

Appendix B: Traffic Reports



407 TRANSITWAY - KENNEDY ROAD TO BROCK ROAD

MINISTRY OF TRANSPORTATION - CENTRAL REGION

Report

Markham Road Station Traffic Study



Prepared for Ministry of Transportation, Ontario
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1 Introduction

The proposed Markham Road Highway 407 Transitway Station is a new transit station in the City of Markham, in the Regional Municipality of York. The station site is located at the southwest corner of the Highway 407 interchange at Markham Road.

This study analyzes the potential traffic impacts of the proposed station on the surrounding road network. The existing conditions year is 2015 with the future horizon year of 2031. Traffic analysis includes station access and adjacent street network to determine any operational deficiencies. In addition, this memo documents the impact of station volumes onto Markham Road due to the park and ride facility at the proposed station.

1.1 Study Area

The study area was confirmed with the Ministry of Transportation, Ontario (MTO) staff and includes the following intersections:

- Highway 407 West Off-ramp at Markham Road;
- Highway 407 East Off-ramp at Markham Road;
- Future site access at Markham Road; and
- 14th Avenue at Markham Road.

The above intersections are shown in Exhibit 1-1 below. Analysis intersections are marked in green while the future site access is shown in blue. The new access intersection, located between the Highway 407 East Off-ramp and 14th Avenue, is the only access to the proposed station. The new layout configuration is included in the future conditions analysis.

Exhibit 1-1: Study Area Map



1.2 Study Objective

The objective of the traffic analysis for Markham Road is to support the planning and preliminary design of the Transitway by identifying problems in the road network, providing needs and justification, and evaluating solutions.

Section 2 provides the existing road network and traffic operations of the analysis intersections in the study area.

Section 3 discusses the traffic volume projections of the proposed station, including the assignment of site-generated trips in the study area

Section 4 provides the projection of future background and future total traffic volumes.

Section 5 provides the internal circulation analysis.

Section 6 analyzes potential improvements and/or road network changes that would improve future operating conditions.

2 Existing Conditions

2.1 Road Network

Markham Road (York Regional Road 68) is a four lane north-south Regional Road with urban cross section within the study area. It has designated left and right turning lanes at the intersections with Highway 7 and 14th Avenue.

Highway 407 is a six lane Express Toll Route. It provides connections from the City of Burlington to the City of Pickering.

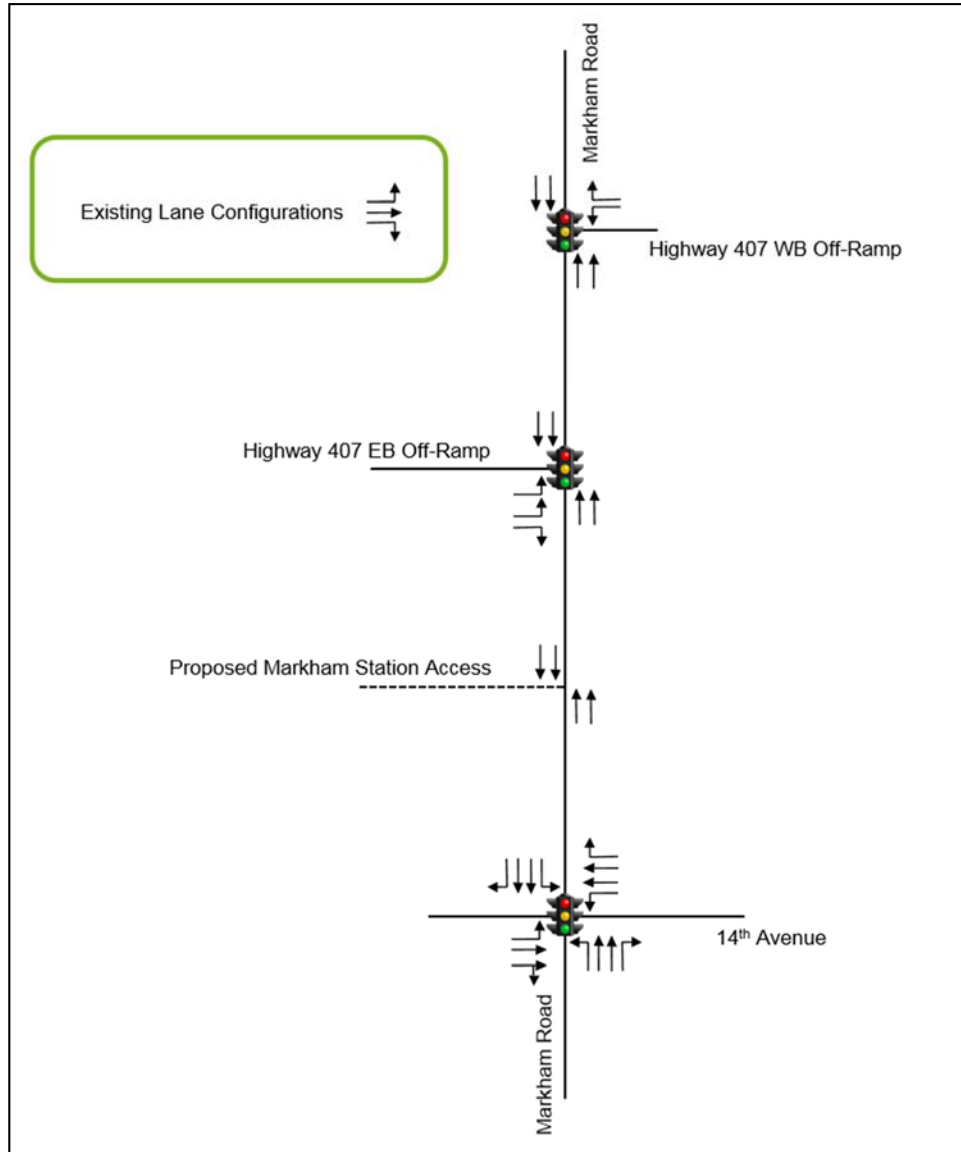
14th Avenue (York Regional Road 71) is a four lane east-west Regional Road with urban cross section within the study area. It has designated left and right turning lanes at the intersection with Markham Road.

Existing Lane Configurations

The existing conditions (2015) lane configuration was developed based on a review of aerial images. See Exhibit 2-1 for a simplified representation of the intersection lane configurations.

Suggested future lane configurations are based on the analyses in this study, discussed in detail later in this section as well as Sections 4 and 6.

Exhibit 2-1: Existing Intersection Lane Configurations



2.2 Data Collection

Traffic data was obtained from York Region. Exhibit 2-2 shows the date of the Turning Movement Count (TMC) for each analysis intersection.

Exhibit 2-2: Count Data

Intersection	Date
Highway 407 EB Offramp & Markham Road	2012 (September)
Highway 407 WB Offramp & Markham Road	2012 (September)
14th Avenue & Markham Road	2012 (September)

2.3 Operations

The existing conditions year is 2015. Analysis was conducted for weekday a.m. and p.m. peak hours. Traffic counts were scaled from 2012 to 2015 using an annual compounded growth rate of 0.8% (total growth of 2.4%), based on the Markham Road traffic growth between 2011 and 2031 from the GGH model results. Although this is a lower growth rate than the recommended general rate of 2.0% in the York Region TIS Guidelines (2007), it is appropriate for this study due to Markham Road operating near/at capacity already in the existing conditions study area intersections. Existing conditions traffic volumes are shown in Exhibit 2-4.

Intersection operations analysis was conducted using Synchro 9, which utilizes the Highway Capacity Manual (HCM) 2000 methodology to evaluate overall intersection and individual movement performances. The level of service (LOS) is a measure of performance based on the control delay, defined as follows in Exhibit 2-3:

Exhibit 2-3: Intersection LOS Reference

HCM	Control Delay per Vehicle (s)	
LOS	Signalized	Unsignalized
A	≤10	≤10
B	>10 and ≤20	>10 and ≤15
C	>20 and ≤35	>15 and ≤25
D	>35 and ≤55	>25 and ≤35
E	>55 and ≤80	>35 and ≤50
F	>80	>50

Critical movements were identified by satisfying any one or more of the following criteria, based on the York Region TIS Guidelines for an urban area:

- Control delay of LOS E or worse;
- 95th percentile queue exceeding provided storage/link length; and
- Volume-to-capacity (v/c) ratio of 0.85 or greater.

A summary of the Synchro analysis including delay, 95th percentile queue, and level-of-service (LOS) indicators is shown in Exhibit 2-5 with the detailed output provided in Appendix A.

Highway 407 West Off-ramp at Markham Road: Intersection operates at LOS B and A in the a.m. and p.m. peak hours, respectively, with no critical movements.

Highway 407 East Off-ramp at Markham Road: Intersection operates at LOS C in the a.m. and p.m. peak hours. The high V/C ratio for the eastbound right turning movement indicates that right-turn channelization of the existing right turn lane or an additional right turn lane may be required as the peak hour turning volume continues to increase.

14th Avenue at Markham Road: Intersection operates at LOS D in the a.m. peak hour and LOS F in the p.m. peak hour. In the a.m. peak hour, the westbound left turn and southbound through movements experience high delays and queue lengths that may exceed the available storage lengths. In the p.m. peak hour, there are several critical movements that experience high delays and critical queue lengths.

Significant improvements would be required to mitigate the operation issues associated with the intersection of 14th Avenue and Markham Road. Volumes on these arterials are very high due to connectivity south to the 401 and Scarborough, and west into Vaughan and North York. Additional through and left turn lanes would be able to relieve congestion; however

improvements are constrained in the short term by the two adjacent railway bridges south and west of the intersection.

Exhibit 2-4: Existing Conditions (2015) Traffic Volumes

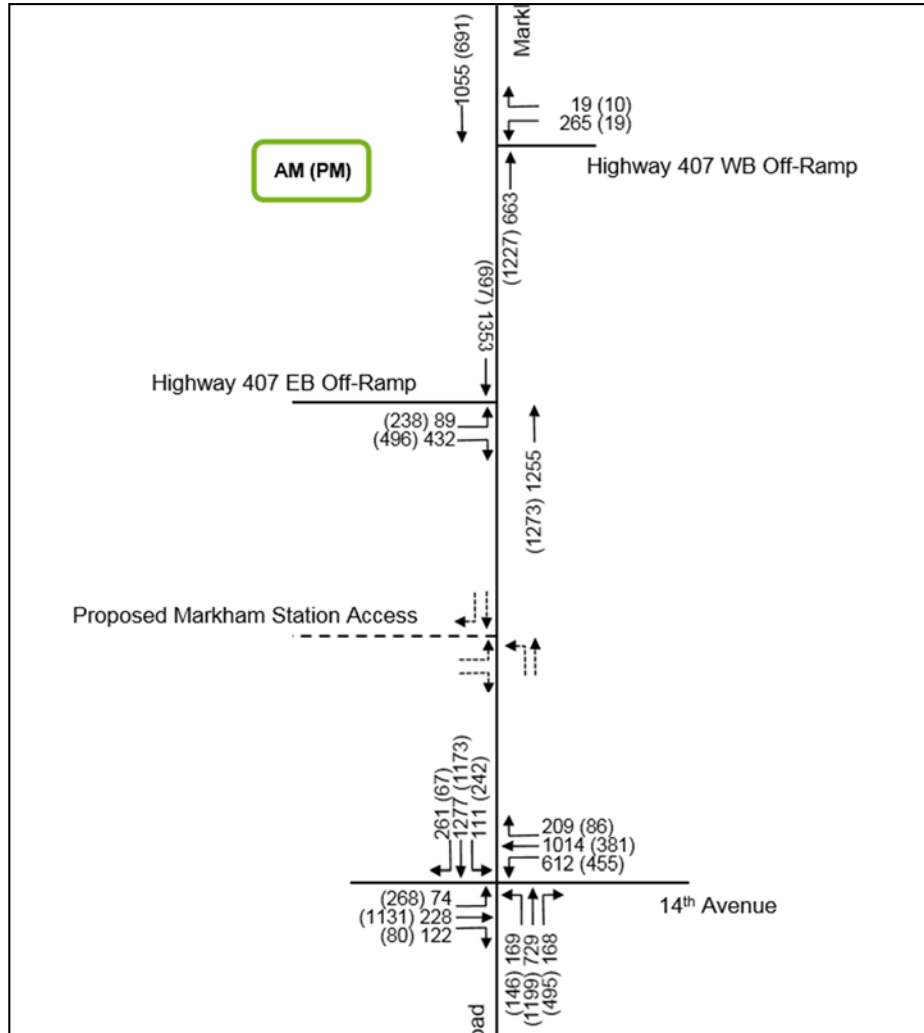


Exhibit 2-5: Existing Conditions Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Markham Road	B					A				
Highway 407 East Off-Ramp at Markham Road	C	EBR	E	0.88	#142	C	EBR	E	0.86	121
14th Avenue at Markham Road	D	WBL SBT	F	1.07	#215	F	EBT	F	1.14	#248
			E	1.02	#253		WBL	F	1.11	#192
							NBT	F	1.05	#233
							NBR	E	0.8	#154
							SBL	F	1.25	#119
						SBT	F	1.03	#225	

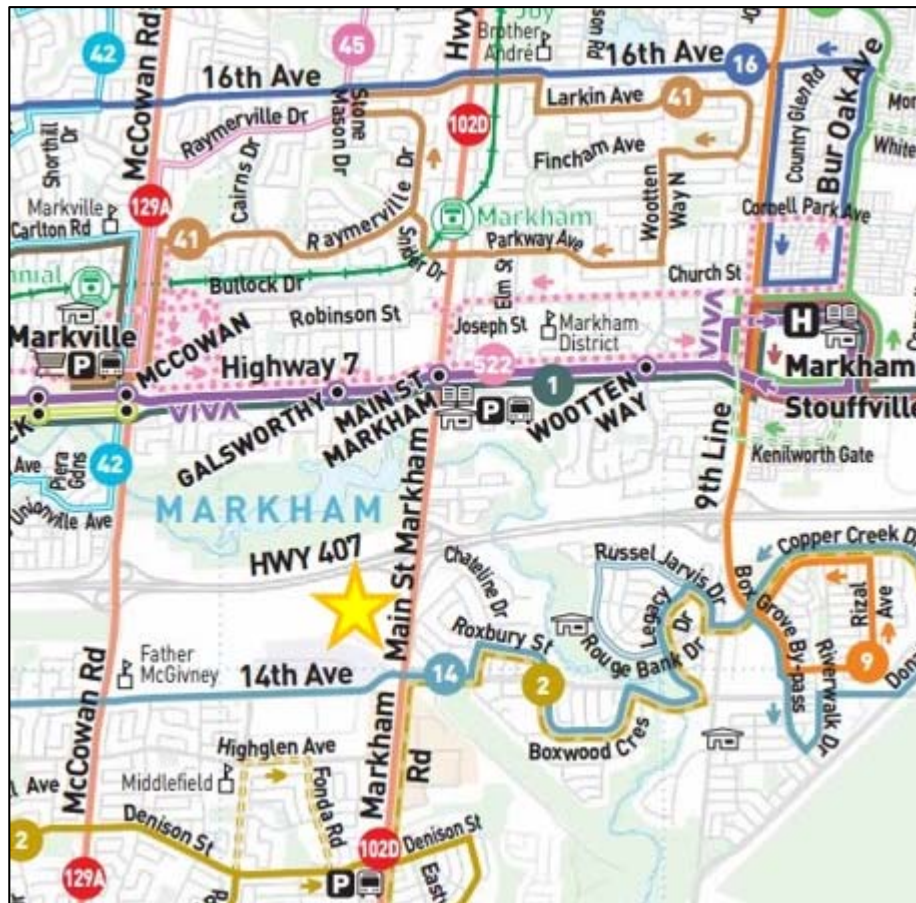
2.4 Transit Access

York Regional Transit (YRT) provides transit access within York Region and also contracts TTC bus routes to connect to the subway service. The YRT/Viva is a Bus Rapid Transit (BRT) network that also operates a number of routes on major arterials. Within the study area of Markham Road Station, the following services are currently in operation:

- **TTC Route 102D** runs along Markham Road and connects Warden Station to Major Mackenzie Drive;
- **YRT Route 1 – Highway 7** runs along Highway 7 and connects the Richmond Hill Centre to the Markham Stouffville Hospital with headways ranging from 20 to 30 minutes during peak hours;
- **YRT Route 14 – 14th Avenue** runs along 14th Avenue and connects Woodbine Avenue to Donald Cousens Parkway;
- **YRT Route 522 – Markham Community Bus** is in operation during rush hour only and connects various communities in the Town of Markham; and
- **Viva Purple** is a major east-west connection from York University to the Markham Stouffville Hospital with peak hour headways ranging from 14 to 19 minutes.

Exhibit 2-6 illustrates the transit connections within the study area.

Exhibit 2-6: YRT in the Study Area



3 Site Traffic

This section provides the methodology and process used to generate and distribute site-generated traffic from the proposed station.

3.1 Station Demand Forecasts

Station demand forecasts were developed based on the Greater Golden Horseshoe (GGH) model scenarios for the 407 Transitway East study. There are two scenarios, a.m. and p.m., each based on the projected 2031 population and employment in the GGH area. For the purposes of this study, demand adjustments were undertaken to better calibrate the transit travel patterns in the east portion of the 407 Transitway between Kennedy Road and Brock Road. Model results for each station include peak period demand in three access categories: park-and-ride (PnR), walk/transit, and interline. See Exhibit 3-1 for the station travel demand forecasts.

ITE Trip Generation Manual (8th edition) provides inbound and outbound peak hour trip rates for transit stations with park and ride service (code #90), based on the number of parking spaces provided. In order to develop the number of parking spaces required at each station, 2011 TTS data at existing GO transit stations were analyzed. The average ratio between a.m. peak period auto driver demand and the number of parking spaces provided at these stations were found to be 0.75. See Exhibit 3-2 for the list of GO stations and their parking provision rates.

The ratio found above was applied to the 407 Transitway East stations to develop the number of parking spaces needed, with the assumption that auto driver demand is equal to park-and-ride demand. See Exhibit 3-3 for the proposed number of parking spaces at each station.

Exhibit 3-1: GGH Model Results – 2031 AM Peak Period Transitway Station Demand

Station	2031 AM Peak Period Travel Adjusted			
	PnR	Walk/Transit	Interline	Total
Brock Road	450	30	1,690	2,170
Whites Road	540	40	1,480	2,060
Donald Cousens Parkway	383	127	0	510
9th Line	503	167	0	670
Markham Road	608	102	100	810

Exhibit 3-2: TTS Data – 2011 AM Peak Period GO Station Demand and Parking Supply

2011 TTS AM Peak Period Travel		Station Parking	
GO Station (Rural)	Auto Driver*	Spaces	% Provision
Stouffville	220	243	91%
Aurora	1,010	1,463	69%
Newmarket	260	265	98%
Milton	1,330	1,544	86%
Georgetown	400	614	65%
Mount Pleasant	830	1,112	75%
Total Rural	4,050	5,241	77%
GO Station (Durham)	Auto Driver	Spaces	% Provision
Oshawa	1,620	2,380	68%
Whitby	2,200	2,958	74%
Ajax	1,730	2,148	81%
Pickering	1,850	2,508	74%
Total Durham	7,400	9,994	74%
Total	11,450	15,235	75%

* Rounded to nearest 10

Exhibit 3-3: Station Parking Space Requirement

Station	PnR Demand	Parking Spaces
Brock Road	450	600
Whites Road	540	720
Donald Cousens Parkway	383	511
9th Line	503	671
Markham Road	608	810
Kennedy Road	820	1,093

3.2 Trip Generation

Trip generations rates were based on the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th Edition. Land use code 90 (Park and Ride Lot for Bus Service) was used to determine the number of auto trips in to and out of the station based on the number of spaces in the station parking lot. The number of parking spaces was estimated based on projected ridership.

The proposed station is to have a single access to Markham Road between the intersections with Highway 407 EB off-ramp and 14th Avenue. Estimated transit ridership is approximately 810 riders in the a.m. peak period, with 75% using the park and ride (PnR) services.

Based on similar other stations, it is assumed that an additional 25% provision of parking would be used by 2031, thus a parking lot size of 810 spaces was assumed for trip generation purposes.

The trip generation rates and resultant traffic volumes projected for 2031 are shown in Exhibit 3-4.

Exhibit 3-4: Trip Generation Rates

Markham Road Station Traffic Volumes						
ITE Land Use Code 90	Total	Entering	Exiting	Total	Entering	Exiting
	AM			PM		
Rate: Trips per Parking Space	0.72	0.81	0.19	0.62	0.23	0.77
# of Trips	583	472	111	502	115	387

3.3 Surface Transit Forecasts

Transit volumes were also added based on the assumption that transit would need to accommodate approximately 1/3 of the users of the PNR (25% non PnR vs 75% PnR). A capacity of 25 people per bus was assumed to determine 7 buses per hour that enter and exit the station during the peak hour.

Note that site-accessing bus volumes are accounted in the station access intersection turning movement volumes, but not in the adjacent intersections as they are considered to be included within background traffic volumes.

3.4 Trip Assignment

Station traffic was estimated based on former studies done for the central section of the Highway 407 Transitway completed in 2011. The distribution was approximately 65% to/from the north and 35% to/from the south along Markham Road. At the intersections of Markham Road at Highway 7 and 14th Avenue, station traffic was assumed to follow the percentage distribution of existing peak hour traffic turning movements.

See Exhibit 3-5 for the trip assignment percentages.

See Exhibit 3-6 for the trip assignment volumes.

Exhibit 3-5: Trip Assignment Percentages

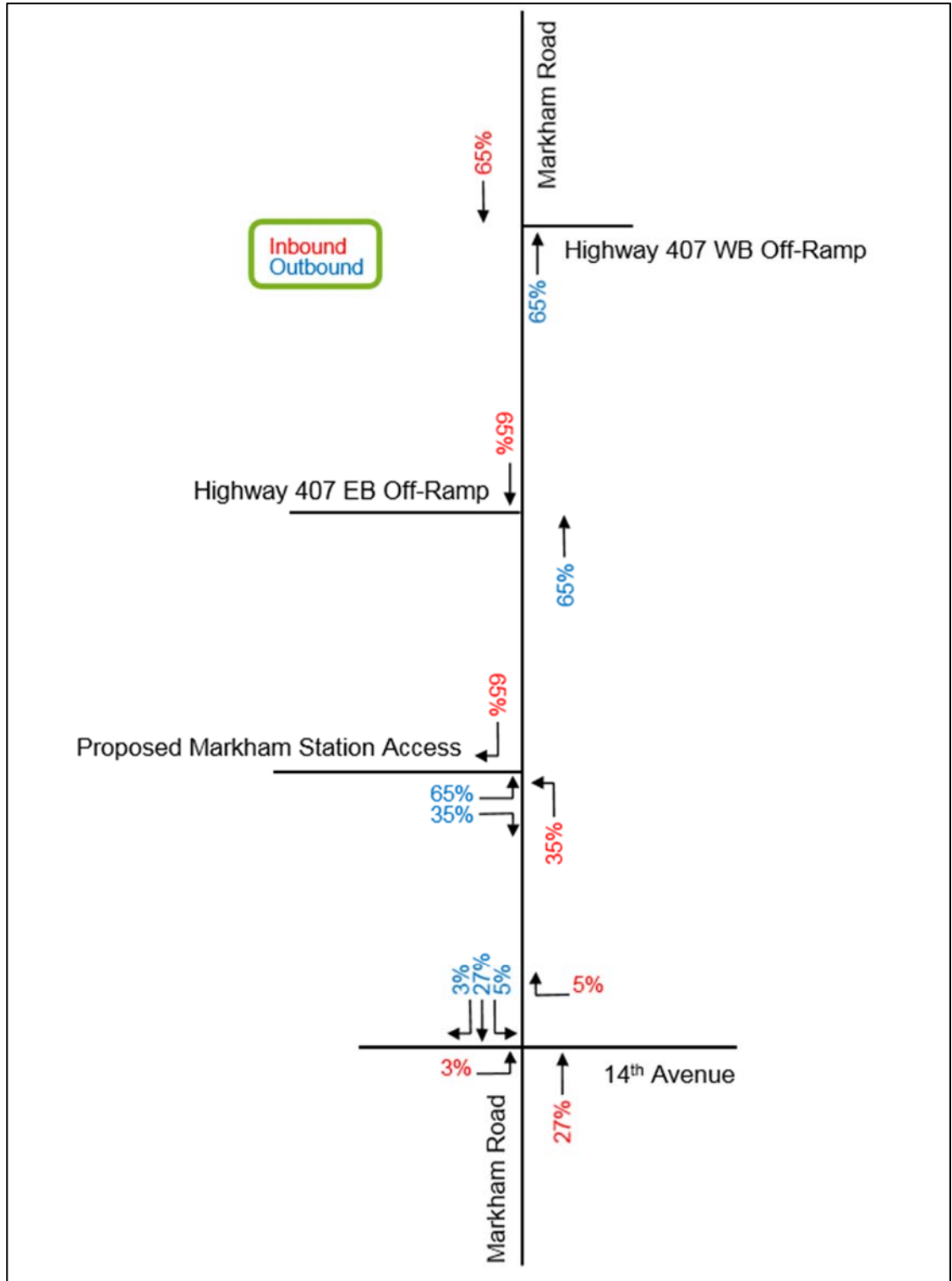
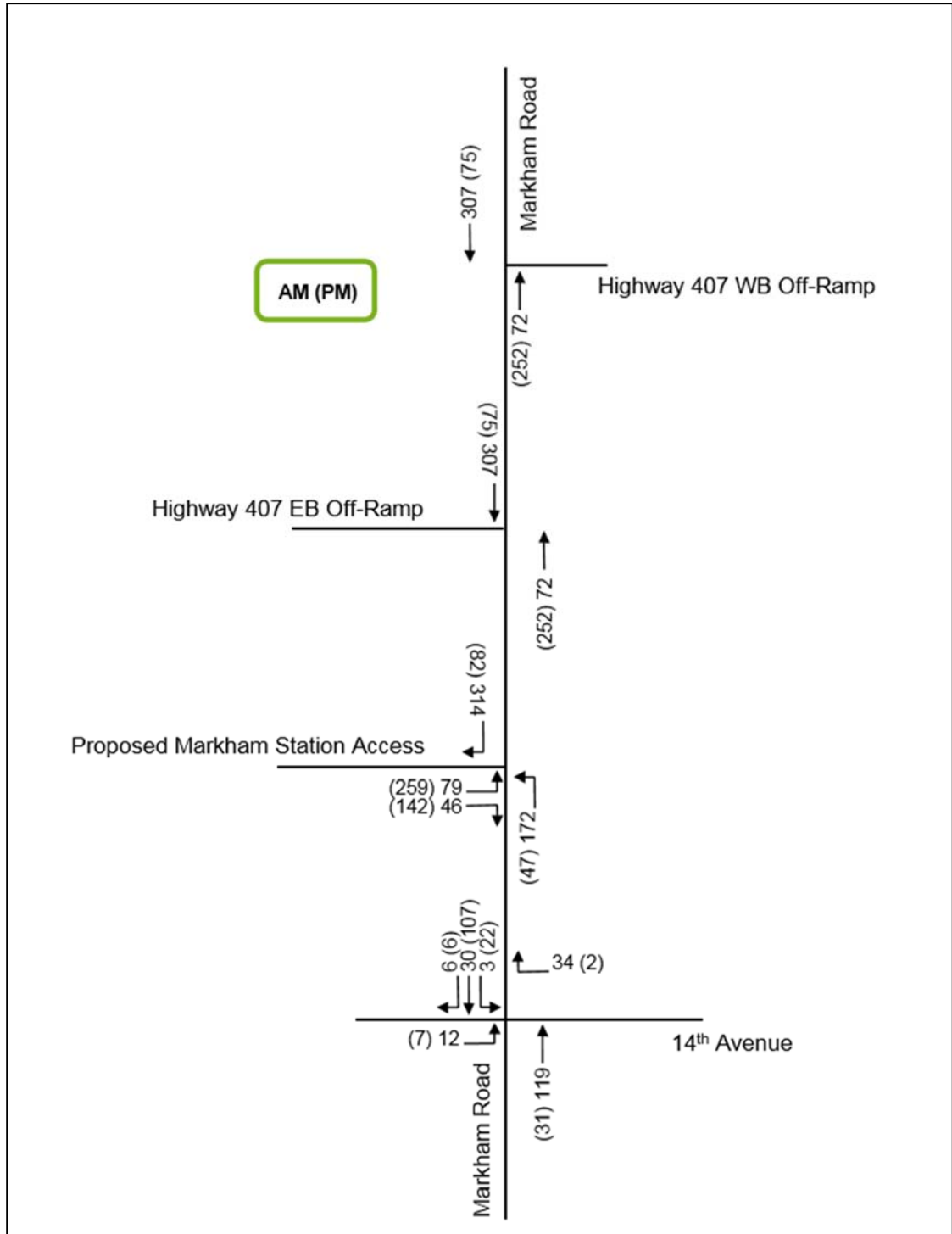


Exhibit 3-6: Trip Assignment Volumes



4 Future Conditions

4.1 Background Operations

The future horizon year of 2031 was analyzed in coordination with overall Transitway phasing strategy. All future conditions analysis scenarios include signal timing optimization based on existing and/or nearby intersection's cycle lengths.

Background traffic growth was obtained from the Greater Golden Horseshoe (GGH) model. For the Markham Road corridor, an annual compound growth rate of 0.8% was applied for all traffic volumes. This accounts for growth and development in and around the study area that would influence the traffic demand.

Highway 407 West Off-Ramp at 9th Line: Intersection operates at LOS B in a.m. peak hour and A in the p.m. peak hour. No critical movements are noted.

Highway 407 East Off-Ramp at 9th Line: The high V/C ratio for the eastbound right turn movement indicates that additional capacity is required as volumes continue to increase. Overall, intersection continues to operate at LOS C in the a.m. and p.m. peak hour.

14th Avenue at Markham Road: As expected based on the existing conditions analysis, the intersection of 14th Avenue and Markham Road deteriorates to LOS E (F) overall in the a.m. (p.m.) peak hours with multiple critical movements. In the p.m. peak hour, the max v/c ratio increases to 1.61 for the westbound left turn movement.

Given the poor conditions of the existing intersection and limitations on expansion, considerations should be made regarding provision of alternatives to 14th Avenue and Markham Road. From the Town of Markham's Transportation Master Plan, Donald Cousens Parkway is expected to be an alternative to Markham Road for north-south travel and connection to Highway 407 (and later south to Highway 401). However, its current iteration is limited from Major Mackenzie Drive to the north and Steeles Avenue Drive to the south which makes it a poor alternative for long-distance north-south travel.

It is expected that the Donald Cousens Parkway will eventually connect with Morningside Drive which would improve the appeal of the by-pass. A timeline regarding the full implementation of this is currently not available and thus was not considered in the future horizon traffic analysis.

The 2031 background volume (without site-generated traffic) is shown in Exhibit 4-1. Summary of the future background conditions analysis is shown in Exhibit 4-2.

Exhibit 4-1: Future 2031 Background Volumes

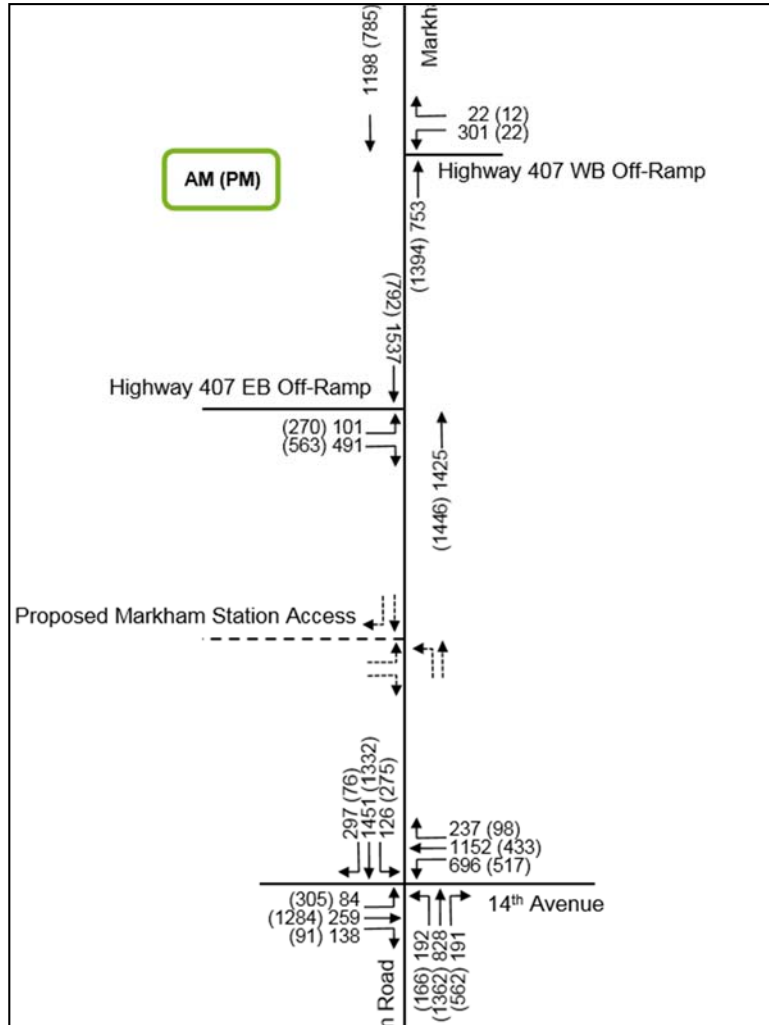


Exhibit 4-2: Future 2031 Background Conditions Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Markham Road	B					A				
Highway 407 East Off-Ramp at Markham Road	C	EBR	E	0.90	#172	C	EBR	D	0.90	#163
14th Avenue at Markham Road	E	WBL	F	1.37	#320	F	EBT	F	1.23	#291
		WBT	D	0.85	177		NBL	F	0.99	#75
		NBL	F	1.12	#93		NBT	F	1.08	#263
		SBT	F	1.06	#278		NBR	E	0.88	#193
		SBL	F	1.42	#141		SBL	F	1.42	#141
		SBT	E	1.01	#246		SBT	E	1.01	#246

4.2 Total Operations

Highway 407 Off-Ramps: Operational performance at both off-ramps deteriorates slightly as a result of increased north-south mainline traffic on Markham Road. Southbound through movement approaches capacity in the a.m. peak hour and northbound through movement approaches capacity in the p.m. peak hour.

Station Access and Markham Road: The proposed site access is assumed to be a signalized intersection on Markham Road. As shown in Exhibit 4-3, it is possible to have this intersection operate at a LOS B overall in both a.m. and p.m. peak periods with only two exiting lanes and one inbound lane. Sufficient northbound left turn storage lane should be provided to prevent queue spillback onto mainline northbound operations.

Markham Road and 14th Avenue: This intersection continues to deteriorate and is over capacity, as expected based on existing and background conditions analysis. Mitigation measures are discussed in further detail in the following section as localized improvement measures are not expected to be sufficient in resolving the operational issues.

Exhibit 4-3: Future 2031 Total Conditions Intersection Operational Performance Summary

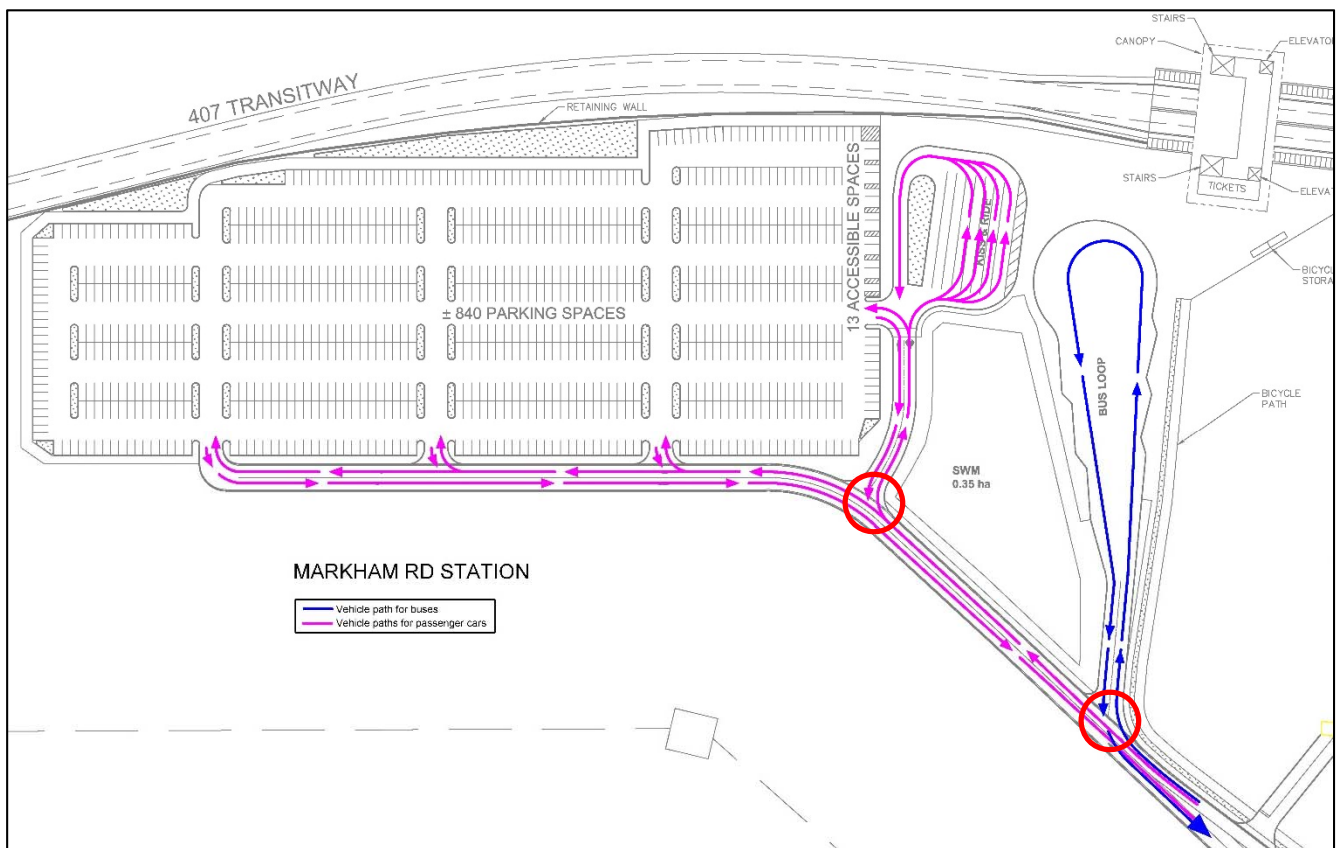
Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Markham Road	B	WBL	E	0.80	105	A				
Highway 407 East Off-Ramp at Markham Road	C	EBR SBT	E C	0.96 0.93	#197 #282	C	EBR NBT	E C	0.96 0.87	#190 242
14th Avenue at Markham Road	F	WBL WBT NBL SBT	F D F F	1.37 0.85 1.12 1.08	#320 178 #93 #288	F	EBT WBL NBL NBT NBR SBL SBT	F F F F E F F	1.23 1.67 0.99 1.08 0.86 1.53 1.07	#291 #261 #75 #269 #190 #155 #275
Markham Station Access at Markham Road	B	NBL	D	0.73	#54	B				

5 Internal Circulation

This section provides an overview of the proposed station's internal circulation design, with vehicle composition and flow derived from the site-generated trips in Section 3. The intersection with the highest number of potential vehicle volumes (and/or conflicting movements) is analyzed as an unsignalized intersection in Synchro, within the a.m. and p.m. peak hours.

The proposed internal circulation plan is shown below in Exhibit 5-1. Analysis intersections are circled in red. Note that the plan is intended to illustrate the internal flow of vehicles (pink) and buses (blue), and that site details such as number of parking spaces and dimensions are subject to revisions.

Exhibit 5-1: Internal Circulation Plan – Markham Road Station



The station internal volumes consist of:

- Passenger vehicles: AM: 472 in, 111 out; PM: 115 in, 387 out; and
- Buses (sum of northbound and southbound buses): AM: 14 in, 14 out; PM: 14 in, 14 out.

For simplicity, all outbound vehicles in the AM and inbound vehicles in the PM are assumed to be associated with drop-off and pick-up activities ("Kiss-and-Ride", abbreviated KnR). The remainder is assumed to be Park-and-Ride (PnR) vehicles, inbound in the AM and outbound in the PM. All buses are modelled as heavy vehicles in Synchro.

Analysis results show that there are no operational issues at the analyzed internal intersections for both peak hour operations. The east-west movement is analyzed as freeflow movements,

which incurs no delay, and the southbound movement is analyzed as a stop-controlled movement, which operates at LOS B (C) in the a.m. (p.m.) peak hour at both intersections.

Results are summarized in Exhibit 5-2 below.

Exhibit 5-2: Internal Circulation Analysis – Markham Road Station

Internal			AM Peak Hour			PM Peak Hour		
Intersection	Mvmt.	Description	Volume	LOS	Queue (95 th , m)	Volume	LOS	Queue (95 th , m)
at KnR	EBT	PnR out	0	A	0	272	A	0
	WBT	PnR in	361	A	0	0	A	0
	WBR	KnR in	111	A	0	115	A	0
	SBL	KnR out	111	B	6	115	B	5
at Bus Loop	EBT	PnR out + KnR out	111	A	0	387	A	0
	WBT	PnR in + KnR in	472	A	0	115	A	0
	WBR	Bus in	14	A	0	14	A	0
	SBL	Bus out	14	C	17	14	C	1

If bus volumes are increased and/or delay issues are observed during operations, it is recommended that the intersection at the bus loop be converted to all-way stop control in order to decrease delays for buses.

6 Mitigation Measures

Highway 407 Off-ramp Intersections and Site Access

As discussed in Section 4.2, the following mitigation measures recommended:

- Highway 407 Westbound Off-ramp: add a westbound left turn lane;
- Highway 407 Eastbound Off-ramp: add an eastbound right turn lane;
- Site Access at Markham Road: add a storage lane for each northbound left turn and southbound right turn; and
- Set a uniform cycle length for all three intersections (120s used in this study) and coordinate the signals for better northbound/southbound flow.

Roundabouts were considered and ruled out at the Highway off-ramps as they would bring little to no operational benefit compared to the analysis conditions and would entail significant construction and re-alignment of off-ramps and through roads.

The above mitigation measures will bring the v/c ratio down to 0.84 or lower for all movements in those intersections. See Exhibit 6-1 for summary of intersection operational performance in the peak hours with the above recommended mitigation measures. See Exhibit 6-2 for the recommended intersection configurations.

14th Avenue at Markham Road

The intersection of 14th Avenue and Markham Road operates poorly in both existing and future background conditions analysis with several movements near-, at-, or over- capacity (in the future). Improvements to the intersection are severely constrained by the two adjacent railway underpasses south and west of the intersection.

Short- or Medium-Term Measures

Improvements at the intersection as mentioned above are extremely constrained by road geometries and the rail bridges. The possibility of a second westbound left turn lane, without requiring removal and replacement of the rail bridges was explored. The additional turning lane would improve operations by shortening queues and delays for the westbound left movement and freeing up green time for other movements. The benefit would be notable in the a.m. peak hour but limited in the p.m. peak hour.

In terms of feasibility, adding a second westbound left turning lane would entail realignment of westbound through lanes. The westbound through lanes would then need to be tapered back to match existing before the bridge at 14th Avenue. The eastbound left turn lane would likely need to be a single lane with some storage lane and would likely need to operate protected only.

Overall, these improvements amount to a major intersection widening and may not be feasible due to geometries.

Due to the difficult geometries and cost associated with the widening, plus a benefit limited to the a.m. peak hour and severe congestion remaining in the p.m. peak hour, it is not likely to be an option worth pursuing by the Region.

Long-Term Measures

Larger-scale widening that would require replacement of the rail crossings was explored, plus other network improvements such as extension of Donald Cousens Parkway to Morningside, thus providing a better alternative for north-south travel than currently exists.

In terms of local intersection improvements, the operational performance summary in Exhibit 6-1 is the result of the following mitigation measures:

- One additional through lane (and corresponding receiving lane) to each of following approaches: eastbound, northbound, and southbound;
- One additional westbound left turn lane;
- Extended storage lanes for northbound right turn, eastbound right turn, eastbound left turn, and westbound left turn; and
- Northbound right turn lane channelization.

The above improvements imply the replacement of both rail crossings and re-construction of the intersection and several hundred metres of roadway. Even with all the above measures implemented and signal timing plan re-optimization, some critical movements remain with v/c between 0.85 and 1.00.

An alternative solution is to divert background traffic to Donald Cousens Parkway, which is discussed in the following section. Diversion options include the Donald Cousens Parkway for which the last Environmental Assessment (EA) Update was completed in 2011. The eventual connectivity of Donald Cousens Parkway to Highway 401 via Morningside Avenue could help reduce portions of peak hour traffic volumes Markham Road and 14th Avenue. Connection directly to Markham Road on the north end is expected in 2018 as per Region of York's Capital Plan. However, connectivity past Steeles Avenue and south to Highway 401 is not currently available and an established timeline is unclear. Users of the by-pass going south would need to go from Markham Road onto Major Mackenzie Drive in order to access Donald Cousens Parkway. Users then get back onto Markham Road at Steeles Avenue to be able to continue southbound.

This increases the travel distance from 8.3 km when using Markham Road to 13.8 km when using Donald Cousens Parkway, along with 4 extra turning movements (2 left-turns, 2 right-turns both northbound and southbound). This makes the by-pass an unattractive alternative option and as a result has limited current impacts on diverting traffic.

Should the connectivity be improved, a significant portion of traffic may then choose to use Donald Cousens Parkway as an alternative which may resolve several issues at the intersection of 14th Avenue and Markham Road and elsewhere along the Markham Road corridor.

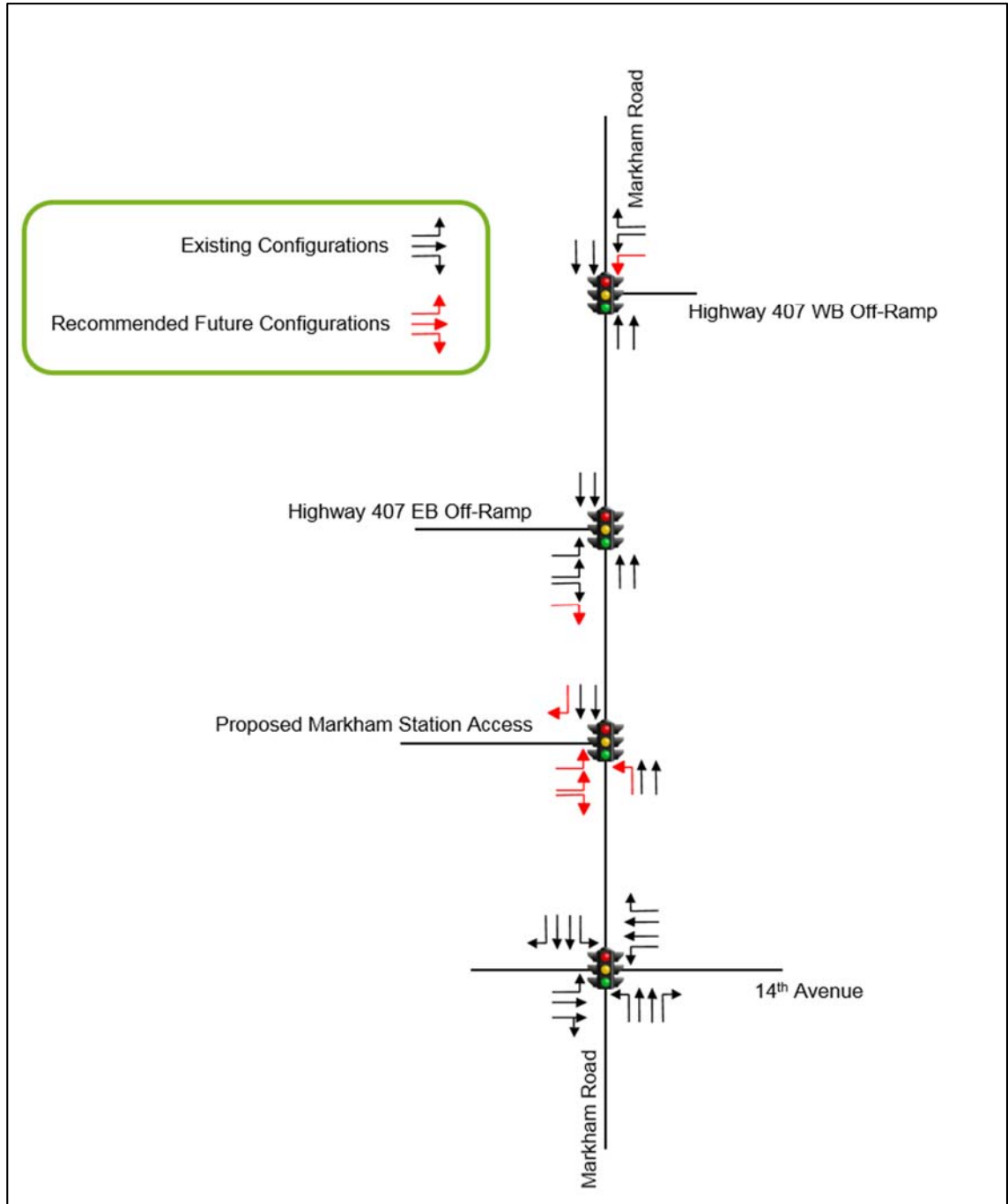
A roundabout was considered at 14th Avenue and Markham Road. A review of existing and future traffic volumes and some preliminary analysis indicated that traffic volumes and in particular conflicting left turns in the a.m. and p.m. peak hour are significantly above the capacity of a two-lane roundabout. Three lane roundabouts are very rare in North America, and generally not in use in Canada due to potential issues in the winter with less visibility of pavement markings. Furthermore a three-lane roundabout would be a major reconstruction of the interchange. Based on the analysis a roundabout is not recommended.

Overall this analysis has indicated that local improvements at 14th Avenue and Markham Road are not likely to be feasible without major reconstruction including bridge work and, being driven by background traffic and regional connectivity issues, are not recommended as part of the Highway 407 Transitway project.

Exhibit 6-1: Future 2031 Total Conditions with All Mitigation Measures – Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Markham Road	B					A				
Highway 407 East Off-Ramp at Markham Road	B					B				
14th Avenue at Markham Road	D	WBL NBL SBT	F D D	0.97 0.77 0.87	#138 #90 162	D	WBL NBL NBT SBL	F E D F	0.95 0.86 0.87 1.00	#108 #67 153 124
Markham Station Access at Markham Road	A					B				

Exhibit 6-2: Recommended Future Intersection Lane Configuration



7 Conclusion

This study presents the traffic impact analysis of the proposed Markham Road Station on the surrounding road network. The proposed station is located at the southwest corner of the Highway 407 interchange at Markham Road in the City of Markham, and can be accessed through a new signalized access intersection located south of the eastbound off-ramp.

Background traffic analysis in the existing conditions year of 2015 show that the intersection of Markham Road and 14th Avenue already operate at capacity with overall LOS D in the a.m. peak hour and F in the p.m. peak hour. Both westbound left turn and southbound through movements are at capacity in the a.m. peak hour, while in the p.m. peak hour there are four additional critical movements operating near or at capacity. With the intersection already at cycle length of 140 seconds, signal timing-based improvements are not sufficient in resolving the capacity issues at this intersection. Road improvements such as widening for additional lanes are constrained due to the two existing rail bridge crossings nearby.

Background traffic analysis in the future conditions year of 2031 show further deterioration of the intersection of Markham Road and 14th Avenue. Based on the projected 0.8% annual compounded background growth, this intersection will operate at LOS E (F) in the a.m. (p.m.) peak hours with several critical movements projected to be over-capacity. Due to the congestion at this intersection, future travel patterns may shift towards greater usage of Highway 407 as drivers weigh the toll costs against the value of lost time at this intersection. The two off-ramp intersections each require an additional turning lane to accommodate future demands.

Site traffic for the proposed Markham Road station was calculated based on the Greater Golden Horseshoe model's projected park-and-ride demand, the required number of on-site parking spaces, and the ITE trip generation manual rates. The proposed station generates 472 (115) inbound and 111 (387) outbound trips in the a.m. (p.m.) peak hour. Site access consists of a single signalized intersection on Markham Road, located between the Highway 407 eastbound off-ramp intersection and the 14th Avenue intersection.

The addition of site-generated traffic affects all intersections in the study area with slight increases in delays for northbound through and southbound through movements.

Internally, the site is expected to operate with no operational issues. Conflicts between buses, park-and-ride vehicles, and kiss-and-ride vehicles are expected to be minimal due to the separation of their access points and the peak hour directional bias of the park-and-ride vehicles.

Summary of Recommendations

To mitigate the impacts of site-generated traffic, the following are recommended:

- **Site Access Intersection:** three eastbound lanes (two left, one right), one storage lane each for northbound left turn and southbound right turn, signalization with a cycle length of 120 seconds, and signal coordination with the Highway 407 off-ramp intersections.

To mitigate background traffic congestion in the study area, the following are recommended:

- **Highway 407 Westbound Off-ramp Intersection:** one additional westbound left turn lane, re-optimization of signal phases to match a cycle length of 120 seconds, and coordination with adjacent signalized intersections;

- Highway 407 Eastbound Off-ramp Intersection: one additional eastbound right turn lane, re-optimization of signal phases to match a cycle length of 120 seconds, and coordination with adjacent signalized intersections; and
- 14th Avenue at Markham Road: further study into long-term improvements or reconstruction of the intersection, travel demand management measures, and alternative routing of peak hour traffic via extension of Donald Cousens Parkway or other network measures.

Appendix A – Existing (2015) Conditions Synchro Output

Queues

6: Markham Road & 14th Avenue

7/10/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	74	350	612	1014	209	169	729	168	111	1277	261
v/c Ratio	0.30	0.42	1.03	0.75	0.29	0.77	0.57	0.26	0.35	1.02	0.37
Control Delay	21.6	33.8	72.0	38.8	6.1	49.8	37.0	10.0	23.9	71.1	7.3
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	21.6	33.8	72.0	38.8	6.1	49.8	37.0	10.0	23.9	71.1	7.3
Queue Length 50th (m)	9.6	31.1	~121.5	117.7	3.2	25.2	80.1	6.1	15.6	~184.1	4.2
Queue Length 95th (m)	17.6	44.8	#214.7	148.7	19.3	#68.3	110.8	23.8	30.1	#252.6	24.9
Internal Link Dist (m)		130.2		163.4			1183.8			615.1	
Turn Bay Length (m)	55.0		80.0		80.0	200.0		15.0	160.0		115.0
Base Capacity (vph)	312	1172	594	1524	790	220	1272	654	322	1256	715
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.24	0.30	1.03	0.67	0.26	0.77	0.57	0.26	0.34	1.02	0.37

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.
























95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/10/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	74	228	122	612	1014	209	169	729	168	111	1277	261
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0		2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	3391		1789	3579	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.18	1.00		0.40	1.00	1.00	0.09	1.00	1.00	0.23	1.00	1.00
Satd. Flow (perm)	345	3391		748	3579	1601	170	3579	1601	442	3579	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	74	228	122	612	1014	209	169	729	168	111	1277	261
RTOR Reduction (vph)	0	55	0	0	0	118	0	0	85	0	0	154
Lane Group Flow (vph)	74	295	0	612	1014	91	169	729	83	111	1277	107
Turn Type	pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4			8		8	6		6	2		2
Actuated Green, G (s)	34.4	26.8		57.0	45.4	45.4	51.5	42.4	42.4	50.3	41.8	41.8
Effective Green, g (s)	38.4	29.8		59.0	48.4	48.4	55.5	45.4	45.4	54.3	44.8	44.8
Actuated g/C Ratio	0.30	0.23		0.46	0.38	0.38	0.43	0.35	0.35	0.42	0.35	0.35
Clearance Time (s)	4.0	8.0		4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	211	787		572	1349	603	213	1265	566	297	1248	558
v/s Ratio Prot	0.03	0.09		c0.23	c0.28		c0.07	0.20		0.03	c0.36	
v/s Ratio Perm	0.08			0.26		0.06	0.27		0.05	0.13		0.07
v/c Ratio	0.35	0.37		1.07	0.75	0.15	0.79	0.58	0.15	0.37	1.02	0.19
Uniform Delay, d1	33.4	41.5		29.8	34.8	26.4	29.8	33.7	28.3	24.0	41.8	29.2
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.0	0.3		57.7	2.4	0.1	18.1	1.9	0.5	0.8	31.5	0.8
Delay (s)	34.4	41.8		87.5	37.2	26.5	47.9	35.6	28.8	24.8	73.3	29.9
Level of Service	C	D		F	D	C	D	D	C	C	E	C
Approach Delay (s)		40.5			52.8			36.5			63.2	
Approach LOS		D			D			D			E	

Intersection Summary

HCM 2000 Control Delay	51.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	128.4	Sum of lost time (s)	14.5
Intersection Capacity Utilization	104.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Queues

12: Markham Road & Highway 407 WB

7/10/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	279	20	698	1111
v/c Ratio	0.74	0.06	0.28	0.45
Control Delay	52.3	13.4	7.5	9.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	52.3	13.4	7.5	9.0
Queue Length 50th (m)	55.5	0.0	26.9	49.9
Queue Length 95th (m)	83.2	6.0	44.8	80.0
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	732	667	2460	2460
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.38	0.03	0.28	0.45
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/10/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↶	↶	↷↷			↷↷
Volume (vph)	265	19	663	0	0	1055
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	279	20	698	0	0	1111
RTOR Reduction (vph)	0	16	0	0	0	0
Lane Group Flow (vph)	279	4	698	0	0	1111
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	22.0	22.0	73.9			73.9
Effective Green, g (s)	23.0	23.0	74.9			74.9
Actuated g/C Ratio	0.21	0.21	0.69			0.69
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	377	338	2461			2461
v/s Ratio Prot	c0.16		0.20			c0.31
v/s Ratio Perm		0.00				
v/c Ratio	0.74	0.01	0.28			0.45
Uniform Delay, d1	40.2	34.0	6.6			7.7
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	7.6	0.0	0.3			0.6
Delay (s)	47.8	34.0	6.9			8.3
Level of Service	D	C	A			A
Approach Delay (s)	46.8		6.9			8.3
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	13.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	108.9	Sum of lost time (s)	11.0
Intersection Capacity Utilization	73.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/10/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	94	455	1321	1424
v/c Ratio	0.09	0.89	0.61	0.66
Control Delay	30.1	57.8	17.9	19.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	30.1	57.8	17.9	19.0
Queue Length 50th (m)	8.3	97.4	105.1	118.8
Queue Length 95th (m)	14.5	#142.3	139.1	156.6
Internal Link Dist (m)	487.7		615.1	389.6
Turn Bay Length (m)				
Base Capacity (vph)	1258	603	2157	2157
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.07	0.75	0.61	0.66

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/10/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	89	432	0	1255	1353	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	94	455	0	1321	1424	0
RTOR Reduction (vph)	0	26	0	0	0	0
Lane Group Flow (vph)	94	429	0	1321	1424	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	36.4	36.4		73.2	73.2	
Effective Green, g (s)	37.4	37.4		74.2	74.2	
Actuated g/C Ratio	0.30	0.30		0.60	0.60	
Clearance Time (s)	6.5	6.5		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1054	486		2157	2157	
v/s Ratio Prot	0.03			0.37	c0.40	
v/s Ratio Perm		c0.27				
v/c Ratio	0.09	0.88		0.61	0.66	
Uniform Delay, d1	30.7	40.8		15.4	16.1	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	17.1		1.3	1.6	
Delay (s)	30.7	57.9		16.7	17.7	
Level of Service	C	E		B	B	
Approach Delay (s)	53.2			16.7	17.7	
Approach LOS	D			B	B	

Intersection Summary

HCM 2000 Control Delay	23.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	123.1	Sum of lost time (s)	11.5
Intersection Capacity Utilization	73.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

6: Markham Road & 14th Avenue

7/10/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	268	1211	455	381	86	146	1199	495	242	1173	67
v/c Ratio	0.52	1.14	1.09	0.27	0.13	0.73	1.05	0.83	1.22	1.03	0.11
Control Delay	22.9	117.0	110.9	30.1	3.3	49.6	88.0	45.0	165.0	81.5	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.9	117.0	110.9	30.1	3.3	49.6	88.0	45.0	165.0	81.5	0.4
Queue Length 50th (m)	39.3	~205.0	~124.7	37.8	0.0	24.5	~190.5	96.9	~64.4	~182.6	0.0
Queue Length 95th (m)	57.2	#247.9	#191.7	50.5	7.3	#52.8	#232.8	#153.6	#118.6	#225.0	0.0
Internal Link Dist (m)		130.2		163.4			1183.8			615.1	
Turn Bay Length (m)	55.0		80.0		80.0	200.0		15.0	160.0		115.0
Base Capacity (vph)	522	1066	416	1391	686	199	1137	598	199	1137	598
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.51	1.14	1.09	0.27	0.13	0.73	1.05	0.83	1.22	1.03	0.11
























Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/10/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	268	1131	80	455	381	86	146	1199	495	242	1173	67
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0		2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	3543		1789	3579	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.53	1.00		0.09	1.00	1.00	0.09	1.00	1.00	0.09	1.00	1.00
Satd. Flow (perm)	991	3543		175	3579	1601	173	3579	1601	173	3579	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	268	1131	80	455	381	86	146	1199	495	242	1173	67
RTOR Reduction (vph)	0	4	0	0	0	53	0	0	90	0	0	46
Lane Group Flow (vph)	268	1208	0	455	381	33	146	1199	405	242	1173	21
Turn Type	pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4			8		8	6		6	2		2
Actuated Green, G (s)	52.6	39.0		69.0	51.4	51.4	50.5	41.5	41.5	50.5	41.5	41.5
Effective Green, g (s)	56.6	42.0		71.0	54.4	54.4	54.5	44.5	44.5	54.5	44.5	44.5
Actuated g/C Ratio	0.40	0.30		0.51	0.39	0.39	0.39	0.32	0.32	0.39	0.32	0.32
Clearance Time (s)	4.0	8.0		4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	489	1062		411	1390	622	194	1137	508	194	1137	508
v/s Ratio Prot	0.06	c0.34		c0.22	0.11		0.06	c0.34		c0.10	0.33	
v/s Ratio Perm	0.16			0.34		0.02	0.23		0.25	0.39		0.01
v/c Ratio	0.55	1.14		1.11	0.27	0.05	0.75	1.05	0.80	1.25	1.03	0.04
Uniform Delay, d1	29.2	49.0		44.8	29.3	26.7	34.5	47.8	43.6	38.7	47.8	33.0
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.3	73.5		76.6	0.1	0.0	15.2	42.3	12.3	146.8	35.2	0.2
Delay (s)	30.5	122.5		121.5	29.4	26.8	49.6	90.0	55.9	185.5	82.9	33.2
Level of Service	C	F		F	C	C	D	F	E	F	F	C
Approach Delay (s)		105.8			74.6			77.7			97.4	
Approach LOS		F			E			E			F	

Intersection Summary

HCM 2000 Control Delay	89.5	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.10		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	121.2%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

12: Markham Road & Highway 407 WB

7/10/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	20	11	1292	727
v/c Ratio	0.07	0.04	0.42	0.24
Control Delay	44.3	22.6	3.8	2.9
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	44.3	22.6	3.8	2.9
Queue Length 50th (m)	4.0	0.0	47.3	21.3
Queue Length 95th (m)	11.3	5.3	57.4	27.1
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	745	673	3081	3081
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.03	0.02	0.42	0.24
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/10/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	19	10	1227	0	0	691
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	20	11	1292	0	0	727
RTOR Reduction (vph)	0	10	0	0	0	0
Lane Group Flow (vph)	20	1	1292	0	0	727
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	8.3	8.3	89.4			89.4
Effective Green, g (s)	9.3	9.3	90.4			90.4
Actuated g/C Ratio	0.08	0.08	0.82			0.82
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	150	134	2922			2922
v/s Ratio Prot	c0.01		c0.36			0.20
v/s Ratio Perm		0.00				
v/c Ratio	0.13	0.01	0.44			0.25
Uniform Delay, d1	47.0	46.5	2.9			2.3
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.0	0.5			0.2
Delay (s)	47.4	46.5	3.4			2.5
Level of Service	D	D	A			A
Approach Delay (s)	47.1		3.4			2.5
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	110.7	Sum of lost time (s)	11.0
Intersection Capacity Utilization	59.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/10/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	251	522	1340	734
v/c Ratio	0.27	0.90	0.59	0.32
Control Delay	33.5	43.3	15.4	11.6
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	33.5	43.3	15.4	11.6
Queue Length 50th (m)	23.4	75.3	92.2	39.7
Queue Length 95th (m)	33.5	121.0	140.7	63.4
Internal Link Dist (m)	487.7		615.1	389.6
Turn Bay Length (m)				
Base Capacity (vph)	1315	733	2270	2270
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.19	0.71	0.59	0.32

Intersection Summary

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/10/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↖↗	↗		↖↖	↖↖	
Volume (vph)	238	496	0	1273	697	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		5.5	5.5	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	251	522	0	1340	734	0
RTOR Reduction (vph)	0	149	0	0	0	0
Lane Group Flow (vph)	251	373	0	1340	734	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	31.1	31.1		74.0	74.0	
Effective Green, g (s)	32.1	32.1		75.0	75.0	
Actuated g/C Ratio	0.27	0.27		0.64	0.64	
Clearance Time (s)	6.5	6.5		6.5	6.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	943	435		2272	2272	
v/s Ratio Prot	0.07			c0.37	0.21	
v/s Ratio Perm		c0.23				
v/c Ratio	0.27	0.86		0.59	0.32	
Uniform Delay, d1	33.8	40.8		12.6	9.9	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.2	15.4		1.1	0.4	
Delay (s)	33.9	56.2		13.7	10.3	
Level of Service	C	E		B	B	
Approach Delay (s)	49.0			13.7	10.3	
Approach LOS	D			B	B	

Intersection Summary

HCM 2000 Control Delay	22.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	118.1	Sum of lost time (s)	11.0
Intersection Capacity Utilization	59.1%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Appendix B – Future (2031) Background Conditions Synchro Output

Queues

6: Markham Road & 14th Avenue

7/10/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	84	397	696	1152	237	192	828	191	126	1451	297
v/c Ratio	0.47	0.40	1.32	0.85	0.33	1.08	0.62	0.28	0.46	1.06	0.42
Control Delay	30.2	33.7	183.1	45.7	7.9	123.6	37.7	11.3	25.7	82.9	17.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.2	33.7	183.1	45.7	7.9	123.6	37.7	11.3	25.7	82.9	17.4
Queue Length 50th (m)	12.1	37.6	~228.8	149.2	7.9	~43.3	98.7	10.7	19.2	~235.7	29.2
Queue Length 95th (m)	21.5	52.4	#320.3	177.5	26.0	#92.8	120.3	28.1	31.5	#278.4	54.4
Internal Link Dist (m)		130.2		163.4			1183.8			615.1	
Turn Bay Length (m)	55.0		80.0		80.0	200.0		15.0	160.0		115.0
Base Capacity (vph)	178	1063	528	1434	755	177	1346	684	276	1369	703
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.47	0.37	1.32	0.80	0.31	1.08	0.62	0.28	0.46	1.06	0.42

Intersection Summary
























~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.

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

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/10/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	84	259	138	696	1152	237	192	828	191	126	1451	297
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0		2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	3392		1789	3579	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.11	1.00		0.39	1.00	1.00	0.08	1.00	1.00	0.19	1.00	1.00
Satd. Flow (perm)	202	3392		727	3579	1601	149	3579	1601	358	3579	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	84	259	138	696	1152	237	192	828	191	126	1451	297
RTOR Reduction (vph)	0	51	0	0	0	118	0	0	82	0	0	91
Lane Group Flow (vph)	84	346	0	696	1152	119	192	828	109	126	1451	206
Turn Type	pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4			8		8	6		6	2		2
Actuated Green, G (s)	42.3	35.3		60.3	49.3	49.3	55.7	48.7	48.7	57.5	49.6	49.6
Effective Green, g (s)	46.3	38.3		62.3	52.3	52.3	59.7	51.7	51.7	61.5	52.6	52.6
Actuated g/C Ratio	0.34	0.28		0.45	0.38	0.38	0.43	0.38	0.38	0.45	0.38	0.38
Clearance Time (s)	4.0	8.0		4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	172	945		507	1362	609	172	1346	602	263	1370	612
v/s Ratio Prot	0.03	0.10		c0.23	c0.32		c0.07	0.23		c0.03	0.41	
v/s Ratio Perm	0.13			0.39		0.07	c0.41		0.07	0.18		0.13
v/c Ratio	0.49	0.37		1.37	0.85	0.19	1.12	0.62	0.18	0.48	1.06	0.34
Uniform Delay, d1	34.2	39.8		32.7	38.9	28.5	37.4	34.8	28.7	24.9	42.4	30.0
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.2	0.2		179.9	5.0	0.2	103.2	2.1	0.7	1.4	41.6	1.5
Delay (s)	36.4	40.0		212.6	43.9	28.6	140.6	36.9	29.3	26.3	84.0	31.5
Level of Service	D	D		F	D	C	F	D	C	C	F	C
Approach Delay (s)		39.4			98.5			52.1			71.8	
Approach LOS		D			F			D			E	

Intersection Summary

HCM 2000 Control Delay	74.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.07		
Actuated Cycle Length (s)	137.4	Sum of lost time (s)	14.5
Intersection Capacity Utilization	116.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

12: Markham Road & Highway 407 WB

7/10/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	317	23	793	1261
v/c Ratio	0.78	0.06	0.33	0.52
Control Delay	55.5	12.6	8.9	11.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.5	12.6	8.9	11.1
Queue Length 50th (m)	67.9	0.0	35.6	68.1
Queue Length 95th (m)	98.8	6.5	58.5	108.0
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	624	574	2421	2421
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.51	0.04	0.33	0.52

Intersection Summary

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/10/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	301	22	753	0	0	1198
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	317	23	793	0	0	1261
RTOR Reduction (vph)	0	18	0	0	0	0
Lane Group Flow (vph)	317	5	793	0	0	1261
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	25.6	25.6	77.7			77.7
Effective Green, g (s)	26.6	26.6	78.7			78.7
Actuated g/C Ratio	0.23	0.23	0.68			0.68
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	409	366	2421			2421
v/s Ratio Prot	c0.18		0.22			c0.35
v/s Ratio Perm		0.00				
v/c Ratio	0.78	0.01	0.33			0.52
Uniform Delay, d1	42.0	34.7	7.8			9.4
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	8.9	0.0	0.4			0.8
Delay (s)	50.9	34.7	8.2			10.2
Level of Service	D	C	A			B
Approach Delay (s)	49.8		8.2			10.2
Approach LOS	D		A			B

Intersection Summary

HCM 2000 Control Delay	15.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.58		
Actuated Cycle Length (s)	116.3	Sum of lost time (s)	11.0
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/10/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	106	517	1500	1618
v/c Ratio	0.09	0.91	0.75	0.81
Control Delay	26.2	57.2	25.2	27.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	26.2	57.2	25.2	27.7
Queue Length 50th (m)	8.7	114.6	147.7	169.1
Queue Length 95th (m)	14.8	#171.5	191.0	217.6
Internal Link Dist (m)	487.7		615.1	389.6
Turn Bay Length (m)				
Base Capacity (vph)	1431	669	1988	1988
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.07	0.77	0.75	0.81

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/10/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↖↗	↖		↖↗	↖↗	
Volume (vph)	101	491	0	1425	1537	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	106	517	0	1500	1618	0
RTOR Reduction (vph)	0	10	0	0	0	0
Lane Group Flow (vph)	106	507	0	1500	1618	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	42.1	42.1		67.3	67.3	
Effective Green, g (s)	43.1	43.1		68.3	68.3	
Actuated g/C Ratio	0.35	0.35		0.56	0.56	
Clearance Time (s)	6.5	6.5		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1217	561		1988	1988	
v/s Ratio Prot	0.03			0.42	c0.45	
v/s Ratio Perm		c0.32				
v/c Ratio	0.09	0.90		0.75	0.81	
Uniform Delay, d1	26.7	37.9		20.9	22.1	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	17.8		2.7	3.8	
Delay (s)	26.8	55.7		23.6	25.9	
Level of Service	C	E		C	C	
Approach Delay (s)	50.8			23.6	25.9	
Approach LOS	D			C	C	

Intersection Summary

HCM 2000 Control Delay	29.1	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.85		
Actuated Cycle Length (s)	122.9	Sum of lost time (s)	11.5
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

6: Markham Road & 14th Avenue

7/10/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	305	1375	517	433	98	166	1362	562	275	1332	76
v/c Ratio	0.60	1.23	1.59	0.37	0.16	0.96	1.08	0.89	1.38	1.01	0.12
Control Delay	26.7	153.0	308.9	37.3	5.8	89.7	91.5	52.5	229.1	71.5	2.8
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	26.7	153.0	308.9	37.3	5.8	89.7	91.5	52.5	229.1	71.5	2.8
Queue Length 50th (m)	49.7	~247.4	~187.9	48.7	0.0	29.3	~220.4	124.8	~84.1	~198.3	0.0
Queue Length 95th (m)	71.0	#290.7	#257.3	63.7	11.3	#74.9	#263.1	#192.7	#140.7	#246.0	5.9
Internal Link Dist (m)		130.2		163.4			1183.8			615.1	
Turn Bay Length (m)	55.0		80.0		80.0	200.0		15.0	160.0		115.0
Base Capacity (vph)	523	1116	326	1175	596	173	1265	631	199	1316	652
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.58	1.23	1.59	0.37	0.16	0.96	1.08	0.89	1.38	1.01	0.12

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.

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

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/10/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	305	1284	91	517	433	98	166	1362	562	275	1332	76
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0		2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	3543		1789	3579	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.42	1.00		0.09	1.00	1.00	0.08	1.00	1.00	0.08	1.00	1.00
Satd. Flow (perm)	797	3543		167	3579	1601	155	3579	1601	149	3579	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	305	1284	91	517	433	98	166	1362	562	275	1332	76
RTOR Reduction (vph)	0	3	0	0	0	66	0	0	65	0	0	48
Lane Group Flow (vph)	305	1372	0	517	433	32	166	1362	497	275	1332	28
Turn Type	pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4			8		8	6		6	2		2
Actuated Green, G (s)	58.0	41.0		62.0	43.0	43.0	53.5	46.5	46.5	57.5	48.5	48.5
Effective Green, g (s)	62.0	44.0		66.0	46.0	46.0	57.5	49.5	49.5	61.5	51.5	51.5
Actuated g/C Ratio	0.44	0.31		0.47	0.33	0.33	0.41	0.35	0.35	0.44	0.37	0.37
Clearance Time (s)	4.0	8.0		4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	487	1113		322	1175	526	168	1265	566	194	1316	588
v/s Ratio Prot	0.08	c0.39		c0.24	0.12		0.06	c0.38		c0.11	0.37	
v/s Ratio Perm	0.19			0.51		0.02	0.34		0.31	0.51		0.02
v/c Ratio	0.63	1.23		1.61	0.37	0.06	0.99	1.08	0.88	1.42	1.01	0.05
Uniform Delay, d1	26.4	48.0		45.0	35.9	32.2	36.6	45.2	42.4	40.6	44.2	28.5
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.5	112.5		286.6	0.2	0.0	65.3	48.7	17.3	215.4	27.8	0.2
Delay (s)	28.9	160.5		331.6	36.1	32.3	101.9	93.9	59.8	256.0	72.1	28.6
Level of Service	C	F		F	D	C	F	F	E	F	E	C
Approach Delay (s)		136.6			181.5			85.4			100.2	
Approach LOS		F			F			F			F	

Intersection Summary

HCM 2000 Control Delay	118.0	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.24		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	135.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

12: Markham Road & Highway 407 WB

7/10/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	23	13	1467	826
v/c Ratio	0.10	0.06	0.47	0.27
Control Delay	48.5	22.0	4.0	2.9
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	48.5	22.0	4.0	2.9
Queue Length 50th (m)	5.0	0.0	58.1	25.1
Queue Length 95th (m)	13.1	6.1	69.4	31.2
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	333	308	3109	3109
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.07	0.04	0.47	0.27

Intersection Summary

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/10/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	22	12	1394	0	0	785
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	23	13	1467	0	0	826
RTOR Reduction (vph)	0	12	0	0	0	0
Lane Group Flow (vph)	23	1	1467	0	0	826
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	8.8	8.8	101.8			101.8
Effective Green, g (s)	9.8	9.8	102.8			102.8
Actuated g/C Ratio	0.08	0.08	0.83			0.83
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	141	126	2976			2976
v/s Ratio Prot	c0.01		c0.41			0.23
v/s Ratio Perm		0.00				
v/c Ratio	0.16	0.01	0.49			0.28
Uniform Delay, d1	53.1	52.4	3.0			2.3
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.5	0.0	0.6			0.2
Delay (s)	53.6	52.4	3.6			2.5
Level of Service	D	D	A			A
Approach Delay (s)	53.2		3.6			2.5
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.9	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	123.6	Sum of lost time (s)	11.0
Intersection Capacity Utilization	65.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/10/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	284	593	1522	834
v/c Ratio	0.23	0.91	0.77	0.42
Control Delay	27.1	47.9	26.0	17.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	27.1	47.9	26.0	17.8
Queue Length 50th (m)	24.0	109.2	150.1	61.6
Queue Length 95th (m)	33.9	#162.6	201.0	85.8
Internal Link Dist (m)	487.7		615.1	389.6
Turn Bay Length (m)				
Base Capacity (vph)	1514	770	1977	1977
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.19	0.77	0.77	0.42

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/10/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↖↗	↗		↖↗	↖↗	
Volume (vph)	270	563	0	1446	792	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		5.5	5.5	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	284	593	0	1522	834	0
RTOR Reduction (vph)	0	82	0	0	0	0
Lane Group Flow (vph)	284	511	0	1522	834	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	42.1	42.1		65.9	65.9	
Effective Green, g (s)	43.1	43.1		66.9	66.9	
Actuated g/C Ratio	0.36	0.36		0.55	0.55	
Clearance Time (s)	6.5	6.5		6.5	6.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1236	570		1978	1978	
v/s Ratio Prot	0.08			0.43	0.23	
v/s Ratio Perm		0.32				
v/c Ratio	0.23	0.90		0.77	0.42	
Uniform Delay, d1	27.3	36.8		21.0	15.8	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.1	16.7		3.0	0.7	
Delay (s)	27.4	53.5		24.0	16.4	
Level of Service	C	D		C	B	
Approach Delay (s)	45.1			24.0	16.4	
Approach LOS	D			C	B	

Intersection Summary

HCM 2000 Control Delay	27.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	121.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	65.9%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Appendix C – Future (2031) Total Conditions Synchro Output

Queues

6: Markham Road & 14th Avenue

7/14/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	96	397	696	1152	271	192	947	191	129	1481	303
v/c Ratio	0.54	0.40	1.32	0.85	0.37	1.08	0.70	0.28	0.55	1.08	0.43
Control Delay	34.1	33.7	183.1	45.7	11.3	123.6	40.3	11.3	29.4	90.2	17.8
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	34.1	33.7	183.1	45.7	11.3	123.6	40.3	11.3	29.4	90.2	17.8
Queue Length 50th (m)	13.9	37.6	~228.8	149.2	15.6	~43.3	118.1	10.7	19.7	~244.8	30.6
Queue Length 95th (m)	25.7	52.4	#320.3	177.5	36.9	#92.8	142.5	28.1	32.2	#287.5	56.2
Internal Link Dist (m)		130.2		163.4			1183.8			255.4	
Turn Bay Length (m)	55.0		80.0		80.0	200.0		15.0	160.0		115.0
Base Capacity (vph)	178	1063	528	1434	751	177	1346	684	235	1369	703
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.54	0.37	1.32	0.80	0.36	1.08	0.70	0.28	0.55	1.08	0.43
























Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/14/2015

													
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lane Configurations													
Volume (vph)	96	259	138	696	1152	271	192	947	191	129	1481	303	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Total Lost time (s)	2.0	5.0		2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5	
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Frt	1.00	0.95		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)	1789	3392		1789	3579	1601	1789	3579	1601	1789	3579	1601	
Flt Permitted	0.11	1.00		0.39	1.00	1.00	0.08	1.00	1.00	0.14	1.00	1.00	
Satd. Flow (perm)	202	3392		727	3579	1601	149	3579	1601	258	3579	1601	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Adj. Flow (vph)	96	259	138	696	1152	271	192	947	191	129	1481	303	
RTOR Reduction (vph)	0	51	0	0	0	113	0	0	82	0	0	91	
Lane Group Flow (vph)	96	346	0	696	1152	158	192	947	109	129	1481	212	
Turn Type	pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	
Protected Phases	7	4		3	8		1	6		5	2		
Permitted Phases	4			8		8	6		6	2		2	
Actuated Green, G (s)	42.3	35.3		60.3	49.3	49.3	55.7	48.7	48.7	57.5	49.6	49.6	
Effective Green, g (s)	46.3	38.3		62.3	52.3	52.3	59.7	51.7	51.7	61.5	52.6	52.6	
Actuated g/C Ratio	0.34	0.28		0.45	0.38	0.38	0.43	0.38	0.38	0.45	0.38	0.38	
Clearance Time (s)	4.0	8.0		4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	172	945		507	1362	609	172	1346	602	225	1370	612	
v/s Ratio Prot	0.04	0.10		c0.23	c0.32		c0.07	0.26		c0.04	c0.41		
v/s Ratio Perm	0.15			0.39		0.10	0.41		0.07	0.21		0.13	
v/c Ratio	0.56	0.37		1.37	0.85	0.26	1.12	0.70	0.18	0.57	1.08	0.35	
Uniform Delay, d1	34.5	39.8		32.7	38.9	29.2	37.4	36.3	28.7	26.3	42.4	30.2	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	3.9	0.2		179.9	5.0	0.2	103.2	3.1	0.7	3.5	49.4	1.5	
Delay (s)	38.4	40.0		212.6	43.9	29.5	140.6	39.5	29.3	29.8	91.8	31.7	
Level of Service	D	D		F	D	C	F	D	C	C	F	C	
Approach Delay (s)		39.7			97.5			52.6			78.1		
Approach LOS		D			F			D			E		
Intersection Summary													
HCM 2000 Control Delay			76.1									HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio			1.08										
Actuated Cycle Length (s)			137.4									Sum of lost time (s)	14.5
Intersection Capacity Utilization			117.1%									ICU Level of Service	H
Analysis Period (min)			15										
c Critical Lane Group													

Queues

12: Markham Road & Highway 407 WB

7/14/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	317	23	868	1584
v/c Ratio	0.80	0.06	0.35	0.64
Control Delay	61.1	13.5	8.9	12.9
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	61.1	13.5	8.9	12.9
Queue Length 50th (m)	72.8	0.0	41.7	103.7
Queue Length 95th (m)	105.1	7.0	61.9	148.0
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	503	466	2466	2466
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.63	0.05	0.35	0.64
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/14/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	301	22	825	0	0	1505
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	317	23	868	0	0	1584
RTOR Reduction (vph)	0	18	0	0	0	0
Lane Group Flow (vph)	317	5	868	0	0	1584
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	26.2	26.2	83.7			83.7
Effective Green, g (s)	27.2	27.2	84.7			84.7
Actuated g/C Ratio	0.22	0.22	0.69			0.69
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	395	354	2466			2466
v/s Ratio Prot	c0.18		0.24			c0.44
v/s Ratio Perm		0.00				
v/c Ratio	0.80	0.01	0.35			0.64
Uniform Delay, d1	45.3	37.4	7.8			10.7
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	11.2	0.0	0.4			1.3
Delay (s)	56.5	37.4	8.2			12.0
Level of Service	E	D	A			B
Approach Delay (s)	55.2		8.2			12.0
Approach LOS	E		A			B

Intersection Summary

HCM 2000 Control Delay	16.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	122.9	Sum of lost time (s)	11.0
Intersection Capacity Utilization	91.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/14/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	106	517	1576	1941
v/c Ratio	0.09	0.96	0.76	0.93
Control Delay	30.1	72.9	23.5	34.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	30.1	72.9	23.5	34.8
Queue Length 50th (m)	9.5	126.8	153.4	231.1
Queue Length 95th (m)	16.2	#196.6	182.1	#281.8
Internal Link Dist (m)	487.7		335.7	389.6
Turn Bay Length (m)				
Base Capacity (vph)	1169	546	2078	2078
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.09	0.95	0.76	0.93

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↖↗	↗		↖↗	↖↗	
Volume (vph)	101	491	0	1497	1844	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	106	517	0	1576	1941	0
RTOR Reduction (vph)	0	7	0	0	0	0
Lane Group Flow (vph)	106	510	0	1576	1941	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	41.7	41.7		74.0	74.0	
Effective Green, g (s)	42.7	42.7		75.0	75.0	
Actuated g/C Ratio	0.33	0.33		0.58	0.58	
Clearance Time (s)	6.5	6.5		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1147	529		2077	2077	
v/s Ratio Prot	0.03			0.44	c0.54	
v/s Ratio Perm		c0.32				
v/c Ratio	0.09	0.96		0.76	0.93	
Uniform Delay, d1	29.9	42.5		20.3	24.8	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	29.8		2.7	9.4	
Delay (s)	29.9	72.3		23.0	34.2	
Level of Service	C	E		C	C	
Approach Delay (s)	65.1			23.0	34.2	
Approach LOS	E			C	C	

Intersection Summary

HCM 2000 Control Delay	34.6	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	129.2	Sum of lost time (s)	11.5
Intersection Capacity Utilization	91.0%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

101: Markham Road & Markham Station Access

7/14/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	83	48	181	1209	1972	331
v/c Ratio	0.24	0.24	0.72	0.40	0.79	0.27
Control Delay	49.6	16.7	43.2	2.9	15.9	1.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.6	16.7	43.2	2.9	15.9	1.7
Queue Length 50th (m)	8.9	0.0	23.7	30.5	156.3	2.1
Queue Length 95th (m)	16.5	11.2	#54.2	37.8	191.4	11.1
Internal Link Dist (m)	268.2			255.4	335.7	
Turn Bay Length (m)			80.0			80.0
Base Capacity (vph)	522	282	256	3050	2488	1204
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.16	0.17	0.71	0.40	0.79	0.27

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

101: Markham Road & Markham Station Access

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	79	46	172	1149	1873	314
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3471	1601	1789	3579	3579	1601
Flt Permitted	0.95	1.00	0.05	1.00	1.00	1.00
Satd. Flow (perm)	3471	1601	90	3579	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	83	48	181	1209	1972	331
RTOR Reduction (vph)	0	44	0	0	0	94
Lane Group Flow (vph)	83	4	181	1209	1972	237
Turn Type	Prot	Perm	pm+pt	NA	NA	Perm
Protected Phases	4		5	2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	8.0	8.0	94.2	94.2	77.5	77.5
Effective Green, g (s)	9.0	9.0	95.2	95.2	78.5	78.5
Actuated g/C Ratio	0.08	0.08	0.83	0.83	0.69	0.69
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	273	126	249	2983	2460	1100
v/s Ratio Prot	c0.02		c0.07	0.34	c0.55	
v/s Ratio Perm		0.00	0.53			0.15
v/c Ratio	0.30	0.03	0.73	0.41	0.80	0.22
Uniform Delay, d1	49.6	48.6	34.5	2.4	12.4	6.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.6	0.1	10.1	0.4	2.9	0.4
Delay (s)	50.3	48.7	44.6	2.8	15.3	7.0
Level of Service	D	D	D	A	B	A
Approach Delay (s)	49.7			8.2	14.1	
Approach LOS	D			A	B	

Intersection Summary

HCM 2000 Control Delay	13.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	114.2	Sum of lost time (s)	15.0
Intersection Capacity Utilization	82.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

6: Markham Road & 14th Avenue

7/14/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	312	1375	517	433	100	166	1393	562	297	1439	82
v/c Ratio	0.63	1.23	1.65	0.37	0.17	0.95	1.08	0.88	1.49	1.07	0.12
Control Delay	28.3	153.0	335.9	37.5	6.1	88.0	91.9	50.0	274.3	88.1	3.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	28.3	153.0	335.9	37.5	6.1	88.0	91.9	50.0	274.3	88.1	3.5
Queue Length 50th (m)	51.8	~247.4	~191.7	48.7	0.0	29.1	~226.0	123.4	~96.8	~232.1	0.0
Queue Length 95th (m)	73.7	#290.7	#261.1	63.7	11.7	#74.5	#268.6	#189.8	#155.1	#274.7	7.3
Internal Link Dist (m)		130.2		163.4			1183.8			314.0	
Turn Bay Length (m)	55.0		80.0		80.0	200.0		15.0	160.0		115.0
Base Capacity (vph)	507	1116	313	1167	592	174	1290	642	199	1342	663
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.62	1.23	1.65	0.37	0.17	0.95	1.08	0.88	1.49	1.07	0.12

Intersection Summary





























~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.

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

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/14/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		 			 			 		 	 	
Volume (vph)	312	1284	91	517	433	100	166	1393	562	297	1439	82
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0		2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	3543		1789	3579	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.42	1.00		0.09	1.00	1.00	0.08	1.00	1.00	0.08	1.00	1.00
Satd. Flow (perm)	789	3543		169	3579	1601	152	3579	1601	146	3579	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	312	1284	91	517	433	100	166	1393	562	297	1439	82
RTOR Reduction (vph)	0	3	0	0	0	67	0	0	65	0	0	51
Lane Group Flow (vph)	312	1372	0	517	433	33	166	1393	497	297	1439	31
Turn Type	pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4			8		8	6		6	2		2
Actuated Green, G (s)	57.3	41.0		60.7	42.7	42.7	54.5	47.5	47.5	58.5	49.5	49.5
Effective Green, g (s)	61.3	44.0		64.7	45.7	45.7	58.5	50.5	50.5	62.5	52.5	52.5
Actuated g/C Ratio	0.44	0.31		0.46	0.33	0.33	0.42	0.36	0.36	0.45	0.38	0.38
Clearance Time (s)	4.0	8.0		4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	476	1113		309	1168	522	168	1290	577	194	1342	600
v/s Ratio Prot	0.09	c0.39		c0.24	0.12		0.06	0.39		c0.12	c0.40	
v/s Ratio Perm	0.20			0.53		0.02	0.35		0.31	0.56		0.02
v/c Ratio	0.66	1.23		1.67	0.37	0.06	0.99	1.08	0.86	1.53	1.07	0.05
Uniform Delay, d1	27.1	48.0		44.8	36.1	32.4	36.9	44.8	41.5	40.9	43.8	27.9
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.2	112.5		316.8	0.9	0.2	65.3	49.6	15.6	263.2	46.5	0.2
Delay (s)	30.3	160.5		361.5	37.0	32.7	102.2	94.4	57.1	304.1	90.2	28.0
Level of Service	C	F		F	D	C	F	F	E	F	F	C
Approach Delay (s)		136.4			196.4			85.1			122.3	
Approach LOS		F			F			F			F	

Intersection Summary

HCM 2000 Control Delay	125.7	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.27		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	137.4%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

12: Markham Road & Highway 407 WB

7/14/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	23	13	1733	905
v/c Ratio	0.10	0.06	0.56	0.29
Control Delay	49.0	22.2	4.7	3.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	49.0	22.2	4.7	3.0
Queue Length 50th (m)	5.1	0.0	78.4	28.3
Queue Length 95th (m)	13.2	6.2	93.8	34.8
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	315	293	3113	3113
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.07	0.04	0.56	0.29
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/14/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	22	12	1646	0	0	860
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	23	13	1733	0	0	905
RTOR Reduction (vph)	0	12	0	0	0	0
Lane Group Flow (vph)	23	1	1733	0	0	905
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	8.8	8.8	102.8			102.8
Effective Green, g (s)	9.8	9.8	103.8			103.8
Actuated g/C Ratio	0.08	0.08	0.83			0.83
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	140	125	2981			2981
v/s Ratio Prot	c0.01		c0.48			0.25
v/s Ratio Perm		0.00				
v/c Ratio	0.16	0.01	0.58			0.30
Uniform Delay, d1	53.6	52.9	3.4			2.3
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.6	0.0	0.8			0.3
Delay (s)	54.1	52.9	4.2			2.6
Level of Service	D	D	A			A
Approach Delay (s)	53.7		4.2			2.6
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	4.3	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	124.6	Sum of lost time (s)	11.0
Intersection Capacity Utilization	68.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/14/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	284	593	1787	913
v/c Ratio	0.24	0.94	0.87	0.45
Control Delay	30.3	56.8	29.9	17.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	30.3	56.8	29.9	17.0
Queue Length 50th (m)	26.0	119.1	204.4	70.1
Queue Length 95th (m)	36.7	#190.1	242.1	86.0
Internal Link Dist (m)	487.7		277.1	389.6
Turn Bay Length (m)				
Base Capacity (vph)	1273	666	2047	2047
Starvation Cap Reductn	0	0	1	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.22	0.89	0.87	0.45

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	270	563	0	1698	867	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		5.5	5.5	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	284	593	0	1787	913	0
RTOR Reduction (vph)	0	82	0	0	0	0
Lane Group Flow (vph)	284	511	0	1787	913	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	42.3	42.3		71.6	71.6	
Effective Green, g (s)	43.3	43.3		72.6	72.6	
Actuated g/C Ratio	0.34	0.34		0.57	0.57	
Clearance Time (s)	6.5	6.5		6.5	6.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1184	546		2047	2047	
v/s Ratio Prot	0.08			c0.50	0.26	
v/s Ratio Perm		c0.32				
v/c Ratio	0.24	0.94		0.87	0.45	
Uniform Delay, d1	30.0	40.4		23.2	15.6	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.1	23.4		5.5	0.7	
Delay (s)	30.1	63.9		28.7	16.3	
Level of Service	C	E		C	B	
Approach Delay (s)	52.9			28.7	16.3	
Approach LOS	D			C	B	

Intersection Summary

HCM 2000 Control Delay	31.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.90		
Actuated Cycle Length (s)	126.9	Sum of lost time (s)	11.0
Intersection Capacity Utilization	68.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

101: Markham Road & Markham Station Access

7/14/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	273	149	49	1858	1771	86
v/c Ratio	0.59	0.59	0.34	0.67	0.63	0.07
Control Delay	52.4	42.0	11.9	7.6	7.1	0.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	52.4	42.0	11.9	7.6	7.1	0.9
Queue Length 50th (m)	30.3	21.9	2.7	83.1	75.2	0.0
Queue Length 95th (m)	43.6	42.8	11.2	124.0	112.5	3.6
Internal Link Dist (m)	273.8			314.0	277.1	
Turn Bay Length (m)			80.0			80.0
Base Capacity (vph)	601	315	145	2791	2791	1267
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.45	0.47	0.34	0.67	0.63	0.07

Intersection Summary

HCM Signalized Intersection Capacity Analysis

101: Markham Road & Markham Station Access

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	259	142	47	1765	1682	82
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3471	1601	1789	3579	3579	1601
Flt Permitted	0.95	1.00	0.10	1.00	1.00	1.00
Satd. Flow (perm)	3471	1601	186	3579	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	273	149	49	1858	1771	86
RTOR Reduction (vph)	0	40	0	0	0	19
Lane Group Flow (vph)	273	109	49	1858	1771	67
Turn Type	Prot	Perm	Perm	NA	NA	Perm
Protected Phases	4			2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	14.4	14.4	89.1	89.1	89.1	89.1
Effective Green, g (s)	15.4	15.4	90.1	90.1	90.1	90.1
Actuated g/C Ratio	0.13	0.13	0.78	0.78	0.78	0.78
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	462	213	145	2791	2791	1248
v/s Ratio Prot	c0.08			c0.52	0.49	
v/s Ratio Perm		0.07	0.26			0.04
v/c Ratio	0.59	0.51	0.34	0.67	0.63	0.05
Uniform Delay, d1	47.1	46.6	3.8	5.8	5.5	2.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.0	2.1	6.2	1.3	1.1	0.1
Delay (s)	49.1	48.6	10.0	7.1	6.6	3.0
Level of Service	D	D	A	A	A	A
Approach Delay (s)	48.9			7.2	6.5	
Approach LOS	D			A	A	

Intersection Summary

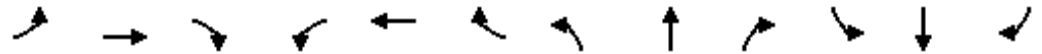
HCM 2000 Control Delay	11.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	115.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	65.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Appendix D – Future (2031) Total with Mitigation Synchro Output

Queues

6: Markham Road & 14th Avenue

7/14/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	96	259	138	696	1152	271	192	947	191	129	1481	303
v/c Ratio	0.55	0.20	0.29	0.97	0.82	0.36	0.76	0.51	0.28	0.46	0.87	0.48
Control Delay	34.9	41.0	7.8	81.6	43.4	9.5	50.8	36.6	8.5	27.7	50.8	21.7
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	34.9	41.0	7.8	81.6	43.4	9.5	50.8	36.6	8.5	27.7	50.8	21.7
Queue Length 50th (m)	13.8	20.7	0.4	99.4	148.3	13.8	34.8	76.7	5.5	19.8	142.4	33.9
Queue Length 95th (m)	23.6	27.3	16.0	#137.5	164.0	31.9	#90.3	92.9	23.0	35.1	162.2	61.7
Internal Link Dist (m)		130.2			163.4			1183.8			314.0	
Turn Bay Length (m)	55.0		25.0	80.0		80.0	200.0		50.0	160.0		115.0
Base Capacity (vph)	175	1505	544	718	1559	805	252	1875	686	281	1703	627
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.55	0.17	0.25	0.97	0.74	0.34	0.76	0.51	0.28	0.46	0.87	0.48

Intersection Summary

Description: Volumes adjusted back to 2012

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/14/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	96	259	138	696	1152	271	192	947	191	129	1481	303
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0	7.0	2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.91	1.00	0.97	0.95	1.00	1.00	0.91	1.00	1.00	0.91	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	5142	1601	3471	3579	1601	1789	5142	1601	1789	5142	1601
Flt Permitted	0.12	1.00	1.00	0.95	1.00	1.00	0.08	1.00	1.00	0.22	1.00	1.00
Satd. Flow (perm)	222	5142	1601	3471	3579	1601	159	5142	1601	413	5142	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	96	259	138	696	1152	271	192	947	191	129	1481	303
RTOR Reduction (vph)	0	0	104	0	0	117	0	0	102	0	0	98
Lane Group Flow (vph)	96	259	34	696	1152	154	192	947	89	129	1481	205
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	38.9	31.9	31.9	27.0	51.9	51.9	60.6	48.1	48.1	51.9	43.4	43.4
Effective Green, g (s)	42.9	34.9	32.9	29.0	54.9	54.9	62.6	51.1	51.1	55.9	46.4	46.4
Actuated g/C Ratio	0.31	0.25	0.23	0.21	0.39	0.39	0.45	0.37	0.37	0.40	0.33	0.33
Clearance Time (s)	4.0	8.0	8.0	4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	168	1281	376	718	1403	627	248	1876	584	268	1704	530
v/s Ratio Prot	0.04	0.05		c0.20	c0.32		c0.08	0.18		0.04	c0.29	
v/s Ratio Perm	0.14		0.02			0.10	0.26		0.06	0.16		0.13
v/c Ratio	0.57	0.20	0.09	0.97	0.82	0.25	0.77	0.50	0.15	0.48	0.87	0.39
Uniform Delay, d1	37.1	41.5	41.9	55.1	38.1	28.6	35.6	34.6	29.9	27.8	43.9	35.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.6	0.1	0.1	25.8	4.0	0.2	14.0	1.0	0.6	1.4	6.3	2.1
Delay (s)	41.7	41.6	42.0	80.9	42.1	28.8	49.6	35.6	30.4	29.2	50.3	38.0
Level of Service	D	D	D	F	D	C	D	D	C	C	D	D
Approach Delay (s)		41.7			53.2			36.9			46.9	
Approach LOS		D			D			D			D	

Intersection Summary

HCM 2000 Control Delay	46.5	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	97.1%	ICU Level of Service	F
Analysis Period (min)	15		

Description: Volumes adjusted back to 2012

c Critical Lane Group

Queues

12: Markham Road & Highway 407 WB

7/14/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	317	23	868	1584
v/c Ratio	0.64	0.09	0.32	0.58
Control Delay	54.2	16.7	3.3	7.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	54.2	16.7	3.3	7.3
Queue Length 50th (m)	36.7	0.0	18.3	70.1
Queue Length 95th (m)	49.3	7.2	21.6	100.3
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	737	358	2737	2737
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.43	0.06	0.32	0.58
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/14/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↙↙	↙	↕↕			↘↘
Volume (vph)	301	22	825	0	0	1505
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	0.97	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	3471	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	3471	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	317	23	868	0	0	1584
RTOR Reduction (vph)	0	20	0	0	0	0
Lane Group Flow (vph)	317	3	868	0	0	1584
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	16.2	16.2	90.8			90.8
Effective Green, g (s)	17.2	17.2	91.8			91.8
Actuated g/C Ratio	0.14	0.14	0.76			0.76
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	497	229	2737			2737
v/s Ratio Prot	c0.09		0.24			c0.44
v/s Ratio Perm		0.00				
v/c Ratio	0.64	0.01	0.32			0.58
Uniform Delay, d1	48.5	44.1	4.4			5.9
Progression Factor	1.00	1.00	0.65			1.00
Incremental Delay, d2	2.7	0.0	0.2			0.9
Delay (s)	51.1	44.1	3.1			6.8
Level of Service	D	D	A			A
Approach Delay (s)	50.7		3.1			6.8
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	11.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	77.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/14/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	106	517	1576	1941
v/c Ratio	0.14	0.81	0.64	0.79
Control Delay	37.3	51.9	11.1	11.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	37.3	51.9	11.1	11.8
Queue Length 50th (m)	10.3	61.4	75.2	123.3
Queue Length 95th (m)	17.3	80.6	85.0	134.4
Internal Link Dist (m)	487.7		277.1	389.6
Turn Bay Length (m)	60.0	60.0		
Base Capacity (vph)	853	719	2458	2458
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	5
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.12	0.72	0.64	0.79

Intersection Summary

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	101	491	0	1497	1844	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		6.0	6.0	
Lane Util. Factor	0.97	0.88		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	2818		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	2818		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	106	517	0	1576	1941	0
RTOR Reduction (vph)	0	27	0	0	0	0
Lane Group Flow (vph)	106	490	0	1576	1941	0
Turn Type	Prot	Prot		NA	NA	
Protected Phases	4	4		2	6	
Permitted Phases						
Actuated Green, G (s)	25.1	25.1		81.4	81.4	
Effective Green, g (s)	26.1	26.1		82.4	82.4	
Actuated g/C Ratio	0.22	0.22		0.69	0.69	
Clearance Time (s)	6.5	6.5		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	754	612		2457	2457	
v/s Ratio Prot	0.03	c0.17		0.44	c0.54	
v/s Ratio Perm						
v/c Ratio	0.14	0.80		0.64	0.79	
Uniform Delay, d1	37.9	44.5		10.5	12.9	
Progression Factor	1.00	1.00		0.88	0.68	
Incremental Delay, d2	0.1	7.4		1.3	2.3	
Delay (s)	38.0	51.9		10.5	11.1	
Level of Service	D	D		B	B	
Approach Delay (s)	49.5			10.5	11.1	
Approach LOS	D			B	B	

Intersection Summary

HCM 2000 Control Delay	16.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.5
Intersection Capacity Utilization	77.7%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

101: Markham Road & Markham Station Access

7/14/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	83	48	181	1209	1972	331
v/c Ratio	0.26	0.25	0.65	0.39	0.78	0.27
Control Delay	52.9	17.6	37.0	2.8	9.5	0.7
Queue Delay	0.0	0.0	0.0	0.0	0.1	0.0
Total Delay	52.9	17.6	37.0	2.8	9.6	0.7
Queue Length 50th (m)	9.5	0.0	24.2	30.5	96.6	1.5
Queue Length 95th (m)	17.3	11.4	46.2	38.0	146.7	m1.9
Internal Link Dist (m)	273.8			314.0	277.1	
Turn Bay Length (m)			80.0			100.0
Base Capacity (vph)	491	268	290	3075	2532	1229
Starvation Cap Reductn	0	0	0	0	46	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.18	0.62	0.39	0.79	0.27

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

101: Markham Road & Markham Station Access

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	79	46	172	1149	1873	314
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	3.0	5.0	5.0	5.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3471	1601	1789	3579	3579	1601
Flt Permitted	0.95	1.00	0.05	1.00	1.00	1.00
Satd. Flow (perm)	3471	1601	91	3579	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	83	48	181	1209	1972	331
RTOR Reduction (vph)	0	44	0	0	0	100
Lane Group Flow (vph)	83	4	181	1209	1972	231
Turn Type	Prot	Perm	pm+pt	NA	NA	Perm
Protected Phases	4		5	2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	8.1	8.1	99.9	99.9	82.7	82.7
Effective Green, g (s)	9.1	9.1	100.9	100.9	83.7	83.7
Actuated g/C Ratio	0.08	0.08	0.84	0.84	0.70	0.70
Clearance Time (s)	6.0	6.0	4.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	263	121	277	3009	2496	1116
v/s Ratio Prot	c0.02		c0.08	0.34	c0.55	
v/s Ratio Perm		0.00	0.47			0.14
v/c Ratio	0.32	0.03	0.65	0.40	0.79	0.21
Uniform Delay, d1	52.5	51.4	34.4	2.3	12.2	6.4
Progression Factor	1.00	1.00	1.00	1.00	0.59	0.37
Incremental Delay, d2	0.7	0.1	5.4	0.4	1.6	0.3
Delay (s)	53.2	51.5	39.8	2.7	8.9	2.7
Level of Service	D	D	D	A	A	A
Approach Delay (s)	52.6			7.5	8.0	
Approach LOS	D			A	A	

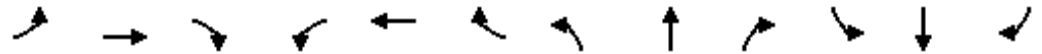
Intersection Summary

HCM 2000 Control Delay	9.3	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.73		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	81.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

6: Markham Road & 14th Avenue

7/14/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	312	1284	91	517	433	100	166	1393	562	297	1439	82
v/c Ratio	0.63	0.85	0.16	0.95	0.39	0.17	0.83	0.87	0.79	0.98	0.76	0.13
Control Delay	28.8	53.3	1.9	85.9	39.6	2.6	63.0	52.7	28.0	86.3	42.1	3.5
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	28.8	53.3	1.9	85.9	39.6	2.6	63.0	52.7	28.0	86.3	42.1	3.5
Queue Length 50th (m)	52.7	123.0	0.0	74.0	50.3	0.0	27.9	133.7	67.6	65.4	127.4	0.0
Queue Length 95th (m)	74.9	141.7	3.6	#107.5	65.8	5.8	#66.7	153.0	117.3	#124.4	145.6	7.3
Internal Link Dist (m)		130.2			163.4			1183.8				314.0
Turn Bay Length (m)	55.0		25.0	80.0		80.0	200.0		50.0	160.0		115.0
Base Capacity (vph)	515	1505	565	545	1108	589	199	1597	712	302	1891	652
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.61	0.85	0.16	0.95	0.39	0.17	0.83	0.87	0.79	0.98	0.76	0.13

Intersection Summary

Description: Volumes adjusted back to 2012

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

6: Markham Road & 14th Avenue

7/14/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	312	1284	91	517	433	100	166	1393	562	297	1439	82
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	2.0	5.0	5.0	2.0	5.0	5.0	2.0	5.5	5.5	2.0	5.5	5.5
Lane Util. Factor	1.00	0.91	1.00	0.97	0.95	1.00	1.00	0.91	1.00	1.00	0.91	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	5142	1601	3471	3579	1601	1789	5142	1601	1789	5142	1601
Flt Permitted	0.42	1.00	1.00	0.95	1.00	1.00	0.09	1.00	1.00	0.09	1.00	1.00
Satd. Flow (perm)	786	5142	1601	3471	3579	1601	177	5142	1601	169	5142	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	312	1284	91	517	433	100	166	1393	562	297	1439	82
RTOR Reduction (vph)	0	0	64	0	0	69	0	0	215	0	0	52
Lane Group Flow (vph)	312	1284	27	517	433	31	166	1393	347	297	1439	30
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		1	6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	55.6	38.0	38.0	20.0	40.4	40.4	49.5	40.5	40.5	61.5	48.5	48.5
Effective Green, g (s)	59.6	41.0	41.0	22.0	43.4	43.4	53.5	43.5	43.5	63.5	51.5	51.5
Actuated g/C Ratio	0.43	0.29	0.29	0.16	0.31	0.31	0.38	0.31	0.31	0.45	0.37	0.37
Clearance Time (s)	4.0	8.0	8.0	4.0	8.0	8.0	4.0	8.5	8.5	4.0	8.5	8.5
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	475	1505	468	545	1109	496	194	1597	497	296	1891	588
v/s Ratio Prot	0.09	c0.25		c0.15	0.12		0.07	c0.27		c0.14	0.28	
v/s Ratio Perm	0.19		0.02			0.02	0.26		0.22	0.32		0.02
v/c Ratio	0.66	0.85	0.06	0.95	0.39	0.06	0.86	0.87	0.70	1.00	0.76	0.05
Uniform Delay, d1	28.2	46.7	35.6	58.4	37.9	34.0	32.8	45.6	42.5	44.0	38.8	28.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.3	6.3	0.2	26.0	1.0	0.2	28.9	6.9	7.9	53.2	2.9	0.2
Delay (s)	31.5	53.0	35.8	84.4	39.0	34.2	61.7	52.5	50.4	97.1	41.8	28.7
Level of Service	C	D	D	F	D	C	E	D	D	F	D	C
Approach Delay (s)		48.1			60.9			52.7			50.2	
Approach LOS		D			E			D			D	

Intersection Summary

HCM 2000 Control Delay	52.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	14.5
Intersection Capacity Utilization	104.8%	ICU Level of Service	G
Analysis Period (min)	15		

Description: Volumes adjusted back to 2012

c Critical Lane Group

Queues

12: Markham Road & Highway 407 WB

7/14/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	23	13	1733	905
v/c Ratio	0.05	0.06	0.56	0.29
Control Delay	45.8	21.2	2.5	3.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	45.8	21.2	2.5	3.1
Queue Length 50th (m)	2.4	0.0	38.6	28.3
Queue Length 95th (m)	6.3	5.9	40.4	35.1
Internal Link Dist (m)	411.3		389.6	951.1
Turn Bay Length (m)				
Base Capacity (vph)	621	297	3095	3095
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.04	0.04	0.56	0.29
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

12: Markham Road & Highway 407 WB

7/14/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↖↗	↖	↕↕			↕↕
Volume (vph)	22	12	1646	0	0	860
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5	5.5			5.5
Lane Util. Factor	0.97	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	3471	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	3471	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	23	13	1733	0	0	905
RTOR Reduction (vph)	0	12	0	0	0	0
Lane Group Flow (vph)	23	1	1733	0	0	905
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	9.0	9.0	98.0			98.0
Effective Green, g (s)	10.0	10.0	99.0			99.0
Actuated g/C Ratio	0.08	0.08	0.82			0.82
Clearance Time (s)	6.5	6.5	6.5			6.5
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	289	133	2952			2952
v/s Ratio Prot	c0.01		c0.48			0.25
v/s Ratio Perm		0.00				
v/c Ratio	0.08	0.01	0.59			0.31
Uniform Delay, d1	50.8	50.5	3.6			2.5
Progression Factor	1.00	1.00	0.47			1.00
Incremental Delay, d2	0.1	0.0	0.7			0.3
Delay (s)	50.9	50.5	2.4			2.7
Level of Service	D	D	A			A
Approach Delay (s)	50.7		2.4			2.7
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

13: Markham Road & Highway 407 EB

7/14/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	284	593	1787	913
v/c Ratio	0.50	0.80	0.67	0.34
Control Delay	47.6	29.2	7.3	6.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	47.6	29.2	7.3	6.1
Queue Length 50th (m)	31.7	34.6	67.3	32.7
Queue Length 95th (m)	41.5	52.9	73.4	53.0
Internal Link Dist (m)	487.7		277.1	389.6
Turn Bay Length (m)	60.0	60.0		
Base Capacity (vph)	795	900	2660	2660
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.36	0.66	0.67	0.34
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

13: Markham Road & Highway 407 EB

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	270	563	0	1698	867	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		5.5	5.5	
Lane Util. Factor	0.97	0.88		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	2818		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	2818		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	284	593	0	1787	913	0
RTOR Reduction (vph)	0	276	0	0	0	0
Lane Group Flow (vph)	284	317	0	1787	913	0
Turn Type	Prot	Prot		NA	NA	
Protected Phases	4	4		2	6	
Permitted Phases						
Actuated Green, G (s)	18.8	18.8		88.2	88.2	
Effective Green, g (s)	19.8	19.8		89.2	89.2	
Actuated g/C Ratio	0.17	0.17		0.74	0.74	
Clearance Time (s)	6.5	6.5		6.5	6.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	572	464		2660	2660	
v/s Ratio Prot	0.08	c0.11		c0.50	0.26	
v/s Ratio Perm						
v/c Ratio	0.50	0.68		0.67	0.34	
Uniform Delay, d1	45.6	47.2		7.9	5.3	
Progression Factor	1.00	1.00		0.69	0.97	
Incremental Delay, d2	0.7	4.1		1.1	0.3	
Delay (s)	46.2	51.3		6.5	5.5	
Level of Service	D	D		A	A	
Approach Delay (s)	49.7			6.5	5.5	
Approach LOS	D			A	A	

Intersection Summary

HCM 2000 Control Delay	16.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

101: Markham Road & Markham Station Access

7/14/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	273	149	49	1858	1771	86
v/c Ratio	0.60	0.60	0.33	0.66	0.63	0.07
Control Delay	54.4	43.3	11.6	7.5	6.1	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	54.4	43.3	11.6	7.5	6.1	0.4
Queue Length 50th (m)	31.7	22.9	2.8	84.7	81.3	0.0
Queue Length 95th (m)	43.6	42.8	11.1	124.0	102.6	m1.1
Internal Link Dist (m)	273.8			314.0	277.1	
Turn Bay Length (m)			80.0			100.0
Base Capacity (vph)	578	305	147	2810	2810	1275
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.47	0.49	0.33	0.66	0.63	0.07

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

101: Markham Road & Markham Station Access

7/14/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	259	142	47	1765	1682	82
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	0.97	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3471	1601	1789	3579	3579	1601
Flt Permitted	0.95	1.00	0.10	1.00	1.00	1.00
Satd. Flow (perm)	3471	1601	188	3579	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	273	149	49	1858	1771	86
RTOR Reduction (vph)	0	40	0	0	0	18
Lane Group Flow (vph)	273	109	49	1858	1771	68
Turn Type	Prot	Perm	Perm	NA	NA	Perm
Protected Phases	4			2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	14.8	14.8	93.2	93.2	93.2	93.2
Effective Green, g (s)	15.8	15.8	94.2	94.2	94.2	94.2
Actuated g/C Ratio	0.13	0.13	0.79	0.79	0.79	0.79
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	457	210	147	2809	2809	1256
v/s Ratio Prot	c0.08			c0.52	0.49	
v/s Ratio Perm		0.07	0.26			0.04
v/c Ratio	0.60	0.52	0.33	0.66	0.63	0.05
Uniform Delay, d1	49.1	48.6	3.8	5.8	5.5	2.9
Progression Factor	1.00	1.00	1.00	1.00	0.85	0.41
Incremental Delay, d2	2.1	2.2	6.0	1.2	1.0	0.1
Delay (s)	51.2	50.7	9.8	7.0	5.7	1.3
Level of Service	D	D	A	A	A	A
Approach Delay (s)	51.0			7.1	5.5	
Approach LOS	D			A	A	

Intersection Summary

HCM 2000 Control Delay	10.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	65.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Appendix E – Internal Circulation

407 TRANSITWAY

RETAINING WALL

STAIRS
CANOPY
ELEVATOR

STAIRS
TICKETS
ELEVATOR

BICYCL
STORAG

BICYCLE
PATH

13 ACCESSIBLE SPACES

± 840 PARKING SPACES

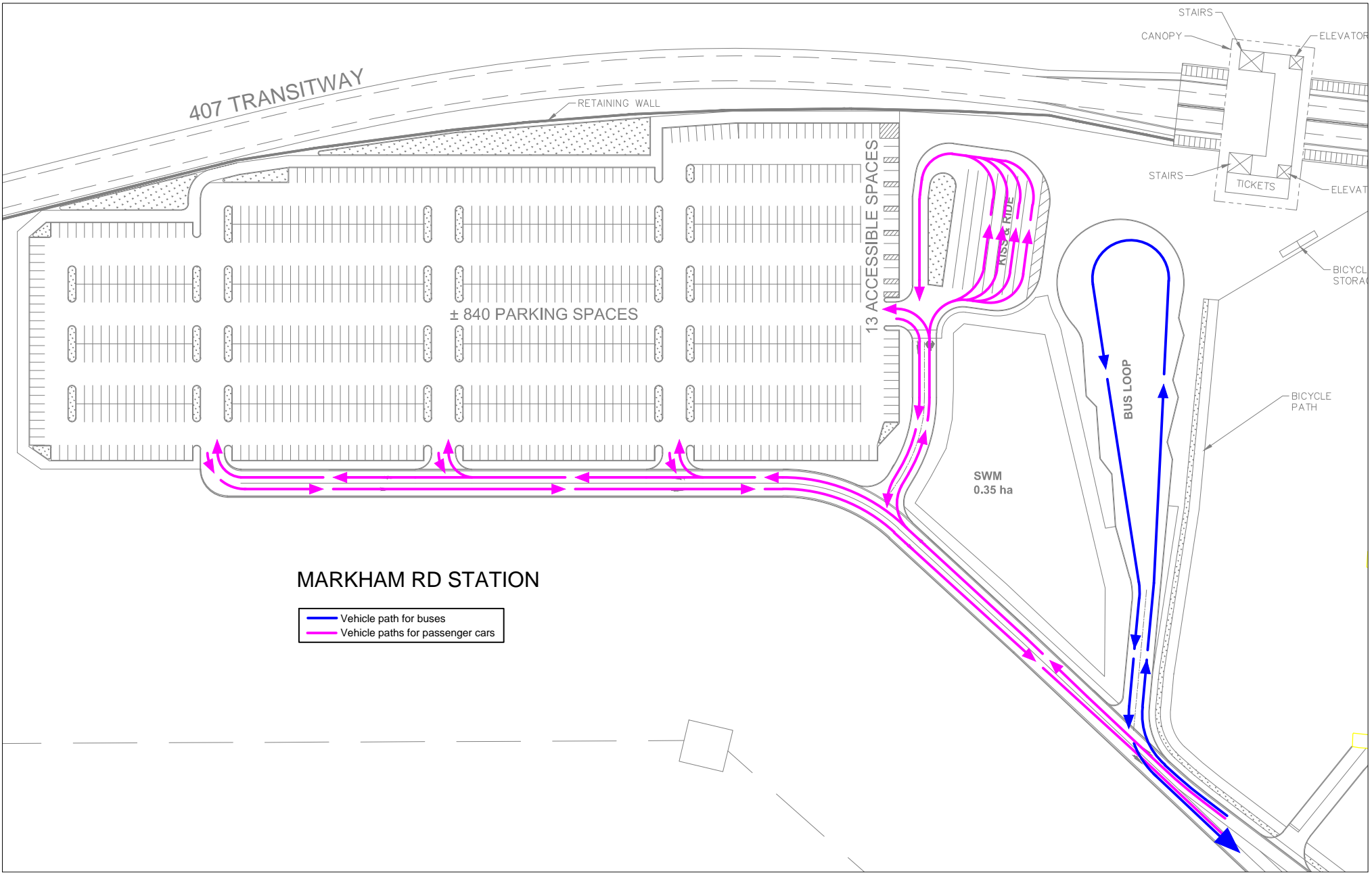
SWM
0.35 ha

BUS LOOP

KISS & RIDE

MARKHAM RD STATION

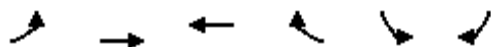
- Vehicle path for buses
- Vehicle paths for passenger cars



HCM Unsignalized Intersection Capacity Analysis

72: KnR

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↶	↷		↶	
Volume (veh/h)	0	0	361	111	111	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	0	380	117	117	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	497				438	438
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	497				438	438
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				80	100
cM capacity (veh/h)	1077				579	623

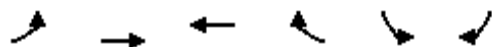
Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	0	497	117
Volume Left	0	0	117
Volume Right	0	117	0
cSH	1700	1700	579
Volume to Capacity	0.00	0.29	0.20
Queue Length 95th (m)	0.0	0.0	5.7
Control Delay (s)	0.0	0.0	12.8
Lane LOS			B
Approach Delay (s)	0.0	0.0	12.8
Approach LOS			B

Intersection Summary			
Average Delay		2.4	
Intersection Capacity Utilization		38.6%	ICU Level of Service A
Analysis Period (min)		15	

HCM Unsignalized Intersection Capacity Analysis

74: Bus Loop

8/11/2015

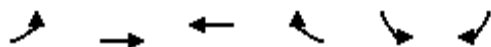


Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	0	111	472	14	14	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	117	497	15	15	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		179	379			
pX, platoon unblocked						
vC, conflicting volume	512				621	504
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	512				621	504
tC, single (s)	4.1				7.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				4.4	3.3
p0 queue free %	100				95	100
cM capacity (veh/h)	1064				326	572
Direction, Lane #	EB 1	WB 1	SB 1			
Volume Total	117	512	15			
Volume Left	0	0	15			
Volume Right	0	15	0			
cSH	1064	1700	326			
Volume to Capacity	0.00	0.30	0.05			
Queue Length 95th (m)	0.0	0.0	1.1			
Control Delay (s)	0.0	0.0	16.6			
Lane LOS			C			
Approach Delay (s)	0.0	0.0	16.6			
Approach LOS			C			
Intersection Summary						
Average Delay			0.4			
Intersection Capacity Utilization			35.7%	ICU Level of Service		A
Analysis Period (min)			15			

HCM Unsignalized Intersection Capacity Analysis

72: KnR

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	0	272	0	115	115	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	286	0	121	121	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)			190			
pX, platoon unblocked						
vC, conflicting volume	121				347	61
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	121				347	61
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				81	100
cM capacity (veh/h)	1479				654	1010

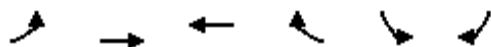
Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	286	121	121
Volume Left	0	0	121
Volume Right	0	121	0
cSH	1479	1700	654
Volume to Capacity	0.00	0.07	0.19
Queue Length 95th (m)	0.0	0.0	5.1
Control Delay (s)	0.0	0.0	11.7
Lane LOS			B
Approach Delay (s)	0.0	0.0	11.7
Approach LOS			B

Intersection Summary			
Average Delay		2.7	
Intersection Capacity Utilization		27.4%	ICU Level of Service A
Analysis Period (min)		15	

HCM Unsignalized Intersection Capacity Analysis

73: Bus Loop

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↶	↷		↘	
Volume (veh/h)	0	387	115	14	14	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	407	121	15	15	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)			400			
pX, platoon unblocked						
vC, conflicting volume	136				536	128
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	136				536	128
tC, single (s)	4.1				7.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				4.4	3.3
p0 queue free %	100				96	100
cM capacity (veh/h)	1461				371	927

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	407	136	15
Volume Left	0	0	15
Volume Right	0	15	0
cSH	1461	1700	371
Volume to Capacity	0.00	0.08	0.04
Queue Length 95th (m)	0.0	0.0	0.9
Control Delay (s)	0.0	0.0	15.1
Lane LOS			C
Approach Delay (s)	0.0	0.0	15.1
Approach LOS			C

Intersection Summary			
Average Delay		0.4	
Intersection Capacity Utilization		30.4%	ICU Level of Service A
Analysis Period (min)		15	

Report

Ninth Line Station Traffic Study



Prepared for Ministry of Transportation, Ontario
by IBI Group

December 20, 2016

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1 Introduction

The proposed Ninth Line Highway 407 Transitway Station is a new transit station in the City of Markham, in the Regional Municipality of York. The station site is located at the southwest corner of the interchange of Ninth Line and Highway 407.

This study analyzes the potential traffic impacts of the proposed station on the surrounding road network. The existing conditions year is 2015 with the future horizon year of 2031. Traffic analysis includes station access and adjacent street network to determine any operational deficiencies. In addition, this memo documents the impact of station volumes onto Ninth Line due to the park and ride facility at the proposed station.

1.1 Study Area

The study area was confirmed with the Ministry of Transportation, Ontario (MTO) staff and includes the following intersections:

- Highway 407 West Off-Ramp at Ninth Line;
- Highway 407 East Off-Ramp at Ninth Line;
- Copper Creek Drive / Rouge Bank Drive at Ninth Line;
- Ninth Line at Rouge Bank Drive (unsignalized); and
- Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive (unsignalized).

In addition to the existing intersections, the preliminary station design includes a new proposed access on the north leg of Ninth Line from Rouge Bank Drive and is the only access to the proposed station. The new layout configuration is included in the future conditions analysis.

The above intersections are shown in Exhibit 1-1 below.

Exhibit 1-1: Study Area Map



1.2 Study Objective

The objective of the traffic analysis for Ninth Line is to support the planning and preliminary design of the Transitway by identifying problems in the road network, providing needs and justification, and evaluating solutions.

Section 2 provides the existing road network and traffic operations of the analysis intersections in the study area.

Section 3 discusses the traffic volume projections of the proposed station, with and without a Transitway station at the Donald Cousens Parkway and Highway 407 interchange. It also includes the assignment of site generated trips in the study area.

Section 4 provides the projection of future background and future total traffic volumes.

Section 5 provides the internal circulation analysis.

Section 6 analyzes potential improvements and/or road network changes that would improve future operating conditions.

2 Existing Conditions

2.1 Road Network

Ninth Line (York Regional Road 69) is a four lane north-south Regional Road with urban cross section within the study area. It has designated left and right turning lanes at the intersections with Highway 7 and Rouge Bank Drive. Ninth Line turns into the Box Groves By-pass south of Rouge Bank Drive. Ninth Line disconnects at Rouge Bank Drive / Copper Creek Drive and continues approximately 210m west of the intersection where it becomes a two lane road.

Highway 407 is a six lane Express Toll Route. It provides connections from the City of Burlington to the City of Pickering.

Copper Creek Drive is a four lane local road with urban cross section. It has designated bike lanes on both sides and has dedicated left and right turning lanes at the intersection with Ninth Line.

Rouge Bank Drive is a two lane local road with urban cross section. The road is wide enough to accommodate on-street parking and has a dedicated left turning lane onto Ninth Line.

Cottontail Avenue and *Russell Jarvis Drive* are local roads with two lanes and urban cross section.

The Highway 407 Off-Ramps and Ninth Line intersections are coordinated signals with a cycle length of 120 seconds in the a.m. peak hour and 140 seconds in the p.m. peak hour.

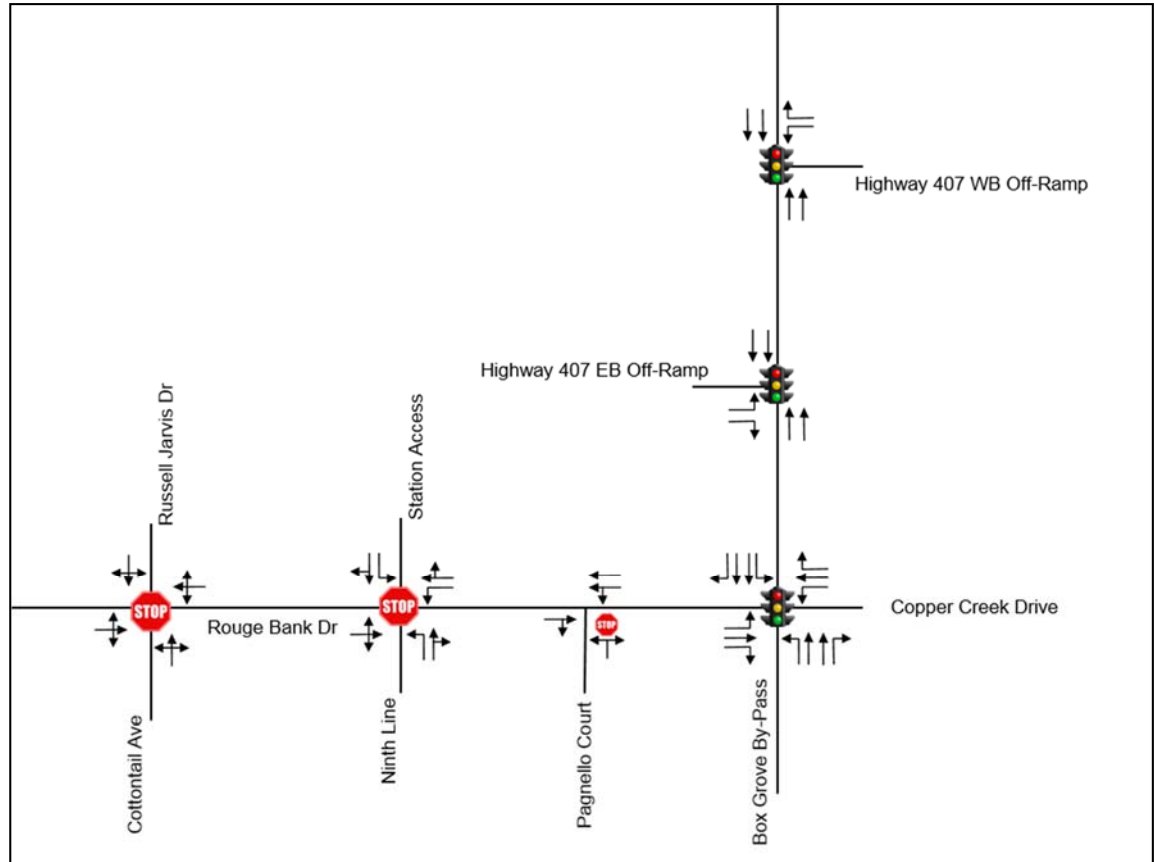
The Ninth Line and Rouge Bank Drive / / Copper Creek Drive intersection is signalized, with advanced lefts for east-west approaches and a 130 second cycle length.

The intersection of Rouge Bank Drive with Ninth Line and Cottontail Avenue are unsignalized, with stop control for each approach.

Existing Lane Configuration

The existing conditions (2015) lane configuration was developed based on a review of aerial images. See Exhibit 2-1 for a simplified representation of the intersection lane configurations.

Exhibit 2-1: Existing Lane Configurations



2.2 Data Collection

Traffic data was obtained from York Region and new counts were undertaken at the locations where data was unavailable. Exhibit 2-2 shows the date of the Turning Movement Count (TMC) for each analysis intersection.

Exhibit 2-2: Count Data

Intersection	Date
Highway 407 EB Offramp & 9th Line	2011, April
Highway 407 WB Offramp & 9th Line	2011, April
Copper Creek Drive & 9th Line	2015, May
Rouge Bank Drive & 9th Line	2015, May
Russell Jarvis Drive & Rouge Bank Drive	2015, May

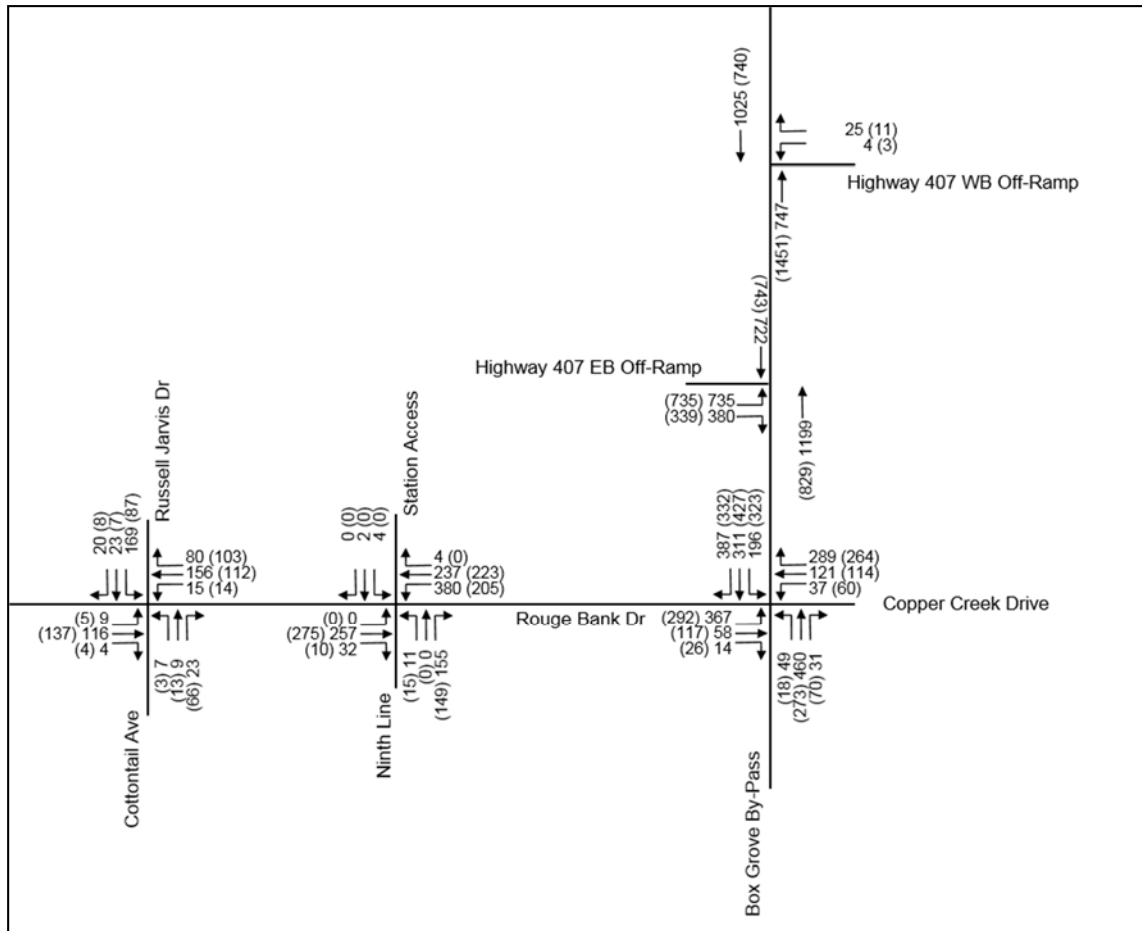
2.3 Operations

The existing conditions year is 2015. Analysis was conducted for weekday a.m. and p.m. peak hours for all study area intersections.

Traffic counts at the Highway 407 offramps were scaled to 2015 using the York Region TIS Guideline’s annual compounded growth rate of 2%. Traffic counts along Rouge Bank, including at Ninth Line / Box Grove By-Pass, were collected in 2015 and therefore not scaled.

Existing conditions traffic volumes are shown in Exhibit 2-3.

Exhibit 2-3: Existing Conditions (2015) Traffic Volumes in AM (PM) Peak Hour



Intersection operations analysis was conducted using Synchro 9, which utilizes the Highway Capacity Manual (HCM) 2000 methodology to evaluate overall intersection and individual movement performances. The level-of-service (LOS) is a measure of performance based on the control delay, defined as follows in Exhibit 2-4.

Exhibit 2-4: Intersection LOS Reference

HCM	Control Delay per Vehicle (s)	
LOS	Signalized	Unsignalized
A	≤10	≤10
B	>10 and ≤20	>10 and ≤15
C	>20 and ≤35	>15 and ≤25
D	>35 and ≤55	>25 and ≤35
E	>55 and ≤80	>35 and ≤50
F	>80	>50

Critical movements were identified by satisfying any one or more of the following criteria, based on the York Region TIS Guidelines for an urban area:

- Control delay of LOS E or worse;

- 95th percentile queue exceeding provided storage/link length; and
- Volume-to-capacity (v/c) ratio of 0.85 or greater.

A summary of the Synchro analysis including delay, 95th percentile queue, and level-of-service (LOS) indicators is shown in Exhibit 2-5 with detailed output provided in Appendix A.

Highway 407 West Off-Ramp at Ninth Line: The critical delay for westbound movements in the p.m. peak hour is the result of a long cycle length and north-south signal coordination. Overall the intersection operates well in both peak hours with LOS A.

Highway 407 East Off-Ramp at Ninth Line: The eastbound left turn movement is critical in both peak periods with LOS C in both peak hours. Expansion of the off-ramp to a three-lane approach with double left turn lanes is required to mitigate the critical movement. This is typical for highway off-ramps reaching capacity.

Copper Creek Drive / Rouge Bank Drive at Ninth Line: There is a large volume of southbound vehicles taking the right turn onto Rouge Bank Drive. It appears that a significant portion of this volume is a result of vehicles using Rouge Bank Drive to Ninth Line as a shortcut to access 14th Avenue rather than using the Box Grove By-Pass.

At the project PIC #1 held in April 2015, residents expressed concerns with traffic operations on Rouge Bank Drive during peak hours. The eastbound queue at the stop signs at Ninth Line and the eastbound left turn queue at the signalized intersection with Box Grove By-Pass were indicated by residents to be critical. The analysis in this section confirms that the eastbound left turn at the intersection of Rouge Bank Drive / Copper Creek Drive and Box Grove By-Pass / Ninth Line is approaching capacity in the a.m. peak hour, with v/c ratio of 0.85 and 95th percentile queue of 107 metres.

No critical issues are experienced at the current stop controlled intersections of Rouge Bank Drive at Ninth Line and at Cottontail Avenue/Russell Jarvis Drive. However, as indicated by residents, the eastbound approach at the intersection of Rouge Bank Drive and Ninth Line may experience some delays during the peak hours due to the intersection's all-way stop control accommodating all movements equally (including the short-cutting westbound left turn traffic).

Exhibit 2-5: Existing Conditions Intersection Operational Performance Summary

Intersection	AM		Critical			PM		Critical		
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at 9th Line	A					A	WBL WBR	E E	0.04 0.01	4 6
Highway 407 East Off-Ramp at 9th Line	C	EBL	D	0.91	#233	C	EBL	D	0.85	213
Copper Creek Drive / Rouge Bank Drive at 9th Line	C	EBL	D	0.85	107	C	WBL	E	0.53	30
		WBL	E	0.36	21		WBT	E	0.51	47
		WBT	E	0.53	49					
9th Line at Rouge Bank Drive	B					B				
Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive	A					A				

2.4 Transit Access

York Regional Transit (YRT) provides transit access within York Region and also contracts TTC bus routes to connect to the subway service. The YRT/Viva is a Bus Rapid Transit (BRT) network that also operates a number of routes on major arterials. Within the study area, the following services are currently in operation:

- **YRT Route 1 – Highway 7** runs along Highway 7 and connects the Richmond Hill Centre to the Markham Stouffville Hospital with headways ranging from 20 to 30 minutes during peak hours;
- **YRT Route 9 – Ninth Line** runs along the corridor and connects the Town of Stouffville to south of Highway 407 with headways of 43 minutes during peak hours; and
- **Viva Purple** is a major east-west route from York University to the Markham Stouffville Hospital with headways ranging from 14 to 19 minutes during peak hours.

Exhibit 2-6 illustrates the transit services within the study area.

Exhibit 2-6: YRT in the Study Area



3 Site Traffic

This section provides the methodology and process used to generate and distribute site-generated traffic from the proposed station.

3.1 Station Demand Forecasts

Station demand forecasts were developed based on the Greater Golden Horseshoe (GGH) model scenarios for the 407 Transitway East study. There are two scenarios, a.m. and p.m., each based on the projected 2031 population and employment in the GGH area. For the purposes of this study, demand adjustments were undertaken to better calibrate the transit travel patterns in the east portion of the 407 Transitway between Kennedy Road and Brock Road. Model results for each station include peak period demand in three access categories: park-and-ride (PnR), walk/transit, and interline. See Exhibit 3-1 for the station travel demand forecasts.

ITE Trip Generation Manual (8th edition) provides inbound and outbound peak hour trip rates for transit stations with park and ride service (code #90), based on the number of parking spaces provided. In order to develop the number of parking spaces required at each station, 2011 TTS data at existing GO transit stations were analyzed. The average ratio between a.m. peak period auto driver demand and the number of parking spaces provided at these stations were found to be 0.75. See Exhibit 3-2 for the list of GO stations and their parking provision rates.

The ratio found above was applied to the 407 Transitway East stations to develop the number of parking spaces needed, with the assumption that auto driver demand is equal to park-and-ride demand.

Donald Cousens Parkway Station (to the east of Ninth Line Station) may or may not be part of the 407 Transitway East final station design. As a result, two site-generation scenarios were analyzed: one with Donald Cousens Parkway Station (5 stations) and one without Donald Cousens Parkway Station (4 stations). For the latter scenario, 80% of demand from Donald Cousens Parkway Station is assigned to Ninth Line Station and remaining 20% to Whites Road Station. See Exhibit 3-3 for the proposed number of parking spaces at each station.

Exhibit 3-1: GGH Model Results – 2031 AM Peak Period Transitway Station Demand

Station	2031 AM Peak Period Travel Adjusted			
	PnR	Walk/Transit	Interline	Total
Brock Road	450	30	1,690	2,170
Whites Road	540	40	1,480	2,060
Donald Cousens Parkway	383	127	0	510
9th Line	503	167	0	670
Markham Road	608	102	100	810

Exhibit 3-2: TTS Data – 2011 AM Peak Period GO Station Demand and Parking Supply

2011 TTS AM Peak Period Travel		Station Parking	
GO Station (Rural)	Auto Driver*	Spaces	% Provision
Stouffville	220	243	91%
Aurora	1,010	1,463	69%
Newmarket	260	265	98%
Milton	1,330	1,544	86%
Georgetown	400	614	65%
Mount Pleasant	830	1,112	75%
Total Rural	4,050	5,241	77%
GO Station (Durham)	Auto Driver	Spaces	% Provision
Oshawa	1,620	2,380	68%
Whitby	2,200	2,958	74%
Ajax	1,730	2,148	81%
Pickering	1,850	2,508	74%
Total Durham	7,400	9,994	74%
Total	11,450	15,235	75%

* Rounded to nearest 10

Exhibit 3-3: Station Parking Space Requirement

Station	PnR Demand	Parking Spaces
Brock Road	450	600
Whites Road	540	720
Whites Road without DC*	617	823
Donald Cousens Parkway	383	511
9th Line	503	671
9th Line without DC**	809	1,079
Markham Road	608	810
Kennedy Road	820	1,093

* Whites Road Station PnR 540 + 20% of 383 from Donald Cousens Parkway = 617

** 9th Line Station PnR 503 + 80% of 383 from Donald Cousens Parkway = 809

3.2 Trip Generation

Trip generations rates were based on the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th Edition. Land use code 90 (Park and Ride Lot for Bus Service) was used to determine the number of auto trips in to and out of the station based on the number of spaces in the station parking lot. The number of parking spaces was estimated based on projected ridership.

With Donald Cousens Parkway Station

The proposed station is designed to have a single access to Ninth Line onto Rouge Bank Drive. No other significant developments are currently expected along this leg of Ninth Line which is currently a cul-de-sac with a waste water treatment facility. Estimated transit ridership is approximately 670 riders in the a.m. peak period, with 503 (75%) using the park and ride (PnR) services.

Based on similar stations, it is assumed that an additional 25% provision of parking would be provided by 2031, thus a parking lot size of 670 spaces was assumed for trip generation purposes.

Due to the geometry of the road network in the area, it was assumed that existing transit routes would not enter and exit the transit station due to potential delays and lost time in accessing the station.

The trip generation rates and resulting traffic volumes are shown in Exhibit 3-4.

Without Donald Cousens Parkway Station

Without a Transitway station at Donald Cousens Parkway to the east of Ninth Line, 80% of the expected PnR trips at Donald Cousens Parkway Station would instead divert to Ninth Line Station. With this consideration, the expected PnR users would grow to 809 and as a result require a new station parking lot of 1,079 spaces.

Again, due to road network geometry, existing transit routes are assumed to not enter and exit the station.

The trip generation rates and resulting traffic volumes are shown in Exhibit 3-4.

Exhibit 3-4: Trip Generation Summary

9 th Line Station Traffic Volumes						
ITE Land Use Code 90	Total	Entering	Exiting	Total	Entering	Exiting
Scenario	AM			PM		
Rates	0.72	0.81	0.19	0.62	0.23	0.77
With Donald Cousens Station	483	391	92	416	96	320
Without Donald Cousens Station	777	629	148	669	154	515

3.3 Trip Assignment

Station traffic trip assignment was estimated based on former studies for the central section of the Highway 407 Transitway completed in 2011. The distribution utilized was approximately 65% to and from the north, 25% to and from the south, and 5% to and from each of the east and west directions. See Exhibit 3-5 for the trip assignment percentages.

The two scenarios – with and without Donald Cousens Parkway Station – were assigned separately. See Exhibit 3-6 and Exhibit 3-7 for the trip assignment volume diagrams of the two scenarios.

Exhibit 3-5: Site Trip Assignment Percentages

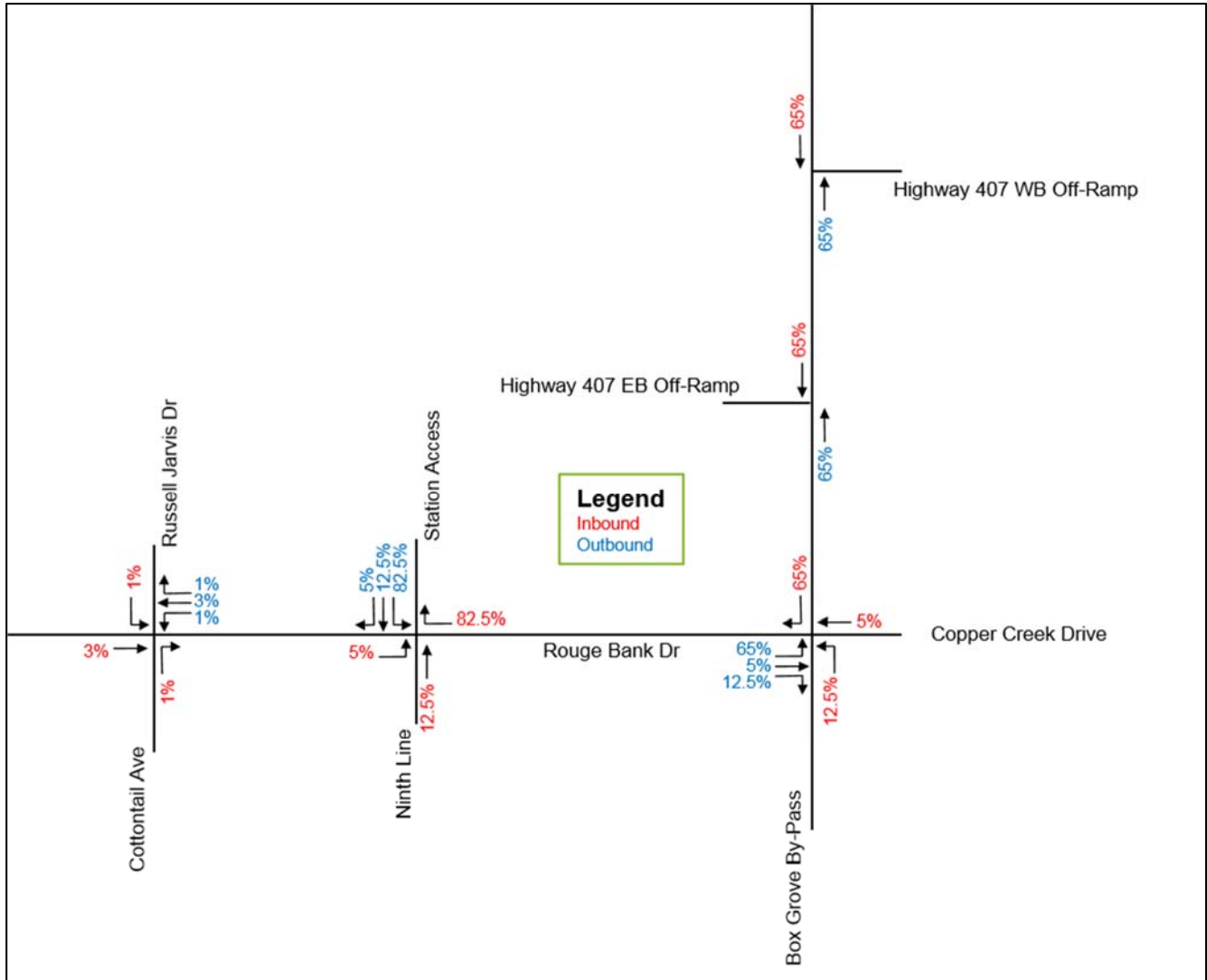


Exhibit 3-6: Site-generated Volumes with Donald Cousens Parkway Station

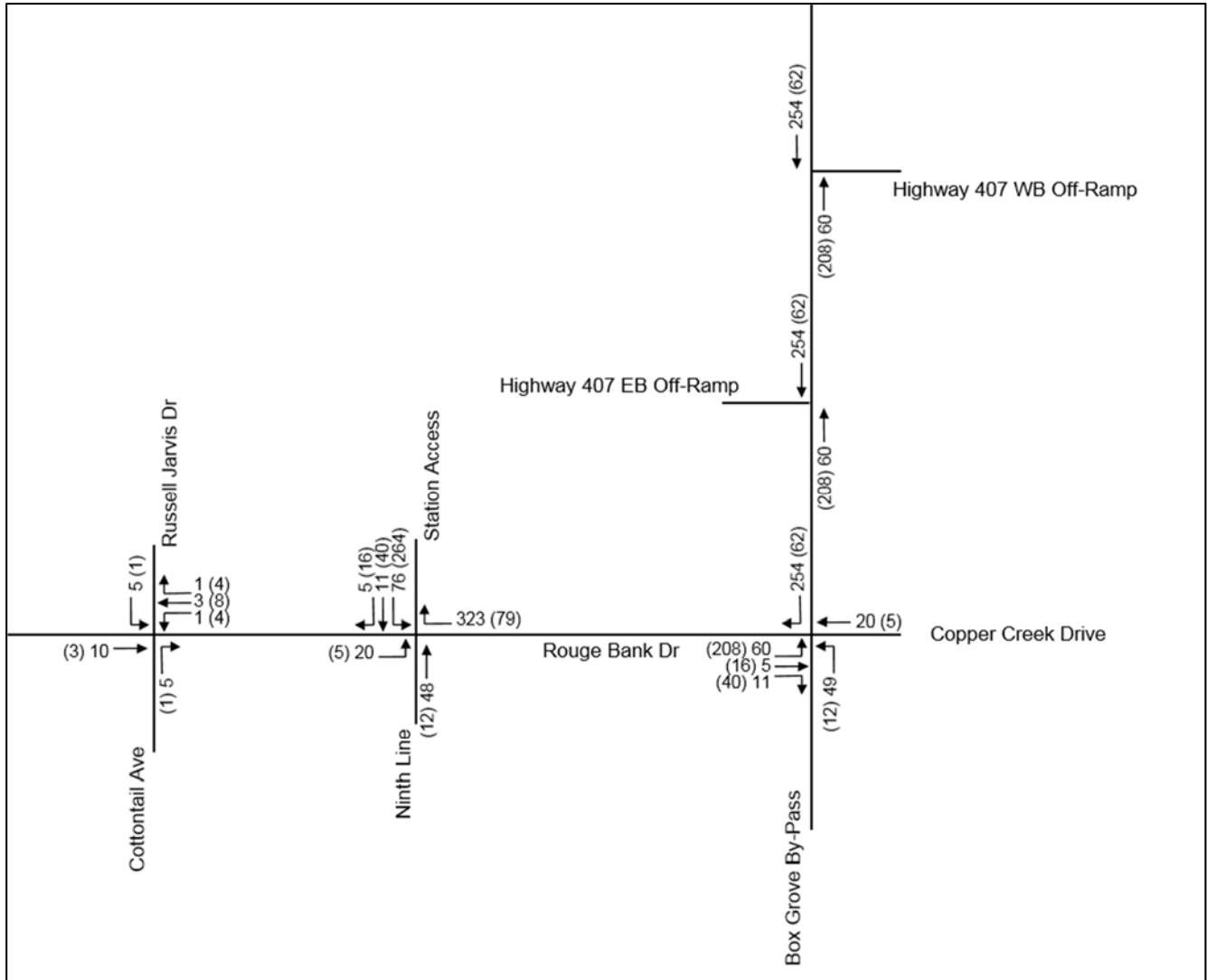
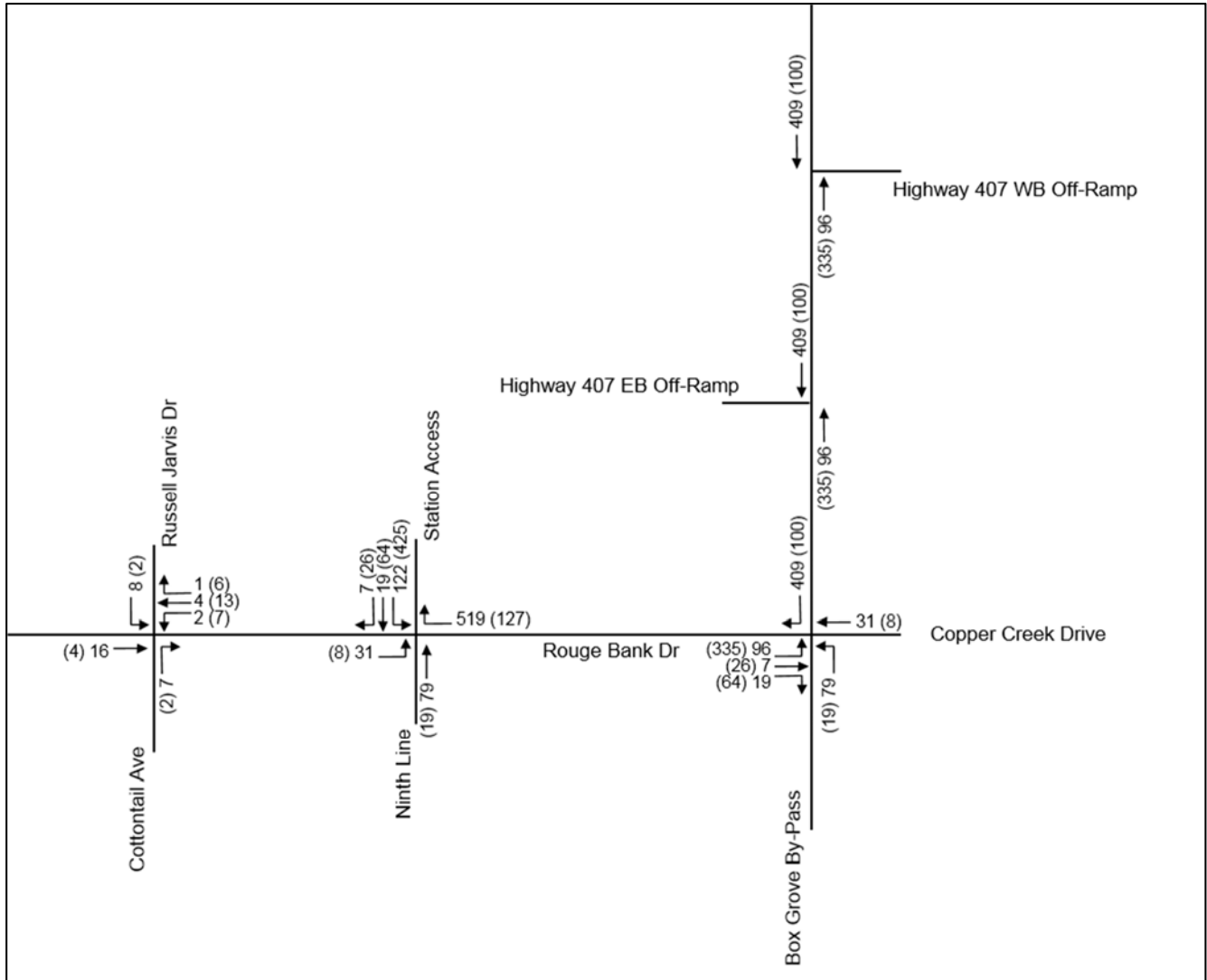


Exhibit 3-7: Site-generated Volumes without Donald Cousens Parkway Station



4 Future Conditions

4.1 Background Operations

The future horizon year of 2031 was analyzed in accordance with overall Transitway phasing strategy. All future conditions analysis scenarios include signal timing optimization based on existing and/or nearby intersection's cycle lengths.

Background traffic growth was obtained based on the comparison between 2011 base scenario and the 2031 base scenario of the Greater Golden Horseshoe (GGH) model. For the Ninth Line corridor, an annual compound growth rate of 2% was applied for the majority of traffic volumes. This accounts for growth and development in and around the study area that would influence the traffic demand. The intersections from the neighbourhood to the west of the Ninth Line and Rouge Bank Drive / Copper Creek Drive were not scaled to 2031 volumes as the neighbourhood is already mostly developed in 2015. The movements that were not grown include:

- All movements at the intersection of Rouge Bank Drive at Russell Jarvis Drive / Cottontail Avenue;
- All movements at the intersection of Rouge Bank Drive at Ninth Line, excluding the westbound left turn movement; and
- All eastbound movements, westbound through, and northbound left movements at the intersection of Ninth Line at Rouge Bank Drive / Copper Creek Drive.

The southbound right movement at Ninth Line and Rouge Bank Drive / Copper Creek Drive was scaled to account for vehicles shortcutting through the neighbourhood in the morning commute, and continues to the westbound left turning movement at Ninth Line and Rouge Bank Drive. This shortcutting pattern was not observed to be reversed in the p.m. peak hour.

Highway 407 West Off-Ramp at Ninth Line: Intersection operates at LOS A in both peak hours. In the p.m. peak hour, the westbound movements operate at LOS E due to long cycle length and coordination of north-south movements.

Highway 407 East Off-Ramp at Ninth Line: Intersection operates at LOS F in the a.m. peak hour and at LOS E in the p.m. peak hour. In the a.m. peak hour, the eastbound left movement sees a large increase in delay and the northbound through movements become critical. Expansion to an eastbound double left is required, this is typical for highway off-ramps reaching capacity and there is ample right-of-way for this expansion. In the p.m. peak hour, several movements have critical queue lengths that may exceed the available storage length and block upstream intersections.

Copper Creek Drive / Rouge Bank Drive at Ninth Line: Intersection operations deteriorate from LOS C to D in the p.m. peak hour. Both peak hours experience high delays and critical queue lengths for several movements.

The stop-controlled intersection of Ninth Line and Rouge Bank Drive deteriorates from LOS B to D in the a.m. peak hour with the westbound movement experiencing high delay.

No issues are experienced at the current stop-controlled intersections of Rouge Bank Drive at Cottontail Avenue/Russell Jarvis Drive.

The 2031 background volume (without site-generated traffic) is shown in Exhibit 4-1. Summary of the future background conditions analysis is shown in Exhibit 4-2.

Exhibit 4-1: Future 2031 Background Volumes – AM (PM) Peak Hour

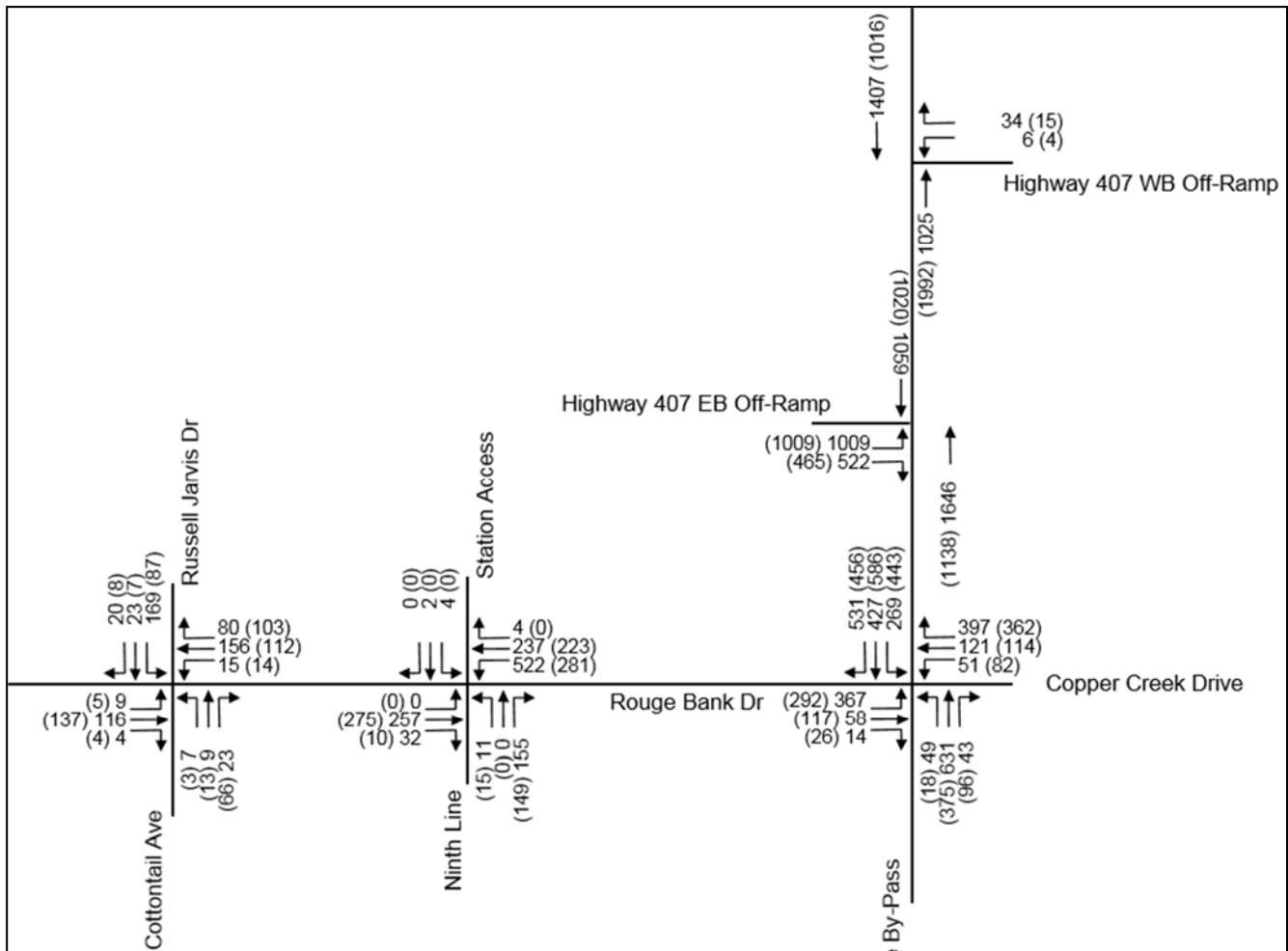


Exhibit 4-2: Future 2031 Background Conditions Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at 9th Line	A					A	WBL WBR	E E	0.06 0.01	5 7
Highway 407 East Off-Ramp at 9th Line	F	EBL NBT	F F	1.27 1.12	#393 #289	E	EBL NBT SBT	E E D	1.03 1.00 0.89	#393 #223 #180
Copper Creek Drive / Rouge Bank Drive at 9th Line	C	EBL WBL	F E	1.02 0.53	#109 27	D	EBL EBT WBL	E E E	1.19 0.56 0.70	#118 48 #46
9th Line at Rouge Bank Drive	D	WB	D	0.92		B				
Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive	A					A				

4.2 Total Operations

The future (2031) total operations analysis is divided into two scenarios: with and without Donald Cousens Parkway Station. Intersection volumes were determined by adding the site-generated volumes from Section 3.3 to the 2031 background volumes from Section 4.1.

All future conditions analysis scenarios include signal timing optimization based on existing and/or nearby intersection's cycle lengths.

With Donald Cousens Parkway Station

Highway 407 West Off-Ramp at Ninth Line: Intersection operates at LOS A in both peak hours. In the p.m. peak hour, the westbound movements operate at LOS E due to the long cycle length. Site-generated trips are assigned only to the northbound and southbound movements, which operate well with no capacity issues.

Highway 407 East Off-Ramp at Ninth Line: Site generated traffic does not have a major effect at this intersection, with overall LOS remaining the same as future background conditions. Site-generated trips are assigned only to the northbound and southbound movements, which operates poorly in both peak hours. The southbound through movement in both peak hours has become critical from future background operations due to an increase in delay.

Copper Creek Drive / Rouge Bank Drive at Ninth Line: Intersection operations deteriorate from LOS C to D in the a.m. peak hour and from LOS D to E in the p.m. peak hour due to site generated traffic. Both peak hours see a large increase in delay and queue length. The primary movement for site-generated traffic exiting the station is eastbound left turn, which is overcapacity (v/c ratio > 1.0) and LOS F in both peak hours.

The stop-controlled intersections of Ninth Line and Rouge Bank Drive deteriorates to LOS E in the a.m. peak hour and LOS C in the p.m. peak hour due to site-generated traffic. Signalizing the intersection would improve the overall LOS in the a.m. peak hour from E to C, with the westbound left movement experiencing a critical queue length.

No issues are experienced at the current stop-controlled intersection of Rouge Bank Drive at Cottontail Avenue/Russell Jarvis Drive.

See Exhibit 4-3 for the intersection volumes and Exhibit 4-4 for the summary of intersection operational performance analysis.

Exhibit 4-3: Future 2031 Total (with Donald Cousens) Volumes – AM (PM) Peak Hour

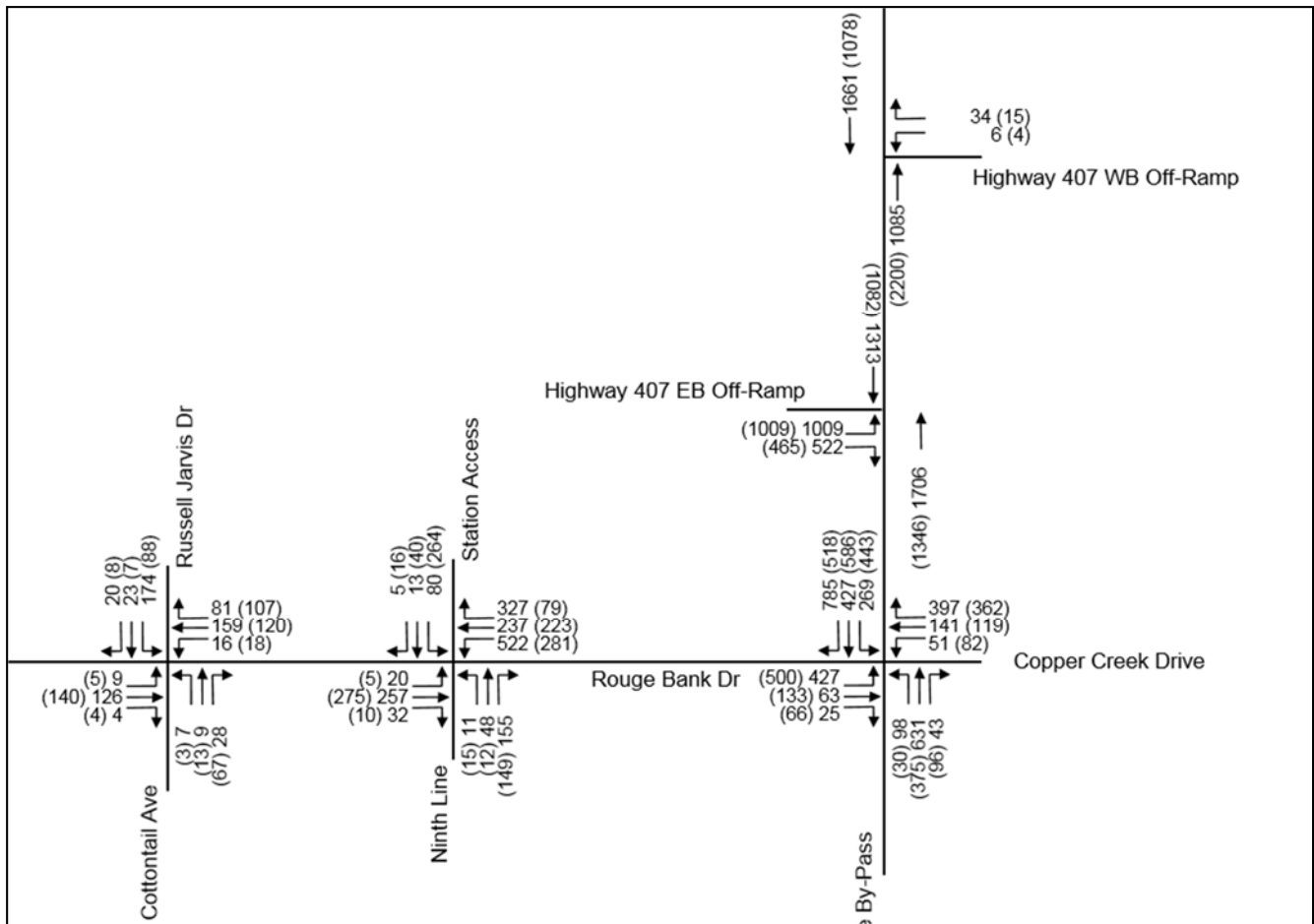


Exhibit 4-4: Future 2031 Total (with Donald Cousens) Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at 9th Line	A					A	WBL WBR	E E	0.06 0.03	5 8
Highway 407 East Off-Ramp at 9th Line	F	EBL NBT SBT	F F C	1.30 1.14 0.87	#397 #302 184	E	EBL NBT SBT	F F D	1.09 1.07 0.86	#411 #270 181
Copper Creek Drive / Rouge Bank Drive at 9th Line	D	EBL WBL	F E	1.11 0.53	#138 27	E	EBL WBL	F E	1.49 0.57	#234 39
9th Line at Rouge Bank Drive (unsignalized)	E	WB	F	1.00		C				
9th Line at Rouge Bank Drive (signalized)	C	WBL	D	0.92	#154	C				
Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive	B					B				

Without Donald Cousens Parkway Station

Highway 407 West Off-Ramp at Ninth Line: Intersection operates at LOS A in both peak hours. In the p.m. peak hour, the westbound movements operate at LOS E due to the long cycle length. Site-generated trips are assigned only to the northbound and southbound movements, which operate well with no capacity issues.

Highway 407 East Off-Ramp at Ninth Line: Site generated traffic does not impact the intersection, with no deterioration in overall LOS from future background conditions. Site-generated trips are assigned only to the northbound and southbound movements, which operates poorly in both peak hours. In the a.m. peak hour, the southbound through movement queue length may exceed the available storage length. In the p.m. peak hour, this movement is no longer critical due to signal optimization.

Copper Creek Drive / Rouge Bank Drive at Ninth Line: Intersection operations have deteriorated from LOS C to D in the a.m. peak hour and from LOS E to F in the p.m. peak hour. Site generated traffic has caused a major increase in delay in both peak hours, with an increase in critical queue lengths.

The stop-controlled intersections of Ninth Line and Rouge Bank Drive deteriorates to LOS F in both peak hours due to site-generated traffic. Signalization the intersection would improve the overall LOS from E to C in both peak hours.

No issues are experienced at the current stop-controlled intersection of Rouge Bank Drive at Cottontail Avenue/Russell Jarvis Drive.

See Exhibit 4-5 for the intersection volumes and Exhibit 4-6 for the summary of intersection operational performance analysis.

Exhibit 4-5: Future 2031 Total (without Donald Cousens) Volumes – AM (PM) Peak Hour

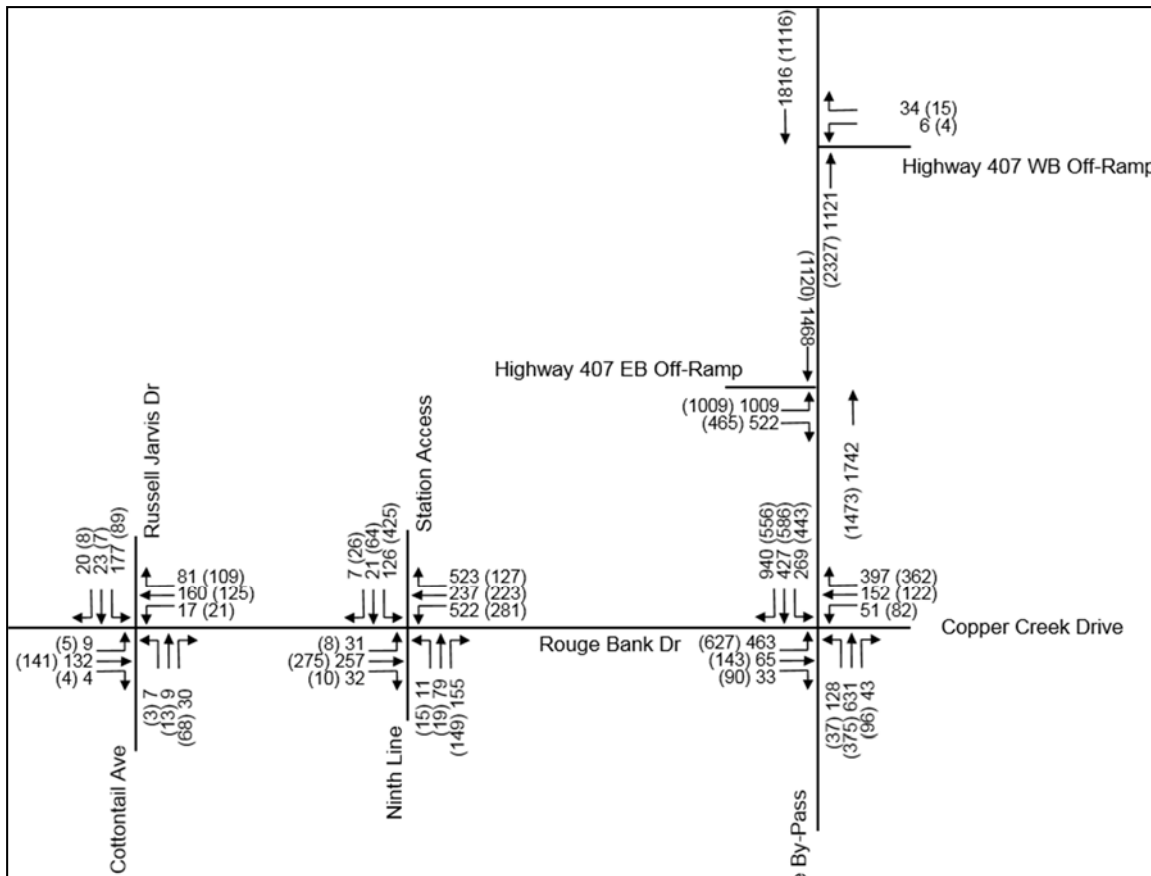


Exhibit 4-6: Future 2031 Total (without Donald Cousens) Intersection Operational Performance Summary

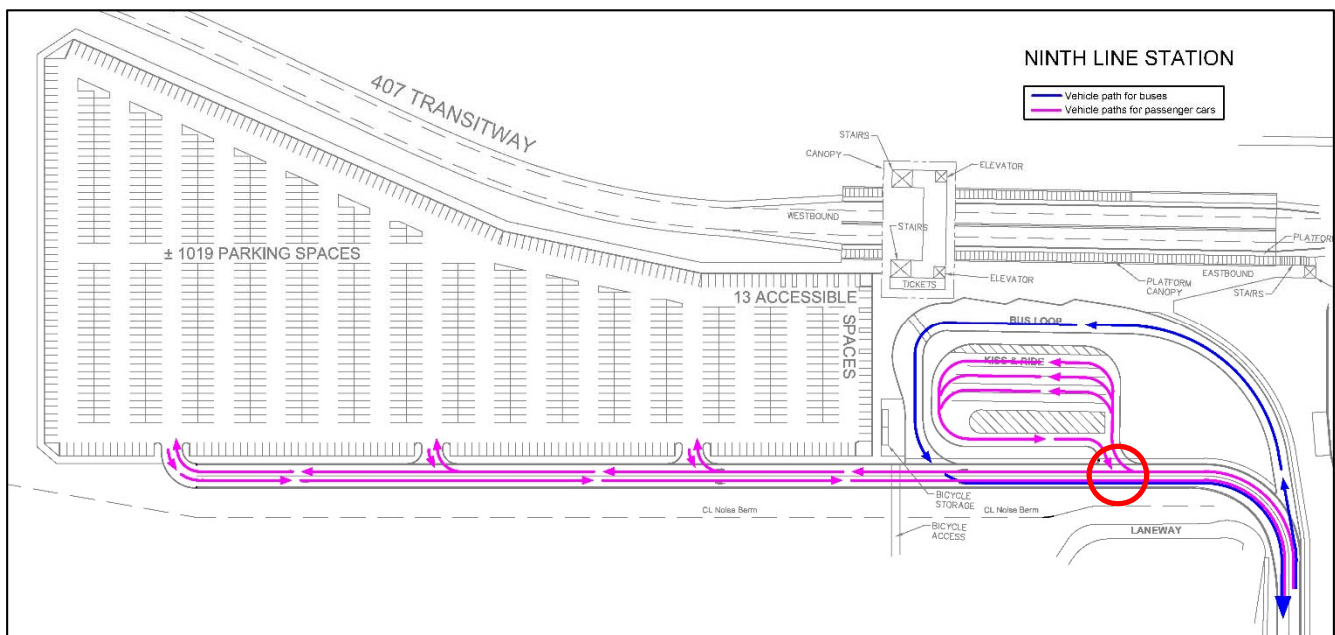
Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at 9th Line	A					A	WBL WBR	E E	0.06 0.09	5 9
Highway 407 East Off-Ramp at 9th Line	F	EBL NBT SBT	F F D	1.32 1.14 0.96	#401 #308 #233	E	EBL NBT	E E	1.14 1.10	#422 #299
Copper Creek Drive / Rouge Bank Drive at 9th Line	D	EBL WBL WBR SBR	F E E C	1.28 0.53 0.63 0.77	#178 27 62 #195	F	EBL WBL WBT	F E E	1.61 0.57 0.54	#288 39 48
9th Line at Rouge Bank Drive (unsignalized)	E	WB	F	0.53		E	SB	F	0.53	
9th Line at Rouge Bank Drive (signalized)	C	WBL NBT	D D	0.92 0.64	#180 #76	C				
Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive	B					A				

5 Internal Circulation

This section provides an overview of the proposed station’s internal circulation design, with vehicle composition and flow derived from the site-generated trips in Section 3. The intersection with the highest number of potential vehicle volumes (and/or conflicting movements) is analyzed as an unsignalized intersection in Synchro, within the a.m. and p.m. peak hours.

The proposed internal circulation plan is shown below in Exhibit 5-1. The analysis intersection is circled in red. Note that the plan is intended to illustrate the internal flow of vehicles (pink) and buses (blue), and that site details such as number of parking spaces and dimensions are subject to revisions.

Exhibit 5-1: Internal Circulation Plan – Ninth Line Station



Based on the “Without Donald Cousens Parkway Station” scenario, the station internal volumes consist of:

- Passenger vehicles: AM: 629 in, 148 out; PM: 154 in, 515 out; and
- Buses (sum of northbound and southbound buses): AM: 10 in, 10 out; PM: 9 in, 9 out.

For simplicity, all outbound vehicles in the AM and inbound vehicles in the PM are assumed to be associated with drop-off and pick-up activities (“Kiss-and-Ride”, abbreviated KnR). The remainder is assumed to be Park-and-Ride (PnR) vehicles, inbound in the AM and outbound in the PM. All buses are modelled as heavy vehicles in Synchro.

Analysis results show that there are no operational issues at the analyzed internal intersection for both peak hour operations. The east-west movement is analyzed as freeflow movements, which incurs no delay, and the southbound movement is analyzed as a stop-controlled movement, which operates at LOS C (B) in the a.m. (p.m.) peak hour with 95th percentile queue less than two-vehicle length.

Results are summarized in Exhibit 5-2 below.

Exhibit 5-2: Internal Circulation Analysis – Ninth Line Station

Internal		AM Peak Hour			PM Peak Hour		
Mvmt.	Description	Volume	LOS	Queue (95 th , m)	Volume	LOS	Queue (95 th , m)
EBT	PnR out + Bus out	10	A	0	370	A	0
WBT	PnR in	481	A	0	0	A	0
WBR	KnR in	148	A	0	154	A	0
SBL	KnR out	148	C	11	154	B	9

6 Mitigation Measures

Mitigation measures were developed with the objective of mitigating all critical movements in the study area with V/C ratios of 0.85 or greater. The following changes are required for both analysis scenarios (with or without Donald Cousens Parkway Station):

- Highway 407 East Off-Ramp at Ninth Line: an additional eastbound left turning lane;
- Copper Creek Drive / Rouge Bank Drive at Ninth Line / Box Grove By-Pass: an additional eastbound left turning lane;
- Rouge Bank Drive at Pagnello Court: an additional eastbound through lane; and
- Rouge Bank Drive and Ninth Line / Station Access: signalization and an additional westbound right turn lane. For the p.m. peak hour, advanced southbound left turn phase is required to accommodate the flows out of the station access.

Roundabouts were considered at all five of the analysis intersections excluding Pagnello Court due to it being a very minor intersection. Along the Ninth Line intersections with the Highway 407 off-ramps and Copper Creek Drive / Rouge Bank Drive, roundabouts were ruled out as it would have no operational benefits and would require significant construction and realignment of the off-ramps and through roads. At the intersections of Rouge Bank Drive at 95th Line and at Cottontail Avenue / Russell Jarvis Drive there is not enough property to accommodate roundabouts.

To further improve both future background and future total operations, the short-cutting of north-south traffic through Rouge Bank Drive need to be mitigated. Several strategies can be implemented to discourage the short-cutting:

- Westbound left-turn restriction at the intersection of Rouge Bank and Ninth Line / Station Access during peak hours – this prevents the majority of traffic from using Ninth Line to go southbound to 14th Avenue. Only an a.m. peak period restriction may be necessary as short-cutting problems are not as prevalent in the p.m. peak hour.
- Expand 14th Avenue to 4 lanes – this improvement is expected from a long-term planning perspective, as 14th Avenue is already 4 lanes further west at Markham Road. In addition, the intersection of 14th Avenue and Ninth Line is currently stop controlled; expansion of this could reduce queues on 14th Avenue. The queues approaching Ninth Line on 14th Avenue westbound could be part of the reason for short-cutting traffic (by-passing queue) as the problem appears to be more severe towards south-/west-bound travel than north-/east-bound travel.
- Traffic calming – physical measures (e.g. speed bumps, barriers/planters) and operational measures (e.g. lower speed limit) can be implemented along Ninth Line and other local north-south connection roads to the west. This makes using these local roads less attractive as cut-through routes and may encourage more traffic to use Box Grove By-Pass.

For the purposes of this analysis, traffic calming measures are assumed to be effective in reducing the short-cutting by 50% in both a.m. and p.m. peak hours. As a result, 50% of the short-cutting peak hour traffic on Rouge Bank Drive are assigned to Box Grove By-Pass.

The option of providing a connection from the station onto the east side of Ninth Line using grade separation was considered as a secondary alternative. It would change the station access route to use Copper Creek Drive as opposed to Rouge Bank Drive. This is a very costly option due to construction requirements and is not recommended.

Widening of the Ninth Line bridge section across Highway 407 from 4 to 6 lanes is required to completely resolve all critical movements at the Highway 407 off-ramp intersections. However, this is not recommended in this study due to the costs and difficulties associated with the construction.

For both analyses, the future recommended lane configuration for the study area is the same. Exhibit 6-3 shows the recommended lane configuration for 2031.

With Donald Cousens Parkway Station

With the recommended lane configuration, Exhibit 6-1 shows the summary of the intersection operational performance.

- Highway 407 East Off-Ramp at Ninth Line improves from LOS F to C in the a.m. peak hour and from LOS E to C in the p.m. peak hour. Critical queue lengths and delays are significantly reduced with the second eastbound left turning lane.
- Copper Creek Drive / Rouge Bank Drive at Box Grove By-Pass / Ninth Line improves from LOS D (E) in the a.m. (p.m.) peak hour to LOS C in both peak hours. With the second eastbound left turning lane, critical queues and delays are minimized.
- Ninth Line at Rouge Bank Drive operations are improved due to the signalization and additional westbound right turn lane, with all movements operating at LOS C or better.

Without Donald Cousens Parkway Station

In addition to all recommended improvements in this section, additional measure is required due to the increased station traffic demand for this scenario:

- Copper Creek Drive / Rouge Bank Drive at Box Grove By-Pass / Ninth Line: pedestrian crossing in the north leg is removed and all east-west pedestrians are forced to the south leg crossing.

This allows the signal phases to be further optimized towards the fully protected eastbound left turn movement while minimizing the impact on other intersection movements. Without the change in pedestrian operations and phasing, the intersection cannot handle the additional demand generated without Donald Cousens Parkway Station.

Exhibit 6-2 shows the summary of the intersection operational performance and includes the following improvements:

- Highway 407 East Off-Ramp at Ninth Line improves from LOS F to D in the a.m. peak hour and from LOS E to C in the p.m. peak hour. Overall, delays and critical queue lengths are reduced with the additional eastbound left turning lane.
- Copper Creek Drive / Rouge Bank Drive at Box Grove By-Pass / Ninth Line improves from LOS D to C and from LOS F to C in the a.m. and p.m. peak hour, respectively.
- Ninth Line at Rouge Bank Drive operations are improved due to the signalization and additional westbound right turn lane, with all movements operating at LOS C or better.

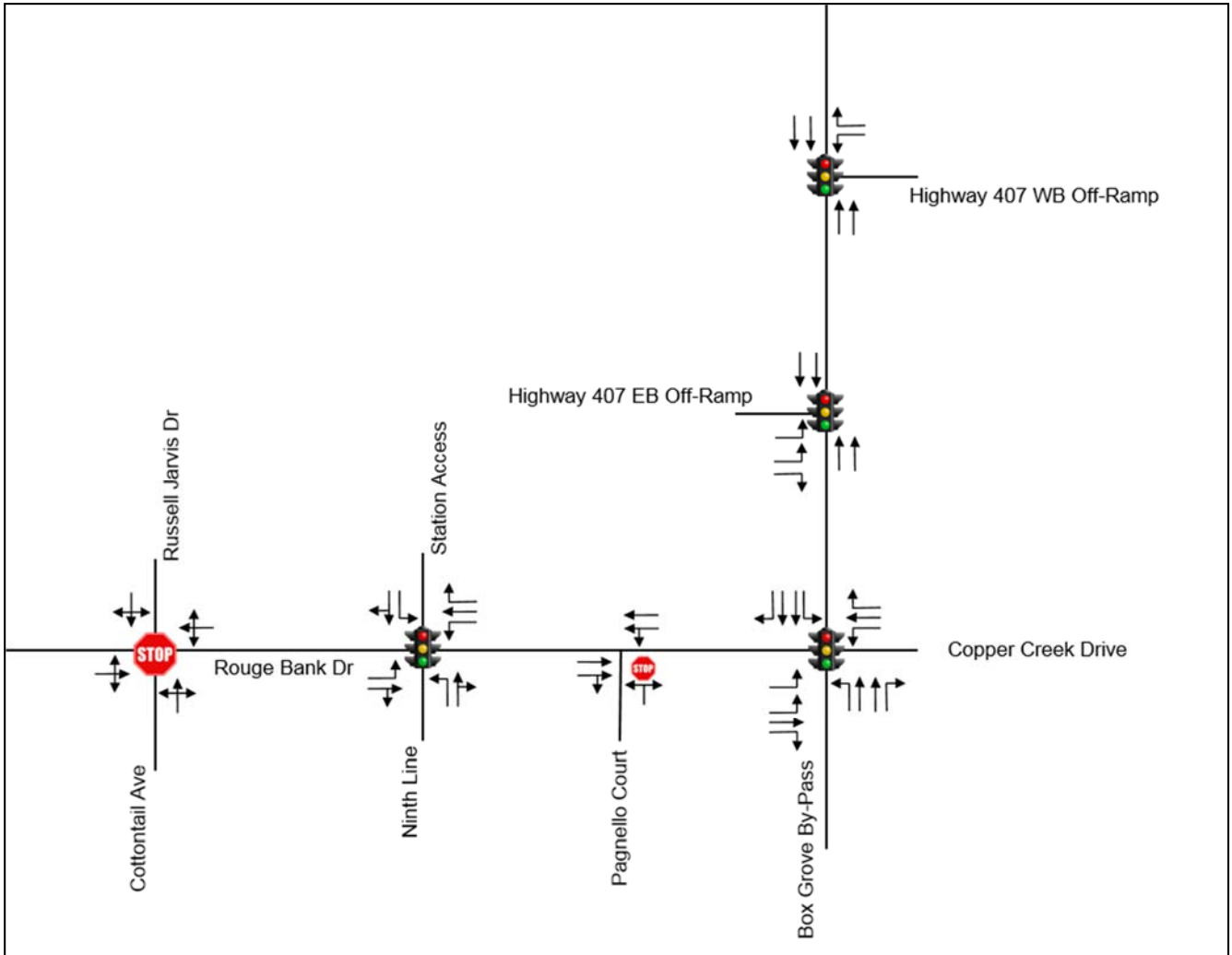
Exhibit 6-1: Future 2031 Total Mitigation Measures (with Donald Cousens) Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at 9th Line	A						WBL WBR	E E	0.06 0.03	5 8
Highway 407 East Off-Ramp at 9th Line	C	EBL EBR NBT	D E C	0.87 0.94 0.91	145 #184 #242	C				
Copper Creek Drive / Rouge Bank Drive at 9th Line	C	EBL WBL	E E	0.85 0.51	#72 27	C	EBL WBL WBR	E E E	0.84 0.53 0.65	#81 38 63
9th Line at Rouge Bank Drive (signalized)	B					B				
Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive	B					A				

Exhibit 6-2: Future 2031 Total Mitigation Measures (without Donald Cousens) Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at 9th Line	A					A	WBL WBR	E E	0.06 0.09	5 9
Highway 407 East Off-Ramp at 9th Line	D	EBL EBR NBT	D E C	0.88 0.96 0.93	#148 #191 #250	C	EBL	D	0.86	160
Copper Creek Drive / Rouge Bank Drive at Box Grove By-Pass / 9th Line	C	EBL WBL WBR	E E E	0.84 0.47 0.70	#75 27 74	C	EBL WBL WBT	E E E	0.85 0.57 0.55	#95 39 50
9th Line at Rouge Bank Drive (signalized)	A					B				
Cottontail Avenue / Russell Jarvis Drive at Rouge Bank Drive	B					A				

Exhibit 6-3: Future Recommended Intersection Configuration



7 Conclusion

This study presents the traffic impact analysis of the proposed Ninth Line Station on the surrounding road network. The proposed station is located at the southwest corner of the Highway 407 interchange at Ninth Line in the City of Markham, and can be accessed through the intersection of Rouge Bank Drive and Ninth Line.

Background traffic analysis in the existing conditions year of 2015 show that the station access intersection, Rouge Bank Drive at Ninth Line, operates well at LOS B in both analysis peak hours. The westbound left turn movement, primarily used by short-cutting traffic between Ninth Line north of Copper Creek Drive and 14th Avenue west of Ninth Line, operates at LOS C. Other intersections in the study area show several movements approaching or operating at capacity in both peak hours, such as the eastbound left turn in the Highway 407 eastbound off-ramp at Ninth Line.

Background traffic analysis in the future horizon year of 2031 show that the westbound left turn movement at the station access intersection deteriorates to LOS E in the a.m. peak hour. Other movements found to be critical in the existing conditions, such as the eastbound left turn at the Highway 407 eastbound off-ramp, further deteriorate in operational performance with higher delays and longer queues.

Site traffic for the proposed Ninth Line station was calculated based on the Greater Golden Horseshoe model's projected park-and-ride demand, the required number of on-site parking spaces, and the ITE trip generation manual rates. Two scenarios were considered: with and without Donald Cousens Parkway Station, where the latter scenario would generate additional traffic in the absence of a Transitway station on Donald Cousens Parkway. For the scenario with Donald Cousens Parkway Station, the proposed Ninth Line Station generates 391 (92) inbound and 96 (320) outbound trips in the a.m. (p.m.) peak hour. For the scenario without Donald Cousens Parkway Station, the proposed Ninth Line Station generates 629 (154) inbound and 148 (515) outbound trips in the a.m. (p.m.) peak hour.

The addition of site-generated traffic, for both with- and without- Donald Cousens Parkway Station scenarios, causes the site access intersection to fail (LOS F) during both peak hours. In addition, eastbound left turn at the intersection of Rouge Bank Drive / Copper Creek Drive and Box Grove Bypass / Ninth Line which is used by a large percentage of (~65%) site-exiting traffic deteriorates to LOS F in both scenarios.

Internally, the site is expected to operate with no operational issues. Conflicts between buses, park-and-ride vehicles, and kiss-and-ride vehicles are expected to be minimal due to the separation of their access points and the peak hour directional bias of the park-and-ride vehicles.

Summary of Recommendations

To mitigate the impacts of site-generated traffic, the following are recommended:

- Rouge Bank Drive at Ninth Line (station access intersection): signalization and additional westbound right turn lane;
- Rouge Bank Drive at Pagnello Court: additional eastbound through lane; and
- Copper Creek Drive / Rouge Bank Drive at Box Grove By-Pass / Ninth Line: additional eastbound left turn lane and re-optimization of signal timings.

To mitigate congestion caused by background traffic in the study area, the following is recommended:

- Highway 407 Eastbound Off-ramp at Ninth Line: additional eastbound left turn lane.

To address the short-cutting issue in on Rouge Bank Drive, it is recommended to:

- Prohibit the westbound left turn during a.m. peak period at the intersection of Rouge Bank Drive and Ninth Line, and/or
- Discourage short-cutting traffic by lowering the speed limit and/or implementing traffic calming measures on local north-south roads such as Ninth Line, Cottontail Avenue, and Legacy Drive.

For the future total scenario with Donald Cousens Parkway Station, the above mitigation measures are sufficient in improving the study area intersections to operate with all movements at volume-to-capacity ratio of 0.85 or lower.

For the future total scenario without Donald Cousens Parkway Station, the additional station demand requires an additional operational measure to be implemented at the intersection of Copper Creek Drive / Rouge Bank Drive and Box Grove By-Pass / Ninth Line:

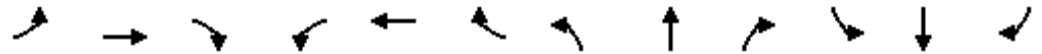
- Remove the pedestrian crossing in the north leg (force all east-west pedestrians to the south leg crossing) and re-optimize signal phase timings.

Appendix A – Existing (2015) Conditions Synchro Output

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	386	61	15	39	127	304	52	484	33	206	327	407
v/c Ratio	0.80	0.14	0.03	0.30	0.56	0.68	0.11	0.30	0.04	0.36	0.16	0.37
Control Delay	49.1	41.8	0.1	63.2	63.2	14.5	24.3	24.5	0.1	13.8	13.6	2.4
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	49.1	41.8	0.1	63.2	63.2	14.5	24.3	24.5	0.1	13.8	13.6	2.4
Queue Length 50th (m)	82.6	12.9	0.0	9.7	31.3	2.3	7.5	40.2	0.0	21.9	19.4	0.0
Queue Length 95th (m)	107.3	24.2	0.0	21.0	49.4	28.8	18.3	61.6	0.0	38.2	30.2	14.6
Internal Link Dist (m)		171.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	480	702	670	151	557	681	470	1613	806	577	2063	1095
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.80	0.09	0.02	0.26	0.23	0.45	0.11	0.30	0.04	0.36	0.16	0.37

Intersection Summary

HCM Signalized Intersection Capacity Analysis
 8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	367	58	14	37	121	289	49	460	31	196	311	387
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.53	1.00	1.00	0.95	1.00	1.00	0.55	1.00	1.00	0.41	1.00	1.00
Satd. Flow (perm)	1004	1883	1601	1789	1883	1601	1044	3579	1601	779	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	386	61	15	39	127	304	52	484	33	206	327	407
RTOR Reduction (vph)	0	0	12	0	0	257	0	0	18	0	0	175
Lane Group Flow (vph)	386	61	3	39	127	47	52	484	15	206	327	232
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	40.5	28.6	28.6	6.9	15.5	15.5	56.6	56.6	56.6	73.0	73.0	73.0
Effective Green, g (s)	41.5	29.6	29.6	7.9	16.5	16.5	57.6	57.6	57.6	74.0	74.0	74.0
Actuated g/C Ratio	0.32	0.23	0.23	0.06	0.13	0.13	0.44	0.44	0.44	0.57	0.57	0.57
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	453	428	364	108	238	203	462	1585	709	547	2037	911
v/s Ratio Prot	c0.14	0.03		0.02	0.07			0.14		c0.04	0.09	
v/s Ratio Perm	c0.13		0.00			0.03	0.05		0.01	c0.18		0.14
v/c Ratio	0.85	0.14	0.01	0.36	0.53	0.23	0.11	0.31	0.02	0.38	0.16	0.25
Uniform Delay, d1	38.9	40.1	38.9	58.6	53.1	51.1	21.2	23.3	20.3	13.9	13.3	14.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	14.3	0.2	0.0	2.1	2.3	0.6	0.5	0.5	0.1	0.4	0.2	0.7
Delay (s)	53.3	40.2	38.9	60.7	55.4	51.6	21.7	23.8	20.4	14.4	13.4	14.8
Level of Service	D	D	D	E	E	D	C	C	C	B	B	B
Approach Delay (s)		51.1			53.4			23.4			14.2	
Approach LOS		D			D			C			B	

Intersection Summary		
HCM 2000 Control Delay	30.9	HCM 2000 Level of Service
HCM 2000 Volume to Capacity ratio	0.58	C
Actuated Cycle Length (s)	130.0	Sum of lost time (s)
Intersection Capacity Utilization	99.9%	21.5
Analysis Period (min)	15	ICU Level of Service
		F
c	Critical Lane Group	

Queues

14: Ninth Line & Highway 407 WB

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	4	26	786	1079
v/c Ratio	0.02	0.15	0.25	0.34
Control Delay	50.2	20.3	3.9	2.5
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	50.2	20.3	3.9	2.5
Queue Length 50th (m)	0.9	0.0	37.6	29.2
Queue Length 95th (m)	4.4	8.7	m45.3	35.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	700	642	3167	3167
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.04	0.25	0.34

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Ninth Line & Highway 407 WB

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	4	25	747	0	0	1025
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	4	26	786	0	0	1079
RTOR Reduction (vph)	0	24	0	0	0	0
Lane Group Flow (vph)	4	2	786	0	0	1079
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	100.0			100.0
Effective Green, g (s)	7.0	7.0	101.0			101.0
Actuated g/C Ratio	0.06	0.06	0.84			0.84
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	104	93	3012			3012
v/s Ratio Prot	c0.00		0.22			c0.30
v/s Ratio Perm		0.00				
v/c Ratio	0.04	0.02	0.26			0.36
Uniform Delay, d1	53.3	53.3	1.9			2.2
Progression Factor	1.00	1.00	1.94			1.00
Incremental Delay, d2	0.2	0.1	0.1			0.3
Delay (s)	53.5	53.3	3.8			2.5
Level of Service	D	D	A			A
Approach Delay (s)	53.3		3.8			2.5
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.9	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	88.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Ninth Line & Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	774	400	1262	813
v/c Ratio	0.91	0.50	0.83	0.54
Control Delay	44.6	19.2	37.4	25.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	44.6	19.2	37.4	25.8
Queue Length 50th (m)	156.3	48.6	142.6	77.0
Queue Length 95th (m)	#233.1	74.6	173.4	96.7
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	894	837	1516	1516
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.87	0.48	0.83	0.54

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Ninth Line & Highway 407 EB

7/7/2015






















Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	735	380	0	1199	772	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	774	400	0	1262	813	0
RTOR Reduction (vph)	0	38	0	0	0	0
Lane Group Flow (vph)	774	362	0	1262	813	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	56.2	56.2		49.8	49.8	
Effective Green, g (s)	57.2	57.2		50.8	50.8	
Actuated g/C Ratio	0.48	0.48		0.42	0.42	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	852	763		1515	1515	
v/s Ratio Prot	c0.43			c0.35	0.23	
v/s Ratio Perm		0.23				
v/c Ratio	0.91	0.47		0.83	0.54	
Uniform Delay, d1	29.0	21.2		30.8	25.8	
Progression Factor	1.00	1.00		1.00	0.92	
Incremental Delay, d2	13.3	0.5		5.5	1.3	
Delay (s)	42.3	21.7		36.3	25.0	
Level of Service	D	C		D	C	
Approach Delay (s)	35.3			36.3	25.0	
Approach LOS	D			D	C	

Intersection Summary

HCM 2000 Control Delay	33.1	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	88.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	257	32	380	237	4	11	0	155	4	2	0
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	271	34	400	249	4	12	0	163	4	2	0
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	304	400	254	12	163	4	2					
Volume Left (vph)	0	400	0	12	0	4	0					
Volume Right (vph)	34	0	4	0	163	0	0					
Hadj (s)	-0.03	0.53	0.02	0.53	-0.67	0.53	0.03					
Departure Headway (s)	5.7	6.0	5.4	7.4	6.1	7.8	7.3					
Degree Utilization, x	0.48	0.66	0.38	0.02	0.28	0.01	0.00					
Capacity (veh/h)	606	595	647	456	544	412	439					
Control Delay (s)	14.0	18.6	10.6	9.3	10.3	9.6	9.1					
Approach Delay (s)	14.0	15.5		10.2		9.4						
Approach LOS	B	C		B		A						
Intersection Summary												
Delay			14.3									
Level of Service			B									
Intersection Capacity Utilization			56.1%	ICU Level of Service								B
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	9	116	4	15	156	80	7	9	23	169	23	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	9	122	4	16	164	84	7	9	24	178	24	21

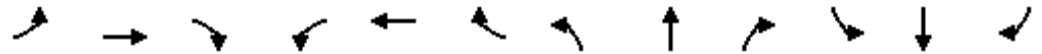
Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	136	264	41	223
Volume Left (vph)	9	16	7	178
Volume Right (vph)	4	84	24	21
Hadj (s)	0.03	-0.15	-0.28	0.14
Departure Headway (s)	5.0	4.6	4.9	5.1
Degree Utilization, x	0.19	0.34	0.06	0.31
Capacity (veh/h)	670	732	649	662
Control Delay (s)	9.1	10.0	8.2	10.4
Approach Delay (s)	9.1	10.0	8.2	10.4
Approach LOS	A	B	A	B

Intersection Summary			
Delay		9.8	
Level of Service		A	
Intersection Capacity Utilization	42.5%		ICU Level of Service A
Analysis Period (min)		15	

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

6/24/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	307	123	27	63	120	278	19	287	74	340	449	349
v/c Ratio	0.64	0.30	0.06	0.46	0.55	0.65	0.05	0.19	0.10	0.46	0.22	0.32
Control Delay	40.4	45.5	0.3	67.9	63.1	13.0	27.9	26.5	0.3	14.9	13.8	2.3
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	40.4	45.5	0.3	67.9	63.1	13.0	27.9	26.5	0.3	14.9	13.8	2.3
Queue Length 50th (m)	62.5	27.6	0.0	15.6	29.6	0.0	2.8	24.0	0.0	39.2	27.5	0.0
Queue Length 95th (m)	83.7	43.4	0.0	30.4	47.2	24.6	9.5	40.6	0.0	63.7	40.7	13.7
Internal Link Dist (m)		172.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	480	702	670	151	557	669	385	1487	756	739	2085	1078
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.64	0.18	0.04	0.42	0.22	0.42	0.05	0.19	0.10	0.46	0.22	0.32

Intersection Summary

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

6/24/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	292	117	26	60	114	264	18	273	70	323	427	332
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.55	1.00	1.00	0.95	1.00	1.00	0.49	1.00	1.00	0.54	1.00	1.00
Satd. Flow (perm)	1039	1883	1601	1789	1883	1601	927	3579	1601	1026	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	307	123	27	63	120	278	19	287	74	340	449	349
RTOR Reduction (vph)	0	0	21	0	0	243	0	0	44	0	0	148
Lane Group Flow (vph)	307	123	6	63	120	35	19	287	30	340	449	201
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	39.8	27.1	27.1	7.7	15.2	15.2	52.0	52.0	52.0	73.7	73.7	73.7
Effective Green, g (s)	40.8	28.1	28.1	8.7	16.2	16.2	53.0	53.0	53.0	74.7	74.7	74.7
Actuated g/C Ratio	0.31	0.22	0.22	0.07	0.12	0.12	0.41	0.41	0.41	0.57	0.57	0.57
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	450	407	346	119	234	199	377	1459	652	699	2056	919
v/s Ratio Prot	c0.11	0.07		0.04	0.06			0.08		c0.07	0.13	
v/s Ratio Perm	c0.10		0.00			0.02	0.02		0.02	c0.21		0.13
v/c Ratio	0.68	0.30	0.02	0.53	0.51	0.17	0.05	0.20	0.05	0.49	0.22	0.22
Uniform Delay, d1	37.0	42.7	40.1	58.7	53.2	50.9	23.3	24.8	23.2	14.6	13.4	13.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	4.2	0.4	0.0	4.2	1.9	0.4	0.3	0.3	0.1	0.5	0.2	0.5
Delay (s)	41.2	43.1	40.1	62.9	55.1	51.3	23.5	25.1	23.4	15.1	13.7	14.0
Level of Service	D	D	D	E	E	D	C	C	C	B	B	B
Approach Delay (s)		41.7			53.9			24.7			14.2	
Approach LOS		D			D			C			B	

Intersection Summary

HCM 2000 Control Delay	28.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	90.8%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Highway 407 WB & Ninth Line

6/24/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	3	12	1527	779
v/c Ratio	0.02	0.08	0.46	0.23
Control Delay	55.0	26.7	2.2	1.4
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.0	26.7	2.2	1.4
Queue Length 50th (m)	0.7	0.0	0.0	0.0
Queue Length 95th (m)	3.9	6.3	60.0	23.4
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	633	574	3325	3325
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.00	0.02	0.46	0.23

Intersection Summary

HCM Signalized Intersection Capacity Analysis

14: Highway 407 WB & Ninth Line

6/24/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	3	11	1451	0	0	740
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	3	12	1527	0	0	779
RTOR Reduction (vph)	0	12	0	0	0	0
Lane Group Flow (vph)	3	0	1527	0	0	779
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.0	4.0	112.0			112.0
Effective Green, g (s)	5.0	5.0	113.0			113.0
Actuated g/C Ratio	0.04	0.04	0.87			0.87
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	68	61	3110			3110
v/s Ratio Prot	c0.00		c0.43			0.22
v/s Ratio Perm		0.00				
v/c Ratio	0.04	0.01	0.49			0.25
Uniform Delay, d1	60.2	60.1	1.9			1.4
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.3	0.0	0.6			0.2
Delay (s)	60.5	60.2	2.5			1.6
Level of Service	E	E	A			A
Approach Delay (s)	60.2		2.5			1.6
Approach LOS	E		A			A

Intersection Summary

HCM 2000 Control Delay	2.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	88.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues
15: Highway 407 EB

6/24/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	774	357	873	782
v/c Ratio	0.85	0.42	0.61	0.54
Control Delay	38.6	18.4	36.6	35.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	38.6	18.4	36.6	35.0
Queue Length 50th (m)	173.0	48.4	102.6	88.9
Queue Length 95th (m)	212.8	66.0	132.4	116.0
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	1009	927	1440	1440
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.77	0.39	0.61	0.54
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

15: Highway 407 EB

6/24/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	735	339	0	829	743	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	774	357	0	873	782	0
RTOR Reduction (vph)	0	27	0	0	0	0
Lane Group Flow (vph)	774	330	0	873	782	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	70.6	70.6		55.4	55.4	
Effective Green, g (s)	71.6	71.6		56.4	56.4	
Actuated g/C Ratio	0.51	0.51		0.40	0.40	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	914	818		1441	1441	
v/s Ratio Prot	c0.43			c0.24	0.22	
v/s Ratio Perm		0.21				
v/c Ratio	0.85	0.40		0.61	0.54	
Uniform Delay, d1	29.5	21.1		33.0	31.9	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	7.3	0.3		1.9	1.5	
Delay (s)	36.8	21.4		34.9	33.4	
Level of Service	D	C		C	C	
Approach Delay (s)	31.9			34.9	33.4	
Approach LOS	C			C	C	




















Intersection Summary

HCM 2000 Control Delay	33.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	88.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

6/24/2015

															
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR			
Lane Configurations															
Sign Control		Stop			Stop			Stop			Stop				
Volume (vph)	0	275	10	205	223	0	15	0	149	0	0	0			
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95			
Hourly flow rate (vph)	0	289	11	216	235	0	16	0	157	0	0	0			
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2								
Volume Total (vph)	300	216	235	16	157	0	0								
Volume Left (vph)	0	216	0	16	0	0	0								
Volume Right (vph)	11	0	0	0	157	0	0								
Hadj (s)	0.01	0.53	0.03	0.53	-0.67	0.00	0.00								
Departure Headway (s)	5.6	5.9	5.4	6.9	5.7	6.7	6.7								
Degree Utilization, x	0.46	0.35	0.35	0.03	0.25	0.00	0.00								
Capacity (veh/h)	622	592	647	482	580	900	900								
Control Delay (s)	13.3	10.9	10.1	8.9	9.4	8.5	8.5								
Approach Delay (s)	13.3	10.5		9.3		0.0									
Approach LOS	B	B		A		A									
Intersection Summary															
Delay			11.2												
Level of Service			B												
Intersection Capacity Utilization			46.0%				ICU Level of Service				A				
Analysis Period (min)			15												

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

6/24/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔			↔			↔			↔	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	137	4	14	112	103	3	13	66	87	7	8
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	144	4	15	118	108	3	14	69	92	7	8
Direction, Lane #	EB 1	WB 1	NB 1	SB 1								
Volume Total (vph)	154	241	86	107								
Volume Left (vph)	5	15	3	92								
Volume Right (vph)	4	108	69	8								
Hadj (s)	0.02	-0.22	-0.44	0.16								
Departure Headway (s)	4.7	4.4	4.5	5.1								
Degree Utilization, x	0.20	0.29	0.11	0.15								
Capacity (veh/h)	719	783	720	649								
Control Delay (s)	8.9	9.1	8.1	9.0								
Approach Delay (s)	8.9	9.1	8.1	9.0								
Approach LOS	A	A	A	A								
Intersection Summary												
Delay			8.9									
Level of Service			A									
Intersection Capacity Utilization			37.4%	ICU Level of Service	A							
Analysis Period (min)			15									

Appendix B – Future (2031) Background Conditions Synchro Output

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	386	61	15	54	127	418	52	664	45	283	449	559
v/c Ratio	0.95	0.17	0.04	0.45	0.50	0.80	0.12	0.39	0.05	0.53	0.20	0.47
Control Delay	74.6	44.2	0.1	70.5	57.5	21.2	24.7	25.1	0.1	14.7	12.1	2.5
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	74.6	44.2	0.1	70.5	57.5	21.2	24.7	25.1	0.1	14.7	12.1	2.5
Queue Length 50th (m)	88.8	13.7	0.0	13.5	31.0	14.7	7.0	54.6	0.0	27.4	24.3	0.0
Queue Length 95th (m)	#109.0	23.6	0.0	27.4	45.9	47.8	19.8	92.1	0.0	53.0	41.3	16.3
Internal Link Dist (m)		171.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	407	622	607	123	550	719	437	1688	837	560	2200	1199
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.95	0.10	0.02	0.44	0.23	0.58	0.12	0.39	0.05	0.51	0.20	0.47

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	367	58	14	51	121	397	49	631	43	269	427	531
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.55	1.00	1.00	0.95	1.00	1.00	0.49	1.00	1.00	0.32	1.00	1.00
Satd. Flow (perm)	1039	1883	1601	1789	1883	1601	927	3579	1601	600	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	386	61	15	54	127	418	52	664	45	283	449	559
RTOR Reduction (vph)	0	0	12	0	0	305	0	0	24	0	0	220
Lane Group Flow (vph)	386	61	3	54	127	113	52	664	21	283	449	339
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	35.6	24.2	24.2	6.4	17.6	17.6	59.3	59.3	59.3	77.9	77.9	77.9
Effective Green, g (s)	36.6	25.2	25.2	7.4	18.6	18.6	60.3	60.3	60.3	78.9	78.9	78.9
Actuated g/C Ratio	0.28	0.19	0.19	0.06	0.14	0.14	0.46	0.46	0.46	0.61	0.61	0.61
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	379	365	310	101	269	229	429	1660	742	506	2172	971
v/s Ratio Prot	c0.12	0.03		0.03	0.07			0.19		c0.07	0.13	
v/s Ratio Perm	c0.17		0.00			0.07	0.06		0.01	c0.27		0.21
v/c Ratio	1.02	0.17	0.01	0.53	0.47	0.49	0.12	0.40	0.03	0.56	0.21	0.35
Uniform Delay, d1	45.1	43.7	42.3	59.6	51.2	51.4	19.8	22.9	18.9	12.9	11.5	12.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	51.0	0.2	0.0	5.4	1.3	1.7	0.6	0.7	0.1	1.3	0.2	1.0
Delay (s)	96.1	43.9	42.3	65.0	52.5	53.0	20.4	23.7	19.0	14.3	11.7	13.7
Level of Service	F	D	D	E	D	D	C	C	B	B	B	B
Approach Delay (s)		87.5			54.0			23.2			13.1	
Approach LOS		F			D			C			B	

Intersection Summary

HCM 2000 Control Delay	34.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	99.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Ninth Line & Highway 407 WB

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	6	36	1079	1481
v/c Ratio	0.04	0.20	0.34	0.47
Control Delay	50.3	18.6	1.2	3.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	50.3	18.6	1.2	3.1
Queue Length 50th (m)	1.3	0.0	16.7	47.7
Queue Length 95th (m)	5.5	10.1	m13.6	57.6
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	357	349	3167	3167
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.02	0.10	0.34	0.47

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Ninth Line & Highway 407 WB

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	6	34	1025	0	0	1407
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	36	1079	0	0	1481
RTOR Reduction (vph)	0	34	0	0	0	0
Lane Group Flow (vph)	6	2	1079	0	0	1481
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	100.0			100.0
Effective Green, g (s)	7.0	7.0	101.0			101.0
Actuated g/C Ratio	0.06	0.06	0.84			0.84
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	104	93	3012			3012
v/s Ratio Prot	c0.00		0.30			c0.41
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.02	0.36			0.49
Uniform Delay, d1	53.4	53.3	2.2			2.6
Progression Factor	1.00	1.00	0.55			1.00
Incremental Delay, d2	0.2	0.1	0.0			0.6
Delay (s)	53.6	53.4	1.2			3.1
Level of Service	D	D	A			A
Approach Delay (s)	53.4		1.2			3.1
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	111.4%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Ninth Line & Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	549	1733	1115
v/c Ratio	1.27	0.72	1.12	0.72
Control Delay	162.2	30.4	95.4	28.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	162.2	30.4	95.4	28.3
Queue Length 50th (m)	~315.8	95.4	~246.9	111.5
Queue Length 95th (m)	#393.2	138.3	#289.2	136.4
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	834	765	1550	1550
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.27	0.72	1.12	0.72

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Ninth Line & Highway 407 EB

7/7/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	522	0	1646	1059	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	549	0	1733	1115	0
RTOR Reduction (vph)	0	18	0	0	0	0
Lane Group Flow (vph)	1062	531	0	1733	1115	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	55.0	55.0		51.0	51.0	
Effective Green, g (s)	56.0	56.0		52.0	52.0	
Actuated g/C Ratio	0.47	0.47		0.43	0.43	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	834	747		1550	1550	
v/s Ratio Prot	c0.59			c0.48	0.31	
v/s Ratio Perm		0.33				
v/c Ratio	1.27	0.71		1.12	0.72	
Uniform Delay, d1	32.0	25.5		34.0	28.0	
Progression Factor	1.00	1.00		1.00	0.91	
Incremental Delay, d2	132.4	3.2		62.5	2.6	
Delay (s)	164.4	28.7		96.5	28.0	
Level of Service	F	C		F	C	
Approach Delay (s)	118.1			96.5	28.0	
Approach LOS	F			F	C	





















Intersection Summary

HCM 2000 Control Delay	87.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.20		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	111.4%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	257	32	522	237	4	11	0	155	4	2	0
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	271	34	549	249	4	12	0	163	4	2	0
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	304	549	254	12	163	4	2					
Volume Left (vph)	0	549	0	12	0	4	0					
Volume Right (vph)	34	0	4	0	163	0	0					
Hadj (s)	-0.03	0.53	0.02	0.53	-0.67	0.53	0.03					
Departure Headway (s)	5.9	6.0	5.5	7.7	6.5	8.1	7.6					
Degree Utilization, x	0.50	0.92	0.39	0.02	0.29	0.01	0.00					
Capacity (veh/h)	590	549	643	454	538	417	444					
Control Delay (s)	14.6	42.1	10.7	9.7	10.9	10.0	9.5					
Approach Delay (s)	14.6	32.2		10.8		9.8						
Approach LOS	B	D		B		A						
Intersection Summary												
Delay			25.0									
Level of Service			D									
Intersection Capacity Utilization			64.0%		ICU Level of Service		B					
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	9	116	4	15	156	80	7	9	23	169	23	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	9	122	4	16	164	84	7	9	24	178	24	21

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	136	264	41	223
Volume Left (vph)	9	16	7	178
Volume Right (vph)	4	84	24	21
Hadj (s)	0.03	-0.15	-0.28	0.14
Departure Headway (s)	5.0	4.6	4.9	5.1
Degree Utilization, x	0.19	0.34	0.06	0.31
Capacity (veh/h)	670	732	649	662
Control Delay (s)	9.1	10.0	8.2	10.4
Approach Delay (s)	9.1	10.0	8.2	10.4
Approach LOS	A	B	A	B

Intersection Summary			
Delay		9.8	
Level of Service		A	
Intersection Capacity Utilization	42.5%		ICU Level of Service A
Analysis Period (min)		15	

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	307	123	27	86	120	381	19	395	101	466	617	480
v/c Ratio	1.01	0.56	0.10	0.70	0.49	0.70	0.05	0.23	0.12	0.60	0.26	0.39
Control Delay	102.5	63.7	0.7	88.5	58.4	12.4	22.2	21.2	3.8	11.7	9.1	1.8
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	102.5	63.7	0.7	88.5	58.4	12.4	22.2	21.2	3.8	11.7	9.1	1.8
Queue Length 50th (m)	~73.5	30.3	0.0	22.0	29.0	0.0	2.5	29.5	0.0	43.1	30.2	0.0
Queue Length 95th (m)	#117.8	48.2	0.0	#46.4	46.5	28.5	8.5	48.8	9.1	69.7	43.8	11.7
Internal Link Dist (m)		172.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	303	550	545	123	579	756	383	1744	838	803	2406	1233
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.01	0.22	0.05	0.70	0.21	0.50	0.05	0.23	0.12	0.58	0.26	0.39

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

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

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	292	117	26	82	114	362	18	375	96	443	586	456
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.68	1.00	1.00	0.95	1.00	1.00	0.42	1.00	1.00	0.48	1.00	1.00
Satd. Flow (perm)	1281	1883	1601	1789	1883	1601	787	3579	1601	908	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	307	123	27	86	120	381	19	395	101	466	617	480
RTOR Reduction (vph)	0	0	24	0	0	331	0	0	52	0	0	157
Lane Group Flow (vph)	307	123	3	86	120	50	19	395	49	466	617	323
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	21.2	14.2	14.2	7.9	16.1	16.1	62.4	62.4	62.4	86.4	86.4	86.4
Effective Green, g (s)	23.2	15.2	15.2	8.9	17.1	17.1	63.4	63.4	63.4	87.4	87.4	87.4
Actuated g/C Ratio	0.18	0.12	0.12	0.07	0.13	0.13	0.49	0.49	0.49	0.67	0.67	0.67
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	259	220	187	122	247	210	383	1745	780	752	2406	1076
v/s Ratio Prot	c0.07	0.07		0.05	0.06			0.11		c0.10	0.17	
v/s Ratio Perm	c0.14		0.00			0.03	0.02		0.03	c0.32		0.20
v/c Ratio	1.19	0.56	0.02	0.70	0.49	0.24	0.05	0.23	0.06	0.62	0.26	0.30
Uniform Delay, d1	52.4	54.2	50.8	59.3	52.4	50.6	17.5	19.2	17.6	9.6	8.4	8.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	115.5	3.1	0.0	16.9	1.5	0.6	0.2	0.3	0.2	1.5	0.3	0.7
Delay (s)	167.9	57.3	50.8	76.2	53.9	51.2	17.7	19.5	17.8	11.1	8.7	9.5
Level of Service	F	E	D	E	D	D	B	B	B	B	A	A
Approach Delay (s)		131.2			55.4			19.1			9.7	
Approach LOS		F			E			B			A	

Intersection Summary

HCM 2000 Control Delay	37.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	90.8%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Highway 407 WB & Ninth Line

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	4	16	2097	1069
v/c Ratio	0.03	0.11	0.63	0.32
Control Delay	55.2	24.5	3.5	1.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.2	24.5	3.5	1.7
Queue Length 50th (m)	1.0	0.0	0.0	0.0
Queue Length 95th (m)	4.6	7.3	114.0	34.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	302	284	3325	3325
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.06	0.63	0.32

Intersection Summary

HCM Signalized Intersection Capacity Analysis

14: Highway 407 WB & Ninth Line

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	4	15	1992	0	0	1016
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	4	16	2097	0	0	1069
RTOR Reduction (vph)	0	15	0	0	0	0
Lane Group Flow (vph)	4	1	2097	0	0	1069
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.0	4.0	112.0			112.0
Effective Green, g (s)	5.0	5.0	113.0			113.0
Actuated g/C Ratio	0.04	0.04	0.87			0.87
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	68	61	3110			3110
v/s Ratio Prot	c0.00		c0.59			0.30
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.01	0.67			0.34
Uniform Delay, d1	60.2	60.1	2.7			1.6
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.1	1.2			0.3
Delay (s)	60.6	60.2	3.9			1.9
Level of Service	E	E	A			A
Approach Delay (s)	60.3		3.9			1.9
Approach LOS	E		A			A

Intersection Summary

HCM 2000 Control Delay	3.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	103.4%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Queues
15: Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	489	1198	1074
v/c Ratio	1.03	0.52	1.00	0.89
Control Delay	64.4	19.8	71.5	54.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	64.4	19.8	71.5	54.8
Queue Length 50th (m)	~312.8	76.4	174.0	148.4
Queue Length 95th (m)	#392.6	106.4	#222.8	#179.6
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	1035	932	1201	1201
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.03	0.52	1.00	0.89

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Highway 407 EB

7/7/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	465	0	1138	1020	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	489	0	1198	1074	0
RTOR Reduction (vph)	0	6	0	0	0	0
Lane Group Flow (vph)	1062	483	0	1198	1074	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	80.0	80.0		46.0	46.0	
Effective Green, g (s)	81.0	81.0		47.0	47.0	
Actuated g/C Ratio	0.58	0.58		0.34	0.34	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1035	926		1201	1201	
v/s Ratio Prot	c0.59			c0.33	0.30	
v/s Ratio Perm		0.30				
v/c Ratio	1.03	0.52		1.00	0.89	
Uniform Delay, d1	29.5	17.8		46.4	44.1	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	34.8	0.5		25.4	10.4	
Delay (s)	64.3	18.3		71.8	54.5	
Level of Service	E	B		E	D	
Approach Delay (s)	49.8			71.8	54.5	
Approach LOS	D			E	D	




















Intersection Summary

HCM 2000 Control Delay	58.0	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	103.4%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	0	275	10	281	223	0	15	0	149	0	0	0
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	289	11	296	235	0	16	0	157	0	0	0
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	300	296	235	16	157	0	0					
Volume Left (vph)	0	296	0	16	0	0	0					
Volume Right (vph)	11	0	0	0	157	0	0					
Hadj (s)	0.01	0.53	0.03	0.53	-0.67	0.00	0.00					
Departure Headway (s)	5.7	5.9	5.4	7.1	5.9	6.9	6.9					
Degree Utilization, x	0.47	0.49	0.35	0.03	0.26	0.00	0.00					
Capacity (veh/h)	611	593	646	470	563	900	900					
Control Delay (s)	13.7	13.2	10.2	9.1	9.7	8.7	8.7					
Approach Delay (s)	13.7	11.9		9.6		0.0						
Approach LOS	B	B		A		A						
Intersection Summary												
Delay			12.0									
Level of Service			B									
Intersection Capacity Utilization			49.9%	ICU Level of Service								A
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔			↔			↔			↔	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	137	4	14	112	103	3	13	66	87	7	8
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	144	4	15	118	108	3	14	69	92	7	8

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	154	241	86	107
Volume Left (vph)	5	15	3	92
Volume Right (vph)	4	108	69	8
Hadj (s)	0.02	-0.22	-0.44	0.16
Departure Headway (s)	4.7	4.4	4.5	5.1
Degree Utilization, x	0.20	0.29	0.11	0.15
Capacity (veh/h)	719	783	720	649
Control Delay (s)	8.9	9.1	8.1	9.0
Approach Delay (s)	8.9	9.1	8.1	9.0
Approach LOS	A	A	A	A

Intersection Summary			
Delay		8.9	
Level of Service		A	
Intersection Capacity Utilization	37.4%		ICU Level of Service A
Analysis Period (min)		15	

Appendix C – Future (2031) Total Conditions Synchro Output

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	449	66	26	54	148	418	103	664	45	283	449	826
v/c Ratio	1.04	0.16	0.06	0.45	0.53	0.82	0.26	0.43	0.06	0.56	0.21	0.68
Control Delay	92.7	40.7	0.2	70.5	56.5	26.4	29.7	28.8	0.1	17.2	14.1	6.5
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	92.7	40.7	0.2	70.5	56.5	26.4	29.7	28.8	0.1	17.2	14.1	6.5
Queue Length 50th (m)	~114.1	14.4	0.0	13.5	36.1	24.7	15.9	59.0	0.0	29.9	26.2	14.6
Queue Length 95th (m)	#137.5	23.6	0.0	27.4	50.7	57.7	38.2	97.5	0.0	58.2	45.0	67.3
Internal Link Dist (m)		171.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	432	651	630	123	550	693	403	1559	785	521	2097	1223
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.04	0.10	0.04	0.44	0.27	0.60	0.26	0.43	0.06	0.54	0.21	0.68

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	427	63	25	51	141	397	98	631	43	269	427	785
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.51	1.00	1.00	0.95	1.00	1.00	0.49	1.00	1.00	0.30	1.00	1.00
Satd. Flow (perm)	963	1883	1601	1789	1883	1601	927	3579	1601	573	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	449	66	26	54	148	418	103	664	45	283	449	826
RTOR Reduction (vph)	0	0	20	0	0	269	0	0	26	0	0	290
Lane Group Flow (vph)	449	66	6	54	148	149	103	664	19	283	449	536
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	39.3	27.9	27.9	6.4	19.3	19.3	54.6	54.6	54.6	74.2	74.2	74.2
Effective Green, g (s)	40.3	28.9	28.9	7.4	20.3	20.3	55.6	55.6	55.6	75.2	75.2	75.2
Actuated g/C Ratio	0.31	0.22	0.22	0.06	0.16	0.16	0.43	0.43	0.43	0.58	0.58	0.58
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	406	418	355	101	294	250	396	1530	684	486	2070	926
v/s Ratio Prot	c0.14	0.04		0.03	0.08			0.19		0.07	0.13	
v/s Ratio Perm	c0.20		0.00			0.09	0.11		0.01	c0.26		c0.33
v/c Ratio	1.11	0.16	0.02	0.53	0.50	0.60	0.26	0.43	0.03	0.58	0.22	0.58
Uniform Delay, d1	42.9	40.7	39.5	59.6	50.2	51.0	24.0	26.1	21.5	14.9	13.2	17.4
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	76.5	0.2	0.0	5.4	1.4	3.8	1.6	0.9	0.1	1.8	0.2	2.6
Delay (s)	119.4	40.9	39.5	65.0	51.6	54.8	25.5	27.0	21.6	16.7	13.4	20.0
Level of Service	F	D	D	E	D	D	C	C	C	B	B	B
Approach Delay (s)		105.9			54.9			26.6			17.5	
Approach LOS		F			D			C			B	

Intersection Summary

HCM 2000 Control Delay	39.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	103.2%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Ninth Line & Highway 407 WB

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	6	36	1142	1748
v/c Ratio	0.04	0.20	0.36	0.55
Control Delay	50.3	18.6	1.2	3.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	50.3	18.6	1.2	3.7
Queue Length 50th (m)	1.3	0.0	17.9	64.7
Queue Length 95th (m)	5.5	10.1	m14.3	77.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	327	322	3167	3167
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.02	0.11	0.36	0.55

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Ninth Line & Highway 407 WB

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↶	↶	↕	↷	↷	↕
Volume (vph)	6	34	1085	0	0	1661
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	36	1142	0	0	1748
RTOR Reduction (vph)	0	34	0	0	0	0
Lane Group Flow (vph)	6	2	1142	0	0	1748
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	100.0			100.0
Effective Green, g (s)	7.0	7.0	101.0			101.0
Actuated g/C Ratio	0.06	0.06	0.84			0.84
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	104	93	3012			3012
v/s Ratio Prot	c0.00		0.32			c0.49
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.02	0.38			0.58
Uniform Delay, d1	53.4	53.3	2.2			2.9
Progression Factor	1.00	1.00	0.54			1.00
Incremental Delay, d2	0.2	0.1	0.0			0.8
Delay (s)	53.6	53.4	1.2			3.8
Level of Service	D	D	A			A
Approach Delay (s)	53.4		1.2			3.8
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.5	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	113.1%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Ninth Line & Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	549	1796	1382
v/c Ratio	1.30	0.74	1.14	0.87
Control Delay	172.4	33.3	102.1	34.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	172.4	33.3	102.1	34.0
Queue Length 50th (m)	~319.5	100.9	~259.3	152.7
Queue Length 95th (m)	#396.9	145.3	#301.6	184.4
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	819	741	1580	1580
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.30	0.74	1.14	0.87

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Ninth Line & Highway 407 EB

7/7/2015






















Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	522	0	1706	1313	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	549	0	1796	1382	0
RTOR Reduction (vph)	0	8	0	0	0	0
Lane Group Flow (vph)	1062	541	0	1796	1382	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	54.0	54.0		52.0	52.0	
Effective Green, g (s)	55.0	55.0		53.0	53.0	
Actuated g/C Ratio	0.46	0.46		0.44	0.44	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	819	733		1580	1580	
v/s Ratio Prot	c0.59			c0.50	0.39	
v/s Ratio Perm		0.34				
v/c Ratio	1.30	0.74		1.14	0.87	
Uniform Delay, d1	32.5	26.6		33.5	30.5	
Progression Factor	1.00	1.00		1.00	0.90	
Incremental Delay, d2	142.5	3.9		69.9	6.1	
Delay (s)	175.0	30.5		103.4	33.5	
Level of Service	F	C		F	C	
Approach Delay (s)	125.8			103.4	33.5	
Approach LOS	F			F	C	

Intersection Summary

HCM 2000 Control Delay	90.7	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.22		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	113.1%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	20	257	32	522	237	327	11	48	155	80	13	5
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	21	271	34	549	249	344	12	51	163	84	14	5
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	325	549	594	12	214	84	19					
Volume Left (vph)	21	549	0	12	0	84	0					
Volume Right (vph)	34	0	344	0	163	0	5					
Hadj (s)	-0.02	0.53	-0.37	0.53	-0.50	0.53	-0.16					
Departure Headway (s)	6.8	6.9	6.0	8.3	7.3	8.6	7.9					
Degree Utilization, x	0.61	1.00	0.98	0.03	0.43	0.20	0.04					
Capacity (veh/h)	516	549	594	417	477	395	427					
Control Delay (s)	19.7	64.3	55.1	10.3	14.5	12.6	10.1					
Approach Delay (s)	19.7	59.5		14.3		12.1						
Approach LOS	C	F		B		B						
Intersection Summary												
Delay			43.9									
Level of Service			E									
Intersection Capacity Utilization			78.9%	ICU Level of Service								D
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	9	126	4	16	159	81	7	9	28	174	23	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	9	133	4	17	167	85	7	9	29	183	24	21

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	146	269	46	228
Volume Left (vph)	9	17	7	183
Volume Right (vph)	4	85	29	21
Hadj (s)	0.03	-0.14	-0.32	0.14
Departure Headway (s)	5.0	4.7	5.0	5.1
Degree Utilization, x	0.20	0.35	0.06	0.33
Capacity (veh/h)	663	723	642	654
Control Delay (s)	9.3	10.2	8.3	10.6
Approach Delay (s)	9.3	10.2	8.3	10.6
Approach LOS	A	B	A	B

Intersection Summary			
Delay		10.0	
Level of Service		B	
Intersection Capacity Utilization	43.6%		ICU Level of Service A
Analysis Period (min)		15	

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	526	140	69	86	125	381	32	395	101	466	617	545
v/c Ratio	1.38	0.51	0.21	0.57	0.55	0.72	0.10	0.27	0.14	0.62	0.27	0.45
Control Delay	220.6	57.7	2.4	72.1	61.9	13.1	29.4	27.9	3.8	14.9	11.7	2.2
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	220.6	57.7	2.4	72.1	61.9	13.1	29.4	27.9	3.8	14.9	11.7	2.2
Queue Length 50th (m)	~135.8	34.2	0.0	21.4	30.8	0.0	4.9	34.3	0.0	49.9	34.3	0.0
Queue Length 95th (m)	#233.6	51.9	2.1	38.5	48.1	28.5	14.4	55.8	8.6	82.7	51.2	14.2
Internal Link Dist (m)		172.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	382	579	573	165	550	737	323	1473	730	753	2248	1208
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.38	0.24	0.12	0.52	0.23	0.52	0.10	0.27	0.14	0.62	0.27	0.45

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

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

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	500	133	66	82	119	362	30	375	96	443	586	518
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.53	1.00	1.00	0.95	1.00	1.00	0.42	1.00	1.00	0.46	1.00	1.00
Satd. Flow (perm)	1004	1883	1601	1789	1883	1601	787	3579	1601	873	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	526	140	69	86	125	381	32	395	101	466	617	545
RTOR Reduction (vph)	0	0	59	0	0	334	0	0	60	0	0	203
Lane Group Flow (vph)	526	140	10	86	125	47	32	395	41	466	617	342
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	31.9	17.9	17.9	10.0	14.9	14.9	52.4	52.4	52.4	80.6	80.6	80.6
Effective Green, g (s)	33.9	18.9	18.9	11.0	15.9	15.9	53.4	53.4	53.4	81.6	81.6	81.6
Actuated g/C Ratio	0.26	0.15	0.15	0.08	0.12	0.12	0.41	0.41	0.41	0.63	0.63	0.63
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	352	273	232	151	230	195	323	1470	657	725	2246	1004
v/s Ratio Prot	c0.17	0.07		0.05	0.07			0.11		c0.12	0.17	
v/s Ratio Perm	c0.22		0.01			0.03	0.04		0.03	c0.28		0.21
v/c Ratio	1.49	0.51	0.04	0.57	0.54	0.24	0.10	0.27	0.06	0.64	0.27	0.34
Uniform Delay, d1	46.4	51.3	47.8	57.2	53.6	51.6	23.5	25.4	23.2	12.4	10.9	11.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	237.0	1.6	0.1	4.9	2.6	0.6	0.6	0.4	0.2	2.0	0.3	0.9
Delay (s)	283.4	52.9	47.9	62.1	56.3	52.2	24.1	25.8	23.4	14.4	11.2	12.4
Level of Service	F	D	D	E	E	D	C	C	C	B	B	B
Approach Delay (s)		217.4			54.5			25.2			12.5	
Approach LOS		F			D			C			B	

Intersection Summary

HCM 2000 Control Delay	64.8	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	107.3%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Highway 407 WB & Ninth Line

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	4	16	2316	1135
v/c Ratio	0.03	0.11	0.70	0.34
Control Delay	55.2	26.3	4.4	1.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.2	26.3	4.4	1.7
Queue Length 50th (m)	1.0	0.3	0.0	0.0
Queue Length 95th (m)	4.6	7.5	148.8	37.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	302	283	3325	3325
Starvation Cap Reductn	0	0	35	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.06	0.70	0.34

Intersection Summary

HCM Signalized Intersection Capacity Analysis

14: Highway 407 WB & Ninth Line

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	4	15	2200	0	0	1078
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	4	16	2316	0	0	1135
RTOR Reduction (vph)	0	14	0	0	0	0
Lane Group Flow (vph)	4	2	2316	0	0	1135
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.0	4.0	112.0			112.0
Effective Green, g (s)	5.0	5.0	113.0			113.0
Actuated g/C Ratio	0.04	0.04	0.87			0.87
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	68	61	3110			3110
v/s Ratio Prot	c0.00		c0.65			0.32
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.03	0.74			0.36
Uniform Delay, d1	60.2	60.2	3.2			1.6
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.2	1.7			0.3
Delay (s)	60.6	60.3	4.8			2.0
Level of Service	E	E	A			A
Approach Delay (s)	60.4		4.8			2.0
Approach LOS	E		A			A

Intersection Summary

HCM 2000 Control Delay	4.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	103.4%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Queues
15: Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	489	1417	1139
v/c Ratio	1.09	0.56	1.07	0.86
Control Delay	89.3	23.2	86.5	48.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	89.3	23.2	86.5	48.3
Queue Length 50th (m)	~331.1	82.9	~227.4	152.2
Queue Length 95th (m)	#411.0	115.7	#270.1	181.4
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	971	876	1329	1329
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.09	0.56	1.07	0.86

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Highway 407 EB

7/7/2015






















Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	465	0	1346	1082	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	489	0	1417	1139	0
RTOR Reduction (vph)	0	8	0	0	0	0
Lane Group Flow (vph)	1062	481	0	1417	1139	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	75.0	75.0		51.0	51.0	
Effective Green, g (s)	76.0	76.0		52.0	52.0	
Actuated g/C Ratio	0.54	0.54		0.37	0.37	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	971	869		1329	1329	
v/s Ratio Prot	c0.59			c0.40	0.32	
v/s Ratio Perm		0.30				
v/c Ratio	1.09	0.55		1.07	0.86	
Uniform Delay, d1	32.0	20.9		44.0	40.6	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	57.9	0.8		44.4	7.3	
Delay (s)	89.9	21.7		88.4	47.9	
Level of Service	F	C		F	D	
Approach Delay (s)	68.4			88.4	47.9	
Approach LOS	E			F	D	

Intersection Summary

HCM 2000 Control Delay	69.6	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.08		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	103.4%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	275	10	281	223	79	15	12	149	264	40	16
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	289	11	296	235	83	16	13	157	278	42	17
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	305	296	318	16	169	278	59					
Volume Left (vph)	5	296	0	16	0	278	0					
Volume Right (vph)	11	0	83	0	157	0	17					
Hadj (s)	0.02	0.53	-0.15	0.53	-0.61	0.53	-0.17					
Departure Headway (s)	7.4	7.7	7.0	8.8	7.6	8.3	7.6					
Degree Utilization, x	0.63	0.63	0.62	0.04	0.36	0.64	0.12					
Capacity (veh/h)	457	457	495	377	426	408	452					
Control Delay (s)	22.2	21.8	19.5	10.9	13.6	23.6	10.4					
Approach Delay (s)	22.2	20.6		13.3		21.3						
Approach LOS	C	C		B		C						
Intersection Summary												
Delay			20.2									
Level of Service			C									
Intersection Capacity Utilization			69.7%	ICU Level of Service		C						
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	140	4	18	120	107	3	13	67	88	7	8
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	147	4	19	126	113	3	14	71	93	7	8
Direction, Lane #	EB 1	WB 1	NB 1	SB 1								
Volume Total (vph)	157	258	87	108								
Volume Left (vph)	5	19	3	93								
Volume Right (vph)	4	113	71	8								
Hadj (s)	0.02	-0.21	-0.44	0.16								
Departure Headway (s)	4.7	4.4	4.6	5.1								
Degree Utilization, x	0.21	0.31	0.11	0.15								
Capacity (veh/h)	713	779	708	638								
Control Delay (s)	8.9	9.4	8.2	9.1								
Approach Delay (s)	8.9	9.4	8.2	9.1								
Approach LOS	A	A	A	A								
Intersection Summary												
Delay			9.0									
Level of Service			A									
Intersection Capacity Utilization			40.1%	ICU Level of Service								A
Analysis Period (min)			15									

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	487	68	35	54	160	418	135	664	45	283	449	989
v/c Ratio	1.20	0.17	0.08	0.45	0.54	0.83	0.33	0.41	0.06	0.55	0.21	0.82
Control Delay	148.7	41.3	0.4	70.5	55.7	28.6	29.8	27.4	0.1	16.8	13.8	14.0
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	148.7	41.3	0.4	70.5	55.7	28.6	29.8	27.4	0.1	16.8	13.8	14.0
Queue Length 50th (m)	~151.4	15.0	0.0	13.5	39.0	30.2	21.3	57.7	0.0	29.1	25.6	63.6
Queue Length 95th (m)	#178.4	24.3	0.0	27.4	53.4	62.3	47.9	94.1	0.0	57.6	44.6	#194.9
Internal Link Dist (m)		171.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	405	622	607	123	550	681	415	1605	803	521	2122	1213
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.20	0.11	0.06	0.44	0.29	0.61	0.33	0.41	0.06	0.54	0.21	0.82

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.

Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	463	65	33	51	152	397	128	631	43	269	427	940
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.49	1.00	1.00	0.95	1.00	1.00	0.49	1.00	1.00	0.31	1.00	1.00
Satd. Flow (perm)	926	1883	1601	1789	1883	1601	927	3579	1601	584	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	487	68	35	54	160	418	135	664	45	283	449	989
RTOR Reduction (vph)	0	0	27	0	0	251	0	0	25	0	0	269
Lane Group Flow (vph)	487	68	8	54	160	167	135	664	20	283	449	720
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	38.4	27.0	27.0	6.4	20.4	20.4	56.3	56.3	56.3	75.1	75.1	75.1
Effective Green, g (s)	39.4	28.0	28.0	7.4	21.4	21.4	57.3	57.3	57.3	76.1	76.1	76.1
Actuated g/C Ratio	0.30	0.22	0.22	0.06	0.16	0.16	0.44	0.44	0.44	0.59	0.59	0.59
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	380	405	344	101	309	263	408	1577	705	488	2095	937
v/s Ratio Prot	c0.15	0.04		0.03	0.08			0.19		0.07	0.13	
v/s Ratio Perm	c0.24		0.00			0.10	0.15		0.01	0.27		c0.45
v/c Ratio	1.28	0.17	0.02	0.53	0.52	0.63	0.33	0.42	0.03	0.58	0.21	0.77
Uniform Delay, d1	43.5	41.5	40.2	59.6	49.6	50.6	23.8	25.0	20.6	14.4	12.8	20.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	145.5	0.2	0.0	5.4	1.5	4.9	2.2	0.8	0.1	1.7	0.2	6.0
Delay (s)	189.0	41.7	40.2	65.0	51.1	55.6	26.0	25.8	20.7	16.1	13.0	26.4
Level of Service	F	D	D	E	D	E	C	C	C	B	B	C
Approach Delay (s)		163.2			55.2			25.5			21.2	
Approach LOS		F			E			C			C	

Intersection Summary

HCM 2000 Control Delay	50.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	109.5%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Ninth Line & Highway 407 WB

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	6	36	1180	1912
v/c Ratio	0.04	0.20	0.37	0.60
Control Delay	50.3	18.6	1.3	4.2
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	50.3	18.6	1.3	4.2
Queue Length 50th (m)	1.3	0.0	18.7	77.6
Queue Length 95th (m)	5.5	10.1	m14.7	93.4
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	327	322	3167	3167
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.02	0.11	0.37	0.60

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Ninth Line & Highway 407 WB

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	6	34	1121	0	0	1816
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	36	1180	0	0	1912
RTOR Reduction (vph)	0	34	0	0	0	0
Lane Group Flow (vph)	6	2	1180	0	0	1912
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	100.0			100.0
Effective Green, g (s)	7.0	7.0	101.0			101.0
Actuated g/C Ratio	0.06	0.06	0.84			0.84
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	104	93	3012			3012
v/s Ratio Prot	c0.00		0.33			c0.53
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.02	0.39			0.63
Uniform Delay, d1	53.4	53.3	2.2			3.2
Progression Factor	1.00	1.00	0.54			1.00
Incremental Delay, d2	0.2	0.1	0.0			1.0
Delay (s)	53.6	53.4	1.2			4.3
Level of Service	D	D	A			A
Approach Delay (s)	53.4		1.2			4.3
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	114.1%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Ninth Line & Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	549	1834	1545
v/c Ratio	1.32	0.76	1.14	0.96
Control Delay	182.3	35.1	102.6	41.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	182.3	35.1	102.6	41.8
Queue Length 50th (m)	~323.2	103.8	~265.3	181.4
Queue Length 95th (m)	#400.6	149.0	#307.5	#233.4
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	805	725	1610	1610
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.32	0.76	1.14	0.96

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Ninth Line & Highway 407 EB

7/7/2015






















Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	522	0	1742	1468	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	549	0	1834	1545	0
RTOR Reduction (vph)	0	6	0	0	0	0
Lane Group Flow (vph)	1062	544	0	1834	1545	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	53.0	53.0		53.0	53.0	
Effective Green, g (s)	54.0	54.0		54.0	54.0	
Actuated g/C Ratio	0.45	0.45		0.45	0.45	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	805	720		1610	1610	
v/s Ratio Prot	c0.59			c0.51	0.43	
v/s Ratio Perm		0.34				
v/c Ratio	1.32	0.75		1.14	0.96	
Uniform Delay, d1	33.0	27.5		33.0	31.9	
Progression Factor	1.00	1.00		1.00	0.90	
Incremental Delay, d2	152.4	4.5		70.7	12.6	
Delay (s)	185.4	32.0		103.7	41.2	
Level of Service	F	C		F	D	
Approach Delay (s)	133.1			103.7	41.2	
Approach LOS	F			F	D	

Intersection Summary

HCM 2000 Control Delay	93.8	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.23		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	114.1%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	31	257	32	522	237	523	11	79	155	126	21	7
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	33	271	34	549	249	551	12	83	163	133	22	7
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	337	549	800	12	246	133	29					
Volume Left (vph)	33	549	0	12	0	133	0					
Volume Right (vph)	34	0	551	0	163	0	7					
Hadj (s)	-0.01	0.53	-0.45	0.53	-0.43	0.53	-0.14					
Departure Headway (s)	7.3	7.4	6.4	8.6	7.7	8.9	8.2					
Degree Utilization, x	0.69	1.00	1.00	0.03	0.53	0.33	0.07					
Capacity (veh/h)	478	549	800	402	446	387	416					
Control Delay (s)	25.0	67.0	62.0	10.7	17.7	14.9	10.6					
Approach Delay (s)	25.0	64.1		17.4		14.2						
Approach LOS	C	F		C		B						
Intersection Summary												
Delay			48.2									
Level of Service			E									
Intersection Capacity Utilization			95.8%	ICU Level of Service								F
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	9	132	4	17	160	81	7	9	30	177	23	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	9	139	4	18	168	85	7	9	32	186	24	21

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	153	272	48	232
Volume Left (vph)	9	18	7	186
Volume Right (vph)	4	85	32	21
Hadj (s)	0.03	-0.14	-0.33	0.14
Departure Headway (s)	5.0	4.7	5.0	5.2
Degree Utilization, x	0.21	0.36	0.07	0.33
Capacity (veh/h)	660	718	637	648
Control Delay (s)	9.4	10.3	8.3	10.7
Approach Delay (s)	9.4	10.3	8.3	10.7
Approach LOS	A	B	A	B

Intersection Summary			
Delay		10.1	
Level of Service		B	
Intersection Capacity Utilization	44.2%		ICU Level of Service A
Analysis Period (min)		15	

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	660	151	95	86	128	381	39	395	101	466	617	585
v/c Ratio	1.49	0.45	0.25	0.57	0.54	0.75	0.14	0.32	0.15	0.64	0.29	0.49
Control Delay	261.8	51.2	5.6	72.1	60.7	16.9	33.7	33.2	1.4	17.7	14.1	2.7
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	261.8	51.2	5.6	72.1	60.7	16.9	33.7	33.2	1.4	17.7	14.1	2.7
Queue Length 50th (m)	~235.4	35.6	0.0	21.4	31.6	6.8	6.8	38.7	0.0	55.5	37.8	0.0
Queue Length 95th (m)	#288.0	52.1	8.9	38.5	47.9	37.2	17.0	56.5	2.6	94.2	57.7	16.4
Internal Link Dist (m)		172.3			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	444	637	619	165	550	717	272	1238	655	733	2122	1187
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.49	0.24	0.15	0.52	0.23	0.53	0.14	0.32	0.15	0.64	0.29	0.49

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
 Queue shown is maximum after two cycles.

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

HCM Signalized Intersection Capacity Analysis
 8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/7/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	627	143	90	82	122	362	37	375	96	443	586	556
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	7.5	7.5	4.0	7.5	7.5	7.0	7.0	7.0	3.0	7.0	7.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.53	1.00	1.00	0.95	1.00	1.00	0.42	1.00	1.00	0.44	1.00	1.00
Satd. Flow (perm)	996	1883	1601	1789	1883	1601	787	3579	1601	833	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	660	151	95	86	128	381	39	395	101	466	617	585
RTOR Reduction (vph)	0	0	78	0	0	308	0	0	66	0	0	238
Lane Group Flow (vph)	660	151	17	86	128	73	39	395	35	466	617	347
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases	4		4			8	6		6	2		2
Actuated Green, G (s)	37.4	22.4	22.4	10.0	15.4	15.4	44.0	44.0	44.0	76.1	76.1	76.1
Effective Green, g (s)	38.4	23.4	23.4	11.0	16.4	16.4	45.0	45.0	45.0	77.1	77.1	77.1
Actuated g/C Ratio	0.30	0.18	0.18	0.08	0.13	0.13	0.35	0.35	0.35	0.59	0.59	0.59
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	410	338	288	151	237	201	272	1238	554	708	2122	949
v/s Ratio Prot	c0.24	0.08		0.05	0.07			0.11		c0.15	0.17	
v/s Ratio Perm	c0.24		0.01			0.05	0.05		0.02	c0.24		0.22
v/c Ratio	1.61	0.45	0.06	0.57	0.54	0.37	0.14	0.32	0.06	0.66	0.29	0.37
Uniform Delay, d1	43.8	47.5	44.2	57.2	53.3	52.0	29.2	31.2	28.4	14.9	13.0	13.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	285.5	0.9	0.1	4.9	2.5	1.1	1.1	0.7	0.2	2.2	0.3	1.1
Delay (s)	329.3	48.5	44.3	62.1	55.8	53.2	30.3	31.9	28.6	17.1	13.4	14.8
Level of Service	F	D	D	E	E	D	C	C	C	B	B	B
Approach Delay (s)		252.6			55.0			31.2			14.9	
Approach LOS		F			E			C			B	

Intersection Summary

HCM 2000 Control Delay	81.9	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.03		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.5
Intersection Capacity Utilization	114.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Highway 407 WB & Ninth Line

7/7/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	4	16	2449	1175
v/c Ratio	0.03	0.11	0.74	0.35
Control Delay	55.2	33.7	5.1	1.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.2	33.7	5.1	1.8
Queue Length 50th (m)	1.0	1.2	0.0	0.0
Queue Length 95th (m)	4.6	8.6	177.3	39.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	302	280	3325	3325
Starvation Cap Reductn	0	0	29	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.06	0.74	0.35
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

14: Highway 407 WB & Ninth Line

7/7/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	4	15	2327	0	0	1116
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	4	16	2449	0	0	1175
RTOR Reduction (vph)	0	11	0	0	0	0
Lane Group Flow (vph)	4	5	2449	0	0	1175
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.0	4.0	112.0			112.0
Effective Green, g (s)	5.0	5.0	113.0			113.0
Actuated g/C Ratio	0.04	0.04	0.87			0.87
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	68	61	3110			3110
v/s Ratio Prot	0.00		c0.68			0.33
v/s Ratio Perm		c0.00				
v/c Ratio	0.06	0.09	0.79			0.38
Uniform Delay, d1	60.2	60.3	3.5			1.7
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.6	2.1			0.4
Delay (s)	60.6	60.9	5.6			2.0
Level of Service	E	E	A			A
Approach Delay (s)	60.9		5.6			2.0
Approach LOS	E		A			A

Intersection Summary

HCM 2000 Control Delay	4.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	106.6%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Queues
15: Highway 407 EB

7/7/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	489	1551	1179
v/c Ratio	1.14	0.58	1.10	0.84
Control Delay	108.0	25.5	97.4	45.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	108.0	25.5	97.4	45.1
Queue Length 50th (m)	~342.1	87.0	~256.3	154.3
Queue Length 95th (m)	#422.0	121.5	#299.0	183.4
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	932	843	1406	1406
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.14	0.58	1.10	0.84

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Highway 407 EB

7/7/2015






















Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	465	0	1473	1120	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	489	0	1551	1179	0
RTOR Reduction (vph)	0	9	0	0	0	0
Lane Group Flow (vph)	1062	480	0	1551	1179	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	72.0	72.0		54.0	54.0	
Effective Green, g (s)	73.0	73.0		55.0	55.0	
Actuated g/C Ratio	0.52	0.52		0.39	0.39	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	932	834		1406	1406	
v/s Ratio Prot	c0.59			c0.43	0.33	
v/s Ratio Perm		0.30				
v/c Ratio	1.14	0.58		1.10	0.84	
Uniform Delay, d1	33.5	22.9		42.5	38.5	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	75.8	1.0		57.5	6.1	
Delay (s)	109.3	23.9		100.0	44.6	
Level of Service	F	C		F	D	
Approach Delay (s)	82.4			100.0	44.6	
Approach LOS	F			F	D	

Intersection Summary

HCM 2000 Control Delay	78.4	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.12		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	106.6%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 18: Ninth Line & Rouge Bank Dr

7/7/2015

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	8	275	10	281	223	127	15	19	149	425	64	26
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	8	289	11	296	235	134	16	20	157	447	67	27
Direction, Lane #	EB 1	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2					
Volume Total (vph)	308	296	368	16	177	447	95					
Volume Left (vph)	8	296	0	16	0	447	0					
Volume Right (vph)	11	0	134	0	157	0	27					
Hadj (s)	0.02	0.53	-0.22	0.53	-0.59	0.53	-0.17					
Departure Headway (s)	8.3	8.5	7.8	9.5	8.4	8.7	8.0					
Degree Utilization, x	0.71	0.70	0.79	0.04	0.41	1.00	0.21					
Capacity (veh/h)	423	410	456	362	401	447	441					
Control Delay (s)	29.1	27.8	33.5	11.7	16.0	73.0	11.9					
Approach Delay (s)	29.1	31.0		15.6		62.3						
Approach LOS	D	D		C		F						
Intersection Summary												
Delay			38.9									
Level of Service			E									
Intersection Capacity Utilization			82.1%	ICU Level of Service								E
Analysis Period (min)			15									

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/7/2015



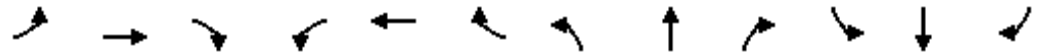
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↔			↔			↔			↔	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	141	4	21	125	109	3	13	68	89	7	8
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	148	4	22	132	115	3	14	72	94	7	8
Direction, Lane #	EB 1	WB 1	NB 1	SB 1								
Volume Total (vph)	158	268	88	109								
Volume Left (vph)	5	22	3	94								
Volume Right (vph)	4	115	72	8								
Hadj (s)	0.02	-0.21	-0.44	0.16								
Departure Headway (s)	4.7	4.4	4.6	5.2								
Degree Utilization, x	0.21	0.33	0.11	0.16								
Capacity (veh/h)	709	777	702	633								
Control Delay (s)	9.0	9.5	8.2	9.1								
Approach Delay (s)	9.0	9.5	8.2	9.1								
Approach LOS	A	A	A	A								
Intersection Summary												
Delay			9.1									
Level of Service			A									
Intersection Capacity Utilization			42.0%	ICU Level of Service	A							
Analysis Period (min)			15									

Appendix D – Future (2031) Total with Mitigation Synchro Output

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	368	66	26	54	148	418	103	745	45	283	724	553
v/c Ratio	0.84	0.14	0.05	0.44	0.44	0.82	0.35	0.49	0.06	0.62	0.35	0.48
Control Delay	73.6	37.6	0.2	69.0	49.8	30.5	34.6	30.8	0.1	20.7	16.5	3.0
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	73.6	37.6	0.2	69.0	49.8	30.5	34.6	30.8	0.1	20.7	16.5	3.0
Queue Length 50th (m)	48.1	13.8	0.0	13.5	34.4	37.7	18.0	72.7	0.0	32.4	49.0	0.0
Queue Length 95th (m)	#71.5	22.5	0.0	27.2	48.0	68.3	40.3	108.1	0.0	61.8	78.5	18.4
Internal Link Dist (m)		91.6			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	440	651	630	130	564	670	295	1522	770	458	2068	1158
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.84	0.10	0.04	0.42	0.26	0.62	0.35	0.49	0.06	0.62	0.35	0.48

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	350	63	25	51	141	397	98	708	43	269	688	525
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	6.5	6.5	4.0	6.5	6.5	7.0	6.0	6.0	3.0	6.0	6.0
Lane Util. Factor	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3471	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.38	1.00	1.00	0.25	1.00	1.00
Satd. Flow (perm)	3471	1883	1601	1789	1883	1601	709	3579	1601	472	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	368	66	26	54	148	418	103	745	45	283	724	553
RTOR Reduction (vph)	0	0	20	0	0	222	0	0	26	0	0	238
Lane Group Flow (vph)	368	66	6	54	148	196	103	745	19	283	724	315
Turn Type	Prot	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases			4			8	6		6	2		2
Actuated Green, G (s)	15.3	29.7	29.7	6.7	22.1	22.1	52.3	52.3	52.3	72.1	72.1	72.1
Effective Green, g (s)	16.3	31.7	31.7	7.7	24.1	24.1	53.3	54.3	54.3	73.1	74.1	74.1
Actuated g/C Ratio	0.13	0.24	0.24	0.06	0.19	0.19	0.41	0.42	0.42	0.56	0.57	0.57
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	435	459	390	105	349	296	290	1494	668	435	2040	912
v/s Ratio Prot	c0.11	0.04		0.03	0.08			0.21		c0.08	0.20	
v/s Ratio Perm			0.00			c0.12	0.15		0.01	c0.28		0.20
v/c Ratio	0.85	0.14	0.02	0.51	0.42	0.66	0.36	0.50	0.03	0.65	0.35	0.35
Uniform Delay, d1	55.6	38.5	37.3	59.3	46.8	49.2	26.5	27.8	22.3	16.9	15.1	15.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	14.1	0.1	0.0	4.2	0.8	5.5	3.4	1.2	0.1	3.5	0.5	1.0
Delay (s)	69.7	38.7	37.3	63.5	47.6	54.7	29.9	29.0	22.4	20.4	15.6	16.0
Level of Service	E	D	D	E	D	D	C	C	C	C	B	B
Approach Delay (s)		63.4			53.8			28.8			16.6	
Approach LOS		E			D			C			B	

Intersection Summary

HCM 2000 Control Delay	32.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	19.5
Intersection Capacity Utilization	87.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Ninth Line & Highway 407 WB

7/9/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	6	36	1142	1748
v/c Ratio	0.04	0.20	0.36	0.55
Control Delay	50.3	18.6	1.7	3.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	50.3	18.6	1.7	3.7
Queue Length 50th (m)	1.3	0.0	17.5	64.7
Queue Length 95th (m)	5.5	10.1	m27.8	77.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	327	322	3167	3167
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.02	0.11	0.36	0.55

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Ninth Line & Highway 407 WB

7/9/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	6	34	1085	0	0	1661
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	36	1142	0	0	1748
RTOR Reduction (vph)	0	34	0	0	0	0
Lane Group Flow (vph)	6	2	1142	0	0	1748
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	100.0			100.0
Effective Green, g (s)	7.0	7.0	101.0			101.0
Actuated g/C Ratio	0.06	0.06	0.84			0.84
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	104	93	3012			3012
v/s Ratio Prot	c0.00		0.32			c0.49
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.02	0.38			0.58
Uniform Delay, d1	53.4	53.3	2.2			2.9
Progression Factor	1.00	1.00	0.71			1.00
Incremental Delay, d2	0.2	0.1	0.2			0.8
Delay (s)	53.6	53.4	1.7			3.8
Level of Service	D	D	A			A
Approach Delay (s)	53.4		1.7			3.8
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.7	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	85.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Ninth Line & Highway 407 EB

7/9/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	549	1796	1382
v/c Ratio	0.87	0.94	0.91	0.70
Control Delay	45.7	61.3	33.2	19.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	45.7	61.3	33.2	19.1
Queue Length 50th (m)	118.2	116.7	196.4	111.6
Queue Length 95th (m)	145.4	#184.1	#241.8	128.5
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	1243	596	1968	1968
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.85	0.92	0.91	0.70

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Ninth Line & Highway 407 EB

7/9/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	522	0	1706	1313	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	549	0	1796	1382	0
RTOR Reduction (vph)	0	23	0	0	0	0
Lane Group Flow (vph)	1062	526	0	1796	1382	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	41.0	41.0		65.0	65.0	
Effective Green, g (s)	42.0	42.0		66.0	66.0	
Actuated g/C Ratio	0.35	0.35		0.55	0.55	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1214	560		1968	1968	
v/s Ratio Prot	0.31			c0.50	0.39	
v/s Ratio Perm		c0.33				
v/c Ratio	0.87	0.94		0.91	0.70	
Uniform Delay, d1	36.5	37.8		24.4	19.8	
Progression Factor	1.00	1.00		1.00	0.85	
Incremental Delay, d2	7.3	23.7		7.9	1.8	
Delay (s)	43.8	61.5		32.3	18.6	
Level of Service	D	E		C	B	
Approach Delay (s)	49.8			32.3	18.6	
Approach LOS	D			C	B	

Intersection Summary

HCM 2000 Control Delay	34.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	85.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

18: Ninth Line & Rouge Bank Dr

7/9/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	21	305	275	249	344	12	133	84	19
v/c Ratio	0.04	0.39	0.65	0.32	0.40	0.02	0.19	0.17	0.03
Control Delay	8.0	10.8	19.2	10.6	2.6	14.3	7.9	15.1	12.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	8.0	10.8	19.2	10.6	2.6	14.3	7.9	15.1	12.5
Queue Length 50th (m)	1.1	17.4	19.1	14.5	0.0	0.7	2.9	5.0	0.8
Queue Length 95th (m)	3.7	30.4	37.6	25.6	9.7	4.2	15.0	16.9	5.1
Internal Link Dist (m)		84.0		62.9			156.9		190.9
Turn Bay Length (m)					60.0	60.0		60.0	
Base Capacity (vph)	775	1264	694	1281	1199	545	715	492	707
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.24	0.40	0.19	0.29	0.02	0.19	0.17	0.03

Intersection Summary

HCM Signalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	257	32	261	237	327	11	48	78	80	13	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Frt	1.00	0.98		1.00	1.00	0.85	1.00	0.91		1.00	0.96	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1789	1852		1789	1883	1601	1789	1709		1789	1809	
Flt Permitted	0.60	1.00		0.54	1.00	1.00	0.75	1.00		0.67	1.00	
Satd. Flow (perm)	1139	1852		1022	1883	1601	1403	1709		1265	1809	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	21	271	34	275	249	344	12	51	82	84	14	5
RTOR Reduction (vph)	0	9	0	0	0	200	0	50	0	0	3	0
Lane Group Flow (vph)	21	296	0	275	249	144	12	83	0	84	16	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2			6		6	8			4		
Actuated Green, G (s)	21.0	21.0		21.0	21.0	21.0	19.5	19.5		19.5	19.5	
Effective Green, g (s)	22.0	22.0		22.0	22.0	22.0	20.5	20.5		20.5	20.5	
Actuated g/C Ratio	0.42	0.42		0.42	0.42	0.42	0.39	0.39		0.39	0.39	
Clearance Time (s)	6.0	6.0		6.0	6.0	6.0	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	477	776		428	789	670	547	667		493	706	
v/s Ratio Prot		0.16			0.13			0.05			0.01	
v/s Ratio Perm	0.02			c0.27		0.09	0.01			c0.07		
v/c Ratio	0.04	0.38		0.64	0.32	0.22	0.02	0.12		0.17	0.02	
Uniform Delay, d1	9.0	10.5		12.1	10.2	9.7	9.8	10.3		10.4	9.8	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.3		3.3	0.2	0.2	0.1	0.4		0.7	0.1	
Delay (s)	9.1	10.9		15.4	10.4	9.9	9.9	10.6		11.2	9.9	
Level of Service	A	B		B	B	A	A	B		B	A	
Approach Delay (s)		10.7			11.8			10.6			11.0	
Approach LOS		B			B			B			B	

Intersection Summary

HCM 2000 Control Delay	11.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	52.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	63.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	9	126	4	16	159	81	7	9	28	174	23	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	9	133	4	17	167	85	7	9	29	183	24	21

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	146	269	46	228
Volume Left (vph)	9	17	7	183
Volume Right (vph)	4	85	29	21
Hadj (s)	0.03	-0.14	-0.32	0.14
Departure Headway (s)	5.0	4.7	5.0	5.1
Degree Utilization, x	0.20	0.35	0.06	0.33
Capacity (veh/h)	663	723	642	654
Control Delay (s)	9.3	10.2	8.3	10.6
Approach Delay (s)	9.3	10.2	8.3	10.6
Approach LOS	A	B	A	B

Intersection Summary			
Delay		10.0	
Level of Service		B	
Intersection Capacity Utilization	43.6%		ICU Level of Service A
Analysis Period (min)		15	

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	448	140	69	86	125	381	32	473	101	466	765	397
v/c Ratio	0.84	0.34	0.16	0.53	0.40	0.81	0.15	0.40	0.16	0.74	0.38	0.37
Control Delay	68.2	43.5	1.5	67.8	50.3	30.3	33.6	34.8	1.4	27.4	17.9	2.8
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	68.2	43.5	1.5	67.8	50.3	30.3	33.6	34.8	1.4	27.4	17.9	2.8
Queue Length 50th (m)	57.9	31.0	0.0	21.3	29.4	33.7	5.8	49.0	0.0	62.5	54.1	0.0
Queue Length 95th (m)	#80.7	43.9	1.8	37.8	42.5	62.7	14.2	64.2	2.4	#164.6	86.1	16.8
Internal Link Dist (m)		91.2			370.4			257.5				283.1
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	547	644	624	192	564	655	220	1183	633	631	2013	1074
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.82	0.22	0.11	0.45	0.22	0.58	0.15	0.40	0.16	0.74	0.38	0.37

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖↗	↑	↖	↖	↑	↖	↖	↖↗	↖	↖	↖↗	↖
Volume (vph)	426	133	66	82	119	362	30	449	96	443	727	377
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	6.5	6.5	4.0	6.5	6.5	7.0	6.0	6.0	3.0	6.0	6.0
Lane Util. Factor	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3471	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.36	1.00	1.00	0.36	1.00	1.00
Satd. Flow (perm)	3471	1883	1601	1789	1883	1601	681	3579	1601	685	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	448	140	69	86	125	381	32	473	101	466	765	397
RTOR Reduction (vph)	0	0	54	0	0	209	0	0	68	0	0	174
Lane Group Flow (vph)	448	140	15	86	125	172	32	473	33	466	765	223
Turn Type	Prot	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases			4			8	6		6	2		2
Actuated Green, G (s)	19.0	26.5	26.5	10.9	19.4	19.4	41.0	41.0	41.0	71.1	71.1	71.1
Effective Green, g (s)	20.0	28.5	28.5	11.9	21.4	21.4	42.0	43.0	43.0	72.1	73.1	73.1
Actuated g/C Ratio	0.15	0.22	0.22	0.09	0.16	0.16	0.32	0.33	0.33	0.55	0.56	0.56
Clearance Time (s)	4.0	8.5	8.5	5.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	534	412	350	163	309	263	220	1183	529	610	2012	900
v/s Ratio Prot	c0.13	0.07		0.05	0.07			0.13		c0.16	0.21	
v/s Ratio Perm			0.01			c0.11	0.05		0.02	c0.26		0.14
v/c Ratio	0.84	0.34	0.04	0.53	0.40	0.65	0.15	0.40	0.06	0.76	0.38	0.25
Uniform Delay, d1	53.4	42.8	40.0	56.4	48.6	50.8	31.3	33.5	29.7	18.4	15.8	14.5
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	11.1	0.5	0.1	3.1	0.9	5.8	1.4	1.0	0.2	5.7	0.5	0.7
Delay (s)	64.5	43.3	40.1	59.4	49.5	56.6	32.6	34.6	30.0	24.0	16.4	15.1
Level of Service	E	D	D	E	D	E	C	C	C	C	B	B
Approach Delay (s)		57.4			55.5			33.7			18.3	
Approach LOS		E			E			C			B	

Intersection Summary

HCM 2000 Control Delay	34.7	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	19.5
Intersection Capacity Utilization	89.2%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Highway 407 WB & Ninth Line

7/9/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	4	16	2316	1135
v/c Ratio	0.03	0.11	0.70	0.34
Control Delay	55.2	26.3	4.4	1.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.2	26.3	4.4	1.7
Queue Length 50th (m)	1.0	0.3	0.0	0.0
Queue Length 95th (m)	4.6	7.5	148.8	37.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	302	283	3325	3325
Starvation Cap Reductn	0	0	35	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.06	0.70	0.34
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

14: Highway 407 WB & Ninth Line

7/9/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	4	15	2200	0	0	1078
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	4	16	2316	0	0	1135
RTOR Reduction (vph)	0	14	0	0	0	0
Lane Group Flow (vph)	4	2	2316	0	0	1135
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.0	4.0	112.0			112.0
Effective Green, g (s)	5.0	5.0	113.0			113.0
Actuated g/C Ratio	0.04	0.04	0.87			0.87
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	68	61	3110			3110
v/s Ratio Prot	c0.00		c0.65			0.32
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.03	0.74			0.36
Uniform Delay, d1	60.2	60.2	3.2			1.6
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.2	1.7			0.3
Delay (s)	60.6	60.3	4.8			2.0
Level of Service	E	E	A			A
Approach Delay (s)	60.4		4.8			2.0
Approach LOS	E		A			A

Intersection Summary

HCM 2000 Control Delay	4.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues
15: Highway 407 EB

7/9/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	489	1417	1139
v/c Ratio	0.84	0.79	0.72	0.58
Control Delay	47.3	44.7	26.9	23.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	47.3	44.7	26.9	23.0
Queue Length 50th (m)	136.4	106.8	151.5	107.8
Queue Length 95th (m)	155.9	144.7	190.1	137.2
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	1388	674	1967	1967
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.77	0.73	0.72	0.58
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

15: Highway 407 EB

7/9/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	465	0	1346	1082	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	489	0	1417	1139	0
RTOR Reduction (vph)	0	36	0	0	0	0
Lane Group Flow (vph)	1062	453	0	1417	1139	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	50.0	50.0		76.0	76.0	
Effective Green, g (s)	51.0	51.0		77.0	77.0	
Actuated g/C Ratio	0.36	0.36		0.55	0.55	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1264	583		1968	1968	
v/s Ratio Prot	c0.31			c0.40	0.32	
v/s Ratio Perm		0.28				
v/c Ratio	0.84	0.78		0.72	0.58	
Uniform Delay, d1	40.8	39.5		23.5	20.8	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	5.2	6.5		2.3	1.2	
Delay (s)	46.0	45.9		25.8	22.0	
Level of Service	D	D		C	C	
Approach Delay (s)	46.0			25.8	22.0	
Approach LOS	D			C	C	

Intersection Summary

HCM 2000 Control Delay	32.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

18: Ninth Line & Rouge Bank Dr

7/9/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	5	300	148	235	83	16	92	278	59
v/c Ratio	0.02	0.58	0.62	0.45	0.16	0.03	0.15	0.36	0.06
Control Delay	14.2	22.4	30.5	19.9	2.5	15.3	6.4	8.6	6.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	14.2	22.4	30.5	19.9	2.5	15.3	6.4	8.6	6.3
Queue Length 50th (m)	0.4	26.9	13.6	20.4	0.0	1.1	0.9	12.6	1.8
Queue Length 95th (m)	2.3	46.2	29.5	36.3	4.7	5.1	9.6	30.3	7.4
Internal Link Dist (m)		88.3		64.6			152.0		192.9
Turn Bay Length (m)					60.0	60.0		60.0	
Base Capacity (vph)	418	743	339	745	704	473	624	770	1000
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.01	0.40	0.44	0.32	0.12	0.03	0.15	0.36	0.06

Intersection Summary

HCM Signalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	275	10	141	223	79	15	12	75	264	40	16
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		3.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Frt	1.00	0.99		1.00	1.00	0.85	1.00	0.87		1.00	0.96	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1789	1873		1789	1883	1601	1789	1641		1789	1802	
Flt Permitted	0.56	1.00		0.45	1.00	1.00	0.72	1.00		0.61	1.00	
Satd. Flow (perm)	1058	1873		856	1883	1601	1353	1641		1145	1802	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	5	289	11	148	235	83	16	13	79	278	42	17
RTOR Reduction (vph)	0	2	0	0	0	60	0	51	0	0	8	0
Lane Group Flow (vph)	5	298	0	148	235	23	16	41	0	278	51	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6		6	8			4		
Actuated Green, G (s)	15.2	15.2		15.2	15.2	15.2	19.4	19.4		31.2	31.2	
Effective Green, g (s)	16.2	16.2		16.2	16.2	16.2	20.4	20.4		32.2	32.2	
Actuated g/C Ratio	0.28	0.28		0.28	0.28	0.28	0.35	0.35		0.55	0.55	
Clearance Time (s)	6.0	6.0		6.0	6.0	6.0	6.0	6.0		4.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	293	519		237	522	444	472	573		728	993	
v/s Ratio Prot		0.16			0.12			0.02		c0.06	0.03	
v/s Ratio Perm	0.00			c0.17		0.01	0.01			c0.15		
v/c Ratio	0.02	0.57		0.62	0.45	0.05	0.03	0.07		0.38	0.05	
Uniform Delay, d1	15.3	18.1		18.4	17.4	15.5	12.5	12.7		7.1	6.0	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	1.5		5.1	0.6	0.0	0.1	0.2		0.3	0.1	
Delay (s)	15.3	19.7		23.5	18.0	15.5	12.6	12.9		7.4	6.1	
Level of Service	B	B		C	B	B	B	B		A	A	
Approach Delay (s)		19.6			19.3			12.9			7.2	
Approach LOS		B			B			B			A	

Intersection Summary

HCM 2000 Control Delay	15.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	58.4	Sum of lost time (s)	13.0
Intersection Capacity Utilization	56.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	140	4	18	120	107	3	13	67	88	7	8
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	147	4	19	126	113	3	14	71	93	7	8
Direction, Lane #	EB 1	WB 1	NB 1	SB 1								
Volume Total (vph)	157	258	87	108								
Volume Left (vph)	5	19	3	93								
Volume Right (vph)	4	113	71	8								
Hadj (s)	0.02	-0.21	-0.44	0.16								
Departure Headway (s)	4.7	4.4	4.6	5.1								
Degree Utilization, x	0.21	0.31	0.11	0.15								
Capacity (veh/h)	713	779	708	638								
Control Delay (s)	8.9	9.4	8.2	9.1								
Approach Delay (s)	8.9	9.4	8.2	9.1								
Approach LOS	A	A	A	A								
Intersection Summary												
Delay			9.0									
Level of Service			A									
Intersection Capacity Utilization			40.1%	ICU Level of Service	A							
Analysis Period (min)			15									

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	406	68	35	54	160	418	135	745	45	283	724	716
v/c Ratio	0.84	0.13	0.07	0.40	0.45	0.83	0.49	0.53	0.06	0.65	0.37	0.60
Control Delay	70.5	34.9	0.3	65.9	48.6	33.3	41.2	34.2	0.2	24.5	18.6	4.2
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	70.5	34.9	0.3	65.9	48.6	33.3	41.2	34.2	0.2	24.5	18.6	4.2
Queue Length 50th (m)	52.7	13.6	0.0	13.4	36.7	43.8	26.6	78.9	0.0	35.2	53.0	2.4
Queue Length 95th (m)	#75.4	22.2	0.0	26.9	50.5	73.7	53.7	109.3	0.0	#66.3	83.0	28.4
Internal Link Dist (m)		94.5			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	493	673	642	151	564	654	277	1404	717	436	1975	1195
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.82	0.10	0.05	0.36	0.28	0.64	0.49	0.53	0.06	0.65	0.37	0.60

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	386	65	33	51	152	397	128	708	43	269	688	680
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	6.5	6.5	3.0	6.5	6.5	6.0	6.0	6.0	3.0	6.0	6.0
Lane Util. Factor	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3471	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.38	1.00	1.00	0.23	1.00	1.00
Satd. Flow (perm)	3471	1883	1601	1789	1883	1601	709	3579	1601	440	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	406	68	35	54	160	418	135	745	45	283	724	716
RTOR Reduction (vph)	0	0	26	0	0	201	0	0	28	0	0	315
Lane Group Flow (vph)	406	68	9	54	160	217	135	745	17	283	724	401
Turn Type	Prot	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases			4			8	6		6	2		2
Actuated Green, G (s)	17.2	33.1	33.1	7.4	23.3	23.3	48.3	48.3	48.3	69.0	69.0	69.0
Effective Green, g (s)	18.2	35.1	35.1	8.4	25.3	25.3	50.3	50.3	50.3	70.0	71.0	71.0
Actuated g/C Ratio	0.14	0.27	0.27	0.06	0.19	0.19	0.39	0.39	0.39	0.54	0.55	0.55
Clearance Time (s)	4.0	8.5	8.5	4.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	485	508	432	115	366	311	274	1384	619	420	1954	874
v/s Ratio Prot	c0.12	0.04		0.03	0.08			0.21		c0.09	0.20	
v/s Ratio Perm			0.01			c0.14	0.19		0.01	c0.27		0.25
v/c Ratio	0.84	0.13	0.02	0.47	0.44	0.70	0.49	0.54	0.03	0.67	0.37	0.46
Uniform Delay, d1	54.5	35.9	34.8	58.7	46.1	48.8	30.2	30.9	24.7	18.8	16.8	17.9
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	11.9	0.1	0.0	3.0	0.8	6.7	6.2	1.5	0.1	4.2	0.5	1.7
Delay (s)	66.4	36.1	34.9	61.7	46.9	55.5	36.4	32.4	24.8	23.1	17.3	19.6
Level of Service	E	D	C	E	D	E	D	C	C	C	B	B
Approach Delay (s)		60.2			53.9			32.6			19.2	
Approach LOS		E			D			C			B	

Intersection Summary

HCM 2000 Control Delay	33.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	18.5
Intersection Capacity Utilization	90.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Ninth Line & Highway 407 WB

7/9/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	6	36	1180	1912
v/c Ratio	0.04	0.20	0.37	0.60
Control Delay	50.3	18.6	1.7	4.2
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	50.3	18.6	1.7	4.2
Queue Length 50th (m)	1.3	0.0	18.3	77.6
Queue Length 95th (m)	5.5	10.1	m28.9	93.4
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	327	322	3167	3167
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.02	0.11	0.37	0.60

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Ninth Line & Highway 407 WB

7/9/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	6	34	1121	0	0	1816
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	6	36	1180	0	0	1912
RTOR Reduction (vph)	0	34	0	0	0	0
Lane Group Flow (vph)	6	2	1180	0	0	1912
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	100.0			100.0
Effective Green, g (s)	7.0	7.0	101.0			101.0
Actuated g/C Ratio	0.06	0.06	0.84			0.84
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	104	93	3012			3012
v/s Ratio Prot	c0.00		0.33			c0.53
v/s Ratio Perm		0.00				
v/c Ratio	0.06	0.02	0.39			0.63
Uniform Delay, d1	53.4	53.3	2.2			3.2
Progression Factor	1.00	1.00	0.71			1.00
Incremental Delay, d2	0.2	0.1	0.2			1.0
Delay (s)	53.6	53.4	1.7			4.3
Level of Service	D	D	A			A
Approach Delay (s)	53.4		1.7			4.3
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	4.0	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	86.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Ninth Line & Highway 407 EB

7/9/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	549	1834	1545
v/c Ratio	0.88	0.96	0.93	0.78
Control Delay	46.5	66.3	34.5	20.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	46.5	66.3	34.5	20.8
Queue Length 50th (m)	119.8	121.1	200.6	135.6
Queue Length 95th (m)	#148.4	#191.0	#249.7	149.1
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	1214	575	1976	1976
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.87	0.95	0.93	0.78

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

15: Ninth Line & Highway 407 EB

7/9/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	522	0	1742	1468	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	549	0	1834	1545	0
RTOR Reduction (vph)	0	16	0	0	0	0
Lane Group Flow (vph)	1062	533	0	1834	1545	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	40.7	40.7		65.3	65.3	
Effective Green, g (s)	41.7	41.7		66.3	66.3	
Actuated g/C Ratio	0.35	0.35		0.55	0.55	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1206	556		1977	1977	
v/s Ratio Prot	0.31			c0.51	0.43	
v/s Ratio Perm		c0.33				
v/c Ratio	0.88	0.96		0.93	0.78	
Uniform Delay, d1	36.8	38.3		24.6	21.1	
Progression Factor	1.00	1.00		1.00	0.84	
Incremental Delay, d2	7.8	27.8		9.1	2.5	
Delay (s)	44.6	66.2		33.8	20.4	
Level of Service	D	E		C	C	
Approach Delay (s)	51.9			33.8	20.4	
Approach LOS	D			C	C	

Intersection Summary

HCM 2000 Control Delay	35.5	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	86.9%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

18: Ninth Line & Rouge Bank Dr

7/9/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	33	305	275	249	551	12	165	133	29
v/c Ratio	0.04	0.24	0.38	0.20	0.44	0.04	0.35	0.49	0.07
Control Delay	6.0	6.2	8.8	6.2	2.0	16.7	12.2	25.7	14.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	6.0	6.2	8.8	6.2	2.0	16.7	12.2	25.7	14.3
Queue Length 50th (m)	1.2	11.8	12.6	9.8	0.0	1.0	7.1	12.0	1.8
Queue Length 95th (m)	4.8	28.5	34.0	23.9	11.3	4.2	19.4	25.1	6.6
Internal Link Dist (m)		84.0		65.2			156.9		190.9
Turn Bay Length (m)					60.0	60.0		60.0	
Base Capacity (vph)	763	1245	724	1262	1255	511	692	452	673
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.24	0.38	0.20	0.44	0.02	0.24	0.29	0.04

Intersection Summary

HCM Signalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	31	257	32	261	237	523	11	79	78	126	21	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Frt	1.00	0.98		1.00	1.00	0.85	1.00	0.93		1.00	0.96	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1789	1852		1789	1883	1601	1789	1743		1789	1815	
Flt Permitted	0.60	1.00		0.57	1.00	1.00	0.74	1.00		0.65	1.00	
Satd. Flow (perm)	1139	1852		1082	1883	1601	1391	1743		1229	1815	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	33	271	34	275	249	551	12	83	82	133	22	7
RTOR Reduction (vph)	0	5	0	0	0	199	0	66	0	0	6	0
Lane Group Flow (vph)	33	300	0	275	249	352	12	99	0	133	23	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases	2			6		6	8			4		
Actuated Green, G (s)	36.3	36.3		36.3	36.3	36.3	10.1	10.1		10.1	10.1	
Effective Green, g (s)	37.3	37.3		37.3	37.3	37.3	11.1	11.1		11.1	11.1	
Actuated g/C Ratio	0.64	0.64		0.64	0.64	0.64	0.19	0.19		0.19	0.19	
Clearance Time (s)	6.0	6.0		6.0	6.0	6.0	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	727	1182		691	1202	1022	264	331		233	344	
v/s Ratio Prot		0.16			0.13			0.06			0.01	
v/s Ratio Perm	0.03			c0.25		0.22	0.01			c0.11		
v/c Ratio	0.05	0.25		0.40	0.21	0.34	0.05	0.30		0.57	0.07	
Uniform Delay, d1	3.9	4.5		5.1	4.4	4.9	19.3	20.3		21.5	19.4	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.1	0.5		1.7	0.4	0.9	0.1	0.5		3.4	0.1	
Delay (s)	4.0	5.1		6.8	4.8	5.8	19.4	20.8		24.8	19.5	
Level of Service	A	A		A	A	A	B	C		C	B	
Approach Delay (s)		5.0			5.8			20.7			23.9	
Approach LOS		A			A			C			C	

Intersection Summary

HCM 2000 Control Delay	8.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	58.4	Sum of lost time (s)	10.0
Intersection Capacity Utilization	62.5%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	9	132	4	17	160	81	7	9	30	177	23	20
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	9	139	4	18	168	85	7	9	32	186	24	21

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	153	272	48	232
Volume Left (vph)	9	18	7	186
Volume Right (vph)	4	85	32	21
Hadj (s)	0.03	-0.14	-0.33	0.14
Departure Headway (s)	5.0	4.7	5.0	5.2
Degree Utilization, x	0.21	0.36	0.07	0.33
Capacity (veh/h)	660	718	637	648
Control Delay (s)	9.4	10.3	8.3	10.7
Approach Delay (s)	9.4	10.3	8.3	10.7
Approach LOS	A	B	A	B

Intersection Summary			
Delay		10.1	
Level of Service		B	
Intersection Capacity Utilization	44.2%		ICU Level of Service A
Analysis Period (min)		15	

Queues

8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	582	151	95	86	128	381	39	473	101	466	765	437
v/c Ratio	0.85	0.34	0.21	0.57	0.55	0.72	0.16	0.38	0.15	0.76	0.38	0.40
Control Delay	62.6	42.6	6.0	72.1	62.1	13.1	36.3	34.8	2.0	25.3	17.4	2.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	62.6	42.6	6.0	72.1	62.1	13.1	36.3	34.8	2.0	25.3	17.4	2.6
Queue Length 50th (m)	73.8	32.2	0.0	21.4	31.3	0.0	7.2	49.7	0.0	66.0	56.8	0.0
Queue Length 95th (m)	94.5	49.8	10.2	38.5	50.2	29.5	17.6	69.0	4.1	98.1	75.3	15.2
Internal Link Dist (m)		101.5			370.4			257.5			283.1	
Turn Bay Length (m)	55.0		55.0	55.0		50.0	80.0		60.0	105.0		70.0
Base Capacity (vph)	720	499	504	165	282	564	237	1244	652	643	1999	1087
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.81	0.30	0.19	0.52	0.45	0.68	0.16	0.38	0.15	0.72	0.38	0.40

Intersection Summary

HCM Signalized Intersection Capacity Analysis
 8: Box Grove By-pass/Ninth Line & Rouge Bank Dr/Copper Creek Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	553	143	90	82	122	362	37	449	96	443	727	415
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	3.0	6.5	6.5	3.0	6.5	6.5	6.0	6.0	6.0	3.0	6.0	6.0
Lane Util. Factor	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	3471	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.36	1.00	1.00	0.37	1.00	1.00
Satd. Flow (perm)	3471	1883	1601	1789	1883	1601	681	3579	1601	702	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	582	151	95	86	128	381	39	473	101	466	765	437
RTOR Reduction (vph)	0	0	72	0	0	334	0	0	66	0	0	193
Lane Group Flow (vph)	582	151	23	86	128	47	39	473	35	466	765	244
Turn Type	Prot	NA	Perm	Prot	NA	Perm	Perm	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8			6		5	2	
Permitted Phases			4			8	6		6	2		2
Actuated Green, G (s)	24.7	28.9	28.9	10.0	14.2	14.2	43.2	43.2	43.2	70.6	70.6	70.6
Effective Green, g (s)	25.7	30.9	30.9	11.0	16.2	16.2	45.2	45.2	45.2	71.6	72.6	72.6
Actuated g/C Ratio	0.20	0.24	0.24	0.08	0.12	0.12	0.35	0.35	0.35	0.55	0.56	0.56
Clearance Time (s)	4.0	8.5	8.5	4.0	8.5	8.5	8.0	8.0	8.0	4.0	8.0	8.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	686	447	380	151	234	199	236	1244	556	590	1998	894
v/s Ratio Prot	c0.17	0.08		0.05	c0.07			0.13		c0.15	0.21	
v/s Ratio Perm			0.01			0.03	0.06		0.02	c0.29		0.15
v/c Ratio	0.85	0.34	0.06	0.57	0.55	0.24	0.17	0.38	0.06	0.79	0.38	0.27
Uniform Delay, d1	50.3	41.1	38.3	57.2	53.5	51.3	29.3	31.9	28.3	18.6	16.1	15.0
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	9.6	0.5	0.1	4.9	2.6	0.6	1.5	0.9	0.2	7.0	0.6	0.8
Delay (s)	59.9	41.5	38.4	62.1	56.1	52.0	30.8	32.8	28.5	25.6	16.7	15.7
Level of Service	E	D	D	E	E	D	C	C	C	C	B	B
Approach Delay (s)		54.0			54.3			31.9			18.9	
Approach LOS		D			D			C			B	

Intersection Summary

HCM 2000 Control Delay	34.6	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	18.5
Intersection Capacity Utilization	92.9%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

Queues

14: Highway 407 WB & Ninth Line

7/9/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	4	16	2449	1175
v/c Ratio	0.03	0.11	0.74	0.35
Control Delay	55.2	33.7	5.1	1.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.2	33.7	5.1	1.8
Queue Length 50th (m)	1.0	1.2	0.0	0.0
Queue Length 95th (m)	4.6	8.6	177.3	39.8
Internal Link Dist (m)	409.0		350.8	710.6
Turn Bay Length (m)				
Base Capacity (vph)	302	280	3325	3325
Starvation Cap Reductn	0	0	29	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.06	0.74	0.35

Intersection Summary

HCM Signalized Intersection Capacity Analysis

14: Highway 407 WB & Ninth Line

7/9/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	4	15	2327	0	0	1116
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	4	16	2449	0	0	1175
RTOR Reduction (vph)	0	11	0	0	0	0
Lane Group Flow (vph)	4	5	2449	0	0	1175
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.0	4.0	112.0			112.0
Effective Green, g (s)	5.0	5.0	113.0			113.0
Actuated g/C Ratio	0.04	0.04	0.87			0.87
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	68	61	3110			3110
v/s Ratio Prot	0.00		c0.68			0.33
v/s Ratio Perm		c0.00				
v/c Ratio	0.06	0.09	0.79			0.38
Uniform Delay, d1	60.2	60.3	3.5			1.7
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.6	2.1			0.4
Delay (s)	60.6	60.9	5.6			2.0
Level of Service	E	E	A			A
Approach Delay (s)	60.9		5.6			2.0
Approach LOS	E		A			A

Intersection Summary

HCM 2000 Control Delay	4.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	82.7%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues
15: Highway 407 EB

7/9/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	1062	489	1551	1179
v/c Ratio	0.85	0.80	0.78	0.59
Control Delay	49.0	46.5	28.6	22.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	49.0	46.5	28.6	22.7
Queue Length 50th (m)	137.1	107.6	175.6	112.7
Queue Length 95th (m)	160.0	148.7	213.8	139.3
Internal Link Dist (m)	491.6		158.9	350.8
Turn Bay Length (m)				
Base Capacity (vph)	1338	651	1990	1990
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.79	0.75	0.78	0.59
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

15: Highway 407 EB

7/9/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	1009	465	0	1473	1120	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	0.97	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	3471	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	3471	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	1062	489	0	1551	1179	0
RTOR Reduction (vph)	0	35	0	0	0	0
Lane Group Flow (vph)	1062	454	0	1551	1179	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	49.1	49.1		76.9	76.9	
Effective Green, g (s)	50.1	50.1		77.9	77.9	
Actuated g/C Ratio	0.36	0.36		0.56	0.56	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1242	572		1991	1991	
v/s Ratio Prot	c0.31			c0.43	0.33	
v/s Ratio Perm		0.28				
v/c Ratio	0.86	0.79		0.78	0.59	
Uniform Delay, d1	41.6	40.3		24.3	20.5	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	6.0	7.4		3.1	1.3	
Delay (s)	47.5	47.7		27.4	21.8	
Level of Service	D	D		C	C	
Approach Delay (s)	47.6			27.4	21.8	
Approach LOS	D			C	C	

Intersection Summary

HCM 2000 Control Delay	33.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	82.7%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

18: Ninth Line & Rouge Bank Dr

7/9/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	8	300	148	235	134	16	99	447	94
v/c Ratio	0.03	0.60	0.67	0.47	0.25	0.04	0.16	0.56	0.09
Control Delay	15.6	24.1	35.1	21.4	4.9	15.9	7.0	10.7	5.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	15.6	24.1	35.1	21.4	4.9	15.9	7.0	10.7	5.9
Queue Length 50th (m)	0.7	28.4	14.5	21.6	0.0	1.2	1.5	23.7	3.1
Queue Length 95th (m)	3.3	48.7	31.7	38.3	9.9	5.1	10.7	47.9	9.6
Internal Link Dist (m)		88.3		64.4			152.0		192.9
Turn Bay Length (m)					60.0	60.0		60.0	
Base Capacity (vph)	362	655	289	657	646	444	613	800	1030
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.46	0.51	0.36	0.21	0.04	0.16	0.56	0.09

Intersection Summary

HCM Signalized Intersection Capacity Analysis

18: Ninth Line & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	8	275	10	141	223	127	15	19	75	425	64	26
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0		3.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Frt	1.00	0.99		1.00	1.00	0.85	1.00	0.88		1.00	0.96	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1789	1873		1789	1883	1601	1789	1658		1789	1802	
Flt Permitted	0.55	1.00		0.44	1.00	1.00	0.70	1.00		0.60	1.00	
Satd. Flow (perm)	1037	1873		829	1883	1601	1311	1658		1139	1802	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	8	289	11	148	235	134	16	20	79	447	67	27
RTOR Reduction (vph)	0	2	0	0	0	98	0	52	0	0	12	0
Lane Group Flow (vph)	8	298	0	148	235	36	16	47	0	447	82	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		2			6			8		7	4	
Permitted Phases	2			6		6	8			4		
Actuated Green, G (s)	15.2	15.2		15.2	15.2	15.2	19.5	19.5		33.2	33.2	
Effective Green, g (s)	16.2	16.2		16.2	16.2	16.2	20.5	20.5		34.2	34.2	
Actuated g/C Ratio	0.27	0.27		0.27	0.27	0.27	0.34	0.34		0.57	0.57	
Clearance Time (s)	6.0	6.0		6.0	6.0	6.0	6.0	6.0		4.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	278	502		222	505	429	444	562		760	1020	
v/s Ratio Prot		0.16			0.12			0.03		c0.10	0.05	
v/s Ratio Perm	0.01			c0.18		0.02	0.01			c0.23		
v/c Ratio	0.03	0.59		0.67	0.47	0.08	0.04	0.08		0.59	0.08	
Uniform Delay, d1	16.3	19.2		19.7	18.5	16.5	13.3	13.6		7.7	6.0	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	1.9		7.4	0.7	0.1	0.2	0.3		1.2	0.2	
Delay (s)	16.3	21.1		27.1	19.2	16.6	13.5	13.9		8.9	6.1	
Level of Service	B	C		C	B	B	B	B		A	A	
Approach Delay (s)		21.0			20.8			13.8			8.4	
Approach LOS		C			C			B			A	

Intersection Summary

HCM 2000 Control Delay	15.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	60.4	Sum of lost time (s)	13.0
Intersection Capacity Utilization	65.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis
 19: Cottontail Ave/Russell Jarvis Dr & Rouge Bank Dr

7/9/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	5	141	4	21	125	109	3	13	68	89	7	8
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	148	4	22	132	115	3	14	72	94	7	8
Direction, Lane #	EB 1	WB 1	NB 1	SB 1								
Volume Total (vph)	158	268	88	109								
Volume Left (vph)	5	22	3	94								
Volume Right (vph)	4	115	72	8								
Hadj (s)	0.02	-0.21	-0.44	0.16								
Departure Headway (s)	4.7	4.4	4.6	5.2								
Degree Utilization, x	0.21	0.33	0.11	0.16								
Capacity (veh/h)	709	777	702	633								
Control Delay (s)	9.0	9.5	8.2	9.1								
Approach Delay (s)	9.0	9.5	8.2	9.1								
Approach LOS	A	A	A	A								
Intersection Summary												
Delay			9.1									
Level of Service			A									
Intersection Capacity Utilization			42.0%	ICU Level of Service	A							
Analysis Period (min)			15									

Appendix E – Internal Circulation

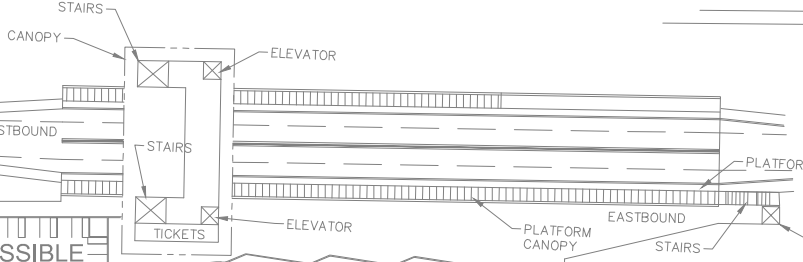
NINTH LINE STATION

- Vehicle path for buses
- Vehicle paths for passenger cars

407 TRANSITWAY

± 1019 PARKING SPACES

13 ACCESSIBLE SPACES



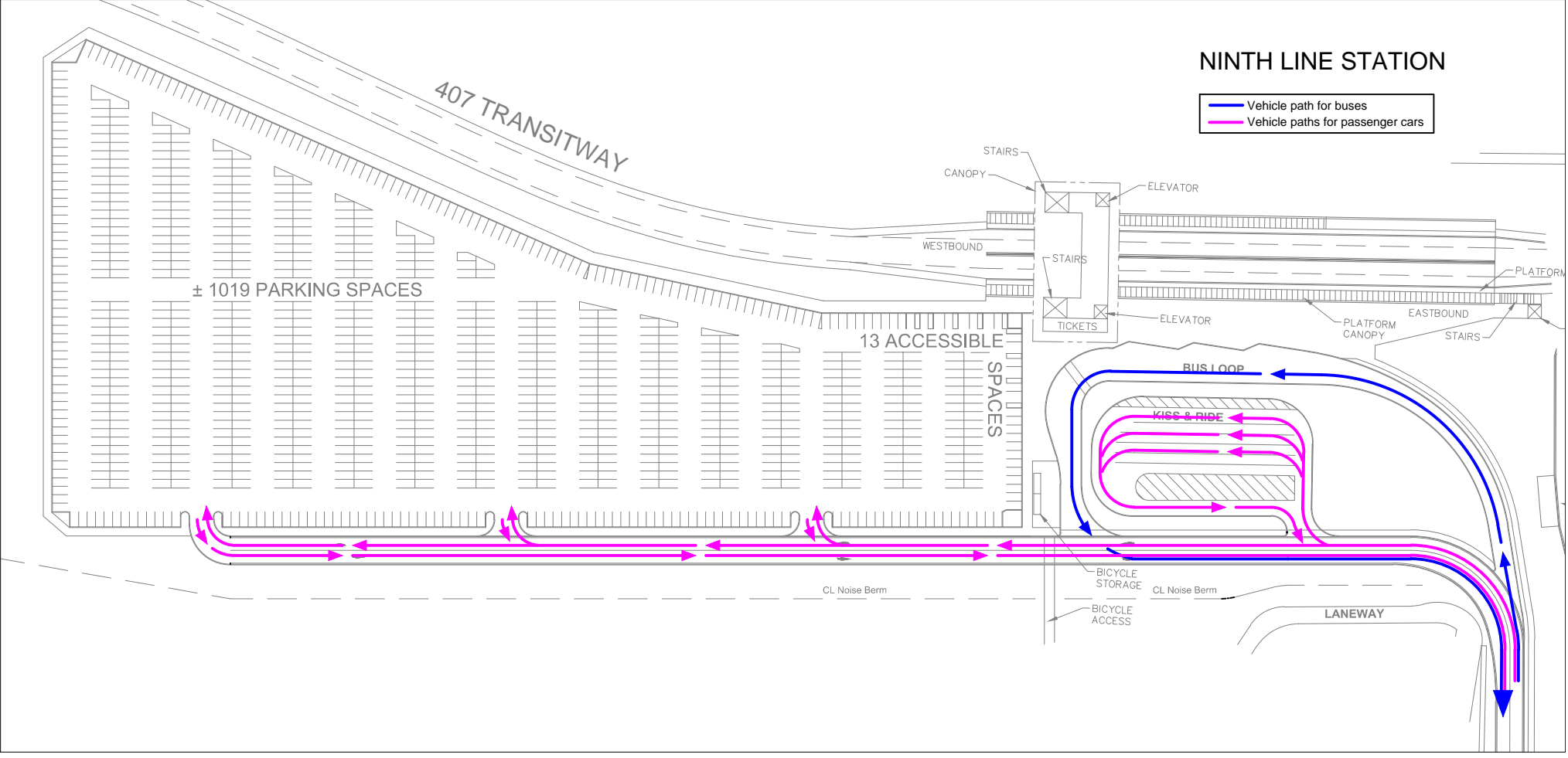
BUS LOOP

KISS & RIDE

CL Noise Berm

BICYCLE STORAGE
BICYCLE ACCESS

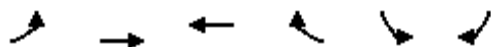
LANEWAY



HCM Unsignalized Intersection Capacity Analysis

74:

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	0	10	481	148	148	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	11	506	156	156	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	662				595	584
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	662				595	584
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				67	100
cM capacity (veh/h)	936				471	515

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	11	662	156
Volume Left	0	0	156
Volume Right	0	156	0
cSH	936	1700	471
Volume to Capacity	0.00	0.39	0.33
Queue Length 95th (m)	0.0	0.0	10.9
Control Delay (s)	0.0	0.0	16.4
Lane LOS			C
Approach Delay (s)	0.0	0.0	16.4
Approach LOS			C

Intersection Summary			
Average Delay		3.1	
Intersection Capacity Utilization		49.2%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis

73:

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	0	370	0	154	154	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	389	0	162	162	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	162				471	81
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	162				471	81
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				71	100
cM capacity (veh/h)	1429				555	984

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	389	162	162
Volume Left	0	0	162
Volume Right	0	162	0
cSH	1429	1700	555
Volume to Capacity	0.00	0.10	0.29
Queue Length 95th (m)	0.0	0.0	9.2
Control Delay (s)	0.0	0.0	14.1
Lane LOS			B
Approach Delay (s)	0.0	0.0	14.1
Approach LOS			B

Intersection Summary			
Average Delay		3.2	
Intersection Capacity Utilization		34.7%	ICU Level of Service A
Analysis Period (min)		15	

Report

Donald Cousens Parkway Station Traffic Study



Prepared for Ministry of Transportation, Ontario
by IBI Group

December 20, 2016

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1 Introduction

The proposed Donald Cousens Parkway Highway 407 Transitway Station is a new transit station in the City of Markham, in the Regional Municipality of York. The station site is located at the southeast corner of the Highway 407 interchange at Donald Cousens Parkway.

This study analyzes the potential traffic impacts of the proposed station on the surrounding road network. The existing conditions year is 2015 with the future horizon year of 2031. Traffic analysis includes station access and adjacent street network to determine any operational deficiencies. In addition, this memo documents the impact of station volumes onto Donald Cousens Parkway due to the park and ride facility at the proposed station.

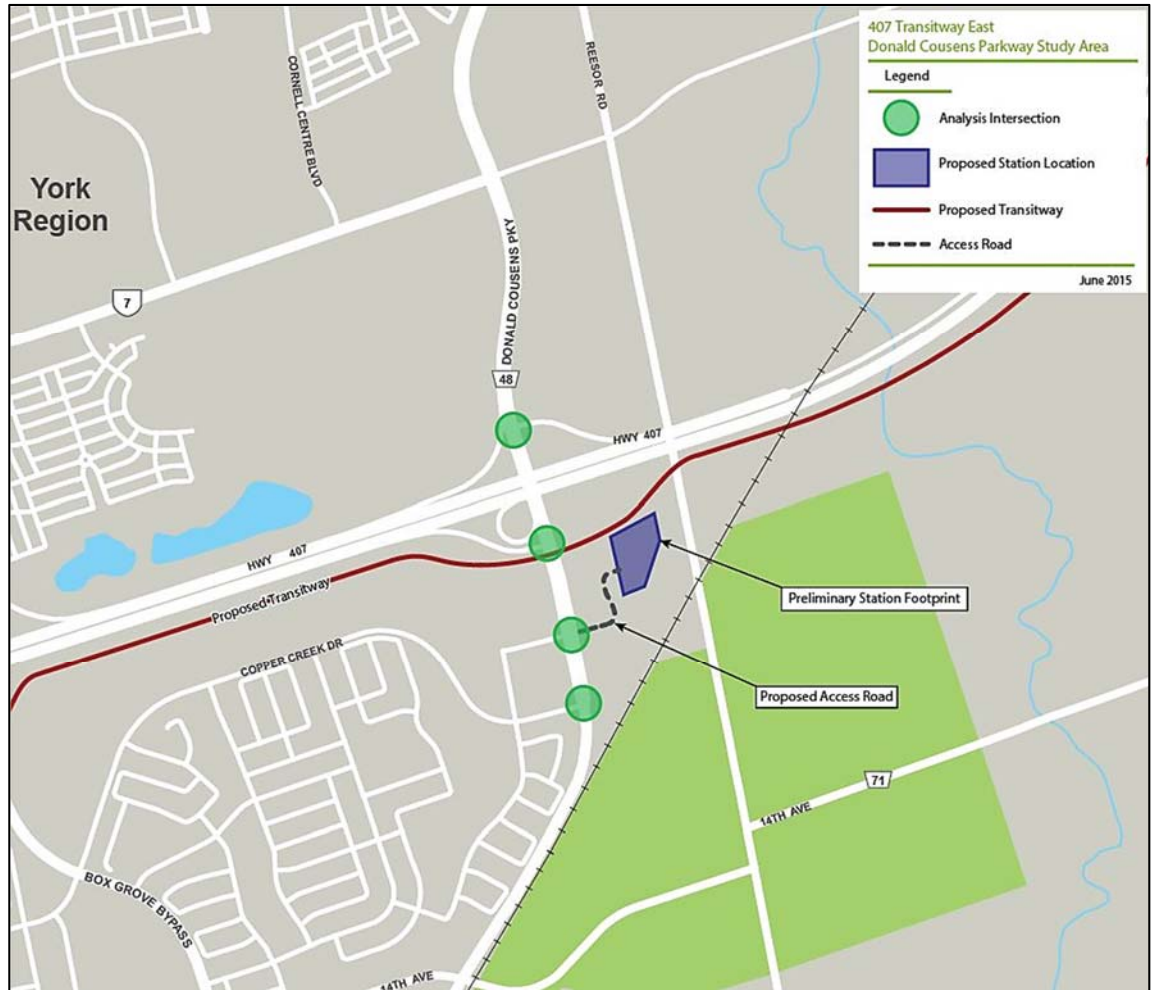
1.1 Study Area

The study area was confirmed with the Ministry of Transportation, Ontario (MTO) staff and includes the following intersections:

- Highway 407 West Off-ramp at Donald Cousens Parkway;
- Highway 407 East Off-ramp at Donald Cousens Parkway;
- Future site access at Donald Cousens Parkway; and
- Copper Creek Drive at Donald Cousens Parkway.

The above intersections are shown in Exhibit 1-1 below. Analysis intersections are marked in green while the future site access is shown in blue. The new access intersection will build upon the current Walmart Right-In, Right-Out (RIRO) access, located between the Highway 407 East Off-ramp and Copper Creek Road. The RIRO will be transformed into a signalized intersection for 2031 and is the only access to the proposed station. The new layout configuration is included in the future conditions analysis in Section 4.

Exhibit 1-1: Study Area Map



1.2 Study Objective

The objective of the traffic analysis for Donald Cousens Parkway is to support the planning and preliminary design of the Transitway by identifying problems in the road network, providing needs and justification, and evaluating solutions.

Section 2 provides the existing road network and traffic operations of the analysis intersections in the study area.

Section 3 discusses the traffic volume projections of the proposed station, including the assignment of site-generated trips in the study area

Section 4 provides the projection of future background and future total traffic volumes. It also includes a discussion of potential improvements and/or road network changes that would improve future operating conditions.

Section 5 provides the station internal circulation analysis.

2 Existing Conditions

2.1 Road Network

Donald Cousens Parkway (York Regional Road 48) is a four lane north-south Regional Road with divided urban cross section within the study area. It has designated left and right turning lanes at the intersections with Highway 7 and Copper Creek Drive.

Highway 407 is a six lane Express Toll Route. It provides connections from the City of Burlington to the City of Pickering.

14th Avenue (York Regional Road 71) is a four lane east-west Regional Road with urban cross section within the study area. It has designated left and right turning lanes at the intersection with Markham Road.

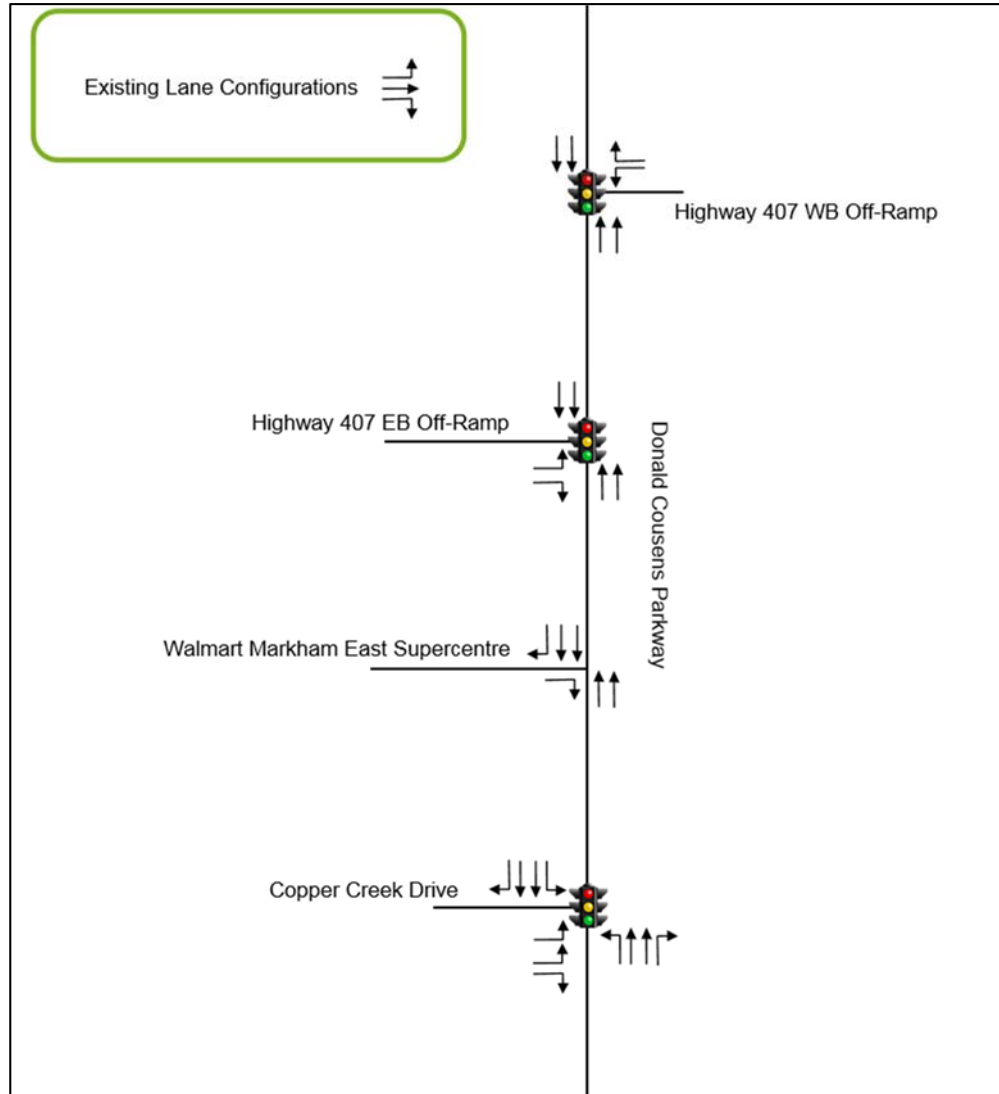
Copper Creek Drive is a four lane east-west local road with urban cross section. It has designated bike lanes on both sides and has dedicated left and right turning lanes at the intersection with Donald Cousens Parkway.

Existing Lane Configurations

The existing conditions (2015) lane configuration was developed based on a review of aerial images. See Exhibit 2-1 for a simplified representation of the intersection lane configurations.

Suggested future lane configurations are based on the analyses in this study, discussed in detail later in this section as well as Section 4.

Exhibit 2-1: Existing Intersection Lane Configurations



2.2 Data Collection

Traffic data was obtained from York Region. Exhibit 2-2 shows the date of the Automatic Traffic Recorder (ATR) count used to determine the existing traffic conditions.

Exhibit 2-2: Count Data

ATR Count Summary	Date
Donald Cousens Parkway between Exit 95 and Highway 7	May 2015
Highway 407 WB Offramp to Donald Cousens Parkway	May 2014
Highway 407 EB Offramp to Donald Cousens Parkway	May 2014
Donald Cousens Parkway to Highway 407 EB Onramp	May 2014
Donald Cousens Parkway to Highway 407 WB Onramp	May 2014

2.3 Operations

The existing conditions year is 2015. Analysis was conducted for weekday a.m. and p.m. peak hours. Traffic counts were scaled from 2014 to 2015 using an annual compounded growth rate of 2.0%, based on the Donald Cousens Parkway traffic growth between 2011 and 2031 from the Greater Golden Horseshoe (GGH) model results. The growth rate also meets the recommended general rate of 2.0% in the York Region TIS Guidelines (2007). Existing conditions traffic volumes are shown in Exhibit 2-3.

Traffic volumes distributed throughout the study area based on the ATR counts on Donald Cousens Parkway (between Highway 7 and the Highway 407 westbound off-ramp) and the Highway 407 ramps. The following assumptions were used in distributing traffic in the study area:

- Off-ramp traffic was distributed equally between the northbound and southbound directions on Donald Cousens Parkway;
- The Walmart Markham East Supercentre (WMES) has two accesses on the west, one to the south, and one on the east that is a Right-In, Right-Out (RIRO). Due to the majority of the development in the area being to the southwest of the Supercentre, 20% of traffic entering and exiting the site will use the east RIRO access;
- For traffic exiting the WMES to head north on Donald Cousens Parkway, traffic will use the south access onto Copper Creek Drive; and
- Based on the review of the proportion of flow from the GGH model, 60% of traffic at the intersection of Donald Cousens Parkway and Copper Creek Drive is distributed as through traffic and 40% use Copper Creek Drive.

ITE Trip Generation Manual (8th edition) provides inbound and outbound peak hour trip rates for the WMES to determine turning movement counts for the east access. The assumed lane use for the Supercentre is #813 Free-Standing Discount Superstore with an estimated area of approximately 15,000 m² (161,459 ft²). Exhibit 2-4 shows the total number of trips entering and exiting the WMES, with only 20% of these trips using the east access.

Exhibit 2-3: Existing Conditions (2015) Traffic Volumes

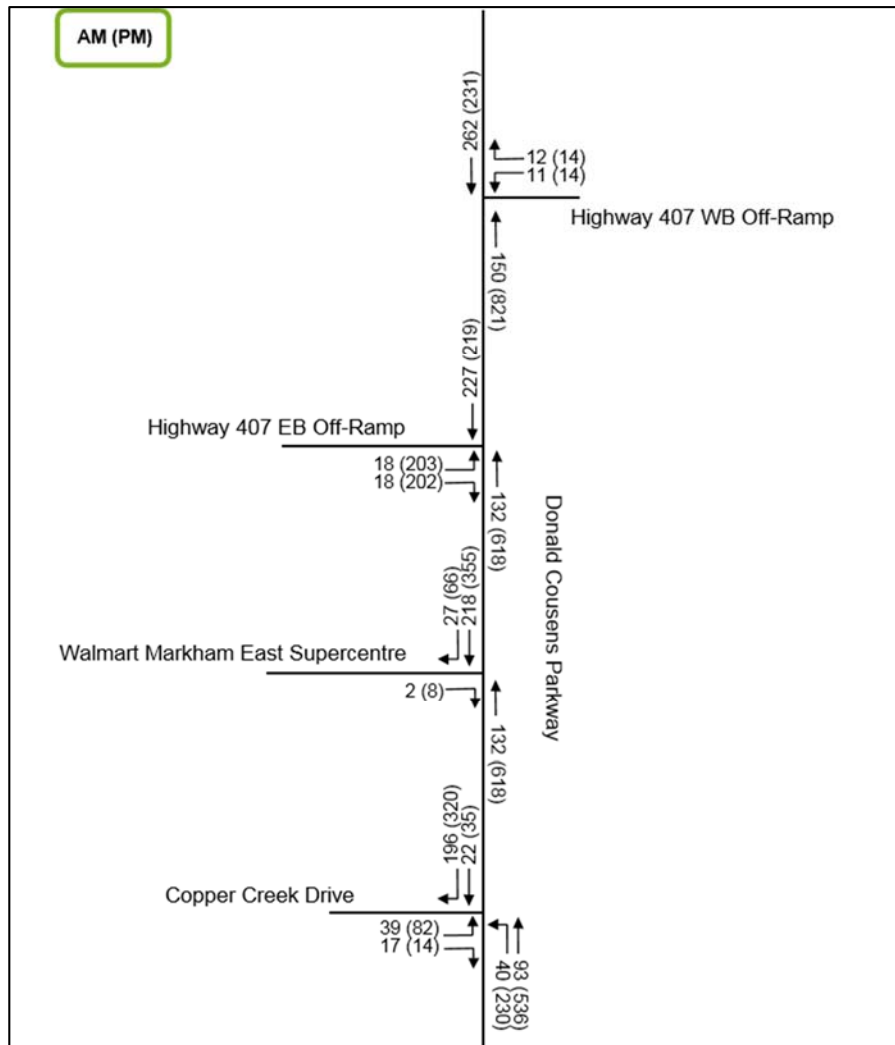


Exhibit 2-4: ITE Trip Generation for the Walmart Markham East Supercentre

ITE Land Code 813	GFA (ft ²)	AM			PM		
		Total	Entering	Exiting	Total	Entering	Exiting
Rate	161,459	1.67	0.56	0.44	4.61	0.49	0.51
Number of Trips		270	151	119	744	365	380

Intersection operations analysis was conducted using Synchro 9, which utilizes the Highway Capacity Manual (HCM) 2000 methodology to evaluate overall intersection and individual movement performances. The level of service (LOS) is a measure of performance based on the control delay, defined as follows in Exhibit 2-5:

Exhibit 2-5: Intersection LOS Reference

HCM LOS	Control Delay per Vehicle (s)	
	Signalized	Unsignalized
A	≤10	≤10
B	>10 and ≤20	>10 and ≤15
C	>20 and ≤35	>15 and ≤25
D	>35 and ≤55	>25 and ≤35
E	>55 and ≤80	>35 and ≤50
F	>80	>50

Critical movements were identified by satisfying any one or more of the following criteria, based on the York Region TIS Guidelines for an urban area:

- Control delay of LOS E or worse;
- 95th percentile queue exceeding provided storage/link length; and
- Volume-to-capacity (v/c) ratio of 0.85 or greater.

A summary of the Synchro analysis including delay, 95th percentile queue, and level-of-service (LOS) indicators is shown in Exhibit 2-6 with the detailed output provided in Appendix A.

All intersections operate with at LOS A or B, with no critical movements.

Exhibit 2-6: Existing Conditions Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Donald Cousens Parkway	A					A				
Highway 407 East Off-Ramp at Donald Cousens Parkway	A					B				
Walmart East Access at Donald Cousens Parkway*		N/A					N/A			
Copper Creek Drive at Donald Cousens Parkway	A					B				

*RIRO, no analysis available

2.4 Transit Access

York Regional Transit (YRT) provides transit access within York Region and also contracts TTC bus routes to connect to the subway service. The YRT/Viva is a Bus Rapid Transit (BRT) network that also operates a number of routes on major arterials. Within the study area of Donald Cousens Parkway Station, the following services are currently in operation:

- **YRT Route 1 – Highway 7** runs along Highway 7 and connects the Richmond Hill Centre to the Markham Stouffville Hospital with headways ranging from 20 to 30 minutes during peak hours;
- **YRT Route 2 – Milliken** runs along John Street and Den and connects the Finch GO Bus Terminal to Markham Road with headways ranging from 20 to 30 minutes during peak hours. Weekend service runs near Donald Cousens Parkway; and
- **YRT Route 14 – 14th Avenue** runs along 14th Avenue and connects Woodbine Avenue to Donald Cousens Parkway.

Exhibit 2-7 illustrates the transit connections within the study area.

Exhibit 2-7: YRT in the Study Area



3 Site Traffic

This section provides the methodology and process used to generate and distribute site-generated traffic from the proposed station.

3.1 Station Demand Forecasts

Station demand forecasts were developed based on the Greater Golden Horseshoe (GGH) model scenarios for the 407 Transitway East study. There are two scenarios, a.m. and p.m., each based on the projected 2031 population and employment in the GGH area. For the purposes of this study, demand adjustments were undertaken to better calibrate the transit travel patterns in the east portion of the 407 Transitway between Kennedy Road and Brock Road. Model results for each station include peak period demand in three access categories: park-and-ride (PnR), walk/transit, and interline. See Exhibit 3-1 for the station travel demand forecasts.

ITE Trip Generation Manual (8th edition) provides inbound and outbound peak hour trip rates for transit stations with park and ride service (code #90), based on the number of parking spaces provided. In order to develop the number of parking spaces required at each station, 2011 TTS data at existing GO transit stations were analyzed. The average ratio between a.m. peak period auto driver demand and the number of parking spaces provided at these stations was found to be 0.75. See Exhibit 3-2 for the list of GO stations and their parking provision rates.

The ratio found above was applied to the 407 Transitway East stations to develop the number of parking spaces needed, with the assumption that auto driver demand is equal to park-and-ride demand. See Exhibit 3-3 for the proposed number of parking spaces at each station.

Exhibit 3-1: GGH Model Results – 2031 AM Peak Period Transitway Station Demand

Station	2031 AM Peak Period Travel Adjusted			
	PnR	Walk/Transit	Interline	Total
Brock Road	450	30	1,690	2,170
Whites Road	540	40	1,480	2,060
Donald Cousens Parkway	383	127	0	510
9th Line	503	167	0	670
Markham Road	608	102	100	810

Exhibit 3-2: TTS Data – 2011 AM Peak Period GO Station Demand and Parking Supply

2011 TTS AM Peak Period Travel		Station Parking	
GO Station (Rural)	Auto Driver*	Spaces	% Provision
Stouffville	220	243	91%
Aurora	1,010	1,463	69%
Newmarket	260	265	98%
Milton	1,330	1,544	86%
Georgetown	400	614	65%
Mount Pleasant	830	1,112	75%
Total Rural	4,050	5,241	77%
GO Station (Durham)	Auto Driver	Spaces	% Provision
Oshawa	1,620	2,380	68%
Whitby	2,200	2,958	74%
Ajax	1,730	2,148	81%
Pickering	1,850	2,508	74%
Total Durham	7,400	9,994	74%
Total	11,450	15,235	75%

* Rounded to nearest 10

Exhibit 3-3: Station Parking Space Requirement

Station	PnR Demand	Parking Spaces
Brock Road	450	600
Whites Road	540	720
Donald Cousens Parkway	383	511
9th Line	503	671
Markham Road	608	810
Kennedy Road	820	1,093

3.2 Trip Generation

Trip generations rates were based on the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th Edition. Land use code 90 (Park and Ride Lot for Bus Service) was used to determine the number of auto trips in to and out of the station based on the number of spaces in the station parking lot. The number of parking spaces was estimated based on projected ridership.

The proposed station is to have a single access to Donald Cousens Parkway between the intersections with Highway 407 EB off-ramp and Copper Creek Drive. Estimated transit ridership is approximately 510 riders in the a.m. peak period, with 75% using the park and ride (PnR) services.

Based on similar other stations, it is assumed that an additional 25% provision of parking would be used by 2031, thus a parking lot size of 511 spaces was assumed for trip generation purposes.

The trip generation rates and resultant traffic volumes projected for 2031 are shown in Exhibit 3-4.

Exhibit 3-4: Trip Generation Rates

Donald Cousens Parkway Station Traffic Volumes						
ITE Land Use Code 90	Total	Entering	Exiting	Total	Entering	Exiting
	AM			PM		
Rate: Trips per Parking Space	0.72	0.81	0.19	0.62	0.23	0.77
# of Trips	368	298	70	317	73	244

3.3 Surface Transit Forecasts

Transit volumes were also added based on the assumption that transit would need to accommodate approximately 1/3 of the users of the PNR (25% non PnR vs 75% PnR). A capacity of 25 people per bus was assumed to determine 10 buses per hour that enter and exit the station during the peak hour.

Note that site-accessing bus volumes are accounted in the station access intersection turning movement volumes, but not in the adjacent intersections as they are considered to be included within background traffic volumes.

3.4 Trip Assignment

Station traffic was estimated based on former studies done for the central section of the Highway 407 Transitway completed in 2011. The distribution was approximately 65% to/from the north and 25% to/from the south along Donald Cousens Parkway, and the remaining 10% to/from the west along the Walmart Access. At the intersections of Donald Cousens Parkway at Copper Creek Drive, station traffic was assumed to follow the percentage distribution of existing peak hour traffic turning movements.

See Exhibit 3-5 for the trip assignment percentages.

See Exhibit 3-6 for the trip assignment volumes.

Exhibit 3-5: Trip Assignment Percentages

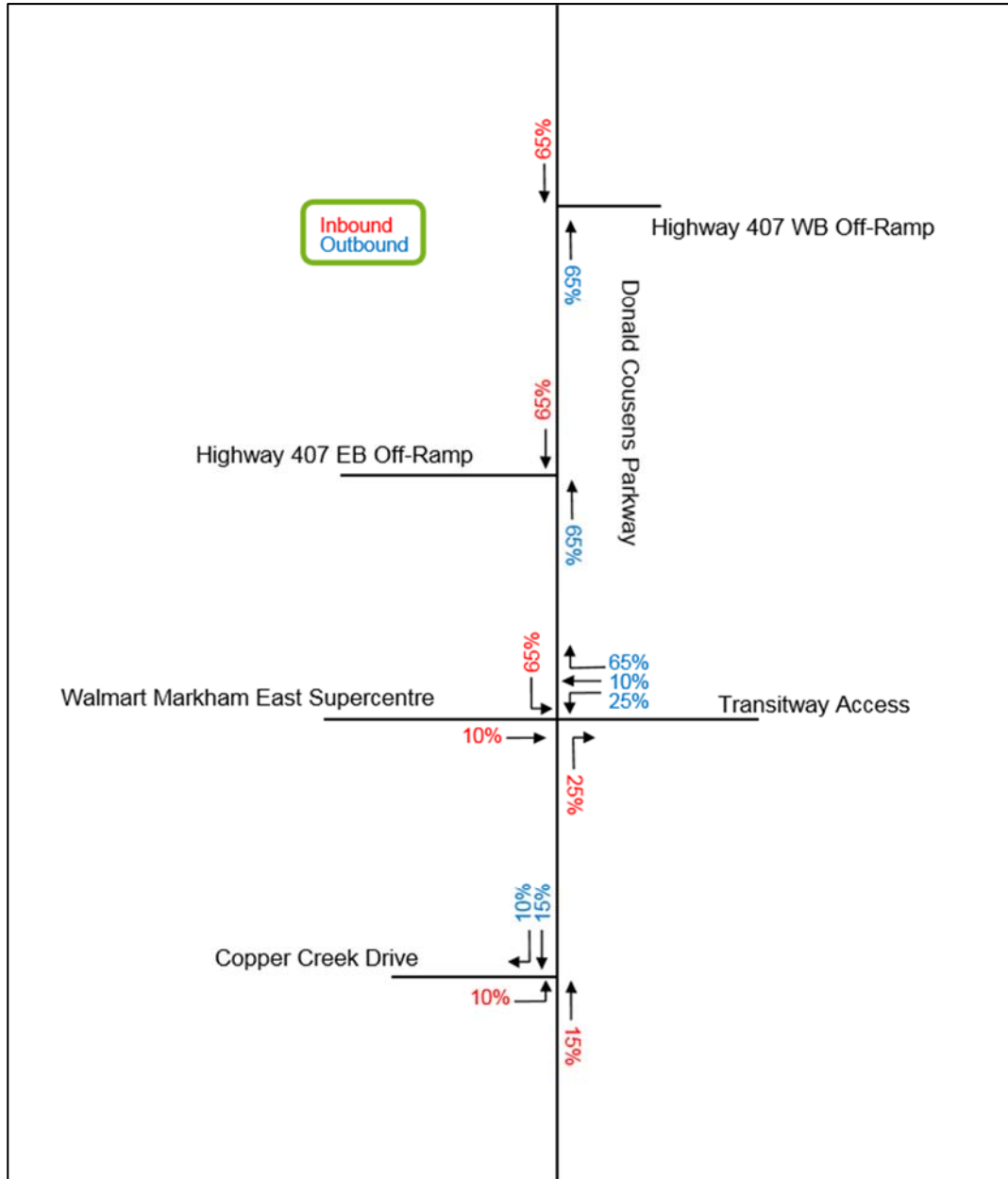
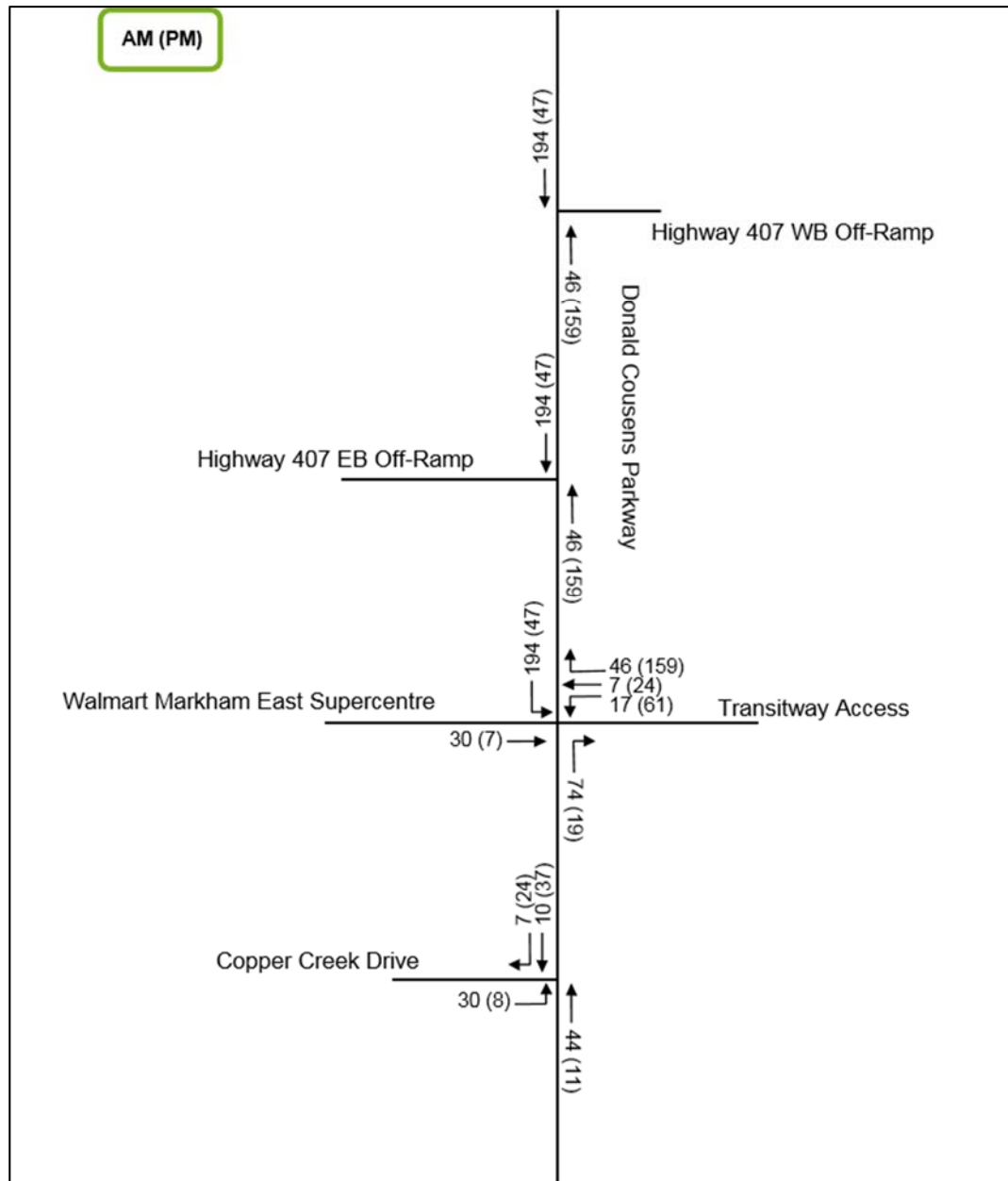


Exhibit 3-6: Trip Assignment Volumes



4 Future Conditions

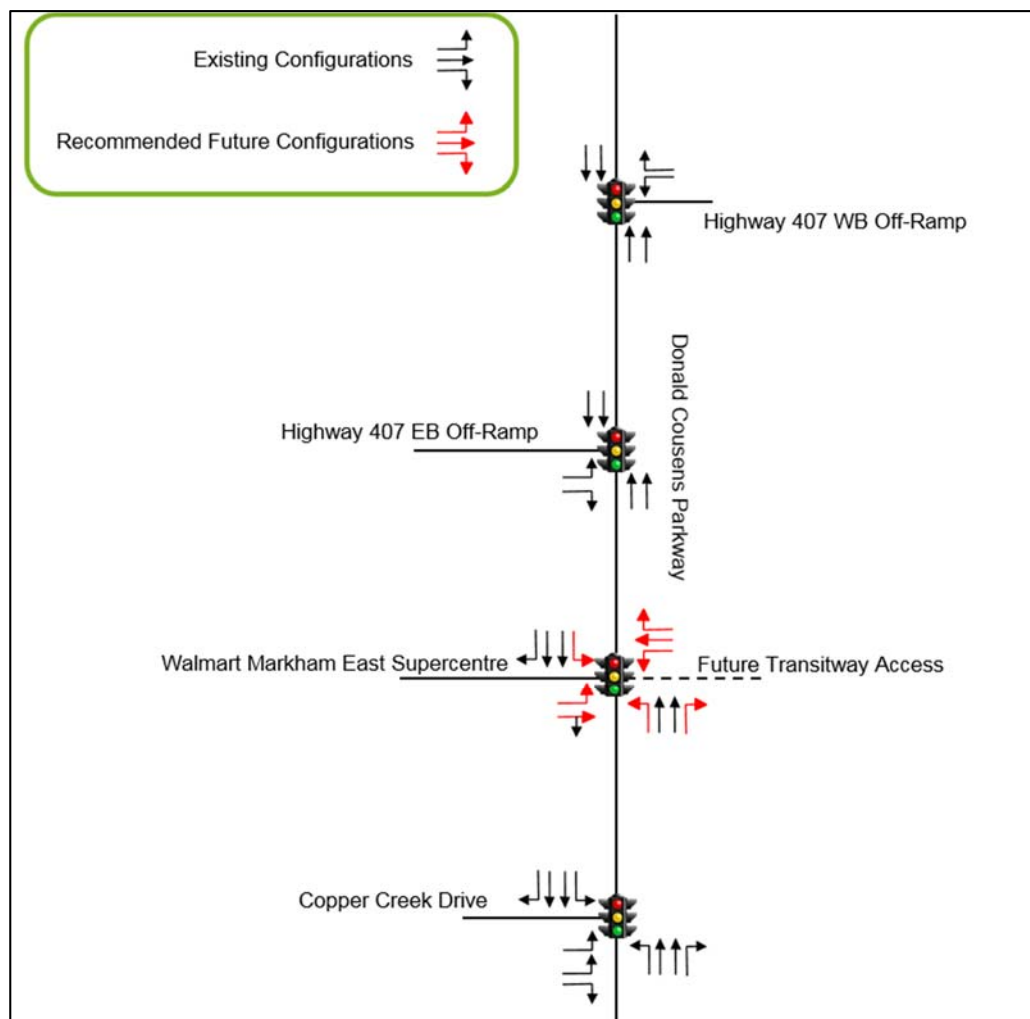
4.1 Road Network

The future conditions (2031) lane configuration was developed based on a review of aerial images. The proposed access road for the Transitway builds upon the intersection of the Walmart Markham East Supercentre and Donald Cousens Parkway. The existing RIRO will be upgraded to a fully operational signalized intersection with the following improvements:

- Each approach will have a left turning bay;
- In addition to a left turning bay, the future Transitway access will have one through lane and one right turning bay;
- The Walmart Markham East Supercentre access will have a shared through/right lane; and
- The north approach on Donald Cousens Parkway will include a right turning bay.

Exhibit 4-1 shows a simplified representation of the intersection lane configurations.

Exhibit 4-1: Future Intersection Lane Configuration



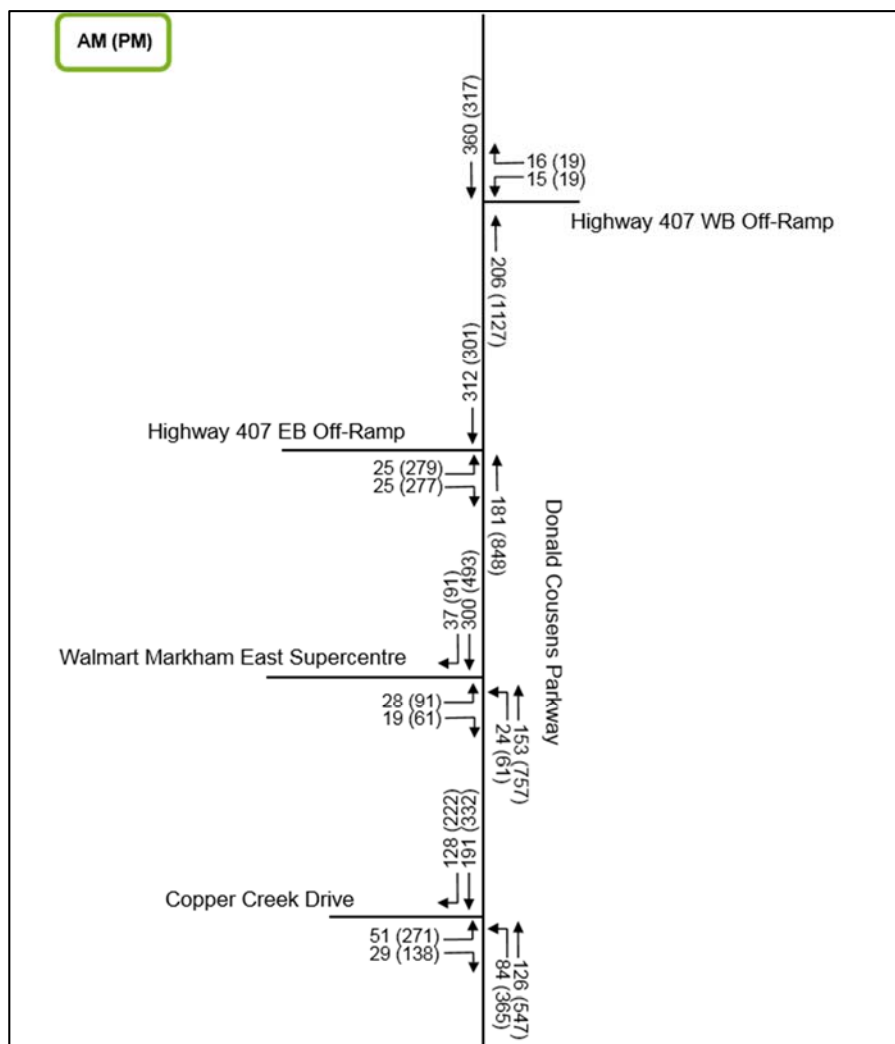
4.2 Background Operations

The future horizon year of 2031 was analyzed in coordination with overall Transitway phasing strategy. All future conditions analysis scenarios include signal timing optimization based on existing and/or nearby intersection's cycle lengths.

Background traffic growth was scaled to future volumes by using an annual compounded growth rate of 2.0% (a total growth of 37.3%). This accounts for growth and development in and around the study area that would influence the traffic demand. In addition to background growth, additional traffic was added due to the development of the retail site adjacent to the Walmart Supercentre. The trips calculated in Section 2.3 for the Supercentre were doubled to indicate the retail development. Volumes on Copper Creek Drive are also lower than expected as traffic exiting the Supercentre using the east access and heading northbound no longer have to go down to Copper Creek Drive due to the fully upgraded intersection.

The 2031 background volume (without site-generated traffic) is shown in Exhibit 4-2. Summary of the future background conditions analysis is shown in Exhibit 4-3.

Exhibit 4-2: Future 2031 Background Volumes



Intersections in the study operate well, with only one reported critical movement. The Highway 407 Westbound Off-Ramp at Donald Cousens Parkway experiences a LOS E in the p.m. peak hour for the westbound left turning movement.

Exhibit 4-3: Future 2031 Background Conditions Intersection Operational Performance Summary

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Donald Cousens Parkway	A					A	WBL	E	0.24	12.3
Highway 407 East Off-Ramp at Donald Cousens Parkway	A					B				
Walmart East Access at Donald Cousens Parkway	A					A				
Copper Creek Drive at Donald Cousens Parkway	A					B				

4.3 Total Operations

The site generated Transitway trips were added to the future background volumes to determine the total traffic operation in the study area. Exhibit 4-4 shows the total 2031 future volumes.

Site generated traffic has no effect on the intersections in the study area. The only critical movement at the Highway 407 Westbound Off-Ramp and Donald Cousens Parkway is the westbound left turning movement with a LOS E.

Roundabouts were considered at all four of the intersections along Donald Cousens Parkway. At the intersection of Walmart Markham East Supercentre, the property requirements for a roundabout would encroach upon private property or cause realignment of Donald Cousens and thus is not feasible. At the intersections of Highway 407 Eastbound and Westbound off-ramps, and at Copper Creek Drive, there is already a good level of service at each intersection. Adding a roundabout would have minimal operational benefits and would entail significant construction and realignment of the off-ramps and through roads.

Exhibit 4-4: Future 2031 Total Volumes

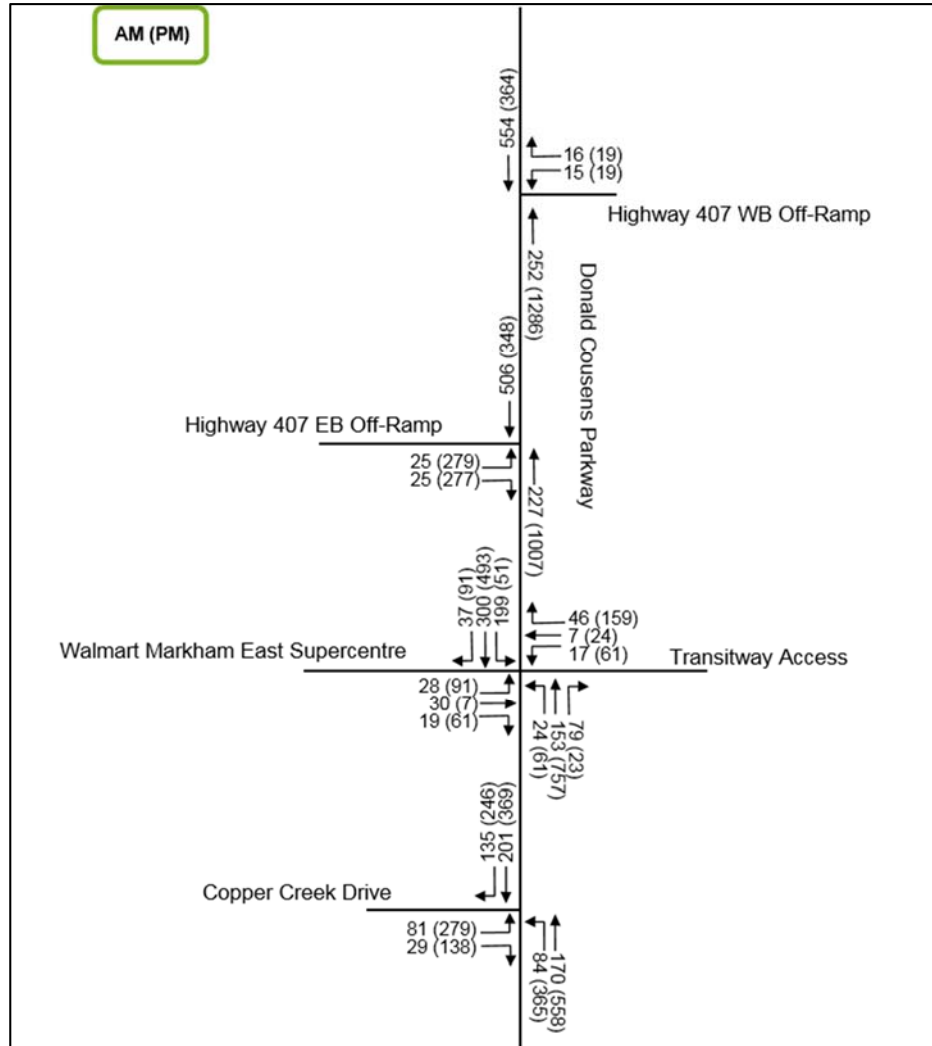


Exhibit 4-5: Future 2031 Total Conditions Intersection Operational Performance Summary

Intersection	AM	Critical			95th Queue (m)	PM	Critical			95th Queue (m)
	Overall LOS	Mvmt	LOS	V/C		Overall LOS	Mvmt	LOS	V/C	
Highway 407 West Off-Ramp at Donald Cousens Parkway	A					A	WBL	E	0.24	12
Highway 407 East Off-Ramp at Donald Cousens Parkway	A					B				
Walmart East Access at Donald Cousens Parkway	A					A				
Copper Creek Drive at Donald Cousens Parkway	A					B				

5 Internal Circulation

This section provides an overview of the proposed station’s internal circulation design, with vehicle composition and flow derived from the site-generated trips in Section 3. The intersection with the highest number of potential vehicle volumes (and/or conflicting movements) is analyzed as an unsignalized intersection in Synchro, within the a.m. and p.m. peak hours.

Internal circulation plan for this station is not available at the time of this report; however, based on other station designs, the following assumptions are made in regards to the internal network to develop a “potential conflict intersection” for analysis purposes:

- The bus loop, Kiss-and-Ride (KnR), and Park-and-Ride (PnR) areas are separated and accessed through unsignalized T-intersections; and
- The bus loop intersection is located closest to the site access intersection at Donald Cousens Parkway.

The station internal volumes consist of:

- Passenger vehicles: AM: 298 in, 70 out; PM: 73 in, 244 out; and
- Buses (sum of northbound and southbound buses): AM: 10 in, 10 out; PM: 8 in, 8 out.

For simplicity, all outbound vehicles in the AM and inbound vehicles in the PM are assumed to be associated with drop-off and pick-up activities (“Kiss-and-Ride”, abbreviated KnR). The remainder is assumed to be Park-and-Ride (PnR) vehicles, inbound in the AM and outbound in the PM. All buses are modelled as heavy vehicles in Synchro.

Analysis results show that there are no operational issues at the analyzed internal intersections for both peak hour operations. The east-west movement is analyzed as freeflow movements, which incurs no delay, and the southbound movement is analyzed as a stop-controlled movement, which operates at LOS A (B) in the a.m. (p.m.) peak hour at both intersections.

Results are summarized in Exhibit 5-1.

Exhibit 5-1: Internal Circulation Analysis – Donald Cousens Parkway Station

Internal			AM Peak Hour			PM Peak Hour		
Intersection	Mvmt.	Description	Volume	LOS	Queue (95 th , m)	Volume	LOS	Queue (95 th , m)
at Bus Loop	EBL	Bus in	10	A	0	8	A	0
	EBT	PnR in + KnR in	298	A	0	73	A	0
	WBT	PnR out + KnR out	70	A	0	244	A	0
	SBR	Bus out	10	A	0	8	B	0
at KnR	EBL	KnR in	70	A	1	73	A	1
	EBT	PnR in	228	A	1	0	A	1
	WBT	PnR out	0	A	0	171	A	0
	SBR	KnR out	70	A	2	73	A	2

6 Conclusion

This study presents the traffic impact analysis of the proposed Donald Cousens Parkway Station on the surrounding road network. The proposed station is located at the southeast corner of the Highway 407 interchange at Donald Cousens Parkway in the City of Markham, and can be accessed through a new signalized access intersection located south of the eastbound off-ramp.

Background traffic analysis in the existing conditions year of 2015 show that all study area intersections operate well in both peak hours. In the future year 2031 background conditions, despite the assumption of a relatively high growth rate (2.0% compounded annually / 37.3% total), all study area intersections continue to operate well in both peak hours. There is only one critical movement in the future background conditions, which is the westbound left turn at the 407 westbound off-ramp intersection. This movement experiences LOS E in the p.m. peak hour due to the intersection's long cycle length. There are no capacity issues in the study area.

Site traffic for the proposed Donald Cousens Parkway station was calculated based on the Greater Golden Horseshoe Model's projected park-and-ride demand, the required number of on-site parking spaces, and the ITE trip generation manual rates. The proposed station generates 298 (73) inbound and 70 (244) outbound trips in the a.m. (p.m.) peak hour. Site access consists of a single signalized intersection on Donald Cousens Parkway, located at the existing right-in, right-out access to the Wal-Mart in the Markham Boxgrove Smartcentre.

The addition of site-generated traffic affects all intersections in the study area with slight increases in delays for northbound through and southbound through movements. At the site access itself, the new signal plan will be required to accommodate the site-accessing traffic and buses.

Internally, the site is expected to operate with no operational issues. Conflicts between buses, park-and-ride vehicles, and kiss-and-ride vehicles are expected to be minimal due to the separation of their access points and the peak hour directional bias of the park-and-ride vehicles.

Summary of Recommendations

For the new site access intersection, the following are recommended:

- Upgrade from T-west unsignalized intersection with right-in, right-out access to full four-leg signalized intersection with northbound left and right, southbound left and right, westbound left and right, and eastbound left turning bays; and
- Signal timing plan with advanced left turn phase for the southbound left turn movement.

Appendix A – Existing (2015) Conditions Synchro Output

Queues

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	56	24	56	83	139	93
v/c Ratio	0.13	0.10	0.06	0.03	0.05	0.07
Control Delay	22.8	4.0	3.2	2.9	2.8	1.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.8	4.0	3.2	2.9	2.8	1.1
Queue Length 50th (m)	3.3	0.0	1.6	1.2	2.0	0.0
Queue Length 95th (m)	6.2	2.5	4.5	2.8	4.2	3.2
Internal Link Dist (m)				845.4	169.5	
Turn Bay Length (m)	80.0	90.0	170.0			90.0
Base Capacity (vph)	2467	1152	1013	2899	2899	1314
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.02	0.06	0.03	0.05	0.07

Intersection Summary

HCM Signalized Intersection Capacity Analysis

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↗↘		↗				↗	↕↕	↗	↗	↕↕	↗
Volume (vph)	53	0	23	0	0	0	53	79	0	0	132	88
Ideal Flow (vphp)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0				6.0	6.0			6.0	6.0
Lane Util. Factor	0.97		1.00				1.00	0.95			0.95	1.00
Frt	1.00		0.85				1.00	1.00			1.00	0.85
Flt Protected	0.95		1.00				0.95	1.00			1.00	1.00
Satd. Flow (prot)	3471		1601				1789	3579			3579	1601
Flt Permitted	0.95		1.00				0.66	1.00			1.00	1.00
Satd. Flow (perm)	3471		1601				1250	3579			3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	56	0	24	0	0	0	56	83	0	0	139	93
RTOR Reduction (vph)	0	0	22	0	0	0	0	0	0	0	0	25
Lane Group Flow (vph)	56	0	2	0	0	0	56	83	0	0	139	68
Turn Type	Prot		Perm				Perm	NA	Perm	Perm	NA	Perm
Protected Phases	4							6			2	
Permitted Phases			4				6		6	2		2
Actuated Green, G (s)	4.0		4.0				43.5	43.5			43.5	43.5
Effective Green, g (s)	5.0		5.0				44.5	44.5			44.5	44.5
Actuated g/C Ratio	0.08		0.08				0.74	0.74			0.74	0.74
Clearance Time (s)	6.0		6.0				7.0	7.0			7.0	7.0
Vehicle Extension (s)	3.0		3.0				3.0	3.0			3.0	3.0
Lane Grp Cap (vph)	286		132				919	2632			2632	1177
v/s Ratio Prot	c0.02							0.02			0.04	
v/s Ratio Perm			0.00				c0.04					0.04
v/c Ratio	0.20		0.02				0.06	0.03			0.05	0.06
Uniform Delay, d1	25.9		25.5				2.2	2.2			2.2	2.2
Progression Factor	1.00		1.00				1.00	1.00			1.00	1.00
Incremental Delay, d2	0.3		0.0				0.1	0.0			0.0	0.1
Delay (s)	26.2		25.5				2.3	2.2			2.2	2.3
Level of Service	C		C				A	A			A	A
Approach Delay (s)		26.0			0.0			2.3			2.3	
Approach LOS		C			A			A			A	

Intersection Summary

HCM 2000 Control Delay	6.5	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.07		
Actuated Cycle Length (s)	60.5	Sum of lost time (s)	11.0
Intersection Capacity Utilization	23.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	12	13	158	276
v/c Ratio	0.04	0.05	0.05	0.09
Control Delay	28.7	16.1	2.2	2.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	28.7	16.1	2.2	2.1
Queue Length 50th (m)	1.2	0.0	0.0	0.0
Queue Length 95th (m)	6.1	4.7	5.4	8.8
Internal Link Dist (m)	421.3		328.4	322.4
Turn Bay Length (m)				
Base Capacity (vph)	1081	973	3162	3162
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.01	0.05	0.09
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	11	12	150	0	0	262
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	12	13	158	0	0	276
RTOR Reduction (vph)	0	12	0	0	0	0
Lane Group Flow (vph)	12	1	158	0	0	276
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	3.5	3.5	55.8			55.8
Effective Green, g (s)	4.5	4.5	56.8			56.8
Actuated g/C Ratio	0.06	0.06	0.77			0.77
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	109	98	2773			2773
v/s Ratio Prot	c0.01		0.04			c0.08
v/s Ratio Perm		0.00				
v/c Ratio	0.11	0.01	0.06			0.10
Uniform Delay, d1	32.5	32.3	1.9			2.0
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.4	0.0	0.0			0.1
Delay (s)	33.0	32.3	2.0			2.1
Level of Service	C	C	A			A
Approach Delay (s)	32.6		2.0			2.1
Approach LOS	C		A			A

Intersection Summary

HCM 2000 Control Delay	3.7	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.10		
Actuated Cycle Length (s)	73.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	35.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	19	19	139	239
v/c Ratio	0.06	0.07	0.04	0.08
Control Delay	27.2	13.6	2.4	2.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	27.2	13.6	2.4	2.3
Queue Length 50th (m)	1.8	0.0	0.0	0.0
Queue Length 95th (m)	7.5	5.2	5.0	7.8
Internal Link Dist (m)	574.3		227.6	328.4
Turn Bay Length (m)				
Base Capacity (vph)	1097	989	3144	3144
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.02	0.02	0.04	0.08

Intersection Summary

HCM Signalized Intersection Capacity Analysis

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	18	18	0	132	227	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	19	19	0	139	239	0
RTOR Reduction (vph)	0	18	0	0	0	0
Lane Group Flow (vph)	19	1	0	139	239	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	3.6	3.6		54.4	54.4	
Effective Green, g (s)	4.6	4.6		55.4	55.4	
Actuated g/C Ratio	0.06	0.06		0.77	0.77	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	114	102		2753	2753	
v/s Ratio Prot	c0.01			0.04	c0.07	
v/s Ratio Perm		0.00				
v/c Ratio	0.17	0.01		0.05	0.09	
Uniform Delay, d1	31.9	31.6		2.0	2.1	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.7	0.0		0.0	0.1	
Delay (s)	32.6	31.6		2.0	2.1	
Level of Service	C	C		A	A	
Approach Delay (s)	32.1			2.0	2.1	
Approach LOS	C			A	A	

Intersection Summary

HCM 2000 Control Delay	4.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.09		
Actuated Cycle Length (s)	72.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	35.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

105: Donald Cousens Parkways

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑↑	↑↑	↘
Volume (veh/h)	0	2	0	132	218	27
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	2	0	139	229	28
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh						
Upstream signal (m)				194	251	
pX, platoon unblocked						
vC, conflicting volume	299	115	258			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	299	115	258			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	668	916	1304			
Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	2	69	69	115	115	28
Volume Left	0	0	0	0	0	0
Volume Right	2	0	0	0	0	28
cSH	916	1700	1700	1700	1700	1700
Volume to Capacity	0.00	0.04	0.04	0.07	0.07	0.02
Queue Length 95th (m)	0.1	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	8.9	0.0	0.0	0.0	0.0	0.0
Lane LOS	A					
Approach Delay (s)	8.9	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.0			
Intersection Capacity Utilization			16.0%		ICU Level of Service	A
Analysis Period (min)			15			

Queues

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	260	112	260	391	229	153
v/c Ratio	0.48	0.32	0.32	0.15	0.09	0.13
Control Delay	32.3	8.9	5.6	3.9	3.7	1.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.3	8.9	5.6	3.9	3.7	1.0
Queue Length 50th (m)	17.7	0.0	11.4	7.7	4.3	0.0
Queue Length 95th (m)	28.1	12.4	23.8	13.4	8.2	4.6
Internal Link Dist (m)				845.4	169.5	
Turn Bay Length (m)	80.0	90.0	170.0			90.0
Base Capacity (vph)	2545	1203	817	2549	2549	1184
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.10	0.09	0.32	0.15	0.09	0.13

Intersection Summary

HCM Signalized Intersection Capacity Analysis
 9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖↗		↖				↖	↖↗	↖	↖	↖↗	↖
Volume (vph)	247	0	106	0	0	0	247	371	0	0	218	145
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0				5.0	5.0			5.0	5.0
Lane Util. Factor	0.97		1.00				1.00	0.95			0.95	1.00
Frt	1.00		0.85				1.00	1.00			1.00	0.85
Flt Protected	0.95		1.00				0.95	1.00			1.00	1.00
Satd. Flow (prot)	3471		1601				1789	3579			3579	1601
Flt Permitted	0.95		1.00				0.61	1.00			1.00	1.00
Satd. Flow (perm)	3471		1601				1147	3579			3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	260	0	112	0	0	0	260	391	0	0	229	153
RTOR Reduction (vph)	0	0	94	0	0	0	0	0	0	0	0	44
Lane Group Flow (vph)	260	0	18	0	0	0	260	391	0	0	229	109
Turn Type	Prot		Perm				Perm	NA	Perm	Perm	NA	Perm
Protected Phases	4							2				6
Permitted Phases			4				2		2	6		6
Actuated Green, G (s)	11.0		11.0				53.4	53.4			53.4	53.4
Effective Green, g (s)	12.0		12.0				54.4	54.4			54.4	54.4
Actuated g/C Ratio	0.16		0.16				0.71	0.71			0.71	0.71
Clearance Time (s)	6.0		6.0				6.0	6.0			6.0	6.0
Vehicle Extension (s)	3.0		3.0				3.0	3.0			3.0	3.0
Lane Grp Cap (vph)	545		251				816	2548			2548	1139
v/s Ratio Prot	c0.07							0.11			0.06	
v/s Ratio Perm			0.01				c0.23					0.07
v/c Ratio	0.48		0.07				0.32	0.15			0.09	0.10
Uniform Delay, d1	29.3		27.4				4.1	3.6			3.4	3.4
Progression Factor	1.00		1.00				1.00	1.00			1.00	1.00
Incremental Delay, d2	0.7		0.1				1.0	0.1			0.1	0.2
Delay (s)	30.0		27.6				5.1	3.7			3.5	3.6
Level of Service	C		C				A	A			A	A
Approach Delay (s)		29.3			0.0			4.3			3.5	
Approach LOS		C			A			A			A	

Intersection Summary

HCM 2000 Control Delay	10.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	76.4	Sum of lost time (s)	10.0
Intersection Capacity Utilization	38.4%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	15	15	864	243
v/c Ratio	0.09	0.09	0.26	0.07
Control Delay	36.6	19.1	1.5	1.2
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	36.6	19.1	1.5	1.2
Queue Length 50th (m)	2.0	0.0	0.0	0.0
Queue Length 95th (m)	7.9	5.5	20.7	5.6
Internal Link Dist (m)	421.3		328.4	322.4
Turn Bay Length (m)				
Base Capacity (vph)	1272	1143	3282	3282
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.01	0.01	0.26	0.07

Intersection Summary

HCM Signalized Intersection Capacity Analysis

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	14	14	821	0	0	231
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0			5.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	15	15	864	0	0	243
RTOR Reduction (vph)	0	14	0	0	0	0
Lane Group Flow (vph)	15	1	864	0	0	243
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	2.6	2.6	68.4			68.4
Effective Green, g (s)	3.6	3.6	69.4			69.4
Actuated g/C Ratio	0.04	0.04	0.84			0.84
Clearance Time (s)	6.0	6.0	6.0			6.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	77	69	2992			2992
v/s Ratio Prot	c0.01		c0.24			0.07
v/s Ratio Perm		0.00				
v/c Ratio	0.19	0.01	0.29			0.08
Uniform Delay, d1	38.3	38.0	1.5			1.2
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	1.2	0.1	0.2			0.1
Delay (s)	39.5	38.0	1.7			1.2
Level of Service	D	D	A			A
Approach Delay (s)	38.8		1.7			1.2
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	2.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.28		
Actuated Cycle Length (s)	83.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	214	213	651	231
v/c Ratio	0.61	0.44	0.27	0.10
Control Delay	37.0	7.2	5.8	5.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	37.0	7.2	5.8	5.0
Queue Length 50th (m)	29.8	0.0	17.3	5.3
Queue Length 95th (m)	50.2	15.8	30.1	10.9
Internal Link Dist (m)	574.3		227.6	328.4
Turn Bay Length (m)				
Base Capacity (vph)	1258	1189	2427	2427
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.17	0.18	0.27	0.10
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	203	202	0	618	219	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	214	213	0	651	231	0
RTOR Reduction (vph)	0	171	0	0	0	0
Lane Group Flow (vph)	214	42	0	651	231	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	14.6	14.6		53.1	53.1	
Effective Green, g (s)	15.6	15.6		54.1	54.1	
Actuated g/C Ratio	0.20	0.20		0.68	0.68	
Clearance Time (s)	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	350	313		2429	2429	
v/s Ratio Prot	c0.12			c0.18	0.06	
v/s Ratio Perm		0.03				
v/c Ratio	0.61	0.13		0.27	0.10	
Uniform Delay, d1	29.3	26.5		5.0	4.4	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	3.1	0.2		0.3	0.1	
Delay (s)	32.4	26.7		5.3	4.5	
Level of Service	C	C		A	A	
Approach Delay (s)	29.6			5.3	4.5	
Approach LOS	C			A	A	

Intersection Summary

HCM 2000 Control Delay	13.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.34		
Actuated Cycle Length (s)	79.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	36.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

105: Donald Cousens Parkways

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑↑	↑↑	↘
Volume (veh/h)	0	8	0	618	355	66
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	8	0	651	374	69
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh						
Upstream signal (m)				194	251	
pX, platoon unblocked						
vC, conflicting volume	699	187	443			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	699	187	443			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	99	100			
cM capacity (veh/h)	374	823	1113			
Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	8	325	325	187	187	69
Volume Left	0	0	0	0	0	0
Volume Right	8	0	0	0	0	69
cSH	823	1700	1700	1700	1700	1700
Volume to Capacity	0.01	0.19	0.19	0.11	0.11	0.04
Queue Length 95th (m)	0.2	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	9.4	0.0	0.0	0.0	0.0	0.0
Lane LOS	A					
Approach Delay (s)	9.4	0.0		0.0		
Approach LOS	A					
Intersection Summary						
Average Delay			0.1			
Intersection Capacity Utilization			20.4%		ICU Level of Service	A
Analysis Period (min)			15			

Appendix B – Future (2031) Background Conditions Synchro Output

Queues

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	54	31	88	133	201	135
v/c Ratio	0.14	0.14	0.09	0.04	0.07	0.10
Control Delay	26.7	6.0	3.0	2.5	2.4	0.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.7	6.0	3.0	2.5	2.4	0.9
Queue Length 50th (m)	3.7	0.0	2.6	1.9	3.0	0.0
Queue Length 95th (m)	7.0	4.1	6.2	4.0	5.6	3.6
Internal Link Dist (m)				845.4	169.5	
Turn Bay Length (m)	80.0	90.0	170.0			90.0
Base Capacity (vph)	1747	830	979	2974	2974	1353
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.04	0.09	0.04	0.07	0.10

Intersection Summary

HCM Signalized Intersection Capacity Analysis

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↗↘		↗				↗	↕↕	↗	↗	↕↕	↗
Volume (vph)	51	0	29	0	0	0	84	126	0	0	191	128
Ideal Flow (vphp)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0				6.0	6.0			6.0	6.0
Lane Util. Factor	0.97		1.00				1.00	0.95			0.95	1.00
Frt	1.00		0.85				1.00	1.00			1.00	0.85
Flt Protected	0.95		1.00				0.95	1.00			1.00	1.00
Satd. Flow (prot)	3471		1601				1789	3579			3579	1601
Flt Permitted	0.95		1.00				0.63	1.00			1.00	1.00
Satd. Flow (perm)	3471		1601				1178	3579			3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	54	0	31	0	0	0	88	133	0	0	201	135
RTOR Reduction (vph)	0	0	29	0	0	0	0	0	0	0	0	32
Lane Group Flow (vph)	54	0	2	0	0	0	88	133	0	0	201	103
Turn Type	Prot		Perm				Perm	NA	Perm	Perm	NA	Perm
Protected Phases	4							6				2
Permitted Phases			4				6		6	2		2
Actuated Green, G (s)	4.1		4.1				51.3	51.3			51.3	51.3
Effective Green, g (s)	5.1		5.1				52.3	52.3			52.3	52.3
Actuated g/C Ratio	0.07		0.07				0.76	0.76			0.76	0.76
Clearance Time (s)	6.0		6.0				7.0	7.0			7.0	7.0
Vehicle Extension (s)	3.0		3.0				3.0	3.0			3.0	3.0
Lane Grp Cap (vph)	258		119				900	2736			2736	1224
v/s Ratio Prot	c0.02							0.04			0.06	
v/s Ratio Perm			0.00				c0.07					0.06
v/c Ratio	0.21		0.02				0.10	0.05			0.07	0.08
Uniform Delay, d1	29.8		29.3				2.0	2.0			2.0	2.0
Progression Factor	1.00		1.00				1.00	1.00			1.00	1.00
Incremental Delay, d2	0.4		0.1				0.2	0.0			0.1	0.1
Delay (s)	30.2		29.4				2.3	2.0			2.1	2.2
Level of Service	C		C				A	A			A	A
Approach Delay (s)		29.9			0.0			2.1			2.1	
Approach LOS		C			A			A			A	

Intersection Summary

HCM 2000 Control Delay	5.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.11		
Actuated Cycle Length (s)	68.4	Sum of lost time (s)	11.0
Intersection Capacity Utilization	26.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	16	17	217	379
v/c Ratio	0.07	0.08	0.07	0.12
Control Delay	37.3	18.2	1.7	1.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	37.3	18.2	1.7	1.7
Queue Length 50th (m)	2.1	0.0	0.0	0.0
Queue Length 95th (m)	8.6	6.1	6.8	11.4
Internal Link Dist (m)	421.3		328.4	322.4
Turn Bay Length (m)				
Base Capacity (vph)	505	464	3236	3236
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.03	0.04	0.07	0.12
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	15	16	206	0	0	360
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	17	217	0	0	379
RTOR Reduction (vph)	0	16	0	0	0	0
Lane Group Flow (vph)	16	1	217	0	0	379
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	3.6	3.6	72.7			72.7
Effective Green, g (s)	4.6	4.6	73.7			73.7
Actuated g/C Ratio	0.05	0.05	0.82			0.82
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	91	81	2921			2921
v/s Ratio Prot	c0.01		0.06			c0.11
v/s Ratio Perm		0.00				
v/c Ratio	0.18	0.01	0.07			0.13
Uniform Delay, d1	41.0	40.7	1.6			1.7
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	0.9	0.1	0.0			0.1
Delay (s)	42.0	40.7	1.7			1.8
Level of Service	D	D	A			A
Approach Delay (s)	41.3		1.7			1.8
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.13		
Actuated Cycle Length (s)	90.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	35.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	26	26	191	328
v/c Ratio	0.11	0.11	0.06	0.11
Control Delay	35.0	14.6	2.6	2.6
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	35.0	14.6	2.6	2.6
Queue Length 50th (m)	4.2	0.0	3.7	6.8
Queue Length 95th (m)	10.5	6.7	6.3	10.3
Internal Link Dist (m)	574.3		227.6	328.4
Turn Bay Length (m)				
Base Capacity (vph)	579	536	3024	3024
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.04	0.05	0.06	0.11

Intersection Summary

HCM Signalized Intersection Capacity Analysis

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	25	25	0	181	312	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	26	26	0	191	328	0
RTOR Reduction (vph)	0	24	0	0	0	0
Lane Group Flow (vph)	26	2	0	191	328	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	5.7	5.7		67.3	67.3	
Effective Green, g (s)	6.7	6.7		68.3	68.3	
Actuated g/C Ratio	0.08	0.08		0.79	0.79	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	137	123		2809	2809	
v/s Ratio Prot	c0.01			0.05	c0.09	
v/s Ratio Perm		0.00				
v/c Ratio	0.19	0.02		0.07	0.12	
Uniform Delay, d1	37.6	37.1		2.1	2.2	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.7	0.1		0.0	0.1	
Delay (s)	38.3	37.2		2.2	2.3	
Level of Service	D	D		A	A	
Approach Delay (s)	37.7			2.2	2.3	
Approach LOS	D			A	A	

Intersection Summary

HCM 2000 Control Delay	5.5	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.12		
Actuated Cycle Length (s)	87.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	35.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

105: Donald Cousens Parkways

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	29	20	25	161	316	39
v/c Ratio	0.09	0.06	0.03	0.05	0.11	0.03
Control Delay	14.8	8.1	3.6	2.8	2.7	1.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	14.8	8.1	3.6	2.8	2.7	1.9
Queue Length 50th (m)	1.5	0.0	0.0	0.0	0.0	0.0
Queue Length 95th (m)	5.7	3.3	2.7	4.8	8.6	2.3
Internal Link Dist (m)	331.0		169.5		227.6	
Turn Bay Length (m)						50.0
Base Capacity (vph)	771	702	879	2984	2984	1341
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.03	0.03	0.05	0.11	0.03

Intersection Summary

HCM Signalized Intersection Capacity Analysis

105: Donald Cousens Parkways

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	28	19	24	153	300	37
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1789	1601	1789	3579	3579	1601
Flt Permitted	0.95	1.00	0.56	1.00	1.00	1.00
Satd. Flow (perm)	1789	1601	1055	3579	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	29	20	25	161	316	39
RTOR Reduction (vph)	0	18	0	0	0	12
Lane Group Flow (vph)	29	2	25	161	316	27
Turn Type	Prot	Perm	Perm	NA	NA	Perm
Protected Phases	4			2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	2.6	2.6	29.0	29.0	29.0	29.0
Effective Green, g (s)	3.6	3.6	30.0	30.0	30.0	30.0
Actuated g/C Ratio	0.08	0.08	0.69	0.69	0.69	0.69
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	147	132	725	2462	2462	1101
v/s Ratio Prot	c0.02			0.04	c0.09	
v/s Ratio Perm		0.00	0.02			0.02
v/c Ratio	0.20	0.01	0.03	0.07	0.13	0.02
Uniform Delay, d1	18.7	18.4	2.2	2.2	2.3	2.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.0	0.1	0.1	0.1	0.0
Delay (s)	19.3	18.4	2.3	2.3	2.4	2.2
Level of Service	B	B	A	A	A	A
Approach Delay (s)	18.9			2.3	2.4	
Approach LOS	B			A	A	

Intersection Summary

HCM 2000 Control Delay	3.7	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.14		
Actuated Cycle Length (s)	43.6	Sum of lost time (s)	10.0
Intersection Capacity Utilization	27.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	285	145	384	576	349	234
v/c Ratio	0.60	0.42	0.49	0.21	0.13	0.18
Control Delay	51.0	10.9	7.5	3.8	3.5	0.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	51.0	10.9	7.5	3.8	3.5	0.8
Queue Length 50th (m)	30.7	0.0	25.3	14.7	8.3	0.0
Queue Length 95th (m)	44.1	17.3	50.4	23.5	14.1	5.5
Internal Link Dist (m)				845.4	169.5	
Turn Bay Length (m)	80.0	90.0	170.0			90.0
Base Capacity (vph)	710	442	789	2769	2769	1291
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.40	0.33	0.49	0.21	0.13	0.18

Intersection Summary

HCM Signalized Intersection Capacity Analysis

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖↗		↖				↖	↖↗	↖	↖	↖↗	↖
Volume (vph)	271	0	138	0	0	0	365	547	0	0	332	222
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0				5.0	5.0			5.0	5.0
Lane Util. Factor	0.97		1.00				1.00	0.95			0.95	1.00
Frt	1.00		0.85				1.00	1.00			1.00	0.85
Flt Protected	0.95		1.00				0.95	1.00			1.00	1.00
Satd. Flow (prot)	3471		1601				1789	3579			3579	1601
Flt Permitted	0.95		1.00				0.54	1.00			1.00	1.00
Satd. Flow (perm)	3471		1601				1022	3579			3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	285	0	145	0	0	0	384	576	0	0	349	234
RTOR Reduction (vph)	0	0	125	0	0	0	0	0	0	0	0	53
Lane Group Flow (vph)	285	0	20	0	0	0	384	576	0	0	349	181
Turn Type	Prot		Perm				Perm	NA	Perm	Perm	NA	Perm
Protected Phases	4							2			6	
Permitted Phases			4				2		2	6		6
Actuated Green, G (s)	14.5		14.5				86.1	86.1			86.1	86.1
Effective Green, g (s)	15.5		15.5				87.1	87.1			87.1	87.1
Actuated g/C Ratio	0.14		0.14				0.77	0.77			0.77	0.77
Clearance Time (s)	6.0		6.0				6.0	6.0			6.0	6.0
Vehicle Extension (s)	3.0		3.0				3.0	3.0			3.0	3.0
Lane Grp Cap (vph)	477		220				790	2768			2768	1238
v/s Ratio Prot	c0.08							0.16			0.10	
v/s Ratio Perm			0.01				c0.38					0.11
v/c Ratio	0.60		0.09				0.49	0.21			0.13	0.15
Uniform Delay, d1	45.6		42.4				4.6	3.4			3.2	3.3
Progression Factor	1.00		1.00				1.00	1.00			1.00	1.00
Incremental Delay, d2	2.0		0.2				2.1	0.2			0.1	0.2
Delay (s)	47.6		42.6				6.8	3.6			3.3	3.5
Level of Service	D		D				A	A			A	A
Approach Delay (s)		45.9			0.0			4.9			3.4	
Approach LOS		D			A			A			A	

Intersection Summary

HCM 2000 Control Delay	13.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	112.6	Sum of lost time (s)	10.0
Intersection Capacity Utilization	48.8%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	20	20	1186	334
v/c Ratio	0.16	0.16	0.37	0.10
Control Delay	55.1	23.1	1.9	1.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.1	23.1	1.9	1.3
Queue Length 50th (m)	4.5	0.0	23.2	4.8
Queue Length 95th (m)	12.3	7.7	33.1	7.8
Internal Link Dist (m)	421.3		328.4	322.4
Turn Bay Length (m)				
Base Capacity (vph)	325	307	3244	3244
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.06	0.07	0.37	0.10

Intersection Summary

HCM Signalized Intersection Capacity Analysis

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	19	19	1127	0	0	317
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0			5.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	20	20	1186	0	0	334
RTOR Reduction (vph)	0	19	0	0	0	0
Lane Group Flow (vph)	20	1	1186	0	0	334
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.5	4.5	101.6			101.6
Effective Green, g (s)	5.5	5.5	102.6			102.6
Actuated g/C Ratio	0.05	0.05	0.87			0.87
Clearance Time (s)	6.0	6.0	6.0			6.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	83	74	3109			3109
v/s Ratio Prot	c0.01		c0.33			0.09
v/s Ratio Perm		0.00				
v/c Ratio	0.24	0.01	0.38			0.11
Uniform Delay, d1	54.3	53.7	1.5			1.1
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	1.5	0.1	0.4			0.1
Delay (s)	55.8	53.8	1.9			1.2
Level of Service	E	D	A			A
Approach Delay (s)	54.8		1.9			1.2
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	118.1	Sum of lost time (s)	10.0
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	294	292	893	317
v/c Ratio	0.72	0.49	0.38	0.13
Control Delay	43.4	6.5	8.3	6.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	43.4	6.5	8.3	6.7
Queue Length 50th (m)	49.0	0.0	33.4	9.7
Queue Length 95th (m)	75.3	18.3	57.7	19.1
Internal Link Dist (m)	574.3		227.6	328.4
Turn Bay Length (m)				
Base Capacity (vph)	918	964	2373	2373
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.32	0.30	0.38	0.13

Intersection Summary

HCM Signalized Intersection Capacity Analysis

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	279	277	0	848	301	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	294	292	0	893	317	0
RTOR Reduction (vph)	0	225	0	0	0	0
Lane Group Flow (vph)	294	67	0	893	317	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	20.5	20.5		61.2	61.2	
Effective Green, g (s)	21.5	21.5		62.2	62.2	
Actuated g/C Ratio	0.23	0.23		0.66	0.66	
Clearance Time (s)	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	410	367		2375	2375	
v/s Ratio Prot	c0.16			c0.25	0.09	
v/s Ratio Perm		0.04				
v/c Ratio	0.72	0.18		0.38	0.13	
Uniform Delay, d1	33.3	29.0		7.1	5.8	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	5.9	0.2		0.5	0.1	
Delay (s)	39.2	29.3		7.5	5.9	
Level of Service	D	C		A	A	
Approach Delay (s)	34.2			7.5	5.9	
Approach LOS	C			A	A	

Intersection Summary

HCM 2000 Control Delay	16.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	93.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	47.2%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

105: Donald Cousens Parkways

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	96	64	64	797	519	96
v/c Ratio	0.24	0.16	0.11	0.32	0.21	0.08
Control Delay	12.9	4.8	6.0	5.4	4.9	2.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	12.9	4.8	6.0	5.4	4.9	2.1
Queue Length 50th (m)	5.4	0.0	1.8	14.1	8.4	0.0
Queue Length 95th (m)	11.4	5.0	6.5	26.0	16.2	4.3
Internal Link Dist (m)	331.0			169.5	227.6	
Turn Bay Length (m)						50.0
Base Capacity (vph)	813	762	599	2475	2475	1137
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.12	0.08	0.11	0.32	0.21	0.08

Intersection Summary

HCM Signalized Intersection Capacity Analysis

105: Donald Cousens Parkways

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	91	61	61	757	493	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	0.95	0.95	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1789	1601	1789	3579	3579	1601
Flt Permitted	0.95	1.00	0.46	1.00	1.00	1.00
Satd. Flow (perm)	1789	1601	866	3579	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	96	64	64	797	519	96
RTOR Reduction (vph)	0	54	0	0	0	38
Lane Group Flow (vph)	96	10	64	797	519	58
Turn Type	Prot	Perm	Perm	NA	NA	Perm
Protected Phases	4			2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	5.0	5.0	22.9	22.9	22.9	22.9
Effective Green, g (s)	6.0	6.0	23.9	23.9	23.9	23.9
Actuated g/C Ratio	0.15	0.15	0.60	0.60	0.60	0.60
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	269	240	518	2143	2143	958
v/s Ratio Prot	c0.05			c0.22	0.15	
v/s Ratio Perm		0.01	0.07			0.04
v/c Ratio	0.36	0.04	0.12	0.37	0.24	0.06
Uniform Delay, d1	15.2	14.5	3.5	4.1	3.8	3.3
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.8	0.1	0.5	0.5	0.3	0.1
Delay (s)	16.0	14.6	4.0	4.6	4.0	3.4
Level of Service	B	B	A	A	A	A
Approach Delay (s)	15.4			4.6	3.9	
Approach LOS	B			A	A	

Intersection Summary

HCM 2000 Control Delay	5.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	39.9	Sum of lost time (s)	10.0
Intersection Capacity Utilization	34.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Appendix C – Future (2031) Total Conditions Synchro Output

Queues

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	85	31	88	179	212	142
v/c Ratio	0.20	0.13	0.10	0.07	0.08	0.11
Control Delay	26.7	5.8	3.6	3.0	3.0	1.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.7	5.8	3.6	3.0	3.0	1.0
Queue Length 50th (m)	5.2	0.0	2.6	2.7	3.3	0.0
Queue Length 95th (m)	9.6	4.1	6.6	5.3	6.2	3.9
Internal Link Dist (m)				845.4	169.5	
Turn Bay Length (m)	80.0	90.0	170.0			90.0
Base Capacity (vph)	1730	823	896	2751	2751	1263
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.04	0.10	0.07	0.08	0.11

Intersection Summary

HCM Signalized Intersection Capacity Analysis

9: Donald Cousens Parkways & Copper Creek Dr

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖↗		↖				↖	↕↕	↖	↖	↕↕	↖
Volume (vph)	81	0	29	0	0	0	84	170	0	0	201	135
Ideal Flow (vphp)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0				6.0	6.0			6.0	6.0
Lane Util. Factor	0.97		1.00				1.00	0.95			0.95	1.00
Frt	1.00		0.85				1.00	1.00			1.00	0.85
Flt Protected	0.95		1.00				0.95	1.00			1.00	1.00
Satd. Flow (prot)	3471		1601				1789	3579			3579	1601
Flt Permitted	0.95		1.00				0.62	1.00			1.00	1.00
Satd. Flow (perm)	3471		1601				1166	3579			3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	85	0	31	0	0	0	88	179	0	0	212	142
RTOR Reduction (vph)	0	0	28	0	0	0	0	0	0	0	0	37
Lane Group Flow (vph)	85	0	3	0	0	0	88	179	0	0	212	105
Turn Type	Prot		Perm				Perm	NA	Perm	Perm	NA	Perm
Protected Phases	4							6				2
Permitted Phases			4				6		6	2		2
Actuated Green, G (s)	5.9		5.9				48.9	48.9			48.9	48.9
Effective Green, g (s)	6.9		6.9				49.9	49.9			49.9	49.9
Actuated g/C Ratio	0.10		0.10				0.74	0.74			0.74	0.74
Clearance Time (s)	6.0		6.0				7.0	7.0			7.0	7.0
Vehicle Extension (s)	3.0		3.0				3.0	3.0			3.0	3.0
Lane Grp Cap (vph)	353		162				858	2634			2634	1178
v/s Ratio Prot	c0.02							0.05			0.06	
v/s Ratio Perm			0.00				c0.08					0.07
v/c Ratio	0.24		0.02				0.10	0.07			0.08	0.09
Uniform Delay, d1	28.0		27.4				2.6	2.5			2.5	2.5
Progression Factor	1.00		1.00				1.00	1.00			1.00	1.00
Incremental Delay, d2	0.4		0.0				0.2	0.0			0.1	0.1
Delay (s)	28.4		27.5				2.8	2.5			2.6	2.7
Level of Service	C		C				A	A			A	A
Approach Delay (s)		28.1			0.0			2.6			2.6	
Approach LOS		C			A			A			A	

Intersection Summary

HCM 2000 Control Delay	6.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.12		
Actuated Cycle Length (s)	67.8	Sum of lost time (s)	11.0
Intersection Capacity Utilization	26.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	16	17	265	583
v/c Ratio	0.07	0.08	0.08	0.18
Control Delay	38.3	18.6	1.7	1.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	38.3	18.6	1.7	1.8
Queue Length 50th (m)	2.2	0.0	0.0	0.0
Queue Length 95th (m)	8.8	6.1	8.1	17.6
Internal Link Dist (m)	421.3		328.4	322.4
Turn Bay Length (m)				
Base Capacity (vph)	451	417	3243	3243
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.04	0.04	0.08	0.18

Intersection Summary

HCM Signalized Intersection Capacity Analysis

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	15	16	252	0	0	554
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0	6.0			6.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	16	17	265	0	0	583
RTOR Reduction (vph)	0	16	0	0	0	0
Lane Group Flow (vph)	16	1	265	0	0	583
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	3.6	3.6	74.6			74.6
Effective Green, g (s)	4.6	4.6	75.6			75.6
Actuated g/C Ratio	0.05	0.05	0.82			0.82
Clearance Time (s)	7.0	7.0	7.0			7.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	89	79	2934			2934
v/s Ratio Prot	c0.01		0.07			c0.16
v/s Ratio Perm		0.00				
v/c Ratio	0.18	0.01	0.09			0.20
Uniform Delay, d1	42.0	41.6	1.6			1.8
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	1.0	0.1	0.1			0.2
Delay (s)	43.0	41.7	1.7			1.9
Level of Service	D	D	A			A
Approach Delay (s)	42.3		1.7			1.9
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	3.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.20		
Actuated Cycle Length (s)	92.2	Sum of lost time (s)	12.0
Intersection Capacity Utilization	35.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	26	26	239	533
v/c Ratio	0.11	0.12	0.08	0.18
Control Delay	36.6	14.9	2.4	2.6
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	36.6	14.9	2.4	2.6
Queue Length 50th (m)	4.4	0.0	4.8	11.8
Queue Length 95th (m)	10.8	6.9	7.6	16.5
Internal Link Dist (m)	574.3		227.6	328.4
Turn Bay Length (m)				
Base Capacity (vph)	497	463	3042	3042
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.05	0.06	0.08	0.18
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

17: Donald Cousens Parkways & Highway 407 EB

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	25	25	0	227	506	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	26	26	0	239	533	0
RTOR Reduction (vph)	0	24	0	0	0	0
Lane Group Flow (vph)	26	2	0	239	533	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	5.7	5.7		70.3	70.3	
Effective Green, g (s)	6.7	6.7		71.3	71.3	
Actuated g/C Ratio	0.07	0.07		0.79	0.79	
Clearance Time (s)	7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	133	119		2835	2835	
v/s Ratio Prot	c0.01			0.07	c0.15	
v/s Ratio Perm		0.00				
v/c Ratio	0.20	0.02		0.08	0.19	
Uniform Delay, d1	39.1	38.6		2.1	2.3	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.7	0.1		0.1	0.1	
Delay (s)	39.8	38.7		2.1	2.4	
Level of Service	D	D		A	A	
Approach Delay (s)	39.2			2.1	2.4	
Approach LOS	D			A	A	

Intersection Summary

HCM 2000 Control Delay	4.7	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.19		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	35.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

105: Donald Cousens Parkways

8/13/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	29	52	18	7	48	25	161	83	209	316	39
v/c Ratio	0.07	0.14	0.05	0.02	0.12	0.03	0.06	0.06	0.22	0.11	0.03
Control Delay	11.0	8.8	10.8	10.6	3.2	4.3	3.4	1.9	4.7	3.3	0.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	11.0	8.8	10.8	10.6	3.2	4.3	3.4	1.9	4.7	3.3	0.9
Queue Length 50th (m)	1.2	1.3	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Queue Length 95th (m)	4.8	6.2	3.5	2.0	3.1	2.7	5.0	3.5	15.4	8.7	1.3
Internal Link Dist (m)		331.0		171.3			169.5			227.6	
Turn Bay Length (m)	50.0		50.0		50.0	50.0		50.0	50.0		50.0
Base Capacity (vph)	910	867	910	910	811	837	2840	1287	971	2840	1286
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.06	0.02	0.01	0.06	0.03	0.06	0.06	0.22	0.11	0.03

Intersection Summary

HCM Signalized Intersection Capacity Analysis

105: Donald Cousens Parkways

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	28	30	19	17	7	46	24	153	79	199	300	37
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.94		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1775		1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	1.00	1.00		1.00	1.00	1.00	0.56	1.00	1.00	0.65	1.00	1.00
Satd. Flow (perm)	1883	1775		1883	1883	1601	1055	3579	1601	1224	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	29	32	20	18	7	48	25	161	83	209	316	39
RTOR Reduction (vph)	0	18	0	0	0	43	0	0	30	0	0	14
Lane Group Flow (vph)	29	34	0	18	7	5	25	161	53	209	316	25
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA	Perm	Perm	NA	Perm
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2		2	6		6
Actuated Green, G (s)	2.9	2.9		2.9	2.9	2.9	24.0	24.0	24.0	24.0	24.0	24.0
Effective Green, g (s)	3.9	3.9		3.9	3.9	3.9	25.0	25.0	25.0	25.0	25.0	25.0
Actuated g/C Ratio	0.10	0.10		0.10	0.10	0.10	0.64	0.64	0.64	0.64	0.64	0.64
Clearance Time (s)	6.0	6.0		6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	188	177		188	188	160	678	2300	1028	786	2300	1028
v/s Ratio Prot		c0.02			0.00			0.04			0.09	
v/s Ratio Perm	0.02			0.01		0.00	0.02		0.03	c0.17		0.02
v/c Ratio	0.15	0.19		0.10	0.04	0.03	0.04	0.07	0.05	0.27	0.14	0.02
Uniform Delay, d1	16.0	16.1		15.9	15.8	15.8	2.5	2.6	2.6	3.0	2.7	2.5
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.4	0.5		0.2	0.1	0.1	0.1	0.1	0.1	0.8	0.1	0.0
Delay (s)	16.4	16.6		16.1	15.9	15.9	2.6	2.7	2.7	3.8	2.8	2.6
Level of Service	B	B		B	B	B	A	A	A	A	A	A
Approach Delay (s)		16.5			15.9			2.7			3.2	
Approach LOS		B			B			A			A	

Intersection Summary

HCM 2000 Control Delay	5.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.26		
Actuated Cycle Length (s)	38.9	Sum of lost time (s)	10.0
Intersection Capacity Utilization	36.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

9: Donald Cousens Parkways/Donald Cousens Parkway & Copper Creek Dr

8/13/2015



Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	294	145	384	587	388	259
v/c Ratio	0.61	0.42	0.50	0.21	0.14	0.20
Control Delay	52.3	10.9	8.0	3.9	3.6	0.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	52.3	10.9	8.0	3.9	3.6	0.8
Queue Length 50th (m)	32.5	0.0	26.6	15.5	9.6	0.0
Queue Length 95th (m)	46.2	17.4	53.4	24.5	16.0	5.8
Internal Link Dist (m)				845.4	169.5	
Turn Bay Length (m)	80.0	90.0	170.0			90.0
Base Capacity (vph)	634	411	761	2771	2771	1298
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.46	0.35	0.50	0.21	0.14	0.20

Intersection Summary

HCM Signalized Intersection Capacity Analysis

9: Donald Cousens Parkways/Donald Cousens Parkway & Copper Creek Dr

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖↗		↖				↖	↖↗	↖	↖	↖↗	↖
Volume (vph)	279	0	138	0	0	0	365	558	0	0	369	246
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0				5.0	5.0			5.0	5.0
Lane Util. Factor	0.97		1.00				1.00	0.95			0.95	1.00
Frt	1.00		0.85				1.00	1.00			1.00	0.85
Flt Protected	0.95		1.00				0.95	1.00			1.00	1.00
Satd. Flow (prot)	3471		1601				1789	3579			3579	1601
Flt Permitted	0.95		1.00				0.52	1.00			1.00	1.00
Satd. Flow (perm)	3471		1601				984	3579			3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	294	0	145	0	0	0	384	587	0	0	388	259
RTOR Reduction (vph)	0	0	125	0	0	0	0	0	0	0	0	58
Lane Group Flow (vph)	294	0	20	0	0	0	384	587	0	0	388	201
Turn Type	Prot		Perm				Perm	NA	Perm	Perm	NA	Perm
Protected Phases	4							2			6	
Permitted Phases			4				2		2	6		6
Actuated Green, G (s)	14.9		14.9				88.1	88.1			88.1	88.1
Effective Green, g (s)	15.9		15.9				89.1	89.1			89.1	89.1
Actuated g/C Ratio	0.14		0.14				0.77	0.77			0.77	0.77
Clearance Time (s)	6.0		6.0				6.0	6.0			6.0	6.0
Vehicle Extension (s)	3.0		3.0				3.0	3.0			3.0	3.0
Lane Grp Cap (vph)	479		221				762	2772			2772	1240
v/s Ratio Prot	c0.08							0.16			0.11	
v/s Ratio Perm			0.01				c0.39					0.13
v/c Ratio	0.61		0.09				0.50	0.21			0.14	0.16
Uniform Delay, d1	46.7		43.2				4.8	3.5			3.3	3.3
Progression Factor	1.00		1.00				1.00	1.00			1.00	1.00
Incremental Delay, d2	2.3		0.2				2.4	0.2			0.1	0.3
Delay (s)	49.0		43.4				7.2	3.7			3.4	3.6
Level of Service	D		D				A	A			A	A
Approach Delay (s)		47.2			0.0			5.0			3.5	
Approach LOS		D			A			A			A	

Intersection Summary

HCM 2000 Control Delay	13.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	115.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	50.0%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	20	20	1354	583
v/c Ratio	0.17	0.16	0.42	0.18
Control Delay	55.1	23.2	2.1	1.4
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	55.1	23.2	2.1	1.4
Queue Length 50th (m)	4.5	0.0	28.6	9.1
Queue Length 95th (m)	12.3	7.7	40.5	13.8
Internal Link Dist (m)	421.3		328.4	322.4
Turn Bay Length (m)				
Base Capacity (vph)	309	293	3244	3244
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.06	0.07	0.42	0.18
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

16: Donald Cousens Parkways & Highway 407 WB

8/13/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	19	19	1286	0	0	554
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0			5.0
Lane Util. Factor	1.00	1.00	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	1789	1601	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	1789	1601	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	20	20	1354	0	0	583
RTOR Reduction (vph)	0	19	0	0	0	0
Lane Group Flow (vph)	20	1	1354	0	0	583
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	4.5	4.5	102.0			102.0
Effective Green, g (s)	5.5	5.5	103.0			103.0
Actuated g/C Ratio	0.05	0.05	0.87			0.87
Clearance Time (s)	6.0	6.0	6.0			6.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	83	74	3110			3110
v/s Ratio Prot	c0.01		c0.38			0.16
v/s Ratio Perm		0.00				
v/c Ratio	0.24	0.01	0.44			0.19
Uniform Delay, d1	54.5	53.9	1.6			1.2
Progression Factor	1.00	1.00	1.00			1.00
Incremental Delay, d2	1.5	0.1	0.4			0.1
Delay (s)	56.0	54.0	2.1			1.3
Level of Service	E	D	A			A
Approach Delay (s)	55.0		2.1			1.3
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	2.9	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	118.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	51.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: Donald Cousens Parkway/Donald Cousens Parkways & Highway 407 EB

8/13/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	294	292	1060	366
v/c Ratio	0.73	0.50	0.44	0.15
Control Delay	46.0	6.7	8.9	6.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	46.0	6.7	8.9	6.8
Queue Length 50th (m)	52.0	0.0	43.7	11.8
Queue Length 95th (m)	78.8	18.9	74.0	22.5
Internal Link Dist (m)	574.3		227.6	328.4
Turn Bay Length (m)				
Base Capacity (vph)	801	878	2403	2403
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.37	0.33	0.44	0.15

Intersection Summary

HCM Signalized Intersection Capacity Analysis
 17: Donald Cousens Parkway/Donald Cousens Parkways & Highway 407 EB

8/13/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	279	277	0	1007	348	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	1.00		0.95	0.95	
Frt	1.00	0.85		1.00	1.00	
Flt Protected	0.95	1.00		1.00	1.00	
Satd. Flow (prot)	1789	1601		3579	3579	
Flt Permitted	0.95	1.00		1.00	1.00	
Satd. Flow (perm)	1789	1601		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	294	292	0	1060	366	0
RTOR Reduction (vph)	0	226	0	0	0	0
Lane Group Flow (vph)	294	66	0	1060	366	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	21.3	21.3		65.2	65.2	
Effective Green, g (s)	22.3	22.3		66.2	66.2	
Actuated g/C Ratio	0.23	0.23		0.67	0.67	
Clearance Time (s)	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	405	362		2405	2405	
v/s Ratio Prot	c0.16			c0.30	0.10	
v/s Ratio Perm		0.04				
v/c Ratio	0.73	0.18		0.44	0.15	
Uniform Delay, d1	35.3	30.7		7.5	5.9	
Progression Factor	1.00	1.00		1.00	1.00	
Incremental Delay, d2	6.4	0.2		0.6	0.1	
Delay (s)	41.6	31.0		8.1	6.0	
Level of Service	D	C		A	A	
Approach Delay (s)	36.3			8.1	6.0	
Approach LOS	D			A	A	

Intersection Summary

HCM 2000 Control Delay	16.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.51		
Actuated Cycle Length (s)	98.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	51.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Queues

105: Donald Cousens Parkway & Walmart Supercentre/Transitway Access

8/13/2015



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	96	71	64	25	167	64	797	24	54	519	96
v/c Ratio	0.28	0.16	0.19	0.05	0.37	0.13	0.39	0.03	0.15	0.25	0.10
Control Delay	12.9	5.0	11.8	10.0	9.2	7.3	7.2	0.4	7.9	6.5	2.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	12.9	5.0	11.8	10.0	9.2	7.3	7.2	0.4	7.9	6.5	2.5
Queue Length 50th (m)	4.6	0.3	3.0	1.1	4.4	1.9	14.4	0.0	1.6	8.5	0.0
Queue Length 95th (m)	11.9	5.6	8.6	4.4	13.6	7.7	30.8	0.6	7.2	19.2	5.1
Internal Link Dist (m)		331.0		133.2			169.5			227.6	
Turn Bay Length (m)	50.0		50.0		50.0	50.0		50.0	50.0		50.0
Base Capacity (vph)	645	787	618	870	779	493	2040	944	367	2040	954
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.15	0.09	0.10	0.03	0.21	0.13	0.39	0.03	0.15	0.25	0.10

Intersection Summary

HCM Signalized Intersection Capacity Analysis

105: Donald Cousens Parkway & Walmart Supercentre/Transitway Access

8/13/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	91	7	61	61	24	159	61	757	23	51	493	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.86		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1629		1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.74	1.00		0.71	1.00	1.00	0.46	1.00	1.00	0.34	1.00	1.00
Satd. Flow (perm)	1396	1629		1339	1883	1601	866	3579	1601	644	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	96	7	64	64	25	167	64	797	24	54	519	96
RTOR Reduction (vph)	0	51	0	0	0	58	0	0	11	0	0	45
Lane Group Flow (vph)	96	20	0	64	25	109	64	797	13	54	519	51
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA	Perm	Perm	NA	Perm
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2		2	6		6
Actuated Green, G (s)	7.0	7.0		7.0	7.0	7.0	19.0	19.0	19.0	19.0	19.0	19.0
Effective Green, g (s)	8.0	8.0		8.0	8.0	8.0	20.0	20.0	20.0	20.0	20.0	20.0
Actuated g/C Ratio	0.21	0.21		0.21	0.21	0.21	0.53	0.53	0.53	0.53	0.53	0.53
Clearance Time (s)	6.0	6.0		6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	293	342		281	396	337	455	1883	842	338	1883	842
v/s Ratio Prot		0.01			0.01			c0.22			0.15	
v/s Ratio Perm	c0.07			0.05		0.07	0.07		0.01	0.08		0.03
v/c Ratio	0.33	0.06		0.23	0.06	0.32	0.14	0.42	0.02	0.16	0.28	0.06
Uniform Delay, d1	12.7	12.0		12.4	12.0	12.7	4.6	5.5	4.3	4.7	5.0	4.4
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.7	0.1		0.4	0.1	0.6	0.6	0.7	0.0	1.0	0.4	0.1
Delay (s)	13.4	12.1		12.9	12.1	13.3	5.3	6.2	4.3	5.7	5.3	4.5
Level of Service	B	B		B	B	B	A	A	A	A	A	A
Approach Delay (s)		12.8			13.0			6.1			5.3	
Approach LOS		B			B			A			A	

Intersection Summary

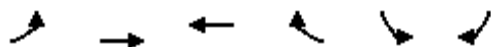
HCM 2000 Control Delay	7.3	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	38.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	48.5%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Appendix D – Internal Circulation

HCM Unsignalized Intersection Capacity Analysis

75: Bus Loop

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↖	↗		↘	
Volume (veh/h)	10	298	70	0	0	10
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	11	314	74	0	0	11
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		243	76			
pX, platoon unblocked						
vC, conflicting volume	74				408	74
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	74				408	74
tC, single (s)	5.1				6.4	7.2
tC, 2 stage (s)						
tF (s)	3.1				3.5	4.2
p0 queue free %	99				100	99
cM capacity (veh/h)	1080				597	772

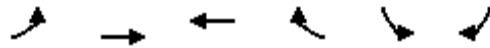
Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	324	74	11
Volume Left	11	0	0
Volume Right	0	0	11
cSH	1080	1700	772
Volume to Capacity	0.01	0.04	0.01
Queue Length 95th (m)	0.2	0.0	0.3
Control Delay (s)	0.4	0.0	9.7
Lane LOS	A		A
Approach Delay (s)	0.4	0.0	9.7
Approach LOS			A

Intersection Summary			
Average Delay		0.5	
Intersection Capacity Utilization		32.9%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis

76: KnR

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	70	228	0	0	0	70
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	74	240	0	0	0	74
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		319				
pX, platoon unblocked						
vC, conflicting volume	0				387	0
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	0				387	0
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				100	93
cM capacity (veh/h)	1636				592	1091

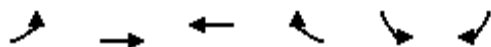
Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	314	0	74
Volume Left	74	0	0
Volume Right	0	0	74
cSH	1636	1700	1091
Volume to Capacity	0.05	0.00	0.07
Queue Length 95th (m)	1.1	0.0	1.6
Control Delay (s)	2.0	0.0	8.5
Lane LOS	A		A
Approach Delay (s)	2.0	0.0	8.5
Approach LOS			A

Intersection Summary			
Average Delay		3.3	
Intersection Capacity Utilization	26.9%		ICU Level of Service
Analysis Period (min)	15		A

HCM Unsignalized Intersection Capacity Analysis

75: Bus Loop

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	8	73	244	0	0	8
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	8	77	257	0	0	8
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		256	109			
pX, platoon unblocked						
vC, conflicting volume	257				351	257
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	257				351	257
tC, single (s)	5.1				6.4	7.2
tC, 2 stage (s)						
tF (s)	3.1				3.5	4.2
p0 queue free %	99				100	99
cM capacity (veh/h)	900				645	593

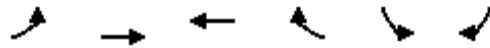
Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	85	257	8
Volume Left	8	0	0
Volume Right	0	0	8
cSH	900	1700	593
Volume to Capacity	0.01	0.15	0.01
Queue Length 95th (m)	0.2	0.0	0.3
Control Delay (s)	1.0	0.0	11.2
Lane LOS	A		B
Approach Delay (s)	1.0	0.0	11.2
Approach LOS			B

Intersection Summary			
Average Delay		0.5	
Intersection Capacity Utilization		22.8%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis

77: KnR

8/11/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	73	0	171	0	0	73
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	77	0	180	0	0	77
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		365				
pX, platoon unblocked						
vC, conflicting volume	180				334	180
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	180				334	180
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				100	91
cM capacity (veh/h)	1408				629	868

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	77	180	77
Volume Left	77	0	0
Volume Right	0	0	77
cSH	1408	1700	868
Volume to Capacity	0.05	0.11	0.09
Queue Length 95th (m)	1.3	0.0	2.2
Control Delay (s)	7.7	0.0	9.6
Lane LOS	A		A
Approach Delay (s)	7.7	0.0	9.6
Approach LOS			A

Intersection Summary			
Average Delay		4.0	
Intersection Capacity Utilization		27.6%	ICU Level of Service
Analysis Period (min)		15	A

Report

Whites Road Station Traffic Study



Prepared for Ministry of Transportation, Ontario
by IBI Group

December 20, 2016

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1 Introduction

The proposed Whites Road Highway 407 Transitway Station is a new transit station in the City of Pickering, in the Regional Municipality of Durham. The station site is located at the southwest corner of the future Highway 407 interchange at Whites Road.

This study provides a preliminary review of traffic conditions at the proposed station. As the Whites Road extension and alignment are currently in planning stage, there is no existing conditions traffic analysis for this study. The future analysis horizon year is 2031. Traffic analysis includes station access and adjacent street network to determine potential operational deficiencies. In addition, this report documents the impact of station volumes onto Whites Road due to the park and ride facility at the proposed station.

1.1 Study Area

The study area was confirmed with the Ministry of Transportation, Ontario (MTO) staff and includes the following intersections:

- Highway 407 West Off-ramp at Whites Road;
- Highway 407 East Off-ramp at Whites Road;
- Future site right-in, right-out (RIRO) access at Whites Road;
- Future site full-movement access at Whites Road; and
- Whitevale Road at Whites Road.

An overview of the proposed alignment of Whites Road is provided in Exhibit 1-1 below.

Exhibit 1-1: Study Area Map



1.2 Study Objective

The objective of the traffic analysis for Whites Road Station is to support the planning and preliminary design of the Transitway by identifying problems in the potential configurations for the future road network, providing needs and justification, and evaluating solutions.

Section 2 provides the contextual information for the existing road network in the study area.

Section 3 discusses the traffic volume projections of the proposed station, including the assignment of site-generated trips in the study area.

Section 4 provides the projection of future background and future total traffic volumes.

Section 5 provides the station internal circulation analysis.

2 Existing Conditions

2.1 Road Network

Whites Road (Durham Regional Road 38) is a north-south Regional Road, currently spanning between Taunton Road in the north and the Petticoat Creek Conservation Area in the south. It has two-lane cross sections in the residential area near the south terminus and rural area near the north terminus. Whites Road is expected to be expanded to a 6 lane arterial and with an interchange at Highway 407. The proposed alignment would connect the existing Whites Road with Sideline 26 and cross Highway 407 as per the Durham/Toronto/York Area Transportation Study completed in 2009. Whites Road is anticipated to act as a major north south arterial in the area with one lane in each direction will be a dedicated HOV lane.

Highway 407 is a six lane Express Toll Route. It provides connections from the City of Burlington to the City of Pickering.

Whitevale Road is a two-lane east-west minor arterial in the study area.

Highway 7 is an east-west Regional Highway that connects major municipalities in the Region of York and the Region of Durham, such as the City of Vaughan, Town of Richmond Hill, City of Markham, and the City of Pickering. In the study area, it is currently under the jurisdiction of the Ministry of Transportation, but is anticipated to be transferred to the Region of Durham in due course and function as a Type A arterial road. The widening of Highway 7 from a two-lane cross-section to a four-lane cross-section is underway from Pickering to Highway 12.

2.2 Operations

Intersection operations analysis was conducted using Synchro 9, which utilizes the Highway Capacity Manual (HCM) 2000 methodology to evaluate overall intersection and individual movement performances. The level of service (LOS) is a measure of performance based on the control delay, defined as follows in Exhibit 2-1:

Exhibit 2-1: Intersection LOS Reference

HCM	Control Delay per Vehicle (s)	
LOS	Signalized	Unsignalized
A	≤10	≤10
B	>10 and ≤20	>10 and ≤15
C	>20 and ≤35	>15 and ≤25
D	>35 and ≤55	>25 and ≤35
E	>55 and ≤80	>35 and ≤50
F	>80	>50

Critical movements were identified by satisfying any one or more of the following criteria, based on the York Region TIS Guidelines for an urban area:

- Control delay of LOS E or worse;
- 95th percentile queue exceeding provided storage/link length; and
- Volume-to-capacity (v/c) ratio of 0.85 or greater.

2.3 Transit Access

Currently, there are no transit services in the study area, though GO Bus operates along Highway 407. Future transit services will likely be implemented driven by adjacent developments and completion of the road network including the new interchange at Whites Road and Highway 407.

3 Site Traffic

This section provides the methodology and process used to generate and distribute site-generated traffic from the proposed station.

3.1 Station Demand Forecasts

Station demand forecasts were developed based on the Greater Golden Horseshoe (GGH) model scenarios for the 407 Transitway East study. There are two scenarios, a.m. and p.m., each based on the projected 2031 population and employment in the GGH area. For the purposes of this study, demand adjustments were undertaken to better calibrate the transit travel patterns in the east portion of the 407 Transitway between Kennedy Road and Brock Road. Model results for each station include peak period demand in three access categories: park-and-ride (PnR), walk/transit, and interline. See Exhibit 3-1 for the station travel demand forecasts.

ITE Trip Generation Manual (8th edition) provides inbound and outbound peak hour trip rates for transit stations with park and ride service (code #90), based on the number of parking spaces provided. In order to develop the number of parking spaces required at each station, 2011 TTS data at existing GO transit stations were analyzed. The average ratio between a.m. peak period auto driver demand and the number of parking spaces provided at these stations were found to be 0.75. See Exhibit 3-2 for the list of GO stations and their parking provision rates.

The ratio found above was applied to the 407 Transitway East stations to develop the number of parking spaces needed, with the assumption that auto driver demand is equal to park-and-ride demand. See Exhibit 3-3 for the proposed number of parking spaces at each station.

Exhibit 3-1: GGH Model Results – 2031 AM Peak Period Transitway Station Demand

Station	2031 AM Peak Period Travel Adjusted			
	PnR	Walk/Transit	Interline	Total
Brock Road	450	30	1,690	2,170
Whites Road	540	40	1,480	2,060
Donald Cousens Parkway	383	127	0	510
9th Line	503	167	0	670
Markham Road	608	102	100	810

Exhibit 3-2: TTS Data – 2011 AM Peak Period GO Station Demand and Parking Supply

2011 TTS AM Peak Period Travel		Station Parking	
GO Station (Rural)	Auto Driver*	Spaces	% Provision
Stouffville	220	243	91%
Aurora	1,010	1,463	69%
Newmarket	260	265	98%
Milton	1,330	1,544	86%
Georgetown	400	614	65%
Mount Pleasant	830	1,112	75%
Total Rural	4,050	5,241	77%
GO Station (Durham)	Auto Driver	Spaces	% Provision
Oshawa	1,620	2,380	68%
Whitby	2,200	2,958	74%
Ajax	1,730	2,148	81%
Pickering	1,850	2,508	74%
Total Durham	7,400	9,994	74%
Total	11,450	15,235	75%

* Rounded to nearest 10

Exhibit 3-3: Station Parking Space Requirement

Station	PnR Demand	Parking Spaces
Brock Road	450	600
Whites Road	540	720
Whites Road without DC*	617	823
Donald Cousens Parkway	383	511
9th Line	503	671
9th Line without DC**	809	1,079
Markham Road	608	810
Kennedy Road	820	1,093

* Whites Road Station PnR 540 + 20% of 383 from Donald Cousens Parkway = 617

** 9th Line Station PnR 503 + 80% of 383 from Donald Cousens Parkway = 809

3.2 Trip Generation

Trip generations rates were based on the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th Edition. Land use code 90 (Park and Ride Lot for Bus Service) was used to determine the number of auto trips in to and out of the station based on the number of spaces in the station parking lot. The number of parking spaces was estimated based on projected ridership.

With Donald Cousens Parkway Station

The proposed station is to have two accesses to Whites Road between the intersections with Highway 407 EB off-ramp and Whitevale Road. Estimated transit ridership is approximately 2,060 riders in the a.m. peak period, with 540 (26%) using the park and ride (PnR) services.

Based on similar other stations, it is assumed that an additional 25% provision of parking would be used by 2031, thus a parking lot size of 720 spaces was assumed for trip generation purposes.

The trip generation rates and resultant traffic volumes projected for 2031 are shown in Exhibit 3-4.

Without Donald Cousens Parkway Station

Without a Transitway station at Donald Cousens Parkway to the west of Whites Road, 20% of expected PnR trips at Donald Cousens Parkway Station would instead divert to Whites Road Station. With this consideration, the expected PnR users would grow to 617 and as a result require a new station parking lot with 823 spaces.

The trip generation rates and resulting traffic volumes projected for 2031 are shown in Exhibit 3-4.

Exhibit 3-4: Trip Generation Rates

Whites Road Station Traffic Volumes						
ITE Land Use Code 90	Total	Entering	Exiting	Total	Entering	Exiting
Scenario	AM			PM		
Rates	0.72	0.81	0.19	0.62	0.23	0.77
With Donald Cousens Station	518	420	98	446	103	343
Without Donald Cousens Station	593	480	113	510	117	393

3.3 Surface Transit Forecasts

Transit volumes were also added based on the assumption that transit would need to accommodate the 1,480 Interline users in the peak period (see Exhibit 3-1). A factor of 0.5 was assumed to convert the peak period demand to peak hour demand, resulting in 740 peak hour surface transit users. An average capacity of 25 people per bus was assumed to determine that 30 buses will access the station in the peak hour.

Note that site-accessing bus volumes are accounted in the station access intersection turning movement volumes, but not in the adjacent intersections as they are considered to be included within background traffic volumes.

3.4 Trip Assignment

Station traffic was estimated based on former studies done for the central section of the Highway 407 Transitway completed in 2011. The distribution was approximately 50% to/from the north and 30% to/from the south and 30% from the proposed south collector road. The station traffic from the scenario without Donald Cousens Station was used in order to account for the highest possible amount of traffic volumes. Trip distributions and volumes to and from the site are shown in Exhibit 3-5 and Exhibit 3-6.

Exhibit 3-5: Site Traffic Distribution

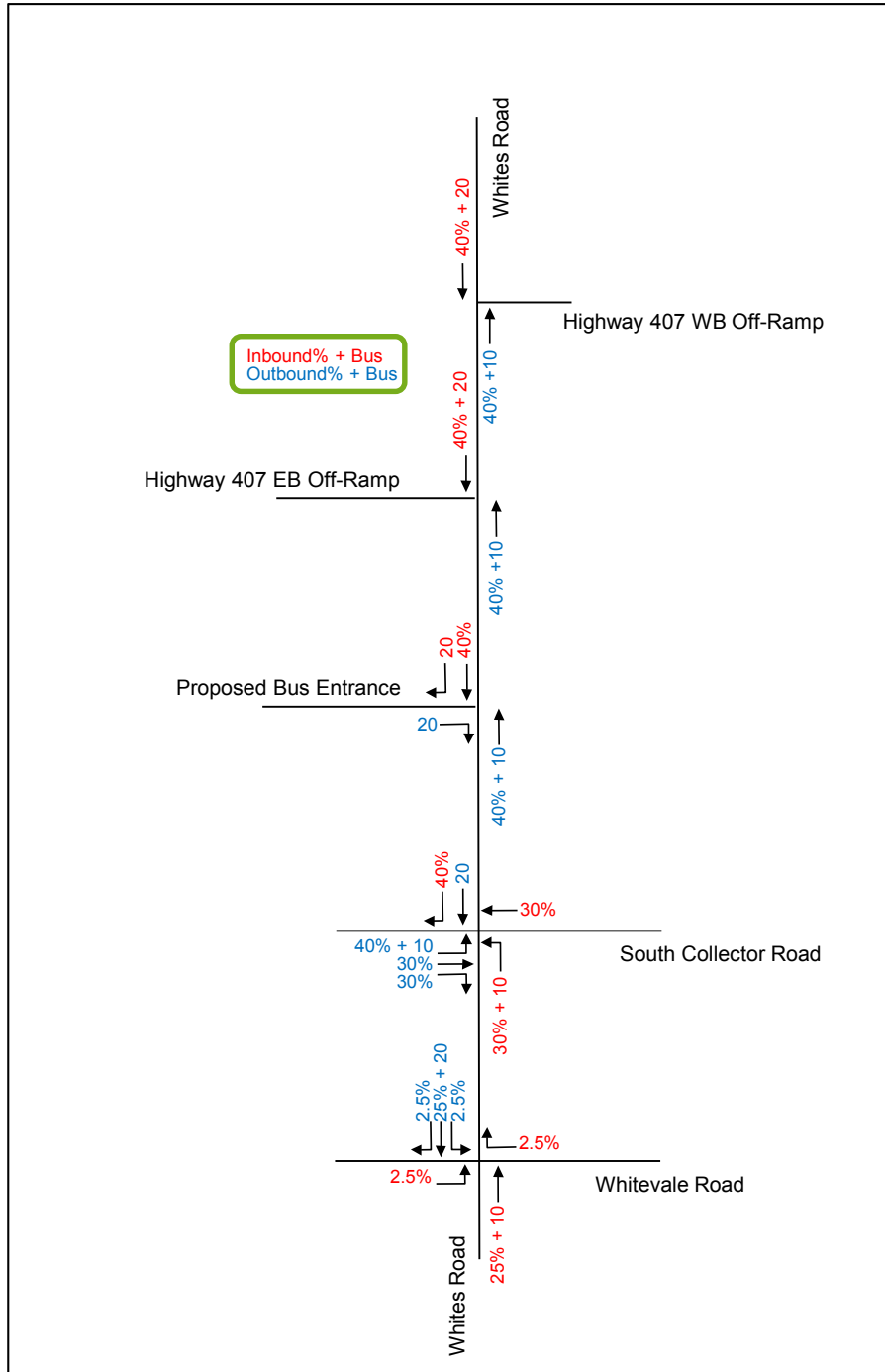
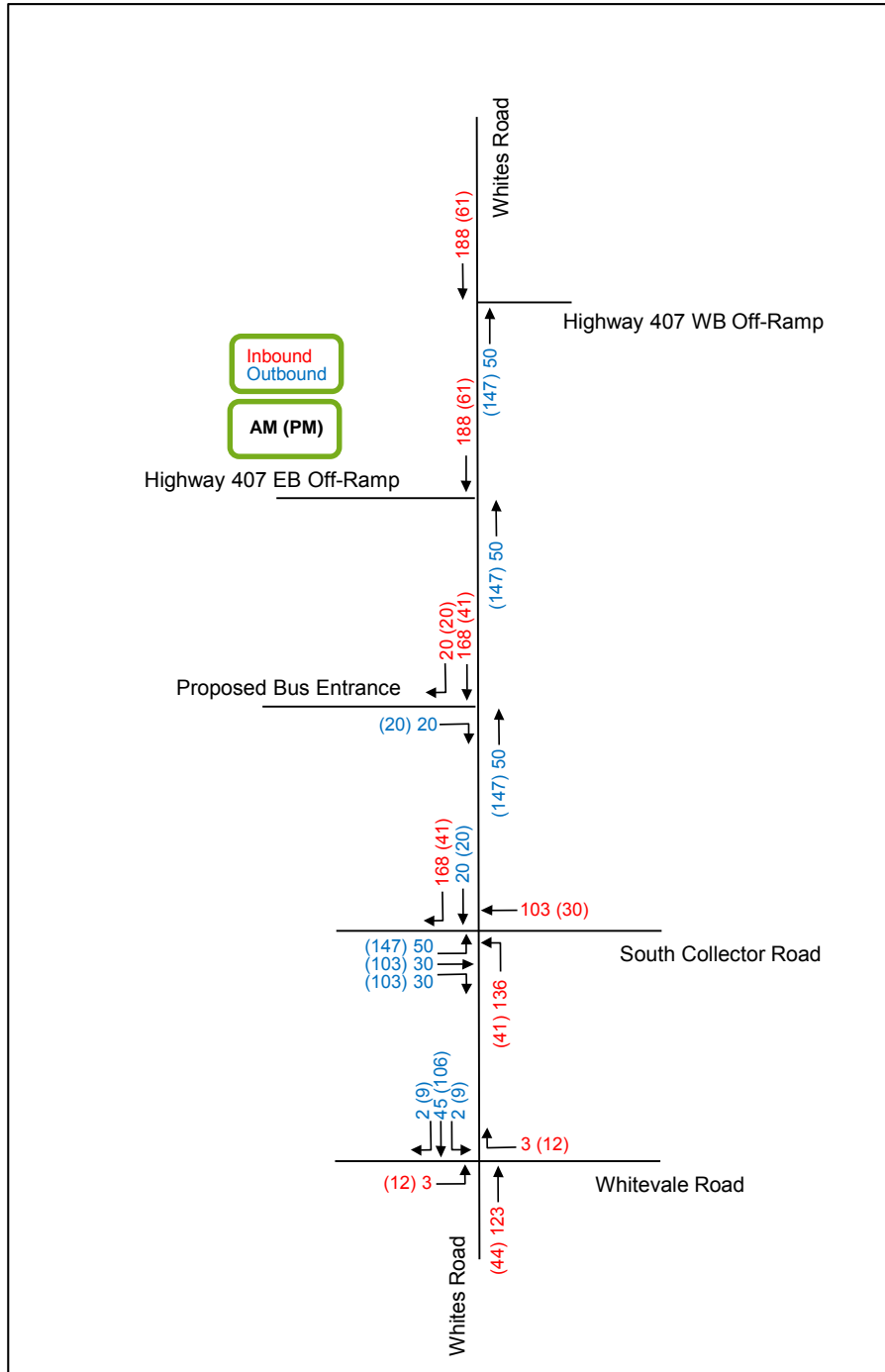


Exhibit 3-6: Site Traffic Volumes



4 Future Conditions

Whites Road was modelled as a 4-lane road due to the fact that the HOV lanes (one per direction) would not be utilized to full capacity by passenger vehicles. The proposed plan is to initially build Whites Road as a 4 lane rural cross-section and then to widen it to a 6 lane urban cross-section as an ultimate configuration.

In order to remain conservative, the HOV lane was left out of the analysis with the understanding that its inclusion would only improve the operations without causing further deficiencies. The ultimate build out configuration is shown in Exhibit 4-1.

Traffic projections were based on information from the following sources:

- Durham/Toronto/York Area Transportation Study (2009);
- Seaton Road Network Review, Update Report (April 2013); and
- Existing/Projected traffic volumes at a similar road/station (Markham Road Station).

The methodology included the following steps:

- Compare traffic volumes at Markham Road intersections and at Brock Road intersections in the future scenarios in order to determine approximate volumes;
- Balance between turning and through movements in order to develop consistent traffic volumes between intersections;
- Validate estimated future corridor volumes against the Seaton Road Network Review and Durham/Toronto/York Area Transportation study.

The future background and total volume projections used for operations analysis are shown in Exhibit 4-2 and Exhibit 4-3.

Exhibit 4-1: Proposed Future Road Configurations

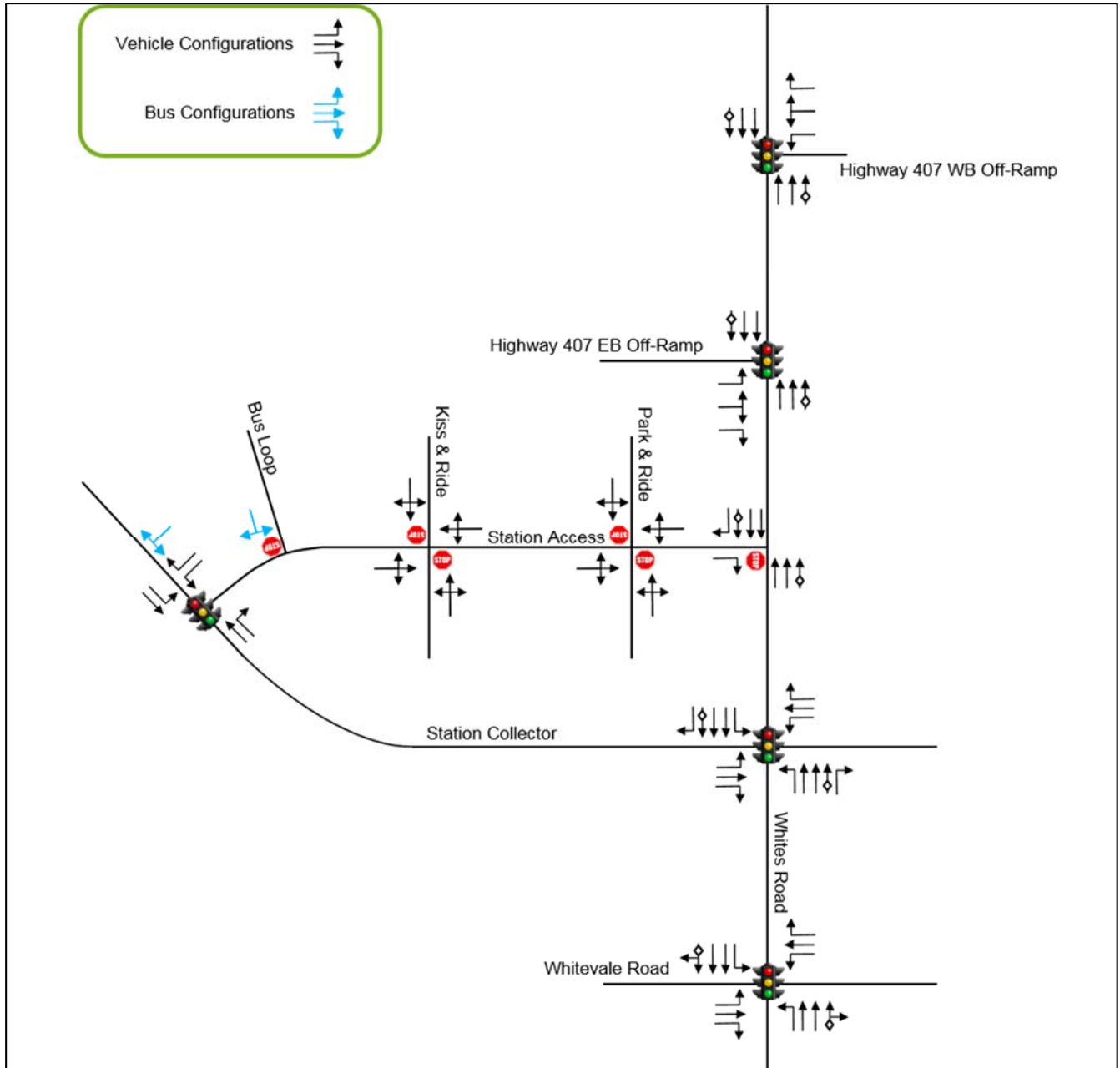


Exhibit 4-2: Future Background Projected Volumes

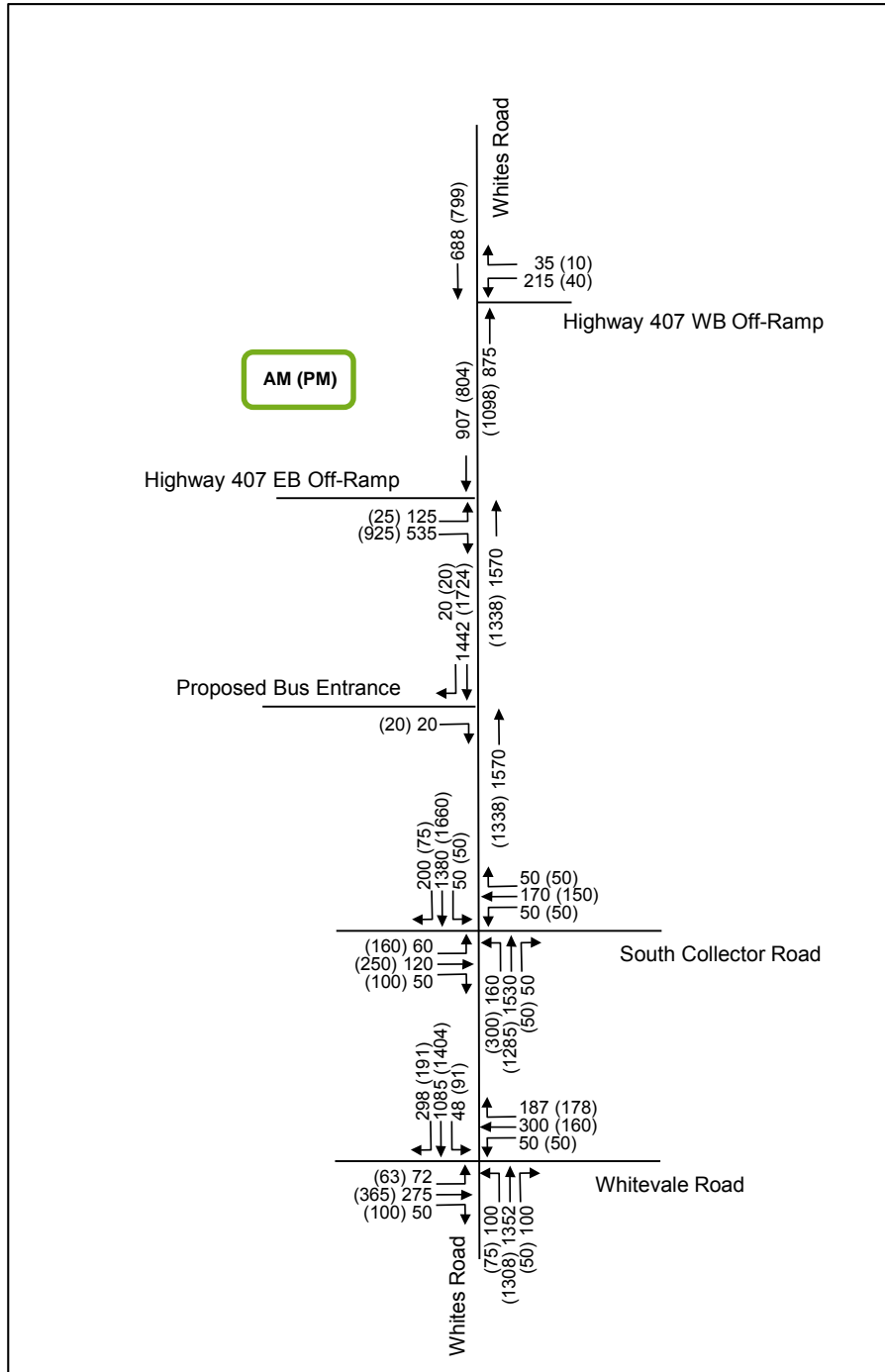
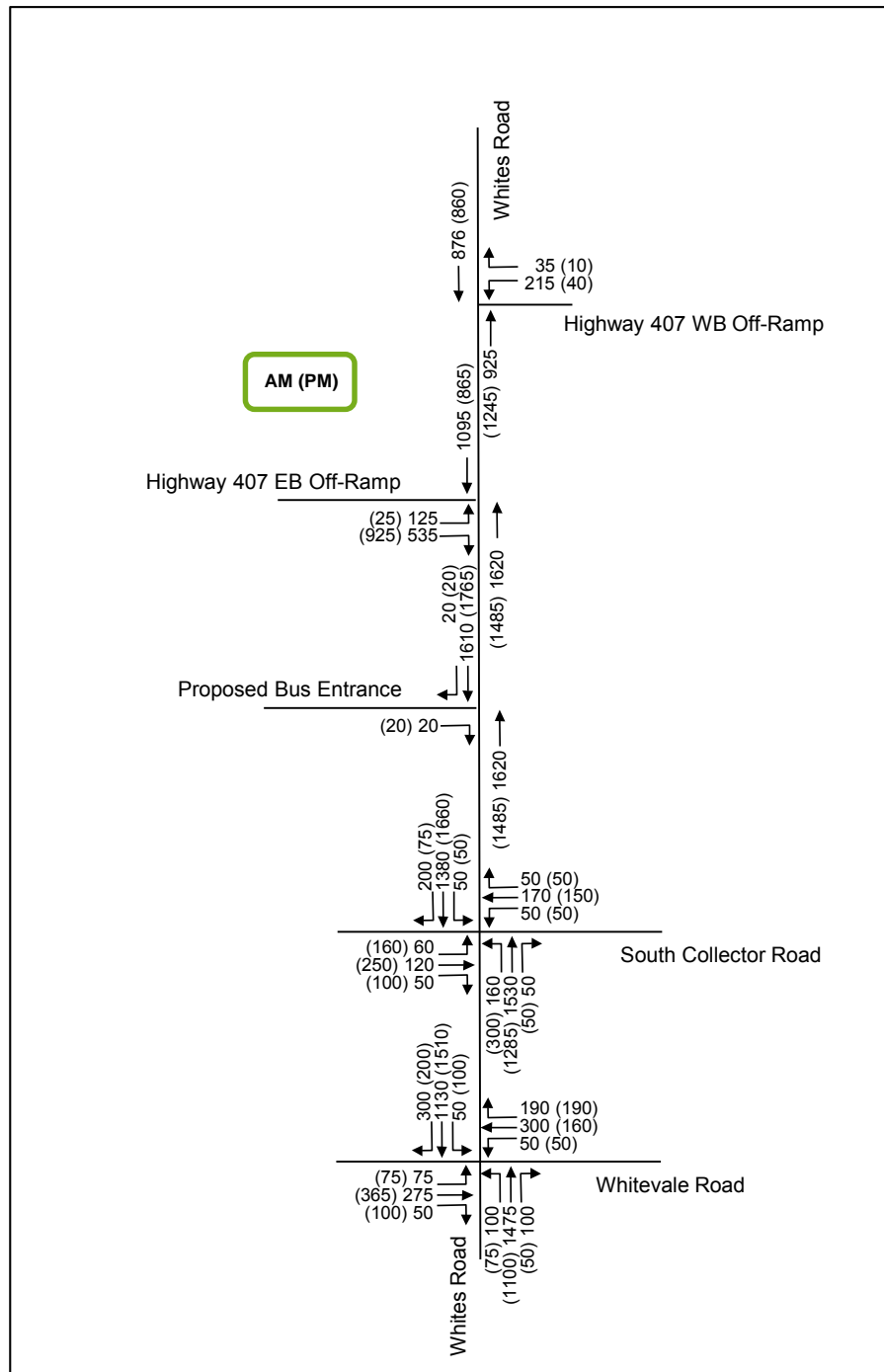


Exhibit 4-3: Future Background Projected Volumes



4.1 Future Traffic Operations

The extension and expansion of Whites Road is driven by the development of the Seaton community within the City of Pickering. Given that the extension of Whites Road is completed, the demand for a transit station would also be in place. Analysis of future scenarios without station traffic would not be realistic as the transit station and integrated transit services are core reasons for the expansion of the road.

Thus, the only results shown are those of the total traffic conditions that includes the transit station.

Highway 407 Off-Ramps: Since the future interchange of Highway 407 and Whites Road is conceptual, the design of the off-ramps will be dictated by future traffic demand. The projected volumes show that, reasonably sized off-ramps with provision of three lanes (one left, one shared left/right and one right) is sufficient to ensure that no movements are critical.

Bus Only Right-in Right-out Access from Whites Road: This intersection was not analysed as both the movement in and out are expected to be free flow with low volumes of buses per hour.

South Employment Collector and Whites Road (full access to station from Whites Road): As shown in Exhibit 4-4, it is possible to have this intersection operate at a LOS B and C in the a.m. and p.m. peak periods respectively. Several movements are operating at a LOS D and one movement (EBL) is operation at LOS E in the p.m. peak period. This is due to using a 120s cycle length in order to account for potential signal coordination along the corridor. The main source of delay is simply waiting for the signal to change rather than actual congestion or capacity constraints.

Whites Road and Whitevale Road: Given the exponential growths expected in the area, the traffic volumes developed show that the proposed road configurations are acceptable for long-term traffic operations. There are a few critical movements in each peak period, however given that this is a conservative estimate of 2031 conditions, designing for operations approaching capacity is appropriate. Furthermore the actual traffic operations would be improved by the HOV lanes.

Roundabouts were considered at all five analysis intersections along Whites Road. It was determined that due to the ultimate plan for three traffic lanes per direction, roundabouts are not suitable along Whites Road at any of the analysis intersections.

Exhibit 4-4: Future 2031 Total Conditions Intersection Operational Performance

Intersection	AM	Critical				PM	Critical			
	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)	Overall LOS	Mvmt	LOS	V/C	95th Queue (m)
Highway 407 West Off-Ramp at Whites Road	A					A				
Highway 407 East Off-Ramp at Whites Road	B					B				
Whites Road and Whitevale Road	C	EBL WBT NBT	F E D	0.92 0.81 0.93	46 101 241	C	EBT WBL	E E	0.86 0.73	128 33
South Employment Collector and Whites Road	B					C	EBL	E	0.75	54

5 Internal Circulation

This section provides an overview of the proposed station’s internal circulation design, with vehicle composition and flow derived from the site-generated trips in Section 3.

The proposed internal circulation plan is shown below in Exhibit 5-2. Analysis intersections are circled in red and numbered to correlate with the analysis summary table. Note that the plan is intended to illustrate the internal flow of vehicles (pink) and buses (blue), and that site details such as number of parking spaces and dimensions are subject to revisions.

The station internal volumes consist of:

- Passenger vehicles: AM: 420 in, 98 out; PM: 103 in, 343 out; and
- Buses (sum of northbound and southbound buses): AM: 30 in, 30 out; PM: 30 in, 30 out.

For simplicity, the majority of outbound vehicles in the a.m. and inbound vehicles in the p.m. are assumed to be associated with drop-off and pick-up activities (“Kiss-and-Ride”, abbreviated KnR). The remainder is assumed to be Park-and-Ride (PnR) vehicles. All buses are modelled as heavy vehicles in Synchro.

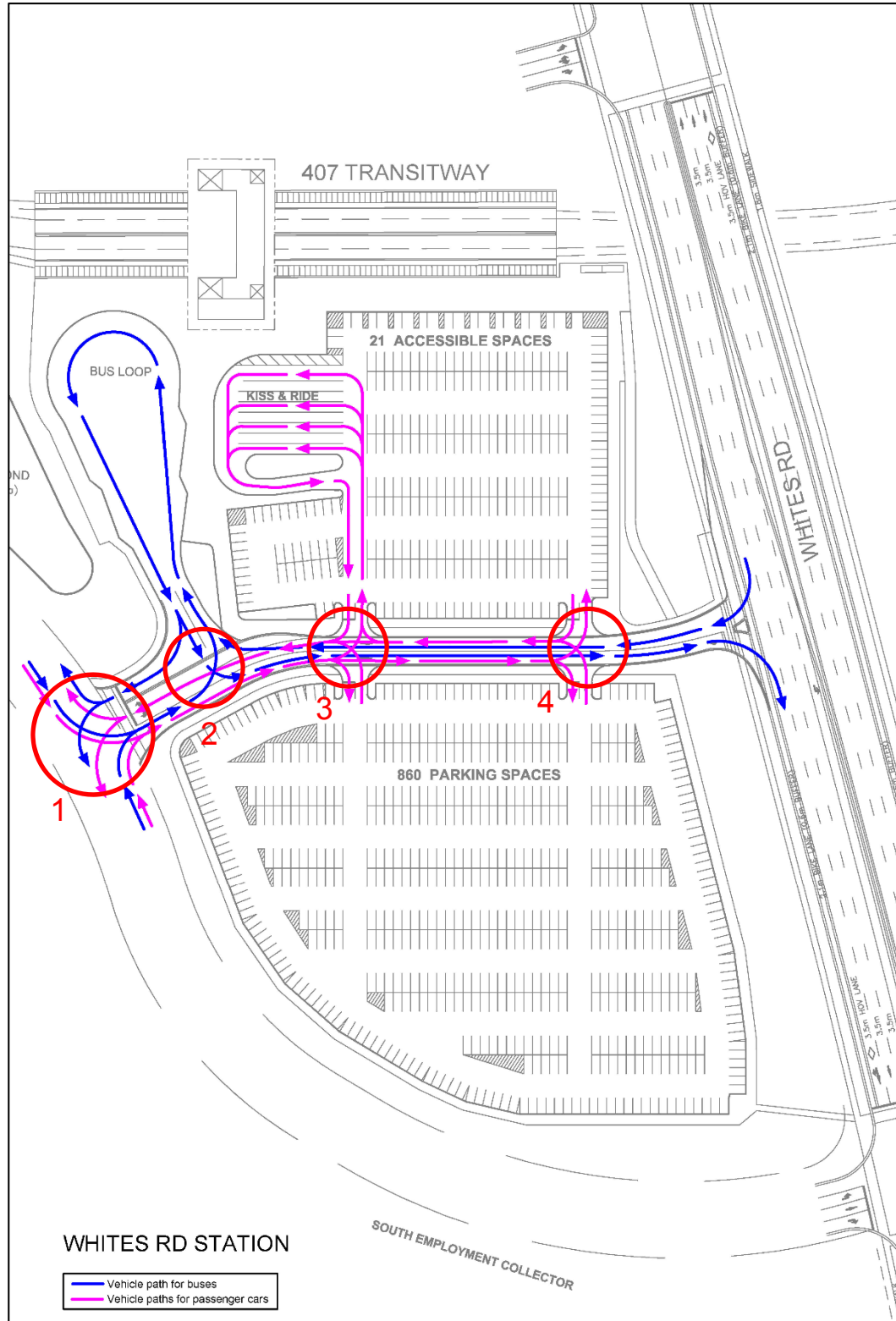
The intersection of the proposed employment collector road south of the proposed station and the station access road is expected to have one signalized intersection with transit signal priority implemented to facilitate bus movements in and out of this intersection. It was found that this intersection operates at a LOS B in both the a.m. and p.m. peak periods even with the added transit phase.

Analysis results show that there are no operational issues at the remaining analyzed internal intersections for both peak hour operations. The east-west movements along the station access road was analyzed as freeflow movements, which incurs no delay. The northbound and southbound movements are analyzed as stop-controlled movements, all of which operate at a LOS C or better in both the a.m. and p.m. peak hours.

Exhibit 5-1: Internal Circulation Analysis Summary

Internal Intersection	Mvmt.	AM Peak Hour			PM Peak Hour		
		Volume	LOS	Queue (95 th , m)	Volume	LOS	Queue (95 th , m)
1	WBL	80	C	19	300	C	65
	WBR	18	C	5	43	B	7
	NBT	150	B	27	175	B	32
	NBR	380	B	16	80	B	8
	SBL	50	A	1	33	A	1
	SBT	130	A	1	200	A	3
2	EBL	10	A	0	10	A	1
	SBL	20	B	13	20	B	12
3	EBL	80	A	2	55	A	4
	EBR	175			18		
	NBL	8	B	15	123	C	15
	SBR	80	A	9	55	A	10
4	EBL	15	A	0	5	A	0
	EBR	150			25		
	NBL	5	A	0	150	A	0
	SBR	5	C	17	15	C	1

Exhibit 5-2: Internal Circulation Plan – Markham Road Station



6 Conclusion

This study presents the traffic impact analysis of the proposed Whites Road Station on the future road network in the area. The proposed station is located at the southwest corner of the proposed Highway 407 interchange at Whites Road in the City of Pickering.

Whites Road is to be re-aligned, extended, and expanded in the future horizon of 2031. It will be a 6-lane major north-south arterial in the region with 2 of the lanes reserved for high occupancy vehicles, with background traffic demands driven by the development of the Seaton community within the City of Pickering.

The proposed station is accessible through a new employment collector road that intersects with Whites Road. There is also a bus-only right-in right-out access. Both access points lead to opposite ends of an internal road to access the all of the stations parking and bus facilities. This internal road shares a signalized intersection with the proposed employment collector and transit signal priority is expected to be implemented to allow for easier in and out access from the bus loop.

Site traffic for the proposed Whites Road station was calculated based on the Greater Golden Horseshoe Model's projected park-and-ride demand, the required number of on-site parking spaces, and the ITE trip generation manual rates. The proposed station generates 420 (103) inbound and 98 (343) outbound trips in the a.m. (p.m.) peak hours.

Intersection operational analysis shows that the site generated traffic can be accommodated by the proposed future road network in the area. The intersection of Whites Road and Whitevale Road begins to approach capacity, but given the high projected growth and the conservative assumptions used for analysis, the projected traffic operations are reasonable.

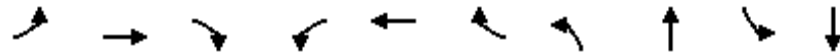
Site internal circulation analysis shows that there are no operational issues for both peak hours. Potential conflicts between buses and vehicles do not result in excessive delays or queues due to overall low volumes.

Appendix A – Future (2031) Total Conditions Synchro Output

Queues

73: Whites Road & Whitevale Road

8/18/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	79	289	53	53	316	200	105	1658	53	1505
v/c Ratio	0.93	0.74	0.13	0.50	0.81	0.42	0.43	0.93	0.13	0.70
Control Delay	125.7	56.2	1.2	57.8	61.5	9.3	12.9	39.0	11.4	18.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	125.7	56.2	1.2	57.8	61.5	9.3	12.9	39.0	11.4	18.6
Queue Length 50th (m)	17.9	62.7	0.0	10.9	69.8	2.2	6.8	186.0	3.8	86.8
Queue Length 95th (m)	#46.4	91.6	1.3	24.5	100.6	20.7	12.5	#240.6	m12.6	132.2
Internal Link Dist (m)	2113.7				829.1		252.8		911.4	
Turn Bay Length (m)	50.0		50.0	50.0		50.0	50.0		50.0	
Base Capacity (vph)	96	439	450	120	439	517	266	1777	393	2143
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.82	0.66	0.12	0.44	0.72	0.39	0.39	0.93	0.13	0.70

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

73: Whites Road & Whitevale Road

8/18/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖	↑	↗	↖	↑	↗	↖	↑↗		↖	↑↗	
Volume (vph)	75	275	50	50	300	190	100	1475	100	50	1130	300
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	3.0	5.0		3.0	5.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99		1.00	0.97	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3545		1789	3466	
Flt Permitted	0.22	1.00	1.00	0.27	1.00	1.00	0.12	1.00		0.06	1.00	
Satd. Flow (perm)	415	1883	1601	516	1883	1601	228	3545		120	3466	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	79	289	53	53	316	200	105	1553	105	53	1189	316
RTOR Reduction (vph)	0	0	42	0	0	149	0	4	0	0	18	0
Lane Group Flow (vph)	79	289	11	53	316	51	105	1654	0	53	1487	0
Turn Type	Perm	NA	Perm	Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)	23.9	23.9	23.9	23.9	23.9	23.9	66.5	59.0		84.1	72.6	
Effective Green, g (s)	24.9	24.9	24.9	24.9	24.9	24.9	68.5	60.0		85.1	73.6	
Actuated g/C Ratio	0.21	0.21	0.21	0.21	0.21	0.21	0.57	0.50		0.71	0.61	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	4.0	6.0		4.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	86	390	332	107	390	332	240	1772		392	2125	
v/s Ratio Prot		0.15			0.17		c0.03	c0.47		0.02	c0.43	
v/s Ratio Perm	c0.19		0.01	0.10		0.03	0.22			0.07		
v/c Ratio	0.92	0.74	0.03	0.50	0.81	0.15	0.44	0.93		0.14	0.70	
Uniform Delay, d1	46.6	44.5	37.9	42.0	45.3	38.9	13.7	28.1		18.4	15.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		2.01	1.03	
Incremental Delay, d2	69.7	7.4	0.0	3.6	12.0	0.2	1.3	10.5		0.6	1.7	
Delay (s)	116.2	51.9	38.0	45.6	57.3	39.1	15.0	38.7		37.5	18.0	
Level of Service	F	D	D	D	E	D	B	D		D	B	
Approach Delay (s)		62.2			49.8			37.3			18.6	
Approach LOS		E			D			D			B	

Intersection Summary

HCM 2000 Control Delay	34.6	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.84		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	83.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

77: Whites Road & Highway 407 EB Off-ramp

8/18/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	414	281	1705	1153
v/c Ratio	0.52	0.76	0.70	0.47
Control Delay	37.8	49.6	2.7	11.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	37.8	49.6	2.7	11.0
Queue Length 50th (m)	40.5	60.4	13.7	52.7
Queue Length 95th (m)	48.6	83.0	15.3	121.0
Internal Link Dist (m)	524.6		161.0	340.7
Turn Bay Length (m)		75.0		
Base Capacity (vph)	1525	698	2434	2434
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.27	0.40	0.70	0.47

Intersection Summary

HCM Signalized Intersection Capacity Analysis
 77: Whites Road & Highway 407 EB Off-ramp

8/18/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	125	535	0	1620	1095	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	0.97	0.91		0.95	0.95	
Frt	0.90	0.85		1.00	1.00	
Flt Protected	0.98	1.00		1.00	1.00	
Satd. Flow (prot)	3229	1457		3579	3579	
Flt Permitted	0.98	1.00		1.00	1.00	
Satd. Flow (perm)	3229	1457		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	132	563	0	1705	1153	0
RTOR Reduction (vph)	26	26	0	0	0	0
Lane Group Flow (vph)	388	255	0	1705	1153	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	27.4	27.4		80.6	80.6	
Effective Green, g (s)	28.4	28.4		81.6	81.6	
Actuated g/C Ratio	0.24	0.24		0.68	0.68	
Clearance Time (s)	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	764	344		2433	2433	
v/s Ratio Prot	0.12			0.48	0.32	
v/s Ratio Perm		0.18				
v/c Ratio	0.51	0.74		0.70	0.47	
Uniform Delay, d1	39.7	42.4		11.7	9.1	
Progression Factor	1.00	1.00		0.09	1.00	
Incremental Delay, d2	0.5	8.3		1.4	0.6	
Delay (s)	40.3	50.7		2.5	9.7	
Level of Service	D	D		A	A	
Approach Delay (s)	44.5			2.5	9.7	
Approach LOS	D			A	A	

Intersection Summary

HCM 2000 Control Delay	13.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	62.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Queues

78: Whites Road & Highway 407 WB Off-ramp

8/18/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	230	33	974	921
v/c Ratio	0.55	0.16	0.34	0.32
Control Delay	54.1	16.5	3.5	3.9
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	54.1	16.5	3.5	3.9
Queue Length 50th (m)	26.4	0.0	11.2	25.2
Queue Length 95th (m)	37.7	10.1	49.6	38.0
Internal Link Dist (m)	512.5		340.7	420.0
Turn Bay Length (m)		75.0		
Base Capacity (vph)	1621	697	2852	2852
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.14	0.05	0.34	0.32
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

78: Whites Road & Highway 407 WB Off-ramp

8/18/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations	↔↔	↗	↕↕			↕↕
Volume (vph)	215	35	925	0	0	875
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0			5.0
Lane Util. Factor	0.97	0.91	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	3474	1457	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	3474	1457	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	226	37	974	0	0	921
RTOR Reduction (vph)	2	29	0	0	0	0
Lane Group Flow (vph)	228	4	974	0	0	921
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	13.4	13.4	94.6			94.6
Effective Green, g (s)	14.4	14.4	95.6			95.6
Actuated g/C Ratio	0.12	0.12	0.80			0.80
Clearance Time (s)	6.0	6.0	6.0			6.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	416	174	2851			2851
v/s Ratio Prot	c0.07		c0.27			0.26
v/s Ratio Perm		0.00				
v/c Ratio	0.55	0.02	0.34			0.32
Uniform Delay, d1	49.7	46.6	3.4			3.3
Progression Factor	1.00	1.00	0.89			1.00
Incremental Delay, d2	1.5	0.1	0.2			0.3
Delay (s)	51.2	46.6	3.3			3.6
Level of Service	D	D	A			A
Approach Delay (s)	50.6		3.3			3.6
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	9.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.37		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	62.3%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

83: Whites Road & Station Access RIRO

8/18/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↕↗	↕↗	↗
Volume (veh/h)	0	20	0	1620	1610	20
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	21	0	1705	1695	21
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage (veh)						
Upstream signal (m)				182	185	
pX, platoon unblocked	0.86	0.84	0.84			
vC, conflicting volume	2547	847	1716			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1658	446	1476			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	100	96	100			
cM capacity (veh/h)	77	472	381			

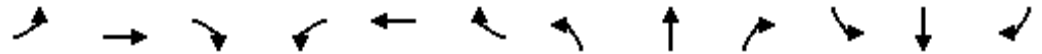
Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	21	853	853	847	847	21
Volume Left	0	0	0	0	0	0
Volume Right	21	0	0	0	0	21
cSH	472	1700	1700	1700	1700	1700
Volume to Capacity	0.04	0.50	0.50	0.50	0.50	0.01
Queue Length 95th (m)	1.1	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	13.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	13.0	0.0		0.0		
Approach LOS	B					

Intersection Summary						
Average Delay			0.1			
Intersection Capacity Utilization		54.5%		ICU Level of Service		A
Analysis Period (min)		15				

Queues

85: Whites Road & Station Collector

8/18/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	42	126	53	53	179	53	168	1611	53	53	1453	211
v/c Ratio	0.35	0.44	0.20	0.32	0.63	0.20	0.78	0.59	0.04	0.30	0.53	0.17
Control Delay	51.8	50.0	25.8	48.8	56.8	25.8	44.4	21.6	5.7	8.0	4.4	0.8
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	51.8	50.0	25.8	48.8	56.8	25.8	44.4	21.6	5.7	8.0	4.4	0.8
Queue Length 50th (m)	9.0	27.4	5.4	11.3	40.1	5.4	25.6	198.0	3.3	1.5	30.1	0.3
Queue Length 95th (m)	19.0	42.9	15.8	22.2	59.1	15.8	m31.7	m222.2	m5.1	9.2	73.4	3.1
Internal Link Dist (m)		275.4			364.0			911.4			158.0	
Turn Bay Length (m)	50.0		50.0	50.0		50.0	75.0		50.0	75.0		50.0
Base Capacity (vph)	371	878	761	507	878	761	216	2737	1230	174	2737	1251
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.11	0.14	0.07	0.10	0.20	0.07	0.78	0.59	0.04	0.30	0.53	0.17

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

85: Whites Road & Station Collector

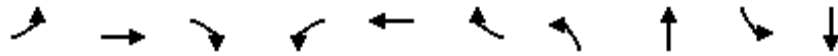
8/18/2015

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	40	120	50	50	170	50	160	1530	50	50	1380	200
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.42	1.00	1.00	0.58	1.00	1.00	0.15	1.00	1.00	0.12	1.00	1.00
Satd. Flow (perm)	797	1883	1601	1087	1883	1601	283	3579	1601	228	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	42	126	53	53	179	53	168	1611	53	53	1453	211
RTOR Reduction (vph)	0	0	23	0	0	23	0	0	6	0	0	27
Lane Group Flow (vph)	42	126	30	53	179	30	168	1611	47	53	1453	184
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA	Perm	Perm	NA	Perm
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	17.2	17.2	17.2	17.2	17.2	17.2	90.8	90.8	90.8	90.8	90.8	90.8
Effective Green, g (s)	18.2	18.2	18.2	18.2	18.2	18.2	91.8	91.8	91.8	91.8	91.8	91.8
Actuated g/C Ratio	0.15	0.15	0.15	0.15	0.15	0.15	0.76	0.76	0.76	0.76	0.76	0.76
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	120	285	242	164	285	242	216	2737	1224	174	2737	1224
v/s Ratio Prot		0.07			c0.10			0.45			0.41	
v/s Ratio Perm	0.05		0.02	0.05		0.02	c0.59		0.03	0.23		0.12
v/c Ratio	0.35	0.44	0.12	0.32	0.63	0.12	0.78	0.59	0.04	0.30	0.53	0.15
Uniform Delay, d1	45.6	46.3	44.0	45.4	47.7	44.0	8.2	6.0	3.4	4.3	5.6	3.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	2.73	3.13	2.12	0.59	0.60	0.24
Incremental Delay, d2	1.8	1.1	0.2	1.1	4.3	0.2	12.2	0.4	0.0	4.1	0.7	0.2
Delay (s)	47.4	47.4	44.2	46.6	52.0	44.2	34.5	19.3	7.3	6.7	4.0	1.1
Level of Service	D	D	D	D	D	D	C	B	A	A	A	A
Approach Delay (s)		46.6			49.6			20.4			3.8	
Approach LOS		D			D			C			A	
Intersection Summary												
HCM 2000 Control Delay			16.8			HCM 2000 Level of Service			B			
HCM 2000 Volume to Capacity ratio			0.75									
Actuated Cycle Length (s)			120.0	Sum of lost time (s)					10.0			
Intersection Capacity Utilization			76.0%	ICU Level of Service			D					
Analysis Period (min)			15									
c	Critical Lane Group											

Queues

73: Whites Road & Whitevale Road

8/18/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	79	384	105	53	168	200	79	1211	105	1800
v/c Ratio	0.32	0.86	0.23	0.72	0.37	0.38	0.47	0.72	0.25	0.84
Control Delay	40.7	62.2	8.8	89.7	40.2	6.9	23.2	28.0	12.6	23.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	40.7	62.2	8.8	89.7	40.2	6.9	23.2	28.0	12.6	23.0
Queue Length 50th (m)	15.0	84.5	0.9	11.2	32.3	0.0	5.8	115.8	9.2	115.4
Queue Length 95th (m)	29.1	#128.3	14.2	#32.8	52.2	17.5	17.2	141.3	m19.9	180.1
Internal Link Dist (m)		2113.7			829.1			252.8		911.4
Turn Bay Length (m)	50.0		50.0	50.0		50.0	50.0		50.0	
Base Capacity (vph)	268	486	487	80	486	561	170	1690	422	2153
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.29	0.79	0.22	0.66	0.35	0.36	0.46	0.72	0.25	0.84

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

73: Whites Road & Whitevale Road

8/18/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	75	365	100	50	160	190	75	1100	50	100	1510	200
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	3.0	5.0		3.0	5.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99		1.00	0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3555		1789	3516	
Flt Permitted	0.55	1.00	1.00	0.16	1.00	1.00	0.07	1.00		0.11	1.00	
Satd. Flow (perm)	1037	1883	1601	310	1883	1601	132	3555		200	3516	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	79	384	105	53	168	200	79	1158	53	105	1589	211
RTOR Reduction (vph)	0	0	76	0	0	152	0	3	0	0	8	0
Lane Group Flow (vph)	79	384	29	53	168	48	79	1208	0	105	1792	0
Turn Type	Perm	NA	Perm	Perm	NA	Perm	pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)	27.6	27.6	27.6	27.6	27.6	27.6	60.9	56.0		80.4	71.5	
Effective Green, g (s)	28.6	28.6	28.6	28.6	28.6	28.6	62.9	57.0		81.4	72.5	
Actuated g/C Ratio	0.24	0.24	0.24	0.24	0.24	0.24	0.52	0.48		0.68	0.60	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	4.0	6.0		4.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	247	448	381	73	448	381	150	1688		419	2124	
v/s Ratio Prot		c0.20			0.09		c0.03	0.34		0.04	c0.51	
v/s Ratio Perm	0.08		0.02	0.17		0.03	0.25			0.13		
v/c Ratio	0.32	0.86	0.08	0.73	0.38	0.13	0.53	0.72		0.25	0.84	
Uniform Delay, d1	37.7	43.7	35.4	42.1	38.2	35.9	20.1	25.1		12.4	19.2	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.77	0.98	
Incremental Delay, d2	0.8	14.9	0.1	29.9	0.5	0.1	3.3	2.6		1.1	3.3	
Delay (s)	38.4	58.6	35.5	72.0	38.8	36.0	23.4	27.7		23.1	22.2	
Level of Service	D	E	D	E	D	D	C	C		C	C	
Approach Delay (s)		51.5			41.6			27.4			22.2	
Approach LOS		D			D			C			C	

Intersection Summary

HCM 2000 Control Delay	29.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.83		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	90.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

77: Whites Road & Highway 407 EB Off-ramp

8/18/2015



Lane Group	EBL	EBR	NBT	SBT
Lane Group Flow (vph)	510	484	1563	911
v/c Ratio	0.43	0.84	0.79	0.46
Control Delay	24.3	41.9	12.4	18.1
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	24.3	41.9	12.4	18.1
Queue Length 50th (m)	39.0	98.0	202.0	69.0
Queue Length 95th (m)	44.6	124.1	#234.4	103.6
Internal Link Dist (m)	524.6		161.0	340.7
Turn Bay Length (m)		75.0		
Base Capacity (vph)	1497	718	1974	1974
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.34	0.67	0.79	0.46

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

77: Whites Road & Highway 407 EB Off-ramp

8/18/2015



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (vph)	25	920	0	1485	865	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		5.0	5.0	
Lane Util. Factor	0.97	0.91		0.95	0.95	
Frt	0.86	0.85		1.00	1.00	
Flt Protected	1.00	1.00		1.00	1.00	
Satd. Flow (prot)	3126	1457		3579	3579	
Flt Permitted	1.00	1.00		1.00	1.00	
Satd. Flow (perm)	3126	1457		3579	3579	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	26	968	0	1563	911	0
RTOR Reduction (vph)	46	46	0	0	0	0
Lane Group Flow (vph)	464	438	0	1563	911	0
Turn Type	Prot	Perm		NA	NA	
Protected Phases	4			2	6	
Permitted Phases		4				
Actuated Green, G (s)	42.8	42.8		65.2	65.2	
Effective Green, g (s)	43.8	43.8		66.2	66.2	
Actuated g/C Ratio	0.36	0.36		0.55	0.55	
Clearance Time (s)	6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	1140	531		1974	1974	
v/s Ratio Prot	0.15			0.44	0.25	
v/s Ratio Perm		0.30				
v/c Ratio	0.41	0.82		0.79	0.46	
Uniform Delay, d1	28.4	34.6		21.4	16.2	
Progression Factor	1.00	1.00		0.35	0.96	
Incremental Delay, d2	0.2	10.0		3.0	0.8	
Delay (s)	28.6	44.6		10.4	16.3	
Level of Service	C	D		B	B	
Approach Delay (s)	36.4			10.4	16.3	
Approach LOS	D			B	B	

Intersection Summary

HCM 2000 Control Delay	19.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	70.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

78: Whites Road & Highway 407 WB Off-ramp

8/18/2015



Lane Group	WBL	WBR	NBT	SBT
Lane Group Flow (vph)	43	10	1311	905
v/c Ratio	0.18	0.09	0.42	0.29
Control Delay	53.2	27.5	3.8	1.9
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	53.2	27.5	3.8	1.9
Queue Length 50th (m)	4.8	0.0	28.1	16.1
Queue Length 95th (m)	10.6	5.9	79.2	22.4
Internal Link Dist (m)	512.5		340.7	420.0
Turn Bay Length (m)		75.0		
Base Capacity (vph)	1620	685	3138	3138
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.03	0.01	0.42	0.29

Intersection Summary

HCM Signalized Intersection Capacity Analysis

78: Whites Road & Highway 407 WB Off-ramp

8/18/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	40	10	1245	0	0	860
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0			5.0
Lane Util. Factor	0.97	0.91	0.95			0.95
Frt	1.00	0.85	1.00			1.00
Flt Protected	0.95	1.00	1.00			1.00
Satd. Flow (prot)	3472	1457	3579			3579
Flt Permitted	0.95	1.00	1.00			1.00
Satd. Flow (perm)	3472	1457	3579			3579
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	42	11	1311	0	0	905
RTOR Reduction (vph)	1	9	0	0	0	0
Lane Group Flow (vph)	42	1	1311	0	0	905
Turn Type	Prot	Perm	NA			NA
Protected Phases	8		2			6
Permitted Phases		8				
Actuated Green, G (s)	6.0	6.0	102.0			102.0
Effective Green, g (s)	7.0	7.0	103.0			103.0
Actuated g/C Ratio	0.06	0.06	0.86			0.86
Clearance Time (s)	6.0	6.0	6.0			6.0
Vehicle Extension (s)	3.0	3.0	3.0			3.0
Lane Grp Cap (vph)	202	84	3071			3071
v/s Ratio Prot	c0.01		c0.37			0.25
v/s Ratio Perm		0.00				
v/c Ratio	0.21	0.01	0.43			0.29
Uniform Delay, d1	53.9	53.2	1.9			1.6
Progression Factor	1.00	1.00	1.82			1.00
Incremental Delay, d2	0.5	0.0	0.3			0.2
Delay (s)	54.4	53.3	3.7			1.9
Level of Service	D	D	A			A
Approach Delay (s)	54.2		3.7			1.9
Approach LOS	D		A			A

Intersection Summary

HCM 2000 Control Delay	4.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	70.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

HCM Unsignalized Intersection Capacity Analysis

83: Whites Road & Station Access RIRO

8/18/2015

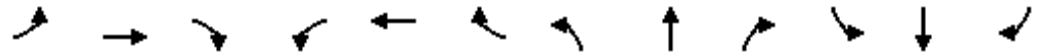


Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations		↗		↑↑	↑↑	↗
Volume (veh/h)	0	20	0	1485	1765	20
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	0	21	0	1563	1858	21
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage (veh)						
Upstream signal (m)				182	185	
pX, platoon unblocked	0.89	0.85	0.85			
vC, conflicting volume	2639	929	1879			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1816	552	1675			
tC, single (s)	8.8	6.9	4.1			
tC, 2 stage (s)						
tF (s)	4.5	3.3	2.2			
p0 queue free %	100	95	100			
cM capacity (veh/h)	21	404	321			
Direction, Lane #	EB 1	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	21	782	782	929	929	21
Volume Left	0	0	0	0	0	0
Volume Right	21	0	0	0	0	21
cSH	404	1700	1700	1700	1700	1700
Volume to Capacity	0.05	0.46	0.46	0.55	0.55	0.01
Queue Length 95th (m)	1.2	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	14.4	0.0	0.0	0.0	0.0	0.0
Lane LOS	B					
Approach Delay (s)	14.4	0.0		0.0		
Approach LOS	B					
Intersection Summary						
Average Delay			0.1			
Intersection Capacity Utilization			58.8%		ICU Level of Service	B
Analysis Period (min)			15			

Queues

85: Whites Road & Station Collector

8/18/2015



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	158	263	105	53	158	53	32	1353	53	53	1747	79
v/c Ratio	0.76	0.68	0.30	0.43	0.41	0.15	0.28	0.53	0.05	0.25	0.69	0.07
Control Delay	65.9	52.5	30.1	50.3	43.2	21.4	31.8	27.8	11.5	8.6	9.9	2.1
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	65.9	52.5	30.1	50.3	43.2	21.4	31.8	27.8	11.5	8.6	9.9	2.1
Queue Length 50th (m)	35.3	57.8	15.5	11.0	32.6	5.0	6.3	166.6	6.0	3.1	119.7	0.6
Queue Length 95th (m)	54.0	77.2	28.1	21.9	47.3	14.2	m11.7	195.5	m11.3	m10.5	137.4	m7.1
Internal Link Dist (m)		275.4			364.0			911.4				158.0
Turn Bay Length (m)	50.0		50.0	50.0		50.0	75.0		50.0	75.0		50.0
Base Capacity (vph)	478	878	761	282	878	761	115	2548	1148	214	2548	1150
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.33	0.30	0.14	0.19	0.18	0.07	0.28	0.53	0.05	0.25	0.69	0.07

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

85: Whites Road & Station Collector

8/18/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	150	250	100	50	150	50	30	1285	50	50	1660	75
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1789	1883	1601	1789	1883	1601	1789	3579	1601	1789	3579	1601
Flt Permitted	0.55	1.00	1.00	0.32	1.00	1.00	0.09	1.00	1.00	0.16	1.00	1.00
Satd. Flow (perm)	1027	1883	1601	607	1883	1601	161	3579	1601	301	3579	1601
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	158	263	105	53	158	53	32	1353	53	53	1747	79
RTOR Reduction (vph)	0	0	21	0	0	21	0	0	9	0	0	10
Lane Group Flow (vph)	158	263	84	53	158	32	32	1353	44	53	1747	69
Turn Type	Perm	NA	Perm	Perm	NA	Perm	Perm	NA	Perm	Perm	NA	Perm
Protected Phases		4			8			2			6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	23.6	23.6	23.6	23.6	23.6	23.6	84.4	84.4	84.4	84.4	84.4	84.4
Effective Green, g (s)	24.6	24.6	24.6	24.6	24.6	24.6	85.4	85.4	85.4	85.4	85.4	85.4
Actuated g/C Ratio	0.21	0.21	0.21	0.21	0.21	0.21	0.71	0.71	0.71	0.71	0.71	0.71
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	210	386	328	124	386	328	114	2547	1139	214	2547	1139
v/s Ratio Prot		0.14			0.08			0.38			c0.49	
v/s Ratio Perm	c0.15		0.05	0.09		0.02	0.20		0.03	0.18		0.04
v/c Ratio	0.75	0.68	0.25	0.43	0.41	0.10	0.28	0.53	0.04	0.25	0.69	0.06
Uniform Delay, d1	44.8	44.1	40.0	41.6	41.4	38.7	6.2	8.0	5.1	6.1	9.7	5.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	2.67	3.02	3.04	0.70	0.77	0.48
Incremental Delay, d2	14.1	4.9	0.4	2.4	0.7	0.1	4.6	0.6	0.0	2.5	1.4	0.1
Delay (s)	58.9	49.0	40.4	43.9	42.1	38.8	21.3	24.8	15.7	6.7	8.9	2.6
Level of Service	E	D	D	D	D	D	C	C	B	A	A	A
Approach Delay (s)		50.3			41.8			24.4			8.6	
Approach LOS		D			D			C			A	

Intersection Summary

HCM 2000 Control Delay	21.6	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.70		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	74.9%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Appendix B – Internal Circulation

WHITES RD STATION

- Vehicle path for buses
- Vehicle paths for passenger cars

SOUTH EMPLOYMENT COLLECTOR

860 PARKING SPACES

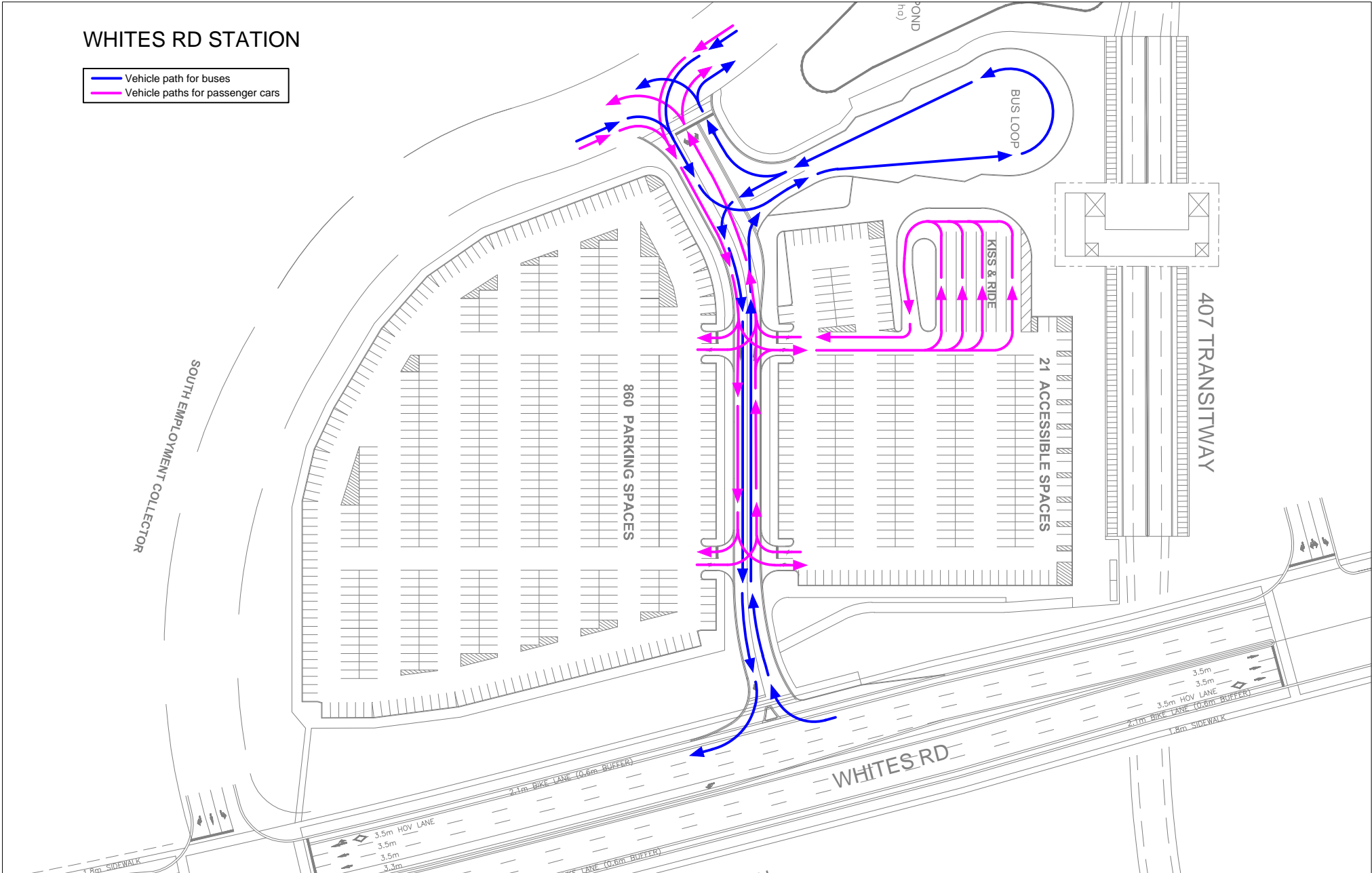
21 ACCESSIBLE SPACES

KISS & RIDE

BUS LOOP

407 TRANSITWAY

WHITES RD



HCM Unsignalized Intersection Capacity Analysis

82: KnR

8/19/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (veh/h)	80	185	175	0	30	0	8	0	0	0	0	80
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	84	195	184	0	32	0	8	0	0	0	0	84
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage (veh)												
Upstream signal (m)		125										
pX, platoon unblocked												
vC, conflicting volume	32			379			571	487	287	487	579	32
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	32			379			571	487	287	487	579	32
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	95			100			98	100	100	100	100	92
cM capacity (veh/h)	1581			1180			381	455	752	471	404	1042

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	463	32	8	84
Volume Left	84	0	8	0
Volume Right	184	0	0	84
cSH	1581	1180	381	1042
Volume to Capacity	0.05	0.00	0.02	0.08
Queue Length 95th (m)	1.3	0.0	0.5	2.0
Control Delay (s)	1.8	0.0	14.7	8.8
Lane LOS	A		B	A
Approach Delay (s)	1.8	0.0	14.7	8.8
Approach LOS			B	A

Intersection Summary			
Average Delay		2.9	
Intersection Capacity Utilization	44.8%		ICU Level of Service
Analysis Period (min)		15	A

Queues

89: Station Collector & Station West Access

8/19/2015



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	84	19	158	400	53	137
v/c Ratio	0.21	0.05	0.24	0.48	0.12	0.11
Control Delay	23.5	10.5	17.0	4.2	2.1	1.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.5	10.5	17.0	4.2	2.1	1.2
Queue Length 50th (m)	8.9	0.0	14.2	0.0	0.4	0.6
Queue Length 95th (m)	19.4	4.6	26.5	15.9	0.9	0.9
Internal Link Dist (m)	32.3		153.2			0.1
Turn Bay Length (m)				50.0		
Base Capacity (vph)	408	380	672	828	441	1210
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.21	0.05	0.24	0.48	0.12	0.11

Intersection Summary

HCM Signalized Intersection Capacity Analysis

89: Station Collector & Station West Access

8/19/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	80	18	150	380	50	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1883
Flt Permitted	0.95	1.00	1.00	1.00	0.66	1.00
Satd. Flow (perm)	1789	1601	1883	1601	1237	1883
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	84	19	158	400	53	137
RTOR Reduction (vph)	0	15	0	257	0	0
Lane Group Flow (vph)	84	4	158	143	53	137
Turn Type	Prot	Perm	NA	Perm	Perm	NA
Protected Phases	8		2			6
Permitted Phases		8		2	6	9
Actuated Green, G (s)	15.0	15.0	24.0	24.0	24.0	39.0
Effective Green, g (s)	16.0	16.0	25.0	25.0	25.0	41.0
Actuated g/C Ratio	0.23	0.23	0.36	0.36	0.36	0.59
Clearance Time (s)	5.0	5.0	6.0	6.0	6.0	6.0
Lane Grp Cap (vph)	408	365	672	571	441	1102
v/s Ratio Prot	c0.05		0.08			c0.04
v/s Ratio Perm		0.00		c0.09	0.04	0.03
v/c Ratio	0.21	0.01	0.24	0.25	0.12	0.12
Uniform Delay, d1	21.9	20.9	15.8	15.9	15.1	6.5
Progression Factor	1.00	1.00	1.00	1.00	0.10	0.21
Incremental Delay, d2	1.1	0.1	0.8	1.0	0.6	0.2
Delay (s)	23.0	20.9	16.6	16.9	2.0	1.6
Level of Service	C	C	B	B	A	A
Approach Delay (s)	22.6		16.8			1.7
Approach LOS	C		B			A

Intersection Summary

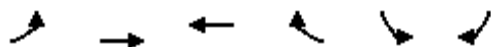
HCM 2000 Control Delay	14.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.21		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	37.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis

91: Station West Access & Bus Loop

8/19/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	10	420	98	20	20	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	11	442	103	21	21	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		56				
pX, platoon unblocked						
vC, conflicting volume	124				577	114
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	124				577	114
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				96	100
cM capacity (veh/h)	1463				475	939

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	453	124	21
Volume Left	11	0	21
Volume Right	0	21	0
cSH	1463	1700	475
Volume to Capacity	0.01	0.07	0.04
Queue Length 95th (m)	0.2	0.0	1.1
Control Delay (s)	0.2	0.0	12.9
Lane LOS	A		B
Approach Delay (s)	0.2	0.0	12.9
Approach LOS			B

Intersection Summary			
Average Delay		0.6	
Intersection Capacity Utilization		39.3%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis
 94: PnR & Station Access RIRO

8/19/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (veh/h)	15	20	150	0	20	0	5	0	0	0	0	5
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	16	21	158	0	21	0	5	0	0	0	0	5
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage (veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	24	13	3	182	16	0	5			0		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	24	13	3	182	16	0	5			0		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	98	98	85	100	98	100	100			100		
cM capacity (veh/h)	967	878	1081	652	876	1085	1616			1623		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	195	21	5	5
Volume Left	16	0	5	0
Volume Right	158	0	0	5
cSH	1045	876	1616	1623
Volume to Capacity	0.19	0.02	0.00	0.00
Queue Length 95th (m)	5.2	0.6	0.1	0.0
Control Delay (s)	9.2	9.2	7.2	0.0
Lane LOS	A	A	A	
Approach Delay (s)	9.2	9.2	7.2	0.0
Approach LOS	A	A		

Intersection Summary			
Average Delay		9.0	
Intersection Capacity Utilization	28.6%		ICU Level of Service
Analysis Period (min)		15	
			A

HCM Unsignalized Intersection Capacity Analysis

82: KnR

8/19/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (veh/h)	55	50	18	0	185	0	123	0	0	0	0	55
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	58	53	19	0	195	0	129	0	0	0	0	58
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage (veh)												
Upstream signal (m)		125										
pX, platoon unblocked												
vC, conflicting volume	195			72			431	373	62	373	382	195
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	195			72			431	373	62	373	382	195
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	96			100			73	100	100	100	100	93
cM capacity (veh/h)	1378			1529			482	534	1003	566	528	847

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	129	195	129	58
Volume Left	58	0	129	0
Volume Right	19	0	0	58
cSH	1378	1529	482	847
Volume to Capacity	0.04	0.00	0.27	0.07
Queue Length 95th (m)	1.0	0.0	8.2	1.7
Control Delay (s)	3.6	0.0	15.2	9.6
Lane LOS	A		C	A
Approach Delay (s)	3.6	0.0	15.2	9.6
Approach LOS			C	A

Intersection Summary			
Average Delay		5.8	
Intersection Capacity Utilization	40.0%		ICU Level of Service
Analysis Period (min)		15	A

Queues

89: Station Collector & Station West Access

8/19/2015



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	316	45	184	84	35	211
v/c Ratio	0.69	0.10	0.30	0.14	0.09	0.18
Control Delay	32.6	7.6	19.2	5.2	3.0	2.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.6	7.6	19.2	5.2	3.0	2.6
Queue Length 50th (m)	37.3	0.0	17.7	0.0	0.3	1.7
Queue Length 95th (m)	#64.9	6.8	32.1	8.2	1.0	2.6
Internal Link Dist (m)	32.3		153.2			0.1
Turn Bay Length (m)				50.0		
Base Capacity (vph)	460	445	618	582	391	1156
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.69	0.10	0.30	0.14	0.09	0.18

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

89: Station Collector & Station West Access

8/19/2015



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	300	43	175	80	33	200
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	0.85	1.00	1.00
Flt Protected	0.95	1.00	1.00	1.00	0.95	1.00
Satd. Flow (prot)	1789	1601	1883	1601	1789	1883
Flt Permitted	0.95	1.00	1.00	1.00	0.63	1.00
Satd. Flow (perm)	1789	1601	1883	1601	1190	1883
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	316	45	184	84	35	211
RTOR Reduction (vph)	0	33	0	56	0	0
Lane Group Flow (vph)	316	12	184	28	35	211
Turn Type	Prot	Perm	NA	Perm	Perm	NA
Protected Phases	8		2			6
Permitted Phases		8		2	6	9
Actuated Green, G (s)	17.0	17.0	22.0	22.0	22.0	37.0
Effective Green, g (s)	18.0	18.0	23.0	23.0	23.0	39.0
Actuated g/C Ratio	0.26	0.26	0.33	0.33	0.33	0.56
Clearance Time (s)	5.0	5.0	6.0	6.0	6.0	6.0
Lane Grp Cap (vph)	460	411	618	526	391	1049
v/s Ratio Prot	c0.18		c0.10			c0.07
v/s Ratio Perm		0.01		0.02	0.03	0.05
v/c Ratio	0.69	0.03	0.30	0.05	0.09	0.20
Uniform Delay, d1	23.5	19.5	17.5	16.1	16.3	7.7
Progression Factor	1.00	1.00	1.00	1.00	0.15	0.38
Incremental Delay, d2	8.1	0.1	1.2	0.2	0.4	0.4
Delay (s)	31.6	19.6	18.7	16.2	2.9	3.3
Level of Service	C	B	B	B	A	A
Approach Delay (s)	30.1		17.9			3.3
Approach LOS	C		B			A

Intersection Summary

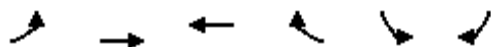
HCM 2000 Control Delay	18.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	43.3%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis

91: Station West Access & Bus Loop

8/19/2015



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	10	103	343	20	20	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	11	108	361	21	21	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage (veh)						
Upstream signal (m)		56				
pX, platoon unblocked						
vC, conflicting volume	382				501	372
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	382				501	372
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				96	100
cM capacity (veh/h)	1176				525	674

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	119	382	21
Volume Left	11	0	21
Volume Right	0	21	0
cSH	1176	1700	525
Volume to Capacity	0.01	0.22	0.04
Queue Length 95th (m)	0.2	0.0	1.0
Control Delay (s)	0.8	0.0	12.1
Lane LOS	A		B
Approach Delay (s)	0.8	0.0	12.1
Approach LOS			B

Intersection Summary			
Average Delay		0.7	
Intersection Capacity Utilization		29.3%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis

94: PnR & Station Access RIRO

8/19/2015



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (veh/h)	5	20	25	0	20	0	150	0	0	0	0	15
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	5	21	26	0	21	0	158	0	0	0	0	16
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	334	324	8	361	332	0	16			0		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	334	324	8	361	332	0	16			0		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	99	96	98	100	96	100	90			100		
cM capacity (veh/h)	556	535	1074	521	530	1085	1602			1623		
Direction, Lane #	EB 1	WB 1	NB 1	SB 1								
Volume Total	53	21	158	16								
Volume Left	5	0	158	0								
Volume Right	26	0	0	16								
cSH	718	530	1602	1623								
Volume to Capacity	0.07	0.04	0.10	0.00								
Queue Length 95th (m)	1.8	0.9	2.5	0.0								
Control Delay (s)	10.4	12.1	7.5	0.0								
Lane LOS	B	B	A									
Approach Delay (s)	10.4	12.1	7.5	0.0								
Approach LOS	B	B										
Intersection Summary												
Average Delay			8.0									
Intersection Capacity Utilization			28.7%		ICU Level of Service					A		
Analysis Period (min)			15									

Report

Brock Road Station Traffic Study



Prepared for Ministry of Transportation, Ontario
by IBI Group

December 20, 2016

Document Control Page

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1 Introduction

The proposed Brock Road Highway 407 Transitway Station is a new transit station in the City of Pickering, in the Regional Municipality of Durham. The station site is located at the southwest corner of the interchange of Brock Road and Highway 407.

This study analyzes the potential traffic impacts of the proposed station on the surrounding road network. Due to the major road network changes in the vicinity of the proposed station (described in Section 2), the performance of the road network is assessed for the future horizon year of 2031 only. Traffic analysis includes station access and adjacent street network to determine any operational deficiencies. In addition, this memo documents the impact of station volumes onto Brock Road due to the park and ride facility at the proposed station.

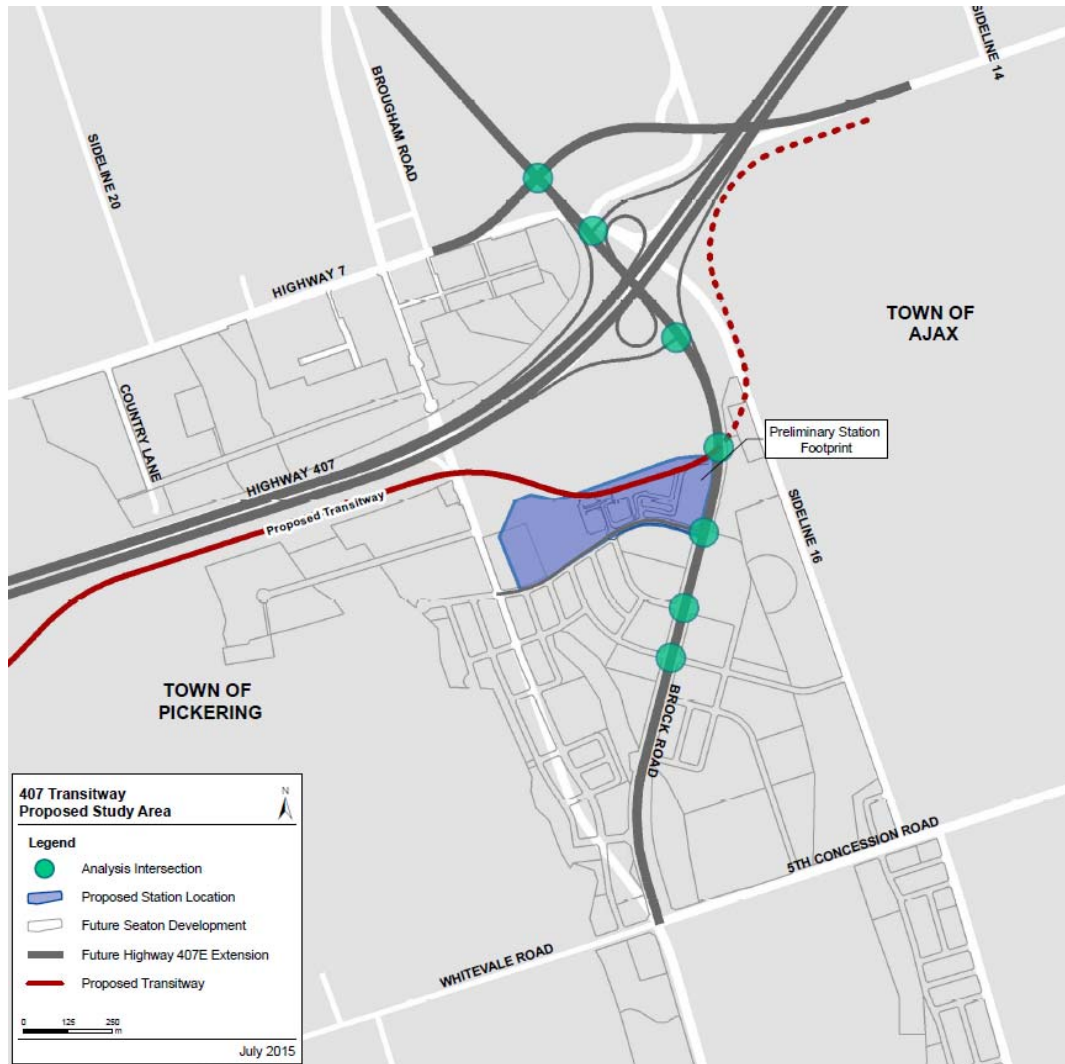
1.1 Study Area

The study area was confirmed with the Ministry of Transportation, Ontario staff and includes the following intersections:

- Highway 7 at Brock Road;
- Highway 407 Westbound Off-Ramp at Brock Road
- Highway 407 Eastbound Off-Ramp at Brock Road;
- Station Access (Bus Only) at Brock Road (unsignalized);
- East-West Residential Collector 2/Station Access (Bus and Regular Traffic);
- Street 20I at Brock Road (unsignalized); and
- Street 20H at Brock Road.

The above intersections are future new intersections according to the Highway 407 East Extension and Seaton Development studies (described in Section 2). The layout of these new intersections is shown in Exhibit 1-1, and the detailed lane configurations are included in Section 2.

Exhibit 1-1: Study Area Map



1.2 Study Objective

The objective of the traffic analysis for Brock Road Station is to support the planning and preliminary design of the Transitway by identifying problems in the road network, providing needs and justification, and evaluating solutions.

Section 2 provides a brief description of the existing road network and the major changes of road networks that are underway and/or planned in the study area.

Section 3 discusses the traffic volume projections of 2031 station traffic. It also includes the trip assignment of site generated trips.

Section 4 provides the projection of future background and future total traffic volume, and summarizes the operational performance analysis results for future background condition and future total condition.

Section 5 provides the internal circulation analysis.

Section 6 suggests improvements and/or road network needs that would improve future operating conditions.

2 Existing and Future Road Network

2.1 Major Road Network

Brock Road is a north-south arterial road under the jurisdiction of Durham Region. The existing Brock Road within the study area is a three-lane section (northbound two lanes and southbound one lane) regional road, which will be currently being realigned in the vicinity of Highway 407 to accommodate the build of a full interchange. Brock Road is also being upgraded to a four-lane cross-section. With the development of the Seaton Community, further upgrade of the Brock Road to a six-lane cross-section connecting Highway 7 (and beyond) to the north with Highway 401 to the south is planned for the long term, and two of the six lanes are intended to be designated either as High Occupancy Vehicle (HOV) lanes or potentially as dedicated Bus Rapid Transit (BRT) lanes in the centre median.

Highway 7 within the study area is currently under the jurisdiction of the Ministry of Transportation, but is anticipated to be transferred to the Region of Durham in due course and function as a Type A arterial road. The widening of Highway 7 from a two-lane cross-section to a four-lane cross-section is underway from Pickering to Highway 12. The build of the Highway 407 and Brock Road interchange requires a realignment of Highway 7 at Brock Road.

Highway 407 is a tolled 400-series highway that presently consists of a four-lane cross-section and terminates at Brock Road (controlled by traffic signal). The extension of Highway 407 to the east is underway, and it will terminate at Highway 35 in Clarington. A full interchange will be built at Highway 407 and Brock Road, and Highway 407 will be widened to a six-lane cross-section.

In addition to the above existing roads that will be realigned and/or reconfigured in near future, several new roads will be built according to the future development plan in the vicinity of the study area as shown in Exhibit 1-1.

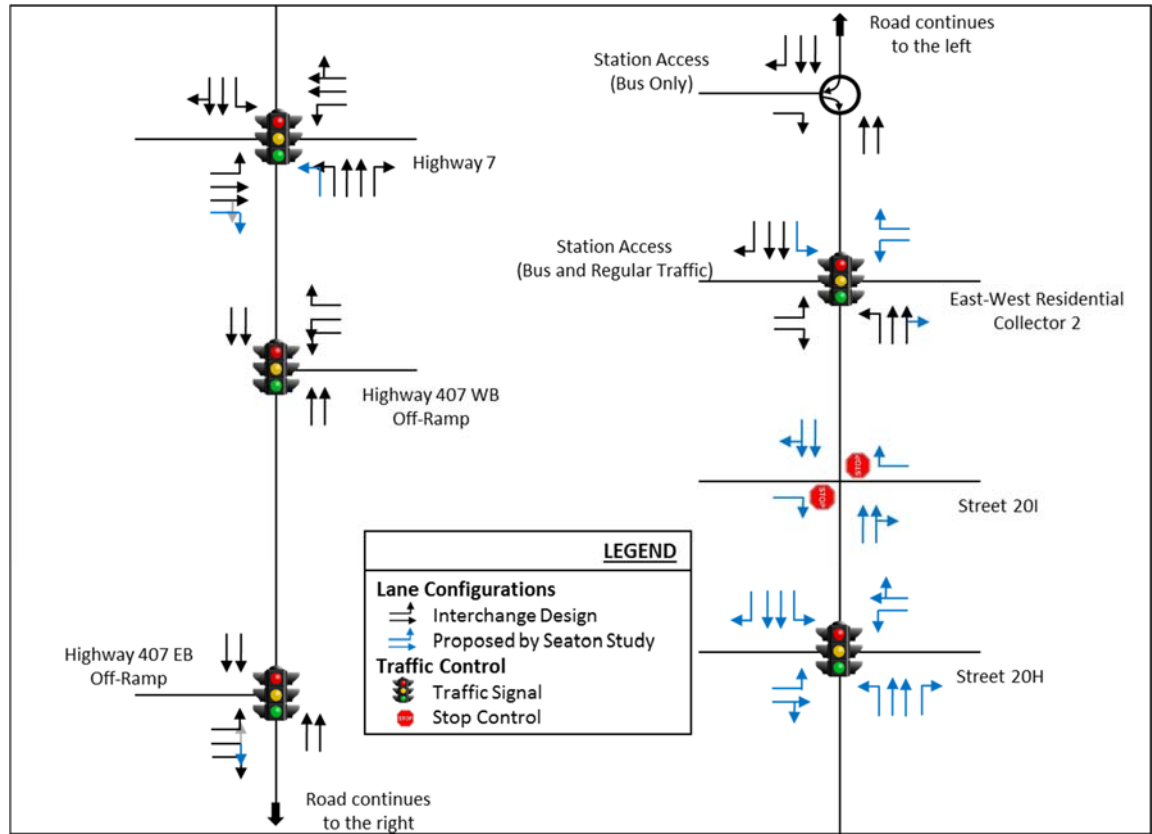
Future Background Lane Configurations

The future background (2031) lane configuration was developed based on the review of the road network designs and transportation studies including:

- *Highway 407 East, Brock Road Interchange Design and Construction (2013) – “Interchange Design”*
- *Seaton Transportation Operations Review (2013) - “Seaton Study”*
- *Brock Road Commuter Parking Lot Detail Design (2014) - “CPL Design”*

Exhibit 2-1 is a simplified representation of the intersection lane configurations that combines the information from the above mentioned projects.

Exhibit 2-1: Future Background Lane Configurations



2.2 Transit Access

Durham Regional Transit (DRT) currently does not provide transit services within the study area. The only transit service that is currently in operation within the study area is 407 East Go Bus provided by Metrolinx.

Exhibit 2-2 illustrates the 407 East Go Bus route map, in which the route 51B runs along Brock Road connects the Pickering GO station to the York University.

Exhibit 2-2: 407 East Go Bus Map



3 Site Traffic

This section provides the methodology and process used to generate and distribute site-generated traffic from the proposed station.

3.1 Station Demand Forecasts

Station demand forecasts were developed based on the Greater Golden Horseshoe (GGH) model scenarios for the 407 Transitway East study. There are two scenarios, a.m. and p.m., each based on the projected 2031 population and employment in the GGH area. For the purposes of this study, demand adjustments were undertaken to better calibrate the transit travel patterns in the east portion of the 407 Transitway between Kennedy Road and Brock Road. Model results for each station include peak period demand in three access categories: park-and-ride (PnR), walk/transit, and interline. See Exhibit 3-1 for the station travel demand forecasts.

ITE Trip Generation Manual (8th edition) provides inbound and outbound peak hour trip rates for transit stations with park and ride service (code #90), based on the number of parking spaces provided. In order to develop the number of parking spaces required at each station, 2011 TTS data at existing GO transit stations were analyzed. The average ratio between a.m. peak period auto driver demand and the number of parking spaces provided at these stations were found to be 0.75. See Exhibit 3-2 for the list of GO stations and their parking provision rates.

The ratio found above was applied to the 407 Transitway East stations to develop the number of parking spaces needed, with the assumption that auto driver demand is equal to park-and-ride demand.

See Exhibit 3-3 for the proposed number of parking spaces at each station.

Exhibit 3-1: GGH Model Results – 2031 AM Peak Period Transitway Station Demand

Station	2031 AM Peak Period Travel Adjusted			
	PnR	Walk/Transit	Interline	Total
Brock Road	450	30	1,690	2,170
Whites Road	540	40	1,480	2,060
Donald Cousens Parkway	383	127	0	510
9th Line	503	167	0	670
Markham Road	608	102	100	810

Exhibit 3-2: TTS Data – 2011 AM Peak Period GO Station Demand and Parking Supply

2011 TTS AM Peak Period Travel		Station Parking	
GO Station (Rural)	Auto Driver*	Spaces	% Provision
Stouffville	220	243	91%
Aurora	1,010	1,463	69%
Newmarket	260	265	98%
Milton	1,330	1,544	86%
Georgetown	400	614	65%
Mount Pleasant	830	1,112	75%
Total Rural	4,050	5,241	77%
GO Station (Durham)	Auto Driver	Spaces	% Provision
Oshawa	1,620	2,380	68%
Whitby	2,200	2,958	74%
Ajax	1,730	2,148	81%
Pickering	1,850	2,508	74%
Total Durham	7,400	9,994	74%
Total	11,450	15,235	75%

* Rounded to nearest 10

Exhibit 3-3: Station Parking Space Calculation

Station	PnR Demand	Parking Spaces
Brock Road	450	600
Whites Road	540	720
Donald Cousens Parkway	383	511
9th Line	503	671
Markham Road	608	810
Kennedy Road	820	1,093

3.2 Trip Generation

Trip generations rates were based on the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th Edition. Land use code 90 (Park and Ride Lot for Bus Service) was used to determine the number of auto trips in to and out of the station based on the number of spaces in the station parking lot. The number of parking spaces was estimated based on projected ridership.

The proposed station is designed to have two accesses to Brock Road between the intersections with Highway 407 EB off-ramp and Street 20I; One of the accesses is a transit bus only access with Right in/Right out lane configuration, and the other is an access for mixed traffic (i.e. bus and regular traffic) that is controlled by signal. There are other accesses designed to be used by local traffic with short distance and walking trips that are not considered in this trip generation model. The following trip generation are quite conservative, as they are auto trips and assumed all generated from Brock Road. The forecasts were based on auto trip demand, considering only longer distance trips for park and ride users that won't come from the local area.

Estimated transit ridership is approximately 600 riders in the a.m. peak period, with 450 (75%) using the park and ride (PnR) services. Based on similar other stations, it is assumed that an additional 25% provision of parking would be provided by 2031, thus a parking lot size of 600 spaces was assumed for trip generation purposes.

The trip generation rates and resultant traffic volumes projected for 2031 are shown in Exhibit 3-4.

Exhibit 3-4: Trip Generation Summary

Brock Road Station Traffic Volumes						
ITE Land Use Code 90	Total	Entering	Exiting	Total	Entering	Exiting
	AM			PM		
Rates: Trips per Parking Space	0.72	0.81	0.19	0.62	0.23	0.77
# of Trips	432	350	82	372	86	286

3.3 Trip Assignment

Station traffic trip assignment was estimated based on former study for the “CPL Design” completed in 2014. The distribution utilized was approximately:

- 80% to and 40% from the north, 20% to and 60% from the south during AM peak;
- 40% to and 80% from the north, 60% to and 20% from the south during PM peak.

Exhibit 3-5 shows the trip assignment percentages for AM (PM) peak hour. Exhibit 3-6 shows the site-generated volumes in the AM (PM) peak hour.

Exhibit 3-5: Site Trip Assignment Percentages

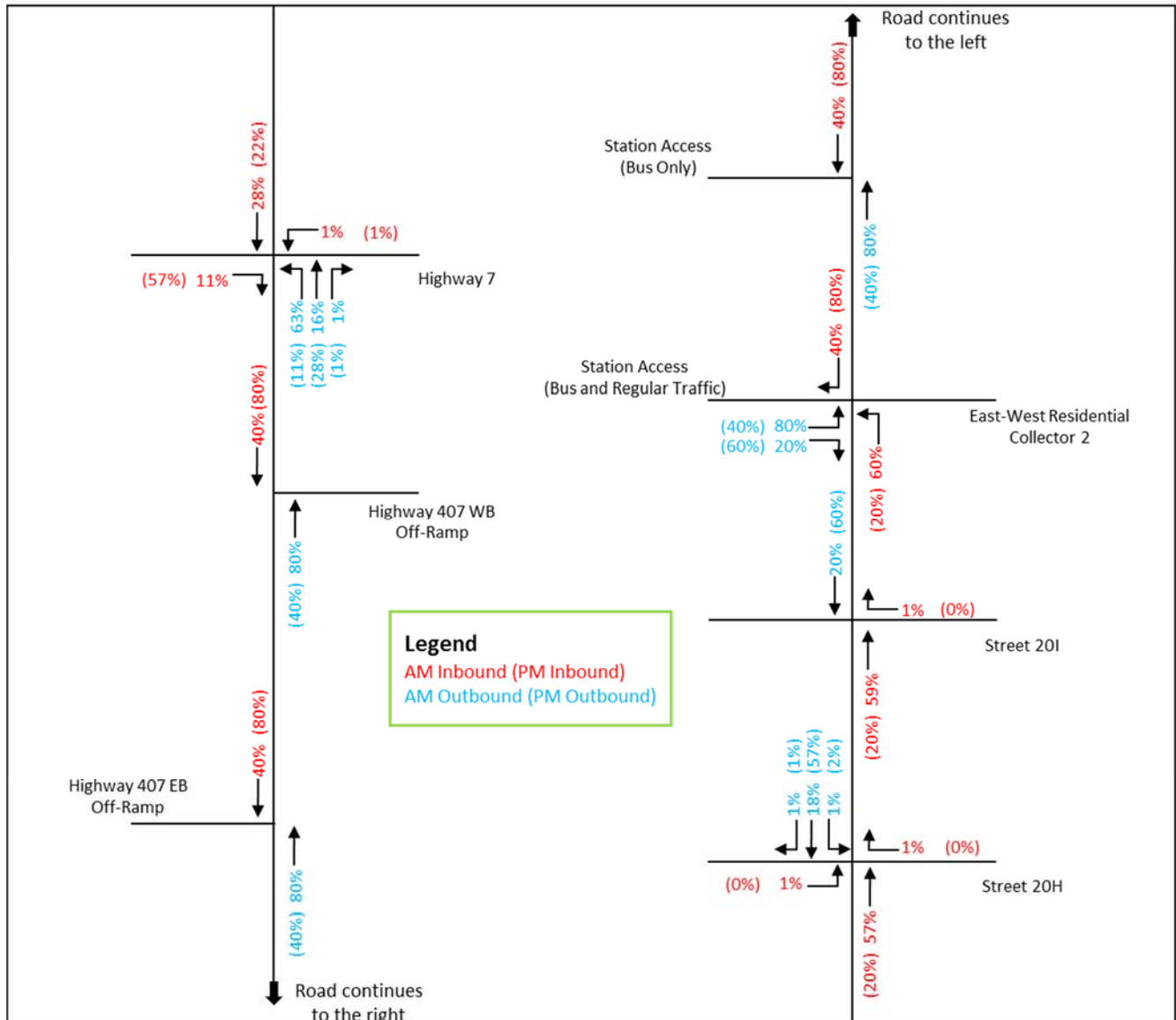
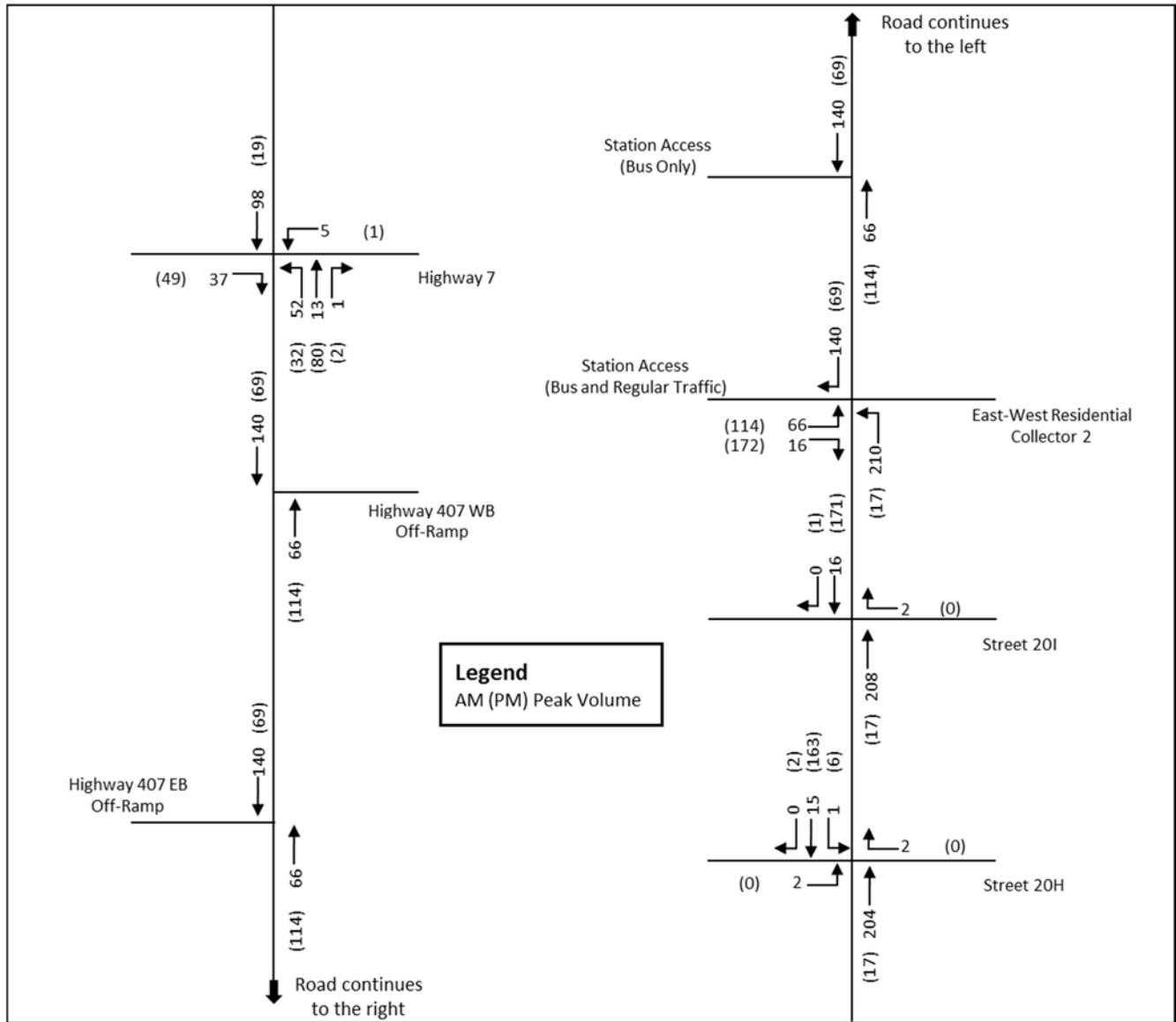


Exhibit 3-6: Site-generated Volumes in the AM (PM) Peak Hour



4 Future Conditions

4.1 Background Operations

The future horizon year of 2031 was analyzed in accordance with overall Transitway phasing strategy. All future conditions analysis scenarios include signal timing optimization based on an assumption that the intersection’s cycle length is 120 seconds.

Background traffic volumes were estimated based on information from the “Seaton Study” and “CPL Design”, and the volume forecasts from the “Seaton Study” were used for the horizon year of 2031, according to the “Master Environmental Servicing Plan Amendment (MESPA) for Seaton Community” completed at 2013. The forecasts account for the key shift in travel patterns that is caused by the Highway 407 east expansion and the traffic volumes growth that is mainly generated by the surrounding developments.

According to the “Seaton Study”, “the use of Taunton Road as a through highway will diminish due to a combination of ‘crowding out’ of cross-regional trips by more local traffic together with a very viable alternative (Highway 407) to the north. Highway 407 will, in effect, replace Taunton Road as the key east-west connector in north Durham Region.”

The 2031 background volume (without site-generated traffic) is shown in Exhibit 4-2.

Intersection operations analysis was conducted using Synchro 8, which utilizes the Highway Capacity Manual (HCM) 2000 methodology to evaluate overall intersection and individual movement performances. The level-of-service (LOS) is a measure of performance based on the control delay, defined as follows in Exhibit 4-1.

Exhibit 4-1: Intersection LOS Reference

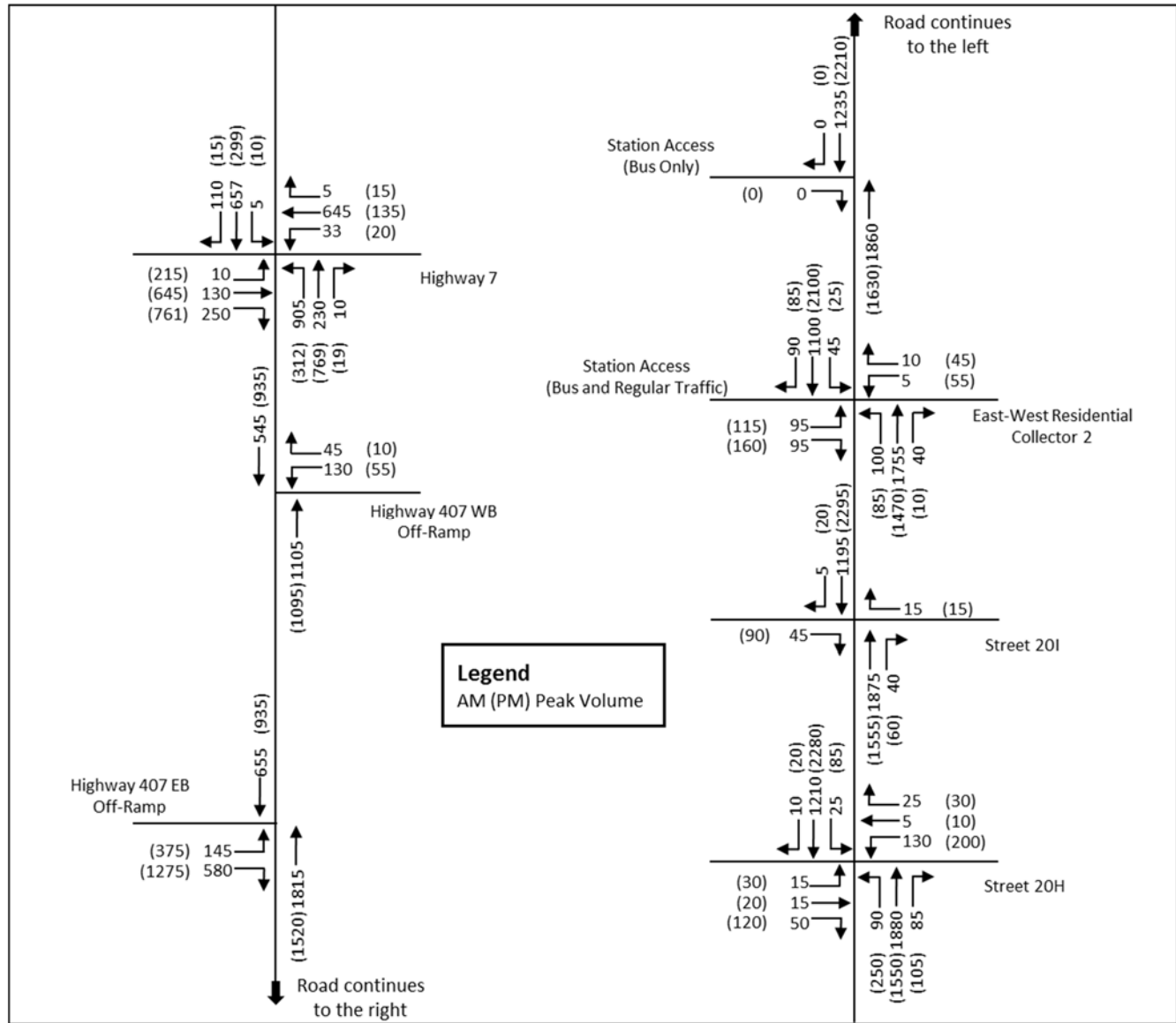
HCM LOS	Control Delay per Vehicle (s)	
	Signalized	Unsignalized
A	≤10	≤10
B	>10 and ≤20	>10 and ≤15
C	>20 and ≤35	>15 and ≤25
D	>35 and ≤55	>25 and ≤35
E	>55 and ≤80	>35 and ≤50
F	>80	>50

Critical movements were identified by satisfying any one or more of the following criteria:

- Control delay of LOS E or worse;
- 95th percentile queue exceeding provided storage/link length; and
- Volume-to-capacity (v/c) ratio of 0.85 or greater.

A summary of the Synchro analysis including delay, 95th percentile queue, and level-of-service (LOS) indicators is shown in Exhibit 4-3 with detailed output provided in Appendix A.

Exhibit 4-2: Future 2031 Background Volumes in the AM (PM) Peak Hour



Highway 7 at Brock Road: Intersection operates at LOS D in a.m. peak hour and LOS C in p.m. peak hour. In the a.m. peak hour, the northbound left turn movement operates at LOS D with V/C ratio 0.88, and the associated queue length may exceed the available storage length and block upstream intersection.

Highway 407 Eastbound Off-Ramp at Brock Road: Intersection operates at LOS B and LOS D in the a.m. peak hour and p.m. peak hour respectively. In the p.m. peak hour, the eastbound right turn movement experiences high delay with LOS F, the demand is over capacity (i.e. V/C ratio > 1). The northbound through movement shows large V/C ratio with the demand reach to capacity.

East-West Residential Collector 2 at Brock Road: Intersection operates at LOS B in both a.m. peak hour and p.m. peak hour. In the p.m. peak hour, southbound through movement sees large

V/C ratio and long queue length which may exceed the link length and block upstream intersection.

Street 20H at Brock Road: Intersection operates at LOS B in the a.m. peak hour and LOS F in the p.m. peak hour. In the p.m. peak hour, the westbound left turn, northbound left turn and southbound through movements all experience high delay with LOS F. The demands are over capacity for these critical movements, and the queue lengths may exceed the available storage length or the link length consequently block upstream intersection.

No issues are experienced at the Highway 407 Westbound Off-Ramp at Brock Road, and the two un-signalized intersections of Station Access (Bus Only) at Brock Road and Street 20I at Brock Road.

Exhibit 4-3: Future 2031 Background Conditions Intersection Operational Performance Summary

Intersection	AM					PM				
	Overall LOS	Critical				Overall LOS	Critical			
		Mvmt	LOS	V/C	95th Queue (m)		Mvmt	LOS	V/C	95th Queue (m)
Highway 7 at Brock Road	D	NBL	D	0.88	140>	C				
Highway 407 WB Off-Ramp at Brock Road	A					A				
Highway 407 EB Off-Ramp at Brock Road	B					D	EBR	F	1.08	#256
							NBT	D	0.99	#265
Station Access (Bus Only) at Brock Road	A					C				
E-W Residential Collector 2 at Brock Road	B					B	SBT	C	0.93	#342>
Street 20I at Brock Road	A					D				
Street 20H at Brock Road	B					F	WBL	F	1.4	#112>*
							NBL	F	1.28	#121>*
							SBT	F	1.19	#419>

> Queue exceeds provided storage/link length

95 percentile volume exceeds capacity, queue may be longer

* Turn storage length is defined based on Durham Region design guideline with minimum storage length

4.2 Total Operations

The future (2031) total operations analysis is summarized in this section. Intersection volumes were determined by adding the site-generated volumes from Section 3.3 to the 2031 background volumes from Section 4.1.

All future conditions analysis scenarios include signal timing optimization based on an assumption that the intersection's cycle length is 120 seconds.

Highway 7 at Brock Road: Intersection operates at LOS D in a.m. peak hour and LOS C in p.m. peak hour. In the a.m. peak hour, the southbound through, northbound left turn and westbound through movements operate at LOS D, LOS D and LOS E respectively with V/C ratios reach to capacity. The northbound left turn queue length may exceed the available storage length and block upstream intersection. In the p.m. peak hour, the eastbound right turn

movement sees a large V/C ratio. The site-generated trips are assigned to the northbound left turn, southbound through and eastbound right turn movements, for which the operations deteriorate.

Highway 407 Eastbound Off-Ramp at Brock Road: Site generated traffic are assigned to the northbound and southbound through movements, which operates well in the a.m. peak hour. In the p.m. peak hour, the overall intersection LOS deteriorate from LOS D to LOS E, the northbound through movement shows a higher V/C ratio and longer queue length, and the LOS deteriorate from LOS D to LOS E.

East-West Residential Collector 2 at Brock Road: Intersection operations deteriorate from LOS B to LOS D in the p.m. peak hour due to site generated traffic. Southbound through movement sees an increase in delay and V/C ratio becomes over 1. The eastbound right turn movement for site-generated traffic exiting the station experiences high delay with LOS E and queue length may exceed the available storage length in the p.m. peak hour.

Street 20I at Brock Road: Site generated traffic are primarily assigned to northbound through movement in the a.m. peak hour and southbound through movement in the p.m. peak hour. In the a.m. peak hour the northbound through movement operation deteriorate with demand reach to capacity due to site generated traffic.

Street 20H at Brock Road: Site generated traffic are primarily assigned to northbound through movement in the a.m. peak hour and southbound through movement in the p.m. peak hour. In the a.m. peak hour, intersection operates well. In the p.m. peak hour the overall intersection LOS remains the same as future background condition with the critical movements operations deteriorate in certain level.

No issues are experienced at the Highway 407 Westbound Off-Ramp at Brock Road, and the un-signalized intersection of Station Access (Bus Only) at Brock Road.

See Exhibit 4-4 for the intersection volumes and Exhibit 4-5 for the summary of intersection operational performance analysis.

Exhibit 4-4: Future 2031 Total Volumes in the AM (PM) Peak Hour

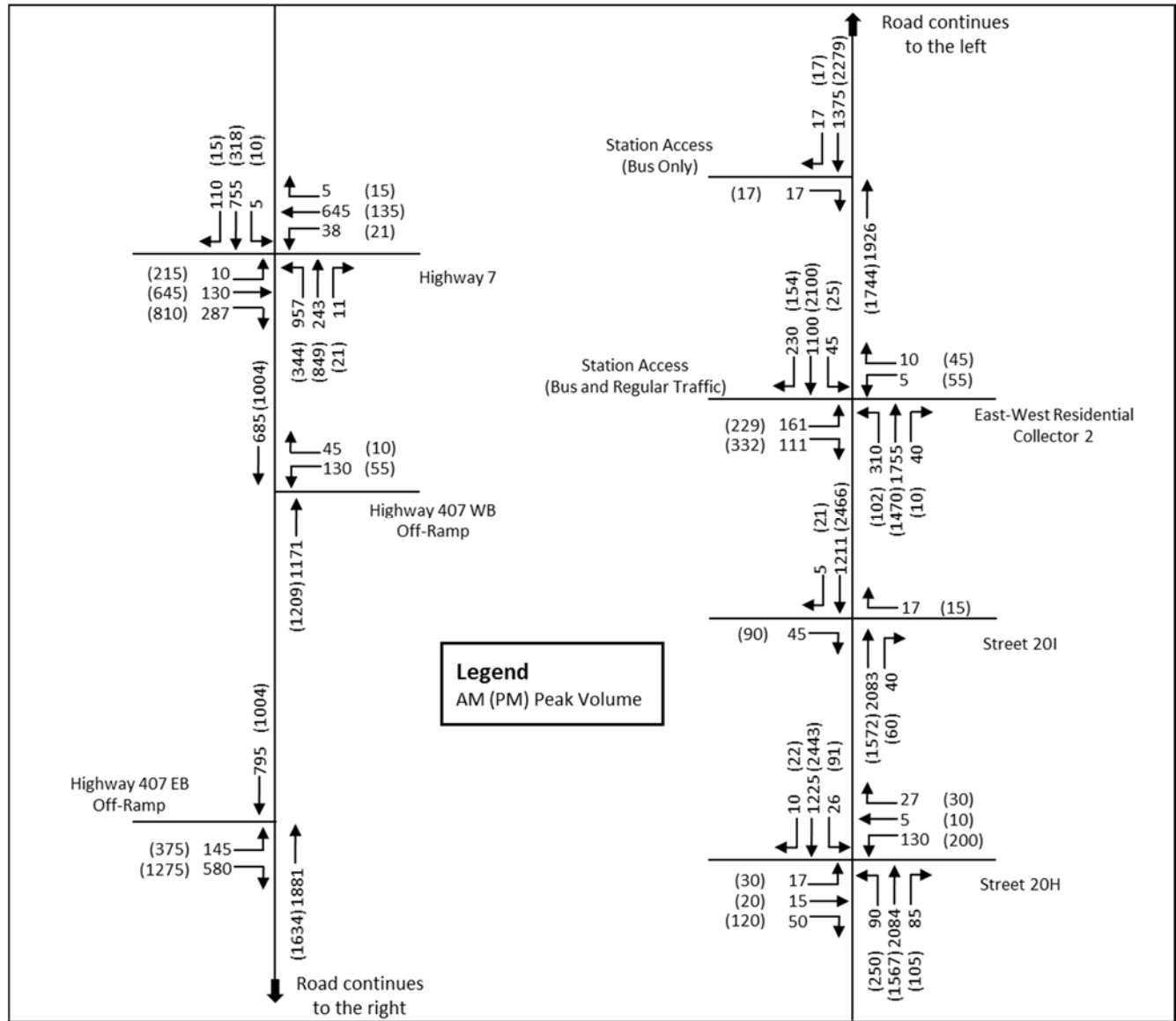


Exhibit 4-5: Future 2031 Total Intersection Operational Performance Summary

Intersection	AM					PM				
	Overall LOS	Critical				Overall LOS	Critical			
		Mvmt	LOS	V/C	95th Queue (m)		Mvmt	LOS	V/C	95th Queue (m)
Highway 7 at Brock Road	D	SBT	D	0.88	#156	C	EBR	C	0.86	163
		NBL	D	0.93	#166>					
		WBT	E	0.92	#125					
Highway 407 WB Off-Ramp at Brock Road	A					A				
Highway 407 EB Off-Ramp at Brock Road	B					E	EBR	F	1.12	#265
							NBT	E	1.02	#291
Station Access (Bus Only) at Brock Road	B					C				
E-W Residential Collector 2 at Brock Road	B					D	EBR	E	0.93	109>
							SBT	D	1.04	#384>
Street 20I at Brock Road	A	NBT	A	0.89	0	D				
Street 20H at Brock Road	B	NBT	B	0.91	#307>	F	WBL	F	1.47	#114>*
							NBL	F	1.28	#119>*
							SBT	F	1.26	#457>

> Queue exceeds provided storage/link length

95 percentile volume exceeds capacity, queue may be longer

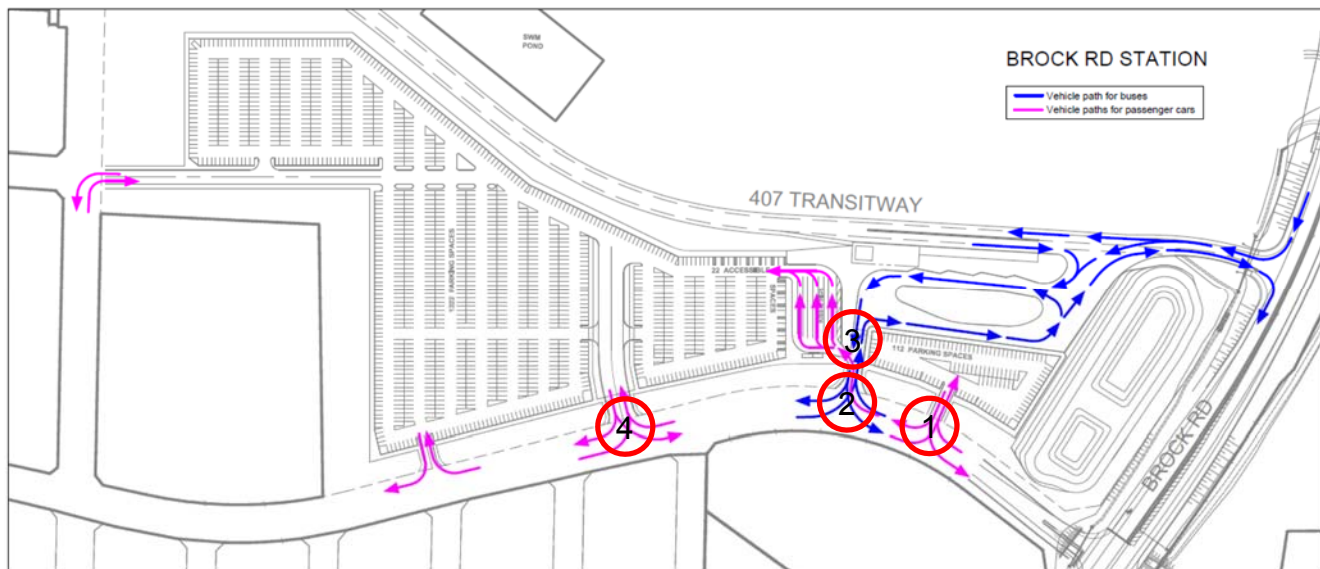
* Turn storage length is defined based on Durham Region design guideline with minimum storage length

5 Internal Circulation

This section provides an overview of the proposed station's internal circulation design, with vehicle composition and flow derived from the site-generated trips in Section 3. The intersection with high numbers of potential vehicle volumes (and/or conflicting movements) are analyzed as unsignalized intersections in Synchro, within the a.m. and p.m. peak hours.

The proposed internal circulation plan is shown below in Exhibit 5-1. Note that the plan is intended to illustrate the internal flow of vehicles (pink) and buses (blue), and that site details such as number of parking spaces and dimensions are subject to revisions. Analysis intersections are intersection #2 and intersection #4 circled in red. The intersection #1 and #4 are similar in terms of geometry and movement conflicts, so analysis is completed for the higher volume intersection (#4). Intersection #3 is not analyzed as the conflicting volumes are not excessive.

Exhibit 5-1: Internal Circulation Plan – Brock Road Station



The station internal volumes consist of:

- Passenger vehicles: AM: 350 in, 82 out; PM: 86 in, 286 out; and
- Buses (based on the following assumptions): AM: 34 in, 34 out; PM: 34 in, 34 out.

Buses assumptions:

- Interline = number of transit passengers in the peak period
- 0.5 factor for 3hr peak period -> peak hour (conservative estimate)
- 1 bus per 25 peak hour transit passengers
- 50/50 split between buses from/to the north and the south

For simplicity, all outbound vehicles in the AM and inbound vehicles in the PM are assumed to be associated with drop-off and pick-up activities ("Kiss-and-Ride", abbreviated KnR). The remainder is assumed to be Park-and-Ride (PnR) vehicles, inbound in the AM and outbound in the PM. All lane configurations are modelled as one shared lane, and all buses are modelled as heavy vehicles in Synchro.

Background volumes were added to the eastbound and westbound through movements at the analysis intersections. Developments to the west of the station is estimated to generate approximately 450 peak hour trips in each a.m. and p.m. peak hours, with a roughly 40/60 directional split (higher westbound in the a.m., higher eastbound in the p.m.).

Analysis results show that there are no operational issues at the analyzed internal intersections for both peak hour operations. The east-west movement is analyzed as freeflow movements, which incurs no delay, and the southbound movement is analyzed as a stop-controlled movement, which operates at LOS C in both a.m. and p.m. peak hour at both intersections. The southbound movement at intersection #4 during p.m. peak hour shows the 95th queue length is about 28 meters, therefore it is recommended that the internal driveway is designed at least 30 meters away from the parking lot access.

Results are summarized in Exhibit 5-2 below.

Exhibit 5-2: Internal Circulation Analysis – Brock Road Station

Internal			AM Peak Hour			PM Peak Hour		
Intersection	Mvmt.	Description	Volume	LOS	Queue (95 th ,m)	Volume	LOS	Queue (95 th ,m)
#2	EBL	Bus in	5	A	0	5	A	0
	EBT	KnR out + PnR out + Background	272	A	0	545	A	0
	WBR	Bus in + KnR in	99	A	0	103	A	0
	WBT	PnR in + Background	437	A	0	170	A	0
	SBL	Bus out	17	C	2.4	17	C	2.3
	SBR	Bus out	5	C	2.4	5	C	2.3
#4	EBL	PnR in	25	A	0	0	-	-
	EBT	Background	190	A	0	275	A	0
	WBR	PnR in	173	A	0	0	-	-
	WBT	PnR in + Background	264	A	0	170	A	0
	SBL	KnR out + PnR out	82	C	6.2	270	C	27.5
	SBR	PnR out	0	-	-	18	C	27.5

6 Mitigation Measures

As described previously, widening Brock Road to be a six-lane cross-section is under consideration, with two lanes designated either as High Occupancy Vehicle (HOV) lanes or dedicated Bus Rapid Transit (BRT) lanes in the centre median. For the purpose of this study, the following scenarios are analyzed:

- Scenario with the road curb lanes of Brock Road assumed to be HOV lanes;
- Scenario with the two additional lanes assumed to be general purpose lanes;

The use of the HOV lanes by multi-occupant vehicles would be restricted, therefore we have assumed 10% of the through traffic on the Brock Road would be multi-occupant, and these traffic volumes would be “shifted” to the HOV lanes.

Roundabouts were considered at all seven analysis intersections along Brock Road. It was determined that due to the ultimate plan for three traffic lanes per direction, roundabouts are not suitable along Brock Road at any of the analysis intersections.

Scenario with HOV Lanes

See Exhibit 6-1 for the recommended lane configurations with HOV lanes on the Brock Road. Exhibit 6-2 shows the traffic volumes reduced from the regular lanes (i.e. “shifted” to the HOV lanes).

Exhibit 6-1: Future Recommended Lane configurations with HOV lanes

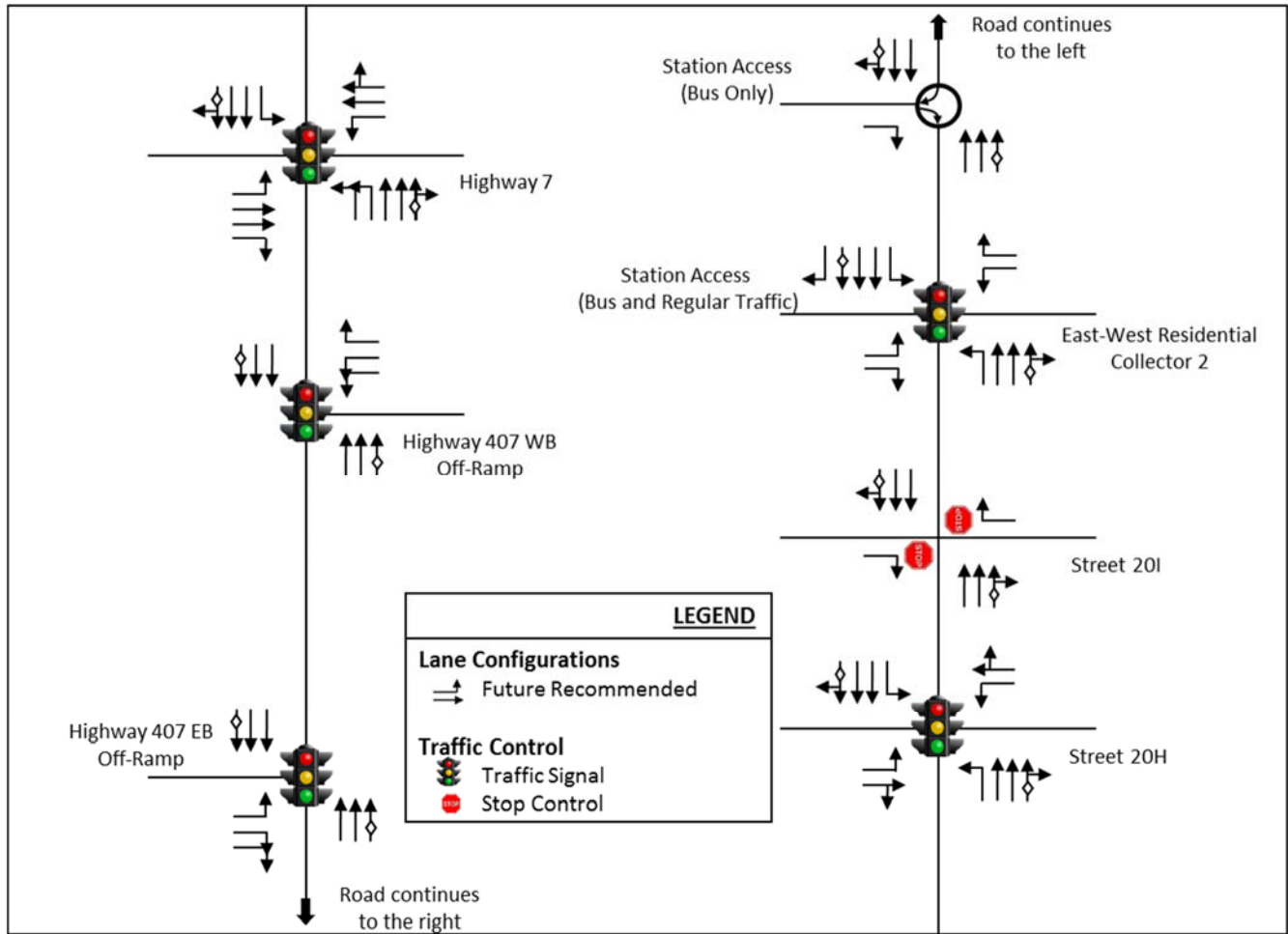
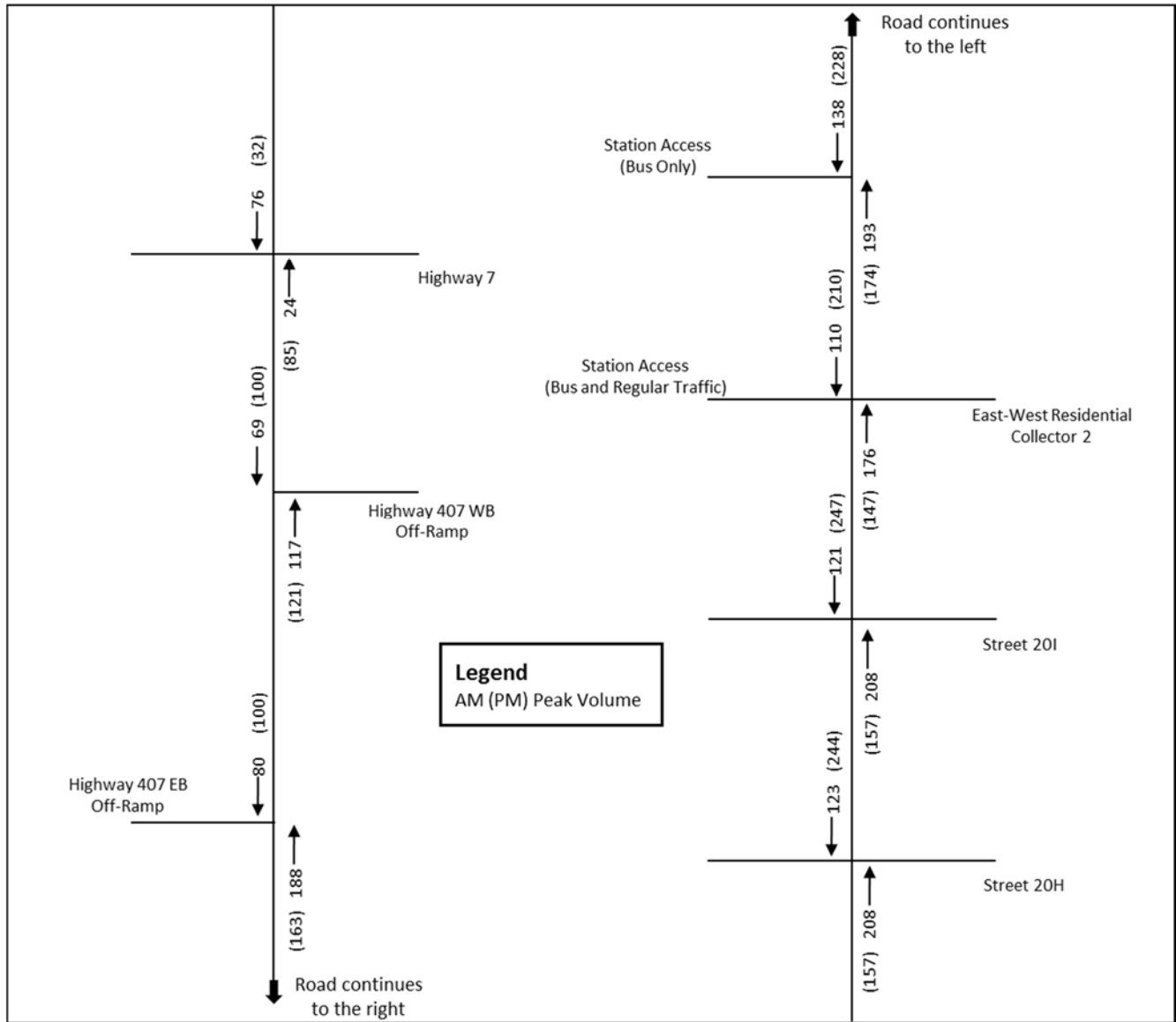


Exhibit 6-2: "Shifted" Traffic Volumes to the HOV lanes (10%)



The scenarios analysis include signal timing optimization based on an assumption that the intersection's cycle length is 120 seconds.

See Exhibit 6-3 for the summary of intersection operational performance analysis.

Exhibit 6-3: Future 2031 Total (with HOV lanes) Intersection Operational Performance Summary

Intersection	AM					PM				
	Overall LOS	Critical				Overall LOS	Critical			
		Mvmt	LOS	V/C	95th Queue (m)		Mvmt	LOS	V/C	95th Queue (m)
Highway 7 at Brock Road	D	NBL	D	0.85	136>	C	EBR	C	0.86	156
Highway 407 WB Off-Ramp at Brock Road	A					A				
Highway 407 EB Off-Ramp at Brock Road	B					D	EBR	F	1.08	#256
							NBT	D	0.99	#259
Station Access (Bus Only) at Brock Road	B					A				
E-W Residential Collector 2 at Brock Road	B					C	EBR	E	0.85	#104>
							SBT	D	0.98	#331>
Street 20I at Brock Road	A					A				
Street 20H at Brock Road	B					E	WBL	F	1.19	#89
							NBL	F	1.27	#118>*
							SBT	F	1.17	#392>

> Queue exceeds provided storage/link length

95 percentile volume exceeds capacity, queue may be longer

* Turn storage length is defined based on Durham Region design guideline with minimum storage length

Highway 7 at Brock Road: The overall intersection LOS remains the same as future total without HOV lanes condition. In the a.m. peak hour, the operational performance of the critical movements identified previously are improved, but northbound left turn movement still sees large V/C ratio and long queue length which may exceed the available storage length and block upstream intersection. In the p.m. peak hour, the queue length of the eastbound right turn movement is improved, but LOS remains the same as future total with HOV lanes condition.

Highway 407 Eastbound Off-Ramp at Brock Road: The overall intersection LOS is improved, the operational performance of the critical movements identified previously are improved as well, but still the eastbound right turn and northbound through movements show large V/C ratio in the p.m. peak hour.

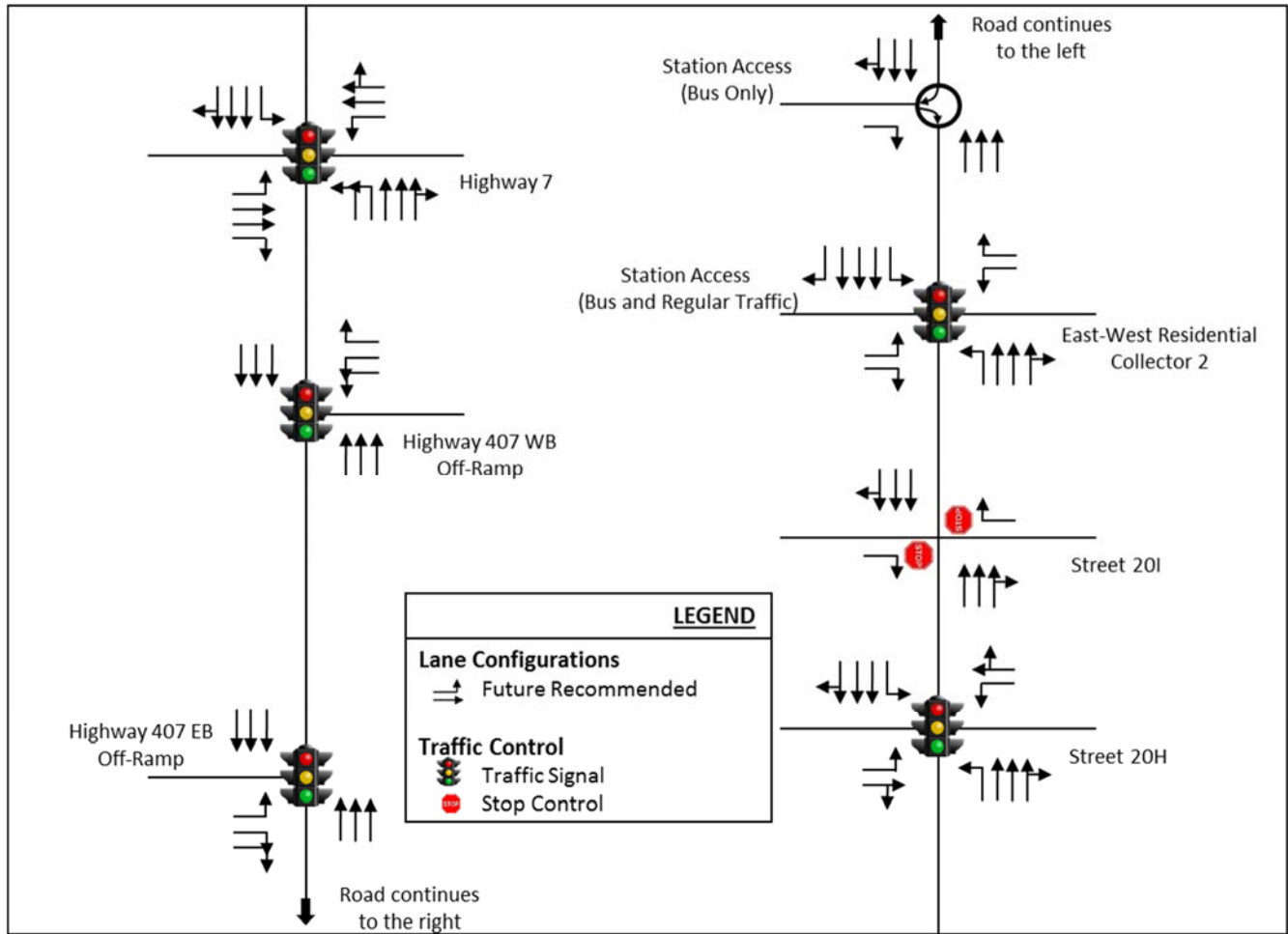
East-West Residential Collector 2 at Brock Road: The overall intersection LOS is improved, the operational performance of the critical movements identified previously are improved as well regarding to the V/C ratio and queue length, but they are still critical with large V/C ratio and long queue length which may exceed the available storage length and block upstream intersection in the p.m. peak hour.

Street 20H at Brock Road: The overall intersection LOS is improved, the operational performance of the critical movements identified previously are improved as well regarding to the V/C ratio and queue length, but still the westbound left turn, northbound left turn and southbound through movements experience large delay due to the high demand and insufficient capacity.

Scenario with General Purpose Lanes

See Exhibit 6-4 for the recommended lane configurations with the two additional lanes assumed to be general purpose lanes.

Exhibit 6-4: Future Recommended Lane configurations with two additional general purpose lanes



The scenarios analysis include signal timing optimization based on an assumption that the intersection's cycle length is 120 seconds. See Exhibit 6-5 for the summary of intersection operational performance analysis.

Exhibit 6-5: Future 2031 Total (two additional general purpose lanes) Intersection Operational Performance Summary

Intersection	AM					PM				
	Overall LOS	Critical				Overall LOS	Critical			
		Mvmt	LOS	V/C	95th Queue (m)		Mvmt	LOS	V/C	95th Queue (m)
Highway 7 at Brock Road	D	NBL	D	0.85	136>	C	EBR	C	0.86	163
Highway 407 WB Off-Ramp at Brock Road	A					A				
Highway 407 EB Off-Ramp at Brock Road	B					D	EBR	D	0.97	#241
							NBT	D	0.88	171
Station Access (Bus Only) at Brock Road	B					A				
E-W Residential Collector 2 at Brock Road	B					B	EBR	D	0.84	96>
							SBT	B	0.75	197>
Street 20I at Brock Road	A					A				
Street 20H at Brock Road	B					D	WBL	F	1.01	#85
							NBL	F	0.97	#102
							SBT	D	1.01	#272>

> Queue exceeds provided storage/link length

95 percentile volume exceeds capacity, queue may be longer

* Turn storage length is defined based on Durham Region design guideline with minimum storage length

Highway 7 at Brock Road: The overall intersection operational performance remains the same as future total with HOV lanes condition. There is no improvements achieved mainly because the signal timing plan has to satisfy the minimum split requirement which is determined by the pedestrian phase.

Highway 407 Eastbound Off-Ramp at Brock Road: The overall intersection LOS remains the same as future total with HOV lanes condition. The operational performance of the critical movements identified previously are improved, but still the eastbound right turn and northbound through movements show large V/C ratio in the p.m. peak hour. This is mainly because the eastbound right turn and the northbound through movements are conflict with each other and both of them are high demand movements.

East-West Residential Collector 2 at Brock Road: The overall intersection LOS is improved, the operational performance of the critical movements identified previously are improved as well regarding to the V/C ratio and queue length, but they are still critical due to the long queue length that may exceed the available storage length and block upstream intersection in the p.m. peak hour.

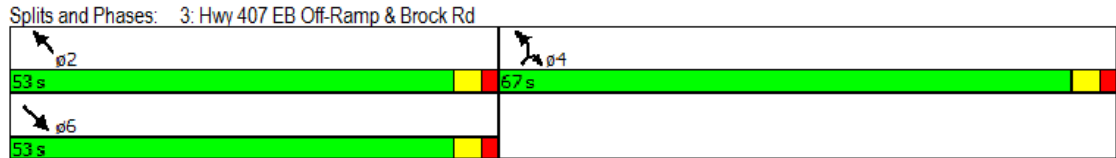
Street 20H at Brock Road: The overall intersection LOS is improved, the operational performance of the critical movements identified previously are improved as well regarding to the V/C ratio and queue length, but still they are critical as the demands are close to/over the capacity. The improvements are not significant mainly because the signal timing plan has to satisfy the minimum split requirement which is determined by the pedestrian phase.

To further mitigate the traffic conditions for the above identified critical movements, we have the following recommendations and comments. Exhibit 6-6 shows the summary of the intersection operational performance with the recommended improvements.

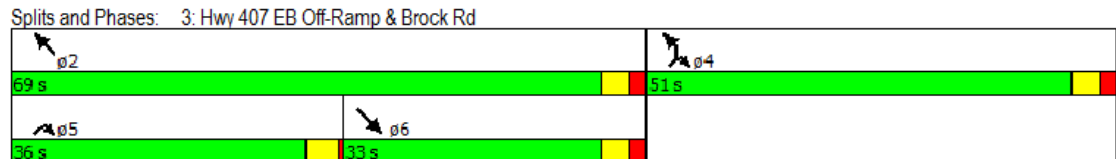
Highway 7 at Brock Road: Do not provide the pedestrian phase.

Highway 407 Eastbound Off-Ramp at Brock Road: Implement atypical phasing. Comparisons between the typical phasing and atypical phasing are shown as follows:

Typical Phasing:



Atypical Phasing:



The application of the proposed atypical phasing will require review and input from Durham Region. Generally it requires restrictions on pedestrian crossings of Brock Road at the 407 Eastbound Off-ramp. MTO may find it acceptable to restrict pedestrians if facilities are adequate at adjacent intersections.

East-West Residential Collector 2 at Brock Road: Provide sufficient (at least 100 meters) storage length for the EBR movement. The link distance between this intersection and the upstream intersection i.e. the Station Access (Bus Only) at Brock Road is only about 180m, therefore the SBT queue spills back to the upstream intersection easily.

Street 20H at Brock Road: Do not provide the pedestrian phase. However, the operation condition of this intersection could not be improved to an acceptable level, because the traffic volume forecasts were too high. Redistribution of the traffic for this location may be needed.

Exhibit 6-6: Future 2031 Total Mitigation Measures (two additional general purpose lanes) Intersection Operational Performance Summary

Intersection	AM					PM				
	Overall LOS	Critical				Overall LOS	Critical			
		Mvmt	LOS	V/C	95th Queue (m)		Mvmt	LOS	V/C	95th Queue (m)
Highway 7 at Brock Road	D					C				
Highway 407 WB Off-Ramp at Brock Road	A					A				
Highway 407 EB Off-Ramp at Brock Road	B					C				
Station Access (Bus Only) at Brock Road	B					A				
E-W Residential Collector 2 at Brock Road	B					B				
Street 20I at Brock Road	A					A				
Street 20H at Brock Road	B					C	WBL	E	0.88	#84
							NBL	E	0.93	#100
							SBT	D	0.98	#275>

> Queue exceeds provided storage/link length

95 percentile volume exceeds capacity, queue may be longer

* Turn storage length is defined based on Durham Region design guideline with minimum storage length

7 Conclusion

This study presents the traffic impact analysis for the proposed Brock Road Station of the Highway 407 Transitway. The proposed station is located at the southwest corner of the interchange of Brock Road and Highway 407, and can be accessed through the intersection of the future E-W Residential Collector 2 at Brock Road (first intersection south of Highway 407).

Background traffic analysis in the existing conditions year of 2015 was not included in this study due to the major road network and development changes in the vicinity of the proposed station. Future background volumes were collected from the “Master Environmental Servicing Plan Amendment (MESPA) for Seaton Community” completed in 2013. The forecasts account for the shift in travel patterns that is caused by the Highway 407 east expansion and the traffic volumes growth that is mainly generated by the surrounding developments.

Background traffic analysis show that the station access intersection, E-W Residential Collector 2 at Brock Road, operates well at LOS B in both analysis peak hours, but the southbound through movement sees high v/c ratio and long queue length in p.m. peak period. Other intersections in the study area show several movements approaching or operating at capacity in the p.m. peak period. The EBR of the Highway 407 EB Off-ramp at Brock Road and the intersection of Street 20H at Brock Road operates at LOS F in p.m. peak period.

Site traffic for the proposed Brock Road station was calculated based on the Greater Golden Horseshoe model’s projected park-and-ride demand, the required number of on-site parking spaces, and the ITE trip generation manual rates. Overall, the proposed Brock Road Station generates 350 (86) inbound and 82 (286) outbound trips in the a.m. (p.m.) peak hour.

The addition of site-generated traffic causes the site access intersection, E-W Residential Collector 2 at Brock Road, to have critical movements during the p.m. peak hour. Other intersections show deterioration which as background traffic already approaches or operates at capacity.

Internally, the site is expected to operate with no operational issues. In the p.m. peak period, the southbound movement at internal intersection #4 shows a relative long queue length (28 meters), but it operates at an acceptable level of service.

Summary of Recommendations

Future widening of Brock Road to a six-lane cross-section has been approved under CPDP Class EA for Regional Services, and in the previous relevant project, it’s mentioned that the two additional lanes might be designated either as High Occupancy Vehicle (HOV) lanes or potentially as dedicated Bus Rapid Transit (BRT) lanes in the centre median. For the purpose of this study, two scenarios were analyzed, which are the scenario with the road curb lanes of Brock Road assumed to be HOV lanes; and the scenario with the two additional lanes assumed to be general purpose lanes. Based on the analysis results, the option with HOV lanes does not appear to provide sufficient capacity for general traffic; therefore this study recommends that the additional lanes are general purpose.

To further mitigate the traffic conditions for critical movements which are not able to be improved by widening Brock Road, the following are recommended:

- Remove the pedestrian crossing phase at intersections of Highway 7 at Brock Road and Street 20H at Brock Road;
- Implement atypical phasing at Highway 407 Eastbound Off-Ramp at Brock Road;
- Provide proper sign at Station Access (Bus Only) at Brock Road to prevent intersection blockage;

- Provide at least 100 meters storage length for the EBR movement at Station Access (Mixed Traffic) at Brock Road;

Internally, we recommend that the internal driveway of the west parking lot is designed at least 30 meters way from the parking lot access.

Appendix A – Future (2031) Background Conditions Synchro Output

Queues
1: Hwy 7 & Brock Rd

Future Background
AM Peak Hour































Lane Group	SEL	SET	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	5	834	984	250	11	11	141	272	36	706
v/c Ratio	0.02	0.84	0.88	0.11	0.01	0.16	0.17	0.28	0.12	0.84
Control Delay	34.6	48.2	47.0	8.0	0.9	41.0	35.0	9.0	35.0	52.2
Queue Delay	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	34.6	48.2	48.0	8.0	0.9	41.0	35.0	9.0	35.0	52.2
Queue Length 50th (m)	0.9	101.5	113.4	11.2	0.0	2.1	14.1	23.1	6.8	84.8
Queue Length 95th (m)	4.5	#153.5	140.3	17.4	0.9	7.8	22.8	33.7	15.8	108.0
Internal Link Dist (m)		445.3		141.0			290.1			315.9
Turn Bay Length (m)	216.0		120.0		110.0	162.0			230.0	
Base Capacity (vph)	316	996	1248	2275	1027	76	958	1039	334	958
Starvation Cap Reductn	0	0	93	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.84	0.85	0.11	0.01	0.14	0.15	0.26	0.11	0.74

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Future Background
AM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		 		 	 			 			 	
Volume (vph)	5	657	110	905	230	10	10	130	250	33	645	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		4.0	6.0	6.0	6.0	6.0	4.0	6.0	6.0	
Lane Util. Factor	1.00	0.95		0.97	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frt	1.00	0.98		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3396		3367	3471	1553	1736	3471	1553	1736	3467	
Flt Permitted	0.60	1.00		0.95	1.00	1.00	0.15	1.00	1.00	0.66	1.00	
Satd. Flow (perm)	1090	3396		3367	3471	1553	277	3471	1553	1210	3467	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	5	714	120	984	250	11	11	141	272	36	701	5
RTOR Reduction (vph)	0	11	0	0	0	4	0	0	12	0	1	0
Lane Group Flow (vph)	5	823	0	984	250	7	11	141	260	36	705	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		Prot	NA	Perm	Perm	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2			4	5		8	
Permitted Phases	6					2	4		4	8		
Actuated Green, G (s)	33.7	33.7		38.4	76.1	76.1	28.0	28.0	66.4	28.0	28.0	
Effective Green, g (s)	33.7	33.7		38.4	76.1	76.1	28.0	28.0	66.4	28.0	28.0	
Actuated g/C Ratio	0.29	0.29		0.33	0.66	0.66	0.24	0.24	0.57	0.24	0.24	
Clearance Time (s)	6.0	6.0		4.0	6.0	6.0	6.0	6.0	4.0	6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	316	985		1113	2275	1017	66	837	888	291	836	
v/s Ratio Prot		c0.24		c0.29	0.07			0.04	0.10		c0.20	
v/s Ratio Perm	0.00					0.00	0.04		0.07	0.03		
v/c Ratio	0.02	0.84		0.88	0.11	0.01	0.17	0.17	0.29	0.12	0.84	
Uniform Delay, d1	29.4	38.6		36.7	7.4	6.9	34.8	34.8	12.8	34.5	42.0	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.1	8.4		8.6	0.1	0.0	1.2	0.1	0.2	0.2	7.8	
Delay (s)	29.5	47.0		45.3	7.5	6.9	36.0	34.9	13.0	34.6	49.7	
Level of Service	C	D		D	A	A	D	C	B	C	D	
Approach Delay (s)		46.9			37.4			20.9			49.0	
Approach LOS		D			D			C			D	

Intersection Summary

HCM 2000 Control Delay	40.3	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	116.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	87.1%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Queues
2: Brock Road & Hwy 407 WB Off-Ramp

Future Background
AM Peak Hour



Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	592	1201	141	49
v/c Ratio	0.21	0.43	0.47	0.27
Control Delay	2.9	4.0	53.0	16.6
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	2.9	4.0	53.0	16.6
Queue Length 50th (m)	13.3	34.2	15.8	0.0
Queue Length 95th (m)	20.4	49.5	25.6	11.7
Internal Link Dist (m)	141.0	289.0	271.3	
Turn Bay Length (m)				140.0
Base Capacity (vph)	2790	2790	658	342
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.21	0.43	0.21	0.14
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

2: Brock Road & Hwy 407 WB Off-Ramp

Future Background
AM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑	↑↑		↑↑	↑
Volume (vph)	0	545	1105	0	130	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0		6.0	6.0
Lane Util. Factor		0.95	0.95		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		3471	3471		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		3471	3471		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	592	1201	0	141	49
RTOR Reduction (vph)	0	0	0	0	0	45
Lane Group Flow (vph)	0	592	1201	0	141	4
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		90.6	90.6		10.1	10.1
Effective Green, g (s)		90.6	90.6		10.1	10.1
Actuated g/C Ratio		0.80	0.80		0.09	0.09
Clearance Time (s)		6.0	6.0		6.0	6.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		2790	2790		301	139
v/s Ratio Prot		0.17	c0.35		c0.04	0.00
v/s Ratio Perm						
v/c Ratio		0.21	0.43		0.47	0.03
Uniform Delay, d1		2.6	3.3		48.7	46.8
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2	0.5		1.2	0.1
Delay (s)		2.8	3.8		49.9	46.9
Level of Service		A	A		D	D
Approach Delay (s)		2.8	3.8		49.1	
Approach LOS		A	A		D	

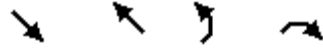
Intersection Summary

HCM 2000 Control Delay	7.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	112.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Road

Future Background
AM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	712	1973	158	630
v/c Ratio	0.27	0.75	0.66	0.76
Control Delay	4.9	10.9	59.9	14.7
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	4.9	10.9	59.9	14.7
Queue Length 50th (m)	22.5	115.2	35.6	12.3
Queue Length 95th (m)	37.2	182.5	58.1	33.5
Internal Link Dist (m)	289.0	281.3	391.1	
Turn Bay Length (m)				120.0
Base Capacity (vph)	2625	2625	336	954
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.27	0.75	0.47	0.66
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Road

Future Background
AM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑			↑↑	↘	↘↘
Volume (vph)	655	0	0	1815	145	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0			6.0	6.0	6.0
Lane Util. Factor	0.95			0.95	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	3471			3471	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	3471			3471	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	712	0	0	1973	158	630
RTOR Reduction (vph)	0	0	0	0	0	455
Lane Group Flow (vph)	712	0	0	1973	158	175
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	86.1			86.1	15.7	15.7
Effective Green, g (s)	86.1			86.1	15.7	15.7
Actuated g/C Ratio	0.76			0.76	0.14	0.14
Clearance Time (s)	6.0			6.0	6.0	6.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	2626			2626	239	377
v/s Ratio Prot	0.21			c0.57	c0.09	0.06
v/s Ratio Perm						
v/c Ratio	0.27			0.75	0.66	0.46
Uniform Delay, d1	4.2			7.8	46.5	45.2
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	0.3			2.0	6.7	0.9
Delay (s)	4.5			9.8	53.2	46.1
Level of Service	A			A	D	D
Approach Delay (s)	4.5			9.8	47.5	
Approach LOS	A			A	D	

Intersection Summary

HCM 2000 Control Delay	17.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	113.8	Sum of lost time (s)	12.0
Intersection Capacity Utilization	68.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Future Background
AM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	SBL	SBT	SBR
Lane Group Flow (vph)	103	103	5	11	109	1951	49	1196	98
v/c Ratio	0.55	0.40	0.03	0.05	0.35	0.72	0.45	0.50	0.09
Control Delay	57.0	13.3	42.2	0.4	6.2	8.3	24.9	9.2	1.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	57.0	13.3	42.2	0.4	6.2	8.3	24.9	9.2	1.5
Queue Length 50th (m)	21.9	0.0	1.0	0.0	4.6	92.4	4.4	59.2	0.0
Queue Length 95th (m)	39.4	15.6	4.7	0.0	10.3	144.2	21.1	85.4	5.5
Internal Link Dist (m)						200.3		128.4	
Turn Bay Length (m)		110.0			150.0				90.0
Base Capacity (vph)	381	421	381	405	312	2709	109	2398	1103
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.27	0.24	0.01	0.03	0.35	0.72	0.45	0.50	0.09

Intersection Summary

HCM Signalized Intersection Capacity Analysis

5: Brock Rd & E-W Residential Collector 2

Future Background
AM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	95	0	95	5	0	10	100	1755	40	45	1100	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		6.0	6.0		6.0	6.0	6.0		6.0	6.0	6.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.95		1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	3460		1736	3471	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.18	1.00		0.09	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	334	3460		158	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	103	0	103	5	0	11	109	1908	43	49	1196	98
RTOR Reduction (vph)	0	0	92	0	0	10	0	1	0	0	0	30
Lane Group Flow (vph)	103	0	11	5	0	1	109	1950	0	49	1196	68
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		Perm	Perm		Perm	pm+pt	NA		Perm	NA	Perm
Protected Phases							5	2			6	
Permitted Phases	4		4	8		8	2			6		6
Actuated Green, G (s)	11.8		11.8	11.8		11.8	85.5	85.5		75.5	75.5	75.5
Effective Green, g (s)	11.8		11.8	11.8		11.8	85.5	85.5		75.5	75.5	75.5
Actuated g/C Ratio	0.11		0.11	0.11		0.11	0.78	0.78		0.69	0.69	0.69
Clearance Time (s)	6.0		6.0	6.0		6.0	6.0	6.0		6.0	6.0	6.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	187		167	187		167	312	2706		109	2397	1072
v/s Ratio Prot							0.01	c0.56			0.34	
v/s Ratio Perm	c0.06		0.01	0.00		0.00	0.26			0.31		0.04
v/c Ratio	0.55		0.07	0.03		0.01	0.35	0.72		0.45	0.50	0.06
Uniform Delay, d1	46.2		43.8	43.6		43.5	4.8	5.9		7.6	8.0	5.5
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	3.5		0.2	0.1		0.0	0.7	1.7		12.8	0.7	0.1
Delay (s)	49.7		44.0	43.7		43.5	5.5	7.6		20.4	8.7	5.6
Level of Service	D		D	D		D	A	A		C	A	A
Approach Delay (s)		46.8			43.6			7.5			8.9	
Approach LOS		D			D			A			A	

Intersection Summary

HCM 2000 Control Delay	10.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	109.3	Sum of lost time (s)	18.0
Intersection Capacity Utilization	73.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Future Background
AM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	16	70	141	32	98	2043	92	27	1315	11
v/c Ratio	0.17	0.43	0.66	0.12	0.36	0.82	0.08	0.39	0.60	0.01
Control Delay	49.5	26.1	51.9	26.9	8.4	14.5	2.1	32.0	13.7	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.5	26.1	51.9	26.9	8.4	14.5	2.1	32.0	13.7	0.0
Queue Length 50th (m)	3.3	3.3	26.3	3.8	5.2	143.0	1.1	2.7	84.5	0.0
Queue Length 95th (m)	10.3	17.3	45.2	12.1	11.3	206.8	6.3	#16.2	116.6	0.0
Internal Link Dist (m)		115.6		96.1		192.9			179.2	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	297	399	215	544	269	2506	1141	70	2189	1016
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.18	0.66	0.06	0.36	0.82	0.08	0.39	0.60	0.01

Intersection Summary























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

HCM Signalized Intersection Capacity Analysis

7: Brock Rd & Street 20H

Future Background

AM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	15	50	130	5	25	90	1880	85	25	1210	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		4.0	6.0		4.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.88		1.00	0.87		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736	1616		1736	1596		1736	3471	1553	1736	3471	1553
Flt Permitted	0.74	1.00		0.43	1.00		0.14	1.00	1.00	0.06	1.00	1.00
Satd. Flow (perm)	1345	1616		785	1596		257	3471	1553	111	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	16	16	54	141	5	27	98	2043	92	27	1315	11
RTOR Reduction (vph)	0	51	0	0	9	0	0	0	21	0	0	4
Lane Group Flow (vph)	16	19	0	141	23	0	98	2043	71	27	1315	7
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		pm+pt	NA		pm+pt	NA	Perm	Perm	NA	Perm
Protected Phases		4		3	8		5	2			6	
Permitted Phases	4			8			2		2	6		6
Actuated Green, G (s)	6.1	6.1		18.1	18.1		75.1	75.1	75.1	65.6	65.6	65.6
Effective Green, g (s)	6.1	6.1		18.1	18.1		75.1	75.1	75.1	65.6	65.6	65.6
Actuated g/C Ratio	0.06	0.06		0.17	0.17		0.71	0.71	0.71	0.62	0.62	0.62
Clearance Time (s)	6.0	6.0		4.0	6.0		4.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	77	93		207	274		260	2477	1108	69	2164	968
v/s Ratio Prot		0.01		c0.05	0.01		0.02	c0.59			0.38	
v/s Ratio Perm	0.01			c0.07			0.25		0.05	0.24		0.00
v/c Ratio	0.21	0.21		0.68	0.08		0.38	0.82	0.06	0.39	0.61	0.01
Uniform Delay, d1	47.2	47.2		39.3	36.6		7.9	10.5	4.5	9.9	12.0	7.5
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.3	1.1		8.9	0.1		0.9	3.3	0.1	15.9	1.3	0.0
Delay (s)	48.6	48.3		48.2	36.7		8.8	13.8	4.6	25.7	13.3	7.5
Level of Service	D	D		D	D		A	B	A	C	B	A
Approach Delay (s)		48.4			46.1			13.2			13.5	
Approach LOS		D			D			B			B	

Intersection Summary

HCM 2000 Control Delay	15.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	105.2	Sum of lost time (s)	20.0
Intersection Capacity Utilization	84.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Queues
1: Hwy 7 & Brock Rd

Future Background
PM Peak Hour






























Lane Group	SEL	SET	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	11	341	339	836	21	234	701	827	22	163
v/c Ratio	0.06	0.36	0.29	0.37	0.02	0.79	0.81	0.80	0.31	0.31
Control Delay	38.0	35.8	26.3	9.6	0.1	55.2	46.4	17.5	52.1	40.1
Queue Delay	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.0	35.8	26.3	9.9	0.1	55.2	46.4	17.5	52.1	40.1
Queue Length 50th (m)	2.0	34.6	26.0	40.9	0.0	45.1	78.1	88.1	4.5	16.4
Queue Length 95th (m)	7.7	53.5	40.8	63.8	0.2	69.5	99.8	134.0	13.0	26.5
Internal Link Dist (m)		445.3		151.4			290.1			479.4
Turn Bay Length (m)	216.0		120.0		110.0	162.0			230.0	
Base Capacity (vph)	171	960	1354	2284	1040	297	1205	1123	118	850
Starvation Cap Reductn	0	0	0	794	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.36	0.25	0.56	0.02	0.79	0.58	0.74	0.19	0.19

Intersection Summary

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Future Background
PM Peak Hour

													
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR	
Lane Configurations		 		 	 			 			 		
Volume (vph)	10	299	15	312	769	19	215	645	761	20	135	15	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Total Lost time (s)	5.0	5.0		4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0		
Lane Util. Factor	1.00	0.95		0.97	0.95	1.00	1.00	0.95	1.00	1.00	0.95		
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99		
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		
Satd. Flow (prot)	1736	3447		3367	3471	1553	1736	3471	1553	1736	3420		
Flt Permitted	0.34	1.00		0.95	1.00	1.00	0.52	1.00	1.00	0.26	1.00		
Satd. Flow (perm)	616	3447		3367	3471	1553	954	3471	1553	482	3420		
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	
Adj. Flow (vph)	11	325	16	339	836	21	234	701	827	22	147	16	
RTOR Reduction (vph)	0	3	0	0	0	7	0	0	52	0	8	0	
Lane Group Flow (vph)	11	338	0	339	836	14	234	701	775	22	155	0	
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	
Turn Type	Perm	NA		Prot	NA	Perm	pm+pt	NA	pm+ov	Perm	NA		
Protected Phases		6		5	2		7	4	5		8		
Permitted Phases	6					2	4		4	8			
Actuated Green, G (s)	30.5	30.5		37.7	72.2	72.2	27.5	27.5	65.2	16.5	16.5		
Effective Green, g (s)	30.5	30.5		37.7	72.2	72.2	27.5	27.5	65.2	16.5	16.5		
Actuated g/C Ratio	0.28	0.28		0.34	0.66	0.66	0.25	0.25	0.59	0.15	0.15		
Clearance Time (s)	5.0	5.0		4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0		
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		
Lane Grp Cap (vph)	171	958		1157	2284	1022	289	870	923	72	514		
v/s Ratio Prot		0.10		0.10	c0.24		0.05	0.20	c0.29		0.05		
v/s Ratio Perm	0.02					0.01	0.15		0.21	0.05			
v/c Ratio	0.06	0.35		0.29	0.37	0.01	0.81	0.81	0.84	0.31	0.30		
Uniform Delay, d1	29.1	31.7		26.3	8.4	6.5	38.0	38.6	18.0	41.5	41.5		
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Incremental Delay, d2	0.7	1.0		0.1	0.5	0.0	15.3	5.5	6.8	2.4	0.3		
Delay (s)	29.8	32.7		26.4	8.9	6.5	53.2	44.1	24.8	43.9	41.8		
Level of Service	C	C		C	A	A	D	D	C	D	D		
Approach Delay (s)		32.6			13.8			36.3			42.1		
Approach LOS		C			B			D			D		
Intersection Summary													
HCM 2000 Control Delay			28.5		HCM 2000 Level of Service					C			
HCM 2000 Volume to Capacity ratio			0.73										
Actuated Cycle Length (s)			109.7		Sum of lost time (s)					18.0			
Intersection Capacity Utilization			70.9%		ICU Level of Service					C			
Analysis Period (min)			15										

c Critical Lane Group

Queues
2: Hwy 407 WB Off-Ramp

Future Background
PM Peak Hour



Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	1016	1190	60	11
v/c Ratio	0.34	0.40	0.28	0.10
Control Delay	2.4	2.7	55.4	26.9
Queue Delay	0.3	0.0	0.0	0.0
Total Delay	2.7	2.7	55.4	26.9
Queue Length 50th (m)	22.7	28.6	7.4	0.0
Queue Length 95th (m)	31.7	39.7	13.9	6.1
Internal Link Dist (m)	151.4	299.7	325.8	
Turn Bay Length (m)				140.0
Base Capacity (vph)	3003	3003	577	275
Starvation Cap Reductn	1226	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.57	0.40	0.10	0.04
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

2: Hwy 407 WB Off-Ramp

Future Background
PM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑	↑↑		↑↑	↑
Volume (vph)	0	935	1095	0	55	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0		6.0	6.0
Lane Util. Factor		0.95	0.95		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		3471	3471		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		3471	3471		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1016	1190	0	60	11
RTOR Reduction (vph)	0	0	0	0	0	10
Lane Group Flow (vph)	0	1016	1190	0	60	1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		99.8	99.8		6.3	6.3
Effective Green, g (s)		99.8	99.8		6.3	6.3
Actuated g/C Ratio		0.85	0.85		0.05	0.05
Clearance Time (s)		6.0	6.0		6.0	6.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		2933	2933		179	82
v/s Ratio Prot		0.29	c0.34		c0.02	0.00
v/s Ratio Perm						
v/c Ratio		0.35	0.41		0.34	0.01
Uniform Delay, d1		2.0	2.2		53.9	52.9
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.3	0.4		1.1	0.0
Delay (s)		2.3	2.6		55.0	53.0
Level of Service		A	A		D	D
Approach Delay (s)		2.3	2.6		54.7	
Approach LOS		A	A		D	

Intersection Summary

HCM 2000 Control Delay	4.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	118.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	77.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Future Background
PM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	1016	1652	408	1386
v/c Ratio	0.61	0.99	0.55	1.07
Control Delay	24.6	49.7	29.5	76.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	24.6	49.7	29.5	76.8
Queue Length 50th (m)	94.1	206.6	74.7	~207.4
Queue Length 95th (m)	116.0	#265.2	107.2	#256.0
Internal Link Dist (m)	299.7	281.8	440.6	
Turn Bay Length (m)				120.0
Base Capacity (vph)	1677	1677	737	1293
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.61	0.99	0.55	1.07

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Rd

Future Background
PM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑			↑↑	↘	↘↘
Volume (vph)	935	0	0	1520	375	1275
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	6.0	3.0
Lane Util. Factor	0.95			0.95	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	3471			3471	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	3471			3471	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1016	0	0	1652	408	1386
RTOR Reduction (vph)	0	0	0	0	0	64
Lane Group Flow (vph)	1016	0	0	1652	408	1322
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	57.0			57.0	51.0	51.0
Effective Green, g (s)	58.0			58.0	51.0	54.0
Actuated g/C Ratio	0.48			0.48	0.42	0.45
Clearance Time (s)	6.0			6.0	6.0	6.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	1677			1677	737	1229
v/s Ratio Prot	0.29			c0.48	0.24	c0.48
v/s Ratio Perm						
v/c Ratio	0.61			0.99	0.55	1.08
Uniform Delay, d1	22.6			30.6	25.9	33.0
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	1.6			18.7	0.9	48.7
Delay (s)	24.3			49.3	26.8	81.7
Level of Service	C			D	C	F
Approach Delay (s)	24.3			49.3	69.2	
Approach LOS	C			D	E	

Intersection Summary

HCM 2000 Control Delay	51.6	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	1.06		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	77.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Future Background
PM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	SBL	SBT	SBR
Lane Group Flow (vph)	125	174	60	49	92	1609	27	2283	92
v/c Ratio	0.57	0.70	0.27	0.20	0.70	0.59	0.15	0.93	0.08
Control Delay	55.4	44.6	46.0	11.6	42.4	6.5	8.8	22.7	2.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	55.4	44.6	46.0	11.6	42.4	6.5	8.8	22.7	2.0
Queue Length 50th (m)	26.9	24.6	12.5	0.0	4.0	61.6	1.7	199.5	0.7
Queue Length 95th (m)	46.2	48.3	25.4	9.7	#18.9	107.7	6.7	#342.2	6.3
Internal Link Dist (m)						196.9		152.6	
Turn Bay Length (m)		110.0			150.0				90.0
Base Capacity (vph)	379	386	379	382	131	2714	180	2464	1125
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.33	0.45	0.16	0.13	0.70	0.59	0.15	0.93	0.08

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

5: Brock Rd & E-W Residential Collector 2

Future Background
PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	115	0	160	55	0	45	85	1470	10	25	2100	85
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.95		1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	3468		1736	3471	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.05	1.00		0.14	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	89	3468		254	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	125	0	174	60	0	49	92	1598	11	27	2283	92
RTOR Reduction (vph)	0	0	53	0	0	43	0	0	0	0	0	23
Lane Group Flow (vph)	125	0	121	60	0	6	92	1609	0	27	2283	69
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		Perm	Perm		Perm	pm+pt	NA		Perm	NA	Perm
Protected Phases							5	2			6	
Permitted Phases	4		4	8		8	2			6		6
Actuated Green, G (s)	13.9		13.9	13.9		13.9	86.1	86.1		78.1	78.1	78.1
Effective Green, g (s)	13.9		13.9	13.9		13.9	86.1	86.1		78.1	78.1	78.1
Actuated g/C Ratio	0.13		0.13	0.13		0.13	0.78	0.78		0.71	0.71	0.71
Clearance Time (s)	5.0		5.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	219		196	219		196	129	2714		180	2464	1102
v/s Ratio Prot							0.03	c0.46			c0.66	
v/s Ratio Perm	0.07		c0.08	0.03		0.00	0.53			0.11		0.04
v/c Ratio	0.57		0.62	0.27		0.03	0.71	0.59		0.15	0.93	0.06
Uniform Delay, d1	45.2		45.5	43.5		42.1	27.1	4.8		5.2	13.5	4.8
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	3.6		5.6	0.7		0.1	17.0	1.0		1.8	7.5	0.1
Delay (s)	48.8		51.2	44.2		42.2	44.1	5.8		6.9	21.0	4.9
Level of Service	D		D	D		D	D	A		A	C	A
Approach Delay (s)		50.2			43.3			7.9			20.3	
Approach LOS		D			D			A			C	
Intersection Summary												
HCM 2000 Control Delay			18.1								HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.88									
Actuated Cycle Length (s)			110.0								Sum of lost time (s)	14.0
Intersection Capacity Utilization			83.0%								ICU Level of Service	E
Analysis Period (min)			15									

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Future Background
PM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	33	152	217	44	272	1685	114	92	2478	22
v/c Ratio	0.16	0.67	1.43	0.19	1.26	0.75	0.11	0.53	1.17	0.02
Control Delay	37.4	37.1	258.0	21.1	174.9	16.1	2.4	20.6	103.8	0.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.4	37.1	258.0	21.1	174.9	16.1	2.4	20.6	103.8	0.1
Queue Length 50th (m)	6.1	14.9	~64.1	2.2	~58.1	118.9	1.0	4.6	~337.4	0.0
Queue Length 95th (m)	14.5	36.2	#112.1	12.9	#120.8	176.7	8.2	#17.2	#418.7	0.0
Internal Link Dist (m)		200.4		197.2		192.4			178.6	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	207	422	152	391	216	2252	1042	172	2121	984
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.16	0.36	1.43	0.11	1.26	0.75	0.11	0.53	1.17	0.02

Intersection Summary























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

HCM Signalized Intersection Capacity Analysis

7: Brock Rd & Street 20H

Future Background

PM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	20	120	200	10	30	250	1550	105	85	2280	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.87		1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736	1593		1736	1621		1736	3471	1553	1736	3471	1553
Flt Permitted	0.73	1.00		0.39	1.00		0.06	1.00	1.00	0.08	1.00	1.00
Satd. Flow (perm)	1331	1593		717	1621		106	3471	1553	146	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	22	130	217	11	33	272	1685	114	92	2478	22
RTOR Reduction (vph)	0	72	0	0	29	0	0	0	36	0	0	9
Lane Group Flow (vph)	33	80	0	217	15	0	272	1685	78	92	2478	13
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2		2	6		6
Actuated Green, G (s)	14.3	12.0		17.7	13.7		78.1	69.1	69.1	70.1	65.1	65.1
Effective Green, g (s)	14.3	12.0		17.7	13.7		78.1	69.1	69.1	70.1	65.1	65.1
Actuated g/C Ratio	0.13	0.11		0.16	0.13		0.72	0.64	0.64	0.65	0.60	0.60
Clearance Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	184	176		155	205		212	2218	992	168	2090	935
v/s Ratio Prot	0.00	0.05		c0.05	0.01		c0.11	0.49		0.03	0.71	
v/s Ratio Perm	0.02			c0.18			c0.82		0.05	0.33		0.01
v/c Ratio	0.18	0.45		1.40	0.07		1.28	0.76	0.08	0.55	1.19	0.01
Uniform Delay, d1	41.5	45.0		45.2	41.6		37.9	13.7	7.4	13.0	21.5	8.6
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	1.9		214.2	0.2		158.3	2.5	0.2	3.6	88.7	0.0
Delay (s)	42.0	46.8		259.3	41.8		196.2	16.2	7.6	16.6	110.2	8.7
Level of Service	D	D		F	D		F	B	A	B	F	A
Approach Delay (s)		46.0			222.6			39.4			106.0	
Approach LOS		D			F			D			F	

Intersection Summary

HCM 2000 Control Delay	82.8	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.37		
Actuated Cycle Length (s)	108.1	Sum of lost time (s)	18.0
Intersection Capacity Utilization	111.4%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Appendix B – Future (2031) Total Conditions Synchro Output

Queues
1: Hwy 7 & Brock Rd

Future Total
AM Peak Hour



Lane Group	SEL	SET	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	5	941	1040	264	12	11	141	312	41	706
v/c Ratio	0.01	0.88	0.93	0.11	0.01	0.18	0.18	0.33	0.15	0.92
Control Delay	29.8	49.6	52.7	6.9	0.8	46.2	38.4	11.4	39.2	63.9
Queue Delay	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	29.8	49.6	58.8	6.9	0.8	46.2	38.4	11.4	39.2	63.9
Queue Length 50th (m)	0.9	116.7	125.9	11.0	0.0	2.2	14.9	31.3	8.2	90.1
Queue Length 95th (m)	4.1	#156.2	#165.5	15.9	0.9	8.3	24.2	48.1	18.6	#125.2
Internal Link Dist (m)		445.3		141.0			290.1			315.9
Turn Bay Length (m)	216.0		120.0		110.0	162.0			230.0	
Base Capacity (vph)	335	1070	1156	2355	1063	62	784	965	273	785
Starvation Cap Reductn	0	0	87	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.01	0.88	0.97	0.11	0.01	0.18	0.18	0.32	0.15	0.90




























Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

1: Hwy 7 & Brock Rd

Future Total
AM Peak Hour

													
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR	
Lane Configurations		 		 	 			 			 		
Volume (vph)	5	755	110	957	243	11	10	130	287	38	645	5	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Total Lost time (s)	6.0	6.0		4.0	6.0	6.0	6.0	6.0	4.0	6.0	6.0		
Lane Util. Factor	1.00	0.95		0.97	0.95	1.00	1.00	0.95	1.00	1.00	0.95		
Frt	1.00	0.98		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00		
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		
Satd. Flow (prot)	1736	3405		3367	3471	1553	1736	3471	1553	1736	3467		
Flt Permitted	0.59	1.00		0.95	1.00	1.00	0.15	1.00	1.00	0.66	1.00		
Satd. Flow (perm)	1076	3405		3367	3471	1553	278	3471	1553	1210	3467		
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	
Adj. Flow (vph)	5	821	120	1040	264	12	11	141	312	41	701	5	
RTOR Reduction (vph)	0	10	0	0	0	4	0	0	12	0	1	0	
Lane Group Flow (vph)	5	931	0	1040	264	8	11	141	300	41	705	0	
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	
Turn Type	Perm	NA		Prot	NA	Perm	Perm	NA	pm+ov	Perm	NA		
Protected Phases		6		5	2			4	5		8		
Permitted Phases	6					2	4		4	8			
Actuated Green, G (s)	37.2	37.2		39.8	81.0	81.0	26.3	26.3	66.1	26.3	26.3		
Effective Green, g (s)	37.2	37.2		39.8	81.0	81.0	26.3	26.3	66.1	26.3	26.3		
Actuated g/C Ratio	0.31	0.31		0.33	0.68	0.68	0.22	0.22	0.55	0.22	0.22		
Clearance Time (s)	6.0	6.0		4.0	6.0	6.0	6.0	6.0	4.0	6.0	6.0		
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		
Lane Grp Cap (vph)	335	1061		1123	2356	1054	61	765	860	266	764		
v/s Ratio Prot		c0.27		c0.31	0.08			0.04	0.12		c0.20		
v/s Ratio Perm	0.00					0.01	0.04		0.08	0.03			
v/c Ratio	0.01	0.88		0.93	0.11	0.01	0.18	0.18	0.35	0.15	0.92		
Uniform Delay, d1	28.4	38.9		38.3	6.7	6.2	37.7	37.8	14.7	37.5	45.5		
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Incremental Delay, d2	0.1	10.3		12.7	0.1	0.0	1.4	0.1	0.2	0.3	16.6		
Delay (s)	28.5	49.2		51.0	6.8	6.2	39.2	37.9	14.9	37.8	62.2		
Level of Service	C	D		D	A	A	D	D	B	D	E		
Approach Delay (s)		49.1			41.7			22.5			60.8		
Approach LOS		D			D			C			E		
Intersection Summary													
HCM 2000 Control Delay			45.3									HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio			0.91										
Actuated Cycle Length (s)			119.3									Sum of lost time (s)	16.0
Intersection Capacity Utilization			91.3%									ICU Level of Service	F
Analysis Period (min)			15										

c Critical Lane Group

Queues
2: Brock Rd & Hwy 407 WB Off-Ramp

Future Total
AM Peak Hour



Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	745	1273	141	49
v/c Ratio	0.27	0.46	0.47	0.27
Control Delay	3.1	4.2	53.0	16.6
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	3.1	4.2	53.0	16.6
Queue Length 50th (m)	17.6	37.4	15.8	0.0
Queue Length 95th (m)	26.5	53.8	25.6	11.7
Internal Link Dist (m)	141.0	289.0	271.3	
Turn Bay Length (m)				140.0
Base Capacity (vph)	2790	2790	658	342
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.27	0.46	0.21	0.14

Intersection Summary

HCM Signalized Intersection Capacity Analysis

2: Brock Rd & Hwy 407 WB Off-Ramp

Future Total
AM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑	↑↑		↑↑	↑
Volume (vph)	0	685	1171	0	130	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0		6.0	6.0
Lane Util. Factor		0.95	0.95		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		3471	3471		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		3471	3471		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	745	1273	0	141	49
RTOR Reduction (vph)	0	0	0	0	0	45
Lane Group Flow (vph)	0	745	1273	0	141	4
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		90.6	90.6		10.1	10.1
Effective Green, g (s)		90.6	90.6		10.1	10.1
Actuated g/C Ratio		0.80	0.80		0.09	0.09
Clearance Time (s)		6.0	6.0		6.0	6.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		2790	2790		301	139
v/s Ratio Prot		0.21	c0.37		c0.04	0.00
v/s Ratio Perm						
v/c Ratio		0.27	0.46		0.47	0.03
Uniform Delay, d1		2.8	3.4		48.7	46.8
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2	0.5		1.2	0.1
Delay (s)		3.0	4.0		49.9	46.9
Level of Service		A	A		D	D
Approach Delay (s)		3.0	4.0		49.1	
Approach LOS		A	A		D	

Intersection Summary

HCM 2000 Control Delay	7.5	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	112.7	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.0%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Future Total
AM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	864	2045	158	630
v/c Ratio	0.34	0.81	0.57	0.85
Control Delay	6.4	14.5	50.6	30.5
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	6.4	14.5	50.6	30.5
Queue Length 50th (m)	32.1	138.8	33.6	35.1
Queue Length 95th (m)	55.5	234.0	54.9	59.0
Internal Link Dist (m)	289.0	281.3	391.1	
Turn Bay Length (m)				120.0
Base Capacity (vph)	2535	2535	422	937
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.34	0.81	0.37	0.67
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Rd

Future Total
AM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑			↑↑	↘	↗
Volume (vph)	795	0	0	1881	145	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0			6.0	6.0	6.0
Lane Util. Factor	0.95			0.95	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	3471			3471	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	3471			3471	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	864	0	0	2045	158	630
RTOR Reduction (vph)	0	0	0	0	0	301
Lane Group Flow (vph)	864	0	0	2045	158	329
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	81.2			81.2	17.9	17.9
Effective Green, g (s)	81.2			81.2	17.9	17.9
Actuated g/C Ratio	0.73			0.73	0.16	0.16
Clearance Time (s)	6.0			6.0	6.0	6.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	2536			2536	279	440
v/s Ratio Prot	0.25			c0.59	0.09	c0.12
v/s Ratio Perm						
v/c Ratio	0.34			0.81	0.57	0.75
Uniform Delay, d1	5.4			9.8	43.0	44.4
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	0.4			2.9	2.6	6.8
Delay (s)	5.7			12.7	45.6	51.2
Level of Service	A			B	D	D
Approach Delay (s)	5.7			12.7	50.1	
Approach LOS	A			B	D	

Intersection Summary

HCM 2000 Control Delay	19.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	111.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.0%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues

Future Total

5: Brock Rd & E-W Residential Collector 2

AM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	SBL	SBT	SBR
Lane Group Flow (vph)	175	121	5	11	337	1951	49	1196	250
v/c Ratio	0.68	0.35	0.04	0.05	0.79	0.76	0.59	0.63	0.26
Control Delay	55.5	9.7	43.4	0.4	30.4	10.9	52.7	19.4	2.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	55.5	9.7	43.4	0.4	30.4	10.9	52.7	19.4	2.5
Queue Length 50th (m)	35.9	0.0	1.1	0.0	33.6	106.5	6.8	90.5	0.0
Queue Length 95th (m)	58.7	15.6	4.7	0.0	#86.5	175.6	#31.2	130.0	12.7
Internal Link Dist (m)						200.3		128.4	
Turn Bay Length (m)		110.0			150.0				90.0
Base Capacity (vph)	514	347	398	433	441	2581	83	1887	958
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.34	0.35	0.01	0.03	0.76	0.76	0.59	0.63	0.26

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

5: Brock Rd & E-W Residential Collector 2

Future Total
AM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	161	0	111	5	0	10	310	1755	40	45	1100	230
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		5.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.95		1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	3460		1736	3471	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.13	1.00		0.08	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	245	3460		153	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	175	0	121	5	0	11	337	1908	43	49	1196	250
RTOR Reduction (vph)	0	0	100	0	0	10	0	1	0	0	0	118
Lane Group Flow (vph)	175	0	21	5	0	1	337	1950	0	49	1196	132
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Prot		custom	Prot		Perm	pm+pt	NA		Perm	NA	Perm
Protected Phases	4 7		7	8			5	2			6	
Permitted Phases			4	8		8	2			6		6
Actuated Green, G (s)	18.7		18.7	5.1		5.1	78.1	78.1		57.0	57.0	57.0
Effective Green, g (s)	18.7		18.7	5.1		5.1	78.1	78.1		57.0	57.0	57.0
Actuated g/C Ratio	0.17		0.17	0.05		0.05	0.72	0.72		0.53	0.53	0.53
Clearance Time (s)			5.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Vehicle Extension (s)			3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	301		269	82		73	414	2506		80	1835	821
v/s Ratio Prot	c0.10		0.01	0.00			0.13	c0.56			0.34	
v/s Ratio Perm			0.01			0.00	c0.46			0.32		0.09
v/c Ratio	0.58		0.08	0.06		0.01	0.81	0.78		0.61	0.65	0.16
Uniform Delay, d1	41.0		37.3	49.1		48.9	21.2	9.4		17.7	18.3	13.1
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.8		0.1	0.3		0.0	11.6	2.5		30.3	1.8	0.4
Delay (s)	43.8		37.5	49.4		49.0	32.9	11.8		48.0	20.1	13.5
Level of Service	D		D	D		D	C	B		D	C	B
Approach Delay (s)		41.2			49.1			14.9			19.9	
Approach LOS		D			D			B			B	
Intersection Summary												
HCM 2000 Control Delay			18.8								HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.83									
Actuated Cycle Length (s)			107.8								Sum of lost time (s)	19.0
Intersection Capacity Utilization			75.4%								ICU Level of Service	D
Analysis Period (min)			15									

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Future Total
AM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	18	70	141	34	98	2265	92	28	1332	11
v/c Ratio	0.19	0.43	0.65	0.13	0.38	0.90	0.08	0.40	0.60	0.01
Control Delay	50.1	26.0	51.7	31.5	8.9	19.7	2.3	32.8	13.4	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	50.1	26.0	51.7	31.5	8.9	19.7	2.3	32.8	13.4	0.0
Queue Length 50th (m)	3.7	3.3	26.3	5.0	5.3	189.2	1.5	2.8	85.0	0.0
Queue Length 95th (m)	11.0	17.3	45.2	13.8	11.3	#307.0	6.8	#17.1	116.8	0.0
Internal Link Dist (m)		115.6		96.1		192.9			179.2	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	296	398	216	539	256	2505	1139	70	2212	1025
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.18	0.65	0.06	0.38	0.90	0.08	0.40	0.60	0.01























Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Brock Rd & Street 20H

Future Total
AM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	17	15	50	130	5	27	90	2084	85	26	1225	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		4.0	6.0		4.0	6.0	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.88		1.00	0.87		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736	1616		1736	1593		1736	3471	1553	1736	3471	1553
Flt Permitted	0.73	1.00		0.43	1.00		0.14	1.00	1.00	0.06	1.00	1.00
Satd. Flow (perm)	1343	1616		790	1593		253	3471	1553	110	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	18	16	54	141	5	29	98	2265	92	28	1332	11
RTOR Reduction (vph)	0	51	0	0	5	0	0	0	19	0	0	4
Lane Group Flow (vph)	18	19	0	141	29	0	98	2265	73	28	1332	7
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		pm+pt	NA		pm+pt	NA	Perm	Perm	NA	Perm
Protected Phases		4		3	8		5	2			6	
Permitted Phases	4			8			2		2	6		6
Actuated Green, G (s)	6.2	6.2		18.2	18.2		75.2	75.2	75.2	66.4	66.4	66.4
Effective Green, g (s)	6.2	6.2		18.2	18.2		75.2	75.2	75.2	66.4	66.4	66.4
Actuated g/C Ratio	0.06	0.06		0.17	0.17		0.71	0.71	0.71	0.63	0.63	0.63
Clearance Time (s)	6.0	6.0		4.0	6.0		4.0	6.0	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	79	95		208	275		248	2476	1108	69	2186	978
v/s Ratio Prot		0.01		c0.05	0.02		0.02	c0.65			0.38	
v/s Ratio Perm	0.01			c0.07			0.26		0.05	0.25		0.00
v/c Ratio	0.23	0.20		0.68	0.11		0.40	0.91	0.07	0.41	0.61	0.01
Uniform Delay, d1	47.3	47.2		39.3	36.7		7.9	12.5	4.5	9.7	11.7	7.2
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	1.1		8.5	0.2		1.0	6.7	0.1	16.8	1.3	0.0
Delay (s)	48.8	48.3		47.8	36.9		9.0	19.1	4.7	26.5	13.0	7.3
Level of Service	D	D		D	D		A	B	A	C	B	A
Approach Delay (s)		48.4			45.7			18.2			13.2	
Approach LOS		D			D			B			B	

Intersection Summary

HCM 2000 Control Delay	18.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	105.4	Sum of lost time (s)	20.0
Intersection Capacity Utilization	89.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Queues
1: Hwy 7 & Brock Rd

Future Total
PM Peak Hour


























Lane Group	SEL	SET	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	11	362	374	923	23	234	701	880	23	163
v/c Ratio	0.08	0.43	0.30	0.40	0.02	0.79	0.81	0.82	0.32	0.31
Control Delay	38.7	38.5	24.8	10.0	0.2	55.2	46.4	17.9	53.0	40.1
Queue Delay	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.7	38.5	24.8	10.4	0.2	55.2	46.4	17.9	53.0	40.1
Queue Length 50th (m)	2.0	37.4	28.8	46.7	0.0	45.1	78.1	103.3	4.7	16.4
Queue Length 95th (m)	7.7	57.0	44.8	72.4	0.5	69.5	99.8	162.5	13.3	26.5
Internal Link Dist (m)		445.3		151.4			290.1			479.4
Turn Bay Length (m)	216.0		120.0		110.0	162.0			230.0	
Base Capacity (vph)	139	850	1354	2284	1040	297	1205	1117	118	850
Starvation Cap Reductn	0	0	0	766	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.08	0.43	0.28	0.61	0.02	0.79	0.58	0.79	0.19	0.19

Intersection Summary

HCM Signalized Intersection Capacity Analysis

1: Hwy 7 & Brock Rd

Future Total
PM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	10	318	15	344	849	21	215	645	810	21	135	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	0.95		0.97	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3448		3367	3471	1553	1736	3471	1553	1736	3420	
Flt Permitted	0.31	1.00		0.95	1.00	1.00	0.52	1.00	1.00	0.26	1.00	
Satd. Flow (perm)	565	3448		3367	3471	1553	954	3471	1553	482	3420	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	346	16	374	923	23	234	701	880	23	147	16
RTOR Reduction (vph)	0	2	0	0	0	8	0	0	41	0	8	0
Lane Group Flow (vph)	11	360	0	374	923	15	234	701	839	23	155	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		Prot	NA	Perm	pm+pt	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2		7	4	5		8	
Permitted Phases	6					2	4		4	8		
Actuated Green, G (s)	27.0	27.0		41.2	72.2	72.2	27.5	27.5	68.7	16.5	16.5	
Effective Green, g (s)	27.0	27.0		41.2	72.2	72.2	27.5	27.5	68.7	16.5	16.5	
Actuated g/C Ratio	0.25	0.25		0.38	0.66	0.66	0.25	0.25	0.63	0.15	0.15	
Clearance Time (s)	5.0	5.0		4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	139	848		1264	2284	1022	289	870	972	72	514	
v/s Ratio Prot		0.10		0.11	c0.27		0.05	0.20	c0.32		0.05	
v/s Ratio Perm	0.02					0.01	0.15		0.22	0.05		
v/c Ratio	0.08	0.42		0.30	0.40	0.01	0.81	0.81	0.86	0.32	0.30	
Uniform Delay, d1	31.8	34.8		24.1	8.7	6.5	38.0	38.6	16.7	41.6	41.5	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.1	1.6		0.1	0.5	0.0	15.3	5.5	8.0	2.6	0.3	
Delay (s)	32.9	36.4		24.2	9.3	6.5	53.2	44.1	24.7	44.1	41.8	
Level of Service	C	D		C	A	A	D	D	C	D	D	
Approach Delay (s)		36.3			13.4			35.9			42.1	
Approach LOS		D			B			D			D	
Intersection Summary												
HCM 2000 Control Delay			28.2				HCM 2000 Level of Service				C	
HCM 2000 Volume to Capacity ratio			0.78									
Actuated Cycle Length (s)			109.7			Sum of lost time (s)				18.0		
Intersection Capacity Utilization			74.4%			ICU Level of Service				D		
Analysis Period (min)			15									

c Critical Lane Group

Queues
2: Brock Road & Hwy 407 WB Off-Ramp

Future Total
PM Peak Hour

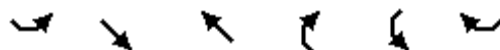


Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	1091	1314	60	11
v/c Ratio	0.37	0.44	0.27	0.10
Control Delay	2.6	3.0	52.8	25.5
Queue Delay	0.3	0.0	0.0	0.0
Total Delay	2.9	3.0	52.8	25.5
Queue Length 50th (m)	25.2	33.4	7.2	0.0
Queue Length 95th (m)	34.9	46.1	13.3	5.7
Internal Link Dist (m)	151.4	299.7	325.8	
Turn Bay Length (m)				140.0
Base Capacity (vph)	2986	2986	784	370
Starvation Cap Reductn	1142	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.59	0.44	0.08	0.03
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

2: Brock Road & Hwy 407 WB Off-Ramp

Future Total
PM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑	↑↑		↑↑	↑
Volume (vph)	0	1004	1209	0	55	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0		6.0	6.0
Lane Util. Factor		0.95	0.95		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		3471	3471		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		3471	3471		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1091	1314	0	60	11
RTOR Reduction (vph)	0	0	0	0	0	10
Lane Group Flow (vph)	0	1091	1314	0	60	1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		94.9	94.9		6.2	6.2
Effective Green, g (s)		94.9	94.9		6.2	6.2
Actuated g/C Ratio		0.84	0.84		0.05	0.05
Clearance Time (s)		6.0	6.0		6.0	6.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		2912	2912		184	85
v/s Ratio Prot		0.31	c0.38		c0.02	0.00
v/s Ratio Perm						
v/c Ratio		0.37	0.45		0.33	0.01
Uniform Delay, d1		2.1	2.4		51.4	50.5
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.4	0.5		1.0	0.0
Delay (s)		2.5	2.9		52.5	50.6
Level of Service		A	A		D	D
Approach Delay (s)		2.5	2.9		52.2	
Approach LOS		A	A		D	

Intersection Summary

HCM 2000 Control Delay	4.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.44		
Actuated Cycle Length (s)	113.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	79.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
 3: Hwy 407 EB Off-Ramp & Brock Rd/Brock Road

Future Total
 PM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	1091	1776	408	1386
v/c Ratio	0.63	1.02	0.58	1.12
Control Delay	23.9	58.0	31.5	94.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	23.9	58.0	31.5	94.3
Queue Length 50th (m)	100.6	~246.5	77.1	~215.9
Queue Length 95th (m)	123.4	#291.0	110.5	#264.5
Internal Link Dist (m)	299.7	281.8	440.6	
Turn Bay Length (m)				120.0
Base Capacity (vph)	1735	1735	708	1242
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.63	1.02	0.58	1.12

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Rd/Brock Road

Future Total
PM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑			↑↑	↘	↘↘
Volume (vph)	1004	0	0	1634	375	1275
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	6.0	3.0
Lane Util. Factor	0.95			0.95	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	3471			3471	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	3471			3471	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1091	0	0	1776	408	1386
RTOR Reduction (vph)	0	0	0	0	0	58
Lane Group Flow (vph)	1091	0	0	1776	408	1328
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	59.0			59.0	49.0	49.0
Effective Green, g (s)	60.0			60.0	49.0	52.0
Actuated g/C Ratio	0.50			0.50	0.41	0.43
Clearance Time (s)	6.0			6.0	6.0	6.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	1735			1735	708	1184
v/s Ratio Prot	0.31			c0.51	0.24	c0.49
v/s Ratio Perm						
v/c Ratio	0.63			1.02	0.58	1.12
Uniform Delay, d1	21.9			30.0	27.5	34.0
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	1.7			27.8	1.1	66.2
Delay (s)	23.6			57.8	28.6	100.2
Level of Service	C			E	C	F
Approach Delay (s)	23.6			57.8	83.9	
Approach LOS	C			E	F	

Intersection Summary

HCM 2000 Control Delay	59.9	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.10		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	79.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Future Total
PM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	SBL	SBT	SBR
Lane Group Flow (vph)	249	361	60	49	111	1609	27	2283	167
v/c Ratio	0.77	0.79	0.19	0.15	0.70	0.64	0.18	1.04	0.16
Control Delay	59.1	48.5	38.9	9.4	41.4	10.2	13.9	51.6	3.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	59.1	48.5	38.9	9.4	41.4	10.2	13.9	51.6	3.4
Queue Length 50th (m)	54.9	73.2	11.8	0.0	8.9	88.3	2.4	~299.4	3.4
Queue Length 95th (m)	83.4	109.4	23.7	9.0	#41.1	140.0	9.0	#384.4	13.6
Internal Link Dist (m)						196.9		152.6	
Turn Bay Length (m)		110.0			150.0				90.0
Base Capacity (vph)	449	455	449	443	159	2509	148	2201	1030
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.55	0.79	0.13	0.11	0.70	0.64	0.18	1.04	0.16

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

5: Brock Rd & E-W Residential Collector 2

Future Total
PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	229	0	332	55	0	45	102	1470	10	25	2100	154
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		4.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.95		1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	3468		1736	3471	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.05	1.00		0.13	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	97	3468		234	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	249	0	361	60	0	49	111	1598	11	27	2283	167
RTOR Reduction (vph)	0	0	14	0	0	40	0	0	0	0	0	46
Lane Group Flow (vph)	249	0	347	60	0	9	111	1609	0	27	2283	121
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		pm+ov	Perm		Perm	pm+pt	NA		Perm	NA	Perm
Protected Phases			5				5	2			6	
Permitted Phases	4		4	8		8	2			6		6
Actuated Green, G (s)	21.0		27.0	21.0		21.0	81.2	81.2		71.2	71.2	71.2
Effective Green, g (s)	21.0		27.0	21.0		21.0	81.2	81.2		71.2	71.2	71.2
Actuated g/C Ratio	0.19		0.24	0.19		0.19	0.72	0.72		0.63	0.63	0.63
Clearance Time (s)	5.0		4.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	324		373	324		290	157	2509		148	2202	985
v/s Ratio Prot			c0.05				0.04	0.46			c0.66	
v/s Ratio Perm	0.14		0.17	0.03		0.01	0.47			0.12		0.08
v/c Ratio	0.77		0.93	0.19		0.03	0.71	0.64		0.18	1.04	0.12
Uniform Delay, d1	43.3		41.7	38.4		37.3	31.4	8.0		8.5	20.5	8.1
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	10.5		29.6	0.3		0.0	13.5	1.3		2.7	29.5	0.3
Delay (s)	53.8		71.3	38.7		37.3	44.9	9.3		11.2	50.0	8.4
Level of Service	D		E	D		D	D	A		B	D	A
Approach Delay (s)		64.2			38.1			11.6			46.8	
Approach LOS		E			D			B			D	

Intersection Summary

HCM 2000 Control Delay	36.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	1.01		
Actuated Cycle Length (s)	112.2	Sum of lost time (s)	14.0
Intersection Capacity Utilization	92.8%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Future Total
PM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	33	152	217	44	272	1703	114	99	2655	24
v/c Ratio	0.17	0.66	1.49	0.19	1.25	0.76	0.11	0.54	1.24	0.02
Control Delay	37.8	33.6	284.9	21.4	171.1	16.7	2.6	22.2	136.6	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.8	33.6	284.9	21.4	171.1	16.7	2.6	22.2	136.6	0.0
Queue Length 50th (m)	6.1	12.3	~65.6	2.2	~57.0	122.0	1.2	4.7	~374.8	0.0
Queue Length 95th (m)	14.7	33.2	#113.6	12.9	#119.1	181.2	8.6	#20.7	#457.3	0.0
Internal Link Dist (m)		200.4		197.2		273.0			178.6	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	200	433	146	393	218	2233	1033	182	2134	990
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.35	1.49	0.11	1.25	0.76	0.11	0.54	1.24	0.02























Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Brock Rd & Street 20H

Future Total
PM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	20	120	200	10	30	250	1567	105	91	2443	22
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.87		1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736	1593		1736	1621		1736	3471	1553	1736	3471	1553
Flt Permitted	0.73	1.00		0.38	1.00		0.06	1.00	1.00	0.07	1.00	1.00
Satd. Flow (perm)	1331	1593		690	1621		107	3471	1553	135	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	22	130	217	11	33	272	1703	114	99	2655	24
RTOR Reduction (vph)	0	83	0	0	29	0	0	0	35	0	0	9
Lane Group Flow (vph)	33	69	0	217	15	0	272	1703	79	99	2655	15
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2		2	6		6
Actuated Green, G (s)	13.6	11.3		17.0	13.0		77.1	68.1	68.1	71.1	65.1	65.1
Effective Green, g (s)	13.6	11.3		17.0	13.0		77.1	68.1	68.1	71.1	65.1	65.1
Actuated g/C Ratio	0.13	0.11		0.16	0.12		0.72	0.63	0.63	0.66	0.61	0.61
Clearance Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	177	167		148	196		213	2200	984	178	2103	941
v/s Ratio Prot	0.00	0.04		c0.05	0.01		c0.11	0.49		0.03	0.76	
v/s Ratio Perm	0.02			c0.18			c0.81		0.05	0.34		0.01
v/c Ratio	0.19	0.41		1.47	0.08		1.28	0.77	0.08	0.56	1.26	0.02
Uniform Delay, d1	41.8	44.9		45.0	41.9		37.4	14.1	7.6	13.8	21.2	8.4
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	1.7		242.8	0.2		155.8	2.7	0.2	3.7	122.1	0.0
Delay (s)	42.3	46.6		287.9	42.0		193.2	16.9	7.7	17.5	143.2	8.4
Level of Service	D	D		F	D		F	B	A	B	F	A
Approach Delay (s)		45.8			246.4			39.3			137.6	
Approach LOS		D			F			D			F	

Intersection Summary

HCM 2000 Control Delay	101.1	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.37		
Actuated Cycle Length (s)	107.4	Sum of lost time (s)	18.0
Intersection Capacity Utilization	115.9%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Appendix C – Future (2031) Total with Mitigation Synchro Output

Queues
1: Hwy 7 & Brock Rd

Mitigation - HOV Lane
AM Peak Hour



























Lane Group	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	5	738	120	1040	238	12	11	141	312	41	706
v/c Ratio	0.02	0.78	0.26	0.85	0.10	0.01	0.18	0.17	0.31	0.14	0.84
Control Delay	37.6	47.5	23.0	41.0	7.3	2.3	42.1	35.0	8.5	35.4	52.2
Queue Delay	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.6	47.5	23.0	41.8	7.3	2.3	42.1	35.0	8.5	35.4	52.2
Queue Length 50th (m)	0.9	88.6	12.2	117.8	10.0	0.0	2.1	14.1	27.3	7.7	84.8
Queue Length 95th (m)	4.7	#146.0	31.7	136.3	15.8	1.7	7.9	22.8	33.2	17.5	108.0
Internal Link Dist (m)		445.3			141.0			290.1			315.9
Turn Bay Length (m)	216.0			120.0		110.0	162.0			230.0	
Base Capacity (vph)	301	949	465	1452	2335	1050	72	958	1115	334	958
Starvation Cap Reductn	0	0	0	170	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.78	0.26	0.81	0.10	0.01	0.15	0.15	0.28	0.12	0.74

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Mitigation - HOV Lane
AM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	5	679	110	957	219	11	10	130	287	38	645	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	4.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1553	3367	3471	1553	1736	3471	1553	1736	3467	
Flt Permitted	0.60	1.00	1.00	0.95	1.00	1.00	0.14	1.00	1.00	0.66	1.00	
Satd. Flow (perm)	1103	3471	1553	3367	3471	1553	261	3471	1553	1210	3467	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	5	738	120	1040	238	12	11	141	312	41	701	5
RTOR Reduction (vph)	0	0	40	0	0	4	0	0	7	0	1	0
Lane Group Flow (vph)	5	738	80	1040	238	8	11	141	305	41	705	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA	Perm	Prot	NA	Perm	Perm	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2			4	5		8	
Permitted Phases	6		6			2	4		4	8		
Actuated Green, G (s)	31.8	31.8	31.8	42.3	78.1	78.1	28.0	28.0	70.3	28.0	28.0	
Effective Green, g (s)	31.8	31.8	31.8	42.3	78.1	78.1	28.0	28.0	70.3	28.0	28.0	
Actuated g/C Ratio	0.27	0.27	0.27	0.36	0.67	0.67	0.24	0.24	0.61	0.24	0.24	
Clearance Time (s)	5.0	5.0	5.0	4.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	302	950	425	1226	2334	1044	62	837	940	291	836	
v/s Ratio Prot		c0.21		c0.31	0.07			0.04	0.12		c0.20	
v/s Ratio Perm	0.00		0.05			0.01	0.04		0.08	0.03		
v/c Ratio	0.02	0.78	0.19	0.85	0.10	0.01	0.18	0.17	0.32	0.14	0.84	
Uniform Delay, d1	30.7	38.9	32.3	33.9	6.7	6.3	34.9	34.8	11.2	34.6	42.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.1	6.2	1.0	5.6	0.1	0.0	1.4	0.1	0.2	0.2	7.8	
Delay (s)	30.8	45.1	33.3	39.6	6.8	6.3	36.3	34.9	11.4	34.8	49.7	
Level of Service	C	D	C	D	A	A	D	C	B	C	D	
Approach Delay (s)		43.4			33.2			19.2			48.9	
Approach LOS		D			C			B			D	

Intersection Summary

HCM 2000 Control Delay	37.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	116.1	Sum of lost time (s)	14.0
Intersection Capacity Utilization	83.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Queues
2: Brock Rd & Hwy 407 WB Off-Ramp

Mitigation - HOV Lane
AM Peak Hour

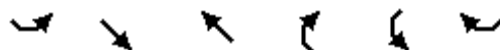


Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	670	1146	141	49
v/c Ratio	0.24	0.40	0.47	0.27
Control Delay	2.6	3.3	51.5	16.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	2.6	3.3	51.5	16.3
Queue Length 50th (m)	13.4	27.6	15.4	0.0
Queue Length 95th (m)	20.7	41.0	25.0	11.3
Internal Link Dist (m)	141.0	289.0	271.3	
Turn Bay Length (m)				140.0
Base Capacity (vph)	2842	2842	765	391
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.24	0.40	0.18	0.13
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

2: Brock Rd & Hwy 407 WB Off-Ramp

Mitigation - HOV Lane
AM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑	↑↑		↑↑	↑
Volume (vph)	0	616	1054	0	130	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	5.0
Lane Util. Factor		0.95	0.95		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		3471	3471		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		3471	3471		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	670	1146	0	141	49
RTOR Reduction (vph)	0	0	0	0	0	45
Lane Group Flow (vph)	0	670	1146	0	141	4
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		90.1	90.1		9.9	9.9
Effective Green, g (s)		90.1	90.1		9.9	9.9
Actuated g/C Ratio		0.82	0.82		0.09	0.09
Clearance Time (s)		5.0	5.0		5.0	5.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		2843	2843		303	139
v/s Ratio Prot		0.19	c0.33		c0.04	0.00
v/s Ratio Perm						
v/c Ratio		0.24	0.40		0.47	0.03
Uniform Delay, d1		2.2	2.7		47.5	45.7
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.2	0.4		1.1	0.1
Delay (s)		2.4	3.1		48.7	45.8
Level of Service		A	A		D	D
Approach Delay (s)		2.4	3.1		47.9	
Approach LOS		A	A		D	

Intersection Summary

HCM 2000 Control Delay	7.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	63.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - HOV Lane
AM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	777	1840	158	630
v/c Ratio	0.29	0.70	0.62	0.82
Control Delay	4.8	9.2	54.0	22.4
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	4.8	9.2	54.0	22.4
Queue Length 50th (m)	22.1	86.6	33.2	23.0
Queue Length 95th (m)	42.4	159.6	54.8	46.5
Internal Link Dist (m)	289.0	281.3	391.1	
Turn Bay Length (m)				120.0
Base Capacity (vph)	2640	2640	450	1032
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.29	0.70	0.35	0.61

Intersection Summary

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - HOV Lane
AM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑			↑↑	↘	↘↘
Volume (vph)	715	0	0	1693	145	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	5.0	5.0
Lane Util. Factor	0.95			0.95	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	3471			3471	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	3471			3471	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	777	0	0	1840	158	630
RTOR Reduction (vph)	0	0	0	0	0	372
Lane Group Flow (vph)	777	0	0	1840	158	258
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	82.2			82.2	15.8	15.8
Effective Green, g (s)	82.2			82.2	15.8	15.8
Actuated g/C Ratio	0.76			0.76	0.15	0.15
Clearance Time (s)	5.0			5.0	5.0	5.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	2641			2641	253	399
v/s Ratio Prot	0.22			c0.53	0.09	c0.09
v/s Ratio Perm						
v/c Ratio	0.29			0.70	0.62	0.65
Uniform Delay, d1	4.0			6.6	43.3	43.5
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	0.3			1.5	4.7	3.6
Delay (s)	4.3			8.1	48.1	47.0
Level of Service	A			A	D	D
Approach Delay (s)	4.3			8.1	47.2	
Approach LOS	A			A	D	

Intersection Summary

HCM 2000 Control Delay	16.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.69		
Actuated Cycle Length (s)	108.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	63.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Mitigation - HOV Lane
AM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	175	121	5	11	337	1716	43	49	1076	250
v/c Ratio	0.67	0.36	0.02	0.04	0.71	0.66	0.04	0.35	0.56	0.26
Control Delay	54.5	10.1	36.4	0.3	18.0	8.4	1.4	26.3	18.2	2.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	54.5	10.1	36.4	0.3	18.0	8.4	1.4	26.3	18.2	2.8
Queue Length 50th (m)	35.5	0.0	0.9	0.0	19.4	78.0	0.0	5.5	74.6	0.0
Queue Length 95th (m)	58.0	15.8	4.3	0.0	57.4	127.1	3.1	20.8	120.6	13.8
Internal Link Dist (m)						200.3			128.4	
Turn Bay Length (m)		110.0			150.0					90.0
Base Capacity (vph)	536	563	536	517	561	2613	1179	140	1922	971
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.33	0.21	0.01	0.02	0.60	0.66	0.04	0.35	0.56	0.26

Intersection Summary

HCM Signalized Intersection Capacity Analysis
5: Brock Rd & E-W Residential Collector 2

Mitigation - HOV Lane
AM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	161	0	111	5	0	10	310	1579	40	45	990	230
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0	5.0		5.0	4.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	3471	1553	1736	3471	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.18	1.00	1.00	0.14	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	326	3471	1553	253	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	175	0	121	5	0	11	337	1716	43	49	1076	250
RTOR Reduction (vph)	0	0	103	0	0	9	0	0	11	0	0	111
Lane Group Flow (vph)	175	0	18	5	0	2	337	1716	32	49	1076	139
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		Perm	Perm		Perm	pm+pt	NA	Perm	Perm	NA	Perm
Protected Phases							5	2			6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	15.6		15.6	15.6		15.6	78.1	78.1	78.1	57.5	57.5	57.5
Effective Green, g (s)	15.6		15.6	15.6		15.6	78.1	78.1	78.1	57.5	57.5	57.5
Actuated g/C Ratio	0.15		0.15	0.15		0.15	0.75	0.75	0.75	0.55	0.55	0.55
Clearance Time (s)	5.0		5.0	5.0		5.0	4.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	261		233	261		233	471	2614	1169	140	1924	861
v/s Ratio Prot							c0.11	0.49			0.31	
v/s Ratio Perm	c0.10		0.01	0.00		0.00	c0.42		0.02	0.19		0.09
v/c Ratio	0.67		0.08	0.02		0.01	0.72	0.66	0.03	0.35	0.56	0.16
Uniform Delay, d1	41.6		37.9	37.5		37.5	10.9	6.2	3.2	12.8	14.9	11.3
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	6.6		0.1	0.0		0.0	5.1	1.3	0.0	6.8	1.2	0.4
Delay (s)	48.2		38.0	37.6		37.5	16.1	7.6	3.3	19.5	16.1	11.7
Level of Service	D		D	D		D	B	A	A	B	B	B
Approach Delay (s)		44.1			37.5			8.8			15.4	
Approach LOS		D			D			A			B	

Intersection Summary		
HCM 2000 Control Delay	14.1	HCM 2000 Level of Service
HCM 2000 Volume to Capacity ratio	0.73	B
Actuated Cycle Length (s)	103.7	Sum of lost time (s)
Intersection Capacity Utilization	68.4%	14.0
Analysis Period (min)	15	ICU Level of Service
		C

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Mitigation - HOV Lane
AM Peak Hour

























Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	18	70	141	34	98	2039	92	28	1198	11
v/c Ratio	0.19	0.43	0.62	0.12	0.33	0.81	0.08	0.40	0.54	0.01
Control Delay	49.6	25.7	49.0	26.4	7.6	13.7	2.0	31.9	12.0	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	49.6	25.7	49.0	26.4	7.6	13.7	2.0	31.9	12.0	0.0
Queue Length 50th (m)	3.7	3.2	25.9	4.0	5.3	137.7	1.1	2.7	70.2	0.0
Queue Length 95th (m)	11.1	17.1	44.8	12.5	11.4	198.8	6.1	#17.3	97.1	0.0
Internal Link Dist (m)		115.6		96.1		192.9			179.2	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	312	417	229	578	298	2528	1150	70	2225	1028
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.17	0.62	0.06	0.33	0.81	0.08	0.40	0.54	0.01

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
7: Brock Rd & Street 20H

Mitigation - HOV Lane
AM Peak Hour












												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	17	15	50	130	5	27	90	1876	85	26	1102	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0		4.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.88		1.00	0.87		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736	1616		1736	1593		1736	3471	1553	1736	3471	1553
Flt Permitted	0.73	1.00		0.43	1.00		0.17	1.00	1.00	0.06	1.00	1.00
Satd. Flow (perm)	1343	1616		790	1593		310	3471	1553	110	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	18	16	54	141	5	29	98	2039	92	28	1198	11
RTOR Reduction (vph)	0	51	0	0	9	0	0	0	20	0	0	4
Lane Group Flow (vph)	18	19	0	141	25	0	98	2039	72	28	1198	7
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		pm+pt	NA		pm+pt	NA	Perm	Perm	NA	Perm
Protected Phases		4		3	8		5	2			6	
Permitted Phases	4			8			2		2	6		6
Actuated Green, G (s)	6.2	6.2		19.1	19.1		75.2	75.2	75.2	66.2	66.2	66.2
Effective Green, g (s)	6.2	6.2		19.1	19.1		75.2	75.2	75.2	66.2	66.2	66.2
Actuated g/C Ratio	0.06	0.06		0.18	0.18		0.72	0.72	0.72	0.63	0.63	0.63
Clearance Time (s)	5.0	5.0		4.0	5.0		4.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	79	96		225	291		291	2502	1119	69	2203	985
v/s Ratio Prot		0.01		c0.05	0.02		0.02	c0.59			0.35	
v/s Ratio Perm	0.01			c0.06			0.23		0.05	0.25		0.00
v/c Ratio	0.23	0.20		0.63	0.09		0.34	0.81	0.06	0.41	0.54	0.01
Uniform Delay, d1	46.8	46.7		38.0	35.4		6.7	9.8	4.3	9.4	10.6	7.0
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	1.0		5.4	0.1		0.7	3.1	0.1	16.8	1.0	0.0
Delay (s)	48.2	47.7		43.3	35.5		7.4	12.9	4.4	26.1	11.6	7.0
Level of Service	D	D		D	D		A	B	A	C	B	A
Approach Delay (s)		47.8			41.8			12.3			11.9	
Approach LOS		D			D			B			B	

Intersection Summary		
HCM 2000 Control Delay	14.4	HCM 2000 Level of Service
HCM 2000 Volume to Capacity ratio	0.84	B
Actuated Cycle Length (s)	104.3	Sum of lost time (s)
Intersection Capacity Utilization	81.6%	18.0
Analysis Period (min)	15	ICU Level of Service
		D

c Critical Lane Group






























Queues
1: Hwy 7 & Brock Rd

Mitigation - HOV Lane
PM Peak Hour

											
Lane Group	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	11	311	16	374	830	23	234	701	880	23	163
v/c Ratio	0.07	0.35	0.03	0.30	0.36	0.02	0.79	0.81	0.82	0.32	0.31
Control Delay	38.3	37.2	0.1	25.4	9.6	0.2	55.2	46.4	17.8	53.0	40.1
Queue Delay	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.3	37.2	0.1	25.4	9.9	0.2	55.2	46.4	17.8	53.0	40.1
Queue Length 50th (m)	2.0	31.8	0.0	28.8	40.6	0.0	45.1	78.1	98.1	4.7	16.4
Queue Length 95th (m)	7.7	49.5	0.0	44.8	63.3	0.5	69.5	99.8	155.6	13.3	26.5
Internal Link Dist (m)	445.3			151.4			290.1			479.4	
Turn Bay Length (m)	216.0			120.0			110.0	162.0		230.0	
Base Capacity (vph)	158	889	465	1354	2284	1040	297	1205	1127	118	850
Starvation Cap Reductn	0	0	0	0	796	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.07	0.35	0.03	0.28	0.56	0.02	0.79	0.58	0.78	0.19	0.19
Intersection Summary											

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Mitigation - HOV Lane
PM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		 		 	 			 			 	
Volume (vph)	10	286	15	344	764	21	215	645	810	21	135	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	1.00	0.95	1.00	1.00	0.95	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3471	1553	3367	3471	1553	1736	3471	1553	1736	3420	
Flt Permitted	0.34	1.00	1.00	0.95	1.00	1.00	0.52	1.00	1.00	0.26	1.00	
Satd. Flow (perm)	620	3471	1553	3367	3471	1553	954	3471	1553	482	3420	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	311	16	374	830	23	234	701	880	23	147	16
RTOR Reduction (vph)	0	0	12	0	0	8	0	0	54	0	8	0
Lane Group Flow (vph)	11	311	4	374	830	15	234	701	826	23	155	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA	Perm	Prot	NA	Perm	pm+pt	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2		7	4	5		8	
Permitted Phases	6		6			2	4		4	8		
Actuated Green, G (s)	28.2	28.2	28.2	40.0	72.2	72.2	27.5	27.5	67.5	16.5	16.5	
Effective Green, g (s)	28.2	28.2	28.2	40.0	72.2	72.2	27.5	27.5	67.5	16.5	16.5	
Actuated g/C Ratio	0.26	0.26	0.26	0.36	0.66	0.66	0.25	0.25	0.62	0.15	0.15	
Clearance Time (s)	5.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	159	892	399	1227	2284	1022	289	870	955	72	514	
v/s Ratio Prot		0.09		0.11	c0.24		0.05	0.20	c0.32		0.05	
v/s Ratio Perm	0.02		0.00			0.01	0.15		0.22	0.05		
v/c Ratio	0.07	0.35	0.01	0.30	0.36	0.01	0.81	0.81	0.86	0.32	0.30	
Uniform Delay, d1	30.8	33.3	30.4	24.9	8.4	6.5	38.0	38.6	17.3	41.6	41.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.8	1.1	0.0	0.1	0.4	0.0	15.3	5.5	8.2	2.6	0.3	
Delay (s)	31.7	34.3	30.4	25.1	8.9	6.5	53.2	44.1	25.6	44.1	41.8	
Level of Service	C	C	C	C	A	A	D	D	C	D	D	
Approach Delay (s)		34.1			13.8			36.3			42.1	
Approach LOS		C			B			D			D	
Intersection Summary												
HCM 2000 Control Delay			28.6									HCM 2000 Level of Service C
HCM 2000 Volume to Capacity ratio			0.76									
Actuated Cycle Length (s)			109.7									Sum of lost time (s) 18.0
Intersection Capacity Utilization			73.1%									ICU Level of Service D
Analysis Period (min)			15									

c Critical Lane Group

Queues
2: Hwy 407 WB Off-Ramp

Mitigation - HOV Lane
PM Peak Hour



Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	983	1183	60	11
v/c Ratio	0.32	0.39	0.28	0.10
Control Delay	2.0	2.2	54.2	26.3
Queue Delay	0.3	0.0	0.0	0.0
Total Delay	2.3	2.2	54.2	26.3
Queue Length 50th (m)	18.4	24.3	7.3	0.0
Queue Length 95th (m)	26.3	34.1	13.6	5.9
Internal Link Dist (m)	151.4	299.7	325.8	
Turn Bay Length (m)				140.0
Base Capacity (vph)	3044	3044	707	335
Starvation Cap Reductn	1264	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.55	0.39	0.08	0.03
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

2: Hwy 407 WB Off-Ramp

Mitigation - HOV Lane
PM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑	↑↑		↑↑	↑
Volume (vph)	0	904	1088	0	55	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	5.0
Lane Util. Factor		0.95	0.95		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		3471	3471		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		3471	3471		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	983	1183	0	60	11
RTOR Reduction (vph)	0	0	0	0	0	10
Lane Group Flow (vph)	0	983	1183	0	60	1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		99.3	99.3		6.2	6.2
Effective Green, g (s)		99.3	99.3		6.2	6.2
Actuated g/C Ratio		0.86	0.86		0.05	0.05
Clearance Time (s)		5.0	5.0		5.0	5.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		2984	2984		180	83
v/s Ratio Prot		0.28	c0.34		c0.02	0.00
v/s Ratio Perm						
v/c Ratio		0.33	0.40		0.33	0.01
Uniform Delay, d1		1.6	1.7		52.7	51.7
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.3	0.4		1.1	0.0
Delay (s)		1.9	2.1		53.8	51.8
Level of Service		A	A		D	D
Approach Delay (s)		1.9	2.1		53.4	
Approach LOS		A	A		D	

Intersection Summary

HCM 2000 Control Delay	3.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.39		
Actuated Cycle Length (s)	115.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	77.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - HOV Lane
PM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	983	1599	408	1386
v/c Ratio	0.61	0.99	0.52	1.07
Control Delay	25.8	51.6	26.8	76.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	25.8	51.6	26.8	76.8
Queue Length 50th (m)	92.9	201.1	71.1	~207.6
Queue Length 95th (m)	115.0	#258.7	102.0	#256.1
Internal Link Dist (m)	299.7	281.8	440.6	
Turn Bay Length (m)				120.0
Base Capacity (vph)	1619	1619	781	1293
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.61	0.99	0.52	1.07

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - HOV Lane
PM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑			↑↑	↘	↗
Volume (vph)	904	0	0	1471	375	1275
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	5.0	5.0
Lane Util. Factor	0.95			0.95	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	3471			3471	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	3471			3471	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	983	0	0	1599	408	1386
RTOR Reduction (vph)	0	0	0	0	0	63
Lane Group Flow (vph)	983	0	0	1599	408	1323
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	56.0			56.0	54.0	54.0
Effective Green, g (s)	56.0			56.0	54.0	54.0
Actuated g/C Ratio	0.47			0.47	0.45	0.45
Clearance Time (s)	5.0			5.0	5.0	5.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	1619			1619	781	1229
v/s Ratio Prot	0.28			c0.46	0.24	c0.48
v/s Ratio Perm						
v/c Ratio	0.61			0.99	0.52	1.08
Uniform Delay, d1	23.8			31.7	23.7	33.0
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	1.7			19.6	0.6	48.8
Delay (s)	25.5			51.3	24.4	81.8
Level of Service	C			D	C	F
Approach Delay (s)	25.5			51.3	68.8	
Approach LOS	C			D	E	

Intersection Summary

HCM 2000 Control Delay	52.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	1.03		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	77.9%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Mitigation - HOV Lane
PM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	249	361	60	49	111	1438	11	27	2054	167
v/c Ratio	0.75	0.74	0.18	0.14	0.58	0.58	0.01	0.15	0.98	0.17
Control Delay	54.6	40.3	36.1	9.0	27.3	9.2	1.9	13.4	36.5	4.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	54.6	40.3	36.1	9.0	27.3	9.2	1.9	13.4	36.5	4.1
Queue Length 50th (m)	51.0	65.7	10.9	0.0	6.6	69.2	0.0	2.4	210.3	3.8
Queue Length 95th (m)	78.7	98.6	22.4	8.7	#28.4	113.7	1.5	8.6	#322.7	14.9
Internal Link Dist (m)						196.9			152.6	
Turn Bay Length (m)		110.0			150.0					90.0
Base Capacity (vph)	578	501	578	553	202	2476	1113	186	2104	988
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.43	0.72	0.10	0.09	0.55	0.58	0.01	0.15	0.98	0.17

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

5: Brock Rd & E-W Residential Collector 2

Mitigation - HOV Lane
PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	229	0	332	55	0	45	102	1323	10	25	1890	154
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		4.0	5.0		5.0	4.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	3471	1553	1736	3471	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.06	1.00	1.00	0.17	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	108	3471	1553	308	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	249	0	361	60	0	49	111	1438	11	27	2054	167
RTOR Reduction (vph)	0	0	13	0	0	40	0	0	3	0	0	47
Lane Group Flow (vph)	249	0	348	60	0	9	111	1438	8	27	2054	120
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		pm+ov	Perm		Perm	pm+pt	NA	Perm	Perm	NA	Perm
Protected Phases			5				5	2			6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	20.2		27.5	20.2		20.2	75.2	75.2	75.2	63.9	63.9	63.9
Effective Green, g (s)	20.2		27.5	20.2		20.2	75.2	75.2	75.2	63.9	63.9	63.9
Actuated g/C Ratio	0.19		0.26	0.19		0.19	0.71	0.71	0.71	0.61	0.61	0.61
Clearance Time (s)	5.0		4.0	5.0		5.0	4.0	5.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	332		405	332		297	189	2476	1108	186	2104	941
v/s Ratio Prot			c0.06				0.04	0.41			c0.59	
v/s Ratio Perm	0.14		0.16	0.03		0.01	0.38		0.01	0.09		0.08
v/c Ratio	0.75		0.86	0.18		0.03	0.59	0.58	0.01	0.15	0.98	0.13
Uniform Delay, d1	40.2		37.1	35.7		34.6	25.1	7.4	4.3	9.0	20.0	8.9
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	9.2		16.3	0.3		0.0	4.6	1.0	0.0	1.6	14.8	0.3
Delay (s)	49.4		53.4	35.9		34.7	29.7	8.4	4.4	10.6	34.8	9.1
Level of Service	D		D	D		C	C	A	A	B	C	A
Approach Delay (s)		51.8			35.4			9.9			32.6	
Approach LOS		D			D			A			C	
Intersection Summary												
HCM 2000 Control Delay			27.4									C
HCM 2000 Volume to Capacity ratio			0.94									
Actuated Cycle Length (s)			105.4								14.0	
Intersection Capacity Utilization			87.0%									E
Analysis Period (min)			15									

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Mitigation - HOV Lane
PM Peak Hour

























Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	33	152	217	44	272	1533	114	99	2390	24
v/c Ratio	0.15	0.64	1.25	0.20	1.24	0.72	0.11	0.44	1.15	0.02
Control Delay	36.2	26.0	185.3	22.3	169.1	16.8	2.8	12.4	96.0	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	36.2	26.0	185.3	22.3	169.1	16.8	2.8	12.4	96.0	0.0
Queue Length 50th (m)	5.9	6.0	~50.5	2.3	~55.5	106.4	1.0	4.9	~313.3	0.0
Queue Length 95th (m)	14.3	26.2	#88.9	13.1	#117.9	160.0	8.9	13.2	#392.4	0.0
Internal Link Dist (m)		200.4		197.2		273.0			178.6	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	230	444	174	380	219	2143	997	238	2080	967
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.14	0.34	1.25	0.12	1.24	0.72	0.11	0.42	1.15	0.02

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
7: Brock Rd & Street 20H

Mitigation - HOV Lane
PM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	20	120	200	10	30	250	1410	105	91	2199	22
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.95	1.00	1.00	0.95	1.00
Frt	1.00	0.87		1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1736	1593		1736	1621		1736	3471	1553	1736	3471	1553
Flt Permitted	0.73	1.00		0.32	1.00		0.06	1.00	1.00	0.10	1.00	1.00
Satd. Flow (perm)	1331	1593		580	1621		112	3471	1553	175	3471	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	22	130	217	11	33	272	1533	114	99	2390	24
RTOR Reduction (vph)	0	112	0	0	29	0	0	0	39	0	0	10
Lane Group Flow (vph)	33	40	0	217	15	0	272	1533	75	99	2390	14
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2		2	6		6
Actuated Green, G (s)	13.8	9.7		19.6	12.6		74.0	65.0	65.0	70.2	63.1	63.1
Effective Green, g (s)	13.8	9.7		19.6	12.6		74.0	65.0	65.0	70.2	63.1	63.1
Actuated g/C Ratio	0.13	0.09		0.18	0.12		0.69	0.61	0.61	0.66	0.59	0.59
Clearance Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	187	144		182	191		214	2112	945	218	2050	917
v/s Ratio Prot	0.01	0.03		c0.08	0.01		c0.11	0.44		0.03	0.69	
v/s Ratio Perm	0.02			c0.14			c0.77		0.05	0.27		0.01
v/c Ratio	0.18	0.28		1.19	0.08		1.27	0.73	0.08	0.45	1.17	0.02
Uniform Delay, d1	41.3	45.3		42.3	41.9		36.3	14.7	8.6	11.7	21.8	9.0
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	0.5	1.1		128.0	0.2		153.3	2.2	0.2	1.5	80.4	0.0
Delay (s)	41.7	46.3		170.3	42.1		189.7	16.9	8.8	13.2	102.2	9.1
Level of Service	D	D		F	D		F	B	A	B	F	A
Approach Delay (s)		45.5			148.6			40.9			97.8	
Approach LOS		D			F			D			F	

Intersection Summary

HCM 2000 Control Delay	76.2	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.32		
Actuated Cycle Length (s)	106.8	Sum of lost time (s)	18.0
Intersection Capacity Utilization	109.2%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues
1: Hwy 7 & Brock Rd

Mitigation - GP Lane
AM Peak Hour
































Lane Group	SEL	SET	NWL	NWT	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	5	941	1040	276	11	141	312	41	706
v/c Ratio	0.02	0.70	0.85	0.08	0.18	0.17	0.31	0.14	0.84
Control Delay	37.6	42.1	41.0	6.8	42.1	35.0	8.5	35.4	52.2
Queue Delay	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.6	42.1	41.8	6.8	42.1	35.0	8.5	35.4	52.2
Queue Length 50th (m)	0.9	74.9	117.8	7.6	2.1	14.1	27.3	7.7	84.8
Queue Length 95th (m)	4.7	#111.6	136.3	11.7	7.9	22.8	33.2	17.5	108.0
Internal Link Dist (m)		445.3		141.0		290.1			315.9
Turn Bay Length (m)	216.0		120.0		162.0			230.0	
Base Capacity (vph)	287	1353	1452	3336	72	958	1115	334	958
Starvation Cap Reductn	0	0	170	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.70	0.81	0.08	0.15	0.15	0.28	0.12	0.74

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Mitigation - GP Lane
AM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		  		  	  				 			 
Volume (vph)	5	755	110	957	243	11	10	130	287	38	645	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0		5.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	0.98		1.00	0.99		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	4892		3367	4955		1736	3471	1553	1736	3467	
Flt Permitted	0.58	1.00		0.95	1.00		0.14	1.00	1.00	0.66	1.00	
Satd. Flow (perm)	1051	4892		3367	4955		261	3471	1553	1210	3467	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	5	821	120	1040	264	12	11	141	312	41	701	5
RTOR Reduction (vph)	0	15	0	0	4	0	0	0	7	0	1	0
Lane Group Flow (vph)	5	926	0	1040	272	0	11	141	305	41	705	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		Prot	NA		Perm	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2			4	5		8	
Permitted Phases	6						4		4		8	
Actuated Green, G (s)	31.8	31.8		42.3	78.1		28.0	28.0	70.3	28.0	28.0	
Effective Green, g (s)	31.8	31.8		42.3	78.1		28.0	28.0	70.3	28.0	28.0	
Actuated g/C Ratio	0.27	0.27		0.36	0.67		0.24	0.24	0.61	0.24	0.24	
Clearance Time (s)	5.0	5.0		4.0	5.0		5.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	287	1339		1226	3333		62	837	940	291	836	
v/s Ratio Prot		c0.19		c0.31	0.05			0.04	0.12		c0.20	
v/s Ratio Perm	0.00						0.04		0.08	0.03		
v/c Ratio	0.02	0.69		0.85	0.08		0.18	0.17	0.32	0.14	0.84	
Uniform Delay, d1	30.8	37.8		33.9	6.6		34.9	34.8	11.2	34.6	42.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.1	3.0		5.6	0.0		1.4	0.1	0.2	0.2	7.8	
Delay (s)	30.9	40.7		39.6	6.6		36.3	34.9	11.4	34.8	49.7	
Level of Service	C	D		D	A		D	C	B	C	D	
Approach Delay (s)		40.7			32.7			19.2			48.9	
Approach LOS		D			C			B			D	
Intersection Summary												
HCM 2000 Control Delay			36.5			HCM 2000 Level of Service			D			
HCM 2000 Volume to Capacity ratio			0.80									
Actuated Cycle Length (s)			116.1			Sum of lost time (s)			14.0			
Intersection Capacity Utilization			81.5%			ICU Level of Service			D			
Analysis Period (min)			15									
c	Critical Lane Group											

Queues
2: Brock Rd & Hwy 407 WB Off-Ramp

Mitigation - GP Lane
AM Peak Hour

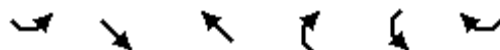


Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	745	1273	141	49
v/c Ratio	0.18	0.31	0.45	0.26
Control Delay	2.4	2.8	49.2	15.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	2.4	2.8	49.2	15.8
Queue Length 50th (m)	9.8	19.1	14.7	0.0
Queue Length 95th (m)	14.6	27.1	24.0	11.0
Internal Link Dist (m)	141.0	289.0	271.3	
Turn Bay Length (m)				140.0
Base Capacity (vph)	4055	4055	923	461
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.18	0.31	0.15	0.11
Intersection Summary				

HCM Signalized Intersection Capacity Analysis

2: Brock Rd & Hwy 407 WB Off-Ramp

Mitigation - GP Lane
AM Peak Hour



Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑↑	↑↑↑		↑↑	↑
Volume (vph)	0	685	1171	0	130	45
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	5.0
Lane Util. Factor		0.91	0.91		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		4988	4988		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		4988	4988		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	745	1273	0	141	49
RTOR Reduction (vph)	0	0	0	0	0	44
Lane Group Flow (vph)	0	745	1273	0	141	5
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		86.1	86.1		9.8	9.8
Effective Green, g (s)		86.1	86.1		9.8	9.8
Actuated g/C Ratio		0.81	0.81		0.09	0.09
Clearance Time (s)		5.0	5.0		5.0	5.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		4055	4055		311	143
v/s Ratio Prot		0.15	c0.26		c0.04	0.00
v/s Ratio Perm						
v/c Ratio		0.18	0.31		0.45	0.03
Uniform Delay, d1		2.2	2.5		45.5	43.7
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.1	0.2		1.1	0.1
Delay (s)		2.3	2.7		46.6	43.8
Level of Service		A	A		D	D
Approach Delay (s)		2.3	2.7		45.9	
Approach LOS		A	A		D	

Intersection Summary

HCM 2000 Control Delay	6.3	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.33		
Actuated Cycle Length (s)	105.9	Sum of lost time (s)	10.0
Intersection Capacity Utilization	52.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - GP Lane
AM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	864	2045	158	630
v/c Ratio	0.24	0.57	0.48	0.83
Control Delay	5.9	8.7	41.7	30.8
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	5.9	8.7	41.7	30.8
Queue Length 50th (m)	19.5	64.6	29.8	39.0
Queue Length 95th (m)	34.6	107.4	49.5	62.0
Internal Link Dist (m)	289.0	281.3	391.1	
Turn Bay Length (m)				120.0
Base Capacity (vph)	3559	3559	627	1178
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.24	0.57	0.25	0.53
Intersection Summary				

HCM Signalized Intersection Capacity Analysis
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - GP Lane
AM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑↑			↑↑↑	↘	↘
Volume (vph)	795	0	0	1881	145	580
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	5.0	5.0
Lane Util. Factor	0.91			0.91	1.00	0.88
Fr _t	1.00			1.00	1.00	0.85
Fl _t Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	4988			4988	1736	2733
Fl _t Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	4988			4988	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	864	0	0	2045	158	630
RTOR Reduction (vph)	0	0	0	0	0	242
Lane Group Flow (vph)	864	0	0	2045	158	388
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	73.3			73.3	19.4	19.4
Effective Green, g (s)	73.3			73.3	19.4	19.4
Actuated g/C Ratio	0.71			0.71	0.19	0.19
Clearance Time (s)	5.0			5.0	5.0	5.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	3560			3560	327	516
v/s Ratio Prot	0.17			c0.41	0.09	c0.14
v/s Ratio Perm						
v/c Ratio	0.24			0.57	0.48	0.75
Uniform Delay, d ₁	5.1			7.1	37.2	39.4
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d ₂	0.2			0.7	1.1	6.1
Delay (s)	5.3			7.8	38.3	45.5
Level of Service	A			A	D	D
Approach Delay (s)	5.3			7.8	44.1	
Approach LOS	A			A	D	

Intersection Summary

HCM 2000 Control Delay	14.9	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	102.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	52.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Mitigation - GP Lane
AM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	SBL	SBT	SBR
Lane Group Flow (vph)	175	121	5	11	337	1951	49	1196	250
v/c Ratio	0.67	0.36	0.02	0.04	0.76	0.53	0.52	0.46	0.27
Control Delay	54.5	10.1	36.4	0.2	24.0	7.1	44.4	17.5	3.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	54.5	10.1	36.4	0.2	24.0	7.1	44.4	17.5	3.0
Queue Length 50th (m)	35.5	0.0	0.9	0.0	26.1	56.1	6.7	57.5	0.0
Queue Length 95th (m)	58.0	15.8	4.3	0.0	65.7	84.7	#29.4	82.9	14.1
Internal Link Dist (m)						200.3		128.4	
Turn Bay Length (m)		110.0			150.0				90.0
Base Capacity (vph)	536	563	536	536	497	3649	95	2602	929
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.33	0.21	0.01	0.02	0.68	0.53	0.52	0.46	0.27

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
5: Brock Rd & E-W Residential Collector 2

Mitigation - GP Lane
AM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	161	0	111	5	0	10	310	1755	40	45	1100	230
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		6.0	6.0		6.0	6.0	6.0		6.0	6.0	6.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.91		1.00	0.91	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	4971		1736	4988	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.16	1.00		0.10	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	300	4971		183	4988	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	175	0	121	5	0	11	337	1908	43	49	1196	250
RTOR Reduction (vph)	0	0	103	0	0	9	0	1	0	0	0	120
Lane Group Flow (vph)	175	0	18	5	0	2	337	1950	0	49	1196	130
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		Perm	Perm		Perm	pm+pt	NA		Perm	NA	Perm
Protected Phases							5	2			6	
Permitted Phases	4		4	8		8	2			6		6
Actuated Green, G (s)	15.6		15.6	15.6		15.6	76.1	76.1		54.1	54.1	54.1
Effective Green, g (s)	15.6		15.6	15.6		15.6	76.1	76.1		54.1	54.1	54.1
Actuated g/C Ratio	0.15		0.15	0.15		0.15	0.73	0.73		0.52	0.52	0.52
Clearance Time (s)	6.0		6.0	6.0		6.0	6.0	6.0		6.0	6.0	6.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	261		233	261		233	441	3647		95	2602	810
v/s Ratio Prot							c0.12	0.39			0.24	
v/s Ratio Perm	c0.10		0.01	0.00		0.00	c0.44			0.27		0.08
v/c Ratio	0.67		0.08	0.02		0.01	0.76	0.53		0.52	0.46	0.16
Uniform Delay, d1	41.6		37.9	37.5		37.5	12.8	6.0		16.2	15.6	12.9
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	6.6		0.1	0.0		0.0	7.7	0.6		18.6	0.6	0.4
Delay (s)	48.2		38.0	37.6		37.5	20.5	6.6		34.8	16.2	13.4
Level of Service	D		D	D		D	C	A		C	B	B
Approach Delay (s)		44.1			37.5			8.7			16.3	
Approach LOS		D			D			A			B	

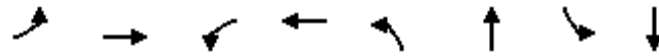
Intersection Summary

HCM 2000 Control Delay	14.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	103.7	Sum of lost time (s)	18.0
Intersection Capacity Utilization	62.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Queues
7: Brock Rd

Mitigation - GP Lane
AM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	18	70	141	34	98	2357	28	1343
v/c Ratio	0.19	0.43	0.65	0.13	0.33	0.66	0.41	0.44
Control Delay	50.1	26.0	51.6	31.5	7.4	9.5	34.1	11.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	50.1	26.0	51.6	31.5	7.4	9.5	34.1	11.6
Queue Length 50th (m)	3.7	3.3	26.3	5.0	5.3	90.4	3.0	53.5
Queue Length 95th (m)	11.0	17.3	45.2	13.8	11.3	120.0	#17.2	70.5
Internal Link Dist (m)		115.6		96.1		192.9		179.2
Turn Bay Length (m)					120.0		150.0	
Base Capacity (vph)	297	399	216	540	306	3579	69	3083
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.18	0.65	0.06	0.32	0.66	0.41	0.44

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

Mitigation - GP Lane

7: Brock Rd

AM Peak Hour



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	17	15	50	130	5	27	90	2084	85	26	1225	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0	6.0		4.0	6.0		4.0	6.0		6.0	6.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.91		1.00	0.91	
Frt	1.00	0.88		1.00	0.87		1.00	0.99		1.00	1.00	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1736	1616		1736	1593		1736	4958		1736	4981	
Flt Permitted	0.73	1.00		0.43	1.00		0.15	1.00		0.06	1.00	
Satd. Flow (perm)	1343	1616		790	1593		281	4958		113	4981	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	18	16	54	141	5	29	98	2265	92	28	1332	11
RTOR Reduction (vph)	0	51	0	0	5	0	0	3	0	0	0	0
Lane Group Flow (vph)	18	19	0	141	29	0	98	2354	0	28	1343	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		pm+pt	NA		pm+pt	NA		Perm	NA	
Protected Phases		4		3	8		5	2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	6.2	6.2		18.2	18.2		75.1	75.1		64.4	64.4	
Effective Green, g (s)	6.2	6.2		18.2	18.2		75.1	75.1		64.4	64.4	
Actuated g/C Ratio	0.06	0.06		0.17	0.17		0.71	0.71		0.61	0.61	
Clearance Time (s)	6.0	6.0		4.0	6.0		4.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	79	95		208	275		292	3536		69	3046	
v/s Ratio Prot		0.01		c0.05	0.02		0.02	c0.47			0.27	
v/s Ratio Perm	0.01			c0.07			0.22			0.25		
v/c Ratio	0.23	0.20		0.68	0.11		0.34	0.67		0.41	0.44	
Uniform Delay, d1	47.3	47.2		39.3	36.7		5.8	8.2		10.6	10.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.5	1.1		8.5	0.2		0.7	1.0		16.8	0.5	
Delay (s)	48.7	48.2		47.8	36.9		6.5	9.3		27.3	11.3	
Level of Service	D	D		D	D		A	A		C	B	
Approach Delay (s)		48.3			45.6			9.1			11.7	
Approach LOS		D			D			A			B	

Intersection Summary

HCM 2000 Control Delay	12.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	105.3	Sum of lost time (s)	20.0
Intersection Capacity Utilization	74.4%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues
1: Hwy 7 & Brock Rd

Mitigation - GP Lane
PM Peak Hour
































Lane Group	SEL	SET	NWL	NWT	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	11	362	374	946	234	701	880	23	163
v/c Ratio	0.08	0.30	0.30	0.29	0.79	0.81	0.82	0.32	0.31
Control Delay	39.0	35.9	24.8	8.7	55.2	46.4	17.9	53.0	40.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	39.0	35.9	24.8	8.7	55.2	46.4	17.9	53.0	40.1
Queue Length 50th (m)	2.0	24.9	28.8	30.0	45.1	78.1	103.3	4.7	16.4
Queue Length 95th (m)	7.8	37.6	44.8	45.3	69.5	99.8	162.5	13.3	26.5
Internal Link Dist (m)		445.3		151.4		290.1			479.4
Turn Bay Length (m)	216.0		120.0		162.0			230.0	
Base Capacity (vph)	130	1222	1354	3271	297	1205	1117	118	850
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.08	0.30	0.28	0.29	0.79	0.58	0.79	0.19	0.19

Intersection Summary

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Mitigation - GP Lane
PM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		 		 	 			 	 		 	 
Volume (vph)	10	318	15	344	849	21	215	645	810	21	135	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0		4.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	0.99		1.00	1.00		1.00	1.00	0.85	1.00	0.99	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	4954		3367	4969		1736	3471	1553	1736	3420	
Flt Permitted	0.29	1.00		0.95	1.00		0.52	1.00	1.00	0.26	1.00	
Satd. Flow (perm)	530	4954		3367	4969		954	3471	1553	482	3420	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	11	346	16	374	923	23	234	701	880	23	147	16
RTOR Reduction (vph)	0	4	0	0	2	0	0	0	41	0	8	0
Lane Group Flow (vph)	11	358	0	374	944	0	234	701	839	23	155	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		Prot	NA		pm+pt	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2		7	4	5		8	
Permitted Phases	6						4		4	8		
Actuated Green, G (s)	27.0	27.0		41.2	72.2		27.5	27.5	68.7	16.5	16.5	
Effective Green, g (s)	27.0	27.0		41.2	72.2		27.5	27.5	68.7	16.5	16.5	
Actuated g/C Ratio	0.25	0.25		0.38	0.66		0.25	0.25	0.63	0.15	0.15	
Clearance Time (s)	5.0	5.0		4.0	5.0		4.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	130	1219		1264	3270		289	870	972	72	514	
v/s Ratio Prot		0.07		0.11	c0.19		0.05	0.20	c0.32		0.05	
v/s Ratio Perm	0.02						0.15		0.22	0.05		
v/c Ratio	0.08	0.29		0.30	0.29		0.81	0.81	0.86	0.32	0.30	
Uniform Delay, d1	31.8	33.6		24.1	7.9		38.0	38.6	16.7	41.6	41.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	1.3	0.6		0.1	0.2		15.3	5.5	8.0	2.6	0.3	
Delay (s)	33.1	34.2		24.2	8.1		53.2	44.1	24.7	44.1	41.8	
Level of Service	C	C		C	A		D	D	C	D	D	
Approach Delay (s)		34.2			12.7			35.9			42.1	
Approach LOS		C			B			D			D	

Intersection Summary

HCM 2000 Control Delay	27.7	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	109.7	Sum of lost time (s)	18.0
Intersection Capacity Utilization	71.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
2: Brock Rd & Hwy 407 WB Off-Ramp

Mitigation - GP Lane
PM Peak Hour



Lane Group	SET	NWT	SWL	SWR
Lane Group Flow (vph)	1091	1314	60	11
v/c Ratio	0.25	0.30	0.28	0.10
Control Delay	1.7	1.8	54.2	26.3
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	1.7	1.8	54.2	26.3
Queue Length 50th (m)	13.1	16.7	7.3	0.0
Queue Length 95th (m)	17.9	22.7	13.6	5.9
Internal Link Dist (m)	151.4	299.7	325.8	
Turn Bay Length (m)				140.0
Base Capacity (vph)	4374	4374	707	335
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.25	0.30	0.08	0.03
Intersection Summary				

HCM Signalized Intersection Capacity Analysis
2: Brock Rd & Hwy 407 WB Off-Ramp

Mitigation - GP Lane
PM Peak Hour



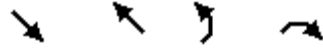
Movement	SEL	SET	NWT	NWR	SWL	SWR
Lane Configurations		↑↑↑	↑↑↑		↑↑	↑
Volume (vph)	0	1004	1209	0	55	10
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	5.0		5.0	5.0
Lane Util. Factor		0.91	0.91		0.97	1.00
Frt		1.00	1.00		1.00	0.85
Flt Protected		1.00	1.00		0.95	1.00
Satd. Flow (prot)		4988	4988		3367	1553
Flt Permitted		1.00	1.00		0.95	1.00
Satd. Flow (perm)		4988	4988		3367	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1091	1314	0	60	11
RTOR Reduction (vph)	0	0	0	0	0	10
Lane Group Flow (vph)	0	1091	1314	0	60	1
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type		NA	NA		Prot	Prot
Protected Phases		6	2		8	8
Permitted Phases						
Actuated Green, G (s)		99.3	99.3		6.2	6.2
Effective Green, g (s)		99.3	99.3		6.2	6.2
Actuated g/C Ratio		0.86	0.86		0.05	0.05
Clearance Time (s)		5.0	5.0		5.0	5.0
Vehicle Extension (s)		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		4288	4288		180	83
v/s Ratio Prot		0.22	c0.26		c0.02	0.00
v/s Ratio Perm						
v/c Ratio		0.25	0.31		0.33	0.01
Uniform Delay, d1		1.5	1.5		52.7	51.7
Progression Factor		1.00	1.00		1.00	1.00
Incremental Delay, d2		0.1	0.2		1.1	0.0
Delay (s)		1.6	1.7		53.8	51.8
Level of Service		A	A		D	D
Approach Delay (s)		1.6	1.7		53.4	
Approach LOS		A	A		D	

Intersection Summary			
HCM 2000 Control Delay	3.2	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.31		
Actuated Cycle Length (s)	115.5	Sum of lost time (s)	10.0
Intersection Capacity Utilization	72.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - GP Lane
PM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	1091	1776	408	1386
v/c Ratio	0.54	0.88	0.46	0.97
Control Delay	28.5	39.5	20.5	46.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	28.5	39.5	20.5	46.0
Queue Length 50th (m)	75.0	148.2	61.7	177.6
Queue Length 95th (m)	89.5	170.6	88.5	#240.6
Internal Link Dist (m)	299.7	281.8	440.6	
Turn Bay Length (m)				120.0
Base Capacity (vph)	2012	2012	904	1447
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.54	0.88	0.45	0.96

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation - GP Lane
PM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑↑			↑↑↑	↘	↗
Volume (vph)	1004	0	0	1634	375	1275
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	5.0	5.0
Lane Util. Factor	0.91			0.91	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	4988			4988	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	4988			4988	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1091	0	0	1776	408	1386
RTOR Reduction (vph)	0	0	0	0	0	23
Lane Group Flow (vph)	1091	0	0	1776	408	1363
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	Prot
Protected Phases	6			2	4	4
Permitted Phases						
Actuated Green, G (s)	48.0			48.0	61.0	61.0
Effective Green, g (s)	48.0			48.0	61.0	61.0
Actuated g/C Ratio	0.40			0.40	0.51	0.51
Clearance Time (s)	5.0			5.0	5.0	5.0
Vehicle Extension (s)	3.0			3.0	3.0	3.0
Lane Grp Cap (vph)	2011			2011	889	1400
v/s Ratio Prot	0.22			c0.36	0.24	c0.50
v/s Ratio Perm						
v/c Ratio	0.54			0.88	0.46	0.97
Uniform Delay, d1	27.1			32.9	18.5	28.2
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	1.1			6.1	0.4	17.9
Delay (s)	28.2			39.0	18.9	46.1
Level of Service	C			D	B	D
Approach Delay (s)	28.2			39.0	39.9	
Approach LOS	C			D	D	

Intersection Summary

HCM 2000 Control Delay	36.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.93		
Actuated Cycle Length (s)	119.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	72.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
5: Brock Rd & E-W Residential Collector 2

Mitigation - GP Lane
PM Peak Hour



Lane Group	EBL	EBR	WBL	WBR	NBL	NBT	SBL	SBT	SBR
Lane Group Flow (vph)	249	361	60	49	111	1609	27	2283	167
v/c Ratio	0.76	0.73	0.18	0.14	0.55	0.45	0.17	0.76	0.17
Control Delay	57.2	40.3	37.9	9.1	25.8	7.4	16.0	19.3	3.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	57.2	40.3	37.9	9.1	25.8	7.4	16.0	19.3	3.0
Queue Length 50th (m)	53.6	69.8	11.5	0.0	7.5	47.9	2.4	124.6	1.2
Queue Length 95th (m)	81.8	96.2	23.2	8.7	28.7	74.9	10.1	196.6	12.5
Internal Link Dist (m)						196.9		152.6	
Turn Bay Length (m)		110.0			150.0				90.0
Base Capacity (vph)	490	560	490	477	269	3586	159	3021	1000
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.51	0.64	0.12	0.10	0.41	0.45	0.17	0.76	0.17

Intersection Summary

HCM Signalized Intersection Capacity Analysis

5: Brock Rd & E-W Residential Collector 2

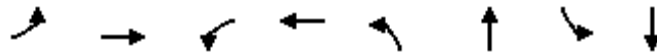
Mitigation - GP Lane
PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	229	0	332	55	0	45	102	1470	10	25	2100	154
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		4.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Lane Util. Factor	1.00		1.00	1.00		1.00	1.00	0.91		1.00	0.91	1.00
Frt	1.00		0.85	1.00		0.85	1.00	1.00		1.00	1.00	0.85
Flt Protected	0.95		1.00	0.95		1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1736		1553	1736		1553	1736	4982		1736	4988	1553
Flt Permitted	0.95		1.00	0.95		1.00	0.06	1.00		0.14	1.00	1.00
Satd. Flow (perm)	1736		1553	1736		1553	103	4982		264	4988	1553
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	249	0	361	60	0	49	111	1598	11	27	2283	167
RTOR Reduction (vph)	0	0	13	0	0	40	0	1	0	0	0	60
Lane Group Flow (vph)	249	0	348	60	0	9	111	1608	0	27	2283	107
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm		pm+ov	Perm		Perm	pm+pt	NA		Perm	NA	Perm
Protected Phases			5				5	2			6	
Permitted Phases	4		4	8		8	2			6		6
Actuated Green, G (s)	20.8		29.3	20.8		20.8	79.2	79.2		66.7	66.7	66.7
Effective Green, g (s)	20.8		29.3	20.8		20.8	79.2	79.2		66.7	66.7	66.7
Actuated g/C Ratio	0.19		0.27	0.19		0.19	0.72	0.72		0.61	0.61	0.61
Clearance Time (s)	5.0		4.0	5.0		5.0	4.0	5.0		5.0	5.0	5.0
Vehicle Extension (s)	3.0		3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)	328		413	328		293	200	3587		160	3024	941
v/s Ratio Prot			c0.06				0.04	0.32			c0.46	
v/s Ratio Perm	0.14		0.16	0.03		0.01	0.35			0.10		0.07
v/c Ratio	0.76		0.84	0.18		0.03	0.56	0.45		0.17	0.75	0.11
Uniform Delay, d1	42.2		38.2	37.5		36.4	18.6	6.4		9.5	15.7	9.2
Progression Factor	1.00		1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	9.7		14.4	0.3		0.0	3.3	0.4		2.3	1.8	0.2
Delay (s)	51.9		52.5	37.7		36.4	21.9	6.8		11.8	17.5	9.4
Level of Service	D		D	D		D	C	A		B	B	A
Approach Delay (s)		52.3			37.1			7.8			16.9	
Approach LOS		D			D			A			B	
Intersection Summary												
HCM 2000 Control Delay			18.5								HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio			0.78									
Actuated Cycle Length (s)			110.0								Sum of lost time (s)	14.0
Intersection Capacity Utilization			75.3%								ICU Level of Service	D
Analysis Period (min)			15									

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Mitigation - GP Lane
PM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	33	152	217	44	272	1817	99	2679
v/c Ratio	0.14	0.63	1.06	0.18	0.95	0.62	0.48	0.99
Control Delay	34.5	23.5	118.0	21.7	73.1	15.2	17.7	40.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	34.5	23.5	118.0	21.7	73.1	15.2	17.7	40.1
Queue Length 50th (m)	5.8	4.5	~46.5	2.2	41.5	81.7	5.4	193.5
Queue Length 95th (m)	14.0	24.4	#84.5	13.1	#102.3	117.6	18.9	#272.0
Internal Link Dist (m)		200.4		197.2		273.0		178.6
Turn Bay Length (m)					120.0		150.0	
Base Capacity (vph)	263	450	205	380	285	2945	233	2702
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.13	0.34	1.06	0.12	0.95	0.62	0.42	0.99

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis

7: Brock Rd & Street 20H

Mitigation - GP Lane
PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	30	20	120	200	10	30	250	1567	105	91	2443	22
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	5.0		4.0	5.0		4.0	5.0		4.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.91		1.00	0.91	
Frt	1.00	0.87		1.00	0.89		1.00	0.99		1.00	1.00	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1736	1593		1736	1621		1736	4941		1736	4981	
Flt Permitted	0.73	1.00		0.29	1.00		0.07	1.00		0.08	1.00	
Satd. Flow (perm)	1331	1593		530	1621		120	4941		154	4981	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	22	130	217	11	33	272	1703	114	99	2655	24
RTOR Reduction (vph)	0	118	0	0	29	0	0	5	0	0	0	0
Lane Group Flow (vph)	33	34	0	217	15	0	272	1812	0	99	2679	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	14.5	9.8		22.8	14.1		74.1	62.6		64.6	57.1	
Effective Green, g (s)	14.5	9.8		22.8	14.1		74.1	62.6		64.6	57.1	
Actuated g/C Ratio	0.14	0.09		0.21	0.13		0.69	0.59		0.60	0.53	
Clearance Time (s)	4.0	5.0		4.0	5.0		4.0	5.0		4.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	198	146		214	213		279	2893		204	2660	
v/s Ratio Prot	0.01	0.02		c0.09	0.01		c0.12	0.37		0.03	0.54	
v/s Ratio Perm	0.02			c0.13			c0.56			0.26		
v/c Ratio	0.17	0.23		1.01	0.07		0.97	0.63		0.49	1.01	
Uniform Delay, d1	40.7	45.1		40.0	40.7		36.4	14.5		11.0	24.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.4	0.8		65.2	0.1		46.6	1.0		1.8	19.1	
Delay (s)	41.1	45.9		105.2	40.8		83.0	15.5		12.8	44.0	
Level of Service	D	D		F	D		F	B		B	D	
Approach Delay (s)		45.0			94.4			24.3			42.9	
Approach LOS		D			F			C			D	

Intersection Summary

HCM 2000 Control Delay	38.2	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	1.04		
Actuated Cycle Length (s)	106.9	Sum of lost time (s)	18.0
Intersection Capacity Utilization	96.1%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Queues
1: Hwy 7 & Brock Rd

Mitigation2 - GP Lane
AM Peak Hour































Lane Group	SEL	SET	NWL	NWT	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	5	941	1040	276	11	141	312	41	706
v/c Ratio	0.02	0.73	0.79	0.08	0.18	0.17	0.30	0.14	0.84
Control Delay	40.2	44.6	36.8	6.9	42.7	35.1	7.8	35.7	52.0
Queue Delay	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	40.2	44.6	37.0	6.9	42.7	35.1	7.8	35.7	52.0
Queue Length 50th (m)	0.9	75.8	109.1	7.6	2.1	13.9	25.7	7.6	83.9
Queue Length 95th (m)	5.0	#123.7	129.3	12.0	8.0	23.6	31.6	18.1	112.3
Internal Link Dist (m)		445.3		141.0		290.1			315.9
Turn Bay Length (m)	216.0		120.0		162.0			230.0	
Base Capacity (vph)	273	1284	1886	3331	73	987	1289	344	987
Starvation Cap Reductn	0	0	239	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.73	0.63	0.08	0.15	0.14	0.24	0.12	0.72

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Mitigation2 - GP Lane
AM Peak Hour

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations		  		 	  			 			 	
Volume (vph)	5	755	110	957	243	11	10	130	287	38	645	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0	5.0		4.0	5.0		5.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	0.91		*1.00	0.91		1.00	0.95	1.00	1.00	0.95	
Frt	1.00	0.98		1.00	0.99		1.00	1.00	0.85	1.00	1.00	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	4892		3471	4955		1736	3471	1553	1736	3467	
Flt Permitted	0.58	1.00		0.95	1.00		0.14	1.00	1.00	0.66	1.00	
Satd. Flow (perm)	1051	4892		3471	4955		260	3471	1553	1210	3467	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	5	821	120	1040	264	12	11	141	312	41	701	5
RTOR Reduction (vph)	0	13	0	0	4	0	0	0	7	0	1	0
Lane Group Flow (vph)	5	928	0	1040	272	0	11	141	305	41	705	0
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Turn Type	Perm	NA		Prot	NA		Perm	NA	pm+ov	Perm	NA	
Protected Phases		6		5	2			4	5		8	
Permitted Phases	6						4		4	8		
Actuated Green, G (s)	30.3	30.3		43.8	78.1		28.1	28.1	71.9	28.1	28.1	
Effective Green, g (s)	30.3	30.3		43.8	78.1		28.1	28.1	71.9	28.1	28.1	
Actuated g/C Ratio	0.26	0.26		0.38	0.67		0.24	0.24	0.62	0.24	0.24	
Clearance Time (s)	5.0	5.0		4.0	5.0		5.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	274	1275		1308	3330		62	839	960	292	838	
v/s Ratio Prot		c0.19		c0.30	0.05			0.04	0.12		c0.20	
v/s Ratio Perm	0.00						0.04		0.08	0.03		
v/c Ratio	0.02	0.73		0.80	0.08		0.18	0.17	0.32	0.14	0.84	
Uniform Delay, d1	31.9	39.2		32.2	6.6		34.9	34.8	10.5	34.6	41.9	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.1	3.7		3.4	0.0		1.4	0.1	0.2	0.2	7.7	
Delay (s)	32.0	42.9		35.6	6.7		36.3	34.9	10.7	34.8	49.6	
Level of Service	C	D		D	A		D	C	B	C	D	
Approach Delay (s)		42.8			29.6			18.7			48.8	
Approach LOS		D			C			B			D	
Intersection Summary												
HCM 2000 Control Delay			35.8			HCM 2000 Level of Service			D			
HCM 2000 Volume to Capacity ratio			0.79									
Actuated Cycle Length (s)			116.2			Sum of lost time (s)			14.0			
Intersection Capacity Utilization			81.5%			ICU Level of Service			D			
Analysis Period (min)			15									

c Critical Lane Group

Queues
1: Hwy 7 & Brock Rd

Mitigation2 - GP Lane
PM Peak Hour



































Lane Group	SEL	SET	NWL	NWT	NEL	NET	NER	SWL	SWT
Lane Group Flow (vph)	11	362	374	946	234	701	880	23	163
v/c Ratio	0.09	0.32	0.28	0.29	0.73	0.81	0.80	0.34	0.45
Control Delay	42.9	39.8	23.6	8.5	51.8	49.5	16.8	61.7	50.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	42.9	39.8	23.6	8.5	51.8	49.5	16.8	61.7	50.5
Queue Length 50th (m)	2.2	27.4	28.8	30.9	48.7	84.2	104.6	5.2	18.7
Queue Length 95th (m)	8.2	39.7	42.9	43.4	74.5	106.9	161.1	14.2	30.0
Internal Link Dist (m)		445.3		151.4		290.1			479.4
Turn Bay Length (m)	216.0		120.0		162.0			230.0	
Base Capacity (vph)	120	1133	1480	3306	321	1017	1156	98	507
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.09	0.32	0.25	0.29	0.73	0.69	0.76	0.23	0.32

Intersection Summary

HCM Signalized Intersection Capacity Analysis
1: Hwy 7 & Brock Rd

Mitigation2 - GP Lane
PM Peak Hour

													
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR	
Lane Configurations		  		 	  			 		 	 	 	
Volume (vph)	10	318	15	344	849	21	215	645	810	21	135	15	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Total Lost time (s)	5.0	5.0		4.0	5.0		4.0	5.0	4.0	5.0	5.0		
Lane Util. Factor	1.00	0.91		0.97	0.91		1.00	0.95	1.00	1.00	0.95		
Frt	1.00	0.99		1.00	1.00		1.00	1.00	0.85	1.00	0.99		
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00		
Satd. Flow (prot)	1736	4954		3367	4969		1736	3471	1553	1736	3420		
Flt Permitted	0.29	1.00		0.95	1.00		0.48	1.00	1.00	0.37	1.00		
Satd. Flow (perm)	530	4954		3367	4969		873	3471	1553	668	3420		
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	
Adj. Flow (vph)	11	346	16	374	923	23	234	701	880	23	147	16	
RTOR Reduction (vph)	0	4	0	0	2	0	0	0	27	0	7	0	
Lane Group Flow (vph)	11	358	0	374	944	0	234	701	853	23	156	0	
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	
Turn Type	Perm	NA		Prot	NA		pm+pt	NA	pm+ov	Perm	NA		
Protected Phases		6		5	2		7	4	5		8		
Permitted Phases	6						4		4	8			
Actuated Green, G (s)	26.5	26.5		46.8	77.3		28.9	28.9	75.7	12.0	12.0		
Effective Green, g (s)	26.5	26.5		46.8	77.3		28.9	28.9	75.7	12.0	12.0		
Actuated g/C Ratio	0.23	0.23		0.40	0.67		0.25	0.25	0.65	0.10	0.10		
Clearance Time (s)	5.0	5.0		4.0	5.0		4.0	5.0	4.0	5.0	5.0		
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0		
Lane Grp Cap (vph)	120	1129		1356	3305		312	863	1011	68	353		
v/s Ratio Prot		c0.07		0.11	0.19		0.08	0.20	c0.34		0.05		
v/s Ratio Perm	0.02						0.10		0.21	0.03			
v/c Ratio	0.09	0.32		0.28	0.29		0.75	0.81	0.84	0.34	0.44		
Uniform Delay, d1	35.4	37.3		23.3	8.0		38.2	41.1	15.7	48.4	49.0		
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00		
Incremental Delay, d2	1.5	0.7		0.1	0.2		9.7	5.9	6.5	2.9	0.9		
Delay (s)	36.9	38.1		23.4	8.3		47.9	47.0	22.2	51.4	49.8		
Level of Service	D	D		C	A		D	D	C	D	D		
Approach Delay (s)		38.0			12.6			35.1			50.0		
Approach LOS		D			B			D			D		

Intersection Summary

HCM 2000 Control Delay	28.1	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	116.2	Sum of lost time (s)	18.0
Intersection Capacity Utilization	71.6%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation2 - GP Lane
PM Peak Hour



Lane Group	SET	NWT	NEL	NER
Lane Group Flow (vph)	1091	1776	408	1386
v/c Ratio	0.77	0.67	0.62	0.80
Control Delay	44.9	21.7	34.8	20.0
Queue Delay	0.0	0.0	0.0	0.0
Total Delay	44.9	21.7	34.8	20.0
Queue Length 50th (m)	92.2	112.2	80.7	130.8
Queue Length 95th (m)	#126.2	129.2	115.7	144.3
Internal Link Dist (m)	299.7	281.8	440.6	
Turn Bay Length (m)				120.0
Base Capacity (vph)	1411	2666	667	1849
Starvation Cap Reductn	0	0	0	0
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.77	0.67	0.61	0.75

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
3: Hwy 407 EB Off-Ramp & Brock Rd

Mitigation2 - GP Lane
PM Peak Hour



Movement	SET	SER	NWL	NWT	NEL	NER
Lane Configurations	↑↑↑			↑↑↑	↘	↘↘
Volume (vph)	1004	0	0	1634	375	1275
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0			5.0	5.0	5.0
Lane Util. Factor	0.91			0.91	1.00	0.88
Frt	1.00			1.00	1.00	0.85
Flt Protected	1.00			1.00	0.95	1.00
Satd. Flow (prot)	4988			4988	1736	2733
Flt Permitted	1.00			1.00	0.95	1.00
Satd. Flow (perm)	4988			4988	1736	2733
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1091	0	0	1776	408	1386
RTOR Reduction (vph)	0	0	0	0	0	1
Lane Group Flow (vph)	1091	0	0	1776	408	1385
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%
Turn Type	NA			NA	Prot	custom
Protected Phases	6			2	4	4 5
Permitted Phases						
Actuated Green, G (s)	33.9			64.0	45.7	76.8
Effective Green, g (s)	33.9			64.0	45.7	76.8
Actuated g/C Ratio	0.28			0.53	0.38	0.64
Clearance Time (s)	5.0			5.0	5.0	
Vehicle Extension (s)	3.0			3.0	3.0	
Lane Grp Cap (vph)	1412			2666	662	1753
v/s Ratio Prot	c0.22			0.36	0.24	c0.51
v/s Ratio Perm						
v/c Ratio	0.77			0.67	0.62	0.79
Uniform Delay, d1	39.4			20.1	29.9	15.6
Progression Factor	1.00			1.00	1.00	1.00
Incremental Delay, d2	4.2			1.3	1.7	2.5
Delay (s)	43.5			21.5	31.6	18.1
Level of Service	D			C	C	B
Approach Delay (s)	43.5			21.5	21.2	
Approach LOS	D			C	C	

Intersection Summary

HCM 2000 Control Delay	26.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	119.7	Sum of lost time (s)	14.0
Intersection Capacity Utilization	72.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Queues
7: Brock Rd & Street 20H

Mitigation2 - GP Lane
PM Peak Hour


























Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	33	152	217	44	272	1703	114	99	2655	24
v/c Ratio	0.17	0.72	0.88	0.18	0.91	0.55	0.11	0.45	0.97	0.03
Control Delay	41.1	33.3	77.6	24.1	67.2	13.9	1.6	13.9	38.4	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	41.1	33.3	77.6	24.1	67.2	13.9	1.6	13.9	38.4	0.0
Queue Length 50th (m)	6.7	5.3	49.1	2.5	50.0	82.9	0.0	6.3	226.5	0.0
Queue Length 95th (m)	15.9	#34.3	#84.3	14.6	#100.3	99.6	5.9	11.6	#275.0	0.0
Internal Link Dist (m)		200.4		197.2		273.0			178.6	
Turn Bay Length (m)					120.0			150.0		
Base Capacity (vph)	335	216	247	248	309	3100	1013	241	2731	924
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.10	0.70	0.88	0.18	0.88	0.55	0.11	0.41	0.97	0.03

Intersection Summary

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

HCM Signalized Intersection Capacity Analysis
7: Brock Rd & Street 20H

Mitigation2 - GP Lane
PM Peak Hour

													
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lane Configurations													
Volume (vph)	30	20	120	200	10	30	250	1567	105	91	2443	22	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Total Lost time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0	
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	0.91	1.00	1.00	0.91	1.00	
Frt	1.00	0.87		1.00	0.89		1.00	1.00	0.85	1.00	1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	
Satd. Flow (prot)	1736	1593		1736	1621		1736	4988	1553	1736	4988	1553	
Flt Permitted	0.73	1.00		0.33	1.00		0.06	1.00	1.00	0.11	1.00	1.00	
Satd. Flow (perm)	1331	1593		599	1621		106	4988	1553	199	4988	1553	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	
Adj. Flow (vph)	33	22	130	217	11	33	272	1703	114	99	2655	24	
RTOR Reduction (vph)	0	121	0	0	29	0	0	0	44	0	0	11	
Lane Group Flow (vph)	33	31	0	217	15	0	272	1703	70	99	2655	13	
Heavy Vehicles (%)	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	
Turn Type	pm+pt	NA		pm+pt	NA		pm+pt	NA	Perm	pm+pt	NA	Perm	
Protected Phases	7	4		3	8		5	2		1	6		
Permitted Phases	4			8			2		2	6		6	
Actuated Green, G (s)	13.2	8.2		25.2	16.2		85.4	74.0	74.0	72.6	65.2	65.2	
Effective Green, g (s)	13.2	8.2		25.2	16.2		85.4	74.0	74.0	72.6	65.2	65.2	
Actuated g/C Ratio	0.11	0.07		0.21	0.13		0.71	0.61	0.61	0.60	0.54	0.54	
Clearance Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	5.0	4.0	5.0	5.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	162	108		247	217		294	3060	952	214	2696	839	
v/s Ratio Prot	0.01	0.02		c0.09	0.01		c0.12	0.34		0.03	c0.53		
v/s Ratio Perm	0.01			c0.09			0.53		0.05	0.25		0.01	
v/c Ratio	0.20	0.29		0.88	0.07		0.93	0.56	0.07	0.46	0.98	0.02	
Uniform Delay, d1	48.7	53.4		43.8	45.6		41.4	13.7	9.4	11.0	27.2	12.8	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	0.6	1.5		27.7	0.1		33.2	0.7	0.1	1.6	14.1	0.0	
Delay (s)	49.4	54.9		71.5	45.8		74.6	14.4	9.6	12.6	41.3	12.9	
Level of Service	D	D		E	D		E	B	A	B	D	B	
Approach Delay (s)		53.9			67.2			22.0			40.1		
Approach LOS		D			E			C			D		

Intersection Summary		
HCM 2000 Control Delay	34.8	HCM 2000 Level of Service C
HCM 2000 Volume to Capacity ratio	0.98	
Actuated Cycle Length (s)	120.6	Sum of lost time (s) 18.0
Intersection Capacity Utilization	95.6%	ICU Level of Service F
Analysis Period (min)	15	

c Critical Lane Group

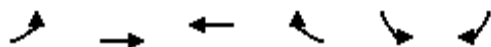
Appendix D – Internal Circulation

HCM Unsignalized Intersection Capacity Analysis

Internal Circulation

4: Bus Loop Access

AM Peak Hour



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	5	272	437	99	17	5
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	5	296	475	108	18	5
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	583				835	529
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	583				835	529
tC, single (s)	5.1				7.4	7.2
tC, 2 stage (s)						
tF (s)	3.1				4.4	4.2
p0 queue free %	99				92	99
cM capacity (veh/h)	647				233	399

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	301	583	24
Volume Left	5	0	18
Volume Right	0	108	5
cSH	647	1700	257
Volume to Capacity	0.01	0.34	0.09
Queue Length 95th (m)	0.2	0.0	2.4
Control Delay (s)	0.3	0.0	20.4
Lane LOS	A		C
Approach Delay (s)	0.3	0.0	20.4
Approach LOS			C

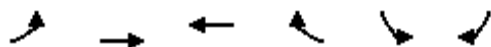
Intersection Summary			
Average Delay		0.6	
Intersection Capacity Utilization		39.0%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis

Internal Circulation

PM Peak Hour

4: Bus Loop Access



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↔	↔		↔	
Volume (veh/h)	5	545	170	103	17	5
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	5	592	185	112	18	5
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	297				844	241
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	297				844	241
tC, single (s)	5.1				7.4	7.2
tC, 2 stage (s)						
tF (s)	3.1				4.4	4.2
p0 queue free %	99				92	99
cM capacity (veh/h)	864				230	607

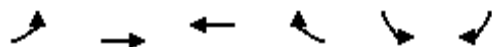
Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	598	297	24
Volume Left	5	0	18
Volume Right	0	112	5
cSH	864	1700	268
Volume to Capacity	0.01	0.17	0.09
Queue Length 95th (m)	0.2	0.0	2.3
Control Delay (s)	0.2	0.0	19.8
Lane LOS	A		C
Approach Delay (s)	0.2	0.0	19.8
Approach LOS			C

Intersection Summary			
Average Delay		0.6	
Intersection Capacity Utilization		42.7%	ICU Level of Service
Analysis Period (min)		15	A

HCM Unsignalized Intersection Capacity Analysis

4: West Parking Lot Access

Internal Circulation
AM Peak Hour

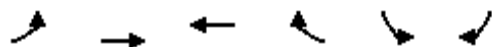


Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↶	↷		↘	
Volume (veh/h)	25	190	264	173	82	0
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	27	207	287	188	89	0
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	475				642	381
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	475				642	381
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				79	100
cM capacity (veh/h)	1098				431	666
Direction, Lane #	EB 1	WB 1	SB 1			
Volume Total	234	475	89			
Volume Left	27	0	89			
Volume Right	0	188	0			
cSH	1098	1700	431			
Volume to Capacity	0.02	0.28	0.21			
Queue Length 95th (m)	0.6	0.0	6.2			
Control Delay (s)	1.2	0.0	15.5			
Lane LOS	A		C			
Approach Delay (s)	1.2	0.0	15.5			
Approach LOS			C			
Intersection Summary						
Average Delay			2.1			
Intersection Capacity Utilization		42.2%		ICU Level of Service		A
Analysis Period (min)		15				

HCM Unsignalized Intersection Capacity Analysis

4: West Parking Lot Access

Internal Circulation
PM Peak Hour



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↖	↖		↗	
Volume (veh/h)	0	275	170	0	270	18
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	299	185	0	293	20
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	185				484	185
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	185				484	185
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				46	98
cM capacity (veh/h)	1402				546	863

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	299	185	313
Volume Left	0	0	293
Volume Right	0	0	20
cSH	1402	1700	558
Volume to Capacity	0.00	0.11	0.56
Queue Length 95th (m)	0.0	0.0	27.5
Control Delay (s)	0.0	0.0	19.4
Lane LOS			C
Approach Delay (s)	0.0	0.0	19.4
Approach LOS			C

Intersection Summary			
Average Delay		7.6	
Intersection Capacity Utilization		37.2%	ICU Level of Service
Analysis Period (min)		15	A