Eglinton East LRT

Transit Project Assessment Process (TPAP)

10% Design Phase

Traffic Impact Assessment Report Revision 2

City of Toronto
April 30, 2024

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1 Context

The report presents the traffic analysis undertaken as part of the Eglinton East LRT (EELRT) 10% Design and Transit Project Assessment Process (TPAP) study, focusing on two primary areas: intersection analysis and network analysis. This technical assessment serves to guide design decisions and understand traffic operations and traffic impacts along the EELRT study area.

- Focus Area / Intersection Analysis: this section reviewed targeted intersections to evaluate their current traffic flow and operational characteristics. The analysis involved examining traffic volumes, signal timings, and other relevant parameters to understand how these intersections would operate under various signal phasing options for the EELRT. This objective was to review the effectiveness of traffic signalling strategies and identifying potential improvements.
- Network Analysis: this section reviewed the overall traffic network operations. The objective here was to build on previously established modelling work and studies and analyze how the updated EELRT design affects traffic operations across a broader area. This objective was to identify systemic issues and areas that require improvements to enhance traffic flow across the network.

The combined analyses from these two perspectives provide an understanding of traffic operations at both the intersection and network levels. However, the intersection analysis component was undertaken to inform and shortlist design options at selected key intersections for the EELRT; while the network analysis was completed with the preferred design for the EELRT in place throughout the study area.

Traffic impacts and subsequent design of the EELRT corridor were discussed with the City of Toronto's Transit Expansion, Transportation Services, and City Planning division at a variety of focused meetings and bi-weekly update meetings. Table 1 lists the focused meetings where traffic impacts were discussed.

Table 1: List of Traffic-Focused Discussions with the City of Toronto

Meeting title	Meeting Date	Notes
Kennedy Station Area - Traffic Operations Analysis	2022-08-23	Discussed the Eglinton Ave/Eglinton loop road intersection and Eglinton Ave/ Midland Ave intersections and LRT operations impact in the Kennedy Station area.
Intersection Working Group #1	2023-04-06	Discussed the traffic impact analysis for Kennedy Station area and Kingston/Morningside intersection
Traffic Study Scope	2023-04-17	Discussed the scope of the traffic study
Intersection Working Group #2	2023-06-08	Discussed Signal Timing Modifications and Implications

2 Approach and Methods

Traffic analysis is organized into two main categories based on the analysis platform utilized: Synchro and Aimsun.

Synchro was used for Focus Area Analysis in support of various intersection options and feasibility assessments for 10% design, which predates the network analysis. Primary objectives of these analyses were to produce quantitative metrics and measures of effectiveness that supported discussions with the City of Toronto and Toronto Transit Commission (TTC) that involving intersection operations.

The Aimsun model was inherited from the previous phase EELRT traffic modelling studies. The model was calibrated to 2017 conditions and modeled for 2041 forecasts. This 10% Design and TPAP phase focused on updating the EELRT alignment to feature the latest transit and intersection design along the right of way, but did not involve any recalibration of the existing conditions model or updates to the underlying demand forecasts. Various shifts in the traffic demand caused by the COVID-19 pandemic and network supply carried out through the City's Vision Zero and RapidTO initiatives could have impacted the network capacity and traffic patterns, which could not be captured without fundamental recalibration and revision to the Aimsun model, which was outside the scope of this study. Therefore, the Aimsun model focuses on a comparison of the traffic effects resulting from design changes specific to the EELRT right of way to identify how the latest 10% design refinement impacts the transit and traffic operation at a network level.

2.1 Synchro

2.1.1 Data and Resources

The base starting point for all intersection-level analysis was an existing conditions model package provided by the City of Toronto, referred to as the "Proposed Bus Lanes Synchro Model". This package was received for the purposes of this project and was assumed to be already-sufficiently compliant to various standards and guidelines employed for models of similar purpose and usage.

The "Proposed Bus Lanes Synchro Model" package included the following Synchro (.syn) model files:

- Eglinton Ave E (5): AM peak, off-peak, PM peak, night, weekend
- Kingston Rd (3): AM peak, off-peak, PM peak
- Morningside Ave (3): AM peak, off-peak, PM peak

Received models were reviewed for the following:

- Intersections included in the model correspond to those needed for the intersection-level analysis (e.g. Eglinton Avenue @ Midland Avenue, Kingston Road @ Morningside Avenue)
- Intersections are coded with sufficient detail: volumes, signal timings with clearances.

No additional data were collected, unless specified in each of the analysis sections below. Volumes and timings were assumed to be representative of existing conditions year (2020 as indicated in the file) without further adjustments. Per general practice given the global and local circumstances in the years 2020 to 2022, the assumption of zero traffic growth was applied across the models and the term "existing conditions" was broadly applied for analysis presented in 2022 and 2023.

2.1.2 Assumptions

To bring in quantitative representations of the Light Rail Vehicle (LRV) into Synchro models, the following assumptions were employed based on recent and on-going Light Rail Transit (LRT) project experiences in the City of Toronto:

- LRV physical length: 50 m, similar to the Alstom LRVs to be deployed on Finch West LRT and shorter than the 60 m (2-car consist) and 90 m (3-car consist) Bombardier LRVs to be deployed on Eglinton Crosstown LRT.
- LRV maximum speeds (except at intersections): matching the road posted speed limit
- LRV through-speed at intersections: limited to 25-35 kph across intersections based on existing practices (TTC streetcar standard operating procedure is 25 kph, considerations in LRT implementations to allow up to 35 kph)
- LRV turning (left or right turn) speed at intersections: 8-15 kph based on a culmination of design and operational requirements in similar LRT implementations in the City of Toronto
- LRV-specific signal clearances based on speeds above (i.e. longer amber and all-red to account for LRV-specific deceleration and clearance profiles)
- LRV phases (whether exclusive or in parallel with traffic) assumed to be called every cycle during peak hour operations (i.e. LRV-specific phases are considered to be on maximum recall for Synchro purposes)

For intersection signal optimization purposes:

- Maximum cycle length during AM and PM peak hours: 135 seconds per City policy
- Pedestrian clearances: minimum 7s walk and FDW based on 1.2 m/s end-to-end single stage clear at typical signalized intersections, minimum 8s walk FDW based on 1.1 m/s end-to-end single stage clear in Senior Safety Zone intersections

As requested by City and TTC, general provisions for projecting to future travel demand growth were assumed to target the year 2041 (i.e. 20 years of growth from 2022 existing conditions year) at 0.5% per annum, applied to every movement including left and right turns.

2.1.3 Output

There were three (3) distinct focus area analyses conducted: at the Kennedy terminus, at the Kingston-Morningside intersection, and the detour required for intersection of Kingston Road at Falaise Road. Depending on the purposes and objectives of each analysis, the output included standard measures of effectiveness (MoEs) in Synchro models utilizing HCM methodology such as delays and levels of service, SimTraffic model runs for additional queueing results, and also analysis-specific outputs (such as detour distances).

Detailed output reports were produced for internal processing and summary, but not formally submitted at the time of presentation and discussion with City of Toronto and TTC. Final model files representative of the analysis presented are included with the electronic submission of this report.

2.2 Aimsun

2.2.1 Overview

The 10% Design and TPAP study includes an update to an existing Aimsun Dynamic Traffic Assignment model that covers the study area between Kennedy Station and Malvern Town Centre, first built during the previous phase EELRT traffic modelling studies. The existing model was established by the City and another consultant and last completed in 2019.

The base Aimsun model was calibrated to 2017 conditions, shown in the following study area map, and modified to include 2041 horizon year traffic forecasts and EELRT transit services. As part of the current study, a small extension to the model was performed to add three intersections to the model up to Sheppard Ave and McCowan Road.

Figure 1: Aimsun Model Study Area and Extension

The 10% Design and TPAP traffic analysis scope focuses on a few key items for the AM and PM peaks:

- EELRT ridership changes and distinct services separate from ECLRT
- Removal of Kingston/Morningside intersection NB and SB left turn lanes and intersection reconfiguration.
- Intersection changes arising from LRT alignment switching from underground to at-grade (e.g. left-turn restrictions, Eglinton/Midland, Eglinton/Loop road).
- Lane reduction on Neilson (From 4 lanes to 2 lanes)
- Centre-running LRT along Morningside and Ellesmere (previously side-running)

2.2.2 Deferred Scope for Vision Zero Road Safety Measures

The 10% TPAP and Design study was first awarded in 2021, when the modelling scope envisioned building on a model only 2 years after the previous EELRT traffic study. It was originally expected to build on the model and incrementally test the effects of these design refinements.

A blanket update to the signal operation policy was not anticipated as part of the scope. However, speed limit reductions have taken place on most parts of the EELRT corridors, as well as many major cross streets:

- Eglinton Ave East – 60 to 50 km/h
- Morningside Ave – 60 to 50 km/h
- Sheppard Ave E – 60 to 50km/h
- Ellesmere Road – 60 to 50 km/h (intersecting Morningside Ave)
- Lawrence Ave – 60 to 50 km/h (intersecting Morningside Ave)
- Markham Road – 60 to 50 km/h (intersecting Kingston Rd)
- McCowan Road – 60 to 50 km/h (intersecting Sheppard Ave)

Figure 2: City of Toronto Speed Limit Reductions near the EELRT Study Area

Since the City deployed its road safety plan, the general signal re-timing strategies since 2021 include:

- Increase in yellow/red times based on updated kinematic equations, thereby reducing green times
- Speed limit reductions on arterial corridors, leading to longer red times
- Leading Pedestrian Intervals on all approaches, reducing vehicle phase capacity

Combined with lower speeds on major corridors, green time and capacity have significantly reduced at many intersections within the study area. The general observed outcome of signal timing changes with these measures include:

- More bottlenecks along the EELRT alignment, where auto and transit travel time will be longer, and speed be slower
- Increased intersection delays will cause traffic to seek other routes in the dynamic model, causing more critical movements throughout the study area
- Updated LOS for the refined concept will be relatively worse than what was reported by Arup in 2018 for both transit and auto, before any design updates are applied

These outcomes are most pronounced when applied to models created before 2019, before any VZRSP measures became standard practice. The EELRT Traffic model study was one of them.

To perform the traffic analysis within the scope, resources, and schedule available to the 10% Design and TPAP study, discussions were held with various units within the City's Transportation Services. A consensus was achieved with the City of Toronto to keep the existing calibrated modelling and forecast conditions unchanged, and modify only the elements made as part of the 10% Design refinements along the EELRT corridor, to provide an apples-to-apples comparison.

2.2.3 Deferred Scope for Durham Scarborough BRT

Further investigations regarding the various configurations along the Ellesmere Road corridor were not included in the scope of this study. The sensitivity analysis which may involve the following design considerations were deferred:

- East-West DSBRT geometric design configuration,
- Nearside versus far side stop configuration,
- Transit signal priority and alternative signal phasing at Ellesmere/Morningside and Ellesmere/New Military Trail

2.2.4 Geometric Updates for 10% Design

The following intersection level updates were captured in the traffic modelling analysis, which reflects the latest design refinements and is summarized in **Table 1**.

Table 2: Summary of Design Changes

Intersection/Segment	Movement	Remark
Eglinton Ave and Midland Ave	SBR	Change to shared through-right lane for SBR
Eglinton Ave and Danforth Rd	EB/WB	Remove channelization
	NBL	Prohibit left turns
	NBR	Change to shared through-right lane
	SBR	Change to shared through-right lane
	WBL	Add dedicated left-turn lane
	EB	Move LRT stop to near-side
Eglinton Ave and Bellamy Rd	NB	Include NB approach as existing
Eglinton Ave and Beachell St	NB	Retained NB approach
Eglinton Ave and Kingston Rd	EBR	Change to dedicated right-turn lane
	SBR	Change to dedicated right-turn lane
	NB	Reduce to 2 through lanes
Kingston Rd and Scarborough Golf Club Rd	EB/WB	Remove channelization

Intersection/Segment	Movement	Remark
Kingston Rd and Westlake Rd	EBR	Change to dedicated right-turn lane
Kingston Rd and Galloway Rd	EB	Remove channelization
Kingston Rd and Poplar Rd	EBL	Maintained Dedicated left turn lane as existing
Kingston Rd and Lawrence Ave	EB/WB	Remove channelization
	NB	Move LRT stop to near-side
	SB	Move LRT stop to far-side
Kingston Rd north of Lawrence Ave	-	Change to 4-lane, add new stop south of Morningside Dr
Morningside Ave north of Kingston Rd	NB/SB	Change to 2-lane, LRT track becomes centre running
Ellesmere Road East of Morningside Ave	EB/WB	LRT track becomes center running
Kingston Rd and Morningside Dr	NB	Change to one through lane plus one right lane
	SB	Change to one through lane plus one right lane
Morningside Dr between Kingston Rd and Ellesmere Rd	-	Update model to reflect 2-lane cross-section
Morningside Dr and Beath St	NB	LRT stop re-location to near-side (south of Lawrence Ave)
	SB	LRT stop re-location to far-side (south of Lawrence Ave)
Morningside Dr and Morningside Park Access	-	Update model to include signalized intersection
Ellesmere Rd between Morningside Dr and New Military Trail	-	Update model to center-running LRT and relocate the stop at UTSC
New Military Trail	-	Update model to reflect design plan configurations which includes the addition of 2 pedestrian crosswalk and an additional UTSC parking access

2.2.5 Output

Based on the above updates, the output of the 10% Design and TPAP study focused on the following:

- Network Level Outputs – Overall model area metrics including Simulated Flow (vehicles per hours), Delay (seconds per km), Total Travel Time (vehicle-hours), Total Travelled Distance (vehicle-km), and Mean Virtual Queue (vehicles) are compared on the network level. The current model outputs are compared against the previous preferred scenario
- Network Level Delay and Level of Service: Overall roadway delay and key road segments with delay hotspots are identified based on roadway delay and HCM level of service
- Key Hotspot and Congested Segments: Segments with Level of Service E or F, as well as segments of interest with key design changes, are examined on a link level in terms of delay, congestion, and queues.

3 Focus Area Analysis

3.1 Kennedy Terminus

The Kennedy terminus focus area analysis was presented to the City and TTC in August 2022, following the discussions surrounding traffic and LRT operations that would be feasible with the at-grade Kennedy terminus design. To support the at-grade terminus, analysis findings would need to support the following in turn:

- Two closely spaced signalized intersections: Eglinton Avenue @ Eglinton Loop / LRT movement to terminus (new) and Eglinton Avenue @ Midland Avenue (existing)
- Signal timing operations and plan(s) that would feature offset coordination for minimizing disruptions to LRT movements, mitigate queues that can potentially block LRT movements, accommodate sufficient pedestrian clearance times (in Senior Safety Zone / single-stage crossing), and then balance-and-minimize delays at the Midland intersection

3.1.1 Clearance Calculations

Based on the updated concept design for the intersection, at-grade terminus, new loop intersection for LRT movements, and aforementioned assumptions, the following were set as the criteria for creating new timing plans for these two closely spaced intersections:

Table 3: Clearance Requirements for Eglinton Avenue @ Midland Avenue

Movement Impacted by LRT	Required Clearance Interval
Pedestrian North-South Crossing	Walk 8s, FDW 39s
NBL/SBL vehicle turns	Amber 3.3s, Red 4.3s
EBL/WBL vehicle turns	Amber 3.3s, Red 5.5s
Vehicle through-movements	Amber 3.3s, Red 3.8s

Table 4: Clearance Requirements for Eglinton Avenue @ Terminus Loop Intersection

Movement Impacted by LRT	Required Clearance Interval
LRT movements (25 kph)	Amber 4.5s, Red 19s
LRT movements (35 kph)	Amber 5.9s, Red 13.6s
EBT general traffic through	Amber 3.3s, Red 5.7s
NBR vehicle turn	Amber 3.3s, Red 1.3s

The notable differences between LRT movements at 25 kph and 35 kph are products of LRV deceleration (amber), reaction time (amber), clearance at speed (red), and length of LRV (red). These calculations imply that the LRV operator would be able to make either decision to proceed or to stop with sufficient time allocated in the clearance intervals to follow through.

Similar clearances (subject to intersection dimensions) would be required for the LRV through-movements at Midland Ave; the assumption is that the parallel/parent vehicular movements (EBG, WBG) would have sufficient total duration to include LRV clearances. As the parallel EBG/WBG and LRV EB/WB would need to line up, the differences between traffic clearances and LRV clearances would be made up for in the shorter green times for LRV.

3.1.2 Draft Signal Timings

For Eglinton @ Midland, timings drafted in this exercise preserve the NBL/SBL protected turns provided in existing conditions, convert the EBL/WBL to fully protected phases, apply the new pedestrian clearances in determining the minimum phase durations for through-movements, and Synchro optimization based on future (2041) protected volumes. As indicated on **Figure 2**, the east-west LRV movements would fit into the EBG/WBG phase.

For Eglinton @ Kennedy Terminus / Loop, LRV movements through the intersection would require an exclusive phase (the "LRT Phase"). The draft in **Figure 2** used a single-insertion of a minimum viable LRT phase; there would be possible optimizations (by utilizing the extra green times assigned to EB traffic) to further increase LRT green times and therefore reduce LRT delays.

Figure 2: Kennedy Terminus Signal Timings @ 135 CL, 25 kph LRV

3.1.3 Findings

The following analysis findings were shared with City of Toronto and TTC in the Committee Meeting on August 23rd, 2022:

- The analysis yielded a set of draft timings that would allow the two closely spaced intersections to operate with the at-grade Kennedy terminus.
- Due to increased clearances, the cycle length at Eglinton @ Midland would be minimum 128 seconds. Draft timings used 135, maximum per current City policy. The choice of cycle length at Eglinton @ Midland would directly impact the operations at the terminus intersection, as the two closely spaced intersections are required to operate under same cycle lengths and offset-coordinated.
- Average delay incurred by the LRT in a single directional trip (e.g. westbound from east of Midland Avenue to the terminus, eastbound from the terminus to east of Midland Avenue) would be approximately 110s based on the draft timing plans.
- Under future traffic demand (2041), the 95th percentile queue for EBL @ Eglinton and Midland may spill back and directly block the LRV paths at the terminus intersection. There is also a risk of

indirect effects – queues spilling over from the EBL storage lane to the EBT lane, and then EBT traffic queuing into the LRV paths.

Overall intersection performance was LOS E at Midland and LOS B at the terminus. Results are tabulated in **Table 5** below.

Table 5: Intersection Results Summary Table (2041 volumes, 135 CL)

Intersection	Movement	AM Peak Hour (CL 135s)					PM Peak Hour (CL 135s)				
		v/c Ratio	Delay(s)	LOS	50th%ile Queue(m)	95th%ile Queue (m)	v/c Ratio	Delay(s)	LOS	50th%ile Queue (m)	95th%ile Queue (m)
Midland Avenue	Overall	0.87	59	E	-	-	0.97	56	E	-	-
	EBL	1.03	158	F	49	**98**	1.34	263	F	87	**143**
	EBTR	0.59	33	C	39	**48**	0.89	44	D	63	**168**
	WBTR	1.05	87	F	196	241	0.71	46	D	104	128
	NBL	0.50	25	C	16	28	0.55	28	C	22	36
	SBTR	0.68	39	D	97	121	0.57	37	D	82	103
LRT Terminus Driveway	Overall	0.52	17	B	-	-	0.44	20	B	-	-
	EBTR	0.36	15	B	52	65	0.55	19	B	95	113
	NBR	0.40	66	E	8	19	0.37	65	E	8	19

Findings above were presented at the August 23rd Committee Meeting, with four (4) potential delay-mitigation strategies for City and TTC considerations:

- Consider two-stage pedestrian crossing at Eglinton @ Midland. This would reduce the minimums for N/S phases, which then allow additional green time to be allocated to E/B phases and also improve LRT operations. Alternatively, this can be used to allow greater range of cycle lengths to be considered for signal optimization – minimum CL drops from 128 to 108. This comes at a cost of additional delays and potential safety risks for N/S pedestrians.
- Consider prohibition of EBL vehicular movement at Eglinton @ Midland. This can be in the form of time- or conditions-based prohibition (e.g. during AM and PM peak periods), or enforced altogether (e.g. prohibited for all vehicles, TTC vehicles exempted). The intended benefits are two-fold; it mitigates the blockage risk at the terminus and allows for greater optimization at the congested intersection of Eglinton @ Midland.
- Enable phase rotation at the terminus intersection. Phase rotation is currently not employed in City of Toronto signalized intersections despite the feature being available in majority (if not all) of modern signal controllers installed at the intersections. The rotation would allow flexibility in accommodating LRV arrivals and departures with minimal delays compared to fixed insertion.
- Double insertion for LRT phase at the terminus intersection. Instead of just one, there would be two callable LRT phases in a single cycle. This is alternatively described as “two kicks at the can”. This can reduce both average and maximum LRT delays, resulting in delay mitigation that is potentially more effective than phase rotation.

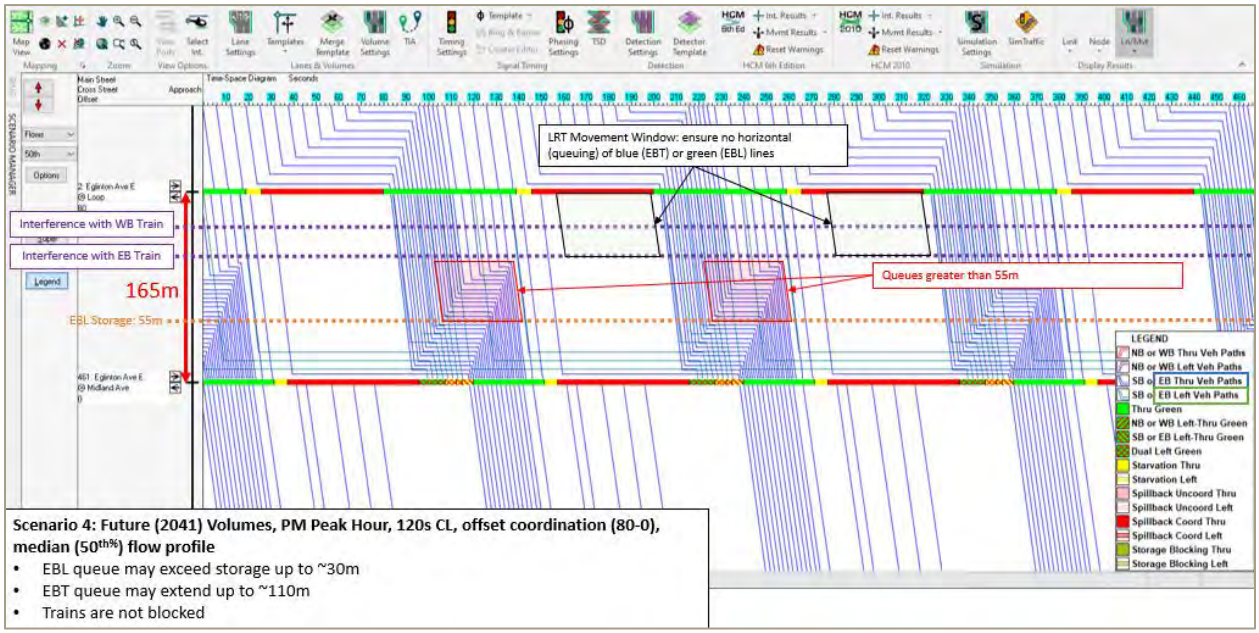
The full presentation can be found in **Appendix 1**, including draft slides that were prepared in case of technical discussions but were not presented due to time constraints.

Following the Committee Meeting, City and TTC responded to the measures: no to two-stage crossing, yes to a policy-level consideration of EBL prohibition at this time (and further refinements during detailed design and modelling phases), and a preference towards double insertion rather than phase rotation (if needed, and to be tested during detailed design and modelling phases).

3.1.4 Follow-up

TTC requested a technical follow-up to show greater details of timing/offset optimizations and queues. In response, a series of time-space flow diagrams were produced with different traffic demand load profiles to show the potential impact of offset coordination on queue mitigation. This exercise was conducted under 120s CL; implying that a level of design optimization and policy decisions would enable the minimum CL to be decreased from the conservative 128s utilized in the base analysis.

Figure 3: Offset Coordination Scenario 4 – 2041 Volumes with Median Flow Profile



The exercise concluded that both the flow profile and offset optimization can have a notable impact on the EBL queuing and the desired mitigation. 95th flow profiles were not fully mitigated by offset mitigation, implying a demand control and mitigation strategy would be required (e.g. EBL prohibition). 50th flow profiles showed queue differences in over 50-60m, thus confirming that offset coordination can have a sizable impact in mitigating vehicular queues under certain volume-and-flow thresholds.

Full output sheets of the coordination exercise can be found in **Appendix 2**.

3.2 Kingston-Morningside

The Kingston-Morningside focus area analysis was conducted in March-April 2023 to support the evaluation of intersection signaling options for the at-grade two-way operations for EELRT at the intersection of Kingston Road and Morningside Avenue.

To support the at-grade operations, the focus area analysis actions were to:

- Produce draft timing plans that are compliant and feasible within City policy and also technically accommodating to LRV operations;
- Identify the geometric constraints and requirements for the intersection; and
- Identify and quantify aspects for delay mitigation, operations improvement, etc.

3.2.1 Preparation

In addition to the City Synchro model package, an additional set of data was received in the form of resources used in the nearby development Traffic Impact Study (TIS). This allowed an internal update of the Synchro model for the intersection of Kingston Road and Morningside Avenue using 2022 counts and latest signal timings, both of which were adopted and considered the existing conditions.

3.2.2 Calculations

Per the at-grade EELRT design and operations at this intersection, LRT tracks in the median of the two intersection roads will make the following turns at the intersection:

- Eastbound/northbound direction: eastbound left turn from Kingston EB to Morningside NB
- Southbound/westbound direction: southbound right turn from Morningside SB to Kingston WB

Consistent with other Synchro analyses, the train length was assumed to be 50 m when calculating clearances.

A major differentiator in the detailed implementation of this intersection would be the average LRV turning speed, generally governed by LRV-and-track capabilities. The nominal assumption used in this exercise is 15 kph; this extrapolation is based on speeds of 8-12 kph in comparable at-grade LRT turn implementations in the City of Toronto but with smaller turn radii. In other words, the skew of Kingston Road is factored into assuming a likely greater turn radius of this turn compared to other similar LRT implementations, and thus 15 kph is used in this exercise. The resulting minimum LRV phase is 37 seconds (6G / 6A / 25R).

3.2.3 Signal Optimization and Draft Timings

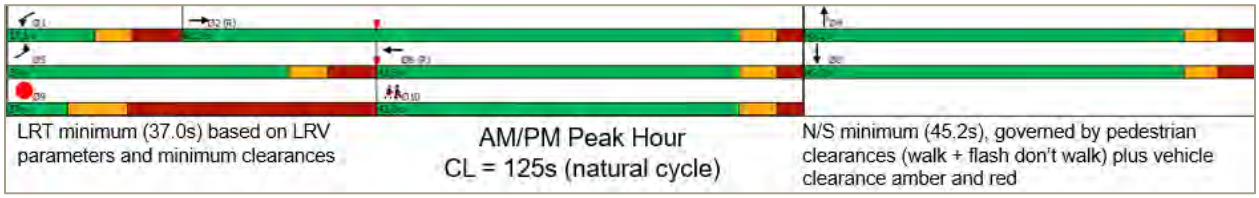
The primary assumption and premise of this exercise is that **two-way LRT movements, traffic EBL, and traffic WBL are all concurrently compatible.** In other words, if all four movements above are shown the green signal simultaneously and movements occur at the same time, they would all be able to complete their movements with no physical conflicts incurred in their path of travel. This assumption is necessary for this intersection to stay within City policy (maximum 135 CL) and for *reasonable* operational viability; with the existing traffic demands at this intersection, a non-compatible insertion of an exclusive 37 second LRV phase would result in a non-compliant CL (above 135) and multiple critical delays and queues for all users on top of that.

Signal optimization and draft timings were developed in the following step-by-step process:

- Start with minimum viable phases; traffic through movements, LRT phase, and then fully-protected EBL/WBL prioritized ahead of NBL/SBL based on existing traffic demand and the assumed compatibility with the LRT phase. NBL/SBL protected phases will be re-introduced at the end if viable; else, to be removed from this exercise.
- Calculate and set phase minimums (LRT = 37, E/W = 40.5, N/S = 45.2);
- Set the LRT phase as the third ring, stacking it with fully protected EBL and WBL;
- Add a "dummy" phase to the third ring in order to complete the barrier;
- Allow EBT to be concurrent with LRT;
- Set CL to natural cycle length (125) and then optimize phases;
- Manually set EBL to have identical total duration with the LRT phase, in order to prevent WBT from starting prior to the completion of LRT phase;
- Check if NBL/SBL protected phases can be added back in; determined that they cannot be added in without going over the CL policy limit.

The resulting draft timings are shown below in **Figure 4**.

Figure 4: Kingston-Morningside Draft Signal Timings (125s CL)



3.2.4 Findings

After multiple iterations and combinations, the above draft timings were applied in two different scenarios: with permissive NBL/SBL and without permissive NBL/SBL. In the latter case, it would mean a permanent removal of NBL/SBL.

Findings show that the permanent of NBL/SBL would achieve the following:

- Reallocation of ROW resulting in lesser property encroachment/intake and/or performance improvement if allocated to an alternative turning lane (e.g. new NBR storage lane)
- Improvement in overall LOS E → D

In either case, the draft timing plan shows that an at-grade LRT operation is viable within the parameters and assumptions in this analysis. In particular, the key assumption that two-way LRT + EBL + WBL would be concurrently compatible must be upheld throughout design for the above draft timing plan to remain viable.

Even with NBL/SBL permanently removed and the intersection overall LOS improved from E to D, several movements are projected to experience critical levels of delay and/or capacity constraints based on existing traffic demand. Any future traffic growth may result in longer queues and delays, congestion, and possible neighbourhood infiltration. Intersection analysis results are summarized in Table 6 below, where "Base" is the scenario with permissive NBL and SBL and "Option 1C" is the

scenario without those turns. Both scenarios use the same timing plan shown earlier in this section and a graphical representation of the intersected operation is shown in FIGURE

Table 6: Kingston-Morningside Analysis Results (Base with NBL/SBL, Option 1C without)

Scenario		Storage Length (m)	AM Peak Hour				PM Peak Hour			
			LOS	Delay (s)	v/c	95th Percentile Queue (m)	LOS	Delay (s)	v/c	95th Percentile Queue (m)
Base			**E**	**70.6**	**1.35**	**-**	**E**	**71.3**	**1.37**	**-**
Eastbound	Left	30	E	62.3	0.77	67.8	E	61.4	0.76	65.8
	Through-Right	320	C	25.7	0.55	101.8	D	39.0	0.88	192.3
Westbound	Left	30	E	59.3	0.51	23.3	F	98.4	0.85	55.5
	Through	225	E	75.7	1.03	244.2	D	38.9	0.75	151.5
	Right	30	C	27.1	0.07	13.3	C	27.6	0.15	23.6
Northbound	Left	30	D	38.3	0.19	7.2	E	68.7	0.55	22.3
	Through-Right	90	D	47.2	0.76	131.0	E	61.1	0.91	160.8
Southbound	Left	30	D	37.0	0.31	19.8	F	187.2	1.16	65.2
	Through-Right	205	F	146.2	1.19	251.4	F	174.4	1.26	283.8
Option 1C			**D**	**47.2**	**1.08**	**-**	**D**	**40.8**	**1.10**	**-**
Eastbound	Left	30	E	59.1	0.75	67.5	E	59.0	0.74	65.4
	Through-Right	320	C	24.6	0.54	99.0	D	38.4	0.88	193.0
Westbound	Left	30	E	58.4	0.49	23.3	E	71.2	0.72	48.7
	Through	225	E	67.1	1.01	239.3	D	37.4	0.73	141.2
	Right	30	C	26.3	0.07	13.1	C	26.7	0.14	23.2
Northbound	Through	90	D	44.0	0.67	111.1	D	46.5	0.73	126.2
	Right	30	C	30.2	0.04	2.1	C	30.7	0.08	11.6
Southbound	Through-Right	205	D	38.4	0.56	71.5	D	40.4	0.65	91.3

Note: Critical movements are highlighted in **RED**. Queue exceeding storage length are highlighted in **BLUE**

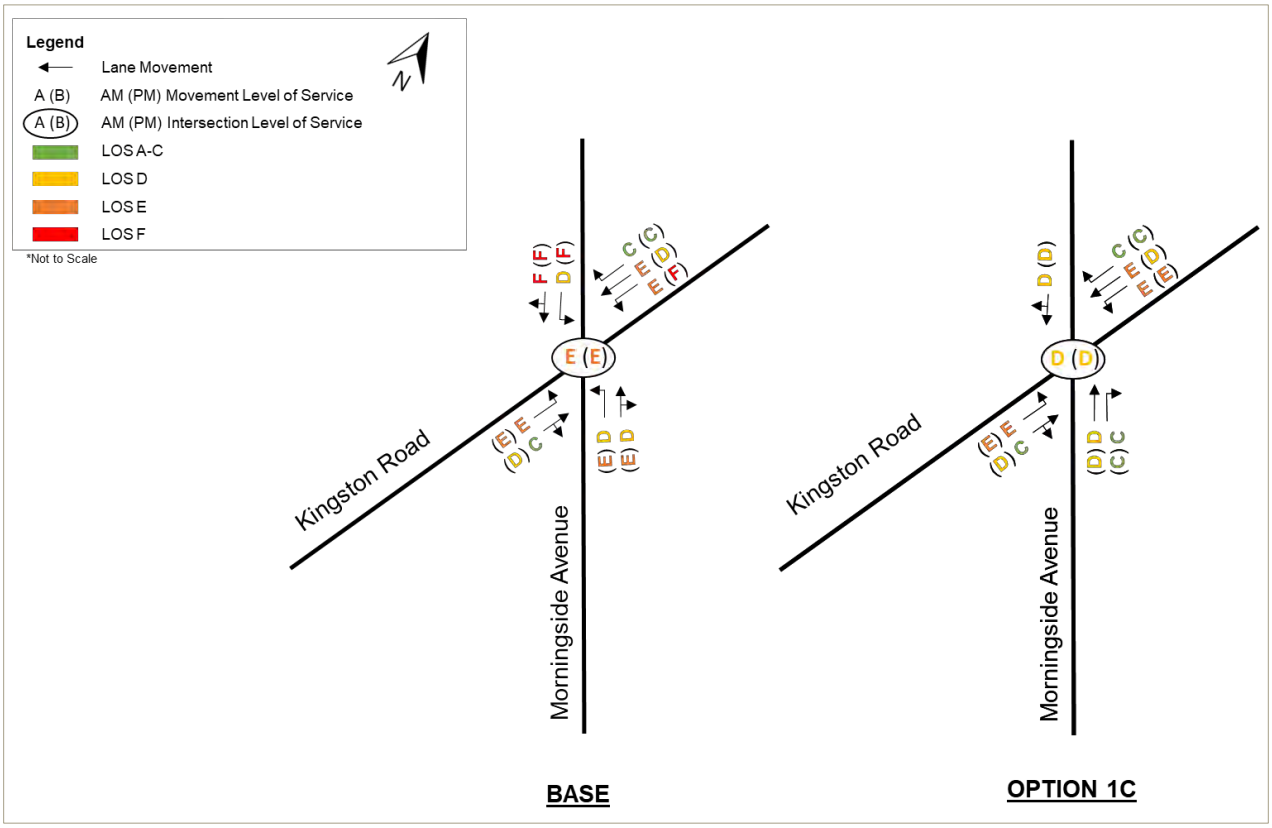


Figure 5: Kingston-Morningside Level of Service – Base Case and Option 1C

Full presentation deck of the Kingston-Morningside Focus Area Analysis is attached in **Appendix 3**.

3.3 Falaise Detour

Upon presentation and discussion of the Kingston-Morningside Focus Area Analysis, City of Toronto requested a follow-up analysis of the impacts to local residents.

The Kingston-Morningside Focus Area Analysis concluded that NBL/SBL protected turns cannot be reasonably accommodated within the draft timings. In the design and implementation stage, detailed assessments and resulting operational safety considerations may lead full prohibition of those movements as opposed to allowing permissive movements. Consequently, local destinations on Falaise Road would face a situation where:

- Existing unsignalized EBL from Kingston Road EB to Falaise Road NB would be removed-and-prohibited due to median EELRT tracks; and
- Existing protected-permissive NBL from Morningside Avenue NB to Kingston Road WB, and then WBR from Kingston Road WB to Falaise Road NB, would be removed due to intersection re-design and operations at Kingston Road @ Morningside Avenue.

The detour analysis studied six (6) entry paths to Falaise Road. The exit paths were excluded from this exercise given that the future conditions with EELRT would not systematically differ from existing conditions (exit via SBR from Falaise SB to Kingston WB). The six paths were evaluated as follows:

1) Lawrence EB: impacted by the removal of Kingston-to-Falaise EBL. Alternative path is to take an earlier EBL at Lawrence @ Rodda, then follow through to Falaise. +0.45 km distance taken.
2) Kingston NB/EB: impacted by the removal of Kingston-to-Falaise EBL. Alternative path is to take an earlier EBL to head north on Galloway, turn towards east on Lawrence, then take the EBL at Rodda. +0.90 km distance taken. If the turn at Galloway is not taken, the next opportunity to turn around would be via U-turn on Kingston Road or Lawrence Avenue far down their respective paths, adding over 1.4 km of distance in addition to the ideal detour; hence, these paths are not recommended.
3) Morningside NB: impacted by the removal of Morningside-to-Kingston NBL. Alternative path is to take an earlier NBL at Lawrence, follow west until taking a WBL to head north on Rodda Boulevard. Follow through Rodda Boulevard to reach Falaise Road. +0.70 km distance taken.
4) Lawrence WB: similar to above, follow through and then use Rodda-Falaise connection. +0.75 km distance taken.
5) Kingston SB/WB: entry to Falaise Road via WBR is not impacted.
6) Morningside SB: entry to Falaise Road via SBR at Kingston then WBR at Falaise is not impacted.

Analysis concluded that for the 4 of 6 entry points identified, Rodda Boulevard would be the primary detour path that would minimize the additional travel distance. Should this path be adopted accordingly, there would be an increased demand for EBL and WBR at the unsignalized intersection of Lawrence Avenue and Rodda Boulevard. Hence, it is recommended that the intersection operations be monitored for increased demand in the future and subsequent upgrade considerations.

Above analysis and findings are summarized below in Figure 6. The full step-by-step analysis is included in **Appendix 4**.

Figure 6: Falaise Road Detour Analysis Summary

4 Network Analysis

The following intersection level updates were captured in the traffic modelling analysis, which reflects the latest design refinements and is summarized in **Table 7.**

Table 7: Summary of Design Changes – Issues and Constraints

Intersection/Segment	Movement	Issues and Constraints
Eglinton Ave and Midland Ave	SBR	Future conditions operate at and LOS F in both peaks
Eglinton Ave and Danforth Rd	EB/WB	Future conditions operate at and LOS F in both peaks
	NBL	
	NBR	
	SBR	
	WBL	
	EB	
Eglinton Ave and Bellamy Rd	NB	-
Eglinton Ave and Beachell St	NB	-
Eglinton Ave and Kingston Rd	EBR	-
	SBR	Future conditions operate at and LOS F in both peaks
	NB	
Kingston Rd and Scarborough Golf Club Rd	EB/WB	-
Kingston Rd and Westlake Rd	EBR	-
Kingston Rd and Galloway Rd	EB	-
Kingston Rd and Poplar Rd	EBL	-
Kingston Rd and Lawrence Ave	EB/WB	Future conditions operate at and LOS F in both peaks as protected turn phases are required due to at grade LRT
	NB	
	SB	
Kingston Rd north of Lawrence Ave	-	-
Morningside Ave north of Kingston Rd	NB/SB	-
Ellesmere Road East of Morningside Ave	EB/WB	Centre running LRT requires protected LT phases. Future conditions operate at and LOS F in both peaks
Kingston Rd and Morningside Dr	NB	-
	SB	-
Morningside Dr between Kingston Rd and Ellesmere Rd	-	-
Morningside Dr and Beath St	NB	-
	SB	-
Morningside Dr and Morningside Park Access	-	-
Ellesmere Rd between Morningside Dr and New Military Trail	-	-
New Military Trail	-	Increase in delay with the addition of pedestrian crossing. LOS E or F.

Due to the LRT, a majority of network delay stems along on LRT route and hot spots are triggers due to dedicated LT phases is required or existing high traffic volumes. The simulated LOS for the network with the latest design refinements for the AM and PM scenario can be visualized in **Figure 7** and **Figure 8**, respectively. Higher resolution plots of these LOS images are provided in Appendix 5.

Figure 7: 2041 Simulated LOS – AM

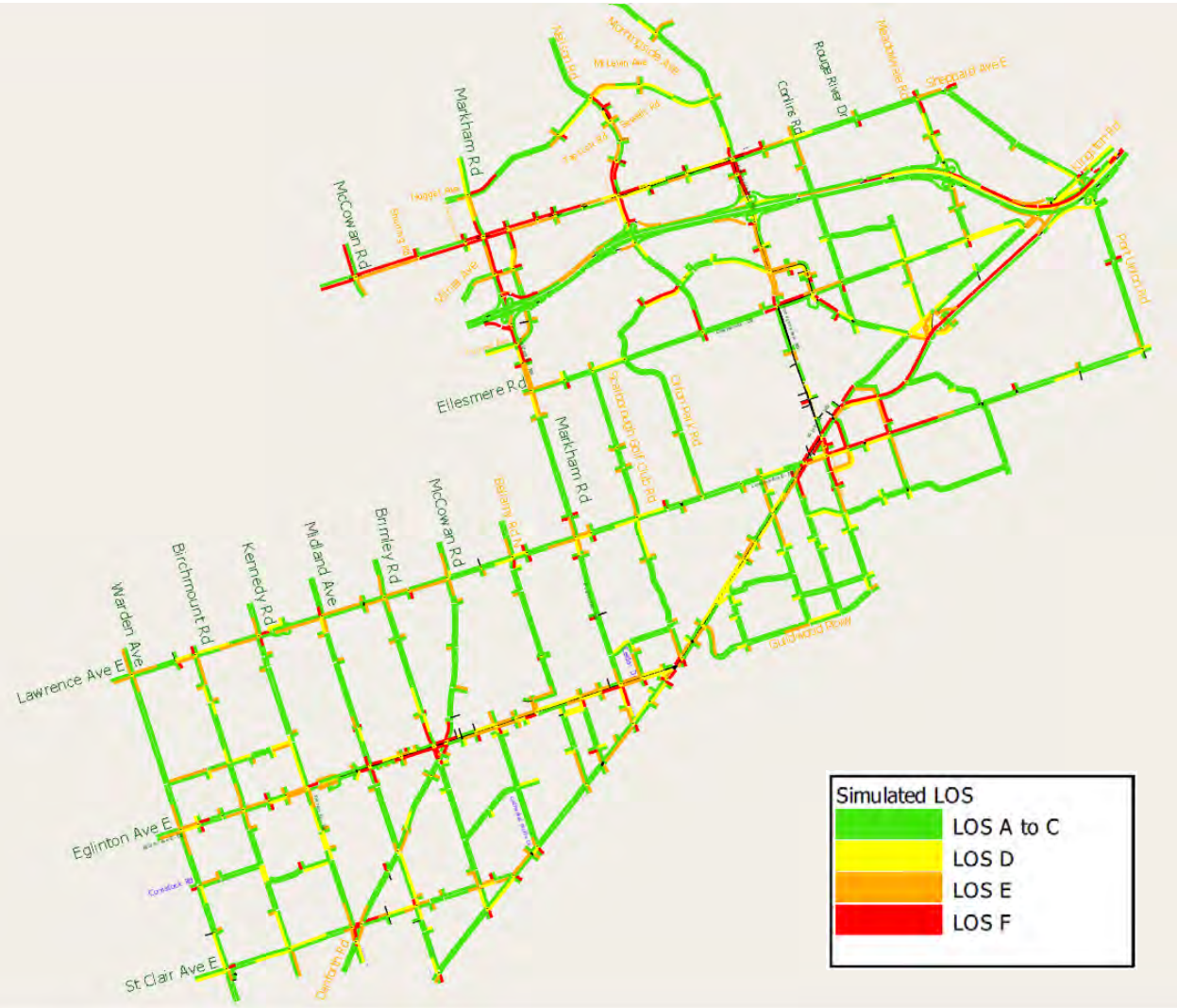
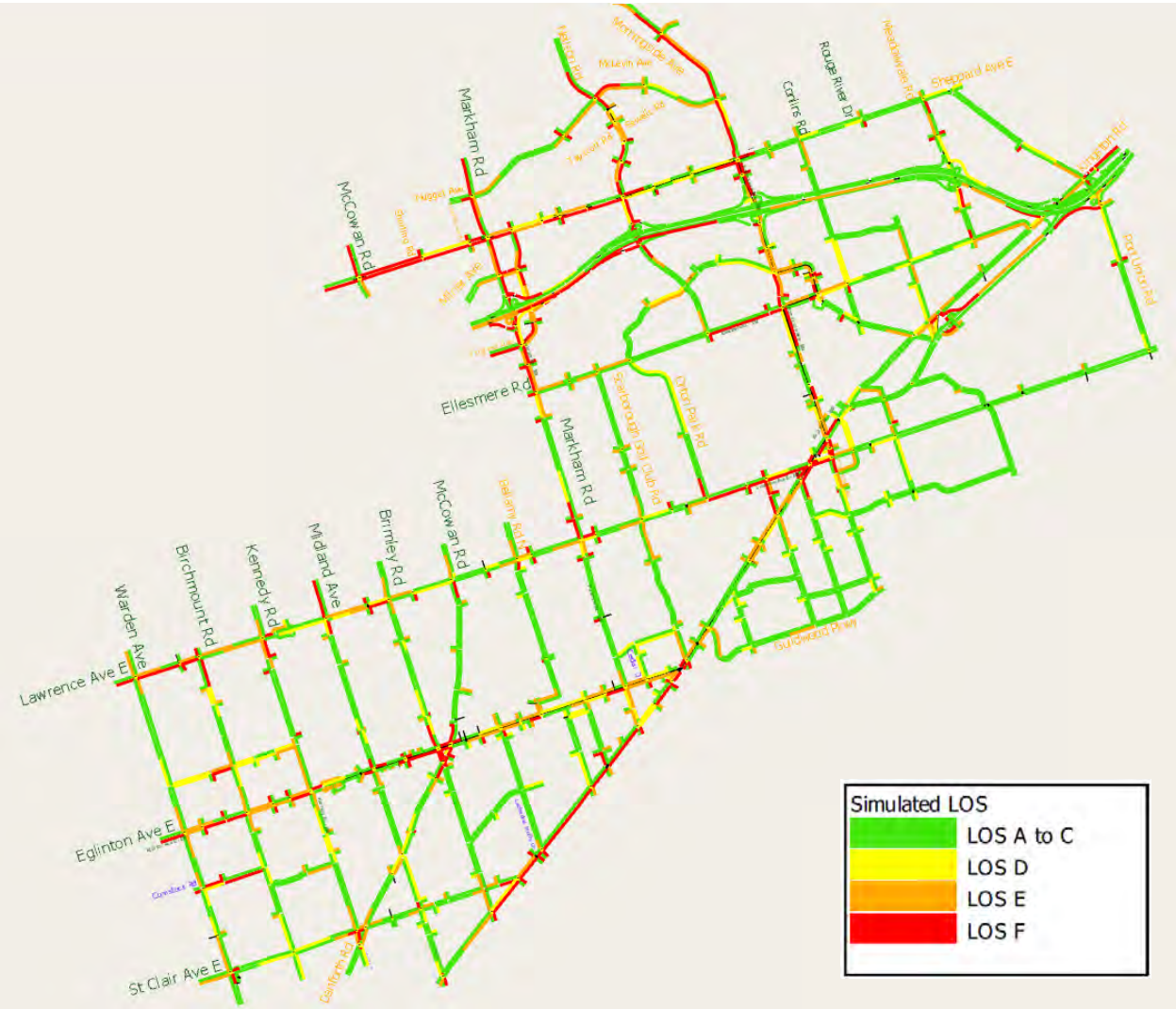


Figure 8: 2041 Simulated LOS – PM



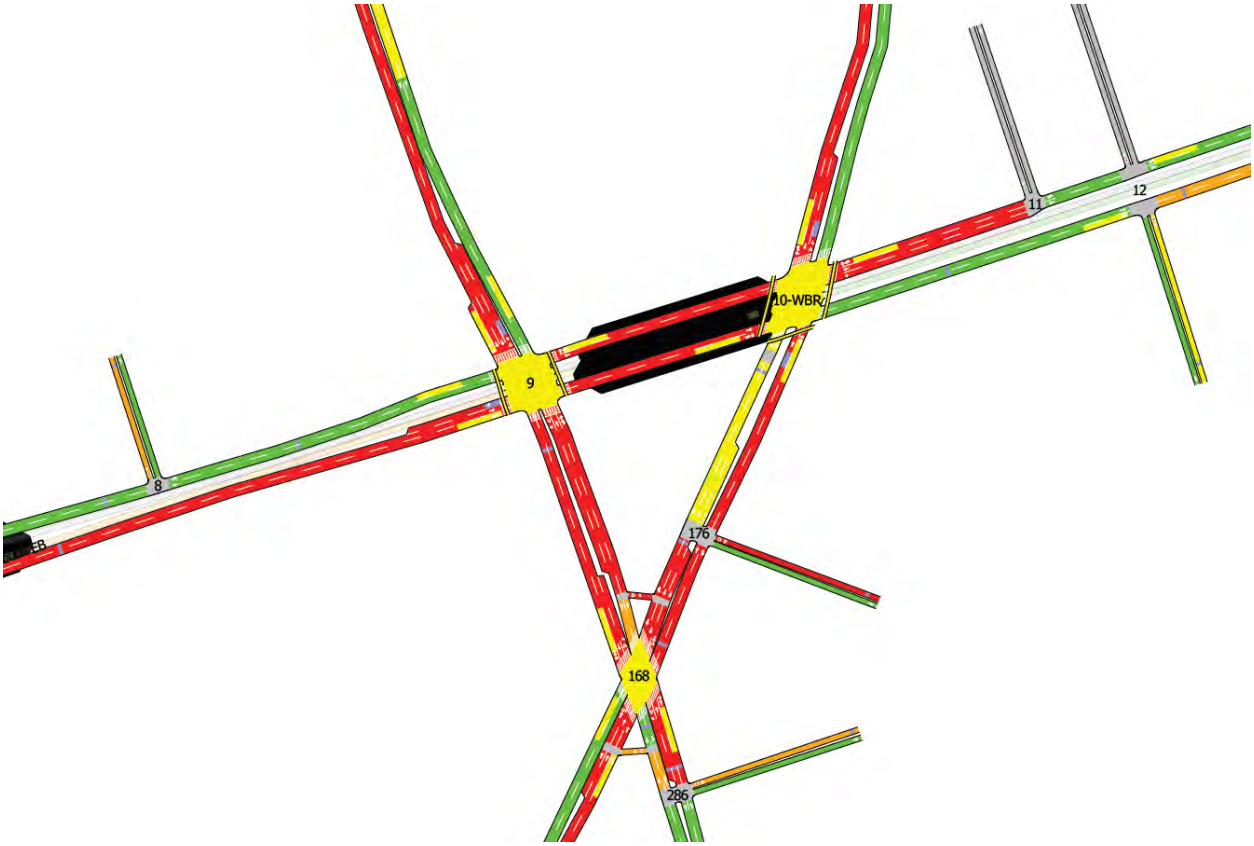
Along the EELRT route, critical intersections where multiple approaches operate at an LOS of F as followed:

- Eglinton Ave E at Midland Ave
- Eglinton Ave E at Brimley Rd
- Eglinton Ave E at McCowan Rd
- Eglinton Ave E at Markham Rd
- Eglinton Ave E at Kingston Rd
- Kingston Rd at Lawrence Ave E
- Kingston Rd at Morningside Ave
- Morningside Ave at Ellesmere Rd
- Ellesmere Rd at Military Trail
- Morningside Ave at Milner Ave

- Morningside Ave at Sheppard Ave E
- Sheppard Ave E at Neilson Rd
- Sheppard Ave E at Markham Rd
- Sheppard Ave E at McCowan Rd

These intersections are anticipated to have multiple approaches at an LOS of F as visualized in **Figure 9,** which can stem from high traffic volumes or latest design which include lane reduction or at grade LRT configuration.

Figure 9: Simulated LOS - Brimley, Eglinton, and Danforth (PM)



5 Findings and Recommendations

5.1 Focus Areas

The Kennedy at-grade terminus focus area analysis developed a set of signal timing plans for the existing intersection of Eglinton Avenue at Midland Avenue and the future signalized intersection of Eglinton Avenue at the Kennedy terminus / Eglinton loop. The two intersections are closely spaced by definition and would require, under City of Toronto policy in signal operations, to be hard-wired and synchronized in cycle length. The draft signal timing plan was completed within City policy and signal operations practices; in essence, demonstrating that the concept is feasible to operate. Concerns regarding traffic queues blocking LRT paths, especially the eastbound left turn, required additional follow-up with time-spaced diagrams to demonstrate that offset coordination can be employed to mitigate and control queue build-up and flush cycles; alternatively, the analysis recommended a policy-level decision to limit and/or prohibit the public use of eastbound left turn movement in order to further mitigate the risk of LRT blockage.

The Kingston-Morningside focus area analysis developed and optimized a draft signal timing plan that would accommodate LRT turning movements (Kingston eastbound to Morningside northbound, Morningside southbound to Kingston westbound). A key design-and-operation assumption employed throughout this analysis was that the two-way LRT movements would be concurrently compatible with both eastbound left and westbound left turning general traffic movements. Insertion of an exclusive LRT phase may not be viable given the existing traffic demands and patterns or would come at a great cost of capacity trade-offs at an already-congested intersection. Intersection operations can be improved for all modes (including LRT and pedestrians) if the existing northbound left and southbound left turns can be prohibited altogether – this allows for better allocation of intersection right-of-way as well as time-within-cycle, and likely mitigates further property impacts. A follow-up detour analysis for Falaise Road was conducted in the case of the above turn closures, which concluded that Rodda Boulevard would be utilized as a primary detour route, with entry paths/routes affected by a magnitude of several hundred metres (of additional travel).

In summary:

- Signal timings with LRT movements are viable at both the at-grade Kennedy terminus and the at-grade turn through Kingston-Morningside intersection
- Both focus areas are already operating near-capacity with existing traffic volumes in existing conditions; for LRT to be accommodated in the at-grade signal operations without an exemption to the existing City policies, some levels of prohibition or full closures of existing left turn movements may need to be considered in the implementation phase.
- Light Rail Vehicle (LRV) characteristics can have a degree of impact in the overall performance of the intersection for all modes; in particular, the LRV length and track design will impact the LRV clearance calculations. The statement of viability in the focus area analyses is based on a theoretical 50m LRV with vehicular performance and track characteristics similar to Finch West LRT in the City of Toronto.

5.2 Network

The Aimsun model analysis reviewed the incremental impacts of the design updates, as well as the overall network operations in terms of hotspots and intersections with operational constraints. Based on the network simulation using Aimsun, the following intersections observed more than one approach where capacity constraints are expected, based on poor level of service (LOS F).

- Eglinton Ave E at Midland Ave
- Eglinton Ave E at Brimley Rd
- Eglinton Ave E at McCowan Rd
- Eglinton Ave E at Markham Rd
- Eglinton Ave E at Kingston Rd
- Kingston Rd at Lawrence Ave E
- Kingston Rd at Morningside Ave
- Morningside Ave at Ellesmere Rd
- Ellesmere Rd at Military Trail
- Morningside Ave at Milner Ave
- Morningside Ave at Sheppard Ave E
- Sheppard Ave E at Neilson Rd
- Sheppard Ave E at Markham Rd
- Sheppard Ave E at McCowan Rd

During subsequent design stages (anticipated to be 30% design), the following design refinement and network optimization are recommended:

- Update signal timing policy for the base network, to account for background Vision Zero signal timing policy updates such as leading pedestrian intervals, clearance timing updates, lowered speed limits
- Update base EELRT alignment for the base case condition, to account for current RapidTO dedicated lane configuration for refinement
- Update base traffic conditions to account for post-COVID traffic demand
- Incorporate the DSBRT design as part of the Ellesmere Rd background configuration in all scenarios
- Perform further network and signal timing optimization based on the updated base network plus refined EELRT transit and intersection design
- Complete a microsimulation and PXO warrant process at Ellesmere/NMT to determine whether proposed PXO is actually operationally feasible/effective
- Incorporate DSBRT design and future operations in the modelling scenarios (this would go a long way even if this is conducted as a sensitivity analysis)

Traffic and LRT Operations at the Kennedy Terminus

Synchro analysis

Purpose and Methodology

- Purpose
  1. Develop a feasible signal timing plan at Midland and at the loop
  2. Analyze intersection delay to LRT service at Midland and at the loop
  3. Determine if EB queues from Midland will block LRT at the loop

- Methodology
  - Calculate intersection clearances based on proposed design, pedestrian crossing length, vehicle length, City policy on signal timings
  - Develop and implement signal timings in Synchro
  - Analyze intersection operations (delays, queues) and interpretations/insights of the results

Assumptions and Parameters

- LRV Length: 50m
- LRV intersection speed: 25-35kph
- Cycle length: max 135s at both study intersections, coordinated
- At terminus/loop: No RTOR for EBR and NBR
- Both study intersections are in a Senior Safety Zone.
  - Minimum walk: 8s; Walk speeds: 0.9m/s overall, 1.1m/s during FDW.
- Standard for calculating clearances for timings:
  - "*Traffic Systems Operations Standard Operating Procedure: Vehicle Change and Clearance Intervals*", City of Toronto (May 11, 2020)
  - Ontario Traffic Manual Book 12 (2012)

Intersection Clearances

At Eglinton/Midland

Movement Impacted by LRT	Required Clearance Interval
Pedestrian North-South Crossing	**Walk 8s, FDW 39s**
NBL/SBL vehicle turns	Amber 3.3s, Red 4.3s
EBL/WBL vehicle turns	Amber 3.3s, Red 5.5s
Vehicle through-movements	Amber 3.3s, Red 3.8s

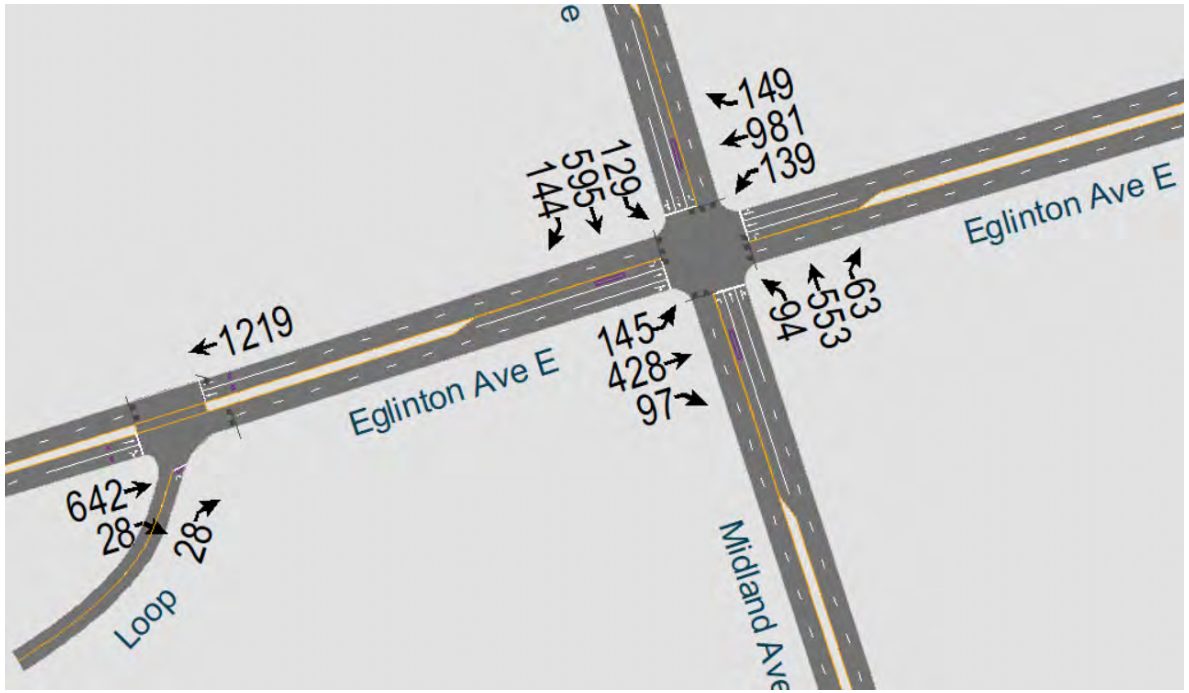
At Eglinton Loop/LRT Terminus Driveway

Movement Impacted by LRT	Required Clearance Interval
LRT movements (25kph)	**Amber 4.5s, Red 19s**
LRT movements (35kph)	Amber 5.9s, Red 13.6s
EBT general traffic through-movement	Amber 3.3s, Red 5.7s
NBR vehicle turn	Amber 3.3s, Red 1.3s

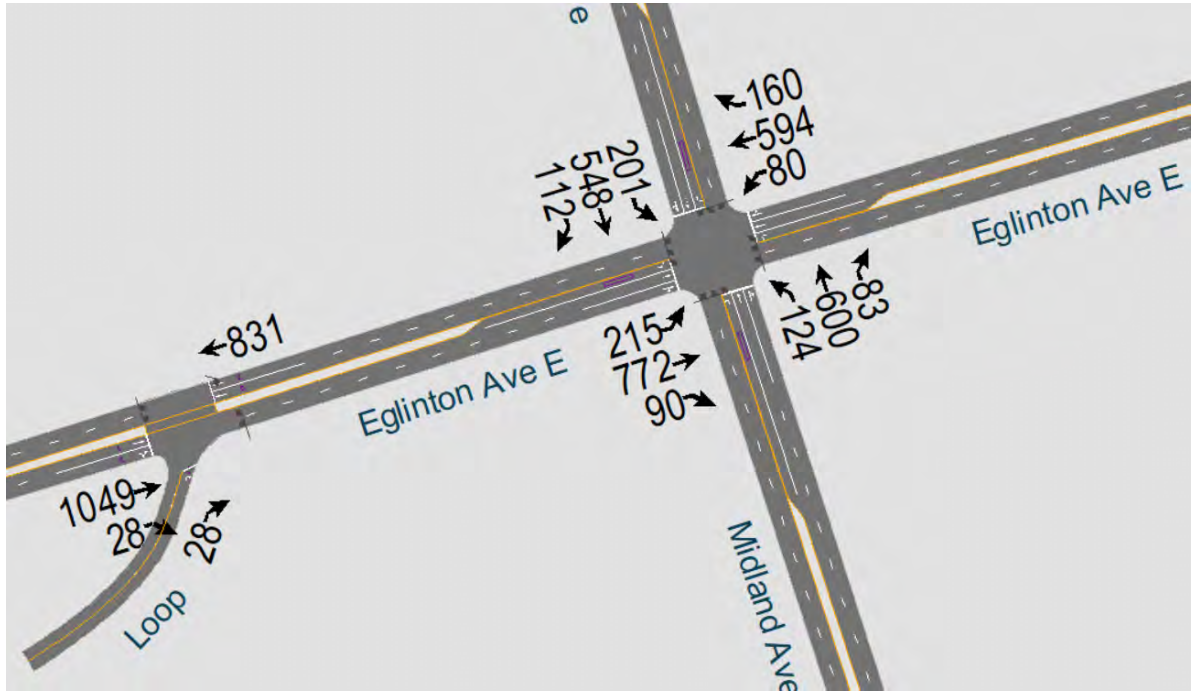
2041 Traffic Volumes

- Derived by applying 0.5% annual growth rate from 2022 to 2041

2041 AM



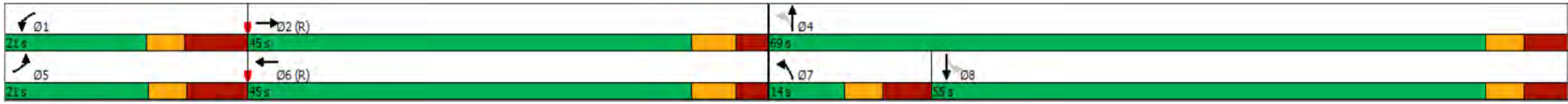
2041 PM



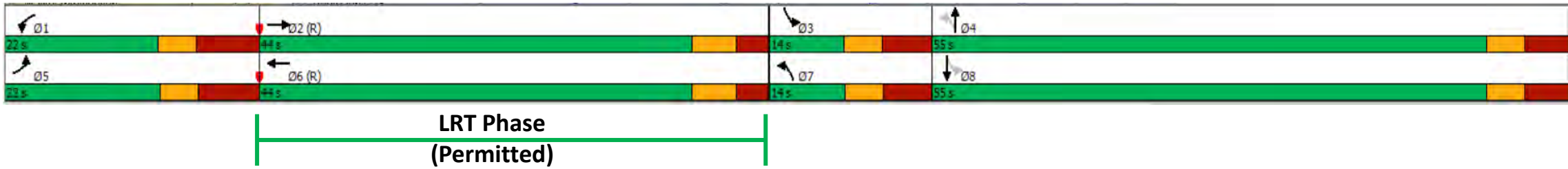
Signal Timings

Eglinton/Midland:

AM



PM



Eglinton/LRT Terminus Driveway (assume LRV@25kph):

AM

PM

Results – LRT

- Average Delay to LRT: calculated based on random arrivals
- Max Delay to LRT is theoretically ~3.5 minutes (if LRT just misses end of green both times), but this is not expected to occur during coordinated operations

Analysis Period	Intersection	Minimum Cycle Length	Analyzed Cycle Length	LRT Phase Duration	Average LRT Delay
AM	Eglinton/Midland	128s	135s	45s	~50s
	LRT Terminus Driveway*	79s	135s	31s	~60s
	Total Delay	-	-	-	~110s
PM	Eglinton/Midland	128s	135s	44s	~50s
	LRT Terminus Driveway*	79s	135s	31s	~60s
	Total Delay	-	-	-	~110s

*Single insertion, assumes no phase rotation

Intersection Results (2041)

Intersection	Movement	AM Peak Hour (CL 135s)					PM Peak Hour (CL 135s)				
		v/c Ratio	Delay(s)	LOS	50th%ile Queue(m)	95th%ile Queue (m)	v/c Ratio	Delay(s)	LOS	50th%ile Queue (m)	95th%ile Queue (m)
Midland Avenue	**Overall**	**0.87**	**59**	**E**	-	-	**0.97**	**56**	**E**	-	-
	EBL	1.03	158	F	49	**98**	1.34	263	F	87	**143**
	EBTR	0.59	33	C	39	**48**	0.89	44	D	63	**168**
	WBTR	1.05	87	F	196	241	0.71	46	D	104	128
	NBL	0.50	25	C	16	28	0.55	28	C	22	36
	SBTR	0.68	39	D	97	121	0.57	37	D	82	103
LRT Terminus Driveway	**Overall**	**0.52**	**17**	**B**	-	-	**0.44**	**20**	**B**	-	-
	EBTR	0.36	15	B	52	65	0.55	19	B	95	113
	NBR	0.40	66	E	8	19	0.37	65	E	8	19

- Distance from EB stopbar @ Midland to LRT tracks at terminus is ~100 m.
- EBL and EBT queues are more concerning in the PM (peak travel direction) than AM.
- PM 95th percentile queues, without mitigations, will likely block the LRT tracks at terminus.

Discussion

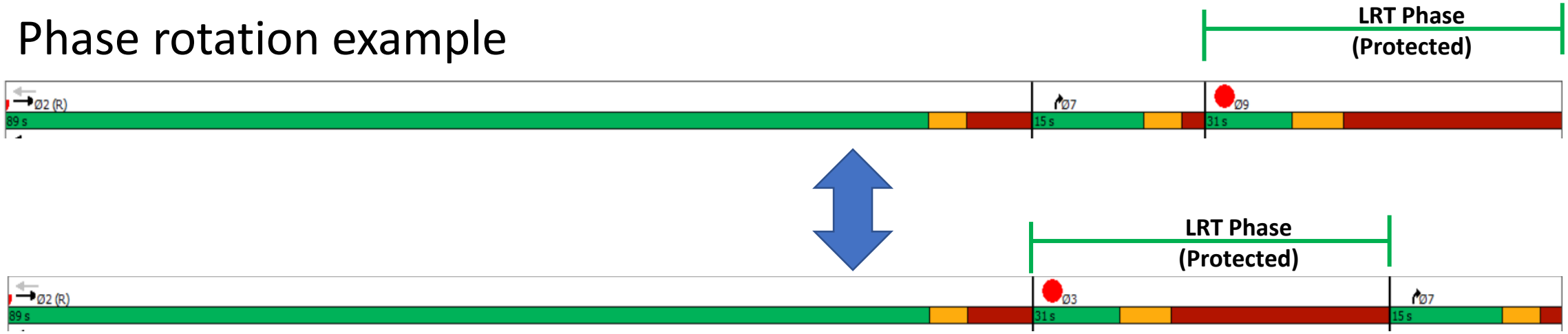
- Notable factors affecting 2041 forecasted intersection conditions:
  - Assumed +10% traffic growth in all movements
  - Assumed geometric changes: 3 -> 2 thru-lanes per direction, EB and WB HOV lanes removed
  - Necessary operational changes: EBL/WBL from protected-permissive to fully protected
  - Cycle length increase 120 -> 135s (City policy maximum) and long north-south pedestrian crossing distance
- EB queues at Midland, if unmitigated, may spill back and block LRT path in the PM peak hour/period.
- Total average (unmitigated) LRT delay incurred in getting through these two intersections = 1.5 to 2 minutes
- **Mitigation measures are recommended to improve LRT operations and reduce eastbound traffic queues**

Potential Operations Mitigation Measures

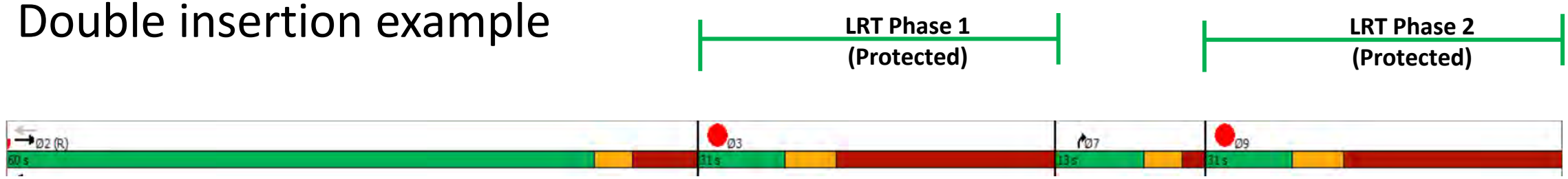
1. Consider two-stage pedestrian crossing at Midland/Eglinton
   - +: more green time for EBL and EB/WB LRT, reduction to EBL traffic queues and LRT delays
   - -: more delay time to pedestrians crossing north-south, pedestrian safety concerns
2. Ban EBL to general traffic at Midland during AM and PM peak periods
   - +: essentially removes EBL queuing issues, may allow slightly shorter cycle length
   - -: enforcement challenges, driver frustration, traffic re-routing
3. Enable phase rotation at Terminus/Loop
   - + reduce average and maximum LRT delays
   - -: operational confusion and safety concerns
4. Double insertion for LRT phase at Terminus/Loop
   - + reduce average and maximum LRT delays (more effective than phase rotation)
   - -: operational confusion and safety concerns

Potential Mitigation Measures (cont'd)

Phase rotation example



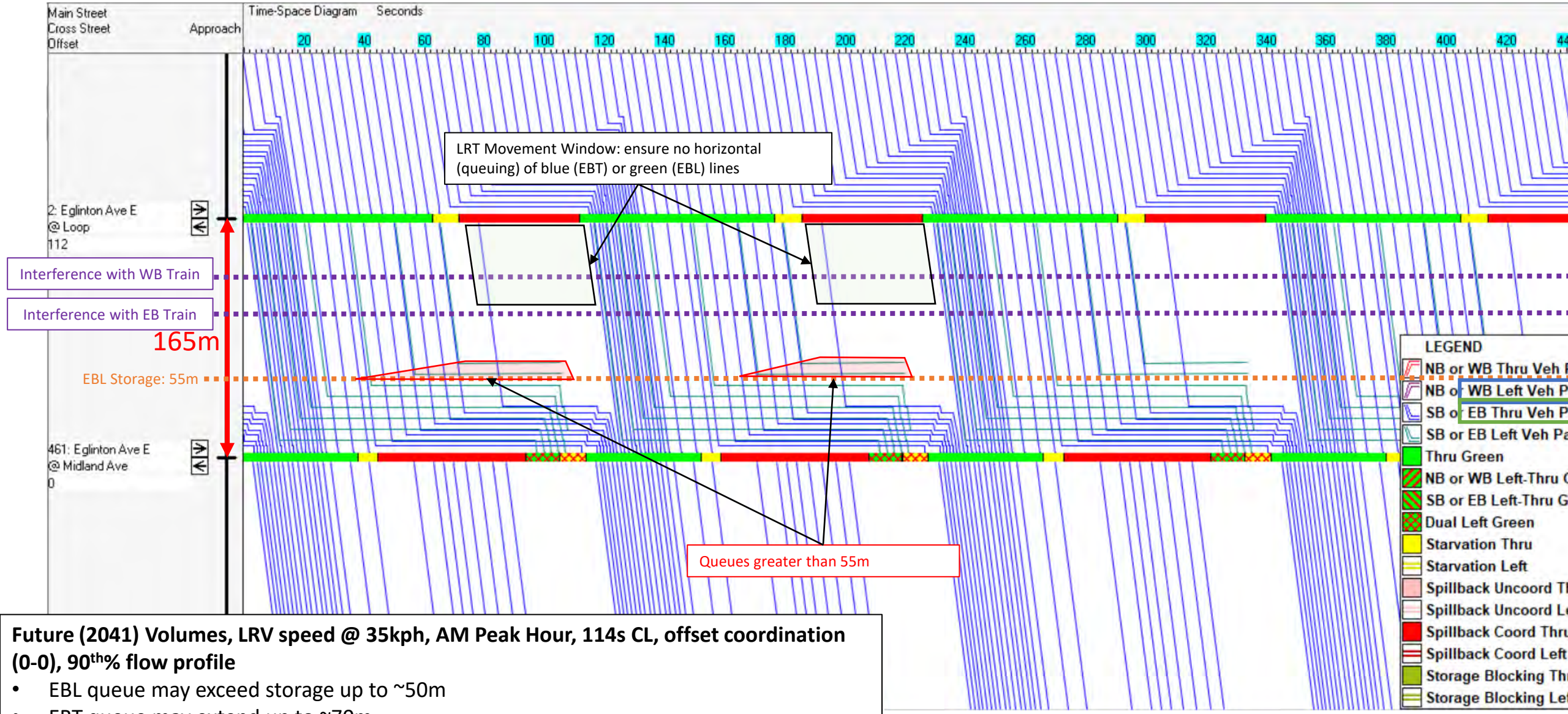
Double insertion example



Conclusions

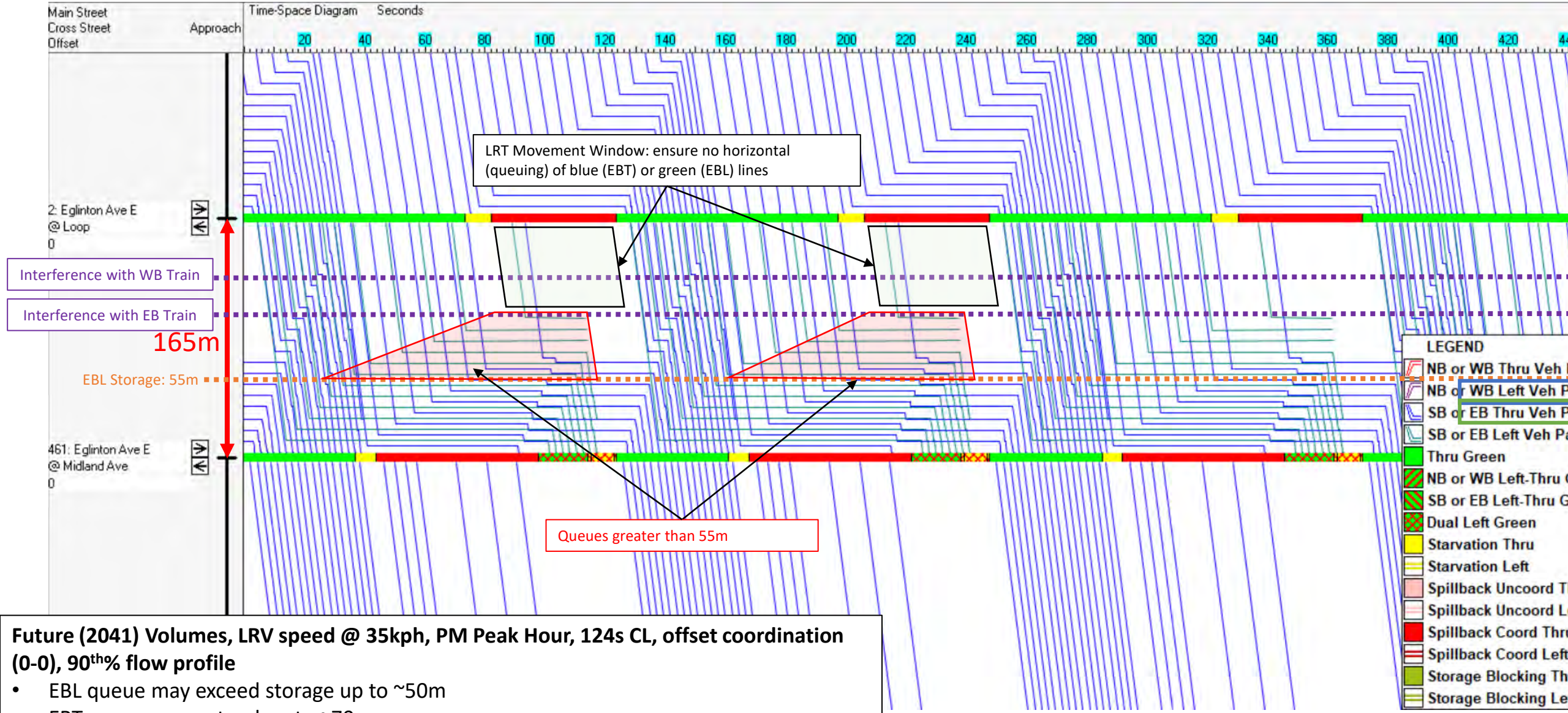
- Signal timing plans are feasible for both intersections
  - Within / compliant to all applicable City of Toronto and OTM guidelines
  - Limited within project assumptions: <50m train
- Future (2041) operations at Midland are at-capacity
  - Unmitigated PM eastbound queues may block LRT path at the Terminus/Loop
  - Traffic pattern monitoring and update recommended (e.g. post-ECLRT)
- Mitigation measures should be considered for further analysis
  - LRT-focused signal optimization and coordination
  - Relative impacts, combinations of measures
- Mitigation measures may be considered for implementation
  - Can be drafted for future contract details (e.g. project output specifications)

Extra Slides



Future (2041) Volumes, LRV speed @ 35kph, AM Peak Hour, 114s CL, offset coordination (0-0), 90th% flow profile

- EBL queue may exceed storage up to ~50m
- EBT queue may extend up to ~70m
- Trains are not blocked



Future (2041) Volumes, LRV speed @ 35kph, PM Peak Hour, 124s CL, offset coordination (0-0), 90th% flow profile

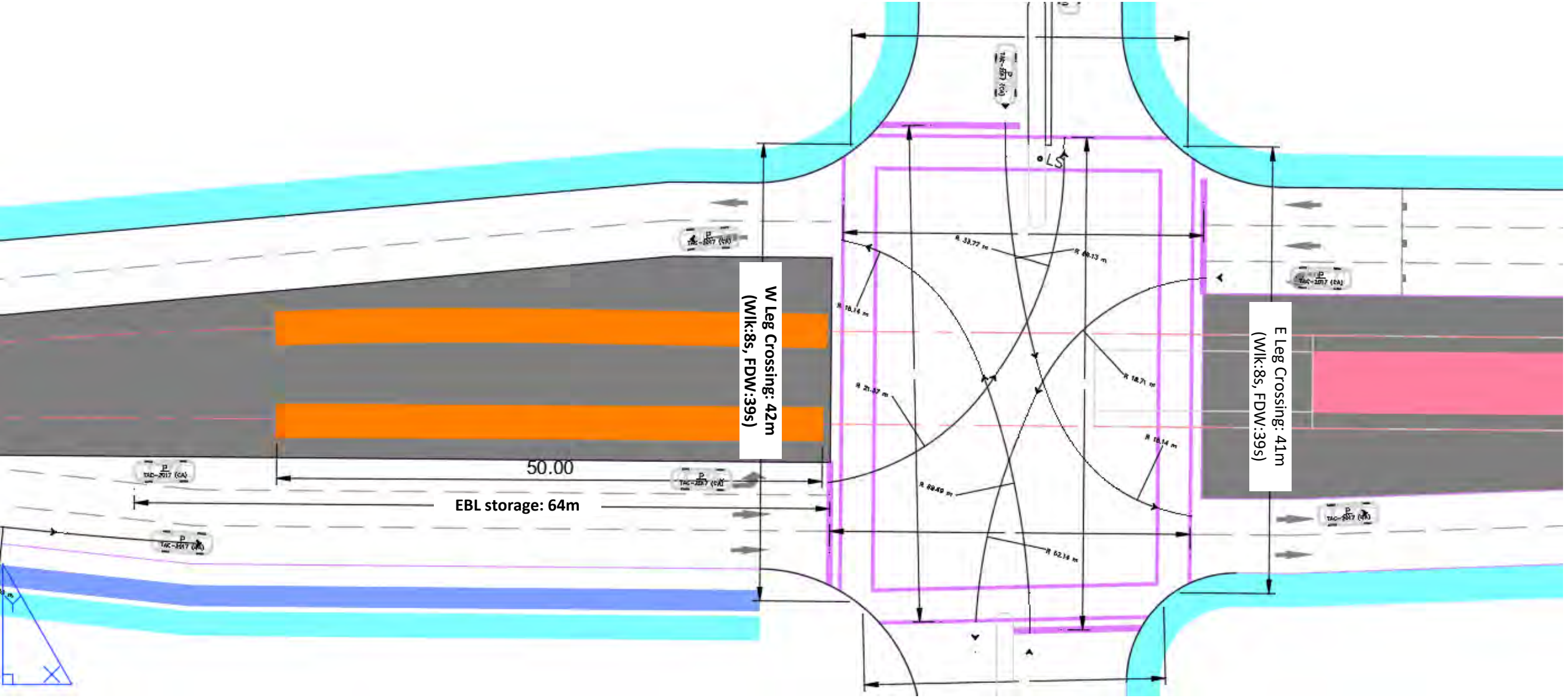
- EBL queue may exceed storage up to ~50m
- EBT queue may extend up to ~70m
- Trains are rarely blocked

Assumptions – Intersection Dimensions

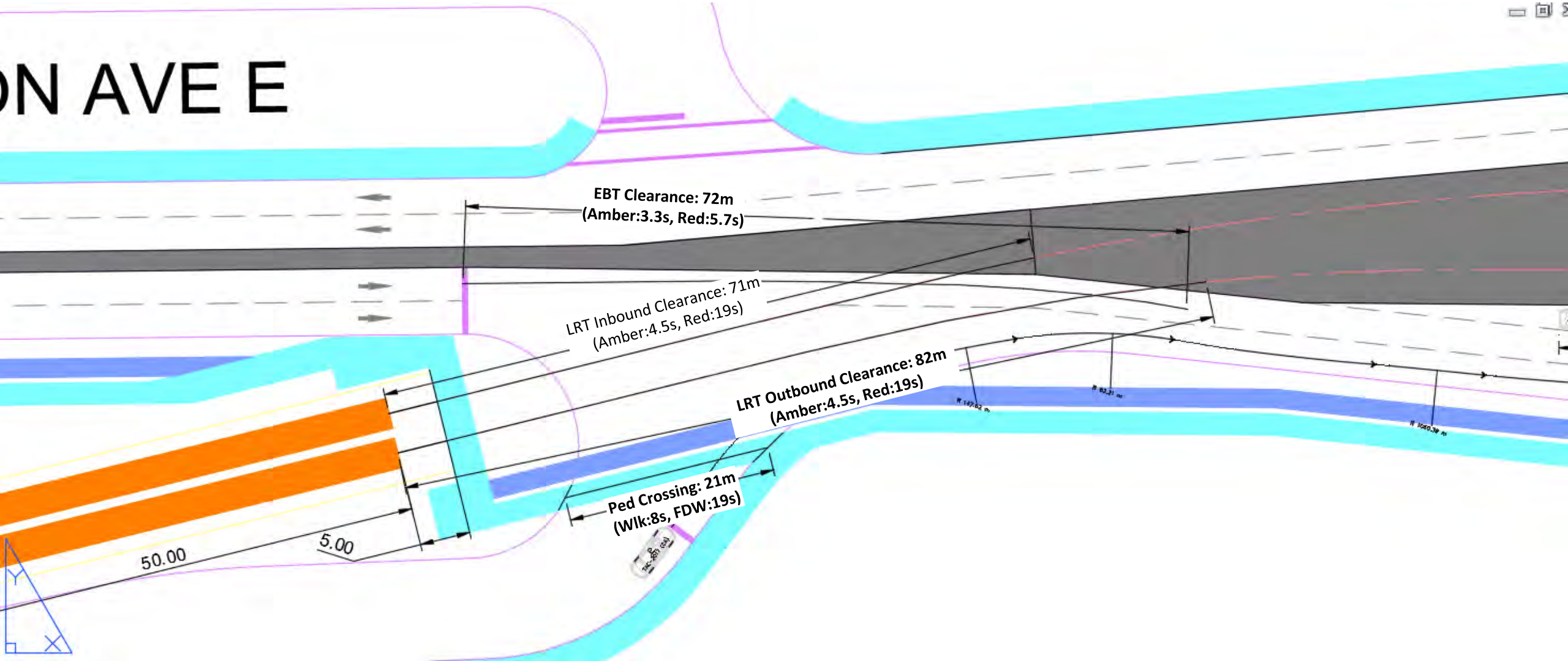
- At Eglinton/Midland:
  - Pedestrian North-South Crossing Distance: 42m (Walk 8s, FDW 39s)
  - NBL/SBL Clearance Distance* & Turn Speed: 43m @ 35kph (Amb:3.3s, Red:4.3s)
  - EBL/WBL Clearance Distance* & Turn Speed: 42m @ 27kph (Amb: 3.3s, Red: 5.5s)
  - NBT/SBT Clearance Distance* & Speed: 45m @ 50kph (Amb: 3.3s, Red: 3.8s)
  - No substantial changes to EBT/WBT Clearances and Crossing Distances
- At LRT Terminus Driveway:
  - LRT inbound distance*: 71m @ 25kph
  - LRT outbound distance*: 82m @ 25kph (Green: 7s, Amb: 4.5s, Red: 19s) - **Governs**
  - EBT General Traffic Clearance Distance & Speed: 72m @ 50kph (Amb: 3.3s, Red: 5.7s)
  - Pedestrian south leg (East-West) Crossing Distance: 21m (Walk 8s, FDW 19s)

***Distance before vehicle length is added (7m for general traffic, 50m for LRT train)**

Assumptions – Midland Key Dimensions



Assumptions – Terminus Key Dimensions



1-stage crossing results

Analysis Period	Intersection	Minimum Cycle Length	Proposed Cycle Length	LRT Phase Duration	Average Delay	Max Delay
AM	Eglinton/Midland	128s	135s	45s	30s	90s
	LRT Terminus Driveway*	79s	135s	31s	40s	104s
	Total Delay	-	-	-	70s (>1min)	194s (>3min)
PM	Eglinton/Midland	128s	135s	44s	31s	91s
	LRT Terminus Driveway*	79s	135s	31s	40s	104s
	Total Delay	-	-	-	71s (>1min)	195s (>3min)

2-stage crossing results

Analysis Period	Location	Minimum Cycle Length	Cycle Length	LRT Phase Duration	Average Delay	Max Delay
AM	Eglinton/Midland	108s	114	45s	21s	69s
	LRT Terminus Driveway*	79s	114	31s	30s	83s
	Total Delay	-	-	-	51s (<1min)	152s (1.5min)
PM	Eglinton/Midland	108s	124	44s	26s	80s
	LRT Terminus Driveway*	79s	124	31s	35s	93s
	Total Delay	-	-	-	61s (1min)	173s (<3min)

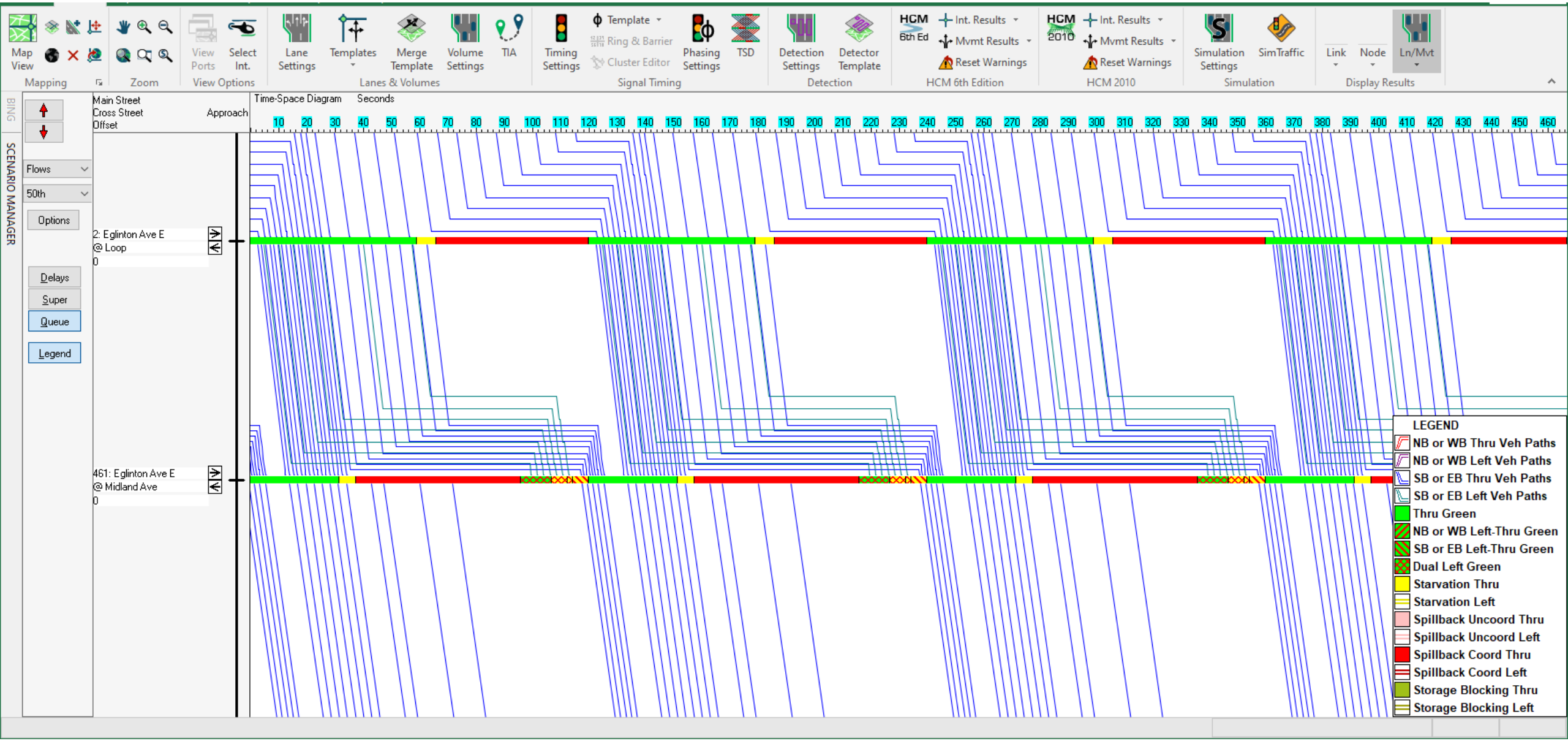
Results for Two-Stage Crossing

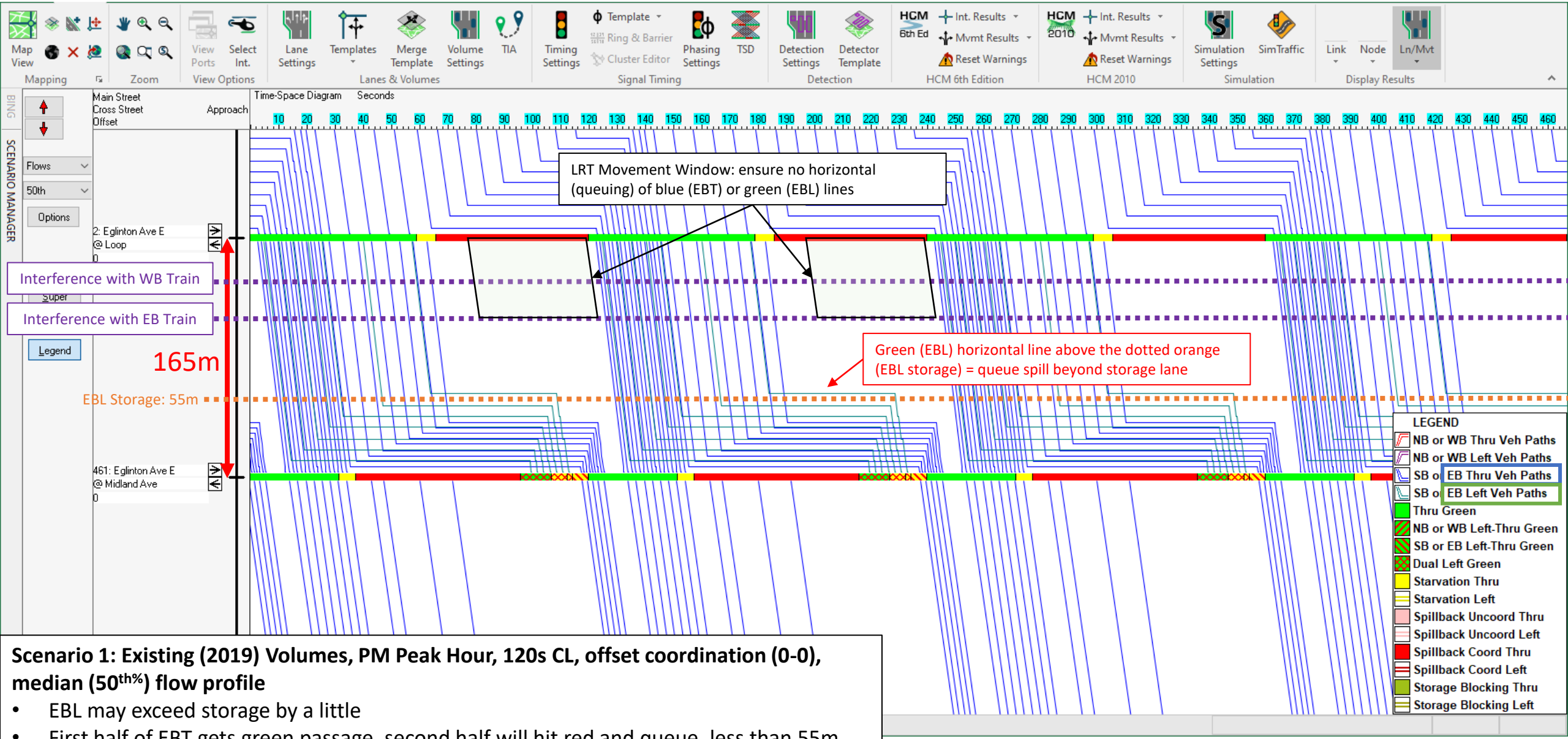
Intersection	Movement	Storage length (m)	AM Peak Hour (CL 114s)					PM Peak Hour (CL 124s)				
			v/c Ratio	Delay(s)	LOS	50th%ile Queue(m)	95th%ile Queue (m)	v/c Ratio	Delay(s)	LOS	50th%ile Queue (m)	95th%ile Queue (m)
Midland Avenue	***Overall***	-	***0.93***	***47.6***	***D***	-	-	***0.96***	***50.6***	***D***	-	-
	EBL	60	0.94	118.1	F	40.1	82.7	0.96	111.8	F	63.7	115.2
	EBTR	95	0.49	20.0	B	23.8	30.1	0.75	28.5	C	52.2	65.6
	WBTR	183.4	0.88	42.5	D	139.4	171.4	0.65	38.5	D	90.4	112.9
	NBL	65	0.65	34.1	C	15.9	33.5	0.70	42.8	D	22.9	42.5
	NBTR	179.8	0.52	29.0	C	62.2	80.5	0.91	62.5	E	95.8	132.1
LRT Terminus Driveway	***Overall***	-	***0.55***	***9.6***	***A***	-	-	***0.45***	***13.4***	***B***	-	-
	EBTR	224.4	0.37	14.4	B	46.3	59.0	0.54	16.6	B	84.6	102.8
	NBR	72.1	0.37	55.0	D	7.0	17.0	0.35	59.5	E	7.2	17.1

Conclusion:

- Two-stage crossing reduces EB queue blockages in the AM.
- PM queue blockages expected to persist occasionally, even after Two-stage crossing

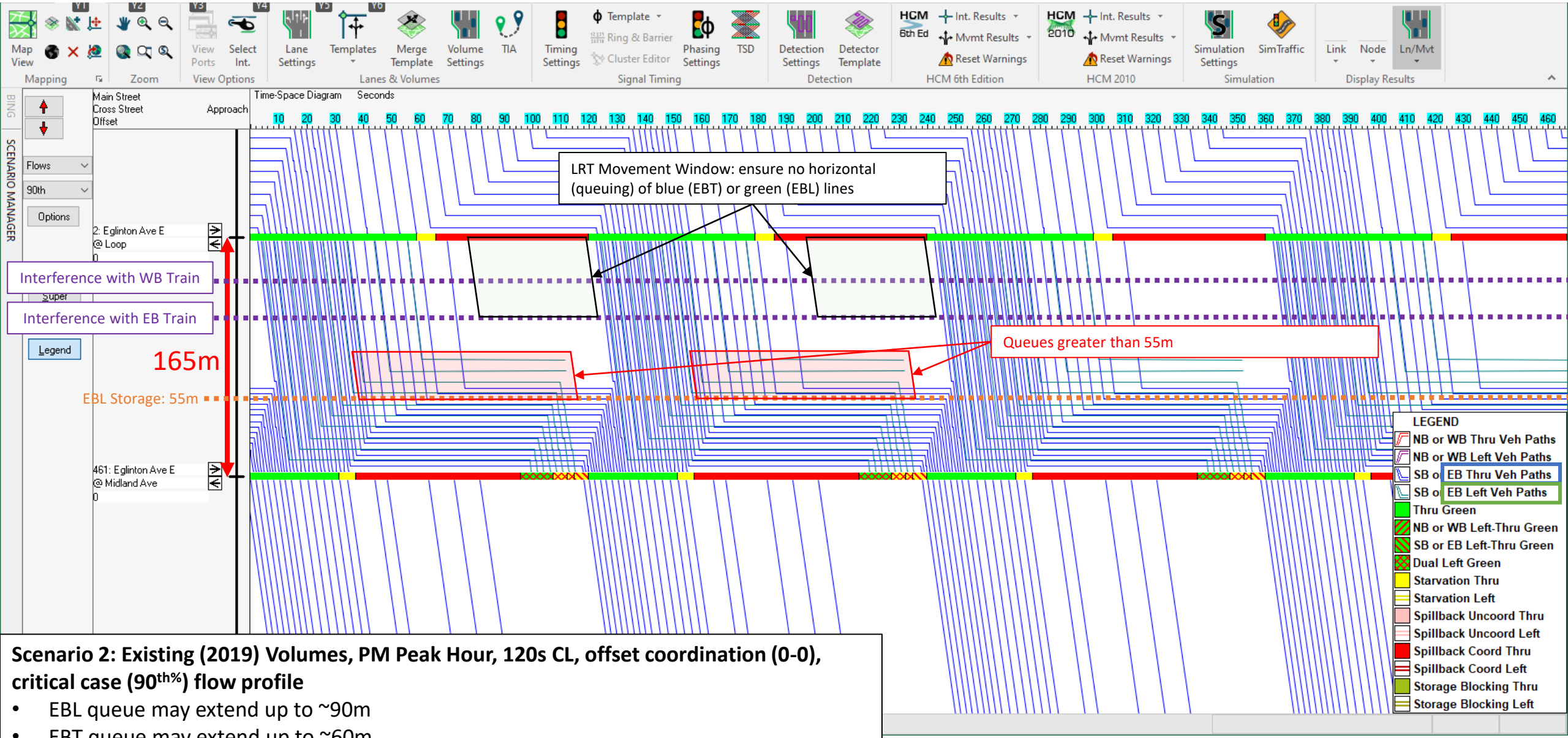
Appendix 2
EB Queue Flush Exercise


Map View
Mapping
Zoom
View Ports
Select Int.
View Options
Lane Settings
Templates
Merge Template
Volume Settings
TIA
Lanes & Volumes
Timing Settings
Template
Ring & Barrier
Cluster Editor
Phasing Settings
TSD
Signal Timing
Detection Settings
Detector Template
Detection
HCM 6th Ed
Int. Results
Mvmt Results
Reset Warnings
HCM 6th Edition
HCM 2010
Int. Results
Mvmt Results
Reset Warnings
HCM 2010
Simulation Settings
SimTraffic
Simulation
Link
Node
Ln/Mvt
Display Results
BING
SCENARIO MANAGER
Main Street
Cross Street
Offset
Approach
Time-Space Diagram
Seconds
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460
Flows
50th
Options
2: Eglinton Ave E
@ Loop
0
Delays
Super
Queue
Legend
461: Eglinton Ave E
@ Midland Ave
0
LEGEND
NB or WB Thru Veh Paths
NB or WB Left Veh Paths
SB or EB Thru Veh Paths
SB or EB Left Veh Paths
Thru Green
NB or WB Left-Thru Green
SB or EB Left-Thru Green
Dual Left Green
Starvation Thru
Starvation Left
Spillback Uncoord Thru
Spillback Uncoord Left
Spillback Coord Thru
Spillback Coord Left
Storage Blocking Thru
Storage Blocking Left



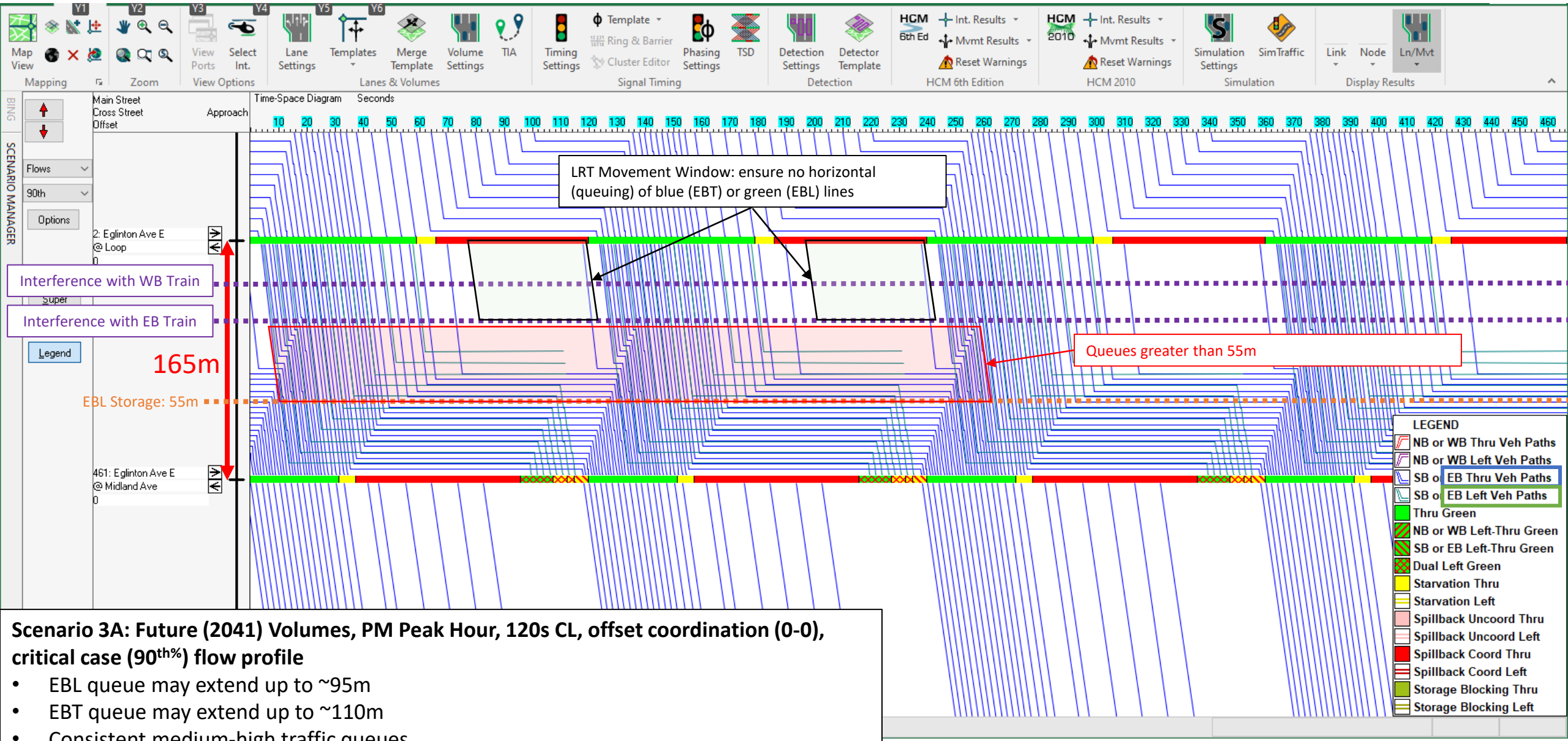
Scenario 1: Existing (2019) Volumes, PM Peak Hour, 120s CL, offset coordination (0-0), median (50$^{th\%}$) flow profile

- EBL may exceed storage by a little
- First half of EBT gets green passage, second half will hit red and queue, less than 55m
- No interference with train movements



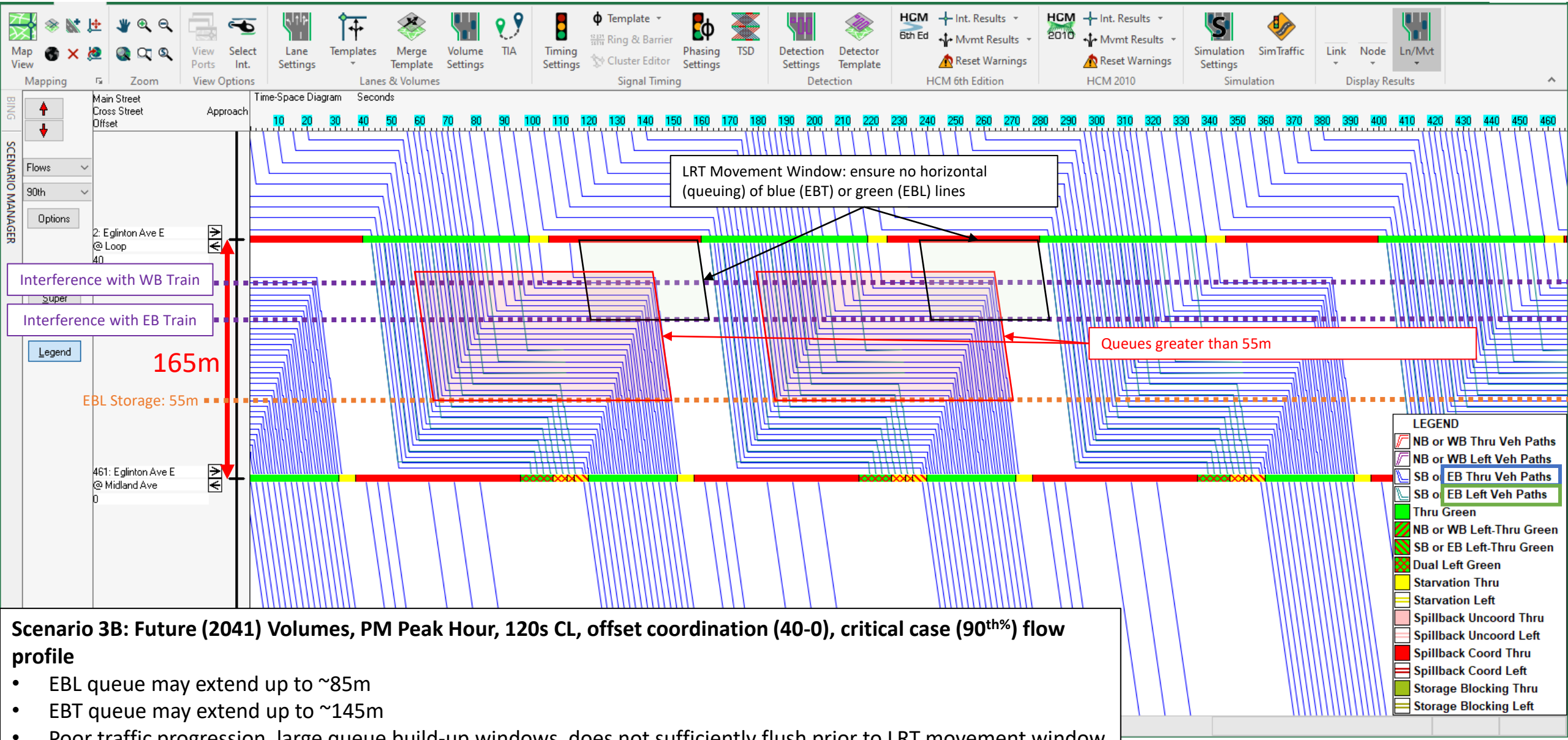
Scenario 2: Existing (2019) Volumes, PM Peak Hour, 120s CL, offset coordination (0-0), critical case (90$^{th\%}$) flow profile

- EBL queue may extend up to ~90m
- EBT queue may extend up to ~60m
- No interference with train movements



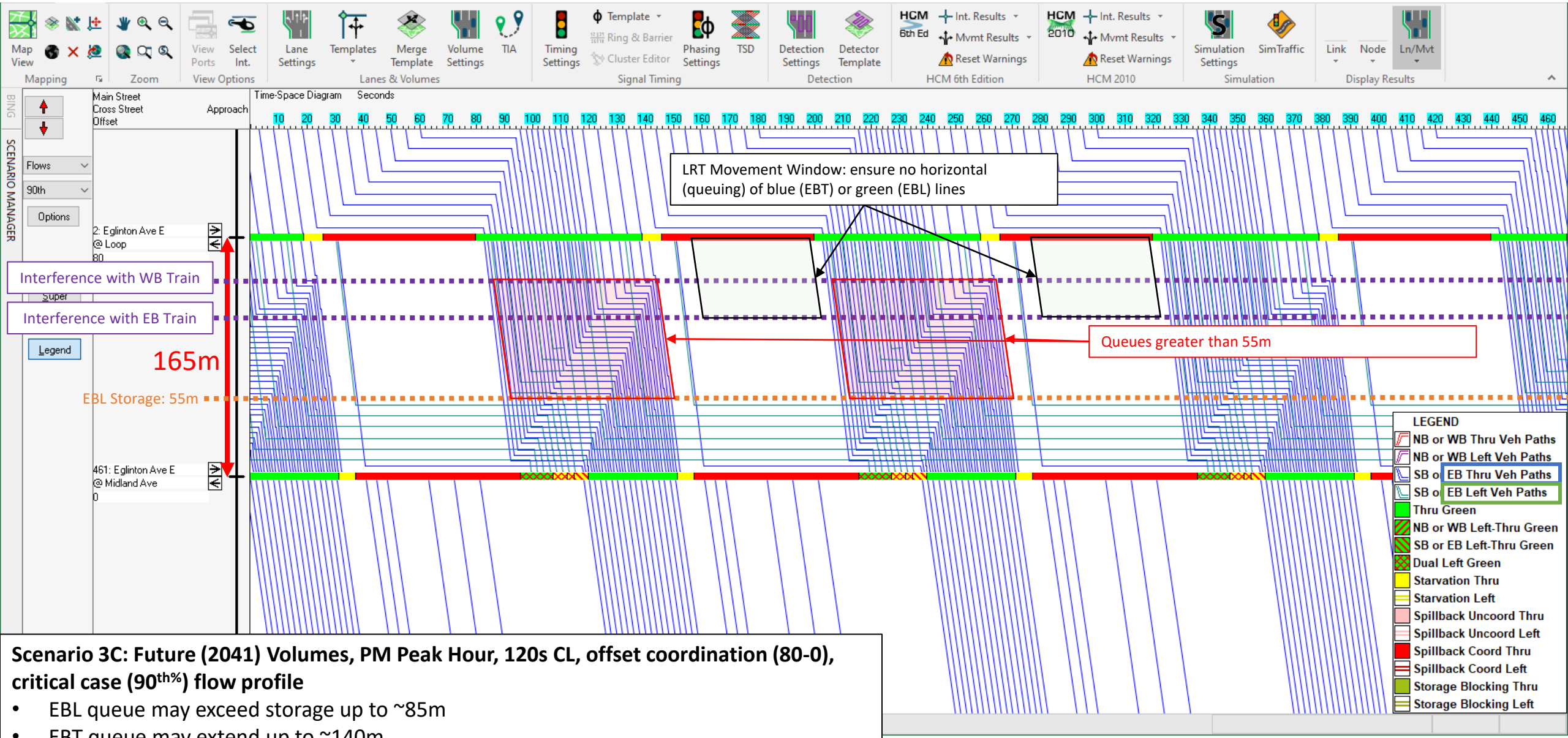
Scenario 3A: Future (2041) Volumes, PM Peak Hour, 120s CL, offset coordination (0-0), critical case (90th%) flow profile

- EBL queue may extend up to ~95m
- EBT queue may extend up to ~110m
- Consistent medium-high traffic queues
- Close… but no interference with train movements



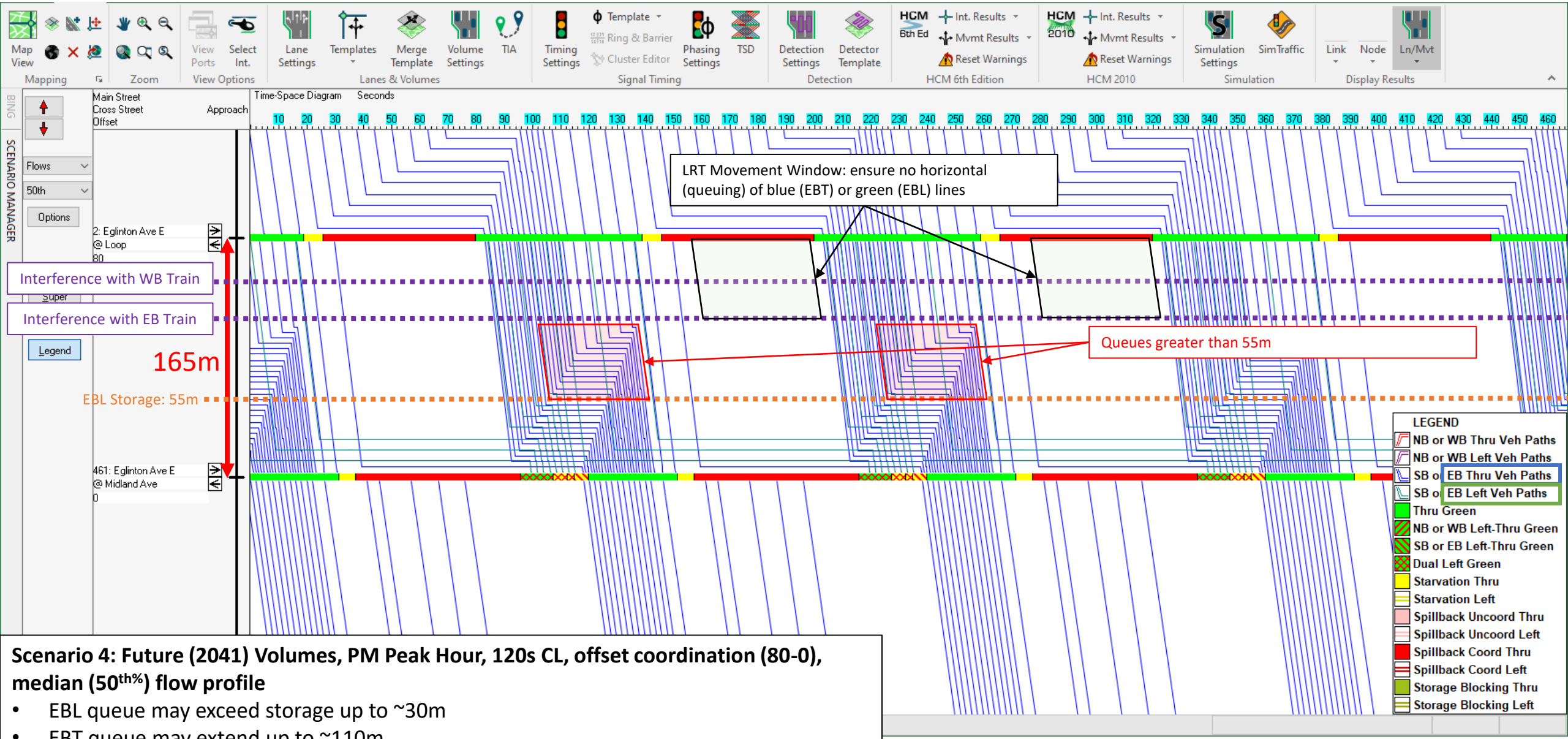
Scenario 3B: Future (2041) Volumes, PM Peak Hour, 120s CL, offset coordination (40-0), critical case (90$^{th\%}$) flow profile

- EBL queue may extend up to ~85m
- EBT queue may extend up to ~145m
- Poor traffic progression, large queue build-up windows, does not sufficiently flush prior to LRT movement window
- Trains are blocked (this is a demonstration of “what to avoid”)



Scenario 3C: Future (2041) Volumes, PM Peak Hour, 120s CL, offset coordination (80-0), critical case (90th%) flow profile

- EBL queue may exceed storage up to ~85m
- EBT queue may extend up to ~140m
- Poor traffic progression but queues are flushed and trains are not blocked



Scenario 4: Future (2041) Volumes, PM Peak Hour, 120s CL, offset coordination (80-0), median (50th%) flow profile

- EBL queue may exceed storage up to ~30m
- EBT queue may extend up to ~110m
- Trains are not blocked

Appendix 3
Kingston – Morningside Traffic Analysis 4

Kingston – Morningside Traffic Analysis 4

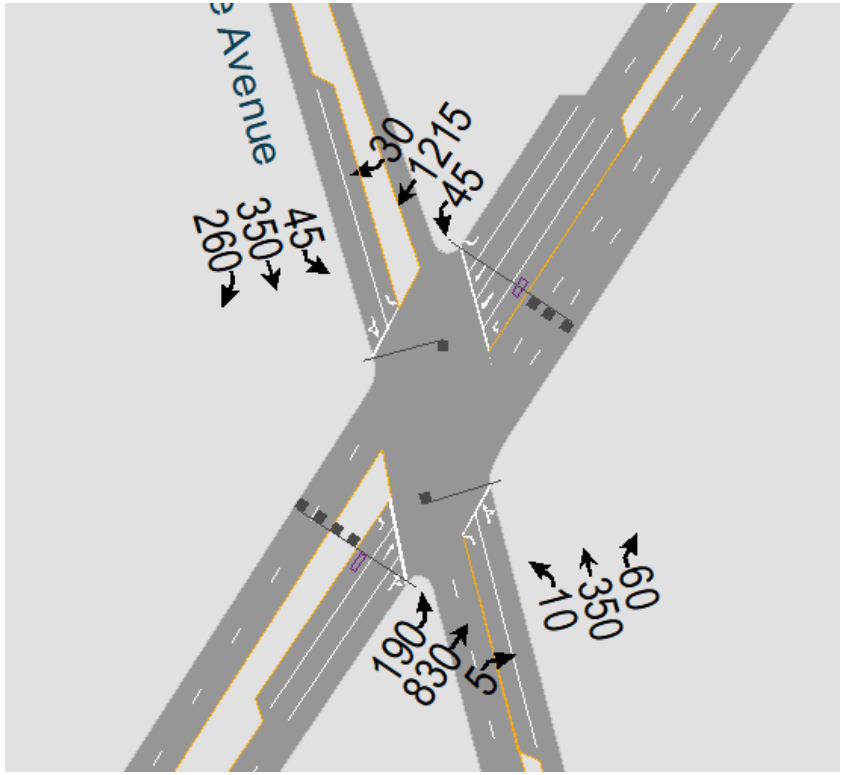
- Objective:
  - Analyze alternatives where northbound left turn and southbound left turns are prohibited
- Method:
  - Synchro analysis
  - Same volume data as Traffic Analysis 1
  - Remove NBL/SBL traffic volumes and storage lanes
  - Intersection geometry updates: WBR storage lane, 2 lanes SB approach
  - Apply general City Synchro modelling practices
  - Add transit phase with appropriate parameters
  - Adopt natural or minimum cycle and then optimize phases

Kingston – Morningside Traffic Analysis 4

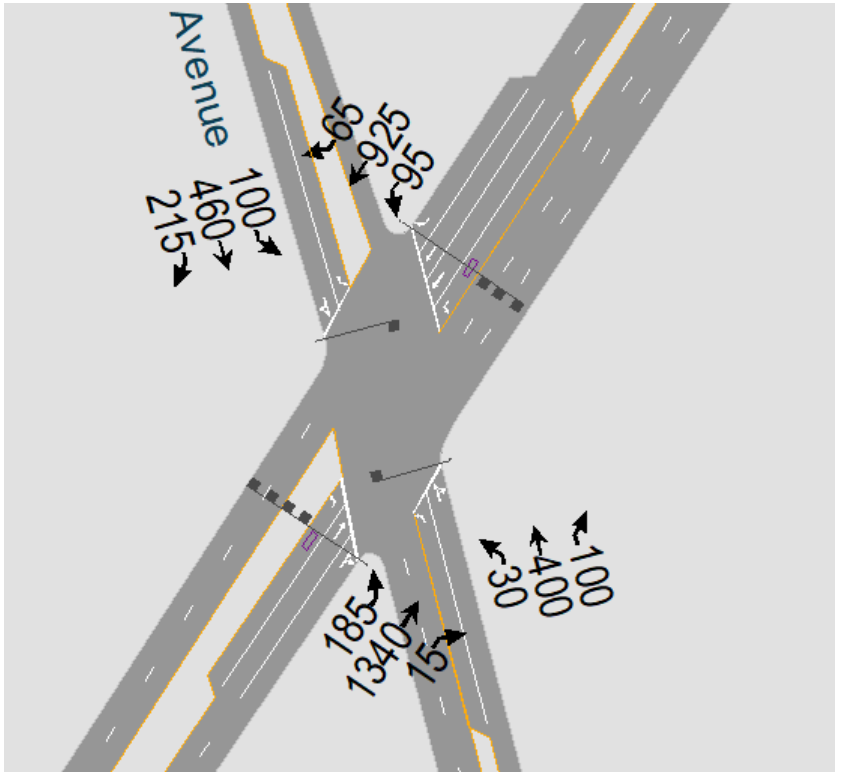
- Key LRT assumptions (same as previous)
  - Train length: 50 m
  - Average speed through intersection turn: 15 kph
  - Phase parameters: single insertion, 6 / 6 / 25 (green / amber / all-red clearance)
  - LRT movements are **compatible with concurrent EBL and WBL vehicular movements**
- Other model parameters and changes
  - Lane configurations updated per EELRT conditions – 2 lanes per direction on Kingston, 1 lane per direction on Morningside
  - Ped clearances per intersection geometry (27s FDW east-west, 31s FDW north-south)
  - RTOR prohibition for WBR
  - 0 curbside bus blockages for Kingston Road
  - 8 curbside bus blockages per direction for Morningside Avenue
  - Nominal 30 m length for all storage lanes (subject to design refinement)

Kingston – Morningside Traffic Analysis 4

- Volumes (base 2022, before NBL/SBL removal)



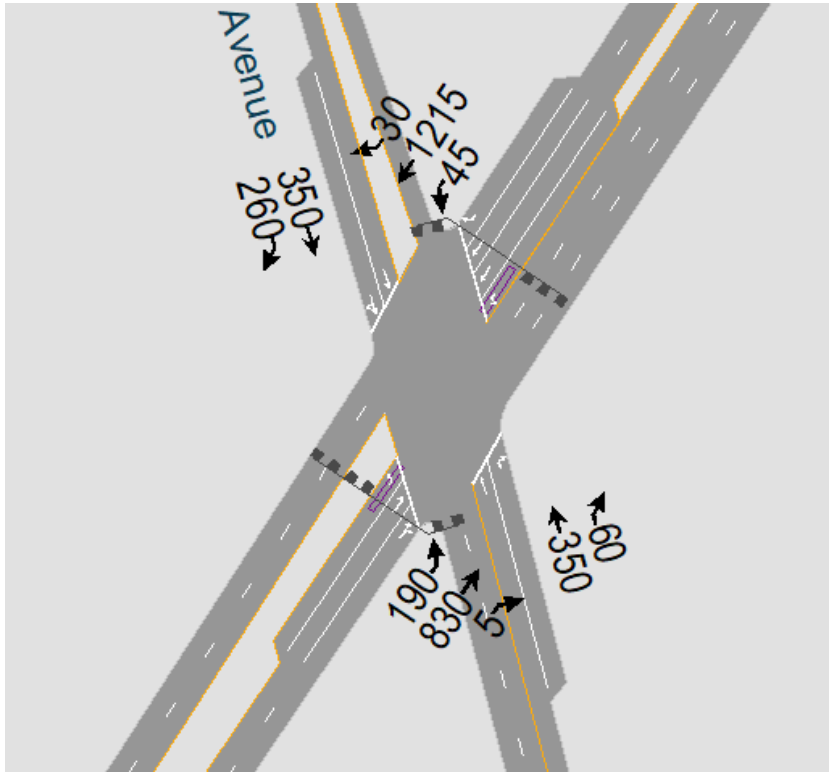
AM Peak Hour



PM Peak Hour

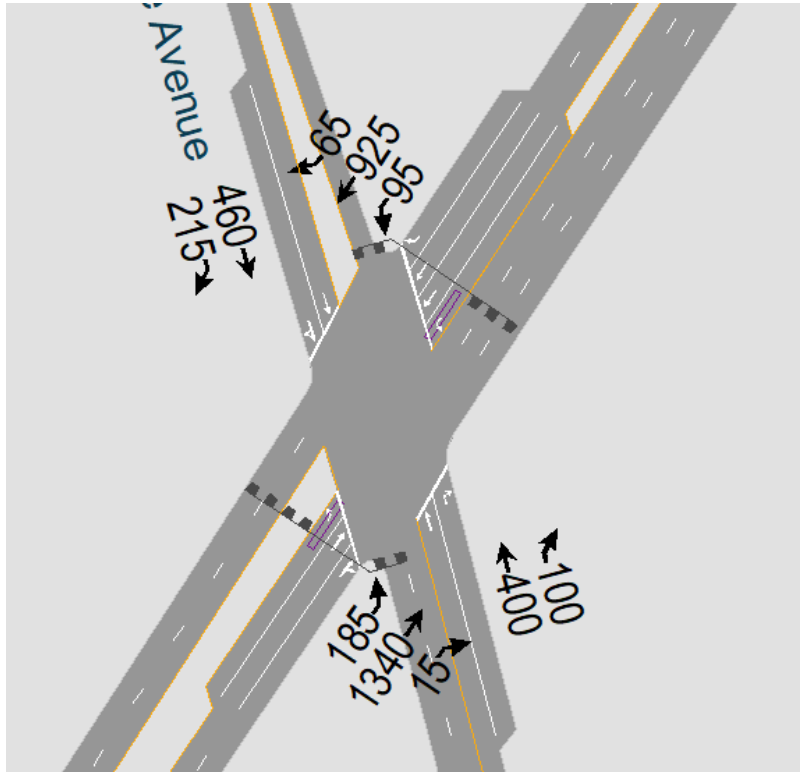
Kingston – Morningside Traffic Analysis 4

- Volumes (2022, after NBL/SBL removal)



AM Peak Hour

AM displaced volume: 45 SBL, 10 NBL



PM Peak Hour

PM displaced volume: 100 SBL, 30 NBL

Kingston – Morningside Traffic Analysis 4

- Signal optimization notes (recent changes in purple)
  - EBL and WBL assumed viable to run concurrently with LRT phase
  - EBL and WBL assumed fully protected (i.e. no permissive turns)
  - LRT + EBL + EBT assumed viable (i.e. lane geometry permitting, safe to operate EBT general traffic side-by-side alongside active LRT movements EBL & SBR)
  - LRT phase minimum is 37 seconds: 6 seconds LRT green (assumed minimum) + 6 seconds LRT amber (based on general LRV deceleration and operator reaction parameters employed on other at-grade LRT implementation in Toronto) + 25 seconds LRT all-red (based on LRV clearance time for the full turn at track speed limit)
  - LRT phase assumed to be called every cycle within weekday peak hours, based on estimated combined headway and for a conservative estimation of intersection capacity for traffic movements
  - Pedestrian FDW calculated based on new crossing distances at 1.2 m/s
  - N/S minimum is 45.2 seconds: 7 seconds ped walk (policy minimum) + 31 seconds ped flash don't walk (based on crossing distance @ 1.2 m/s) + 3.4 seconds traffic amber + 3.8 seconds traffic all red

Kingston – Morningside Traffic Analysis 4

1. Calculate and set minimums (LRT = 37, N/S = 45.2, E/W = 40.5)
2. Synchro calculated natural cycle length = 125s
3. Optimize phases for best overall performance
4. Set EBL = LRT (WB cannot be green until LRT is fully clear)

LRT minimum (37.0s) based on LRV parameters and minimum clearances

AM/PM Peak Hour
CL = 125s (natural cycle)

N/S minimum (45.2s), governed by pedestrian clearances (walk + flash don't walk) plus vehicle clearance amber and red

Kingston – Morningside Traffic Analysis 4

- Findings summary
  - Removing NBL/SBL will achieve the following:
    - Reallocation of N/S ROW: SBL → SBTR, NBL → NBR, performance improvement (N/S LOS E/F → C/D)
    - Signal re-optimization: run both AM and PM peak hours at natural cycle (125s), close to minimum (122.7s).
    - Improvement in overall LOS E → D
  - At-grade LRT operation is **viable** within the parameters used in this analysis
    - Signal timings compatible with pedestrian and LRT clearances
  - Intersection **at capacity** during peak hours
    - Overall LOS D in both AM and PM
    - Critical v/c < 1.01 (WBT) in the AM
    - Any further volume growth may result in longer queues and congestion, increased neighbourhood infiltration, and improper use of private property for turns

Kingston – Morningside Traffic Analysis 4

Scenario		Storage Length (m)	AM Peak Hour				PM Peak Hour			
			LOS	Delay (s)	v/c	95th Percentile Queue (m)	LOS	Delay (s)	v/c	95th Percentile Queue (m)
Base			**E**	**70.6**	**1.35**	-	**E**	**71.3**	**1.37**	-
Eastbound	Left	30	E	62.3	0.77	67.8	E	61.4	0.76	65.8
	Through-Right	320	C	25.7	0.55	101.8	D	39.0	0.88	192.3
Westbound	Left	30	E	59.3	0.51	23.3	F	98.4	0.85	55.5
	Through	225	E	75.7	1.03	244.2	D	38.9	0.75	151.5
	Right	30	C	27.1	0.07	13.3	C	27.6	0.15	23.6
Northbound	Left	30	D	38.3	0.19	7.2	E	68.7	0.55	22.3
	Through-Right	90	D	47.2	0.76	131.0	E	61.1	0.91	180.8
Southbound	Left	30	D	37.0	0.31	19.8	F	187.2	1.16	65.2
	Through-Right	205	F	146.2	1.19	251.4	F	174.4	1.26	283.8
Option 1C			**D**	**47.2**	**1.08**	-	**D**	**40.8**	**1.10**	-
Eastbound	Left	30	E	59.1	0.75	67.5	E	59.0	0.74	65.4
	Through-Right	320	C	24.6	0.54	99.0	D	38.4	0.88	193.0
Westbound	Left	30	E	58.4	0.49	23.3	E	71.2	0.72	48.7
	Through	225	E	67.1	1.01	239.3	D	37.4	0.73	141.2
	Right	30	C	26.3	0.07	13.1	C	26.7	0.14	23.2
Northbound	Through	90	D	44.0	0.67	111.1	D	46.5	0.73	126.2
	Right	30	C	30.2	0.04	2.1	C	30.7	0.08	11.6
Southbound	Through-Right	205	D	38.4	0.56	71.5	D	40.4	0.65	91.3

Note: Critical movements are highlighted in **RED**. Queue exceeding storage length are highlighted in **BLUE**

Kingston – Morningside Traffic Analysis 4

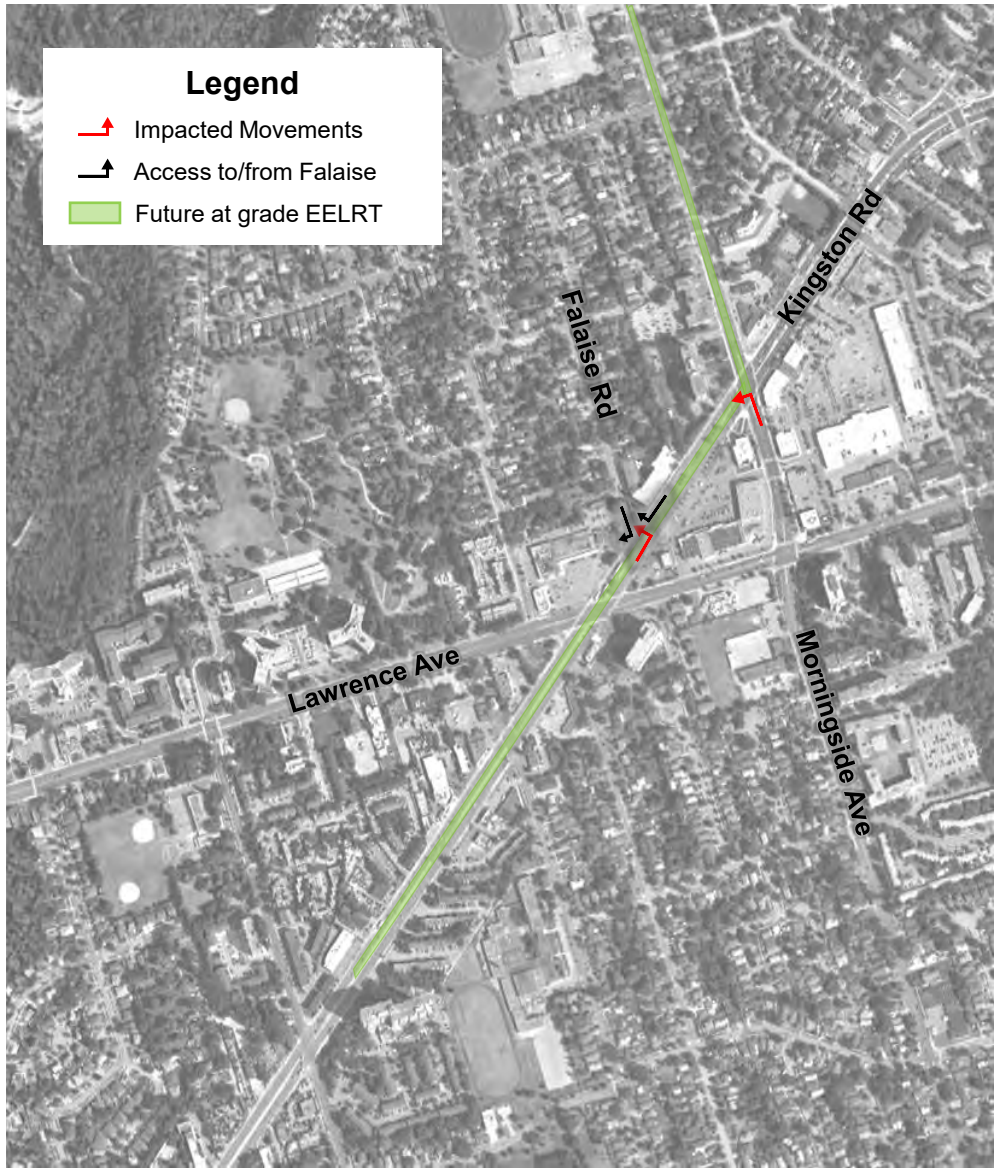
- Recommendations and considerations for future design refinement:
  - Geometric design and storage lanes – turning movement storage lanes may need to be longer than existing conditions to accommodate future traffic
  - Train-based re-calculation of train average speed through intersection turn
  - Alternative routes for the removed NBL and SBL turns, assess capacity and impacts on adjacent intersections and on local neighbourhoods and commercial properties
  - Demand management strategies to discourage further traffic volume growth

EELRT

Falaise Rd Detour Analysis

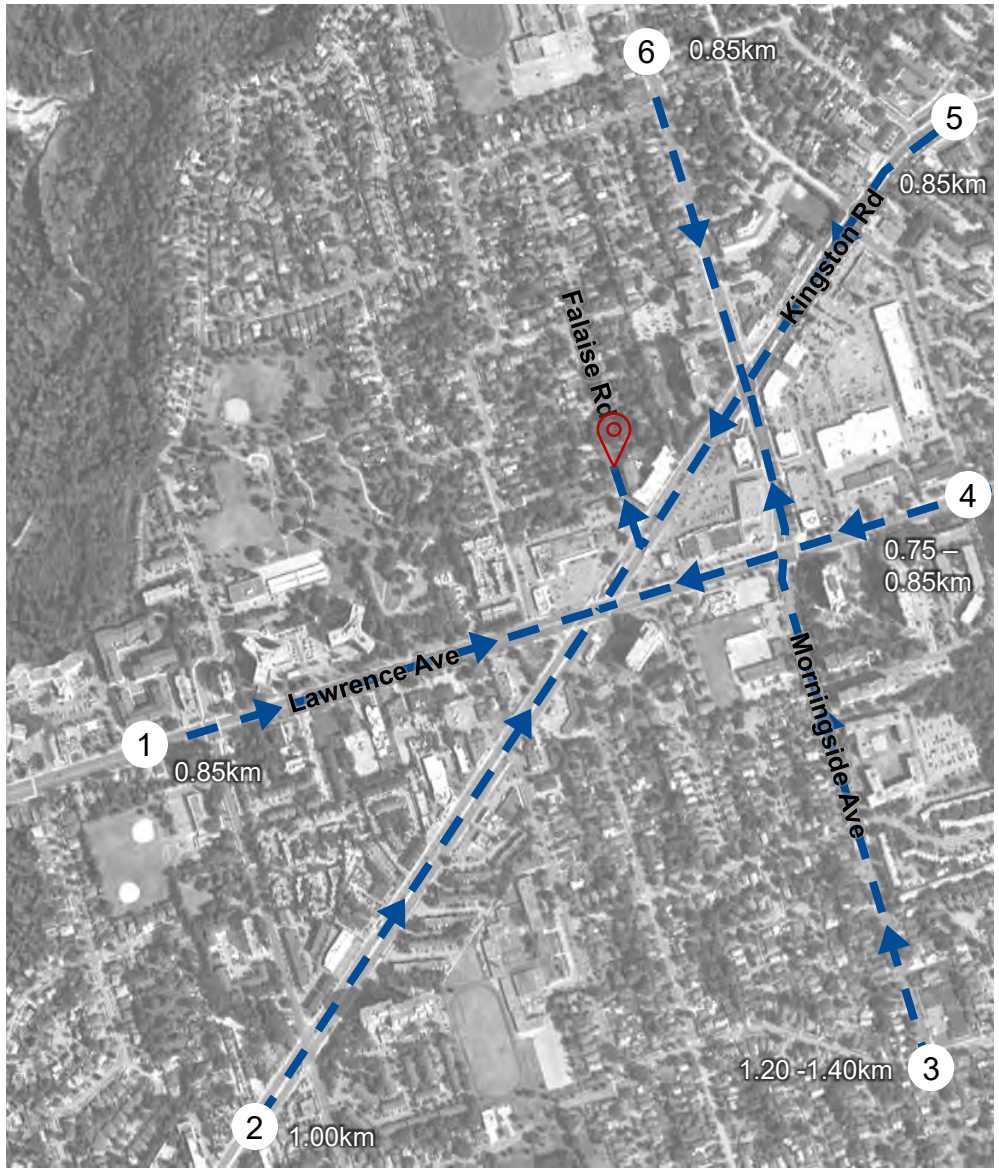
April 27, 2023

Context



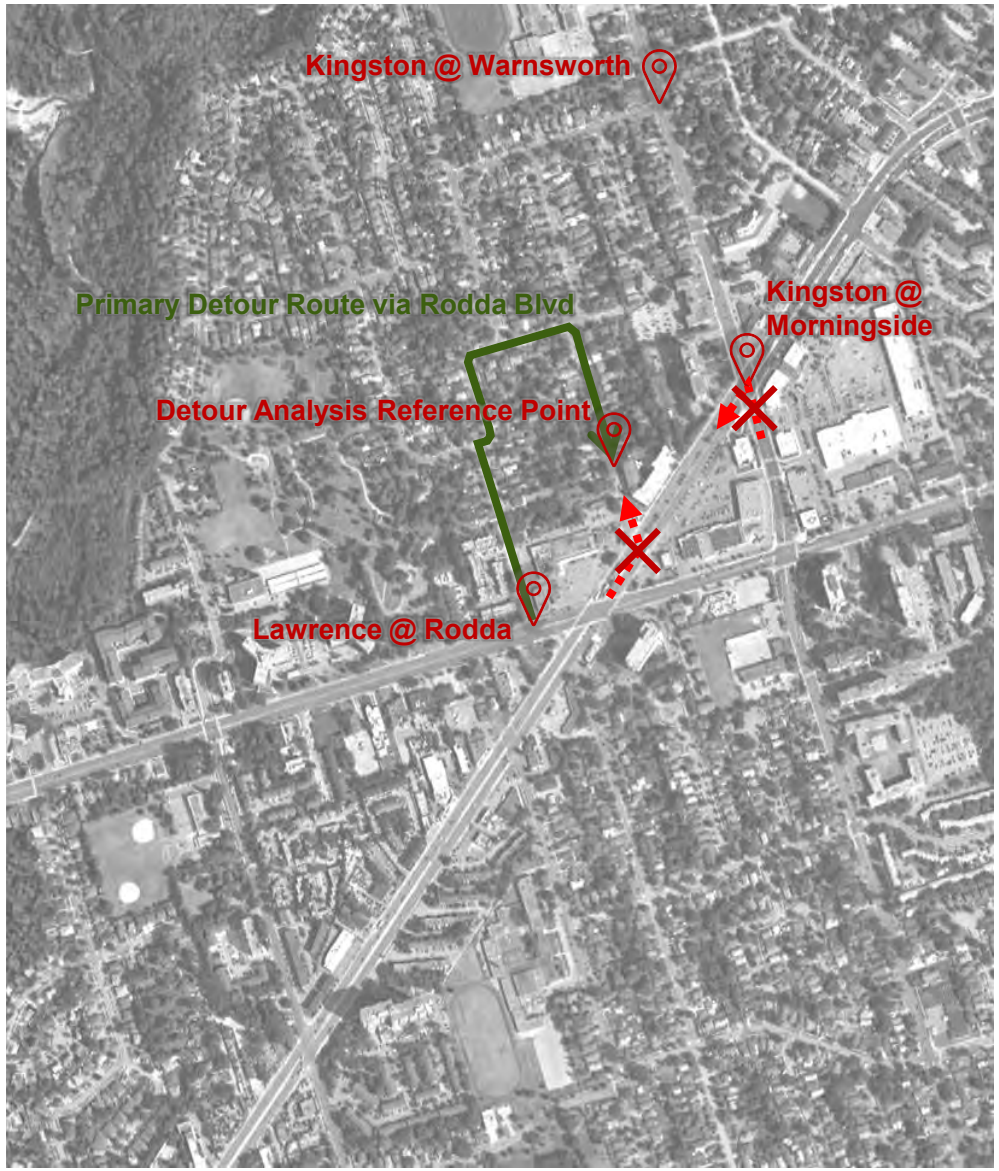
- Background
  - Falaise Road provides local neighbourhood access
- Existing Conditions of Kingston Rd at Falaise Rd
  - Unsignalized, stop-controlled on Falaise Rd.
  - Right-in, right-out plus left-in from Kingston Rd eastbound towards Falaise Rd northbound.
  - Left-out is understood to be prohibited based on the median one-way signs on Kingston Rd.
- Traffic Movement Impacts by EELRT
  - Kingston @ Falaise: EBL removed due to EELRT running median at-grade
  - Kingston @ Morningside: NBL and SBL removed due to EELRT bi-directional turn path and intersection geometry constraints
- Objective
  - Find detour routes for the local access movements impacted by the turn removals

Existing Paths



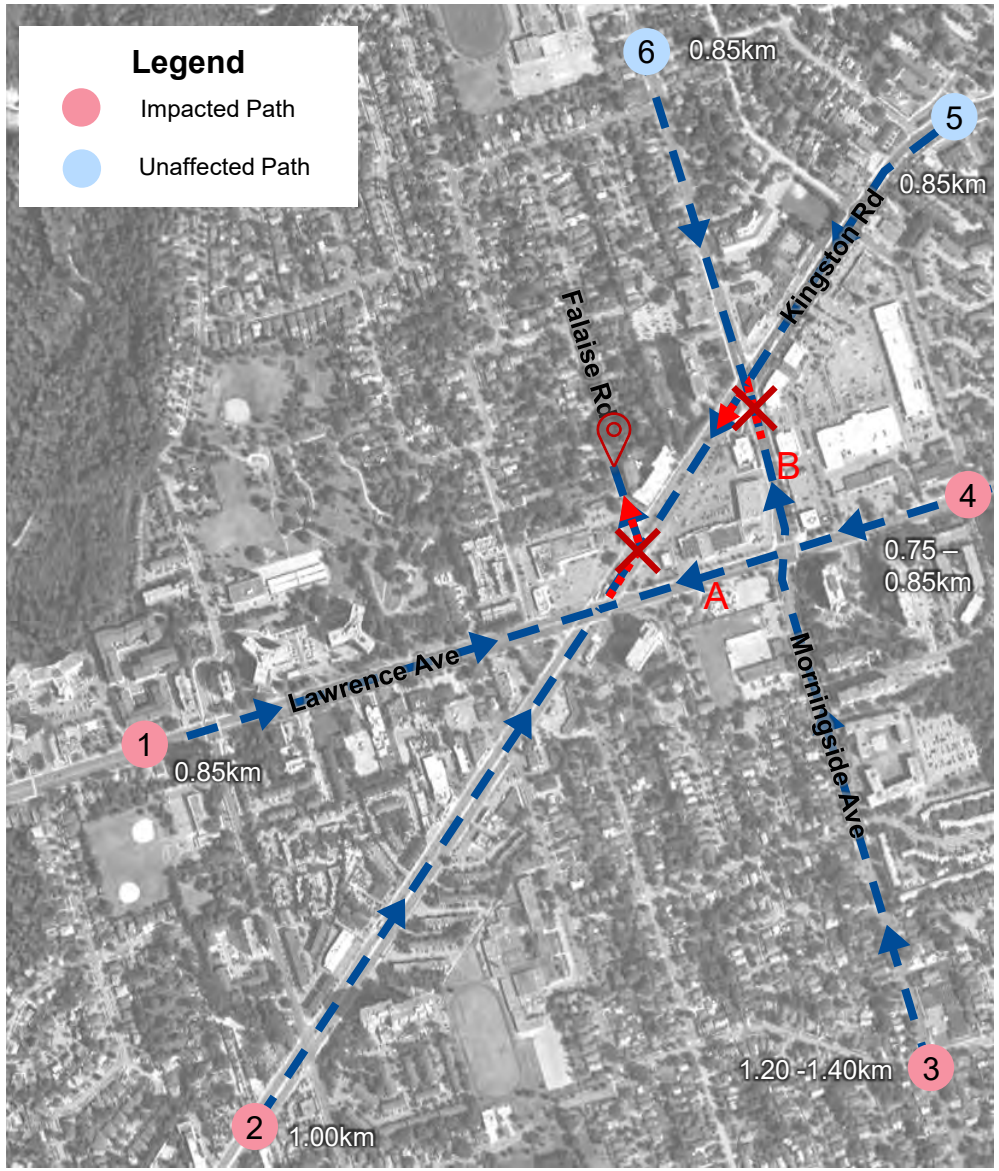
- Existing Entry Paths
  - 1. Lawrence EB: will use Falaise EBL
  - 2. Kingston Northbound: will use Falaise EBL
  - 3. Morningside NB:
    - NBL Lawrence – WBR Kingston – EBL Falaise
    - NBL Kingston – WBR Falaise
  - 4. Lawrence WB:
    - WBR Kingston – EBL Falaise
    - WBR Morningside – NBL Kingston – WBR Falaise
  - 5. Kingston SB: will use Falaise WBR
  - 6. Morningside SB: will use Falaise WBR

Assumptions



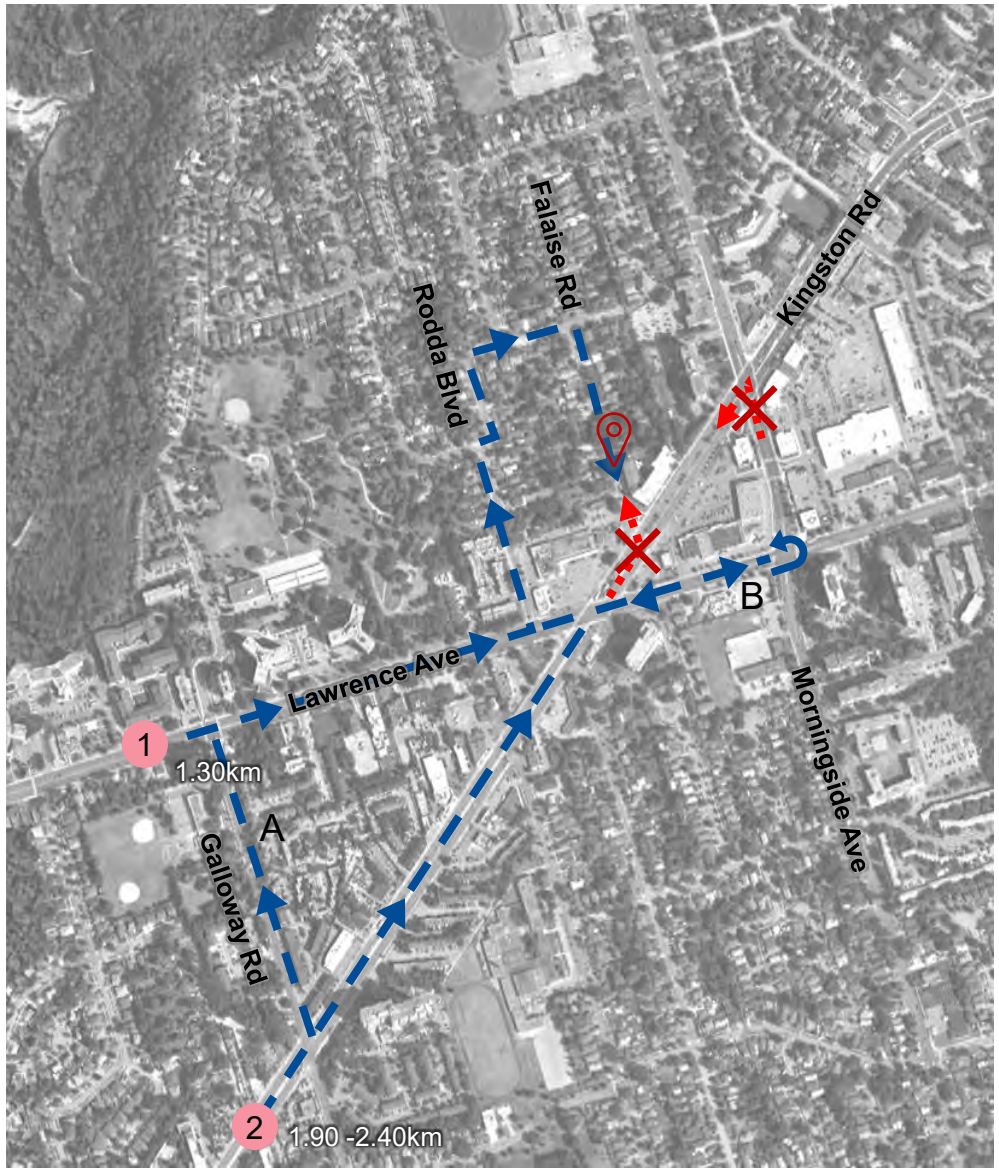
- Left turns are prohibited along Morningside Ave at Kingston Rd with the addition of the EELRT
- U-turns are also prohibited at Kingston & Morningside intersection due to the turning EELRT
- Future left-in access to the neighbourhood via Warnsworth St will require signalization
- **Primary detour route via Rodda Blvd**
- Lawrence @ Rodda will retain all existing movements (left-in/out, right-in/out)
- Exit paths from Falaise to Kingston not included in analysis as they are not impacted

Entry Paths



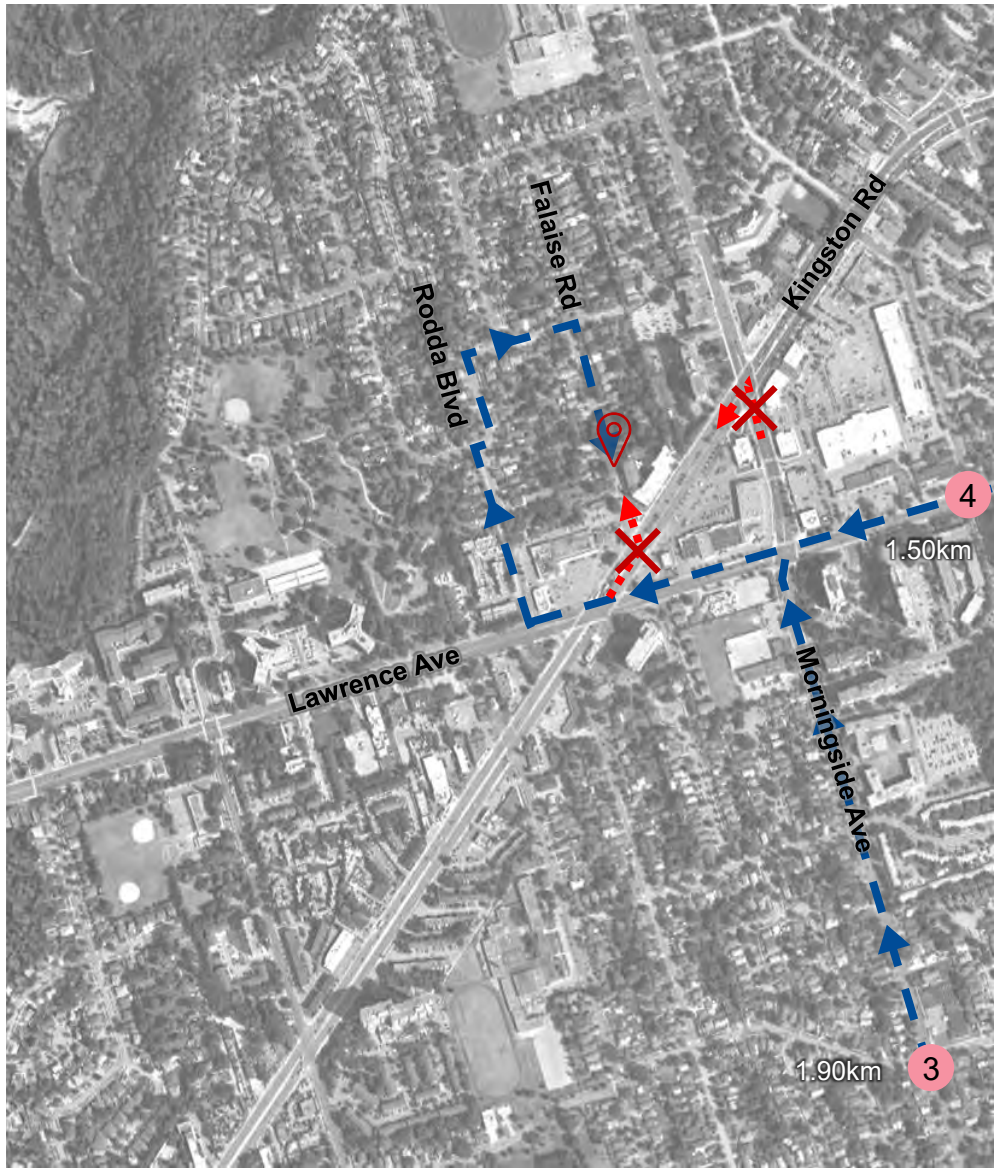
- Impacts on entry paths
  - 1. Lawrence EB: east on Lawrence → northeast on Kingston → north on Falaise
  - 2. Kingston NB: northeast on Kingston → north on Falaise
  - 3. Morningside NB:
    - A: north on Morningside → west on Lawrence → northeast on Kingston → north on Falaise
    - B: north on Morningside → southwest on Kingston → north on Falaise
  - 4. Lawrence WB:
    - A: west on Lawrence → northeast on Kingston → north on Falaise
    - B: west on Lawrence → north on Morningside → southwest on Kingston → north on Falaise
  - 5. Kingston SB: southwest on Kingston → north on Falaise
  - 6. Morningside SB: south on Morningside → southwest on Kingston → north on Falaise

Detour for Falaise EBL Removal



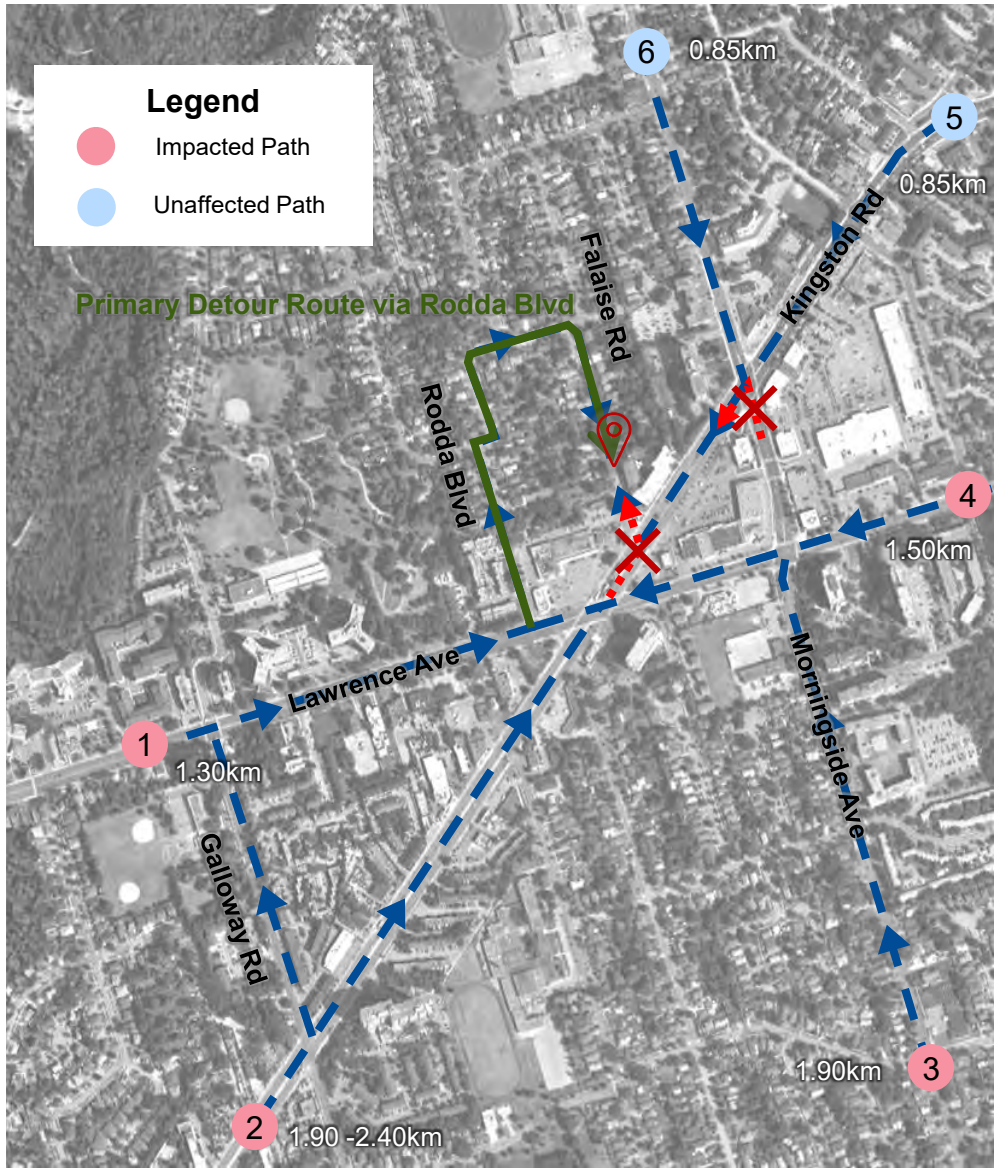
- 1. Lawrence EB
  - EBL at Rodda, then around Rodda – Falaise
    - Existing path 0.85 km to detour path 1.3 km
    - 0.45 km of additional travel distance
- 2. Kingston NB
  - A: Galloway – Lawrence – Rodda
    - Existing path 1.0 km to detour path 1.9 km of travel
    - 0.9 km of additional travel distance
  - B: Kingston – Lawrence (eastbound) – EB U-turn at Lawrence at Morningside and then access via Rodda
    - Kingston northbound cannot directly left turn to Lawrence westbound
    - Existing path 1.0 km to detour path 2.4 km
    - 1.4 km of additional travel distance (less desirable than path A)

Detours for Morningside-Kingston NBL Removal



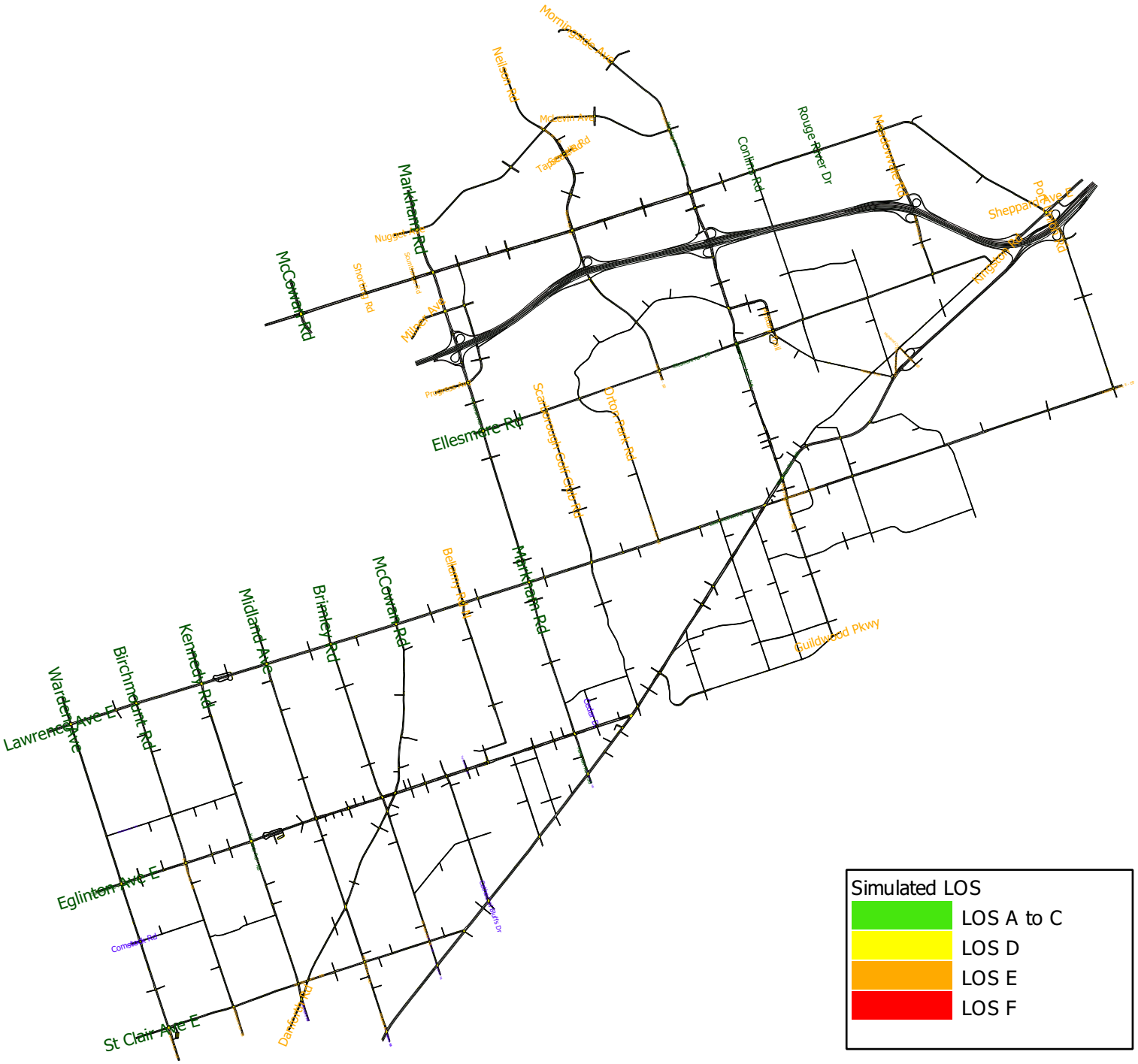
- 3. Morningside NB:
  - Will turn NBL onto Lawrence and access via WBR at Rodda Blvd
    - Existing 1.2 km to detour 1.9 km of travel
    - 0.7 km of extra travel
- 4. Lawrence WB:
  - Will enter the neighbourhood via WBR at Rodda Blvd
    - Existing 0.75 km to detour 1.5 km of travel
    - 0.75 km of extra travel

Summary



- Detours necessitated by removals of EBL at Kingston & Falaise, NBL at Kingston & Morningside
- Analysis scope included 6 entry movements into Falaise, 4 of which are impacted by the EELRT removals
- Main detour route is via Lawrence-Rodda-Falaise
- Extra distance travelled by users of the affected routes are in the range of 0.45 km to 0.9 km

Simulated LOS - AM



Simulated LOS - PM