Atlantic Road & Traffic Management

Traffic Engineering Specialists

Final Report

Mundy Pond Road Neighbourhood Traffic Impact Study

St. John's, NL

Prepared for

City of St. John's
Department of Engineering

September 2005

0532

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Executive Summary

Background

The City of St. John's has received an application to develop 228 residential dwelling units on land west of Columbus Drive. The parcel of land is bounded by Jensen Camp Road to the west, New Pennywell Road to the north, Columbus Drive to the east, and Empire Avenue to the south.

Since the Mundy Pond neighbourhood already has traffic problems, including heavy volumes on Blackmarsh Road and high shortcutting volumes on Mundy Pond Road, as well as westbound PM peak hour shortcutting on Empire Avenue between Columbus Drive and Blackmarsh Road, the City has required completion of a Traffic Impact Study (TIS) to evaluate the impacts of the proposed residential development and determine if mitigation measures are required.

Proposed Site Accesses

Accesses to the proposed development include three new street intersections on New Pennywell Road, and another access in the southeast corner of the site at the extension of Jensen Camp Road, just north of the Jensen Camp Place and Empire Avenue intersections.

Study Objectives

The primary objectives for the Study are:

- Review and evaluate the existing traffic volumes in the Mundy Pond Neighbourhood;
- Evaluate the traffic impacts of the proposed rezoning and development of 228 residential dwelling units on the Study Area street network;
- Review street alignment modification recommendations included in *Mundy Pond Road Neighbourhood Traffic Calming Study* (April 2004);
- Review plans that City of St. John's has prepared for improvements at the Blackmarsh Road / Empire Avenue and Hamlyn Road / Captain Whalen Drive intersections;
- Provide recommendations for traffic improvements to mitigate existing traffic problems;
- Provide recommendations for traffic improvements that may be needed to mitigate traffic impacts of the proposed residential development.

Study Area Streets

Columbus Drive is a major arterial street that provides a predominantly north-south connection along the eastern boundary of the Study Area. It is a four lane divided limited access street with a posted speed limit of 70 km/h. Average weekday two-way volumes are estimated to range from 29,000 vehicles per day (vpd) between Captain Whelan Drive and Blackmarsh Drive intersections to about 37,000 vpd between Mundy Pond Road and Old Pennywell Road intersections.

Blackmarsh Road is a minor arterial street that provides a connection between the City of Mount Pearl and St. John's western subdivisions to Columbus Drive and the central business district. The street has two

travel lanes (one for each direction of travel) with numerous intersections and driveways throughout its length. Average weekday two-way volumes range from about 15,000 vpd west of Empire Avenue, to 13,600 vpd west of Mundy Pond Road, and 6600 vpd between Mundy Pond Road and Columbus Drive.

Captain Whelan Drive is a collector street that provides a connection between Blackmarsh Road and Columbus Drive. The average weekday volume on the street is about 6500 vpd.

Empire Avenue is an east-west local street that connects Blackmarsh Road at the western Study Area boundary, to Jensen Camp Road which is an access road for the proposed residential development, and then to Columbus Drive at the eastern Study Area boundary. Average weekday volumes on Empire Avenue between Columbus Drive and Jensen Camp Road are about 2200 vpd, however, the majority of the traffic is in the westbound direction.

Mundy Pond Road, in the Study Area, is an east-west local street that connects Blackmarsh Road to Columbus Drive. Average weekday two-way volumes are about 8000 vpd east of Coefield Street and about 7400 vpd west of Coefield Street. While the trips from the Empire Avenue neighbourhoods that use Mundy Pond Road to access Columbus Drive can be considered local trips, this section of Mundy Pond Road is also use by large numbers of shortcutting trips from Blackmarsh Road west to access Columbus Drive northbound or continue east on Mundy Pond Road east of Columbus Drive.

New Pennywell Road is a local street that forms the northwest boundary of the Study Area. The existing traffic volume on the street is low with an average weekday two-way volume of about 1100 vpd.

Old Pennywell Road connects New Pennywell Road to Columbus Drive and also provides for east-west travel from the Columbus Drive intersection via Empire Avenue and Freshwater Road. Average weekday two-way volumes are estimated to be about 7000 vpd west of Columbus Drive and about 15,000 vpd east of Columbus Drive.

Collisions at Study Area intersections

Review of collision records for Study Area intersections for 2003 and 2004 indicates the following:

- There were 27 collisions (17 property damage and 10 injury) in 2003 and 27 collisions (15 property damage and 12 injury) in 2004;
- There is no significant difference between 2003 and 2004 data;
- 59% of collisions involved property damage only;
- 54% of collisions were rear end collisions;
- 87% occurred at signalized intersections; and
- There is no indication of existing safety problems at the STOP sign controlled intersections.

Trip Generation Estimates

Trip generation estimates for the proposed subdivision have been calculated using trip generation rates published in *Trip Generation, 7th Edition.* It is estimated that the 228 residential units will generate approximately 2200 two-way trips per day, including 171 trips (43 in and 128 out) during the AM peak hour and 230 trips (146 in and 84 out) during the PM peak hour.

Trip Distribution

The St. John's Regional Transportation QRS II Model was used to determine trip distribution for the proposed residential development. Based on trip distribution provided by the model, the following trip distribution was established for site generated trips:

- 45% north
- 25% east
- 20% south
- 10% west.

Summary Level of Service Analysis

Level of service analyses completed using Synchro 6.0 indicate:

- During 2005, all intersections operate with LOS 'C' or better, except the Columbus Drive / Mundy Pond Road intersection achieves only LOS 'D' during AM peak hours.
- During 2005, all intersection approaches operate at LOS 'D or better except the following:
  - Mundy Pond Road EB at Columbus Drive - LOS 'E' - AM
  - Columbus Drive NB at Mundy Pond Road - LOS 'E' - AM
  - Jensen Camp Road STOP approach to Blackmarsh Road - LOS 'E' - PM
  - Captain Whelan STOP approach to Blackmarsh Road - LOS 'F' - PM.
- During 2008 AM peak hours 'without' addition of site generated trips, annual traffic volume increases will cause significant reductions in level of performance at the Mundy Pond Road / Columbus Drive intersection. The overall intersection will operate at LOS 'E'; EB approach LOS 'E', and NB Columbus Drive approach will operate at LOS 'F'.
- Level of service analyses for 2008 volumes that include site generated trips, do not indicate any noticeable difference between the analyses for 2008 volumes 'without' site generated trips.
- Trips generated by the proposed 228 residential units are not expected to have any significant impacts on the level of performance of intersections or streets in the Study Area.

Summary of Study Area Traffic Problems

West - North Traffic Challenge - There is no convenient direct connection from the western part of the City of St. John's and the City of Mount Pearl to access the northern retail, industrial and institutional areas of Kenmount Road and Prince Philip Drive. Lacking a direct connection for this traffic movement, Blackmarsh Road has become one of the principal routes for travel between the western outskirts of the City and Columbus Drive. These trips create significant AM and PM shortcutting traffic problems on Study Area local streets. It is estimated that shortcutting trips may account for between 75% and 80% of the approximately 8000 vehicles per weekday on Mundy Pond Road between Blackmarsh Road and Columbus Drive.

Mundy Pond Road Neighbourhood Traffic Challenge - Since left turns from Empire Avenue to Columbus Drive northbound are not permitted, large numbers of trips from the Empire Avenue neighbourhoods and the western end of Blackmarsh Road use Mundy Pond Road to access Columbus Drive and to cross Columbus Drive to continue easterly towards the central business district. Traffic counts at Study Area intersections indicate that 41% of the eastbound trips use Mundy Pond Road to access or cross Columbus Drive. During the AM peak hour, about 535 vph of Mundy Pond Road eastbound trips are estimated to be shortcutting trips. Also, during the PM peak hour, about 460 vph of the westbound trips on Mundy Pond Road are shortcutting trips.

Empire Avenue Neighbourhood Traffic Challenge - During PM peak hours, traffic from Columbus Drive north and areas east of Columbus Drive use Study Area streets to travel to Blackmarsh Road at the western boundary of St. John's, as well as to Mount Pearl. About 50% of the 330 vph of southbound traffic from Columbus Drive that turns right to Empire Avenue during the PM peak hour uses Empire Avenue as a short cut to travel west towards Blackmarsh Road.

Recommendations Concerning Mundy Pond Road Shortcutting

The following changes are recommended to reduce shortcutting on Mundy Pond Road:

- Reduce the amount of green time allocated to Mundy Pond Road at the Columbus Drive traffic signals;
- Increase green time for Columbus Drive and add a northbound right turn lane on Columbus Drive at Mundy Pond Road;
- Construct both northbound and southbound right turn lanes on Columbus Drive at Blackmarsh Road intersection;
- Add an eastbound left-turn phase to the Blackmarsh Road traffic signals at Columbus Drive for the AM peak period;
- Install 3-way STOP signs at the Mundy Pond Road / Coefield Street intersection; and
- After observing impacts of signal timing changes, consider need for a curb extension on the south side of Mundy Pond Road east of the Alderberry Lane intersection to restrict eastbound Mundy Pond Road to one travel lane.

Recommendations Concerning Empire Avenue Shortcutting

Since the daily volume on Empire Avenue is low (2200 vpd), shortcutting volumes are low to moderate, and shortcutting occurs only in the westbound direction, mitigation measures are not needed and no actions are recommended.

Recommendations Concerning Modifications to the Blackmarsh Road / Empire Avenue Intersection

It is recommended that the west end of Empire Avenue become a cul-de-sac when modifications are completed for the Blackmarsh / Empire intersection during construction of a connector road to the East - West Arterial Road. Removal of Empire Avenue approach to the intersection will reduce the number of turning movements which will simply intersection design and improve operation, and will also reduce the attractiveness of Empire Avenue as a shortcutting or through street.

Conclusions Concerning Modifications to the Blackmarsh Road / Captain Whelan Drive Intersection

Relocation of the existing Blackmarsh / Captain Whelan intersection to form a four-way intersection with Captain Whelan Drive and Hamlyn Road will reduce the number of intersections on what will become the Captain Whelan / Blackmarsh / George's Pond minor arterial street connection to the East - West Arterial Road. The change will also make Captain Whelan Drive the through street which will make travel on Blackmarsh Road less attractive and will divert some traffic from the residential sections of Blackmarsh Road and Mundy Pond Road to the more limited access Captain Whelan Drive.

Conclusions - Mundy Pond Road Neighbourhood Traffic Impact Study

Conclusions reached from the Mundy Pond Road Neighbourhood Traffic Impact Study include:

- Trips generated by the proposed 228 residential units are not expected to have any significant impacts on the level of performance of intersections or streets in the Study Area.

- It is estimated that the Mundy Pond Road shortcutting traffic includes approximately:
  - 6000 two-way trips during a 24 hour weekday;
  - 535 eastbound trips during an AM peak hour;
  - 460 westbound trips during a PM peak hour.

- While some of the peak hour shortcutting trips on Mundy Pond Road may be diverted to Blackmarsh Road and Captain Whelan Drive, it must be realized that capacities are limited on those streets to accommodate additional eastbound left turning trips during peak periods. Also, there is limited capacity available on Columbus Drive during peak periods to accommodate additional northbound and southbound trips that may be diverted from Mundy Pond Road.

- The Study Area shortcutting problems can be attributed to lack of a convenient direct connection from the western part of St. John's and Mount Pearl to access the northern retail, industrial and institutional areas of Kenmount Road and Prince Philip Drive. As such, the ultimate solution to Study Area traffic problems is the construction of the proposed East - West Arterial Road with connections to Kenmount Road and the Outer Ring Highway.

1.0 Introduction

Background

The City of St. John's has received an application to develop 228 residential dwelling units on land west of Columbus Drive. The parcel of land is bounded by Jensen Camp Road to the west, New Pennywell Road to the north, Columbus Drive to the east, and Empire Avenue to the south (Figure 1).

Since the Mundy Pond neighbourhood already has traffic problems, including heavy volumes on Blackmarsh Road and high shortcutting volumes on Mundy Pond Road, as well as westbound PM peak hour shortcutting on Empire Avenue between Columbus Drive and Blackmarsh Road, the City has retained *Atlantic Road & Traffic Management* to complete a Traffic Impact Study (TIS) to evaluate the impacts of the proposed residential development and determine if mitigation measures are required.

A Traffic Impact Study Usually Considers Four Questions

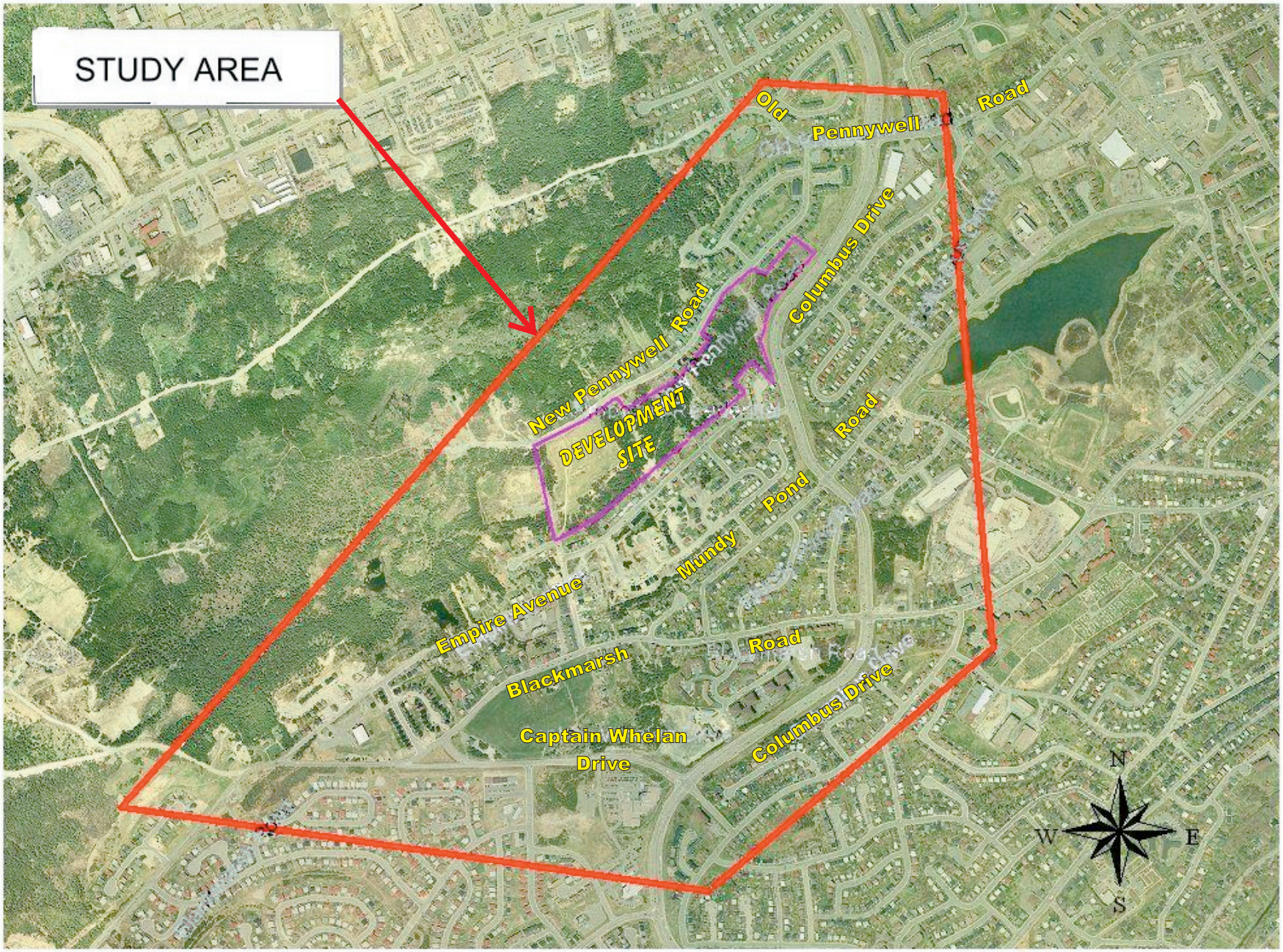
A TIS usually consists of four steps to answer the following questions:

1. **What are the existing traffic situations** on roads adjacent to the study site? How have traffic volumes increased historically?
2. **What traffic changes are expected** at Study Area intersections? How many vehicle trips will be generated by the proposed development during peak hours, as well as for a 24 hour weekday? How will the traffic be distributed at the exits from the development and to Study Area roads and intersections?
3. **What traffic impacts will occur** on Study Area roads and intersections? How will level of service at intersections be affected?
4. **What road or intersection improvements are required** to mitigate project impacts on Study Area traffic movements?

Study Objectives

The primary objectives for the Study are:

1. Review and evaluate the existing traffic volumes in the Mundy Pond Neighbourhood;
2. Evaluate the traffic impacts of the proposed rezoning and development of 228 residential dwelling units on the Study Area street network;
3. Review street alignment modification recommendations included in *Mundy Pond Road Neighbourhood Traffic Calming Study* (April 2004);
4. Review plans that City of St. John's has prepared for improvements at the Blackmarsh Road / Empire Avenue and Hamlyn Road / Captain Whalen Drive intersections;
5. Provide recommendations for traffic improvements to mitigate existing traffic problems;
6. Provide recommendations for traffic improvements that may be needed to mitigate traffic impacts of the proposed residential development.



Source: City of St. John's

Figure 1 - Study Area

September 2005

2.0 Description of Study Area

Study Area Boundaries

The Study Area boundaries (Figure 1) can be loosely described as:

- North - Old Pennywell Road at Columbus Drive intersection;
- East - Columbus Drive (except extending to Mercer's Lane / Dominion Store entrance intersection on Blackmarsh Road);
- South - Captain Whalen Drive between Blackmarsh Road and Columbus Drive, and Blackmarsh Road between Empire Avenue and Captain Whalen Drive;
- West - Empire Avenue at Blackmarsh Road intersection; Empire Avenue from Blackmarsh Road to Jensen Camp Road; and New Pennywell Road.

Description of Study Area Streets

Columbus Drive is a major arterial street that provides a predominantly north-south connection along the eastern boundary of the Study Area. The street connects with Pitts Memorial Drive in the south and the retail, industrial and institutional areas of Kenmount Road and Prince Philip Drive to the north. This is a four lane divided limited access street with a posted speed limit of 70 km/h. Average weekday two-way volumes are estimated to range from 29,000 vehicles per day (vpd) between Captain Whelan Drive and Blackmarsh Road intersections to about 37,000 vpd between Mundy Pond Road and Old Pennywell Road intersections. Two off-set Empire Avenue T-intersections are controlled by STOP signs and left-out turn restrictions from Empire to Columbus, and the following 4-way intersections are controlled by traffic signals:

- Captain Whelan Drive,
- Blackmarsh Road,
- Mundy Pond Road, and
- Old Pennywell Road.

Blackmarsh Road is a minor arterial street that provides a connection between the City of Mount Pearl and St. John's western subdivisions to Columbus Drive and the central business district. The street has two travel lanes (one for each direction of travel) with numerous intersections and driveways throughout its length. Average weekday two-way volumes range from about 15,000 vpd west of Empire Avenue, 13,600 vpd west of Mundy Pond Road, to 6600 vpd between Mundy Pond Road and Columbus Drive. With the exception of the signalized Columbus Drive and Mercer's Lane intersections, and all other street intersections are controlled by STOP signs on the side streets.

Captain Whelan Drive is a short collector street that provides a connection between Blackmarsh Road and Columbus Drive. The average weekday volume on the street section is about 6500 vpd. The street section has only three intersections throughout its length, including two street intersections and a major commercial entrance.

Empire Avenue is an east-west local street that connects Blackmarsh Road at the western Study Area boundary, to Jensen Camp Road which is an access road for the proposed residential development, and then to Columbus Drive at the eastern Study Area boundary. Traffic

using Empire Avenue is controlled by STOP signs at the west and east ends, as well at as the two intersections with Jensen Camp Road. While left turns 'from', and right turns 'to and from' Columbus Drive are permitted, left turns from Empire Avenue eastbound to Columbus Drive are not permitted. As a consequence, trips from Empire Avenue residential neighbourhood areas that wish to travel north on Columbus Drive must access Blackmarsh Road via Welland Street or Jensen Camp Road, or Mundy Pond Road via Coefield Street, and turn left from Blackmarsh Road or Mundy Pond Road onto Columbus Drive. Since a directional machine traffic count on Empire Avenue just west of Columbus Drive (Table A-6) indicates very low eastbound traffic volumes, trips from Empire Avenue neighbourhoods probably use either Mundy Pond Road or Blackmarsh Road to travel east of Columbus Drive.

Average weekday volumes on Empire Avenue between Columbus Drive and Jensen Camp Road are about 2200 vpd, however, as illustrated in Figures A-6 and A-7 (Appendix A), the majority of the traffic is in the westbound direction. During PM peak hours, traffic from Columbus Drive north of Empire Avenue, uses the sections of Empire Avenue in the Study Area as a short cut to travel to Blackmarsh Road at the western Study Area boundary as illustrated by the abrupt PM peak 'spikes' in Figures A-6 and A-7. Westbound PM peak hourly volumes vary from 330 vph between Columbus Drive and Jensen Camp Road (Table A-7), to 215 vph west of Jensens Camp Road (Table A-18) and 185 vph at Blackmarsh Road (Table A-13).

Mundy Pond Road, in the Study Area, is an east-west local street that connects Blackmarsh Road to Columbus Drive. East of Columbus Drive, Mundy Pond Road is a collector street providing east-west connections from the Mundy Pond Neighbourhoods and Columbus Drive areas to the CBD. Average weekday two-way volumes are about 8000 vpd east of Coefield Street (Table A-4) and about 7400 vpd west of Coefield Street (Table A-5). As illustrated in Figures A-4 and A-5, both AM and PM peak periods exhibit the peak hour 'spikes' which are typical of commuter routes.

Since traffic from Empire Avenue neighbourhoods cannot access Columbus Drive northbound at Empire Avenue, and also cannot travel eastbound at that intersection, many trips from that area use Mundy Pond Road for northbound access to Columbus Drive, as well as to travel east of Columbus Drive. While the trips from the Empire Avenue neighbourhoods can be considered local trips, this section of Mundy Pond Road has also become the route of choice for large numbers of shortcutting trips from Blackmarsh Road west to access Columbus Drive northbound or continue east on Mundy Pond Road east of Columbus Drive. It is estimated that shortcutting trips account for between 75% and 80% of the approximately 8000 vehicles per weekday on Mundy Pond Road between Blackmarsh Road and Columbus Drive.

New Pennywell Road is a local street that forms the northwest boundary of the Study Area. This street will provide the primary access for the proposed residential development including direct street access for about 29 units and three access street intersections to serve the subdivision. The existing traffic volume on the street is low with the average weekday two-way volume being about 1100 vpd (Table A-8).

Old Pennywell Road connects New Pennywell Road to Columbus Drive and also provides for east-west travel from the Columbus Drive intersection via Empire Avenue and Freshwater Road. The sections of Old Pennywell Road immediately west and east of Columbus Drive are classified as a minor arterial street. Average weekday two-way volumes are estimated to be about 7000 vpd west of Columbus Drive and about 15,000 vpd east of Columbus Drive.

Manual Turning Movement Counts and 2005 Peak Hour Volumes

AM and PM peak hour manual turning movement counts listed in Table 1 and tabulated in the indicated tables in Appendix A, have been used in this Study. Volumes for intersections on Blackmarsh Road and Columbus Drive have been balanced where appropriate and are shown diagrammatically on Figure B-1A (AM peak hour) and Figure B-1B (PM peak hour). These are existing 2005 AM and PM peak hour volumes that do not include any trips that will be generated by the proposed residential development.

Table 1 - Manual Turning Movement Counts

Intersection	Date	Day	Table
Columbus Drive @ Captain Whelan Drive / Hogan Street	Sept. 21, 2004	Tuesday	A-9
Columbus Drive @ Blackmarsh Road	June 22, 2005	Wednesday	A-10
Columbus Drive @ Mundy Pond Road	Oct. 19, 2004	Tuesday	A-11
Columbus Drive @ Old Pennywell Road	June 9, 2005	Thursday	A-12
Blackmarsh Road @ Empire Avenue	June 14. 2005	Tuesday	A-13
Blackmarsh Road @ Captain Whelan Drive	June 14, 2005	Tuesday	A-14
Blackmarsh Road @ Mundy Pond Road	June 7, 2005	Tuesday	A-15
Blackmarsh Road @ Mercers's Lane / Dominion Store	June 7, 2005	Tuesday	A-16
Blackmarsh Road @ Jensen Camp Road	Feb. 3, 2004	Tuesday	A-17
Empire Avenue @ Jensen Camp Road	Jan. 29, 2004	Thursday	A-18
Empire Avenue @ Dammerills Lane	Feb. 3, 2004	Tuesday	A-19
Mundy Pond Road @ Coefield Street	Feb. 3, 2004	Tuesday	A-20

Projected 2008 Peak Hour Volumes

An annual traffic volume growth rate of 1.3% per year was used during preparation of the *Final Report - Traffic Impact Study - Dominion Store - Blackmarsh Road* (*ARTM*, February 2004). A similar growth rate (4.0% for three years) has been used with 2005 peak hour volumes to provide projected 2008 peak hour volumes. Projected 2008 volumes for intersections on Blackmarsh Road and Columbus Drive are shown diagrammatically on Figure B-2A (AM peak hour) and Figure B-2B (PM peak hour). These are projected 2008 AM and PM peak hour volumes that do not include any trips that will be generated by the proposed residential development.

Machine Traffic Count Volumes

During June 2005, City of St. John's Traffic Division obtained several 24 hour weekday machine counts on Study Area streets. Volumes are tabulated in Tables A-1 to A-8, Appendix A, and are displayed diagrammatically in Figures A-1 to A-8. Machine count traffic volume data are summarized in Table 2.

The following average weekday two-way volumes have also been estimated using PM peak hour volumes from manual counts and the relationship between the PM peak hour and the weekday volume for the various machine counts, generally in the 8.5% to 9.0% range:

- Columbus Drive - north of Captain Whelan Drive - 29,000 vpd;
- Columbus Drive - south of Old Pennywell Road - 37,000 vpd;
- Blackmarsh Road - west of Empire Avenue - 15,000 vpd;
- Captain Whelan Drive - west of Columbus Drive - 6,500 vpd;
- Old Pennywell Road - west of Columbus Drive -7,000 vpd; and
- Old Pennywell Road - east of Columbus Drive - 15,000 vpd.

Table 2 - Summary of Machine Traffic Count Volumes

Table and Figure	Location	Date June 2005	Weekday Two-Way Volumes		
			Average Day (vpd)	AM Peak Hour (vph)	PM Peak Hour (vph)
A-1	Blackmarsh Road - west of Mundy Pond Road	13 - 15	13,900	1,200	1,160
A-2	Blackmarsh Rd. - EB Ramp to Captain Whelan Dr.	13 - 15	1,100 [1]	125 [1]	85 [1]
A-3	Blackmarsh Road - east of Mundy Pond Road	7 & 8	6,600	525	605
A-4	Mundy Pond Road - east of Coefield Street	7 & 8	8,040	575	710
A-5	Mundy Pond Road - west of Coefield Street	7 & 8 [2]	7,370	655	640
A-6	Empire Avenue - west of Columbus Drive	23 & 24	2,220 [3]	50	361
A-7	Empire Avenue - east of Jensen Camp Road	23 & 24	2,190 [4]	70	365
A-8	New Pennywell Road - west of Beothuck Street	27 & 28	1,075	45	95

NOTE:
1. One-way eastbound volumes only for the right turn channel from Blackmarsh Road to Captain Whelan Drive.
2. Westbound count was obtained on June 7 & 8, while eastbound count was obtained on June 23 & 24.
3. Volume is 96% westbound for the day; 92% WB during AM peak hour; and 96% WB during PM peak hour.
4. Volume is 80% westbound for the day; 72% WB during AM peak hour; and 90% WB during PM peak hour.

Review of Intersection Collision Records

Collision records for Study Area intersections for 2003 and 2004, obtained from the City's Traffic Division, are summarized by Collision Severity in Table 3 and by Collision Type in Table 4. The following observations have been noted from review of the data tables:

- There is no significant difference between 2003 and 2004 data;
- 59% involved property damage only;
- 54% involved rear end collisions;
- 87% occurred at signalized intersections; and
- There is no indication of existing safety problems at the STOP sign controlled intersections.

Table 3 - Summary of 2003 and 2004 Collision Records by Severity

Intersection	2003 Collisions by Severity			2004 Collisions by Severity		
	PDO	Injury	Total	PDO	Injury	Total
Columbus Dr @ Captain Whelan Dr	4	2	6	5	2	7
Columbus Dr @ Blackmarsh Rd	4	3	7	5	2	7
Columbus Dr @ Mundy Pond Rd	7	3	10	4	4	8
Columbus Dr @ Emipre Ave West	0	0	0	1	0	1
Columbus Dr @ Old Pennywell Rd	0	1	1	0	1	1
New Pennywell Rd @ Old Pennywell Rd	1	0	1	0	0	0
Blackmarsh Rd @ Mundy Pond Rd	1	0	1	0	1	1
Blackmarsh Rd @ Jensen Camp Rd	0	0	0	0	1	1
Blackmarsh Rd @ Empire Ave	0	1	1	0	1	1
TOTALS	17	10	27	15	12	27

NOTES: PDO means Property Damage Only.
Shaded boxes indicate traffic signal controlled intersections.

Table 4 - Summary of 2003 and 2004 Collision Records by Collision Type

Intersection	2003 Collisions by Type						2004 Collisions by Type					
	Right Angle	Rear End	Sideswipe	Turning	Other	Total	Right Angle	Rear End	Sideswipe	Turning	Other	Total
Columbus Dr @ Captain Whelan Dr	2	2	0	1	1	6	1	4	0	0	2	7
Columbus Dr @ Blackmarsh Rd	0	6	0	1	0	7	2	3	0	2	0	7
Columbus Dr @ Mundy Pond Rd	3	4	1	1	1	10	3	4	0	1	0	8
Columbus Dr @ Emipre Ave West	0	0	0	0	0	0	0	1	0	0	0	1
Columbus Dr @ Old Pennywell Rd	0	1	0	0	0	1	0	0	0	0	1	1
New Pennywell Rd @ Old Pennywell Rd	0	1	0	0	0	1	0	0	0	0	0	0
Blackmarsh Rd @ Mundy Pond Rd	0	1	0	0	0	1	0	0	0	1	0	1
Blackmarsh Rd @ Jensen Camp Rd	0	0	0	0	0	0	1	0	0	0	0	1
Blackmarsh Rd @ Empire Ave	0	1	0	0	0	1	0	1	0	0	0	1
TOTALS	5	16	1	3	2	27	7	13	0	4	3	27

NOTE: PDO means Property Damage Only
Shaded boxes indicate traffic signal controlled intersections.

3.0 Project Description and Trip Generation

Description of Proposed Development

The development (Figure 2) is proposed for a site bounded by Jensen Camp Road to the west, New Pennywell Road to the north, Columbus Drive to the east, and existing development on Empire Avenue to the south. A total of 228 residential units are proposed including 71 single unit dwellings with 15 meter lots, 83 single unit dwellings with 12 meter lots, and 37 semi-detached 18 meter frontage lots (74 units). While the majority of the dwellings will be located on new streets, loops and cul-de-sacs, about 29 units will have lot frontage on existing New Pennywell Road, six will have lot frontage on existing Empire Avenue, and two lots will have frontage in the existing Empire Place cul-de-sac.

Proposed Site Accesses

The approximately 191 lots in the proposed development that will be located on new streets within the development, will have four access points to adjacent streets (Figure 2). Three new street intersections will be created on New Pennywell Road, and the fourth access will be in the southeast corner of the site at the extension of Jensen Camp Road, just north of the Jensen Camp Place and Empire Avenue intersections.

Calculation of Trip Generation Estimates

Trip Generation, 7th Edition (Institute of Transportation Engineers (ITE), Washington, 2003) contains trip generation rates for various land uses which are usually recorded as 'trips per residential unit' for residential developments. Since trip characteristics for single unit and semi-detached (duplex) units are expected to be similar, trip generation rates for Single Family Detached Housing (Land Use 210) have been used in this Study. Land Use 210 rates are based on approximately 300 studies of residential developments having an average size of about 200 units.

Trip generation estimates (Table 5) for the proposed 228 residential unit subdivision have been calculated using trip generation rates from *Trip Generation, 7th Edition.* It is estimated that the 228 residential units will generate approximately 2200 two-way trips per day, including 171 trips (43 in and 128 out) during the AM peak hour and 230 trips (146 in and 84 out) during the PM peak hour.

Table 5 - Trip Generation for 228 Residential Dwelling Units

Land Use [1]	Number Units	Trip Generation Rates [1]					Trips Generated [2]				
		AM Peak		PM Peak		Day 2- Way	AM Peak		PM Peak		Day 2 -Way
		In	Out	In	Out		In	Out	In	Out	
Single Unit (ITE 210)	228	0.19	0.56	0.64	0.37	9.57	43	128	146	84	2182

NOTES:
1. Trip generation rates are 'vehicles per hour per unit' for the peak hour and two-way vehicles per day per unit for the daily rate. Since trip characteristics for single unit and semi-detached (duplex) units are expected to be similar, trip generation rates for Single Family Detached Housing (Land Use 210) have been used in this Study. Rates have been obtained from *Trip Generation*, *7th Edition*, Institute of Transportation Engineers, 2003.
2. Vehicles per hour for peak hours; vehicles per weekday for 'day 2 way'.

LEGEND:

Ⓐ = SINGLE FAMILY DWELLINGS, 15M FRONTAGE = 71

Ⓑ = SINGLE FAMILY DWELLINGS, 12M FRONTAGE = 83

Ⓒ = SEMI-DETACHED DWELLINGS, 18M FRONTAGE = 37

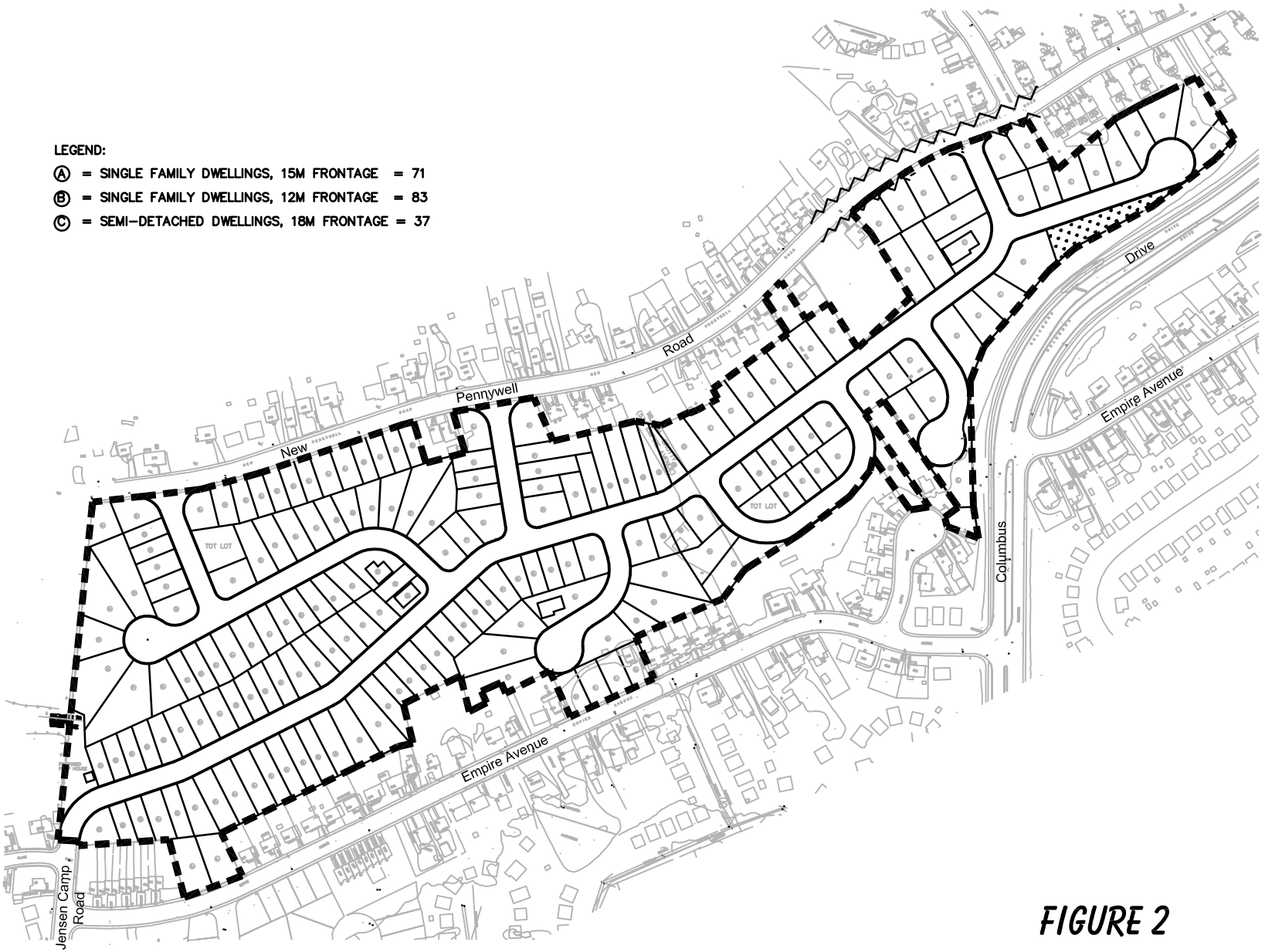


FIGURE 2

NOTES

No.	Description	Date
02	Added Tot Lots	27/04/05
01	Revised to comply with City's comments 04/22/05 & 05/16/05	05/27/05

REVISIONS

PROVINCE OF NEWFOUNDLAND
PERMIT HOLDER
CLASS "A"
This Permit Allows
Earle Barclay & Company Inc.
To practice Professional Engineering in Engineering & Lands.
Permit No. as issued by APEGN 02132
which is valid for the year 2005

Reference North

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A Professional Engineering Firm
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Surveyor
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Authority
City of St. John's

Drawn by AB/JPS | Developed by AB
Checked by | Date
Approved by | Date
Scale 1 : ----

PROJECT
Proposed Residential Development

DRAWING TITLE
Site Plan

SHT OF | PLOT DATE: July 04/05
PROJECT NO. 144-03 | DRAWING NO. 144-03-01

Trip Distribution and Assignment

The St. John's Regional Transportation QRS II Model was used to determine trip distribution for the proposed residential development. A centroid with a daily trip production equal to the estimated weekday trip generation for the proposed residential development was added to the model at the approximate center of the development.

Based on trip distribution provided by the model to all other centroids in the network, the following trip distribution was established for site generated trips:

- 45% north
- 25% east
- 20% south
- 10% west.

Trips generated by the proposed residential development have been assigned to site accesses and adjacent streets and intersections based on the trip distribution obtained using the QRS II model. Assignment of AM peak hour trips generated by the site is shown diagrammatically in Figure B-3A, and assignment of PM peak hour site generated trips is shown in Figure B-3B.

Projected 2008 Peak Hour Volumes that Include Site Generated Trips

Site generated trips (Figures B-3A and B-3B) have been added to projected 2008 peak hour volumes that do not include site generated trips (Figures B-2A and B-2B) to provide projected 2008 AM and PM peak hour volumes that include site generated trips (Figures B-4A and B-4B).

4.0 Intersection Performance Analysis

Intersection Level of Service Analysis

The level or quality of performance of an intersection in terms of traffic movement is determined by a level of service (LOS) analysis. LOS for intersections is defined in terms of delay, which is a measure of driver discomfort and frustration, fuel consumption, and increased travel time.

Table 6 - Level of Service (LOS) Criteria for Intersections

LOS	Signalized Intersections Control Delay (seconds per vehicle)	LOS Description	Two Way Stop Controlled (TWSC) Intersections Control Delay (seconds per vehicle)
A	less than 10.0	Very low delay; most vehicles do not stop **(Excellent)**	less than 10.0
B	between 10.0 and 20.0	Higher delay; more vehicles stop **(Very Good)**	between 10.0 and 15.0
C	between 20.0 and 35.0	Higher level of congestion; number of vehicles stopping is significant, although many still pass through intersection without stopping **(Good)**	between 15.0 and 25.0
D	between 35.0 and 55.0	Congestion becomes noticeable; vehicles must sometimes wait through more than one red light; many vehicles stop **(Satisfactory)**	between 25.0 and 35.0
E	between 55.0 and 80.0	Vehicles must often wait through more than one red light; considered by many agencies to be the limit of **acceptable** delay	between 35.0 and 50.0
F	greater than 80.0	This level is considered to be unacceptable to most drivers; occurs when arrival flow rates exceed the capacity of the intersection **(Unacceptable)**	greater than 50.0

Level of Service (LOS) Criteria

LOS criteria (Table 6) are stated in terms of average control delay per vehicle which includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. LOS 'A' describes an intersection approach with a very low control delay of up to ten seconds per vehicle. LOS 'F' describes an intersection with control delay greater than 80 seconds for signalized intersections (50 seconds for unsignalized) which is considered unacceptable by most drivers.

Highway Capacity Analysis Software

Intersection level of service or performance analysis procedures incorporate the methodologies from the most recent *Highway Capacity Manual* (2000). *Synchro 6.0* software has been used for intersection performance evaluation.

LOS Analysis

LOS analyses have been completed for the following scenarios:

1. 2005 peak hour volumes without added development (Figures B-1A and B-1B);
2. 2008 peak hour volumes without added development (Figures B-2A and B-2B); and
3. 2008 peak hour volumes with added development generated trips (Figures B-4A and B-4B).

Level of service (LOS) analysis results for the following intersections are included in Appendix C and are summarized in Table 7 (AM peak hours) and Table 8 (PM peak hours):

1. Captain Whelan Drive and Columbus Drive
2. Blackmarsh Road and Columbus Drive
3. Mundy Pond Road and Columbus Drive
4. Old Pennywell Road and Columbus Drive
5. Blackmarsh Road and Mercer's Lane
6. Blackmarsh Road and Mundy Pond Road
7. Blackmarsh Road and Jensen Camp Road
8. Blackmarsh Road and Captain Whalen Drive
9. Blackmarsh Road and Empire Avenue.

Summary Level of Service Analysis

- During 2005, all intersections operate with LOS 'C' or better during both AM and PM peak hours, except the Columbus Drive / Mundy Pond Road intersection achieves only LOS 'D' during AM peak hours.
- During 2005, all intersection approaches operate at LOS 'D or better except the following:
  - Mundy Pond Road EB at Columbus Drive - LOS 'E' - AM
  - Columbus Drive NB at Mundy Pond Road - LOS 'E' - AM
  - Jensen Camp Road STOP approach to Blackmarsh Road - LOS 'E' - PM
  - Captain Whelan STOP approach to Blackmarsh Road - LOS 'F' - PM.
- During 2008 AM peak hours 'without' addition of site generated trips, annual traffic volume increases will cause significant reductions in level of performance at the Mundy Pond Road / Columbus Drive intersection. The overall intersection will operate at LOS 'E'; EB approach LOS 'E', and NB Columbus Drive approach will operate at LOS 'F'.
- Level of service analyses for 2008 volumes that include site generated trips, do not indicate any significant or noticeable differences between the analyses for 2008 volumes 'without' site generated trips.

Conclusions from Traffic Impact Analysis

- Trips generated by the proposed 228 residential units are not expected to have any significant impacts on the level of performance of intersections or streets in the Study Area.

- During AM and PM peak hours, 59% of site generated trips exit and enter at the Old Pennywell Road intersection on Columbus Drive and will not impact other Study Area streets. Also, since about 68% of the site generated trips using the Old Pennywell Road intersection are to/from Columbus Drive north, the additional trips are using intersection approaches that have available capacity and, as such, are not causing noticeable impacts on the level of performance of that intersection.

Table 7 - Summary of Level of Service Evaluations for AM Peak Hours

Year & Conditions	Appendix C Page #	Control Delay in Seconds and Level of Service				
		Delay and LOS by Approach				Overall Intersection
		EB	WB	NB	SB	
1. Intersection Captain Whelan Drive & Columbus Drive (AM Peak Hours)						
2005 Existing	C-1	51.5 / D	43.3 / D	21.2 / C	6.4 / A	26.1 / C
2008 Without Site	C-19	53.0 / D	45.2 / D	21.9 / C	7.0 / A	27.1 / C
2008 With Site	C-37	53.0 / D	45.2 / D	22.1 / C	7.4 / A	27.0 / C
2. Intersection Blackmarsh Road & Columbus Drive (AM Peak Hours)						
2005 Existing	C-2	45.2 / D	18.0 / B	43.5 / D	13.9 / B	34.9 / C
2008 Without Site	C-20	47.0 / D	19.1 / B	45.2 / D	14.3 / B	36.2 / D
2008 With Site	C-38	50.7 / D	20.5 / C	45.2 / D	14.2 / B	37.0 / D
3. Intersection Mundy Pond Road & Columbus Drive (AM Peak Hours)						
2005 Existing	C-3	63.7 / E	29.4 / C	67.0 / E	10.2 / B	51.0 / D
2008 Without Site	C-21	72.9 / E	30.4 / C	85.3 / F	10.6 / B	62.2 / E
2008 With Site	C-39	73.0 / E	30.6 / C	88.0 / F	10.5 / B	63.5 / E
4. Intersection Old Pennywell Road and Columbus Drive (AM Peak Hours)						
2005 Existing	C-4	40.0 / D	29.9 / C	10.7 / B	34.4 / C	21.2 / C
2008 Without Site	C-22	40.5 / D	30.0 / C	11.1 / B	37.4 / D	22.2 / C
2008 With Site	C-40	43.9 / D	30.3 / C	11.1 / B	36.8 / D	22.9 / C
5. Intersection Blackmarsh Road & Mercer's Lane / Dominion East Driveway (AM Peak Hours)						
2005 Existing	C-5	17.6 / B	11.3 / B	11.5 / B	25.4 / C	14.2 / B
2008 Without Site	C-23	18.3 / B	11.6 / B	11.4 / B	25.4 / C	14.5 / B
2008 With Site	C-41	18.2 / B	11.7 / B	11.4 / B	25.4 / C	14.5 / B
6. Intersection Blackmarsh Road & Mundy Pond Road (AM Peak Hours)						
2005 Existing	C-6	5.5 / A	0.0 / A		16.2 / C	6.8 / A
2008 Without Site	C-24	5.5 / A	0.0 / A		17.1 / C	7.0 / A
2008 With Site	C-42	5.4 / A	0.0 / A		18.1 / C	7.0 / A
7. Intersection Blackmarsh Road & Jensen Camp Road (AM Peak Hours)						
2005 Existing	C-7	0.1 / A	0.0 / A		24.4 / C	1.0 A
2008 Without Site	C-25	0.1 / A	0.0 / A		25.8 / D	1.0 / A
2008 With Site	C-43	0.1 / A	0.0 / A		44.2 / E	2.9 / A
8. Intersection Blackmarsh Road & Captain Whelan Drive (AM Peak Hours)						
2005 Existing	C-8	0.0 / A	3.3 / A	28.7 / D		3.7 / A
2008 Without Site	C-26	0.0 / A	3.4 / A	33.4 / D		4.2 / A
2008 With Site	C-44	0.0 / A	3.3 / A	33.8 / D		4.3 / A
9. Intersection Blackmarsh Road & Empire Avenue (AM Peak Hours)						
2005 Existing	C-9	0.5 / A	0.0 / A		11.9 / B	0.9 / A
2008 Without Site	C-27	0.5 / A	0.0 / A		12.2 / B	0.9 / A
2008 With Site	C-45	0.6 / A	0.0 / A		12.2 / B	1.0 / A

NOTES: 1. Intersections 1 to 5 have been analyzed as signalized intersections and intersections 6 to 9 have been analyzed as two-way STOP controlled (TWSC) intersections.

Table 8 - Summary of Level of Service Evaluations for PM Peak Hours

Year & Conditions	Appendix C Page #	Control Delay in Seconds and Level of Service				
		Delay and LOS by Approach				Overall Intersection
		EB	WB	NB	SB	
1. Intersection Captain Whelan Drive & Columbus Drive (PM Peak Hours)						
2005 Existing	C-10	37.1 / D	47.1 / D	17.7 / B	10.7 / B	17.7 / B
2008 Without Site	C-28	37.0 / D	47.1 / D	18.1 / B	11.2 / B	18.1 / B
2008 With Site	C-46	37.0 / D	47.1 / D	18.4 / B	11.4 / B	18.2 / B
2. Intersection Blackmarsh Road & Columbus Drive (PM Peak Hours)						
2005 Existing	C-11	43.0 / D	38.0 / D	36.1 / D	24.8 / C	31.6 / C
2008 Without Site	C-29	48.3 / D	41.7 / D	36.6 / D	28.5 / C	34.5 / C
2008 With Site	C-47	57.0 / E	45.5 / D	36.6 / D	28.9 / C	36.2 / D
3. Intersection Mundy Pond Road & Columbus Drive (PM Peak Hours)						
2005 Existing	C-12	45.9 / D	39.2 / D	6.7 / A	15.8 / B	19.1 / B
2008 Without Site	C-30	60.0 / E	42.7 / D	6.6 / A	18.6 / B	22.1 / C
2008 With Site	C-48	62.8 / E	43.1 / D	6.7 / A	19.2 / B	22.7 / C
4. Intersection Old Pennywell Road and Columbus Drive (PM Peak Hours)						
2005 Existing	C-13	31.7 / C	51.3 / D	10.7 / B	40.9 / D	33.5 / C
2008 Without Site	C-31	34.1 / C	55.9 / E	10.5 / B	44.5 / D	36.1 / D
2008 With Site	C-49	36.3 / D	56.0 / E	10.6 / B	44.3 / D	36.4 / D
5. Intersection Blackmarsh Road & Mercer's Lane / Dominion East Driveway (PM Peak Hours)						
2005 Existing	C-14	28.2 / C	16.3 / B	13.1 / B	24.6 / C	20.4 / C
2008 Without Site	C-32	29.3 / C	17.4 / B	12.9 / B	25.0 / C	21.2 / C
2008 With Site	C-50	29.2 / C	17.7 / B	12.9 / B	25.0 / C	21.4 / C
6. Intersection Blackmarsh Road & Mundy Pond Road (PM Peak Hours)						
2005 Existing	C-15	4.5 / A	0.0 / A		29.7 / D	12.1 / B
2008 Without Site	C-33	4.6 / A	0.0 / A		35.7 / E	14.3 / B
2008 With Site	C-51	4.5 / A	0.0 / A		42.9 / E	16.4 / C
7. Intersection Blackmarsh Road & Jensen Camp Road (PM Peak Hours)						
2005 Existing	C-16	0.3 / A	0.0 / A		35.9 / E	2.9 / A
2008 Without Site	C-34	0.3 / A	0.0 / A		40.2 / E	3.3 / A
2008 With Site	C-52	0.5 / A	0.0 / A		69.3 / F	6.6 / A
8. Intersection Blackmarsh Road & Captain Whelan Drive (PM Peak Hours)						
2005 Existing	C-17	0.0 / A	2.3 / A	129.1 / F		16.6 / C
2008 Without Site	C-35	0.0 / A	2.3 / A	160.7 / F		19.8 / C
2008 With Site	C-53	0.0 / A	2.3 / A	167.3 / F		20.4 / C
9. Intersection Blackmarsh Road & Empire Avenue (PM Peak Hours)						
2005 Existing	C-18	1.0 / A	0.0 / A		22.4 / C	3.8 / A
2008 Without Site	C-36	1.1 / A	0.0 / A		24.7 / C	4.2 / A
2008 With Site	C-54	1.3 / A	0.0 / A		25.5 / D	4.4 / A

NOTES: 1. Intersections 1 to 5 have been analyzed as signalized intersections and intersections 6 to 9 have been analyzed as two-way STOP controlled (TWSC) intersections.

5.0 Review of Study Area Traffic Problems

The West - North Traffic Challenge in the Study Area

There is no convenient direct connection from the western part of the City of St. John's and the City of Mount Pearl to access the northern retail, industrial and institutional areas of Kenmount Road and Prince Philip Drive. Lacking a direct connection for this traffic movement, Blackmarsh Road has become one of the principal routes for travel between the western outskirts of the City and Columbus Drive. While significant numbers of trips then travel north on Columbus Drive to reach Kenmount Road and Prince Philip Drive, many motorists continue to travel easterly towards the central business district (CBD). These trips from the west to the north and east create significant AM and PM shortcutting traffic problems on Study Area local streets. It is estimated that shortcutting trips may account for between 75% and 80% of the approximately 8000 vehicles per weekday on Mundy Pond Road between Blackmarsh Road and Columbus Drive.

The East - West Traffic Challenge in Mundy Pond Road Neighbourhood

Since left turns from Empire Avenue to Columbus Drive northbound are not permitted, large numbers of trips from the western end of Blackmarsh Road use Mundy Pond Road to access Columbus Drive and to cross Columbus Drive to continue easterly towards the CBD.

Eastbound AM peak hour trips at four Study Area intersections are summarized in Table 9. As illustrated, 41% of the eastbound trips use Mundy Pond Road to access or cross Columbus Drive. Since the majority of trips turning left from Blackmarsh Road to Mundy Pond Road during the AM peak hour (535 vph in Figure B-1A) can be considered as shortcutting trips, about 75% of the eastbound trips on Mundy Pond Road during the AM peak hour are shortcutting trips. Also, during the PM peak hour, about 460 vph (Figure B-1B), or 80% of the westbound trips, on Mundy Pond Road westbound are shortcutting trips.

Table 9 - Eastbound AM Peak Hour Trips at Columbus Drive Intersections

Intersection	Left Turn to Columbus Drive Northbound		Straight Across Columbus Drive		Combined Left and Straight Trips	
	Number	% of Total	Number	% of Total	Number	% of Total
Empire Avenue	0	0	0	0	0	0
Mundy Pond Road	285	34	415	48	700	41
Blackmarsh Road	145	17	335	39	480	28
Captain Whelan Drive	410	49	115	13	525	31
TOTALS	840	100	865	100	1705	100

NOTE: Traffic volumes for the AM peak hour are included in Figure B-1A, Appendix B.

The East - West Traffic Challenge in the Empire Avenue Neighbourhood

During PM peak hours, traffic from Columbus Drive north and areas east of Columbus Drive use Study Area streets to travel to Blackmarsh Road at the western boundary of St. John's, as well as to Mount Pearl. Southbound traffic from Columbus Drive north of Empire Avenue uses sections of Empire Avenue in the Study Area as a short cut to travel to Blackmarsh Road. Westbound PM peak hour trips at four Study Area intersections are summarized in Table 10.

As illustrated in Table 10, 20% of the westbound trips use Empire Avenue and 35% use Mundy Pond Road. While about 25% of the Empire Avenue PM peak hour westbound traffic continues south on Jensen Camp Road (Table A-18) towards Blackmarsh Road, about 185 vph (Figure B-1B) continue to the west end of Empire Avenue at Blackmarsh Road. If the majority of westbound traffic remaining at the west end of Empire Avenue can be assumed to be shortcutting trips, then over 50% of the westbound trips on Empire Avenue are shortcutting trips.

Table 10 - Westbound PM Peak Hour Trips at Columbus Drive Intersections

Intersection	Right Turn from Columbus Drive Southbound		Straight Across Columbus Drive		Combined Right and Straight Trips	
	Number	% of Total	Number	% of Total	Number	% of Total
Empire Avenue	330	38	0	0	330	20
Mundy Pond Road	240	28	330	42	570	35
Blackmarsh Road	80	9	365	47	445	27
Captain Whelan Drive	215	25	85	11	300	18
TOTALS	865	100	780	100	1645	100

NOTE: Traffic volumes for the AM peak hour are included in Figure B-1B, Appendix B.

Mundy Pond Neighbourhood Traffic Calming Study(April 2004)

Recognizing the traffic shortcutting problems in the Mundy Pond Road and Empire Avenue neighbourhoods, the City of St. John's and Memorial University Faculty of Engineering cooperated to have a group of engineering students (*APEX Solutions*) prepare the *Mundy Pond Road Neighbourhood Traffic Calming Study* in April 2004.

The Study developed and evaluated several alternatives to discourage shortcutting on both Mundy Pond Road and Empire Avenue. The Study also reviewed concept plans that the City of St. John's has for network modifications at the Blackmarsh Road intersections with Empire Avenue and Captain Whelan Drive intended to divert traffic from the residential sections of Blackmarsh Road, Mundy Pond Road, and Empire Avenue to the more limited access Captain Whelan Drive.

Mundy Pond Road Shortcutting Alternatives

APEX Solutions developed and reviewed four alternatives to prevent shortcutting on Mundy Pond Road. They determined that removal of the Mundy Pond Road connection to the west side of Columbus Drive

by creation of a cul-de-sac at the east end of Mundy Pond Road was the preferred solution. While severing the connection between Mundy Pond Road and Columbus Drive will eliminate all through traffic from the neighbourhood, it also removes the only convenient connection that local traffic from the Mundy Pond Road and Empire Avenue neighbourhoods has to access Columbus Drive northbound, or to access streets east of Columbus Drive. Also, the closure of the Mundy Pond Road intersection with Columbus Drive would force the approximately 8000 vehicles per day using Mundy Pond Road to divert to Blackmarsh Road or Captain Whelan Drive to access Columbus Drive. While these streets may be able to absorb some of the diverted traffic, they will be unable to accommodate all of the traffic. The eastbound approaches to Columbus Drive for both streets now operate at level of service (LOS) 'D' during AM peak hours (Table 7). Also, the existing 2005 intersection volumes include 410 vph turning left from Captain Whelan Drive to Columbus Drive, which is near the capacity for that movement given the green time required to maintain an acceptable level of performance on Columbus Drive.

During this Study, *ARTM* has considered the following traffic control measures for reducing shortcutting on Mundy Pond Road:

- Prohibit left turns from Mundy Pond Road eastbound to Columbus Drive - While this would remove 285 vph during the AM peak hour (Table 9), it would inconvenience local traffic that needs to turn left and would not affect the more than 400 vph eastbound through traffic on Mundy Pond Road. Also, diverting all 285 vph of left turning vehicles may exceed the capacities of Blackmarsh Road and Captain Whelan Drive intersections to accommodate added left turn traffic. The capacity of Columbus Drive to accommodate additional northbound trips, from Mundy Pond trips that may be diverted to Captain Whelan Drive, must also be considered.
- Create a curb extension on the south side of Mundy Pond Road at the east side of the Alderberry Lane intersection so that only one eastbound lane is available on Mundy Pond Road. While two eastbound approach lanes would be retained at the Columbus Drive intersection, the 'choke-down' in Mundy Pond Road width at Alderberry Lane will create congestion on Mundy Pond Road that may force some traffic to divert to other routes. Also, the reduced street width on Mundy Pond Road immediately east of Alderberry Lane will reduce the attractiveness of using Alderberry Lane to travel from Blackmarsh Road to Mundy Pond Road.
- Install a 3-way STOP at the Mundy Pond / Coefield Street intersection - This will act as both a traffic calming device and also allow Coefield Street traffic better access to Mundy Pond Road at times when traffic is queued through the intersection.
- Reduce the amount of green time allocated to Mundy Pond Road at the Columbus Drive traffic signals - Good traffic engineering practice would suggest that signal timing should be such as to provide 'good' performance and progression on the main street, while still providing reasonable performance on the side street. However, if traffic is to be encouraged to divert from Mundy Pond

Road, green time must be shifted from Mundy Pond Road to Columbus Drive approaches. This will reduce the attractiveness of Mundy Pond Road while improving the performance of Columbus Drive. For example, shifting 10 seconds of green time from Mundy Pond Road to Columbus Drive and addition of a northbound right turn lane on Columbus Drive, will improve the northbound AM peak hour level of performance from LOS 'F' (Table 7) to LOS 'C' (Page C-56, Appendix C). Eastbound Mundy Pond Road volumes were reduced in steps until the v/c ratios for the eastbound movements were at 0.99 v/c ratios. The timing change indicated that about 135 vph westbound left turning, and 35 vph through traffic, could be diverted to Blackmarsh Road.

The reduced Mundy Pond Road green time during the PM peak hour resulted in LOS 'F' (Page C-58, Appendix C) for the westbound approach which realistically should force some traffic to seek alternate routes. Also, increased green time for Columbus Drive southbound approach during the PM peak hour, and intersection improvements on Columbus Drive at the Blackmarsh Road intersection may encourage southbound traffic to continue on Columbus Drive and turn right to Blackmarsh Road rather than using Mundy Pond Road.

The ability of Captain Whelan Drive intersection with Columbus Drive to accommodate additional left tuning vehicles was considered. The existing 2005 AM peak hour (Figure B-1A) includes 410 vph left turning vehicle, which is projected to increase to 425 vph by 2008. Review of the intersection performance indicated that about 100 vph additional left turning vehicles could probably be accommodated, however, the capacity of Columbus Drive to accommodate additional northbound trips at Blackmarsh Road must also be considered.

Mundy Pond Road Shortcutting Recommendations

The following changes are recommended to reduce shortcutting on Mundy Pond Road:

- Reduce the amount of green time allocated to Mundy Pond Road at the Columbus Drive traffic signals;
- Increase green time for Columbus Drive, and add a northbound right turn lane on Columbus Drive;
- Install 3-way STOP signs at the Mundy Pond Road / Coefield Street intersection; and
- After observing impacts of signal timing changes, consider need for a curb extension on the south side of Mundy Pond Road east of the Alderberry Lane intersection to restrict eastbound Mundy Pond Road to one travel lane.

Empire Avenue Shortcutting Alternatives

APEX Solutions developed and reviewed three alternatives to prevent or reduce westbound shortcutting on Empire Avenue. They determined that prohibition of right turns from Columbus Drive to Empire Avenue from 4:00 PM to 6:00 PM on weekdays was the preferred solution.

Prohibition of PM peak hour right turns from Columbus Drive southbound to Empire Avenue, together with enforcement of the turn prohibitions, would remove the approximately 185 vehicles per hour that may be shortcutting on Empire Avenue. However, it will also prevent access for local traffic and will force about 330 vph (Table 10) of westbound traffic to divert to Mundy Pond Road or Blackmarsh Road.

Since the daily volume on Empire Avenue is low (2200 vpd Table A-6), shortcutting volumes are low to moderate, and shortcutting occurs only in the westbound direction, mitigation measures are not needed and no actions are recommended.

Addition of Right Turn Lanes to Columbus Drive at Blackmarsh Road Intersection

There are significant right turning volumes from Columbus Drive northbound to Blackmarsh Road during the AM peak hour (160 vph, Figure B-1A) and the PM peak hour (150 vph, Figure B-1B). Construction of a right turn lane on the Columbus Drive northbound approach will provide improved level of service on for Columbus Drive (Pages C-55 and C-57, Appendix C) which while still allowing the intersection to accommodate an added eastbound left turn phase and about 170 vph added eastbound traffic during the AM peak hour. The eastbound left turn phase has been added during the AM peak hour only, to accommodate left turning trips diverted from Mundy Pond Road. The improved northbound level of service on Columbus Drive will also assist in providing capacity to accept eastbound left turning traffic that may be encouraged to divert to Captain Whalen Drive by intersection modifications being considered at the Blackmarsh Road / Captain Whalen Drive intersection as discussed in the following section.

Existing right turn volumes from Colombus Drive southbound to Blackmarsh Road are low during the AM peak hour (35 vph, Figure B-1A) and moderate during the PM peak hour (80 vph, Figure B-1B). Provision of a long southbound right turn lane with a right turn channel to Blackmarsh Road westbound, together with increased Columbus Drive green times at the Mundy Pond Road intersection, may create sufficient travel time reductions to encourage Columbus Drive southbound traffic now turning right to Mundy Pond Road to divert to Blackmarsh Road.

Concept Plans for an East - West Arterial Road

The City of St. John's has prepared concept plans (Figure 3) for an East - West Arterial Road that will be constructed north of, and approximately parallel to, Blackmarsh Road from the west City Limit to meet Columbus Drive at the Old Pennywell Road intersection. The concept plan also includes a north - south roadway between the East - West Arterial and Kenmount Road, and then to the TCH Outer Ring Highway by the connector under construction and expected to open during fall of 2005.

This network of new roads will provide the missing direct connection from the western part of the City of St. John's and the City of Mount Pearl to the Kenmount Road and Prince Philip Drive areas. The connector to the Outer Ring Highway will also provide freeway type

routes to the Airport and the Stavanger Drive retail area. These additions to the road network will reduce the volumes shortcutting on Mundy Pond Road and Empire Avenue.

Concept Plans for Modifications at the Blackmarsh Road Intersections with Empire Avenue and Captain Whelan Drive

A connector between the East - West Arterial Road and Blackmarsh Road is planned at George's Pond Road near the intersection of Blackmarsh Road and Empire Avenue. The City has prepared a concept plan (Figure 4) to modify the Blackmarsh / Empire and Blackmarsh / Captain Whelan intersections to improve access to the Arterial. Modification suggested for the Blackmarsh / Captain Whelan intersection will also divert traffic from the residential sections of Blackmarsh Road and Mundy Pond Road to the more limited access Captain Whelan Drive.

Blackmarsh Road @ Empire Avenue - Improvements considered for the Blackmarsh / Empire intersection, include street realignments to create a four-way intersection with Blackmarsh Road east of the existing intersection connecting directly to George's Pond Road towards the Arterial Road and Blackmarsh Road west of the intersection connecting directly to Empire Avenue.

APEX Solutions considered traffic signal control for a four-way intersection, a modern roundabout, or ending Empire Avenue at a cul-de-sac, and recommended construction of a roundabout with four approaches. Discussion of the merits of roundabout control compared to traffic signals is considered beyond the scope of this Study, however, reconsideration of ending Empire Avenue at a cul-de-sac is recommended. Traffic that will be diverted from the western end of Empire Avenue can be easily accommodated by Welland Street or Jensen Camp Road connections to Blackmarsh Road. Removal of Empire Avenue approach to the intersection will reduce the number of turning movements which will simplify intersection design and improve operation, and will also reduce the attractiveness of Empire Avenue as a shortcutting or through street.

Blackmarsh Road @ Captain Whelan Drive - Concept plans for modification of the Blackmarsh / Captain Whelan intersection (Figure 4) include diverting Blackmarsh Road southerly immediately west of Jensen Camp Road intersection to cross farm land and to form a four-way intersection with Captain Whelan Drive and Hamlyn Road. The existing Blackmarsh / Captain Whelan intersection near Welland Street will be removed with the cut-off portion of Blackmarsh Road connected directly to the south end of Welland Street.

This improvement will reduce the number of intersections on what will become the Captain Whelan / Blackmarsh / George's Pond minor arterial street connecting the East - West Arterial Road to Columbus Drive. The change will also make Captain Whelan Drive the through street which will make travel on Blackmarsh Road less attractive and will divert traffic from the residential sections of Blackmarsh Road and Mundy Pond Road to the more limited access Captain Whelan Drive.

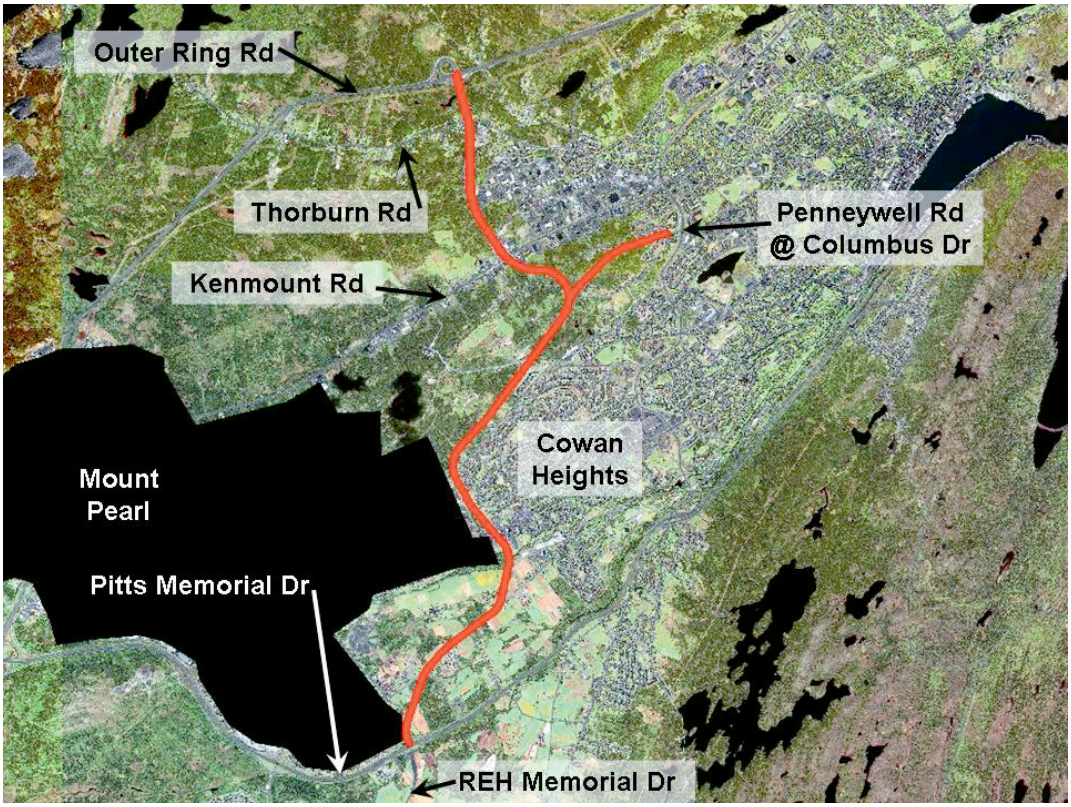


Figure 3 - East - West Arterial Road

Source: City of St. John's

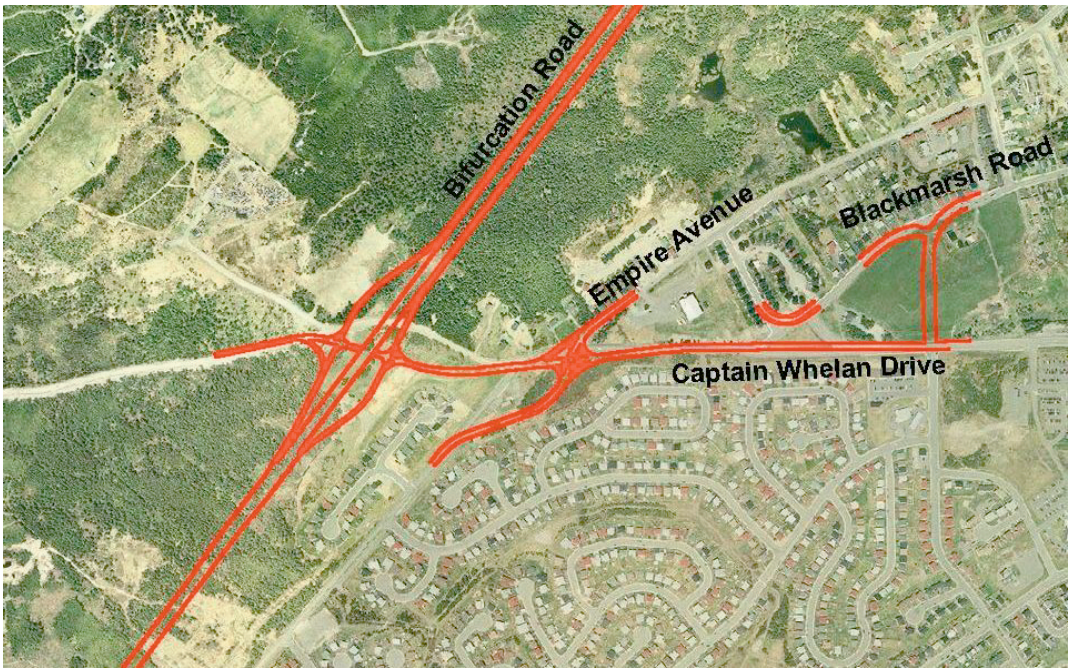


Figure 4 - Modification Concepts for Blackmarsh Road Intersections at Empire Avenue and Captain Whelan Drive

Source: City of St. John's

6.0 Summary and Conclusions

Description of the Proposed Development

1. The proposed residential development will be on a site bounded by Jensen Camp Road to the west, New Pennywell Road to the north, Columbus Drive to the east, and existing development on Empire Avenue to the south. A total of 228 residential units are proposed including 71 single unit dwellings with 15 meter frontage, 83 single unit dwellings with 12 meter, and 37 semi-detached 18 meter frontage lots (74 units). The proposed development is expected to be completed by 2008.

Proposed Site Accesses

2. While the majority of the dwellings will be located on new streets, loops and cul-de-sacs, about 29 units will have lot frontage on existing New Pennywell Road, six will have lot frontage on existing Empire Avenue, and two lots will have frontage in the existing Empire Place cul-de-sac. The approximately 191 lots in the proposed development that will be located on new streets within the development, will have four access points to adjacent streets. Three new street intersections will be created on New Pennywell Road, and the fourth access will be in the southeast corner of the site at the extension of Jensen Camp Road, just north of the Jensen Camp Place and Empire Avenue intersections.

Collisions at Study Area intersections

3. Review of collision records for Study Area intersections for 2003 and 2004 indicates the following:
   - There were 27 collisions (17 property damage and 10 injury) in 2003 and 27 collisions (15 property damage and 12 injury) in 2004;
   - There is no significant difference between 2003 and 2004 data;
   - 59% of collisions involved property damage only;
   - 54% of collisions were rear end collisions;
   - 87% occurred at signalized intersections; and
   - There is no indication of existing safety problems at the STOP sign controlled intersections.

Trip Generation Estimates

4. Trip generation estimates for the proposed 228 residential unit subdivision have been calculated using trip generation rates from *Trip Generation, 7th Edition.* It is estimated that the 228 residential units will generate approximately 2200 two-way trips per day, including 171 trips (43 in and 128 out) during the AM peak hour and 230 trips (146 in and 84 out) during the PM peak hour.

Trip Distribution

5. The St. John's Regional Transportation QRS II Model was used to determine trip distribution for the proposed residential development. Based on trip distribution provided by the model, the following trip distribution was established for site generated trips:
   - 45% north
   - 25% east
   - 20% south
   - 10% west.

Summary Level of Service Analysis

6. Level of service analyses completed using Synchro 6.0 indicate:
   - During 2005, all intersections operate with LOS 'C' or better, except the Columbus Drive / Mundy Pond Road intersection achieves only LOS 'D' during AM peak hours.
   - During 2005, all intersection approaches operate at LOS 'D or better except the following:
     - Mundy Pond Road EB at Columbus Drive - LOS 'E' - AM
     - Columbus Drive NB at Mundy Pond Road - LOS 'E' - AM
     - Jensen Camp Road STOP approach to Blackmarsh Road - LOS 'E' - PM
     - Captain Whelan STOP approach to Blackmarsh Road - LOS 'F' - PM.
   - During 2008 AM peak hours 'without' addition of site generated trips, annual traffic volume increases will cause significant reductions in level of performance at the Mundy Pond Road / Columbus Drive intersection. The overall intersection will operate at LOS 'E'; EB approach LOS 'E', and NB Columbus Drive approach will operate at LOS 'F'.
   - Level of service analyses for 2008 volumes that include site generated trips, do not indicate any significant or noticeable difference between the analyses for 2008 volumes 'without' site generated trips.
   - Trips generated by the proposed 228 residential units are not expected to have any significant impacts on the level of performance of intersections or streets in the Study Area.

Summary of Study Area Traffic Problems

7. ***West - North Traffic Challenge -*** There is no convenient direct connection from the western part of the City of St. John's and the City of Mount Pearl to access the northern retail, industrial and institutional areas of Kenmount Road and Prince Philip Drive. Lacking a direct connection for this traffic movement, Blackmarsh Road has become one of the principal routes for travel between the western outskirts of the City and Columbus Drive. These trips create significant AM and PM shortcutting traffic problems on Study Area local streets. It is estimated that shortcutting trips may account for between 75% and 80% of the approximately 8000 vehicles per weekday on Mundy Pond Road between Blackmarsh Road and Columbus Drive.

   Mundy Pond Road Neighbourhood Traffic Challenge - Since left turns from Empire Avenue to Columbus Drive northbound are not permitted, large numbers of trips from the western end of Blackmarsh Road use Mundy Pond Road to access Columbus Drive and to cross Columbus Drive to continue easterly towards the CBD. Traffic counts at Study Area intersections indicate that 41% of the eastbound trips use Mundy Pond Road to access or cross Columbus Drive. During the AM peak hour, about 535 vph of Mundy Pond Road eastbound trips are estimated to be shortcutting trips. Also, during the PM peak hour, about 460 vph of the westbound trips on Mundy Pond Road are shortcutting trips.

Empire Avenue Neighbourhood Traffic Challenge - During PM peak hours, traffic from Columbus Drive north and areas east of Columbus Drive use Study Area streets to travel to Blackmarsh Road at the western boundary of St. John's, as well as to Mount Pearl. About 50%, of the 330 vph of southbound traffic from Columbus Drive that turns right to Empire Avenue during the PM peak hour, uses Empire Avenue as a short cut to travel west towards Blackmarsh Road.

Recommendations Concerning Mundy Pond Road Shortcutting

8. The following changes are recommended to reduce shortcutting on Mundy Pond Road:
   - Reduce the amount of green time allocated to Mundy Pond Road at the Columbus Drive traffic signals;
   - Increase green time for Columbus Drive and add a northbound right turn lane on Columbus Drive at Mundy Pond Road;
   - Construct both northbound and southbound right turn lanes on Columbus Drive at Blackmarsh Road intersection;
   - Add an eastbound left-turn phase to the Blackmarsh Road traffic signals at Columbus Drive for the AM peak period;
   - Install 3-way STOP signs at the Mundy Pond Road / Coefield Street intersection; and
   - After observing impacts of signal timing changes, consider need for a curb extension on the south side of Mundy Pond Road east of the Alderberry Lane intersection to restrict eastbound Mundy Pond Road to one travel lane.

Recommendations Concerning Empire Avenue Shortcutting

9. Since the daily volume on Empire Avenue is low (2200 vpd), shortcutting volumes are low to moderate, and shortcutting occurs only in the westbound direction, mitigation measures are not needed and no actions are recommended.

Recommendations Concerning Modifications to the Blackmarsh Road / Empire Avenue Intersection

10. It is recommended that the west end of Empire Avenue become a cul-de-sac when modifications are completed for the Blackmarsh / Empire intersection during construction of a connector road to the East - West Arterial Road. Removal of Empire Avenue approach to the intersection will reduce the number of turning movements which will simply intersection design and improve operation, and will also reduce the attractiveness of Empire Avenue as a shortcutting or through street.

Conclusions Concerning Modifications to the Blackmarsh Road / Captain Whelan Drive Intersection

11. Relocation of the existing Blackmarsh / Captain Whelan intersection to form a four-way intersection with Captain Whelan Drive and Hamlyn Road will reduce the number of intersections on what will become the Captain Whelan / Blackmarsh / George's Pond minor arterial street connecting the East - West Arterial Road to Columbus Drive. The change will also make Captain Whelan Drive the through street which will make travel on Blackmarsh Road less attractive and will divert some traffic from the residential sections of Blackmarsh Road and Mundy Pond Road to the more limited access Captain Whelan Drive.

Conclusions - Mundy Pond Road Neighbourhood Traffic Impact Study

12. Conclusions reached from the Mundy Pond Road Neighbourhood Traffic Impact Study include:

    - Trips generated by the proposed 228 residential units are not expected to have any significant impacts on the level of performance of intersections or streets in the Study Area.

    - It is estimated that the Mundy Pond Road shortcutting traffic includes approximately:
        - 6000 two-way trips during a 24 hour weekday;
        - 535 eastbound trips during an AM peak hour;
        - 460 westbound trips during a PM peak hour.

    - While some of the peak hour shortcutting trips on Mundy Pond Road may be diverted to Blackmarsh Road and Captain Whelan Drive, it must be realized that capacities are limited on those streets to accommodate additional eastbound left turning trips during peak periods. Also, there is limited capacity available on Columbus Drive during peak periods to accommodate additional northbound and southbound trips that may be diverted from Mundy Pond Road.

    - The Study Area shortcutting problems can be attributed to lack of a convenient direct connection from the western part of the City of St. John's and the City of Mount Pearl to access the northern retail, industrial and institutional areas of Kenmount Road and Prince Philip Drive. As such, the ultimate solution to Study Area traffic problems is the construction of the proposed East - West Arterial Road with connections to Kenmount Road and the Outer Ring Highway.

7.0 Bibliography

Mundy Pond Road Neighbourhood Traffic Calming Study. APEX Solutions, April 2004.

Trip Generation, 7th Edition. Institute of Transportation Engineers, Washington, DC, 2003.

Appendix A

Machine Counts

Manual Turning Movement Counts

Table A - 1 - Blackmarsh Road - West of Mundy Pond Road
Average Hourly Volumes - Monday to Wednesday, June 13 - 15, 2005

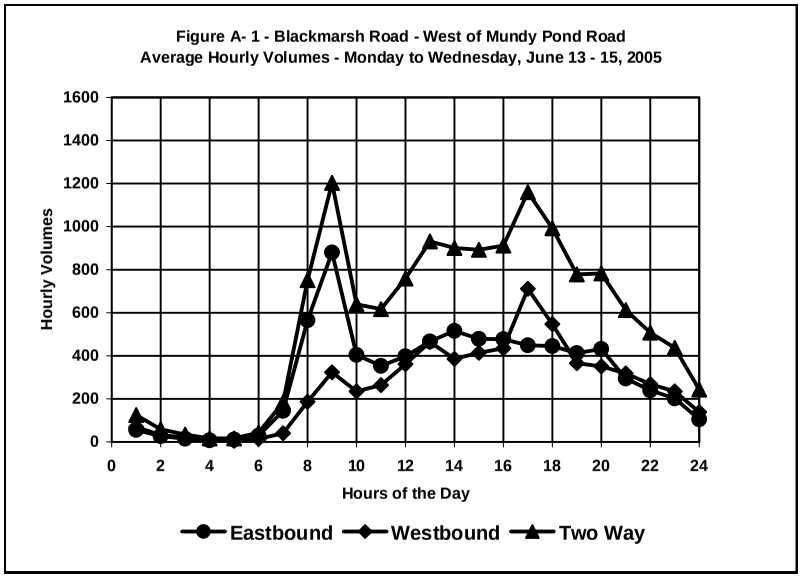
Hour	Eastbound	Westbound	Two-Way
1	56	69	125
2	27	32	59
3	15	20	35
4	8	9	17
5	12	5	17
6	29	14	43
7	145	40	185
8	565	187	751
9	880	323	1203
10	404	235	639
11	353	264	617
12	398	362	759
13	467	465	932
14	516	386	901
15	479	414	893
16	477	435	912
17	449	711	1160
18	445	547	992
19	413	366	778
20	432	351	783
21	295	318	613
22	240	268	508
23	202	235	437
24	105	138	243
TOTALS	7405	6191	13596

Note: PM Peak Hour volume is 8.5% of the daily volume

Table A - 2 - Blackmarsh Road Eastbound Ramp to Captain Whelan Drive
Average Hourly Volumes - Monday to Wednesday, June 13 - 15, 2005

Hour	June 13 & 15	June 14	Average
1	12	6	9
2	5	1	3
3	2	3	3
4	0	2	1
5	1	0	1
6	2	4	3
7	11	8	10
8	74	67	71
9	121	130	126
10	53	52	53
11	37	46	42
12	64	61	63
13	89	78	84
14	69	65	67
15	50	69	60
16	69	66	68
17	78	94	86
18	81	76	79
19	67	60	64
20	78	65	72
21	63	50	57
22	45	46	46
23	25	23	24
24	15	12	14
TOTALS	1111	1084	1098

Note: PM Peak Hour volume is 7.8% of the daily volume



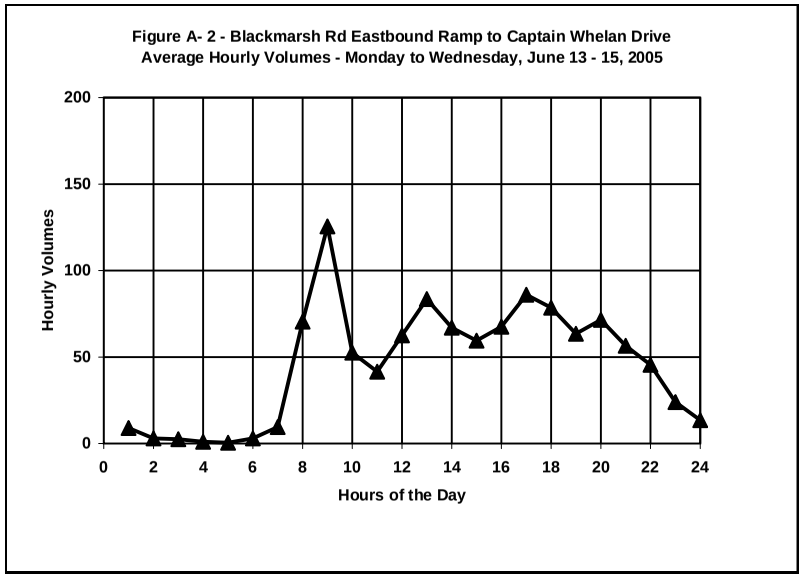


Table A - 3 - Blackmarsh Road - East of Mundy Pond Road
Hourly Volumes - Tuesday and Wednesday, June 7 & 8, 2005

Hour	Eastbound	Westbound	Two-Way
1	24	29	53
2	13	17	30
3	6	7	13
4	6	7	13
5	4	5	9
6	8	4	12
7	28	19	47
8	237	79	316
9	383	141	524
10	195	121	316
11	161	143	304
12	209	186	395
13	217	178	395
14	284	213	497
15	248	218	466
16	281	234	515
17	273	334	607
18	249	300	549
19	206	212	418
20	225	153	378
21	186	149	335
22	21	156	177
23	20	118	138
24	45	57	102
TOTALS	3529	3080	6609

Note: PM Peak Hour volume is 9.2% of the daily volume

Table A - 4 - Mundy Pond Road - East of Coefield Street
Hourly Volumes - Tuesday and Wednesday, June 7 & 8, 2005

Hour	Eastbound	Westbound	Two-Way
1	29	33	62
2	10	10	20
3	11	2	13
4	7	7	14
5	11	3	14
6	30	9	39
7	84	22	106
8	260	126	386
9	357	218	575
10	262	146	408
11	204	177	381
12	228	215	443
13	249	307	556
14	262	245	507
15	244	296	540
16	237	383	620
17	226	482	708
18	243	371	614
19	239	219	458
20	247	229	476
21	181	176	357
22	136	220	356
23	91	155	246
24	54	88	142
TOTALS	3902	4139	8041

Note: PM Peak Hour volume is 8.8% of the daily volume

Figure A- 3 - Blackmarsh Road - East of Mundy Pond Road
Hourly Volumes - Tuesday and Wednesday, June 7 & 8, 2005

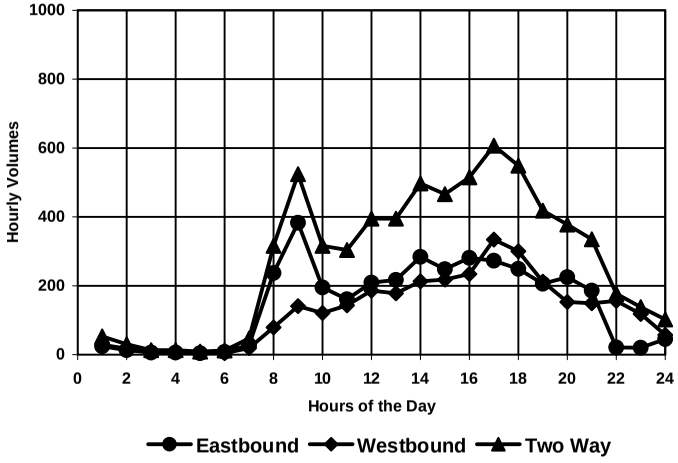


Figure A- 4 - Mundy Pond Road - East of Coefield Street
Hourly Volumes - Tuesday and Wednesday, June 7 & 8, 2005

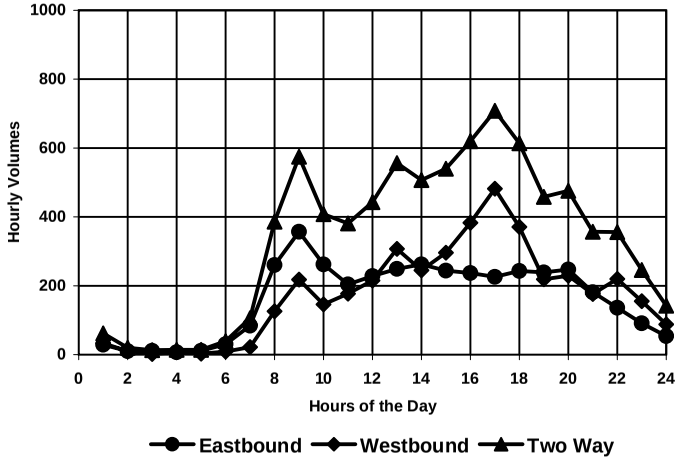


Table A - 5 - Mundy Pond Road - West of Coefield Street
Hourly Volumes - WB Tue / Wed, June 7 & 8 & EB Thu / Fri, June 23 & 24, 2005

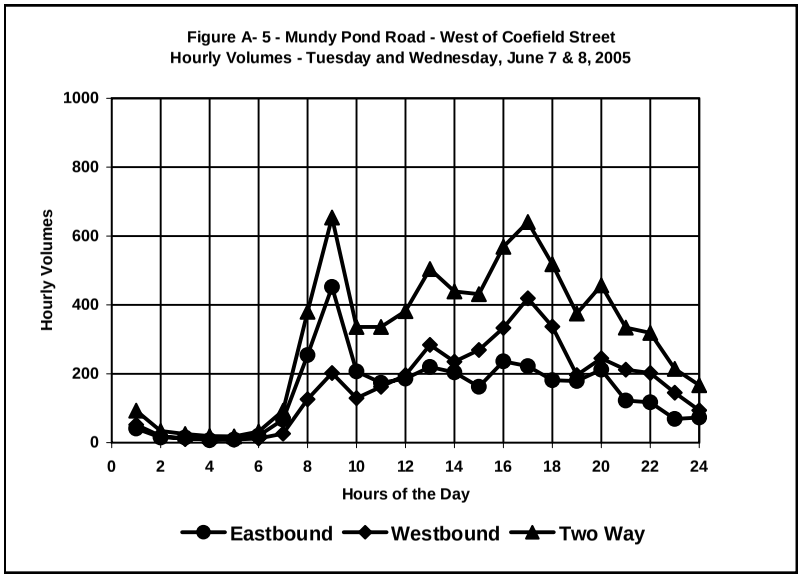
Hour	Eastbound	Westbound	Two-Way
1	41	52	93
2	15	19	34
3	15	10	25
4	7	12	19
5	9	9	18
6	20	12	32
7	67	26	93
8	254	126	380
9	452	202	654
10	207	129	336
11	174	162	336
12	186	196	382
13	220	284	504
14	204	235	439
15	162	269	431
16	236	333	569
17	222	419	641
18	181	337	518
19	179	196	375
20	212	245	457
21	122	212	334
22	117	202	319
23	69	145	214
24	73	94	167
TOTALS	3444	3926	7370

Note: PM Peak Hour volume is 8.7% of the daily volume

Table A - 6 - Empire Avenue - West of Columbus Drive
Hourly Volumes - Thursday and Friday, June 23 & 24, 2005

Hour	Eastbound	Westbound	Two-Way
1	1	34	35
2	1	10	11
3	0	7	7
4	1	7	8
5	1	6	7
6	0	3	3
7	1	19	20
8	4	47	51
9	2	49	51
10	2	53	55
11	2	67	69
12	3	79	82
13	8	174	182
14	6	137	143
15	8	104	112
16	7	188	195
17	13	348	361
18	4	253	257
19	2	120	122
20	1	90	91
21	13	97	110
22	3	103	106
23	6	85	91
24	0	51	51
TOTALS	89	2131	2220

Note: PM Peak Hour volume is 16.3% of the daily volume



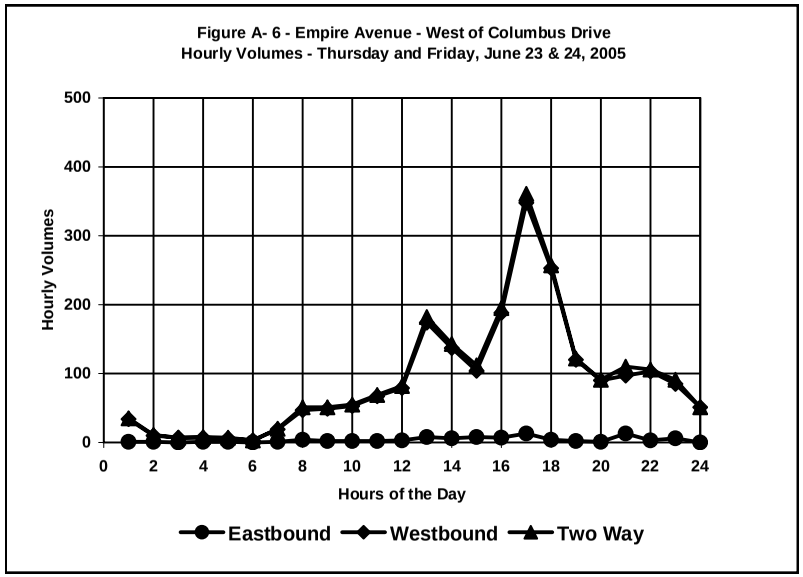


Table A - 7 - Empire Avenue - East of Jensen Camp Road
Hourly Volumes - Thursday and Friday, June 23 & 24, 2005

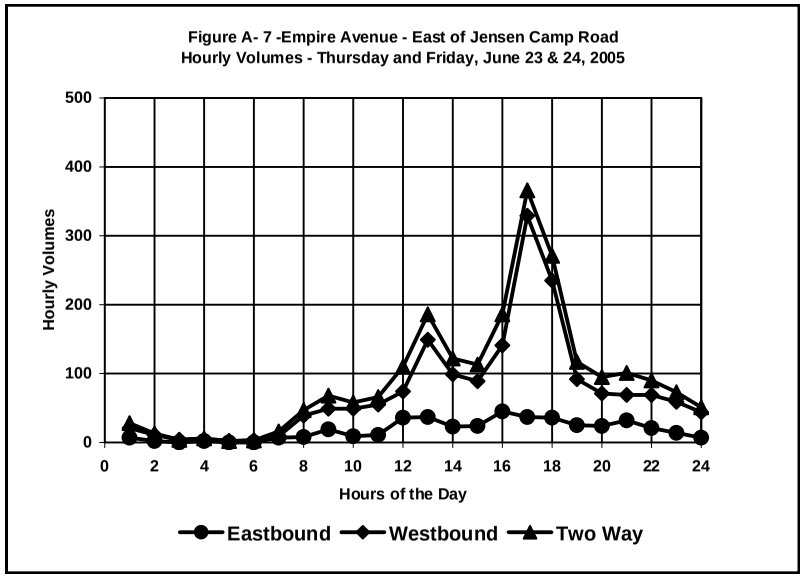
Hour	Eastbound	Westbound	Two-Way
1	7	21	28
2	2	11	13
3	0	4	4
4	2	4	6
5	0	2	2
6	0	3	3
7	7	9	16
8	8	39	47
9	19	49	68
10	9	49	58
11	11	55	66
12	36	74	110
13	37	149	186
14	23	99	122
15	24	89	113
16	45	141	186
17	37	329	366
18	36	235	271
19	25	92	117
20	24	71	95
21	32	69	101
22	21	69	90
23	14	59	73
24	7	44	51
TOTALS	426	1766	2192

Note: PM Peak Hour volume is 16.7% of the daily volume

Table A -8 - New Pennywell Road - West of Beothuck Street
Hourly Volumes - Monday and Tuesday, June 27 & 28, 2005

Hour	Eastbound	Westbound	Two-Way
1	12	11	23
2	2	2	4
3	2	2	4
4	3	2	5
5	2	1	3
6	2	2	4
7	8	4	12
8	24	9	33
9	25	22	47
10	19	14	33
11	27	19	46
12	23	24	47
13	32	47	79
14	30	44	74
15	23	35	58
16	37	47	84
17	33	63	96
18	35	53	88
19	35	23	58
20	41	31	72
21	25	32	57
22	39	38	77
23	15	26	41
24	13	17	30
TOTALS	507	568	1075

Note: PM Peak Hour volume is 8.9% of the daily volume



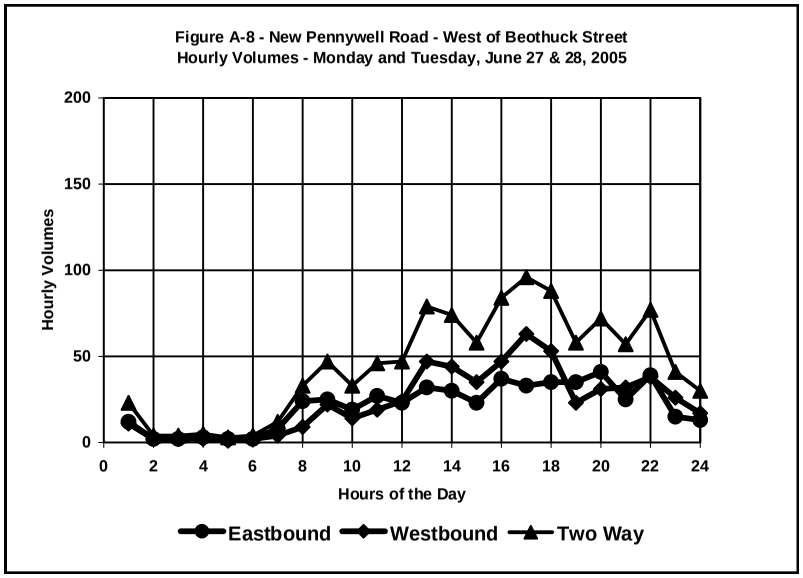
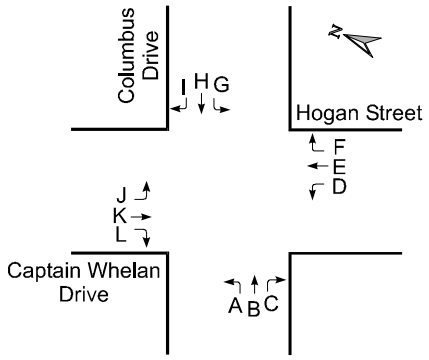


Table A-9

Columbus Drive
@
Captain Whelan Drive / Hogan Street

St. John's, NL

September 21, 2004



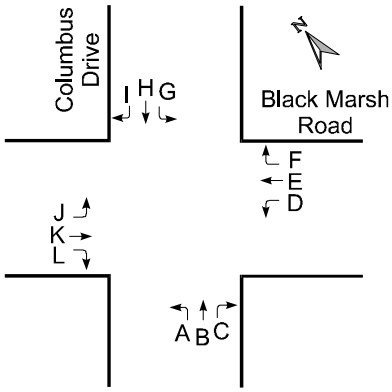
Time	Columbus Drive Northbound Approach			Hogan Road Westbound Approach			Columbus Drive Southbound Approach			Captain Whelan Drive Eastbound Approach			Total Vehicles
	A	B	C	D	E	F	G	H	I	J	K	L	
08:00-08:15	4	320	8	6	20	22	2	114	27	100	28	7	658
08:15-08:30	5	344	8	22	21	25	5	100	39	134	27	0	730
08:30-08:45	1	318	25	11	22	20	5	127	26	115	45	5	720
08:45-09:00	6	257	10	4	7	7	9	129	26	62	15	0	532
09:00 -09:15	6	167	8	3	4	10	8	100	17	39	8	0	370
09:15-09:30	0	119	1	6	5	9	4	80	5	22	5	0	256
AM Peak	16	1239	51	43	70	74	21	470	118	411	115	12	2640
Entering	1306			187			609			538			2640
Exiting	525			187			1724			204			2640
Two Way	1831			374			2333			742			
16:00-16:15	2	175	10	18	18	16	11	303	35	56	21	9	674
16:15-16:30	1	168	8	8	18	11	10	259	54	44	16	7	604
16:30-16:45	9	195	19	24	16	15	22	356	71	68	16	4	815
16:45-17:00	7	188	9	14	25	9	17	343	6	61	21	5	705
17:00-17:15	3	149	9	14	26	14	14	378	78	33	10	3	731
17:15-17:30	1	174	20	11	17	7	14	277	59	29	24	5	638
17:30 -17:45	1	127	13	10	9	6	10	203	40	1	17	2	439
PM Peak	20	706	57	63	84	45	67	1354	214	191	71	17	2889
Entering	783			192			1635			279			2889
Exiting	1434			195			942			318			2889
Two Way	2217			387			2577			597			

Table A-10

Columbus Drive
@
Blackmarsh Road

St. John's, NL

Wednesday, June 22, 2005



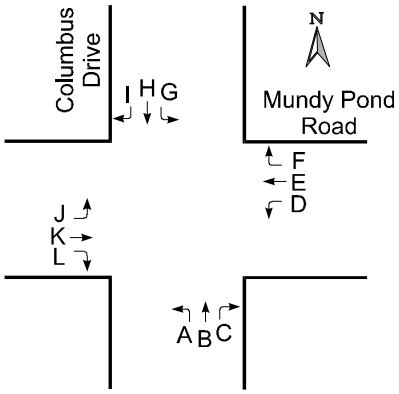
Time	Columbus Drive Northbound Approach			Blackmarsh Road Westbound Approach			Columbus Drive Southbound Approach			Blackmarsh Road Eastbound Approach			Total Vehicles
	A	B	C	D	E	F	G	H	I	J	K	L	
07:30-07:45	3	264	33	4	24	41	15	104	5	12	46	1	552
07:45-08:00	3	339	41	7	36	36	39	115	9	40	108	0	773
08:00-08:15	2	296	27	6	29	35	27	123	8	26	70	5	654
08:15-08:30	1	367	19	10	38	35	25	139	10	41	86	1	772
08:30-08:45	1	347	27	14	28	33	25	139	10	37	73	1	735
08:45-09:00	1	272	19	9	30	50	44	142	9	13	53	6	648
09:00 -09:15	3	169	24	9	31	17	29	124	11	9	46	1	473
09:15-09:30	2	173	17	11	37	14	25	110	10	19	56	1	475
AM Peak	7	1349	114	37	131	139	116	516	37	144	337	7	2934
Entering	1470			307			669			488			2934
Exiting	560			567			1632			175			2934
Two Way	2030			874			2301			663			
16:00-16:15	3	190	26	41	98	31	51	333	24	11	35	6	849
16:15-16:30	6	177	30	37	78	36	50	352	18	18	37	2	841
16:30-16:45	3	197	46	44	94	22	77	318	23	13	48	1	886
16:45-17:00	3	221	34	35	76	42	69	392	21	12	55	3	963
17:00-17:15	3	199	37	34	92	43	60	323	19	11	52	7	880
17:15-17:30	3	192	35	31	102	41	72	338	19	21	53	6	913
17:30 -17:45	4	164	17	42	74	30	45	234	15	12	41	6	684
17:45-18:00	3	146	26	26	55	21	35	199	9	12	42	4	578
PM Peak Hour	12	809	152	144	364	148	278	1371	82	57	208	17	3642
Entering	973			656			1731			282			3642
Exiting	1532			638			1014			458			3642
Two Way	2505			1294			2745			740			

Table A-11

Columbus Drive
@
Mundy Pond Road

St. John's, NL

Tuesday, October 19, 2004



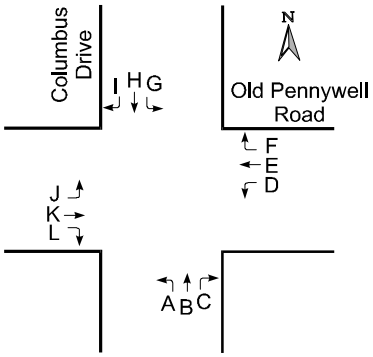
Time	Columbus Drive Northbound Approach			Mundy Pond Road Westbound Approach			Columbus Drive Southbound Approach			Mundy Pond Road Eastbound Approach			Total Vehicles
	A	B	C	D	E	F	G	H	I	J	K	L	
07:30-07:45	0	252	12	10	17	8	8	89	11	62	48	4	521
07:45-08:00	0	333	17	11	29	9	13	128	13	90	65	9	717
08:00-08:15	0	379	23	5	11	4	24	154	23	78	86	3	790
08:15-08:30	0	440	19	9	23	27	24	139	16	82	134	3	916
08:30-08:45	0	421	14	8	39	20	31	154	10	64	109	2	872
08:45-09:00	0	419	24	17	50	21	20	152	14	62	85	4	868
09:00 -09:15	0	224	17	17	26	12	8	150	14	43	30	3	544
AM Peak	0	1659	80	39	123	72	99	599	63	286	414	12	3446
Entering	1739			234			761			712			3446
Exiting	650			593			2017			186			3446
Two Way	2389			827			2778			898			
16:00-16:15	2	222	21	23	64	25	23	352	39	28	35	1	835
16:15-16:30	0	227	24	45	64	13	20	364	44	31	41	2	875
16:30-16:45	1	257	33	36	66	10	27	359	51	29	32	3	904
16:45-17:00	1	265	21	36	89	18	17	407	60	23	69	2	1008
17:00-17:15	1	242	25	38	85	15	19	418	59	24	51	2	979
17:15-17:30	1	204	15	47	89	15	26	438	69	23	50	3	980
17:30 -17:45	3	146	16	31	70	20	22	292	50	35	37	4	726
17:45-18:00	3	220	13	23	37	13	16	264	27	36	46	1	699
PM Peak	4	968	94	157	329	58	89	1622	239	99	202	10	3871
Entering	1066			544			1950			311			3871
Exiting	1789			385			1125			572			3871
Two Way	2855			929			3075			883			

Table A-12

Columbus Drive
@
Old Pennywell Road

St. John's, NL

Thursday, June 9,2005



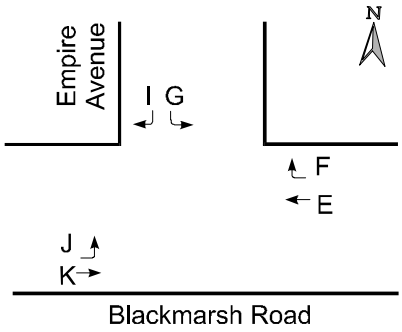
Time	Columbus Drive Northbound Approach			Old Pennywell Road Westbound Approach			Columbus Drive Southbound Approach			Old Pennywell Road Eastbound Approach			Total Vehicles
	A	B	C	D	E	F	G	H	I	J	K	L	
07:30-07:45	13	294	33	14	9	31	43	120	5	12	19	7	600
07:45-08:00	9	410	45	21	12	34	43	135	5	24	31	12	781
08:00-08:15	6	389	50	29	11	32	50	154	9	13	31	13	787
08:15-08:30	7	453	58	50	15	27	52	164	9	25	31	14	905
08:30-08:45	7	344	68	46	19	29	69	154	8	24	40	11	819
08:45-09:00	11	334	39	33	13	50	46	167	9	16	28	11	757
09:00 -09:15	8	221	34	35	11	31	46	131	6	8	25	7	563
09:15-09:30	6	170	26	30	14	32	43	116	4	12	9	8	470
AM Peak	29	1596	221	146	57	122	214	607	31	86	133	50	3292
Entering	1846			325			852			269			3292
Exiting	803			568			1804			117			3292
Two Way	2649			893			2656			386			
16:00-16:15	26	233	41	95	27	45	75	393	12	10	36	30	1023
16:15-16:30	17	284	34	84	29	47	50	378	19	15	31	21	1009
16:30-16:45	15	232	40	146	33	58	61	425	15	12	41	52	1130
16:45-17:00	14	271	38	136	34	44	59	399	16	17	33	41	1102
17:00-17:15	17	229	30	126	26	69	48	396	20	5	28	59	1053
17:15-17:30	23	183	26	89	30	43	50	365	14	9	26	42	900
17:30 -17:45	15	201	32	76	29	38	41	313	8	12	29	21	815
17:45-18:00	8	211	34	50	26	33	41	233	7	7	34	30	714
PM Peak	63	1016	142	492	122	218	218	1598	70	49	133	173	4294
Entering	1221			832			1886			355			4294
Exiting	2263			493			1283			255			4294
Two Way	3484			1325			3169			610			

Table A-13

Blackmarsh Road
@
Empire Avenue

St. John's, NL

Tuesday, June 14, 2005



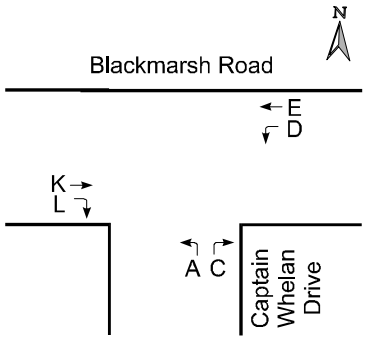
Time	Blackmarsh Road Westbound Approach		Empire Avenue Southbound Approach		Blackmarsh Road Eastbound Approach		Total Vehicles
	E	F	G	I	J	K	
07:30-07:45	63	0	1	11	5	182	262
07:45-08:00	57	0	1	8	5	231	302
08:00-08:15	68	0	2	20	1	213	304
08:15-08:30	55	0	0	15	8	278	356
08:30-08:45	80	1	4	10	4	195	294
08:45-09:00	72	2	3	12	5	140	234
09:00 -09:15	70	0	1	10	6	109	196
09:15-09:30	54	1	3	3	2	116	179
AM Peak	260	1	7	53	18	917	1256
Entering	261		60		935		1256
Exiting	924		19		313		1256
Two Way	1185		79		1248		
16:00-16:15	150	1	2	56	7	102	318
16:15-16:30	159	0	2	26	5	98	290
16:30-16:45	171	1	1	55	7	111	346
16:45-17:00	146	0	2	49	5	82	284
17:00-17:15	164	0	4	56	13	113	350
17:15-17:30	113	2	1	45	14	76	251
17:30 -17:45	95	0	0	21	13	98	227
17:45-18:00	73	2	2	6	10	95	188
PM Peak	640	1	9	186	30	404	1270
Entering	641		195		434		1270
Exiting	413		31		826		1270
Two Way	1054		226		1260		

Table A-14

Blackmarsh Road
@
Captain Whelan Drive

St. John's, NL

Tuesday, June 14, 2005



Time	Captain Whelan Drive Northbound Approach		Blackmarsh Road Westbound Approach		Blackmarsh Road Eastbound Approach		Total Vehicles
	A	C	D	E	K	L [1]	
07:30-07:45	11	16	23	54	173	6	283
07:45-08:00	16	18	28	43	204	4	313
08:00-08:15	8	25	22	67	198	4	324
08:15-08:30	9	18	30	54	232	2	345
08:30-08:45	8	29	27	74	210	7	355
08:45-09:00	10	26	35	75	153	3	302
09:00 -09:15	10	15	30	62	100	1	218
09:15-09:30	9	14	8	57	107	3	198
AM Peak	41	90	107	238	844	143	1337
Entering	131		345		987		1463
Exiting	250		934		279		1463
Two Way	381		1279		1266		
16:00-16:15	22	19	52	150	75	0	318
16:15-16:30	17	19	58	151	124	1	370
16:30-16:45	21	19	66	172	77	3	358
16:45-17:00	25	13	47	174	99	9	367
17:00-17:15	25	32	56	172	101	3	389
17:15-17:30	24	16	61	143	103	3	350
17:30 -17:45	10	36	33	107	70	3	259
17:45-18:00	9	29	36	76	92	1	243
PM Peak	88	83	227	669	401	102	1484
Entering	171		896		503		1570
Exiting	329		484		757		1570
Two Way	500		1380		1260		

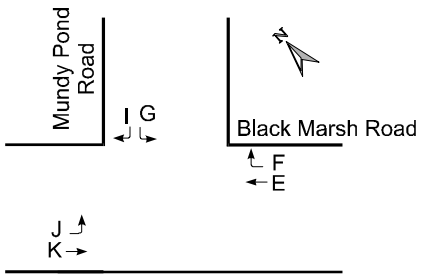
NOTE: The majority of right turn movement traffic from Blackmarsh Road eastbound to Captain Whalen Drive was counted by a machine and the AM and PM peak hour volumes (Table A-2) have been added to AM and PM peak hour volumes for movement 'L' in this table.

Table A-15

Blackmarsh Road
@
Mundy Pond Road

St. John's, NL

Tuesday, June 7, 2005



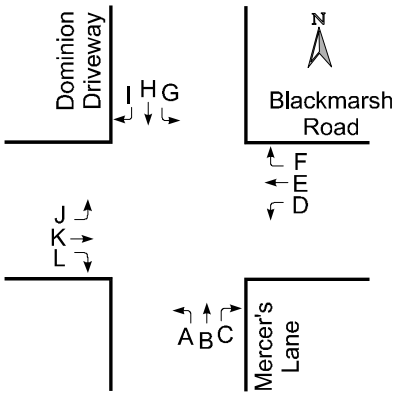
Time	Blackmarsh Road Westbound Approach		Mundy Pond Road Southbound Approach		Blackmarsh Road Eastbound Approach		Total Vehicles
	E	F	G	I	J	K	
07:30-07:45	29	3	2	48	113	86	281
07:45-08:00	43	1	2	39	122	79	286
08:00-08:15	33	3	1	45	150	112	344
08:15-08:30	34	3	5	57	158	112	369
08:30-08:45	39	1	3	54	121	97	315
08:45-09:00	49	2	7	77	104	69	308
09:00 -09:15	30	3	2	40	59	62	196
09:15-09:30	34	3	4	39	50	46	176
AM Peak	155	9	16	233	533	390	1336
Entering	164		249		923		1336
Exiting	406		542		388		1336
Two Way	570		791		1311		
16:00-16:15	102	3	7	95	54	62	323
16:15-16:30	72	7	5	104	45	73	306
16:30-16:45	92	10	8	99	53	61	323
16:45-17:00	98	16	7	141	63	71	396
17:00-17:15	100	5	6	127	58	50	346
17:15-17:30	81	10	10	93	58	59	311
17:30 -17:45	56	8	9	71	56	69	269
17:45 -18:00	66	4	9	69	57	52	257
PM Peak	371	41	31	460	232	241	1376
Entering	412		491		473		1376
Exiting	272		273		831		1376
Two Way	684		764		1304		

Table A-16

Blackmarsh Road
@
Mercer's Lane

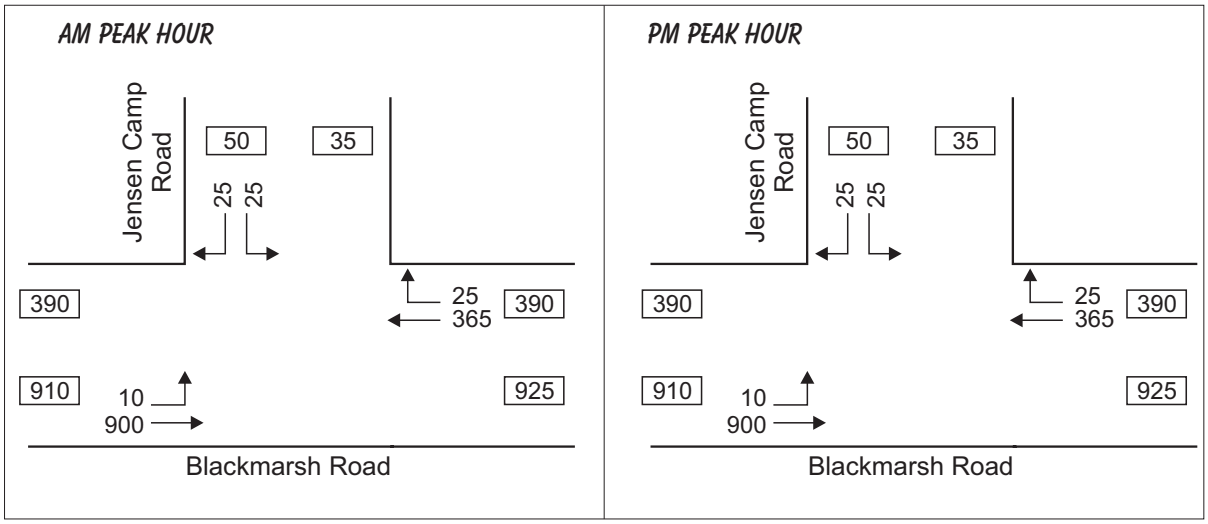
St. John's, NL

Tuesday, June 7 ,2005



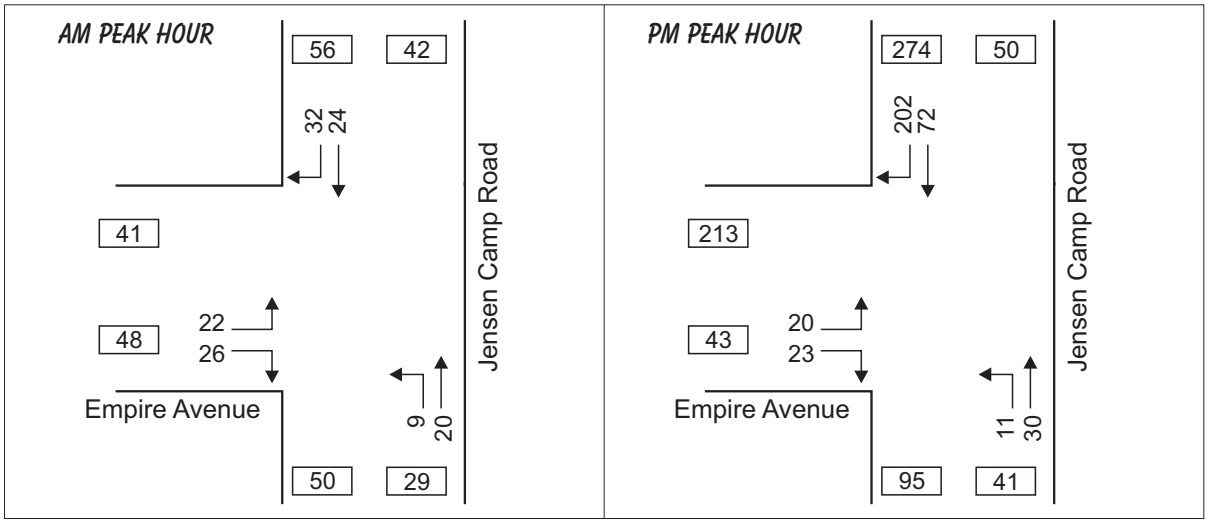
Time	Mercer's Lane Northbound Approach			Blackmarsh Road Westbound Approach			Dominion Driveway Southbound Approach			Blackmarsh Road Eastbound Approach			Total Vehicles
	A	B	C	D	E	F	G	H	I	J	K	L	
07:30-07:45	16	0	46	9	39	1	0	1	5	1	97	9	224
07:45-08:00	17	3	71	21	38	3	0	1	0	0	140	17	311
08:00-08:15	31	3	70	22	43	3	0	0	0	0	152	9	333
08:15-08:30	18	2	84	24	61	8	2	2	0	2	190	15	408
08:30-08:45	27	6	91	33	65	9	2	4	2	1	179	10	429
08:45-09:00	22	3	43	35	59	8	3	1	0	1	130	21	326
09:00 -09:15	7	1	25	19	33	7	6	0	0	0	90	12	200
09:15-09:30	8	3	17	18	50	12	11	5	1	1	69	13	208
AM Peak	98	14	288	114	228	28	7	7	2	4	651	55	1496
Entering	400			370			16			710			1496
Exiting	176			946			46			328			1496
Two Way	576			1316			62			1038			
16:00-16:15	18	8	41	50	127	34	15	9	4	1	94	27	428
16:15-16:30	11	1	37	46	108	27	16	17	4	1	123	11	402
16:30-16:45	13	7	25	41	102	28	29	10	14	6	108	19	402
16:45-17:00	14	5	30	79	102	56	24	11	5	4	121	22	473
17:00-17:15	16	13	31	66	138	43	30	12	12	2	78	29	470
17:15-17:30	13	11	29	55	108	26	24	13	14	1	73	22	389
17:30 -17:45	11	9	33	35	59	26	22	13	11	4	57	19	299
17:45-18:00	9	16	33	20	58	20	25	9	9	5	60	12	276
PM Peak	54	26	123	232	450	154	99	50	35	13	430	81	1747
Entering	203			836			184			524			1747
Exiting	363			652			193			539			1747
Two Way	566			1488			377			1063			

Table A-17 - Jensen Camp Road @ Blckmarsh Road
(Tuesday, February 3, 2004)



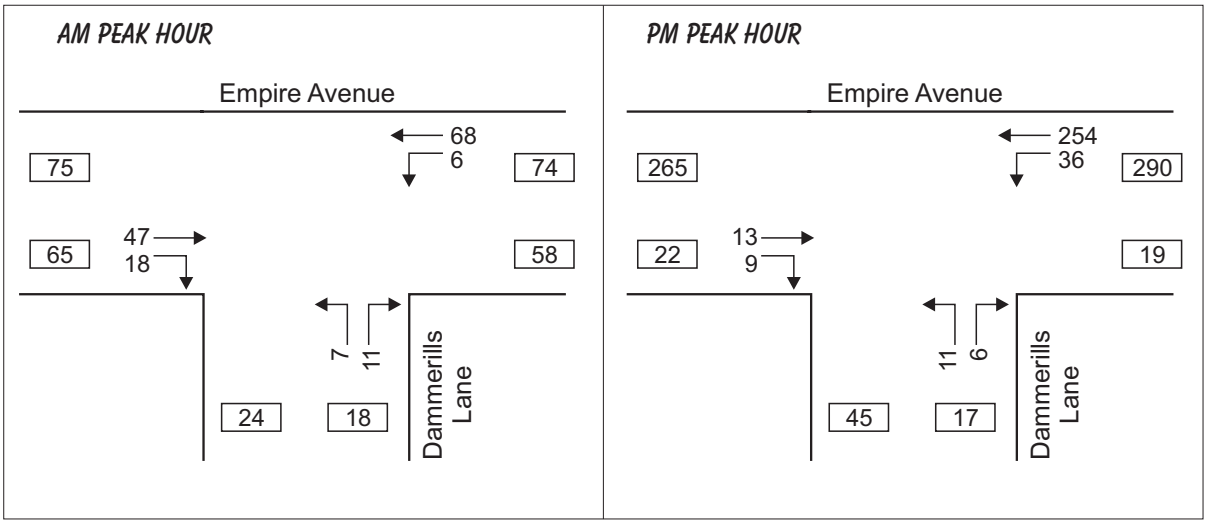
(Source: Mundy Pond Road Neighbourhood Traffic Calming Study, APEX Solutions, April 2004)

Table A-18 - Empire Avenue @ Jensen Camp Road
(Thursday, January 29, 2004)



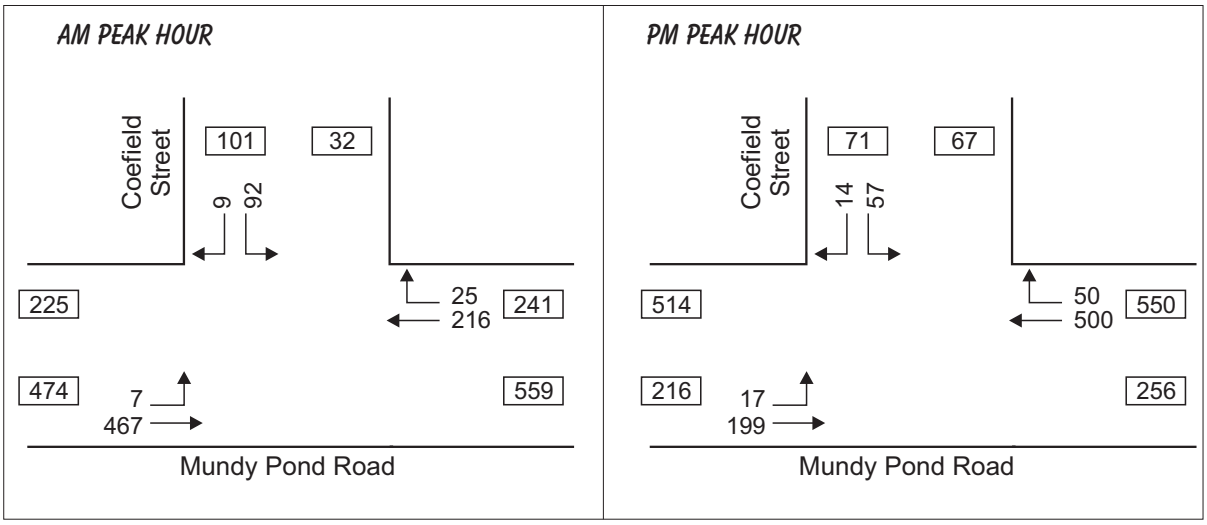
(Source: Mundy Pond Road Neighbourhood Traffic Calming Study, APEX Solutions, April 2004)

Table A-19 - Empire Avenue @ Dammerills Lane
(Tuesday, February 3, 2004)



(Source: Mundy Pond Road Neighbourhood Traffic Calming Study, APEX Solutions, April 2004)

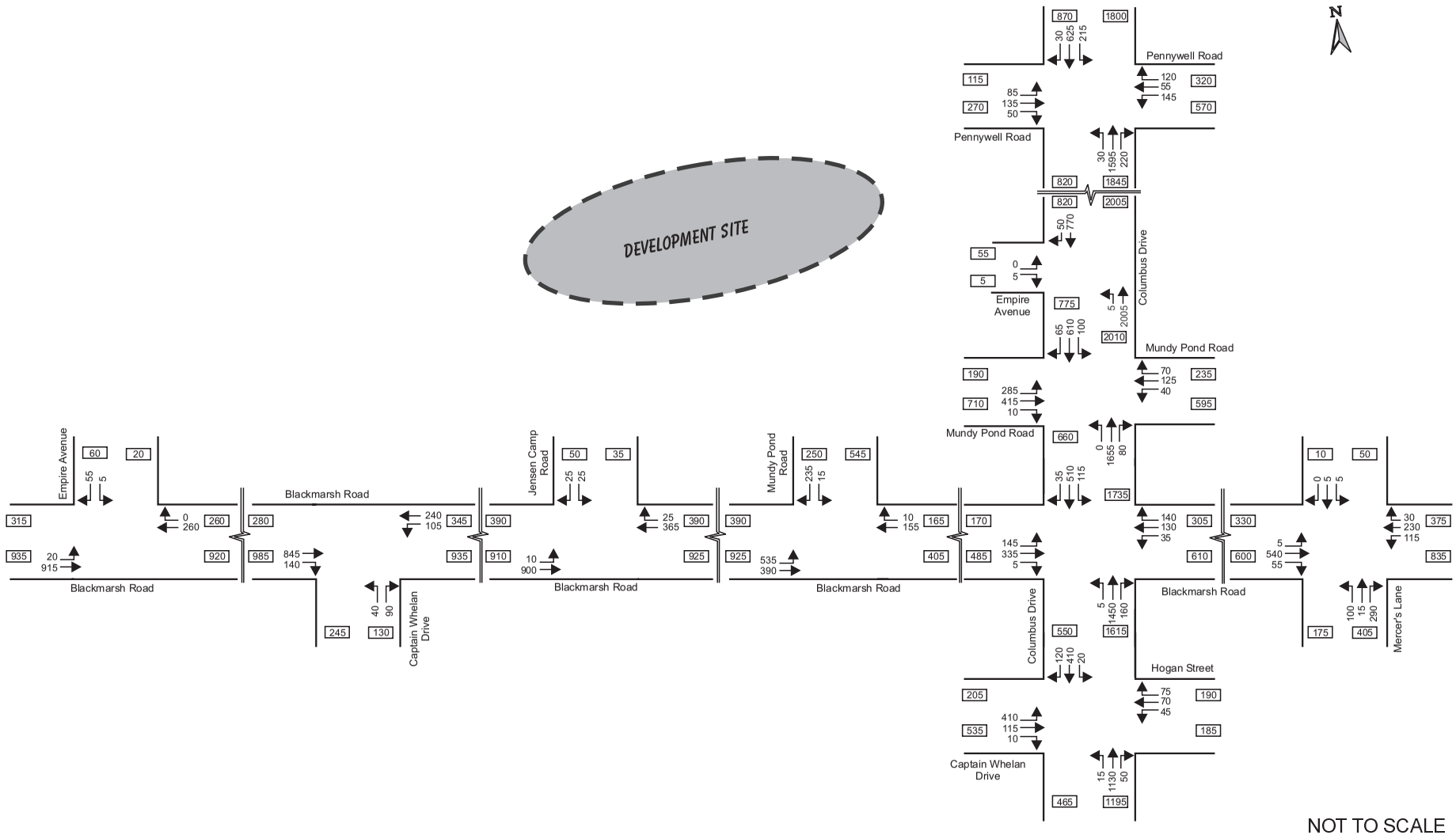
Table A-20 - Mundy Pond Road @ Coefield Street
(Tuesday, February 3, 2004)



(Source: Mundy Pond Road Neighbourhood Traffic Calming Study, APEX Solutions, April 2004)

Appendix B

Traffic Volume Diagrams



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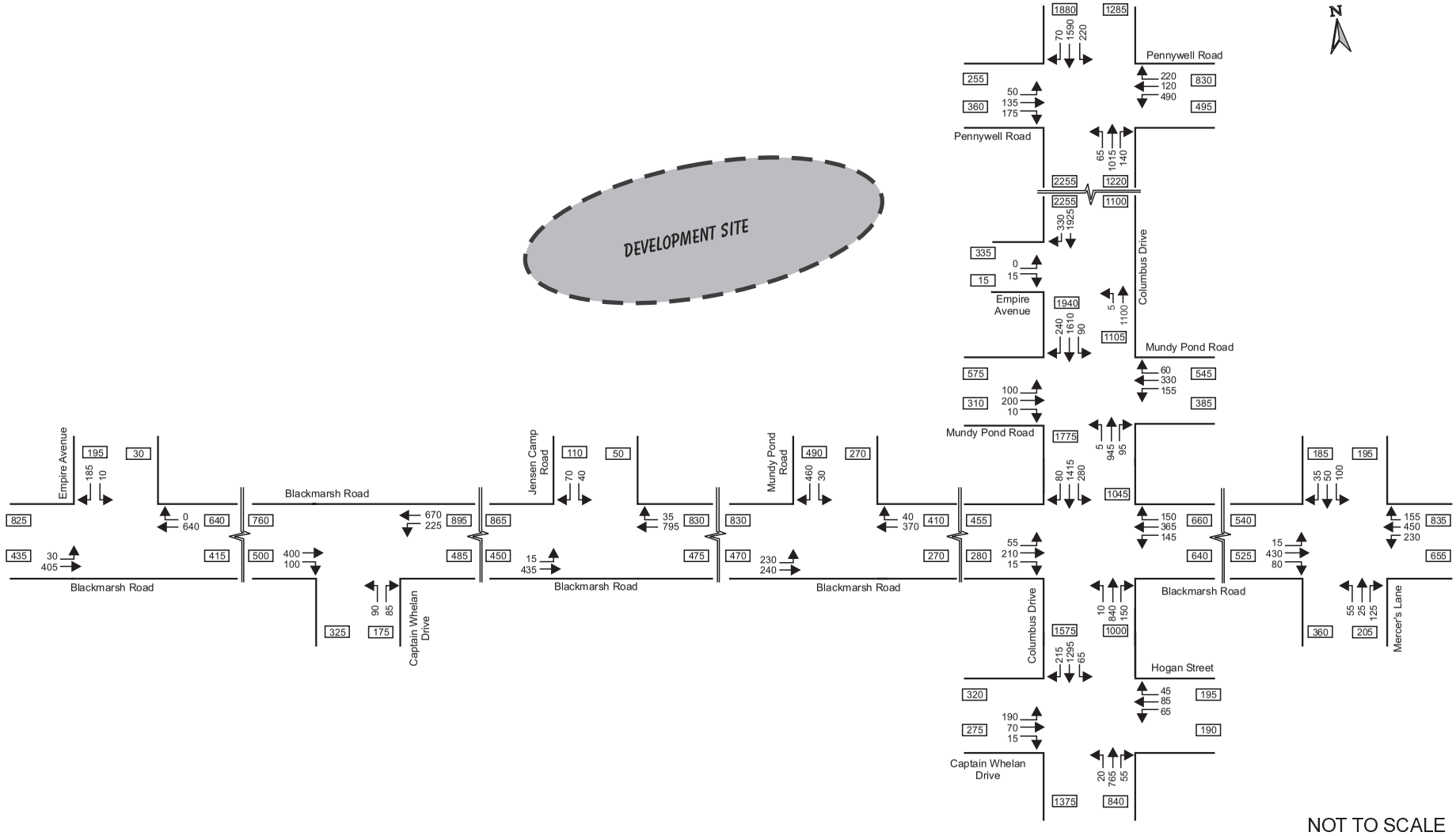
Traffic Engineering Specialists

Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

2005 AM Peak Hour Volume without Site Development

Figure B-1A

August 2005



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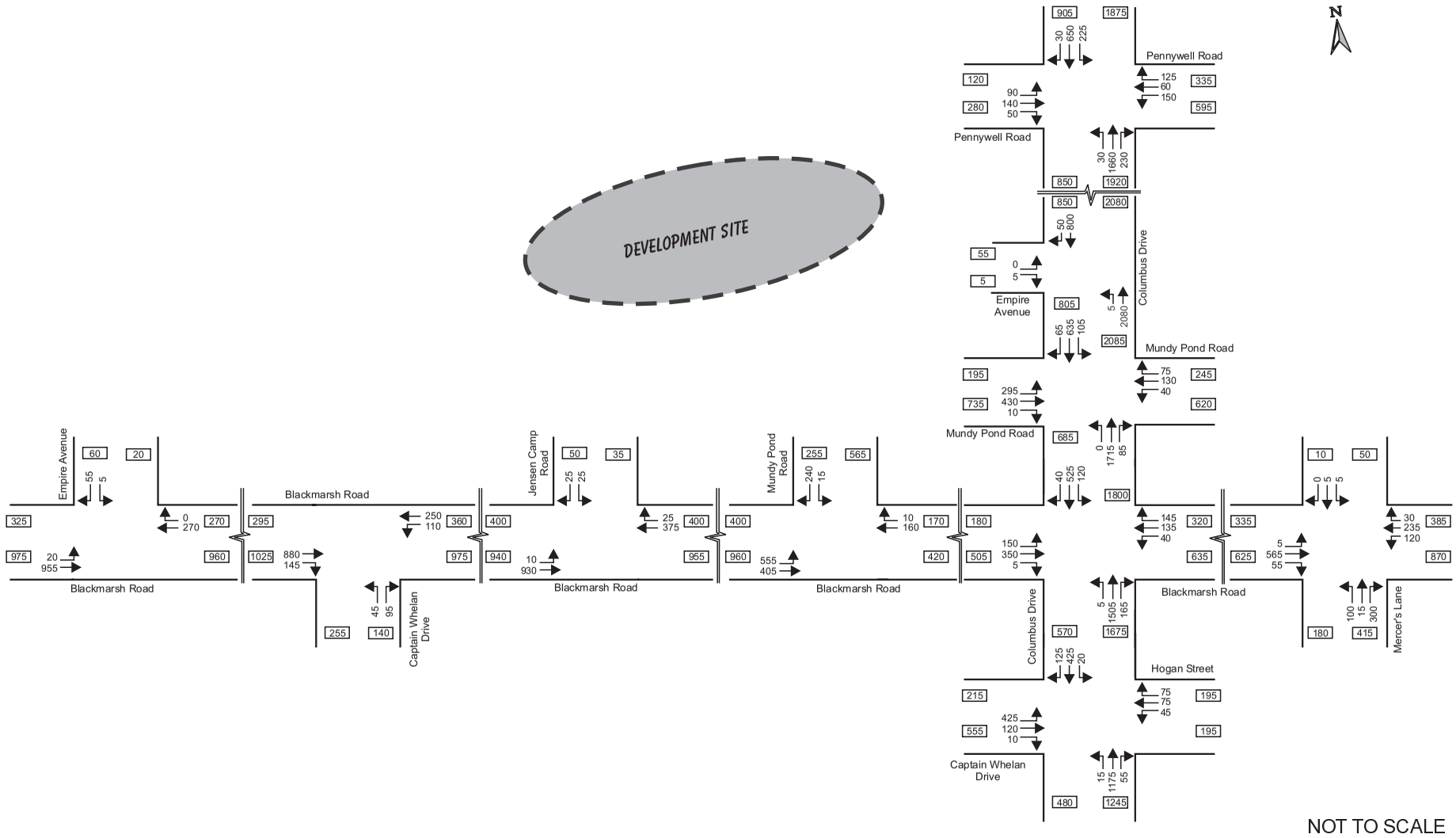
Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

2005 PM Peak Hour Volume without Site Development

Figure B-1B

August 2005



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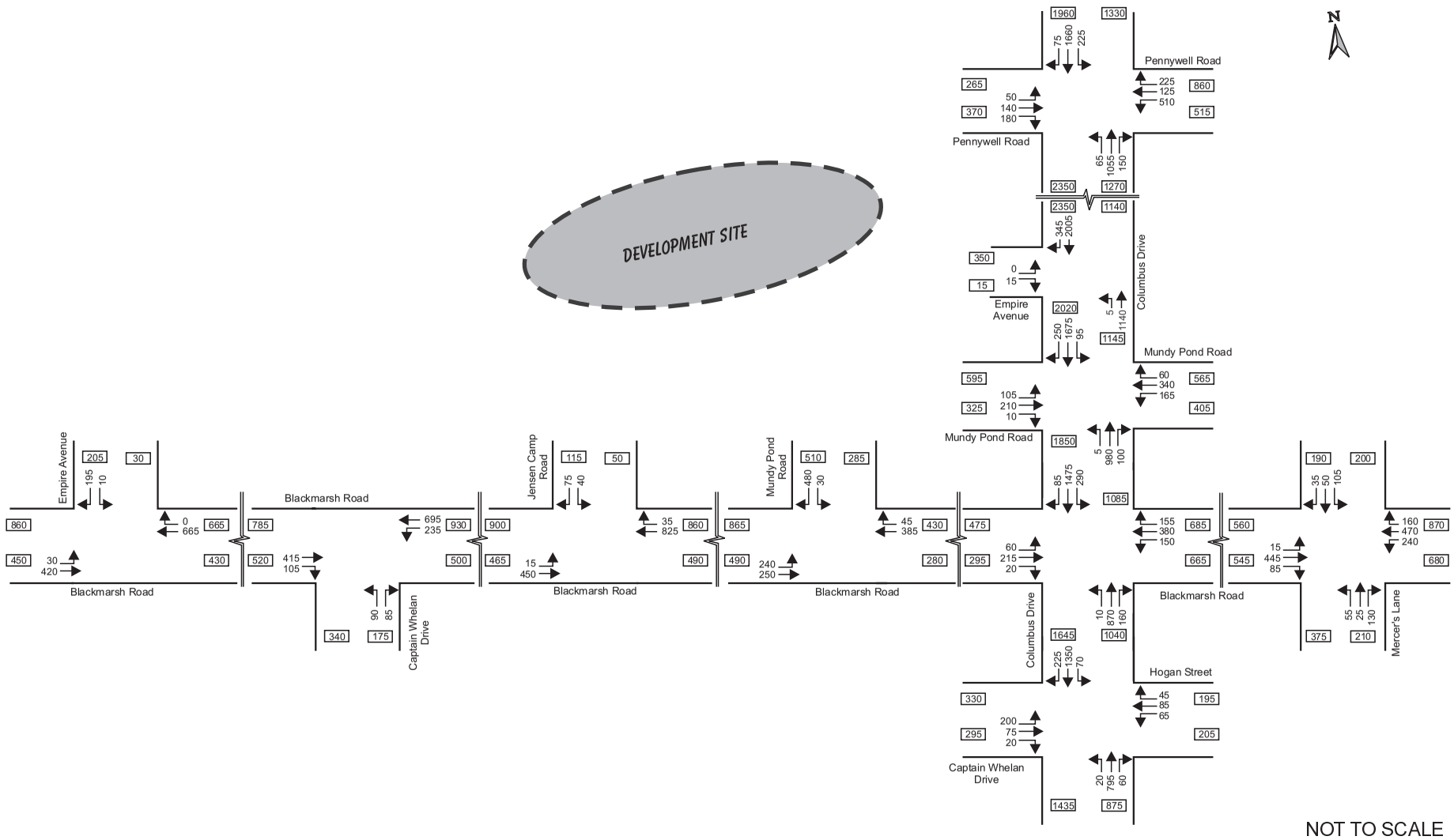
Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

2008 AM Peak Hour Volume without Site Development

Figure B-2A

August 2005



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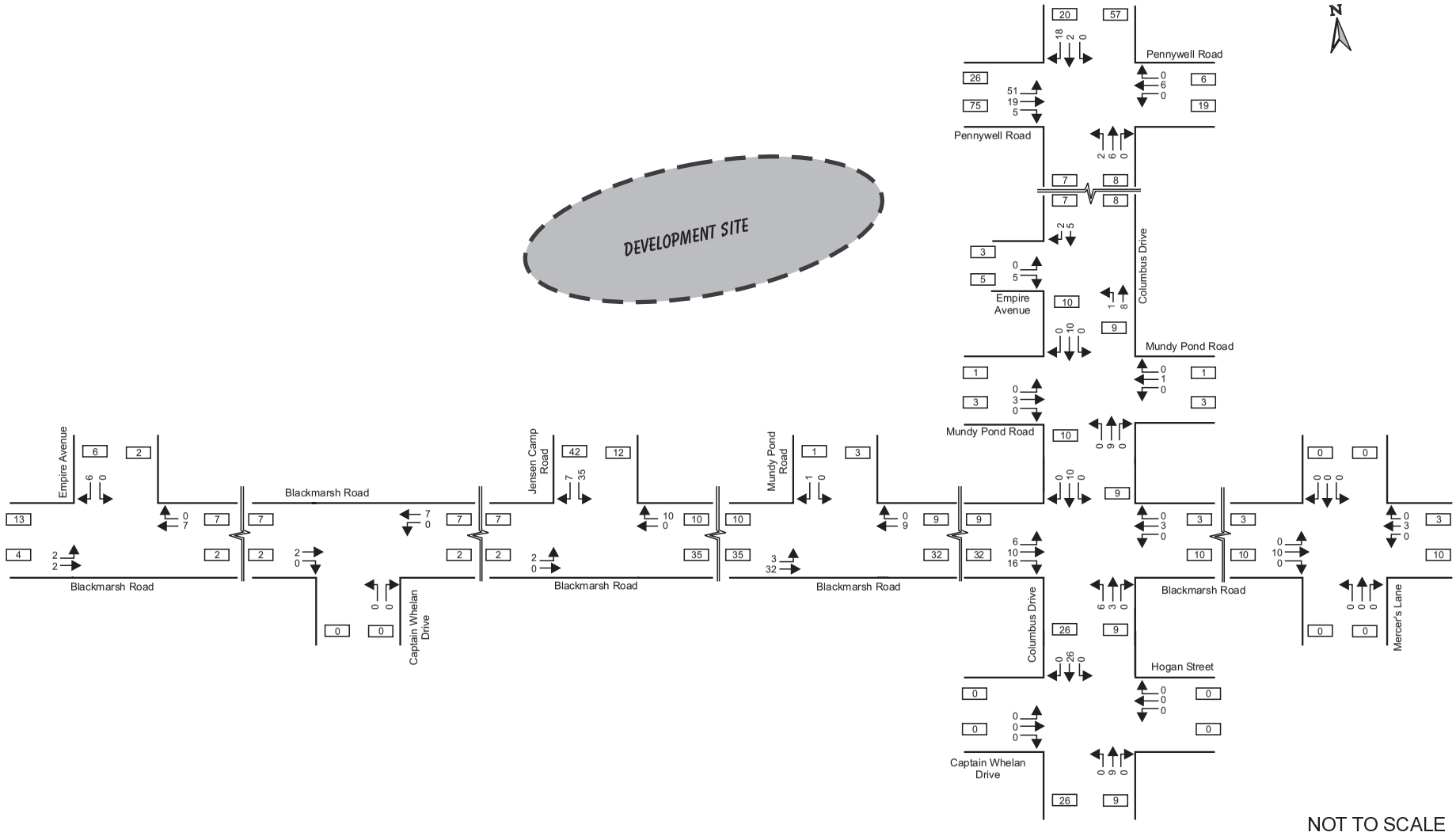
Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

2008 PM Peak Hour Volume without Site Development

Figure B-2B

August 2005



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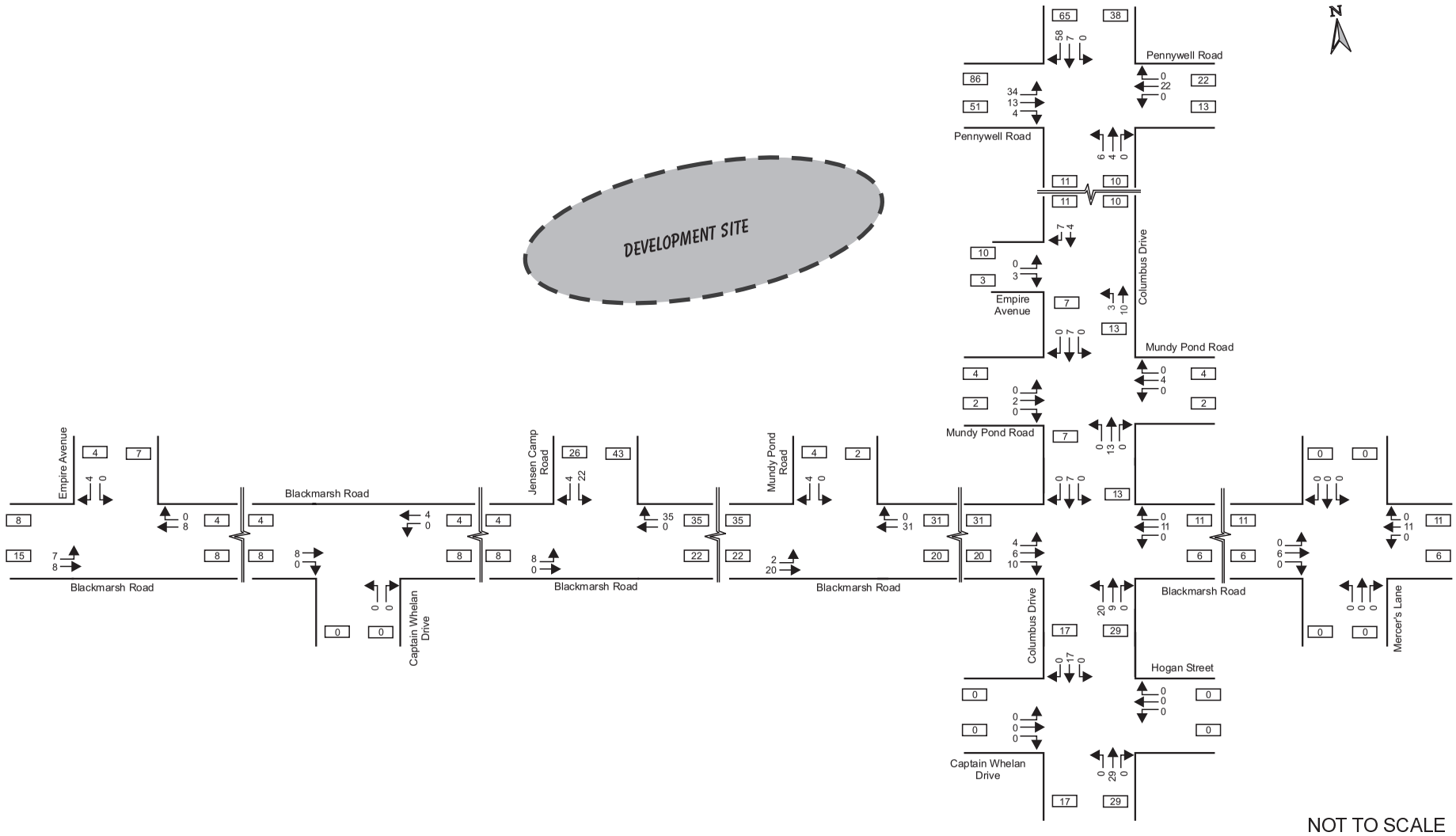
Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

AM Peak Hour Site Generated Traffic

Figure B-3A

August 2005



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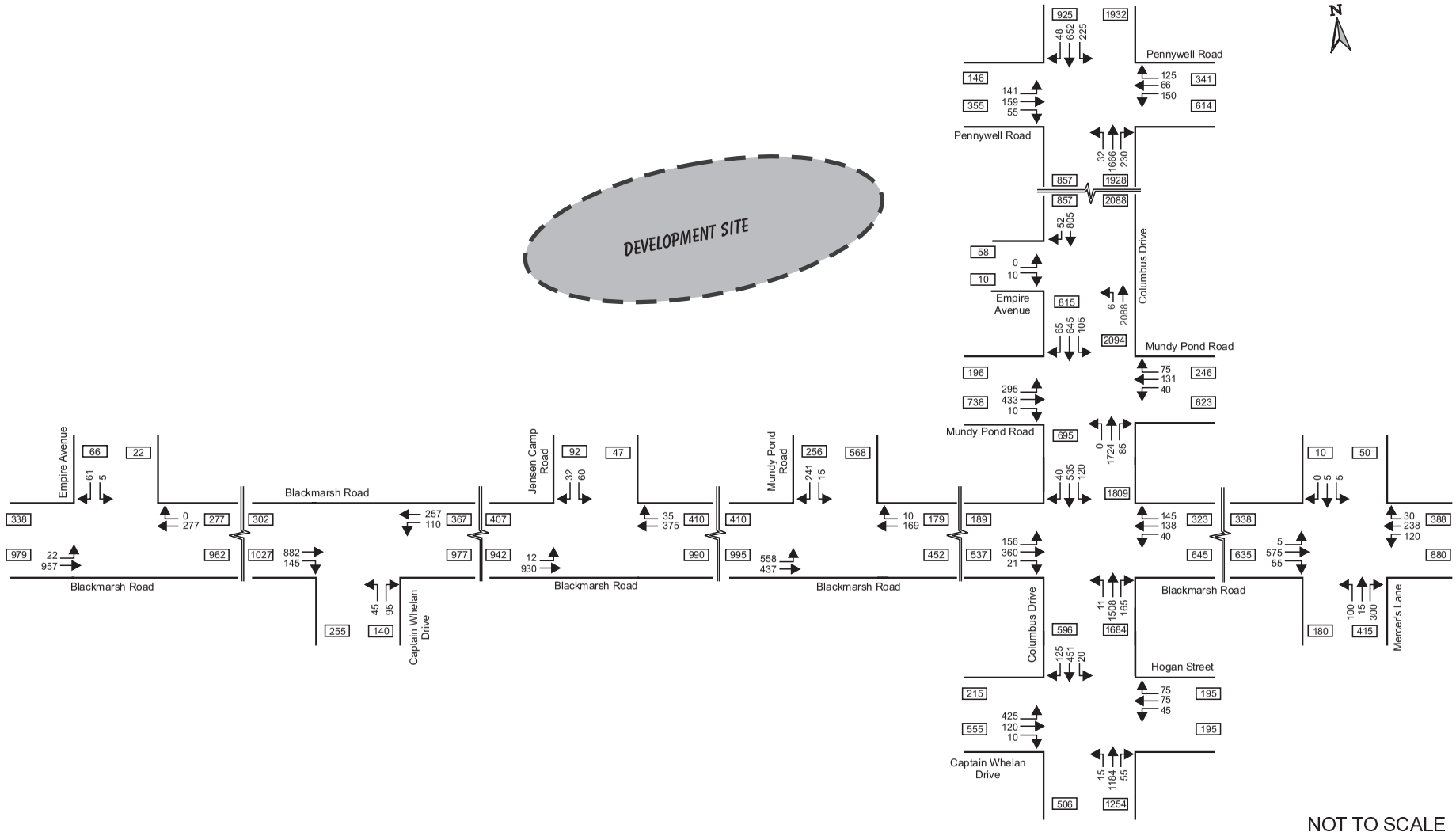
Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

PM Peak Hour Site Generated Traffic

Figure B-3B

August 2005



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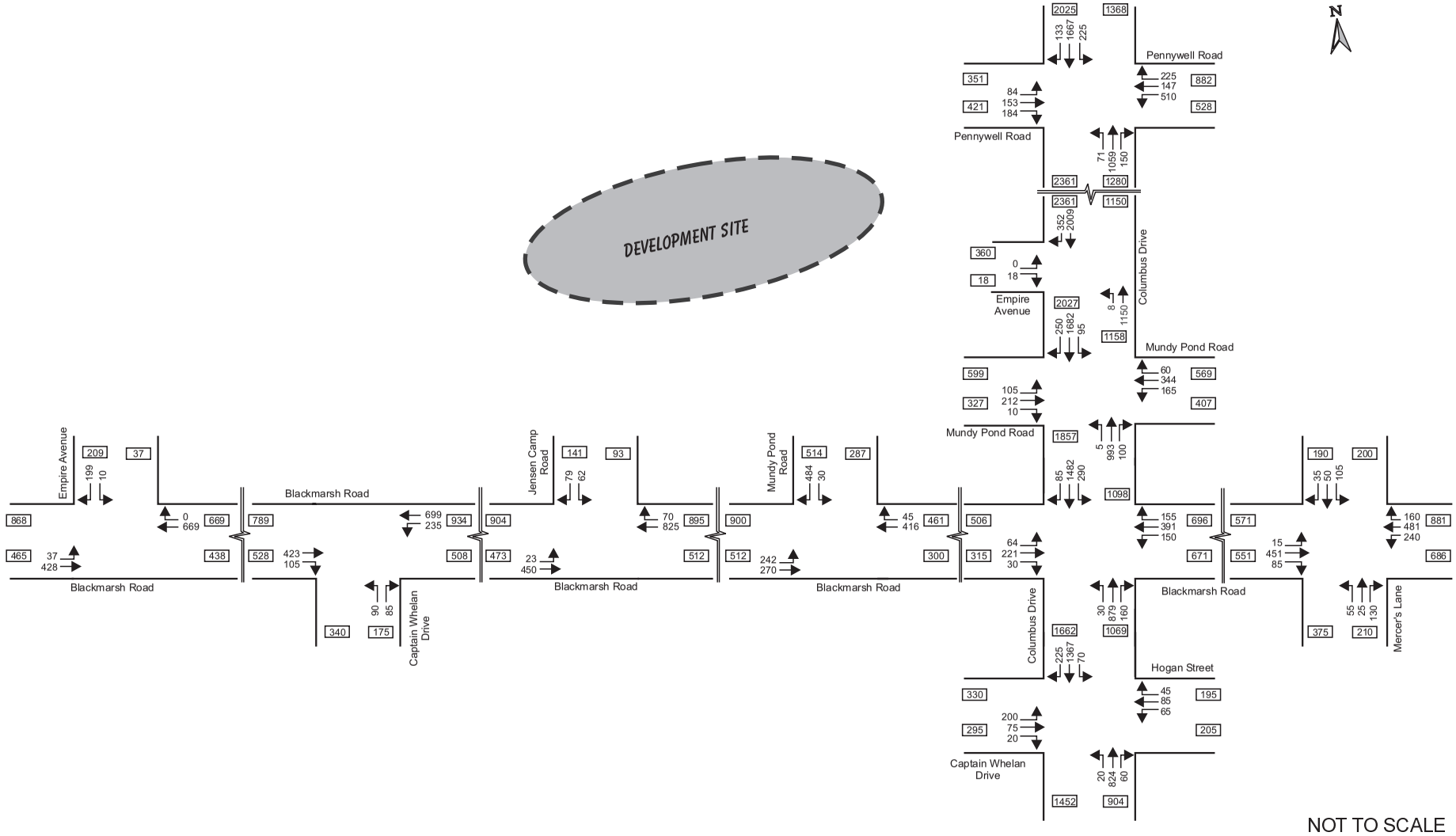
Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL

2008 AM Peak Hour Volume with Site Development

Figure B-4A

August 2005



NOT TO SCALE

Atlantic Road & Traffic Management *Traffic Engineering Specialists*	**Mundy Pond Road Neighbourhood Traffic Impact Study, St. John's, NL**	**Figure B-4B**
	2008 PM Peak Hour Volume with Site Development	**August 2005**

Appendix C

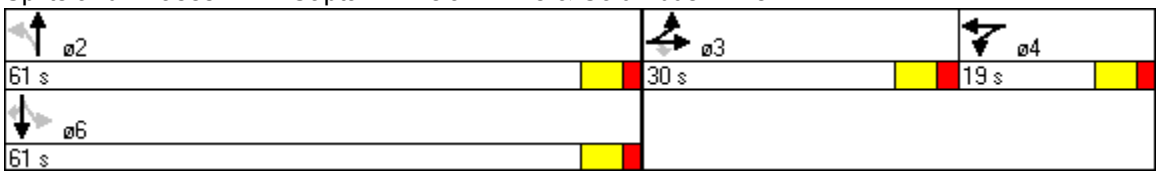
Level of Service Analysis

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1569	1701	1601	1652	1698	0	1750	3753	0	1750	3775	1601
Flt Permitted	0.950	0.972		0.950			0.460			0.111		
Satd. Flow (perm)	1569	1701	1580	1649	1698	0	847	3753	0	204	3775	1601
Satd. Flow (RTOR)			11		41			6				130
Volume (vph)	410	115	10	45	70	75	15	1130	50	20	410	120
Lane Group Flow (vph)	270	301	11	49	158	0	16	1282	0	22	446	130
Turn Type	Split		Perm	custom			Perm			Perm		Perm
Protected Phases	3	3		4	4			2			6	
Permitted Phases			3	4			2			6		6
Total Split (s)	30.0	30.0	30.0	19.0	19.0	0.0	61.0	61.0	0.0	61.0	61.0	61.0
Act Effct Green (s)	26.0	26.0	26.0	15.0	15.0		57.0	57.0		57.0	57.0	57.0
Actuated g/C Ratio	0.24	0.24	0.24	0.14	0.14		0.52	0.52		0.52	0.52	0.52
v/c Ratio	0.73	0.75	0.03	0.22	0.59		0.04	0.66		0.21	0.23	0.15
Control Delay	51.5	51.9	16.4	45.2	42.8		13.5	21.3		12.9	7.7	1.2
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	51.5	51.9	16.4	45.2	42.8		13.5	21.3		12.9	7.7	1.2
LOS	D	D	B	D	D		B	C		B	A	A
Approach Delay		51.1			43.3			21.2			6.4	
Approach LOS		D			D			C			A	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 24 (22%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 26.1 Intersection LOS: C
Intersection Capacity Utilization 65.5% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Captain Whelan Drive & Columbus Drive

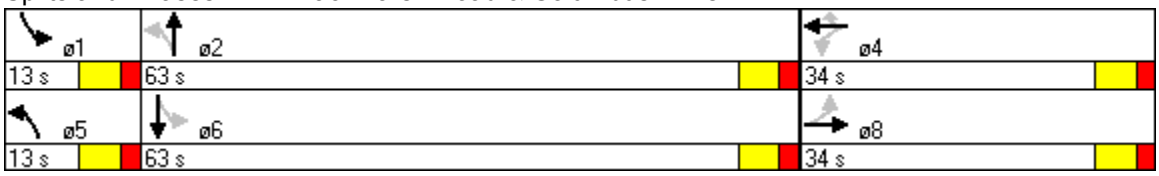


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1838	0	1652	1842	1601	1750	3719	0	1750	3732	0
Flt Permitted	0.605			0.241			0.380			0.068		
Satd. Flow (perm)	1052	1838	0	419	1842	1601	699	3719	0	125	3732	0
Satd. Flow (RTOR)		1				137		16			10	
Volume (vph)	145	335	5	35	130	140	5	1450	160	115	510	35
Lane Group Flow (vph)	158	369	0	38	141	152	5	1750	0	125	592	0
Turn Type	Perm			Perm		Perm	pm+pt			pm+pt		
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2			6		
Total Split (s)	34.0	34.0	0.0	34.0	34.0	34.0	13.0	63.0	0.0	13.0	63.0	0.0
Act Effct Green (s)	30.0	30.0		30.0	30.0	30.0	68.0	59.0		68.0	59.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.62	0.54		0.62	0.54	
v/c Ratio	0.55	0.74		0.33	0.28	0.28	0.01	0.87		0.60	0.30	
Control Delay	42.8	46.3		34.6	26.7	5.7	11.8	43.6		43.2	7.8	
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay	42.8	46.3		34.6	26.7	5.7	11.8	43.6		43.2	7.8	
LOS	D	D		C	C	A	B	D		D	A	
Approach Delay		45.2			18.0			43.5			13.9	
Approach LOS		D			B			D			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.87
Intersection Signal Delay: 34.9 Intersection LOS: C
Intersection Capacity Utilization 88.7% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

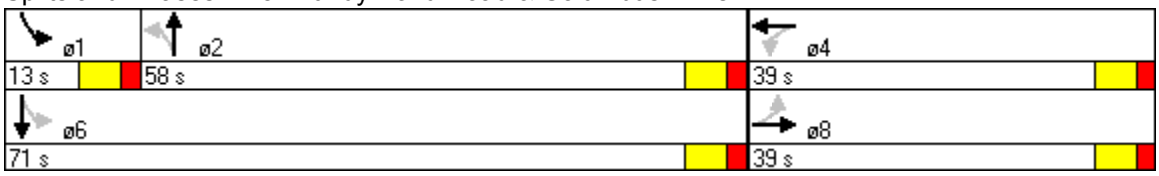


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1978	0	1750	1868	0	1652	3475	0	1652	3440	0
Flt Permitted	0.518			0.186			0.373			0.069		
Satd. Flow (perm)	951	1978	0	343	1868	0	648	3475	0	120	3440	0
Satd. Flow (RTOR)		1			27			6			19	
Volume (vph)	285	415	10	40	125	70	1	1655	80	100	610	65
Lane Group Flow (vph)	310	462	0	43	212	0	1	1886	0	109	734	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2			6		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	58.0	58.0	0.0	13.0	71.0	0.0
Act Effct Green (s)	35.0	35.0		35.0	35.0		54.0	54.0		67.0	67.0	
Actuated g/C Ratio	0.32	0.32		0.32	0.32		0.49	0.49		0.61	0.61	
v/c Ratio	1.02	0.73		0.39	0.35		0.00	1.10		0.55	0.35	
Control Delay	96.5	41.7		42.3	26.8		11.0	67.0		46.8	4.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	96.5	41.7		42.3	26.8		11.0	67.0		46.8	4.8	
LOS	F	D		D	C		B	E		D	A	
Approach Delay		63.7			29.4			67.0			10.2	
Approach LOS		E			C			E			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.10
Intersection Signal Delay: 51.0 Intersection LOS: D
Intersection Capacity Utilization 98.3% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

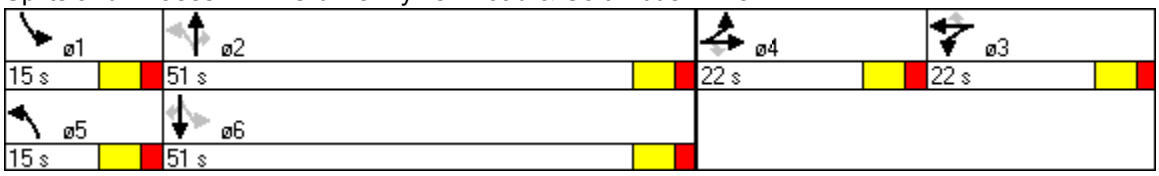


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1883	1601	3471	1883	1601	1789	5142	1601	1789	4238	1601
Flt Permitted	0.950			0.950			0.268			0.085		
Satd. Flow (perm)	1789	1883	1601	3471	1883	1601	505	5142	1601	160	4238	1601
Satd. Flow (RTOR)			54			130			191			33
Volume (vph)	85	135	50	145	55	120	30	1595	220	215	625	30
Lane Group Flow (vph)	92	147	54	158	60	130	33	1734	239	234	679	33
Turn Type	custom		Perm	custom		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases	4		4	3		3	2		2	6		6
Total Split (s)	22.0	22.0	22.0	22.0	22.0	22.0	15.0	51.0	51.0	15.0	51.0	51.0
Act Effct Green (s)	18.0	18.0	18.0	18.0	18.0	18.0	58.0	47.0	47.0	58.0	47.0	47.0
Actuated g/C Ratio	0.16	0.16	0.16	0.16	0.16	0.16	0.53	0.43	0.43	0.53	0.43	0.43
v/c Ratio	0.31	0.48	0.18	0.28	0.19	0.35	0.08	0.79	0.30	0.95	0.37	0.05
Control Delay	44.0	47.6	12.4	41.8	41.7	9.9	5.2	12.2	0.4	73.6	22.2	6.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.0	47.6	12.4	41.8	41.7	9.9	5.2	12.2	0.4	73.6	22.2	6.4
LOS	D	D	B	D	D	A	A	B	A	E	C	A
Approach Delay		40.0			29.9			10.7			34.4	
Approach LOS		D			C			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 72 (65%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.95
Intersection Signal Delay: 21.2 Intersection LOS: C
Intersection Capacity Utilization 69.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 4: Old Pennywell Road & Columbus Drive

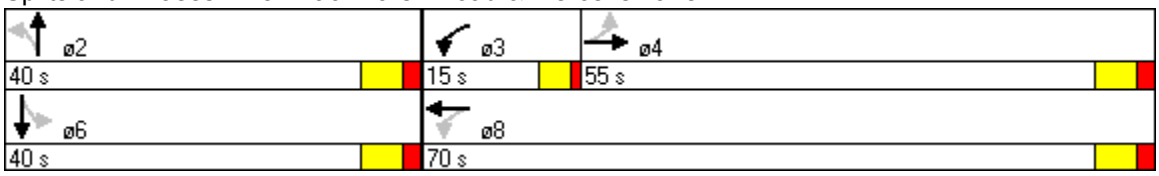


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1857	0	1789	1851	0	1789	1614	0	1789	1883	0
Flt Permitted	0.586			0.167			0.754			0.363		
Satd. Flow (perm)	1104	1857	0	315	1851	0	1420	1614	0	684	1883	0
Satd. Flow (RTOR)		6			11			315				
Volume (vph)	5	540	55	115	230	30	100	15	290	5	5	0
Lane Group Flow (vph)	5	647	0	125	283	0	109	331	0	5	5	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	55.0	55.0	0.0	15.0	70.0	0.0	40.0	40.0	0.0	40.0	40.0	0.0
Act Effct Green (s)	51.0	51.0		66.0	66.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio	0.46	0.46		0.60	0.60		0.33	0.33		0.33	0.33	
v/c Ratio	0.01	0.75		0.37	0.25		0.23	0.45		0.02	0.01	
Control Delay	11.0	17.7		12.7	10.7		28.7	5.9		25.6	25.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	11.0	17.7		12.7	10.7		28.7	5.9		25.6	25.2	
LOS	B	B		B	B		C	A		C	C	
Approach Delay		17.6			11.3			11.5			25.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 10 (9%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 14.2 Intersection LOS: B
Intersection Capacity Utilization 66.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 5: Blackmarsh Road & Mercer's Lane



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	535	390	155	10	15	235
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	582	424	168	11	16	255
Pedestrians			2		2	
Lane Width (m)			3.7		3.7	
Walking Speed (m/s)			1.2		1.2	
Percent Blockage			0		0	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	181				1765	176
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	181				1765	176
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	58				70	70
cM capacity (veh/h)	1392				54	866

Direction, Lane #	EB 1	EB 2	WB 1	SB 1	SB 2
Volume Total	582	424	179	16	255
Volume Left	582	0	0	16	0
Volume Right	0	0	11	0	255
cSH	1392	1700	1700	54	866
Volume to Capacity	0.42	0.25	0.11	0.30	0.30
Queue Length 95th (m)	16.0	0.0	0.0	8.1	9.4
Control Delay (s)	9.4	0.0	0.0	99.4	10.9
Lane LOS	A			F	B
Approach Delay (s)	5.5		0.0	16.2	
Approach LOS				C	

Intersection Summary			
Average Delay	6.8		
Intersection Capacity Utilization	51.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	10	900	365	25	25	25
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	11	978	397	27	27	27
Pedestrians		6	3		6	
Lane Width (m)		3.7	3.7		3.7	
Walking Speed (m/s)		1.2	1.2		1.2	
Percent Blockage		1	0		1	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	430				1419	422
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	430				1419	422
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	99				82	96
cM capacity (veh/h)	1124				148	625

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	11	978	424	54
Volume Left	11	0	0	27
Volume Right	0	0	27	27
cSH	1124	1700	1700	239
Volume to Capacity	0.01	0.58	0.25	0.23
Queue Length 95th (m)	0.2	0.0	0.0	6.5
Control Delay (s)	8.2	0.0	0.0	24.4
Lane LOS	A			C
Approach Delay (s)	0.1		0.0	24.4
Approach LOS				C

Intersection Summary			
Average Delay	1.0		
Intersection Capacity Utilization	59.2%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	845	10	105	240	40	90
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	918	11	114	261	43	98
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			929		1413	924
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			929		1413	924
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			84		66	70
cM capacity (veh/h)			736		128	327

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	929	114	261	43	98
Volume Left	0	114	0	43	0
Volume Right	11	0	0	0	98
cSH	1700	736	1700	128	327
Volume to Capacity	0.55	0.16	0.15	0.34	0.30
Queue Length 95th (m)	0.0	4.2	0.0	10.4	9.3
Control Delay (s)	0.0	10.8	0.0	46.8	20.7
Lane LOS		B		E	C
Approach Delay (s)	0.0	3.3		28.7	
Approach LOS				D	

Intersection Summary			
Average Delay	3.7		
Intersection Capacity Utilization	64.2%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	20	915	260	1	5	55
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	22	995	283	1	5	60
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	284				1321	283
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	284				1321	283
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				97	92
cM capacity (veh/h)	1279				170	756

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	1016	284	65
Volume Left	22	0	5
Volume Right	0	1	60
cSH	1279	1700	587
Volume to Capacity	0.02	0.17	0.11
Queue Length 95th (m)	0.4	0.0	2.8
Control Delay (s)	0.5	0.0	11.9
Lane LOS	A		B
Approach Delay (s)	0.5	0.0	11.9
Approach LOS			B

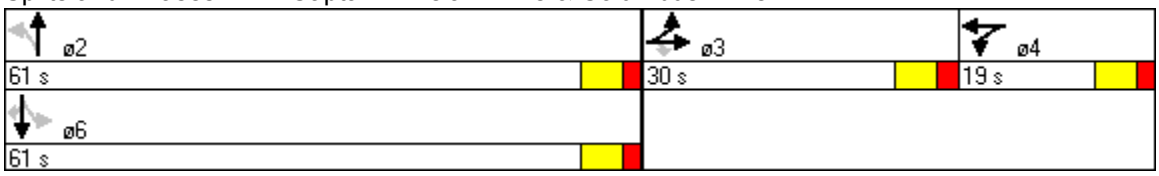
Intersection Summary			
Average Delay	0.9		
Intersection Capacity Utilization	74.6%	ICU Level of Service	D
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1569	1708	1601	1652	1746	0	1750	3737	0	1750	3775	1601
Flt Permitted	0.950	0.976		0.950			0.080			0.237		
Satd. Flow (perm)	1569	1708	1580	1649	1746	0	147	3737	0	437	3775	1601
Satd. Flow (RTOR)			16		20			10				234
Volume (vph)	190	70	15	65	85	45	20	765	55	65	1295	215
Lane Group Flow (vph)	134	149	16	71	141	0	22	892	0	71	1408	234
Turn Type	Split		Perm	custom			Perm			Perm		Perm
Protected Phases	3	3		4	4			2			6	
Permitted Phases			3	4			2			6		6
Total Split (s)	30.0	30.0	30.0	19.0	19.0	0.0	61.0	61.0	0.0	61.0	61.0	61.0
Act Effct Green (s)	26.0	26.0	26.0	15.0	15.0		57.0	57.0		57.0	57.0	57.0
Actuated g/C Ratio	0.24	0.24	0.24	0.14	0.14		0.52	0.52		0.52	0.52	0.52
v/c Ratio	0.36	0.37	0.04	0.32	0.55		0.29	0.46		0.31	0.72	0.25
Control Delay	38.4	38.3	14.5	47.2	47.0		27.4	17.5		12.0	12.3	0.9
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	38.4	38.3	14.5	47.2	47.0		27.4	17.5		12.0	12.3	0.9
LOS	D	D	B	D	D		C	B		B	B	A
Approach Delay		37.1			47.1			17.7			10.7	
Approach LOS		D			D			B			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 24 (22%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.72
Intersection Signal Delay: 17.7 Intersection LOS: B
Intersection Capacity Utilization 75.5% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: Captain Whelan Drive & Columbus Drive

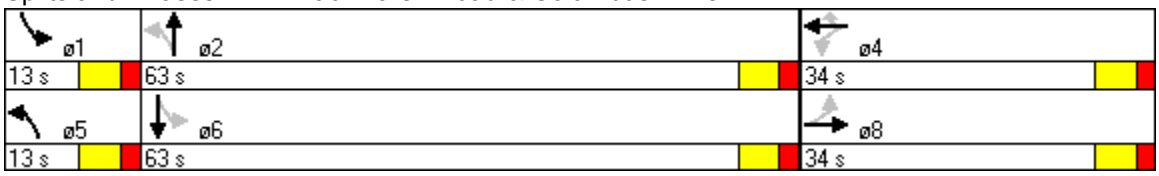


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1824	0	1652	1842	1601	1750	3688	0	1750	3740	0
Flt Permitted	0.200			0.434			0.068			0.178		
Satd. Flow (perm)	348	1824	0	755	1842	1601	125	3688	0	328	3740	0
Satd. Flow (RTOR)		3				163		29			8	
Volume (vph)	55	210	15	145	365	150	10	840	150	280	1415	80
Lane Group Flow (vph)	60	244	0	158	397	163	11	1076	0	304	1625	0
Turn Type	Perm			Perm		Perm	pm+pt			pm+pt		
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2			6		
Total Split (s)	34.0	34.0	0.0	34.0	34.0	34.0	13.0	63.0	0.0	13.0	63.0	0.0
Act Effct Green (s)	30.0	30.0		30.0	30.0	30.0	68.0	59.0		68.0	59.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.62	0.54		0.62	0.54	
v/c Ratio	0.63	0.49		0.77	0.79	0.29	0.05	0.54		0.95	0.81	
Control Delay	66.8	37.1		56.0	43.9	6.3	15.8	36.4		45.8	20.9	
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay	66.8	37.1		56.0	43.9	6.3	15.8	36.4		45.8	20.9	
LOS	E	D		E	D	A	B	D		D	C	
Approach Delay		43.0			38.0			36.1			24.8	
Approach LOS		D			D			D			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.95
Intersection Signal Delay: 31.6 Intersection LOS: C
Intersection Capacity Utilization 85.9% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

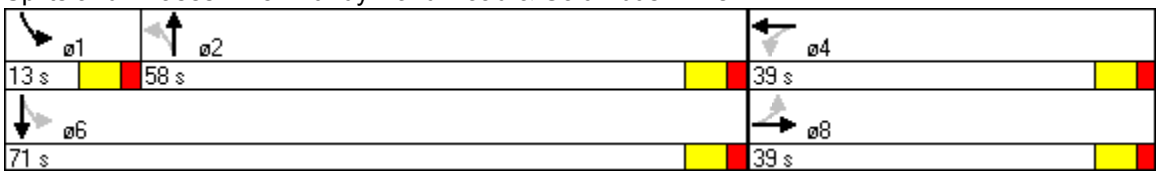


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1972	0	1750	1936	0	1652	3451	0	1652	3423	0
Flt Permitted	0.234			0.495			0.074			0.132		
Satd. Flow (perm)	431	1972	0	911	1936	0	129	3451	0	229	3423	0
Satd. Flow (RTOR)		2			9			13			27	
Volume (vph)	100	200	10	155	330	60	5	945	95	90	1610	240
Lane Group Flow (vph)	109	228	0	168	424	0	5	1130	0	98	2011	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2			6		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	58.0	58.0	0.0	13.0	71.0	0.0
Act Effct Green (s)	35.0	35.0		35.0	35.0		54.0	54.0		67.0	67.0	
Actuated g/C Ratio	0.32	0.32		0.32	0.32		0.49	0.49		0.61	0.61	
v/c Ratio	0.80	0.36		0.58	0.68		0.08	0.66		0.38	0.96	
Control Delay	75.2	32.0		40.8	38.5		6.8	6.7		9.1	16.1	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	75.2	32.0		40.8	38.5		6.8	6.7		9.1	16.1	
LOS	E	C		D	D		A	A		A	B	
Approach Delay		45.9			39.2			6.7			15.8	
Approach LOS		D			D			A			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.96
Intersection Signal Delay: 19.1 Intersection LOS: B
Intersection Capacity Utilization 98.2% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

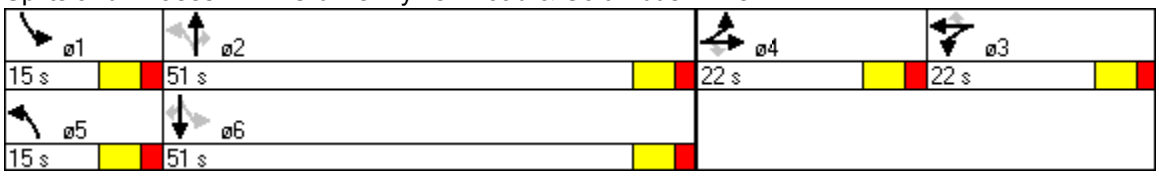


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1883	1601	3471	1883	1601	1789	5142	1601	1789	4238	1601
Flt Permitted	0.950			0.950			0.085			0.172		
Satd. Flow (perm)	1789	1883	1601	3471	1883	1601	160	5142	1601	324	4238	1601
Satd. Flow (RTOR)			146			239			152			43
Volume (vph)	50	135	175	490	120	220	65	1015	140	220	1590	70
Lane Group Flow (vph)	54	147	190	533	130	239	71	1103	152	239	1728	76
Turn Type	custom		Perm	custom		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases	4		4	3		3	2		2	6		6
Total Split (s)	22.0	22.0	22.0	22.0	22.0	22.0	15.0	51.0	51.0	15.0	51.0	51.0
Act Effct Green (s)	18.0	18.0	18.0	18.0	18.0	18.0	58.0	47.0	47.0	58.0	47.0	47.0
Actuated g/C Ratio	0.16	0.16	0.16	0.16	0.16	0.16	0.53	0.43	0.43	0.53	0.43	0.43
v/c Ratio	0.18	0.48	0.49	0.94	0.42	0.52	0.29	0.50	0.20	0.75	0.95	0.11
Control Delay	41.6	47.6	16.6	71.3	46.1	9.6	19.1	11.5	0.8	30.0	43.8	10.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	41.6	47.6	16.6	71.3	46.1	9.6	19.1	11.5	0.8	30.0	43.8	10.1
LOS	D	D	B	E	D	A	B	B	A	C	D	B
Approach Delay		31.7			51.3			10.7			40.9	
Approach LOS		C			D			B			D	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 72 (65%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.95
Intersection Signal Delay: 33.5 Intersection LOS: C
Intersection Capacity Utilization 71.0% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 4: Old Pennywell Road & Columbus Drive

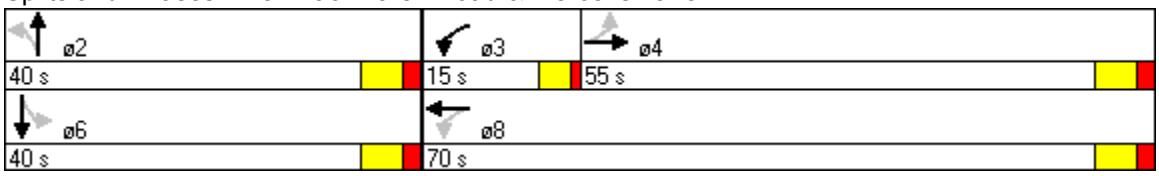


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1838	0	1789	1812	0	1789	1648	0	1789	1767	0
Flt Permitted	0.364			0.239			0.697			0.593		
Satd. Flow (perm)	686	1838	0	450	1812	0	1313	1648	0	1117	1767	0
Satd. Flow (RTOR)		11			28			136			34	
Volume (vph)	15	430	80	230	450	155	55	25	125	100	50	35
Lane Group Flow (vph)	16	554	0	250	657	0	60	163	0	109	92	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	55.0	55.0	0.0	15.0	70.0	0.0	40.0	40.0	0.0	40.0	40.0	0.0
Act Effct Green (s)	51.0	51.0		66.0	66.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio	0.46	0.46		0.60	0.60		0.33	0.33		0.33	0.33	
v/c Ratio	0.05	0.65		0.62	0.60		0.14	0.26		0.30	0.15	
Control Delay	20.7	28.4		17.4	15.9		27.3	7.9		30.4	17.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.7	28.4		17.4	15.9		27.3	7.9		30.4	17.8	
LOS	C	C		B	B		C	A		C	B	
Approach Delay		28.2			16.3			13.1			24.6	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 10 (9%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.65
Intersection Signal Delay: 20.4 Intersection LOS: C
Intersection Capacity Utilization 68.4% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 5: Blackmarsh Road & Mercer's Lane



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	230	240	370	40	30	460
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	250	261	402	43	33	500
Pedestrians			2		2	
Lane Width (m)			3.7		3.7	
Walking Speed (m/s)			1.2		1.2	
Percent Blockage			0		0	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	448				1189	426
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	448				1189	426
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	77				80	20
cM capacity (veh/h)	1111				160	627

Direction, Lane #	EB 1	EB 2	WB 1	SB 1	SB 2
Volume Total	250	261	446	33	500
Volume Left	250	0	0	33	0
Volume Right	0	0	43	0	500
cSH	1111	1700	1700	160	627
Volume to Capacity	0.23	0.15	0.26	0.20	0.80
Queue Length 95th (m)	6.6	0.0	0.0	5.6	59.9
Control Delay (s)	9.2	0.0	0.0	33.1	29.4
Lane LOS	A			D	D
Approach Delay (s)	4.5		0.0	29.7	
Approach LOS				D	

Intersection Summary			
Average Delay	12.1		
Intersection Capacity Utilization	57.0%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	15	435	795	35	40	70
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	16	473	864	38	43	76
Pedestrians		6	3		6	
Lane Width (m)		3.7	3.7		3.7	
Walking Speed (m/s)		1.2	1.2		1.2	
Percent Blockage		1	0		1	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	908				1398	895
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	908				1398	895
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				71	77
cM capacity (veh/h)	746				151	336

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	16	473	902	120
Volume Left	16	0	0	43
Volume Right	0	0	38	76
cSH	746	1700	1700	232
Volume to Capacity	0.02	0.28	0.53	0.52
Queue Length 95th (m)	0.5	0.0	0.0	20.4
Control Delay (s)	9.9	0.0	0.0	35.9
Lane LOS	A			E
Approach Delay (s)	0.3		0.0	35.9
Approach LOS				E

Intersection Summary			
Average Delay	2.9		
Intersection Capacity Utilization	58.7%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	400	10	225	670	90	85
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	435	11	245	728	98	92
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			446		1658	440
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			446		1658	440
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			78		0	85
cM capacity (veh/h)			1115		84	617

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	446	245	728	98	92
Volume Left	0	245	0	98	0
Volume Right	11	0	0	0	92
cSH	1700	1115	1700	84	617
Volume to Capacity	0.26	0.22	0.43	1.17	0.15
Queue Length 95th (m)	0.0	6.4	0.0	53.1	4.0
Control Delay (s)	0.0	9.1	0.0	239.7	11.9
Lane LOS		A		F	B
Approach Delay (s)	0.0	2.3		129.1	
Approach LOS				F	

Intersection Summary			
Average Delay	16.6		
Intersection Capacity Utilization	49.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	30	405	640	1	10	185
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	33	440	696	1	11	201
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	697				1202	696
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	697				1202	696
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	96				94	54
cM capacity (veh/h)	899				197	442

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	473	697	212
Volume Left	33	0	11
Volume Right	0	1	201
cSH	899	1700	415
Volume to Capacity	0.04	0.41	0.51
Queue Length 95th (m)	0.9	0.0	21.4
Control Delay (s)	1.0	0.0	22.4
Lane LOS	A		C
Approach Delay (s)	1.0	0.0	22.4
Approach LOS			C

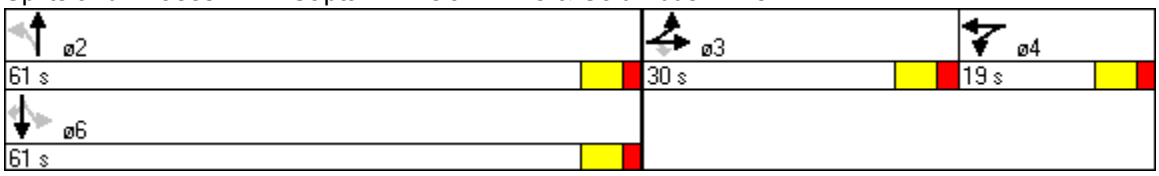
Intersection Summary			
Average Delay	3.8		
Intersection Capacity Utilization	64.7%	ICU Level of Service	C
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1569	1701	1601	1652	1704	0	1750	3749	0	1750	3775	1601
Flt Permitted	0.950	0.972		0.950			0.450			0.097		
Satd. Flow (perm)	1569	1701	1580	1649	1704	0	829	3749	0	179	3775	1601
Satd. Flow (RTOR)			11		38			6				136
Volume (vph)	425	120	10	45	75	75	15	1175	55	20	425	125
Lane Group Flow (vph)	280	312	11	49	164	0	16	1337	0	22	462	136
Turn Type	Split		Perm	custom			Perm			Perm		Perm
Protected Phases	3	3		4	4			2			6	
Permitted Phases			3	4			2			6		6
Total Split (s)	30.0	30.0	30.0	19.0	19.0	0.0	61.0	61.0	0.0	61.0	61.0	61.0
Act Effct Green (s)	26.0	26.0	26.0	15.0	15.0		57.0	57.0		57.0	57.0	57.0
Actuated g/C Ratio	0.24	0.24	0.24	0.14	0.14		0.52	0.52		0.52	0.52	0.52
v/c Ratio	0.75	0.78	0.03	0.22	0.62		0.04	0.69		0.24	0.24	0.15
Control Delay	53.4	53.9	16.4	45.2	45.3		13.5	22.0		15.2	8.2	1.4
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	53.4	53.9	16.4	45.2	45.3		13.5	22.0		15.2	8.2	1.4
LOS	D	D	B	D	D		B	C		B	A	A
Approach Delay		53.0			45.2			21.9			7.0	
Approach LOS		D			D			C			A	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 24 (22%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 27.1 Intersection LOS: C
Intersection Capacity Utilization 67.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Captain Whelan Drive & Columbus Drive

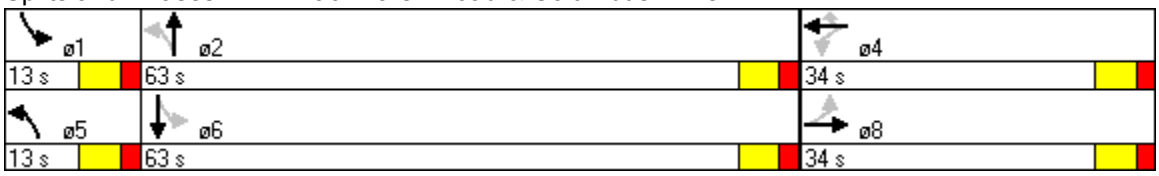


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1838	0	1652	1842	1601	1750	3719	0	1750	3728	0
Flt Permitted	0.595			0.218			0.368			0.068		
Satd. Flow (perm)	1034	1838	0	379	1842	1601	677	3719	0	125	3728	0
Satd. Flow (RTOR)		1				134		16			11	
Volume (vph)	150	350	5	40	135	145	5	1505	165	120	525	40
Lane Group Flow (vph)	163	385	0	43	147	158	5	1815	0	130	614	0
Turn Type	Perm			Perm		Perm	pm+pt			pm+pt		
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2			6		
Total Split (s)	34.0	34.0	0.0	34.0	34.0	34.0	13.0	63.0	0.0	13.0	63.0	0.0
Act Effct Green (s)	30.0	30.0		30.0	30.0	30.0	68.0	59.0		68.0	59.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.62	0.54		0.62	0.54	
v/c Ratio	0.58	0.77		0.42	0.29	0.30	0.01	0.91		0.62	0.31	
Control Delay	44.1	48.2		40.0	26.9	6.2	11.4	45.3		45.0	7.7	
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay	44.1	48.2		40.0	26.9	6.2	11.4	45.3		45.0	7.7	
LOS	D	D		D	C	A	B	D		D	A	
Approach Delay		47.0			19.1			45.2			14.3	
Approach LOS		D			B			D			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 36.2 Intersection LOS: D
Intersection Capacity Utilization 91.4% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

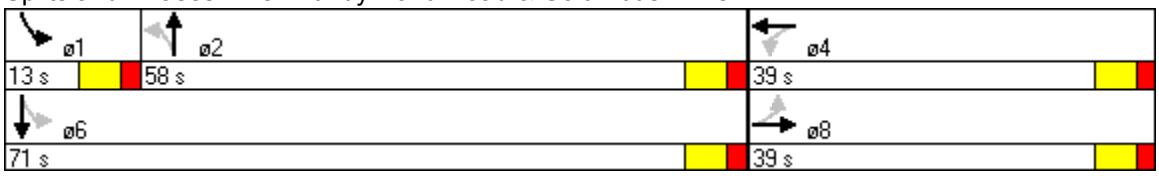


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1980	0	1750	1866	0	1652	3475	0	1652	3443	0
Flt Permitted	0.502			0.166			0.363			0.069		
Satd. Flow (perm)	922	1980	0	306	1866	0	630	3475	0	120	3443	0
Satd. Flow (RTOR)		1			28			6			18	
Volume (vph)	295	430	10	40	130	75	1	1715	85	105	635	65
Lane Group Flow (vph)	321	478	0	43	223	0	1	1956	0	114	761	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2			6		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	58.0	58.0	0.0	13.0	71.0	0.0
Act Effct Green (s)	35.0	35.0		35.0	35.0		54.0	54.0		67.0	67.0	
Actuated g/C Ratio	0.32	0.32		0.32	0.32		0.49	0.49		0.61	0.61	
v/c Ratio	1.10	0.76		0.44	0.36		0.00	1.14		0.58	0.36	
Control Delay	117.6	42.9		47.0	27.2		11.0	85.3		49.0	4.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	117.6	42.9		47.0	27.2		11.0	85.3		49.0	4.8	
LOS	F	D		D	C		B	F		D	A	
Approach Delay		72.9			30.4			85.3			10.6	
Approach LOS		E			C			F			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.14
Intersection Signal Delay: 62.2 Intersection LOS: E
Intersection Capacity Utilization 100.6% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

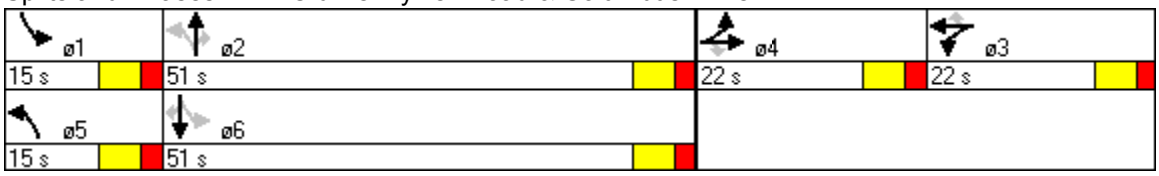


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1883	1601	3471	1883	1601	1789	5142	1601	1789	4238	1601
Flt Permitted	0.950			0.950			0.255			0.085		
Satd. Flow (perm)	1789	1883	1601	3471	1883	1601	480	5142	1601	160	4238	1601
Satd. Flow (RTOR)			54			136			192			33
Volume (vph)	90	140	50	150	60	125	30	1660	230	225	650	30
Lane Group Flow (vph)	98	152	54	163	65	136	33	1804	250	245	707	33
Turn Type	custom		Perm	custom		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases	4		4	3		3	2		2	6		6
Total Split (s)	22.0	22.0	22.0	22.0	22.0	22.0	15.0	51.0	51.0	15.0	51.0	51.0
Act Effct Green (s)	18.0	18.0	18.0	18.0	18.0	18.0	58.0	47.0	47.0	58.0	47.0	47.0
Actuated g/C Ratio	0.16	0.16	0.16	0.16	0.16	0.16	0.53	0.43	0.43	0.53	0.43	0.43
v/c Ratio	0.33	0.49	0.18	0.29	0.21	0.36	0.09	0.82	0.31	0.99	0.39	0.05
Control Delay	44.4	48.0	12.4	41.9	41.9	9.9	5.2	12.6	0.5	84.7	22.5	6.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.4	48.0	12.4	41.9	41.9	9.9	5.2	12.6	0.5	84.7	22.5	6.4
LOS	D	D	B	D	D	A	A	B	A	F	C	A
Approach Delay		40.5			30.0			11.1			37.4	
Approach LOS		D			C			B			D	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 72 (65%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 22.2 Intersection LOS: C
Intersection Capacity Utilization 71.1% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 4: Old Pennywell Road & Columbus Drive

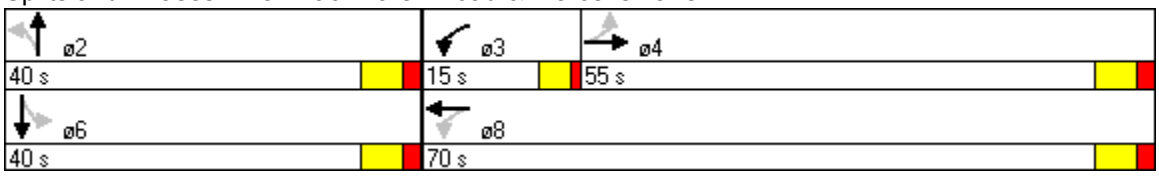


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1859	0	1789	1851	0	1789	1614	0	1789	1883	0
Flt Permitted	0.583			0.146			0.754			0.349		
Satd. Flow (perm)	1098	1859	0	275	1851	0	1420	1614	0	657	1883	0
Satd. Flow (RTOR)		6			11			326				
Volume (vph)	5	565	55	120	235	30	100	15	300	5	5	0
Lane Group Flow (vph)	5	674	0	130	288	0	109	342	0	5	5	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	55.0	55.0	0.0	15.0	70.0	0.0	40.0	40.0	0.0	40.0	40.0	0.0
Act Effct Green (s)	51.0	51.0		66.0	66.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio	0.46	0.46		0.60	0.60		0.33	0.33		0.33	0.33	
v/c Ratio	0.01	0.78		0.41	0.26		0.23	0.46		0.02	0.01	
Control Delay	11.0	18.4		13.6	10.7		28.7	5.9		25.6	25.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	11.0	18.4		13.6	10.7		28.7	5.9		25.6	25.2	
LOS	B	B		B	B		C	A		C	C	
Approach Delay		18.3			11.6			11.4			25.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 10 (9%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 14.5 Intersection LOS: B
Intersection Capacity Utilization 69.1% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 5: Blackmarsh Road & Mercer's Lane



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	555	405	155	10	15	240
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	603	440	168	11	16	261
Pedestrians			2		2	
Lane Width (m)			3.7		3.7	
Walking Speed (m/s)			1.2		1.2	
Percent Blockage			0		0	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	181				1825	176
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	181				1825	176
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	57				66	70
cM capacity (veh/h)	1392				48	866

Direction, Lane #	EB 1	EB 2	WB 1	SB 1	SB 2
Volume Total	603	440	179	16	261
Volume Left	603	0	0	16	0
Volume Right	0	0	11	0	261
cSH	1392	1700	1700	48	866
Volume to Capacity	0.43	0.26	0.11	0.34	0.30
Queue Length 95th (m)	17.1	0.0	0.0	9.1	9.7
Control Delay (s)	9.6	0.0	0.0	115.1	10.9
Lane LOS	A			F	B
Approach Delay (s)	5.5		0.0	17.1	
Approach LOS				C	

Intersection Summary			
Average Delay	7.0		
Intersection Capacity Utilization	52.8%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	10	930	375	25	25	25
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	11	1011	408	27	27	27
Pedestrians		6	3		6	
Lane Width (m)		3.7	3.7		3.7	
Walking Speed (m/s)		1.2	1.2		1.2	
Percent Blockage		1	0		1	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	441				1463	433
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	441				1463	433
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	99				80	96
cM capacity (veh/h)	1113				139	616

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	11	1011	435	54
Volume Left	11	0	0	27
Volume Right	0	0	27	27
cSH	1113	1700	1700	227
Volume to Capacity	0.01	0.59	0.26	0.24
Queue Length 95th (m)	0.2	0.0	0.0	6.9
Control Delay (s)	8.3	0.0	0.0	25.8
Lane LOS	A			D
Approach Delay (s)	0.1		0.0	25.8
Approach LOS				D

Intersection Summary			
Average Delay	1.0		
Intersection Capacity Utilization	60.8%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	880	10	110	250	45	95
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	957	11	120	272	49	103
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			967		1473	962
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			967		1473	962
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			83		58	67
cM capacity (veh/h)			712		116	310

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	967	120	272	49	103
Volume Left	0	120	0	49	0
Volume Right	11	0	0	0	103
cSH	1700	712	1700	116	310
Volume to Capacity	0.57	0.17	0.16	0.42	0.33
Queue Length 95th (m)	0.0	4.6	0.0	13.7	10.8
Control Delay (s)	0.0	11.1	0.0	56.8	22.3
Lane LOS		B		F	C
Approach Delay (s)	0.0	3.4		33.4	
Approach LOS				D	

Intersection Summary			
Average Delay	4.2		
Intersection Capacity Utilization	66.3%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	20	955	270	1	5	55
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	22	1038	293	1	5	60
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	295				1376	294
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	295				1376	294
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				97	92
cM capacity (veh/h)	1267				157	745

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	1060	295	65
Volume Left	22	0	5
Volume Right	0	1	60
cSH	1267	1700	568
Volume to Capacity	0.02	0.17	0.11
Queue Length 95th (m)	0.4	0.0	2.9
Control Delay (s)	0.5	0.0	12.2
Lane LOS	A		B
Approach Delay (s)	0.5	0.0	12.2
Approach LOS			B

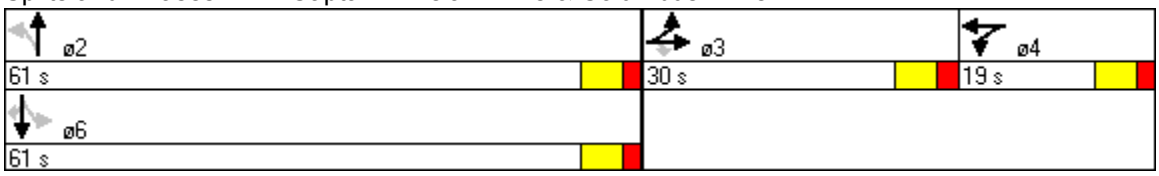
Intersection Summary			
Average Delay	0.9		
Intersection Capacity Utilization	76.7%	ICU Level of Service	D
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1569	1710	1601	1652	1746	0	1750	3737	0	1750	3775	1601
Flt Permitted	0.950	0.977		0.950			0.070			0.222		
Satd. Flow (perm)	1569	1710	1580	1649	1746	0	129	3737	0	409	3775	1601
Satd. Flow (RTOR)			22		20			10				245
Volume (vph)	200	75	20	65	85	45	20	795	60	70	1350	225
Lane Group Flow (vph)	141	158	22	71	141	0	22	929	0	76	1467	245
Turn Type	Split		Perm	custom			Perm			Perm		Perm
Protected Phases	3	3		4	4			2			6	
Permitted Phases			3	4			2			6		6
Total Split (s)	30.0	30.0	30.0	19.0	19.0	0.0	61.0	61.0	0.0	61.0	61.0	61.0
Act Effct Green (s)	26.0	26.0	26.0	15.0	15.0		57.0	57.0		57.0	57.0	57.0
Actuated g/C Ratio	0.24	0.24	0.24	0.14	0.14		0.52	0.52		0.52	0.52	0.52
v/c Ratio	0.38	0.39	0.06	0.32	0.55		0.33	0.48		0.36	0.75	0.26
Control Delay	38.8	38.8	13.1	47.2	47.0		31.9	17.8		13.0	12.8	1.1
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	38.8	38.8	13.1	47.2	47.0		31.9	17.8		13.0	12.8	1.1
LOS	D	D	B	D	D		C	B		B	B	A
Approach Delay		37.0			47.1			18.1			11.2	
Approach LOS		D			D			B			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 24 (22%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 18.1 Intersection LOS: B
Intersection Capacity Utilization 77.0% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: Captain Whelan Drive & Columbus Drive

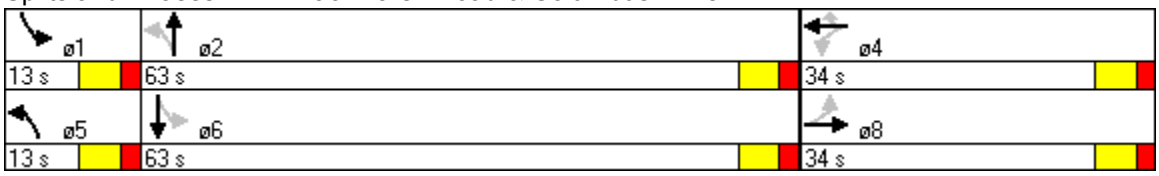


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1818	0	1652	1842	1601	1750	3688	0	1750	3740	0
Flt Permitted	0.177			0.415			0.068			0.164		
Satd. Flow (perm)	308	1818	0	722	1842	1601	125	3688	0	302	3740	0
Satd. Flow (RTOR)		4				168		30			8	
Volume (vph)	60	215	20	150	380	155	10	870	160	290	1475	85
Lane Group Flow (vph)	65	256	0	163	413	168	11	1120	0	315	1695	0
Turn Type	Perm			Perm		Perm	pm+pt			pm+pt		
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2			6		
Total Split (s)	34.0	34.0	0.0	34.0	34.0	34.0	13.0	63.0	0.0	13.0	63.0	0.0
Act Effct Green (s)	30.0	30.0		30.0	30.0	30.0	68.0	59.0		68.0	59.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.62	0.54		0.62	0.54	
v/c Ratio	0.77	0.51		0.83	0.82	0.30	0.05	0.56		1.03	0.84	
Control Delay	90.5	37.6		64.6	46.9	6.7	15.6	36.8		63.8	21.9	
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay	90.5	37.6		64.6	46.9	6.7	15.6	36.8		63.8	21.9	
LOS	F	D		E	D	A	B	D		E	C	
Approach Delay		48.3			41.7			36.6			28.5	
Approach LOS		D			D			D			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.03
Intersection Signal Delay: 34.5 Intersection LOS: C
Intersection Capacity Utilization 88.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

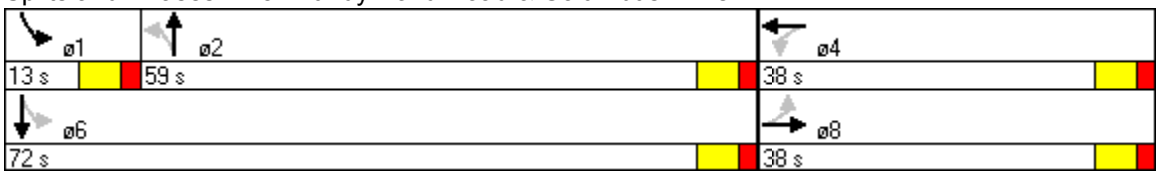


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1972	0	1750	1938	0	1652	3451	0	1652	3423	0
Flt Permitted	0.207			0.473			0.073			0.124		
Satd. Flow (perm)	381	1972	0	870	1938	0	127	3451	0	216	3423	0
Satd. Flow (RTOR)		2			8			14			28	
Volume (vph)	105	210	10	165	340	60	5	980	100	95	1675	250
Lane Group Flow (vph)	114	239	0	179	435	0	5	1174	0	103	2093	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2			6		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	59.0	59.0	0.0	13.0	72.0	0.0
Act Effct Green (s)	34.0	34.0		34.0	34.0		55.0	55.0		68.0	68.0	
Actuated g/C Ratio	0.31	0.31		0.31	0.31		0.50	0.50		0.62	0.62	
v/c Ratio	0.97	0.39		0.67	0.72		0.08	0.68		0.41	0.98	
Control Delay	115.9	33.3		46.9	41.0		6.4	6.6		10.2	19.0	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	115.9	33.3		46.9	41.0		6.4	6.6		10.2	19.0	
LOS	F	C		D	D		A	A		B	B	
Approach Delay		60.0			42.7			6.6			18.6	
Approach LOS		E			D			A			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 22.1 Intersection LOS: C
Intersection Capacity Utilization 100.9% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

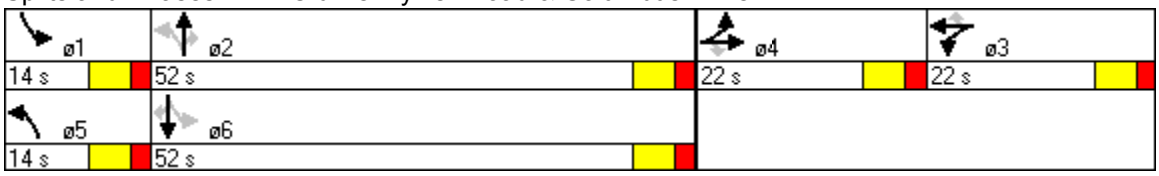


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1883	1601	3471	1883	1601	1789	5142	1601	1789	4238	1601
Flt Permitted	0.950			0.950			0.083			0.162		
Satd. Flow (perm)	1789	1883	1601	3471	1883	1601	156	5142	1601	305	4238	1601
Satd. Flow (RTOR)			129			245			163			45
Volume (vph)	50	140	180	510	125	225	65	1055	150	225	1660	75
Lane Group Flow (vph)	54	152	196	554	136	245	71	1147	163	245	1804	82
Turn Type	custom		Perm	custom		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases	4		4	3		3	2		2	6		6
Total Split (s)	22.0	22.0	22.0	22.0	22.0	22.0	14.0	52.0	52.0	14.0	52.0	52.0
Act Effct Green (s)	18.0	18.0	18.0	18.0	18.0	18.0	58.0	48.0	48.0	58.0	48.0	48.0
Actuated g/C Ratio	0.16	0.16	0.16	0.16	0.16	0.16	0.53	0.44	0.44	0.53	0.44	0.44
v/c Ratio	0.18	0.49	0.53	0.98	0.44	0.52	0.31	0.51	0.21	0.83	0.98	0.11
Control Delay	41.6	48.0	21.3	78.6	46.6	9.6	19.6	11.3	0.8	38.6	46.8	9.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	41.6	48.0	21.3	78.6	46.6	9.6	19.6	11.3	0.8	38.6	46.8	9.9
LOS	D	D	C	E	D	A	B	B	A	D	D	A
Approach Delay		34.1			55.9			10.5			44.5	
Approach LOS		C			E			B			D	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 72 (65%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 36.1 Intersection LOS: D
Intersection Capacity Utilization 73.2% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 4: Old Pennywell Road & Columbus Drive

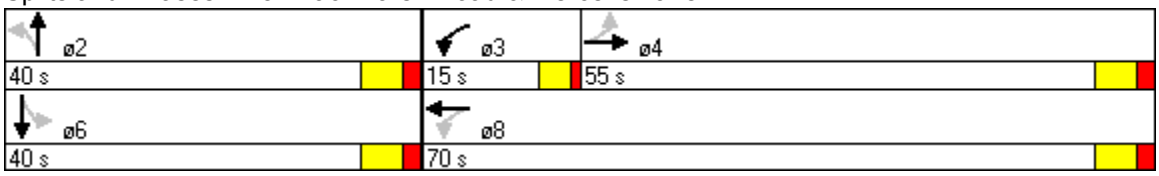


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1838	0	1789	1812	0	1789	1646	0	1789	1767	0
Flt Permitted	0.341			0.222			0.697			0.585		
Satd. Flow (perm)	642	1838	0	418	1812	0	1313	1646	0	1102	1767	0
Satd. Flow (RTOR)		12			28			141			34	
Volume (vph)	15	445	85	240	470	160	55	25	130	105	50	35
Lane Group Flow (vph)	16	576	0	261	685	0	60	168	0	114	92	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	55.0	55.0	0.0	15.0	70.0	0.0	40.0	40.0	0.0	40.0	40.0	0.0
Act Effct Green (s)	51.0	51.0		66.0	66.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio	0.46	0.46		0.60	0.60		0.33	0.33		0.33	0.33	
v/c Ratio	0.05	0.67		0.67	0.62		0.14	0.26		0.32	0.15	
Control Delay	20.9	29.5		19.6	16.5		27.3	7.8		30.8	17.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.9	29.5		19.6	16.5		27.3	7.8		30.8	17.8	
LOS	C	C		B	B		C	A		C	B	
Approach Delay		29.3			17.4			12.9			25.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 10 (9%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.67
Intersection Signal Delay: 21.2 Intersection LOS: C
Intersection Capacity Utilization 70.4% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 5: Blackmarsh Road & Mercer's Lane



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	240	250	385	45	30	480
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	261	272	418	49	33	522
Pedestrians			2		2	
Lane Width (m)			3.7		3.7	
Walking Speed (m/s)			1.2		1.2	
Percent Blockage			0		0	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	469				1240	445
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	469				1240	445
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	76				78	15
cM capacity (veh/h)	1090				147	612

Direction, Lane #	EB 1	EB 2	WB 1	SB 1	SB 2
Volume Total	261	272	467	33	522
Volume Left	261	0	0	33	0
Volume Right	0	0	49	0	522
cSH	1090	1700	1700	147	612
Volume to Capacity	0.24	0.16	0.27	0.22	0.85
Queue Length 95th (m)	7.1	0.0	0.0	6.2	71.7
Control Delay (s)	9.3	0.0	0.0	36.5	35.6
Lane LOS	A			E	E
Approach Delay (s)	4.6		0.0	35.7	
Approach LOS				E	

Intersection Summary			
Average Delay	14.3		
Intersection Capacity Utilization	59.4%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	15	450	825	35	40	75
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	16	489	897	38	43	82
Pedestrians		6	3		6	
Lane Width (m)		3.7	3.7		3.7	
Walking Speed (m/s)		1.2	1.2		1.2	
Percent Blockage		1	0		1	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	941				1446	928
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	941				1446	928
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				69	75
cM capacity (veh/h)	725				141	322

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	16	489	935	125
Volume Left	16	0	0	43
Volume Right	0	0	38	82
cSH	725	1700	1700	222
Volume to Capacity	0.02	0.29	0.55	0.56
Queue Length 95th (m)	0.5	0.0	0.0	23.4
Control Delay (s)	10.1	0.0	0.0	40.2
Lane LOS	B			E
Approach Delay (s)	0.3		0.0	40.2
Approach LOS				E

Intersection Summary			
Average Delay	3.3		
Intersection Capacity Utilization	60.6%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	415	10	235	695	90	85
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	451	11	255	755	98	92
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			462		1723	457
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			462		1723	457
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			77		0	85
cM capacity (veh/h)			1099		75	604

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	462	255	755	98	92
Volume Left	0	255	0	98	0
Volume Right	11	0	0	0	92
cSH	1700	1099	1700	75	604
Volume to Capacity	0.27	0.23	0.44	1.30	0.15
Queue Length 95th (m)	0.0	6.8	0.0	58.0	4.1
Control Delay (s)	0.0	9.3	0.0	301.0	12.0
Lane LOS		A		F	B
Approach Delay (s)	0.0	2.3		160.7	
Approach LOS				F	

Intersection Summary			
Average Delay	19.8		
Intersection Capacity Utilization	50.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	30	420	665	1	10	195
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	33	457	723	1	11	212
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	724				1245	723
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	724				1245	723
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	96				94	50
cM capacity (veh/h)	879				185	426

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	489	724	223
Volume Left	33	0	11
Volume Right	0	1	212
cSH	879	1700	401
Volume to Capacity	0.04	0.43	0.56
Queue Length 95th (m)	0.9	0.0	24.9
Control Delay (s)	1.1	0.0	24.7
Lane LOS	A		C
Approach Delay (s)	1.1	0.0	24.7
Approach LOS			C

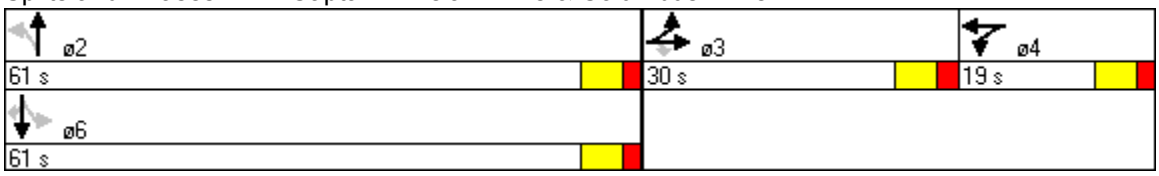
Intersection Summary			
Average Delay	4.2		
Intersection Capacity Utilization	66.1%	ICU Level of Service	C
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1569	1701	1601	1652	1704	0	1750	3749	0	1750	3775	1601
Flt Permitted	0.950	0.972		0.950			0.433			0.094		
Satd. Flow (perm)	1569	1701	1580	1649	1704	0	798	3749	0	173	3775	1601
Satd. Flow (RTOR)			11		38			6				136
Volume (vph)	425	120	10	45	75	75	15	1184	55	20	451	125
Lane Group Flow (vph)	280	312	11	49	164	0	16	1347	0	22	490	136
Turn Type	Split		Perm	custom			Perm			Perm		Perm
Protected Phases	3	3		4	4			2			6	
Permitted Phases			3	4			2			6		6
Total Split (s)	30.0	30.0	30.0	19.0	19.0	0.0	61.0	61.0	0.0	61.0	61.0	61.0
Act Effct Green (s)	26.0	26.0	26.0	15.0	15.0		57.0	57.0		57.0	57.0	57.0
Actuated g/C Ratio	0.24	0.24	0.24	0.14	0.14		0.52	0.52		0.52	0.52	0.52
v/c Ratio	0.75	0.78	0.03	0.22	0.62		0.04	0.69		0.24	0.25	0.15
Control Delay	53.4	53.9	16.4	45.2	45.3		13.5	22.2		16.1	8.7	1.4
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	53.4	53.9	16.4	45.2	45.3		13.5	22.2		16.1	8.7	1.4
LOS	D	D	B	D	D		B	C		B	A	A
Approach Delay		53.0			45.2			22.1			7.4	
Approach LOS		D			D			C			A	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 24 (22%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 27.0 Intersection LOS: C
Intersection Capacity Utilization 67.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Captain Whelan Drive & Columbus Drive

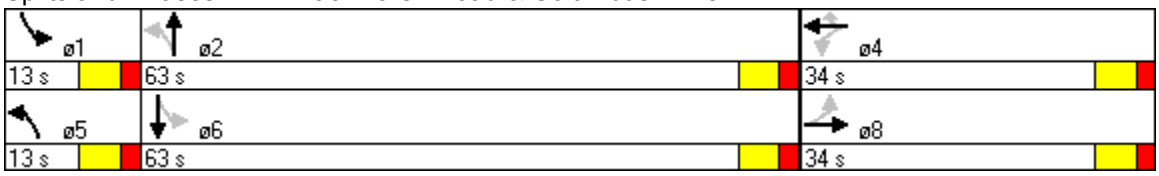


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1827	0	1652	1842	1601	1750	3719	0	1750	3731	0
Flt Permitted	0.589			0.175			0.363			0.068		
Satd. Flow (perm)	1024	1827	0	304	1842	1601	668	3719	0	125	3731	0
Satd. Flow (RTOR)		3				134		16			11	
Volume (vph)	156	360	21	40	138	145	11	1508	165	120	535	40
Lane Group Flow (vph)	170	414	0	43	150	158	12	1818	0	130	625	0
Turn Type	Perm			Perm		Perm	pm+pt			pm+pt		
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2			6		
Total Split (s)	34.0	34.0	0.0	34.0	34.0	34.0	13.0	63.0	0.0	13.0	63.0	0.0
Act Effct Green (s)	30.0	30.0		30.0	30.0	30.0	68.0	59.0		68.0	59.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.62	0.54		0.62	0.54	
v/c Ratio	0.61	0.83		0.52	0.30	0.30	0.02	0.91		0.62	0.31	
Control Delay	45.7	52.8		51.5	26.9	6.1	11.6	45.4		45.0	7.8	
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay	45.7	52.8		51.5	26.9	6.1	11.6	45.4		45.0	7.8	
LOS	D	D		D	C	A	B	D		D	A	
Approach Delay		50.7			20.5			45.2			14.2	
Approach LOS		D			C			D			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 37.0 Intersection LOS: D
Intersection Capacity Utilization 93.0% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

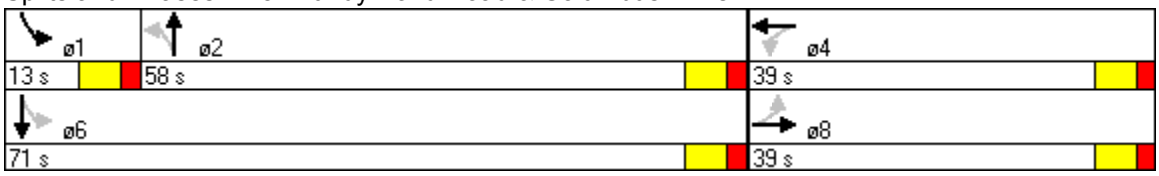


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1980	0	1750	1866	0	1652	3475	0	1652	3444	0
Flt Permitted	0.501			0.161			0.359			0.069		
Satd. Flow (perm)	920	1980	0	297	1866	0	623	3475	0	120	3444	0
Satd. Flow (RTOR)		1			28			6			18	
Volume (vph)	295	433	10	40	131	75	1	1724	85	105	645	65
Lane Group Flow (vph)	321	482	0	43	224	0	1	1966	0	114	772	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2			6		
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	58.0	58.0	0.0	13.0	71.0	0.0
Act Effct Green (s)	35.0	35.0		35.0	35.0		54.0	54.0		67.0	67.0	
Actuated g/C Ratio	0.32	0.32		0.32	0.32		0.49	0.49		0.61	0.61	
v/c Ratio	1.10	0.76		0.45	0.37		0.00	1.15		0.58	0.37	
Control Delay	117.6	43.2		48.0	27.2		11.0	88.1		48.7	4.9	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	117.6	43.2		48.0	27.2		11.0	88.1		48.7	4.9	
LOS	F	D		D	C		B	F		D	A	
Approach Delay		73.0			30.6			88.0			10.5	
Approach LOS		E			C			F			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.15
Intersection Signal Delay: 63.5 Intersection LOS: E
Intersection Capacity Utilization 100.9% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

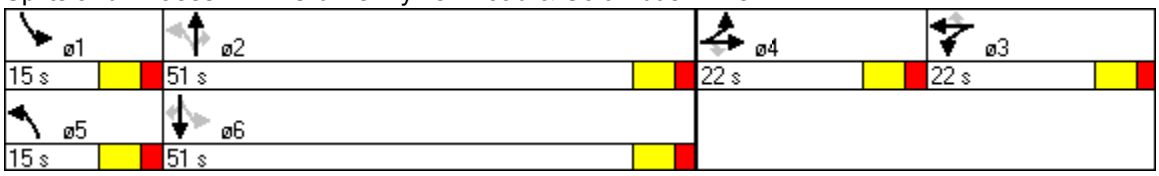


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1883	1601	3471	1883	1601	1789	5142	1601	1789	4238	1601
Flt Permitted	0.950			0.950			0.254			0.085		
Satd. Flow (perm)	1789	1883	1601	3471	1883	1601	478	5142	1601	160	4238	1601
Satd. Flow (RTOR)			60			136			192			52
Volume (vph)	141	159	55	150	66	125	32	1666	230	225	652	48
Lane Group Flow (vph)	153	173	60	163	72	136	35	1811	250	245	709	52
Turn Type	custom		Perm	custom		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases	4		4	3		3	2		2	6		6
Total Split (s)	22.0	22.0	22.0	22.0	22.0	22.0	15.0	51.0	51.0	15.0	51.0	51.0
Act Effct Green (s)	18.0	18.0	18.0	18.0	18.0	18.0	58.0	47.0	47.0	58.0	47.0	47.0
Actuated g/C Ratio	0.16	0.16	0.16	0.16	0.16	0.16	0.53	0.43	0.43	0.53	0.43	0.43
v/c Ratio	0.52	0.56	0.19	0.29	0.23	0.36	0.09	0.82	0.31	0.99	0.39	0.07
Control Delay	49.3	50.3	11.9	41.9	42.3	9.9	5.2	12.6	0.5	84.7	22.5	5.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.3	50.3	11.9	41.9	42.3	9.9	5.2	12.6	0.5	84.7	22.5	5.5
LOS	D	D	B	D	D	A	A	B	A	F	C	A
Approach Delay		43.9			30.3			11.1			36.8	
Approach LOS		D			C			B			D	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 72 (65%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 22.9 Intersection LOS: C
Intersection Capacity Utilization 72.2% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 4: Old Pennywell Road & Columbus Drive

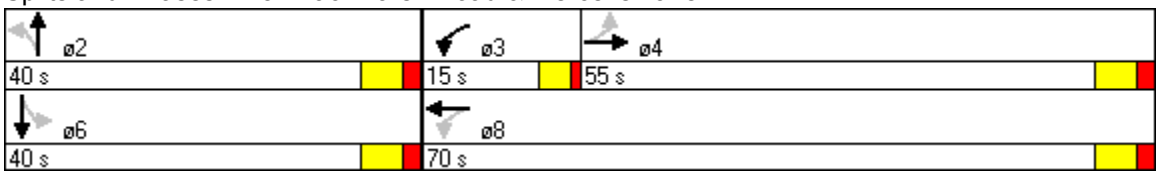


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1859	0	1789	1851	0	1789	1614	0	1789	1883	0
Flt Permitted	0.581			0.138			0.754			0.349		
Satd. Flow (perm)	1094	1859	0	260	1851	0	1420	1614	0	657	1883	0
Satd. Flow (RTOR)		6			10			326				
Volume (vph)	5	575	55	120	238	30	100	15	300	5	5	0
Lane Group Flow (vph)	5	685	0	130	292	0	109	342	0	5	5	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	55.0	55.0	0.0	15.0	70.0	0.0	40.0	40.0	0.0	40.0	40.0	0.0
Act Effct Green (s)	51.0	51.0		66.0	66.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio	0.46	0.46		0.60	0.60		0.33	0.33		0.33	0.33	
v/c Ratio	0.01	0.79		0.42	0.26		0.23	0.46		0.02	0.01	
Control Delay	11.0	18.2		13.8	10.8		28.7	5.9		25.6	25.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	11.0	18.2		13.8	10.8		28.7	5.9		25.6	25.2	
LOS	B	B		B	B		C	A		C	C	
Approach Delay		18.2			11.7			11.4			25.4	
Approach LOS		B			B			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 10 (9%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 14.5 Intersection LOS: B
Intersection Capacity Utilization 69.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 5: Blackmarsh Road & Mercer's Lane



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	558	437	169	10	15	241
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	607	475	184	11	16	262
Pedestrians			2		2	
Lane Width (m)			3.7		3.7	
Walking Speed (m/s)			1.2		1.2	
Percent Blockage			0		0	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	197				1881	191
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	197				1881	191
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	56				62	69
cM capacity (veh/h)	1374				43	849

Direction, Lane #	EB 1	EB 2	WB 1	SB 1	SB 2
Volume Total	607	475	195	16	262
Volume Left	607	0	0	16	0
Volume Right	0	0	11	0	262
cSH	1374	1700	1700	43	849
Volume to Capacity	0.44	0.28	0.11	0.38	0.31
Queue Length 95th (m)	17.6	0.0	0.0	9.9	10.0
Control Delay (s)	9.7	0.0	0.0	130.9	11.1
Lane LOS	A			F	B
Approach Delay (s)	5.4		0.0	18.1	
Approach LOS				C	

Intersection Summary			
Average Delay	7.0		
Intersection Capacity Utilization	53.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	12	930	375	35	60	32
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	13	1011	408	38	65	35
Pedestrians		6	3		6	
Lane Width (m)		3.7	3.7		3.7	
Walking Speed (m/s)		1.2	1.2		1.2	
Percent Blockage		1	0		1	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	452				1473	439
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	452				1473	439
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	99				52	94
cM capacity (veh/h)	1103				137	612

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	13	1011	446	100
Volume Left	13	0	0	65
Volume Right	0	0	38	35
cSH	1103	1700	1700	188
Volume to Capacity	0.01	0.59	0.26	0.53
Queue Length 95th (m)	0.3	0.0	0.0	20.8
Control Delay (s)	8.3	0.0	0.0	44.2
Lane LOS	A			E
Approach Delay (s)	0.1		0.0	44.2
Approach LOS				E

Intersection Summary			
Average Delay	2.9		
Intersection Capacity Utilization	62.5%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	882	10	110	257	45	95
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	959	11	120	279	49	103
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			970		1483	964
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			970		1483	964
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			83		57	67
cM capacity (veh/h)			711		115	310

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	970	120	279	49	103
Volume Left	0	120	0	49	0
Volume Right	11	0	0	0	103
cSH	1700	711	1700	115	310
Volume to Capacity	0.57	0.17	0.16	0.43	0.33
Queue Length 95th (m)	0.0	4.6	0.0	13.9	10.8
Control Delay (s)	0.0	11.1	0.0	58.0	22.3
Lane LOS		B		F	C
Approach Delay (s)	0.0	3.3		33.8	
Approach LOS				D	

Intersection Summary			
Average Delay	4.3		
Intersection Capacity Utilization	66.5%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	22	957	277	1	5	61
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	24	1040	301	1	5	66
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	302				1390	302
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	302				1390	302
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				96	91
cM capacity (veh/h)	1259				154	738

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	1064	302	72
Volume Left	24	0	5
Volume Right	0	1	66
cSH	1259	1700	573
Volume to Capacity	0.02	0.18	0.13
Queue Length 95th (m)	0.4	0.0	3.2
Control Delay (s)	0.6	0.0	12.2
Lane LOS	A		B
Approach Delay (s)	0.6	0.0	12.2
Approach LOS			B

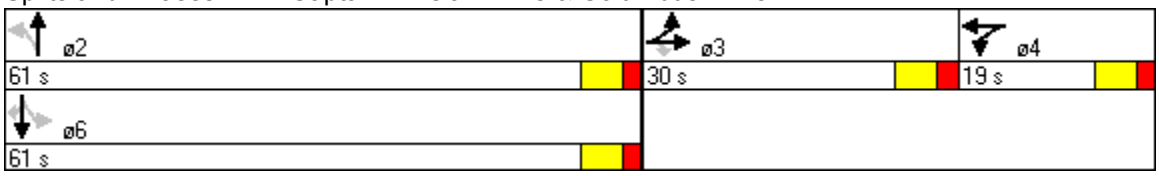
Intersection Summary			
Average Delay	1.0		
Intersection Capacity Utilization	78.8%	ICU Level of Service	D
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1569	1710	1601	1652	1746	0	1750	3737	0	1750	3775	1601
Flt Permitted	0.950	0.977		0.950			0.070			0.211		
Satd. Flow (perm)	1569	1710	1580	1649	1746	0	129	3737	0	389	3775	1601
Satd. Flow (RTOR)			22		20			10				245
Volume (vph)	200	75	20	65	85	45	20	824	60	70	1367	225
Lane Group Flow (vph)	141	158	22	71	141	0	22	961	0	76	1486	245
Turn Type	Split		Perm	custom			Perm			Perm		Perm
Protected Phases	3	3		4	4			2			6	
Permitted Phases			3	4			2			6		6
Total Split (s)	30.0	30.0	30.0	19.0	19.0	0.0	61.0	61.0	0.0	61.0	61.0	61.0
Act Effct Green (s)	26.0	26.0	26.0	15.0	15.0		57.0	57.0		57.0	57.0	57.0
Actuated g/C Ratio	0.24	0.24	0.24	0.14	0.14		0.52	0.52		0.52	0.52	0.52
v/c Ratio	0.38	0.39	0.06	0.32	0.55		0.33	0.50		0.38	0.76	0.26
Control Delay	38.8	38.8	13.1	47.2	47.0		31.9	18.1		13.4	13.0	1.1
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0
Total Delay	38.8	38.8	13.1	47.2	47.0		31.9	18.1		13.4	13.0	1.1
LOS	D	D	B	D	D		C	B		B	B	A
Approach Delay		37.0			47.1			18.4			11.4	
Approach LOS		D			D			B			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 24 (22%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 18.2 Intersection LOS: B
Intersection Capacity Utilization 77.5% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: Captain Whelan Drive & Columbus Drive

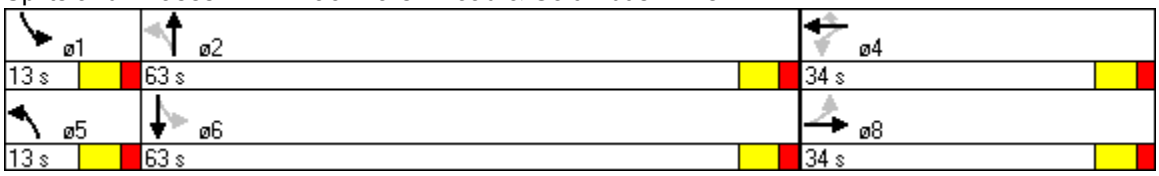


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1809	0	1652	1842	1601	1750	3688	0	1750	3740	0
Flt Permitted	0.159			0.388			0.068			0.162		
Satd. Flow (perm)	276	1809	0	675	1842	1601	125	3688	0	298	3740	0
Satd. Flow (RTOR)		6				168		29			8	
Volume (vph)	64	221	30	150	391	155	30	879	160	290	1482	85
Lane Group Flow (vph)	70	273	0	163	425	168	33	1129	0	315	1703	0
Turn Type	Perm			Perm		Perm	pm+pt			pm+pt		
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2			6		
Total Split (s)	34.0	34.0	0.0	34.0	34.0	34.0	13.0	63.0	0.0	13.0	63.0	0.0
Act Effct Green (s)	30.0	30.0		30.0	30.0	30.0	68.0	59.0		68.0	59.0	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.62	0.54		0.62	0.54	
v/c Ratio	0.93	0.55		0.89	0.85	0.30	0.16	0.57		1.04	0.85	
Control Delay	129.7	38.3		75.8	49.2	6.9	17.2	37.2		65.8	22.0	
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay	129.7	38.3		75.8	49.2	6.9	17.2	37.2		65.8	22.0	
LOS	F	D		E	D	A	B	D		E	C	
Approach Delay		57.0			45.5			36.6			28.9	
Approach LOS		E			D			D			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.04
Intersection Signal Delay: 36.2 Intersection LOS: D
Intersection Capacity Utilization 89.3% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

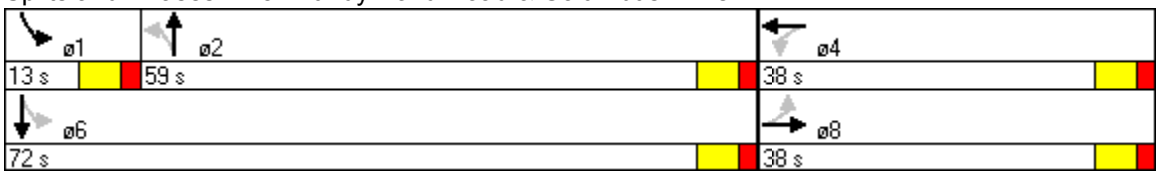


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1972	0	1750	1938	0	1652	3451	0	1652	3423	0
Flt Permitted	0.201			0.470			0.073			0.120		
Satd. Flow (perm)	370	1972	0	865	1938	0	127	3451	0	209	3423	0
Satd. Flow (RTOR)		2			8			14			28	
Volume (vph)	105	212	10	165	344	60	5	993	100	95	1682	250
Lane Group Flow (vph)	114	241	0	179	439	0	5	1188	0	103	2100	0
Turn Type	Perm			Perm			Perm			pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2			6		
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	59.0	59.0	0.0	13.0	72.0	0.0
Act Effct Green (s)	34.0	34.0		34.0	34.0		55.0	55.0		68.0	68.0	
Actuated g/C Ratio	0.31	0.31		0.31	0.31		0.50	0.50		0.62	0.62	
v/c Ratio	1.00	0.39		0.67	0.73		0.08	0.69		0.42	0.99	
Control Delay	126.1	32.9		47.3	41.3		6.6	6.7		10.9	19.6	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	126.1	32.9		47.3	41.3		6.6	6.7		10.9	19.6	
LOS	F	C		D	D		A	A		B	B	
Approach Delay		62.8			43.1			6.7			19.2	
Approach LOS		E			D			A			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 1.00
Intersection Signal Delay: 22.7 Intersection LOS: C
Intersection Capacity Utilization 101.3% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

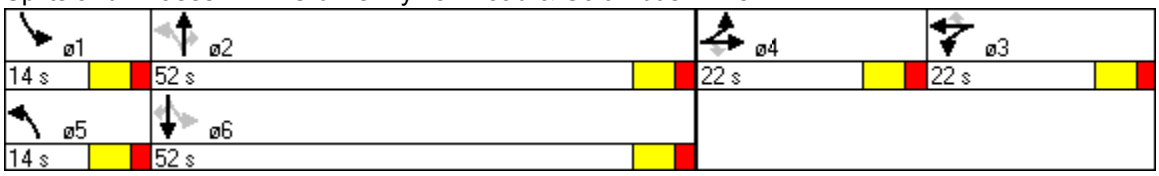


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1883	1601	3471	1883	1601	1789	5142	1601	1789	4238	1601
Flt Permitted	0.950			0.950			0.083			0.161		
Satd. Flow (perm)	1789	1883	1601	3471	1883	1601	156	5142	1601	303	4238	1601
Satd. Flow (RTOR)			129			245			163			79
Volume (vph)	84	153	184	510	147	225	71	1059	150	225	1667	133
Lane Group Flow (vph)	91	166	200	554	160	245	77	1151	163	245	1812	145
Turn Type	custom		Perm	custom		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases	4		4	3		3	2		2	6		6
Total Split (s)	22.0	22.0	22.0	22.0	22.0	22.0	14.0	52.0	52.0	14.0	52.0	52.0
Act Effct Green (s)	18.0	18.0	18.0	18.0	18.0	18.0	58.0	48.0	48.0	58.0	48.0	48.0
Actuated g/C Ratio	0.16	0.16	0.16	0.16	0.16	0.16	0.53	0.44	0.44	0.53	0.44	0.44
v/c Ratio	0.31	0.54	0.54	0.98	0.52	0.52	0.33	0.51	0.21	0.83	0.98	0.20
Control Delay	43.9	49.5	21.9	78.6	48.8	9.6	21.7	11.2	0.8	39.1	47.7	9.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	43.9	49.5	21.9	78.6	48.8	9.6	21.7	11.2	0.8	39.1	47.7	9.7
LOS	D	D	C	E	D	A	C	B	A	D	D	A
Approach Delay		36.3			56.0			10.6			44.3	
Approach LOS		D			E			B			D	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 72 (65%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 36.4 Intersection LOS: D
Intersection Capacity Utilization 74.0% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 4: Old Pennywell Road & Columbus Drive

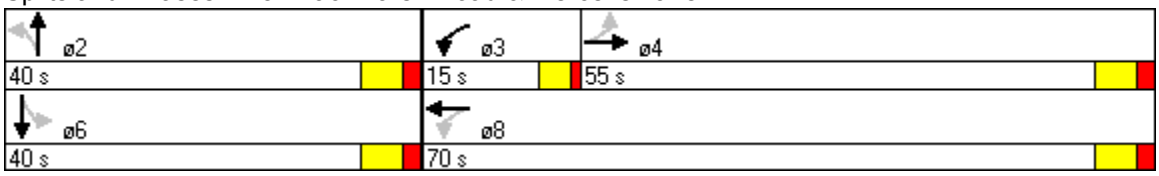


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1789	1838	0	1789	1814	0	1789	1646	0	1789	1767	0
Flt Permitted	0.331			0.217			0.697			0.585		
Satd. Flow (perm)	623	1838	0	409	1814	0	1313	1646	0	1102	1767	0
Satd. Flow (RTOR)		11			27			141			34	
Volume (vph)	15	451	85	240	481	160	55	25	130	105	50	35
Lane Group Flow (vph)	16	582	0	261	697	0	60	168	0	114	92	0
Turn Type	Perm			pm+pt			Perm			Perm		
Protected Phases		4		3	8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	55.0	55.0	0.0	15.0	70.0	0.0	40.0	40.0	0.0	40.0	40.0	0.0
Act Effct Green (s)	51.0	51.0		66.0	66.0		36.0	36.0		36.0	36.0	
Actuated g/C Ratio	0.46	0.46		0.60	0.60		0.33	0.33		0.33	0.33	
v/c Ratio	0.06	0.68		0.68	0.63		0.14	0.26		0.32	0.15	
Control Delay	20.7	29.5		20.1	16.8		27.3	7.8		30.8	17.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.7	29.5		20.1	16.8		27.3	7.8		30.8	17.8	
LOS	C	C		C	B		C	A		C	B	
Approach Delay		29.2			17.7			12.9			25.0	
Approach LOS		C			B			B			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 10 (9%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.68
Intersection Signal Delay: 21.4 Intersection LOS: C
Intersection Capacity Utilization 70.7% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 5: Blackmarsh Road & Mercer's Lane



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	242	270	416	45	30	484
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	263	293	452	49	33	526
Pedestrians			2		2	
Lane Width (m)			3.7		3.7	
Walking Speed (m/s)			1.2		1.2	
Percent Blockage			0		0	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	503				1300	479
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	503				1300	479
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	75				76	10
cM capacity (veh/h)	1060				133	586

Direction, Lane #	EB 1	EB 2	WB 1	SB 1	SB 2
Volume Total	263	293	501	33	526
Volume Left	263	0	0	33	0
Volume Right	0	0	49	0	526
cSH	1060	1700	1700	133	586
Volume to Capacity	0.25	0.17	0.29	0.24	0.90
Queue Length 95th (m)	7.5	0.0	0.0	6.9	82.1
Control Delay (s)	9.5	0.0	0.0	40.6	43.0
Lane LOS	A			E	E
Approach Delay (s)	4.5		0.0	42.9	
Approach LOS				E	

Intersection Summary			
Average Delay	16.4		
Intersection Capacity Utilization	61.3%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	23	450	825	70	62	79
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	25	489	897	76	67	86
Pedestrians		6	3		6	
Lane Width (m)		3.7	3.7		3.7	
Walking Speed (m/s)		1.2	1.2		1.2	
Percent Blockage		1	0		1	
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	979				1483	947
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	979				1483	947
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	96				49	73
cM capacity (veh/h)	701				132	314

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	25	489	973	153
Volume Left	25	0	0	67
Volume Right	0	0	76	86
cSH	701	1700	1700	195
Volume to Capacity	0.04	0.29	0.57	0.79
Queue Length 95th (m)	0.8	0.0	0.0	41.1
Control Delay (s)	10.3	0.0	0.0	69.3
Lane LOS	B			F
Approach Delay (s)	0.5		0.0	69.3
Approach LOS				F

Intersection Summary			
Average Delay	6.6		
Intersection Capacity Utilization	63.9%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Volume (veh/h)	423	10	235	699	90	85
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	460	11	255	760	98	92
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			471		1736	465
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			471		1736	465
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			77		0	85
cM capacity (veh/h)			1091		74	597

Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2
Volume Total	471	255	760	98	92
Volume Left	0	255	0	98	0
Volume Right	11	0	0	0	92
cSH	1700	1091	1700	74	597
Volume to Capacity	0.28	0.23	0.45	1.33	0.15
Queue Length 95th (m)	0.0	6.9	0.0	58.9	4.1
Control Delay (s)	0.0	9.3	0.0	313.9	12.1
Lane LOS		A		F	B
Approach Delay (s)	0.0	2.3		167.3	
Approach LOS				F	

Intersection Summary			
Average Delay	20.4		
Intersection Capacity Utilization	50.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Volume (veh/h)	37	428	669	1	10	199
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	40	465	727	1	11	216
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type					None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	728				1273	728
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	728				1273	728
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	95				94	49
cM capacity (veh/h)	875				176	424

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	505	728	227
Volume Left	40	0	11
Volume Right	0	1	216
cSH	875	1700	397
Volume to Capacity	0.05	0.43	0.57
Queue Length 95th (m)	1.1	0.0	26.2
Control Delay (s)	1.3	0.0	25.5
Lane LOS	A		D
Approach Delay (s)	1.3	0.0	25.5
Approach LOS			D

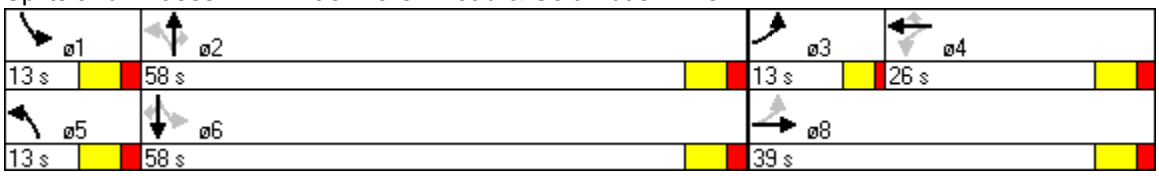
Intersection Summary			
Average Delay	4.4		
Intersection Capacity Utilization	72.7%	ICU Level of Service	C
Analysis Period (min)	15		

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1827	0	1652	1842	1601	1750	3775	1601	1750	3775	1601
Flt Permitted	0.458			0.320			0.373			0.074		
Satd. Flow (perm)	796	1827	0	556	1842	1601	686	3775	1601	136	3775	1564
Satd. Flow (RTOR)		3				138			171			43
Volume (vph)	291	393	21	40	138	145	11	1508	165	120	535	40
Lane Group Flow (vph)	316	450	0	43	150	158	12	1639	179	130	582	43
Turn Type	pm+pt			Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	3	8			4		5	2		1	6	
Permitted Phases	8			4		4	2		2	6		6
Total Split (s)	13.0	39.0	0.0	26.0	26.0	26.0	13.0	58.0	58.0	13.0	58.0	58.0
Act Effct Green (s)	35.0	35.0		22.0	22.0	22.0	63.0	54.0	54.0	63.0	54.0	54.0
Actuated g/C Ratio	0.32	0.32		0.20	0.20	0.20	0.57	0.49	0.49	0.57	0.49	0.49
v/c Ratio	0.98	0.77		0.39	0.41	0.37	0.03	0.88	0.21	0.62	0.31	0.05
Control Delay	81.0	44.1		42.5	35.2	7.6	11.6	42.3	10.3	44.7	9.8	1.1
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	81.0	44.1		42.5	35.2	7.6	11.6	42.3	10.3	44.7	9.8	1.1
LOS	F	D		D	D	A	B	D	B	D	A	A
Approach Delay		59.3			23.6			39.0			15.3	
Approach LOS		E			C			D			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 36.9 Intersection LOS: D
Intersection Capacity Utilization 89.5% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive

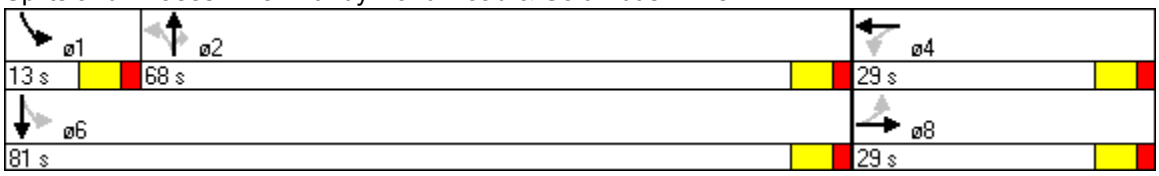


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1978	0	1750	1866	0	1652	3500	1601	1652	3444	0
Flt Permitted	0.419			0.160			0.359			0.059		
Satd. Flow (perm)	769	1978	0	295	1866	0	623	3500	1601	103	3444	0
Satd. Flow (RTOR)		1			24				66		23	
Volume (vph)	160	400	10	40	131	75	1	1859	85	105	645	65
Lane Group Flow (vph)	174	446	0	43	224	0	1	2021	92	114	772	0
Turn Type	Perm			Perm			Perm		Perm	pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2		2	6		
Total Split (s)	29.0	29.0	0.0	29.0	29.0	0.0	68.0	68.0	68.0	13.0	81.0	0.0
Act Effct Green (s)	25.0	25.0		25.0	25.0		64.0	64.0	64.0	77.0	77.0	
Actuated g/C Ratio	0.23	0.23		0.23	0.23		0.58	0.58	0.58	0.70	0.70	
v/c Ratio	0.99	0.99		0.64	0.51		0.00	0.99	0.10	0.57	0.32	
Control Delay	111.0	83.7		81.5	37.6		5.0	26.8	1.1	50.0	4.4	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	111.0	83.7		81.5	37.6		5.0	26.8	1.1	50.0	4.4	
LOS	F	F		F	D		A	C	A	D	A	
Approach Delay		91.3			44.7			25.6			10.3	
Approach LOS		F			D			C			B	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 98.0% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive

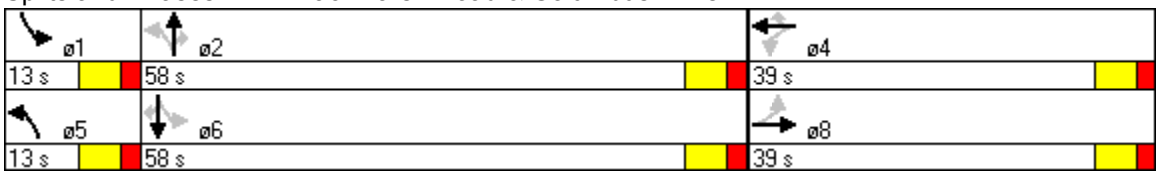


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1652	1809	0	1652	1842	1601	1750	3775	1601	1750	3775	1601
Flt Permitted	0.233			0.432			0.074			0.201		
Satd. Flow (perm)	405	1809	0	751	1842	1601	136	3775	1601	370	3775	1564
Satd. Flow (RTOR)		7				168			174			91
Volume (vph)	109	221	30	170	391	155	30	879	160	290	1462	85
Lane Group Flow (vph)	118	273	0	185	425	168	33	955	174	315	1589	92
Turn Type	Perm			Perm		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases		8			4		5	2		1	6	
Permitted Phases	8			4		4	2		2	6		6
Total Split (s)	39.0	39.0	0.0	39.0	39.0	39.0	13.0	58.0	58.0	13.0	58.0	58.0
Act Effct Green (s)	35.0	35.0		35.0	35.0	35.0	63.0	54.0	54.0	63.0	54.0	54.0
Actuated g/C Ratio	0.32	0.32		0.32	0.32	0.32	0.57	0.49	0.49	0.57	0.49	0.49
v/c Ratio	0.91	0.47		0.77	0.73	0.27	0.16	0.52	0.20	0.97	0.86	0.11
Control Delay	98.3	32.5		52.3	37.4	6.3	17.2	35.1	14.1	50.4	28.2	6.6
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	98.3	32.5		52.3	37.4	6.3	17.2	35.1	14.1	50.4	28.2	6.6
LOS	F	C		D	D	A	B	D	B	D	C	A
Approach Delay		52.4			34.2			31.5			30.7	
Approach LOS		D			C			C			C	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 109 (99%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 33.5 Intersection LOS: C
Intersection Capacity Utilization 86.2% ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 2: Blackmarsh Road & Columbus Drive



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1750	1972	0	1750	1938	0	1652	3500	1601	1652	3423	0
Flt Permitted	0.160			0.386			0.062			0.168		
Satd. Flow (perm)	295	1972	0	710	1938	0	108	3500	1601	292	3423	0
Satd. Flow (RTOR)		2			7				109		36	
Volume (vph)	60	212	10	145	344	60	5	1038	100	95	1682	250
Lane Group Flow (vph)	65	241	0	158	439	0	5	1128	109	103	2100	0
Turn Type	Perm			Perm			Perm		Perm	pm+pt		
Protected Phases		8			4			2		1	6	
Permitted Phases	8			4			2		2	6		
Total Split (s)	29.0	29.0	0.0	29.0	29.0	0.0	68.0	68.0	68.0	13.0	81.0	0.0
Act Effct Green (s)	25.0	25.0		25.0	25.0		64.0	64.0	64.0	77.0	77.0	
Actuated g/C Ratio	0.23	0.23		0.23	0.23		0.58	0.58	0.58	0.70	0.70	
v/c Ratio	0.97	0.54		0.98	0.98		0.08	0.55	0.11	0.33	0.87	
Control Delay	149.5	44.4		110.4	81.4		7.2	7.0	0.2	4.4	9.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	149.5	44.4		110.4	81.4		7.2	7.0	0.2	4.4	9.8	
LOS	F	D		F	F		A	A	A	A	A	
Approach Delay		66.7			89.1			6.4			9.6	
Approach LOS		E			F			A			A	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 13 (12%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 23.6 Intersection LOS: C
Intersection Capacity Utilization 101.3% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 3: Mundy Pond Road & Columbus Drive