DRAFT REPORT

TRANSIMS in Buffalo-Niagara Falls: Case Study

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Executive Summary

Like many Metropolitan Planning Organizations, the Greater Buffalo Niagara Regional Transportation Council (GBNRTC) faces transportation and land use issues that require a variety of tools to analyze them. In particular, there is an interest in looking at operational changes, and how they affect both the immediate area and the entire region.

The Transportation Analysis and Simulation System (TRANSIMS) is an integrated, open-source set of transportation planning models designed to provide a number of capabilities that go beyond the traditional "four-step" modeling process. It provides a foundation for activity-based modeling, its router (traffic assignment) allows for much greater time-of-day detail than is typically seen in existing four-step models, and its microsimulation component enables very detailed modeling of portions of the network, to capture congestion and queuing.

The Buffalo-Niagara Falls area was chosen for a this project because:

- The Buffalo region hosts several major international border crossings and experiences delay challenges at these locations.
- The Buffalo region has traditionally served as a major freight gateway serving as a key hub in the regional, state and national economies.
- An adequate amount of "off-the-shelf" traffic data was available in the Buffalo area to support a more advanced planning model. In particular, a substantial number of hourly and classification traffic counts were available. Testing the development of a TRANSIMS application without conducting an expensive activity-based travel survey became a goal of this project

GBNRTC had recently completed an update to its existing four-step planning model, recognized the need to use multiple travel demand modeling and simulation tools to support their planning needs and was eager to become involved in the four-step model "cross-walk" to simulation modeling aspects of this project.

A preliminary Feasibility Study was conducted as a first step in this project and demonstrated that a regional TRANSIMS model could be developed based on existing data. The router portion of the model, which covered the entire region, used the existing network and trip tables, with only minor changes to the network. It produced results comparable in quality to those from the existing four-step model.

The microsimulator portion of the model, which covered a sub-region, required more refinements to the network, but they were manageable, involving changes in lanes and signals at a few intersections and changes in speeds on a few corridors. It produced more detailed results, enabling effective presentation of congestion, queuing and time-of-day shifts.

Key technical lessons learned include the following:

- It is possible to build a TRANSIMS model using existing data.
- The TRANSIMS software functioned well, but like any complex system, has a steep learning curve. When embarking on a TRANSIMS project, it is best to join the TRANSIMS open source community, seeking help from more experienced users as needed.

- TRANSIMS inputs are very detailed, but in most cases, the default parameters in the network conversion process produced a reasonable conversion from the links and nodes of a four-step model to the network files of a TRANSIMS model.
- The microsimulation portion of TRANSIMS is much more sensitive to network fidelity than the router. By using a subarea, the size of the network that must be scrutinized becomes reasonable.

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1 Introduction

The Transportation Analysis and Simulation System (TRANSIMS) is an integrated, open-source set of transportation planning models designed to provide a number of capabilities that go beyond the traditional "four-step" modeling process. The TRANSIMS framework has four components: a population synthesizer, an activity generator, a route planner, and a microsimulator.

The **population synthesizer** creates a synthetic population of the modeled region using census data. This synthetic population is input into the activity generator.

The **activity generator** uses data from travel diaries to assign travel activities to each synthetic household based on socio-economic similarities between surveyed households and synthetic households. The activity generator creates travel tours, which consist of all travel legs from a home base until the traveler returns to the home base.

The **route planner, or router,** chooses the best route for travel activity based on the shortest travel time as calculated either by the microsimulator or by link delay functions. The resulting output is a set of route plans: specific routes for each trip. Trips may be on highway or transit networks. The router operates at a greater level of time-of-day detail than is typical in 4-step models, typically using congested link travel times at 15-minute intervals.

The **microsimulator** executes the route plans and calculates travel times which are then fed back into the route planner. This iterative process is continued until the system reaches equilibrium.

Since TRANSIMS simulates individual trips, and their interactions (traffic congestion) with other trips, it explicitly represents time-of-day to the second for both people and vehicles. This microsimulation allows for a continuous time distribution, and thus provides a significant advantage over the typical 4-step methodology, which only accommodates a limited number of discrete time intervals. In addition, the TRANSIMS network is typically much more detailed than the typical 4-step network, allowing it to more realistically simulate travel.

In 2006, the Federal Highway Administration (FHWA) asked the Volpe Center to perform a Scoping Study that would assess the feasibility of constructing a TRANSIMS traffic simulation model, with a particular focus on truck movements, in the Buffalo-Niagara Falls Region. Characteristics of this area include a major tourist attraction (Niagara Falls), several heavily-used and congested border crossings with a substantial number of truck movements, and a significant number of external truck movements passing through the region, both along the I-90 corridor within the U.S., and to and from Canada.

This region was of interest to FHWA for several reasons:

- US DOT has an interest in both the further deployment of TRANSIMS, and in addressing issues with the Canadian and Mexican borders. With a project in Buffalo, both interests are addressed.
- It appeared that enough data was available in the Buffalo area to support a more advanced planning model. In particular, a substantial number of hourly and classification traffic counts were available.

- Finally, and most important, the Greater Buffalo Niagara Regional Transportation Council (GBNRTC)[1] had both the technical capability and interest in supporting this effort. They had recently completed an update to their existing planning model, but also recognized the need to use multiple tools.

The Feasibility Scoping Study found that by piecing together existing data from various sources, it would be possible to develop a pilot TRANSIMS microsimulation application for truck movements and other traffic in the Buffalo-Niagara Falls area. Such an application would focus on the supply side of TRANSIMS, i.e., the router and microsimulator. It would also focus on highway, and not transit, trips.

Given the results of the Feasibility Scoping Study, in 2007 FHWA asked the Volpe Center to work with GBNRTC to develop a pilot TRANSIMS microsimulation application.

Objectives of this pilot included the following:

1. To show that a regional TRANSIMS model could be developed based on existing data, using an existing four-step model as a basis
2. To demonstrate the capabilities of this model, some of which go beyond those of a typical four-step model
3. To transfer the TRANSIMS model and the development of further capabilities to GBNRTC

1.1 Issues in the Buffalo / Niagara Falls Area

Buffalo and Niagara Falls are located on the U.S./Canada border at the eastern end of Lake Erie, just south of Lake Ontario (Figure 1). It is part of the “Golden Horseshoe,” the heavily industrialized area along the western end of Lake Ontario that stretches from Toronto, Ontario to Rochester, New York. The area covered by the existing GBNRTC regional model includes Erie and Niagara counties in the State of New York (shaded in green in Figure 1). This includes the cities of Buffalo and Niagara Falls and matches the Buffalo-Cheektowaga-Tonawanda Metropolitan Statistical Area in the Freight Analysis Framework (FAF)[2].

[1] GBNRTC is the Metropolitan Planning Organization (MPO) for the Buffalo – Niagara Falls region.
[2] The Freight Analysis Framework (FAF) provides 2002 annual commodity flow estimates (both by tons and by dollar value) for both domestic and import/export freight flows disaggregated by mode. Its origin-destination zone structure is at a national level, with the United States split into 114 regions.

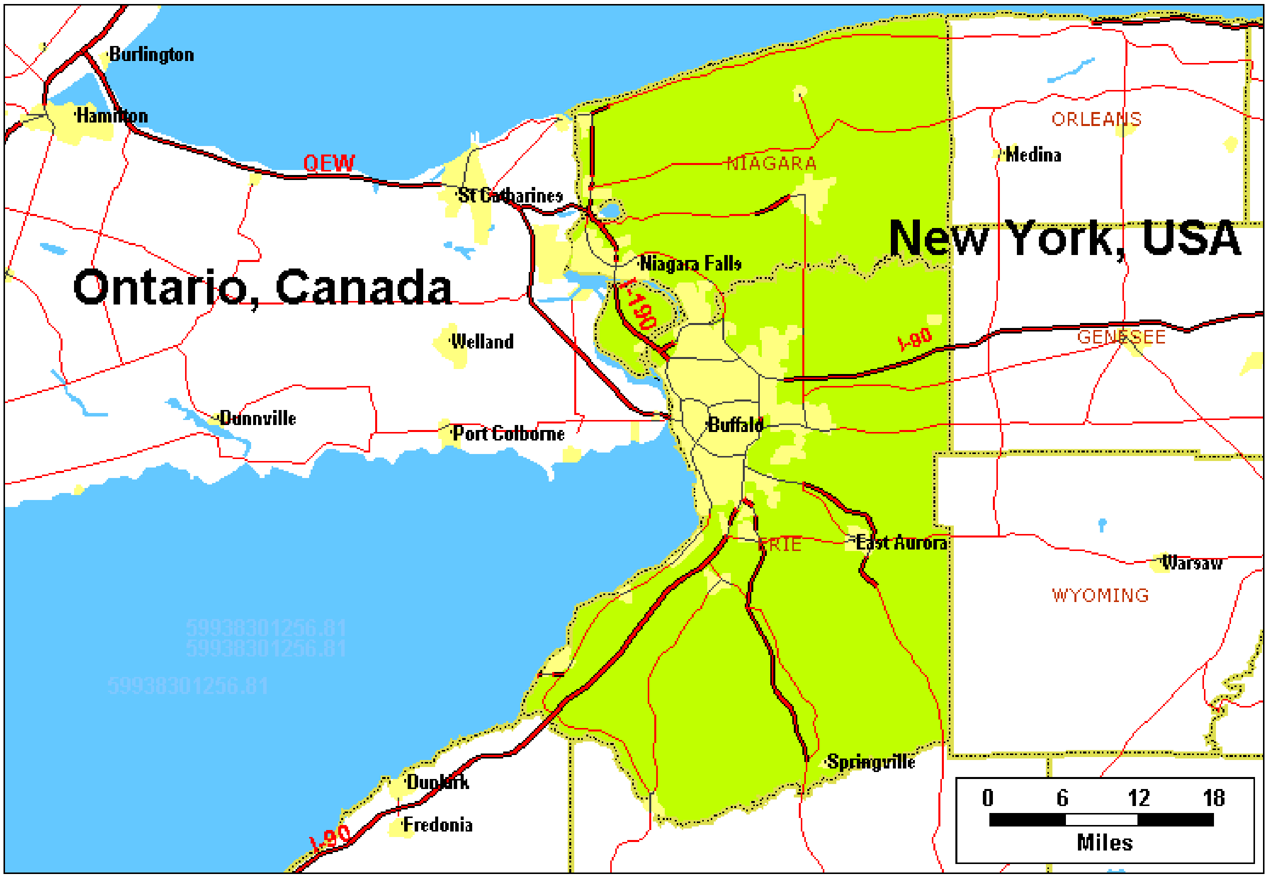

Figure 1 Buffalo-Niagara Falls Area

Major highway connections include:

- Interstate 90 from the east (Rochester, Albany, and Boston)
- Interstate 90 from the southwest (Erie, Cleveland, and Chicago)
- U.S. 219 from the south
- Queen Elizabeth Way (QEW) and Route 405 from the west and north (points in Ontario including Hamilton and Toronto)

Of the four bridges connecting the U.S. and Canada, two allow truck movements: the Lewiston-Queenston Bridge just north of Niagara Falls (Figure 2), and the Peace Bridge, which connects Buffalo, New York, and the QEW, in Fort Erie, Ontario. The other cross-border bridges—the Rainbow Bridge and the Whirlpool Bridge—do not allow trucks.

Most freight movements to and through the area are by truck, although several rail lines exist, and Buffalo has a port on Lake Erie.

Figure 2 Lewiston-Queenston Bridge

In order to understand their concerns, and to identify what data might be available from them to support an improved planning model, members of the project team contacted stakeholders from the following organizations:

- Greater Buffalo-Niagara Regional Transportation Council (GBNRTC)
- Niagara International Transportation Technology Coalition (NITTEC)
- New York State Thruway Authority
- New York State Department of Transportation (NYSDOT)
- Ontario Ministry of Transportation
- Ontario Trucking Association
- Federal Highway Administration (FHWA) Office of Freight Operations and Technology

In addition, a Volpe Center representative attended presentations at two technical meetings. The first was the Institute of Transportation Engineers/New York State Association of Metropolitan Planning Organizations Fall Technical Conference, held October 3, 2006 in Niagara Falls, New York. The second was the Transportation Border Working Group Plenary Meeting, held October 23-25, 2006 in Niagara Falls, Ontario. Both meetings included presentations from many of the above listed organizations as well as the Buffalo and Fort Erie Public Bridge Authority, which operates the Peace Bridge.

Concerns expressed by stakeholders include economic growth, uncertainty with border crossing policies, and specific bottlenecks in the highway and rail systems.

Over the past 50 years, Buffalo has seen its manufacturing base and population decline. Accordingly, the area is seeking opportunities for growth. Two ideas that could have a significant impact on freight movements are the proposed development of the Niagara Falls airport area, and the use of Buffalo as a reliever port-of-entry for the New York/New Jersey area. Following the 1994 North American Free Trade Agreement (NAFTA), cross-border truck traffic in the area grew by about 25% from 1995 to 2000. There has been no growth between 2000 and 2005.

The local impacts of border crossing policies are a second area of concern. For truck movements, there are the issues of new fees and documentation requirements, as well as delay and uncertainty in crossing times. For passenger movements, there is the fear that the passport requirements of the Western Hemisphere Travel Initiative may harm area tourism, which to some extent depends on easily crossing the U.S./Canada border. Passenger cross-border traffic has declined significantly between 2000 and 2005.

Finally, although the Buffalo-Niagara Falls area does not experience the congestion of major cities such as New York City or Toronto, a number of specific bottlenecks are of some concern. Areas mentioned include the border crossings (only two bridges allow truck traffic), the I-90 / I-290 interchange and the Grand Island bridges. Non-freeway corridors of concern include routes 219 and 63 (Batavia).

Significant planning studies in the region include the Scajaquada, I-290 and I-90 in Buffalo corridors, the University at Buffalo master plan, transit and regional freight studies, corridor signalization, congestion management and intergovernmental land use coordination.

The past few years have seen an increased focus on regional operations. There is more real-time data on congestion and travel times, and this is beginning to be used. Multiple agencies are involved, including NYSDOT (Region 5), the NYSTA Buffalo Division, the Peace Bridge Authority, the Niagara Falls Bridge Commission, and the Ontario Ministry of Transportation.

Possible transportation facility improvements mentioned by stakeholders that could be analyzed with a planning model and would help address these concerns are listed below:

- Customs plaza relocation and expansion at the Peace Bridge
- Customs plaza expansion at the Lewiston-Queenston Bridge.
- Widening of Highway 405 on the approach to the Lewiston-Queenston Bridge
- Grand Island Bridges resurfacing
- I-90 / I-290 interchange improvements
- Grand Island Bridges reconstruction
- In Ontario, mid-peninsula corridor highway
- New bridge in the Buffalo/Fort Erie area
- Route 219 improvements (Continental One)

Near the end of this report, the scenario of electronic toll collection at highway speeds on the South Grand Island Bridge is discussed.

1.2 Organization of this Report

This document presents the case study resulting from the development of a TRANSIMS application for the Buffalo/Niagara Falls area. It is organized as follows:

- Current GBNRTC Model
- TRANSIMS Model – Development
- TRANSIMS Model - Calibration
- Scenario Tests
- Conclusions

2 Current GBNRTC Model

The current GBNRTC model covers Erie and Niagara counties in Western New York State, a region with a population of approximately 1.1 million. The current model includes major roads in the region and extends into Canada with a more limited network (Figure 3). However, the only Canadian trips that are modeled are those that that travel to, from or via Erie or Niagara counties in the United States.

The model has approximately 4000 nodes and 6000 links, of which approximately 1200 are zone centroid connectors. 3.7 million daily trips are modeled.

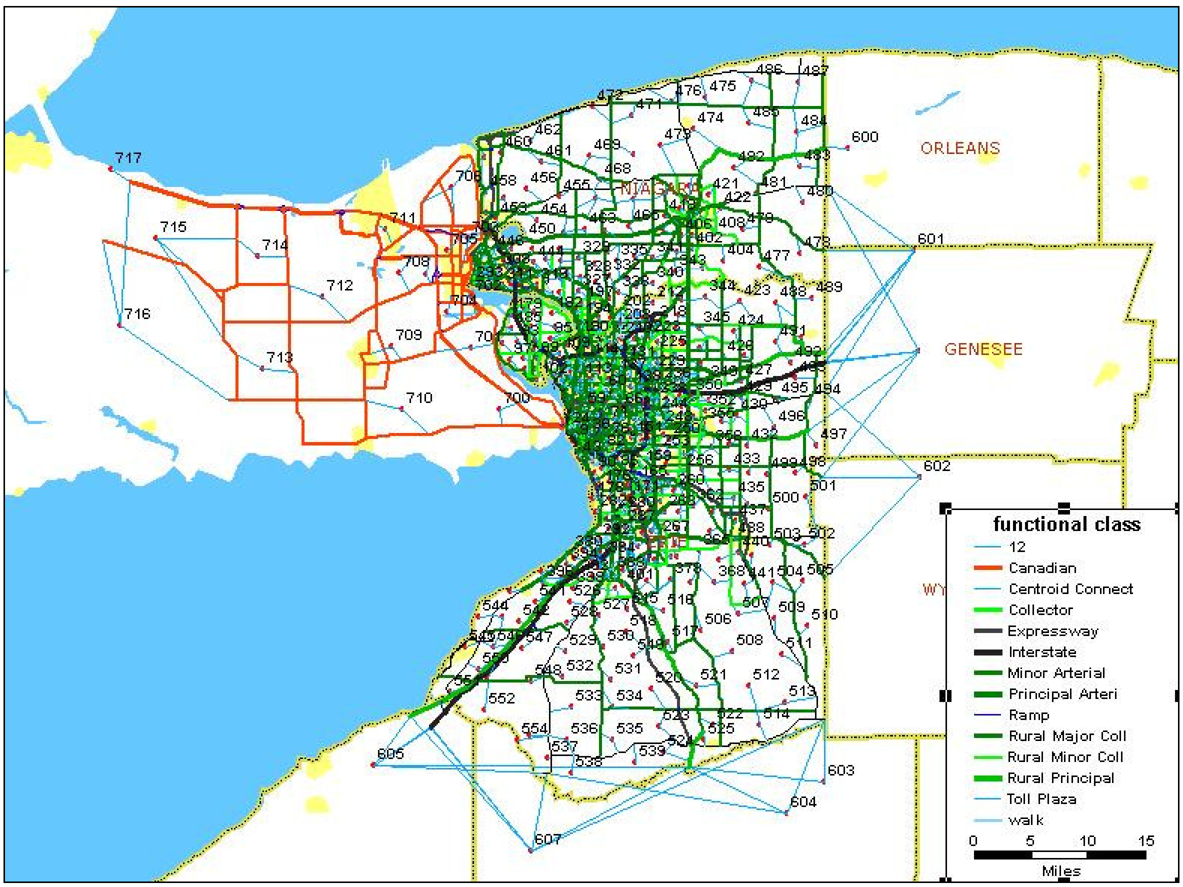

Figure 3 GBNRTC TransCAD Network

The origin-destination matrices used in the current model are divided into 16 sub-matrices, dependent on time-of-day and movement/vehicle type. The time periods used are

- AM Peak (AM): 7 – 10 AM
- Mid Day (MD): 10 AM – 3 PM
- PM Peak (PM): 3 – 6 PM
- Night (NT): 6 PM – 7 AM

The movement/vehicle types are

- Automobile – Internal
- Automobile – External
- Medium Truck
- Heavy Truck

For these matrices, automobile includes FHWA vehicle classes 1 – 4 (i.e., it includes buses), medium truck includes classes 5 – 7, and heavy truck includes classes 8 and higher (see Figure 4).

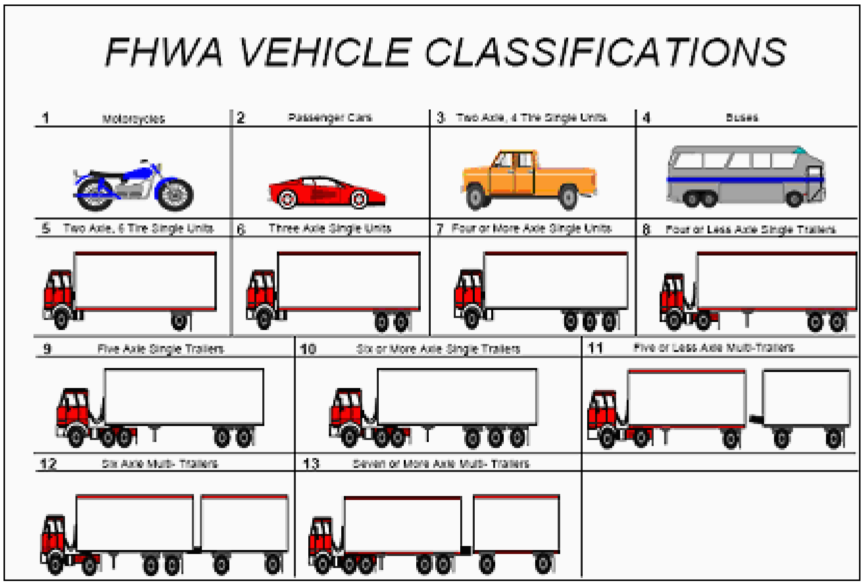

Figure 4 FHWA Vehicle Classifications

Figure 5 shows the daily traffic flows from each traffic analysis zone (TAZ), categorized by movement/vehicle type. In this figure, the size of each pie is the daily flow, the colors are the movement/vehicle types, and the line thicknesses correspond to flows on the links.

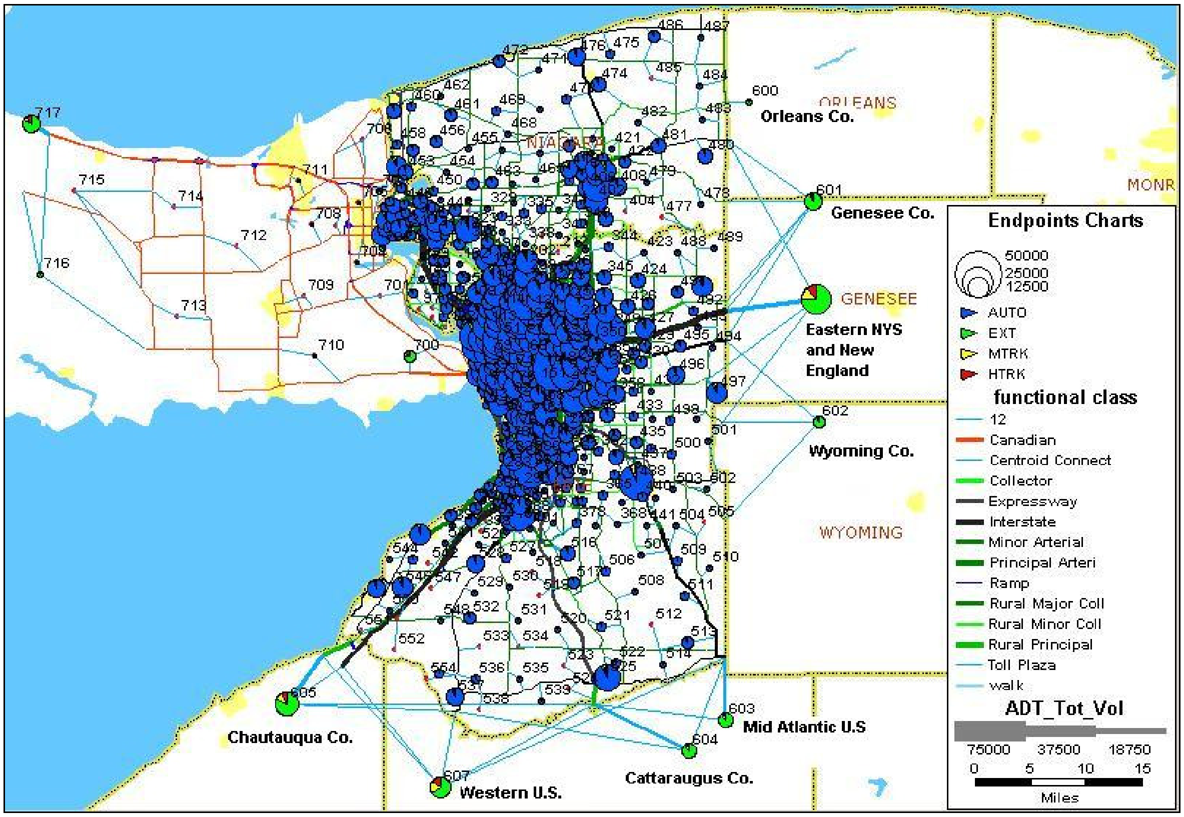

Figure 5 GBNRTC Model: Current Flow from each TAZ

In addition to the internal and external TAZs, Figure 5 also shows the adjacent counties in New York State.

Figure 6 shows the modeled flows of heavy trucks from each TAZ, categorized by destination type. Not surprisingly, the external movements become more prominent. For example, the large pie chart near the right edge of Figure 6 (located in Genesee County and representing flow from eastern New York and New England) represents a total daily inbound volume of approximately 2,500 heavy trucks with destinations divided as follows:

- Approximately ½ in Erie or Niagara Counties (the blue slice).
- Approximately 1/6 to points in the U.S. outside these counties (the green slice).
- Approximately 1/3 to Canada (the orange and red slices).
  - The Orange slice corresponds to Canadian TAZs near Niagara Falls.
  - The Red slice corresponds to Canadian TAZs on the edge of the region, including trips to Hamilton and Toronto.

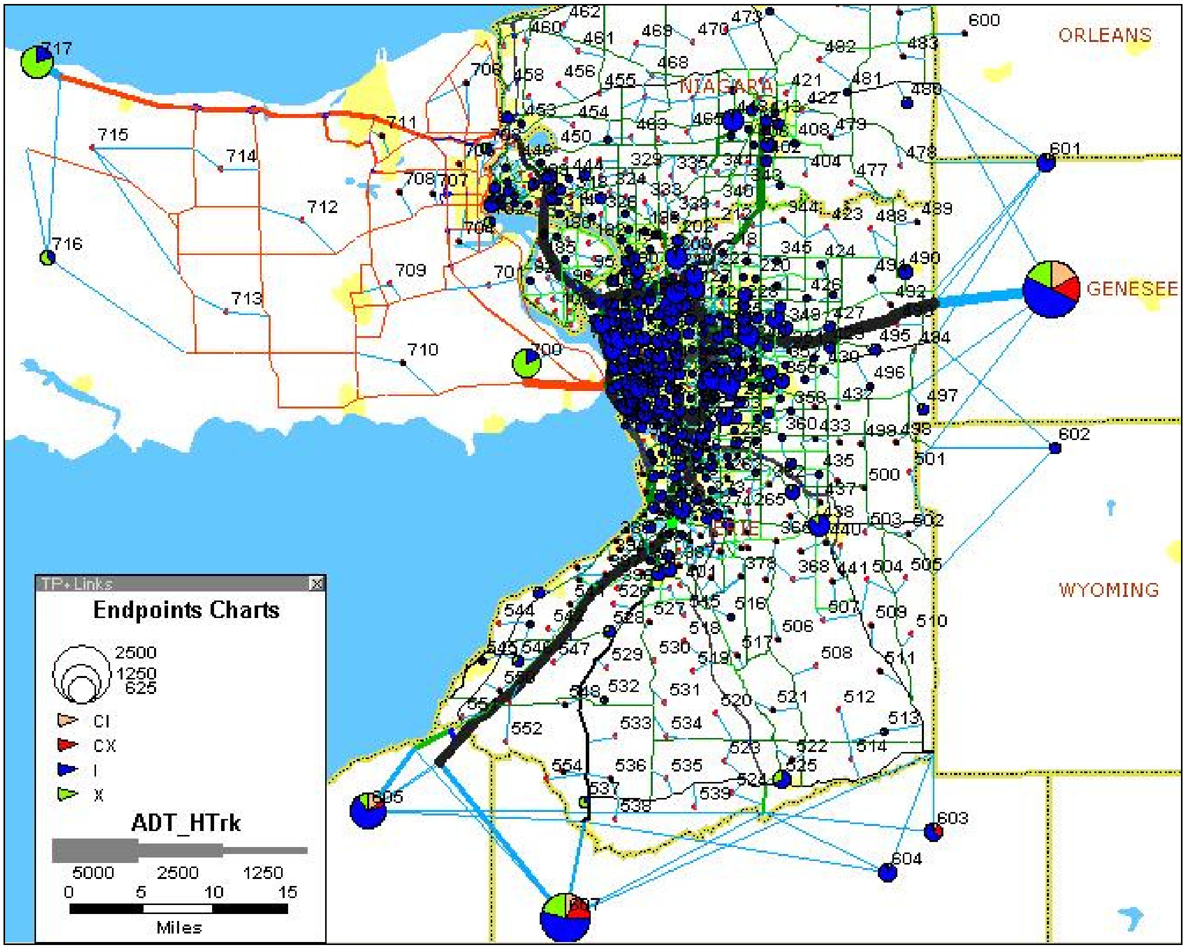

Figure 6 GBNRTC Model: Heavy Truck Flow from each TAZ

2.1 Why Use a Simulation Model?

Many areas, including the Buffalo/Niagara Falls region, face transportation planning issues that are not adequately addressed by current models. They include the impacts of operational changes (such as highway-speed tolling) on travel, and the impacts of corridor management strategies. Increased freight traffic and land use changes (such as the transit-supportive development, and development of intermodal centers) need to be considered. Finally, there is a desire to look at time-of-day information and queuing at a greater level of detail than is possible now.

To address these many issues, multiple models are needed, with varying levels-of-detail. Intersection-level models might be used to address queues, signalization changes, and the detailed impacts of land use changes. Corridor-level models might be used to address changes to a freeway. Regional models consider the entire region. A toolbox of models is needed, along with a way to easily make the transition from one level to another. The use of multiple models also addresses data availability issues, where detailed data to support a simulation might be available in one part of the region, but not in another.

Transportation improvement projects typically cost many millions of dollars, and have impacts that last for decades. Modeling is used to assess those impacts. A way to mitigate the risk that a model might produce inaccurate results is to use multiple models, preferably with different methodologies and input data needs. If the models give grossly different results, this suggests that the underlying assumptions or data need to be further investigated.

Because of the need to address multiple levels of modeling, GBNRTC uses tools such as Synchro (intersection modeling) and had begun to investigate TransModeler (the simulation add-on to TransCAD).

By integrating microsimulation and network assignment (routing), TRANSIMS offers the ability to seamlessly move between regional and detailed levels of modeling. In both microsimulation and routing, TRANSIMS has the capability to represent the movement of both vehicles and individuals on a second by second basis throughout the day. TRANSIMS can represent detail from the intersection level to the entire region. By simulating second by second behavior, the effects of operational changes, congestion and queues can be represented.

To demonstrate this capability to easily move between levels, a sub-area model was deployed in Buffalo. The router was run over the entire region. Its capabilities and data requirements were similar to those for the current planning model, but it has much more time-of-day detail. Apart from the time-of-day detail, results were similar to those from the current model.

Although the computer capability existed to run the microsimulation over the entire region, it was run in a subarea. The subarea was a 15-mile corridor along I-190 between the south Grand Island Bridge and the Lewiston-Queenston Bridge. The number of trips in the subarea was approximately 1/10 of the total regional trips. The subarea had many fewer links than the network has a whole; it was thus a manageable task to refine the network sufficiently so that the microsimulation would work well. The subarea is outlined in black in Figure 7.

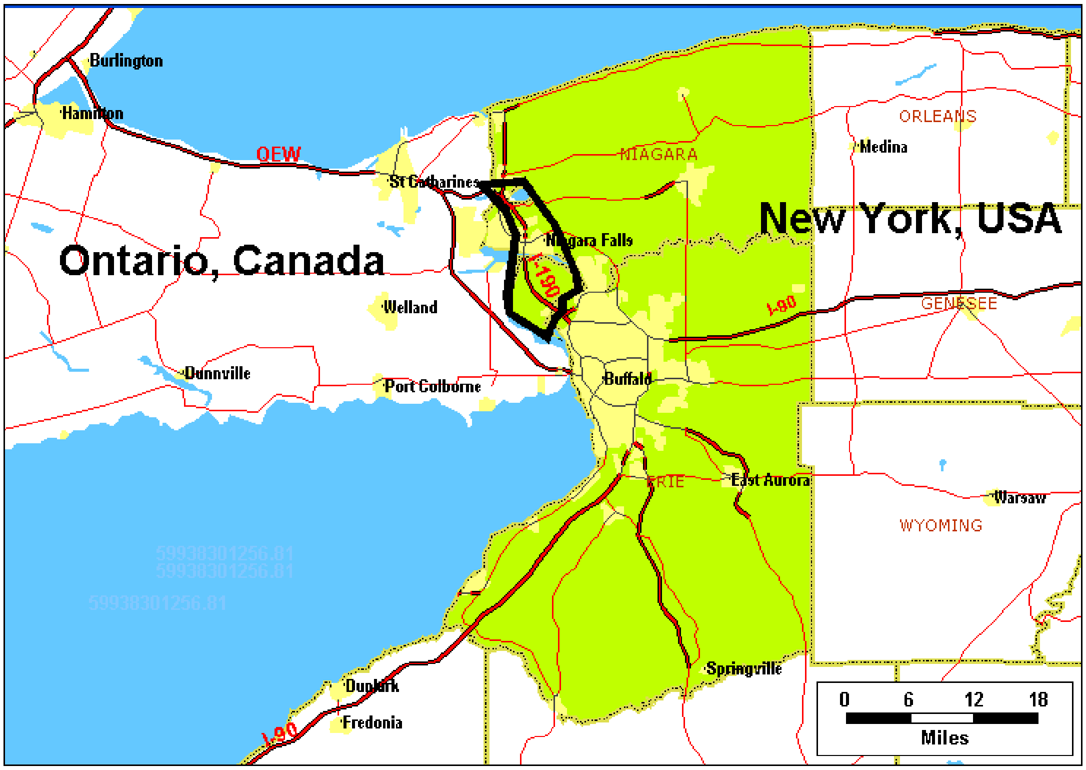

Figure 7 Buffalo-Niagara Falls Area and Subarea

Outputs of the router (Figure 8), which was run over the entire region, are similar to those from a four-step planning model, and include link flows and speeds (in meters / second). The simulator looks at individual vehicles, second-by-second. For example, Figure 9 (the area in the red rectangle in Figure 8) shows the simulated car and truck queue at the U.S. Primary Inspection station in Lewiston, New York.

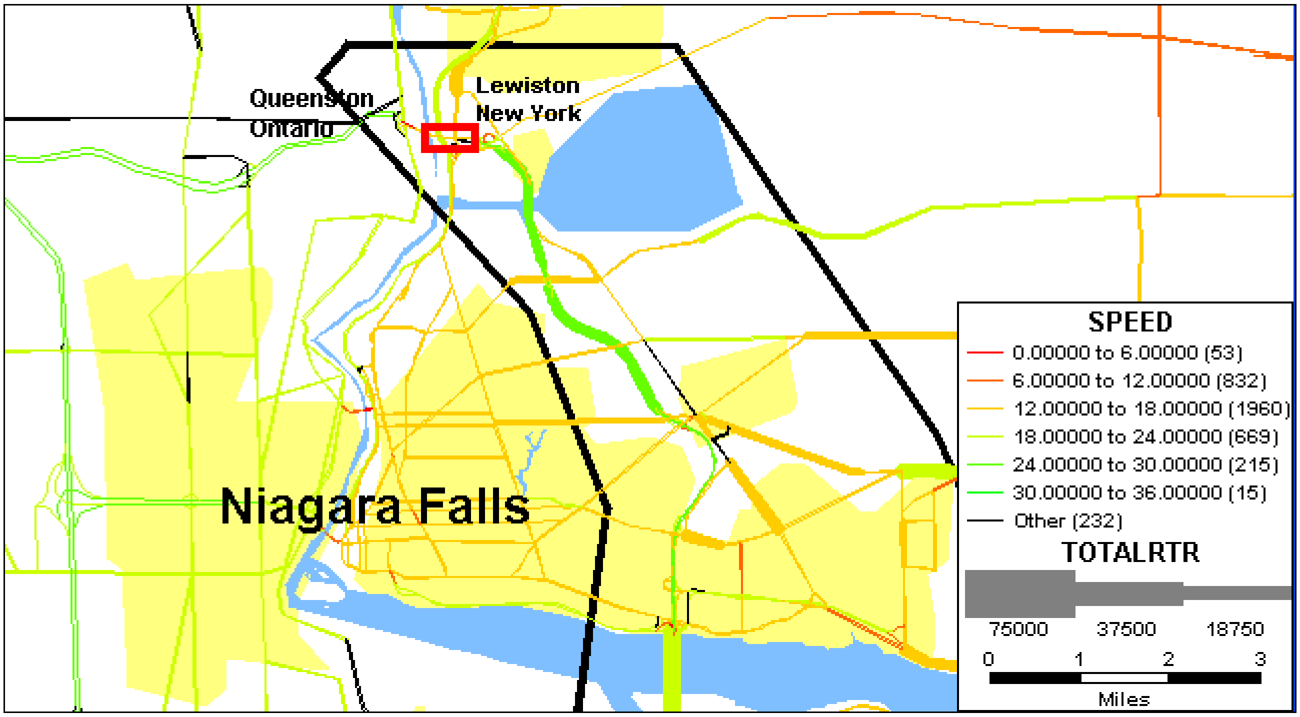

Figure 8 Link Flows and Speeds from TRANSIMS Router

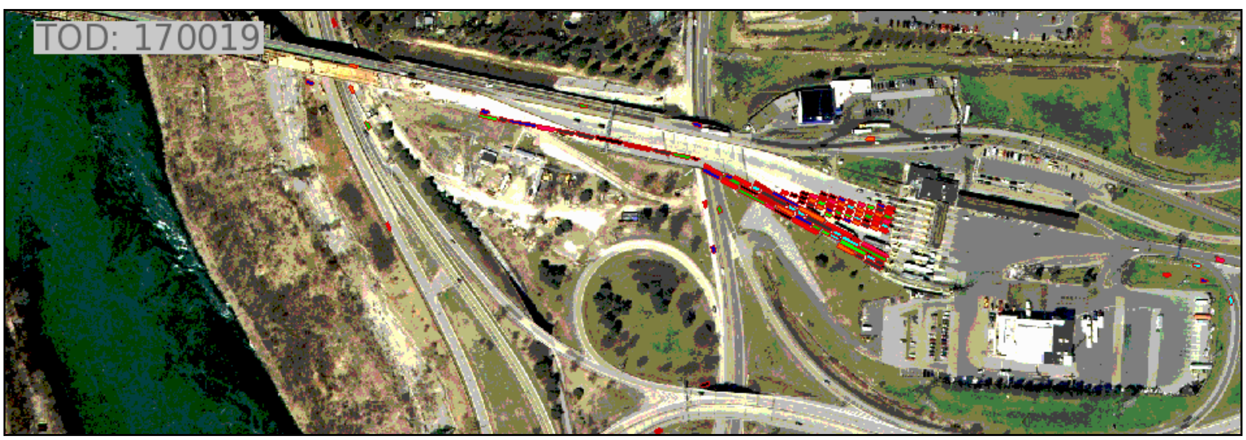

Figure 9 Vehicles from TRANSIMS Microsimulator

3 TRANSIMS Model: Development

GBNRTC currently uses a model based on TransCAD. Link descriptors in the model include the commonly-available information such as functional class, number of lanes, capacity, and speed. The node data includes intersection (node) capacities and in some cases a node classification that indicates whether a signal exists, as well as the lane configuration at the node.

As previously noted, the microsimulation process in TRANSIMS is considerably more sensitive to the fidelity of the network than the traffic assignment process of a typical four-step model. Some approximations that are used in the legacy network and produce good results in a four-step model may need to be modified for use with TRANSIMS.

Broadly speaking, the steps for building a TRANSIMS network include the following:

- Modifying portions of the legacy (TransCAD) network that appeared to need closer examination and validation to resolve issues that might adversely impact a TRANSIMS model
- Exporting the links and nodes of the legacy network into a tab-delimited text format that can be used by TRANSIMS
- Using the TRANSIMS programs TransimsNet and IntControl to generate the TRANSIMS network
- Manually editing the TRANSIMS network, with a particular emphasis on those portions of the network that will be included in the subarea microsimulation.

A trip-table based TRANSIMS implementation uses trip table, trip time and activity location files. The trip table files list the trips by origin zone and destination zone. The trip time files define how those trips are distributed by time-of-day. The activity location file associates each zone with activity locations. The steps for building TRANSIMS trip tables include the following:

- Modifying the input trip tables that came from the GBNRTC TransCAD Model
- Running a script to create TRANSIMS-format trip tables and trip times suitable for input into the TRANSIMS ConvertTrips program
- Making any needed modifications to the activity locations
- Running the TRANSIMS ConvertTrips program to convert the trip tables and trip time data into Trip, Household, Population and Vehicle files. These files contain the individual trips that are used as input to the TRANSIMS Router.

3.1 Building the Network

The TRANSIMS network was based on the links and nodes of the existing TransCAD network. It was supplemented by a traffic signal database obtained from traffic engineering personnel including NYSDOT's Region 5 Office via GBNRTC staff, so that actual traffic signal locations could be used, rather than the defaults generated by TRANSIMS. Essential link information in the GBNRTC network that was used in the conversion included

- Endpoints (nodes)
- Direction (one-way versus two-way)
- Number of lanes in each direction
- Functional class

- Free flow speed

The following modifications were made to the network. While some of these modifications were unique to a TRANSIMS model (including 3.1.1 Removal of Zone Connectors for the Internal Zones, 3.1.4 Lane Use Restrictions, 3.1.8 Lane Connectivity Adjustments), the others were the types of changes that would typically be made in refining a four-step model.

3.1.1 Removal of Zone Connectors for the Internal Zones

For internal trips in TRANSIMS, activity locations take the place of zones and zone connectors. Therefore, the nodes that represented the internal zones and the links connected to these nodes were no longer necessary and could be removed.

3.1.2 Addition of Links

Several links were added to the network to enable the separation of cars and trucks at the Lewiston-Queenston border crossing, and to allow for the separation of EZPass and non-EZPass vehicles at the south Grand Island Bridge.

3.1.3 Correction of Coding Errors

Examples of these changes include:

- Correction of functional classes (a few centroid connectors were misclassified)
- Correction of links with 0 length, 0 lanes and very low (sub 5-mph) speed limits
- Removal of walk and transit links that are not relevant to this model

3.1.4 Lane Use Restrictions

The TRANSIMS lane_use table allows particular links, or particular lanes on a link, to be restricted by vehicle_type. In this model, lane_use restrictions were used to enforce the following:

- No trucks in the left lane of certain segments of I-90 and I-190
- No trucks on the Whirlpool or Rainbow bridges
- Separate lanes for trucks and cars in the U.S. primary inspection lanes on the Lewiston-Queenston bridge
- Separate lanes for EZPass and cash/EZPass on the south Grand Island Bridge.

3.1.5 Canadian Speed Adjustments

The current model has a number of links and zones in Canada. These are used to allocate traffic among the four international bridges. In the current model, all of these links had special functional class (Canadian), with a speed of approximately 40 mph. The reality is that the links in Canada are a mix of freeway (in particular, the QEW, with freeway speeds), rural highway and urban roads (with speeds lower than 40 mph). For flow coming from the Toronto area these inaccurate speeds had the following consequences:

- Too little flow on the Peace Bridge (due to the artificially low speed on the QEW)

- Too much flow on the Rainbow Bridge (presumably because urban streets in Niagara Falls, Ontario had artificially high speeds)

To address this issue, the freeway links in Canada (QEW and Route 405) were reclassified as such, and given speeds of 100 km / hr (62 mph or 27.8 m/s). Furthermore, the Rainbow and Whirlpool bridges were given artificially high tolls, discussed in the next section.

3.1.6 Toll Adjustments

The current model has no border delay going to or from Canada. As a result, it might route some U.S. domestic trips via Canada, although such a routing would be unrealistic. To address this issue, artificial tolls were added to all of the border crossings as follows[3]. Tolls are expressed in seconds of travel time and were applied in both directions:

Table 1 Toll Adjustments: International Bridges

Bridge	Toll	Comment
Lewiston-Queenston	900 seconds	One of the two truck crossings
Whirlpool	1200 seconds	No trucks; NEXUS only[4]
Rainbow	1050 seconds	No trucks
Peace	900 seconds	Trucks are permitted

3.1.7 Speed and Capacity Adjustments

One arterial link outside of the subarea (Union Road, near Walden Street) had far too much flow. Its capacity was adjusted downward, from 1600 to 1200 vehicles/ hour.

Several ramp capacities were adjusted upwards. These are primarily high speed ramps connecting freeways:

Several speed adjustments were made to links in the subarea, based on NYSDOT observed speed data, or in one case (Mountain Road) on the posted speed. Free flow speeds were adjusted to match observed 85^{th} percentile speeds.

3.1.8 Lane Connectivity Adjustments

Performance of the microsimulator is sensitive to lane connectivity and pocket lanes, particularly in areas where multiple turn lanes are used to increase intersection capacity. Pocket lanes and lane connectivity were modified for approximately 10 links in the subarea to improve microsimulation

[3] The actual cash toll, collected in the westbound direction, is $3 US for the Peace Bridge and $3.25 US for the other bridges (in 2009). The "toll" in the TRANSIMS model is intended to represent the border crossing delay and the slower speeds on the Canadian approaches to the Whirlpool and Rainbow bridges.
[4] NEXUS is a joint United States / Canada program to allow pre-screened travelers expedited processing when crossing the U.S. / Canada border.

performance. In general, we found that lane connectivity needs to be scrutinized at intersections where multiple turn lanes exist.

A number of changes were also made to activity locations. They are discussed later, in section 3.2.6.

3.2 TRANSIMS Model: Demand

The origin-destination matrices used in the current GBNRTC model include 16 sub-matrices, based on time-of-day and movement/vehicle type. Four time periods were used:

- AM Peak (AM): 7 – 10 AM
- Mid Day (MD): 10 AM – 3 PM
- PM Peak (PM): 3 – 6 PM
- Night (NT): 6 PM – 7 AM

In addition, four movement/vehicle types were used in the GBNRTC model:

- Automobile / Bus – Internal Trips
- Automobile / Bus – External Trips
- Medium Truck - Internal and External Trips
- Heavy Truck - Internal and External Trips

The Internal and External Automobile / Bus tables were merged into one table so that three classifications, based on vehicle type, were used instead of four. Each sub-matrix contains approximately 300,000 lines; each line corresponds to a zone pair.

A number of changes were made to the trip table, trip time and activity location files:

- Assignment of EZPass and non-EZPass trips
- Conversion of the Origin-Destination (O-D) flows in the trip tables from real numbers to integers
- Removal of intrazonal trips from the input trip tables
- Adjustments to certain Canadian trips
- Modifications to the diurnal trip time distribution
- Modifications to the associations of activity locations with zones

The remainder of this section discusses these changes.

3.2.1 EZPass / non-EZPass Trips

EZPass is a toll tag system widely used in the northeastern United States, including the New York State Thruway and the Peace Bridge. One scenario that was tested as part of this TRANSIMS effort was the impact of various lane configurations (EZPass versus cash) at the toll plaza on the South Grand Island Bridge. To accurately represent EZPass usage at this location, actual EZPass usage data was obtained from the New York State Thruway. Trips were split into EZPass and non-EZPass trips, and then routed via the appropriate links at the toll plaza.

3.2.2 Conversion of O-D Flows to Integers

Each of the approximately 300,000 zone pairs represents flow for a single vehicle type (auto, truck, heavy truck) and a single time period (AM, PM, MD, NT). The flow for each zone pair is usually less than 0.5 vehicles during a time period, and is supplied as a non-integer value in TransCAD. TRANSIMS, however, expects integer values in the trip tables. In a situation such as this, simple rounding of the flow values will create significant bias, because the vast majority of values will be rounded to zero. Therefore, a randomized rounding scheme was employed. It used the following formula for each origin-destination pair in the trip table: I = INT (A + R), where

- I is the integer value used by TRANSIMS
- A is the actual (non-integer) value from TransCAD
- R is a random number between 0 and 1.
- INT is a function that rounds down to the nearest integer

This procedure produces two desirable outcomes:

- An integer value that is adjacent to the actual non-integer value. For example, if the value in the trip table is 23.14, the rounding procedure will produce a value of either 23 or 24.
- An unbiased result, where the sum of the integer flows is approximately equal to the sum of the non-integer flows.

3.2.3 Removal of Intrazonal Trips

In TRANSIMS, the intrazonal trips traverse links on the network because they start and end at activity locations as opposed to zone centroids. In early model runs, this resulted in network link loadings that were substantially higher than either the actual counts or those in the TransCAD model. In an effort to produce more realistic results, the intrazonal trips were consequently removed. This reduced the total number of daily trips from approximately 3.7 million to 3.3 million. It should be noted that in the current GBNRTC model, these trips never entered the network. Physically, the intrazonal trips may be viewed as those short trips that stay primarily on local streets, with little use of the links in the modeled network.

3.2.4 Adjustments to Canadian Trips

The purpose of the Canadian links and zones is to allocate cross-border traffic correctly among the four international bridges. Since intra-Canadian trips are not part of this model, it was not necessary to match link flows to observed flows on Canadian roads. Most of the cross-border traffic comes from the Hamilton/Toronto area traveling on a freeway (the Queen Elizabeth Way, or QEW) that had a modeled speed far lower than its actual speed. To ensure adequate flow on the Peace Bridge, a zone near the Peace Bridge at Fort Erie had been given an artificially high volume in the GBNRTC model, especially for truck trips.

Since we had corrected the speed on the QEW (section 3.1.5), we also had to correct the flows. For trucks, this correction was based on data from the 1999 Canadian Roadside Survey of truckers, a survey that provided detailed Canadian origin information for trucks crossing the border.

Based on this survey information, some international trips where shifted away from the external zone near the Peace Bridge to the external zone that represents trips coming from Hamilton and Toronto. This, along with the toll adjustments discussed earlier in section 3.1.6, produced more reasonable traffic volumes on the bridges.

3.2.5 Trip Time Distribution

The current four-step model uses four time periods for the day. If trips were uniformly distributed within each of the four time periods, it would result in a plot of trips by time-of-day and vehicle type shown in Figure 10.

For the TRANSIMS model, an hourly time of day distribution was created based on traffic counts, and used to refine the time of day for movements within each of the 4 time periods used in the GBNRTC model. This distribution is based on the approximately 90 traffic counts that were used in model calibration. Taken together, these locations produced the time of day distribution depicted in Figure 11**.**

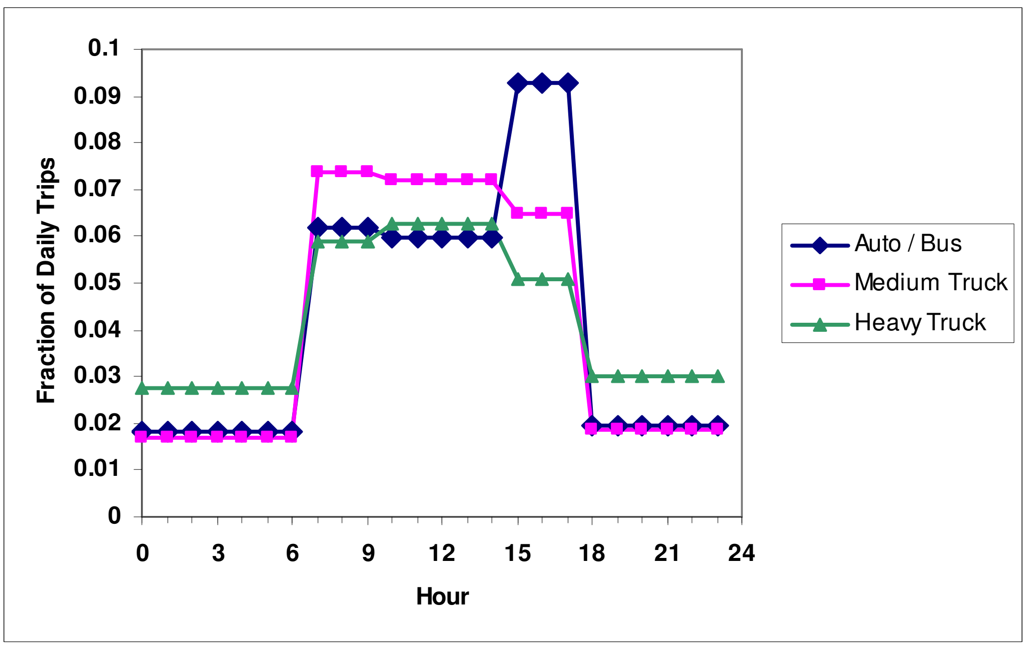

Figure 10 GBNRTC Trip Table Time-of-Day Distribution

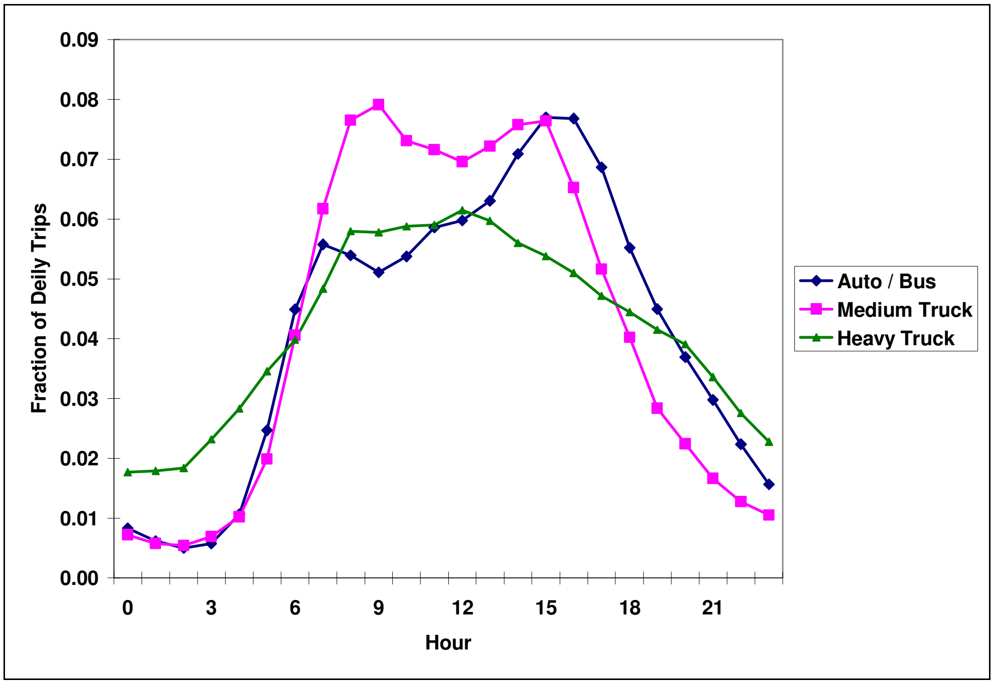

Figure 11 Time of Day Distribution based on Traffic Counts

For the TRANSIMS trip table, hourly time of day factors were established to produce a time of day distribution closer to that observed in the hourly traffic count distributions as shown in Figure 11. In a few cases, it was necessary to move trips out of their originally intended time period, so that the traffic flows produced by the hourly volume distribution from the trip tables would better match the observed traffic count data. For example, some of the AM period auto and truck trips were moved to the 6 – 7 AM slot. Some of the PM auto trips were moved to the 6 – 7 PM slot.

After the TRANSIMS model was run, hourly flows for all vehicles and for heavy trucks were compared to the hourly classification data for some 90 links. Figure 12 shows the distribution by hour for the sum of the available counts versus TRANSIMS results on the same links.

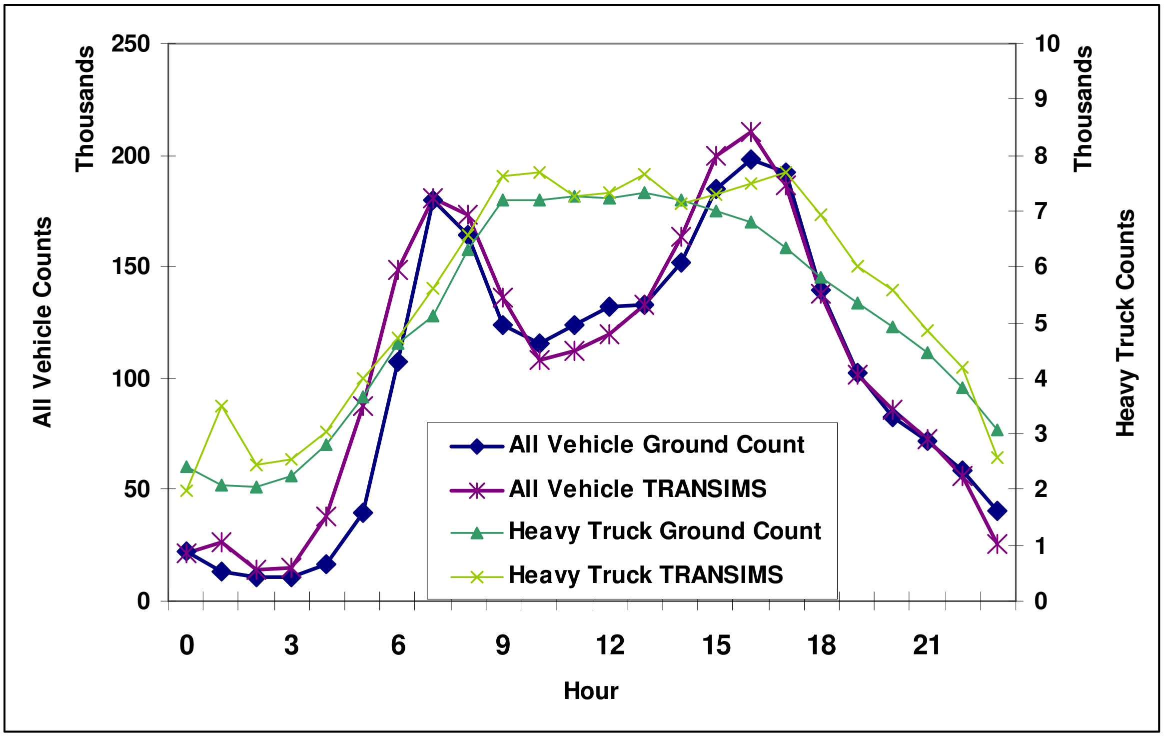

Figure 12 TRANSIMS vs. Counts By Hour

3.2.6 Activity Location Adjustments

When the TRANSIMS network is generated, activity locations are generated on each side of a link. Although activity locations are not normally generated by TRANSIMS for freeways, ramps, and zone connectors, they are generated for other types of links, such as arterials, collectors and local streets. Pairs of activity locations are generated, with one location on each side of the link. Activity locations are also generated near each **external** zone. Each activity location is associated with a zone, and since a zone typically includes many activity locations, they permit the creation of a very fine grained zone system based on activity location. Figure 13 illustrates a few zones and activity locations for a small portion (approximately 3 miles by 2 miles) of the network. The activity locations are red dots, and are created along non-freeway links. The numbers in Figure 13 are zone numbers.

By default, each activity location can automatically be assigned to either the nearest zone centroid, or to the zone that it is physically located in. In a few cases, a zone had no activity locations associated with it, and it was necessary to manually assign at least one activity location to that zone. For example (Figure 13), zone 209 originally had no activity locations associated with it, because the link on the western edge of zone 209 was actually in zone 124. Therefore, all of the activity locations along that link were originally assigned to zone 124. To correct this, one pair of the activity locations on that link was manually changed to be associated with zone 209, as is shown in the location circled in blue in Figure 13.

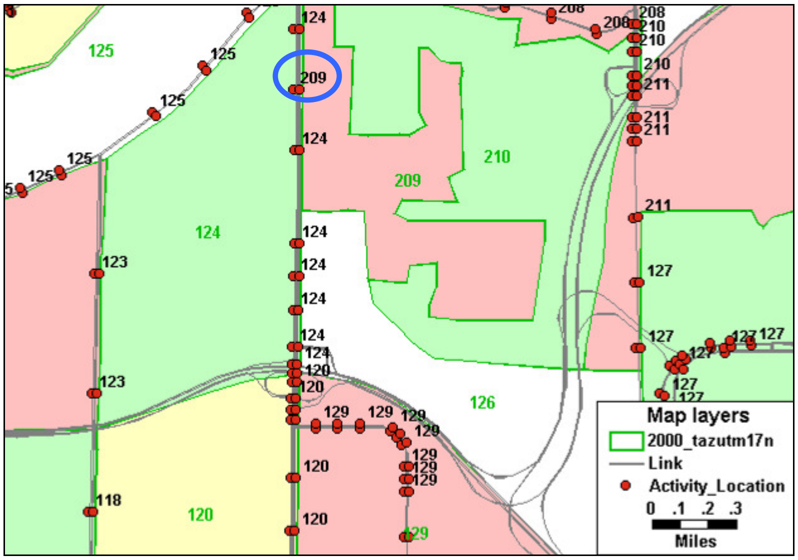

Figure 13 Activity Locations

3.3 Running the TRANSIMS Model

Once the network and trip tables have been assembled, the next step is to run the TRANSIMS model. There are three phases to this effort:

- **Router stabilization**-the router is run on subsets of the trips to produce reasonable Volume-to-Capacity (V/C) ratios across the network. It provides the initial estimates of traffic flow for the microsimulator, but is not the final step.
- **Microsimulator stabilization**-both the router and the microsimulator are run in order to produce a stable set of trips
- **User equilibrium**-both the router and the microsimulator are run to adjust trips to reach a true user equilibrium where no user can improve travel times by changing routes

In this implementation, router stabilization was performed over 10 iterations, microsimulator stabilization over 5 iterations, and user equilibrium over 10 iterations. The entire process (25 iterations) requires about 6 hours on a high-end personal computer (Dell Optiplex 755 with Core 2 Duo processor and 2 GB of RAM).

3.4 Technical Lessons Learned

First, it is possible to set up a usable TRANSIMS model using existing link attribute and traffic volume data that is typically available for a four-step model. This is because although TRANSIMS can use much more data, particularly in the microsimulator, it also provides reasonable defaults, thus reducing the number of manual adjustments required during the conversion process from a four-step model environment to a simulation regime.

Typical issues encountered in going from a four-step model to TRANSIMS include the following:

- TRANSIMS is more sensitive to time-of-day information in the trip tables.
- Some four-step models have advanced features that would need to be addressed in the microsimulator, rather than the router. The TRANSIMS router is a fairly simple shortest path model that uses congested travel times on each link. It relies on a number of runs to produce a reasonable user equilibrium.
- The TRANSIMS microsimulator is much more sensitive to network fidelity (signals, stop/yield signs, lane configurations, etc.) than a four-step model. Therefore, even in cases where the simulator can run over the entire network, it may be best to start with a subarea network so that any network refinement effort can be quickly performed on a small area. This enables a faster demonstration that the process of converting from a four-step model to TRANSIMS produces valid results.

4 Calibration and Validation

Since this study focused on truck movements, calibration was primarily based on a comparison with hourly vehicle classification counts. 92 traffic count stations produced hourly counts; of these, 82 had vehicle classification counts. Count dates were primarily in the fall of 2006 and 2007. Due to tolling considerations at play within the region, it was agreed early in the project that the calibration target would be October 2006. This was a period where Buffalo MPO staff felt confident that the network was in a "stable" condition regarding travel demand. The following types of traffic volume data were gathered:

- **Toll**: These are toll-based counts from the four international bridges (Lewiston-Queenston, Whirlpool, Rainbow and Peace). They provide limited classification data for the westbound (tolled) direction on the international bridges.
- **Traffic Monitoring**: These are vehicle classification counts based on axle counts and supplied by NYSDOT and GBNRTC compliant with FHWA's Traffic Monitoring Guidelines (TMG).
- **Length**: These are vehicle classification counts employing vehicle length measurements received from the New York State Thruway Traffic Data System.[5]
- **Non-Classified**: These are non-classification counts that provide volumes by hour of day.

Figures 14 through 16 show the locations of the links containing count stations that furnished hourly data. Most of these locations also provided classification data.

Two screenlines were established using these count stations. The first, called CANADA, comprises the four international bridges. The second, called EAST, approximates the domestic border of the subarea where westbound traffic approaches the I-190 corridor on Grand Island or Niagara Falls. The color coding on Figures 14 through 16 is as follows:

- **Red:** stations that are part of the CANADA screenline
- **Purple:** stations that are part of the EAST screenline
- **Green:** all other stations

Some of the links on the EAST screenline did not have classification counts that distinguished heavy trucks from other vehicle types. Therefore, the reported truck volumes on those screenlines exclude those links. Affected links include 5024 and 5046 (both with low to moderate traffic volumes).

[5] Lengths up to 25 feet are considered to be auto, 25.1 to 50 feet medium truck, and over 50 feet heavy truck.

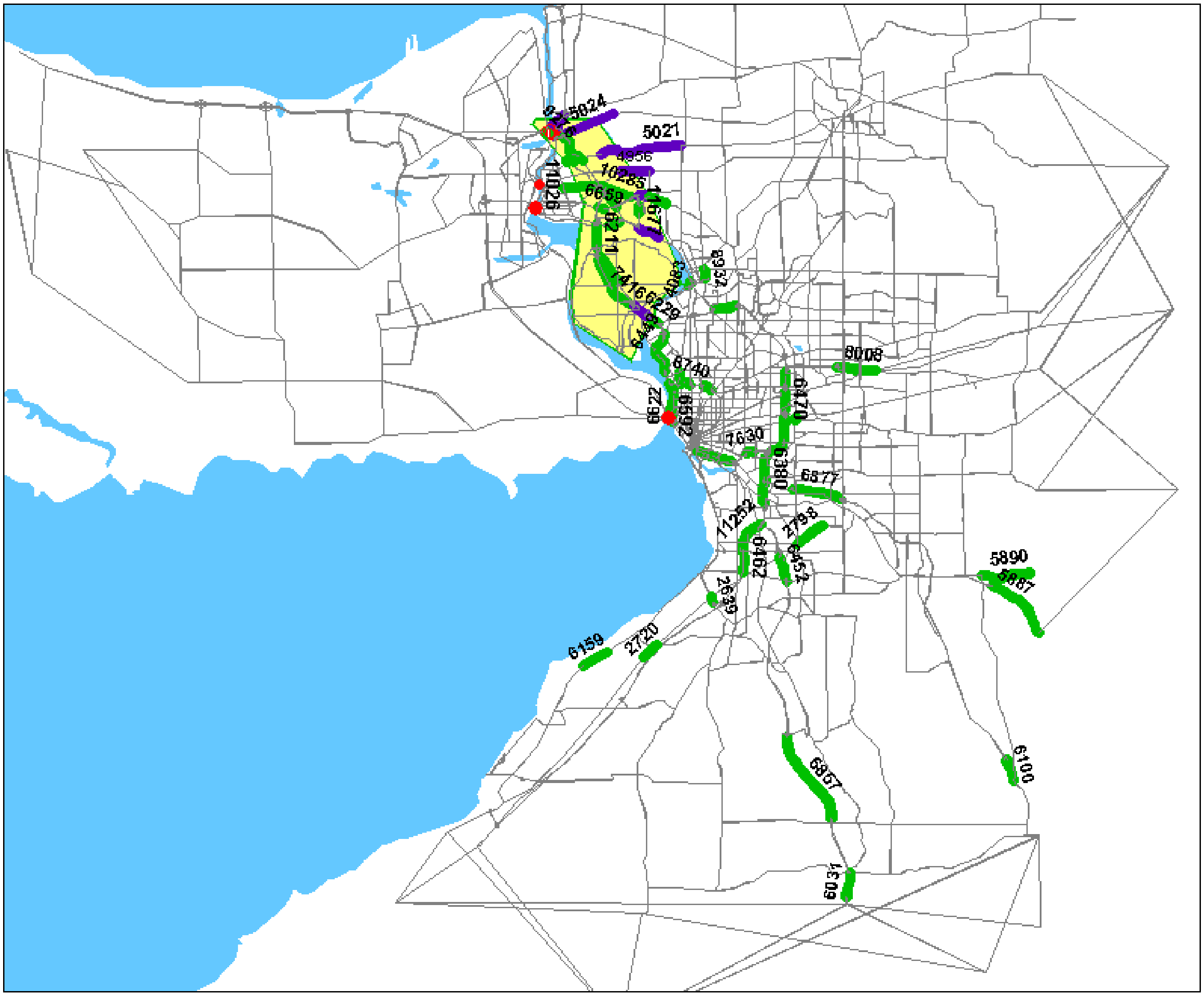

Figure 14 Calibration Locations: Entire Region

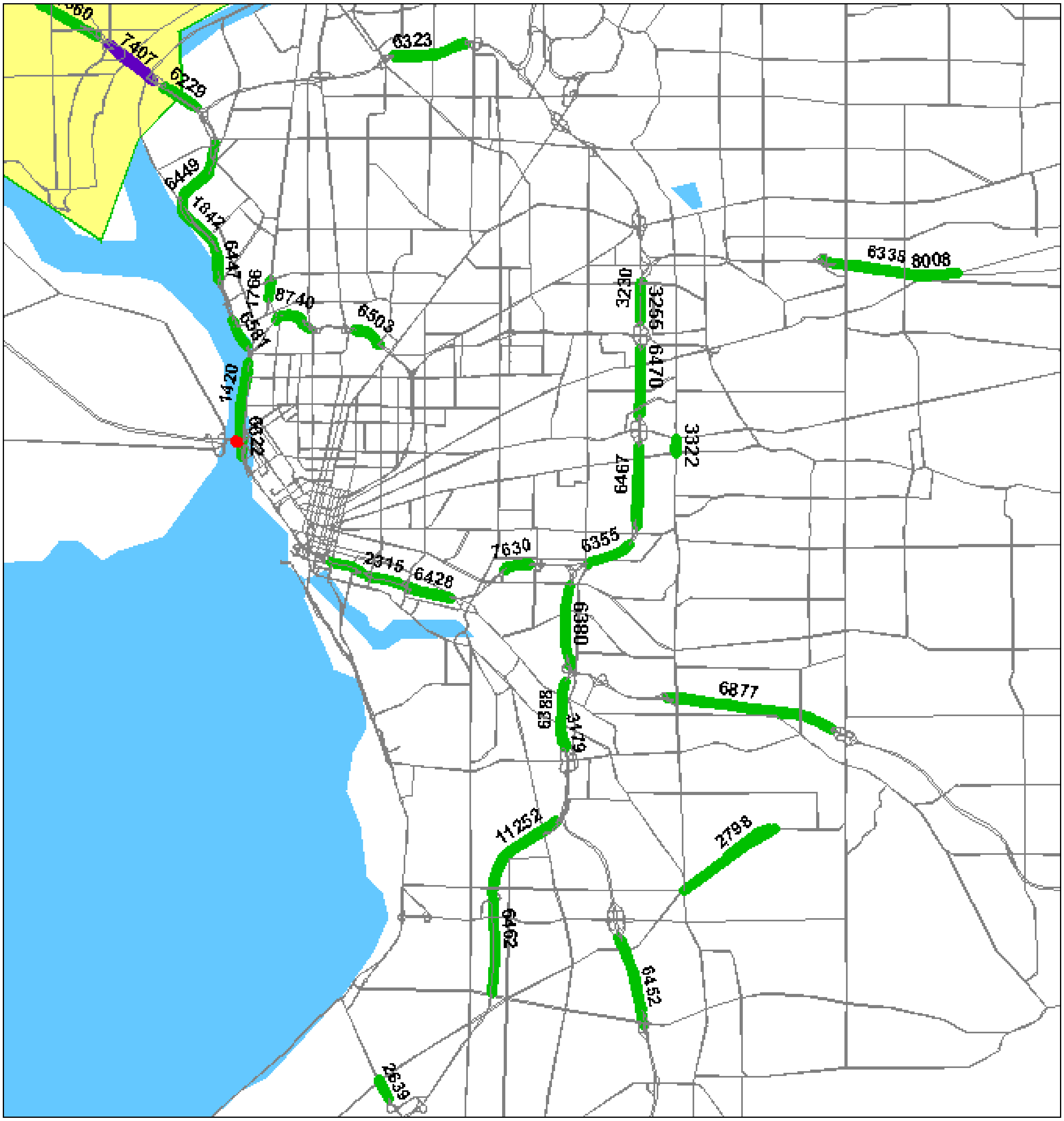

Figure 15 Calibration Locations: Buffalo

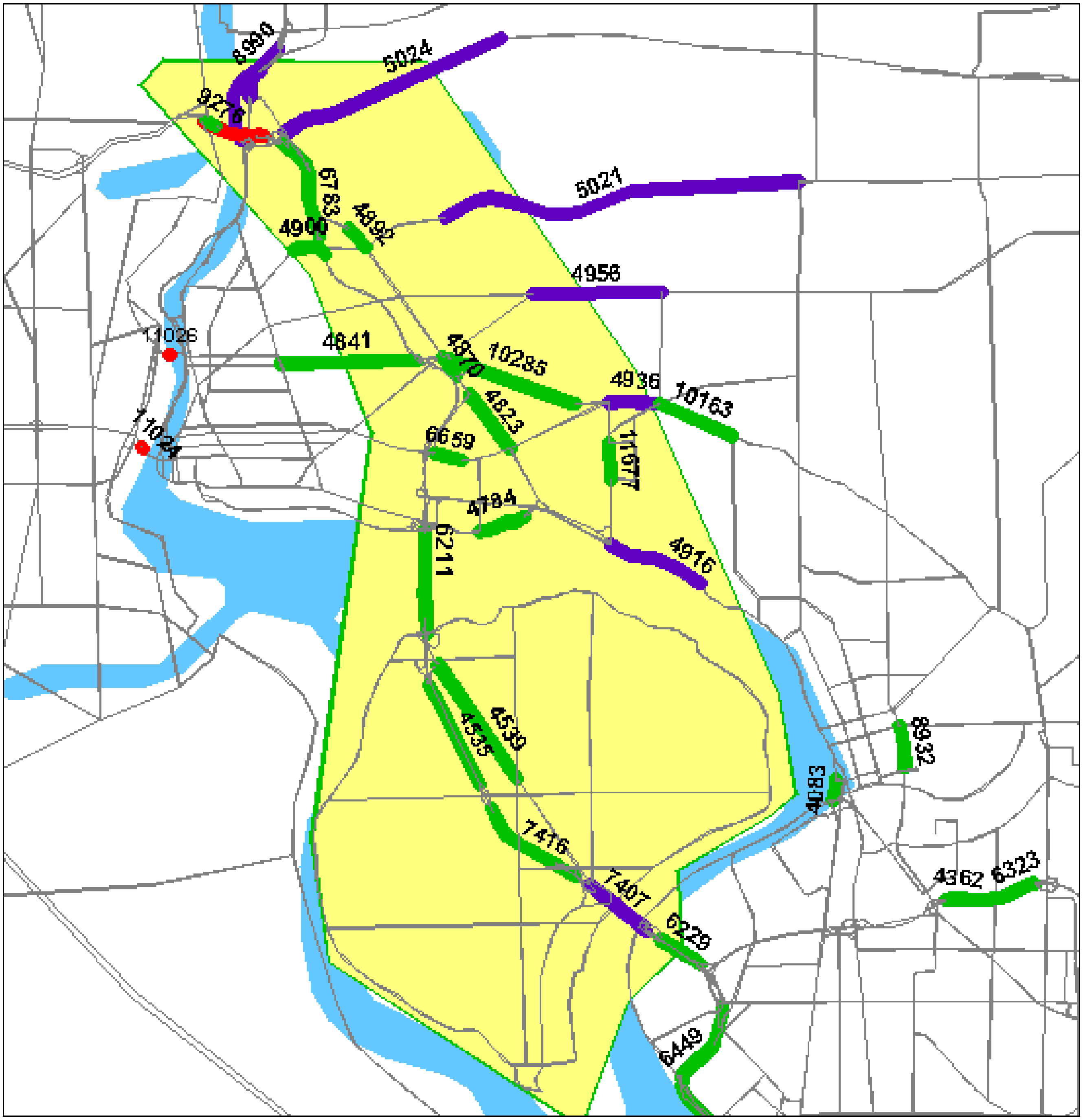

Figure 16 Calibration Locations: Subarea

Summary measures were calculated for the entire region and for those counts located on links that were either partially or entirely within the subarea. Summary measures were calculated for the following time periods: all day, the three-hour morning and evening peak periods (7-10:00 AM and 3-6:00 PM, respectively), and the hourly peak periods. Both overall counts and heavy truck counts were compared. Figure 17 shows the daily comparison between counts and modeled flows for both GBNRTC and TRANSIMS models.

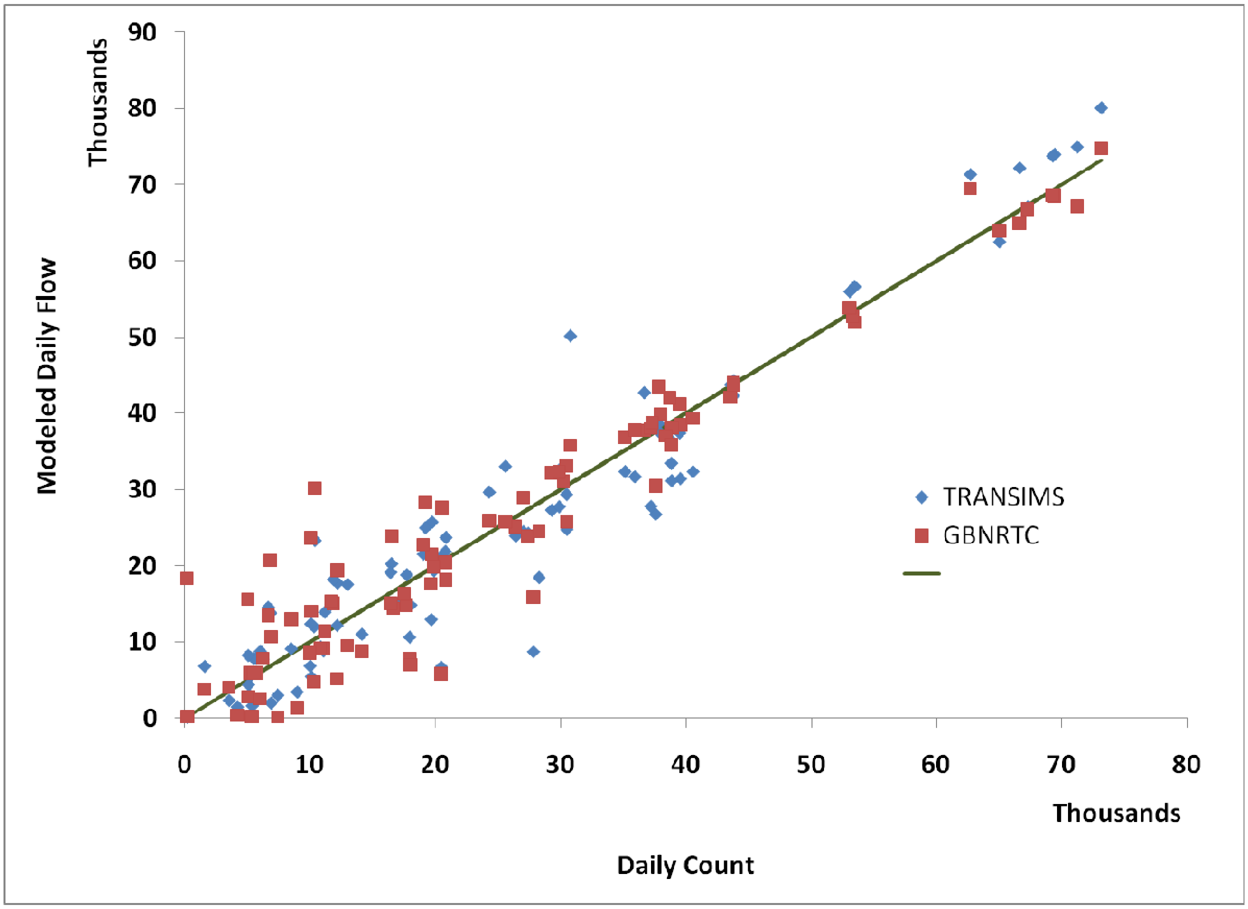

Figure 17 Daily Counts vs. Modeled Daily Flow

Tables 2 and 3 show the root mean square errors (RMSE)[6]. RMSE is a commonly used measure for model validation. It measures the difference between modeled count and the actual ground-truth count. Lower values indicate that the modeled counts are closer to the actual counts. The daily and three-hour flows are bi-directional flows while the peak-hour flows are uni-directional flows. Therefore, the number of links for the peak-hour flows is somewhat higher than those for the other modeled time periods. In these tables, actual counts are shaded in blue, TRANSIMS results are in yellow, and GBNRTC current model results are in green.

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[6] RMSE: 100 x √[(∑(Modeled Count)^2 / (NumLink – 1))] / (∑Count / NumLink)

Table 2 TRANSIMS Model Results (5/7/09) – All Vehicles

Area	Period	Number of Links	Sum of Flows			RMSE	
			Counts	TRANSIMS	GBNRTC	TRANSIMS	GBNRTC
Entire Region	7-10 AM	91	470266	457835	415996	17.31	23.14
	3-6 PM	91	580059	578506	621407	22.25	27.57
	Daily	92	2414287	2544603	2348708	20.19	20.72
	8-9 AM	119	164225	159591	176256	23.16	30.26
	5-6 PM	119	192142	204726	185303	29.50	22.08
Subarea	7-10 AM	34	101281	103512	101281	19.30	29.42
	3-6 PM	34	144128	123626	141462	22.78	38.14
	Daily	34	598076	565203	529908	20.32	31.54
	8-9 AM	50	34180	35568	37675	25.82	56.73
	5-6 PM	50	46757	42136	40973	23.23	29.13
CANADA Screenline	7-10 AM	5	3866	4202	4213	24.66	20.17
	3-6 PM	5	6573	7906	12474	74.31	164.60
	Daily	5	31275	36564	40013	32.45	59.13
	8-9 AM	6	1359	1337	1099	41.49	54.60
	5-6 PM	6	2171	3023	2791	96.79	56.79
EAST Screenline	7-10 AM	9	30197	30398	30692	20.96	29.14
	3-6 PM	9	40012	37805	42066	21.10	30.10
	Daily	9	165622	167389	159033	19.83	23.94
	8-9 AM	15	10193	10670	11438	27.84	62.23
	5-6 PM	15	13108	13439	12575	28.27	22.41

Table 3 TRANSIMS Model Results (5/7/09) – Heavy Trucks

Area	Period	Number of Links	Sum of Flows			RMSE	
			Counts	TRANSIMS	GBNRTC	TRANSIMS	GBNRTC
Entire Region	7-10 AM	83	19134	20144	28099	46.64	88.25
	3-6 PM	83	20828	20525	28971	50.04	102.27
	Daily	83	125946	128252	162559	54.63	81.90
	8-9 AM	106	6458	7114		53.97	
	5-6 PM	106	6537	7125		61.50	
Subarea	7-10 AM	28	3578	5168	8289	74.15	196.95
	3-6 PM	28	3895	4196	11035	58.33	267.95
	Daily	28	24297	30854	52690	59.60	171.21
	8-9 AM	39	1172	1920		94.96	
	5-6 PM	39	1222	1533		86.38	
CANADA Screenline	7-10 AM	3	742	560	924	57.08	52.36
	3-6 PM	3	1017	783	1905	38.83	116.67
	Daily	3	6104	4224	7107	52.61	44.61
	8-9 AM	4	259	194		69.18	
	5-6 PM	4	335	339		56.31	
EAST Screenline	7-10 AM	7	656	1133	1720	117.90	291.86
	3-6 PM	7	633	1009	2040	100.36	405.35
	Daily	7	3943	7022	10679	123.77	289.80
	8-9 AM	11	220	441		152.72	
	5-6 PM	11	191	373		156.11	

In terms of root mean square error, these results show slightly better results for TRANSIMS for all traffic, and usually much better results for heavy trucks. The reasons for this are not obvious but may include the following:

- Initial work on the network led to a number of refinements, particularly in the number of lanes and capacities at major freeway interchanges.
- Adjustments to the portions of the network that involve international traffic led to more realistic cross-border flows (trip table changes, Canadian highway speeds, border crossing penalties).
- Time of day is modeled at a greater level of detail than in the GBNRTC model.
- A number of additional refinements to the network were made in the subarea, particularly in lane connectivity at major intersections. The microsimulator was able to consider these refinements, limiting flow through these intersections and associated links to reasonable values.

5 Scenario Testing

Following the completion of the technical work constructing the TRANSIMS modeling tool, calibration of the flow conditions produced by TRANSIMS with the base traffic volume information and validating the simulated travel patterns and link characteristics used in the model, application of the TRANSIMS Model was ready. Early in the project, it was agreed that two scenarios would be modeled in order to demonstrate the benefits of adding TRANSIMS to the Buffalo MPO's suite of travel demand modeling tools. These scenarios are presented in this section. The first deals with all-electronic toll collection on the south Grand Island Bridge. The second deals with incrementally increasing regional truck travel demand including international cross-border truck traffic volumes.

5.1 Toll Plaza at the South Grand Island Bridge

One area of particular interest for the sub-area model was the South Grand Island Bridge, which is the primary entry point to the project's subarea accommodating travel from the south. It is circled in blue in Figure 18 . The north and southbound sides of the bridge comprise two of the count stations on the East screenline.

In this section, we present both baseline performance (with the friction on the link caused by toll plaza transactions) and the results of one scenario (removal of this friction producing a "free-flow" travel pattern for traffic accessing the northbound leg of the South Grand Island Bridge).

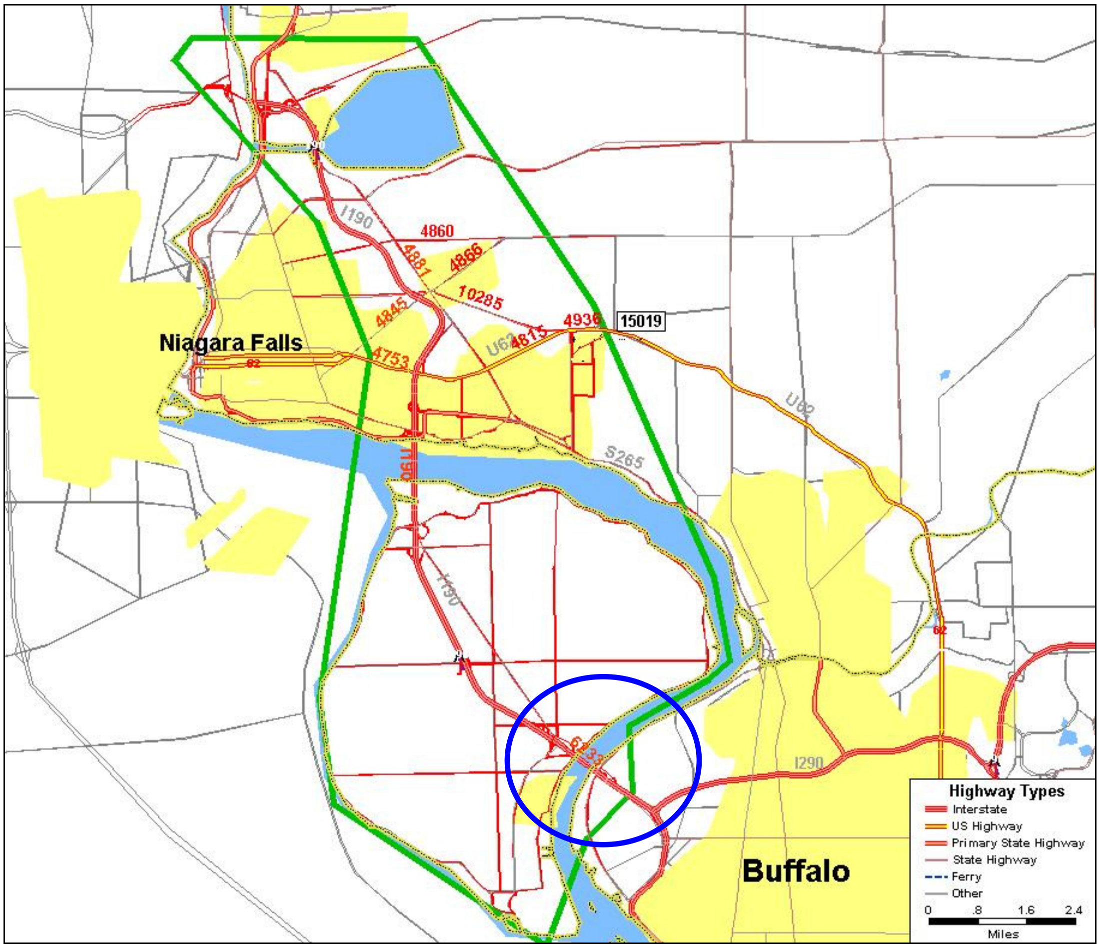

Figure 18 Subarea with South Grand Island Bridge

There are two bridges, one for each direction of traffic. Each bridge has two lanes and a fairly steep 5% grade. There is a toll plaza for northbound traffic only on the south side of the bridge. The area experiences frequent peak hour congestion (Figure 19). This picture was taken at approximately 5 PM on Tuesday 10/3/2006.

Figure 20 shows the nodes and links for the bridge approach. The inset shows the detail of the toll plaza, while the red dot represents the approximate camera location for the picture in Figure 19.

Figure 19 Grand Island Bridge Toll Plaza, facing northwest

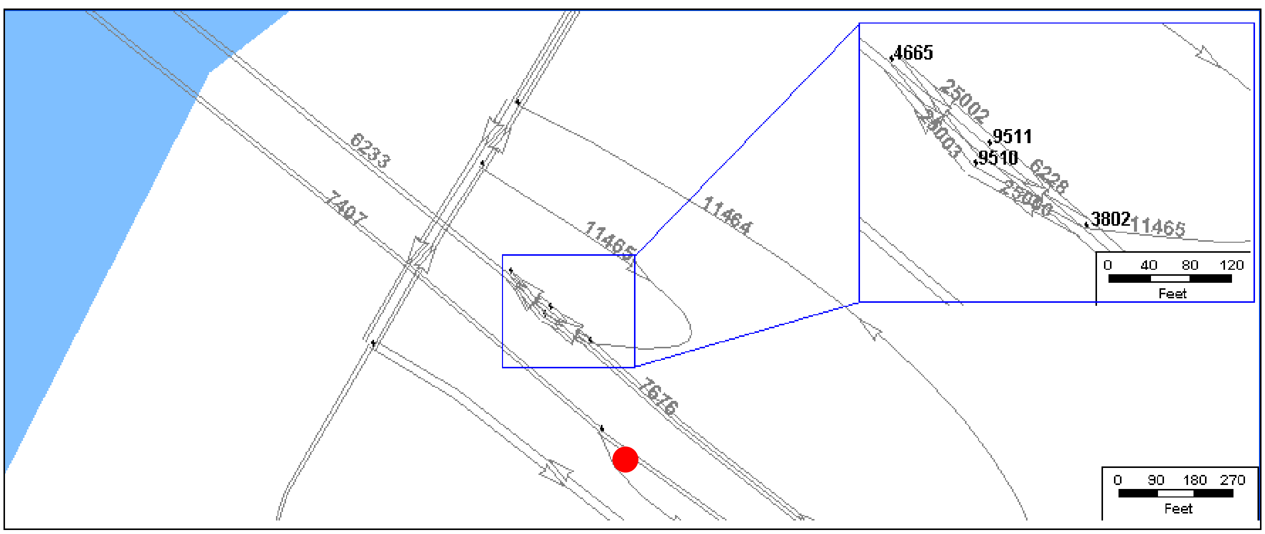

Figure 20 Nodes and Links at the Bridge Approach

Three lanes on the I-190 mainline (link 7676) approach the toll plaza. Shortly before the plaza, link 11465 merges into the right lane of I-190. The current layout of the toll plaza is as follows. Lane numbering follows the TRANSIMS left-to-right convention, which is opposite to what is posted on the toll booths (Figure 19):

- Left-most lane 1: EZPass only
- Lane 2: EZPass only (in Figure 19 this was EZPass or cash; it has since changed)
- Lanes 3 – 5: EZPass or cash
- Right-most lane 6: EZPass only.

Since both the cash and EZPass lanes currently require traffic to either slow down drastically (5 mph posted speed) or stop, an all-or-nothing model was created. In the baseline, there was a 6-second delay for all traffic at the toll plaza. This produced queues similar to what are currently observed, particularly during the evening peak period. The scenario had no delay, to mimic near-highway speed tolling.

Given the importance of this link to thru trips, impacts of the scenario on traffic flows were far reaching (Figure 21). As expected, there was an increase in traffic on the bridge, as well as on I-190 on Grand Island (red and orange links in Figure 21 and Figure 22). There were decreases in traffic on alternate routes including Porter Road/Niagara Falls Boulevard, River Road, and even as far as the Peace Bridge (green and purple links in Figure 21 and Figure 22). Some cross border trips shifted from using the Peace Bridge, to using the Grand Island bridge and the Lewiston-Queenston Bridge.

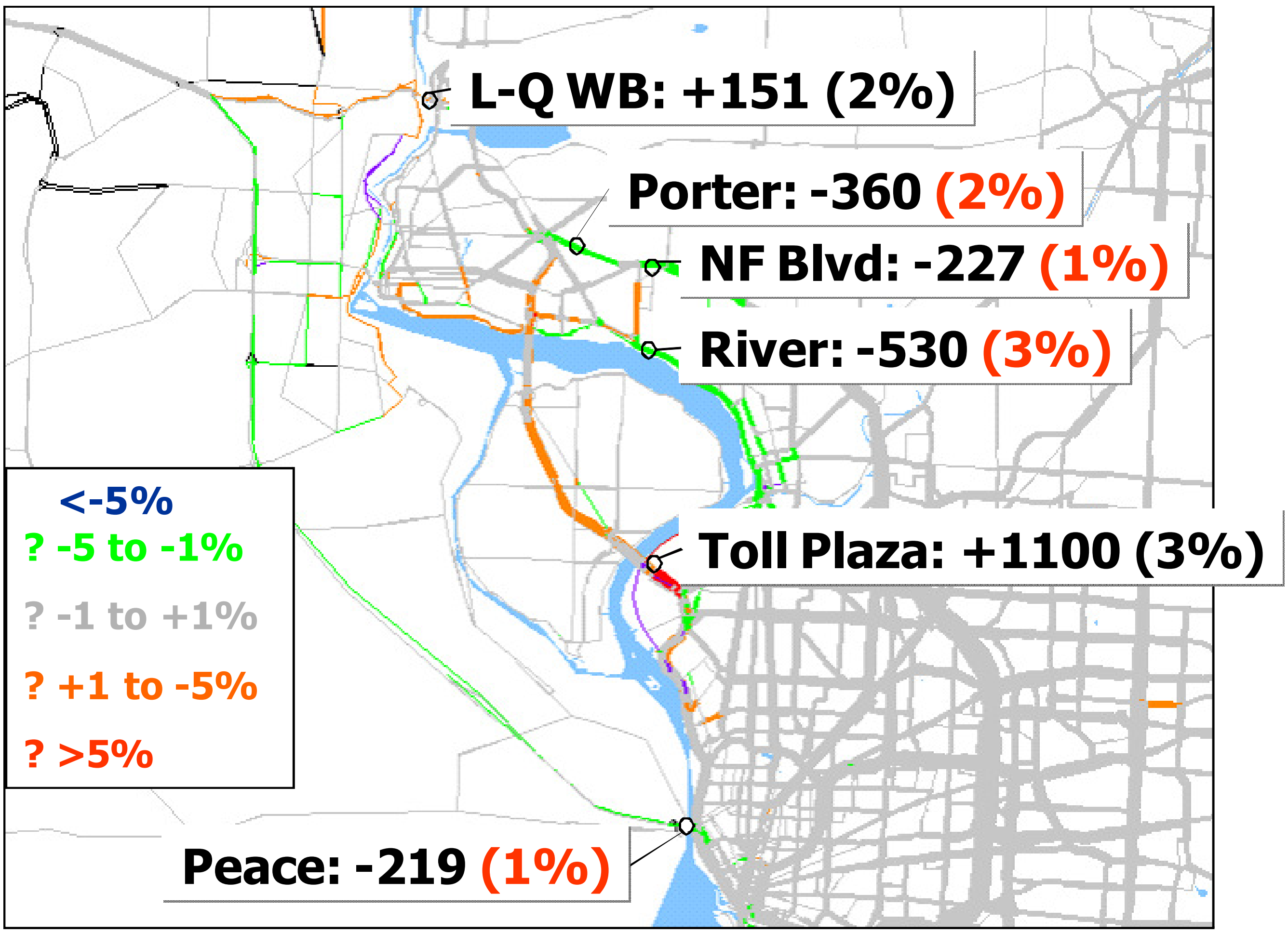

Figure 21 Grand Island Bridge Scenario: Changes in Daily Flows

There were also a number of local impacts. Figure 22 shows the changes in flows in the area immediately surrounding the toll plaza. Flows on I-190 northbound increased, as expected. Flows on some of the local streets (the purple lines) decreased. We believe this is because the current congestion on the approach to the toll plaza makes the immediate upstream exit from I-190 less attractive to those motorists who wish to access local streets. Motorists use other upstream exits and travel on local roads to access the local uses near the toll plaza. With the reduction in congestion at the plaza, the exit at the plaza becomes more attractive, and there is less need to use local roads to reach this area.

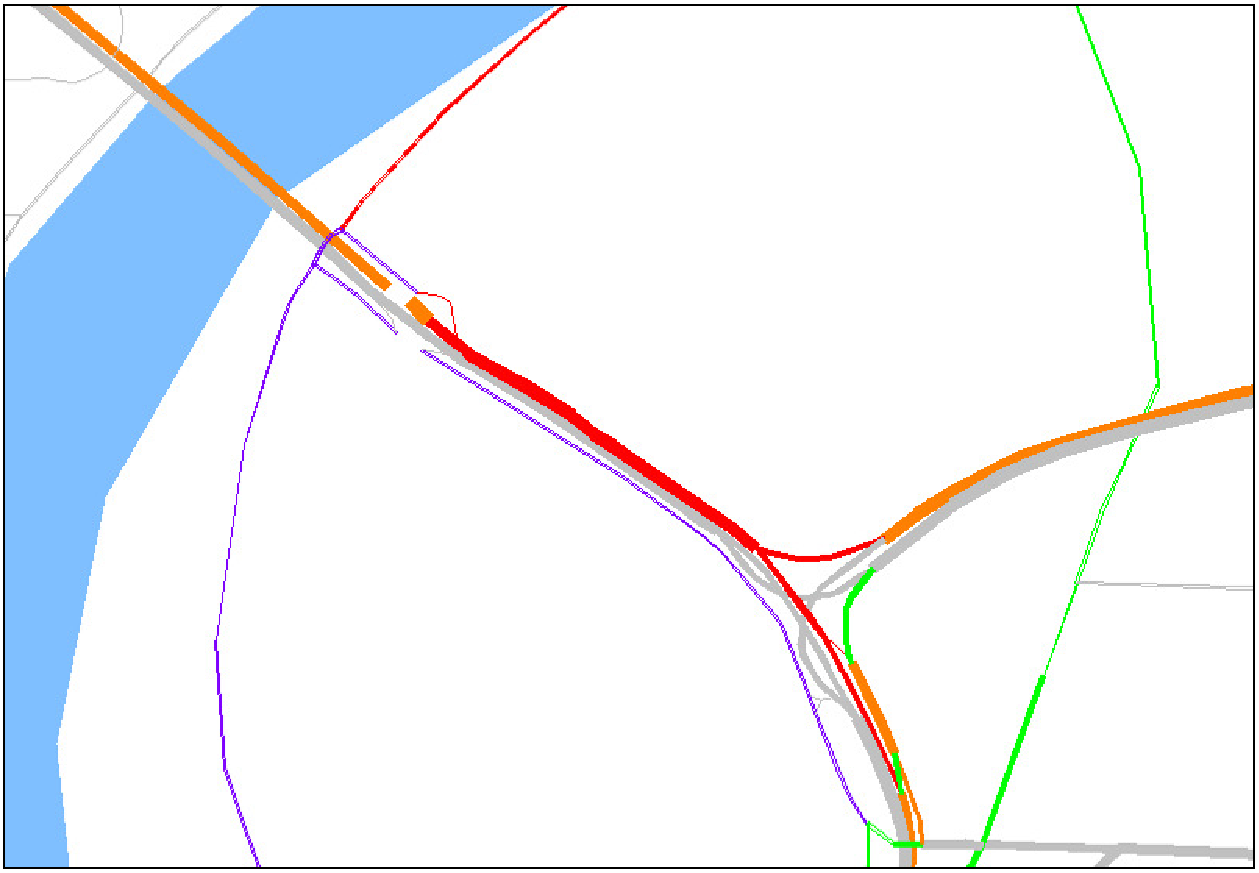

Figure 22 Impacts on Roads Near the Toll Plaza

The next four figures show the time-of-day impacts of these changes. Figure 23 shows the flow approaching the toll plaza as a function of time-of-day. Under current conditions (the delay line) this appears to be constrained to be no more than approximately 800 vehicles / 15 minutes. Given the assumptions of the model (6 lanes, with 6 seconds of delay per vehicle per lane), the absolute maximum flow, assuming that all lanes are efficiently used and there is no added car-following delay, would be 900 vehicles / 15 minutes (1 vehicle each second). Therefore, the practical maximum of 800 vehicles / 15 minutes appears reasonable.

Under the no-stop scenario, this flow is not constrained by the toll plaza, and can be higher than 800 vehicles / 15 minutes.

At other times of day, there is little congestion, even with the stop for the toll, hence little change in flow. Figure 24 shows the speed at the toll plaza as a function of time-of-day.

Figure 25 shows the flow on an alternate route (River Road), and illustrates the shift in flow away from this road during the evening peak period. On this section of the River Road, flows were not at capacity, so there was little change in speed (Figure 26).

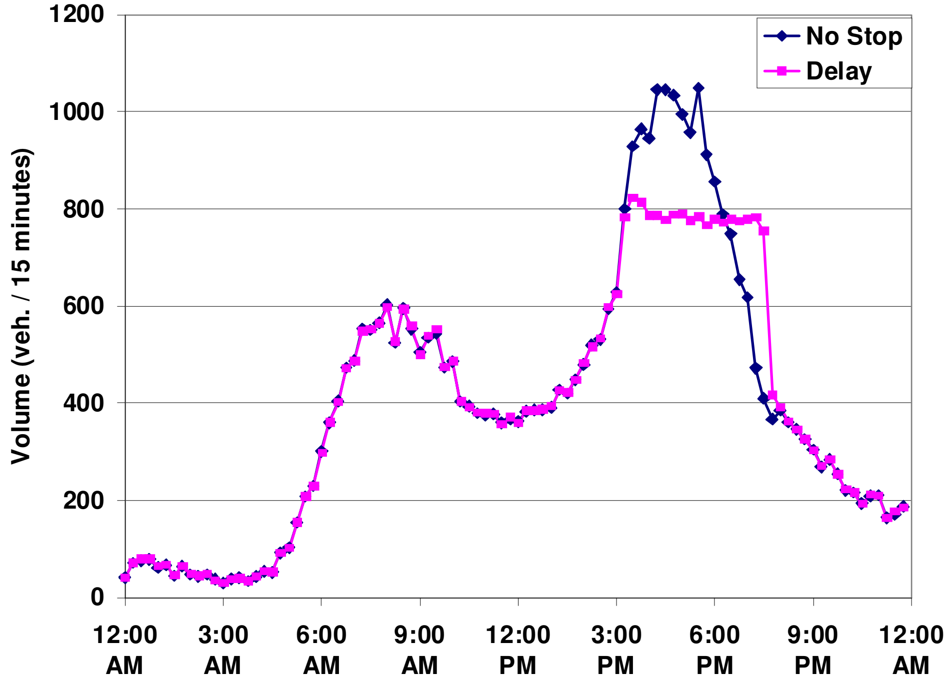

Figure 23 Flow at Toll Plaza

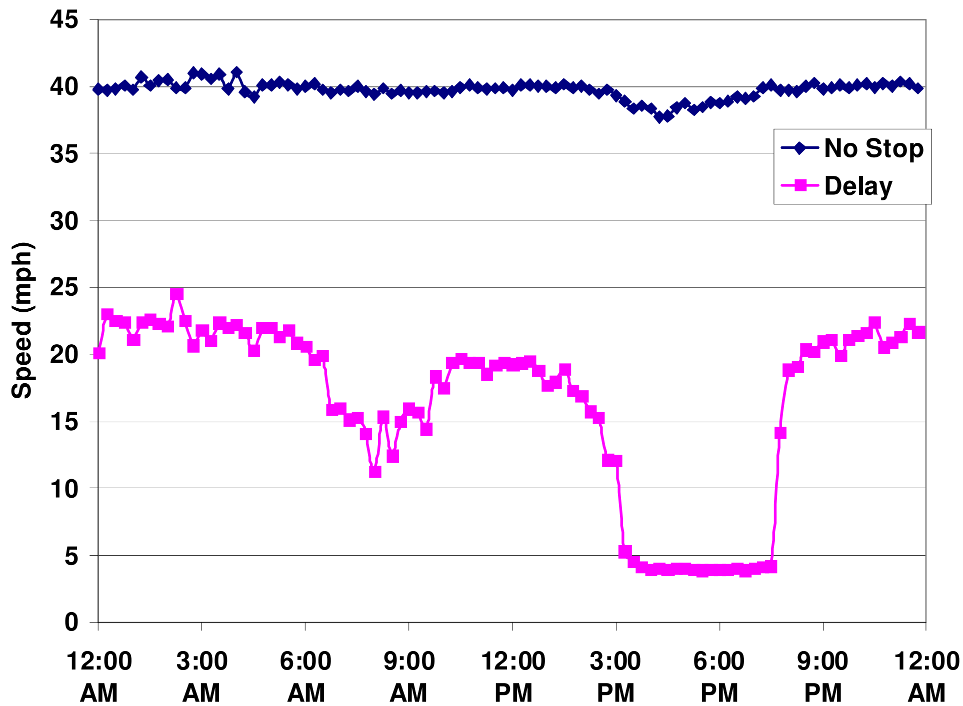

Figure 24 Speed at Toll Plaza

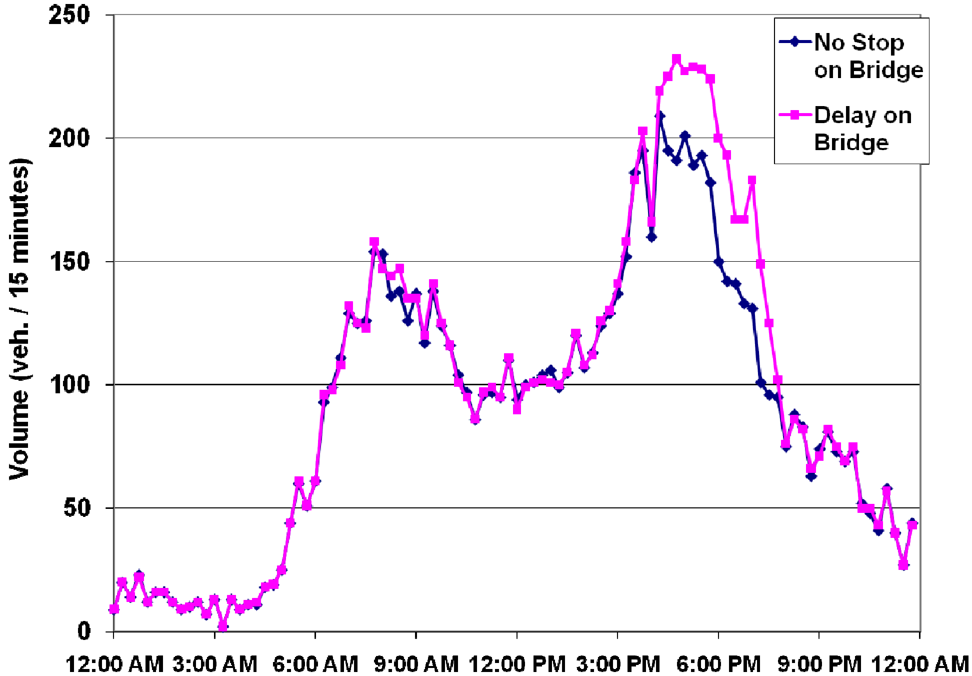

Figure 25 Flow on Alternate Route (River Road Westbound)

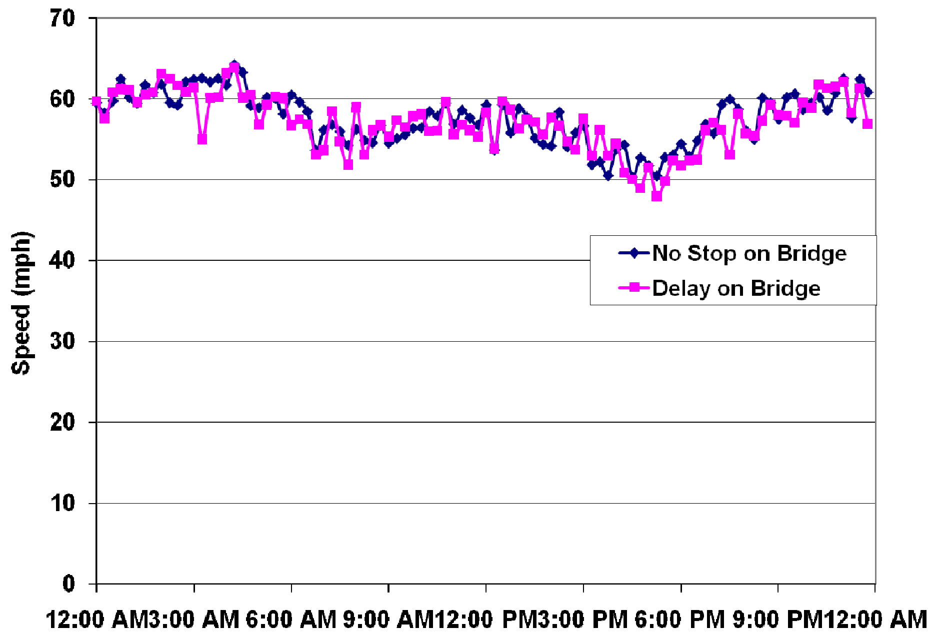

Figure 26 Speed on Alternate Route (River Road Westbound)

5.2 Increased Truck Traffic

This scenario was to investigate the impact of an additional 3400 daily long haul trucks across US/Canadian border. These were external movements, traveling between the Toronto/Hamilton area to I-90 either east or west (Figure 27).

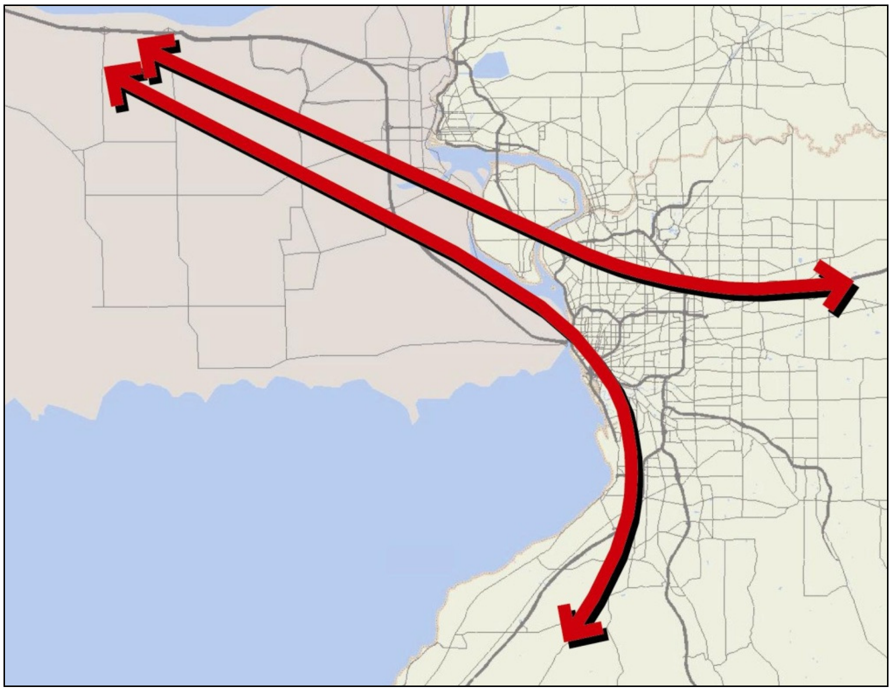

Figure 27 Increased Truck Traffic Scenario

Figure 28 shows the baseline heavy truck flows on the network, and Figure 29 shows the changes in truck flows after the scenario was run. In Figure 29, the red and orange lines represent increases, while the blue and green lines represent decreases. The thickness of each line is proportional to the magnitude of the increase or decrease.

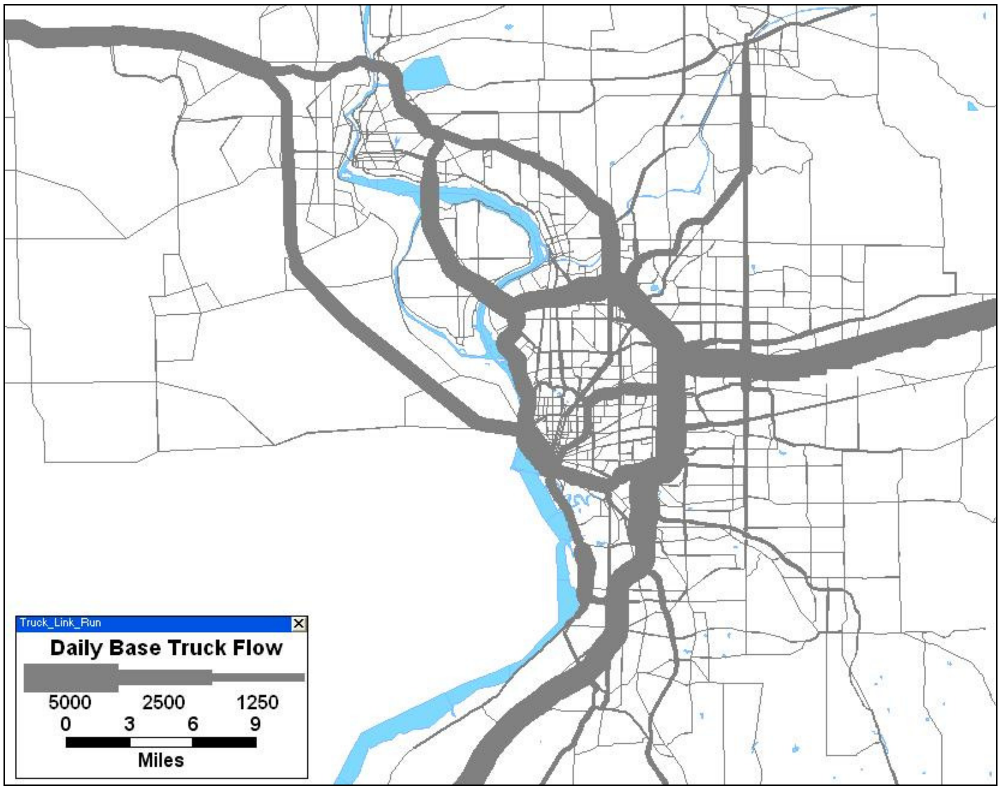

Figure 28 Baseline Truck Flow

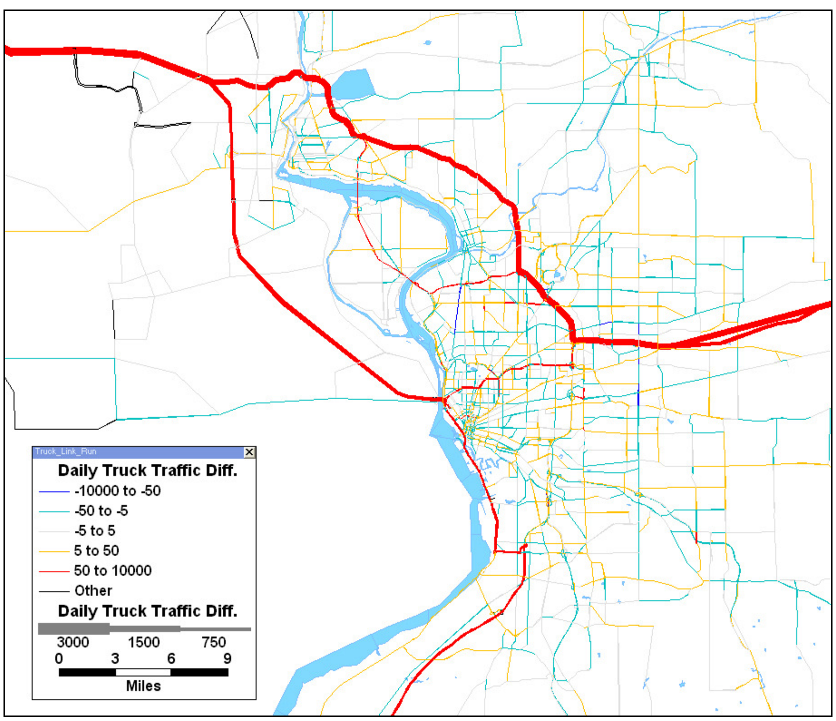

Figure 29 Change in Truck Flow

Interestingly, some significant changes in automobile flows also occurred. They were particularly prominent along Route 62 (the thick blue line on Figure 30), and were the reverse of the truck flow changes.

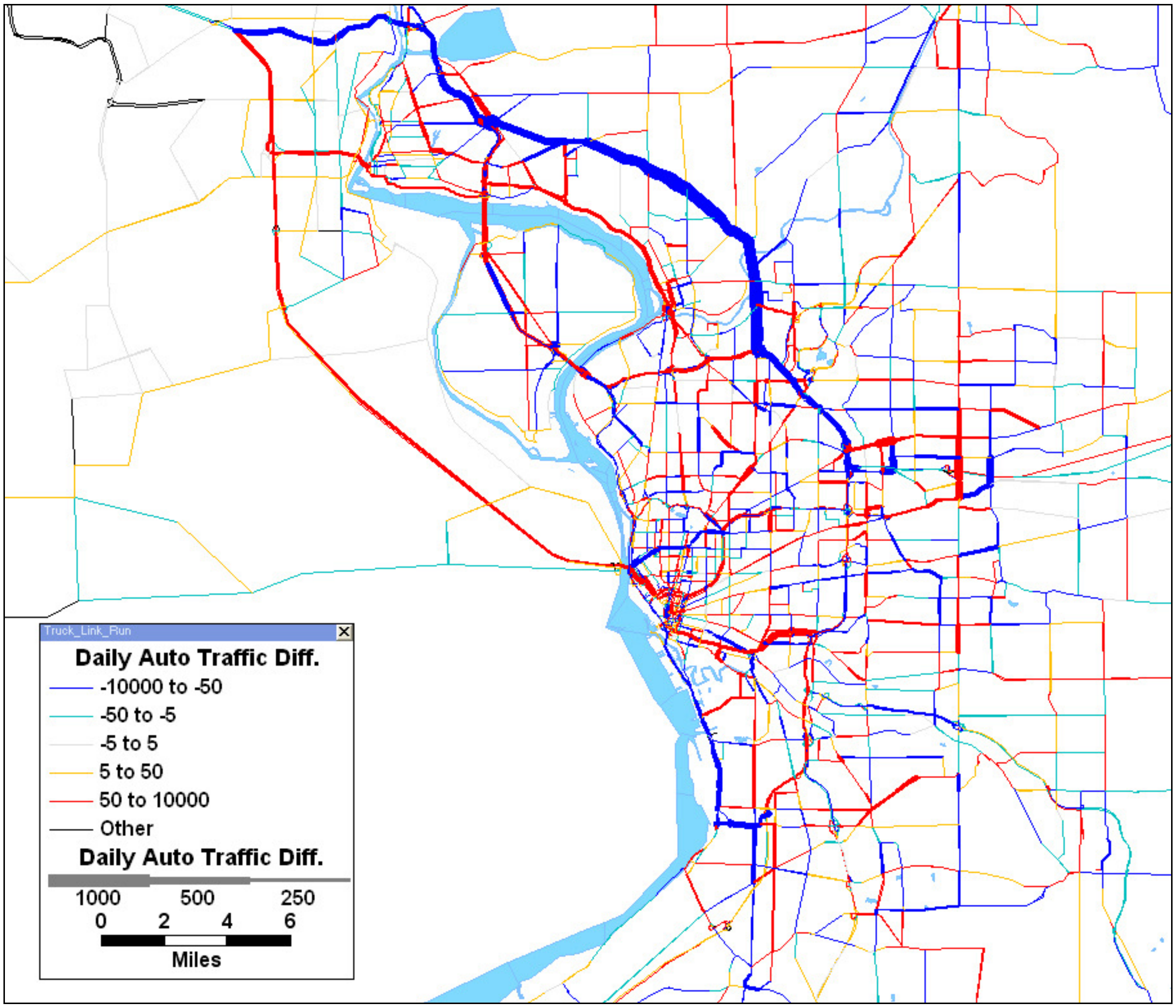

Figure 30 Change in Auto Flow

From this experiment, we were able to conclude that the highway system can absorb the modeled increases in truck travel demand, but at some cost. While the higher functionally classified roadway network could accept higher truck volumes, travel on the local street system increased. For example, there will be significant increases in trucks on certain corridors, including Route 62 (Niagara Falls Boulevard) under this modeled scenario; simultaneously, automobile traffic may shift from these corridors to other routes, such as River Road. Shifting travel volumes to the local street network has direct, adverse implications on fuel consumption patterns and roadway based emissions. The simulation model was able to capture and demonstrate, quite effectively, such shifts in travel patterns with significant environmental consequences tied to this finding.

6 Conclusion

Like many MPOs, GBNRTC faces transportation and land use issues that require a variety of tools to analyze them. In particular, there is an interest in looking at operational changes, and how they affect both the immediate area and the entire region.

This TRANSIMS pilot study demonstrated that a regional TRANSIMS model could be developed based on readily available traffic monitoring data. This consideration eliminated the need for expensive data collection efforts with regard to activity based travel surveys typically used to support simulation modeling. Also, the cross-walk from a four-step model to a simulation modeling regime was shown to be possible with minimal levels of effort to apply the necessary refinements required in a simulation modeling exercise. The router portion of the model, which covered the entire region, used the existing network and trip tables, with only minor changes to the network. The microsimulator portion of the model, which covered a sub-region, required more refinements to the network, but they were manageable, only involving changes in lanes and signals at a few intersections and changes in speeds on a few corridors.

The TRANSIMS model operated a much greater level of time-of-day detail than the existing four-step model. In the four-step model, the day had four time periods. In TRANSIMS, trips were simulated second-by-second, and link travel times were summarized at a 15-minute level of detail, yielding some 96 time periods for the day. This enabled operational issues, congestion, queuing and time-of-day shifts to be modeled and consequences of these shifts to be more readily apparent..

The ability to simulate portions of the network, and to show the results of that simulation, whether it be through vehicle movements, link speeds or queue lengths, will enhance understanding and communications. Adding a simulation modeling tool like TRANSIMS that has the ability to pan back from micro-simulation modeling applications to the macro-simulation or regional network level can directly contribute to a better understanding of transportation project improvements on a region wide level.

Finally, although activity-based modeling was not the focus of this particular project, TRANSIMS does provide activity-based modeling capabilities. Thus, with this TRANSIMS implementation, GBNRTC has a solid base for future work in activity-based modeling.

Recommendations for further refinement of the TRANSIMS modeling tool in Buffalo include:

- Work with transportation agency and facility partners to enrich the vehicle classification data set so that truck travel patterns in the Buffalo Region can be better understood;
- Work with NITTEC to capture, archive and use ITS based traffic detection data to refine the actual, real-time traffic distribution patterns;
- Currently, the freight data community is targeting improvements in data sets to improve the state of freight modeling. Making use of advancements in this area will increase the value of the TRANSIMS tool to GBNRTC.