Grand Valley Metro Council

Model Calibration Report

Prepared by GVMC Staff
In cooperation with the
Michigan Department of Transportation
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Table of Contents

1. Introduction

2. Network Development and TAZ Refinement

    2.1 Network Development

    2.2 TAZ Refinement

    2.3 Socioecnomic Data

3. External Trip Model

    3.1 External Station Determination

    3.2 External Traffic Counts

    3.3 Base Year EE Trips Exchanges

    3.4 Internal-External/ External-External Ratios

4. Trip Generation

    4.1 Trip Production Model

    4.2 Trip Attraction Model

    4.3 Trip Balancing

    4.4 Trip Generation Results & Validation

5. Trip Distribution

6. Trip Assignment

7. Screenline Analysis

8. Summary

1. Introduction

The purpose of this document is to provide preliminary documentation of the results of the Grand Rapids regional model calibration to the year 2010. This report updates current GVMC travel demand model and provides technical detail for each of the modeling components. The model steps in this report are summarized as follows:

- Network and traffic analysis zone (TAZ) definition and development. The GVMC TransCAD network was established based upon the approved National Functional Classification for the region. Every facility that is eligible for federal funding has been included in the model. The Traffic Analysis Zone (TAZ) is the geographic unit used for trip making data in the model. TAZs are used to divide the entire region into manageable "zones" to which socioeconomic data can be associated. Base on the discussion between GVMC and MDOT staff, four townships in Ottawa County has been added into GVMC model area. Therefore, new model work and TAZs has been rebuilt to accommodate the changes, which are shown in Figure 2 and Figure 3.
- External Trip. External trips are trips with at least one trip end outside of the model area. External stations are determined by GVMC and MDOT staff to represent the major roadways lead into and out of GVMC model area.
- Trip generation. Trip generation forecasts the number of motorized personal trips produced and attracted in each TAZ in the study area. This model uses cross classification for trip production and regression for trip attraction. Socioeconomic data are used in this step to estimate the number of motorized personal trips within the study area, and with either of the trip ends outside of the study area.
- Trip distribution. Trip distribution procedure determines the destination of the trips produces in each zone and distributes the trips to all other zones in the study area. The trip distribution model used by the GVMC model is based on the gravity model, which is most common for of model used for trip distribution. Data from the 2000 CTPP and the 2004 Michigan Travel Counts are used to obtain the observed trip length distribution by purpose for model calibration.
- Trip assignment. Trip assignment procedure determines the paths that the distributed trips will take. The equilibrium assignment method is used in the GVMC model because of the

advantages it has over the other methods, especially in a large network where congestion exists. Equilibrium assignment is an iterative process and requires many iterations to converge. It is recommended that at least 3 iterations be used for convergence. The GVMC model has 20 iterations.

The GVMC travel demand model deploys the TransCAD software to develop four-step modeling process. In addition, reasonableness check is performed after each individual modeling step instead of the reasonableness check based on the overall results of the travel model. The advantage of this approach is that it can reduce aggregation errors in each modeling step. The modeling process is shown in Figure 1.

This report has eight chapters, including the introduction and appendices. The second chapter describes the model network, socioeconomic data, TAZ refinement and external stations. The third to sixth chapters describe the trip generation model, trip distribution model and trip assignment model.

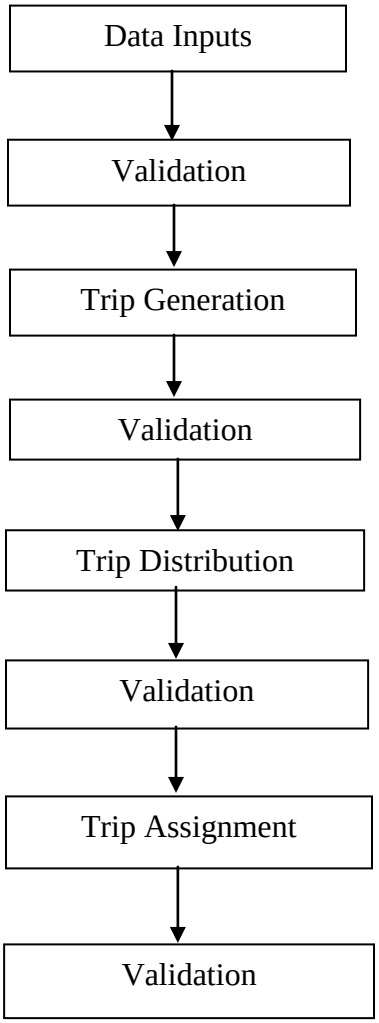


Figure 1 Modeling Process

2. Network Development and TAZ Refinement

The process of model network development and TAZ refinement are described in this section. As indicated in the first chapter, four additional townships in Ottawa County has been added to the model area, thus both the network and TAZ has been updated in this model, which are shown in Figure 2 and 3.

2.1 Network Development

Network development should deal with both highway and transit networks for the urbanized area. The Transit element of the model will not be addressed in this document due to the fact that a transit network and a separate transit model are currently maintained by Interurban Transit Partnership,which proviedes public transportation to Grand Rapids metropolitan area and beyond. Link characteristics such as coordinates (used for distance calculation), number of lanes, area type, and facility type are important data inputs for highway travel simulation.

Other critical data items in the travel demand model process are the speed and capacity parameters used in assigning traffic to the network. The GVMC Model uses the UTPS procedure for assigning speeds and capacities to model links using lookup tables based upon area type, facility type, and number of lanes. Model capacities are standardized according to capacity table provided to GVMC by the MDOT. In addition to area and facility types, capacities are stratified by number of lanes.

The single most important level data item to be utilized in the model development and maintenance process is the internal and external traffic counts compiled for the base year 2009. These counts will be addressed in the last section regarding calibration.

A standard procedure was adopted in the building of the GVMC TransCAD highway network file in order to allow the analyst to move from one study area to another with little adjustment. Network data items fall into two categories of highway and transit network data. The highway network data items include external traffic counts, internal traffic counts, area types, facility types, numbers of lanes, free flow travel time, speed, capacity one way capacity, posted speed, length and link coordinates. These items are discussed below,

Internal Traffic Counts

Internal traffic counts are daily vehicle volumes generally used to check model accuracy. The 2010 GVMC traffic count database provides valuable information for this process. The latest traffic counts for all Federal-Aid roadways have been obtained to accurately represent the observed traffic volume on the GVMC network.

Approximately 1800 total traffic counts are requested from our MPO members on a three year rotation. These are counts taken during a continuous 24-hour period depicting traffic volumes on the greater Grand Rapids federal aid road system. These volumes represent Average Daily Traffic and are used to help determine capacity deficiencies when modeling for our Long Range Transportation Plan.

Every year our agency is responsible for generating count request lists and delivering them to their respective maintenance agencies for collection. We adhere to a three year rotational schedule to ensure that the count is current and accurate for the transportation model. Every year we request on average 600 counts and reimburse our agencies for their effort. All counts are unadjusted, meaning that no growth factors for seasonal, day-of-week, or axle correction factors have been applied. We request however that our members provide us with midweek counts during late spring and early to mid summer.

Area Type

The area type parameter for a given network link identifies the predominate land use activity occurring around that link. The land use activities are categorized into land use types that define different operational characteristics for the roadway, and thereby contribute to defining a typical speed and roadway capacity. GVMC staff uses actual field data collection supplemented by the use of aerial photography. The best reasonable data set would be developed based on local knowledge of the area with field checking for areas with significant growth.

The area type category definitions utilized within the GVMC TransCAD model include central business district, fringe, residential, outlying business district, and rural. The definition of those area types are listed below:

Central Business District (CBD): An area where the predominant land use is intense business activity. Characterized by large numbers of pedestrians, a large demand for parking space, and a high degree of turnover in parking.

Fringe Area : The portion of the municipality immediately outside the CBD. Exhibits a wide range of business activities. Traffic in these areas generally involves trips that do not have an origin or a destination in the area. Less pedestrian traffic and less parking turnover than a CBD.

Residential Area : An area within the influence of a municipality in which the predominant land use is residential development. This area is characterised by few pedestrians and low parking turnover.

Outlying Business District: An area within the influence of a municipality that is normally separated by some distance from the CBD and its fringe area, but that has an intense activity characteristics of a central area. The principle land use land use is business, and there may be heavy traffic and through movements.

Rural Area : A sparely developed area within the influence of a municipality in which the predominent land use is other than those described above.

Facility Types

The link parameter facility type is determined by category of the roadway faciltiy on that link. The GVMC maintains the functional class map in cooperation with MDOT. These classes are modified and used within the model network. The 2005 GVMC TransCAD model uses the facility type categories listed below:

Freeway : A facility with full control of access to give preference to through traffic (i.e. Interstate).

Divided Arterial: Facility with a painted area wide enough to protect left turning traffic, or with a barrier or raised median separating opposing traffic flows.

Undivided Arterial: Similar to the divided arterial, except no painted area or physical barrier separating opposing traffic flows.

Collector: Street that collects traffic from local streets in neighborhoods and channels traffic into the arterial system. A small amount of traffic may be carried on collector streets.

Centroid Connectors: Local streets may not be represented by centroid connectors and should not be identified here.

One-Way Street : Any facility on which traffic may move in one direction only.

Ramps : Any facility on which traffic may access or exit freeways.

Number of Lanes

The number of lanes for a roadway link are defined as number of through lanes provided on a roadway, excluded right and left turn lanes and taper areas. Network coding convention calls for the total number of lanes per direction of travel to be coded into the appropriate space on the link data file. GVMC gathers number of lane information through its pavement management system which tracks pavement width.

Highway Speeds

Highway speeds in combination with distance determine the free flow travel time on each link in the highway network. Speeds can be entered on a link basis. However the most common practice is to use a speed lookup table. The GVMC model uses this process. A speed capacity table has been developed to serve this purpose. Speeds were borrowed from other urbanized areas and were adjusted accordingly. See attachments for a list of inputs speeds and assigned speeds based on facility types and area types and number of lanes used in the model.

Highway Capacity

Highway capacity is defined in the Highway Capacity Manual as “the maximum number of vehicles which has a reasonable expectation of passing over a given section of lane or roadway in a given period of time”. Like speeds, capacity can be entered on a link by link basis. However, the GVMC model uses a speed/capacity lookup table. The capacities included in the model were developed using the MDOT capacity tables provided to GVMC by MDOT staff. A K factor of 0.09 was used to convert hourly capacities to daily capacities per lane.

The GVMC TransCAD network was established based upon the approved National Functional Classification for the region. Every facility that is eligible for federal funding has been included in the model. In some cases facilities that are not officially on the NFC have been included to assure that the model accurately replicates reality. These facilities are not counted for overall VMT or for air quality analysis purposes similar to freeway ramps and centroid connectors. Centroid Connectors were added manually to connect the SE data to the transportation network.

The TransCAD network statistics is depicted as in Table 1 below:

Model Statistics	2005 TransCAD	2009 TransCAD	2010 TransCAD
Zones	840	864	864
Total Population	681,015	715,146	709,656
Total Employment	374,715	403,148	425,635
Total Person Trips	2,912,347	3,310,821	3,302,895
Total VMT	17,771,283	16,970,076	16,953,269

Table 1 GVMC Model Network Statistics

Figure 2 shows the 2005 GVMC travel demand model network, and Figure 3 presents the updated model network.

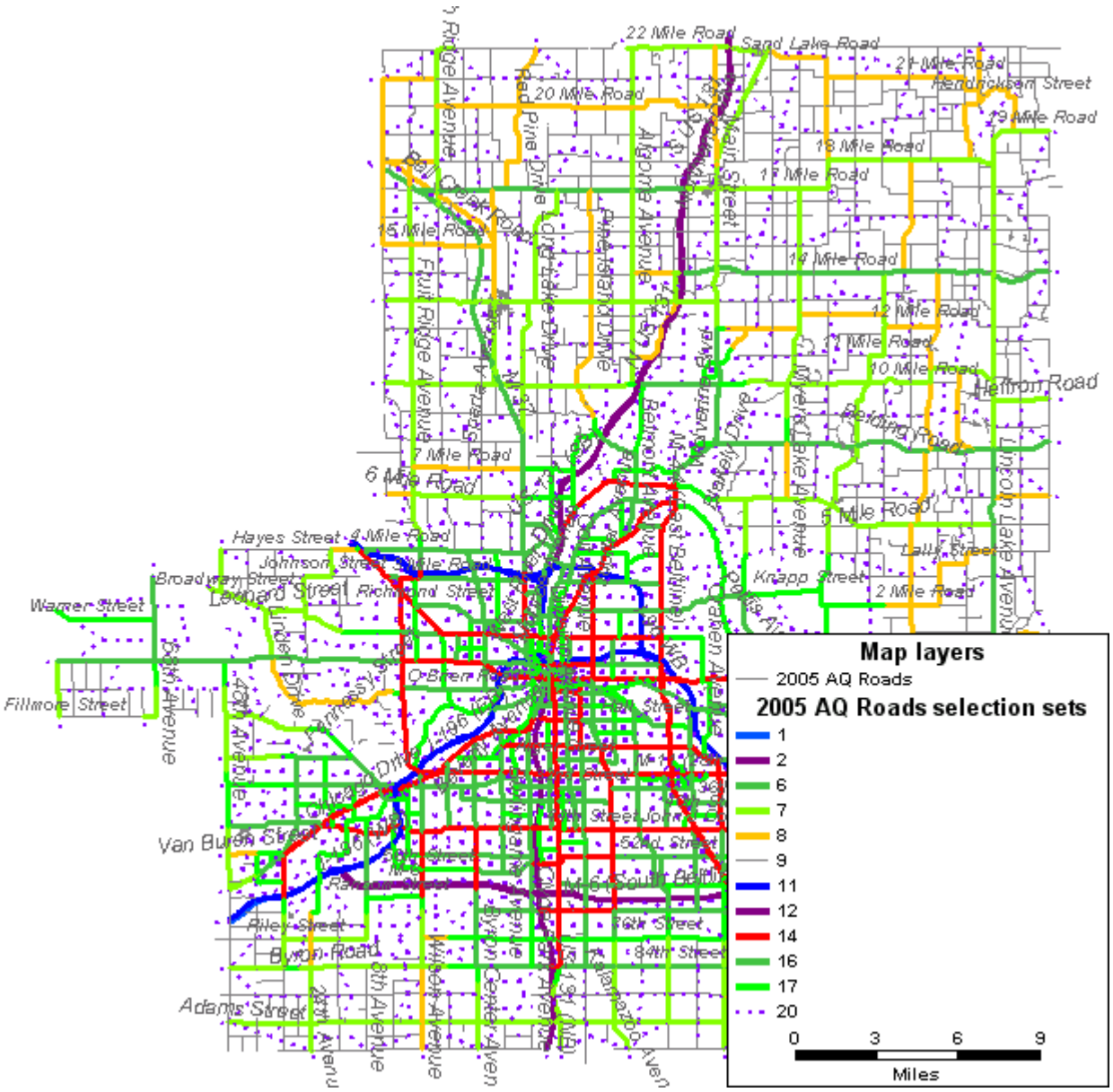


Figure 2 2005 GVMC Model Network

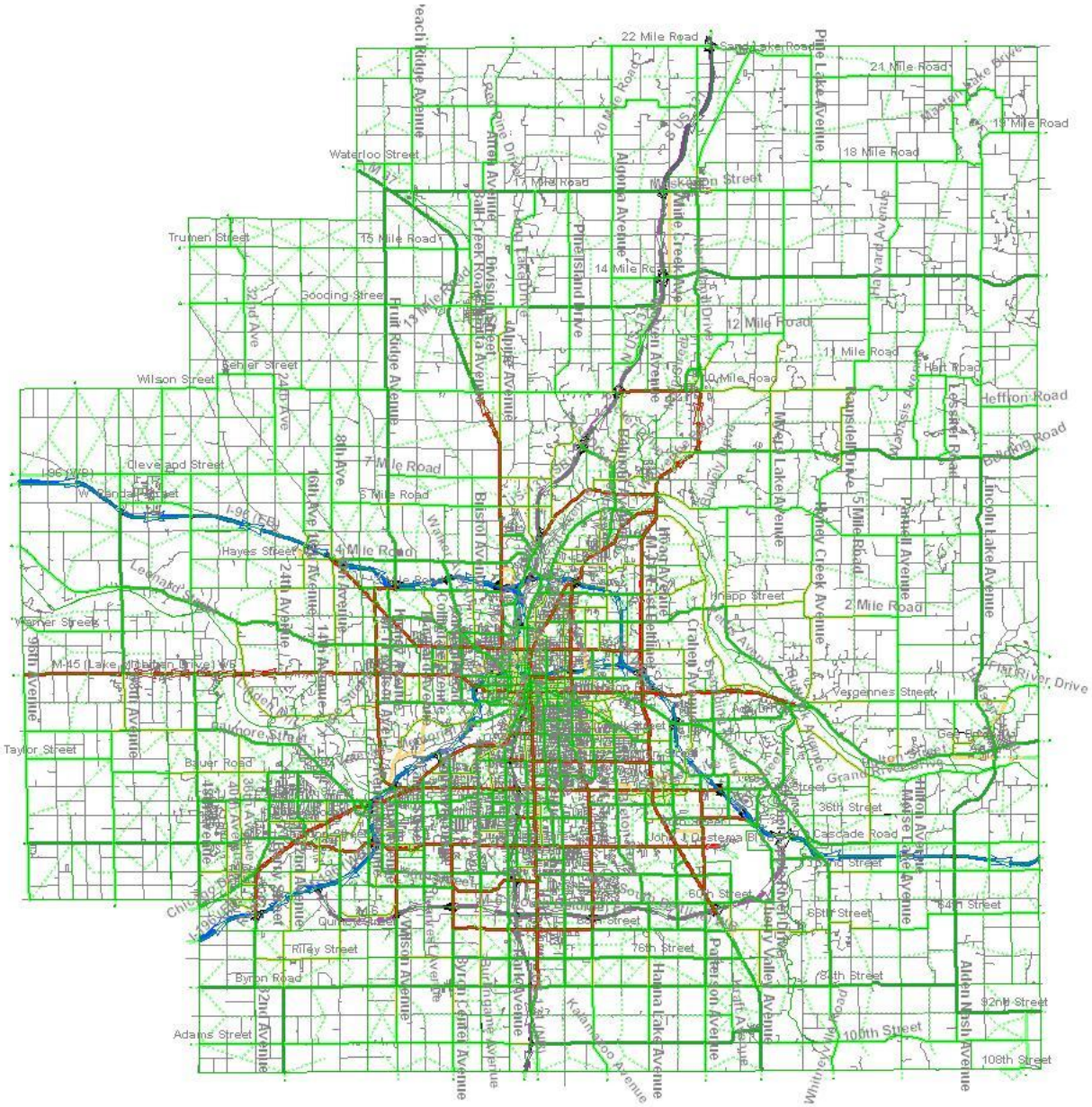


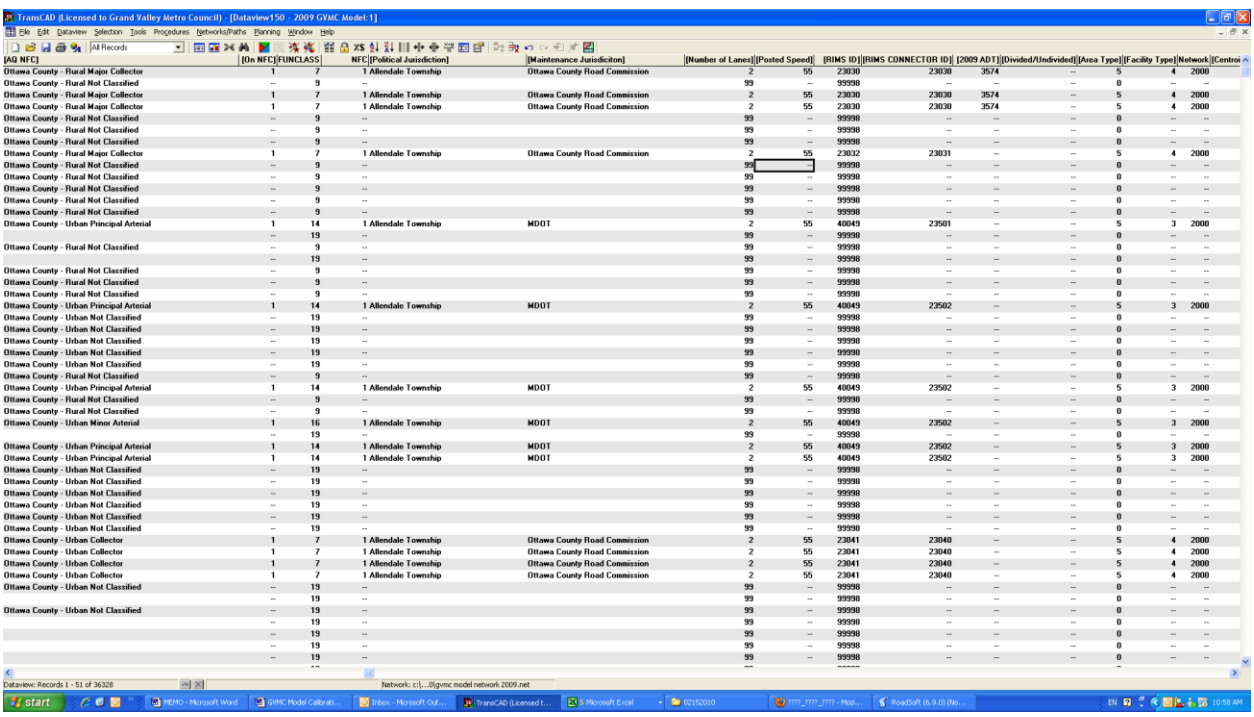
Figure 3 2010 GVMC Model Network

There are 12 function classifications in the GVMC model network as shown in Table 2,

Number	Function Classification
1	Rural Interstate
2	Rural Freeway
6	Rural Minor Arterial
7	Rural Major Collector
8	Rural Minor Collector
9	Rural Local Roadway
11	Urban Interstate
12	Urban Freeway
14	Urban Principal Arterial
16	Urban Minor Arterial
17	Urban Collector
19	Urban Local Roadway
20	Centroid Connector

Table 2 Roadway Function Classification

The network attributes, including link length, facility class, posted speed limit, capacity,etc., are shown in the following Figure 4.



[AQ NFC]	[On NFC]	FUNCLASS	NFC	[Political Jurisdiction]	[Maintenance Jurisdiciton]	[Number of Lanes]	[Posted Speed]	[RIMS ID]	[RIMS CONNECTOR ID]	[2009 ADT]	[Divided/Undivided]	[Area Type]	[Facility Type]	Network	[Centroi
Ottawa County - Rural Major Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23030	23030	3574	--	5	4	2000	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Major Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23030	23030	3574	--	5	4	2000	
Ottawa County - Rural Major Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23030	23030	3574	--	5	4	2000	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Major Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23032	23031	--	--	5	4	2000	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Principal Arterial	1	14	1	Allendale Township	MDOT	2	55	40049	23501	--	--	5	3	2000	
	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Principal Arterial	1	14	1	Allendale Township	MDOT	2	55	40049	23502	--	--	5	3	2000	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Principal Arterial	1	14	1	Allendale Township	MDOT	2	55	40049	23502	--	--	5	3	2000	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Rural Not Classified	--	9	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Minor Arterial	1	16	1	Allendale Township	MDOT	2	55	40049	23502	--	--	5	3	2000	
	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Principal Arterial	1	14	1	Allendale Township	MDOT	2	55	40049	23502	--	--	5	3	2000	
Ottawa County - Urban Principal Arterial	1	14	1	Allendale Township	MDOT	2	55	40049	23502	--	--	5	3	2000	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23041	23040	--	--	5	4	2000	
Ottawa County - Urban Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23041	23040	--	--	5	4	2000	
Ottawa County - Urban Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23041	23040	--	--	5	4	2000	
Ottawa County - Urban Collector	1	7	1	Allendale Township	Ottawa County Road Commission	2	55	23041	23040	--	--	5	4	2000	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
	--	19	--			99	--	99998	--	--	--	0	--	--	
Ottawa County - Urban Not Classified	--	19	--			99	--	99998	--	--	--	0	--	--	
	--	19	--			99	--	99998	--	--	--	0	--	--	
	--	19	--			99	--	99998	--	--	--	0	--	--	
	--	19	--			99	--	99998	--	--	--	0	--	--	
	--	19	--			99	--	99998	--	--	--	0	--	--	

Figure 4 Model Network Attributes

The Traffic Analysis Zone (TAZ) is the geographic unit used for trip making data in the model. TAZ's are used to divide the entire region into manageable "zones" to which socioeconomic data

can be associated. Socioeconomic data (i.e. population, dwelling units, autos owned, household income, and employment figures) determines where in the region trips will begin and end.

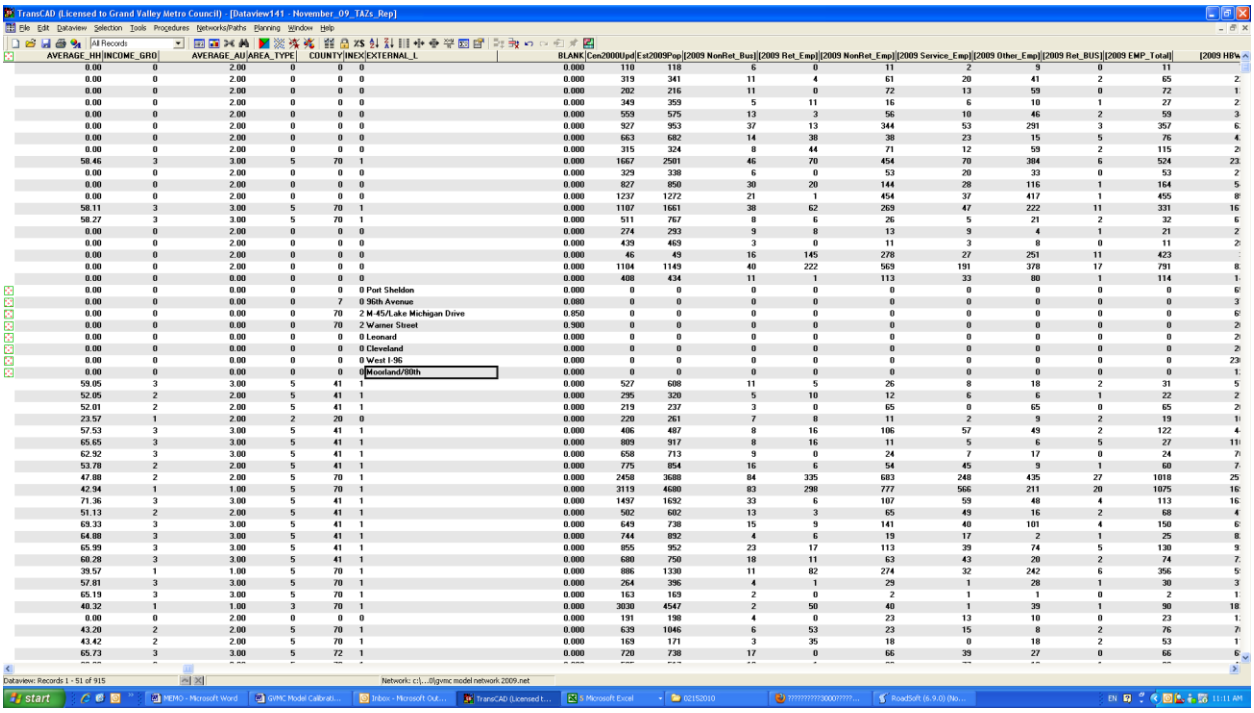
2.2 TAZ Refinement

In general, the TAZ system for the area was formed using the following hierarchy guidelines:

1). National Functional Class Network
2). Census defined boundaries
3). Physical and geographical barriers that restrict surface travel
4). Ease of data gathering
5). Homogeneous Land Use
6). Political jurisdictions
7). Each TAZ should have between 10,000 and 25,000 daily trip ends where possible
8). Each TAZ should be in the shape of a regular polygon where possible

Traffic Analysis Zones for the Grand Rapids Urban Area were carefully formed to ensure compatibility between zones and the transportation network. Care was also taken to ensure that zones were shaped in a manner that would ease the gathering and manipulation of the data.
There are 864 TAZs in GVMC model area, including the recently added four townships in Ottawa county. Each zone is specified by a series of attributes, which include TAZ number, population, income, employments, vehicle ownership, etc.

The TAZ attributes, including area type, population, employment, and dwelling,etc., are indicated in the following Figure 5.



AVERAGE_HH	INCOME_GRO	AVERAGE_AU	AREA_TYPE	COUNTY	INEX	EXTERNAL_L	BLANK	Cen2000Upd	Est2009Pop	[2009 NonRet_Bus]	[2009 Ret_Emp]	[2009 NonRet_Emp]	[2009 Service_Emp]	[2009 Other_Emp]	[2009 Ret_BUS]	[2009 EMP_Totall]	[2009 HB
0.00	0	2.00	0	0	0		0.000	110	118	6	0	11	2	9	0	11	
0.00	0	2.00	0	0	0		0.000	319	341	11	4	61	20	41	2	65	2
0.00	0	2.00	0	0	0		0.000	202	216	11	0	72	13	59	0	72	1
0.00	0	2.00	0	0	0		0.000	349	359	5	11	16	6	10	1	27	2
0.00	0	2.00	0	0	0		0.000	559	575	13	3	56	10	46	2	59	3
0.00	0	2.00	0	0	0		0.000	927	953	37	13	344	53	291	3	357	6
0.00	0	2.00	0	0	0		0.000	663	682	14	38	38	23	15	5	76	4
0.00	0	2.00	0	0	0		0.000	315	324	8	44	71	12	59	2	115	2
58.46	3	3.00	5	70	1		0.000	1667	2581	46	70	454	70	384	6	524	23
0.00	0	2.00	0	0	0		0.000	329	338	6	0	53	20	33	0	53	2
0.00	0	2.00	0	0	0		0.000	827	850	30	20	144	28	116	1	164	5
0.00	0	2.00	0	0	0		0.000	1237	1272	21	1	454	37	417	1	455	8
58.11	3	3.00	5	70	1		0.000	1107	1661	38	62	269	47	222	11	331	16
58.27	3	3.00	5	70	1		0.000	511	767	8	6	26	5	21	2	32	6
0.00	0	2.00	0	0	0		0.000	274	293	9	8	13	9	4	1	21	2
0.00	0	2.00	0	0	0		0.000	439	469	3	0	11	3	8	0	11	2
0.00	0	2.00	0	0	0		0.000	46	49	16	145	278	27	251	11	423	
0.00	0	2.00	0	0	0		0.000	1104	1149	40	222	569	191	378	17	791	8
0.00	0	0.00	0	0	0		0.000	408	434	11	1	113	33	80	1	114	1
0.00	0	0.00	0	0	0	Port Sheldon	0.000	0	0	0	0	0	0	0	0	0	6
0.00	0	0.00	0	7	0	96th Avenue	0.000	0	0	0	0	0	0	0	0	0	3
0.00	0	0.00	0	70	2	M 45/Lake Michigan Drive	0.850	0	0	0	0	0	0	0	0	0	6
0.00	0	0.00	0	70	2	Warner Street	0.900	0	0	0	0	0	0	0	0	0	2
0.00	0	0.00	0	0	0	Leonard	0.000	0	0	0	0	0	0	0	0	0	2
0.00	0	0.00	0	0	0	Cleveland	0.000	0	0	0	0	0	0	0	0	0	2
0.00	0	0.00	0	0	0	West I-96	0.000	0	0	0	0	0	0	0	0	0	23
0.00	0	0.00	0	0	0	Moorland/60th	0.000	0	0	0	0	0	0	0	0	0	1
59.05	3	3.00	5	41	1		0.000	527	688	11	5	26	8	18	2	31	5
52.05	2	2.00	5	41	1		0.000	295	320	5	10	12	6	6	1	22	2
52.01	2	2.00	5	41	1		0.000	219	237	3	0	65	0	65	0	65	2
23.57	1	2.00	2	20	0		0.000	220	261	7	8	11	2	9	2	19	1
57.53	3	3.00	5	41	1		0.000	406	487	8	16	106	57	49	2	122	4
65.65	3	3.00	5	41	1		0.000	809	917	8	16	11	5	6	5	27	11
62.92	3	3.00	5	41	1		0.000	658	713	9	0	24	7	17	0	24	7
53.78	2	2.00	5	41	1		0.000	775	854	16	6	54	45	9	1	60	7
47.88	2	2.00	5	70	1		0.000	2458	3688	84	335	683	248	435	27	1018	25
42.94	1	1.00	5	70	1		0.000	3119	4680	83	298	777	566	211	20	1075	16
71.36	3	3.00	5	41	1		0.000	1497	1632	33	6	107	59	48	4	113	16
51.13	2	2.00	5	41	1		0.000	502	682	13	3	65	49	16	2	68	4
63.33	3	3.00	5	41	1		0.000	649	738	15	9	141	40	101	4	150	6
64.88	3	3.00	5	41	1		0.000	744	892	4	6	19	17	2	1	25	8
65.99	3	3.00	5	41	1		0.000	855	952	23	17	113	39	74	5	130	9
68.28	3	3.00	5	41	1		0.000	680	750	18	11	63	43	20	2	74	7
39.57	1	1.00	5	70	1		0.000	886	1330	11	82	274	32	242	6	356	5
57.81	3	3.00	5	70	1		0.000	264	396	4	1	29	1	28	1	30	3
65.19	3	3.00	5	70	1		0.000	163	169	2	0	2	1	1	0	2	1
48.32	1	1.00	3	70	1		0.000	3030	4547	2	50	40	1	39	1	90	18
0.00	0	2.00	0	0	0		0.000	191	198	4	0	23	13	10	0	23	1
43.20	2	2.00	5	70	1		0.000	639	1046	6	53	23	15	8	2	76	7
43.42	2	2.00	5	70	1		0.000	169	171	3	35	18	0	18	2	53	1
65.73	3	3.00	5	72	1		0.000	720	738	17	0	66	39	27	0	66	6

Figure 5 TAZ Attributes

2.3 Socioecnomic Data

Every four years, GVMC as the designated Metropolitan Planning Organization (MPO) for the region is federally required to produce a Long Range Transportation Plan document. To begin the LRTP update, staff need to collect population and employment projections through the year 2035 for use in the transportation model.

Using U.S. Census estimates/American Community Survey (ACS) data, Regional Economic Model Inc (REMI) data, Subregional process data, and Claritas employment data, staff has been able to determine the 2010 base year population and employment numbers by Traffic Analysis Zone (TAZ), and also area-wide projections for population and employment increases between 2010 and 2040.

The data collected is recorded by TAZ, as this is the unit used in the transportation planning model. Population and employment information is populated into the model by TAZ to help understand the number of trips produced and attracted to each zone. With information about the number of trips by zone the model can calculate those road segments anticipated to be deficient in the future. It is important to keep in mind that GVMC is responsible for modeling

for some areas beyond the MPO boundaries by the Michigan Department of Transportation (MDOT). These areas, including Blendon, Polkton, Wright, and Chester Townships and the City of Coopersville, are not part of any MPO, but they were included in our data collection process.

To better understand the Socio-Economic (SE) data projections, following this memorandum are two spreadsheets: 1) 2009-2035 Population Projections by TAZ, 2) 2009-2035 Employment Projections by TAZ. TAZ maps by jurisdiction were handed out at the August 2009 Technical Committee meeting and are available by jurisdiction in hard copy as well as on the GVMC website (www.gvmc.org).

Subregional Process

At the August 19, 2009 Policy Committee meeting, the 2009 Base Year Population and Employment Data by TAZ was approved. With this approval, staff proceeded to collect updated SE data projections for the outer years of the Long Range Transportation Plan. The collection process, which several of the Transportation Technical and Policy Committee members participated in, was slightly different from previous Plans. Staff worked closely with the Land Use Planning Department to build on previous efforts to regionally determine where growth will/is likely to occur (Blueprint and Framework). By dividing the area that GVMC is required (by MDOT) to model for (an area slightly larger than the MPO) into five subregions, staff was able to work with local municipalities to create a vision for growth.

From the total growth anticipated for the study area (REMI indicates a population increase of 135,000 people from 2009-2035 or about a 19% increase in 26 years) each subregion determined what percentage of the overall growth should/was likely to occur in their subregion as well as for the other four subregions. For each meeting, a detailed base map was created to depict information such as water-sewer boundaries and zoning. Upon this map, representatives from each subregion strategically placed “chips” that represented population based on different development styles (suburban, traditional neighborhood, infill etc.) up to the population number (% of 135,000) that each subregion agreed upon. The maps created indicated both the style/density of development as well as the geographic location of population increase. Employment numbers were generated alongside population using the same “chip” methodology.

These maps were then photographed and overlaid in GIS with the TAZ boundaries. Staff was able to derive population and employment numbers from these maps with minimal modifications.

Population

The University of Michigan Regional Economic Model Inc. (REMI) is a great source of information for county-wide population projections in the State of Michigan. For Kent and Eastern Ottawa County, REMI projects a population increase of 135,000 people over the next 26 years. During the subregional meetings, each subregion agreed on what percentage of the growth they felt would/should occur for every subregion. As with previous studies, the subregions were in agreement for the most part about where growth would occur; and after all of the subregional meetings were concluded, staff summarized the meeting input to arrive at basic percentages by subregion.

2.3.1 Subregional Population Distribution

Subregion	% Future Pop. Increase	Additional Pop. Growth 2009-2035
Rogue River/Fruitridge (Tyrone Twp., Casnovia, Kent City, Solon Twp., Sparta, Sparta Twp., Alpine Twp., Algoma Twp., Cedar Springs, Sand Lake, Rockford, Nelson Twp., Courtland Twp., Spencer Twp., Oakfield Twp.)	11%	14,850
East Metro (Cannon Twp., Grattan Twp., Ada Twp., Vergennes Twp., Cascade Twp., Lowell, Lowell Twp., Bowne Twp.)	14%	18,900
West Metro (Chester Twp., Coopersville, Polkton Twp., Wright Twp., Allendale Twp., Tallmadge Twp., Blendon Twp., Georgetown Twp., Hudsonville, Jamestown Twp.)	17%	22,950
South Belt (Byron Twp., Gaines Twp., Caledonia Twp., Caledonia)	19%	25,650
Urban Metro (Plainfield Twp., Grand Rapids Twp., Grand Rapids, Walker, East Grand Rapids, Grandville, Wyoming, Kentwood)	39%	52,650
Total	100%	135,000

Table 3 Subregional Population Distribution

Methodology

As described above, each subregion geographically placed their growth upon the base maps and that information was converted to GIS in order to derive population numbers by TAZ. Staff made three modifications to the population data as it was recorded at the subregional meetings.

First, some of the subregional meetings had enough participation that multiple maps were created. For those subregions staff aggregated the mapped data into a single map.

Second, staff allocated one-third of the total population growth (45,900) to be distributed to every TAZ based on the individual TAZ's growth rate from 2000 to 2009. The remaining two-thirds of the growth was distributed to the TAZs based on the geographic placement provided through the subregional process. The rationalization behind the allocation of one-third "ambient" or "natural" growth to every TAZ based on its historic growth rate is because: 1) while every jurisdiction was invited, not every jurisdiction participated in the subregional meetings, 2) it is unrealistic to expect vast geographic areas as having zero growth over the next 26 years, as some of the maps indicated.

The third modification that staff made to the population data provided by the subregional meetings was to weight the increase in population more heavily in the last 10 years (2025-2035). This was done simply because the further into the future one projects, the more uncertain the projections.

For the specific population numbers by TAZ please refer to the attached spreadsheet: 2009-2035 Population Projections by TAZ.

2.3.2 Retail/Non Retail Employment

Using population growth rates and information from REMI it is estimated that the area will see an increase of approximately 74,000 jobs between 2009 and 2035. Of these jobs, about 14% will be retail, 81% will be office jobs, and about 4% will be other non-retail jobs. It is anticipated that there will be about 15% fewer industrial jobs between 2009 and 2035.

Methodology

Through the subregional meeting process population placement, jurisdictions also placed where they anticipated job growth to occur. In addition to employment "chips," some of the population development styles, such as "Infill neighborhood" or "Town Center," included both population and employment totals within a single "chip." To the employment data provided through the subregional process staff made three modifications.

First, as described above, when multiple maps were created, staff consolidated the information (both population and employment) into a single map.

Second, two-thirds of the employment growth between 2009 and 2035, or 49,299 jobs, were distributed as "ambient" or "natural" employment growth to every TAZ based on the percentage of total employment that TAZ had in 2009. Again, the "natural" employment distribution was incorporated because: 1) of lack of participation from every jurisdiction, 2) it is unrealistic to expect vast geographic areas as having zero growth, 3) the Subregional meeting process, as designed by the Land-Use Department for previous growth scenarios, is strongest for recording population growth/style. The remaining one-third or 24,723 jobs were distributed to the TAZs based on the geographic placement provided through the subregional process.

The third modification that staff made to the employment data was to once again weight the increase in employment more heavily in the last 10 years of the plan to track population growth and because projections far into the future are increasingly uncertain.

The spatial distributions of socioeconomic data, including population, household and employment by each TAZ, are presented in Figure 6, 7 and 8.

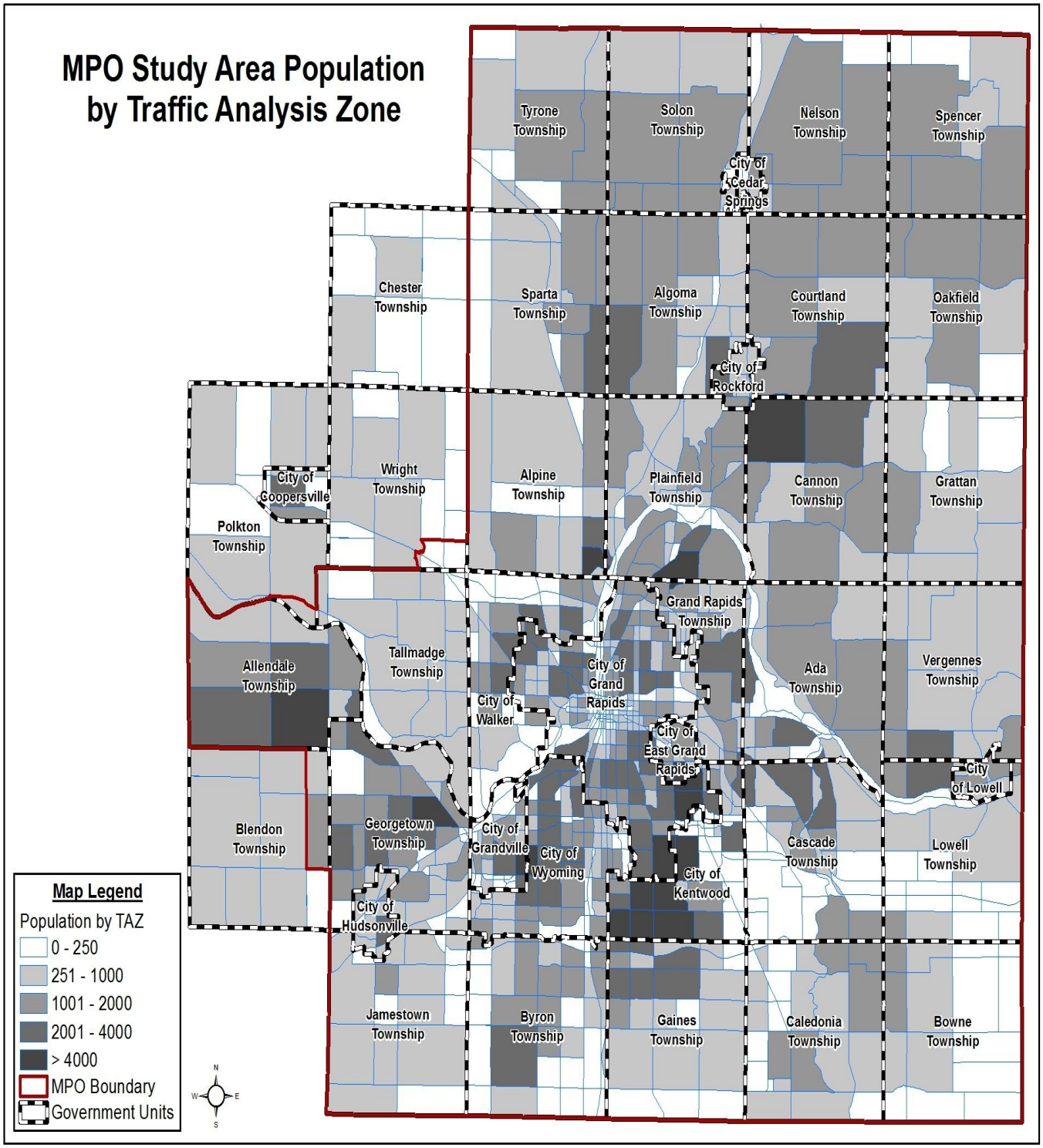


Figure 6 Distribution of Population by TAZ

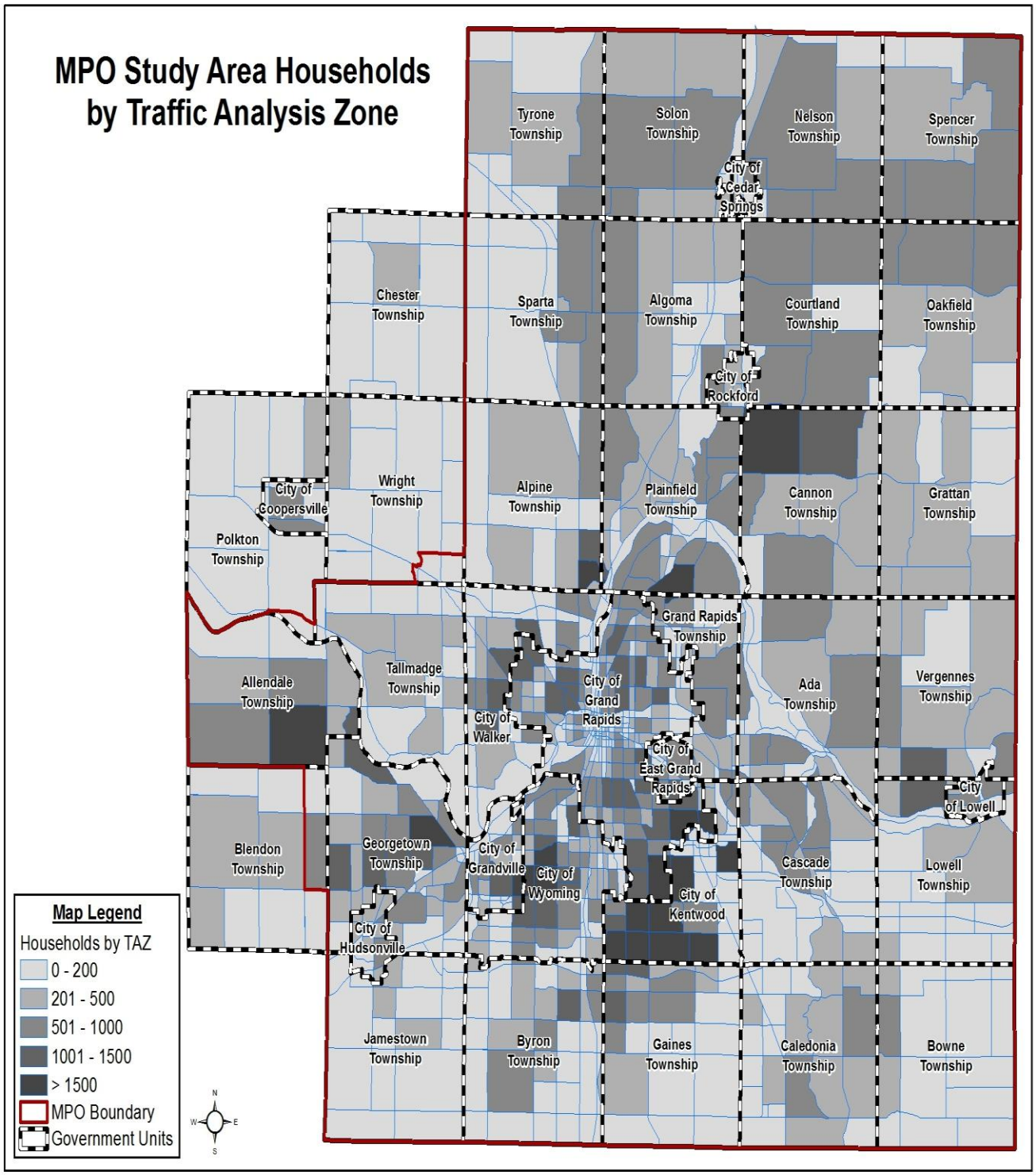


Figure 7 Distribution of Dwellings by TAZ

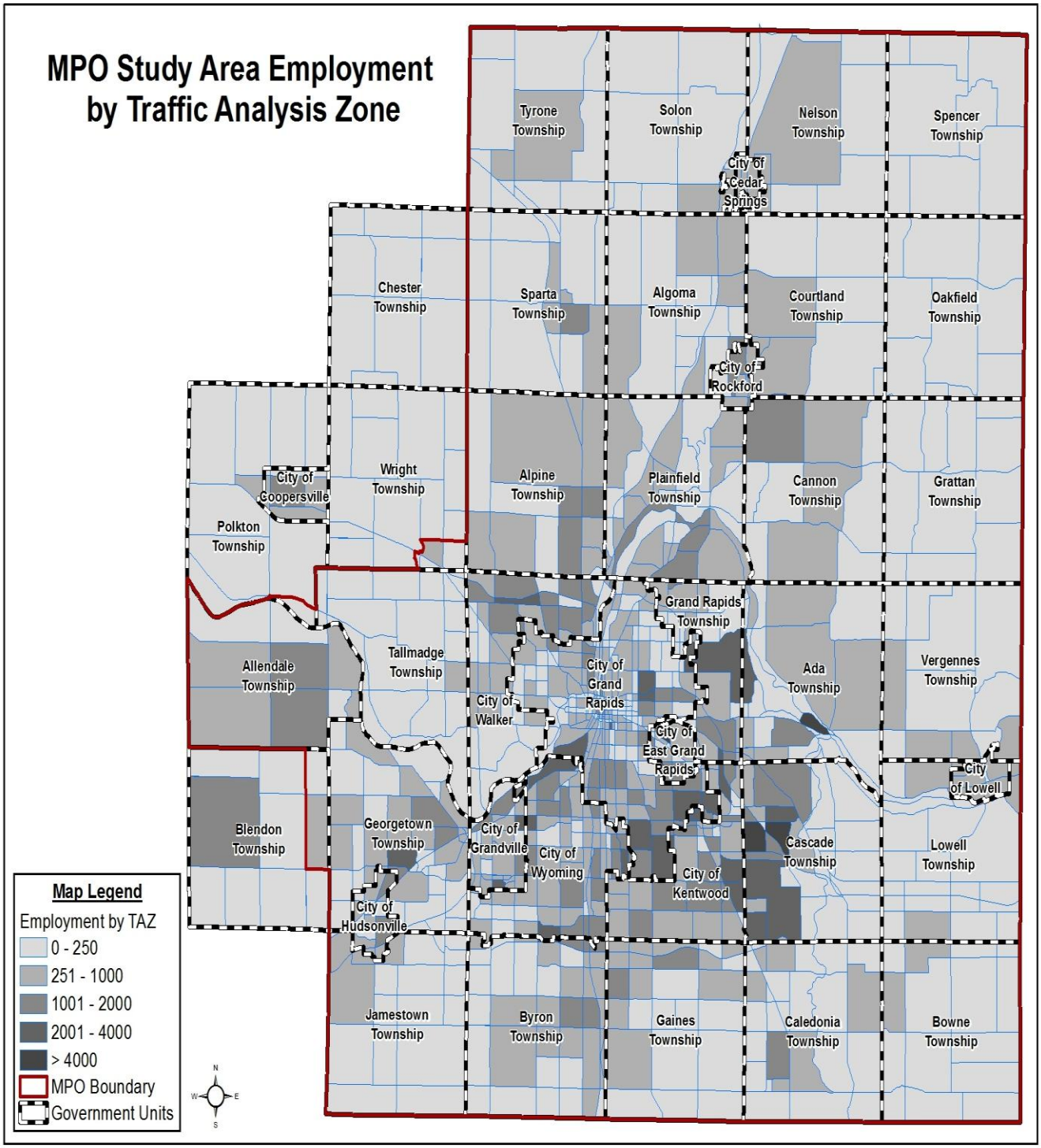


Figure 8 Distribution of Employment by TAZ

3. External Trips Model

The input data for the external trips model is the base year external to external (E-E) interchanges file. The E-E trips data file is derived from external stations traffic counts and other related information. Once an acceptable external to external trip table has been established for the base year, the growth of through trips can be obtained for the future year.

Other model parameters input into the external model include the growth rates for each external station. These rates factor trips at each of the external stations to the future year. These factors are generally derived using historical trends of traffic counts taken at the external station and projected growth near the study area boundaries. The future growth rates for the external stations have yet to be developed and will be used for modeling the Long Range Plan.

A final data item within the external model is a ratio of through EE trips to internal-external (IE) trips at each external station. This ratio separates external station volumes into IE or EE trips. The level of accuracy required of these parameters depends upon the percentage of external trips to total trips in the network.

In summary, the modeling of external traffic requires up to four data items as listed below:

- External Traffic Counts
- Base Year EE Trips
- Growth rates for each external station
- Internal-external/external-external ratios

3.1 External Station Determination

The 2000 TRANPLAN model contained only 22 external stations. This relatively small number of external stations is due in large part to a staff decision to eliminate any external station that did not have a 24-hour traffic count of less than 5,000. The 2000 TransCAD model contained 57 external zones. This large increase was done to assure that future assignments are as accurate as possible. An external station with a small volume today may be a large external trip generator in the future. There are 51 external stations for the 2009 and 2010 TransCAD model with four added townships to the study area. The determination of external stations is

based on the discussion between GVMC and MDOT staff. Figure 9 below shows the external stations in the GVMC model area.

3.2 External Traffic Counts

The external traffic count is the number of vehicles crossing the urban study boundary on any link of the major street and highway network. All external traffic volumes must be adjusted to the same base year and be of similar type. GVMC external traffic counts reflect year 2010 conditions.

3.3 Base Year EE Trips Interchanges

External-External trip interchanges, or through trips, represent travel from one study area boundary to another without stopping in the study area. The external-external trip interchanges table has been developed jointly with GVMC and local MDOT staff. An external-external trips table was developed using the external-external trip table to be used in the EXTERNAL model

.

3.4 Internal-External/External-External Ratios

The IE/EE split is the percentage split between external trips bound for external stations and external trips bound for locations within the study area. This split is generally expressed as two percentages, such as “80/20”, for each station. These ratios can be developed based on local knowledge of conditions or based upon percentage splits from a similar area. Splits for the 2010 model were developed using 1995 ratios developed jointly with MDOT staff. Of the 51 external stations, 15 stations are selected to manually assign the external-external trips based on the traffic counts at the external stations. The following Table 4 and Table 5 summarize I-E and E-E trips.

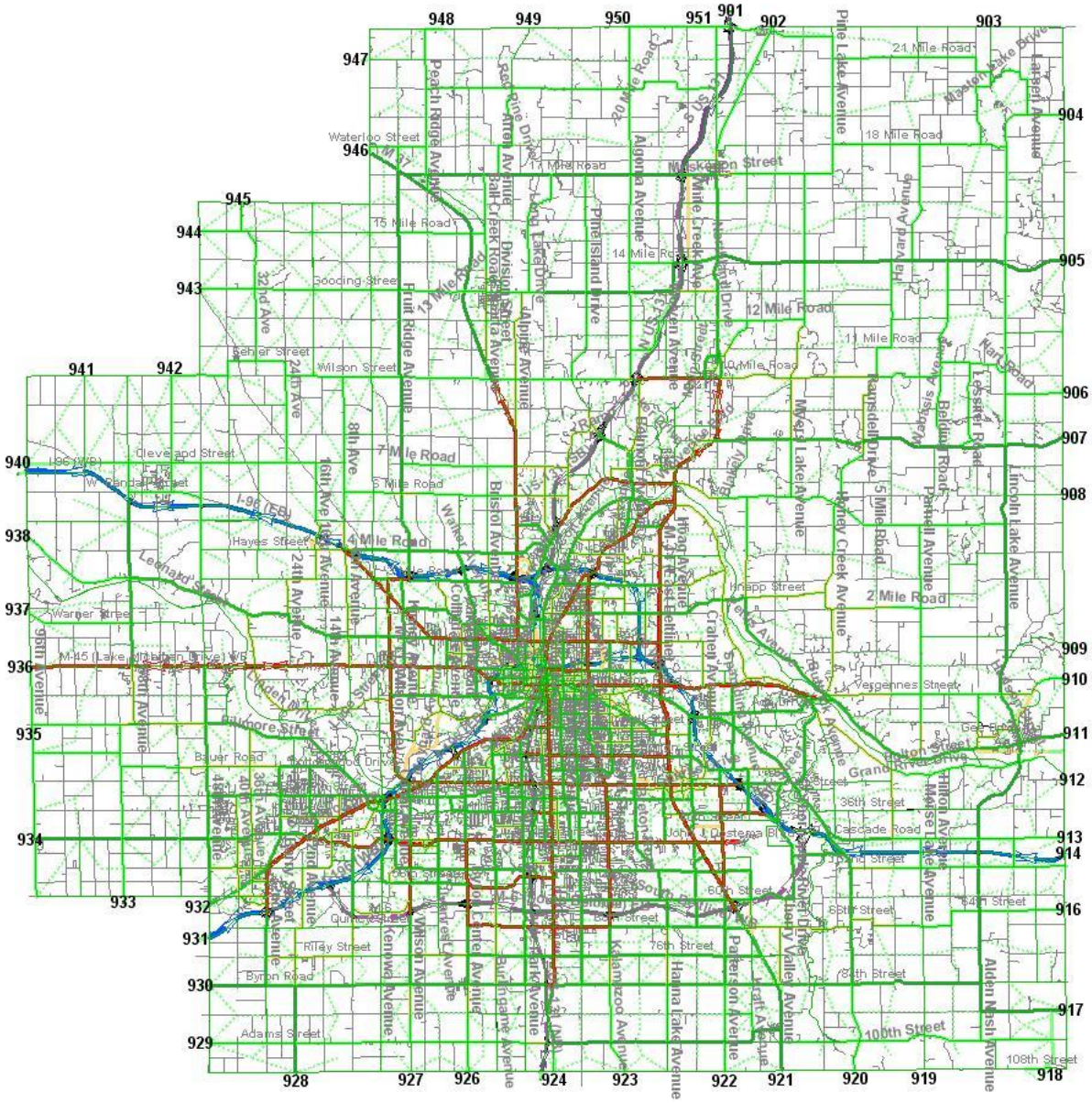


Figure 9 External Stations

External Station	TAZ	2009 Traffic Count	% Through	I-E Trips	E-E Trips	I-E Trips (Vehicle Trip)						I-E Trips (Person trip)					
						Production			Attraction			Production			Attraction		
						HBW	HBO	NHB	HBW	HBO	NHB	HBW	HBO	NHB	HBW	HBO	NHB
US-131	901	25000	40	15000	10000	1650	4200	1650	1650	4200	1650	1733	6468	2360	1733	6468	2360
Northland	902	7400	10	6660	740	732	1864	732	732	1864	732	769	2872	1048	769	2872	1048
Trufant	903	400	0	400	0	44	112	44	44	112	44	46	172	63	46	172	63
19 Mile Road	904	4500	0	4500	0	495	1260	495	495	1260	495	520	1940	708	520	1940	708
M-57	905	15200	40	9120	6080	1003	2553	1003	1003	2553	1003	1053	3933	1435	1053	3933	1435
Heffron	906	1300	0	1300	0	143	364	143	143	364	143	150	561	204	150	561	204
M-44	907	5800	30	4060	1740	446	1136	446	446	1136	446	469	1751	639	469	1751	639
6 Mile Road	908	1600	0	1600	0	176	448	176	176	448	176	185	690	252	185	690	252
McPherson	909	900	0	900	0	99	252	99	99	252	99	104	388	142	104	388	142
Flat River	910	2300	0	2300	0	253	644	253	253	644	253	266	992	362	266	992	362
M-21	911	6000	30	4200	1800	462	1176	462	462	1176	462	485	1811	661	485	1811	661
Oberley Dr	912	1600	0	1600	0	176	448	176	176	448	176	185	690	252	185	690	252
Cascade Rd	913	2600	0	2600	0	286	728	286	286	728	286	300	1121	409	300	1121	409
I-96 East	914	32000	50	16000	16000	1760	4480	1760	1760	4480	1760	1848	6899	2517	1848	6899	2517
52nd Street	915	450	0	450	0	49.5	126	49.5	49.5	126	49.5	52	194	71	52	194	71
64th Street	916	1200	0	1200	0	132	336	132	132	336	132	139	517	189	139	517	189
M-50/92nd St	917	3300	0	3300	0	363	924	363	363	924	363	381	1423	519	381	1423	519
Freeport	918	1400	0	1400	0	154	392	154	154	392	154	162	604	220	162	604	220
Morse Lake	919	500	0	500	0	55	140	55	55	140	55	58	216	79	58	216	79
Whitneyville	920	3500	20	2800	700	308	784	308	308	784	308	323	1207	440	323	1207	440
M-37	921	13000	30	9100	3900	1001	2548	1001	1001	2548	1001	1051	3924	1431	1051	3924	1431
Patterson	922	6200	20	4960	1240	545	1388	545	545	1388	545	573	2139	780	573	2139	780
Kalamazoo	923	2100	20	1680	420	184	470	184	184	470	184	194	724	264	194	724	264
Division	924	7400	20	5920	1480	651	1657	651	651	1657	651	684	2553	931	684	2553	931
US-131 South	925	35000	40	21000	14000	2310	5880	2310	2310	5880	2310	2426	9055	3303	2426	9055	3303

Table 4 External Station I-E Trips

External Station	TAZ	2009 Traffic Count	% Through	I-E Trips	E-E Trips	I-E Trips (Vehicle Trip)						I-E Trips (Person trip)					
						Production			Attraction			Production			Attraction		
						HBW	HBO	NHB	HBW	HBO	NHB	HBW	HBO	NHB	HBW	HBO	NHB
Byron Center	926	5600	20	4480	1120	492	1254	492	492	1254	492	517	1932	705	517	1932	705
Wilson Ave	927	1200	0	1200	0	132	336	132	132	336	132	139	517	189	139	517	189
24th Ave	928	3700	0	3700	0	407	1036	407	407	1036	407	427	1595	582	427	1595	582
Adams	929	2900	0	2900	0	319	812	319	319	812	319	335	1250	456	335	1250	456
Byron	930	4100	0	4100	0	451	1148	451	451	1148	451	474	1768	645	474	1768	645
I-196	931	51000	40	30600	20400	3366	8568	3366	3366	8568	3366	3534	13195	4813	3534	13195	4813
Chicago Dr	932	12000	20	9600	2400	1056	2688	1056	1056	2688	1056	1109	4140	1510	1109	4140	1510
72nd	933	4200	0	4200	0	462	1176	462	462	1176	462	485	1811	661	485	1811	661
Port Sheldon	934	7100	20	5680	1420	624	1590	624	624	1590	624	656	2449	893	656	2449	893
Fillmore	935	3200	0	3200	0	352	896	352	352	896	352	370	1380	503	370	1380	503
M-45	936	8100	30	5670	2430	623	1587	623	623	1587	623	655	2445	892	655	2445	892
Osborn	937	2300	0	2300	0	253	644	253	253	644	253	266	992	362	266	992	362
Leonard	938	2300	0	2300	0	253	644	253	253	644	253	266	992	362	266	992	362
I-96	939	34100	40	20460	13640	2250	5728	2250	2250	5728	2250	2363	8822	3218	2363	8822	3218
Cleveland	940	2300	0	2300	0	253	644	253	253	644	253	266	992	362	266	992	362
Moorland	941	1100	0	1100	0	121	308	121	121	308	121	127	474	173	127	474	173
56th	942	2800	0	2800	0	308	784	308	308	784	308	323	1207	440	323	1207	440
Gooding	943	1700	0	1700	0	187	476	187	187	476	187	196	733	267	196	733	267
Truman	944	1150	0	1150	0	126	322	126	126	322	126	133	496	181	133	496	181
Trent	945	1000	0	1000	0	110	280	110	110	280	110	116	431	157	116	431	157
M-37	946	12100	20	9680	2420	1064	2710	1064	1064	2710	1064	1118	4174	1523	1118	4174	1523
Baily	947	1750	0	1750	0	192	490	192	192	490	192	202	755	275	202	755	275
Spruce	948	1100	0	1100	0	121	308	121	121	308	121	127	474	173	127	474	173
Red Pine Drive	949	800	0	800	0	88	224	88	88	224	88	92	345	126	92	345	126
Cypress Ave	950	800	0	800	0	88	224	88	88	224	88	92	345	126	92	345	126
Newcosta Ave	951	800	0	800	0	88	224	88	88	224	88	92	345	126	92	345	126

Table 4(Continue) External Station Trips based on ground counts

TAZ	901	902	905	907	911	914	921	924	925	926	931	932	936	939	946
901	0	100	400	300	0	750	400	0	1000	0	750	0	400	600	300
902	74	0	0	0	0	74	0	0	74	0	74	0	0	74	
905	760	0	0	0	0	243	213	0	608	0	456	0	0	608	152
907	218	0	0	0	0	70	61	0	174	0	131	0	0	174	44
911	225	0	0	0	0	45	90	0	180	0	135	0	0	180	45
914	1600	0	0	0	0	0	400	0	2000	0	1600	0	400	1600	400
920	70	0	0	0	0	105	0	0	0	0	105	0	0	70	0
921	390	0	98	98	0	390	0	0	98	0	293	0	98	293	195
922	124	0	0	0	0	186	0	0	0	0	186	0	0	124	0
923	42	0	0	0	0	63	0	0	0	0	63	0	0	42	0
924	148	0	0	0	0	111	0	0	222	0	148	0	0	111	0
925	2100	0	350	350	0	1400	350	0	0	0	1400	0	350	350	350
926	56	0	0	0	0	112	0	0	168	0	168	0	0	56	0
931	2040	0	816	816	510	2040	816	0	1530	0	0	0	612	510	510
932	300	0	0	0	0	300	120	0	60	0	0	0	0	300	120

Table 5 E-E Trips based on ground counts

4. Trip Generation

Trip generation model consists of trip production and trip attraction models by purpose. The trip production and attraction rates are two of the most important model parameters used in the modeling process because of their role in explaining the magnitude of trip making. The main issues are whether these trip generation rates remain constant over time for any given study area and the degree to which unique trip generation rates should be applies in each urbanized area. The traditional method of establishing trips generation rates has been through origin-destination surveys conducted on the household interview levels. If the O-D information is not available, rates are usually borrowed from like areas or from other publications.

The trip production model in GVMC model includes production cross classification tables derived from information included in the Travel Estimation Techniques for Urban Planning (TRB Special Report 365, 1998),, while trip attraction model use regression methods and trip attraction rates provided by MDOT (Michigan Department of Transportation).

Several classifications of trip purpose are used in the GVMC trip generation model for two reasons: to increase accuracy of the simulation by accounting for variations in the trip rates and trip length frequency distributions, which alter the trip making characteristics of a specific purpose.

The number of trip purposes used in urban area ranges from one to twenty or more in some areas depending on size of the area and the scope and objectives of the study. The greater the number of purposes, the greater the amount of time required to prepare data, run the data through the model, and to analyze and verify the results. The GVMC model uses the following trip purposes:

1).Home-Based Work (HBW): Trips between a person's home and place of work

2).Home Based Other (HBO): Trips between a person's home and a destination for any purpose other than work.

3).Non-Home Based (NHB): Trips that neither end at home, regardless of purpose

4.1 Trip Production Model

Trip production rate is based on Michigan Travel Counts Survey conducted in 2004 and 2005. Table 6 through 8 below show the trip production rate cross classified by household size and auto ownership for each trip purpose.

Household Size	Vehicle Available			
	0	1	2	3+
1	0.19	0.68	0.75	1.10
2	0.24	0.89	1.73	2.11
3	0.63	1.07	1.88	2.75
4	1.05	1.22	2.14	2.98
5+	1.05	1.22	2.14	2.98

Table 6 HBW Trip Production Rates (Source: MI Travel Counts 2004-2005)

Household Size	Vehicle Available			
	0	1	2	3+
1	1.21	1.68	1.63	1.16
2	2.61	3.61	3.57	3.15
3	6.17	5.64	5.90	4.90
4	7.18	8.33	10.49	9.70
5+	7.18	8.33	10.49	9.70

Table 7 HBO Trip Production Rates (Source: MI Travel Counts 2004-2005)

Household Size	Vehicle Available			
	0	1	2	3+
1	0.38	1.27	1.46	0.80
2	0.88	2.01	2.54	2.64
3	1.33	3.61	3.28	3.65
4	1.27	3.04	4.52	4.58
5+	1.27	3.04	4.52	4.58

Table 8 NHB Trip Production Rates (Source MI Travel Counts 2004-2005)

4.2 Trip Attraction Model

Trip attraction model are linked to employment number and dwelling units by TAZ. MDOT provided trip attraction equations as following,

HBW = 1.45 * Total employment

HBO = 9 * Retail Employment + 1.7 * Service Employment + .5 * Other Employment + .9 * Households

NHB = 4.10 * Retail Employment + 1.2 Service Employment + .5 * Other Employment + .5 * Households

4.3 Trip Balancing

Trip balancing is necessary after estimation of trip production and trip attraction because the number of trips being produced by households in the region should be equal to the number of trips attracted to activity center. To balance the regional total trips, either the zonal productions or attractions are scaled to equal regional total trips. Trip production totals in the region are normally used as control totals since there is a much confidence in the production models than in the attraction models.

4.4 Trip Generation Results and Validation

The numbers of trips by purpose are obtained based on the trip production and trip attraction models. The results are listed in Table 9.

Trip Purpose	Personal Trips	Trips/HH	Trips/Person	Percentage(%)	***Target** (%)
HBW	547,478	1.91	0.77	16.58	18-27
HBNW	1,748,869	6.11	2.46	52.95	47-54
NHB	1,006,548	3.51	1.42	30.47	22-31
Total	3,302,895	11.53	4.65	100	100
***Validation Target**	N/A	8.0 to 12.0	3.5 to 4.0		

Table 9 Trip Generation Results (* Source: NCHRP 365)

5. Trip Distribution

Trip distribution procedure determines the destination of the trips produces in each zone and distributes the trips to all other zones in the study area. The trip distribution model used by the GVMC model is based on the gravity model. The gravity model is based on Newton's Gravitational Law, e.g., the assumption that all trips starting from a given zone are attracted by various traffic generators in other zones and that this attraction is directly proportional to the attractiveness of the zone and inversely proportional to the separation between the zones in the gravity model. The measure of separation is generally accepted as the zone-to-zone travel time via the specified transportation network.

The gravity model data items include the number of trip purposes, normalized or balanced production and attraction trips by purpose developed in the trip generation model, friction factors by purpose, number of gravity model iterations and terminal and intrazonal times. Friction factors are the impedance related factors used within the gravity model equation to indicate the effect of separation between traffic zones.

The Gravity model equation is depicted below,

$$T_{ij} = \frac{P_i * A_j * K_{ij} * F_{ij}}{\sum A_j * F_{ij} * K_{ij}}$$

Where,

T_{ij} : Trip between zone i and j

P_i : Trip production in zone i

A_j : Trip attraction in zone j

F_{ij} : Friction factor for the travel time between zone i and zone j

K_{ij} : Socioeconomic adjustment factor

The friction factor in the model represents the magnitude of impedances in traffic flows between a TAZ and another. The friction factor table used in the GVMC model is borrowed from national default friction factor table (NCHRP Report 365, chapter 4, P65). The following Table 10

displays the initial friction factor used in the GVMC model. After trip distribution is done, friction factor should be adjusted based on the comparison between observed and modeled trip length distribution by trip purposes. The adjusted friction factor table for GVMC model is shown in Table 11.

Socioeconomic factors, or K-factors, account for social or economic linkages those impact travel behaviors that are not accounted for by the gravity model. But according to NGHRP Report 365, the use of K-factors is generally discouraged since K-factors represents characteristics of the population which change over time, therefore, the assumption that K-factors keep constant in the gravity model will cause a significant amount of error in predictions of future trip distributions.

Terminal times represent the average time required for a person travelling to and or from their vehicle to the front door of their origin or destination. The intrazonal time is the average time required to travel from the edge of a TAZ to the origin or destination within the TAZ. Terminal time is usually linked to an area type definition. GVMC staff developed the terminal time data file based on the above concept and on the familiarity with the study area. The intrazonal travel time is often calculated with the nearest zone concept divided by 2. The GVMC TransCAD model calculates the intrazonal travel times internally.

In addition, there is a general requirement to apply the gravity model in an interactive fashion until trip attractions are adjusted to match a relative attractiveness of each traffic zone. This data item simply defines the number of iteration considered to be satisfactory to achieve this even balance between trip attractions and trips attracted. The GVMC model typically uses 20 iterations.

Friction Factors							
Travel Time(min)	HBW	HBNW	NHB	Travel Time(min)	HBW	HBNW	NHB
1	25214	126632	198293	**31**	592	90	102
2	21990	47295	71303	**32**	523	79	89
3	19291	25562	37607	**33**	462	69	77
4	16963	16072	23203	**34**	409	60	67
5	14936	10979	15601	**35**	361	53	58
6	13161	7904	11075	**36**	319	47	51
7	11605	5900	8163	**37**	282	41	44
8	10236	4522	6184	**38**	249	36	39
9	9032	3537	4784	**39**	221	32	34
10	7972	2811	3763	**40**	195	28	30
11	7037	2263	2999	**41**	172	25	26
12	6213	1841	2417	**42**	152	22	23
13	5486	1511	1966	**43**	135	19	20
14	4845	1250	1612	**44**	119	17	18
15	4280	1041	1331	**45**	105	15	15
16	3780	872	1105	**46**	93	13	14
17	3339	734	923	**47**	82	12	12
18	2950	620	774	**48**	73	10	10
19	2607	527	652	**49**	64	9	9
20	2303	449	551	**50**	57	8	8
21	2035	383	467	**51**	50	7	7
22	1798	329	397	**52**	44	6	6
23	1589	282	339	**53**	39	6	6
24	1404	243	290	**54**	35	5	5
25	1241	210	248	**55**	31	4	4
26	1097	182	213	**56**	27	4	4
27	969	158	184	**57**	24	4	3
28	857	137	158	**58**	21	3	3
29	757	119	137	**59**	19	3	3
30	669	104	118	**60**	17	3	2

Table 10 Friction Factor Table (Source: NCHRP Report 365)

Friction Factors							
Travel Time(min)	HBW	HBNW	NHB	Travel Time(min)	HBW	HBNW	NHB
1	27735	177284	277610	**31**	538	64	72
2	24189	66213	99824	**32**	475	56	63
3	21220	35786	52649	**33**	419	49	55
4	18659	22500	32484	**34**	371	42	47
5	16429	15370	21841	**35**	328	37	41
6	14477	11065	15504	**36**	290	33	36
7	12765	8260	11428	**37**	256	29	31
8	11259	6330	8657	**38**	226	25	27
9	9935	4951	6697	**39**	200	22	24
10	8769	3935	5268	**40**	177	20	21
11	7740	3168	4198	**41**	156	17	18
12	6834	2577	3383	**42**	138	15	16
13	6034	2115	2752	**43**	122	13	14
14	5329	1750	2256	**44**	108	12	12
15	4708	1457	1863	**45**	95	10	10
16	4158	1220	1547	**46**	84	9	10
17	3672	1027	1292	**47**	74	8	8
18	3245	868	1083	**48**	66	7	7
19	2867	737	912	**49**	58	6	6
20	2533	628	771	**50**	51	5	5
21	1849	273	333	**51**	45	5	5
22	1634	235	283	**52**	40	4	4
23	1444	201	242	**53**	35	4	4
24	1276	173	207	**54**	31	3	3
25	1128	150	177	**55**	28	2	2
26	997	130	152	**56**	24	2	2
27	880	112	131	**57**	21	2	2
28	779	97	112	**58**	19	2	2
29	688	85	97	**59**	17	2	2
30	608	74	84	**60**	15	2	1

Table 11 Adjusted Friction Factor Table

The output results of trip distribution model are person trips by purpose. It is necessary to convert person trips to vehicle trips based on auto occupancy, and therefore the vehicle trips can be assigned to highway network. As shown in Table 12, data of auto occupancy by purpose in GVMC model is provided by MDOT based on Michigan Travel Counts in 2005.

Trip Purpose	Auto Occupancy
HBW	1.05
HBNW	1.54
NHB	1.43

Table 12 Auto Occupancy

The final output results of trip distribution are shown in Table 13,

Trip Purpose	Personal Trips	Vehicle Trips	Estimated Average Travel Time(min)	Observed Average Travel Time(min)
HBW	547,478	521,408	20.06	21
HBNW	1,748,869	1,135,629	17.36	
NHB	1,006,548	703,879	16.73	
Total	3,302,895	2,367,291		N/A

Table 13 Trip Distribution Output Results

Figure 10 shows the trip length distribution for each trip purpose. The distribution indicates that the trip types of Home Based Non-Working and Non-Home Based reach peak percentage at about 15 minute trip length, while the Home based work peaks at about 20 minute trip length.

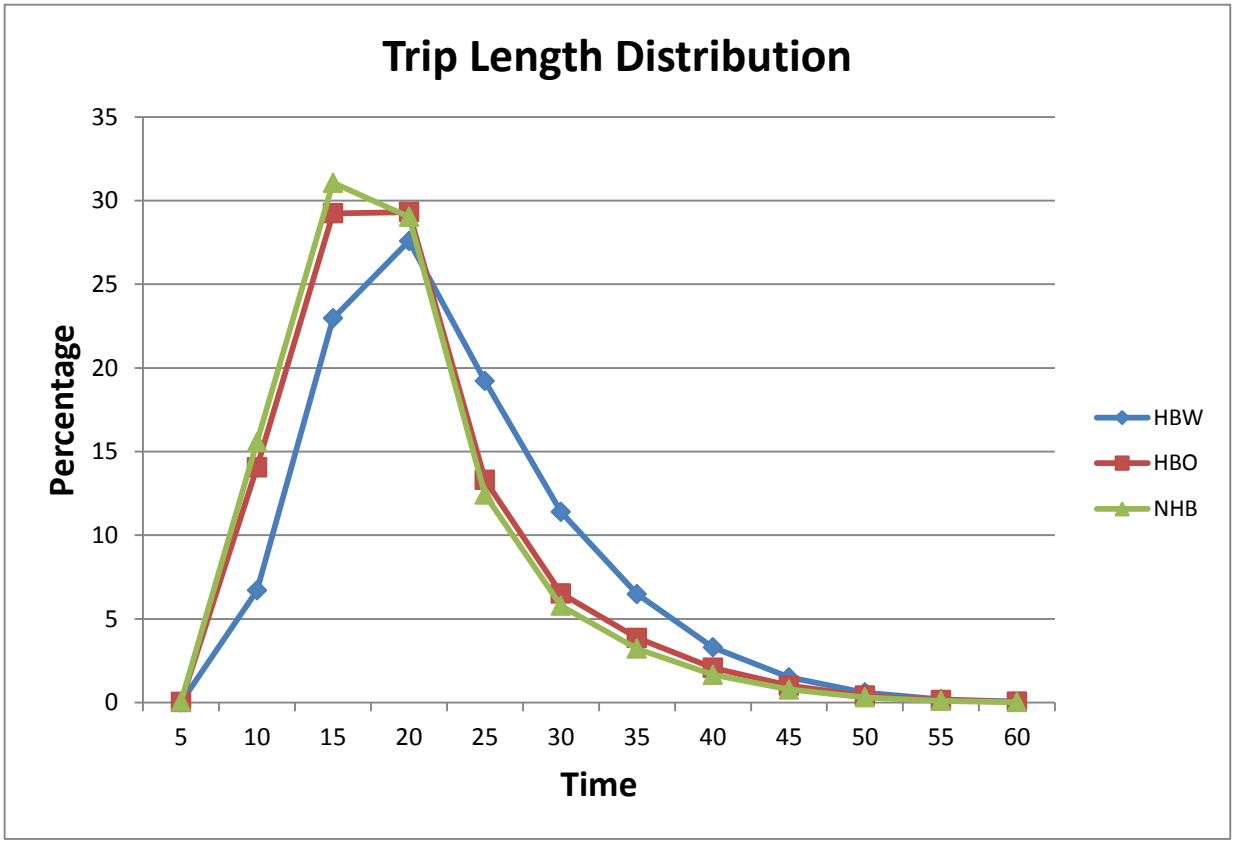


Figure 10 Trip Length Distribution by Purpose

6. Trip Assignment

Using the TransCAD model five different assignment methods are available to choose from. The first methods an all or nothing assignment that assigns all vehicle trips between two zones in a trip table to the links in the highway network comprising of a single minimum path. Assignments using this method do not account for delay caused by limited capacity due to congestion on the links comprising the minimum time path. This method is not appropriate in congested areas.

The second method is the capacity restraint assignment which attempts to balance the assigned volumes with links capacity and speed coded within the highway network. This method is an iterative procedure in which links speed is adjusted based on a speed volume curve.

The third method is an incremental loading technique, which is similar to the capacity restraint assignment. This method will load trips onto the highway network incrementally according to specific percentages set by the user. Link speeds are also adjusted based on the BPR curve.

The fourth method is the stochastic highway load which performs a probabilistic multi-path traffic assignment. Trips are assigned on the highway network to all "reasonable" paths between each origin and destination, each path receiving a fraction of the interzonal trips.

The fifth method is equilibrium assignment which is based on similar concepts used by methods 1, 2, and 3. In an equilibrium assignment there are usually several equally good paths through the highway network for each origin/destination pair. These extra paths help produce a more accurate assignment. The existence of an extra path helps tone down the wide fluctuations in the assignment due to changes in speed. A small change in speed will result in an appropriately small change in assigned volume.

The equilibrium assignment method is used in the GVMC model because of the advantages it has over the other methods; especially in a large network where congestion exists. Equilibrium assignment is an iterative process and requires many iterations to converge. It is recommended that at least 3 iterations be used for convergence. The GVMC model uses 20 iterations.

The trip assignment model data items include daily origin-destination vehicle trip table, which is the output result from the trip distribution procedure; and the highway network with significant link attributes such as link free-flow travel time, working travel time, link capacity, number of lanes, and area type. In addition, different volume-delay parameters can be selected in trip assignment process, where the default numbers are set to 0.15 and 4, respectively. The GVMC staff chose 0.1 and 3.3 as these two parameters to get better assignment results. The output results from the trip assignment model include assigned volumes on each link in the network, vehicle miles of travel (VMT), and vehicle hours of travel (VHT).

Table 14 below summarizes the differences of observed and modeled VMT by functional classification. In this table, % difference represents the percentage difference between count VMT and modeled VMT. This comparison shows that all functional classifications are within the

validation targets, with the total VMT over-estimated by 1.14% only. Overall this comparison is very reasonable.

Functional Class	2010 Modeled VMT	2010 Observed VMT	% Difference	FHWA Target (%)	MDOT Target (%)
Urban Interstate(11)	2,560,060	2,644,001	-3.17	7	6
Urban Freeway(12)	2,498,195	2,646,562	-5.61	7	6
Urban Principal Arterial (14)	4,069,976	3,961,808	2.73	10	7
Urban Minor Arterial (16)	3,722,001	3,698,093	0.65	15	10
Urban Collector(17)	1,284,760	1,201,639	6.92	25	20
Rural Interstate(1)	577,445	602,358	-4.14	7	6
Rural Freeway(2)	176,541	186,561	-5.37	7	6
Rural Minor Arterial(6)	820,379	754,019	8.8	15	10
Rural Major Collector(7)	1,144,080	954,484	19.86	25	20
Rural Minor Collector(8)	99,832	84,923	17.56	25	20
Total	16,953,269	16,734,448	1.31	5	5

Table 14 Observed and Estimated VMT by Functional Classification

Table 15 presents a comparison of observed and modeled traffic volumes by functional classifications. The comparison shows that most of functional classifications are within target, except urban freeway and rural interstate are under-estimated by 10.22 and 15.83, respectively.

Functional Class	**2010 Modeled Volume**	**2010 Observed Volume**	**% Difference**	**FHWA Target (%)**	**MDOT Target (%)**
Urban Interstate(11)	5,436,613	5,380,380	1.05	7	6
Urban Freeway(12)	4,615,588	4,425,938	4.28	7	6
Urban Principal Arterial (14)	47,037,930	46,529,574	1.09	10	7
Urban Minor Arterial (16)	29,901,451	30,099,294	-0.66	15	10
Urban Collector(17)	7,637,643	7,768,194	-1.68	25	20
Rural Interstate(1)	292,353	274,884	6.36	7	6
Rural Freeway(2)	116,191	104,024	11.7	7	6
Rural Minor Arterial(6)	2,497,260	2,382,842	4.8	15	10
Rural Major Collector(7)	3,694,283	3,640,495	1.48	25	20
Rural Minor Collector(8)	296,893	257,524	15.29	25	20
Total	101,526,205	100,863,147	0.66	5	5

Table 15 Observed and Estimated Daily Volumes by Functional Classification

Table 16 summarizes a comparison of observed and modeled traffic volumes by volume group. The result also shows a reasonable comparison based on the MDOT and FHWA targets.

Volume Group	**Traffic Counts**	**Model Volume**	**Absolute Difference**	**Percent Difference**	**MDOT Target**	**FHWA Target**
<1000	236,218	481,228	245,010	103.72	200%	60%
1000-2500	1,328,584	2,231,968	903,384	68	100%	47%
2500-5000	5,635,702	6,940,490	1,304,788	23.15	50%	36%
5000-10000	17,350,208	17,565,798	215,590	1.24	25%	29%
10000-25000	51,461,881	47,052,240	-4,409,641	-8.57	20%	25%
25000-50000	23,407,485	23,793,622	386,137	1.65	15%	22%
>50000	2,471,062	2,154,834	-316,228	-12.8	10%	21%
Total	101,891,140	100,220,180	-1,670,960	-1.64		5%

Table 16 Observed and Estimated Daily Volumes by Volume Group

Table 17 presents a comparison of observed and modeled traffic volumes by area type.

Area Type	**Traffic Counts**	**Model Volume**	**Absolute Difference**	**Percent Difference**	**Target**
CBD	7,774,591	6,654,579	-1,120,012	-9.74	10%
Fringe Area	18,781,533	18,817,742	36,209	-3	10%
Residential Area	30,337,396	29,008,094	-1,329,302	-5.44	10%
Outlying Business District	23,716,354	25,220,743	1,504,389	-0.71	10%
Rural Area	20,860,991	22,683,582	1,822,591	8.64	10%
Total	101,470,865	102,384,740	913,875	-1.36	5%

Table 17 Observed and Estimated Daily Volumes by Area Type

The process for trip assignment calibration includes the steps shown in the following Figure 11,

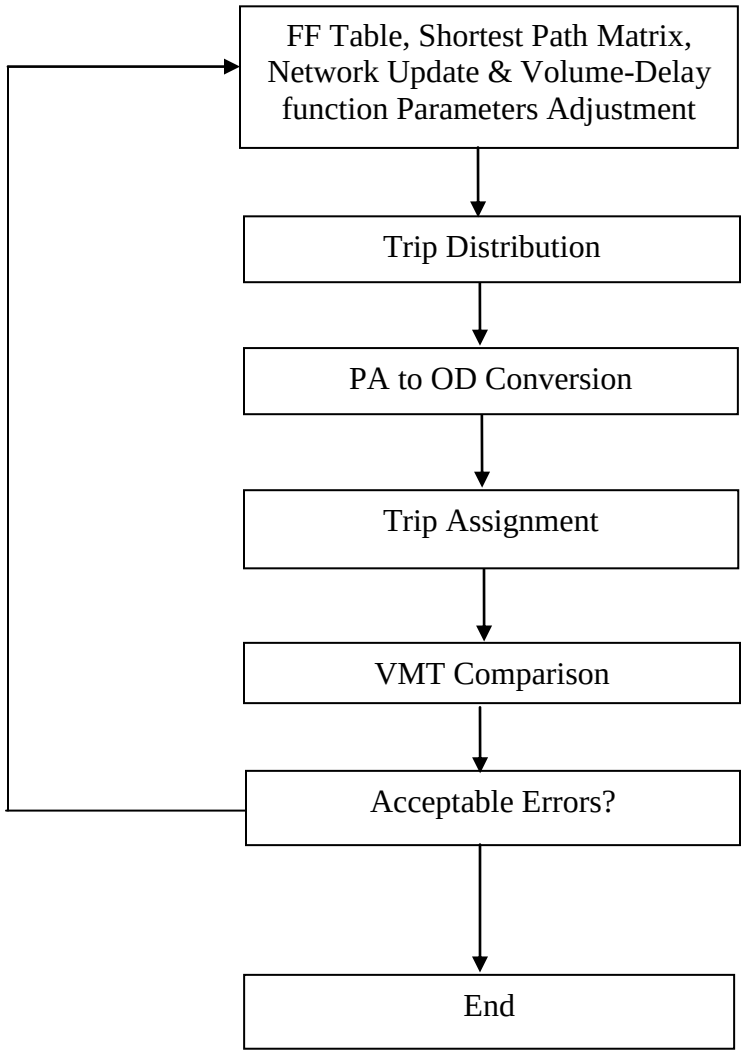
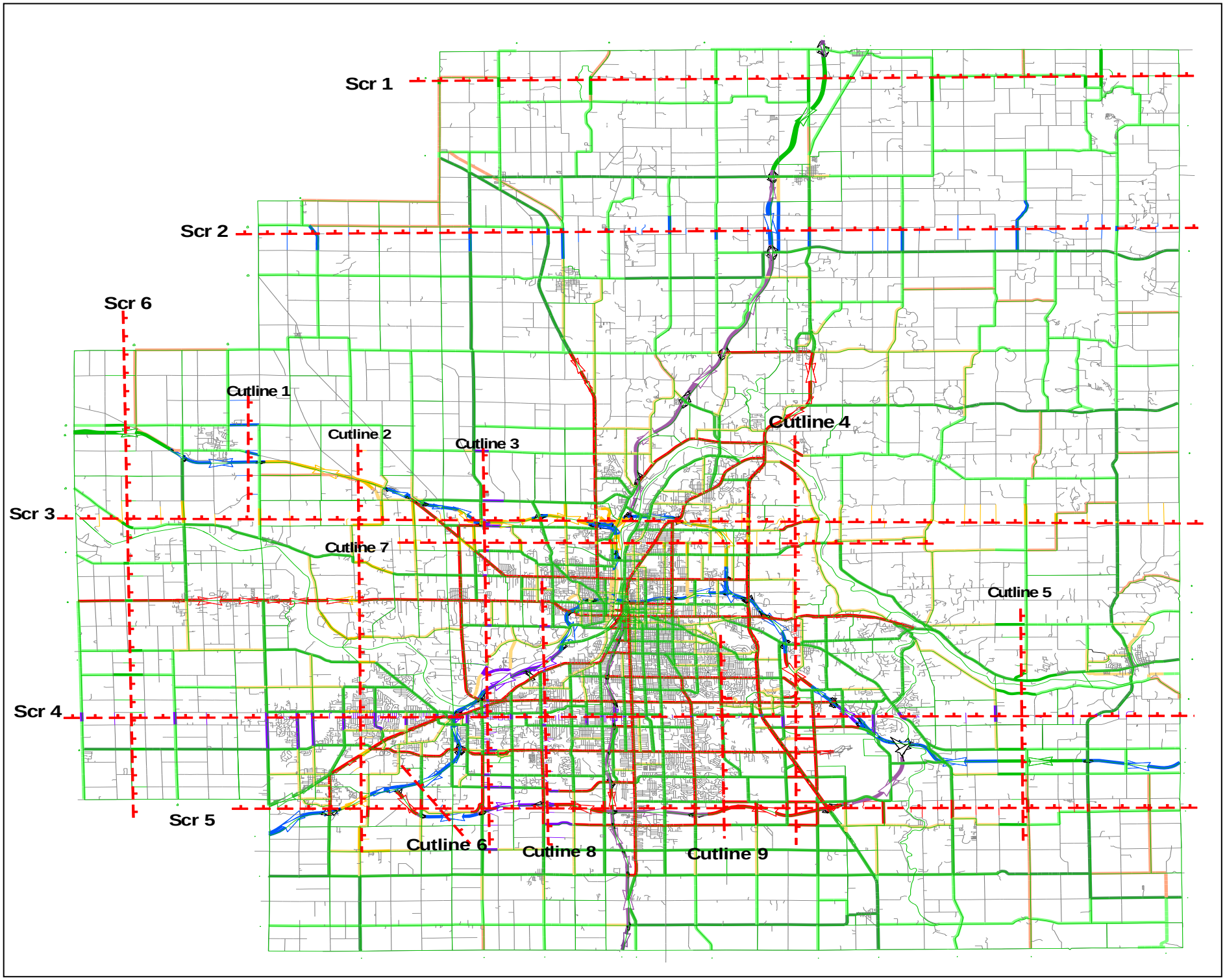


Figure 11 Trip Assignment Calibration and Validation Process

7. Screenline/Cutline Analysis

A screenline is an imaginary line which is related to physical barriers such as rivers, railroads, or major roadways. The traffic volume crossing that line is then compared with observed traffic counts. A cutline is a short screenline which provides traffic volumes in the model for specific corridors. Screen/Cutline analysis is used in model calibration and validation to identify the reasonableness of distributed trips across the network. Six screenlines and 9 cutlines, which are shown in the following page, are selected to analyze whether the traffic volumes in the model are

within acceptable calibration ranges. The result shown in Table 18 indicates that the total assigned traffic flows for these routes match well with the total traffic counts.


Scr 1
Scr 2
Scr 3
Scr 4
Scr 5
Scr 6
Cutline 1
Cutline 2
Cutline 3
Cutline 4
Cutline 5
Cutline 6
Cutline 7
Cutline 8
Cutline 9

NO.	Screenline/Cutline	Total Flow	Total Count	Difference (%)	Target (%)
1	ScreenLine 1	41,349	40,860	1.2	5
2	ScreenLine 2	88,305	90,931	2.9	5
3	ScreenLine 3	592,168	600,731	1.4	5
4	ScreenLine 4	549,239	541,088	1.5	5
5	ScreenLine 5	454,806	450,288	1.0	5
6	ScreenLine 6	71,106	65,116	9.2	5
7	Cutline 1	39,937	43,518	8.2	10
8	Curline 2	208,871	189,890	10	10
9	Cutline 3	338,397	312,380	8.3	10
10	Curline 4	326,134	310,627	5	10
11	Cutline 5	59,021	64,594	8.6	10
12	Curline 6	79,452	80,183	1.0	10
13	Cutline 7	310,339	299,379	3.7	10
14	Curline 8	274,569	250,036	9.8	10
15	Cutline 9	216,947	208,221	4.2	10

Table 18 Screenline Analysis Result

8. Summary

The primary goal of the model calibration is to replicate existing traffic conditions for the base year, and then determine deficiency list for current and future planning. The model result can be used to develop Congestion Management Process as well as Long Range Transportation Planning. As the analysis indicates, the GVMC model accomplishes this with a high level of accuracy. Based upon the calibration results presented in this report, GVMC believes that the model is fully calibrated and will serve as an accurate tool for highway transportation planning within the study area for the future years.