Appendix F

Model Development and Application

VAUGHAN

F1. Model Development (Halcrow)

F1.1 November 2010 Technical Memorandum

F1.2 July 6, 2010 Memorandum

VAUGHAN

F1.1 November 2010 Technical Memorandum

City of Vaughan

Transportation Master Plan Study
Vaughan Sub-Area Model (VSAM)
Technical Report
November 2010

Halcrow Consulting Inc

City of Vaughan

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City of Vaughan

Transportation Master Plan Study
Vaughan Sub-Area Model (VSAM)
Technical Report

Contents Amendment Record

This report has been issued and amended as follows:

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1		Draft Final Report	6/11/09	DFC
2		Final Report	6/11/10	DFC

Contents

1 Introduction

1.1 Background

As part of the on-going Vaughan Transportation Master Plan (TMP) Study, Halcrow was commissioned by the City of Vaughan and the prime consultant, AECOM, to develop a sub-area travel demand model for the City of Vaughan based on a local refinement of the York Rapid Transit Plan (YRTP) regional model. For the purposes of this TMP Study, Halcrow refined, updated and validated the YRTP model to a 2006 base to reflect the more current travel habits and traffic count information specific to the study area. This new Vaughan Sub-Area Model (VSAM) will be used to evaluate future transportation infrastructure requirements for the City of Vaughan in the long and short terms (2011, 2021 and 2031), in support of the study objectives to encourage public transit use, alleviate congestion and promote liveable street networks and neighbourhoods within the City. The model will also be used by the City Staff for their in-house traffic forecasting after completion of the TMP Study. This technical report documents the VSAM development and validation process as well as the resulting forecasts generated for this study.

1.2 Key Tasks

Some of the key tasks involved in the VSAM model development and validation are described below:

- Refined traffic zone system within the City of Vaughan to provide more realistic representation of the network and of walking distances to transit stations/stops;
- Updated the existing YRTP model base year from 2001 to 2006 on the latest EMME 3 platform;
- Added local collector roads which are under the jurisdiction of the City of Vaughan for local traffic diversion and infiltration analysis;
- Improved the YRTP modelling process to provide more reliable auto traffic and transit ridership forecast;
- Validated the model results at the screenline level for the base year 2006;
- Developed a PM model based on the calibrated AM model to estimate future PM peak hour auto traffic demand; and
- Developed future 2031 base model using updated land use and demographic data, road networks and external matrices.

1.3 Deliverables

The following deliverables were prepared for this VSAM study:

- A refined sub-area model for the base year 2006 and 2031;
- 2006 and 2031 auto and transit base networks;
- An enhanced model input preparation spreadsheet to incorporate land use and other necessary zonal data; and
- A set of EMME macros for implementing base and future year model runs.

1.4 Report Organization

This report is organized into six sections. **Section 2** describes the model structure, model updates and model inputs for the 2006 base year. **Section 3** presents the validation results for the AM model. **Section 4** describes the PM modelling approach, shopping trip analysis and the PM model validation. **Section 5** summarizes the 2031 model assumptions and the resulting forecasts. Finally, **Section 6** provides a summary and conclusions.

2 AM Model Development

2.1 Introduction

This chapter documents the model development and validation of the AM Vaughan Sub-Areal Model (VSAM). This chapter is organized into five sections:

- Section 2.2 describes the YRTP and Western Vaughan IEA model
- Section 2.3 provides an overview of the VSAM model
- Section 2.4 documents the model update process
- Section 2.5 describes the traffic zone system and demographic inputs
- Section 2.6 describes the road and transit networks

2.2 YRTP and Western Vaughan IEA Models

VSAM is an updated version of the YRTP regional model, which is a traditional 4-Stage EMME/2-based model developed by IBI Group for the York Region Rapid Transit Plan (YRTP) Study in 2003. The YRTP model was designed primarily for forecasting transit ridership on the proposed rapid transit lines along the Yonge Street and Highway 7 rapid transit corridors at the time of the study. It has the capabilities to model three trip purposes including work, school and other trips during the AM peak period (6AM-9AM) by the motorized travel modes.

The YRTP model uses the standard 2001 GTA traffic zone system developed by the Data Management Group, with enhanced zonal detail in the transit-oriented intensification areas to better reflect variations in walk access to transit stops. This multi-modal model was originally calibrated using 2001 travel data collected as part of the 2001 Transportation Tomorrow Survey (TTS) and 2001 traffic and transit count information. It estimates peak period traffic demands for the base and future horizon years at the arterial and collector road level within the Greater Toronto and Hamilton Area (GTHA) as well as transit demands for planned rapid transit facilities and feeder bus routes.

In the fall of 2007, Halcrow was commissioned by York Region and UMA (now AECOM) to update the YRTP model and provide travel demand forecasts for different auto and transit network alternatives in support of the Western Vaughan Individual Environmental Assessment (IEA) Study. While the traffic zone system of the YRTP model was retained, demographics and networks were updated to 2006 base for the Western Vaughan IEA. The resulting 2006 trip matrices were validated against the 2006 TTS and traffic assignment were checked against 2006 traffic counts. Given the full 4-stage multi-modal modelling capability and the geographic similarity of the revised Western Vaughan IEA model, it was the logical choice as the basis for the VSAM.

2.3 VSAM Overview

2.3.1 Modelling Approach

VSAM is a standard travel demand model that estimates the overall trip-making decisions of individuals within the GTHA. Such models are often referred to as “macroscopic” models. The techniques used and degree of detail of model results are in sharp contrast to traffic simulation or “microscopic” models that simulate the expected behaviour of individual trip makers as they negotiate their respective paths through a section of the transportation network.

The principal inputs to VSAM are:

- Land use (e.g. population and employment information by traffic zone)
- Road network (e.g. number of lanes, lane capacity, etc.)
- Transit network and services (e.g. route alignment, stops, headways, etc.)
- Economic and travel cost data (e.g., value of time, vehicle operating costs, parking costs, transit fares, etc.)

The model outputs are forecasts of travel volumes and times and out-of-pocket costs by travel mode for:

- All origin-destination pairs
- Each roadway link in the coded road network
- Each transit line segment in the coded transit network

VSAM is a multi-modal transportation model that estimates travel demand in the following steps:

- Trip generation
- Trip distribution
- Mode split
- Trip assignment

These steps are covered in the following sections in more detail.

2.3.2 Trip Generation

Trip generation equations estimate the number of trips produced and attracted by each traffic zone during the AM peak period based on demographic data, trip rates and calibrated regression equations for the following major trip purposes and the corresponding sub-categories:

- Work trips for 3 occupational groups (Office / Manufacturing / Professional)
- School trips (Secondary / Post-secondary)
- Other trips

External trips with an origin or destination outside the GTHA are not modelled specifically in VSAM as they were extracted directly from the 2006 TTS data with a standard growth rate assumed for future years. These external trips are added to the internal trips after the mode split stage and prior to the trip assignment procedure.

2.3.3 Trip Distribution

The trip distribution sub-model estimates the number of person trips travelling between O-D pairs for each trip purpose. For work trips, distinct trip distributions are estimated for 3 occupational groups. Gravity models are calibrated to estimate work trip distributions through a multi-step process involving calculation of travel costs between O-D pairs and the corresponding impedance or "friction" factors that describe the propensity to travel between different locations. The friction factors are then incorporated in a balancing algorithm to convert the resulting trip production and attraction vectors from the trip generation stage into full O-D matrices for each occupation group. This process ensures that work trips are sensitive to changes in transit level-of-service and traffic congestion as the gravity model utilizes the auto and transit travel time between O-D pairs. It should also be noted that the work trip distribution models also use K-Factors to adjust for a significant undersimulation of travel to the Toronto CBD.

For school and other trips that are relatively less sensitive to traffic conditions on roads, a Fratar balancing process was used instead of the gravity model approach in estimating home to school and other, non-work, O-D matrices.

2.3.4 Mode Split

A multinomial logit sub-model is calibrated to estimate the percentage of work trips by the following motorized modes:

- Auto driver
- Public transit with walk access
- Public transit with auto access (Park/Kiss-and-ride at subway stations)
- GO Rail with walk or public transit access
- GO Rail with auto access (Park/Kiss-and-ride at GO Rail stations)

The following input variables are used in the multinomial logit formulation:

- Level-of-service and cost (e.g. In-vehicle travel time, auto operating cost, parking cost etc.)
- Transit supportive land use variables (e.g. Urban density, land use mix etc.)
- Percentage of households without auto access estimated by an auto-ownership sub-model

A standard logit function is used for estimating modal share for post-secondary school trips while observed modal split rates for each planning district are used for secondary school and other trips.

2.3.5 Trip Assignment

Trip assignment is the final step of the 4-stage modelling process. A standard generalized cost equilibrium auto assignment is implemented in this stage to model route choices for the auto drivers as well as transit patronage based on the weighted generalized cost (i.e. travel time and cost) between each O-D pair. These travel times for auto and transit were estimated using volume-delay functions and transit time functions that are described in **Section 2.6** of this chapter. Park-and-ride trips are also assigned onto the auto sub-network in this stage to allow potential users to access all the commuter parking lots for transit stations within the GTHA (e.g. TTC Finch Station). Peak hour auto traffic are estimated for assigned traffic by applying appropriate peak hour factors (PHFs) that reflect observed peaking characteristics for the auto mode.

The YRTP model does not model high-occupancy vehicles (HOV). VSAM represents HOV lanes by assuming two thirds of the capacities of the general purpose lanes in order to reflect lower traffic usage in the trips assignment stage. Trucks are not modelled in VSAM. Observed truck percentages on specific roadways or classes of roadway can be applied to the assigned auto volumes manually (post-model run) to estimate the approximate impact of truck volumes on traffic conditions.

2.3.6 Modelling Process

The modelling process is iterative, involving the recycling of outputs to achieve “convergence”. For example, travel times or travel costs are the key inputs for the trip distribution process. Whenever significant changes occur that affect travel times or travel costs in the trip distribution stage, the subsequent modelling procedures (i.e. mode split and trip assignment) are also affected. Therefore, the model must be cycled multiple times until input travel times in the trip distribution stage and the resulting output times generated from the trip assignment stage are consistent in order to achieve model convergence. It has been tested that four cycles are sufficient for the VSAM to meet the convergence criteria.

The model structure and calibration parameters of the YRTP model were largely preserved in VSAM. For more details regarding modelling methodology and calibration parameters, please refer to the following documents prepared for the YRTP program:

- Ridership Forecasting Model Development Draft Report, July 2003
- Ridership Forecasting – Model Development Report: v1.1, Dec 2003
- YRTP Model User's Manual v1.11, Feb 2005

2.4 Model Update

2.4.1 Background

As a forecasting tool designed for transit service planning, the YRTP model was calibrated specifically to provide ridership forecasts during the AM peak period with traffic zone refinement focused primarily in the rapid transit corridors along Yonge Street and Highway 7. Given its coarse traffic zone system outside the designated rapid transit corridors and its inability to forecast PM traffic (when travel demand is highest due to additional discretionary trips on the local roads), the YRTP model is not suitable for generating detailed traffic and ridership data for the network assessment required by this TMP study. To address these specific issues, Halcrow developed a sub-area model, VSAM, based on the existing YRTP model to produce more reliable traffic forecasts in local development areas within Vaughan for both AM and PM periods. The following sections document the VSAM update process.

2.4.2 Traffic Zone Refinement

In consultation with City Staff and the study team, traffic zones within the City of Vaughan were refined to produce a more detailed network and a more precise depiction of walk distances to transit stations/stops. Centroid connectors for trips coming in and out of traffic zones were also adjusted to ensure appropriate vehicle loading to road network for these refined traffic zones. Total number of traffic zone within the City increased from 124 in the YRTP model to 185 in VSAM, with 61 new zones added as a part of the refinement process.

2.4.3 Demographics Update

2006 to 2031 population and employment estimates for the entire York Region at the 2001 TTS traffic zone level were provided by the Region's Planning Department for the use of this study. However, these numbers did not reflect the anticipated growth or intensification within the City, particularly for the focused study areas (e.g. Vaughan Metropolitan Centre, Vaughan Mills and Woodbridge Core areas). As such, additional land use re-allocation was undertaken by Halcrow in close collaboration with Urban Strategies Inc. and the City Staff, to incorporate the City's latest growth scenarios, to update demographics for each 2001 TTS traffic zone, and to disaggregate the demographic and other land use data for the VSAM refined traffic zones.

2.4.4 Auto and Transit Network Refinement

Network coding for the 2006 auto network within the City was validated using 2007 aerial photos available on the York Region Geomatics Branch website to ensure proper representation of road alignment and lane configuration[1]. Travel speeds and road capacities within the City were also vetted for reasonableness. Transit route alignment, stop location and frequency were verified using published schedules provided by York Region Transit (YRT) and GO Transit for all transit routes that traverse Vaughan. Selected local collector roads that are under the jurisdiction of the City were coded in the VSAM in consultation with City Staff to allow for analysis of local traffic diversion and infiltration. Volume delay functions for estimating travel times on 407ETR were updated to reflect 2006 toll costs and estimated value of time.

2.4.5 PM Model Development

In order to address the need for PM peak period forecasts (when traffic loads are the highest for the day), a PM model was developed to estimate base year and future PM peak hour auto traffic demand based on the calibrated AM model. This PM model was developed by a procedure that transposes and factors AM auto driver matrices to PM based on relationships between the AM and PM trips by purpose, as identified from the 2006 TTS data. More importantly, this new PM model has the capability to estimate local shopping or pass-by trips for shopping centres or retail stores based on the number retail jobs for each individual traffic zone. This feature greatly improves the robustness of the PM peak forecasting results as large numbers of discretionary trips are made during the afternoon peak period, which cannot be adequately accounted for with the transpose and factor method.

2.4.6 Model Validation and Fine-Tuning

AM and PM trip matrices estimated by the VSAM were compared to the observed 2006 TTS data, and assigned traffic volumes in the VSAM were validated against observed traffic counts for each individual screenline station. Based on these validation results, an adjustment matrix was developed, after successive testing, to account for differences between the forecasted and observed 2006 AM and PM auto driver trips. Effectively, this matrix reflects the variations in trip generation rates (from the average rates used by the model) that are observed for specific land uses within the study area. This refinement significantly improves the accuracy of the model in the base year and is applied to all horizon year scenarios.

The following sections describe the model inputs required for the forecasting process.

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[1] York Aerial Photographs. York Region. Available at <http://maps.york.ca/imf/imf.jsp?site=geoRegOrtho>

2.5 Traffic Zone System and Demographics

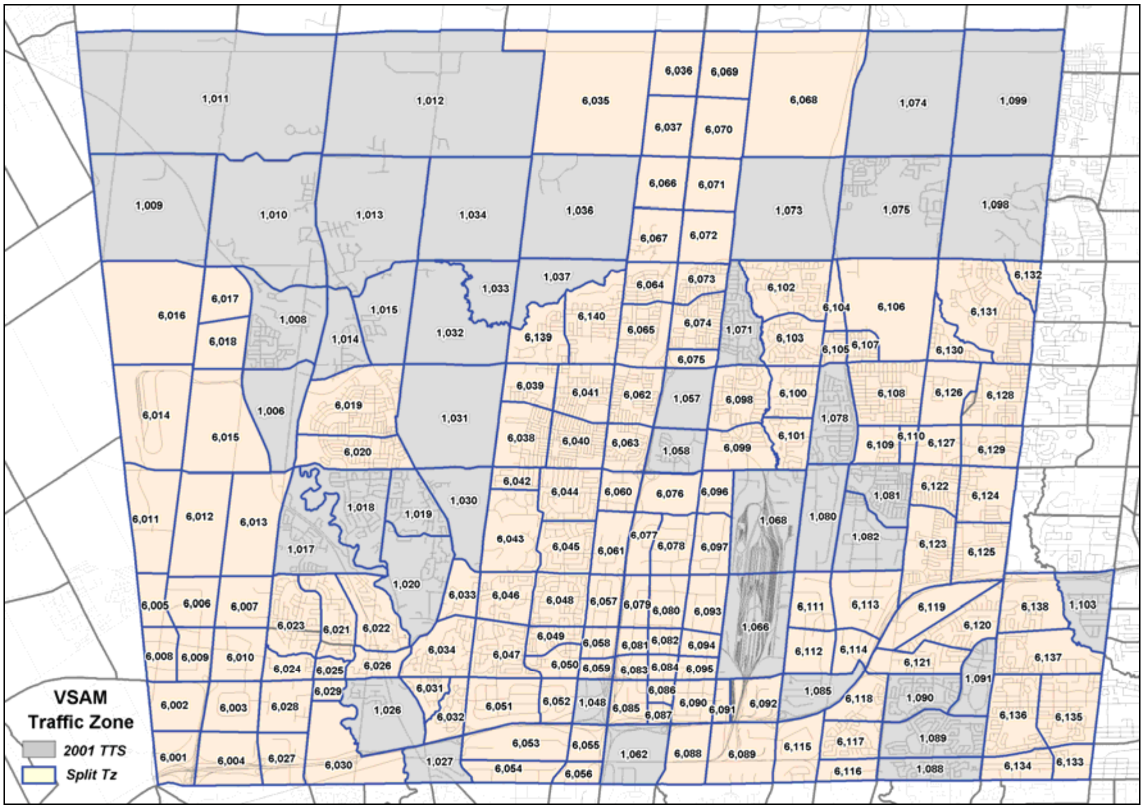
2.5.1 Traffic Zone System

The standard 2001 TTS traffic zone system developed by DMG divides the entire GTHA into 1,717 traffic zones with 103 zones located within Vaughan. Some of these 103 traffic zones along Yonge St. and Highway 7 have been split in the previous YRTP Study, which increased the total number of traffic zones in Vaughan to 124 for the YRTP Model. However, the level of traffic zone detail in the YRTP model was not sufficient for the sub-area modelling in Vaughan. A more refined sub-area zone system was therefore redefined in conjunction with the City, to better model the zonal access points throughout the city. As a result of this traffic zone refinement process, a total of 60 traffic zones were added in the VSAM, with the YRTP traffic zone system was maintained outside of Vaughan. The VSAM has a total of 1,885 traffic zones, with 184 zones in Vaughan, and 26 external traffic zones that represent trips coming from and to areas outside of the GTHA,. **Table 1** shows the traffic zone number assigned for each zone group and **Figure 1** illustrates the Vaughan sub-area zone system.

Table 1– VSAM Traffic Zone Numbering System

VSAM Study Area	Tz # Range
Vaughan	1006-1103
Vaughan (VSAM Split)	6001-6140
GTA Region	**Tz # Range**
City of Toronto	1-481
Durham Region	501-765
York Region	1006-1353
York Region(VSAM Split)	6001-6319
Peel Region	1501-1753
Halton Region	2001-2197
City of Hamilton	2501-2670
External Zones	4000-4410

Figure 1- VSAM Traffic Zone System Map



2.5.2 Land Use (Population and Employment)

Current and future year population and employment by traffic zone are key inputs to the VSAM model. For the base year (2006) VSAM, the latest population and employment data for the City of Vaughan provided by the City's Planning Department at the 2001 traffic zone level were utilized for the City, and the comparable data assumed by York Region for the YRTP model were adopted for areas outside Vaughan.

Since traffic zones within Vaughan have been refined in detail for better network representation, manual allocation were undertaken in collaboration with Urban Strategies Inc. and City Staff to distribute 2006 population and employment estimates at the 2001 traffic zone system to each smaller and refined zone. Split percentages used to distribute zonal employment into sub-categories (office / manufacturing / professional) in the YRTP model were retained for the VSAM. **Table 2** summarizes the 2006 population and employment estimates for Vaughan and GTHA municipals.

Table 2 – 2006 Population and Employment

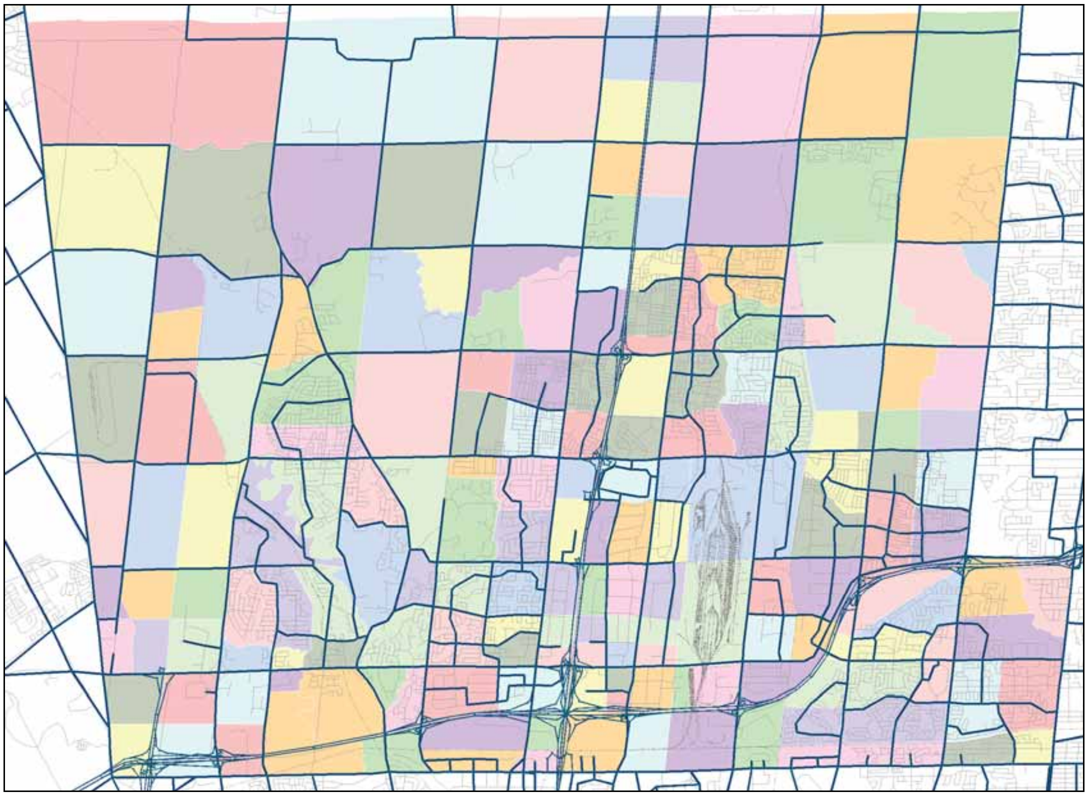
Area	Pop	Emp
Toronto PD1	190,937	451,065
Rest of Toronto	2,405,601	1,082,880
Durham	588,935	194,375
York	929,865	459,152
Peel	1,205,877	636,884
Halton	429,900	194,000
Hamilton	515,000	199,600
GTHA	**6,266,115**	**3,217,956**
Vaughan	***248,807***	***158,999***

2.6 Road and Transit Networks

2.6.1 Road Network

The road network in the YRTP model was first developed based on the 2001 GTA EMME/2 network provided by DMG. It was updated in 2006 by York Region staff for their modelling purposes and subsequently by Halcrow for the Western Vaughan IEA Study. While most of the network attributes (number of lanes, speed, capacity, length, turn restriction, etc.) from these previous models were preserved for VSAM, Halcrow conducted an extensive check and refinement of network coding within the Vaughan sub-area to ensure accurate network representation. Road geometry for the roadways within Vaughan was also refined to improve visual appearance by adding details to the highway interchanges and arterial roads. Selected local collector roads under the jurisdiction of the City were also added to the VSAM for local traffic diversion and infiltration analysis. The revised network is illustrated in **Figure 2**.

Figure 2 – 2006 VSAM Road Network



2.6.2 Transit Network

Similar to the road network, the transit network in the YRTP was first developed based on the 2001 GTA EMME/2 network with further updates by York Region staff and Halcrow. For this Vaughan TMP Study, Halcrow reviewed and updated the transit headways, route alignments and stops based on the latest schedule available for all the YRT, TTC and GO transit routes that traverse the City of Vaughan. **Table 3** shows all the transit routes that have been verified and updated for VSAM.

Table 3 – VSAM AM Transit Network

Transit Agency	Route #	Route ID	Transit Agency	Route #	Route ID
GO bus	32	Brampton - Sheppard	TTC	165F	Weston Rd South F
GO bus	42	Bolton - York Mills	TTC	191	Hwy 27 Rocket
GO bus	44	Mount Joy - York U	TTC	Subway	Bloor - Danforth Subway
GO bus	45	Streetsville-York U	TTC	Subway	Finch - Downsview Subway
GO bus	45A	York U - Square One	TTC	Subway	Scarborough RT
GO bus	46	Oakville - York U	TTC	Subway	Sheppard Subway
GO bus	47	Hamilton - York U	VIVA	Pink	VIVA Pink
GO bus	48A	Meadowville - York U	VIVA	Purple	VIVA Purple
GO bus	48B	Meadowville - York U	VIVA	Green	VIVA Green
GO bus	49	York U - Pickering	VIVA	Orange	VIVA Orange
GO bus	49	Pickering - York U	VIVA	Blue	VIVA Blue
GO bus	49	Pickering - York U 407	YRT	3	Thornhill - York U
GO bus	52	Oshawa-York U	YRT	3B	Thornhill - YorkU
GO bus	61	Richmond Hill - Union	YRT	4	Major Mackenzie
GO bus	62	Newmarket - York Mills	YRT	4A	Major Mackenzie
GO bus	64	Newmarket - York U	YRT	5	Clark
GO bus	65	Barrie - Maple	YRT	7	Martin Grove
GO bus	65	Newmarket - Union	YRT	10	Woodbridge - York U
GO bus	65	King City - Union	YRT	11	Woodbridge
GO bus	66	Newmarket - Yorkdale	YRT	12	Pine Valley
GO bus	66	Yorkdale - Newmarket	YRT	13A	Islington NapaValley
GO bus	68	Bradford - Yorkdale	YRT	13B	Islington Nashville
GO rail	65	Bradford - Yorkdale	YRT	20	Jane
TTC	35A	Jane A	YRT	22	King City
TTC	35C	Jane C	YRT	23	Thornhill Woods
TTC	35D	Jane D	YRT	27	Highway 27
TTC	35E	Jane E	YRT	77	Hwy 7 / Centre
TTC	37D	Islington North	YRT	83	Trench
TTC	37	Islington	YRT	83A	Trench
TTC	46	Martin Grove	YRT	85	Rutherford - 16 Ave.
TTC	60E	Steeles West E	YRT	85A	Rutherford - 16 Ave
TTC	60F	Steeles West F	YRT	85B	Rutherford - 16 Ave
TTC	84A	Sheppard West A	YRT	86	Weldrick Newkirk
TTC	84D	Sheppard West D	YRT	87	Langstaff Maple
TTC	105B	Dufferin North	YRT	88	Bathurst
TTC	107B	Keele North	YRT	90	Leslie South
TTC	107C	Keele North	YRT	98	Yonge North
TTC	107F	Keele North	YRT	99	Yonge South
TTC	160	Bathurst North	YRT	260	Rutherford GO Shuttle
TTC	165	Weston Road North	YRT	360	Maple Express
TTC	165D	Weston Road North D	YRT	463	Emily Carr Sec Sch
TTC	165F	Weston Rd North F			

2.6.3 Volume Delay Functions

A volume delay function (vdf) estimates the link travel time (in minutes) as a function of the link length, number of lanes, free flow speed and road capacity. As traffic volume increases, travel speeds decline, resulting in higher travel times on the link. VSAM adopts the standard Bureau of Public Road (BPR) type of vdf's for arterial road and freeway from the YRTP model as shown in **Equation 1** and **Equation 2.** The shape of the volume delay function, which is determined by the calibration parameters α and β functions, are plotted in **Figure 3**. **Table 4** shows the typical capacity assumptions for each road class.

Equation 1 – Travel Time for Arterial Road (α=1.0 and β=4.0)

$$Auto\ Travel\ Time = Length \times \frac{60}{FreeFlowSpeed} \times \left\{ 1 + 1.0 \times \left(\frac{Total\ Volume}{Lanes \times RoadCapacity} \right)^{4.0} \right\}$$

Equation 2 – Travel Time for Freeway (α=1.0 and β=6.0)

$$Auto\ TravelTime = Length \times \frac{60}{FreeFlowSpeed} \times \left\{ 1 + 1.0 \times \left(\frac{Total\ Volume}{Lanes \times RoadCapacity} \right)^{6.0} \right\}$$

Figure 3 – Volume Delay Functions

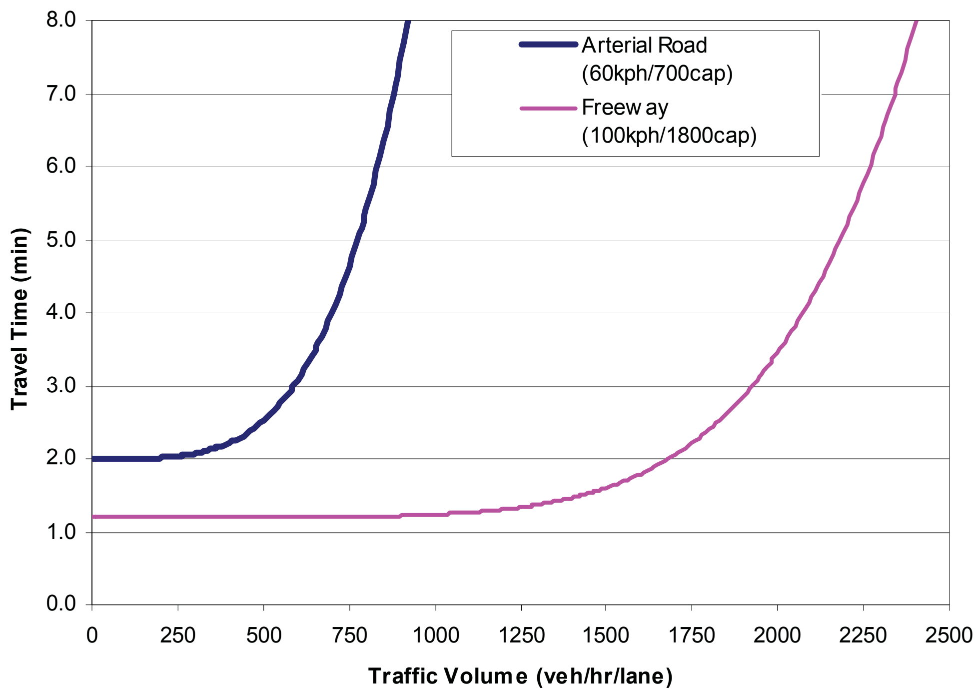


Table 4 – Typical Capacity for Each Road Class

Road Classification	Typical Capacity (veh/hr/lane)
Freeways	1,800
Freeway ramps	1,400
Controlled access or rural highways & arterial roads	1,200-1,500
High capacity urban arterial roads	900
Medium capacity urban arterial roads	700
CBD/minor arterial and collector roads	500
Centroid Connectors	9,999

2.6.4 407ETR Traffic Assignment

The 407ETR is the only toll road in Ontario and its usage is strongly influenced by toll rates and potential users' willingness to pay the associated costs. Typically, associated toll costs for a complete trip are included in the volume-delay function to model the usage of this toll facility. The resulting total travel cost is often called "generalized time", which is a combination of the actual driving time and the perceived toll charge in minutes. The YRTP model uses this generalized time in the trip distribution stage, but treats the 407ETR is the same as other 400-series freeways in the last stage of trip assignment. This treatment would potentially lead to underestimation of travel demand on Vaughan's local road system since traffic would divert from severely congested alternative roads (e.g. Highway 7) to the 407ETR without considering the toll costs associated with the usage of the toll facility. This issue was addressed in the VSAM by applying generalized time assignment in both trip distribution and trip assignment stages. An updated toll charge of 14.72¢/km and value of time of $22/hr were used to reflect 2006 values. A discount of 20 percent calculated on top of the toll cost is estimated based on recent toll road studies in North America to reflect the travel reliability gained by using the 407ETR. All these parameters have been refined and validated through an iterative calibration process and the traffic assignment was validated against the observed 407ETR traffic counts (provided to Vaughan by 407ETR staff) to ensure a reasonable goodness of fit. **Equation 3** shows the volume-delay function used for estimating 407ETR travel time.

Equation 3 – Generalized Travel Time for 407ETR (α=1.0 and β=6.0)

$$AutoTravelTime\,for\,407ETR =$$

$$Length \times \frac{60}{FreeFlowSpeed} \times \left\{ 1 + 1.0 \times \left(\frac{TotalVolume}{Lanes \times RoadCapacty} \right)^{6.0} \right\} + Length \times \frac{TollRate}{ValueofTime} \times 0.8$$

2.6.5 Transit Travel Time

The VSAM uses an average operating speed for each individual bus route to estimate the transit travel time. For transit routes that run on exclusive rights-of-ways (e.g. commuter rail, subways and rapid transit), transit travel times are used to estimate transit speeds on specific transit segments instead. However, as is the case with the YRTP model, transit travel time is not sensitive to congestion on auto networks as the travel speeds are hardcoded.

Equation 4 – Transit Segment Travel Time for Transit with Explicit Rights-of-Way

$$\textit{Transit Segment Travel Time} = \textit{Length} \times \frac{60}{\textit{TransitSegmentSpeed}}$$

2.7 Model Inputs

2.7.1 Seeding Matrix and External Trips

Besides land use data and transportation networks, the VSAM also requires a set of input matrices that are prepared prior to a full model run. One of these input matrices is the auto driver “seeding” matrix, which is used at the first cycle of the trip distribution stage to initiate the gravity model for estimating the number of trips between O-D pairs. This seeding matrix contains the AM peak auto driver trip data collected from the 2006 TTS. Seeding is used only once throughout the model feedback loop and is overridden by the output trip matrix generated by the final trip assignment for the rest of the modelling cycles. The external auto driver trip matrix is another input matrix that is added to the internal trip matrix to include all the trips that would potentially travel on the VSAM transportation network. Both of these matrices were updated in this study to reflect the latest 2006 TTS data released by DMG in fall of 2008. The seeding and external matrices, together with other required input matrices inherited from the YRTP Model, have been split and allocated to the refined VSAM traffic zone system using the appropriate population and employment distributions. An annual growth rate of 1.5% is assumed for all external trips in the future horizon years.

2.7.2 Incremental Matrices

Given the complexity of model procedures and algorithms, the model coefficients and parameters were rigorously calibrated to replicate observed travel behaviour as close as possible. However, the model algorithms represent the average condition and are not able to reflect the subtle differences associated with the specific socio-demographic and/or land use characteristics in one area versus another (e.g., a Walmart may have higher trip generation rates than a Zellers, but both are retail stores). Like many regional models, the YRTP model provides reasonable travel demand estimates at the regional level but travel demand estimates are less than satisfactory for sub-areas like the City of Vaughan. To help solve this problem, an “incremental matrix” was introduced in the VSAM to enhance the fit to observed auto traffic at key screenlines within Vaughan. The first step in the development of incremental matrices was to apply an iterative assignment and demand adjustment process. The initial model matrix was then subtracted from the demand-adjusted matrices to create an “incremental matrix” for auto driver trips. This incremental matrix is subsequently added to the auto driver trip matrices prior to assignment for base and future years. This step significantly improves the base model validation and these adjustments are carried forward in future years. The final validation results are presented in the next chapter.

3 AM Model Validation

3.1 AM Trip Summary

Table 5 compares the 2006 VSAM AM peak period person trip totals with the 2006 TTS targets by travel mode. TTS data collected by DMG in 2006 shows that there are 2.6 million total trips travelling on GTHA network during AM peak period. Among these 2.6 million motorized trips, 1.75 million of the trip makers are auto drivers, 0.4 million are auto passengers and the remaining 0.5 million are transit passengers. The model generates very similar trip totals with less than 5 percent differences between the survey data and modelled trips. Regional transit mode share is estimated at 17% in VSAM compared to 18% from the survey.

Table 5 – 2006 AM Peak Period Person Trip Totals - GTHA

Region	Mode	Orig Trips			Dest Trips		
		Survey*	Model	Diff	Survey*	Model	Diff
GTAH	Auto Driver	1,732,290	1,818,390	5%	1,732,290	1,818,390	5%
	Auto Passenger	383,760	388,820	1%	383,760	388,820	1%
	Transit	467,890	463,640	-1%	467,890	463,640	-1%
	Total Trips	***2,583,940***	***2,670,850***	***3%***	***2,583,940***	***2,670,850***	***3%***
	Transit Mode Share	***18%***	***17%***	***-1%***	***18%***	***17%***	***-1%***

** - 2006 Transportation Tomorrow Survey (TTS) Data*

For a smaller study area like Vaughan, however, model's goodness-of-fit is usually less accurate compared to the aggregated regional numbers due to difficulties in estimating local traffic variation and the unique travel characteristics for neighbourhoods. **Table 6** shows that VSAM overestimates the travel demand by 6 percent for trips generated by Vaughan and 14 percent for trips attracted to Vaughan. To solve this problem without undergoing a major re-calibration effort to update the YRTP model parameters, an "incremental matrix" was introduced to enhance the fit to the observed auto traffic at key screenlines within Vaughan. This incremental matrix was estimated based on the latest 2006/2007 traffic counts on major arterials and local collectors within Vaughan. An iterative approach was undertaken to validate the matrix at both trip and screenline level. **Table 7** shows the improved AM peak hour auto driver trips for trip assignment. Screenline validation is described in the next section.

Table 6 – 2006 AM Peak Period Person Trip Totals - Vaughan

Region	Mode	Orig Trips			Dest Trips		
		Survey*	Model	Diff	Survey*	Model	Diff
Vaughan	Auto Driver	82,980	89,060	7%	88,500	101,250	14%
	Auto Passenger	17,750	18,810	6%	17,850	18,970	6%
	Transit	11,570	11,690	1%	5,010	6,440	29%
	Total Trips	***112,300***	***119,560***	***6%***	***111,360***	***126,660***	***14%***
	Transit Mode Share	***10%***	***10%***	***-1%***	***4%***	***5%***	***1%***

** - 2006 Transportation Tomorrow Survey (TTS) Data*

Table 7 – 2006 AM Peak Hour Auto Driver Trip Totals - Vaughan

Region	Mode	Orig Trips			Dest Trips		
		Survey	Model	Diff	Survey	Model	Diff
Vaughan	Auto Driver	35,670	36,220	2%	38,170	38,870	2%

3.2 Screenline Validation

Screenline validation was undertaken by comparing the observed traffic counts with the modelled volumes generated by VSAM. **Figure 4** and **Figure 5** show the 11 screenlines (22 directional screenlines) and 214 count stations identified for this validation to account for most of the major arterials and local collectors within Vaughan. ATR and turning movement counts were provided by York Region and the City of Vaughan while cordon counts from DMG and traffic counts from the 407 ETR were also utilized.

In measuring the goodness of fit for individual screenlines, the GEH statistic was used. A GEH analysis provides a different form of review and adds value because it considers the relative importance of specific roads or transit lines crossing each screenline in relation to the volume of traffic that they carry. For example, a 10% error on a count of 100 cars is less significant than a 10% error on a count of 3,000 cars.

The GEH statistic measures the overall level of error associated with traffic volumes on the individual roads being analyzed, with lower values reflecting a better fit between model-based estimates and the observed traffic. A GEH statistic of less than 10 on individual screenlines is an accepted standard by international agencies (e.g. TransFund New Zealand) and, therefore, an effort has been made to achieve this standard for most, if not all screenlines . This statistic is defined as:

$$GEH = \sqrt{\frac{(V_{obs} - V_{est})^2}{0.5 \times (V_{obs} + V_{est})}}$$

Figure 4 – East-West Screenline

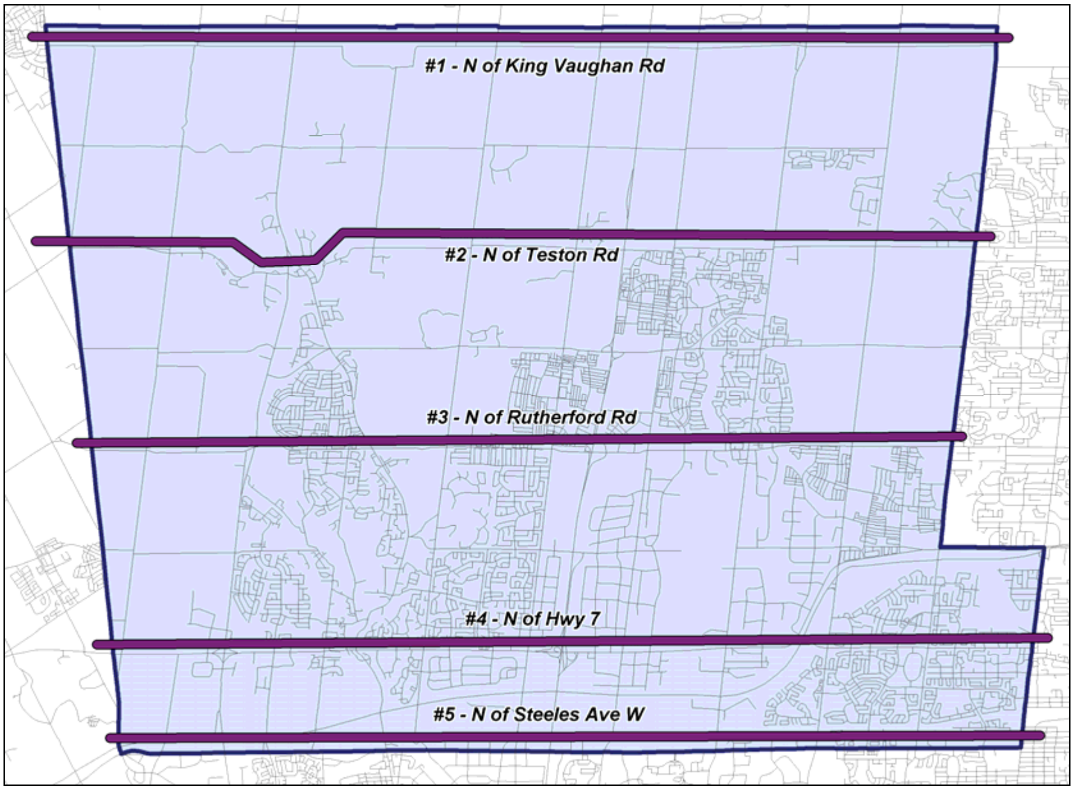


Figure 5 – North-South Screenline

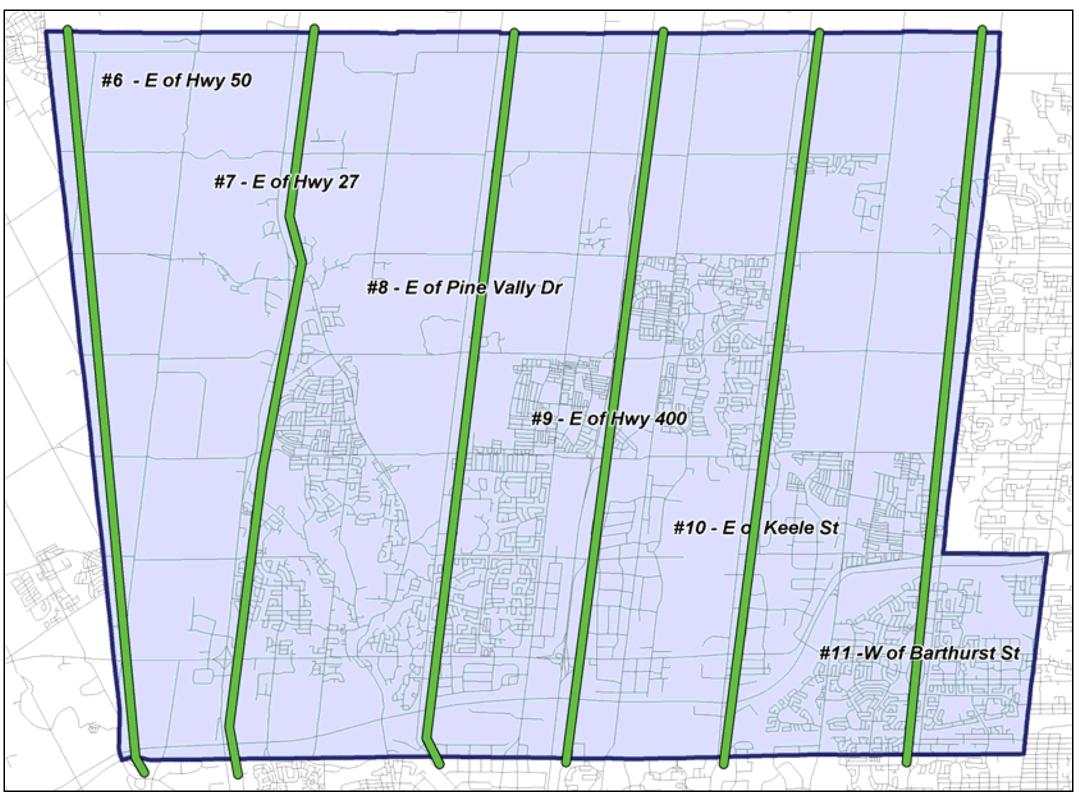


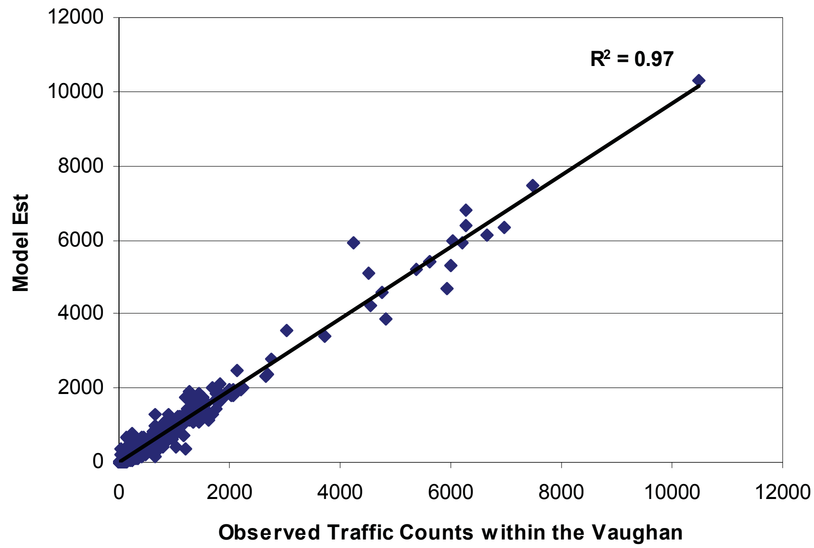
Table 8 compares the modelled AM peak hour auto volumes with the observed traffic counts. 18 out of 22 directional screenlines (82%) produce a GEH lower than 10 and approximately 77% of the auto count stations (165 out of 214) produce a GEH lower than 10.

Table 8 – AM Sub-Area Traffic Count Comparison

Scln	Dir	Screenline	Obs	Est	GEH
1	N	N of King Vaughan Rd	3,630	3,250	6.5
1	S	N of King Vaughan Rd	10,580	9,830	7.4
2	N	N of Teston Rd	4,970	4,430	7.8
2	S	N of Teston Rd	12,570	12,760	1.7
3	N	N of Rutherford Rd	7,170	6,490	8.2
3	S	N of Rutherford Rd	16,360	17,510	8.9
4	N	N of Hwy 7	10,670	10,100	5.6
4	S	N of Hwy 7	23,560	23,820	1.7
5	N	N of Steeles Ave W	13,540	11,950	14.1
5	S	N of Steeles Ave W	24,680	25,910	7.8
6	E	E of Hwy 50	12,090	12,730	5.7
6	W	E of Hwy 50	8,820	7,130	18.9
7	E	E of Hwy 27	10,960	11,250	2.8
7	W	E of Hwy 27	11,200	9,600	15.8
8	E	E of Pine Valley Dr	11,490	12,040	5.1
8	W	E of Pine Valley Dr	10,230	9,430	8.0
9	E	E of Hwy 400	15,860	14,830	8.3
9	W	E of Hwy 400	12,820	12,190	5.7
10	E	E of Keele St	7,920	8,550	7.0
10	W	E of Keele St	9,760	10,180	4.2
11	E	W of Bathurst St	10,470	11,510	9.9
11	W	W of Bathurst St	14,370	11,600	24.3

Figure 6 shows that the R-squared of the model fit to observed counts for all screenline stations is 0.97. Based on these validation statistics, it can be concluded that the model provides reasonable travel demand estimation within the Vaughan sub-area.

Figure 6 – 2006 AM VSAM Screenline Validation



4 PM Model Development and Validation

4.1 Modelling Approach

To address the need to forecast auto traffic during the PM peak hour, conversion procedures were developed to transpose and factor the AM auto driver trip matrices to obtain the PM peak hour traffic. This chapter provides a summary of this conversion procedure, which involves the following steps:

- Analyze the 2006 TTS data and estimate conversion factors
- Introduce local shopping trip estimation
- Estimate and apply incremental matrices
- Validate the PM model at the screenline level

4.2 TTS Survey Data Analysis

4.2.1 Introduction

The TTS collected travel information from households within the GTHA and the survey data were used to develop the trip generation, trip distribution and mode choice model in the YRTP and VSAM AM models. Since the TTS database contains 24-hour origin and destination information, the survey data were analyzed to understand relationship between the morning and afternoon trip purposes in the study area. Through the analysis of the TTS survey data, appropriate afternoon trip purposes were identified and compared to the morning trip purposes. Conversion factors were then developed to convert the AM auto driver trip matrices to the PM trip controls for each trip purpose. This section outlines the cross-tabulation conducted to obtain the conversion factors, followed by the validation of these conversion factors to ensure the consistency of the data.

4.2.2 PM Peak Period

It was necessary to determine the modelled PM peak period before establishing the AM to PM relationship. **Table 9** shows the total number of GTHA destination trips that start from 3pm till 7pm by 3-hours intervals. It is observed that higher demand normally occurs between 3pm to 6pm, which is a reasonable choice for the PM modelling period.

Table 9 – PM Peak Period Selection

Trip Purpose of Destination	2001			2006		
	3:00-5:59PM	3:30-6:29PM	4:00-6:59PM	3:00-5:59PM	3:30-6:29PM	4:00-6:59PM
Other	**345,100**	392,630	445,000	**366,190**	410,590	458,430
Subsequent work	**72,830**	61,190	52,350	**68,390**	55,070	46,680
School	**12,820**	15,410	16,850	**12,460**	13,970	14,730
Subsequent school	**5,080**	5,210	5,450	**4,740**	5,330	6,060
Daycare	**20,590**	19,520	17,470	**25,000**	23,760	20,940
Facilitate a passenger	**213,860**	186,990	163,120	**239,490**	202,050	179,690
Work	**104,050**	85,430	72,330	**96,670**	78,850	66,090
Home	**2,076,860**	1,999,120	1,790,880	**2,198,460**	2,063,660	1,837,990
Market/Shop	**208,240**	217,030	229,200	**237,980**	240,680	247,510
Unknown	**180**	230	220	**80**	60	60
Total	**3,059,610**	**2,982,760**	**2,792,870**	**3,249,460**	**3,094,020**	**2,878,180**

4.2.3 PM Trip Purposes

The TTS survey data collected information according to 9 origin and 10 destination trip purposes that combined to produce over 90 unique trip purposes. For the purpose of model calibration, it was essential to consolidate these trip purposes into major categories with similar travel characteristics. Initially, the TTS data were aggregated into 14 main trip purposes that describe travel throughout the day. **Table 10** shows the auto driver trip totals for the major trip purposes during the PM peak period (1500-1759). The 4 trip categories aggregated from these 12 main trip purposes for the VSAM AM Model are: to work, to secondary school, to post-secondary school and to other.

2006 trips by purpose were examined to understand PM travel patterns and to establish the relationship between AM and PM trip purposes. The cross tabulation analysis indicates that approximately 42 percent of the afternoon trips are related to work. The rest of the trips are mostly home-based other or non-home-based other trips. The linkage between AM “to work” trips and “work to home” trips in the PM is obvious. Less “work to home” trips are observed in the PM, which is logical as start time for work trips are usually more “peaked” during the AM period. For the rest of the trip purposes, however, relationships between AM and PM peak periods were less obvious.

Table 10 – Auto Driver Trip Purpose Analysis for PM Peak Period

	AM			PM		
Trip Purpose	**Trips**	**%**	**Trip Purp**	**Trips**	**%**	**Trip Purp**
To Work	920,990	55%	To Work	49,480	3%	Other (HBO & NHBO)
From Work to Home	27,460	2%	Other	703,080	36%	From Work
To SS	8,910	1%	To SS	370	0%	Other (HBO & NHBO)
SS to Home	20	0%	Other	5,110	0%	From SS
To PS	23,700	1%	To PS	5,240	0%	Other (HBO & NHBO)
PS to Home	60	0%	Other	18,610	1%	From PS
To Other	139,040	8%	Other	288,170	15%	Other (HBO & NHBO)
From Other to Home	14,810	1%	Other	157,530	8%	Other (HBO & NHBO)
To Serve	297,730	18%	Other	161,680	8%	Other (HBO & NHBO)
From Serve to Home	95,310	6%	Other	169,750	9%	Other (HBO & NHBO)
Serve to Work	109,860	7%	To Work	1,230	0%	Other (HBO & NHBO)
Work to Serve	860	0%	Other	65,050	3%	From Work
To Shop	18,820	1%	Other	168,160	9%	Other (HBO & NHBO)
From Shop to Home	3,090	0%	Other	139,660	7%	Other (HBO & NHBO)
Total	**1,660,660**			**1,933,120**		

As a result of this analysis, the 14 main trip purposes were re-aggregated for the afternoon to produce the following PM peak hour trip purposes as defined below:

- From Work – Based on the transposed and factored AM “to work” trips
- From Secondary School – Based on the transposed and factored AM “to SS” trips
- From Post Secondary School – Based on the transposed and factored AM “to PS” trips
- Other trips (Home-Based Other and Non-Home-Based Other) – Based on the AM “Other” trips

4.2.4 Conversion Factor of Auto Driver Trip Matrices

After selecting the modelled time period and trip purposes, conversion factors are to be estimated to adjust the transposed AM matrices to the PM control totals. **Table 1** shows the aggregated auto driver trip totals for the AM and the PM peak periods. There are approximately 16% more trips in total during the PM period with double the amount of “other” trips observed during the PM. This is due to more discretionary trips being made in the afternoon.

Table 11 – Auto Driver Trip Totals by purpose (AM & PM Periods)

AM		PM	
Trip Purpose	**Trips**	**Trip Purpose**	**Trips**
To Work	1,030,860	From Work	768,130
To SS	8,910	From SS	5,110
To PS	23,700	From PS	18,610
Other	597,170	Other (HBO, NHBO)	1,141,270
Total	**1,660,640**	**Total**	**1,933,120**

PM to AM Ratio: 1.16

Different super-zone systems have been tested to compute the conversion matrix. **Table 12** shows the conversion factor set out for the conversion of AM work trips to PM. **Table 13** shows the factors used for other trips.

Table 12 – AM to PM Conversion Factor for Auto Driver Work Trips

Region	Toronto	Durham	York	Peel	Halton	Hamilton	total
Toronto	0.7029	0.7930	0.7228	0.7387	0.7906	1.0623	**0.7220**
Durham	0.6944	0.7428	0.8100	0.9468	1.8118	1.2000	**0.7448**
York	0.7148	0.8160	0.7540	0.7752	0.6653	1.3989	**0.7497**
Peel	0.7299	0.9610	0.7185	0.7773	0.7372	0.7317	**0.7613**
Halton	0.7373	1.3569	0.6340	0.7942	0.7605	0.8221	**0.7779**
Hamilton	0.6425	0.7687	0.6518	0.7215	0.7239	0.7807	**0.7722**
total	**0.7082**	**0.7720**	**0.7388**	**0.7694**	**0.7526**	**0.7963**	**0.7451**

Table 13 – AM to PM Conversion Factor for Auto Driver Other Trips

Region	Toronto	Durham	York	Peel	Halton	Hamilton	Total
Toronto	1.8713	2.2588	1.9919	2.1608	2.7671	1.9364	**1.9061**
Durham	2.0273	1.9152	2.5229	1.4689	0.3684	1.1143	**1.9236**
York	2.6550	2.4187	1.7264	2.4859	4.7727	3.2532	**1.8561**
Peel	2.7541	2.3388	2.8792	1.6384	2.8996	3.3668	**1.7652**
Halton	3.2396	1.4103	3.2967	2.6504	1.9980	2.8605	**2.0961**
Hamilton	3.9177	1.9500	3.5179	1.5978	2.4829	2.2029	**2.2208**
Total	**1.9519**	**1.9472**	**1.7981**	**1.7163**	**2.1070**	**2.2427**	**1.9111**

To validate the conversion method, the control PM trip matrices cross-tabulated by the TTS data were compared against estimated PM matrices that were developed by transposing and factoring of the AM trip matrices at the sub-area level. **Table 14** to **Table 16** demonstrate the validation of the auto driver work trip matrix. Initially, TTS data were cross-tabulated to generate an AM trip matrix. The AM trip matrix was then transposed and factored to produce the output PM auto driver work trip matrix. Finally, this output PM auto driver work trip matrix was compared against the control PM trip matrix generated by cross-tabulation of TTS database. R-Squared of 0.99 as shown in **Table 17** indicates a close fit between two matrices.

Table 14 – 2006 TTS AM Auto Driver Work Trips

2006	Toronto PD 1	Rest of TO	Durham	Georgina	E Gwillimbury	NewMarket	Aurora	Richmond Hill	Whitchurch Stouffville	Markham	King	Vaughan	Peel	Halton	Hamilton	Total
PD 1	5,650	7,140	250	-	-	70	100	270	-	870	-	480	2,790	250	160	18,030
Rest of TO	39,290	175,560	5,900	170	110	1,480	1,090	5,600	540	18,990	330	20,070	38,470	3,690	560	311,850
Durham	3,290	26,530	63,670	190	150	810	580	1,410	1,020	7,760	50	1,470	2,510	300	130	109,870
Georgina	180	980	220	1,680	320	2,090	600	490	140	850	20	340	200	60	20	8,190
E Gwillimbury	150	840	90	110	470	1,410	470	360	120	410	120	280	140	-	-	4,970
NewMarket	510	3,400	180	290	230	4,860	1,430	1,080	390	2,020	250	1,260	610	80	20	16,610
Aurora	470	2,820	90	60	110	1,200	1,880	1,080	110	1,520	230	1,020	710	90	20	11,410
Richmond Hill	2,000	10,500	290	80	20	880	620	5,190	150	5,030	230	4,560	2,590	330	20	32,490
Whitchurch Stouffville	160	1,180	220	40	40	270	170	540	1,070	1,090	40	350	250	-	-	5,420
Markham	2,960	20,340	1,090	20	30	570	410	3,090	520	14,510	40	2,940	3,640	290	110	50,560
King	140	1,070	-	-	50	210	150	410	80	260	240	640	560	90	-	3,900
Vaughan	2,590	20,980	380	40	70	470	260	1,930	70	3,030	220	15,270	7,320	450	60	53,140
Peel	9,260	43,860	700	-	20	340	290	1,010	150	2,980	170	10,240	147,020	13,060	1,400	230,500
Halton	2,300	7,800	90	-	20	20	70	320	40	670	-	1,050	30,640	45,050	5,900	93,970
Hamilton	470	1,320	90	-	-	-	20	40	20	90	-	220	4,660	17,170	56,030	80,130
Total	69,420	324,320	73,260	2,680	1,640	14,680	8,140	22,820	4,420	60,080	1,940	60,190	242,110	80,910	64,430	1,031,040

Table 15 – Estimated PM Auto Work Trip Matrix (Transposed and Factored AM Matrix)

2006	Toronto PD 1	Rest of TO	Durham	Georgina	E Gwillimbury	NewMarket	Aurora	Richmond Hill	Whitchurch Stouffville	Markham	King	Vaughan	Peel	Halton	Hamilton	Total
PD 1	3,970	27,610	2,610	130	110	370	340	1,440	120	2,140	100	1,870	6,840	1,700	340	49,690
Rest of TO	5,020	123,410	21,030	700	610	2,460	2,040	7,590	850	14,700	770	15,160	32,400	5,760	970	233,470
Durham	170	4,100	47,290	180	70	140	70	240	180	880	-	310	660	80	90	54,460
Georgina	-	120	150	1,270	80	220	40	60	30	20	-	30	-	-	-	2,020
E Gwillim bury	-	80	120	240	350	170	80	10	30	30	40	60	10	10	-	1,230
NewMarket	50	1,060	660	1,580	1,070	3,660	900	660	200	430	160	350	260	10	-	11,050
Aurora	70	780	470	450	350	1,080	1,420	460	130	310	110	190	230	50	20	6,120
Richmond Hill	190	4,010	1,150	370	270	820	810	3,910	410	2,330	310	1,460	780	210	50	17,080
Whitchurch Stouffville	-	390	830	110	90	290	80	110	810	390	60	50	120	20	20	3,370
Markham	620	13,570	6,340	640	310	1,520	1,150	3,790	820	10,940	190	2,280	2,310	440	120	45,040
King	-	240	40	10	90	190	170	170	30	30	180	160	130	-	-	1,440
Vaughan	340	14,340	1,200	260	210	950	770	3,440	260	2,220	480	11,510	7,930	700	300	44,910
Peel	2,040	28,080	2,410	150	100	440	510	1,860	180	2,620	400	5,260	114,290	22,580	3,410	184,330
Halton	190	2,720	400	40	-	50	60	210	-	190	60	290	10,370	34,260	14,120	62,960
Hamilton	100	360	100	10	-	10	10	10	-	70	-	40	1,010	4,270	43,750	49,740
Total	12,760	220,870	84,800	6,140	3,710	12,370	8,450	23,960	4,050	37,300	2,860	39,020	177,340	70,090	63,190	766,910

Table 16 – 2006 TTS PM Auto Driver Trip Control Totals

2006	Toronto PD 1	Rest of TO	Durham	Georgina	E Gwillimbury	NewMarket	Aurora	Richmond Hill	Whitchurch Stouffville	Markham	King	Vaughan	Peel	Halton	Hamilton	Total
PD 1	3,750	24,350	2,760	150	100	410	280	1,090	120	1,650	130	2,040	6,120	1,760	610	45,320
Rest of TO	4,730	127,180	20,890	1,020	770	2,670	2,130	7,440	750	14,610	890	15,270	33,120	6,220	1,280	238,970
Durham	90	4,180	47,290	240	70	180	50	230	230	870	30	170	660	150	110	54,550
Georgina	-	80	180	1,320	70	230	20	60	40	-	-	20	-	-	-	2,020
E Gwillimbury	-	20	90	300	350	250	70	-	60	-	30	60	-	20	-	1,250
NewMarket	20	1,080	740	1,410	1,010	3,430	920	610	190	470	150	410	260	-	-	10,700
Aurora	70	840	420	430	370	1,160	1,300	450	160	350	100	250	230	30	-	6,160
Richmond Hill	200	3,800	950	380	240	840	720	3,750	370	2,290	240	1,440	810	160	80	16,270
Whitchurch Stouffville	-	470	1,100	130	100	430	70	120	840	440	40	40	110	20	40	3,950
Markham	580	13,240	6,200	740	310	1,510	1,330	3,610	740	10,620	160	2,030	2,000	440	70	43,580
King	-	220	90	-	90	190	230	170	60	60	260	200	150	-	20	1,740
Vaughan	270	14,980	1,210	450	300	980	820	3,380	200	2,170	530	12,110	8,210	790	310	46,710
Peel	1,670	28,450	2,410	240	140	540	510	1,730	180	2,430	410	5,350	114,290	22,580	3,410	184,340
Halton	130	2,780	400	40	20	40	50	230	-	180	20	310	10,370	34,260	14,120	62,950
Hamilton	80	380	100	-	-	-	-	20	-	80	-	60	1,010	4,270	43,750	49,750
Total	11,590	222,050	84,830	6,850	3,940	12,860	8,500	22,890	3,940	36,220	2,990	39,760	177,340	70,700	63,800	768,260

Table 17 – Estimated PM Auto Driver Work Trips vs. TTS PM Trips (with R-Squared=0.99) (Volume>500)

2006	Toronto PD 1	Rest of TO	Durham	Georgina	E Gwillimbury	NewMarket	Aurora	Richmond Hill	Whitchurch Stouffville	Markham	King	Vaughan	Peel	Halton	Hamilton	Total
PD 1	-6%	-12%	6%	-	-	-	-	-25%	-	-23%	-	9%	-11%	4%	77%	-9%
Rest of TO	-6%	3%	-1%	44%	27%	9%	5%	-2%	-12%	-1%	15%	1%	2%	8%	32%	2%
Durham	-	2%	0%	-	-	-	-	-	-	-1%	-	-	0%	-	-	0%
Georgina	-	-	-	4%	-	-	-	-	-	-	-	-	-	-	-	0%
E Gwillimbury	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1%
NewMarket	-	2%	12%	-11%	-5%	-6%	2%	-8%	-	-	-	-	-	-	-	-3%
Aurora	-	8%	-	-	-	8%	-8%	-	-	-	-	-	-	-	-	0%
Richmond Hill	-	-5%	-17%	-	-	3%	-11%	-4%	-	-2%	-	-1%	4%	-	-	-5%
Whitchurch Stouffville	-	-	32%	-	-	-	-	-	4%	-	-	-	-	-	-	17%
Markham	-6%	-2%	-2%	17%	-	-1%	16%	-5%	-10%	-3%	-	-11%	-13%	-	-	-3%
King	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19%
Vaughan	-	4%	1%	-	-	3%	7%	-2%	-	-2%	11%	5%	4%	12%	-	4%
Peel	-18%	1%	0%	-	-	23%	-1%	-7%	-	-7%	-	2%	0%	0%	0%	0%
Halton	-	2%	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%
Hamilton	-	-	-	-	-	-	-	-	-	-	-	-	0%	0%	0%	0%
Total	-9%	1%	0%	12%	6%	4%	1%	-5%	-3%	-3%	4%	2%	0%	1%	1%	-

4.3 Local Shopping Trips

4.3.1 Introduction

A satisfactory fit to regional travel data for the PM peak period is expected using the transpose and factor method. However, like many other macroscopic models, model fit on some local streets and commercial streets in the afternoon is less than satisfactory with substantial under-estimation of traffic. One of the reasons for this problem is the lack of shopping trips during the AM peak period (dominated by work and school-related travel), which means that very few if any shopping trip samples are collected in travel surveys during this period. Therefore the flip-and-factor approach cannot be used to capture the shopping trips generated in the afternoon. Also, it is a common problem in household travel surveys that short / by-pass trips and particularly “multiple-destination” shopping trips may not be reported at all. Furthermore, many local trips do not cross a regional screenline and may therefore not be part of the data to which the regional model like YRTP model is calibrated. To compensate for this under-representation of short-distance auto trips to/from shopping areas, a new shopping trip purpose was introduced to represent short trips to and from neighbouring shops or shopping centres. Such trips include home-based shopping as well as work-to-shop and shop-to-shop travel (a high proportion of which can be described as pass-by traffic where persons returning from work to home may stop on the way to pick up household items etc.).

4.3.2 Shopping Trip Estimation

A matrix growth factoring process was adopted to estimate PM shopping trips for Vaughan based on retail job ratios and shopping trip matrices extracted from the TTS database. As for the refined traffic zones where TTS retail job ratios cannot be applied directly, a set of split percentages developed with the aid of aerial photos was applied to distribute retail jobs to every refined zone in Vaughan. The resulting retail job estimates were used as control vectors in the factoring process to adjust the 2006 TTS “to shop” and “from shop” O-D matrices to reflect observed retail trips.

An iterative process was used to calibrate shopping trip attraction and production rates. After testing different sets of trip rates and validating against local screenlines and ITE trip rate targets, considering other trip purposes generated by shopping centres, PM peak hour shopping trip rates of 0.45 and 0.60 trips per retail job (for productions and attractions, respectively) were determined to be appropriate for estimating shopping trip trip generation associated with major shopping centres in Vaughan. These trip rates are to be used to forecast shopping trips for base and future horizon years for comparable shopping centres. It should be noted that the resulting shopping matrix also includes by-pass trips that were made by the “non-shoppers” as listed in the travel survey due to undercounting issue associated with “multiple-destination trips”. These by-pass trips, which are now included in the new shopping trip matrix, can backed out from the non-shopping trip matrix using a calibrated factor of 0.80.

4.3.3 Shopping Trips at Major Shopping Centres

The following six major shopping centres located in Vaughan were selected for validation purpose:

- RioCan Colossus Centre
- The Promenade
- The Interchange
- Westridge Power Centre
- Seven and 400 Power Centre
- Vaughan Mills

After attempts to collect traffic cordon counts for these major shopping centres, it was determined that traffic data were not sufficient for estimating total incoming and outgoing trips for the model base year. Therefore, Institute of Transportation Engineers (ITE) trip rates were used instead to estimate auto trip productions and attractions based on Gross Leasable Area (GLA) information provided by urbanMetrics inc. A comparison between trips associated with these locations and the nearby traffic counts indicate that ITE trip rates could be overstating the traffic to/from these shopping areas, especially for shopping centres along Highway 7, where frequent transit services and limited parking spaces might reduce auto usage. This issue is addressed by lowering the ITE trip "target" by 20% to reflect more reasonable trip generation rates for the study area. **Table 18** summarizes the adjusted ITE trip totals for these six retail centres used for validation and the corresponding model forecasts.

Table 18 – ITE Trip Estimates for PM Peak Hour

Location	Used GLA(sf) Retail	Category	ITE Trips*		VSAM Model		Diff vs. ITE	
			IN	OUT	IN	OUT	IN	OUT
RioCan Colossus Centre	572,600	Retail	760	820	770	860	-9%	-8%
	113,100	Theatre	90	110				
The Promenade	632,300	Retail	810	880	1,010	1,080	19%	15%
	24,200	Theatre	40	60				
The Interchange	510,200	Retail	700	760	810	980	-5%	4%
	111,000	Theatre	150	180				
Westridge Power Centre	496,350	Retail	690	750	680	780	-1%	4%
Seven and 400 Power Centre	330,600	Retail	670	720	480	680	-28%	-6%
Vaughan Mills**	1,336,350	Retail	1,330	1,440	1,370	1,550	3%	8%
Overall			**5,240**	**5,720**	**5,120**	**5,930**	**-2%**	**4%**

** - Based on adjusted ITE Trip Rates. ITE Trip Generation, 7th edition*

*** - Including Tuscany Pl & The Village*

4.4 PM Model Validation

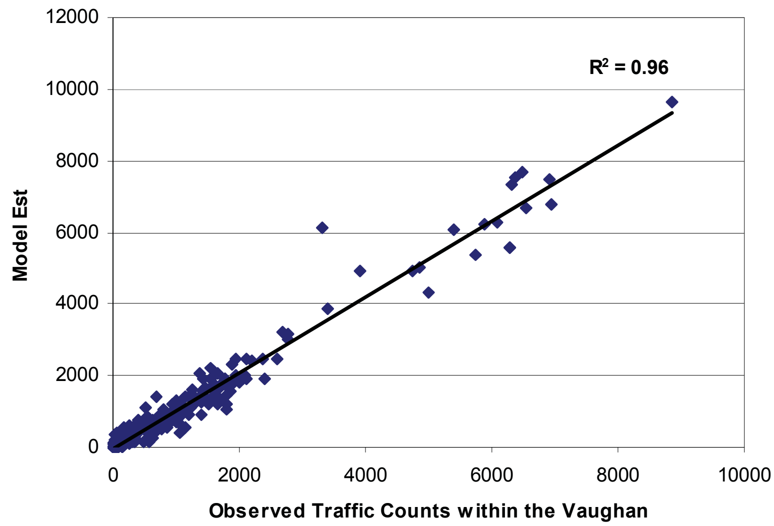
As with the AM VSAM model, an incremental matrix is developed to enhance the fit to the observed auto traffic at key screenlines during the PM peak period.

Table 19 provides a comparison of the model auto flow versus the observed PM peak hour auto counts for the 22 directional screenlines. It shows that 15 (68%) out of 22 screenlines produce a GEH lower than 10 and the overall R-Squared is 0.96 as shown in **Figure 7**. Among all the 214 screenline stations, 160 of them (75%) are within a GEH of 10. Based on these validation statistics, it can be concluded that the model provides reasonable travel demand estimation for the PM peak period within the Vaughan sub-area.

Table 19 - PM Sub-Area Traffic Count Comparison

Scln	Dir	Screenline	Obs	Est	GEH
1	N	N of King Vaughan Rd	11,030	10,570	4.4
1	S	N of King Vaughan Rd	3,900	3,810	1.3
2	N	N of Teston Rd	12,950	13,240	2.5
2	S	N of Teston Rd	5,190	5,280	1.2
3	N	N of Rutherford Rd	16,180	17,580	10.8
3	S	N of Rutherford Rd	7,180	7,870	8.0
4	N	N of Hwy 7	21,810	23,470	11.0
4	S	N of Hwy 7	14,180	12,810	11.8
5	N	N of Steeles Ave W	24,670	26,490	11.4
5	S	N of Steeles Ave W	16,320	15,560	6.0
6	E	E of Hwy 50	8,790	7,650	12.6
6	W	E of Hwy 50	11,370	12,440	9.8
7	E	E of Hwy 27	11,210	10,600	5.8
7	W	E of Hwy 27	11,640	11,900	2.4
8	E	E of Pine Valley Dr	11,510	12,280	7.0
8	W	E of Pine Valley Dr	12,220	13,450	10.9
9	E	E of Hwy 400	14,890	15,560	5.4
9	W	E of Hwy 400	17,000	17,210	1.6
10	E	E of Keele St	10,600	11,280	6.5
10	W	E of Keele St	8,250	9,170	9.8
11	E	W of Bathurst St	13,180	12,190	8.7
11	W	W of Bathurst St	9,860	11,640	17.2

Figure 7 - 2006 PM VSAM Screenline Validation



5 2031 Travel Demand Forecasts

5.1 Introduction

AM and PM travel demand forecasts were developed for the future 2031 base model. This chapter provides a summary of the following key model assumptions as well as the future year forecasts:

- Demographics
- Road and transit network improvements

5.2 Demographics

The Region of York is undertaking studies of future land use patterns in response to the Provincial “Place to Grow” Growth Plan, which calls for less greenfield development and greater intensification in transit-oriented development corridors and nodes. A set of demographics and land use projections that would conform to the Growth Plan was provided by the Region for this study in early 2009. Based on the Region’s estimates, an update of the demographic data was undertaken by Urban Strategies Inc. and the City Staff to incorporate growth strategies that have been developed recently for Vaughan. Additional land use intensification in focused areas (e.g. Vaughan Metropolitan Centre (VMC) and the Vaughan Mills area) was also incorporated in the future base scenario. For areas outside of York Region, population and employment estimates assumed in the YRTP Model were retained in VSAM. **Table 20** summarizes the population and employment projections for 2006 and 2031.

Table 20 – 2006 and 2031 Population and Employment Estimates

Area	Population				Employment			
	2006	2031	Diff	CAGR	2006	2031	Diff	CAGR
Toronto PD1	190,940	266,170	39%	1.3%	451,070	568,610	26%	0.9%
Rest of Toronto	2,405,600	2,615,350	9%	0.3%	1,082,880	1,265,670	17%	0.6%
Durham	588,930	1,000,010	70%	2.1%	194,380	434,100	123%	3.3%
York	929,870	1,513,800	63%	2.0%	459,150	786,300	71%	2.2%
Peel	1,205,880	1,640,010	36%	1.2%	636,880	876,110	38%	1.3%
Halton	429,900	703,390	64%	2.0%	194,000	389,640	101%	2.8%
Hamilton	515,000	597,270	16%	0.6%	199,600	248,150	24%	0.9%
GTHA	**6,266,120**	**8,335,990**	**33%**	**1.1%**	**3,217,960**	**4,568,570**	**42%**	**1.4%**
Vaughan	***248,810***	***425,150***	**71%**	**2.2%**	***159,000***	***262,800***	**65%**	**2.0%**

5.3 Road and Transit Network Improvements

5.3.1 Road Network

Future road network improvements were provided by different agencies. Within Vaughan, proposed improvements for the local collector system were prepared by the City Staff while the latest regional arterial improvements assumed in the Western Vaughan IEA study were provided by the York Region. For areas outside Vaughan in York Region, the latest York Region Transportation Master Plan assumptions were coded into the 2031 base network while future network assumptions assumed in the YRTP Model are used for areas outside York Region. **Table 21** identifies the key road network improvements for the 2031 base auto network assumed in VSAM.

Table 21 – 2031 Future Road Network Assumptions

			Within Vaughan			
A. Provincial						
#	Roadway	From	To	Improvement	2006	2031
1	Hwy 50	Steeles Ave.	Mayfield Rd.	Widen	2 / 2	3 / 3
2	Hwy 50	Mayfield Rd.	Kirby Rd.	Widen	1 / 1	3 / 3
3	Hwy 427	NB off-ramp, SB on-ramp at Albion Rd.	Hwy 407	Widen	2 / 2	4 / 4
4	Hwy 427	Hwy 407	NB on-ramp, SB off-ramp at Hwy 407	Widen	2/3	4 / 4
5	Hwy 427	Hwy 7	Major Mac Dr.	Extension	-	3 / 3
6	Hwy 400	NB off-ramp, SB on-ramp at Steeles Ave.	Hwy 407	Widen	4 / 4	5 / 5
7	Hwy 400	Hwy 407	Hwy 7	Widen	3 / 4	5 / 5
8	Hwy 400	NB off-/SB on-ramp at Bass Pro Mills Dr.	Rutherford Rd.	Widen	5 / 4	5 / 5
9	Hwy 400	SB off-ramp, NB on-ramp at Rutherford Rd.	N of Rutherford Rd.	Widen	4 / 5	5 / 5
10	Hwy 400	NB off-ramp, SB on-ramp at Major Mac Dr.	Major Mac Dr.	Widen	4 / 3	5 / 5
11	Hwy 400	Major Mac Dr.	NB on-ramp, SB off-ramp at Major Mac Dr.	Widen	3 / 3	5 / 5
12	Hwy 400	NB on-ramp, SB off-ramp at Major Mac Dr.	King-Vaughan Rd.	Widen	3 / 3	4 / 4
13	New Interchange	Martingrove Rd. / Hwy 407		East-Oriented Partial IC	-	-
14	New Interchange	Hwy 407 / Centre St.		Partial IC	-	-
15	Improved Interchange	Extended Hwy 427 / Hwy 7		Full	-	-
16	New Interchange	Extended Hwy 427 / Langstaff Rd.		Full	-	-
17	New Interchange	Extended Hwy 427 / Rutherford Rd.		Full	-	-
18	New Interchange	Extended Hwy 427 / Major Mac Dr.		Full	-	-
B. Regional						
#	Roadway	From	To	Improvement	2006	2031
19	Hwy 27	Steeles Ave.	Major Mac Dr.	HOV	2 / 2	2 / 2 GP + 1 / 1
20	Hwy 27	Major Mac Dr.	Wilsen Rd. (King)	Widen	1 / 1	2 / 2
21	Pine Valley Dr.	Steeles Ave.	Hwy 7	HOV	2 / 2	2 / 2 GP + 1 / 1
22	Weston Rd.	Steeles Ave.	Major Mac Dr.	HOV	2 / 2	2 / 2 GP + 1 / 1
23	Weston Rd.	Major Mac Dr.	Kirby Rd.	Widen	1 / 1	2 / 2
24	Jane St.	Hwy 407	Major Mac Dr.	HOV	2 / 2	2 / 2 GP + 1 / 1
25	Jane St.	Teston Rd.	King-Vaughan Rd.	Widen	1 / 1	2 / 2
26	Keele St.	Steeles Ave.	Major Mac Dr.	HOV	2 / 2	2 / 2 GP + 1 / 1
27	Dufferin St.	Steeles Ave.	Glen Shields Ave.	HOV	2 / 2	2 / 2 GP + 1 / 1
28	Dufferin St.	Major Mac Dr.	King Rd.	Widen	1 / 1	2 / 2
29	Bathurst St.	Crestwood Rd.	Worth Blvd.	HOV	2 / 2	2 / 2 GP + 1 / 1
30	Bathurst St.	N of Autumn Hill Blvd.	Elgin Mills Rd.	HOV	2 / 2	2 / 2 GP + 1 / 1
31	King-Vaughan Rd.	Hwy 400	Bathurst St.	Widen	1 / 1	2 / 2
32	Teston Rd.	Weston Rd.	E of Hwy 400	Widen	1 / 1	2 / 2
33	Teston Rd.	Keele St.	E of Rodinea Rd.	Widen	1 / 1	2 / 2
34	Teston Rd.	E of Rodinea Rd.	Dufferin St.	Extension	-	2 / 2
35	Teston Rd.	Dufferin St.	Shaftsbury Ave.	Widen	1 / 1	2 / 2
36	Major Mac Dr.	Hwy 50	W of Weston Rd.	Widen, HOV Jog elimination	1 / 1	2 / 2 GP + 1 / 1
37	Major Mac Dr.	W of Weston Rd.	McNaughton Rd.	HOV	2 / 2	2 / 2 GP + 1 / 1
38	Rutherford Rd.	Hwy 50	Weston Rd.	HOV	2 / 2	2 / 2 GP + 1 / 1
39	Rutherford Rd.	Weston Rd.	Jane St.	HOV	3 / 3	2 / 2 GP + 1 / 1
40	Rutherford Rd.	Jane St.	Bathurst St.	HOV	2 / 2	2 / 2 GP + 1 / 1
41	Langstaff Rd.	Hwy 50	Hwy 27	Widen	1 / 1	2 / 2
42	Langstaff Rd.	Keele St.	Dufferin St.	Widen	1 / 1	2 / 2
43	Steeles Ave.	Weston Rd.	Jane St.	Widen	2 / 2	3 / 3

Table 21 (con't) – 2031 Future Road Network Assumptions

#	Roadway	From	To	Improvement	2006	2031
			Within Vaughan			
C. Cityof Vaughan						
#	Roadway	From	To	Improvement	2006	2031
44	Future E-W Rd., N of Major Mac Dr.	Hwy 50	Huntington Rd.	New Link	-	1 / 1
45	Huntington Rd.	McGillvray Rd.	Teston Rd.	Truncate + Realign	1 / 1	1 / 1
46	McGillvray Rd.	Rutherford Rd.	N of Rutherford Rd.	Realign	1 / 1	1 / 1
47	Future E-W Rd., N of Langstaff Rd.	Huntington Rd.	Hwy 27	New Link	-	1 / 1
48	*Zenway Blvd.	Old Huntington Rd.	Rainbow Creek Dr.	New Link	-	1 / 1
49	Huntington Rd.	Fogal Rd.	N of Hwy 7	Extension	-	1 / 1
50	New Huntington Rd.	S of Langstaff Rd.	Hwy 7	New Link	-	2 / 2
51	Future E-W Rd., S of Langstaff	Old Huntington Rd.	New Huntington Rd.	New Link	-	1 / 1
52	Vaughan Valley Blvd.	Hwy 7	Zenway Blvd.	New Link	-	1 / 1
53	Future E-W Rd., N of Kirby Rd.	Weston Rd.	Jane St.	New Link	-	1 / 1
54	Future E-W Rd., N of Teston Rd.	Weston Rd.	Jane St.	New Link	-	1 / 1
55	Cityview Blvd.	Canada Dr.	Teston Rd.	Extension	-	1 / 1
56	Future E-W Rd., N of Major Mac Dr.	Canada Dr.	America Ave.	New Link	-	1 / 1
57	Future E-W Rd., N of Major Mac Dr.	Weston Rd.	Future N-S Rd.	New Link	-	1 / 1
58	Future N-S Rd., E of Pine Vallye Dr.	Future E-W Rd.	Major Mac Dr.	New Link	-	1 / 1
59	Future N-S Rd., W of Weston Rd.	Future E-W Rd.	Major Mac Dr.	New Link	-	1 / 1
60	Via Campanile	Davos Rd.	Major Mac Dr.	Extension	-	1 / 1
61	Davos Rd.	Via Campanile	Pine Valley Dr.	Extension	-	1 / 1
62	Future N-S Rd., W of Hwy 400	Creditview Rd. Terminus	Rutherford Rd.	New Link	-	1 / 1
63	Bass Pro Mills Dr.	Weston Rd.	Hwy 400 SB on-ramp	Extension	-	1 / 1
64	Bass Pro Mills Dr.	Romina Dr.	Jane St.	Extension	-	1 / 1
65	Peter Rupert Ave.	Rutherford Rd.	McNaughton Rd.	New Link	-	1 / 1
66	Maurier Blvd.	Peter Rupert Ave.	Dufferin St.	New Link	-	1 / 1
67	Via Romano Blvd.	Major Mac Dr.	Teston Rd.	New Link	-	1 / 1
68	Queen Filomena Ave.	Via Romano Blvd.	Bathurst St.	New Link	-	1 / 1
69	Thomas Cook Ave.	Rutherford Rd.	Major Mac Dr.	New Link	-	1 / 1
70	Lebovic Campus Dr.	Thomas Cook Ave.	Bathurst St.	New Link	-	1 / 1
71	Pleasant Ridge Blvd.	Apple Blossom Dr.	Rutherford Rd.	Extension	-	1 / 1
72	Future E-W Rd., N of Hwy 7	Chrislea Rd.	Applewood Crescent	New Link	-	2 / 2
73	Fieldstone Dr.	Blue Willow Dr.	Weston Rd.	Widen	1 / 1	2 / 2
74	Applewood Cres. (N of Hwy 7)	Applewood Cres.	Jane St.	Widen	1 / 1	2 / 2
75	Future Ring Rd.	E of Hwy 400 Off-ramp	Maplecrete Rd.	New Links	-	2 / 2
76	Future N-S Rd.	Interchange Way	Ring Rd.	New Link	-	2 / 2
77	Future N-S Rd.	Hwy 7	Chrislea Rd.	New Link	-	2 / 2
78	Future N-S Rd.	Hwy 400 NB off-ramp	Future Hwy 400 NB on-ramp	New Link	-	1 / 2
79	Future N-S Rd.	Future Hwy 400 NB on-ramp	Applewood Crescent	New Link	-	2 / 2
80	Famous Ave.	Weston Rd.	Hwy 7	Widen	1 / 1	2 / 2
81	Credistone Rd.	MacIntosh Blvd.	N of Hwy 407	Widen	1 / 1	2 / 2
			Outside Vaughan, in GTHA			
D. Provincial						
#	Roadway	From	To	Improvement	2006	2031
81	Hwy 407	Hwy 401 (Peel)	Hwy 427	Widen	3 / 3	5 / 5
82	Hwy 407	Weston Rd.	Hwy 404	Widen	4 / 4	5 / 5
83	Hwy 407	Hwy 404	Kennedy Rd.	Widen	3 / 4	5 / 5
84	Hwy 407	Kennedy Rd.	Markham Rd.	Widen	3 / 3	5 / 5
85	Hwy 407	Markham Rd.	Brock Rd. (Durham)	Widen	2 / 2	5 / 5
86	Hwy 407	Brock Rd.	Hwy 401 (Oshawa)	Extension via Whitby	-	2 / 2
87	Hwy 407	Britannia Rd. West	Hwy 403	HOV	2 / 2	2 / 2 GP + 1 / 1
88	Hwy 401	Guelph Line	Trafalgar Rd.	HOV	3 / 3	3 / 3 GP + 1 / 1
89	Hwy 401	Trafalgar Rd.	Winston Churchill Blvd.	Widen + HOV	3 / 3	5 / 5 GP + 1 / 1
90	Hwy 401	Winston Churchill Blvd.	Hwy 410	Widen + HOV	3 / 3 - 4 / 4	6 / 6 GP + 1 / 1
91	Hwy 401	Brock Rd.	Regional Rd. 34 / Courtice Rd	Widen + HOV	3 / 3 - 5 / 5	6 / 6 GP + 1 / 1

5.3.2 Transit Network

Transit network assumptions were coded based on the latest preferred option developed for the Western Vaughan IEA study which includes significant improvement in headway for most of the bus routes that pass through Vaughan. Other key transit investments in the study area include:

- Bolton GO Rail
- TTC Spadina Subway Extension
- TTC Yonge Subway Extension
- 407 Transitway
- Improve transit headway for YRT VIVA line to 2-4 min
- Acceleride from Brampton to VMC

5.4 2031 Base Case Forecasts

5.4.1 AM & PM Trip Summary

Table 22 presents the 2006 and 2031 trip totals for Vaughan and GTHA. In 2006, origin and destination trip totals for Vaughan were approximately 119,600 and 126,700 respectively. In 2031, trips originating from Vaughan is forecast to grow to 205,300 (72% growth), while destination trip total is estimated at 203,900 (61% growth). These high growth rates of total trips can be explained by the similar growth rates of population (71%) and employment (65%) in Vaughan as shown in **Table 20**. These growth rates also highlight the fact that future road and transit network within the study area is expected to accommodate almost double amount of travel demand in 2031.

Table 22 – AM Peak Period Trip Forecasts (2006 and 2031)

Region	Mode	Orig Trips				Dest Trips			
		2006	2031	Diff	CAGR	2006	2031	Diff	CAGR
GTHA	Auto Driver	1,818,390	2,470,240	36%	1.2%	1,818,390	2,470,240	36%	1.2%
	Auto Passenger	388,820	517,260	33%	1.1%	388,820	517,260	33%	1.1%
	Transit	463,640	633,040	37%	1.3%	463,640	633,040	37%	1.3%
	Total Trips	***2,670,850***	***3,620,540***	***36%***	***1.2%***	***2,670,850***	***3,620,540***	***36%***	***1.2%***
	Transit Mode Share	***17%***	***17%***	***0%***	***0.0%***	***17%***	***17%***	***0%***	***0.0%***
Vaughan	Auto Driver	89,060	143,480	61%	1.9%	101,250	159,790	58%	1.8%
	Auto Passenger	18,810	31,210	66%	2.0%	18,970	29,970	58%	1.8%
	Transit	11,690	30,640	162%	3.9%	6,440	14,090	119%	3.2%
	Total Trips	***119,560***	***205,330***	***72%***	***2.2%***	***126,660***	***203,850***	***61%***	***1.9%***
	Transit Mode Share	***10%***	***15%***	***5%***	***1.7%***	***5%***	***7%***	***2%***	***1.2%***

The growth of transit users is anticipated to be much faster than the auto drivers, as shown by the 5 percent increase of ridership for origin trips and 2 percent increase for destination trips. This increased transit mode share is mostly due to significant heavy transit service improvements, including the Spadina subway extension to VMC, planned improvement of transit frequency of the VIVA bus rapid bus, introduction of Bolton GO rail and also the improved services for other YRT bus routes as defined in the Western Vaughan IEA study.

The expected traffic growth rates in Vaughan are relatively higher than the rest of the GTA regions.

Table 23 summarizes the AM and PM peak hour traffic forecasts that are used for trip network assignment. Annual traffic growth rate for AM peak hour trips is 2 percent, which is reasonably close to the growth rate of 1.9% for the AM peak period while PM peak hour trips would grow at the similar rate of 1.7% per annum.

Table 23 – AM and PM Peak Hour Traffic Forecasts (2006 to 2031)

Mode	Orig Trips				Dest Trips			
	2006	2031	Diff	CAGR	2006	2031	Diff	CAGR
AM Auto Driver	36,220	60,140	66%	2.0%	38,870	64,410	66%	2.0%
PM Auto Driver	58,070	89,100	53%	1.7%	55,300	84,680	53%	1.7%

Detailed forecasts for each focused area (e.g. VMC) required for this Vaughan TMP study are documented separately by Halcrow.

6 Summary and Conclusions

This report describes the model update and validation process of the AM and PM Vaughan Sub-Area Model (VSAM) developed for the Vaughan Transportation Master Plan (TMP) Study. The validation results presented show that VSAM generates reasonable and acceptable 2006 traffic volume estimates at both regional and local levels for both the AM and PM peak hours as documented in Sections 3 and 4.

The new PM VSAM model, which now has the capability of estimating total PM peak traffic including local shopping trips, produces reasonable traffic forecasts at and near major shopping centres during the afternoon peak period when auto traffic volumes are highest.

Traffic forecasts for the 2031 base land use/transportation system scenario indicate that the model is sensitive to the extensive transit investment planned for Vaughan, particularly for the VMC focused areas where aggressive land use intensification is planned. This model is thus applicable for the Vaughan TMP Study and is a practical tool to evaluate the City's future transportation infrastructure requirements that can be expected to encourage increased public transit use, alleviate congestion and promote livable street networks and neighbourhoods.

Other deliverables, including detailed transportation analysis for the designated focused areas and the final transportation model package, will be provided separately as the study proceeds.

F1.2 July 6, 2010 Memorandum

VAUGHAN

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Memo

To	Dick Gordon	Project	Vaughan Transportation Master Plan (update to Feb 10 Memo)
From	Halcrow Consulting Inc	Project no.	
Date	6 July 2010	Re	
Copy	Leah Russell, Lisa Wang, Mahboobeh Sohi		

VSAM 2031 - Revised Base (AM & PM), Alternative 1 (AM & PM)

Further to discussions with the City of Vaughan and AECOM at a meeting on December 10, 2009, HCI has updated the Vaughan Sub-Area Model (VSAM) 2031 base network (developed November 2009) by incorporating the following revised inputs within the City of Vaughan study area:

- Land Use: population and employment
    - source: Urban Strategies Inc. January 8, 2010
- Auto Network: number of lanes, capacity, and alignment
    - source: revised York Rapid Transit Plan (YRTP model), July 24, 2009;
    - source: Peel Region model, January 13, 2010
    - source: Urban Strategies, January 20, 2010
- Transit Network: headway, speeds, alignment, station locations, and related access links
    - source: base transit network as per YRTP model provided by York Region for Western Vaughan IEA, August, 17 2007.
    - source: updated transit network as per YRTP model provided by York Region (used for changes in VSAM study area), December 11, 2009.
    - source: GO Transit, December 16, 2009.
    - source: York Region Transportation Master Plan Update, November 2009
- Parking: parking costs and locations
    - source: revised YRTP model, December 11, 2009

The 2031 Alternative 1 scenario was developed based on this 2031 revised VSAM base, with the same assumptions in land use, transit network, and parking costs. Adjustments were made to the auto network with guidance from AECOM (February 22, 2010), i.e. regarding number of lanes, capacity, and alignment. This tech memo will address the 2031 revised VSAM base (a.m. and p.m.), the 2031 Alternative 1 (a.m. and p.m.), and the 2021 base (a.m. and p.m.).

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Land Use

Population and employment figures within the City of Vaughan were revised by Urban Strategies Inc. to match the land use control totals for Vaughan provided by York Region on December 11, 2009. Figure 1 and Figure 2 show the location and magnitude of the population and employment differences between the original VSAM 2031 base (November 2009) and the updated VSAM 2031 base (January 2010), respectively. The resultant population and employment totals can be seen in Table 1 below.

Figure 1 - Population Differences
(Rev. VSAM 2031 Base versus Orig. VSAM 2031 Base)

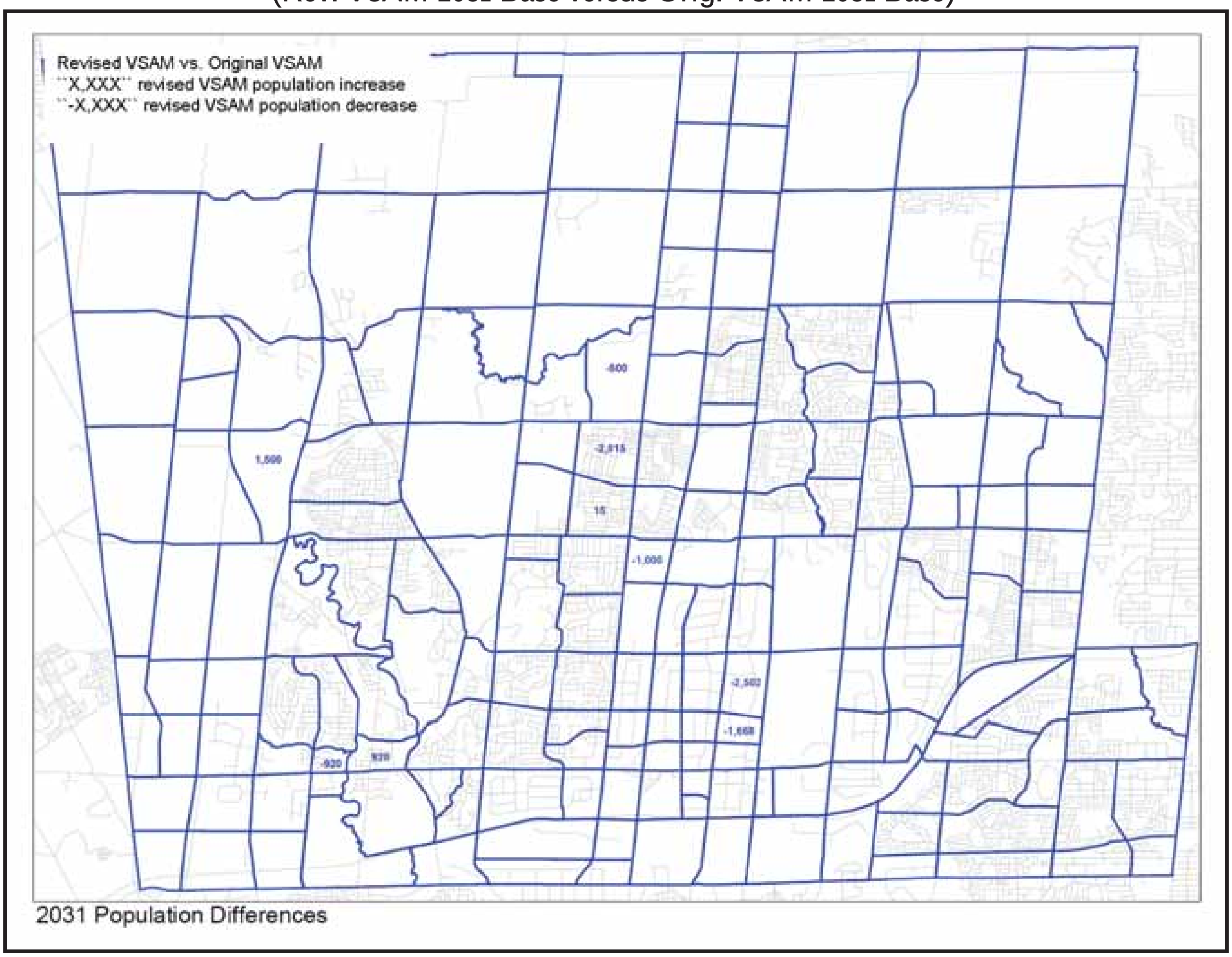

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Figure 2 – Employment Differences
(Rev. VSAM 2031 Base versus Orig. VSAM 2031 Base)

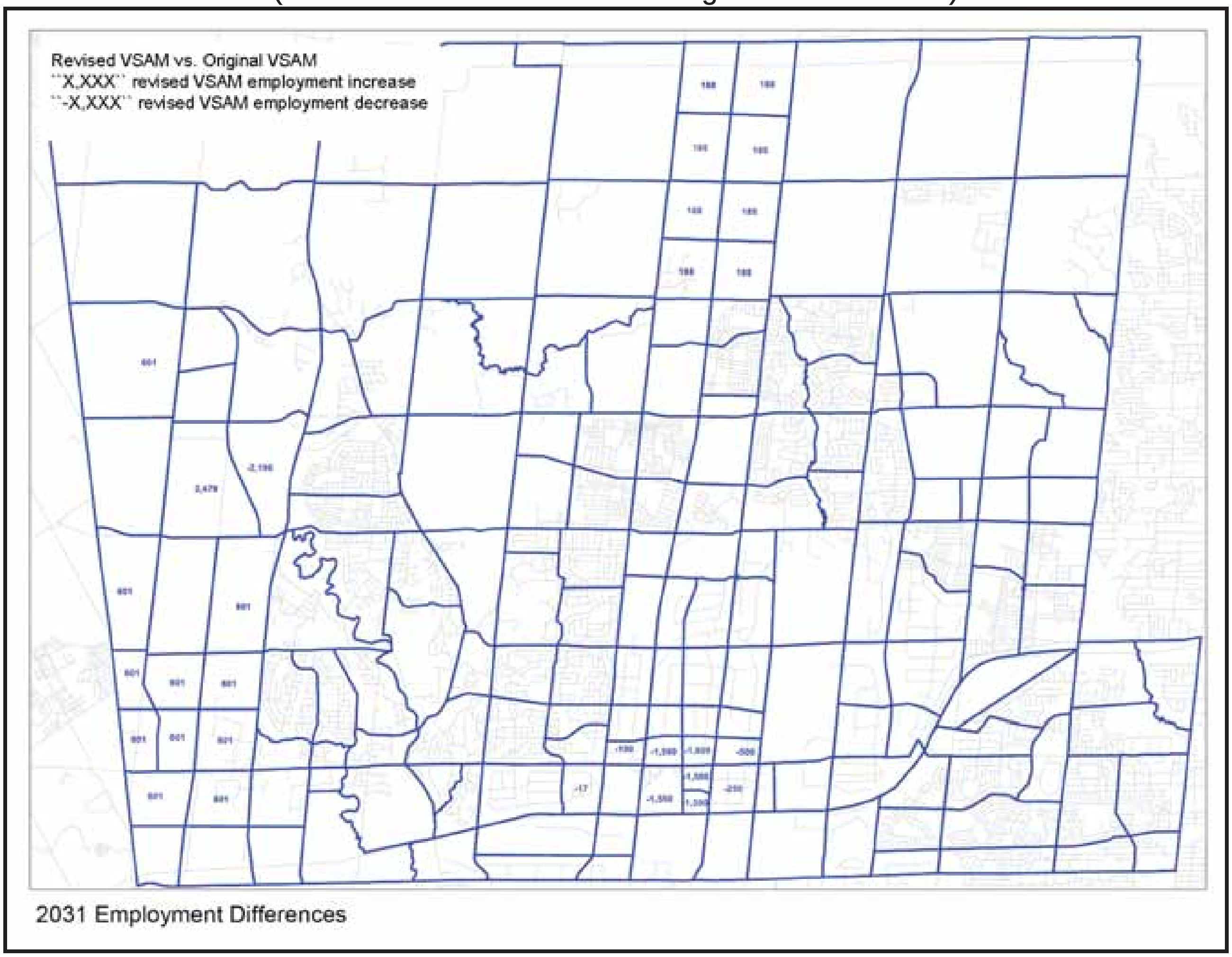

Table 1 – 2031 Population and Employment City of Vaughan Totals

VSAM Version	2031 Population Totals	2031 Employment Totals
November 9, 2009	425,150	262,802*
January 8, 2010	418,980	262,581*

*Adjustments were made for employment in Wonderland to reflect average fall weekday traffic (TZ 1059)

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York Region also provided population and employment control totals for the rest of York Region outside of the City of Vaughan. While the overall totals for population did not change, the allocation by zone did change in some regions. The employment control totals were revised for all York Region municipalities. These updated GTHA 2031 forecasts were included in the revised 2031 VSAM base and the 2031 Alternative 1. Table 2 below illustrates the control totals outside of the City of Vaughan within York Region for both the original VSAM 2031 base (November 2009) and the revised VSAM 2031 base (January 2010).

Table 2 – Population and Employment Totals outside Vaughan
Orig. and Rev. VSAM 2031 Base

Region	2031 Population		2031 Employment	
	VSAM Nov 9, 2009	VSAM Jan 8, 2010	VSAM Nov 9, 2009	VSAM Jan 8, 2010
Aurora	70,449	70,449	34,800	34,203
East Gwillimbury	87,997	87,997	31,738	34,412
Georgina	70,691	70,691	21,721	21,244
King	35,095	35,095	12,111	11,915
Markham	423,468	423,468	248,936	240,572
Newmarket	97,346	97,346	49,647	49,445
Richmond Hill	242,816	242,816	100,749	99,388
Whitchurch-Stouffville	60,792	60,792	23,800	23,034
York Region*	1,507,480	1,507,480	799,748	780,267

*Totals include Vaughan

Retail Employment

Retail employment for the 2006 base was generated using 2006 Transportation Tomorrow Survey (TTS) employment data. In zones that had been further split by HCI, the retail employment was allocated based on the location of retail development. Retail employment for each traffic zone was then expressed as a percentage of a total employment in each zone. Necessary adjustments to the percentages were made to ensure that the six major shopping centres located in Vaughan (RioCan Colossus Centre, The Promenade, The Interchange, Westridge Power Centre, Seven and 400 Power Centre, and Vaughan Mills) had the appropriate retail employment allocated for their respective traffic zones .

Subsequent to the calibration exercise, Urban Strategies provided (on a zonal basis) 2031 retail employment growth for the Vaughan Metropolitan Centre (VMC) area as well as 2031 total employment for the VSAM study area.

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The retail percentages per zone developed from the 2006 base were applied to the 2031 total employment to generate 2031 retail employment, while ensuring that the retail employment estimates in the VMC area were consistent with the employment growth figures provided by USI for VMC.

Auto Network

Updated auto network assumptions regarding number of lanes, capacity, and alignments were adopted from the YRTP auto network (updated July 24, 2009) into the revised VSAM model for the City of Vaughan and in neighbouring municipalities where they were expected to have a significant impact on traffic patterns within the City of Vaughan. In addition, network refinements within the West Vaughan Secondary Employment Centre along the Highway 427 corridor were incorporated into the revised VSAM network based on recommendations from Urban Strategies. Table 3 and the accompanying Figure 3 provide details regarding the nature and the location of these updates within the Study area. Table 4 and Figure 4 provide details regarding network updates in Peel Region.

Table 3 – Auto network updates / refinements
(Orig. VSAM 2031 Base and Rev. VSAM 2031 Base)

ref	Revision	Orig. Base		New Base	
		Lane	Cap	Lane	Cap
1	New NS road	na	na	1/1	400
2	New NS road	na	na	1/1	500
3	Capacity change		800		700
4	Lane/Capacity Change	1/1	400	2/2	900
5	Add EW road	na	na	1/1	400
6	Lane/Capacity Change	1/1	600	2/2	800
7	Lane Change for SB lane	4		5	
8	Lane Change for NS lane	6		5	
9	Add NS road	na	na	1/1	600
10	Add EW road	na	na	1/1	600
11	Lane/Capacity Change	2/2	1000	1/1	800
12	Lane/Capacity Change	3/3	800	2/2	900
13	Lane Change	2/2		1/1	
14	Lane Change	2/2		1/1	
15	Lane/Capacity Change	3/3	800	2/2	900
16	Lane Change	3/3		2/2	
17	Lane Change	3/3	800	2/2	800, 900

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Figure 3 – Location of Auto Network Updates
(Orig. VSAM 2031 Base versus Rev. VSAM 2031 Base)

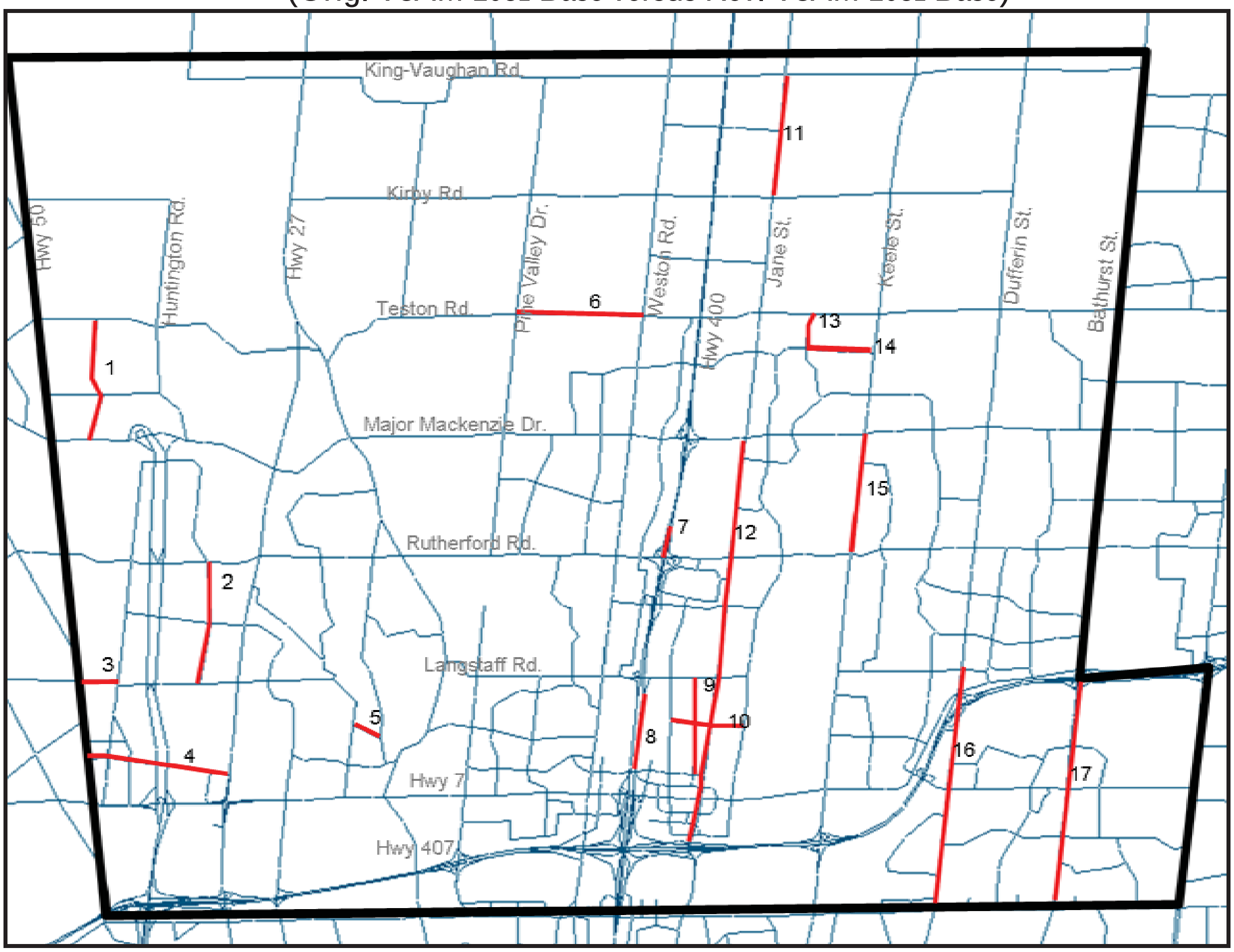

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Table 4 – Auto Network Updates / Refinements in Peel Region
(Orig. VSAM 2031 Base and Rev. VSAM 2031 Base)

ref	Revision	Orig. Base	New Base
		Lane	Lane
1	Lane Change	2/2	3/3
2	Lane Change	2/1	1/1
3	Add EW road	na	1/1
4	Lane Change	2/2	1/1
5	Lane Change	2/2	3/3
6	Lane Change	1/1	2/2
7	Lane Change	1/1	2/2
8	Lane Change	1/1	2/2
9	Lane Change	2/2	3/3
10	Remove NS Road	2/2	na
11	Lane Change	1/1	2/2
12	Lane Change	1/1	2/2
13	Lane Change	2/2	3/3
14	Lane Change	1/1	2/2
15	Lane Change	1/1	2/2
16	Lane Change	2/2	3/3
17	Lane Change	1/1	2/2
18	Lane Change	3/3	2/2
19	Lane Change	1/1	2/2
20	Lane Change	3/3	2/2
21	Lane Change	2/2	1/1
22	Lane Change	2/2	3/3
23	Lane Change	2/2	1/1
24	Lane Change	2/2	3/3
25	Lane Change	2/2	3/3
26	Lane Change	1/1	2/2
27	Lane Change	3/3	2/2
28	Lane Change	1/1	2/2
29	Lane Change	2/2	3/3
30	Lane Change	2/2	3/3
31	Lane Change	1/1	2/2
32	Lane Change	3/3	2/2
33	Lane Change	2/2	3/3
34	Lane Change	1/1	3/3
35	Lane Change	3/3	2/2
36	Lane Change	4/4 + 1/1 HOV	3/3 + 1/1 HOV
37	Lane Change	2/2	3/3
38	Lane Change	3/3	2/2
39	Lane Change	3/3	2/2
40	Lane Change	2/2	3/3

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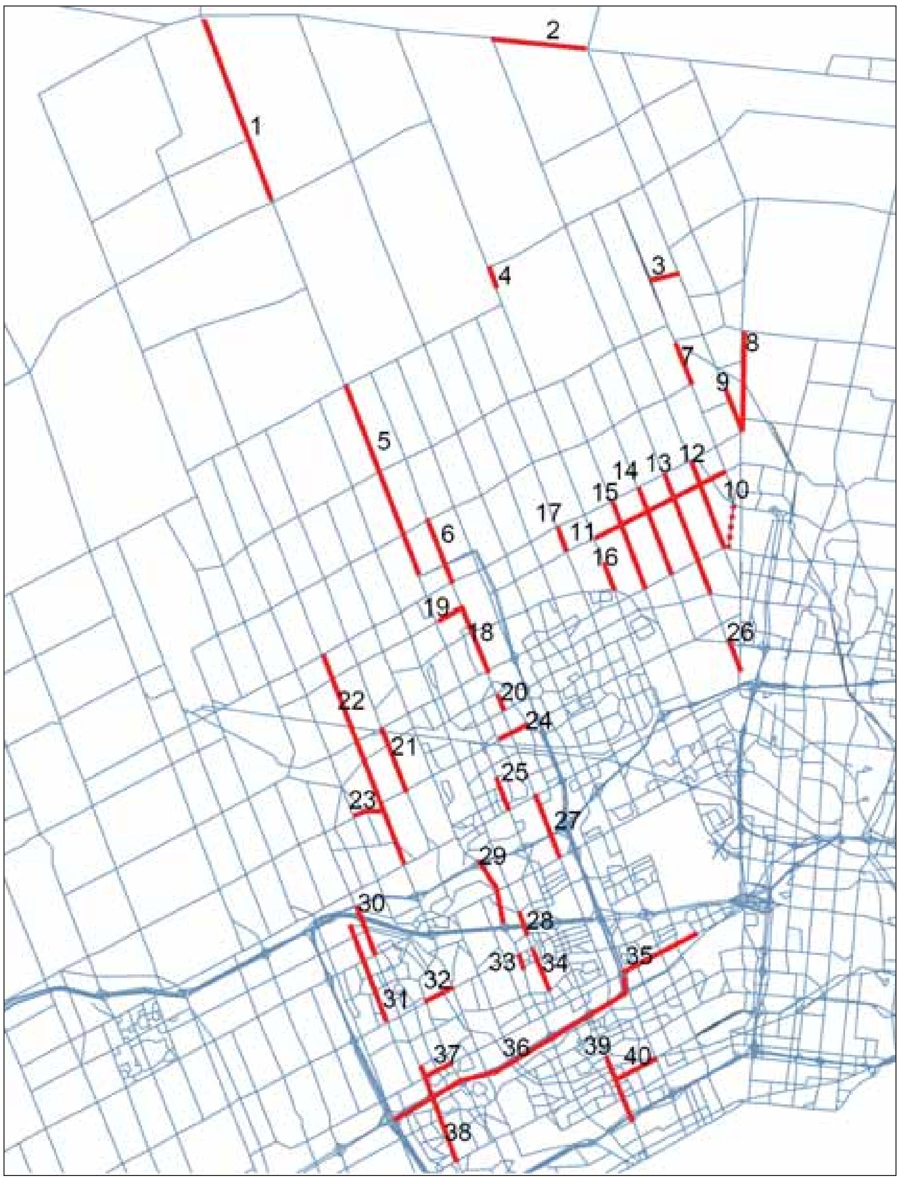
Figure 4 - Location of Auto Network Updates in Peel Region
(Orig. VSAM 2031 Base versus Rev. VSAM 2031 Base)



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Transit Service

Service frequencies and speeds of transit routes traversing the City of Vaughan were revised by HCI primarily based on WVIEA version 8G assumptions adjusted to reflect the Region's updated TMP. In some cases, such as Major Mackenzie Dr., west of Weston Road, bus speeds were adjusted downward to reflect forecast traffic conditions, and headways were reduced from the Region's recent assumptions to reflect experience in comparable mature urban areas. The alignment of the Bolton GO line was adjusted to reflect the latest York Region TMP update document (November 2009) and the locations of future stations were confirmed with GO Transit staff. Furthermore, walk access link assumptions for the revised transit lines were adjusted accordingly. Details regarding the changes in headway, service frequency, route alignment, and station locations can be seen in Table 5 and the associated Figure 5.

Table 5 – Transit Service Updates
(Orig. VSAM 2031 Base versus Rev. VSAM 2031 Base)

Line Name	Description	Headway		Speed	
		Ori. VSAM	Rev. VSAM	Ori. VSAM	Rev. VSAM
T105XN	Dufferin North NB	5		28	15
T105XS	Dufferin North SB	5		28	15
Y004AE	Major Mackenzie EB	10		37.6	24
Y004AW	Major Mackenzie WB	10		37.6	24
Y004B	Major Mackenzie Extension	3	7.5	37.6	27.6
Y004LE	Major Mackenzie BRT EB	na	5	na	27
Y004LW	Major Mackenzie BRT WB	na	5	na	27
Y022N	King City NB	15		36	25
Y022S	King City SB	15		36	25
Y085	Rutherford-16th	3	8	25.1	
Y087E	Langstaff Maple EB	30		31.8	19.8
Y087W	Langstaff Maple WB	25		31.8	19.8
G9008[1]	Bolton GO line	20		99	

[1] Station locations revised

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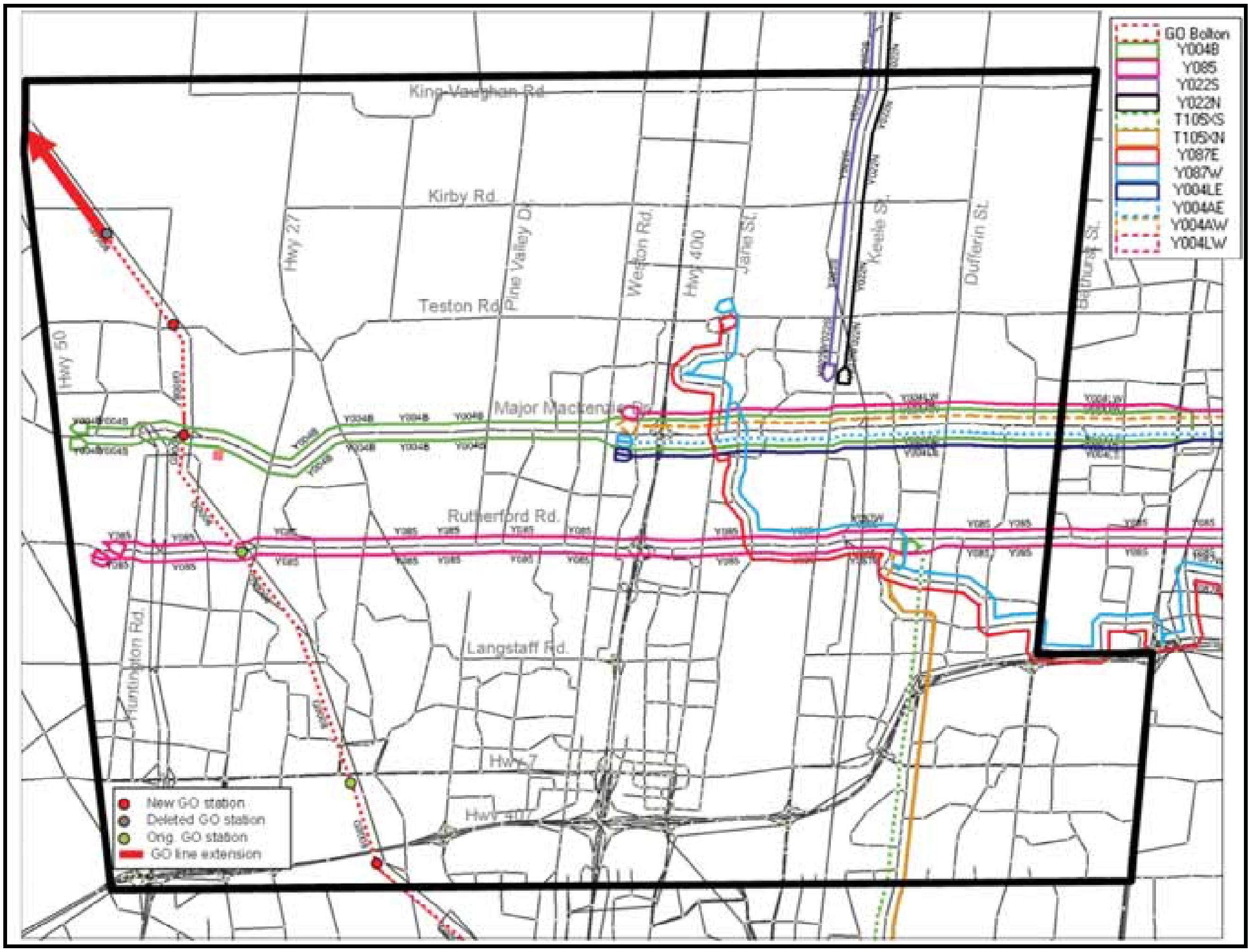
Figure 5 – Revised Transit Lines in Revised VSAM 2031 Base



Parking

York Region provided revised parking costs (December 11, 2009) that were included in revised the 2031 VSAM base network. The resultant difference between the original VSAM 2031 base (November, 2009) and the revised VSAM 2031 base (January 2010) were the additional parking locations (along with associated daily parking costs) shown in Figure 6.

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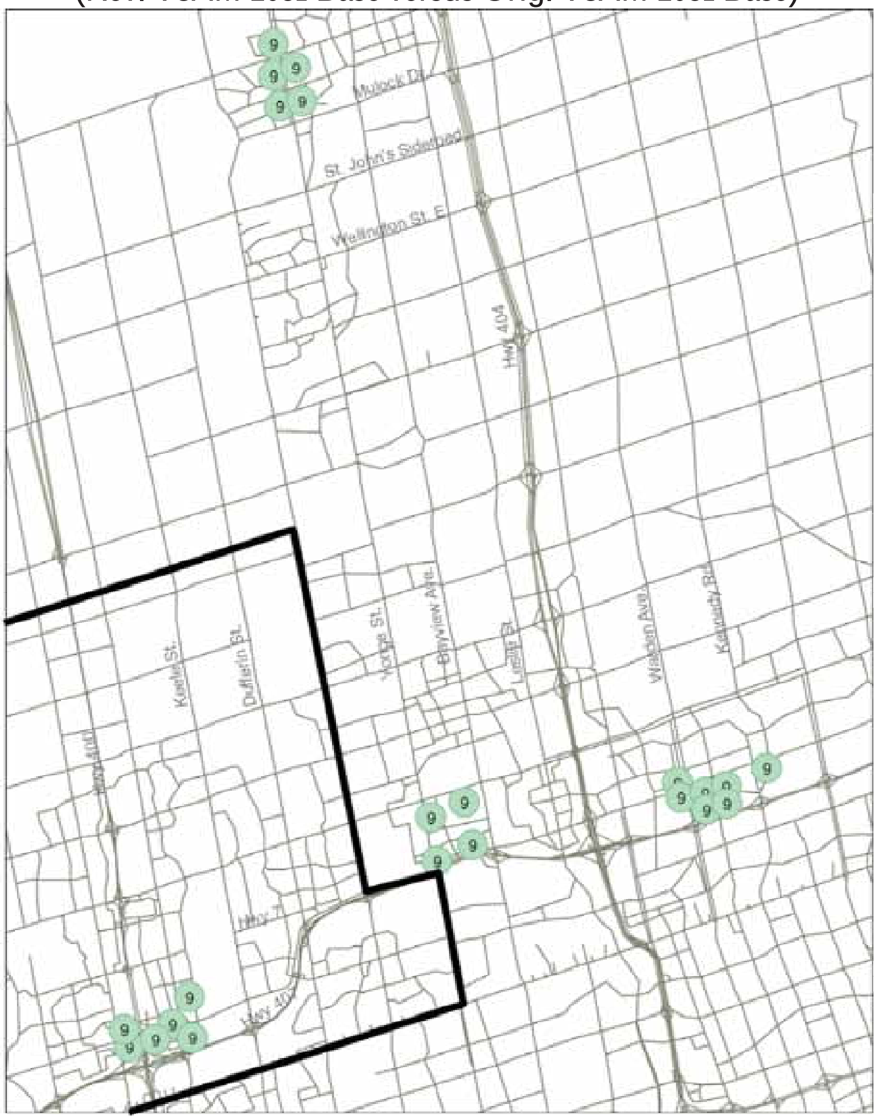
Figure 6 - Location of Parking Updates
(Rev. VSAM 2031 Base versus Orig. VSAM 2031 Base)



Base AM Model Results

The model results package for the revised VSAM 2031 base (Scenario 50813) including auto volume, auto and truck volume, v/c ratio (with and without trucks), transit ridership, and various network attributes can be found in Appendix A.

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Auto Volumes

In order to assess the effects of land use on auto volumes separate from auto and transit network changes and parking costs. Comparisons were made between scenarios with alternate network and land use assumptions:

	Orig. LU	New LU
Orig. Network	Sc40013	Sc40113
New Network	Sc50713	Sc50813

In order to isolate the effects of *land use* changes, Scenario 50813 (new land use, new auto and transit network) was compared against Scenario 50713 (original land use, new auto and transit network). To evaluate the impacts of *network changes*, Scenario 50813 (new land use, new auto and transit network) was compared against 40113 (new land use, original auto and transit network).

Land Use Impacts

Overall, the differences in auto volumes within the City of Vaughan shown in Figure 7 correlate with the changes made in land use shown in Figure 1 and Figure 2. The green colour in the following figures indicates a reduction in traffic in the revised VSAM base, while red indicates an increase. The reduction of trips in the VMC area is due to the reduction of employment within the VMC core area. This reduction in employment also resulted in the decrease of inbound traffic along Highway 407 and Highway 400. The increases in traffic outside the VMC are attributed to the additional employment along the Highway 50 and Highway 427 corridors.

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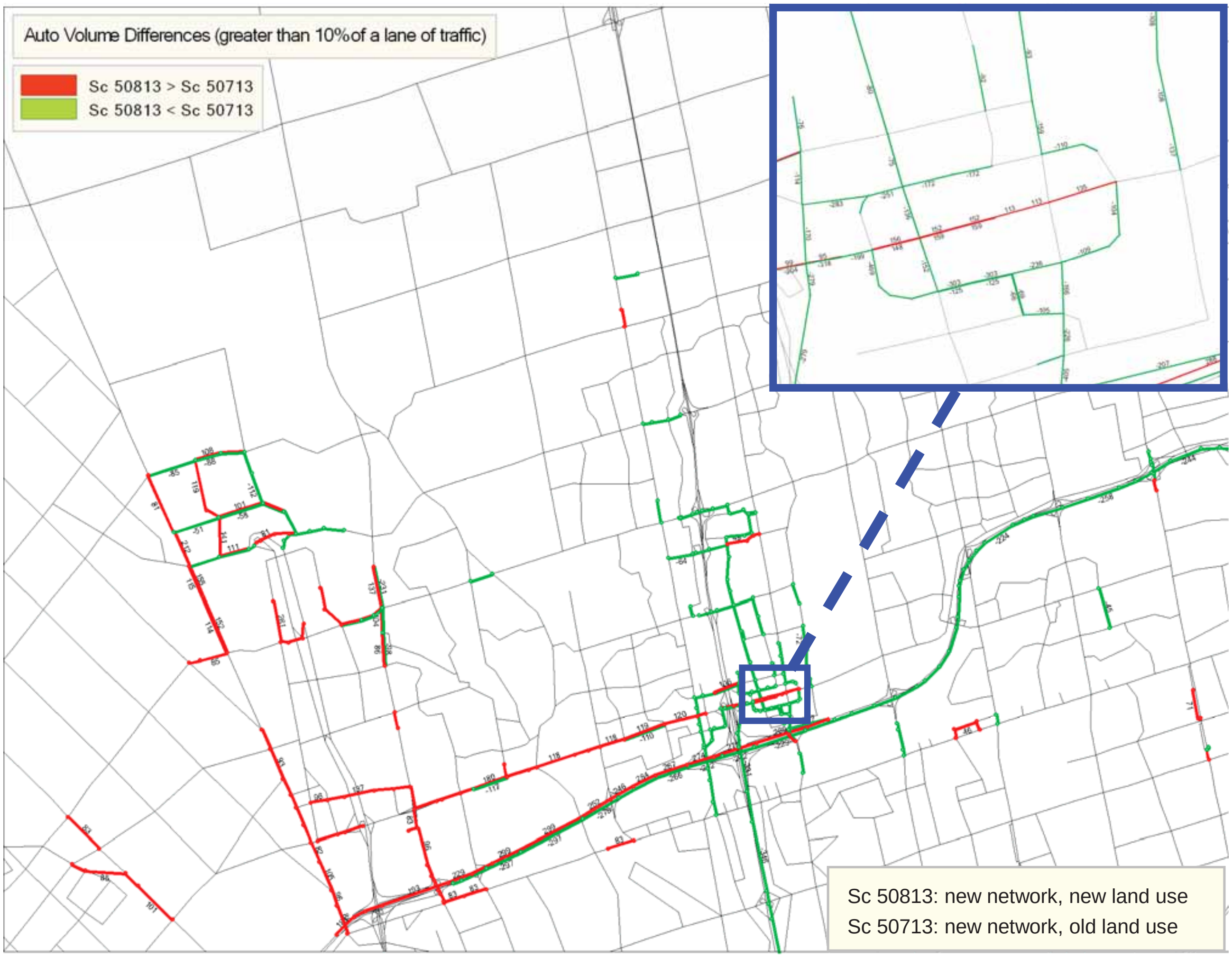
Figure 7 – Land Use Impact on Auto Network



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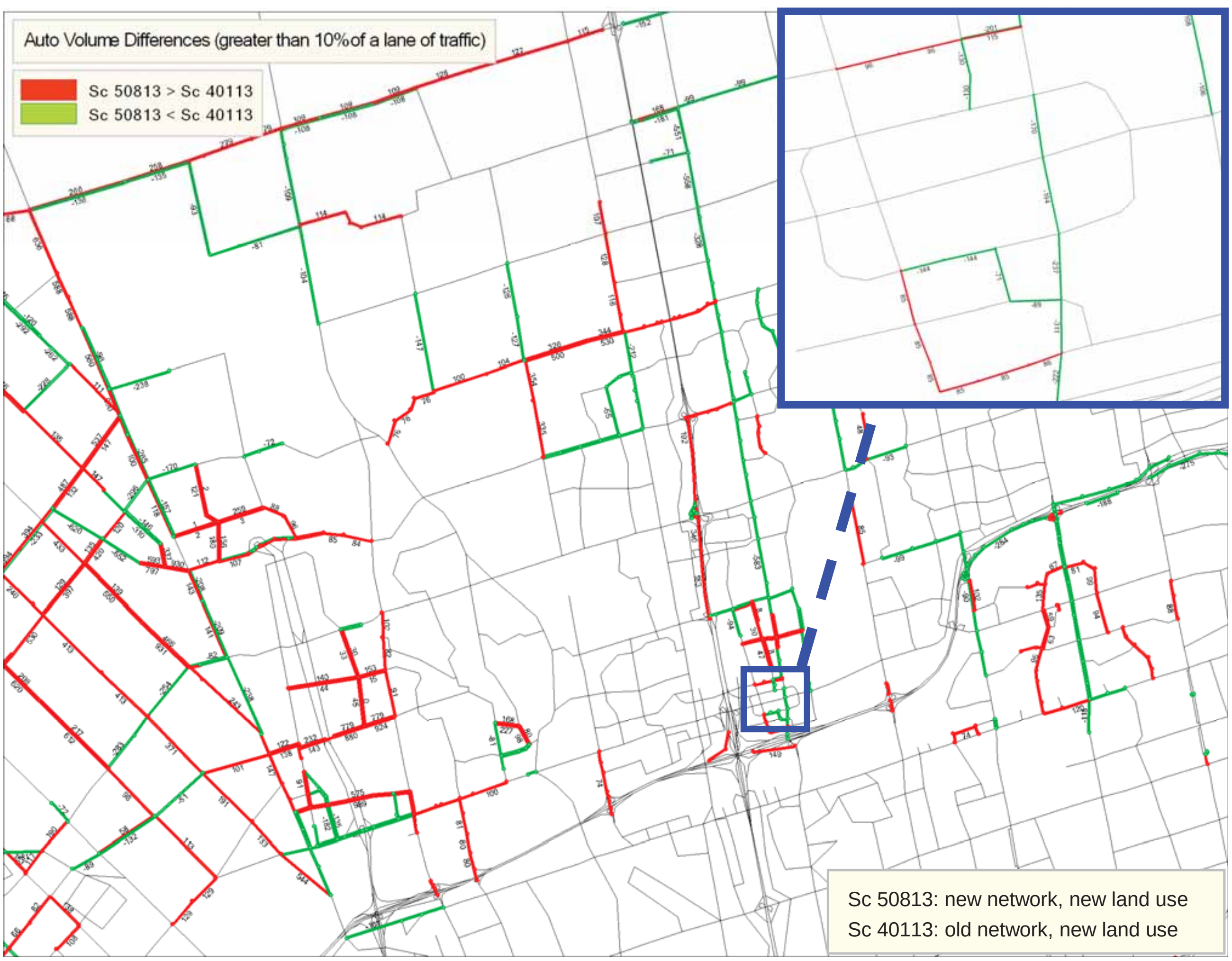
Network Impacts

Similarly, the changes in traffic volumes shown in Figure 8 correlate closely with the changes made in the auto network (refer to Figure 3 and Table 3). The reduction of traffic in Peel Region was due to the removal of the NS roadway between Castlemore Road and Coleraine Drive (refer to Figure 4 and Table 4, item 10). An additional lane, along with increased capacity, was added to Zenway Boulevard in the revised VSAM 2031 base, and reflects the increased traffic volume (shown in red), as well as traffic diversion from Highway 7. The traffic reduction (shown in green) on Jane St correlates with the lane/capacity reduction, and the increases in traffic on the smaller collector roads are sensible since they were not included in the Nov 2009 VSAM and were included in this VSAM revision.

Figure 8 – Network Impacts on Auto Network



Transit Ridership

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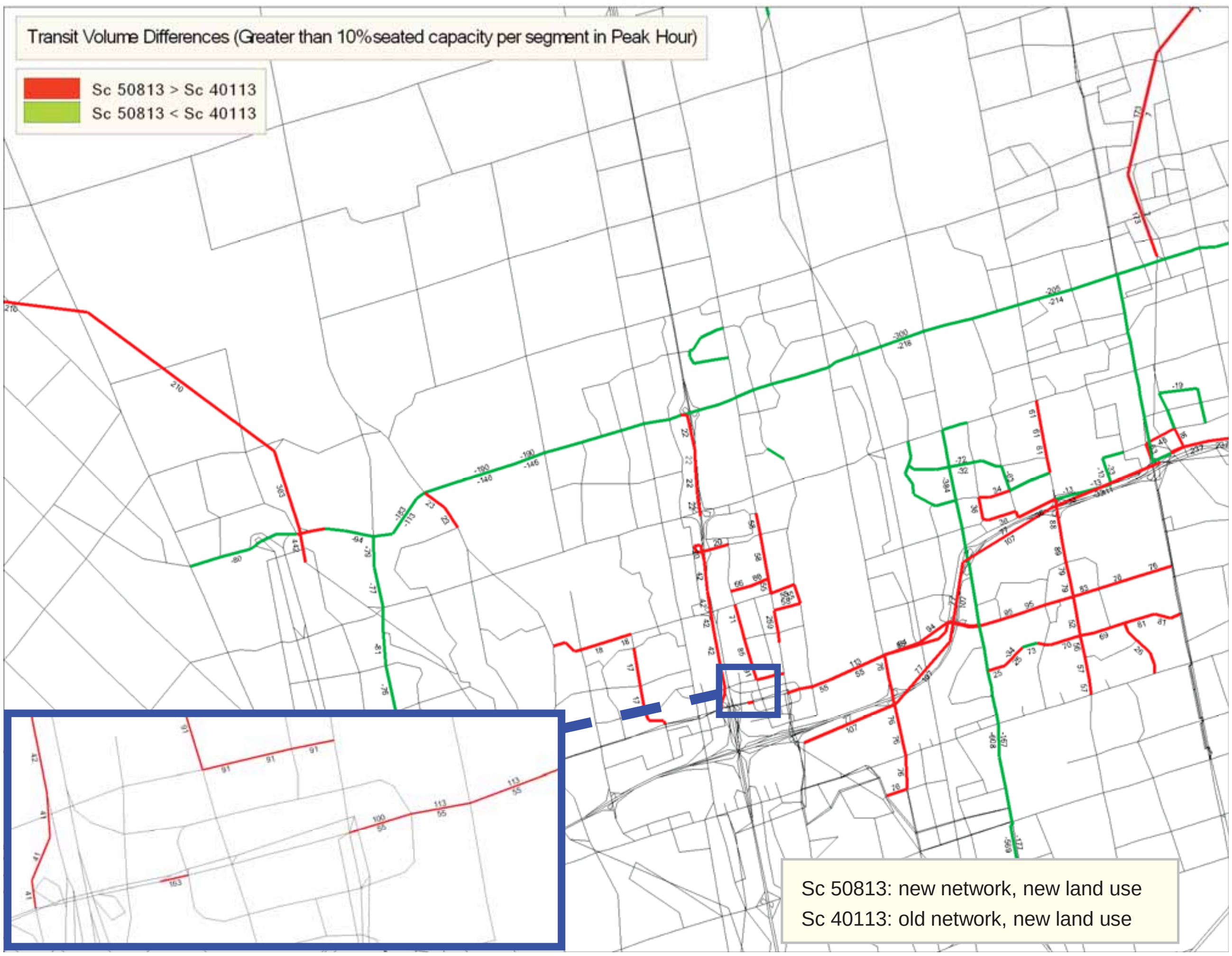
Transit service assumptions for headway and speed exert a direct and significant influence on transit ridership. Figure 9 compares the transit ridership differences between Scenario 50613 and Scenario 40113 (same land use, original versus revised network). Green indicates a decrease in ridership on the new network with the new landuse, and red indicates an increase.

Figure 9 – Transit Network Impacts on Transit Demand



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Network Impacts

Within the City of Vaughan, the relative increase and decrease in ridership can all be reasonably accounted for based on the transit network adjustments documented in Figure 5 and Table 5 (i.e. headway, speeds, alignment, stations locations and related access links).

Base PM Model Results

The model results package for the revised VSAM 2031 PM base (Scenario 55813) including auto volume, auto and truck volume, v/c ratio (with and without trucks), and various network attributes can be found in Appendix B.

Auto Volumes

In order to assess the effects of land use on auto volumes separate from auto and transit network changes and parking costs. Comparisons were made between scenarios with alternate network and land use:

	Orig. LU	New LU
Orig. Network	Sc45013	Sc45113
New Network	Sc55713	Sc55813

In order to isolate the effects of *land use* changes, Scenario 55813 (new land use, new auto and transit network) was compared against Scenario 55713 (original land use, new auto and transit network). To evaluate the impacts of *network changes*, Scenario 55813 (new land use, new auto and transit network) was compared against 45113 (new land use, original auto and transit network).

Land Use Impacts

Overall, the differences in auto volumes within the City of Vaughan shown in Figure 10 correlate with the changes made in land use. The reduction of trips in the VMC area is due to the reduction of employment within the VMC core area. This reduction in employment also resulted in the decrease of outbound traffic along Highway 407 and Highway 400.

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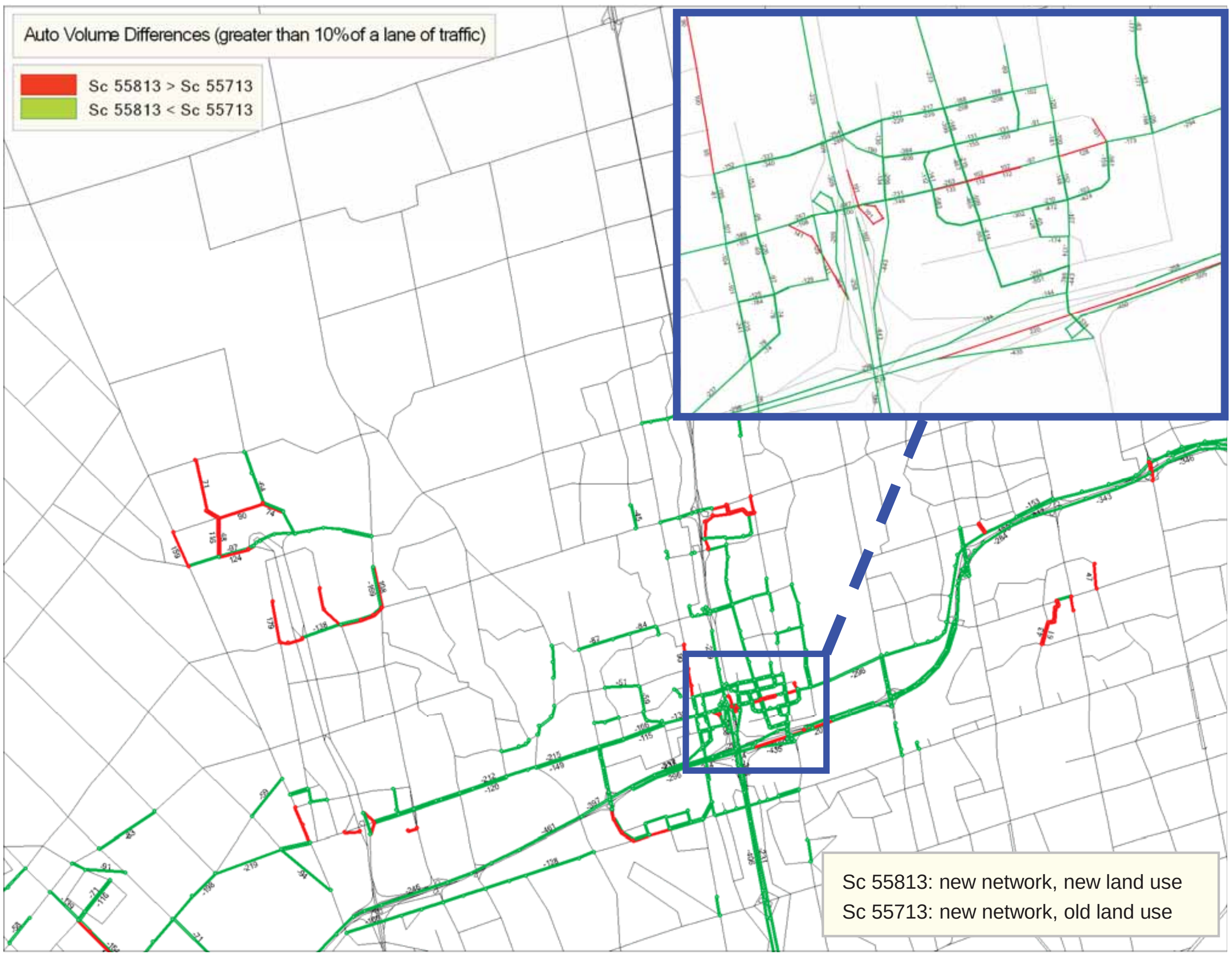
Figure 10 – Land Use Impact on PM Auto Network



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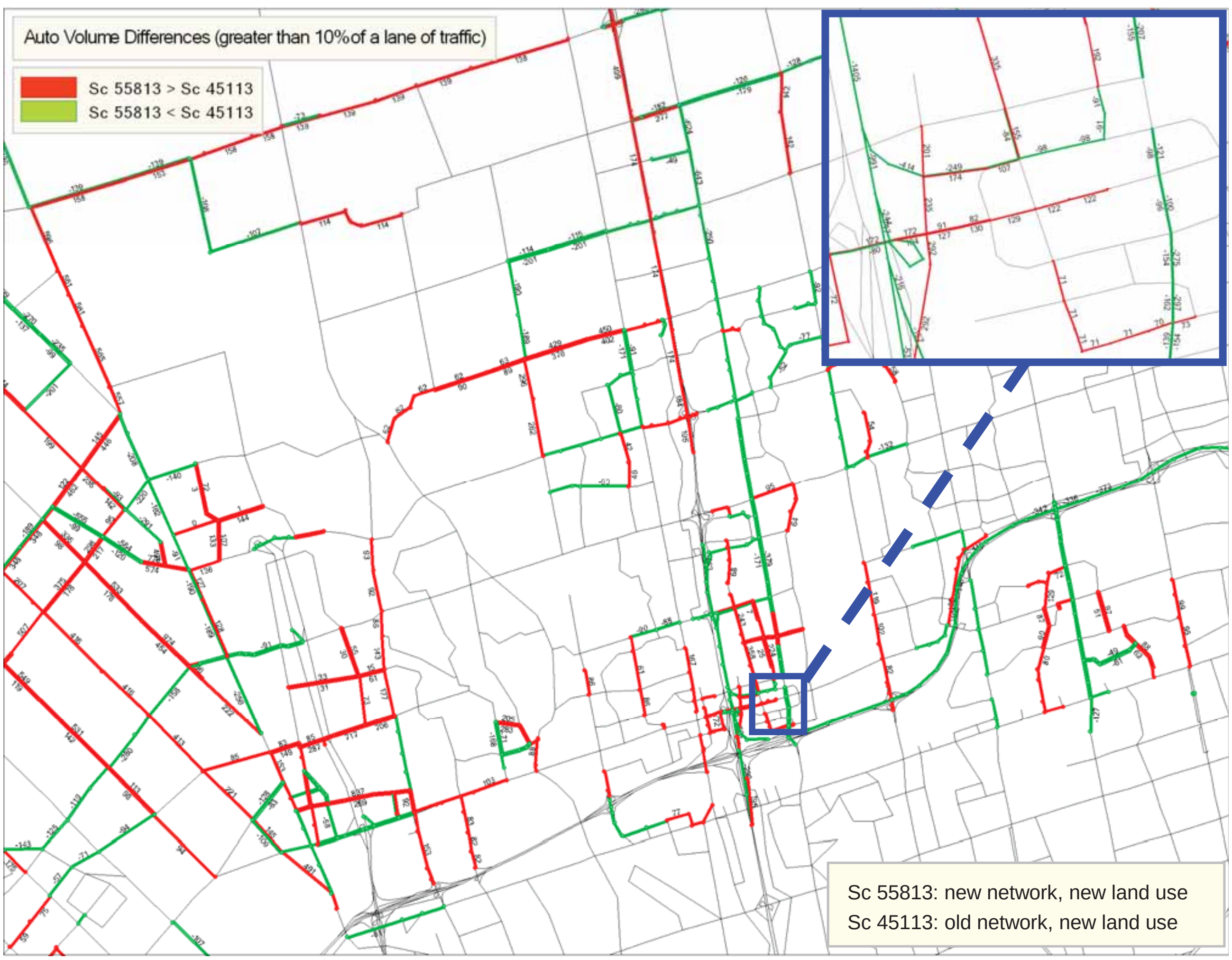
Network Impacts

Similarly, the changes in traffic volumes shown in Figure 11 correlates closely with the changes made in the auto network. The reduction of traffic in Peel Region (north of Castlemore Rd. and West of Highway 50) was due to the removal of the NS roadway between Castlemore Road and Coleraine Drive (refer to Figure 4 and Table 4). An additional lane, along with increased capacity, was added to Zenway Boulevard in the revised VSAM 2031 base, and reflects the increased traffic volume, as well as traffic diversion from Highway 7. The traffic reduction on Jane St correlates with the lane/capacity reduction, and the increases in traffic on the smaller collector roads are sensible since they were not included in the Nov 2009 VSAM and were included in this VSAM revision.

Figure 11 – Network Impacts on PM Auto Network



Alternative 1

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The 2031 Alternative 1 network was developed based on the 2031 Revised VSAM base with variations to the auto network. Some significant changes include the addition of Langstaff and Colossus bridges and the replacement of the VMC ring road network with a grid network. Table 6 and the accompanying Figure 12 provide details regarding the nature and the location of these updates.

Table 6 – Alt. 1 Auto network updates / refinements

ref	Revision	New Base		New Alt 1	
		Lane	Cap	Lane	Cap
1	Add NS link	na	na	1/1	700
2	Add EW link	na	na	1/1	700
3	Lane/Capacity Change	1/1	400	2/2	600
4	Add NS link	na	na	1/1	400
5	Add EW link	na	na	1/1	400
6	Add NS link	na	na	1/1	400
7	Add EW link	na	na	1/1	400
8	Add EW link	na	na	1/1	400
9	Interchange Improvement	na	na	2/2	1400
10	Add EW link	na	na	2/2	600
11	Delete links	2/2	900	na	na
12	Lane/Capacity Change	1/1	400	2/2	600
13	Add NS link	na	na	2/2	600
14	Add EW link	na	na	2/2	900
15	Add EW link	na	na	2/2	600
16	Add EW link	na	na	2/2	900
17	Add EW link	na	na	1/1	400
18	Add NS link	na	na	1/1	400
19	Add EW link	na	na	1/1	400
20	Add EW link	na	na	1/1	400
21	Add NS link	na	na	1/1	400
22	Add EW link	na	na	1/1	400
23	Add EW link	na	na	1/1	900

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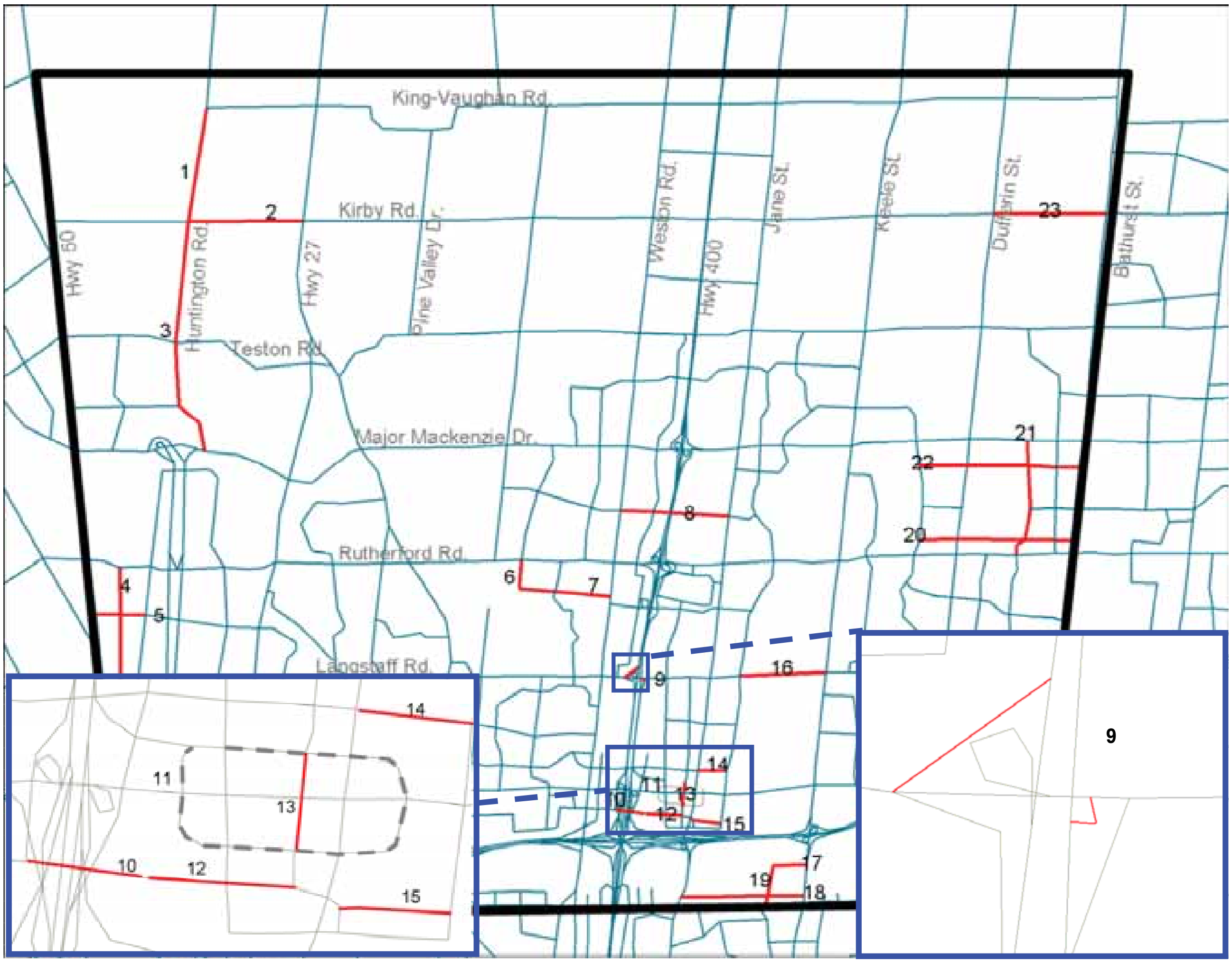
Figure 12– Alternative 1 Auto Network Changes



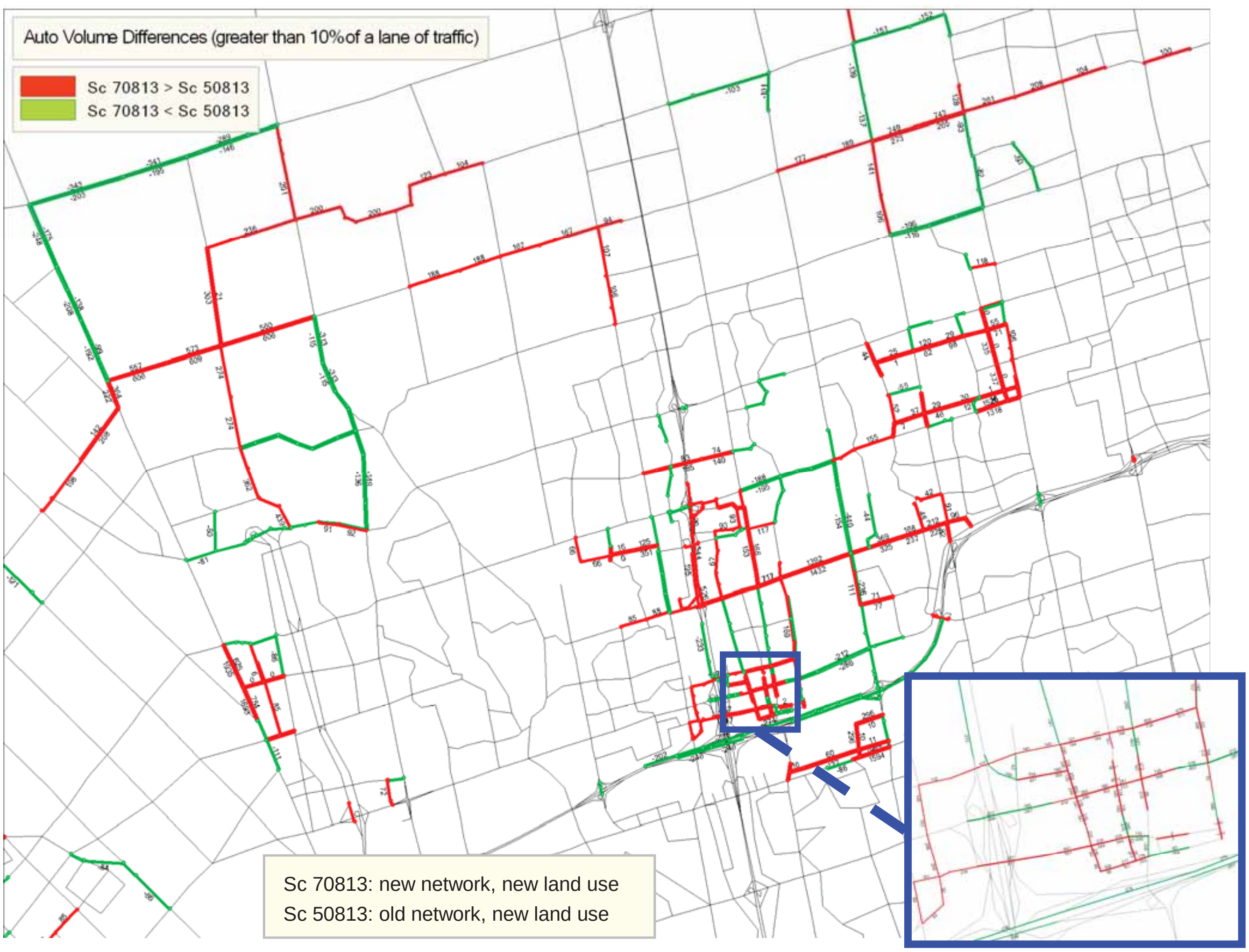
Alternative 1 AM Model Results

The model results package for the 2031 Alternative 1 AM (Scenario 70813) including auto volume, auto and truck volume, v/c ratio (with and without trucks), transit ridership, and various network attributes can be found in Appendix C.

Network Impacts

To evaluate the impacts of *network changes*, Scenario 70813 was compared against 50813 (same land use and transit assumptions, different auto network). The changes in auto volume shown in Figure 12 correlate closely with the changes made in the auto network shown in Figure 12 and Table 6. The increase of traffic (shown in red) along Huntington Rd., King-Vaughan Rd. and Kirby Rd. can be attributed to the extension of Huntington Rd. between Kirby Rd. and King-Vaughan Rd. and the extension of Kirby Rd. between Huntington and Hwy 27 (labelled as #1 and #2 in Figure 12, respectively). These extensions divert some traffic away from Hwy 27 and Teston Rd (shown in green). Similarly, the providing connectivity between Dufferin St. and Bathurst St. (labelled as #23 in Figure 12) diverted traffic away from Elgin Mills Rd. W and King-Vaughan Rd.. The addition of the Langstaff Bridge across the CN stockyards as well as the improvements at the Langstaff and Hwy 400 interchange led to significant traffic increase along Langstaff Rd. and some diversion from Rutherford Rd. Within the VMC area, the replacement of the ring road system with a grid system caused significant changes in traffic patterns. The new Colossus Bridge alleviated Highway 7 of some traffic, while the improved connections provided by the extension of Millway St. and Portage Rd. resulted in increased traffic.

Figure 13 – Network Impacts on AM Auto Network



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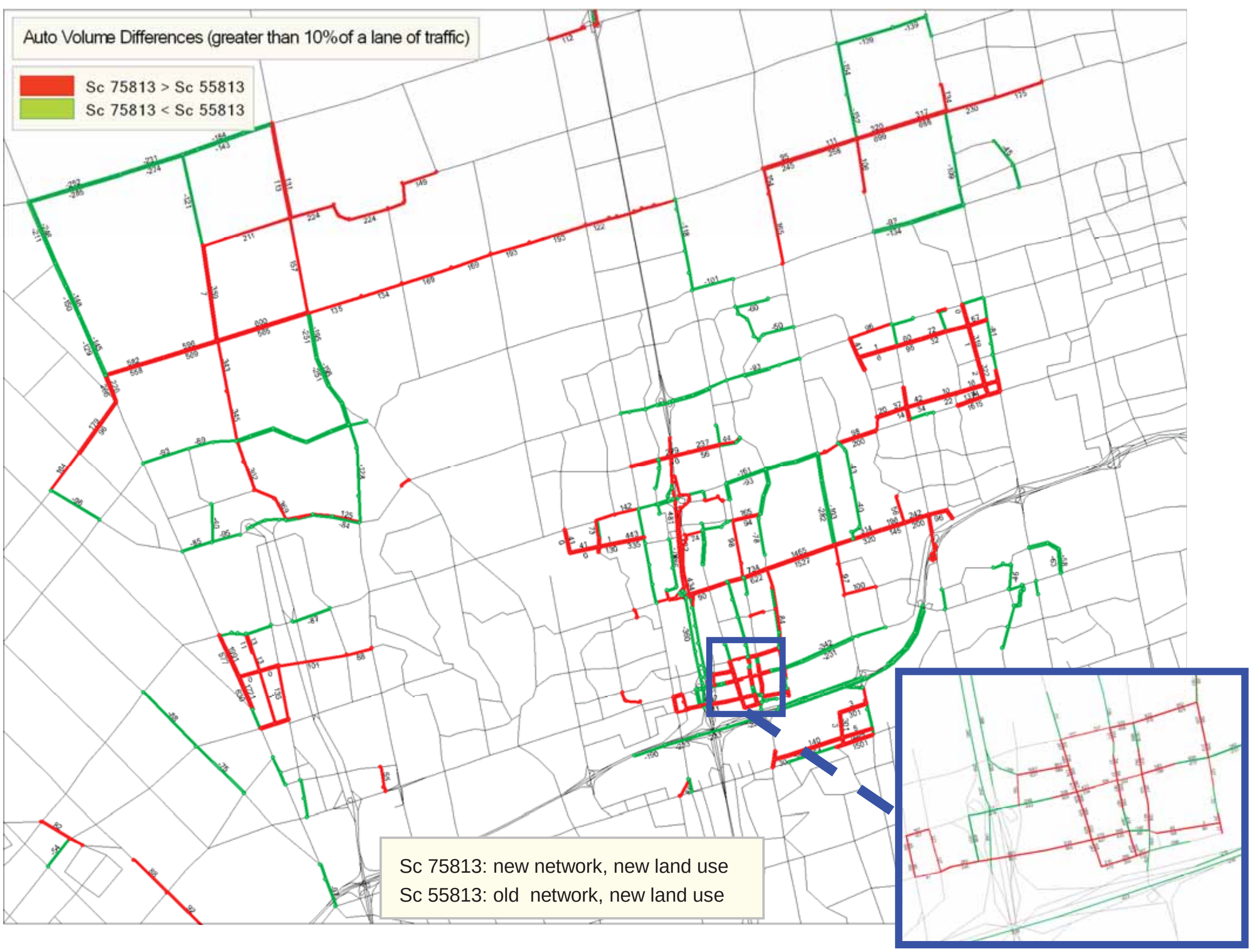
Alternative 1 PM Model Results

The model results package for Alternative 1 PM (Scenario 75813) including auto volume, auto and truck volume, v/c ratio (with and without trucks), and various network attributes can be found in Appendix D.

Network Impacts

In order to evaluate the impacts of *network changes*, Scenario 75813 was compared against 55813 (same land use and transit assumptions, different auto network). The changes in auto volume shown in Figure 14 are very similar to the changes shown in Figure 13 and can be attributed to the changes made in the auto network. An increase in traffic is shown in red and green indicates a decrease.

Figure 14 – Network Impacts on PM Alt. 1 Auto Network



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Memo

VSAM 2021 – Base

As per discussions with AECOM, a 2021 VSAM base network was developed based on 2031 VSAM Alternative 1, with minor modifications to the road network. These include the removal of the Langstaff Bridge and the Colossus Bridge, the removal of the Kirby Rd. link between Huntington Rd. and Hwy 27 and between Dufferin St. and Bathurst St., Huntington between Kirby Rd. and King-Vaughan Rd., as well as the removal of the N-S local road between Major Mackenzie Dr. and Teston Rd. In addition, sections of several arterials will not be widened in 2021 and their lane assumptions also changed. Table 7 and the accompanying Figure 15 provide details regarding the nature and the location of these network differences.

Table 7 – 2021 Base Auto Network Modifications

ref	Revision	2021 Base		2031 Alt 1	
		Lane	Cap	Lane	Cap
1	Remove link	na	na	1/1	700
2	Remove link	na	na	1/1	700
3	Remove link	na	na	1/1	400
4	Remove lane	2/2	900	3/3	800
5	Remove lane	2/2	900	3/3	800
6	Remove lane	2/2	800	3/3	711
7	Remove link	na	na	2/2	600
8	Remove link	na	na	2/2	900
9	Remove link	na	na	1/1	900

Figure 15 – 2021 Network vs. 2031 Network

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Land Use

Population and employment figures within the City of Vaughan were revised by Halcrow to match the land use control totals for Vaughan provided by York Region on December 11, 2009 using interpolation between 2006 and 2031.

Figure 16 and Figure 17 show the location and magnitude of the population and employment for Year 2021, respectively. The resultant population and employment totals can be seen in Table 8 below.

Figure 16 – 2021 Population Assumptions

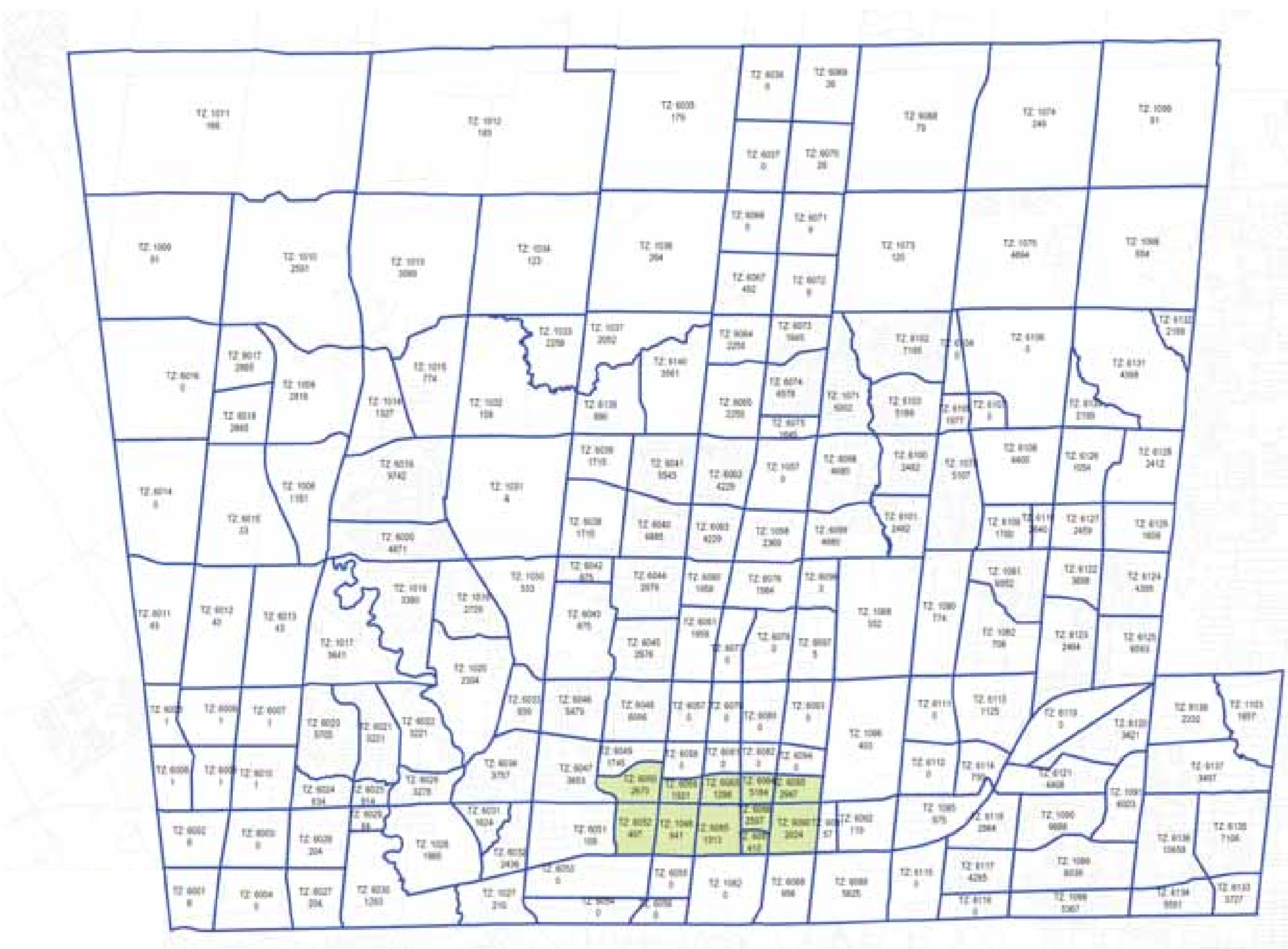

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Figure 17 – 2021 Employment Assumptions

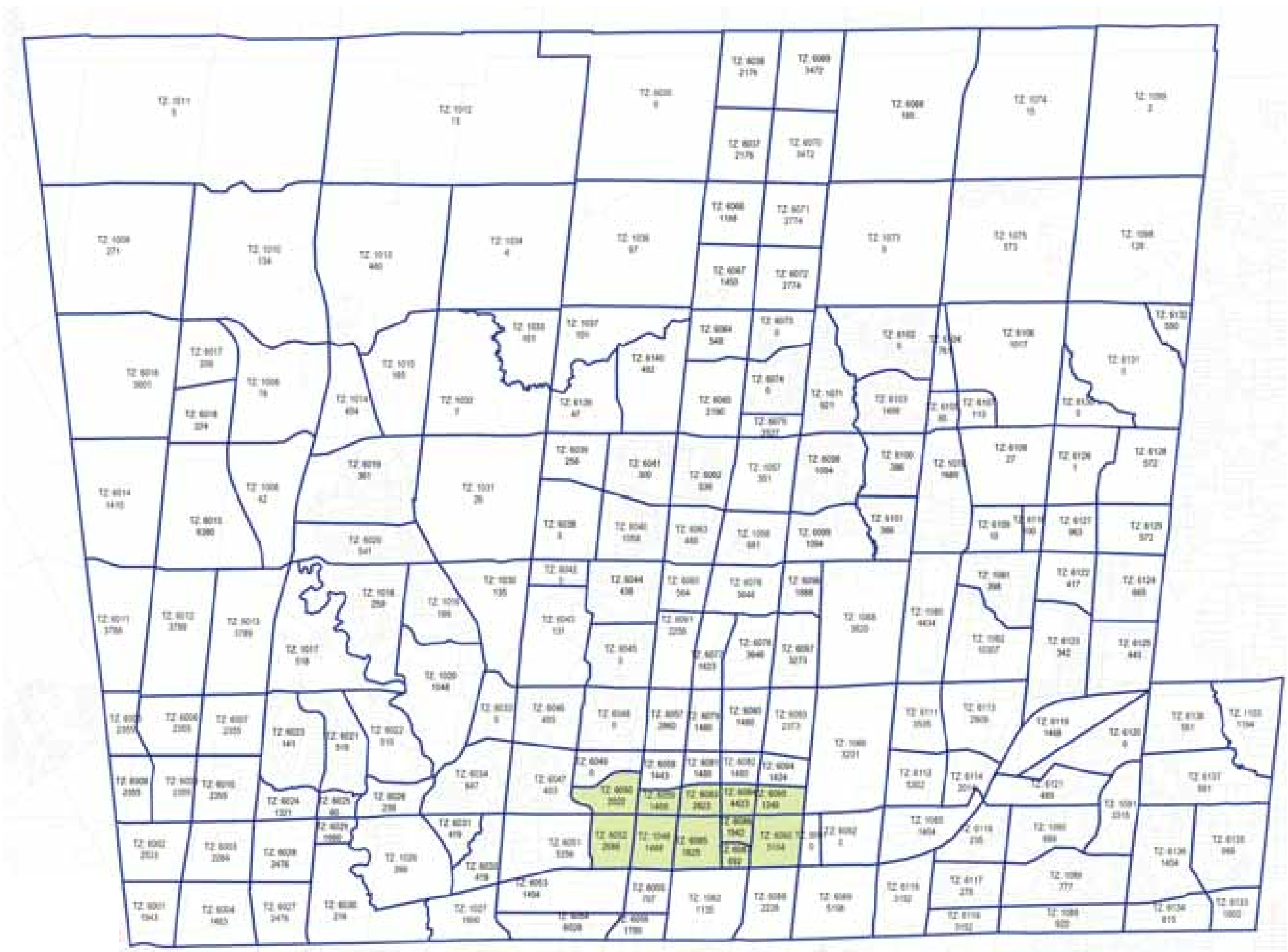

Table 8 – 2021 Population and Employment City of Vaughan Totals

Date Vetted	2021 Population Totals	2021 Employment Totals
January 26, 2009	360,281	248,665*

*Adjustments were made for employment in Wonderland to reflect average fall weekday traffic (TZ 1059)

2021 Model Results

The model results package for the 2021 Base AM (Scenario 30813) and PM (Scenario 35813) including auto volume, auto and truck volume, v/c ratio (with and without trucks), transit ridership, and various network attributes can be found in Appendix E and Appendix F, respectively.

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Conclusions

The 2031 VSAM base update was carried out at the request of the City of Vaughan. HCI has incorporated revised road network lane and capacity assumptions, parking cost assumptions, transit headway, speed, and stop/station location assumptions, as well as population and employment forecasts.

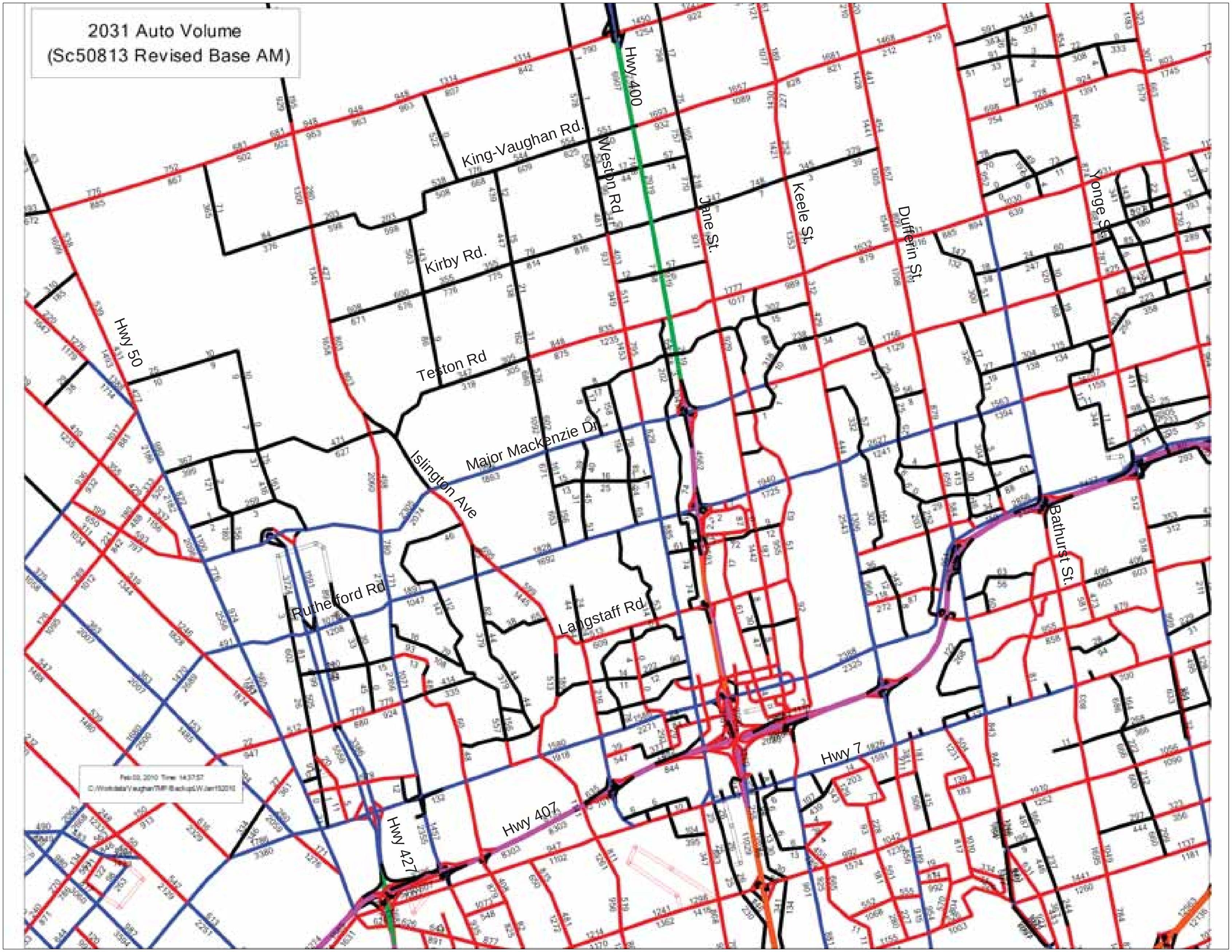
As documented above, the changes in road and transit demand in the revised base scenario resulting from the changes to transportation inputs (road, transit, and parking assumptions) are both modest and logical. The changes in demand associated with the land use modifications, primarily due to substantial reductions in VMC employment and increases to West Vaughan Secondary Employment Centre employment, are consistent with the scale of the changes assumed. The major impacts are concentrated in the vicinity of the VMC, particularly on Avenue 7 in the vicinity of Highway 400 where PM peak hour demands were reduced by approximately 700 vehicles.

The transit ridership was reduced along Major Mackenzie Dr., in line with the assumed changes to speed and headway which reflect the planned 2031 transit services in the YTMP Update and experience in comparable urban corridors. Peak hour ridership estimates decreased substantially as a result of reduced speeds and lower headways for both 2021 and 2031. Whereas the earlier peak hour demand estimates justified frequencies of 7 to 8 buses per hour on Major Mackenzie Dr. west of Weston Road, the assumed transit service changes resulted in AM peak hour demand levels of less than 227 in 2031.

The 2031 Alternative 1 scenario was developed based on the 2031 revised base network, with changes to the auto network. These changes redistribute traffic along parallel links that were extended, added or widened, especially within the VMC area.

The 2021 VSAM base was developed based on 2031 Alternative 1, with minor modifications to the road network. There are no differences in the 2021 transit network input assumptions when compared to the 2031 transit network. The resulting transit ridership was also similar to 2031 such that it achieved AM peak hour demand levels of less than 218 on Major Mackenzie Dr west of Weston. With the 2021 land use control totals being marginally less than the 2031 land use control totals, the overall 2021 results are very similar to the 2031 results. The V/C ratio plots indicate that congestion occurs on most major facilities by 2021, and widening improvements are necessary in order to accommodate 2031 forecasts. The VMC area and Avenue 7 are operating at an acceptable level of service, but Avenue 7 is assumed to be six lanes by 2021 in this analysis.

Appendix A
Sc 50813
Revised VSAM 2031 Base AM



2031 Auto Volume
(Sc50813 Revised Base AM)
Hwy 400
King-Vaughan Rd.
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Kirby Rd.
Teston Rd
Major Mackenzie Dr.
Islington Ave
Hwy 50
Rutherford Rd
Langstaff Rd.
Bathurst St.
Hwy 7
Hwy 407
Hwy 427

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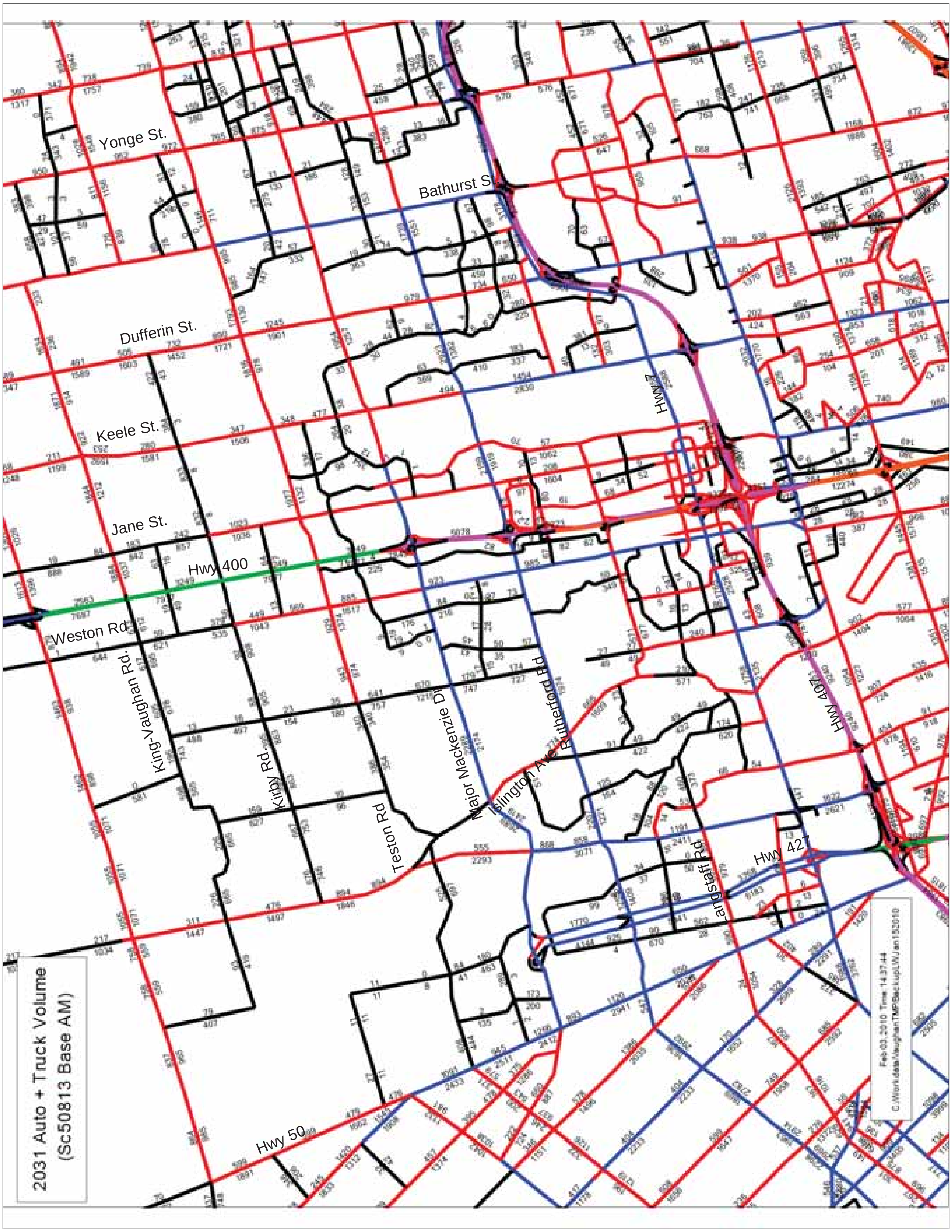
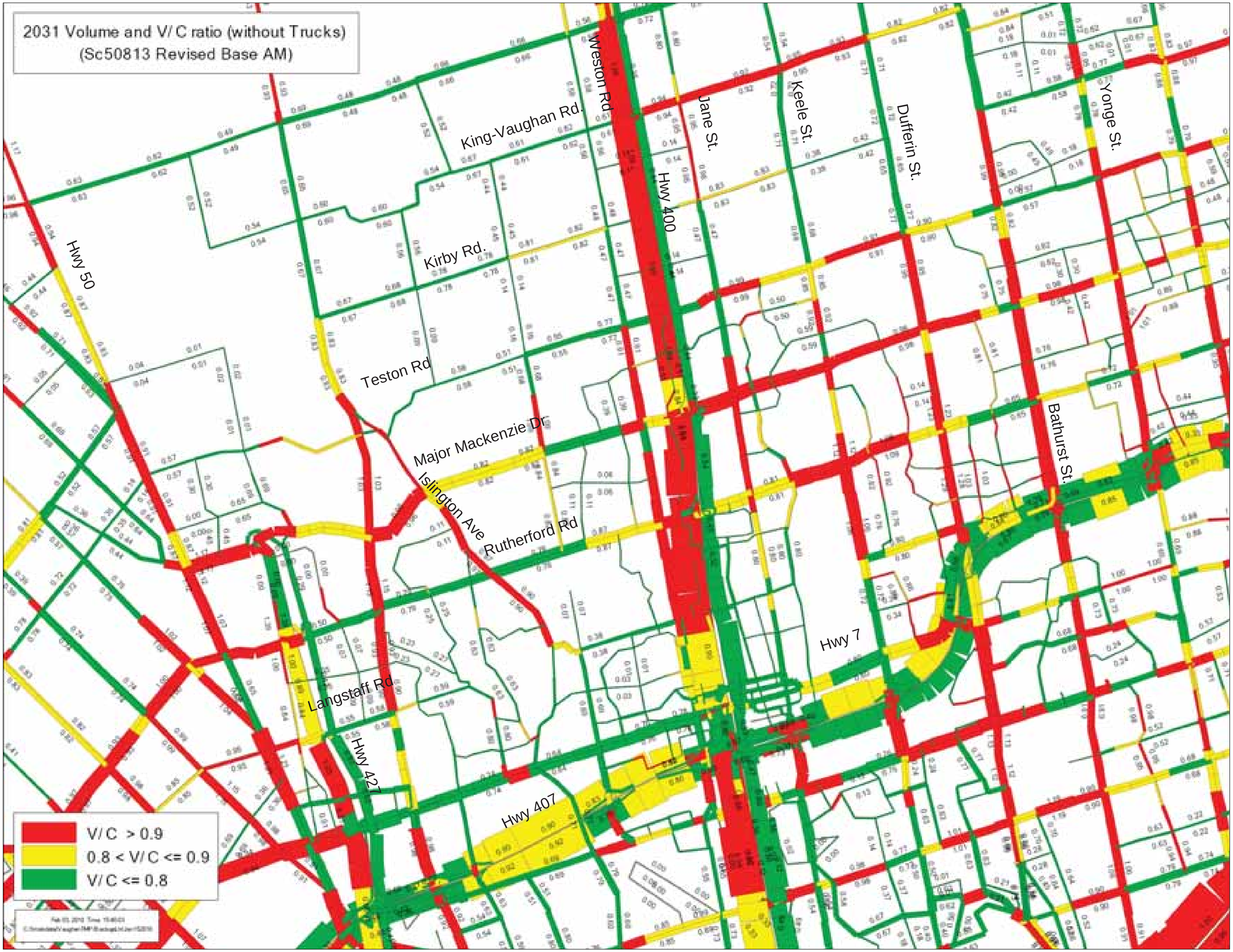


2031 Auto + Truck Volume
(Sc50813 Base AM)
Yonge St.
Bathurst St.
Dufferin St.
Keele St.
Jane St.
Hwy 400
Weston Rd
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Hwy 7
Langstaff Rd
Hwy 427
Hwy 407
Hwy 50

Halcrow



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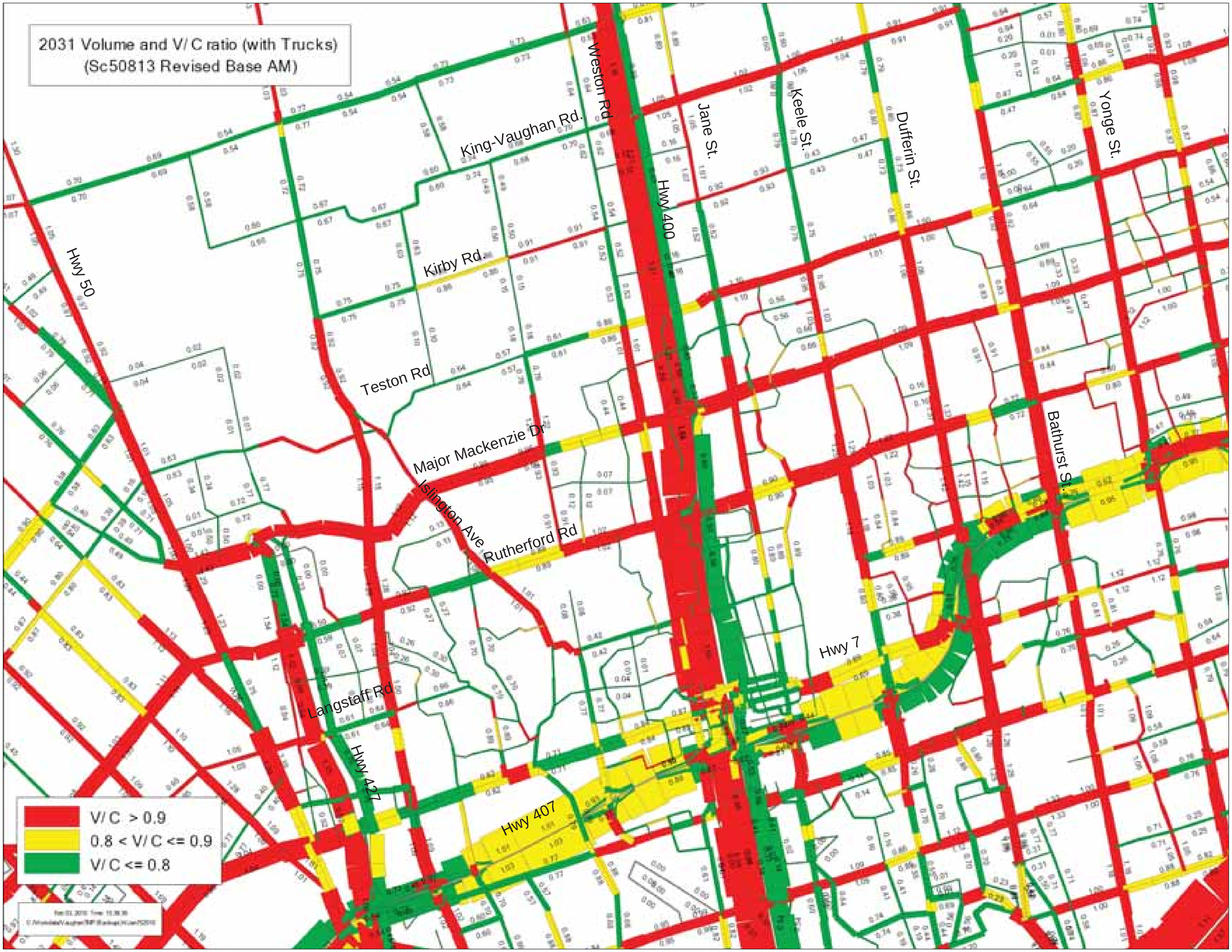
Halcrow



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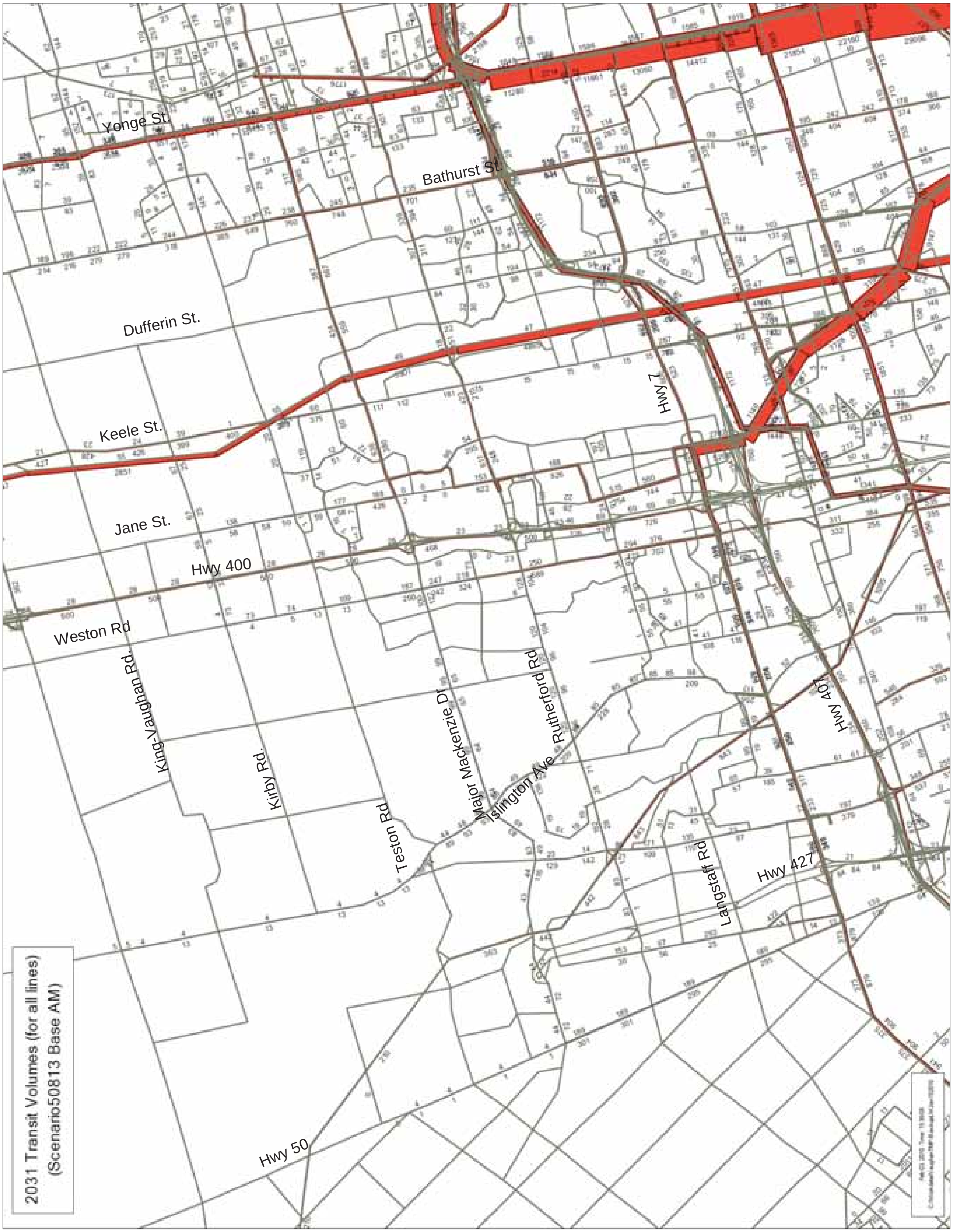
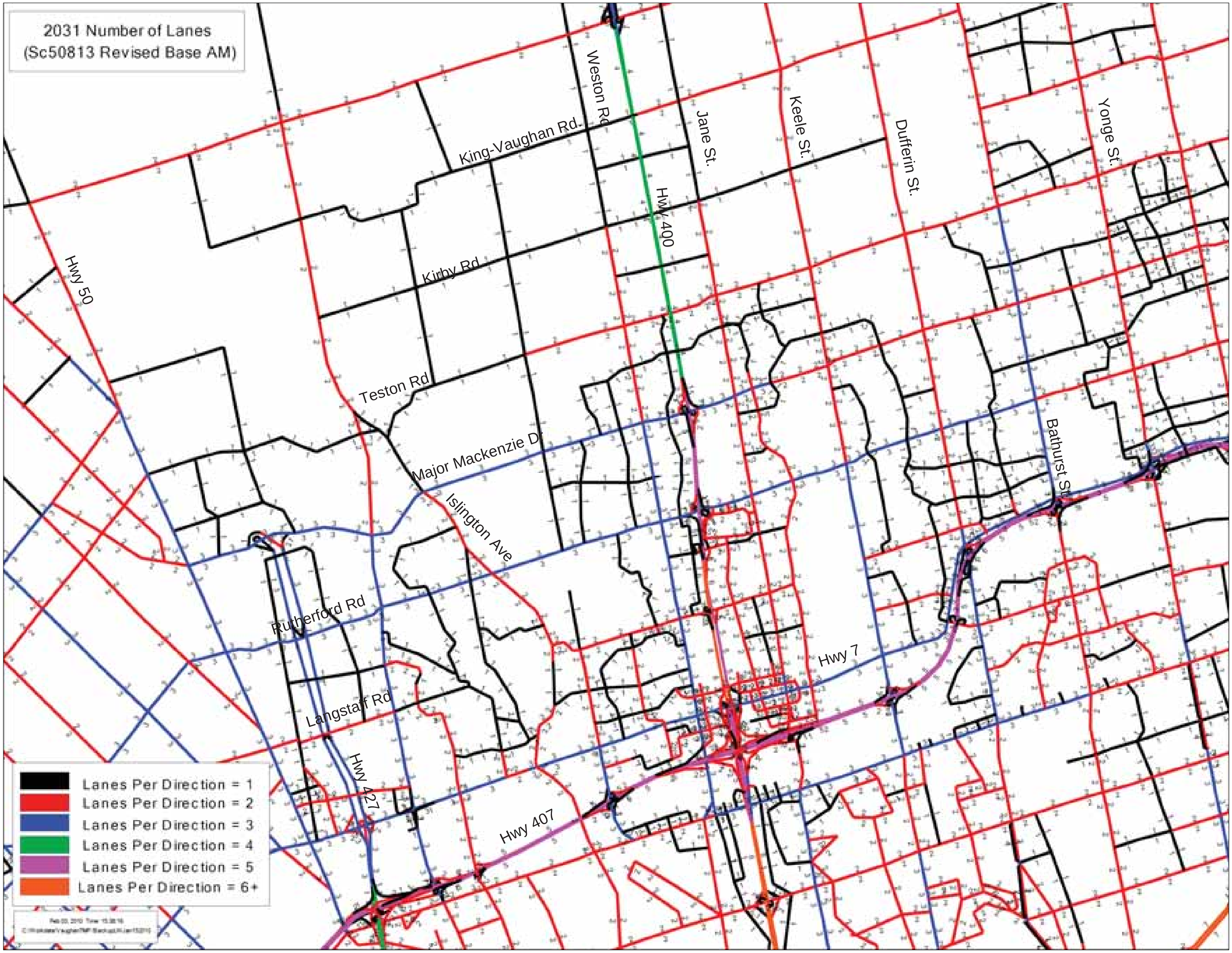


2031 Transit Volumes (for all lines)
(Scenario50813 Base AM)

Halcrow

Halcrow



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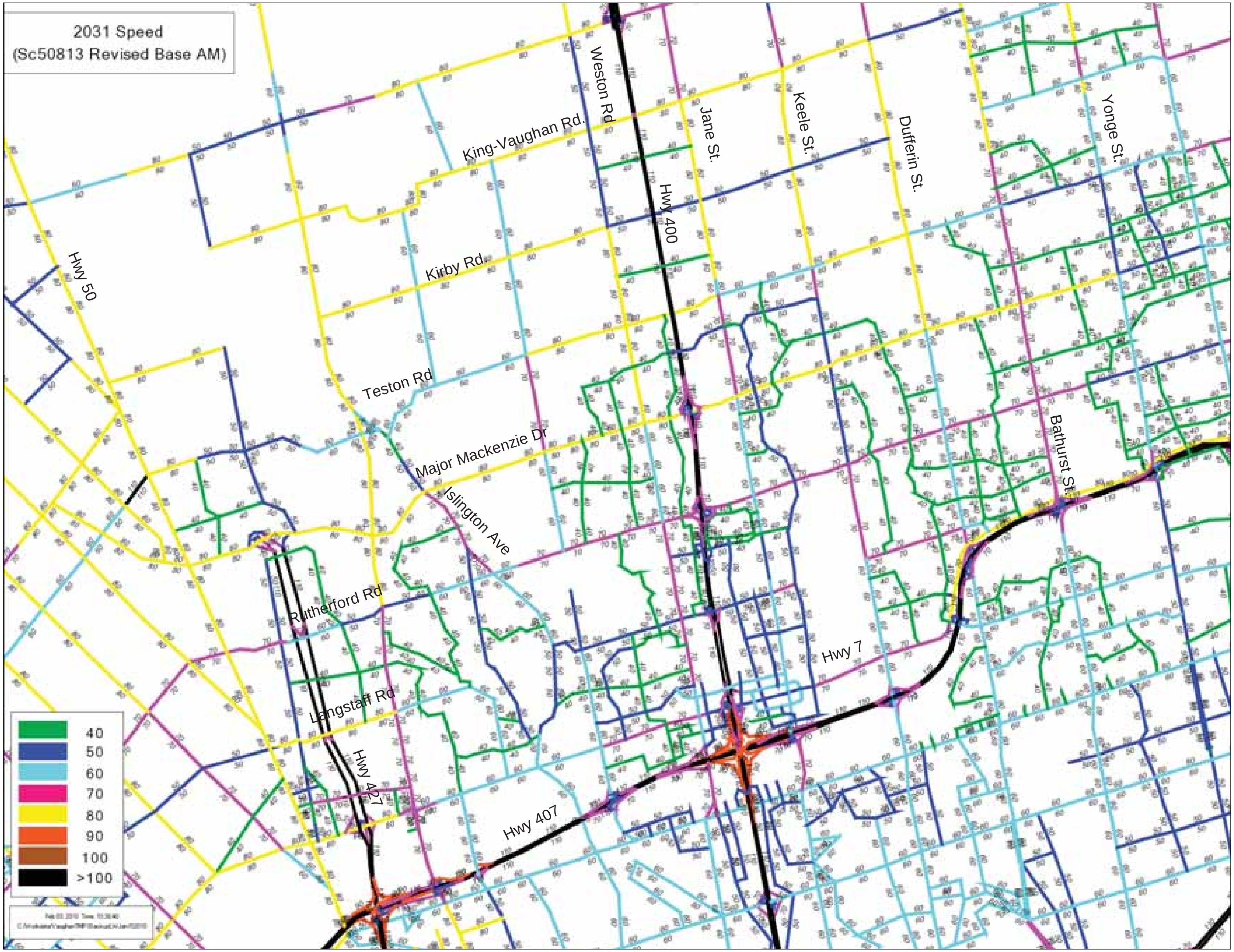
Halcrow



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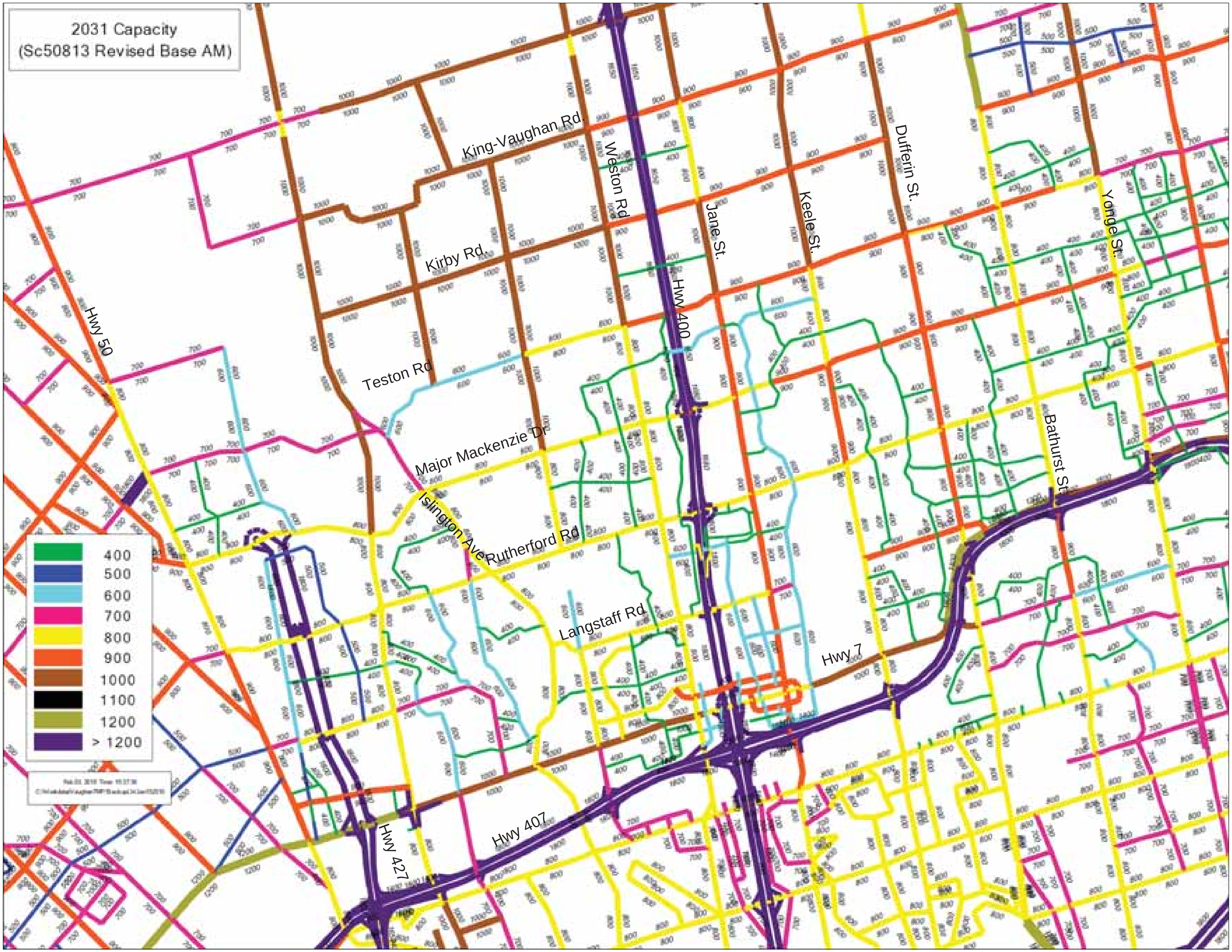
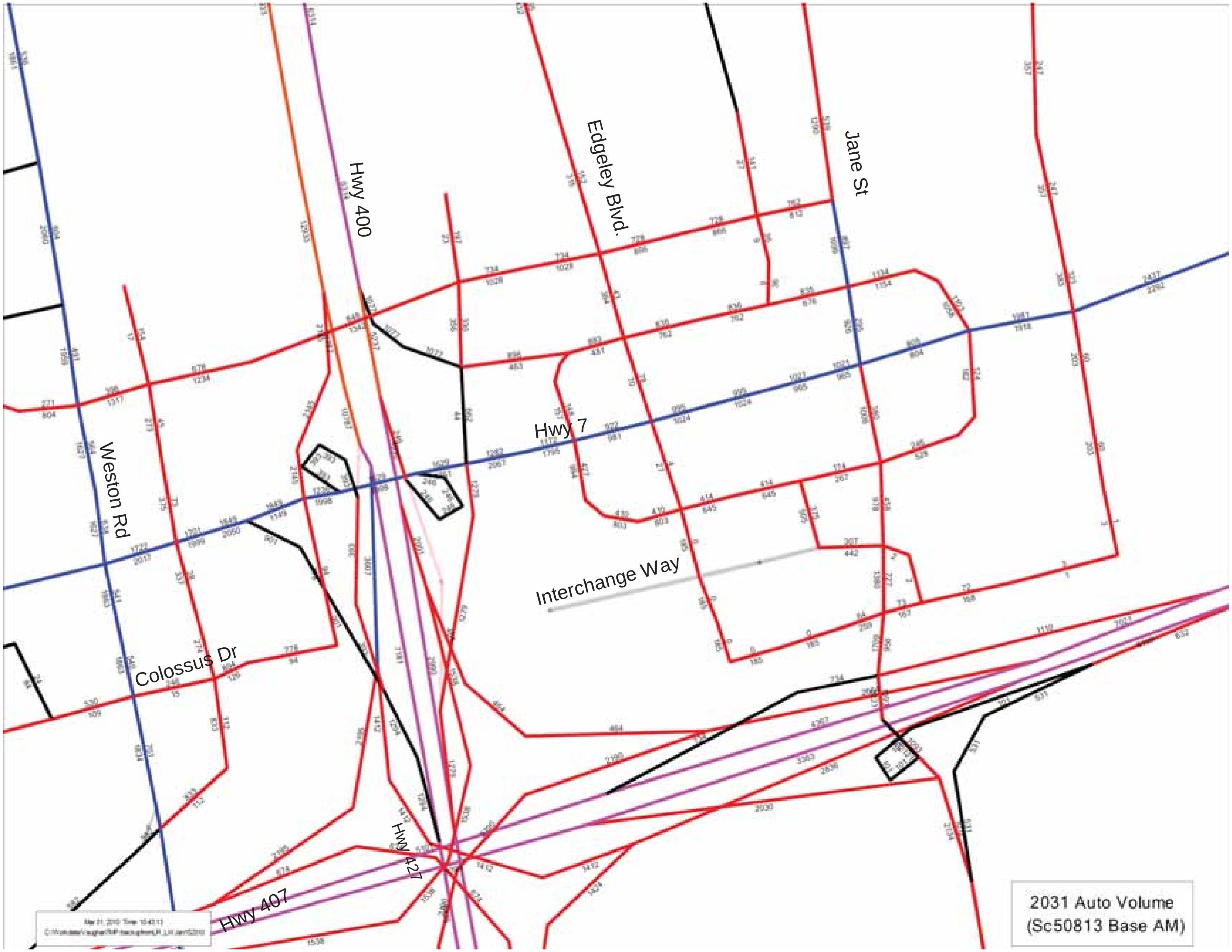

2031 Capacity
(Sc50813 Revised Base AM)
King-Vaughan Rd.
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Bathurst St.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Hwy 400
Hwy 7
Hwy 407
Hwy 427
Hwy 50
400
500
600
700
800
900
1000
1100
1200
> 1200

DRAFT


Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Auto Volume
(Sc50813 Base AM)

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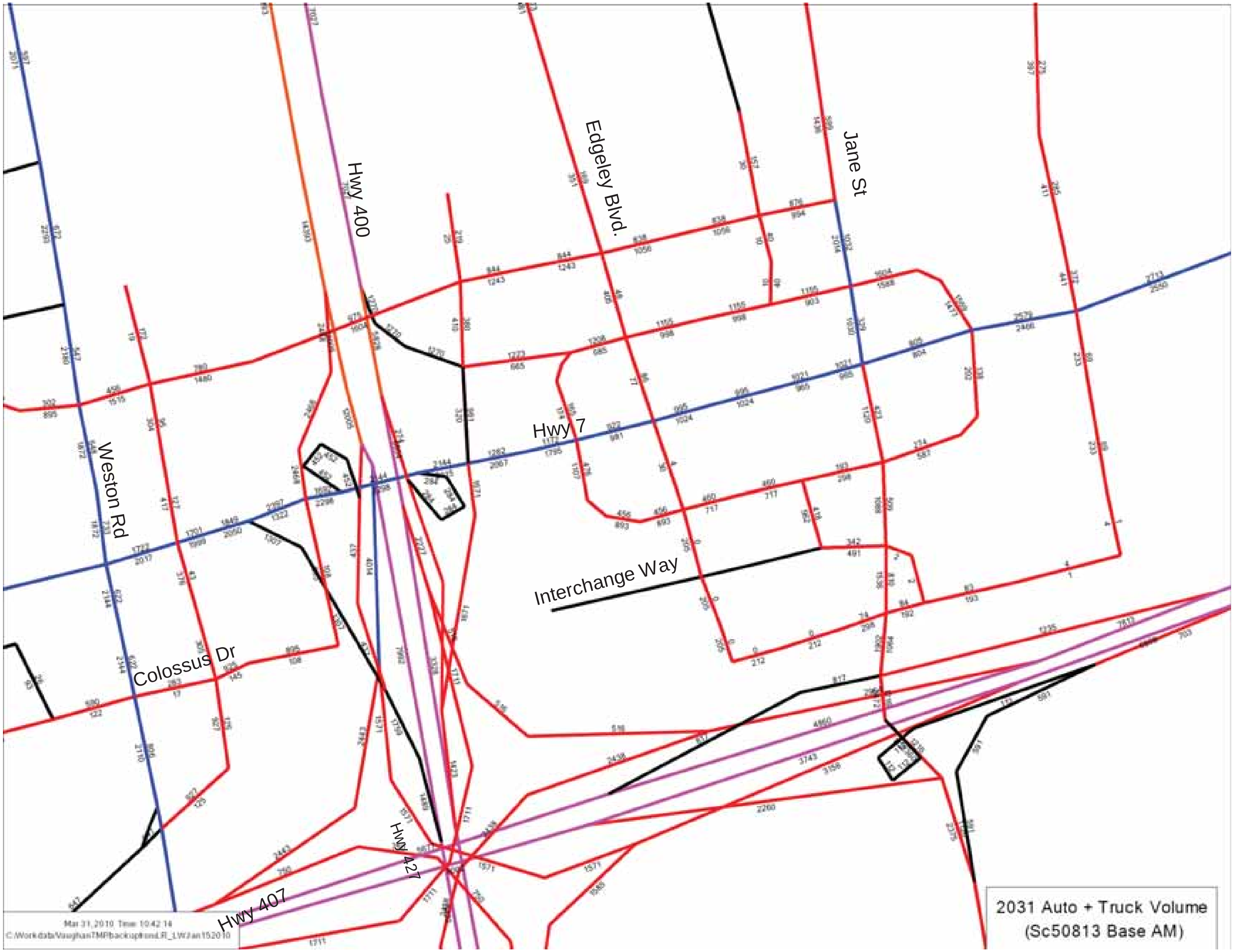

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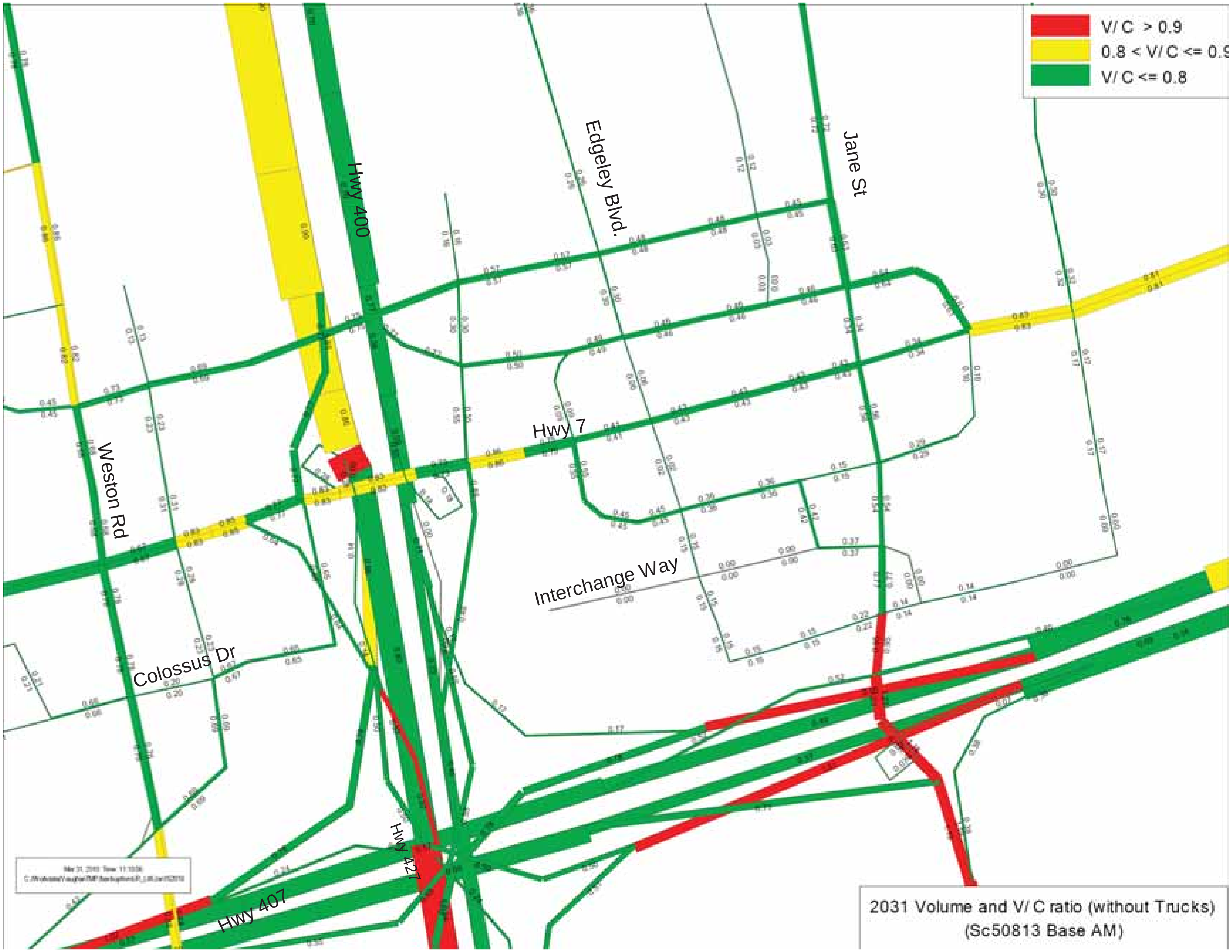

2031 Volume and V/C ratio (without Trucks) (Sc50813 Base AM)

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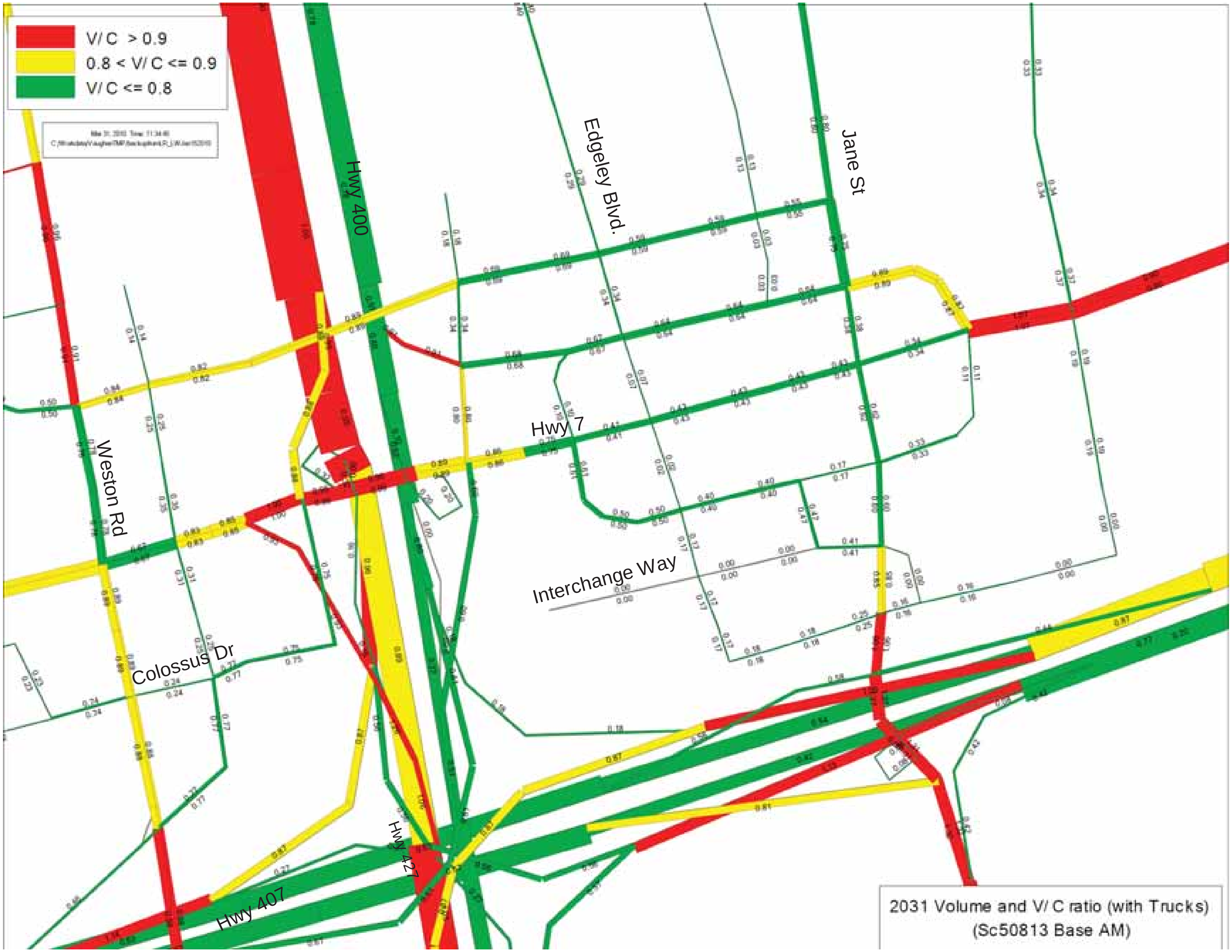
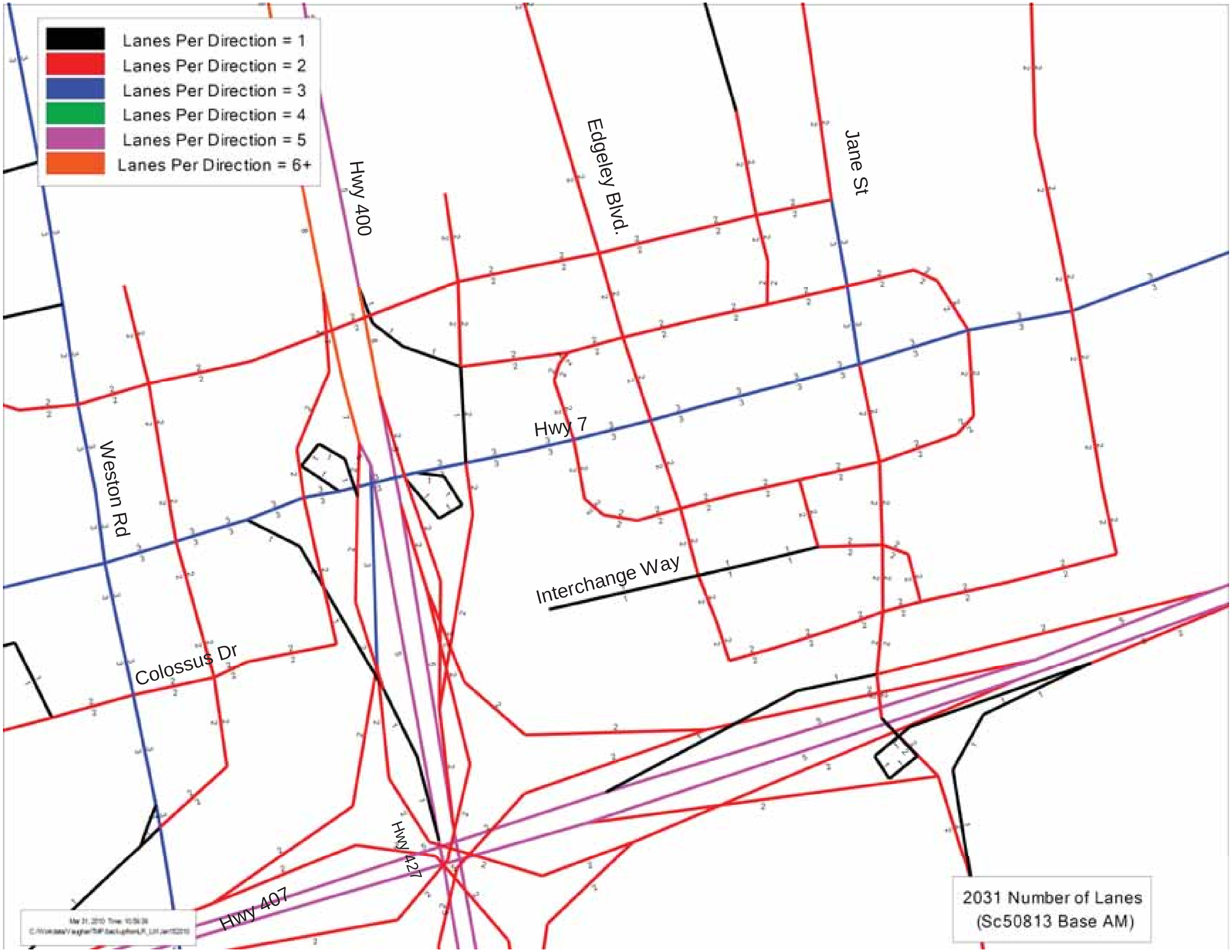

V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Volume and V/C ratio (with Trucks)
(Sc50813 Base AM)


2031 Transit Volumes (for all lines)
Sc50813 Base AM
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407

DRAFT



Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6+
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Number of Lanes
(Sc50813 Base AM)

DRAFT

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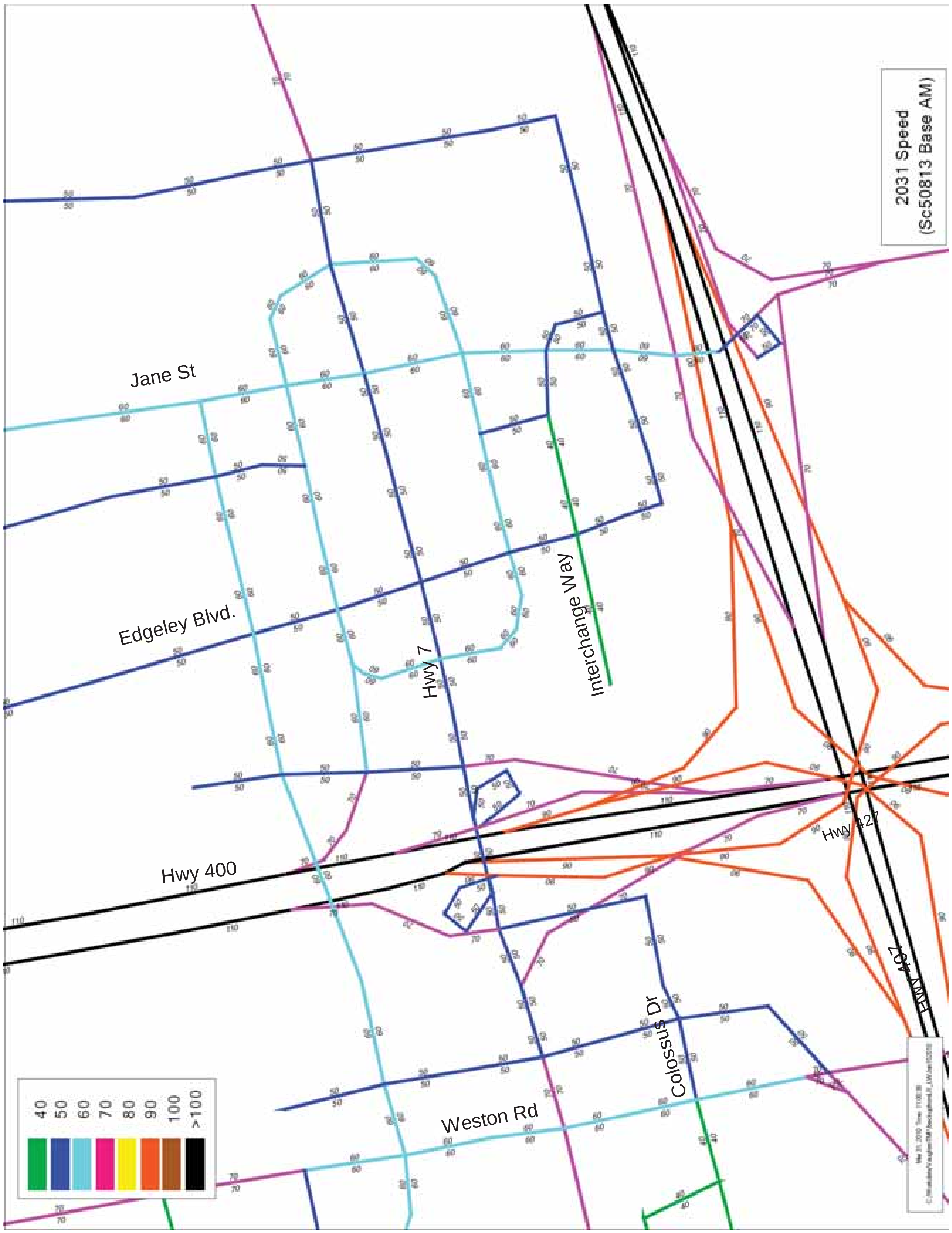

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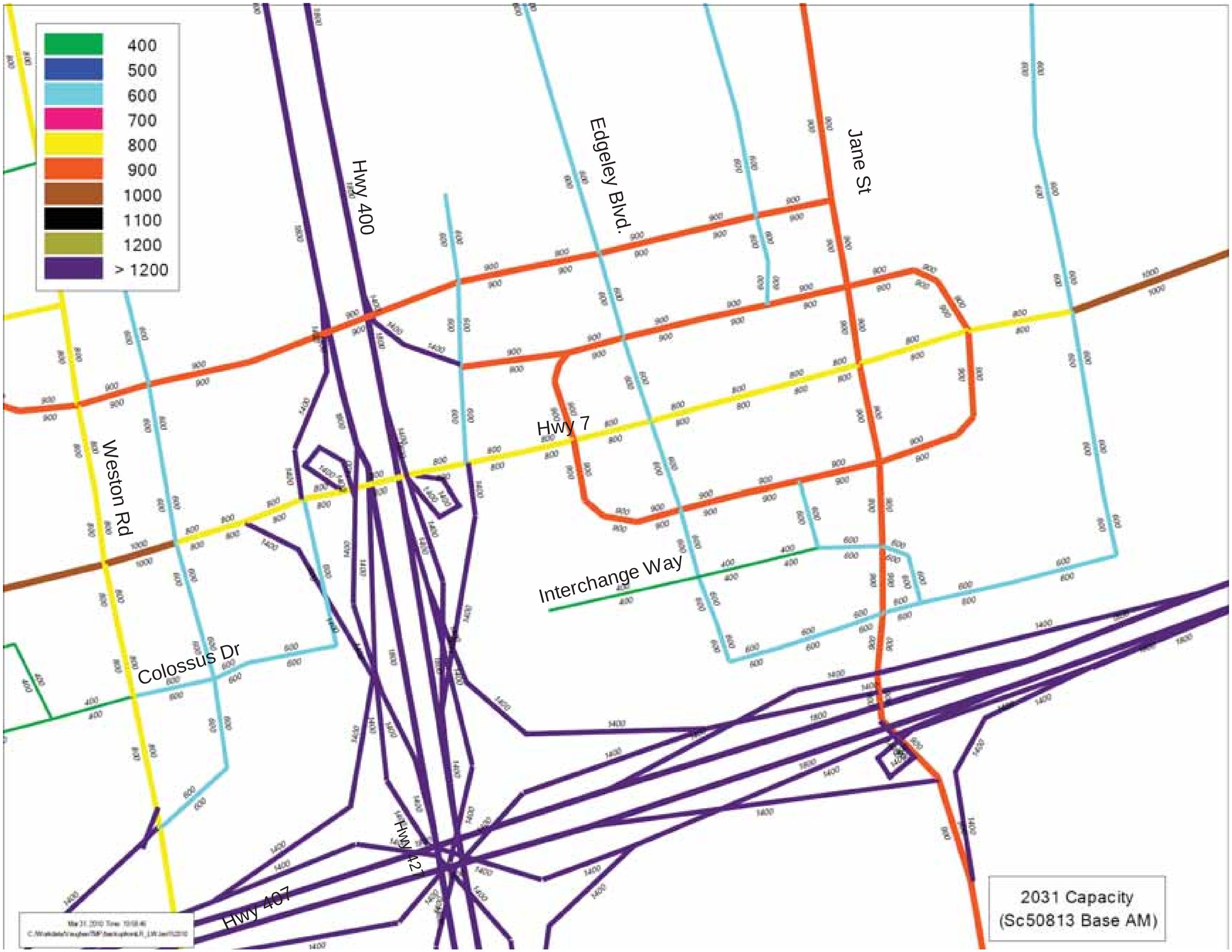

400
500
600
700
800
900
1000
1100
1200
> 1200
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Capacity
(Sc50813 Base AM)

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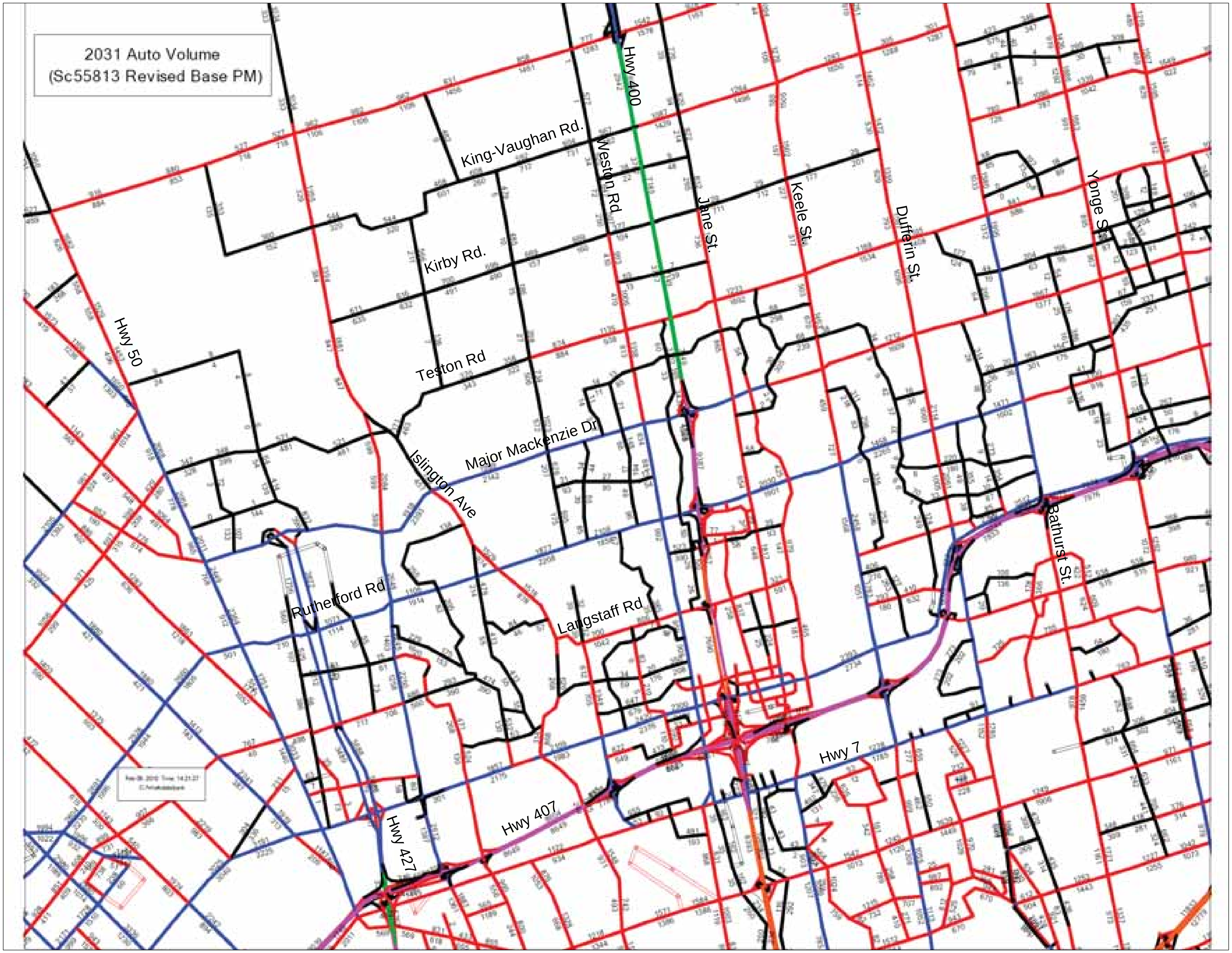
Appendix B
Sc 55813
Revised VSAM 2031 Base PM



2031 Auto Volume
(Sc55813 Revised Base PM)
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Hwy 7
Hwy 407
Hwy 427
Hwy 50
Hwy 400
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Bathurst St.

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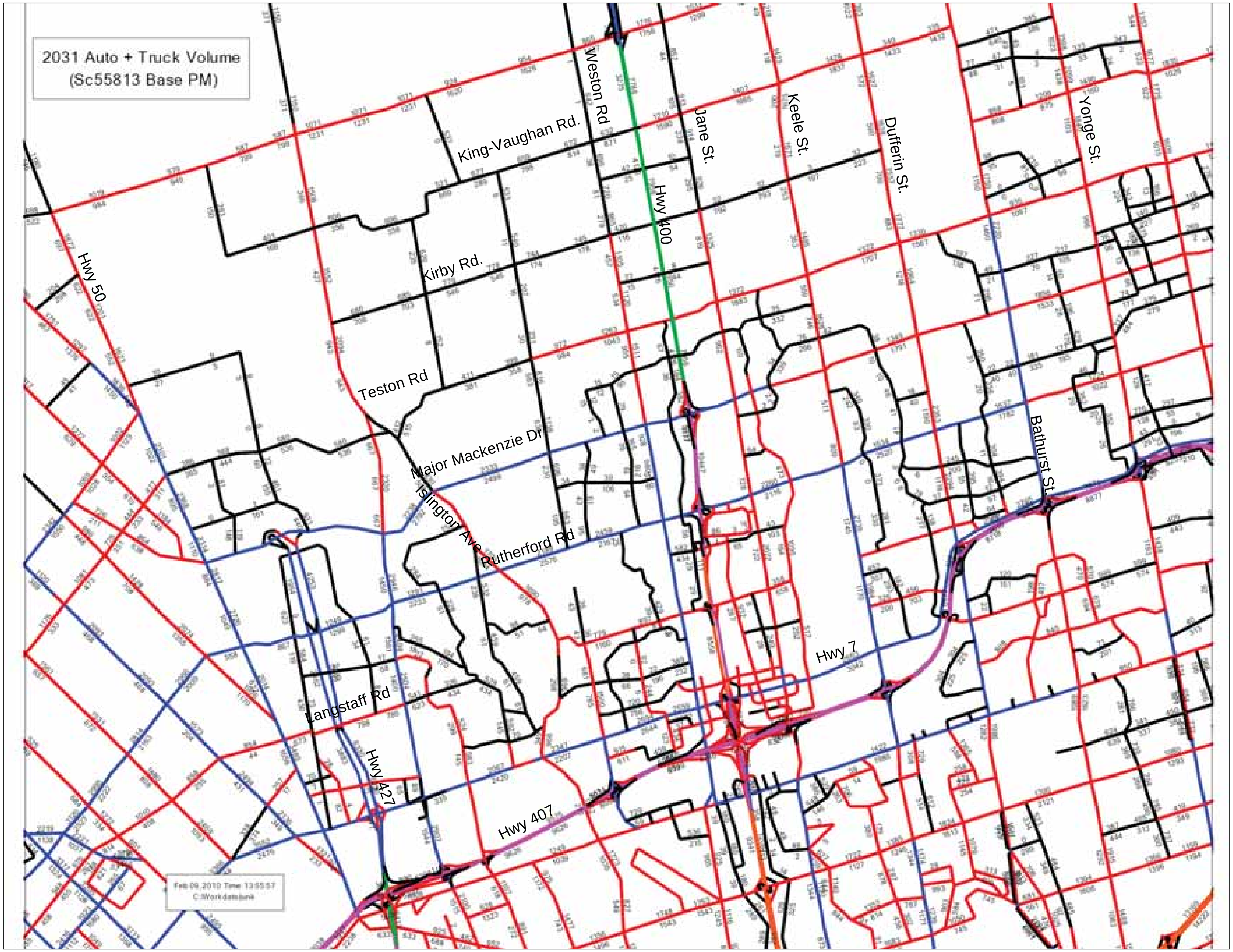
Halcrow



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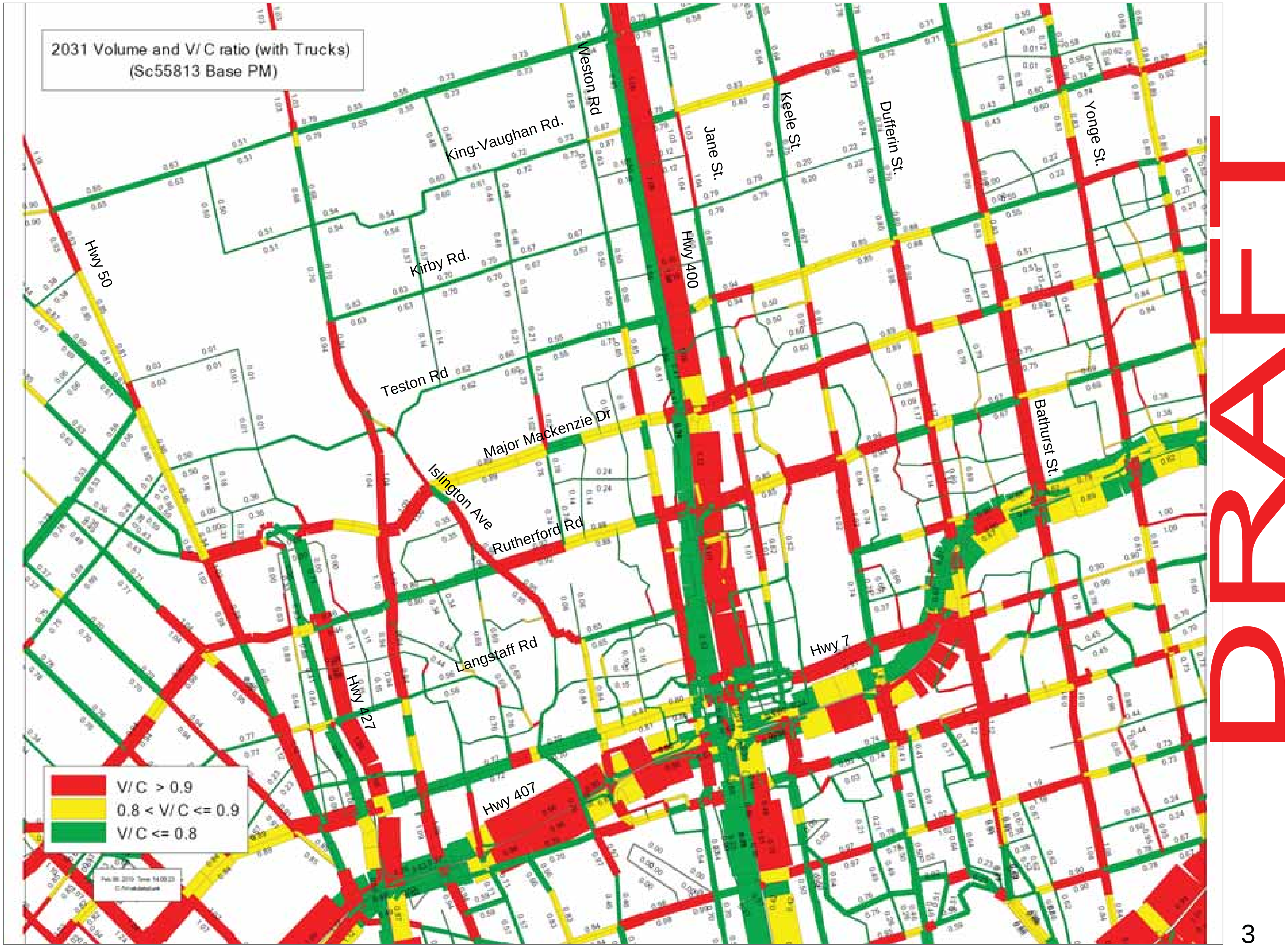
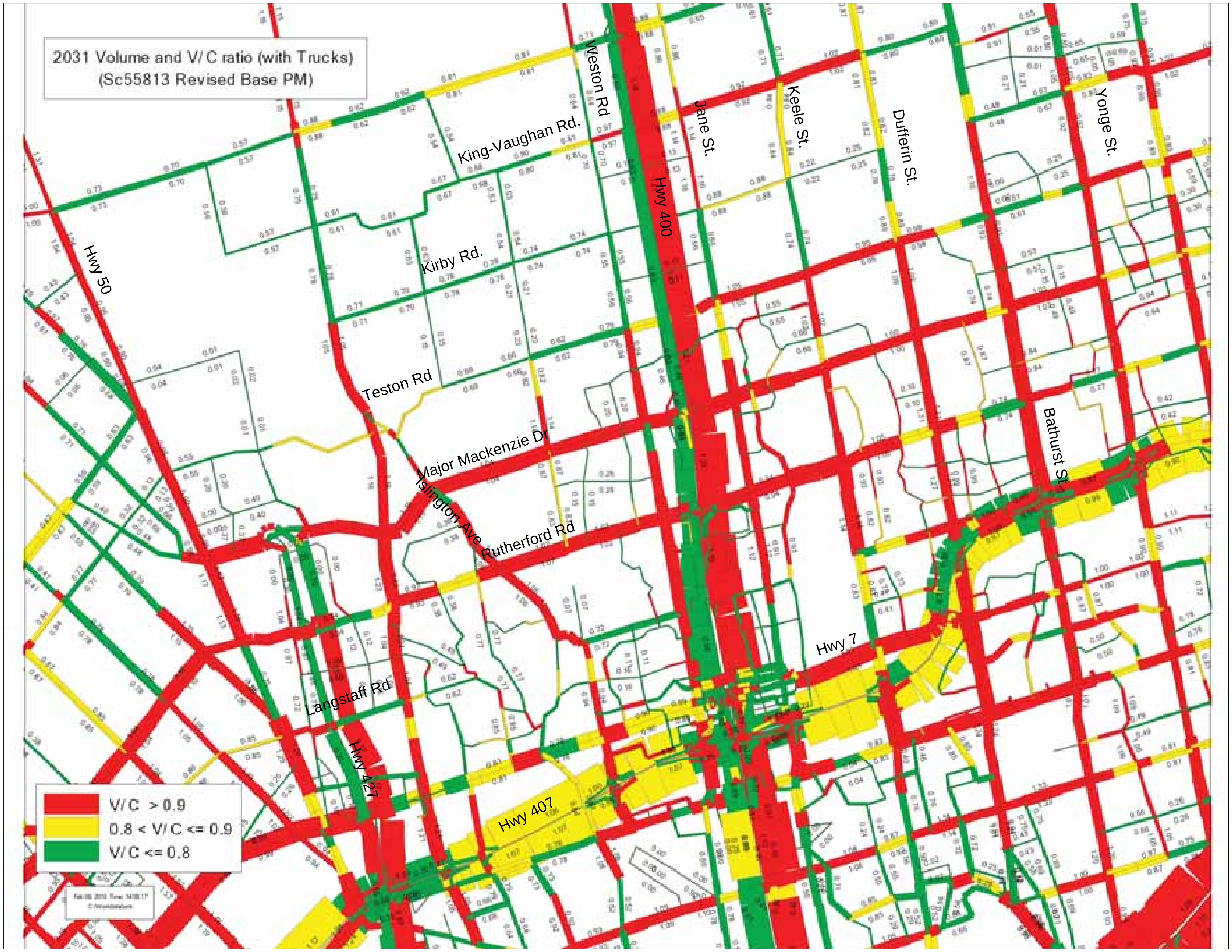
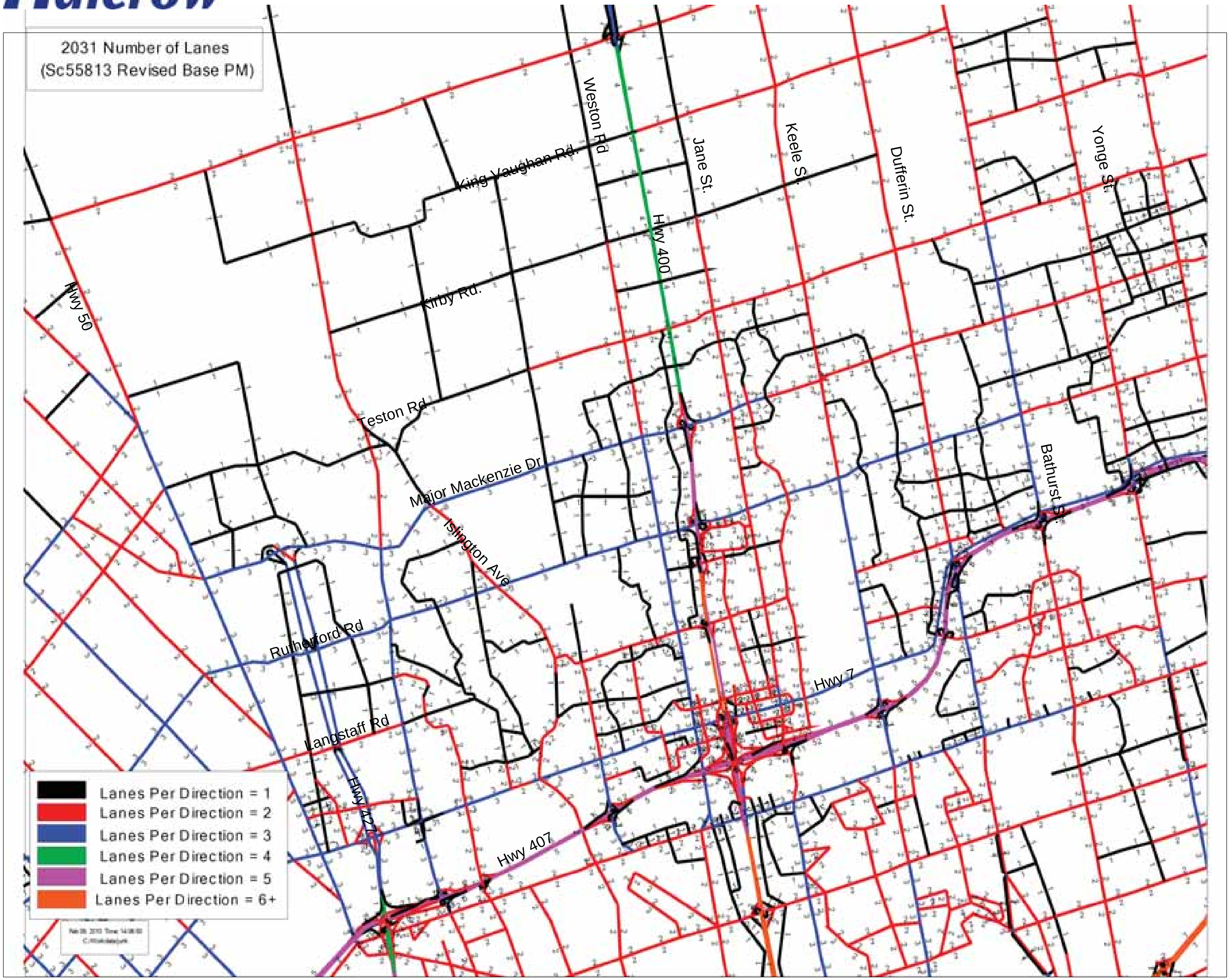

2031 Volume and V/ C ratio (with Trucks)
(Sc55813 Base PM)
V/ C > 0.9
0.8 < V/ C <= 0.9
V/ C <= 0.8
Weston Rd
King-Vaughan Rd.
Jane St.
Keele St.
Dufferin St.
Yonge St.
Hwy 400
Hwy 50
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Bathurst St.
Hwy 7
Langstaff Rd
Hwy 427
Hwy 407
DRAFT


2031 Volume and V/C ratio (with Trucks)
(Sc55813 Revised Base PM)
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Weston Rd
King-Vaughan Rd.
Jane St.
Keele St.
Dufferin St.
Yonge St.
Hwy 400
Hwy 50
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Bathurst St.
Hwy 7
Langstaff Rd
Hwy 427
Hwy 407

Halcrow



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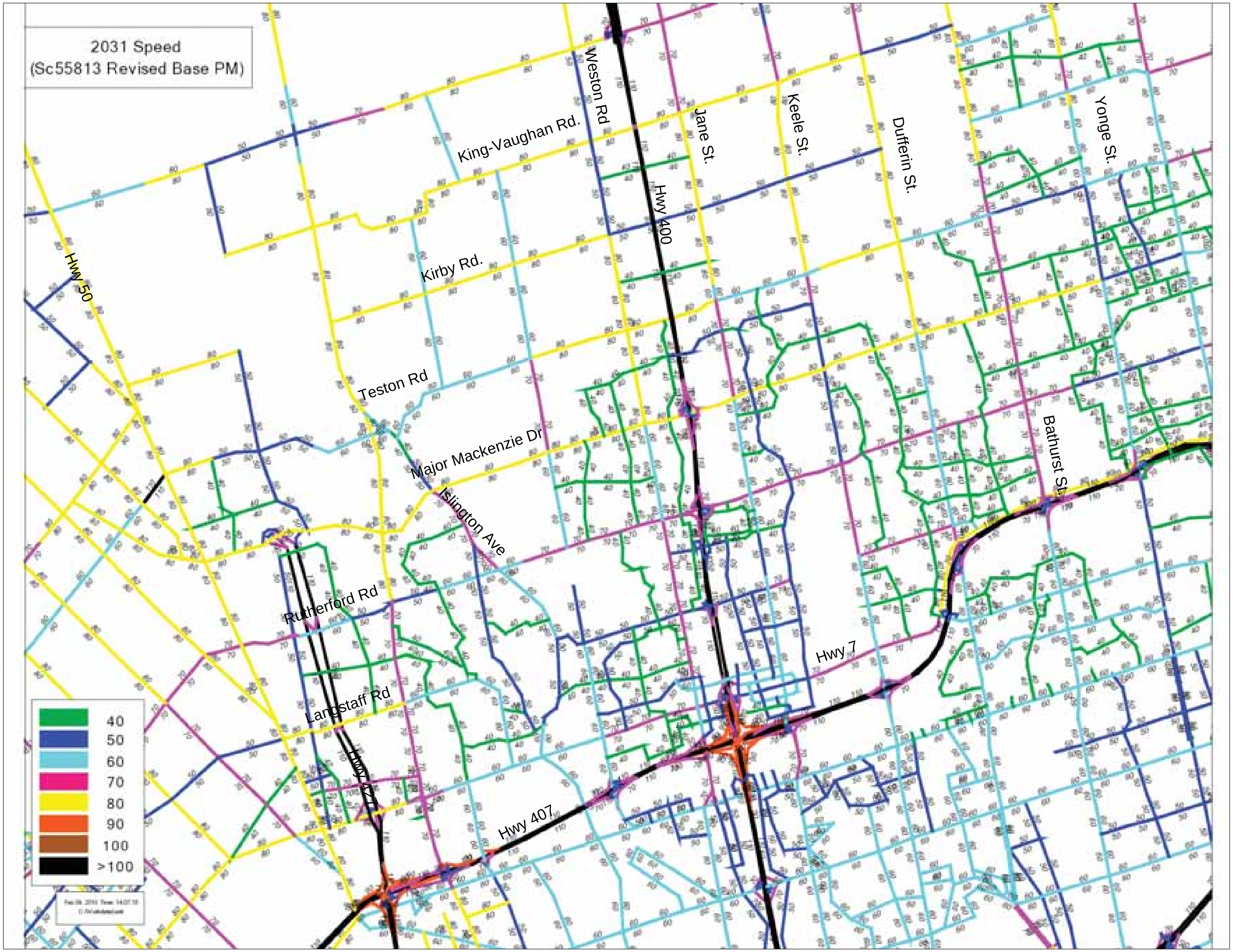

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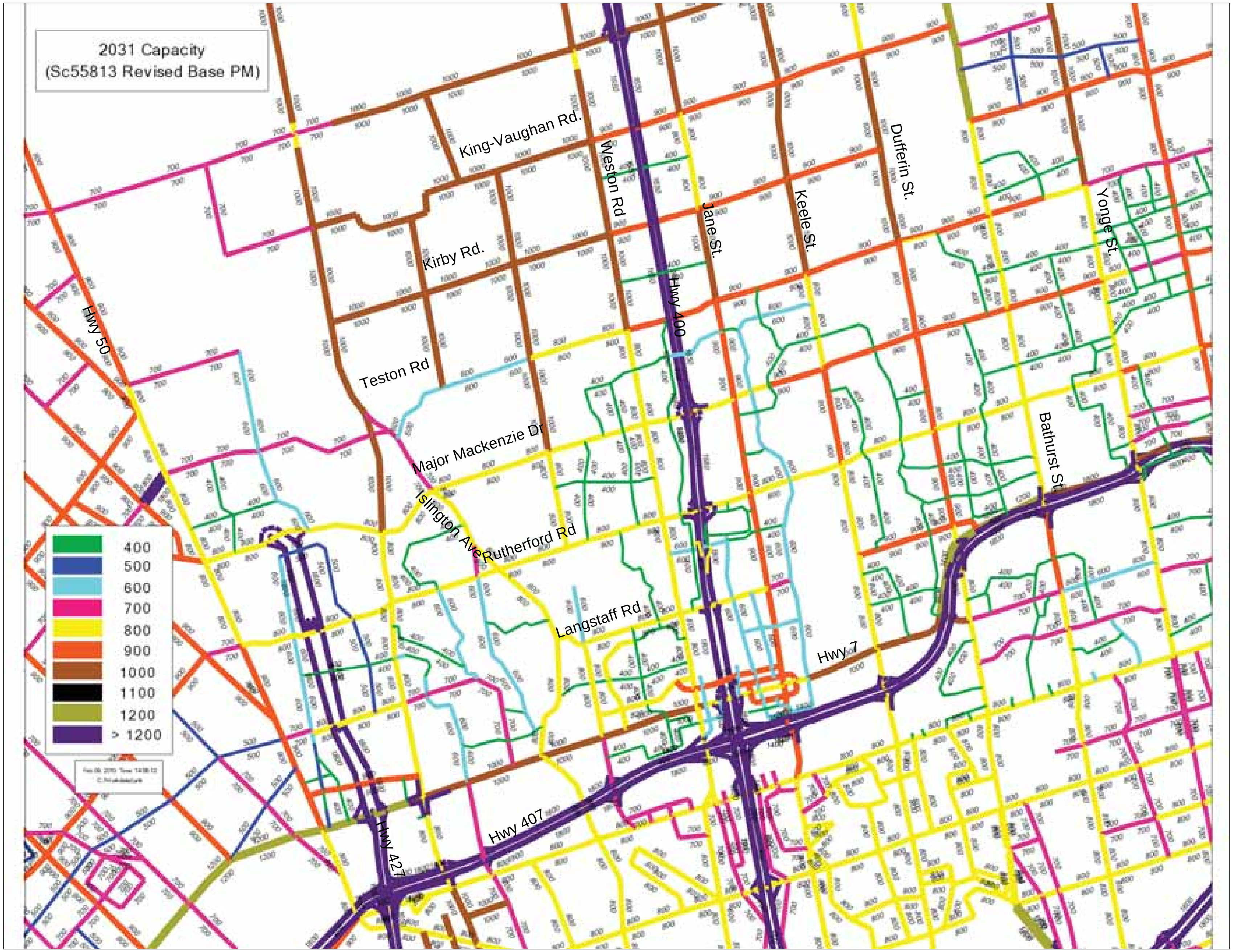

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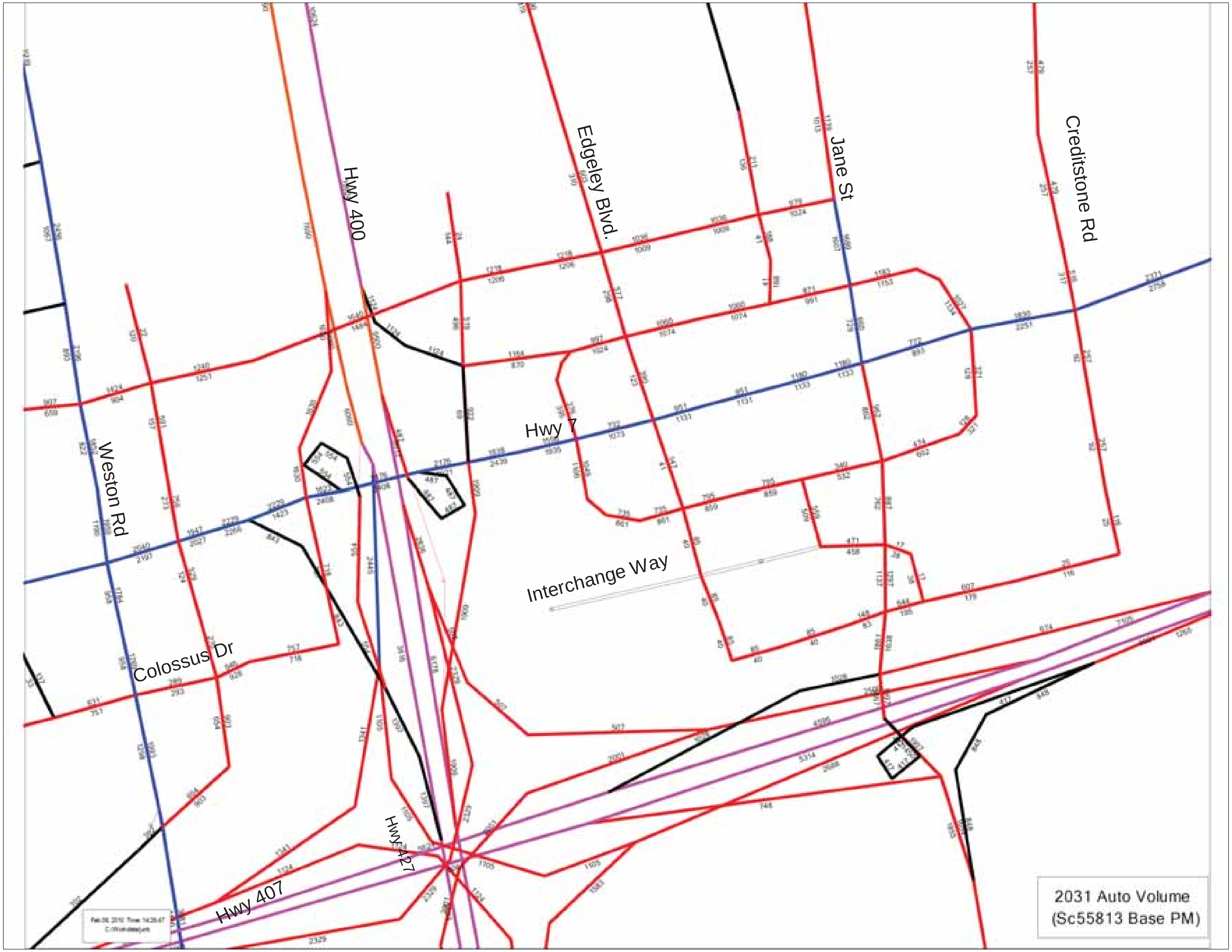
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 400
Hwy 7
Interchange Way
Weston Rd
Colossus Dr
Hwy 407
Hwy 427
2031 Auto Volume
(Sc55813 Base PM)

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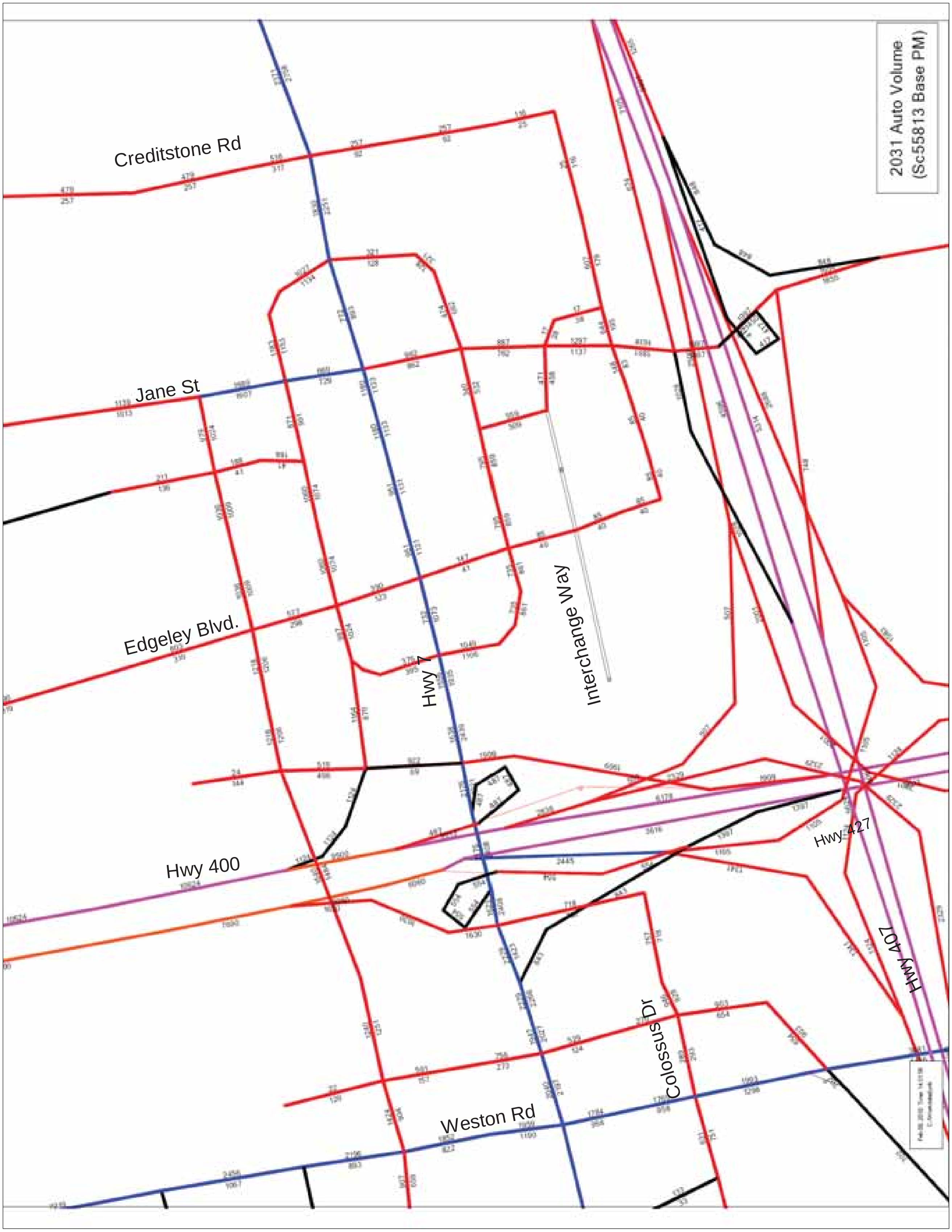

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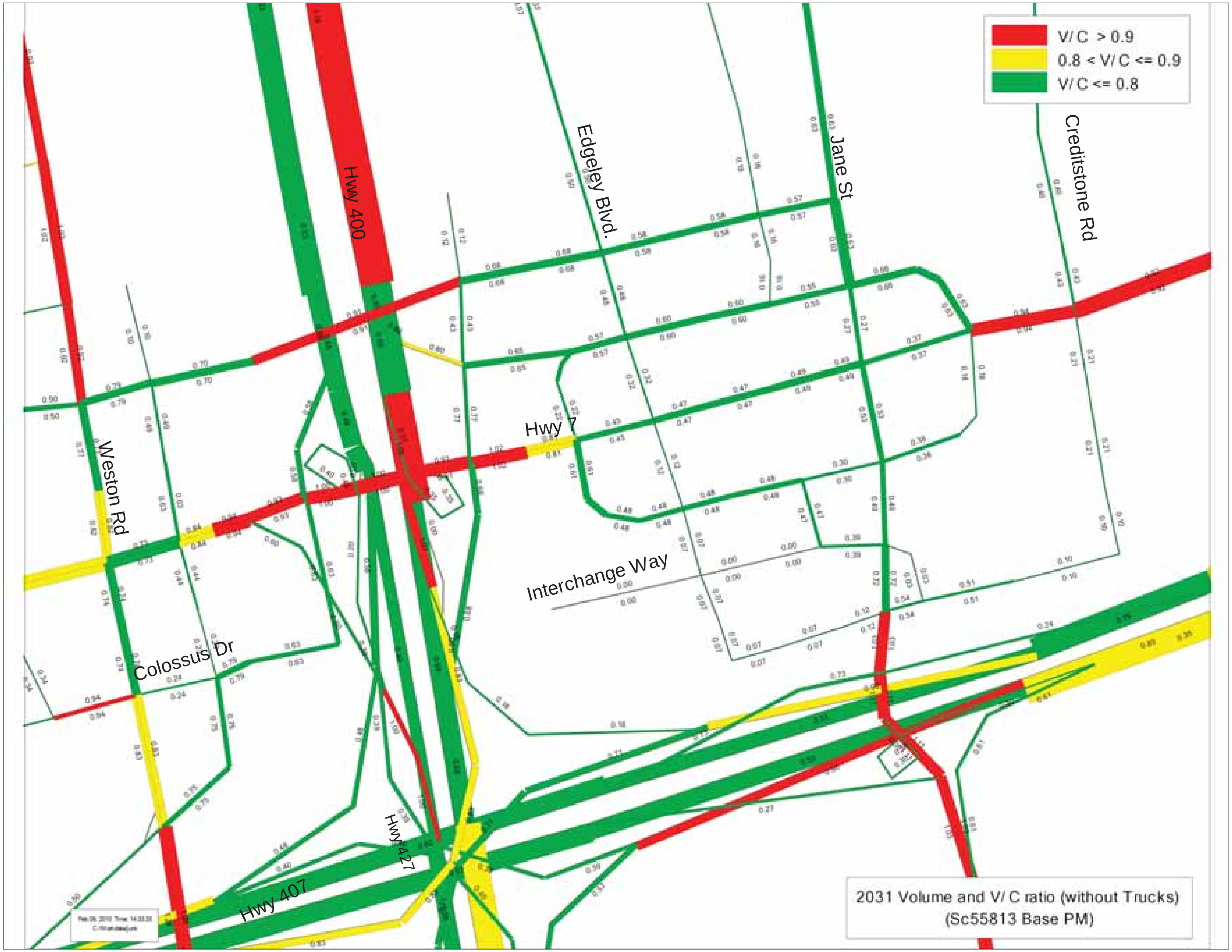
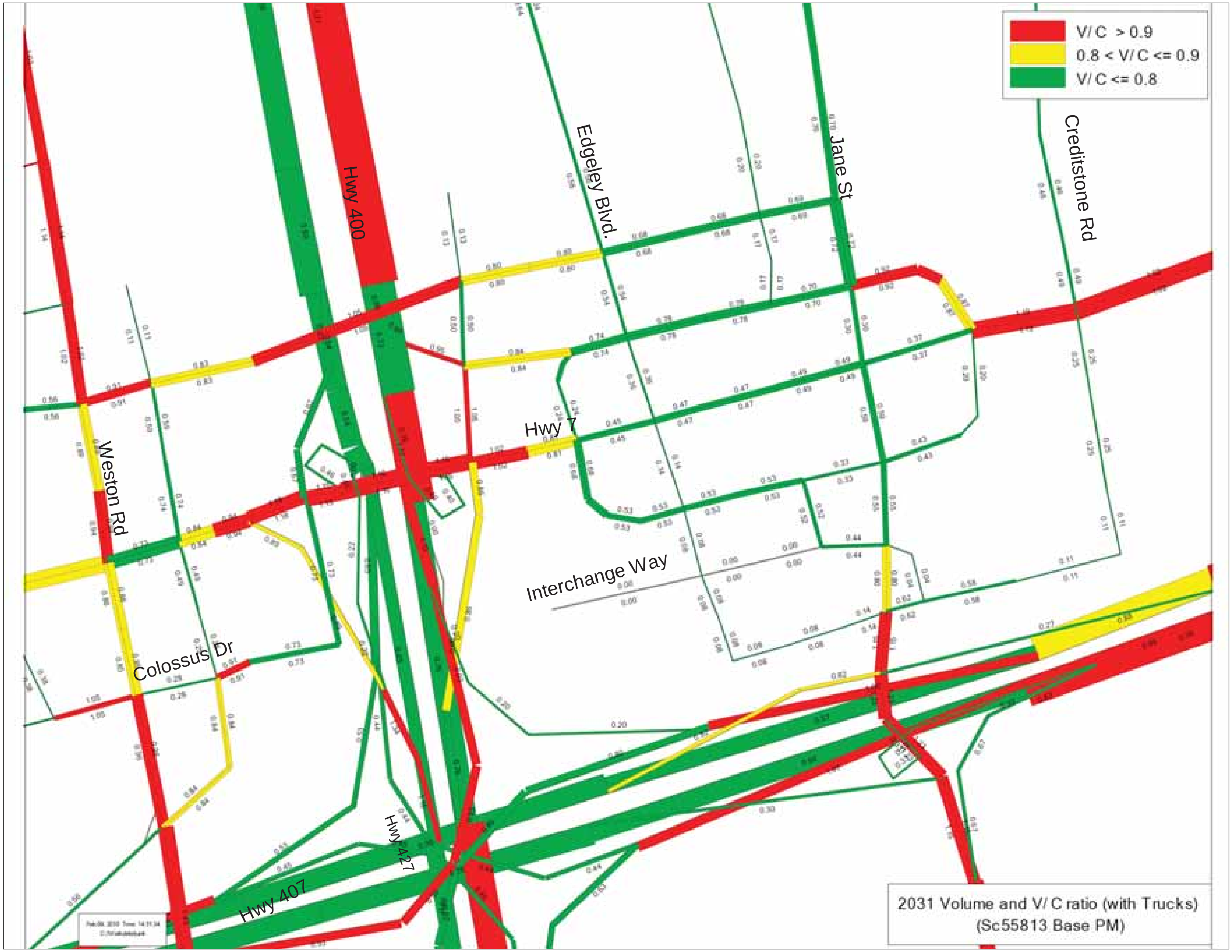
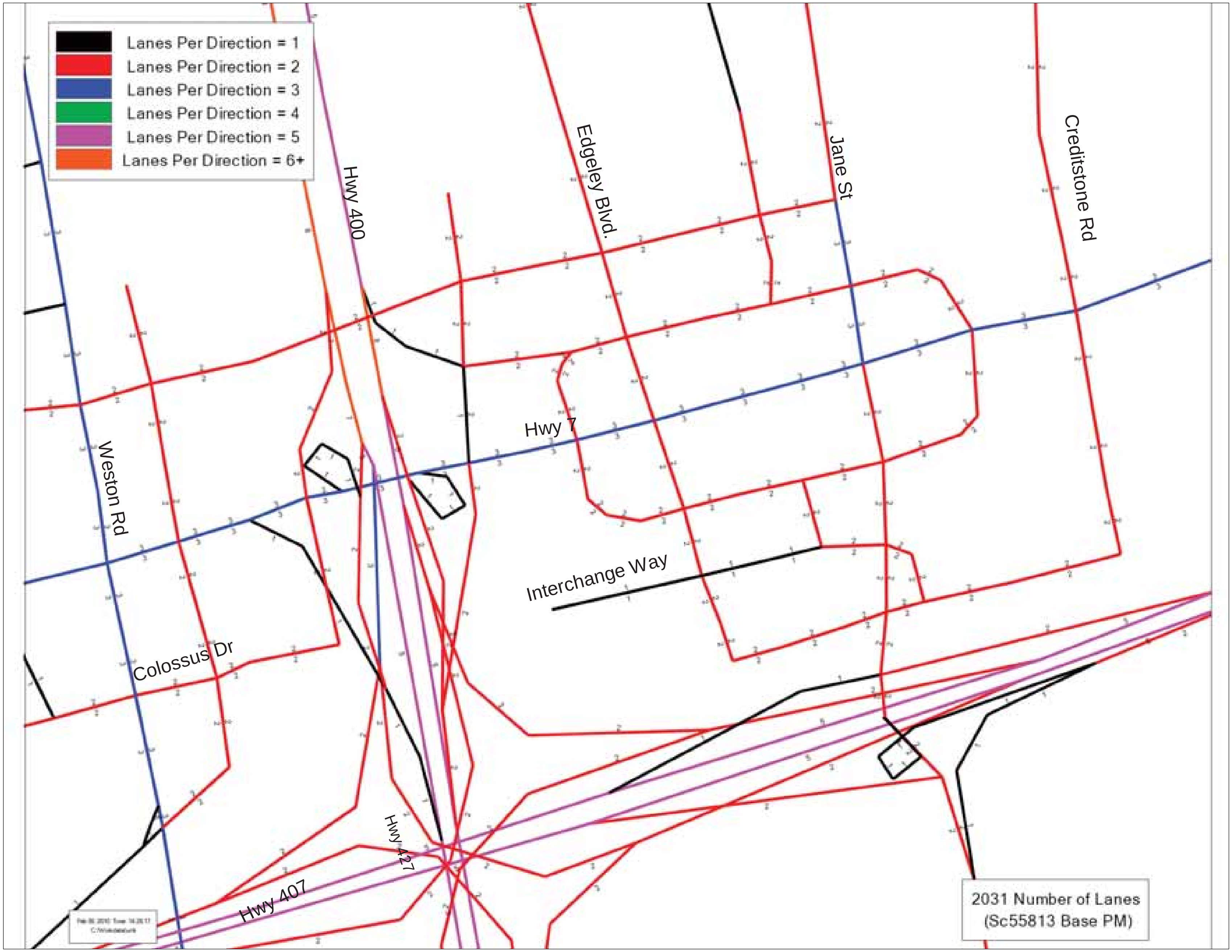

V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 400
Hwy 7
Interchange Way
Weston Rd
Colossus Dr
Hwy 427
Hwy 407
2031 Volume and V/C ratio (without Trucks)
(Sc55813 Base PM)



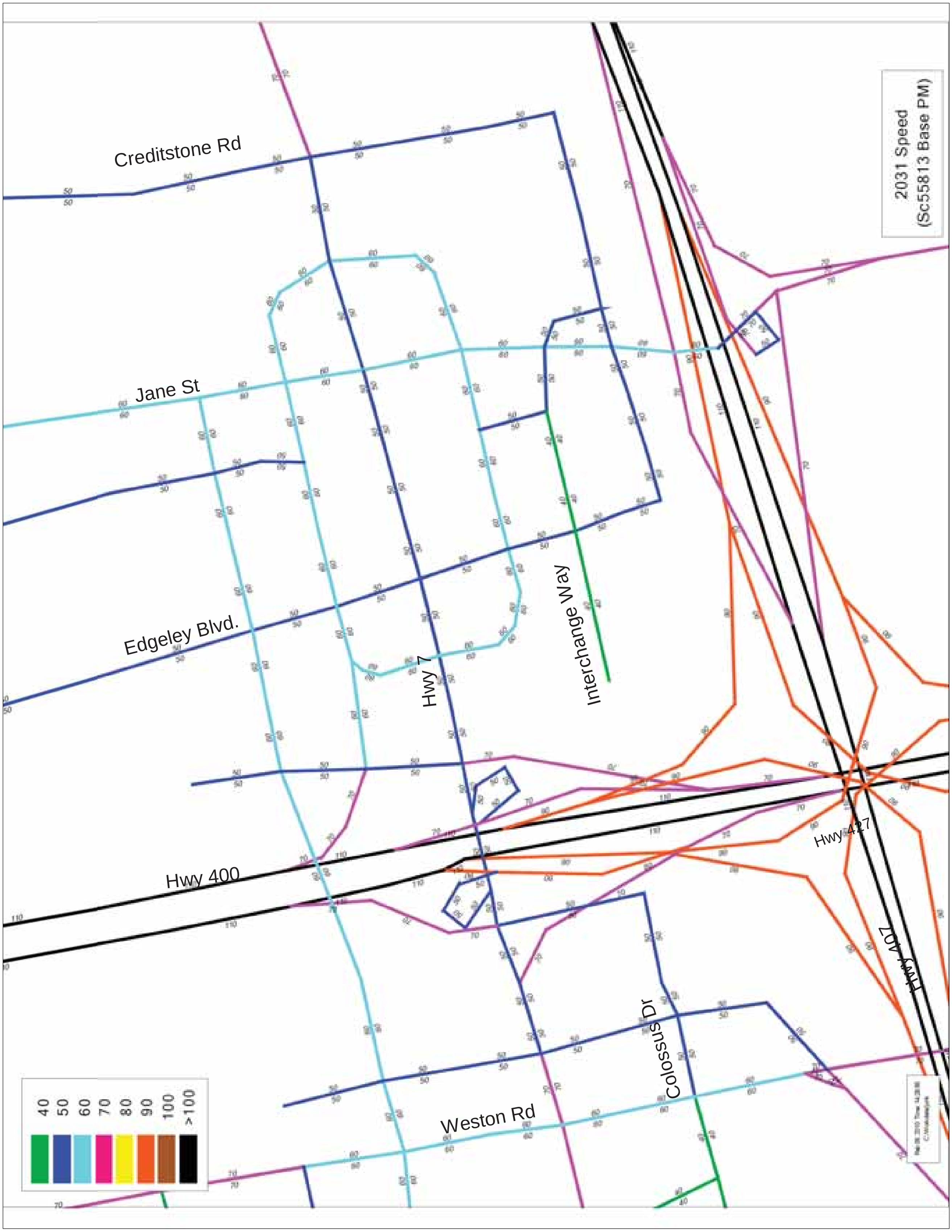
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 400
Hwy 7
Interchange Way
Weston Rd
Colossus Dr
Hwy 407
Hwy 427
2031 Volume and V/C ratio (with Trucks)
(Sc55813 Base PM)

DRAFT


Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6+
Hwy 400
Edgeley Blvd.
Jane St
Creditstone Rd
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Number of Lanes
(Sc55813 Base PM)

DRAFT

DRAFT



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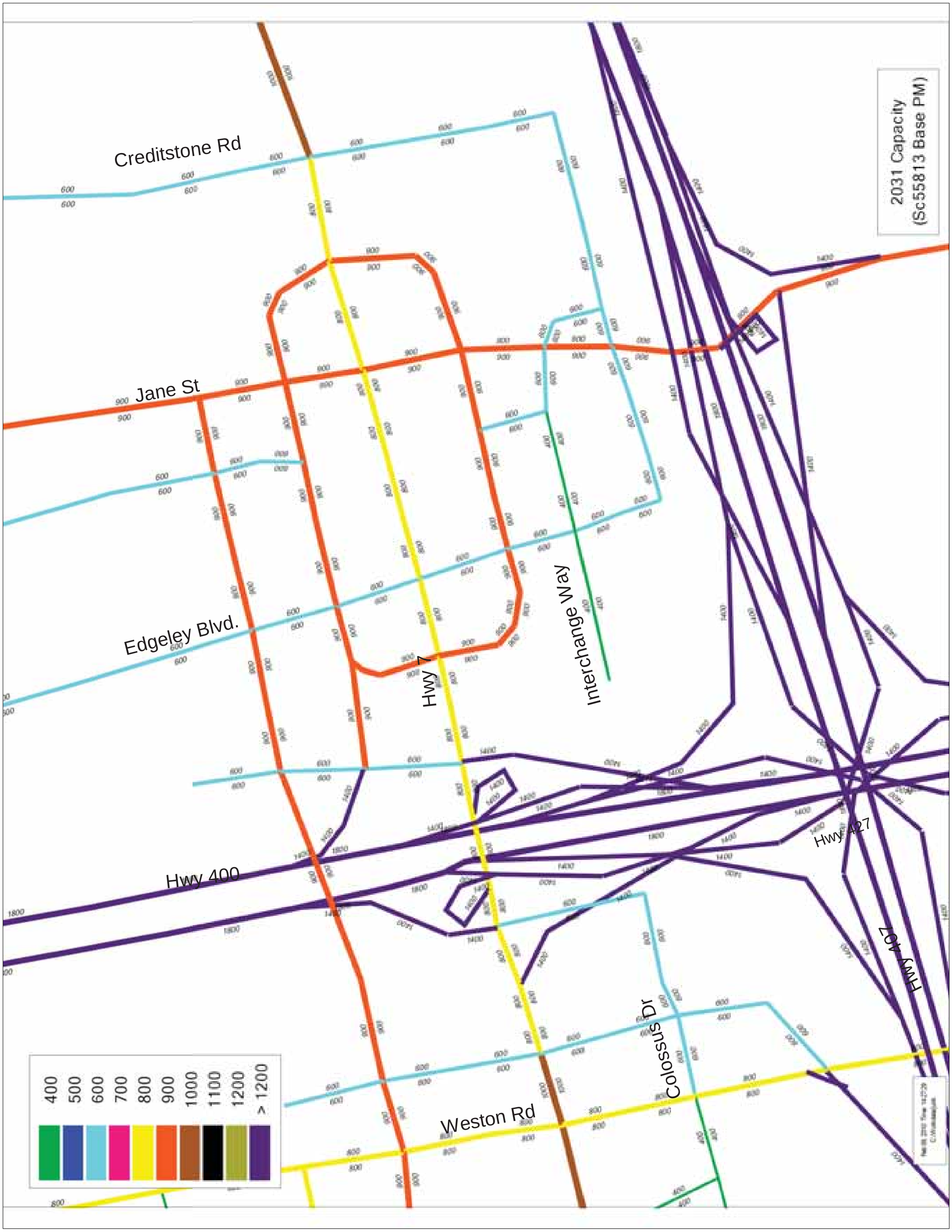

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Appendix C
Sc 70813
Revised VSAM 2031 Alt AM

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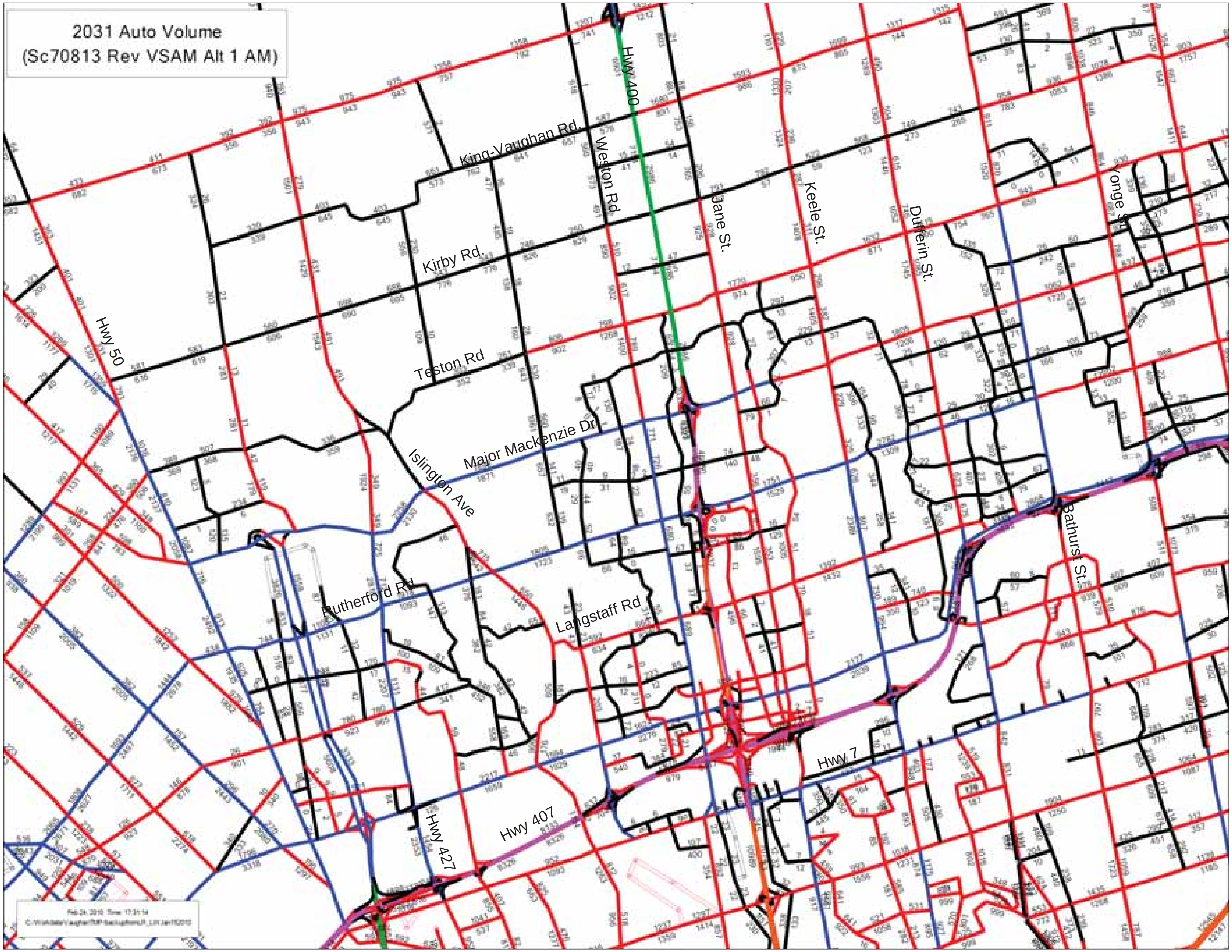

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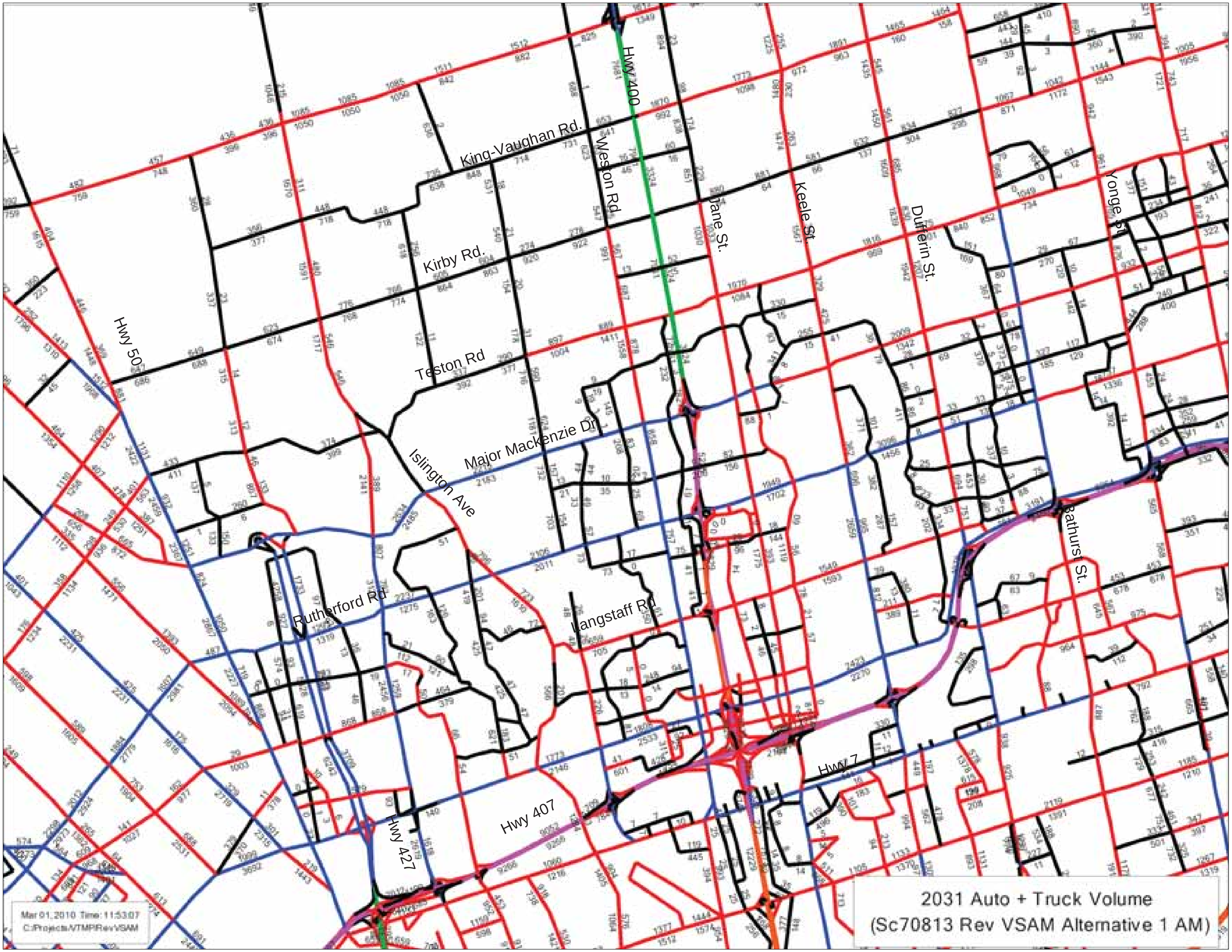

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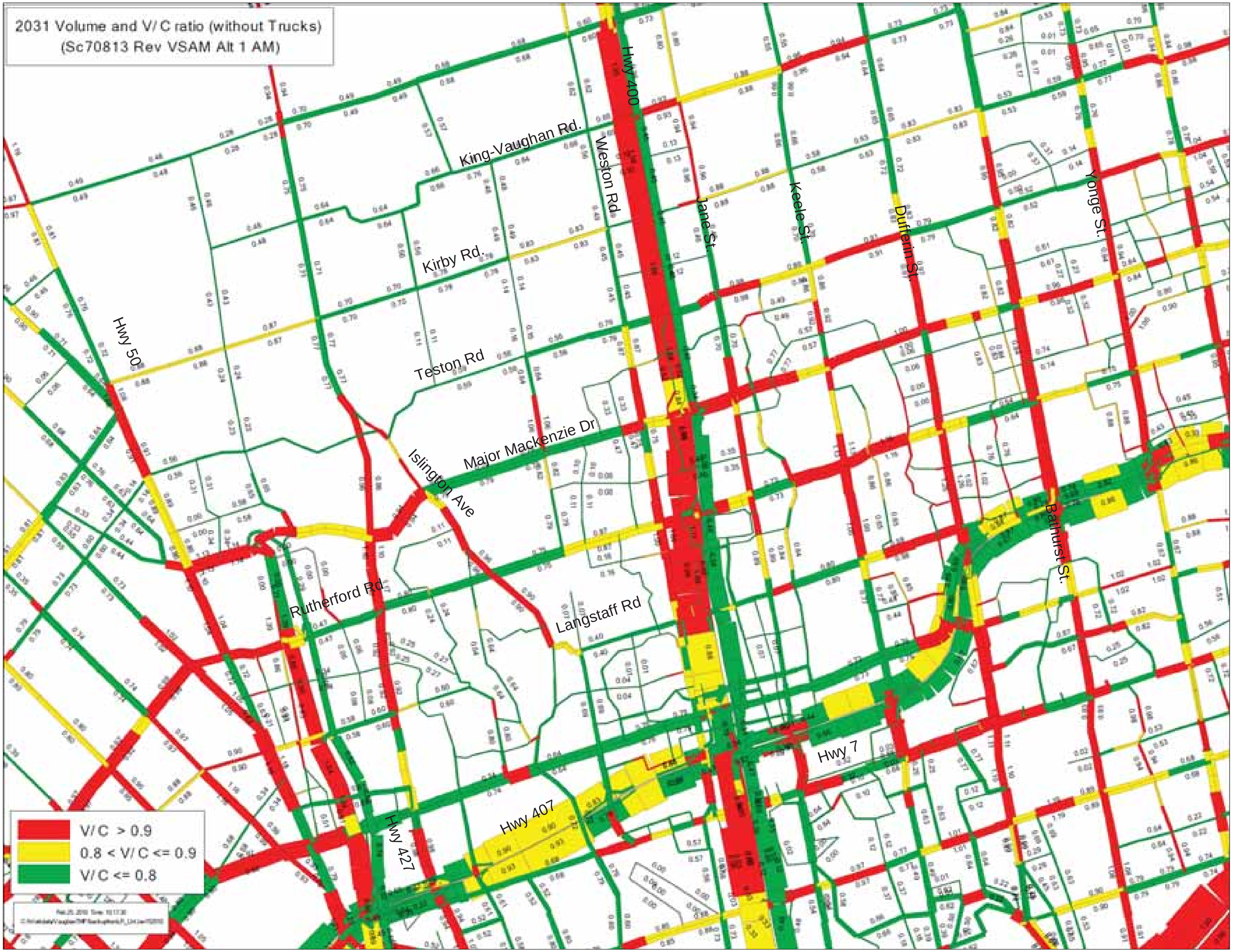
2031 Volume and V/C ratio (without Trucks)
(Sc70813 Rev VSAM Alt 1 AM)
Hwy 400
King-Vaughan Rd.
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Kirby Rd.
Hwy 50
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Bathurst St.
Hwy 7
Hwy 407
Hwy 427
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8

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2031 Volume and V/C ratio (with Trucks)
(Sc70813 Revised Alternative 1 AM)
Hwy 400
Weston Rd
King-Vaughan Rd.
Jane St.
Keele St.
Dufferin St.
Yonge St.
Kirby Rd.
Hwy 50
Teston Rd
Major Mackenzie Dr
Islington Ave
Bathurst St.
Rutherford Rd
Langstaff Rd
Hwy 7
Hwy 407
Hwy 427
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8

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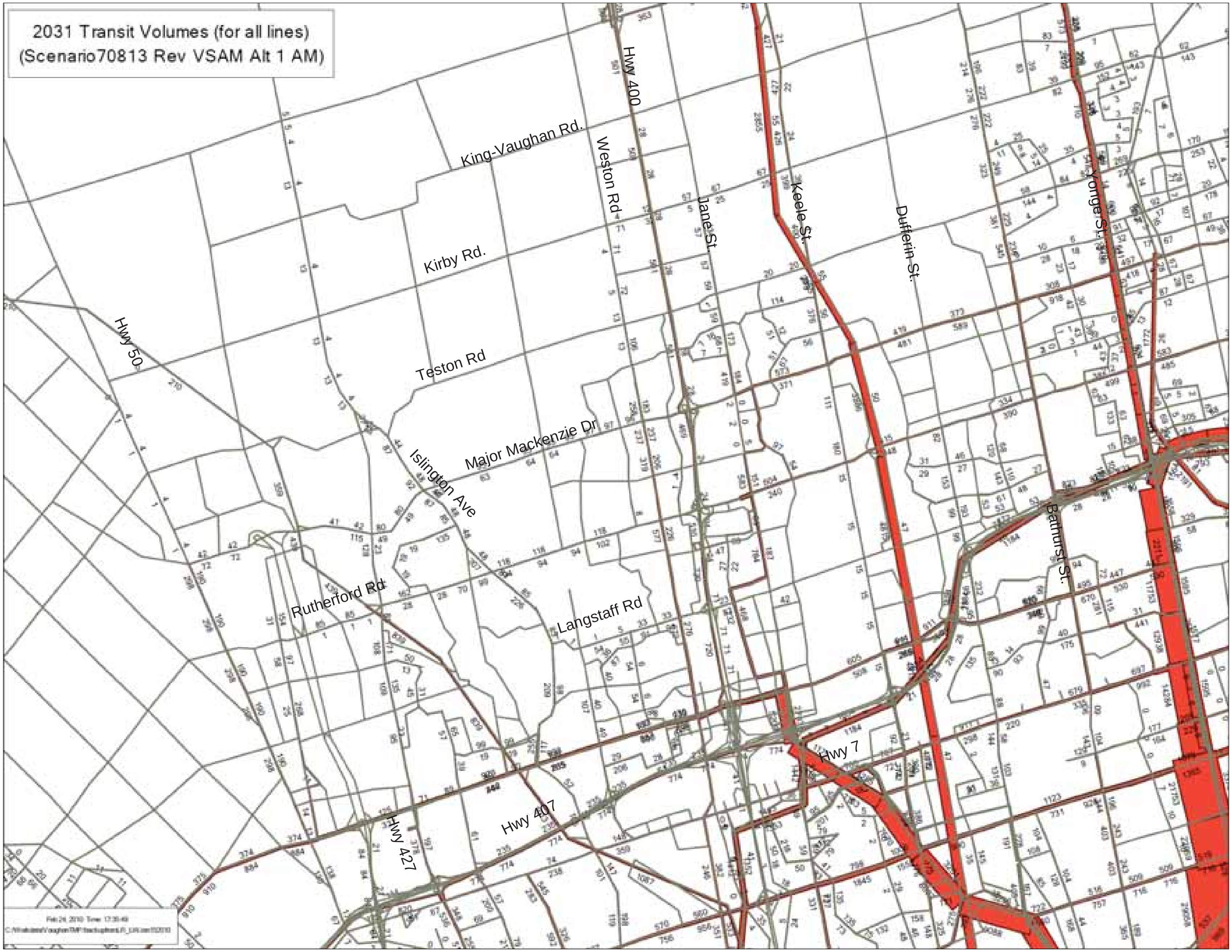
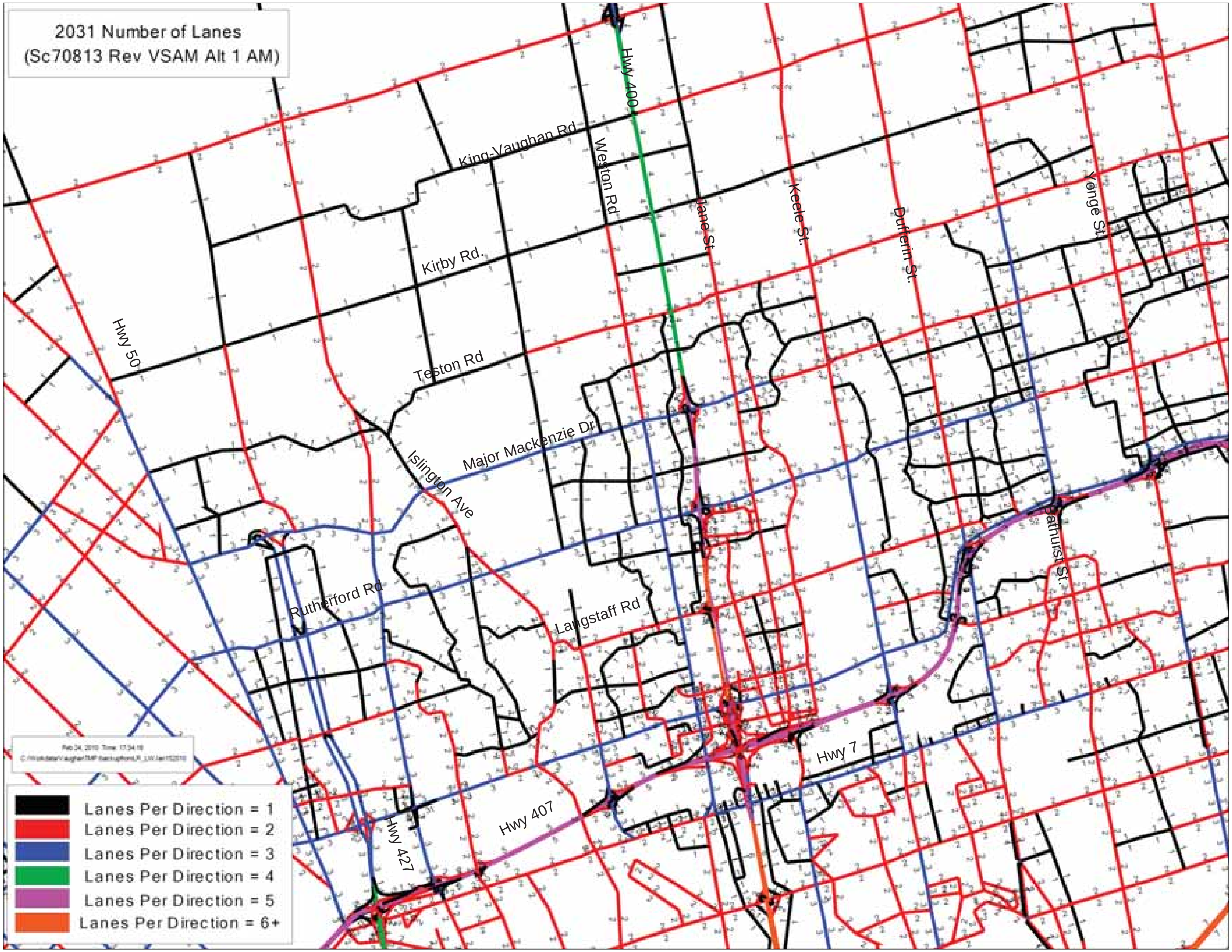
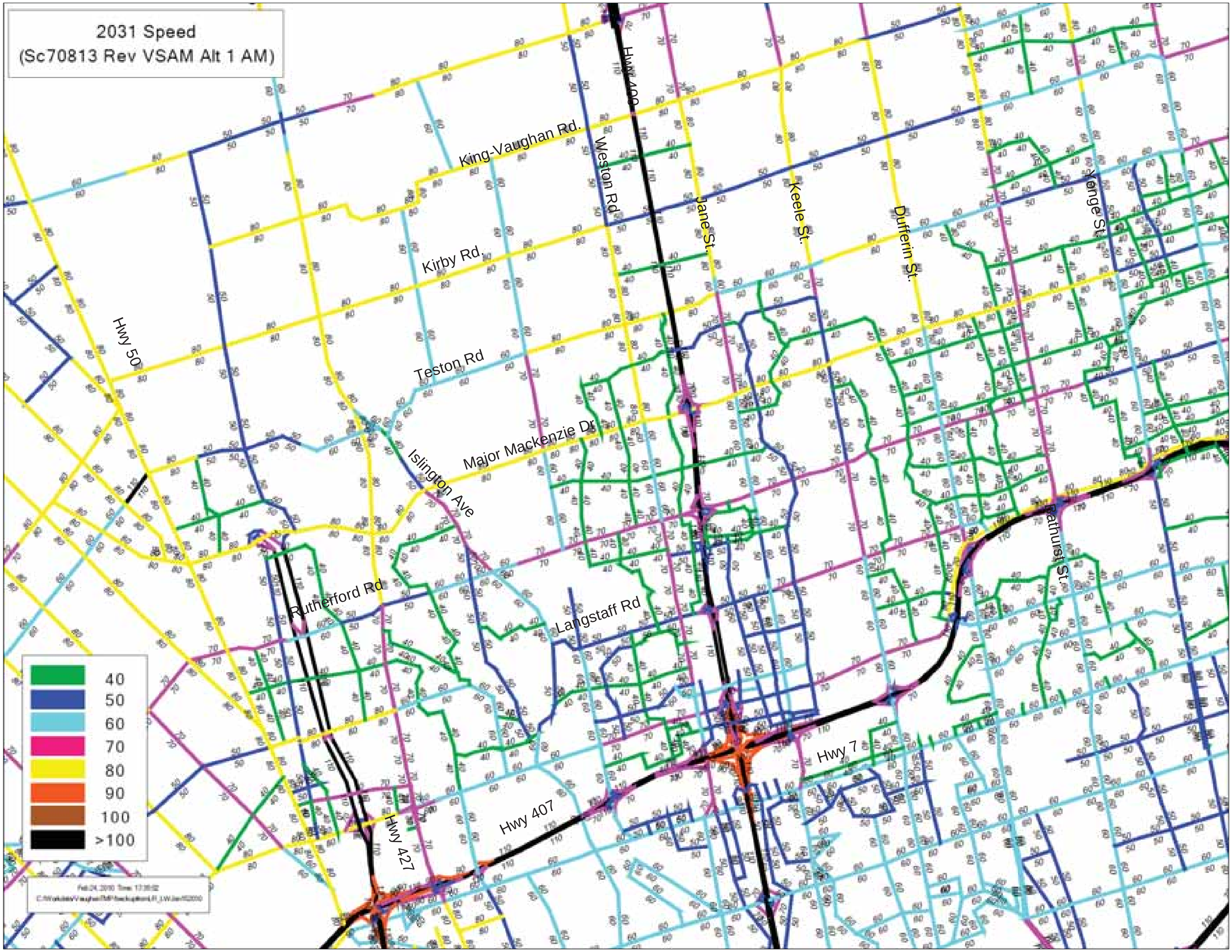


DRAFT

Halcrow



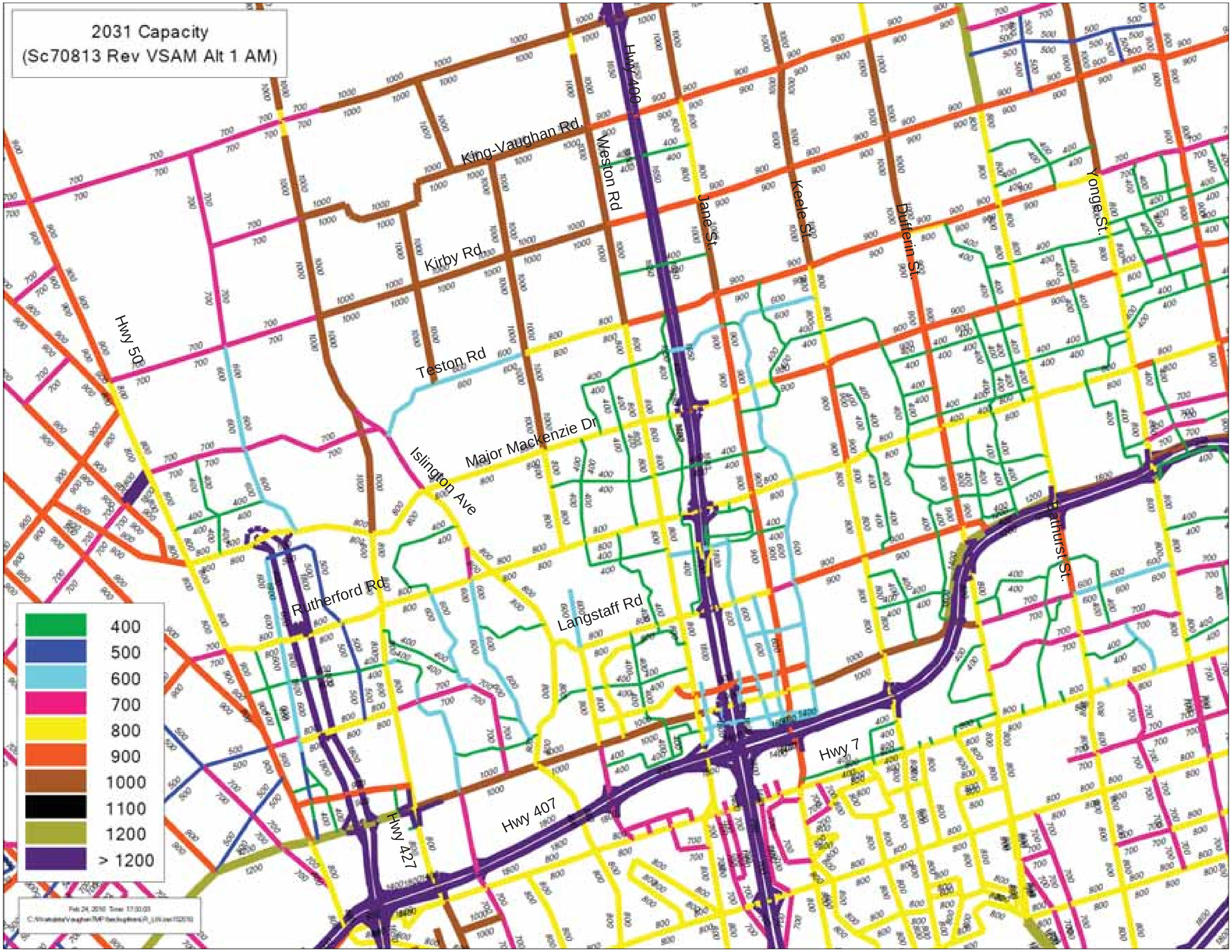
DRAFT



2031 Speed
(Sc70813 Rev VSAM Alt 1 AM)
King-Vaughan Rd.
Weston Rd
Hwy 400
Jane St.
Keele St.
Dufferin St.
Yonge St.
Kirby Rd.
Teston Rd
Hwy 50
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Bathurst St.
Hwy 7
Hwy 407
Hwy 427
40
50
60
70
80
90
100
>100

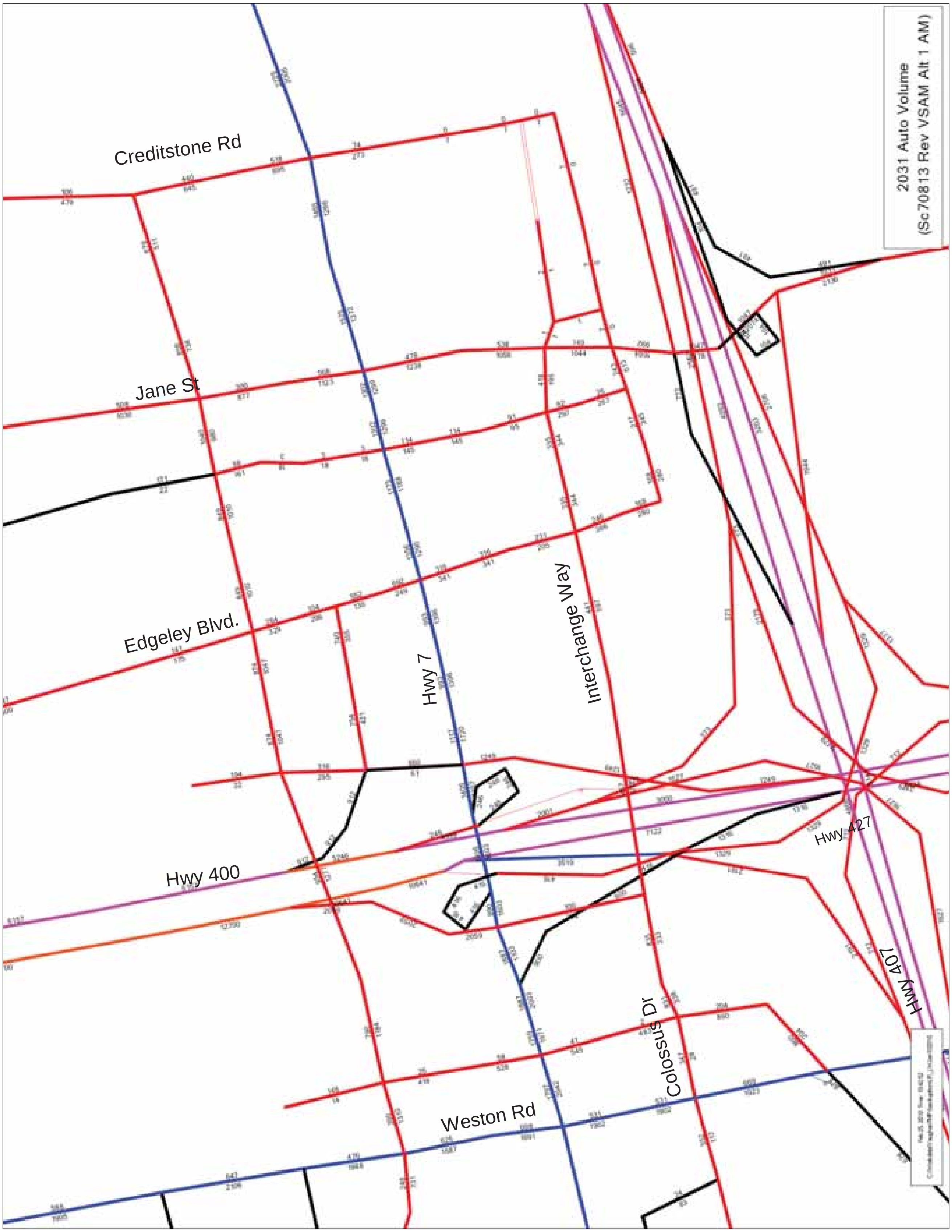
DRAFT

Halcrow



DRAFT

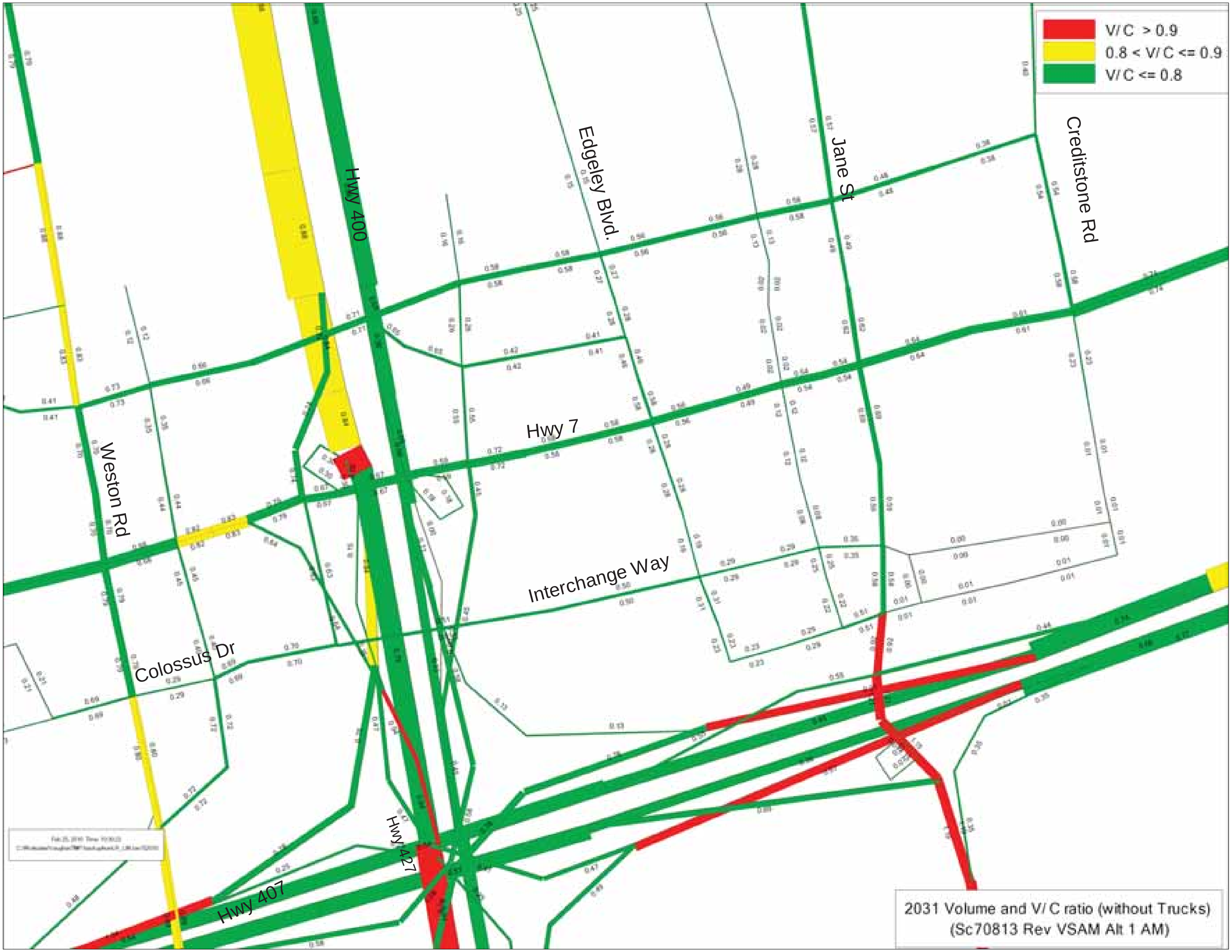
DRAFT



Halcrow

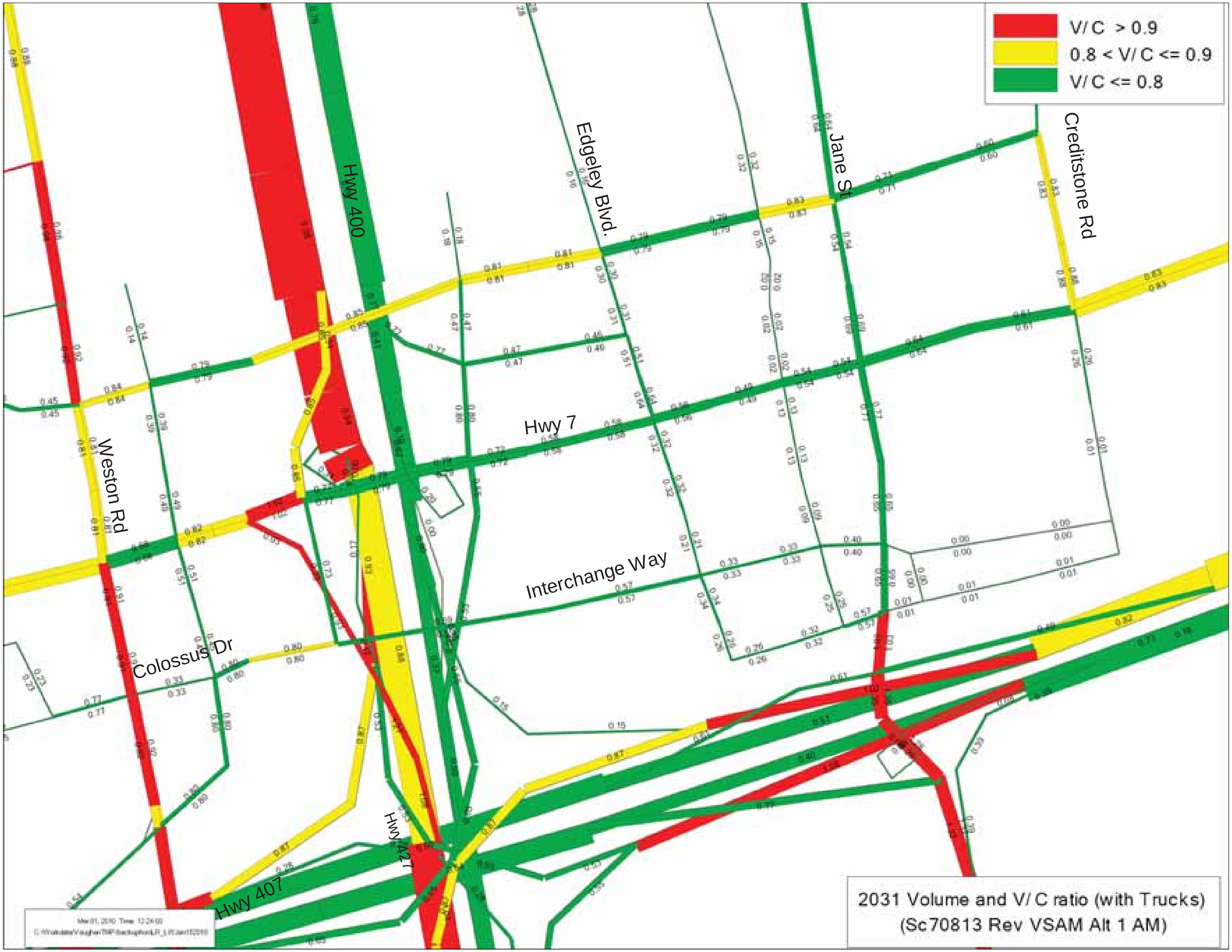
Halcrow

Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 400
Hwy 7
Interchange Way
Weston Rd
Colossus Dr
Hwy 427
Hwy 407
Mar 01, 2010 Time: 12:21:18
2031 Auto + Truck Volume
(Sc70813 Rev VSAM Atl 1 AM)


V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 7
Interchange Way
Hwy 400
Hwy 427
Hwy 407
Colossus Dr
Weston Rd
2031 Volume and V/C ratio (without Trucks)
(Sc70813 Rev VSAM Alt 1 AM)

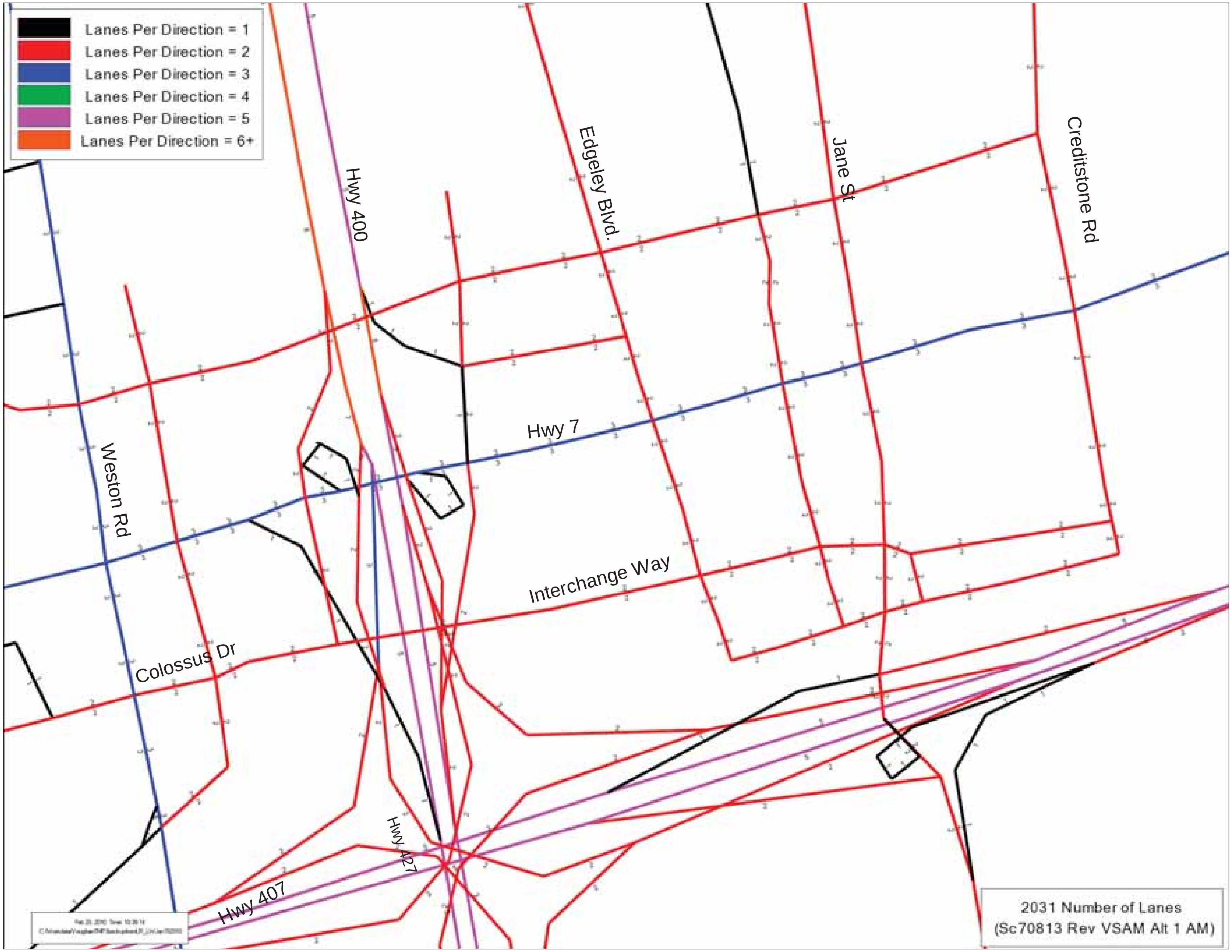
DRAFT

Halcrow



DRAFT

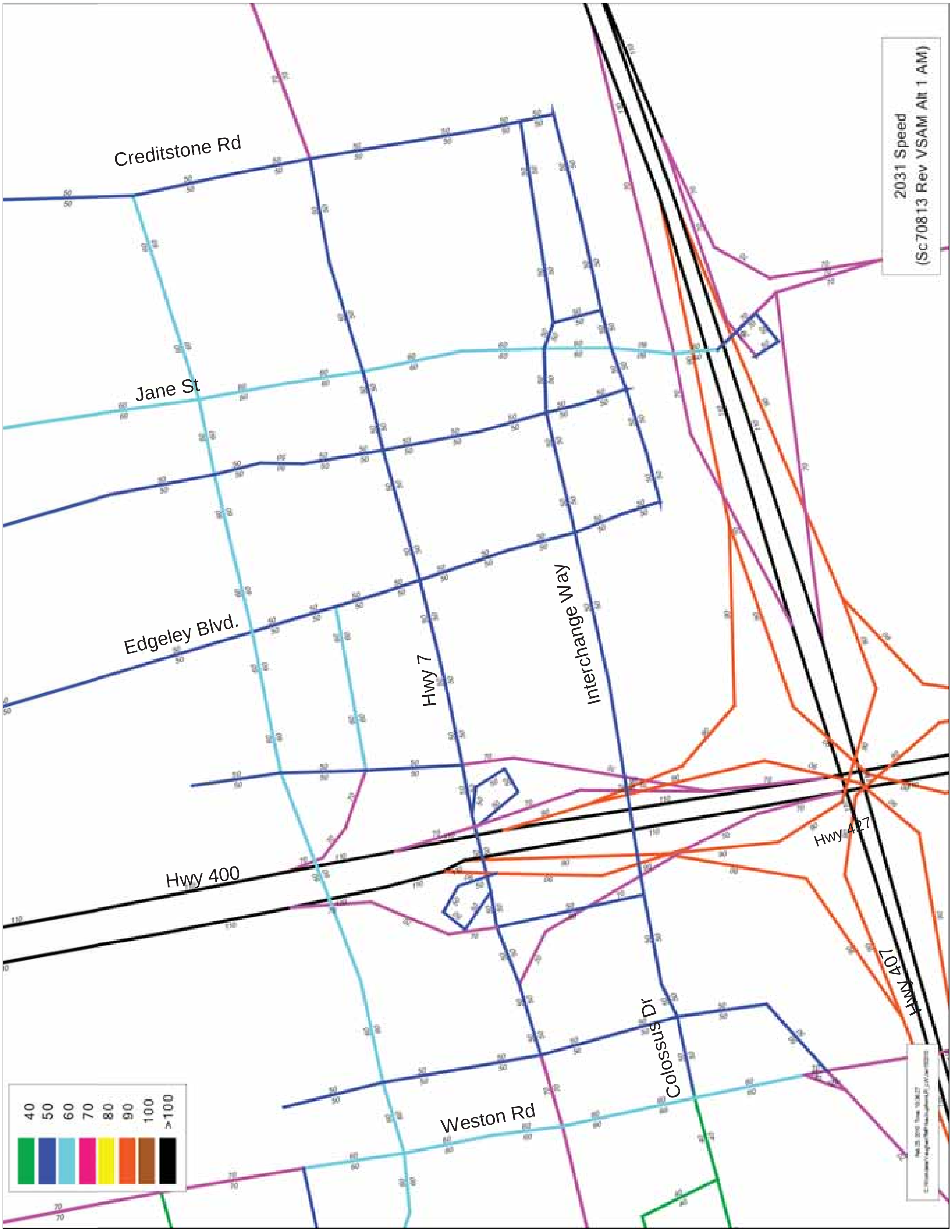
2031 Transit Volumes (for all lines)
(Scenario70813 Rev VSAM Alt 1 AM)
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 7
Interchange Way
Hwy 400
Hwy 427
Hwy 407
Colossus Dr
Weston Rd



Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6+
Hwy 400
Edgeley Blvd.
Jane St
Creditstone Rd
Weston Rd
Hwy 7
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Number of Lanes
(Sc70813 Rev VSAM Alt 1 AM)

DRAFT

DRAFT



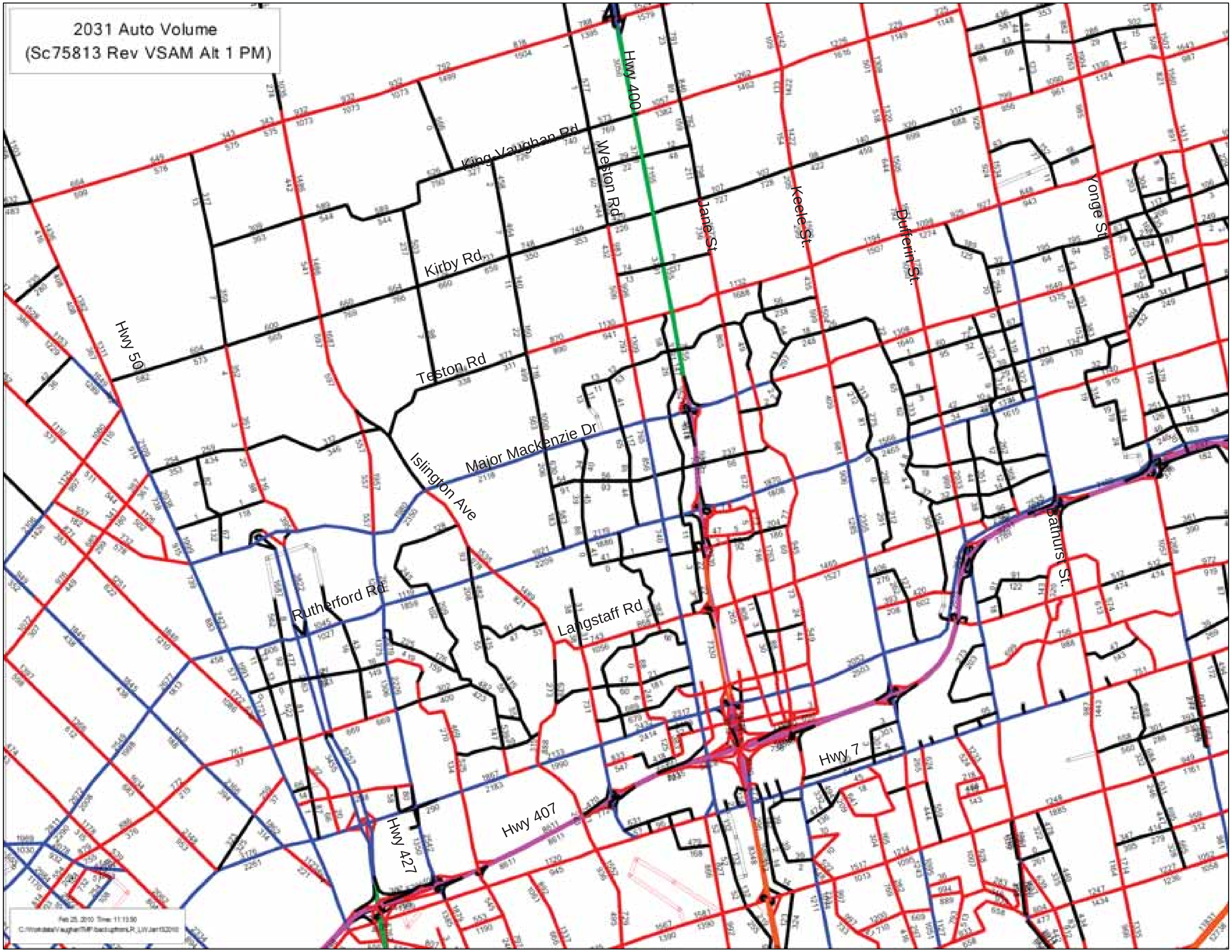
Halcrow

400
500
600
700
800
900
1000
1100
1200
> 1200
Hwy 400
Edgeley Blvd.
Jane St
Creditstone Rd
Weston Rd
Hwy 7
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Capacity
(Sc70813 Rev VSAM Alt 1 AM)

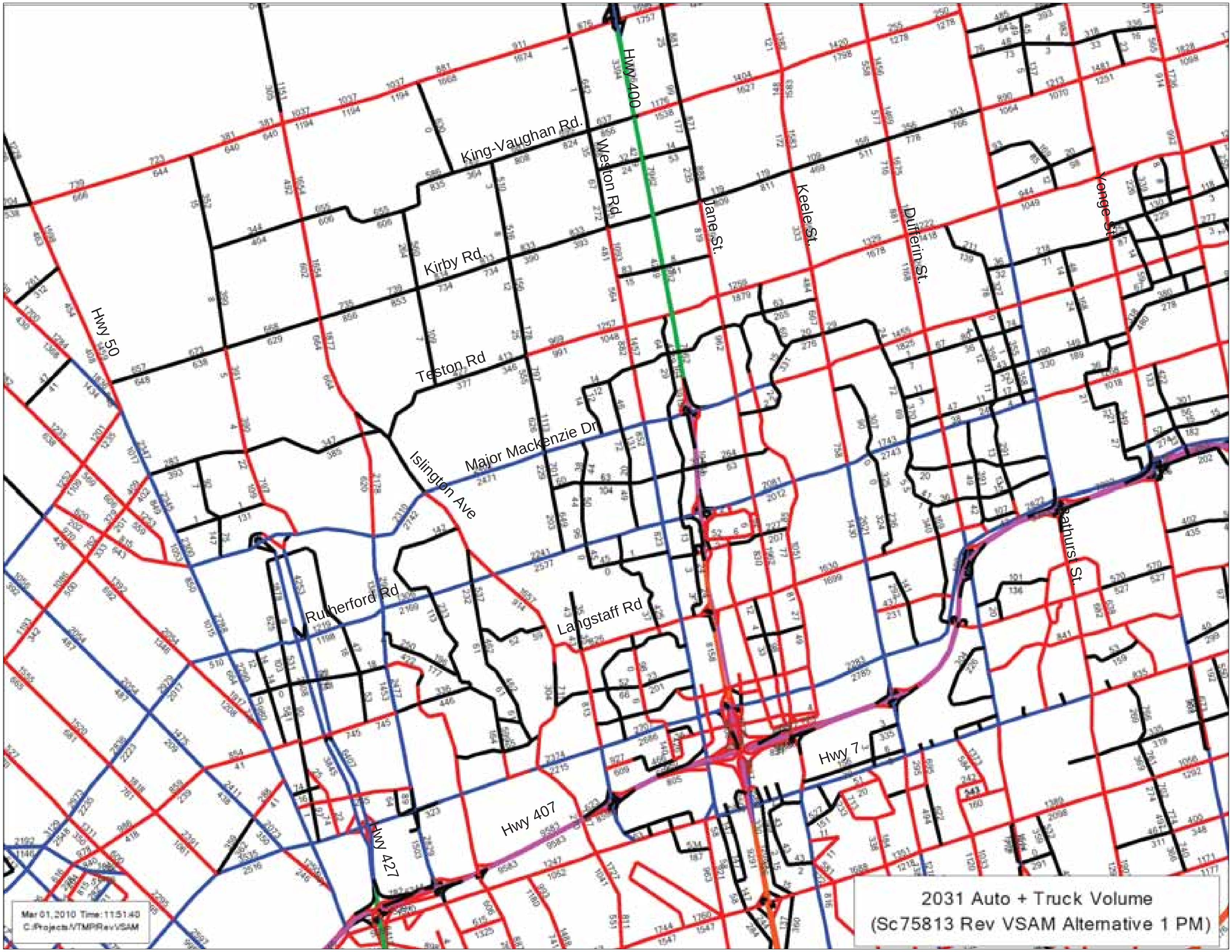
DRAFT

Appendix D
Sc 75813
Revised VSAM 2031 Alt PM

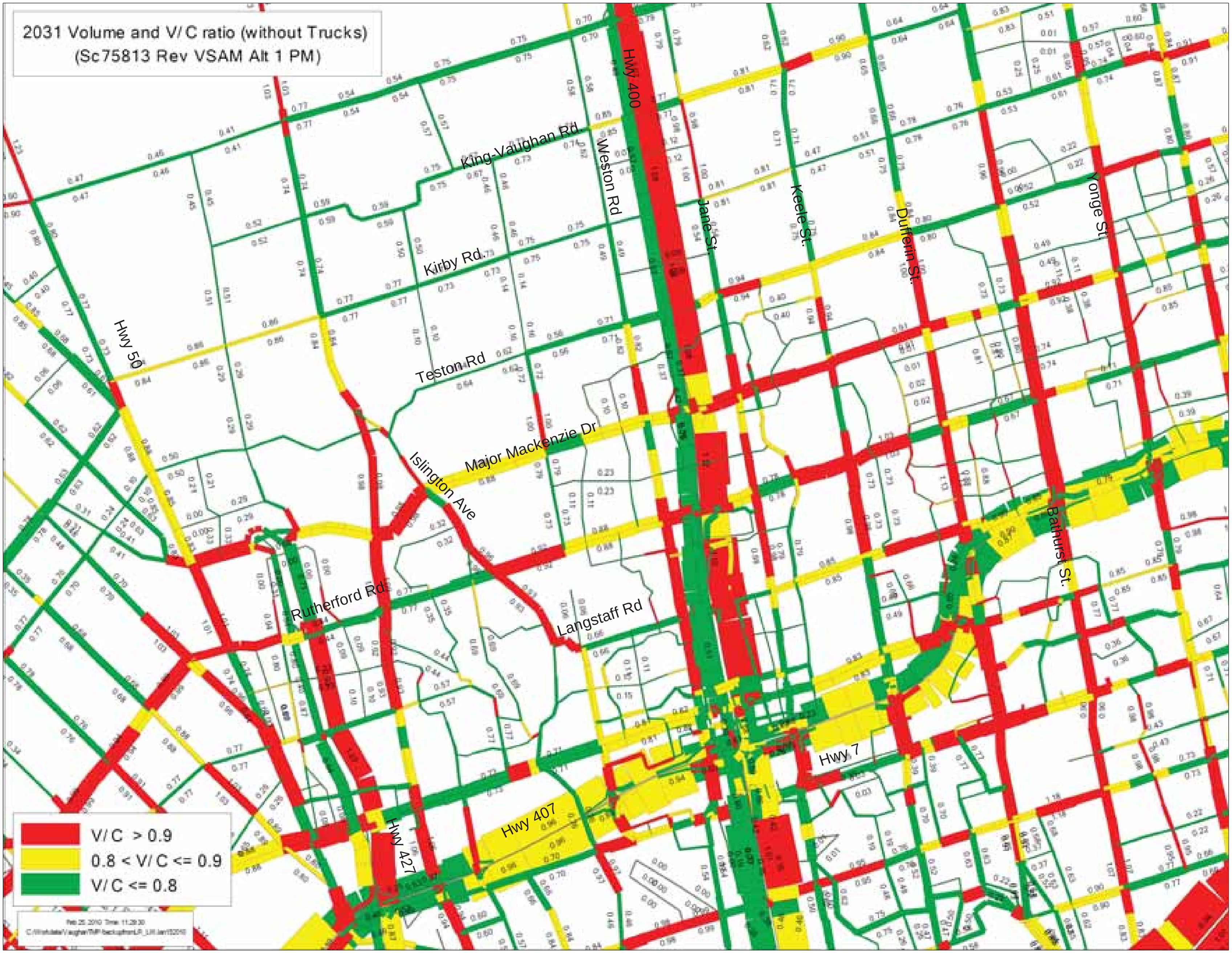
Halcrow



2031 Auto Volume
(Sc75813 Rev VSAM Alt 1 PM)
Hwy 400
King Vaughan Rd
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Kirby Rd.
Hwy 50
Teston Rd
Islington Ave
Major Mackenzie Dr
Bathurst St.
Rutherford Rd
Langstaff Rd
Hwy 7
Hwy 407
Hwy 427


2031 Auto + Truck Volume
(Sc75813 Rev VSAM Alternative 1 PM)
Mar 01, 2010 Time: 11:51:40
C:/Projects/VTMP/RevVSAM
Hwy 400
Hwy 50
Hwy 7
Hwy 407
Hwy 427
King-Vaughan Rd.
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Bathurst St.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd

DRAFT

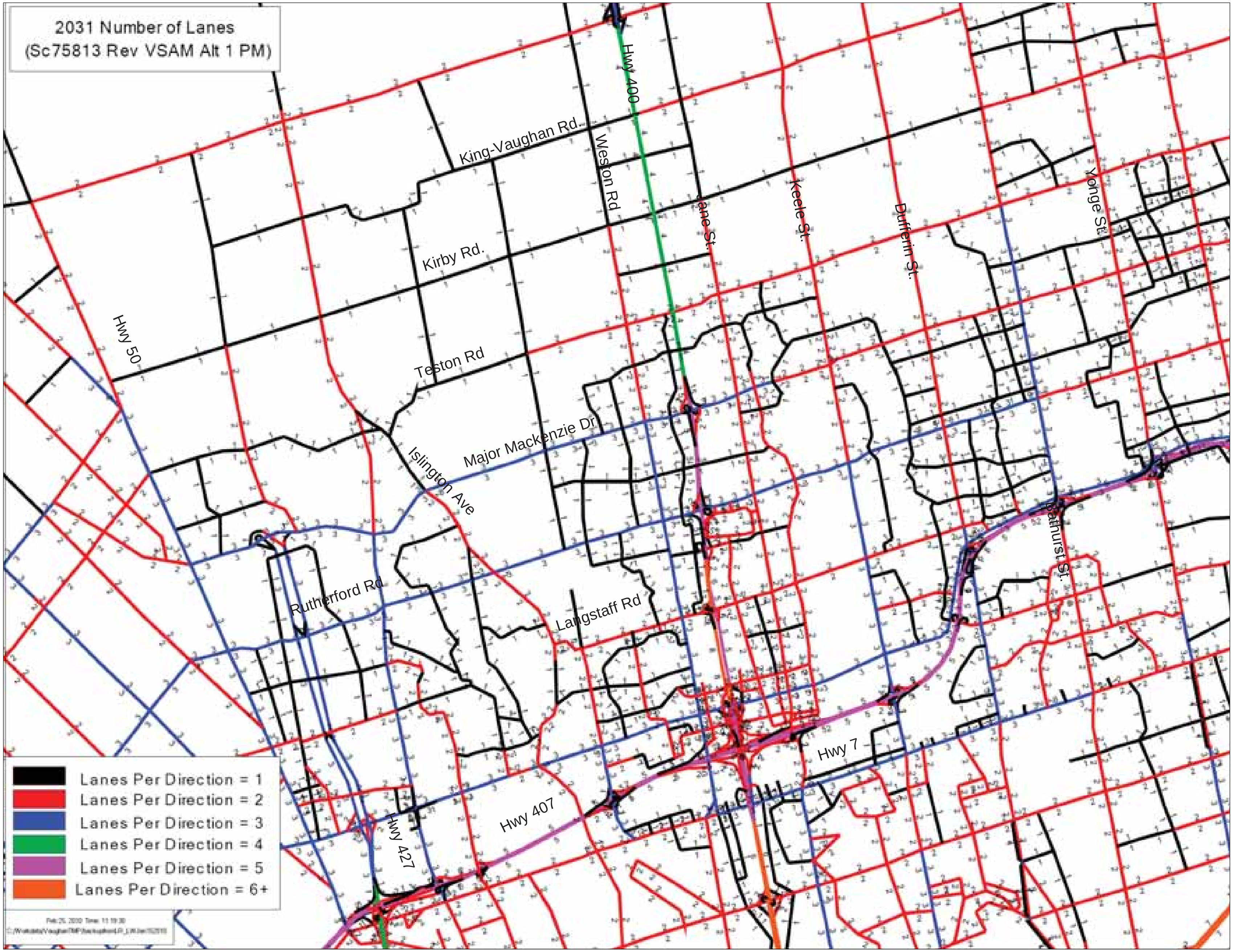

2031 Volume and V/C ratio (without Trucks)
(Sc75813 Rev VSAM Alt 1 PM)
Hwy 400
Weston Rd
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Bathurst St.
Hwy 7
Hwy 407
Hwy 427
Hwy 50
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8

DRAFT

Halcrow

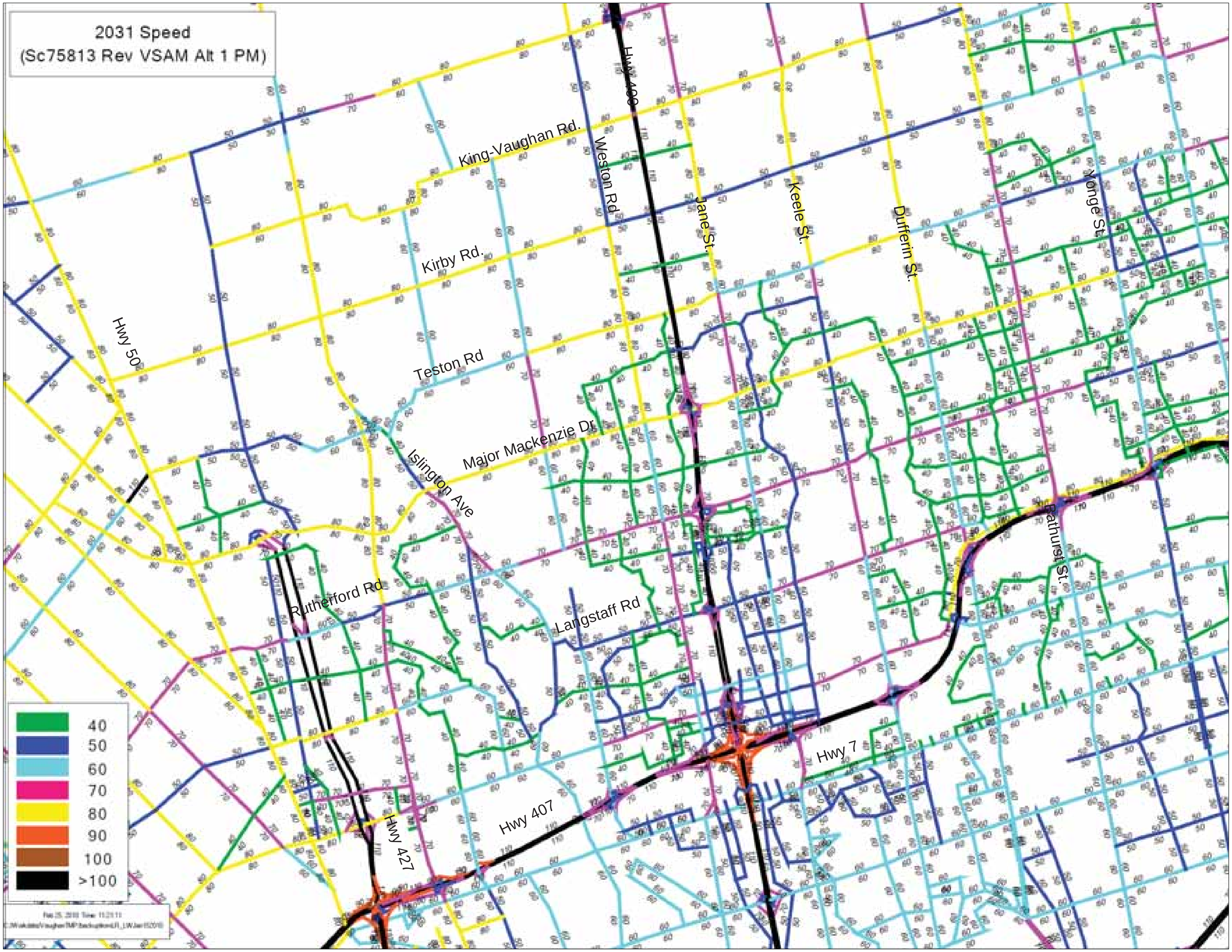
DRAFT

Halcrow



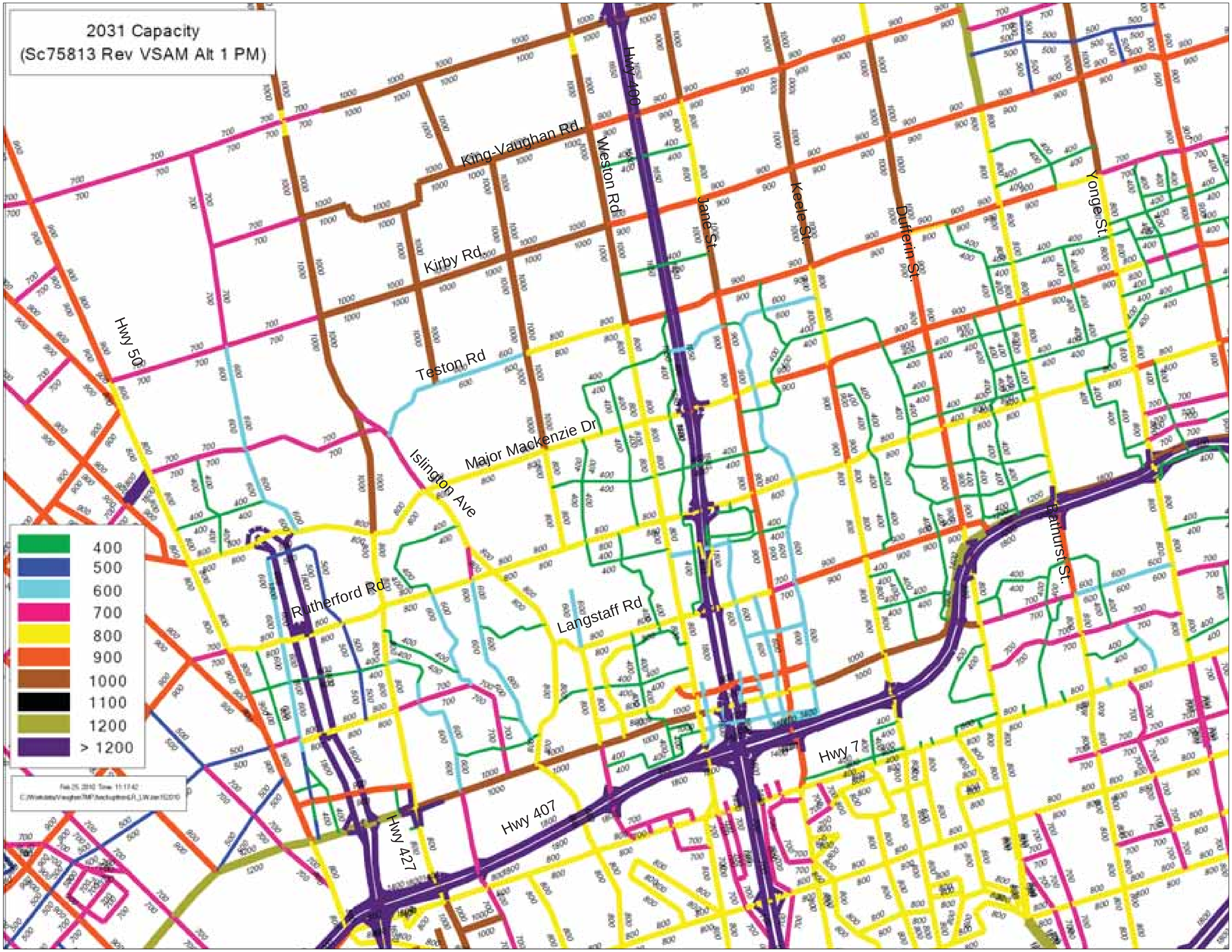
DRAFT

Halcrow



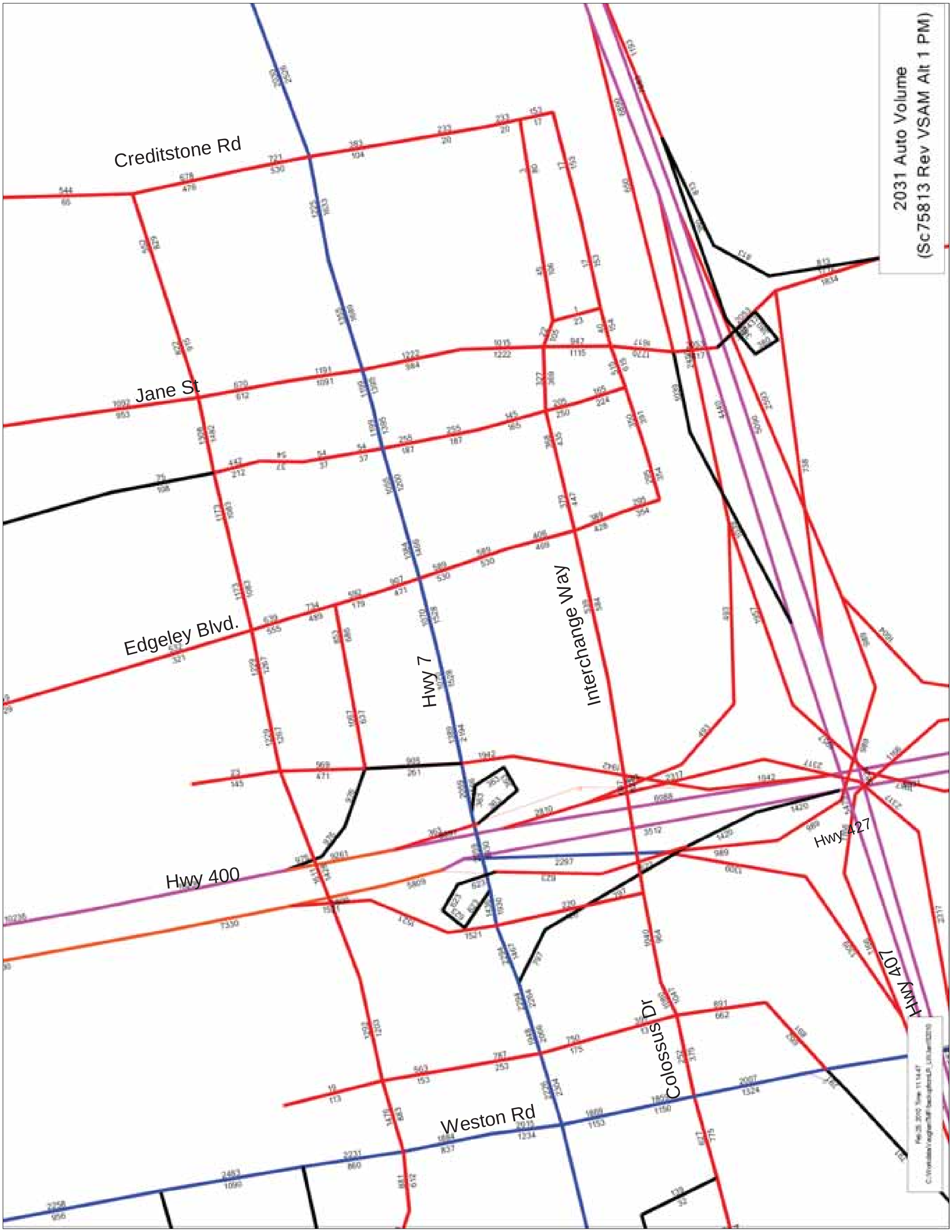
DRAFT

Halcrow

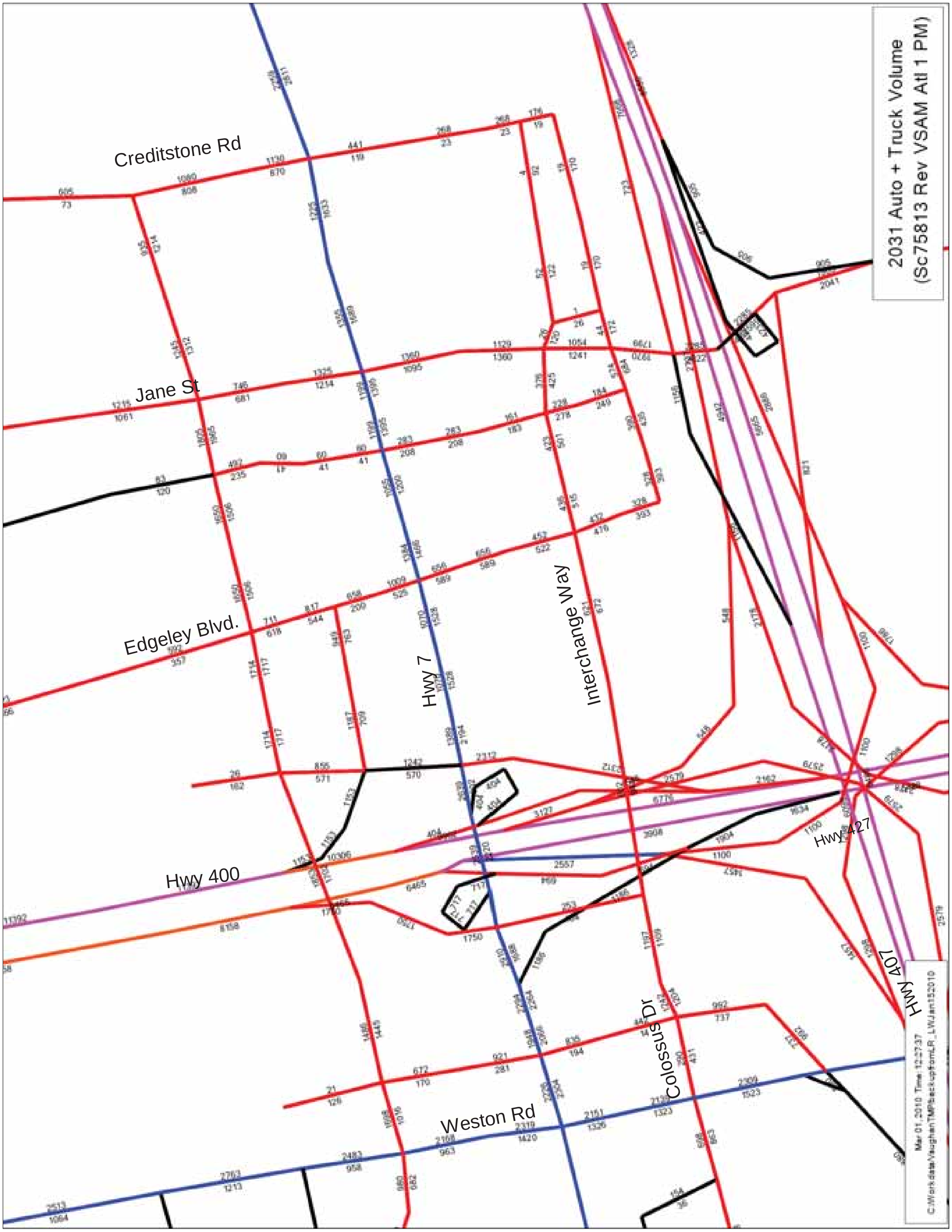


DRAFT

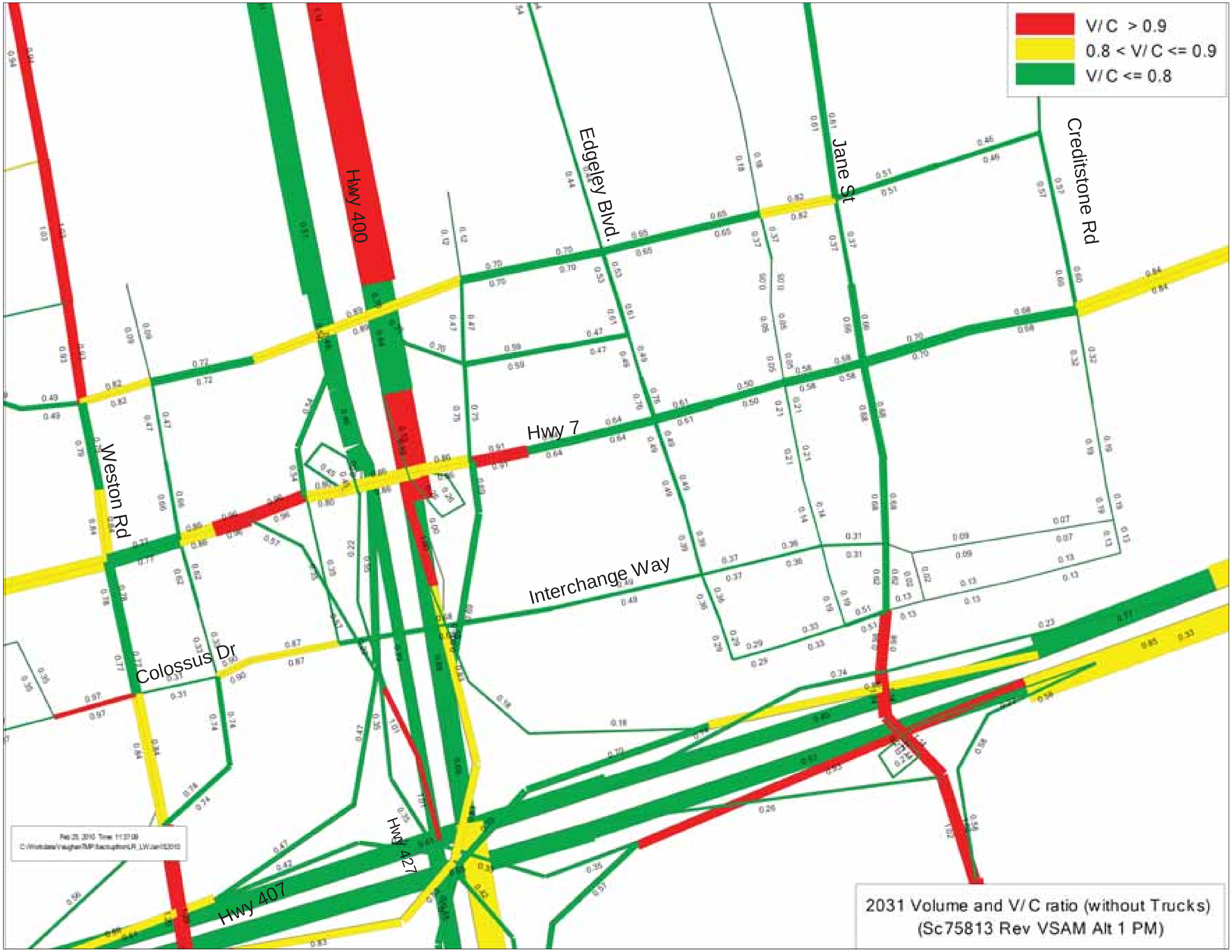
DRAFT



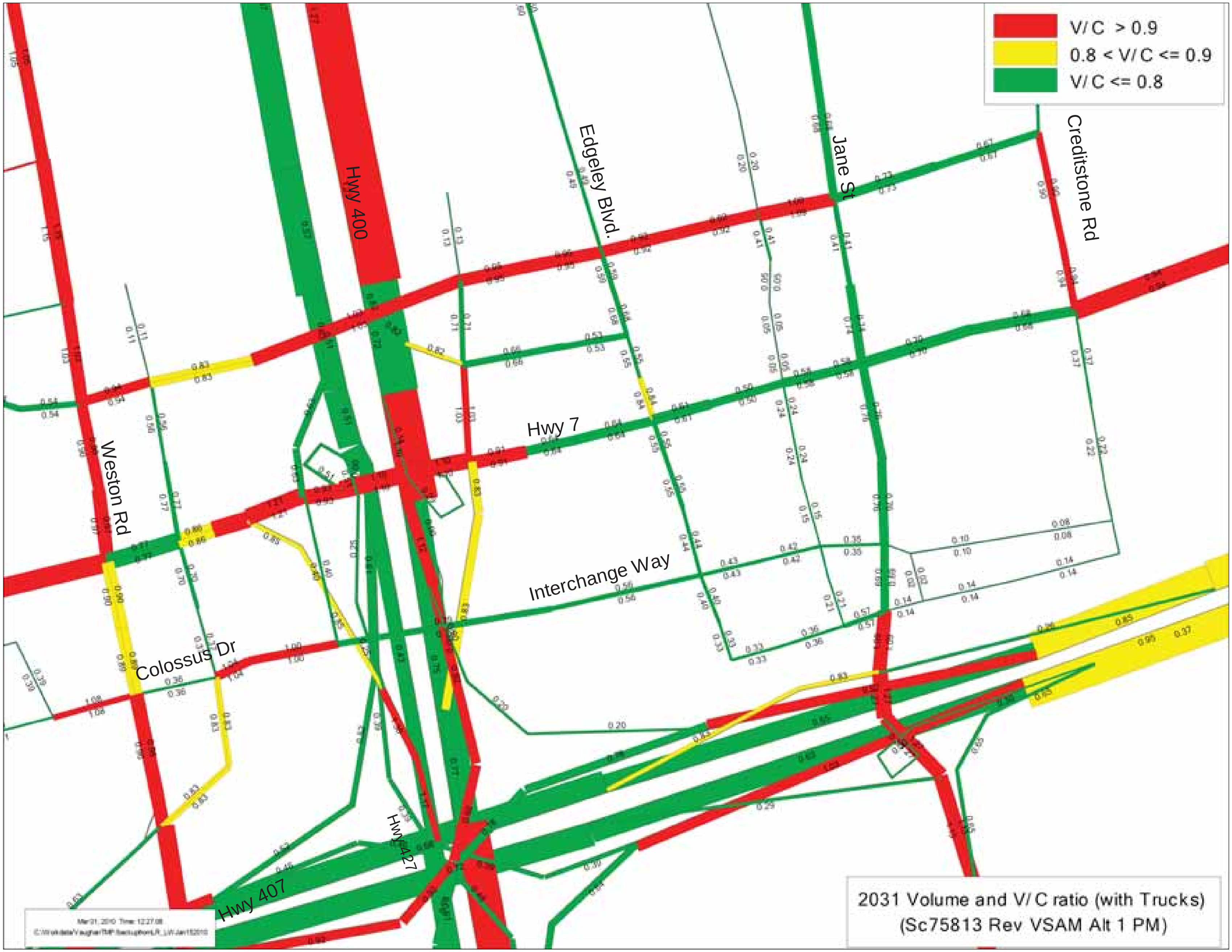
Halcrow


2031 Auto + Truck Volume
(Sc75813 Rev VSAM Atl 1 PM)
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 7
Interchange Way
Hwy 400
Hwy 427
Hwy 407
Colossus Dr
Weston Rd

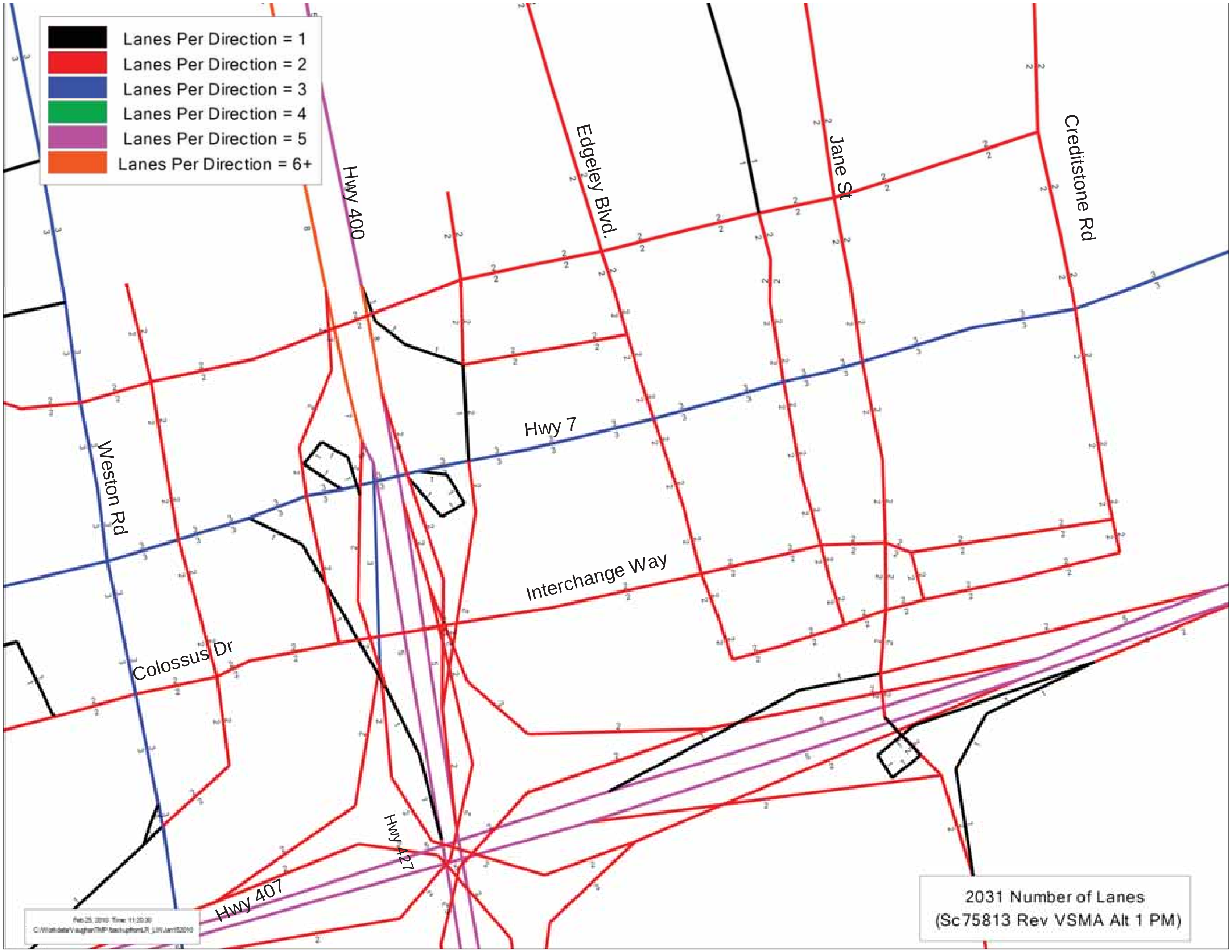
Halcrow


V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 400
Hwy 7
Interchange Way
Weston Rd
Colossus Dr
Hwy 407
Hwy 427
2031 Volume and V/C ratio (without Trucks)
(Sc75813 Rev VSAM Alt 1 PM)

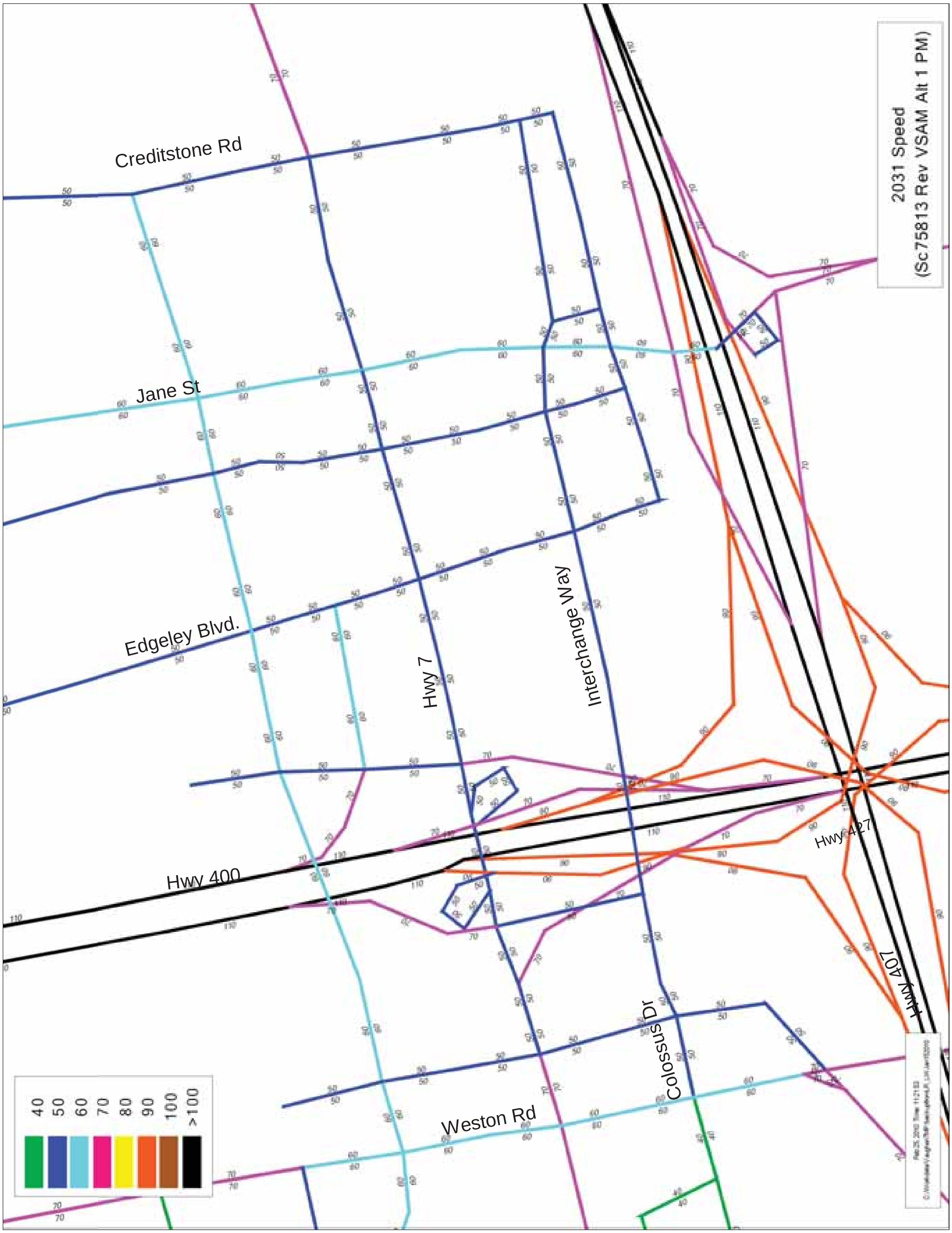
DRAFT


V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 400
Hwy 7
Interchange Way
Weston Rd
Colossus Dr
Hwy 407
Hwy 427
2031 Volume and V/C ratio (with Trucks)
(Sc75813 Rev VSAM Alt 1 PM)
DRAFT

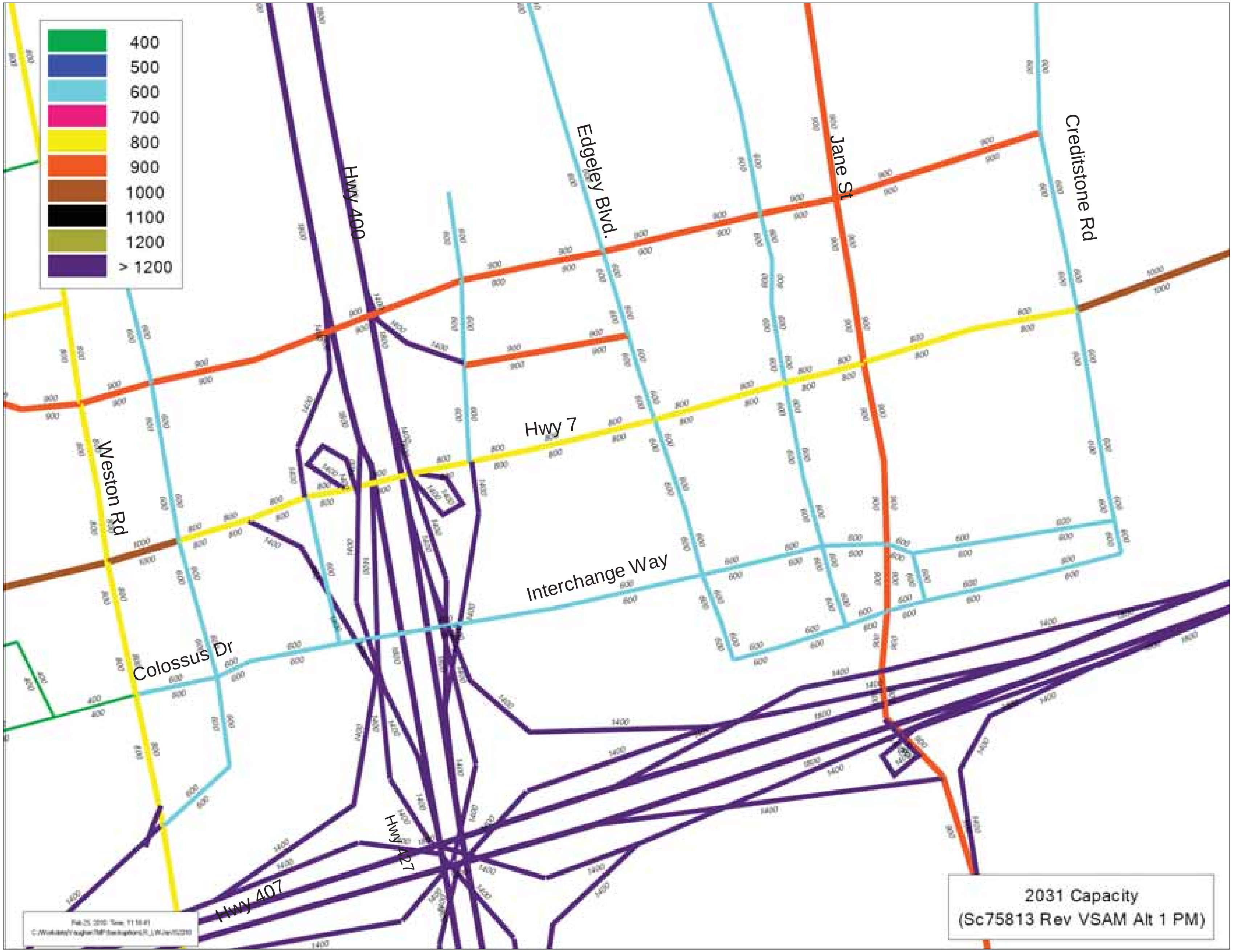
Halcrow



DRAFT


2031 Speed
(Sc75813 Rev VSAM Alt 1 PM)
Creditstone Rd
Jane St
Edgeley Blvd.
Hwy 7
Interchange Way
Hwy 400
Hwy 427
Hwy 407
Colossus Dr
Weston Rd
40
50
60
70
80
90
100
>100

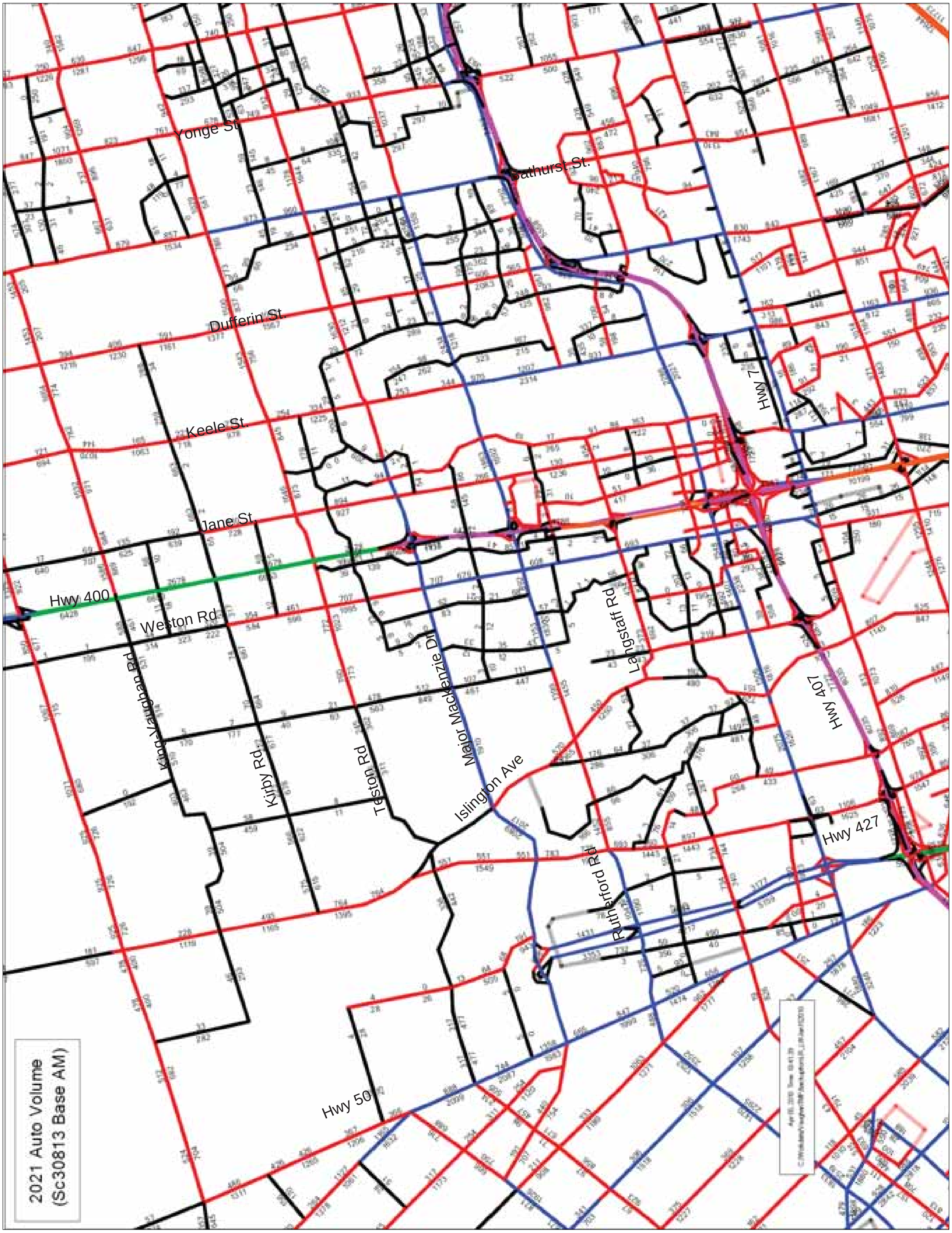
Halcrow


400
500
600
700
800
900
1000
1100
1200
> 1200
Hwy 400
Edgeley Blvd.
Jane St
Creditstone Rd
Weston Rd
Hwy 7
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2031 Capacity
(Sc75813 Rev VSAM Alt 1 PM)

DRAFT

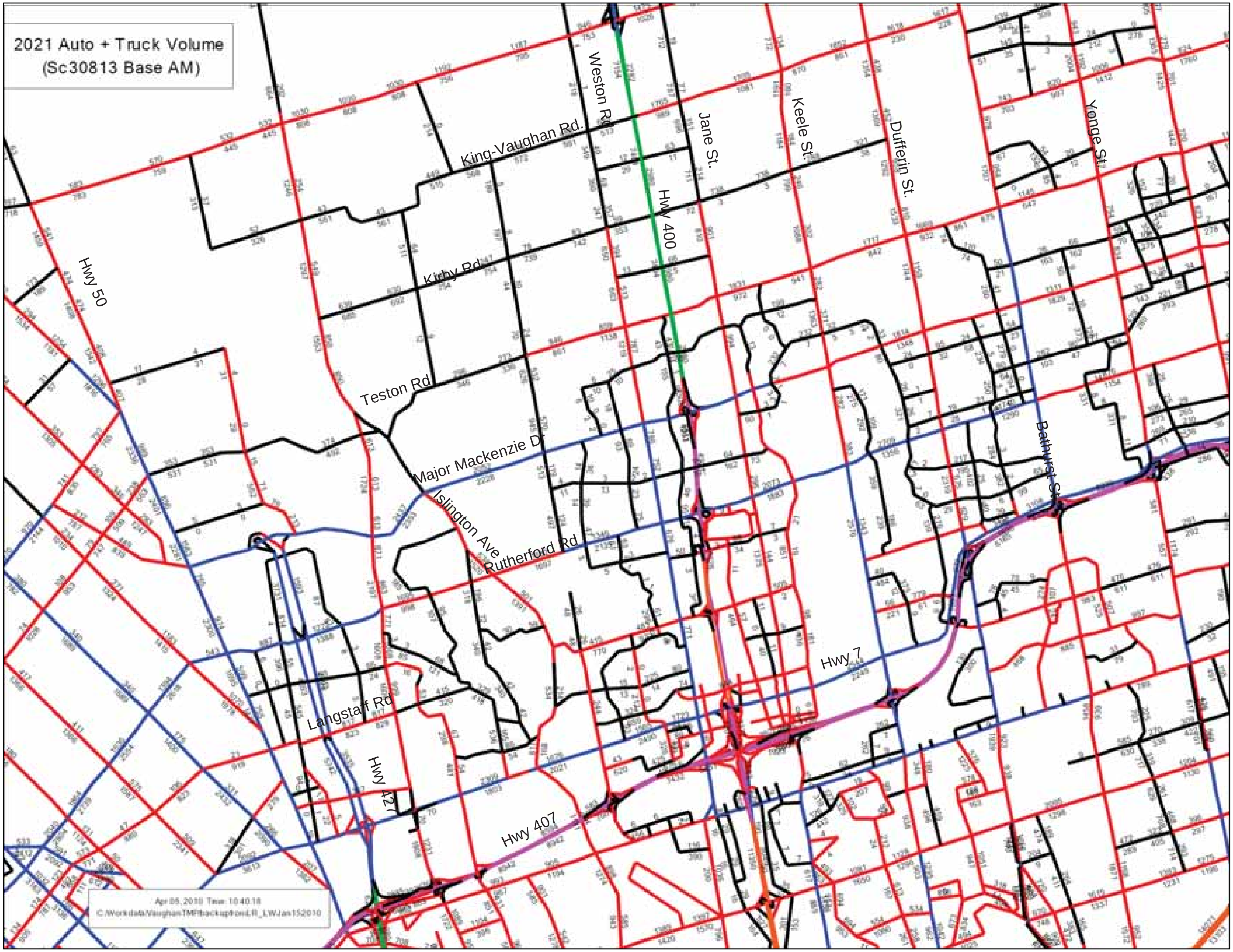
Appendix E
Sc 30813
Revised VSAM 2021 AM

DRAFT



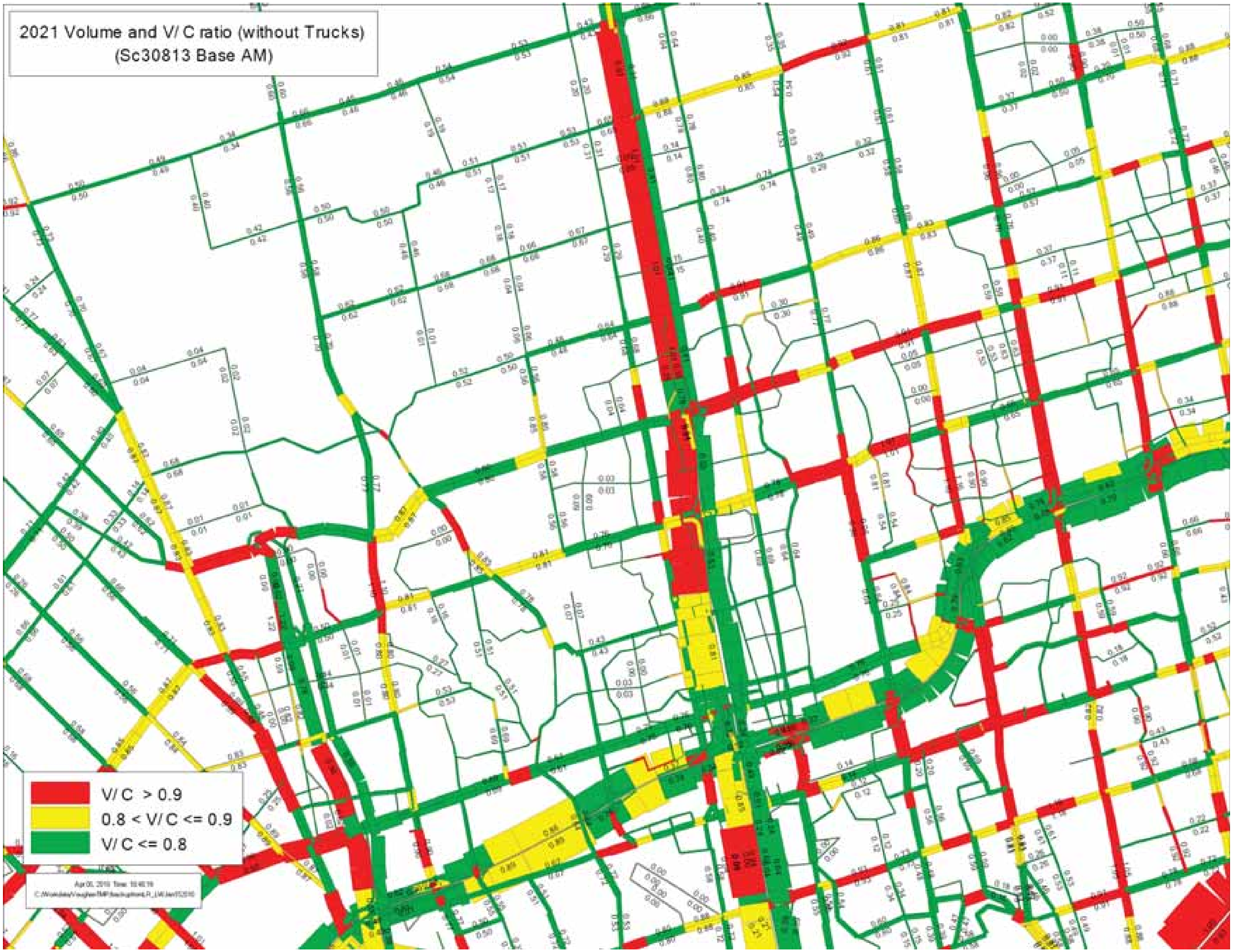
Halcrow

Halcrow

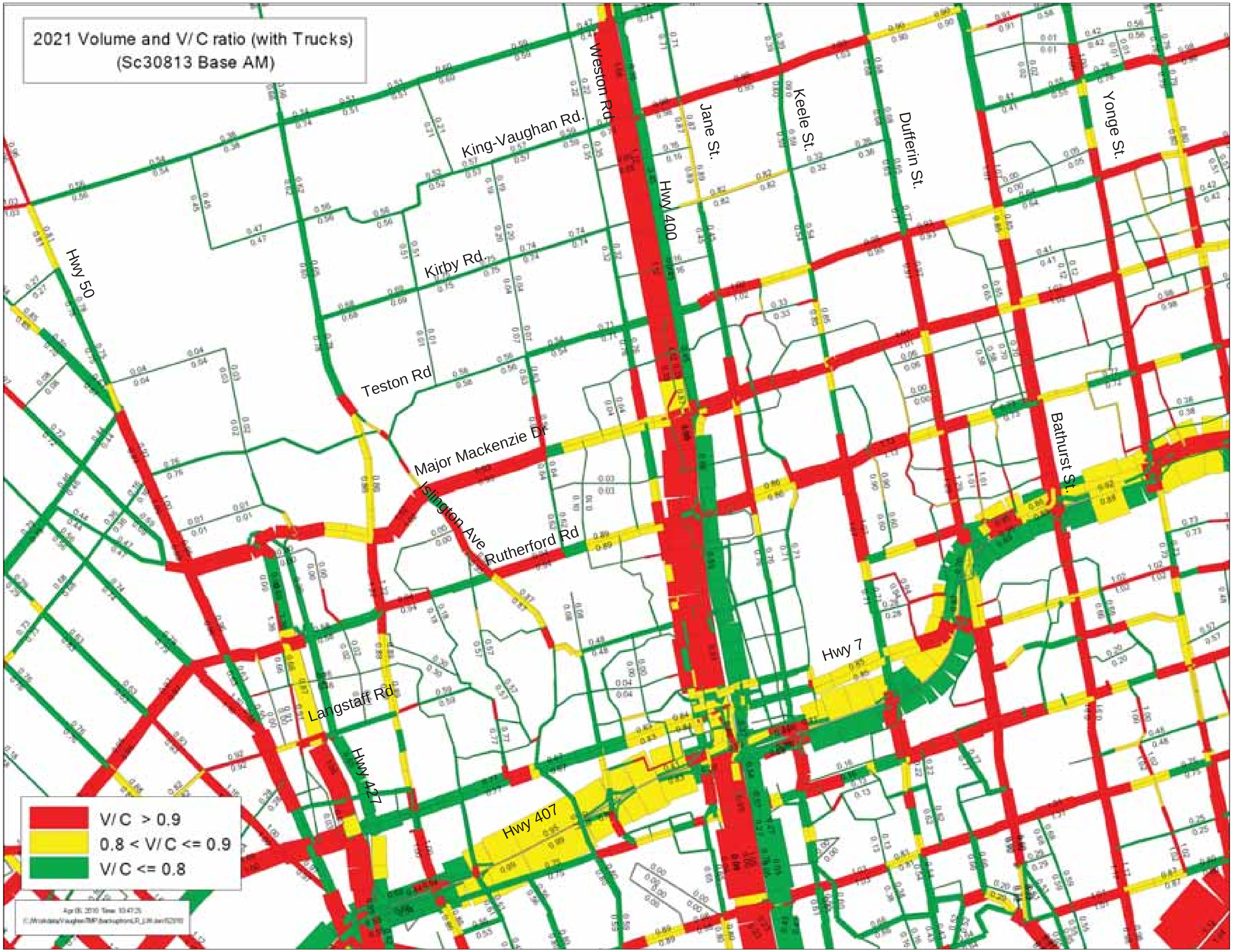


DRAFT

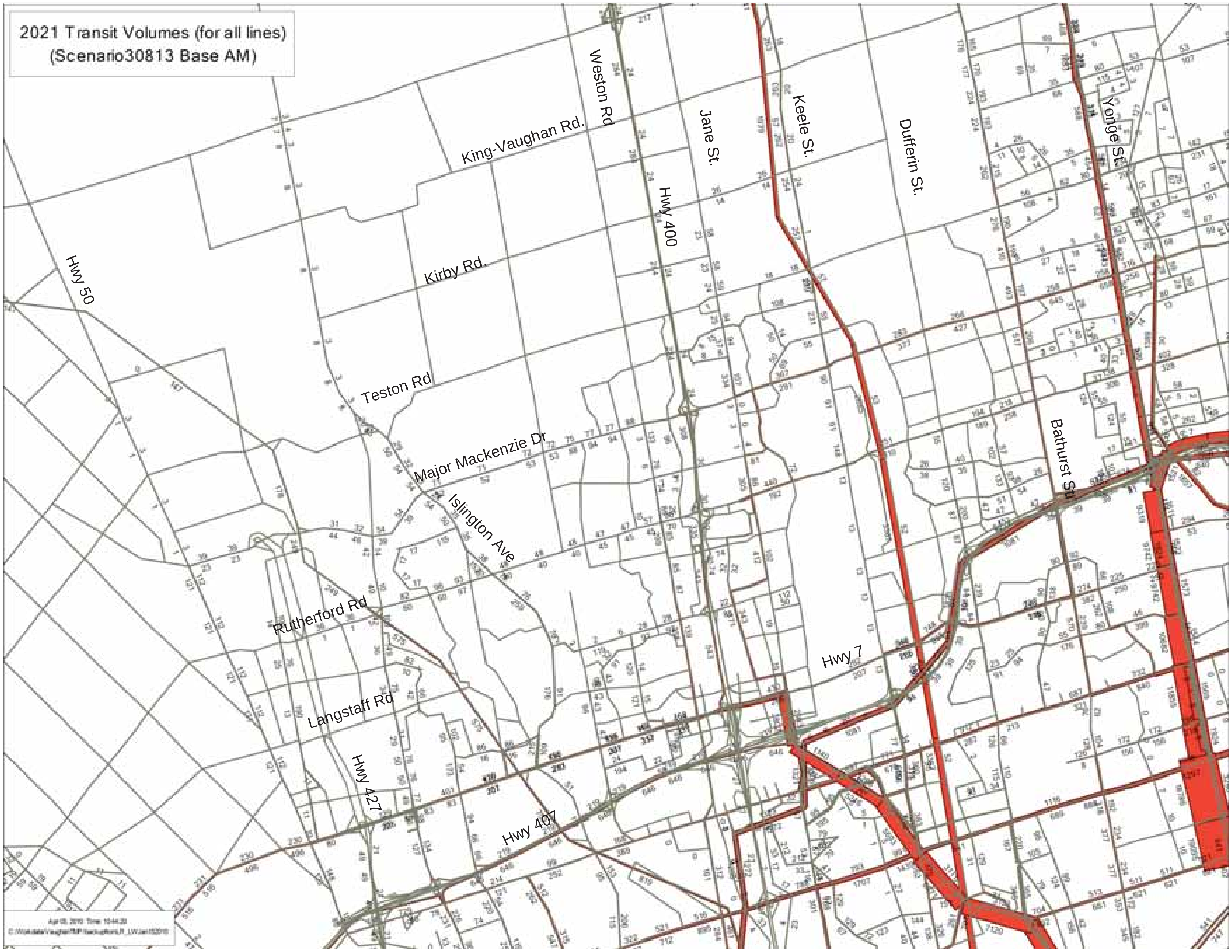
Halcrow



DRAFT

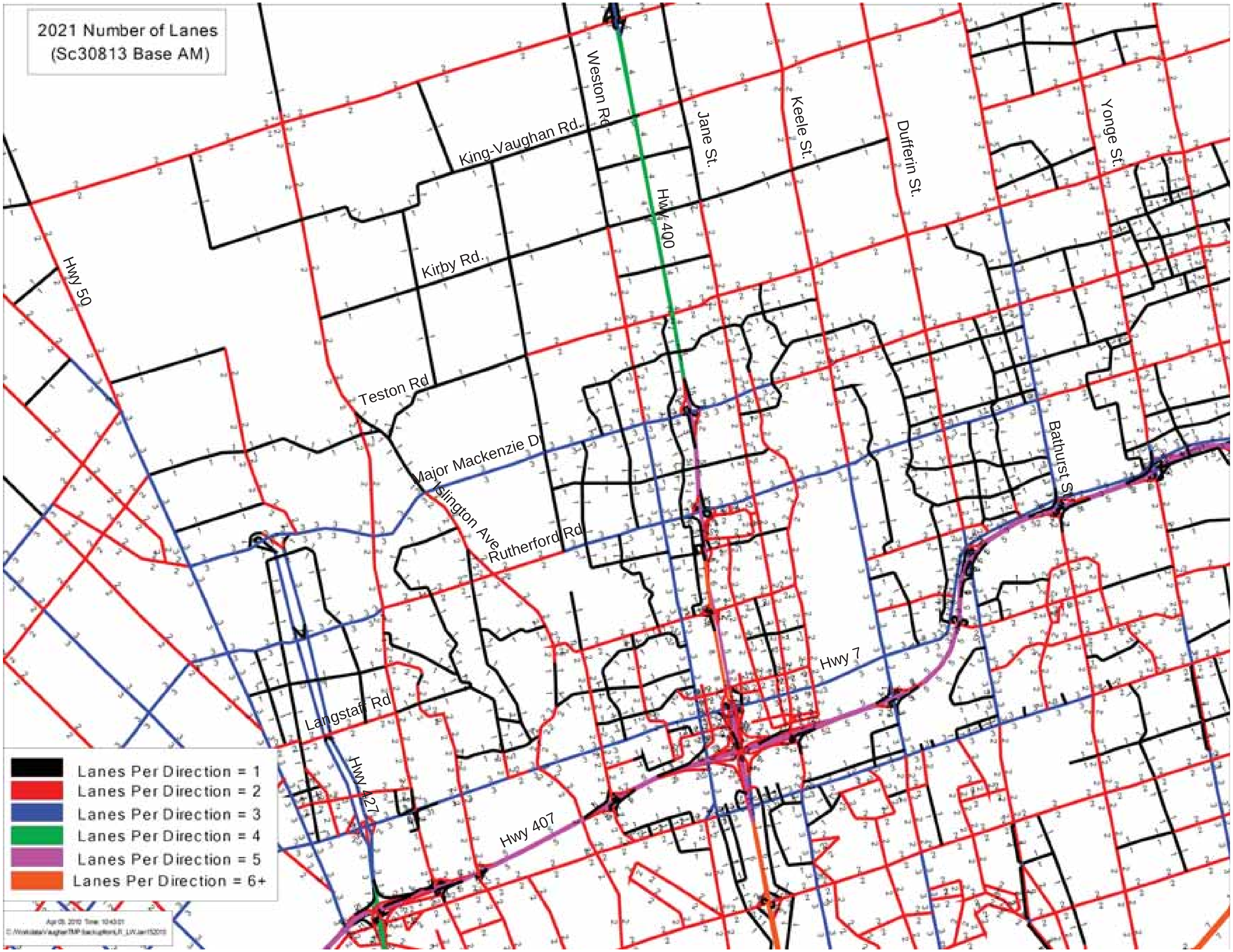

2021 Volume and V/C ratio (with Trucks)
(Sc30813 Base AM)
Weston Rd
King-Vaughan Rd.
Jane St.
Keele St.
Dufferin St.
Yonge St.
Hwy 400
Kirby Rd.
Hwy 50
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Bathurst St.
Hwy 7
Langstaff Rd
Hwy 427
Hwy 407
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8

DRAFT



2021 Transit Volumes (for all lines)
(Scenario30813 Base AM)
Hwy 50
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Hwy 427
Hwy 407
Weston Rd
Hwy 400
Jane St.
Keele St.
Dufferin St.
Hwy 7
Bathurst St.
Yonge St.

DRAFT

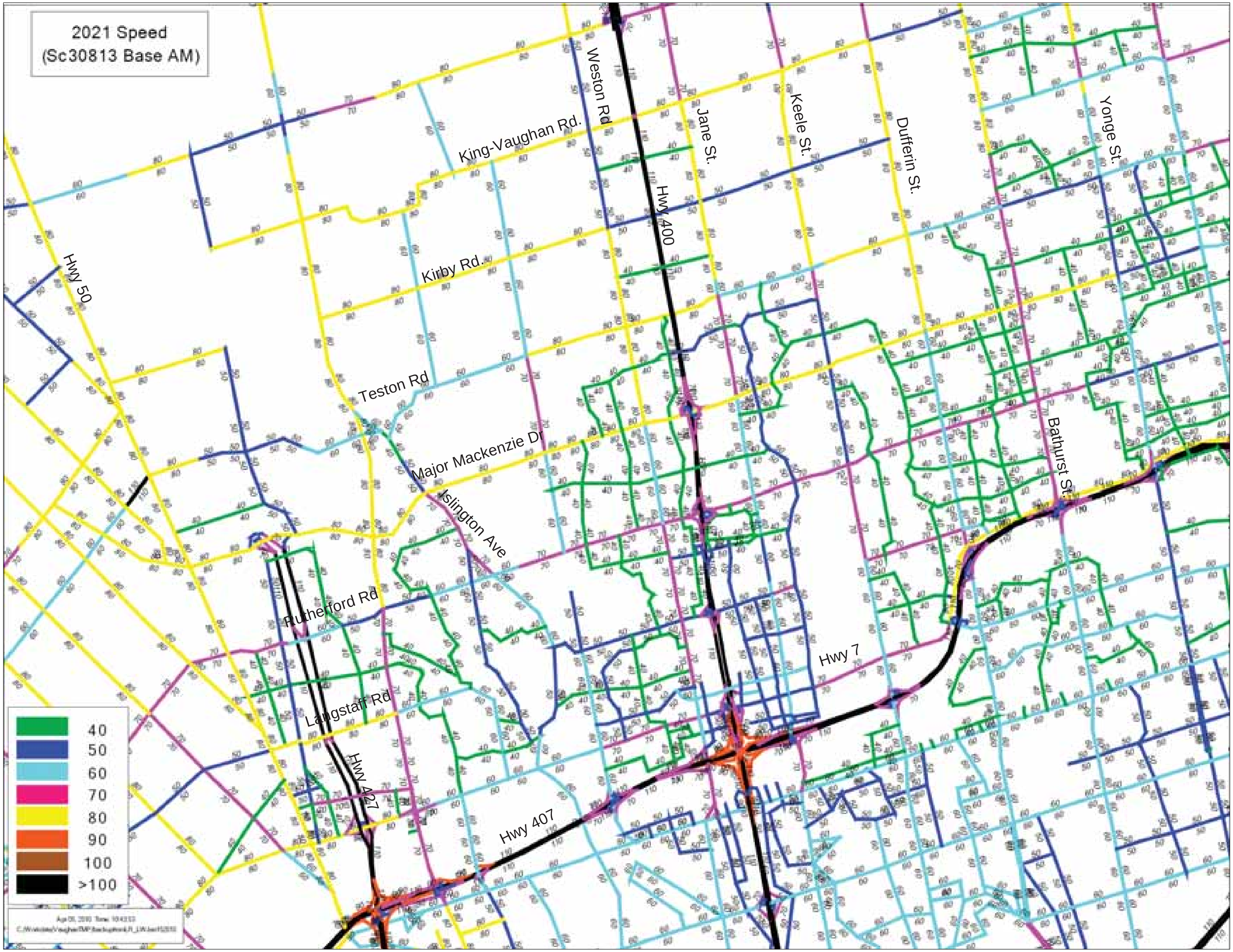


2021 Number of Lanes
(Sc30813 Base AM)
Yonge St.
Bathurst St
Dufferin St.
Keele St.
Jane St.
Hwy 400
Weston Rd
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Hwy 7
Langstaff Rd
Hwy 427
Hwy 407
Hwy 50
Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6+

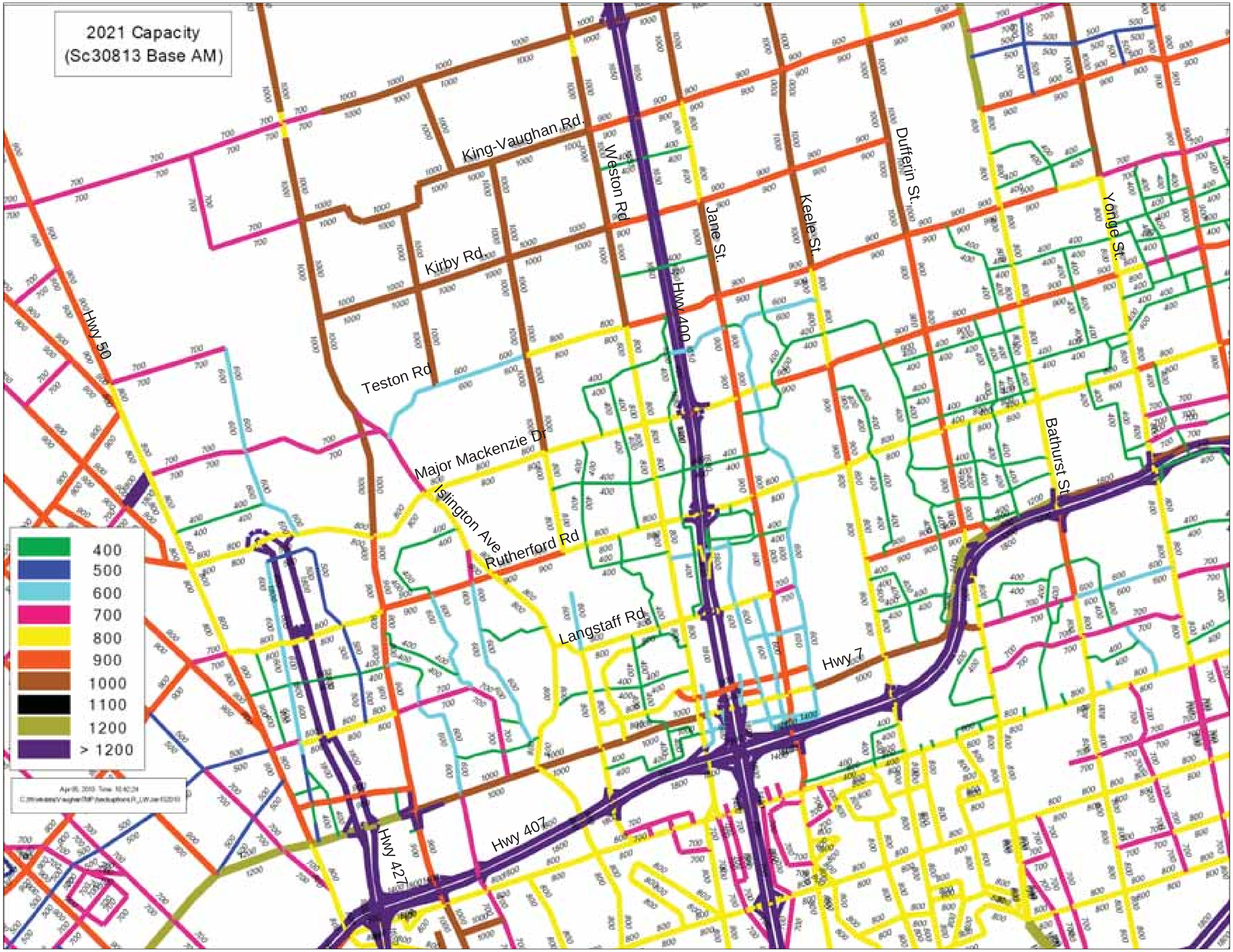
DRAFT

Halcrow

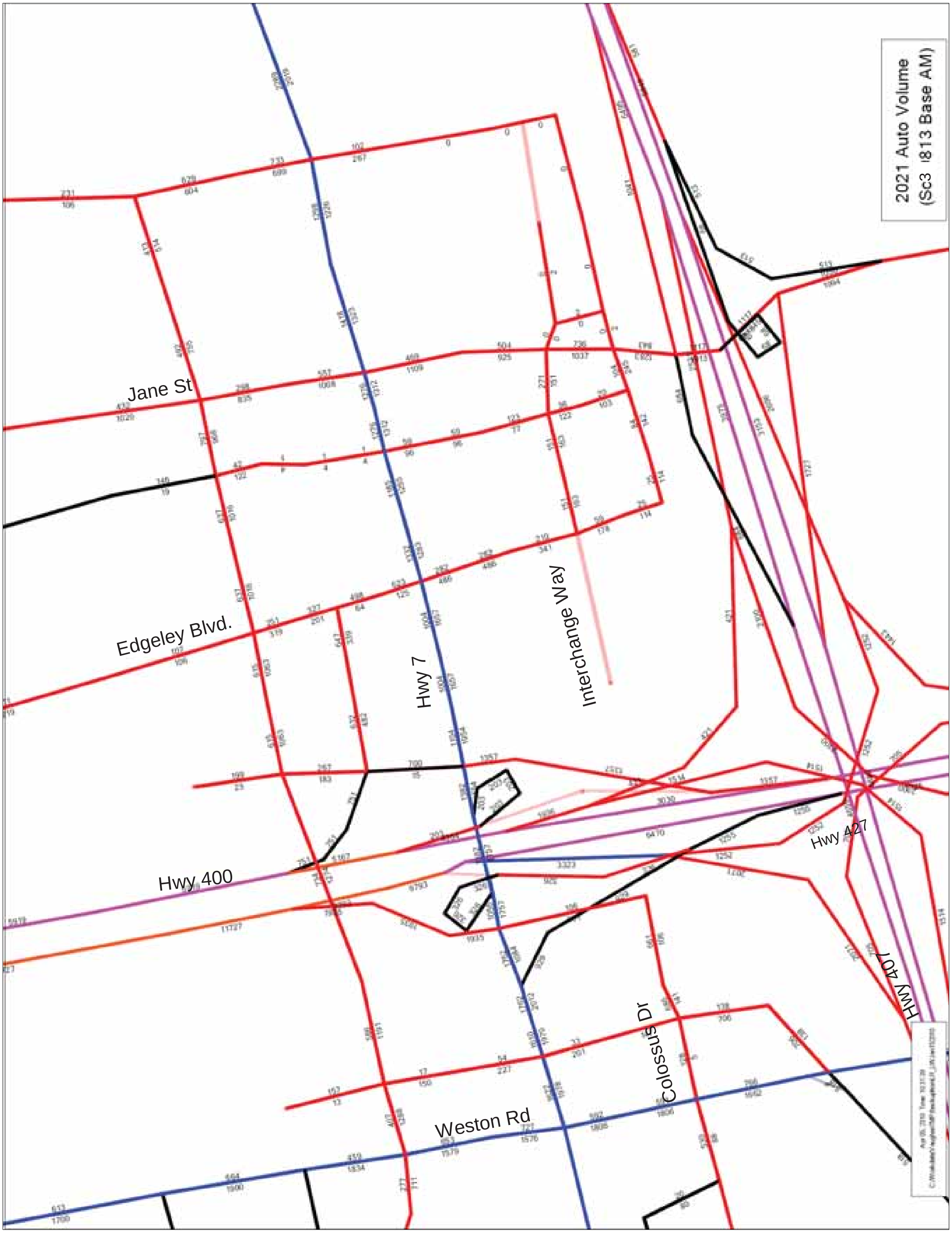
DRAFT



Halcrow


2021 Capacity
(Sc30813 Base AM)
Yonge St.
Bathurst St.
Dufferin St.
Keele St.
Jane St.
Hwy 400
Weston Rd
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Hwy 7
Hwy 407
Hwy 427
Hwy 50
400
500
600
700
800
900
1000
1100
1200
> 1200

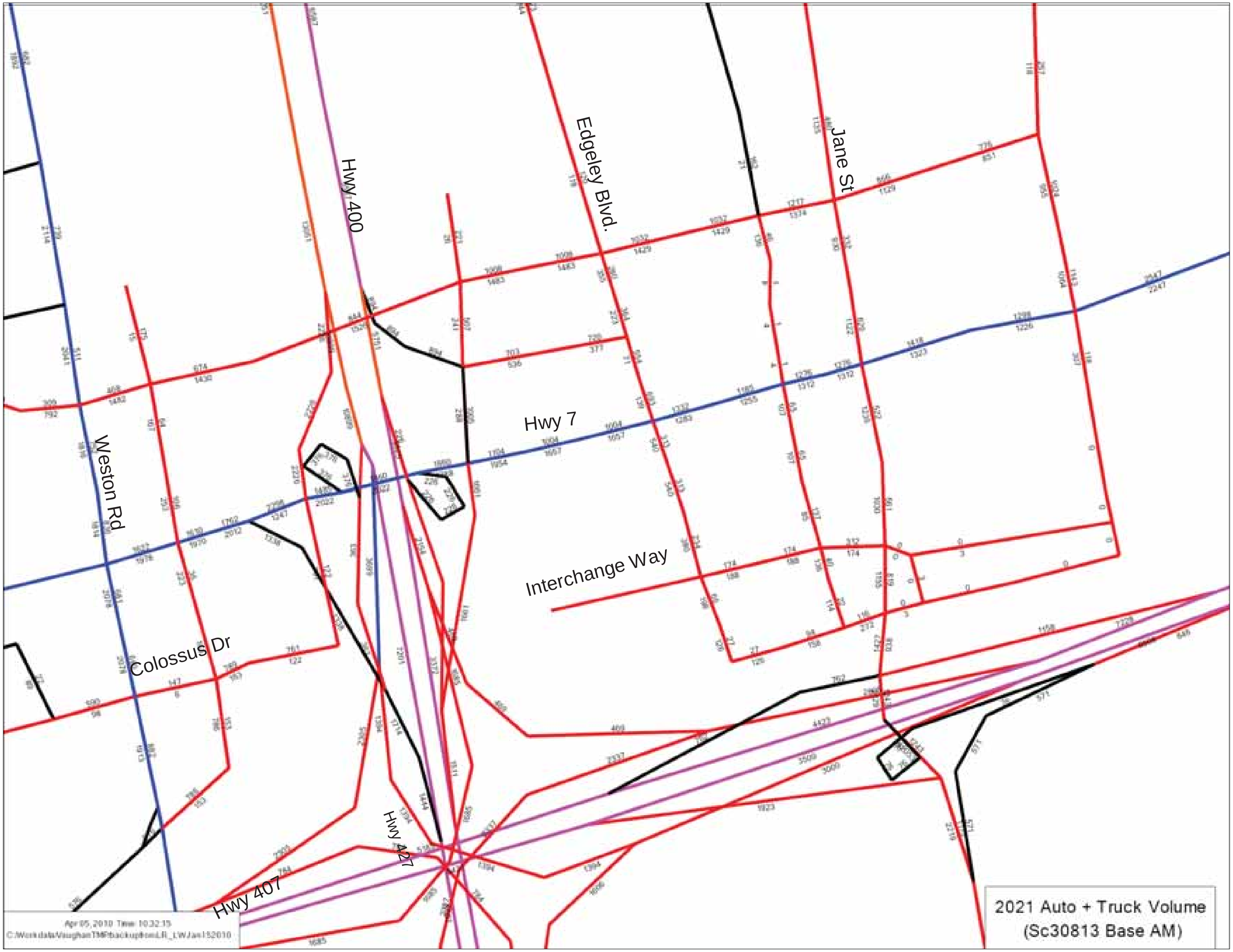
DRAFT

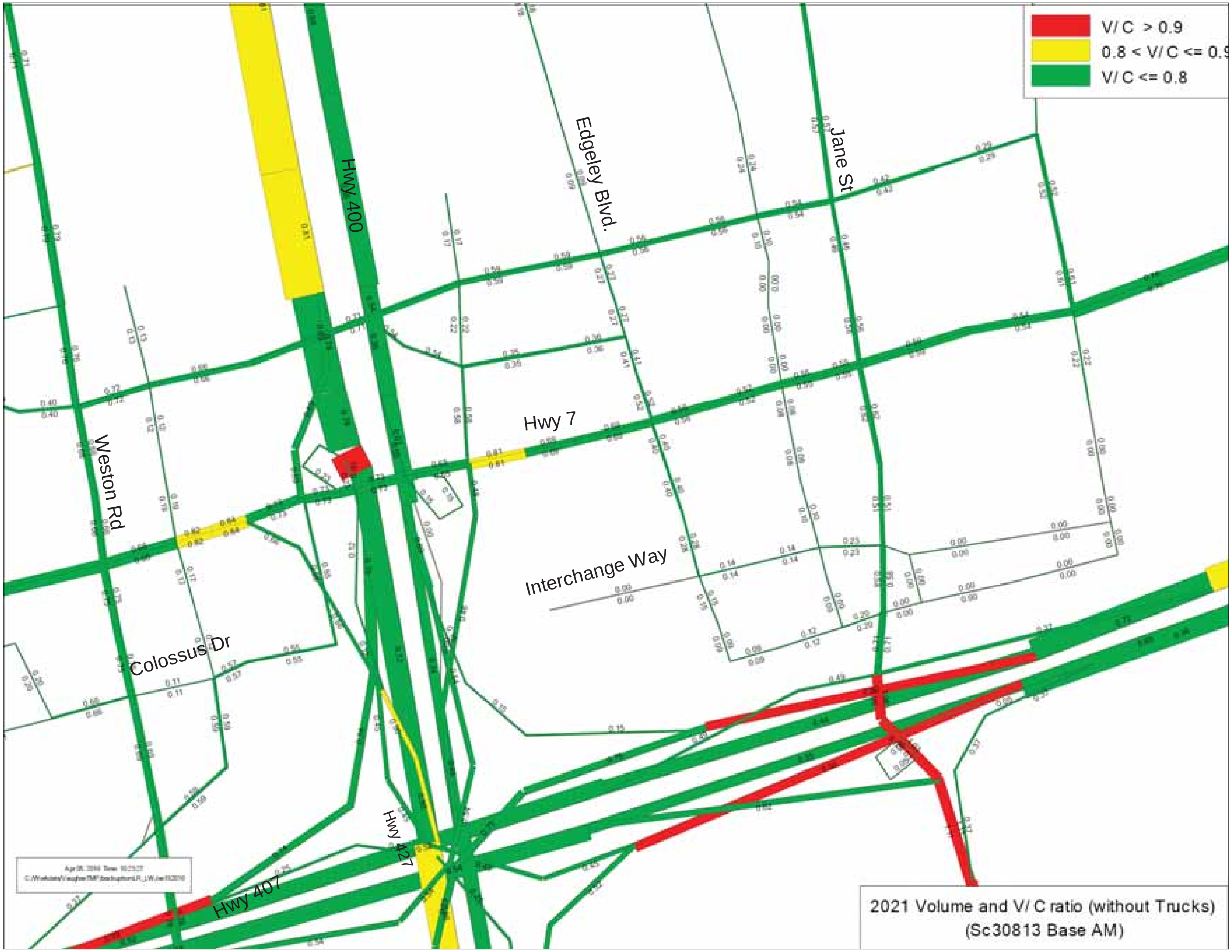


Halcrow

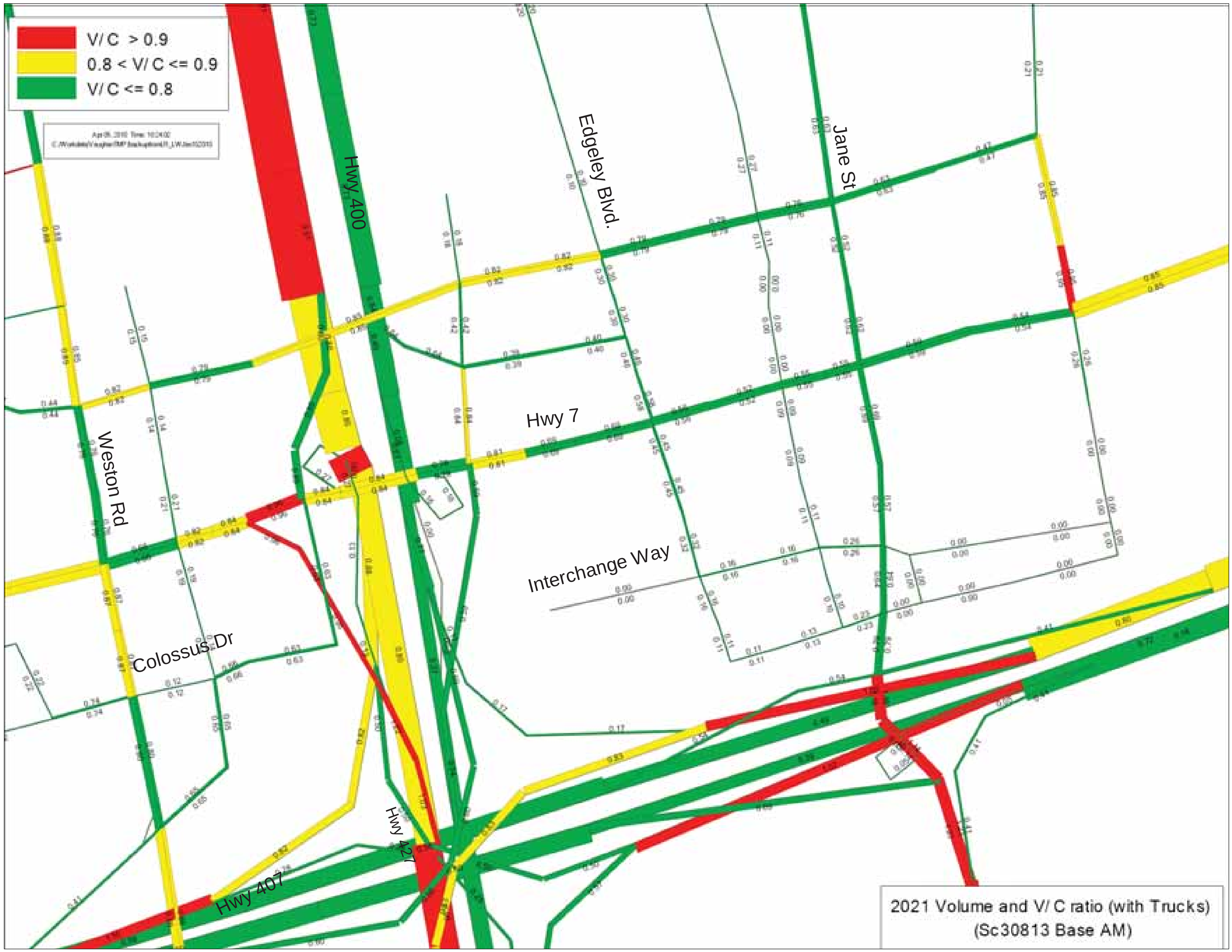
Halcrow

DRAFT



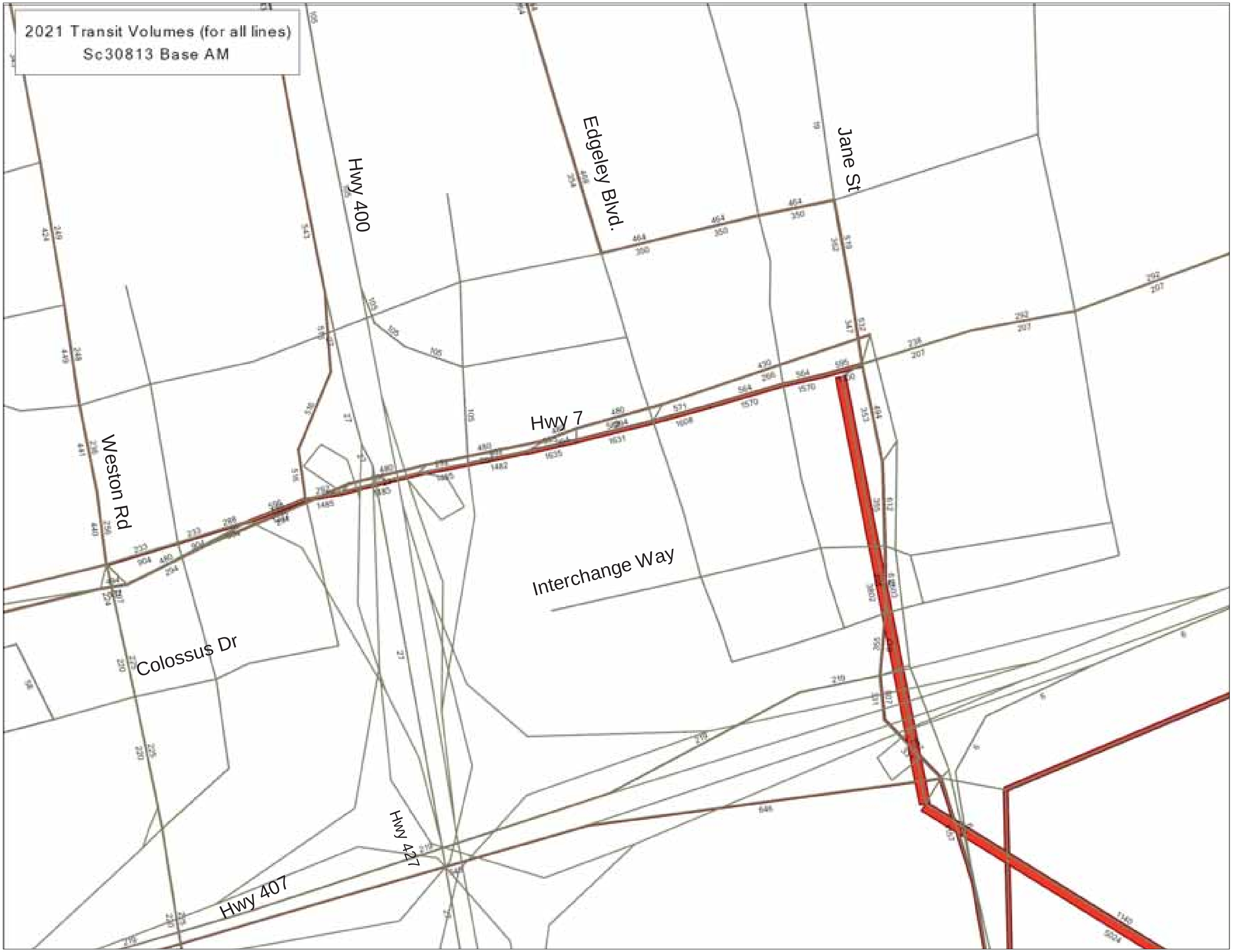

V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Edgeley Blvd.
Jane St
Hwy 400
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2021 Volume and V/C ratio (without Trucks)
(Sc30813 Base AM)

DRAFT

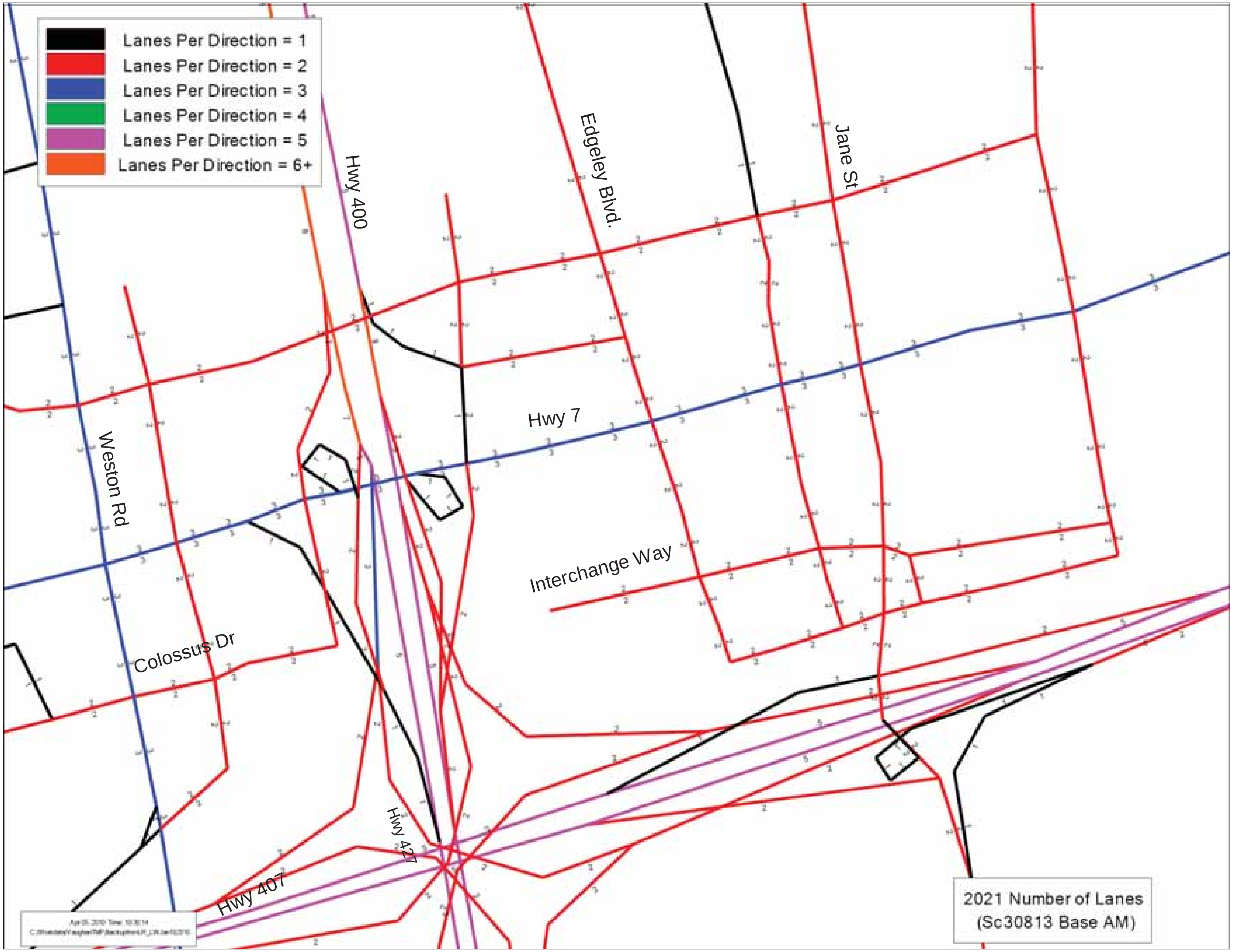

V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2021 Volume and V/C ratio (with Trucks)
(Sc30813 Base AM)

DRAFT

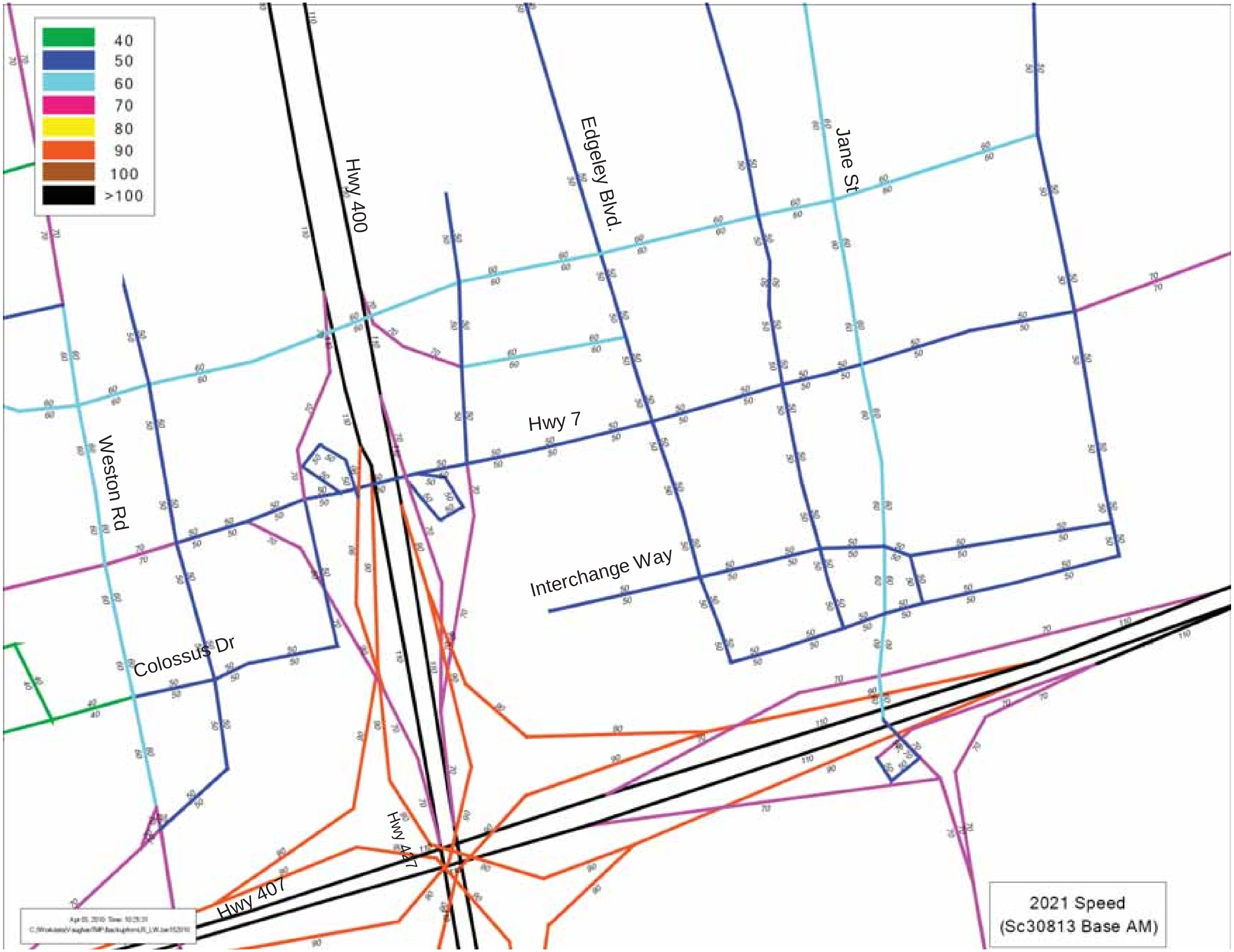
Halcrow



DRAFT

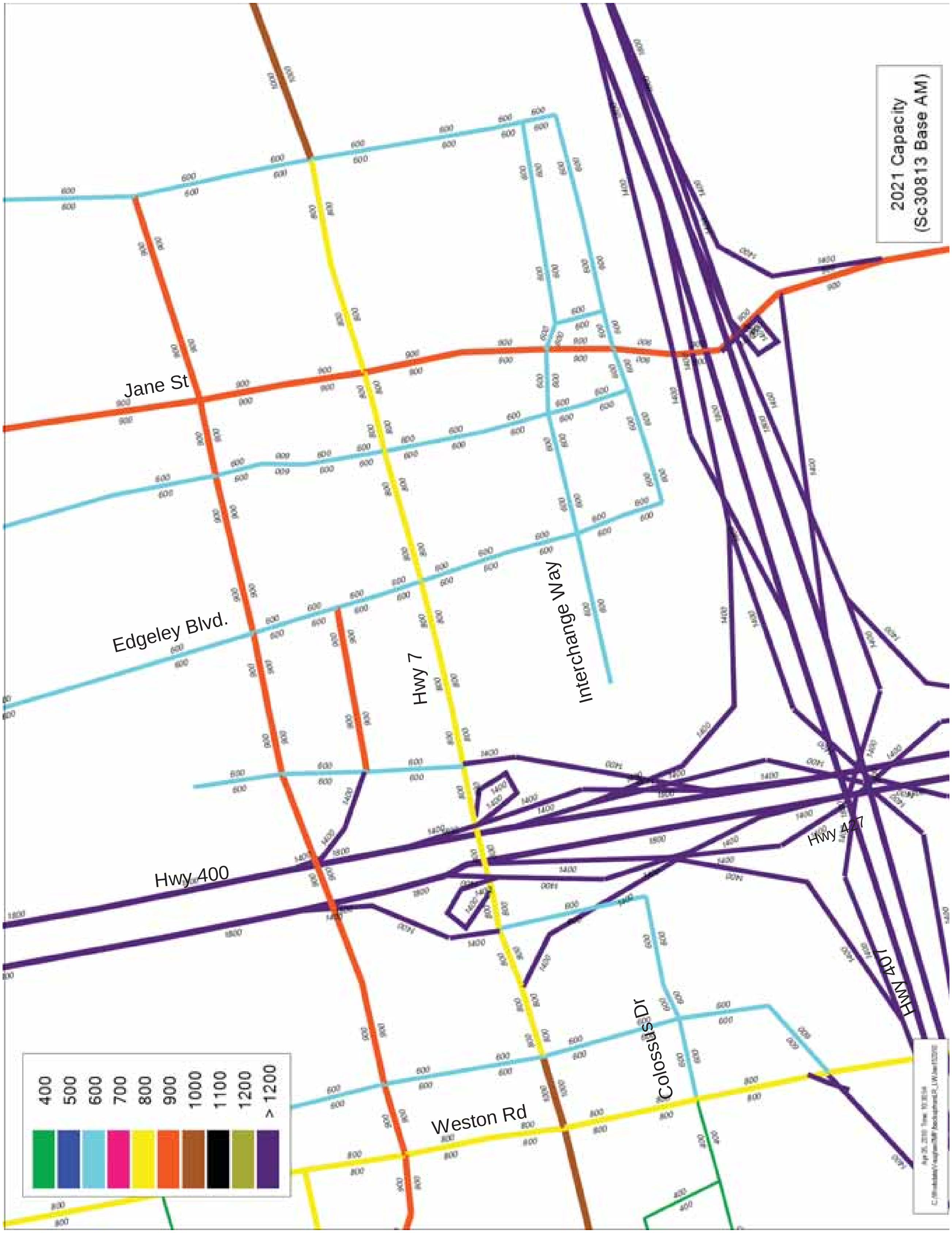

Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6+
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2021 Number of Lanes
(Sc30813 Base AM)

DRAFT


40
50
60
70
80
90
100
>100
Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2021 Speed
(Sc30813 Base AM)

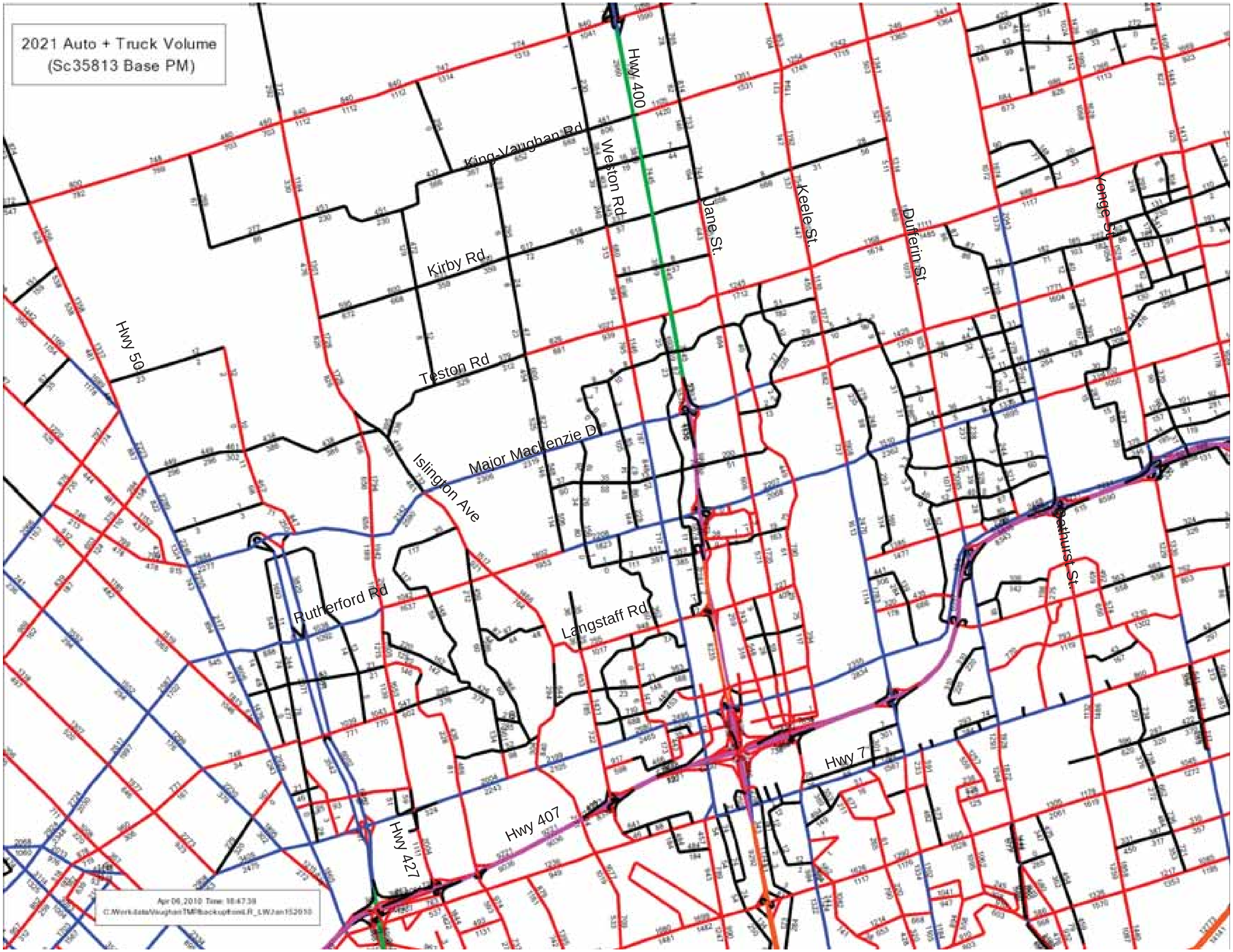
DRAFT

DRAFT



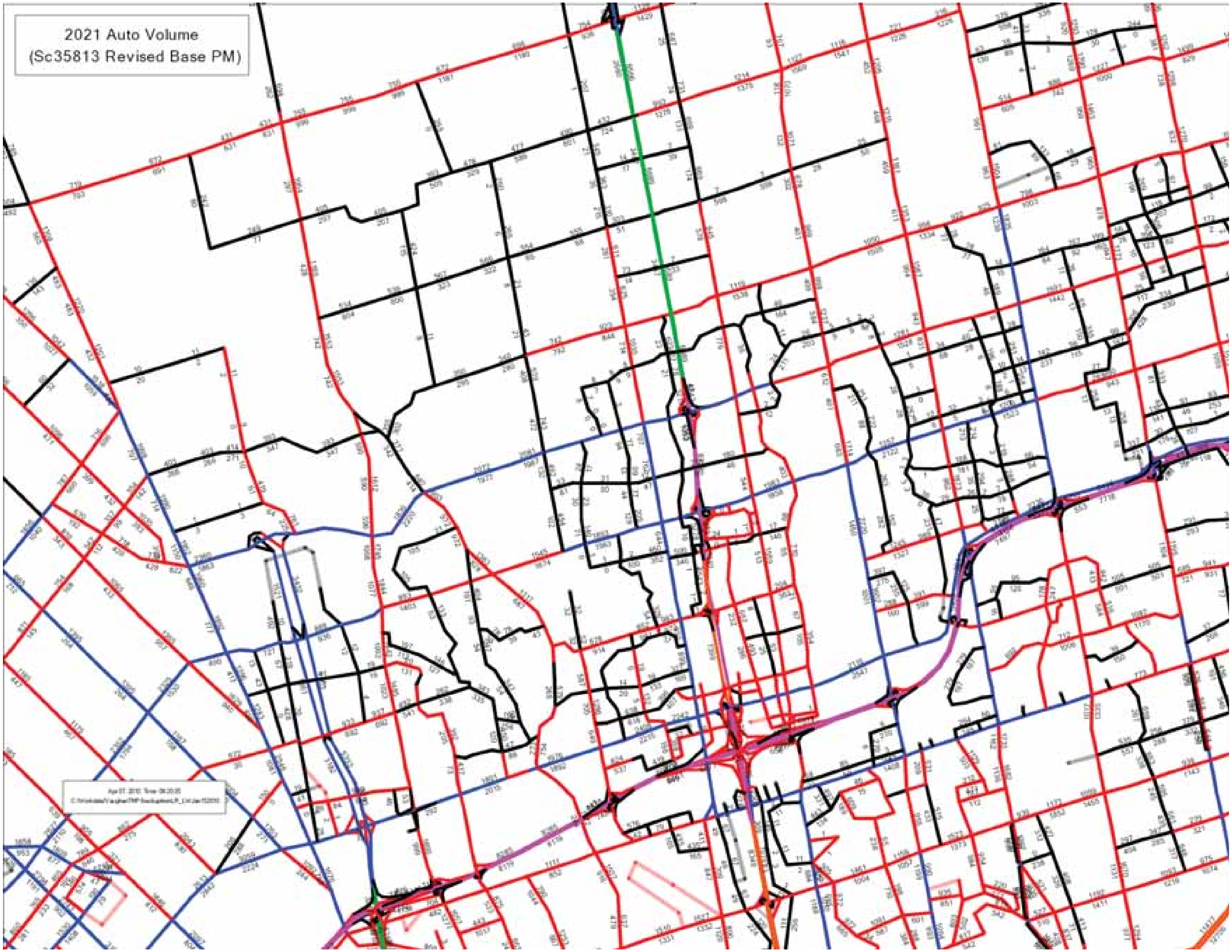
Halcrow

Appendix F
Sc 35813
Revised VSAM 2021 PM


2021 Auto + Truck Volume
(Sc35813 Base PM)
Hwy 400
King-Vaughan Rd
Weston Rd
Jane St.
Keele St.
Dufferin St.
Yonge St.
Kirby Rd.
Hwy 50
Teston Rd
Major Mackenzie Dr
Islington Ave
Bathurst St.
Rutherford Rd
Langstaff Rd
Hwy 7
Hwy 407
Hwy 427

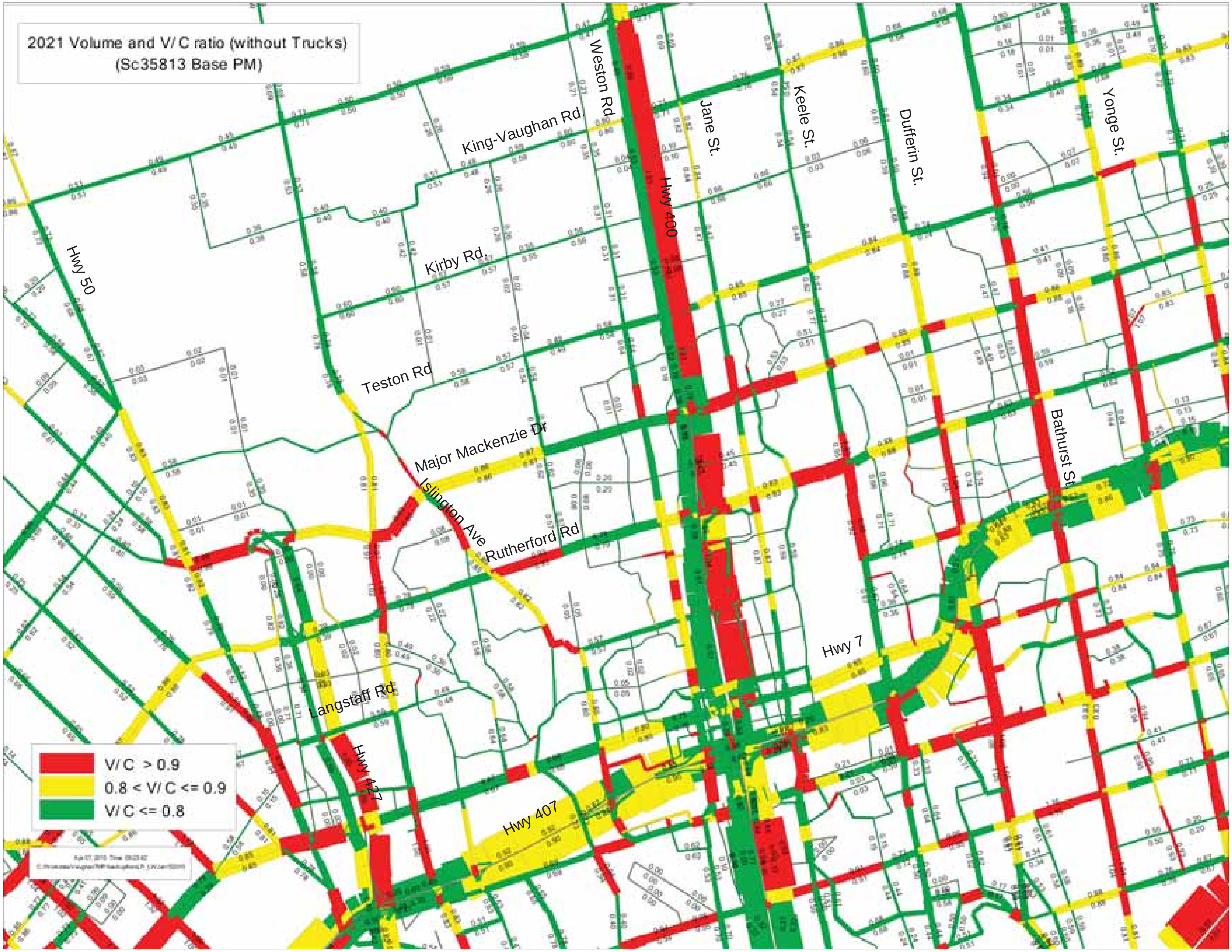
DRAFT

Halcrow

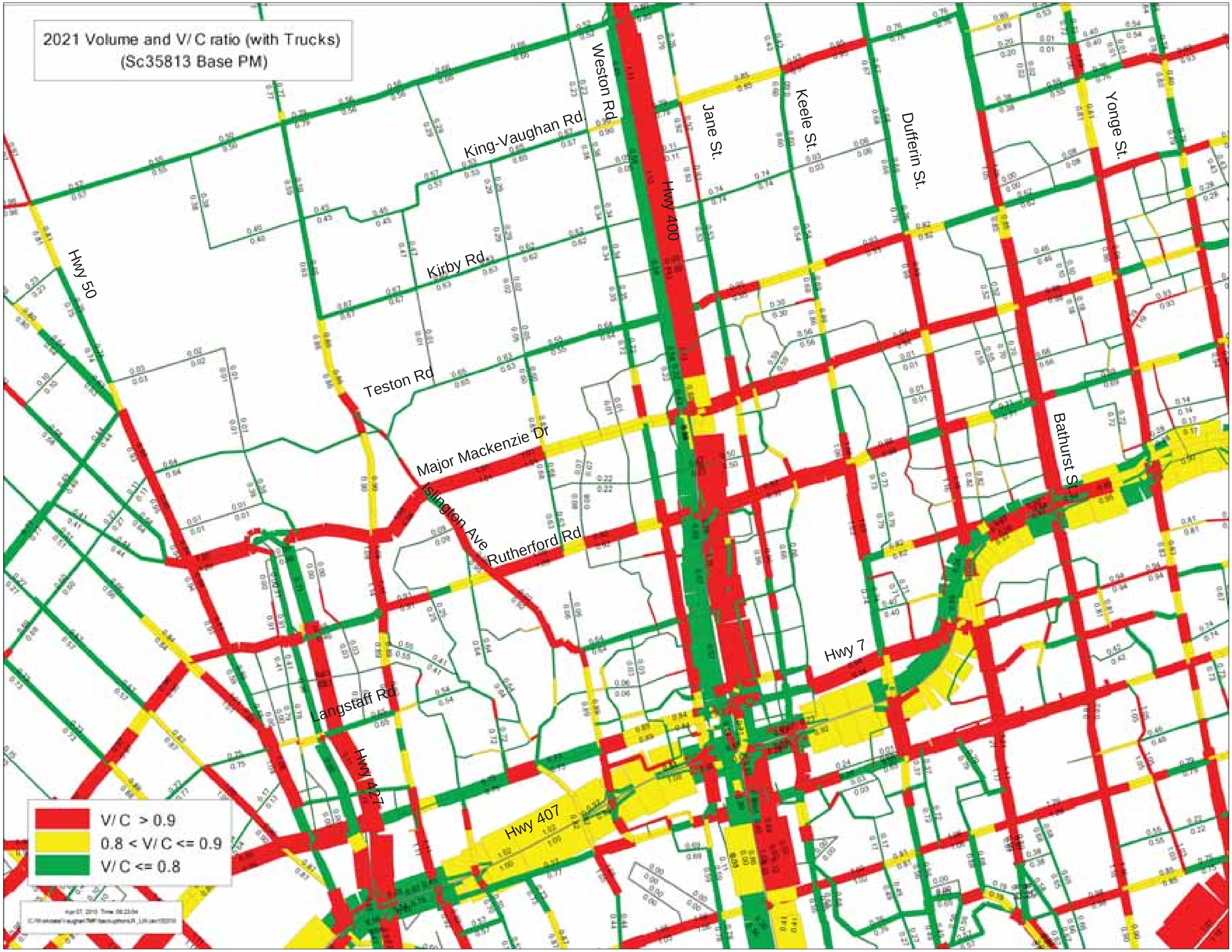


DRAFT

Halcrow

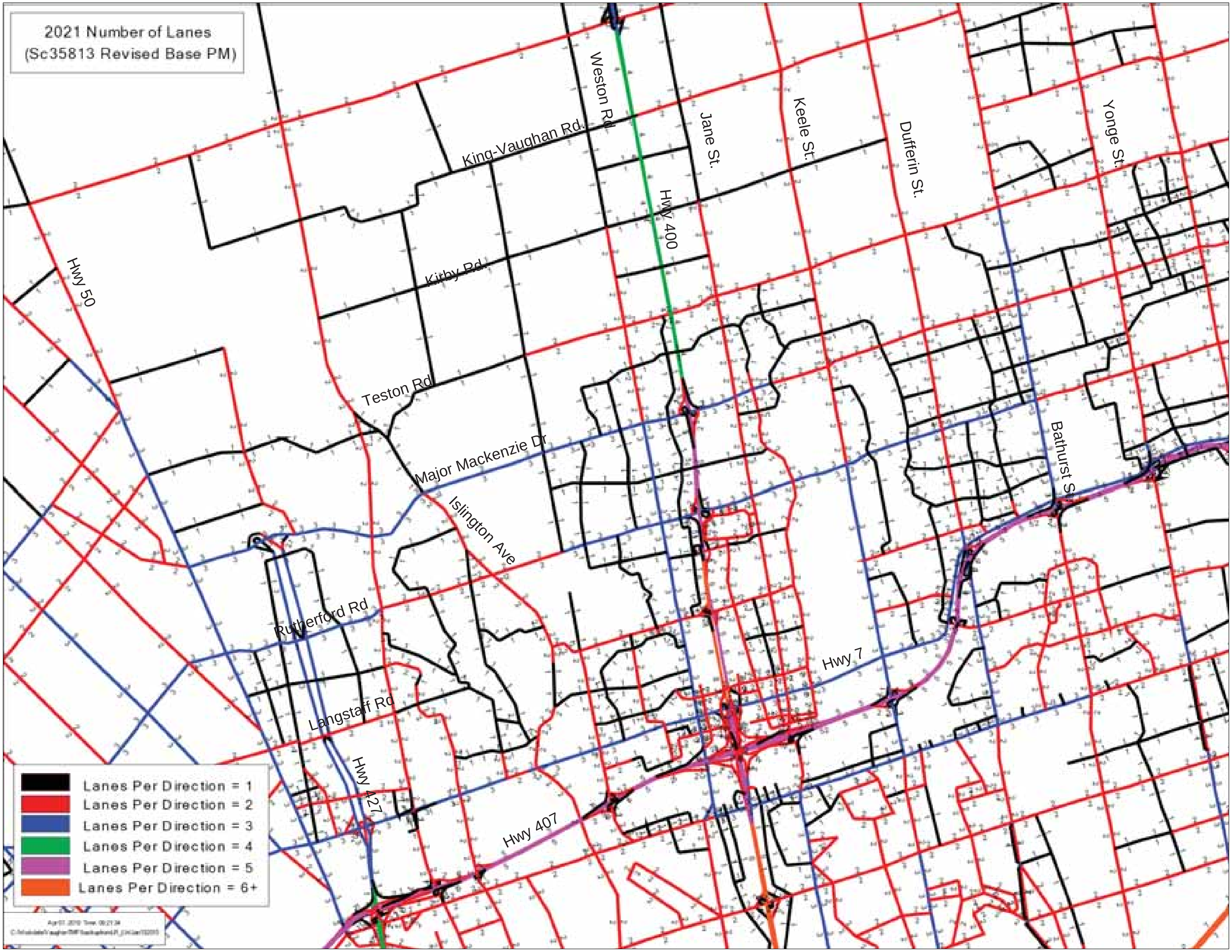


DRAFT

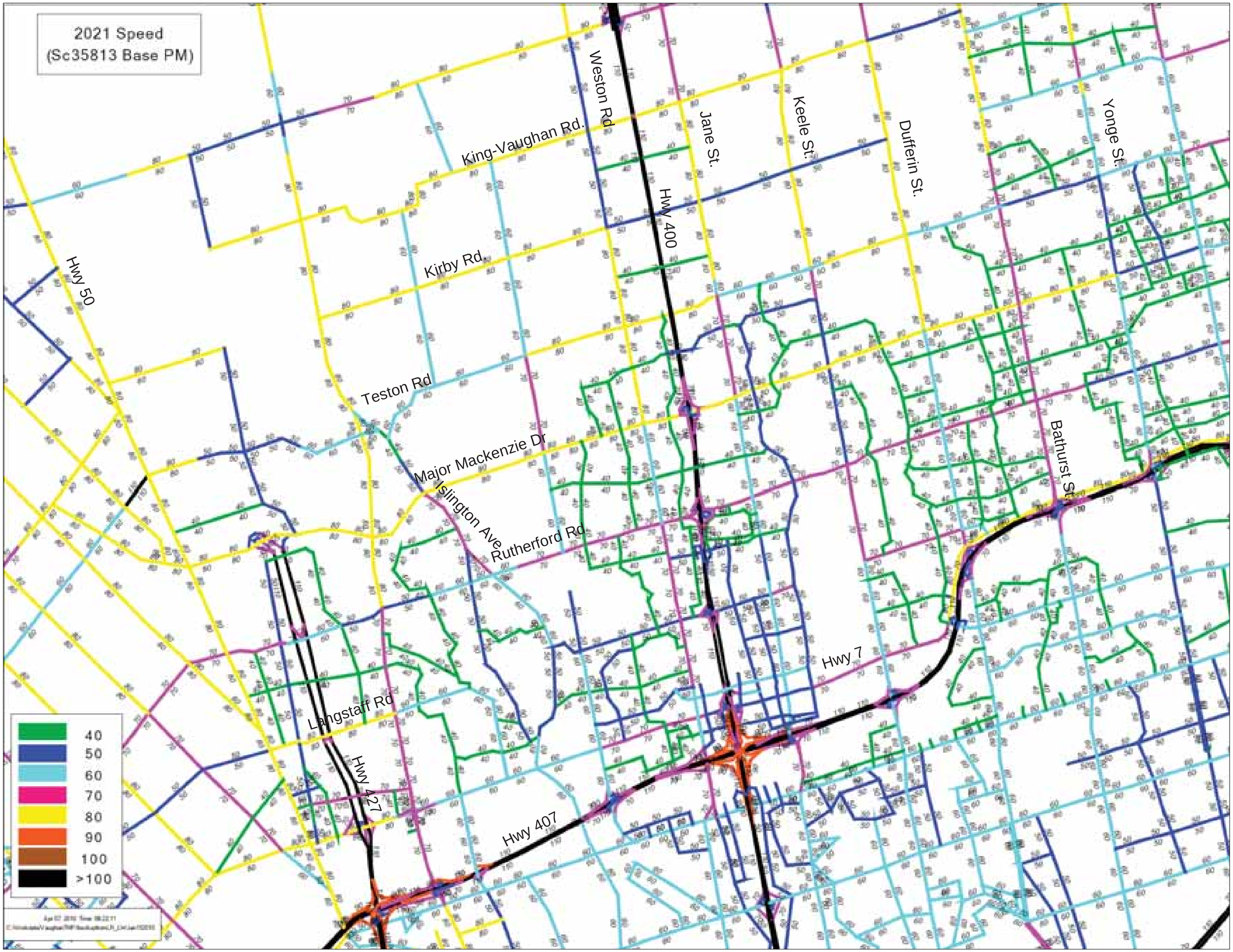

2021 Volume and V/C ratio (with Trucks)
(Sc35813 Base PM)
Weston Rd
King-Vaughan Rd.
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Langstaff Rd
Hwy 427
Hwy 407
Hwy 400
Hwy 50
Hwy 7
Jane St.
Keele St.
Dufferin St.
Bathurst St.
Yonge St.
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8

DRAFT

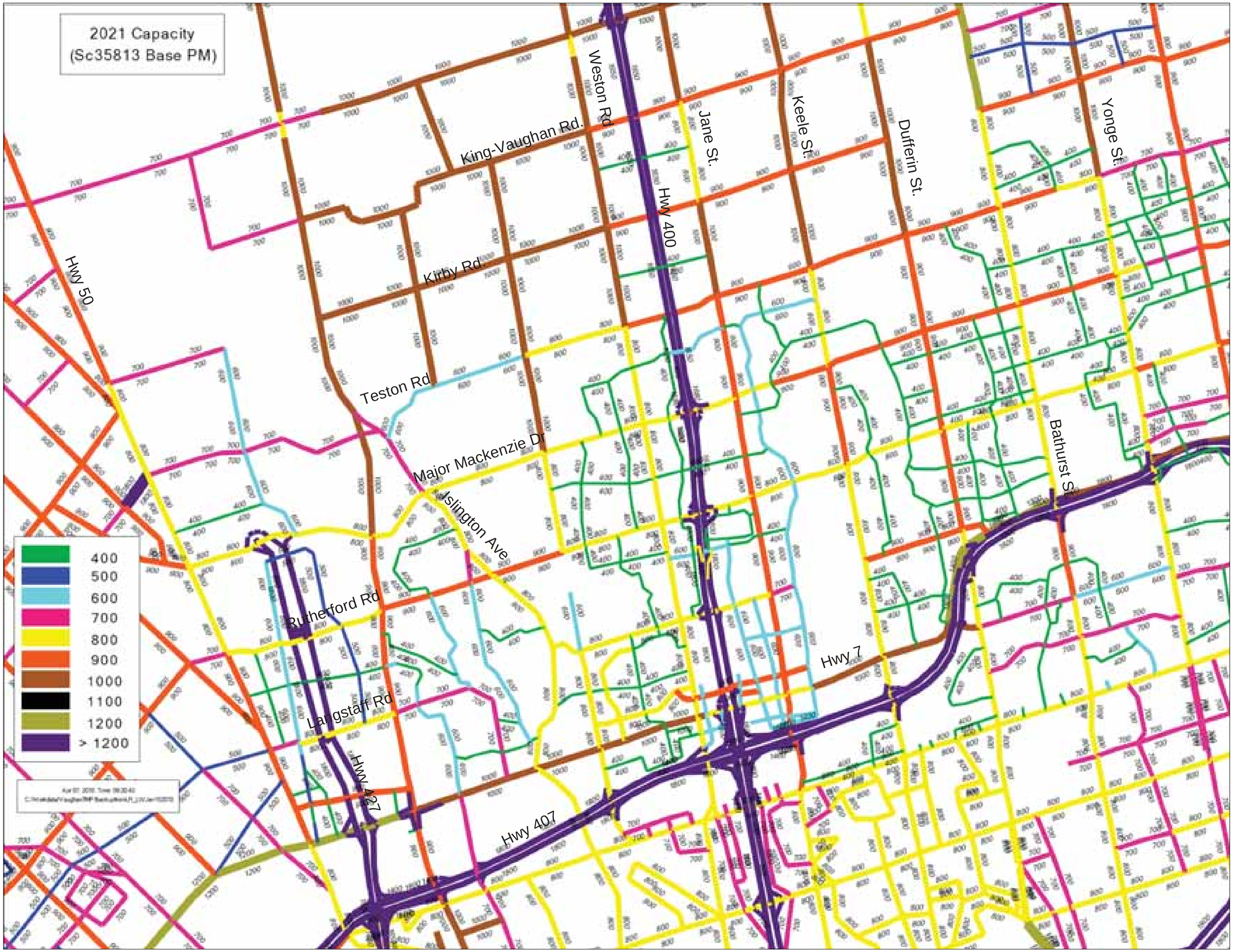
Halcrow



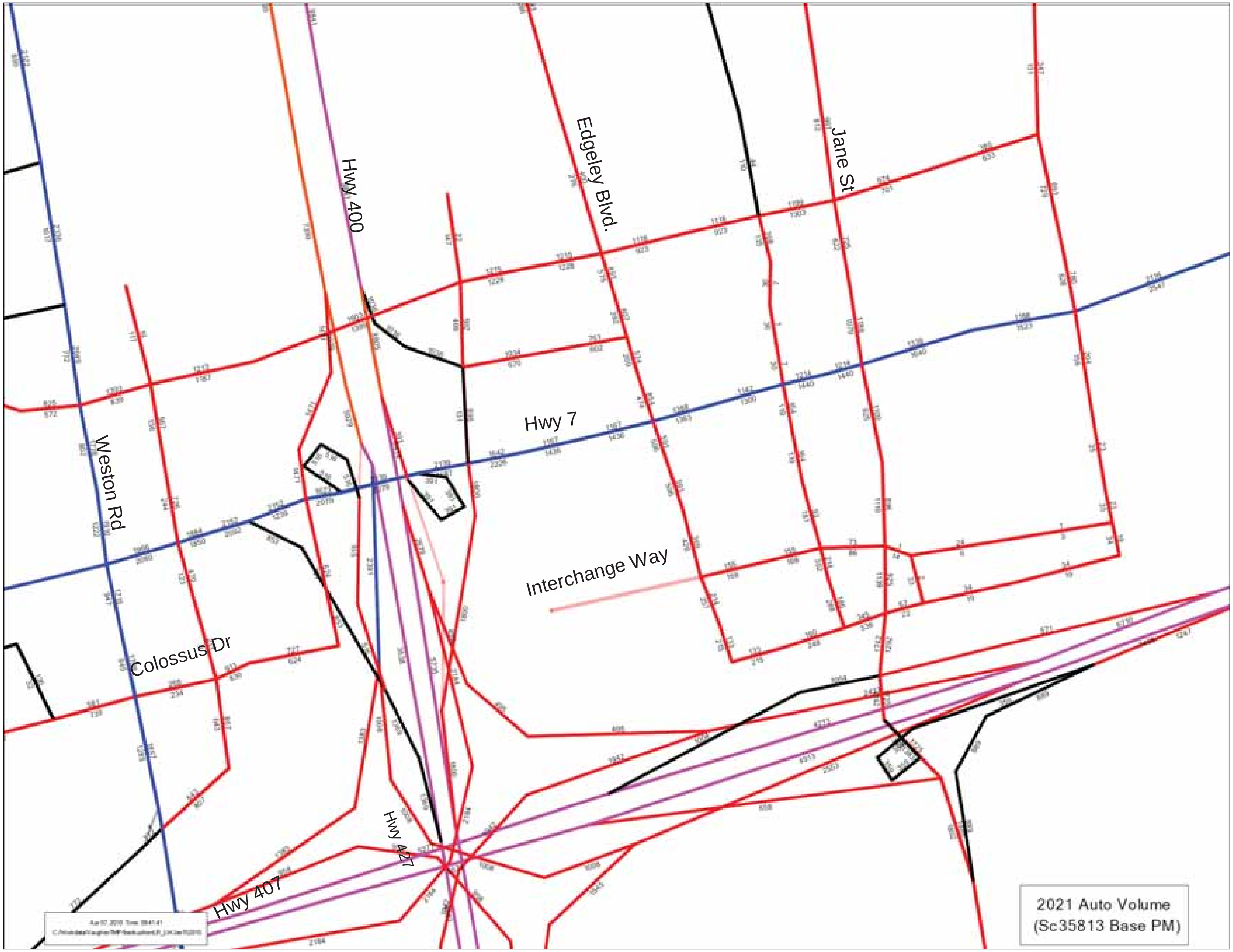
DRAFT


2021 Speed
(Sc35813 Base PM)
Weston Rd.
King-Vaughan Rd.
Jane St.
Keele St.
Dufferin St.
Yonge St.
Hwy 400
Hwy 50
Kirby Rd.
Teston Rd
Major Mackenzie Dr
Islington Ave
Rutherford Rd
Bathurst St.
Hwy 7
Langstaff Rd
Hwy 427
Hwy 407
40
50
60
70
80
90
100
>100

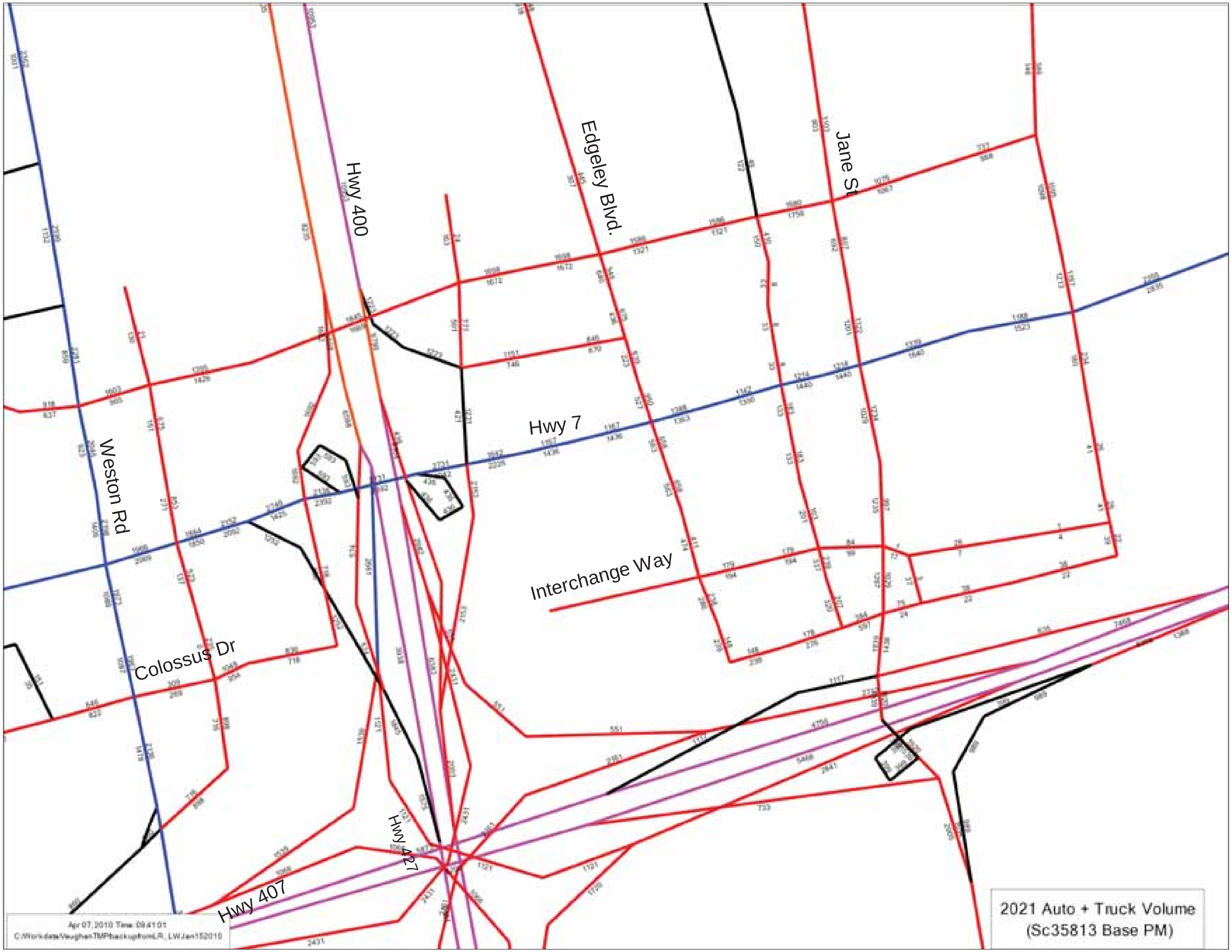
DRAFT


2021 Capacity
(Sc35813 Base PM)
400
500
600
700
800
900
1000
1100
1200
> 1200
Weston Rd
King-Vaughan Rd.
Jane St.
Keele St.
Dufferin St.
Yonge St.
Hwy 400
Kirby Rd.
Hwy 50
Teston Rd
Major Mackenzie Dr
Islington Ave
Bathurst St.
Rutherford Rd
Langstaff Rd
Hwy 427
Hwy 7
Hwy 407

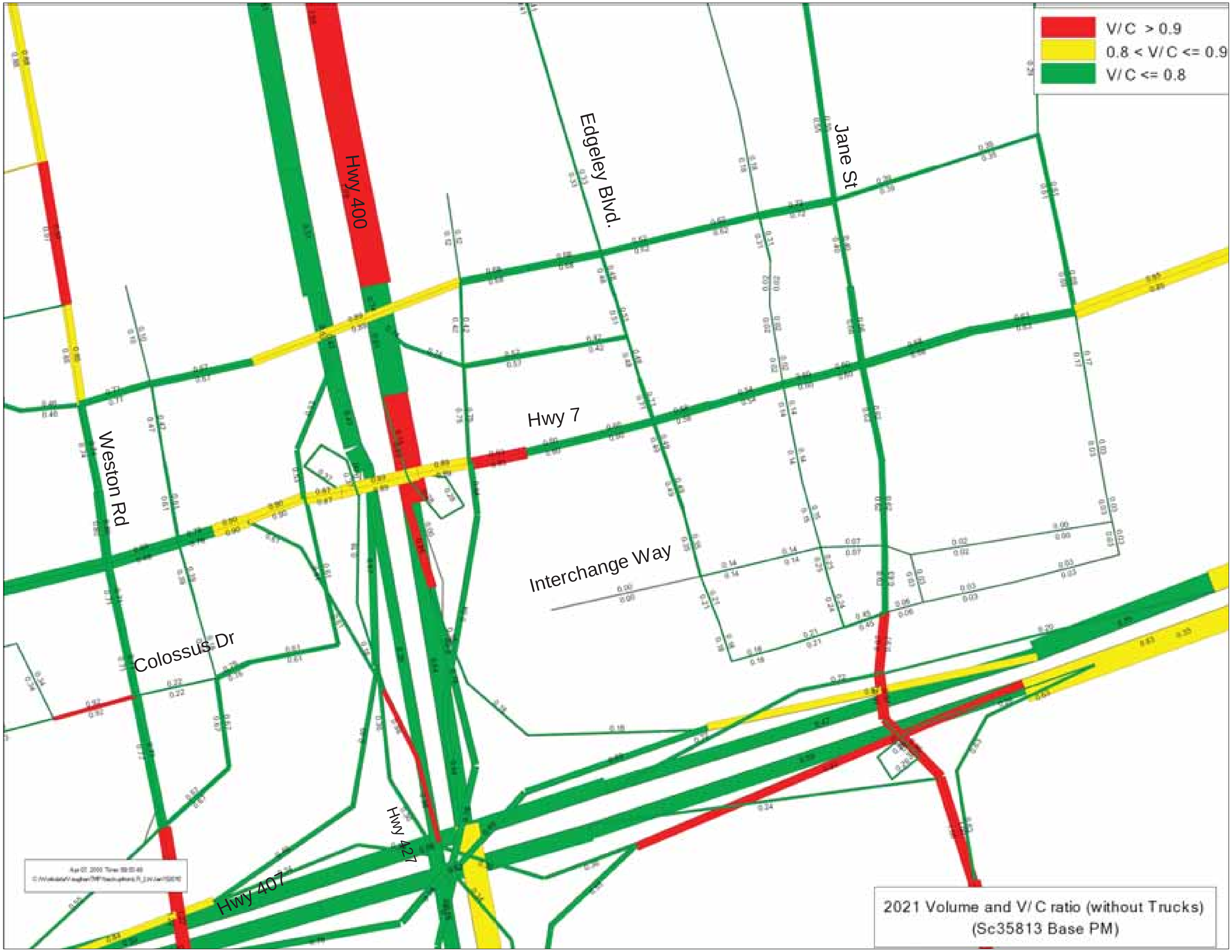
DRAFT


Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 407
Hwy 427
2021 Auto Volume
(Sc35813 Base PM)

DRAFT

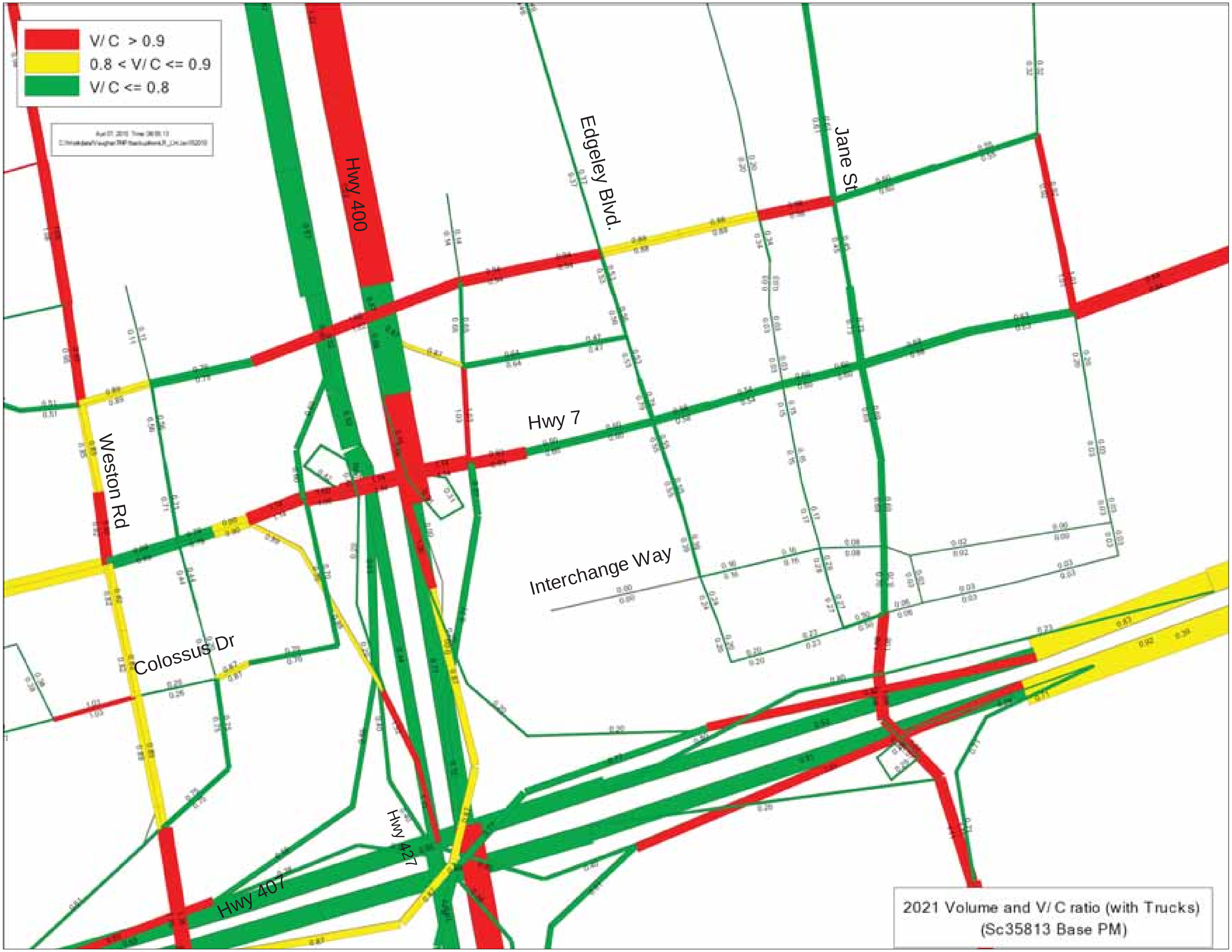

Hwy 400
Edgeley Blvd.
Jane St
Hwy 7
Weston Rd
Interchange Way
Colossus Dr
Hwy 427
Hwy 407
2021 Auto + Truck Volume
(Sc35813 Base PM)

Halcrow



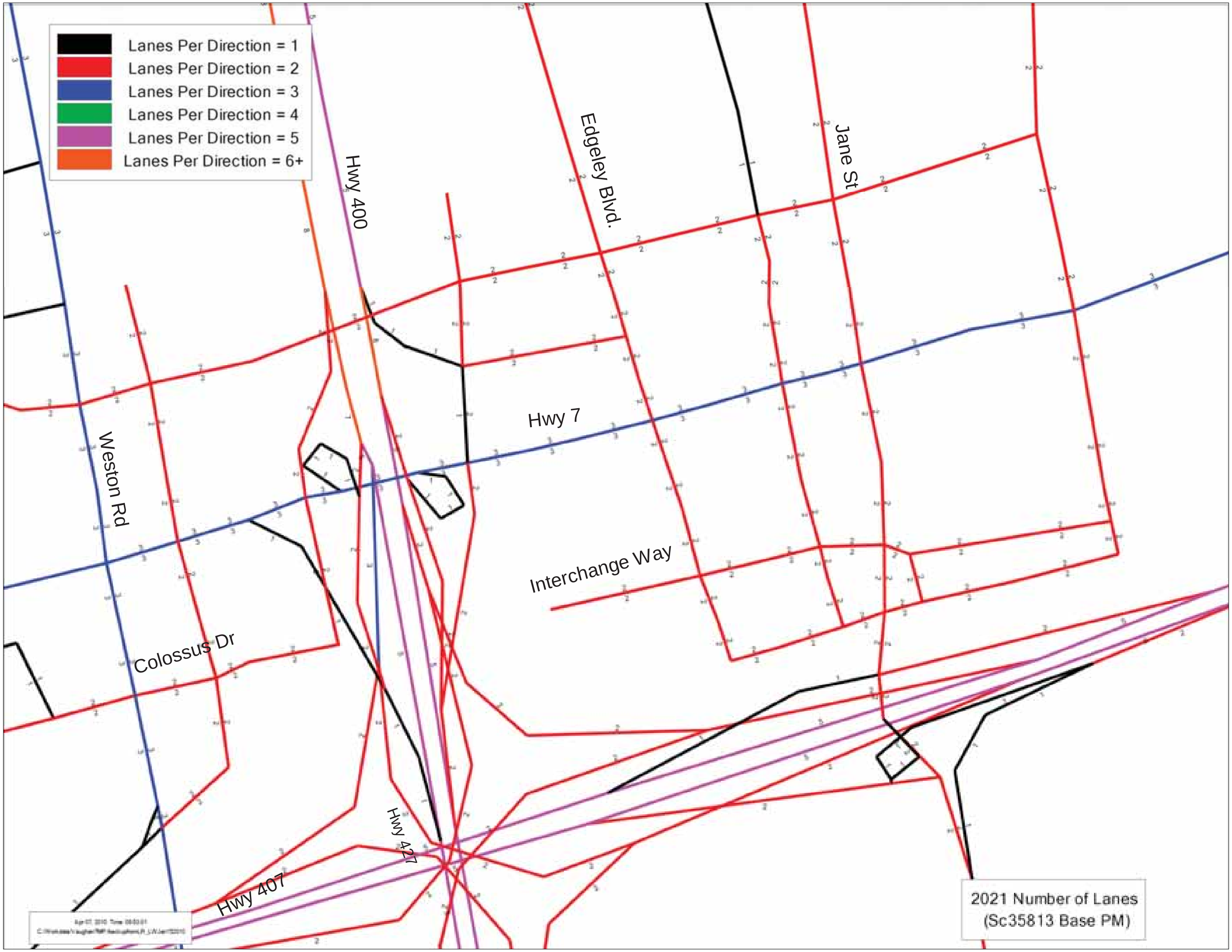
DRAFT

Halcrow



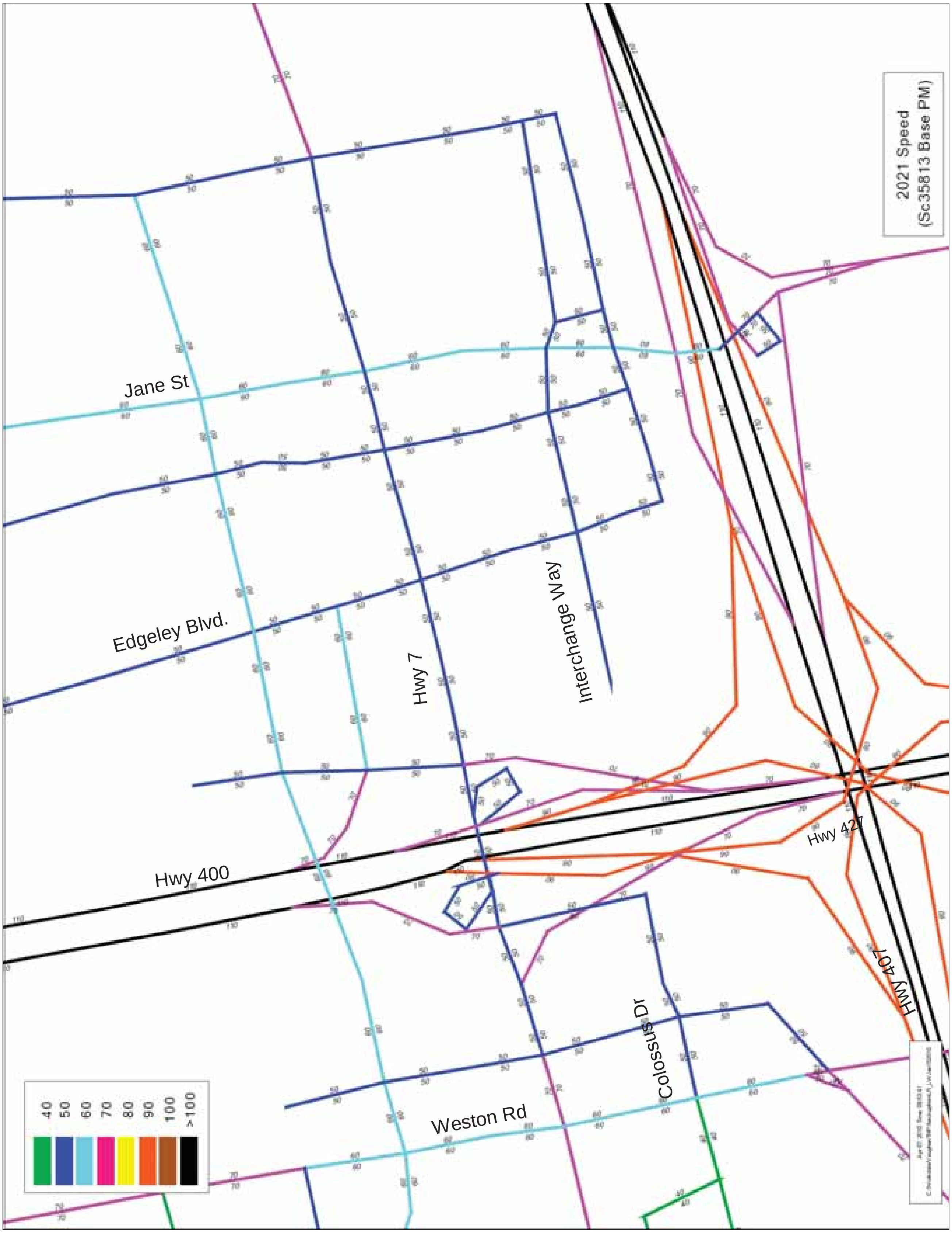
DRAFT

Halcrow



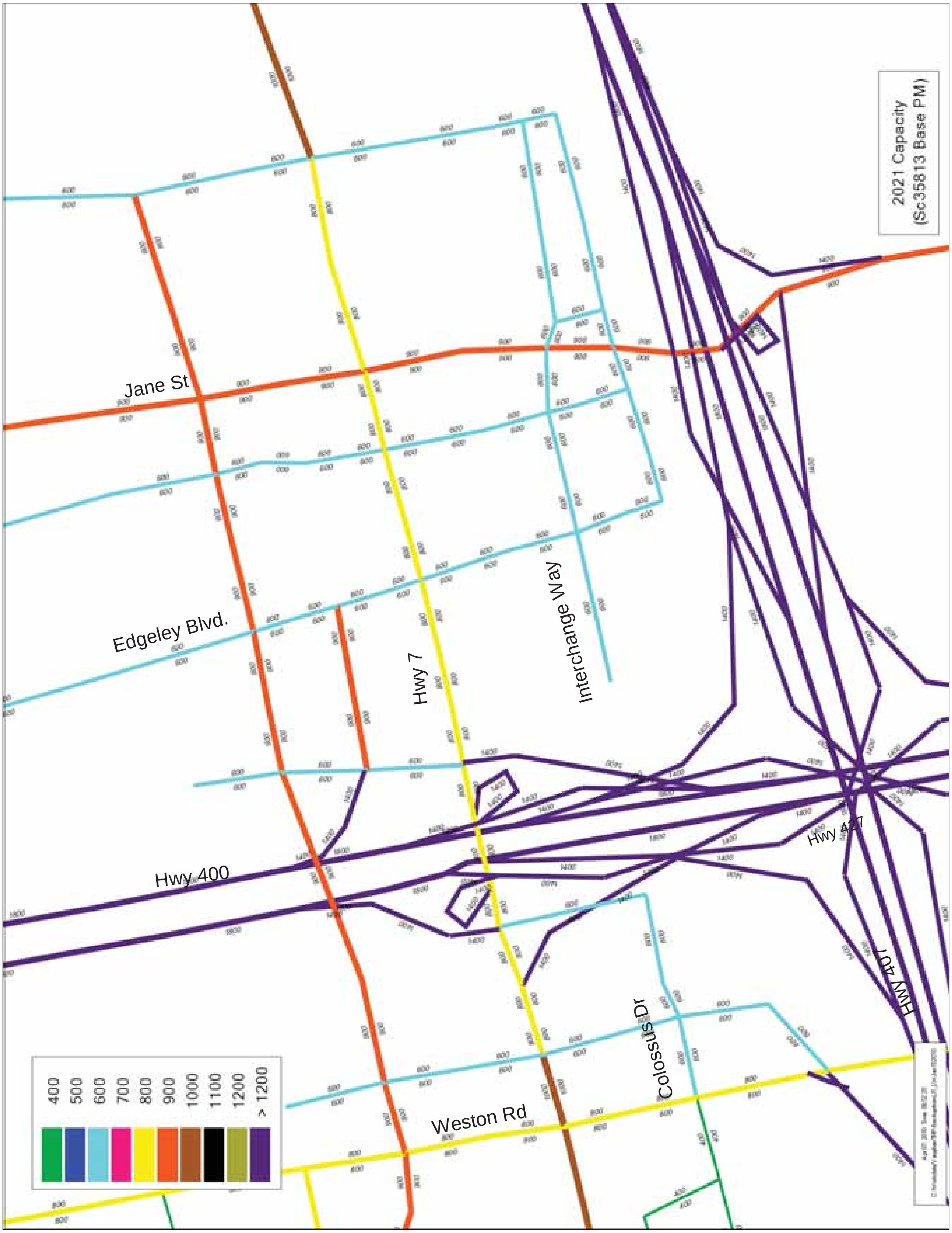
DRAFT

DRAFT



Halcrow

DRAFT



Halcrow

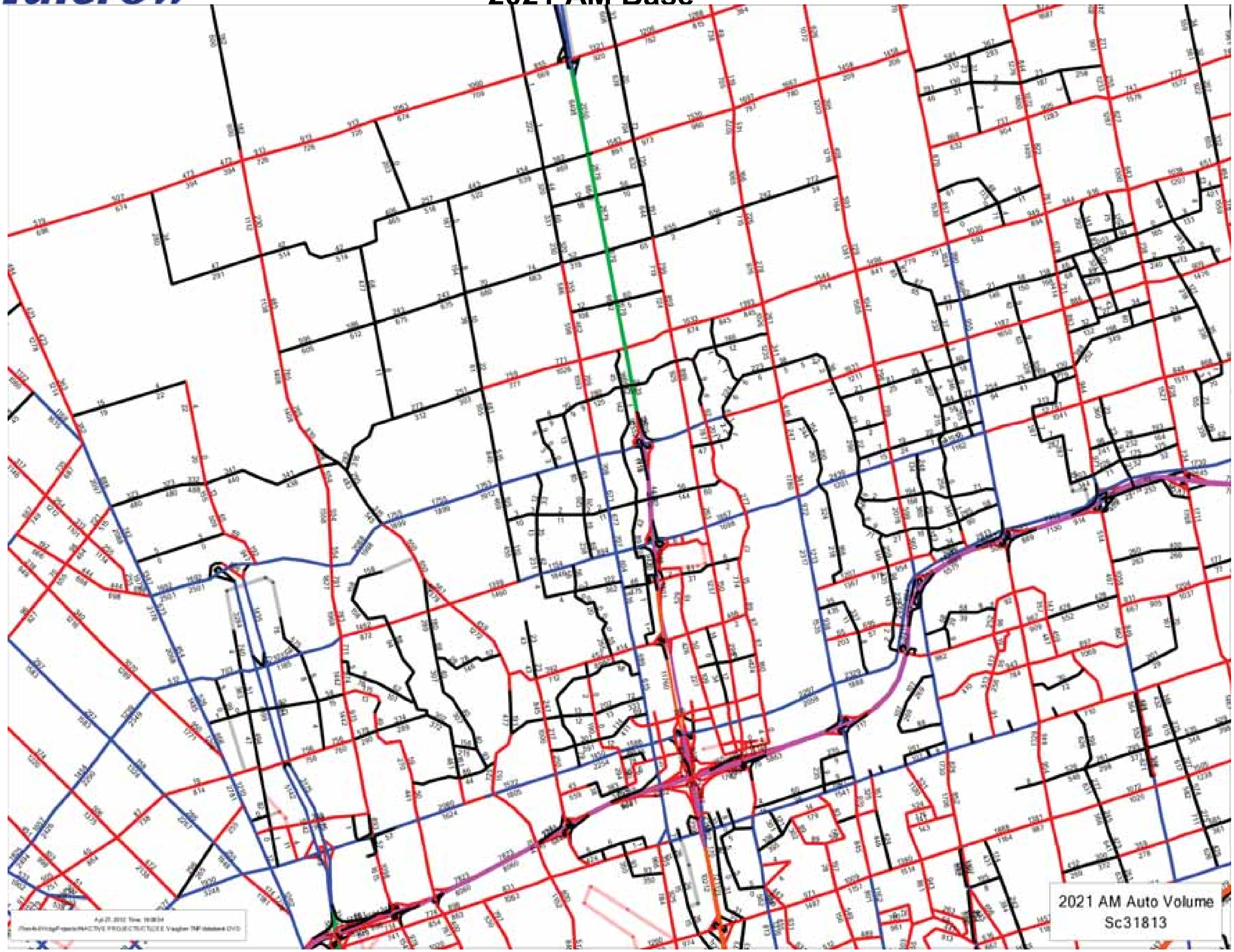
F2. Model Applications (Halcrow)

VAUGHAN

F2.1 2021 Base Network – AM Peak Hour

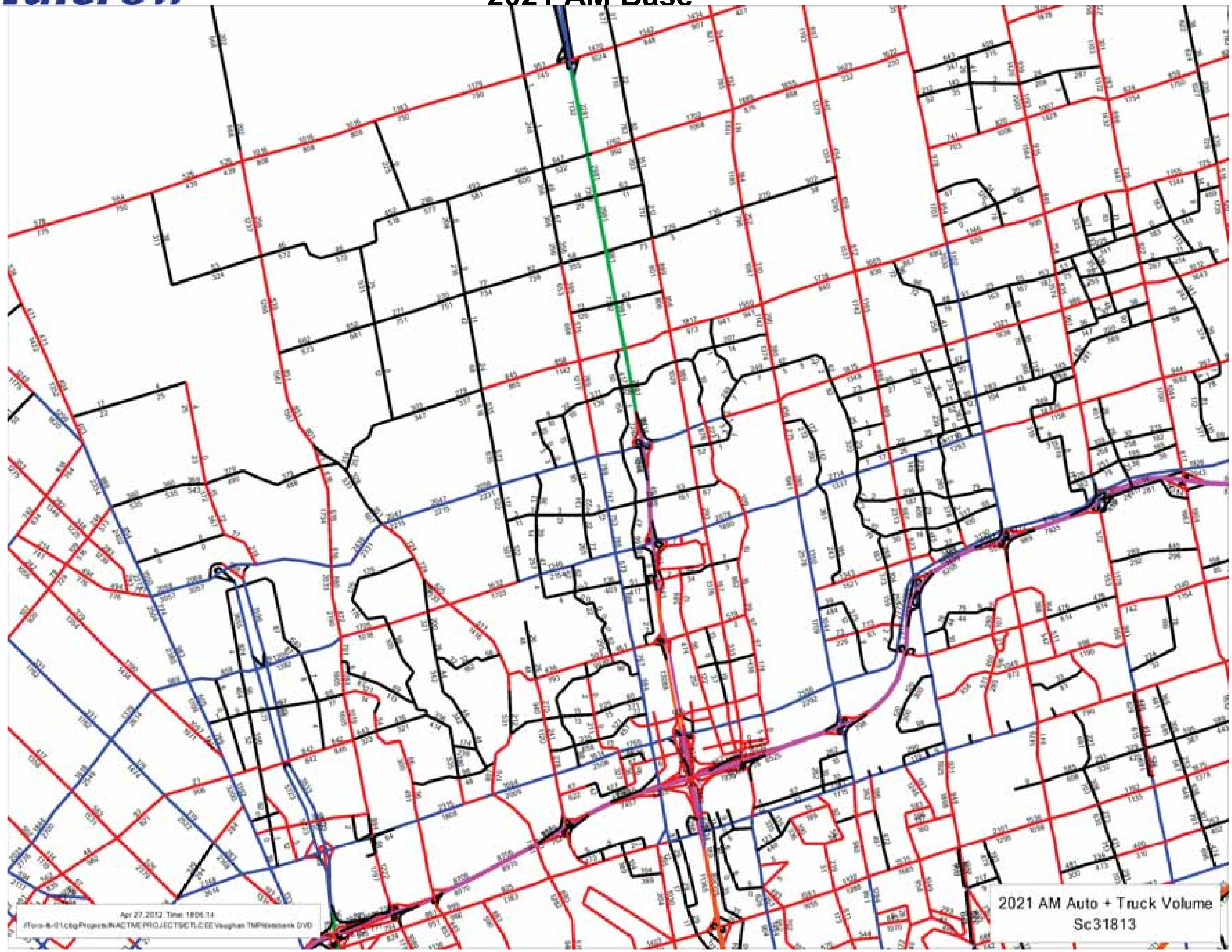
VAUGHAN

2021 AM Base



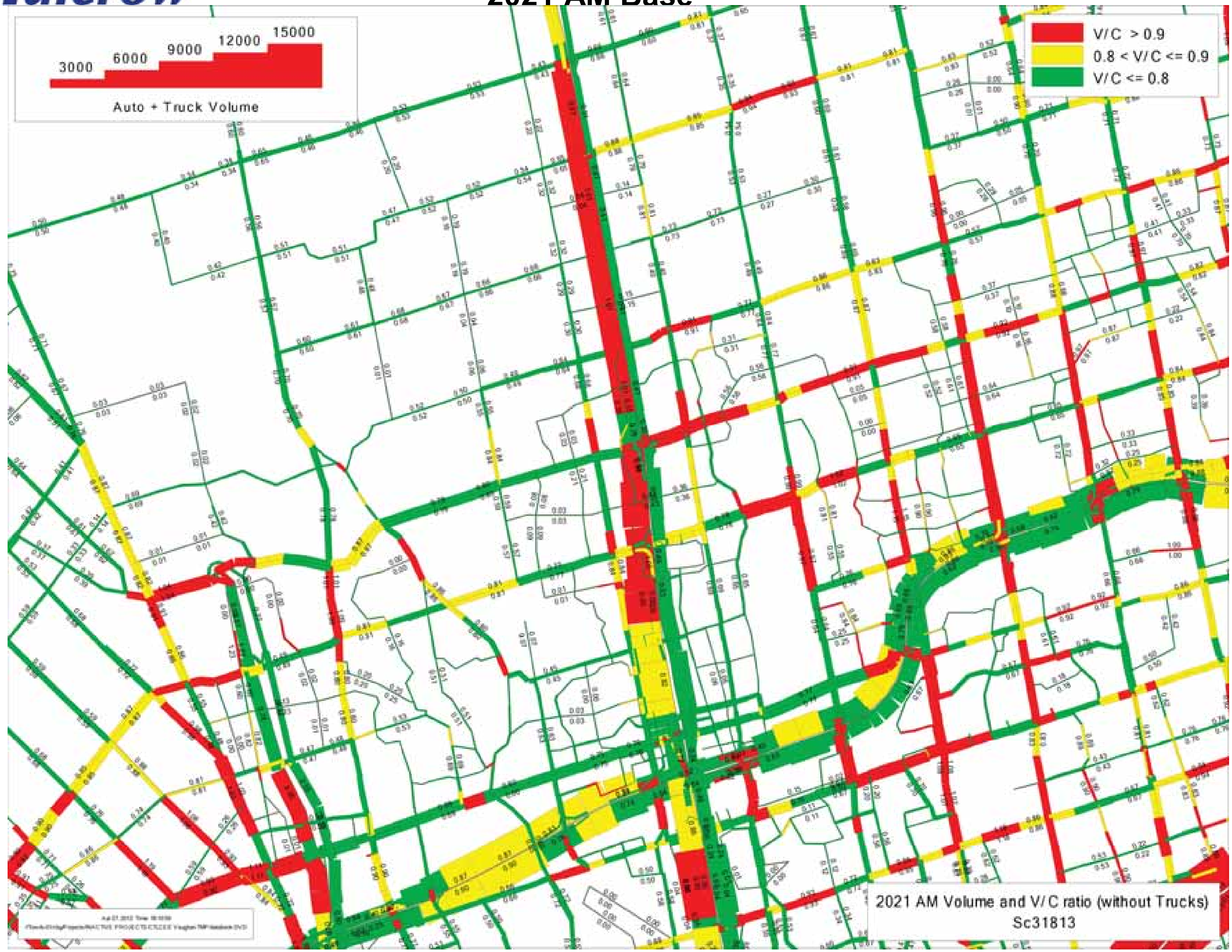
Halcrow

2021 AM Base



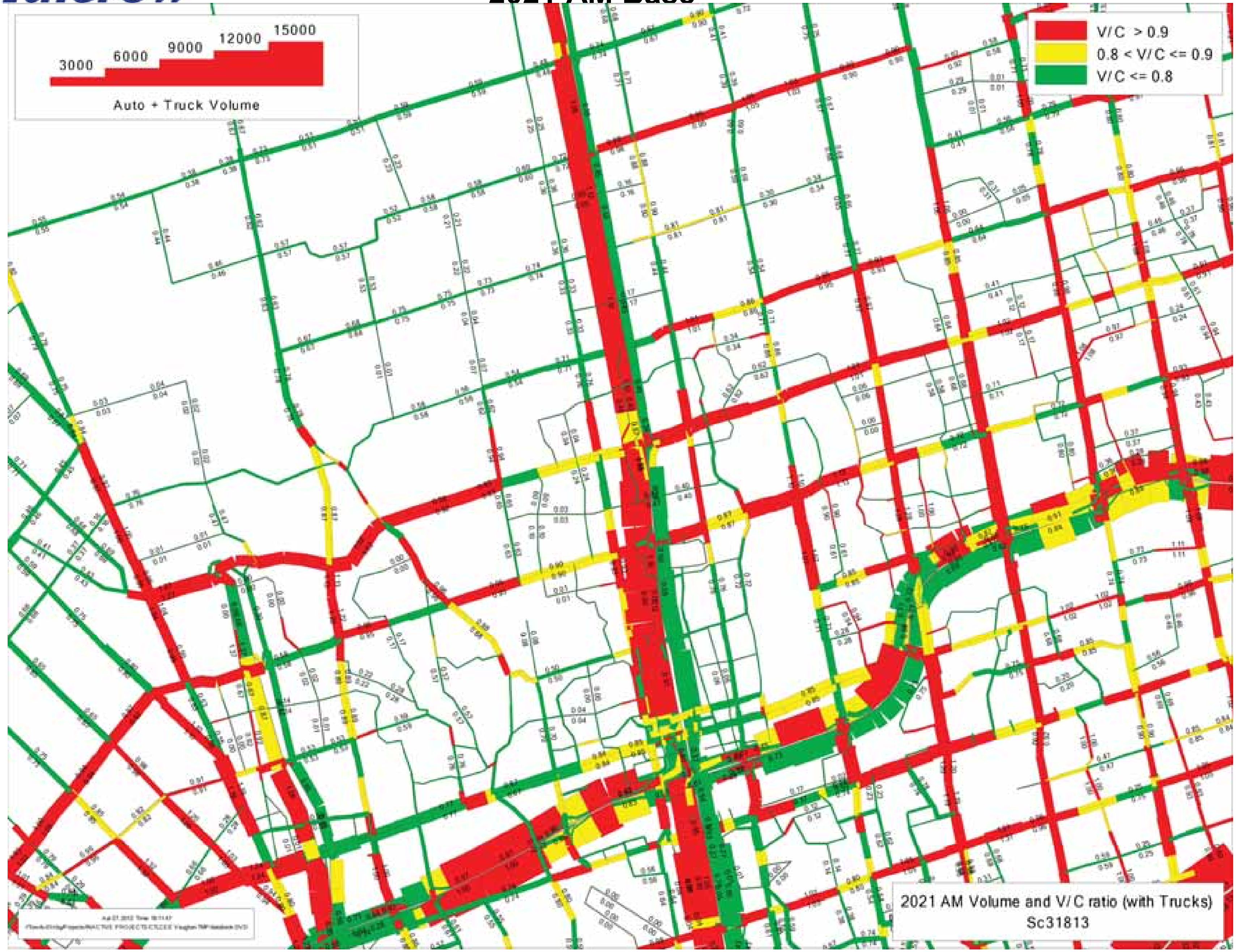
Halcrow

2021 AM Base



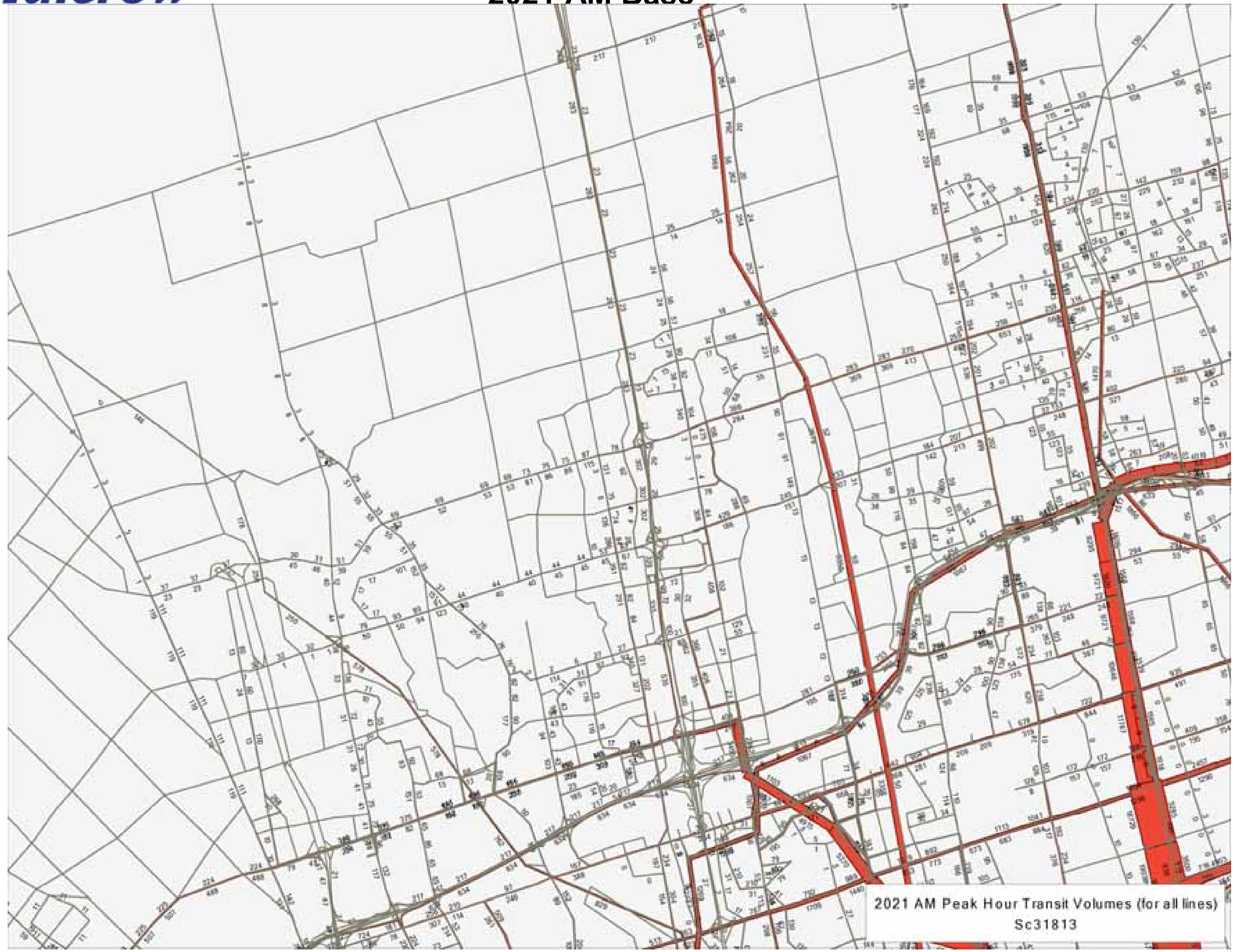
Halcrow

2021 AM Base

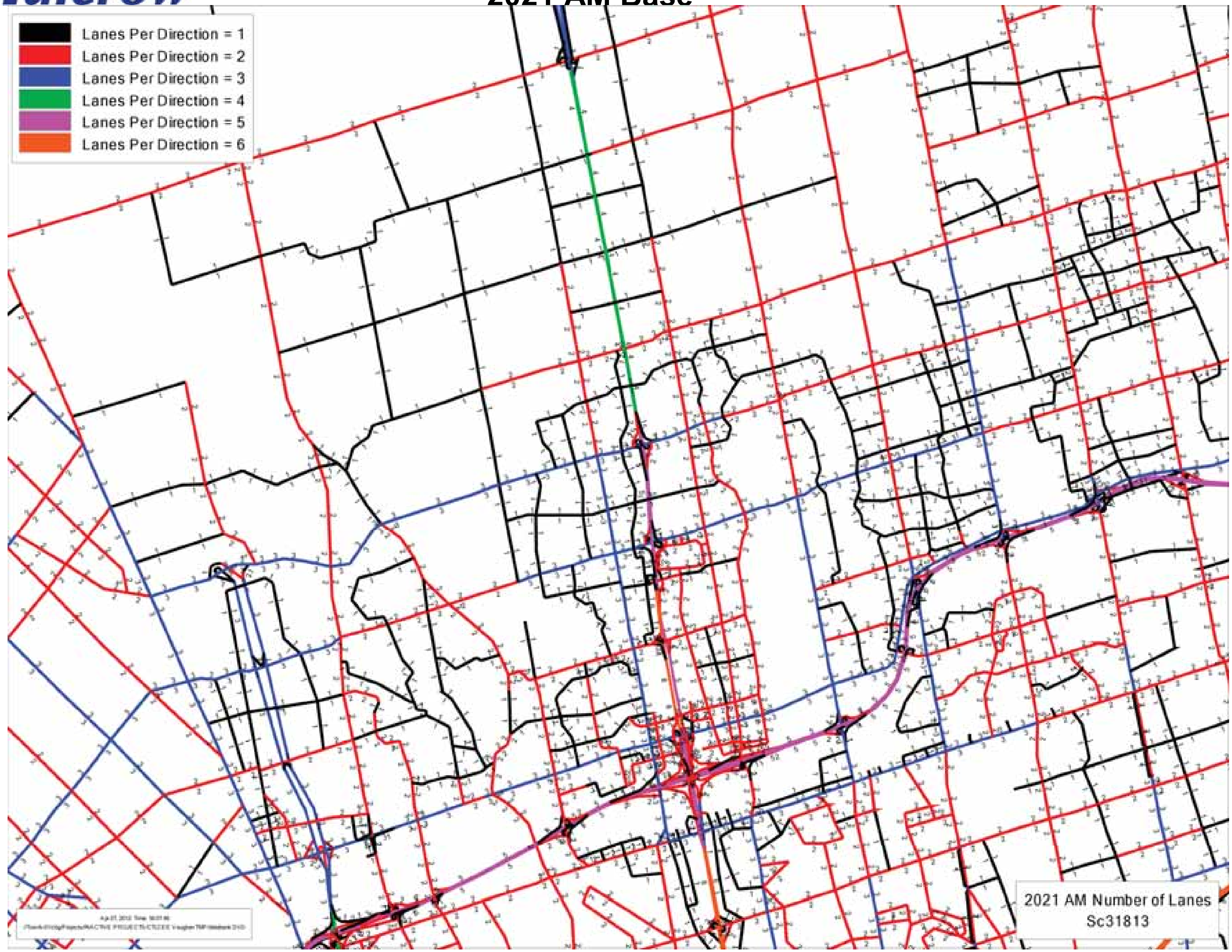


Halcrow

2021 AM Base

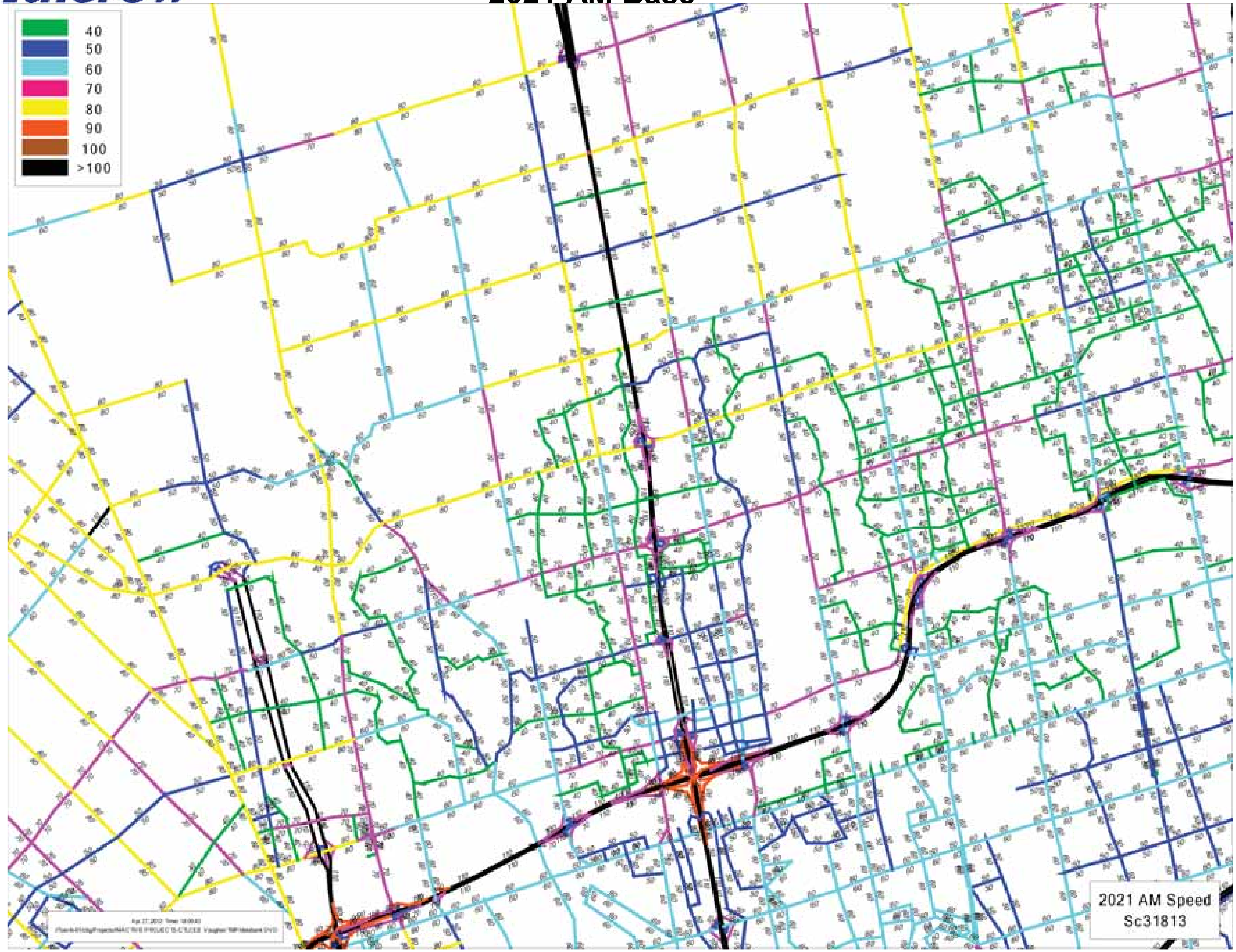


2021 AM Base

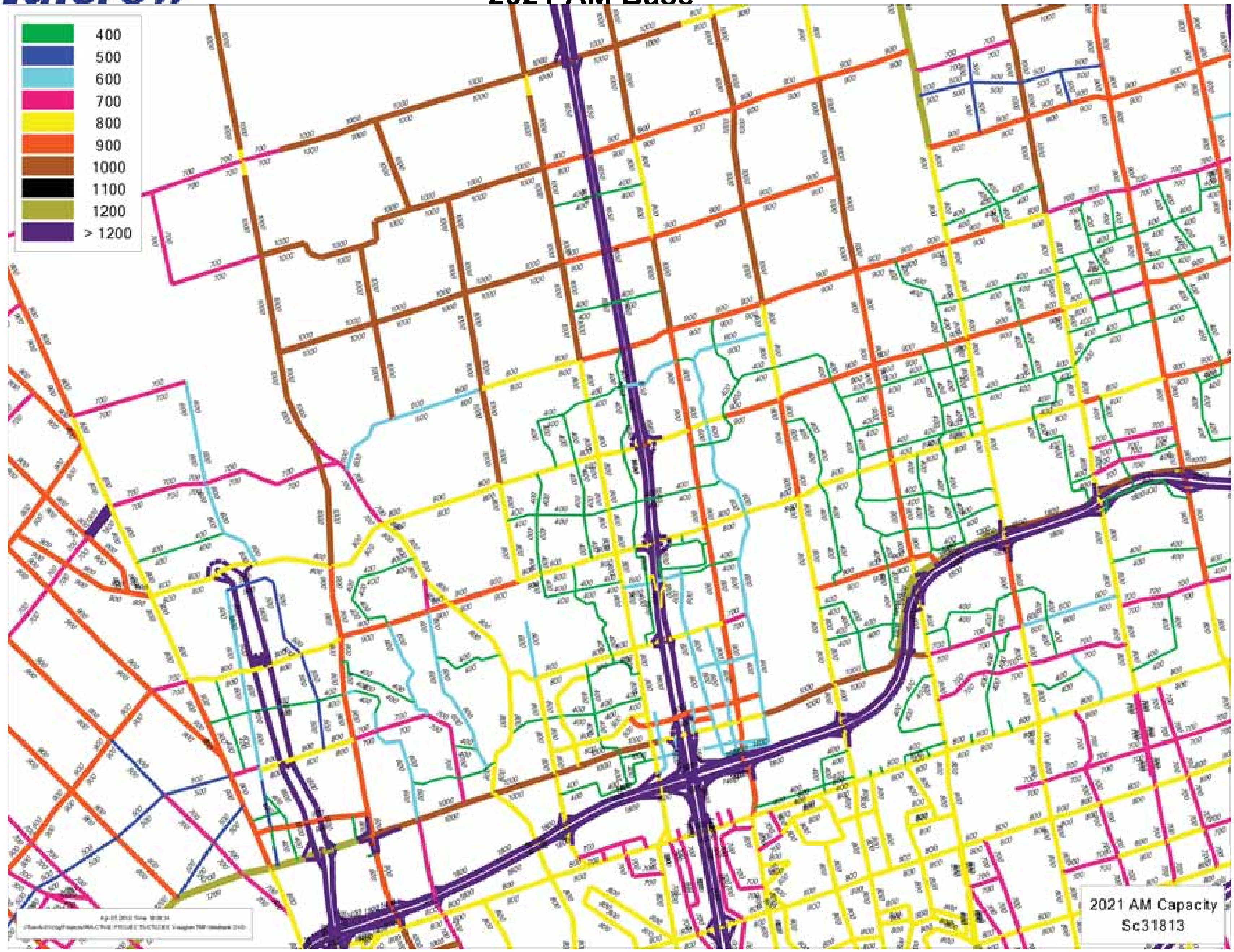


Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6
2021 AM Number of Lanes
Sc31813

2021 AM Base



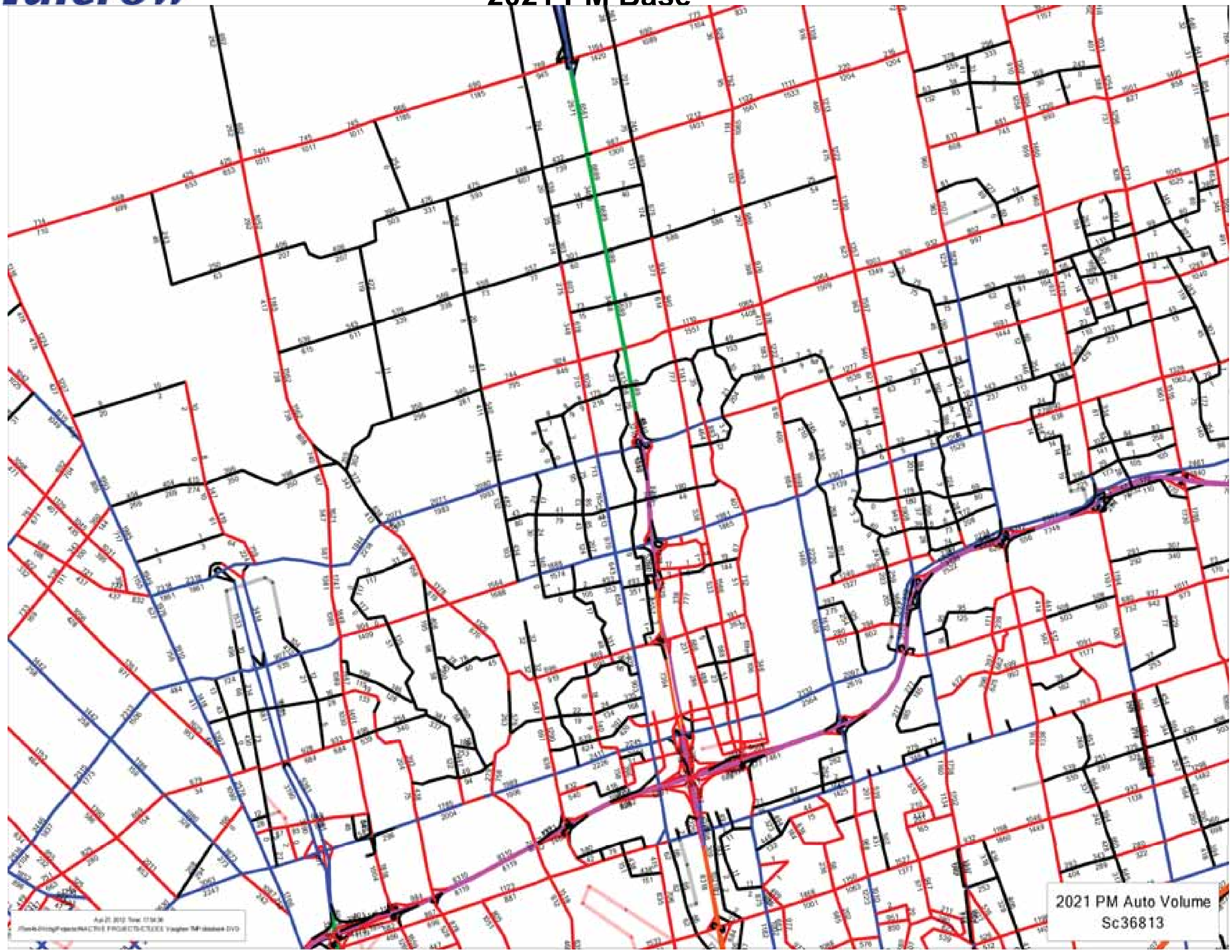
2021 AM Base


400
500
600
700
800
900
1000
1100
1200
> 1200
2021 AM Capacity
Sc31813

F2.2 2021 Base Network – PM Peak Hour

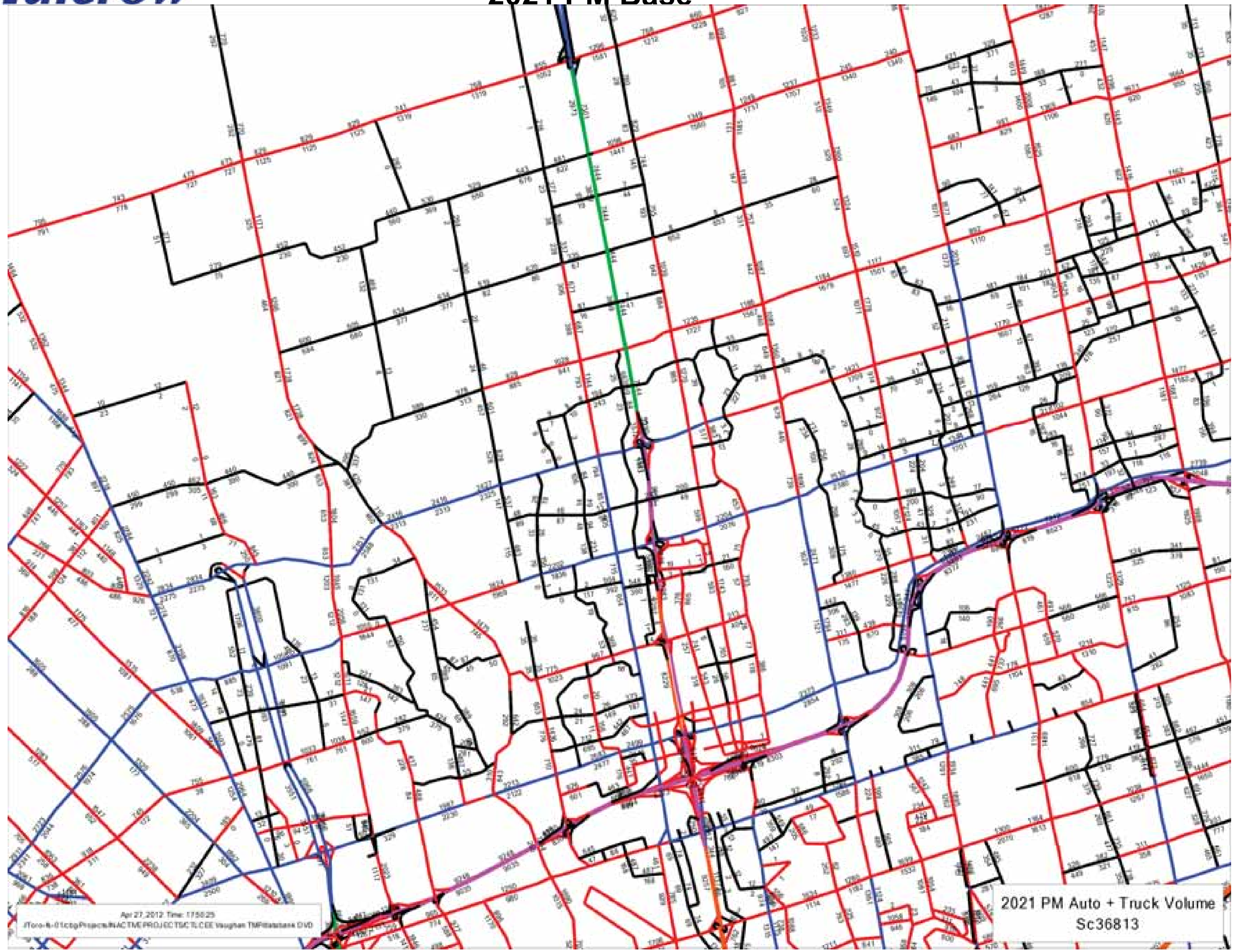
Halcrow

2021 PM Base

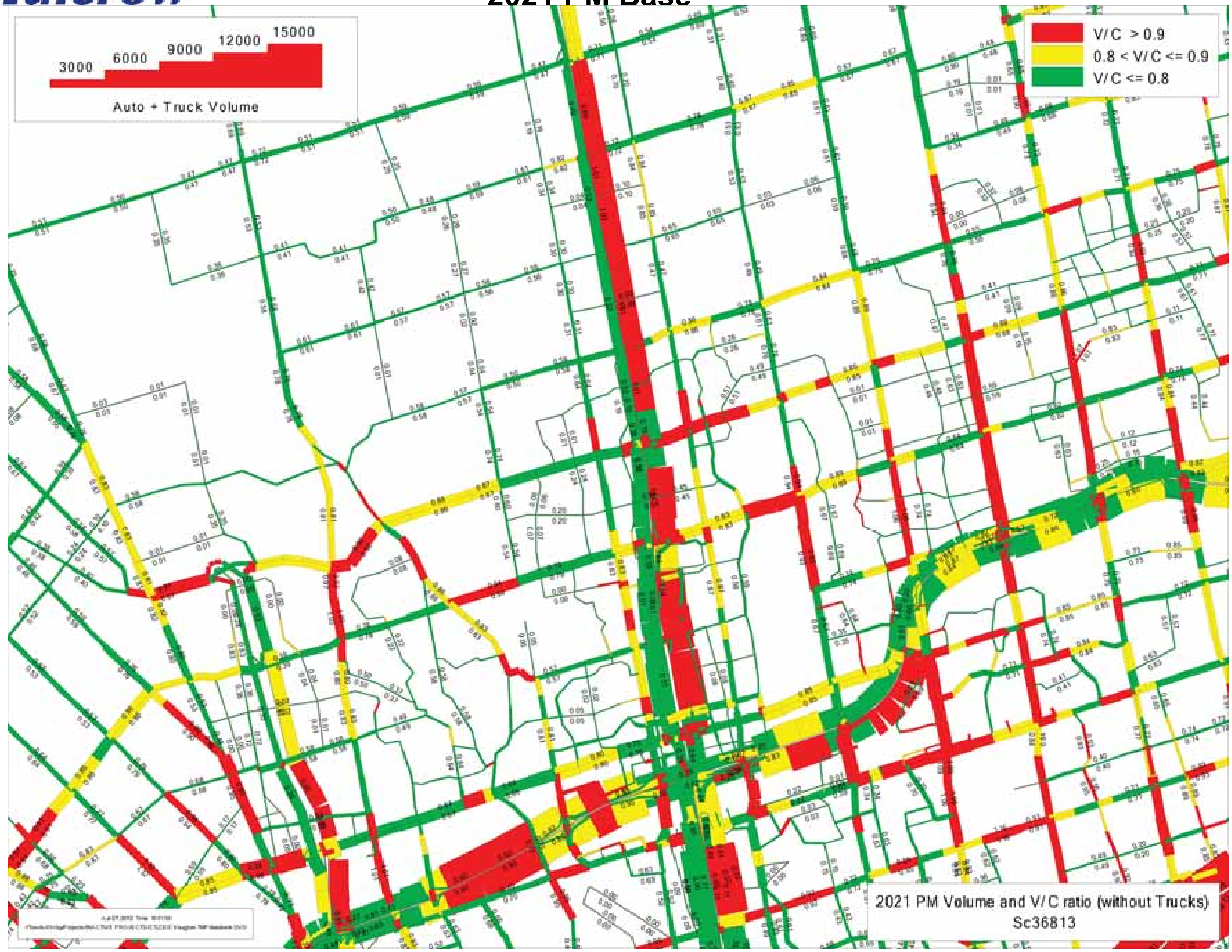


Halcrow

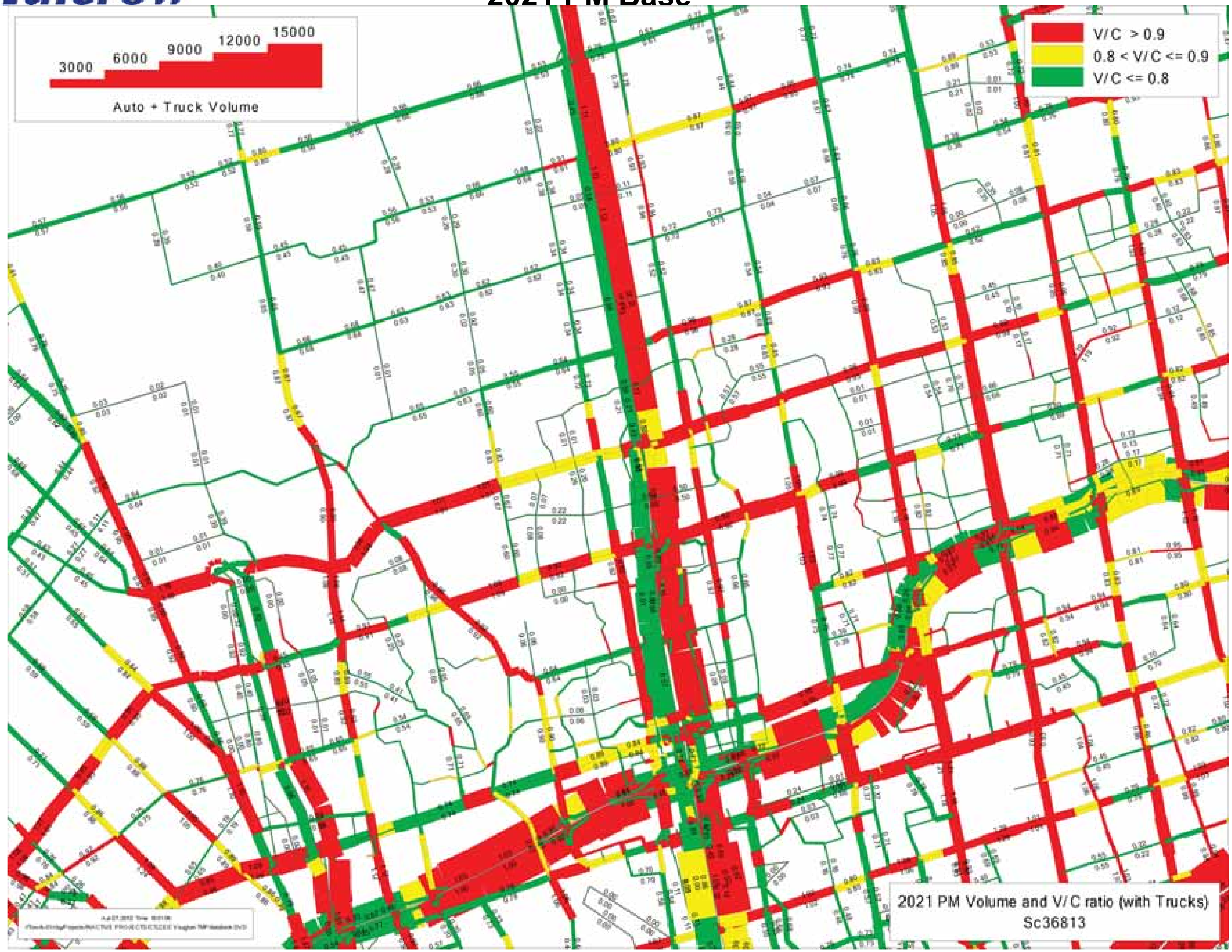
2021 PM Base



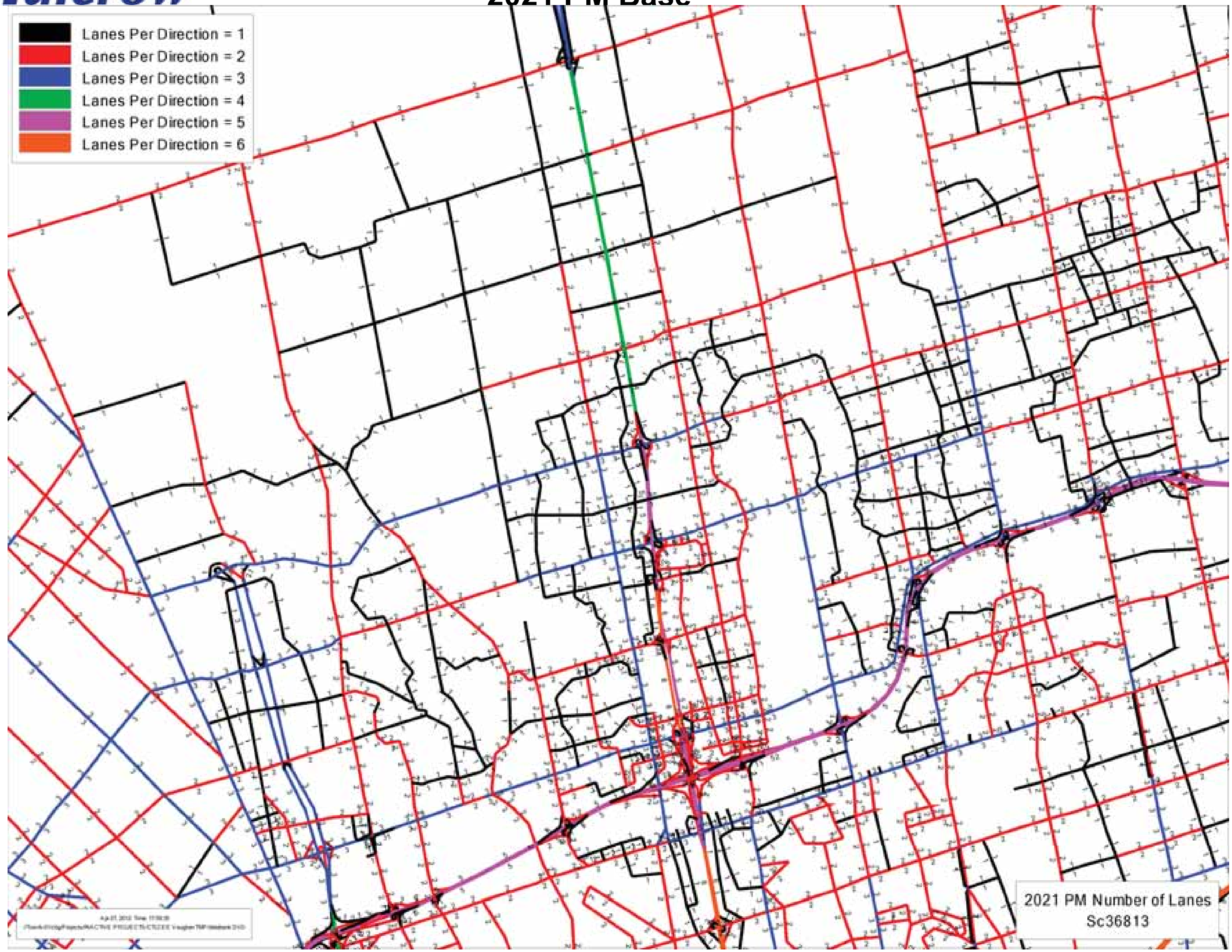
2021 PM Base


3000
6000
9000
12000
15000
Auto + Truck Volume
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
2021 PM Volume and V/C ratio (without Trucks)
Sc36813

2021 PM Base


3000
6000
9000
12000
15000
Auto + Truck Volume
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
2021 PM Volume and V/C ratio (with Trucks)
Sc36813

2021 PM Base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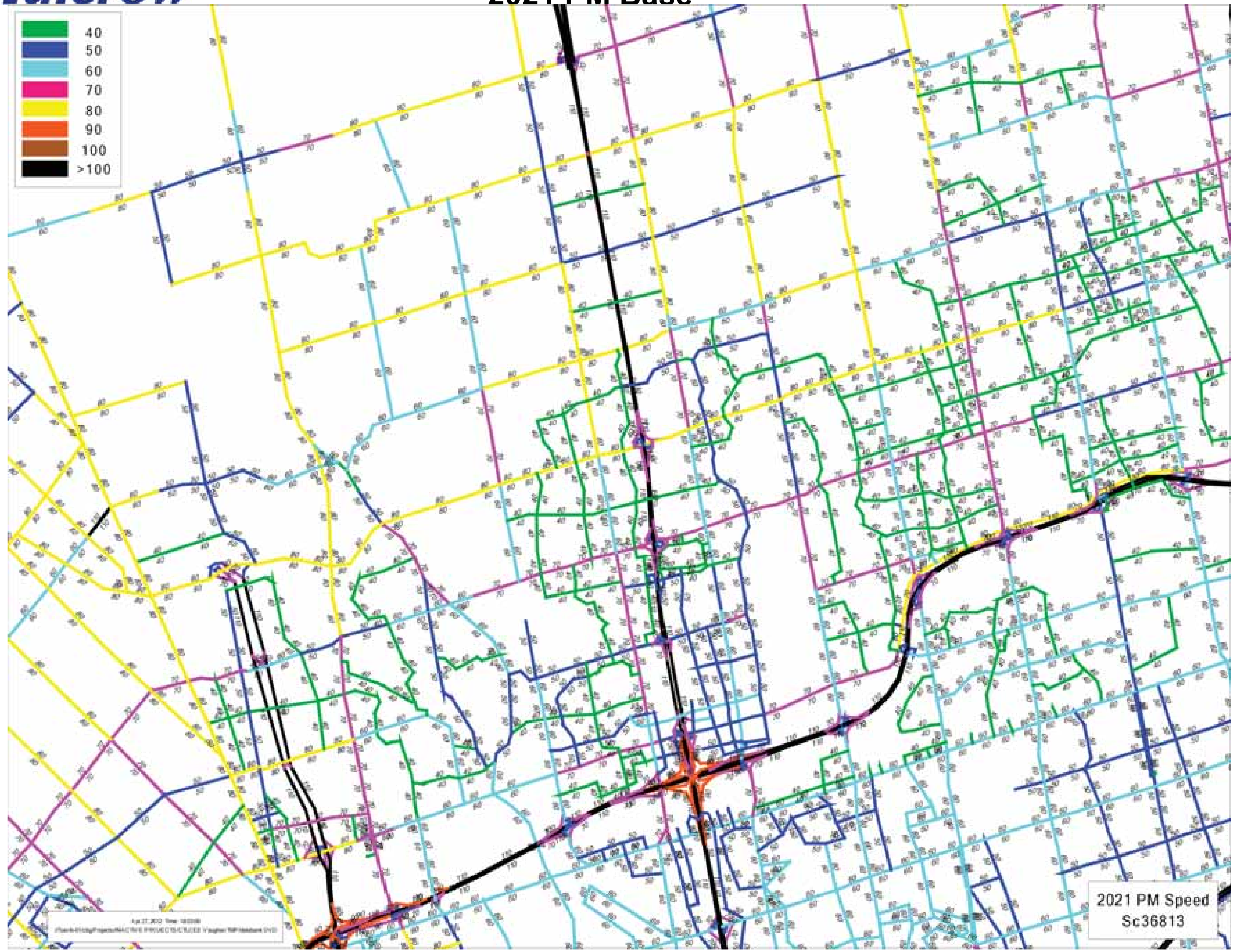
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6
2021 PM Number of Lanes
Sc36813

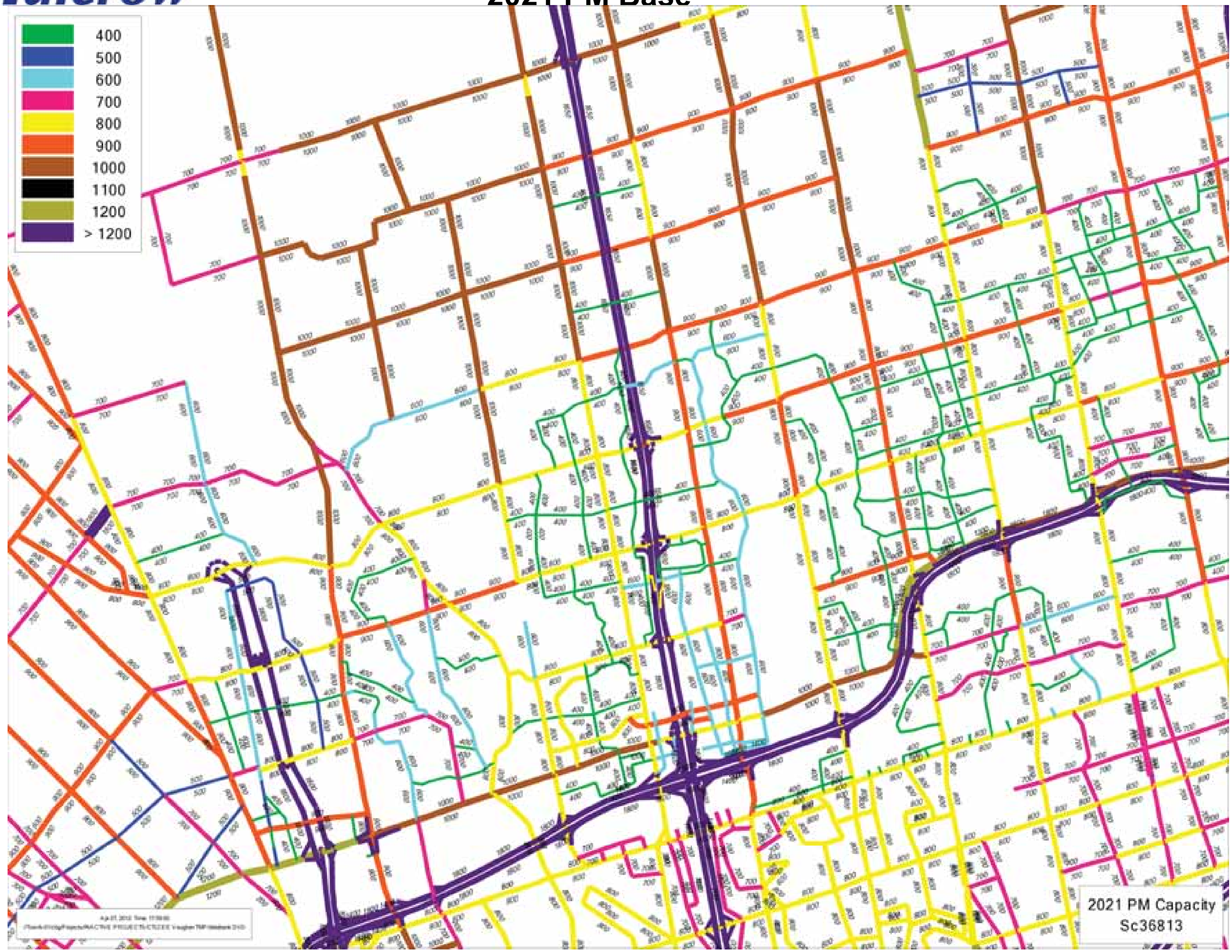
Halcrow

2021 PM Base



Halcrow

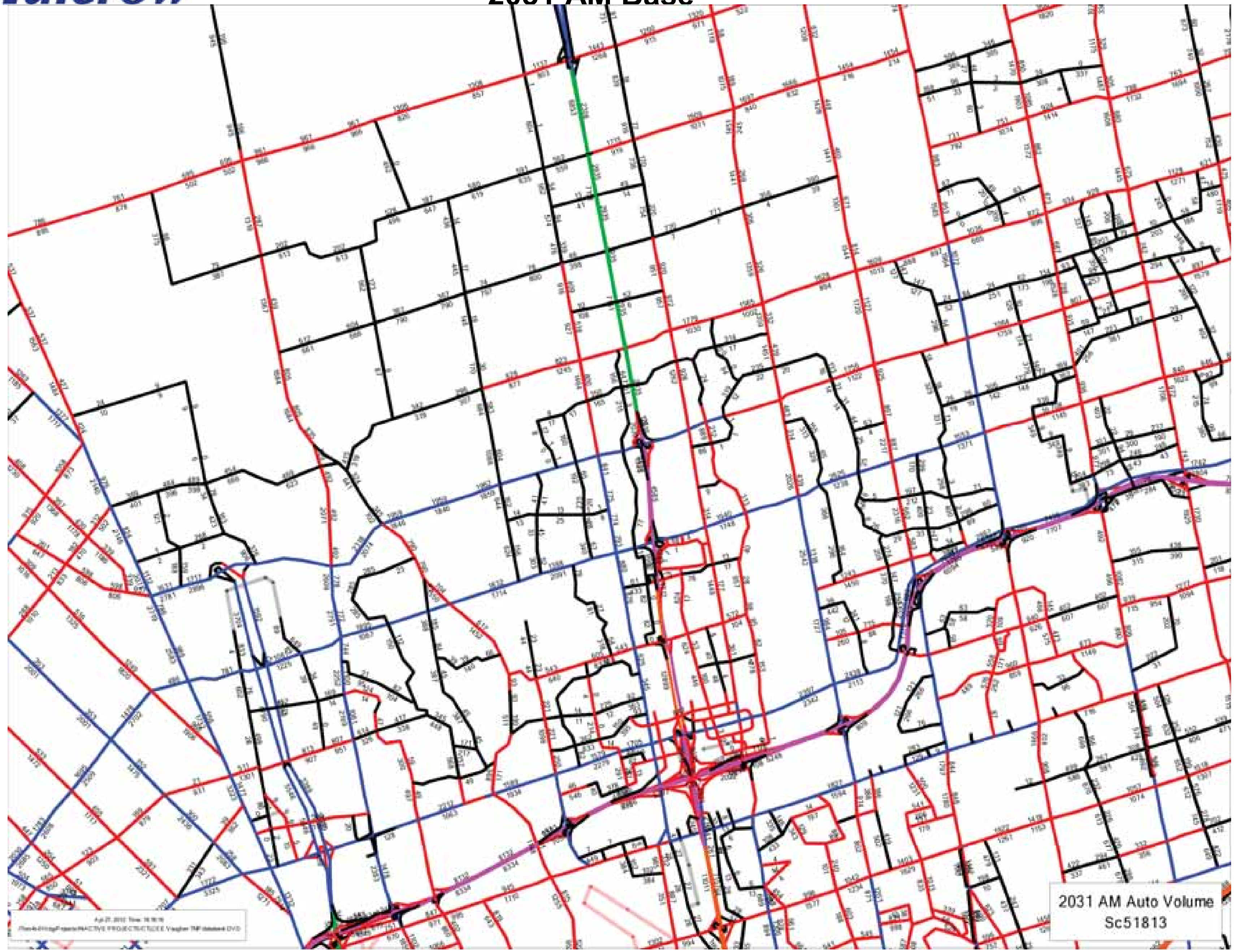
2021 PM Base



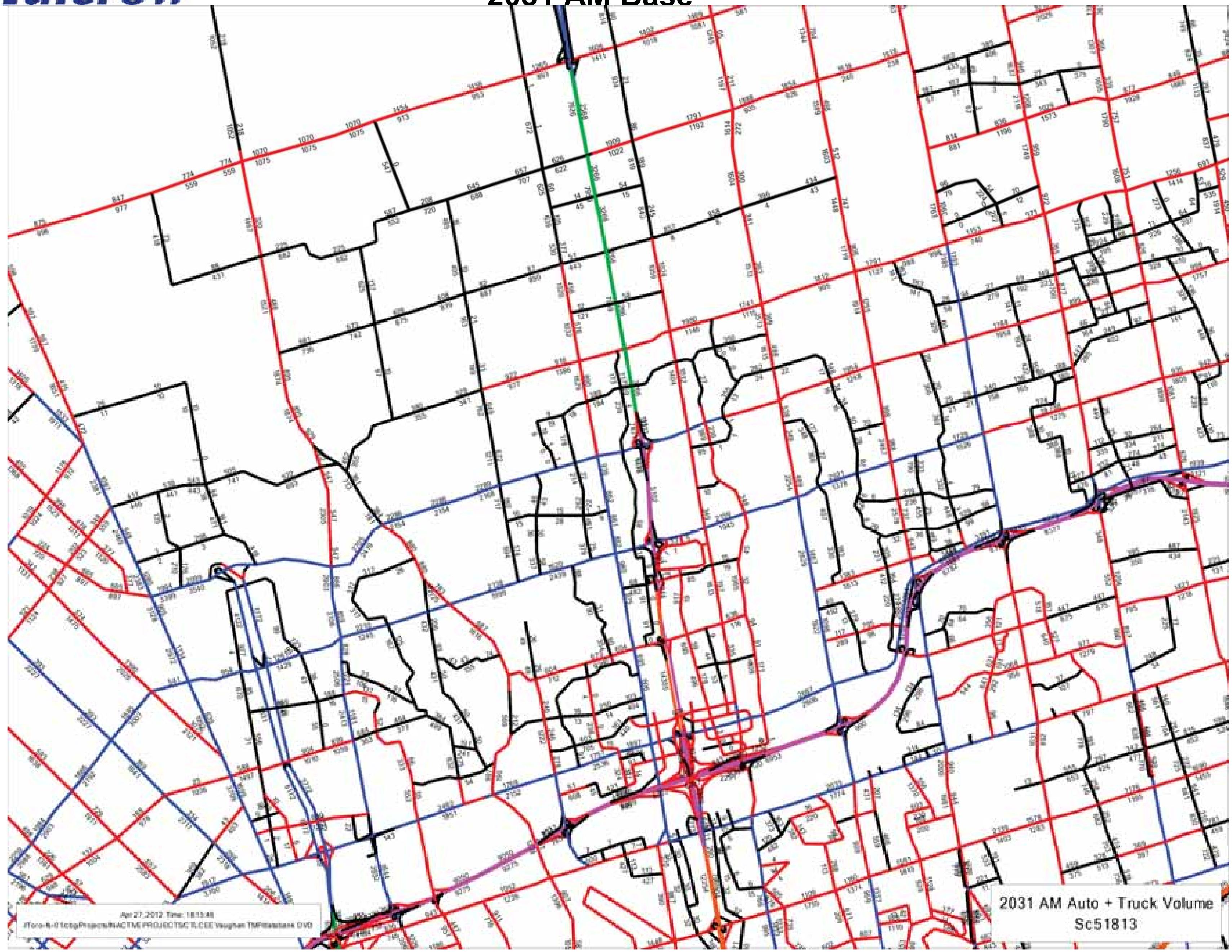
F2.3 2031 Base Network – AM Peak Hour

VAUGHAN

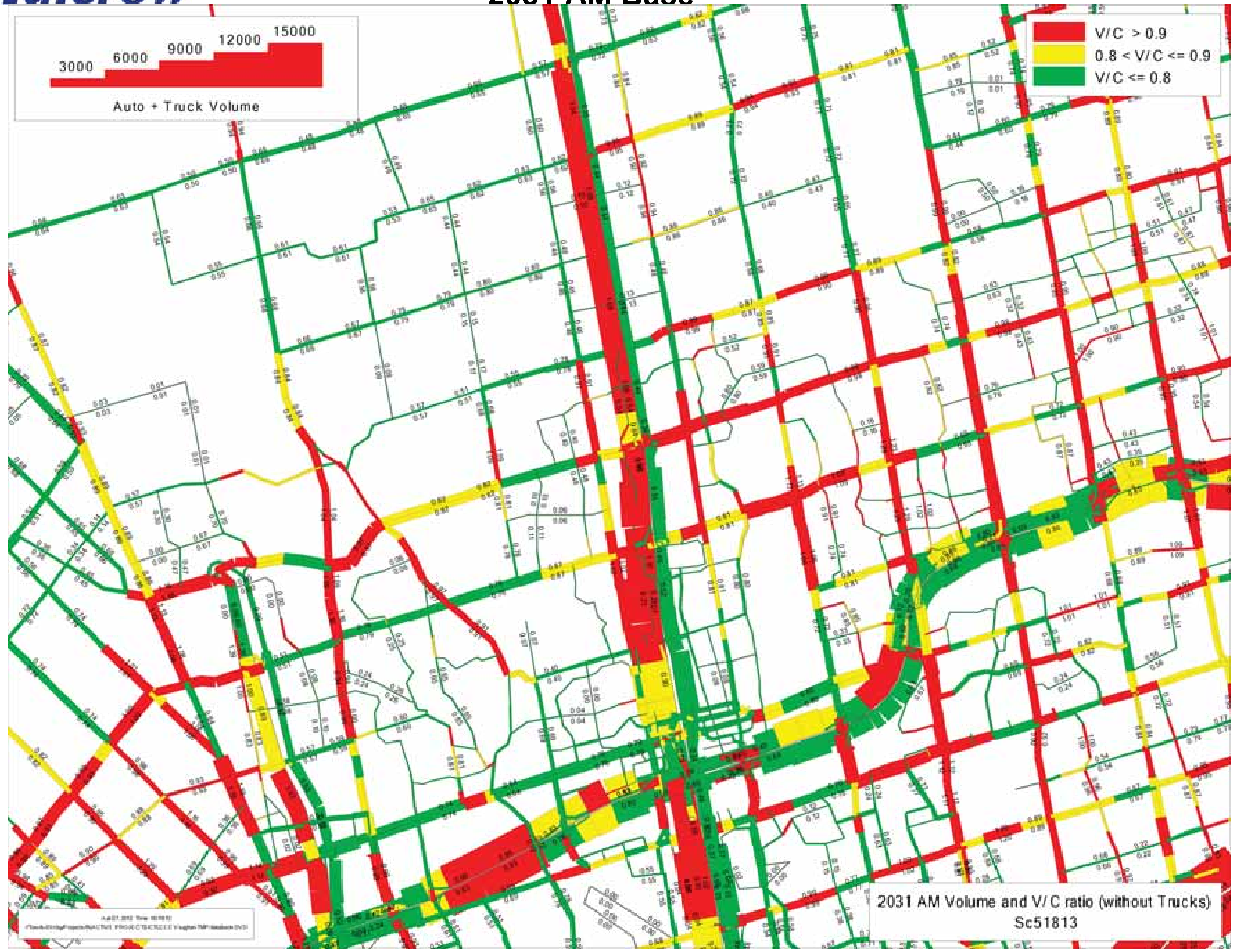
2031 AM Base



2031 AM Base


2031 AM Auto + Truck Volume
Sc51813
Apr 27,2012 Time: 18:15:48
/Toro-fs-01/cbg/Projects/INACTIVE PROJECTS/CTL CEE Vaughan TMP/database DVD

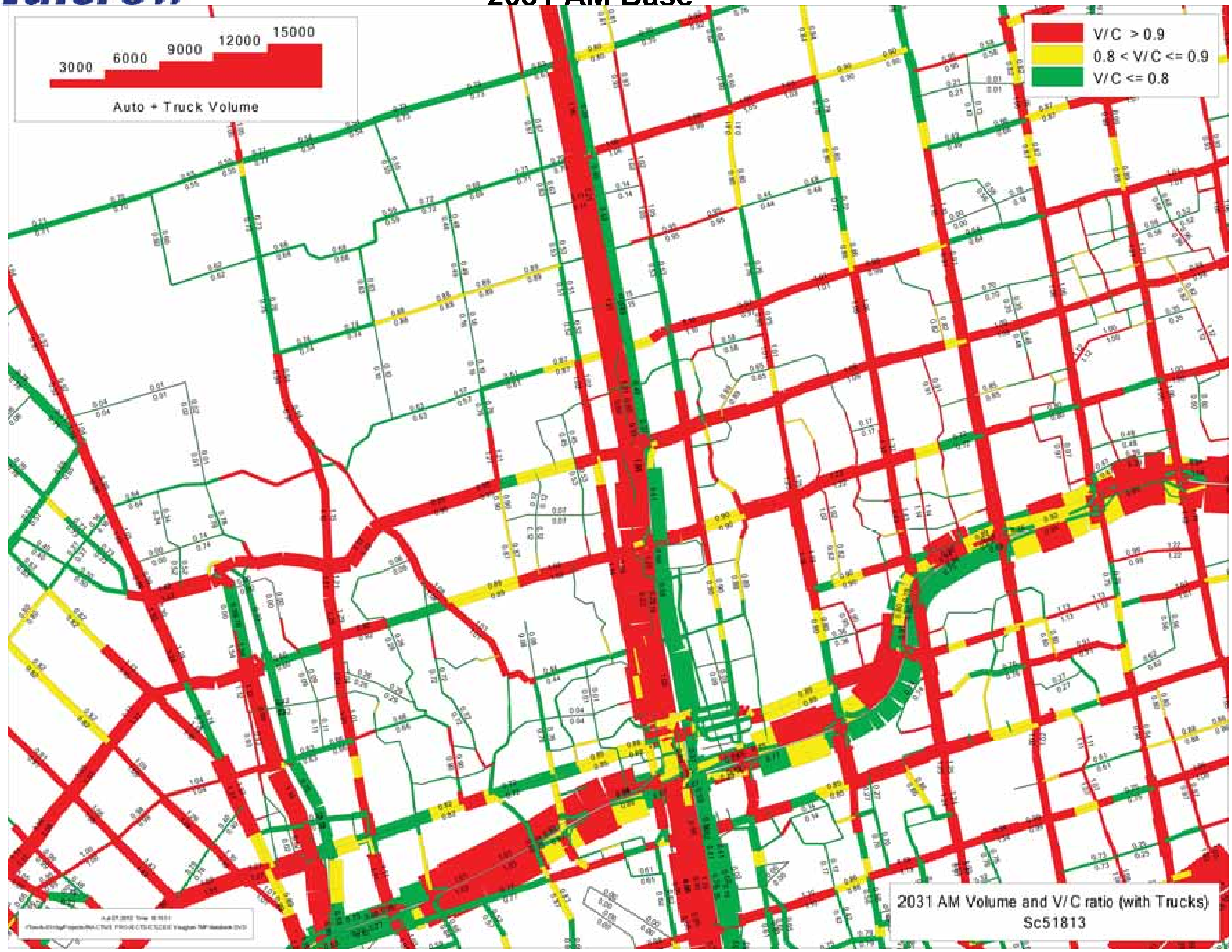
2031 AM Base



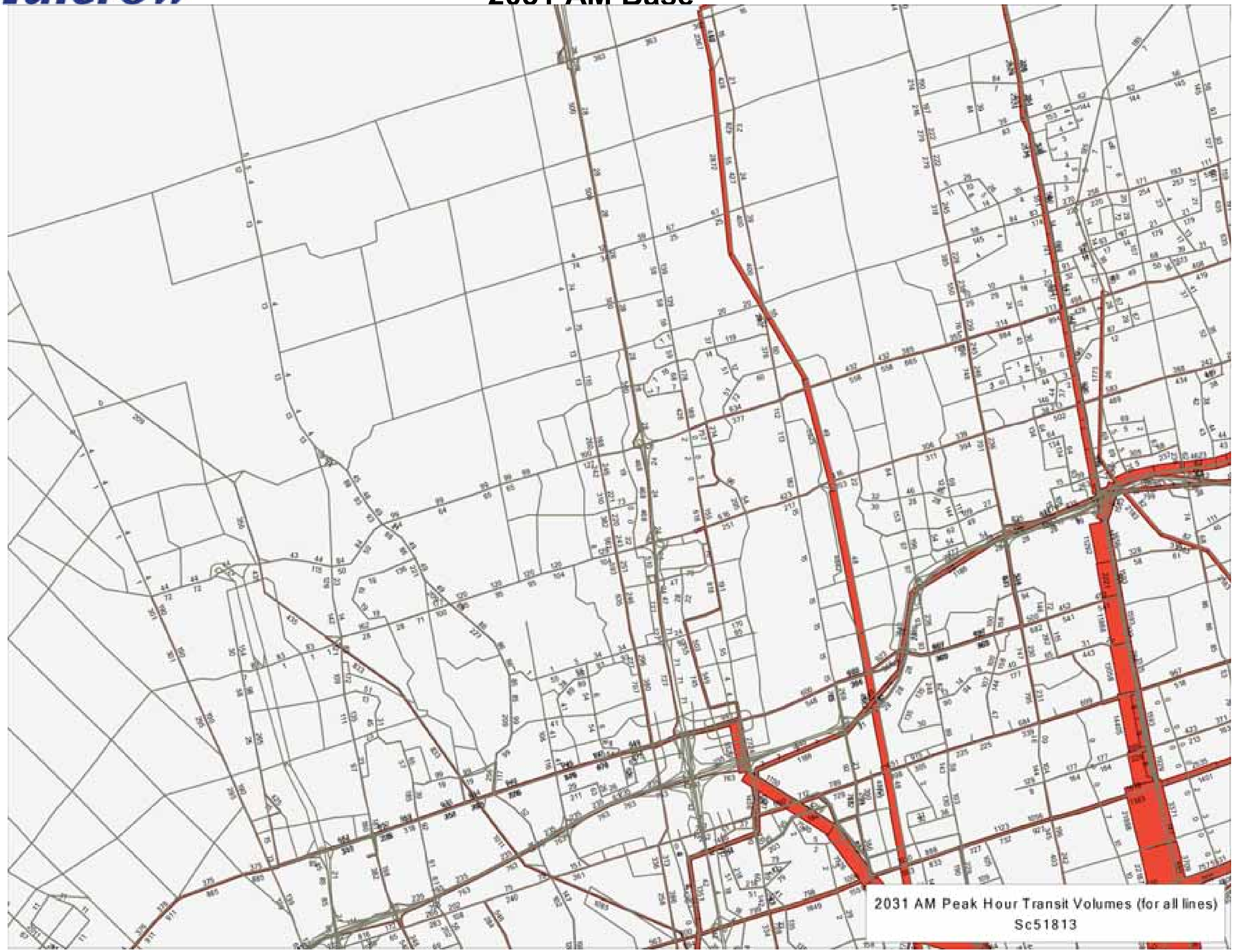
3000
6000
9000
12000
15000
Auto + Truck Volume
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
2031 AM Volume and V/C ratio (without Trucks)
Sc51813

Halcrow

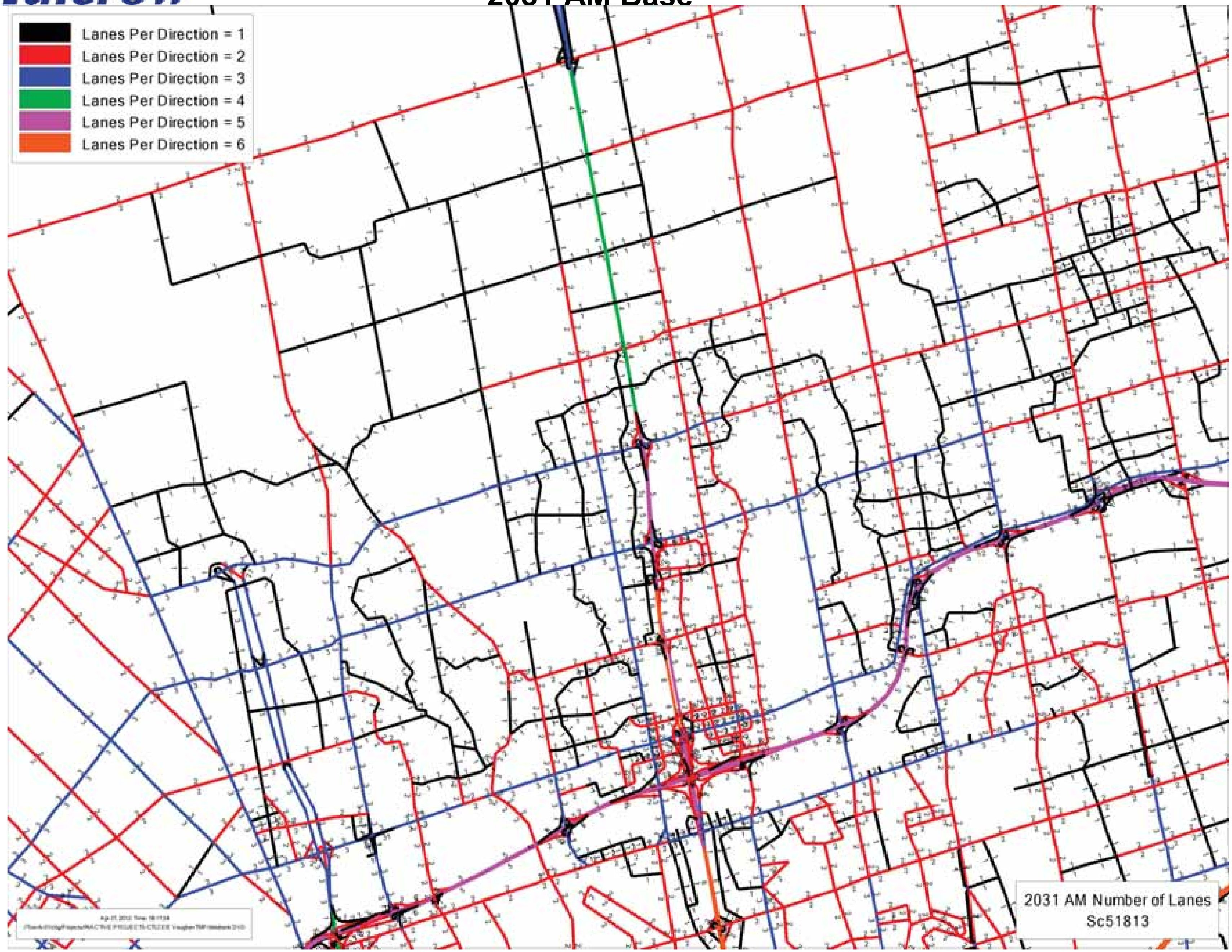
2031 AM Base



2031 AM Base

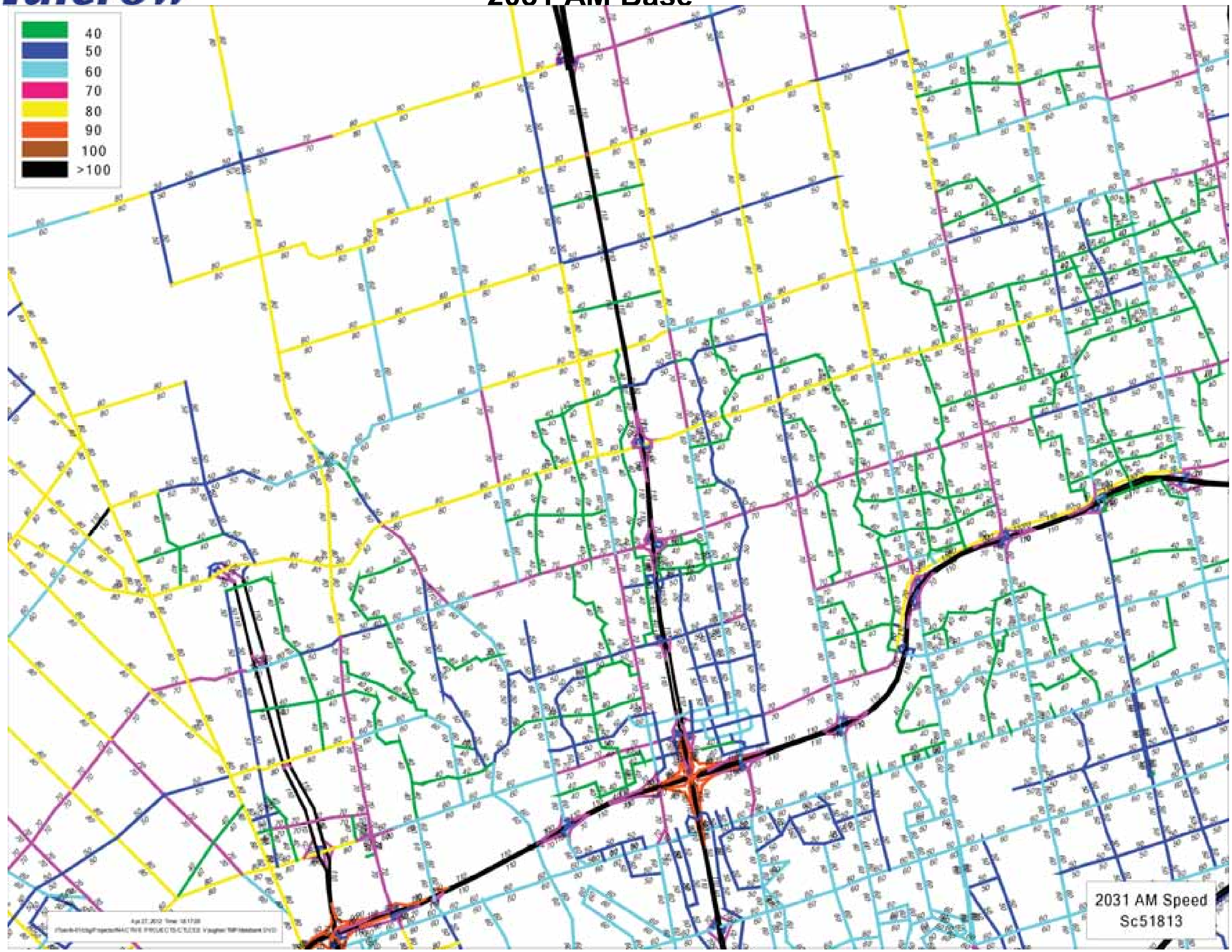


2031 AM Base

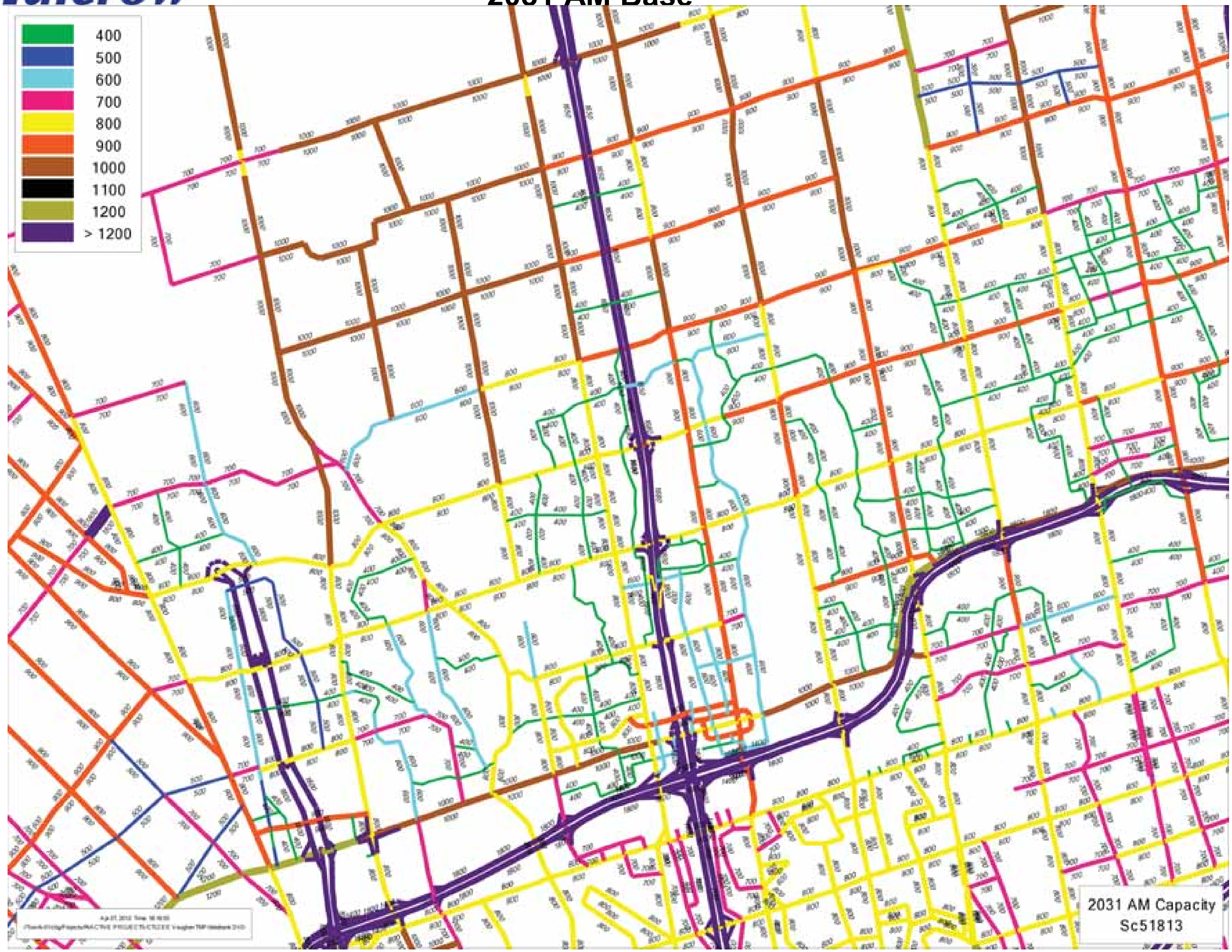

Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6
2031 AM Number of Lanes
Sc51813

Halcrow

2031 AM Base



2031 AM Base



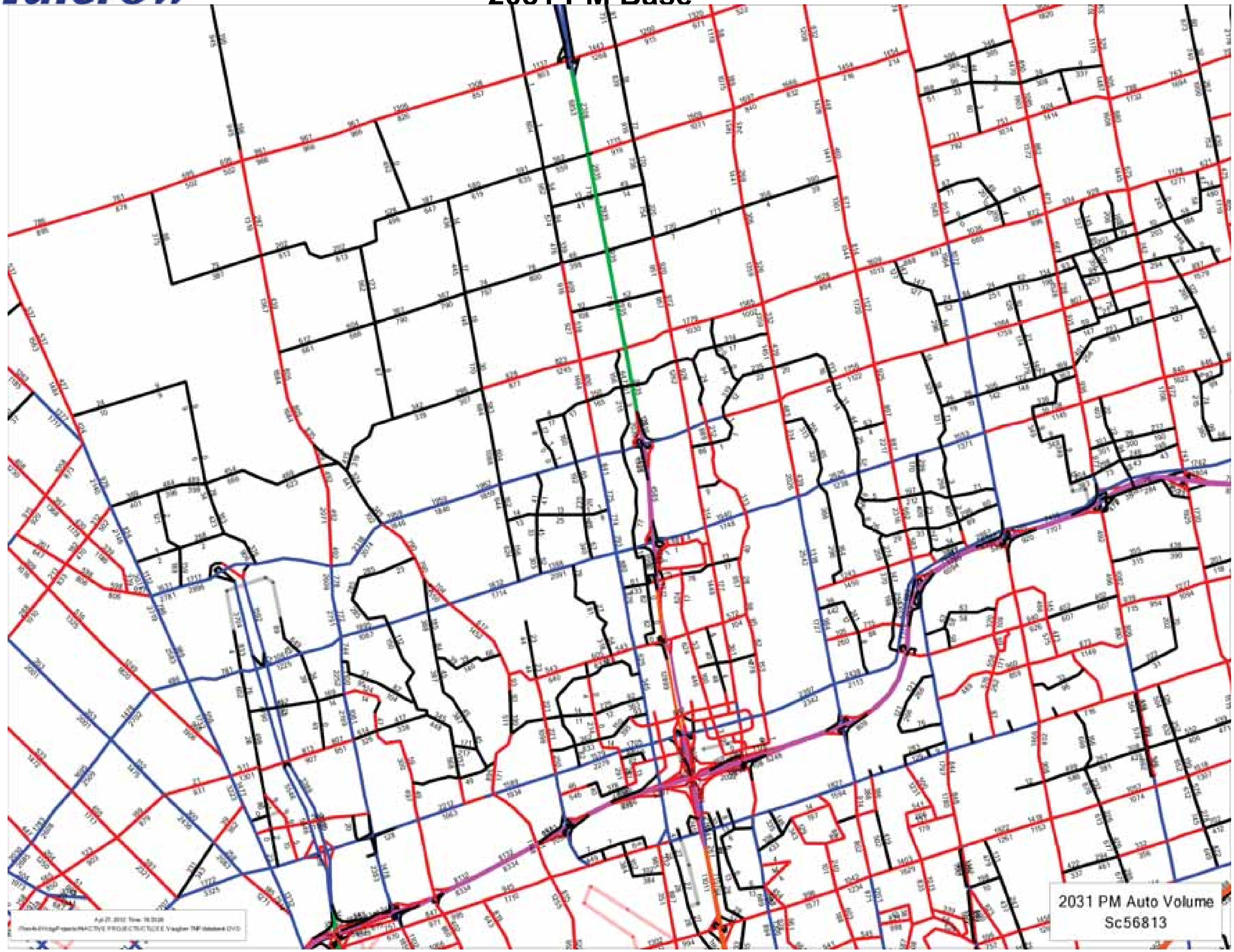
400
500
600
700
800
900
1000
1100
1200
> 1200
2031 AM Capacity
Sc51813

F2.4 2031 Base Network – PM Peak Hour

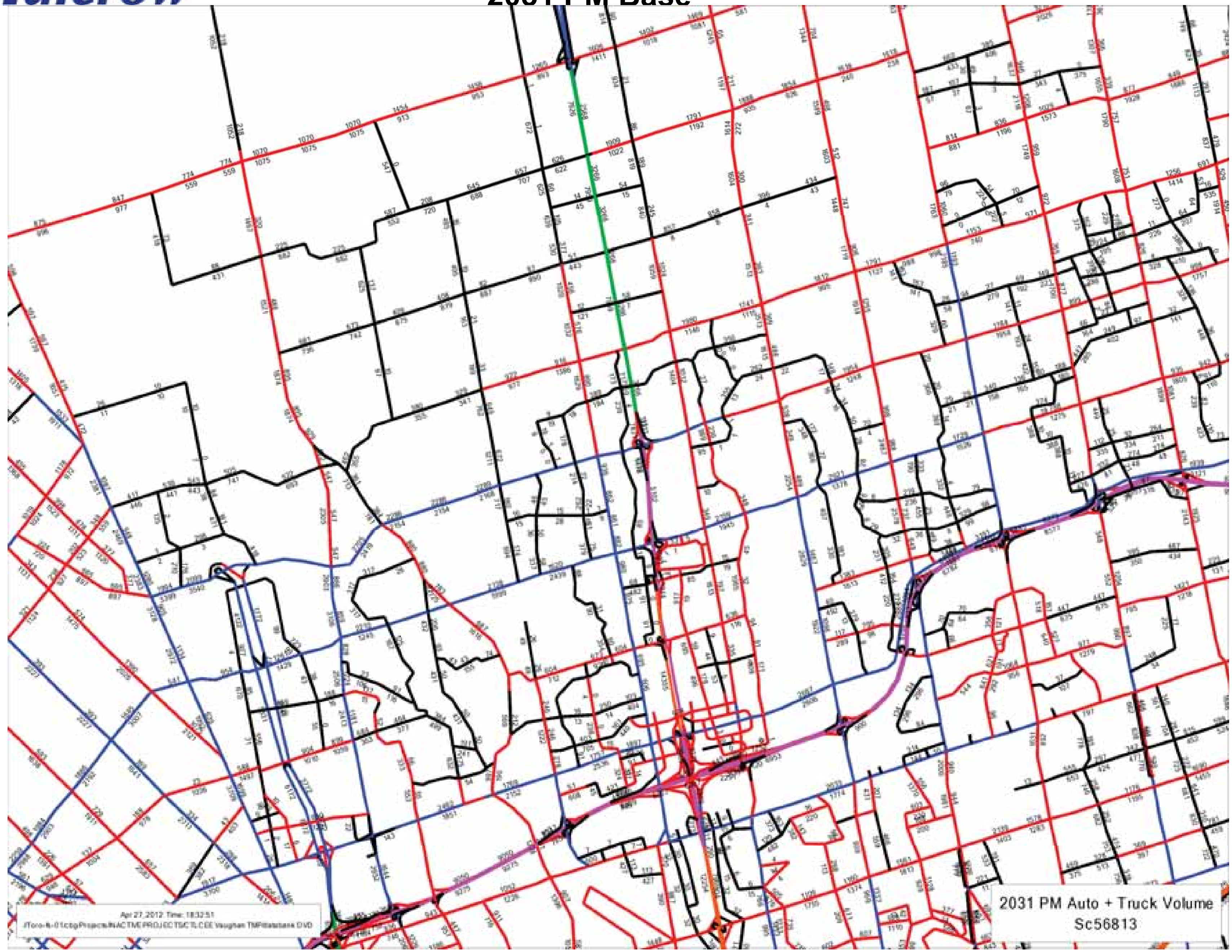
VAUGHAN

Halcrow

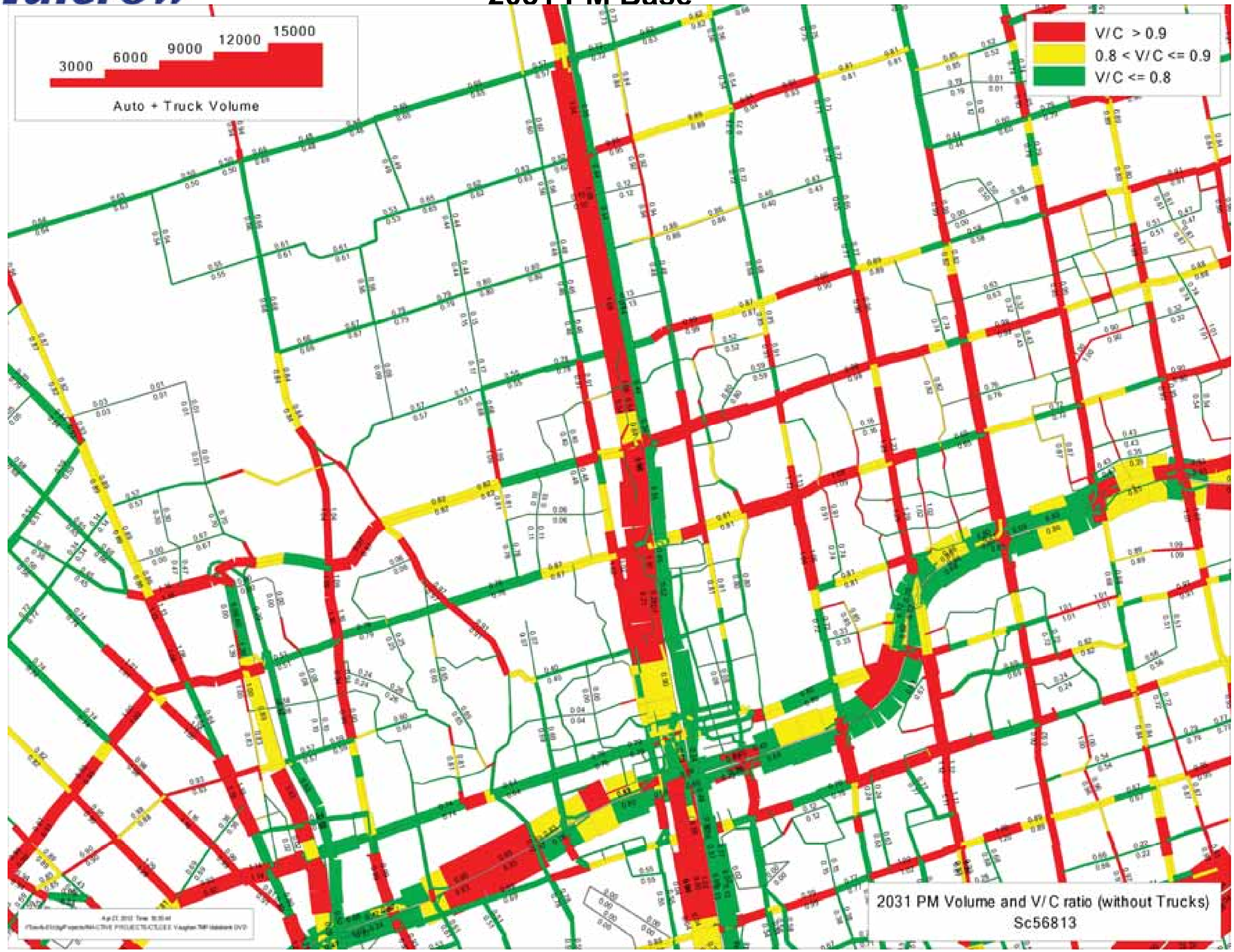
2031 PM Base



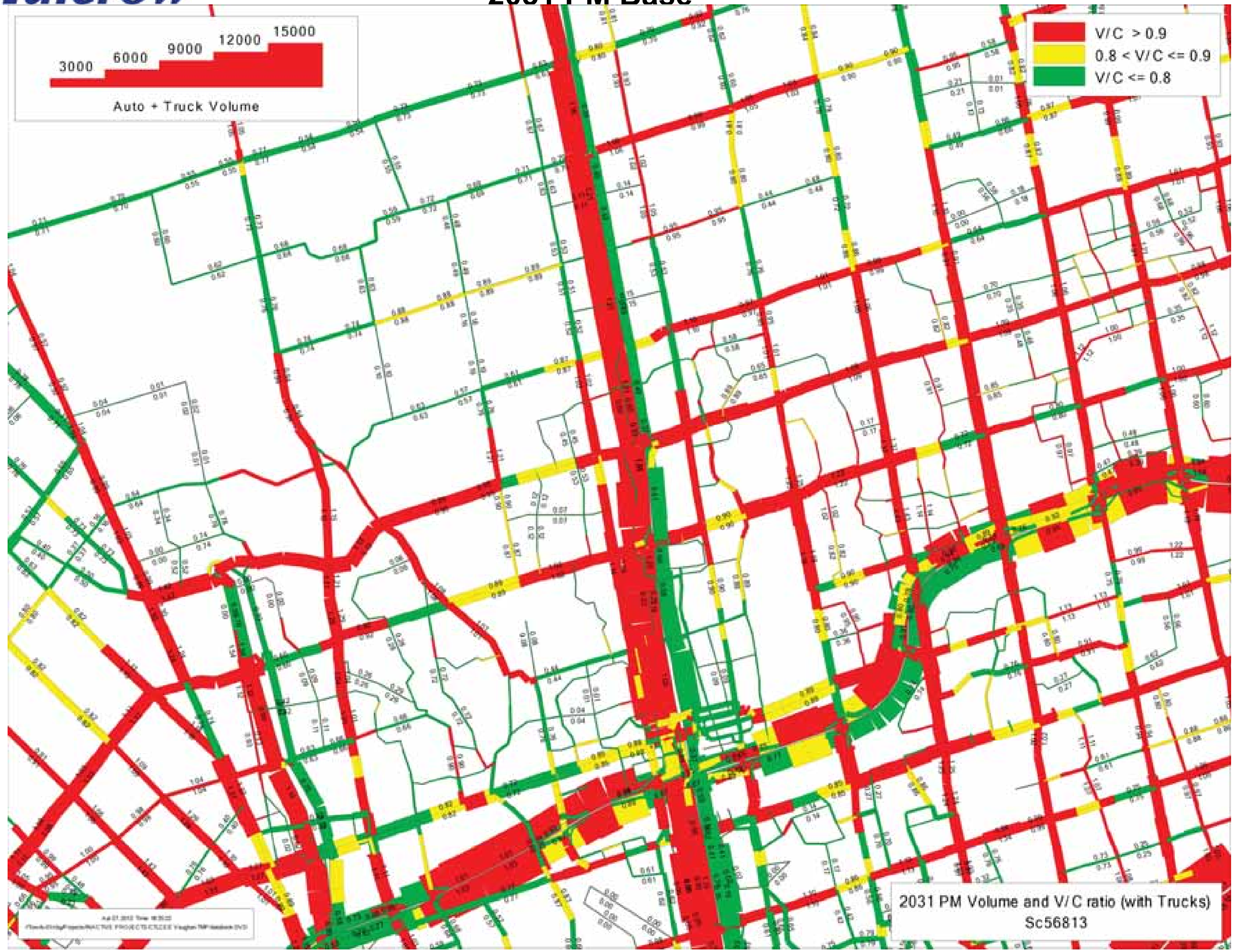
2031 PM Base



2031 PM Base

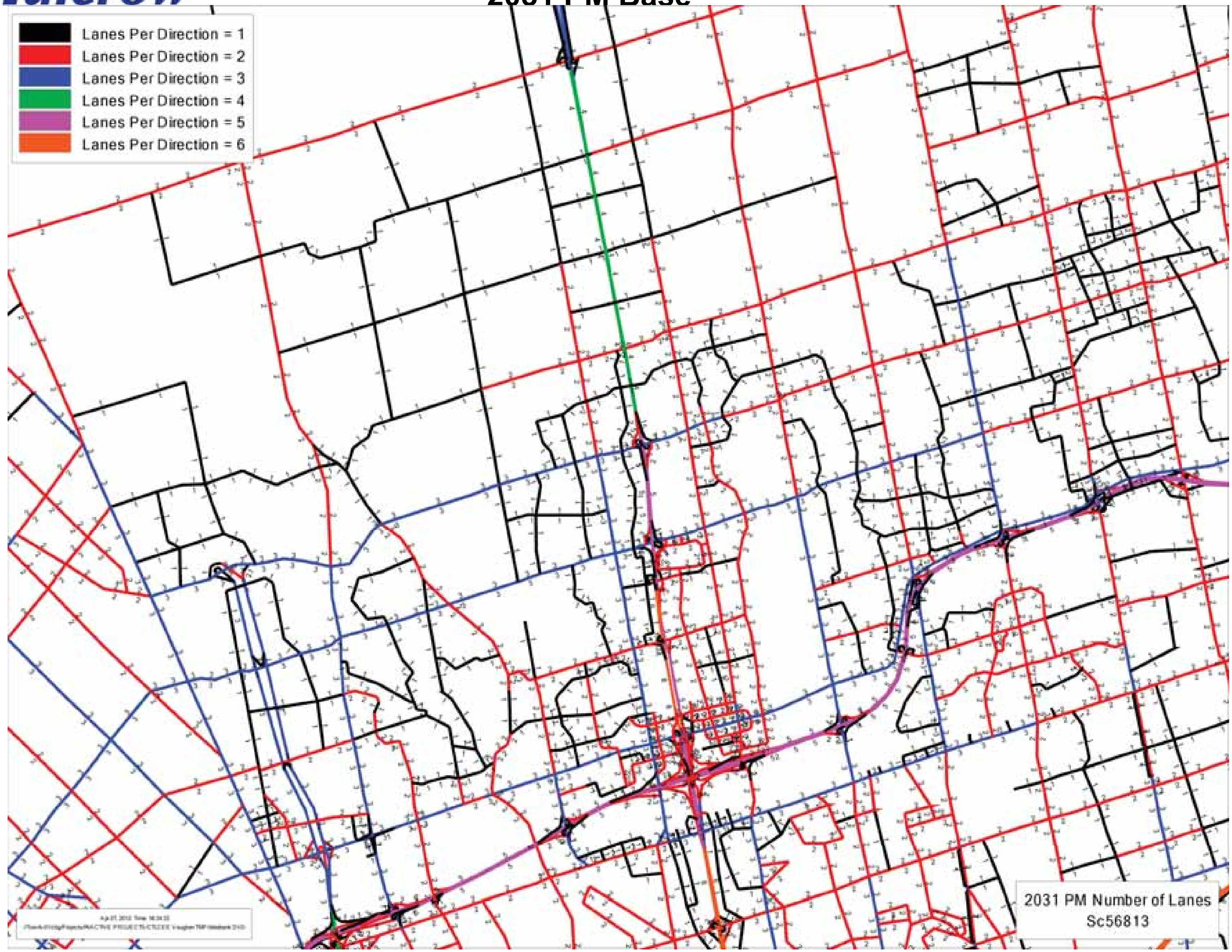

3000
6000
9000
12000
15000
Auto + Truck Volume
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
2031 PM Volume and V/C ratio (without Trucks)
Sc56813

2031 PM Base

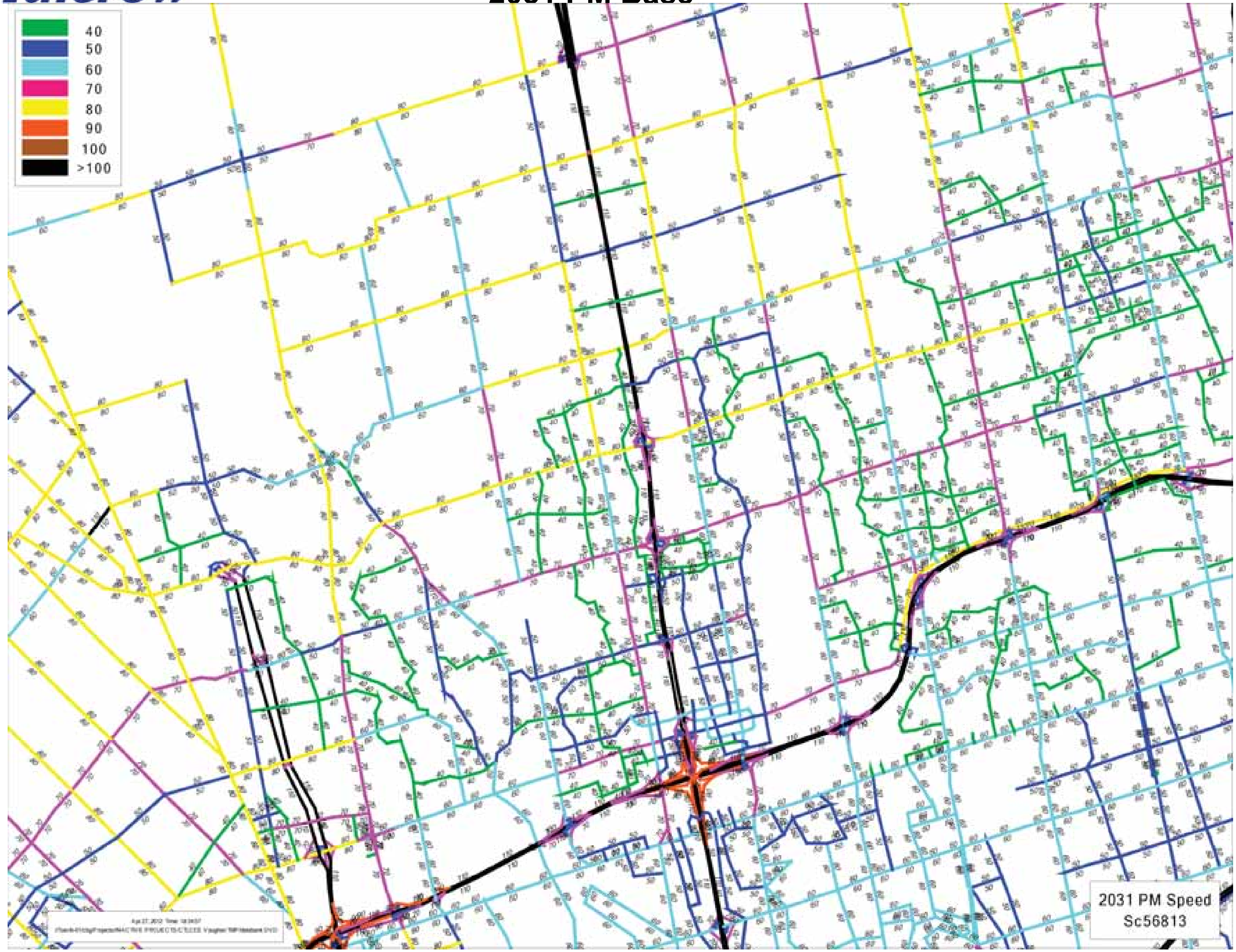

3000
6000
9000
12000
15000
Auto + Truck Volume
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
2031 PM Volume and V/C ratio (with Trucks)
Sc56813

Halcrow

2031 PM Base

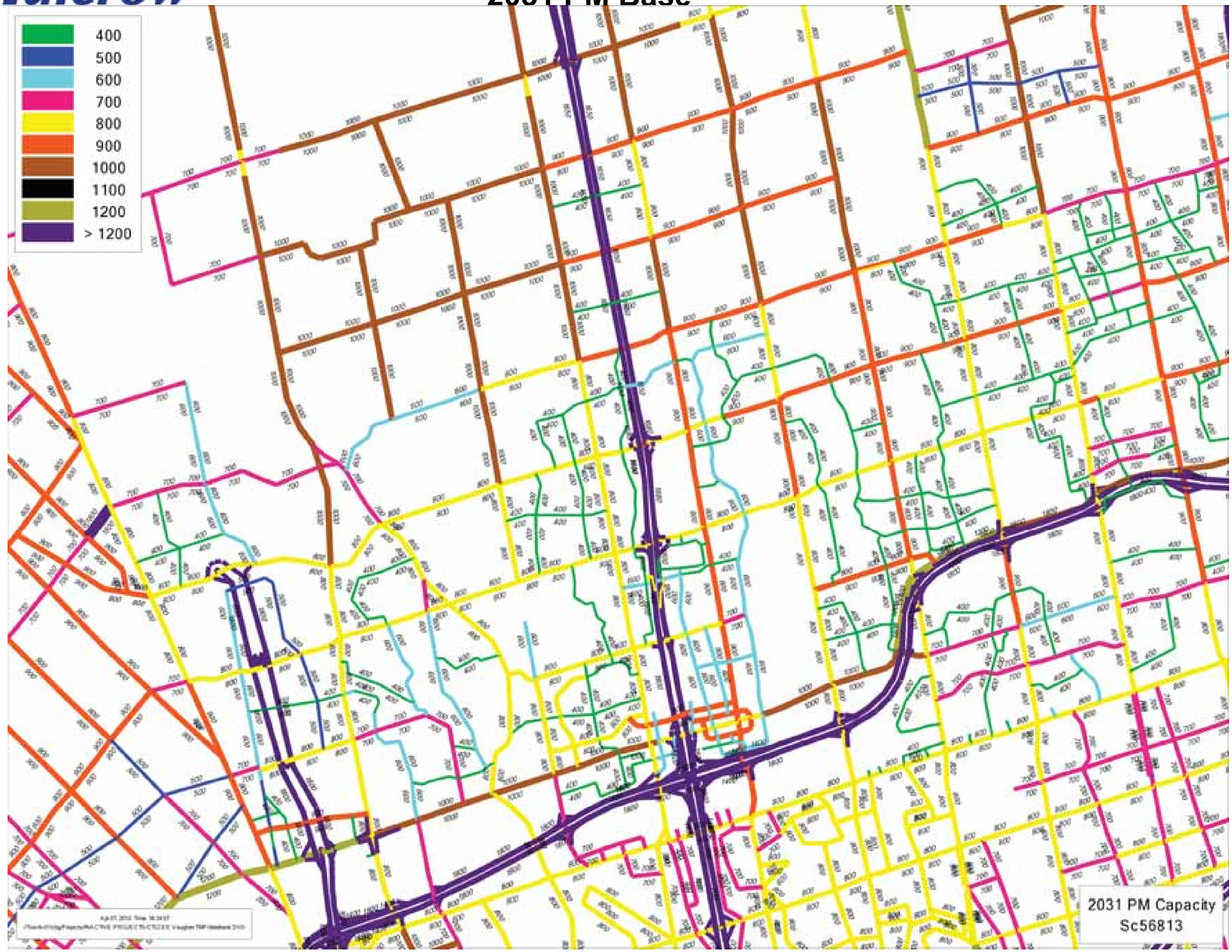


2031 PM Base



Halcrow

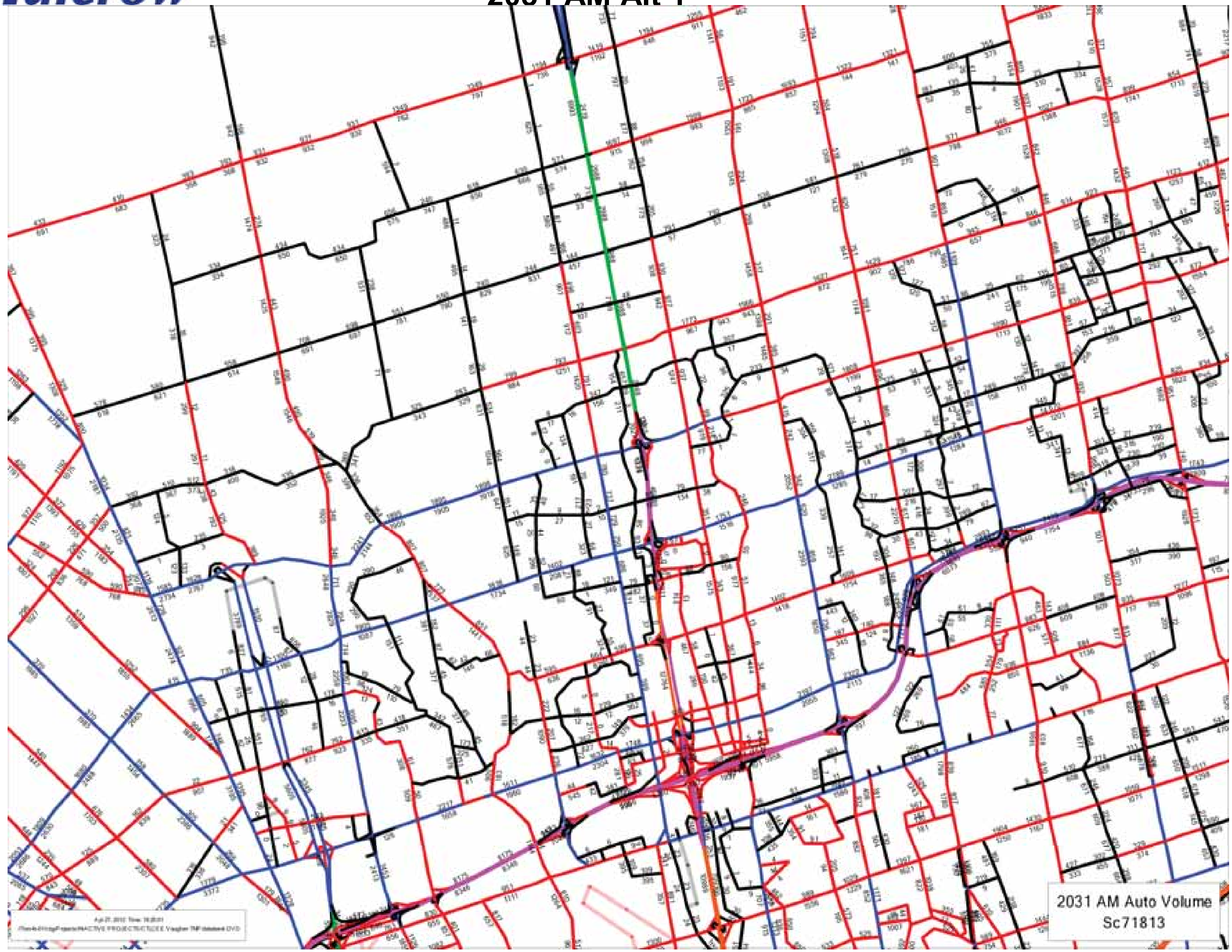
2031 PM Base



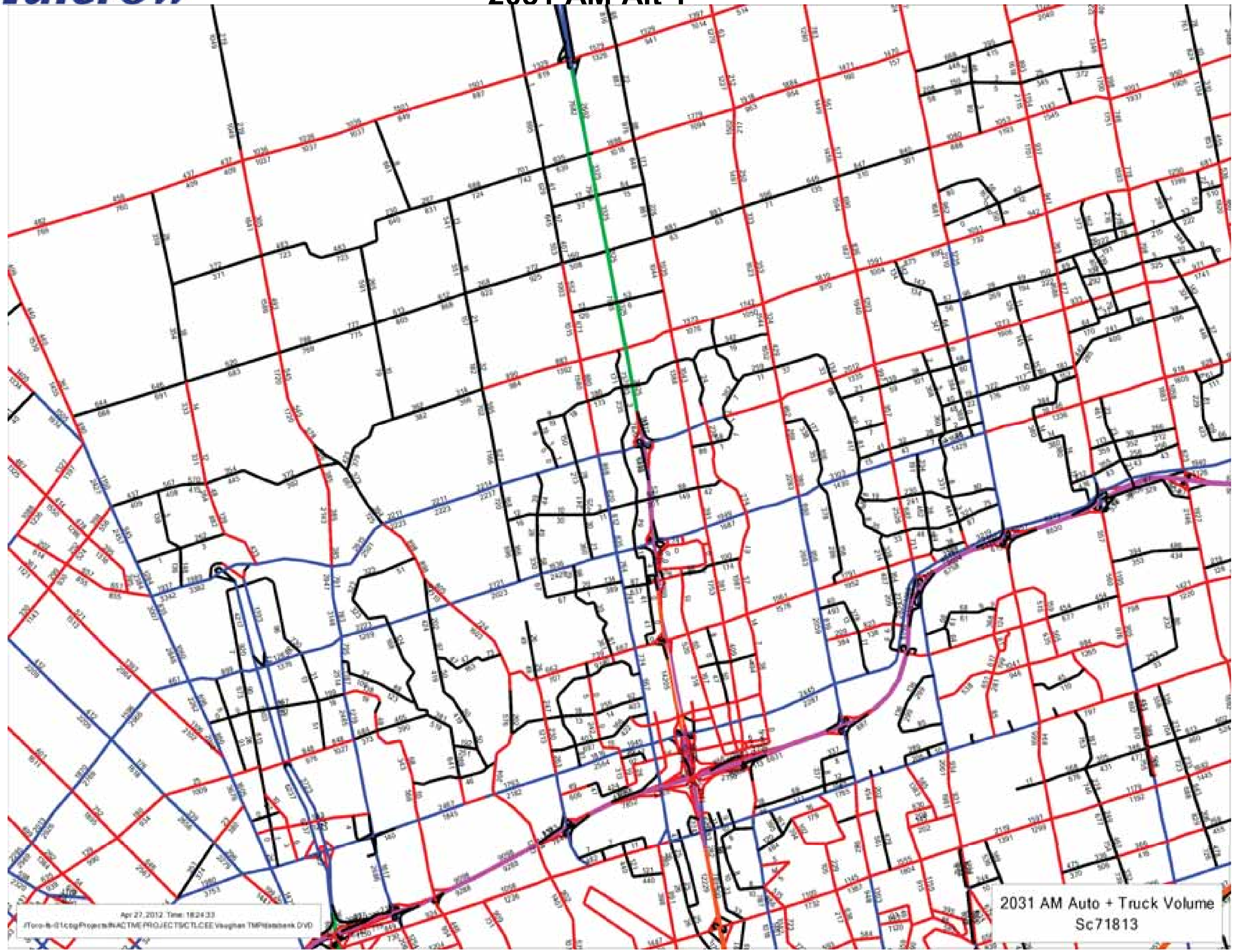
F2.5 2031 Alternative Network – AM Peak Hour

Halcrow

2031 AM Alt 1

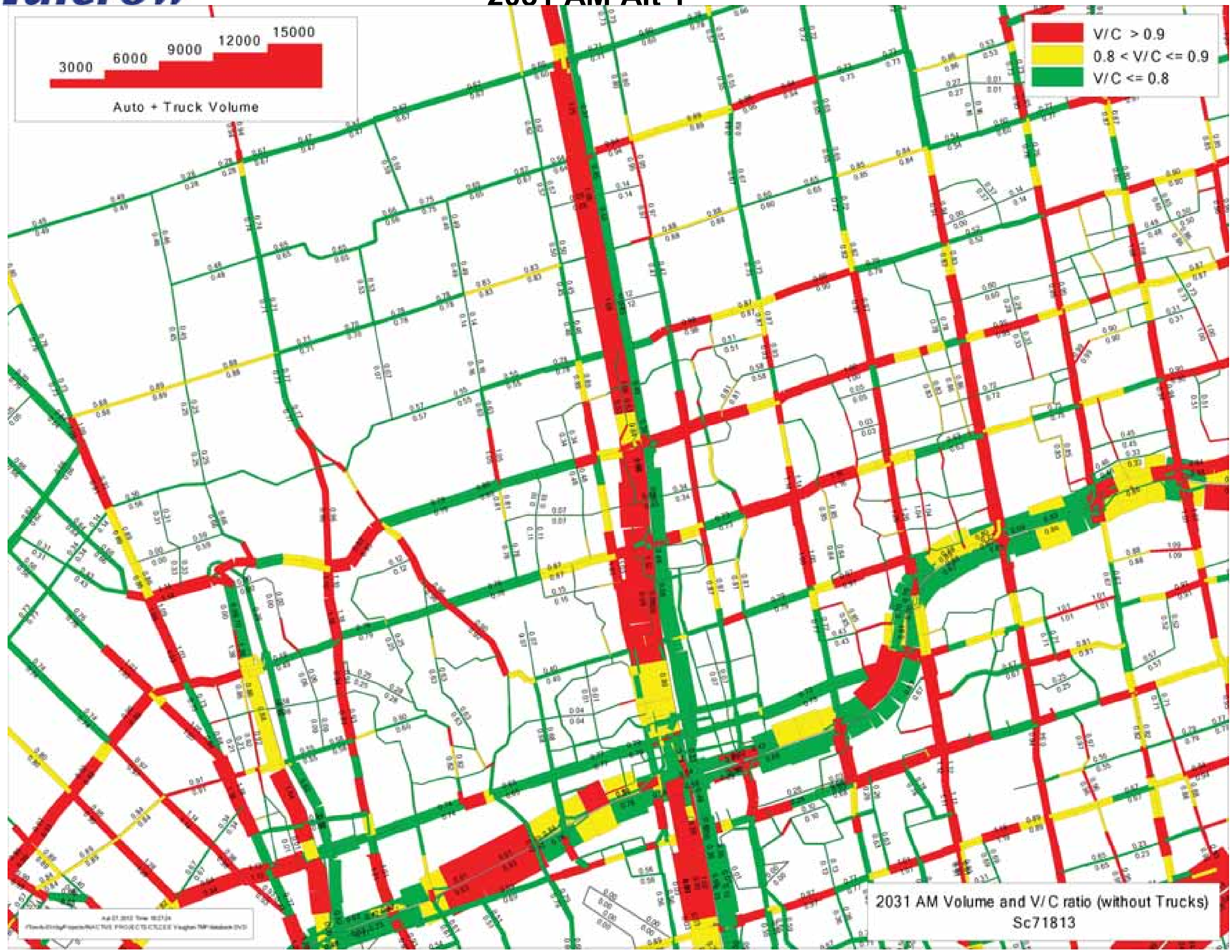


2031 AM Alt 1

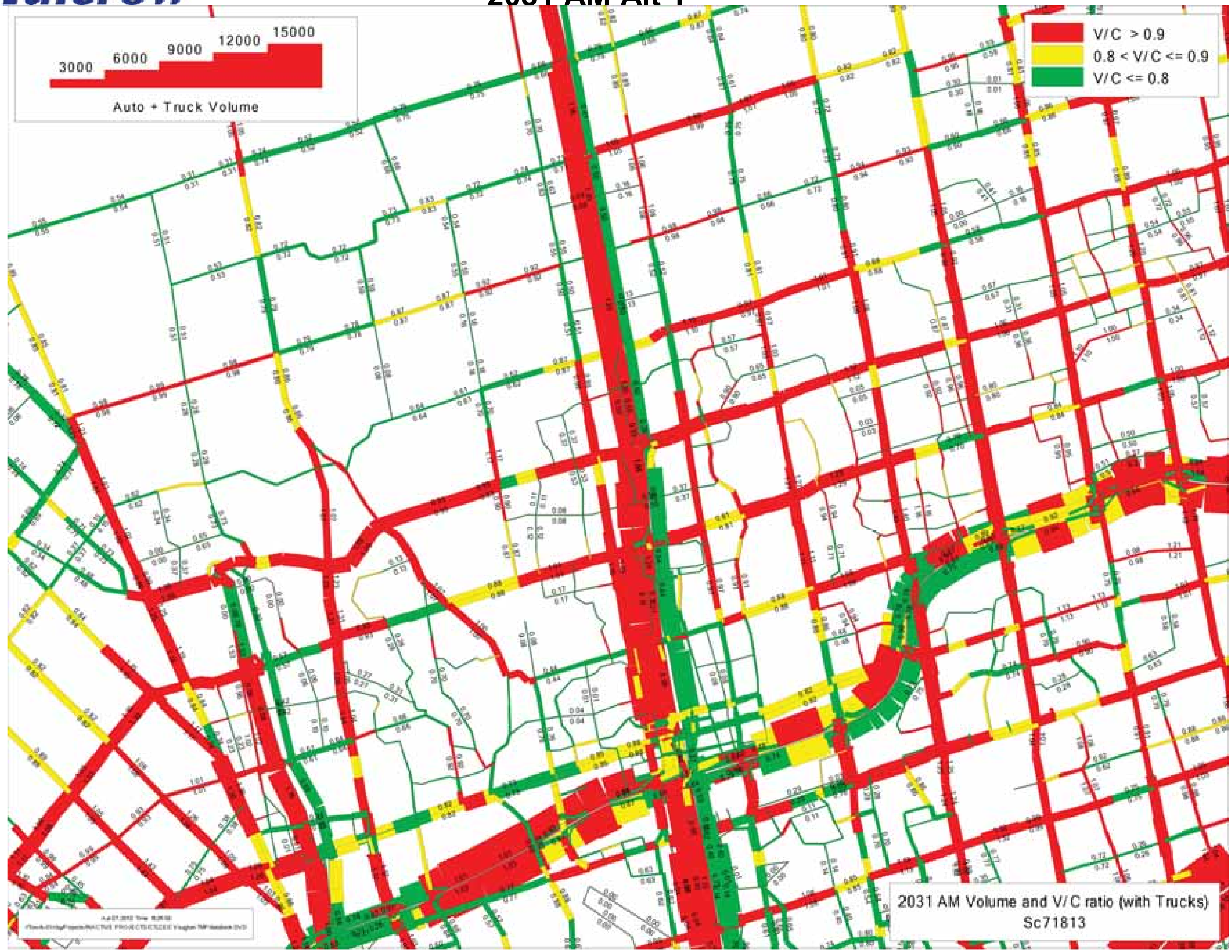


Halcrow

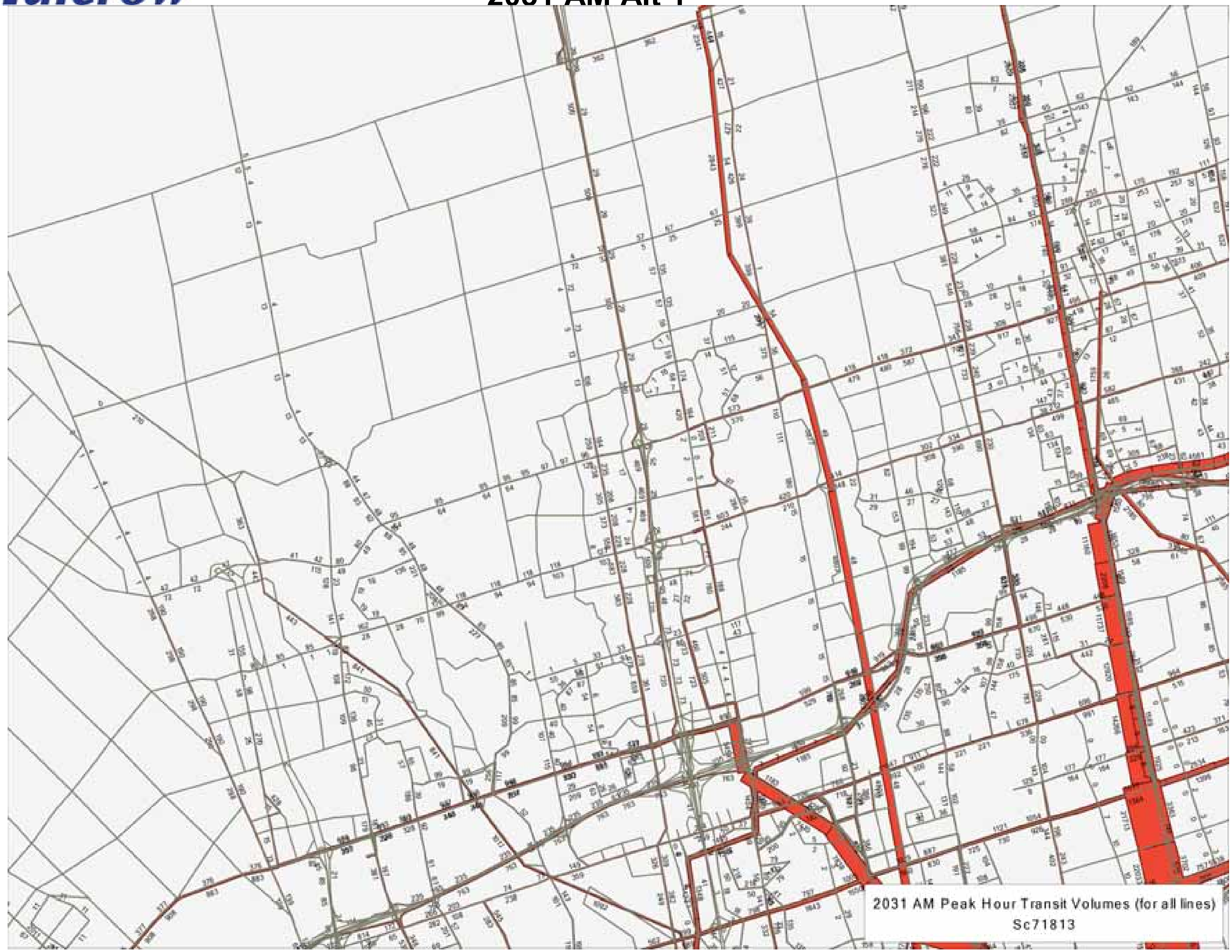
2031 AM Alt 1



2031 AM Alt 1

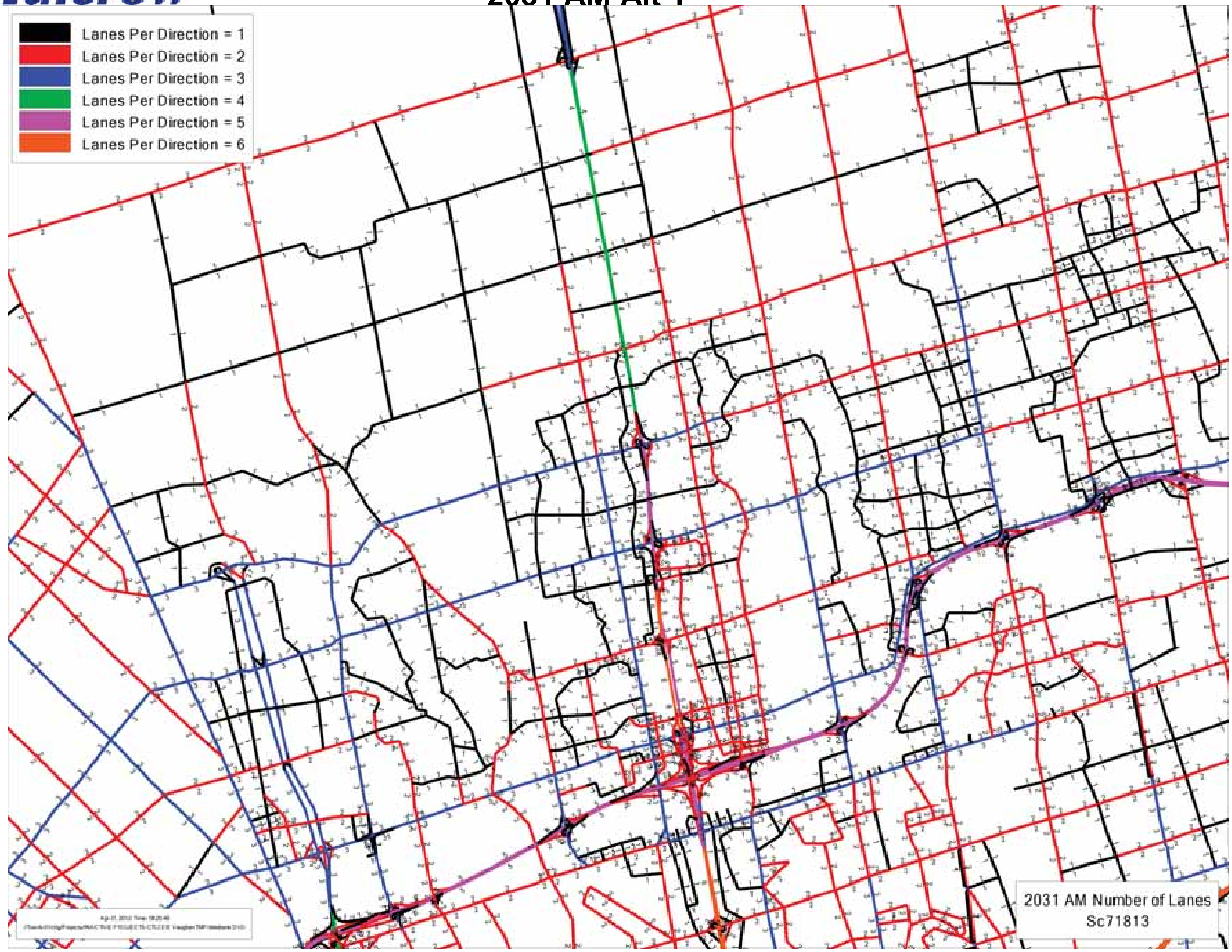

3000
6000
9000
12000
15000
Auto + Truck Volume
V/C > 0.9
0.8 < V/C <= 0.9
V/C <= 0.8
2031 AM Volume and V/C ratio (with Trucks)
Sc71813

2031 AM Alt 1

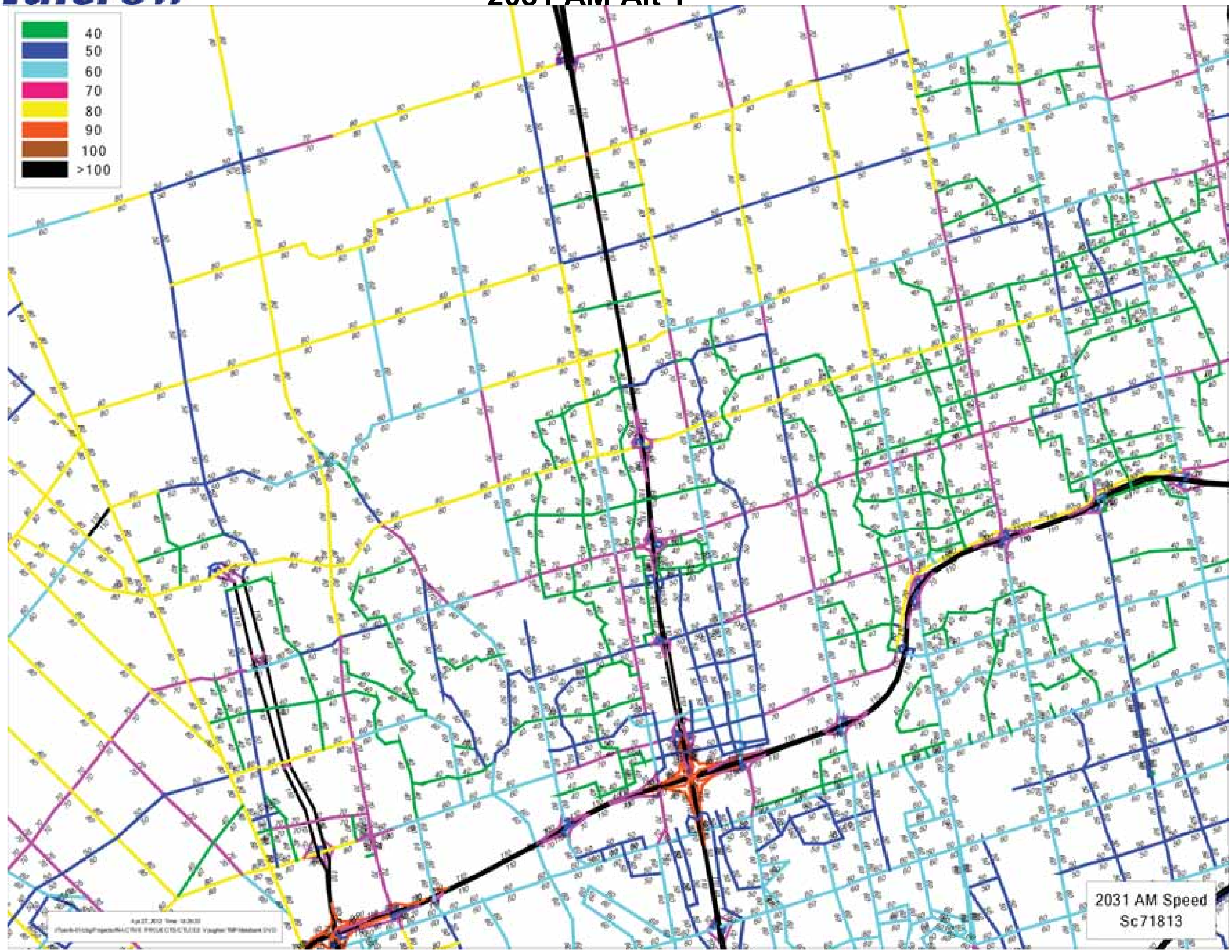


Halcrow

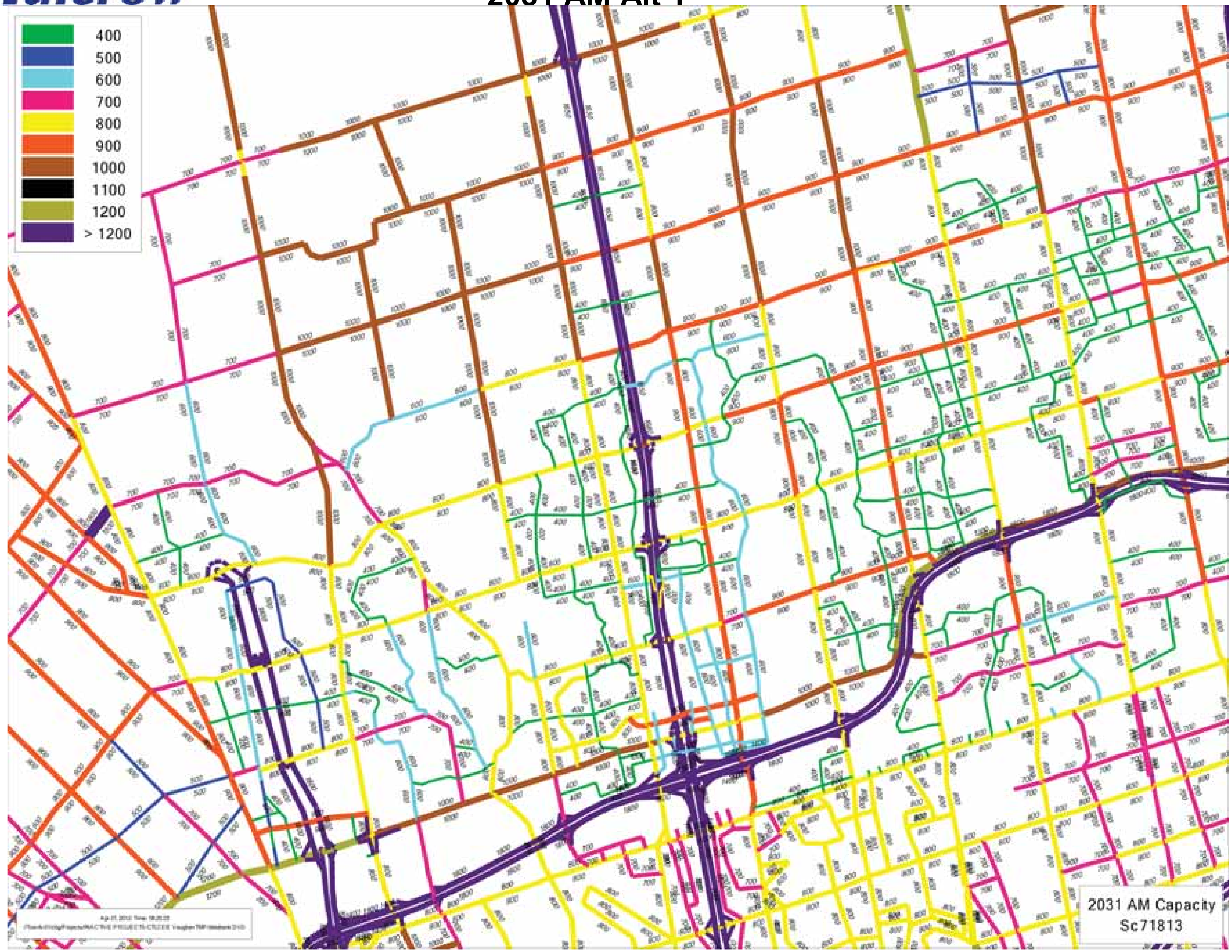
2031 AM Alt 1



2031 AM Alt 1



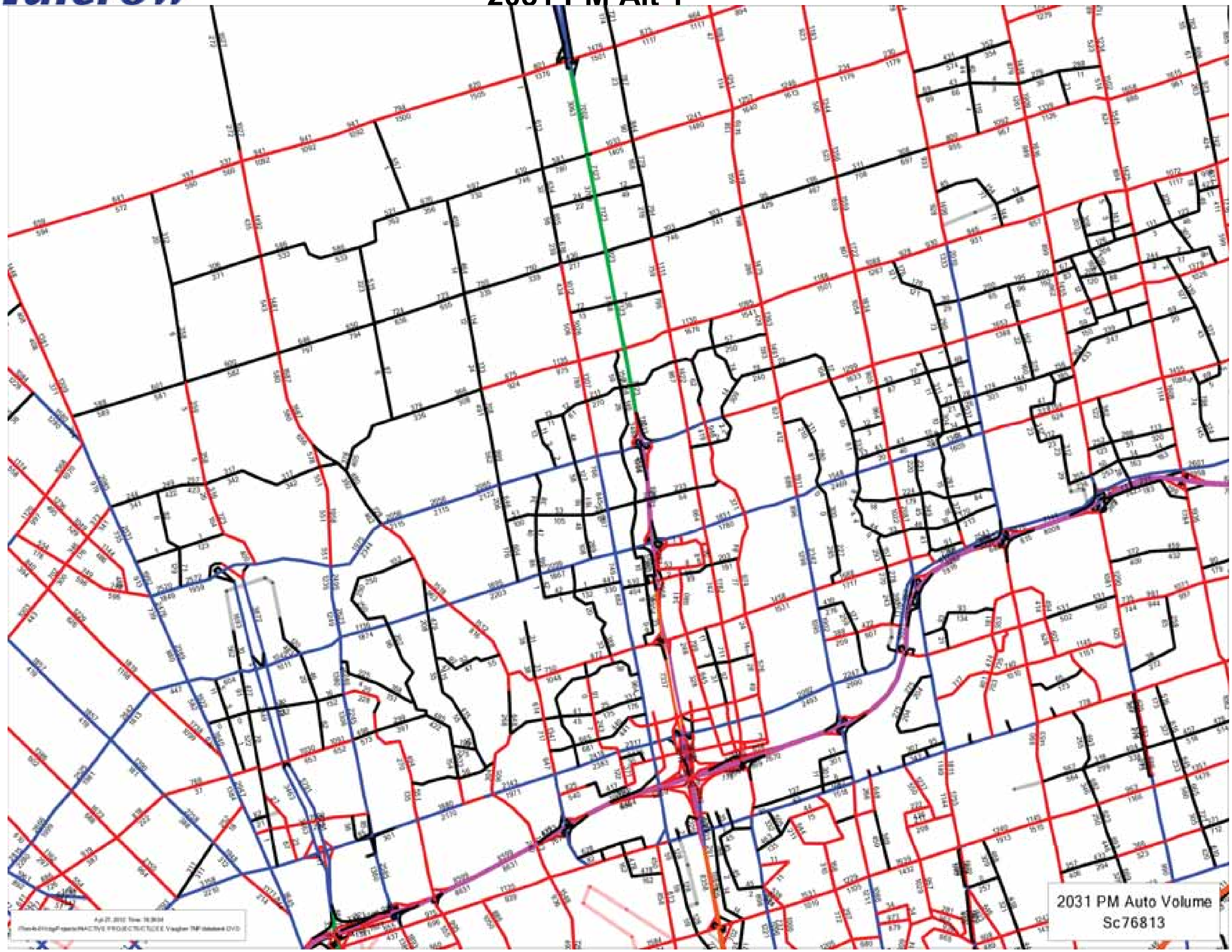
2031 AM Alt 1



400
500
600
700
800
900
1000
1100
1200
> 1200
2031 AM Capacity
Sc71813

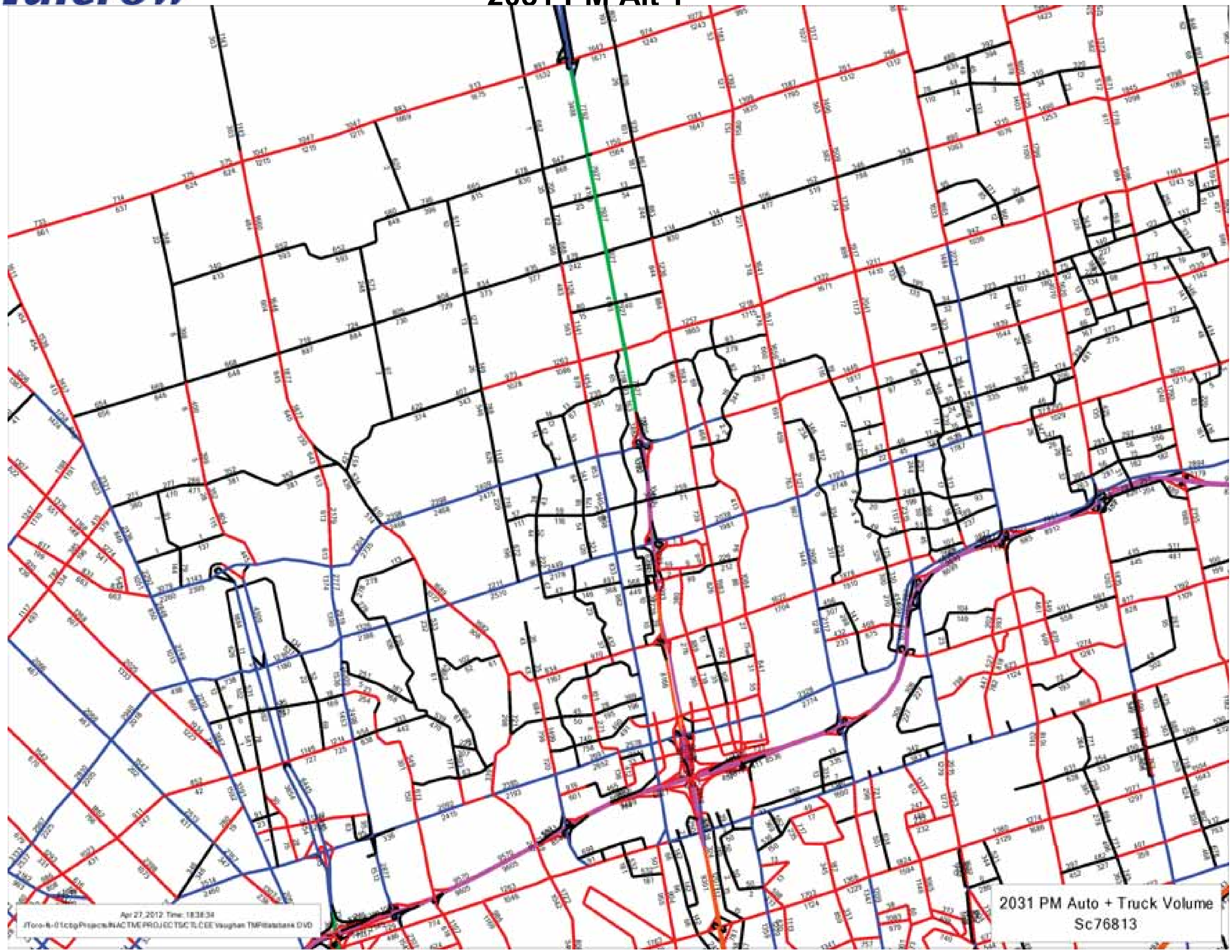
F2.6 2031 Alternative Network – PM Peak Hour

2031 PM Alt 1



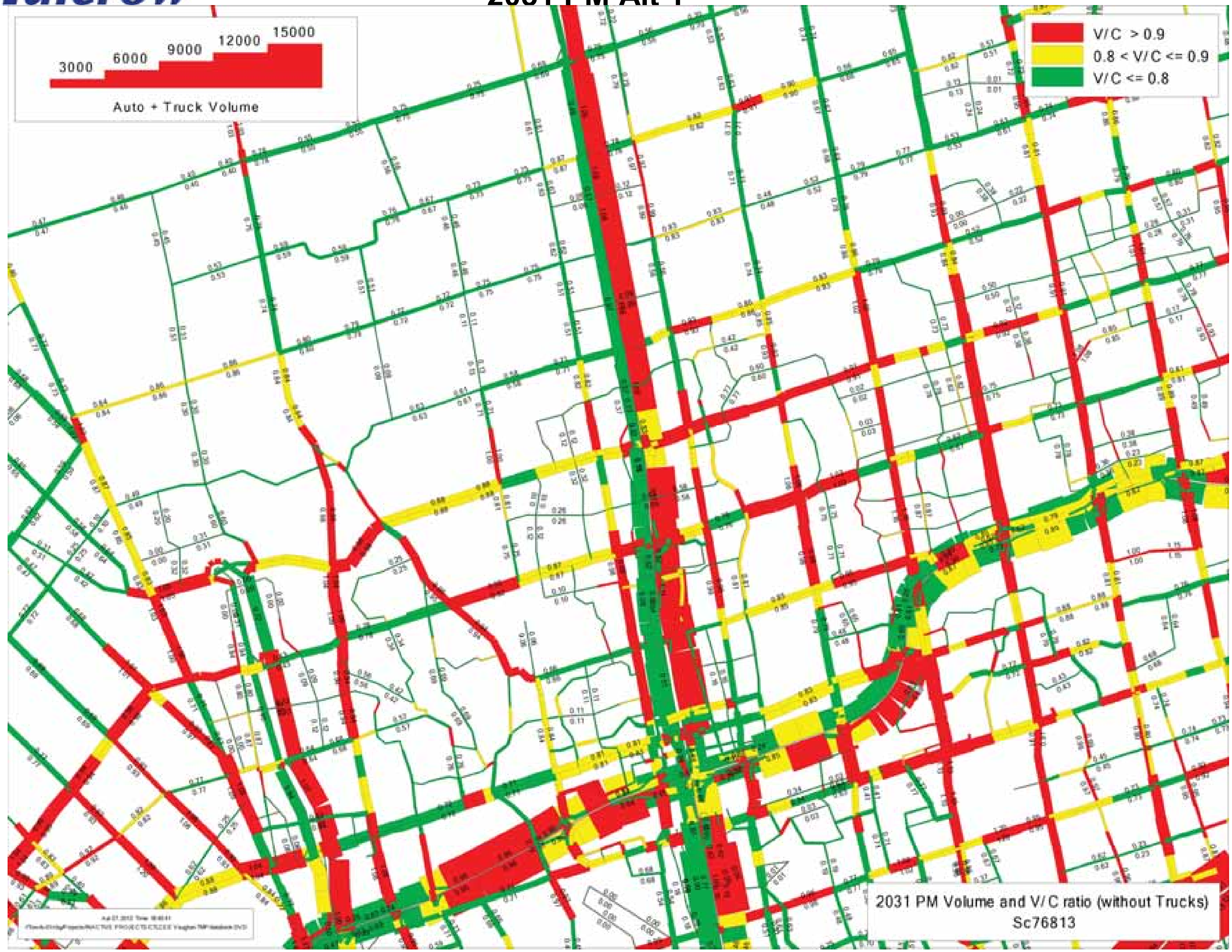
Halcrow

2031 PM Alt 1



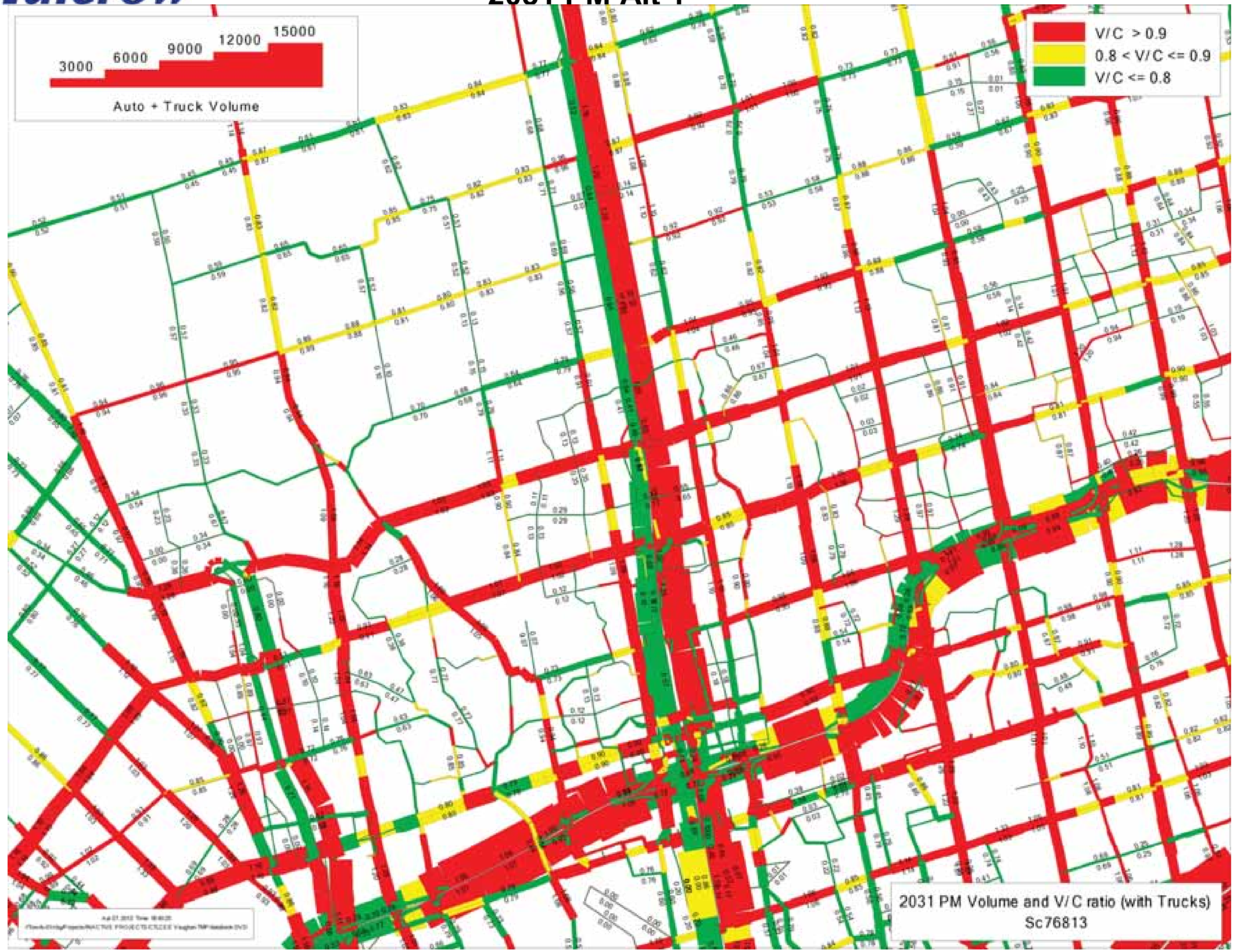
Halcrow

2031 PM Alt 1

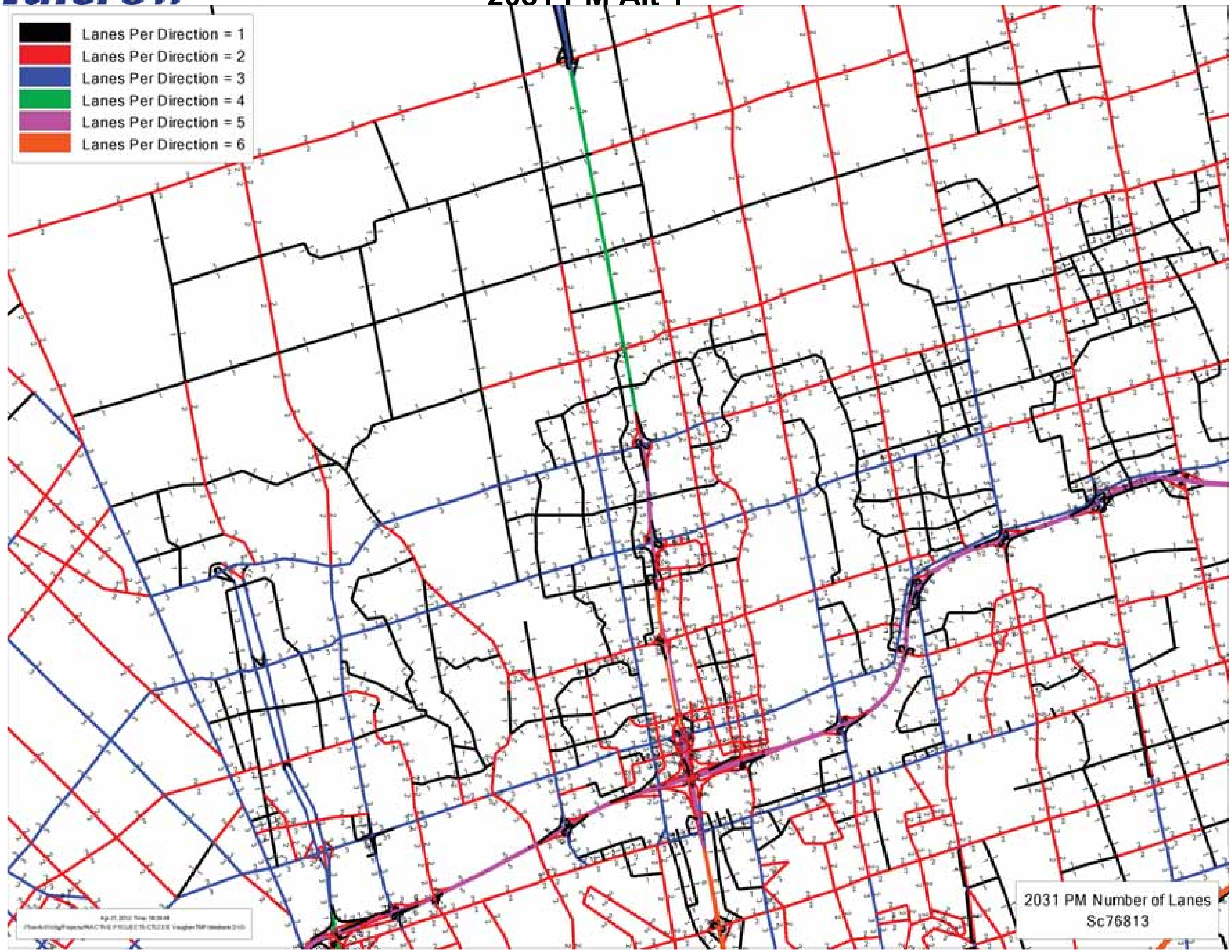


Halcrow

2031 PM Alt 1



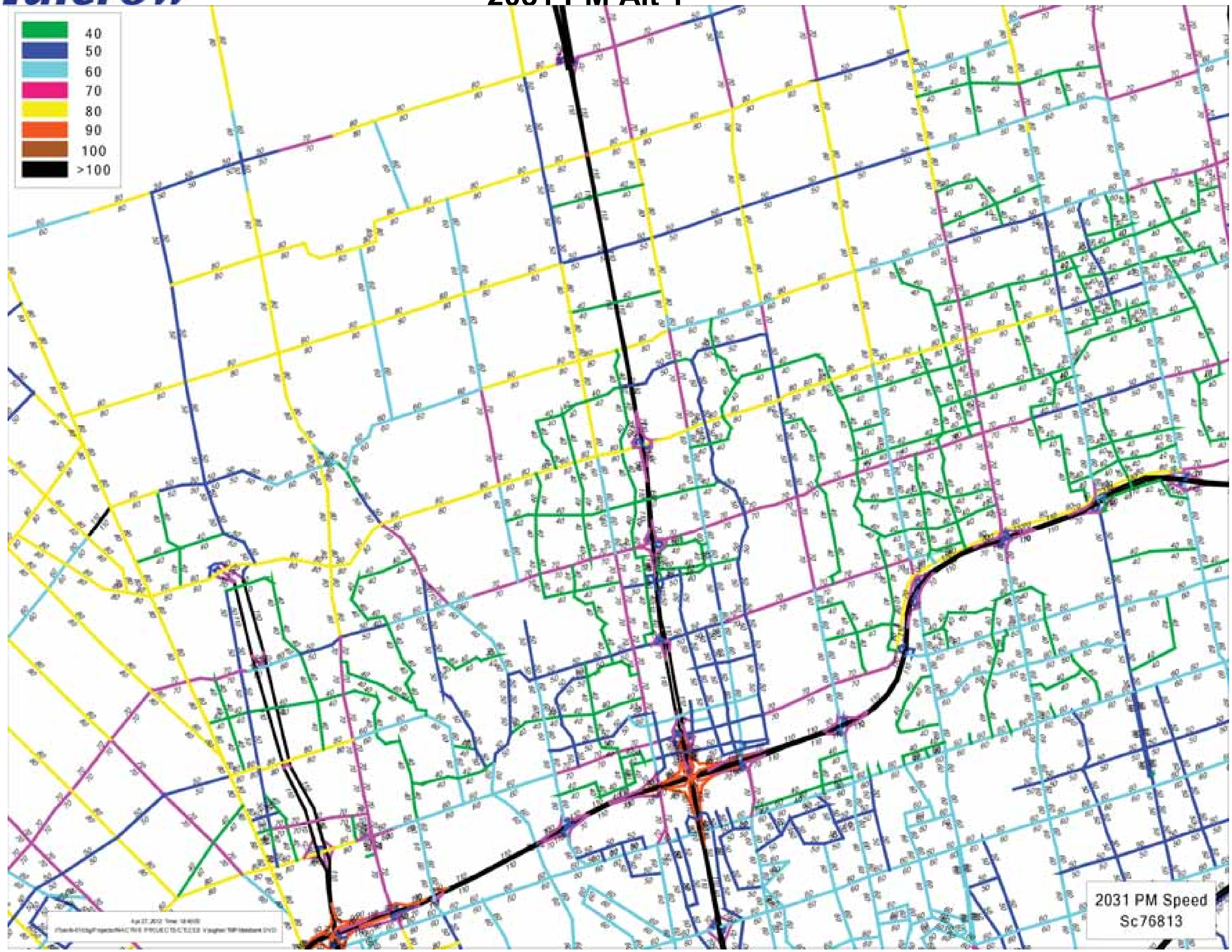
2031 PM Alt 1



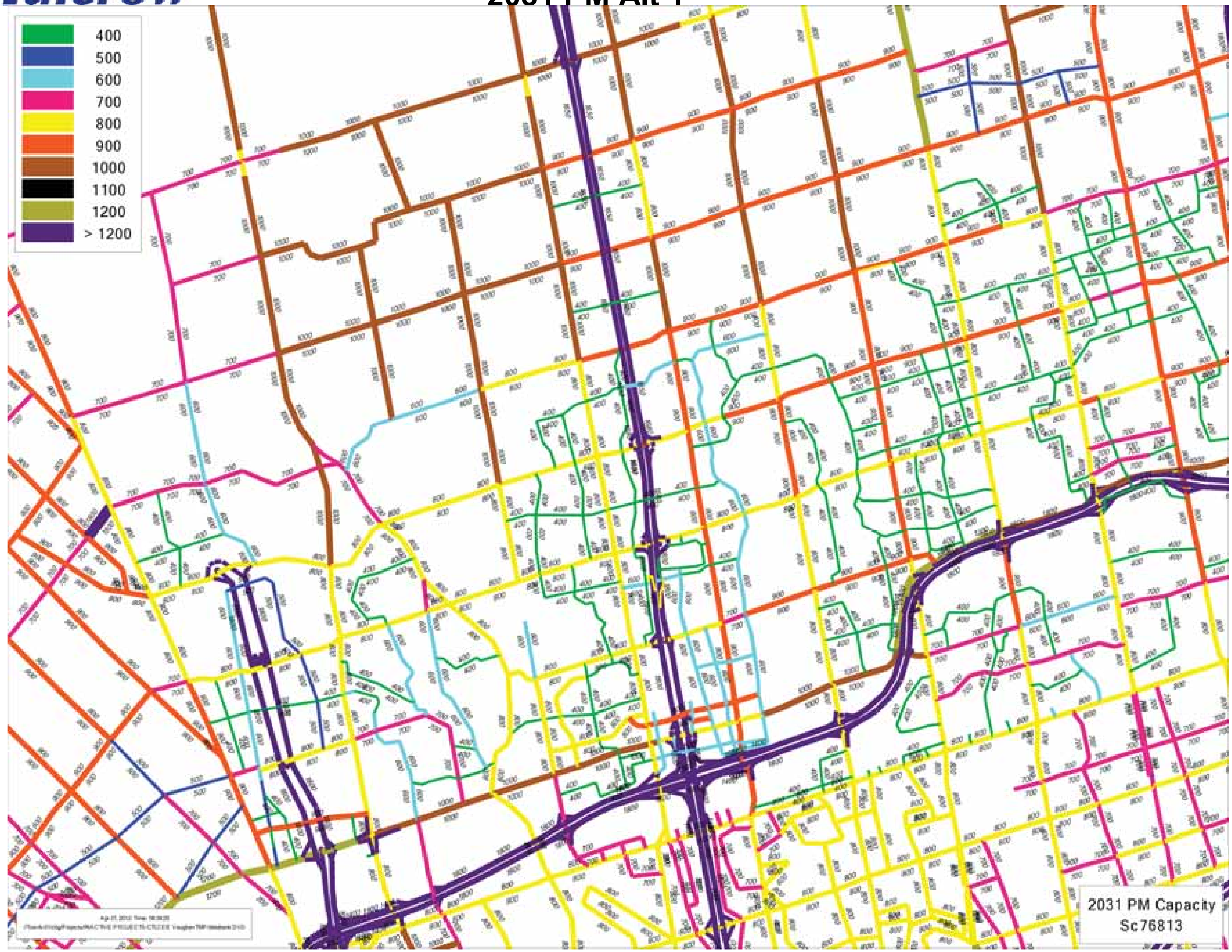
Lanes Per Direction = 1
Lanes Per Direction = 2
Lanes Per Direction = 3
Lanes Per Direction = 4
Lanes Per Direction = 5
Lanes Per Direction = 6
2031 PM Number of Lanes
Sc76813

Halcrow

2031 PM Alt 1



2031 PM Alt 1



400
500
600
700
800
900
1000
1100
1200
> 1200
2031 PM Capacity
Sc76813

F3. 2021 and 2031 Corridor Deficiencies

Appendix F3

2021 and 2031 Corridor Deficiencies

1. Deficiency Analysis Methodology

1.1 Screenlines

Screenlines are imaginary lines located in a grid pattern over a transportation network to evaluate the completeness and accuracy of predicted trips in calibrating travel demand models by comparing simulated trip volumes on the facilities with those actually observed. Also screenline counts are used to conduct deficiency analysis with the aim of assessing the existing or planned road network capacity within a study area. According to Meyer and Miller (2001) because the validity of a screenline analysis depends on considering as many of the roads that cross the screenline as possible, the screenlines should be chosen very carefully. Often, barriers to traffic flow (e.g., rivers or railroad tracks) are used because they “funnel” movements through a small number of crossings, making total movements easier to count.

For the purpose of this study, the screenlines were defined as follows.

East-West Screenlines extending from Highway 50 to Bathurst Street:

1. North of Steeles Avenue;
2. North of Highway 7;
3. North of Rutherford Road;
4. North of Teston Road; and
5. North of King-Vaughan Road

North-South Screenlines extending from Steeles Avenue to King-Vaughan Road:

1. East of Highway 50;
2. East of Highway 27;
3. East of Pine Valley Drive;
4. East of Highway 400;
5. East of Keele Street; and
6. West of Bathurst Street

1.2 Corridors

The transportation facilities (roads, transit services, and bike paths / lanes) crossing the screenlines can be grouped into larger analysis units reflecting corridors of travel in both east-west and north-south directions of travel. Traffic data collected at the individual facility level can be aggregated to these larger geographical units for analysis undertaken at this level and for calibration / validation of travel forecasting models. Corridor level analysis is an accepted methodological approach in transportation planning. Master Plan and area-wide transportation studies focus on well-defined travel corridors for which very specific strategies can be considered at a relatively fine level of detail.

For the purpose of this study, the study team defined the following travel corridors:

East-West (E-W) Corridors

1. Kirby Corridor including all the east-west roads from Teston Road (including Teston Road) to King-Vaughan Road (including King-Vaughan Road);
2. Major Mackenzie - Rutherford (Major Mac – Rutherford) Corridor including all the east-west roads from north of Langstaff Road (excluding Langstaff Road) to south of Teston Road (excluding Teston Road); and
3. Highway 407 Corridor including all the east-west roads from Steeles Avenue (including Steeles Avenue) to Langstaff Road (including Langstaff Road)

North-South (N-S) Corridors

1. Highway 427 Corridor including all the north-south roads from Highway 50 (including Highway 50) to Highway 27 (including Highway 27);
2. Islington Corridor including all the north-south roads from Highway 27 (excluding Highway 27) to Weston Road (excluding Weston Road);
3. Highway 400 Corridor including all the north-south roads from Weston Road (including Weston Road) to Keele Street (excluding Keele Street); and
4. Dufferin Corridor including all the north-south roads from Keele Street (including Keele Street) to Bathurst Street (including Bathurst Street)

1.3 Summary of Expected Growth by Corridor

The following sections deal with the projections for growth in population and employment in the City of Vaughan between 2006 and 2031.

1.3.1 Population

As can be seen in **Table 1**, between 2006 and 2031, the population of the City of Vaughan is estimated to grow by 67% (from 253,000 to over 423,000). Also **Table 1** illustrates that the population growth rate is predicted to slow significantly in all the corridors as of 2021 (in comparison, the average annual rate of population increase in the City of Vaughan between 2006 and 2021 is predicted to be 2 percent, whereas between 2021 and 2031 it is predicted to be only 1 percent). Overall 66% percent of the population growth projected between 2006 and 2031 is expected to occur by 2021.

As can be seen in **Figure 1**, among E-W corridors, the Major Mac - Rutherford and Highway 407 corridors are predicted to accommodate 95% of overall projected population growth in the City of Vaughan between 2006 and 2031 with growth shares of 55% and 40% respectively. Although according to **Figure 1**, the population growth share is the lowest for the Kirby corridor (5%), **Table 1** illustrates that this corridor is predicted to have the largest annual growth rate among the E-W corridors (4% between 2006 and 2021; 2% between 2021 and 2031). Also according to **Table 1**, the Highway 407 corridor is expected to have the smallest annual growth rate (2% between 2006 and 2021; 1% between 2021 and 2031).

Table 1. Population and Employment Growth by Corridor (2006 – 2031)

Corridors		Data Item	Population			Employment		
			2006	2021	2031	2006	2021	2031
North-South	Highway 427 Corridor	Absolute Number	1422	12755	19125	6557	45891	57315
		Absolute Growth *		11333	6370		39334	11424
		Annual Growth Rate		16%	4%		14%	2%
		Relative Growth %		**64%**	**36%**		**77%**	**23%**
	Islington Corridor	Absolute Number	95998	115256	123987	33630	37202	37202
		Absolute Growth		19258	8731		3572	0
		Annual Growth Rate		1%	1%		1%	0%
		Relative Growth %		**69%**	**31%**		**100%**	**0%**
	Highway 400 Corridor	Absolute Number	49831	89829	111135	64183	102329	104821
		Absolute Growth		39998	21306		38146	2492
		Annual Growth Rate		4%	2%		3%	0%
		Relative Growth %		**65%**	**35%**		**94%**	**6%**
	Dufferin Corridor	Absolute Number	105640	147335	168960	55494	64566	64566
		Absolute Growth		41695	21625		9072	0
		Annual Growth Rate		2%	1%		1%	0%
		Relative Growth %		**66%**	**34%**		**100%**	**0%**
East-West	Kirby Corridor	Absolute Number	7556	13315	16175	1837	21396	23888
		Absolute Growth		5759	2860		19559	2492
		Annual Growth Rate		4%	2%		18%	1%
		Relative Growth %		**67%**	**33%**		**89%**	**11%**
	Major Mac - Rutherford Corridor	Absolute Number	130538	191389	224670	51590	86835	92634
		Absolute Growth		60851	33281		35245	5799
		Annual Growth Rate		3%	2%		4%	1%
		Relative Growth %		**65%**	**35%**		**86%**	**14%**
	Highway 407 Corridor	Absolute Number	114797	160471	182362	106437	141757	147382
		Absolute Growth		45674	21891		35320	5625
		Annual Growth Rate		2%	1%		2%	0%
		Relative Growth %		**68%**	**32%**		**86%**	**14%**
Total City of Vaughan		Absolute Number	252891	365175	423207	159864	249988	263904
		Absolute Growth		112284	58032		90124	13916
		Annual Growth Rate		2%	1%		3%	1%
		Relative Growth %		**66%**	**34%**		**87%**	**13%**

Note: ** The first number is the 15 year growth between 2006 and 2021, and the second one is the 10 year growth between 2021 and 2031*

Figure 1 also shows the projected population growth shares for N-S corridors with the Dufferin and Highway 400 corridors predicted to almost equally accommodate 73% of the overall population growth between 2006 and 2031. Again as can be seen from **Figure 1** and **Table 1**, although the Highway 427 corridor is expected to have the lowest population growth share (11%) among the N-S corridors, it is

predicted to show the largest annual growth rate (16%) between 2006 and 2021 by a significant margin in comparison to those growth rates in other E-W corridors. Also as can be seen in **Table 1**, the Islington corridor is estimated to have the lowest annual growth rate (1% between 2006 and 2031).

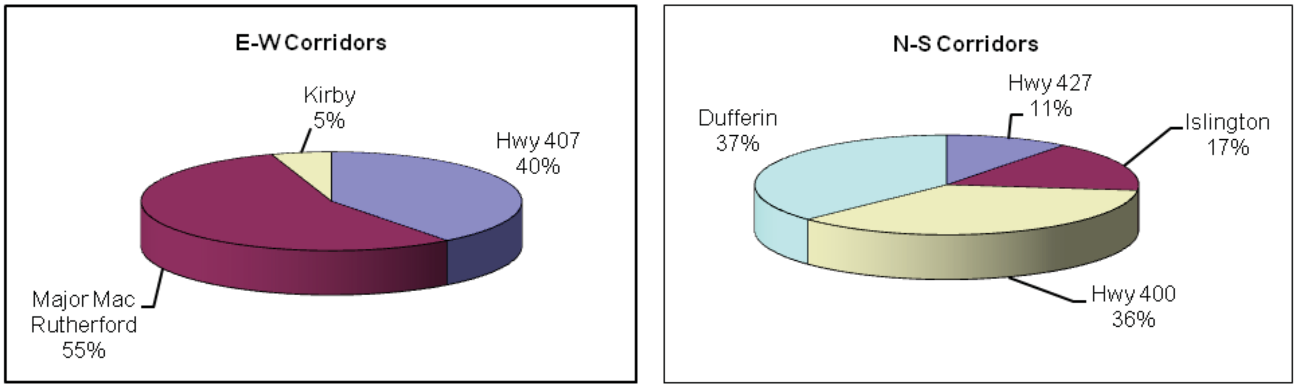


Figure 1. Projected Population Growth Share for Defined Corridors between 2006 and 2031

1.3.2 Employment

Table 1 illustrates that the number of workers in the labour force between 2006 and 2031 is predicted to increase from 160,000 to 264,000, at almost the same rate that the population grows. Also **Table 1** illustrates that virtually all of the employment growth predicted to occur by 2031 (87%) is expected by 2021 (in comparison, the average annual rate of employment increase in the City of Vaughan between 2006 and 2021 is predicted to be 3 percent, whereas between 2021 and 2031 it is predicted to be only 1 percent). Also it is essential to note that the employment growth in E-W corridors is estimated to occur for the most part (86% to 89%) between 2006 and 2021, following the same overall trend as the City as a whole. However except for the Highway 427 corridor, all of the expected employment growth in N-S corridors is predicted to be achieved by 2021.

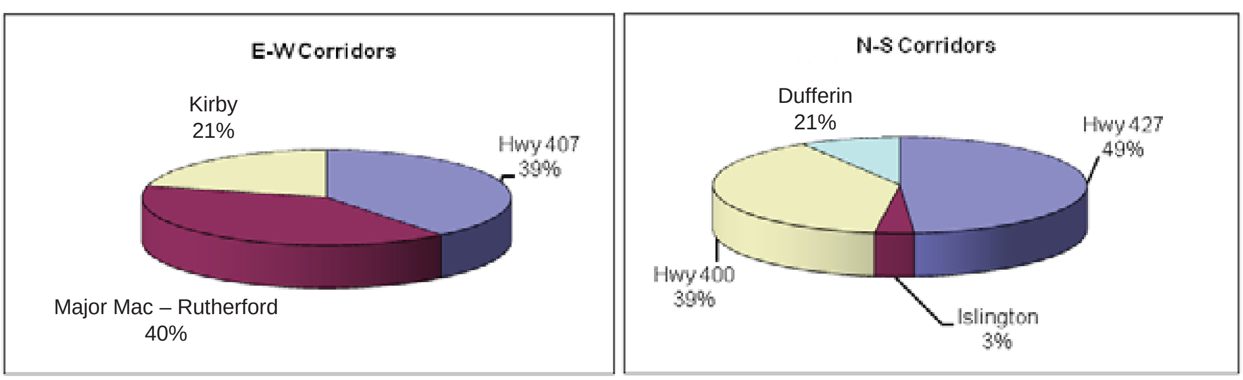


Figure 2. Projected Employment Growth Share for Defined Corridors between 2006 and 2031

As can be seen in **Figure 2**, among E-W corridors, 79% of overall projected employment growth in the City of Vaughan between 2006 and 2031 is predicted to occur within the Major Mackenzie – Rutherford and Highway 407 corridors with almost equal growth shares of 40% and 39% respectively. Although according to **Figure 2**, the employment growth share is the lowest for the Kirby corridor (21%), the **Table 1** illustrates that this corridor is predicted to have the largest annual employment growth rate among the E-W corridors by a significant margin (18% between 2006 and 2021; 1% between 2021 and 2031). Also according to **Table 1**, the Highway 407 corridor is expected to have the smallest annual employment growth rate (2% between 2006 and 2021; 0% between 2021 and 2031).

Figure 2 shows the employment growth shares for N-S corridors with the Highway 427 corridor predicted to accommodate almost half of the overall growth in employment between 2006 and 2031, followed by the Highway 400 corridor (estimated to accommodate 39% of overall employment growth in the City). These two corridors together are predicted to have an 88% share of the overall employment growth between 2006 and 2031. Also as can be seen in **Figure 2**, the Islington corridor is expected to have the lowest share (3%) of overall employment growth in the City between 2006 and 2031. As can be seen from **Table 1**, the Highway 427 corridor is expected to have the largest annual growth rate (14% between 2006 and 2021; 2% between 2021 and 2031) by a significant margin in comparison to those growth rates in other N-S corridors, whereas the Islington and Dufferin corridors are estimated to have the lowest annual growth rate (1% between 2006 and 2031).

1.4 Road Network Improvement Assumptions

The future growth in population and employment will result in increased travel in the City of Vaughan and it will place considerable strain on its road system unless a long-term transportation vision, and integrated road and transit plan supportive of the growth is defined. For many years, managing the transportation system by adding new lanes or new roads or by making operational changes to improve the system performance has been the most common response to address future travel needs and to avoid possible transportation problems. **Table 2** shows the entire assumed road network improvements considered in the network testing for this study. These improvements were evaluated as potential solutions with the aim of selecting the preferred improvements to keep pace with the travel needs of a growing population and expanding employment base in the City of Vaughan. The typical road network improvements include building new roads, new interchanges, railway grade separations with intersecting roads, and road widenings (see **Table 2**). Some of these improvements are major initiatives that have already been planned to be constructed as part of Provincial and Regional plans, as noted below:

- The Highway 427 extension northerly from Highway 7 to Major Mackenzie Drive (with 3 new interchanges);
- Highway 400 widening north of Major Mackenzie Drive;
- Interchange improvements on Highway 400 at Langstaff Road, Highway 7, and Steeles Avenue and on Highway 407 at Centre Street;

Table 2. Assumed Road Improvements in the City of Vaughan

Direction	Corridor	Provincial Roads		Regional Roads		Local Roads	
		Road Improvement	*Limits/Location*	*Road Improvement*	*Limits/Location*	*Road Improvement*	*Limits/Location*
East-West Corridors East-West Road Improvements	**Highway 407 Corridor**	▶ New Interchange ▶ Interchange Improvements	▶ Martin Grove / Highway 407 ▶ Centre Street / Highway 407	▶ Langstaff Road Widening (2 to 4) ▶ Langstaff Extension (New 4-lane) ▶ Langstaff Road Widening (2 to 4) ▶ Steeles Avenue Widening (4 to 6) ▶ Steeles Avenue Widening (4 to 6) ▶ Highway 7 Widening (4 to 6)	▶ Highway 50 to Highway 27 (Already Constructed) ▶ Creditstone Road to Keele Street ▶ Keele Street to Dufferin Street ▶ West of Pine Valley Drive ▶ Weston Road to Jane Street ▶ West and East of Islington Avenue	▶ Portage Parkway Extension (2-Lane) ▶ New E-W 4-Lane Road ▶ Colossus Drive Extension (4-Lane) ▶ Interchange Way Extension (2 Lane) ▶ New Highway 400 NB On Ramp (Link 5)	▶ Jane Street to Creditstone Road ▶ North of Steeles between Jane Street and Keele Street ▶ Colossus Drive to Interchange Way ▶ Jane Street to Creditstone Road ▶ Link 4 to Highway 400 NB
	Rutherford – Major Mackenzie Corridor			▶ Rutherford Road Widening (4 to 6) ▶ Major Mackenzie Drive Widening (2 to 6) ▶ Major Mackenzie Drive Widening (4 to 6)	▶ Highway 50 to Weston Road ▶ Highway 50 to Weston Road ▶ Weston Road to Bathurst Street	▶ New Highway 400 Crossing (4-Lane) ▶ New Highway 400 Crossing (4-Lane) ▶ New E-W 4-Lane Local Road ▶ New E-W 2-Lane Local Road ▶ New E-W 2-Lane Local Road ▶ New E-W 4-Lane Local Road	▶ North of Major Mackenzie Drive (North Maple Community Bridge) ▶ North of Rutherford Road ▶ South of Rutherford Road between Highway 50 and Highway 27 ▶ South of Rutherford Road, West of Weston Road to Highway 400 ▶ South of Rutherford Road, East of Highway 400 ▶ North of Major Mackenzie Drive between Highway 50 and Huntington Road
	Kirby Corridor			▶ Teston Road Widening (2 to 4) ▶ Teston Road (New 4 Lane) ▶ Teston Road Widening (2 to 4) ▶ King-Vaughan Road Widening (2 to 4) ▶ Kirby Road Widening (2 to 4) ▶ Kirby Road (New 4-Lane)	▶ Pine Valley Drive to Highway 400 ▶ Keele Street to Dufferin Street ▶ Bathurst Street to Dufferin Street ▶ Bathurst Street to Pine Valley Drive ▶ Keele Street to Dufferin Street ▶ Dufferin Street to Bathurst Street	▶ Highway 400 Crossing	▶ North of Kirby Road (Subject to Results of GTA West Studies)

Table 2. Assumed Road Improvements in the City of Vaughan

Direction	Corridor	Provincial Roads		Regional Roads		Local Roads	
		Road Improvement	***Limits/Location***	***Road Improvement***	***Limits/Location***	***Road Improvement***	***Limits/Location***
North-South Corridors **North-South Road Improvements**	**Highway 427 Corridor**	▶ Highway 427 Extension ▶ Interchange Improvement ▶ New Interchange ▶ New Interchange ▶ New Interchange	▶ Highway 7 to Major Mackenzie Drive ▶ Highway 7 / Highway 427 ▶ Langstaff Road / Highway 427 ▶ Rutherford Road / Highway 427 ▶ Major Mackenzie Drive / Highway 427	▶ Highway 50 Widening (4 to 6) ▶ Highway 27 Widening (4 to 6) ▶ Highway 27 Widening (2 to 4)	▶ Steeles Avenue to the South of Kirby Road ▶ Steeles Avenue to Major Mackenzie Drive ▶ Major Mackenzie Drive to King-Vaughan Road	▶ Huntington Road Widening (2 to 4) ▶ New N-S 2-Lane Local Road ▶ 2 New Local N-S 2-Lane Roads ▶ New Huntington Road ▶ 2 New N-S 2-Lane Local Roads ▶ MacGillvray Road	▶ Langstaff Road Drive to Kirby Road ▶ North of Highway 7 to Zenway Boulevard ▶ Langstaff Road to Rutherford Road (west of Huntington Road) ▶ Highway 7 to Langstaff Road ▶ Major Mackenzie to Nashville Road (east and west of Huntington Rd) ▶ Langstaff Road to south of Major Mackenzie Dr
	Islington Corridor			▶ Pine Valley Drive Widening (4 to 6)	▶ Steeles Avenue to Highway 7	▶	
	Highway 400 Corridor	▶ Highway 400 Widening (6 to 10) ▶ Interchange Improvements ▶ Interchange Improvements ▶ Interchange Improvement ▶ New Interchange	▶ Major Mackenzie Drive to King-Vaughan Road ▶ Langstaff / Highway 400 ▶ Steeles / Highway 400 ▶ Highway 7 / Highway 400 ▶ King-Vaughan / Highway 400	▶ Weston Road Widening (2 to 4) ▶ Weston Road Widening (4 to 6) ▶ Jane Street Widening (2 to 4) ▶ Jane Street Widening (4 to 6)	▶ Major Mackenzie Drive to Kirby Road ▶ Steeles Avenue to Major Mackenzie Drive ▶ Teston Road to Kirby Road ▶ Steeles Avenue to Major Mackenzie Drive	▶ Millway Avenue Extension (4 Lanes) ▶ Local Roads (New) ▶ Millway Avenue Widening (2 to 4) ▶ Creditstone Road Widening (2 to 4) ▶ New Extension of Highway 400 NB off Ramp (Link 4) ▶ 2 New N-S 2-Lane Local Roads ▶ New N-S 2-Lane Local Road	▶ South of Highway 7 to Interchange Way ▶ East and West of Weston Road ▶ North of Highway 7 to Portage Parkway ▶ Peeler Road to Langstaff Road ▶ Highway 7 to Portage Parkway ▶ West of Weston Road, North of Major Mackenzie Drive ▶ East of Highway 400 from Teston Road to King-Vaughan Road
	Dufferin Corridor			▶ Keele Street Widening (4 to 6) ▶ Bathurst Street Widening (4 to 6) ▶ Dufferin Street Widening (2 to 4) ▶ Dufferin Street Widening (4 to 6)	▶ Steeles Avenue to Major Mackenzie Drive ▶ South of Rutherford Road to Teston Road ▶ Major Mackenzie Drive to King-Vaughan Road ▶ Langstaff Road to Major Mackenzie Drive		

- A new interchange on Highway 407 at Martin Grove Road;
- Widenings of Major Mackenzie Drive, Rutherford Road, Highway 27, Weston Road, and Pine Valley Drive that are being recommended by the Region of York through the Western Vaughan Transportation Improvements Individual Environmental Assessment (IEA);
- Other widenings of Regional roads east of Highway 400, including sections of Jane Street, Keele Street, Dufferin Street and Bathurst Street in the north-south direction; and widenings of Major Mackenzie Drive and sections of Langstaff Road and Teston Road, together with construction of the Langstaff and Teston missing links; and
- New and improved railway grade separations associated with the above-noted Western Vaughan IEA recommended arterial widenings.

1.5 Corridor Deficiencies

Figures 3 to **10** show the volume-to-capacity ratios by direction along all of the N-S and E-W corridors during both the AM and PM peak hours in 2021 and 2031. These figures identify the corridor deficiencies and provide the basis for more detailed corridor analysis of needed improvements for 2021 documented in **Appendix L**.

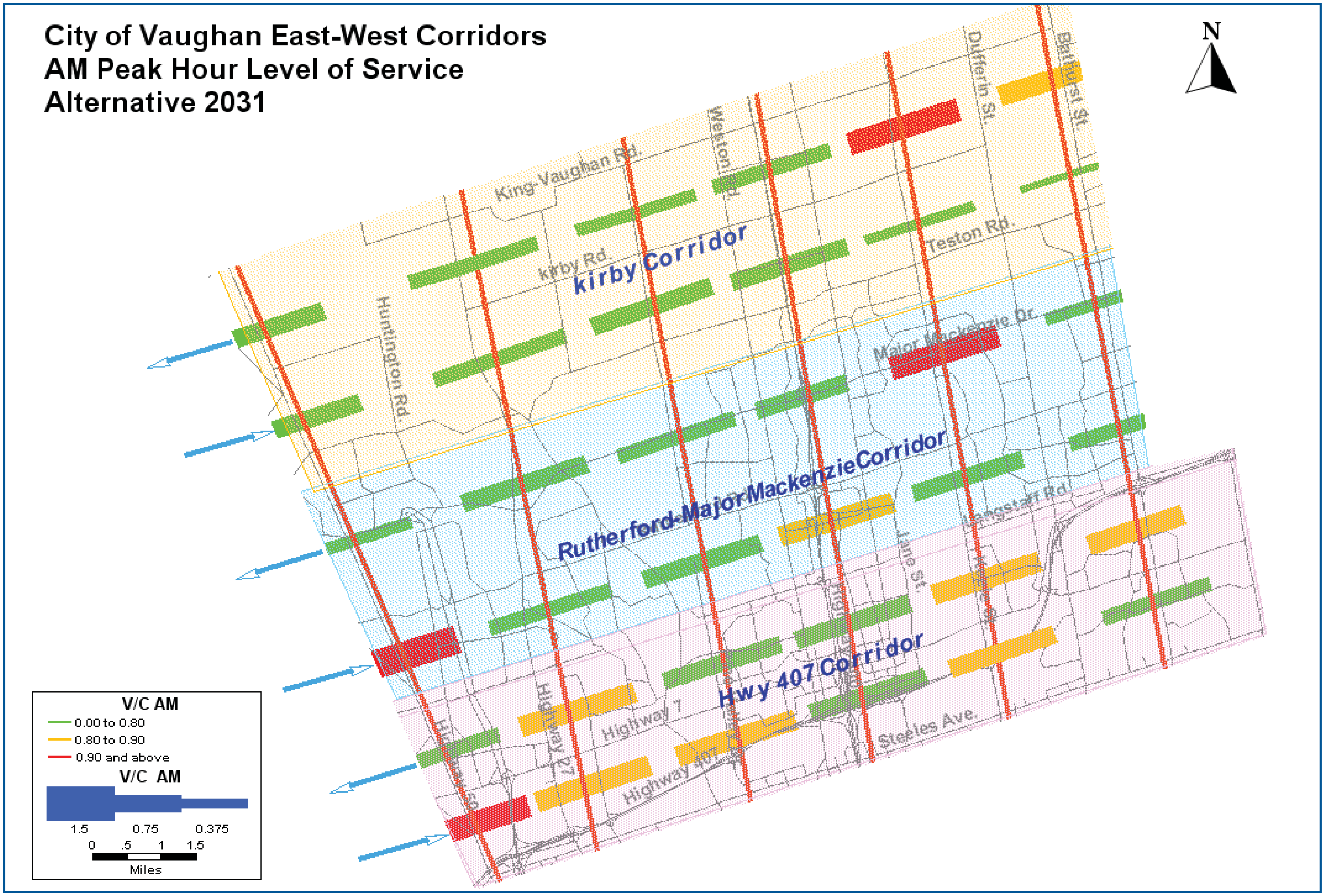


Figure 3. Level of Service for E-W Corridors in the City of Vaughan during AM Peak Period in 2031

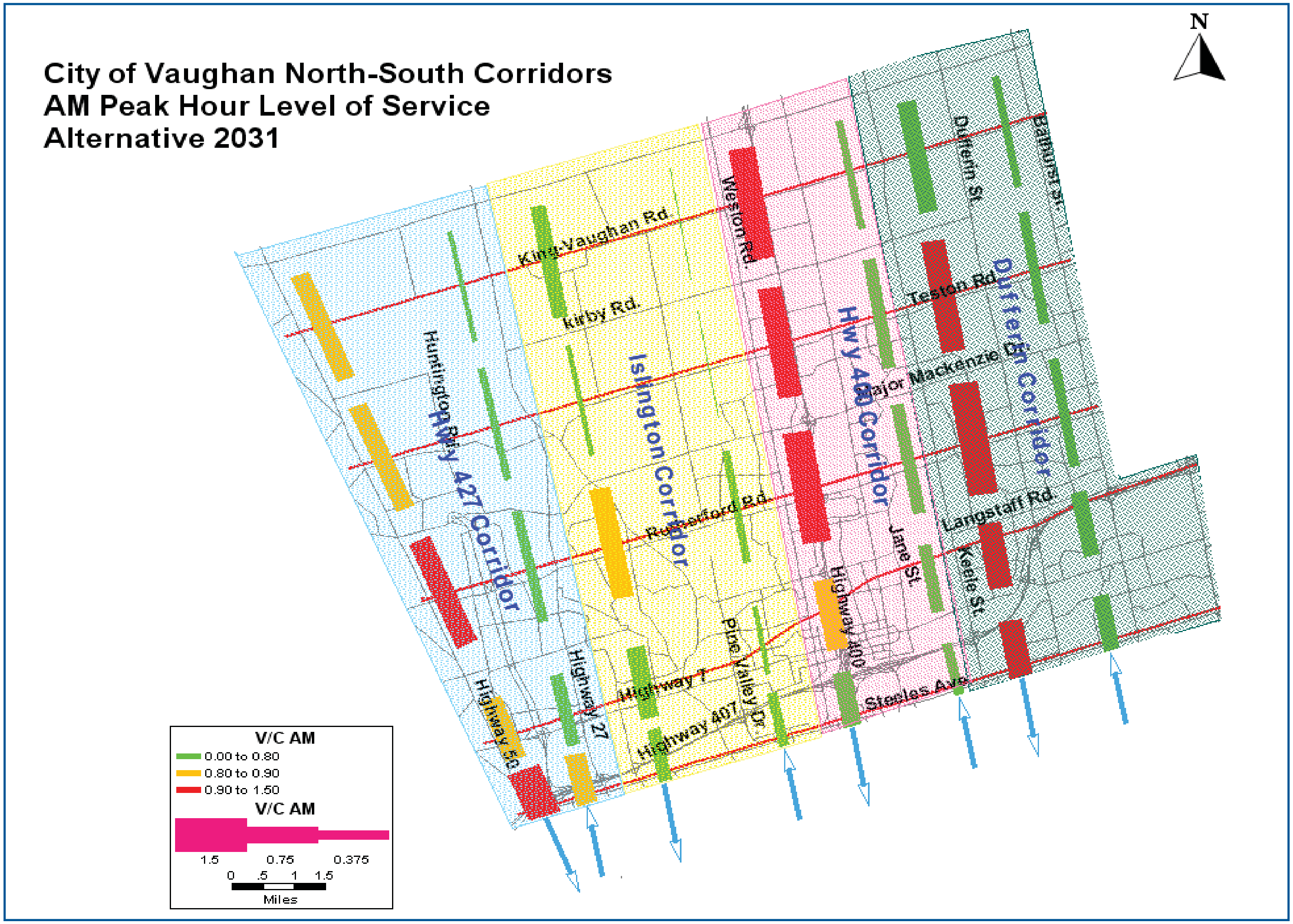


Figure 4. Level of Service for N-S Corridors in the City of Vaughan during AM Peak Period in 2031

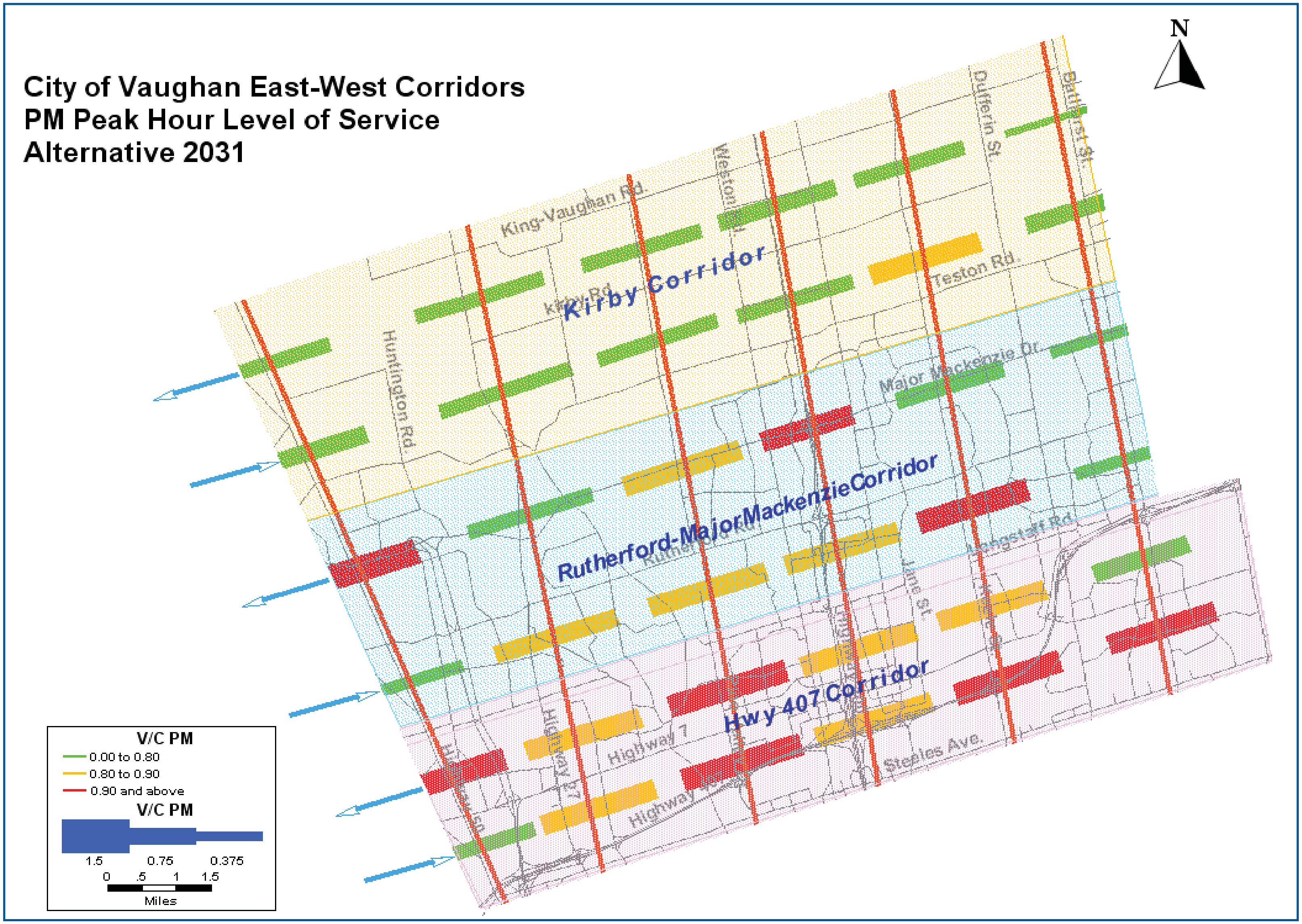


Figure 5. Level of Service for E-W Corridors in the City of Vaughan during PM Peak Period in 2031

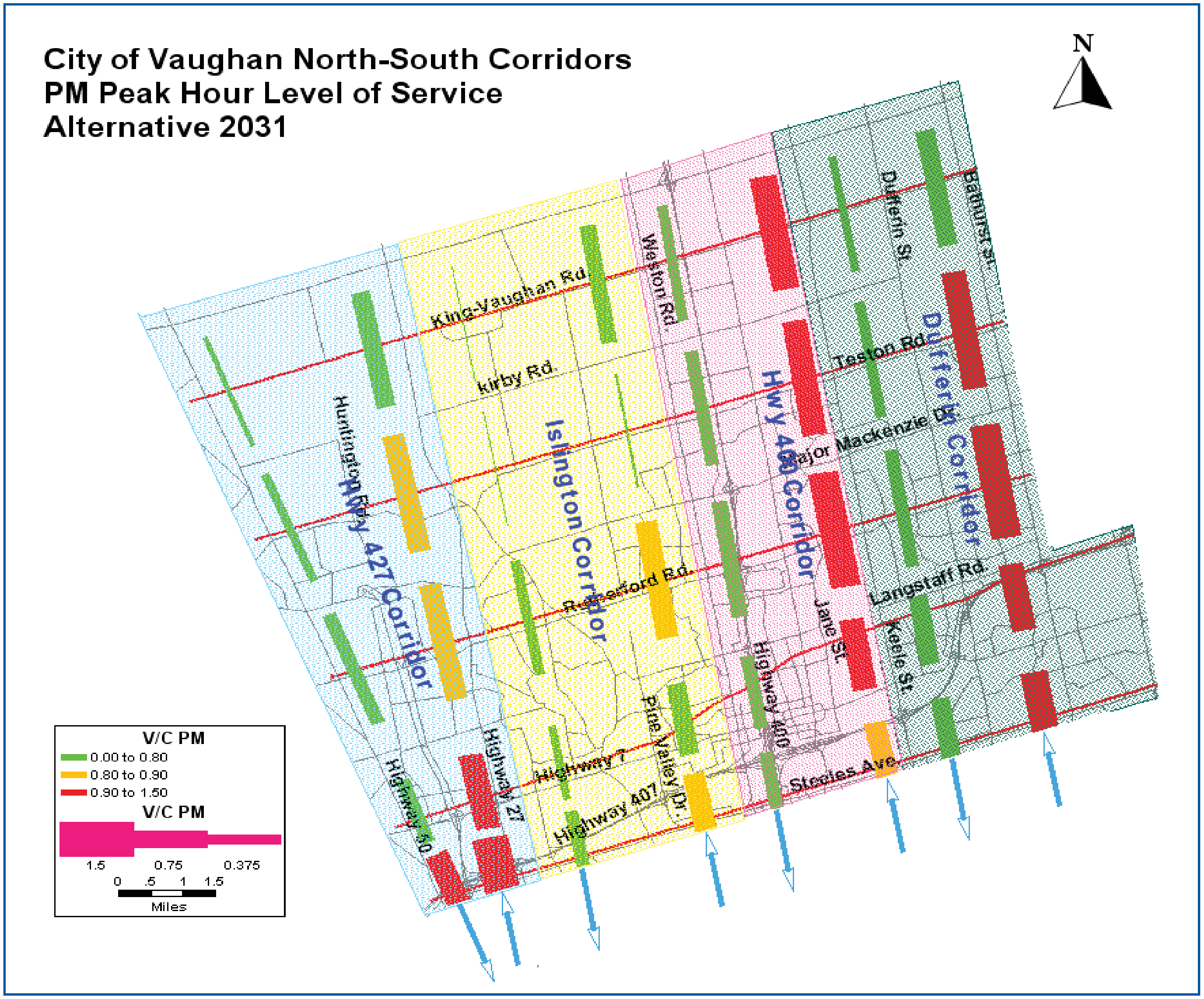


Figure 6. Level of Service for N-S Corridors in the City of Vaughan during PM Peak Period in 2031

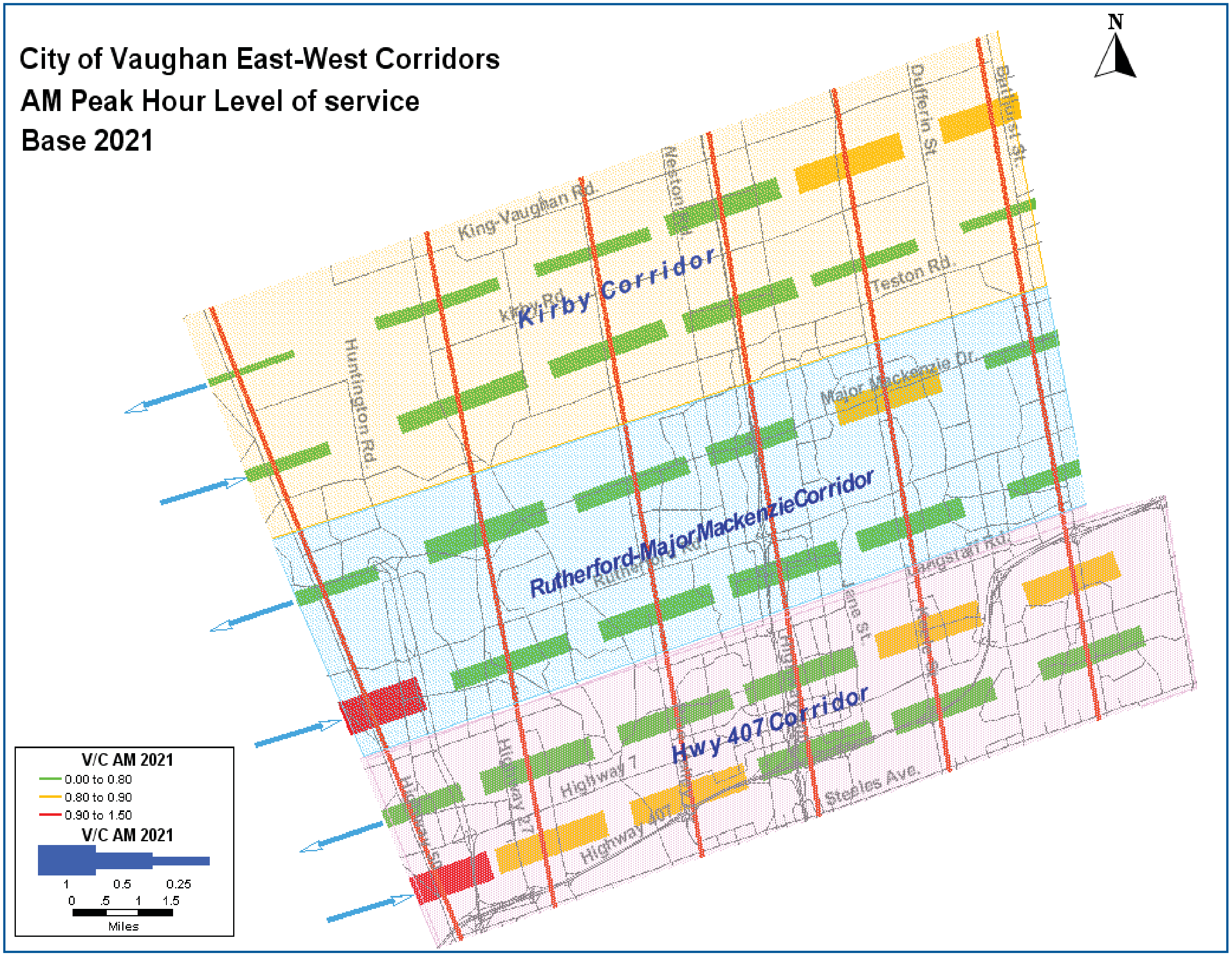


Figure 7. Level of Service for E-W Corridors in the City of Vaughan during AM Peak Period in 2021

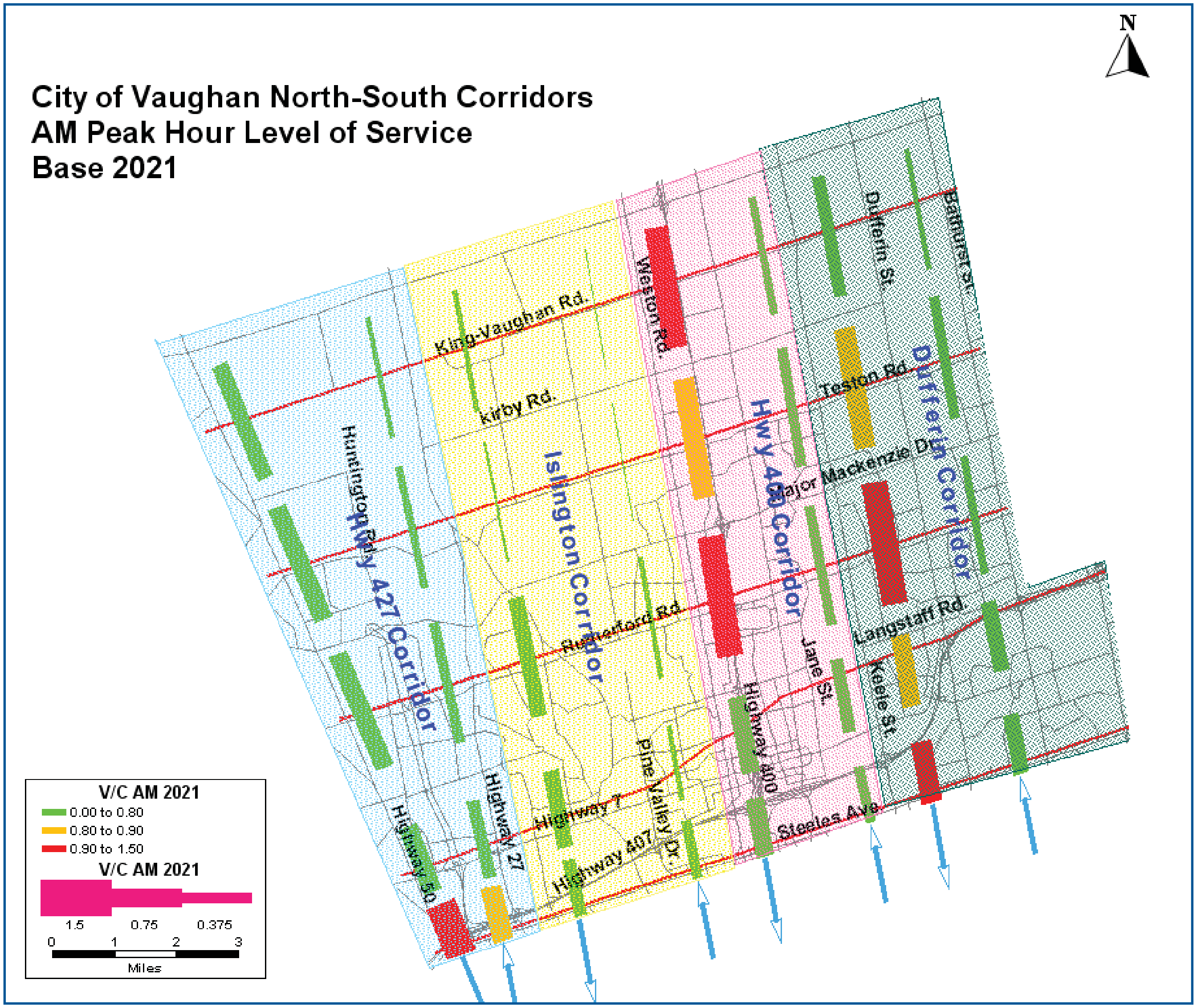


Figure 8. Level of Service for N-S Corridors in the City of Vaughan during AM Peak Period in 2021

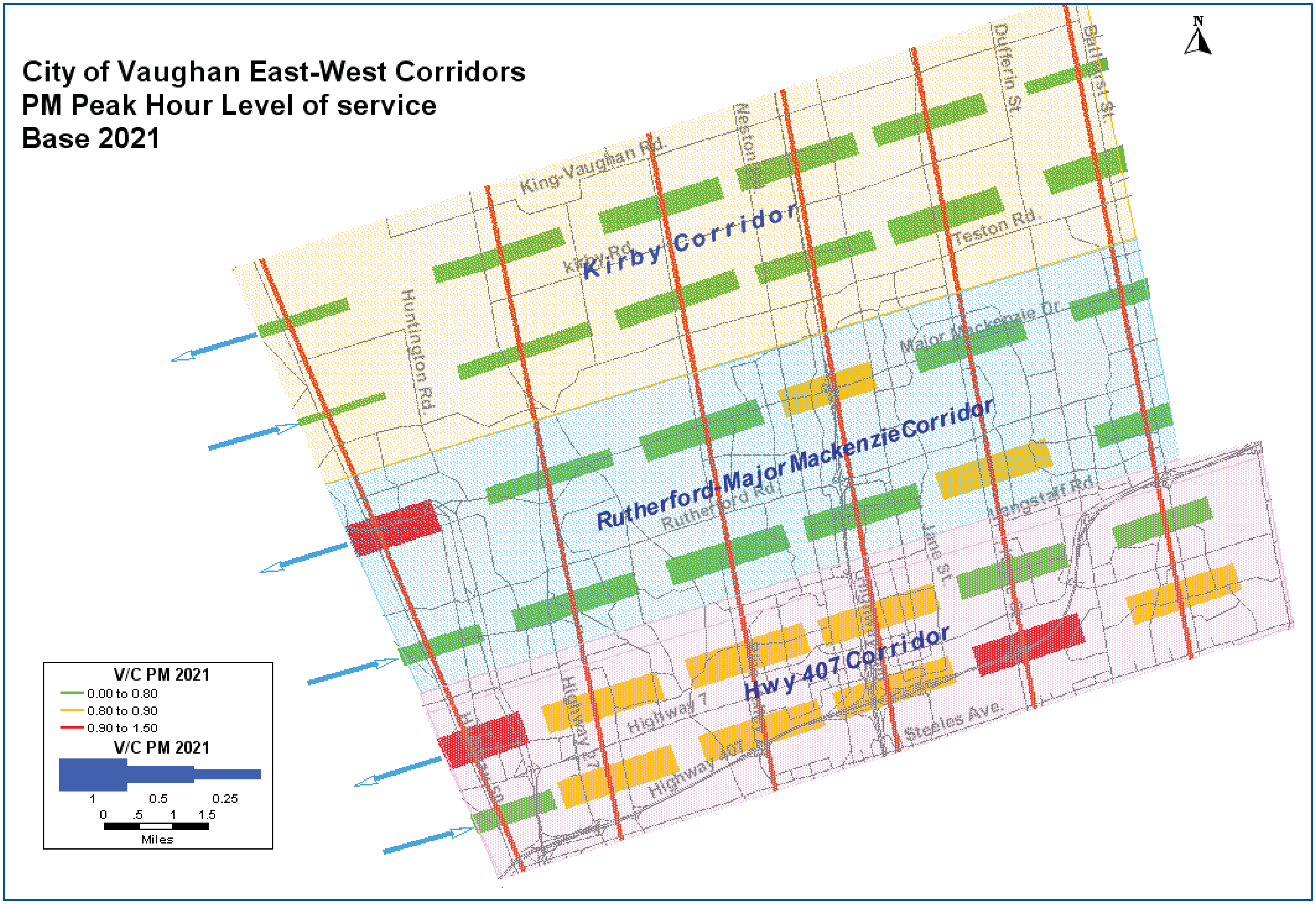


Figure 9. Level of Service for E-W Corridors in the City of Vaughan during PM Peak Period in 2021

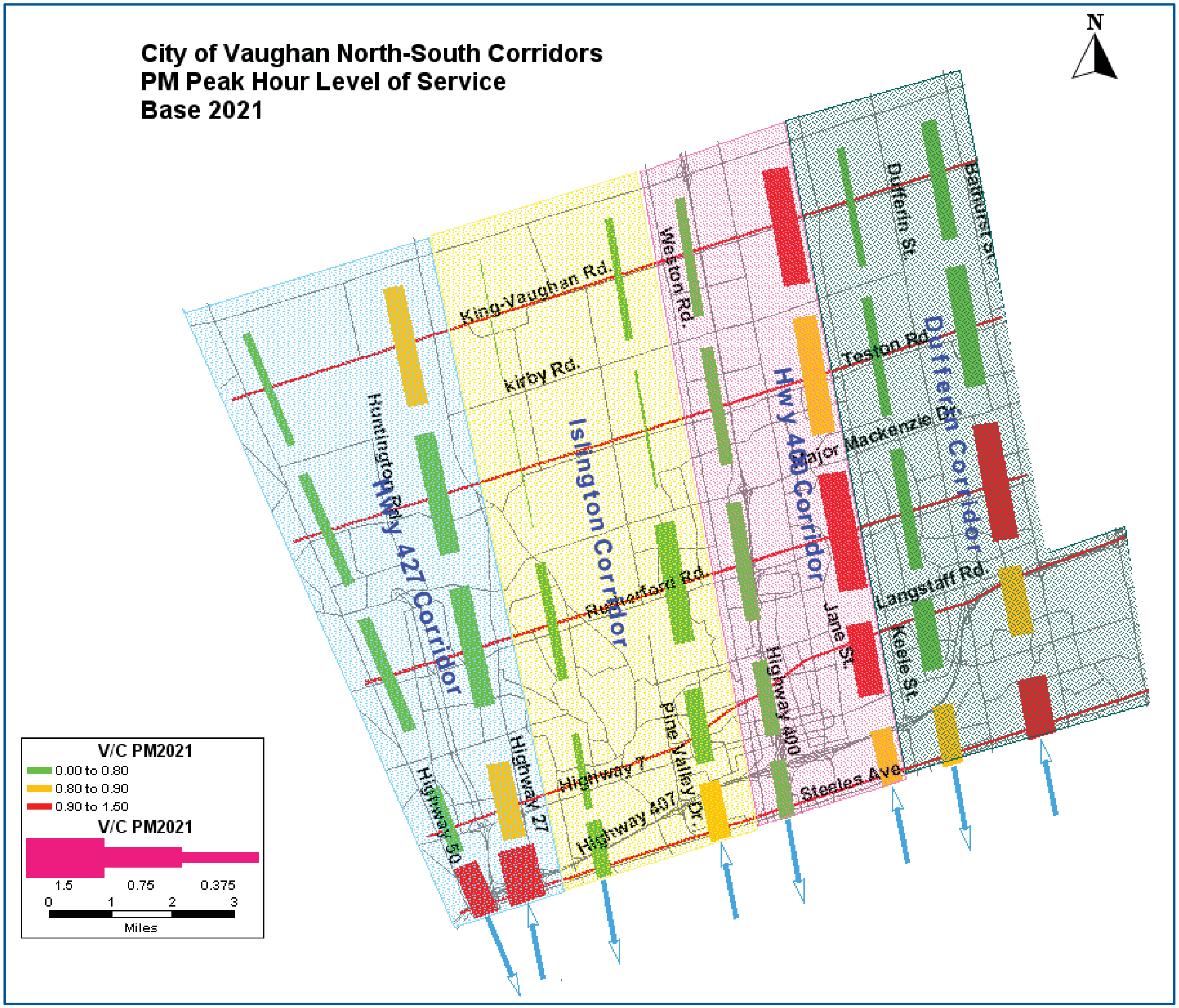


Figure 10. Level of Service for N-S Corridors in the City of Vaughan during PM Peak Period in 2021