

**APPENDIX J -
TRAFFIC MODELING AND TRAFFIC SIGNAL GUIDELINES
Packages A - F**

Package A - Guidelines for Synchro/SimTraffic and Sidra – Service Interchange Modeling

Detailed configurations of service interchanges and at signalized intersections were determined and confirmed by traffic simulation using the **Synchro/SimTraffic Studio 9** and **Sidra Intersection 6.0** suite of programs. **Synchro** was used to establish the basic model programming of the Synchro model, as well as provide preliminary assessment of signal timing and the effectiveness of the lane configuration in accommodating traffic demands. **Sidra Intersection** was used to establish the basic model programming of the roundabout model and provide preliminary assessment of the lane configuration in accommodating traffic demand. **SimTraffic** was used to provide simulation statistics in the assessment of interchange performance. The measures of effectiveness used in interchange operation analysis are output parameters.

Synchro/SimTraffic and/or Sidra Intersection files for the service interchanges below are identified in **Package B**. The Contractor acknowledges receipt of said files as follows:

- 6 Street SW/Sheriff King Street SW
- James McKeivitt Road/Spruce Meadows Way
- 162 Avenue SW
- 146 Avenue SW/Fish Creek Blvd
- 130 Avenue SW
- 90 Avenue SW
- Strathcona Street SW
- Westhills Way SW/Strathcona Street SW
- Glenmore Tr/37 Street SW
- 69 Street SW/Discovery Ridge Blvd SW

A.1 Synchro/SimTraffic Service Interchange Modeling

A.1.1 Synchro/SimTraffic Criteria for Failed Interchange Operations

Criteria for failed interchange operations are:

- 1) Excessive queue in turn bay spilling out of bay and blocking adjacent through lane
- 2) Excessive queue in through lane blocking turn bay
- 3) Successive cycle failure (vehicles need to wait for multiple signal cycles to clear an intersection)
- 4) Substantial consecutive stops (undesirable traffic progression performance)

A.1.2 Synchro/SimTraffic Models

Synchro/SimTraffic models were created to demonstrate that the recommended interchange configurations would satisfy the following requirements:

- 1) Storage Requirement – to accommodate the maximum queue of turning traffic so that the queues in the turn bay will not spill out of the turn bay and block the through traffic movement
- 2) Blocking Prevention Requirement – to prevent blockage of access to turn bay by queue of through traffic
- 3) In addition, the minimum deceleration requirement was also checked for compliance for the turn bay design at interchange ramp intersections.

A.1.3 Determination of Crossroad Turn Bay Dimensions at Service Interchanges

The **required turn bay length** shall satisfy all three requirements below:

- 1) Deceleration Requirement – based on the specified design speed of the crossroad
- 2) Storage Requirement – to accommodate the maximum queue of turning traffic

- 3) Blocking Pavement Requirement – to prevent blockage of access to turn bay by queue of through traffic

Notes:

- a) The **length of a turn bay** is to be measured from the start of bay painted taper to the stop line at the end of the turn bay.
- b) In determining the storage requirements of a turn bay, the portion of the taper where the turn bay lane painted width is narrower than 3.0m will be considered unusable for vehicle storage. This initial unusable portion of the bay taper, therefore, shall not be included as the available storage distance calculation. For the purposes of this project, the lengths of the unavailable portion of the bay taper for storage are as follows:

Length of unusable bay taper:

- (i) Design Speed of 60 km/h – 50m for single lane turn lane & 70m for double lane turn lanes
- (ii) Design Speed of 70 km/h – 60m for single lane turn lane & 80m for double lane turn lanes
- (iii) Design Speed of 80 km/h – 70m for single lane turn lane & 90m for double lane turn lanes

Accordingly, the turn bay length provided shall therefore meet the following criteria in **Table 1**:

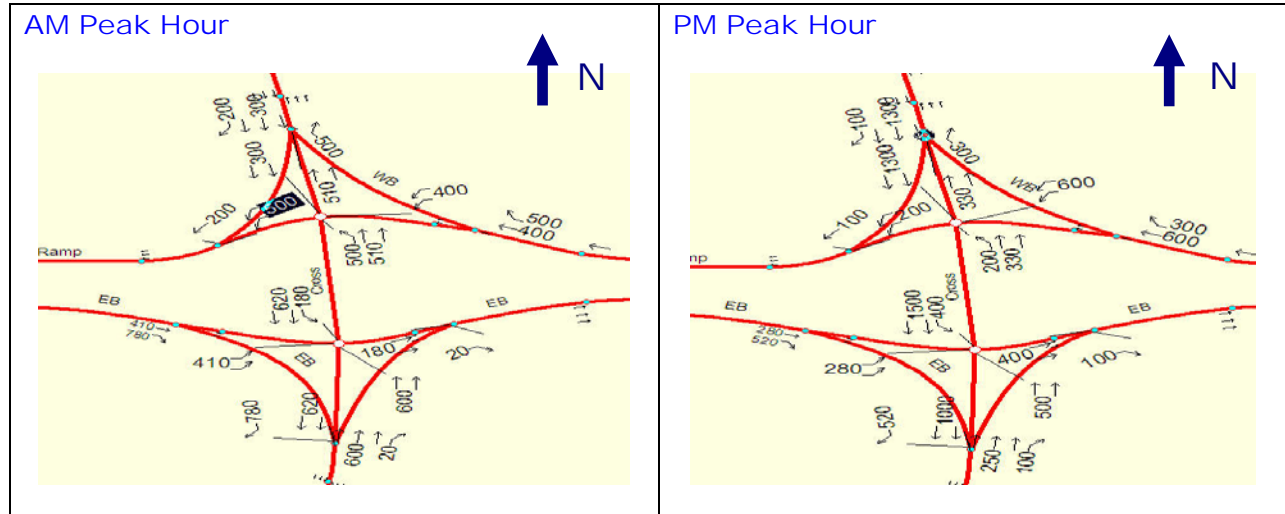
Table 1 – Criteria for Determination of Turn Bay Lengths at Crossroad Ramp Intersections*

Crossroad Design Speed	Required Turn Bay Length (Use the largest value of the following 3 criteria to design for the turn bay) (measured from start of bay taper to stop line at the end of turn bay)				
	Deceleration Requirement	Storage Requirement (turn bay length)		Blocking Prevention Requirement	
		Single-Lane Turn Lane	Double-Lane Turn Lane	Single-Lane Turn Lane	Double-Lane Turn Lane
60 km/h	90 m	SimTraffic Maximum Queue in turn bay + 50m	SimTraffic Maximum Queue in turn bay + 70m	SimTraffic Maximum Queue in through lane + 50m	SimTraffic Maximum Queue in through lane + 70m
70 km/h	110 m	SimTraffic Maximum Queue in turn bay + 60m	SimTraffic Maximum Queue in turn bay + 80m	SimTraffic Maximum Queue in through lane + 60m	SimTraffic Maximum Queue in through lane + 80m
80 km/h	130 m	SimTraffic Maximum Queue in turn bay + 70m	SimTraffic Maximum Queue in turn bay + 90m	SimTraffic Maximum Queue in through lane + 70m	SimTraffic Maximum Queue in through lane + 90m

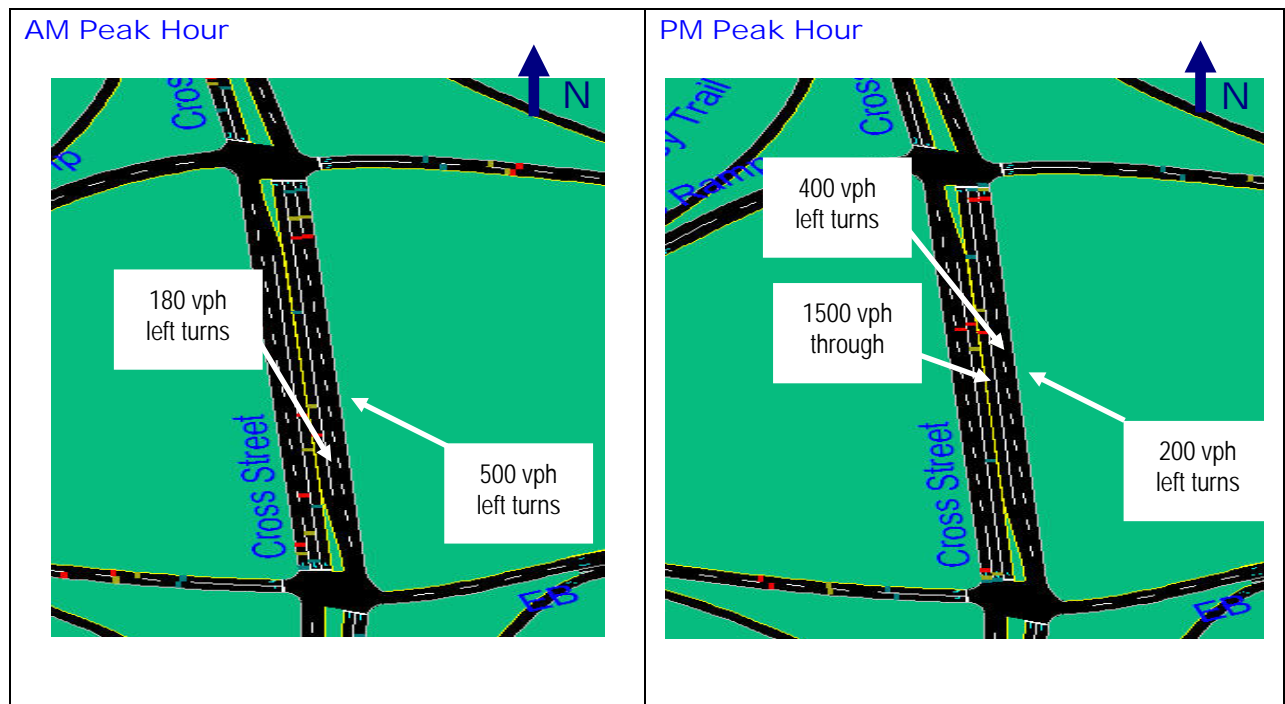
* SimTraffic maximum queue to be based on the average of a minimum of five (5) 60-minute simulation runs

A.1.3.1 Example - Diamond Interchange on North / South Crossroad (with 70 km/h Design Speed)

A.1.3.1.1 Lane Configurations and Peak Hour Volumes
(Note: The ramp intersection spacing is assumed to be 240m)



A.1.3.1.2 SimTraffic Maximum Queue Plot



Observations:

- a) The northbound left turns are more critical during the AM peak hour.
- b) The southbound left turns are more critical during the PM peak hour.
- c) Queues for southbound through traffic are also long in the PM peak hour.

A.1.3.1.3 SimTraffic Queuing and Blocking Report

AM Peak Hour (Critical Intersection: North Intersection – Node 3)

Intersection: 3: WB Ramp & Cross Street

Movement	WB	WB	NB	NB	NB	SB	SB
Directions Served	L	L	L	T	T	T	T
Maximum Queue (m)	84.0	85.4	146.7	34.0	33.3	55.5	37.3
Average Queue (m)	41.2	35.3	76.5	7.2	6.7	30.2	18.0
95th Queue (m)	62.0	55.9	130.3	22.8	22.0	46.4	33.3
Link Distance (m)	110.2	110.2		222.2	222.2	111.5	111.5
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (m)			180.0				
Storage Blk Time (%)							
Queuing Penalty (veh)							

PM Peak Hour (Critical Intersection: South Intersection – Node 6)

Intersection: 6: EB Ramp & Cross Street

Movement	EB	EB	NB	NB	SB	SB	SB
Directions Served	L	L	T	T	L	T	T
Maximum Queue (m)	70.7	66.6	69.9	38.9	145.6	142.9	6.4
Average Queue (m)	27.7	24.2	32.9	21.4	88.2	0.6	0.2
95th Queue (m)	47.5	46.6	49.7	37.2	131.6	3.8	2.2
Link Distance (m)	112.3	112.3	110.6	110.6		222.2	222.2
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (m)					180.0		
Storage Blk Time (%)							
Queuing Penalty (veh)							

North Ramp Intersection:

- 1) Deceleration requirement for the northbound left turns is 110m (from Table 1)
- 2) The northbound left turns have maximum queue of 146.7m in the AM peak hour (critical traffic period). At 70 km/h design speed, unusable taper length is 60m. Storage requirement for northbound left turns is therefore 147m+60m=207m
- 3) During the AM peak hour, the through lane queue is considerably shorter at 34m. Bay length requirement to allow left turn traffic to drive around the through lane queue is therefore 34m+60m=94m
- 4) **Conclusion:** Left Turn Storage of 207m is more critical - Use 210m turn bay length in design

South Ramp Intersection:

- 1) Deceleration requirement for the northbound left turns is 110m (from Table 1)
- 2) The southbound left turns have maximum queue of 145.6m in the PM peak hour (critical traffic period). At 70 km/h design speed, unusable taper length is 60m. Storage requirement for northbound left turns is therefore 146m+60m=206m
- 3) During the PM peak hour, the through lane queue is slightly shorter at 142.9m. Bay length requirement to allow left turn traffic to drive around the through lane queue is therefore 143m+60m=203m
- 4) **Conclusion:** Left Turn Storage of 206m is more critical – Use 210m turn bay length in design

A.1.4 Synchro Modeling Approach

- 1) Ramp intersections at an interchange must be coordinated and share the same cycle length
- 2) Cycle length should be realistic and shall be at least 70s and perhaps a minimum of 100s to 120s on major corridors, depending on the number of signal phases, the amount of traffic, and congestion along the arterial (longer cycle length for heavier traffic). Use 5s increments (preferably 10s increments) for signal cycle lengths

- 3) If the arterial is a major thoroughfare, the minimum green timings for the main street phase shall be at least 20s. If the roadway is neither a major arterial nor a thoroughfare, the minimum green timings can be reduced to 10s.
- 4) Minimum green band along arterials (through the two interchange ramp intersections) shall be at least 20s, preferably significantly more so that there will be a reasonable level of progression along that arterial. If the roadway is neither a major arterial nor a thoroughfare, the minimum green band can be reduced to 10s.
- 5) Lead or lag for any given signal left turn phase shall be consistent during a particular peak traffic period (i.e. may be different in the AM and PM periods)
- 6) Avoid consecutive stops. This includes through movements along the arterial, as well as heavy left turns from ramps onto the arterial.
- 7) Need to examine both AM and PM peak hour needs. The more critical condition governs the intersection geometry and signal timing requirements. Turn bay storage, spill back, and blocking requirements must be satisfied for both AM and PM peak periods.
- 8) Adjust for link Origin Destination (OD) for trips between 2 ramp intersections to eliminate freeway trips utilizing the interchange to make U-turns.
- 9) For left turn volumes greater than 500 vph, double left turn lanes should be considered.
- 10) Two lane approaches shall be used for ramp approaches for arterials with 2 or more lanes receiving the double left turns from the ramp approach
- 11) Protected-Only (i.e. Protected-Prohibited) left turns shall be used for double left turn movements
- 12) Shared through/left turn lanes shall not be used along the arterials, unless there are only 1 opposing through lane; or when the following 3 criteria are met - (i) the opposing through traffic volumes are light (less than 200 vph per lane); (ii) the concurrent through traffic volumes are light (less than 200 vph per lane); (iii) the interchange is not located near an industrial area where more than 5% trucks are expected in the traffic streams.
- 13) Split signal phasing shall not be used on major arterials or thoroughfares.

A.1.4.1 Synchro Modeling Parameters

Synchro Factors		Parameters	Recommended Values (* - non-adjustable)
A.1.4.1.1 Ideal Saturation Flow		Left Turns	1900 pc/h/ln *
		Through	1900 pc/h/ln *
		Right Turns	1900 pc/h/ln *
A.1.4.1.2 Lane Width		Left & Right Turns	3.5 m
		Through	3.7 m
A.1.4.1.3 Lost Time Adjustment			0 s *
A.1.4.1.4 Detectors	Left Turn Lane	No. of Detectors	1 *
		Leading Detector	2 m *
		Trailing Detector	0 m *
		Detector 1 Position	0.0 m *
		Detector 1 Size	2.0 m *
		Detector 1 Type	Call + Extension *
	Through Lane	No. of Detectors	1 *
		Leading Detector	10 m *
		Trailing Detector	0 m *
		Detector 1 Position	0.0 m *
		Detector 1 Size	0.6m *
		Detector 1 Type	Call + Extension *
	Right Turn Lane	No. of Detectors	1 *
		Leading Detector	2 m *
		Trailing Detector	0 m *
		Detector 1 Position	0.0 m *
		Detector 1 Size	2.0 m *
		Detector 1 Type	Call + Extension
A.1.4.1.5 Turning Speed		Left Turns	40 km/h (use higher speeds at locations where turn angle is > 100 degrees)
		Right Turns	30 / 40 / 50 km/h (use higher speeds if turning radii are designed for higher speeds)
A.1.4.1.6 Lane Utilization			Defaults *
A.1.4.1.7 Conflicting Peds			0 ped (ignore) *
A.1.4.1.8 Conflicting Bikes			0 bike (ignore) *
A.1.4.1.9 Peak Hour Factor			0.94 AM / 0.95 PM *
A.1.4.1.10 Heavy vehicles			5% * (unless specified noted otherwise)

Synchro Factors		Parameters	Recommended Values (* - non-adjustable)
A.1.4.1.11 Signal Timing	Min. Initial	Main Street	Major Arterial / Thoroughfare - 20 s Minor Arterial / Collector / Non Thoroughfare – 20 s
		Side Street	12s *
		Left Arrows	7s *
	Amber	Through	Posted Speed: 4.5s for 80 km/h; 4.0s for 70 km/h; 3.5s for 60 km/h; 3.5s for 50 km/h *
		Lagging Left Arrow	3.5s amber *
		Leading Left arrow (Prot-Proh)	3.5s amber *
		Leading Left arrow (Prot-Perm)	2.9s amber *
	All Red	Through	From Major Road (Arterial) – 2.5 s * From Minor Road (Ramps), crossing 6 lanes – 2.5s * From Minor Road (Ramps), crossing 4 lanes – 2.0s *
		Lagging Left Arrow	Same as concurrent through phase *
		Leading Left arrow (Prot-Proh)	1.5s all red *
		Leading Left arrow (Prot-Perm)	0.1s al red *
	A.1.4.1.12 Recall Mode	Major Street	C-Min *
		Minor Street	None (can be adjusted to min recall with the appropriate min Green setting if it is needed to create a desirable signal coordination pattern)
Left Turns		None (can be adjusted to min recall with the appropriate min Green setting if it is needed to create a desirable signal coordination pattern)	
A.1.4.1.13 Lead / Lag		Lead or Lag as warranted by operational benefits	
A.1.4.1.14 Pedestrian Timings (generally not set except noted otherwise specifically. If that's the case, use these parameters)	Walk Time	8 s	
	Walking Speed	1.2 m/s	
	Flashing Don't Walk Time (FDW)	FDW = Crosswalk Distance / 1.2 – amber – Red; Crosswalk distance to be measured along the centre of crosswalk, measure to ~ 2 m beyond edge of conflicting through lane	

Synchro Factors	Parameters	Recommended Values (* - non-adjustable)
A.1.4.1.15 Block Intersection	Signal Controlled	Block Intersection not allowed
	Yield / Stop / Free-Flow	Block Intersection allowed

A.1.5 SimTraffic Modeling Approach

- 1) SimTraffic model must represent the proposed interchange accurately i.e. link length, bay length, turn radius, link speed, turn speed, etc.
- 2) Consider longer external links / boundary links to avoid potential denied entry occurring outside the model network
- 3) Headway factor shall be adjusted for loop ramps / C-D lanes – apply adjustment factor using ratio of road segment capacity over ideal link capacity.
- 4) Headway factor shall be adjusted for free-flow C-D roads / ramp segments with higher capacity.
- 5) Additional adjustments in SimTraffic may include:
 - a. If there are long queues, add feeder intersection to simulate effects of upstream traffic signals (metering effect)
 - b. May consider using signal coordination to dictate progression pattern so that arrival patterns of conflicting platoons can be separated. Longer ramp minimum green may be used to create gaps at downstream intersection
 - c. If there is uneven lane distribution at double left turn lanes, the number of receiving lanes may be increased to improve the downstream traffic flow in the SimTraffic model.

A.1.5.1 SimTraffic Modeling Parameters

SimTraffic Simulation Settings	Parameters	Recommended Values (* - non-adjustable)
A.1.5.1.1 Interval Parameters	Seeding Interval	One 15 minutes interval *
	Recording Interval	Four 15 minutes intervals *
	Peak Hour Factor (PHF) Adjust	Yes for Third Recording Interval *
	Anti-PHF Adjust	Yes for First, second and Fourth Recording Intervals *
A.1.5.1.2 Vehicle Parameters	Truck Percentage by Class	Use 0.05 Semi-1; 0.02 Semi-2; 0.03 Bus * (unless specifically stated otherwise)
A.1.5.1.3 Driver Parameters	All parameters	Use default values *
A.1.5.1.4 Enter Blocked Intersection?	Signalized Intersection	No *
	Unsignalized Intersection	Yes *
	Ramp Merge / Diverge Terminal	Yes *
A.1.5.1.5 Median Width	Single Left Turn Lane Without median	3.5m
	Single Left Turn Lane with Median	6.0m (= 3.5m + 2.5m)
	Double Left Turn Lanes with Median	9.5m (=3.5m + 3.5m + 2.5m)
A.1.5.1.6 Headway Factor	Ramp/C-D Lane with Operating Speed	Headway Factor
	> 80 km/h	0.97
	66 to 80 km/h	0.93
	51 to 65 km/h	0.88
	31 to 50 km/h	0.84
A.1.5.1.7 Turning Speed	Left Turns	30 km/h (use higher speeds at locations where turn angle is > 100 degrees)
	Right Turns	30 / 40 / 50 km/h (use higher speeds if turning radii are designed for higher speeds)

A.1.5.2 SimTraffic Output Evaluation Criteria

- 1) Average Delay Per Vehicle - Flag (for operational problems) raised when value > 60 s/veh
- 2) Queue Length – view static queue plot or maximum queue length in simulation report. In cases where the maximum queue in the simulation report is very long and yet this level of queue is not observed in the simulation, the simulation visual observation will be used. The maximum queue length can be estimated by scaling (from plot of the maximum observed simulated queue) the observed maximum queue length.
- 3) Denied Entries – need to confirm at the end of the simulation run that there are minimum denied entries
- 4) Lane Distribution – Check simulation for lane distribution in double left turn lanes to see if simulation is reasonable
- 5) Optimum design is a balance between signal split timing allocation and bay storage / approach LOS (queue management / control)

A.2 Roundabout Service Interchange Modeling

A.2.1 Sidra Intersection Criteria for Failed Interchange Operations

Criteria for failed interchange operations are:

- 1) Excessive delay and/or capacity at any of the roundabout approach and/or the circulating lanes
- 2) Excessive queue at the roundabout approach

A.2.2 Sidra Parameters

Sidra Input Parameters	Recommended Values (* - non-adjustable)
A.2.2.1 Model Setting	SIDRA Standard delay model SIDRA Standard queue model LOS based on delay of signalized intersection Environment factor 1.1
A.2.2.2 Evaluation Period	60 minutes with a 15 minute peak flow period (unless specifically stated otherwise)
A.2.2.3 Peak Hour Factor	1.0
A.2.2.4 Queue Lengths	Evaluated at 95 percentile at the back of queue HCM Delay and Queue are the selected measures of evaluation
A.2.2.5 Area Type	default
A.2.2.6 Level of Service	Evaluated by Delay and Degree of Saturation Ideal Degree of Saturation = 1850 for all movements Saturation flow scale = 100%
A.2.2.7 Geometry (if unknown)	Lane width 4.3m (each lane) Circulating width 5m (each lane) Island diameter 20m Entry radius 20m Entry angle 30 degree Approach cruise speed 35 km/h Exit cruise speed 35 km/h
A.2.2.8 Heavy Vehicles	5%
A.2.2.9 Lane Utilization	Default
A.2.2.10 Growth Factor = Flow Scale	100%
A.2.2.11 Practical Degree of Saturation	85%
A.2.2.12 Lane Width for single lane roundabouts	4.3m
A.2.2.13 Platooning = Extra Bunching	Per guidelines of the program

A.2.3 Sidra Intersection Output Evaluation Criteria

The following evaluation criteria were evaluated in the Sidra analyses:

- 1) Queue Length – to ensure the queue at each approach of the roundabout will not spill past the interchange ramp or adjacent intersection

A2.4 Sidra Modeling Approach

- 1) Begin with the analysis of a single-lane roundabout
- 2) Verify if the evaluation criteria are met, if not, check if enhancements could be added to the single-lane roundabout to improve operations. Example enhancements includes: channelized right turn, right turn slip lane, roundabout geometry adjustments, etc.
- 3) If none of the enhancements could improve the operations of the single-lane roundabout, evaluate a two-lane roundabout. Verify if the evaluation criteria are met, if not, check if enhancements could be added to the two-lane roundabout to improve operations. Example enhancements includes: channelized right turn, right turn slip lane, roundabout geometry adjustments, etc.
- 4) If none of the enhancements could improve the operations of the two-lane roundabout, a traffic signal should also be evaluated and compared with the roundabout.

Package B - Synchro/SimTraffic and Sidra Traffic Models

B.1 - Synchro/SimTraffic and Sidra Files [Note to Proponents: the most current files are posted in the Electronic Data Room. The Department will insert the list of files at SR2B, or later with the agreement of the Successful Proponent, into the above table for identification purposes.]

The names of the Synchro/ SimTraffic and Sidra files are as follows:

Interchange No. [Interchange Location]	Stage 1 Models		Ultimate Stage Lanes Models 2050 Horizon
	2035 Horizon	2050 Horizon	
01 [6 Street SW/Sheriff King Street SW & SWCRR]	01-SWCRR-STG1-35-AM 01-SWCRR-STG1-35-PM	01-SWCRR-STG1-50- AM 01-SWCRR-STG1-50-PM	01-SWCRR-ULT-50-AM 01-SWCRR-ULT-50-PM
02 [James McKeivitt Road/Spruce Meadows Way & SWCRR]	02-SWCRR-STG1-35-AM 02-SWCRR-STG1-35-PM	02-SWCRR-STG1-50-AM 02-SWCRR-STG1-50-PM	02-SWCRR-ULT-50-AM 02-SWCRR-ULT-50-PM
03 [162 Avenue SW & SWCRR]	03-SWCRR-STG1-35-AM 03-SWCRR-STG1-35-PM	03-SWCRR-STG1-50-AM 03-SWCRR-STG1-50-PM	03-SWCRR-ULT-50-AM 03-SWCRR-ULT-50-PM
04 [146 Avenue SW/Fish Creek Blvd & SWCRR]	04-SWCRR-STG1-35-AM 04-SWCRR-STG1-35-PM	04-SWCRR-STG1-50-AM 04-SWCRR-STG1-50-PM	04-SWCRR-ULT-50-AM 04-SWCRR-ULT-50-PM
05 [130 Avenue SW & SWCRR]	05-SWCRR-STG1-35-AM 05-SWCRR-STG1-35-PM	05-SWCRR-STG1-50-AM 05-SWCRR-STG1-50-PM	05-SWCRR-ULT-50-AM 05-SWCRR-ULT-50-PM
06 [90 Avenue SW & SWCRR]	06-SWCRR-STG1-35-AM 06-SWCRR-STG1-35-PM	06-SWCRR-STG1-50-AM 06-SWCRR-STG1-50-PM	06-SWCRR-ULT-50-AM 06-SWCRR-ULT-50-PM
07 [Strathcona Street SW & SWCRR]	07-SWCRR-STG1-35-AM 07-SWCRR-STG1-35-PM	07-SWCRR-STG1-50-AM 07-SWCRR-STG1-50-PM	07-SWCRR-ULT-50-AM 07-SWCRR-ULT-50-PM
08 [Westhills Way SW & SWCRR]	08-SWCRR-STG1-35-AM 08-SWCRR-STG1-35-PM	08-SWCRR-STG1-50-AM 08-SWCRR-STG1-50-PM	08-SWCRR-ULT-50-AM 08-SWCRR-ULT-50-PM
09 [37 Street SW & SWCRR]	09-SWCRR-STG1-35-AM 09-SWCRR-STG1-35-PM	09-SWCRR-STG1-50-AM 09-SWCRR-STG1-50-PM	09-SWCRR-ULT-50-AM 09-SWCRR-ULT-50-PM
10 [69 Street SW/Discovery Ridge Blvd SW & SWCRR]	10-SWCRR-STG1-35-AM 10-SWCRR- STG1-35-PM	10-SWCRR-STG1-50-AM 10-SWCRR-STG1-50-PM	10-SWCRR-ULT-50-AM 10-SWCRR-ULT-50- PM

The Synchro, SimTraffic, and Sidra filename nomenclatures are as follows:

XX-SWCRR-STAGE-HORIZON-AM / PM

Where:

STAGE	STG1	– Stage 1
	ULT	– Ultimate Stage Lanes
HORIZON	35	– 2035 Horizon
	50	– 2050 Horizon
AM /PM	AM	– AM Peak Hour
	PM	– PM Peak Hour

B.2 - Synchro Background File Linkages

The directions for linking Synchro Files to their respective Interchange Background image files are provided in this section.

- 1) The Interchange Background image files should be kept in a subfolder folder located on the local hard drive (e.g. "C:\SWCRR Backgrounds"). This allows the simulation files to be located anywhere on the computer, and the link to the Interchange Background image files will still be accessible (i.e. properly linked) to the Synchro programs.
- 2) To link the Interchange Background image files (jpeg files) to a Synchro file, the following steps are required. (The **highlighted** words correspond to keystrokes within the Synchro program)
 - a) **"File", "Select Backgrounds"**
 - b) **"Remove"** linkage to any existing jpegs.
 - c) **"Add"** linkage to the appropriate jpeg file, using the file requestor.
 - d) Double-click on the any of the parameters to open the "Set Bitmap Scale & Offset" window.
 - e) Set the World Coordinates to match those found at the "X" on the background jpeg image. The X-coordinate is the smaller number. Use a negative number if it is negative on the jpeg. The numbers are typed into the World Coordinate boxes.
 - f) To Set the Bitmap coordinates, press the **"Find"** button, and then click on the center of the "X". Zooming in on the "X" will be necessary.
 - g) Set Scale to **XXXm = XXX** pixels
 - h) Select **"OK"**, and the background should be visible behind the Synchro Link / Node file. If not, go through the steps again.

Package C – Criteria for Evaluating Alternative Service Interchange Types**AND****Modifications to the Interchange Lane Configurations as shown on the Plans attached to Schedule 18****C.1 Synchro/SimTraffic Service Interchange Modeling****C.1.1 Minimum Requirements for Synchro/SimTraffic Modeling**

Proposals for alternative service interchange types (e.g. change from Parclo A4 to Diamond) or modifications to the interchange lane configurations as shown on the plans attached to Schedule 18 (e.g. use of shorter turn bays, deletion of number of turn or through lanes) shall be accompanied by **Synchro/SimTraffic** (using Synchro Studio 9 package) and **Sidra** (using Sidra 6.0 package) files. The Synchro/SimTraffic files serve to demonstrate that the proposed alternative interchange configurations will satisfy the following requirements:

- 1) Storage Requirement – to accommodate maximum queue of turning traffic so that the queue in the turn bay will not spill out of the turn bay and blocks the through traffic movement
- 2) Blocking Prevention Requirement – to prevent blockage of access to turn bay by queue of through traffic.
- 3) In addition, the minimum deceleration requirement was also checked for compliance for the turn bay design at interchange ramp intersections.

The Synchro/SimTraffic files shall be prepared using the traffic volumes used in the Synchro/SimTraffic files provided in Package B of Appendix J. The Contractor shall not adjust these traffic volumes.

The same Synchro/SimTraffic modeling parameters shall be used in preparing the new Synchro/SimTraffic files for the alternative interchange types or the alternative interchange lane configurations.

C.1.2 Evaluating Synchro/SimTraffic Models

The following is a sample approach to evaluate if the interchange layout plan is prepared consistent with the requirements determined by the Synchro/SimTraffic files:

The following three checks are made and the check results are shaded in the table: (refer to Table 1 in Package A):

- 1) Check if there is queue failure in the simulation (i.e. simulated maximum queue is longer than the queue storage provided in the Synchro/SimTraffic models)
- 2) Check if the turn bay length shown on the interchange layout plans is sufficiently long to contain the maximum queue length
- 3) Check if the turn bay length on the interchange layout plans meets the deceleration distance requirement.

Example 1 – Design meet minimum operational requirements (factitious numbers used):

Example of design that meets minimum operational requirements – Interchange 1	Stage 1	Ultimate Lanes	Remarks
a) Simulated Max Queue	125m	142m	
b) Storage provided in Synchro	250m	250m	
c) Is the storage in Synchro Adequate?	OK	OK	Turn bay provided in Synchro is acceptable
d) Bay length needed	185m	202m	
e) Bay length provided in the interchange layout plan	250m	250m	
f) Is Bay Length in interchange layout plan adequate?	OK	OK	Turn bay provided in the interchange layout plan is acceptable – i.e. meets or exceeds minimum operational requirements
g) Deceleration requirement	130m	130m	
h) Is deceleration requirement adequate?	OK	OK	Turn bay length in interchange layout plan meets minimum deceleration requirement

Example 2 – Design does not meet minimum operational requirements (factitious numbers used):

Example of design that meets minimum operational requirements – Interchange 2	Stage 1	Ultimate Lanes	Remarks
a) Simulated Max Queue	106m	142m	
b) Storage provided in Synchro	130m	130m	
c) Is the storage in Synchro Adequate?	OK	Short	Need to revise Synchro file so that the turn bay can accommodate the anticipated maximum queue length
d) Bay length needed	166m	202m	
e) Bay length provided in the interchange layout plan	130m	130m	
f) Is Bay Length in interchange layout plan adequate?	Short	Short	Queue failure expected with the 130m bay length provided in the interchange layout plan. Need to extend turn bay pass the 202m required minimum bay length
g) Deceleration requirement	130m	130m	
h) Is deceleration requirement adequate?	OK	OK	Turn bay length in interchange layout plan meets minimum deceleration requirement

Example 3 – Design in the Interchange Layout Plan is inconsistent with the Synchro/SimTraffic models provided:

Example of design that meets minimum operational requirements – Interchange 3	Stage 1	Ultimate Lanes	Remarks
a) Simulated Max Queue	125m	142m	
b) Storage provided in Synchro	250m	250m	
c) Is the storage in Synchro Adequate?	OK	OK	Turn bay provided in Synchro is acceptable
d) Bay length needed	185m	202m	
e) Bay length provided in the interchange layout plan	150m	150m	
f) Is Bay Length in interchange layout plan adequate?	Fail	Fail	The 150m bay length provided in the interchange layout plan is not consistent with the required bay length determined by Synchro.
g) Deceleration requirement	130m	130m	
h) Is deceleration requirement adequate?	OK	OK	Turn bay length in interchange layout plan meets minimum deceleration requirement

A.1.3 Eliminating Queue Failures

Queue failure may be eliminated by implementing one or more of the following measures:

- 1) Increase length of turn bay storage
- 2) Change signal timings including signal coordination timings or lead-lag arrangements for left turn signal phases
- 3) Change signal cycle length
- 4) Change signal phasing
- 5) Adjust the traffic control (e.g. change from yield to free flow)
- 6) Adjust the number of lanes at the intersection approach
- 7) For lane distribution problems at double left turn lanes, it may be necessary to create a longer section of receiving lanes or even increase the number of receiving lanes downstream to avoid a situation where SimTraffic avoids assigning vehicles to the outside left turn lane (in anticipation of lane merge shortly after the left turn maneuver)
- 8) Add feeder intersection to simulate effects of upstream traffic signals (to create a metering effect or generate more compact platoons of arrival traffic)
- 9) Adjust interchange configuration

A.1.4 Using Department’s Synchro/SimTraffic Models

The Contractor may choose to use the original files referenced in Package B to determine the turn bay requirements using the same process shown above. To achieve a reasonably optimal turn bay length requirements, it is recommended that the signal timings in the original Synchro/SimTraffic models be retained or at least be used as a starting point.

C.2 Roundabout Service Interchange Modeling

C.2.1 Sidra Intersection Output Evaluation Criteria

The same Sidra modeling parameters shall be used in preparing the new Sidra files for the alternative interchange types or the alternative interchange lane configurations. The following evaluation criteria shall be evaluated in the Sidra analyses:

- 1) Queue length – to ensure the queue at each approach of the roundabout will not spill past the interchange ramp or adjacent intersection

C.2.2 Sidra Modeling Approach

- 1) Begin with the analysis of a single-lane roundabout
- 2) Verify if the evaluation criteria are met, if not, check if enhancements could be added to the single-lane roundabout to improve operations. Example enhancements includes: channelized right turn, right turn slip lane, roundabout geometry adjustments, etc.
- 3) If none of the enhancements could improve the operations of the single-lane roundabout, evaluate a two-lane roundabout. Verify if the evaluation criteria are met, if not, check if enhancements could be added to the two-lane roundabout to improve operations. Example enhancements includes: channelized right turn, right turn slip lane, roundabout geometry adjustments, etc.
- 4) If none of the enhancements could improve the operations of the two-lane roundabout, a traffic signal should also be evaluated and compared with the roundabout.

Package D - Guidelines for Synchro/SimTraffic and Sidra Modeling – For At-Grade Intersections

Detailed configurations of the at-grade signalized intersection was determined and confirmed by traffic simulation using the **Synchro/SimTraffic Studio 9** suite of programs. **Synchro** was used to establish basic model programming of the Synchro model, as well as provide preliminary assessment of signal timing and the effectiveness of the lane configuration in accommodating traffic demands. **Sidra Intersection** was used to establish the basic model programming of the roundabout model and provide preliminary assessment of the lane configuration in accommodating traffic demand. **SimTraffic** is used to provide simulation statistics in the assessment of intersection performance. The measures of effectiveness used in intersection operation analysis are SimTraffic output parameters.

[Synchro/SimTraffic and/or Sidra files for the at-grade intersections below are identified in Package E. The Contractor acknowledges receipt of said files as follows.](#)

- 37 Street/Strathcona Street SW & Grey Eagle Drive SW;
- Highway 8 & Lott Creek Boulevard;
- Highway 8 & 101 Street SW;
- Highway 22 & 53 Street SW/112 Street; and
- 90 Avenue SW & Southland Drive SW.

D.1 Synchro/SimTraffic At-Grade Intersection Modeling

D.1.1 Criteria for Failed Intersection Operations

Criteria for failed intersection operations for at-grade signalized intersections are:

- 1) Excessive queue in turn bay spilling out of bay and blocking adjacent through lane
- 2) Excessive queue in through lane blocking turn bay
- 3) Successive cycle failure (vehicles need to wait for multiple signal cycles to clear an intersection)

D.1.2 Synchro/SimTraffic Models

Synchro/SimTraffic models were created to demonstrate that the recommended intersection lane configurations would satisfy the following requirements:

- 1) Storage Requirement – to accommodate maximum queue of turning traffic so that the queues in the turn bay will not spill out of the turn bay and block the through traffic movement
- 2) Blocking Prevention Requirement – to prevent blockage of access to turn bay by queue of through traffic
- 3) In addition, the minimum deceleration requirement was also checked for compliance for the turn bay design at intersections.

D.1.3 Determination of Turn Bay Dimensions at At-Grade Intersections

The **required turn bay length** shall satisfy all three requirements below:

- 1) Deceleration Requirement – based on the specified design speed of the approach
- 2) Storage Requirement – to accommodate the maximum queue of turning traffic
- 3) Blocking Pavement Requirement – to prevent blockage of access to turn bay by queue of through traffic

Notes:

- a) The **length of a turn bay** is to be measured from the start of bay taper to the stop line at the end of the turn bay.
- b) In determining the storage requirements of a turn bay, the portion of the taper where the turn bay lane width is narrower than 3.0m will be considered unusable for vehicle storage. This initial unusable portion of the bay taper, therefore, shall not be included as the available storage distance calculation. For the purposes of this project, the lengths of the unavailable portion of the bay taper for storage are as follows:

Length of unusable bay taper:

- (i) Design Speed of 60 km/h – 50m for single lane turn lane & 70m for double lane turn lanes
- (ii) Design Speed of 70 km/h – 60m for single lane turn lane & 80m for double lane turn lanes
- (iii) Design Speed of 80 km/h – 70m for single lane turn lane & 90m for double lane turn lanes

Accordingly, the turn bay length provided shall therefore meet the following criteria in Table 1:

Table 1 – Criteria for Determination of Turn Bay Lengths at At-Grade Intersections

Crossroad Design Speed	Required Turn Bay Length (Use the largest value of the following 3 criteria to design for the turn bay) (measured from start of bay taper to stop line at the end of turn bay)				
	Deceleration Requirement	Storage Requirement (turn bay length)		Blocking Prevention Requirement	
		Single-Lane Turn Lane	Double-Lane Turn Lane	Single-Lane Turn Lane	Double-Lane Turn Lane
60 km/h	90 m	SimTraffic Maximum Queue in turn bay + 50m	SimTraffic Maximum Queue in turn bay + 70m	SimTraffic Maximum Queue in through lane + 50m	SimTraffic Maximum Queue in through lane + 70m
70 km/h	110 m	SimTraffic Maximum Queue in turn bay + 60m	SimTraffic Maximum Queue in turn bay + 80m	SimTraffic Maximum Queue in through lane + 60m	SimTraffic Maximum Queue in through lane + 80m
80 km/h	130 m	SimTraffic Maximum Queue in turn bay + 70m	SimTraffic Maximum Queue in turn bay + 90m	SimTraffic Maximum Queue in through lane + 70m	SimTraffic Maximum Queue in through lane + 90m

D.1.4 Synchro Modeling Approach – for At-Grade Intersections

- 1) Cycle length should be realistic and shall be at least 60s and perhaps a minimum of 100s to 120s on major corridors, depending on the number of signal phases, the amount of traffic, and congestion along the arterial (longer cycle length for heavier traffic). Use 5s increments (preferably 10s increments) for signal cycle lengths.
- 2) If the arterial is a major thoroughfare, the minimum green timing for the main street phase shall be at least 30s. If the roadway is not a major arterial or only the initial phase of a future major arterial, the minimum green timings can be reduced to 15s.
- 3) Lead or lag for any given signal left turn phase shall be consistent during a particular peak traffic period (i.e. may be different in the AM and PM periods)

- 4) Need to examine both AM and PM peak hour needs.
- 5) The more critical condition governs the intersection geometry and signal timing requirements. Turn bay storage, spill back, and blocking requirements must be satisfied for both AM and PM peak periods
- 6) Left turn volumes greater than 500 vph, double left turn lanes should be considered.
- 7) Protected-Only (i.e. Protected-Prohibited) left turns shall be used for double left turn movements
- 8) Shared through/left turn lanes shall not be used along the arterials, unless there are only 1 opposing through lane; or when the following 3 criteria are met - (i) the opposing through traffic volumes are light (less than 200 vph per lane); (ii) the concurrent through traffic volumes are light (less than 200 vph per lane); (iii) the intersection is not located near an industrial area where more than 5% trucks are expected in the traffic streams.
- 9) Split signal phasing shall not be used on major arterials or thoroughfares.

D.1.4.1 Synchro Modeling Parameters – For At-Grade Intersections

Synchro Factors		Parameters	Recommended Values (* - non-adjustable)
D.1.4.1.1 Ideal Saturation Flow		Left Turns	1900 pc/h/ln *
		Through	1900 pc/h/ln *
		Right Turns	1900 pc/h/ln *
D.1.4.1.2 Lane Width		Left & Right Turns	3.5 m *
		Through	3.7 m *
D.1.4.1.3 Lost Time Adjustment			0 s *
D.1.4.1.4 Detectors	Left Turn Lane	No. of Detectors	1 *
		Leading Detector	2 m *
		Trailing Detector	0 m *
		Detector 1 Position	0.0 m *
		Detector 1 Size	2.0 m *
		Detector 1 Type	Call + Extension *
	Through Lane	No. of Detectors	1 *
		Leading Detector	10 m *
		Trailing Detector	0 m *
		Detector 1 Position	0.0 m *
		Detector 1 Size	0.6m *
		Detector 1 Type	Call + Extension *
	Right Turn Lane	No. of Detectors	1 *
		Leading Detector	2 m *
		Trailing Detector	0 m *
		Detector 1 Position	0.0 m *
		Detector 1 Size	2.0 m *
		Detector 1 Type	Call + Extension
D.1.4.1.5 Turning Speed		Left Turns	30 km/h (use higher speeds at locations where turn angle is > 100 degrees)

		Right Turns	30 / 40 / 50 km/h (use higher speeds if turning radii are designed for higher speeds)
D.1.4.1.6 Lane Utilization			Defaults *
D.1.4.1.7 Conflicting Peds			0 ped (ignore) *
D.1.4.1.8 Conflicting Bikes			0 bike (ignore) *
D.1.4.1.9 Peak Hour Factor			0.94 AM / 0.95 PM *
D.1.4.1.10 Heavy vehicles			5% * (unless specified noted otherwise)
D.1.4.1.11 Signal Timing	Min. Initial	Main Street	As per parameters in the Synchro files
		Side Street	12 s *
		Left Arrows	7s *
	Amber	Through	Posted Speed: 4.5s for 80 km/h; 4.0s for 70 km/h; 3.5s for 60 km/h; 3.5s for 50 km/h *
		Lagging Left Arrow	3.5s amber *
		Leading Left arrow (Prot-)	3.5s amber *
		Leading Left arrow (Prot-)	2.9s amber *
	All Red	Through	From Major Road (Arterial) – 2.5 s * From Minor Road (Ramps), crossing 6 lanes – 2.5s * From Minor Road (Ramps), crossing 4 lanes – 2.0s *
		Lagging Left Arrow	Same as concurrent through phase *
		Leading Left arrow (Prot-)	1.5s all red *
		Leading Left arrow (Prot-)	0.1s all red *
D.1.4.1.12 Recall Mode	Major Street		Min
	Minor Street		None
	Left Turns		None
D.1.4.1.13 Lead / Lag			Lead or Lag as demonstrated by operational benefits
D.1.4.1.14 Pedestrian Timings (generally not set except noted otherwise specifically. If that's the case, use these parameters)	Walk Time		8 s
	Walking Speed		1.2 m/s
	Flashing Don't Walk Time (FDW)		FDW = Crosswalk Distance / 1.2 – amber – Red; Crosswalk distance to be measured along the centre of crosswalk, measure to ~ 2 m beyond edge of conflicting through lane
D.1.4.1.15 Block Intersection	Signal Controlled		Block Intersection not allowed
	Yield / Stop / Free-Flow		Block Intersection allowed

Pc/h/ln – passenger car per hour per lane

D.1.5 SimTraffic Modeling Approach – For At-Grade Intersections

- 1) SimTraffic model must **represent the proposed intersection accurately** i.e. link length, bay length, turn radius, link speed, turn speed, etc.
- 2) **Consider longer external links at boundary** to avoid potential denied entry occurring outside the model network.

D.1.5.1 SimTraffic Modeling Parameters – For At-Grade Intersections

SimTraffic Simulation Settings	Parameters	Recommended Values (* - non-adjustable)
D.1.5.1.1 Interval Parameters	Seeding Interval	One 15 minutes interval *
	Recording Interval	Four 15 minutes intervals *
	PHF Adjust	Yes for Third Recording Interval *
	Anti-PHF Adjust	Yes for First, second and Fourth Recording Intervals *
D.1.5.1.2 Vehicle Parameters	Truck Percentage by Class	Use 0.05 Semi-1; 0.02 Semi-2; 0.03 Bus * (unless specifically stated otherwise)
D.1.5.1.3 Driver Parameters	All parameters	Use default values *
D.1.5.1.4 Enter Blocked Intersection?	Signalized Intersection	No *
	Unsignalized Intersection	Yes *
	Ramp Merge / Diverge Terminal	Yes *
D.1.5.1.5 Median Width	Single Left Turn Lane Without median	3.5m
	Single Left Turn Lane with Median	6.0m (= 3.5m + 2.5m)
	Double Left Turn Lanes with Median	9.5m (=3.5m + 3.5m + 2.5m)
D.1.5.1.6 Headway Factor	Ramp/C-D Lane with Operating Speed	Headway Factor
	> 80 km/h	0.97
	66 to 80 km/h	0.93
	51 to 65 km/h	0.88
	31 to 50 km/h	0.84
	≤ 30 km/h	0.80
D.1.5.1.7 Turning Speed	Left Turns	30 km/h (use higher speeds at locations where turn angle is > 100 degrees)
	Right Turns	30 / 40 / 50 km/h (use higher speeds if turning radii are designed for higher speeds)

D.1.5.3 SimTraffic Output Evaluation Criteria – For At-Grade Intersections

- 1) **Average Delay Per Vehicle** - Flag (for operational problems) raised when value > 60 s/veh
- 2) **Queue Length** – view static queue plot or maximum queue length in simulation report. In cases where the maximum queue in the simulation report is very long and yet this level of queue is not

observed in the simulation, the simulation visual observation will be used. The maximum queue length can be estimated by scaling (from plot of the maximum observed simulated queue) the observed maximum queue length.

- 3) **Denied Entries** – need to confirm at the end of the simulation run that there are minimum denied entries.
- 4) **Lane Distribution** – Check simulation for lane distribution in double left turn lanes to see if simulation is reasonable.
- 5) Optimum design is a **balance** between signal split timing allocation and bay storage / approach LOS (queue management / control).

D.2 Roundabout At-Grade Intersection Modeling

D.2.1 Sidra Intersection Criteria for Failed Intersection Operations

Criteria for failed intersection operations are:

- 1) Excessive delay and/or capacity at any of the roundabout approach and/or the circulating lanes.
- 2) Excessive queue at the roundabout approach.

D.2.2 Sidra Parameters

Sidra Input Parameters	Recommended Values (* - non-adjustable)
D.2.2.1 Model Setting	SIDRA Standard delay model SIDRA Standard queue model LOS based on delay of signalized intersection Environment factor 1.1
D.2.2.2 Evaluation Period	60 minutes with a 15 minute peak flow period (unless specifically stated otherwise)
D.2.2.3 Peak Hour Factor	1.0
D.2.2.4 Queue Lengths	Evaluated at 95 percentile at the back of queue HCM Delay and Queue are the selected measures of evaluation
D.2.2.5 Area Type	default
D.2.2.6 Level of Service	Evaluated by Delay and Degree of Saturation Ideal Degree of Saturation = 1850 for all movements Saturation flow scale = 100%
D.2.2.7 Geometry (if unknown)	Lane width 4.3m (each lane) Circulating width 5m (each lane) Island diameter 20m Entry radius 20m Entry angle 30 degree Approach cruise speed 35 km/h Exit cruise speed 35 km/h
D.2.2.8 Heavy Vehicles	5%
D.2.2.9 Lane Utilization	Default
D.2.2.10 Growth Factor = Flow Scale	100%
D.2.2.11 Practical Degree of Saturation	85%
D.2.2.12 Lane Width for single lane roundabouts	4.3m
D.2.2.13 Platooning = Extra Bunching	Per guidelines of the program

A.2.3 Sidra Intersection Output Evaluation Criteria

The following evaluation criteria were evaluated in the Sidra analyses:

- 1) Queue Length – to ensure the queue at each approach of the roundabout will not spill past the interchange ramp or adjacent intersection

D.2.4 Sidra Modeling Approach

- 1) Begin with the analysis of a single-lane roundabout
- 2) Verify if the evaluation criteria are met, if not, check if enhancements could be added to the single-lane roundabout to improve operations. Example enhancements includes: channelized right turn, right turn slip lane, roundabout geometry adjustments, etc.
- 3) If none of the enhancements could improve the operations of the single-lane roundabout, evaluate a two-lane roundabout. Verify if the evaluation criteria are met, if not, check if enhancements could be added to the two-lane roundabout to improve operations. Example enhancements includes: channelized right turn, right turn slip lane, roundabout geometry adjustments, etc.
- 4) If none of the enhancements could improve the operations of the two-lane roundabout, a traffic signal should also be evaluated and compared with the roundabout.

Package E - AT Synchro/SimTraffic and Sidra Models – For At-Grade Intersections

E.1 Synchro/SimTraffic and Sidra Files – for At-Grade Intersections [Note to Proponents: the most current files are posted in the Electronic Data Room. The Department will insert the list of files at SR2B, or later with the agreement of the Successful Proponent, into the above table for identification purposes.]

The names of the Synchro/SimTraffic and Sidra files are as follows:

Intersection No. [Intersection Location]	Stage 1 Synchro Models		Ultimate Lanes Stage Models
	2035	2050	
01 [37 Street SW /Strathcona St & Grey Eagle Dr]	01-SWCRR-STG1-35-AM 01-SWCRR-STG1-35-PM	01-SWCRR-STG1-50-AM 01-SWCRR-STG1-50-PM	01-SWCRR-ULT-50-AM 01-SWCRR-ULT-50-PM
02 [Highway 8 & Lott Creek Boulevard]	02-SWCRR-STG1-35-AM 02-SWCRR-STG1-35-PM	Not applicable	Not applicable
03 [Highway 8 & 101 Street SW]	03-SWCRR-STG1-35-AM 03-SWCRR-STG1-35-PM	Not applicable	Not applicable
04 [Highway 22 & 53 Street SW/112 Street]	04-SWCRR-STG1-35-AM 04-SWCRR-STG1-35-PM	04-SWCRR-STG1-50-AM 04-SWCRR-STG1-50-PM	04-SWCRR-ULT-50-AM 04-SWCRR-ULT-50-PM
05 [90 Avenue SW & Southland Drive SW]	05-SWCRR-STG1-35-AM 05-SWCRR-STG1-35-PM	05-SWCRR-STG1-50-AM 05-SWCRR-STG1-50-PM	05-SWCRR-ULT-50-AM 05-SWCRR-ULT-50-PM

The Synchro/SimTraffic, and Sidra filename nomenclatures are as follows:

XX - SWCRR - Stage - Horizon - AM / PM

Where:

Stage	STG1	Stage 1
	ULT	Ultimate Stage
Horizon	35	2035 Horizon
	50	2050 Horizon
AM /PM	AM	AM Peak Hour
	PM	PM Peak Hour

E.2 Synchro Background Files Linkages

The directions for linking Synchro Files to their respective intersection Background image files are provided in this section.

- 1) The intersection Background image files should be kept in a subfolder folder located on the local hard drive (e.g. "C:\SWCRR Backgrounds"). This allows the simulation files to be located anywhere on the computer, and the link to the intersection Background image files will still be accessible (i.e. properly linked) to the Synchro programs.
- 2) To link the intersection Background image files (jpeg files) to a Synchro file, the following steps are required. (The **highlighted** words correspond to keystrokes within the Synchro program)
 - a) **"File"**, **"Select Backgrounds"**
 - b) **"Remove"** linkage to any existing jpegs.
 - c) **"Add"** linkage to the appropriate jpeg file, using the file requestor.
 - d) Double-click on the any of the parameters to open the "Set Bitmap Scale & Offset" window.
 - e) Set the World Coordinates to match those found at the "X" on the background jpeg image. The X-coordinate is the smaller number. Use a negative number if it is negative on the jpeg. The numbers are typed into the World Coordinate boxes.
 - f) To Set the Bitmap coordinates, press the **"Find"** button, and then click on the center of the "X". Zooming in on the "X" will be necessary.
 - g) Set Scale to **XXXm = XXX** pixels
 - h) Select **"OK"**, and the background should be visible behind the Synchro Link / Node file. If not, go through the steps again.

Package F – Traffic Signals

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1.0 Introduction

This document was developed to provide a consistent, rational and effective approach for the design, construction and operation of traffic signals within the Province's component of the Southwest Calgary Ring Road project.

Traffic signal equipment for the Southwest Calgary Ring Road project shall be consistent in design, manufacture and installation for all intersections within the project. Equipment shall be selected from the Province's Products List and substitutions shall not be permitted without prior written authorization from Province.

1.1 Design

The following key elements are included within the document:

- Selection of signal displays, detection systems, controller and cabinet, signal hardware;
- Determination of equipment location;
- Preparation of the electrical design;
- Determination of traffic signal timings;
- Identification of operational and maintenance documentation requirements;
- Guidance for the commissioning of the traffic signals; and
- Guidance for the operation of the traffic signals.

According to the *Traffic Safety Act* (Alberta), the Minister of Transportation has authority and control over all traffic control devices placed on provincial highways in Alberta. The Minister in turn may enter into an agreement with other service authorities to operate and maintain traffic control devices on provincial highways, but the devices are still under management and control of the Province. All traffic signals, signs, pavement markings and delineation should be installed in accordance with the guidelines and standards adopted by AT.

This document shall be used in conjunction with other guides, manuals and specifications for the planning and design of traffic signals. Key references include:

- Alberta Transportation, Highway Geometric Design Guide, 1999
- Alberta Transportation, Highway Pavement Marking Guide, 2003
- Alberta Transportation, Roadside Design Guide, 2013
- Alberta Transportation, Standard Specifications for Highway Construction, 2013
- Alberta Transportation, Traffic Control Standards
- Alberta Transportation, Highway Lighting Guide, 2003
- Alberta Transportation, Standard Specifications for Highway Maintenance, 2010
- Alberta Transportation, Standard Drawings for Traffic Signals
- Alberta Transportation, Design Bulletins
- Alberta Transportation, Products List
- Transport Canada, Grade Crossing Standards, July 2014
- Transportation Association of Canada, Manual of Uniform Traffic Control Devices for Canada, 2014
- Transportation Association of Canada, Traffic Signal and Pedestrian Signal Head Warrant Handbook, 2014
- Transportation Association of Canada, Advance Warning Flashers: Guidelines for Application and Installation, 2005
- Transportation Association of Canada, Canadian Traffic Signal Warrant Matrix Procedure, 2005
- Transportation Association of Canada, Guide for the Design of Roadway Lighting, 2006
- Transportation Association of Canada, Synthesis of Current Practices for Enhancing Traffic Signal Conspicuity, 2009
- Transportation Association of Canada, Canadian Capacity Guide for Signalized Intersections, 2008
- Institute of Transportation Engineers, Guidelines for Determining Traffic Signal Change and Clearance Intervals: An ITE Proposed Recommended Practice, 2015

- Institute of Transportation Engineers and the International Municipal Signal Association, Traffic Signal Maintenance Handbook, 2010
- Institute of Transportation Engineers, Traffic Signal Timing Manual, 2009
- Including any references within the preceding documents relevant to traffic signal design, construction and maintenance.

1.1.1 . Abbreviations

The following abbreviations are used within this document:

Abbreviation	Description
AISC	American Institute of Steel Construction
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ATSSA	American Traffic Safety Services Association
AWF	Advance Warning Flasher
CEMA	Canadian Electrical Manufacturers Association
CNIB	Canadian National Institute for the Blind
CSA	Canadian Standards Association
CSCE	Canadian Society of Civil Engineers
EEMCA	Electrical and Electronic Manufacturer's Association of Canada
FHWA	U.S. Federal Highways Administration
IMSA	International Municipal Signal Association
ITE	Institute of Transportation Engineers
LED	Light Emitting Diode
MUTCDC	Manual of Uniform Traffic Control Devices (for Canada)
NEMA	National Electric Manufacturing Association
PCS	Pedestrian Countdown Signal
PDC	Power Distribution Cabinet
ROW	Right of Way
TAC	Transportation Association of Canada
TCC	Traffic Controller Cabinet

1.1.2 . Definitions

Any words implying male persons shall include female persons and corporations. Words used in the plural include singular and vice versa.

For the purposes of these specifications, the following definitions apply:

Work Zone – the area extending from the “Construction Ahead” sign to the “End of Construction” sign.

Work Area – the area or location of the actual traffic disruption or hazard. (There may be several Work Areas within the Work Zone)

Traffic Control Devices – are traffic signs, traffic signals, pavement markings, delineators, special crosswalks, flashing beacons, etc.

2.0 Traffic Signal Timing / Phasing / Operation

2.1 Background

2.1.1 Objectives

This chapter presents the typical signal phasing configurations, warrants for left turn and special phasing and guidelines for signal timings. It also includes operational considerations which must be followed in the design, operation and maintenance of traffic signals on provincial highways.

2.1.2 Flash Operation

The highway through phases should flash amber and cross street phases flash red. However, under the following circumstances, the intersection shall flash red in all directions (all-way stop):

- There are protected-prohibited left turns off the highway (including flashing red for the left turn signals);
- There are sight distance restrictions at the intersection;
- The intersection has a high collision rate;
- The side street operation is strategically important and it would operate poorly under a flashing amber / flashing red situation;
- At interchange off-ramp ramp terminal with heavy ramp traffic volumes (to avoid traffic backup into the freeway).

The first order of priority for flash operation shall be safety, followed by operational efficiency.

2.2 Signal Phasing Plan

2.2.1 Alberta Signal Phasing Convention

Figure 1 Signal Phasing Convention illustrates the signal phasing convention required for all traffic signals included in the Project Limits except Service Roads.

Vehicle Through Movements (Even Number)

- Southbound (southwest) – Phase 2
- Westbound (northwest) – Phase 4
- Northbound (northeast) – Phase 6
- Eastbound (southeast) – Phase 8

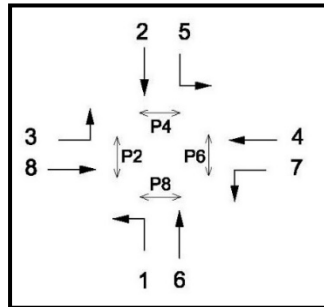
Pedestrian Movements (Even Number)

The pedestrian movements in the crosswalk are positioned to the right of the vehicle movement phase

- | | |
|-----------------------------|-----------------------------------|
| • West Crosswalk – Phase 2 | • Southbound Left Turns – Phase 5 |
| • North Crosswalk – Phase 4 | • Westbound Left Turns – Phase 7 |
| • East Crosswalk – Phase 6 | • Northbound – Phase 1 |
| • South Crosswalk – Phase 8 | • Eastbound – Phase 3 |

Vehicle Left Turn Movements (Odd Number)

Figure 1 Signal Phasing Convention



Traffic signal design shall include the minimum of an 8-phase cabinet with 36 circuits.

2.2.2 . Left Turn Phasing

Left turn phasing shall follow the operational requirements for traffic control signals as identified in the Manual of Uniform Traffic Control Devices for Canada.

2.3 Signal Timing Parameters

Each component of the signal timings has a direct effect on operations and safety at the intersection. The following sections set out signal timing parameters for traffic signals. All phases and components of the signal timings shall be rounded to the nearest tenth of a second (s). The clearance interval should be further rounded up to the nearest 0.5s to promote consistency of intergreen times.

2.3.1 . Intergreen Period

The intergreen period, also known as the signal change interval or vehicle clearance, is defined as the time between the end of green for one phase and the beginning of the earliest green interval for the next phase in the same signal cycle. It usually consists of an amber interval and an all-red period separating potentially conflicting movements. The intergreen period shall be calculated based on the Canadian Capacity Guide for Signalized Intersections.

2.3.2 . Minimum Walk

The timing plans shall accommodate the following minimum walk times:

- 7 s - lightly used intersections
- 10 s - heavily used intersections
- 5 s - very light pedestrian traffic and wide highway

2.3.3 . Pedestrian Clearance Interval

Calculation of the pedestrian clearance interval shall accommodate the following walking speeds:

- 1.2 m/s - typical pedestrian population
- 1.0 m/s - children expected, near playgrounds and schools
- 0.9 m/s - seniors/disabled/visually impaired expected

The pedestrian clearance interval shall terminate prior to the intergreen period.

2.3.4 . Minimum Green

The timing plans shall utilize the following minimum green times:

- 20 s - highway through movements
- 7 s - left turns

- 12 s - side street through movements

2.3.5 . Maximum Green

Maximum green times shall be determined through intersection capacity analysis with a traffic analysis program such as Synchro.

3.0 Signal and Layout Design

This Section provides guidelines and direction for all aspects of a physical traffic signal to achieve consistency with the design, layout and operation of traffic signals designed and constructed for the Project - from the below ground conduit system design to above ground pole selection, signal indications, signing, pavement markings and other signal control related areas.

3.1 Visibility of Traffic Control Signals

Stopping sight distance, decision sight distance, intersection sight distance, signal visibility, conspicuity and cone of vision requirements shall be determined based on standard procedures outlined in the Alberta Transportation and Transportation Association of Canada reference materials.

3.2 Backboards

Backboards shall be provided on all signal heads to enhance the visibility of the signal. Backboards have a dull black finish to enhance the contrast between the signal display and the surroundings. Where additional conspicuity is needed to increase the contrast between the signal head and its surroundings, a strip of yellow retro-reflective tape may be placed around the outside edge of the backboard.

3.3 Programmable Lenses

An optically programmed (or visibility limited) signal head is a lens that limits the field of view of that signal. Another way this is done is with directional LED displays. These options can be helpful to drivers at intersections where:

- There is more than one conflicting signal display may be visible,
- Sun glare may wash out a red indication, and
- There are two closely spaced intersections, such as a tight diamond interchange.

Where optically programmed signal heads cannot be accommodated, louvers (physical visibility barriers) may be used to limit the visibility of the signal head. One concern with louvers is that if the signal is moved by the wind or knocked out of adjustment (without damage), the display may not be visible from the intended lane / position. If possible, signal design should avoid use of these products.

3.4 Signal Heads

All signal heads shall use 300mm diameter LED signal lenses to enhance the traffic signal display for motorists.

3.5 Roadside Hazards and Clear Zone

Signal poles are potential roadside hazards for errant vehicles leaving the roadway. However, signal poles need to be placed reasonably close to an intersection so the signal mast arm does not exceed 15m in span, and pedestrian pushbuttons on the pole are provided a maximum distance of 5.5m from crosswalk locations.

Signal poles are allowable in the median on 5m stub poles. Longer poles in the median, excepting pole extensions for a median-mounted camera, shall not be used due to the increased danger that a struck and downed pole may become a hazard for opposing traffic.

The placement of active advance warning flasher poles should be located outside the clear zone of the roadway.

Clear zone requirements for traffic signal poles are measured from the closest edge of the through travel lanes to the centre of the traffic signal pole, and are based on posted speed, traffic volume and land use.

Clear zone requirements on provincial highways are defined in the Alberta Transportation Roadside Design Guide.

At urban intersections, it is impractical and often not feasible to meet the clear zone requirements for traffic signal poles at an intersection simply due to the narrower road widths of urban roads; as well as the need to provide accessibility of the pushbuttons to pedestrians. Therefore, the placement requirements for signal poles at an urban intersection are recommended as follows:

- In urban areas where the signal poles are located on raised centre medians, the recommended practice is a minimum offset of 0.75m (measured from the near edge of the pole to the face of curb) and the pole shall be located at least 3.0m from the median nose.
- In urban areas, for locations other than the centre median, the minimum offset is 1.5m; measured from the centre of the pole to the face of curb.
- In urban areas, along higher speed roadways (70 km/h or higher posted speeds), the minimum offset shall be increased from 1.5m to 2.0m; measured from the centre of the pole to the face of the curb.
- Due to concern for secondary collisions, breakaway bases are not recommended for traffic signal cantilever poles. Similarly, the use of barriers can cause problems for pedestrian access to the push buttons on the pole.

3.6 Advance Warning Flashers

Warrant, design and operation of advance warning flashers shall be based on Transportation Association of Canada, Advance Warning Flashers: Guidelines for Application and Installation.

On Alberta highways, typically the posted speed is high and there are a significant number of larger and more heavily loaded highway trucks. Analysis shall consider an average perception-reaction time for motorists of 1.5s, and an average deceleration rate of the vehicle of 1.6 m/s^2 .

3.7 Traffic Signal Pole, Mast Arm and Base

The current Alberta standard for traffic signal poles requires a mast arm mounting height of 6.5m (to the center of the Mast Arm). This requirement will typically provide sufficient flexibility in pole base placements to achieve the 5.8m minimum vertical clearance requirement.

With the minimum signal head mounting height of 5.8m vertical clearance, the signal heads need to be at least 21m in front of the stop line to satisfy the vertical cone of vision criteria.

The maximum heights the pole base shall protrude from the surrounding surface are 50mm on an island and 100mm within the clear zone. Outside the clear zone a maximum protrusion of 300mm may be used if grading limitations are justified.

For advance warning flasher poles, the mast arm mounting height is 7.0m to account for the height of the large overhead Advance Warning Flasher (AWF) signs.

If the height of the signal display has to be increased, then the distance between the signal display and the stop line must be increased to ensure the signal head is within a passenger car driver's cone of vision.

3.8 Rotatable Bases

Rotatable bases shall be included in the design of traffic signals located on over-dimensional load corridors to allow rotation of the mast arm and primary displays out of the way of the over-dimensional load.

3.9 Pedestrian / Cyclist Requirements

All pedestrian signal displays shall be Pedestrian Countdown Signal (PCS) displays.

At intersections with bike lanes, the design shall take into account special detection for cyclists where the signal phasing does not automatically return to the approach with the bike lane. In these circumstances, the designer shall either use detection within the bike lane at the stop bar or a small post with pushbutton located adjacent to the curb at the stop bar, for the cyclist to actuate.

- Where applicable, pole foundations (including at minimum all pushbutton locations) should be adjacent to and flush with concrete sidewalks or asphalt pathways.
- Where concrete sidewalks or asphalt pathways are not available adjacent to a pushbutton location, the hard surfacing of the concrete sidewalk or asphalt pathway shall be extended to provide pedestrian access to the pedestrian pushbutton from the nearest concrete sidewalk or asphalt pathway.

3.10 Pavement Markings

Durable pavement markings shall be used for stoplines, crosswalk lines and track lines (left turn guide lines) for left turns (where they are warranted).

4.0 Base Plan Content

4.1 Field Investigation

Once the initial plan has been established (typically, a 1:500 scale) by either a survey of the area around the intersection or an aerial photograph of the area, it is essential to follow up with a field investigation to identify and confirm any features that are brought into the drawing.

4.2 Intersection Geometry

The base plan shall include at least the following roadway geometrics:

- North Arrow and SWC, NWC, NEC, SEC (identifying SW Corner, NW Corner, NE Corner and SE Corner);
- Street names;
- Right of way (ROW) or property lines;
- Curb lines (or edge of pavement);
- Ramps, sidewalks or pathways;
- Medians and islands;
- Utility lines, poles, power source;
- Any nearby driveways or access points;
- Any sight-line obstructions;
- Any adjacent railway infrastructure; and
- Development in each quadrant (where applicable).

4.3 Traffic Control Features

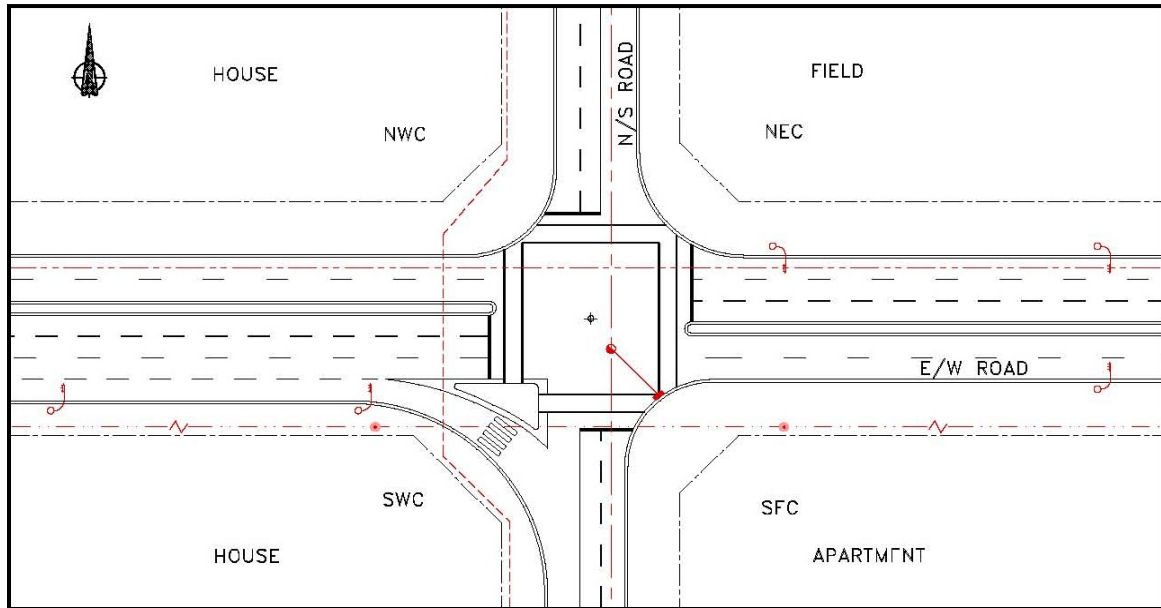
The base plan shall also include at least the following traffic control features:

- Existing pavement markings (locations and dimensions);
- Existing signals (location and operation);
- Existing signs (location and message);
- Turning restrictions;
- Parking restrictions;
- Transit stops and loading zones; and

- Existing speed limits.

Figure 2 Base Plan for Traffic Signal Below Ground Installation Design illustrates a typical base plan for an urban intersection. Prior to initiating the traffic signal design the designer shall ensure that all operational analysis checks have been completed including confirmation that there will be adequate intersection capacity and the geometry of the intersection will be adequate to accommodate the design vehicles.

Figure 2 Base Plan for Traffic Signal Below Ground Installation Design



5.0 Traffic Signal Drawings

The following sections outline the traffic signal drawing requirements. Typically a minimum of four (4) drawings are required:

- Above Ground,
- Below Ground,
- Pole Elevations, and
- Tables and Schedules.

A fifth drawing for Pavement Markings should be used at complex locations.

5.1 Drawing Scales

The standard drawing size for a traffic signal drawing is 559mm x 864mm (22" x 34") when prepared at a scale of 1:250 for Above Ground and Below Ground drawings, and 1:75 for the Pole Elevation drawing. The Tables and Schedules drawing is not set to any particular scale.

Plotted at half size, this will result in a more portable drawing size of 279mm x 432mm (11"x 17"). At this drawing size, the Above Ground and Below Ground drawings will be plotted at a scale of 1:500 whereas the Pole Elevation drawing will be plotted at a scale of 1:150.

The 279mm x 432mm (11"x 17") format will allow all the intersection details to fit onto one sheet for most if not all signalized intersection types, and still keep the design details legible. The general guideline is that key design details and design information in the design drawings, tables and schedules shall be legible when plotted at half scale on 279mm x 432mm (11"x 17") sheets.

6.0 Above Ground Design

The Above Ground Installation design drawing is illustrated in **Figure 3** Traffic Signal - Above Ground Installations and shall include at least the following:

- Pole (with Pole numbers and Mast Arm Reach)
- Cabinets
- All traffic signal related signage (overhead sign alignment with positioning / alignment notes)
- All signal heads and traffic control devices (with phase number, signal head alignment for left turn signals, with positioning / alignment notes)
- Traffic detection zones (number, location, size).
- Location, orientation and mounting position of detection devices such as cameras, detector loops and pedestrian pushbuttons, and
- Sidewalks and pedestrian ramp locations
- Guardrail design (typical design)
- Pavement markings and signs

The above ground installation design will identify:

- logical display of traffic control devices and messages that will meet the expectations of the road users (both drivers and pedestrians)
- all primary signal heads positioned within the most effective cone of vision;
- displays that are consistent with province wide display guidelines;
- cost effective pole sizes;
- sufficient buffer between the travel lanes and the signal poles;
- TCC located away from the immediate intersection impact zone;
- pushbuttons that are accessible to pedestrians; and
- detection zones.

Figure 3 Traffic Signal - Above Ground Installations

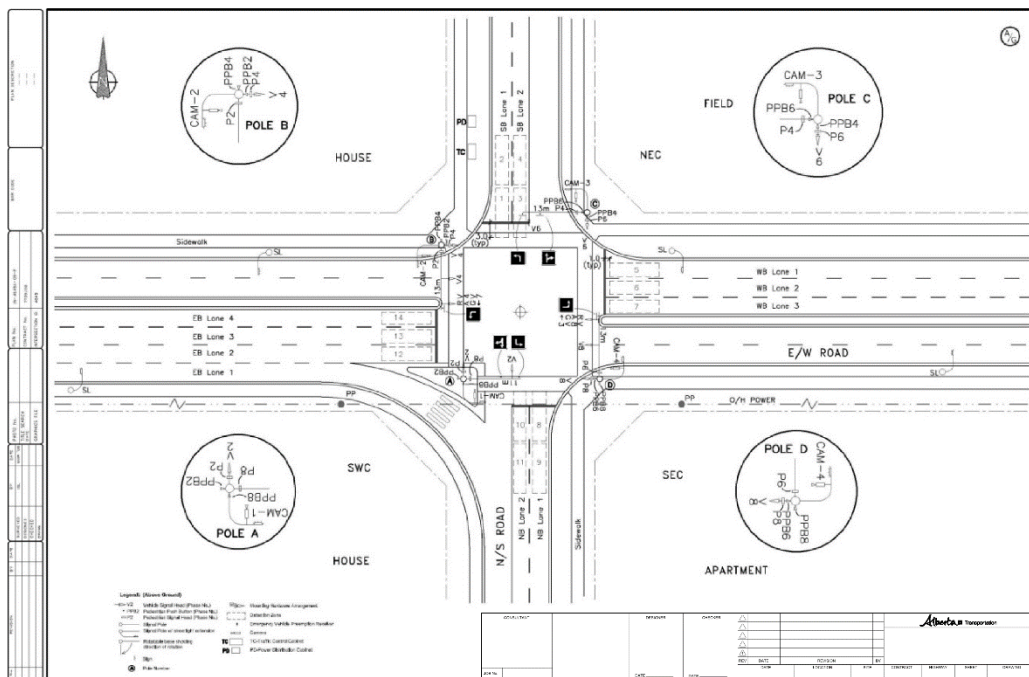
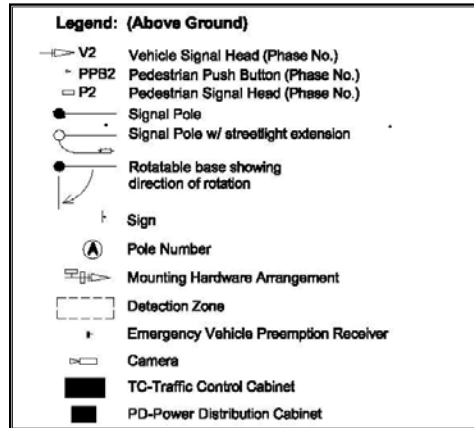


Figure 4 illustrates the legends used for Above Ground Installations drawings.

Figure 4 Legend for Above Ground Installation



6.1 Poles

- Poles shall be located to allow for overhead signal and sign display.
- Label signal head alignment (e.g. CL of EB Lane 1. Numbering of lane is from the lane adjacent to the outside shoulder towards median).
- Pole selection shall be based on standard mast arm lengths of 7m, 9m, 11m, 13m and 15m.
- Poles with mast arm lengths longer than 15m shall be avoided as these poles would require a special bolt circle diameter and/or more than 4 anchor bolts, and therefore would not fit onto the standard pole base anchor bolt pattern.
- Poles shall be labelled in the above ground installation drawing (poles) as well as in the below ground installation drawing (pole bases). The numbering sequence of the poles and pole bases shall be the same, as summarized below:
 - Corner Poles:
 - A – SWC;
 - B – NWC,
 - C – NEC,
 - D – SEC (clockwise)
 - Median Poles:
 - E – South Median;
 - F – West Median;
 - G – North Median;
 - H – East Median (clockwise)
 - AWF Poles:
 - I – North Leg;
 - J – East Leg;
 - K – South Leg;
 - L – West Leg

6.2 Pole Mounted Fixtures

Fixtures to be shown on the Above Ground Plans shall be at least as follows: signal heads; signs; pedestrian signals; pushbuttons; street name signs; video cameras or microwave detectors; radio antenna; streetlight extension; rotatable base with direction of rotation.

- If the fixtures on the poles appear too cluttered, the designer shall add a scaled up detail showing the fixture attachments at the pole.

- All signs – both pole mounted and ground mounted – shall be shown.
- If video cameras are used as the detection devices, the video cameras (CAM) shall be numbered in a clockwise fashion:
 - CAM1 – Southbound Traffic
 - CAM2 – Westbound Traffic
 - CAM3 – Northbound Traffic
 - CAM4 – Eastbound Traffic
- If microwave detectors are used as the detection devices, the microwave detectors (MWD) shall be numbered in a similar clockwise fashion:
 - MWD1 – Southbound Traffic
 - MWD2 – Westbound Traffic
 - MWD3 – Northbound Traffic
 - MWD4 – Eastbound Traffic
- Label the phasing of the signal heads, pedestrian signals, and pushbuttons. Horizontally mounted signal heads shall be labelled with horizontal labelling; likewise, vertical labelling shall be used for vertically mounted signal heads.
- Phasing for vehicle signals shall be labelled as **V**. Phasing for pedestrian signals shall be labelled as **P**. Phasing for pedestrian pushbuttons shall be labelled as **PPB**.
- For 4-section signal heads, the detailed colour and arrangement of the signal head shall be provided (i.e. RAG← or RA←G for horizontal 4-section signal heads; or RRA← or RAG← for vertical 4-section signal heads, etc.).
- If there are AWF poles, details shall be provided for the AWF pole, using drawing insets if necessary.
- The plan view of the pole shall also show the permitted range of the pole rotation as well as the location of the pipe sleeve on the pole for pole rotation purposes.
- All primary and secondary vehicle displays shall be 300 mm diameter.

The phase sequence of the traffic signal dictates the signal display requirements. The phasing requirements in turn determine the signal display needs on the mast arm and the location of the signal poles. The orientation and mounting position of the signal heads, pedestrian signals and pushbuttons shall also be illustrated schematically on the above ground installation drawing.

6.3 Number / Placement of Signal Indications

Standard Through Phase Movements

A minimum of two signal heads (a primary head and a secondary head) shall face each approach of the intersection, including public-use driveways within the intersection.

At typical intersections, the primary signal heads shall be mounted on poles with mast arms suspended over the pavement. The secondary signal head is mounted on the right side on the signal pole trunk.

Where there are two or more receiving lanes, there shall be two primary signal displays mounted on the mast arm.

Where geometric conditions make it necessary, a far left secondary signal head may be used. To minimize confusion to motorists, the far left secondary signal head should be shielded.

Left Turn Phases

For approaches where there are separate left turn lanes, the signal heads shall be vertically mounted on the median pole or the end of the mast arm. For approaches where there is a shared left / through lane, the signal heads shall be horizontally mounted on the mast arm, and left turn lane signs shall be installed left of the signal display.

Protected / Permissive Left Turn Phases

Protected / Permissive Left Turn phases shall utilize a minimum of one signal display. At intersections where the left turn slot is offset from the adjacent through lanes, the one signal display shall be vertically mounted on a median pole centered with the left turn lane (subject to clear zone offset requirements). At narrow cross-section intersections, the one signal display should be horizontally mounted centered over the adjacent through receiving lane. At locations where there is a mixture of protected-permissive and protected-only signal displays, it is required to have a "LEFT TURNS YIELD ON SOLID GREEN" sign (black lettering on white background) installed beside or below the protected-permissive signal head.

Protected / Prohibited Left Turn Phases

Protected / Prohibited Left Turn phases shall utilize a minimum of one signal display (preferably two) with the left turn signal head centered with the approaching left turn traffic. This signal display shall accommodate the appropriate signal sequence (flashing green arrow, followed by yellow ball, followed by a red ball). When protected-only left turn signals are used, a "NO LEFT TURN ON RED" (RB-17L) sign shall be installed beside the protected-only left turn signal head. When a single display is utilized for a protected / prohibited left turn phase, the single display shall provide two red balls.

6.3.1 . Visibility, Shielding, and Positioning of Signal Faces

The primary consideration in signal face placement, aiming, and adjustment shall be to optimize the visibility of signal indications to approaching traffic. Road users approaching a signalized intersection or other signalized area, such as a mid-block crosswalk, shall be given a clear and unmistakable indication of their right-of-way assignment.

Secondary signal heads mounted on a vertical pole shaft shall be positioned so that the bottom of the lowest signal head is 3.0m above finished grade.

On centre median poles, the signal head is vertically mounted so that the bottom of the lowest signal head is 3.5m to 4.0m above finish grade. This provides additional sightline for the signal display to the vehicles in the left turn lane.

The vertical, longitudinal, and lateral position of the signal faces shall be determined by typical driver-eye position in relation to:

- vertical grades,
- horizontal curves,
- obstructions, and
- lateral and vertical angles of sight toward a signal face.

In cases where irregular street design necessitates placing signal faces for different street approaches with a comparatively small angle between their respective signal lenses, each signal lens shall, to the extent practical, be shielded or directed by signal (cone or tunnel) visors, signal louvers, directional LEDs, or other means so that an approaching road user can see only the signal lens(es) controlling the movements on the road user's approach. Where this is not possible, the intersection shall be redesigned to increase the angle between successive legs around the intersection.

The use of signal visors, or the use of signal faces or devices that direct the light without a reduction in intensity, shall be considered as the preferred alternative to signal louvers because of the reduction in light output caused by signal louvers. Other aspects of increasing visibility include:

- **Backboards** shall be used on all vehicle signal indications to improve the contrast and visibility of the signal indication to drivers. Backboards shall be black in colour.
- **Visors** shall generally be used on all vehicle signal indications. Cowl visors should be used in most applications.

- **Auxiliary Signal Head** At locations where visibility of the signal head is restricted or reduced due to intersection width, curved road alignment, or potential sun glare, auxiliary signal heads shall be used to improve the visibility of the signal display.
- **Auxiliary Signal heads for wide intersections** Near-side signal heads should be considered where the primary signal head is more than 45m (MUTCDC) from the stop line, and should be placed as near as possible to the stop line.

6.4 Pedestrian Countdown Signal Head Indications and Locations

All pedestrian crossings shall utilize pedestrian countdown signal displays. Refer to the Alberta Transportation Recommended Practice for Pedestrian Countdown Signals.

Pedestrian countdown signal (PCS) displays shall follow the ITE requirements for the walk and clearance symbols. They shall be mounted lower than traffic signal heads but shall not be lower than 2.5m above the sidewalk. For best visibility to pedestrians, PCS displays shall be placed directly in line with the pedestrian crosswalk which it controls. PCS heads should ideally be located on the vertical pole of the main traffic signal mast arm in each corner of the intersection, however secondary pedestrian display poles shall be used where necessary to provide adequate visibility of the PCS display.

The countdown to zero and Flashing Hand shall be used in all traffic signals as a clearance interval. It warns pedestrians that they should complete their crossing and not enter the crosswalk if they haven't already.

PCS shall be installed in conjunction with vehicular traffic signals wherever pedestrians are expected. They shall be included in the design under the following conditions:

- When pedestrians and vehicles are moving during the same phase and properly adjusted pedestrian clearance intervals are needed to minimize vehicle-pedestrian conflicts;
- When heavy vehicular turning movements require a semi-exclusive pedestrian phase for the protection and convenience of the pedestrian;
- When pedestrian movement on one side of an intersection is permissible while traffic from only one approach is moving;
- When an intersection is so large and complicated or a road so wide that vehicular signals would not adequately serve pedestrians;
- When the minimum green intervals for vehicles at intersections with traffic-actuated controls is less than the minimum crossing time for pedestrians and equipment is provided which extends the green time upon pedestrian actuation (normally by pushbutton);
- When complex phasing operation would tend to confuse pedestrians guided only by traffic signal indications;
- When traffic signal heads using arrows are used;
- When pedestrians cross only part of the road, to or from an island, during a particular phase; and
- When the traffic signal heads fall outside of the normal vision of pedestrians such as at "T" intersections, one-way streets or at large intersections.

Clam-shell style mounting hardware shall be used for PCS displays.

If practical, PCS should be mounted directly behind the sidewalk facing along the crosswalk. Where necessary, the heads may be mounted within 3.0m of the edge of the sidewalk in the crosswalk-facing direction and within 1.5m of the edge of the crosswalk laterally. The pedestrian head shall not be located such that it may be hidden from pedestrians on the other side of the roadway by vehicles at the stop line.

6.4.1 . Pedestrian Countdown Signal Head Layout and Configuration

- The countdown timer shall consist of Portland orange numbers that are at least 135mm in height (220mm lens height) on a black opaque background. The countdown numbers should preferably be "double stroke" to improve visibility, and provide a certain amount of "fail-safe."

- Where the pedestrian enters the crosswalk more than 30m from the far-side countdown pedestrian signal display, the numbers shall be at least 175mm in height (305mm lens height).
- The PCS fixture shall be of bimodal/countdown side by side configuration with solid symbols. The fixtures shall be compliant with the most recent Institute of Transportation Engineers (ITE) Pedestrian Traffic Control Signal Indicators (PTCSI) LED Signal Module Specification.
- The PCS display shall conform to the indications identified by the U.S. Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD).

6.4.2 . Number and Placement

PCS shall be installed at all urban traffic signals where pedestrians can be expected.

It may be possible to eliminate pedestrian crosswalks across certain approaches, such as at interchange ramp terminals where there is no place for the pedestrians to go, or on the side of the intersection which receives left turning traffic from the ramp terminal. Such restrictions must be supported by proper signing (RB-66, RB-66T).

6.4.3 . PCS Countdown Timing Strategy

The display of the number of remaining seconds in a PCS shall begin only at the beginning of the flashing HAND interval. After the countdown has terminated, that portion of the display shall remain dark until the beginning of the next countdown.

The PCS shall display the number of seconds remaining until the termination of the flashing HAND interval. Countdown displays during the walk interval shall not be used.

Under vehicle actuated control, if the vehicle green phase is extended longer than the walk and flashing HAND durations, the countdown portion of the display shall remain dark with the steady HAND display for a certain duration until the onset of the next flashing HAND display.

If the PCS is used for a pedestrian phase without a concurrent vehicle phase, the PCS shall display the number of seconds in the pedestrian clearance period minus a duration equivalent to the intergreen period, such that the countdown's zero point is reached some seconds prior to the green light being displayed to conflicting vehicle traffic.

6.4.4 . Pedestrian Pushbuttons

The use of PCS shall require pedestrian pushbuttons at pedestrian actuated traffic signals. Pedestrian pushbuttons shall be located with the following guidelines:

- Installed on the "through sidewalk" side of the pole (instead of the road / traffic side of the pole);
- Easy pedestrian / wheelchair access on hard surfacing;
- Installed perpendicular to the crosswalk, within 5.5m of the edge of the crosswalk;
- Mounting height of the pushbutton 1.0m above surrounding ground; and
- Installed with a (ID-21-L/R) sign, mounted perpendicular to the main road with the arrow pointing to the crossing direction, mounted above the pushbutton.

6.5 Signs and Markings

Signs and markings are an integral part of traffic signal design and shall be included and shown on the traffic signal drawings. Signs are typically shown on the Above Ground Installations drawing, whereas pavement markings are shown on both Above and Below Ground drawings as an integral part of the intersection base plan.

Examples of traffic signal related signs to be included are:

- Overhead lane designation signs (on mast arm),
- Lane designation signs (on signal poles),
- Stop line signs,

- Advance warning flasher signs,
- NEW SIGNAL signs (placed 100 to 250m upstream of the intersection),
- Street name signs, and
- Any other signs that are on the signal poles or the stop line sign posts.

Existing signs shall be labelled “EXISTING” or “EX”.

6.6 Detection Design

The Above Ground Installations Drawing illustrates the design for the detection zones. The detection design is based on requirements for various approach / road types and the type of left turn signal phasing.

The Detector Design on the Above Ground Installations drawing shall include the following information:

- Detection Zones (detection zone number, shape, size and location, detector call phase, settings for locking and delays)
- Above Ground Detectors, if used (detector number, aiming alignment)

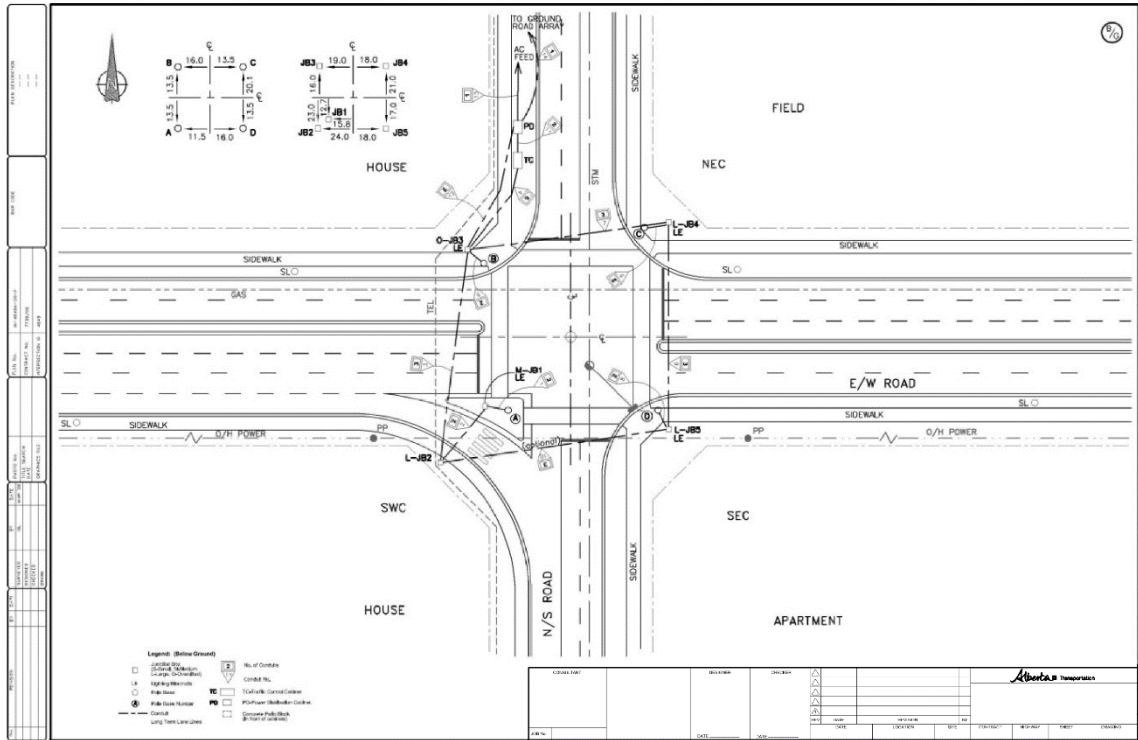
The numbering of the detection zones shall start from Lane No 1 of the southbound lanes (or Phase 2), and be assigned lane by lane in a clockwise fashion. If there are two detection zones in a lane, the front detection zone shall be numbered first.

7.0 Below Ground Design

The Below Ground design drawing is illustrated in **Figure 5** and shall include at least the following information:

- Pole bases (with Pole numbers)
- Cabinet bases (with labelling)
- Junction Boxes (with Junction Box Number, Grounding / Lightning Electrode needs, size)
- Conduits (size, quantity, Conduit Number)
- Power Source location
- Layout information for the main pole bases and main junction boxes
- All underground utilities,
- Overhead utilities such as streetlights, power poles, power lines, etc.

Figure 5 Below Ground Design



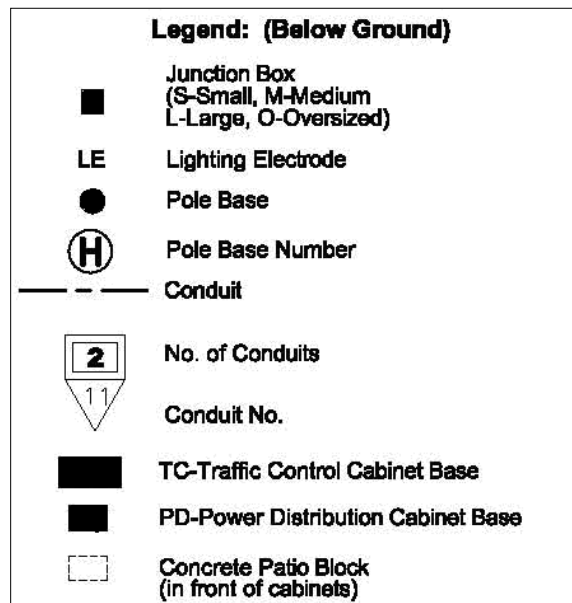
Crossing permit applications are required where traffic signal cable crosses over most utilities. The designer must contact the applicable utility company to determine the exact documentation requirements for the crossing permit application.

A cautionary note related to work around underground utilities shall be inserted in the drawing, with wording similar to:

“Contractors shall contact Alberta One Call and, if needed the utility companies, to confirm the actual utility locations. Final location of all underground utilities to be verified by utility locators. Pole bases within 2.0 metres of existing utilities shall be excavated by hydrovac method or equivalent. Expose all utilities that are within 1.0 metres of underground installations to confirm exact location.”

The following legends (**Figure 6**) shall be used at minimum for Below Ground Installations drawings.

Figure 6 Legend for Below Ground Installation



7.1 Conduit Design

Underground conduit design shall consider the following:

- Conduit shall be designed in a complete conduit ring around the intersection. At least 2-50mm conduits shall be used for cross-road conduit runs, terminated in corner junction boxes. Additional conduits are included where necessary to meet cabling requirements.
- A minimum of 2-50mm conduits shall be used between pole bases and the adjacent junction boxes. Additional conduit are required for signal poles that include streetlights.
- 2-50mm conduits shall be used between the traffic controller cabinet (TCC) and the power distribution cabinet (PDC).
- 1-50mm conduit shall be used between the PDC and the power source.
- 2-50mm conduits shall be used between the PDC and the adjacent junction box for housing the streetlight cables (Note: This allows the streetlight cable to be connected directly to the signal poles without routing through the TCC).
- A minimum 1-50mm conduit shall be used to connect to the junction box beside the advance warning flasher (AWF) pole
- All conduits shall be labelled and numbered on the drawing. Conduit numbering begins with the conduit run for Pole A, from the pole to the TCC, then Pole B, etc. The number of conduits in the conduit run shall be shown on the plan.
- A minimum of 6-50mm conduits shall be provided between the TCC and the junction box adjacent to it (main cabling run) for a typical 4 pole traffic signal intersection.
- A minimum of 8-50mm conduits shall be provided between the TCC and the junction box adjacent to it (main cabling run) for a large 8 pole traffic signal intersection (e.g. 4 corner poles, 2 median poles, and 2 AAWF poles).
- Flexible conduits or polytubes may be used between poles and adjacent junction boxes.
- Guidelines for conduit requirements are summarized in **Table 1** below.

Table 1 Conduit Requirements

Application	No of Conduits Needed	Size (mm)	Type
Minor Road Crossing	2 (Minimum)	50	HDPE
Major Road Crossing	3 (Minimum), 4 (if streetlight cable included)	50	HDPE
Main Pole to Junction Box	2 (Minimum); 3 (if the streetlight davit is on the signal pole)	50	Flexible or Polytube
Minor Pole to Junction Box	1	50	Flexible or Polytube
TCC to PDC	2	50	HDPE
PDC to Power Source	1	50	Black Rigid PVC
TCC to AWF Pole	1	50	Polytube or HDPE
TCC to adjacent Junction Box (Main Run)	6 (Minimum) 8 (for larger traffic signals with additional median poles and AAWF poles)	50	HDPE

Conduit design and construction requirements shall conform with the specifications for Underground Electrical Conduit and Traffic Signals in the Alberta Transportation Standard Specifications for Highway Construction, Edition 15.

7.2 Junction Boxes

When locating junction boxes the designer shall avoid the following locations:

- low areas where water may collect inside the box and
- within sidewalks or pathways, as they become potential tripping hazards.

Junction boxes shall be used in the following situations:

- Wherever conduit run exceeds approximately 150 m in length;
- Beside a signal pole for grounding purposes via lighting electrodes (LE); and
- To avoid sharp bends on the conduit run alignment.

Junction boxes shall be labelled and numbered on the drawing. Junction box numbering starts from the southwest corner of the intersection (SWC) and continues clockwise. Junction box labelling shall also show size of the box (S - Small, M – Medium, L - Large, O - Oversize) and the presence of lightning electrodes (LE). The minimum dimension and depth of the various junction boxes and the criteria for selection of junction boxes of various sizes are summarized in **Table 2**.

In a rural situation with median traffic signal poles, junction boxes shall be placed in the median to provide access to the signal poles.

Table 2 Junction Box Sizes

JB Type	Width (mm)	Length (mm)	Depth (mm)	Maximum No. of Conduits (no Lightning Electrodes)	Maximum No. of Conduits (with Lightning Electrodes)
Small (S)	300 (12")	300 (12")	300 (12")	3	2
Medium (M)	330 (13")	600 (24")	300 (12")	8	6
Large (L)	430 (17")	760 (30")	450 (18")	12	10
Oversized (O)	600 (24")	910 (36")	450 (18")	20	18

Junction boxes shall be precast of approved plastic or poly-concrete material. The boxes shall have removable covers equipped with cap screws and threaded holes to facilitate removal of the cover. All covers shall be made of an approved poly-concrete material and capable of supporting heavy loads of 20 kN or more. Metal lids shall not be accepted.

7.3 Traffic Controller Cabinet

The traffic controller cabinet (TCC) shall be located in accordance with the following principles:

- Strict attention shall be paid to the principles of good grounding and relative freedom from interference from overhead power lines;
- In areas of 80 km/h posted speed or greater, a TCC offset of 10 m from the edge of pavement is desirable (an offset of 6 m is the absolute minimum).
- The TCC location shall not interfere with storm water flows in ditches,
- The intersection approaches should be visible from the TCC site;
- The traffic signal displays on at least two conflicting directions shall be visible from the TCC location.
- Electric and traffic signal maintenance staff should be consulted as to their preference of TCC orientation (facing oncoming traffic, or facing the intersection);
- The TCC location shall be less than 75m from the power supply, and it is desirable to have the controller more than 11m from the power supply pole due to the possibility of a double knock-down upon vehicle collision;
- The TCC location must not interfere with the sight lines of the drivers; and the controller location should consider proposed or existing landscaping; and.
- The TCC base shall have two sidewalk patio blocks placed in front of the cabinet door to provide a level area for operations personnel to work inside cabinets.

Traffic signal cabinets shall be P-44 size and include:

- Colour Liquid Crystal Display (LCD) Video Monitor (minimum size 10")
- Global Positioning System (GPS) Clock to update to the traffic controller time.
- Uninterruptable Power Supply (UPS) system including batteries capable of seven (7) hours operation with a 500 W load.
- Traffic signal controller, and
- All required components for a complete and functioning traffic signal cabinet.

Traffic signal equipment for the Southwest Calgary Ring Road project shall be consistent in design and manufacture for all intersections within the Project Limits.

7.4 Wiring

The wiring for traffic signals shall be designed to minimize the requirement for splicing. Each signal pole shall have a separate multi-conductor signal cable which runs continuous from the TCC to the signal pole hand-hole. Splicing shall only occur inside the pole hand-hole. The minimum multi-conductor size to use for the main cantilever signal poles is 16-conductor, No. 14 American Wire Gauge (AWG) (standard). This cable provides full flexibility for adding a full complement of vehicle and pedestrian phases at each pole to accommodate future changes, if and when required. Median poles that have a single signal head, or other poles that have a single head, may only require a 7-conductor cable.

In locations where camera detection is used or may be considered in the future, the recommended minimum signal cable is a 19-conductor, No. 14 AWG cable. This cable size provides three additional conductors which may be used for camera wiring.

If the design incorporates inductive loop detection, each inductive loop shall have a separate lead-in cable back to the TCC to maximize the functionality of separate inputs into the traffic controller.

7.5 Power Distribution Cabinet

The power distribution cabinet (PDC) shall be located in accordance with the following principles:

- The cabinet may be located on a ground-mounted pedestal designed for that purpose;
- The PDC may be mounted on a separate pole suiting the purpose and may be fed aerially or underground.
- The PDC shall have an electrical energy meter;
- The PDC shall be within 75m of the TCC and should be visible from both the TCC and the roadway;
- The PDC should also be located at least 11.0m from the TCC and at least 11 m from the nearest traffic signal pole;
- Ground rods for the PDC shall be installed at least 5.5 m from the TCC and the PDC; and
- The PDC base shall have two sidewalk patio blocks placed in front of the cabinet door to provide a level area for operations personnel to work inside cabinets.

Metering requirements at the PDC are as follows:

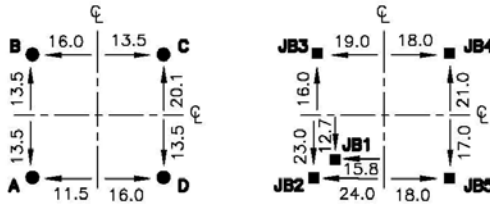
- Meter shall connect to the main power disconnect of the PDC. The meter is not to be installed on the TCC because it invalidates the NEMA and CSA ratings of the cabinet.
- The main power disconnect shall feed an appropriately sized distribution panel with separate breakers for the TCC, streetlights and other required branch circuiting.
- If the PDC is fed at 347/600V, the use of a step down transformer to supply 120/240V to the TCC is permitted. The step down transformer must supply an appropriately sized electrical panel with a dedicated branch circuit to feed the TCC.
- Luminaires installed on the streetlight extension davits on the traffic signal poles shall be powered through the PDC.
- Power to street light luminaires on traffic signal poles shall be fed at 120V unless permanently labelled both inside the cabinet and in the signal pole hand hole as an alternate voltage.

7.6 Layout Information

The design drawings shall provide layout information for the main poles and key junction boxes at the 4 corners. Layout reference is normally to the centerline of the two intersecting roadways, however it can be to the face of curb or island if the curbs or islands are already in place.

Figure 7 Example Layout Information illustrates the layout information required on the Below Ground Installation drawing.

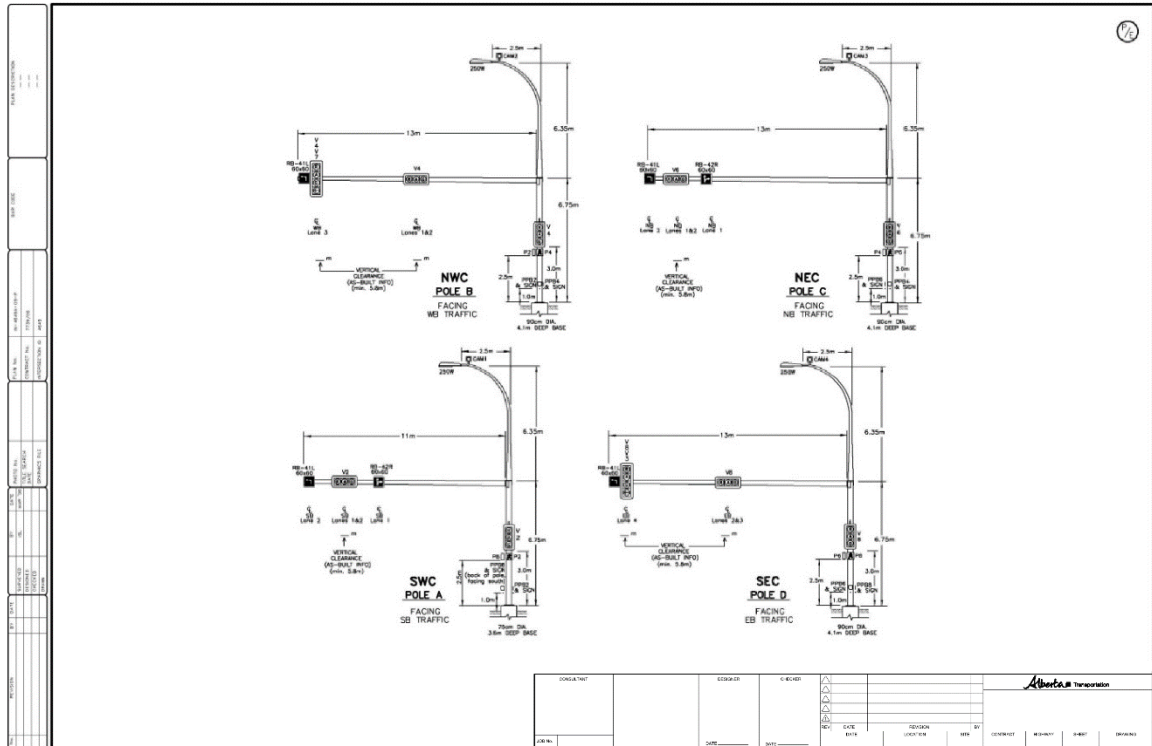
Figure 7 Example Layout Information



8.0 Pole Elevations Design

The Pole Elevation design, as illustrated in **Figure 8**, shall clearly show the location, size and shape of the traffic control devices of the traffic signal design. In addition, it shows the mounting or alignment requirements of the overhead traffic control devices mounted on the mast arm of the signal pole. It also shows information such as pole base type and sizes, pole anchor bolt dimensions (bolt circle diameter, or BCD), streetlight davit orientation, mounting position of traffic cameras, and mounting height of traffic signal heads, pedestrian signal heads and pedestrian pushbuttons.

Figure 8 Traffic Signal – Pole Elevations



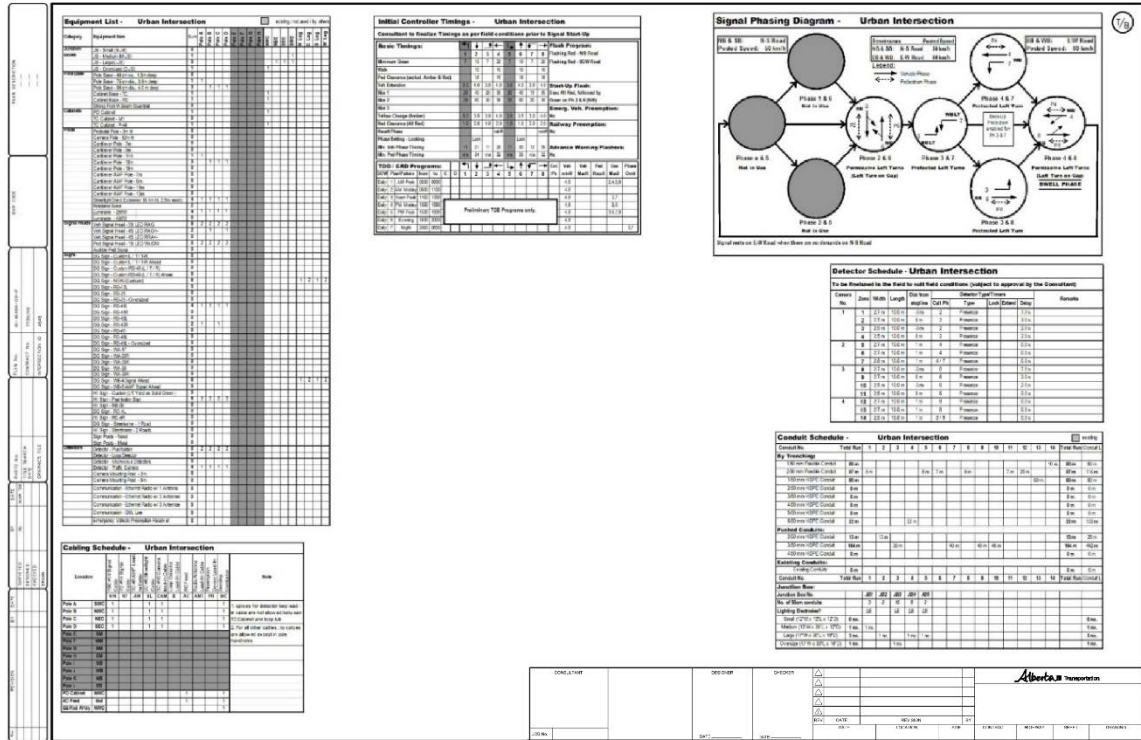
The Pole Elevation drawing shall provide at least the following information:

- Scaled (1:75) representation of a front elevation view of all signal poles with all pole mounted traffic control devices including signal heads, signs, pushbuttons, video cameras, luminaires and radio antennae;
- Dimensions for mast arm, streetlight davit, sign placement, alignment and mounting heights for vehicle and pedestrian signal heads and pushbuttons, as well as the vertical clearance of the overhead traffic control devices (as-built information);
- Sign sizes, sign number, signal head phasing and lenses positioning;
- Mounting location and aiming direction of cameras and radio antennae;
- Pole number, direction of facing traffic, and quadrant where pole is located;
- Pole base size (depth, diameter and BCD);
- Rotatable base (if needed); and
- Location and placement of pipe sleeves used for pole turning (where a rotatable base is used)

9.0 Tables and Schedules

The Table and Schedules drawing is illustrated in **Figure 9** and shall provide crucial information on signal phasing, signal timings (initial timings), cabling requirements, detection setting requirements, conduit schedule, as well as an equipment list.

Figure 9 Urban Traffic Signal – Tables and Schedules



9.1 Design Tables and Schedules

The Tables and Schedules drawing shall include at least the following information:

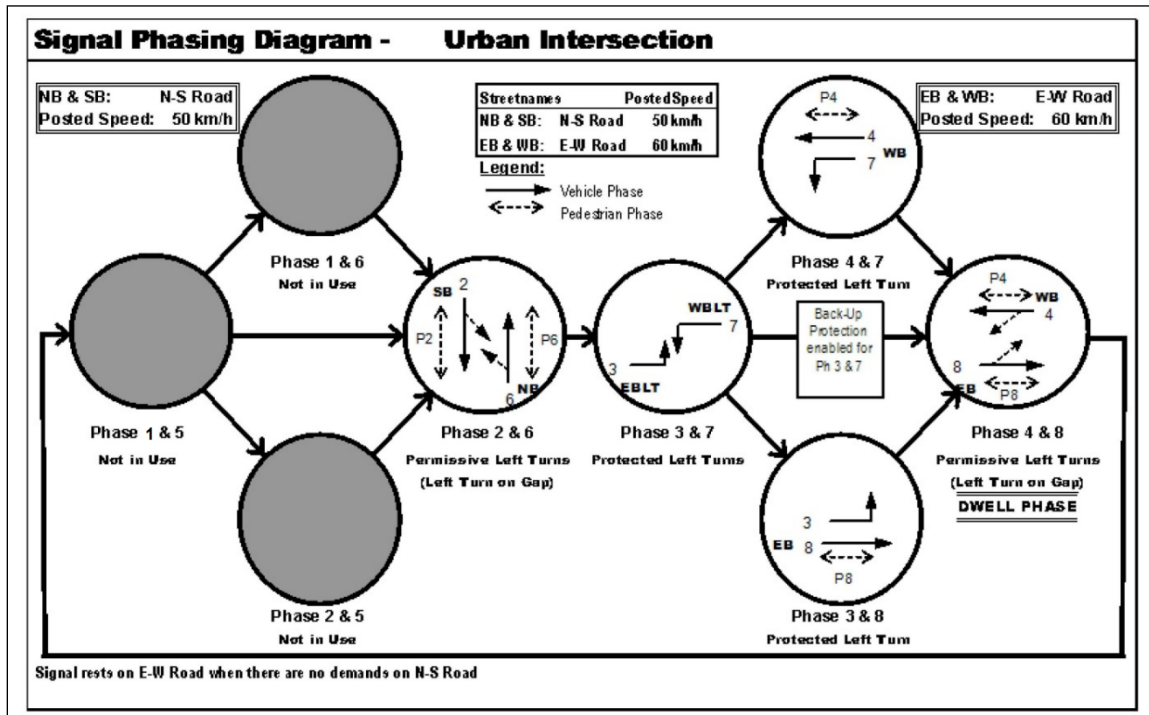
- Signal Phasing Sequence Schedule;
- Initial Controller Timings Table;
- Detector Schedule;
- Conduit Schedule;
- Equipment List Table; and
- Cabling Schedule.

9.2 Signal Phasing Sequence Schedule

The Signal Phasing Sequence Schedule (Figure 10) shall provide the following information at minimum:

- Signal phasing numbers and sequence for both vehicle and pedestrian phases (based on convention that southbound movement is Phase 2. Westbound is Phase 4, etc.);
- Posted speeds of both intersecting roads;
- Names of the intersecting roads;
- Left turn phasing type (i.e. protected / permissive or protected / prohibited);
- Advance Warning Flashers timing;
- Phase recall design (i.e. which road is the green signal resting on); and
- Needs for signal coordination, signal communication, or pre-emption.

Figure 10 Signal Phasing Diagram



9.3 Initial Controller Timings Table

The Initial Controller Timings Table (Figure 11) shall provide the following information at minimum:

- A note stating the timings are initial timings only, subject to field adjustment following signal start-up;
- Information (as-built) stating the make and model number of the traffic controller;
- Pre-commissioning flash program;
- Flash programming (emergency flash);
- Start-Up Flash Programming;
- Emergency Vehicle / railway pre-emption (present or not);
- Advance Warning Flashers (present / not, timings);
- Basic Timings (including min green, walk, ped clearance, veh extension, Max1, Max2, Max3, Yellow Change, Red Clearance, Recall Phase, Min Veh Phase timing, Min Ped Phase timing);
- Phase Recall setting;
- Phase Locking setting; and
- Time of Day (TOD) Program setting (including program number, program start / finish time, min recall phase, max recall phase, ped recall phase, Max2 enable phase, Phase omit).

Figure 11 Initial Signal Timings

Initial Controller Timings - Urban Intersection																		
Consultant to finalize Timings as per field conditions prior to Signal Start-Up																		
Basic Timings:						Flash Program:												
	←	↓	↑	←	↓	↑	→											
	1	2	3	4	5	6	7											
Minimum Green	7	15	7	20	7	15	7	Flash Program:										
Walk		10		10		10		Flashing Red - N/S Road										
Ped Clearance (exclud. Amber & Red)		18		16		18		Flashing Red - 9E/W Road										
Veh Extension	3.0	4.0	3.0	4.0	3.0	4.0	3.0	Start-Up Flash:										
Max 1	20	40	20	30	20	40	15	5 sec All Red, followed by										
Max 2	25	50	30	35	25	50	20	Green on Ph 2 & 6 (N/S)										
Max 3								Emerg. Veh. Preemption:										
Yellow Change (Amber)	3.0	3.5	3.0	4.0	3.0	3.5	3.0	No										
Red Clearance (All Red)	1.0	2.0	1.0	2.0	1.0	1.0	2.0	Railway Preemption:										
Recall Phase				minR			minR	No										
Phase Setting - Locking		Lock				Lock												
Min. Veh Phase Timing	11	21	11	26	11	20	12	Advance Warning Flashers:										
Min. Ped Phase Timing	n/a	34	n/a	32	n/a	33	n/a	No										
TOD / CRD Programs:																		
DOW	Plan/Pattern	from	to	C	O	←	↓	↑	←	↓	↑	→	Crd Ph	Veh minR	Veh MaxR	Ped Recall	Use Max2	Phase Omit
Daily	1 AM Peak	0630	0930											4,8			2,4,6,8	
Daily	2 AM Midday	0930	1100											4,8				
Daily	3 Noon Peak	1100	1330											4,8			3,7	
Daily	4 PM Midday	1330	1530											4,8			2,6	
Daily	5 PM Peak	1530	1830											4,8			3,4,7,8	
Daily	6 Evening	1830	2000											4,8				
Daily	7 Night	2000	0630											4,8				3,7

9.4 Detector Schedule

The Detector Schedule (Figure 12) shall provide the following information at minimum:

- Detector number (camera, microwave, or loop number);
- Detection zone number;
- Detection zone size (width, length);
- Detection zone position (distance forward to the stop line); and
- Detector Type / Settings (delay timer, remarks) (Note: It is not advisable to program in Lock and Extend setting at the detector level or at the detector amplifier. The Lock and Extend Settings should be programmed in the controller under phase timing setting instead.)

Figure 12 Detector Setting Schedule

Detector Schedule - Urban Intersection										
To be finetuned in the field to suit field conditions (subject to approval by the Consultant)										
Camera No.	Zone	Width	Length	Dist from stopline	Detector Type/Timers					Remarks
					Call Ph	Type	Lock	Extend	Delay	
1	1	2.7 m	10.0 m	-3 m	2	Presence			7.0 s	
	2	2.7 m	10.0 m	8 m	2	Presence			3.0 s	
	3	2.5 m	10.0 m	-3 m	2	Presence			2.0 s	
	4	2.5 m	10.0 m	8 m	2	Presence			2.0 s	
2	5	2.7 m	10.0 m	1 m	4	Presence			0.0 s	
	6	2.7 m	10.0 m	1 m	4	Presence			0.0 s	
	7	2.5 m	10.0 m	1 m	4 / 7	Presence			0.0 s	
3	8	2.7 m	10.0 m	-3 m	6	Presence			7.0 s	
	9	2.7 m	10.0 m	8 m	6	Presence			3.0 s	
	10	2.5 m	10.0 m	-3 m	6	Presence			2.0 s	
	11	2.5 m	10.0 m	8 m	6	Presence			2.0 s	
4	12	2.7 m	10.0 m	1 m	8	Presence			0.0 s	
	13	2.7 m	10.0 m	1 m	8	Presence			0.0 s	
	14	2.5 m	10.0 m	1 m	3 / 8	Presence			0.0 s	

9.5 Conduit Schedule

The Conduit Schedule (**Figure 13**) shall provide the following information at minimum:

- Conduit number;
- Conduit type, quantity and length;
- Conduit installation method (trench vs. push);
- Conduit lengths (individual runs and total trenched / pushed lengths by type);
- Junction box number;
- Junction box size and lightning electrodes quantity;
- Number of conduits terminating at the junction box; and
- Junction box quantity by type.

9.6 Cabling Schedule

The Cabling Schedule (**Figure 14**) shall provide the following information at minimum:

- Pole number where signal cables are terminating to;
- Cabinet type where cables are terminating to; and
- Cable type by function (e.g. main signal cable run, secondary signal cable run, advance warning flasher cable, streetlight cable, detector lead-in cable, AC Feed cable, radio antenna cable, pre-emption devices lead-in cable, bonding conductor cable).

Figure 13 Conduit Schedule

Conduit Schedule - Urban Intersection																existing	
Conduit No.	Total Run	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Run	Conduit L
By Trenching:																	
1-50 mm Flexible Conduit	80 m														10 m	80 m	80 m
2-50 mm Flexible Conduit	57 m	6 m				6 m	7 m		6 m			7 m	25 m			57 m	114 m
1-50 mm HDPE Conduit	80 m													80 m		80 m	80 m
2-50 mm HDPE Conduit	0 m															0 m	0 m
3-50 mm HDPE Conduit	0 m															0 m	0 m
4-50 mm HDPE Conduit	0 m															0 m	0 m
5-50 mm HDPE Conduit	0 m															0 m	0 m
6-50 mm HDPE Conduit	22 m				22 m											22 m	132 m
Pushed Conduits:																	
2-50 mm HDPE Conduit	13 m		13 m													13 m	26 m
3-50 mm HDPE Conduit	164 m			38 m				40 m		40 m	46 m					164 m	492 m
4-50 mm HDPE Conduit	0 m															0 m	0 m
Existing Conduits:																	
Existing Conduits:	0 m															0 m	0 m
Conduit No.	Total Run	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Run	Conduit L
Junction Box:																	
Junction Box No.		JB1	JB2	JB3	JB4	JB5											
No. of 50cm conduits		3	8	16	8	8											
Lighting Electrodes?		LE		LE	LE	LE											
Small (12"W x 12"L x 12"D)	0 no.																0 no.
Medium (13"W x 24"L x 12"D)	1 no.	1 no.															1 no.
Large (17"W x 30"L x 18"D)	3 no.		1 no.		1 no.	1 no.											3 no.
Oversize (17"W x 30"L x 18"D)	1 no.			1 no.													1 no.

Figure 14 Cabling Schedule

Cabling Schedule - Urban Intersection													
Location		16C #14 Signal Cable	7C #14 Signal Cable	3C #8 AWF Lead-In Cable	2C #8 Streetlight Cable	3C #16 Camera lead-In Cable	Loop Detector Lead-In Cable	AC Feed	Radio Antenna Lead-In Cable	Preemption Device Lead-In	Bonding Conductor	Note	
		S16	S7	AW	SL	CAM	B	AC	ANT	PR	BC		
Pole A	SWC	1			1	1					1	1. splices for detector loop lead-in cable are not allowed between TC Cabinet and loop tub 2. For all other cables, no splices are allowed except in pole handholes	
Pole B	NWC	1			1	1					1		
Pole C	NEC	1			1	1					1		
Pole D	SEC	1			1	1					1		
Pole E	SM												
Pole F	WM												
Pole G	NM												
Pole H	EM												
Pole I	SB												
Pole J	WB												
Pole K	NB												
Pole L	EB												
PD Cabinet	NWC							1			1		
AC Feed	tbid							1			1		
Gd.Rod Array	NWC										1		

9.7 Equipment List

The Equipment List (Figure 15) shall provide the following information at minimum:

- Cabinet type, quantity by location;

- Pole type, size, quantity by location and pole number;
- Pole base type, size, quantity by location and pole base number;
- Signal head type, quantity by pole number;
- Detectors type and quantity by location/pole number (camera, loop, microwave detector);
- Junction box type, size and quantity by location;
- Sign type, size, quantity by location / pole number;
- Sign post size, quantity by location; and
- Special devices quantity and location (e.g. guardrail, radio antennae, emergency vehicle pre-emption receivers, etc.).

Figure 15 Equipment List

Equipment List - Urban Intersection		existing / not used / by others																
Category	Equipment Item	Sum	Pole A	Pole B	Pole C	Pole D	Pole E	Pole F	Pole G	Pole H	NWC	NEC	SEC	SWC	N Leg	E Leg	S Leg	W Leg
Junction Boxes	JB - Small (S-JB)	0																
	JB - Medium (M-JB)	1																
	JB - Large(L-JB)	3											1	1	1			
	JB - Oversized (O-JB)	1										1						
Pole Base	Pole Base - 40 cm sq., 1.5m deep	0																
	Pole Base - 75 cm dia., 3.6m deep	1	1															
	Pole Base - 90 cm dia., 4.0 m deep	3		1	1	1												
	Cabinet Base - TC	1										1						
	Cabinet Base - PD	1										1						
	Strong Post W-Beam Guardrail	0																
Cabinets	PD Cabinet	1										1						
	TC Cabinet - M1	0																
	TC Cabinet - P-44	1										1						
Poles	Pedestal Pole - 3m ht	0																
	Camera Pole - 12m ht	0																
	Cantilever Pole - 7m	0																
	Cantilever Pole - 9m	0																
	Cantilever Pole - 11m	1	1															
	Cantilever Pole - 13m	3		1	1	1												
	Cantilever Pole - 15m	0																
	Cantilever AWF Pole - 7m	0																
	Cantilever AWF Pole - 9m	0																
	Cantilever AWF Pole - 11m	0																
	Cantilever AWF Pole - 13m	0																
	Streetlight Davit Extension 13.1m ht, 2.5m reach)	4	1	1	1	1												
	Rotatable Base	2																
	Luminaire - 250W	4	1	1	1	1												
	Luminaire - 400W	0																
Signal Heads	Veh Signal Head - 3S LED RAG	8	2	2	2	2												
	Veh Signal Head - 4S LED RAG<-	2		1	1	1												
	Veh Signal Head - 4S LED RRA<-	0																
	Ped Signal Head - 1S LED Wk/DW	0	2	2	2	2												
	Audible Ped Signal	0																
Signs	DG Sign - Custom L / T / TR	0																
	DG Sign - NEW (Sunburst)	6													1	2	1	2
	DG Sign - RB-41L	4	1	1	1	1												
	DG Sign - RB-41R	0																
	DG Sign - RB-42L	0																
	DG Sign - RB-42R	2	1		1													
	DG Sign - RB-45	0																
	DG Sign - WA-38R	0																
	DG Sign - WB-4 Signal Ahead	6													1	2	1	2
	DG Sign - WB-5 AWF Signal Ahead	0																
	HI Sign - Custom (L/T Yield on Solid Green)	0																
	Sign Posts - Wood	0																
Sign Posts - Metal	0																	
Detectors	Detector - Pushbutton	0	2	2	2	2												
	Detector - Loop Detector	0																
	Detector - Microwave Detectors	0																
	Communication - DSL Line	0																
	Emergency Vehicle Preemption Receiver	0																

Example only. Not inclusive of all equipment or signage.

10.0 Signs and Pavement Markings Design

Normally, the extent of signing and pavement marking changes at existing intersections are relatively small and can be incorporated in the Above Ground Plan. Likewise, if the location is a newly-constructed intersection, the Above Ground Plan can normally depict all related signing and pavement markings.

A separate signing and pavement marking drawing shall be prepared if the traffic signal design calls for considerable lane configuration changes, or for intersections with complex intersection lane configurations or which require precise lane markings placement for positioning of detection zones or guidance of left-turning vehicles.

The minimum pavement marking requirements for traffic signal drawings are:

- Stop lines (accurate locations);
- Crosswalks (accurate locations); and
- Left turn guide lines for double left turn lanes and for left turns that require supplementary guidance (e.g. wide, long intersections with tight opposing left turn swept paths)

The minimum signing requirements for traffic signals drawings are:

- Signal stop line signs (RC-107-especially at wide rural intersections with large corner radii and for locations where stop line locations are critical to prevent encroachment of the stopped vehicles into the left turn vehicle swept paths); and
- Signs that are crucial for use in combination with traffic signal displays (e.g. left turn signs adjacent to left turn signal heads, No Left Turn On Red signs adjacent to protected-prohibited left turn signal heads).

Designers shall also refer to Alberta Transportation, TCS-F-501, Typical Placement of Sign and Signal Equipment for placement of overhead lane designation signage.

11.0 Detection Design

11.1 Detection – Highway vs Cross Street Applications

The design of detection zones at highway approaches is different from that at cross street approaches. The following assumes that the signal rests in green/is recalled to the highway approaches.

11.1.1 Detection Zone – Highway Approaches

- For extension of signal phase
- Non-locking setting
- For video cameras, detection zones shall be placed just behind the stopline. Only 1 detection zone is needed per lane
- For loop detectors, detection zones shall be 2m x 2m diamond shaped loops placed 5.0 m behind the stopline (This assumes that there is a recall function programmed to the highway signal phase)
- For microwave detectors, detection zone shall be placed across the approaching lanes

11.1.2 Detection Zone – Cross Street Applications

- Presence detection so that any vehicles stopped within the detection zone will trigger a call.
- For video cameras, detection zones shall be placed 3.0 m before the stopline. A secondary detection zone is also needed at and slightly past the stopline to ensure that adequate presence detector coverage is provided
- For loop detectors, detection zones shall be 5.0 m long and their sides offset 0.5 m from the lane lines / gutter / shoulder lines. A total of 2 loops are needed for each cross street lane – one in front of the stopline and one behind.

- For microwave detectors, the detection zone shall be placed across all approaching lanes, and the detector shall be programmed with a locking setting. In addition, a slightly longer minimum green time is typically required to ensure that a certain minimum vehicle speed can be achieved before the minimum green interval expires.

11.2 Detector Settings

Detectors can be programmed to perform various functions via programming of the traffic controllers.

Loop and video detectors are programmable with a user settable time delay (0 to 15s) feature to allow vehicles to stop, pause and continue without registering a call (as in right turn lanes or protected / permissive leading left turn phases). Microwave detectors are not used if a delay function needs to be programmed for that detection zone.

The correct location and positioning of each detection zone is important if actuated control is to be effective. Good design requires that objects affecting detector performance be taken into account. This includes adjacent parking, manhole covers, transit stops, driveways, busy retail entrances, etc. In the case of video detection, the location and positioning of the camera also needs to be taken into account, such as vehicles in one lane blocking vehicles in another lane (occlusion), lighting conditions, trees, etc.

11.2.1 Delay and Locking Settings

- All detector delay and locking settings shall be programmed in the controller, not on the detector amplifier
- Delay settings shall be programmed in the Detector Setting page in the controller. A delay setting is needed for each detector.
- A detector with a delay setting shall not register a call into the controller until the vehicle is positioned within the detection zone for the prescribed delay time.
- Locking settings shall be programmed in the Phase Setting page in the controller. A locking setting (non-locking or locking) is needed for each signal phase in use.
- A signal phase programmed with locking will “lock” in a call as soon as a call is received. This shall be used for cross-street approaches or for left turn lanes facing a protected-prohibited left turn signal.

11.2.2 Detection Zone – Delay Settings

- Right Turn on Highway – no delay required
- Through movement on Highway – no delay required
- Left Turn on Highway (no left turn signal) – no delay required
- Left Turn on Highway (with left turn signal) – 1 to 2 s of delay to minimize accidental call caused by through traffic on the adjacent lane
- Right Turn on Cross Street – a delay of 5 to 7 s should be initially programmed, subject to field observations and potential adjustments
- Through movement on Cross Street – delay of 2s (to minimize accidental call caused by right turning traffic on the cross street)
- Left Turn on Cross Street – 2 s of delay to minimize accidental call caused by either through traffic on the adjacent lane, or by left turning traffic from highway clipping the cross street detector loops.

11.2.3 Detection Zone – Locking Settings

- Highway – no locking required
- Cross-Street – locking required
- Left Turns (permissive or protected-permissive) – no locking required
- Left Turns (Protected-prohibited) – locking required

11.3 Design of Detection Zones

Detection zones depend on clear travel paths. Lane ambiguity can cause erratic detection operations.

11.3.1 Detection Zone – Video Cameras

- Zones shall be 10.0 m long.
- Sides of the zone shall be offset 0.5m from the lane line or the gutter / shoulder line (larger sometimes in windy areas)
- Avoid vertical lines in the detection zone

11.3.2 Detection Zone – Loop Detectors

- Zones shall be either diamond shaped (2m x 2m) or rectangular shaped (4m long by 2.5m to 2.7m wide, side offset 0.5m from gutter / shoulder line / lane line)

11.3.3 Detection Zone – Microwave Detectors

- Radar detectors for motion sensor type pulse or passage detection
- For major road approaches of an intersection where there are recalls for the traffic signal to rest in green on the major road, the microwave detectors shall be used as pulse detection detectors. The detection zone along the major road should be established by aiming the detector at the centreline of the approach lanes and the detector tilted or adjusted so that vehicles crossing an imaginary line 50m upstream from the microwave detector will trigger detection. This detection trigger point should be no closer than 10 m upstream of the approach stopline.
- For minor road approaches of an intersection where the recall setting is for the traffic signal to rest in green on the major road, a locking setting shall be used in the signal phase setting of the controller for the minor road detectors. This allows the detection call to be locked in even though the approaching vehicle has come to a complete stop in front of the red signal at the minor road. The detection zone along the minor road should be established by aiming the detector at the centreline of the approach lanes and the detector tilted or adjusted so that vehicles crossing an imaginary line no farther than 10 m upstream from the approach stopline. (Note: special caution should be exercised to ensure that there will not be missed calls or dropped calls when using motion sensor style microwave detectors for minor road intersections without recall setting.)

11.3.4 Detection Zone – Infrared Detectors

- For presence or passage types of detection
- The detection zone of a presence detection infrared detector is relatively short in comparison to a radar type microwave detector. As a result, the infrared detectors shall be installed close to the detection zone.
- A relatively sturdy or rigid mounting support is required. (i.e. they shall not be installed on the end of a long mast arm, or on the pole where there is a rotatable base)
- As the operational effectiveness of these detectors are quite sensitive to installation methods and the quality of the installation, it is essential that the detector manufacturer's instruction be accurately followed.
- These detectors are sensitive to environmental conditions and are also somewhat inaccurate in congested situations. They should not be used at high-volume intersections.
- Due to the short range of these detectors, they should be used with caution and are typically limited to minor road applications and also at locations where it is important to achieve presence detection.

11.4 Pre-emption Considerations

11.4.1 Railway Pre-emption

Traffic signals designed and installed in close proximity to railways lines shall be designed and installed based on the Grade Crossing Standards, July 2014 by Transport Canada.

The design method adopted by the Province is the ITE methodology. Transport Canada has published guidelines on the wiring requirements for the interconnection between the railway signaling cabinet and the traffic signal controller.

Most systems are based upon a constant warning time application for interconnection operation. What this means is irrespective of the train speed, the pre-empt request always goes into the controller when the train is X seconds from entering the intersection.

Generally, pre-emption is required if there is the potential of traffic queuing back onto the railway tracks as a result of the traffic signal operations at an adjacent intersection. The design for railway pre-emption needs to provide for the following:

- Hard wire 24VAC normally closed interconnect between the traffic controller and the railway control / relay interface.
- UPS power supply cabinet to maintain power to the LED traffic signals and railway interconnect in the event of a power outage.
- Railway pre-empt interface panel within the controller cabinet. This interface panel is supplied by the traffic control vendor and generally the signal designer does not need to specify anything beyond stating the controller cabinet must be configured for railway pre-emption interface.
- Special blank-out (LED or fibre-optic) signs are required at protected / permissive left turn movements to tell drivers not to turn left when a train is in the railway crossing.

The design for the railway interconnect between the TCC and the railway control / relay interface cabinet should use a 50mm PVC conduit which runs between both cabinets. Inside the conduit, a 3 Pair No. 18 shielded cable provides the required wiring for the relay / controls.

The design for railway pre-emption needs to be reviewed by the railway authority and Transport Canada to ensure each authority is aware of the intended operation and proposed revisions to infrastructure to support the intended operation. Wherever there is a need to do any work within the rail right of way (install conduit, cable, junction box, etc.), a separate railway crossing permit application must be made to the railway authority prior to the work taking place. Each railway company has their own specific requirements for information to be shown on the permit application drawing, but in general, the permit application must include at least the following:

- Site plan showing exact location of railway tracks, railway ROW, location of conduit, boxes
- Profile showing the depth of the conduit below the tracks
- Cross-section of the conduit entrance and exit locations relative to the tracks
- Angle and dimension of the conduit relative to the centre line of the tracks.
- The operating voltage of the cables inside the conduit
- Dimensions of any junction boxes or signal poles closest to the tracks.

11.4.2 Emergency Vehicle Pre-emption

Emergency vehicle pre-emption should be considered if emergency vehicles are consistently having difficulty responding to calls due to the operation of the traffic signals. If approved by the Province, emergency vehicle pre-emption may contain the following design components:

- Pre-emption sensors, associated electronics, cabinet and wiring;
- Isolation relay inside the controller cabinet; and

- Pre-emption indicating lights (optional).

For the Southwest Calgary Ring Road project, all pre-emption equipment and configuration shall meet the City of Calgary's pre-emption requirements. The designer shall contact the City of Calgary to confirm specific equipment and design requirements in these cases.

12.0 Inspection Requirements

The Contractor has the responsibility to verify that the constructed traffic signals are accordance with the drawings and specifications. This is done by conducting inspections at various stages of the project:

12.1 Field Inspection No. 1 – Site Inspection

- Review, confirm and approve preliminary locations of pole bases, junction boxes, and cabinet bases laid out by the contractor. Confirm that the approved pole base locations will result in signal and sign placements in compliance with the design shown on the Above Ground Installations drawing and the Pole Elevations drawing.
- Review, confirm and approve detector loop locations laid out by the contractor.
- Identify bad pavement sections (ruts, cracks) that may affect detector loop installations. Ensure that the detector loop locations are placed away from these bad pavement sections.
- An inspection of the site conditions and shallow utility locations to confirm location of installations of pole bases, junction boxes, conduit alignments, cabinet locations and power source location.
- Confirm all subsurface utilities have been located. Record on the Below Ground Installations drawing the locations and alignments of all previously unmarked subsurface utilities.

12.2 Field Inspection No. 2 – Shallow Utility Inspection

- If necessary, propose design modifications to resolve utility conflict problems.
- Record on the Below Ground Installations drawing the locations and alignments of all previously unmarked subsurface utilities, as well as utilities that were shown in incorrect locations on the drawings.
- Take record photos.

12.3 Field Inspection No. 3 – Below Ground Installations Inspection

- Check for completion of the below ground installation.
- Check that the Power Distribution Cabinet has the electrical permit placed inside.
- Contractor to prepare splices to all detector loops in the presence of the consultant.
- Contractor to carry out loop tests (resistance, inductance, continuity, and megger) and grounding test in the presence of the Owner's Engineer. Results of the tests shall be documented by the contractor and submit to the Owner's Engineer within 3 days after Field Inspection No. 3. Acceptance of the loops is contingent on the receipt of these test results.

12.4 Field Inspection No. 4 – Pre-Commissioning Inspection

- Check if major deficiencies from previous inspections have been rectified
- Check for completion of the above ground installation
- Check for readiness of the traffic signal for full operation
- Check if the controller signal timings (including start-up flash program) are in place and would operate as per design.

12.5 Field Inspection No. 5 – Final Inspection / Signal Start-Up

- Check if major deficiencies from previous inspections have been rectified
- Check for readiness of the traffic signal for full operation
- Check if necessary precautions and tasks (such as removal of barricades, site clean-up) are done before it is safe to be opened up for vehicular and pedestrian traffic
- Check if all regulatory signs and warning signs (including the “NEW TRAFFIC SIGNAL” signs) are in place
- Check if the controller signal timings are in place and would operate as per design.
- Start-up traffic signal for full operation
- Re-check aim of signal heads and pedestrian heads.
- Monitor signal operation including detector operations (both vehicle and pedestrian detectors) and phasing sequences. Adjust or fine-tune signal timings if needed (by the Consultant).
- Contractor to provide the Owner’s Engineer with the controller database (by uploading it in the field just before the Final Inspection is wrapped up). The format of the database shall be usable by database programs such as Aries or Traconet. Text or ASCII file is not an acceptable database format.
- A deficiency list shall be prepared based on deficiencies identified in the final inspection. The list shall provide the dates when the deficiencies are expected to be rectified.

12.6 Controller Cabinet Bench Test Inspection

- The consultant verifies the correct operation of the proposed traffic signal cabinet and program timings.
- Programming of the controller shall be done by the contractor.
- The intent of the bench testing is for the Consultant to witness that the Contractor has correctly followed the steps involved in programming the controller unit and verifying the correct operation of the controller unit. It also allows for burning in of components and to confirm that phasing is correct, and cabinet is built correctly as per the design intent.

12.7 Deficiency Inspections

- Check off the deficiencies from the deficiency list

12.8 Warranty Inspection

- Check site and equipment to identify any damage or premature wear. Identify defects in material or workmanship.
- Review logbook to identify operational issues encountered since start-up.
- Prepare a list of identified warranty issues.

13.0 Maintenance

The Contractor shall be responsible for preventative and reactive maintenance.

13.1 Preventive Maintenance

Preventive maintenance is defined as a set of checks and procedures to be performed at regularly scheduled intervals for the upkeep of traffic signal equipment. It includes inspections; record keeping; cleaning; and replacement based on the function and rated service life of the components. Some of the major tasks include:

- Group re-lamping (less needed due to the use of LED lamps)
- Cleaning signal lenses
- Aligning signal heads
- Vacuuming cabinets/changing air filters

- Inspecting signal poles and mast arms
- Tuning detector amplifiers (older models)
- Inspecting signal controller operations
- Testing conflict monitors
- Checking electrical readings
- Aiming and calibrating detectors

Preventive maintenance is intended to improve the reliability of mechanical and electrical equipment, thereby reducing equipment failures, response maintenance, road user costs, air quality, fuel consumption, accidents, and liability exposure due to operational failure.

Preventive maintenance is commonly done twice a year (Spring Maintenance and Fall Maintenance), and in these cases, consists of both external maintenance of the signalized installations and internal maintenance of the controls and apparatus within the traffic controller cabinet.

13.1.1 External Preventive Maintenance

External preventive maintenance refers to the general up-keeping of the traffic signal components and it includes the following tasks:

Re-Lamping of Signals

The lamps for LED installations have a longer duty cycle and therefore will only be replaced upon failure or as requested by AT. AT has adopted an 8 year replacement schedule for LED signal lamps (based on research by the Missouri University of Science and Technology) unless lamp failure is experienced. All bulbs must be properly installed to ensure that they are secure and properly oriented so as to maximize the life cycle of the lamp. The correct orientation and proper securing of the lamp maximizes the light output to the lens as specified in the ITE Standards for Traffic Signal Displays in an Intersection.

In spring and in fall, the entire reflective system shall be thoroughly cleaned and all sockets and connections checked for integrity of the electrical connection. Any defects or broken items shall be repaired immediately at the time the maintenance is done.

Lamp replacement shall be performed by personnel knowledgeable in the operation of traffic signals. Failure to observe proper procedure may cause the signal to malfunction creating a safety hazard to the public

Cleaning of Signals

Each spring the entire traffic signal system shall be cleaned using a power washer to remove the dirt and grime that has built up over the winter. This work should be scheduled to be late enough in the spring so that other road cleanup will not be affected.

Cleaning shall include all signals, poles, and cabinets as a minimum. The contractor shall inspect the work when completed to ensure that there has been no damage, moisture leaking in, loose parts or misalignment of the signals by the power washing. All moving parts such as pedestrian pushbuttons, door hinges and handles, as an example, shall be tested and lubricated after the washing is completed.

Repainting of Signal System Components

The various components of the traffic signal system may require repainting. These components are typically the painted poles, structures, and cabinets. Those components identified as being the worst for wear should receive the first priority.

The contractor shall remove all rust and scale efficiently and prepare the surface for painting. The paint shall be a rust inhibiting type that will act as a primer and paint combined. The paint should be suitable for this type of application and provide a durable finish for at least five year. If painting one component partially results in an incompatible finish with the remainder of the component, then the entire component shall be repainted to be compatible and look finished.

Verification of Detection Devices

The operation of the traffic and pedestrian detection devices should be verified on a regular basis. This is done through the regular spring and fall cabinet maintenance program by the contractor, as well as regular field checks.

Any failure of these devices shall be noted and corrective action taken. As part of the external maintenance, the repair of certain detection devices such as in-road loop detectors shall be undertaken in the spring season. The above ground detection is not as sensitive to the seasonal weather conditions and, as such, can be repaired on an ongoing basis.

13.1.2 Internal (Cabinet) Preventive Maintenance

The cabinet and the controls within the cabinet are the heart of the traffic signal operation regardless of the complexity. As such it is important that the tests performed address not only the functional operation but also the safety and fail safe features of the system. Internal cabinet maintenance shall be carried out by a qualified signal technician. If there is emergency vehicle pre-emption present for a traffic signal location then contact should be made with the controlling municipality before any maintenance modifications are made to the signal.

The controls at each traffic signal location shall be checked twice annually at intervals not to exceed six months (generally in the spring and fall). At these checks specific items are tested and recorded on the inspection form. In addition to this the contractor should check the operation of all environment equipment such as heaters and exhaust fans for proper operation. This should be done in the late fall and early spring.

When the maintenance is completed, the controls and cabinet shall be left neat, clean, and in a safe operating mode. Any deficiencies, which result in a degraded signal operation shall be repaired immediately to restore proper operation. All remedial changes to existing wiring and controller functions to affect repairs or to keep the system operational shall be documented and AT notified of all actions. The system shall never be left in an unsafe mode.

Internal Maintenance – Winterizing Cabinet (Late Fall)

- Clean interior of cabinet by wiping down any dust and vacuuming
- Wash exterior of cabinet and wipe dry
- Check main door locks and police door lock
- Check terminations of all wires and re-tighten as necessary
- Close lower vent in door by inserting winter guard behind filter
- Check operation of the cabinet heater and thermostat, and adjust thermostat
- Ground connections shall be tested by means of a ground-rod tester to make sure that the ground resistance meets Canadian Electrical Code specifications – the test measurement shall be recorded.
- All light relays checked for leakage using a suitable digital voltmeter. The levels noted shall be recorded. Turned on voltage shall be recorded to check that it is within the allowable standards
- Solid-state flasher shall be tested for operation
- Flash transfer relays shall be tested for operation and any visible wear
- Intersection is completely tested for flash operation

Internal Maintenance – Summerizing Cabinet (Early Spring)

- Clean interior of cabinet by wiping down any dust and vacuuming
- Wash exterior of cabinet and wipe dry
- Check main door locks and police door lock
- Check terminations of all wires and re-tighten as necessary
- Remove winter guard from behind filter. Clean or replace filter as required.
- Check operation of the cabinet fan and thermostat, and adjust thermostat
- All electrical connections shall be checked to verify that they are secure and tight
- Care shall be taken not to over-tighten or damage wire ends and terminal lugs

- Ground connections shall be tested by means of a ground-rod tester to make sure that the ground resistance meets Canadian Electrical Code specifications – the test measurement shall be recorded.
- All light relays shall be checked for leakage using a suitable digital voltmeter. The levels noted shall be recorded. Turned on voltage shall be recorded to check that it is within the allowable standards
- Solid-state flasher shall be tested for operation
- Test flash transfer relays for operation and any visible wear
- Test that flash operation works for the entire intersection.

Terminal Facility Pluggables

- All indicators shall be tested for proper operation and accuracy
- All devices and connectors shall be mechanically and electrically sound
- Applicable ground and line voltages shall be checked and recorded
- Applicable controller inputs, as they relate to specific locations, shall be tested and shall operate accurately, e.g. vehicle and pedestrian detectors, pre-empt, coordination and communication, etc.
- Proper controller outputs shall be tested for accurate and reliable operation (e.g. light relays coordination commands, conflict monitor inputs, etc.)
- In case of a coordinated traffic signal systems, the controller shall be checked for system operation. This consists of the interface with coordinator, acceptance of information from master, coordination check, coordinated free operation and special communication tests.

Conflict Monitor / Malfunction Management Unit (MMU)

The conflict monitor / MMU is an integral part of the control assembly providing protection from failure of the main control assembly. To ensure this device is reliable and accurate it is necessary to test its operation at regular intervals. These tests are performed in the environment that the unit operates in so that it can be reliably recorded for liability purposes. The following tests as a minimum shall be performed on the conflict monitor in the terminal facility to ensure that the device meets current NEMA standards for this type of device. If the device fails to pass the tests, the unit shall be replaced with a spare which will be tested in the same manner prior to being put in service.

- Trip at no more than 28 volts + 10%
- Trip on low 24 volt DC
- Fail on low voltage AC
- Voltage monitor is accurately checked
- Red fail or absence of signal is detected and causes the monitor to fail
- Green, amber and red inputs all cause conflict properly
- Trip properly when AC signals are placed on the cabinet field terminals
- The intersection control assembly not operating with the monitor removed

Conflict Monitor Bench Test

In addition to testing the conflict monitor in its environment, the terminal facility, it is important to bench test the monitor to manufacturer and NEMA standards. To do this, each unit shall be removed and tested using a certified automatic conflict monitor tester. This test shall be performed once annually after the initial cabinet test is performed. If the unit fails to pass the test, the unit shall be replaced and a new unit installed until the original unit can be repaired. Repaired or new units shall be bench tested as above prior to being installed for operation, and the certified test results provided to AT. Monitors failing to meet or pass the tests, shall be repaired or replaced.

Signal Timing Updates

When requested, the contractor shall undertake a full check of the traffic signal database to confirm operation in accordance with the designed and approved coordination plan, and any discrepancies shall be brought to the attention of AT.

The contractor is responsible to implement timing updates as required and monitor the results.

As directed by AT, the contractor shall implement changes to optimize the system operation. The contractor shall monitor the signal operation following the implementation of the new timings and shall not leave the site until he is certain that there are no safety or operational concerns.

The contractor shall perform audits of traffic signals on an as required basis to verify the operation and timing of the traffic signals at various locations. This information is to be provided to AT in electronic format (which include the uploading of the controller database) and paper medium as part of this task.

13.2 Response (Reactive) Maintenance

Response maintenance is defined as the initial response to any reported equipment or system malfunction. Response maintenance includes both field procedures used to restore operations and shop procedures followed to repair and test the malfunctioning equipment. One of the most crucial components of the field procedures related to response maintenance is emergency response and emergency operations when a trouble call is received. Proper procedures and assignment of responsibilities for the operations and maintenance team in dealing with response maintenance is paramount to ensuring public safety and maintaining the efficient operation of the system.

13.2.1 Emergency Response and Off-Hour Emergency Response

When a trouble call is dispatched or received, the traffic signal typically is in one of the four following conditions:

- Traffic signal is in flash
- Traffic signal is powered off (dark)
- Traffic signal is not working properly – partial operation such as signal cycling
- Traffic signal is operating normally but there is an incident that affected the integrity of the traffic signal

The traffic signal contractor shall be dispatched to the intersection if:

- There is imminent danger to public.
- Immediate response by the traffic signal maintenance contractor is needed.
- A specific response timeframe is required of the traffic signal maintenance contractor.
- Law enforcement personnel need to be notified so that they can assist in directing traffic (e.g., signal is dark and the intersection is very busy).
- The traffic signal needs to be placed in dark to minimize confusion to public (e.g. one pole is knocked-down and/or potential electrical hazards are present due to live wires).
- The traffic signal needs to be placed in a flashing mode or 4-way stop and the best emergency traffic control method needs to be determined.

Response Time

A response plan describing acceptable response times for every conceivable, reportable problem is critical to the success of a response maintenance strategy.

The initial response time to arrive at a reported problem intersection and verify and identify the problem can be established based on the guidelines outlined in **Table 3**.

Table 3 Recommended Response Time (for Response Maintenance Contractor)

Type of Trouble Call	Response Time
Imminent Danger (interim measures may be needed by police or by placing the signal in flash or via 4-way stop)	3 hr
Knockdowns	
Damaged Signal Pole – Imminent Danger	3 hr
Damaged Pole / Cabinet / signal heads– No Impending Safety Problem	2 days
Damaged Visor / Backboard	2 weeks
Equipment Failure	
Lamp Burnout – Red or AWF	3 hr
Lamp Burnout – Green/Amber (with Secondary Display)	2 days
Lamp Burnout – Pedestrian Signals	2 weeks
Detection Failure – Cross Street, Left Turns	1 week
Detection Failure – Highway, Pushbuttons	2 weeks
Signal in Flash – With Major Operational Problems	3 hr
Signal in Flash – Without Major Operational Problems	1 day