GARDINER EXPRESSWAY AND LAKE SHORE BOULEVARD EAST RECONFIGURATION ENVIRONMENTAL ASSESSMENT

Transportation Planning Technical Report

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1.0 Introduction

This appendix summarises the transportation planning technical work undertaken including transportation modelling that was completed to support the evaluation of alternatives as part of the Gardiner Expressway EA study.

1.1 Transportation Modelling Approach

Transportation modeling was undertaken at two levels:

- A macroscopic model providing estimates of travel to, from and through the downtown area on the road and transit network, with travel estimates prepared at a regional scale; and
- A microscopic simulation of traffic flows and traffic operations on roadways in the study area.

The macroscopic modeling was undertaken by City of Toronto staff using the City's regional travel model, prepared with EMME travel demand modeling software. Traffic and transit demand forecasts were prepared for existing conditions and 2031 baseline conditions. The number of vehicle trips and transit trips to, from and through the study area was forecasted. An origin-destination matrix was also prepared showing the number of trips made between different points within the regional study area.

The EMME model results were then used as the starting point for microsimulation undertaken by the project team using the Paramics software package. The Paramics model took the origin-destination data obtained from the EMME model, and assigned the resulting traffic volumes to the study area roadways and intersections through a detailed simulation of all vehicles in the study area. The microsimulation continuously assessed traffic operations and delays at each point of the network, and continually adjusted vehicle travel paths to respond to delays in the network (recognizing the ability of motorists to choose different routes depending on traffic conditions). This yielded information on traffic operations within the study area, on specific routes, and between specific origins and destinations, under existing conditions and 2031 future baseline conditions.

1.2 Transportation Microsimulation Introduction

Microsimulation provides the greatest flexibility in representing the unique operational conditions of real-world transportation facilities. Microsimulation provides an enhanced ability to forecast and simulate the interaction of all transportation modes using the transportation system. The differentiators for microsimulation that make it the most appropriate tool for this analysis are as follows:

- **Unique behaviour for every travel mode** – Microsimulation establishes detailed and unique "agent" behaviour as they move through the transportation network. An agent is any user of the system – pedestrian, cyclist, bus, car, or truck. Each class of agent (or mode) has unique behaviour or a set of rules that allow it to react (or they can be taught to react) to any infrastructure situation in a realistic manner. This is different to traditional analysis that applies static formulas based on empirical observation, which limits its applicability or validity in complex situations. Microsimulation allows the analyst the flexibility to best represent the real-world operations for any situation.

- **Individual User Behaviour** – In addition to the different types of modes behaving independently, every agent within a microsimulation model is an individual with a specified origin, destination, and set of behaviour parameters that control their awareness, aggressiveness, and path selection through the model. This allows the model to simulate behaviour that varies from one agent to the next and how this behaviour influences the efficiency of transportation infrastructure.
- **Connected environment** – Each agent of the system must physically move through the model from their origin to their destination. Traditional analysis typically treats each intersection movement or conflict point as a separate "island" with no interaction between upstream or downstream elements. This connected environment allows the effects of queuing and interaction between different modes to play into the analysis as users move through the model.
- **Stochastic Processes** – The distribution of agent behaviour, flow rates entering the model, and other parameters are governed by a set of stochastic processes, which provide a controlled randomness to their distribution. These processes are governed by a 'random seed'. Maintaining the same random seed value (a simple integer value) across runs ensures that they will produce consistent results, while varying the seed value will distribute these items slightly differently and produce a different result. It is important in microsimulation to run the model with various random seeds to ensure an accurate average condition is reached. The simplified concept is to consider the typical weekday work commute where the same amount of people need to travel to work during the morning every day, but leave their house at a slightly different time or behave slightly differently from one day to the next. Varying the random seed allows the analyst to take an average of this variance across a number of "Tuesdays" and "Wednesdays" from the same dataset.

2.0 Microsimulation Model Construction

This section describes the construction, calibration, and validation of the Paramics microsimulation model. The model covers a larger area than the main project study area to allow for analysis of the effects of the changes to the larger downtown area.

2.1 Roadway Geometry

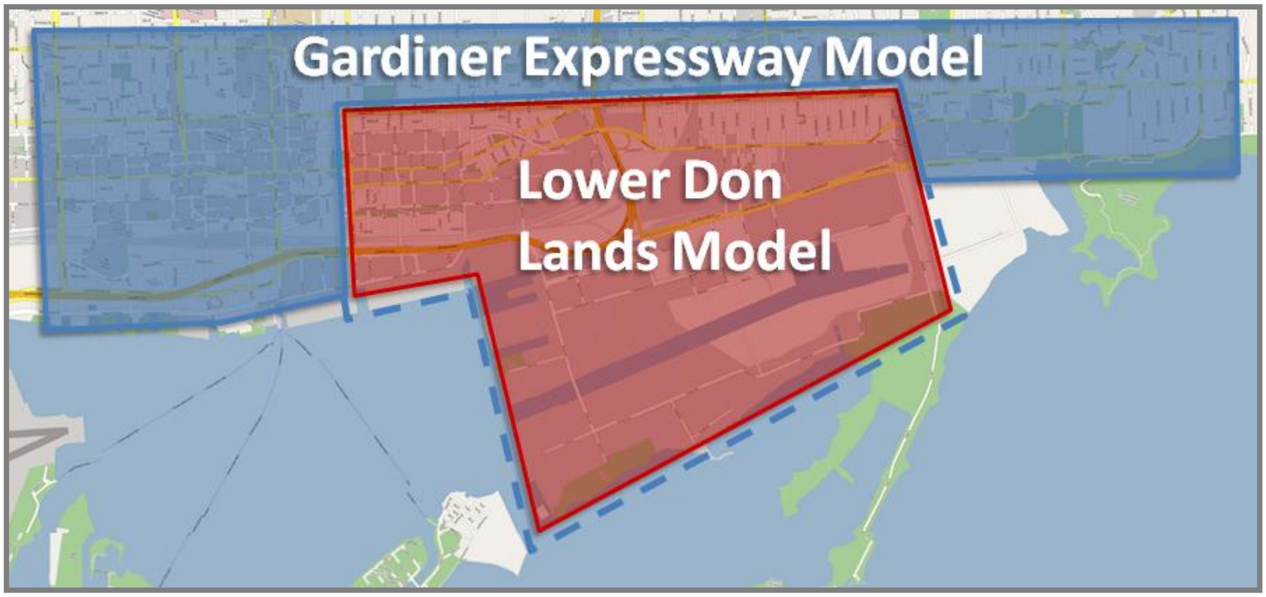
The study area for the transportation model is bounded by Spadina Avenue to the west, Woodbine Avenue to the east, Dundas Street to the north, and Lake Ontario to the south. Based on the official City designation of functional class, all roads of class arterial and above are included in the model, some collectors are included in the model, and no local streets are included (with a few minor exceptions), as shown in

Figure 1 below:

Figure 1 – Sketch of roadway geometry for the Gardiner Expressway Model

A Paramics microsimulation model was previously created and used for analysis as part of the Lower Don Lands EA. The Gardiner Expressway study area completely contains the boundaries set out by the previous model; the City of Toronto and their consultant, therefore, provided the existing model and related data for use as a starting point on this study. The area prescribed for the Gardiner EA simulation approximately doubled that of the previous effort, with the new model essentially adding 'shoulders' to the existing model extending it mainly to the east and west, as shown in **Figure 2**.

Figure 2 – Comparison of study areas for the Gardiner Expressway study versus the Lower Don Lands Study



The additional existing roadway geometry was coded into the model based on high-resolution aerials and the use of internet-based mapping tools. This allowed for precise scaling and positioning of all visible roadway elements, such as: number of lanes, lane allocation, turn radii, lane drop/add locations, turn restrictions. Any elements not clear in available data were supplemented by the local knowledge of the study team and site visits.

2.2 Intersection Control

Signal directives for all signalized intersections in the study area were obtained from the City of Toronto. These were entered directly into the Paramics model. Operations along Lake Shore Boulevard are flexible and dictated by the SCOOT system, which seeks to optimize the signal timing along specific corridors. With the exception of intersections with special accommodations for transit priority, the SCOOT settings were not used in the model since the majority of signals will be 'maxed out' during the peak periods.

2.3 Transit Routes

All bus and streetcar routes and stops obtained from the website of Toronto transit commission (TTC) in 2009 in the study area were entered into the model. These were updated in 2013 to include routes and stops present in the City of Toronto DTOS Paramics model. Average stop times were entered according to passenger on and off counts at all locations. Transit vehicles are fed into the network according to the headway found on the official TTC schedules.

2.4 Zone Structure

Traffic is assigned in a Paramics model via an origin / destination table, where vehicles are told the start and end point of their journey through the model. These origin/destination points are referred to as Traffic Analysis Zones (TAZs), or simply 'zones'. These must be laid out in a manner logical to the purpose and scale of the model. The focus of the study on the effects of modification of the Gardiner Expressway over the larger study area necessitated a generally denser zone structure than may be typical. Trip patterns in dense urban areas can be complex and would be difficult to represent with a sparse zone structure.

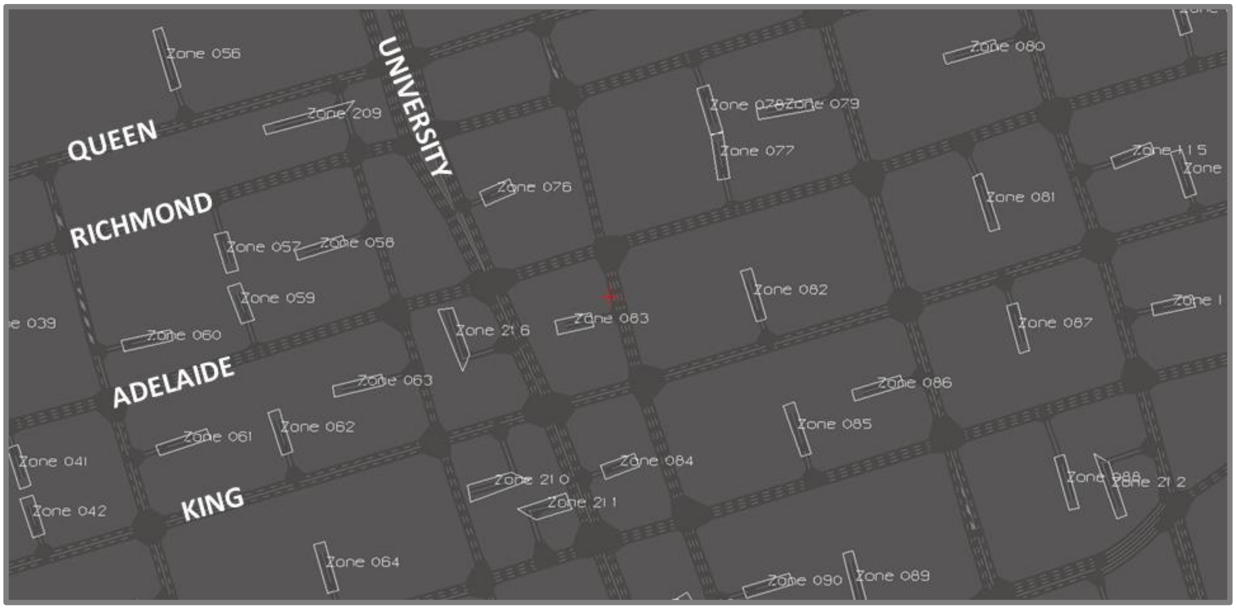
External zones were assigned simply to every modeled street that touches the edge of the model. For ease of analysis during the latter stages of model development, the zones were numbered in a clockwise direction from the southwest (Queen's Quay west of Spadina Avenue) around to the southeast (Cherry Street at Unwin Avenue).

Internal zones were laid out in the model via visual inspection of each 'block' in the model, where the blocks in the model are larger than in real life due to the absence of the majority of local streets. For the most part, each block face in the model received a zone in order to properly describe the complex origin/destination patterns in such a large model. The presence of local roads, parking facilities, or driveways was used to determine the validity of placement of a zone along the block face. Block faces with little access or with few discernible traffic generators were not assigned a zone. Again for ease of later analysis, the internal zones were numbered increasing from west to east.

A zone occurring on a block face represents all of the access to and from that block between major streets. The new intersection created by the zone at the mid-block point is not controlled by stop signs or a signal as it represents several intersections and the volume entering and exiting the zone may exceed that of a single minor intersection. This structure allows vehicles to efficiently leave and be fed into the network without causing artificial congestion.

With all of the above conditions met, the final number of zones in the model was 222. An example of the zone layout in a section of the model is shown in **Figure 3**.

Figure 3 – Example Zone Layout



2.5 Volume Balancing

The creation of the origin/destination matrix is essential to the realistic operation of the Paramics model. This table defines the A to B journey for every vehicle in the model (except transit vehicles) and must be based on sound vehicle link and turning movement counts and any information on real-world travel patterns that may be available.

Turning movement counts were obtained from the City of Toronto for the vast majority of intersections in the study area. These were supplemented with Automatic Traffic Recorder (ATR) counts at many locations. It was necessary to balance these counts for use in the model.

Balancing of the traffic counts was performed in a series of Microsoft Excel spreadsheets. The goal of the balancing was to eliminate any large discrepancies between adjacent intersections and arrive at a set of reasonable data representing the AM and PM peak hours. The original turning count volumes were modified as little as possible to result in a logical series of counts.

The Internal Zones occurring on block faces act as 'vehicle sinks' between the counted intersections, removing any differences between adjacent counts. The study team examined the 'differences' calculated at each zone for reasonableness given the land uses apparent or known on each block such as housing, businesses, and parking facilities.

2.6 Matrix Estimation

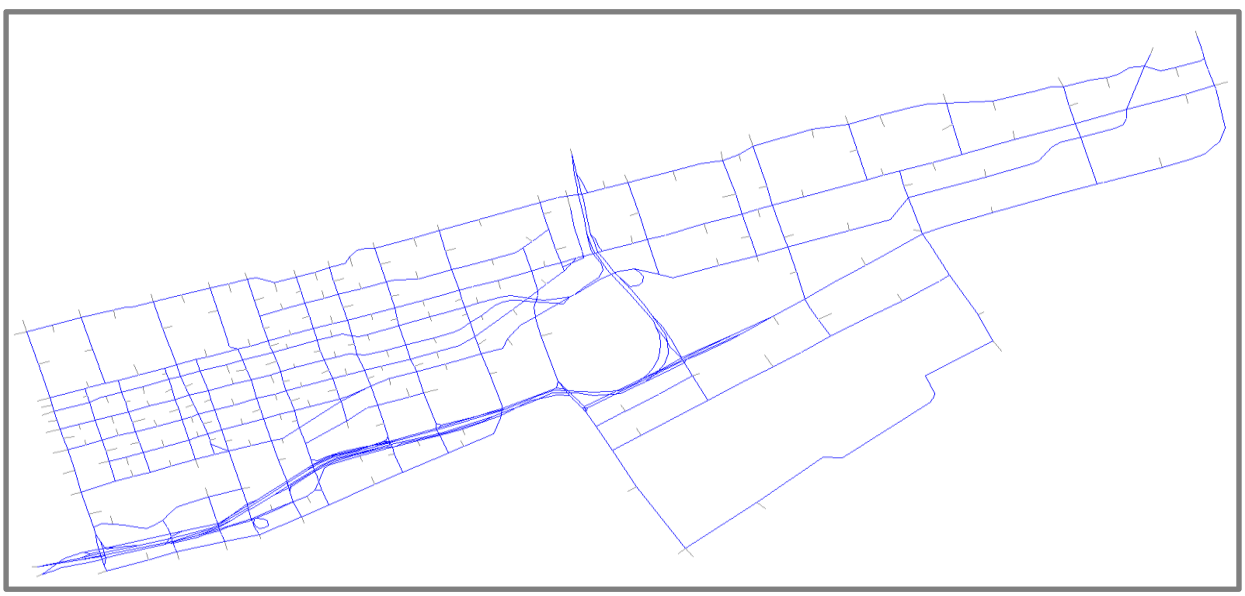
The matrix estimation procedure was performed in a separate travel demand model created for this project in the Cube software. Paramics has specialized software for matrix estimation, Estimator, but this was not used in this case, as originally planned, to help expedite the matrix estimation process. To run Estimator, a completed Paramics model must already exist; the use of Cube allowed the study team to complete the matrix estimation in parallel with construction of the Paramics model. The output from the Cube matrix estimation procedure is equivalent to that performed in Paramics.

The Cube model created for this procedure was not a true 'travel demand model', where trips are generated based on socioeconomic data and future land use patterns. Instead, the software is used simply to assign volume from an origin/destination trip table on a roadway network. The results of this assignment were slowly adjusted so that the assignment matched the balanced turning movement counts at all locations as closely as possible.

The initial trip table to be used in the Cube model was created based on information from the City's EMME2 model. A subarea extraction was performed by City modeling staff to provide an extracted trip table representing the EMME2 model's estimation of travel patterns in the study area.

Being that it is of a large, regional scale, the EMME2 subarea model has only 79 zones in the study area, versus the 222 required for the more detailed Cube and Paramics models. It was therefore necessary to split the information for the 79 existing zones into 222 pieces based on an equivalency table between the two models. Each of the larger EMME2 model zones was split into several smaller Cube/Paramics zones based on their overlap. The proportions for each subzone were estimated based on the location of land uses within the larger EMME2 zone.

Figure 4 – Gardiner Expressway Cube Model



Because of the large discrepancy in the number of zones between the EMME2 and Cube/Paramics models, the resultant split 222-zone trip table did not have much detail and the new zones were very homogenous in their trip patterns, a logical artifact of the splitting procedure. This is, of course, not the case in reality.

To better represent potential trip patterns in the area, a simple gravity model was created based on the original split 222-zone trip table. A gravity model is a simple relationship created between zones based on their total trip activity and the distance between them and is classically used in travel demand modeling for trip distribution purposes. This, in essence, 'opened up' many more zone pairs for use in the matrix estimation procedure; this was important as the Cube procedure is based on using factors to adjust the initial trip table up or down and any zone pairs with zero trips would not have been available for factoring.

The two trip tables, directly from EMME2 and as produced by the gravity model, were combined at a ratio of 60%/40% EMME2 versus Gravity to create a new hybrid trip table to act as the initial table for estimation.

The Matrix Estimation procedure was iterated in the Cube model until the model met the criteria that 85% of the turning movement counts in the model had a GEH of 5 or less[1]. This procedure was performed separately for the all combinations of AM and PM peak hour, Cars, and Trucks, resulting in four matrices which were later combined for use in the Paramics model.

3.0 Microsimulation Model Calibration / Validation

Model calibration is simply the modification of inputs, settings, or geometry in the model to ensure that it matches certain sets of data related to the performance of the network in reality within a reasonable tolerance. Validation is the confirmation of model calibration via data not directly used in the model calibration phase to ensure that the model is 'valid' for its intended purpose.

There are currently no mandated standards for model calibration and validation. The FHWA's Traffic Analysis Toolbox lists criteria used by the Wisconsin Department of Transportation, an agency that concerns itself greatly with the use of microsimulation models, as shown in

[1] The GEH is a self-scaling statistic used to compare modeled to counted volumes. It removes the issues presented when comparing volumes of a wide range via absolute or percentage differences. Its formula is as follows: $GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$, where M = Modeled Volume and C = Counted Volume.

Table 1 below. These criteria were based on guidelines developed in the United Kingdom[2].

Table 1 - Wisconsin DOT criteria for model calibration from FHWA's Traffic Analysis Toolbox: Vol III

Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Within 400 veh/h, for Flow > 2700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	> 85% of cases
GEH Statistic for Sum of All Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey Times, Network	
Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Individual Link Speeds	
Visually Acceptable Speed-Flow relationship	To analyst's satisfaction
Bottlenecks	
Visually Acceptable Queuing	To analyst's satisfaction

The criteria chosen for calibration/validation for Arup's Lower Don Lands model are shown in

[2] Federal Highway Administration, Traffic Analysis Toolbox: Volume III, http://ops.fhwa.dot.gov/trafficanalysistools/index.htm

Table 2.

Table 2 - Calibration Criteria for the Lower Don Lands Model (Arup)

Category	Criteria	Target
Screenline Flow	Within 5 or 10%*	100% of counts
	GEH < 5	100% of counts
Individual Link Flows	Overall counts R^2	> 0.85
	% counts where GEH < 5	> 75% of counts
Individual Turn Flows	% counts where GEH < 5	> 65% of counts
	% counts where GEH < 10	> 90% of counts
	GEH > 10	No key movements

*5% was originally seclected, but increased to 10% due to difficulty balancing different sources of counts between screenlines and the small volumes along certain screenlines.

The calibration statistics chosen for the Gardiner Expressway model are very similar to those used for the LDL Model. The difficulty in matching turning and link counts increased substantially given the model's larger area, especially the area to the west of Jarvis Street, which is a dense urban grid. To accommodate this condition, the percent match for individual link flows was reduced to be: 65% of all counts must have a GEH of 5 or lower. The 'key movements' selected for analysis here include all turning movements along the Gardiner Expressway and east-west through movements along Lake Shore Boulevard, as they are the main focus of the analysis. To offset the reduction in match percentage for the individual link counts, the density of screenlines for the model was increased; where the LDL model had seven screenlines, the Gardiner Expressway model has 28. This ensured that, while the individual links may have had more variance, the overall 'movement' of volume through the model was consistent with the observed data.

In addition to the criteria listed above, information was collected as to the real-world origin/destination patterns and travel times through the corridor via a Bluetooth-based origin/destination study undertaken in November, 2009 (summarised in a technical memorandum for this project: *'Gardiner Expressway EA – Results of Bluetooth Origin / Destination Survey'* – Feb. 11, 2010). This survey provided information on the origin and destination patterns and travel times for a large sample size of vehicles through the study area corridor. These were used in the validation of the model once it was calibrated to the above criteria. The modeled travel time was required to match within 15% (or 1 minute, if higher) of that observed during the Bluetooth survey, as suggested by the FHWA guidelines. No guidance could be found regarding the suggested match to collected origin/destination data as this information is not typically available. A match of +/- 10% for 85% of the observed segments was used in this case.

The Calibration and Validation statistics for the Gardiner Expressway model are summarized in

Table 3. The percentage of screenline flow difference is provided here, but is not a primary index. Using the GEH Statistic avoids some pitfalls that occur when using simple percentages to compare two sets of volumes. This is because the traffic volumes in real-world transportation systems vary over a wide range.

Table 3 – Calibration/Validation Targets for the Gardiner Expressway Model

Category	Criteria	Target
Screenline Flow	Within 10%	100% of counts
	GEH < 5	100% of counts
Individual Link Flows	Overall counts R^2	> 0.85
	% counts where GEH < 5	> 70% of counts
Individual Turn Flows	% counts where GEH < 5	> 65% of counts
	% counts where GEH < 10	> 90% of counts
	GEH > 10	No key movements
Travel Time	Within 15% (or 1 min, if higher)	>85% of cases
Origin / Destination Data	Within 10%	>85% of cases

3.1 Calibration Results

Table 4 shows a summary of the results of the model calibration for existing conditions. Results for each are discussed below.

Table 4 – Calibration / Validation Results

			MODELED	
Category	**Criteria**	**Target**	**AM Peak Hour**	**PM Peak Hour**
Screenline Flow	Within 10%	100% of counts	96%	73%
	GEH < 10	100% of counts	100%	100%
Individual Link Flows	Overall counts R^2	> 0.85	0.9711	0.9616
	% counts where GEH < 5	> 65% of counts	67%	68%
	% counts where GEH < 10	> 90% of counts	94%	94%
Individual Turn Flows	% counts where GEH < 5	> 65% of counts	69%	68%
	% counts where GEH < 10	> 90% of counts	92%	93%
	GEH > 10	No key movements	0%	0%
Travel Time	Within 15% (or larger than 1 min, if higher)	>85% of cases	92%	100%
Origin / Destination Data	Within 10%	>85% of cases	100%	94%

3.1.1 Individual Turn Flows

Turning volumes were observed in the model at 160 'locations', as shown in **Figure 5** and **Figure 6**. These represent intersections and interchanges in the study area, comprised of a total of approximately 1500 turning movements. This information was collected from Paramics output files for the AM and PM peak hours. As shown in Table 4, the model meets the calibration goals for turning movements with GEH less than 5, GEH less than 10, and for key movements.

3.1.2 Individual Link Flows

Link volumes in the model were the summation of turning count volumes for each approach at the 160 locations, collapsing the 1500 turn count records into 600 link count records. These serve as a good backup to turning count verification, as it is possible that each turning movement could be deemed acceptable, but their sum may show otherwise if all are either below or above their target count. **The individual link flows meet the calibration goals for percent under GEH 5 and for the R^2 statistic, as shown in** Table 3.

3.1.3 Screenlines

A total of 28 screenlines were placed throughout the model, as shown in **Figure** 7. These are generally located to one side of a major street and the total volume crossing the screenline is summed in each direction. This helps describe the general travel patterns for traffic in the area during the time period.

Given the large width of the model, the screenlines stretching east to west (which count north-south volume) were divided into several segments, in order to give some useful detail to the screenlines. North to South screenlines (which count volume traveling east-west) extend from the top to the bottom of the model. The data for each screenline is a summation of the turning count movements that cross them.

As mentioned previously, the density of the screenlines in the model was increased to offset the reduction of match percentage for the individual link counts; the density of screenlines in the Gardiner Expressway model is twice that of the LDL model.

All of the screenlines meet the calibration criteria for GEH and Percent Deviation, with the exception of three in the AM period and one in the PM period whose percent difference was higher than 10, as shown in **Table 5**. In all cases, the aberrations are screenlines with total volumes under 1000 and the differences are all under 100 vehicles and should not be significant to the model's operations.

Figure 5 – Western Intersection Locations

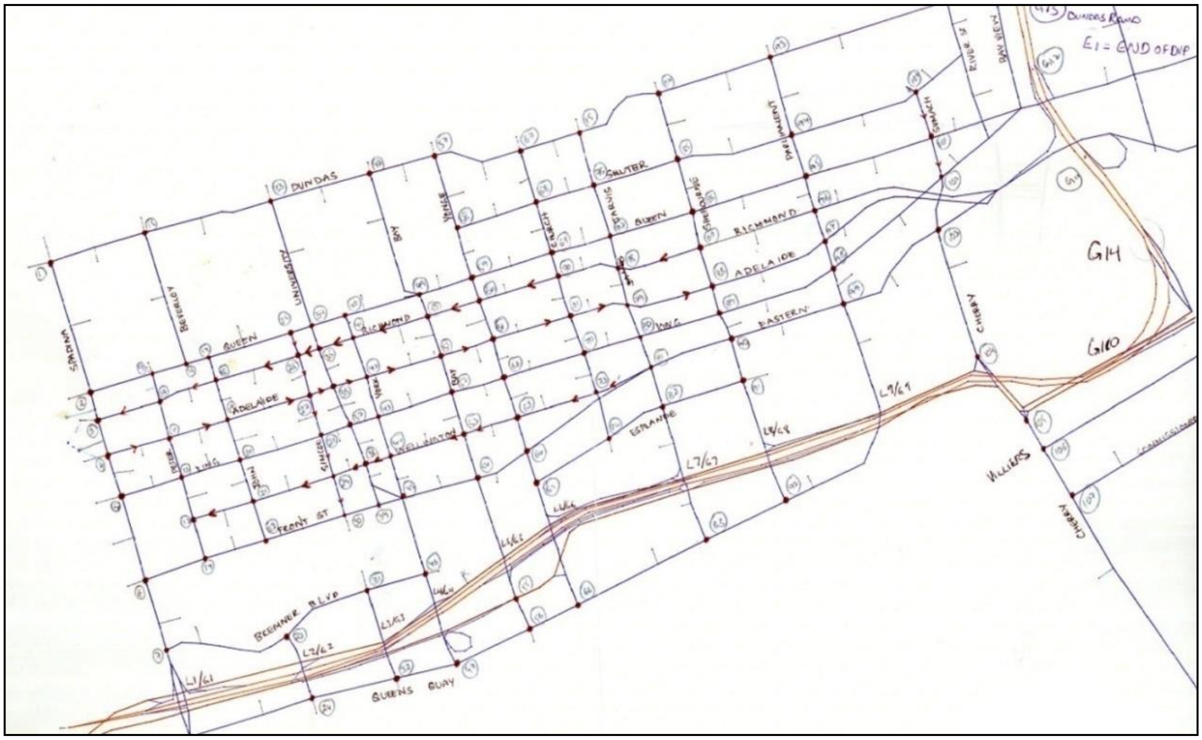


Figure 6 – Eastern Intersection Locations

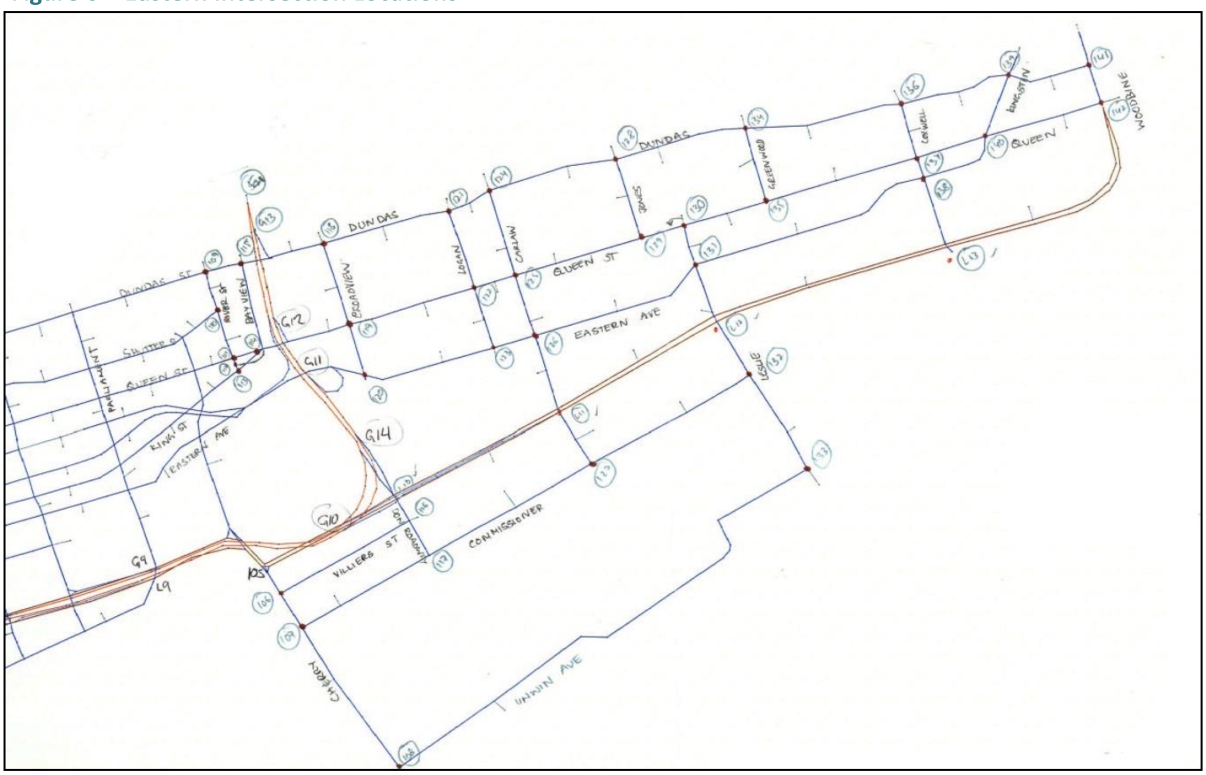


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Figure 7 – Screenlines for the Gardiner Expressway Model

3.1.4 Origin / Destination Patterns

The origin/destination patterns described by the Bluetooth survey data were compared to the volumes assigned by the model. This lends credibility to what is often the most abstract, most difficult to determine, and yet likely the most important part of a microsimulation model – the origin/destination table.

The data was limited to vehicles traveling along the Gardiner Expressway and entering the study area at the west end, Lake Shore Boulevard just east of the DVP, and the DVP just north of the study area. These, however, trace the routes which traverse the Gardiner Expressway and denote the percentage of traffic using each exit, which are the most important to the study.

Table 5 –Screenline Results for AM and PM Peak Models

			AM					PM				
#	Name	Direction	Count	Model	DIFF	% DIFF	GEH	Count	Model	DIFF	% DIFF	GEH
1	Spadina	EB	14259	13829	-430	-3.00%	3.6	11651	11939	288	2.47%	2.7
	Spadina	WB	9591	9004	-587	-6.10%	6.1	11803	11537	-266	-2.25%	2.5
2	University	EB	12296	12196	-100	-0.80%	0.9	11632	12028	396	3.40%	3.6
	University	WB	10482	10122	-360	-3.40%	3.5	10332	10239	-93	-0.90%	0.9
3	Yonge	EB	7452	7487	35	0.50%	0.4	9581	9881	300	3.13%	3.0
	Yonge	WB	11474	11064	-410	-3.60%	3.9	9267	9209	-58	-0.63%	0.6
4	Jarvis	EB	9621	9660	39	0.40%	0.4	12592	12828	236	1.87%	2.1
	Jarvis	WB	13259	12368	-891	-6.70%	7.9	10529	9550	-979	-9.30%	9.8
5	Parliament	EB	6554	6373	-181	-2.80%	2.3	10739	11015	276	2.57%	2.6
	Parliament	WB	11938	11532	-406	-3.40%	3.7	7947	8019	72	0.91%	0.8
6	DVP / Don Rdwy	EB	3036	2748	-288	-9.50%	5.4	6634	6786	152	2.29%	1.9
	DVP / Don Rdwy	WB	6510	5928	-582	-8.90%	7.4	4041	4037	-4	-0.10%	0.1
7	Carlaw	EB	2290	2315	25	1.10%	0.5	5446	5685	239	4.39%	3.2
	Carlaw	WB	5120	4814	-306	-6.00%	4.3	3379	3282	-97	-2.87%	1.7
8	Leslie	EB	1668	1791	123	7.40%	3	4534	5078	544	12.00%	7.8
	Leslie	WB	4780	4709	-71	-1.50%	1	2116	2588	472	22.31%	9.7
9	Coxwell	EB	1381	1456	75	5.40%	2	3965	4041	76	1.92%	1.2
	Coxwell	WB	3932	3866	-66	-1.70%	1.1	1819	1630	-189	-10.39%	4.6
10	Woodbine	EB	769	725	-44	-5.70%	1.6	2092	2432	340	16.25%	7.1
	Woodbine	WB	2219	2319	100	4.50%	2.1	904	804	-100	-11.06%	3.4
11	Dundas 1 (Spadina-Yonge)	NB	3307	3268	-39	-1.20%	0.7	3809	3725	-84	-2.21%	1.4
	Dundas 1 (Spadina-Yonge)	SB	3711	3627	-84	-2.30%	1.4	3632	3710	78	2.15%	1.3
12	Dundas 2 (Yonge-DVP)	NB	2430	2208	-222	-9.10%	4.6	3712	3665	-47	-1.27%	0.8
	Dundas 2 (Yonge-DVP)	SB	3594	3728	134	3.70%	2.2	2309	2384	75	3.25%	1.5
13	Dundas 3 (DVP-Grwood)	NB	1038	954	-84	-8.10%	2.7	1849	1787	-62	-3.35%	1.5
	Dundas 3 (DVP-Grwood)	SB	1394	1402	8	0.60%	0.2	1233	1480	247	20.03%	6.7
14	Dundas 4 (Grwood-Wbine)	NB	1053	1099	46	4.40%	1.4	2720	2784	64	2.35%	1.2
	Dundas 4 (Grwood-Wbine)	SB	2465	2414	-51	-2.10%	1	1144	1042	-102	-8.92%	3.1
15	Queen 1 (Spadina-Yonge)	NB	4026	4274	248	6.20%	3.8	4753	4514	-239	-5.03%	3.5
	Queen 1 (Spadina-Yonge)	SB	4058	4048	-10	-0.20%	0.2	4315	4111	-204	-4.73%	3.1
16	Queen 2 (Yonge-DVP)	NB	6184	6159	-25	-0.40%	0.3	6445	6726	281	4.36%	3.5
	Queen 2 (Yonge-DVP)	SB	8541	8720	179	2.10%	1.9	7080	7649	569	8.04%	6.6
17	Queen 3 (DVP-GrWood)	NB	556	513	-43	-7.70%	1.9	1160	1308	148	12.76%	4.2
	Queen 3 (DVP-GrWood)	SB	876	857	-19	-2.20%	0.6	990	1255	265	26.77%	7.9
18	Queen 4 (GrWood-Wdbine)	NB	1992	1864	-128	-6.40%	2.9	3355	3755	400	11.92%	6.7
	Queen 4 (GrWood-Wdbine)	SB	2286	2190	-96	-4.20%	2	1002	827	-175	-17.47%	5.8
19	King 1 (Spadina-Yonge)	NB	4540	4741	201	4.40%	3	4077	4028	-49	-1.20%	0.8
	King 1 (Spadina-Yonge)	SB	4687	4785	98	2.10%	1.4	4967	5043	76	1.53%	1.1
20	King 2 (Yonge-DVP)	NB	2648	2823	175	6.60%	3.3	3058	3073	15	0.49%	0.3
	King 2 (Yonge-DVP)	SB	1989	1871	-118	-5.90%	2.7	2183	2303	120	5.50%	2.5
21	Front (Spadina-Yonge)	NB	3588	3564	-24	-0.70%	0.4	2605	2649	44	1.69%	0.9
	Front (Spadina-Yonge)	SB	4045	3938	-107	-2.60%	1.7	3814	4069	255	6.69%	4.1
22	LSB1 (Spadina-Yonge)	NB	7692	7211	-481	-6.30%	5.6	6205	5552	-653	-10.52%	8.5
	LSB1 (Spadina-Yonge)	SB	2513	2628	115	4.60%	2.3	4213	4214	1	0.02%	0.0
23	LSB2 (Yonge-DVP)	NB	7509	7673	164	2.20%	1.9	7223	7159	-64	-0.89%	0.8
	LSB2 (Yonge-DVP)	SB	5371	5263	-108	-2.00%	1.5	4709	4711	2	0.04%	0.0
24	LSB3 (DVP-GrWood)	NB	835	861	26	3.10%	0.9	1830	1711	-119	-6.50%	2.8
	LSB3 (DVP-GrWood)	SB	2383	2558	175	7.30%	3.5	1187	1348	161	13.56%	4.5
25	Queen's Quay 1	NB	1507	1333	-174	-11.50%	4.6	1335	1420	85	6.37%	2.3
	Queen's Quay 1	SB	1514	1481	-33	-2.20%	0.9	1299	1358	59	4.54%	1.6
26	Queens' Quay 2 (Yonge-P'ment)	NB	701	639	-62	-8.80%	2.4	1127	1038	-89	-7.90%	2.7
	Queens' Quay 2 (Yonge-P'ment)	SB	758	669	-89	-11.70%	3.3	451	620	169	37.47%	7.3
27	Villiers	NB	885	866	-19	-2.10%	0.6	1280	1041	-239	-18.67%	7.0
	Villiers	SB	1162	1169	7	0.60%	0.2	715	737	22	3.08%	0.8
28	Comissioners	NB	229	240	11	4.80%	0.7	373	348	-25	-6.70%	1.3
	Comissioners	SB	234	233	-1	-0.40%	0.1	310	253	-57	-18.39%	3.4

Table 6 – Origin/Destination Results

		AM PEAK HOUR			PM PEAK HOUR		
Origin	Rule Name (O - D)	Model	Bluetooth	difference	Model	Bluetooth	difference
DVP SB	DVP SB - FGE WB	31%	18%	13%	32%	20%	12%
DVP SB	DVP SB - Jarvis/Sherbourne Off	6%	10%	-4%	7%	6%	1%
DVP SB	DVP SB - LSB EB	3%	3%	0%	6%	5%	1%
DVP SB	DVP SB - LSB WB	2%	4%	-2%	1%	5%	-4%
DVP SB	DVP SB - Richmond Off	35%	40%	-5%	35%	44%	-9%
DVP SB	DVP SB - Spadina Off	9%	25%	-1%	1%	20%	6%
DVP SB	DVP SB - YBY Off	15%		15%	25%		
FGE EB	FGE EB - DVP NB Exit	23%	16%	7%	20%	14%	6%
FGE EB	FGE EB - Jarvis/Sherbourne Off	23%	25%	-2%	13%	15%	-2%
FGE EB	FGE EB - LSB Off	7%	6%	1%	23%	14%	9%
FGE EB	FGE EB - Spadina Off	18%	54%	-8%	13%	58%	-18%
FGE EB	FGE EB - YBY Off	28%		28%	26%		
LSB WB	LSB WB - DVP NB	5%	6%	-1%	7%	6%	1%
LSB WB	LSB WB - FGE WB	29%	25%	4%	35%	25%	10%
LSB WB	LSB WB - LSB WB	15%	17%	-2%	12%	17%	-5%
LSB WB	LSB WB - Spadina Off	13%	50%	-7%	15%	50%	-6%
LSB WB	LSB WB - YBY Off	30%			29%		
LSB WB	LSB WB - Jarvis/Sherbourne Off	8%	2%	6%	1%	2%	-1%

3.1.5 Speed / Travel Time

Also produced by the Bluetooth survey was data concerning the travel speed / travel time at various points through the corridor. Point to point travel times can be collected from Paramics along specific routes. These were collected at several points through the corridor, as shown in

Figure 8**.**

Portions of the travel time segments from Dufferin Street to Simcoe Street and from Danforth Avenue to Parliament Street lie outside of the model area. The travel time on these segments were reduced proportionate to the length of these segments contained in the model to gain an approximate measure of travel time.

Figure 8 – Location of Bluetooth detectors

As shown in **Table 7**, the average travel time for the majority of segments in the study area are within 15% of the collected value or no greater than 1 minute higher, as suggested by FHWA.

Table 7 – Travel Time Results

AM PEAK HOUR		BLUETOOTH SURVEY					GARDINER EXPRESSWAY MODEL			
		SEGMENT LENGTH (km)		TRAVEL TIME (min)		TRAVEL SPEED (km/h)	TRAVEL TIME (min)	Percent Difference	Absolute Difference (min)	TRAVEL SPEED (km/h)
Origin	Destination	Actual	Model	Observed Average	Modified For Length					
Dufferin	Simcoe	3.75	1.40	2.68	1.00	84.0	1.36	36%	0.36	61.7
Simcoe	Dufferin	3.75	1.40	2.78	1.04	81.0	0.85	-18%	-0.19	98.6
Simcoe	Jarvis	1.40	1.40	0.89	0.89	94.6	0.79	-11%	-0.10	106.1
Jarvis	Simcoe	1.40	1.40	1.02	1.02	82.4	1.01	-1%	-0.01	82.8
Jarvis	Parliament	0.70	0.70	0.43	0.43	97.7	0.56	30%	0.13	75.1
Parliament	Jarvis	0.70	0.70	0.49	0.49	85.1	0.97	98%	0.48	43.1
Parliament	Danforth	3.68	2.50	2.39	1.63	92.2	1.92	18%	0.30	77.9
Danforth	Parliament	3.68	2.50	2.30	1.57	95.8	2.74	75%	1.17	54.8
Parliament	Morse	2.00	2.00	1.46	1.46	82.5	2.18	50%	0.73	55.0
Morse	Parliament	2.00	2.00	1.55	1.55	77.4	2.95	90%	1.40	40.7
Danforth	Morse	3.30	2.10	3.65	2.32	54.2	3.32	43%	1.00	37.9
Morse	Danforth	3.30	2.10	4.15	2.64	47.7	3.27	24%	0.63	38.5

PM PEAK HOUR		BLUETOOTH SURVEY					GARDINER EXPRESSWAY MODEL			
		SEGMENT LENGTH (km)		TRAVEL TIME (min)		TRAVEL SPEED (km/h)	TRAVEL TIME (min)	Percent Difference	Absolute Difference (min)	TRAVEL SPEED (km/h)
Origin	Destination	Actual	Model	Observed Average	Modified For Length					
Dufferin	Simcoe	3.75	1.40	2.99	1.12	75.3	1.43	28%	0.32	58.7
Simcoe	Dufferin	3.75	1.40	6.33	2.36	35.5	2.17	-8%	-0.20	38.8
Simcoe	Jarvis	1.40	1.40	0.91	0.91	91.9	0.77	-16%	-0.14	109.0
Jarvis	Simcoe	1.40	1.40	5.36	5.36	15.7	1.58	-71%	-3.78	53.3
Jarvis	Parliament	0.70	0.70	0.47	0.47	89.8	0.56	20%	0.09	74.7
Parliament	Jarvis	0.70	0.70	1.07	1.07	39.3	0.62	-42%	-0.45	68.1
Parliament	Danforth	3.68	2.50	3.27	2.22	67.5	2.47	11%	0.25	60.7
Danforth	Parliament	3.68	2.50	2.31	1.57	95.7	2.13	36%	0.56	70.5
Parliament	Morse	2.00	2.00	1.78	1.78	67.4	2.35	32%	0.57	51.2
Morse	Parliament	2.00	2.00	1.60	1.60	75.0	2.05	28%	0.45	58.4
Danforth	Morse	3.30	2.10	3.57	2.27	55.5	3.41	50%	1.14	36.9
Morse	Danforth	3.30	2.10	4.93	3.14	40.1	3.45	10%	0.31	36.5

The single major exception to this is the westbound PM travel time between Jarvis and Simcoe; this segment operates faster than in reality. In reality, the westbound direction of the Gardiner Expressway is congested for the entire peak hour with queues typically extending east to Jarvis Street. In the Paramics model, it is extremely difficult to have a constant queue form for the duration of the model run as the dynamic feedback (information to motorists on the congestion ahead of them) causes many motorists to attempt to divert through the model to bypass the constant congestion. This quickly gridlocks the entire model, rendering analysis impossible (and with growth to future years the problem would only worsen). As such, the westbound travel speed was reduced to an extent that caused queuing that extends to Jarvis at certain points, but builds and dissipates throughout the model run. This allows the model to function and replicates the length of typical queuing, if not the constancy. This effectively means that the real life travel time / speed through this section cannot be replicated in this model, though it would indeed be possible in a tight corridor model with no possible alternate routes.

4.0 Transportation Demand Forecasting

With a calibrated and validated existing year microsimulation model in place, it was then necessary to project the demand for transportation facilities to the future horizon year – 2031. Forecasting the demand to the future horizon then allowed for testing of alternate geometry and control scenarios.

4.1 Approach

Estimating the future year transportation demand for a large study area required a complex approach involving the interaction of the City of Toronto's GTA regional travel demand model in EMME with the calibrated Paramics model.

The GTA model is a highly complex amalgam of land use and demographic data, which is calibrated against the findings of the Transportation Tomorrow Survey to produce an accurate representation of travel behaviour and patterns in the GTA. Modification of the land use and demographic data to represent the future horizon allows the models calibrated processes to then predict how these changes in land use and demographics will affect the trips that residents in the GTA need to make to live their lives.

The basic approach in forecasting the future year travel demand involved examination of the number of vehicle trips produced in the two regional model analysis years – 2001 and 2031, the creation of compound annual growth rates, and application of these rates to the calibrated Paramics model.

This process produced a future year origin / destination matrix in the Paramics that was applied in the analysis of the Alternative Solutions.

4.2 Methodology

The methodology followed in creation of the future year transportation demands can be broken into three major steps, as follows:

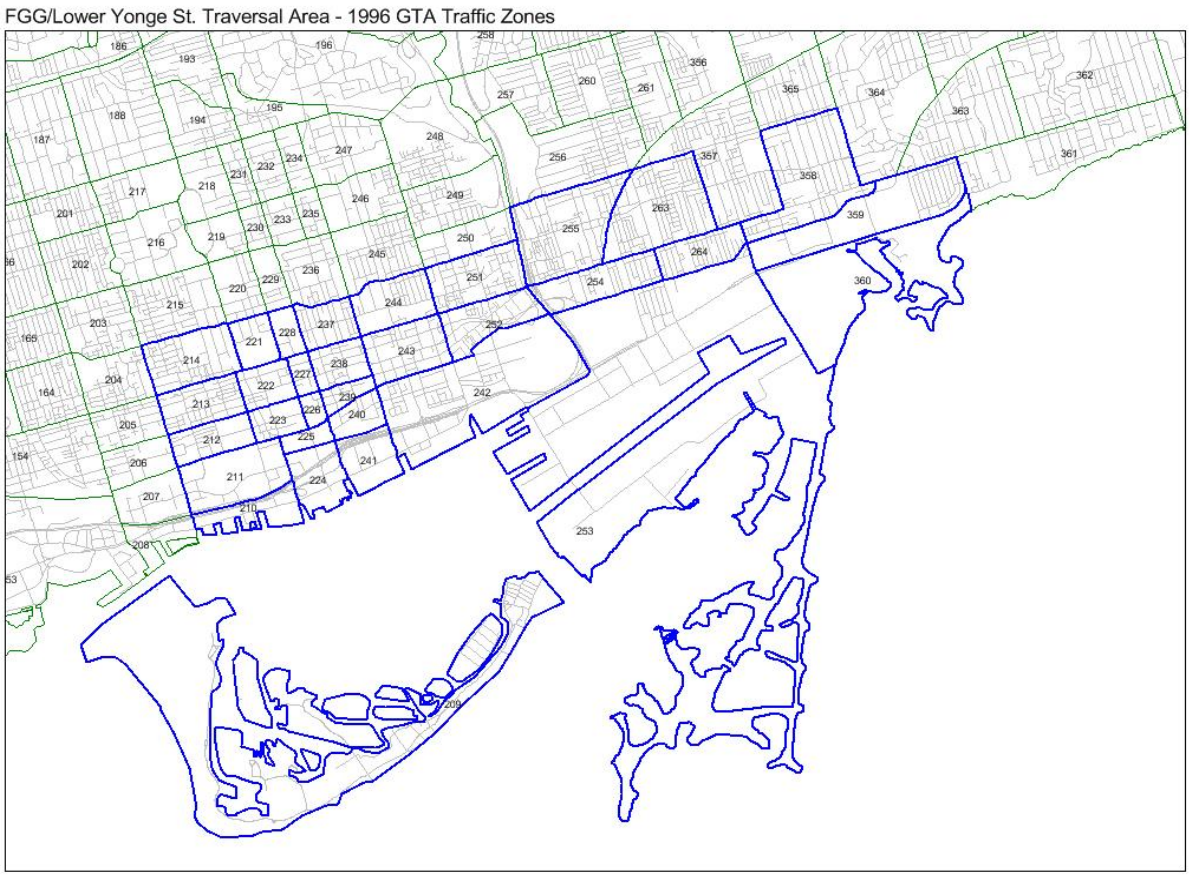
- Extract EMME Study Area Traversal Matrices
- Calculate EMME Zone Compound Annual Growth Rates
- Relate EMME and Paramics Model Zones
- Apply Compound Annual Growth Rates

4.2.1 Extract EMME Study Area Traversal Matrices

City of Toronto transportation modelling staff first extracted a portion of the regional EMME model representing the overall study area. This extraction process creates a "traversal matrix", which is an origin-destination table representing travel across and within the study area. During the model's assignment processes, the program is directed to calculate the demand between various points, most importantly along the edges of the “cut line” that act as the study area boundary. In this process, the software creates a smaller subarea origin/destination table that represents the study area important to this study. This allowed the modelling team the ability to examine the growth along the edges and within the study area. This process was performed for the 2001 and 2031 model years.

Figure 9 shows the traversal area (or subarea) applied in the EMME model for use in production of the traversal matrix.

Figure 9 – Gardiner East Traversal Area and EMME Model Zones



4.2.2 Calculate EMME Zone Compound Annual Growth Rates

The extracted traversal matrices were then applied in the calculation of compound annual growth rates (CAGR) for the individual zones. The CAGR provides a factor with which the existing year travel demand can be increased or decreased over long periods. Calculation of the CAGR at the individual zone level allows for differential growth across the study area, as cities do not grow homogeneously at the same growth rate. This allows greater precision in the forecasting of future travel demands than the traditional application of a single “background growth rate” and allows the various parts of the city to grow and change independently as they will in reality.

Use of the CAGR (as opposed to absolute growth in vehicle trips) was necessary as the model years of the EMME and Paramics models were significantly different. Whereas the EMME model provides estimates of travel for the years 2001 and 2031, the Paramics model was calibrated to match recent count data and approximates the year 2013. The CAGR then provides a rate of growth per year that can be applied to modify the 2013 model to represent 2031. The CAGR was calculated via the following formula:

$$CAGR = \left(\frac{\text{Ending Value}}{\text{Beginning Value}}\right)^{\left(\frac{1}{\#\text{ of years}}\right)} - 1$$

4.2.3 Relate EMME and Paramics Model Zones

The regional EMME travel demand model and the study area Paramics microsimulation model were both created to serve quite different purposes – the former to examine the macroscopic travel decisions and patterns of residents across a very large area, and the latter to analyse the detailed operations of roadways in a relatively small focus area. As such, they were created with vastly different zone structures. This, then, required that a table relating the two models to each to be created.

A direct mapping of the smaller “child” zones in the Paramics to the larger “parent” zones in the EMME model was created. This relates the two zones together to assign the appropriate growth rate via the previously calculated CAGR for each EMME model zone.

4.2.4 Apply Compound Annual Growth Rates

With appropriate CAGR calculated for each EMME model zone and the larger EMME zones related to the smaller Paramics zones, it was then possible to apply the CAGR to the origin destination table in the Paramics model for both AM and PM peak hour periods.

The above process resulted in origin / destination matrices for the 2031 AM and PM peak hours. These form the basis of the future year travel demand for testing.

4.3 Transportation Demand Management

Traditional travel demand models such at the City of Toronto’s EMME model are tools that are calibrated based on observed trends and past behaviour – they look to the past to predict the future. This assumes that the present day behaviour will not change into the future. However, it can be shown that behaviour does change over time with changing attitudes towards automobile ownership, suburban versus urban life, and other elements visible in recent trends. Changes in municipal, provincial, and federal policies can also have a direct effect on people’s decisions on where to live and how to get around.

It was, therefore, worthwhile to investigate the various elements that make up the demand for transportation infrastructure and estimate how this may change over time in ways that traditional models are not capable of predicting.

Producing a more accurate estimate of travel demand for the future will allow the facilities to be "right-sized" for the reality of the world at that point. Traditionally, the approach has been to always err on the conservative side of demand forecasting, which lead to higher demand forecasts and thereby larger roads. This approach runs contradictory to modern transportation planning and city-building attitudes that are attempting to curb the use of single-occupant automobiles and increase the use of alternate modes such as walking, biking, and transit.

This section of the document discusses various concepts behind potential changes in transportation behaviour and quantifies a reduction to the forecasts produced by the methodology followed in **Section 4.2**.

4.3.1 Underlying Context, Principles and Considerations

4.3.1.1 Destined vs. Through Traffic

The Gardiner / LSB corridor serves four different travel patterns:

- Inbound to downtown (peak direction);
- Outbound from downtown (counter-peak direction);
- Through (crosstown) traffic;
- Local traffic (may be considered subset of inbound / outbound categories).

The greatest benefit to reducing overall demand in the corridor would be derived by reducing inbound and through traffic, although outbound (counter-peak) traffic has grown rapidly of late due to increased residential population commuting to suburban employment areas, where transit is unavailable or less attractive.

The Bluetooth survey found that less than one-quarter of vehicles approaching downtown on the Gardiner, Lake Shore and DVP was using those routes to travel through (rather than to) downtown.

- 20% of eastbound Gardiner traffic at Dufferin was destined to the DVP or east Lake Shore;
- 15% of southbound DVP traffic north of Bayview/Bloor was destined to the Gardiner west of Spadina;
- 25% of westbound Lake Shore traffic at Carlaw was destined to the Gardiner west of Spadina.

However, in absolute terms, the through traffic on the Gardiner/Lake Shore is substantial, especially when measured against arterial lane capacity.

- 1,600 vph westbound
- 1,250 vph eastbound

The majority of through traffic is not traveling the full distance of the Gardiner and DVP (e.g., not motorists traveling from south Mississauga to Durham and deciding whether to cross Toronto via the 427 / 401 or the Gardiner / DVP).

The distinction between downtown and crosstown traffic is important. Some solutions are more feasible than others depending on the nature of the trip.

4.3.1.2 Why people change their travel behaviour

A review of Cairns et al[3] highlights a number of points listed below.

A transportation model is based on decisions being broadly stable in aggregate, but this stability masks many underlying changes that constantly occur and sometimes cancel each other out. For example, one person retires from the workforce while another enters; one person moves to a different home or job, but is replaced by another. Normally this would cancel out and no net change would be observed in aggregate. In some cases, the change from one cohort to another is substantial enough that it gradually impacts overall results (e.g., downward trends in vehicle ownership, % of adults with driver's licenses, increased propensity to use transit).

Major life events occurring from time to time that could influence study area travel:

- Place of residence:
  - Move within Toronto (local)
  - Move within GTA
  - Move to / from outside GTA
  - New residence
- Place of employment
  - Change place of employment
  - Enter workforce
  - Leave workforce (retire / unemployed)
  - Change in nature of job (hours, position, responsibility)
- Demographic changes
  - Marriage
  - Birth of dependent (or new dependent – e.g., elders)
  - Death
  - Other change in home responsibilities
- Transportation changes
  - Increase or decrease number of cars in household

[3] Sally Cairns, Carmen Hass-Klau and Phil Goodwin. *Traffic Impact of Highway Capacity Reductions: Assessment of the Evidence.* Landor Publishing, March 1998.

- ○ Obtain driver's license

When making transportation choices, one is generally more amenable to changing behaviour when it occurs in conjunction with other life changes ("starting fresh").

In life changes involving choice / options (e.g., decision to move), the decision considers many different factors; the prevailing transportation context can be a major factor. If the prevailing transportation context is different, it may result in a different decision for some people. (e.g., people may buy a home that will result in them commuting across town with the perception that the Gardiner will allow them to travel "against traffic" most of the way; people make different activity and travel choices when they know that the Gardiner is closed for the weekend).

Each of these thousands of individual changes is based on a variety of factors, including transportation. People consider the transportation network when they decide where to move, where to work, what travel mode and route to choose; and when to travel. If the transportation network changes, this may result in different choices.

Response to capacity reductions is comprised of two subsets of users:

- Response by stable population of individuals (no change in place of residence, work, etc.) – change will occur to the extent that change is desirable and reasonably feasible. May be some initial changes ("low-hanging fruit"), but generally slow for the majority. This group has developed existing habits in their travel patterns; habits can be difficult to break.
- Response due to ongoing changes in the population using the road – some people would have automatically left the road regardless due to underlying life changes; they would normally be backfilled by new arrivals making generally similar choices, but if the context is different, the new arrivals may make different choices or may not arrive.

It is easy to focus on the first category – "how do we get people to change?", but the second category may lead to greater opportunity.

Cairns et al have UK examples of life changes over time (e.g., % moving over the past *x* years). An important subset may be new development in the waterfront area since it will be populated exclusively by new residents, each of whom will be making certain transportation choices (O/D and mode). We can follow a "transit first" principle, although note political / financial challenges in implementing east waterfront LRT… will a transit habit develop if the underlying transit network is not in place?

Change will occur on a spectrum. Some users may need little further incentive to change; others may have no flexibility and are unlikely to change.

4.3.2 Data sources

- EMME model:
    - Trip matrices (person, auto, transit)
    - Select link analyses (Gardiner, LSB, Richmond/Adelaide/Eastern)
    - Others tabulations
- Transportation Tomorrow Survey:
    - Modal split (CBD-oriented trips – inbound and outbound) – percentages; dot density plots
    - Modal split (through trips – e.g., from east of downtown to planning districts in west Toronto, Mississauga, Brampton) – percentages; dot density plots
    - Trip purpose breakdown (work-based vs. discretionary)
    - Trends from 1986 through 2006
    - Other tabulations
- Bluetooth O/D survey
    - Through vs. local traffic breakdown
- Gardiner Expressway / Lake Shore Boulevard Reconfiguration Environmental Assessment Study Attitudinal Survey
    - Travel habits of expressway users, residents in the corridor
    - Views on future changes to the transportation network
- Cordon count
    - Trends (auto occupancy, etc.)
    - Impact during Gardiner construction
- Census data
- City traffic data (permanent count stations)
    - Traffic volume changes during major construction projects
- Case studies from other jurisdictions
    - Sally Cairns et al – *Traffic Impact of Highway Capacity Reductions: Assessment of the Evidence* (March 1998 report); Victoria Transport Policy Institute
    - Case study may not be directly comparable – different transportation, land use, attitudinal contexts
    - May quantify the overall traffic reduction effects, but may not quantify the range or nature of the changes (e.g., xx% of people moved into the city so that they would not have to drive in)

4.3.3 Smaller-scale or temporary capacity reductions in Toronto

Effects can be reviewed in Toronto by reviewing impacts of construction or other smaller capacity reductions:

- Streetcar track reconstruction;

- Gardiner / DVP closures;
- West Don Lands closure of Bayview south of Queen;
- Road lane reallocation for bike lanes (road diet);
- Pedestrian scramble phase at Yonge / Dundas;
- Planned subway closures (transit ridership) – e.g., recent closure of downtown "U".

Investigation of these types of projects would likely see a combination of reduced volumes (or ridership) and increased congestion (e.g., when the Gardiner is closed, the Lake Shore is severely congested, but traffic demand is also likely lower). This approach might give the end results, but may not fully explain the reasons why.

It was initially hypothesized that the removal of the eastern stub of the Gardiner could be a case study. However, it actually represented a capacity increase, because it eliminated a previously existing bottleneck at the single-lane ramps to/from Leslie. Net result was a shift in traffic from Lake Shore (overflow traffic) to the Gardiner.

4.3.4 Model variability and risk management

Model results are, at best, an estimate of operations under a certain set of conditions and assumptions, but traffic volumes (and results) are not likely to materialize as modeled, even under the Maintain solution. There are numerous sources of variability in traffic modeling that would impact the results:

- Natural day-to-day traffic fluctuations;
- Increased traffic due to special events;
- Temporary closures or lane reductions due to construction, collisions / emergency response, or special events;
- Unanticipated transportation network changes not accounted for in the model;
- Unanticipated development proposals or changes to currently anticipated development proposals;
- Demographic trends leading to changes in attitudes / preferences (e.g., younger cohort obtaining driver's license / purchasing vehicles at a later age or not at all; differing live/work location preferences);
- Technological changes leading to changes in attitudes / preferences (e.g., telecommuting, smartphones);
- Policy changes resulting from shift in political environment;
- Changes in activity beyond 20-year model horizon

There are also common modelling errors that could impact the results:

- Model calibration may be off (O/D pairings, trip rates, modal splits, specific assignments etc.);
- Microsimulation parameters may be off (e.g., pedestrian interaction; centroid connectors).

At best, the model helps us understand - given a certain set of conditions, would this particular transportation network work?

We make our best estimates, and build in flexibility where possible to address unanticipated fluctuation and deviation. Our challenge is how to define that set of conditions, including making our best estimate of changes that we would expect to happen that the model cannot adequately capture.

Therefore, it is important in transportation planning and city-building projects to understand and account for a certain level of risk associated with transportation modelling and any other types of assumption-based analysis. Elements of risk to consider would be:

- How certain can we be of a particular shift occurring?
- If we are unsure, are there other measures/changes that we can better rely on?
- What is the backup plan in case the shift does not come to fruition?
- Identify policies and infrastructure to encourage the desired shifts in behavior, but also identify changes to mitigate congestion for transit and determine which links/movements should be prioritized (e.g., metering traffic access to the network sensitive portions of the network) in the event that the shifts do not materialize

4.3.5 Categories of Vehicle Trip Reductions

The body of research suggests a variety of ways that traffic may respond to capacity reductions. The magnitude of the response varies depending on the severity of the impacts of the capacity reduction. If capacity constraints are limited to shorter periods during the day or specific routes, motorists may only make minor adjustments to their departure time or may make routing adjustments. As capacity constraints become more geographically widespread, more severe, or of longer duration, motorists begin to make more substantial shifts.

Generally from easiest to most difficult to quantify or perhaps shorter term response to longer term response:

- Shift of trips to alternate routes (local or regional);
- Shift of auto driver trips to alternate modes (TTC/GO; walking/cycling);
- Increased auto occupancy;
- Shift of trips to other times of the day (either outside the peak hour, or outside the peak period);
- Reduced frequency of trip-making (including alternate work arrangements such as telecommuting, conference calling or compressed work week);
- Changing origin/destination patterns (increased downtown population and employment enabling increased non-auto commuting; residents move to opposite side of the city to avoid having to commute crosstown);
- Discretionary trips just don't happen (e.g., shopping more locally instead of downtown or crosstown), a particular trip is not worth the effort of traveling through congested area, or trips consolidated to occur less frequently.

For each of the categories above, it was necessary to consider a number of questions:

- Do the EMME or Paramics models account for this type of shift?
  - Is the change sufficient or is it possible that the model is understating the magnitude of the change?
- Is there evidence of this change already happening?
- If not, how likely is it to occur? Is this a reasonable assumption?
- What is the potential for growth in behaviour that will reduce vehicular demand?
- Would the shift happen organically, or would there need to be specific infrastructure, initiatives and/or policies in order to encourage the shift and reach the desired targets? (What would be required for the assumption to be true or to push the boundaries?)
- How to quantify the baseline and the likely maximum shift?
- If additional adjustment required, how to accommodate in the model(s)?
- Should the adjustment be made globally or targeted to specific links, zones, O/D pairs? Or to one particular classification of trip (e.g., telecommuting only applicable for office work).

The following sections examine the various ways that trip-making behaviour may change and how that change can be effected. Each section provides a discussion of the considerations, a recommended approach, and the likely outcome (or range of outcomes) with respect to this effort.

4.3.5.1 Trip Reassignment

Trip reassignment involves travellers still making the same trip, but completing it via a different route.

EMME accounts for this in regional trip assignment (macro level) and Paramics accounts for this in local trip assignment within the study area (micro level). The results are limited by underlying assumptions and parameters within the models.

Considerations:

The traversal matrices for Maintain and Remove (as described in the main body of the EA report) indicate EMME is modeling a reduction of 856 trips (1.7% of trips in study area). The majority of the reduction has been at the gateways; the internal study area zones only experienced a reduction of 65 trips. This suggests that most of the modeled change is due to traffic rerouting away from the study area.

In the Gardiner Attitudinal survey, 24% of drivers said that they were likely or somewhat likely to select an alternate route if travel time on the Gardiner / Lake Shore increased. This could be a different route within the study area (as modeled by Paramics).

Approach:

Assume that the models have addressed this measure as much as practical and make no further changes.

Outcome:

Assume that the models have addressed this measure as much as practical and make no further changes.

Reduction:

- None recommended

4.3.5.2 Mode Shift

With changes to the state of transportation on their daily journeys (e.g., travel time, available modes, attitudes towards alternate modes), there is a potential for travellers to make the same journey as previous, but via a different mode of travel where that is possible and/or convenient. The most likely driver of this change is congestion on roadways.

The EMME model divides person trips into auto, transit and "other" (walking and cycling) trips based on factors such as travel time, trip purpose, traveler demographics (including auto ownership), and historical traveler attitudes and characteristics. In theory, then, if road capacity is reduced such that auto delays increase substantially, the model should show a shift to transit ridership to the extent that there is an attractive transit alternative available for that particular trip.

Considerations

In the Gardiner Attitudinal survey, 11% said it was likely or somewhat likely that they would respond to increased congestion by switching to GO (5%) or TTC (6%), and 6% said they might switch to walking or cycling.

Downtown-oriented trips:

The following is already occurring in peak direction for downtown-oriented trips:

- Auto driver mode typically around 25% for inbound AM peak period trips originating both in 416 and 905;
- Most of the rest is on TTC (416) or GO (905);
- Walking trips are mostly internal to PD1 (targeted adjustment);
- Cycling trips to PD1 are mostly from zones immediately surrounding PD1 ("inner ring")
    - During the winter, cycling activity decreases by ~90%. Is increased cycling as a TDM measure contingent on it continuing through the winter?
- Auto modal split in the 2001 EMME model appears to be somewhat higher than TTS data (37% in model vs. 31% in TTS). Areas are not exactly the same (TTS = PD1; EMME = EA study area). If focusing solely on the EA study area, one might expect the TTS auto modal split to be lower.

Surveyed vs. Modeled Modal Split – AM Peak Period Inbound Trips

	Driver	Passenger	TTC	GO	Walking	Cycling
Inbound trips to PD1 (2006 TTS)						
From 416	25%	6%	54%	3%	9%	2%
From 905	27%	5%	19%	48%	0%	0%
From all GTA	26%	5%	43%	17%	6%	2%
Inbound trips to EA study area (2001 and 2031 EMME models)						
EMME 2001	37%		58%		5%	
EMME 2031	28%		66%		6%	

The 2008 Kings Travel Survey modal split data were compared against 2006 TTS data. The auto modal split is reasonably close (23% KTS; 25% TTS), although there has been a substantial reduction compared to the 2001 KTS (35%). If the model is calibrated to 2001 TTS data, there may be an overstatement of vehicle trips generated in those areas, as well as similar high-density precincts in the downtown area (CityPlace; new waterfront precincts). This presented an opportunity to adjust the travel demands, given that the model may be currently over-producing trips from specific areas.

Crosstown and counter-peak trips:

Auto mode share is much higher for counter-peak and "through" trips that are not as well served by transit (either for entire trip or at external trip end; e.g., outbound congestion on Gardiner / DVP with increased downtown population commuting to suburban auto-oriented employment areas along 427 and 404).

Opportunities for mode shift may be more limited depending on:

- Specific origin/destination pairings
- Transit improvements (esp. GO counter-peak service and local service levels at destination end / "last mile")

In this case, it was determined that it would likely not be appropriate to apply global reductions – any adjustments should be more targeted to geography, trip purpose, O/D pairings, if possible. The assessment of opportunities related to this was more challenging due to more widely dispersed o/d patterns (many-to-many vs. many-to-one).

Opportunities for reduction were limited to transit (GO and local) where travel distances would be likely too great to accommodate via shifts to walking / cycling. Counter-peak trips via GO were also limited by the GO schedule and by transit availability / attractiveness at the outlying GO station.

Approach:

Model runs were reviewed (Origin/Destination matrices) to determine if there was any discernible difference in modal split between Maintain and Remove alternatives (as described in the main body of the EA report). If the shift is commensurate with expectations, accept and take no further action. If not, or if walking and cycling are underrepresented, then further analysis would be required and possible post EMME model adjustments to the Paramics traversal matrix.

Outcome:

Through examination of the available data and model outputs, a post-modelling adjustment was required. Considerations in this adjustment included:

- EMME model includes a mode choice module (known as a logit model) that distributes trips between auto, transit, and other modes (cycling and walking).
- Modal assignment relies on:
  - Transit service
  - Travel times for various modes
  - Trip purpose; traveller demographics
  - Historical traveller attitudes and characteristics
- Numerous changes to the transportation environment are expected that will make transit and cycling/walking generally more attractive than it has been historically:
  - Policies governing land use patterns (mixed-use developments, smart growth) and site design (transit-oriented design) are promoting developments with higher density, increased proximity of employment and amenities to residents, and more street orientation, particularly in areas well served by high-frequency or higher-order transit
  - Non-auto modes are being promoted through education programs, implementation of better on-street amenities, better access to transit passes, and tax incentives
  - Generation Y is personally less inclined to drive than Generation X/Baby Boomers
  - Integration and cooperation between GTA transit authorities is improving (most relevant for cross-boundary trips, primarily counter-peak direction)
- The EMME model will account for some of the factors (such as transit service and facilities), but will not account for all of the factors.
- GTA transportation planning exercises (Metrolinx Transportation Master Plan) have assumed 2% global reductions post-modelling and an additional 5% reductions post-modelling for trips less than 10 km long for this factor. This factor is GTA wide and it is likely that a higher number is supportable in the study area.

Given the data in the model and the above considerations, the following reduction in auto travel may be possible.

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Reduction:
- 5-7% reduction in auto trips – shift to transit
- Further 5-7% reduction in auto trips for internal trips (under 5 km) – shift to walking and cycling

4.3.5.3 Auto Occupancy

Increased auto occupancy and carpooling is frequently identified as a policy goal, with some measures in place to encourage this (e.g., HOV lanes, preferred parking).

Considerations

TTS and cordon count data both indicate a trend toward lower auto occupancy levels, which runs counter to the stated policy goals and serves to increase roadway congestion. It was important to examine the likelihood of this trend being reversed and reversed substantially enough to have a noticeable impact on model results. Cities facing this trend need to examine what specific measures would need to be enacted that are not already in place (since the status quo is resulting in a decrease in auto occupancy).

Cairns et al indicate that ridesharing is a rare response to capacity reductions. As well, the Gardiner Attitudinal survey indicated that only 5% of respondents were likely or somewhat likely to switch to carpooling in response to increasing congestion in the corridor.

There are some cities with stronger ridesharing (e.g., “slugging” in Washington – certain highways into the city are reserved for HOVs only during rush hour). There are suggestions that carpoolers are taken from transit rather than single-occupant vehicles (or more prevalent where transit options are limited). The suggestion is that the carpooling incentive is predominantly based on time savings compared to general traffic rather than financial or altruistic incentives (i.e., I can use the HOV lanes to get around congestion in the general traffic lanes).

Approach:

Increased auto occupancy is not likely without aggressive policy direction and measures to encourage HOVs. This would only be of benefit if new passengers were taken from existing drivers rather than existing transit riders. This suggested that the analysis should assume existing auto occupancy levels for modeling purposes.

Outcome:

Post-modelling adjustment is not required:
- TTS and cordon count data both indicate a trend toward lower auto occupancy levels
- There are suggestions that carpoolers are taken from transit rather than single-occupant vehicle

- Increased auto occupancy and carpooling is frequently identified as a policy goal, with some measures in place to encourage (HOV lanes, preferred parking), but ability to affect auto occupancy globally or within the FGE/LSB corridor is unproven
- GTA transportation planning exercises (Metrolinx TMP) have assumed 4% global reductions post-modelling for this factor. While this suggests there may be some room GTA wide, we will not make adjustment for this to/from the study area.

Reduction:

- None recommended

4.3.5.4 Peak Spreading

As demand for transportation facilities increases over the long term, there comes a point when the peak hour or peak period becomes fully saturated – signified by consistent daily congestion and queuing levels; there is quite simply no remaining capacity despite increases in demand. This causes a phenomenon known as 'peak spreading' where the excess demand for the peak hour or period has no choice but to arrive earlier or depart later (or is simply delayed longer). The demand is therefore spread out to the 'shoulders' of the peak, which gradually lengthens from the traditional 'rush hour' to a longer multi-hour period. This concept can also be applied to reduce the sharpest peak demand for transportation facilities, thereby reducing the 'shock' period where the system is overwhelmed and congestion forms. If that demand can be smoothed out over a longer period, the system is more able to respond and accommodate travelers without significant delay.

Potential data sources:

- Permanent count station data / cordon count data (for baseline);
- TTS data (discretionary vs. work trips);
- EMME modeling.

Considerations:

- How much capacity is available in the shoulders of peak hour? Peak hour volumes on major corridors are experienced for nearly entire duration of AM and PM peak periods (EMME model assumes 3-hour peak periods);
- How much capacity is available in the off-peak? (mid-day; mid-evening);
- What is the tolerance for users to shift to other times? There is already evidence that this is occurring (anecdotal; hourly traffic profiles); is there more willingness to spread trips further? Impact on scheduling (meetings / work), convenience (start or end trip at intolerable time). Shift high-tolerance users first to make room for low-tolerance users;
- The Paramics model and analysis was limited to one peak hour;

- Gardiner Attitudinal survey: 14% of drivers said that it was likely or somewhat likely that they would make the trip at a different time, if congestion increased in the corridor. This was the second highest response (after choosing an alternate route at 24%);
- The EMME model includes an auto peak period to peak hour factor of 0.405 and a similar transit factor of 0.55. This suggests there is room to shift within the peak period, as a fully balanced peak period factor would be 0.333;
- Shifting trips outside the peak period to mid-day or the weekend would be over and above shifts within the peak period.

Approach:

Examine trends and available data and estimate. A global adjustment within Paramics was required.

Outcome:

Post-modelling adjustment was required:

- Capacity of the system is a hard cap and will ultimately restrict the volume served in the peak hour;
- Demand that is above capacity will be forced out of the commuter peak hour into shoulders (i.e., the hours before and after the peak hour) – this despite the fact that the volume served in shoulders is also approaching capacity;
- If the hours immediately before and after the peak hour are also nearly saturated, there may be some further spreading of demand outside the conventional three-hour peak period;
- Gardiner Attitudinal survey: 14% of drivers said that it was likely or somewhat likely that they would make the trip at a different time, if congestion increased in the corridor;
- GTA transportation planning exercises (Metrolinx TMP) have not included post-modelling reductions for this factor. This may be appropriate across the GTA, but, in the capacity constrained downtown, shifting is quite likely.

Reduction:

- 3-7% reduction in auto trips – global adjustment

4.3.5.5 Origin/Destination Changes

The origin and destination for travellers are not necessarily fixed in both the short and long term; changes to the transportation options or congestion could result in changes to small and large choices for residents (e.g., shopping elsewhere, moving to a new residence).

This could encompass two broad categories:

- Longer-term changes to population and employment locations and O/D pairings (increased downtown population and employment enabling increased non-auto commuting; residents move to opposite side of the city to avoid having to commute crosstown).
- Shorter-term decisions on discretionary trips (e.g., shopping, entertainment):
  - Trips made to a different generator (e.g., shopping more locally instead of downtown or crosstown);
  - Trip purpose fulfilled at a different location that eliminates the need to travel through the congested area.

Data sources:

- Baseline conditions – TTS; Bluetooth; EMME select link analysis;
- EMME modeling (EMME model is AM – fewer discretionary trips than during the PM or on weekends);
- TTS: number of auto trips to PD1 by type and by PD; number of auto trips by PD1 residents (dot density map) by non-work trip type – AM and overall;
- Kings Travel Survey: 11% of AM peak period trips appear to be discretionary (all modes).

Considerations:

Longer-term O/D pattern changes

- Would be less feasible for households where there are two people commuting to opposite sides of the city.
- Longer-term change – you would keep it in mind as a factor if you were planning to move or take a job, but it is not applicable if you are remaining in your current residence / place of employment for the foreseeable future. In the first instance you can avoid impact if desired, but in the second instance you would be impacted.
- The change could start to happen before the capacity reduction takes effect. If the City announced tomorrow that the Gardiner was to be removed, any subsequent decisions by individuals would take those plans into consideration even though the actual road network change would not have occurred yet.
- People already choose to live and work in certain places in part because they can travel on the subway or the GO train, or because they can use 400-series highways.
- 2008 Kings Travel Survey reveals an increasing trend toward live-work downtown (59% of Kings residents worked in PD1 in 2001, vs. 66% in 2008).

Shorter-term discretionary trip changes

- Could have a variety of impacts:
  - Trips currently made to downtown are instead made to similar facilities outside downtown;

- Trips currently made from downtown to facilities outside downtown are instead made to more local facilities;
- Trips currently made to facilities on the opposite side of the city (e.g., east end residents shopping at Sherway Gardens) are subsequently made more locally to avoid traveling through downtown;
- Trip purpose is fulfilled electronically (e.g., internet shopping).

- Generally easier to make this change as the trip itself is more transient, although some destinations are not available elsewhere (e.g., ferry to islands, major attractions etc.).

Approach:

EMME model captures the longer-term O/D changes based on current trip distribution stage in the model (Gravity model). This included considerations on the sensitivity to other trip-making behaviour. For discretionary trips, the available information was assessed to determine the feasibility of adjustment in Paramics. Consideration was given to whether this should be targeted to gateway study area zones.

Outcome:

- EMME model establishes broad relationships between Origin and Destination pairs and makes broad assignments of trips to corridors based on system performance and travel times;
- There is some question as to whether or not the EMME model sufficiently accounts for the increasing number of people who both live and work downtown – a relationship that promotes transit, cycling, and walking as preferred modes of travel;
- It was initially assumed for this exercise that EMME sufficiently accounts for this phenomenon;
- Subsequent review of EMME output indicates that O/D pairings do not appear to change substantially between 2031 Maintain and 2031 Remove (only the specific route choices between those zones). As the EMME model showed insensitivity to for different O/D choices under Remove, this may be one area where additional reduction above baseline levels can be justified (but would need to be quantified).

Reduction:

- 0% reduction in auto trips – under the assumption that this is handled by the EMME model
- Additional reduction may be justifiable under Remove. This may be offset by other mode choice behaviour.

4.3.5.6 Trip Reduction

This covers a situation in which fewer total trips are made within the study area due to external factors. The frequency of trip-making might be reduced due to alternate work arrangements such as telecommuting, conference calling for business travel, or a compressed work week.

Considerations:

- There has been a shift toward increasing telecommuting/teleconferencing with recent technological changes. While there is a significant amount of this already occurring today, there is still a potential for further increases. Though, there may come a time when this reduction will max out (similar to other online phenomena such as e-commerce.).
- How much is occurring now? How much more can realistically occur?
- 2006 commuter survey:
  - Of motorists that expressed willingness to switch from auto at least one day a week (unknown %), 44% expressed a willingness to telework at least one day a week. This statistic may not be directly comparable, since it is on an unknown baseline percentage and applies to all commuters living in Toronto (regardless of O/D pairings).
  - 34% to 45% of respondents (unknown) said that teleworking was "an option" but did not specify how many days per week.
- Apply increase (if any) globally to work trips, perhaps limited to certain employment sectors
- Would any additional work trip reductions occur uniformly throughout the week or would they be weighted toward Monday/Friday? (reduced benefit if still have to accommodate higher traffic Tues-Thurs)
- Would currently unforeseen technological advances make this type of reduction more feasible? (Substantially better than today?) Can we rely on the hope that this type of unknown technological advancement will materialize?

Outcome:

Post-modelling adjustment is required:

- Home-based work is increasing as a percentage of the employment base;
- Teleworking is increasing as the supporting infrastructure improves and the proportion of information-based jobs increases;
- Teleconferencing is an accepted method of business interaction with an increasing trend;
- E-commerce is increasing in popularity, reducing discretionary shopping trips;
- E-learning is increasing in popularity, reducing school-related trips;
- Baby boomers retiring and travelling less as a demographic group;
- GTA transportation planning exercises (Metrolinx TMP, Halton TMP) have assumed between 2.7% and 8% reductions post-modelling for this factor.

Reductions:

- Trip reduction (trips are reduced due to telework, compressed work week, etc.):
  - 2-4% reduction in auto trips – global adjustment

4.3.5.7 Trip Elimination

Discretionary trips (e.g., non-essential shopping, entertainment) can be such that changes in congestion or convenience of the trip can cause the traveller to eliminate the trip altogether or combine it with other trips so that it occurs less frequently.

Data sources:

- TTS, EMME model — discretionary vs. non-discretionary trips;
- Cairns et al list case studies with a wide range of net traffic impacts, but they predominantly refer to the net trip reduction without categorizing into where (if anywhere) the eliminated trips went;
- Some examples:
  - Embarcadero closure: “42% of drivers found alternate routes within six weeks of the earthquake, remainder reduced discretionary trips or switched to transit)”;
  - Central Freeway closure: “A survey mailed to 8,000 drivers whose license plates had been recorded on the freeway prior to the closure revealed that 66% had shifted to another freeway, 11% used city streets for their entire trips, 2.2% switched to public transit, and 2.8% said they no longer made the trip previously made on the freeway. The survey also found that 19.8% of survey respondents stated they made fewer trips since the freeway closure. Most were discretionary trips, such as for recreation.”
- Gardiner Attitudinal survey: 7% of drivers said they would likely not make the trip if congestion increased in the corridor.

Recommendation:

The data are limited in this category, typically documenting the overall reduction and not how it was accommodated. Often “trips not made” are captured by one of the other categories of trip reduction mentioned above. Some trip elimination of discretionary trips is expected, but it is difficult to quantify.

Reductions:
- Trip elimination (trip is completely eliminated):
  - 1-2% reduction in auto trips – global adjustment

4.3.6 Summary

Table 8 summarizes the range of possible travel demand adjustments and how the change could be applied in the context of the project. Section 4.3.7 details how these were applied in the models.

Table 8 – Recommended Post-EMME Modelling Adjustments to Auto Demand Forecasts

Recommended Post-EMME Modelling Adjustments to Auto Demand Forecasts		
Areas for Adjustment to Forecasted Peak Hour Auto Trip Generation	**Magnitude of Adjustment***	**Trip Forecasts Requiring Adjustment**
Trip Reassignment *Trip shifts to alternate route, but not within the FGE/LSB corridor*	0%	Handled by EMME model, no additional change
Mode Shift *Trip occurs, but not as auto driver* • Transit Mode Share increase • Cycling and Walking Mode Share increase	5 - 7% 5 - 7%	Global reduction to Study Area Demand Primarily applied to shorter, internal trips (under 5 km)
Auto Occupancy	0%	No substantive change expected
Peak Spreading *Trip occurs, but not in peak commuter hour/period*	3 - 7%	Global reduction
Trip Redistribution *Origin and/or destination of trip is changed*	0%	Handled by EMME model, no additional change
Trip Reduction *Trips are reduced due to telework, teleconferencing, compressed work week, etc.*	2 - 4%	Global reduction
Trip Elimination *Trip is completely eliminated*	1 - 2%	Global reduction
Overall	**16 - 27%**	
** Note the term "adjustment" in this case refers to reductions to peak hour auto trip generation rate*		

4.3.7 Application of Travel Demand Management Adjustments

Transportation demand for the Gardiner Expressway EA study area was forecasted using output from the City of Toronto's EMME travel demand model, as described above. This presents the best estimate of future transportation demand given the future land uses and socioeconomic conditions forecast for the future.

The EMME model, as with most transportation forecasting models, projects future transportation demand based on real-world observations and trends. Models like these are, by definition, fairly insensitive to future changes in technology, societal norms, and user preference. As such, the forecasts were adjusted in September of 2013 to account for reductions in travel demand via a range of Travel Demand Management (TDM) techniques. These were intended to represent those changes to which the model is not sensitive and give a more reasonable level of transportation demand for the future.

Trips were adjusted at two levels to create two independent demand scenarios. 15% reduction was applied to the Maintain, Improve, and Replace alternatives (as detailed in the main body of the EA report), which each experienced a moderate amount of congestion. The application of this reduction rate was slightly more refined, as described below. The Remove alternative received 25% reduction to account for additional congestion that would induce more commuters to find alternate modes, times, or ways of working. These demand reduction rates are explained further below:

Maintain / Improve / Replace – "15%" Reduction

- 10% for all auto trips;
- 5% reduction for internal trips <5km (i.e., increased transit, walk, and bike trips within the study area).

Remove – "25%" Reduction

- 20% reduction to internal trips, external trips from north and south of the study area;
- 17% reduction for external trips from west of Spadina;
- 5% reduction for internal trips <5km (i.e., increased transit, walk, and bike trips within the study area).

Through application of the transportation demand adjustments as described above, overall automobile trips were reduced from an original 84,000 during the AM peak hour to 70,500 for the 15% Reduction scenario, and 63,000 for the 25% Reduction scenario. Overall, these were equivalent to a 1.5-2% shift in mode share from automobiles to transit.

Through the initial rounds of analysis, it became apparent that, despite the above noted adjustments to transportation demand, there were still facilities in the model that were receiving excessive demand. The microsimulation models showed that at the major stations (DVP southbound, FGE eastbound, and LSB eastbound) as they entered the study area, there was still a significant number of motorists that were unsatisfied at the end of the peak hour and required some alternate treatment.

While the overall reduction in transportation demand was deemed reasonable by the study team and the peer reviewer, it became evident that the application of that demand reduction could be more equitably distributed. It was reasonable to assume that the corridors experiencing the most congestion would necessarily see the highest diversion rates to other routes, modes, times, etc. And conversely to that, it could be argued that the corridors that will not experience significant congestion will see minimal or no diversion. This was not adequately represented in the initial application of demand reduction, which applied a general reduction to all demands in the model with some refinement for short local trips (i.e., potentially bike or walk) and for those from specific cardinal directions. Therefore, the distribution of the travel demand reduction was not distributed equitably.

Given the above, the reductions for TDM were applied more realistically by more closely examining the areas that would be most affected by congestion and likely better served by existing and future transit service. Specifically, the major facilities entering the study area (FGE, DVP, LSB) were the most realistic areas for the reductions in demand to occur.

Dillon examined the results of the December 2013 microsimulation modelling exercise to determine the corridors or areas that were underserved or over-served by the TDM reductions and adjusted the demands at these points to a new equilibrium. For example, if demands at the FGE eastbound entering the study area exceeded the capacity by 1000 vehicles, these 1000 trips would be returned to the greater pool of demand for that area of the model and redistributed to other corridors. In this way, the overall reduction in trip making will not change, but is instead distributed more equitably across the study area. This treatment can be considered relatively equivalent to an equilibrium assignment applied in travel demand modelling (such as in the City's EMME model), but is instead more restrictive on the roadway capacity. Vehicles are denied entry at roads that are over capacity and redistributed to other nearby facilities.

5.0 Alternative Solutions

Four alternative solutions were presented by the City of Toronto for analysis. Each alternative includes all of the planned transportation upgrades to roadways within the study area. The alternative solutions themselves focused on the arrangement and interaction of the Gardiner and Lake Shore Boulevard facilities and can be basically described as follows:

Maintain – This scenario presents a status quo for the Gardiner Expressway and Lake Shore Boulevard within the study area. This represents a new operational baseline for the FGE and LSB facilities, given the future changes in land use, population, employment, and other transportation infrastructure. The basic cross-sections for the FGE and LSB provide three lanes per direction on both facilities, as per existing conditions.

Improve – This scenario presents an improvement of the FGE and LSB facilities within their existing alignments. The FGE is rebuilt as a continuous four-lane cross section (two lanes per direction) within the study area; the LSB is reimagined as two lanes in each direction with left turn lanes at each intersection. This alternative represents an optimisation of the current alignment of the two facilities to ensure they can meet future travel demands, while also improving the public realm conditions in the study area corridor. This represents a removal of one lane of capacity on both facilities.

Replace – This solution realigns the FGE to the north to the rail embankment in an attempt to improve the impacts of the infrastructure via a reduction the swath of land occupied by major transportation infrastructure. The cross sections for the FGE and LSB are similar to those in the Improve option with two lanes per direction on the FGE, and two lanes per direction on the LSB (not including intersection turn lanes). As in the Improve scenario, this represents the removal of a lane of capacity on both facilities.

Remove – This scenario presents a bold change from the current day situation in that the FGE is removed within the study area between Jarvis and the DVP (including the ramps to Logan). This leaves the at-grade LSB with an expanded 8-lane cross section and the existing signalised intersections at major cross streets. This alternative represents an attempt to improve the area via reprioritisation of the space away from automobile-focused infrastructure and remove a visual and physical barrier between the downtown and the waterfront.

Each of the alternative solutions was constructed in the Paramics microsimulation software, optimised within the study area and run to produce representative statistics for the performance measures described in Section 5.0.

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5.1 Performance Measures

This section outlines the transportation system Performance Measures used in the development and evaluation of the Gardiner East Alternative Solutions via the Paramics microsimulation model.

The Alternative Solutions created very different transportation conditions both within the corridor and elsewhere in the Paramics model. The Transportation System Performance Measures were needed to assess, quantify, and evaluate the:

- Ability of the Alternative Solutions to meet the transportation demands in the corridor; and
- Impact of the Alternative Solutions on the performance of rest of the transportation network.

Given the role of the Gardiner Expressway/Lake Shore Boulevard (FGE/LSB) in the City transportation system, it can be expected that each Alternative Solution will potentially impact system performance beyond the FGE/LSB corridor itself. Impacts will likely be more significant locally (i.e., within the Study Area) than regionally, because regional travellers have a broader range of travel options and the study area represents a smaller portion of the total regional trips.

It was deemed appropriate to measure a number of parameters regionally and locally to allow a comparison of Alternative Solutions with appropriate context (e.g., travel time from the north measured as travel time from Victoria Park / Finch and travel time from DVP/Dundas). "Regional" consideration was limited to approximately the City of Toronto boundary, as route and mode choice for longer inter-regional trips (e.g., to/from and within Durham or Halton) will be unaffected.

5.1.1 Local Performance

Local performance was measured in the Paramics microsimulation model for the overall study area, as well as a selection of representative corridors and routes.

The measures of performance that were useful to observe at a study area level included:

- Model Average Trip Time – The average trip time for all vehicles in the model. This provides a simple and understandable metric for comparison across various Alternative Solutions.
- Model Average Speed – The average travel speed for all vehicles in the model. As with model average trip time, this provides a direct and simple comparison across Alternative Solutions.
- Average Speed in Corridor (FGE, LSB) – The average travel speed along the two major study area corridors provides a direct comparison in the areas most likely affected by any modifications.
- Vehicle Distance Travelled / Vehicle Hours of Travel– Two related statistics that calculated the overall distance and hours travelled by vehicles in the model. Consideration of the relative changes of both statistics can be useful in judging the larger effects of the Alternative Solutions. Division of the VDT by the VHT creates the overall Model Average Speed.

Measures of performance at the corridor and route level included:

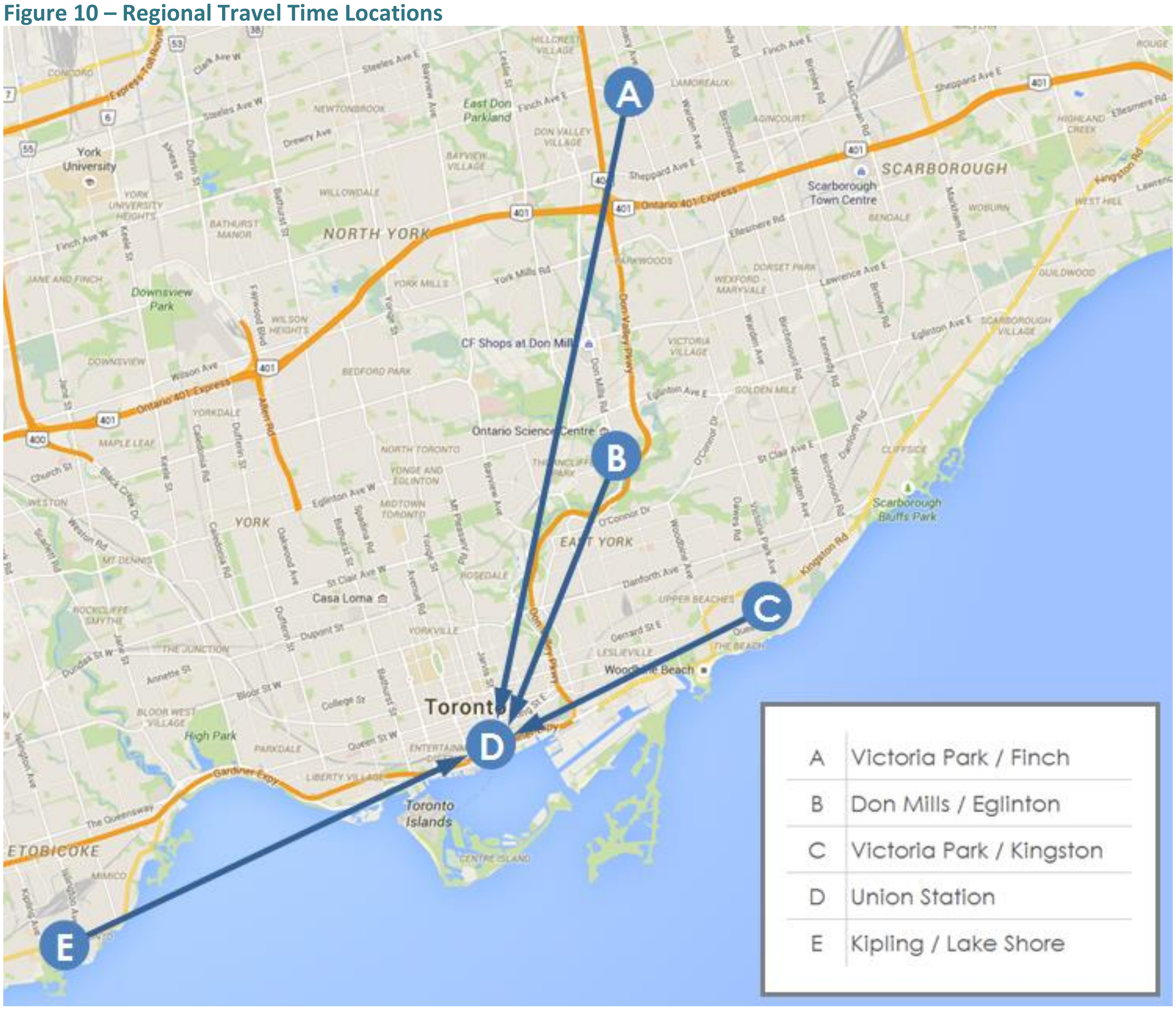
- Origin-Destination Travel Time – This is a measurement of travel time *via any route* between two significant points. As a dense urban area with a traditional gridiron network, there are typically several possible routes between destinations. This was measured in three directions, each with three origin/destination pairs:
    - Inbound (to downtown)
        - Spadina at FGE to Front at Parliament
        - DVP at Dundas to Front at Parliament
        - Queen at Woodbine to Front at Parliament
    - Outbound (from downtown)
        - Front at Parliament to Spadina at FGE
        - Front at Parliament to DVP at Dundas
        - Front at Parliament to Queen at Woodbine
    - Through (passing through downtown)
        - Spadina at FGE to DVP at Dundas
        - DVP at Dundas to Spadina at FGE
- Key Route Travel Time – This is a measurement of travel time *via specific routes* between two significant points. This measure allowed the analysts to observe changes on critical routes due to the modifications for the Alternative Solutions. This was measured in three directions, each with several specific routes:
    - Eastbound
        - Spadina to DVP at LSB (via FGE)
        - Spadina to DVP at LSB (via LSB)
        - Spadina to Front at Parliament (via FGE)
        - Spadina to Front at Parliament (via LSB)
    - Westbound
        - DVP at LSB to Spadina (via FGE)
        - DVP at LSB to Spadina (via LSB)
        - DVP at Dundas to Front at Parliament (via FGE)
        - DVP at Dundas to Front at Parliament (via LSB)
    - Within the study area
        - Jarvis at Dundas to DVP at LSB
        - Richmond at DVP to Richmond at Yonge
        - Adelaide at Yonge to Adelaide at DVP

5.1.2 Regional Performance

As above, changes to the FGE and LSB will have impacts that reach beyond the Paramics study area. Given this, it was necessary to create a methodology to combine the travel times from the regional EMME model with the more detailed outputs from the Paramics microsimulation, which provides a more accurate and nuanced assessment of local travel times than the regional model.

The project team including city staff selected five points to the west, north, and east of the study area to act as representative destinations that allowed for quantification of the changes in each of the cardinal directions. Union Station was selected as a representative downtown location that provides an excellent comparison point against regional transit travel times. Figure 10 shows the selected points.

Figure 10 – Regional Travel Time Locations



It was assumed that the travel time between the major points would not be significantly different in the regional model between the various Alternative Solutions, as the model is inherently not sensitive to localized modifications when examining long distance travel. As well, at the time of the study, the EMME regional model only represented travel during the AM peak period, which required a focus on the inbound trips towards downtown. Therefore, inbound travel times between the five selected points were extracted from the 2031 AM EMME model for use in calculating the travel time for each

Alternative Solution. In addition, the inbound travel time from the edge of the project study area to Union Station (represented by the Bay Street and Front Street intersection) was extracted.

For each Alternative Solution, inbound travel time in the AM peak hour Paramics microsimulation model was also extracted for the major entry points to Union Station.

The final regional travel time was calculated as follows:

Regional Travel Time = EMME Regional Travel Time – EMME Study Area Travel Time + Paramics Study Area Travel Time

The calculated regional travel time provided a consistent base on which to compare the alternatives. These values also provided an important comparison point to judge the impacts on longer commutes from representative areas.

5.2 Initial Findings

Table 9 presents the global outputs of the Paramics microsimulation model runs for the alternative solutions. Existing network performance is included for context. All Alternative Solutions include the travel demand reductions discussed in Section 4.0.

Table 9 – Alternative Solutions General Statistics

Measures of Effectiveness	AM Peak Hour					PM Peak Hour				
	Existing	Maintain	Improve	Replace	Remove	Existing	Maintain	Improve	Replace	Remove
Average Speed in Corridor										
FGE EB*	89.1	94.8	79.7	79.5	33.3	92.6	88.7	44.7	35.9	24.3
FGE WB*	77.7	69.3	80.0	87.7	47.2	72.1	76.8	68.4	65.6	31.9
LSB EB	43.3	43.2	37.4	40.3	37.7	43.3	40.0	36.3	37.1	32.5
LSB WB	40.8	42.0	36.3	35.4	31.1	40.8	42.5	40.6	44.3	37.6
Model Average Trip Time										
Overall	0:04:36	0:04:43	0:05:12	0:05:24	0:05:39	0:04:57	0:05:18	0:05:48	0:05:49	0:06:08
Overall Network Statistics										
Average Speed	30.0	35.4	29.5	28.0	22.8	31.9	30.3	26.1	26.1	21.3
Vehicle Distance Travelled	156,953	189,630	175,231	169,367	159,619	185,359	178,254	171,430	171,539	145,030
Vehicle Hours of Travel	5,227	5,359	5,943	6,045	7,010	5,812	5,880	6,556	6,567	6,816

** Average speed between Don Valley Parkway and Spadina Avenue via FGE. For Remove, this includes some travel at-grade via LSB.*

It can be seen from the table that the Maintain model clearly performs the best of the alternative solutions as initially tested. This is logical as the Maintain scenario provides the most capacity on the FGE and LSB corridors (6 lanes per direction on both facilities) and provides the most auto-focused solution of the four. The Maintain scenario is, in fact, equivalent or better from an auto operations standpoint than the existing condition due to management of the travel demands on the major facilities as they enter the study area.

The Improve and Replace alternatives largely function relatively similarly with a general reduction of performance along the LSB and FGE corridors due to the reduction of the cross sections for both facilities. Performance is reduced when compared to Maintain, but still relatively comparable to the Existing condition.

The Remove alternative was shown to operate the poorest of the four tested alternatives due to its clear focus on providing less primacy to the auto mode during the peak hours. The reduction of the cross-section in the study area to an arterial boulevard with signals is the most dramatic change of any of the tested alternatives, and this is shown clearly in the model outputs with the lowest operating speeds along the major corridors and with the overall network statistics.

Figure 11 to **Figure 14** present the regional travel time results from the four selected regional points to Union Station during the 2031 AM peak hour.

The figures show a clear progression of travel time impacts from Maintain to Improve to Replace to Remove, as the travel time between various origin-destination pairs is seen to increase incrementally from one alternative to the next.

It was important to examine the impacts that the changes to the FGE and LSB within the study area would have to the overall cohort of commuters into the city on a typical weekday morning. The travel times presented simply, as in **Figure 10** above, can belie the impact that the travel times will have, as drivers along the FGE, LSB, and DVP form only a portion of the total commuters. Steady improvements to transit service have seen it eclipse auto travel into and out of the city's downtown core. To better place the results in context of the overall commuting public, the results were stratified into various time groups based on the delay they would experience. This required a number of assumptions, namely:

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Table 10 presents the travel time results from the initial alternative solutions model runs.

The general trends observed above about the overall model operations can be said to apply equally when examining the travel time results: the Maintain scenario performs as well or better than Existing; Improve and Replace are generally equivalent with some minor differences; and, Remove was shown to perform the poorest due to its lack of a free-flow expressway through the study corridor.

Figure 11 to **Figure 14** present the regional travel time results from the four selected regional points to Union Station during the 2031 AM peak hour.

The figures show a clear progression of travel time impacts from Maintain to Improve to Replace to Remove, as the travel time between various origin-destination pairs is seen to increase incrementally from one alternative to the next.

It was important to examine the impacts that the changes to the FGE and LSB within the study area would have to the overall cohort of commuters into the city on a typical weekday morning. The travel times presented simply, as in **Figure 10** above, can belie the impact that the travel times will have, as drivers along the FGE, LSB, and DVP form only a portion of the total commuters. Steady improvements to transit service have seen it eclipse auto travel into and out of the city's downtown core. To better place the results in context of the overall commuting public, the results were stratified into various time groups based on the delay they would experience. This required a number of assumptions, namely:

Table 10 – Alternative Solutions Travel Time Results

Measures of Effectiveness	AM Peak Hour					PM Peak Hour				
	Existing	Maintain	Improve	Replace	Remove	Existing	Maintain	Improve	Replace	Remove
Average Speed (kilometres per hour)	30.0	35.4	29.5	28.0	22.8	31.9	30.3	26.1	26.1	21.3
Origin-Destination Travel Time (average in minutes)										
Inbound (to downtown)										
Spadina @ FGE to Front @ Parliament	0:05:24	0:05:00	0:08:12	0:09:37	0:10:09	0:05:28	0:05:49	0:09:52	0:10:27	0:19:05
DVP @ Dundas to Front @ Parliament	0:06:50	0:05:55	0:06:55	0:08:51	0:09:19	0:03:36	0:03:49	0:03:46	0:04:39	0:09:05
Queen @ Woodbine to Front @ Parliament	0:09:32	0:08:59	0:10:31	0:12:37	0:18:33	0:08:15	0:08:06	0:09:38	0:09:23	0:11:36
Outbound (from downtown)										
Front @ Parliament to Spadina @ FGE	0:04:58	0:05:15	0:06:59	0:07:03	0:07:01	0:10:37	0:11:42	0:15:36	0:10:55	0:13:50
Front @ Parliament to DVP @ Dundas	0:04:54	0:04:58	0:05:10	0:05:40	0:06:27	0:05:48	0:06:48	0:07:10	0:06:44	0:10:44
Front @ Parliament to Queen @ Woodbine	0:10:08	0:10:28	0:10:18	0:11:29	0:11:04	0:11:13	0:11:52	0:13:18	0:12:14	0:15:22
Through										
Spadina @ FGE to DVP @ Dundas	0:05:54	0:05:33	0:07:30	0:06:36	0:12:15	0:05:40	0:05:50	0:08:14	0:09:14	0:21:41
DVP @ Dundas to Spadina @ FGE	0:08:48	0:07:32	0:10:33	0:12:39	0:14:12	0:07:21	0:07:00	0:07:15	0:07:21	0:15:41
Queen @ Woodbine to Spadina @ FGE	0:09:23	0:09:31	0:10:33	0:14:27	0:20:00	0:11:20	0:10:26	0:11:38	0:13:23	0:20:11
Key Route Travel Time (minutes)										
Eastbound										
Spadina to DVP @ LSB via FGE	00:03:11	00:02:53	00:04:59	00:03:16	00:10:22	00:02:58	00:03:10	00:06:10	00:07:35	00:18:20
Spadina to DVP @ LSB via LSB	00:06:27	00:09:31	00:11:58	00:07:35	00:10:22	00:06:18	00:11:45	00:14:40	00:15:12	00:16:56
Spadina to Front @ Parliament via FGE	00:06:00	00:05:17	00:08:38	00:05:48	00:10:20	00:05:11	00:05:42	00:10:16	00:10:56	00:16:56
Spadina to Front @ Parliament via LSB	00:07:40	00:08:28	00:10:53	00:08:33	00:09:18	00:06:57	00:10:36	00:13:30	00:13:42	00:15:11
Westbound										
DVP @ LSB to Spadina via FGE	00:03:31	00:04:02	00:04:36	00:03:35	00:12:41	00:04:35	00:04:07	00:04:22	00:04:06	00:12:10
DVP @ LSB to Spadina via LSB	00:08:15	00:09:57	00:13:26	00:08:15	00:17:14	00:08:15	00:09:29	00:14:58	00:10:11	00:13:41
DVP @ Dundas to Front @ Parliament via FGE	00:05:20	00:05:32	00:09:28	00:11:12	00:11:15	00:04:33	00:04:18	00:06:40	00:06:05	00:10:02
DVP @ Dundas to Front @ Parliament via LSB	00:04:14	00:06:01	00:07:16	00:08:56	00:14:03	00:04:14	00:04:56	00:05:48	00:06:50	00:11:00
Within										
Jarvis @ Dundas to DVP @ LSB	00:06:16	00:08:31	00:08:33	00:08:32	00:09:54	00:08:34	00:10:00	00:13:57	00:12:46	00:11:34
Richmond @ DVP to Richmond @ Yonge	00:03:34	00:04:42	00:04:51	00:08:23	00:08:04	00:03:24	00:03:49	00:04:18	00:04:15	00:05:26
Adelaide @ Yonge to Adelaide @ DVP	00:03:13	00:03:16	00:03:23	00:03:34	00:03:54	00:03:33	00:04:01	00:04:11	00:04:15	00:04:10

Figure 11 – Inbound Travel Time – 2031 AM – Maintain

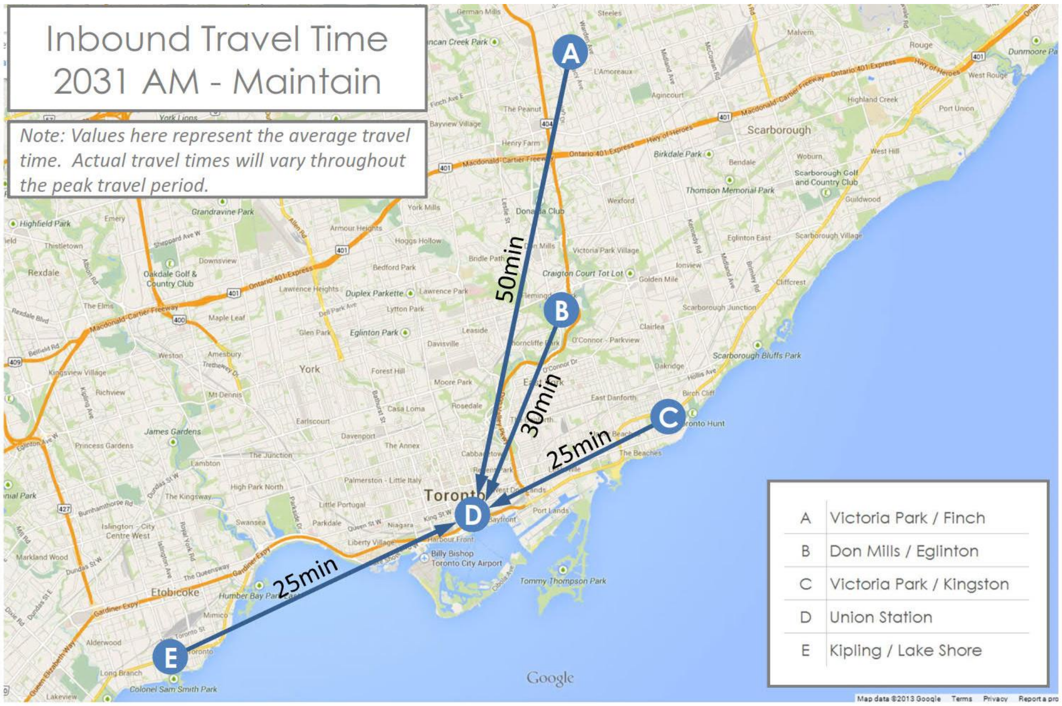


Figure 12 – Inbound Travel Time – 2031 AM - Improve

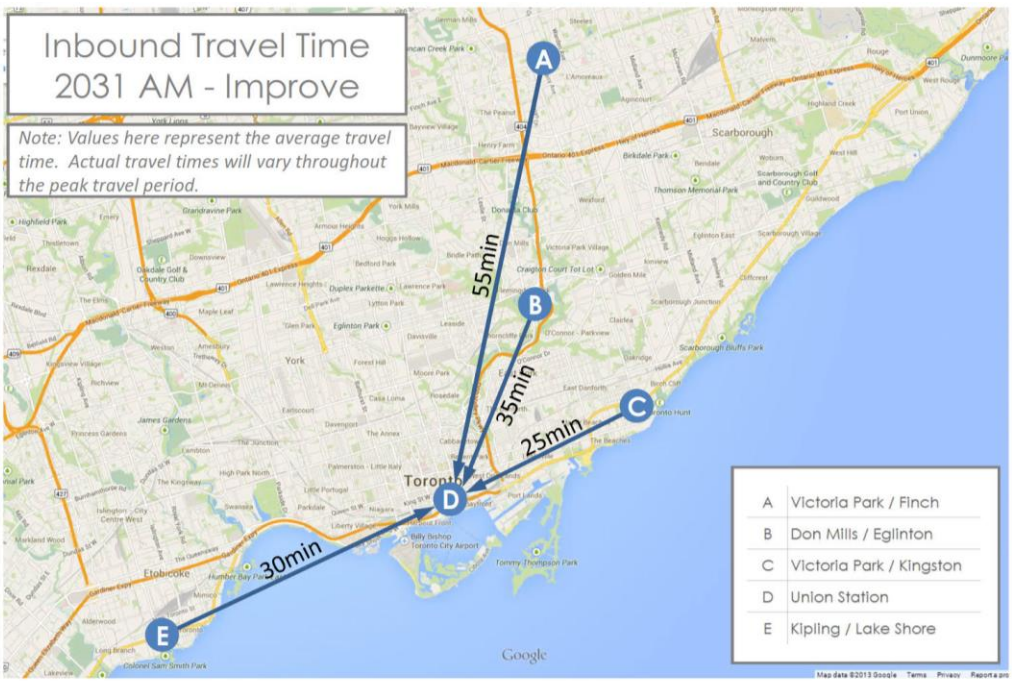


Figure 13 – Inbound Travel Time – 2031 AM - Replace

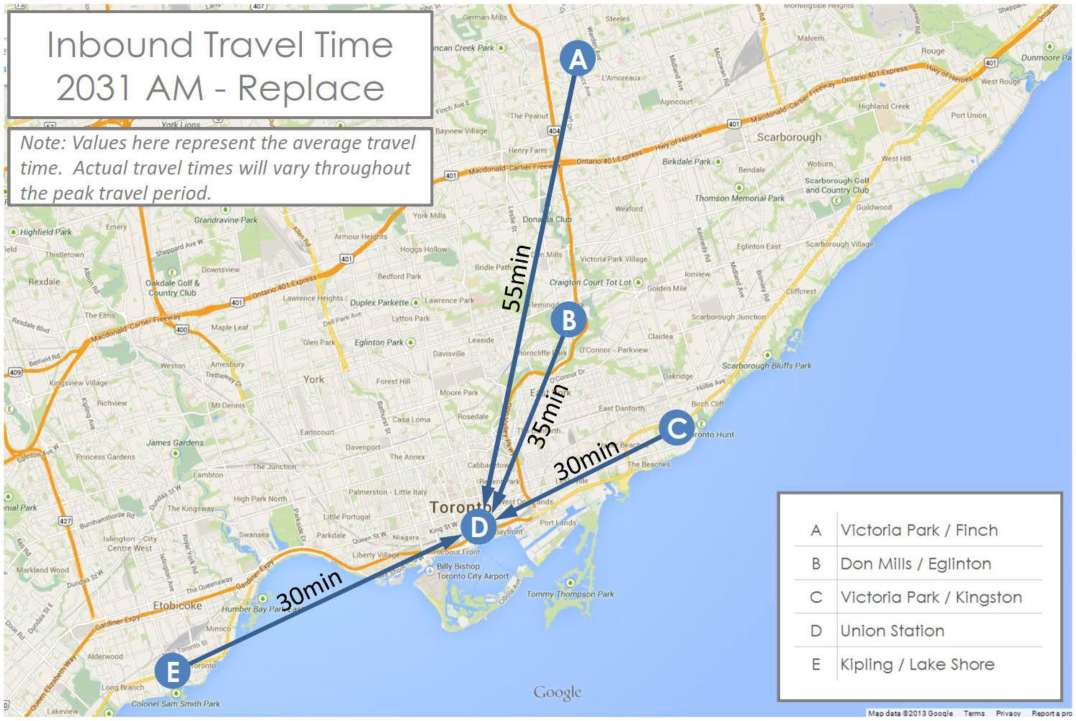
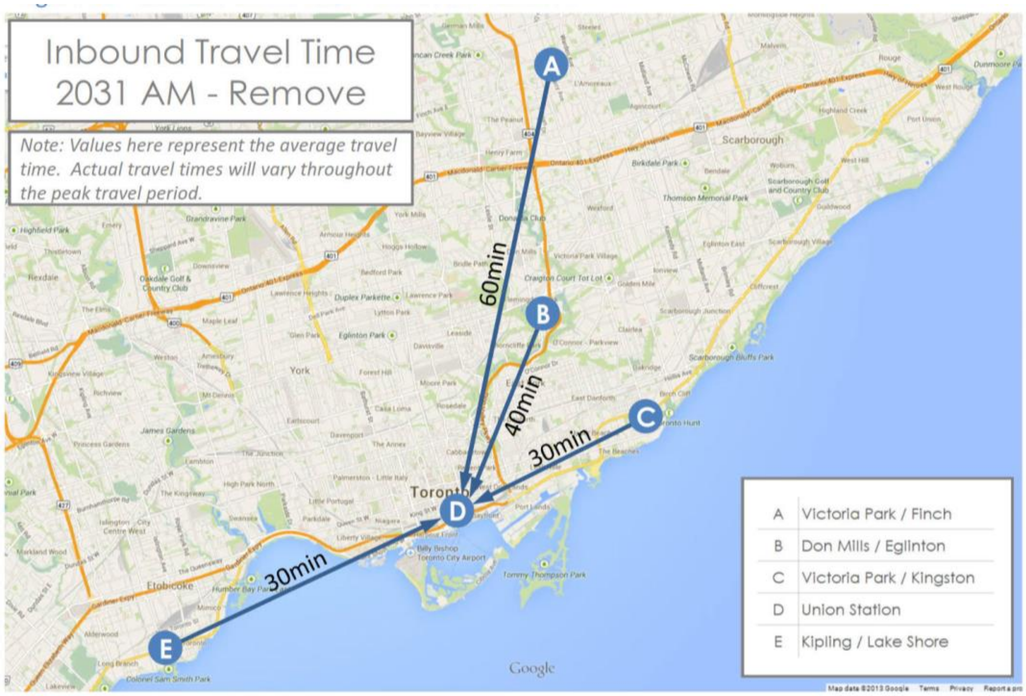


Figure 14 – Inbound Travel Time – 2031 AM - Remove



- 2011 City of Toronto Cordon Count data indicates that there are currently 157,000 AM Peak Hour commuters inbound to downtown Toronto (across the Central Cordon). This number may increase by 2031, but 157,000 was used for the purposes of this discussion.

- Approximately 40,000 of these AM Peak hour inbound trips are auto person trips, translating to approximately 35,000 vehicles for the AM Peak hour inbound. Note that this is approximately 25% of all inbound commuter trips. The remaining 75% of trips (mainly transit) will be largely unaffected by changes to the level of congestion in the auto network.

Comparing Improve, Replace, and Remove to Maintain, the implications of the Alternative Solutions on travel time are shown in

Table 11. The table presents the change in travel time for all travellers within the study area (i.e., not solely the 35,000 vehicle trips entering from the external areas) when compared to the Maintain condition – the new future baseline. (Note that the total volume assigned under Remove is lower than the other Alternative Solutions due to more aggressive travel demand management reductions, as described in Section 4.3.7.)

Table 11 – Change in Travel Time for FGE Alternatives Compared to Maintain

Change in Travel Time for FGE Alternatives Compared to Maintain (considers all vehicles assigned by Paramics model to any route in any direction)							
Magnitude of Impact Alternative vs Maintain		**Improve**		**Replace**		**Remove**	
		%	**Vph**	**%**	**vph**	**%**	**vph**
No change	Less than 2 min	85%	59,500	80%	57,000	75%	48,000
Minor Impact	2 min-7 min	15%	11,000	20%	13,500	20%	12,500
Noticeable Impact	More than 7 min					5%	2,500
Total Volume Assigned ***Note additional auto demand reduction under Remove Scenario due to TDM means that % shown are based on lower total auto volume***			70,500		70,500		63,000

The following conclusions can be drawn from the table:

Improve	• 93% of all inbound travellers are unaffected; (146k/157k) • 7% of all inbound travellers are impacted by 7 minutes or less (11k/157k)
Replace	• 91.5% of all inbound travellers are unaffected; (143.5k/157k) • 8.5% of all inbound travellers are impacted by 7 minutes or less (13.5k/157k)
Remove	• 90.5% of all inbound travellers are unaffected; (142k/157k)

	• 8.0% of all inbound travellers are impacted by 7 minutes or less; (12.5k/157k) • 1.5% of all inbound travellers are impacted by more than 7 minutes (2.5k/157k)

The above analysis shows that the impacts of the changes to the FGE and LSB, no matter for which alternative, will be minor in comparison to the total pool of commuters. The relative ranking of the alternatives for their impact is in line with previous analyses: Maintain, Improve, Replace, and Remove.

It should be noted that only the Remove scenario showed significant impact to travel times to any traveller in the system. This was restricted to only 1.5% of all travellers entering the downtown area in the 2031 AM peak hour. This means that 98.5% of travellers will not be significantly affected by the changes of the Remove options.

5.3 Boulevard Optimisation and Hybrid Development

After careful consideration of the initial model results, in response to direction from City Public Works and Infrastructure Committee (PWIC) the Project team undertook an exercise to determine if the additional auto travel time associated with the Remove alternative could be reduced. In undertaking this exercise, meetings and workshops were held that included staff from Waterfront Toronto, City of Toronto, Dillon, and Sam Schwartz Engineering to examine possible modifications to the Remove alternative that would reduce its impact on the auto-driving public. Also, during this period, the Remove alternative was renamed “Boulevard” to better describe the alternative (the creation of a new at-grade roadway or boulevard).

In addition to the optimization of the Remove alternative, at the request PWIC the Project Team also developed a Hybrid alternative that involved the removal of the Logan off-ramps and keeping a continuous freeway connection between the DVP and the Gardiner.

5.3.1 Boulevard Optimization

Optimisation of the Boulevard concept was a multi-stage process that involved feedback between the Gardiner Expressway microsimulation model (Paramics) and an operations analysis model (Synchro) of the core study area to examine options and provide precise optimisation for the traffic controls in the area. The Synchro analysis focused solely on the optimisation of the traffic controls along Lake Shore Boulevard, as it is not capable of modelling the behaviour on the FGE and its associated ramps.

The steps in the process to optimize the Boulevard alternative were as follows:

Model Construction in Paramics

Physical modifications required by the individual designs were implemented in the Paramics model to create new Boulevard and Hybrid models. Both the Boulevard and Hybrid models used the Maintain condition as their base.

Initial Paramics Model Run and Visual Optimisation

The constructed models were run in Paramics to create an initial set of turning movement volumes for use in the Synchro optimisation of traffic controls. This involved a light visual optimisation in Paramics to ensure that the assigned volumes were reasonably close to their final state.

Detailed Optimisation and Lane Allocation

The turning movement volumes from Paramics were applied in Synchro models of the two alternatives to optimise the timing and coordination of traffic signals in the core study area. Intersections were studied in detail as to their function and relation to surrounding intersections. Where necessary, lane allocations at intersections were repurposed – adding and subtracting movements or lanes dependent on the needs shown by the volumes. The final timing plans were then imported into Paramics.

Final Paramics Adjustments and Model Runs

With the optimised Synchro signal timings in place in the Paramics model, several runs were observed and signal inputs tweaked as necessary to ensure proper flow in the simulation. Some adjustments are typically required when passing information between a static model such as Synchro and simulation software such as Paramics, as the vehicle dynamics, lane changing and other factors that are present in simulation are not evident in Synchro. Following the adjustments, full model runs were performed for both alternatives and model statistics were extracted for analysis.

Table 12 describes the changes made to the Boulevard model throughout the optimisation process.

Table 12 – Boulevard Optimisation Elements By Location

Item	Original Boulevard model	Optimized Boulevard model
Gardiner cross-section		
Eastbound lanes	- 2 eastbound lanes between York–Bay–Yonge off-ramp and base of ramp to Lake Shore Boulevard (not including merging lane from Rees on-ramp) - Eastbound left turn lane at Jarvis Street is added to the left of the 2 Gardiner lanes	- 3 eastbound lanes between Rees on-ramp and base of ramp to Lake Shore Boulevard - Leftmost (inside) of the 3 Gardiner lanes becomes the eastbound left turn lane at Jarvis Street
Westbound lanes	- 2 westbound lanes at base of ramp from Lake Shore Boulevard; widens to 3 westbound lanes at the top of the ramp - Lake Shore / Gardiner split occurs one block west of Jarvis Street (2 lanes to Lake Shore; 2 lanes to Gardiner)	- 3 westbound lanes at base of ramp from Lake Shore Boulevard - Lake Shore / Gardiner split occurs on west side of Jarvis Street intersection (2 lanes to Gardiner; 1 lane to Lake Shore; 1 shared lane to both)
Lake Shore / Simcoe		
Signal phasing	- Eastbound Lake Shore and Gardiner off-ramp traffic proceeds on same	- Eastbound Lake Shore and Gardiner off-ramp traffic given separate green

Item	Original Boulevard model	Optimized Boulevard model
	green signal; requires weaving within short block between Simcoe and York	signals to minimize the need for weaving east of Simcoe
Harbour / York		
Eastbound approach lane configuration	- L – T – T – TR	- L – L – T – TR - Dual left turn lane created by converting one of the through lanes - Dedicated eastbound left turn phase required
Harbour / Bay		
Eastbound approach lane configuration	- L – T – TR - Two through lanes on west side of intersection; 3 lanes east of intersection	- L – T – T – TR - Matches pavement width identified in York–Bay–Yonge Interchange ESR - 3 through lanes on west and east sides of intersection
Lake Shore / Jarvis		
Signal operations	- Eastbound and westbound proceed independently (split phasing)	- Eastbound and westbound proceed concurrently, with separate left turn phases
Southbound approach lane configuration	- L – TR (right turns from through lane)	- L – T – R - Curb lane through rail underpass becomes right turn lane - Short left turn lane developed south of rail underpass
Westbound approach lane configuration	- 4 through lanes plus left turn lane	- Added westbound right turn lane
Lake Shore / Sherbourne		
Southbound approach lane configuration	- L – TR (right turns from through lane)	- L – T – R (short left and right turn lanes developed south of rail underpass)
Lake Shore / Parliament		
Southbound approach lane configuration	- L – TR - Inside lane through rail underpass becomes left turn lane - Right turns made from through lane	- L – T – R - Curb lane through rail underpass becomes right turn lane - Short left turn lane developed south of rail underpass
Southbound approach lane configuration	- L – TR (right turns from through lane)	- L – T – R (add dedicated right turn lane)
Lake Shore / Cherry		
Streetcar signal operations	- Short dedicated transit phase after end of east-west green	- Streetcars proceed during main north-south green signal - Dedicated transit phase eliminated - Northbound right turns and southbound left turns prohibited to eliminate conflict with streetcars

Item	Original Boulevard model	Optimized Boulevard model
Queens Quay East		
Easterly extension	- Queens Quay extended from Parliament Street to Cherry Street	- Queens Quay extended further from Cherry Street to Lake Shore Boulevard - New east leg at Cherry Street intersection - New signalized intersection at Lake Shore Boulevard between DVP ramps and Don Roadway
Lake Shore / Don Roadway		
Eastbound lane configuration	- 2 through lanes	- Third through lane added; begins at west end of Don River bridge
Northbound and southbound lane configuration	- L – TR - Right turns made from through lane	- L – T – R - Added exclusive right turn lanes)
Left turn phases	- Eastbound and westbound left turn phases	- Eastbound and northbound left turn phases
Port Lands		
Intersections between Don Roadway and Carlaw	- One signalized intersection (Bouchette)	- Two signalized intersections (Saulter; Logan)

5.3.2 Hybrid Development

Considering the study area constraints and the input received from the public and various stakeholders, three Hybrid alternative designs were developed and carried forward into an evaluation. The process to develop the Hybrid alternatives and illustrative plans showing the hybrids are presented in Section 5.2 of the EA Report. The following provides a summary of the developed Hybrids.

All three Hybrid alternative designs build upon the Hybrid Preferred Solution endorsed by Toronto City Council in June 2015. In particular, all three Hybrid designs include:

- Preservation of continuous Gardiner-DVP freeway linkage, with nominal to zero impact on road capacity and travel times;
- Removal of the existing Logan on/off ramps and a replacement of these access ramps with new ramps to be placed in the Keating Channel Precinct;
- Re-alignment of Lake Shore Boulevard through the Keating Channel Precinct;
- Full compatibility with planned rehabilitation of the elevated Gardiner Expressway west of Cherry Street; and
- The extension of a multi-use pathway along the north side of Lake Shore Boulevard that connect with a planned new pathway east of Cherry Street and the existing pathways that runs up the Don Valley and east of the Don River.

The key design elements of each of the three Hybrid alternatives (Hybrids 1, 2 and 3) are described below.

Hybrid Design Alternative 1

- Remove Logan ramps that fly over and to the east of the Don River;
- Maintain the existing Gardiner Expressway through the Keating Channel Precinct along the north edge of the Keating Channel;
- Construct new two-lane westbound on and eastbound off Lake Shore Boulevard-Gardiner ramp connections east of Cherry Street;
- Construct new approach roads to provide connection to the new on/off Gardiner ramps that run under or beside the elevated Gardiner along the north side of the Keating Channel; and,
- Construct a new Lake Shore Boulevard alignment that runs mid-block through the Keating Channel Precinct.

Hybrid Design Alternative 2

- Remove Logan ramps that fly over and extend to the east of the Don River;
- Remove the existing DVP-Gardiner connection and rebuild it to run through the Keating Channel Precinct further north (than Hybrid 1), away from the Keating Channel edge, constructing new "tighter" (130 m radius) ramp connections to the Don Valley Parkway with a lowered speed limit (radius for existing ramps is approximately 375m);
- Construct new westbound on and eastbound off (both 2 lanes) Lake Shore Boulevard-Gardiner ramp connections east of Cherry Street that would connect with a planned Munition Street extension; and,
- Construct a new Lake Shore Boulevard alignment that runs mid-block through the Keating Channel Precinct.

Hybrid Design Alternative 3

- Remove Logan ramps that fly over and extend to the east of the Don River;
- Remove the existing DVP-Gardiner connection and rebuild it to run through the Keating Channel Precinct further north (than Hybrid 2) closer to the rail corridor, and construct a new "tighter" (130 m radius) ramp connection to the Don Valley Parkway with a lowered speed limit;
- Widen Metrolinx Don River/DVP Rail Bridge underpass to the east to allow for a more northern DVP-Gardiner ramp location;
- Construct new two-lane Lake Shore Boulevard-Gardiner ramp westbound on and eastbound off connections east of Cherry Street; and,
- Construct a new Lake Shore Boulevard alignment that runs mid-block through the Keating Channel Precinct.

Lake Shore Boulevard Alignments

The proposed mid-Keating Channel Precinct alignment for Lake Shore Boulevard that is associated with each of the Hybrid alternatives is consistent with the alignment that is proposed under the City approved Keating Channel Precinct Plan. As part of this EA study, an alternative alignment for Lake

Shore Boulevard was explored that involved a "straightened" alignment through the Precinct that would also involve a more northern crossing of the Don River. This alignment was considered to have some urban design benefits. However, it was determined that this alternate alignment would need to pass through a portion of the planned Don River Sediment Management Facility. This alternate Lake Shore Boulevard alignment was reviewed with the TRCA and they indicated the sediment management facility would require significant redesign with this alignment and were uncertain if it could be accommodated. Further, with the straightened Lake Shore Boulevard alignment, the Lake Shore Boulevard/Don Roadway intersection would require a skewed intersection design which is not ideal. As a result, this alternative Lake Shore Boulevard alignment was not explored further in the EA study

5.4 Boulevard and Hybrid Analysis

Testing of the Boulevard and Hybrid solutions occurred over several iterations, as the options were refined and examined to find the best solution.

Table 13 and *** Average** *speed between Don Valley Parkway and Spadina Avenue via FGE. For Boulevard, this includes some travel at-grade via LSB.*

Table 14 show the results from the final set of options that compare the original Maintain results with the optimised Boulevard and the Hybrid solution.

Table 13 – Boulevard and Hybrid – General Statistics

	AM Peak Hour		
Measures of Effectiveness	Maintain	Boulevard	Hybrid
Average Speed in Corridor (km/h)			
FGE EB *	94.8	24.8	93.3
FGE WB *	69.3	92.7	73.7
LSB EB	43.2	36.2	37.1
LSB WB	42.0	31.5	32.6
Model Average Trip Time (h:mm:ss)			
Overall	0:04:43	0:05:51	0:05:11
Overall Network Statistics			
Average Speed (km/h)	28.8	24.0	31.4
Vehicle Distance Travelled (km)	154,580	164,875	185,637
Vehicle Hours of Travel (hours)	5,359	6,856	5,914
Unmet demand at major stations (veh)			
FGE EB	0	343	0
LSB EB	0	201	0
DVP SB	198	223	25

** Average speed between Don Valley Parkway and Spadina Avenue via FGE. For Boulevard, this includes some travel at-grade via LSB.*

Table 14 – Boulevard and Hybrid – Travel Times

Measures of Effectiveness	AM Peak Hour		
	Maintain (Dec 2013)	Boulevard (March 10, 2015)	Hybrid (March 10, 2015)
Average Speed (kilometres per hour)	28.8	24.0	31.4
Origin-Destination Travel Time (h:mm:ss)			
Inbound (to downtown)			
Spadina @ FGE to Front @ Parliament	0:05:00	0:08:26	0:07:11
DVP @ Dundas to Front @ Parliament	0:05:55	0:07:52	0:06:12
Queen @ Woodbine to Front @ Parliament	0:08:59	0:11:47	0:09:44
Outbound (from downtown)			
Front @ Parliament to Spadina @ FGE	0:05:15	0:06:02	0:05:20
Front @ Parliament to DVP @ Dundas	0:04:58	0:05:35	0:05:02
Front @ Parliament to Queen @ Woodbine	0:10:28	0:10:37	0:10:24
Through			
Spadina @ FGE to DVP @ Dundas	0:05:33	0:12:04	0:05:47
DVP @ Dundas to Spadina @ FGE	0:07:32	0:11:26	0:07:06
Queen @ Woodbine to Spadina @ FGE	0:09:31	0:16:13	0:13:41
Key Route Travel Time (h:mm:ss)			
Eastbound			
Spadina to DVP @ LSB via FGE	0:02:53	0:09:41	0:02:50
Spadina to DVP @ LSB via LSB	0:09:31	0:14:09	0:11:34
Spadina to Front @ Parliament via FGE	0:05:17	0:11:57	0:07:28
Spadina to Front @ Parliament via LSB	0:08:28	0:12:50	0:11:00
Westbound			
DVP @ LSB to Spadina via FGE	0:04:02	0:09:36	0:03:48
DVP @ LSB to Spadina via LSB	0:09:57	0:14:05	0:11:03
DVP @ Dundas to Front @ Parliament via FGE	0:05:32	0:09:58	0:06:30
DVP @ Dundas to Front @ Parliament via LSB	0:06:01	0:11:06	0:06:28
Within			
Jarvis @ Dundas to DVP @ LSB	0:08:31	0:12:50	0:09:12
Richmond @ DVP to Richmond @ Yonge	0:04:42	0:09:07	0:05:54
Adelaide @ Yonge to Adelaide @ DVP	0:03:16	0:03:43	0:03:41

It can be seen from the tables that the optimised Hybrid model operates the best overall, with an average speed of 31.4 km/h, which exceeds the Maintain condition. The Hybrid solution essentially takes the Maintain geometry and tweaks it to meet future demands more appropriately than the existing geometry. As an expressway-focused solution, the Hybrid attempts to maximise the number of vehicles able to reach Downtown Toronto via fast-moving expressways. The Boulevard solution, naturally, operates slower overall, as it removes the expressway options, and re-prioritizes more of the urban space for pedestrians and cyclists.

5.5 Consolidated and Viaduct Solutions Assessment

This document presents a qualitative review of the transportation implications from two independently submitted alternatives for the Gardiner Expressway (FGE) and Lake Shore Boulevard (LSB) between the Don Valley Parkway (DVP) and Yonge Street. These included:

Consolidated – The Consolidated or Green Gardiner design presents an elevated FGE with a general six-lane cross section that provides connections at Yonge Street and LSB near Cherry. Ramps in between these two end points have been removed. The alignment of the Gardiner Expressway has generally been shifted to the north of LSB and above the existing rail corridor. LSB has a typical running cross-section of six lanes with additional turning lanes where necessary.

Viaduct – Under the Viaduct option, the FGE and LSB corridors are more intimately connected. This maintains the largely upstairs/downstairs approach that is characteristic of much of the corridor in this study area, where the upstairs expressway (FGE) provides most of the mobility and the downstairs arterial provides most of the access. The FGE maintains a six-lane cross-section between the DVP and Yonge Street, whereas the LSB carries a four-lane cross-section with additional turning lanes where necessary.

Both designs provide a 60 km/h design speed ramp connection between the DVP and FGE, which is significantly slower than existing conditions. In addition, both designs have a connection to LSB near Cherry Street that brings the LSB on in the westbound direction via the inner lanes. And similarly in the opposite direction, the eastbound FGE allows motorists to connect with LSB via the inner lanes near Cherry Street.

5.5.1 Approach

The investigation of the Consolidated and Viaduct designs was performed by examining three aspects important to transportation infrastructure: Mobility, Access, and Safety.

Mobility and Access are two generally opposing but intimately related terms. Mobility is a measure of the speed and convenience of travel that often involves a maximisation of speed and minimisation of diversion points. Access, on the other hand, trades speed and movement for convenient access to destinations and alternative routes. Both Mobility and Access trade in *convenience* – speed and simplicity over longer distances versus options and interaction. Shifting the balance of Mobility and Access on a facility defines its purpose and perception to travellers. The extreme end of Mobility is the access-controlled rural freeway, with its long, straight, and gently curving sections of fast road that feature interchanges with smaller routes only occasionally; compare this with the roadway focused on maximising Access, such as the local road with short blocks, stop signs, and crosswalks. There are, of course, a range of facilities that trade off various elements to fill a finer purpose in between the two extremes. The FGE in our study area, for example, is an urban expressway, which provides general freeway geometry (fast, straight) with an increased level of access via more frequent interchanges. And LSB is a typical major arterial – a generally multi-laned facility with signalised intersections at regular intervals focused on moving large numbers of vehicles efficiently through an urban area.

The third element of the investigation was Safety. Though a true investigation of the safety of a facility requires detailed analysis of designs, crash data and other elements, it was possible to perform a high level investigation by examining various design elements and contrasting the two designs.

These three aspects of the review were investigated via two variables: motorised modes and active modes, as the meaning and important elements are different from the two perspectives.

5.5.2 Mobility - Motorised

Mobility for the FGE/LSB corridor is generally a question of how well they provide capacity in a regional sense. Both facilities provide critical access to downtown Toronto by allowing large numbers of vehicles to move long distances between their origin and destination. The number of lanes provided and the number of access points will play directly into the mobility provided in the corridor, as shown **Table 15**.

Table 15 – Consolidated and Viaduct - Number of Lanes per Major Movement

Facility	Direction	Movement	Consolidated	Viaduct
FGE	WESTBOUND	Ramp from DVP	2	2
		Ramp from LSB	2	2
		WB Merge with DVP from LSB	1	2
		WB Merge with LSB from DVP	2	1
		WB between Cherry and Yonge	3	3
		WB Off to Sherbourne	0	1
		WB Off to Yonge	1	2
	EASTBOUND	EB on from Bay	1	1
		EB On from Jarvis	0	1
		EB Between Cherry and Yonge	3	3
		Ramp to DVP	2	2
		Ramp to LSB	2	2
LSB	WESTBOUND	East of Don	3	3
		Don to Munitions	3	3
		Munitions to Cherry	2	2

Facility	Direction	Movement	Consolidated	Viaduct
		Cherry to Yonge	3	2
	EASTBOUND	Yonge to Cherry	3	2
		Cherry to Munitions	2	2
		Munitions to Don	4	4
		East of Don Roadway	3	3

Looking at the overall cross-section of the two facilities, both present a reduction when compared to existing conditions in this section and the current design for the Hybrid alternative. The FGE has been reduced to three lanes in each direction in the vicinity of the LSB/DVP ramps (currently four westbound lanes from DVP to Sherbourne and four eastbound lanes per direction from Parliament to DVP). This is a reduction in mobility, as the capacity for movement at higher speeds is reduced.

This reduction to three lanes in the westbound direction means that a design decision is required where the ramps from the southbound DVP and westbound LSB come together. The confluence of four lanes from the two facilities into the three lane cross-section requires that one of the approaches is necked down to a single lane prior to merging together. The choice on which approach to reduce is an indicator as to which flow is more important to the design.

In the current iteration of the designs, the Viaduct reduces the ramp from the DVP to a single lane, whereas the Consolidated reduces the LSB ramp to a single lane. The design choice in the Viaduct design indicates that the flow from the DVP is of lower priority than that from LSB. This reduces the utility of the downstream off-ramps at Sherbourne and Yonge by limiting the number of vehicles moving from DVP to FGE and encouraging traffic from LSB. As the primary purpose for the FGE in this corridor is to provide access to downtown, this is not an ideal choice for the confluence. This decision places more pressure on the upstream off-ramp from DVP to Richmond by limiting capacity for vehicles to exit to the FGE and does not provide significant new options for LSB traffic, which can remain on LSB and still access the cross streets. This has a negative impact on mobility.

The Consolidated design currently applies the opposite decision, where the approach from LSB is limited to a single lane. This places priority on the southbound DVP vehicles looking to travel to Yonge Street or further west. The removal of the Sherbourne off ramp and reduction of the Yonge Street off-ramp to a single lane, limits the options for those same southbound DVP commuters, despite the maintenance of capacity between the two facilities. The design is signalling that the FGE should perform more of a through function (i.e., increase mobility) instead of provide access to downtown. Similar to Viaduct, these design decisions place pressure on the Richmond off-ramp and, additionally for Consolidated, the Yonge Street off-ramp. Demands under existing conditions and future forecasts already show the Richmond ramp to be well over capacity. The reduced capacity for the Yonge Street ramp will be an issue here as it must now accommodate demands for the Sherbourne off-ramp and those existing for a two-lane off-ramp at Yonge Street. This will have a negative effect on mobility in Consolidated.

The cross-section for LSB differs between the two designs, where the Consolidated design provides three lanes per direction between Yonge and Cherry and the Viaduct provides only two. In absolute terms simply looking at number of lanes, the mobility will be greater under Consolidated than under Viaduct. However, the above discussion on the removal of the ramp to Sherbourne, as well as the EB on ramp from Jarvis, will play into mobility here as the number of options for drivers has been reduced and volumes on LSB will likely increase. Viaduct's reduced cross-section is also not likely to be sufficient for future demands along LSB. It is likely that congestion would result along LSB.

5.5.3 Access - Motorised

The two designs take significantly different approaches to access, as indicated in Table 15 and discussed peripherally under the Mobility section. Stated plainly, the Consolidated design removes any connection between FGE and LSB between Cherry and Yonge, whereas the Viaduct maintains existing connections.

One major feature of the Consolidated design was the decision to separate the FGE from its vertical alignment over LSB, which also impacts the connections between the two. This purposely removes the relationship between the expressway and the arterial and foregoes any future possibility of reconnecting the two. From an access perspective, this is a significant negative change in that the options for motorists wishing to travel to and from the DVP are now limited to access points to the west of Yonge Street or those along the DVP itself at Richmond Street and the multiple entry points on its east side. Motorists in eastern downtown can no longer use existing ramps to enter or exit the FGE in this area. While this is generally a boon for mobility along FGE, it is a significant decrease in access to and from the downtown, forcing many motorists to use the already overloaded Richmond ramp and a Yonge Street ramp that has had its capacity reduced. Future forecasted volume in the 2031 AM period, for example, indicates that approximately 1600 motorists are destined to the eastern downtown area (east of Yonge, south of Richmond, west of DVP). These motorists must now compete for access via a reduced number of ramps.

One alternate access provided to DVP commuters in eastern downtown is via the Don Roadway / LSB intersection. Via the DVP southbound off-ramp and northbound on-ramp there is an opportunity for DVP commuters to access eastern downtown at this location. However, this intersection will be quite limited and does not provide significant capacity as the significant volumes already on LSB will limit the available gaps and capacity for southbound right turns and the signal time available for a heavier eastbound left turn. The Consolidated design is likely to push an increased number of motorists to this intersection due to its limitation of access along FGE, reduction in capacity at the Yonge Street off-ramp and an already full Richmond Street off-ramp.

The Don Roadway north of LSB will also play a key role in the future of access to and from the Unilever / First Gulf site to the east of the DVP. In our analysis of the parallel Port Lands and South of Eastern EA, the access road to the site just to the north of LSB will play a major role. Increasing the number of vehicles through this location due to access limitations to the west will have significant negative effects on operations here and likely cause significant queues on the southbound ramp and the DVP mainline.

As discussed above, the limitation of the DVP to FGE ramp to a single lane prior to merging plays a role in the utility of the downstream access points in the Viaduct design. As the options for southbound DVP commuters into downtown are limited to Richmond Street, Sherbourne, and Yonge Street, it is worthwhile in maintaining two lanes between DVP and FGE and reducing the LSB connection to a single lane (as in Consolidated). The current design encourages LSB westbound travelers to use the FGE to avoid congestion on LSB and take the FGE to their specific access point (e.g., Sherbourne) instead of staying on LSB. As access is already provided to LSB motorists via the signalised intersections, this provides some redundancy to serve this movement and discourages use of the ramps via DVP commuters, who, as before, have very few options.

LSB sees no significant differences in access between Consolidated and Viaduct and generally maintains similar access to existing conditions.

5.5.4 Mobility / Access – Active Modes

The presence of a two-way east-west bicycle facility along the northern side of LSB in both alternatives provides excellent mobility through the area, though access does have its limitations, simply due to the location of the facility. Placement of the bike lane on the north side of LSB limits the access for these users to attractive uses to their south, where they must disembark at an intersection and cross via the pedestrian crosswalk to travel south safely. This is common to both the Consolidated and Viaduct alternatives (as well as Hybrid). And at the same time, they are also naturally separated from uses to the north due to the rail corridor. For these reasons, the bike path here will likely be mainly focused on mobility for longer east-west trips.

For active users looking to cross the LSB/FGE corridors, there is an advantage to the current design for Viaduct as it has a cross-section of two lanes on LSB versus the three for Consolidated (plus turning lanes at intersections). This reduced cross-section greatly reduces the time required to cross LSB and creates a more comfortable and convenient environment for active users.

5.5.5 Safety – All Modes

As discussed above, there is relatively little that can be definitively gleaned as a safety concern in a qualitative analysis of early functional designs. However, there are some considerations to discuss.

The current design for the Viaduct shows a reduction from two lanes to one on the southbound DVP ramp connection to FGE. This may be a safety consideration as users are travelling on a facility transitioning from a freeway to an expressway and will require proper notification of the change. The queuing that may result from this due to demands from DVP to the FGE may also create queuing that could appear unexpectedly to inexperienced or inattentive motorists. The 60 km/h design speed on the transition between the two ramps is warranted and should be applied as necessary to indicate the change in facility type and potential for queuing.

Safety for active users is typically concerned with provision of separated facilities (sidewalks and cycle tracks, as provided in both designs) and their exposure at conflict points with motorists. These conflict points are generally the crosswalks across wider corridors and at the corners where free-flow right turn lanes have been implemented for motorists.

In general, the Viaduct design provides for a slightly safer environment for active users crossing LSB due to its reduced cross-section. This is important in provision of adequate crossing time, primarily for persons with mobility issues or young children.

5.5.6 Conclusions

It can be concluded from the above qualitative analysis that both alternatives presented herein have some positive and some negative attributes with respect to transportation in the corridor.

The Consolidated option attempts to streamline the urban design of the FGE by consolidating it with the rail corridor, thereby removing a significant section where the FGE looms overhead. In doing so, there are necessary concessions to removal of access along the section between Cherry Street and Yonge Street and a disconnection of the facility from LSB. This is will have significant negative effects on the access and general mobility in the area, as the options for accessing and leaving the downtown have been limited to ramps that were previously forecasted to be full and will now be required to accommodate more demand. The Consolidated design also reduces the existing capacity of the Yonge Street WB off-ramp to a single lane, which will also have negative effects in the corridor that will compound with the reduction in access. Significant congestion is very likely to occur given currently forecasted travel demands.

The Viaduct option presents a design that maintains the majority of existing connections between FGE, LSB and the local road network, thereby maintaining access into and out of downtown. The reduced cross-section for both the FGE and LSB will result in a significant decrease in mobility in the area, as demands along LSB likely exceed a four-lane cross section in this area. Attempts to accommodate this are evident in the provision of two lanes onto the FGE from LSB, which may be an effective tradeoff for LSB motorists. However, the significant demand into eastern downtown from the DVP during the AM peak hour will be limited by the provision of a single lane connection from DVP to FGE. This will likely place more pressure on the Richmond Street and Don Roadway ramps, which cannot likely be accommodated.

Both design options, as presented here, have a number of issues that will need to be addressed before they can be said to be viable options for discussion. The limitations on access and mobility due to required tradeoffs in each design will have significant negative effects on the transportation network in the area.

6.0 Alternative Designs

Following Toronto City Council's selection of the Hybrid design as the preferred solution, this solution was further tested through the Paramics model to provide insight into further development of the design as part of the EA process. This section describes the results of the Paramics microsimulation model runs that were undertaken with respect to the following configurations

- **Maintain with Lower Yonge Geometry** – This option updates the original Maintain analysis to include the updated roadway network recommended from the Lower Yonge EA in the vicinity of LSB / Jarvis / Yonge. This provides a new baseline with which to compare the revised Hybrid solution.
- **Hybrid** – The selected alternative solution with Lower Yonge geometry
- **Hybrid Option 1A** – Hybrid without Keating Channel ramps
- **Hybrid Option 1B** – Hybrid with only the WB on-ramp at Cherry (no EB off ramp)
- **Hybrid Option 3** – Hybrid with 60km/h design speed on DVP/FGE ramps

Note that the Maintain with Lower Yonge Geometry configuration was run to provide context to the performance of the Hybrid configurations.

For ease of understanding in the text, these will be referred to in short hand as: Maintain LY, Hybrid, Hybrid 1A, Hybrid 1B, and Hybrid 3, respectively. As well as the differences indicated in the alternative names, each alternative also incorporates the roadway modifications in the Lower Yonge (LY) precinct, as recommended from the Lower Yonge Precinct EA.

Table 16 and **Table 17** present the results of the transportation modelling for the above noted alternatives.

Table 16 – Alternative Designs – General Statistics

	AM PEAK HOUR						PM PEAK HOUR					
Measures of Effectiveness	Maintain	Maintain (with Lower Yonge)	Hybrid	Hybrid 1A No Keating Ramps	Hybrid 1B WB Keating Ramp Only	Hybrid 3 60kmh Ramps	Maintain	Maintain (with Lower Yonge)	Hybrid	Hybrid 1A No Keating Ramps	Hybrid 1B WB Keating Ramp Only	Hybrid 3 60kmh Ramps
Average Speed in Corridor (km/h)												
FGE EB	94.8	74.7	94.1	63.5	75.5	71.9	88.7	75.3	93.4	80.1	75.5	62.3
FGE WB	69.3	68.9	74.9	64.3	72.1	69.2	76.8	96.0	90.7	100.1	93.7	93.8
LSB EB	43.2	35.1	37.7	27.7	37.6	37.0	40.0	36.4	38.5	35.7	35.6	34.8
LSB WB	42.0	38.6	33.5	29.5	33.8	34.9	42.5	42.9	40.1	35.4	40.8	42.4
Model Average Trip Time (h:mm:ss)												
Overall	0:04:43	0:05:37	0:05:09	0:06:24	0:05:39	0:05:33	0:05:18	0:05:47	0:05:55	0:06:54	0:06:28	0:06:00
Overall Network Statistics												
Average Speed (km/h)	35.4	27.6	32.2	25.1	27.3	28.4	30.3	30.9	31.1	23.9	26.1	28.9
Vehicle Distance Travelled (km)	189,630	170,664	187,931	182,099	172,245	176,169	178,254	185,831	191,417	175,368	173,790	181,850
Vehicle Hours of Travel (hours)	5,359	6,178	5,841	7,849	6,303	6,194	5,880	6,015	6,148	7,323	6,649	6,303
Unmet demand at major stations												
FGE EB	84	1,054	0	850	1,003	434	0	248	0	542	1,372	0
LSB EB	43	449	0	423	543	251	0	7	0	0	313	0
DVP SB	121	521	340	577	354	469	0	0	0	0	0	0

Table 17 – Alternative Designs – Travel Times

	AM PEAK HOUR						PM PEAK HOUR					
Measures of Effectiveness	Maintain	Maintain (with Lower Yonge)	Hybrid	Hybrid 1A No Keating Ramps	Hybrid 1B WB Keating Ramp Only	Hybrid 3 60kmh Ramps	Maintain	Maintain (with Lower Yonge)	Hybrid	Hybrid 1A No Keating Ramps	Hybrid 1B WB Keating Ramp Only	Hybrid 3 60kmh Ramps
Average Speed (kilometres per hour)	35.4	27.6	32.2	25.1	27.3	28.4	30.3	30.9	31.1	23.9	26.1	28.9
Origin-Destination Travel Time												
Inbound (to downtown)												
Spadina @ FGE to Front @ Parliament	0:05:00	0:10:13	0:06:33	0:08:35	0:10:37	0:09:30	0:05:49	0:07:54	0:05:04	0:09:23	0:14:42	0:09:10
DVP @ Dundas to Front @ Parliament	0:05:55	0:06:57	0:06:12	0:07:26	0:06:40	0:07:06	0:03:49	0:04:20	0:04:25	0:05:26	0:04:23	0:04:20
Queen @ Woodbine to Front @ Parliament	0:08:59	0:07:41	0:09:31	0:12:17	0:11:04	0:11:34	0:08:06	0:07:45	0:09:40	0:11:34	0:09:29	0:09:18
Outbound (from downtown)												
Front @ Parliament to Spadina @ FGE	0:05:15	0:05:56	0:05:22	0:06:38	0:05:54	0:05:25	0:11:42	0:08:01	0:09:00	0:12:58	0:08:07	0:08:35
Front @ Parliament to DVP @ Dundas	0:04:58	0:04:59	0:05:09	0:06:09	0:05:09	0:05:01	0:06:48	0:05:19	0:07:11	0:09:12	0:05:29	0:05:45
Front @ Parliament to Queen @ Woodbine	0:10:28	0:10:30	0:10:26	0:10:24	0:10:21	0:10:13	0:11:52	0:12:05	0:13:28	0:14:02	0:11:14	0:11:53
Through												
Spadina @ FGE to DVP @ Dundas	0:05:33	0:09:37	0:05:34	0:08:00	0:10:27	0:09:01	0:05:50	0:06:51	0:05:38	0:08:51	0:12:31	0:08:59
DVP @ Dundas to Spadina @ FGE	0:07:32	0:09:02	0:06:52	0:08:08	0:07:24	0:07:36	0:07:00	0:05:34	0:05:25	0:05:20	0:05:21	0:05:26
Queen @ Woodbine to Spadina @ FGE	0:09:31	0:09:02	0:13:31	0:14:37	0:13:43	0:12:20	0:10:26	0:08:15	0:11:19	0:19:28	0:10:22	0:10:19
Key Route Travel Time (minutes)												
Eastbound												
Spadina to DVP @ LSB via FGE	00:02:53	0:06:01	0:02:42	0:06:47	0:06:52	0:05:01	00:03:10	0:03:39	0:02:13	0:05:01	0:06:59	0:05:30
Spadina to DVP @ LSB via LSB	00:09:31	0:13:52	0:11:04	0:14:13	0:15:23	0:14:11	00:11:45	0:11:46	0:09:52	0:13:55	0:15:57	0:13:09
Spadina to Front @ Parliament via FGE	00:05:17	0:09:55	0:06:43	0:09:31	0:10:18	0:08:10	00:05:42	0:08:21	0:05:29	0:10:02	0:11:15	0:08:22
Spadina to Front @ Parliament via LSB	00:08:28	0:13:46	0:10:26	0:12:20	0:14:13	0:12:40	00:10:36	0:13:00	0:09:05	0:14:54	0:16:21	0:13:23
Westbound												
DVP @ LSB to Spadina via FGE	00:04:02	0:04:35	0:03:41	0:04:48	0:03:55	0:04:11	00:04:07	0:02:43	0:02:53	0:02:38	0:02:48	0:02:49
DVP @ LSB to Spadina via LSB	00:09:57	0:11:41	0:10:33	0:12:00	0:11:27	0:12:09	00:09:29	0:09:17	0:09:04	0:17:05	0:10:56	0:09:36
DVP @ Dundas to Front @ Parliament via FGE	00:05:32	0:09:04	0:06:26	0:07:39	0:06:52	0:06:54	00:04:18	0:04:58	0:05:07	0:06:15	0:05:13	0:05:03
DVP @ Dundas to Front @ Parliament via LSB	00:06:01	0:05:49	0:06:27	0:06:25	0:06:23	0:06:37	00:04:56	0:06:16	0:05:49	0:10:09	0:05:48	0:05:47
Within												
Jarvis @ Dundas to DVP @ LSB	00:08:31	0:08:26	0:09:01	0:09:45	0:08:29	0:08:34	00:10:00	0:11:35	0:10:55	0:16:00	0:11:25	0:10:21
Richmond @ DVP to Richmond @ Yonge	00:04:42	0:06:03	0:05:51	0:07:08	0:06:25	0:06:20	00:03:49	0:04:44	0:04:53	0:05:41	0:04:45	0:04:45
Adelaide @ Yonge to Adelaide @ DVP	00:03:16	0:03:41	0:03:41	0:04:41	0:03:41	0:03:41	00:04:01	0:04:27	0:05:09	0:06:13	0:04:56	0:04:27

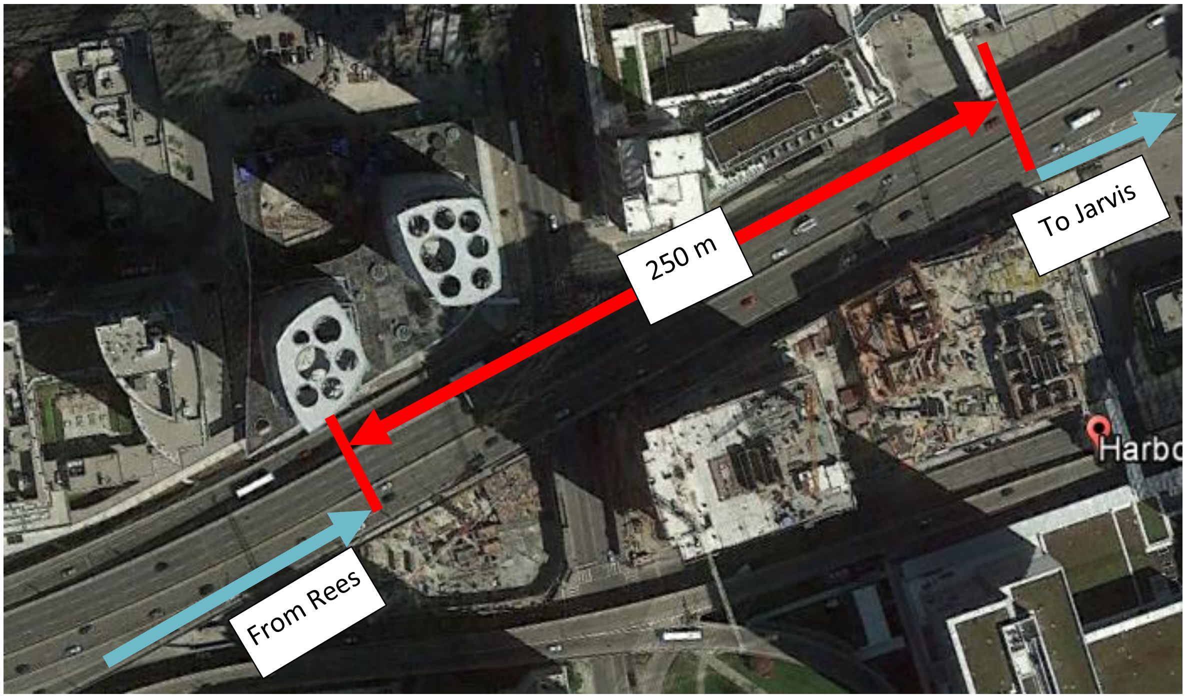
The following provides commentary on the model run results for each of the alternatives:

6.1 Maintain LY

Operations are slightly degraded when compared to the original Maintain model with existing geometry in the Lower Yonge precinct. This is largely due to the changes to Lake Shore Boulevard (LSB) and Harbour Street, as well as the off-ramp from the Gardiner (FGE) to Jarvis. These changes have made LSB discontinuous in the eastbound direction – vehicles on LSB/Harbour west of Jarvis Street are forced to make an eastbound left turn from Harbour and northbound right turn onto LSB EB to continue further east. There is a significant EB volume along LSB, especially in the AM peak hour, so these vehicles experience increased delay. *This condition is common to all alternatives*, though the extent of congestion apparently caused by this condition varies between the alternatives. These changes are essentially indicating to commuters from the west that the primary commuting route into the downtown area is the FGE – it provides a continuous connection and is now the primary connection to LSB east of Jarvis.

Related to this change in the Lower Yonge geometry and discontinuous LSB, there is also an apparent shift of vehicles from LSB EB west of the Lower Yonge precinct onto the FGE via the Rees Street ramp. This option becomes attractive for vehicles headed further east as they attempt to avoid the changes in the LY precinct. The FGE provides a fast and direct route further east. The increase in vehicles on the Rees on-ramp to the FGE exacerbates an operational issue on the FGE in that there is a very short weave distance between the Rees on-ramp and the Jarvis off-ramp of approximately 250m. This is also combined with the increased attractiveness of the Jarvis off-ramp, which is now the primary connection to LSB EB. Both of these factors create operational issues on FGE and LSB due to the weaving conflicts on this segment. These issues are not directly solvable through modification of signal timing at the downstream intersections and may require more significant solutions (e.g., ramp closure). *This issue is also common to all of the alternatives in this test*, though again with varying effects.

Figure 15 – Rees / Jarvis Weaving Area



The most significant effect of these issues on the examination of model operations elsewhere is the significant downstream ‘starvation’ that occurs due to the EB congestion on FGE and LSB. The congestion on LSB and FGE holds back significant volume from the eastern areas of the model (e.g., Lower Yonge and Keating precincts). Vehicle operations in these areas to the east, therefore, are relatively free of congestion.

Considering the context outside of the Paramics model, which ends to the west at Spadina Avenue, travelers headed further east may be more likely to opt for the FGE over LSB in consideration of their options relative to these changes. This level of change cannot be automatically considered in the Paramics model, due to its extents and would require further investigation.

Apart from the issues noted above, Maintain LY generally performs well. There are some predictable elements of congestion on the major facilities inbound in the AM and outbound in the PM with no major differences between Maintain and Maintain LY apart from the congestion for eastbound vehicles due to the noted weaving and access issues created by implementation of the LY changes.

The average speed in the study area for Maintain LY ranks in the middle of the other tested alternatives at 27.6 km/h in the AM peak hour. Corridor travel times are essentially on par with other alternatives with no particularly glaring issues. Movement eastbound movement along LSB is elevated above most of the other alternatives at 13:52 and 13:46 moving from Spadina to DVP and from Spadina to Front/Parliament, respectively. Westbound movement along the FGE from the DVP to Spadina is also elevated in the AM. Maintain LY performs generally the best of the tested alternatives with an average speed that exceeds Maintain and with corridor travel times that are generally among the best of the tested options.

6.2 Hybrid

The Hybrid alternative is the result of modifications to the geometry present in the Maintain condition, modified to better match with the forecasted demands, as described in section 5.3.

The roadway operations of the Hybrid alternative are generally the best of the alternatives tested in this portion of the project. At 32.2 km/h and 31.1 km/h in the AM and PM peak hours, respectively, the overall average travel time for Hybrid exceeds all tested alternatives, with the exception of the AM peak hour for Maintain. Corridor travel times for the Hybrid alternative are generally better and in some cases significantly better than Hybrid 1A, 1B, and 3 (e.g., eastbound via the FGE and LSB from Spadina to DVP is 2-4 minutes faster than all other tested alternatives). The Hybrid alternative does not show a single corridor travel time that is the highest among the tested alternatives. There is also little to no unmet demand shown during the peak hour simulations of the Hybrid alternative, with the exception of 340 vehicles southbound during the AM peak hour, which is average when compared to the other alternatives.

6.3 Hybrid 1A

Hybrid 1A modifies the original Hybrid alternative through removal of both ramps connecting the FGE to LSB near Cherry Street in the Keating Precinct.

Hybrid 1A, as with all alternatives that implement the recommended geometry in the Lower Yonge Precinct, shares the issues described above with respect to the Rees/Jarvis weave and the discontinuity of LSB. This inherently reduces and removes the through function for LSB through the downtown and focuses it on moving commuters to and from the downtown core instead of through it.

Along those same lines, the removal of the ramps in the Keating Precinct near Cherry Street also constitutes a change in the role and function of the FGE in the study area. The FGE ramps, as they exist today, allow motorists the opportunity to bypass surface traffic along large portions of LSB. Removal of the ramps removes this relationship and interaction between the two facilities and in some form isolates them to perform more singular functions – the FGE to serve the longer distance commuters from the suburbs, and the LSB to serve the local commuters.

As this limits an important auto-focused relationship in an area with significant peak hour congestion even today, the issues become exacerbated and congestion increases in the model significantly. The removal of these access points to the LSB places greater pressure on the ramps to and from the FGE/DVP throughout the study area, which increases congestion.

This alternative operates the poorest of all of the tested Hybrid alternatives, with the lowest overall average speed in the study area. Many of the observed travel times for Hybrid 1A are the highest amongst the tested alternatives or in the top two or three in both time periods. The westbound travel time from the DVP to Spadina along the LSB, for example, is six minutes longer than the next closest travel time, or approximately 55% higher than the next closest value. This can also be seen for the movement between Jarvis/Dundas and DVP/LSB which shows a travel time of 16 minutes, versus the next closest time of 11:25 during the PM peak hour.

6.4 Hybrid 1B

Hybrid 1B modifies the original Hybrid alternative through removal of the FGE EB off-ramp near Cherry Street. This alternative also applies a modified ramp design for the FGE WB on-ramp near Cherry Street; the new ramp departs from the north side of LSB to join the north side of FGE.

Hybrid 1B shares the common issues described above with respect to the Rees/Jarvis weave and the discontinuity of LSB. The removal of the FGE EB off-ramp near Cherry Street further limits options for EB travelers, primarily in the PM peak hour where there is a significant number of commuters leaving the downtown area to travel east. One negative effect of this is that the discontinuity of LSB causes issues for trips originating west of Jarvis Street headed east; there is no longer an option for these travelers to use the FGE to skip over the signals and congestion on LSB to touch down east of Don Roadway. These travelers must now find alternate travel paths to travel from west to east, which increases travel time. This is balanced by a positive change in that the discontinuity is helpful for those commuters originating east of Jarvis Street; this segment of LSB is now more directed towards the service of these travelers, as it is less attractive as a route through the area from points west, which reduces the conflicting volume.

One new issue in Hybrid 1B is the new ramp design for the FGE WB on ramp from LSB at Munitions Street. This ramp joins the FGE on the right-hand side as a confluence where two lanes come together from the DVP and LSB to create a four-lane cross-section. This confluence is separated from the downstream exit for Sherbourne by approximately 350m. Any vehicles from the DVP wishing to exit to Sherbourne will need to cross over two lanes over that short stretch to get to the exit. This is potentially a concern, especially during the peak commuting periods. The Transportation Association of Canada (TAC) Geometric Design Guide for Canadian Roads indicates that for efficient operation weaving length be in the range of 550 m and 700 m minimum. They recognize that in many cases shorter weaving lengths may be imposed by intersecting road spacing (such as the case with the Sherbourne exit) and that such shorter weaving lengths will operate with varying levels of quality and safety depending on local conditions and features such as traffic volumes, sight distance, visibility, horizontal and vertical alignment and cross section elements. The models show some congestion caused by weaving in this section as vehicles jockey for position on a high-speed roadway. Modifications to the design of this area may be required. It may be worthwhile to maintain a barrier between the DVP and LSB traffic on FGE that runs just to the west of the Sherbourne and prevents vehicles from SB DVP from accessing the Sherbourne off-ramp. This may also have some benefits to the confluence of the two roadways, as vehicles will have a longer parallel stretch to become acclimated to the new facility before being blended together.

The performance of LSB WB is slightly degraded compared to Maintain LY, as vehicles on LSB WB east of Don Roadway that are destined for FGE WB must travel through two more signalized intersections to reach the ramp near Munitions Street. Congestion during the AM peak hour generally exists from Don Roadway to Logan or Carlaw, though this is mainly a result of the signalization in the area and not related to congestion on the ramp itself. The signals essentially act as an effective meter for traffic on the FGE WB, releasing large platoons of vehicles intermittently.

Overall performance is relatively similar to Maintain LY with some degradation due to the issues described above. Hybrid 1B generally can be ranked between Hybrid 1A and Hybrid 3 with an average operating speed that falls at the midpoint of the other two options. Corridor travel times are typically average as well, with a few aberrations. Eastbound movement from Spadina along FGE and LSB to DVP/Dundas and to Front/Parliament show Hybrid 1B as the highest travel time in both periods, for example, for four separate movements. This difficulty with eastbound movement is also shown in the unmet demand for FGE EB, which is shown to be by far the highest in the PM peak hour at 1,372 vehicles, and essentially identical to the highest value in the AM period at 1000 vehicles.

6.5 Hybrid 3

Hybrid 3 presents similar access options to Hybrid 1B with only a FGE WB on-ramp near Cherry Street and no EB off-ramp. This option reduces the design speed of the DVP/FGE ramps to create a new alignment for FGE between the DVP and Cherry Street via a sharper curve.

The issues caused by limited access are very similar between Hybrid 3 and Hybrid 1B as the connections are identical between the two options. Operations are also similar on LSB WB during the AM peak period with congestion generally seen throughout the hour at the Don, Broadview, Logan, and Carlaw signals. Hybrid 3 also maintains the common issue with the Rees/Jarvis weaving area.

Hybrid 3 exacerbates the WB weaving issue to the Sherbourne ramp by shortening the available weave distance even further to approximately 300m. The movement from DVP SB to the Sherbourne ramp, however, seems to be less attractive to vehicles under this simulation, which may be a result of the shortened distance and difficulty in completing the maneuver. The behaviour of the confluence between the DVP SB and LSB WB traffic entering FGE WB seems to be improved via this design – likely related to this reduced weaving volume. In the larger sense, the reduced design speed also reduces the primacy of the DVP/FGE corridor as a through commuting route by limiting the travel speeds through the area. In combination with the discontinuity of LSB in the EB direction, these changes encourage the facilities to more focused local access, and less on the through function of the facilities.

Overall performance of Hybrid 3 is generally the better of the three Hybrid alternatives in both periods, though both Maintain LY and the original Hybrid perform generally as good or better than Hybrid 3. It shows some advantages due to the improvements in weaving behaviour where the DVP and LSB traffic comes together. Corridor travel times show that Hybrid 3 is consistently better or not significantly worse than Hybrid 1A and 1B. For the most part, however, there is a clear distinction between the travel times for the Hybrid model and the three alternatives, where travel times in Hybrid are better by several minutes along key corridors, especially eastbound (e.g., 2-9 minutes faster from Spadina/FGE to Front/Parliament in both periods, 3-5 minutes faster along both the FGE and LSB to the DVP during both periods).