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450-460 Weber Street North and 435 King Street North, Waterloo, ON Transportation Impact Assessment

Paradigm Transportation Solutions Limited

2023-04-24
220805

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Project Summary

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Executive Summary

Content

2439672 Ontario Inc. retained Paradigm Transportation Solutions Limited (Paradigm) to conduct this Transportation Impact Assessment (TIA) for a proposed mixed-use development located at 450-460 Weber Street North and 435 King Street North in Waterloo, Ontario.

This TIA includes an analysis of existing traffic conditions, a description of the proposed development, traffic forecasts for opening year of the assumed phase 1 build-out, opening year of the assumed phase 2 build-out, opening year of the assumed full-buildout, five years after the assumed full build-out, and ten years after the assumed full build-out, and any recommendations required to manage future traffic conditions.

Development Concept

The subject site is proposed to be developed into 2,972 residential apartment units in seven buildings along with retail uses totalling 2,686 square metres, office uses totalling 10,877 square metres and an 815 square metre daycare centre.

Vehicle access is proposed via the existing connection to King Street North opposite of Blue Springs Drive and via two new all-moves accesses to Weber Street North opposite Blythwood Road and Milford Avenue.

Phase 1 is assumed to be completed by 2027 with access only to Weber Street North opposite of Blythwood Road. Phase 2 is assumed to be completed by 2032 with all three accesses opened. The full build-out is assumed to be completed by 2037.

Conclusions

Based on the investigations carried out, it is concluded that:

- **Existing Traffic Conditions:** The study area intersections are operating at acceptable levels of service during the AM and PM peak hours with critical movements noted at the King Street North intersection with Blue Springs Drive, and the Northbound and Southbound Ramps for Highway 85 at King Street North.
- **Development Trip Generation:** Phase 1 is forecast to generate approximately 209 and 251 trips during the AM and PM peak hours respectively. Phase 2 is forecast to generate approximately 539 and 603 net external trips during the AM and

PM peak hours respectively. The full build-out is forecast to generate approximately 861 and 938 net external trips during the AM and PM peak hours respectively for 2037 and 789 and 859 net external trips during the AM and PM peak hours respectively for 2042 and 2047.

- **2027 Background Traffic Conditions:** The study area intersections are operating at acceptable levels of service during the AM and PM peak hours with critical movements noted at all signalized intersections.
- **2027 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2027 background traffic conditions.
- **2032 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2027 background traffic conditions.
- **2032 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2032 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.
- **2037 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2032 background traffic conditions.
- **2037 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2037 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.
- **2042 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2037 background traffic conditions.
- **2042 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2042 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.
- **2047 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2042 background traffic conditions.
- **2047 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2047 background traffic conditions with an additional critical

movement noted at the intersection of Weber Street North and Milford Avenue.

- **Remedial Measures:** Traffic control signals are not justified at the intersections of Weber Street North at Milford Avenue and Weber Street North and Blythwood Road.

Recommendations

Based on existing and background traffic conditions, it is recommended to extend:

- The southernmost westbound left-turn storage length from 60 m to 220 m at the intersection of King Street North and the Highway 85 Northbound Ramp; and
- The eastbound left-turn storage length from 80 to 165 m at the intersection of King Street North and the Highway 85 Southbound Ramp.

Based on total traffic conditions, it is recommended that

- The internal design of the driveway connection to Weber Street, opposite Milford Road include a separated left-turn lane and shared through-right lane. The design of the site should include space for a minimum queue of 35 metres for left-turning traffic;
- To help prevent the eastbound left-turn queue at the intersection of King Street North and Blue Springs Drive from blocking the eastbound through and right-turn movements, the storage length should be extended to the maximum length available internal to the site; and
- A pedestrian refuge island, similar to that on Weber Street and Blythwood Road, be constructed at the intersection of Weber Street North and Milford Avenue on the south leg, opposite the left-turn lane, to provide the most direct access to nearby schools and commercial attractions.

Contents

Appendices

Figures

Tables

1 Introduction

1.1 Overview

2439672 Ontario Inc. Retained Paradigm Transportation Solutions Limited (Paradigm) to conduct this Transportation Impact Assessment for a mixed development located at 450-460 Weber Street North and 435 King Street North in Waterloo, Ontario. **Figure 1.1** illustrates the location of the subject site.

This study reviews the forecast impacts of the site-generated traffic on the surrounding road network and identifies any required remedial measures. The scope of the study includes:

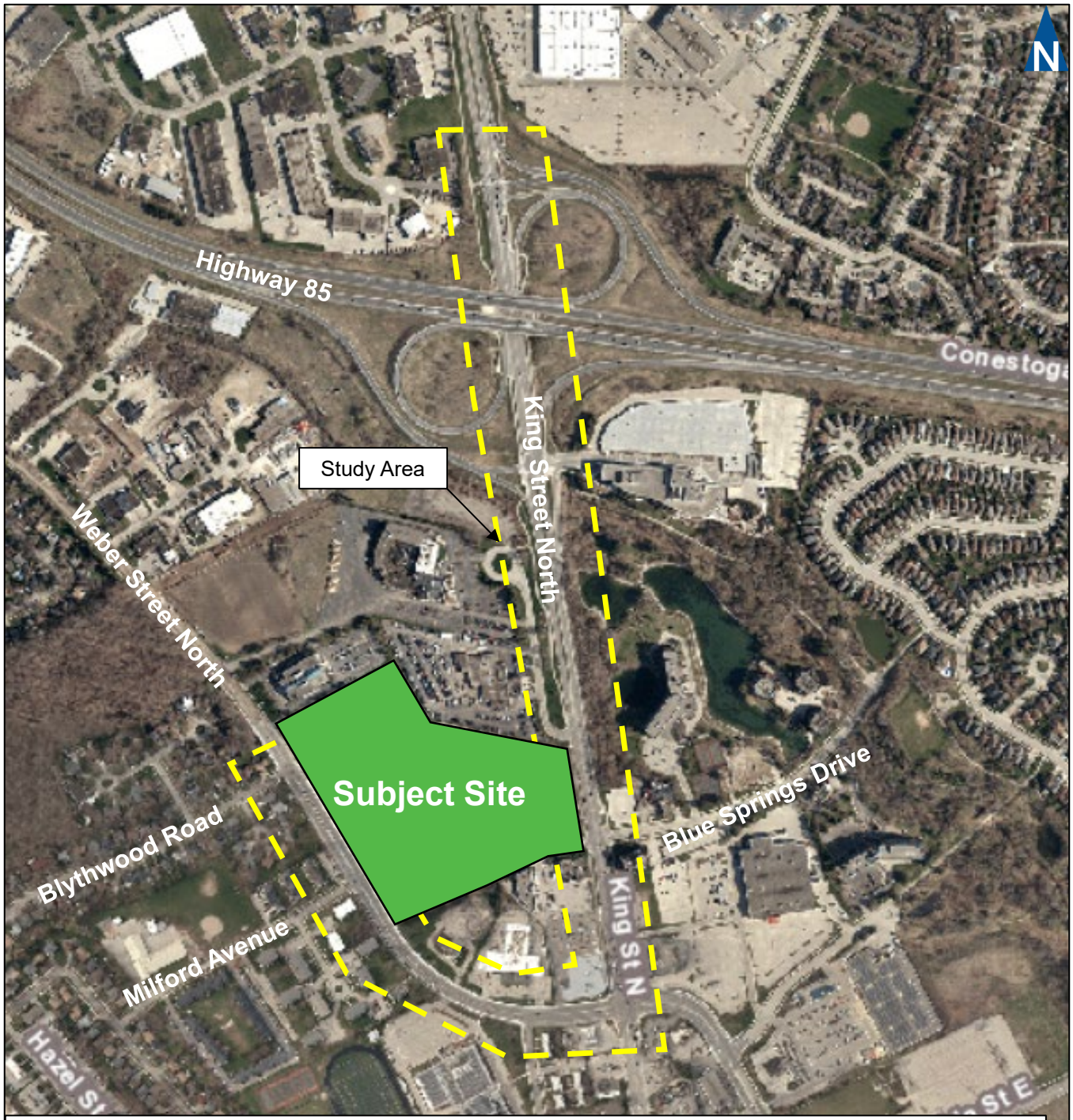
- Assessing current traffic and site conditions within the study area;
- Forecasting future non-development (background) traffic growth;
- Forecasting site-generated traffic;
- Analysing future traffic impacts on the surrounding road network for opening year of the assumed phase 1 build-out, opening year of the assumed phase 2 build-out, opening year of the assumed full-buildout, five years after the assumed full build-out, and ten years after the assumed full build-out; and
- Recommending any necessary mitigation.

The study scope was developed in consultation with the City of Waterloo, Region of Waterloo, and the Ministry of Transportation Ontario (MTO) in February 2023. **Appendix A** contains the pre-study consultation material and response from the City, Region, and MTO.

1.2 Study Area

The intersections assessed in this study include:

- King Street North and Blue Springs Drive (Signalized);
- Weber Street North and Blythwood Road (Unsignalized);
- Weber Street North and Milford Avenue (Unsignalized);
- King Street North and Weber Street North (Signalized);
- King Street North and Highway 85 Southbound Ramp (Signalized); and
- King Street North and Highway 85 Northbound Ramp (Signalized).



NTS
Image Source: "City Map," City of Waterloo, https://maps.waterloo.ca/Html5Viewer/?viewer=waterlooviewer&viewer=waterlooviewer&_ga=2.185780015.7285529.1678375024-1641158142.1665493570.

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Location of Subject Site

2 Existing Conditions

2.1 Road Characteristics

The roadways of interest within the study area include[1] Region of Waterloo governed Weber Street North and King Street North, City of Waterloo streets Blue Springs Drive, Blythwood Road, and Milford Avenue, and MTO governed Highway 85. The roadways are generally described as follows:

- **Highway 85** is a four-lane, 90 km/h provincial highway within the study area.
- **Weber Street North** is a four-lane, 60 km/h regional arterial within the study area. Between High Street and Milford Avenue the speed limit is 40 km/h Monday to Friday from 7am to 5pm during the school year. South of Blythwood Road, there is a sidewalk on the east side of the roadway. South of Forwell Creek Road and north of Blythwood Road, there is a sidewalk on the west side of the roadway.
- **King Street North** is a regional arterial within the study area. North of Weber Street North, the speed limit 60 km/h. South of Weber Street North, the speed limit is 50 km/h and there are sidewalks on both sides of the roadway. Between Weber Street North and the northbound Highway 85 Ramp, the roadway has a four-lane cross section. North of the Highway 85 Ramp, the roadway has a five-lane cross section with three northbound lanes and two southbound lanes. Between Weber Street North and Columbia Street, the roadway has a four-lane cross section plus a two-way left-turn lane. South of Columbia Street, the roadway has a two-lane cross section.
- **Blythwood Road** is a two-lane, 50 km/h local roadway within the study area. Sidewalks are provided on both sides of the roadway.
- **Milford Avenue** is a two-lane, mostly 40 km/h local roadway within the study area. Sidewalks are provided on both sides of the roadway.
- **Blue Springs Drive** is a two-lane, 50 km/h local roadway within the study area. Sidewalks are provided on both sides of the roadway.

[1] City of Waterloo, *Official Plan: Road Classification System Schedule 'E',* (Waterloo: City of Waterloo, 2018).

Figure 2.1 details the existing traffic control and lane configurations at the study area intersections.

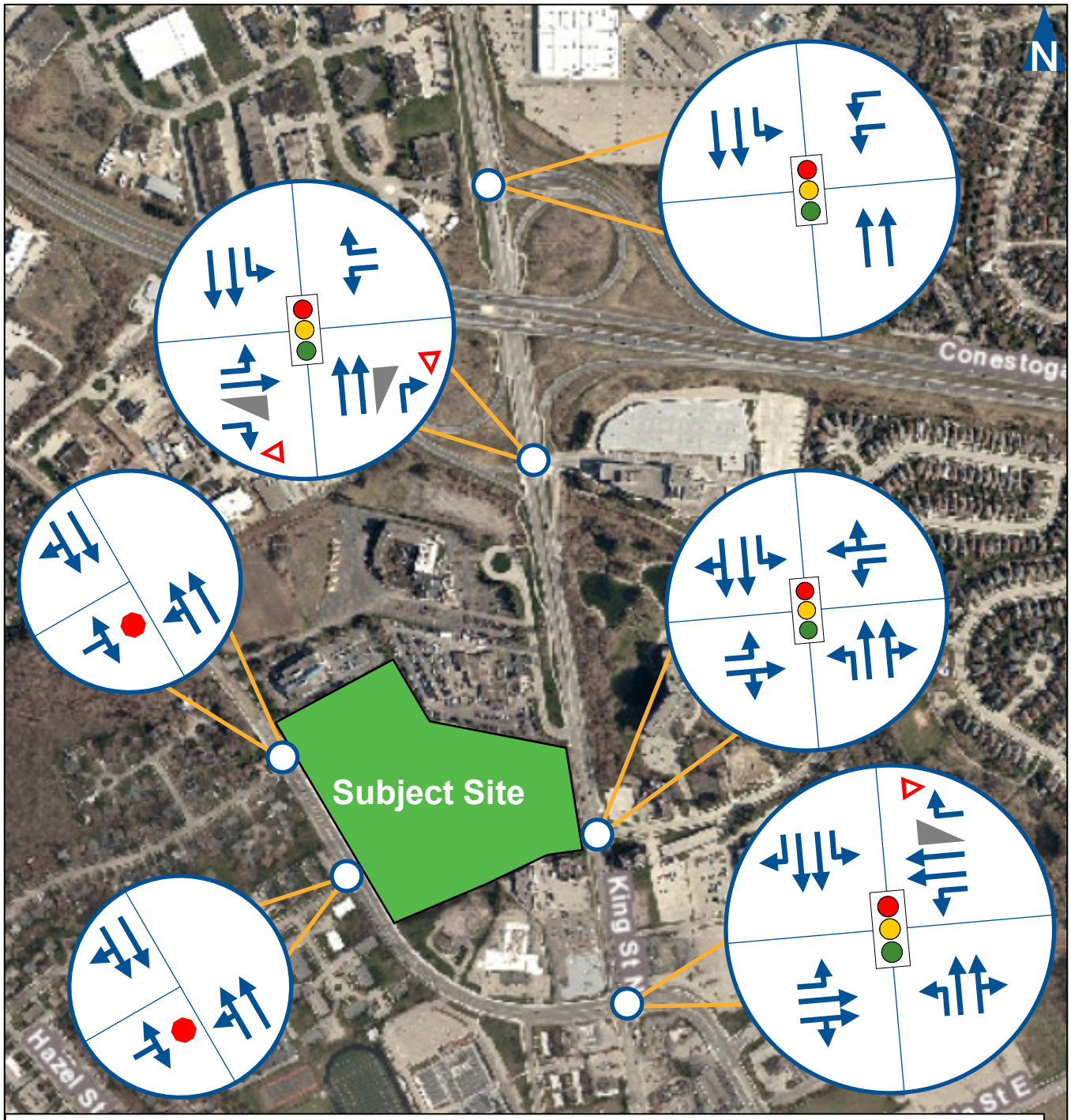

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Image Source: “City Map,” City of Waterloo, https://maps.waterloo.ca/Html5Viewer/?viewer=waterlooviewer&viewer=waterlooviewer&_ga=2.185780015.7285529.1678375024-1641158142.1665493570.

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Existing Lane Configuration and Traffic Control

2.2 Active Transportation

Sidewalks are provided on at least one side of all study area roadways except for Highway 85.

Figure 2.2, **Figure 2.3**, and **Figure 2.4** illustrate the active transportation network near the subject site.

The active transportation network infrastructure includes:

- Multi-use paths north of Weber Street North running along both sides of King Street North;
- A multi-use path running along the west side of Weber Street North between Forwell Creek Road and Blythwood Road;
- A multi-use path north of Blythwood Road running along the east side of Weber Street North;
- A connection to the Forwell Trail near King Street North at the Manulife Driveway;
- A recreational trail connection near Weber Street North at the Inn of Waterloo Driveway;
- A signed cycle route running along Blythwood Road; and
- A proposed active transportation route running between the Waterloo Trail and Forwell Trail.

NTS
Image Source: “City Map,” City of Waterloo, https://maps.waterloo.ca/Html5Viewer/?viewer=waterlooviewer&viewer=waterlooviewer&_ga=2.185780015.7285529.1678375024-1641158142.1665493570.

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Existing Trail Network

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Figure 2.2

NTS
Image Source: “City Map,” City of Waterloo, https://maps.waterloo.ca/Html5Viewer/?viewer=waterlooviewer&viewer=waterlooviewer&_ga=2.185780015.7285529.1678375024-1641158142.1665493570.

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Existing Cycling Network

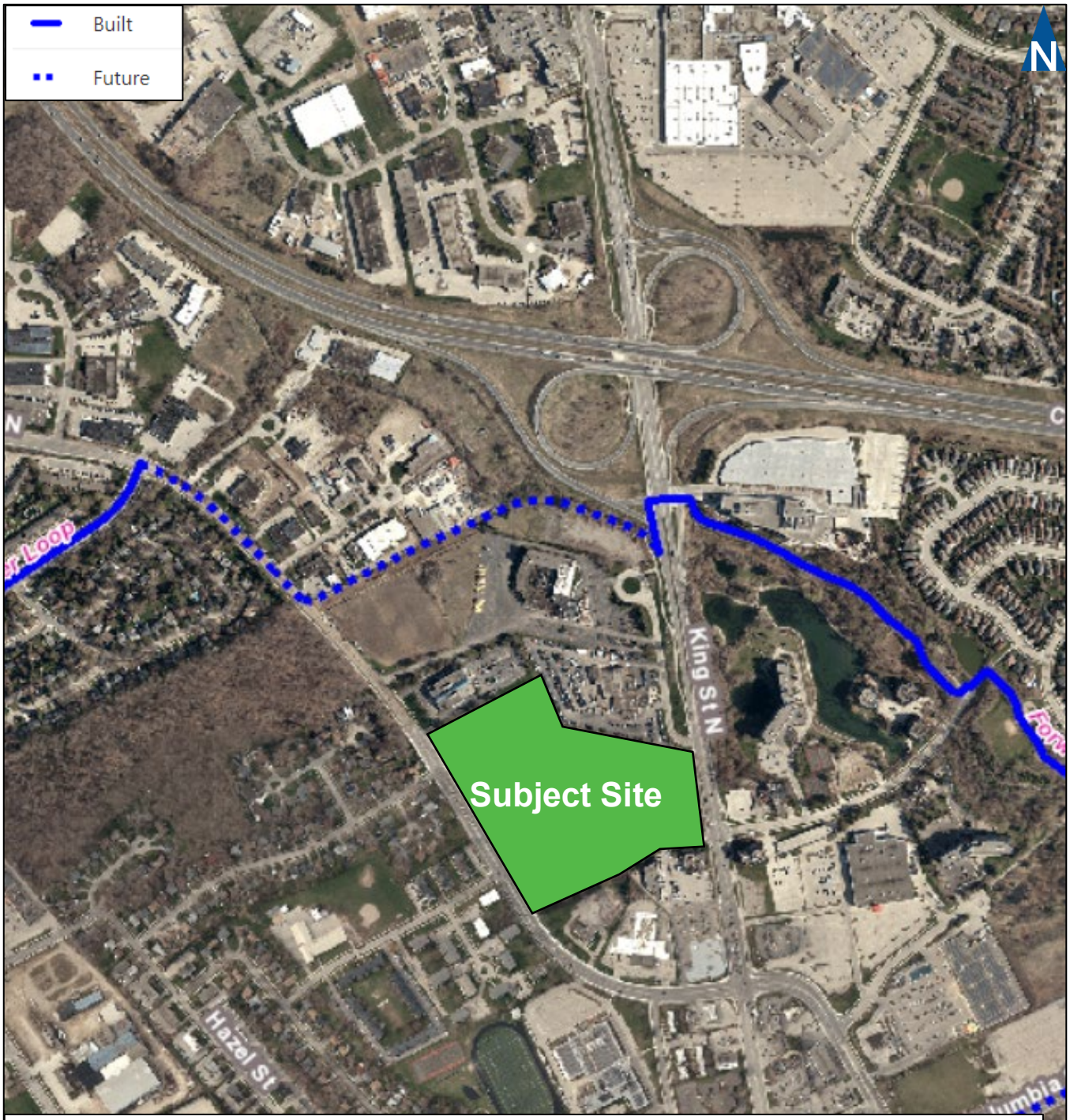

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Image Source: “City Map,” City of Waterloo, https://maps.waterloo.ca/Html5Viewer/?viewer=waterlooviewer&viewer=waterlooviewer&_ga=2.185780015.7285529.1678375024-1641158142.1665493570.

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Main Active Transportation Routes

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Figure 2.4

2.3 Transit Service

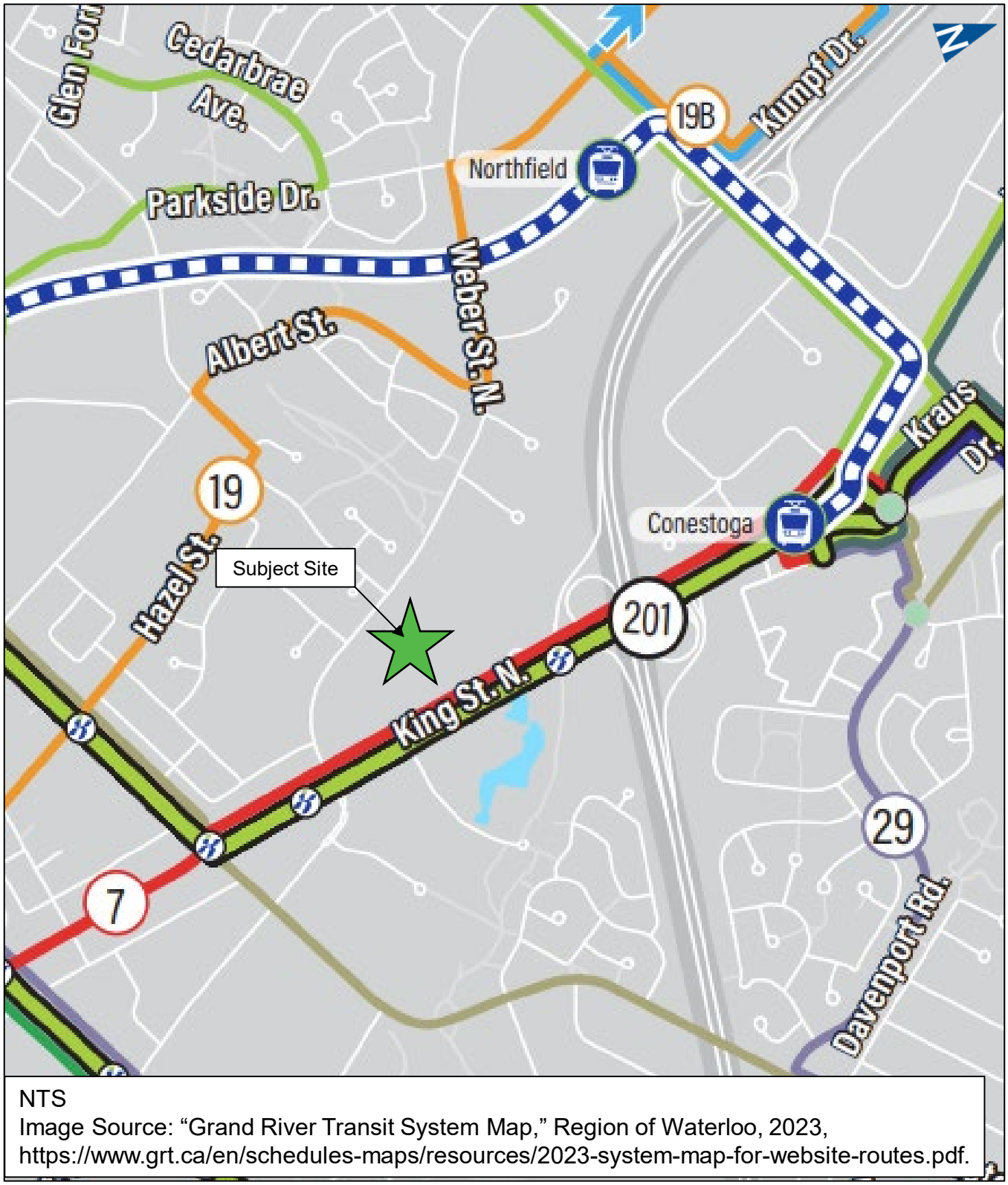
Grand River Transit[2] operates four routes near the study area:

- **Route 7 (King)** travels between Fairview Park Mall in Kitchener and Conestoga Mall in Waterloo. This route operates Monday to Friday from 5:25 AM to 12:40 AM with headways approximately between 8 to 17 minutes. On Saturday, the route operates from 5:40 AM to 12:40 AM from with headways approximately between 15 to 30 minutes. On Sunday, the route operates from 8:00 AM to 12:40 AM with headways approximately between 15 to 30 minutes;
- **Route 19 (Hazel)** travels between St. Jacobs/north end of Waterloo and the University of Waterloo. This route operates Monday to Friday from 5:35 AM to 12:00 AM with headways between 7 to 30 minutes and from 6:25 AM to 12:20 AM on Saturday with headways between 30 minutes to an hour. On Sunday, it operates from 7:55 AM to 12:05 AM with headways between 30 minutes to an hour;
- **Route 31 (Columbia)** operates between Conestoga Mall and the west end of Waterloo. This route operates Monday to Friday from 5:35 AM to 11:20 PM with headways generally between 30 to 50 minutes; and
- **Route 201 (iXpress Fischer-Hallman)** travels between the Doon Campus (Conestoga College) in Kitchener and Conestoga Mall in Waterloo. This route operates Monday to Friday from 5:15 AM to 12:50 AM with headways between 7 to 30 minutes. On Saturday, it operates from 6:20 AM to 12:50 AM with headways approximately every 30 minutes. On Sunday, it operates from 6:50 AM to 12:50 AM with headways approximately every 30 minutes.

The closest transit stops to the subject site are located in the northwest and northeast corners of the King Street North and Blue Springs Drive intersection.

Figure 2.5 illustrates the existing transit network.

[2] "Grand River Transit System Map," Region of Waterloo, 2017, https://www.grt.ca/en/schedules-maps/system-map.aspx.



NTS
Image Source: "Grand River Transit System Map," Region of Waterloo, 2023, https://www.grt.ca/en/schedules-maps/resources/2023-system-map-for-website-routes.pdf.

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Transit Network

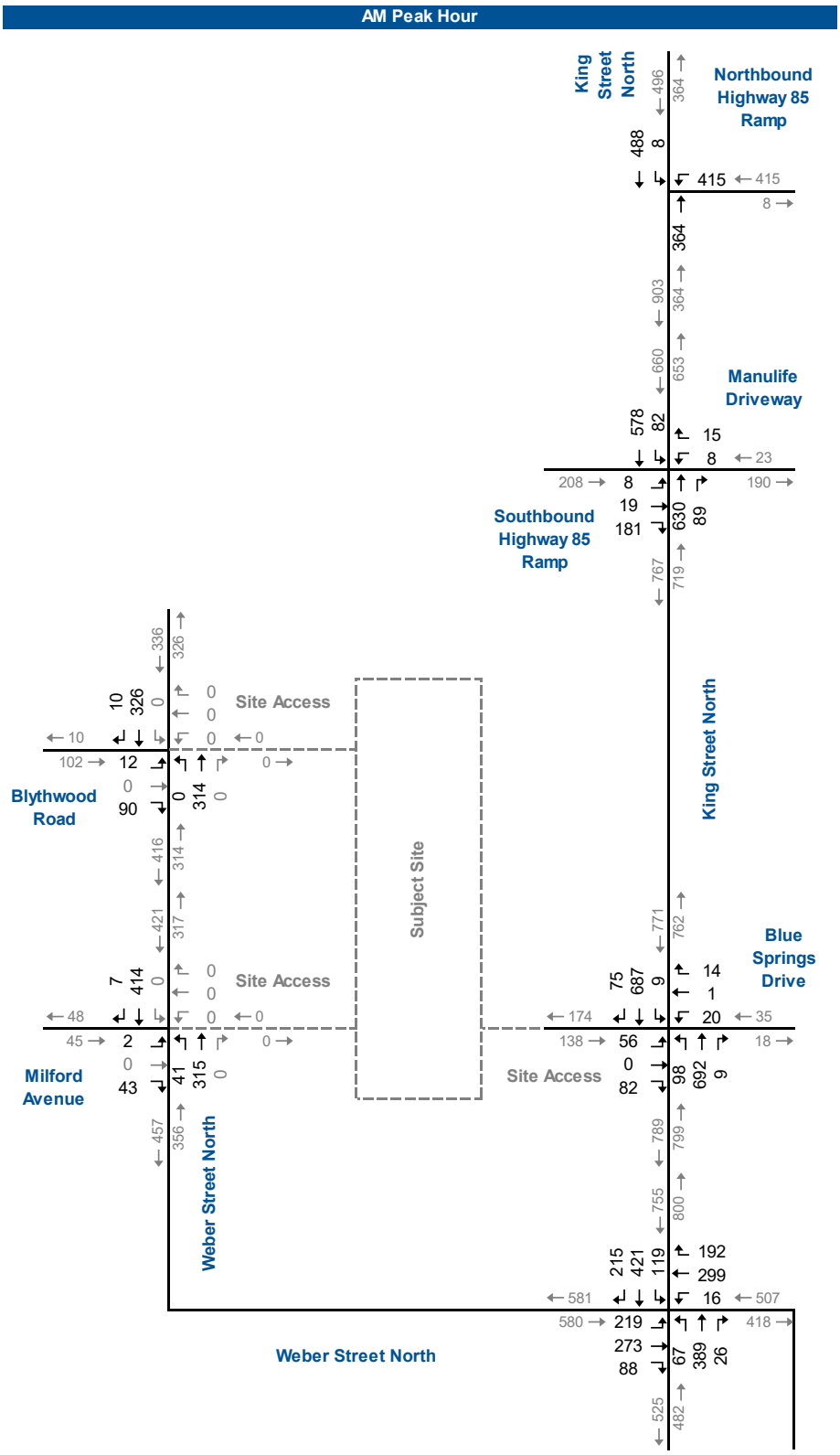
2.4 Traffic Volumes

Paradigm undertook turning movement counts at the study area intersections in January 2023.

Appendix B contains the observed traffic counts for the study area intersections.

The northbound left-turn volumes at the intersection of Weber Street North and Blythwood Road were added to the northbound through volumes as northbound left-turn movements are not permitted during the AM and PM peak hours.

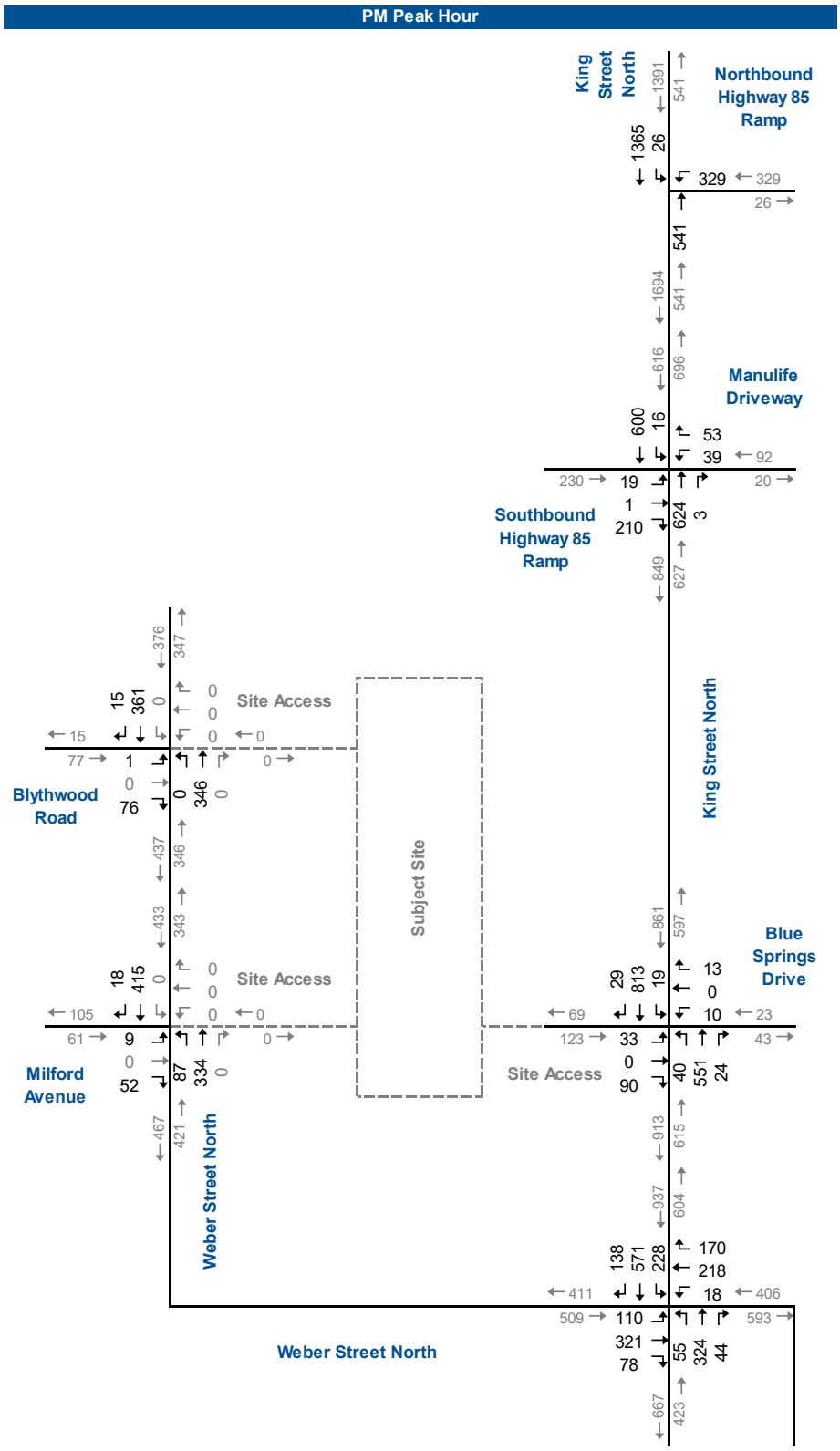
Figure 2.6a and **Figure 2.6b** illustrate the base year weekday AM and PM peak hour traffic volumes.



Base Year Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 2.6a



Base Year Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 2.6b

2.5 Traffic Operations

Intersection level of service (LOS) is a recognized method of quantifying the average delay experienced by drivers 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 intending to make a particular movement, compared to the estimated capacity for that movement. The capacity is based on a number of criteria related to the opposing traffic flows and intersection geometry.

The highest possible rating is LOS A, under which the average total delay is equal or less than 10.0 seconds per vehicle. When the average delay exceeds 80 seconds for signalized intersections, 50 seconds for unsignalized intersections or when the volume to capacity ratio is greater than 1.0, the movement is classed as LOS F and remedial measures are usually implemented if they are feasible. LOS E is usually used as a guideline for the determination of road improvement needs on through lanes, while LOS F may be acceptable for left-turn movements at peak times, depending on delays.

Right-turn storage lengths at the two intersections with the Highway 85 Ramps were generated using the Geometric Design Guide for Canadian Roads[3].

Through and left-turn queue lengths at the two intersections with the Highway 85 Ramps were generated using MTO's Traffic Signal Operating & Timing Policy[4].

The operations of the study intersections were evaluated using the existing lane configurations, traffic controls, and the base year traffic peak hour volumes.

The level of service conditions on the existing road network have been assessed using Synchro 11. As noted in the Region of Waterloo TIS guidelines[5], movements are considered critical under the following conditions:

- Estimated 95th percentile queue length for an exclusive movement exceeds the available storage space;
- Exclusive turning lanes are inaccessible because of queue lengths in adjacent through lanes;

[3] Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).
[4] Ontario Ministry of Transportation, *Implementation of the Traffic Signal Operating & Timing Policy # 2010-02,* (Toronto: Queen's Printer for Ontario, 2017).
[5] Region of Waterloo, *Transportation Impact Study Guidelines,* (Kitchener: Region of Waterloo, 2014).

- Estimated 95th percentile queue length for an individual movement will block an existing access; and
- The average control delay for individual movements is greater that 55 seconds.

Intersections are considered critical under the following conditions:

- An unsignalized intersection has an average control delay larger than 35 seconds (LOS E or F); and
- A signalized intersection has an average control delay larger than 55 seconds (LOS E or F).

As noted in MTO TIS guidelines[6], movements are considered critical under the following conditions:

- At signalized intersections, movements with v/c ratio greater than 0.85 are deemed to be “critical” in terms of operations. Movements that experience a v/c ratio of 0.85 or greater shall be evaluated for possible operational improvements.
- For ramps, a v/c ratio for terminal ramp approaches with a value greater than 0.75 would be deemed critical and shall be evaluated for possible operational improvements.

Table 2.1a and **Table 2.1b** summarize the existing intersection operations. The entries in the table indicating the AM and PM peak hour level of service (LOS), volume to capacity ratios (V/C), and 95th percentile queues experienced.

Table 2.2a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 2.2b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO’s Traffic Signal Operating & Timing Policy.

All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and Highway 85 Northbound Ramp:

[6] Ontario Ministry of Transportation, *General Guidelines for the preparation of Traffic Impact Studies,* (Toronto: Queen’s Printer for Ontario, 2021).

- The westbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM peak hour;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM peak hour.

Appendix C contains the detailed Synchro reports.

TABLE 2.1A: BASE YEAR OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		B		B	A	A		A	C
			Delay					49			49		13		13	5	6		6	22
			V/C					0.72					0.17			0.01	0.23			
			Q					60					50			2	28			
			Stor.					60					-			20	-			
			Avail.					0					-			18	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	B	B	D		A	B		A	A	A	A	A		A	A
			Delay	45	46	15	19	46		1	17		7	2	6	4	4		4	7
			V/C	0.06	0.11	0.60		0.07		0.08			0.28	0.09		0.15	0.23			
			Q	6	11	20		6		0			40	5		9	27			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	74	-	60		-		50			-	110		21	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	1	>	19	40	19	>	31	4	3	>	3	3	3	>	3	5
			V/C	0.36	0.19	>		0.13	0.08	>		0.19	0.27	>		0.02	0.29	>		
			Q	21	0	>		10	6	>		10	25	>		1	26	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		5	-	>		15	-	>		24	-	>		
	King Street North & Weber Street North	TCS	LOS	B	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	B
			Delay	18	12	>	14	24	26	5	18	20	29	>	28	20	26	5	19	19
			V/C	0.45	0.23	>		0.06	0.27	0.33		0.21	0.43	>		0.38	0.38	0.36		
			Q	37	24	>		7	32	14		16	47	>		17	48	15		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	3	-	>		48	-	41		44	-	>		93	-	75		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	10		>	10					8	0		1		0	0	0	
			V/C	0.06		>						0.04	0.00				0.00	0.00		
			Q	2		>						1	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	10		>	10						0		0		0	0	0	
			V/C	0.13		>							0.00				0.00	0.00		
			Q	3		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 2.1B: BASE YEAR OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	A		A	B
			Delay					50			50		4		4	4	8		8	13
			V/C					0.68					0.25			0.04	0.56			
			Q					50					16			4	92			
			Stor.					60					-			20	-			
			Avail.					10					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		B	C		A	A	A	A	A		A	A
			Delay	44	41	21	23	49		14	29		8	1	8	3	3		3	9
			V/C	0.12	0.00	0.68		0.28		0.26			0.25	0.00		0.03	0.24			
			Q	11	2	29		18		11			51	0		1	21			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	69	-	51		-		39			-	115		29	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	B	A	A	>	A	A	A	>	A	A
			Delay	50	2	>	15	46	0	>	20	2	1	>	1	2	2	>	2	3
			V/C	0.25	0.26	>		0.09	0.03	>		0.08	0.21	>		0.03	0.30	>		
			Q	16	0	>		7	0	>		3	12	>		2	23	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		8	-	>		22	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	B	B	>	B	B	B	A	B	C	C	>	C	D	C	A	C	C
			Delay	14	16	>	16	12	19	4	12	24	32	>	31	36	29	5	27	23
			V/C	0.20	0.25	>		0.04	0.14	0.24		0.23	0.41	>		0.73	0.52	0.26		
			Q	20	36	>		5	22	12		15	45	>		52	69	6		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	20	-	>		50	-	43		45	-	>		58	-	84		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	11		>	11					8	0		2		0	0	0	
			V/C	0.10		>						0.08	0.00				0.00	0.00		
			Q	2		>						2	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	10		>	10						0		0		0	0	0	
			V/C	0.10		>							0.00				0.00	0.00		
			Q	2		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 2.2A: BASE YEAR RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	181	89	210	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	189	90	215	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	87	42	99	2
	Storage (m)	80	115	80	115
	Available (m)	-7	73	-19	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 2.2B: BASE YEAR THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			249	166	364	8	488			197	132	541	26	1365
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			254	170	390	10	537			201	135	563	26	1393
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			7.8	5.2	6.0	0.3	8.2			6.1	4.1	8.6	0.8	21.3
	Queue (vehicles)*			13	9	10	1	13			10	8	14	2	29
	Queue (m)			98	68	75	8	98			75	60	105	15	218
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-8	-	12	-			-	0	-	5	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	8	19			630	82	578	19	1			624	16	600
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	10	19			668	85	602	22	1			643	16	618
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.3	0.6			10.2	2.6	9.2	0.7	0.0			9.8	0.5	9.4
	Queue (vehicles)*	1	2			16	5	14	2	1			15	2	15
	Queue (m)	8	15			120	38	105	15	8			113	15	113
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	65	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

3 Development Concept

3.1 Development Description

The subject site is located at 450-460 Weber Street North and 435 King Street North in Waterloo, Ontario.

The subject site is proposed to be developed into 2,972 residential units in seven buildings along with retail uses totalling 2,686 square metres, office uses totalling 10,877 square metres and an 815 square metre daycare centre.

Vehicle access is proposed via the existing connection to King Street North opposite of Blue Springs Drive and via two all-moves accesses to Weber Street North opposite of Blythwood Road and Milford Avenue.

Phase 1 is assumed to be completed by 2027 with access only to Weber Street North opposite of Blythwood Road. Phase 2 is assumed to be completed by 2032 with all three accesses opened. The full build-out is assumed to be completed by 2037.

Figure 3.1 shows the proposed development concept.

3.2 Pedestrian Crossover (PXO) Warrant

As requested by City staff, the intersections of Weber Street North at Milford Avenue and Weber Street North at Blythwood Road were assessed using the Ontario Traffic Manual (OTM Book 15 – Pedestrian Crossing Treatments)[7].

According to OTM Book 15, the following should be considered if a pedestrian crosswalk is to be installed:

- 8 hours worth of vehicular traffic is equal to or surpasses 750 vehicles and 8 hours worth of pedestrian traffic crossing the major street is equal to or surpasses 100 pedestrians. Or 4 hours worth of vehicular traffic is equal to or surpasses 395 vehicles and 4 hours worth of pedestrian traffic crossing the major street is equal to or surpasses 65 pedestrians;
- The proposed spot for the pedestrian crossover fits within walking desire lines; and

[7] Ontario Ministry of Transportation, *Ontario Traffic Manual Book 15: Pedestrian Crossing Treatments,* (Toronto: Queen's Printer for Ontario, 2016).

- The proposed spot for the pedestrian crossover is or is not within 200 metres of a traffic control device.

The 8-hour pedestrian volume crossing Weber Street North at Blythwood Road and Milford Avenue is only 6 and 3 pedestrians respectively.

There is an existing pedestrian refuge island on Weber Street at Blythwood Road. With full build-out of the site, it is recommended that a pedestrian refuge island, similar to that at Blythwood Road, be installed at the intersection of Weber Street North and Milford Avenue on the south leg. This will provide the most direct access to St. David Catholic Secondary School and Winston Churchill Public School. The proposed location connects to the sidewalk on the north side of Milford Avenue leading to Winston Churchill Public School. The proposed location also connects to the multi-use path on the west side of Weber Street North leading to St. David Catholic Secondary School. This location is well suited given the expected pedestrian desire lines from the development to the nearby schools and commercial attractions to the east.

NTS

paradigm TRANSPORTATION SOLUTIONS LIMITED

Concept Plan

435 King Street North, Waterloo TIS
220805

Figure 3.1

3.3 Site Trip Generation

The Institute of Transportation Engineers (ITE) Trip Generation manual[8] methods are used to forecast site-generated trips. The following Land Use Codes (LUC) were used to estimate the site trip generation:

- LUC 222 (Multi-family Housing, High-Rise);
- LUC 565 (Day Care Centre);
- LUC 710 (General Office Building); and
- LUC 822 (Strip Retail Plaza,<40k).

Table 3.1 summarizes the forecast phase 1 site-generated trips indicating 209 AM peak hour and 251 PM peak hour trips.

TABLE 3.1: PHASE 1 FORECAST SITE-GENERATED TRIPS

Land Use	Quantity		AM Peak Hour				PM Peak Hour			
			Rate	In	Out	Total	Rate	In	Out	Total
LUC 222 - Multi-Family Housing (High-Rise)	991	Units	Avg	70	198	268	Avg	197	121	318
LUC 822 - Strip Retail Plaza (<40k)	1.02	GLA/1000 ft^2	Avg	1	1	2	Avg	3	4	7
Total Trip Generation				**71**	**199**	**270**		**200**	**125**	**325**
Regional Road Trips				*46*	*129*	*175*		*130*	*81*	*211*
Mode Share (35%)				*16*	*45*	*61*		*46*	*28*	*74*
Net Trip Generation				***55***	***154***	***209***		***154***	***97***	***251***

LUC 222 - AM: Average Rate = 0.27 | PM: Average Rate = 0.32
LUC 822 - AM: Average Rate = 2.36 | PM: Average Rate = 6.59

Table 3.2 summarizes the forecast phase 1 and 2 site-generated trips indicating 539 AM peak hour and 603 PM peak hour net external trips.

TABLE 3.2: PHASE 1 AND 2 FORECAST SITE-GENERATED TRIPS

Land Use	Quantity		AM Peak Hour				PM Peak Hour			
			Rate	In	Out	Total	Rate	In	Out	Total
LUC 222 - Multi-Family Housing (High-Rise)	1782	Units	Avg	126	355	481	Avg	354	217	571
LUC 822 - Strip Retail Plaza (<40k)	7.94	GLA/1000 ft^2	Avg	11	7	18	Avg	26	27	53
LUC 565 - Day Care Center	8.78	GFA/1000 ft^2	Avg	51	46	97	Avg	46	52	98
LUC 710 - General Office Building	55.96	GFA/1000 ft^2	Eq	89	13	102	Eq	17	86	103
Total Trip Generation				**277**	**421**	**698**		**443**	**382**	**825**
Pass-By Trips LUC 565			*0%*	*0*	*0*	*0*	*44%*	*22*	*22*	*44*
Regional Road Trips				*180*	*274*	*454*		*274*	*234*	*508*
Mode Share (35%)				*63*	*96*	*159*		*96*	*82*	*178*
Net Trip Generation				***214***	***325***	***539***		***325***	***278***	***603***

LUC 222 - AM: Average Rate = 0.27 | PM: Average Rate = 0.32
LUC 565: AM - Average Rate = 11.00 | PM - Average Rate = 11.12
LUC 710 - AM: Ln(T) = 0.86 Ln(X) + 1.16 | PM: Ln(T) = 0.83 Ln(X) + 1.29
LUC 822 - AM: Average Rate = 2.36 | PM: Average Rate = 6.59

Table 3.3 summarizes the forecast full build-out site-generated trips indicating 861 AM peak hour and 938 PM peak hour net external trips

[8] Institute of Transportation Engineers, *Trip Generation Manual,* 11th ed., (Washington DC: ITE, 2021).

for 2037 and 789 AM peak hour and 859 PM peak hour net external trips for 2042 and 2047.

TABLE 3.3: FULL BUILD-OUT FORECAST SITE-GENERATED TRIPS

Land Use	Quantity		AM Peak Hour				PM Peak Hour			
			Rate	In	Out	Total	Rate	In	Out	Total
LUC 222 - Multi-Family Housing (High-Rise)	2972	Units	Avg	209	593	802	Avg	590	362	952
LUC 822 - Strip Retail Plaza (<40k)	28.91	GLA/1000 ft^2	Avg	41	26	67	Avg	95	96	191
LUC 565 - Day Care Center	8.78	GFA/1000 ft^2	Avg	51	46	97	Avg	46	52	98
LUC 710 - General Office Building	117.08	GFA/1000 ft^2	Eq	185	27	212	Eq	36	177	213
Total Trip Generation				**486**	**692**	**1178**		**767**	**687**	**1454**
Pass-By Trips LUC 565			*0%*	*0*	*0*	*0*	*44%*	*22*	*22*	*44*
Pass-By Trips LUC 822			*0%*	*0*	*0*	*0*	*40%*	*35*	*35*	*70*
Internal Capture				*31*	*31*	*62*		*63*	*63*	*126*
Regional Road Trips				*296*	*430*	*726*		*421*	*369*	*790*
Mode Share (35%)				*104*	*151*	*255*		*147*	*129*	*276*
Net Trip Generation with 35%				***351***	***510***	***861***		***500***	***438***	***938***
Mode Share (45%)				*133*	*194*	*327*		*189*	*166*	*355*
New Trip Generation with 45%				***322***	***467***	***789***		***458***	***401***	***859***

LUC 222 - AM: Average Rate = 0.27 | PM: Average Rate = 0.32
LUC 565: AM - Average Rate = 11.00 | PM - Average Rate = 11.12
LUC 710 - AM: Ln(T) = 0.86 Ln(X) + 1.16 | PM: Ln(T) = 0.83 Ln(X) + 1.29
LUC 822 - AM: Average Rate = 2.36 | PM: Average Rate = 6.59

An ITE pass-by trip reduction of 44% was applied during the PM peak hour for LUC 565. An ITE pass-by trip reduction of 40% was applied during the PM peak hour for LUC 822 per LUC 821.

ITE internal capture calculations were used to determine the internal capture rates between the residential, retail, and office uses. **Appendix D** contains the internal capture calculations.

A mode share reduction of 35% was applied during the AM and PM peak hours for the 2027, 2032, and 2037 horizon years. A mode share reduction of 45% was applied during the AM and PM peak hours for the 2042 and 2047 horizon years, as noted by Regional staff. The mode share reduction was not applied to trips travelling on Highway 85, as noted by MTO staff.

The trip assignment used for this study was based on the existing assignment and 2016 Transportation Tomorrow Survey (TTS) data[9]. The trip assignment is appropriate for this study because 75% of trips travel to/from the south leading to a larger portion of urbanized development. The trip assignment assumes that no traffic will travel through the residential community to the west of the subject site via Milford Avenue and Blythwood Road as there are turn restrictions into this neighbourhood. The internal road network of the development does not allow for Phase 1 trip to access either Phase 2 or 3. All phase 1 traffic is assigned to the access opposite Blythwood Road and all

[9] Data Management Group, *Transportation Tomorrow Survey 2016,* University of Toronto, 2016, http://www.transportationtomorrow.on.ca/

Phase 2 and 3 traffic is assigned to the accesses opposite Milford Avenue and Blue Springs Drive. The trip assignment is shown in **Table 3.4.**

Table 3.4: Trip Assignment

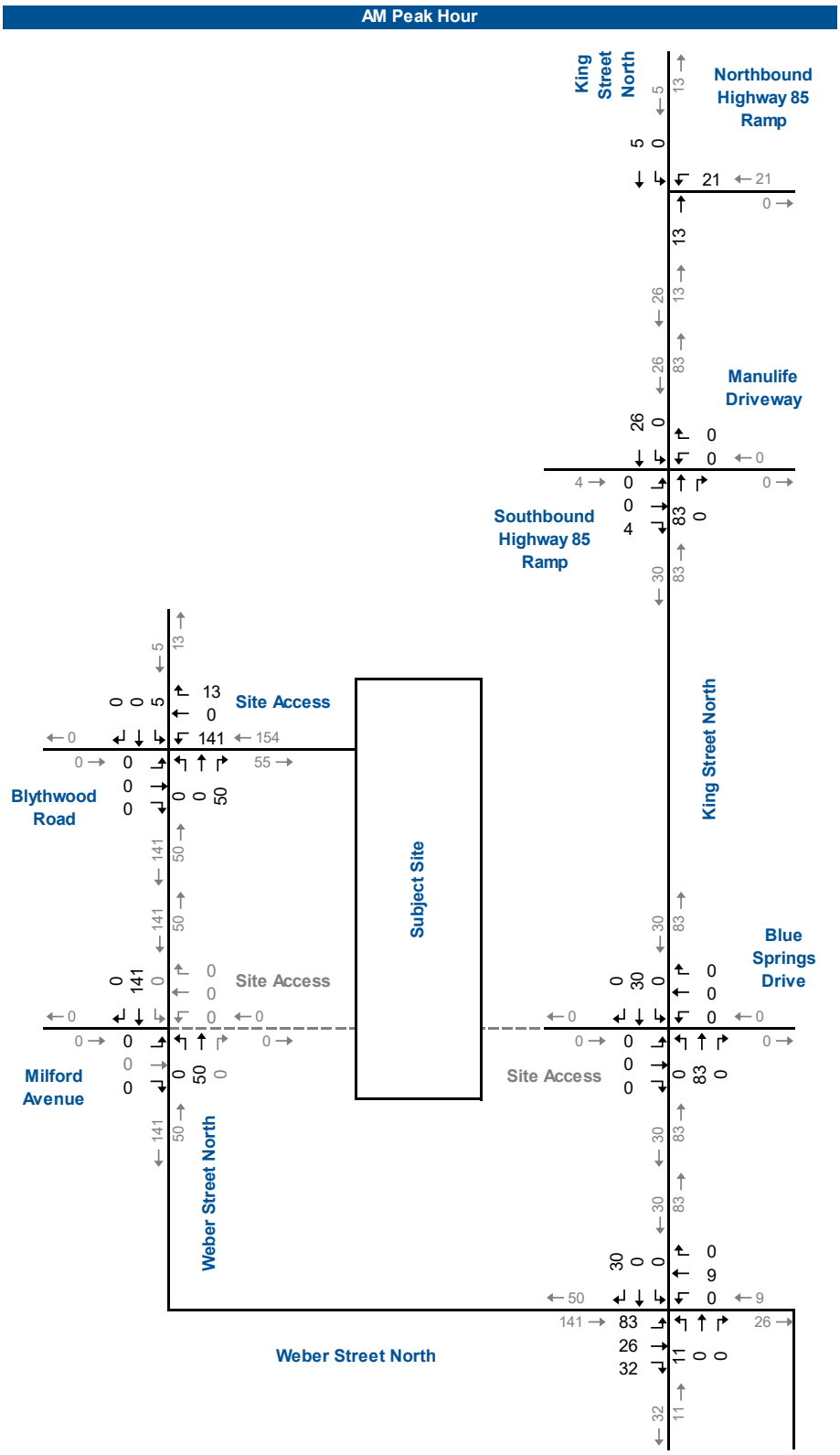
Origin/Destination	In	Out
Highway 85 Northbound	30%	5%
Highway 85 Southbound	5%	30%
North via King Street North	10%	10%
North via Weber Street North	10%	10%
South via King Street North	25%	25%
South via Weber Street North	20%	20%
Total	**100%**	**100%**

Figure 3.2a and **Figure 3.2b** illustrate the AM and PM peak hour trip assignment for Phase 1.

Figure 3.3a and **Figure 3.3b** illustrate the AM and PM peak hour trip assignment for Phases 1 and 2.

Figure 3.4a and **Figure 3.4b** illustrate the AM and PM peak hour trip assignment for the full build-out with a 35% mode share reduction.

Figure 3.5a and **Figure 3.5b** illustrate the AM and PM peak hour trip assignment for the full build-out with a 45% mode share reduction.



Phase 1 Site Generated Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
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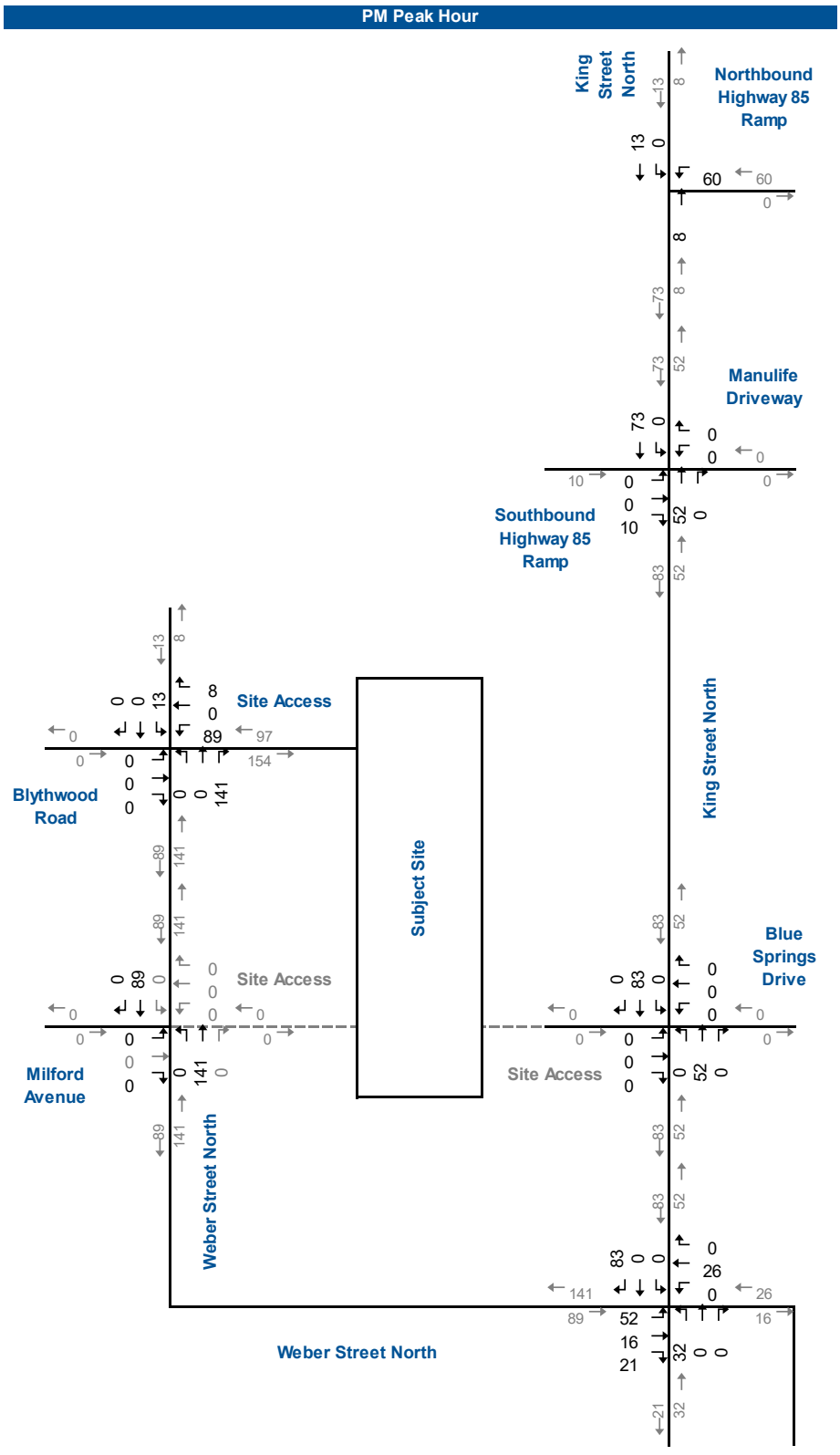
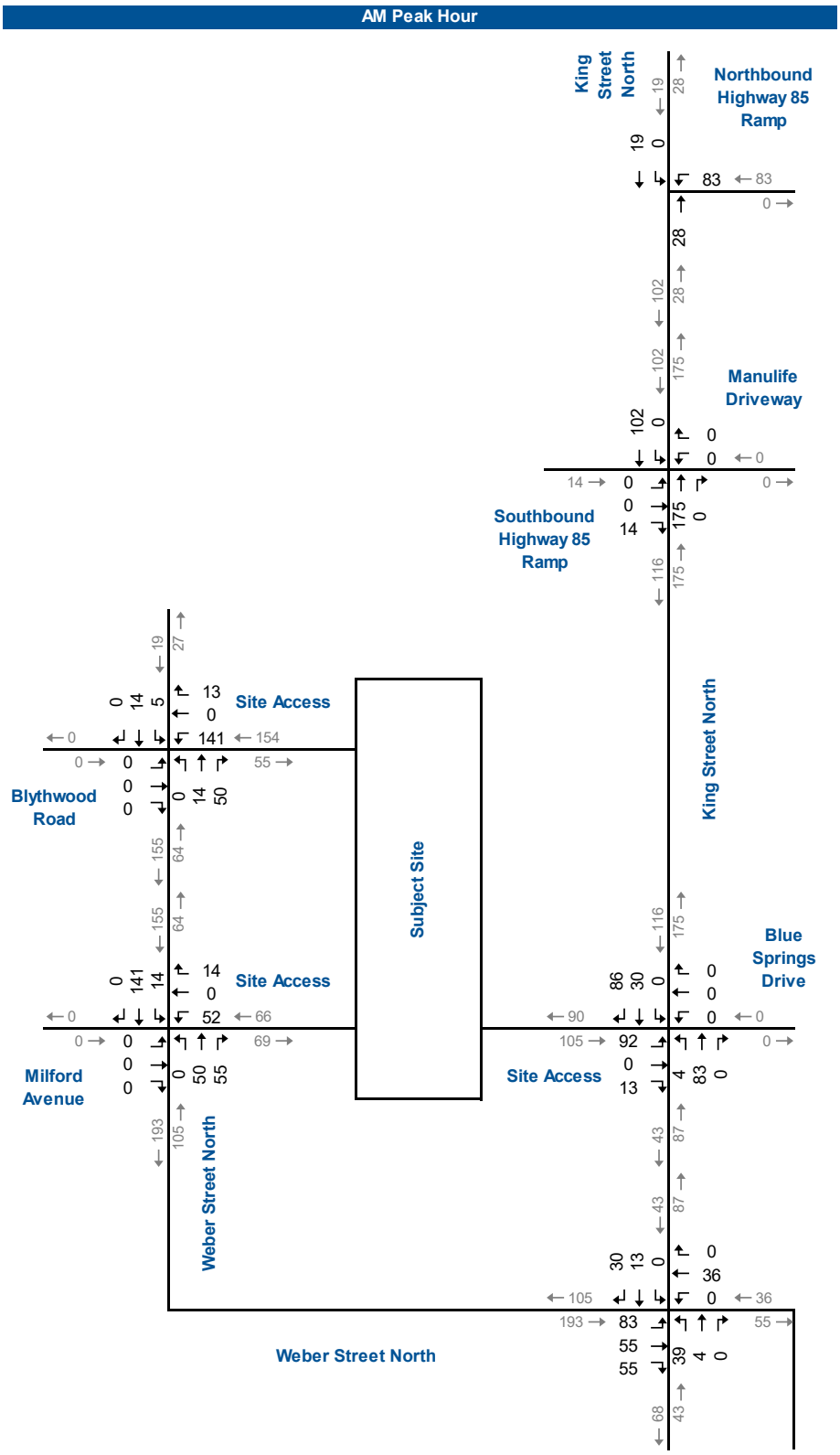
Figure 3.2a



Phase 1 Site Generated Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

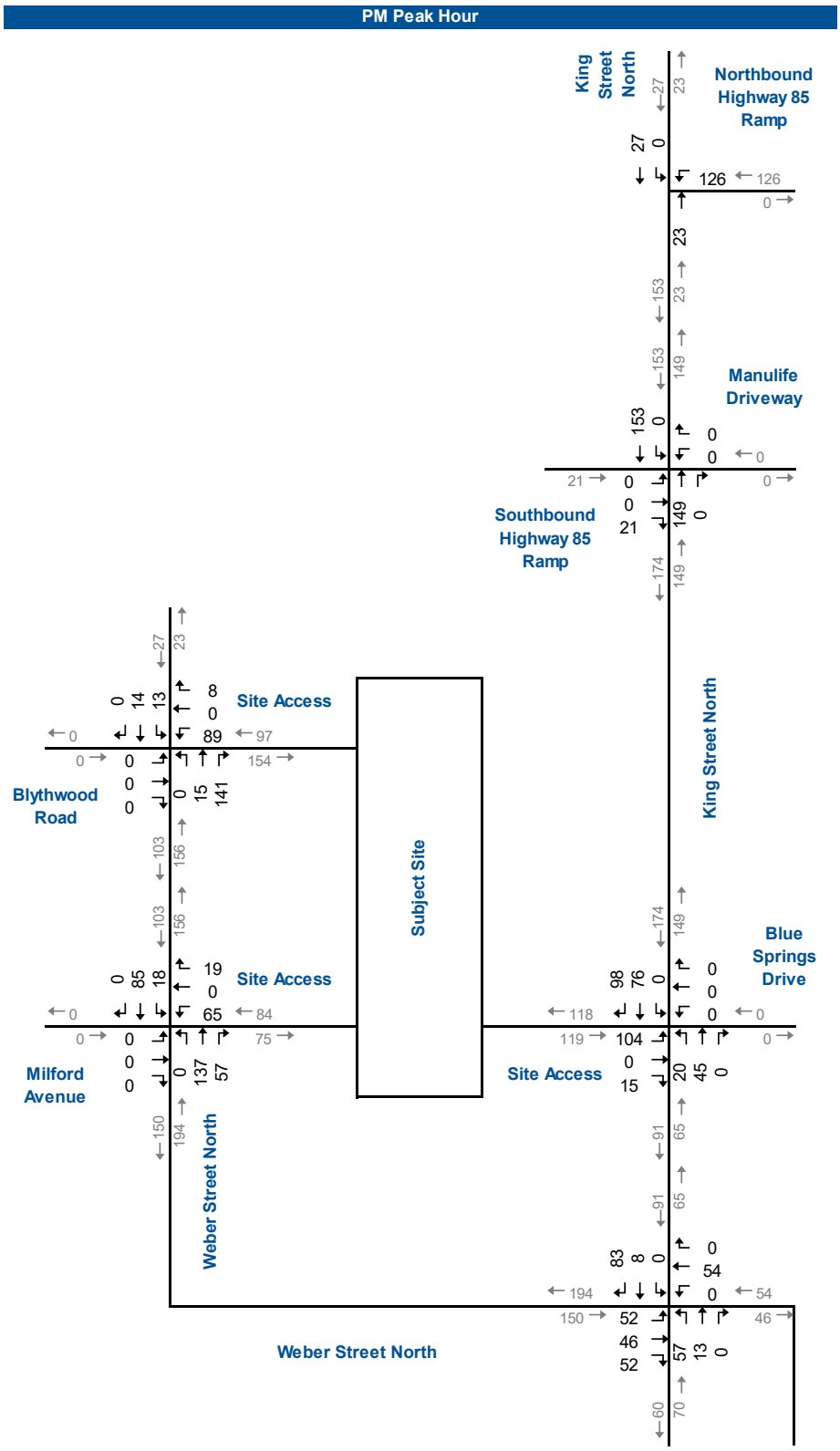
Figure 3.2b



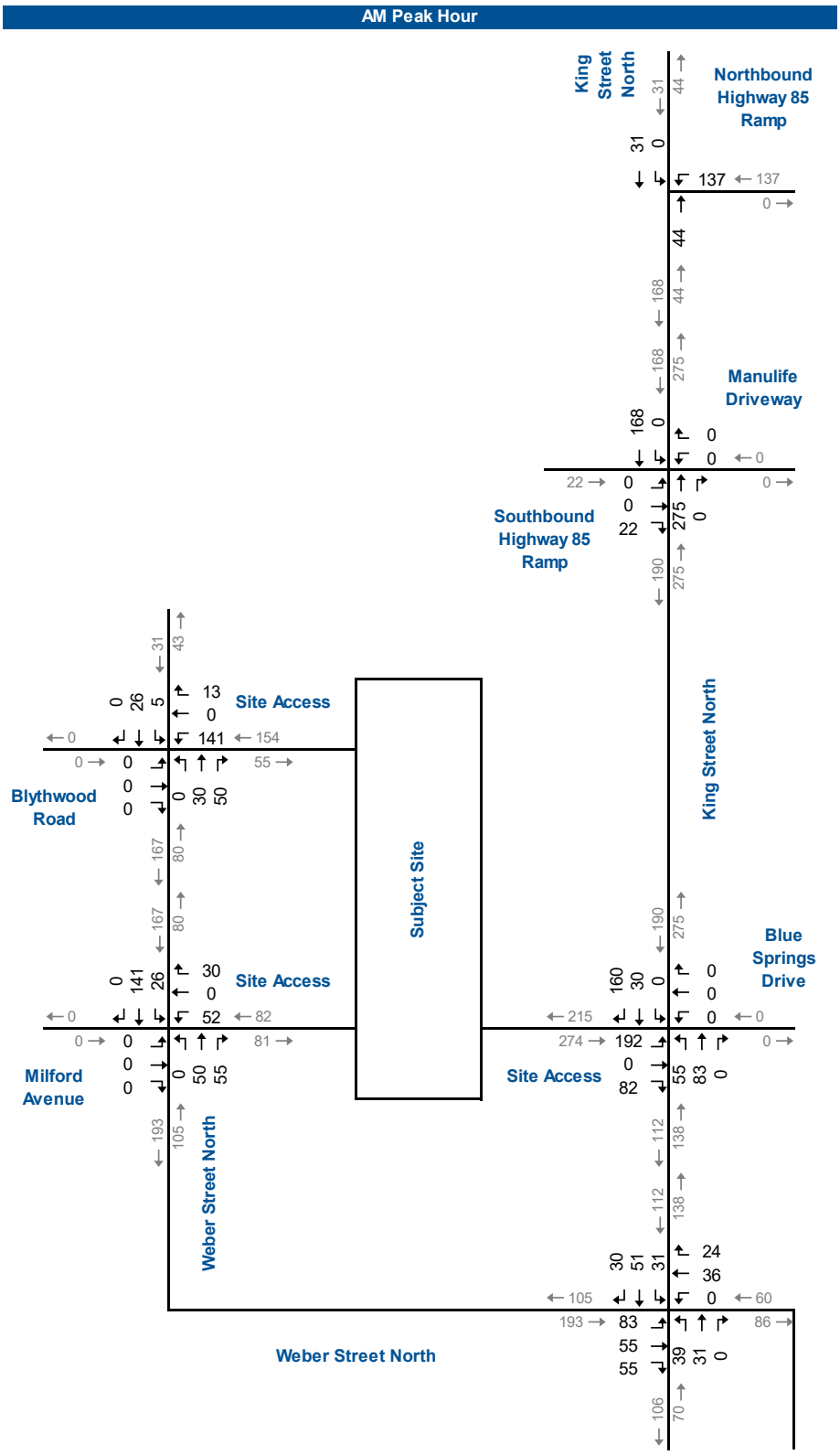
Phases 1 and 2 Site Generated Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

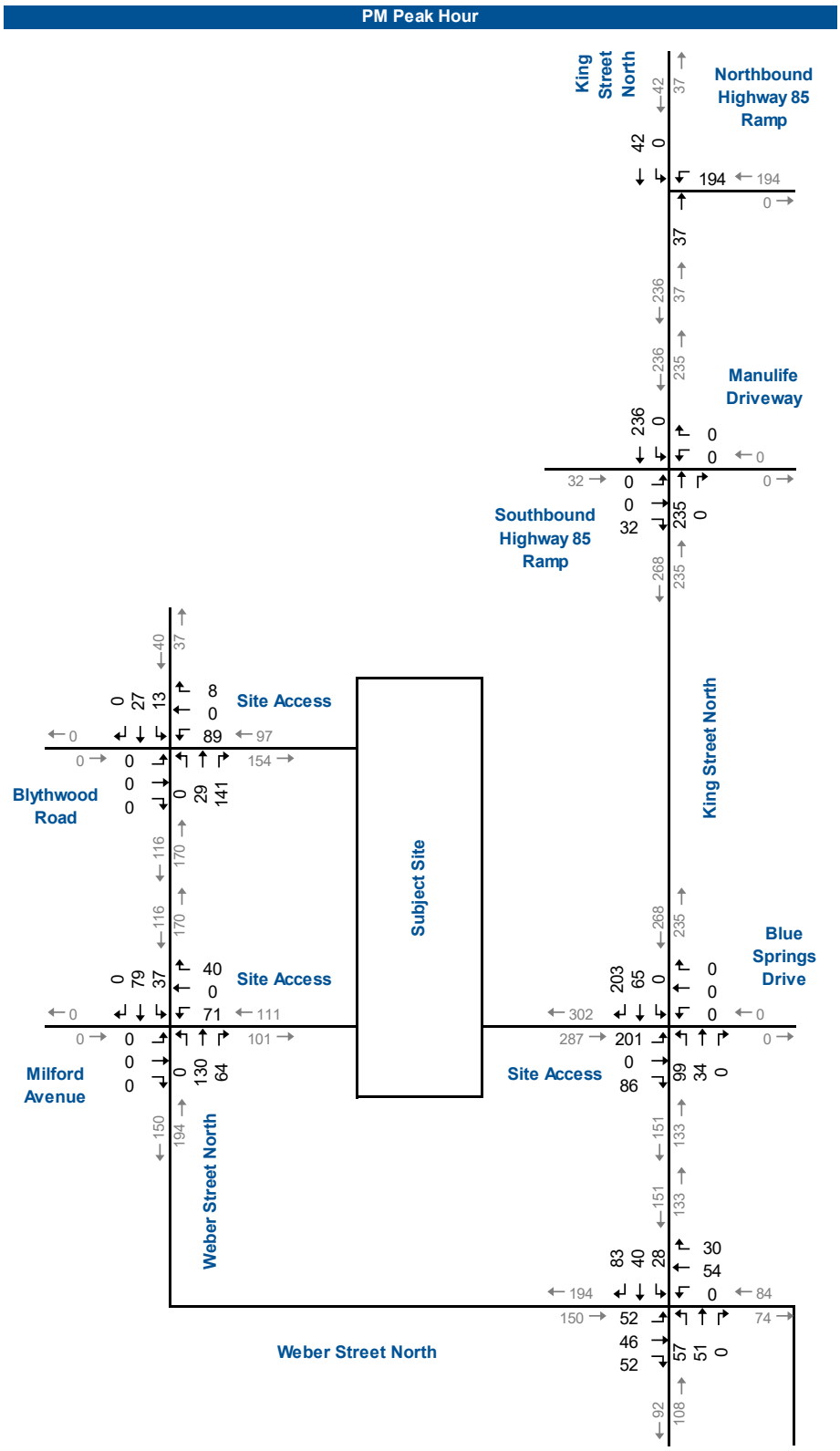
Figure 3.3a



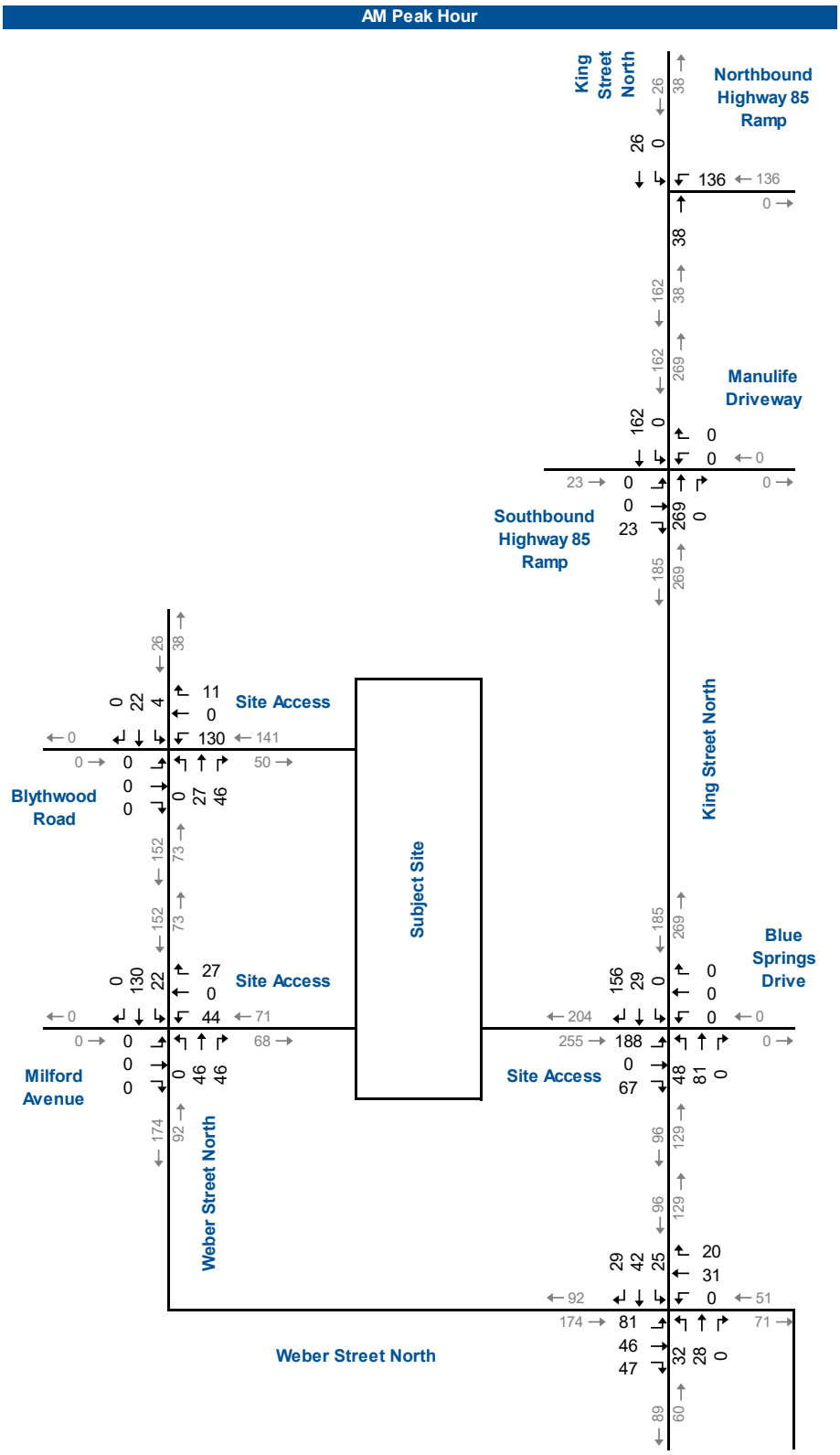
Phases 1 and 2 Site Generated Traffic Volumes (PM Peak Hour)



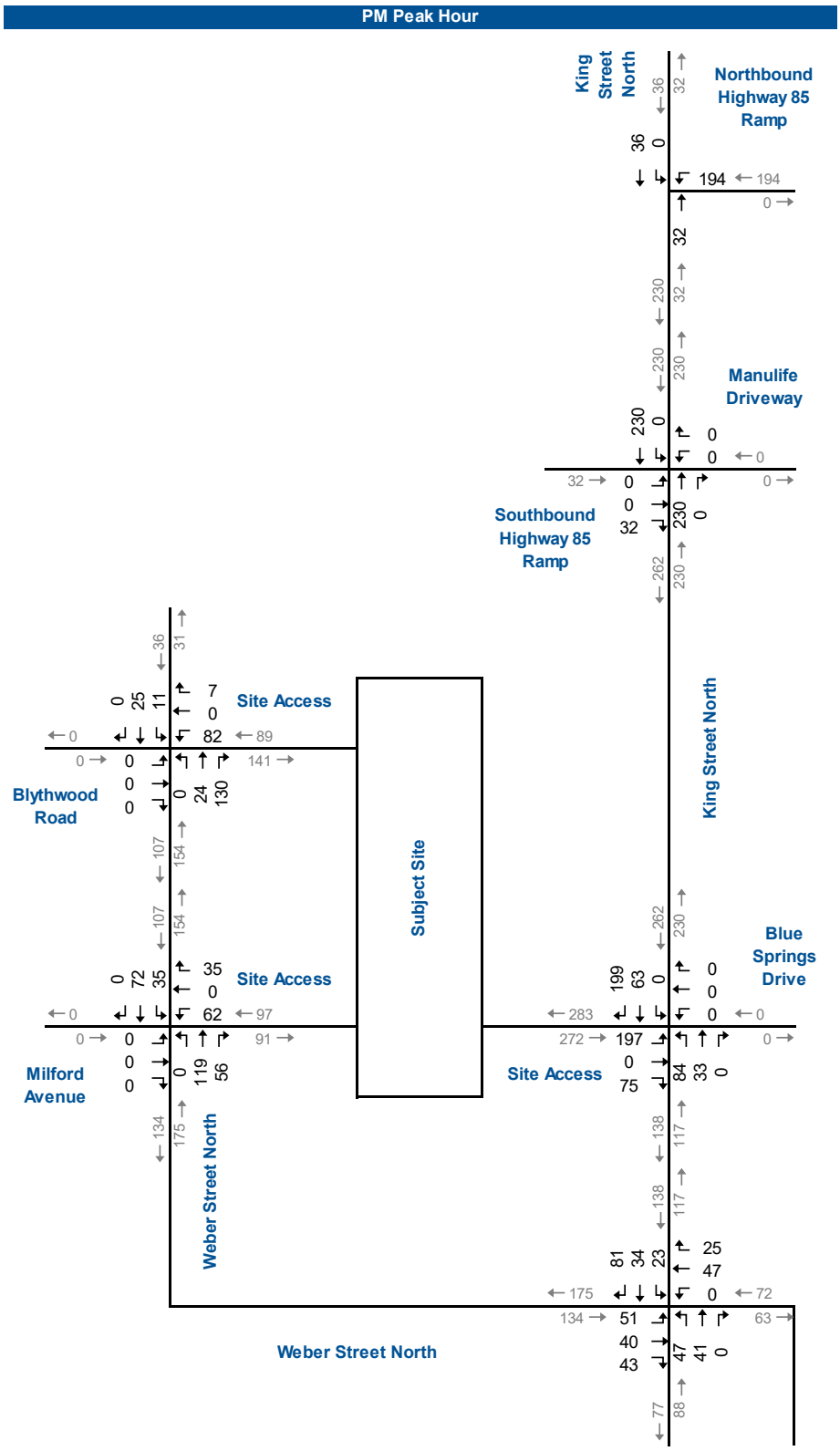
Full Build-Out Site Generated Traffic Volumes (AM Peak Hour 35% Mode Share Reduction)



Full Build-Out Site Generated Traffic Volumes (PM Peak Hour 35% Mode Share Reduction)



Full Build-Out Site Generated Traffic Volumes (AM Peak Hour 45% Mode Share Reduction)



Full Build-Out Site Generated Traffic Volumes (PM Peak Hour 45% Mode Share Reduction)

4 Evaluation of Future Traffic Conditions

The assessment of the future traffic conditions contained in this section includes the future traffic forecasts as an intersection operational analysis. An opening year of the assumed phase 1 build-out, opening year of the assumed phase 2 build-out, opening year of the assumed full-buildout, five years after the assumed full build-out, and ten years after the assumed full build-out of the subject site has been assessed to determine the impact of the subject site.

A growth rate of 2.0% per annum was applied to City of Waterloo governed roadways for all horizon years, as noted by City staff. A growth rate of 1.0% was applied to the 85 Highway 85 Ramps for all horizon years, as noted by MTO staff.

The following growth rates were applied to the Region of Waterloo governed roadways, as noted by Regional staff:

- 1.0% per annum for the 2027 and 2032 horizon years;
- 0.5% per annum for the 2037 horizon; and
- 0% per annum for the 2042 and 2047 horizon years.

No growth rate was applied to the Manulife Driveway and the plaza driveway connecting to the intersection of King Street North and Blue Springs Drive for all horizon years.

Work completed on Weber Street in 2022 included construction of 25 metre left-turn lanes into the future site access connections opposite Blythwood Road and Milford Avenue. Under existing conditions these lanes are painted as shadow lanes. With build-out of the development, the lanes will be painted as turn lanes. These turn lanes have been carried through all horizon years.

In addition, the following developments were included in the background traffic volumes:

- 405 King Street North: The development is located south of the subject site in the southwest corner of the intersection of King Street North and Weber Street North. The development consists of 179 residential units and 259 square metres of commercial space. The development is forecast to generate 54 and 74 trips during the AM and PM peak hours, respectively. The Institute of Transportation Engineers (ITE) Trip Generation rates were used to estimate the trip generation for the development. No reductions for alternate modes of transportation were used in

the calculation. The trip assignment was based on the assignment from **Section 3.2**.

- 475-485 King Street North[10]: The development is located directly north of the subject site. For stage 1, the development consists of 646 residential units and 12,380 square metres of office space. The development is forecast to generate 305 and 317 trips during the AM and PM peak hours, respectively. For stage 2 (assumed to be completed by 2044), the development consists of 1,132 residential units and an additional 4,320 square metres of commercial space. The development is forecast to generate 480 and 536 trips during the AM and PM peak hours, respectively with a 45% mode share reduction applied (not included in the 2022 TIS).
- 525-565 Conestogo Road[11]: The development is located north of the subject site in the southwest corner of the intersection of Northfield Drive and Conestogo Road. The development consists of 2,543 residential units, 196,100 square feet of office space, and 21,400 square feet of commercial space. The development is forecast to generate 787 and 861 trips during the AM and PM peak hours, respectively.
- 551 King Street North: The development is located north of the subject site in the northwest corner of the intersection of King Street North and Conestogo Road. The development consists of 678 residential units and is close to the Conestoga Mall ION station. The development is forecast to generate 156 and 176 trips during the AM and PM peak hours, respectively. The Institute of Transportation Engineers (ITE) Trip Generation rates were used to estimate the trip generation for the development. The trip assignment was based on the assignment from **Section 3.2**. Although, adjustments were made to decrease trips by 5% using Weber Street north of the subject site and increase trips by 5% using King Street north of the subject site.

Appendix E contains the background development material.

4.1 2027 Background Horizon

4.1.1 2027 Background Traffic Growth

Figure 4.1a and **Figure 4.1b** illustrate the 2027 forecast background traffic volumes for the weekday AM and PM peak hours.

[10] Paradigm Transportation Solutions Limited, *475 & 485 King Street North, Waterloo Transportation Impact Study,* (Cambridge: PTSL, 2022).
[11] Paradigm Transportation Solutions Limited, *525-565 Conestogo Road Waterloo Transportation Impact Study and Transportation Demand Management Report,* (Cambridge: PTSL, 2021).

4.1.2 2027 Background Traffic Operations

The study area intersection operations analysis for the 2027 background traffic scenario followed the same methodology used for the existing traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.1a** and **Table 4.1b** detail the level of service conditions.

Table 4.2a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.2b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

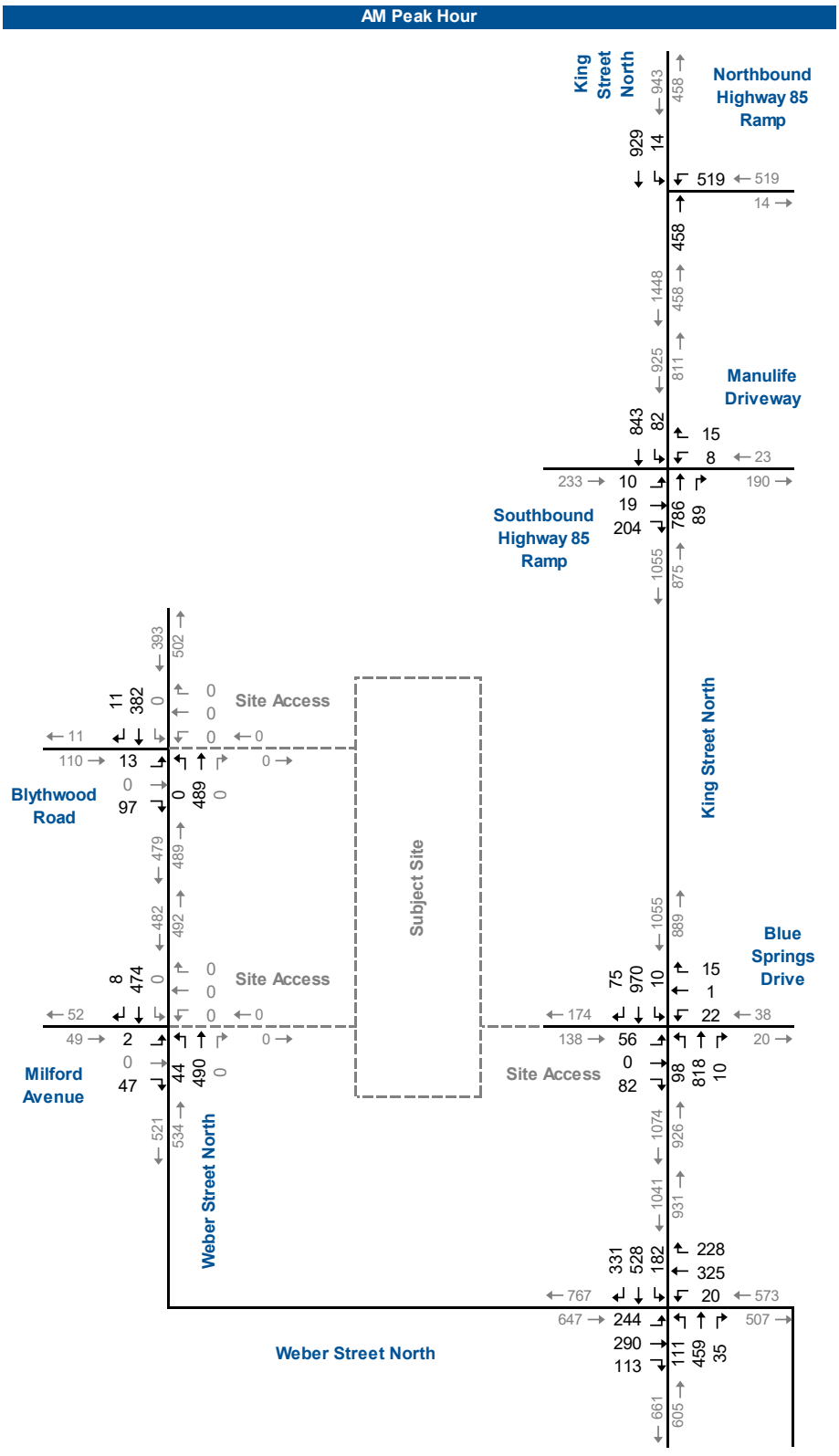
All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 during the AM peak hour and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and

- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM peak hour; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 0.85 and a delay surpassing 55 seconds during the PM peak hour.

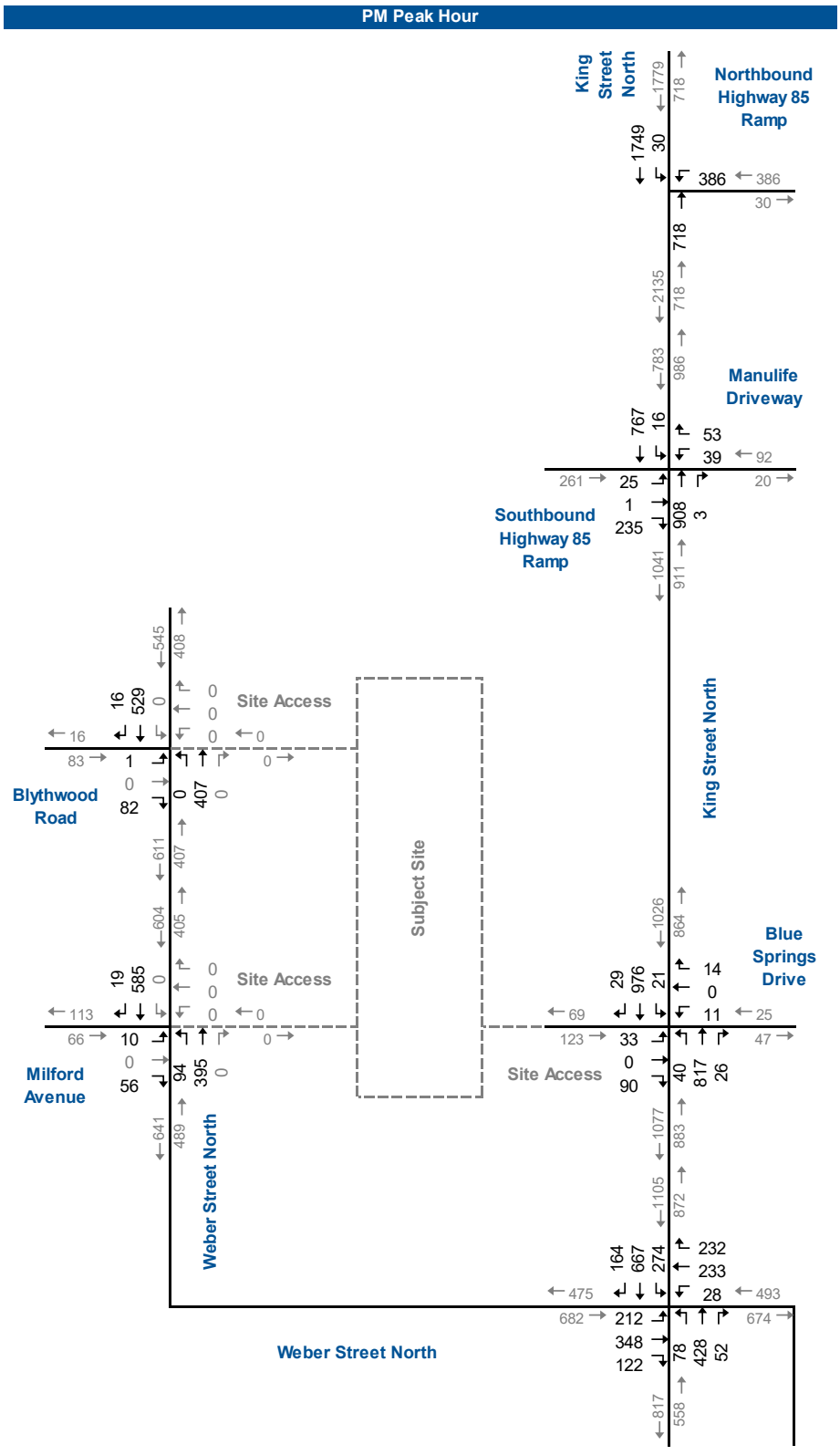
Appendix F contains the supporting detailed Synchro 11 reports.



2027 Background Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.1a



2027 Background Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.1b

TABLE 4.1A: 2027 BACKGROUND OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		B		B	A	A		A	C
			Delay					48			48		19		19	6	9		9	22
			V/C					0.77					0.23			0.03	0.45			
			Q					72					72			3	69			
			Stor.					60					-			20	-			
			Avail.					-12					-			17	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		A	B		A	A	A	A	A		A	A
			Delay	43	44	22	24	43		1	16		8	2	7	4	5		5	8
			V/C	0.06	0.10	0.68		0.07		0.07			0.36	0.09		0.18	0.34			
			Q	7	11	30		6		0			58	6		8	54			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	50		-		50			-	109		22	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	2	>	20	40	19	>	31	5	3	>	4	3	3	>	3	5
			V/C	0.36	0.26	>		0.15	0.09	>		0.26	0.32	>		0.02	0.40	>		
			Q	21	0	>		10	6	>		11	32	>		2	40	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		5	-	>		14	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	B
			Delay	22	13	>	16	24	26	5	18	22	30	>	28	23	26	5	18	20
			V/C	0.55	0.26	>		0.07	0.29	0.38		0.39	0.51	>		0.57	0.47	0.49		
			Q	44	28	>		8	35	15		23	55	>		22	57	8		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-4	-	>		47	-	40		37	-	>		88	-	82		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	11		>	11					8	0		1		0	0	0	
			V/C	0.07		>						0.04	0.00				0.00	0.00		
			Q	2		>						1	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.15		>							0.00				0.00	0.00		
			Q	4		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.1B: 2027 BACKGROUND OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					52			52		4		4	4	11		11	15
			V/C					0.74					0.33			0.07	0.74			
			Q					58					19			4	150			
			Stor.					60					-			20	-			
			Avail.					2					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		B	C		B	A	B	A	A		A	B
			Delay	42	38	28	29	45		13	26		10	0	10	4	3		3	11
			V/C	0.14	0.00	0.74		0.24		0.24			0.37	0.00		0.04	0.31			
			Q	12	2	39		17		11			79	0		1	28			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	68	-	41		-		39			-	115		29	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	C	A	A	>	A	A	A	>	A	A
			Delay	50	3	>	15	46	0	>	20	2	2	>	2	2	2	>	2	3
			V/C	0.25	0.30	>		0.10	0.04	>		0.10	0.31	>		0.04	0.36	>		
			Q	16	0	>		7	0	>		3	20	>		2	29	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		8	-	>		22	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	B	B	>	B	B	B	A	B	C	C	>	C	E	C	A	D	C
			Delay	19	17	>	18	14	19	4	12	25	34	>	33	67	34	6	38	28
			V/C	0.41	0.31	>		0.07	0.15	0.31		0.35	0.52	>		0.94	0.58	0.29		
			Q	38	42	>		7	23	13		20	59	>		87	72	9		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	2	-	>		48	-	42		40	-	>		23	-	81		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	13		>	13					9	0		2		0	0	0	
			V/C	0.13		>						0.10	0.00				0.00	0.00		
			Q	3		>						2	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.12		>							0.00				0.00	0.00		
			Q	3		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.2A: 2027 BACKGROUND RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	204	89	235	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	213	90	240	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	98	42	110	2
	Storage (m)	80	115	80	115
	Available (m)	-18	73	-30	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.2B: 2027 BACKGROUND THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			311	208	458	14	929			232	154	718	30	1749
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			318	213	491	16	1022			237	158	747	30	1784
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			9.7	6.5	7.5	0.5	15.6			7.2	4.8	11.4	0.9	27.3
	Queue (vehicles)*			15	11	12	2	22			12	9	17	3	35
	Queue (m)			113	83	90	15	165			90	68	128	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-23	-	5	-			-	-8	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	10	19			786	82	843	25	1			908	16	767
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	12	19			834	85	877	28	1			936	16	791
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			12.7	2.6	13.4	0.9	0.0			14.3	0.5	12.1
	Queue (vehicles)*	1	2			19	5	20	2	1			21	2	18
	Queue (m)	8	15			143	38	150	15	8			158	15	135
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	65	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.2 2027 Total Traffic Horizon

4.2.1 2027 Total Traffic Volumes

Figure 4.2a and **Figure 4.2b** illustrate the forecast 2027 total (background + site traffic) traffic volumes.

4.2.2 2027 Total Traffic Operations

The study area intersection operations analysis for the 2027 total traffic scenario followed the same methodology used for the existing and 2027 background traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.3a** and **Table 4.3b** detail the level of service conditions for the weekday AM and PM peak hours.

Table 4.4a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.4b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

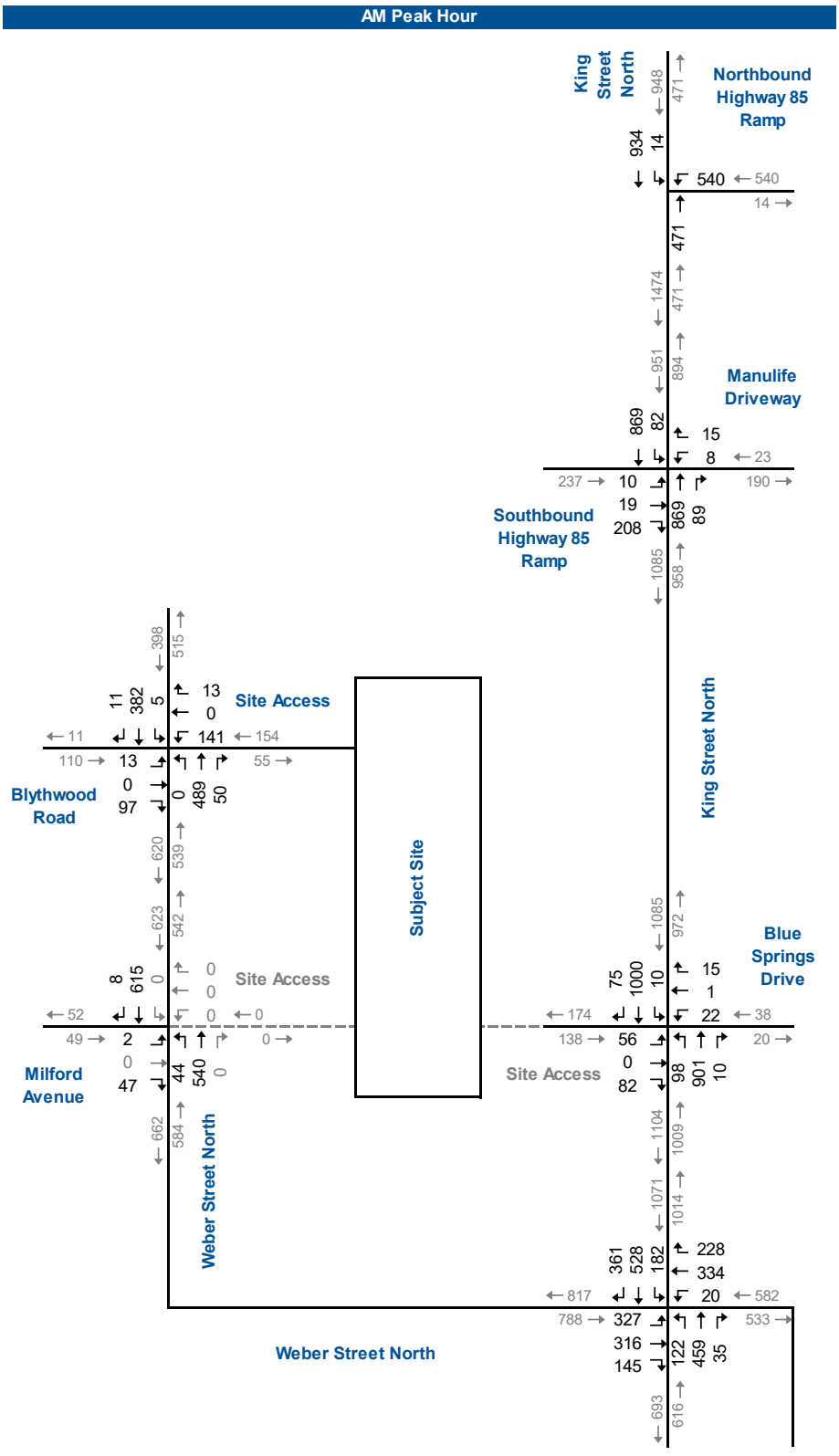
- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 during the PM peak hour and a queue length that surpasses its storage length during the AM and PM peak hours;

- The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 0.85 and a delay surpassing 55 seconds during the PM peak hour.

With the addition of the site generated traffic volumes, the existing approach delays at the study area intersections increase by six seconds or less during the AM and PM peak hours.

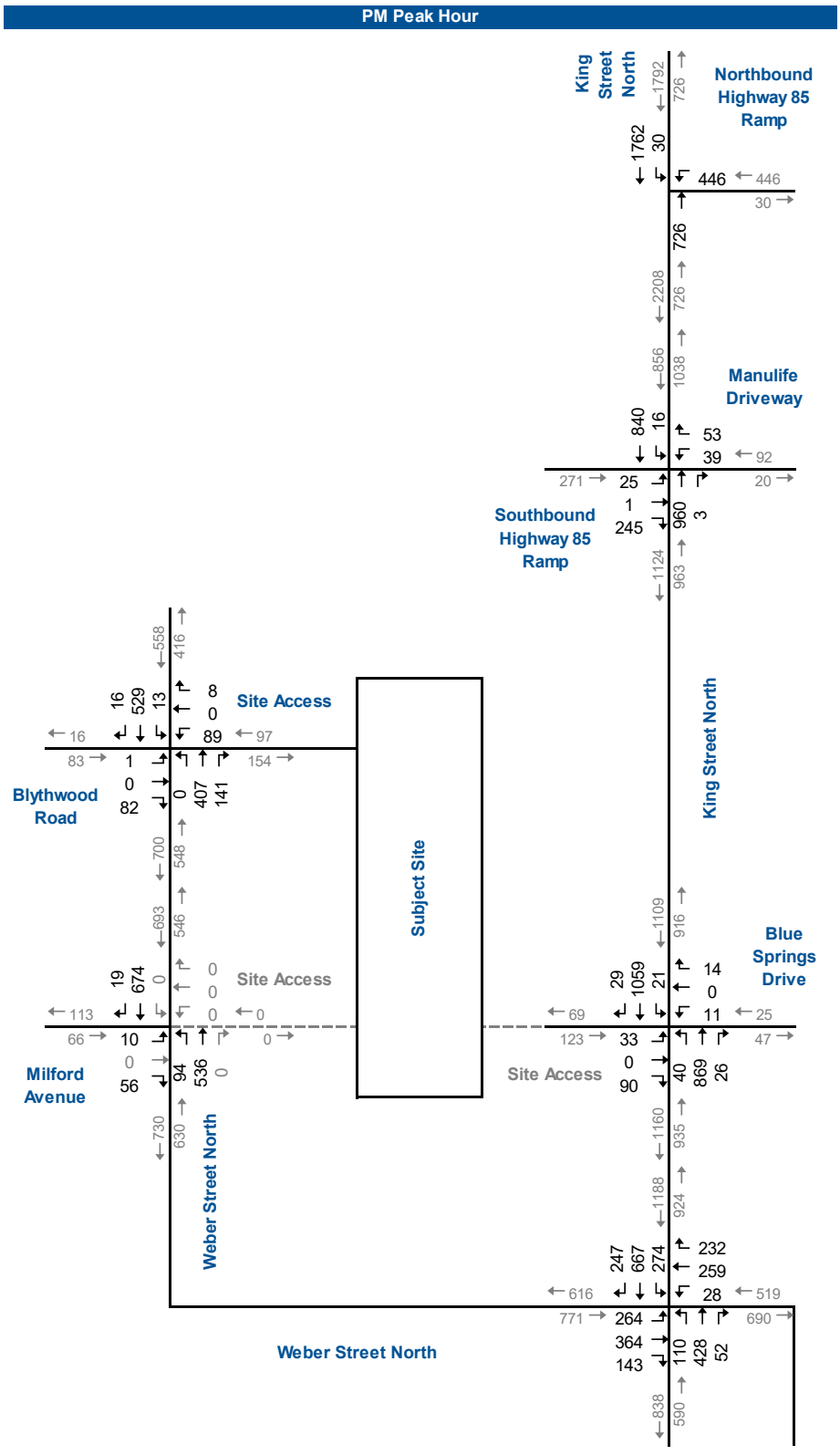
Appendix G contains the supporting detailed Synchro 11 reports.



2027 Total Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.2a



2027 Total Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.2b

TABLE 4.3A: 2027 TOTAL OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	A		A	C
			Delay					48			48		20		20	6	10		10	23
			V/C					0.78					0.24			0.03	0.46			
			Q					74					74			3	71			
			Stor.					60					-			20	-			
			Avail.					-14					-			17	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		A	B		A	A	A	A	A		A	A
			Delay	42	43	25	27	42		1	16		9	2	8	4	5		5	9
			V/C	0.06	0.10	0.70		0.06		0.07			0.40	0.09		0.20	0.35			
			Q	7	11	33		6		0			68	6		9	57			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	47		-		50			-	109		21	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	2	>	20	40	19	>	31	6	4	>	4	3	4	>	4	5
			V/C	0.36	0.27	>		0.15	0.09	>		0.27	0.35	>		0.03	0.41	>		
			Q	21	0	>		10	6	>		11	36	>		2	41	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		5	-	>		14	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	C
			Delay	26	12	>	17	24	26	5	18	26	30	>	29	28	26	5	20	21
			V/C	0.70	0.29	>		0.08	0.30	0.38		0.47	0.51	>		0.63	0.49	0.53		
			Q	59	29	>		8	36	15		26	55	>		23	58	12		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-19	-	>		47	-	40		34	-	>		87	-	78		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	12		>	12					9	0		1		0	0	0	
			V/C	0.08		>						0.05	0.00				0.00	0.00		
			Q	2		>						1	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	D	>	D		A	A	A	A	A	A	A	
			Delay	<	11	>	11	<	30	>	30		0	0	0	8	0	0	0	
			V/C	<	0.16	>		<	0.52	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	4	>		<	21	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>			-	-		25	-	-		
			Avail.	<	-	>		<	-	>			-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.3B: 2027 TOTAL OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					51			51		4		4	5	13		13	16
			V/C					0.77					0.34			0.07	0.76			
			Q					66					18			5	163			
			Stor.					60					-			20	-			
			Avail.					-6					-			15	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	C	C	D	D		B	C		B	A	B	A	A		A	B
			Delay	39	35	35	35	41		12	24		12	0	12	5	4		4	12
			V/C	0.12	0.00	0.77		0.21		0.21			0.40	0.00		0.05	0.35			
			Q	12	2	48		16		10			84	0		1	42			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	68	-	32		-		40			-	115		29	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	C	A	A	>	A	A	A	>	A	A
			Delay	50	4	>	16	46	0	>	20	3	2	>	2	2	2	>	2	3
			V/C	0.25	0.33	>		0.10	0.04	>		0.11	0.33	>		0.05	0.39	>		
			Q	16	1	>		7	0	>		3	27	>		1	29	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		8	-	>		22	-	>		24	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	B	B	A	B	C	C	>	C	E	C	A	C	C
			Delay	22	17	>	19	14	19	4	12	32	34	>	34	63	33	6	34	27
			V/C	0.53	0.34	>		0.07	0.17	0.31		0.53	0.52	>		0.93	0.60	0.40		
			Q	48	45	>		7	25	13		26	59	>		83	70	10		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-8	-	>		48	-	42		34	-	>		27	-	80		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	14		>	14					10	0		2		0	0	0	
			V/C	0.15		>						0.10	0.00				0.00	0.00		
			Q	4		>						3	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	D	>	D		A	A	A	A	A	A	A	
			Delay	<	11	>	11	<	26	>	26		0	0	0	9	0	0	0	
			V/C	<	0.12	>		<	0.36	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	3	>		<	12	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>			-	-		25	-	-		
			Avail.	<	-	>		<	-	>			-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.4A: 2027 TOTAL RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	208	89	245	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	217	90	250	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	100	42	115	2
	Storage (m)	80	115	80	115
	Available (m)	-20	73	-35	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.4B: 2027 TOTAL THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			324	216	471	14	934			268	178	726	30	1762
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			331	221	504	16	1028			274	182	756	30	1798
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			10.1	6.8	7.7	0.5	15.7			8.4	5.6	11.6	0.9	27.5
	Queue (vehicles)*			16	11	12	2	22			13	10	17	3	35
	Queue (m)			120	83	90	15	165			98	75	128	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-23	-	5	-			-	-15	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	10	19			869	82	869	25	1			960	16	840
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	12	19			922	85	904	28	1			989	16	866
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			14.1	2.6	13.8	0.9	0.0			15.1	0.5	13.2
	Queue (vehicles)*	1	2			20	5	20	2	1			22	2	19
	Queue (m)	8	15			150	38	150	15	8			165	15	143
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	65	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.3 2032 Background Horizon

4.3.1 2032 Background Traffic Growth

Figure 4.3a and **Figure 4.3b** illustrate the 2032 forecast background traffic volumes for the weekday AM and PM peak hours.

4.3.2 2032 Background Traffic Operations

The study area intersection operations analysis for the 2032 background traffic scenario followed the same methodology used for the existing traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.5a** and **Table 4.5b** detail the level of service conditions.

Table 4.6a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.6b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

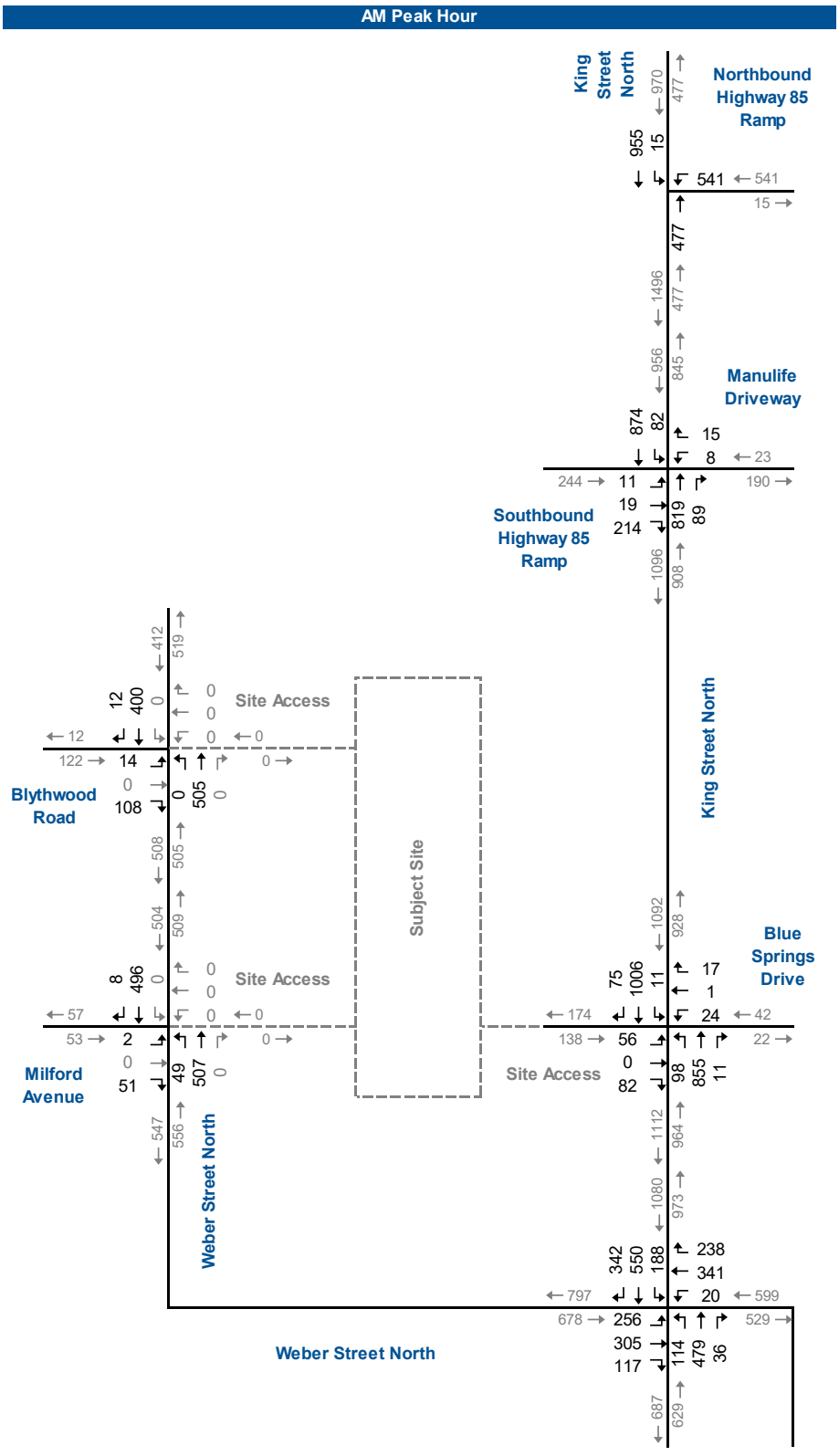
All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 during the AM peak hour and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 during the PM peak hour and a queue length that surpasses its storage length during the AM and PM peak hours;

- The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM peak hour; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and peak hour;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

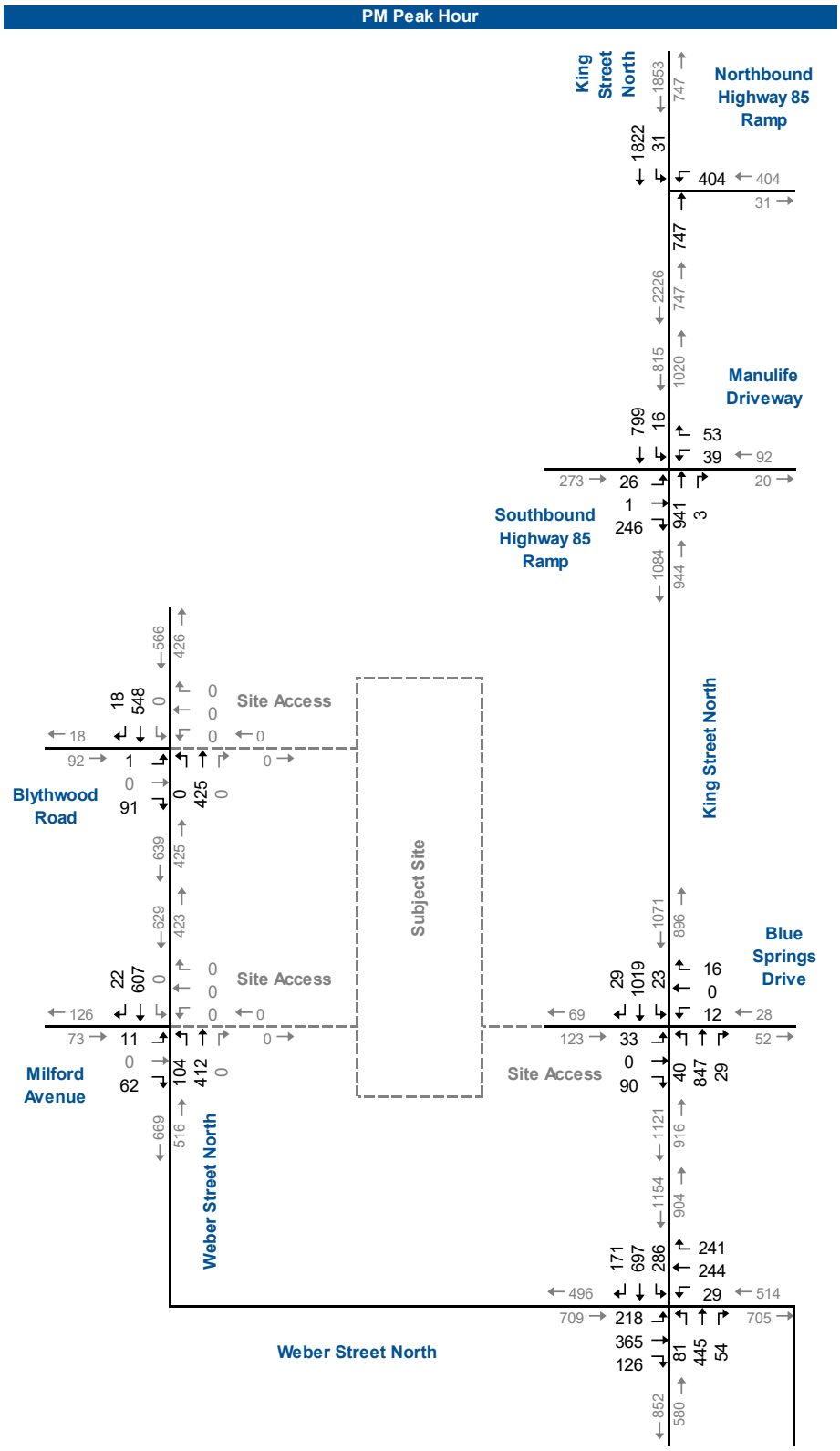
Appendix H contains the supporting detailed Synchro 11 reports.



2032 Background Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.3a



2032 Background Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.3b

TABLE 4.5A: 2032 BACKGROUND OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	A		A	C
			Delay					48			48		20		20	6	10		10	23
			V/C					0.78					0.24			0.03	0.47			
			Q					74					74			4	74			
			Stor.					60					-			20	-			
			Avail.					-14					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		A	B		A	A	A	A	A		A	A
			Delay	42	42	26	28	42		0	15		9	2	8	4	6		6	9
			V/C	0.06	0.10	0.71		0.06		0.07			0.38	0.09		0.19	0.36			
			Q	7	11	35		6		0			64	6		9	58			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	45		-		50			-	109		21	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	2	>	20	40	18	>	31	5	4	>	4	3	4	>	4	5
			V/C	0.37	0.27	>		0.16	0.10	>		0.27	0.33	>		0.03	0.41	>		
			Q	21	0	>		11	6	>		11	34	>		2	42	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		4	-	>		14	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	C
			Delay	23	13	>	17	24	26	5	18	21	30	>	29	24	27	6	20	21
			V/C	0.59	0.28	>		0.07	0.31	0.39		0.40	0.53	>		0.61	0.51	0.51		
			Q	47	29	>		8	36	16		24	58	>		23	62	14		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-7	-	>		47	-	39		36	-	>		87	-	76		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	11		>	11					9	0		1		0	0	0	
			V/C	0.08		>						0.05	0.00				0.00	0.00		
			Q	2		>						1	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.17		>							0.00				0.00	0.00		
			Q	4		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.5B: 2032 BACKGROUND OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					52			52		4		4	4	12		12	16
			V/C					0.75					0.35			0.07	0.77			
			Q					61					18			4	164			
			Stor.					60					-			20	-			
			Avail.					-1					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		B	C		B	A	B	A	A		A	B
			Delay	40	36	33	33	42		12	25		12	0	12	4	4		4	12
			V/C	0.13	0.00	0.77		0.22		0.22			0.39	0.00		0.05	0.33			
			Q	12	2	46		17		10			86	0		1	38			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	68	-	34		-		40			-	115		29	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	C	A	A	>	A	A	A	>	A	A
			Delay	50	3	>	16	47	0	>	20	2	2	>	2	2	2	>	2	3
			V/C	0.25	0.31	>		0.11	0.05	>		0.10	0.32	>		0.05	0.38	>		
			Q	16	0	>		8	0	>		3	21	>		1	28	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		7	-	>		22	-	>		24	-	>		
	King Street North & Weber Street North	TCS	LOS	B	B	>	B	B	B	A	B	C	C	>	C	F	C	A	D	C
			Delay	20	18	>	18	14	19	4	12	26	34	>	33	84	34	5	42	29
			V/C	0.43	0.33	>		0.07	0.16	0.32		0.38	0.54	>		1.01	0.61	0.30		
			Q	39	44	>		7	24	14		20	62	>		92	73	8		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	1	-	>		48	-	41		40	-	>		18	-	82		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	14		>	14					9	0		2		0	0	0	
			V/C	0.15		>						0.11	0.00				0.00	0.00		
			Q	4		>						3	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.14		>							0.00				0.00	0.00		
			Q	4		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.6A: 2032 BACKGROUND RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	214	89	246	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	223	90	251	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	103	42	116	2
	Storage (m)	80	115	80	115
	Available (m)	-23	73	-36	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.6B: 2032 BACKGROUND THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			325	216	477	15	955			242	162	747	31	1822
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			332	221	511	17	1051			247	166	777	31	1859
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			10.1	6.8	7.8	0.5	16.1			7.5	5.1	11.9	0.9	28.4
	Queue (vehicles)*			16	11	13	2	23			12	9	18	3	35
	Queue (m)			120	83	98	15	173			90	68	135	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-23	-	5	-			-	-8	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	11	19			819	82	874	26	1			941	16	799
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	13	19			869	85	909	29	1			970	16	823
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			13.3	2.6	13.9	0.9	0.0			14.8	0.5	12.6
	Queue (vehicles)*	1	2			19	5	20	2	1			21	2	19
	Queue (m)	8	15			143	38	150	15	8			158	15	143
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	65	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.4 2032 Total Traffic Horizon

4.4.1 2032 Total Traffic Volumes

Figure 4.4a and **Figure 4.4b** illustrate the forecast 2032 total (background + site traffic) traffic volumes.

4.4.2 2032 Total Traffic Operations

The study area intersection operations analysis for the 2032 total traffic scenario followed the same methodology used for the existing and 2032 background traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.7a** and **Table 4.7b** detail the level of service conditions for the weekday AM and PM peak hours.

Table 4.8a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.8b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;

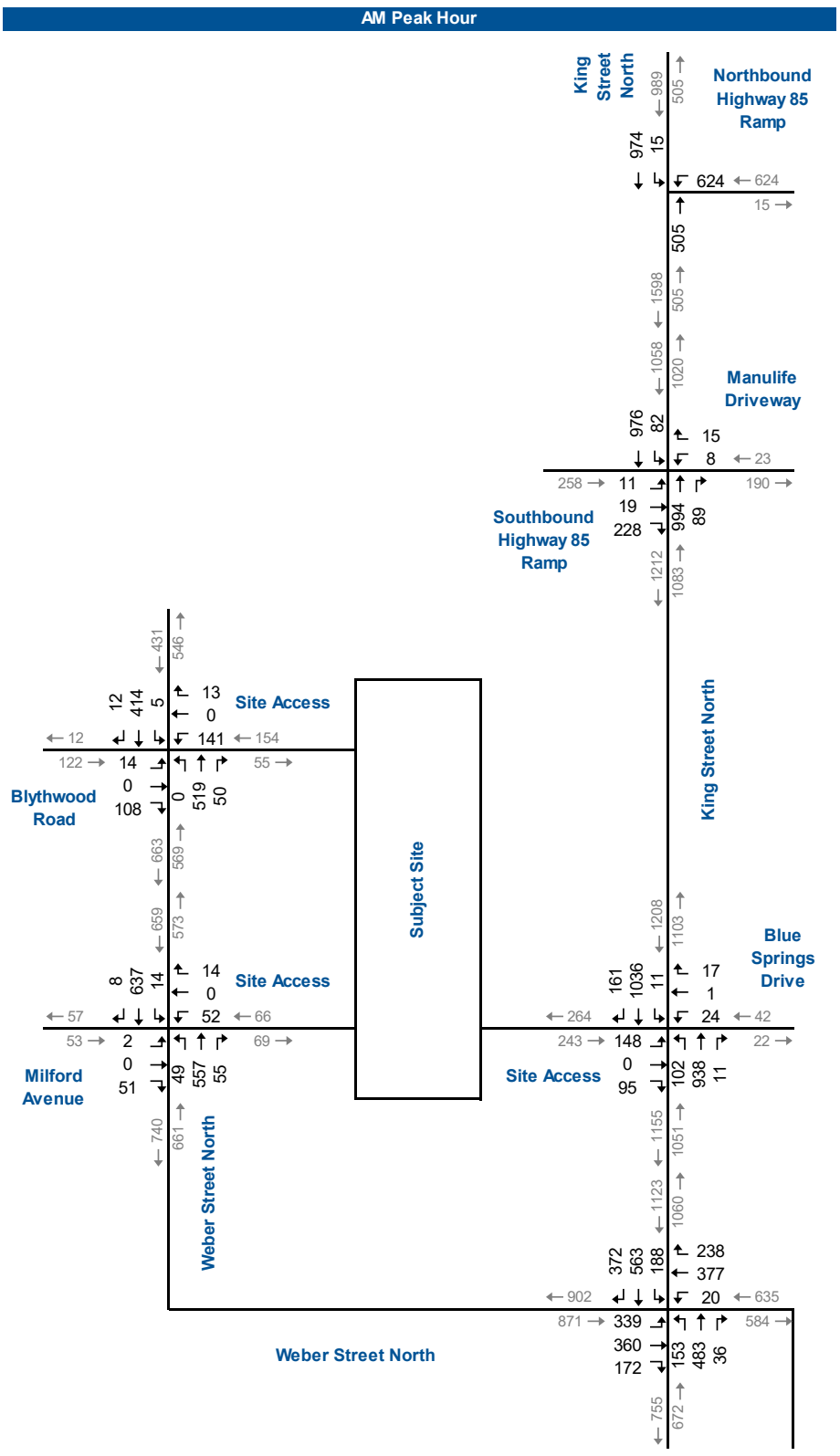
- The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a delay surpassing 55 seconds during the PM peak hour and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.
- King Street North and Milford Avenue:
  - The westbound through/left-turn/right-turn movement is forecast to have a delay surpassing 55 seconds during the PM peak hour.

With the addition of the site generated traffic volumes, the existing approach delays at the study area intersections increase by ten

seconds or less during the AM and PM peak hours. Although, the eastbound approach delay at the intersection of King Street North and Blue Springs Drive increases by 12 and 18 seconds during the AM and PM peak hours, respectively.

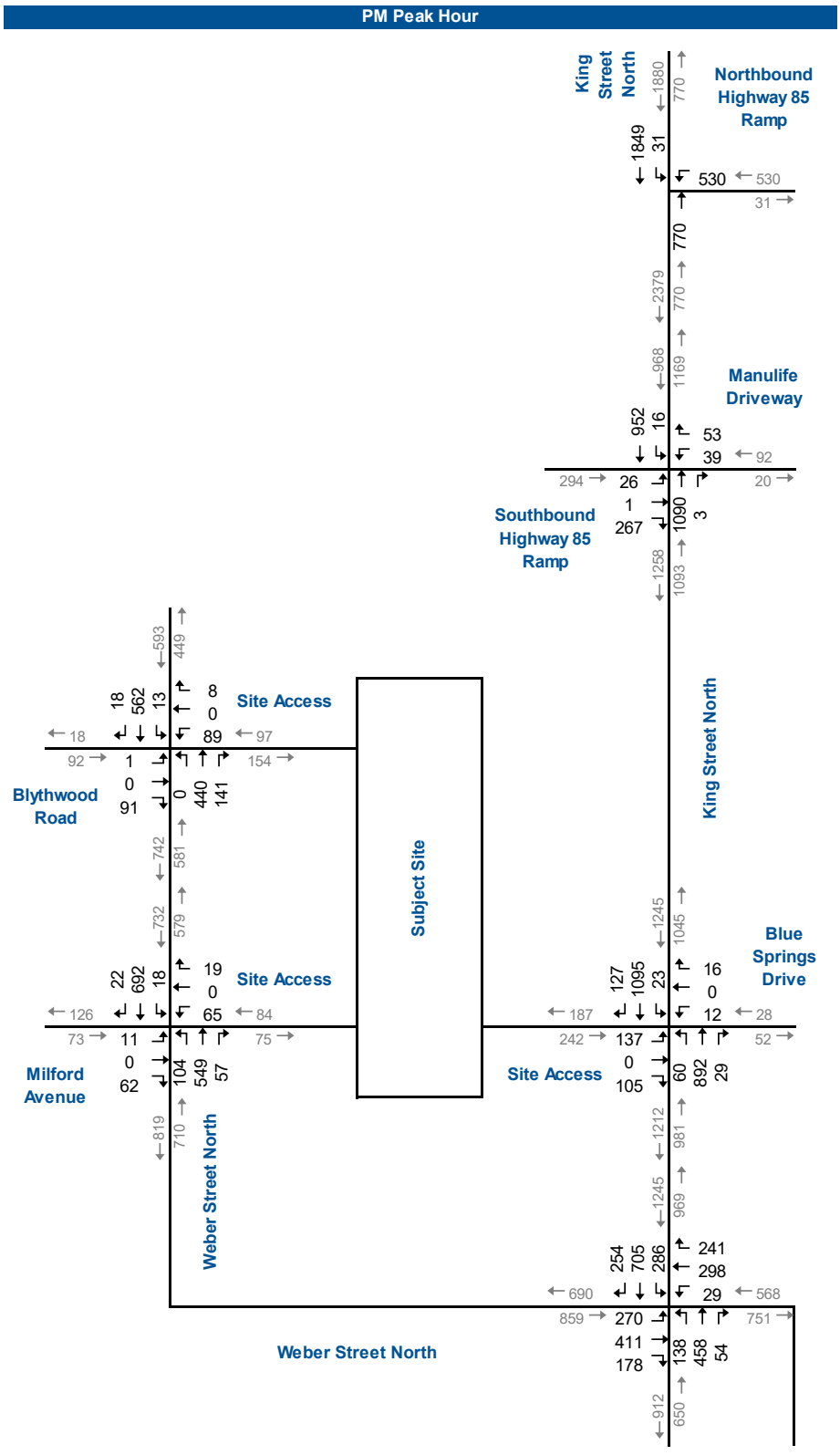
Appendix I contains the supporting detailed Synchro 11 reports.



2032 Total Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.4a



2032 Total Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.4b

TABLE 4.7A: 2032 TOTAL OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					46			46		24		24	8	12		12	25
			V/C					0.80					0.27			0.03	0.50			
			Q					83					82			4	84			
			Stor.					60					-			20	-			
			Avail.					-23					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	D	D	D		A	B		B	A	B	A	A		A	B
			Delay	38	39	36	36	38		0	14		11	2	10	5	7		6	11
			V/C	0.05	0.08	0.76		0.05		0.06			0.48	0.09		0.23	0.41			
			Q	7	10	47		6		0			88	7		10	77			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	33		-		50			-	108		20	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	C	C	B	>	C	B	A	>	A	A	A	>	A	A
			Delay	51	3	>	32	33	15	>	25	11	6	>	7	5	7	>	7	9
			V/C	0.65	0.26	>		0.11	0.07	>		0.39	0.41	>		0.03	0.52	>		
			Q	44	4	>		10	6	>		14	44	>		2	65	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-29	-	>		5	-	>		11	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	C
			Delay	29	12	>	19	24	26	5	18	31	32	>	31	29	25	4	19	21
			V/C	0.76	0.33	>		0.08	0.34	0.39		0.60	0.55	>		0.66	0.53	0.55		
			Q	67	34	>		8	40	16		32	59	>		29	46	8		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-27	-	>		47	-	39		28	-	>		81	-	82		
	Weber Street North & Milford Avenue	TWSC	LOS	<	B	>	B	<	D	>	D	A	A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	34	>	34	9	0	0	1	9	0	0	0	
			V/C	<	0.09	>		<	0.35	>		0.05	0.00	0.00		0.01	0.00	0.00		
			Q	<	2	>		<	10	>		2	0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	E	>	E		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	35	>	35		0	0	0	9	0	0	0	
			V/C	<	0.18	>		<	0.57	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	5	>		<	25	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.7B: 2032 TOTAL OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					52			52		4		4	6	16		16	19
			V/C					0.83					0.38			0.08	0.82			
			Q					78					18			5	189			
			Stor.					60					-			20	-			
			Avail.					-18					-			15	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	C	D	D	D		A	C		B	A	B	A	A		A	B
			Delay	35	32	44	43	36		10	21		15	0	15	7	6		6	15
			V/C	0.10	0.00	0.81		0.17		0.18			0.48	0.00		0.06	0.42			
			Q	11	1	62		16		10			101	0		2	64			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	69	-	18		-		40			-	115		28	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	A	>	C	D	A	>	B	A	A	>	A	A	A	>	A	A
			Delay	56	5	>	34	37	0	>	16	6	4	>	4	4	4	>	4	7
			V/C	0.64	0.30	>		0.07	0.04	>		0.22	0.38	>		0.06	0.50	>		
			Q	45	6	>		7	0	>		7	35	>		2	44	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-30	-	>		8	-	>		18	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	B	B	A	B	D	C	>	D	F	C	A	D	C
			Delay	24	18	>	20	14	20	4	13	39	35	>	36	80	34	5	38	29
			V/C	0.56	0.39	>		0.08	0.19	0.32		0.67	0.55	>		1.01	0.67	0.43		
			Q	49	52	>		7	29	14		33	64	>		81	75	11		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-9	-	>		48	-	41		27	-	>		29	-	79		
	Weber Street North & Milford Avenue	TWSC	LOS	<	C	>	C	<	F	>	F	A	A	A	A	A	A	A	A	
			Delay	<	17	>	17	<	62	>	62	10	1	0	2	9	0	0	0	
			V/C	<	0.20	>		<	0.60	>		0.12	0.00	0.00		0.02	0.00	0.00		
			Q	<	5	>		<	23	>		3	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	D	>	D		A	A	A	A	A	A	A	
			Delay	<	11	>	11	<	29	>	29		0	0	0	9	0	0	0	
			V/C	<	0.14	>		<	0.40	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	4	>		<	14	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.8A: 2032 TOTAL RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	228	89	267	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	238	90	273	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	110	42	126	2
	Storage (m)	80	115	80	115
	Available (m)	-30	73	-46	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.8B: 2032 TOTAL THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			374	250	505	15	974			318	212	770	31	1849
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			382	255	541	17	1072			325	217	801	31	1886
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			11.7	7.8	8.3	0.5	16.4			9.9	6.6	12.2	0.9	28.8
	Queue (vehicles)*			18	13	13	2	23			15	11	18	3	35
	Queue (m)			135	98	98	15	173			113	83	135	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-38	-	5	-			-	-23	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	11	19			994	82	976	26	1			1090	16	952
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	13	19			1054	85	1016	29	1			1123	16	981
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			16.1	2.6	15.5	0.9	0.0			17.2	0.5	15.0
	Queue (vehicles)*	1	2			23	5	22	2	1			24	2	21
	Queue (m)	8	15			173	38	165	15	8			180	15	158
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	65	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.5 2037 Background Horizon

4.5.1 2037 Background Traffic Growth

Figure 4.5a and **Figure 4.5b** illustrate the 2037 forecast background traffic volumes for the weekday AM and PM peak hours.

4.5.2 2037 Background Traffic Operations

The study area intersection operations analysis for the 2037 background traffic scenario followed the same methodology used for the existing traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.9a** and **Table 4.9b** detail the level of service conditions.

Table 4.10a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.10b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

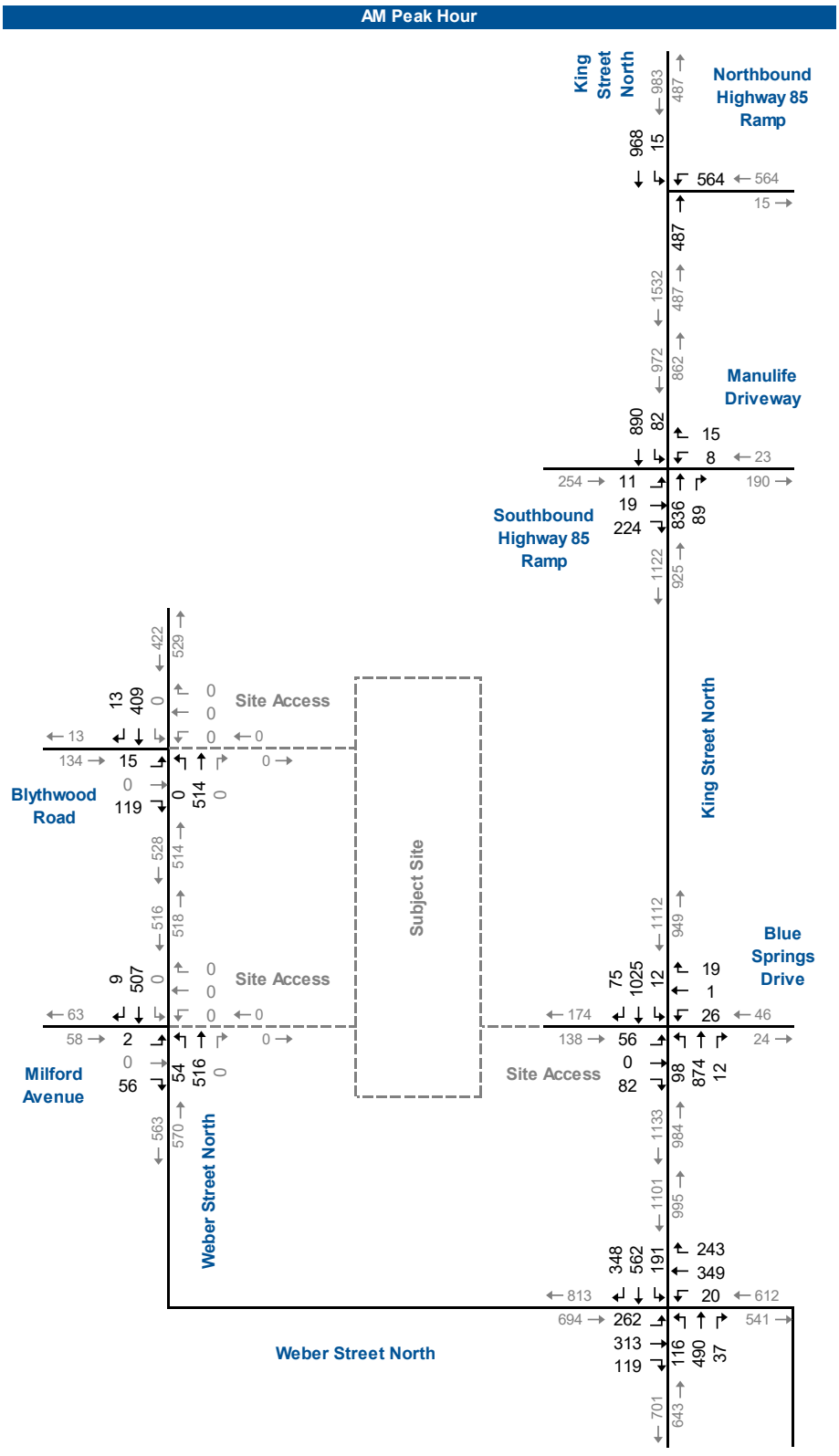
All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;

- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 during the PM peak hour and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM peak hour; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

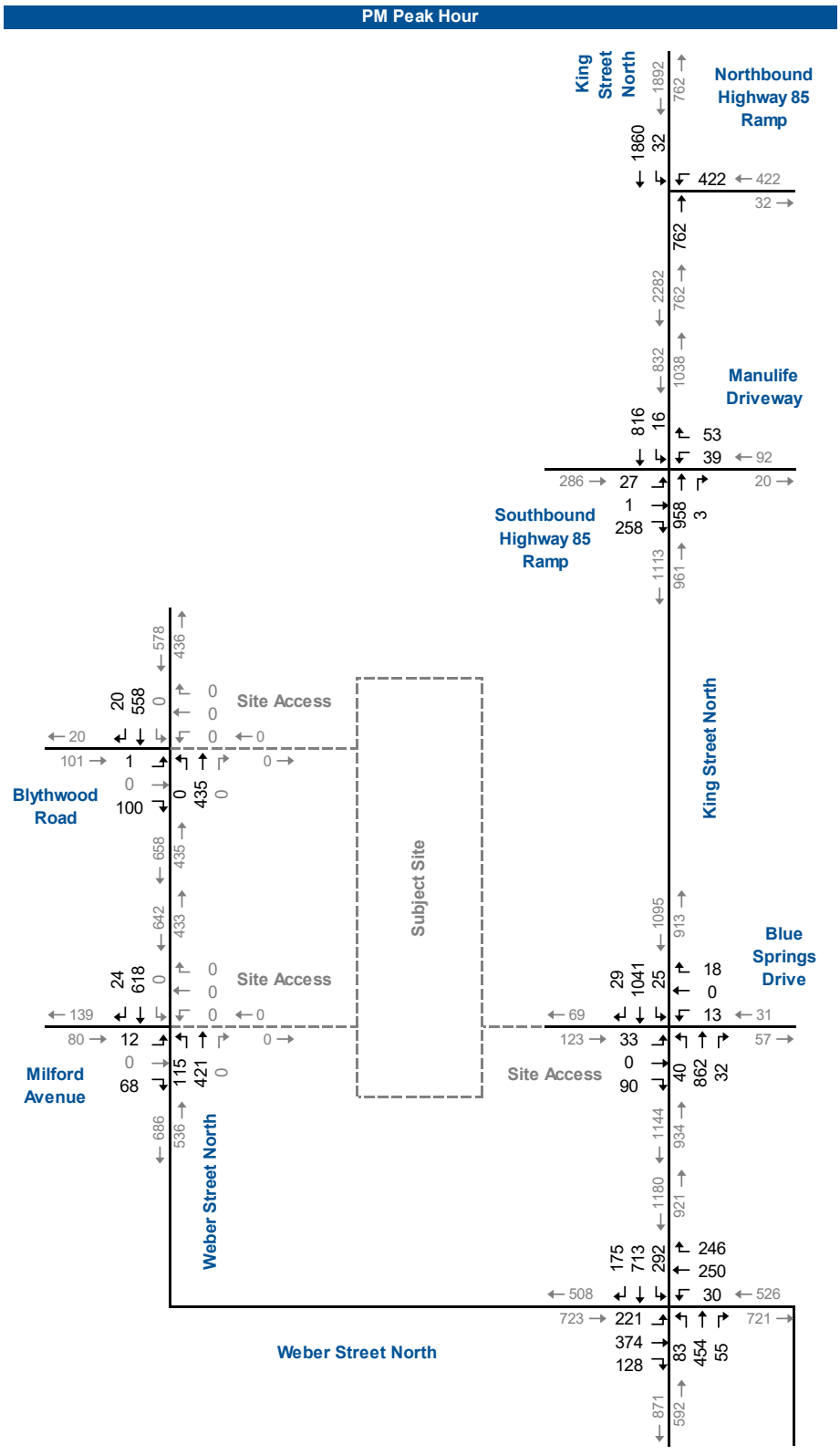
Appendix J contains the supporting detailed Synchro 11 reports.



2037 Background Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.5a



2037 Background Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.5b

TABLE 4.9A: 2037 BACKGROUND OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					48			48		22		22	7	10		10	23
			V/C					0.79					0.25			0.03	0.48			
			Q					77					77			4	77			
			Stor.					60					-			20	-			
			Avail.					-17					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		A	B		A	A	A	A	A		A	A
			Delay	40	41	29	30	40		0	15		9	2	8	4	6		6	10
			V/C	0.06	0.09	0.73		0.06		0.07			0.39	0.09		0.19	0.37			
			Q	7	10	39		6		0			67	6		9	62			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	41		-		50			-	109		21	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	2	>	20	41	17	>	31	6	4	>	4	3	4	>	4	5
			V/C	0.36	0.27	>		0.17	0.11	>		0.28	0.34	>		0.03	0.42	>		
			Q	21	0	>		12	6	>		11	34	>		2	43	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		3	-	>		14	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	C
			Delay	24	13	>	17	24	26	5	18	23	31	>	29	25	25	5	19	20
			V/C	0.61	0.28	>		0.07	0.31	0.39		0.43	0.54	>		0.62	0.49	0.50		
			Q	48	30	>		8	37	16		24	59	>		23	60	8		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-8	-	>		47	-	39		36	-	>		87	-	82		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	11		>	11					9	0		1		0	0	0	
			V/C	0.09		>						0.05	0.00				0.00	0.00		
			Q	2		>						2	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.19		>							0.00				0.00	0.00		
			Q	5		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.9B: 2037 BACKGROUND OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					52			52		4		4	5	14		13	16
			V/C					0.77					0.36			0.07	0.79			
			Q					64					16			4	174			
			Stor.					60					-			20	-			
			Avail.					-4					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	C	D	D	D		B	C		B	A	B	A	A		A	B
			Delay	38	35	35	36	40		11	23		14	0	14	5	5		5	14
			V/C	0.12	0.00	0.78		0.20		0.20			0.40	0.00		0.05	0.34			
			Q	12	2	51		16		10			93	0		1	45			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	68	-	29		-		40			-	115		29	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	B	A	A	>	A	A	A	>	A	A
			Delay	50	3	>	16	47	0	>	20	2	2	>	2	2	2	>	2	3
			V/C	0.25	0.32	>		0.12	0.05	>		0.10	0.33	>		0.05	0.39	>		
			Q	16	0	>		8	0	>		3	22	>		2	28	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		7	-	>		22	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	B	B	>	B	B	B	A	B	C	C	>	C	F	C	A	D	C
			Delay	20	18	>	18	14	19	4	12	26	35	>	33	93	33	5	44	30
			V/C	0.44	0.34	>		0.08	0.16	0.32		0.40	0.55	>		1.04	0.62	0.30		
			Q	40	45	>		8	25	14		20	63	>		94	73	7		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	0	-	>		47	-	41		40	-	>		16	-	83		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	14		>	14					9	0		2		0	0	0	
			V/C	0.17		>						0.12	0.00				0.00	0.00		
			Q	4		>						3	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.15		>							0.00				0.00	0.00		
			Q	4		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.10A: 2037 BACKGROUND RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	224	89	258	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	233	90	264	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	107	42	121	2
	Storage (m)	80	115	80	115
	Available (m)	-27	73	-41	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.10B: 2037 BACKGROUND THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			338	226	487	15	968			253	169	762	32	1860
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			345	231	522	17	1065			259	173	793	32	1898
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			10.5	7.1	8.0	0.5	16.3			7.9	5.3	12.1	1.0	29.0
	Queue (vehicles)*			16	12	13	2	23			13	9	18	3	35
	Queue (m)			120	90	98	15	173			98	68	135	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-30	-	5	-			-	-8	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	11	19			836	82	890	27	1			958	16	816
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	13	19			887	85	926	30	1			987	16	841
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			13.6	2.6	14.1	0.9	0.0			15.1	0.5	12.8
	Queue (vehicles)*	1	2			20	5	21	3	1			22	2	19
	Queue (m)	8	15			150	38	158	23	8			165	15	143
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	57	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.6 2037 Total Traffic Horizon

4.6.1 2037 Total Traffic Volumes

Figure 4.6a and **Figure 4.6b** illustrate the forecast 2037 total (background + site traffic) traffic volumes.

4.6.2 2037 Total Traffic Operations

The study area intersection operations analysis for the 2037 total traffic scenario followed the same methodology used for the existing and 2037 background traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.11a** and **Table 4.11b** detail the level of service conditions for the weekday AM and PM peak hours.

Table 4.12a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.12b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;

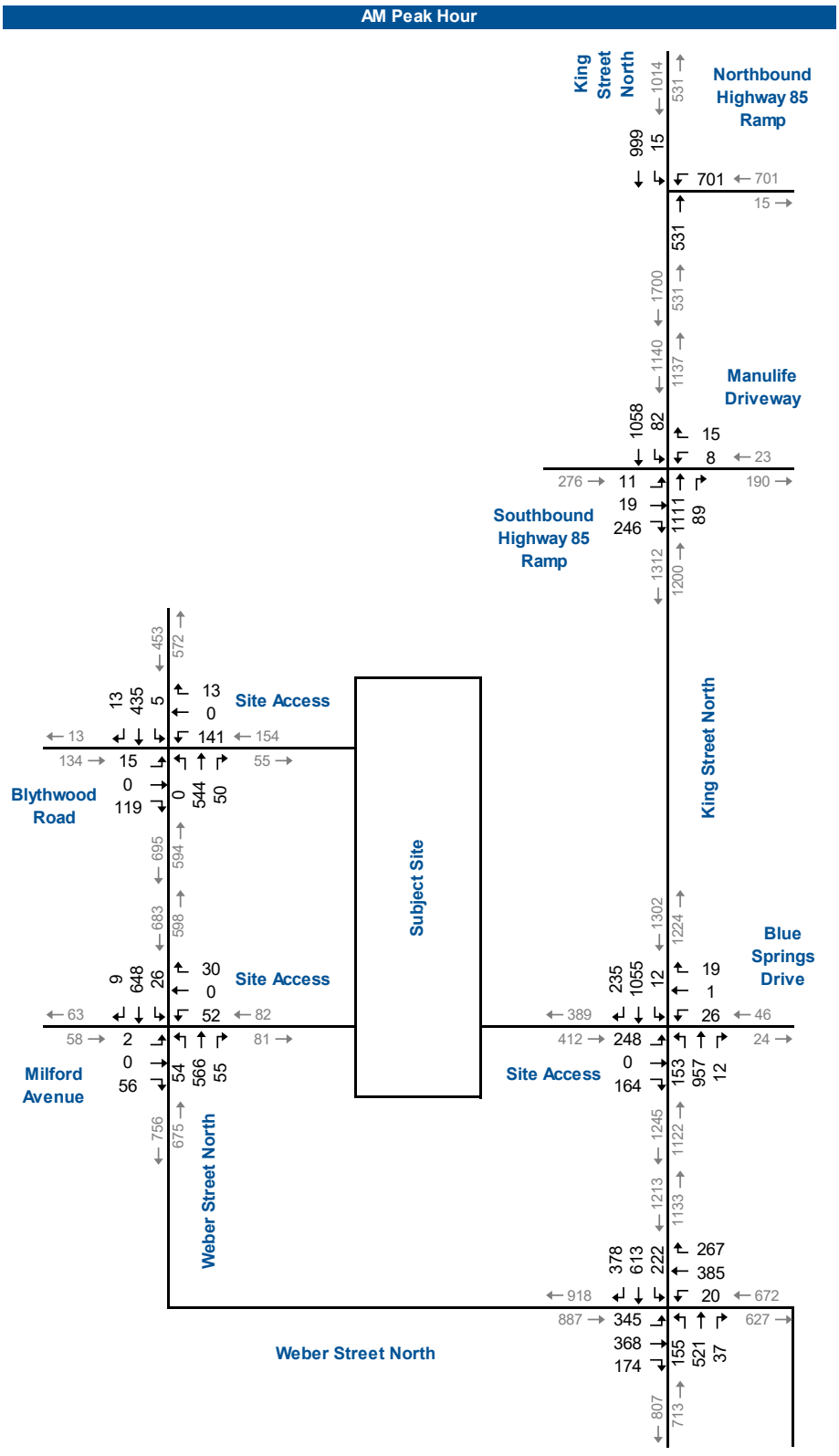
- The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a delay surpassing 55 seconds, a v/c ratio surpassing 0.85, and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the AM and PM peak hours;
  - The northbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

- King Street North and Milford Avenue:
  - The westbound through/left-turn/right-turn movement is forecast to have a delay surpassing 55 seconds during the PM peak hour.

With the addition of the site generated traffic volumes, the existing approach delays at the study area intersections increase by eleven seconds or less during the AM and PM peak hours. Although, the eastbound approach delay at the intersection of King Street North and the Highway 85 Southbound Ramp increases by 13 seconds during the AM peak hour. The eastbound approach delay at the intersection of King Street North and Blue Springs Drive increases by 27 and 31 seconds during the AM and PM peak hours, respectively.

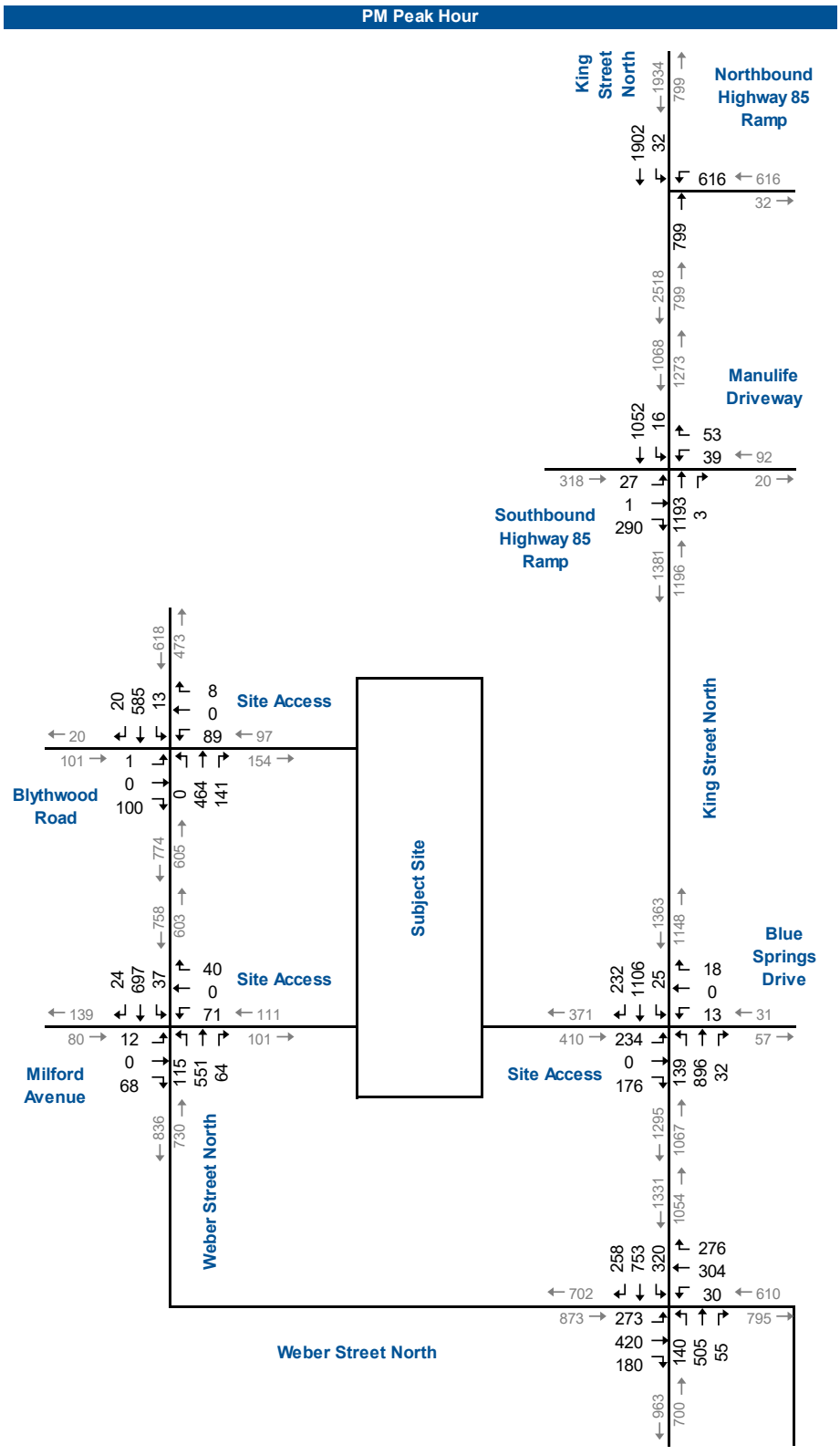
Appendix K contains the supporting detailed Synchro 11 reports.



2037 Total Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.6a



2037 Total Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.6b

TABLE 4.11A: 2037 TOTAL OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					45			45		27		27	9	13		13	26
			V/C					0.82					0.29			0.03	0.53			
			Q					92					86			4	92			
			Stor.					60					-			20	-			
			Avail.					-32					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	D	D	D		A	B		B	A	B	A	A		A	B
			Delay	35	36	44	43	35		0	13		14	2	13	6	9		8	14
			V/C	0.05	0.07	0.80		0.04		0.05			0.55	0.09		0.28	0.46			
			Q	7	10	58		6		0			108	7		10	96			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	22		-		50			-	108		20	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	B	>	D	C	B	>	C	C	A	>	B	A	A	>	A	B
			Delay	72	11	>	47	32	14	>	24	31	7	>	11	5	9	>	9	15
			V/C	0.89	0.40	>		0.12	0.06	>		0.74	0.44	>		0.04	0.59	>		
			Q	88	19	>		11	6	>		51	46	>		2	73	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-73	-	>		4	-	>		-26	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	C	C	C	A	B	C	C	>	C	D	C	A	C	C
			Delay	35	13	>	21	24	26	5	18	32	31	>	32	38	24	4	20	22
			V/C	0.81	0.35	>		0.08	0.35	0.42		0.63	0.57	>		0.80	0.56	0.54		
			Q	76	36	>		8	41	16		32	63	>		41	52	6		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-36	-	>		47	-	39		28	-	>		69	-	84		
	Weber Street North & Milford Avenue	TWSC	LOS	<	B	>	B	<	D	>	D	A	A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	34	>	34	9	0	0	1	9	0	0	0	
			V/C	<	0.10	>		<	0.40	>		0.06	0.00	0.00		0.03	0.00	0.00		
			Q	<	2	>		<	14	>		2	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	E	>	E		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	41	>	41		0	0	0	9	0	0	0	
			V/C	<	0.20	>		<	0.62	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	6	>		<	28	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.11B: 2037 TOTAL OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					E			E		A		A	A	B		B	C
			Delay					55			55		4		4	6	20		19	22
			V/C					0.88					0.40			0.09	0.87			
			Q					96					19			5	209			
			Stor.					60					-			20	-			
			Avail.					-36					-			15	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	C	D	D	C		B	C		B	A	B	A	A		A	B
			Delay	32	29	48	46	33		12	21		17	0	17	9	9		9	17
			V/C	0.08	0.00	0.82		0.14		0.15			0.55	0.00		0.08	0.49			
			Q	11	1	74		15		10			115	0		2	76			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	69	-	6		-		40			-	115		28	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	B	>	D	D	A	>	B	C	A	>	A	A	A	>	A	B
			Delay	71	14	>	47	36	0	>	15	25	5	>	8	4	6	>	6	12
			V/C	0.86	0.45	>		0.07	0.04	>		0.68	0.40	>		0.07	0.59	>		
			Q	88	26	>		7	0	>		54	37	>		2	46	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-73	-	>		8	-	>		-29	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	B	B	A	B	D	D	>	D	F	C	A	D	D
			Delay	24	18	>	20	14	20	4	12	49	36	>	38	146	33	5	55	36
			V/C	0.58	0.40	>		0.09	0.20	0.35		0.75	0.60	>		1.21	0.70	0.42		
			Q	50	54	>		8	30	14		40	70	>		110	87	14		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-10	-	>		47	-	41		20	-	>		0	-	76		
	Weber Street North & Milford Avenue	TWSC	LOS	<	C	>	C	<	F	>	F	A	A	A	A	A	A	A	A	
			Delay	<	19	>	19	<	91	>	91	10	1	0	2	9	0	0	0	
			V/C	<	0.23	>		<	0.79	>		0.13	0.00	0.00		0.04	0.00	0.00		
			Q	<	7	>		<	37	>		4	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	D	>	D		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	32	>	32		0	0	0	9	0	0	0	
			V/C	<	0.15	>		<	0.43	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	4	>		<	15	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.12A: 2037 TOTAL RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	246	89	290	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	256	90	296	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	118	42	136	2
	Storage (m)	80	115	80	115
	Available (m)	-38	73	-56	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.12B: 2037 TOTAL THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			421	280	531	15	999			370	246	799	32	1902
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			430	286	569	17	1099			378	251	831	32	1941
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			13.1	8.7	8.7	0.5	16.8			11.6	7.7	12.7	1.0	29.7
	Queue (vehicles)*			19	14	14	2	24			17	12	19	3	35
	Queue (m)			143	105	105	15	180			128	90	143	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-45	-	5	-			-	-30	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	11	19			1111	82	1058	27	1			1193	16	1052
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	13	19			1178	85	1101	30	1			1229	16	1084
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			18.0	2.6	16.8	0.9	0.0			18.8	0.5	16.6
	Queue (vehicles)*	1	2			25	5	24	3	1			26	2	23
	Queue (m)	8	15			188	38	180	23	8			195	15	173
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	57	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.7 2042 Background Horizon

4.7.1 2042 Background Traffic Growth

Figure 4.7a and **Figure 4.7b** illustrate the 2042 forecast background traffic volumes for the weekday AM and PM peak hours.

4.7.2 2042 Background Traffic Operations

The study area intersection operations analysis for the 2042 background traffic scenario followed the same methodology used for the existing traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.13a** and **Table 4.13b** detail the level of service conditions.

Table 4.14a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.14b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

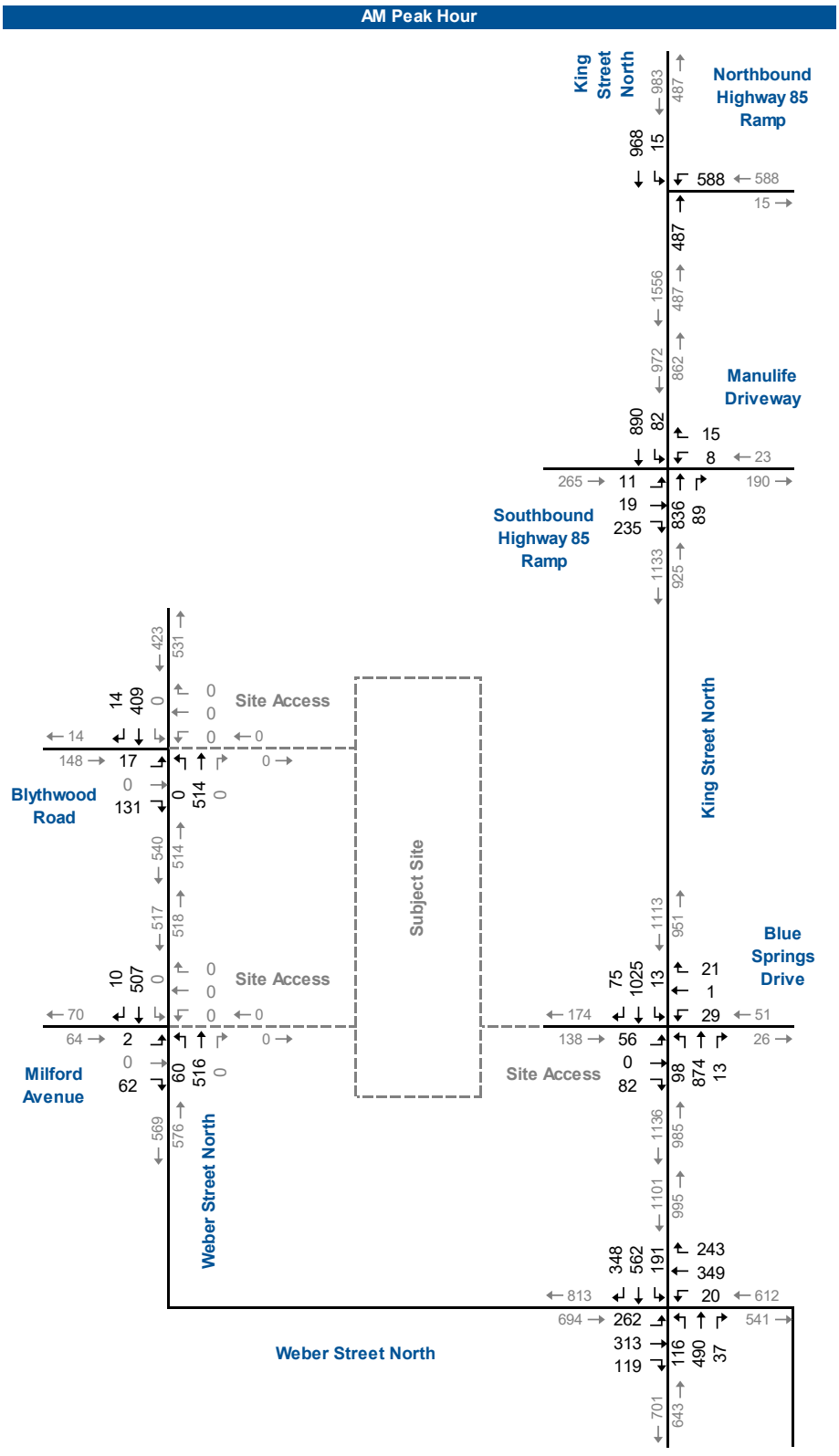
All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;

- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM peak hour; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

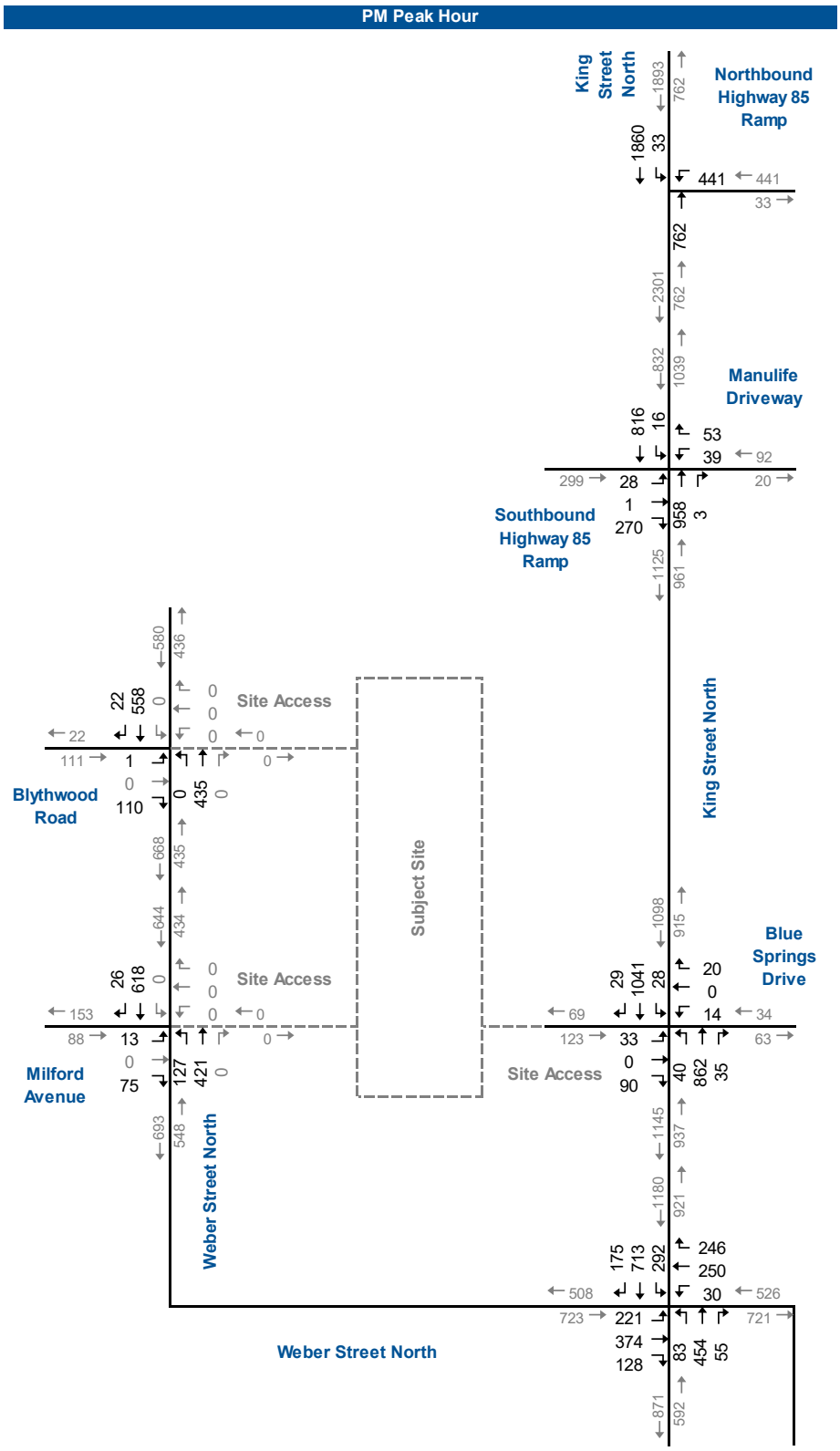
Appendix L contains the supporting detailed Synchro 11 reports.



2042 Background Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.7a



2042 Background Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.7b

TABLE 4.13A: 2042 BACKGROUND OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					47			47		23		23	7	11		11	24
			V/C					0.79					0.25			0.03	0.49			
			Q					79					79			4	80			
			Stor.					60					-			20	-			
			Avail.					-19					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	C	C	D		A	B		A	A	A	A	A		A	B
			Delay	39	40	32	32	39		0	14		10	2	9	4	6		6	10
			V/C	0.06	0.08	0.76		0.06		0.06			0.40	0.09		0.19	0.37			
			Q	7	10	43		6		0			69	6		10	65			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	37		-		50			-	109		20	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	2	>	20	41	17	>	31	6	4	>	4	3	4	>	4	5
			V/C	0.37	0.27	>		0.19	0.12	>		0.28	0.34	>		0.03	0.42	>		
			Q	21	0	>		13	7	>		11	34	>		2	43	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		2	-	>		14	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	C
			Delay	24	13	>	17	24	26	5	18	23	31	>	29	25	25	5	19	20
			V/C	0.61	0.28	>		0.07	0.31	0.39		0.43	0.54	>		0.62	0.49	0.50		
			Q	48	30	>		8	37	16		24	59	>		23	59	8		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-8	-	>		47	-	39		36	-	>		87	-	82		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	11		>	11					9	0		1		0	0	0	
			V/C	0.10		>						0.06	0.00				0.00	0.00		
			Q	2		>						2	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	12		>	12						0		0		0	0	0	
			V/C	0.21		>							0.00				0.00	0.00		
			Q	6		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.13B: 2042 BACKGROUND OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					52			52		4		4	5	14		14	17
			V/C					0.77					0.36			0.08	0.80			
			Q					66					16			5	179			
			Stor.					60					-			20	-			
			Avail.					-6					-			15	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	C	D	D	D		B	C		B	A	B	A	A		A	B
			Delay	37	34	37	37	39		11	23		15	0	15	6	5		5	14
			V/C	0.12	0.00	0.80		0.19		0.19			0.41	0.00		0.05	0.35			
			Q	12	2	54		16		10			94	0		1	48			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	68	-	26		-		40			-	115		29	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	B	A	A	>	A	A	A	>	A	A
			Delay	50	3	>	16	47	0	>	20	2	2	>	2	2	2	>	2	3
			V/C	0.25	0.32	>		0.13	0.06	>		0.10	0.33	>		0.06	0.39	>		
			Q	16	0	>		9	0	>		3	22	>		2	27	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		6	-	>		22	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	B	B	>	B	B	B	A	B	C	C	>	C	F	C	A	D	C
			Delay	20	18	>	18	14	19	4	12	26	35	>	33	92	33	5	44	30
			V/C	0.44	0.34	>		0.08	0.16	0.32		0.40	0.55	>		1.04	0.62	0.30		
			Q	40	45	>		8	25	14		20	63	>		95	74	7		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	0	-	>		47	-	41		40	-	>		15	-	83		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	14		>	14					10	0		3		0	0	0	
			V/C	0.19		>						0.14	0.00				0.00	0.00		
			Q	5		>						4	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	11		>	11						0		0		0	0	0	
			V/C	0.17		>							0.00				0.00	0.00		
			Q	4		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.14A: 2042 BACKGROUND RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	235	89	270	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	245	90	276	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	113	42	127	2
	Storage (m)	80	115	80	115
	Available (m)	-33	73	-47	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.14B: 2042 BACKGROUND THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			353	235	487	15	968			265	176	762	33	1860
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			361	240	522	17	1065			271	180	793	33	1898
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			11.0	7.3	8.0	0.5	16.3			8.3	5.5	12.1	1.0	29.0
	Queue (vehicles)*			17	12	13	2	23			13	10	18	3	35
	Queue (m)			128	90	98	15	173			98	75	135	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-30	-	5	-			-	-15	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	11	19			836	82	890	28	1			958	16	816
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	13	19			887	85	926	32	1			987	16	841
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			13.6	2.6	14.1	1.0	0.0			15.1	0.5	12.8
	Queue (vehicles)*	1	2			20	5	21	3	1			22	2	19
	Queue (m)	8	15			150	38	158	23	8			165	15	143
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	57	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.8 2042 Total Traffic Horizon

4.8.1 2042 Total Traffic Volumes

Figure 4.8a and **Figure 4.8b** illustrate the forecast 2042 total (background + site traffic) traffic volumes.

4.8.2 2042 Total Traffic Operations

The study area intersection operations analysis for the 2042 total traffic scenario followed the same methodology used for the existing and 2042 background traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.15a** and **Table 4.15b** detail the level of service conditions for the weekday AM and PM peak hours.

Table 4.16a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.16b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;

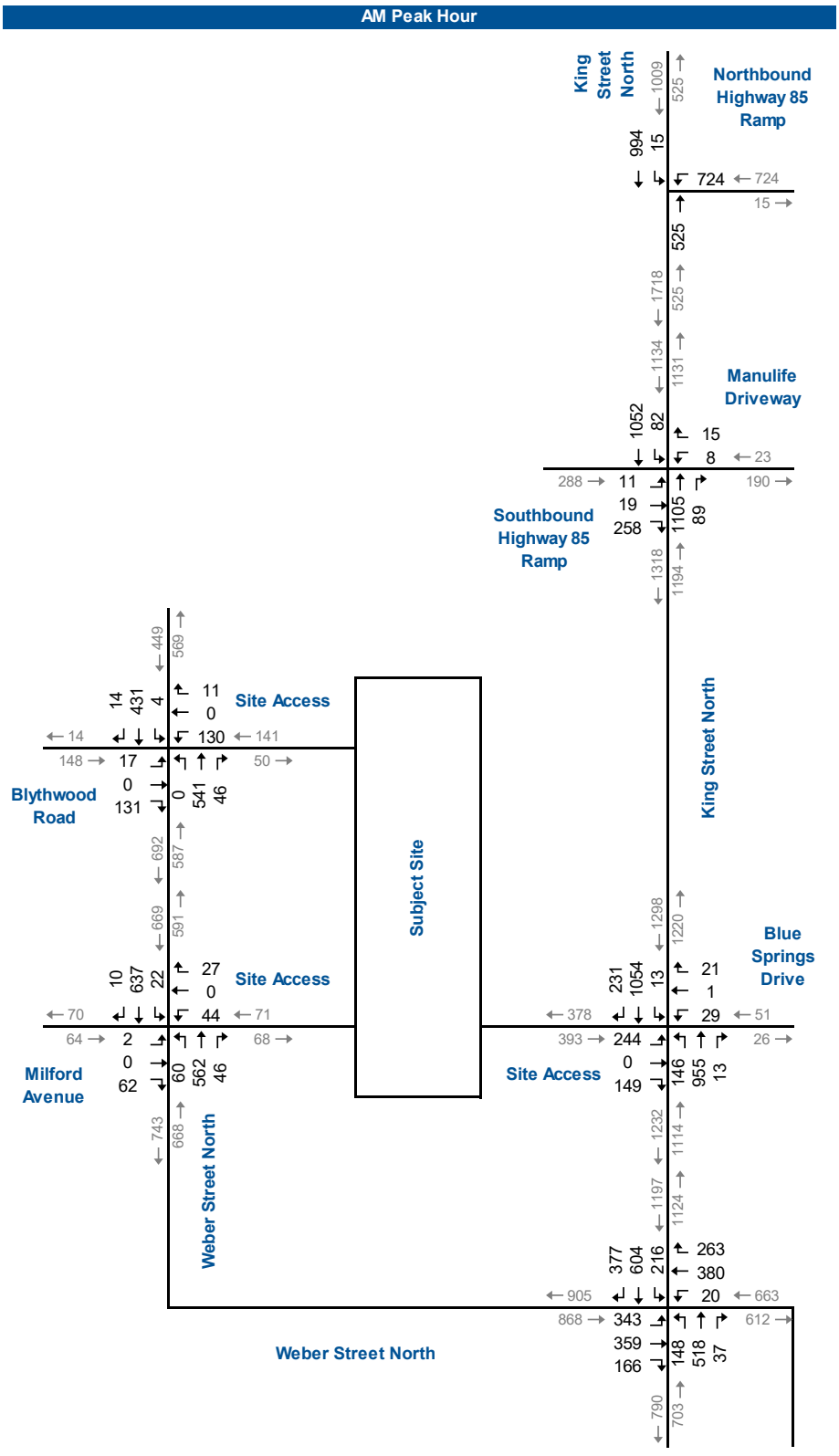
- The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a v/c ratio equal to or surpassing 0.85, a delay surpassing 55 seconds, and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the AM and PM peak hours;
  - The northbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

- King Street North and Milford Avenue:
  - The westbound through/left-turn/right-turn movement is forecast to have a delay surpassing 55 seconds during the PM peak hour.

With the addition of the site generated traffic volumes, the existing approach delays at the study area intersections increase by nine seconds or less during the AM and PM peak hours. Although, the eastbound approach delay at the intersection of King Street North and the Highway 85 Southbound Ramp increases by 12 seconds during the AM peak hour. The eastbound approach delay at the intersection of King Street North and Blue Springs Drive increases by 27 and 30 seconds during the AM and PM peak hours, respectively.

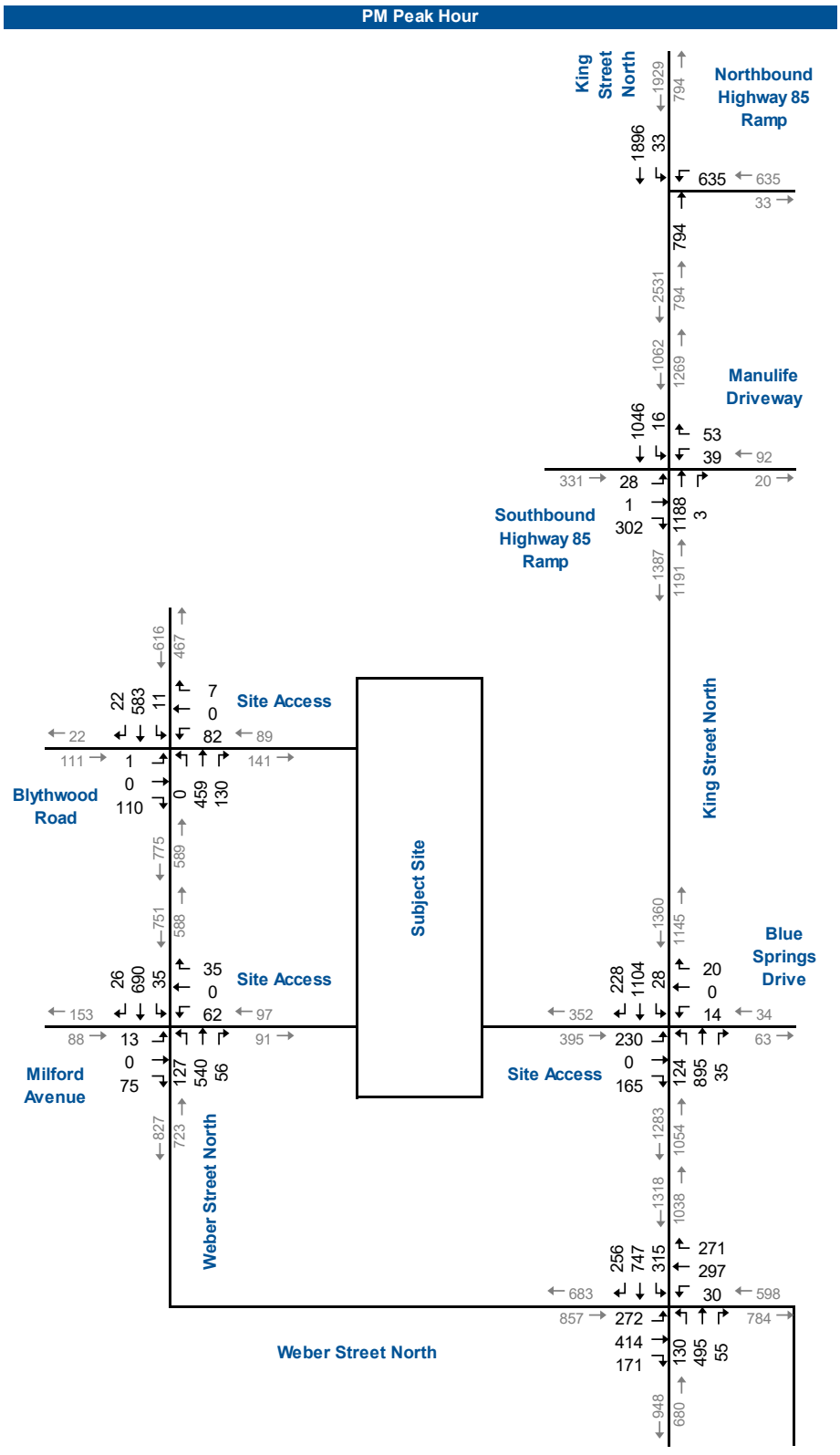
Appendix M contains the supporting detailed Synchro 11 reports.



2042 Total Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.8a



2042 Total Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.8b

TABLE 4.15A: 2042 TOTAL OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					44			44		28		28	9	14		14	27
			V/C					0.82					0.29			0.03	0.53			
			Q					94					86			4	94			
			Stor.					60					-			20	-			
			Avail.					-34					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	D	D	D	C		A	B		B	A	B	A	A		A	B
			Delay	34	35	46	44	34		0	12		14	3	13	7	9		9	15
			V/C	0.04	0.06	0.81		0.04		0.05			0.55	0.09		0.28	0.46			
			Q	7	10	61		5		0			110	7		11	96			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	19		-		50			-	108		19	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	A	>	D	C	B	>	C	C	A	>	A	A	A	>	A	B
			Delay	70	9	>	47	32	14	>	24	27	7	>	10	6	9	>	9	15
			V/C	0.88	0.36	>		0.13	0.07	>		0.70	0.44	>		0.05	0.59	>		
			Q	86	16	>		12	6	>		47	46	>		3	73	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-71	-	>		3	-	>		-22	-	>		22	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	C	C	C	A	B	C	C	>	C	D	C	A	B	C
			Delay	34	13	>	21	24	26	5	18	30	31	>	31	35	24	4	20	22
			V/C	0.80	0.34	>		0.08	0.34	0.42		0.59	0.57	>		0.77	0.56	0.54		
			Q	75	35	>		8	41	16		30	63	>		38	51	6		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-35	-	>		47	-	39		30	-	>		72	-	84		
	Weber Street North & Milford Avenue	TWSC	LOS	<	B	>	B	<	D	>	D	A	A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	31	>	31	9	0	0	1	9	0	0	0	
			V/C	<	0.11	>		<	0.34	>		0.07	0.00	0.00		0.02	0.00	0.00		
			Q	<	3	>		<	11	>		2	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	E	>	E		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	37	>	37		0	0	0	9	0	0	0	
			V/C	<	0.22	>		<	0.57	>			0.00	0.00		0.00	0.00	0.00		
			Q	<	7	>		<	24	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.15B: 2042 TOTAL OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	C		C	C
			Delay					54			54		5		5	6	20		20	23
			V/C					0.88					0.40			0.09	0.87			
			Q					95					22			6	214			
			Stor.					60					-			20	-			
			Avail.					-35					-			14	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	C	D	D	C		B	B		B	A	B	A	A		A	B
			Delay	31	28	48	46	32		11	20		17	0	17	9	9		9	18
			V/C	0.08	0.00	0.82		0.13		0.15			0.56	0.00		0.08	0.49			
			Q	11	1	76		14		10			118	0		2	76			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	69	-	4		-		40			-	115		28	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	B	>	D	D	A	>	B	B	A	>	A	A	A	>	A	B
			Delay	70	13	>	46	36	0	>	15	19	5	>	7	4	6	>	6	12
			V/C	0.85	0.42	>		0.07	0.04	>		0.60	0.41	>		0.08	0.58	>		
			Q	86	22	>		8	0	>		18	37	>		2	45	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-71	-	>		7	-	>		7	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	B	B	A	B	D	D	>	D	F	C	A	D	C
			Delay	24	18	>	20	14	20	4	12	42	36	>	37	132	33	5	51	34
			V/C	0.57	0.39	>		0.08	0.19	0.35		0.69	0.59	>		1.17	0.69	0.42		
			Q	50	52	>		8	29	14		34	69	>		106	88	15		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-10	-	>		47	-	41		26	-	>		4	-	75		
	Weber Street North & Milford Avenue	TWSC	LOS	<	C	>	C	<	F	>	F	A	A	A	A	A	A	A	A	
			Delay	<	19	>	19	<	78	>	78	10	1	0	2	9	0	0	0	
			V/C	<	0.26	>		<	0.71	>		0.14	0.00	0.00		0.04	0.00	0.00		
			Q	<	8	>		<	30	>		4	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	D	>	D		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	31	>	31		0	0	0	9	0	0	0	
			V/C	<	0.17	>		<	0.39	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	4	>		<	14	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.16A: 2042 TOTAL RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	258	89	302	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	269	90	309	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	124	42	142	2
	Storage (m)	80	115	80	115
	Available (m)	-44	73	-62	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.16B: 2042 TOTAL THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			434	290	525	15	994			381	254	794	33	1896
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			443	296	562	17	1094			389	260	826	33	1934
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			13.5	9.0	8.6	0.5	16.7			11.9	7.9	12.6	1.0	29.5
	Queue (vehicles)*			20	14	14	2	24			18	13	19	3	35
	Queue (m)			150	105	105	15	180			135	98	143	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-45	-	5	-			-	-38	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	11	19			1105	82	1052	28	1			1188	16	1046
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	13	19			1172	85	1095	32	1			1224	16	1078
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			17.9	2.6	16.7	1.0	0.0			18.7	0.5	16.5
	Queue (vehicles)*	1	2			25	5	24	3	1			26	2	23
	Queue (m)	8	15			188	38	180	23	8			195	15	173
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	72	-			-	-8	-	57	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.9 2047 Background Horizon

4.9.1 2047 Background Traffic Growth

Figure 4.9a and **Figure 4.9b** illustrate the 2047 forecast background traffic volumes for the weekday AM and PM peak hours.

4.9.2 2047 Background Traffic Operations

The study area intersection operations analysis for the 2047 background traffic scenario followed the same methodology used for the existing traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.17a** and **Table 4.17b** detail the level of service conditions.

Table 4.18a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.18b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

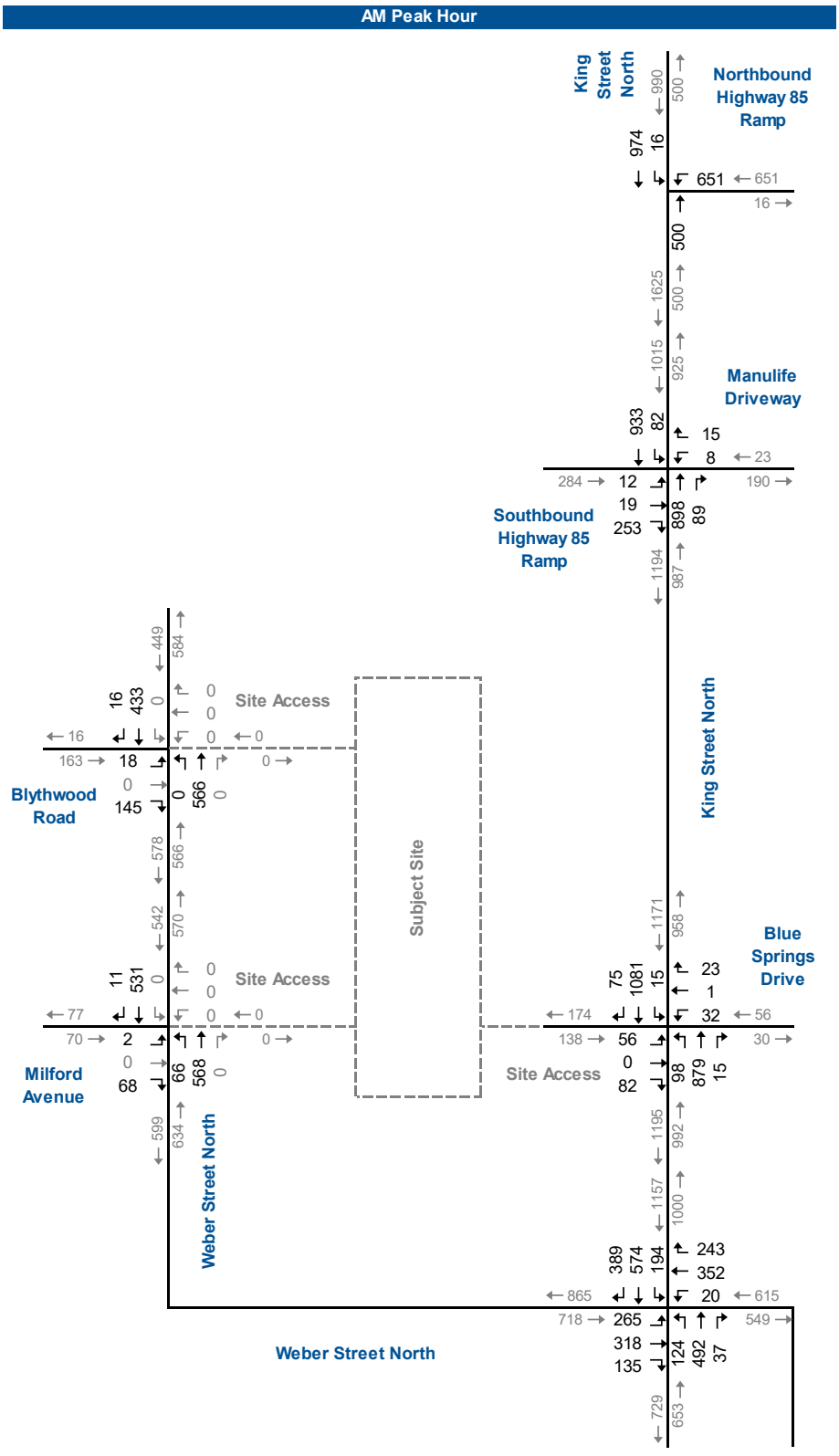
All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;

- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM peak hour; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM peak hour.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hour;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the PM peak hour; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

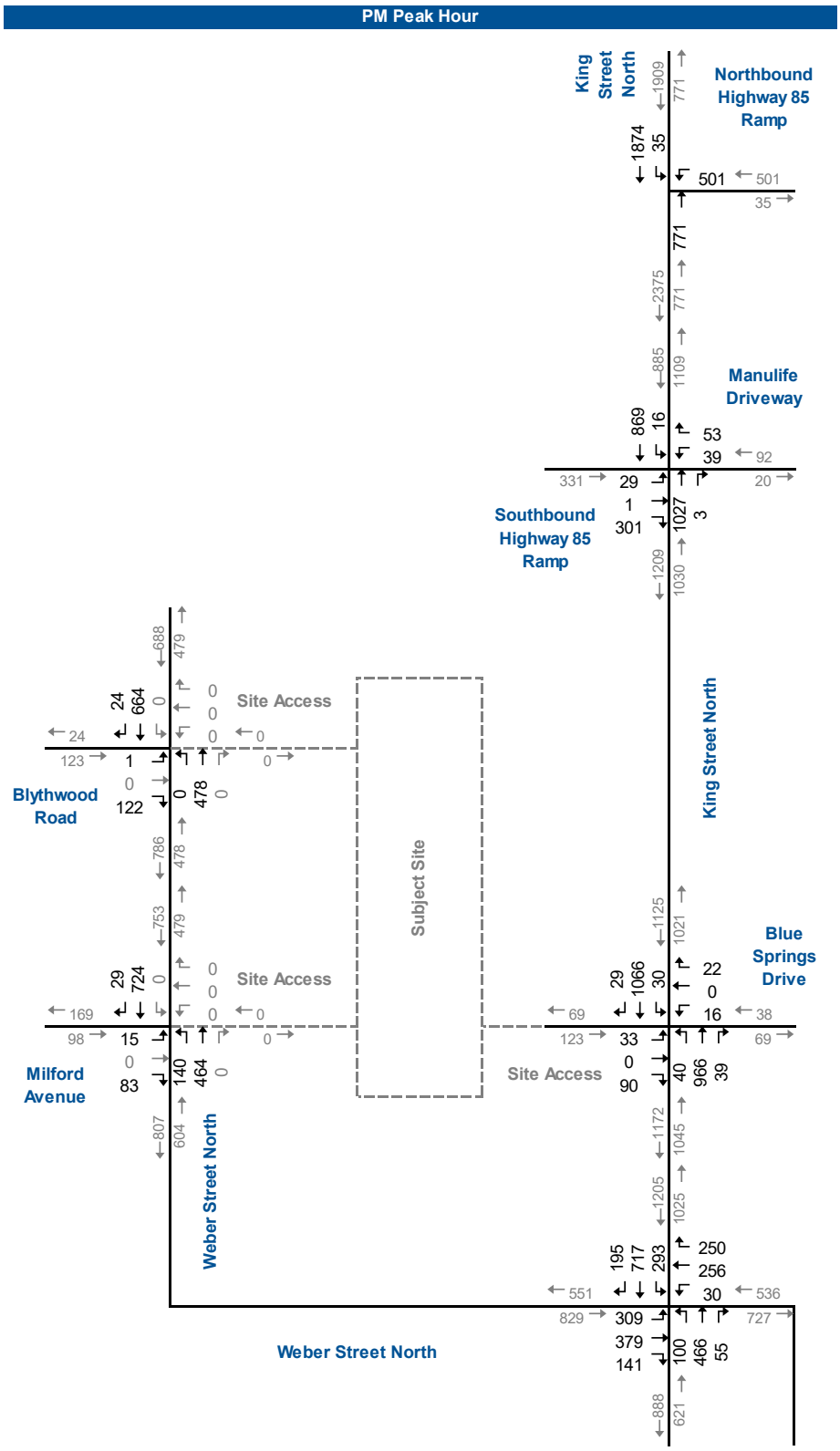
Appendix N contains the supporting detailed Synchro 11 reports.



2047 Background Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.9a



2047 Background Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.9b

TABLE 4.17A: 2047 BACKGROUND OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					46			46		25		25	8	12		12	26
			V/C					0.81					0.27			0.03	0.50			
			Q					86					81			4	86			
			Stor.					60					-			20	-			
			Avail.					-26					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	D	D	D	D	D		A	B		B	A	B	A	A		A	B
			Delay	36	37	37	37	36		0	13		11	2	10	5	7		7	12
			V/C	0.05	0.07	0.79		0.05		0.06			0.44	0.09		0.22	0.40			
			Q	7	10	52		6		0			77	7		10	78			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	28		-		50			-	108		20	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	C	D	B	>	C	A	A	>	A	A	A	>	A	A
			Delay	46	4	>	21	42	17	>	31	6	4	>	4	3	4	>	4	5
			V/C	0.37	0.28	>		0.21	0.13	>		0.30	0.34	>		0.04	0.44	>		
			Q	21	3	>		14	7	>		11	34	>		2	47	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-6	-	>		1	-	>		14	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	C	C	A	B	C
			Delay	24	13	>	17	24	26	5	18	24	31	>	29	25	26	5	19	20
			V/C	0.62	0.30	>		0.08	0.32	0.39		0.46	0.54	>		0.64	0.51	0.55		
			Q	49	31	>		8	38	16		26	59	>		24	62	8		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-9	-	>		47	-	39		34	-	>		86	-	82		
	Weber Street North & Milford Avenue	TWSC	LOS	B		>	B					A	A		A		A	A	A	
			Delay	11		>	11					9	0		1		0	0	0	
			V/C	0.11		>						0.07	0.00				0.00	0.00		
			Q	3		>						2	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	12		>	12						0		0		0	0	0	
			V/C	0.24		>							0.00				0.00	0.00		
			Q	7		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.17B: 2047 BACKGROUND OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	B		B	B
			Delay					53			53		3		3	5	16		16	18
			V/C					0.81					0.37			0.08	0.82			
			Q					74					12			5	189			
			Stor.					60					-			20	-			
			Avail.					-14					-			15	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	C	D	D	C		A	B		B	A	B	A	A		A	B
			Delay	33	30	43	42	34		9	20		17	0	17	8	7		7	17
			V/C	0.10	0.00	0.83		0.15		0.16			0.46	0.00		0.06	0.39			
			Q	12	1	68		15		9			101	0		2	62			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	68	-	12		-		41			-	115		28	-			
	King Street North & Blue Springs Drive	TCS	LOS	D	A	>	B	D	A	>	C	A	A	>	A	A	A	>	A	A
			Delay	50	4	>	16	48	0	>	20	3	2	>	2	2	2	>	2	3
			V/C	0.25	0.33	>		0.15	0.07	>		0.11	0.37	>		0.07	0.40	>		
			Q	16	2	>		10	0	>		3	30	>		2	24	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-1	-	>		5	-	>		22	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	C	B	B	A	B	C	C	>	C	F	C	A	D	C
			Delay	25	18	>	20	14	19	4	12	32	35	>	34	94	33	5	43	30
			V/C	0.61	0.35	>		0.08	0.17	0.33		0.52	0.56	>		1.05	0.65	0.34		
			Q	57	46	>		8	25	14		24	65	>		97	76	9		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-17	-	>		47	-	41		36	-	>		13	-	81		
	Weber Street North & Milford Avenue	TWSC	LOS	C		>	C					B	A		A		A	A	A	
			Delay	17		>	17					10	1		3		0	0	0	
			V/C	0.25		>						0.17	0.00				0.00	0.00		
			Q	8		>						4	0				0	0		
	Weber Street North & Blythwood Road	TWSC	LOS	B		>	B						A		A		A	A	A	
			Delay	12		>	12						0		0		0	0	0	
			V/C	0.20		>							0.00				0.00	0.00		
			Q	5		>							0				0	0		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.18A: 2047 BACKGROUND RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	253	89	301	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	264	90	308	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	121	42	142	2
	Storage (m)	80	115	80	115
	Available (m)	-41	73	-62	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.18B: 2047 BACKGROUND THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			391	260	500	16	974			301	200	771	35	1874
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			399	266	535	19	1072			308	204	802	35	1912
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			12.2	8.1	8.2	0.6	16.4			9.4	6.2	12.3	1.1	29.2
	Queue (vehicles)*			18	13	13	2	23			15	11	18	3	35
	Queue (m)			135	98	98	15	173			113	83	135	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-38	-	5	-			-	-23	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	12	19			898	82	933	29	1			1027	16	869
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	14	19			952	85	971	33	1			1058	16	896
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			14.5	2.6	14.8	1.0	0.0			16.2	0.5	13.7
	Queue (vehicles)*	2	2			21	5	21	3	1			23	2	20
	Queue (m)	15	15			158	38	158	23	8			173	15	150
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	65	-			-	-8	-	57	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

4.10 2047 Total Traffic Horizon

4.10.1 2047 Total Traffic Volumes

Figure 4.10a and **Figure 4.10b** illustrate the forecast 2047 total (background + site traffic) traffic volumes.

4.10.2 2047 Total Traffic Operations

The study area intersection operations analysis for the 2047 total traffic scenario followed the same methodology used for the existing and 2047 background traffic conditions. Although, the timing splits were optimized at all signalized intersections. **Table 4.19a** and **Table 4.19b** detail the level of service conditions for the weekday AM and PM peak hours.

Table 4.20a summarizes the right-turn storage lengths at the intersections with Highway 85 using the Geometric Design Guide for Canadian Roads.

Table 4.20b summarizes the through and left-turn queue lengths at the intersections with Highway 85 using MTO's Traffic Signal Operating & Timing Policy.

All study area intersections are forecast to operate at acceptable levels of service during the AM and PM peak hour with the following critical movements noted:

- King Street North and the Highway 85 Northbound Ramp:
  - The westbound left-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the PM peak hour; and
  - The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and the Highway 85 Southbound Ramp:
  - The eastbound right-turn movement is forecast to have a v/c ratio surpassing 0.75 and a queue length that surpasses its storage length during the AM and PM peak hours;

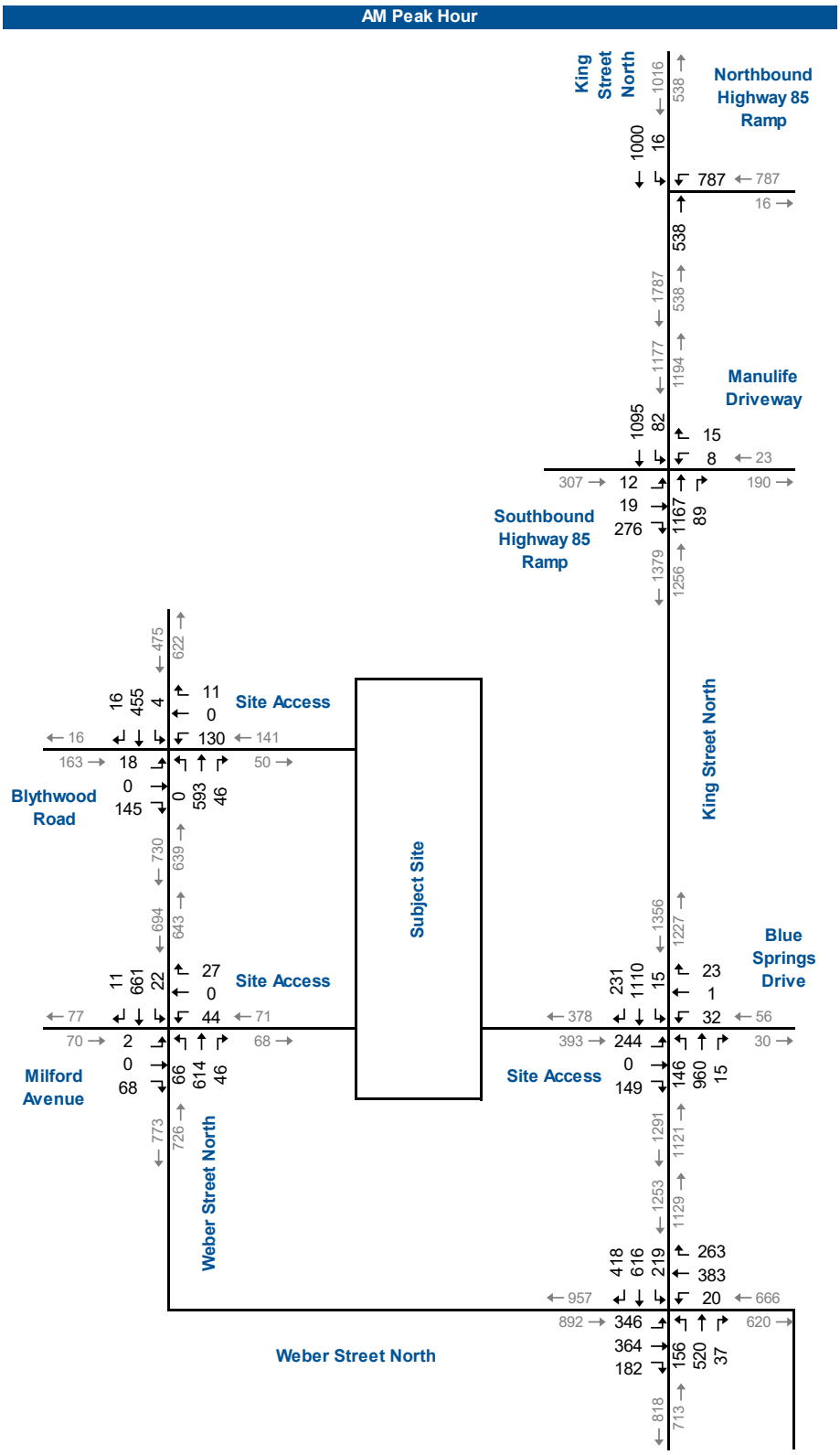
- The northbound through movement is forecast to have a queue length that blocks the northbound-right turn lane during the AM and PM peak hours;
- The southbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM peak hour; and
- The southbound through movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.

- King Street North and Blue Springs Drive:
  - The eastbound left-turn movement is forecast to have a delay surpassing 55 seconds, a v/c ratio equal to or surpassing 0.85, and a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the AM and PM peak hours;
  - The northbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound through/right-turn movement is forecast to have a queue length that blocks the southbound-left turn lane during the AM and PM peak hours.
- King Street North and Weber Street North:
  - The eastbound left-turn movement is forecast to have a queue length that surpasses its storage length during the AM and PM peak hours;
  - The eastbound through/right-turn movement is forecast to have a queue length that blocks the eastbound-left turn lane during the PM peak hours;
  - The northbound through/right-turn movement is forecast to have a queue length that blocks the northbound-left turn lane during the AM and PM peak hours; and
  - The southbound left-turn movement is forecast to have a v/c ratio surpassing 1.00 and a delay surpassing 55 seconds during the PM peak hour.

- King Street North and Milford Avenue:
  - The westbound through/left-turn/right-turn movement is forecast to have a v/c ratio surpassing 0.85 a delay surpassing 55 seconds during the PM peak hour.

With the addition of the site generated traffic volumes, the existing approach delays at the study area intersections increase by eleven seconds or less during the AM and PM peak hours. Although, the eastbound approach delay at the intersection of King Street North and Blue Springs Drive increases by 27 and 30 seconds during the AM and PM peak hours, respectively.

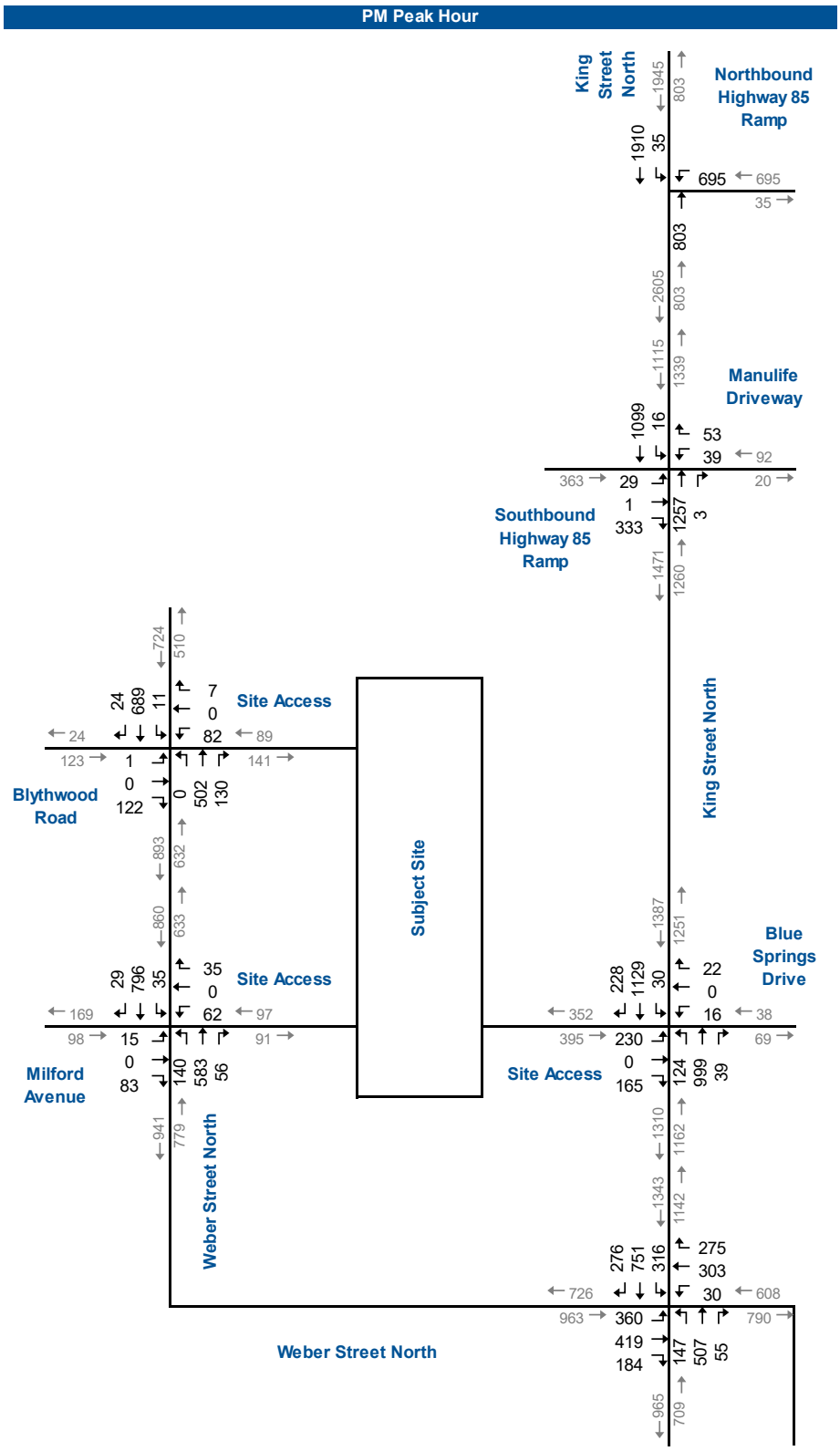
Appendix O contains the supporting detailed Synchro 11 reports.



2047 Total Traffic Volumes (AM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.10a



2047 Total Traffic Volumes (PM Peak Hour)

435 King Street North, Waterloo TIS
220805

Figure 4.10b

TABLE 4.19A: 2047 TOTAL OPERATIONS (AM PEAK HOUR)

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	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		C		C	A	B		B	C
			Delay					44			44		28		28	10	15		15	28
			V/C					0.83					0.31			0.04	0.55			
			Q					101					88			4	98			
			Stor.					60					-			20	-			
			Avail.					-41					-			16	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	C	D	D	C		A	B		B	A	B	A	B		B	B
			Delay	33	33	49	48	33		0	12		16	3	15	8	10		10	17
			V/C	0.04	0.06	0.83		0.04		0.05			0.60	0.10		0.32	0.49			
			Q	7	9	70		5		0			121	7		11	103			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	73	-	10		-		50			-	108		19	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	B	>	D	C	B	>	C	C	A	>	B	A	A	>	A	B
			Delay	70	11	>	48	33	13	>	24	34	7	>	10	6	9	>	9	15
			V/C	0.88	0.37	>		0.14	0.07	>		0.76	0.45	>		0.05	0.61	>		
			Q	86	19	>		13	6	>		51	45	>		3	79	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-71	-	>		2	-	>		-26	-	>		22	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	B	C	C	A	B	C	C	>	C	D	C	A	C	C
			Delay	31	12	>	19	24	26	5	18	33	32	>	33	40	26	4	21	22
			V/C	0.78	0.34	>		0.08	0.34	0.42		0.64	0.59	>		0.81	0.60	0.59		
			Q	72	35	>		8	41	16		34	64	>		42	55	6		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-32	-	>		47	-	39		26	-	>		68	-	84		
	Weber Street North & Milford Avenue	TWSC	LOS	<	B	>	B	<	E	>	E	A	A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	38	>	38	9	0	0	1	9	0	0	0	
			V/C	<	0.13	>		<	0.40	>		0.07	0.00	0.00		0.02	0.00	0.00		
			Q	<	3	>		<	14	>		2	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	E	>	E		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	48	>	48		0	0	0	9	0	0	0	
			V/C	<	0.25	>		<	0.65	>			0.00	0.00		0.00	0.00	0.00		
			Q	<	8	>		<	30	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.19B: 2047 TOTAL OPERATIONS (PM PEAK HOUR)

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	
PM Peak Hour	King Street North & Highway 85 Northbound Ramp	TCS	LOS					D			D		A		A	A	C		C	C
			Delay					54			54		8		8	7	24		23	26
			V/C					0.89					0.42			0.10	0.90			
			Q					108					30			6	229			
			Stor.					60					-			20	-			
			Avail.					-48					-			14	-			
	King Street North & Highway 85 Southbound Ramp/Manulife Driveway	TCS	LOS	C	C	D	D	C		B	C		B	A	B	B	B		B	B
			Delay	28	25	49	47	29		14	20		18	0	18	12	12		12	19
			V/C	0.08	0.00	0.84		0.12		0.13			0.62	0.00		0.10	0.54			
			Q	11	1	86		14		12			122	0		2	91			
			Stor.	80	-	80		-		50			-	115		30	-			
			Avail.	69	-	-6		-		38			-	115		28	-			
	King Street North & Blue Springs Drive	TCS	LOS	E	B	>	D	D	A	>	B	C	A	>	A	A	A	>	A	B
			Delay	70	14	>	46	36	0	>	15	21	6	>	8	4	6	>	6	12
			V/C	0.85	0.43	>		0.09	0.05	>		0.62	0.45	>		0.10	0.59	>		
			Q	86	24	>		9	0	>		38	48	>		2	42	>		
			Stor.	15	-	>		15	-	>		25	-	>		25	-	>		
			Avail.	-71	-	>		6	-	>		-13	-	>		23	-	>		
	King Street North & Weber Street North	TCS	LOS	C	B	>	C	B	B	A	B	D	D	>	D	F	C	A	D	D
			Delay	33	18	>	24	14	20	4	12	48	36	>	39	141	35	6	54	36
			V/C	0.76	0.40	>		0.09	0.20	0.35		0.76	0.60	>		1.19	0.72	0.45		
			Q	75	54	>		8	29	14		44	70	>		108	91	19		
			Stor.	40	-	>		55	-	55		60	-	>		110	-	90		
			Avail.	-35	-	>		47	-	41		16	-	>		2	-	71		
	Weber Street North & Milford Avenue	TWSC	LOS	<	D	>	D	<	F	>	F	B	A	A	A	A	A	A	A	
			Delay	<	26	>	26	<	149	>	149	10	1	0	3	9	0	0	0	
			V/C	<	0.37	>		<	0.94	>		0.17	0.00	0.00		0.04	0.00	0.00		
			Q	<	12	>		<	43	>		4	0	0		1	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		24	-	-		
	Weber Street North & Blythwood Road	TWSC	LOS	<	B	>	B	<	E	>	E		A	A	A	A	A	A	A	
			Delay	<	12	>	12	<	41	>	41		0	0	0	9	0	0	0	
			V/C	<	0.20	>		<	0.48	>			0.00	0.00		0.01	0.00	0.00		
			Q	<	6	>		<	17	>			0	0		0	0	0		
			Stor.	<	-	>		<	-	>		-	-	-		25	-	-		
			Avail.	<	-	>		<	-	>		-	-	-		25	-	-		

MOE - Measure of Effectiveness
LOS - Level of Service
Delay - Average Delay per Vehicle in Seconds
V/C - Volume to Capacity Ratio
Q - 95th Percentile Queue Length (m)
Stor. - Existing Storage (m)
Avail. - Available Storage (m)
TCS - Traffic Control Signal
TWSC - Two-Way Stop Control
< / > - Shared with through movement

TABLE 4.20A: 2047 TOTAL RIGHT-TURN STORAGE LENGTHS

Intersection	Parameter	Direction/Movement			
		AM Peak Hour		PM Peak Hour	
		EBR	NBR	EBR	NBR
King Street North and Highway 85 Southbound Ramp	Volume (vph)	276	89	333	3
	Heavy Vehicle %	4%	1%	2%	0%
	Cycle Length (s)	110	110	110	110
	Passenger Cars Per Hour	288	90	340	3
	Design Speed (km/h)	80	80	80	80
	Queue (m)	132	42	156	2
	Storage (m)	80	115	80	115
	Available (m)	-52	73	-76	113

Transportation Association of Canada, *Geometric Design Guide for Canadian Roads: Section 9.14.4,* (Ottawa: TAC, 2017).

TABLE 4.20B: 2047 TOTAL THROUGH AND LEFT-TURN QUEUE LENGTHS

Intersection	Parameter	Direction/Movement													
		AM Peak Hour							PM Peak Hour						
		EBL	EBT	WBL1	WBL2	NBT	SBL	SBT	EBL	EBT	WBL1	WBL2	NBT	SBL	SBT
King Street North and Highway 85 Northbound Ramp	Volume (vph)			472	315	538	16	1000			417	278	803	35	1910
	Heavy Vehicle %			2%	2%	7%	13%	10%			2%	2%	4%	0%	2%
	Cycle Length (s)			110	110	110	110	110			110	110	110	110	110
	Passenger Cars Per Hour			482	322	576	19	1100			426	284	836	35	1949
	Number of Lanes			1	1	2	1	2			1	1	2	1	2
	Arrival Rate (veh/s/lane)			14.7	9.8	8.8	0.6	16.8			13.0	8.7	12.8	1.1	29.8
	Queue (vehicles)*			21	15	14	2	24			19	14	19	3	35
	Queue (m)			158	113	105	15	180			143	105	143	23	263
	Storage (m)			-	60	-	20	-			-	60	-	20	-
	Available (m)			-	-53	-	5	-			-	-45	-	-3	-
King Street North and Highway 85 Southbound Ramp	Volume (vph)	12	19			1167	82	1095	29	1			1257	16	1099
	Heavy Vehicle %	13%	0%			6%	3%	4%	11%	0%			3%	0%	3%
	Cycle Length (s)	110	110			110	110	110	110	110			110	110	110
	Passenger Cars Per Hour	14	19			1238	85	1139	33	1			1295	16	1132
	Number of Lanes	1	1			2	1	2	1	1			2	1	2
	Arrival Rate (veh/s/lane)	0.4	0.6			18.9	2.6	17.4	1.0	0.0			19.8	0.5	17.3
	Queue (vehicles)*	2	2			26	5	24	3	1			27	2	24
	Queue (m)	15	15			195	38	180	23	8			203	15	180
	Storage (m)	80	-			-	30	-	80	-			-	30	-
	Available (m)	65	-			-	-8	-	57	-			-	15	-

*Traffic Signal Timing Policy, Ministry of Transportation Ontatrio, June 1 2016 - Table 1 or 2

5 Remedial Measures

5.1 Critical Movements

King Street North & Highway 85 Northbound Ramp

Under base year conditions, the westbound left-turn movement at King Street North and the Highway 85 Northbound Ramp is forecast to have a queue length that surpasses its storage length. Under 2027 background conditions, this movement is forecast to have a v/c ratio surpassing 0.75 during the AM peak hour. To avoid blockage from the dual westbound left-turn queue length under 2047 total traffic conditions the southernmost westbound left-turn storage lane should be extended to 220 m. The extension provides an opportunity for traffic using the channelized westbound right-turn lane to bypass the queued up left-turning traffic.

King Street North & Highway 85 Southbound Ramp/Manulife Driveway

Under base year conditions, the eastbound right-turn movement at this intersection is forecast to have a queue length that surpasses its storage length. Under 2027 total traffic conditions and 2032 background traffic conditions, this movement is also forecast to have a v/c ratio surpassing 0.75 during the PM peak hour. To avoid blockage from the maximum eastbound right-turn queue length of 156 m under 2047 total traffic conditions the eastbound left-turn storage length should be extended to 165 m. The extension provides an opportunity for traffic using the eastbound through and left-turn lanes to bypass the eastbound right turning traffic. Currently, an 80 m eastbound left-turn lane exists at this intersection.

King Street North & Blue Springs Drive

Under base year conditions, the eastbound left-turn movement at this intersection is forecast to have a queue length that surpasses its storage length. This represents the internal queue turning left out of the site onto King Street to head north towards Highway 85. Under 2037 total traffic conditions, this movement is also forecast to have a v/c ratio equal to 0.85 during the AM and PM peak hours. The queue formed on site will be distributed through the internal drive aisles, particularly the aisle between Tower C1 and Tower B/D1, based on the layout of the parking garage entrances. These entrances are distributed through the site and will feed this intersection from several directions, allowing ample stacking for this queue within the site.

To help prevent the eastbound left-turn queue from blocking the eastbound through and right-turn movements, the storage length should be extended to the maximum length available internal to the site.

Weber Street North & Milford Avenue

Under 2032 total traffic conditions, the westbound shared through/left-turn/right-turn movement at Weber Street North and Milford Avenue (movements exiting the site driveway) is forecast to have a delay surpassing 55 seconds during the PM peak hour. To accommodate the queue length on site under 2047 total traffic conditions, a separated left-turn lane with space for 35 metres of storage be considered in the detailed design. This will allow the through and right-turn movements to happen independent of the left-turn movement. The ultimate lane configuration at this driveway is recommended to be two exit lanes (shared right/through and left-turn lane) and one entry lane.

5.2 Traffic Signal Control

The intersections of Weber Street North at Milford Avenue and Weber Street North at Blythwood Road were assessed using the Ontario Traffic Manual (OTM Book 12 – Justification 7) signal warrant[12] procedures. **Appendix P** contains the warrant analysis required under Justification 7. It indicates that traffic control signals are not justified at the intersections of Weber Street North at Milford Avenue and Weber Street North at Blythwood Road under 2047, 2042, and 2037 total traffic conditions.

5.3 Left-Turn Lanes

The intersections of Weber Street North at Milford Avenue and Weber Street North at Blythwood Road were assessed to determine whether the newly constructed 25 meter left-turn lanes on Weber Street will support the forecast site generated traffic volumes. The warrants for left-turn lanes follow the requirements in the Ministry of Transportation's (MTO) Geometric Design Standards[13].

Table 5.1 and **Table 5.2** summarize the left-turn lane warrant for the intersections of Weber Street North at Milford Avenue and Weber Street North at Blythwood Road. The warrant analysis suggests that a southbound left-turn lane is not warranted at the intersection of Weber Street North and Blythwood Road under 2047, 2042, and 2037 total

[12] Ontario Ministry of Transportation, *Ontario Traffic Manual Book 12: Traffic Signals,* (Toronto: Queen's Printer for Ontario, 2012).

[13] Ontario Ministry of Transportation, *MTO Design Supplement for TAC Geometric Design Guide for Canadian Roads,* (Toronto: Queen's Printer for Ontario, 2020).

traffic conditions. A 15 m southbound left-turn lane is warranted at the intersection of Weber Street North and Milford Avenue under 2032, 2037, 2042 and 2047 total traffic conditions.

Appendix Q contains the left-turn lane warrant nomographs.

The southbound left-turn movements at the intersections of Weber Street North at Milford Avenue and Weber Street North at Blythwood Road are expected to operate at LOS A with delays not surpassing ten seconds under 2037, 2042, and 2047 total traffic conditions. Therefore, the 25 m southbound left turn lanes at both intersections are suitable for the forecast traffic conditions.

TABLE 5.1: LEFT-TURN LANE WARRANT SUMMARY – MILFORD AVENUE

Roadway	Weber Street North							
Approach Direction	Southbound							
Intersection	Milford Avenue							
Horizon	Total 2047		Total 2042		Total 2037		Total 2032	
Peak Hour	AM	PM	AM	PM	AM	PM	AM	PM
Opposing Volume	726	779	668	723	675	730	661	710
Left Turning Traffic	22	35	22	35	26	37	14	18
Figure Used*	9A-31	9A-31	9A-31	9A-31	9A-31	9A-31	9A-31	9A-31
Warranted	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Storage Length Required	15 m	15 m	15 m	15 m	15 m	15 m	-	15 m

*Ontario Ministry of Transportation, *MTO Design Supplement for TAC Geometric Design Guide for Canadian Roads,* (Toronto: Queens Printer for Ontario, 2020).

TABLE 5.2: LEFT-TURN LANE WARRANT SUMMARY – BLYTHWOOD ROAD

Roadway	Weber Street North					
Approach Direction	Southbound					
Intersection	Blythwood Road					
Horizon	Total 2047		Total 2042		Total 2037	
Peak Hour	AM	PM	AM	PM	AM	PM
Opposing Volume	639	632	587	589	594	605
Left Turning Traffic	4	11	4	11	5	13
Figure Used*	9A-31	9A-31	9A-31	9A-31	9A-31	9A-31
Warranted	No	No	No	No	No	No
Storage Length Required	-	-	-	-	-	-

*Ontario Ministry of Transportation, *MTO Design Supplement for TAC Geometric Design Guide for Canadian Roads,* (Toronto: Queens Printer for Ontario, 2020).

6 Conclusions and Recommendations

6.1 Conclusions

Based on the investigations carried out, it is concluded that:

- **Existing Traffic Conditions:** The study area intersections are operating at acceptable levels of service during the AM and PM peak hours with critical movements noted at the King Street North intersection with Blue Springs Drive, and the Northbound and Southbound Ramps for Highway 85 at King Street North.
- **Development Trip Generation:** Phase 1 is forecast to generate approximately 209 and 251 trips during the AM and PM peak hours respectively. Phase 2 is forecast to generate approximately 539 and 603 net external trips during the AM and PM peak hours respectively. The full build-out is forecast to generate approximately 861 and 938 net external trips during the AM and PM peak hours respectively for 2037 and 789 and 859 net external trips during the AM and PM peak hours respectively for 2042 and 2047.
- **2027 Background Traffic Conditions:** The study area intersections are operating at acceptable levels of service during the AM and PM peak hours with critical movements noted at all signalized intersections.
- **2027 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2027 background traffic conditions.
- **2032 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2027 background traffic conditions.
- **2032 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2032 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.
- **2037 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2032 background traffic conditions.
- **2037 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2037 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.

- **2042 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2037 background traffic conditions.
- **2042 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2042 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.
- **2047 Background Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2042 background traffic conditions.
- **2047 Total Traffic Conditions:** The study area intersections are forecast to operate at level of service conditions similar to 2047 background traffic conditions with an additional critical movement noted at the intersection of Weber Street North and Milford Avenue.
- **Remedial Measures:** Traffic control signals are not justified at the intersections of Weber Street North at Milford Avenue and Weber Street North and Blythwood Road.

6.2 Recommendations

Based on existing and background traffic conditions, it is recommended to extend:

- The southernmost westbound left-turn storage length from 60 m to 220 m at the intersection of King Street North and the Highway 85 Northbound Ramp;
- The eastbound left-turn storage length from 80 to 165 m at the intersection of King Street North and the Highway 85 Southbound Ramp.

Based on total traffic conditions, it is recommended that

- The internal design of the driveway connection to Weber Street, opposite Milford Road include a separated left-turn lane and shared through-right lane. The design of the site should include space for a minimum queue of 35 metres for left-turning traffic;
- To help prevent the eastbound left-turn queue at the intersection of King Street North and Blue Springs Drive from blocking the eastbound through and right-turn movements, the storage length should be extended to the maximum length available internal to the site; and

- A pedestrian refuge island, similar to that on Weber Street and Blythwood Road, be constructed at the intersection of Weber Street North and Milford Avenue on the south leg, opposite the left-turn lane, to provide the most direct access to nearby schools and commercial attractions.

Appendix A

Pre-Consultation Material

Appendix B

Traffic Data

Appendix C

Base Year Operations

Appendix D

Internal Capture Calculations

Appendix E

Background Development Material

Appendix F

2027 Background Operations

Appendix G

2027 Total Operations

Appendix H

2032 Background Operations

Appendix I

2032 Total Operations

Appendix J

2037 Background Operations

Appendix K

2037 Total Operations

Appendix L

2042 Background Operations

Appendix M

2042 Total Operations

Appendix N

2047 Background Operations

Appendix O

2047 Total Operations

Appendix P

Traffic Control Warrant

Appendix Q

Left-Turn Lane Warrant