



January 30, 2018

Our Ref. 18277.200

Dan Terziewski

Town of Richmond Hill
225 East Beaver Creek Road
Richmond Hill, ON
L4B 3P4

RE: Red Maple Road Follow-Up: Operations and Safety Review

Dear Dan Terziewski,

Red Maple Road north of Highway 7 and south of High Tech Road in the Town of Richmond Hill currently provides access to Langstaff GO Station, Home Depot, Tim Horton's, and other shopping destinations at 45 Red Maple Road via a series of full-moves unsignalized intersections. This segment of Red Maple Road was previously analyzed in the 2015 Red Maple High Tech Road Operations Review (RMHT Operations Review), which investigated existing traffic operations, and evaluated existing safety conditions for drivers and pedestrians. The segment of Red Maple Road and the key properties of interest along the roadway are depicted in **Figure 1** for reference.

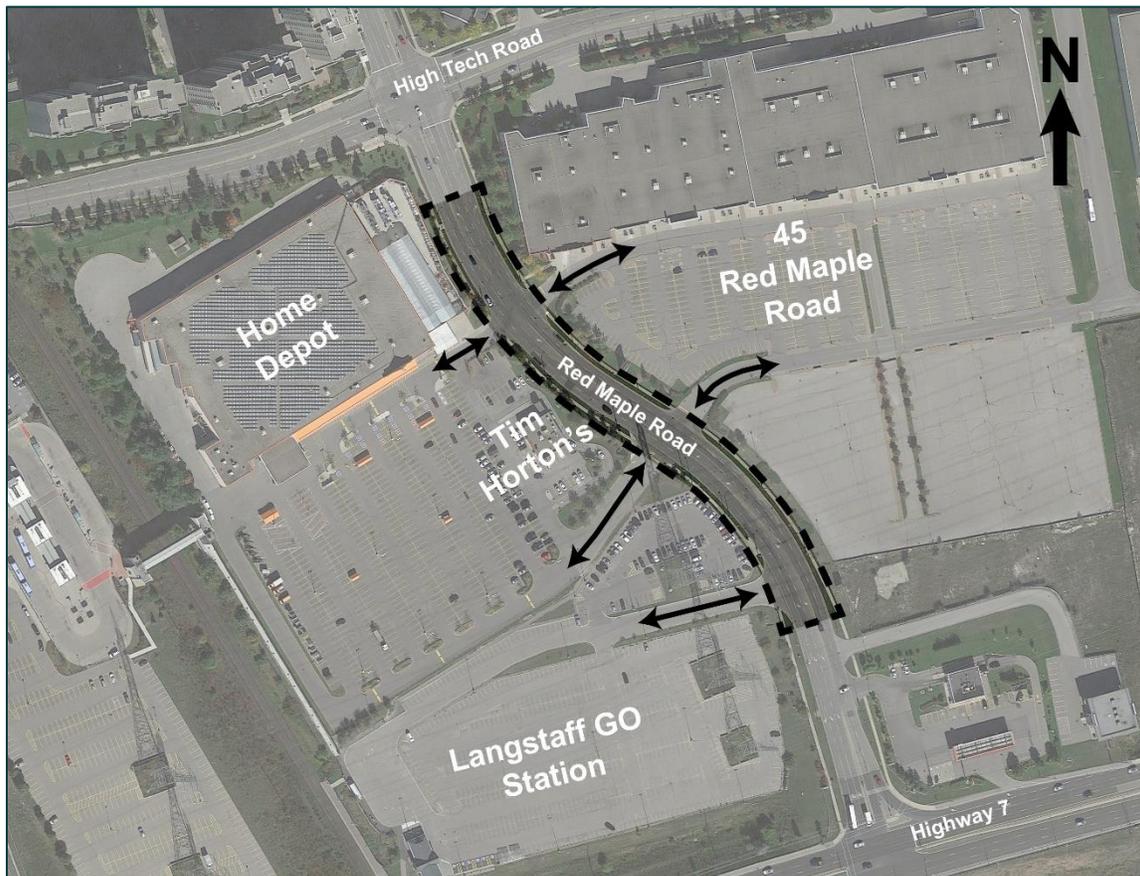


Figure 1: Red Maple Road – Context Map



It is known through the findings of the RMHT Operations Review that this segment of Red Maple Road has operational constraints, while also presenting safety concerns to pedestrians and drivers. More specifically, this segment of Red Maple Road can be characterized by:

- **Over-capacity outbound left-turning movements from Langstaff GO, Home Depot/Tim Horton’s, and 45 Red Maple Road onto Red Maple Road;**
- **Significant incidence of turning collisions between drivers turning onto/off of Red Maple Road; and,**
- **Pedestrians crossing Red Maple Road mid-block between Home Depot/Tim Horton’s and 45 Red Maple Road unprotected and without a formal pedestrian crossing.**

The details of these characteristics can be reviewed more comprehensively in the RMHT Operations Review. Given the present concerns on Red Maple Road, the purpose of this study is to provide the Town of Richmond Hill recommendations to improve the existing condition and eliminate the abovementioned issues.

This report takes the form of a follow-up to the RMHT Operations Review, and will function as a final recommendation for the Town of Richmond Hill subsequent to the findings of the RMHT Operations Review, and the project consultation. This follow-up will proceed by discussing the development of the initial recommendations in the RMHT Operations Review, and the stakeholder consultation. In addition, the collision analysis of the RMHT Operations Review has been updated using recent collision data. Finally, the final recommendation that is now put forward to the Town will be discussed.

PROJECT BACKGROUND

The RMHT Operations Review provided initial recommendations to the Town of Richmond Hill to eliminate the observed operational and safety concerns present on Red Maple Road. Implementing these recommendations required the involvement of Metrolinx and DG Group (Home Depot), as implementing the initial recommendations involved modifications to the Langstaff GO Station and Home Depot parking lots. Through discussion with the two (2) landowners, a satisfactory agreement could not be reached, and therefore, implementing the initial recommendations has been determined to not be possible. In continuing to work toward the objective of alleviating capacity constraints along Red Maple Road and addressing safety concerns, final recommendations have been developed as informed by the stakeholder consultation.

EXISTING CONDITIONS

Safety Review

A review of the existing safety conditions on Red Maple Road has been conducted here to confirm that safety concerns are still present on Red Maple Road. In conducting a safety review of the existing conditions, collision data were provided by the Town between 2013 and 2017, representing five (5) years of collision data. These collision data were reviewed for location, type of collision, and number of collisions reported. **Table 1** below presents a summary of the number and type of collisions observed between High Tech Road and Highway 7 along Red Maple Road.

Collision Type	Frequency
Pedestrian	1
Rear End	2
Right Angle	8
Turning	18
Total	29

Table 1: Collision Type and Frequency 2013 - 2017

A total of 29 collisions were observed over five (5) years, with the majority of collisions being turning collisions, as expected. The turning collisions are likely a result of limited gap opportunities to outbound turning drivers who become impatient and conduct unsafe turning maneuvers. In comparison, the safety review conducted in the RMHT Operations Review found a total of 39 collisions between 2008 and 2013 (5 years). While the total number of collisions observed over the latest five (5) year period is reduced, 29 total collisions is significant.

Of greater concern is the observed collision with a pedestrian. According to the accident report, this pedestrian was struck while crossing Red Maple Road from the Home Depot north driveway. The collision occurred under clear conditions. Overall, the safety review here confirms that safety concerns are still present along Red Maple Road, and should be addressed.

Operations Review

The operational review of the unsignalized driveway accesses on Red Maple Road can be reviewed in the RMHT Operations Review. The RMHT Operations Review found that outbound left-turning movements onto Red Maple Road are operating over-capacity and with delay. This included the Langstaff GO parking lot access, and the accesses to Home Depot/Tim Horton's and 45 Red Maple Road.

RECOMMENDED IMPROVEMENTS

Upon considering the review of the existing conditions, as well as upon considering the consultation with the stakeholders, a final recommendation has been developed for the Town of Richmond Hill to address operational and safety concerns on Red Maple Road. **Figure 2** and **Table 2** summarize the recommended improvements. A functional design of the recommended improvements is provided in **Appendix A**.



Figure 2: Red Maple Road – Recommended Improvements



Location	Recommendations
1: North Driveway / Red Maple Rd (Home Depot)	- Restrict outbound left-turn movements
2: South Driveway / Red Maple Rd (Home Depot)	- Reconfigure to provide a signalized control with formalized pedestrian crossing
3: Langstaff GO Driveway / Red Maple Rd	- Maintain current configuration - Provide increased gap opportunities via South Driveway/Red Maple Rd signal

Table 2: Red Maple Road – Recommended Improvements

Accompanying these recommended improvements is the opportunity to improve outbound left-turning movements at the Langstaff GO parking lot despite no modifications being directly made to this driveway. Since a signal is recommended to be installed at the southern Home Depot driveway, at the time the eastbound/westbound phase is active, greater gap opportunities will be granted to outbound left-turning vehicles at the GO Station parking lot, thereby assisting in alleviating capacity constraints. Furthermore, the recommended improvements will not in any way preclude modifications to either the Home Depot or Langstaff GO parking lot, or the Langstaff GO driveway access. The recommendations have been developed in a manner that protects for the eventual sharing of access between the two (2) properties.

Recommended Improvements – Safety Review

The recommended improvements within the right-of-way of Red Maple Road will restrict all inbound and outbound left-turning movements at the north Home Depot driveway. Further, the south Home Depot driveway will be signalized. Overall, with these recommended improvements, the following future conditions are forecasted in relation to safety:

- Significant reduction in all types of collisions at the north Home Depot driveway;
- Significant reduction in turning collisions at the south Home Depot driveway; and,
- Significant improvement to pedestrian safety via the provision of a protected crossing of Red Maple Road.

The recommended improvements are expected to substantially improve both driver and pedestrian safety.

Recommended Improvements – Operations Review

The operations review of the recommended improvements has been conducted using Synchro 9.1 software, adhering to the methodology of the Highway Capacity Manual (HCM) 2000. Traffic volumes collected for the RMHT Operations Review have been used to conduct the capacity analysis of the following time periods:

- Weekday AM peak hour;
- Weekday PM peak hour; and,
- Weekend Midday peak hour.

Given the recommended improvements, all inbound and outbound left-turning movements observed at the north Home Depot driveway have been reassigned to the recommended signal at the south Home Depot driveway. Since no modification is proposed at the Langstaff GO driveway, no reassignment of traffic volumes has been performed at this access. **Figure 3, Figure 4, and Figure 5** depict the change in traffic volumes at the



Home Depot accesses that can be expected with the north driveway converted to a RIRO during the studied identified peak hours.

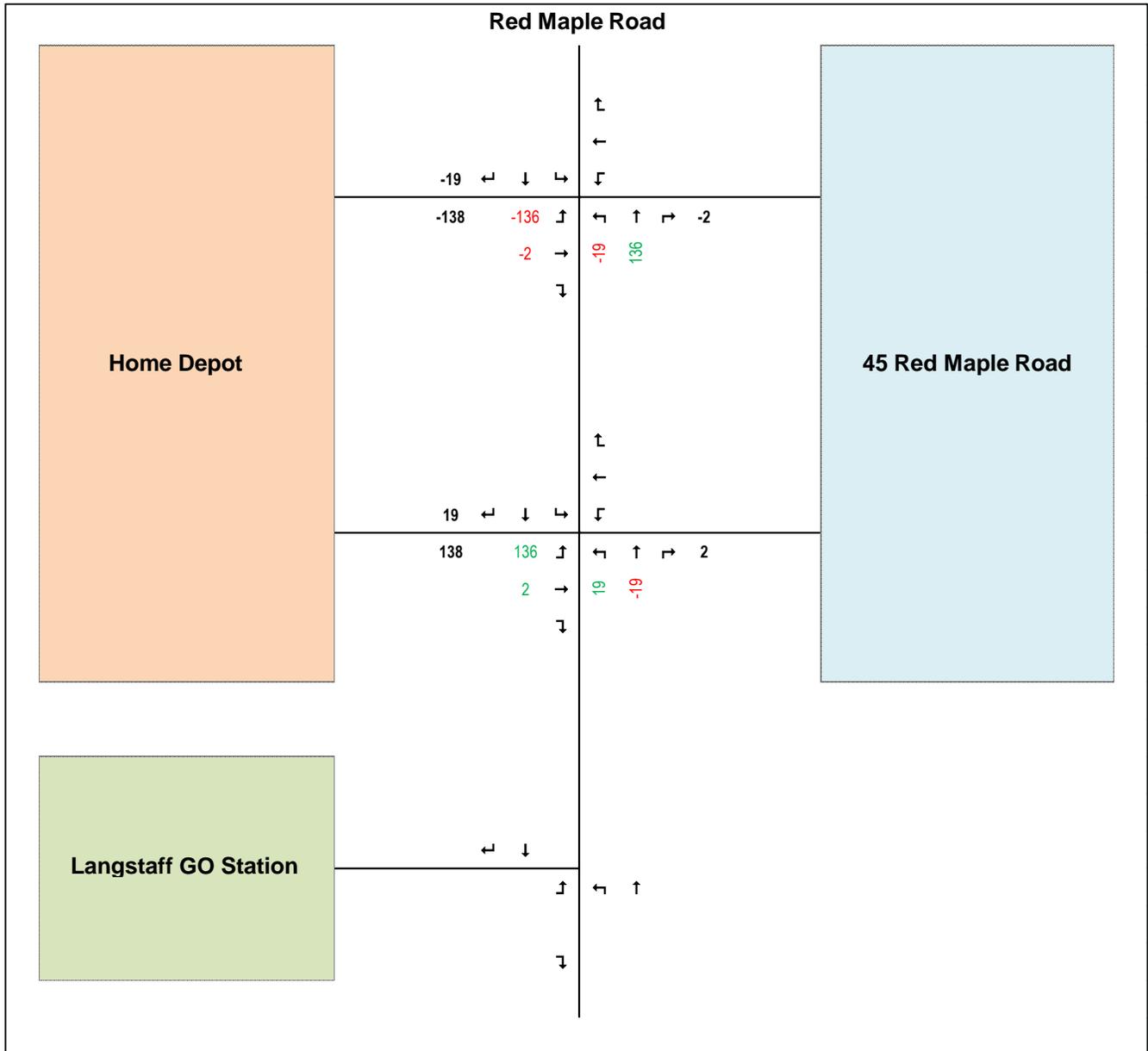


Figure 3: Change in Traffic Volumes (Weekday AM Peak Hour)

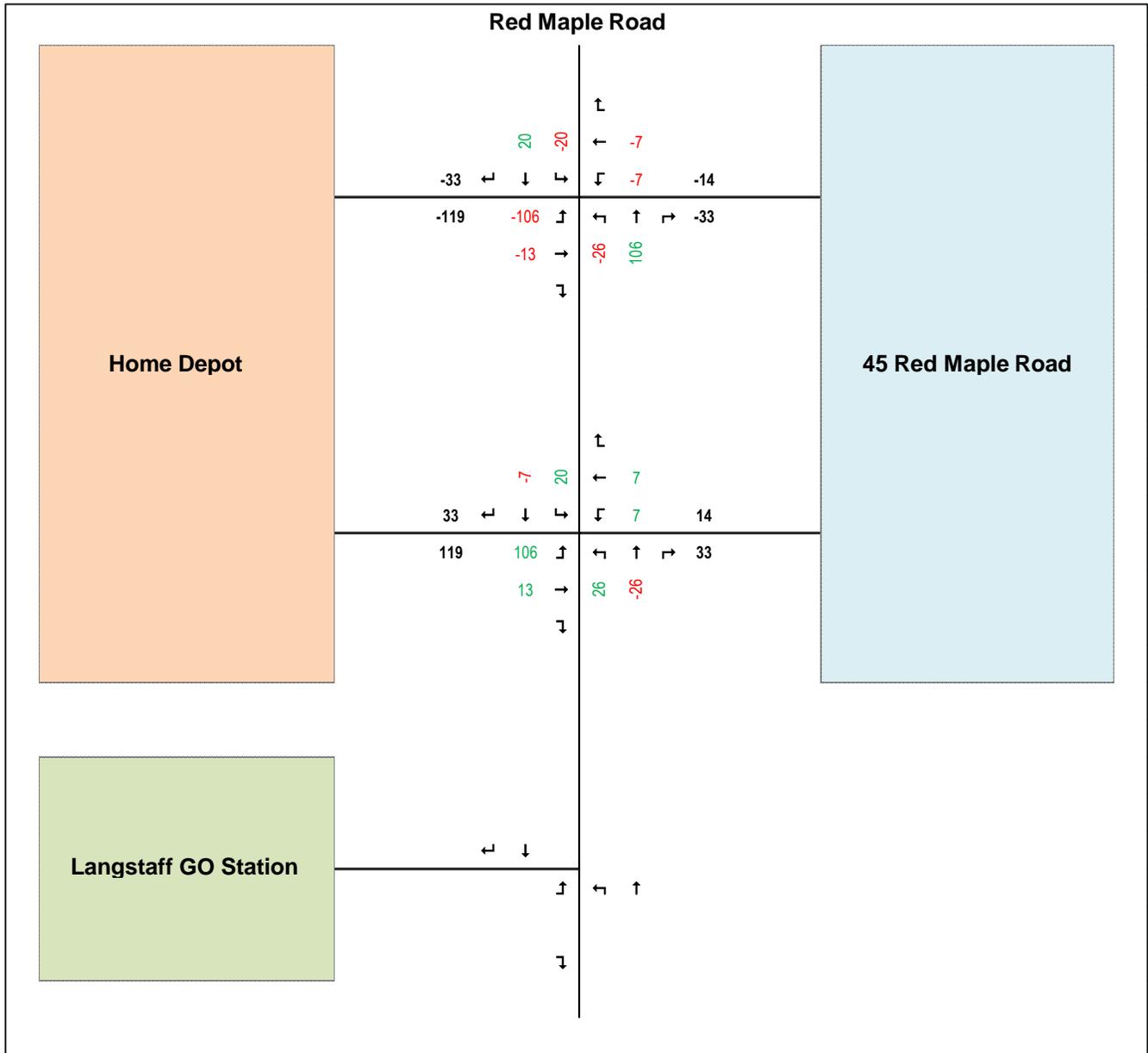


Figure 4: Change in Traffic Volumes (Weekday PM Peak Hour)

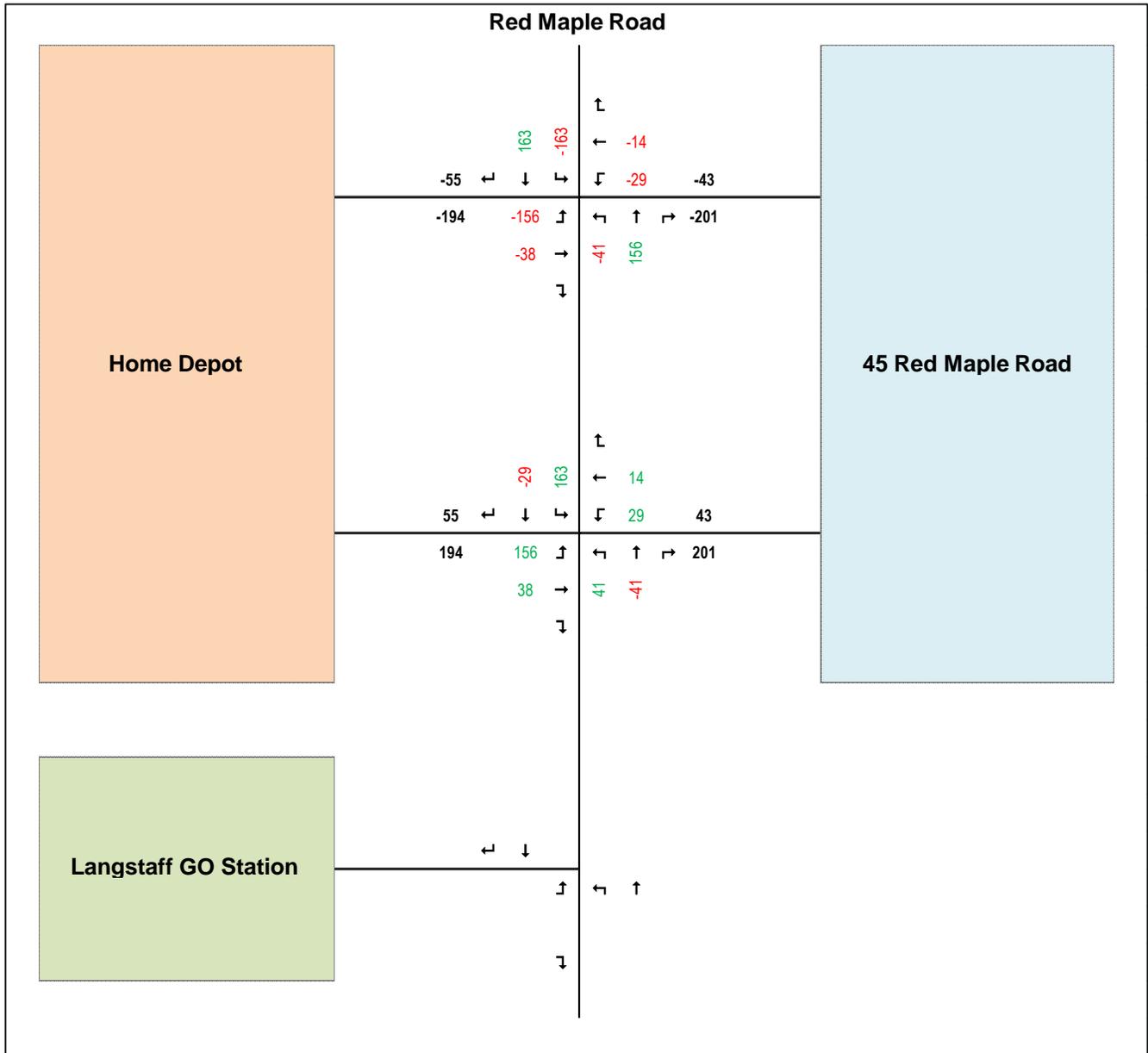


Figure 5: Change in Traffic Volumes (Weekend Midday Peak Hour)

In developing a signal timing plan for the southern Home Depot driveway intersection, cycle length was kept in consistency with the cycle length at the Red Maple Road & High Tech Road intersection. The signal timing plan is summarized in **Table 3**.



Timing	NB		SB		EB		WB	
	L	TR	L	TR	L	TR	L	TR
Yellow Time (sec)	-	4	-	4	-	4	-	4
All-Red Time (sec)	-	2	-	2	-	2	-	2
Cycle Length (sec)	75							
Weekday AM Peak Hour								
Total Split (sec)	-	46	-	46	-	29	-	29
Weekday PM Peak Hour								
Total Split (sec)	-	33	-	33	-	42	-	42
Weekend Midday Peak Hour								
Total Split (sec)	-	38	-	38	-	37	-	37

Table 3: Signal Timing Plans

The resulting intersection capacity analyses have been conducted with the north Home Depot driveway modified to a RIRO and the south Home Depot driveway signalized. Existing Peak Hour Factor (PHF) has been maintained and applied per movement. This is summarized in **Table 4** for the signalized intersection, and **Table 5** for the unsignalized intersections for all peak hours. Capacity analysis results are available in **Appendix B**.

Intersection	Overall			Movements of Interest					
	V/C	Delay (s)	LOS	Movement	V/C	Delay (s)	LOS	Queue (m)	
								50th	95th
Weekday AM Peak Hour									
Red Maple Road & South Driveway	0.65	15	B	EBL	0.73	32	C	37	34
				EBTR	0.15	21	C	3	11
				NBL	0.62	22	C	12	#27.2
				NBTR	0.07	6	A	4	7
				SBL	0.01	6	A	0	1
				SBTR	0.53	10	A	45	36
Weekday PM Peak Hour									
Red Maple Road & South Driveway	0.65	19	B	EBL	0.90	44	D	52	30
				EBTR	0.13	16	B	3	9
				WBLTR	0.42	19	B	21	22
				NBL	0.26	12	B	11	21
				NBTR	0.47	13	B	39	60
				SBL	0.23	13	B	5	9
				SBTR	0.20	11	B	14	22
Weekend Midday Peak Hour									
Red Maple Road & South Driveway	0.57	21	C	EBL	0.88	49	D	37	50
				EBTR	0.25	21	C	9	21
				WBLTR	0.81	38	D	38	33
				NBL	0.28	10	A	13	26
				NBTR	0.17	8	A	7	17
				SBL	0.41	12	B	18	39
				SBTR	0.12	8	A	6	14

Table 4: Intersection Capacity Analysis – Signalized Intersections (All Peak Hours)



Intersection	Movement of Interest	Flow Rate (vph)	Capacity (vph)	Control Delay (s)	95th Queue (m)	V/C	LOS
Weekday AM Peak Hour							
Red Maple Road & North Driveway	EBR	40	648	11	2	0.06	B
	WBR	0	1700	0	0	0.00	A
Red Maple Road & GO Driveway	EBL	28	75	79	11	0.37	F
	EBR	134	870	10	4	0.15	A
	NBL	321	776	12	16	0.41	B
Weekday PM Peak Hour							
Red Maple Road & North Driveway	EBR	48	727	10	2	0.07	B
	WBR	76	696	11	3	0.11	B
Red Maple Road & GO Driveway	EBL	331	257	194	133	1.29	F
	EBR	210	799	11	8	0.26	B
	NBL	28	1054	1	1	0.03	A
Weekend Midday Peak Hour							
Red Maple Road & North Driveway	EBR	64	624	11	3	0.10	B
	WBR	117	684	11	5	0.17	B
Red Maple Road & GO Driveway	EBL	0	1700	0	0	0.00	A
	EBR	0	1700	0	0	0.00	A

Table 5: Intersection Capacity Analysis – Unsignalized Intersections (All Peak Hours)

With the signalization of the south Home Depot driveway, the intersection operates with good levels of service. The constrained outbound movements from the Home Depot have been mitigated during all peak hours. Improvement to the GO driveway is also expected with the recommended modifications. This is attributed to upstream metering of traffic flow from the signalization of the south Home Depot driveway which results in vehicles to travel in platoons southbound on Red Maple Road. Thereby, providing longer gaps for vehicles to exit the GO driveway when the north/south traffic is controlled. Delay is forecasted to decrease by 60 seconds and 40 seconds during the weekday AM and PM peak hours, respectively. The outbound left-turn movement however will still operate over-capacity during the weekday PM peak hour.

IMPLEMENTATION

Implementing the recommended improvements will require the Town to navigate the Environmental Assessment process of the Environmental Assessment Act. In understanding which Class of Environmental Assessment, the Town will need to enact, the totality of the recommended improvements has been reviewed, including:

- Maintaining all site access locations, but restricting turning movements at one (1) access;
- Installing a centre median within the right-of-way of Red Maple Road;
- Installing a signal and accompanying signal equipment at the Red Maple Road & South Home Depot driveway; and,
- Modifying and adding pavement markings and road signage as required with the installation of the signal, centre median, and turning restrictions.

Based on the criteria set forth by the Environmental Assessment Act, it is anticipated that the Town will need to enact a Class B Environmental Assessment.



CONCLUSIONS

Red Maple Road between Highway 7 and High Tech Road currently operates with operational and safety concerns. The Town of Richmond Hill in response to these concerns have been undergoing a process to implement a number of design improvements to Red Maple Road following the findings of the RMHT Operations Review. Through the consultation process of the RMHT Operations Review with the involved stakeholders, it had been determined a satisfactory agreement could not be reached between the stakeholders and the Town to implement the initial recommendations. Therefore, this follow-up report is to provide a final recommendation for the Town resulting from the findings of RMHT Operations Review, and the stakeholder consultation.

The recommended improvements include restricting all inbound and outbound left-turning movements at the north driveway to the Home Depot via a centre median and installing a signal at the southern driveway to the Home Depot. These modifications are anticipated to reduce the number of collisions and increase pedestrian safety by providing a protected pedestrian crossing. Future operations of the Home Depot accesses are also expected to improve significantly with existing capacity constraints eliminated and delays minimized. The signalization also has the effect of improving operations at the Langstaff GO driveway by metering southbound traffic on Red Maple Road and providing more gap opportunities for outbound vehicles. Delays are reduced by 40 to 60 seconds during the studied peak hours. However, the outbound left-turn movement continues to operate over capacity during the weekday PM peak hour.

With respect to implementation, the implementation of the recommended improvements is expected to require the Town to enact a Class B Environmental Assessment.

Should you have any questions, please do not hesitate to contact me at (905) 470-0015 extension 292 or at kchan@lea.ca.

Sincerely,

LEA Consulting Ltd.

Kenneth Chan, P.Eng., PTOE, PMP
Head of Transportation Engineering

:pg/sc

Encl: Appendix A – Recommended Improvements – Functional Design
Appendix B – Recommended Improvements – Intersection Capacity Analysis

APPENDIX A

Recommended Improvements – Functional Design



APPENDIX B

Recommended Improvements – Intersection Capacity Analysis



Weekday AM Peak Hour



HCM Unsignalized Intersection Capacity Analysis
1: Red Maple Road & North Driveway

RIRO + Signalization Option
Weekday AM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↗			↗		↕			↕	↘
Traffic Volume (veh/h)	0	0	29	0	0	0	0	264	0	0	644	162
Future Volume (Veh/h)	0	0	29	0	0	0	0	264	0	0	644	162
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.79	0.25	0.73	0.90	0.25	0.90	0.68	0.73	0.90	0.90	0.65	0.65
Hourly flow rate (vph)	0	0	40	0	0	0	0	362	0	0	991	249
Pedestrians								4			31	
Lane Width (m)								3.6			3.6	
Walking Speed (m/s)								1.2			1.2	
Percent Blockage								0			3	
Right turn flare (veh)												
Median type								None			None	
Median storage (veh)												
Upstream signal (m)								90			107	
pX, platoon unblocked	0.86	0.86	0.86	0.86	0.86		0.86					
vC, conflicting volume	1328	1478	624	902	1602	212	1240			362		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1059	1233	243	565	1378	212	958			362		
IC, single (s)	7.5	6.5	7.0	7.5	6.5	6.9	4.1			4.1		
IC, 2 stage (s)												
IF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	94	100	100	100	100			100		
cM capacity (veh/h)	151	154	648	332	126	779	626			1208		
Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2						
Volume Total	40	0	241	121	661	579						
Volume Left	0	0	0	0	0	0						
Volume Right	40	0	0	0	0	249						
cSH	648	1700	1700	1700	1700	1700						
Volume to Capacity	0.06	0.00	0.14	0.07	0.39	0.34						
Queue Length 95th (m)	1.6	0.0	0.0	0.0	0.0	0.0				0.0		
Control Delay (s)	10.9	0.0	0.0	0.0	0.0	0.0				0.0		
Lane LOS	B	A										
Approach Delay (s)	10.9	0.0	0.0		0.0							
Approach LOS	B	A										
Intersection Summary												
Average Delay	0.3											
Intersection Capacity Utilization	34.2%											
ICU Level of Service	A											
Analysis Period (min)	15											

Queues

2: Red Maple Road & South Driveway

RIRO + Signalization Option
Weekday AM Peak Hour

Lane Group	EBL	EBT	NBL	NBT	SBL	SBT	Ø8
Lane Configurations	↗	↘	↗	↕	↗	↘	
Traffic Volume (vph)	162	8	99	102	3	533	
Future Volume (vph)	162	8	99	102	3	533	
Lane Group Flow (vph)	275	152	134	140	4	1128	
Turn Type	Perm	NA	Perm	NA	Perm	NA	
Protected Phases		4		2		6	8
Permitted Phases	4		2		6		
Detector Phase	4	4	2	2	6	6	
Switch Phase							
Minimum Initial (s)	8.0	8.0	10.0	10.0	10.0	10.0	8.0
Minimum Split (s)	29.0	29.0	24.0	24.0	24.0	24.0	29.0
Total Split (s)	29.0	29.0	46.0	46.0	46.0	46.0	29.0
Total Split (%)	38.7%	38.7%	61.3%	61.3%	61.3%	61.3%	39%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Lost Time Adjust (s)	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
Total Lost Time (s)	5.0	5.0	5.0	5.0	5.0	5.0	
Lead/Lag							
Lead-Lag Optimize?							
Recall Mode	None	None	C-Max	C-Max	C-Max	C-Max	None
v/c Ratio	0.73	0.30	0.62	0.07	0.01	0.54	
Control Delay	36.7	7.7	27.9	6.6	7.7	10.0	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	36.7	7.7	27.9	6.6	7.7	10.0	
Queue Length 50th (m)	36.7	3.3	11.6	3.7	0.3	44.7	
Queue Length 95th (m)	33.9	10.5	#27.2	7.2	1.3	35.9	
Internal Link Dist (m)		41.7		71.2		65.6	
Turn Bay Length (m)			60.0		30.0		
Base Capacity (vph)	458	584	217	2078	760	2099	
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	0.60	0.26	0.62	0.07	0.01	0.54	
Intersection Summary							
Cycle Length: 75							
Actuated Cycle Length: 75							
Offset: 0 (0%), Referenced to phase 2:NBT and 6:SBTL, Start of Green							
Natural Cycle: 75							
Control Type: Actuated-Coordinated							
# 95th percentile volume exceeds capacity, queue may be longer.							
Queue shown is maximum after two cycles.							
Splits and Phases: 2: Red Maple Road & South Driveway							
↕ Ø2 (R)	46 s					↘ Ø4	29 s
↘ Ø6 (R)	46 s					↖ Ø8	29 s

HCM Signalized Intersection Capacity Analysis
2: Red Maple Road & South Driveway

RIRO + Signalization Option
Weekday AM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔			↕		↔	↔		↔	↔	
Traffic Volume (vph)	162	8	107	0	0	0	99	102	8	3	533	137
Future Volume (vph)	162	8	107	0	0	0	99	102	8	3	533	137
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	1.00	1.00					1.00	0.95		1.00	0.95	
Frbp, ped/bikes	1.00	0.99					1.00	1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00					1.00	1.00		1.00	1.00	
Frt	1.00	0.86					1.00	0.99		1.00	0.97	
Flt Protected	0.95	1.00					0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1800	1568					1718	3431		1802	3432	
Flt Permitted	0.76	1.00					0.20	1.00		0.66	1.00	
Satd. Flow (perm)	1434	1568					359	3431		1258	3432	
Peak-hour factor, PHF	0.59	0.75	0.76	0.33	0.38	0.50	0.74	0.80	0.67	0.75	0.59	0.61
Adj. Flow (vph)	275	11	141	0	0	0	134	128	12	4	903	225
RTOR Reduction (vph)	0	90	0	0	0	0	0	5	0	0	26	0
Lane Group Flow (vph)	275	62	0	0	0	0	134	135	0	4	1102	0
Confl. Peds. (#/hr)	3		4	4		3	1		1	1		1
Heavy Vehicles (%)	0%	0%	3%	0%	0%	0%	5%	4%	0%	0%	2%	0%
Turn Type	Perm	NA					Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	18.7	18.7					44.3	44.3		44.3	44.3	
Effective Green, g (s)	19.7	19.7					45.3	45.3		45.3	45.3	
Actuated g/C Ratio	0.26	0.26					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)	376	411					216	2072		759	2072	
v/s Ratio Prot		0.04						0.04			0.32	
v/s Ratio Perm	c0.19						c0.37			0.00		
v/c Ratio	0.73	0.15					0.62	0.07		0.01	0.53	
Uniform Delay, d1	25.2	21.2					9.4	6.1		5.9	8.7	
Progression Factor	1.00	1.00					1.00	1.00		1.00	1.00	
Incremental Delay, d2	7.2	0.2					12.7	0.1		0.0	1.0	
Delay (s)	32.4	21.4					22.1	6.2		5.9	9.6	
Level of Service	C	C					C	A		A	A	
Approach Delay (s)		28.5			0.0			14.0			9.6	
Approach LOS		C			A			B			A	

Intersection Summary			
HCM 2000 Control Delay	14.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	56.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
3: Red Maple Road & Go Driveway

RIRO + Signalization Option
Weekday AM Peak Hour

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↔	↔		↕	↕	
Traffic Volume (veh/h)	19	51	109	190	494	146
Future Volume (Veh/h)	19	51	109	190	494	146
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.68	0.38	0.34	0.88	0.86	0.30
Hourly flow rate (vph)	28	134	321	216	574	487
Pedestrians					2	
Lane Width (m)					3.6	
Walking Speed (m/s)					1.2	
Percent Blockage					0	
Right turn flare (veh)						
Median type				None	None	
Median storage (veh)						
Upstream signal (m)				138	95	
pX, platoon unblocked	0.83	0.83	0.83			
vC, conflicting volume	1568	532	1061			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1273	26	663			
IC, single (s)	6.9	6.9	4.1			
IC, 2 stage (s)						
IF (s)	3.5	3.3	2.2			
p0 queue free %	63	85	59			
cM capacity (veh/h)	75	870	776			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1	SB 2
Volume Total	28	134	393	144	383	678
Volume Left	28	0	321	0	0	0
Volume Right	0	134	0	0	0	487
cSH	75	870	776	1700	1700	1700
Volume to Capacity	0.37	0.15	0.41	0.08	0.23	0.40
Queue Length 95th (m)	11.4	4.3	16.3	0.0	0.0	0.0
Control Delay (s)	78.5	9.9	11.5	0.0	0.0	0.0
Lane LOS	F	A	B			
Approach Delay (s)	21.7		8.4		0.0	
Approach LOS	C					

Intersection Summary			
Average Delay	4.6		
Intersection Capacity Utilization	40.7%	ICU Level of Service	A
Analysis Period (min)	15		

Weekday PM Peak Hour



HCM Unsignalized Intersection Capacity Analysis
1: Red Maple Road & North Driveway

RIRO + Signalization Option
Weekday PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↗			↗	↕	↕			↕	↕
Traffic Volume (veh/h)	0	0	36	0	0	19	0	825	5	0	269	136
Future Volume (Veh/h)	0	0	36	0	0	19	0	825	5	0	269	136
Sign Control		Stop			Stop		Free			Free		
Grade		0%			0%		0%			0%		
Peak Hour Factor	0.76	0.65	0.75	0.25	0.58	0.25	0.93	0.74	0.25	0.25	0.77	0.89
Hourly flow rate (vph)	0	0	48	0	0	76	0	1115	20	0	349	153
Pedestrians		24			1			1			17	
Lane Width (m)		3.6			3.6			3.6			3.6	
Walking Speed (m/s)		1.2			1.2			1.2			1.2	
Percent Blockage		2			0			0			1	
Right turn flare (veh)												
Median type							None				None	
Median storage (veh)												
Upstream signal (m)							90				107	
pX, platoon unblocked	0.86	0.86	0.99	0.86	0.86	0.86	0.99			0.86		
vC, conflicting volume	1100	1586	276	1350	1652	586	526			1136		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	766	1328	258	1055	1405	194	509			834		
IC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.1			4.1		
IC, 2 stage (s)												
IF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	93	100	100	89	100			100		
cM capacity (veh/h)	215	132	727	145	119	696	1038			695		
Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2						
Volume Total	48	76	743	392	233	269						
Volume Left	0	0	0	0	0	0						
Volume Right	48	76	0	20	0	153						
cSH	727	696	1700	1700	1700	1700						
Volume to Capacity	0.07	0.11	0.44	0.23	0.14	0.16						
Queue Length 95th (m)	1.7	2.9	0.0	0.0	0.0	0.0				0.0		
Control Delay (s)	10.3	10.8	0.0	0.0	0.0	0.0				0.0		
Lane LOS	B	B										
Approach Delay (s)	10.3	10.8	0.0		0.0							
Approach LOS	B	B										

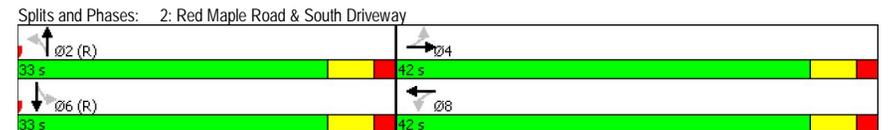
Intersection Summary		
Average Delay		0.7
Intersection Capacity Utilization	37.3%	ICU Level of Service A
Analysis Period (min)		15

Queues
2: Red Maple Road & South Driveway

RIRO + Signalization Option
Weekday PM Peak Hour

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Configurations	↗	↗		↕	↗	↕	↗	↕
Traffic Volume (vph)	192	23	90	24	94	589	34	242
Future Volume (vph)	192	23	90	24	94	589	34	242
Lane Group Flow (vph)	376	152	0	239	132	846	59	358
Turn Type	Perm	NA	Perm	NA	Perm	NA	Perm	NA
Protected Phases		4	4	8	8	2	2	6
Permitted Phases	4		8		2		6	
Detector Phase	4	4	8	8	2	2	6	6
Switch Phase								
Minimum Initial (s)	8.0	8.0	8.0	8.0	10.0	10.0	10.0	10.0
Minimum Split (s)	29.0	29.0	29.0	29.0	24.0	24.0	24.0	24.0
Total Split (s)	42.0	42.0	42.0	42.0	33.0	33.0	33.0	33.0
Total Split (%)	56.0%	56.0%	56.0%	56.0%	44.0%	44.0%	44.0%	44.0%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Lost Time Adjust (s)	-1.0	-1.0		-1.0	-1.0	-1.0	-1.0	-1.0
Total Lost Time (s)	5.0	5.0		5.0	5.0	5.0	5.0	5.0
Lead/Lag								
Lead-Lag Optimize?								
Recall Mode	None	None	None	None	C-Max	C-Max	C-Max	C-Max
v/c Ratio	0.90	0.23	0.46	0.26	0.48	0.23	0.21	
Control Delay	47.0	4.7	15.9	15.0	14.3	16.7	11.5	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	47.0	4.7	15.9	15.0	14.3	16.7	11.5	
Queue Length 50th (m)	51.5	2.6	20.6	10.7	39.4	4.7	13.6	
Queue Length 95th (m)	30.2	9.4	22.3	20.6	60.3	9.1	22.3	
Internal Link Dist (m)			41.7	154.6		71.2	65.6	
Turn Bay Length (m)					60.0		30.0	
Base Capacity (vph)	567	854		692	500	1765	258	1738
Starvation Cap Reductn	0	0		0	0	0	0	0
Spillback Cap Reductn	0	0		0	0	0	0	0
Storage Cap Reductn	0	0		0	0	0	0	0
Reduced v/c Ratio	0.66	0.18		0.35	0.26	0.48	0.23	0.21

Intersection Summary	
Cycle Length:	75
Actuated Cycle Length:	75
Offset:	0 (0%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle:	55
Control Type:	Actuated-Coordinated



HCM Signalized Intersection Capacity Analysis
2: Red Maple Road & South Driveway

RIRO + Signalization Option
Weekday PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔		↔	↔	↔	↔	↔	↔	↔	↔	↔
Traffic Volume (vph)	192	23	84	90	24	49	94	589	115	34	242	29
Future Volume (vph)	192	23	84	90	24	49	94	589	115	34	242	29
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	
Lane Util. Factor	1.00	1.00			1.00		1.00	0.95		1.00	0.95	
Frbp, ped/bikes	1.00	0.99			0.99		1.00	1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00			1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.88			0.95		1.00	0.98		1.00	0.98	
Flt Protected	0.95	1.00			0.97		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1798	1603			1736		1752	3471		1804	3423	
Flt Permitted	0.61	1.00			0.76		0.54	1.00		0.27	1.00	
Satd. Flow (perm)	1153	1603			1355		992	3471		513	3423	
Peak-hour factor, PHF	0.51	0.83	0.68	0.72	0.71	0.61	0.71	0.82	0.90	0.58	0.77	0.66
Adj. Flow (vph)	376	28	124	125	34	80	132	718	128	59	314	44
RTOR Reduction (vph)	0	79	0	0	31	0	0	15	0	0	11	0
Lane Group Flow (vph)	376	73	0	0	208	0	132	831	0	59	347	0
Confl. Peds. (#/hr)	6		4	4		6			1		1	
Heavy Vehicles (%)	0%	10%	1%	2%	0%	0%	3%	1%	3%	0%	4%	0%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	26.2	26.2			26.2		36.8	36.8		36.8	36.8	
Effective Green, g (s)	27.2	27.2			27.2		37.8	37.8		37.8	37.8	
Actuated g/C Ratio	0.36	0.36			0.36		0.50	0.50		0.50	0.50	
Clearance Time (s)	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	
Lane Grp Cap (vph)	418	581			491		499	1749		258	1725	
v/s Ratio Prot		0.05						c0.24			0.10	
v/s Ratio Perm	c0.33				0.15		0.13			0.12		
v/c Ratio	0.90	0.13			0.42		0.26	0.47		0.23	0.20	
Uniform Delay, d1	22.6	16.0			18.0		10.6	12.1		10.4	10.3	
Progression Factor	1.00	1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	21.5	0.1			0.6		1.3	0.9		2.1	0.3	
Delay (s)	44.1	16.1			18.6		11.9	13.1		12.5	10.5	
Level of Service	D	B			B		B	B		B	B	
Approach Delay (s)		36.0			18.6			12.9			10.8	
Approach LOS		D			B			B			B	

Intersection Summary			
HCM 2000 Control Delay	18.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	58.2%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
3: Red Maple Road & Go Driveway

RIRO + Signalization Option
Weekday PM Peak Hour

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↔	↔		↔	↔	
Traffic Volume (veh/h)	162	105	18	636	385	31
Future Volume (Veh/h)	162	105	18	636	385	31
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.49	0.50	0.64	0.82	0.73	0.78
Hourly flow rate (vph)	331	210	28	776	527	40
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None	None		
Median storage (veh)						
Upstream signal (m)				138	95	
pX, platoon unblocked	0.97	0.97	0.97			
vC, conflicting volume	991	284	567			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	921	189	482			
IC, single (s)	6.8	6.9	4.1			
IC, 2 stage (s)						
IF (s)	3.5	3.3	2.2			
p0 queue free %	0	74	97			
cM capacity (veh/h)	257	799	1054			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1	SB 2
Volume Total	331	210	287	517	351	216
Volume Left	331	0	28	0	0	0
Volume Right	0	210	0	0	0	40
cSH	257	799	1054	1700	1700	1700
Volume to Capacity	1.29	0.26	0.03	0.30	0.21	0.13
Queue Length 95th (m)	133.4	8.4	0.7	0.0	0.0	0.0
Control Delay (s)	194.4	11.1	1.1	0.0	0.0	0.0
Lane LOS	F	B	A			
Approach Delay (s)	123.3		0.4		0.0	
Approach LOS	F					

Intersection Summary			
Average Delay	35.0		
Intersection Capacity Utilization	46.2%	ICU Level of Service	A
Analysis Period (min)	15		

Weekend Midday Peak Hour



HCM Unsignalized Intersection Capacity Analysis
1: Red Maple Road & North Driveway

RIRO + Signalization Option
Weekend Midday Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations			↖			↖	↖	↖			↖	↖
Traffic Volume (veh/h)	0	0	47	0	0	96	0	439	18	0	344	222
Future Volume (Veh/h)	0	0	47	0	0	96	0	439	18	0	344	222
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.81	0.67	0.73	0.60	0.84	0.82	0.79	0.83	0.75	0.92	0.93	0.72
Hourly flow rate (vph)	0	0	64	0	0	117	0	529	24	0	370	308
Pedestrians		9			4			9			22	
Lane Width (m)		3.6			3.6			3.6			3.6	
Walking Speed (m/s)		1.2			1.2			1.2			1.2	
Percent Blockage		1			0			1			2	
Right turn flare (veh)												
Median type							None				None	
Median storage (veh)												
Upstream signal (m)							90				107	
pX, platoon unblocked												
vC, conflicting volume	936	1090	357	803	1232	302	687			557		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	936	1090	357	803	1232	302	687			557		
IC, single (s)	7.5	6.5	7.0	7.5	6.5	6.9	4.1			4.1		
IC, 2 stage (s)												
IF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	100	100	90	100	100	83	100			100		
cM capacity (veh/h)	177	215	624	245	177	684	896			1020		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total	64	117	353	200	247	431
Volume Left	0	0	0	0	0	0
Volume Right	64	117	0	24	0	308
cSH	624	684	1700	1700	1700	1700
Volume to Capacity	0.10	0.17	0.21	0.12	0.15	0.25
Queue Length 95th (m)	2.7	4.9	0.0	0.0	0.0	0.0
Control Delay (s)	11.4	11.3	0.0	0.0	0.0	0.0
Lane LOS	B	B				
Approach Delay (s)	11.4	11.3	0.0		0.0	
Approach LOS	B	B				

Intersection Summary		
Average Delay	1.5	
Intersection Capacity Utilization	30.3%	ICU Level of Service A
Analysis Period (min)	15	

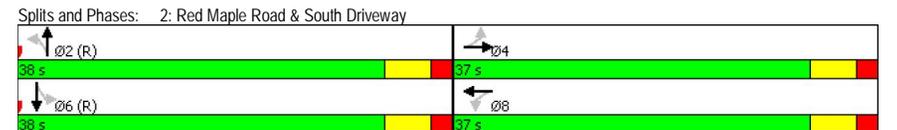
Queues
2: Red Maple Road & South Driveway

RIRO + Signalization Option
Weekend Midday Peak Hour

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Configurations	↖	↖		↖	↖	↖	↖	↖
Traffic Volume (vph)	218	70	124	47	134	186	186	157
Future Volume (vph)	218	70	124	47	134	186	186	157
Lane Group Flow (vph)	266	223	0	298	172	387	227	250
Turn Type	Perm	NA	Perm	NA	Perm	NA	Perm	NA
Protected Phases		4		8		2		6
Permitted Phases	4		8		2		6	
Detector Phase	4	4	8	8	2	2	6	6
Switch Phase								
Minimum Initial (s)	8.0	8.0	8.0	8.0	10.0	10.0	10.0	10.0
Minimum Split (s)	29.0	29.0	29.0	29.0	24.0	24.0	24.0	24.0
Total Split (s)	37.0	37.0	37.0	37.0	38.0	38.0	38.0	38.0
Total Split (%)	49.3%	49.3%	49.3%	49.3%	50.7%	50.7%	50.7%	50.7%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0

Lead/Lag							
Lead-Lag Optimize?							
Recall Mode	None	None	None	None	C-Max	C-Max	C-Max
v/c Ratio	0.88	0.38	0.82	0.28	0.20	0.41	0.13
Control Delay	53.6	9.0	39.9	12.3	5.9	14.7	7.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	53.6	9.0	39.9	12.3	5.9	14.7	7.0
Queue Length 50th (m)	37.4	8.8	37.6	12.5	7.4	18.1	5.8
Queue Length 95th (m)	49.8	20.5	33.1	25.7	16.5	38.9	14.3
Internal Link Dist (m)		41.7	154.6		71.2		65.6
Turn Bay Length (m)				60.0		30.0	
Base Capacity (vph)	440	784	520	611	1904	547	1900
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.60	0.28	0.57	0.28	0.20	0.41	0.13

Intersection Summary	
Cycle Length:	75
Actuated Cycle Length:	75
Offset:	0 (0%), Referenced to phase 2:NBT and 6:SBTL, Start of Green
Natural Cycle:	55
Control Type:	Actuated-Coordinated



HCM Signalized Intersection Capacity Analysis
2: Red Maple Road & South Driveway

RIRO + Signalization Option
Weekend Midday Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔	↔		↔	↔	↔	↔	↔	↔	↔	↔	↔
Traffic Volume (vph)	218	70	121	124	47	53	134	186	142	186	157	48
Future Volume (vph)	218	70	121	124	47	53	134	186	142	186	157	48
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	
Lane Util. Factor	1.00	1.00			1.00		1.00	0.95		1.00	0.95	
Frbp, ped/bikes	1.00	1.00			1.00		1.00	0.98		1.00	0.99	
Flpb, ped/bikes	1.00	1.00			1.00		1.00	1.00		0.99	1.00	
Frt	1.00	0.90			0.97		1.00	0.93		1.00	0.95	
Flt Protected	0.95	1.00			0.98		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1799	1694			1772		1750	3284		1787	3355	
Flt Permitted	0.56	1.00			0.67		0.60	1.00		0.52	1.00	
Satd. Flow (perm)	1067	1694			1223		1099	3284		984	3355	
Peak-hour factor, PHF	0.82	0.89	0.84	0.82	0.63	0.74	0.78	0.86	0.83	0.82	0.90	0.63
Adj. Flow (vph)	266	79	144	151	75	72	172	216	171	227	174	76
RTOR Reduction (vph)	0	103	0	0	19	0	0	76	0	0	34	0
Lane Group Flow (vph)	266	120	0	0	279	0	172	311	0	227	216	0
Confl. Peds. (#/hr)	6				6	1		8		8		1
Heavy Vehicles (%)	0%	0%	2%	0%	3%	0%	3%	1%	1%	0%	2%	2%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	21.3	21.3			21.3		41.7	41.7		41.7	41.7	
Effective Green, g (s)	21.3	21.3			21.3		41.7	41.7		41.7	41.7	
Actuated g/C Ratio	0.28	0.28			0.28		0.56	0.56		0.56	0.56	
Clearance Time (s)	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	
Lane Grp Cap (vph)	303	481			347		611	1825		547	1865	
v/s Ratio Prot		0.07						0.09			0.06	
v/s Ratio Perm	c0.25				0.23		0.16			c0.23		
v/c Ratio	0.88	0.25			0.81		0.28	0.17		0.41	0.12	
Uniform Delay, d1	25.6	20.7			24.9		8.8	8.2		9.6	7.9	
Progression Factor	1.00	1.00			1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	23.6	0.3			12.7		1.2	0.2		2.3	0.1	
Delay (s)	49.3	21.0			37.7		9.9	8.4		11.9	8.0	
Level of Service	D	C			D		A	A		B	A	
Approach Delay (s)		36.4			37.7			8.8			9.9	
Approach LOS		D			D			A			A	

Intersection Summary			
HCM 2000 Control Delay	21.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	71.3%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
3: Red Maple Road & Go Driveway

RIRO + Signalization Option
Weekend Midday Peak Hour

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↔	↔		↔	↔	
Traffic Volume (veh/h)	0	0	0	462	402	0
Future Volume (Veh/h)	0	0	0	462	402	0
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.68	0.38	0.34	0.88	0.86	0.30
Hourly flow rate (vph)	0	0	0	525	467	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)				138	95	
pX, platoon unblocked						
vC, conflicting volume	730	234	467			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	730	234	467			
IC, single (s)	6.8	6.9	4.1			
IC, 2 stage (s)						
IF (s)	3.5	3.3	2.2			
p0 queue free %	100	100	100			
cM capacity (veh/h)	362	775	1105			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1	SB 2
Volume Total	0	0	175	350	311	156
Volume Left	0	0	0	0	0	0
Volume Right	0	0	0	0	0	0
cSH	1700	1700	1105	1700	1700	1700
Volume to Capacity	0.00	0.00	0.00	0.21	0.18	0.09
Queue Length 95th (m)	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0
Lane LOS	A	A				
Approach Delay (s)	0.0		0.0		0.0	
Approach LOS	A					

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	16.1%	ICU Level of Service	A
Analysis Period (min)	15		