Model Calibration and Validation Guide

Vaughan Transportation Plan

City of Vaughan

FINAL

Vaughan, ON

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1 Model Overview

1.1 Coverage Area and Model Purpose

Travel demand models are an important tool for municipalities to support forecasting and transportation planning work, such as transportation master plans, corridor planning/EA studies, and focused area analyses such as Secondary Plans or traffic impact studies. This report describes the model calibration and validation for the Vaughan Travel Demand Model developed as part of the Vaughan Transportation Plan.

The model described in this report was developed for the City of Vaughan based on an adaptation of the multimodal activity-based GTAModel (version 4.1) created by the Travel Modelling Group at the University of Toronto. The model was customized and calibrated for Vaughan by disaggregating the zone system, adding and refining network detail, and adjusting calibration parameters to approximate more closely the prevailing travel conditions within the City. While the model covers the complete Greater Toronto and Hamilton Area and will generate outputs for the whole coverage area, it has only been calibrated, and thus should only be applied, for travel to, from and within Vaughan. The wider coverage area allows a more realistic simulation of the complexity of the external end of travel patterns to and from Vaughan.

The model was developed to support analysis and forecasting work for the Vaughan Transportation Plan, as well as, potentially, other high-level planning exercises to be carried out by or for the City. As a regional model, its focus is on city-wide travel flows and its calibration to flows across major arterials and municipal boundaries reflects this. However, its structure could be readily adapted for more detailed subarea models and analyses, in combination with a more focused local calibration.

1.2 Modes, Purposes and Time Periods

The model simulates travel conditions for a 24-hour period; however, only the AM peak period (6 to 9 am) and the PM peak period (3 to 7 pm) have been validated against observed transportation data. The comparisons of modelled assignment results to observed counts are described separately in the validation section of this report.

The model includes four trip purposes; home-based work, home-based school, home-based shopping/market, and other, as well as external non-purpose specific trips, starting or ending beyond the GTHA. Trips are generated as part of daily activity tours and converted to OD trips within a specific time period for the purpose of assignment using a scheduling process.

The model also includes the following modes of travel[1]:

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[1] The precise definition of modes within the model has some additional complexities; however, for the purposes of calibration, reporting and forecasting, the above level of detail is used.

- Auto driver
- Auto passenger (driven by another household member)
- Rideshare (auto passenger driven by a non-household member)
- Transit (walk access or egress)
- Transit (vehicular access or egress)
- School bus
- Active (walk or cycle)

In addition, light, medium, and heavy trucks, generated as a function of employment levels, are assigned to the network, though are not part of mode choice (people cannot choose to travel by truck).

Active mode demand, though generated by the model at a zone-to-zone OD level, is not directly assigned to the network, nor are active transportation infrastructure elements (such as bike lanes and trails) coded into the network. To forecast the responsiveness of future mode share to active transportation infrastructure development, an add-on module (described separately) would be needed.

1.3 Calibration and Forecasting Years

The model has been calibrated to a 2016 base year, corresponding to the most recent available year of Transportation Tomorrow Survey (TTS) data at the time of model development, as well as available population and employment statistics. Because of the major changes experienced by the transportation network in Vaughan between 2016 and 2018; specifically, the opening of the extension of the TTC subway line 1 to Vaughan Metropolitan Centre (VMC), a 2018 sensitivity scenario focused specifically on rapid transit and connections was also developed to test the model's response to the introduction of a subway, and to apply calibration adjustments accordingly. This model applied 2016 land use to a 2018 network including the new subway and resulting reconfiguration of bus routes in southern Vaughan.

Forecast scenarios have been identified for a 2051 horizon year incorporating the City's land use and network plans. Major projects from the MTO Southern Highways Program and the Metrolinx Regional Transportation Plan that are expected to be implemented by then and are likely to affect Vaughan by running through or in close proximity to the City are also included. These projects are described further in the forecasting chapter.

2 Zone System

2.1 Base Zone System

The starting point for developing the zone system was the 2006 GTA zone system that is commonly used for land use projections across the region. This zone system included 142 zones within the City of Vaughan. For the Vaughan model, these zones have been disaggregated further within the City, while preserving the GTA zone system in the rest of the York Region, Toronto, Peel, Durham, Halton and Hamilton.

2.2 Network Disaggregation and Centroid Connection

The zone system within the City of Vaughan was disaggregated using a one-to-many process (no boundaries between existing zones were amalgamated). The splitting of zones was carried out according to the following guidelines:

- MTSA boundaries (based on available draft information from April 2019)
- Arterial and major collector roads (including those not yet existing, but planned)
- Major land use type variations

The resulting zone system, which added 126 zones within Vaughan, for a new total of 268, is shown in **Figure 2-1.** To facilitate model consistency and comparisons, the zone system was kept consistent between the base and forecast years (there are some exceptions for station zones as described below).

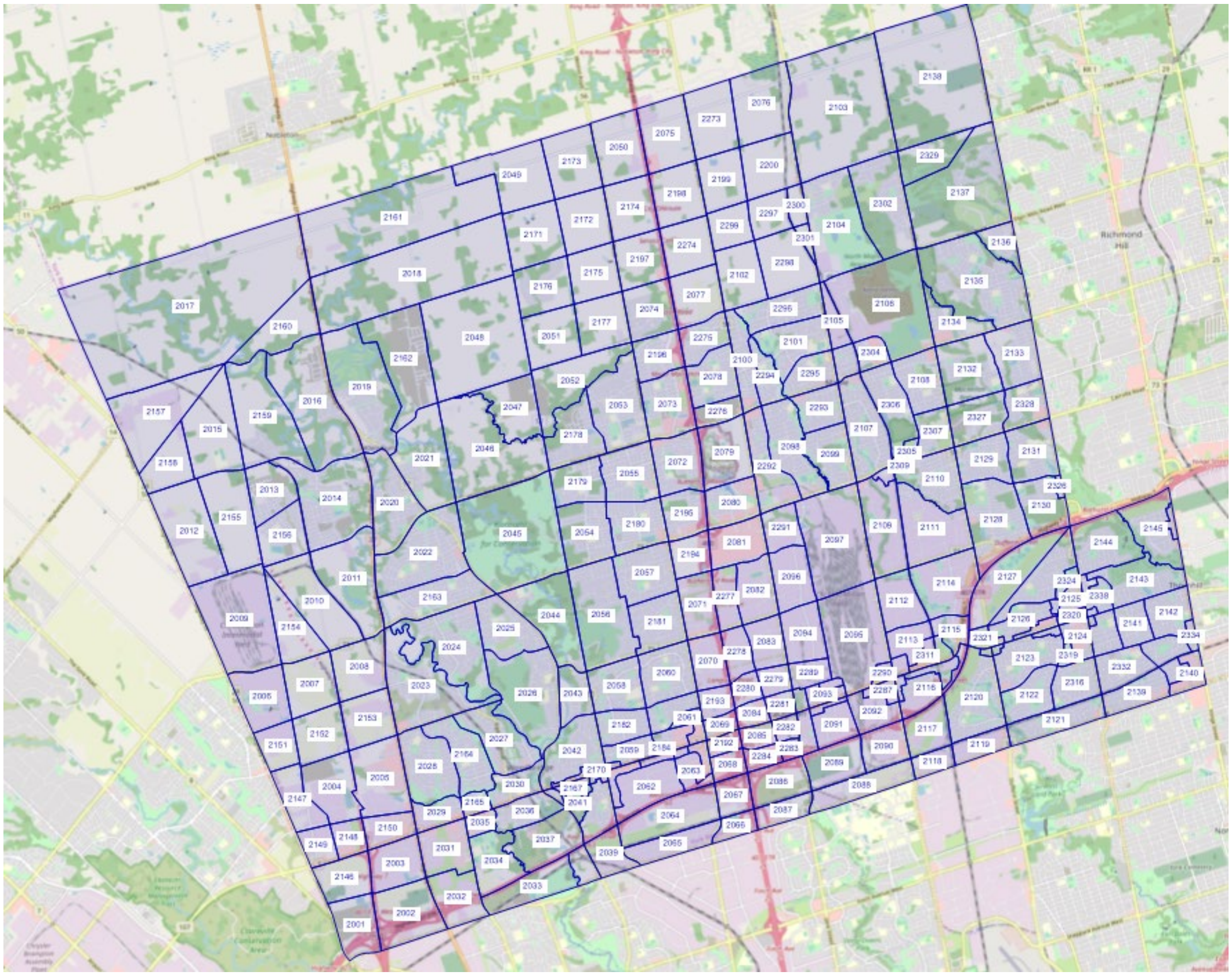


Figure 2-1: Vaughan Model Zone System

The network was refined within the City of Vaughan to add details of collector roads and connector links to the new zone centroids.

2.3 Special Generators and Other Zones

The model is structured such that each station park and ride lot is treated in the model as a separate traffic zone, though without associated demographic characteristics. Each GO station in the model, and many subway stations (including all those in Vaughan, for post-2016 networks) have an associated zone. This means that trips can be split into auto and transit components, and assigned as two separate trips within the model. Parking lot capacity is included as a property of the zone, which influences parking choice in the model, but is not a hard cap on station access demand (as some people travelling to and from stations may be dropped off and picked up by car rather than driving).

While the model could be adapted to feature other special generators such as major shopping centres, these are not presently included.

2.4 Land Use

The core land use for model calibration is based on the TTS with disaggregation applied to match the updated zone system. For forecasting, this is modified by forecasts provided by the City of Vaughan. The GTAModel uses a synthesis of population and employment data that has been converted (using TTS survey data) into household members who carry out daily activities based on personal characteristics (age, occupation/employment status, household auto ownership and household composition).

Disaggregation of the core 2016 TTS-based land use was undertaken by applying the disaggregated zone system. Population by zone is presented in **Figure 2-2**, and employment by zone in **Figure 2-3**.

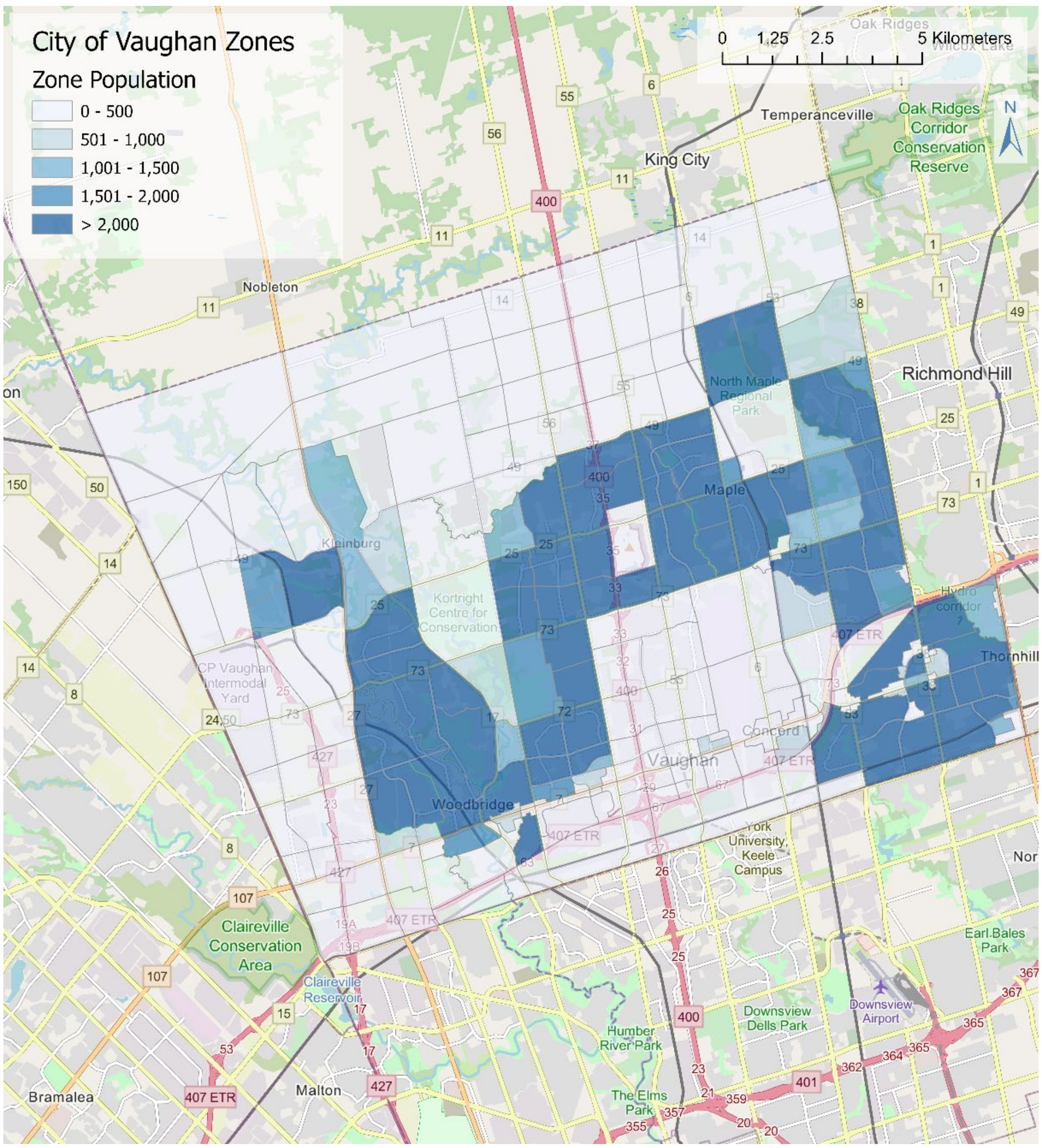


Figure 2-2: Vaughan Population by Zone, 2016

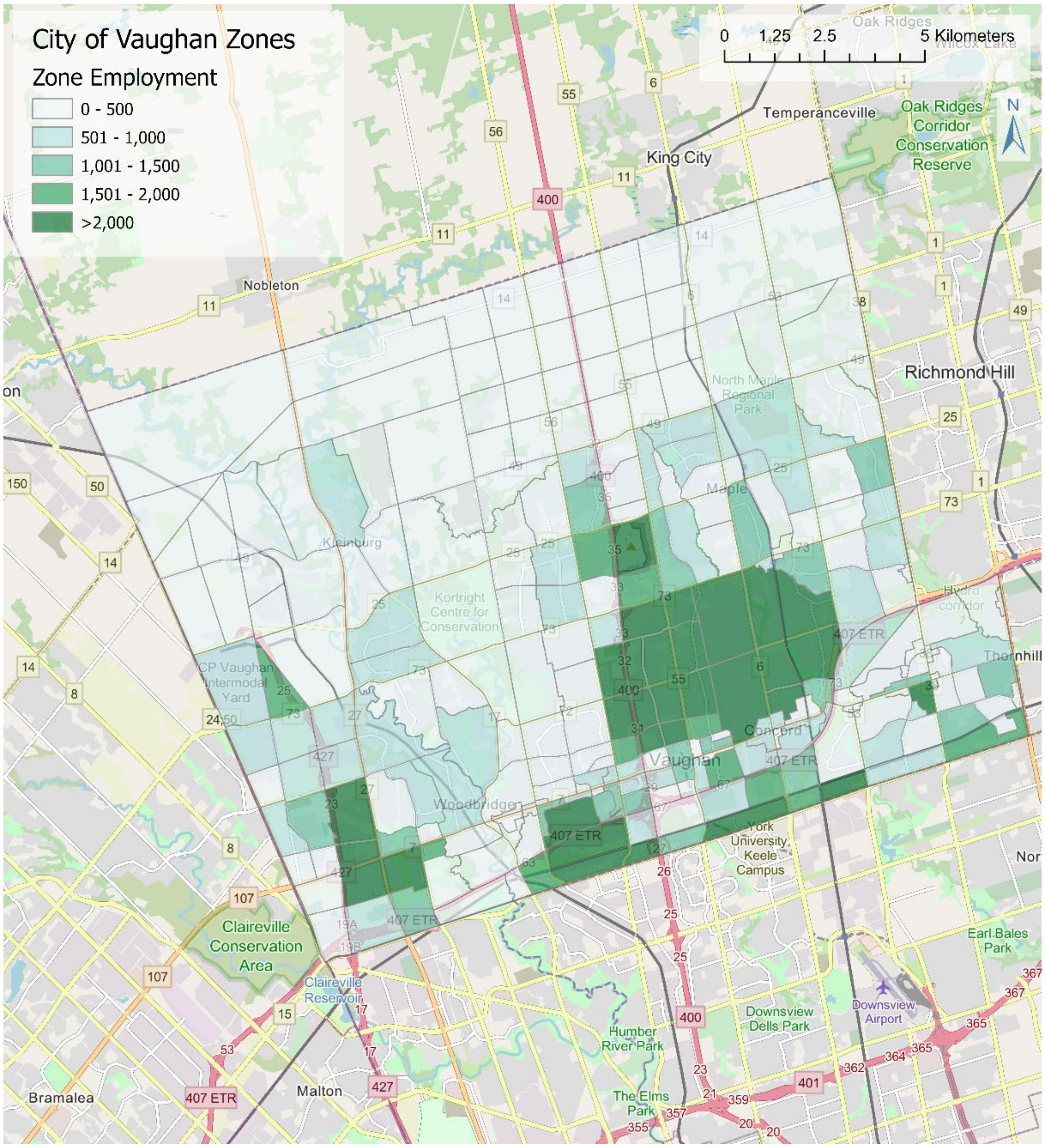


Figure 2-3: Vaughan Employment by Zone, 2016

3 Model Development and Calibration

3.1 Data Sources

The model was calibrated to data from the 2016 Transportation Tomorrow Survey. Additional sources used in validation are described in the next chapter.

3.2 Calibration Process

The calibration process involved making adjustments to the GTAModel (which was originally calibrated at a region-wide level) so as to match more closely the observed travel patterns by mode to, from and within Vaughan, focusing on the peak direction of travel.

The key elements are:

- OD comparisons by mode for travel to/from/within Vaughan and check for reasonability
- Refinements to model generation and mode choice parameters (by purpose in some cases) for trips to, from or within Vaughan
- OD demand adjustments at the auto assignment level (applied to address the tendency for TTS to under-simulate that is especially noted in PM—we have not needed to do this for the AM).
- Comparison of (primarily) GEH metrics for peak-hour auto assignment, and percentage differences for transit.

3.3 Calibration Adjustment Parameters

In the original GTA model from which this model was derived, some consistent values for household properties were used across multiple municipalities. Following a review of outputs from initial runs and comparison against Vaughan-specific TTS results, some changes were made for Vaughan. These are described in **Table 3-1**. Values for other municipalities and regions were left unchanged. In some cases, an iterative process of multiple runs was carried out to achieve mode share and auto ownership results closer to TTS Vaughan numbers. A more detailed comparison of modelled and TTS Vaughan mode share and auto ownership is available in **Appendix A**.

Table 3-1: Calibration parameter variations for City of Vaughan

Variable	Original value	New Vaughan-specific value
Auto ownership constant (acts to increase or decrease household number of vehicles)	2.1488	3
Episode generation factor (acts to increase or decrease daily trip rates for residents and employees)	1.5	2
Walk trip constant (daily intra-Vaughan)	-4	-3
Bicycle trip constant (daily intra-Vaughan)	-4	-3
Walk access to transit coefficient (daily intra-Vaughan)	-2	-2.5
Walk access to transit coefficient (PM Toronto to Vaughan)	1	-2
Drive access to transit coefficient (PM Vaughan to Toronto)	1	-3
Passenger access to transit coefficient (PM Vaughan to Toronto)	1	-3
Passenger egress from transit coefficient (PM Vaughan to Toronto)	1	-3

3.4 Origin-Destination Demand

While the model produces results for trips across the GTHA, it is important to note that, for the purposes of the Vaughan model, the OD flows and assigned volumes by mode within and between other municipalities than Vaughan have not been reviewed or calibrated, and it is possible that some of the calibration adjustments made to obtain a better fit in Vaughan may lead to distortions elsewhere in the region. Therefore, as currently calibrated the model should only be used for estimating travel to, from or within Vaughan.

The model was calibrated at a city-wide OD level by mode, for the following trip types:

- Trips from an external zone to a Vaughan zone (AM and PM peak periods)
- Trips from a Vaughan zone to an external zone (AM and PM peak periods)
- Trips between two Vaughan zones (AM and PM peak periods).

The zones do not include stations, as these are used only at an assignment level, not for comparing OD demand.

For city-wide OD calibration, the comparisons of modelled to observed numbers are shown in **Table 3-2** and **Table 3-3.** "Observed" numbers are based on the TTS. Modelled numbers include the calibration adjustments applied in the previous section. A more detailed breakdown of observed and modelled demand is available in **Appendix A.**

Table 3-2: City-wide OD demand (observed and modelled, AM)[2]

Citywide calibration:

	AM Peak (3 hours)				
Observed	Driver	Transit	Active	Other	Total
External Trips To Vaughan	72,904	4,542	364	7,335	85,145
External Trips From Vaughan	61,051	14,542	762	10,164	86,519
Trips Within Vaughan	45,103	1,397	9,079	16,951	72,530
	179,058	20,481	10,205	34,450	244,194

	AM Peak (3 hours)				
Modelled	Driver	Transit	Active	Other	Total
External Trips To Vaughan	57,269	7,180	706	11,572	76,726
External Trips From Vaughan	51,281	17,348	805	10,006	79,439
Trips Within Vaughan	33,937	1,380	9,138	19,166	63,620
	142,486	25,907	10,648	40,745	219,786

	AM Peak (3 hours)				
% Difference	Driver	Transit	Active	Other	Total
External Trips To Vaughan	-21%	58%	94%	58%	-10%
External Trips From Vaughan	-16%	19%	6%	-2%	-8%
Trips Within Vaughan	-25%	-1%	1%	13%	-12%
	-20%	26%	4%	18%	-10%

In the AM peak, the model tends to under-simulate demand relative to the TTS by around 10% in total, slightly less in the “from Vaughan” peak direction. Some of the variations may be due to differences in what precisely constitutes a trip in the tour-based GTAModel compared with the TTS, which is dependent on reporting by the surveyed participants but includes each recorded stop as a break and start of a new trip. Transit is over-simulated and auto drive trips under-simulated, but the TTS is known to under-represent transit in York Region, as reported in the 2016 TTS Validation Guide, so this should help to compensate for that under-representation.

[2] “Other” trips refer to multiple passenger modes—auto passenger, ridesharing, or school bus

Table 3-3: City-wide OD demand (observed and modelled, PM)

Citywide calibration:

	PM Peak (4 hours)				
Observed	Driver	Transit	Active	Other	Total
External Trips To Vaughan	78,608	16,806	1,240	14,000	110,654
External Trips From Vaughan	93,858	5,644	820	12,892	113,214
Trips Within Vaughan	66,627	2,130	9,628	17,568	95,953
	239,093	24,580	11,688	44,460	319,821

	PM Peak (4 hours)				
Modelled	Driver	Transit	Active	Other	Total
External Trips To Vaughan	57,629	18,878	995	13,682	91,184
External Trips From Vaughan	76,739	12,569	912	17,523	107,744
Trips Within Vaughan	68,190	2,645	6,062	30,880	107,777
	202,558	34,092	7,970	62,085	306,705

	PM Peak (4 hours)				
% Difference	Driver	Transit	Active	Other	Total
External Trips To Vaughan	-27%	12%	-20%	-2%	-18%
External Trips From Vaughan	-18%	123%	11%	36%	-5%
Trips Within Vaughan	2%	24%	-37%	76%	12%
	-15%	39%	-32%	40%	-4%

In the PM peak, the model is also slightly under-simulating relative to the TTS. It would be possible to apply correction factors to obtain a closer approximation; however, the northbound flows across the southern border of Vaughan (the dominant source of trips to Vaughan) match observed counts to within 2%, so adding factors here would then lead to needing to add another set of factors to validate the assignment. Again, the oversimulation of transit relative to the TTS is at least partially due to the under-representation of transit in the TTS. Active transportation volumes within Vaughan are also low (unlike in the AM), but much of this is intrazonal demand and does not appear on the network.

4 Model Validation

Whereas calibration describes the process of fitting a model to observed data (in this case, observations from the TTS), validation is the comparison of model outputs against independent observed data to test the extent to which it can reasonably replicate observed conditions. For the Vaughan model, validation involved comparing 2016 vehicle and transit ridership data to model outputs, as well as a 2018 sensitivity test (though with unchanged land use) to test the model's responsiveness to the opening of the VMC subway extension in 2017, compared with observed 2018 transit counts at the new subway stations and major bus routes. The model will provide an overall picture of traffic conditions across the City but may not capture localized issues or short-distance travel because of its larger-scale nature.

As a result of the validation tests, some additional adjustment factors were applied to the PM transit assignment matrices. These helped to counter differences between the TTS's 5% sample of surveyed findings and actual observed conditions, as well as make refinements to flows beyond those calibrated at the OD and mode levels described in the previous chapter. The numbers reported in this chapter include the adjustments.

4.1 Data Sources

Validation data were taken from the following sources for the AM and PM peak periods:

- York Region 2016 cordon count traffic data, taken from the University of Toronto's online cordon count database (CCDRS) at the Data Management Group website;
- York Region and City of Vaughan 2016 turning movement counts, supplied by the City of Vaughan;
- Provincial highway ramp terminal counts, supplied by MTO;
- 2016 and 2018 transit line ridership counts from YRT, supplied by the City of Vaughan
- 2016 GO Bus ridership counts and GO Rail boarding and alighting counts, supplied by Metrolinx; and
- 2018 TTC subway boarding and alighting counts, supplied by the TTC.

The 2016 TTS Data Validation Guide, produced by the Data Management Group, was also used as a reference for its comparison of TTS with observed transit ridership numbers in York Region in the AM peak period. This indicated that, on average, the TTS under-reported transit ridership by 35% on YRT routes. As the Vaughan model was calibrated to TTS OD flows, an under-simulation of transit volumes could be expected as a result, though partially compensated for by the over-simulation of transit relative to TTS at a city-wide level noted in the calibration section.

4.2 Validation Methodology

For validation of a regional model, there are generally no set rules for validation targets; instead, there are guidelines based on industry consensus that can be used.

Validation work is usually focused largely on assignment, where modelled numbers can be compared directly to 100% samples of observed data rather than the limited subsets provided by surveys. There are a number of metrics to compare assignment results against screenline counts.

These include performance relative to statistics including the GEH (which involves a blend of absolute and relative differences, the formula for which is given in **Figure 4-1**), the RMSE percentage (root mean square error, based on the square root of the sum of the square of differences between observed and modelled numbers, divided by the number of observations), the R-squared statistic (a measure of statistical correlation between two sets of numbers where 1 indicates a perfect correlation and 0 totally independent data sets), and percentage differences.

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

Figure 4-1: The GEH Statistic (M represents modelled, C counted or observed data)

The model validation was focused on peak-hour peak direction flows for both peak periods and the auto and transit modes. Validating to the screenline level confirms the appropriateness of volumes and directions (confirming trip distribution and magnitude of flows) while comparing at individual locations confirms the accuracy of the model at a more detailed level; both were employed to some degree. When comparing stations, it needs to be recognized that these comparisons are more susceptible to variations due to localized impacts such as construction, network improvements between the count recording date and the model base year, and incidents on the day of count collection, as well as the day-to-day variability of counts. Screenlines thus offer a more stable measure of comparison, so station-level numbers are typically harder to match as closely to observed numbers. For these reasons, certain stations were excluded from the overall station calibration statistics but still counted towards the screenline totals and calibration statistics.

Our target to validate modelled peak-hour peak-direction traffic flows compared to observed flows across screenlines to within an average GEH (at least 50% of screenlines less than or equal to) of 5, with 85% or more of screenlines recording a GEH of 10 or less for each set of directional hourly flows for each time period.

The overall R-squared statistical correlation of predicted to observed screenline volumes should exceed 0.9, and the RMSE percentage of differences between predicted and observed should be less than 30% at the screenline level, as long as the screenline volumes are at least equivalent to a major arterial road. The RMSE target percentage, when applied to specific locations such as individual stations on a screenline, increases with decreasing mean volume on the locations to be compared—examples of targets are seen in the TMIP Validation Guide, Figure 9.8[3] as well as in the FDOT Calibration and Validation Standards[4].

There are also no existing guidelines for applying the GEH statistic to transit validation, where comparative percentages are usually applied. However, it is important, rather than simply trying to match numbers within a given percentage, to understand why differences are occurring relative to observed, what could be causing these and how the model can be interpreted in light of these. In this case, possible reasons may be:

- The model is undersimulating because it is based on an OD survey that also undersimulates transit, especially for off-peak and discretionary travel
- In reality, people do not have a good enough knowledge of the transit network to deviate from “their” route—they may be able to save five minutes by transferring to another line but they will not know about it, or consider it worthwhile, while the model will apply the transfer, even with a transfer penalty in place (if transfer penalties are set too high to avoid this, they may discourage transit use altogether, which is counterproductive in calibration).
- Park and ride lots are often capacity constrained; these tight constraints, and behavioural impacts such as people driving to a different station because they can park closer to the platform, are not usually well captured in macro models.
- Transit use is very susceptible to seasonal variations and special events.
- The model does not require people to return in the PM to the same station they boarded at in the AM unless they left their car there (i.e. they can be dropped off at one station and picked up at another).
- Fare policies, with discounts for use, unlimited use policies, reductions for some age groups, and time-expiry policies, are difficult to model and influence route choice.

Our aim for validation of this model was to match observed traffic flows to within a reasonable level of accuracy, as identified by the targets above, without applying adjustment factors excessively (as this can call into question the reliability of forecasting).

4.3 Auto Screenline Definitions

A screenline is an imaginary line, usually associated with a major road, natural boundary or municipal boundary, across which modelled volumes are compared with observed counts as a

3 https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/validation_and_reasonableness_2010/fhwahep10042.pdf, Figure 9.8.

4 http://www.fsutmsonline.net/images/uploads/reports/FR2_FDOT_Model_CalVal_Standards_Final_Report_10.2.08.pdf

validation measure. The screenlines for the Vaughan model include the municipal boundaries as well as major roads and railway lines. These are shown in **Figure 4-2** below, with the red lines indicating cordons included in the municipal cordon count program and the blue lanes representing additional screenlines added for a finer level of calibration detail.

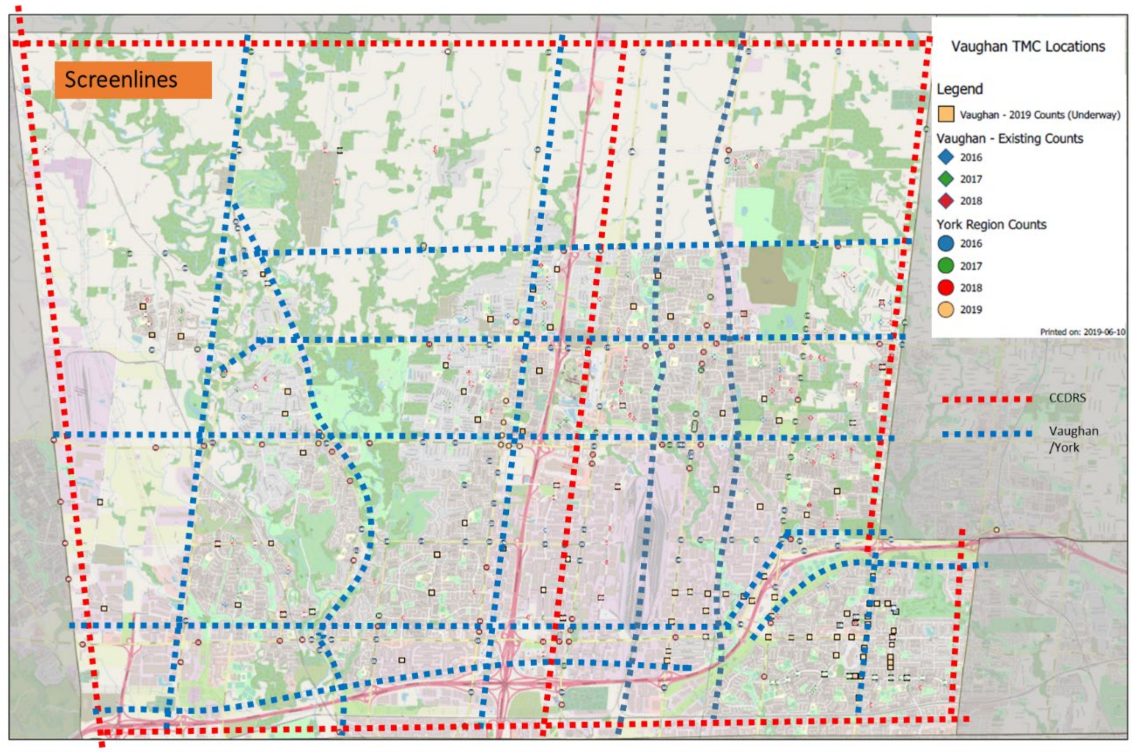


Figure 4-2: Vaughan Travel Demand Model calibration screenlines

In summary, eight east-west screenlines (capturing and comparing north-south traffic) and ten north-south screenlines (capturing and comparing east-west traffic) were defined, as listed below.

East-west screenlines:

- South boundary cordon
- North of 407 (west boundary to Dufferin)
- North of 407 (Bathurst to east boundary)
- North of Highway 7
- North of Rutherford
- North of Major MacKenzie (Highway 27 to east boundary)
- North of Teston and connecting roads (Highway 27 to east boundary)
- North boundary cordon

North-south screenlines:

- West boundary cordon
- West of Highway 27

- West of Islington (south boundary to Highway 27)
- West of Highway 400
- East of Highway 400 cordon
- Don River west branch and CN Rail Line/MacMillan Yard
- Barrie GO Line
- West of Bathurst (Highway 407 to south boundary)
- East boundary cordon (Bathurst)
- East boundary cordon (Yonge)

Individual count locations were defined as the points on the roads crossing these screenlines, or as close to these as practical. Where possible, counts taken in or close to 2016, and as near to the screenline crossing location as possible, were used, though those from more recent or distant years were used when necessary (dating as far back as 2003). An annual growth factor of 3.6% was assumed, based on approximate historical growth in Vaughan, for converting trips to a 2016 equivalent value. However, in some cases localized developments or expansion of the road network in the years between the count being taken and 2016 meant that the count, even with the factor in place, was not reporting a reasonable estimate of 2016 conditions; these were flagged and, after further review, not included in the station-level modelled-to-observed comparisons (but still counted towards screenline totals). These locations were:

- Bathurst St N of Highway 7 (counted in 2008)
- Clarence St N Rutherford Rd (counted in 2010)
- Barrhill Rd N Rutherford Rd,& Rutherford E of Barrhill Rd (counted in 2008)
- King-Vaughan Rd W of Keele St (counted in 2010)
- Kirby Rd W of Keele St (counted in 2004)
- Teston Rd E of Keele St (counted in 2011)
- King-Vaughan Rd E of Jane St (counted in 2010)
- King-Vaughan Rd E of Weston Rd (counted in 2010)

4.4 Auto Screenline Validation Summary

Screenline and screenline station GEH/RMSE statistics are summarized in **Table 4-1**, with the RMSE statistics broken down by road type (highways, arterials and collectors). These statistics meet the validation criteria described in the previous section and did not require any additional adjustments to the model (apart from the calibration adjustments described in the previous chapter1. Station-level volume and GEH statistics are included in **Appendix A**, which is provided as an external spreadsheet attachment to this report.

Table 4-1: Auto screenline validation summary

	AM Peak Hour						
Screenline validation (2016):	Peak Direction				Offpeak Direction		
Screenlines	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total %
GEH within 5	7	4	**69%**	50%	0	1	6%
GEH within 10	8	7	**94%**	85%	5	2	44%
Total Screenlines	**8**	**8**			8	8	

	AM Peak Hour						
	Peak Direction				Offpeak Direction		
Screenlines	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	10,091	13,776	11,933	-	8,082	7,496	7,789
RMSE	3%	6%	**5%**	**30%**	23%	46%	36%
R-squared	1.00	1.00	**1.00**	**0.90**	0.99	0.95	0.97

	AM Peak Hour						
	Peak Direction				Offpeak Direction		
Highways	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	5,819	6,801	6,310	-	5,201	5,138	5,170
RMSE	22%	17%	**20%**	**40%**	30%	41%	36%
R-squared	0.95	0.93	**0.94**	-	0.93	0.93	0.93

	AM Peak Hour						
	Peak Direction				Offpeak Direction		
Arterials	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	1,155	1,360	1,258	-	870	591	731
RMSE	41%	23%	**31%**	**50%**	41%	54%	46%
R-squared	0.88	0.89	**0.89**	-	0.91	0.77	0.84

	AM Peak Hour						
	Peak Direction				Offpeak Direction		
Collectors	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	832	953	892	-	650	557	603
RMSE	37%	35%	**36%**	**75%**	42%	55%	48%
R-squared	0.90	0.90	**0.90**	-	0.87	0.72	0.79

	AM Peak Hour						
	Peak Direction				Offpeak Direction		
All Roads	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	1,207	1,366	1,287	-	959	751	855
RMSE	40%	29%	**34%**	-	48%	69%	58%
R-squared	0.90	0.87	**0.88**	-	0.88	0.77	0.83

	PM Peak Hour						
Screenline validation (2016):	Peak Direction				Offpeak Direction		
Screenlines	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total %
GEH within 5	5	5	**63%**	50%	1	1	13%
GEH within 10	7	8	**94%**	85%	3	2	31%
Total Screenlines	**8**	**8**			8	8	

	PM Peak Hour						
	Peak Direction				Offpeak Direction		
Screenlines	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	9,888	13,920	11,904	-	9,095	8,895	8,995
RMSE	6%	5%	**5%**	**30%**	27%	20%	24%
R-squared	1.00	1.00	**1.00**	**0.90**	0.98	0.96	0.97

	PM Peak Hour						
	Peak Direction				Offpeak Direction		
Highways	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	4,580	7,267	5,923	-	5,596	4,774	5,185
RMSE	33%	20%	**25%**	**40%**	50%	24%	41%
R-squared	0.91	0.91	**0.91**	-	0.86	0.97	0.92

	PM Peak Hour						
	Peak Direction				Offpeak Direction		
Arterials	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	1,158	1,272	1,215	-	1,004	741	873
RMSE	41%	23%	**32%**	**50%**	37%	46%	41%
R-squared	0.86	0.89	**0.88**	-	0.88	0.76	0.82

	PM Peak Hour						
	Peak Direction				Offpeak Direction		
Collectors	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	892	1,037	965	-	751	738	744
RMSE	30%	34%	**33%**	**75%**	42%	44%	43%
R-squared	0.94	0.86	**0.90**	-	0.88	0.86	0.87

	PM Peak Hour						
	Peak Direction				Offpeak Direction		
All Roads	**East-West**	**North-South**	**Total %**	Target	East-West	North-South	Total
Observed Mean	1,181	1,387	1,284	-	1,089	897	993
RMSE	42%	31%	**36%**	-	64%	44%	55%
R-squared	0.85	0.84	**0.85**	-	0.79	0.80	0.79

The peak-hour peak direction screenlines that do not match to observed numbers within a GEH of 5 are:

- AM Peak west border—GEH of 7, but still matches to within 6%, the higher GEH reflects heavy volumes across the border.
- PM Peak West of Islington—GEH of 17. This is under-simulated by around 20%. This was investigated and the following points were noted:
  - The undersimulation is not noted at either the west border of the City or at the Highway 400 screenline, so it appears to be a relatively local issue
  - No equivalent pattern (for the opposite direction) is observed in the AM peak, for which the modelled screenline volumes match closely to observed flows

Figure 4-3 and **Figure 4-4**, below, compare the validation level with RMSE of the Vaughan model to industry standards for the AM and PM peak, based on comparing against the FHWA Travel Model Improvement Program manual.[5] For both time periods, the Vaughan model reports results below the curve (RMSE targets are higher as volume increases).

It is notable, in comparing to the calibration numbers, that auto drive demand is underestimated for the peak periods (compared to TTS) at an OD level, but matches well at the screenline level. This may be explained by one or a combination of several factors that are frequently prevalent in static regional demand models, including:

- Potential inconsistency between sources, and the TTS overestimating driver demand relative to other modes
- Short-distance trips that do not cross screenlines, which the model does not capture (especially if they are intrazonal trips) and which do not contribute significantly to network load, get counted in the OD totals.
- Variations in the peak-hour factor (the model uses a constant peak hour factor that is based on start times derived from TTS, while counts are based on the time they cross a particular screenline), or flattening of the peak-hour (congestion can reduce flows at the time of highest demand, meaning that demand ends up being more spread across the peak period, as measured at screenlines, than would be indicated by the distribution of start times). Peak-hour factors are applied at the OD level, rather than at a link level, which can lead to a discrepancy.

The extent of these factors is difficult to quantify in a city-side static assignment model of this type. That being said, for the purposes of this study, these factors are expected to be

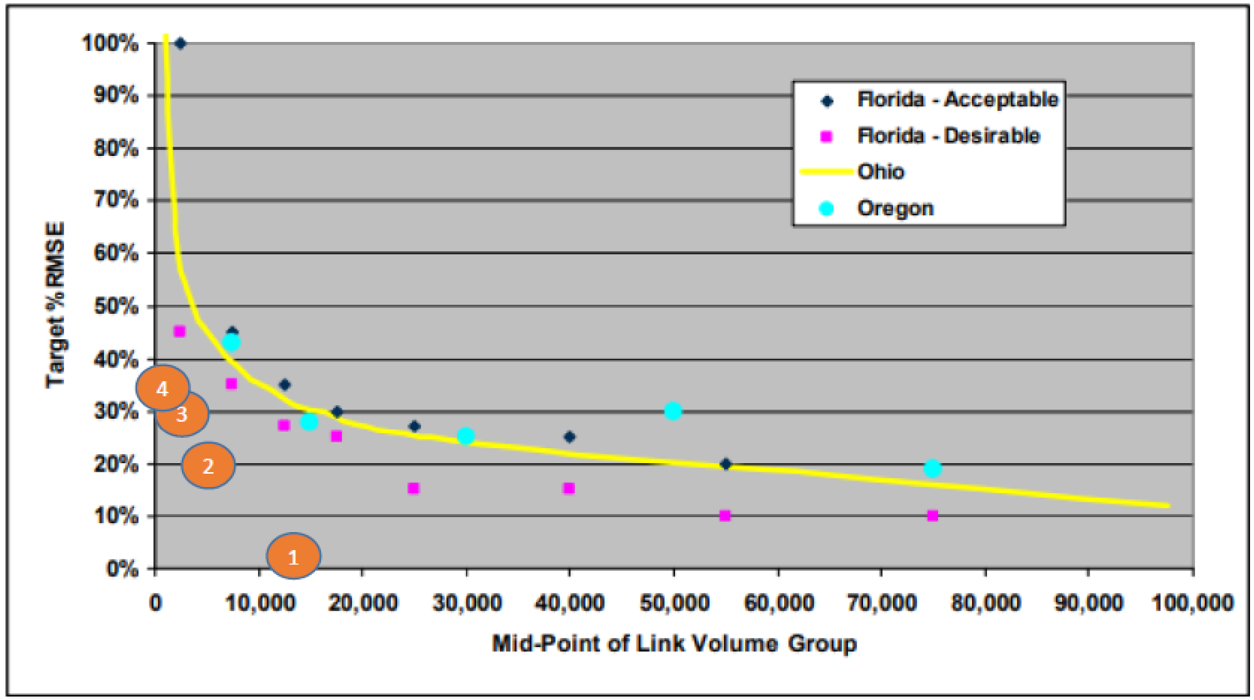
[5] FHWA, Validation and Reasonableness Checking Manual, Figure 9.8, https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/validation_and_reasonableness_2010/fhwahep10042.pdf,

prevalent in the future and thus, calibrating the modelled auto traffic to “ground truth” counts allows the model to intrinsically account for these factors.

AM peak RMSE% for Vaughan model (compared with FHWA TMIP manual):

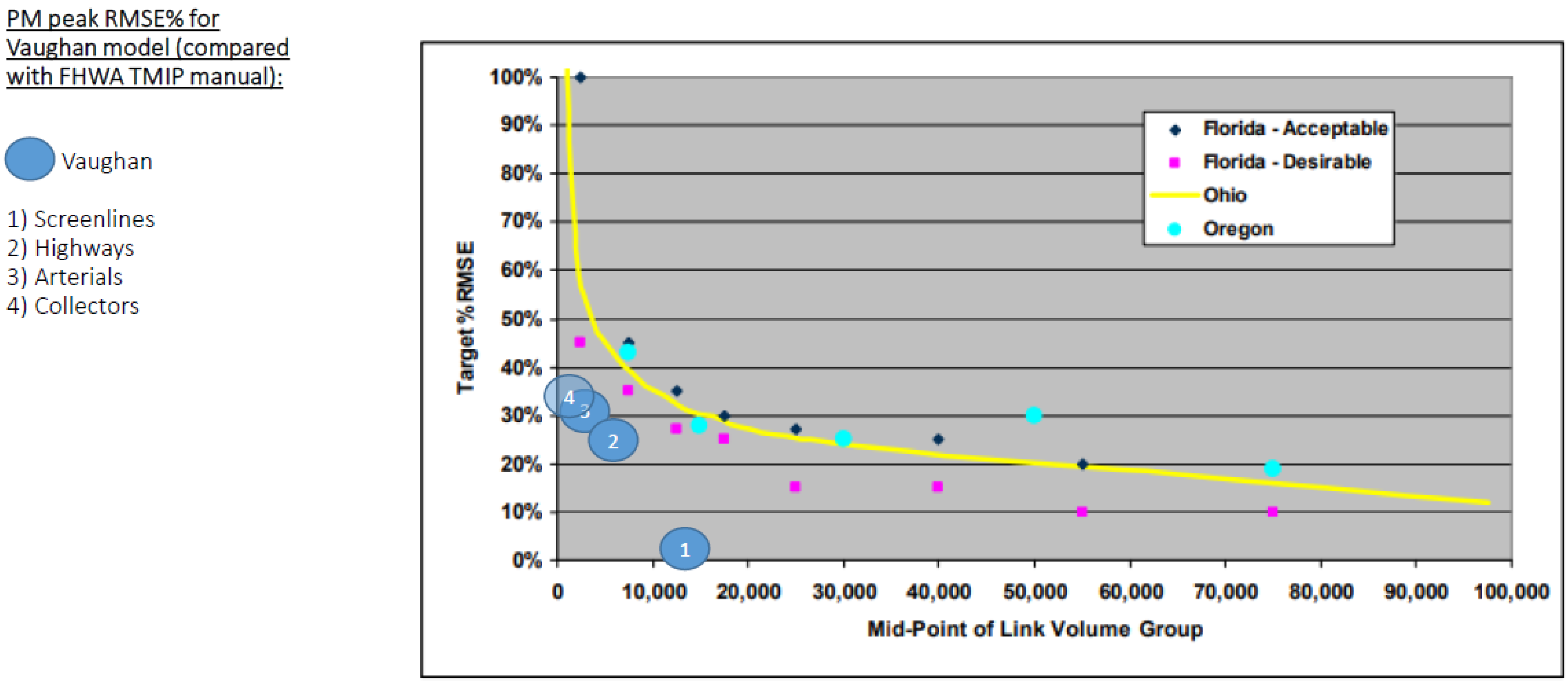
Vaughan

1) Screenlines
2) Highways
3) Arterials
4) Collectors



Sources: Ohio: Giaimo, Gregory, Travel Demand Forecasting Manual 1-Traffic Assignment Procedures; Florida: FSUTMS-Cube Framework Phase II, Model Calibration and Validation Standards: Model Validation Guidelines and Standards; and Oregon: FSUTMS-Cube Framework Phase II, Model Calibration and Validation Standards, Draft Technical Memorandum 1.

Figure 4-3: Comparison of Vaughan station RMSE performance against industry guidelines (AM Peak)



Sources: Ohio: Giaimo, Gregory, Travel Demand Forecasting Manual 1-Traffic Assignment Procedures; Florida: FSUTMS-Cube Framework Phase II, Model Calibration and Validation Standards: Model Validation Guidelines and Standards; and Oregon: FSUTMS-Cube Framework Phase II, Model Calibration and Validation Standards, Draft Technical Memorandum 1.

Figure 4-4: Comparison of Vaughan station RMSE performance against industry guidelines (PM Peak)

4.5 Transit Validation Adjustments and Summary

As previously mentioned, the model was run using both a 2016 and 2018 transit network (as a sensitivity test, with 2016 land use) in order to test the impact of the extension of the TTC subway line 1 to VMC on transit ridership in the model. Validation adjustments were then applied based on comparisons of transit ridership in both the 2016 (focusing on GO Rail and YRT) and the 2018 (focusing on the subway) networks. The GO Rail and subway comparisons were focused on locations within or near Vaughan, and the YRT comparisons considered the top 12 routes with the highest ridership (some branches were combined). These stations and routes are listed below.

YRT (2016 comparisons):

- 20 - Jane
- 22A - Keele-Yonge (or 96)
- 3 - Thornhill
- 4 / 4A- Major Mackenzie
- 5 - Clark
- 605 - Viva orange
- 77 / 77A - Highway 7
- 85 / 85C - Rutherford
- 88 - Bathurst

GO Rail (2016 comparisons):

- Rutherford GO station
- Maple GO station
- King City GO station

Subway (2018 comparisons):

- VMC subway station
- Highway 407 subway station
- Pioneer Village subway station
- York University subway station

The AM peak period transit results compared reasonably well to observed transit ridership, particularly on GO Rail. Although the results showed under-simulation on YRT routes (-31%) and the subway (-18%), any adjustments to these would have also impacted GO rail ridership, likely causing it to be over-simulated. Considering the under-simulation of transit trips in the TTS, the AM results were not subjected to additional adjustments.

On the other hand, the initial PM peak period results showed significant under-simulation on GO Rail (-57%), minor under-simulation on YRT (-23%), and minor over-simulation on the subway (+13%). These results required additional adjustments to get them to a validation level that is more consistent with the AM period. These adjustments were applied as a matrix of calibration factors directly to the PM transit assignment matrix, which was developed using Emme's demand adjustment module[6] in both the 2016 and 2018 networks. However, as these factors are to be applied to the future horizon years' transit assignment matrices, they were capped at a factor of 5 to avoid significantly skewing the model forecasts, particularly since a considerable level of new development is expected in Vaughan over the next few decades. These adjustments resulted in more reasonable comparisons with observed transit boardings in 2016 and 2018.

While the calibration at a mode level in Section 3.4 indicated that the model does over-simulate transit relative to TTS, the 35% underestimation in the AM peak from the TTS survey is an average of routes across York Region, many of which match quite well between TTS and observed. This means that there are some routes, including some major Vaughan routes, where the level of underestimation is significantly greater and so even when we over-simulate transit relative to TTS at an OD level, we under-simulate it at a route level. This reflects an inconsistency in calibration sources that should be recognized when using the model for ridership projections. However, some of these bus routes do get reconfigured as a result of the opening of the subway extension in 2017, so they may be less significant to forecasts.

The final AM and PM peak period transit assignment results are summarized in **Table 4-2**.

[6] This module adjusts the assignment matrix to better match observed counts of transit volumes or boardings, which were coded into the networks.

Table 4-2: Transit validation summary

GO Transit (2016)

		AM SB Boardings (3 hours)		
GO Rail	Station	Observed	Modelled	Diff%
Barrie	Rutherford	1,528	2,319	52%
Barrie	Maple	2,094	1,214	-42%
Barrie	King City	971	828	-15%
	TOTAL	4,593	4,361	-5%

		AM Ridership (3 hours)		
GO Bus	Direction	Observed	Modelled	Diff%
65	NB	112	94	-16%
65	SB	224	213	-5%
66	NB	41	7	-82%
66	SB	265	141	-47%
68	NB	59	8	-87%
68	SB	95	46	-51%
	TOTAL	796	510	-36%

GO Transit (2016)

		PM NB Alightings (4 hours)		
GO Rail	Station	Observed	Modelled	Diff%
Barrie	Rutherford	1,682	1,319	-22%
Barrie	Maple	2,515	2,380	-5%
Barrie	King City	949	919	-3%
	TOTAL	5,146	4,618	-10%

		PM Ridership (4 hours)		
GO Bus	Direction	Observed	Modelled	Diff%
65	NB	3	1	-61%
65	SB	211	437	107%
66	NB	311	409	31%
66	SB	40	24	-41%
68	NB	46	61	32%
68	SB	95	81	-15%
	TOTAL	707	1,013	43%

Top YRT Routes (2016)

		AM Ridership (3 hours)		
AM Period	Direction	Observed	Modelled	Diff%
20 - Jane	All	897	628	-30%
22A - Keele-Yonge (or 96)	All	445	92	-79%
3 - Thornhill	All	355	122	-66%
4 / 4A- Major Mackenzie	All	703	439	-37%
5 - Clark	All	378	94	-75%
605 - Viva orange	All	450	389	-14%
77 / 77A - Highway 7	All	1,429	971	-32%
85 / 85C - Rutherford	All	674	1,139	69%
88 - Bathurst	All	1,321	746	-44%
	TOTAL	6,652	4,622	-31%

Top YRT Routes (2016)

		PM Ridership (4 hours)		
PM Period	Direction	Observed	Modelled	Diff%
20 - Jane	All	1,365	1,025	-25%
22A - Keele-Yonge (or 96)	All	570	691	21%
3 - Thornhill	All	404	177	-56%
4 / 4A- Major Mackenzie	All	1,263	817	-35%
5 - Clark	All	497	155	-69%
605 - Viva orange	All	564	467	-17%
77 / 77A - Highway 7	All	1,981	1,726	-13%
85 / 85C - Rutherford	All	1,235	1,679	36%
88 - Bathurst	All	1,612	793	-51%
	TOTAL	9,491	7,532	-21%

TTC Subway (2018)

		AM Boardings (3 hours)		
Station	Direction	Observed	Modelled	Diff%
VMC	All	3,907	2,187	-44%
407	All	729	2,068	184%
Pioneer Village	All	2,660	2,111	-21%
York University	All	794	282	-64%
	TOTAL	8,090	6,648	-18%

TTC Subway (2018)

		PM Alightings (4 hours)		
Station	Direction	Observed	Modelled	Diff%
VMC	All	3,258	3,214	-1%
407	All	707	781	10%
Pioneer Village	All	2,967	2,987	1%
York University	All	3,562	2,537	-29%
	TOTAL	10,494	9,519	-9%

5 Model Forecasting

5.1 Definition of Future Horizons

In addition to the 2018 sensitivity scenario described in the previous section, the model horizon year (consistent with the Vaughan TMP) is 2051. Land use forecasts were implemented for the model in future horizons. Similar to the scenarios used for calibration and validation, population synthesis was undertaken for 2051 land use based on the further disaggregated Vaughan model zone system. Population and employment in 2051, by zone, is presented in **Figure 5-1** and **Figure 5-2**, respectively.

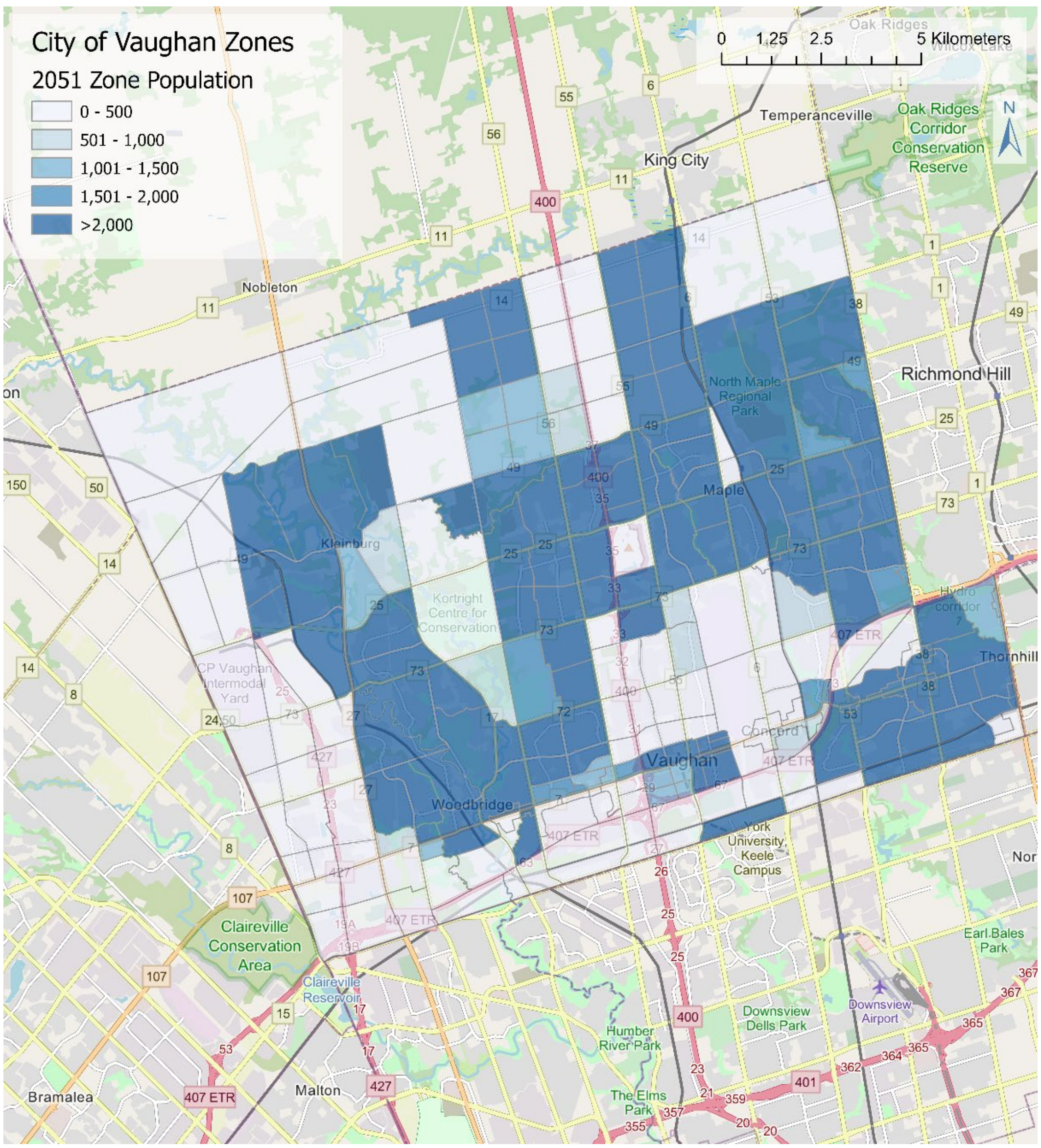


Figure 5-1: Vaughan Population by Zone, 2051

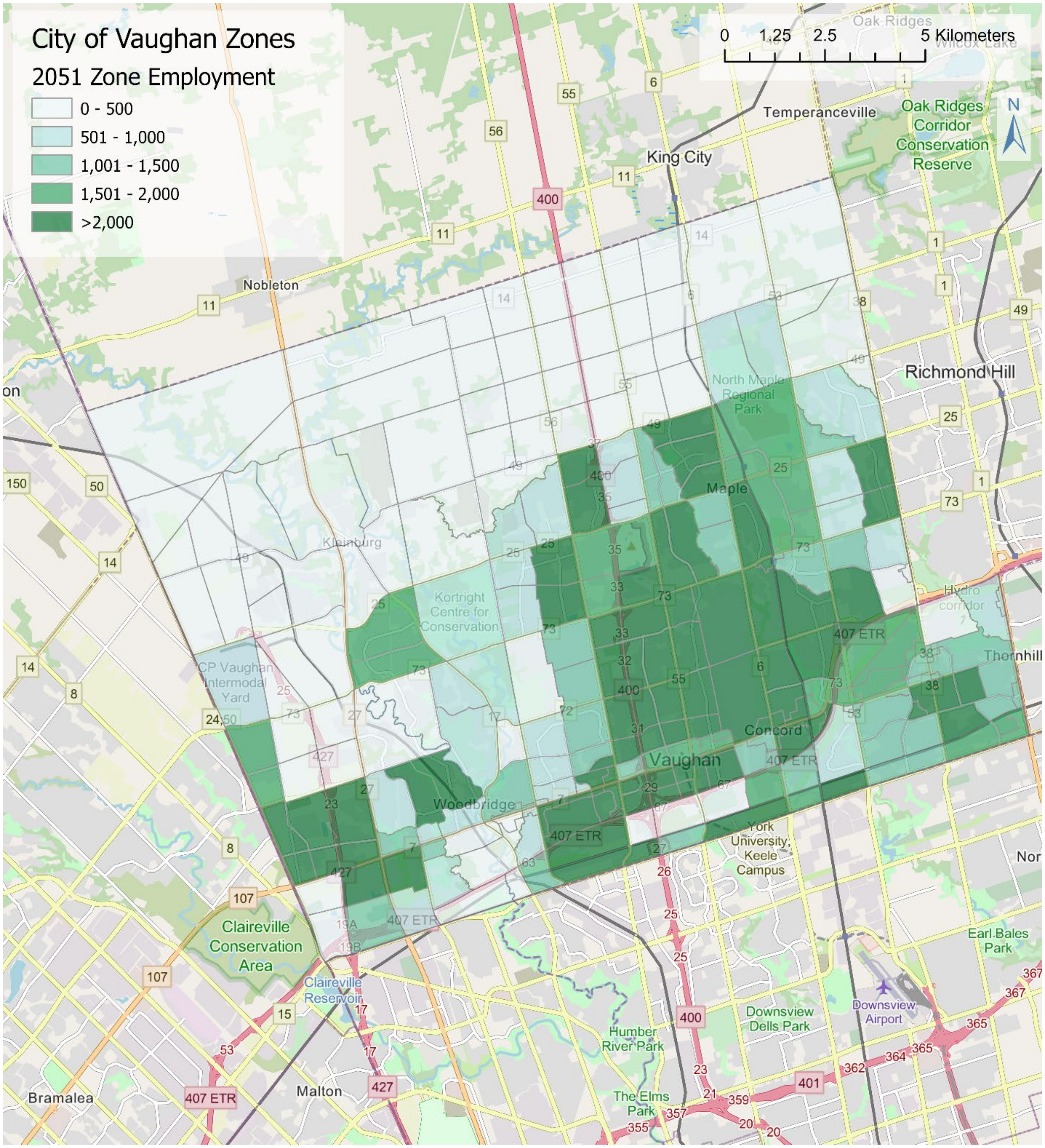


Figure 5-2: Vaughan Employment by Zone, 2051

Comparing the 2016 TTS land use (presented in **Section 2.4**) against the 2051 forecast, growth is expected, and high growth was noted for the following areas within Vaughan:

- For population, high growth is noted in North Vaughan, North-east Vaughan, Vaughan Metropolitan Centre and Kleinburg.

- For employment, high growth is noted in West Vaughan, Maple, and along the Highway 7/Highway 407 corridors.

5.2 Future Projects

To bring the 2018 network to 2051, additional road and transit improvements were coded in Emme to build the 2051 network. These projects formed the “Do Nothing” (or, DN) alternative, which represents the base alternative upon which others would be formed. The improvements added were obtained from the City, York Region and other provincial agencies (MTO, Metrolinx) and were filtered to identify projects with high priority and relevancy to Vaughan. These improvements are already underway or have committed implementation funding and represent a minimum future base of projects that are certain to be in place by the time horizon.

Road projects in this alternative are presented in **Table 5-1**, and transit projects in this alternative are presented in **Table 5-2**.

Within this report, the DN alternative is described only, and the other alternatives are described further in the **Transportation Needs Assessment and Alternative Development** report, which covers the gap analysis process and other alternatives, built on top of the DN alternative. In addition to the road projects listed in **Table 5-1**, other major provincial highway projects were also incorporated, such as the Highway 427 Extension and GTAWest Highway (Highway 413).

Table 5-1: Road Projects Added in DN Alternative

Project	From	To	Improvement Type
Applemill Road	Edgeley	Applewood Road	4-Lane New Construction
Applemill Road Extension	Applewood Crescent	Jane Street	4-Lane Extension
Applewood Crescent Extension	Portage Parkway	Highway 7	4-Lane Extension
Bass Pro Mills Drive	Romina Drive	Jane Street	4-Lane Extension
Bathurst Street	Autumn Hill Boulevard	Major MacKenzie Drive	6-Lane Widening
Block 59 Midblock Connector	Huntington Road	Highway 27	4-Lane Extension
Block 33 (Canada Dr/America Ave) Midblock Connector	Weston Road	Jane Street	2-Lane Extension
Commerce Way - Applemill to Highway 7	Applemill Road	Highway 7	2-Lane New Construction
Dufferin Avenue	Major MacKenzie Drive	Teston Road	4-Lane Widening
Dufferin Avenue	Langstaff Road	Rutherford Road	6-Lane Widening
Highway 27	Major MacKenzie Drive	North City limits	4-Lane Widening
Highway 50	Steeles Avenue	Highway 7	6-Lane Widening
Highway 50	Rutherford Road	GTA West	6-Lane Widening
Highway 7	Kipling Avenue	West of Pine Valley Drive	6-Lane Widening

Project	From	To	Improvement Type
Huntington Road (Part B of EA)	Major Mackenzie Drive	Nashville Road	4-Lane Extension
Keele Street	Steeles Avenue	Highway 407	6-Lane Widening
Keele Street	Highway 7	Rutherford Road	6-Lane Widening
Kirby Avenue	Dufferin Street	Bathurst Street	4-Lane Extension
Langstaff Road	Weston Road	Dufferin Street	6-Lane Extension and Widening
Major MacKenzie Drive	Huntington Road	Pine Valley Drive	6-Lane Widening
Major MacKenzie Drive	Highway 400	Jane Street	6-Lane Widening
Pine Valley Drive	Rutherford Road	Teston Road	4-Lane Widening
Portage Parkway Extension	Highway 400	Jane Street	4-Lane Extension
Primary East/West Collector (Steeles West Plan)	Jane Street	Keele Street	4-Lane Extension
Primary North/South Collector (Steeles West Plan)	East-West Collector Road	Steeles Avenue	4-Lane Extension
Rutherford Road	Jane Street	Bathurst Street	6-Lane Widening
Teston Road	Pine Valley Drive	Weston Road	4-Lane Widening
Teston Road	Dufferin Street	Bathurst Street	4-Lane Widening
Weston Road	South of Rutherford Road	North of Rutherford Road	6-Lane Widening

Table 5-2: Transit Projects Added in DN Alternative

Project	From	To
Barrie 15-min GO Service	Union Station	Aurora GO
Barrie GO Extension	Barrie South GO	Allandale GO
Barrie Two-Way, All-Day GO Service	Aurora GO	Allandale Waterfront GO
Bloomington GO Extension	Gormley GO	Bloomington GO
Bowmanville GO Extension	West of Oshawa GO	Martin Rd.
Brampton Queen St. BRT	Main St.	Highway 50
Confederation GO Extension	West Harbour GO	Confederation GO
Eglinton Crosstown LRT	Weston Rd.	Kennedy Station
Eglinton West LRT	Weston Rd.	Toronto Pearson International Airport
Finch West LRT	Finch West Station	Humber College
Highway 7 West BRT	Helen St.	Yonge St.
Highway 7 West BRT Extension	Highway 50	Helen St.
Kitchener GO Extension	Georgetown GO	Kitchener GO
Kitchener Two-Way, All-Day GO Service	Mount Pleasant GO	Kitchener GO
Lakeshore East 15-min GO Service	Union Station	Oshawa GO

Project	From	To
Lakeshore West 15-min GO Service	Union Station	Aldershot GO
Lakeshore West Two-Way, All-Day GO Service	Aldershot GO	Hamilton GO
Niagara GO Service	Confederation GO	Niagara Falls GO
Ontario Line	Don Mills/Eglinton	Ontario Place
Scarborough Subway	Kennedy Station	Scarborough Town Centre
Stouffville 15-min GO Service	Union Station	Unionville GO
Stouffville Two-Way, All-Day GO Service	Unionville GO	Mount Joy GO
West Harbour GO Extension	Aldershot GO	West Harbour GO
Yonge BRT (South)	Highway 7	19th Ave.
Yonge BRT (North)	Mulock Dr.	Davis Dr.
Yonge BRT (Richmond Hill, Aurora, Newmarket)	19th Ave.	Mulock Dr.
Yonge North Subway Extension	Finch Station	Highway 7

As noted above, the projects presented in the above tables are to bring the 2018 network to the 2051 horizon to form the DN network. As alternatives are developed for the VTP, they will add projects complementary to the alternatives' goals on top of the above listed.

5.3 Incorporating Active Transportation

In addition to projects being coded into future horizon networks, there was a need identified to incorporate active transportation improvements into the network, in alignment with City objectives.

Since active transportation modes, namely walking and cycling, are not coded into the GTAModel networks for assignment, mode choice parameters were adjusted to incorporate improvements to these modes in specific zones. Specifically, spatial constants were added for walking and cycling trips within and between zones with expected active transportation uplift; these constants modify the utility function for specific trips based on specified origins and destinations. These were applied during the mode choice step and were changed within the model. It should be noted, however, that these were not applied to the DN alternative (as it is a base case), but only for alternatives and for zones where active transportation uplift should be implemented were identified.

5.4 Model Forecasting Results

As noted in Section 3.4, the model is calibrated at a city-wide OD level, specifically for trips to/from Vaughan, and for trips within Vaughan. The model should, therefore, be used to estimate travel demand to, from or within Vaughan. In this earlier section, results were presented for 2016 observed trips, 2016 modelled trips, and the difference (on a percentage basis) was also presented. The following trip types were used to calibrate the model by primary travel mode:

- Trips from an external zone to a Vaughan zone (AM and PM peak periods)
- Trips from a Vaughan zone to an external zone (AM and PM peak periods)
- Trips between two Vaughan zones (AM and PM peak periods).

To present the growth in trip demand for the same trip types listed above, a comparison was made between 2051 DN demand and 2016 modelled demand above. Note that the results presented below correspond directly to the 2016 calibration results presented above. **Table 5-3** presents the City-wide OD demand for the trip types described above for the AM peak and **Table 5-4** for the PM peak.

Table 5-3: City-wide OD demand (2016 Modelled, 2051 Modelled, AM)[7]

Citywide calibration:					
	AM Peak (3 hours)				
Modelled - 2016	Driver	Transit	Active	Other	Total
External Trips To Vaughan	57,269	7,180	706	11,572	76,726
External Trips From Vaughan	51,281	17,348	805	10,006	79,439
Trips Within Vaughan	33,937	1,380	9,138	19,166	63,620
	142,486	25,907	10,648	40,745	219,786
Mode Share	65%	12%	5%	19%	
	AM Peak (3 hours)				
Modelled - 2051	Driver	Transit	Active	Other	Total
External Trips To Vaughan	118,731	17,299	1,382	20,192	157,603
External Trips From Vaughan	92,686	37,314	1,173	12,700	143,873
Trips Within Vaughan	79,169	1,761	6,207	23,758	110,895
	290,585	56,374	8,762	56,650	412,371
Mode Share	70%	14%	2%	14%	
	AM Peak (3 hours)				
% Difference	Driver	Transit	Active	Other	Total
External Trips To Vaughan	107%	141%	96%	74%	105%
External Trips From Vaughan	81%	115%	46%	27%	81%
Trips Within Vaughan	133%	28%	-32%	24%	74%
	104%	118%	-18%	39%	88%

[7] "Other" trips refer to multiple passenger modes—auto passenger, ridesharing, or school bus

Table 5-4: City-wide OD demand (2016 Modelled, 2051 Modelled, PM)

Citywide calibration:

	PM Peak (4 hours)				
Modelled - 2016	Driver	Transit	Active	Other	Total
External Trips To Vaughan	57,629	18,878	995	13,682	91,184
External Trips From Vaughan	76,739	12,569	912	17,523	107,744
Trips Within Vaughan	68,190	2,645	6,062	30,880	107,777
	202,558	34,092	7,970	62,085	306,705
Mode Share	66%	11%	3%	20%	
	PM Peak (4 hours)				
Modelled - 2051	Driver	Transit	Active	Other	Total
External Trips To Vaughan	108,402	42,110	1,955	19,325	171,793
External Trips From Vaughan	151,536	27,565	2,011	31,136	212,248
Trips Within Vaughan	170,077	4,015	7,960	55,906	237,959
	430,015	73,691	11,926	106,368	622,000
	69%	12%	2%	17%	
	PM Peak (4 hours)				
% Difference	Driver	Transit	Active	Other	Total
External Trips To Vaughan	88%	123%	96%	41%	88%
External Trips From Vaughan	97%	119%	120%	78%	97%
Trips Within Vaughan	149%	52%	31%	81%	121%
	112%	116%	50%	71%	103%

As anticipated, trip demand increases, as population and employment both experience substantial growth in the GTHA over the 35 years between the calibrated year and the forecasting period. Some trends can be noted from the above tables:

- The AM peak experiences higher changes in mode share (between -4% to 5% change) compared to the PM peak (between -3% to 3% change).
- For both the AM Peak and PM Peak, total trip demand to, from and within Vaughan roughly doubles between 2016 and 2051.
- In the DN scenario, drive and transit mode shares increase in both peak periods, with drive mode share increasing most. The active mode shares decrease. In general, this is anticipated as there are improvements to the road and transit networks in the 2051 network.

The DN network serves as the base to build other alternatives, which involve multiple sets of projects grouped as alternatives. This is described separately in the **Transportation Needs Assessment and Alternative Development** report, which covers the needs assessment process of identifying gaps in existing and future conditions, and the development of future alternatives to address them.

Appendix A: Model Calibration Comparisons

A.1. Introduction

This appendix prepares a summary of adjustments and compares them to TTS for two primary purposes:

1. To identify how adjustments made to original household calibration variables in the GTA Model impact household characteristics in a model run, and;
2. To identify origin-destination specific demand flows and compare these against TTS for the AM and PM peak periods.

This appendix is intended to provide contextual information to better inform limitations and tendencies when leveraging this model for other projects, and areas where further refinements to the model could be targeted.

A.2. Adjustments to Household Calibration Variables

Variations were made to calibration parameters to attempt to improve Vaughan-specific household characteristics. This included auto ownership, episode generations, as well as coefficients related to the generation of trips by active and transit modes. This is summarized in **Table A - 1**, below.

Table A - 1: Household Calibration Variables and Comparison to TTS

Variable	Original value	New Vaughan-specific value	Calibrated Metric	Observed	Modelled
Auto ownership constant (acts to increase or decrease household number of vehicles)	2.1488	3	**Number of households with specified number of vehicles**	See Table Below	See Table Below
Episode generation factor (acts to increase or decrease daily trip rates for residents and employees)	1.5	2	**Number of daily trips originating in or destined for Vaughan**	921,332	965,748
Walk trip constant (daily intra-Vaughan)	-4	-3	**Active mode share for daily trips within Vaughan**	8%	10%
Bicycle trip constant (daily intra-Vaughan)	-4	-3			
Walk access to transit coefficient (daily intra-Vaughan)	-2	-2.5	**Walk access to transit mode share for daily trips within Vaughan**	2%	2%

Variable	Original value	New Vaughan-specific value	Calibrated Metric	Observed	Modelled
Walk access to transit coefficient (PM Toronto to Vaughan)	1	-2	Walk access to transit mode share for PM trips from Toronto to Vaughan	11%	14%
Drive access to transit coefficient (PM Vaughan to Toronto)	1	-3	Drive access to transit, passenger access to transit, and passenger egress from transit mode share for PM trips from Vaughan to Toronto	1%	3%
Passenger access to transit coefficient (PM Vaughan to Toronto)	1	-3			
Passenger egress from transit coefficient (PM Vaughan to Toronto)	1	-3			

As shown above in **Table A - 1**, the coefficient for auto ownership was adjusted. It should be noted that additional coefficients for the auto ownership logit mode exist. These could generally be used to adjust between the likelihood of falling in one category of ownership (e.g., going between owning either one car, or two cars instead. The number of household vehicles for Vaughan households is shown in **Table A - 2**.

Table A - 2: Number of Vehicles for Households in the City of Vaughan

Number of Household Vehicles	Observed	Modelled	% Difference
0 Vehicles	3,066	3,706	21%
1 Vehicle	26,201	20,512	-22%
2 Vehicles	47,029	45,988	-2%
3 Vehicles	12,059	14,436	20%
4+ Vehicles	5,881	8,420	43%

A.3. AM Origin-Destination Travel Demand Flows

The following tables present results for the AM peak. The following tables present the modelled and observed travel demand (with observed in brackets) for flows to Vaughan (**Table A - 3)** and from Vaughan (**Table A - 4**)**. Table A - 5** presents the differences between modelled and observed travel demand for flows to Vaughan (percentage differences in brackets), and **Table A - 6** presents the same differences for travel originating from Vaughan.

Results are presented at the planning district level, but totals (at the bottom of each table for each mode) may differ from other reporting as the set of planning districts shown are those where the model records at least one trip for the origin-destination pair.

Table A - 3: AM Peak (3 Hour) Modelled and Observed Travel Demand to Vaughan, by mode

Origin Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	33,937 (45,103)	12,540 (12,474)	1,380 (1,397)	9,138 (9,079)	6,626 (4,477)	63,620 (72,530)
Toronto	21,509 (27,828)	5,794 (3,406)	4,170 (3,325)	489 (255)	0 (241)	31,961 (35,055)
Brock	83 (29)	1 (0)	0 (0)	0 (0)	0 (0)	84 (29)
Uxbridge	199 (177)	7 (39)	3 (0)	0 (0)	0 (0)	209 (216)
Scugog	146 (74)	7 (15)	1 (0)	0 (0)	0 (0)	154 (89)
Pickering	598 (489)	65 (58)	36 (0)	0 (0)	0 (0)	698 (547)
Ajax	649 (737)	78 (0)	20 (0)	0 (0)	0 (0)	748 (737)
Whitby	695 (310)	81 (16)	19 (0)	0 (0)	0 (0)	795 (326)
Oshawa	590 (310)	68 (25)	13 (0)	0 (0)	0 (0)	671 (335)
Clarington	396 (74)	39 (0)	5 (0)	0 (0)	0 (0)	440 (74)
Georgina	650 (488)	53 (28)	10 (0)	0 (0)	3 (0)	716 (516)
East Gwillimbury	383 (414)	31 (6)	19 (0)	0 (0)	5 (0)	439 (420)
Newmarket	1,421 (1,842)	147 (125)	96 (24)	0 (0)	3 (31)	1,668 (2,022)
Aurora	1,294 (1,692)	164 (64)	111 (48)	0 (0)	19 (0)	1,587 (1,804)
Richmond Hill	6,075 (7,624)	978 (701)	891 (298)	79 (75)	156 (26)	8,179 (8,724)
Whitchurch-Stouffville	617 (505)	71 (57)	35 (0)	0 (0)	27 (0)	749 (562)
Markham	4,607 (4,606)	736 (305)	566 (222)	62 (34)	113 (56)	6,083 (5,223)
King	1,150 (1,405)	161 (130)	73 (5)	1 (0)	41 (122)	1,427 (1,662)
Caledon	1,732 (2,362)	188 (149)	16 (0)	2 (0)	0 (0)	1,938 (2,511)
Brampton	8,417 (9,366)	1,668 (846)	736 (350)	70 (0)	0 (94)	10,890 (10,656)
Mississauga	3,710 (4,475)	563 (379)	251 (141)	2 (0)	0 (59)	4,526 (5,054)
Halton Hills	496 (334)	110 (0)	31 (0)	0 (0)	0 (57)	636 (391)
Milton	573 (758)	62 (13)	23 (0)	0 (0)	0 (0)	658 (771)
Oakville	475 (731)	66 (0)	16 (0)	0 (0)	0 (26)	556 (757)
Burlington	288 (305)	28 (0)	27 (0)	0 (0)	0 (0)	342 (305)
Flamborough	80 (240)	5 (0)	2 (0)	0 (0)	0 (0)	88 (240)
Dundas	30 (75)	0 (0)	1 (0)	0 (0)	0 (0)	30 (75)
Ancaster	46 (50)	2 (0)	1 (0)	0 (0)	0 (0)	49 (50)
Glanbrook	27 (0)	6 (0)	2 (0)	0 (0)	0 (0)	35 (0)
Stoney Creek	65 (43)	2 (0)	1 (0)	0 (0)	0 (0)	68 (43)
Hamilton	270 (137)	26 (0)	8 (0)	0 (0)	0 (0)	304 (137)
All	91,205 (112,583)	23,746 (18,836)	8,559 (5,810)	9,844 (9,443)	6,993 (5,189)	140,347 (151,861)

Table A - 4: AM Peak (3 Hour) Modelled and Observed Travel Demand from Vaughan, by mode

Destination Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	33,937 (45,103)	12,540 (12,474)	1,380 (1,397)	9,138 (9,079)	6,626 (4,477)	63,620 (72,530)
Toronto	30,709 (33,914)	5,628 (5,498)	14,321 (13,545)	444 (304)	0 (501)	51,102 (53,762)
Brock	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Uxbridge	15 (9)	0 (28)	0 (0)	0 (0)	0 (0)	15 (37)
Scugog	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0)
Pickering	98 (19)	8 (0)	6 (0)	0 (0)	0 (0)	112 (19)
Ajax	64 (102)	4 (0)	3 (0)	0 (22)	0 (33)	70 (157)
Whitby	32 (211)	4 (0)	2 (0)	0 (0)	0 (0)	37 (211)
Oshawa	31 (228)	1 (0)	3 (10)	0 (0)	0 (0)	35 (238)
Clarington	11 (68)	0 (14)	0 (0)	0 (0)	0 (0)	11 (82)
Georgina	20 (25)	1 (0)	0 (0)	0 (0)	0 (0)	21 (25)
East Gwillimbury	54 (73)	4 (0)	3 (0)	0 (0)	0 (0)	61 (73)
Newmarket	360 (885)	38 (23)	26 (14)	0 (0)	1 (0)	425 (922)
Aurora	444 (865)	120 (64)	124 (0)	0 (0)	100 (417)	788 (1,346)
Richmond Hill	3,624 (4,418)	694 (965)	848 (171)	148 (23)	227 (271)	5,540 (5,848)
Whitchurch-Stouffville	97 (191)	14 (0)	5 (0)	0 (0)	0 (0)	116 (191)
Markham	4,774 (5,590)	799 (760)	868 (361)	199 (129)	308 (134)	6,949 (6,974)
King	356 (636)	242 (114)	188 (75)	1 (0)	261 (184)	1,049 (1,009)
Caledon	933 (749)	153 (9)	10 (0)	4 (0)	0 (0)	1,100 (758)
Brampton	3,630 (3,991)	524 (340)	392 (116)	9 (9)	0 (22)	4,555 (4,478)
Mississauga	5,472 (7,078)	760 (464)	469 (129)	0 (106)	0 (70)	6,700 (7,847)
Halton Hills	58 (14)	6 (0)	2 (0)	0 (0)	0 (0)	65 (14)
Milton	87 (226)	8 (0)	7 (0)	0 (0)	0 (0)	101 (226)
Oakville	227 (582)	21 (0)	7 (29)	0 (21)	0 (0)	254 (632)
Burlington	99 (244)	62 (29)	45 (0)	0 (0)	0 (69)	206 (342)
Flamborough	5 (25)	0 (0)	0 (0)	0 (0)	0 (0)	5 (25)
Dundas	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)
Ancaster	3 (48)	0 (0)	0 (0)	0 (0)	0 (0)	3 (48)
Glanbrook	2 (0)	2 (0)	0 (0)	0 (0)	0 (0)	4 (0)
Stoney Creek	0 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (11)
Hamilton	72 (63)	18 (0)	20 (0)	0 (0)	0 (0)	110 (63)
All	85,217 (105,368)	21,650 (20,782)	18,727 (15,847)	9,943 (9,693)	7,522 (6,178)	143,059 (157,868)

Table A - 5: AM Peak (3 Hour) Modelled to Observed Differences in Demand to Vaughan, by mode

Origin Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	-11,166 (-25%)	66 (1%)	-17 (-1%)	59 (1%)	2,149 (48%)	-8,910 (-12%)
Toronto	-6,320 (-23%)	2,388 (70%)	845 (25%)	234 (92%)	-241 (-100%)	-3,094 (-9%)
Brock	54 (185%)	1 (-)	0 (-)	0 (-)	0 (-)	55 (190%)
Uxbridge	22 (12%)	-32 (-82%)	3 (-)	0 (-)	0 (-)	-7 (-3%)
Scugog	72 (97%)	-8 (-55%)	1 (-)	0 (-)	0 (-)	65 (73%)
Pickering	109 (22%)	7 (11%)	36 (-)	0 (-)	0 (-)	151 (28%)
Ajax	-88 (-12%)	78 (-)	20 (-)	0 (-)	0 (-)	11 (1%)
Whitby	385 (124%)	65 (409%)	19 (-)	0 (-)	0 (-)	469 (144%)
Oshawa	280 (90%)	43 (173%)	13 (-)	0 (-)	0 (-)	336 (100%)
Clarington	322 (435%)	39 (-)	5 (-)	0 (-)	0 (-)	366 (495%)
Georgina	162 (33%)	25 (90%)	10 (-)	0 (-)	3 (-)	200 (39%)
East Gwillimbury	-31 (-7%)	25 (415%)	19 (-)	0 (-)	5 (-)	19 (4%)
Newmarket	-421 (-23%)	22 (18%)	72 (301%)	0 (-)	-28 (-90%)	-354 (-18%)
Aurora	-398 (-24%)	100 (156%)	63 (130%)	0 (-)	19 (-)	-217 (-12%)
Richmond Hill	-1,549 (-20%)	277 (40%)	593 (199%)	4 (5%)	130 (501%)	-545 (-6%)
Whitchurch-Stouffville	112 (22%)	14 (24%)	35 (-)	0 (-)	27 (-)	187 (33%)
Markham	1 (0%)	431 (141%)	344 (155%)	28 (81%)	57 (101%)	860 (16%)
King	-255 (-18%)	31 (24%)	68 (1356%)	1 (-)	-81 (-66%)	-235 (-14%)
Caledon	-630 (-27%)	39 (26%)	16 (-)	2 (-)	0 (-)	-573 (-23%)
Brampton	-950 (-10%)	822 (97%)	386 (110%)	70 (-)	-94 (-100%)	234 (2%)
Mississauga	-765 (-17%)	184 (49%)	110 (78%)	2 (-)	-59 (-100%)	-528 (-10%)
Halton Hills	162 (48%)	110 (-)	31 (-)	0 (-)	-57 (-100%)	245 (63%)
Milton	-185 (-24%)	49 (380%)	23 (-)	0 (-)	0 (-)	-113 (-15%)
Oakville	-256 (-35%)	66 (-)	16 (-)	0 (-)	-26 (-100%)	-201 (-27%)
Burlington	-17 (-6%)	28 (-)	27 (-)	0 (-)	0 (-)	37 (12%)
Flamborough	-160 (-67%)	5 (-)	2 (-)	0 (-)	0 (-)	-152 (-63%)
Dundas	-46 (-61%)	0 (-)	1 (-)	0 (-)	0 (-)	-45 (-60%)
Ancaster	-4 (-8%)	2 (-)	1 (-)	0 (-)	0 (-)	-1 (-2%)
Glanbrook	27 (-)	6 (-)	2 (-)	0 (-)	0 (-)	35 (-)
Stoney Creek	22 (51%)	2 (-)	1 (-)	0 (-)	0 (-)	25 (58%)
Hamilton	133 (97%)	26 (-)	8 (-)	0 (-)	0 (-)	167 (122%)
All	-21,378 (-19%)	4,910 (26%)	2,749 (47%)	401 (4%)	1,804 (35%)	-11,515 (-8%)

Table A - 6: AM Peak (3 Hour) Modelled to Observed Differences in Demand from Vaughan, by mode

Destination Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	-11,166 (-25%)	66 (1%)	-17 (-1%)	59 (1%)	2,149 (48%)	-8,910 (-12%)
Toronto	-3,205 (-9%)	130 (2%)	776 (6%)	140 (46%)	-501 (-100%)	-2,660 (-5%)
Brock	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Uxbridge	6 (66%)	-28 (-100%)	0 (0%)	0 (0%)	0 (0%)	-22 (-59%)
Scugog	4 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (0%)
Pickering	79 (416%)	8 (0%)	6 (0%)	0 (0%)	0 (0%)	93 (491%)
Ajax	-38 (-38%)	4 (0%)	3 (0%)	-22 (-100%)	-33 (-100%)	-87 (-55%)
Whitby	-179 (-85%)	4 (0%)	2 (0%)	0 (0%)	0 (0%)	-174 (-82%)
Oshawa	-197 (-87%)	1 (0%)	-7 (-69%)	0 (0%)	0 (0%)	-204 (-86%)
Clarington	-57 (-84%)	-14 (-100%)	0 (0%)	0 (0%)	0 (0%)	-71 (-87%)
Georgina	-5 (-21%)	1 (0%)	0 (0%)	0 (0%)	0 (0%)	-4 (-18%)
East Gwillimbury	-19 (-26%)	4 (0%)	3 (0%)	0 (0%)	0 (0%)	-12 (-17%)
Newmarket	-525 (-59%)	15 (65%)	12 (86%)	0 (0%)	1 (0%)	-498 (-54%)
Aurora	-422 (-49%)	56 (88%)	124 (0%)	0 (0%)	-317 (-76%)	-558 (-41%)
Richmond Hill	-794 (-18%)	-271 (-28%)	677 (396%)	125 (543%)	-44 (-16%)	-308 (-5%)
Whitchurch-Stouffville	-94 (-49%)	14 (0%)	5 (0%)	0 (0%)	0 (0%)	-75 (-39%)
Markham	-816 (-15%)	39 (5%)	507 (141%)	70 (54%)	174 (130%)	-25 (0%)
King	-280 (-44%)	128 (113%)	113 (151%)	1 (0%)	77 (42%)	40 (4%)
Caledon	184 (25%)	144 (1604%)	10 (0%)	4 (0%)	0 (0%)	342 (45%)
Brampton	-361 (-9%)	184 (54%)	276 (238%)	0 (-2%)	-22 (-100%)	77 (2%)
Mississauga	-1,606 (-23%)	296 (64%)	340 (263%)	-106 (-100%)	-70 (-100%)	-1,147 (-15%)
Halton Hills	44 (312%)	6 (0%)	2 (0%)	0 (0%)	0 (0%)	51 (365%)
Milton	-139 (-62%)	8 (0%)	7 (0%)	0 (0%)	0 (0%)	-125 (-55%)
Oakville	-355 (-61%)	21 (0%)	-22 (-77%)	-21 (-100%)	0 (0%)	-378 (-60%)
Burlington	-145 (-59%)	33 (114%)	45 (0%)	0 (0%)	-69 (-100%)	-136 (-40%)
Flamborough	-20 (-80%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-20 (-80%)
Dundas	2 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (0%)
Ancaster	-45 (-94%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-45 (-94%)
Glanbrook	2 (0%)	2 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (0%)
Stoney Creek	-11 (-100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-11 (-100%)
Hamilton	9 (14%)	18 (0%)	20 (0%)	0 (0%)	0 (0%)	47 (74%)
All	-20,151 (-19%)	868 (4%)	2,880 (18%)	249 (3%)	1,344 (22%)	-14,809 (-9%)

Several findings can be noted when evaluating the difference tables above (**Table A - 5** and **Table A - 6**):

- AM trips destined to Vaughan are under simulated by approximately 8%. This is primarily driven by an under simulation of auto driver trips. It can also be noted that transit is also over simulated, but the 2016 TTS Validation Guide indicates that TTS does generally underrepresent transit demand in York Region.

- AM trips originating from Vaughan are under simulated by approximately 9%. Similar to trips destined to Vaughan, auto driver trips are under simulated and transit trips are over simulated.

A.4. PM Origin-Destination Travel Demand Flows

Table A - 7: PM Peak (3 Hour) Modelled and Observed Travel Demand to Vaughan, by mode

Origin Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	68,190 (66,627)	24,676 (14,702)	2,645 (2,117)	6,062 (9,628)	6,204 (2,879)	107,777 (95,953)
Toronto	35,084 (42,261)	8,706 (7,328)	14,984 (15,569)	676 (694)	0 (506)	59,450 (66,358)
Brock	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0)
Uxbridge	23 (25)	1 (43)	0 (0)	0 (0)	0 (0)	24 (68)
Scugog	4 (14)	0 (0)	0 (0)	0 (0)	0 (0)	4 (14)
Pickering	72 (155)	9 (51)	6 (0)	0 (0)	0 (0)	88 (206)
Ajax	61 (116)	4 (0)	4 (0)	0 (12)	0 (33)	69 (161)
Whitby	36 (311)	4 (15)	3 (0)	0 (0)	0 (0)	43 (326)
Oshawa	36 (280)	4 (24)	4 (13)	0 (0)	0 (0)	43 (317)
Clarington	23 (38)	3 (0)	1 (0)	0 (0)	0 (0)	27 (38)
Georgina	34 (25)	1 (0)	1 (0)	0 (0)	0 (0)	36 (25)
East Gwillimbury	64 (130)	6 (14)	4 (0)	0 (0)	0 (0)	74 (144)
Newmarket	380 (1,215)	53 (53)	36 (0)	0 (0)	2 (0)	470 (1,268)
Aurora	510 (1,177)	107 (132)	130 (19)	0 (0)	74 (170)	821 (1,498)
Richmond Hill	5,319 (6,888)	1,053 (1,521)	1,337 (368)	179 (92)	218 (199)	8,107 (9,068)
Whitchurch-Stouffville	126 (297)	16 (47)	9 (0)	0 (0)	1 (0)	152 (344)
Markham	4,596 (7,059)	798 (973)	992 (471)	112 (206)	282 (155)	6,780 (8,864)
King	632 (916)	263 (165)	232 (111)	1 (0)	207 (184)	1,336 (1,376)
Caledon	1,120 (1,094)	217 (260)	42 (0)	7 (0)	0 (0)	1,386 (1,354)
Brampton	4,448 (5,383)	777 (783)	529 (30)	18 (0)	0 (0)	5,772 (6,196)
Mississauga	4,626 (8,586)	750 (698)	518 (158)	1 (88)	0 (54)	5,895 (9,584)
Halton Hills	47 (136)	5 (49)	2 (0)	0 (0)	0 (0)	53 (185)
Milton	76 (143)	19 (29)	5 (0)	0 (0)	0 (0)	100 (172)
Oakville	170 (590)	18 (0)	12 (29)	0 (0)	0 (0)	201 (619)
Burlington	73 (169)	73 (0)	9 (0)	0 (0)	0 (98)	155 (267)
Flamborough	7 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (0)
Dundas	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Ancaster	2 (77)	0 (154)	0 (0)	0 (0)	0 (0)	2 (231)
Glanbrook	1 (5)	1 (0)	0 (0)	0 (0)	0 (0)	2 (5)

Origin Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Stoney Creek	0 (52)	0 (45)	0 (0)	0 (0)	0 (0)	0 (97)
Hamilton	0 (137)	0 (0)	0 (0)	0 (0)	0 (0)	0 (137)
All	125,764 (143,906)	37,565 (27,086)	21,504 (18,885)	7,057 (10,720)	6,988 (4,278)	198,878 (204,875)

Table A - 8: PM Peak (3 Hour) Modelled and Observed Travel Demand from Vaughan, by mode

Destination Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	68,190 (66,627)	24,676 (14,702)	2,645 (2,117)	6,062 (9,628)	6,204 (2,879)	107,777 (95,953)
Toronto	41,042 (36,277)	11,471 (6,760)	7,717 (4,278)	659 (666)	0 (133)	60,890 (48,114)
Brock	59 (0)	0 (0)	0 (0)	0 (0)	0 (0)	59 (0)
Uxbridge	151 (317)	15 (0)	0 (0)	0 (0)	0 (0)	166 (317)
Scugog	100 (51)	6 (15)	0 (0)	0 (0)	0 (0)	106 (66)
Pickering	432 (540)	54 (66)	45 (0)	0 (0)	0 (0)	531 (606)
Ajax	486 (1,007)	71 (0)	43 (12)	0 (0)	0 (0)	599 (1,019)
Whitby	476 (470)	67 (16)	40 (0)	0 (0)	0 (0)	583 (486)
Oshawa	422 (346)	57 (77)	27 (0)	0 (0)	0 (0)	506 (423)
Clarington	258 (55)	43 (0)	11 (0)	0 (0)	0 (0)	312 (55)
Georgina	452 (857)	47 (28)	3 (0)	0 (0)	5 (0)	506 (885)
East Gwillimbury	306 (593)	28 (40)	23 (0)	0 (0)	6 (0)	363 (633)
Newmarket	1,285 (1,969)	129 (132)	128 (4)	0 (0)	4 (25)	1,545 (2,130)
Aurora	1,232 (2,091)	138 (148)	160 (0)	0 (0)	15 (0)	1,545 (2,239)
Richmond Hill	7,833 (10,205)	1,353 (1,397)	1,568 (450)	119 (140)	143 (76)	11,016 (12,268)
Whitchurch-Stouffville	491 (405)	57 (25)	45 (0)	0 (0)	21 (0)	614 (430)
Markham	4,812 (6,368)	754 (925)	858 (222)	65 (14)	104 (47)	6,594 (7,576)
King	1,193 (2,212)	234 (56)	104 (5)	3 (0)	43 (47)	1,576 (2,320)
Caledon	1,761 (2,800)	250 (197)	32 (0)	3 (0)	0 (27)	2,046 (3,024)
Brampton	8,719 (11,141)	1,600 (1,411)	1,182 (426)	60 (0)	0 (72)	11,560 (13,050)
Mississauga	3,569 (5,653)	551 (370)	416 (41)	3 (0)	0 (94)	4,539 (6,158)
Halton Hills	371 (476)	79 (14)	48 (0)	0 (0)	0 (57)	499 (547)
Milton	393 (1,010)	46 (13)	47 (0)	0 (0)	0 (0)	486 (1,023)
Oakville	378 (676)	74 (39)	24 (0)	0 (0)	0 (26)	477 (741)
Burlington	195 (518)	26 (36)	29 (0)	0 (0)	0 (0)	250 (554)
Flamborough	59 (285)	6 (12)	2 (0)	0 (0)	0 (0)	67 (297)
Dundas	12 (75)	0 (0)	0 (0)	0 (0)	0 (0)	12 (75)
Ancaster	21 (145)	1 (26)	0 (0)	0 (0)	0 (0)	22 (171)
Glanbrook	17 (0)	5 (0)	0 (0)	0 (0)	0 (0)	22 (0)
Stoney Creek	39 (233)	3 (0)	0 (0)	0 (0)	0 (0)	42 (233)
Hamilton	177 (268)	18 (22)	17 (0)	0 (0)	0 (0)	211 (290)

Destination Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
All	144,929 (153,670)	41,858 (26,527)	15,214 (7,555)	6,974 (10,448)	6,545 (3,483)	215,521 (201,683)

Table A - 9: AM Peak (3 Hour) Modelled to Observed Differences in Demand to Vaughan, by mode

Origin Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	1,563 (2%)	9,974 (68%)	528 (25%)	-3,566 (-37%)	3,325 (115%)	11,824 (12%)
Toronto	-7,177 (-17%)	1,378 (19%)	-585 (-4%)	-19 (-3%)	-506 (-100%)	-6,908 (-10%)
Brock	4 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (0%)
Uxbridge	-2 (-9%)	-42 (-97%)	0 (0%)	0 (0%)	0 (0%)	-44 (-65%)
Scugog	-10 (-71%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-10 (-71%)
Pickering	-83 (-53%)	-42 (-82%)	6 (0%)	0 (0%)	0 (0%)	-118 (-57%)
Ajax	-55 (-47%)	4 (0%)	4 (0%)	-12 (-100%)	-33 (-100%)	-92 (-57%)
Whitby	-275 (-88%)	-11 (-73%)	3 (0%)	0 (0%)	0 (0%)	-283 (-87%)
Oshawa	-244 (-87%)	-20 (-85%)	-9 (-72%)	0 (0%)	0 (0%)	-274 (-86%)
Clarington	-15 (-39%)	3 (0%)	1 (0%)	0 (0%)	0 (0%)	-11 (-29%)
Georgina	9 (34%)	1 (0%)	1 (0%)	0 (0%)	0 (0%)	11 (42%)
East Gwillimbury	-67 (-51%)	-8 (-56%)	4 (0%)	0 (0%)	0 (0%)	-70 (-49%)
Newmarket	-835 (-69%)	0 (0%)	36 (0%)	0 (0%)	2 (0%)	-798 (-63%)
Aurora	-667 (-57%)	-25 (-19%)	111 (582%)	0 (0%)	-96 (-56%)	-677 (-45%)
Richmond Hill	-1,569 (-23%)	-468 (-31%)	969 (263%)	87 (95%)	19 (9%)	-961 (-11%)
Whitchurch-Stouffville	-171 (-58%)	-31 (-66%)	9 (0%)	0 (0%)	1 (0%)	-192 (-56%)
Markham	-2,463 (-35%)	-175 (-18%)	521 (111%)	-94 (-45%)	127 (82%)	-2,084 (-24%)
King	-284 (-31%)	98 (60%)	121 (109%)	1 (0%)	23 (12%)	-40 (-3%)
Caledon	26 (2%)	-43 (-16%)	42 (0%)	7 (0%)	0 (0%)	32 (2%)
Brampton	-935 (-17%)	-6 (-1%)	499 (1662%)	18 (0%)	0 (0%)	-424 (-7%)
Mississauga	-3,960 (-46%)	52 (7%)	360 (228%)	-87 (-99%)	-54 (-100%)	-3,689 (-38%)
Halton Hills	-89 (-65%)	-45 (-91%)	2 (0%)	0 (0%)	0 (0%)	-132 (-71%)
Milton	-67 (-47%)	-10 (-34%)	5 (0%)	0 (0%)	0 (0%)	-72 (-42%)
Oakville	-420 (-71%)	18 (0%)	-17 (-59%)	0 (0%)	0 (0%)	-418 (-68%)
Burlington	-97 (-57%)	73 (0%)	9 (0%)	0 (0%)	-98 (-100%)	-112 (-42%)
Flamborough	7 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	7 (0%)
Dundas	1 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0%)
Ancaster	-75 (-98%)	-154 (-100%)	0 (0%)	0 (0%)	0 (0%)	-229 (-99%)
Glanbrook	-4 (-86%)	1 (0%)	0 (0%)	0 (0%)	0 (0%)	-3 (-66%)
Stoney Creek	-52 (-100%)	-45 (-100%)	0 (0%)	0 (0%)	0 (0%)	-97 (-100%)
Hamilton	-137 (-100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-137 (-100%)
All	-18,142 (-13%)	10,479 (39%)	2,619 (14%)	-3,663 (-34%)	2,710 (63%)	-5,997 (-3%)

Table A - 10: AM Peak (3 Hour) Modelled to Observed Differences in Demand from Vaughan, by mode

Destination Planning District	Auto Driver	Auto Passenger/VFH	Transit	Active	Other	Total
Vaughan	1,563 (2%)	9,974 (68%)	528 (25%)	-3,566 (-37%)	3,325 (115%)	11,824 (12%)
Toronto	4,765 (13%)	4,711 (70%)	3,439 (80%)	-7 (-1%)	-133 (-100%)	12,776 (27%)
Brock	59 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	59 (0%)
Uxbridge	-166 (-52%)	15 (0%)	0 (0%)	0 (0%)	0 (0%)	-151 (-48%)
Scugog	49 (95%)	-9 (-58%)	0 (0%)	0 (0%)	0 (0%)	40 (61%)
Pickering	-108 (-20%)	-12 (-19%)	45 (0%)	0 (0%)	0 (0%)	-75 (-12%)
Ajax	-521 (-52%)	71 (0%)	31 (257%)	0 (0%)	0 (0%)	-420 (-41%)
Whitby	6 (1%)	51 (317%)	40 (0%)	0 (0%)	0 (0%)	97 (20%)
Oshawa	76 (22%)	-20 (-25%)	27 (0%)	0 (0%)	0 (0%)	83 (20%)
Clarington	203 (369%)	43 (0%)	11 (0%)	0 (0%)	0 (0%)	257 (467%)
Georgina	-405 (-47%)	19 (66%)	3 (0%)	0 (0%)	5 (0%)	-379 (-43%)
East Gwillimbury	-287 (-48%)	-12 (-31%)	23 (0%)	0 (0%)	6 (0%)	-270 (-43%)
Newmarket	-685 (-35%)	-3 (-2%)	124 (3090%)	0 (0%)	-21 (-84%)	-585 (-27%)
Aurora	-859 (-41%)	-10 (-6%)	160 (0%)	0 (0%)	15 (0%)	-694 (-31%)
Richmond Hill	-2,372 (-23%)	-44 (-3%)	1,118 (248%)	-21 (-15%)	67 (88%)	-1,252 (-10%)
Whitchurch-Stouffville	86 (21%)	32 (129%)	45 (0%)	0 (0%)	21 (0%)	184 (43%)
Markham	-1,556 (-24%)	-171 (-18%)	636 (287%)	51 (366%)	57 (122%)	-982 (-13%)
King	-1,019 (-46%)	178 (317%)	99 (1984%)	3 (0%)	-4 (-9%)	-744 (-32%)
Caledon	-1,039 (-37%)	53 (27%)	32 (0%)	3 (0%)	-27 (-100%)	-978 (-32%)
Brampton	-2,422 (-22%)	189 (13%)	756 (177%)	60 (0%)	-72 (-100%)	-1,490 (-11%)
Mississauga	-2,084 (-37%)	181 (49%)	375 (913%)	3 (0%)	-94 (-100%)	-1,619 (-26%)
Halton Hills	-105 (-22%)	65 (466%)	48 (0%)	0 (0%)	-57 (-100%)	-48 (-9%)
Milton	-617 (-61%)	33 (254%)	47 (0%)	0 (0%)	0 (0%)	-537 (-53%)
Oakville	-298 (-44%)	35 (91%)	24 (0%)	0 (0%)	-26 (-100%)	-264 (-36%)
Burlington	-323 (-62%)	-10 (-27%)	29 (0%)	0 (0%)	0 (0%)	-304 (-55%)
Flamborough	-226 (-79%)	-6 (-52%)	2 (0%)	0 (0%)	0 (0%)	-230 (-77%)
Dundas	-64 (-85%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	-63 (-84%)
Ancaster	-124 (-86%)	-25 (-97%)	0 (0%)	0 (0%)	0 (0%)	-149 (-87%)
Glanbrook	17 (0%)	5 (0%)	0 (0%)	0 (0%)	0 (0%)	22 (0%)
Stoney Creek	-194 (-83%)	3 (0%)	0 (0%)	0 (0%)	0 (0%)	-191 (-82%)
Hamilton	-91 (-34%)	-4 (-20%)	17 (0%)	0 (0%)	0 (0%)	-79 (-27%)
All	-8,741 (-6%)	15,331 (58%)	7,659 (101%)	-3,474 (-33%)	3,062 (88%)	13,838 (7%)

Similar to the AM results, several findings for the PM can be noted when evaluating the difference tables above (**Table A - 9** and **Table A - 10**):

- PM trips destined to Vaughan are under simulated by approximately 3%. This is primarily driven by an under simulation of auto driver trips. Auto passenger/VFH and transit trips are over simulated.
- PM trips originating from Vaughan are over simulated by approximately 9%. Similar to trips destined to Vaughan, auto passenger and transit trips are over simulated. Transit trips, in particular are roughly double, but are (partially, at least) due to under-representation of York Region transit demand in TTS.
- Active demand appears low (roughly 33% under simulated for trips to/from Vaughan). In the AM, these were roughly 3% over simulated for trips to/from Vaughan. This demand is, however, largely intrazonal and would not appear in the network.