



Transportation Impact Brief 508 Beechwood Drive, Waterloo, ON

Paradigm Transportation Solutions Limited

November 2017



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24 November 2017
Project: 170292

Steve Schwartzentruber
Concept Development Group Inc.
c/o Amanda Drumond
Project Coordinator
Labreche Patterson and Associates
330-F Trillium Drive
Kitchener ON N2E 3J2

Dear Ms. Drumond:

**RE: TRANSPORTATION IMPACT BRIEF
PROPOSED RESIDENTIAL DEVELOPMENT, 508 BEECHWOOD DRIVE,
WATERLOO, ON**

Concept Development Group Inc. through Labreche Patterson and Associates retained **Paradigm Transportation Solutions Limited** to prepare this Transportation Impact Brief (TIB) for a proposed residential development located at 508 Beechwood Drive in Waterloo, Ontario. This brief summarizes existing transportation conditions near the subject site, provides estimates of the trips generated by the proposed redevelopment, and identifies the potential impact of the site-generated traffic on the adjacent road network. **Figure 1** illustrates the subject site location.

Existing Transportation Conditions

Roadways

Beechwood Drive is the roadway that will be directly impacted by the proposed development. Beechwood Drive falls under the jurisdiction of the City of Waterloo and is a two-lane, local roadway with an urban cross-section. It has one travel lane in each direction. Within the vicinity of the subject site, the speed limit is not posted and assumed to be 50 kilometres per hour. Sidewalks are provided on both sides of the roadway. East of the subject site driveway, parking is not permitted on the south side of Beechwood Drive.

Grand River Transit Service

Figure 2 illustrates the existing transit service in the study area. There is only one (1) route currently operating within walking distance (400 metres) of the subject site:

- ▶ **Route 5 Erb:** This route provides service from The Boardwalk in the west, through downtown Waterloo and to Bloomingdale Road in the east. Weekday service operates on 30-minute headways from about 6:00 AM to 12:00 AM. Saturday service operates on 30-minute headways from about 7:00 AM to 12:00 AM. Sunday and holiday service operates on 45-minute headways from about 10:00 AM to 6:00 PM;

The closest transit stops are located approximately 330 metres from the subject site at the intersection of Erb Street West and Beechwood Drive/Gateview Drive.

ION LRT

The ION LRT is scheduled to begin service in early 2018. Once implemented, the bus routes in the Region will be modified to connect directly to ION stations. The re-alignment of these bus routes to support a grid network will help make travel more efficient. This will significantly change the existing transit service offered in the Region of Waterloo. Once the LRT is running, Route 5 will provide direct service to Waterloo Public Square Station in downtown Waterloo, providing efficient connections to the greater LRT network.

Traffic Volumes

Paradigm conducted AM and PM peak period traffic counts on November 14, 2017 at the study intersections. **Figure 3** summarizes the existing traffic volumes at the study intersections during the AM and PM peak hours. **Appendix A** contains the detailed count data.

Existing Traffic Operations

Intersection Level of Service (LOS) is a recognized method of quantifying the efficiency of traffic flow at intersections. It is based on the delay experienced by individual vehicles executing the various movements. The delay is related to the number of vehicles that desire to make a certain movement compared to the estimated capacity for that movement. The capacity is based on several criteria related to the opposing traffic flow. The highest possible rating is LOS A, under which the average total delay is equal to or less than 10 seconds per vehicle. When the average delay exceeds 50 seconds for unsignalized intersections, the movement is classified as LOS F and remedial measures are typically implemented, if they are feasible.

Under the Region of Waterloo TIS guidelines¹, the following defines critical movements or intersections:

- ▶ The intersection operates with an overall LOS E or F for unsignalized or signalized intersections;
- ▶ The average control delay for individual movements is greater than 55 seconds;
- ▶ The estimated 95th percentile queue length for an exclusive movement exceeds the available storage space;
- ▶ The estimated 95th percentile queue length for an individual movement will block an existing access;

¹ Region of Waterloo, Transportation Impact Study Guidelines, July 2014



- ▶ Exclusive turning lanes are inaccessible because of queue lengths in adjacent through lanes; and
- ▶ Poor quality of service for non-auto modes.

The operation of the proposed site driveway was evaluated using Synchro 9 with HCM 2010 procedures. The intersection analysis considered three separate measures of effectiveness:

- ▶ The LOS for each turning movement;
- ▶ The volume to capacity (v/c) ratio for each turning movement; and
- ▶ The 95th percentile queue lengths.

The existing intersection operations for the AM and PM peak hours are summarized in **Table 1**. As shown, the intersection is currently operating at acceptable levels of service during the AM and PM peak hours.

Appendix B contains the detailed Synchro reports.

TABLE 1: EXISTING TRAFFIC OPERATIONS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				Overall
				Left	Through	Right	Approach	Left	Through	Right	Approach	Left	Through	Right	Approach	Left	Through	Right	Approach	
AM Peak Hour	1 - Beechwood Drive & Site Driveway	TWSC	LOS Delay V/C Q	A 7 0.00 0	A 0 0.00 0		A 0		A 0 0.00 0	A 0 0.00 0	A 0					A 10 0.01 0		A 10 0.01 0	A 10	1
PM Peak Hour	1 - Beechwood Drive & Site Driveway	TWSC	LOS Delay V/C Q	A 0 0.00 0	A 0 0.00 0		A 0		A 0 0.00 0	A 0 0.00 0	A 0					A 9 0.01 0		A 9 0.01 0	A 9	0

MOE - Measure of Effectiveness
LOS - Level of Service

Delay - Average Delay per Vehicle in Seconds
Q - 95th Percentile Queue Length

TWSC - Two-Way Stop Control

Proposed Development Description

The subject site is located at 508 Beechwood Drive in Waterloo, Ontario. Currently the site consists of one 41-unit apartment building. This building will remain in place. The proposed development will be a 13 floor, 139-unit apartment building. It will be constructed to the south and east of the existing building. In addition, three (3) parking levels, consisting of 243 parking spaces in total, will be provided: one (1) underground and two (2) above ground. The anticipated full build-out year is 2020.

The existing site access is on the southwest corner of the site providing access to Beechwood Drive. The new site plan proposes to move this driveway to the southeast corner of the site with access to remain on Beechwood Drive.

Figure 4 illustrates the proposed site plan.



Site Trip Generation

The vehicle trips generated by the proposed development were estimated for the AM and PM peak hours using the ITE Trip Generation Manual². The equation rates for the trip generation of Land Use Code (LUC) 220 Apartment were used since criteria for use of the regression equations were met.

Table 2 shows the resulting base trip generation, and indicates that the site is estimated to generate 72 trips in the AM peak hour and 94 trips in the PM peak hour.

TABLE 2: BASE TRIP GENERATION

ITE Land Use Code	Independent Variable	AM Peak Hour				PM Peak Hour			
		Rate	In	Out	Total	Rate	In	Out	Total
LUC 220 - Apartment	139 Units	FCE ¹	14	58	72	FCE ²	61	33	94
Total Trip Generation			14	58	72		61	33	94

$$^1 T = 0.49(X) + 3.73$$

$$^2 T = 0.55(X) + 17.65$$

Due to the subject site's proximity to transit and walking facilities, it is anticipated that some of the trips to/from the development will not be made by vehicles and instead will be made by transit, walking or biking. To account for this mode share, the results of the 2011 Transportation Tomorrow Survey³ (TTS) were reviewed. The TTS data is compiled from "a time series telephone survey on travel behaviours in the greater Toronto and surrounding area. Data are categorized into household, person and trip tables". The data is structured so that it can be accessed by traffic analysis zone (TAZ) and trip mode to produce more accurate and site-specific results. That data was queried to display results for all daily trips for the subject site traffic analysis zone (7254). The resulting mode share reduction for non-automotive trips is 8%. When applied to the base trip generation, the total AM peak hour site-generated trips are reduced by 6, to 66 trips, and the total PM peak hour site-generated trips are reduced by 8, to 86 trips. **Table 3** summarizes final site-generated trip estimates adjusted to account for mode share.

TABLE 3: ADJUSTED TRIP GENERATION

ITE Land Use Code	Independent Variable	AM Peak Hour				PM Peak Hour			
		Rate	In	Out	Total	Rate	In	Out	Total
LUC 220 - Apartment	139 Units	FCE ¹	14	58	72	FCE ²	61	33	94
<i>Mode share reduction</i>		8%	-1	-5	-6	8%	-5	-3	-8
Total Trip Generation			13	53	66		56	30	86

$$^1 T = 0.49(X) + 3.73$$

$$^2 T = 0.55(X) + 17.65$$

It should be noted that as observed from the existing counts the existing site, with 41 units, is only generating 13 trips in the AM peak hour and 14 trips in the PM peak hour. This results in a trip generation rate of approximately 0.35 which is significantly lower than the rates specified in the trip generation manual. Thus, the estimated site-generated trips shown in **Table 3** are likely over estimating the number of trips that the additional development will generate. Consequently, the actual operation of the site driveway will operate better than the analysis will predict.

² ITE Trip Generation Manual, 9th Edition, Institute of Transportation Engineers, 2012.

³ Transportation Tomorrow Survey (TTS), 2011, Data Management Group, University of Toronto.



Site Trip Distribution and Assignment

Table 4 summarizes the observed site-generation trip distribution. The updated, post-development site-generated trips were assigned to the road network based using this same pattern. **Figure 5** displays the resulting assignment.

TABLE 4: TRIP DISTRIBUTION

Direction	Route	AM Peak		PM Peak	
		Inbound	Outbound	Inbound	Outbound
East	Beechwood Drive	66%	31%	36%	61%
West	Beechwood Drive	34%	69%	64%	39%
<i>Total</i>		<i>100%</i>	<i>100%</i>	<i>100%</i>	<i>100%</i>

2025 Horizon

2025 Background Traffic Volumes

The 2025 horizon year (five-years from full build-out/occupancy) was used for the analysis of the future background and future total traffic conditions. Pre-study consultation with the Region and the City did not result in the identification of any approved or in-stream developments within the vicinity of the subject site. Thus, the estimated background traffic consists of only the generalized background traffic growth. This growth, as confirmed with the City and the Region, was applied to the existing volumes at 2% per annum, compounded for eight (8) years (total growth of 17.2%).

Figure 6 illustrates the 2025 AM and PM peak hour total background traffic volumes.

2025 Background Traffic Operating Conditions

Operational analysis was conducted using Synchro 9 (HCM 2010) to determine the AM and PM peak hour conditions for the study intersection. **Table 5** summarizes the estimated 2025 background traffic operations.

Appendix C contains the detailed Synchro 9 reports.



TABLE 5: 2025 BACKGROUND TRAFFIC OPERATIONS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				Overall
				Left	Through	Right	Approach	Left	Through	Right	Approach	Left	Through	Right	Approach	Left	Through	Right	Approach	
AM Peak Hour	1 - Beechwood Drive & Site Driveway	TWSC	LOS Delay V/C Q Ex Avail.	A 7 0.00 0 0	A 0 0.00 0 0		A 0		A 0 0.00 0 0	A 0 0.00 0 0	A 0					A 10 0.01 0 0		A 10 0.01 0 0	A 10	1
PM Peak Hour	1 - Beechwood Drive & Site Driveway	TWSC	LOS Delay V/C Q Ex Avail.	A 0 0.00 0 0	A 0 0.00 0 0		A 0		A 0 0.00 0 0	A 0 0.00 0 0	A 0					A 10 0.01 0 0		A 10 0.01 0 0	A 10	0

MOE - Measure of Effectiveness
LOS - Level of Service

Delay - Average Delay per Vehicle in Seconds
Q - 95th Percentile Queue Length

TWSC - Two-Way Stop Control

As shown, the Beechwood Drive and Site Driveway intersection is expected to operate at acceptable conditions for the AM and PM peak hours.

2025 Total Traffic Volumes

The estimated site-generated traffic was added to the 2025 background traffic to establish the 2025 total traffic. **Figure 6** shows the estimated total 2025 traffic volumes.

2025 Total Traffic Operating Conditions

Operational analysis was conducted using Synchro 9 (HCM 2010) to determine the AM and PM peak hour conditions for the study intersection. **Table 6** summarizes the estimated 2025 total traffic operations.

TABLE 6: 2025 TOTAL TRAFFIC OPERATIONS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				Overall
				Left	Through	Right	Approach	Left	Through	Right	Approach	Left	Through	Right	Approach	Left	Through	Right	Approach	
AM Peak Hour	1 - Beechwood Drive & Site Driveway	TWSC	LOS Delay V/C Q Ex Avail.	A 7 0.01 0	A 0 0.00 0		A 1		A 0 0.00 0	A 0 0.00 0	A 0				A 10 0.09 0		A 10 0.09 0	A 10	3	
PM Peak Hour	1 - Beechwood Drive & Site Driveway	TWSC	LOS Delay V/C Q Ex Avail.	A 8 0.02 0	A 0 0.00 0		A 2		A 0 0.00 0	A 0 0.00 0	A 0				A 10 0.05 0		A 10 0.05 0	A 10	2	

MOE - Measure of Effectiveness
LOS - Level of Service

Delay - Average Delay per Vehicle in Seconds
Q - 95th Percentile Queue Length

TWSC - Two-Way Stop Control

As shown, the Beechwood Drive and Site Driveway intersection is expected to operate at acceptable conditions for the AM and PM peak hours. In addition, as previously mentioned, the Site Driveway is



expected to operate better than detailed in **Table 6** due to the probable overestimation of the site-generated traffic.

Appendix D contains the detailed Synchro 9 reports.

Intersection Review

The site access is proposed to be moved to the southeast corner of the property. This new location was reviewed to ensure adequate safety and traffic operations.

Sight Distance

At a driveway access, the minimum intersection sight distance is to be provided. The Geometric Design Guide from Canadian Roads⁴ (TAC), Chapter 9.9 (Sight Triangles), Section 9.9.2.3 (Intersection Control) states that *"The intersection sight distance in both directions should be equal to the distance traveled at the design speed of the major road during a period of time equal to the time gap"*. The time gap refers to the time between subsequent vehicles on the major road that a vehicle on the minor road needs to turn onto the major road without causing the major-road vehicle to slow to less than 70% of their initial speed. TAC specifies that an intersection sight distance of 130 metres is required⁵ for the proposed intersection at Beechwood Drive (using a design speed equal to 60 kilometres per hour, or 10 kilometres per hour over the posted speed limit).

Sight distance measurements were taken at the proposed relocated driveway connection to Beechwood Drive. The measurements were taken from a point five metres from the approximate centerline of the proposed driveway (the rear of a vehicle turning into the driveway) with a target object height of 0.60 metres (as per TAC) along a line of sight to the furthest point in the respective direction at 1.08 metres above the pavement (the height of a driver's eye). The following was noted for a design speed of 60 kilometres per hour (assumed posted speed limit of 50 kilometres per hour):

- ▶ Outbound site traffic making a left-turn from the Site Driveway onto Beechwood Drive has a field of view of approximately 130 metres after which, a bend in the roadway restricts sight. This is equal to the intersection sight distance specified by TAC and thus satisfies the requirements.
- ▶ Outbound site traffic making a right turn from the Site Driveway onto Beechwood Drive has a field of view of approximately 105 metres to the west, which is limited by an existing bend in the roadway. This means that the available sight distance falls short by 25 metres.

For the vehicles travelling on Beechwood Drive, TAC specifies sight distance requirements for stopping sight distance. TAC states⁶ "Stopping sight distance is the sum of the distance travelled during the perception and reaction time and the braking distance" where the brake reaction time is 2.5 seconds. The perception-reaction time refers to the process of detecting the presence of a target,

⁴ Transportation Association of Canada, Geometric Design Guide for Canadian Roads, June 2017.

⁵ Table 9.9.4: Design Intersection Sight Distance – Case B1, Left Turn From Stop, Transportation Association of Canada, Geometric Design Guide for Canadian Roads, June 2017.

⁶ The TAC Guide Chapter 2.5 (Sight Distance), Section 2.5.3 (Stopping Sight Distance) Transportation Association of Canada, Geometric Design Guide for Canadian Roads, June 2017.



recognizing it as something requiring action, and then doing what is necessary to initiate the appropriate action. The braking distance is the time it takes for the vehicle to come to a complete stop once the driver has activated the brake. Based on a design speed of 60 kilometres per hour (10 kilometres per hour over the assumed speed limit), the minimum stopping sight distance for design is 65 metres. This means that a sight distance of 105 metres for eastbound vehicles traveling along Beechwood Drive is more than sufficient for them to stop or slow down, if required, as a result of vehicles pulling onto Beechwood Drive from the Site Driveway.

In addition, it should be noted that vehicles traveling in both directions on Beechwood Drive, along the bend, will be negotiating the curves at speeds equal to or lower than the (assumed) posted speed limit. This reduction in speed will be maintained as drivers near the Site Driveway. If a design speed of 50 kilometres is assumed, the required intersection sight distance becomes 105 metres. This is equal to the provided sight distance looking west from the Site Driveway on Beechwood Drive meeting the target specified by TAC.

In summary, the limited intersection sight distance presents a low safety risk at the proposed Site Driveway location due to more than adequate stopping sight distance being available and the expected reduction in speed of the vehicles on Beechwood Drive.

Figure 8 illustrates the provided sight distance from the proposed Site Driveway.

Left-Turn Lane Warrant

A warrant for an eastbound left-turn lane on Beechwood Drive was conducted using the left-turn lane warrant nomographs contained in the Geometric Design Guide for Ontario Highways.

The design speed was taken to be 60 km/h (10 km/h greater than the speed limit of 50 km/h). **Figure 9** shows the warrant nomograph for the 2025 total traffic horizon for the AM and PM peak hour. Both nomographs indicate that an eastbound left-turn lane on Beechwood Drive is not warranted.

Summary

In summary, the traffic impacts of 139 additional units to the 508 Beechwood Drive site fall well-within acceptable parameters. It is estimated that when using the ITE trip generation rates and once adjusted to account for mode share, 66 trips will be generated by the additional units in the AM peak hour and 86 trips will be generated by the additional units in the PM peak hour. However, based on the existing site trip generation, it is expected that this is an overestimation of the actual trips that the new development will generate. Thus, the resulting operational conditions detailed in this report are conservative estimations.

Based on the foregoing, the following is concluded:

- ▶ The Site Driveway and Beechwood Drive intersection, in its new location, with a stop sign located on the southbound approach, is expected to operate at acceptable operating conditions.
- ▶ At the Site Driveway, limited intersection sight distance is noted to be present to the west for a 60-kilometre design speed. However, it was found that the intersection sight distance is sufficient for a design speed of 50-kilometres per hour, meeting the posted speed limit. This presents a low safety risk.



It is therefore recommended that the development plan be approved with no conditions related to off-site transportation improvements.

Please do not hesitate to contact me if you have any questions.

Yours very truly,

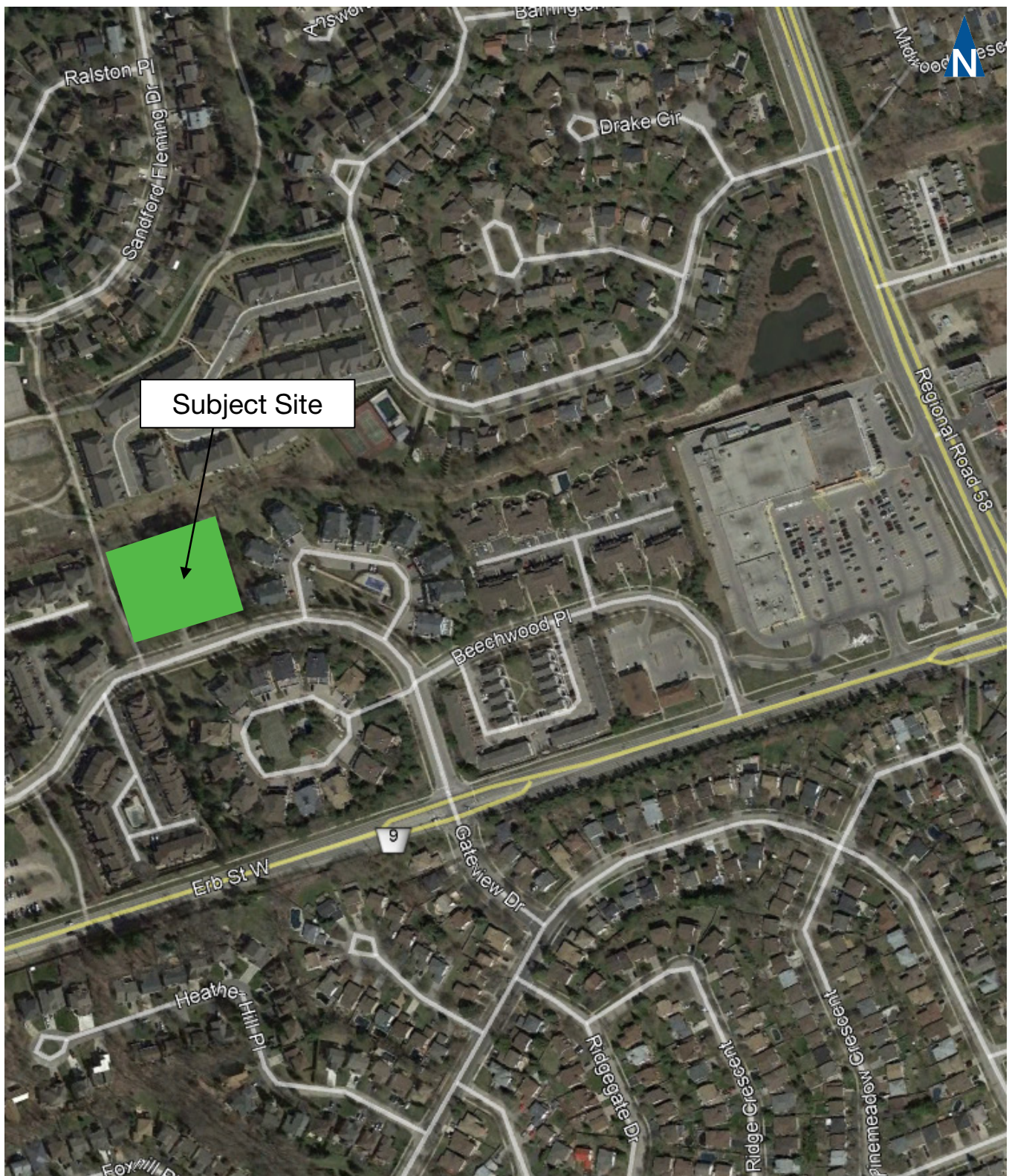
PARADIGM TRANSPORTATION SOLUTIONS LIMITED

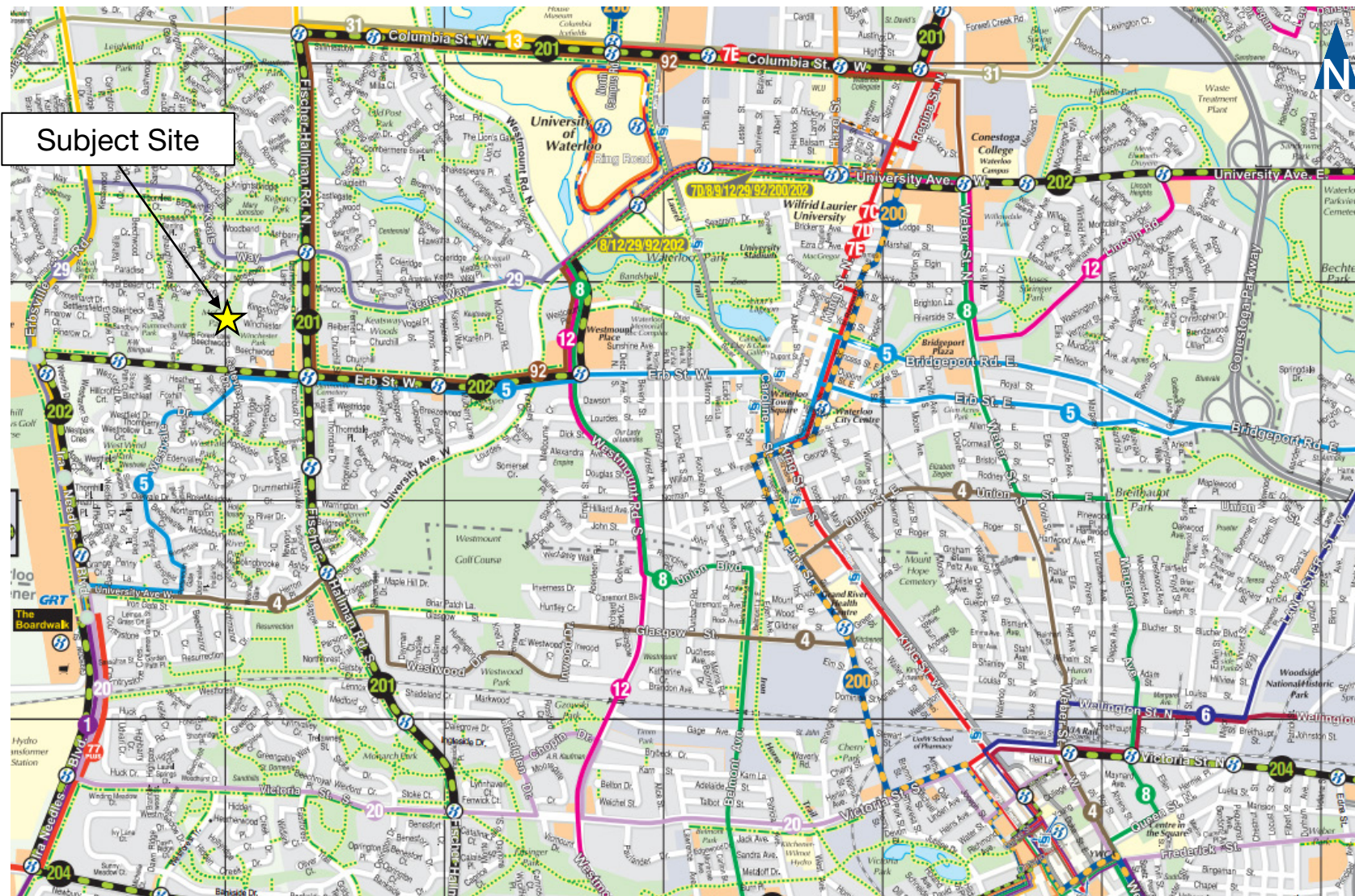
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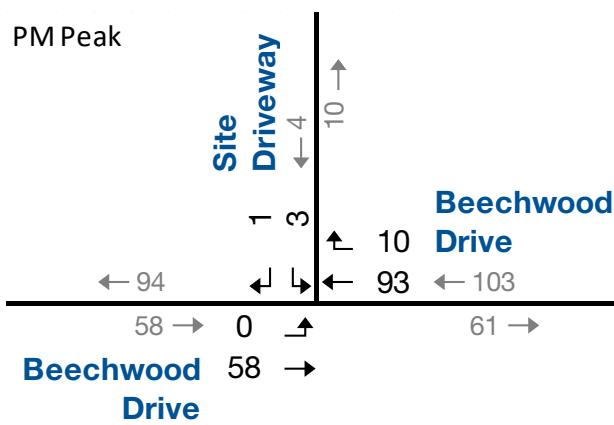
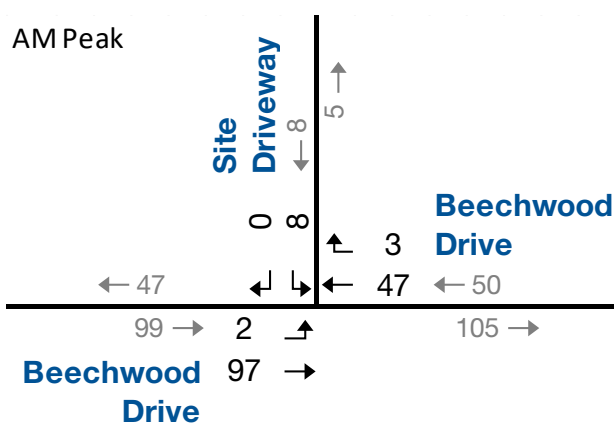
Jim Mallett

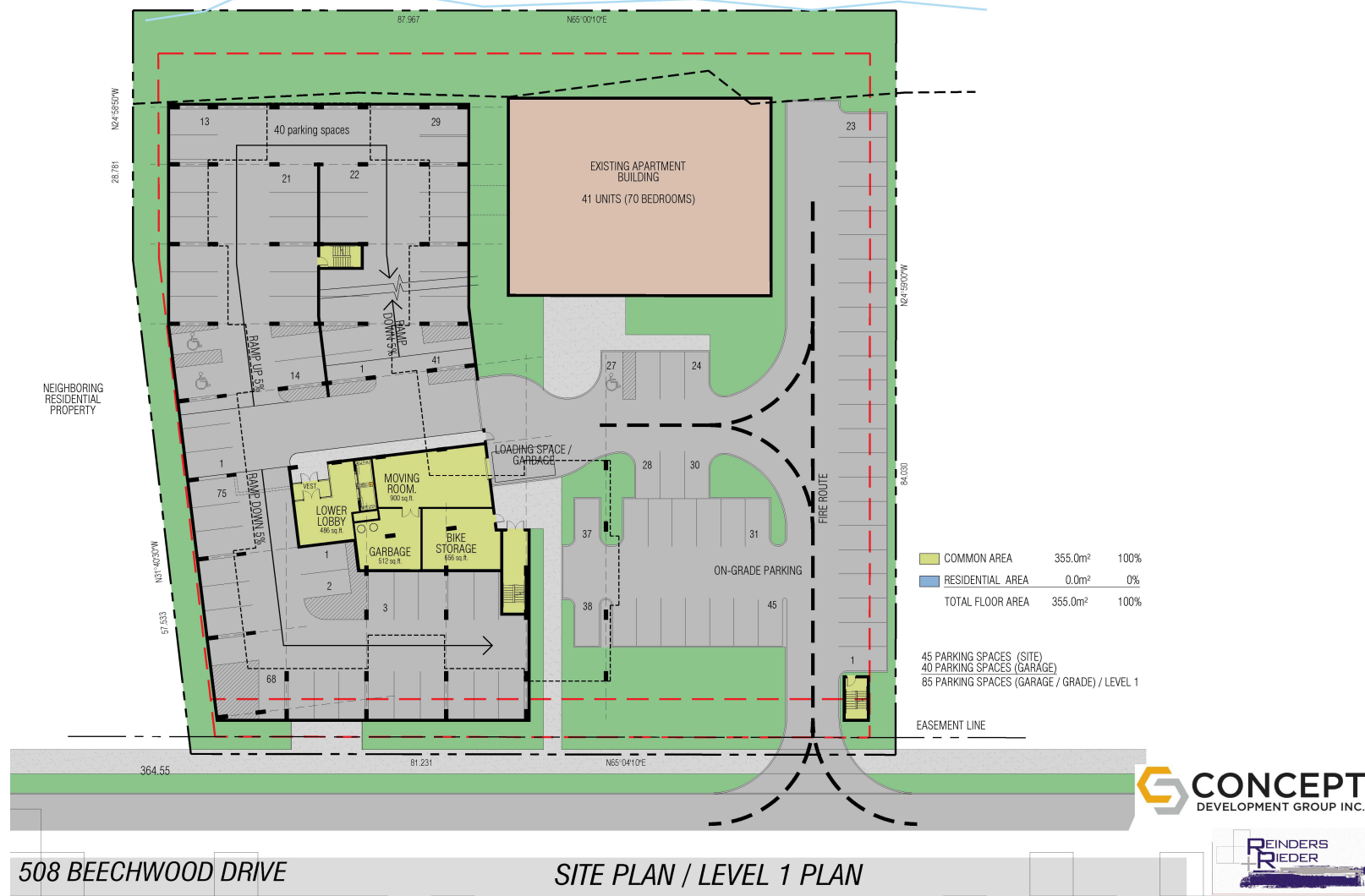
M.A.Sc., P.Eng., PTOE
President

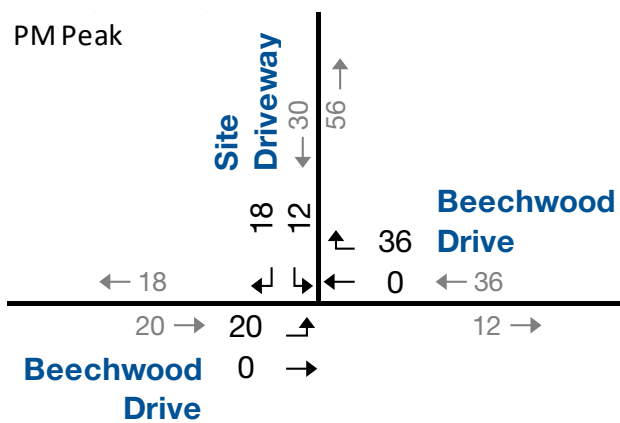
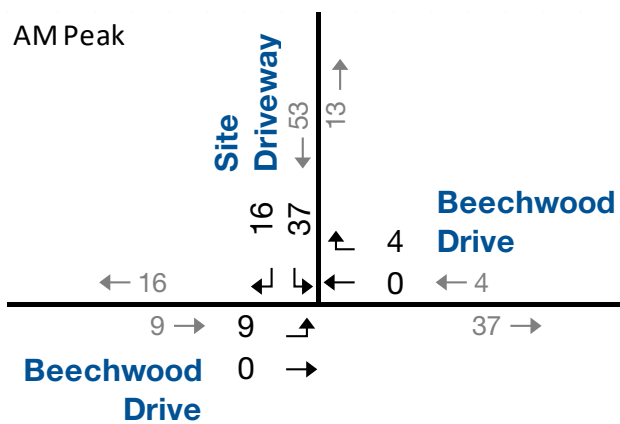


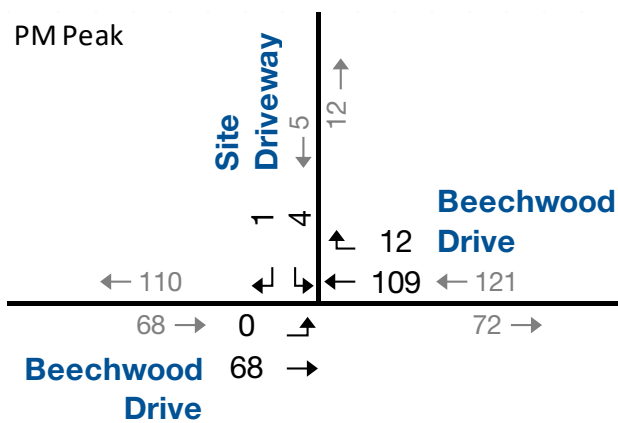
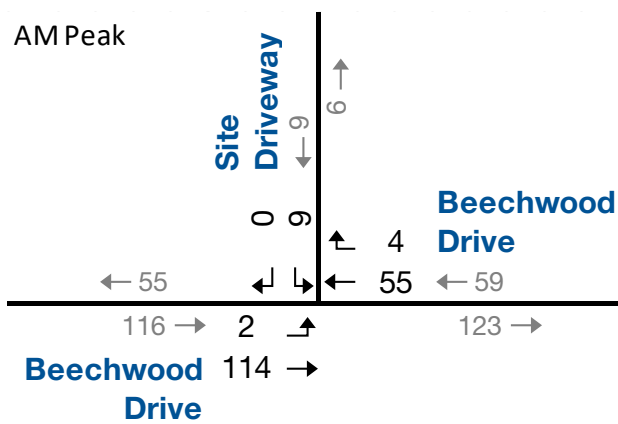


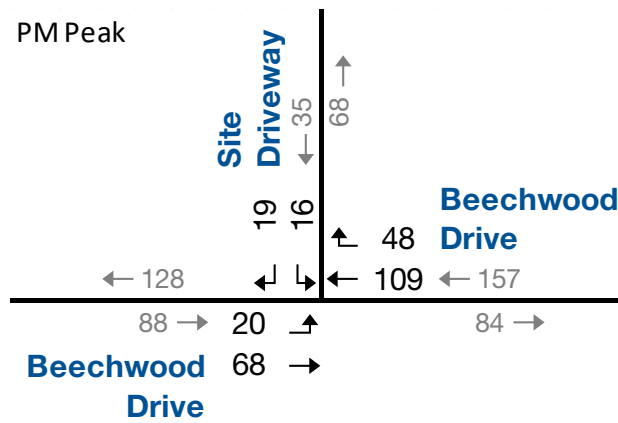
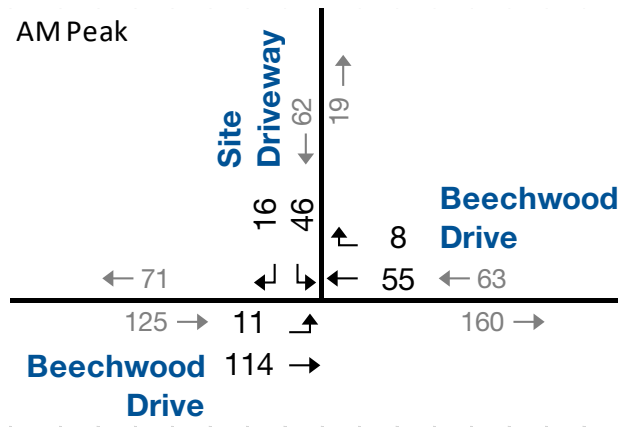










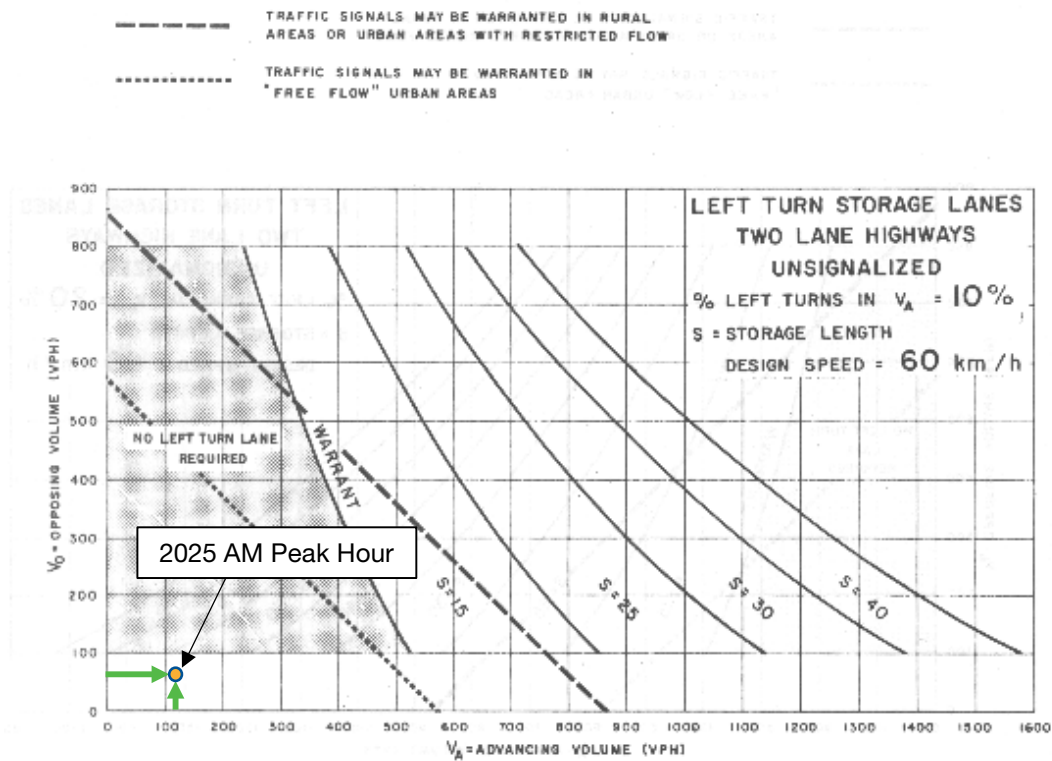




Looking east from proposed Site Driveway

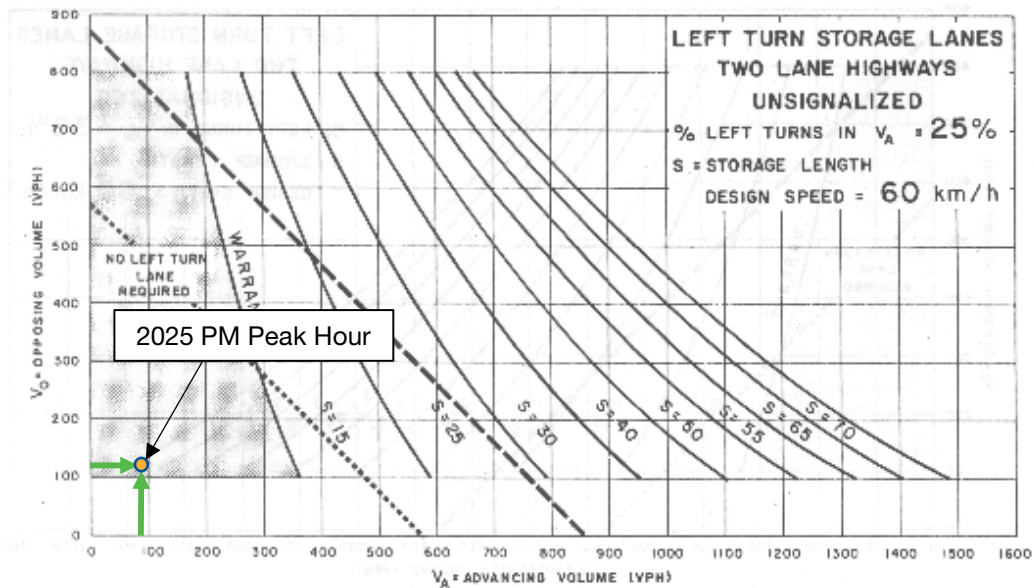


Looking west from proposed Site Driveway



AT-GRADE INTERSECTIONS

APPENDIX A



Source: Geometric Design Guide for Ontario Highways



Left-turn Lane Warrants for Site Driveway

APPENDIX A – TMC





Paradigm Transportation Solutions Limited
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Count Name: 508 Beechwood Drive
Site Code:
Start Date: 11/14/2017
Page No: 1

Turning Movement Data

Start Time	Beechwood Drive Eastbound					Beechwood Drive Westbound					508 Beechwood Drive Southbound					Int. Total
	Left	Thru	U-Turn	Peds	App. Total	Thru	Right	U-Turn	Peds	App. Total	Left	Right	U-Turn	Peds	App. Total	
7:00 AM	0	16	0	0	16	3	0	0	0	3	1	0	0	3	1	20
7:15 AM	0	12	0	0	12	4	0	0	0	4	2	0	0	0	2	18
7:30 AM	0	24	0	0	24	6	2	0	0	8	1	0	0	1	1	33
7:45 AM	1	25	0	2	26	12	1	0	0	13	3	0	0	2	3	42
Hourly Total	1	77	0	2	78	25	3	0	0	28	7	0	0	6	7	113
8:00 AM	0	25	0	0	25	10	1	0	0	11	1	0	0	4	1	37
8:15 AM	0	24	0	0	24	14	0	0	0	14	3	0	0	2	3	41
8:30 AM	1	23	0	0	24	11	1	1	0	13	1	0	0	3	1	38
8:45 AM	0	18	0	0	18	10	1	0	0	11	2	0	0	2	2	31
Hourly Total	1	90	0	0	91	45	3	1	0	49	7	0	0	11	7	147
9:00 AM	0	11	0	0	11	11	1	0	0	12	0	0	0	1	0	23
9:15 AM	0	14	0	0	14	5	0	1	0	6	0	0	0	1	0	20
9:30 AM	0	12	0	0	12	7	0	0	0	7	3	0	0	3	3	22
9:45 AM	0	12	0	0	12	16	0	0	0	16	1	0	0	0	1	29
Hourly Total	0	49	0	0	49	39	1	1	0	41	4	0	0	5	4	94
10:00 AM	0	8	0	0	8	9	1	0	0	10	1	0	0	1	1	19
10:15 AM	2	9	0	0	11	10	0	0	0	10	6	0	0	2	6	27
10:30 AM	0	12	0	0	12	10	2	0	0	12	1	0	0	6	1	25
10:45 AM	0	8	0	0	8	7	0	0	0	7	0	0	0	4	0	15
Hourly Total	2	37	0	0	39	36	3	0	0	39	8	0	0	13	8	86
*** BREAK ***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3:00 PM	0	13	0	0	13	19	0	0	0	19	0	0	0	7	0	32
3:15 PM	1	6	0	0	7	10	1	0	0	11	1	0	0	3	1	19
3:30 PM	1	8	0	0	9	15	3	0	0	18	0	0	0	2	0	27
3:45 PM	0	7	0	0	7	21	1	0	0	22	1	0	0	0	1	30
Hourly Total	2	34	0	0	36	65	5	0	0	70	2	0	0	12	2	108
4:00 PM	0	13	0	0	13	23	1	0	0	24	1	1	0	1	2	39
4:15 PM	0	11	0	0	11	21	0	0	0	21	1	0	0	1	1	33
4:30 PM	1	7	0	0	8	18	1	0	0	19	0	0	0	1	0	27
4:45 PM	0	15	0	0	15	29	1	0	0	30	5	0	0	4	5	50
Hourly Total	1	46	0	0	47	91	3	0	0	94	7	1	0	7	8	149
5:00 PM	0	12	0	0	12	16	0	0	0	16	2	0	0	2	2	30
5:15 PM	1	6	0	0	7	30	1	0	0	31	0	0	0	7	0	38
5:30 PM	0	18	0	0	18	27	0	0	0	27	0	0	0	1	0	45
5:45 PM	0	12	0	0	12	24	5	0	0	29	1	1	0	1	2	43
Hourly Total	1	48	0	0	49	97	6	0	0	103	3	1	0	11	4	156
6:00 PM	0	14	0	0	14	18	3	0	0	21	0	0	0	1	0	35
6:15 PM	0	14	0	0	14	24	2	0	0	26	2	0	0	1	2	42

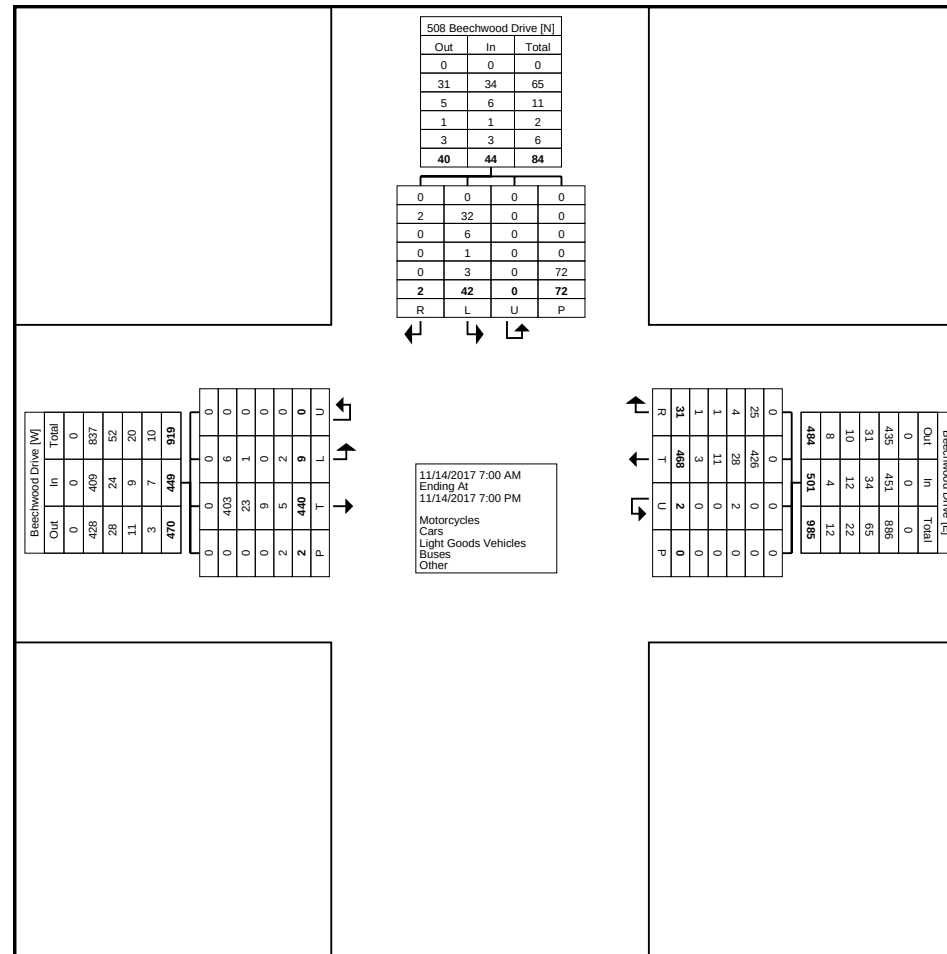
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Count Name: 508 Beechwood Drive
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Turning Movement Data Plot



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Waterloo, Ontario, Canada N2J 1N8
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Count Name: 508 Beechwood Drive
Site Code:
Start Date: 11/14/2017
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Turning Movement Peak Hour Data (7:45 AM)

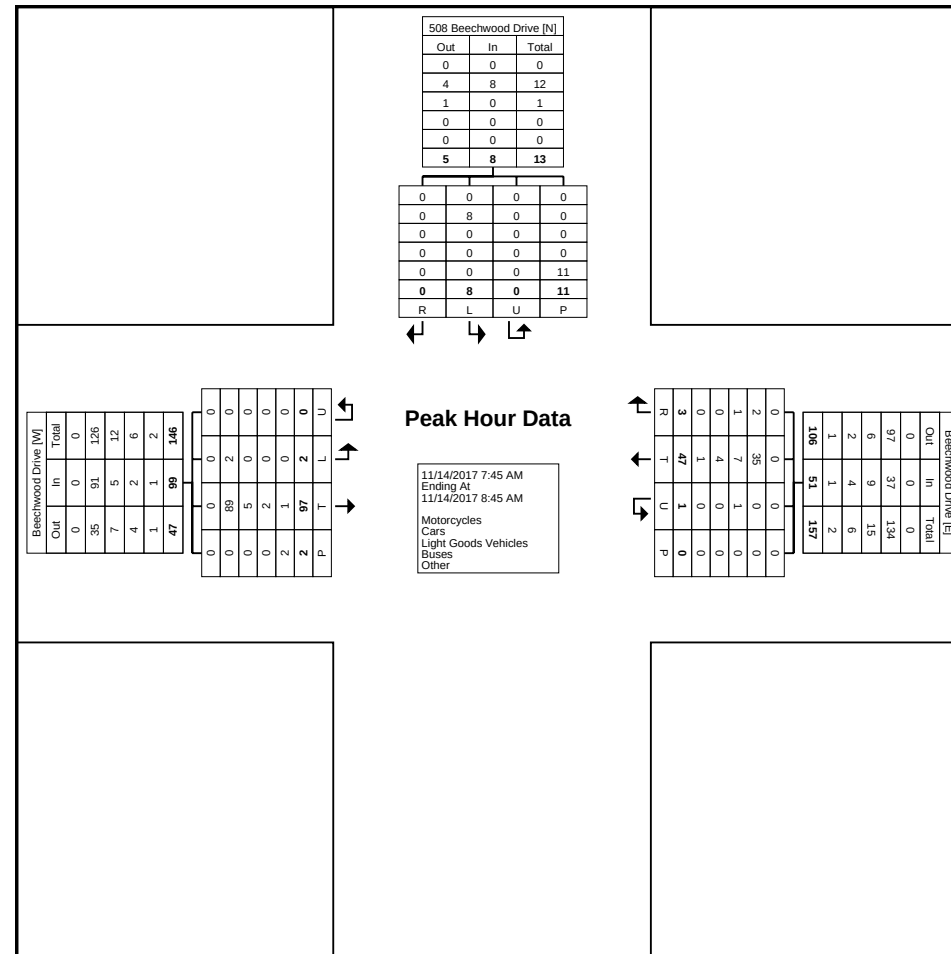
Start Time	Beechwood Drive Eastbound					Beechwood Drive Westbound					508 Beechwood Drive Southbound					Int. Total
	Left	Thru	U-Turn	Peds	App. Total	Thru	Right	U-Turn	Peds	App. Total	Left	Right	U-Turn	Peds	App. Total	
7:45 AM	1	25	0	2	26	12	1	0	0	13	3	0	0	2	3	42
8:00 AM	0	25	0	0	25	10	1	0	0	11	1	0	0	4	1	37
8:15 AM	0	24	0	0	24	14	0	0	0	14	3	0	0	2	3	41
8:30 AM	1	23	0	0	24	11	1	1	0	13	1	0	0	3	1	38
Total	2	97	0	2	99	47	3	1	0	51	8	0	0	11	8	158
Approach %	2.0	98.0	0.0	-	-	92.2	5.9	2.0	-	-	100.0	0.0	0.0	-	-	-
Total %	1.3	61.4	0.0	-	62.7	29.7	1.9	0.6	-	32.3	5.1	0.0	0.0	-	5.1	-
PHF	0.500	0.970	0.000	-	0.952	0.839	0.750	0.250	-	0.911	0.667	0.000	0.000	-	0.667	0.940
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Motorcycles	0.0	0.0	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0	-	-	-	0.0	0.0
Cars	2	89	0	-	91	35	2	0	-	37	8	0	0	-	8	136
% Cars	100.0	91.8	-	-	91.9	74.5	66.7	0.0	-	72.5	100.0	-	-	-	100.0	86.1
Light Goods Vehicles	0	5	0	-	5	7	1	1	-	9	0	0	0	-	0	14
% Light Goods Vehicles	0.0	5.2	-	-	5.1	14.9	33.3	100.0	-	17.6	0.0	-	-	-	0.0	8.9
Buses	0	2	0	-	2	4	0	0	-	4	0	0	0	-	0	6
% Buses	0.0	2.1	-	-	2.0	8.5	0.0	0.0	-	7.8	0.0	-	-	-	0.0	3.8
Single-Unit Trucks	0	1	0	-	1	1	0	0	-	1	0	0	0	-	0	2
% Single-Unit Trucks	0.0	1.0	-	-	1.0	2.1	0.0	0.0	-	2.0	0.0	-	-	-	0.0	1.3
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Articulated Trucks	0.0	0.0	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0	-	-	-	0.0	0.0
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Bicycles on Road	0.0	0.0	-	-	0.0	0.0	0.0	0.0	-	0.0	0.0	-	-	-	0.0	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	0.0	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	2	-	-	-	-	0	-	-	-	-	11	-	-
% Pedestrians	-	-	-	100.0	-	-	-	-	-	-	-	-	-	100.0	-	-



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Count Name: 508 Beechwood Drive
Site Code:
Start Date: 11/14/2017
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Turning Movement Peak Hour Data (5:30 PM)

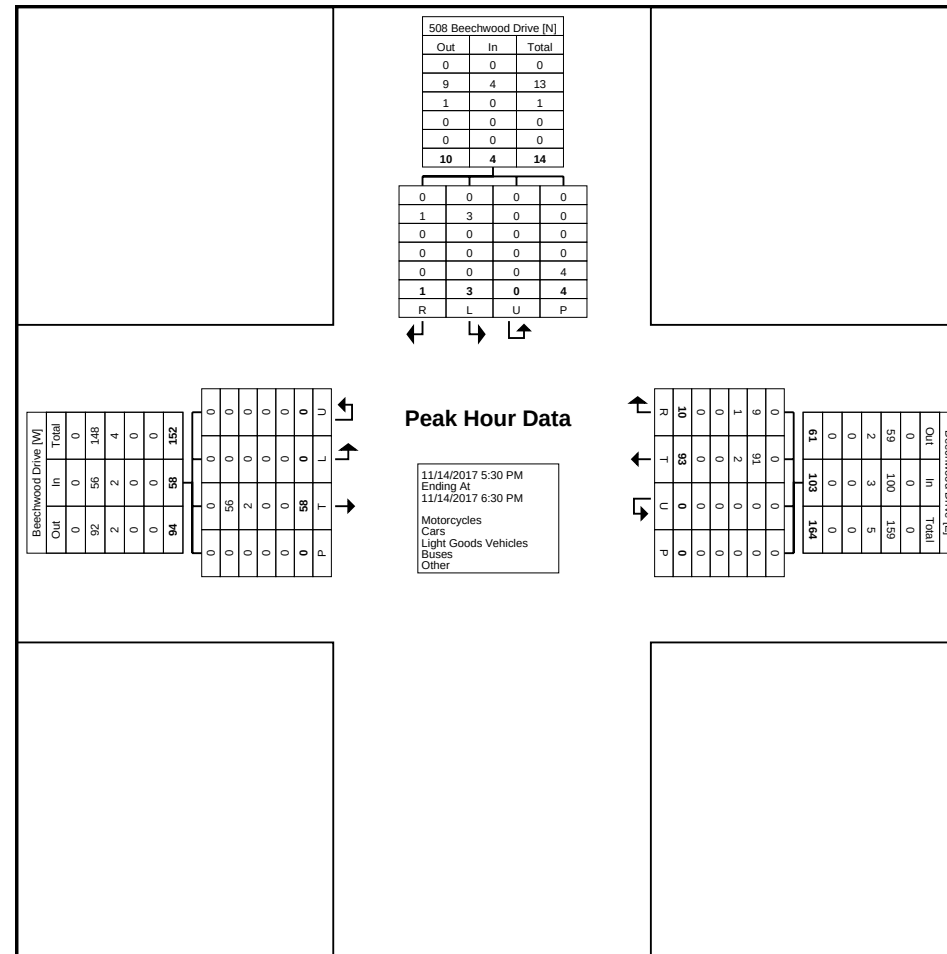
Start Time	Beechwood Drive Eastbound					Beechwood Drive Westbound					508 Beechwood Drive Southbound					Int. Total
	Left	Thru	U-Turn	Peds	App. Total	Thru	Right	U-Turn	Peds	App. Total	Left	Right	U-Turn	Peds	App. Total	
5:30 PM	0	18	0	0	18	27	0	0	0	27	0	0	0	1	0	45
5:45 PM	0	12	0	0	12	24	5	0	0	29	1	1	0	1	2	43
6:00 PM	0	14	0	0	14	18	3	0	0	21	0	0	0	1	0	35
6:15 PM	0	14	0	0	14	24	2	0	0	26	2	0	0	1	2	42
Total	0	58	0	0	58	93	10	0	0	103	3	1	0	4	4	165
Approach %	0.0	100.0	0.0	-	-	90.3	9.7	0.0	-	-	75.0	25.0	0.0	-	-	-
Total %	0.0	35.2	0.0	-	35.2	56.4	6.1	0.0	-	62.4	1.8	0.6	0.0	-	2.4	-
PHF	0.000	0.806	0.000	-	0.806	0.861	0.500	0.000	-	0.888	0.375	0.250	0.000	-	0.500	0.917
Motorcycles	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Motorcycles	-	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Cars	0	56	0	-	56	91	9	0	-	100	3	1	0	-	4	160
% Cars	-	96.6	-	-	96.6	97.8	90.0	-	-	97.1	100.0	100.0	-	-	100.0	97.0
Light Goods Vehicles	0	2	0	-	2	2	1	0	-	3	0	0	0	-	0	5
% Light Goods Vehicles	-	3.4	-	-	3.4	2.2	10.0	-	-	2.9	0.0	0.0	-	-	0.0	3.0
Buses	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Buses	-	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Single-Unit Trucks	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Single-Unit Trucks	-	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Articulated Trucks	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Articulated Trucks	-	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Bicycles on Road	0	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0
% Bicycles on Road	-	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0	0.0	-	-	0.0	0.0
Bicycles on Crosswalk	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-
% Bicycles on Crosswalk	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	-	-
Pedestrians	-	-	-	0	-	-	-	-	0	-	-	-	-	4	-	-
% Pedestrians	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	-	-



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Turning Movement Peak Hour Data Plot (5:30 PM)



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APPENDIX B - EXISTING TRAFFIC OPERATIONS



Intersection

Int Delay, s/veh 0.5

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	2	97	47	3	8	0
Future Vol, veh/h	2	97	47	3	8	0
Conflicting Peds, #/hr	11	0	0	11	0	2
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	90	90	90	90
Heavy Vehicles, %	0	3	10	0	0	0
Mvmt Flow	2	108	52	3	9	0

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	67	0	0 177 67
Stage 1	-	-	- 65 -
Stage 2	-	-	- 112 -
Critical Hdwy	4.1	-	- 6.4 6.2
Critical Hdwy Stg 1	-	-	- 5.4 -
Critical Hdwy Stg 2	-	-	- 5.4 -
Follow-up Hdwy	2.2	-	- 3.5 3.3
Pot Cap-1 Maneuver	1547	-	- 817 1002
Stage 1	-	-	- 963 -
Stage 2	-	-	- 918 -
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1545	-	- 802 992
Mov Cap-2 Maneuver	-	-	- 802 -
Stage 1	-	-	- 955 -
Stage 2	-	-	- 909 -

Approach	EB	WB	SB
HCM Control Delay, s	0.1	0	9.5
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1545	-	-	-	802
HCM Lane V/C Ratio	0.001	-	-	-	0.011
HCM Control Delay (s)	7.3	0	-	-	9.5
HCM Lane LOS	A	A	-	-	A
HCM 95th %tile Q(veh)	0	-	-	-	0

Intersection						
Int Delay, s/veh	0.2					
Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations		↰	↱		↰	↱
Traffic Vol, veh/h	0	58	93	10	3	1
Future Vol, veh/h	0	58	93	10	3	1
Conflicting Peds, #/hr	4	0	0	4	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	90	90	90	90
Heavy Vehicles, %	0	0	0	0	0	0
Mvmt Flow	0	64	103	11	3	1

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	118	0	0
Stage 1	-	-	-
Stage 2	-	-	-
Critical Hdwy	4.1	-	-
Critical Hdwy Stg 1	-	-	-
Critical Hdwy Stg 2	-	-	-
Follow-up Hdwy	2.2	-	-
Pot Cap-1 Maneuver	1483	-	-
Stage 1	-	-	-
Stage 2	-	-	-
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1483	-	-
Mov Cap-2 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-

Approach	EB	WB	SB
HCM Control Delay, s	0	0	9.3
HCM LOS	A		

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1483	-	-	-	841
HCM Lane V/C Ratio	-	-	-	-	0.005
HCM Control Delay (s)	0	-	-	-	9.3
HCM Lane LOS	A	-	-	-	A
HCM 95th %tile Q(veh)	0	-	-	-	0

APPENDIX C - 2025 BACKGROUND TRAFFIC OPERATIONS



Intersection						
Int Delay, s/veh	0.5					
Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	2	114	55	4	9	0
Future Vol, veh/h	2	114	55	4	9	0
Conflicting Peds, #/hr	11	0	0	11	0	2
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	90	90	90	90
Heavy Vehicles, %	0	3	10	0	0	0
Mvmt Flow	2	127	61	4	10	0
Major/Minor	Major1	Major2		Minor2		
Conflicting Flow All	77	0	-	0	205	76
Stage 1	-	-	-	-	74	-
Stage 2	-	-	-	-	131	-
Critical Hdwy	4.1	-	-	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	2.2	-	-	-	3.5	3.3
Pot Cap-1 Maneuver	1535	-	-	-	788	991
Stage 1	-	-	-	-	954	-
Stage 2	-	-	-	-	900	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1533	-	-	-	774	981
Mov Cap-2 Maneuver	-	-	-	-	774	-
Stage 1	-	-	-	-	946	-
Stage 2	-	-	-	-	891	-
Approach	EB	WB		SB		
HCM Control Delay, s	0.1	0		9.7		
HCM LOS				A		
Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1	
Capacity (veh/h)	1533	-	-	-	774	
HCM Lane V/C Ratio	0.001	-	-	-	0.013	
HCM Control Delay (s)	7.4	0	-	-	9.7	
HCM Lane LOS	A	A	-	-	A	
HCM 95th %tile Q(veh)	0	-	-	-	0	

Intersection

Int Delay, s/veh 0.2

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	0	68	109	12	4	1
Future Vol, veh/h	0	68	109	12	4	1
Conflicting Peds, #/hr	4	0	0	4	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	90	90	90	90
Heavy Vehicles, %	0	0	0	0	0	0
Mvmt Flow	0	76	121	13	4	1

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	138	0	0 208 132
Stage 1	-	-	- 132 -
Stage 2	-	-	- 76 -
Critical Hdwy	4.1	-	- 6.4 6.2
Critical Hdwy Stg 1	-	-	- 5.4 -
Critical Hdwy Stg 2	-	-	- 5.4 -
Follow-up Hdwy	2.2	-	- 3.5 3.3
Pot Cap-1 Maneuver	1458	-	- 785 923
Stage 1	-	-	- 899 -
Stage 2	-	-	- 952 -
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1458	-	- 780 920
Mov Cap-2 Maneuver	-	-	- 780 -
Stage 1	-	-	- 896 -
Stage 2	-	-	- 949 -

Approach	EB	WB	SB
HCM Control Delay, s	0	0	9.5
HCM LOS			A

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1458	-	-	-	804
HCM Lane V/C Ratio	-	-	-	-	0.007
HCM Control Delay (s)	0	-	-	-	9.5
HCM Lane LOS	A	-	-	-	A
HCM 95th %tile Q(veh)	0	-	-	-	0

APPENDIX D - 2025 TOTAL TRAFFIC OPERATIONS



HCM 2010 TWSC
1: Beechwood Drive & Site Driveway

2025 Total AM Peak Hour
170292 - 508 Beechwood Dr Traffic Brief

Intersection						
Int Delay, s/veh	2.8					
Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	11	114	55	8	46	16
Future Vol, veh/h	11	114	55	8	46	16
Conflicting Peds, #/hr	11	0	0	11	0	2
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	90	90	90	90
Heavy Vehicles, %	0	3	10	0	0	0
Mvmt Flow	12	127	61	9	51	18
Major/Minor	Major1	Major2	Minor2			
Conflicting Flow All	81	0	-	0	228	79
Stage 1	-	-	-	-	77	-
Stage 2	-	-	-	-	151	-
Critical Hdwy	4.1	-	-	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	2.2	-	-	-	3.5	3.3
Pot Cap-1 Maneuver	1529	-	-	-	765	987
Stage 1	-	-	-	-	951	-
Stage 2	-	-	-	-	882	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1527	-	-	-	746	977
Mov Cap-2 Maneuver	-	-	-	-	746	-
Stage 1	-	-	-	-	943	-
Stage 2	-	-	-	-	867	-
Approach	EB	WB		SB		
HCM Control Delay, s	0.6	0		10		
HCM LOS				B		
Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1	
Capacity (veh/h)	1527	-	-	-	-	794
HCM Lane V/C Ratio	0.008	-	-	-	-	0.087
HCM Control Delay (s)	7.4	0	-	-	-	10
HCM Lane LOS	A	A	-	-	-	B
HCM 95th %tile Q(veh)	0	-	-	-	-	0.3

Intersection						
Int Delay, s/veh	1.7					
Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Vol, veh/h	20	68	109	48	16	19
Future Vol, veh/h	20	68	109	48	16	19
Conflicting Peds, #/hr	4	0	0	4	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	90	90	90	90	90	90
Heavy Vehicles, %	0	0	0	0	0	0
Mvmt Flow	22	76	121	53	18	21
Major/Minor	Major1	Major2		Minor2		
Conflicting Flow All	178	0	-	0	272	152
Stage 1	-	-	-	-	152	-
Stage 2	-	-	-	-	120	-
Critical Hdwy	4.1	-	-	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	2.2	-	-	-	3.5	3.3
Pot Cap-1 Maneuver	1410	-	-	-	722	900
Stage 1	-	-	-	-	881	-
Stage 2	-	-	-	-	910	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	1410	-	-	-	706	897
Mov Cap-2 Maneuver	-	-	-	-	706	-
Stage 1	-	-	-	-	878	-
Stage 2	-	-	-	-	893	-
Approach	EB	WB		SB		
HCM Control Delay, s	1.7	0		9.7		
HCM LOS				A		
Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1	
Capacity (veh/h)	1410	-	-	-	798	
HCM Lane V/C Ratio	0.016	-	-	-	0.049	
HCM Control Delay (s)	7.6	0	-	-	9.7	
HCM Lane LOS	A	A	-	-	A	
HCM 95th %tile Q(veh)	0	-	-	-	0.2	