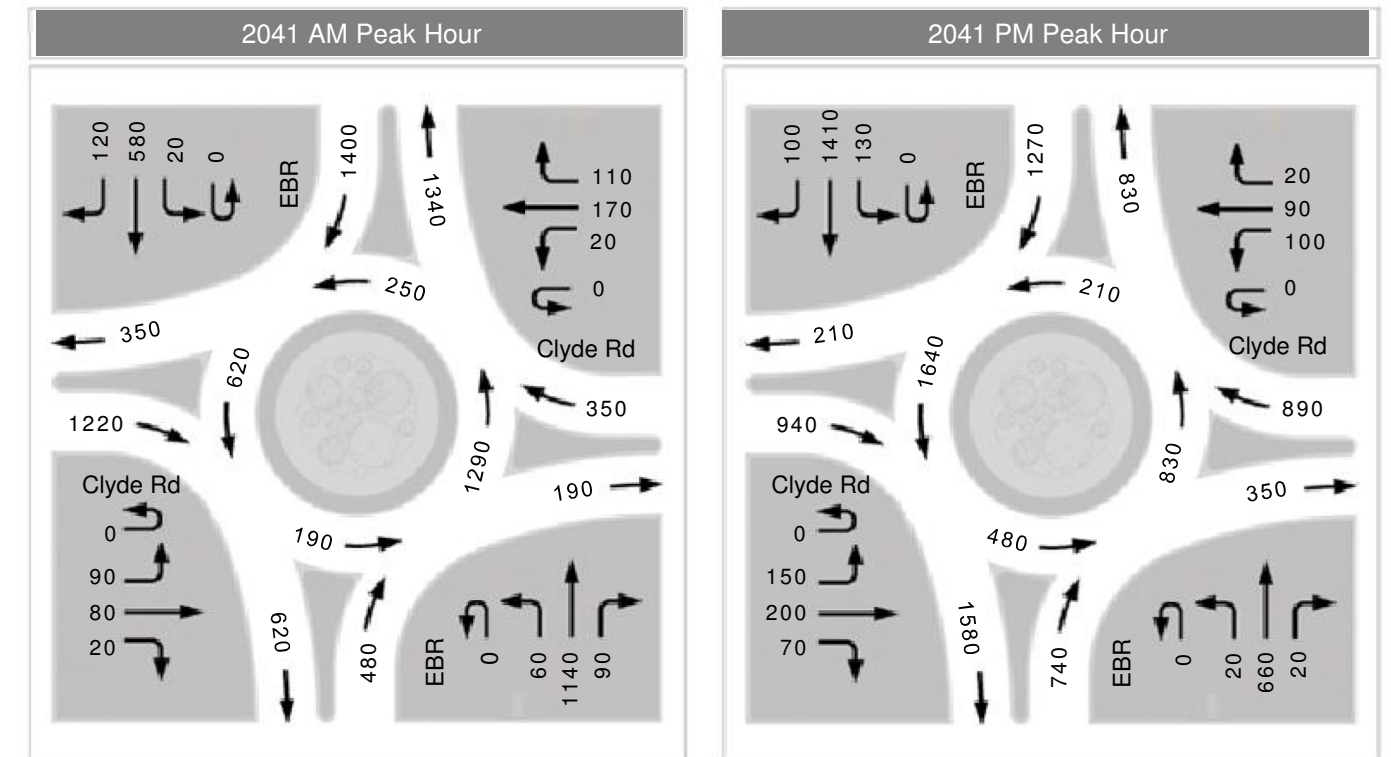
2041 AM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	<25	2.2	0.38	A	7	A	5% [WB - Gore Rd]
Avenue Rd EB	<25	4.5	0.34	A			
EBR NB	<25	4.3	0.64	A			
Gore Rd WB	104.8	20.2	0.77	C			
95% y-int. Adjustment							
EBR SB	<25	2.1	0.36	A	<5	A	11% [WB - Gore Rd]
Avenue Rd EB	<25	4.0	0.31	A			
EBR NB	<25	3.6	0.60	A			
Gore Rd WB	39	12.9	0.69	B			

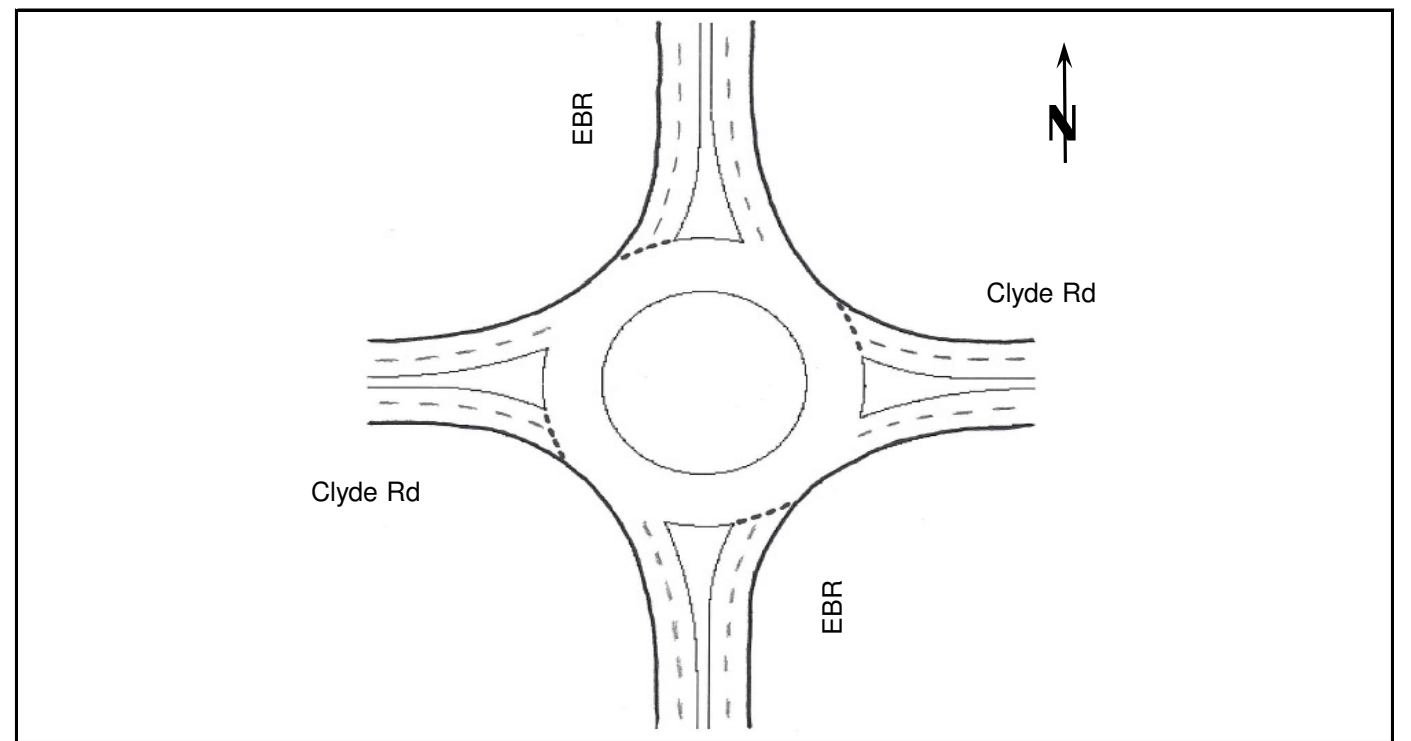
2041 PM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	357.1	34.7	0.97	D	27	D	-5% [EB - Aveue Rd]
Avenue Rd EB	175.5	79.9	0.91	F			
EBR NB	<25	2.9	0.42	A			
Gore Rd WB	<25	5.4	0.44	A			
95% y-int. Adjustment							
EBR SB	164.6	16.0	0.92	C	13	B	1% [EB - Aveue Rd]
Avenue Rd EB	71.2	28.9	0.70	D			
EBR NB	<25	2.6	0.40	A			
Gore Rd WB	<25	4.7	0.40	A			

Turning Movement Forecasts



Source: Region of Waterloo



Geometric Design Parameters

Conceptual Design Geometry

	Road Half Width, V (m)	Entry Width, E (m)	Eff. Flare Length, l' (m)	Entry Radius, R (m)	Inscribed Circle Dia, D (m)	Entry Angle, Ø (deg.)	Exit Only (T/F)	Right-Turn Bypass (T/F)
EBR SB	7.00	8.00	10	25	50	20	FALSE	FALSE
Clyde Rd EB	4.25	8.00	20	20	54	20	FALSE	FALSE
EBR NB	7.00	8.00	10	25	50	20	FALSE	FALSE
Clyde Rd WB	4.25	8.00	20	20	54	20	FALSE	FALSE

Other Inputs

	Flare Storage (m)	Pedestrian Crossings	% Trucks	Flow Profile	Scaling Factor
EBR SB	0	0	2.0	ONE HOUR	1.00
Clyde Rd EB	10	0	2.0	ONE HOUR	1.00
EBR NB	0	0	2.0	ONE HOUR	1.00
Clyde Rd WB	10	0	2.0	ONE HOUR	1.00

Capacity Analysis Results

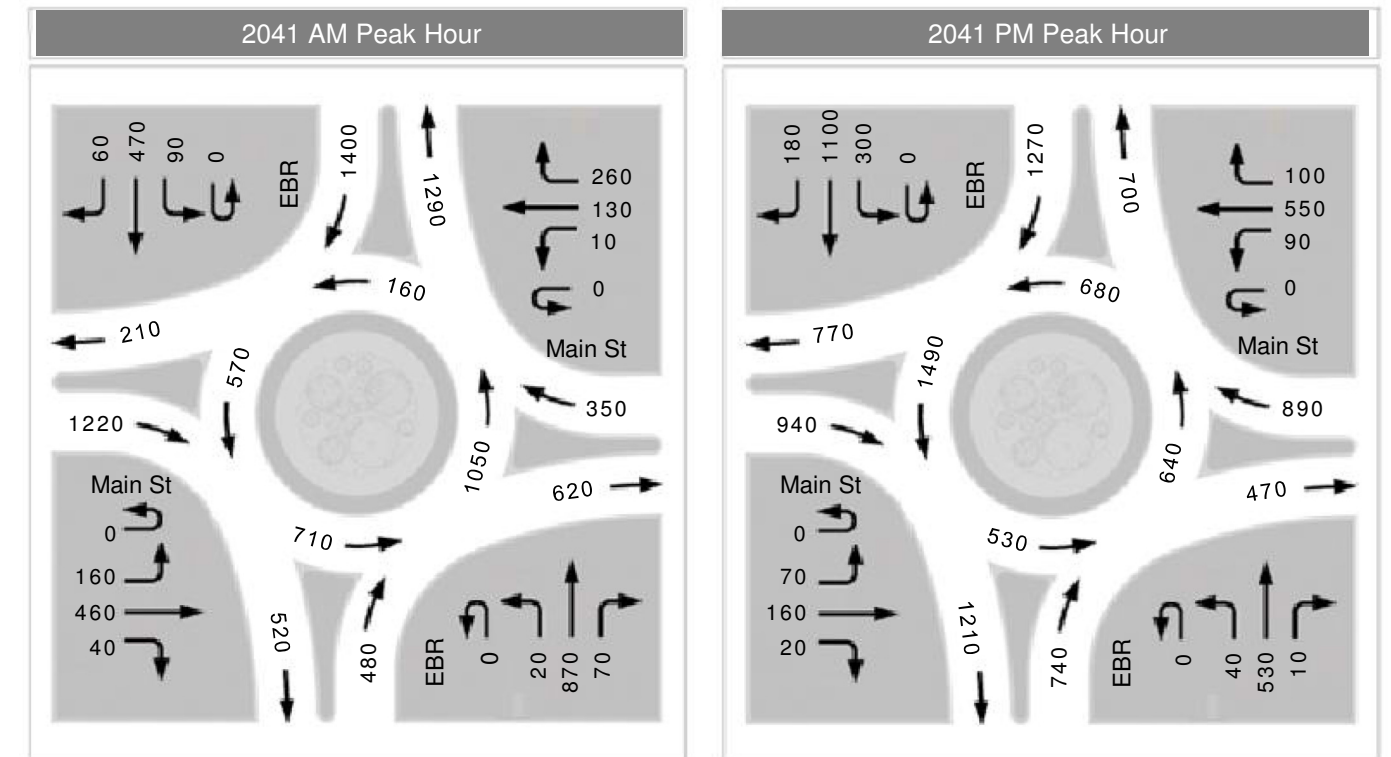
2041 AM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	<25	3.1	0.41	A	5	A	32% [NB - EBR]
Clyde Rd EB	<25	3.1	0.15	A			
EBR NB	<25	6.1	0.71	A			
Clyde Rd WB	<25	6.6	0.38	A			
95% y-int. Adjustment							
EBR SB	<25	2.8	0.38	A	<5	A	40% [NB - EBR]
Clyde Rd EB	<25	2.9	0.14	A			
EBR NB	<25	5.1	0.67	A			
Clyde Rd WB	<25	5.6	0.34	A			

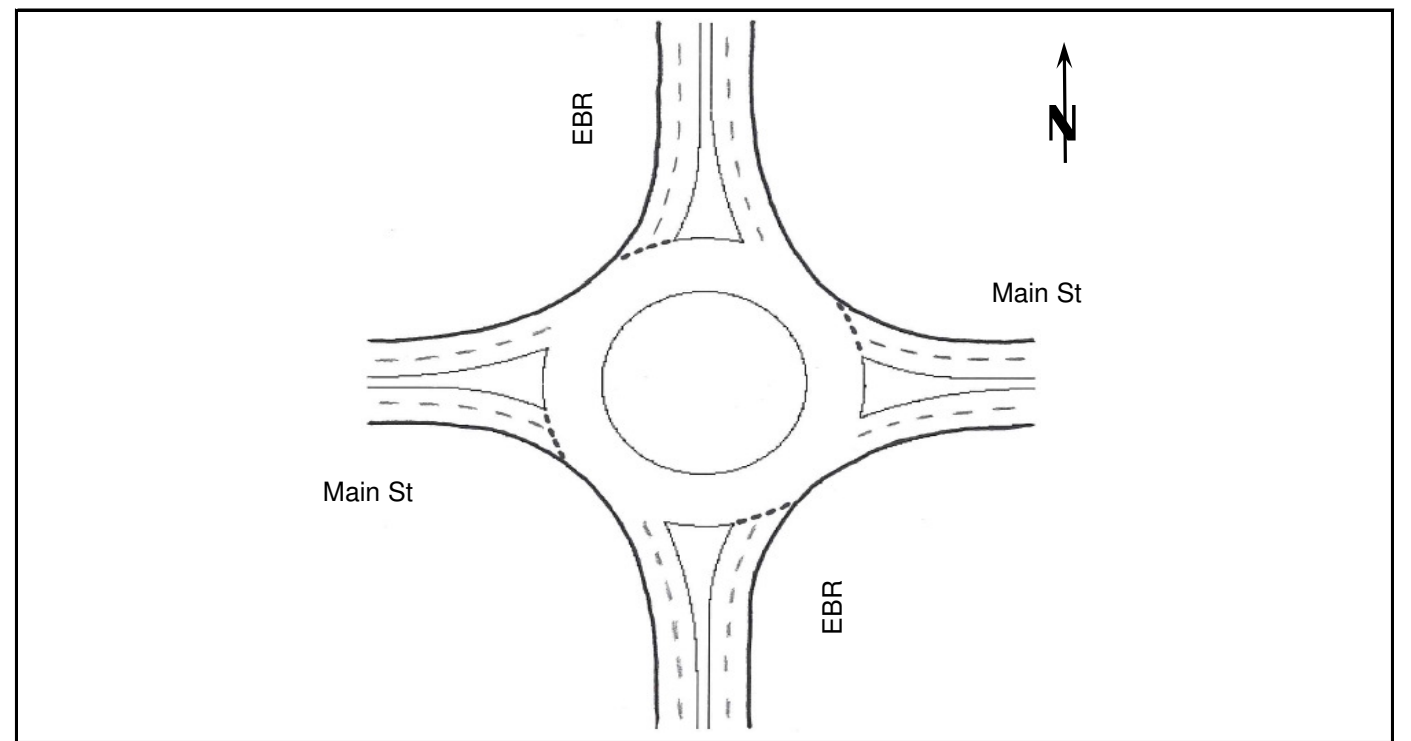
2041 PM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	160.3	18.7	0.91	C	15	B	4% [EB - Clyde Rd]
Clyde Rd EB	81	22.2	0.74	C			
EBR NB	<25	3.6	0.44	A			
Clyde Rd WB	<25	3.7	0.19	A			
95% y-int. Adjustment							
EBR SB	98.4	11.7	0.86	B	9	A	10% [EB - Clyde Rd]
Clyde Rd EB	36.2	13.8	0.64	B			
EBR NB	<25	3.2	0.41	A			
Clyde Rd WB	<25	3.3	0.18	A			

Turning Movement Forecasts



Source: Region of Waterloo



Geometric Design Parameters

Conceptual Design Geometry

	Road Half Width, V (m)	Entry Width, E (m)	Eff. Flare Length, l' (m)	Entry Radius, R (m)	Inscribed Circle Dia, D (m)	Entry Angle, Ø (deg.)	Exit Only (T/F)	Right-Turn Bypass (T/F)
EBR SB	7.00	8.00	10	25	50	20	FALSE	TRUE
Main St EB	4.25	8.00	20	20	54	20	FALSE	FALSE
EBR NB	7.00	8.00	10	25	50	20	FALSE	FALSE
Main St WB	4.25	8.00	20	20	54	20	FALSE	FALSE

Other Inputs

	Flare Storage (m)	Pedestrian Crossings	% Trucks	Flow Profile	Scaling Factor
EBR SB	0	0	2.0	ONE HOUR	1.00
Main St EB	10	0	2.0	ONE HOUR	1.00
EBR NB	0	0	2.0	ONE HOUR	1.00
Main St WB	10	0	2.0	ONE HOUR	1.00

Capacity Analysis Results

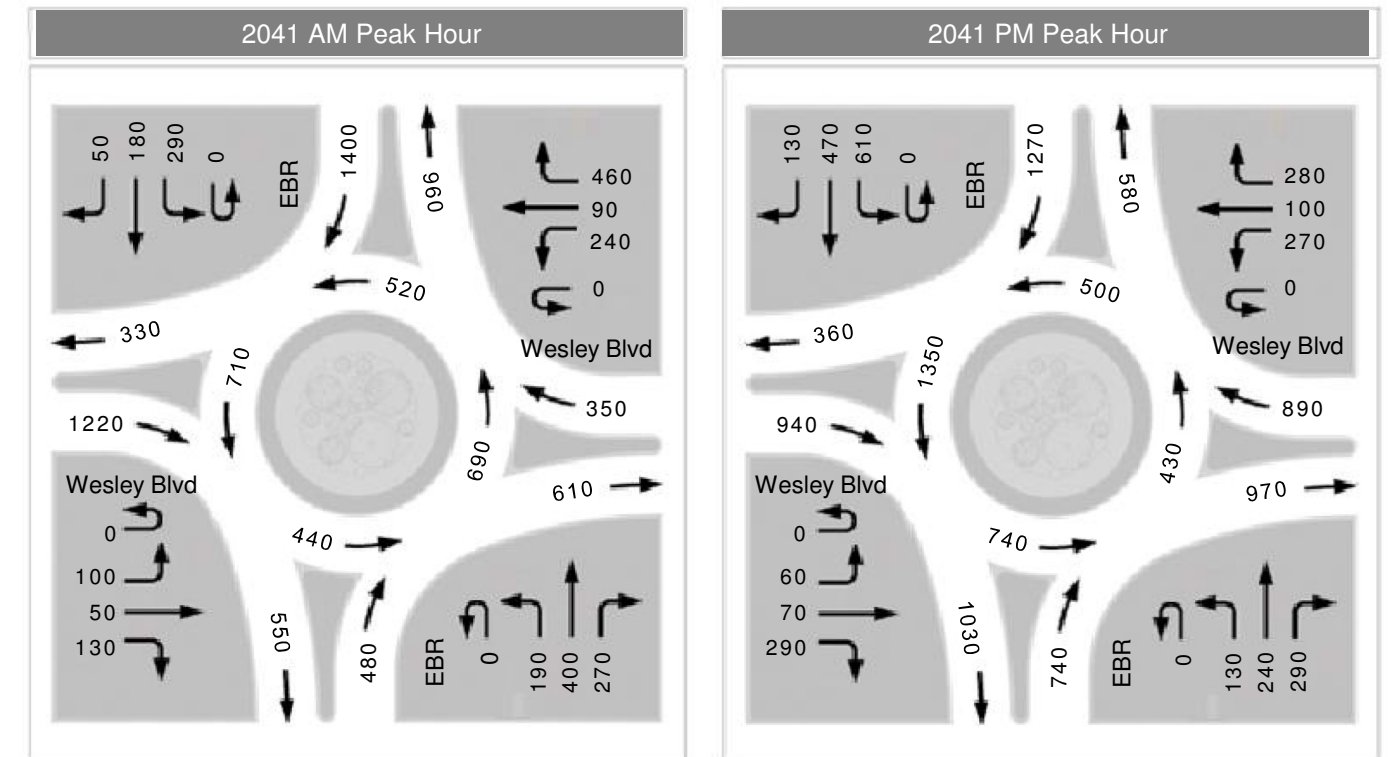
2041 AM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	<25	2.5	0.30	A	5	A	26% [NB - EBR]
Main St EB	<25	5.3	0.52	A			
EBR NB	<25	7.0	0.67	A			
Main St WB	<25	5.9	0.42	A			
95% y-int. Adjustment							
EBR SB	<25	2.3	0.29	A	<5	A	33% [NB - EBR]
Main St EB	<25	4.6	0.48	A			
EBR NB	<25	5.7	0.63	A			
Main St WB	<25	5.0	0.38	A			

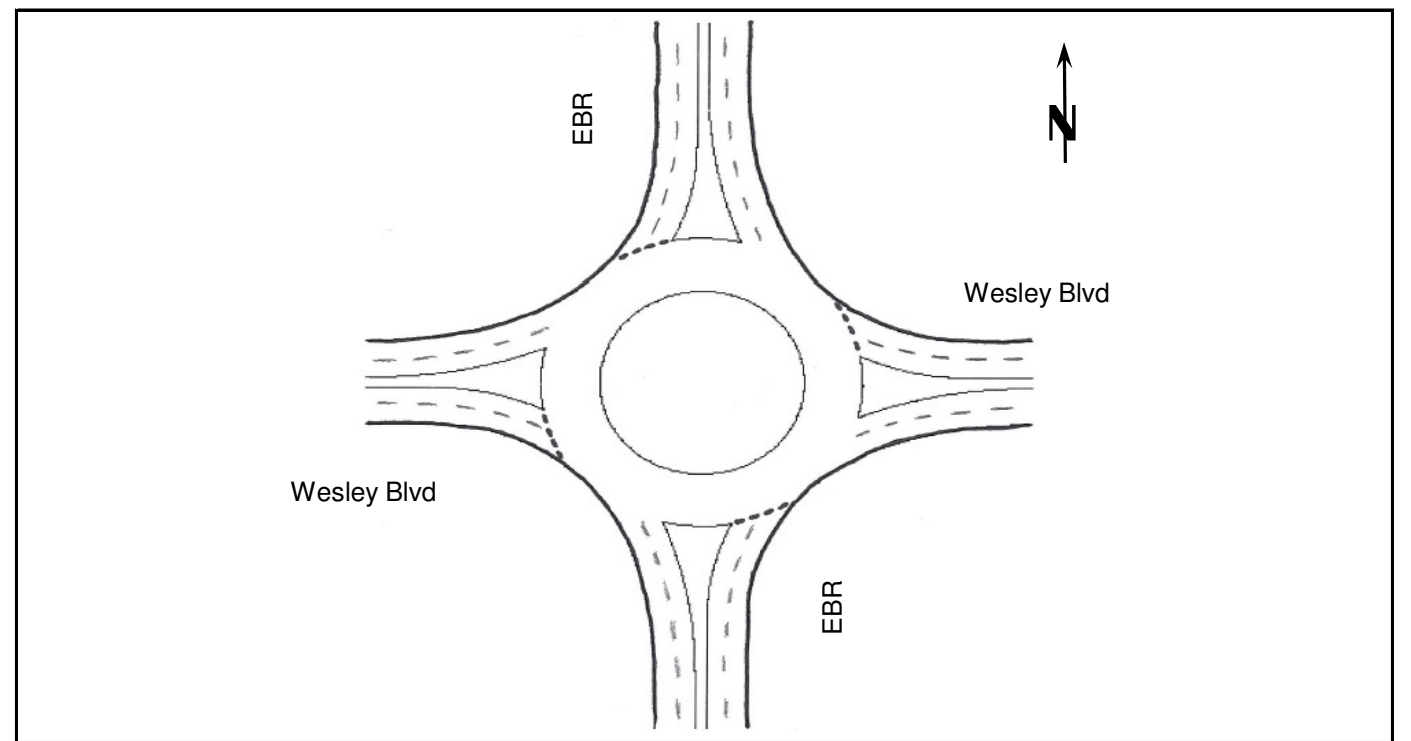
2041 PM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	288.4	42.4	0.97	E	24	C	-2% [SB - EBR]
Main St EB	<25	7.7	0.37	A			
EBR NB	<25	3.3	0.37	A			
Main St WB	<25	6.7	0.60	A			
95% y-int. Adjustment							
EBR SB	145.6	19.9	0.90	C	12	B	4% [SB - EBR]
Main St EB	<25	6.5	0.33	A			
EBR NB	<25	3.0	0.35	A			
Main St WB	<25	5.6	0.56	A			

Turning Movement Forecasts



Source: Region of Waterloo



Geometric Design Parameters

Conceptual Design Geometry

	Road Half Width, V (m)	Entry Width, E (m)	Eff. Flare Length, l' (m)	Entry Radius, R (m)	Inscribed Circle Dia, D (m)	Entry Angle, Ø (deg.)	Exit Only (T/F)	Right-Turn Bypass (T/F)
EBR SB	7.00	8.00	10	25	50	20	FALSE	FALSE
Wesley Blvd EB	4.25	8.00	20	20	54	20	FALSE	FALSE
EBR NB	7.00	8.00	10	25	50	20	FALSE	FALSE
Wesley Blvd WB	4.25	8.00	20	20	54	20	FALSE	FALSE

Other Inputs

	Flare Storage (m)	Pedestrian Crossings	% Trucks	Flow Profile	Scaling Factor
EBR SB	0	0	2.0	ONE HOUR	1.00
Wesley Blvd EB	10	0	2.0	ONE HOUR	1.00
EBR NB	0	0	2.0	ONE HOUR	1.00
Wesley Blvd WB	10	0	2.0	ONE HOUR	1.00

Capacity Analysis Results

2041 AM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	<25	3.1	0.33	A	5	A	26% [WB - Wesley Blvd]
Wesley Blvd EB	<25	3.6	0.24	A			
EBR NB	<25	4.2	0.53	A			
Wesley Blvd WB	<25	8.0	0.66	A			
95% y-int. Adjustment							
EBR SB	<25	2.8	0.31	A	<5	A	33% [WB - Wesley Blvd]
Wesley Blvd EB	<25	3.3	0.22	A			
EBR NB	<25	3.7	0.49	A			
Wesley Blvd WB	<25	6.6	0.61	A			

2041 PM Peak Hour

	95% Queue (m)	Delay (s/vehicle)	V/C Ratio	LOS	Int. Delay (s/vehicle)	Int. LOS	Intersection Residual Capacity
90% y-int. Adjustment							
EBR SB	34.7	8.7	0.76	A	7	A	19% [SB - EBR]
Wesley Blvd EB	<25	9.7	0.55	A			
EBR NB	<25	4.4	0.47	A			
Wesley Blvd WB	<25	4.5	0.47	A			
95% y-int. Adjustment							
EBR SB	<25	6.7	0.71	A	6	A	26% [SB - EBR]
Wesley Blvd EB	<25	7.6	0.49	A			
EBR NB	<25	3.8	0.44	A			
Wesley Blvd WB	<25	4.0	0.44	A			

B

Appendix B Safety Analysis





INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041**

Major Road: **East Boundary Road**
Minor Road: **Avenue Road**

Major Road Direction: North / South
Urban or Rural: Urban
Proposed Control: Signalized
Proposed Config: 4-Leg Intersection

LT Lanes Proposed (non roundabout):
Major: 2 Approaches
Minor: 2 Approaches

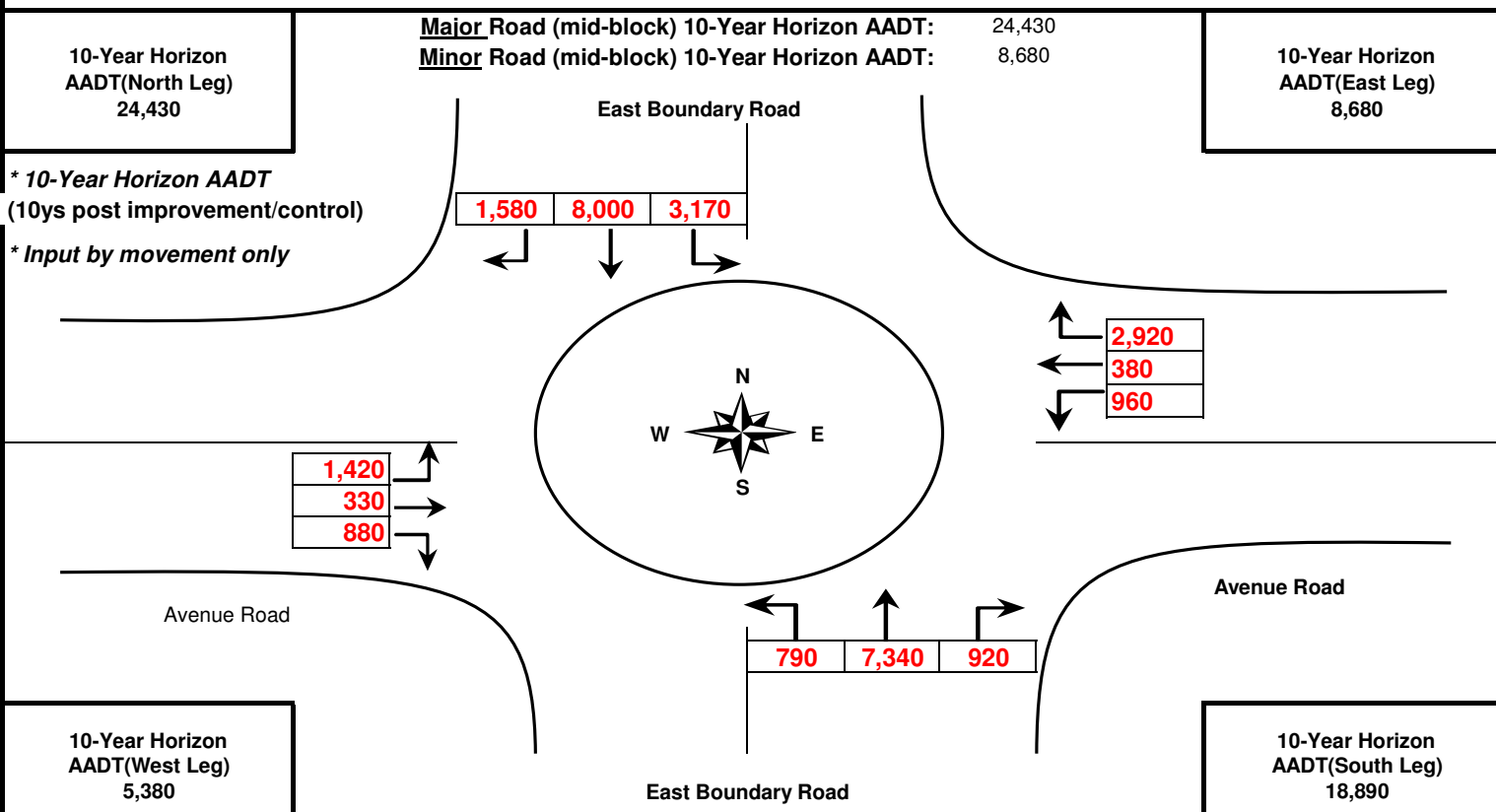
RT Lanes Proposed (non roundabout):
Major: No RT Lanes
Minor: No RT Lanes

Is there going to be any fully protected left-turn phasing? YES
Number of approaches with FPLTP: 1

Is the proposed intersection "new" or is it existing: NEW
Does control and number of approaches remain the same: NO
Will the proposed intersection have illumination: YES

5-Year Total Collisions: 0
5-Year PDO Collisions: 0

Proposed Multi-Lane or Single Lane RA? MULTI-LANE ROUNDABOUT



Direct Capital Costs

Fatal = \$1,656,500
Injury = \$60,500
PDO = \$5,000

Discount Rate = 0.06

20-Year Present Value Collision Costs (DIRECT CAPITAL COSTS)				
Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	\$2,928,850.12	\$360,156	\$2,435,695	\$132,999.47
Roundabout	\$2,162,850.40	\$922,542.82	\$1,240,307.57	\$0.00



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041**

Major Road: **East Boundary Road**
Minor Road: **Avenue Road**

Major Road Direction: North / South
Urban or Rural: Urban
Proposed Control: Signalized
Proposed Config: 4-Leg Intersection

Roundabout Conflicts: **40310**
5-Year Total Collisions: **0**
5-Year PDO Collisions: **0**

Estimated ANNUAL (1-YEAR ONLY) Collisions				
Future Expected Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	9.79	6.28	3.51	0.01
Roundabout	17.9	16.1	1.8	0.0

TOTAL CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-10.99	1.07	0.23	N/A	0.002	n/a

PDO CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-11.02	1.02	0.24	N/A	0.002	n/a

Collision Modification Factors (cmf's)	Left Turn Lane	Right Turn Lane	Calibration Factor	Empirical Bays Weighting	
	0.81		2.1	Total	PDO
	0.91	Protected LT Phasing		N/A	N/A

Comments:



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041** Major Road: **East Boundary Road**
Minor Road: **Clyde Road**

Major Road Direction: North / South
Urban or Rural: Urban
Proposed Control: Signalized
Proposed Config: 4-Leg Intersection

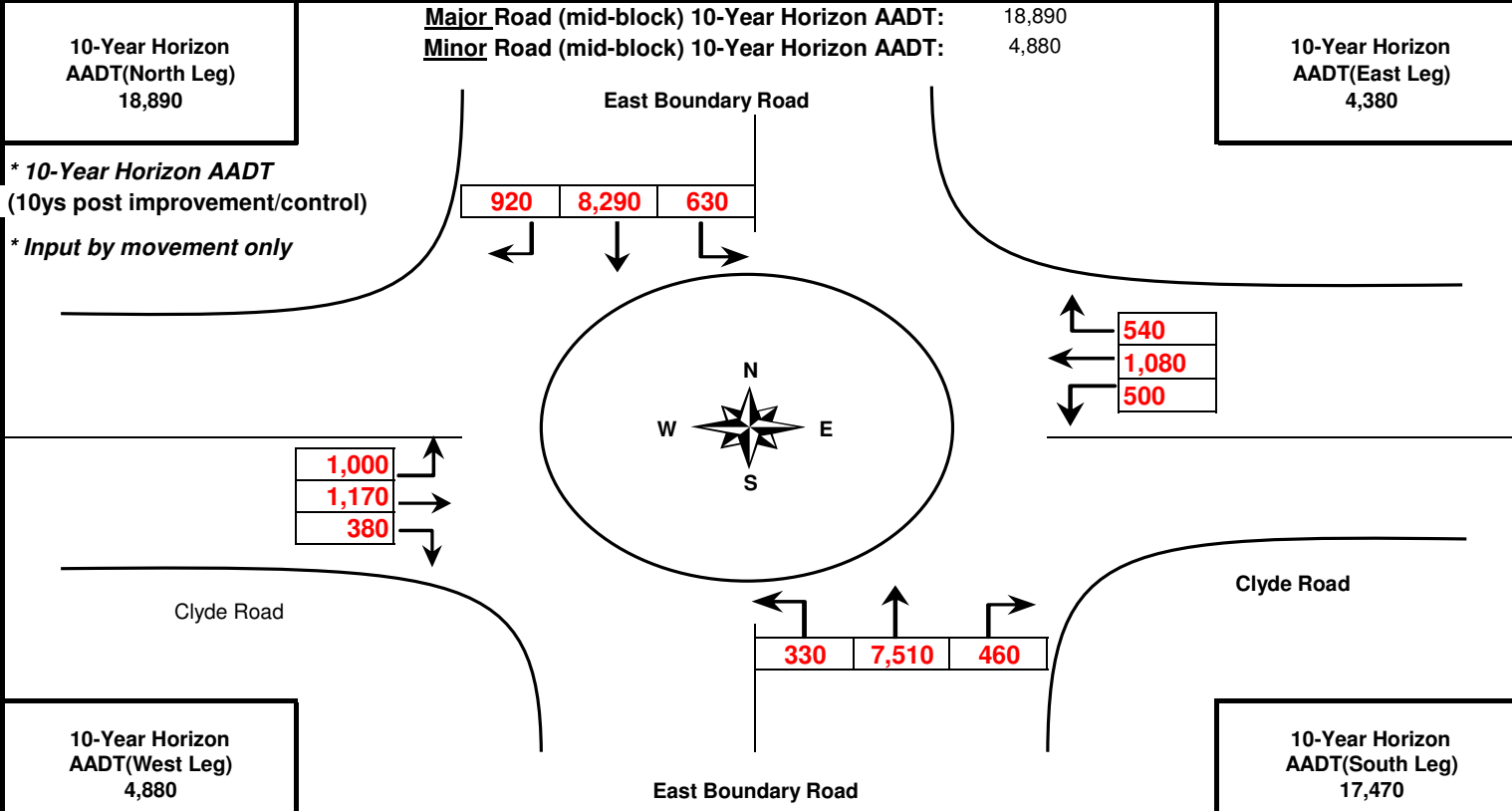
LT Lanes Proposed (non roundabout): Major 2 Approaches, Minor 2 Approaches
RT Lanes Proposed (non roundabout): Major No RT Lanes, Minor No RT Lanes

Is there going to be any fully protected left-turn phasing? NO
Number of approaches with FPLTP: N/A

Is the proposed intersection "new" or is it existing? NEW
Does control and number of approaches remain the same? NO
Will the proposed intersection have illumination? YES

5-Year Total Collisions: 0
5-Year PDO Collisions: 0

Proposed Multi-Lane or Single Lane RA? MULTI-LANE ROUNDABOUT



Direct Capital Costs
Fatal = \$1,656,500
Injury = \$60,500
PDO = \$5,000
Discount Rate = 0.06

20-Year Present Value Collision Costs (DIRECT CAPITAL COSTS)				
Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	\$2,052,054.93	\$256,926	\$1,700,129	\$94,999.62
Roundabout	\$1,752,637.64	\$747,570.56	\$1,005,067.08	\$0.00



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041** Major Road: **East Boundary Road**
Minor Road: **Clyde Road**

Major Road Direction: North / South
Urban or Rural: Urban
Proposed Control: Signalized
Proposed Config: 4-Leg Intersection

Roundabout Conflicts: 31140
5-Year Total Collisions: 0
5-Year PDO Collisions: 0

Estimated ANNUAL (1-YEAR ONLY) Collisions				
Future Expected Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	6.93	4.48	2.45	0.01
Roundabout	14.5	13.0	1.4	0.0

TOTAL CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-10.99	1.07	0.23	N/A	0.002	n/a

PDO CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-11.02	1.02	0.24	N/A	0.002	n/a

Collision Modification Factors (cmf's)	Left Turn Lane	Right Turn Lane	Calibration Factor	Empirical Bays Weighting	
	0.81		2.1	Total	PDO
	Illumination	Protected LT Phasing		N/A	N/A
	0.91	1.00			

Comments:



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041**

Major Road: **East Boundary Road**

Minor Road: **Main Street**

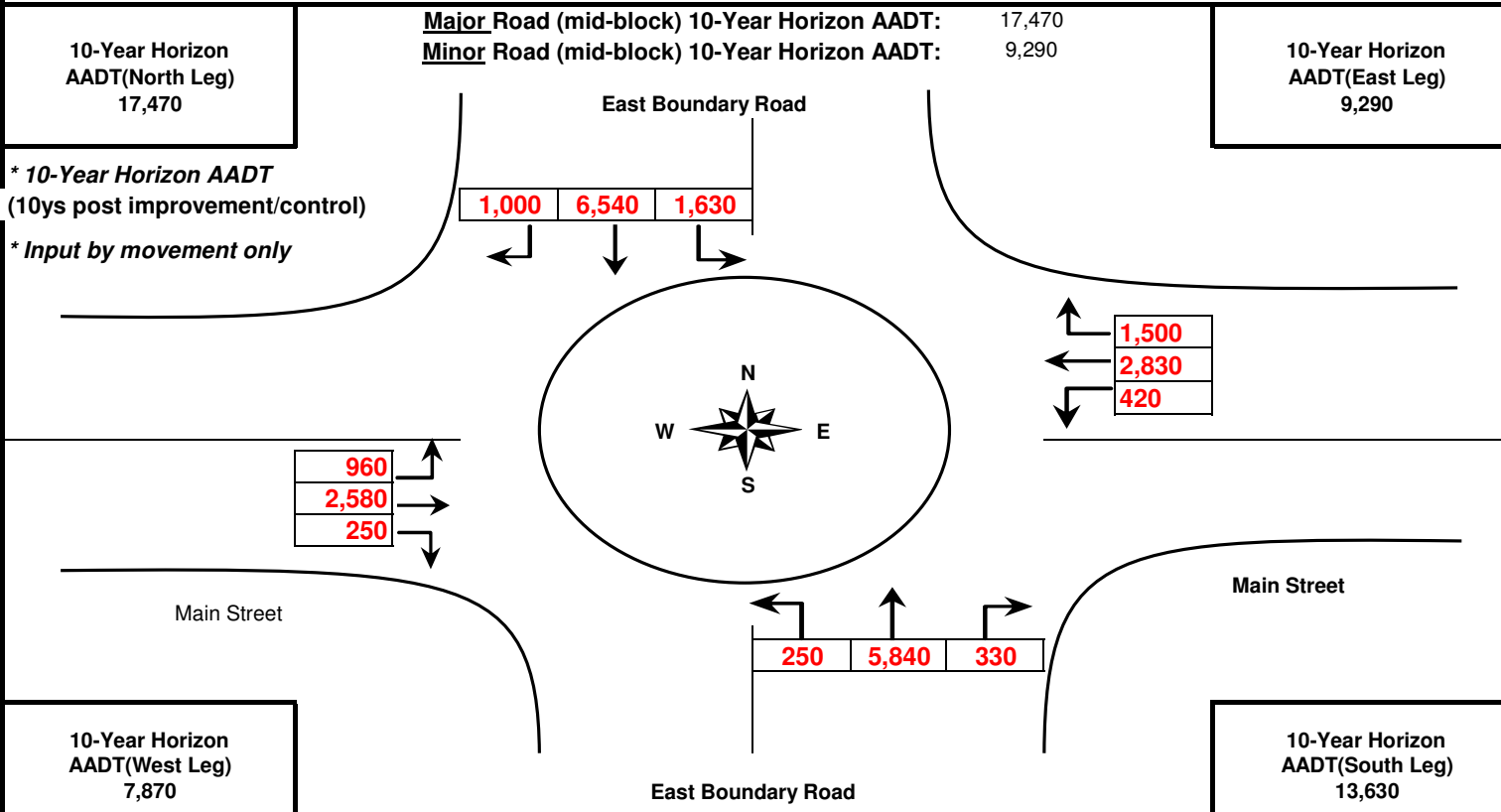
Major Road Direction: North / South
 Urban or Rural: Urban
 Proposed Control: Signalized
 Proposed Config: 4-Leg Intersection

LT Lanes Proposed (non roundabout):		RT Lanes Proposed (non roundabout):	
Major	2 Approaches	Major	No RT Lanes
Minor	2 Approaches	Minor	No RT Lanes

Is there going to be any fully protected left-turn phasing? NO
 Number of approaches with FPLTP: N/A

Is the proposed intersection "new" or is it existing: NEW
 Does control and number of approaches remain the same: NO
 Will the proposed intersection have illumination: YES

5-Year Total Collisions: **0**
 5-Year PDO Collisions: **0**
 Proposed Multi-Lane or Single Lane RA? MULTI-LANE ROUNDABOUT



Direct Capital Costs

Fatal = \$1,656,500
 Injury = \$60,500
 PDO = \$5,000

Discount Rate = 0.06

20-Year Present Value Collision Costs (DIRECT CAPITAL COSTS)				
Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	\$2,154,825.42	\$276,425	\$1,783,401	\$94,999.62
Roundabout	\$2,544,188.58	\$1,085,198.92	\$1,458,989.66	\$0.00



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041**

Major Road: **East Boundary Road**

Minor Road: **Main Street**

Major Road Direction: North / South
 Urban or Rural: Urban
 Proposed Control: Signalized
 Proposed Config: 4-Leg Intersection

Roundabout Conflicts: **49200**
 5-Year Total Collisions: **0**
 5-Year PDO Collisions: **0**

Estimated ANNUAL (1-YEAR ONLY) Collisions				
Future Expected Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	7.39	4.82	2.57	0.01
Roundabout	21.0	18.9	2.1	0.0

TOTAL CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-10.99	1.07	0.23	N/A	0.002	n/a

PDO CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-11.02	1.02	0.24	N/A	0.002	n/a

Collision Modification Factors (cmf's)	Left Turn Lane	Right Turn Lane	Calibration Factor	Empirical Bays Weighting	
	0.81		2.1	Total	PDO
	Illumination	Protected LT Phasing		N/A	N/A
	0.91	1.00			

Comments:



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041**

Major Road: **East Boundary Road**
Minor Road: **Wesley Boulevard**

Major Road Direction: North / South
Urban or Rural: Urban
Proposed Control: Signalized
Proposed Config: 4-Leg Intersection

LT Lanes Proposed (non roundabout):
Major: 2 Approaches
Minor: 2 Approaches

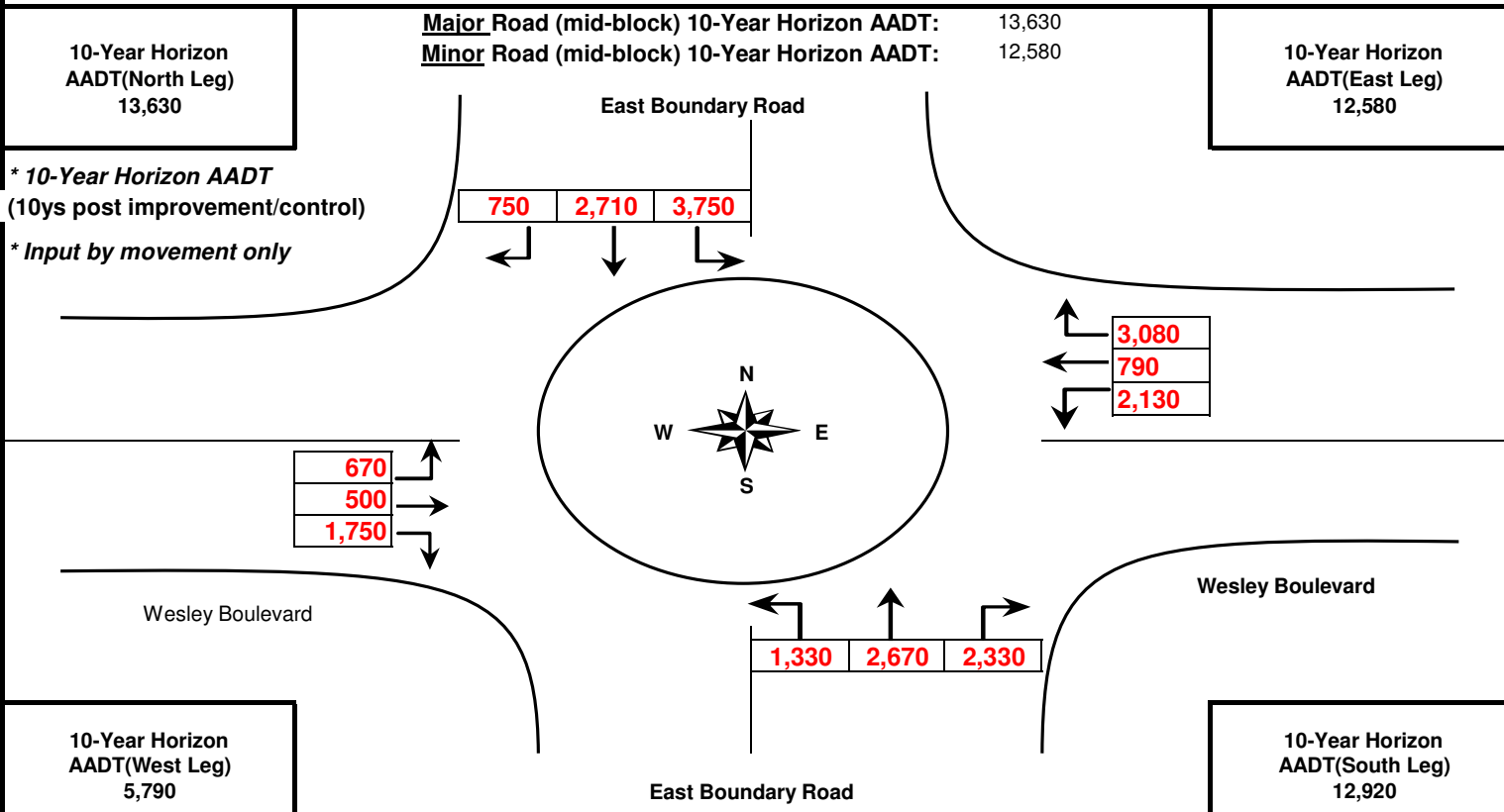
RT Lanes Proposed (non roundabout):
Major: No RT Lanes
Minor: No RT Lanes

Is there going to be any fully protected left-turn phasing? NO
Number of approaches with FPLTP: N/A

Is the proposed intersection "new" or is it existing: NEW
Does control and number of approaches remain the same: NO
Will the proposed intersection have illumination: YES

5-Year Total Collisions: 0
5-Year PDO Collisions: 0

Proposed Multi-Lane or Single Lane RA? MULTI-LANE ROUNDABOUT



Direct Capital Costs

Fatal = \$1,656,500
Injury = \$60,500
PDO = \$5,000

Discount Rate = 0.06

20-Year Present Value Collision Costs (DIRECT CAPITAL COSTS)				
Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	\$1,722,736.29	\$231,119	\$1,415,618	\$75,999.70
Roundabout	\$2,646,115.42	\$1,128,674.83	\$1,517,440.60	\$0.00



INTERSECTION CONTROL STUDIES SAFETY ASSESSMENT METHODOLOGY (HSM)

Last Rev Mar 2017

Scenario: **2041**

Major Road: **East Boundary Road**
Minor Road: **Wesley Boulevard**

Major Road Direction: North / South
Urban or Rural: Urban
Proposed Control: Signalized
Proposed Config: 4-Leg Intersection

Roundabout Conflicts: **51630**
5-Year Total Collisions: **0**
5-Year PDO Collisions: **0**

Estimated ANNUAL (1-YEAR ONLY) Collisions				
Future Expected Collisions by Severity	Total	PDO	Injury	Fatal
Signalized	6.08	4.03	2.04	0.00
Roundabout	21.9	19.7	2.2	0.0

TOTAL CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-10.99	1.07	0.23	N/A	0.002	n/a

PDO CRASH COEFFICIENTS USED IN CALCULATION						Fatal/Inj. Ratio	Collision Factor
Control	Intersection Config	Intercept	AADTmaj	AADTmin	Overdispersion		
Signalized	4-Leg Intersection	-11.02	1.02	0.24	N/A	0.002	n/a

Collision Modification Factors (cmf's)	Left Turn Lane	Right Turn Lane	Calibration Factor	Empirical Bays Weighting	
	0.81		2.1	Total	PDO
		Protected LT Phasing		N/A	N/A
	Illumination				
	0.91	1.00			

Comments:

C

Appendix C

Construction Cost Estimates



Summary			
Section	Description	Estimated Cost	
		Int. SIG	Int. RBT
A	Property acquisition subtotal	\$ 478,500	\$ 553,500
B	General requirements	\$ 106,334	\$ 116,407
C	Utility relocations and adjustments	\$ 80,000	\$ 130,000
D	Remove, dispose or reinstall	\$ 102,700	\$ 137,690
E	Road construction	\$ 829,225	\$ 1,212,900
F	Pavement markings and signage	\$ 48,040	\$ 66,760
G	Street lighting, signals and electrical	\$ 214,000	\$ 23,500
H	Landscaping, erosion control and maintenance	\$ 26,879	\$ 31,817
I	Construction subtotal	\$ 1,407,178	\$ 1,719,074
J	Engineering fees 15%	\$ 211,077	\$ 257,861
K	Contingency 20%	\$ 281,436	\$ 343,815
L	Construction total	\$ 1,899,690	\$ 2,320,749
M	HST 1.76%	\$ 33,435	\$ 40,845
N	Grand total (including property acquisition)	\$ 2,411,625	\$ 2,915,095



Section A - Property Acquisition							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
A - 1	Business park			m ²	\$ 62	\$ -	\$ -
A - 2	Industrial			m ²	\$ 49	\$ -	\$ -
A - 3	Commercial			m ²	\$ 124	\$ -	\$ -
A - 4	Residential - low density	770	770	m ²	\$ 50	\$ 38,500	\$ 38,500
A - 5	Residential - high density			m ²	\$ 74	\$ -	\$ -
A - 6	Agricultural or vacant	8800	10300	m ²	\$ 50	\$ 440,000	\$ 515,000
A - 7	Additional impacts			LS	\$ 100,000	\$ -	\$ -
Subtotal						\$ 478,500	\$ 553,500
Section B - General Requirements							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
B - 1	Mobilization and demobilization	1	1	LS	\$ 16,000	\$ 16,000	\$ 16,000
B - 2	Construction layout by contractor	1	1	LS	\$ 9,000	\$ 9,000	\$ 9,000
B - 3	Traffic control and construction staging (incl. materials)	1	1	LS	\$ 32,500	\$ 32,500	\$ 32,500
B - 4	Bonds (assumes 2% of parts D-H)	1	1	LS	2%	\$ 24,417	\$ 29,453
B - 5	Insurance (assumes 2% of parts D-H)	1	1	LS	2%	\$ 24,417	\$ 29,453
B - 6	Supply and place contract admin. office	1	1	LS	\$ 29,500	\$ 29,500	\$ 29,500
Subtotal						\$ 106,334	\$ 116,407
Section C - Utility Relocations and Adjustments							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
C - 1	Remove and dispose of existing hydro poles	2	4	ea	\$ 25,000	\$ 50,000	\$ 100,000
C - 2	Adjust to grade existing hydro poles			ea	\$ 4,000	\$ -	\$ -
C - 3	Relocation of underground power supply			LS	\$ 10,000	\$ -	\$ -
C - 4	Relocate or adjust to grade existing phone pedestals			ea	\$ 500	\$ -	\$ -
C - 5	Relocate existing gas mains (incl. adjustments to valves)			LS	\$ 25,000	\$ -	\$ -
C - 6	Relocate or adjust to grade existing light standards			ea	\$ 1,500	\$ -	\$ -
C - 7	Relocate existing fibre-optic cables	1	1	LS	\$ 30,000	\$ 30,000	\$ 30,000
C - 8	Relocate or adjust existing water mains (major)			LS	\$ 10,000	\$ -	\$ -
C - 9	Relocate or adjust existing water mains (minor)			LS	\$ 15,000	\$ -	\$ -
C - 10	Adjust watermain appurtenances (incl. valves, chambers and manholes)			ea	\$ 200	\$ -	\$ -
C - 11	Relocate hydrant and valve			ea	\$ 4,000	\$ -	\$ -
C - 12	Adjust manholes to grade (all types)			ea	\$ 855	\$ -	\$ -
C - 13	Relocate storm sewer catchbasins			ea	\$ 3,000	\$ -	\$ -
Subtotal						\$ 80,000	\$ 130,000



Section D - Remove, Dispose and Reinstall							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
D - 1	Clearing and grubbing (estimated 5.0 m back from face of curb)	13500	17300	m ²	\$ 1.3	\$ 17,550	\$ 22,490
D - 2	Stripping and stockpiling of topsoil and sod (300 mm depth)	4050	5190	m ³	\$ 20	\$ 81,000	\$ 103,800
D - 3	Remove, dispose or store and reinstall existing fence (all types)			m	\$ 8	\$ -	\$ -
D - 4	Remove, dispose or store and reinstall existing signs	6	6	ea	\$ 150	\$ 900	\$ 900
D - 5	Remove and dispose of existing sidewalk			m ²	\$ 7	\$ -	\$ -
D - 6	Sawcut existing road asphalt (any thickness)	1	1	LS	\$ 1,000	\$ 1,000	\$ 1,000
D - 7	Mill existing pavement surface (avg. 50 mm depth, 3.0 m wide at limit of asphalt incl. HL-3 asphalt for restoration)	1	1	LS	\$ 1,500	\$ 1,500	\$ 1,500
D - 8	Pulverization and stockpiling of existing asphalt (min. 300 mm depth, incl. grade and compact pulverized section)			m ²	\$ 3	\$ -	\$ -
D - 9	Remove existing road pavement (full depth incl. all granular material)	150	1600	m ²	\$ 5	\$ 750	\$ 8,000
D - 10	Remove and dispose of existing conc. curb (all types incl. conc. gutters)			m	\$ 11	\$ -	\$ -
D - 11	Remove and dispose of other existing conc. or asphalt (median islands, splash pads, etc.)			m ²	\$ 14	\$ -	\$ -
D - 12	Remove and dispose of minor culverts			m	\$ 30	\$ -	\$ -
D - 13	Remove and dispose of major culverts			m	\$ 40	\$ -	\$ -
D - 14	Remove existing signal light poles			ea	\$ 250	\$ -	\$ -
D - 15	Remove existing signal appurtenances (handwells, wire loop sensors, etc.)			ea	\$ 100	\$ -	\$ -
D - 16	Remove, salvage and restore miscellaneous appurtenances			LS	\$ 2,000	\$ -	\$ -
Subtotal						\$ 102,700	\$ 137,690
Section E - Road Construction							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
E - 1	Imported fill for road construction	13500	17300	m ³	\$ 25	\$ 337,500	\$ 432,500
E - 2	Prepare subgrade surface for road construction	4700	7800	m ²	\$ 2	\$ 9,400	\$ 15,600
E - 3	Granular 'A' for roadworks (assume 150 mm depth - incl. shoulders)	1763	2925	ton	\$ 17.00	\$ 29,963	\$ 49,725
E - 4	Granular 'A' for miscellaneous items (incl. driveways, splash pads, sidewalks, etc., avg 200 mm depth)	300	450	ton	\$ 17.00	\$ 5,100	\$ 7,650
E - 5	Granular 'B' for roadworks (assume 450 mm depth - incl. shoulders)	5288	8775	ton	\$ 12.00	\$ 63,450	\$ 105,300
E - 6	Surface course asphalt (assume HL-3, min. 50 mm depth)	587.5	975	ton	\$ 115.0	\$ 67,563	\$ 112,125
E - 7	Heavy duty binder course (HDBC) - (PG64-28) 100 mm depth	1175	1950	ton	\$ 82.0	\$ 96,350	\$ 159,900
E - 8	Miscellaneous asphalt (assume HL3, min. 75 mm depth, for driveways, splash pads, splitter islands, etc.)			m	\$ 16.54	\$ -	\$ -
E - 9	Concrete curb and gutter (all types)	1950	2100	m	\$ 48	\$ 93,600	\$ 100,800
E - 10	Reconstruction of existing driveways (asphalt or gravel)			m ²	\$ 52	\$ -	\$ -
E - 11	Perforated subdrains under concrete curbs (assume 150 mm)	1280	1350	m	\$ 25	\$ 32,000	\$ 33,750
E - 12	Concrete for splitter islands	350	950	m ²	\$ 50	\$ 17,500	\$ 47,500
E - 13	Concrete - coloured and stamped for truck apron (200 mm thick)		450	m ²	\$ 123	\$ -	\$ 55,350
E - 14	Concrete sidewalk (assume 3.0 m width)	600	900	m ²	\$ 53	\$ 31,800	\$ 47,700
E - 15	Rip-rap for roadway spillways and along ditches (incl. geotextile fabric)			m ²	\$ 30	\$ -	\$ -
E - 16	Allowance for night paving	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 17	Short-term lane closure	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 18	Supply and install CSP culverts (minor)	50	50	m	\$ 100	\$ 5,000	\$ 5,000



E - 19	Supply and install CSP culverts (major)			m	\$ 125	\$ -	\$ -
Subtotal						\$ 829,225	\$ 1,212,900
Section F - Pavement Markings and Signage							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
F - 1	Temporary pavement marking for construction staging	2000	2000	m	\$ 6	\$ 12,000	\$ 12,000
F - 2	Painted pavement markings	2500	2400	m	\$ 10	\$ 25,000	\$ 24,000
F - 3	Durable pavement markings	240	400	m	\$ 20	\$ 4,800	\$ 8,000
F - 4	Durable pavement messages (arrows, crosswalk markings, etc.)	20	30	ea	\$ 180	\$ 3,600	\$ 5,400
F - 5	Supply and install custom map-type signs (incl. base and posts)		8	ea	\$ 1,200	\$ -	\$ 9,600
F - 6	Supply and install signs (incl. base and posts)	4	36	ea	\$ 160	\$ 640	\$ 5,760
F - 7	Supply and install temporary project sign board (incl. base and posts)	8	8	ea	\$ 250	\$ 2,000	\$ 2,000
Subtotal						\$ 48,040	\$ 66,760
Section G - Street Lighting, Signals and Electrical							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
G - 1	Supply and install light standards (all types incl. appurtenances)	14	16	ea	\$ 1,000	\$ 14,000	\$ 16,000
G - 2	Supply and install signals for intersections	1		LS	\$ 200,000	\$ 200,000	\$ -
G - 3	Electrical service to central island		1	LS	\$ 5,000	\$ -	\$ 5,000
G - 4	Connect to grid		1	LS	\$ 2,500	\$ -	\$ 2,500
G - 5	Temporary signals			LS	\$ 50,000	\$ -	\$ -
Subtotal						\$ 214,000	\$ 23,500
Section H - Landscaping, Erosion Control and Miscellaneous							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
H - 1	Utility locates or dig-ups			ea	\$ 450	\$ -	\$ -
H - 2	Supply, install and maintain sediment control fence (OPSD 219.110)			m	\$ 12	\$ -	\$ -
H - 3	Supply and install straw bale check dams (OPSD 219.180)			ea	\$ 150	\$ -	\$ -
H - 4	Landscaping (incl. topsoil, sod, seeding and central island plantings, assume 2% of parts D-G)	2	2	LS	2%	\$ 23,879	\$ 28,817
H - 5	Supply and install new or reinstated fences			m	40	\$ -	\$ -
H - 6	Dust and noise control	2	2	LS	\$ 1,500	\$ 3,000	\$ 3,000
Subtotal						\$ 26,879	\$ 31,817



Summary			
Section	Description	Estimated Cost	
		SIG	RBT
A	Property acquisition subtotal	\$ 735,000	\$ 830,000
B	General requirements	\$ 140,755	\$ 151,610
C	Utility relocations and adjustments	\$ -	\$ -
D	Remove, dispose or reinstall	\$ 148,500	\$ 159,650
E	Road construction	\$ 1,513,025	\$ 1,907,913
F	Pavement markings and signage	\$ 131,240	\$ 138,520
G	Street lighting, signals and electrical	\$ 225,000	\$ 64,500
H	Landscaping, erosion control and maintenance	\$ 63,605	\$ 82,162
I	Construction subtotal	\$ 2,222,125	\$ 2,504,354
J	Engineering fees 15%	\$ 333,319	\$ 375,653
K	Contingency 20%	\$ 444,425	\$ 500,871
L	Construction total	\$ 2,999,869	\$ 3,380,878
M	HST 1.76%	\$ 52,798	\$ 59,503
N	Grand total (including property acquisition)	\$ 3,787,667	\$ 4,270,381



Section A - Property Acquisition							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
A - 1	Business park			m ²	\$ 62	\$ -	\$ -
A - 2	Industrial			m ²	\$ 49	\$ -	\$ -
A - 3	Commercial			m ²	\$ 124	\$ -	\$ -
A - 4	Residential - low density			m ²	\$ 50	\$ -	\$ -
A - 5	Residential - high density			m ²	\$ 74	\$ -	\$ -
A - 6	Agricultural or vacant	14700	16600	m ²	\$ 50	\$ 735,000	\$ 830,000
A - 7	Additional impacts			LS	\$ 100,000	\$ -	\$ -
Subtotal						\$ 735,000	\$ 830,000
Section B - General Requirements							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
B - 1	Mobilization and demobilization	1	1	LS	\$ 16,000	\$ 16,000	\$ 16,000
B - 2	Construction layout by contractor	1	1	LS	\$ 9,000	\$ 9,000	\$ 9,000
B - 3	Traffic control and construction staging (incl. materials)	1	1	LS	\$ 32,500	\$ 32,500	\$ 32,500
B - 4	Bonds (assumes 2% of parts D-H)	1	1	LS	2%	\$ 41,627	\$ 47,055
B - 5	Insurance (assumes 2% of parts D-H)	1	1	LS	2%	\$ 41,627	\$ 47,055
B - 6	Supply and place contract admin. office	1	1	LS	\$ 29,500	\$ 29,500	\$ 29,500
Subtotal						\$ 140,755	\$ 151,610
Section C - Utility Relocations and Adjustments							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
C - 1	Remove and dispose of existing hydro poles			ea	\$ 25,000	\$ -	\$ -
C - 2	Adjust to grade existing hydro poles			ea	\$ 4,000	\$ -	\$ -
C - 3	Relocation of underground power supply			LS	\$ 10,000	\$ -	\$ -
C - 4	Relocate or adjust to grade existing phone pedestals			ea	\$ 500	\$ -	\$ -
C - 5	Relocate existing gas mains (incl. adjustments to valves)			LS	\$ 25,000	\$ -	\$ -
C - 6	Relocate or adjust to grade existing light standards			ea	\$ 1,500	\$ -	\$ -
C - 7	Relocate existing fibre-optic cables			LS	\$ 30,000	\$ -	\$ -
C - 8	Relocate or adjust existing water mains (major)			LS	\$ 10,000	\$ -	\$ -
C - 9	Relocate or adjust existing water mains (minor)			LS	\$ 15,000	\$ -	\$ -
C - 10	Adjust watermain appurtenances (incl. valves, chambers and manholes)			ea	\$ 200	\$ -	\$ -
C - 11	Relocate hydrant and valve			ea	\$ 4,000	\$ -	\$ -
C - 12	Adjust manholes to grade (all types)			ea	\$ 855	\$ -	\$ -
C - 13	Relocate storm sewer catchbasins			ea	\$ 3,000	\$ -	\$ -
Subtotal						\$ -	\$ -



Section D - Remove, Dispose and Reinstall							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
D - 1	Clearing and grubbing (estimated 5.0 m back from face of curb)	20000	23000	m ²	\$ 1.3	\$ 26,000	\$ 29,900
D - 2	Stripping and stockpiling of topsoil and sod (300 mm depth)	6000	6300	m ³	\$ 20	\$ 120,000	\$ 126,000
D - 3	Remove, dispose or store and reinstall existing fence (all types)			m	\$ 8	\$ -	\$ -
D - 4	Remove, dispose or store and reinstall existing signs			ea	\$ 150	\$ -	\$ -
D - 5	Remove and dispose of existing sidewalk			m ²	\$ 7	\$ -	\$ -
D - 6	Sawcut existing road asphalt (any thickness)	1	1	LS	\$ 1,000	\$ 1,000	\$ 1,000
D - 7	Mill existing pavement surface (avg. 50 mm depth, 3.0 m wide at limit of asphalt incl. HL-3 asphalt for restoration)	1	1	LS	\$ 1,500	\$ 1,500	\$ 1,500
D - 8	Pulverization and stockpiling of existing asphalt (min. 300 mm depth, incl. grade and compact pulverized section)			m ²	\$ 3	\$ -	\$ -
D - 9	Remove existing road pavement (full depth incl. all granular material)		250	m ²	\$ 5	\$ -	\$ 1,250
D - 10	Remove and dispose of existing conc. curb (all types incl. conc. gutters)			m	\$ 11	\$ -	\$ -
D - 11	Remove and dispose of other existing conc. or asphalt (median islands, splash pads, etc.)			m ²	\$ 14	\$ -	\$ -
D - 12	Remove and dispose of minor culverts			m	\$ 30	\$ -	\$ -
D - 13	Remove and dispose of major culverts			m	\$ 40	\$ -	\$ -
D - 14	Remove existing signal light poles			ea	\$ 250	\$ -	\$ -
D - 15	Remove existing signal appurtenances (handwells, wire loop sensors, etc.)			ea	\$ 100	\$ -	\$ -
D - 16	Remove, salvage and restore miscellaneous appurtenances			LS	\$ 2,000	\$ -	\$ -
Subtotal						\$ 148,500	\$ 159,650
Section E - Road Construction							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
E - 1	Imported fill for road construction	20000	23000	m ³	\$ 25	\$ 500,000	\$ 575,000
E - 2	Prepare subgrade surface for road construction	11000	14550	m ²	\$ 2	\$ 22,000	\$ 29,100
E - 3	Granular 'A' for roadworks (assume 150 mm depth - incl. shoulders)	4125	5456.3	ton	\$ 17.00	\$ 70,125	\$ 92,756
E - 4	Granular 'A' for miscellaneous items (incl. driveways, splash pads, sidewalks, etc., avg 200 mm depth)	1125	1150	ton	\$ 17.00	\$ 19,125	\$ 19,550
E - 5	Granular 'B' for roadworks (assume 450 mm depth - incl. shoulders)	12375	16369	ton	\$ 12.00	\$ 148,500	\$ 196,425
E - 6	Surface course asphalt (assume HL-3, min. 50 mm depth)	1375	1818.8	ton	\$ 115.0	\$ 158,125	\$ 209,156
E - 7	Heavy duty binder course (HDBC) - (PG64-28) 100 mm depth	2750	3637.5	ton	\$ 82.0	\$ 225,500	\$ 298,275
E - 8	Miscellaneous asphalt (assume HL3, min. 75 mm depth, for driveways, splash pads, splitter islands, etc.)			m	\$ 16.54	\$ -	\$ -
E - 9	Concrete curb and gutter (all types)	2050	2350	m	\$ 48	\$ 98,400	\$ 112,800
E - 10	Reconstruction of existing driveways (asphalt or gravel)			m ²	\$ 52	\$ -	\$ -
E - 11	Perforated subdrains under concrete curbs (assume 150 mm)	1280	1350	m	\$ 25	\$ 32,000	\$ 33,750
E - 12	Concrete for splitter islands	1500	2500	m ²	\$ 50	\$ 75,000	\$ 125,000
E - 13	Concrete - coloured and stamped for truck apron (200 mm thick)		400	m ²	\$ 123	\$ -	\$ 49,200
E - 14	Concrete sidewalk (assume 3.0 m width)	2250	2300	m ²	\$ 53	\$ 119,250	\$ 121,900
E - 15	Rip-rap for roadway spillways and along ditches (incl. geotextile fabric)			m ²	\$ 30	\$ -	\$ -
E - 16	Allowance for night paving	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 17	Short-term lane closure	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 18	Supply and install CSP culverts (minor)	50	50	m	\$ 100	\$ 5,000	\$ 5,000



E - 19	Supply and install CSP culverts (major)			m	\$ 125	\$ -	\$ -
Subtotal						\$ 1,513,025	\$ 1,907,913
Section F - Pavement Markings and Signage							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
F - 1	Temporary pavement marking for construction staging	8000	8000	m	\$ 6	\$ 48,000	\$ 48,000
F - 2	Painted pavement markings	6500	5400	m	\$ 10	\$ 65,000	\$ 54,000
F - 3	Durable pavement markings	240	400	m	\$ 20	\$ 4,800	\$ 8,000
F - 4	Durable pavement messages (arrows, crosswalk markings, etc.)	60	62	ea	\$ 180	\$ 10,800	\$ 11,160
F - 5	Supply and install custom map-type signs (incl. base and posts)		8	ea	\$ 1,200	\$ -	\$ 9,600
F - 6	Supply and install signs (incl. base and posts)	4	36	ea	\$ 160	\$ 640	\$ 5,760
F - 7	Supply and install temporary project sign board (incl. base and posts)	8	8	ea	\$ 250	\$ 2,000	\$ 2,000
Subtotal						\$ 131,240	\$ 138,520
Section G - Street Lighting, Signals and Electrical							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
G - 1	Supply and install light standards (all types incl. appurtenances)	25	57	ea	\$ 1,000	\$ 25,000	\$ 57,000
G - 2	Supply and install signals for intersections	1		LS	\$ 200,000	\$ 200,000	\$ -
G - 3	Electrical service to central island		1	LS	\$ 5,000	\$ -	\$ 5,000
G - 4	Connect to grid		1	LS	\$ 2,500	\$ -	\$ 2,500
G - 5	Temporary signals			LS	\$ 50,000	\$ -	\$ -
Subtotal						\$ 225,000	\$ 64,500
Section H - Landscaping, Erosion Control and Miscellaneous							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
H - 1	Utility locates or dig-ups			ea	\$ 450	\$ -	\$ -
H - 2	Supply, install and maintain sediment control fence (OPSD 219.110)	1500	2500	m	\$ 12	\$ 18,000	\$ 30,000
H - 3	Supply and install straw bale check dams (OPSD 219.180)	15	25	ea	\$ 150	\$ 2,250	\$ 3,750
H - 4	Landscaping (incl. topsoil, sod, seeding and central island plantings, assume 2% of parts D-G)	2	2	LS	2%	\$ 40,355	\$ 45,412
H - 5	Supply and install new or reinstated fences			m	40	\$ -	\$ -
H - 6	Dust and noise control	2	2	LS	\$ 1,500	\$ 3,000	\$ 3,000
Subtotal						\$ 63,605	\$ 82,162



Summary			
Section	Description	Estimated Cost	
		SIG	RBT
A	Property acquisition subtotal	\$ 872,500	\$ 1,006,500
B	General requirements	\$ 154,967	\$ 173,113
C	Utility relocations and adjustments	\$ -	\$ -
D	Remove, dispose or reinstall	\$ 148,500	\$ 229,000
E	Road construction	\$ 1,861,355	\$ 2,365,605
F	Pavement markings and signage	\$ 131,240	\$ 138,520
G	Street lighting, signals and electrical	\$ 225,000	\$ 64,500
H	Landscaping, erosion control and maintenance	\$ 70,572	\$ 92,703
I	Construction subtotal	\$ 2,591,634	\$ 3,063,441
J	Engineering fees 15%	\$ 388,745	\$ 459,516
K	Contingency 20%	\$ 518,327	\$ 612,688
L	Construction total	\$ 3,498,705	\$ 4,135,645
M	HST 1.76%	\$ 61,577	\$ 72,787
N	Grand total (including property acquisition)	\$ 4,432,783	\$ 5,214,932



Section A - Property Acquisition							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
A - 1	Business park			m ²	\$ 62	\$ -	\$ -
A - 2	Industrial			m ²	\$ 49	\$ -	\$ -
A - 3	Commercial			m ²	\$ 124	\$ -	\$ -
A - 4	Residential - low density			m ²	\$ 50	\$ -	\$ -
A - 5	Residential - high density			m ²	\$ 74	\$ -	\$ -
A - 6	Agricultural or vacant	17450	20130	m ²	\$ 50	\$ 872,500	\$ 1,006,500
A - 7	Additional impacts		0	LS	\$ 100,000	\$ -	\$ -
Subtotal						\$ 872,500	\$ 1,006,500
Section B - General Requirements							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
B - 1	Mobilization and demobilization	1	1	LS	\$ 16,000	\$ 16,000	\$ 16,000
B - 2	Construction layout by contractor	1	1	LS	\$ 9,000	\$ 9,000	\$ 9,000
B - 3	Traffic control and construction staging (incl. materials)	1	1	LS	\$ 32,500	\$ 32,500	\$ 32,500
B - 4	Bonds (assumes 2% of parts D-H)	1	1	LS	2%	\$ 48,733	\$ 57,807
B - 5	Insurance (assumes 2% of parts D-H)	1	1	LS	2%	\$ 48,733	\$ 57,807
B - 6	Supply and place contract admin. office	1	1	LS	\$ 29,500	\$ 29,500	\$ 29,500
Subtotal						\$ 154,967	\$ 173,113
Section C - Utility Relocations and Adjustments							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
C - 1	Remove and dispose of existing hydro poles			ea	\$ 25,000	\$ -	\$ -
C - 2	Adjust to grade existing hydro poles			ea	\$ 4,000	\$ -	\$ -
C - 3	Relocation of underground power supply			LS	\$ 10,000	\$ -	\$ -
C - 4	Relocate or adjust to grade existing phone pedestals			ea	\$ 500	\$ -	\$ -
C - 5	Relocate existing gas mains (incl. adjustments to valves)			LS	\$ 25,000	\$ -	\$ -
C - 6	Relocate or adjust to grade existing light standards			ea	\$ 1,500	\$ -	\$ -
C - 7	Relocate existing fibre-optic cables			LS	\$ 30,000	\$ -	\$ -
C - 8	Relocate or adjust existing water mains (major)			LS	\$ 10,000	\$ -	\$ -
C - 9	Relocate or adjust existing water mains (minor)			LS	\$ 15,000	\$ -	\$ -
C - 10	Adjust watermain appurtenances (incl. valves, chambers and manholes)			ea	\$ 200	\$ -	\$ -
C - 11	Relocate hydrant and valve			ea	\$ 4,000	\$ -	\$ -
C - 12	Adjust manholes to grade (all types)			ea	\$ 855	\$ -	\$ -
C - 13	Relocate storm sewer catchbasins			ea	\$ 3,000	\$ -	\$ -
Subtotal						\$ -	\$ -



Section D - Remove, Dispose and Reinstall							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
D - 1	Clearing and grubbing (estimated 5.0 m back from face of curb)	20000	30000	m ²	\$ 1.3	\$ 26,000	\$ 39,000
D - 2	Stripping and stockpiling of topsoil and sod (300 mm depth)	6000	9000	m ³	\$ 20	\$ 120,000	\$ 180,000
D - 3	Remove, dispose or store and reinstall existing fence (all types)			m	\$ 8	\$ -	\$ -
D - 4	Remove, dispose or store and reinstall existing signs			ea	\$ 150	\$ -	\$ -
D - 5	Remove and dispose of existing sidewalk			m ²	\$ 7	\$ -	\$ -
D - 6	Sawcut existing road asphalt (any thickness)	1	1	LS	\$ 1,000	\$ 1,000	\$ 1,000
D - 7	Mill existing pavement surface (avg. 50 mm depth, 3.0 m wide at limit of asphalt incl. HL-3 asphalt for restoration)	1	1	LS	\$ 1,500	\$ 1,500	\$ 1,500
D - 8	Pulverization and stockpiling of existing asphalt (min. 300 mm depth, incl. grade and compact pulverized section)			m ²	\$ 3	\$ -	\$ -
D - 9	Remove existing road pavement (full depth incl. all granular material)		1500	m ²	\$ 5	\$ -	\$ 7,500
D - 10	Remove and dispose of existing conc. curb (all types incl. conc. gutters)			m	\$ 11	\$ -	\$ -
D - 11	Remove and dispose of other existing conc. or asphalt (median islands, splash pads, etc.)			m ²	\$ 14	\$ -	\$ -
D - 12	Remove and dispose of minor culverts			m	\$ 30	\$ -	\$ -
D - 13	Remove and dispose of major culverts			m	\$ 40	\$ -	\$ -
D - 14	Remove existing signal light poles			ea	\$ 250	\$ -	\$ -
D - 15	Remove existing signal appurtenances (handwells, wire loop sensors, etc.)			ea	\$ 100	\$ -	\$ -
D - 16	Remove, salvage and restore miscellaneous appurtenances			LS	\$ 2,000	\$ -	\$ -
Subtotal						\$ 148,500	\$ 229,000
Section E - Road Construction							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
E - 1	Imported fill for road construction	20000	30000	m ³	\$ 25	\$ 500,000	\$ 750,000
E - 2	Prepare subgrade surface for road construction	15900	17900	m ²	\$ 2	\$ 31,800	\$ 35,800
E - 3	Granular 'A' for roadworks (assume 150 mm depth - incl. shoulders)	5960	6710	ton	\$ 17.00	\$ 101,320	\$ 114,070
E - 4	Granular 'A' for miscellaneous items (incl. driveways, splash pads, sidewalks, etc., avg 200 mm depth)	1025	1125	ton	\$ 17.00	\$ 17,425	\$ 19,125
E - 5	Granular 'B' for roadworks (assume 450 mm depth - incl. shoulders)	17880	20130	ton	\$ 12.00	\$ 214,560	\$ 241,560
E - 6	Surface course asphalt (assume HL-3, min. 50 mm depth)	1980	2240	ton	\$ 115.0	\$ 227,700	\$ 257,600
E - 7	Heavy duty binder course (HDBC) - (PG64-28) 100 mm depth	4000	4500	ton	\$ 82.0	\$ 328,000	\$ 369,000
E - 8	Miscellaneous asphalt (assume HL3, min. 75 mm depth, for driveways, splash pads, splitter islands, etc.)			m	\$ 16.54	\$ -	\$ -
E - 9	Concrete curb and gutter (all types)	2525	3000	m	\$ 48	\$ 121,200	\$ 144,000
E - 10	Reconstruction of existing driveways (asphalt or gravel)			m ²	\$ 52	\$ -	\$ -
E - 11	Perforated subdrains under concrete curbs (assume 150 mm)	1650	1650	m	\$ 25	\$ 41,250	\$ 41,250
E - 12	Concrete for splitter islands	1800	2800	m ²	\$ 50	\$ 90,000	\$ 140,000
E - 13	Concrete - coloured and stamped for truck apron (200 mm thick)		400	m ²	\$ 123	\$ -	\$ 49,200
E - 14	Concrete sidewalk (assume 3.0 m width)	2700	3000	m ²	\$ 53	\$ 143,100	\$ 159,000
E - 15	Rip-rap for roadway spillways and along ditches (incl. geotextile fabric)			m ²	\$ 30	\$ -	\$ -
E - 16	Allowance for night paving	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 17	Short-term lane closure	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 18	Supply and install CSP culverts (minor)	50	50	m	\$ 100	\$ 5,000	\$ 5,000



E - 19	Supply and install CSP culverts (major)			m	\$ 125	\$ -	\$ -
Subtotal						\$ 1,861,355	\$ 2,365,605
Section F - Pavement Markings and Signage							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
F - 1	Temporary pavement marking for construction staging	8000	8000	m	\$ 6	\$ 48,000	\$ 48,000
F - 2	Painted pavement markings	6500	5400	m	\$ 10	\$ 65,000	\$ 54,000
F - 3	Durable pavement markings	240	400	m	\$ 20	\$ 4,800	\$ 8,000
F - 4	Durable pavement messages (arrows, crosswalk markings, etc.)	60	62	ea	\$ 180	\$ 10,800	\$ 11,160
F - 5	Supply and install custom map-type signs (incl. base and posts)		8	ea	\$ 1,200	\$ -	\$ 9,600
F - 6	Supply and install signs (incl. base and posts)	4	36	ea	\$ 160	\$ 640	\$ 5,760
F - 7	Supply and install temporary project sign board (incl. base and posts)	8	8	ea	\$ 250	\$ 2,000	\$ 2,000
Subtotal						\$ 131,240	\$ 138,520
Section G - Street Lighting, Signals and Electrical							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
G - 1	Supply and install light standards (all types incl. appurtenances)	25	57	ea	\$ 1,000	\$ 25,000	\$ 57,000
G - 2	Supply and install signals for intersections	1		LS	\$ 200,000	\$ 200,000	\$ -
G - 3	Electrical service to central island		1	LS	\$ 5,000	\$ -	\$ 5,000
G - 4	Connect to grid		1	LS	\$ 2,500	\$ -	\$ 2,500
G - 5	Temporary signals			LS	\$ 50,000	\$ -	\$ -
Subtotal						\$ 225,000	\$ 64,500
Section H - Landscaping, Erosion Control and Miscellaneous							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
H - 1	Utility locates or dig-ups			ea	\$ 450	\$ -	\$ -
H - 2	Supply, install and maintain sediment control fence (OPSD 219.110)	1500	2500	m	\$ 12	\$ 18,000	\$ 30,000
H - 3	Supply and install straw bale check dams (OPSD 219.180)	15	25	ea	\$ 150	\$ 2,250	\$ 3,750
H - 4	Landscaping (incl. topsoil, sod, seeding and central island plantings, assume 2% of parts D-G)	2	2	LS	2%	\$ 47,322	\$ 55,953
H - 5	Supply and install new or reinstated fences			m	40	\$ -	\$ -
H - 6	Dust and noise control	2	2	LS	\$ 1,500	\$ 3,000	\$ 3,000
Subtotal						\$ 70,572	\$ 92,703



Summary			
Section	Description	Estimated Cost	
		SIG	RBT
A	Property acquisition subtotal	\$ 798,500	\$ 885,000
B	General requirements	\$ 136,767	\$ 141,601
C	Utility relocations and adjustments	\$ -	\$ -
D	Remove, dispose or reinstall	\$ 139,430	\$ 153,300
E	Road construction	\$ 1,424,360	\$ 1,668,938
F	Pavement markings and signage	\$ 131,240	\$ 138,520
G	Street lighting, signals and electrical	\$ 225,000	\$ 64,500
H	Landscaping, erosion control and maintenance	\$ 61,651	\$ 77,255
I	Construction subtotal	\$ 2,118,448	\$ 2,244,113
J	Engineering fees 15%	\$ 317,767	\$ 336,617
K	Contingency 20%	\$ 423,690	\$ 448,823
L	Construction total	\$ 2,859,905	\$ 3,029,553
M	HST 1.76%	\$ 50,334	\$ 53,320
N	Grand total (including property acquisition)	\$ 3,708,739	\$ 3,967,873



Section A - Property Acquisition							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
A - 1	Business park			m ²	\$ 62	\$ -	\$ -
A - 2	Industrial			m ²	\$ 49	\$ -	\$ -
A - 3	Commercial			m ²	\$ 124	\$ -	\$ -
A - 4	Residential - low density			m ²	\$ 50	\$ -	\$ -
A - 5	Residential - high density			m ²	\$ 74	\$ -	\$ -
A - 6	Agricultural or vacant	15970	17700	m ²	\$ 50	\$ 798,500	\$ 885,000
A - 7	Additional impacts			LS	\$ 100,000	\$ -	\$ -
Subtotal						\$ 798,500	\$ 885,000
Section B - General Requirements							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
B - 1	Mobilization and demobilization	1	1	LS	\$ 16,000	\$ 16,000	\$ 16,000
B - 2	Construction layout by contractor	1	1	LS	\$ 9,000	\$ 9,000	\$ 9,000
B - 3	Traffic control and construction staging (incl. materials)	1	1	LS	\$ 32,500	\$ 32,500	\$ 32,500
B - 4	Bonds (assumes 2% of parts D-H)	1	1	LS	2%	\$ 39,634	\$ 42,050
B - 5	Insurance (assumes 2% of parts D-H)	1	1	LS	2%	\$ 39,634	\$ 42,050
B - 6	Supply and place contract admin. office	1	1	LS	\$ 29,500	\$ 29,500	\$ 29,500
Subtotal						\$ 136,767	\$ 141,601
Section C - Utility Relocations and Adjustments							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
C - 1	Remove and dispose of existing hydro poles			ea	\$ 25,000	\$ -	\$ -
C - 2	Adjust to grade existing hydro poles			ea	\$ 4,000	\$ -	\$ -
C - 3	Relocation of underground power supply			LS	\$ 10,000	\$ -	\$ -
C - 4	Relocate or adjust to grade existing phone pedestals			ea	\$ 500	\$ -	\$ -
C - 5	Relocate existing gas mains (incl. adjustments to valves)			LS	\$ 25,000	\$ -	\$ -
C - 6	Relocate or adjust to grade existing light standards			ea	\$ 1,500	\$ -	\$ -
C - 7	Relocate existing fibre-optic cables			LS	\$ 30,000	\$ -	\$ -
C - 8	Relocate or adjust existing water mains (major)			LS	\$ 10,000	\$ -	\$ -
C - 9	Relocate or adjust existing water mains (minor)			LS	\$ 15,000	\$ -	\$ -
C - 10	Adjust watermain appurtenances (incl. valves, chambers and manholes)			ea	\$ 200	\$ -	\$ -
C - 11	Relocate hydrant and valve			ea	\$ 4,000	\$ -	\$ -
C - 12	Adjust manholes to grade (all types)			ea	\$ 855	\$ -	\$ -
C - 13	Relocate storm sewer catchbasins			ea	\$ 3,000	\$ -	\$ -
Subtotal						\$ -	\$ -



Section D - Remove, Dispose and Reinstall							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
D - 1	Clearing and grubbing (estimated 5.0 m back from face of curb)	19100	21000	m ²	\$ 1.3	\$ 24,830	\$ 27,300
D - 2	Stripping and stockpiling of topsoil and sod (300 mm depth)	5730	6300	m ³	\$ 20	\$ 114,600	\$ 126,000
D - 3	Remove, dispose or store and reinstall existing fence (all types)			m	\$ 8	\$ -	\$ -
D - 4	Remove, dispose or store and reinstall existing signs			ea	\$ 150	\$ -	\$ -
D - 5	Remove and dispose of existing sidewalk			m ²	\$ 7	\$ -	\$ -
D - 6	Sawcut existing road asphalt (any thickness)			LS	\$ 1,000	\$ -	\$ -
D - 7	Mill existing pavement surface (avg. 50 mm depth, 3.0 m wide at limit of asphalt incl. HL-3 asphalt for restoration)			LS	\$ 1,500	\$ -	\$ -
D - 8	Pulverization and stockpiling of existing asphalt (min. 300 mm depth, incl. grade and compact pulverized section)			m ²	\$ 3	\$ -	\$ -
D - 9	Remove existing road pavement (full depth incl. all granular material)			m ²	\$ 5	\$ -	\$ -
D - 10	Remove and dispose of existing conc. curb (all types incl. conc. gutters)			m	\$ 11	\$ -	\$ -
D - 11	Remove and dispose of other existing conc. or asphalt (median islands, splash pads, etc.)			m ²	\$ 14	\$ -	\$ -
D - 12	Remove and dispose of minor culverts			m	\$ 30	\$ -	\$ -
D - 13	Remove and dispose of major culverts			m	\$ 40	\$ -	\$ -
D - 14	Remove existing signal light poles			ea	\$ 250	\$ -	\$ -
D - 15	Remove existing signal appurtenances (handwells, wire loop sensors, etc.)			ea	\$ 100	\$ -	\$ -
D - 16	Remove, salvage and restore miscellaneous appurtenances			LS	\$ 2,000	\$ -	\$ -
Subtotal						\$ 139,430	\$ 153,300
Section E - Road Construction							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
E - 1	Imported fill for road construction	19100	21000	m ³	\$ 25	\$ 477,500	\$ 525,000
E - 2	Prepare subgrade surface for road construction	11000	12450	m ²	\$ 2	\$ 22,000	\$ 24,900
E - 3	Granular 'A' for roadworks (assume 150 mm depth - incl. shoulders)	4125	4668.8	ton	\$ 17.00	\$ 70,125	\$ 79,369
E - 4	Granular 'A' for miscellaneous items (incl. driveways, splash pads, sidewalks, etc., avg 200 mm depth)	1230	1250	ton	\$ 17.00	\$ 20,910	\$ 21,250
E - 5	Granular 'B' for roadworks (assume 450 mm depth - incl. shoulders)	12375	14006	ton	\$ 12.00	\$ 148,500	\$ 168,075
E - 6	Surface course asphalt (assume HL-3, min. 50 mm depth)	1375	1556.3	ton	\$ 115.0	\$ 158,125	\$ 178,969
E - 7	Heavy duty binder course (HDBC) - (PG64-28) 100 mm depth	2750	3112.5	ton	\$ 82.0	\$ 225,500	\$ 255,225
E - 8	Miscellaneous asphalt (assume HL3, min. 75 mm depth, for driveways, splash pads, splitter islands, etc.)			m	\$ 16.54	\$ -	\$ -
E - 9	Concrete curb and gutter (all types)	1600	2000	m	\$ 48	\$ 76,800	\$ 96,000
E - 10	Reconstruction of existing driveways (asphalt or gravel)			m ²	\$ 52	\$ -	\$ -
E - 11	Perforated subdrains under concrete curbs (assume 150 mm)	1120	1150	m	\$ 25	\$ 28,000	\$ 28,750
E - 12	Concrete for splitter islands	600	1400	m ²	\$ 50	\$ 30,000	\$ 70,000
E - 13	Concrete - coloured and stamped for truck apron (200 mm thick)		400	m ²	\$ 123	\$ -	\$ 49,200
E - 14	Concrete sidewalk (assume 3.0 m width)	2300	2400	m ²	\$ 53	\$ 121,900	\$ 127,200
E - 15	Rip-rap for roadway spillways and along ditches (incl. geotextile fabric)			m ²	\$ 30	\$ -	\$ -
E - 16	Allowance for night paving	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 17	Short-term lane closure	1	1	LS	\$ 20,000	\$ 20,000	\$ 20,000
E - 18	Supply and install CSP culverts (minor)	50	50	m	\$ 100	\$ 5,000	\$ 5,000



E - 19	Supply and install CSP culverts (major)			m	\$ 125	\$ -	\$ -
Subtotal						\$ 1,424,360	\$ 1,668,938
Section F - Pavement Markings and Signage							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
F - 1	Temporary pavement marking for construction staging	8000	8000	m	\$ 6	\$ 48,000	\$ 48,000
F - 2	Painted pavement markings	6500	5400	m	\$ 10	\$ 65,000	\$ 54,000
F - 3	Durable pavement markings	240	400	m	\$ 20	\$ 4,800	\$ 8,000
F - 4	Durable pavement messages (arrows, crosswalk markings, etc.)	60	62	ea	\$ 180	\$ 10,800	\$ 11,160
F - 5	Supply and install custom map-type signs (incl. base and posts)		8	ea	\$ 1,200	\$ -	\$ 9,600
F - 6	Supply and install signs (incl. base and posts)	4	36	ea	\$ 160	\$ 640	\$ 5,760
F - 7	Supply and install temporary project sign board (incl. base and posts)	8	8	ea	\$ 250	\$ 2,000	\$ 2,000
Subtotal						\$ 131,240	\$ 138,520
Section G - Street Lighting, Signals and Electrical							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
G - 1	Supply and install light standards (all types incl. appurtenances)	25	57	ea	\$ 1,000	\$ 25,000	\$ 57,000
G - 2	Supply and install signals for intersections	1		LS	\$ 200,000	\$ 200,000	\$ -
G - 3	Electrical service to central island		1	LS	\$ 5,000	\$ -	\$ 5,000
G - 4	Connect to grid		1	LS	\$ 2,500	\$ -	\$ 2,500
G - 5	Temporary signals			LS	\$ 50,000	\$ -	\$ -
Subtotal						\$ 225,000	\$ 64,500
Section H - Landscaping, Erosion Control and Miscellaneous							
Item	Description	Estimated Quantity		Unit	Unit Rate	Estimated Cost	
		SIG	RBT			SIG	RBT
H - 1	Utility locates or dig-ups			ea	\$ 450	\$ -	\$ -
H - 2	Supply, install and maintain sediment control fence (OPSD 219.110)	1500	2500	m	\$ 12	\$ 18,000	\$ 30,000
H - 3	Supply and install straw bale check dams (OPSD 219.180)	15	25	ea	\$ 150	\$ 2,250	\$ 3,750
H - 4	Landscaping (incl. topsoil, sod, seeding and central island plantings, assume 2% of parts D-G)	2	2	LS	2%	\$ 38,401	\$ 40,505
H - 5	Supply and install new or reinstated fences			m	40	\$ -	\$ -
H - 6	Dust and noise control	2	2	LS	\$ 1,500	\$ 3,000	\$ 3,000
Subtotal						\$ 61,651	\$ 77,255

SUBMITTED BY CIMA CANADA INC.
 500-5935 Airport Road
 Mississauga, ON L4V 1W5
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APPENDIX G

**Stormwater Management Technical Memo
(MTE Consultants Inc., January 2019)**



TECHNICAL MEMORANDUM

TO:	<u>Dave Hallman</u>	MTE FILE NO.:	<u>C 36900-300</u>
		REGION FILE NO.:	<u>07299.E</u>
COMPANY:	<u>MTE Consultants Inc.</u>	DATE:	<u>January 21, 2019</u>
		FROM:	<u>Jennifer Joye, P.Eng.</u>
EMAIL:	<u>dhallman@mte85.com</u>	PROJECT NAME:	<u>East Boundary Road</u>

Re: East Boundary Road (EBR), Cambridge, ON – Stormwater Management (30% Design)

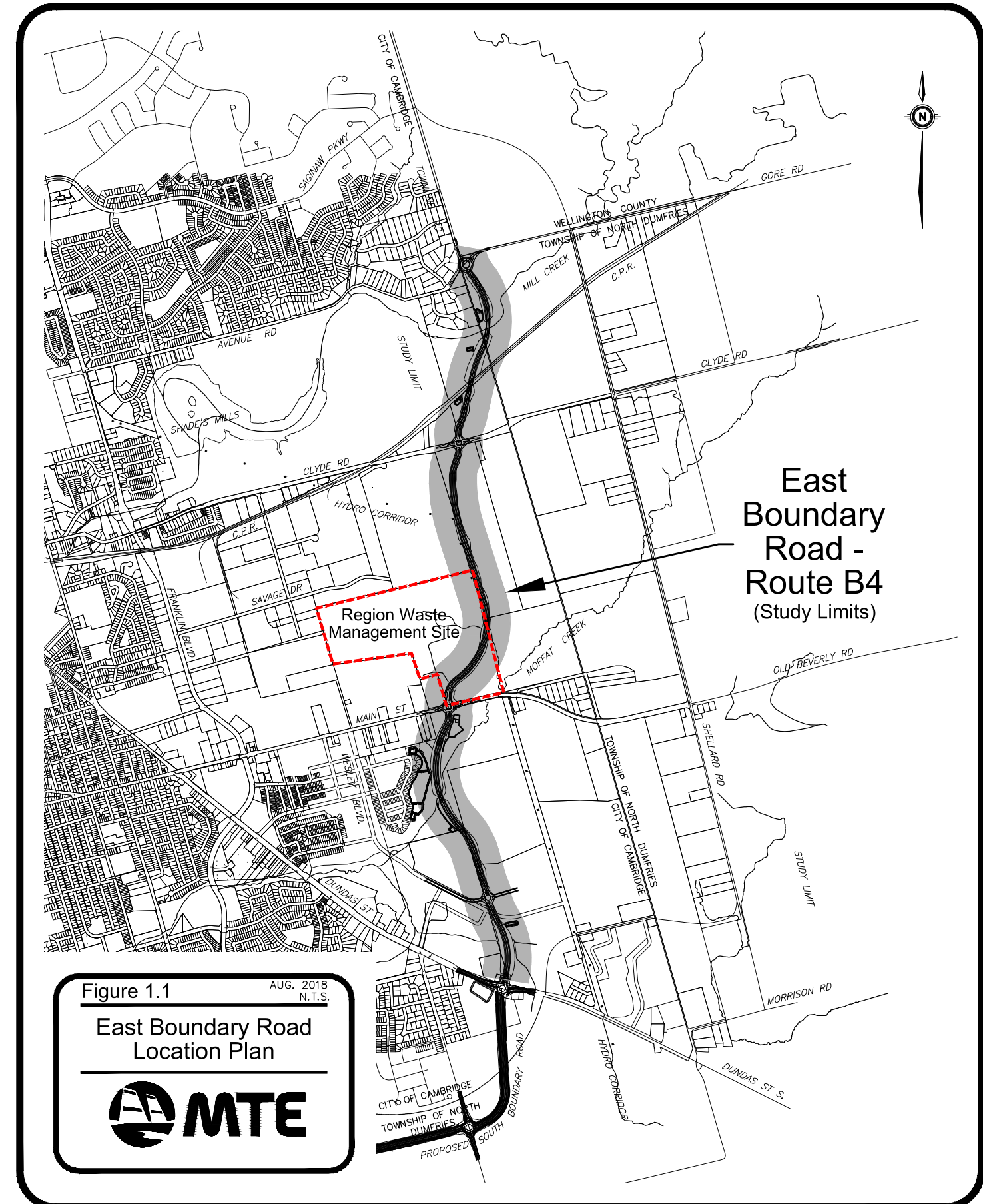
This Stormwater Management (30% Design) technical memorandum was completed as a supporting document for the Environmental Study Report of the Regional Municipality of Waterloo's Schedule C Class Environmental Assessment (Class EA) process undertaken for the EBR Corridor Study in the City of Cambridge and Township of North Dumfries. Lands within the EA Study Limits are primarily owned by private land owners, the Grand River Conservation Authority (GRCA), and the Regional Municipality of Waterloo (the Region), generally located in the southeastern quadrant of Cambridge. The Class EA subject lands incorporate lands north of Dundas Street South (Highway 8) and south of Avenue Road in Cambridge / Gore Road in North Dumfries with boundary limits as follows:

- North:** Avenue Road east of Shade's Mills Conservation Area to Townline Road and Gore Road;
- East:** 500 m east of Shellard Road in North Dumfries;
- South:** Dundas Street South (Highway 8) south of Myers Road; and
- West:** East of Franklin Boulevard / Dundas Street South and minimizing impacts to the Moffat Creek Wetland Complex, Cambridge Waste Management Site, and Mill Creek Wetland Complex.

This report presents the stormwater management quality and quantity considerations that are proposed to be provided for the East Boundary Road (EBR). This report should also be read in conjunction with the *East Boundary Road Class Environmental Assessment – Environmental Study Report (ESR)* prepared by MTE. The Regional Council-approved Preferred EBR route is route B4. Full discussion and analysis of potential routes can be seen in the Class EA ESR.

For the purposes of this Stormwater Management Design Brief, the subject lands comprise a total area of approximately 26.9ha, and are proposed to be the EBR and associated stormwater management blocks. Preliminary Design Plans for the proposed EBR have been prepared by MTE and form the basis for the proposed SWM strategy. Refer to **Figure 1.1 – Location Plan**.

The stormwater management strategy is based on water quality, quantity, and retention requirements stated in both the Moffat and Mill Creek Subwatershed studies. The recommended stormwater management solution is designed to provide enhanced levels of total suspended solids (TSS) removal, support surface water inputs into local wetland features, and mitigate the potential for stream erosion. The recommended solution consists of several extended detention, end-of-pipe stormwater management facilities.



The Natural Environment Report by Savanta (2015) written as part of a Class EA process was reviewed and its results were taken into consideration throughout the preliminary stormwater management design process. This report aided in identifying wetlands and other natural areas which required buffer zones and other design considerations.

The ultimate purpose of this study is to prepare a stormwater management strategy for the proposed EBR which implements the measures stated in all respective subwatershed studies, and that is acceptable to the Region of Waterloo, City of Cambridge, GRCA, and Ministry of the Environment, Conservation and Parks (MECP).

The objective of this stormwater management plan is to ensure that the proposed SWM infrastructure includes the necessary controls to protect the hydrology and water quality of the receiving water systems. Further, this plan also ensures that the East Boundary Road can be feasibly constructed while adhering to all SWM requirements. The primary objectives are as follows:

- Document criteria for the management of stormwater runoff from the study area;
- Recommend a general plan for controlling the quality and quantity of stormwater runoff from the study area;
- Recommend a comprehensive plan for balancing infiltration to groundwater and surface water inputs to existing features, with due consideration given to chloride/groundwater interaction; and
- Prepare preliminary designs for the recommended stormwater management infrastructure.

EXISTING CONDITIONS AND BACKGROUND INFORMATION

Topographical Information

The subject lands are currently comprised of a mix of agricultural, waste management, and forested areas. Significant portions of affected properties include wetland and woodland features within the Moffat and Mill Creek Wetland Complexes.

Topographical information was based on Region of Waterloo contours (2009). In areas where existing watercourse conditions needed to be confirmed, site visits took place to document general site conditions. Existing topographic conditions for the subject lands, as well as the surrounding lands, are shown in **Appendix A Drawings SWM1.1 – SWM1.3**. The subject lands range in elevation from approximately 284–319masl with slopes ranging from flat to 11%.

Catchment Drainage Conditions

The northern portion of the proposed EBR lands is currently within the Mill Creek subwatershed, with the southern portion within the Moffat Creek subwatershed.

The southern portion of the proposed EBR lands (Area 1 on **Drawing SWM1.1**, approximately 2.7ha) primarily drains to a centrally located wetland feature surrounding an upstream branch of Moffat Creek. This wetland area is in a low-lying flat area with approximately 95ha of upstream

drainage area. This upstream branch of Moffat Creek travels through the proposed path of the EBR and a culvert will be incorporated in the design of the EBR to maintain current flow patterns and volumes.

North of Area 1, the next portion of the East Boundary Road lands (Areas 2 and 3 on **Drawings SWM1.1 and SWM1.2**, approximately 4.7ha and 11.6ha, respectively) primarily drain to a centrally located wetland feature surrounding Moffat Creek as identified by the GRCA. The northern section of this wetland area (Area 3) has been given ecological land classifications of reed-canary grass mineral meadow marsh by Savanta and the southern portion (Area 2) has been classified as dry-moist old field meadow and a portion which was inaccessible for the Savanta review. The southern portion (Area 2) was also classified as part of the Moffat Creek Swamp Wetland. This section of Moffat Creek has approximately 850ha of upstream drainage area. This branch of Moffat Creek travels through the proposed path of the EBR and a culvert will be incorporated in the design of the EBR to maintain current flow characteristics. One upstream branch of the Creek is proposed to be realigned such that the confluence point with the main Creek branch occurs upstream of the proposed EBR location. This will also create additional creek bed (potential) habitat for benthics and fisheries.

The Region of Waterloo Cambridge Waste Management Site has designed stormwater and purge well water outlets within Area 3 north of Main Street. These outletting conditions are closely monitored by Region staff and the MECP to ensure water quality effluent from the Waste Management Site meets all MECP requirements. Stormwater runoff as well as groundwater purge well flows, are directed to a central stormwater management pond on site which provides quality and quantity control before the water is outletted (easterly) into a wetland feature which drains towards Moffat Creek. Consideration was given to maintaining these flow characteristics in the eventual design of the EBR to avoid any disruption of the Region's Waste Management Site effluent monitoring program and its association with Moffat Creek.

The Region of Waterloo Cambridge Waste Management Site has a SWM facility just north of Main Street in Area 3. This existing SWM facility lies in the proposed path of the EBR. The Region of Waterloo Cambridge Waste Management Site have acknowledged this conflict and are in agreement that detailed design for EBR will include consideration of the existing SWM facility at the south end of the property, utilizing currently undeveloped land adjacent to EBR.

Area 4 as shown on **Drawings SWM1.2 and SWM1.3** represents 5.4ha of the subject property, which primarily drains to a low point south of the CP Rail line before flowing generally north towards Mill Creek. Area 5, shown on **Drawing SWM1.3**, represents 2.5ha of the subject property which generally drains towards a collection of local wetlands feeding into Mill Creek. The existing Mill Creek drainage conditions will be preserved by a proposed EBR bridge being constructed over the reservoir created by an inline dam structure on Mill Creek immediately upstream of Shades Mill Conservation Area.

Floodplain Hydraulic Modelling

Current agency models were provided for both Mill and Moffat Creek by GRCA and were used as the base for floodplain hydraulic modelling using HEC-RAS. Floodplain elevations in the Mill Creek subwatershed were obtained from the provided model. Floodplain elevations in the Moffat Creek watershed were also generally obtained from the provided model. However, a revised model was created by MTE wherein cross sections 92 through 82.5 were modified to represent the proposed East Boundary Road, the proposed bridge crossing, and culverts, to determine whether potential floodplain elevation impacts result from the preferred EBR alignment and crossing.

STORMWATER MANAGEMENT CRITERIA

Relevant documents have been referenced in the design of the stormwater management plan for the subject lands, including:

- Stormwater Management Planning and Design Manual (MOE, 2003) (SWMPDM);
- GRCA Policies for the Administration of Ontario Regulation 150/06 (GRCA, October 2015);
- City of Cambridge Stormwater Management Policies and Guidelines (2011);
- Mill Creek Subwatershed Plan (1997);
- Moffat Creek Watershed Plan and Comprehensive Environmental Impact Statement (1996); and
- Low Impact Development Stormwater Management Planning and Design Guide (TRCA, 2010) (LID SWMPDG).

Based on the above policies and relevant documents, the following stormwater management criteria have been established for this study area:

- **Water Quality** – Provide an *Enhanced* (MOE, 2003) level of stormwater quality treatment prior to discharge to surface or groundwater systems.
- **Water Quantity and Erosion Control**
 - *Mill Creek* – Control peak flow rates to creek systems to existing levels, to minimize flooding and preserve hydraulic and hydrologic functions. Provide erosion control by maintaining existing flow duration characteristics.
 - *Moffat Creek* – Control peak flow rates to creek systems to 0.01m³/s/ha for the 5-year design storm and 0.03m³/s/ha for the 100-year design storm, to minimize flooding and preserve hydraulic and hydrologic functions. Provide erosion control by retaining the increase in runoff volume for the 5-year storm for a 36-hour drawdown period.
- **Water Balance**
 - *Infiltration* – Maintain or enhance existing recharge rates across the development area.
 - *Surface Water* – Maintain existing surface water volume inputs into significant environmental features.

Water Quality

All new stormwater management facilities proposed for the development will need to provide an Enhanced Level of water quality protection prior to discharge to the wetland features, Mill Creek or Moffat Creek. This is established in Table 3.2 of the *SWMPDM* (2003).

Water Quantity and Erosion Control

SWM Facilities 1, 2, and 3

SWM Facilities 1 through 3 all are within the Moffat Creek subwatershed and all will be subjected to the same quantity and erosion control requirements. The *Moffat Creek Watershed Plan* (1996) erosion control recommendations state the increase in the 5-year storm runoff volume should be detained within the SWM facility. A 36-hour drawdown period will be targeted. This volume will be calculated using two MIDUSS models for the catchment area, both with the same area but different impervious percentages, and will then be used with the falling head method of drawdown time per equations 4.10 and 4.11 in the *SWMPDM* (2003). The remaining quantity controls will be implemented to ensure that the 5-year and 100-year storm outflows do not exceed 0.01m³/s/ha and 0.03m³/s/ha, respectively.

SWM Facilities 4, 5A, and 5B

SWM Facilities 4 through 5B all are within the Mill Creek subwatershed and all will be subjected to the same quantity and erosion control requirements. Erosion control will be calculated using the extended detention value calculated as 40m³/ha from Table 3.2 of the *SWMPDM* (2003) for a 24-hour drawdown period. This volume will then be used with the falling head method of drawdown time per equations 4.10 and 4.11 in the *SWMPDM* (2003). The remaining quantity controls will be implemented to design the post-development SWM facility outflows to be less than or equal to the pre-development flow rates for each catchment area.

Water Balance (Infiltration)

Both the Mill and Moffat Creek subwatershed studies identify goals and targets for stormwater infiltration practices. These criteria should be implemented unless physical characteristics such as surface soils and the underlying geology of the development area are not conducive to infiltration. The applicable targets are as follows:

Mill Creek

- Utilize infiltration best management practices to effectively mimic the existing areal and timing characteristics of recharge (promote pre-development infiltration and runoff characteristics).
- Infiltration of stormwater should not negatively impact groundwater quality.

Moffat Creek

- Promote infiltration of the runoff volume generated during the first 13mm of rainfall.

LID measures should be considered that would serve to provide infiltration and/or quality treatment of EBR storm runoff.

Spatial Constraints

Given the relative proximity to local wetland and watercourse features, some additional design considerations were made with respect to specific special constraints, detailed as follows:

- Wetland buffers**
 A 30 metre buffer was provided between the edge of defined wetland features and any area grading to do with the SWMF design. The only exceptions were SWMF 3 and 5B; in these areas there was not available space to avoid the wetland buffer, so extents of related area grading changes were limited to be outside of any defined wetland area.
- Floodplain**
 Floodplain elevations were based on a combination of GRCA regulatory floodplain and the Stantec engineered floodplain from the February 2016 Moffat Creek subdivision report. SWM Facilities which needed to be within the wetland buffer areas were designed with preference to be outside of the 100-year and Regulatory floodplains. If a SWM Facility needed to be designed within the Regulatory floodplain, it was designed to ensure the 100-year floodplain will not be higher than the overflow weir; design specifics for each SWM Facility are provided later in this technical memorandum.

STORMWATER MANAGEMENT DESIGN

Hydrologic Modelling

The proposed development conditions were modeled for the:

- 5yr and 100yr return period rainfall events (3hr Chicago distribution derived from the City of Cambridge Intensity-Duration-Frequency parameters)
- Regional storm event (48-hr, 285mm depth – Hurricane Hazel)

Water Quality

All facilities, with the exception of SWM Facility 5A, have been designed as wet pond/wetland hybrids with permanent pool depths of 1.5m and wetland depths of 0.3m. SWM Facility 5A was designed as a combination of an oil/grit separator and detention basin. The wet facilities will incorporate a sediment forebay with a depth of 1.5m, which offer benefits of dilution and settling of sediment. All forebay designs will be explored in the detailed design stage based on classic particle settling and flow dispersion equations as presented in the *SWMPDM (2003)*.

A planting scheme will be prepared that carefully selects plant species and their location in and around the basins to stabilize banks, deter waterfowl from nesting within the area, and provide aesthetics and safety benefits.

Incorporation of LID measures might provide quality treatment of EBR storm runoff prior to reaching the proposed end-of-pipe SWM facilities.

Facility 1

Facility 1 services Dundas Street South to Wesley Boulevard. The total drainage area for Facility 1 (Area 1) is 2.5ha at 48% imperviousness. MECP requires 136m³/ha of total storage for an enhanced wet pond/wetland hybrid, 40m³/ha of which is extended detention. Since this facility is in the Moffat Creek watershed the extended detention volume is equal to the increase in the 5-year storm runoff volume from pre to post-development conditions. As such the required permanent pool and extended detention volumes for SWM Facility 1 are 239m³ and 334m³, respectively.

The forebay and main pond have permanent pool volumes of 66m³ and 173m³, respectively, for a total permanent pool volume of 239m³. In order to provide 36-hour extended detention for 334m³ of storage, a 63mm orifice is required. The facility outlets at an elevation of 288.0m and flows toward the adjacent wetland surrounding a branch/tributary of Moffat Creek; Moffat Creek is at approximately 285.0m. A culvert and channel realignment is proposed as EBR crosses Moffat Creek in this vicinity. Facility 1 design characteristics are summarized in **Table 1**. Refer to **Appendix B** for the relevant design sheets and calculations. Refer to **Drawing SWM1.1** for a conceptual location of Facility 1.

TABLE 1 - DESIGN CHARACTERISTICS – FACILITY 1

General	Facility Characteristics
Stormwater Management Facility Type	Wet Pond/Wetland Hybrid
Required MECP Water Quality Protection	Level 1 (Enhanced)
Total Contributing Area	2.49ha
Imperviousness	48%
Bottom Elevation (of main facility)	286.5m
Storage	
Unit Area Storage Volume Requirements - SWMPDM (MOE, 2003)	136m ³ /ha
Required Total Volume	338m ³
Permanent Pool	
Required Permanent Pool Volume	239m ³
Permanent Pool Elevation / Outlet Orifice Elevation	288.00m
Extended Detention	
Minimum Required Volume (Δ5-year runoff volume)	334m ³
Approximate Drawdown Time (for Moffat Creek requirement)	36hr
Extended Detention Elevation (Δ5-year runoff volume)	288.70m
Outlet Controls	
Orifice 1 Diameter (Extended Detention)	63mm
Weir 1 Crest (Quantity Control)	5.0m
Weir 1 Side-slopes (Quantity Control)	0.33
Weir 1 Elevation (Quantity Control)	288.60m



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Facility 2

Facility 2 services Wesley Boulevard northerly to the proposed bridge crossing of Moffat Creek (main branch). The total drainage area for Facility 2 (Area 2) is 4.7ha at 33% imperviousness. MECP requires 103.7m³/ha of total storage for an enhanced wet pond/wetland hybrid, 40 m³/ha of which is extended detention. Since this facility is in the Moffat Creek watershed the extended detention volume is equal to the increase in the 5-year storm runoff volume from pre to post-development conditions. As such, the required permanent pool and extended detention volumes for SWM Facility 2 are 302m³ and 436m³, respectively.

The forebay and main pond have permanent pool volumes of 80m³ and 222m³, respectively, for a total permanent pool volume of 302m³. In order to provide 36-hour extended detention for 436m³ of storage, a 64mm orifice is required. The facility outlets at an elevation of 286.0m and then flows along a proposed ditch swale along EBR, through the wetland feature to Moffat Creek; the local invert of Moffat Creek is approximately 282.9m. Facility 2 design characteristics are summarized in **Table 2**. Refer to **Appendix B** for the relevant design sheets and calculations. Refer to **Drawing SWM1.1** for a conceptual location of Facility 2.

TABLE 2 - DESIGN CHARACTERISTICS – FACILITY 2

General	Facility Characteristics
Stormwater Management Facility Type	Wet Pond/Wetland Hybrid
Required MOE Water Quality Protection	Level 1 (Enhanced)
Total Contributing Area	4.74ha
Imperviousness	33%
Bottom Elevation (of main facility)	283.00m
Storage	
Unit Area Storage Volume Requirements - SWMPDM (MOE, 2003)	103.7m ³ /ha
Required Total Volume	491m ³
<i>Permanent Pool</i>	
Required Permanent Pool Volume	301m ³
Permanent Pool Elevation / Outlet Orifice Elevation	286m
<i>Extended Detention</i>	
Minimum Required Volume (Δ5-year runoff volume)	436m ³
Approximate Drawdown Time (for Moffat Creek requirement)	36-hr
Extended Detention Elevation (Δ5-year runoff volume)	286.84m
Permanent Pool Elevation	286.00m
Bottom Elevation	284.50m
Outlet Controls	
Orifice 1 Diameter (Extended Detention)	64mm
Orifice 1 Elevation (Extended Detention)	286.00m
Weir 1 Crest	2.0m
Weir 1 Side-slopes	0.33
Weir 1 Elevation	286.80m



TECHNICAL MEMORANDUM

Facility 3

Facility 3 services the proposed bridge crossing of Moffat Creek (main branch), through Main Street, north of the RMOW Waste Management Site. The total drainage area for Facility 3 (Area 3) is 12.5ha at 39% imperviousness. MECP requires 118m³/ha of total storage for an enhanced wet pond/wetland hybrid, 40m³/ha of which is extended detention. Since this facility is in the Moffat Creek watershed the extended detention volume is equal to the increase in the 5-year storm runoff volume from pre to post-development conditions. The required permanent pool and extended detention volumes for SWM Facility 3 are 977m³ and 1364m³, respectively. The forebay and main pond have permanent pool volumes of 330m³ and 845m³, respectively, for a total permanent pool volume of 1175m³. In order to provide 36-hour extended detention for 1364m³ of storage, a 134mm orifice is required. The facility outlets at an elevation of 284.5m and then flows along a proposed ditch swale along EBR, through the wetland feature to Moffat Creek; the local invert of Moffat Creek is approximately 283.7m. The Facility 3 design characteristics are summarized in **Table 3**. Refer to **Appendix B** for the relevant design sheets and calculations. Refer to **Drawing SWM1.2** for a conceptual location of Facility 3.

TABLE 3 - DESIGN CHARACTERISTICS – FACILITY 3

General	Facility Characteristics
Stormwater Management Facility Type	Wet Pond/Wetland Hybrid
Required MOE Water Quality Protection	Level 1 (Enhanced)
Total Contributing Area	12.53ha
Imperviousness	39%
Bottom Elevation (of main facility)	283.00m
100-year Floodplain Elevation (MTE Moffat Creek HEC-RAS XS 84.1)	284.84m
Reg. Floodplain Elevation (MTE Moffat Creek HEC-RAS XS 84.1)	286.32m
Storage	
Unit Area Storage Volume Requirements - SWMPDM (MOE, 2003)	118m ³ /ha
Required Total Volume	1479m ³
<i>Permanent Pool</i>	
Required Permanent Pool Volume	977m ³
Permanent Pool Elevation / Outlet Orifice Elevation	284.50m
<i>Extended Detention</i>	
Minimum Required Volume (Δ5-year runoff volume)	1364m ³
Approximate Drawdown Time (for Moffat Creek requirement)	36-hr
Extended Detention Elevation (Δ5-year runoff volume)	284.90m
Permanent Pool Elevation	284.50m
Bottom Elevation	283.00m
Outlet Controls	
Orifice 1 Diameter (Extended Detention)	134mm
Orifice 1 Elevation (Extended Detention)	284.50m
Weir 1 Crest & Side Slopes	4.75m - 0.5
Weir 1 Elevation	285.10m

Facility 4

Facility 4 services the RMOW Waste Management Site, through Clyde Road, to the CP Rail Line. The total drainage area for Facility 4 (Area 4) is 5.6ha at 32% imperviousness. MECP requires 100.6m³/ha of total storage for an enhanced wet pond/wetland hybrid, 40m³/ha of which is extended detention. The required permanent pool and extended detention volumes for the SWM Facility 4 are therefore 336m³ and 222m³, respectively. Facility 4 is located within the Mill Creek subwatershed.

The forebay and main pond have permanent pool volumes of 84m³ and 252m³, respectively, for a total permanent pool volume of 336m³. The 222m³ of extended detention volume is controlled with a 65mm orifice. The facility outlets at an elevation of 301.0m, to an existing culvert under the CP Rail Line. This culvert should be examined for suitability in detailed design. The Facility 4 design characteristics are summarized in **Table 4**. Refer to **Appendix B** for the relevant design sheets and calculations. Refer to **Drawing SWM1.3** for a conceptual location of Facility 4.

TABLE 4 - DESIGN CHARACTERISTICS – FACILITY 4

General	Facility Characteristics
Stormwater Management Facility Type	Wet Pond/Wetland Hybrid
Required MOE Water Quality Protection	Level 1 (Enhanced)
Total Contributing Area	5.55ha
Imperviousness	32%
Bottom Elevation (of main facility)	299.50m
Storage	
Unit Area Storage Volume Requirements - SWMPDM (MOE, 2003)	100.6m ³ /ha
Required Total Volume	558.5m ³
<i>Permanent Pool</i>	
Required Permanent Pool Volume	336.4m ³
Permanent Pool Elevation / Outlet Orifice Elevation	301.00m
<i>Extended Detention</i>	
Minimum Required Volume	222m ³
Approximate Drawdown Time	24-hr
Extended Detention Elevation	301.50m
Bottom Elevation	299.50m
Outlet Controls	
Orifice 1 Diameter (Extended Detention)	65mm
Orifice 1 Elevation (Extended Detention)	301.00m
Weir 1 Crest Length (Vertical Side Slopes)	1.2m
Weir 1 Elevation	301.50m

Facility 5A

Facility 5A services the CP Rail Line to the south side of the proposed Mill Creek bridge crossing. The total drainage area for Facility 5A (Area 5A) is 1.2ha at 57% imperviousness. Enhanced suspended solids treatment is achieved using an oil/grit separator sized to capture 90% of runoff and capture 80% of solids. This capture rate can be achieved using a Stormceptor STC2000 or approved equivalent, see **Appendix B** for oil/grit separator sizing sheet. After flowing through the oil/grit separator, the runoff travels through a grassed swale before entering the dry cell portion of the facility. As the EBR profile continues lower across the proposed bridge crossing, major storm events are to be captured in an inlet storm grate and piped to the SWM Facility.

The dry cell has a volume capacity of 373m³. In order to meet pre-development runoff flow rates, a 155mm diameter orifice is needed. The facility outlets at an elevation of 296.0m and then flows overland to Mill Creek; the local upper bank of Mill Creek is approximately 294.8m. Facility 5A design characteristics are summarized in **Table 5**. Refer to **Drawing SWM1.3** for a conceptual location of Facility 5A.

TABLE 5 - DESIGN CHARACTERISTICS – FACILITY 5A

General	Facility Characteristics
Stormwater Management Facility Type	Dry Pond
Required MECP Water Quality Protection	Level 1 (Enhanced)
Oil/Grit Separator (or approved equivalent)	STC 2000
Total Contributing Area	1.19ha
Imperviousness	57%
Bottom Elevation (of main facility)	296.00m
Storage	
Total Storage Available	373m ³
Bottom Elevation	296.00m
Outlet Controls	
Orifice 1 Diameter (Extended Detention)	155mm
Orifice 1 Elevation (Extended Detention)	296.00m
Weir 1 Crest Length (3:1 Side slopes)	4.0m
Weir 1 Elevation	296.65m



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Facility 5B

Facility 5B services the south side of the proposed Mill Creek bridge crossing to the termination of EBR at Avenue/Gore Road. The total drainage area for Facility 5B (Area 5B) is 2.3ha at 47% imperviousness. MECP requires 134 m³/ha of total storage for an enhanced wet pond/wetland hybrid, 40m³/ha of which is extended detention. The required permanent pool and extended detention volumes for the SWM Facility 5B are therefore 214m³ and 91m³, respectively.

The forebay and main pond have permanent pool volumes of 54m³ and 160m³, respectively, for a total permanent pool volume of 214m³. In order to provide 24-hour extended detention for 91m³ of storage, a 70mm orifice is required. The facility outlets at an elevation of 294.25m and discharges to Mill Creek at approximately 293.5m. Facility 5B design characteristics are summarized in **Table 6**. Refer to **Appendix B** for the relevant design sheets and calculations. Refer to **Drawing SWM1.3** for a conceptual location of Facility 5B.

TABLE 6 - DESIGN CHARACTERISTICS – FACILITY 5B

General	Facility Characteristics
Stormwater Management Facility Type	Wet Pond/Wetland Hybrid
Required MOE Water Quality Protection	Level 1 (Enhanced)
Total Contributing Area	2.28ha
Imperviousness	47%
Bottom Elevation (of main facility)	292.75m
Regulatory (1982) Floodplain Elevation (Mill Creek HEC-RAS Model XS 3160)	294.07m
Storage	
Unit Area Storage Volume Requirements - SWMPDM (MOE, 2003)	134m ³ /ha
Required Total Volume	305m ³
<i>Permanent Pool</i>	
Required Permanent Pool Volume	214m ³
Permanent Pool Elevation / Outlet Orifice Elevation	294.25m
<i>Extended Detention</i>	
Minimum Required Volume	91m ³
Approximate Drawdown Time	22-hr
Extended Detention Elevation	294.35m
Permanent Pool Elevation	294.25m
Bottom Elevation	292.75m
Outlet Controls	
Orifice 1 Diameter (Extended Detention)	70mm
Orifice 1 Elevation (Extended Detention)	294.25m
Weir 1 Crest Length	1.2m
Weir 1 Elevation	294.45m
Weir 2 Crest Length	5.0m
Weir 2 Elevation	294.65m



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Water Quantity

Flows for all storm events will be conveyed to the end-of-pipe stormwater management facilities by a combination of storm sewer and overland flow route (road right-of-way).

Facility 1

The facility outlet to existing Moffat Creek wetlands is proposed to be a typical reverse slope pipe which outlets into the control manhole through a 63mm orifice plate at elevation 288.0m. This will provide extended detention, and control larger storms to an outflow which may be adequately dissipated by the outlet into the Wetland buffer.

The peak ponding elevation, storage, and outflow for Facility 1 for the various design storms are shown in **Table 7**, assuming a single 63mm orifice control until the weir at elevation 288.60m. Refer to **Appendix B** for preliminary design calculations.

TABLE 7 - PROPOSED EVENT MODEL OUTPUT – FACILITY 1

Storm Event	Maximum Ponding Elevation (m)	Peak Storage Requirement (m ³)	Allowable Outflow (m ³ /s)	Peak Outflow (m ³ /s)
5-year	288.61	521	0.027	0.019
100-year	288.64	551	0.082	0.069
Regional	288.62	535	-	0.042

Facility 2

The facility outlet to existing Moffat Creek wetlands is proposed to be a typical reverse slope pipe which outlets into the control manhole through a 64mm orifice plate at elevation 286.0m. This will provide extended detention, and control larger storms to an outflow which may be adequately dissipated by the outlet into the Wetland buffer.

The peak ponding elevation, storage, and outflow for Facility 2 for the various design storms are shown in **Table 8**, assuming a single 64mm orifice control until the weir at elevation 286.80m. In this section of Moffat Creek, the 100-year and Regulatory floodplain elevation were sourced using the MTE updated agency model Cross-Section 82.5 as 284.83m and 286.29m, respectively. Refer to **Appendix B** for preliminary design calculations.

TABLE 8 - PROPOSED EVENT MODEL OUTPUT – FACILITY 2

Storm Event	Maximum Ponding Elevation (m)	Peak Storage Requirement (m ³)	Allowable Outflow (m ³ /s)	Peak Outflow (m ³ /s)
5-year	286.80	692	0.047	0.047
100-year	286.87	772	0.142	0.142
Regional	286.89	793	-	0.099

Facility 3

The facility outlet to existing Moffat Creek wetlands is proposed to be a typical reverse slope pipe which outlets into the control manhole through a 134mm orifice plate at elevation 284.5m.



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This will provide extended detention, and control larger storms to an outflow which may be adequately dissipated by the outlet into Moffat Creek.

The peak ponding elevation, storage, and outflow for Facility 3 for the various design storms are shown in **Table 9**, assuming a single 134mm orifice control until the weir at elevation 285.10m. In this section of Moffat Creek, the 100-year and regulatory floodplain elevation were sources using the MTE updated agency models cross section 87 as 284.94m and 286.36m, respectively. Refer to **Appendix B** for preliminary design calculations.

TABLE 9 - PROPOSED EVENT MODEL OUTPUT – FACILITY 3

Storm Event	Maximum Ponding Elevation (m)	Peak Storage Requirement (m ³)	Allowable Outflow (m ³ /s)	Peak Outflow (m ³ /s)
5-year	285.14	2176.3	0.116	0.114
100-year	285.21	2443.3	0.348	0.286
Regional	285.18	2343.9	-	0.216

Facility 4

The facility outlet to existing surface drainage near the CP Rail line in the Mill Creek watershed is proposed to be a typical reverse slope pipe which outlets into the control manhole through a 65mm orifice plate at elevation 301.0m. This will provide extended detention, and control larger storms to an outflow which may be adequately dissipated by the outlet to local surface drainage flowing north towards Mill Creek.

The peak ponding elevation, storage, and outflow for Facility 4 for the various design storms are shown in **Table 10**, assuming a single 65mm orifice control until the weir at elevation 301.5m. Refer to **Appendix B** for preliminary design calculations.

TABLE 10 - PROPOSED EVENT MODEL OUTPUT – FACILITY 4

Storm Event	Maximum Ponding Elevation (m)	Peak Storage Requirement (m ³)	Pre-Development Flow (m ³ /s)	Peak Outflow (m ³ /s)
5-year	301.69	527	0.157	0.157
100-year	301.77	603	0.267	0.265
Regional	302.22	1071	-	0.182

Facility 5A

The facility outlet to existing wetland buffer to Mill Creek and is proposed to be a typical dry pond detention basin which outlets into the control manhole through a 155mm orifice plate at elevation 296.0m. This will provide control for larger storms to an outflow which may be adequately dissipated by the outlet to local surface drainage flowing north towards Mill Creek. Quality Control will be provided by an oil/grit separator the standard of STC2000 or approved equivalent.



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The peak ponding elevation, storage, and outflow for Facility 5A for the various design storms are shown in **Table 11**, assuming a single 155mm orifice control until the weir at elevation 296.65m. Refer to **Appendix B** for preliminary design calculations.

TABLE 11 - PROPOSED EVENT MODEL OUTPUT – FACILITY 5A

Storm Event	Maximum Ponding Elevation (m)	Peak Storage Requirement (m ³)	Pre-Development Flow (m ³ /s)	Peak Outflow (m ³ /s)
5-year	296.53	154	0.034	0.034
100-year	296.61	198	0.057	0.050
Regional	296.70	213	-	0.098

Facility 5B

The facility outlet to existing wetland buffer leading to Mill Creek is proposed to be a typical reverse slope pipe which outlets into the control manhole through a 70mm orifice plate at elevation 294.25m. This will provide extended detention, and control larger storms to an outflow which may be adequately dissipated by the outlet to local surface drainage flowing south towards Mill Creek.

The peak ponding elevation, storage, and outflow for Facility 5B for the various design storms are shown in **Table 12**, assuming a single 70mm orifice control until the weir at elevation 294.45m. In this section of Mill Creek, the regulatory floodplain elevation was sources using the agency models cross section 3160 as 294.07m. Refer to **Appendix B** for preliminary design calculations.

TABLE 12 - PROPOSED EVENT MODEL OUTPUT – FACILITY 5B

Storm Event	Maximum Ponding Elevation (m)	Peak Storage Requirement (m ³)	Pre-Development Flow (m ³ /s)	Peak Outflow (m ³ /s)
5-year	294.53	364	0.064	0.041
100-year	294.58	432	0.110	0.073
Regional	294.63	496	-	0.120

Water Balance

During urban development, the conversion of pervious, vegetated area to impervious surfaces leads to a decrease in evapotranspiration and infiltration volumes and an increase in runoff volumes. The Mill and Moffat Creek subwatershed studies established that both existing infiltration rates and existing surface water inputs to key natural features were to be maintained in the post-development condition.

Infiltration

At this stage of the study, due to the absence of geotechnical information, infiltration water balances will neither be calculated nor considered. Detailed design should involve detailed geotechnical investigations to provide a confident baseline of information, to consider infiltration potential and water balance characteristics.

To mitigate potential loss of infiltration due to increased imperviousness of the EBR, conveyance infiltration controls might be considered as design progresses. The storm sewer system has been kept out of the right-of-way centreline to provide potential locations for conveyance facilities or other measures (eg. Low Impact Development).

Floodplain Hydraulic Model Revisions

Floodplain elevations in the Mill Creek subwatershed were obtained from the model provided by the GRCA in April, 2018. This model was not revised as part of the 30% design process.

Floodplain elevations in the Moffat Creek watershed were generally obtained from a model provided by the GRCA in April, 2018. However, as part of the 30% design process, cross sections 92 through 82.5 were modified by MTE to represent the placement of the proposed East Boundary Road within the floodplain, the proposed bridge crossing and effective opening, and proposed drainage culverts, to determine whether potential floodplain elevation impacts result from the preferred EBR alignment and bridge crossing. It is proposed that the Moffat Creek channel be realigned through the proposed bridge opening and that an approximate 25m opening be provided. The modified sections and resulting flood elevations are shown in **Appendix A** on **Figure A-1**.

MTE consulted with Stantec (representing the Moffat Creek Subdivision developer) in May, 2018 regarding the hydraulic model modifications. Floodline elevations on the west side (development portion of the LVH lands) of the EBR remain unchanged from that provided by the GRCA, and accordingly, the proposed Moffat Creek Estates subdivision storm water management pond (SWM Pond) design will not be impacted due to changes in the floodline elevation resulting from proposed EBR. An equalization box culvert is proposed to convey an unnamed tributary north of the bridge crossing to maintain existing drainage conditions. Floodline elevations on the east side (undevelopable portion of the LVH lands) of the EBR increased by approximately 0.02m (2 cm).

SUMMARY

In summary, at the EBR stormwater management 30% design stage:

- Five (5) quality/quantity control stormwater management facilities and one (1) dry pond quantity control stormwater management facility with associated oil/grit separator are proposed to provide control of stormwater.
- The stormwater management strategy outlined herein can provide the site with appropriate levels of quality, quantity, erosion, and water balance controls, in the form of LID/conveyance or end-of-pipe measures, to meet the criteria set out for the East Boundary Road proposed development in accordance with subwatershed studies for Moffat Creek and Mill Creek.
- 'Enhanced' quality control of stormwater runoff can be provided in the proposed stormwater management facilities.

- Quantity control targets for post-development peak flow rates can be achieved in the proposed stormwater management facilities.

It is recommended the following be taken into consideration as design progresses:

- That a monitoring program be completed to determine groundwater elevations and seasonal fluctuations to establish the water table in the vicinity of the SWM facilities.
- That infiltration targets and SWM Pond elevations be evaluated once detailed geotechnical, groundwater, and topographical information is available to analyze infiltration and facility depth viability.
- That, through implementation of LID measures, the size of the proposed end-of-pipe facilities could be potentially reduced.
- That surface water inputs to the existing local wetlands/ESPAs be considered in the post-development condition.
- That hydraulic modelling of Moffat and Mill Creek for more frequent storm events (ie. 2-yr & 5-yr return events) is considered to ensure pond outlet functionality with respect to backwater effects.
- That hydraulic modelling of the proposed bridge crossings be updated to ensure no negative impacts to Regulatory flood elevations and that proposed channel realignments be reviewed with the appropriate review agencies.
- That existing culverts be assessed to establish form and capacity.
- That proposed culverts through EBR detailed design be suitably designed for flow capacity or equalization function.
- Ensure major overland flow routes are provided through intersections (including traffic circles), where applicable.
- The existing SWM facility at the south end of the Region of Waterloo Cambridge Waste Management Site is in the path of the proposed EBR route, and will need consideration through detailed design, prior to EBR implementation.
- During detailed design, a copy of the *Region of Waterloo Cambridge Waste Management Site – Stormwater Management and Design Brief (Lonsdale Consulting Engineers Inc., 2003)* should be reviewed to ensure any SWM facility revisions maintain existing quality, and quantity, controls.

SWM DESIGN SHEETS

APPENDIX B

East Boundary Road
30% STORMWATER MANAGEMENT DESIGN - SWMF 1
 Cambridge, Ontario

Project Number: 36900-300
 Date: January 21, 2019
 Design By: JCC/JNJ
 File: C:\36900\300\SWMS\SWMP1\36900-300 SWMP1 Design Sheet_Jan2019.xlsx



Step 1: Choose Level of Water Quality Control

Enhanced 80% long-term S.S. removal

Step 2: Choose Type of Facility

Hybrid Wet Pond/Wetland

Step 3: Define Catchment area and Imperviousness

Imperviousness (%)

48.00

Catchment Area (ha)

2.491

Interpolated Storage Volume Requirement (m³/ha)

136.00

338.8 m³

Permanent Pool Required (m³)

239.14

Extended Detention Volume Required (m³) (40 m³/ha)

99.64

Table 3-2 Water Quality Storage Requirements based on Receiving Waters (from MOE Stormwater Management Planning and Design Manual, March 2003)

Protection Level	SWMP Type	Storage Volume (m ³ /ha) for Impervious Level				
		35	55	70	85	85
Enhanced 80% long-term S.S. removal	Wetlands	80	105	120	140	140
	Hybrid Wet Pond/Wetland	110	150	175	195	195
Normal 70% long-term S.S. Removal	Wet Pond	140	190	225	250	250
	Wetlands	60	70	80	90	90
	Hybrid Wet Pond/Wetland	75	90	105	120	120
	Wet Pond	90	110	130	150	150
Basic 60% long-term S.S. Removal	Wetlands	60	60	60	60	60
	Hybrid Wet Pond/Wetland	60	70	75	80	80
	Wet Pond	60	75	85	95	95
	Dry Pond (Continuous Flow)	90	150	200	240	240

50-60% of PP should be in FB and wet cell in hybrid style ponds

Erosion Control Detention Volume Required (m³) (Δ5 year design storm volume)

406.00

**East Boundary Road
30% STORMWATER MANAGEMENT DESIGN - SWMF2**
Cambridge, Ontario



Project Number: 36900-300
Date: January 21, 2019
Design By: JCC/JNJ
File: C:\36900\300\SWM\SWMP1\36900-300 SWMP1 Design Sheet_Jan2019.xlsx

Step 1: Choose Level of Water Quality Control

Enhanced 80% long-term S.S. removal

Step 2: Choose Type of Facility

Hybrid Wet Pond/Wetland

Step 3: Define Catchment area and Imperviousness

Catchment Area (ha)

Imperviousness (%)

4.736

33.00

Interpolated Storage Volume Requirement (m³/ha)

103.71

491.2 m³

Permanent Pool Required (m³)

301.75

Extended Detention Volume Required (m³) (40 m³/ha)

189.44

50-60% of PP should be in FB and wet cell in hybrid style ponds

Erosion Control Detention Volume Required (m³) (Δ5 year design storm volume)

427

Table 3-2 Water Quality Storage Requirements based on Receiving Waters (from MOE Stormwater Management Planning and Design Manual, March 2003)

Protection Level	Storage Volume (m ³ /ha) for Impervious Level		
	35	55	70
Enhanced 80% long-term S.S. removal	Wetlands	80	105
	Hybrid Wet Pond/Wetland	110	150
	Wet Pond	140	190
Normal 70% long-term S.S. Removal	Wetlands	60	70
	Hybrid Wet Pond/Wetland	75	90
	Wet Pond	90	110
Basic 60% long-term S.S. Removal	Wetlands	60	60
	Hybrid Wet Pond/Wetland	60	70
	Wet Pond	60	75
	Dry Pond (Continuous Flow)	90	150
		200	240

**East Boundary Road
30% STORMWATER MANAGEMENT DESIGN - SWMF 3**
Cambridge, Ontario



Project Number: 36900-300
Date: January 21, 2019
Design By: JCC/JNJ
File: C:\36900\300\SWM\SWMP1\36900-300 SWMP1 Design Sheet_Jan2019.xlsx

Step 1: Choose Level of Water Quality Control

Enhanced 80% long-term S.S. removal

Step 2: Choose Type of Facility

Hybrid Wet Pond/Wetland

Step 3: Define Catchment area and Imperviousness

Catchment Area (ha)

Imperviousness (%)

12.53

39.00

Interpolated Storage Volume Requirement (m³/ha)

118.00

1479 m³

Permanent Pool Required (m³)

977.34

Extended Detention Volume Required (m³) (40 m³/ha)

501.20

50-60% of PP should be in FB and wet cell in hybrid style ponds

Erosion Control Detention Volume Required (m³) (Δ5 year design storm volume)

1259

Table 3-2 Water Quality Storage Requirements based on Receiving Waters (from MOE Stormwater Management Planning and Design Manual, March 2003)

Protection Level	Storage Volume (m ³ /ha) for Impervious Level		
	35	55	70
Enhanced 80% long-term S.S. removal	Wetlands	80	105
	Hybrid Wet Pond/Wetland	110	150
	Wet Pond	140	190
Normal 70% long-term S.S. Removal	Wetlands	60	70
	Hybrid Wet Pond/Wetland	75	90
	Wet Pond	90	110
Basic 60% long-term S.S. Removal	Wetlands	60	60
	Hybrid Wet Pond/Wetland	60	70
	Wet Pond	60	75
	Dry Pond (Continuous Flow)	90	150
		200	240



Table 3-2 Water Quality Storage Requirements based on Receiving Waters (from MOE Stormwater Management Planning and Design Manual, March 2003)

Protection Level	SWMP Type	Storage Volume (m ³ /ha) for Impervious Level				
		35	55	70	85	140
Enhanced 80% long-term S.S. removal	Wetlands	80	105	120	140	195
	Hybrid Wet Pond/Wetland	110	150	175	225	250
	Wet Pond	140	190	225	250	250
Normal 70% long-term S.S. Removal	Wetlands	60	70	80	90	120
	Hybrid Wet Pond/Wetland	75	90	105	120	150
	Wet Pond	90	110	130	150	150
Basic 60% long-term S.S. Removal	Wetlands	60	60	60	60	60
	Hybrid Wet Pond/Wetland	60	70	75	80	80
	Wet Pond	60	75	85	95	95
	Dry Pond (Continuous Flow)	90	150	200	240	240

50-60% of PP should be in FB and wet cell in hybrid style ponds

Step 1: Choose Level of Water Quality Control

Enhanced 80% long-term S.S. removal

Step 2: Choose Type of Facility

Hybrid Wet Pond/Wetland

Step 3: Define Catchment area and Imperviousness

Catchment Area (ha)

5.553

Imperviousness (%)

32.00

Interpolated Storage Volume Requirement (m³/ha)

100.57

558.5 m³

Permanent Pool Required (m³)

336.35

Extended Detention Volume Required (m³) (40 m³/ha)

222.12

Brief Stormceptor Sizing Report - East Boundary Road

Project Information & Location			
Project Name	East Boundary Road	Project Number	36900-300
City	Cambridge	State/ Province	Ontario
Country	Canada	Date	1/18/2019
Designer Information		EOR Information (optional)	
Name	Jake Carman	Name	
Company	MTE Consultants	Company	
Phone #	519-743-6500	Phone #	
Email	jcarman@mte85.com	Email	

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	East Boundary Road
Target TSS Removal (%)	71
TSS Removal (%) Provided	80
Recommended Stormceptor Model	STC 2000

The recommended Stormceptor Model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary		
Stormceptor Model	% TSS Removal Provided	% Runoff Volume Captured Provided
STC 300	63	75
STC 750	74	88
STC 1000	76	88
STC 1500	76	88
STC 2000	80	94
STC 3000	81	94
STC 4000	85	97
STC 5000	86	97
STC 6000	87	98
STC 9000	91	99
STC 10000	91	99
STC 14000	93	100
StormceptorMAX	Custom	Custom



Sizing Details			
Drainage Area		Water Quality Objective	
Total Area (ha)	1.19	TSS Removal (%)	71.0
Imperviousness %	57.0	Runoff Volume Capture (%)	90.00
Rainfall		Oil Spill Capture Volume (L)	
Station Name	WATERLOO WELLINGTON A	Peak Conveyed Flow Rate (L/s)	
State/Province	Ontario	Water Quality Flow Rate (L/s)	
Station ID #	9387	Up Stream Storage	
Years of Records	34	Storage (ha-m)	Discharge (cms)
Latitude	43°27'N	0.000	0.000
Longitude	80°23'W	Up Stream Flow Diversion	
		Max. Flow to Stormceptor (cms)	

Particle Size Distribution (PSD) The selected PSD defines TSS removal		
Fine Distribution		
Particle Diameter (microns)	Distribution %	Specific Gravity
20.0	20.0	1.30
60.0	20.0	1.80
150.0	20.0	2.20
400.0	20.0	2.65
2000.0	20.0	2.65

Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
- For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

For Stormceptor Specifications and Drawings Please Visit:
<http://www.imbriumsystems.com/technical-specifications>

**East Boundary Road
 30% STORMWATER MANAGEMENT DESIGN - SWMF 5B**
 Cambridge, Ontario

Project Number: 36900-300
 Date: January 21, 2019
 Design By: JCC/JNJ
 File: C:\36900\300\SWMM\SWMP1\36900-300 SWMP1 Design Sheet_Jan2019.xlsx

Step 1: Choose Level of Water Quality Control
 Enhanced 80% long-term S.S. removal

Step 2: Choose Type of Facility
 Hybrid Wet Pond/Wetland

Step 3: Define Catchment area and Imperviousness

Catchment Area (ha) **2.278** Imperviousness (%) **47.00**

Interpolated Storage Volume Requirement (m³/ha) **134.00** 305.3 m³

Permanent Pool Required (m³) **214.13**

Extended Detention Volume Required (m³) **91.12**

Table 3-2 Water Quality Storage Requirements based on Receiving Waters (from MOE Stormwater Management Planning and Design Manual, March 2003)

Protection Level	SWMP Type	Storage Volume (m ³ /ha) for Impervious Level				
		35	55	70	85	85
Enhanced 80% long-term S.S. removal	Wetlands	80	105	120	140	140
	Hybrid Wet Pond/Wetland	110	150	175	195	195
Normal 70% long-term S.S. Removal	Wet Pond	140	190	225	250	250
	Wetlands	60	70	80	90	90
Basic 60% long-term S.S. Removal	Hybrid Wet Pond/Wetland	75	90	105	120	120
	Wet Pond	90	110	130	150	150
	Wetlands	60	60	60	60	60
	Hybrid Wet Pond/Wetland	60	70	75	80	80
	Wet Pond	60	75	85	95	95
	Dry Pond (Continuous Flow)	90	150	200	240	240