# Appendix O – yongeTOmorrow Design Concept Evaluation Aimsun Modelling Report

City of Toronto

Final Report
May 2021

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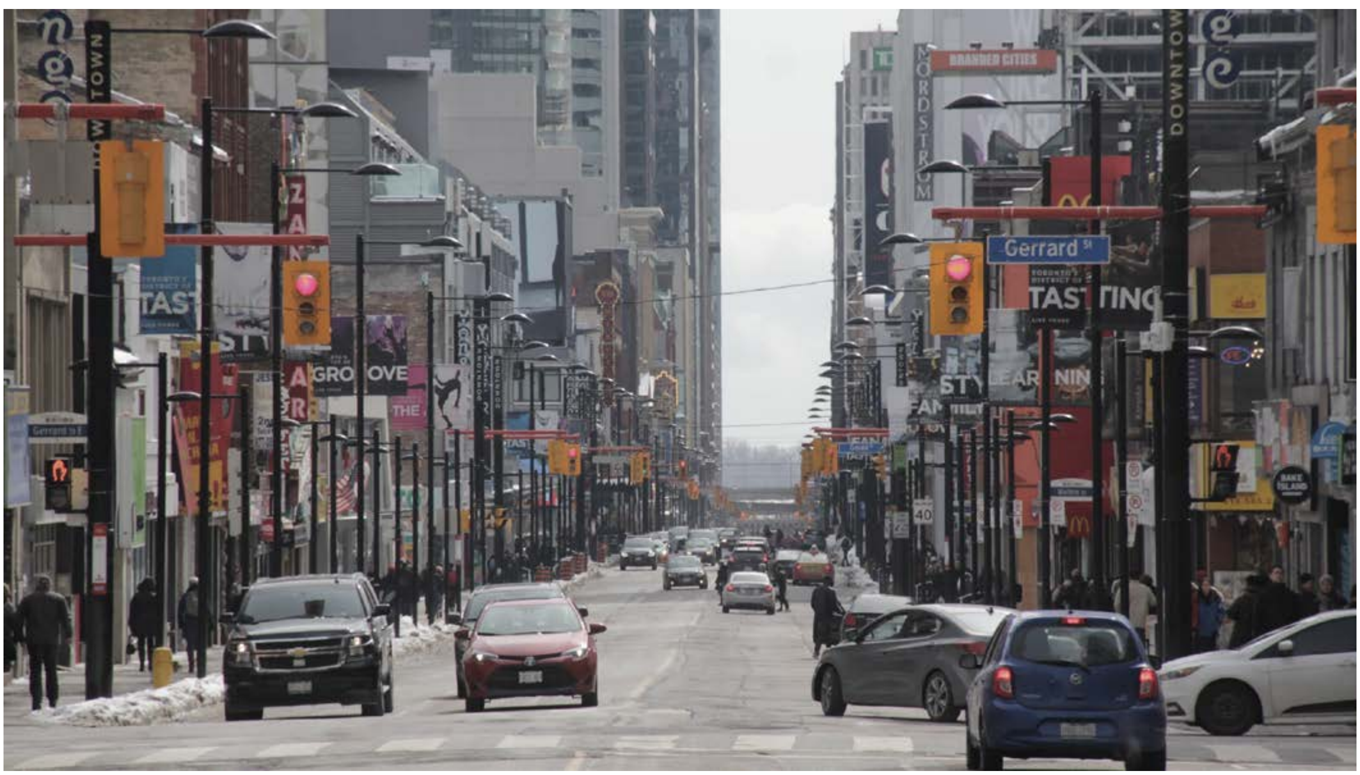


City of Toronto
23079001

steer

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# yongeTOmorrow Environmental Assessment – Design Concept Evaluation Aimsun Modelling Report


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# 1 Introduction

The Yonge Street Environmental Assessment (EA) Study ("yongeTOmorrow") is an exciting opportunity to redevelop Yonge Street into an attractive, convenient and compelling destination that works for people of all walks of life. Yonge Street needs to encompass a range of travel demands, from pedestrians, cyclists and vehicles, to special events and goods movement. Each demand type must be adequately assessed to develop holistic solutions that provide functionality for all users. A traffic model helps assess travel demands and traffic operations for auto and transit vehicles, and their interactions with pedestrians and cyclists.

## 1.1 Previous Work

In November 2019, as part of the Short List Evaluation Phase of this study, traffic and transit modelling analysis was completed to assess four high-level scheme alternatives for Yonge Street between Queen Street in the south and College Street in the north. The proposed shortlisted solutions were modelled and compared against outputs from a calibrated and validated base case model, as well as a 2031 Do-Nothing future conditions model to inform decisions about potential changes to the layout of Yonge Street.

Through the above shortlisting process, the Preferred Alternative Solution was identified (Alternative 4). This alternative saw Yonge Street closed to vehicular travel in both directions between Dundas Square and Gerrard Street, reduced to a single lane of northbound traffic between Shuter Street and Dundas Sq, and reduced to one lane of travel in each direction between Queen Street and Shuter Street, as well as between Gerrard Street and College Street. It also featured a lane removal in each direction on University Avenue between Adelaide Street and College Street, to represent the addition of cycling infrastructure there.

Alternative 4 was further refined into three Design Concepts, which applied differing approaches to implement and operate the high-level alternative. The design concepts varied by the specific restrictions to turning movements, placement of loading / ride hailing zones, and overall level of pedestrianization along each segment of the street. Following further evaluation of these concepts, Design Concept 4c was selected as the Recommended Design and is the subject of the modelling described in this report.

## 1.2 Purpose of this Report

Having identified Design Concept 4c as the Recommended Design, additional traffic and transit modelling of the concept design has been undertaken to provide further insight into the effects the scheme will have on the road network. This report will discuss:

- Model development process;
- Calibration and validation;

- Micro-simulation results;
- Testing of Design Concept 4c; and,
- Sensitivity testing.

### 1.2.1 Model Purpose

The models detailed in this report were developed for the purposes of providing insight into how the Yonge Street Design Concept 4c proposal impacts general traffic and road-based transit. It provides a comparative analysis of general traffic and road transit journey times for those parts of the road network likely to see the greatest impacts. In doing so, the models account for future demand growth, future road network changes and the interaction between different modes of travel.

To meet the above evaluation requirements of Design Concept 4c, the City of Toronto requested an expanded extent of the original model's reported area. While the original model was, in agreement with the City, only calibrated and validated in the area bounded by College Street, Queen Street, Church Street and Bay Street, the updated extents expanded this area east-west to include University Avenue and Jarvis Street. Therefore, the original model had to be recalibrated and revalidated to reflect these updated extents, followed by an update to the 2031 Do-Nothing future conditions model, before the Design Concept 4c model could be developed.

## 1.3 Approach

A hybrid micro-meso traffic simulation model was developed in the Aimsun Next platform. The integrated transport modelling software Aimsun (v8.2.4 2019-01-23 da8d554 x64) in conjunction with the ATC Controller Emulator Extension (v1.0.0) for the accurate representation of Transit Signal Priority (TSP) has been used. TSP was not coded for intersections in the mesoscopic part of the model as the TSP extension API only works within the microscopic part of the model.

Traversal matrices were developed from the City of Toronto's (City) GTA V4.0 EMME demand model. Additional data sets used for calibration and validation include City traffic counts, HERE location-based data travel times and on-site field surveys of queuing.

Public transit route details and headways were obtained from the Toronto Transit Commission (TTC) website. Each route was coded in the models individually to allow detailed changes and tests of future scenarios.

Three peak periods were developed for the purposes of this analysis, AM and PM weekday peak hours, and a Saturday peak hour. A Saturday peak was selected due to the significance of commercial and recreational activities along Yonge Street. In conjunction with City staff, the future horizon of 2031 was selected for the analysis.

## 1.4 Limitations

Although the Aimsun model provides good comparative results for existing and future traffic and transit operations, there are several limitations including:

- Limited to peak hour (AM, PM, Saturday), further consideration of temporal solutions is not reflected;

- The Aimsun model is built using the traffic demand of the City's 2011 EMME model, in addition to datasets (turn counts, travel time data, etc.) from a range of days, months and years. Received data was projected to 2018 values in order to reflect a 2018 baseline scenario, but this does not account for potential changes in travel behaviour or travel patterns beyond that;
- On-street cycling traffic is not supported;
- Future modal shifts towards electric and / or shared transportation opportunities are not reflected;
- Detailed behaviour of taxi services and other loading / unloading operations that block live lanes of traffic are not effectively modelled (however, randomized temporary lane blockages are included along major arterial roads in the microsimulation area);
- The model was created based on data collected prior to the onset of the COVID-19 pandemic, and as such does not take into account any short-term or long-term changes to travel patterns that may occur as a result, nor does it include any of the interventions (such as ActiveTO) that were implemented in response;
- Not all minor roads are included in the model, particularly in the mesoscopic area. In certain cases, minor roads in the overall study area were represented via centroid connectors.
- Due to the significant number of route choice options in the model, the dynamic assignment often posed significant challenges in achieving stable results along major corridors. To address these stability issues, dynamic cost functions were applied to specific links and turns where driver routing behaviour was unrealistic. This included on a number of minor streets where the model was assigning unrealistically high volumes of traffic. It can be concluded that a 40% dynamic assignment is too high for a model of this size. It is recommended that if any future work is to be conducted, this percentage be lowered.
- The Bay Street bus lane was modelled with 100% compliance. This does cause some issues in the design concept and sensitivity tests, as through traffic must queue behind turning traffic. There is no elegant way in Aimsun to model cars bypassing turning traffic, particularly when they would need to turn into a bus lane to do so. Therefore, the impacts on Bay Street may be overstated in the model.
- The results of the Saturday model should be viewed with some caution; the demand fed into the model is that of the City's weekday off-peak model, and only a quarter of all signalized intersections in the study area had Saturday counts available for calibration. As a result of these data limitations the modelled travel patterns are not likely to be as accurate as the other modelled time periods.
- The modelled demand in the future scenarios was taken as given from the City's demand modelling. The demand does not include any mode shift realized from the future pedestrianization of Yonge Street, nor does it consider the proposed closures on University Avenue and Church Street. Therefore, the modelled demand is likely to be significantly higher than will be experienced in the future.
- The modelling work does not include the future Ontario Line, which will likely have a significant impact on both pedestrian, cyclist and vehicular movements in the downtown and induce further mode shift away from private vehicles.
- The modelled area is located in Downtown Toronto, which is a dense urban area with closely spaced intersections. Vehicles entering and leading the model do so at centroids located around the study area's perimeter. Congestion *beyond* the extent of the study area is not

considered, even if that congestion would back up into the study area in reality. This may explain some of the high real-world travel times presented in the observed data, particularly on Queen Street. In the model, a periodic section blockage was used on Queen Street westbound right before the exiting centroid to account for observed levels of congestion outside the model and improve journey time validation of this corridor.

- Several stakeholders have made detailed inquires regarding modelling results as they pertain to their specific developments. However, this modelling work only considers demand at an aggregate (zonal) level, and future demand was taken as given from the City's demand model. The purpose of this modelling exercise has not been to consider specific developments and their needs. Future more detailed analysis may be required at specific intersections or along specific corridors to better address individual concerns.

## 1.5 Study Area

As per the needs of the EA study, the project is examined through multiple lenses and scales. The overall **Study Area** that has been modeled is formed by:

- Roxborough Street / Crescent Avenue in the north;
- Mount Pleasant Road / Jarvis Street in the east;
- King Street in the south; and
- University Avenue / Queens Park / Avenue Road in the west.

A more detailed area was used for micro-simulation. In the previous round of modelling, the microsimulation area initially covered the study's **Focus Area** and was bound by the following streets:

- College Street / Carlton Street in the north;
- Church Street in the east;
- Queen Street in the south; and
- Bay Street in the west.

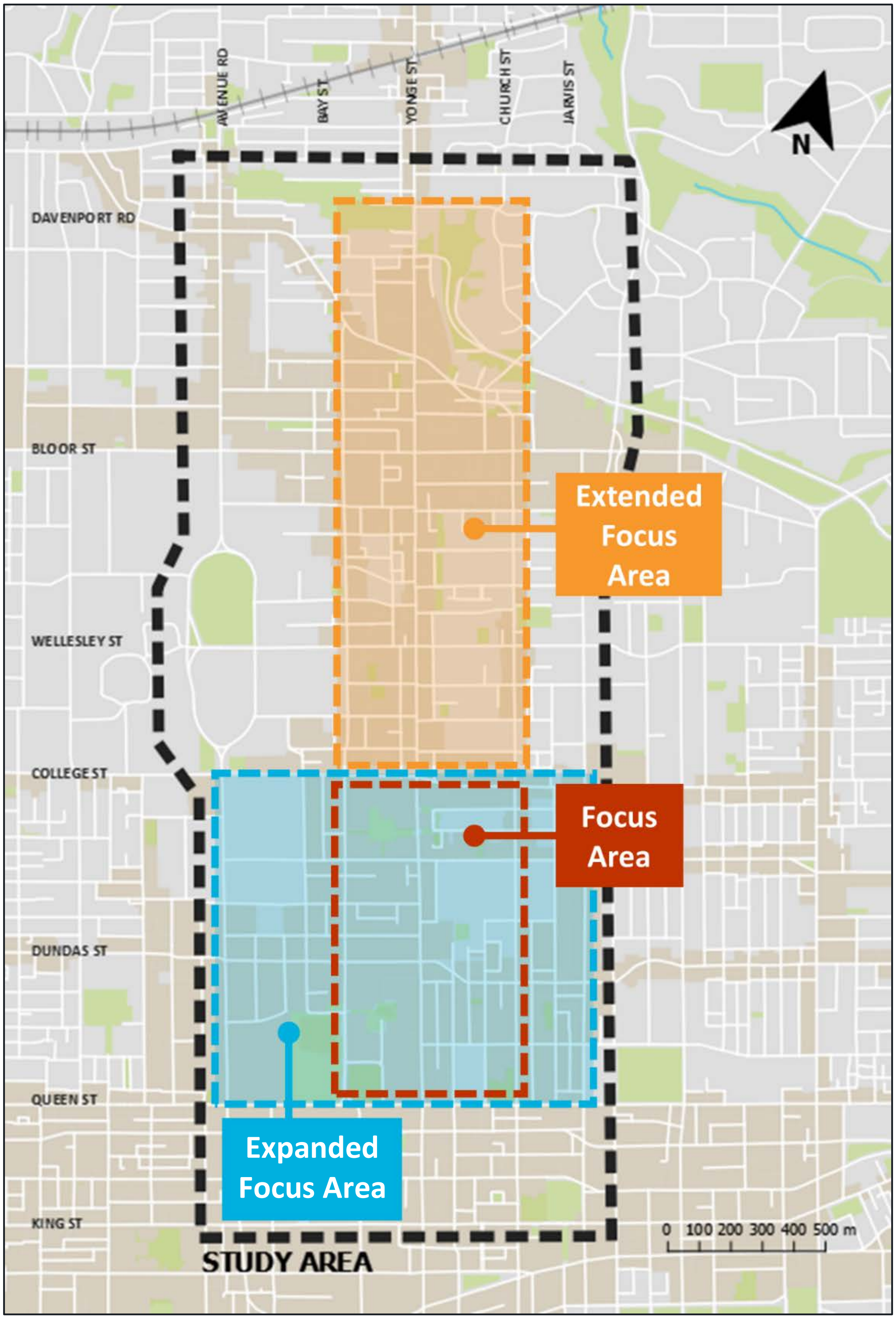
For this round of traffic modelling, the extents of the reported area were expanded beyond the focus area east and westward, to Jarvis Street and University Avenue, respectively (hereafter referred to as the **Expanded Focus Area**). The microsimulation area was extended only along the east-west arterial roads (Queen Street, Dundas Street, and College Street); University Avenue and Jarvis Street remained in the mesoscopic area. Including the original extent listed above, the updated extent of the reported area includes:

- College Street / Carlton Street in the north;
- Jarvis Street in the east;
- Queen Street in the south; and
- University Avenue in the west.

The full extent of the study and focus areas is shown in Figure 1. The **Extended Focus Area** as shown represents the area to be under study in a subsequent EA, to extend the yongeTOmorrow project northward. It lies entirely within the mesoscopic area, and is beyond the extents of the Expanded Focus Area that is the focus of this report.

All signalized intersections in the study area were included in the model and most unsignalized intersections were included in the expanded focus area. In certain cases, minor roads in the overall study area were sometimes represented via centroid connectors.

**Figure 1: Study Area**



# 2 Data Summary

A summary of the data collection efforts and items received is provided below. As noted above, the data collected reflects conditions prior to the COVID-19 pandemic.

## 2.1 Signal Timing Cards

Weekday signal timing cards in PDF format were received from the City for all signalized intersections within the study area bounded by:

- Roxborough Street to the north;
- Jarvis Street to the east;
- King Street to the south; and
- University Avenue / Queens Park / Avenue Road to the west.

The signal timings received were the most-recent in-use timing cards as of the time they were initially requested from the City, in 2017. Updated 2019 signal timing cards were also received in the area between King Street and Queen Street, reflecting the King Street pilot project.

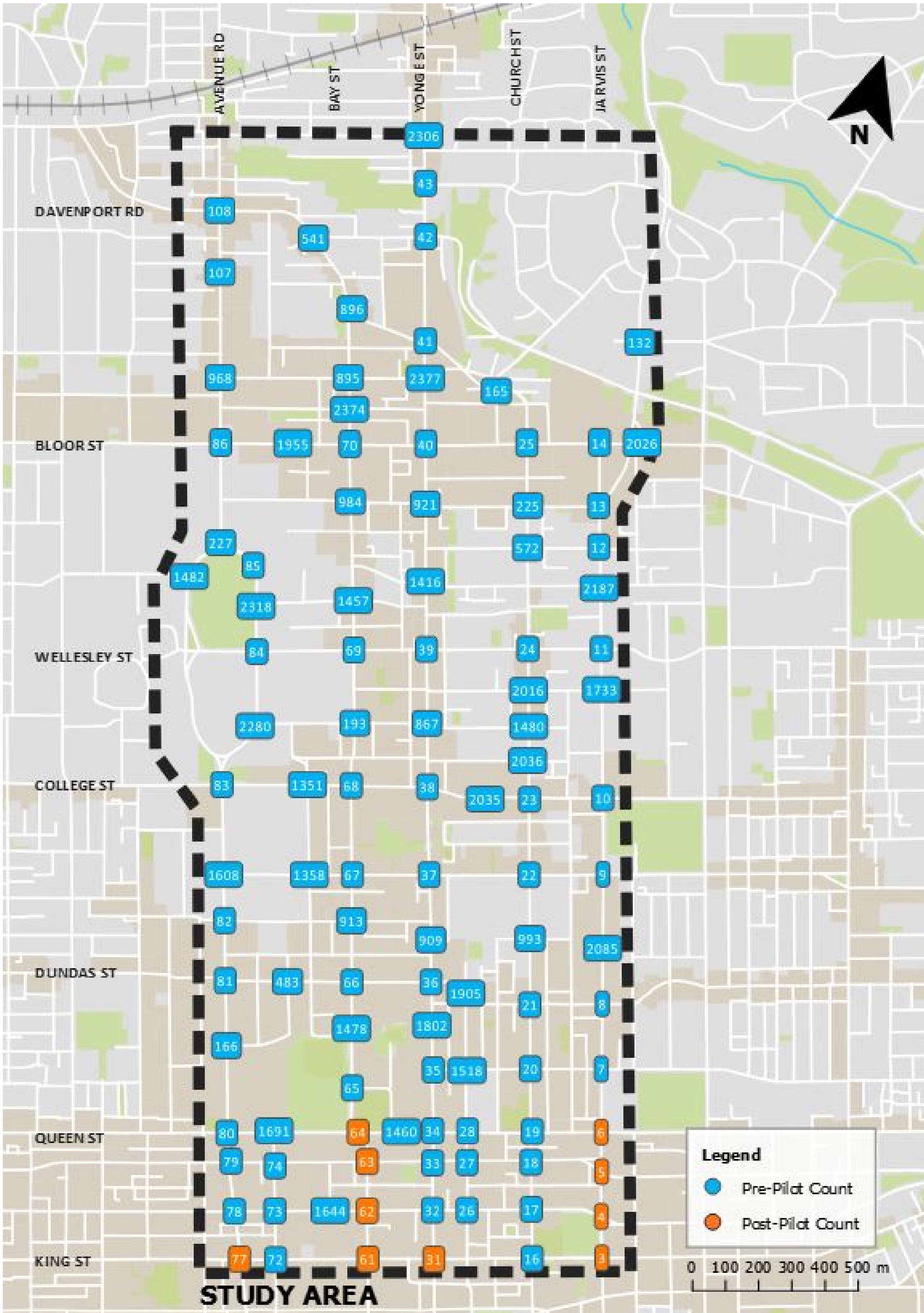
## 2.2 Turning Movement Counts

Weekday turning movement count (TMC) summaries were received for all signalized intersections within the study area outlined above. The counts were collected between 2008 and 2018 with most of the data collected between 2016 and 2017. To reflect the operation of the King Street Pilot, the City provided updated turning counts from 2018 (September 2018 for the AM and PM counts, and April 2018, for the Saturday counts) for intersections within the area bound by:

- Queen Street to the north;
- Jarvis Street to the east;
- King Street to the south; and
- University Avenue to the west.

The locations where turning movement counts were available for the AM and PM peak models are shown in Figure 2.

**Figure 2: Available weekday turning movement counts**



Traffic flows within the study area were balanced with a focus on the most recent counts in line with the volume balancing procedures set out in the City of Toronto's Synchro 9 Guidelines.

## 2.3 Existing Aimsun Next Models

Steer was provided with a calibrated King Street EA Study Aimsun Next Model (dated 31 October 2017) of the AM peak period only. The model extent only partly overlapped with the yongeTOmorrow EA study area and was therefore only used for the purposes of base network development and the import of general model parameters.

## 2.4 EMME Databanks

The City of Toronto has provided Steer with AM and PM peak EMME databanks of the wider yongeTOmorrow EA study area for the following scenarios based on the GTA V4.0 EMME Model:

- 2011 Base Case (existing conditions);
- 2031 Future Baseline ('Do Nothing');
- 2031 Yonge Street reduced to two lanes; and
- 2031 Yonge Street closed / pedestrianized.

The demand from the EMME databanks was used to develop demand sets for the Aimsun Next models. The extents of the EMME databanks extended beyond the boundaries of the study area to ensure realistic representation of traffic reassignment in the study area. This extent is outlined below:

- St Clair Avenue to the north;
- Broadview Avenue / Don Roadway to the east;
- Queens Quay / Commissioners Street to the south; and
- Strachan Avenue / Ossington Avenue to the west.

The EMME demand model is only reflective of weekday traffic, as a result, EMME databanks for a typical Saturday were not available.

## 2.5 StreetLight Origin-Destination Data

The EMME databanks only provide weekday AM and PM peak hour origin-destination information for passenger vehicles and transit. StreetLight location-based data was used to develop 2018 origin-destination matrices for truck traffic and for the Saturday peak period. StreetLight can create origin-destination matrices for the study area for both vehicles and trucks for multiple time periods based on GPS data from multiple navigational sources. The process used to develop these matrices using StreetLight data is outlined later in this document.

## 2.6 Public Transit Information

*Routes and Frequencies*

Transit service data was gathered from the Toronto Transit Commission's (TTC) service summaries corresponding with the dates selected for the traffic flow balancing (which have been outlined in section 2.2 Turning Movement Counts above).

*Dwell Times at Stops*

The City of Toronto provided boarding and alighting data for all surface transit routes within the study area for the purposes of determining dwell times. Dwell times were implemented for all transit routes within the study area based on calculation formulae provided by the City.

## 2.7 Pedestrian Flow Data

Pedestrian flow data from the traffic turning movement counts have been implemented within the model at signalized intersections along each cross-walk.

## 2.8 Cyclists

Cyclists in mixed traffic have not been included in the Aimsun Next traffic models. Dedicated bike lanes and tracks have been coded where they cross intersections. Volumes were based on existing TMC information and cyclist counts, and separate analysis of the potential future travel demands. In the Design Concept Model, bike lanes on University Avenue are modelled by a reduction of one auto lane in each direction, as the street is in the meso area.

# 3 Base Model Development

## 3.1 Base Network

### 3.1.1 General

The models have been developed for the weekday AM, PM and Saturday peak hours, which have been determined from the TMC counts received from the City of Toronto. The peak hours are:

- AM peak hour: 8:00-9:00;
- PM peak hour: 17:00-18:00; and
- SAT peak hour: 16:00-17:00.

For the purposes of calibration, the modelled network has been coded to reflect a 2018 base year to include the implementation of the King Street Pilot. The horizon year is 2031, in line with the EMME data banks received from the City of Toronto.

The development of the yongeTOmorrow base network was based on the King Street Study model which was provided to Steer by the City of Toronto on 10th November 2017. The following notes should be taken into consideration with regards to the King Street Study model:

- The study areas only partially overlapped;
- The model did not include traffic demand information;
- The model received covered the AM peak period only;
- No Transit Signal Priority (TSP) parameters were included in the model; and
- No information on the model development was received.

To provide as much consistency as possible across the models, most of the parameters have been left unchanged from the King Street model, including lane types, road types, vehicle types and vehicle classes. However, in order to improve the base model's traffic assignment, the road type of Yonge St and Bay St were changed, with their capacities reduced to 800 PCU/hr in both directions.

It was noted during the calibration process that the vehicle types cars were based on in the King Street model had been modified from the default Aimsun Next parameters. As no documentation was received with the model to provide justification, the parameters were changed back to the default Aimsun Next settings. As these default settings are based on a typical European fleet mix, it became apparent through the calibration process that vehicle lengths would need to be increased to more accurately reflect a typical North American fleet mix. Therefore, the default mean, minimum and maximum vehicle lengths were increased based on previous experience from projects in North America. No other parameters were amended. The adjusted parameters are listed in Table 3-1.

**Table 3-1: Adjusted vehicle length parameters for car-based vehicle types**

| Vehicle Length (m) | Mean | Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Default | 4.00 | 0.50 | 3.50 | 4.50 |
| Adjusted | 4.72 | 0.50 | 4.27 | 5.49 |

Additionally, streetcar type ALRV was added as it had not been included in the King Street model. Microscopic model parameters for vehicle acceleration and deceleration for streetcar types CLRV and LFLRV were updated based on information provided by the City, as shown in Table 3-2.

**Table 3-2: Streetcar parameters**

| Streetcar Type | LFLRV | CLRV | ALRV |
|---|---|---|---|
| Acceleration (avg to 30 km/h) | 1.3 | 1.2 | 1.1 |
| Service Brake | -1.2 | -1.1 | -1.1 |
| Emergency Brake (empty) | -2.75 | -1.6 | -1.6 |
| Emergency Brake (loaded) | -2.2 | -1.5 | -1.5 |

The basic network structure was imported using Aimsun Next's integrated OpenStreetMap (OSM) data importer. All sections, turns and nodes were checked against high resolution satellite imagery and online mapping tools such as Bing Maps and Google Maps, including Google Streetview. Right turn on red (RTOR) bans were implemented in the models where they are prohibited on site and turning bans were implemented in accordance with current restrictions. Turning bans were implemented in the following ways:

- *Attributes Overrides* for static assignments; and,
- *Traffic Conditions* for dynamic assignments.

Where online resources were insufficient or outdated, site visits and local knowledge of the study team assisted in completing the model network. This assisted in accurately representing link and node characteristics, such as the number of lanes, storage lengths, speed limits, turning restrictions and other geometrical details.

### 3.1.2 Parking

Based on field reviews and available information, parking restrictions have been implemented in the models using traffic conditions (lane closures). The curbside lanes at the following locations have been identified for the respective peak hours:

- AM Peak:
  - Queens Park Cres E: from Grosvenor Road to north of Street Joseph Street.
- PM Peak
  - None.
- SAT Peak:
  - Bay Street: College Street to Bloor Street (both directions);
  - Church Street: King Street to Gerrard Street and Alexander Street to Bloor Street (both directions);
  - Gerrard Street: University Avenue to Elizabeth Street (both directions);
  - Jarvis Street: Isabella Street to Queen Street (southbound only);

- Queen Street: Church Street to Jarvis Street (both directions);
- Queens Park Cres E: from Grosvenor Road to north of Street Joseph Street; and
- University Avenue: Queen Street to College Street (both direction).

### 3.1.3 Reversible Operation of Jarvis Street

The centre reversible lane on Jarvis Street operates in a northbound direction between 3:45pm and 6:30pm from Monday to Friday between Queen Street in the south and Isabella Street in the north. At all other times, the centre lane is available to southbound traffic.

In Aimsun Next, Jarvis Street has been modelled with three lanes in each direction. Two different approaches were used to reflect the reversible operation in the static and dynamic assignments:

- Static assignments: attributes overrides were used to reduce the capacity of relevant sections along Jarvis Street. For the respective sections, the capacity has been reduced from 2,700 PCUs/h (3 lanes of 900 PCUs/h each) to 1,800 PCUs/h. This was done to reflect the respective capacity of Jarvis Street and optimise the static assignments; and
- Dynamic assignments: traffic management strategies were used to close the centre lane of either the northbound or the southbound sections of Jarvis Street during the respective peak hours.

### 3.1.4 Diamond Lane on Bay Street

The northbound and southbound curbside lanes of Bay Street from Cumberland Street in the north to Front Street in the south are restricted to use by cyclists, taxis and buses only from Monday to Friday between 7:00am and 7:00pm. This restriction has been replicated in the Aimsun Next model by introducing a lane closure. Traffic conditions were used to ensure the restrictions are only applied to the AM and PM peak scenarios. The model assumes 100% compliance; however, cars are able to turn into the restricted lane in advance of making a right turn to a perpendicular street. This may not reflect actual conditions in practice (where some non-permitted vehicles may illegally use the curbside lanes). This has not been reflected in the model, as general modelling practice is to assume that vehicles obey traffic laws, and in any case no information was available to quantify how many vehicles may be illegally using the curbside lanes.

### 3.1.5 Dedicated Cycle Lanes

There are several locations within the Focus Area where dedicated cycle lanes are currently present, namely:

- Bay Street, from Dundas Street to College Street;
- Gerrard Street, from Bay Street to Church Street; and
- Shuter Street, from Victoria Street to Church Street.

These cycle lanes were included in Aimsun Next to represent the impact on turning vehicles at intersections. The cycle lanes were coded as separate sections (rather than added lanes to the existing sections) and mixed traffic is therefore not represented in the models. Cyclists are not able to turn left or right at intersections but travel straight ahead only. This approach was outlined to the City and accepted during a modelling workshop held at the City's offices in November 2018.

Cyclist flows were based on the same TMC traffic counts which were used for the development of the traffic demand. However, for the AM and PM peak models, no flows were available for the intersection of Bay Street / Gerrard Street (TCS67). Flows were therefore based on the adjacent intersections:

- Gerrard Street / Yonge Street (TCS37) for east-west cycle flows; and
- Bay Street / Elm Street (TCS913) for north-south cycle flows.

For the Saturday peak model, cyclist flows were only available for the intersection of Gerrard Street / Yonge Street (TCS37). Those east-west cycle flows were copied to the following intersections:

- Gerrard Street / Bay Street (TCS67); and
- Gerrard Street / Church Street (TCS22).

No further cycle flows were included in the model due to the lack of data.

#### 3.1.6 Locations with Operational Restrictions

The City provided Steer with a list of locations identified to suffer from operational issues and constraints, such as excessive queuing, low pedestrian compliance with provided crossing points or vehicles frequently stopping in the curbside lane for loading. The complete list received from the City is outlined below:

- Significant queuing:
  - Queen Street / Bay Street: northbound queues from Richmond Street to Queen Street;
  - Yonge Street / Dundas Street: east- & westbound queues to Bay Street / Victoria Street;
  - Queens Park Crescent: southbound right turn at Hoskin Avenue (AM Peak);
  - Adelaide Street / University Avenue: eastbound left turn (AM and PM Peak); and
  - Richmond Street / University Avenue: westbound right turn (PM Peak).
- Significant curbside activity:
  - Yonge Street northbound from Queen Street to Dundas Street;
  - Queen Street east- and westbound between Bay Street and Yonge Street; and
  - Area of Shuter Street / O'Keefe Lane / Dundas Square / Victoria Street.
- Low pedestrian compliance:
  - Yonge Street / Gould Street, especially in north-south direction; and
  - Yonge Street from College Street to Gerrard Street: many pedestrians crossing midblock.

Information about significant queuing was used during the calibration process as input for the *Static OD Adjustment Scenarios* to prioritize demand over traffic counts. More information can be found in section 3.7.3 Matrix Adjustment.

Frequent curbside activity was replicated in the hybrid scenarios by traffic management strategies, which were set to periodically cause the curbside lane to be blocked. Field visits were not undertaken as the City provided detailed information about affected locations. Curbside activity was not replicated in the static assignments.

Low pedestrian compliance and a high number of pedestrians crossing midblock on Yonge Street was replicated in the Aimsun Next models through Attributes Overrides, lowering the speed limit of the affected sections from 40km/h to 30km/h to reflect more cautious behaviour of drivers.

## 3.2 Signal Timings

Signal timing cards for all signalized intersections in the model area were obtained from the City of Toronto. The timing cards are provided separately to this document. These signal timing cards included information about the operation of each intersection, including:

- Stage sequences;
- Average stage lengths where the signals operated based on vehicle actuation (as opposed to a fixed time operation);
- Extension times for side street stages and left turn movements if vehicles are detected;
- Cycle lengths;
- Offset times to adjacent intersections; and
- Details regarding Transit Signal Priority (TSP).

SCOOT settings outlined on the signal timing cards were not implemented in the models.

In accordance with the signal timing cards received, the following intersections within the Focus Area have been coded to operate with active TSP in the model:

**Table 3-3: TSP Locations and Algorithms**

| TCS # | Location | TSP Algorithm |
|---|---|---|
| 19 | Queen & Church | A |
| 21 | Dundas & Church | A |

Transit signal priority for streetcars was modelled in line with the corresponding TSP extension API as per City of Toronto guidelines, including accurate representation of flashing don't walk (FDW) times. TSP request and cancel detectors were added and TSP parameters set in accordance with the signal timing cards. Where the signal timing cards did not provide information regarding exact locations of the TSP detectors, they were placed at similar locations to intersections where the information was available. TSP was not coded for intersections in the mesoscopic part of the model as the TSP extension API only works within the microscopic part of the model (focus area).

## 3.3 Transit

Transit routes were coded into the model based on the information available on the TTC website. Details for each bus and streetcar service can be queried, including exact routes and stop locations. The TTC Service summary dated 2 September 2018 – 6 October 2018 was used to enter transit information for the AM and PM peaks and the TTC Service summary dated 1 April 2018 – 12 May 2018 was used to enter transit information for the Saturday peak. The information entered from the service summaries includes:

- Transit route and sub-routes (e.g. 510A, 510B);
- Vehicle type used on the route; and
- Average headways during various time periods, including AM and PM peak periods.

Boarding and alighting data was obtained from the TTC for each bus or streetcar route running through the study area, which was used to estimate dwell times for each bus stop. Data was given for the time periods between 0:00-9:00 and 15:00-19:00. This was converted to AM and PM peak hour ridership by applying peak hour factors provided by the City of Toronto:

- 0.55 for AM peak; and
- 0.40 for PM peak.

The ridership at each stop was not separated by route branch. Passengers were assigned to each branch, where applicable, proportionally based on the headway of each branch, as outlined in the service summary. Dwell time per boarding and alighting passenger depends on the vehicle type, as shown in Table 3-4, in addition to a base clearance time at each stop. It was assumed that the current and future streetcar fleet all share the same dwell time assumptions.

**Table 3-4: Boarding & Alighting Time Per Passenger**

| Vehicle Type | Clearance Time | Boarding Time (Per Boarding Passenger) | Alighting Time (Per Alighting Passenger) |
|---|---|---|---|
| Standard Bus | 8 seconds | 3 seconds | 2 seconds |
| Articulated Bus | 8 seconds | 3 seconds | 1 second |
| Streetcars | 10 seconds | 0.6 second | 0.6 second |

The streetcar routes included in the model are:

- 501 Queen;
- 502 Downtowner;
- 503 Kingston Road;
- 504 King;
- 505 Dundas;
- 506 Carlton; and
- 514 Cherry.

The bus routes included in the model are:

- 5 Avenue Road;
- 6 Bay;
- 94 Wellesley; and,
- 97B Yonge.

The express bus routes included in the model are:

- 141 Downtown / Mt Pleasant Express;
- 142 Downtown / Avenue Road Express;
- 143 Downtown / Beach Express;
- 144 Downtown / Don Valley Express; and
- 145 Downtown / Humber Bay Express.

All branch routes that pass through the study area were also included.

Triggers and Strategies were used in Aimsun Next to accurately replicate driver behaviour at streetcar stops, ensuring that vehicles stop to allow passengers to alight and board the streetcar. This representation is based on the transit vehicle being directly on top of the stop using two detectors, one at the front and on at the rear of the vehicle. Once the transit vehicle is no longer on top of both detectors, regular traffic will be able to queue/pass beside the transit vehicle. This behaviour only works properly in the microscopic area, and is the reason the microscopic area was extended along the east-west corridors.

## 3.4 Pedestrians

Pedestrian counts at all signalized intersections and crossings were received from the City of Toronto TMC information and have been included in the model. These counts measure pedestrian volumes on each crosswalk in 15-Minute intervals. This allows for an accurate representation of signal activations and of delays for turning vehicles at intersections. The traffic counts only show total volume along each cross-walk, and it was assumed that pedestrian traffic on each crosswalk is equal in each direction. The diagonal crosswalks at the intersection of Yonge Street and Dundas Street (TCS36) have been included in the model for an accurate visualisation of pedestrian movements. AM peak counts were used where no Saturday count data was available.

## 3.5 Cyclists

Cyclist demands along dedicated bike lanes and tracks have been based on available TMC counts. AM peak counts were used where no Saturday count data was available.

## 3.6 Demand Development

### 3.6.1 EMME Import

The City of Toronto provided EMME databanks for the weekday peak periods (AM and PM) and for the weekday off-peak periods (midday and evening). The databanks were created using the GTA V4.0 EMME model for the following scenarios:

- 2011 Base Case (existing conditions);
- 2031 Future Baseline ('Do Nothing');
- 2031 Yonge Street reduced to two lanes; and
- 2031 Yonge Street closed / pedestrianized.

The outputs included traffic demand in the form of origin-destination (OD) matrices and transit demand within the study area. No truck demand is included in the City's GTA V4.0 EMME model. The information from the EMME outputs fed into the development of the demand matrices for the Aimsun models, for both the existing conditions and the 2031 demand.

The extent of the EMME network was cropped to the wider downtown Toronto area and is shown in Figure 3. An area significantly larger than the yongeTOmorrow study area has been chosen to capture wider traffic reassignment due to some of the proposed impacts on capacity along Yonge Street.

There are 21 internal zones in the EMME model within the yongeTOmorrow study area, shown more clearly in Figure 4. These zones match those of the Transportation Tomorrow Survey (TTS) 2006. External centroids represent the rest of the Greater Toronto Area.

**Figure 3: EMME Network**

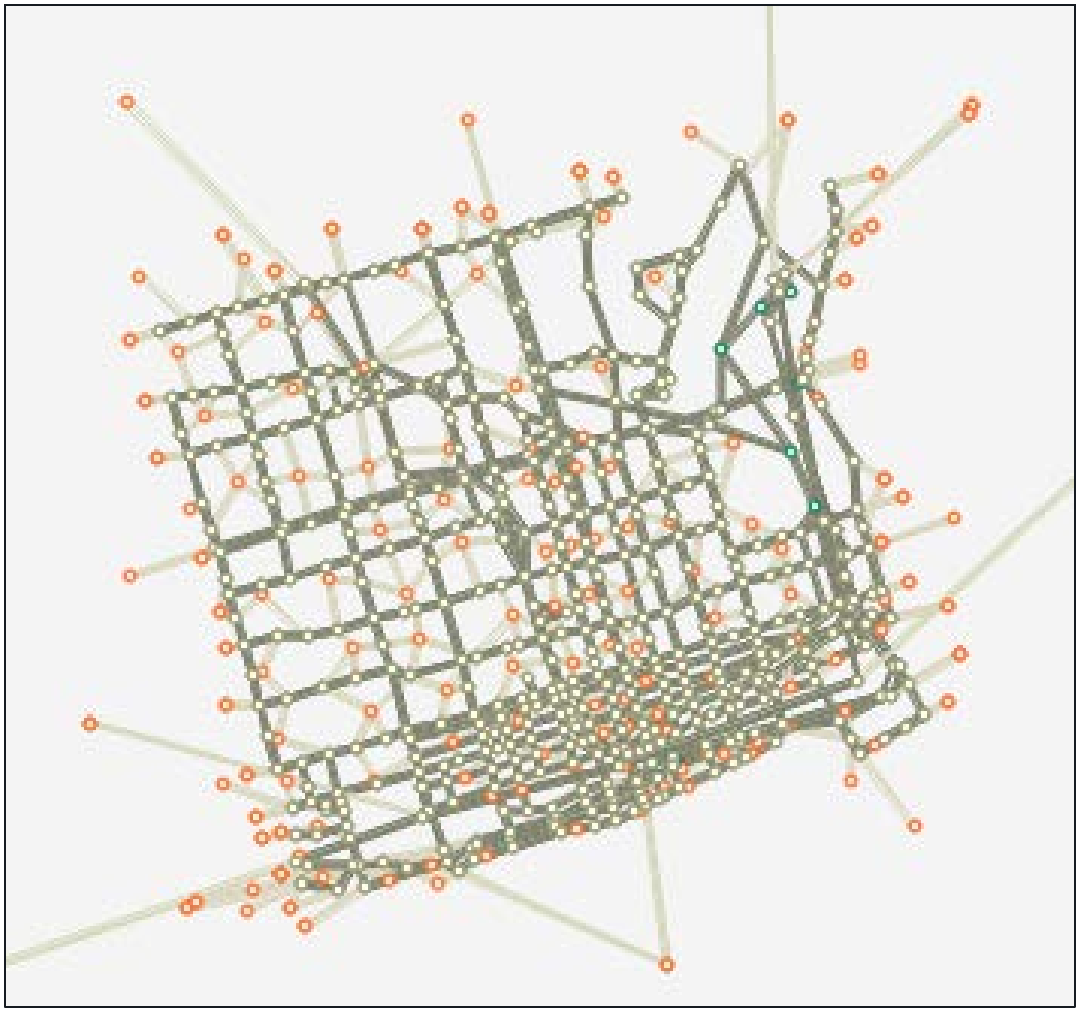
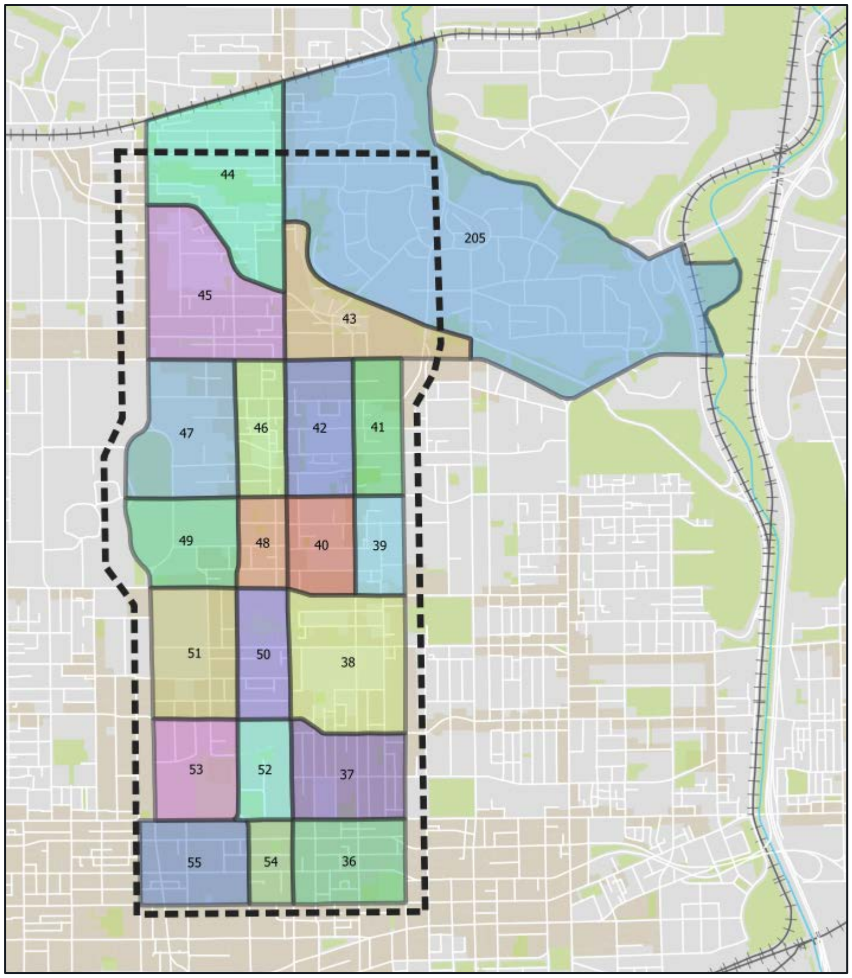


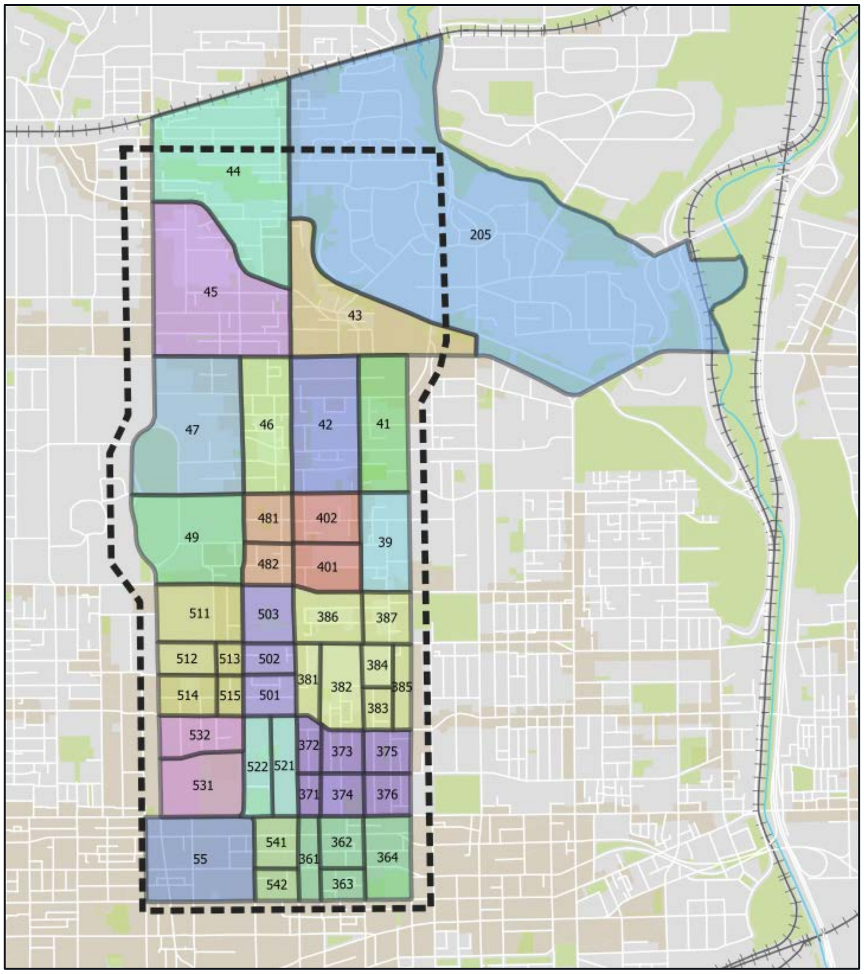
**Figure 4: Original TTS/EMME Internal Zones**




### 3.6.2 Zone Disaggregation

To have better flexibility in modelling future conditions, the EMME zones within the study area were disaggregated into smaller areas. Disaggregation was conducted mainly for zones in the Phase 1 focus area and the areas immediately adjacent; zones further out were not disaggregated. The disaggregation was done based on current and future expected land use as well as local urban form (building size, amount of parking, etc.), typically along major roads, and ensures that demand can be attributed at a finer level of detail particularly within the focus area. The disaggregated zones are shown in Figure 5.

**Figure 5: Disaggregated TTS/EMME Internal Zones**




### 3.6.3 Traffic Counts

To support more detailed analysis of traffic operations, 15-minute interval vehicular turning movement counts were provided by the City for each intersection within the study area. For each count, AM and PM peak periods were determined. For intersections along the King Street, Adelaide Street, Richmond Street and Queen Street corridors, the City provided Miovision count data from September 2018 to reflect traffic conditions during the King Street Pilot. The Miovision data was converted to match the format of the City's 15-minute TMC counts. Therefore, Miovision's vehicle categories *Single-Unit Trucks* and *Articulated Trucks* were combined to a single vehicle class *Duals* to represent trucks in the Aimsun Next model.

Volume balancing was performed at intersections along the major corridors to develop representative existing traffic volumes at signalized intersections as per the City of Toronto's Synchro 9 Guidelines. The balancing process was performed in Microsoft Excel and aimed to reduce discrepancies of counts between intersections. Volumes were balanced using major/major intersections as a reference, adjusting the smaller adjacent intersections to within 10% of the major intersection. In general, volumes were not adjusted by more than 30%, and only through movement volumes were adjusted (in line with the City's guidelines for flow balancing which are outlined in the *City of Toronto's Synchro 9 Guidelines*).

Since general traffic is not allowed to go through in the east-west directions at the intersections along King Street (nor are they allowed to turn left), those intersections were exempted the above restriction. Through movements and left turns were manually set to zero and flows were redistributed to the right turn movements during the balancing.

The traffic counts were used to create a real data set for all turning movements in the study area, and a cordon that measured volumes on each link into and out of the study area. These data sets were used for the matrix Furness and adjustment processes and for the calibration of the model.

#### 3.6.4 Truck Matrix

The City's EMME model does not include truck traffic. Therefore, StreetLight data was used to determine the distribution of truck traffic through the study area. StreetLight data was used to estimate the amount of truck traffic as a factor of auto traffic, for each OD-pair (for example, between zones X and Y, truck traffic was 20% as large as auto traffic).

1. Two OD matrices for the study area were extracted from StreetLight data: personal vehicles (i.e cars) and commercial vehicles (i.e trucks).
2. The magnitude of each OD pair in the truck matrix was compared to the magnitude of the OD pair in the auto matrix, to generate a factor for each OD pair relating the magnitude of truck traffic to auto traffic.
3. These factors were then applied to the respective adjusted demand matrices in Aimsun within Aimsun Next to obtain initial matrices of truck traffic.
4. The initial truck matrices were subsequently adjusted based on the TMC turning counts provided by the City to obtain final matrices used in the Aimsun Next models.

## 3.7 Matrix Adjustment and Estimation

During the development of the original Aimsun model as part of the Short List Evaluation Modelling Phase, the EMME databanks were converted into Aimsun traversal matrices for the purposes of modelling. First a static assignment was completed using the entire imported EMME network, which was then trimmed to the study area's extents via a Furness adjustment process using the provided traffic counts at all signalized intersections along the study area's edges. Finally, the traversal demand matrix was completed using the provided traffic counts at each signalized intersection in the study area. The first two steps of this process are unchanged from the initial round of modelling.

#### 3.7.1 Static Assignment of EMME demand

During the previous round of modelling, the initial EMME OD matrices were used in static assignment experiments, which assign flows to the network. Static assignments do not use individual vehicles but are based on trip volumes as well as speeds and flows along road sections and are typically used to define the demand in peak hour OD matrices. The method used was Frank & Wolfe Assignment (as per the approved King Street Pilot model which the City provided to Steer), which is based on the calculation of shortest paths and path percentage usage and uses the cost of the different network elements (i.e. capacity of individual links) to assign flows to the network. The volume delay functions (VDF) which are part of those calculations have been left unchanged from the approved King Street Pilot model.

The results of the static assignments were stored in path files, which contained information about the shortest paths between OD pairs and the percentage of vehicles taking each path. The path files are provided with the model files.

This step was done during the first round of modelling and was unchanged during the model update in this phase. This is because the static assignment of the EMME demand was done at a much larger extent than just the study area (covering all of Planning District 1), and therefore already included the updated extents of the reported modelling area in this phase.

### 3.7.2 Furness Estimation

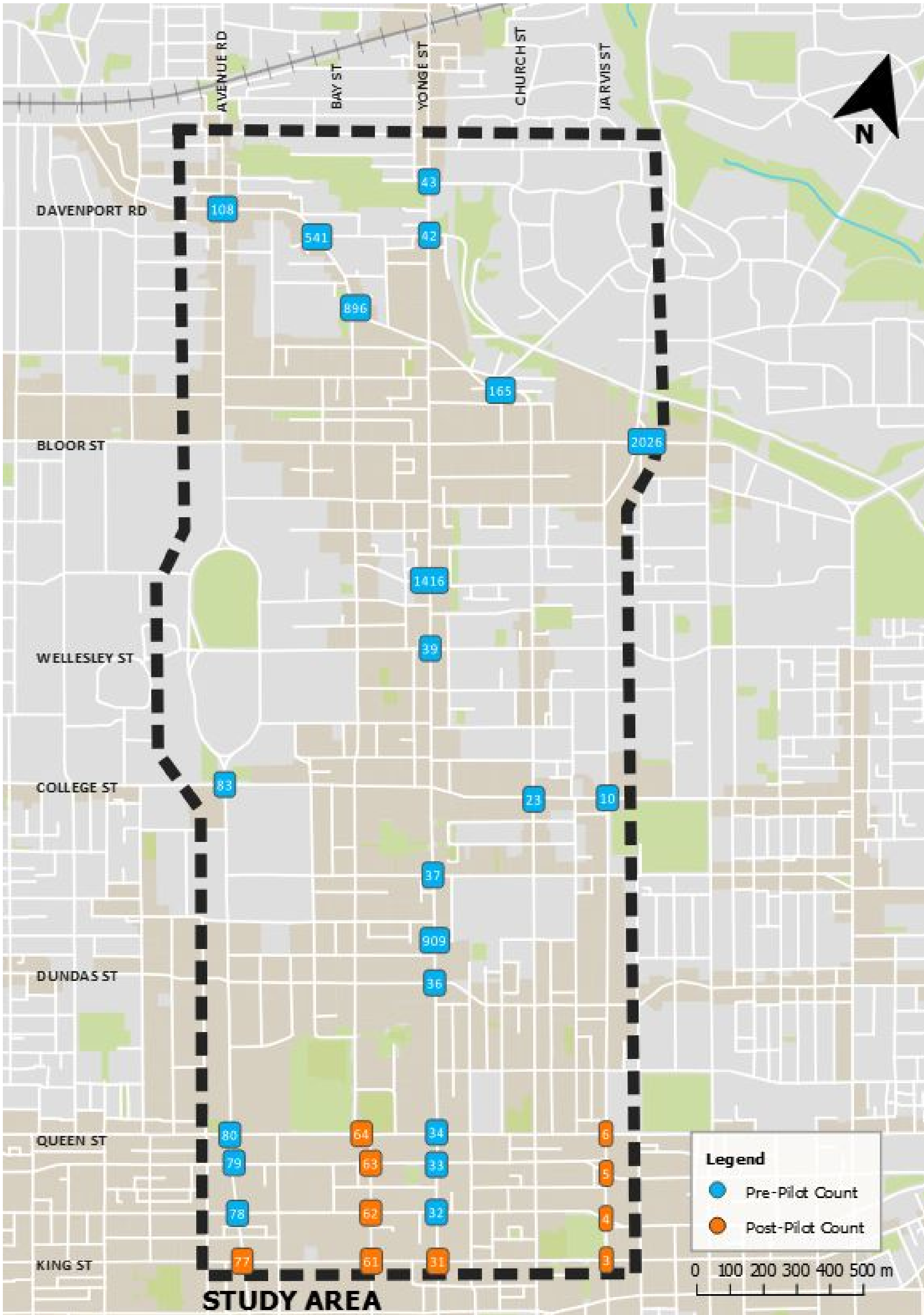
The EMME databanks provided by the City are for a 2011 Base year. As a result, they are not reflective of base year (2018) conditions. The key was to determine the differences between the EMME model and traffic counts as a result of travel demands, and as a result of EMME model issues. An EMME model is typically meant for reviewing macroscopic demands, and in the context of the GTA model, the study area for this study would not be calibrated to a high level of accuracy for individual links.

Thus, the first step in the adjustment process was to modify external zones (centroids) of the study area and adjusting them using a Furness estimation process. Furness estimation approximates the demands in these external zones to better reflect actual demands. A cordon of traffic flows across the study area boundaries was created using the balanced traffic count data and used as an input for this process.

Due to the limited amount of data available, no Furness estimation could be undertaken for the Saturday peak. The locations where turning movement counts were available for the Saturday peak model are shown in Figure 6.

This step was done during the first round of modelling, and was unchanged during the model update in this phase. This is because the static assignment of the EMME demand and the Furness adjustment were both done at the study area level, and therefore already included the updated extents of the reported modelling area in this phase.

**Figure 6: Available Saturday turning movement counts**



### 3.7.3 OD Matrix Adjustment

A matrix estimation process was completed to adjust the traversal matrices for all centroids, to better reflect the traffic counts within the study area. It was noted that Centroid 521, which represents the Eaton Centre, had significantly more demand than would be expected, which was skewing the adjustment process and leading to unrealistic behaviour in the network. A factor of 0.2 was applied to the origins and destinations coming from/to this centroid to better reflect the observed counts at the intersection of Yonge Street and Shuter Street, and on-site observations at the Bay Street garage entrance.

Additionally, both Yonge Street and Church Street were revised to road type “Minor Street” for the purposes of modelling. The reduced capacities of minor streets were necessary to ensure a strong OD adjustment; without it, both streets were drawing too much traffic relative to what was shown in the counts.

Areas with significant queuing were added to *Groupings* and included in the *Static OD Adjustment Scenarios* as *Congested Sections* to prioritize demand over count data. The relevant locations have already been outlined in section 3.1.6 Locations with Operational Restrictions.

The results of the OD adjustment were again stored in path files. The settings used for the static OD adjustment scenarios and experiments are outlined in sections 4.2 Static OD Adjustment Scenario Parameters and 4.3 Static OD Adjustment Experiment Parameters.

### 3.7.4 Manual Matrix Adjustments

Additional manual adjustments were made in each period to improve the calibration so that the model showed a better fit to the traffic counts. For reference, centroids with numerical identifiers are internal zones, while centroids with a street name identifier are along the study area’s boundary.

In the AM model, this included:

- -75 vehicles from centroid University Avenue to centroid Avenue Road
- -250 vehicles from centroid Avenue Road to centroid University Avenue

In the PM model, this included:

- +60 vehicles from centroid 361 to centroid 42
- +70 vehicles from centroid 55 to centroid 46
- -200 vehicles from centroid 514 to centroid Avenue Road
- -150 vehicles from centroid Adelaide Street West to centroid Avenue Road
- +75 vehicles from centroid Carlton Street to centroid College Street
- -181 vehicles from centroid 532 to centroid Dundas Street West
- -25 vehicles from centroid 375 to centroid Dundas Street East
- -25 vehicles from centroid 375 to centroid Mt Pleasant Road

In the Saturday mode, this included:

- -200 vehicles from Richmond Street East centroid to centroid 362
- -200 vehicles from University Avenue centroid to centroid 47
- -50 vehicles from Hoskin centroid Avenue to University Avenue centroid

- -50 vehicles from centroid 45 to University Avenue centroid
- -20 vehicles from centroid 47 to University Avenue centroid

### 3.7.5 Final Traversal Demand Matrix

The final adjusted matrices were used in the hybrid assignments. In order to improve the final assignment, the simulated demand was set to 110% of the final demand matrix in the AM and PM models, and to 115% of the final demand matrix in the Saturday model. This is because the unchanged levels of demand did not result in acceptable GEH levels for the signalized intersections, likely due to the fact that the starting matrix was from the City's 2011 demand model.

The dynamic assignments used a combination of vehicles following the input path assignment (60%) and vehicles being dynamically assigned to the shortest path at the time of them being loaded into the network (40%). The dynamic assignment was based on the past two five minute increments in the network, therefore taking into consideration recently formed queues. The settings used for the dynamic hybrid scenarios and experiments are outlined in section 4.4 Dynamic Hybrid Experiment Parameters.

The combination of static and dynamic routes assures that not all traffic between a specific OD pair gets assigned to the shortest path at any given moment. This reduces instances of the traffic 'flip-flop-effect', where demand jumps from one OD-route to another multiple times throughout the simulation period.

# 4 Model Parameters

This section outlines various parameters and settings used in the Aimsun Next model.

## 4.1 Static Experiment Parameters

This section outlines parameters of the static assignment experiments. Each sub-section refers to a tab in the experiment settings window.

### 4.1.1 Main

*Engine: Frank and Wolfe Assignment*

*Assignment Parameters*
- Maximum Iterations: 100
- Relative Gap: 0.1%
- Conjugate Frank-Wolfe: deactivate

*Quasi-Dynamic Network Loading*
- Activate Quasi-Dynamic Network Loading: deactivated

## 4.2 Static OD Adjustment Scenario Parameters

This section outlines parameters of the static OD adjustment scenarios. Each sub-section refers to a tab in the scenario settings window.

### 4.2.1 Centroids and Sections

*Use Original Matrix as Detection Data*
- Matrix Elasticity: 1.00

*Use Trip Length Distribution as Detection Data*
- Trip Length Distribution Elasticity: 0.50

*Use Entrance/Exit Volumes as Detection Data*
- Exit from Centroid Reliability Vector: None
- Entrance to Centroid Reliability Vector: None

*Maximum Deviation Permitted*
- Max Deviation Matrix: None

*Weight Function*
- Function: None

*Congested Sections (Demand over Detection)*
- Selected grouping for respective peak hour, listing sections with significant congestion.

- Sections defined based on information provided by the City:
  - S/B right queues Queens Park Cr at Hoskin AM Peak
  - E/B left turn queues Adelaide and University AM and PM Peak
  - W/B right turn queues Richmond and University PM Peak
  - Queen and Bay: Northbound queues from Queen to Richmond
  - Yonge and Dundas: Eastbound/Westbound queues to Bay/Victoria

## 4.3 Static OD Adjustment Experiment Parameters

This section outlines parameters of the static OD adjustment experiments. Each sub-section refers to a tab in the experiment settings window.

### 4.3.1 Main

*Engine: All or Nothing Assignment*

*Quasi-Dynamic Network Loading*

- Activate Quasi-Dynamic Network Loading: deactivated

## 4.4 Dynamic Hybrid Experiment Parameters

This section outlines parameters of the dynamic hybrid assignment experiments. Each sub-section refers to a tab in the experiment settings window.

### 4.4.1 Main

*Dynamic Traffic Assignment*

- Network Loading: Hybrid Simulator
- Assignment Approach: Stochastic Route Choice (SRC)

*Warm-Up*

- Warm-up demands have been specified based on the respective peak hour demands:
  - 1-hour duration
  - 80% of respective peak hour demand

*Performance Settings*

- Simulation Threads: 4
- Route Choice Threads: 4

### 4.4.2 Behaviour

*Micro Parameters*

- Car Following
  - Two-Lane Car-Following Model: deactivated
- Lane Changing
  - Two-Way Two-Lane Overtaking Model: deactivated
- Queue Speeds
  - Queue Entry Speed: 1.00 m/s
  - Queue Exit Speed: 4.00 m/s
- Behavioural Models
  - Activate External Behavioural Models: deactivated

*Hybrid Parameters*

- Car Following
  - Apply Slope Model: deactivated
- Lane Changing
  - Distance Zone and Look-Ahead Distance Variability: 40%

### 4.4.3 Reaction Time

*Simulation Step*

- Simulation Step: 0.80 sec

*Reaction Time Settings*

- Fixed
- Values
  - Micro Reaction Time: (Same as Simulation Step)
  - Micro Reaction Time at Stop: 1.10 sec
  - Micro Reaction Time at Traffic Light: 1.60 sec
  - Meso Reaction Time: 1.65 sec
  - Meso Reaction Time at Traffic Light: 2.8 sec

### 4.4.4 Arrivals

*Global Arrivals*

- Uniform

### 4.4.5 Dynamic Traffic Assignment

*Costs*

- Cycle: 00:05:00
- Number of Intervals: 2
- Attractiveness Weight: 5.00
- User-Defined Cost Weight: 0.00
- Use Link Costs from replication: None
- Use Profiles RC: deactivated

*Fixed Routes*

| Vehicle Type | Following OD Routes * | Following Input Path Assignment |
|---|---|---|
| 53: SOV Compliant | 100% | 60% |
| 302271: Medium Trucks | 100% | 60% |
| 996303368: Pedestrian | 100% | 100% |
| 996813646: Bicycles | 100% | 100% |

* Please note that no OD routes have been defined in the models and therefore this setting does not impact on any routes or results.

- Maximum Paths to Use from Input Path Assignment: All

*Stochastic Route Choice*

- Model: C-Logit
  - Enroute: deactivated
  - Enroute After Virtual Queue: deactivated
- Basic

| Source | Maximum Number of Initial Paths to Consider |
|---|---|
| K-SP | 1 |

  - Maximum Paths per Interval (For All the Vehicles): 5
- Parameters

| Origin | Destination | Scale | Beta | Gamma |
|---|---|---|---|---|
| All | All | 6 | 0.15 | 1 |

# 5 Calibration, Validation & Results

## 5.1 GEH Calibration

The criteria selected for the base model calibration was based on thresholds of the *City of Toronto's Methodology for Aimsun Modeling*, as shown in Table 5-1 below.

**Table 5-1: Calibration criteria (*City of Toronto Methodology for Aimsun Modeling*)**

| Criteria & Measures | | Calibration Target |
|---|---|---|
| Individual Link Hourly Flow Rates | % counts where GEH < 5 | > 85% of counts |
| | % counts where GEH < 10 | > 95% of counts |

The GEH Statistic is a widely accepted formula allowing the comparison of two sets of traffic volumes – in this case balanced flows against modelled flows in the base case scenario – to represent goodness-of-fit of a model. Including both absolute and percentage differences between modelled and observed flows, it puts emphasis on links or turns with higher flows.

The model calibration was done against the balanced flows within the expanded focus area which were based on the turning counts obtained from the city. Summaries of the calibration criteria and results of the base model in the expanded focus area are outlined in Table 5-2.

**Table 5-2: GEH calibration results**

| Criteria & Measures | | AM Results | PM Results | SAT Results |
|---|---|---|---|---|
| Individual Turn Hourly Flow Rates | % counts where GEH < 5 | 85% | 82% | 84% |
| | % counts where GEH < 10 | 98% | 96% | 99% |

All modelled time periods meet the criteria of 95% of modelled link flows within a GEH < 10.

The AM peak hour also meets the City of Toronto's second threshold of at least 85% of modelled flows being within a GEH < 5.

The PM peak and Saturday peak hours sit outside this range, but only just, with 82% and 84% of flows within a GEH < 5. Due to the wide range of dates (months and years) the TMC turning counts data was provided for, as well as the very small sample of data at each intersection, the GEH calibration results outlined above are considered acceptable for the purpose of the models, especially since the proportion of GEH<6 is 87% and 90% for the PM and Saturday peaks, respectively, suggesting that the model is not particularly far off from the target. As well, in both time periods, the combined modelled flows on those links outside the targeted GEH range are generally slightly higher than the combined turning counts. This suggests the model is over estimating demand slightly and therefore represents a robust, conservative baseline, upon which options analysis can be performed. Finally, it should also be noted that this GEH performance is improved upon from the previous round of modelling.

Tables outlining all turns with a GEH larger than 5 can be found in Appendix A.

## 5.2 Travel Time Validation

Two sets of travel times were collected during the original model's construction:

- **In-house Google API Tool by Steer**: the tool captures average speeds of traffic during the respective peak hours by using an API to extract Google's travel time information between two points (individually specified sections); and
- **StreetLight (SL) dataset**: average speed information from the dataset, extracted for the respective peak hours.

However, data was only captured in the microsimulation area at the time. For the extension of the model during this phase, the Google API could not be used due to the ongoing COVID-19 pandemic, and the StreetLight data licence had since expired. Therefore, a new data source was used for the revalidation of the model:

- **HERE dataset**: captures total travel time between signalized intersections within the extended reporting area. It captured a total of 4 weeks of data, therefore providing a maximum of 12 days of observations for AM & PM peaks (4 x Tue / Wed / Thu) and a maximum of 4 days of observations for SAT peak.

It was also noted that some records in the HERE dataset, particularly in the PM peak, had high standard deviations. The statistical interquartile rule was used to remove outliers for each road segment, if applicable.

Modelled travel times of general traffic have been validated along the key north-south corridors (Bay Street, Yonge Street, Church Street, University Avenue, Jarvis Street) and key east-west corridors (College Street / Carlton Street, Dundas Street, Queen Street) in the expanded reporting area, against the average observed values of the HERE dataset. In some cases where the HERE data seemed overly high, a comparison was done with the original StreetLight and Google API data, as a last resort.

Travel times of transit routes were validated against AVL data provided by the City for east-west corridors only due to limitations in the data provided for north-south routes.

The *City of Toronto's Methodology for Aimsun Modeling* does not provide a target criterion for travel time validation. Therefore, the criterion set out in Transport for London's (TfL) Model Auditing Process (MAP) has been used as a guide for the study. The criterion is outlined in Table 5-3.

**Table 5-3: Travel time validation criteria (*TfL MAP*)**

| Criteria | Calibration Target |
|---|---|
| 20 seed average modelled corridor travel time | Within 15% of observed travel time |

The results are outlined in the sections below.

### 5.2.1 AM Travel Time Validation

The comparison of observed travel times and modelled travel times (in seconds) for the AM peak is shown below. Table 5-4 and Table 5-5 show the comparison for general traffic and **Error! Reference source not found.**Table 5-6 below shows the comparison for transit routes.

**Table 5-4: AM base general traffic travel time validation (north-south)**

| Corridor | NB | | | SB | | |
|---|---|---|---|---|---|---|
| | HERE data | Aimsun | % Difference | HERE data | Aimsun | % Difference |
| University Avenue | 163.2 | 191.8 | 17% | 162.2 | 142.9 | -12% |
| Bay Street | 203.8 | 200.8 | -1% | 184.2 | 210.9 | 14% |
| Yonge Street | 205.5 | 200.6 | -2% | 186.1 | 205.7 | 11% |
| Church Street | 195.0 | 210.5 | 8% | 186.1 | 255.1 | 37%* |
| Jarvis Street | 186.7 | 185.2 | -1% | 214.2 | 166.3 | -22% |

**While the modelled travel time on Church Street does not match well with the HERE data, it does match well with the previous datasets used during the first round of modelling (223s) and is very close to the previously modelled result (254s). A visual review of the simulation on this street could not identify any realistic way to quicken traffic further. Therefore this result can be considered acceptable.*

**Table 5-5: AM base general traffic travel time validation (east-west)**

| Corridor | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | HERE data | Aimsun | % Difference | HERE data | Aimsun | % Difference |
| College Street | 269.2 | 285.0 | 6% | 301.3 | 324.9 | 8% |
| Dundas Street | 258.3 | 237.9 | -8% | 339.5 | 281.5 | -17% |
| Queen Street | 300.5 | 278.3 | -7% | 299.4 | 342.5 | 14% |

**Table 5-6: AM base transit travel time validation (east-west)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | AVL data | Aimsun | % Difference | AVL data | Aimsun | % Difference |
| 501 | 440.0 | 535.0 | 22% | 486.0 | 622.6 | 28% |
| 505 | 394.0 | 478.9 | 22% | 464.0 | 534.2 | 15% |
| 506 | 434.0 | 475.3 | 10% | 479.0 | 498.5 | 4% |

Of the 22 routes assessed for validation, 15 achieve the target journey time variance of 15%, and one (Church Street SB) achieves the target value when considered the SteerLight dataset used in the previous round of modelling. Of the remaining 6 outside the criteria, 5 show the model to be just slightly over estimating journey times. We also note some conflicts between the AVL and HERE data, such as on Dundas Street EB, in which auto travel time is slightly quick, while transit travel time is slightly slow, resulting in a situation in which matching both values within the 15% target is not feasible.

Overall, these results demonstrates that overall the model is well validated in the AM peak hour and fit for assessing future impacts of the Yonge Street proposals, as it matches the targets well on most corridors, and is slightly conservative on the few corridors that are just above the target.

### 5.2.2 PM Travel Time Validation

The comparison of observed travel times and modelled travel times (in seconds) for the PM peak is shown below. Table 5-7 and Table 5-8 show the comparison for general traffic and **Error! Reference source not found.**Table 5-9 below shows the comparison for transit routes.

**Table 5-7: PM base general traffic travel time validation (north-south)**

| Corridor | NB | | | SB | | |
|---|---|---|---|---|---|---|
| | HERE data | Aimsun | % Difference | HERE data | Aimsun | % Difference |
| University Avenue | 127.5 | 126.2 | -1% | 183.2 | 196.7 | 7% |
| Bay Street | 320.3 | 293.8 | -8% | 299.1 | 276.4 | -8% |
| Yonge Street | 288.5 | 287.1 | 0% | 330.9 | 282.4 | -15% |
| Church Street | 273.2 | 243.6 | -11% | 230.5 | 264.7 | 15% |
| Jarvis Street | 221.4 | 227.5 | 3% | 246.1 | 206.9 | -16% |

**Table 5-8: PM base general traffic travel time validation (east-west)**

| Corridor | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | HERE data | Aimsun | % Difference | HERE data | Aimsun | % Difference |
| College Street | 393.8 | 308.1 | -22% | 337.9 | 288.8 | -15% |
| Dundas Street | 520.9 | 353.8 | -32% | 314.4 | 286.3 | -9% |
| Queen Street | 449.8 | 338.5 | -25% | 523.0 | 366.2 | -30% |

**Table 5-9: PM base transit travel time validation (east-west)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | AVL data | Aimsun | % Difference | AVL data | Aimsun | % Difference |
| 501 | 635.5 | 617.9 | -3% | 590.5 | 612.2 | 4% |
| 505 | 632.0 | 617.0 | -2% | 505.0 | 587.0 | 16% |
| 506 | 539.0 | 503.8 | -7% | 530.0 | 480.5 | -9% |

Of the 22 routes assessed for validation 16 achieve the target journey time variance of 15%. Of the remaining 6 outside the criteria, 2 are within 1% of the target. Once again, we note conflicts between the HERE data used for auto validation and the AVL data used for transit validation on the east-west corridors. Compared to the HERE data, auto volumes are slightly fast, however, compared to the AVL data, transit travel times are well within the targets. It would be difficult to slow down auto traffic to reach the targets without sending the transit travel times over their targets. Given that the transit travel times validate well, we believe these results to be acceptable.

This demonstrates that overall the model is well validated in the PM peak hour and fit for assessing future impacts of the Yonge Street proposals. Given the acceptable goodness of fit between modelled and observed turning movements, larger deviations to auto travel times on east-west streets were likely caused by congestion outside of the study area causing delays within the study area. On Queen Street, where this was most apparent (and supported up by real world observations pre-pandemic), a periodic temporary road blockage was added at the western extent of the study area, to model westbound congestion occasionally backing up into the study area.

### 5.2.3 SAT Travel Time Validation

The comparison of observed travel times and modelled travel times (in seconds) for the Saturday peak is shown below. Table 5-10 and Table 5-11 show the comparison for general traffic and **Error! Reference source not found.**Table 5-12 below shows the comparison for transit routes.

In order to match modelled Saturday travel times with the observed data, an additional 2 seconds of reaction time was added when cars started from stop, as well as 2 seconds of additional reaction time at red lights in the micro area along major arterial roads. These factors were added only in the Saturday model, reflecting driver's tendencies to drive less aggressively on the weekends and when there is less congestion. This was carried through to all future models. The observed travel times were otherwise significantly higher than those produced by the model, in spite of a strong GEH and additional calibration parameters (such as road blockages, reduced maximum speeds, etc.); therefore, the addition of these factors is justified.

**Table 5-10: SAT base general traffic travel time validation (north-south)**

| Corridor | NB | | | SB | | |
|---|---|---|---|---|---|---|
| | HERE data | Aimsun | % Difference | HERE data | Aimsun | % Difference |
| University Avenue | 124.7 | 120.9 | -3% | 248.1 | 209.5 | -16% |
| Bay Street | 223.7 | 193.5 | -13% | 228.5 | 221.9 | -3% |
| Yonge Street | 336.9 | 288.1 | -14% | 353.7 | 313.2 | -11% |
| Church Street | 335.1 | 275.2 | -18% | 262.7 | 270.8 | 3% |
| Jarvis Street | 290.6 | 261.7 | -10% | 208.2 | 225.3 | 8% |

**Table 5-11: SAT base general traffic travel time validation (east-west)**

| Corridor | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | HERE data | Aimsun | % Difference | HERE data | Aimsun | % Difference |
| College Street | 355.2 | 309.1 | -13% | 260.7 | 266.1 | 2% |
| Dundas Street | 331.2 | 344.9 | 4% | 415.7 | 498.5 | 20% |
| Queen Street | 387.9 | 274.5 | -29% | 369.8 | 269.9 | -27% |

**Table 5-12: SAT base transit travel time validation (east-west)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | AVL data | Aimsun | % Difference | AVL data | Aimsun | % Difference |
| 505 | 452.0 | 500.3 | 11% | 451.0 | 668.4 | 48% |

Of the 18 routes assessed for validation 12 achieve the target journey time variance of 15%. Of the remaining 6 outside the criteria, 3 are within 5% of the target.

It is likely that the HERE data on Queen Street was over-estimating east and west auto travel times. The Streetlight Data used in the previous round of modelling showed 124 seconds for eastbound travel, and 119 seconds for westbound travel. The HERE data is over three times these amounts, even though the HERE data's extent is only double the length (from University Avenue to Jarvis Street, instead of Bay Street to Church Street). Observations of the simulation did not identify any feasible way to better match the HERE travel times; observed modelled behaviour on the street appeared to be realistic.

While transit travel time on Dundas Street westbound is notably higher than the observed data, the auto travel time validates reasonably well. Given that this is the sole outlier, and the auto travel times are acceptable, the modelled travel times can also be seen as acceptable and conservative.

Overall, this demonstrates that overall, the model is well validated in the PM peak hour and fit for assessing future impacts of the Yonge Street proposals.

## 5.3 Queue Length Validation

Field reviews were conducted at 17 intersections within the focus area to validate the modelled queue lengths. A minimum of ten minutes was spent at each intersection during the AM and PM peak periods. The results are outlined in the sections below. In all periods, the model generally had comparable or longer queues than what was seen in reality, demonstrating the robustness and conservatism of the model.

However, it is important to be cognisant of how Aimsun reports queuing information: it only counts cars on the link immediately adjacent to the intersection node. If queues extend across multiple links, the full length of the queue may not be captured here. This is a limitation of the software.

### 5.3.1 AM Queues

**Table 5-13: AM queue length validation (# of vehicles in queue)**

| TCS # | Street 1 | Street 2 | Direction | Observed (# Veh) | Modelled (#Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 4 | 10 | 6 |
| | | | SBT | 4 | 7 | 3 |
| | | | EBT | 4 | 7 | 3 |
| | | | WBT | 10 | 11 | 1 |
| 38 | Yonge Street | College Street | NBT | 1 | 7 | 6 |
| | | | SBT | 4 | 9 | 5 |
| | | | EBT | 2 | 12 | 10 |
| | | | WBT | 7 | 12 | 5 |
| 23 | Church Street | College Street | NBT | 6 | 7 | 1 |
| | | | SBT | 6 | 8 | 2 |
| | | | EBT | 6 | 11 | 5 |
| | | | WBT | 11 | 16 | 5 |
| 67 | Bay Street | Gerrard Street | NBT | 6 | 5 | -1 |
| | | | SBT | 4 | 7 | 3 |
| | | | EBT | 5 | 6 | 1 |
| | | | WBL | 0 | 5 | 5 |
| | | | WBT | 20 | 5 | -15 |
| 37 | Yonge Street | Gerrard Street | NBT | 3 | 6 | 3 |
| | | | SBT | 3 | 9 | 6 |
| | | | EBT | 5 | 10 | 5 |
| | | | WBT | 17 | 8 | -9 |

| TCS # | Street 1 | Street 2 | Direction | Observed (# Veh) | Modelled (#Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 22 | Church Street | Gerrard Street | NBT | 2 | 9 | 7 |
| | | | SBT | 3 | 9 | 6 |
| | | | EBL | 1 | 4 | 3 |
| | | | EBT | 1 | 4 | 3 |
| | | | WBL | 2 | 9 | 7 |
| | | | WBT | 11 | 9 | -2 |
| 66 | Bay Street | Dundas Street | NBT | 4 | 6 | 2 |
| | | | SBT | 6 | 4 | -2 |
| | | | EBT | 5 | 8 | 3 |
| | | | WBT | 10 | 9 | -1 |
| 36 | Yonge Street | Dundas Street | NBT | 16 | 8 | -8 |
| | | | SBT | 9 | 6 | -3 |
| | | | EBT | 8 | 10 | 2 |
| | | | WBT | 10 | 15 | 5 |
| 21 | Church Street | Dundas Street | NBT | 3 | 5 | 2 |
| | | | SBT | 3 | 12 | 9 |
| | | | EBT | 2 | 6 | 4 |
| | | | WBT | 5 | 6 | 1 |
| 1905 | Victoria Street | Dundas Street | NBT | 3 | 2 | -1 |
| | | | SBT | 0 | 3 | 3 |
| | | | EBT | 3 | 8 | 5 |
| | | | WBT | 6 | 7 | 1 |
| 20 | Church Street | Shuter Street | NBT | 5 | 5 | 0 |
| | | | SBT | 2 | 8 | 6 |
| | | | EBL | 1 | 3 | 2 |
| | | | EBT | 1 | 3 | 2 |
| | | | WBL | 1 | 3 | 2 |
| | | | WBT | 8 | 3 | -5 |
| 1518 | Victoria Street | Shuter Street | NBT | 2 | 5 | 3 |
| | | | SBT | 2 | 5 | 3 |
| | | | EBT | 2 | 6 | 4 |
| | | | WBT | 9 | 8 | -1 |
| 35 | Yonge Street | Shuter Street | NBT | 2 | 5 | 3 |
| | | | SBT | 0 | 4 | 4 |
| | | | EBT | - | - | - |
| | | | WBL | 1 | 3 | 2 |
| | | | WBT | 7 | 3 | -4 |
| 28 | Victoria Street | Queen Street | NBT | 2 | 6 | 4 |
| | | | SBT | 5 | 3 | -2 |
| | | | EBT | 3 | 9 | 6 |
| | | | WBT | 5 | 7 | 2 |
| 19 | Church Street | Queen Street | NBT | 8 | 5 | -3 |
| | | | SBT | 5 | 17 | 12 |

| TCS # | Street 1 | Street 2 | Direction | Observed (# Veh) | Modelled (#Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| | | | EBT | 6 | 7 | 1 |
| | | | WBT | 8 | 6 | -2 |
| 64 | Bay Street | Queen Street | NBT | 2 | 8 | 6 |
| | | | SBT | 5 | 4 | -2 |
| | | | EBT | 4 | 7 | 3 |
| | | | WBT | 5 | 10 | 5 |
| 34 | Yonge Street | Queen Street | NBT | 5 | 4 | -1 |
| | | | SBT | 7 | 7 | 0 |
| | | | EBT | 2 | 6 | 4 |
| | | | WBT | 6 | 13 | 7 |

**Cars exiting car park were obscured, and therefore an observed queue length could not be determined.*

### 5.3.2 PM Queues

**Table 5-14: PM queue length validation (# of vehicles in queue)**

| TCS # | Street 1 | Street 2 | Direction | Observed (# Veh) | Modelled (#Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 8 | 11 | 3 |
| | | | SBT | 4 | 7 | 3 |
| | | | EBT | 16 | 8 | -8 |
| | | | WBT | 4 | 10 | 6 |
| 38 | Yonge Street | College Street | NBT | 2 | 7 | 5 |
| | | | SBT | 3 | 6 | 3 |
| | | | EBT | 10 | 14 | 4 |
| | | | WBT | 6 | 8 | 2 |
| 23 | Church Street | College Street | NBT | 9 | 9 | 0 |
| | | | SBT | 10 | 8 | -2 |
| | | | EBT | 15 | 12 | -3 |
| | | | WBT | 15 | 8 | -7 |
| 67 | Bay Street | Gerrard Street | NBT | 6 | 4 | -2 |
| | | | SBT | 3 | 7 | 4 |
| | | | EBT | 13 | 6 | -7 |
| | | | WBL | 0 | 5 | 5 |
| | | | WBT | 4 | 5 | 1 |
| 37 | Yonge Street | Gerrard Street | NBT | 1 | 7 | 6 |
| | | | SBT | 2 | 6 | 4 |
| | | | EBT | 5 | 15 | 10 |
| | | | WBT | 4 | 8 | 4 |
| 22 | Church Street | Gerrard Street | NBT | 5 | 14 | 9 |
| | | | SBT | 7 | 8 | 1 |
| | | | EBL | 1 | 4 | 3 |
| | | | EBT | 7 | 4 | -3 |
| | | | WBL | 1 | 10 | 9 |
| | | | WBT | 16 | 10 | -6 |

| TCS # | Street 1 | Street 2 | Direction | Observed (# Veh) | Modelled (#Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 66 | Bay Street | Dundas Street | NBT | 5 | 10 | 5 |
| | | | SBT | 5 | 4 | -1 |
| | | | EBT | 5 | 10 | 5 |
| | | | WBT | 5 | 9 | 4 |
| 36 | Yonge Street | Dundas Street | NBT | 11 | 7 | -4 |
| | | | SBT | 4 | 6 | 2 |
| | | | EBT | 7 | 18 | 11 |
| | | | WBT | 10 | 11 | 1 |
| 21 | Church Street | Dundas Street | NBT | 3 | 6 | 3 |
| | | | SBT | 3 | 14 | 11 |
| | | | EBT | 8 | 7 | -1 |
| | | | WBT | 5 | 6 | 1 |
| 1905 | Victoria Street | Dundas Street | NBT | 3 | 2 | -1 |
| | | | SBT | 1 | 4 | 3 |
| | | | EBT | 4 | 9 | 5 |
| | | | WBT | 2 | 6 | 4 |
| 20 | Church Street | Shuter Street | NBT | 2 | 6 | 4 |
| | | | SBT | 2 | 8 | 6 |
| | | | EBL | 1 | 3 | 2 |
| | | | EBT | 8 | 3 | -5 |
| | | | WBL | 1 | 3 | 2 |
| | | | WBT | 3 | 3 | 0 |
| 1518 | Victoria Street | Shuter Street | NBT | 4 | 9 | 5 |
| | | | SBT | 2 | 7 | 5 |
| | | | EBT | 6 | 7 | 1 |
| | | | WBT | 2 | 8 | 6 |
| 35 | Yonge Street | Shuter Street | NBT | 11 | 8 | -3 |
| | | | SBT | 3 | 8 | 5 |
| | | | EBT* | - | - | - |
| | | | WBL | 1 | 2 | 1 |
| | | | WBT | 1 | 2 | 1 |
| 28 | Victoria Street | Queen Street | NBT | 5 | 6 | 1 |
| | | | SBT | 7 | 3 | -4 |
| | | | EBT | 7 | 12 | 5 |
| | | | WBT | 3 | 7 | 4 |
| 19 | Church Street | Queen Street | NBT | 4 | 6 | 2 |
| | | | SBT | 5 | 17 | 12 |
| | | | EBT | 12 | 10 | -2 |
| | | | WBT | 4 | 4 | 0 |
| 64 | Bay Street | Queen Street | NBT | 5 | 8 | 3 |
| | | | SBT | 10 | 4 | -7 |
| | | | EBT | 4 | 7 | 3 |
| | | | WBT | 3 | 7 | 4 |

| TCS # | Street 1 | Street 2 | Direction | Observed (# Veh) | Modelled (#Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | NBT | 6 | 12 | 6 |
| | | | SBT | 6 | 7 | 1 |
| | | | EBT | 5 | 9 | 4 |
| | | | WBT | 5 | 9 | 4 |

**Cars exiting car park were obscured, and therefore an observed queue length could not be determined.*

### 5.3.3 SAT Queues

No on-site queuing information is available for the Saturday peak period.

## 5.4 Model Stability

To ensure that the model exhibits a consistent behavior for a range of arrival patterns based on the model seed, the following tests were conducted on the base model to test model stability in the AM, PM and SAT peak periods. For each test, a total of 20 runs were conducted.

- Test 1 – Travel time standard deviations for each corridor and transit route in the focus area are provided below. There is no agreed upon metric for what is acceptable standard deviations for travel time on specific corridors between model runs. However, the observed deviations are generally small, with most being less than 30 seconds long, and only a few instances of larger deviations, particularly on Saturday (which is to be expected given the smaller amount of data available in that model's construction). The travel times observed along each corridor is generally stable. This demonstrates that the model results are reasonably consistent between model runs, suggesting that the model results are accurately capturing observed travel time performance (rather than being skewed by significant variation).

**Figure 7: Base Vehicle Travel Time Standard Deviations**

| Direction | AM | | PM | | SAT | |
|---|---|---|---|---|---|---|
| Street | NB/EB | SB/WB | NB/EB | SB/WB | NB/EB | SB/WB |
| Bay Street | 00:18 | 00:17 | 00:22 | 00:19 | 00:15 | 00:17 |
| Yonge Street | 00:05 | 00:05 | 00:05 | 00:04 | 00:15 | 00:49 |
| Church Street | 00:12 | 00:36 | 00:37 | 00:30 | 01:24 | 00:25 |
| University Avenue | 00:01 | 00:02 | 00:01 | 00:02 | 00:03 | 00:02 |
| Jarvis Street | 00:02 | 00:02 | 00:07 | 00:03 | 00:11 | 00:16 |
| Queen Street | 00:09 | 00:20 | 00:11 | 00:37 | 00:09 | 00:18 |
| Dundas Street | 00:05 | 00:21 | 00:19 | 00:08 | 00:29 | 00:56 |
| College Street | 00:09 | 00:11 | 00:10 | 00:09 | 00:31 | 00:25 |

**Figure 8: Base Transit Travel Time Standard Deviations**

| Direction | AM | | PM | | SAT | |
|---|---|---|---|---|---|---|
| Street | NB/EB | SB/WB | NB/EB | SB/WB | NB/EB | SB/WB |
| 501 | 00:21 | 00:29 | 00:37 | 01:00 | 00:11 | 00:15 |
| 505 | 00:10 | 00:26 | 00:27 | 00:16 | 00:32 | 00:50 |
| 506 | 00:15 | 00:16 | 00:12 | 00:16 | 00:37 | 00:29 |

- Test 2 - The total vehicle kilometres travelled in the model was recorded in each run. An acceptable limit of two standard deviations was agreed upon with the City. Runs beyond this limit were deemed outliers and removed from the calculations. In each of the three periods, only one or two of the twenty runs fell outside the agreed upon limits, demonstrating the stability of the models, particularly given their size and complexity, and providing further evidence of their validity.
  - AM: No outliers
  - PM: Replication 19
  - SAT: Replication 11

**Figure 9: Base AM Stability**

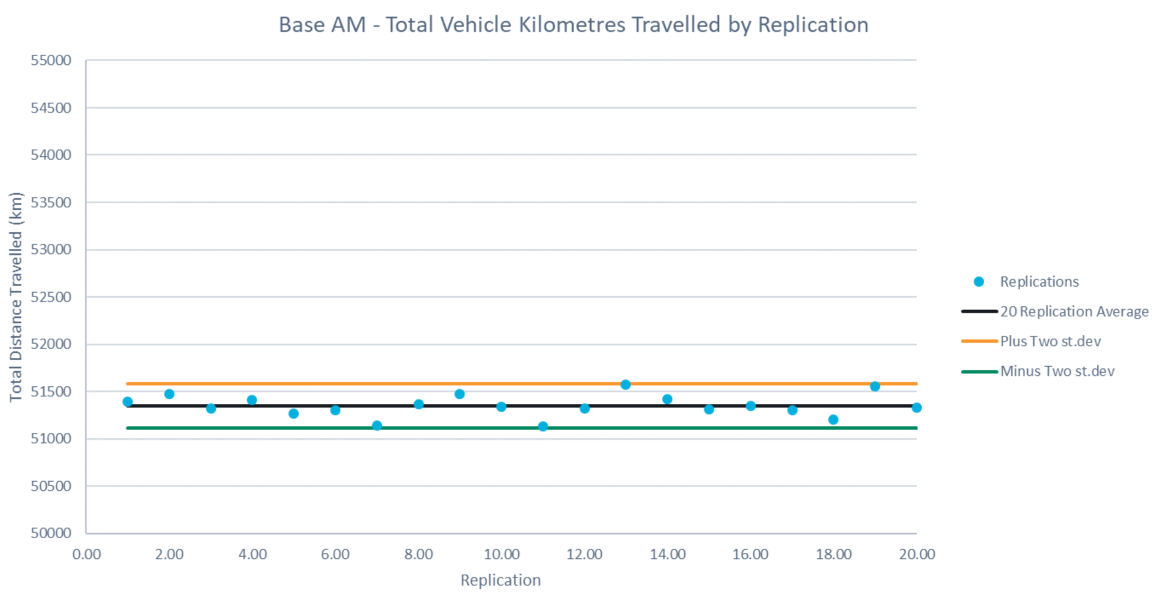


**Figure 10: Base PM Stability**

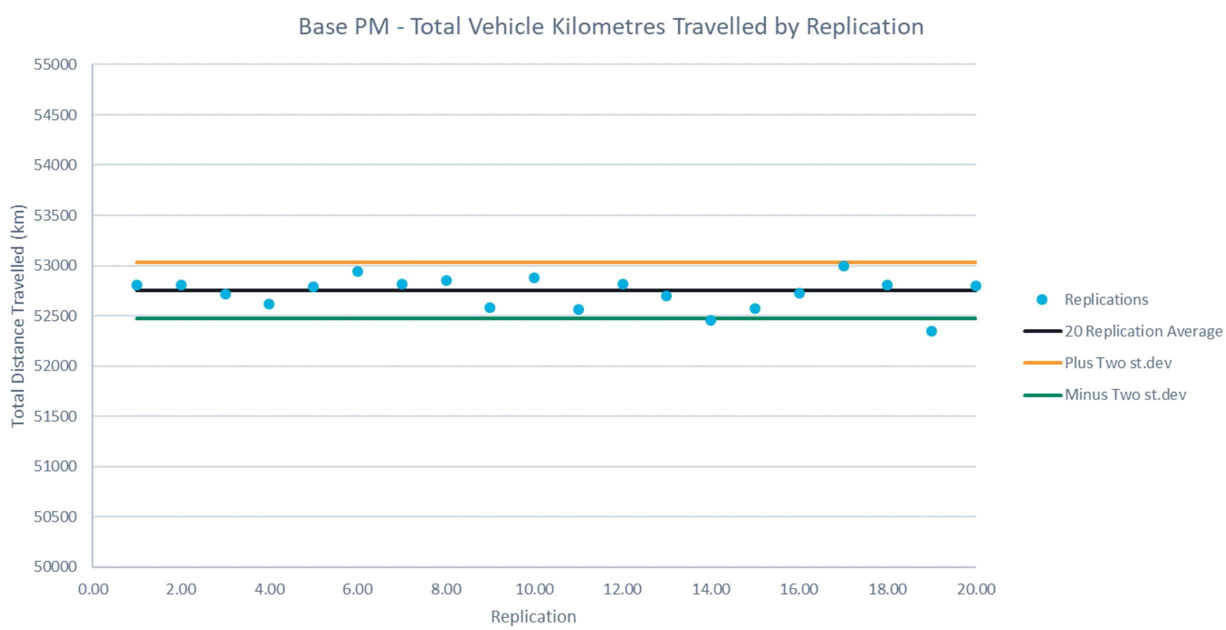
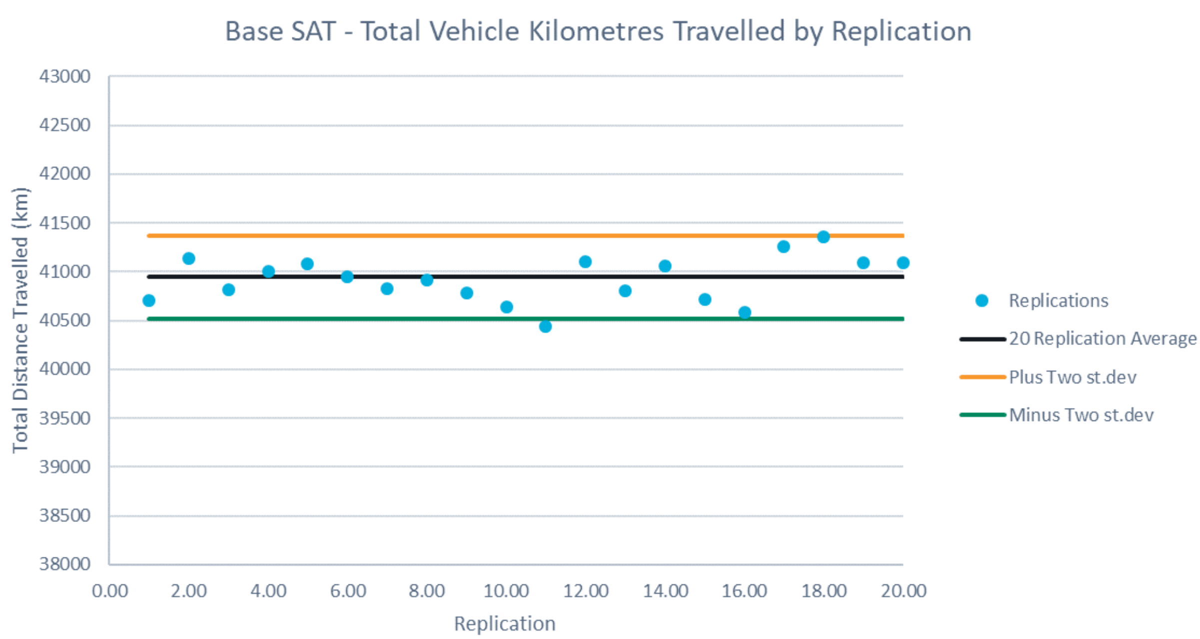



**Figure 11: Base SAT Stability**




## 5.5 Network Wide Performance

Performance statistics have been extracted from the completed model runs for the entire study area as it is currently not possible to extract this information for the expanded focus area only. The tables below show the results of the averages of 20 seeds, separated by mode, albeit with the outliers identified above removed.

These results will primarily be used as a comparison when reviewing the results of the Future Base model. However, we can note that for all modes, virtual queuing outside the study area, as well as the number of vehicles getting lost are either zero or negligible in all three periods. This confirms that the model runs well: the traffic that is meant to be in the model is able to enter, and so there are no concerns about the modelled volume of traffic being lower than intended. As well, cars are able to exit the model without getting lost or stuck, confirming that there is not too much traffic in the model, and that the model does not gridlock.

### 5.5.1 AM Network Performance

**Table 5-15: AM network performance results**

| Statistic | SOV Compliant | Streetcar (Based on CLRV) | Streetcar (Based on ALRV) | Bus |
|---|---|---|---|---|
| Delay Time (sec/km) | 99 | 50 | 48 | 68 |
| Density (veh/km) | 8 | 0 | 0 | 0 |
| Flow (veh/h) | 32742 | 81 | 28 | 115 |
| Harmonic Speed (km/h) | 19 | 13 | 9 | 12 |
| Input Count (veh) | 33464 | 82 | 28 | 116 |
| Input Flow (veh/h) | 33464 | 82 | 28 | 116 |
| Max. Virtual Queue (veh) | 68 | 2 | 1 | 3 |
| Mean Queue (veh) | 262 | 6 | 3 | 6 |
| Mean Virtual Queue (veh) | 25 | 0 | 0 | 0 |
| Missed Turns (#) | 84 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 157 | 0 | 0 | 1 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 |
| Speed (km/h) | 21 | 14 | 9 | 14 |
| Stop Time (sec/km) | 41 | 80 | 15 | 76 |
| Total Distance Travelled (km) | 45465 | 114 | 38 | 247 |
| Total Distance Travelled (Vehicles Inside) (km) | 4012 | 12 | 6 | 39 |
| Total Number of Lane Changes (#) | 47871 | 1 | 0 | 206 |
| Total Number of Stops (#) | 51839 | 230 | 168 | 452 |
| Total Travel Time (h) | 2274 | 9 | 4 | 19 |
| Total Travel Time (Vehicles Inside) (h) | 171 | 1 | 0 | 2 |
| Total Travel Time (Waiting Out) (h) | 1 | 0 | 0 | 0 |
| Travel Time (sec/km) | 192 | 276 | 414 | 289 |
| Vehicles Inside (veh) | 2407 | 9 | 5 | 18 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 0 | 0 | 0 | 0 |

| Statistic | SOV Compliant | Streetcar (Based on CLRV) | Streetcar (Based on ALRV) | Bus |
|---|---|---|---|---|
| Vehicles Outside (veh) | 32742 | 81 | 28 | 115 |
| Vehicles Waiting to Enter (veh) | 53 | 0 | 0 | 0 |
| Waiting Time in Virtual Queue (sec) | 4 | 1 | 1 | 3 |

### 5.5.2 PM Network Performance

**Table 5-16: PM network performance results**

| Statistic | SOV Compliant | Streetcar (Based on CLRV) | Streetcar (Based on ALRV) | Bus |
|---|---|---|---|---|
| Delay Time (sec/km) | 109 | 48 | 30 | 71 |
| Density (veh/km) | 9 | 0 | 0 | 0 |
| Flow (veh/h) | 34393 | 58 | 24 | 98 |
| Harmonic Speed (km/h) | 17 | 14 | 9 | 11 |
| Input Count (veh) | 35267 | 57 | 25 | 94 |
| Input Flow (veh/h) | 35267 | 57 | 25 | 94 |
| Max. Virtual Queue (veh) | 75 | 1 | 1 | 1 |
| Mean Queue (veh) | 173 | 3 | 3 | 6 |
| Mean Virtual Queue (veh) | 29 | 0 | 0 | 0 |
| Missed Turns (#) | 48 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 164 | 0 | 0 | 1 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 |
| Speed (km/h) | 20 | 15 | 9 | 13 |
| Stop Time (sec/km) | 52 | 62 | 11 | 91 |
| Total Distance Travelled (km) | 47345 | 78 | 33 | 218 |
| Total Distance Travelled (Vehicles Inside) (km) | 4519 | 6 | 5 | 38 |
| Total Number of Lane Changes (#) | 50013 | 0 | 0 | 188 |
| Total Number of Stops (#) | 64381 | 124 | 139 | 414 |
| Total Travel Time (h) | 2552 | 6 | 4 | 18 |
| Total Travel Time (Vehicles Inside) (h) | 221 | 0 | 0 | 2 |
| Total Travel Time (Waiting Out) (h) | 5 | 0 | 0 | 0 |
| Travel Time (sec/km) | 209 | 263 | 423 | 319 |
| Vehicles Inside (veh) | 2733 | 5 | 4 | 14 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 34393 | 58 | 24 | 98 |
| Vehicles Waiting to Enter (veh) | 64 | 0 | 0 | 0 |
| Waiting Time in Virtual Queue (sec) | 2 | 0 | 1 | 0 |

### 5.5.3 SAT Network Performance

**Table 5-17: SAT network performance results**

| Row Labels | SOV Compliant | Streetcar (Based on ALRV) | Streetcar (Based on CLRV) | Streetcar (LFLRV) | Bus |
|---|---|---|---|---|---|
| Delay Time | 114 | 34 | 62 | 61 | 75 |
| Density | 7 | 0 | 0 | 0 | 0 |
| Flow | 23520 | 23 | 27 | 12 | 65 |
| Harmonic Speed | 17 | 10 | 18 | 19 | 12 |
| Input Count | 24546 | 23 | 27 | 14 | 68 |
| Input Flow | 24546 | 23 | 27 | 14 | 68 |
| Max. Virtual Queue | 55 | 1 | 1 | 1 | 1 |
| Mean Queue | 383 | 2 | 1 | 1 | 4 |
| Mean Virtual Queue | 13 | 0 | 0 | 0 | 0 |
| Missed Turns | 34 | 0 | 0 | 0 | 0 |
| Number of Lane Changes | 146 | 0 | 0 | 0 | 1 |
| Number of Stops | 0 | 0 | 0 | 0 | 0 |
| Speed | 20 | 11 | 19 | 19 | 14 |
| Stop Time | 54 | 14 | 0 | 0 | 127 |
| Total Distance Travelled | 37246 | 31 | 36 | 16 | 133 |
| Total Distance Travelled (Vehicles Inside) | 4411 | 4 | 1 | 2 | 22 |
| Total Number of Lane Changes | 44520 | 0 | 0 | 0 | 173 |
| Total Number of Stops | 46565 | 138 | 0 | 0 | 334 |
| Total Travel Time | 2027 | 3 | 2 | 1 | 10 |
| Total Travel Time (Vehicles Inside) | 233 | 0 | 0 | 0 | 1 |
| Total Travel Time (Waiting Out) | 3 | 0 | 0 | 0 | 0 |
| Travel Time | 209 | 344 | 195 | 192 | 294 |
| Vehicles Inside | 2382 | 3 | 2 | 2 | 12 |
| Vehicles Lost Inside | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside | 0 | 0 | 0 | 0 | 0 |
| Vehicles Outside | 23520 | 23 | 27 | 12 | 65 |
| Vehicles Waiting to Enter | 39 | 0 | 0 | 0 | 0 |
| Waiting Time in Virtual Queue | 1 | 1 | 0 | 0 | 0 |

# 6 Future Model Development

The future base models ("Do Nothing") assess the operation of the existing network the future demand forecast. No changes to the physical road network have been undertaken, however the signal timings have been optimised to cater for changes in traffic flows.

The results from the future base models have been compared to the results of the base models.

## 6.1 Demand

Future car demand has been developed based on the 2031 EMME databanks provided to Steer by the City. Adjustments made during the 2018 base year calibration and validation have been replicated in the future demand. The process is outlined in more detail below:

- Import 2031 EMME databanks into Aimsun Next;
- Re-run static assignment (taking into consideration updated transit information);
- Create traversal matrices for study area;
- Apply factors to traversal matrices which replicate the adjustments undertaken during the 2018 base year calibration and validation and include matrix Furness and static OD adjustment scenarios;
- Run static assignment of updated matrices to the subnetwork; and,
- Apply the manual adjustments made to the Base matrices.

## 6.2 Trucks

The factors used to derive the 2018 base year model truck demand have been used to calculate the 2031 truck demand from the final 2031 car matrices. More information on this process has already been highlighted in section 3.6.4.

## 6.3 Transit

The City provided Steer with the following information:

- A future year service summary for all TTC routes which included service intervals and vehicle types for each transit route; and
- Advice that growth on transit trips destined to Planning District 1 (which roughly equates to the Toronto downtown area) was similar to pedestrian trip growth at about 29% between the 2011 and 2031 EMME models.

The information was used to update boarding and alighting data using a 1.5% annual growth rate and re-calculate dwell times based on the updated numbers of boarders and alighters at each stop.

Transit routes in the models have been amended to reflect updated service intervals, dwell times and vehicle types.

## 6.4 Pedestrians

The City provided Steer with the growth in walk trips in the 2011 and 2031 EMME models within Planning District 1 (which roughly equates to the Toronto downtown area). The growth for this area is approximately 28% over the 20 years. Based on this figure and to provide consistency with similar assumptions made by the City on other projects, the growth rate has been assumed to be 1.5% per year between the 2018 base model and the 2031 future base model. The annual factor of 1.5% resulted in a growth of roughly 21.4% between 2018 and 2031 which has been applied on a cell-by cell basis to the 2018 base model pedestrian matrices to calculate the future pedestrian demand.

## 6.5 Cyclists

In absence of predicted growth rates or other information, the rate of growth in line with growth in the EMME demand models provided by transportation services has been applied to the cycle demand (as instructed by the City).

## 6.6 Excluded Seeds

After all 20 runs were completed, the runs were checked for outliers using VKT as a metric, based on the limit of plus or minus two standard deviations. Individual seeds beyond this limit have been excluded from the analysis to not impact on the results. The affected seeds are:

- AM: Replication 18
- PM: Replication 13
- SAT: Replication 3

## 6.7 Travel Time Results

### 6.7.1 AM Peak

**Table 6-1: AM base vs. future base general traffic travel time comparison (north-south)**

| Corridor | NB | | | SB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| University Avenue | 03:21 | 04:15 | +54 | 03:31 | 04:09 | +38 |
| Bay Street | 03:21 | 02:58 | -23 | 03:26 | 03:25 | -1 |
| Yonge Street | 03:31 | 04:03 | +32 | 04:16 | 05:18 | +62 |
| Church Street | 03:12 | 03:22 | +10 | 02:23 | 02:46 | +23 |
| Jarvis Street | 03:05 | 03:28 | +23 | 02:47 | 04:06 | +79 |

**Table 6-2: AM base vs. future base general traffic travel time comparison (east-west)**

| Corridor | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| College Street | 04:38 | 06:42 | +124 | 05:44 | 07:09 | +85 |
| Dundas Street | 03:58 | 05:17 | +79 | 04:43 | 06:28 | +106 |
| Queen Street | 04:46 | 05:27 | +41 | 05:26 | 07:03 | +97 |

**Table 6-3: AM base vs. future base transit travel time comparison (north-south)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| 5A | 05:56 | 05:59 | +3 | 05:11 | 07:20 | +129 |
| 6A | 17:15 | 17:22 | +7 | 16:54 | 16:54 | -0 |
| 6B | 14:41 | 14:54 | +13 | 16:04 | 16:29 | +25 |

**Table 6-4: AM base vs. future base transit travel time comparison (east-west)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| 501 | 08:55 | 08:59 | +4 | 10:23 | 10:24 | +1 |
| 505 | 07:59 | 08:56 | +57 | 08:54 | 08:49 | -6 |
| 506 | 07:55 | 10:22 | +147 | 08:18 | 11:58 | +219 |

The modelled Future Base AM results show generally modest increases in travel time on the major arterials in the north and south direction, with only Jarvis Street southbound and Yonge Street southbound showing increases above a minute. Impacts are more substantial on the east-west corridors (especially given the short 1 km length of this segment), with most routes showing over a minute increase in travel time, and several nearing or above two minutes. Impacts to transit are only significant on College Street, where both directions see significant increases to travel time, as well as Dundas Street in the eastbound direction, which sees a one minute increase.

### PM Peak

**Table 6-5: PM base vs. future base general traffic travel time comparison (north-south)**

| Corridor | NB | | | SB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| University Avenue | 04:54 | 06:08 | +75 | 04:36 | 05:03 | +27 |
| Bay Street | 04:47 | 05:06 | +19 | 04:42 | 05:00 | +17 |
| Yonge Street | 04:04 | 04:33 | +30 | 04:25 | 05:59 | +95 |
| Church Street | 02:06 | 02:07 | +1 | 03:17 | 03:46 | +29 |
| Jarvis Street | 03:48 | 05:42 | +114 | 03:27 | 04:42 | +75 |

**Table 6-6: PM base vs. future base general traffic travel time comparison (east-west)**

| Corridor | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| College Street | 05:39 | 07:42 | +123 | 03:41 | 04:32 | +51 |
| Dundas Street | 05:54 | 10:08 | +254 | 05:14 | 06:03 | +49 |
| Queen Street | 05:08 | 07:08 | +120 | 04:31 | 05:21 | +50 |

**Table 6-7: PM base vs. future base transit travel time comparison (north-south)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| 5A | 05:41 | 05:38 | -3 | 04:46 | 04:46 | +0 |
| 6A | 17:26 | 18:31 | +65 | 15:48 | 16:03 | +15 |
| 6B | 15:15 | 15:56 | +41 | 15:21 | 15:38 | +16 |

**Table 6-8: PM base vs. future base transit travel time comparison (east-west)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| 501 | 10:18 | 09:18 | -60 | 10:12 | 14:11 | +239 |
| 505 | 10:17 | 13:20 | +183 | 09:47 | 10:11 | +24 |
| 506 | 08:24 | 13:12 | +288 | 08:01 | 12:41 | +280 |

Significant increases in travel time are seen on the east-west corridors, particularly eastbound, with over two minutes of travel time seen on all three east-west streets. Increases to travel time on the east-west axis can be attributed to the future demand matrix received from the City; it appears that demand east-west will increase significantly more than the demand in the north-south direction. Of particular concern is Dundas Street eastbound – this is a conflict point, as both Church Street and Dundas Street are very busy at this location, and giving preference to one means sacrificing performance on the other. Major increases in travel time on the east-west transit routes were also observed, reflecting the higher auto transit times seen there.

### 6.7.2 SAT Peak

**Table 6-9: SAT base vs. future base general traffic travel time comparison (north-south)**

| Corridor | NB | | | SB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| University Avenue | 03:14 | 03:21 | +7 | 03:41 | 04:32 | +51 |
| Bay Street | 04:49 | 05:10 | +21 | 05:14 | 06:03 | +49 |
| Yonge Street | 04:38 | 03:45 | -52 | 04:31 | 05:21 | +50 |
| Church Street | 02:01 | 02:03 | +2 | 03:30 | 03:39 | +9 |
| Jarvis Street | 04:21 | 04:10 | -11 | 03:45 | 04:31 | +46 |

**Table 6-10: SAT base vs. future base general traffic travel time comparison (east-west)**

| Corridor | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| College Street | 04:35 | 05:24 | +49 | 04:31 | 05:29 | +58 |
| Dundas Street | 05:44 | 07:29 | +105 | 08:20 | 08:21 | +1 |
| Queen Street | 05:05 | 05:00 | -5 | 04:27 | 05:31 | +64 |

**Table 6-11: SAT base vs. future base transit travel time comparison (north-south)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| 5A | 04:09 | 04:21 | +12 | 04:08 | 04:18 | +10 |
| 6A | 14:24 | 15:07 | +43 | 14:48 | 15:51 | +63 |
| 6B | | | | | | |

**Table 6-12: SAT base vs. future base transit travel time comparison (east-west)**

| Route | EB | | | WB | | |
|---|---|---|---|---|---|---|
| | Base | FB | Diff (s) | Base | FB | Diff (s) |
| 501 | 07:37 | 08:07 | +30 | 07:07 | 07:21 | +14 |
| 505 | 08:20 | 09:28 | +68 | 11:08 | 11:05 | -3 |
| 506 | 08:04 | 10:57 | +173 | 07:15 | 08:16 | +61 |

As before, the east-west streets are more strongly impacted than the north-south streets in the future baseline. College Street, Dundas Street and Queen Street all see at least a minute of increased travel time in at least one direction, though that direction varies. North-south streets are impacted less significantly, though some do still see nearly a minute of increased travel time.

The most significant impacts to transit are seen in both directions ion College Street, with over a minute of increased travel time westbound, and nearly three minutes eastbound, mirroring the increase in auto travel times on this street. The 505 also sees over a minute of increased travel time, mirroring the increase in auto travel time there.

## 6.8 Queue Lengths

The queue results shown below identify a modest increase in queue length between the base and future base models in the AM and SAT periods, and a more significant increase in the PM period. However, it is important to remember that these results only show queues on the first link adjacent to an intersection. Queues that extend across multiple links in the model will not be identified here properly. A visual inspection of the simulation shows that queue lengths have increased along the major arterials due to the increased volume of traffic in the model. This was especially notable in the PM period eastbound on Dundas Street and westbound on Queen Street.

### 6.8.1 AM Peak

**Table 6-13: AM base vs. future base queue length comparison**

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 10 | 10 | 0 |
| | | | SBT | 7 | 7 | 1 |
| | | | EBT | 7 | 8 | 1 |
| | | | WBT | 11 | 16 | 5 |
| 38 | Yonge Street | College Street | NBT | 7 | 7 | 0 |
| | | | SBT | 9 | 9 | 0 |
| | | | EBT | 12 | 14 | 2 |
| | | | WBT | 12 | 12 | 0 |
| 23 | Church Street | College Street | NBT | 7 | 8 | 1 |
| | | | SBT | 8 | 15 | 6 |
| | | | EBT | 11 | 14 | 2 |
| | | | WBT | 16 | 16 | 1 |
| 67 | Bay Street | Gerrard Street | NBT | 5 | 5 | 0 |
| | | | SBT | 7 | 7 | 0 |
| | | | EBT | 6 | 6 | 0 |
| | | | WBL | 5 | 5 | 0 |
| | | | WBT | 5 | 5 | 0 |
| 37 | Yonge Street | Gerrard Street | NBT | 6 | 7 | 1 |
| | | | SBT | 9 | 10 | 2 |
| | | | EBT | 10 | 14 | 4 |
| | | | WBT | 8 | 8 | 0 |
| 22 | Church Street | Gerrard Street | NBT | 9 | 9 | 0 |
| | | | SBT | 9 | 9 | 0 |
| | | | EBL | 4 | 4 | 0 |
| | | | EBT | 4 | 4 | 0 |
| | | | WBL | 9 | 10 | 1 |
| | | | WBT | 9 | 10 | 1 |
| 66 | Bay Street | Dundas Street | NBT | 6 | 6 | 0 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 8 | 16 | 8 |
| | | | WBT | 9 | 16 | 6 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 36 | Yonge Street | Dundas Street | NBT | 8 | 8 | 0 |
| | | | SBT | 6 | 6 | 0 |
| | | | EBT | 10 | 18 | 8 |
| | | | WBT | 15 | 16 | 1 |
| 21 | Church Street | Dundas Street | NBT | 5 | 5 | 0 |
| | | | SBT | 12 | 14 | 1 |
| | | | EBT | 6 | 7 | 1 |
| | | | WBT | 6 | 6 | 0 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 0 |
| | | | SBT | 3 | 3 | 0 |
| | | | EBT | 8 | 13 | 5 |
| | | | WBT | 7 | 8 | 1 |
| 20 | Church Street | Shuter Street | NBT | 5 | 5 | 0 |
| | | | SBT | 8 | 11 | 2 |
| | | | EBL | 3 | 3 | 0 |
| | | | EBT | 3 | 3 | 0 |
| | | | WBL | 3 | 3 | 0 |
| | | | WBT | 3 | 3 | 0 |
| 1518 | Victoria Street | Shuter Street | NBT | 5 | 7 | 2 |
| | | | SBT | 5 | 6 | 1 |
| | | | EBT | 6 | 6 | 0 |
| | | | WBT | 8 | 8 | 0 |
| 35 | Yonge Street | Shuter Street | NBT | 5 | 7 | 2 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 2 | 5 | 3 |
| | | | WBL | 3 | 3 | 0 |
| | | | WBT | 3 | 3 | 0 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 6 | 0 |
| | | | SBT | 3 | 3 | 0 |
| | | | EBT | 9 | 12 | 4 |
| | | | WBT | 7 | 7 | 0 |
| 19 | Church Street | Queen Street | NBT | 5 | 5 | 0 |
| | | | SBT | 17 | 19 | 2 |
| | | | EBT | 7 | 10 | 3 |
| | | | WBT | 6 | 6 | 0 |
| 64 | Bay Street | Queen Street | NBT | 8 | 8 | 0 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 10 | 9 | -1 |
| 34 | Yonge Street | Queen Street | NBT | 4 | 3 | -1 |
| | | | SBT | 7 | 7 | 0 |
| | | | EBT | 6 | 9 | 2 |
| | | | WBT | 13 | 12 | 0 |

### 6.8.2 PM Peak

**Table 6-14: PM base vs. future base queue length comparison**

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 11 | 11 | 0 |
| | | | SBT | 7 | 8 | 1 |
| | | | EBT | 8 | 8 | 0 |
| | | | WBT | 10 | 19 | 9 |
| 38 | Yonge Street | College Street | NBT | 7 | 7 | 0 |
| | | | SBT | 6 | 5 | 0 |
| | | | EBT | 14 | 17 | 3 |
| | | | WBT | 8 | 12 | 4 |
| 23 | Church Street | College Street | NBT | 9 | 9 | 0 |
| | | | SBT | 8 | 13 | 5 |
| | | | EBT | 12 | 13 | 2 |
| | | | WBT | 8 | 16 | 8 |
| 67 | Bay Street | Gerrard Street | NBT | 4 | 4 | 0 |
| | | | SBT | 7 | 7 | 0 |
| | | | EBT | 6 | 6 | 0 |
| | | | WBL | 5 | 5 | 0 |
| | | | WBT | 5 | 5 | 0 |
| 37 | Yonge Street | Gerrard Street | NBT | 7 | 8 | 1 |
| | | | SBT | 6 | 6 | 0 |
| | | | EBT | 15 | 16 | 1 |
| | | | WBT | 8 | 8 | 0 |
| 22 | Church Street | Gerrard Street | NBT | 14 | 10 | -4 |
| | | | SBT | 8 | 10 | 2 |
| | | | EBL | 4 | 4 | 0 |
| | | | EBT | 4 | 4 | 0 |
| | | | WBL | 10 | 11 | 1 |
| | | | WBT | 10 | 11 | 1 |
| 66 | Bay Street | Dundas Street | NBT | 10 | 10 | 0 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 10 | 18 | 8 |
| | | | WBT | 9 | 13 | 4 |
| 36 | Yonge Street | Dundas Street | NBT | 7 | 7 | 0 |
| | | | SBT | 6 | 6 | 0 |
| | | | EBT | 18 | 19 | 1 |
| | | | WBT | 11 | 16 | 5 |
| 21 | Church Street | Dundas Street | NBT | 6 | 6 | 0 |
| | | | SBT | 14 | 14 | 0 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 6 | 6 | 0 |
| 1905 | | | NBT | 2 | 2 | 0 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| | Victoria Street | Dundas Street | SBT | 4 | 4 | 1 |
| | | | EBT | 9 | 14 | 5 |
| | | | WBT | 6 | 8 | 2 |
| 20 | Church Street | Shuter Street | NBT | 6 | 6 | 0 |
| | | | SBT | 8 | 11 | 3 |
| | | | EBL | 3 | 3 | 0 |
| | | | EBT | 3 | 3 | 0 |
| | | | WBL | 3 | 3 | 0 |
| | | | WBT | 3 | 3 | 0 |
| 1518 | Victoria Street | Shuter Street | NBT | 9 | 11 | 2 |
| | | | SBT | 7 | 6 | -1 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 8 | 8 | 0 |
| 35 | Yonge Street | Shuter Street | NBT | 8 | 8 | 0 |
| | | | SBT | 8 | 8 | 0 |
| | | | EBT | 26 | 22 | -4 |
| | | | WBL | 2 | 2 | 0 |
| | | | WBT | 2 | 2 | 0 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 7 | 0 |
| | | | SBT | 3 | 3 | 0 |
| | | | EBT | 12 | 13 | 1 |
| | | | WBT | 7 | 7 | 1 |
| 19 | Church Street | Queen Street | NBT | 6 | 6 | 0 |
| | | | SBT | 17 | 21 | 4 |
| | | | EBT | 10 | 10 | 0 |
| | | | WBT | 4 | 6 | 2 |
| 64 | Bay Street | Queen Street | NBT | 8 | 8 | 1 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 7 | 12 | 4 |
| 34 | Yonge Street | Queen Street | NBT | 12 | 5 | -7 |
| | | | SBT | 7 | 5 | -3 |
| | | | EBT | 9 | 10 | 1 |
| | | | WBT | 9 | 13 | 4 |

### 6.8.3 SAT Peak

**Table 6-15: SAT base vs. future base queue length comparison**

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 13 | 13 | 0 |
| | | | SBT | 10 | 10 | 0 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 6 | 10 | 4 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| 38 | Yonge Street | College Street | NBT | 2 | 2 | 0 |
| | | | SBT | 8 | 8 | 0 |
| | | | EBT | 11 | 9 | -2 |
| | | | WBT | 8 | 11 | 4 |
| 23 | Church Street | College Street | NBT | 9 | 8 | -1 |
| | | | SBT | 8 | 12 | 4 |
| | | | EBT | 14 | 13 | 0 |
| | | | WBT | 11 | 15 | 4 |
| 67 | Bay Street | Gerrard Street | NBT | 4 | 5 | 0 |
| | | | SBT | 10 | 9 | 0 |
| | | | EBT | 5 | 5 | 0 |
| | | | WBL | 5 | 5 | 0 |
| | | | WBT | 5 | 5 | 0 |
| 37 | Yonge Street | Gerrard Street | NBT | 6 | 7 | 1 |
| | | | SBT | 13 | 13 | 0 |
| | | | EBT | 16 | 16 | 0 |
| | | | WBT | 8 | 8 | 0 |
| 22 | Church Street | Gerrard Street | NBT | 9 | 9 | 0 |
| | | | SBT | 8 | 10 | 2 |
| | | | EBL | 4 | 3 | 0 |
| | | | EBT | 4 | 3 | 0 |
| | | | WBL | 10 | 10 | 0 |
| | | | WBT | 10 | 10 | 0 |
| 66 | Bay Street | Dundas Street | NBT | 8 | 9 | 0 |
| | | | SBT | 7 | 7 | 0 |
| | | | EBT | 11 | 15 | 4 |
| | | | WBT | 6 | 7 | 1 |
| 36 | Yonge Street | Dundas Street | NBT | 8 | 8 | 0 |
| | | | SBT | 6 | 6 | 0 |
| | | | EBT | 18 | 19 | 1 |
| | | | WBT | 14 | 15 | 1 |
| 21 | Church Street | Dundas Street | NBT | 5 | 5 | 0 |
| | | | SBT | 10 | 9 | -1 |
| | | | EBT | 6 | 6 | 0 |
| | | | WBT | 6 | 6 | 0 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 0 |
| | | | SBT | 2 | 2 | 0 |
| | | | EBT | 3 | 4 | 0 |
| | | | WBT | 8 | 8 | 0 |
| 20 | Church Street | Shuter Street | NBT | 4 | 4 | 0 |
| | | | SBT | 5 | 9 | 4 |
| | | | EBL | 3 | 3 | 0 |
| | | | EBT | 3 | 3 | 0 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | Difference (# Veh) |
|---|---|---|---|---|---|---|
| | | | WBL | 3 | 3 | 0 |
| | | | WBT | 3 | 3 | 0 |
| 1518 | Victoria Street | Shuter Street | NBT | 3 | 3 | 0 |
| | | | SBT | 3 | 2 | 0 |
| | | | EBT | 6 | 6 | 0 |
| | | | WBT | 8 | 8 | 0 |
| 35 | Yonge Street | Shuter Street | NBT | 6 | 6 | -1 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 2 | 2 | 0 |
| | | | WBL | 2 | 3 | 0 |
| | | | WBT | 2 | 3 | 0 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 7 | 0 |
| | | | SBT | 3 | 3 | 0 |
| | | | EBT | 9 | 9 | 0 |
| | | | WBT | 7 | 7 | 0 |
| 19 | Church Street | Queen Street | NBT | 4 | 4 | 0 |
| | | | SBT | 11 | 14 | 3 |
| | | | EBT | 8 | 10 | 2 |
| | | | WBT | 5 | 6 | 0 |
| 64 | Bay Street | Queen Street | NBT | 9 | 12 | 2 |
| | | | SBT | 7 | 7 | 0 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 7 | 7 | -1 |
| 34 | Yonge Street | Queen Street | NBT | 2 | 1 | 0 |
| | | | SBT | 4 | 5 | 0 |
| | | | EBT | 7 | 7 | 0 |
| | | | WBT | 11 | 11 | 0 |

## 6.9 Network Wide Performance

### 6.9.1 AM Peak

**Table 6-16: AM base vs. future base network wide performance comparison**

| Statistic | SOV Compliant | Change from Base | Streetcar (LFLRV) | Change from Base | Bus | Change from Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 158 | 59 | 83 | 34 | 97 | 29 |
| Density (veh/km) | 12 | 4 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 35968 | 3226 | 112 | 58 | 80 | -34 |
| Harmonic Speed (km/h) | 14 | -4 | 10 | -1 | 14 | 1 |
| Input Count (veh) | 37895 | 4431 | 116 | 61 | 84 | -33 |
| Input Flow (veh/h) | 37895 | 4431 | 116 | 61 | 84 | -33 |
| Max. Virtual Queue (veh) | 1354 | 1286 | 7 | 6 | 5 | 2 |
| Mean Queue (veh) | 709 | 447 | 12 | 7 | 5 | -1 |
| Mean Virtual Queue (veh) | 588 | 564 | 2 | 2 | 2 | 2 |
| Missed Turns (#) | 65 | -18 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 197 | 40 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 18 | -4 | 10 | -1 | 14 | 0 |
| Stop Time (sec/km) | 66 | 26 | 71 | 23 | 122 | 46 |
| Total Distance Travelled (km) | 51617 | 6152 | 153 | 77 | 212 | -35 |
| Total Distance Travelled (Vehicles Inside) (km) | 6397 | 2385 | 20 | 11 | 43 | 4 |
| Total Number of Lane Changes (#) | 60085 | 12214 | 2 | 2 | 148 | -59 |
| Total Number of Stops (#) | 73729 | 21890 | 489 | 291 | 285 | -167 |
| Total Travel Time (h) | 3352 | 1078 | 16 | 10 | 16 | -3 |
| Total Travel Time (Vehicles Inside) (h) | 459 | 288 | 2 | 1 | 3 | 0 |
| Total Travel Time (Waiting Out) (h) | 131 | 130 | 1 | 1 | 0 | 0 |
| Travel Time (sec/km) | 250 | 58 | 374 | 28 | 262 | -26 |

| Statistic | SOV Compliant | Change from Base | Streetcar (LFLRV) | Change from Base | Bus | Change from Base |
|---|---|---|---|---|---|---|
| Vehicles Inside (veh) | 4184 | 1777 | 19 | 12 | 15 | -2 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 35968 | 3226 | 112 | 58 | 80 | -34 |
| Vehicles Waiting to Enter (veh) | 1339 | 1286 | 5 | 5 | 3 | 3 |
| Waiting Time in Virtual Queue (sec) | 45 | 42 | 23 | 22 | 35 | 32 |

The results identify an increased level of traffic volume in the model (over 3000 auto veh/hr), resulting in increased congestion, represented by a 4 km/hr decrease in the average auto speed in the model, a 58 second increase in the total auto travel time (represented as seconds per kilometre), and a significant increase in the average number of cars queuing at a time (447 additional vehicles). There has been an increase in vehicles waiting outside the network, as well as virtual queue lengths, due to this demand. However, it does not appear that this is significant, as does not mean that the flow in the model is understated.

Transit vehicles see a significant increase in delay per kilometre (34 s/km for streetcar and 29 s/km for bus), and travel time per kilometre (28 s/km for streetcar) on average, though the travel time per kilometre for buses actually goes down (-26 s/km). Streetcars also see a decrease in average speed by 1 km/hr, while busses do not see any change.

### 6.9.2 PM Peak

**Table 6-17: PM base vs. future base network wide performance comparison**

| Statistic | SOV Compliant | Change from Base | Streetcar (LFLRV) | Change from Base | Bus | Change from Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 177 | 68 | 104 | 65 | 122 | 51 |
| Density (veh/km) | 14 | 5 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 37908 | 3515 | 95 | 54 | 70 | -28 |
| Harmonic Speed (km/h) | 13 | -4 | 9 | -3 | 13 | 1 |
| Input Count (veh) | 40411 | 5144 | 100 | 58 | 73 | -21 |
| Input Flow (veh/h) | 40411 | 5144 | 100 | 58 | 73 | -21 |
| Max. Virtual Queue (veh) | 1149 | 1073 | 8 | 7 | 3 | 2 |

| Statistic | SOV Compliant | Change from Base | Streetcar (LFLRV) | Change from Base | Bus | Change from Base |
|---|---|---|---|---|---|---|
| Mean Queue (veh) | 721 | 548 | 12 | 9 | 5 | -1 |
| Mean Virtual Queue (veh) | 403 | 374 | 2 | 2 | 0 | 0 |
| Missed Turns (#) | 63 | 15 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 209 | 45 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | -3 | 10 | -2 | 14 | 1 |
| Stop Time (sec/km) | 89 | 37 | 102 | 66 | 118 | 27 |
| Total Distance Travelled (km) | 54390 | 7045 | 128 | 72 | 179 | -38 |
| Total Distance Travelled (Vehicles Inside) (km) | 7457 | 2938 | 21 | 16 | 39 | 2 |
| Total Number of Lane Changes (#) | 63870 | 13856 | 0 | 0 | 134 | -54 |
| Total Number of Stops (#) | 89944 | 25563 | 425 | 294 | 231 | -183 |
| Total Travel Time (h) | 3767 | 1216 | 15 | 10 | 14 | -4 |
| Total Travel Time (Vehicles Inside) (h) | 628 | 407 | 2 | 2 | 2 | 1 |
| Total Travel Time (Waiting Out) (h) | 116 | 111 | 1 | 1 | 0 | 0 |
| Travel Time (sec/km) | 275 | 67 | 421 | 78 | 284 | -34 |
| Vehicles Inside (veh) | 4995 | 2263 | 18 | 13 | 15 | 0 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 1 | 1 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 37908 | 3515 | 95 | 54 | 70 | -28 |
| Vehicles Waiting to Enter (veh) | 1139 | 1075 | 6 | 6 | 1 | 1 |
| Waiting Time in Virtual Queue (sec) | 17 | 15 | 21 | 21 | 2 | 2 |

The results identify the PM peak period as the most critical in terms of impact in the future baseline. There is a significant increased level of traffic volume in the model (over 5000 auto veh/hr), resulting in significantly increased congestion, represented by a 3 km/hr decrease in the average auto speed in the model, a 67 second increase in the total auto travel time (represented as seconds per kilometre), and a significant increase in the average number of cars queuing at a time (548 additional vehicles). There has been an increase in vehicles waiting outside the network, as well as virtual queue lengths, due to this demand. However, it does not appear that this is significant, as does not mean that the flow in the model is understated.

Transit vehicles see a significant increase in delay per kilometre (65 s/km for streetcar and 51 s/km for bus), and travel time per kilometre (78 s/km for streetcar) on average, though the travel time per kilometre for buses actually goes down (-34 s/km). Streetcars also see a decrease in average speed by 2 km/hr, while busses increase slightly by 1km/hr.

### 6.9.3 SAT Peak

**Table 6-18: SAT base vs. future base network wide performance comparison**

| Statistic | SOV Compliant | Change from Base | Streetcar (LFLRV) | Change from Base | Bus | Change from Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 140 | 26 | 72 | 20 | 65 | -10 |
| Density (veh/km) | 8 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 25094 | 1575 | 79 | 58 | 29 | -36 |
| Harmonic Speed (km/h) | 15 | -2 | 11 | -5 | 18 | 6 |
| Input Count (veh) | 26487 | 1941 | 82 | 60 | 32 | -37 |
| Input Flow (veh/h) | 26487 | 1941 | 82 | 60 | 32 | -37 |
| Max. Virtual Queue (veh) | 209 | 154 | 4 | 3 | 1 | 0 |
| Mean Queue (veh) | 456 | 73 | 7 | 6 | 2 | -2 |
| Mean Virtual Queue (veh) | 64 | 51 | 1 | 1 | 0 | 0 |
| Missed Turns (#) | 18 | -16 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 165 | 19 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 19 | -1 | 12 | -4 | 19 | 5 |
| Stop Time (sec/km) | 68 | 14 | 66 | 61 | 130 | 3 |
| Total Distance Travelled (km) | 39460 | 2213 | 110 | 83 | 85 | -48 |
| Total Distance Travelled (Vehicles Inside) (km) | 5259 | 848 | 16 | 13 | 16 | -6 |
| Total Number of Lane Changes (#) | 50415 | 5895 | 0 | 0 | 126 | -46 |
| Total Number of Stops (#) | 56153 | 9588 | 336 | 290 | 114 | -220 |

| Statistic | SOV Compliant | Change from Base | Streetcar (LFLRV) | Change from Base | Bus | Change from Base |
|---|---|---|---|---|---|---|
| Total Travel Time (h) | 2346 | 318 | 10 | 8 | 5 | -5 |
| Total Travel Time (Vehicles Inside) (h) | 314 | 81 | 1 | 1 | 1 | 0 |
| Total Travel Time (Waiting Out) (h) | 19 | 16 | 0 | 0 | 0 | 0 |
| Travel Time (sec/km) | 234 | 25 | 328 | 84 | 200 | -94 |
| Vehicles Inside (veh) | 2896 | 514 | 12 | 10 | 7 | -5 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 25094 | 1575 | 79 | 58 | 29 | -36 |
| Vehicles Waiting to Enter (veh) | 201 | 162 | 2 | 2 | 0 | 0 |
| Waiting Time in Virtual Queue (sec) | 4 | 3 | 2 | 2 | 0 | 0 |

There is a small increased level of traffic volume in the model (over 1575 auto veh/hr), resulting in small increased congestion, represented by a 1 km/hr decrease in the average auto speed in the model, a 25 second increase in the total auto travel time (represented as seconds per kilometre), and a significant increase in the average number of cars queuing at a time (73 additional vehicles). There has been a small increase in vehicles waiting outside the network, as well as virtual queue lengths, due to this demand. However, it does not appear that this is significant, as does not mean that the flow in the model is understated.

Transit vehicles see a significant increase in delay per kilometre (20 s/km for streetcar), and travel time per kilometre (84 s/km for streetcar) on average. Streetcars also see a decrease in average speed by 4 km/hr. Busses actually see a decrease in delay time of 10s/km, and a reduction in travel time per km of 94 s/km.

# 7 Preferred Design Concept

## 7.1 Alternatives

Design Concept 4c was identified as the Recommended Design Concept and modelled in Aimsun to assess traffic impacts. It should be noted that during previous rounds of modelling it was assumed that the University Avenue bike lanes would run between Adelaide Street and College Street. However, during this latest evaluation phase, it was assumed that the bike lanes would extend from Adelaide Street to Bloor Street, in line with the current ActiveTO bike scheme. Additionally, leading pedestrian intervals have been implemented at the intersections of Yonge Street & Shuter Street (east-west), and Yonge Street & Gerrard Street (north-south), in line with the City of Toronto's Traffic Signal Operations Policies & Strategies, section 5.4.9.

A separate revision has been created for the Design Concept Model so that changes required in the base model are carried forward, whilst the physical network changes required for the alternatives are not impacting on the calibrated and validated base model.

Two different approaches were used for the static and dynamic assignments to ensure the physical changes are modelled accurately:

- **Static assignments:** attributes overrides were used to reduce the capacity of relevant sections along Yonge Street. For the respective sections, the capacity has been reduced from 800 PCUs/h (2 lanes of 400 PCUs/h each) to 400 PCUs/h where Yonge Street was reduced to one lane in each direction, and to 0.01 PCUs/hr where Yonge Street was closed entirely. This was done to reflect the respective capacity of Yonge Street and ensure traffic is re-assigned accordingly in the static assignments. Additionally, University Avenue was also reduced by 900 PCUs/hr in both directions between Adelaide Street and Bloor Street, to reflect the recommendation of cycling facilities on that street;
- **Dynamic assignments:** traffic management strategies (turn closures and lane closures) were used to close the required lanes during the hybrid simulation itself. The lane closures matched those of the static assignment capacity adjustments in all cases. Turning movements currently using the center lane have been amended to go from and to the curbside lane.

Methods of control at affected intersections have been adjusted to cater for the amended traffic conditions, reflecting the lane configurations specified in the Recommended Design Concept plans.

Bus route 97B has been re-routed from Yonge Street to Church Street, between College Street / Carlton Street in the north and Richmond Street (southbound direction) / Adelaide Street (northbound direction) in the south. This was just an assumption for modelling purposes, given that the ultimate fate of the bus line has not yet been confirmed. Due to the low frequency of this route (once every half hour), should the TTC decide to discontinue the route, or choose a different deviation, the impacts on the model will be negligible.

Modelling results along major corridors were somewhat volatile due to the dynamic assignment. Therefore, dynamic cost functions were applied to specific links and turns where driver routing behaviour was unrealistic. This included on a number of minor streets where the model was assigning unrealistically high volumes of traffic.

## 7.2 Excluded Seeds

After all 20 runs were completed, the runs were checked for outliers using VKT as a metric, based on the limit of plus or minus two standard deviations. Individual seeds beyond this limit have been excluded from the analysis to not impact on the results. The affected seeds are:

- AM: Replications 8
- PM: Replications 9 and 13
- SAT: Replication 7

## 7.3 Travel Time

### 7.3.1 AM Peak

**Table 7-1: AM General traffic travel time comparison (north-south)**

| Corridor | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| Bay Street | 03:21 | 04:15 | 05:21 | 03:31 | 04:09 | 05:42 |
| Yonge Street | 03:21 | 02:58 | | 03:26 | 03:25 | |
| Church Street | 03:31 | 04:03 | 05:50 | 04:16 | 05:18 | 05:32 |
| University Avenue | 03:12 | 03:22 | 03:52 | 02:23 | 02:46 | 03:33 |
| Jarvis Street | 03:05 | 03:28 | 03:46 | 02:47 | 04:06 | 04:23 |

**Table 7-2: AM General traffic travel time comparison (east-west)**

| Corridor | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| Queen Street | 04:38 | 06:42 | 06:53 | 05:44 | 07:09 | 07:55 |
| Dundas Street | 03:58 | 05:17 | 05:46 | 04:43 | 06:28 | 05:46 |
| College | 04:46 | 05:27 | 05:27 | 05:26 | 07:03 | 07:25 |

**Table 7-3: AM transit travel time comparison (north-south)**

| Route | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| 5A | 05:56 | 05:59 | 06:01 | 05:11 | 07:20 | 11:11 |
| 6A | 17:15 | 17:22 | 17:39 | 16:54 | 16:54 | 18:42 |
| 6B | 14:41 | 14:54 | 15:04 | 16:04 | 16:29 | 18:09 |

**Table 7-4: AM transit travel time comparison (east-west)**

| Route | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| 501/502 | 08:55 | 08:59 | 08:42 | 10:23 | 10:24 | 12:10 |
| 505 | 07:59 | 08:56 | 08:39 | 08:54 | 08:49 | 08:11 |
| 506 | 07:55 | 10:22 | 10:16 | 08:18 | 11:58 | 12:51 |

In the north and southbound directions, Bay Street and Church Street see the largest increases in travel time, which is to be expected given their proximity to Yonge Street. It is important to remember that because of the 100% bus lane compliance on Bay Street, the impacts on Bay Street are likely overstated. Dundas Street sees a benefit of 30-45 seconds in the westbound directions, due to the reduced cycle length at the Yonge-Dundas intersection. In the eastbound direction, delays at the Dundas Street and Church Street intersection offset this.

Moderate increases in travel time were seen on Queen Street in both directions (less than a minute of increase); due to the imposed lane closures west of Queen Street used to model congestion beyond the extent of the study area, occasionally westbound green phases would match with the timing of the lane closure resulting in additional delays and queues between University Avenue and Bay Street.

Transit time increases were generally insignificant on the east-west corridors, except for the 501 westbound, which was subject to the conditions on Queen Street listed above. The 5A also saw over 3 minutes of additional travel time in the southbound direction; however, this bus does not run within the focus area beyond looping around just south of College Street; the delays are likely caused by the reduction in travel lanes on University Avenue due to the added bike lanes.

### 7.3.2 PM Peak

**Table 7-5: PM General traffic travel time comparison (north-south)**

| Corridor | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| Bay Street | 04:54 | 06:08 | 06:51 | 04:36 | 05:03 | 05:47 |
| Yonge Street | 04:47 | 05:06 | | 04:42 | 05:00 | |
| Church Street | 04:04 | 04:33 | 06:04 | 04:25 | 05:59 | 04:35 |
| University Avenue | 02:06 | 02:07 | 02:22 | 03:17 | 03:46 | 05:04 |
| Jarvis Street | 03:48 | 05:42 | 06:58 | 03:27 | 04:42 | 04:33 |

**Table 7-6: PM General traffic travel time comparison (east-west)**

| Corridor | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| Queen Street | 05:39 | 07:42 | 07:45 | 06:06 | 08:54 | 10:52 |
| Dundas Street | 05:54 | 10:08 | 09:02 | 04:46 | 07:22 | 07:09 |
| College | 05:08 | 07:08 | 07:09 | 04:49 | 07:26 | 06:35 |

**Table 7-7: PM transit travel time comparison (north-south)**

| Route | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| 5A | 05:41 | 05:38 | 06:11 | 04:46 | 04:46 | 04:54 |
| 6A | 17:26 | 18:31 | 18:34 | 15:48 | 16:03 | 16:42 |
| 6B | 15:15 | 15:56 | 16:06 | 15:21 | 15:38 | 16:12 |

**Table 7-8: PM transit travel time comparison (east-west)**

| Route | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| 501/502 | 10:18 | 09:18 | 09:44 | 10:12 | 14:11 | 13:08 |
| 505 | 10:17 | 13:20 | 11:41 | 09:47 | 10:11 | 10:53 |
| 506 | 08:24 | 13:12 | 10:30 | 08:01 | 12:41 | 12:46 |

As in the AM, both Bay Street and Church Street see increases in travel time (Church Street only in the northbound direction) due to the Yonge Street closure, though the Bay Street impact is overstated due to the bus lane. Jarvis Street northbound also sees a sizeable increase in travel time, at over a minute increase. Dundas Street sees a benefit in both directions due to the reduced cycle length at the Yonge Street and Dundas Street intersection. Impacts on College Street are not significant. Again it should be noted that the impacts to Queen Street westbound are partially caused by green cycle time synching up with the random closures just west of University Avenue which were put in place to model congestion beyond the limits of the study area.

Transit impacts in this period were negligible, with most streetcars seeing either a benefit or minimal increase from the future baseline, and negligible increases to bus service.

### 7.3.3 SAT Peak

**Table 7-9: SAT General traffic travel time comparison (north-south)**

| Corridor | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| Bay Street | 03:14 | 03:21 | 03:02 | 03:41 | 04:32 | 04:27 |
| Yonge Street | 04:49 | 05:10 | | 05:14 | 06:03 | |
| Church Street | 04:38 | 03:45 | 04:33 | 04:31 | 05:21 | 06:13 |
| University Avenue | 02:01 | 02:03 | 03:52 | 03:30 | 03:39 | 04:35 |
| Jarvis Street | 04:21 | 04:10 | 04:25 | 03:45 | 04:31 | 04:08 |

**Table 7-10: SAT General traffic travel time comparison (east-west)**

| Corridor | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| Queen Street | 04:35 | 05:24 | 07:14 | 04:31 | 05:29 | 08:03 |
| Dundas Street | 05:44 | 07:29 | 06:07 | 08:20 | 08:21 | 06:23 |
| College | 05:05 | 05:00 | 05:18 | 04:27 | 05:31 | 04:28 |

**Table 7-11: SAT transit travel time comparison (north-south)**

| Route | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| 5A | 04:09 | 04:21 | 04:24 | 04:08 | 04:18 | 05:45 |
| 6A | 14:24 | 15:07 | 14:50 | 14:48 | 15:51 | 15:52 |
| 6B | | | | | | |

**Table 7-12: SAT transit travel time comparison (east-west)**

| Route | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | Base | FB | 4C | Base | FB | 4C |
| 501/502 | 07:37 | 08:07 | 09:02 | 07:07 | 07:21 | 09:58 |
| 505 | 08:20 | 09:28 | 08:07 | 11:08 | 11:05 | 08:42 |
| 506 | 08:04 | 10:57 | 07:55 | 07:15 | 08:16 | 06:58 |

Unlike the AM and PM peak hours, the SAT period does not feature a bus lane on Bay Street; impacts to Bay Street during this period are much more modest as a result, with both directions seeing very small decreases in travel time. On the other hand, Church Street sees roughly 45 seconds of additional travel time in each direction, and University Avenue sees over a minute and a half increase northbound, and a minute increase southbound. These are both caused by the presence of on-street parking on these streets, which, when combined with the additional traffic from the Yonge Street closure, as well as reduced capacity on University Avenue from the bike lanes, results in considerable travel time impacts. Parking provisions on these streets may need to be revised to reflect additional demands on these corridors.

Dundas Street sees a travel time benefit in both directions due to the decreased cycle length at Yonge and Dundas. Queen Street increases in both directions however, largely due to on street parking and temporary road blockages, such as those mentioned previously. The impact to College Street is minimal.

There is negligible impact to bus routes in the SAT peak model. The 505 streetcar benefits from the reduction in cycle time at Yonge and Dundas, and the 506 also sees a positive impact in both directions from modifications to cycle times. The 501 on the other hand sees an increase in travel time, particularly in the westbound direction; on street parking again can be attributed to this.

**Figure 12: Weekday AM Peak Hour Automotive Travel Time Estimates per Scenario – North-South Streets**

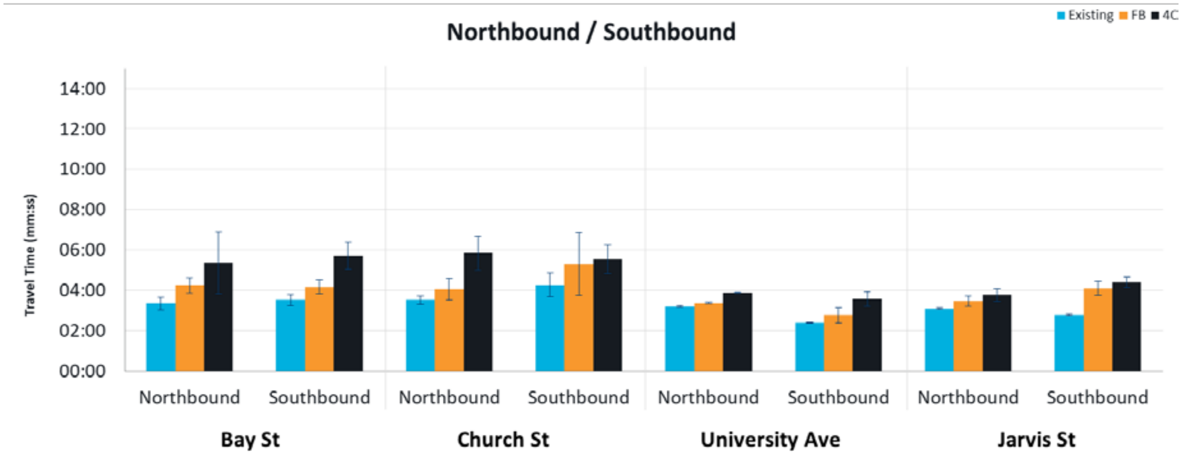



**Figure 13: Weekday AM Peak Hour Automotive Travel Time Estimates per Scenario – East-West Streets**

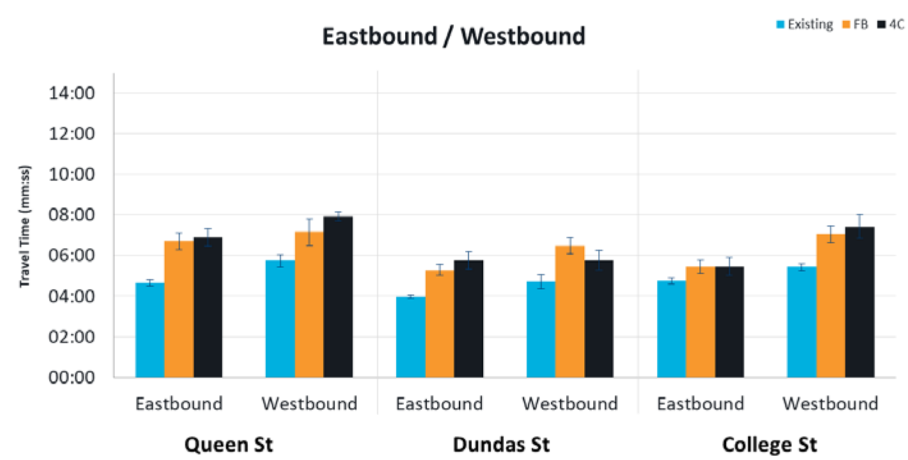


**Figure 14: Weekday AM Peak Hour Transit Travel Time Estimates per Scenario – North-South Streets**

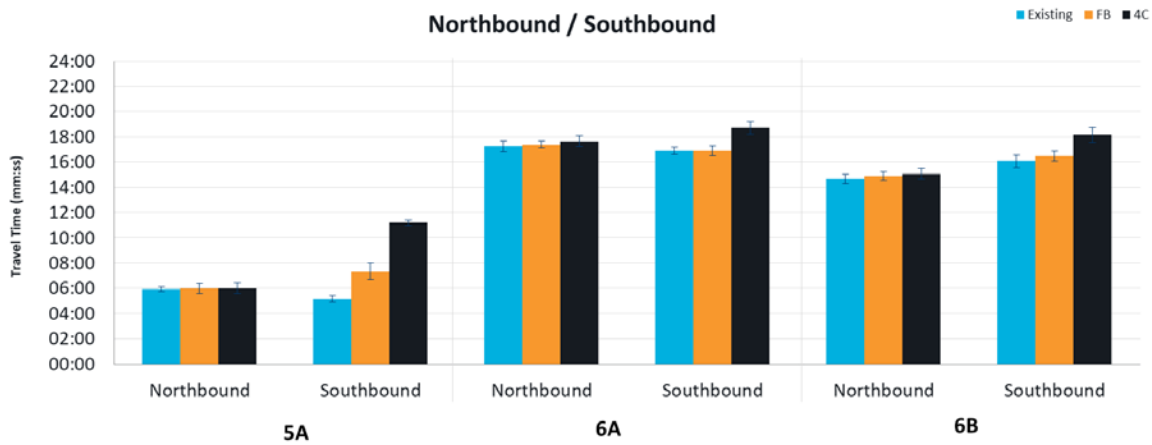



**Figure 15: Weekday AM Peak Hour Transit Travel Time Estimates per Scenario – East-West Streets**

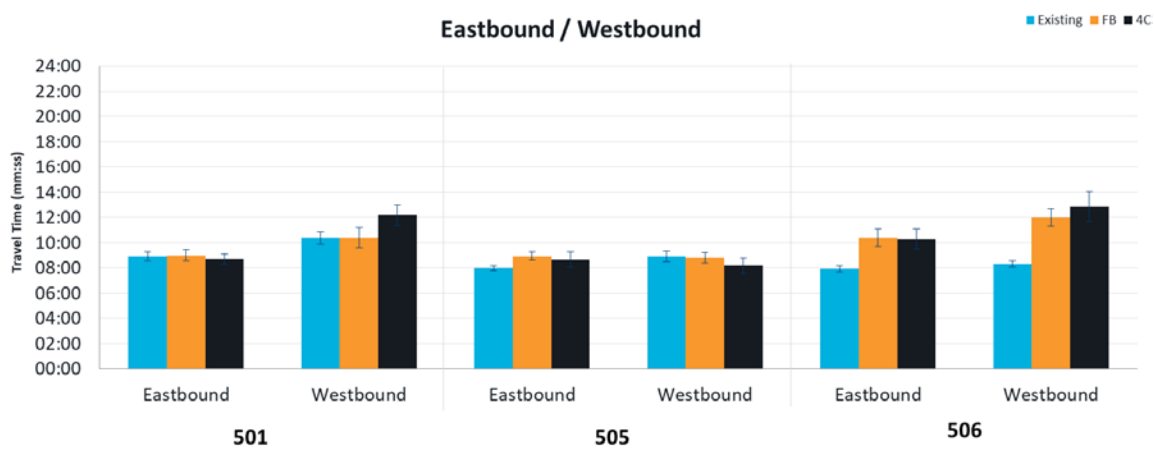


**Figure 16: Weekday PM Peak Hour Automotive Travel Time Estimates per Scenario – North-South Streets**

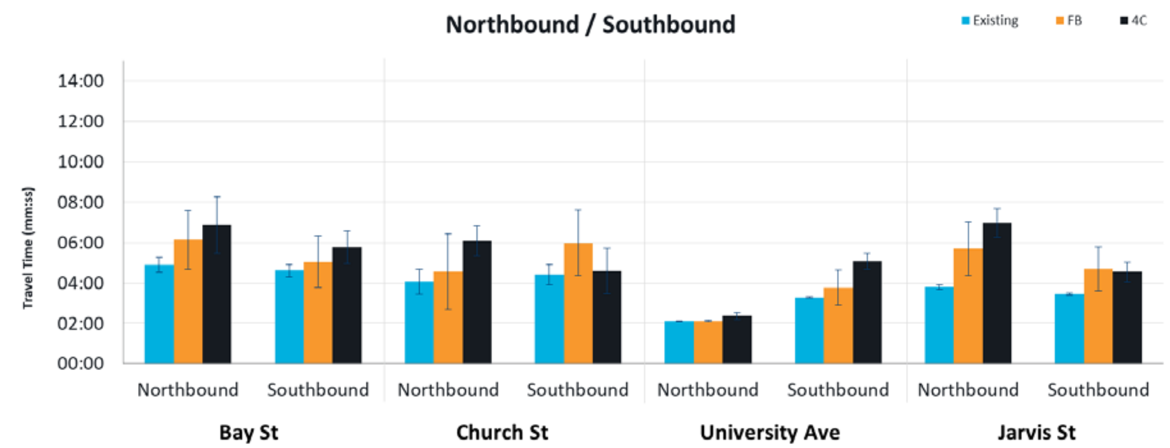



**Figure 17: Weekday PM Peak Hour Automotive Travel Time Estimates per Scenario – East-West Streets**

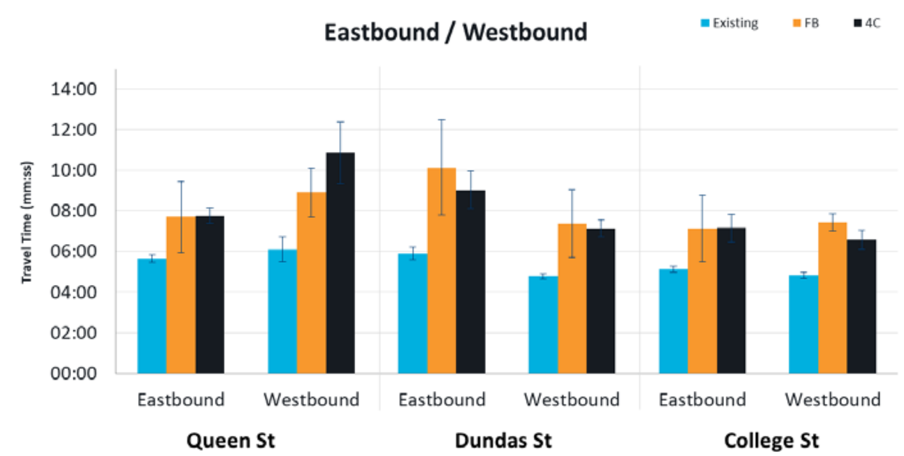



**Figure 18: Weekday PM Peak Hour Transit Travel Time Estimates per Scenario – North-South Streets**

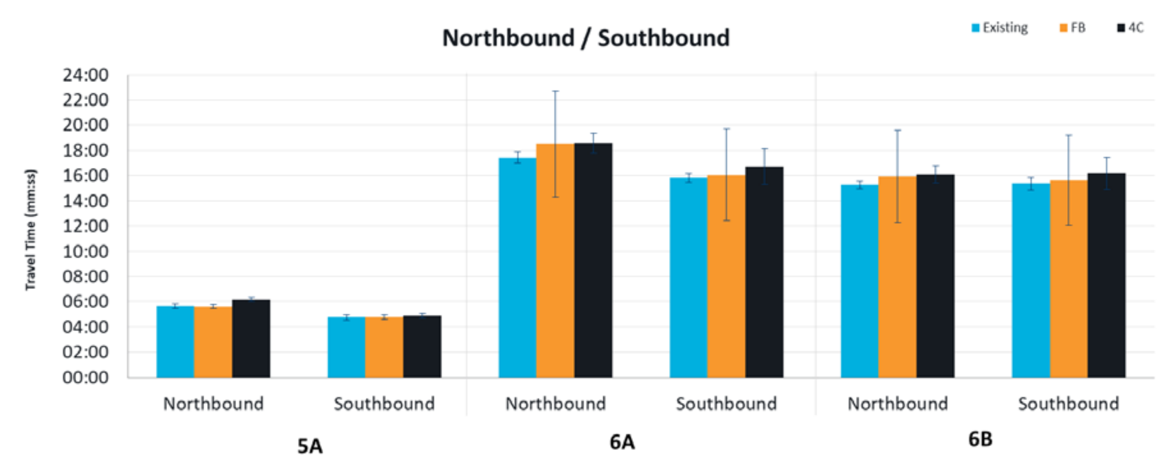


**Figure 19: Weekday PM Peak Hour Transit Travel Time Estimates per Scenario – East-West Streets**

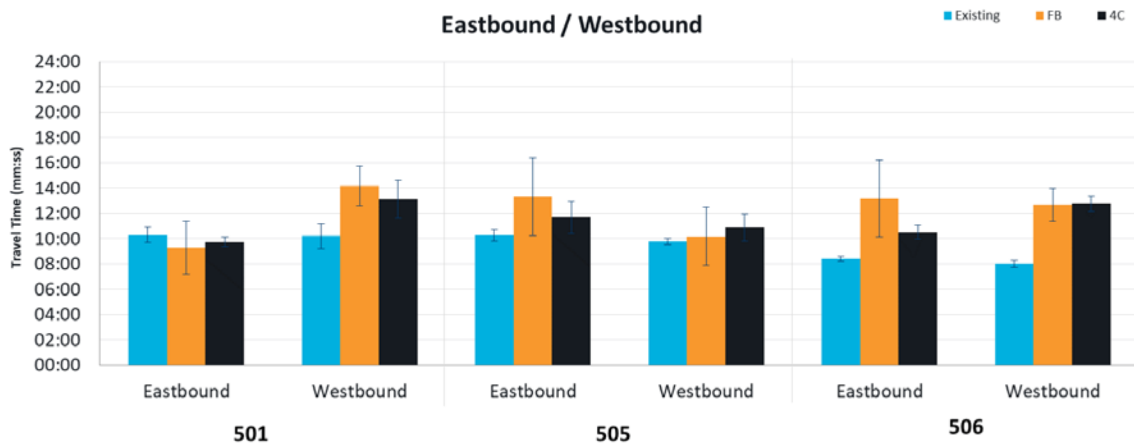



**Figure 20: SAT Peak Hour Automotive Travel Time Estimates per Scenario – North-South Streets**

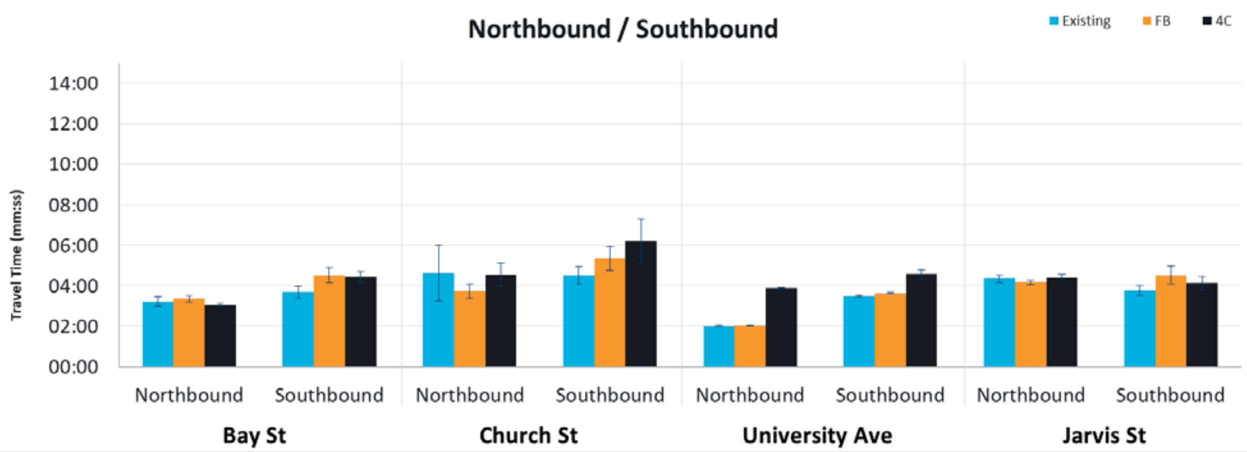



**Figure 21: SAT Peak Hour Automotive Travel Time Estimates per Scenario – East-West Streets**

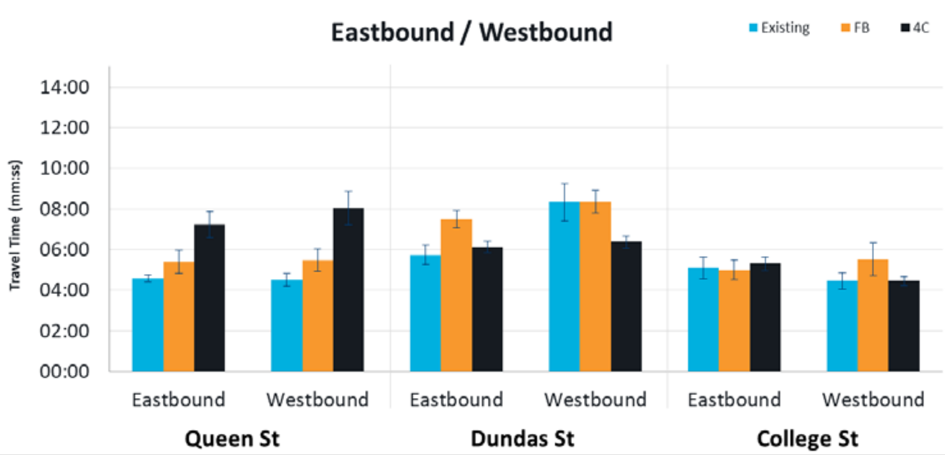


**Figure 22: SAT PM Peak Hour Transit Travel Time Estimates per Scenario – North-South Streets**

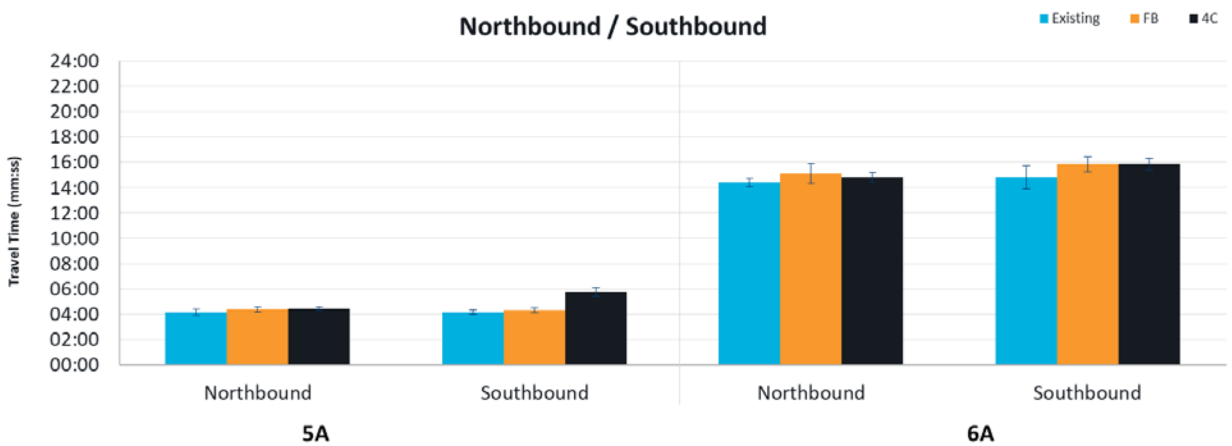
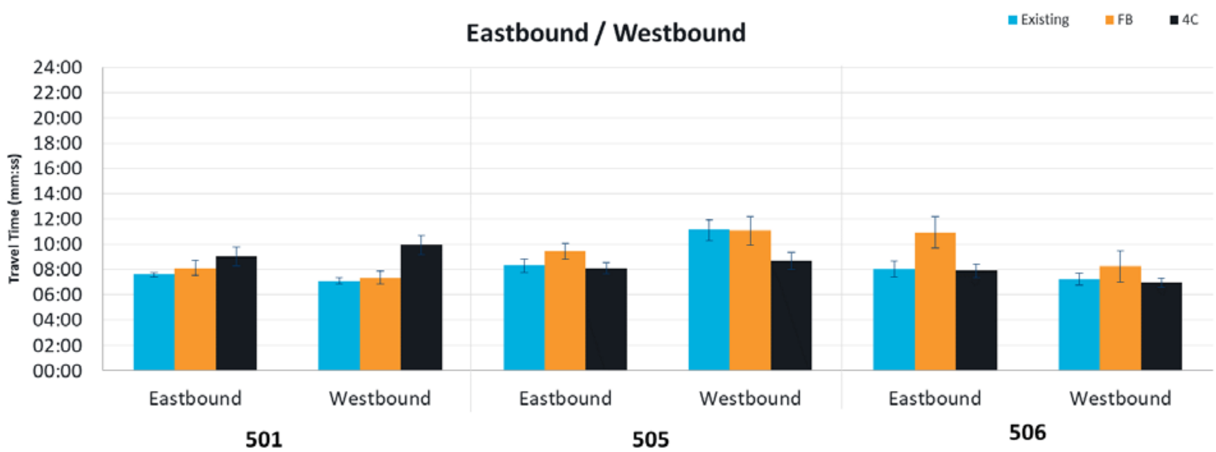



**Figure 23: SAT PM Peak Hour Transit Travel Time Estimates per Scenario – East-West Streets**



## 7.4 Queues

There was a significant increase in queuing between the design concept model and the future base in all periods, with the greatest impact seen in the PM peak hour. The greatest impacts were seen:

- Dundas Street eastbound at Church Street; as mentioned, this is a key conflict point with significant traffic in both the N-S and E-W directions. Giving priority to one direction means sacrificing service in another.
- Queen Street westbound at University Avenue: the road blockage just west of University Avenue used to model congestion beyond the limits of the study area had an amplified impact in the design concept models, particularly in the PM.
- Bay Street northbound and southbound both saw significant increases in queueing due to increase traffic volumes from cars diverting around the Yonge Street closure. This was amplified by the presence of the bus lane. As the bus lane was modelled with 100% compliance, a single left turning vehicle could result in long queues. The model likely overstates the queueing on Bay Street for this reason.

Queue length results for each period are below; however, it is important to remember that these results only show queues on the first link adjacent to an intersection. Queues that extend across multiple links in the model will not be identified here properly.

### 7.4.1 AM Peak

**Table 7-13: AM queue length comparison**

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 10 | 10 | 11 |
| | | | SBT | 7 | 7 | 8 |
| | | | EBT | 7 | 8 | 8 |
| | | | WBT | 11 | 16 | 23 |
| 38 | Yonge Street | College Street | NBT | 7 | 7 | 2 |
| | | | SBT | 9 | 9 | 7 |
| | | | EBT | 12 | 14 | 13 |
| | | | WBT | 12 | 12 | 10 |
| 23 | Church Street | College Street | NBT | 7 | 8 | 9 |
| | | | SBT | 8 | 15 | 15 |
| | | | EBT | 11 | 14 | 14 |
| | | | WBT | 16 | 16 | 16 |
| 67 | Bay Street | Gerrard Street | NBT | 5 | 5 | 5 |
| | | | SBT | 7 | 7 | 7 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBL | 5 | 5 | 5 |
| | | | WBT | 5 | 5 | 5 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| 37 | Yonge Street | Gerrard Street | NBT | 6 | 7 | 0 |
| | | | SBT | 9 | 10 | 2 |
| | | | EBT | 10 | 14 | 15 |
| | | | WBT | 8 | 8 | 8 |
| 22 | Church Street | Gerrard Street | NBT | 9 | 9 | 13 |
| | | | SBT | 9 | 9 | 11 |
| | | | EBL | 4 | 4 | 4 |
| | | | EBT | 4 | 4 | 4 |
| | | | WBL | 9 | 10 | 11 |
| | | | WBT | 9 | 10 | 11 |
| 66 | Bay Street | Dundas Street | NBT | 6 | 6 | 7 |
| | | | SBT | 4 | 4 | 5 |
| | | | EBT | 8 | 16 | 18 |
| | | | WBT | 9 | 16 | 19 |
| 36 | Yonge Street | Dundas Street | NBT | 8 | 8 | 0 |
| | | | SBT | 6 | 6 | 0 |
| | | | EBT | 10 | 18 | 13 |
| | | | WBT | 15 | 16 | 14 |
| 21 | Church Street | Dundas Street | NBT | 5 | 5 | 6 |
| | | | SBT | 12 | 14 | 14 |
| | | | EBT | 6 | 7 | 7 |
| | | | WBT | 6 | 6 | 6 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 2 |
| | | | SBT | 3 | 3 | 2 |
| | | | EBT | 8 | 13 | 15 |
| | | | WBT | 7 | 8 | 8 |
| 20 | Church Street | Shuter Street | NBT | 5 | 5 | 6 |
| | | | SBT | 8 | 11 | 11 |
| | | | EBL | 3 | 3 | 3 |
| | | | EBT | 3 | 3 | 3 |
| | | | WBL | 3 | 3 | 3 |
| | | | WBT | 3 | 3 | 3 |
| 1518 | Victoria Street | Shuter Street | NBT | 5 | 7 | 5 |
| | | | SBT | 5 | 6 | 8 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBT | 8 | 8 | 8 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| 35 | Yonge Street | Shuter Street | NBT | 5 | 7 | 7 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 2 | 5 | 5 |
| | | | WBL | 3 | 3 | 2 |
| | | | WBT | 3 | 3 | 2 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 6 | 3 |
| | | | SBT | 3 | 3 | 3 |
| | | | EBT | 9 | 12 | 11 |
| | | | WBT | 7 | 7 | 7 |
| 19 | Church Street | Queen Street | NBT | 5 | 5 | 4 |
| | | | SBT | 17 | 19 | 13 |
| | | | EBT | 7 | 10 | 10 |
| | | | WBT | 6 | 6 | 6 |
| 64 | Bay Street | Queen Street | NBT | 8 | 8 | 9 |
| | | | SBT | 4 | 4 | 4 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 10 | 9 | 10 |
| 34 | Yonge Street | Queen Street | NBT | 4 | 3 | 4 |
| | | | SBT | 7 | 7 | 1 |
| | | | EBT | 6 | 9 | 10 |
| | | | WBT | 13 | 12 | 13 |

### 7.4.2 PM Peak

**Table 7-14: PM queue length comparison**

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 11 | 11 | 11 |
| | | | SBT | 7 | 8 | 8 |
| | | | EBT | 8 | 8 | 8 |
| | | | WBT | 10 | 19 | 22 |
| 38 | Yonge Street | College Street | NBT | 7 | 7 | 1 |
| | | | SBT | 6 | 5 | 5 |
| | | | EBT | 14 | 17 | 17 |
| | | | WBT | 8 | 12 | 11 |
| 23 | | | NBT | 9 | 9 | 9 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| | Church Street | College Street | SBT | 8 | 13 | 13 |
| | | | EBT | 12 | 13 | 14 |
| | | | WBT | 8 | 16 | 16 |
| 67 | Bay Street | Gerrard Street | NBT | 4 | 4 | 4 |
| | | | SBT | 7 | 7 | 7 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBL | 5 | 5 | 5 |
| | | | WBT | 5 | 5 | 5 |
| 37 | Yonge Street | Gerrard Street | NBT | 7 | 8 | 0 |
| | | | SBT | 6 | 6 | 3 |
| | | | EBT | 15 | 16 | 11 |
| | | | WBT | 8 | 8 | 8 |
| 22 | Church Street | Gerrard Street | NBT | 14 | 10 | 14 |
| | | | SBT | 8 | 10 | 13 |
| | | | EBL | 4 | 4 | 4 |
| | | | EBT | 4 | 4 | 4 |
| | | | WBL | 10 | 11 | 11 |
| | | | WBT | 10 | 11 | 11 |
| 66 | Bay Street | Dundas Street | NBT | 10 | 10 | 10 |
| | | | SBT | 4 | 4 | 5 |
| | | | EBT | 10 | 18 | 18 |
| | | | WBT | 9 | 13 | 20 |
| 36 | Yonge Street | Dundas Street | NBT | 7 | 7 | 0 |
| | | | SBT | 6 | 6 | 0 |
| | | | EBT | 18 | 19 | 18 |
| | | | WBT | 11 | 16 | 15 |
| 21 | Church Street | Dundas Street | NBT | 6 | 6 | 6 |
| | | | SBT | 14 | 14 | 14 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 6 | 6 | 6 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 2 |
| | | | SBT | 4 | 4 | 5 |
| | | | EBT | 9 | 14 | 16 |
| | | | WBT | 6 | 8 | 8 |
| 20 | Church Street | Shuter Street | NBT | 6 | 6 | 6 |
| | | | SBT | 8 | 11 | 8 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| | | | EBL | 3 | 3 | 3 |
| | | | EBT | 3 | 3 | 3 |
| | | | WBL | 3 | 3 | 3 |
| | | | WBT | 3 | 3 | 3 |
| 1518 | Victoria Street | Shuter Street | NBT | 9 | 11 | 9 |
| | | | SBT | 7 | 6 | 8 |
| | | | EBT | 7 | 7 | 6 |
| | | | WBT | 8 | 8 | 8 |
| 35 | Yonge Street | Shuter Street | NBT | 8 | 8 | 5 |
| | | | SBT | 8 | 8 | 0 |
| | | | EBT | 26 | 22 | 24 |
| | | | WBL | 2 | 2 | 1 |
| | | | WBT | 2 | 2 | 1 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 7 | 6 |
| | | | SBT | 3 | 3 | 3 |
| | | | EBT | 12 | 13 | 12 |
| | | | WBT | 7 | 7 | 7 |
| 19 | Church Street | Queen Street | NBT | 6 | 6 | 6 |
| | | | SBT | 17 | 21 | 17 |
| | | | EBT | 10 | 10 | 10 |
| | | | WBT | 4 | 6 | 6 |
| 64 | Bay Street | Queen Street | NBT | 8 | 8 | 8 |
| | | | SBT | 4 | 4 | 4 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 7 | 12 | 12 |
| 34 | Yonge Street | Queen Street | NBT | 12 | 5 | 2 |
| | | | SBT | 7 | 5 | 1 |
| | | | EBT | 9 | 10 | 10 |
| | | | WBT | 9 | 13 | 12 |

### 7.4.3 SAT Peak

**Table 7-15: SAT queue length comparison**

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 13 | 13 | 15 |
| | | | SBT | 10 | 10 | 10 |
| | | | EBT | 7 | 7 | 8 |
| | | | WBT | 6 | 10 | 11 |
| 38 | Yonge Street | College Street | NBT | 2 | 2 | 2 |
| | | | SBT | 8 | 8 | 3 |
| | | | EBT | 11 | 9 | 10 |
| | | | WBT | 8 | 11 | 8 |
| 23 | Church Street | College Street | NBT | 9 | 8 | 9 |
| | | | SBT | 8 | 12 | 14 |
| | | | EBT | 14 | 13 | 14 |
| | | | WBT | 11 | 15 | 10 |
| 67 | Bay Street | Gerrard Street | NBT | 4 | 5 | 6 |
| | | | SBT | 10 | 9 | 11 |
| | | | EBT | 5 | 5 | 5 |
| | | | WBL | 5 | 5 | 5 |
| | | | WBT | 5 | 5 | 5 |
| 37 | Yonge Street | Gerrard Street | NBT | 6 | 7 | 0 |
| | | | SBT | 13 | 13 | 3 |
| | | | EBT | 16 | 16 | 17 |
| | | | WBT | 8 | 8 | 8 |
| 22 | Church Street | Gerrard Street | NBT | 9 | 9 | 9 |
| | | | SBT | 8 | 10 | 11 |
| | | | EBL | 4 | 3 | 4 |
| | | | EBT | 4 | 3 | 4 |
| | | | WBL | 10 | 10 | 9 |
| | | | WBT | 10 | 10 | 9 |
| 66 | Bay Street | Dundas Street | NBT | 8 | 9 | 10 |
| | | | SBT | 7 | 7 | 7 |
| | | | EBT | 11 | 15 | 18 |
| | | | WBT | 6 | 7 | 19 |
| 36 | Yonge Street | Dundas Street | NBT | 8 | 8 | 0 |
| | | | SBT | 6 | 6 | 0 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| | | | EBT | 18 | 19 | 10 |
| | | | WBT | 14 | 15 | 10 |
| 21 | Church Street | Dundas Street | NBT | 5 | 5 | 5 |
| | | | SBT | 10 | 9 | 10 |
| | | | EBT | 6 | 6 | 7 |
| | | | WBT | 6 | 6 | 6 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 2 |
| | | | SBT | 2 | 2 | 2 |
| | | | EBT | 3 | 4 | 12 |
| | | | WBT | 8 | 8 | 7 |
| 20 | Church Street | Shuter Street | NBT | 4 | 4 | 5 |
| | | | SBT | 5 | 9 | 7 |
| | | | EBL | 3 | 3 | 3 |
| | | | EBT | 3 | 3 | 3 |
| | | | WBL | 3 | 3 | 3 |
| | | | WBT | 3 | 3 | 3 |
| 1518 | Victoria Street | Shuter Street | NBT | 3 | 3 | 4 |
| | | | SBT | 3 | 2 | 5 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBT | 8 | 8 | 7 |
| 35 | Yonge Street | Shuter Street | NBT | 6 | 6 | 5 |
| | | | SBT | 4 | 4 | 0 |
| | | | EBT | 2 | 2 | 3 |
| | | | WBL | 2 | 3 | 1 |
| | | | WBT | 2 | 3 | 1 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 7 | 6 |
| | | | SBT | 3 | 3 | 2 |
| | | | EBT | 9 | 9 | 9 |
| | | | WBT | 7 | 7 | 7 |
| 19 | Church Street | Queen Street | NBT | 4 | 4 | 4 |
| | | | SBT | 11 | 14 | 11 |
| | | | EBT | 8 | 10 | 9 |
| | | | WBT | 5 | 6 | 6 |
| 64 | Bay Street | Queen Street | NBT | 9 | 12 | 12 |
| | | | SBT | 7 | 7 | 7 |
| | | | EBT | 7 | 7 | 7 |

| TCS # | Street 1 | Street 2 | Direction | Base (# Veh) | FB (# Veh) | 4c (# Veh) |
|---|---|---|---|---|---|---|
| | | | WBT | 7 | 7 | 6 |
| 34 | Yonge Street | Queen Street | NBT | 2 | 1 | 3 |
| | | | SBT | 4 | 5 | 1 |
| | | | EBT | 7 | 7 | 9 |
| | | | WBT | 11 | 11 | 11 |

## 7.5 Network Wide Performance

### 7.5.1 AM Peak

**Table 7-16: AM network wide performance comparison**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 181 | 22 | 94 | 10 | 129 | 32 |
| Density (veh/km) | 13 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 35010 | -958 | 111 | -2 | 77 | -3 |
| Harmonic Speed (km/h) | 13 | -1 | 10 | 0 | 12 | -2 |
| Input Count (veh) | 37771 | -124 | 114 | -2 | 83 | 0 |
| Input Flow (veh/h) | 37771 | -124 | 114 | -2 | 83 | 0 |
| Max. Virtual Queue (veh) | 1837 | 483 | 7 | 0 | 7 | 1 |
| Mean Queue (veh) | 1019 | 309 | 12 | 0 | 6 | 1 |
| Mean Virtual Queue (veh) | 728 | 140 | 2 | 0 | 2 | 0 |
| Missed Turns (#) | 59 | -6 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 184 | -13 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | -1 | 10 | 0 | 13 | -1 |
| Stop Time (sec/km) | 74 | 8 | 80 | 9 | 128 | 7 |
| Total Distance Travelled (km) | 48790 | -2826 | 150 | -3 | 201 | -11 |
| Total Distance Travelled (Vehicles Inside) (km) | 7221 | 824 | 20 | 1 | 47 | 4 |
| Total Number of Lane Changes (#) | 55727 | -4358 | 2 | 0 | 120 | -28 |
| Total Number of Stops (#) | 77605 | 3876 | 493 | 4 | 269 | -16 |
| Total Travel Time (h) | 3560 | 208 | 16 | 0 | 17 | 1 |
| Total Travel Time (Vehicles Inside) (h) | 635 | 175 | 2 | 0 | 3 | 1 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Total Travel Time (Waiting Out) (h) | 191 | 60 | 1 | 0 | 1 | 0 |
| Travel Time (sec/km) | 273 | 23 | 378 | 5 | 295 | 33 |
| Vehicles Inside (veh) | 4869 | 685 | 18 | -1 | 18 | 3 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 2 | 2 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 35010 | -958 | 111 | -2 | 77 | -3 |
| Vehicles Waiting to Enter (veh) | 1829 | 490 | 6 | 1 | 3 | 0 |
| Waiting Time in Virtual Queue (sec) | 48 | 2 | 15 | -8 | 9 | -26 |

The AM peak hour sees slightly less demand in the design concept model than in the future baseline. As part of the assignment process, the City's demand model is assigned to the entirety of planning district 1 (the downtown core), which allows cars to divert around the study area, if necessary. There is also an increase in the number of vehicles waiting to enter the model, due to congestion within the model.

The decrease in network capacity exceeds the number of cars that divert around the study area. This results in significantly increased congestion (represented by a 22 s/km increase in delay time, a 1 km/hr decrease in the average auto speed in the model, a 23 second increase in the total auto travel time (represented as seconds per kilometre), and a significant increase in the average number of cars queuing at a time (309 additional vehicles), when compared to the future baseline. There has been an increase in vehicles waiting outside the network, as well as virtual queue lengths, due to this demand. However, it does not appear that this is significant, as does not mean that the flow in the model is understated.

Transit vehicles see a significant increase in delay per kilometre (10 s/km for streetcar and 32 s/km for bus), and travel time per kilometre (5 s/km for streetcar, 33 s/km for bus) on average. Average streetcar speed remains unchanged, though busses see a decrease in average speed by 1 km/hr.

### 7.5.2 PM Peak

**Table 7-17: PM network wide performance comparison**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 194 | 17 | 93 | -10 | 149 | 27 |
| Density (veh/km) | 15 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 36885 | -1023 | 98 | 3 | 66 | -4 |
| Harmonic Speed (km/h) | 12 | -1 | 9 | 0 | 12 | -1 |
| Input Count (veh) | 40409 | -2 | 101 | 1 | 71 | -2 |
| Input Flow (veh/h) | 40409 | -2 | 101 | 1 | 71 | -2 |
| Max. Virtual Queue (veh) | 1628 | 480 | 6 | -2 | 5 | 2 |
| Mean Queue (veh) | 1222 | 501 | 12 | 0 | 6 | 0 |
| Mean Virtual Queue (veh) | 528 | 124 | 1 | -1 | 1 | 1 |
| Missed Turns (#) | 64 | 1 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 195 | -15 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | 0 | 10 | 0 | 13 | -1 |
| Stop Time (sec/km) | 91 | 2 | 91 | -11 | 131 | 13 |
| Total Distance Travelled (km) | 51691 | -2700 | 132 | 4 | 173 | -6 |
| Total Distance Travelled (Vehicles Inside) (km) | 7982 | 525 | 20 | -1 | 43 | 4 |
| Total Number of Lane Changes (#) | 58930 | -4940 | 0 | 0 | 102 | -31 |
| Total Number of Stops (#) | 85959 | -3985 | 448 | 23 | 221 | -10 |
| Total Travel Time (h) | 3832 | 65 | 15 | 0 | 14 | 1 |
| Total Travel Time (Vehicles Inside) (h) | 828 | 200 | 2 | 0 | 3 | 1 |
| Total Travel Time (Waiting Out) (h) | 199 | 83 | 0 | 0 | 0 | 0 |
| Travel Time (sec/km) | 292 | 16 | 411 | -10 | 312 | 28 |
| Vehicles Inside (veh) | 5709 | 714 | 17 | -1 | 17 | 2 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 2 | 1 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 36885 | -1023 | 98 | 3 | 66 | -4 |
| Vehicles Waiting to Enter (veh) | 1624 | 484 | 5 | -1 | 3 | 2 |
| Waiting Time in Virtual Queue (sec) | 18 | 0 | 12 | -9 | 3 | 1 |

Similar to the AM peak hour, the PM peak hour sees slightly less demand in the design concept model than in the future baseline, as some of the demand is distributed to the rest of the downtown. There is also an increase in the number of vehicles waiting to enter the model, due to congestion within the model.

These results identify the PM peak hour as the most critical hour in terms of auto demand and network performance, though the relative difference between it and the FB is less than the relative difference seen in the AM period. There is significantly increased congestion (represented by a 17 s/km increase in delay time), a 16 second increase in the total auto travel time (represented as seconds per kilometre), and a significant increase in the average number of cars queuing at a time (501 additional vehicles). There has been an increase in vehicles waiting outside the network, as well as virtual queue lengths, due to this demand. However, it does not appear that this is significant, as does not mean that the flow in the model is understated.

Streetcars see a 10 s/km reduction in delay per kilometre, and a 27 s/km increase for busses. Average streetcar speed remains unchanged, though busses see a decrease in average speed by 1 km/hr.

### 7.5.3 SAT Peak

**Table 7-18: SAT network wide performance comparison**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 157 | 17 | 68 | -5 | 77 | 12 |
| Density (veh/km) | 9 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 24567 | -527 | 81 | 2 | 29 | 0 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Harmonic Speed (km/h) | 14 | -1 | 11 | 0 | 17 | -1 |
| Input Count (veh) | 26331 | -156 | 84 | 2 | 32 | 0 |
| Input Flow (veh/h) | 26331 | -156 | 84 | 2 | 32 | 0 |
| Max. Virtual Queue (veh) | 413 | 205 | 2 | -1 | 1 | 0 |
| Mean Queue (veh) | 252 | -204 | 7 | 0 | 2 | 0 |
| Mean Virtual Queue (veh) | 153 | 89 | 0 | -1 | 0 | 0 |
| Missed Turns (#) | 17 | -1 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 155 | -10 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 18 | -1 | 12 | 0 | 18 | -1 |
| Stop Time (sec/km) | 72 | 4 | 62 | -4 | 116 | -14 |
| Total Distance Travelled (km) | 38336 | -1124 | 113 | 3 | 86 | 1 |
| Total Distance Travelled (Vehicles Inside) (km) | 5652 | 393 | 16 | 0 | 16 | 0 |
| Total Number of Lane Changes (#) | 46981 | -3434 | 0 | 0 | 120 | -6 |
| Total Number of Stops (#) | 57716 | 1563 | 366 | 29 | 115 | 1 |
| Total Travel Time (h) | 2463 | 117 | 10 | 0 | 5 | 0 |
| Total Travel Time (Vehicles Inside) (h) | 387 | 73 | 1 | 0 | 1 | 0 |
| Total Travel Time (Waiting Out) (h) | 50 | 31 | 0 | 0 | 0 | 0 |
| Travel Time (sec/km) | 250 | 17 | 322 | -6 | 211 | 11 |
| Vehicles Inside (veh) | 3176 | 279 | 11 | -1 | 7 | 0 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 24567 | -527 | 81 | 2 | 29 | 0 |
| Vehicles Waiting to Enter (veh) | 401 | 200 | 0 | -2 | 0 | 0 |
| Waiting Time in Virtual Queue (sec) | 7 | 3 | 1 | -1 | 0 | 0 |

Similar to the AM and PM peak hours, the SAT peak hour sees slightly less demand in the design concept model than in the future baseline, as some of the demand is distributed to the rest of the downtown. There is also an increase in the number of vehicles waiting to enter the model, due to congestion within the model.

There is moderately increased congestion (represented by a 17 s/km increase in travel time and 4 s/km increase in stop time; however the mean queueing is lower by over 200 vehicles. Streetcars see a 6 s/km reduction in delay per kilometre, and an 11 s/km increase for busses. These results show that while SAT is impacted by the Yonge Street closure, the effects are not nearly as pronounced as during rh weekday AM and PM periods.

## 7.6 Delays

A comparison of delays at major intersections between the design concept model and the base and future base models are shown below. Generally a modest increase is observed of just a few seconds, though some larger jumps do occur in the PM peak period (such as at Church Street and Gerrard Street, and Church Street and Dundas Street).

### 7.6.1 AM Peak

**Table 7-19: AM intersection delay comparison (s)**

| TCS # | Street 1 | Street 2 | Base | FB | 4c |
|---|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | 20 | 18 | 19 |
| 36 | Yonge Street | Dundas Street | 26 | 27 | 23 |
| 37 | Yonge Street | Gerrard Street | 21 | 23 | 20 |
| 38 | Yonge Street | College Street | 22 | 21 | 23 |
| 64 | Bay Street | Queen Street | 26 | 28 | 31 |
| 66 | Bay Street | Dundas Street | 19 | 24 | 30 |
| 67 | Bay Street | Gerrard Street | 21 | 22 | 23 |
| 68 | Bay Street | College Street | 22 | 21 | 26 |
| 19 | Church Street | Queen Street | 30 | 35 | 37 |
| 21 | Church Street | Dundas Street | 28 | 32 | 35 |
| 22 | Church Street | Gerrard Street | 22 | 27 | 29 |
| 23 | Church Street | College Street | 32 | 52 | 55 |

### 7.6.2 PM Peak

**Table 7-20: PM intersection delay comparison (s)**

| TCS # | Street 1 | Street 2 | Base | FB | 4c |
|---|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | 20 | 19 | 21 |
| 36 | Yonge Street | Dundas Street | 25 | 27 | 25 |
| 37 | Yonge Street | Gerrard Street | 19 | 20 | 22 |
| 38 | Yonge Street | College Street | 21 | 21 | 24 |
| 64 | Bay Street | Queen Street | 27 | 26 | 29 |

| | | | | | |
|---|---|---|---|---|---|
| 66 | Bay Street | Dundas Street | 23 | 25 | 30 |
| 67 | Bay Street | Gerrard Street | 20 | 22 | 36 |
| 68 | Bay Street | College Street | 25 | 26 | 26 |
| 19 | Church Street | Queen Street | 37 | 39 | 32 |
| 21 | Church Street | Dundas Street | 29 | 30 | 37 |
| 22 | Church Street | Gerrard Street | 28 | 27 | 49 |
| 23 | Church Street | College Street | 22 | 37 | 37 |

### 7.6.3 SAT Peak

**Table 7-21: SAT intersection delay comparison (s)**

| TCS # | Street 1 | Street 2 | Base | FB | 4c |
|---|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | 17 | 18 | 20 |
| 36 | Yonge Street | Dundas Street | 43 | 43 | 22 |
| 37 | Yonge Street | Gerrard Street | 24 | 23 | 20 |
| 38 | Yonge Street | College Street | 19 | 18 | 23 |
| 64 | Bay Street | Queen Street | 25 | 29 | 31 |
| 66 | Bay Street | Dundas Street | 26 | 31 | 42 |
| 67 | Bay Street | Gerrard Street | 21 | 21 | 22 |
| 68 | Bay Street | College Street | 25 | 26 | 25 |
| 19 | Church Street | Queen Street | 26 | 36 | 38 |
| 21 | Church Street | Dundas Street | 29 | 30 | 40 |
| 22 | Church Street | Gerrard Street | 25 | 27 | 25 |
| 23 | Church Street | College Street | 31 | 35 | 30 |

# 8 Church Street Sensitivity Tests

## 8.1 Overview

The Design Concept modelled in the previous section was also subject to two sensitivity tests, based on two proposed alternatives for road rehabilitation on Church Street between Maitland Street and Gloucester Avenue.

**Church Street Sensitivity Test 1 (CSST1)**

- No bike lanes
- 2 lanes of traffic
- Layby parking on both sides of the road

**Church Street Sensitivity Test 2 (CSST2)**

- No bike lanes
- 2 lanes of traffic + 1 lane of peak hour traffic on the west side/parking during non-peak hours.
- Layby parking on the east side

A separate revision has been created for each of the two sensitivity tests so that changes required in the base model and design concept are carried forward, whilst the physical network changes required for the sensitivity tests do not impact the calibrated and validated base model, nor the results of the design concept model. Note that during the SAT peak hour, both sensitivity tests are effectively the same in the model, and so results will only be shown for CSST1.

Two different approaches were used for the static and dynamic assignments to ensure the physical changes are modelled accurately. These are additive to the changes identified in the design concept model:

- **Static assignments:** attributes overrides were used to reduce the capacity of relevant sections along Church Street. For the respective sections, the capacity has been reduced from 800 PCUs/h (2 lanes of 400 PCUs/h each) to 400 PCUs/h where Church Street was reduced to one lane in each direction.
- **Dynamic assignments:** traffic management strategies (turn closures and lane closures) were used to close the required lanes during the hybrid simulation itself. The lane closures matched those of the static assignment capacity adjustments in all cases. Turning movements currently using the center lane have been amended to go from and to the curbside lane.

Methods of control at affected intersections have been adjusted to cater for the amended traffic conditions, reflecting the lane configurations specified in the Recommended Design Concept plans.

## 8.2 Excluded Seeds

After all 20 runs were completed, the runs were checked for outliers using VKT as a metric, based on the limit of plus or minus two standard deviations. Individual seeds beyond this limit have been excluded from the analysis to not impact on the results.

The affected seeds in CSST1 are:

- AM: Replication 1
- PM: Replications 15, 19
- SAT: Replication 18

The affected seeds in CSST2 are:

- AM: Replications 11
- PM: Replications 11, 15
- SAT: N/A

## 8.3 Travel Time

The Church Street sensitivity tests did not show significant increases or differences in travel time from the design concept model in any period. This shows that the Yonge Street design concept will perform similarly regardless of which option on Church Street is put in place.

### 8.3.1 AM Peak

**Table 8-1: AM General traffic travel time sensitivity test (north-south)**

| Corridor | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| Bay Street | 05:21 | 05:12 | 05:11 | 05:42 | 05:35 | 05:31 |
| Yonge Street | | | | | | |
| Church Street | 05:50 | 05:10 | 05:01 | 05:32 | 03:39 | 03:37 |
| University Avenue | 03:52 | 03:52 | 03:52 | 03:33 | 03:18 | 03:25 |
| Jarvis Street | 03:46 | 03:41 | 03:47 | 04:23 | 04:12 | 04:04 |

**Table 8-2: AM General traffic travel time sensitivity test (east-west)**

| Corridor | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| Queen Street | 06:53 | 07:14 | 07:22 | 07:55 | 07:41 | 07:40 |
| Dundas Street | 05:46 | 06:43 | 06:49 | 05:46 | 06:05 | 06:01 |
| College | 05:27 | 05:47 | 05:37 | 07:25 | 07:27 | 07:24 |

**Table 8-3: AM transit travel time sensitivity test (north-south)**

| Route | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| 5A | 06:01 | 06:04 | 06:01 | 11:11 | 11:17 | 10:58 |
| 6A | 17:39 | 17:33 | 17:36 | 18:42 | 18:45 | 18:29 |
| 6B | 15:04 | 15:01 | 15:05 | 18:09 | 18:25 | 18:12 |

**Table 8-4: AM transit travel time sensitivity test (east-west)**

| Route | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| 501/502 | 08:42 | 09:53 | 10:01 | 12:10 | 12:22 | 12:37 |
| 505 | 08:39 | 09:28 | 09:38 | 08:11 | 10:12 | 09:37 |
| 506 | 10:16 | 10:32 | 10:23 | 12:51 | 12:46 | 12:35 |

### 8.3.2 PM Peak

**Table 8-5: PM General traffic travel time sensitivity test (north-south)**

| Corridor | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| Bay Street | 06:51 | 06:43 | 07:00 | 05:47 | 05:44 | 05:03 |
| Yonge Street | | | | | | |
| Church Street | 06:04 | 06:10 | 06:19 | 04:35 | 04:42 | 05:05 |
| University Avenue | 02:22 | 02:20 | 02:19 | 05:04 | 05:12 | 05:09 |
| Jarvis Street | 06:58 | 07:04 | 07:06 | 04:33 | 04:43 | 04:40 |

**Table 8-6: PM General traffic travel time sensitivity test (east-west)**

| Corridor | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| Queen Street | 07:45 | 07:40 | 07:39 | 10:52 | 11:17 | 11:17 |
| Dundas Street | 09:02 | 09:02 | 09:08 | 07:09 | 07:03 | 06:59 |
| College | 07:09 | 07:09 | 06:58 | 06:35 | 06:40 | 06:43 |

**Table 8-7: PM transit travel time sensitivity test (north-south)**

| Route | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| 5A | 06:11 | 06:05 | 06:07 | 04:54 | 04:55 | 04:52 |
| 6A | 18:34 | 18:23 | 18:40 | 16:42 | 16:46 | 17:03 |
| 6B | 16:06 | 15:59 | 16:10 | 16:12 | 16:18 | 16:52 |

**Table 8-8: PM transit travel time sensitivity test (east-west)**

| Route | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| 501/502 | 09:44 | 09:46 | 09:41 | 13:08 | 13:26 | 13:24 |
| 505 | 11:41 | 11:22 | 11:24 | 10:53 | 11:22 | 11:15 |
| 506 | 10:30 | 10:15 | 10:12 | 12:46 | 12:56 | 12:45 |

### 8.3.3 SAT Peak

**Table 8-9: SAT General traffic travel time sensitivity test (north-south)**

| Corridor | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| Bay Street | 03:02 | 03:46 | | 04:27 | 04:39 | |
| Yonge Street | | | | | | |
| Church Street | 04:33 | 03:57 | | 06:13 | 04:31 | |
| University Avenue | 03:52 | 03:48 | | 04:35 | 04:18 | |
| Jarvis Street | 04:25 | 04:16 | | 04:08 | 04:36 | |

**Table 8-10: SAT General traffic travel time sensitivity test (east-west)**

| Corridor | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| Queen Street | 07:14 | 05:51 | | 08:03 | 07:04 | |
| Dundas Street | 06:07 | 07:35 | | 06:23 | 07:41 | |
| College | 05:18 | 05:46 | | 04:28 | 04:29 | |

**Table 8-11: SAT transit travel time sensitivity test (north-south)**

| Route | Northbound | | | Southbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| 5A | 04:24 | 04:22 | | 05:45 | 05:43 | |
| 6A | 14:50 | 18:25 | | 15:52 | 16:24 | |
| 6B | | | | | | |

**Table 8-12: SAT transit travel time sensitivity test (east-west)**

| Route | Eastbound | | | Westbound | | |
|---|---|---|---|---|---|---|
| | 4C | CSST1 | CSST2 | 4C | CSST1 | CSST2 |
| 501/502 | 09:02 | 07:50 | | 09:58 | 09:36 | |
| 505 | 08:07 | 09:48 | | 08:42 | 10:58 | |
| 506 | 07:55 | 08:31 | | 06:58 | 07:03 | |

**Figure 24: Weekday AM Peak Hour Automotive Travel Time Sensitivity Test – North-South Streets**

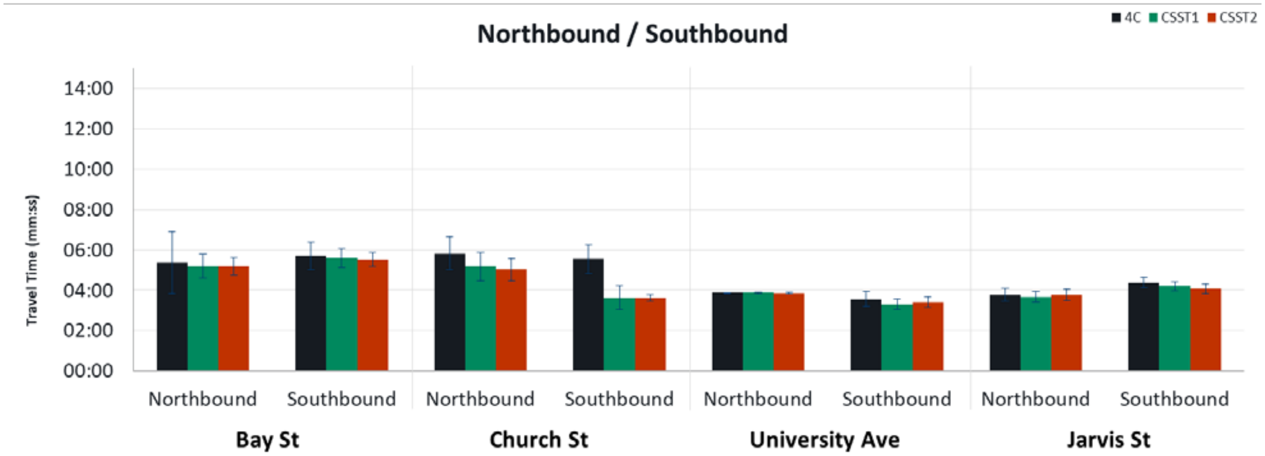



**Figure 25: Weekday AM Peak Hour Automotive Travel Time Sensitivity Test – East-West Streets**

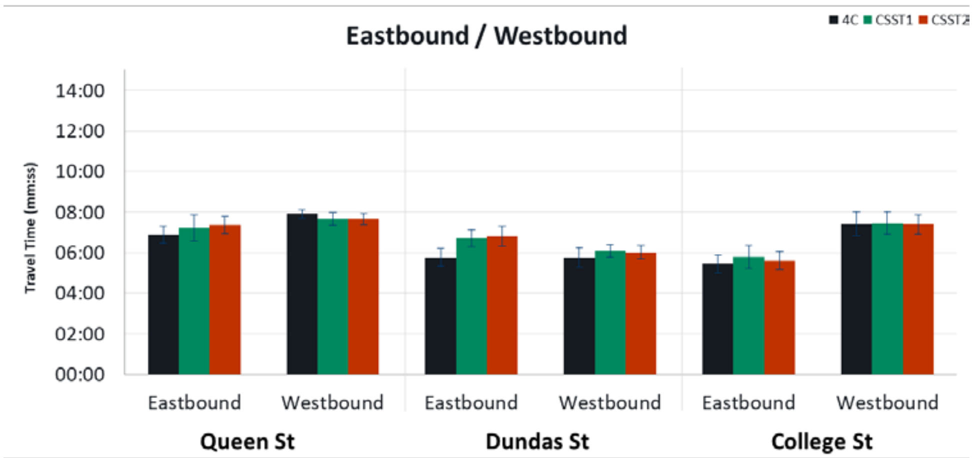


**Figure 26: Weekday AM Peak Hour Transit Travel Time Sensitivity Test – North-South Streets**

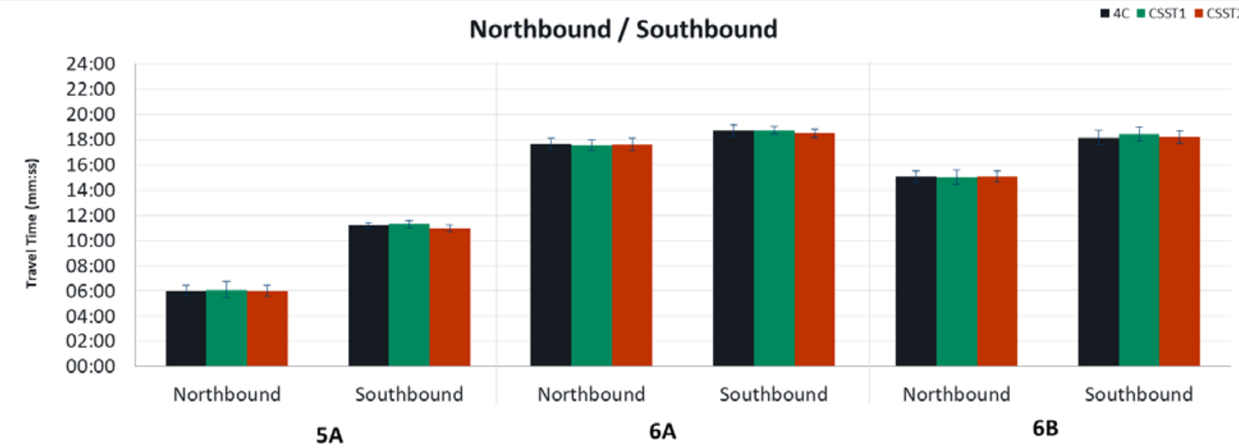



**Figure 27: Weekday AM Peak Hour Transit Travel Sensitivity Test – East-West Streets**

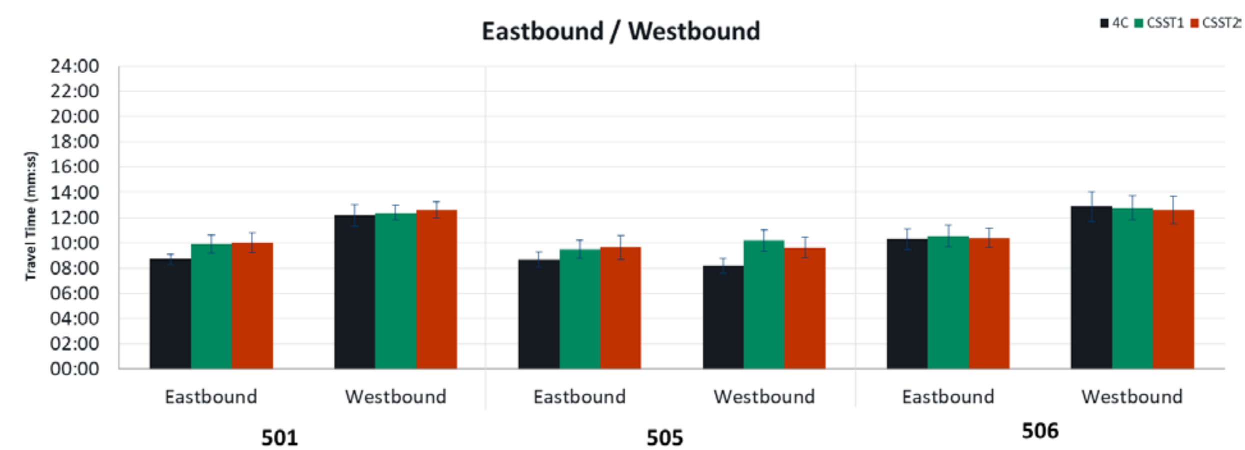


**Figure 28: Weekday PM Peak Hour Automotive Travel Time Sensitivity Test – North-South Streets**

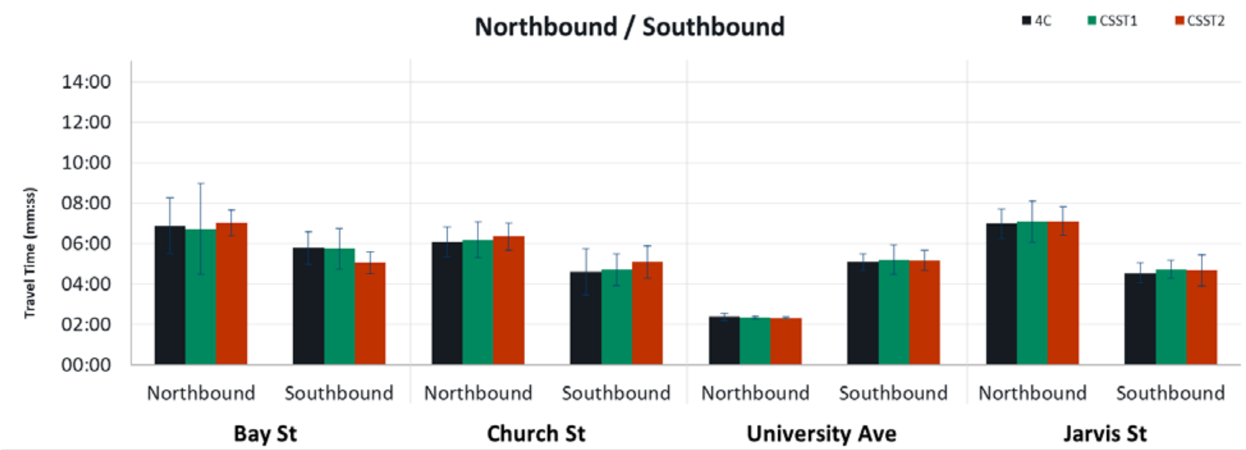



**Figure 29: Weekday PM Peak Hour Automotive Travel Time Sensitivity Test – East-West Streets**

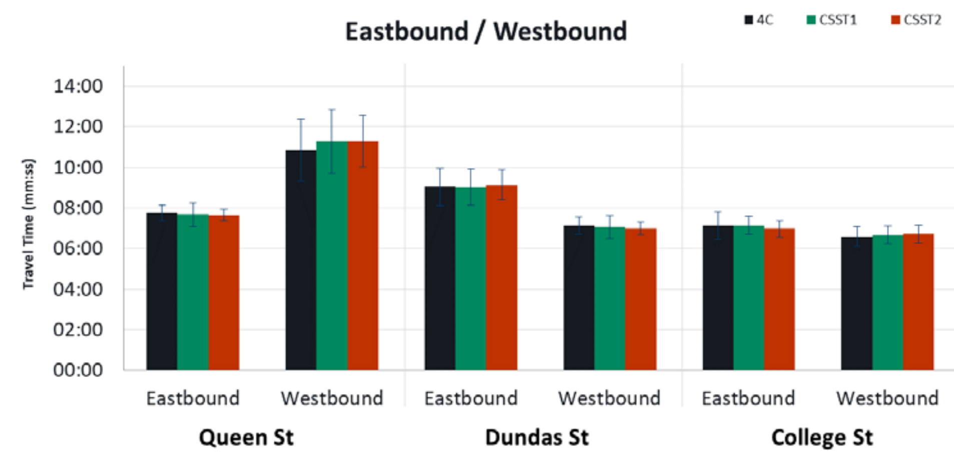



**Figure 30: Weekday PM Peak Hour Transit Travel Time Sensitivity Test – North-South Streets**

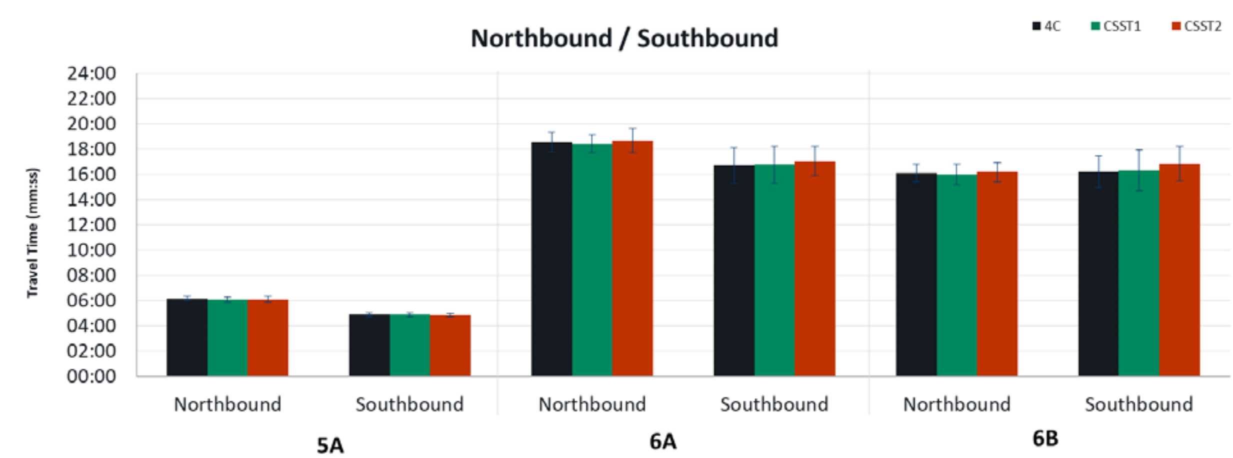


**Figure 31: Weekday PM Peak Hour Transit Travel Time Sensitivity Test – East-West Streets**

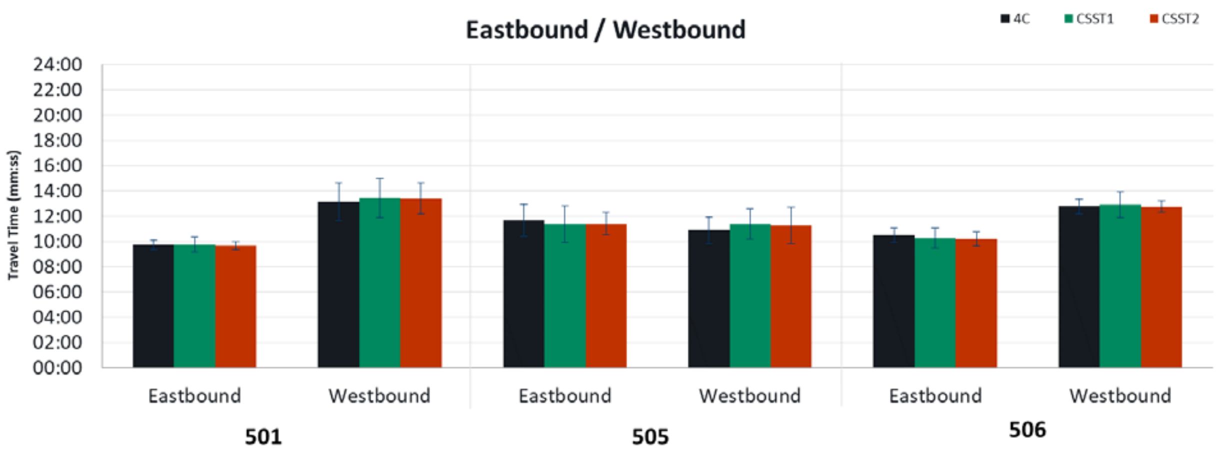



**Figure 32: SAT Peak Hour Automotive Travel Time Sensitivity Test – North-South Streets**

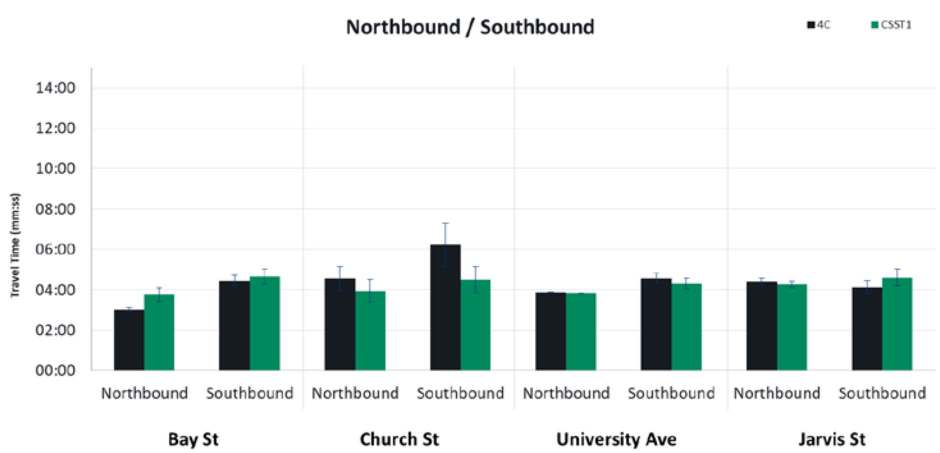



**Figure 33: SAT Peak Hour Automotive Travel Time Sensitivity Test – East-West Streets**

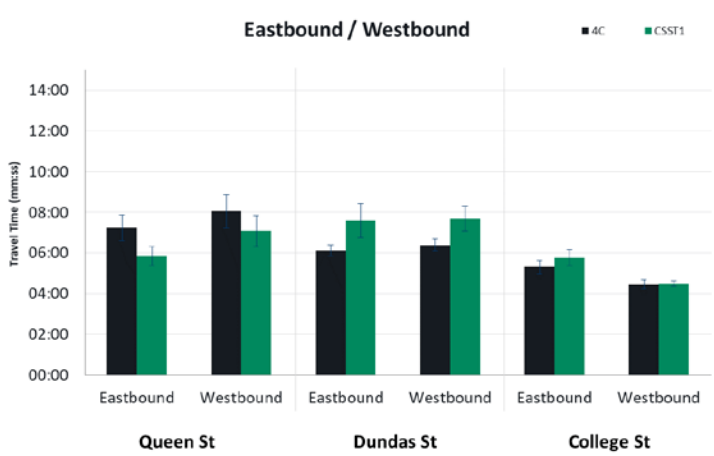


**Figure 34: SAT PM Peak Hour Transit Travel Time Sensitivity Test – North-South Streets**

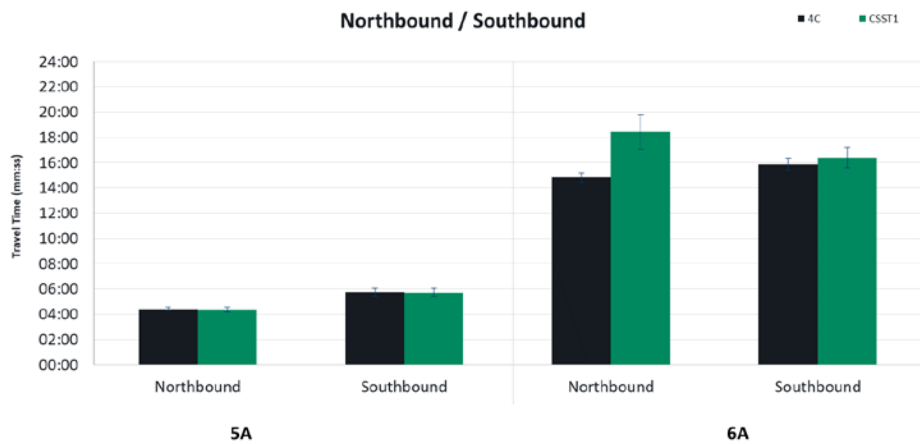
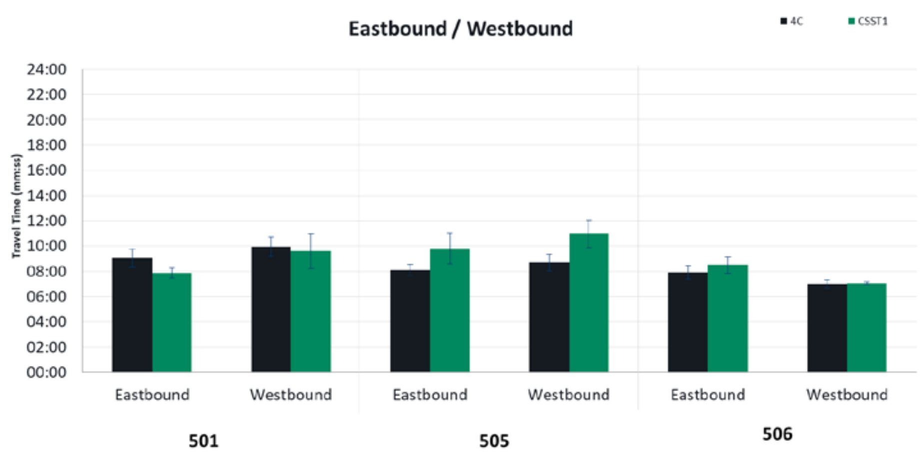



**Figure 35: SAT PM Peak Hour Transit Travel Time Sensitivity Test – East-West Streets**



## 8.4 Queues

Queue lengths were not observed to be significantly different from the design concept models, and both sensitivity tests performed similarly when judged against each other. Some increased queueing northbound on Church Street was observed entering the meso area north of College Street due to the reduction in lanes of the sensitivity test; however, this did not appear to be significant.

Queue length results for each period are below; however, it is important to remember that these results only show queues on the first link adjacent to an intersection. Queues that extend across multiple links in the model will not be identified here properly.

### 8.4.1 AM Peak

**Table 8-13: AM queue length sensitivity tests**

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# Veh) | CSST2 (# veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 11 | 11 | 11 |
| | | | SBT | 8 | 8 | 8 |
| | | | EBT | 8 | 8 | 8 |
| | | | WBT | 23 | 24 | 23 |
| 38 | Yonge Street | College Street | NBT | 2 | 2 | 2 |
| | | | SBT | 7 | 8 | 7 |
| | | | EBT | 13 | 13 | 13 |
| | | | WBT | 10 | 12 | 10 |
| 23 | Church Street | College Street | NBT | 9 | 9 | 9 |
| | | | SBT | 15 | 15 | 15 |
| | | | EBT | 14 | 14 | 14 |
| | | | WBT | 16 | 16 | 16 |
| 67 | Bay Street | Gerrard Street | NBT | 5 | 5 | 5 |
| | | | SBT | 7 | 7 | 7 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBL | 5 | 5 | 5 |
| | | | WBT | 5 | 5 | 5 |
| 37 | Yonge Street | Gerrard Street | NBT | 0 | 0 | 0 |
| | | | SBT | 2 | 2 | 2 |
| | | | EBT | 15 | 14 | 15 |
| | | | WBT | 8 | 8 | 8 |
| 22 | Church Street | Gerrard Street | NBT | 13 | 14 | 13 |
| | | | SBT | 11 | 12 | 11 |
| | | | EBL | 4 | 4 | 4 |
| | | | EBT | 4 | 4 | 4 |

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# Veh) | CSST2 (# veh) |
|---|---|---|---|---|---|---|
| | | | WBL | 11 | 11 | 11 |
| | | | WBT | 11 | 11 | 11 |
| 66 | Bay Street | Dundas Street | NBT | 7 | 7 | 7 |
| | | | SBT | 5 | 4 | 5 |
| | | | EBT | 18 | 17 | 18 |
| | | | WBT | 19 | 18 | 19 |
| 36 | Yonge Street | Dundas Street | NBT | 0 | 0 | 0 |
| | | | SBT | 0 | 0 | 0 |
| | | | EBT | 13 | 14 | 13 |
| | | | WBT | 14 | 14 | 14 |
| 21 | Church Street | Dundas Street | NBT | 6 | 6 | 6 |
| | | | SBT | 14 | 13 | 14 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 6 | 6 | 6 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 2 |
| | | | SBT | 2 | 2 | 2 |
| | | | EBT | 15 | 15 | 15 |
| | | | WBT | 8 | 8 | 8 |
| 20 | Church Street | Shuter Street | NBT | 6 | 6 | 6 |
| | | | SBT | 11 | 12 | 11 |
| | | | EBL | 3 | 3 | 3 |
| | | | EBT | 3 | 3 | 3 |
| | | | WBL | 3 | 3 | 3 |
| | | | WBT | 3 | 3 | 3 |
| 1518 | Victoria Street | Shuter Street | NBT | 5 | 6 | 5 |
| | | | SBT | 8 | 7 | 8 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBT | 8 | 8 | 8 |
| 35 | Yonge Street | Shuter Street | NBT | 7 | 7 | 7 |
| | | | SBT | 0 | 0 | 0 |
| | | | EBT | 5 | 6 | 5 |
| | | | WBL | 2 | 2 | 2 |
| | | | WBT | 2 | 2 | 2 |
| 28 | Victoria Street | Queen Street | NBT | 3 | 3 | 3 |
| | | | SBT | 3 | 3 | 3 |
| | | | EBT | 11 | 11 | 11 |

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# Veh) | CSST2 (# veh) |
|---|---|---|---|---|---|---|
| | | | WBT | 7 | 7 | 7 |
| 19 | Church Street | Queen Street | NBT | 4 | 4 | 4 |
| | | | SBT | 13 | 14 | 13 |
| | | | EBT | 10 | 10 | 10 |
| | | | WBT | 6 | 6 | 6 |
| 64 | Bay Street | Queen Street | NBT | 9 | 9 | 9 |
| | | | SBT | 4 | 4 | 4 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 10 | 10 | 10 |
| 34 | Yonge Street | Queen Street | NBT | 4 | 4 | 4 |
| | | | SBT | 1 | 1 | 1 |
| | | | EBT | 10 | 10 | 10 |
| | | | WBT | 13 | 13 | 13 |

### 8.4.2 PM Peak

**Table 8-14: PM queue length sensitivity tests**

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# Veh) | CSST2 (# veh) |
|---|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 11 | 11 | 12 |
| | | | SBT | 8 | 8 | 9 |
| | | | EBT | 8 | 8 | 8 |
| | | | WBT | 22 | 16 | 15 |
| 38 | Yonge Street | College Street | NBT | 1 | 2 | 2 |
| | | | SBT | 5 | 3 | 3 |
| | | | EBT | 17 | 22 | 20 |
| | | | WBT | 11 | 13 | 12 |
| 23 | Church Street | College Street | NBT | 9 | 9 | 9 |
| | | | SBT | 13 | 15 | 15 |
| | | | EBT | 14 | 14 | 14 |
| | | | WBT | 16 | 16 | 16 |
| 67 | Bay Street | Gerrard Street | NBT | 4 | 6 | 6 |
| | | | SBT | 7 | 7 | 7 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBL | 5 | 5 | 5 |
| | | | WBT | 5 | 5 | 5 |

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# Veh) | CSST2 (# veh) |
|---|---|---|---|---|---|---|
| 37 | Yonge Street | Gerrard Street | NBT | 0 | 0 | 0 |
| | | | SBT | 3 | 3 | 2 |
| | | | EBT | 11 | 18 | 18 |
| | | | WBT | 8 | 8 | 8 |
| 22 | Church Street | Gerrard Street | NBT | 14 | 13 | 13 |
| | | | SBT | 13 | 11 | 12 |
| | | | EBL | 4 | 4 | 4 |
| | | | EBT | 4 | 4 | 4 |
| | | | WBL | 11 | 11 | 11 |
| | | | WBT | 11 | 11 | 11 |
| 66 | Bay Street | Dundas Street | NBT | 10 | 7 | 8 |
| | | | SBT | 5 | 5 | 5 |
| | | | EBT | 18 | 19 | 19 |
| | | | WBT | 20 | 17 | 17 |
| 36 | Yonge Street | Dundas Street | NBT | 0 | 0 | 0 |
| | | | SBT | 0 | 0 | 0 |
| | | | EBT | 18 | 19 | 19 |
| | | | WBT | 15 | 15 | 14 |
| 21 | Church Street | Dundas Street | NBT | 6 | 6 | 6 |
| | | | SBT | 14 | 15 | 15 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 6 | 6 | 6 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 | 2 |
| | | | SBT | 5 | 6 | 5 |
| | | | EBT | 16 | 16 | 16 |
| | | | WBT | 8 | 8 | 8 |
| 20 | Church Street | Shuter Street | NBT | 6 | 6 | 6 |
| | | | SBT | 8 | 12 | 11 |
| | | | EBL | 3 | 3 | 3 |
| | | | EBT | 3 | 3 | 3 |
| | | | WBL | 3 | 3 | 3 |
| | | | WBT | 3 | 3 | 3 |
| 1518 | Victoria Street | Shuter Street | NBT | 9 | 12 | 11 |
| | | | SBT | 8 | 10 | 11 |
| | | | EBT | 6 | 6 | 6 |
| | | | WBT | 8 | 8 | 8 |

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# Veh) | CSST2 (# veh) |
|---|---|---|---|---|---|---|
| 35 | Yonge Street | Shuter Street | NBT | 5 | 7 | 7 |
| | | | SBT | 0 | 0 | 0 |
| | | | EBT | 24 | 28 | 24 |
| | | | WBL | 1 | 2 | 1 |
| | | | WBT | 1 | 2 | 1 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 4 | 5 |
| | | | SBT | 3 | 3 | 3 |
| | | | EBT | 12 | 11 | 11 |
| | | | WBT | 7 | 7 | 7 |
| 19 | Church Street | Queen Street | NBT | 6 | 5 | 5 |
| | | | SBT | 17 | 9 | 9 |
| | | | EBT | 10 | 10 | 10 |
| | | | WBT | 6 | 6 | 6 |
| 64 | Bay Street | Queen Street | NBT | 8 | 8 | 9 |
| | | | SBT | 4 | 4 | 4 |
| | | | EBT | 7 | 7 | 7 |
| | | | WBT | 12 | 11 | 12 |
| 34 | Yonge Street | Queen Street | NBT | 2 | 3 | 3 |
| | | | SBT | 1 | 1 | 1 |
| | | | EBT | 10 | 10 | 10 |
| | | | WBT | 12 | 11 | 12 |

### 8.4.3 SAT Peak

**Table 8-15: SAT queue length sensitivity tests**

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# veh) |
|---|---|---|---|---|---|
| 68 | Bay Street | College Street | NBT | 15 | 15 |
| | | | SBT | 10 | 10 |
| | | | EBT | 8 | 8 |
| | | | WBT | 11 | 11 |
| 38 | Yonge Street | College Street | NBT | 2 | 2 |
| | | | SBT | 3 | 3 |
| | | | EBT | 10 | 10 |
| | | | WBT | 8 | 8 |
| 23 | | | NBT | 9 | 9 |

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# veh) |
|---|---|---|---|---|---|
| | Church Street | College Street | SBT | 14 | 14 |
| | | | EBT | 14 | 14 |
| | | | WBT | 10 | 10 |
| 67 | Bay Street | Gerrard Street | NBT | 6 | 6 |
| | | | SBT | 11 | 11 |
| | | | EBT | 5 | 5 |
| | | | WBL | 5 | 5 |
| | | | WBT | 5 | 5 |
| 37 | Yonge Street | Gerrard Street | NBT | 0 | 0 |
| | | | SBT | 3 | 3 |
| | | | EBT | 17 | 17 |
| | | | WBT | 8 | 8 |
| 22 | Church Street | Gerrard Street | NBT | 9 | 9 |
| | | | SBT | 11 | 11 |
| | | | EBL | 4 | 4 |
| | | | EBT | 4 | 4 |
| | | | WBL | 9 | 9 |
| | | | WBT | 9 | 9 |
| 66 | Bay Street | Dundas Street | NBT | 10 | 10 |
| | | | SBT | 7 | 7 |
| | | | EBT | 18 | 18 |
| | | | WBT | 19 | 19 |
| 36 | Yonge Street | Dundas Street | NBT | 0 | 0 |
| | | | SBT | 0 | 0 |
| | | | EBT | 10 | 10 |
| | | | WBT | 10 | 10 |
| 21 | Church Street | Dundas Street | NBT | 5 | 5 |
| | | | SBT | 10 | 10 |
| | | | EBT | 7 | 7 |
| | | | WBT | 6 | 6 |
| 1905 | Victoria Street | Dundas Street | NBT | 2 | 2 |
| | | | SBT | 2 | 2 |
| | | | EBT | 12 | 12 |
| | | | WBT | 7 | 7 |
| 20 | Church Street | Shuter Street | NBT | 5 | 5 |
| | | | SBT | 7 | 7 |

| TCS # | Street 1 | Street 2 | Direction | 4c (# Veh) | CSST1 (# veh) |
|---|---|---|---|---|---|
| | | | EBL | 3 | 3 |
| | | | EBT | 3 | 3 |
| | | | WBL | 3 | 3 |
| | | | WBT | 3 | 3 |
| 1518 | Victoria Street | Shuter Street | NBT | 4 | 4 |
| | | | SBT | 5 | 5 |
| | | | EBT | 6 | 6 |
| | | | WBT | 7 | 7 |
| 35 | Yonge Street | Shuter Street | NBT | 5 | 5 |
| | | | SBT | 0 | 0 |
| | | | EBT | 3 | 3 |
| | | | WBL | 1 | 1 |
| | | | WBT | 1 | 1 |
| 28 | Victoria Street | Queen Street | NBT | 6 | 6 |
| | | | SBT | 2 | 2 |
| | | | EBT | 9 | 9 |
| | | | WBT | 7 | 7 |
| 19 | Church Street | Queen Street | NBT | 4 | 4 |
| | | | SBT | 11 | 11 |
| | | | EBT | 9 | 9 |
| | | | WBT | 6 | 6 |
| 64 | Bay Street | Queen Street | NBT | 12 | 12 |
| | | | SBT | 7 | 7 |
| | | | EBT | 7 | 7 |
| | | | WBT | 6 | 6 |
| 34 | Yonge Street | Queen Street | NBT | 3 | 3 |
| | | | SBT | 1 | 1 |
| | | | EBT | 9 | 9 |
| | | | WBT | 11 | 11 |

## 8.5 CSST 1 - Network Wide Performance

Network level statistics in all periods were comparable to those of the design concept, in both sensitivity tests. This confirms that the Yonge Street design concept performs roughly equally well regardless of which option is selected on Church Street.

### 8.5.1 AM Peak

**Table 8-16: AM network wide performance sensitivity test – CSST 1**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 181 | 23 | 102 | 19 | 124 | 27 |
| Density (veh/km) | 13 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 34886 | -1082 | 108 | -5 | 79 | -1 |
| Harmonic Speed (km/h) | 13 | -1 | 9 | -1 | 12 | -1 |
| Input Count (veh) | 37653 | -242 | 112 | -3 | 84 | 0 |
| Input Flow (veh/h) | 37653 | -242 | 112 | -3 | 84 | 0 |
| Max. Virtual Queue (veh) | 1919 | 565 | 9 | 2 | 5 | 0 |
| Mean Queue (veh) | 1103 | 394 | 13 | 1 | 6 | 1 |
| Mean Virtual Queue (veh) | 712 | 123 | 2 | 0 | 1 | -1 |
| Missed Turns (#) | 65 | -1 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 182 | -15 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | -1 | 10 | 0 | 13 | -1 |
| Stop Time (sec/km) | 75 | 8 | 89 | 18 | 126 | 4 |
| Total Distance Travelled (km) | 48565 | -3051 | 146 | -7 | 205 | -7 |
| Total Distance Travelled (Vehicles Inside) (km) | 7016 | 619 | 21 | 2 | 46 | 3 |
| Total Number of Lane Changes (#) | 54962 | -5123 | 2 | 0 | 123 | -24 |
| Total Number of Stops (#) | 77780 | 4051 | 490 | 1 | 280 | -6 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Total Travel Time (h) | 3525 | 173 | 16 | 0 | 17 | 1 |
| Total Travel Time (Vehicles Inside) (h) | 628 | 169 | 2 | 1 | 3 | 0 |
| Total Travel Time (Waiting Out) (h) | 183 | 52 | 1 | 0 | 0 | 0 |
| Travel Time (sec/km) | 273 | 23 | 398 | 25 | 290 | 27 |
| Vehicles Inside (veh) | 4837 | 653 | 20 | 1 | 17 | 1 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 2 | 2 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 34886 | -1082 | 108 | -5 | 79 | -1 |
| Vehicles Waiting to Enter (veh) | 1911 | 572 | 8 | 3 | 3 | 0 |
| Waiting Time in Virtual Queue (sec) | 46 | 1 | 20 | -3 | 8 | -27 |

### 8.5.2 PM Peak

**Table 8-17: PM network wide performance sensitivity test – CSST 1**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 191 | 14 | 95 | -9 | 150 | 28 |
| Density (veh/km) | 15 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 36036 | -1872 | 95 | 0 | 64 | -6 |
| Harmonic Speed (km/h) | 12 | -1 | 9 | 0 | 12 | -1 |
| Input Count (veh) | 40002 | -409 | 101 | 1 | 70 | -2 |
| Input Flow (veh/h) | 40002 | -409 | 101 | 1 | 70 | -2 |
| Max. Virtual Queue (veh) | 2024 | 875 | 7 | -1 | 5 | 2 |
| Mean Queue (veh) | 1318 | 597 | 12 | 0 | 6 | 1 |
| Mean Virtual Queue (veh) | 586 | 182 | 2 | -1 | 1 | 0 |
| Missed Turns (#) | 66 | 4 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 189 | -20 | 0 | 0 | 0 | 0 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | 0 | 10 | 0 | 13 | -1 |
| Stop Time (sec/km) | 89 | 1 | 90 | -12 | 126 | 8 |
| Total Distance Travelled (km) | 50298 | -4092 | 128 | 0 | 166 | -13 |
| Total Distance Travelled (Vehicles Inside) (km) | 7926 | 469 | 22 | 1 | 45 | 6 |
| Total Number of Lane Changes (#) | 57118 | -6752 | 0 | 0 | 98 | -36 |
| Total Number of Stops (#) | 83264 | -6680 | 433 | 7 | 207 | -24 |
| Total Travel Time (h) | 3704 | -63 | 15 | 0 | 13 | 0 |
| Total Travel Time (Vehicles Inside) (h) | 994 | 365 | 3 | 0 | 4 | 1 |
| Total Travel Time (Waiting Out) (h) | 258 | 142 | 1 | 0 | 0 | 0 |
| Travel Time (sec/km) | 289 | 13 | 412 | -9 | 312 | 28 |
| Vehicles Inside (veh) | 6163 | 1168 | 19 | 2 | 18 | 3 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 2 | 1 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 36036 | -1872 | 95 | 0 | 64 | -6 |
| Vehicles Waiting to Enter (veh) | 2021 | 881 | 5 | -1 | 4 | 3 |
| Waiting Time in Virtual Queue (sec) | 16 | -1 | 12 | -10 | 1 | -2 |

### 8.5.3 SAT Peak

**Table 8-18: SAT network wide performance sensitivity test – CSST 1**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 158 | 17 | 73 | 1 | 88 | 23 |
| Density (veh/km) | 9 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 24434 | -660 | 80 | 1 | 28 | -1 |
| Harmonic Speed (km/h) | 14 | -1 | 11 | 0 | 16 | -2 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Input Count (veh) | 26473 | -14 | 84 | 2 | 32 | 0 |
| Input Flow (veh/h) | 26473 | -14 | 84 | 2 | 32 | 0 |
| Max. Virtual Queue (veh) | 261 | 52 | 2 | -1 | 1 | 0 |
| Mean Queue (veh) | 330 | -126 | 7 | 0 | 2 | 0 |
| Mean Virtual Queue (veh) | 78 | 14 | 0 | -1 | 0 | 0 |
| Missed Turns (#) | 34 | 16 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 151 | -14 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 18 | -1 | 12 | 0 | 18 | -2 |
| Stop Time (sec/km) | 68 | 0 | 69 | 3 | 124 | -6 |
| Total Distance Travelled (km) | 38160 | -1299 | 112 | 2 | 82 | -4 |
| Total Distance Travelled (Vehicles Inside) (km) | 6021 | 763 | 16 | 0 | 20 | 4 |
| Total Number of Lane Changes (#) | 45807 | -4608 | 2 | 2 | 105 | -22 |
| Total Number of Stops (#) | 57453 | 1300 | 355 | 19 | 106 | -7 |
| Total Travel Time (h) | 2463 | 117 | 10 | 0 | 5 | 0 |
| Total Travel Time (Vehicles Inside) (h) | 447 | 133 | 1 | 0 | 1 | 0 |
| Total Travel Time (Waiting Out) (h) | 18 | -1 | 0 | 0 | 0 | 0 |
| Travel Time (sec/km) | 251 | 18 | 329 | 1 | 223 | 22 |
| Vehicles Inside (veh) | 3418 | 522 | 12 | 0 | 8 | 1 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 24434 | -660 | 80 | 1 | 28 | -1 |
| Vehicles Waiting to Enter (veh) | 247 | 46 | 0 | -2 | 0 | 0 |
| Waiting Time in Virtual Queue (sec) | 5 | 1 | 1 | -1 | 0 | 0 |

## 8.6 CSST 1 - Network Wide Performance

### 8.6.1 AM Peak

**Table 8-19: AM network wide performance sensitivity test – CSST2**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 183 | 24 | 102 | 19 | 125 | 28 |
| Density (veh/km) | 13 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 34795 | -1173 | 109 | -3 | 78 | -2 |
| Harmonic Speed (km/h) | 13 | -1 | 9 | -1 | 12 | -1 |
| Input Count (veh) | 37690 | -205 | 113 | -3 | 84 | 0 |
| Input Flow (veh/h) | 37690 | -205 | 113 | -3 | 84 | 0 |
| Max. Virtual Queue (veh) | 1864 | 510 | 9 | 2 | 6 | 0 |
| Mean Queue (veh) | 1094 | 384 | 13 | 1 | 6 | 0 |
| Mean Virtual Queue (veh) | 733 | 145 | 3 | 0 | 2 | 0 |
| Missed Turns (#) | 65 | 0 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 181 | -16 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | -1 | 10 | 0 | 13 | -1 |
| Stop Time (sec/km) | 75 | 8 | 88 | 17 | 126 | 5 |
| Total Distance Travelled (km) | 48467 | -3150 | 148 | -5 | 203 | -9 |
| Total Distance Travelled (Vehicles Inside) (km) | 7164 | 766 | 20 | 0 | 48 | 5 |
| Total Number of Lane Changes (#) | 54796 | -5289 | 1 | -1 | 122 | -26 |
| Total Number of Stops (#) | 77762 | 4033 | 497 | 7 | 270 | -15 |
| Total Travel Time (h) | 3552 | 200 | 17 | 1 | 17 | 1 |
| Total Travel Time (Vehicles Inside) (h) | 642 | 183 | 2 | 0 | 3 | 1 |
| Total Travel Time (Waiting Out) (h) | 188 | 57 | 1 | 0 | 0 | 0 |
| Travel Time (sec/km) | 275 | 25 | 398 | 25 | 291 | 29 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Vehicles Inside (veh) | 4948 | 764 | 19 | 0 | 18 | 3 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 3 | 2 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 34795 | -1173 | 109 | -3 | 78 | -2 |
| Vehicles Waiting to Enter (veh) | 1855 | 516 | 8 | 2 | 3 | -1 |
| Waiting Time in Virtual Queue (sec) | 49 | 3 | 22 | -1 | 8 | -27 |

### 8.6.2 PM Peak

**Table 8-20: PM network wide performance sensitivity test – CSST2**

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Delay Time (sec/km) | 195 | 18 | 94 | -9 | 152 | 30 |
| Density (veh/km) | 15 | 1 | 0 | 0 | 0 | 0 |
| Flow (veh/h) | 36781 | -1127 | 98 | 3 | 67 | -4 |
| Harmonic Speed (km/h) | 12 | -1 | 9 | 0 | 11 | -1 |
| Input Count (veh) | 40338 | -73 | 102 | 2 | 71 | -2 |
| Input Flow (veh/h) | 40338 | -73 | 102 | 2 | 71 | -2 |
| Max. Virtual Queue (veh) | 1597 | 448 | 5 | -3 | 5 | 2 |
| Mean Queue (veh) | 1203 | 481 | 12 | 0 | 5 | 0 |
| Mean Virtual Queue (veh) | 505 | 102 | 1 | -1 | 1 | 1 |
| Missed Turns (#) | 75 | 12 | 0 | 0 | 0 | 0 |
| Number of Lane Changes (#/km) | 194 | -16 | 0 | 0 | 0 | 0 |
| Number of Stops (#/veh/km) | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed (km/h) | 17 | 0 | 10 | 0 | 13 | -1 |
| Stop Time (sec/km) | 90 | 2 | 90 | -12 | 140 | 21 |
| Total Distance Travelled (km) | 51397 | -2993 | 133 | 5 | 174 | -5 |

| Statistic | SOV Compliant | Change from Future Base | Streetcar (LFLRV) | Change from Future Base | Bus | Change from Future Base |
|---|---|---|---|---|---|---|
| Total Distance Travelled (Vehicles Inside) (km) | 8088 | 631 | 21 | 0 | 45 | 6 |
| Total Number of Lane Changes (#) | 58549 | -5321 | 0 | 0 | 100 | -34 |
| Total Number of Stops (#) | 85595 | -4349 | 449 | 24 | 226 | -4 |
| Total Travel Time (h) | 3822 | 55 | 16 | 0 | 14 | 1 |
| Total Travel Time (Vehicles Inside) (h) | 827 | 199 | 2 | 0 | 3 | 1 |
| Total Travel Time (Waiting Out) (h) | 189 | 73 | 0 | 0 | 0 | 0 |
| Travel Time (sec/km) | 293 | 17 | 412 | -9 | 315 | 31 |
| Vehicles Inside (veh) | 5714 | 718 | 18 | 0 | 17 | 2 |
| Vehicles Lost Inside (veh) | 0 | 0 | 0 | 0 | 0 | 0 |
| Vehicles Lost Outside (veh) | 3 | 2 | 0 | 0 | 0 | 0 |
| Vehicles Outside (veh) | 36781 | -1127 | 98 | 3 | 67 | -4 |
| Vehicles Waiting to Enter (veh) | 1591 | 451 | 4 | -2 | 3 | 2 |
| Waiting Time in Virtual Queue (sec) | 16 | -1 | 10 | -11 | 4 | 1 |

## 8.7 Delays

A comparison of delays at major intersections between the design concept model and the two sensitivity tests for each period is shown below. Similar to the other results, there is minimal difference between the design concept and sensitivity tests, with variations between them being generally limited to a few seconds.

### 8.7.1 AM Peak

**Table 8-21: AM intersection delay sensitivity tests (s)**

| TCS # | Street 1 | Street 2 | 4c | CSST1 | CSST2 |
|---|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | 19 | 19 | 19 |
| 36 | Yonge Street | Dundas Street | 23 | 22 | 22 |
| 37 | Yonge Street | Gerrard Street | 20 | 21 | 21 |
| 38 | Yonge Street | College Street | 23 | 22 | 21 |
| 64 | Bay Street | Queen Street | 31 | 30 | 30 |
| 66 | Bay Street | Dundas Street | 30 | 27 | 28 |
| 67 | Bay Street | Gerrard Street | 23 | 23 | 23 |
| 68 | Bay Street | College Street | 26 | 26 | 25 |
| 19 | Church Street | Queen Street | 37 | 29 | 28 |
| 21 | Church Street | Dundas Street | 35 | 30 | 31 |
| 22 | Church Street | Gerrard Street | 29 | 33 | 33 |
| 23 | Church Street | College Street | 55 | 55 | 56 |

### 8.7.2 PM Peak

**Table 8-22: PM intersection delay sensitivity tests (s)**

| TCS # | Street 1 | Street 2 | 4c | CSST1 | CSST2 |
|---|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | 21 | 21 | 21 |
| 36 | Yonge Street | Dundas Street | 25 | 26 | 26 |
| 37 | Yonge Street | Gerrard Street | 22 | 21 | 21 |
| 38 | Yonge Street | College Street | 24 | 25 | 25 |
| 64 | Bay Street | Queen Street | 29 | 32 | 32 |
| 66 | Bay Street | Dundas Street | 30 | 28 | 29 |
| 67 | Bay Street | Gerrard Street | 36 | 24 | 25 |
| 68 | Bay Street | College Street | 26 | 26 | 26 |
| 19 | Church Street | Queen Street | 32 | 22 | 23 |
| 21 | Church Street | Dundas Street | 37 | 41 | 42 |
| 22 | Church Street | Gerrard Street | 49 | 27 | 28 |
| 23 | Church Street | College Street | 37 | 43 | 45 |

### 8.7.3 SAT Peak

**Table 8-23: SAT intersection delay sensitivity tests (s)**

| TCS # | Street 1 | Street 2 | 4c | CSST1 |
|---|---|---|---|---|
| 34 | Yonge Street | Queen Street | 20 | 19 |
| 36 | Yonge Street | Dundas Street | 22 | 22 |
| 37 | Yonge Street | Gerrard Street | 20 | 20 |
| 38 | Yonge Street | College Street | 23 | 18 |
| 64 | Bay Street | Queen Street | 31 | 33 |
| 66 | Bay Street | Dundas Street | 42 | 40 |
| 67 | Bay Street | Gerrard Street | 22 | 22 |
| 68 | Bay Street | College Street | 25 | 27 |
| 19 | Church Street | Queen Street | 38 | 35 |
| 21 | Church Street | Dundas Street | 40 | 38 |
| 22 | Church Street | Gerrard Street | 25 | 27 |
| 23 | Church Street | College Street | 30 | 34 |

# 9 Conclusions

## 9.1 Approach

Aimsun Next hybrid micro-meso traffic simulation models have been developed to enable a high-level comparison of various proposed concept designs for Phase 1 of the Yonge Street corridor between Queen Street in the south and College Street / Carlton Street in the north.

The 2018 base model for AM and PM weekday peak hours, and a Saturday peak hour have been calibrated and validated against turning counts and travel time information obtained from the City of Toronto. Subsequently, a Do-Nothing future conditions model and Design Concept 4c have been modelled and compared against outputs from the base case to inform decisions about potential changes to the layout of Yonge Street. Two sensitivity tests relating to Church Street were also undertaken.

Traversal matrices developed based on the City of Toronto's (City) GTA V4.0 EMME demand model were used to obtain base origin destination matrices. Additional data sets used for calibration and validation include traffic counts, Streetlight location-based data, travel times and queues.

The overall study area forming the extent of the mesoscopic model area is formed by:

- Roxborough Street / Crescent Avenue in the north;
- Mount Pleasant Road / Jarvis Street in the east;
- King Street in the south; and
- University Avenue / Queens Park / Avenue Road in the west.

In the last round of modelling, the more detailed focus area for the microscopic simulation was bound by:

- College Street / Carlton Street in the north;
- Church Street in the east;
- Queen Street in the south; and
- Bay Street in the west.

The expanded analysis area for this round of modelling was bound by:

- College Street / Carlton Street in the north;
- Queen Street in the south;
- Jarvis Street in the east; and,
- University Avenue / Queens Park / Avenue Road in the west.

The results show that the 2018 base case models calibrate and validate to an acceptable standard, particularly considering the large model area and that data inputs ranged from 2008 to 2018 and therefore needed a significant amount of processing.

## 9.2 Discussion

For the purposes of the Environmental Assessment, the most pertinent comparison is between the results of the future baseline model and the Design Concept 4c model. These comparisons demonstrate that the proposed design concept for the yongeTOmorrow Environmental Assessment can work within the existing traffic environment and in the future, without significant disruptions to traffic or transit.

However, modelling results of the individual corridors were varied; while some corridors do increase in travel time, others see a net decrease, rather than a uniform increase or decrease across the studied area. This is to be expected with a scheme of this nature that results in some significant changes to traffic routing in the study area. This indicates that more detailed operational refinements may need to be considered in due course as part of subsequent stages of work or as part of a monitoring strategy during the early stages of scheme implementation.

- Queen Street sees an increase in travel times in all periods, particularly in the westbound direction. However, this is partially caused by an imposed periodic road blockage added to the model during calibration to model the impact of downstream congestion backing up into the study area. Additionally, the dynamic assignment was observed to occasionally would push more traffic onto Queen Street than it could realistically accommodate, even while other corridors remain clear.
- Dundas Street generally benefits from a reduced cycle time at the Yonge-Dundas intersection, due to the removal of the pedestrian scramble. Dundas Street only sees an increase in travel times eastbound during the AM peak period; this is minor in Design Concept 4c, but more substantial (over a minute) in the two sensitivity tests, likely due to cars diverting from Church Street in advance of the closure.
- College Street sees negligible to small impacts in all time periods; the highest increase is 50 seconds eastbound in the CSST 1.
- Bay Street sees a significant impact (up to 90s) in both directions and both the AM and PM peak hours. This is due in part to traffic redistributing around the network from the Yonge Street closure. However, the impact is amplified due to the 100% compliance of the bus lanes, which means through traffic must queue behind turning vehicles. Specific segments of the bus lane were removed to reduce this impact at key points near the Gerrard Street intersection to reflect the fact that cars would turn into the lane to bypass turning vehicles if required. The City will need to decide whether allowing vehicles into the bus lane to turn is permissible – the benefits to traffic are significant, and the impacts to bus traffic should be minimal, though proper enforcement of good behaviour is and will continue to be concern. The impact on Bay Street in the Saturday model is negligible, as the bus lane is not present.
- University Avenue sees moderate to significant increases in travel time in the AM and PM peak periods (30-45 seconds northbound, and 45s-95s southbound), and a significant impact in the Saturday peak period (110s northbound, and 50 seconds southbound), due to the reduced capacity caused by the bike lanes. The impact on Saturday is also caused by the presence of on street parking on Saturday, meaning that University Avenue drops to just two

lanes of traffic in each direction, which, when combined with the Yonge Street closure, overloads the street. Reductions in on-street parking may be required.
- Jarvis Street sees significant impacts northbound in the PM period. This appears to be due to congestion north and south of the study area, and due to congestion on Shuter Street.
- Church Street sees a moderate to significant increase in travel times (up to 2 minutes) in Design Concept 4c in all periods (except for a reduction southbound in the PM), though northbound appears to be worse. The Church Street sensitivity test sees a general benefit on Church Street due to cars diverting to other corridors. Note that the closures indicated in these tests are not a part of Design Concept 4c. Significant turning volumes were observed at Dundas Street, College Street and Queen Street due to diverting traffic from the Yonge Street closure.
- Few cars were observed using the northern segment of Yonge Street between College Street and Gerrard Street. The southern segment, between Shuter Street and Queen Street is more heavily used. The Design Concept 4c model and sensitivity tests allow the right turn out of the Eaton Centre parking garage, and vehicles would frequently use Yonge Street to get to the Shuter Street area.
- Transit impacts for the 5A, 6A and 6B bus were negligible in all periods, with the exception of a significant (several minutes long) increase in the southbound direction in the AM. However, note that this bus primarily runs north of the expanded focus area. The increase in travel time is likely due to the reduced capacity on University Avenue due to the bike lane.
- The 505 Dundas Streetcar sees a minor benefit in all periods (significant in the Saturday period) due to the removal of the pedestrian scramble at Yonge-Dundas and the associated reduction in cycle length, except for westbound in the PM due to the signal timings at Church/Dundas. This benefit disappears in the AM period in the sensitivity tests.
- The 501 Queen Streetcar is impacted most significantly in the AM, due to turning vehicles at Church Street in both directions, and in the SAT period, due to the presence of on-street parking.
- The 506 College/Carlton Streetcar is impacted most significantly in the AM period, westbound, due to turning vehicles at Church Street and Bay Street in both directions, due to cars diverting around Yonge Street. In all other periods, impacts to the 506 are minimal.

The scale of these impacts must therefore be weighed alongside the importance of each corridor relative to each other to gain a full appreciation of their acceptability, and against the other benefits that the design concept brings through enhanced pedestrian and cycling connections and experiences. On aggregate, the PM model showed the largest negative traffic impacts for Design Concept 4c, followed by SAT, then AM.

Any future scheme on Church Street is unlikely to have a significant impact on the travel times in the study area beyond that of Design Concept 4c.

## 9.3 Limitations

Key limitations from the modelling include:
- Limited to peak hour (AM, PM, Saturday), further consideration of temporal solutions is not reflected;
- The Aimsun model is built using the traffic demand of the City's 2011 EMME model, in addition to datasets (turn counts, travel time data, etc.) from a range of days, months and

years. Received data was projected to 2018 values in order to reflect a 2018 baseline scenario, but this does not account for potential changes in travel behaviour or travel patterns beyond that;
- On-street cycling traffic is not supported;
- Future modal shifts towards electric and / or shared transportation opportunities are not reflected;
- Detailed behaviour of taxi services and other loading / unloading operations that block live lanes of traffic are not effectively modelled (however, randomized temporary lane blockages are included along major arterial roads in the microsimulation area);
- The model was created based on data collected prior to the onset of the COVID-19 pandemic, and as such does not take into account any short-term or long-term changes to travel patterns that may occur as a result, nor does it include any of the interventions (such as ActiveTO) that were implemented in response;
- Not all minor roads are included in the model, particularly in the mesoscopic area. In certain cases, minor roads in the overall study area were represented via centroid connectors.
- Due to the significant number of route choice options in the model, the dynamic assignment often posed significant challenges in achieving stable results along major corridors. To address these stability issues, dynamic cost functions were applied to specific links and turns where driver routing behaviour was unrealistic. This included on a number of minor streets where the model was assigning unrealistically high volumes of traffic. It can be concluded that a 40% dynamic assignment is too high for a model of this size. It is recommended that if any future work is to be conducted, this percentage be lowered.
- The Bay Street bus lane was modelled with 100% compliance. This does cause some issues in the design concept and sensitivity tests, as through traffic must queue behind turning traffic. There is no elegant way in Aimsun to model cars bypassing turning traffic, particularly when they would need to turn into a bus lane to do so. Therefore, the impacts on Bay Street may be overstated in the model.
- The results of the Saturday model should be viewed with some caution; the demand fed into the model is that of the City's weekday off-peak model, and only a quarter of all signalized intersections in the study area had Saturday counts available for calibration. As a result of these data limitations the modelled travel patterns are not likely to be as accurate as the other modelled time periods.
- The modelled demand in the future scenarios was taken as given from the City's demand modelling. The demand does not include any mode shift realized from the future pedestrianization of Yonge Street, nor does it consider the proposed closures on University Avenue and Church Street. Therefore, the modelled demand is likely to be significantly higher than will be experienced in the future.
- The modelling work does not include the future Ontario Line, which will likely have a significant impact on both pedestrian, cyclist and vehicular movements in the downtown and induce further mode shift away from private vehicles.
- The modelled area is located in Downtown Toronto, which is a dense urban area with closely spaced intersections. Vehicles entering and leading the model do so at centroids located around the study area's perimeter. Congestion *beyond* the extent of the study area is not considered, even if that congestion would back up into the study area in reality. This may explain some of the high real-world travel times presented in the observed data, particularly

on Queen Street. In the model, a periodic section blockage was used on Queen Street westbound right before the exiting centroid to account for observed levels of congestion outside the model and improve journey time validation of this corridor.

- Several stakeholders have made detailed inquires regarding modelling results as they pertain to their specific developments. However, this modelling work only considers demand at an aggregate (zonal) level, and future demand was taken as given from the City's demand model. The purpose of this modelling exercise has not been to consider specific developments and their needs. Future more detailed analysis may be required at specific intersections or along specific corridors to better address individual concerns.

# A Base Model: Turns with GEH > 5

## A1 AM Peak

**Table 9-1: AM turns with GEH > 5**

| Movement | Observed | Modelled | GEH |
|---|---|---|---|
| 80NBR | 23 | 0 | 6.78233 |
| 80WBR | 90 | 46.5 | 5.26548 |
| 1691NBR | 187 | 350.85 | 9.9915 |
| 1691EBR | 26 | 0 | 7.2111 |
| 64NBT | 646 | 503.4 | 5.94838 |
| 64NBR | 81 | 137.35 | 5.39302 |
| 64WBR | 85 | 4.95 | 11.9365 |
| 34NBT | 460 | 653.8 | 8.21231 |
| 28NBT | 106 | 18 | 11.176 |
| 28SBR | 25 | 2.15 | 6.20178 |
| 6NBT | 441 | 615.3 | 7.58436 |
| 6NBR | 46 | 2.25 | 8.90727 |
| 6WBR | 3 | 63.15 | 10.4589 |
| 166NBR | 124 | 14.65 | 13.1333 |
| 166WBR | 27 | 0.45 | 7.16652 |
| 35NBT | 362.52 | 524.2 | 7.67852 |
| 35WBR | 64 | 26.5 | 5.57471 |
| 1518WBL | 81 | 138.6 | 5.49694 |
| 1518WBR | 94 | 17.1 | 10.3177 |
| 20NBT | 333.542 | 245.75 | 5.15849 |
| 20WBL | 60 | 125.5 | 6.80118 |
| 7NBR | 32 | 0.15 | 7.9439 |
| 7EBR | 31 | 6.3 | 5.71949 |
| 7WBL | 32 | 1.6 | 7.41684 |
| 1802SBT | 339 | 550.65 | 10.0351 |
| 483SBT | 83 | 26.5 | 7.63583 |
| 483EBL | 25 | 87.45 | 8.32852 |
| 36NBT | 315 | 478.45 | 8.20616 |
| 1905WBR | 33 | 7.8 | 5.57937 |

| | | | |
|---|---|---|---|
| 21WBT | 448.75 | 571.4 | 5.43063 |
| 8SBR | 113 | 233.6 | 9.16111 |
| 8EBR | 37 | 10.05 | 5.55641 |
| 8WBL | 40 | 11.8 | 5.54114 |
| 82NBL | 24 | 0 | 6.9282 |
| 82EBR | 121 | 208.65 | 6.82716 |
| 913SBR | 117 | 23.45 | 11.1634 |
| 909NBT | 261 | 425.95 | 8.9003 |
| 993NBR | 0 | 13.9 | 5.27257 |
| 1358NBL | 25 | 67.45 | 6.24366 |
| 1358SBL | 48 | 17.8 | 5.26513 |
| 1358EBL | 47 | 2.95 | 8.81441 |
| 1358WBR | 70 | 12.75 | 8.90034 |
| 67WBR | 77 | 9.5 | 10.2639 |
| 37NBT | 272.287 | 372 | 5.55555 |
| 37SBL | 2 | 31.15 | 7.15998 |
| 9SBR | 94 | 161.5 | 5.97205 |
| 9WBR | 29 | 4.3 | 6.05327 |
| 83NBR | 106 | 56.2 | 5.52992 |
| 1351NBR | 45 | 3.5 | 8.42737 |
| 1351SBT | 78 | 23.55 | 7.6414 |
| 1351SBR | 59 | 113.05 | 5.82751 |
| 1351EBR | 88 | 29.75 | 7.59155 |
| 68NBR | 50 | 11.15 | 7.02599 |
| 68WBR | 52 | 0 | 10.198 |
| 38NBT | 259.852 | 385.25 | 6.9822 |
| 38WBT | 578 | 453 | 5.50549 |
| 10WBR | 85 | 177.75 | 8.09203 |

## A2 PM Peak

**Table 9-2: PM turns with GEH > 5**

| Movement | Observed | Modelled | GEH |
|---|---|---|---|
| 80NBR | 22 | 0 | 6.63325 |
| 80SBT | 1274 | 1519 | 6.5561 |
| 80SBR | 114 | 251.895 | 10.1949 |
| 1691NBL | 62 | 120.421 | 6.11712 |
| 1691NBR | 116 | 262.263 | 10.6354 |

| | | | |
|---|---|---|---|
| 1691EBR | 17 | 0 | 5.83095 |
| 64WBR | 48 | 8.15789 | 7.51886 |
| 34SBT | 170.5 | 268.526 | 6.61626 |
| 28NBT | 166 | 18.4737 | 15.3609 |
| 28NBR | 61 | 22.3158 | 5.99356 |
| 28SBR | 59 | 21.8421 | 5.8445 |
| 19EBL | 59 | 0 | 10.8628 |
| 19WBL | 28 | 0 | 7.48331 |
| 6NBT | 399 | 686.105 | 12.3259 |
| 6WBR | 17 | 218.316 | 18.5595 |
| 166NBR | 70 | 1.94737 | 11.3463 |
| 166SBT | 1302 | 1506.68 | 5.46195 |
| 166WBR | 227 | 1.73684 | 21.0638 |
| 65WBR | 87 | 148.158 | 5.64011 |
| 35WBL | 53 | 11.7895 | 7.24054 |
| 1518NBR | 90 | 150.053 | 5.48143 |
| 1518SBL | 71 | 11.1053 | 9.34799 |
| 1518SBR | 44 | 5.31579 | 7.79033 |
| 1518EBL | 43 | 11.5263 | 6.02781 |
| 1518WBR | 103 | 19.4211 | 10.6828 |
| 20WBL | 30 | 104.105 | 9.04984 |
| 7NBR | 57 | 5.26316 | 9.27255 |
| 1802NBT | 452 | 349.895 | 5.09923 |
| 81NBR | 74 | 13.8947 | 9.06663 |
| 81SBT | 1259 | 1457.63 | 5.38949 |
| 483NBR | 125 | 69.3158 | 5.64928 |
| 483SBT | 68 | 21.4737 | 6.9561 |
| 483SBR | 29 | 69.2105 | 5.7382 |
| 483EBL | 38 | 95.1053 | 6.99993 |
| 1905SBL | 41 | 5.05263 | 7.49126 |
| 1905WBR | 55 | 18.5789 | 6.00469 |
| 21SBL | 42 | 12.4211 | 5.67041 |
| 8NBR | 28 | 4.21053 | 5.9279 |
| 8SBR | 81 | 136.842 | 5.35064 |
| 82EBL | 19 | 0 | 6.16441 |
| 82EBR | 150 | 247.158 | 6.89464 |
| 82WBR | 90 | 281.211 | 14.0351 |

| | | | |
|---|---|---|---|
| 913SBR | 84 | 28.1053 | 7.46574 |
| 993EBR | 20 | 2.15789 | 5.3604 |
| 1608WBR | 108 | 202.632 | 7.59326 |
| 1358NBL | 29 | 136.316 | 11.8038 |
| 1358SBL | 36 | 11.3684 | 5.06131 |
| 1358EBL | 34 | 8.31579 | 5.5838 |
| 1358WBL | 80 | 151.947 | 6.6809 |
| 1358WBR | 87 | 6.21053 | 11.8342 |
| 67WBR | 98 | 8.26316 | 12.311 |
| 37WBR | 42 | 5.94737 | 7.36325 |
| 22WBR | 67 | 123 | 5.74548 |
| 9EBL | 14 | 0 | 5.2915 |
| 9EBR | 32 | 89 | 7.3282 |
| 83NBR | 126 | 32.2632 | 10.5374 |
| 83SBT | 936 | 1162.79 | 7.00089 |
| 1351NBL | 98 | 19.8421 | 10.1821 |
| 1351NBR | 69 | 28.1053 | 5.86896 |
| 1351SBL | 19 | 57 | 6.16441 |
| 1351SBT | 58 | 11.1579 | 7.96582 |
| 68NBR | 78 | 15.8947 | 9.06406 |
| 68WBR | 49 | 0 | 9.89949 |
| 38NBR | 45 | 7 | 7.45241 |
| 38EBR | 64 | 7.36842 | 9.48027 |
| 2035WBT | 328 | 451.526 | 6.2569 |
| 23NBT | 367 | 522.053 | 7.35411 |
| 23SBR | 59 | 13 | 7.66667 |
| 10WBT | 281 | 403.789 | 6.63587 |

## A3 SAT Peak

**Table 9-3: SAT turns with GEH > 5**

| Movement | Observed | Modelled | GEH |
|---|---|---|---|
| 80NBR | 57 | 0 | 10.677 |
| 64NBR | 98 | 156.474 | 5.1839 |
| 64SBL | 0 | 24.5789 | 7.0113 |
| 34SBT | 329 | 235.105 | 5.5908 |
| 34WBT | 475 | 607 | 5.6751 |
| 6EBL | 22 | 0 | 6.6333 |
| 36SBT | 458 | 328.158 | 6.549 |
| 909SBT | 405 | 281.105 | 6.6892 |
| 37SBL | 0 | 28.5789 | 7.5603 |
| 83SBT | 977 | 1159.32 | 5.5784 |
| 83EBT | 374 | 494.158 | 5.7672 |
| 23SBT | 321 | 422.368 | 5.2579 |
| 10EBL | 88 | 34.5789 | 6.8237 |
| 10WBL | 18 | 0 | 6 |
| 10WBR | 44 | 109.526 | 7.4789 |

## Control Information

| **Prepared by** | **Prepared for** |
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