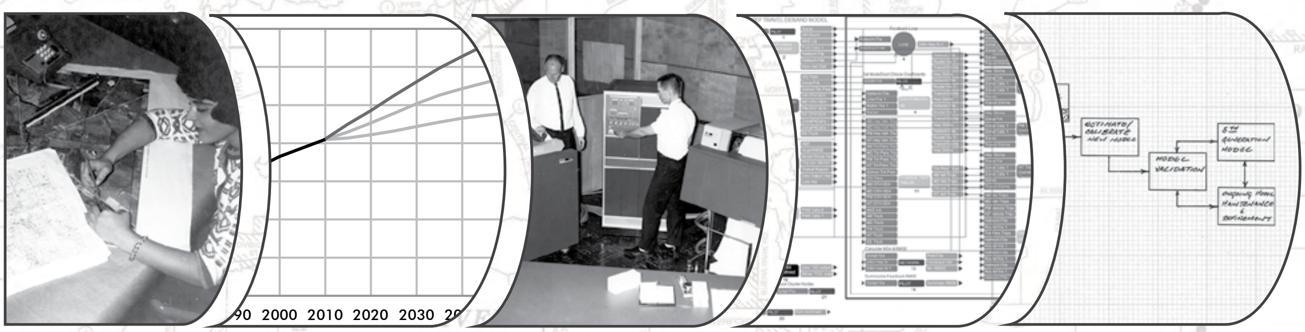
TECHNICAL REPORT NO. 51

TRAVEL SIMULATION MODELS OF SOUTHEASTERN WISCONSIN



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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One Region, Focusing on Our Future

TECHNICAL REPORT
NUMBER 51

TRAVEL SIMULATION MODELS OF SOUTHEASTERN WISCONSIN

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1 INTRODUCTION

Credit: SEWRPC Staff

Transportation plans prepared without quantitative test and evaluation are little more than policy driven, intuitively created street patterns and transit networks. Unless transportation system plans are subject to quantitative test and evaluation including preparation of forecasts of the amount of travel and traffic the transportation system may be expected to carry, the adequacy of the plans to meet existing and future travel needs remains in doubt.

Two basic principles upon which the Commission's regional transportation planning is based are as follows:

- Highway facilities, transit facilities, bicycle and pedestrian facilities and travel demand and transportation systems management measures should be planned together. Transit facilities, bicycle and pedestrian facilities, and travel demand and transportation systems management measures have the potential to affect, and reduce future highway traffic and improvement needs. Their potential to address highway traffic volume and congestion should be quantitatively tested and determined, and highway improvements should then be considered to address highway traffic and congestion that is not expected to be alleviated by transit facilities, bicycle and pedestrian facilities, or travel demand and transportation systems management measures.
- Highway facilities should be planned as an integrated system, as should transit facilities. The capacities of each link in each system should be carefully fitted to travel or traffic loads, and the effects of each proposed facility on the remainder of the system should be quantitatively tested.

These principles require the quantitative testing and evaluation of alternative transportation system plans, through the development and application of travel simulation models.

BASIC CONCEPTS OF TRAVEL SIMULATION MODELS

The simulation of existing and future travel demand through travel simulation models is a complex procedure requiring development and application of a variety of mathematical and statistical techniques. The simulation of travel and traffic is based upon the premise that the magnitude and pattern of travel is a stable function of the characteristics of the land use pattern and of the transportation system, with the term land use broadly referring not only to land use type and intensity, but also to population, household, and employment levels and characteristics. In travel simulation modeling, those aspects and characteristics of the land use pattern and of the highway and public transit system that affect the magnitude and distribution of travel demand are identified, quantified, and correlated through the analysis of detailed travel, land use, and transportation system survey data. It has been demonstrated that the relationships between travel and land use and transportation system characteristics remain reasonably stable over time, thus enabling the forecast of future travel and traffic patterns based upon postulated future land use patterns and transportation system configurations.

Typically, the sequence of travel simulation occurs in four steps, although there are variations that include additional steps such as time-of-day of travel, and models that combine some steps, or combine all steps into a single model:

1. Trip generation, in which the total number of trips generated in each subarea of the planning area for the time period under analysis is determined by using relationships between land use and travel established by analyses of the land use and travel inventory data. The output from this step is the total number of trip ends, that is, trips entering and leaving each subarea of the study area.
2. Trip distribution, in which the trips generated in each subarea are linked with trip ends in other subareas, thereby defining the universe of trips by point of origin and point of destination. The output from this step is the number of trips made between each subarea pair.
3. Modal choice, in which the number of trips between each subarea pair is divided among the travel modes, primarily public transit and automobile. The output of this step is the number of trips made between each subarea pair by each mode.
4. Traffic assignment, in which the subarea transit trips are assigned to existing or proposed alternative transit system networks and the subarea vehicle trips are assigned to existing or proposed alternative arterial street and highway facility networks. The output of this step is the number of people utilizing the routes and facilities of the existing or proposed public transit system and the number of vehicles utilizing each segment of the existing or proposed public transit and arterial street and highway systems.

The result of the four-step travel simulation process is a complete description of the use of an existing or proposed transportation system consisting of both arterial streets and highways and transit lines.

PURPOSE OF THIS REPORT

The purpose of this report is to document the revalidation of Commission fourth-generation travel simulation models, the recommendations of a peer review conducted of the Commission's fourth-generation travel simulation models, and the development, calibration and validation of the fifth-generation travel simulation models. The fifth-generation travel simulation models were developed based on the recommendations of the peer review and utilizing the fifth household, truck, external cordon, and public transit travel surveys conducted by the Commission in 2011 and 2012. Following this introductory chapter, Chapter 2 of this report presents the history of travel simulation models of Southeastern Wisconsin and provides the description and validation of the fourth-generation travel simulation models. Chapter 3 documents the results of a peer review conducted by the Commission on December 18, 2014, and the potential improvements to the Commission's current model considered during the development of the fifth-generation travel simulation model. Chapter 4 describes the Commission's new fifth-generation travel simulation models. Chapter 5 provides a summary of the model development and some potential short- and long- term improvements to be considered as part of the ongoing model maintenance and refinement activities carried out by the Commission.

HISTORY OF AND VALIDATION OF FOURTH-GENERATION TRAVEL SIMULATION MODELS

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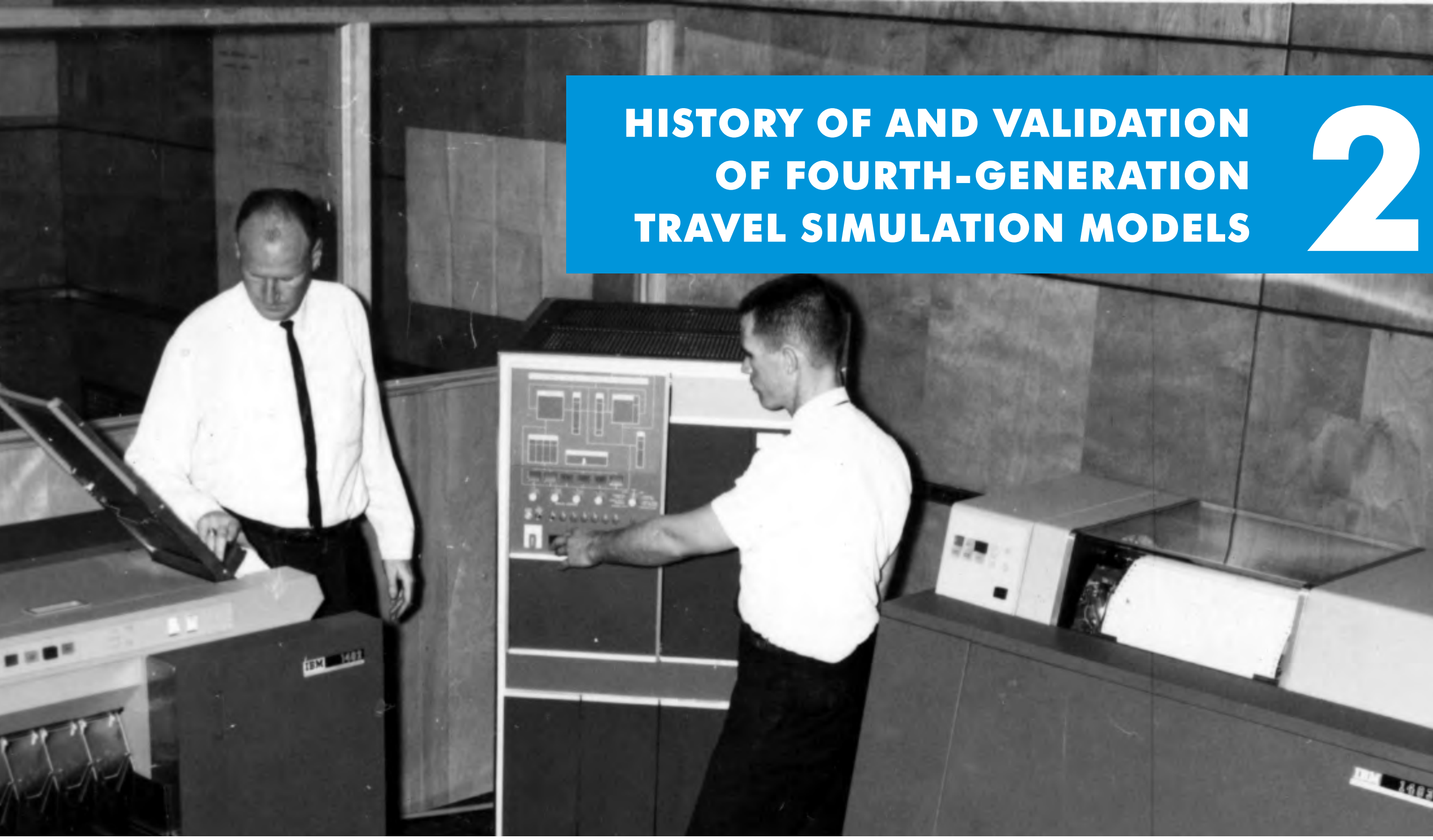

Credit: SEWRPC Staff

FIRST–GENERATION TRAVEL SIMULATION MODELS

About 55 years ago, travel simulation models were first developed and applied in transportation planning. The first time that travel simulation models were developed and applied on a regional scale in Wisconsin was over 50 years ago during the initial regional land use-transportation planning study for Southeastern Wisconsin conducted by the Commission in the early to mid-1960s.[1] The first-generation travel simulation models were developed by using an extensive data base developed from land use, socio-economic, and travel inventories conducted by the Commission. A massive travel survey was conducted in the late spring of 1963 to obtain data describing the amount, kind, and distribution of travel occurring throughout the Region on an average weekday and the characteristics of the tripmakers. Three separate travel surveys were conducted, including a resident household travel survey, a resident truck travel survey, and an external travel survey. The resident household travel survey was the largest of the surveys, providing an inventory of the travel habits and patterns and socio-economic characteristics of over 20,000 households, or about 4 percent of the Region's households. The truck travel survey provided an inventory of the travel of over 7,500 commercial trucks, or over 12 percent of the Region's registered commercial trucks. In the external travel survey, nearly 75,000 of the 101,500 vehicles crossing the boundaries of the Region, or about 74 percent, were stopped and interviewed. The extensive travel inventory data were combined for the purposes of travel model development with 1963 land use inventory data and 1960 U.S. Census data on population and housing.

[1] *See SEWRPC Planning Report No. 7,* The Regional Land Use-Transportation Study, *Volume Two,* Forecasts and Alternative Plans: 1990.

The development of the Commission's original design year 1990 regional transportation system plan was in part based upon quantitative analyses of the performance of alternative highway and transit systems permitted by the battery of travel simulation models developed under that study. This first generation battery of travel simulation models was subsequently applied in detailed jurisdictional highway planning studies for each of the seven counties in the Region, freeway and other arterial highway location and design studies, a preliminary engineering study of a busway in the Milwaukee east-west corridor, and other transportation studies.

SECOND–GENERATION TRAVEL SIMULATION MODELS

As part of the preparation of the design year 2000 second generation regional transportation plan in the 1970s, this initial battery of Commission travel simulation models was reviewed and refined.[2] This review and refinement of the initial models was possible because the Commission conducted a new regional inventory of travel in 1972. The 1972 surveys included all the basic origin-destination surveys conducted in 1963, including household, truck, and external travel surveys, and also a public transit user survey. The household travel survey included 17,500 households, or about 3 percent of the Region's households. About 5 percent of all commercial trucks registered within the Region were surveyed under the truck travel inventory. In the external travel survey, interviewers at roadside stations stopped and interviewed about 80,300 of the 130,300 motor vehicles crossing the Region's boundaries, or about 59 percent. About 25 percent of all weekday transit riders, representing about 50,000 transit trips, were surveyed under the transit travel survey. Land use and employment data for the Region were also updated to the year 1970 and 1970 U.S. Census data was collated and analyzed, as was done in 1963, for use in the review and refinement of the models. These refinements included increasing the number of traffic analysis zones in the Region from 619 to 1,220 zones; use of cross-classification in place of linear regression for trip production forecasting; use of a post-trip distribution logit mode choice model in place of a pre-trip distribution regression equation mode choice model; calibration of trip production and mode choice models with household rather than zonal data; and development of a vehicle ownership forecasting model.

The first step in this model review and refinement process consisted of an analysis of the adequacy to predict actual 1972 travel of the original travel simulation model battery and of each individual model developed in the initial study. The Commission's original travel simulation models, calibrated using 1963 home interview survey data, were shown through this testing to estimate accurately travel and traffic in Southeastern Wisconsin in 1972. This successful testing of the initial study procedures constituted an important validation of the accuracy of those procedures. The testing included a test of each individual model, as well as a comparison of the final model estimate of transit ridership and highway traffic to actual counts of transit ridership and highway traffic. Although the validity of the initial study procedures was proven through these analyses, an investigation of alternative modeling strategies was conducted and, as applicable, refined techniques were incorporated into a second-generation battery of travel simulation models.

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[2] *See SEWRPC Planning Report No. 25,* A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, *Volume Two,* Alternative and Recommended Plans, 1978.

This refined second-generation battery of travel simulation models was used in the design year 2000 regional land use-transportation plan reevaluation effort completed in 1978, and in several short- and long-range highway and transit planning studies. One such study that involved extensive application of travel simulation models was the areawide rapid transit system planning study completed in 1982, which extensively evaluated alternative rapid transit systems for the Milwaukee area.[3] Another such study that involved extensive application of the models was the Northwest Corridor Rapid Transit Study, an in-depth analysis of light-rail and express bus alternatives in the corridor that constituted a transit alternatives analysis under the review of the Federal Transit Administration.[4]

THIRD–GENERATION TRAVEL SIMULATION MODELS

As part of the preparation of the third-generation design year 2010 regional transportation plan in the early 1990s, the refined second generation battery of Commission travel simulation models was reviewed and refined.[5] A third regional inventory of travel was conducted in the fall of 1991 and spring of 1992. The 1991-1992 survey included all the basic travel surveys conducted in 1972, including household, truck, external cordon, and public transit travel surveys. The household travel and public transit user surveys were conducted in the fall of 1991; the external and truck travel surveys were conducted in the spring of 1992. The household survey involved about 17,500 households, or about 2.5 percent of the Region's households. About 5 percent of all commercial trucks within the Region were sampled under the truck survey. In the external travel survey, interviewers at roadside stations stopped and distributed postal card interview forms to about 160,000 of the 230,000 motor vehicles crossing the Region's boundaries. Approximately 30 percent of the vehicles surveyed returned the survey forms, providing about a 20 percent sample. About 10 percent of average weekday transit riders or over 15,000 transit riders were surveyed. Land use and employment data for the Region were updated to the year 1990 and 1990 U.S. Census data was collated and analyzed for use in the review and refinement of the models.

The first step in the travel model review and refinement process again consisted of an analysis of the adequacy of the travel simulation model battery and of each individual model to predict actual current year 1991 travel. The Commission's second-generation travel simulation models, developed in the early 1970s with 1972 data, were shown through this testing, to estimate accurately travel in Southeastern Wisconsin in 1991—nearly 20 years later. This successful testing of the travel modeling procedures constituted an important validation of the accuracy of those procedures. Although the validity of the second-generation travel modeling procedures developed in the mid-1970s was proven through these analyses an investigation of alternative modeling strategies was again conducted and, as applicable, refined techniques were incorporated into a refined battery of travel and traffic simulation models. These refinements included increasing the number of traffic analysis zones in the Region from 1,220 to 1,431; use of trip rates

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[3] *See SEWRPC Planning Report No. 33,* A Primary Transit System Plan for the Milwaukee Area, *June 1982.*

[4] *See SEWRPC Community Assistance Planning Report No. 150,* A Rapid Transit Facility Plan for the Milwaukee Northwest Corridor, *January 1988, and the* Milwaukee Northwest Corridor Rapid Transit Study, *Report No. 2, "Travel Simulation Models," 1986.*

[5] *See SEWRPC Planning Report No. 41,* A Regional Transportation System Plan for Southeastern Wisconsin: 2010*, 1994.*

in place of linear regression equations for person trip attraction forecasting; the inclusion of travel cost in addition to travel time in the gravity model used for trip distribution forecasting; the development of a mode choice model for work trips that would forecast choice between public transit, drive alone, and shared ride alternatives; use of a vehicle occupancy model based on cross-classification; and development of alternative means to forecast peak hour and period travel as well as travel by time period of the day.

This refined third-generation battery of travel simulation models was used in the Kenosha-Racine-Milwaukee corridor commuter rail transit alternatives analysis, the Milwaukee east-west corridor study, the regional freeway system reconstruction study, and the update and extension of the regional transportation plan to the year 2020. The models were also applied several times throughout the 1990s and early 2000s to demonstrate the conformity of the regional transportation plan and improvement program to the State of Wisconsin implementation plan to attain ozone national ambient air quality standards (NAAQS).[6] Due to designated air quality nonattainment and maintenance areas being designated within Southeastern Wisconsin, the Commission's travel simulation models must be used to provide air quality conformity demonstrations within Southeastern Wisconsin and meet a higher level of requirements, described in Federal regulations, than metropolitan planning organizations meeting the national ambient air quality standards. These demonstrations are subject to review and approval by the U.S. Department of Transportation. The U.S. Department of Transportation reviewed the Commission's travel simulation models and modeling process in 1997, and concluded that the Commission's third-generation battery of travel simulation models substantially met the Federal requirements for travel simulation modeling.

FOURTH–GENERATION TRAVEL SIMULATION MODELS

As part of the preparation of the fourth-generation design year 2035 regional transportation plan in the early 2000s, the refined third-generation battery of Commission travel simulation models was reviewed and refined.[7]A fourth regional inventory of travel was conducted in the fall of 2001 and spring of 2002. The 2001-2002 survey included all the basic travel surveys conducted in 1991-1992, including household, truck, external cordon, and public transit travel surveys. The household survey conducted in fall 2001 involved about 17,000 households, or over 2 percent of the Region's households. About 2,000 commercial trucks within the Region were sampled under the truck survey conducted in spring 2002. In the external travel survey, conducted in spring 2002, about 150,000 of the 350,000 vehicles crossing the region's boundaries were surveyed, with 20 percent of the vehicles surveyed returning survey forms, providing about a 10 percent sample. About 7 percent of weekday public transit riders or over 10,000 transit riders were surveyed in spring 2002. Land use and employment data were updated to the year 2000 and year 2000 U.S. Census data was collated for use in model development and application.

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[6] *Currently within Southeastern Wisconsin, Kenosha County east of IH 94 is designated as a 2008 ozone NAAQS nonattainment area and the three counties of Milwaukee, Racine and Waukesha are in maintenance for the 2006 24-hour fine particulate NAAQS ($PM_{2.5}$).*

[7] *See SEWRPC Planning Report No. 49,* A Regional Transportation System Plan for Southeastern Wisconsin: 2035, *2006.*

The first step in the travel model review and refinement process again consisted of an analysis of the adequacy of the travel simulation model battery and of each individual model to predict actual current year 2001 travel. The Commission's third-generation travel simulation models, developed in the early 1990s with 1991-1992 data, were shown through this testing to estimate accurately travel in Southeastern Wisconsin in 2001. This successful testing of the travel modeling procedures constituted an important validation of the accuracy of those procedures. Although the validity of the third-generation travel modeling procedures developed in the mid-1990s was proven through these analyses, an investigation of alternative modeling strategies was again conducted and, as applicable, refined techniques were incorporated into a refined battery of travel and traffic simulation models. These refinements included increasing the number of traffic analysis zones in the Region from 1,431 to 2,374; inclusion of non-motorized travel in trip generation; stratification of trip generation based on density of development; and development of a nested logit home-based work mode choice model.

This refined fourth-generation battery of travel simulation models was used in the Zoo Interchange study, IH 94 East-West corridor study, IH 43 North-South corridor study and corridor studies for several state, county, and local arterial facilities. The models were also applied several times throughout the 2000s and early 2010s to demonstrate the conformity of the year 2035 regional transportation plan and transportation improvement program, to assist in the development of the State of Wisconsin implementation plan to attain ozone air quality standards, and in the development of a maintenance plan for the $PM_{2.5}$ standard.

VALIDATION OF FOURTH-GENERATION TRAVEL SIMULATION MODELS

As part of the preparation of the fifth-generation design year 2050 regional transportation plan, the fourth-generation battery of Commission travel simulation models was reviewed. The review of the fourth-generation models and the development of the fifth-generation models was made possible by a fifth regional inventory of travel, which was conducted in 2011 and 2012. The 2011 and 2012 survey included all the basic surveys conducted in 1963, 1972, 1991, and 2001 including household, truck, public transit, and external travel surveys. The household survey conducted in the Spring and Fall of 2011 involved about 15,400 households, or approximately 2 percent of the Region's households. About 640 commercial trucks within the Region were sampled under the truck survey conducted in Spring 2012. In the external travel survey conducted in 2011 and 2012, about 162,000 of the 385,000 vehicles crossing the region's boundaries were surveyed, with approximately 12 percent of the vehicles surveyed returning survey forms, providing about a 5 percent sample. About 4 percent of weekday public transit riders or over 7,500 transit riders were surveyed in Spring 2012. Land use and employment data were updated to the year 2010 and year 2010 U.S. Census data was collated for use in model development and application. The calibration and development of the Commission's fifth-generation travel simulation model is discussed in Chapter 4 of this report.

The remaining sections of this chapter are devoted to the description, in summary form, of the Commission's current fourth-generation travel simulation models, and present the results of a review of the ability of the fourth-generation models developed and calibrated in the early 2000s to predict actual year 2011 travel and traffic using year 2010-2011 land use and transportation system inputs. The fourth-generation models are described in detail in Chapter VI, "Travel Simulation Models", of SEWRPC Planning Report No. 49, A Regional Transportation System Plan for Southeastern Wisconsin: 2035.

CLASSIFICATION OF TRAVEL

The Commission's battery of travel simulation models, and indeed travel simulation models for all urban regions, are based upon a classification of the different components of travel within an urban region. This classification of travel is necessary because different types of trips exhibit different characteristics and, as a consequence, require different simulation techniques. In addition, some of these types of trips represent very small proportions of total travel in an urban region. The classification of trips and the determination of the relative proportion of total travel they represent allow travel simulation modeling resources to be focused on those types of trips that represent the greater proportions of travel.

As shown in Table 2.1, the first major division of trips for the fourth-generation travel demand models involves the distinction between internal and external trips. Internal trips are defined as those trips that have both ends within the Southeastern Wisconsin Region. External trips are defined as those trips that have one or both ends outside of the Region. As internal travel has consistently, since 1963, accounted for over 93 percent of the person and vehicle trips observed on an average weekday, the primary emphasis in the travel modeling process is on internal trips. External trips do, however, have important effects on the use of facilities in certain travel corridors, particularly near the boundaries of the Region.

Among internal travel a further classification is made between commercial truck and personal travel. The vast majority of total weekday internal travel—over 90 percent—belongs to the category of internal personal travel. Internal personal travel may be further classified into travel by resident households and group-quartered residents. Travel by group-quartered residents of the Region is separated for special consideration because of the unique travel habits and patterns exhibited by these people. Group-quartered residents are defined as those people residing in shelters, dormitories, convents, Huber law jail facilities, and similar group residences. Group-quartered person trips have consistently accounted for substantially less than 1 percent of the total travel within the Region since 1963.

The primary emphasis of travel simulation models in Southeastern Wisconsin and all urban regions is on internal resident household travel. These trips represent over 85 percent of total travel made within the Southeastern Wisconsin Region on an average weekday. This group of trips may be further subdivided by trip purpose. For the fourth-generation models, the trip purposes used were home-based work; home-based shopping; home-based other (excluding school); nonhome-based work and nonhome-based other (excluding school); and school trips. Home-based trips are defined as those trips having one end located at the residence of the tripmaker. The purpose of a home-based trip is thus determined by the nonhome end of the trip as either work, shopping, or other (including personal business, medical/dental, social/dining, recreation, and serving a passenger's purpose). Nonhome-based trips are defined as those trips having neither end located at the place of residence of the tripmaker and can be made for any purpose except school. Separate consideration of home-based and nonhome-based school trips is necessary because of the constraints imposed upon travel patterns by elementary, middle, and high school service area boundaries. Trips to and from all schools, elementary, middle,

Table 2.1
Trip Classification and Fourth-Generation Travel Simulation Model Procedure

Trip Classification					Simulation Model				
					Trip Generation				
Internal or External	Type of Travel	Tripmaker	Trip Purpose	Percent of Total Trips[a]	Production	Attraction	Trip Distribution	Modal Split	Traffic Assignment
Internal	Personal	Resident Households	Home-based work	21	Cross-classification analysis	Trip rate analysis	Gravity model	Logit analysis	Minimum path (24 hour and time period)
			Home-based shopping	11					
			Home-based other (excluding school)	28					
			Nonhome-based work and nonhome-based other (excluding school)	17					
			School	9	Factor existing total college and university person trip levels and adjust existing patterns			Logit analysis	
					Factor existing other school trip levels and adjust existing patterns by mode				
		Group-Quartered Residents	All	--[b]	Factor existing trip levels and adjust existing patterns by mode				
	Commercial Truck	Resident Trucks	All	8	Multiple Regression Analysis		Fratar Factor Model		
External	Personal and Commercial Truck	Resident and Non-Resident Personal Vehicles and Commercial Trucks	All	6	Factor existing trip levels		Fratar Factor Model		

Note: N/A indicates not applicable

[a] *Percentage of total travel based upon 2001 travel surveys.*

[b] *Substantially less than one percent.*

Source: SEWRPC

high, vocational, and technical schools, and colleges and universities, have consistently represented approximately 10 percent of all travel observed in the Region on an average weekday.

Table 2.1 also indicates the specific modeling techniques used for each type of trip in the Commission's fourth-generation travel simulation model battery. Following a discussion of the geographic aggregation system utilized in the Commission's fourth-generation battery of travel simulation models, each of the Commission's fourth-generation models will be described.

GEOGRAPHIC AGGREGATION SYSTEM

All travel simulation models are developed and/or applied by subarea of the region under study. The greater the degree of homogeneity of the land uses in the subareas and the closer the replication of subarea access to the transportation system, the better able the models are to accurately simulate actual travel and traffic.

The basic unit of geographic identification used by the Commission for the collection and analysis of land use, demographic, economic, and travel inventory data is the U.S. Public Land Survey quarter-section, consisting of an approximately one-half mile on a side rectilinear area containing approximately 160 acres. There are approximately 10,800 quarter-sections within the Region. The principal system of region subareas used in the fourth-generation travel simulation models was a system of 2,470 traffic analysis zones, composed of entire quarter-sections, combinations of quarter-sections, or groupings of city blocks smaller than a quarter-section – the latter principally in the Milwaukee, Racine, and Kenosha central business districts (CBDs). The traffic analysis zones, as shown on Map 2.1, range in area from 0.04 square mile in the Milwaukee central business district to 18 square miles in the more sparsely settled portions of the Region.

Aggregations of these traffic analysis zones are used from time-to-time for planning analysis purposes, such as travel pattern analysis. One such aggregation system of planning analysis areas is shown on Map 2.1. These analysis areas are intended to represent rational areas for comprehensive urban planning purposes and are generally intended to be composed of a number of "neighborhoods" grouped to form "communities," which may consist of smaller minor civil divisions—cities, villages, and towns—groupings of the smallest minor civil divisions, or subareas of the larger minor civil divisions.

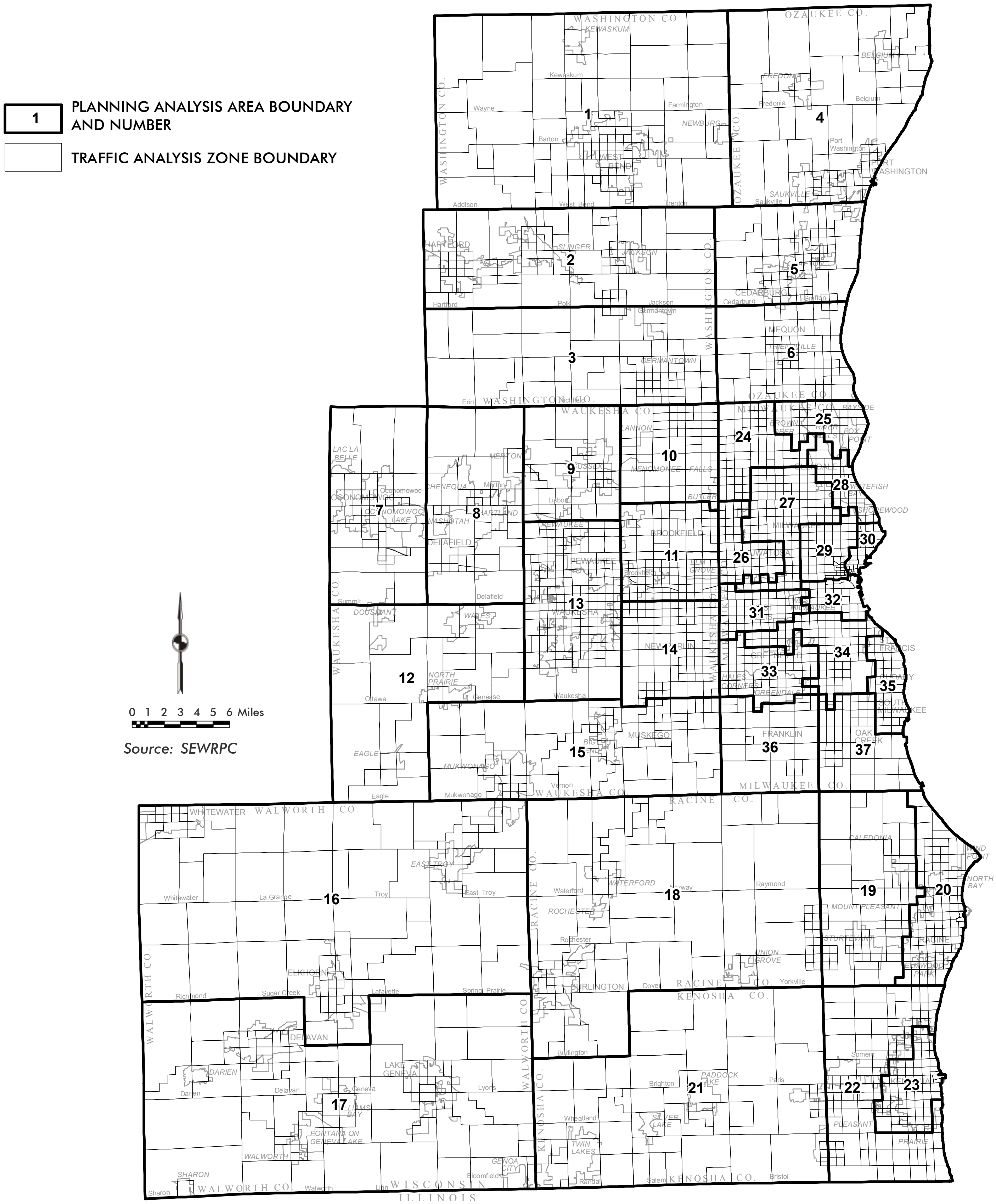
To improve the modeling of external vehicle travel, outside of Southeastern Wisconsin, the fourth-generation travel simulation models include 78 external zones that are comprised of aggregations of communities, counties or states. Map 2.2 shows the external zone system utilized in the Commission's fourth-generation travel simulation models.

PERSONAL VEHICLE AVAILABILITY MODEL

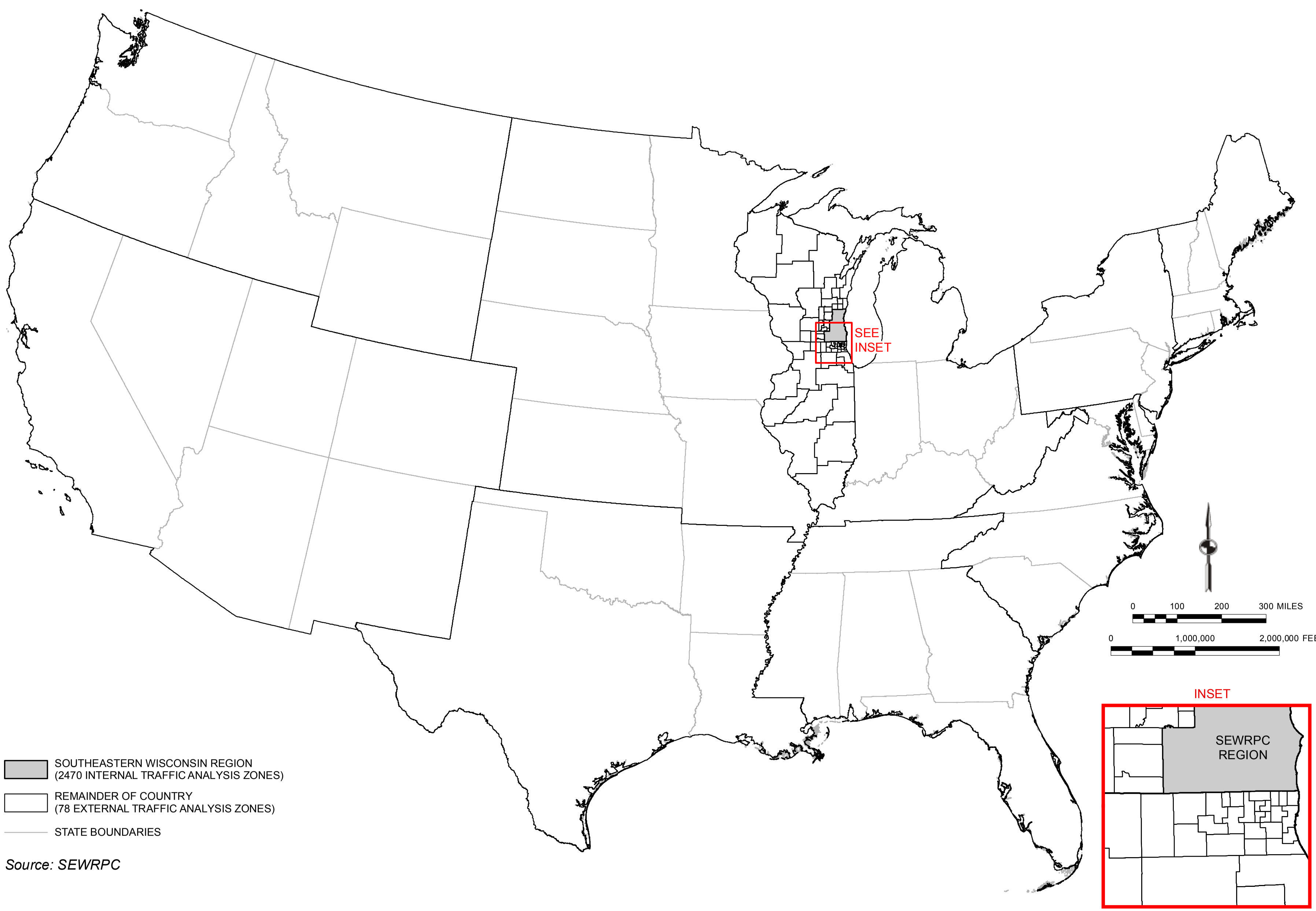
The availability of a personal vehicle (automobile, van, or truck) is a significant variable in travel simulation modeling, influencing not only the number of trips made by a household, or trip generation, but also the choice of mode. Under the Commission's fourth-generation battery of travel simulation models, household vehicle availability was determined with three equations developed through multiple regression analyses with 2001 household travel survey data, 2000 U.S. Bureau of Census data, and 2000 Commission land use data. The model for household vehicle availability in central Milwaukee County expresses household vehicle availability as a function of household income. The model for the remainder of Milwaukee area expresses household vehicle availability as a function of household income, household size, and transit accessibility. For the remainder of the Region, the model expresses household vehicle availability as a function of household size and residential density. A household stratification model was also developed and applied to forecast the distribution of households by both vehicle availability and household size, specifically, the distribution of households with zero, one, two, three, or four or more vehicles available by household size—one person, two people, three people, four people, and five or more people.

The ability of the fourth-generation travel simulation model for personal vehicle availability to predict year 2010 vehicle availability was determined by applying the fourth-generation model with year 2010 socio-economic and land use data, and year 2011 travel survey and transportation system network data. Between 2000 and 2010 regional personal vehicle availability is estimated to have increased from 1,227,050 to 1,355,305 personal vehicles, an increase of 128,255 vehicles, or 10.5 percent. As shown in Table 2.2, the fourth-generation model was able to accurately estimate this change in vehicle availability, as model-estimated year 2010 vehicle availability of 1,284,135 personal vehicles was 71,170 personal vehicles or 5.3 percent less than estimated actual vehicle availability.

Map 2.1
Fourth-Generation Travel Simulation Model Traffic Analysis Zones and Planning Analysis Areas in the Region



Map 2.2
Fourth-Generation Travel Simulation Model External Traffic Analysis Zones



SOUTHEASTERN WISCONSIN REGION (2470 INTERNAL TRAFFIC ANALYSIS ZONES)

REMAINDER OF COUNTRY (78 EXTERNAL TRAFFIC ANALYSIS ZONES)

STATE BOUNDARIES

Source: SEWRPC

Table 2.2
Comparison of Estimated Actual and Travel Model Estimated Personal Vehicle Availability: 2010

County	2000 Census Transportation Planning Package Estimate	2006-2010 Census Transportation Planning Package Estimate	Percent Change 2000-2010	2011 Travel Model Estimate[a]	Percent Difference 2006-2010 CTPP and Travel Model Estimates
Kenosha	98,970	114,600	15.8	110,510	-3.6
Milwaukee	526,340	553,250	5.1	537,530	-2.8
Ozaukee	60,440	66,765	10.5	62,810	-5.9
Racine	123,940	135,560	9.4	131,380	-3.1
Walworth	65,690	77,300	17.7	73,750	-4.6
Washington	86,320	104,245	20.8	95,460	-8.4
Waukesha	265,350	303,585	14.4	272,695	-10.2
Region	1,227,050	1,355,305	10.5	1,284,135	-5.3

[a] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: 2000 and 2006-2010 Census Transportation Planning Package, and SEWRPC

The fourth-generation model-estimated year 2010 distribution of households by vehicle availability and household size is compared to the estimated actual year 2010 distribution of households in Table 2.3. The fourth-generation model calibrated with 2000 and 2001 data is able to closely predict the distribution of households by vehicle availability and household size within the Region in 2010.

TRIP GENERATION MODEL

The first major step in the Commission's fourth-generation travel simulation models is trip generation whereby the total number of trip ends generated within each zone of the study area is determined through the identification and quantification of relationships between travel and land use. The fourth-generation trip generation models developed by the Commission with 2001 travel survey data for internal regional travel by resident households of the Region use cross-classification analysis for trip productions and trip attractions for all trip purposes except school trips.

Internal home-based and nonhome-based trips by the resident households in the Region for all purposes except school constitute the vast majority of daily trips made within the Region, nearly 80 percent. The production of these home-based and nonhome-based trips was analyzed and forecast under the fourth-generation models through the use of cross-classification analysis. Home-based trips were stratified into trip purpose categories of home-based work, home-based shopping, and home-based other. Cross-classification models were developed for each trip purpose for three areas within the Region—urban, suburban, and rural—based upon population and employment density. Household automobile availability and household size were selected to quantify the level of tripmaking in the fourth-generation trip production model, and the number of jobs by type and number of households were used to quantify tripmaking in the trip attraction model. The ability of the fourth-generation trip production and attraction models to simulate year 2011 internal person tripmaking was investigated by comparing the results of the application of the fourth-generation models using year 2010 land use data to actual year 2011 travel survey trip generation data. As shown in Table 2.4, the travel surveys conducted by the Commission indicated that resident household trip generation within Southeastern Wisconsin decreased by about 8.2 percent from 2001 to 2011. The ability of the trip generation models developed in 2001 to predict these changes

Table 2.3
Comparison of Estimated Actual and Travel Model Estimated Distribution of Southeastern Wisconsin Households by Vehicles Available and Household Size

2006-2010 Census Transportation Planning Package Estimate (percents)					
	Household Size				
Vehicles Available	One	Two	Three	Four or More	Total
None	6.0	1.7	0.9	0.9	9.5
One	20.8	8.0	3.6	3.4	35.8
Two	2.9	19.0	6.2	10.3	38.4
Three	0.5	3.4	3.7	4.1	11.7
Four or More	0.3	0.9	0.9	2.5	4.6
Total	30.5	33.0	15.3	21.2	100.0

2011 Model Estimate (percents)					
	Household Size				
Vehicles Available	One	Two	Three	Four or More	Total
None	5.0	2.6	1.3	2.0	10.9
One	15.7	10.4	4.2	5.6	35.9
Two	5.5	16.1	6.7	11.0	39.3
Three	1.2	3.0	2.8	3.9	10.9
Four or More	0.3	0.6	0.6	1.5	3.0
Total	27.7	32.7	15.6	24.0	100.0

[a] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

in regional trip generation accurately is also demonstrated in Table 2.4. Model-estimated year 2011 region resident household trip generation of 5,500,100 trips on an average weekday was 566,700 trips or 11.5 percent more than travel survey estimated actual trips of 4,933,400 trips in 2011. The model's overproduction of trips is not surprising as household travel declined between 2001 and 2011 due to the recession, and the models were based on the higher motorized trip generation rates observed in 2001. An additional factor was a doubling of the share of non-motorized travel that occurred between 2001 and 2011.

The generation—and distribution—of school trips in the fourth-generation travel models was accomplished by factoring existing school travel volumes and patterns. Such separate consideration of school trips was necessitated by the limitations imposed by fixed elementary, middle, and high school service area boundaries. Trips to and from all schools, including elementary, middle, high, vocational, and technical schools, and colleges and universities, amounted to about 13 percent of total trips generated within the Region on an average weekday in 2011. Growth factors were applied by mode—automobile, school bus, and public transit—to the observed 2001 trip tables of elementary, middle, and high school trips. The growth factors were based upon the forecast changes in population, and were adjusted to account for potential changes in school service boundaries and the construction of new schools. With respect to trips to universities and colleges such as the University of Wisconsin-Milwaukee, Marquette University, Milwaukee Area Technical College, and Milwaukee School of Engineering, the growth factor procedure was applied to total person, rather than to individual mode travel volume and patterns, and the growth factor was based on forecast changes in population. A mode choice model, described later in this report, was then used to divide the total person trips into those using public transit and those using the automobile.

Table 2.4
Comparison of Survey Estimated Actual and Fourth-Generation Model Estimated Internal Resident Household Trip Generation in the Region: 2001 and 2011

Trip Purpose	2001 Survey Estimated	2011 Survey Estimated	Percent Change 2001-2011	2011 Model Estimated[a]	Percent Difference
Home-Based Work	1,435,300	1,273,600	-11.3	1,434,100	12.6
Home-Based Shopping	761,600	651,100	-14.5	788,200	21.1
Home-Based Other	1,962,500	1,701,300	-13.3	2,023,500	18.9
Nonhome-Based	1,215,000	1,307,400	7.6	1,254,300	-4.1
Total	5,374,400	4,933,400	-8.2	5,500,100	11.5

[a] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

The ability of the fourth-generation model procedures to predict the future generation of school trips can be discerned by a comparison of the model estimated and travel survey estimated trip generation for 2011. The travel surveys indicated that the number of school trips in the Region on an average weekday increased by 15.1 percent between 2001 and 2011, from 656,900 to 755,900, respectively. These totals represent all school trips made on an average weekday by personal vehicle (driver or passenger), public transit, or school bus. Using the fourth-generation travel models, a 2011 estimate of 757,600 school trips was derived, a total approximately 0.2 percent more than that observed.

The generation—and distribution—of internal personal vehicle trips by group-quartered residents was forecast in the fourth-generation travel models by the application of growth factors, reflecting the anticipated change in the number of group-quartered residents by zone of residence. The travel surveys indicated that, from 2001 to 2011, average weekday personal vehicle travel by group-quartered residents significantly increased from 9,100 trips to 27,400 trips, due to a redefinition by the U.S. Bureau of Census of the group-quartered population. Due to this redefinition of group-quartered residents in 2010, the fourth-generation models, using 2001 survey data, under-predicted travel by group-quartered residents on an average weekday in 2011 by a total of 9,200 personal vehicle trips.

In 2001, travel internal to the Region by commercial trucks registered within the Region constituted about 9 percent of total tripmaking within the Region on an average weekday and approximately 10 percent of total vehicle trips generated within the Region on an average weekday. In the fourth-generation travel simulation models the generation—and distribution—of truck trips was accomplished by factoring the existing volume and pattern of truck trips. The forecast future generation of truck trips was accomplished by the use of multiple linear regression analysis relating truck trips to households and employment.

The ability of the commercial truck trip generation model utilized in the fourth-generation travel model battery to predict year 2011 truck travel was evaluated by using data from the 2012 commercial vehicle travel surveys. The travel surveys indicated that truck travel within the Region had increased from 582,500 to 614,500 trips per average weekday over the past decade. The fourth-generation travel forecasting techniques, as developed using 2001 data, predicted this increase in regional truck travel to within 4.7 percent of the actual number of truck trips observed in the commercial vehicle 2012 travel survey.

External trips comprised about 6 percent of total tripmaking and total vehicle trips within the Region in 2001. In the fourth-generation travel simulation models, the generation—and distribution—of external travel was forecast by extrapolating the existing 2001 pattern of external tripmaking by applying growth factors to the 2001 trips on the basis of the forecast changes in households and employment at the production and attraction ends of the trips, respectively.

The ability of this forecasting technique to forecast external tripmaking within the Region in 2011 was tested by using the travel inventory data collected by the Commission in 2011-2012. Over the past decade, external vehicle travel affecting the Region was estimated to have increased by approximately 2.3 percent, from 357,500 vehicle trips per average weekday in 2001 to 363,800 trips in 2011-2012. Comparison of observed and model forecast 2011 external travel indicated that the fourth-generation model procedures developed modestly underestimated the increase in external travel by 23,900 trips, or 6.6 percent.

TRIP DISTRIBUTION

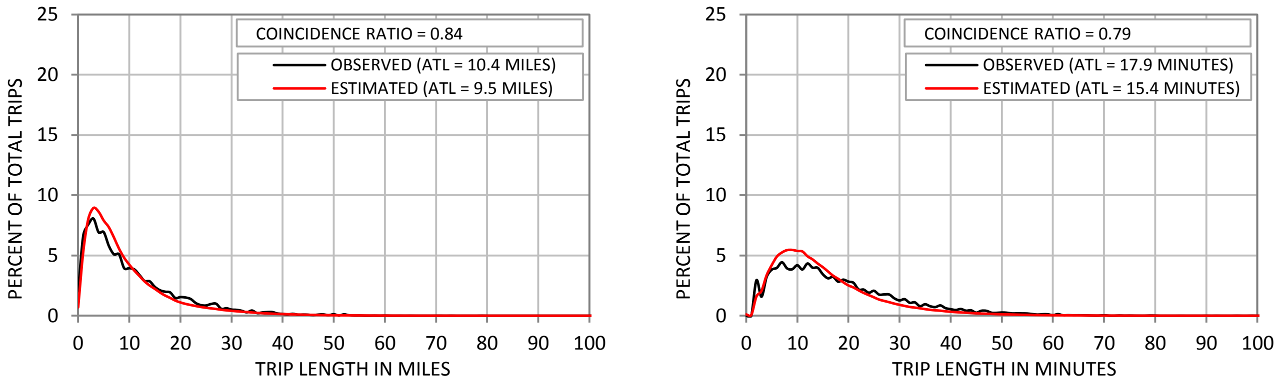
The second major step in the travel simulation process is trip distribution whereby the number of trips between each zonal pair is determined. The input to this step from trip generation includes the number of trips ends produced by, or attracted to, each zone by resident households of the Southeastern Wisconsin Region for home-based work, home-based shopping, home-based other, and nonhome-based trips.

The fourth-generation model battery's trip distribution procedure employed the gravity model, which is the most widely accepted and used trip distribution model. In the gravity model, the number of trips between two zones in the study area is a function of the number of trip ends in each zone and their spatial separation measured in terms of travel time, distance, and/or cost. The fourth-generation model used both travel time (peak hour for work trips and off-peak for other trips) and travel cost as the measure of spatial separation. The fourth-generation trip distribution models were developed with 2001 travel survey and transportation system network data. Individual gravity models were calibrated for home-based work, home-based shopping, home-based other, and nonhome-based trip purposes for resident household internal trips. As noted earlier, the distribution of internal school trips, group-quartered person trips, internal truck trips, and external trips was accomplished by factoring and adjusting then existing 2001 trip travel patterns.

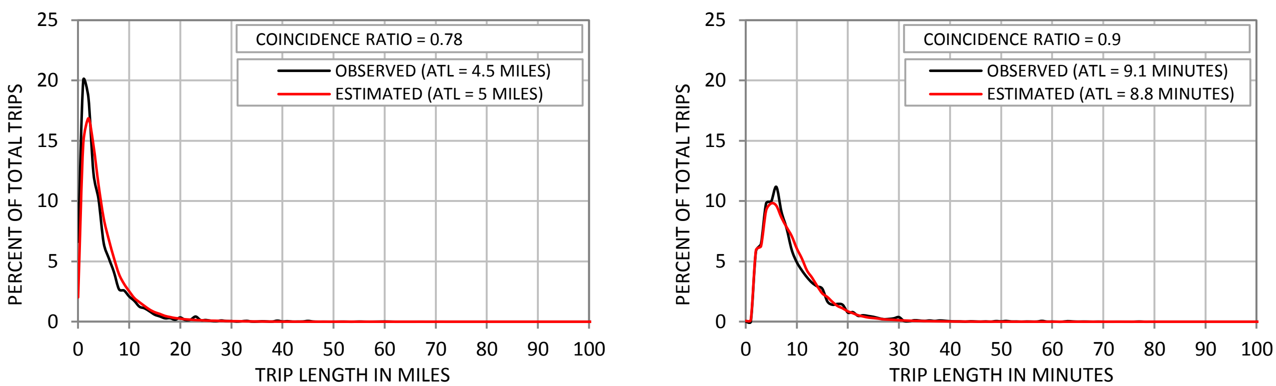
The ability of the fourth-generation gravity trip distribution models to predict changes to the year 2011 in trip distribution, as measured by average trip lengths and trip length frequency distribution, was determined through the application of the models with year 2011 data. Based on travel survey data, the average trip length between 2001 and 2011 decreased from 13.7 minutes to 13.3 minutes, or about 2.9 percent. However, the distance of those trips increased from 6.8 miles to 7.1 miles, or about 4.4 percent. As shown in Figure 2.1 and Table 2.5, the average trip length in 2011 was predicted by the fourth-generation models within 16.7 percent in terms of travel time and 6.6 percent in terms of travel distance, a reasonable degree of accuracy considering that the actual estimated trip lengths were estimates derived from travel surveys and traffic count data, which are a sample data themselves and subject to varying degrees expansion-related error. Figure 2.2 provides a comparison of modeled to survey estimated trip

Figure 2.1
Comparison of Travel Survey and Model Estimated Average Weekday Trip Length (ATL) Frequency Distribution in the Region: 2011[a]

HOME-BASED WORK TRIPS



HOME-BASED SHOPPING TRIPS



HOME-BASED OTHER TRIPS

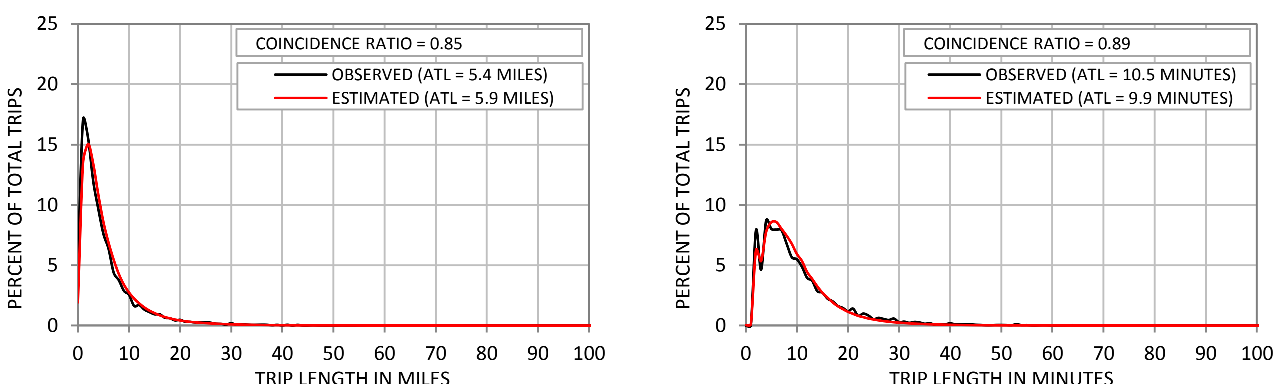


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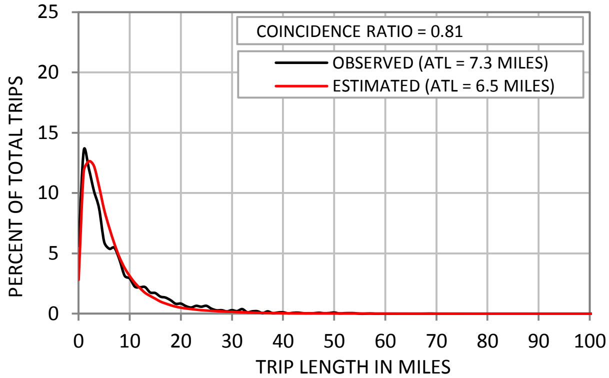
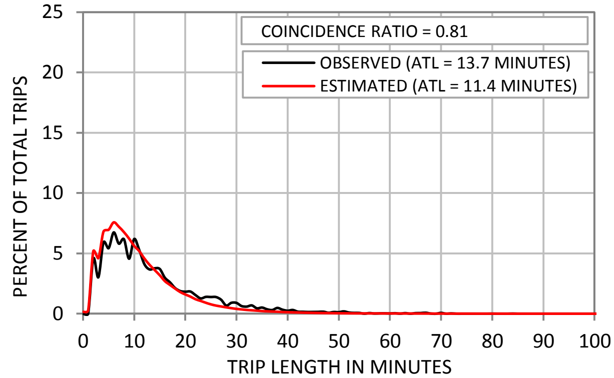
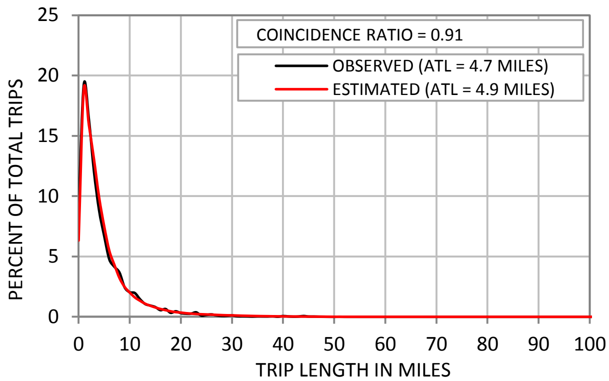
Figure 2.1 (Continued)

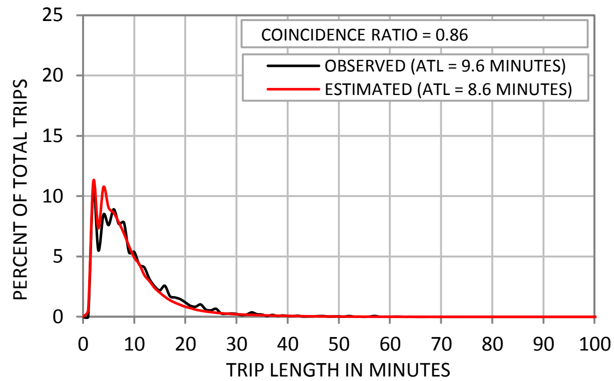
NONHOME-BASED WORK TRIPS





NONHOME-BASED WORK TRIPS





[a]*Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 2.5
Comparison of Survey Estimated Actual and Fourth-Generation Model Estimated Average Trip Length for Internal Resident Household Person Travel in the Region: 2001 and 2011

Trip Purpose	2001 Survey Estimated Trip Length		2011 Survey Estimated Trip Length		Percent Change 2001 - 2011		2011 Model Estimated[a] Trip Length		Percent Difference	
	Minutes	Miles	Minutes	Miles	Minutes	Miles	Minutes	Miles	Minutes	Miles
Home-Based Work	19.1	9.8	19.6	11.0	2.6	12.2	15.4	9.5	-21.6	-13.5
Home-Based Shopping	9.6	4.7	9.8	4.8	2.1	2.1	8.8	5.0	-10.3	4.0
Home-Based Other	11.6	6.0	11.3	5.9	-2.6	-1.7	9.9	5.9	-12.3	-0.8
Nonhome-Based	12.3	5.9	11.7	6.2	-4.9	5.1	9.5	5.7	-18.5	-8.9
Average	13.7	6.8	13.3	7.1	-2.9	4.4	11.1	6.6	-16.7	-6.6

[a] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Figure 2.2
Comparison of Travel Survey and Model Estimated Internal Person Trip Travel Patterns by 37 Planning Areas: 2011[a]

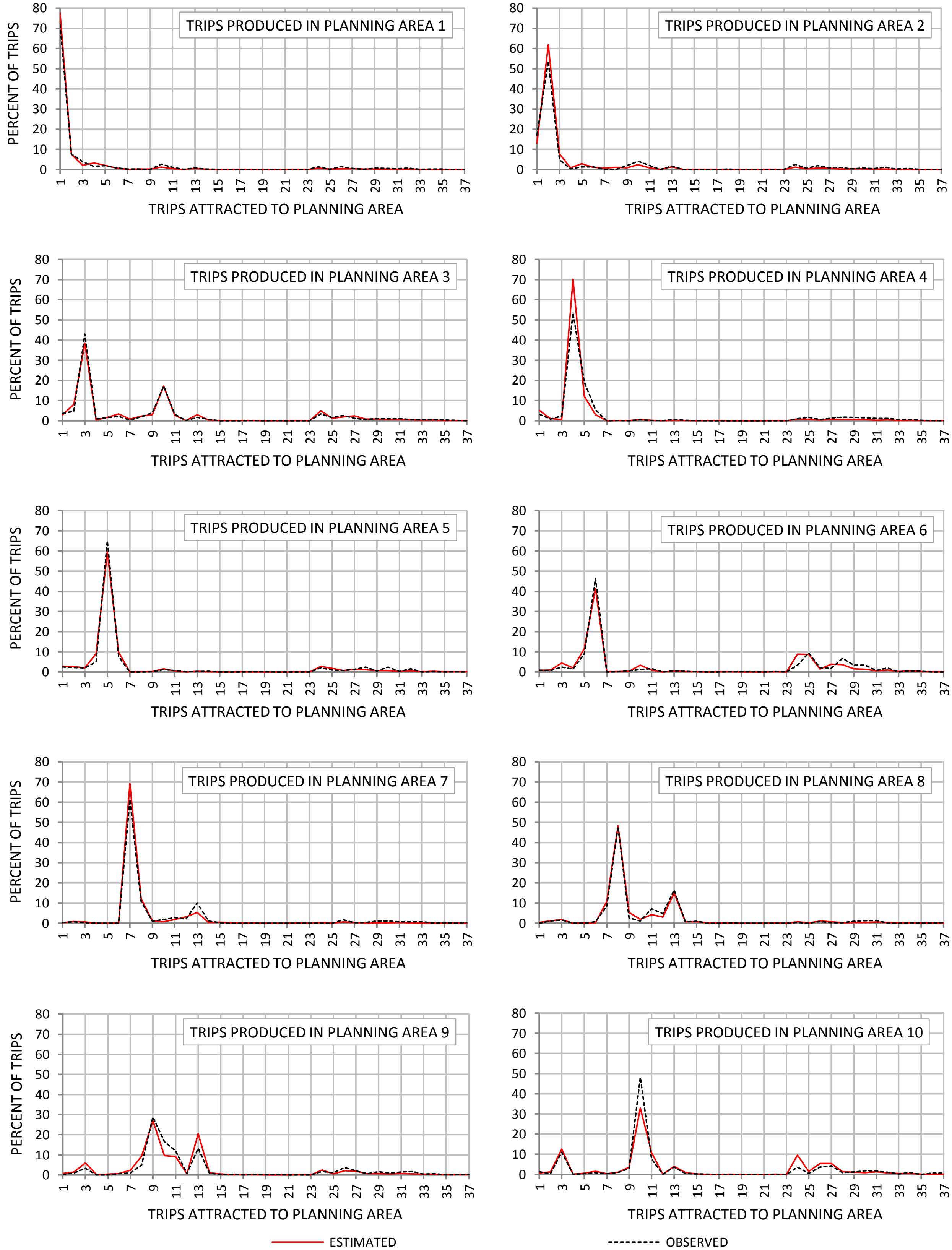


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Figure 2.2 (Continued)

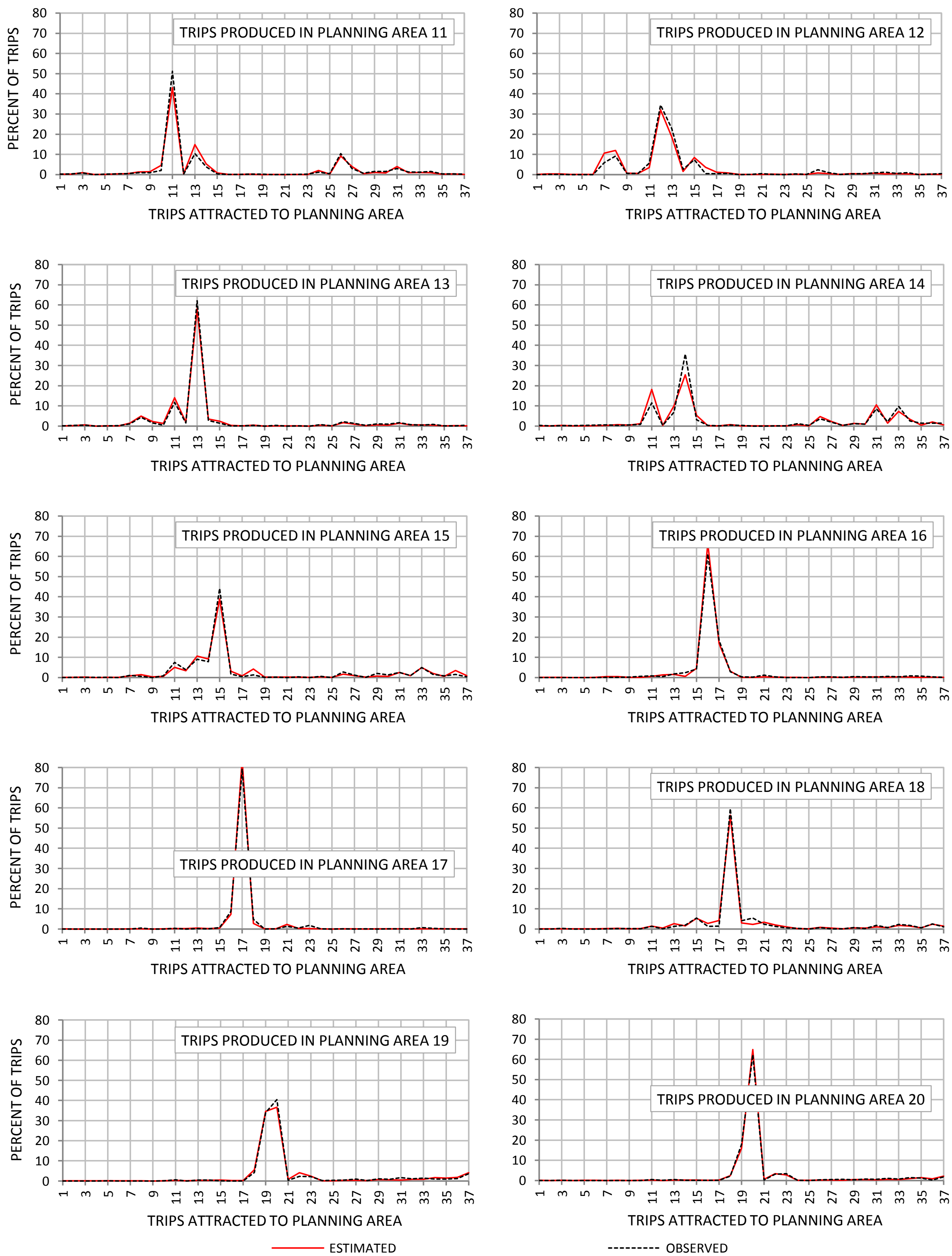

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Figure 2.2 (Continued)

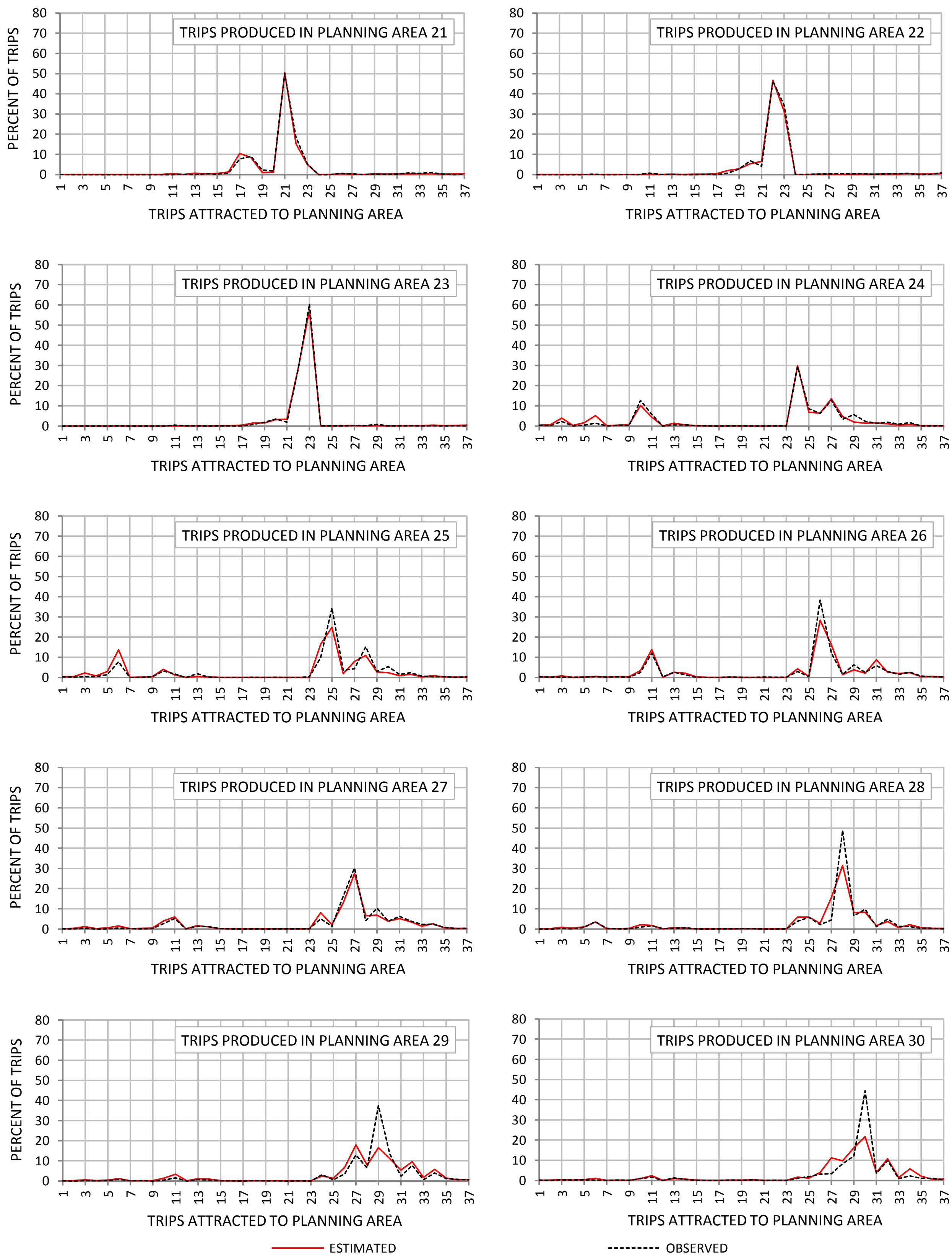

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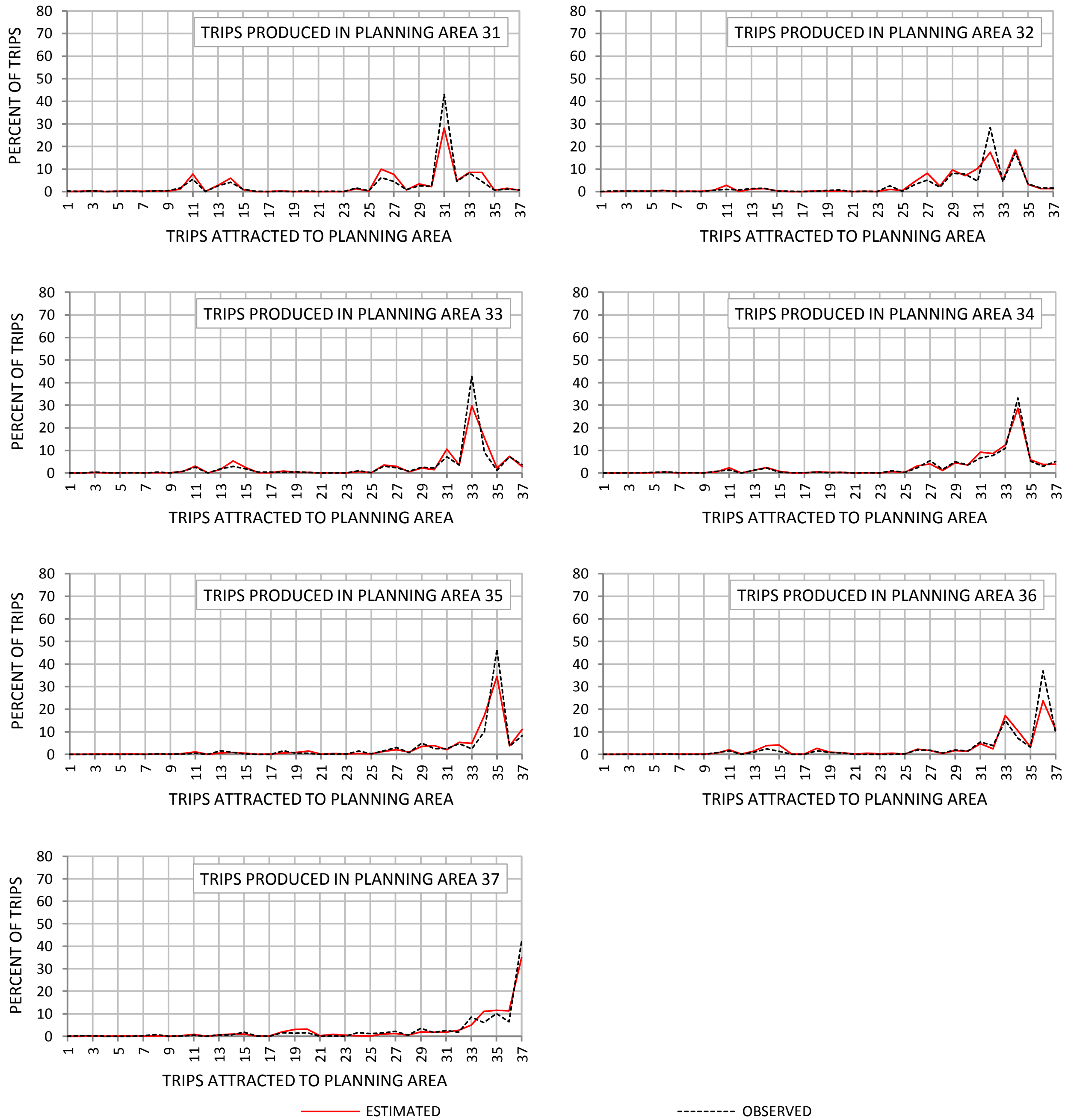
Figure 2.2 (Continued)



[a]*Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

distribution by planning analysis area and shows that the model developed with 2001 data is able to replicate the pattern of travel observed in 2011.

MODAL CHOICE

The third major step in the travel simulation process is modal choice, or split, whereby the total number of trips traveling between each pair of traffic analysis zones by trip purpose is divided on the basis of travel mode used. Primarily, this step involves the division of internal person trips between the two major modes of travel, public transit and the private automobile. The determination of modal choice is essentially an evaluation of the potential demand for public transit service. The modal choice step must also determine for each zone-to-zone interchange those auto trips that will drive alone and those that will carpool, or "share a ride," and thus determine the average number of people per automobile trip. Both automobile vehicle trips and transit person trips are determined in this step as necessary inputs to the final traffic assignment step of the travel simulation process.

The fourth-generation modal choice models developed with 2001 travel survey and transportation network data use logit analysis for the trip purposes of home-based work, home-based shopping and other purposes combined, nonhome-based, and home-based school (only trips to and from colleges and universities). The modal choice model calibrated for the home-based work trip purpose expresses the probability of mode choice as a function of household automobile availability, in-vehicle travel time, out-of-vehicle travel time, and out-of-pocket cost differences between three modes: public transit, drive alone, and shared ride. The models calibrated for home-based shopping, other, and school trip purposes express the probability of mode choice as a function of household automobile availability, in-vehicle travel time, out-of-vehicle travel time, and out-of-pocket cost differences between automobile and transit modes. The nonhome-based mode choice model expresses the probability of mode choice as a function of in-vehicle travel time, out-of-vehicle travel time, and out-of-pocket cost differences between automobile and transit modes. An automobile occupancy model is used to convert total automobile person trips to vehicle trips for home-based shopping, other, and school trips, and nonhome-based trips based on household size and personal vehicle availability.

The ability of the fourth-generation modal choice model calibrated with 2001 travel survey and transportation network data to predict changes to the year 2011 in mode choice and transit ridership was determined by applying the models with year 2011-2012 data. A comparison of the average weekday linked passenger trips from origin to destination and unlinked passenger trips, or boarding passengers, observed in the Region during 2011 versus those estimated by the fourth-generation model for 2011 is presented in Table 2.6. About 176,700 average weekday boarding passengers were simulated for 2011 by the models, or about 3.9 percent greater than the 170,000 average weekday boarding passengers observed during 2011. About 125,700 linked passenger trips from trip origin to destination were simulated by the models for 2011, or about 2.6 percent less than the 129,100 linked passenger trips observed in 2011. The model estimated transfer ratio of 1.4 transfers per linked revenue trip simulated on the transit network for 2011 was only slightly greater than the transfer ratio of 1.3 transfers per trip observed for the same routes in 2011. A comparison of the linked passenger trip transit ridership by trip purpose as estimated by travel surveys and travel models for the year 2011 is shown in Table 2.7. The fourth-generation travel simulation models developed in 2001 slightly

Table 2.6
Comparison of Estimated Actual and Fourth-Generation Model Estimated Average Weekday Transit Ridership in the Region: 2011

Trip Category	Average Weekday Transit Passengers		
	2011 Estimated[a]	2011 Model Estimated[b]	Percent Difference
Linked Revenue Passenger Trips	129,100	125,700	-2.6
Unlinked Passenger Trips (boarding passengers)	170,000	176,700	3.9
Boards per Passenger Trip	1.3	1.4	6.8

[a] *Does not include trips made by disabled individuals on complimentary paratransit service.*

[b] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 2.7
Comparison of Estimated Actual and Fourth-Generation Model Estimated Average Weekday Linked Passenger Trip Transit Ridership by Trip Purpose in the Region: 2011

Trip Category	Linked Transit Revenue Passenger Trips		
	Survey Estimated[a] 2011	Model Estimated[b] 2011	Percent Difference
Home-Based Work	33,700	40,700	20.8
Home-Based Shopping	12,700	8,900	-29.9
Home-Based Other	22,700	22,300	-1.8
Nonhome-Based	21,500	15,100	-29.8
School[c]	38,500	38,700	0.5
Total	129,100	125,700	-2.6

[a] *Does not include trips made by people with disabilities on complimentary paratransit service.*

[b] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

under-predict 2011 transit ridership by 2.6 percent. More specifically, the travel simulation model under-predicts home-based shopping, home-based other and nonhome-based trips, while over-predicting home-based work and school trips. A comparison of the linked passenger trip transit ridership by time period of the average weekday as estimated by travel surveys and travel models for 2011 is shown in Table 2.8. As shown in Table 2.8, the model, while predicting total transit travel to within 2.6 percent, over-predicted the morning peak by 27 percent and under-predicted transit trips in the other periods of the day. This difference is due to an observed change in the daily distribution of transit trips between 2001 and 2011 and the period factors used to convert daily transit trips into the time periods for assignment being based on the observed distribution in 2001.

With respect to automobile occupancy, Table 2.9 compares the 2011 survey-estimated and fourth-generation model-estimated automobile occupancy by trip purpose. The fourth-generation models under-predicted the vehicle occupancy by 2.3 percent overall and to within five percent by purpose.

Table 2.8
Comparison of Estimated Actual and Fourth-Generation Model Estimated Average Weekday Linked Passenger Trip Transit Ridership by Time Period in the Region: 2011

	Average Weekday Linked Passenger Trips				
	2011 Survey Estimated[a]		2011 Model Estimated[b]		
Time Period	Number	Percent of Daily Total	Number	Percent of Daily Total	Percent Difference
Morning Peak Period	28,900	22.4	36,800	29.3	27.3
Midday Nonpeak Period	39,300	30.4	32,600	25.9	-17.0
Evening Peak Period	42,300	32.8	41,100	32.7	-2.8
Night Nonpeak Period	18,600	14.4	15,200	12.1	-18.3
Total	129,100	100.0	125,700	100.0	-2.6

[a] *Does not include trips made by people with disabilities on complimentary paratransit service.*

[b] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 2.9
Comparison of Survey and Fourth-Generation Model Estimated Automobile Occupancy by Trip Purpose: 2001 and 2011

Trip Purpose	2001 Survey-Estimated People per Automobile	2011 Survey-Estimated People per Automobile	2011 Model-Estimated People per Automobile[a]	Percentage Difference – 2011 Survey and Model Estimates
Home-Based Work	1.05	1.06	1.03	-2.8
Home-Based Shopping	1.22	1.25	1.19	-4.8
Home-Based Other	1.32	1.31	1.30	-0.8
Nonhome-Based	1.18	1.19	1.16	-2.5
Average	1.19	1.20	1.17	-2.3

[a] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

TRAFFIC ASSIGNMENT

The fourth and final step in the travel simulation modeling process is the assignment of the zone-to-zone trip volumes forecast in the modal choice step to specific routes of existing and proposed transportation systems. The output of traffic assignments for the arterial street and highway system is a forecast of the number of vehicles on an annual average weekday that may be expected to use each segment of the arterial street and highway system. The output of traffic assignment for the transit system is an estimate of the number of passengers on an annual average weekday that may be expected to use each segment of the transit system.

The ability of the fourth-generation traffic assignment model, and entire fourth-generation travel simulation model battery developed in 2005 and calibrated with years 2000 and 2001 travel, transportation, socio-economic and land use data to predict year 2011 traffic volumes and transit ridership was determined through application of the entire fourth-generation travel demand model battery with years 2010 and 2011 socio-economic, land use, and transportation network data. The estimated 2011 arterial street average weekday traffic volumes derived from application of the fourth-generation traffic simulation model battery were compared to estimated 2011 average weekday traffic volumes derived from actual traffic counts.

Table 2.10
Comparison of Fourth-Generation Model Estimated and Traffic Count Estimated Arterial System Vehicle-Miles of Travel on an Average Weekday in the Region: 2011

County	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Traffic Counts (thousands)	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Travel Simulation Models[a] (thousands)	Percent Difference
Kenosha	3,497	3,582	2.4
Milwaukee	16,210	15,736	-2.9
Ozaukee	2,378	2,622	10.3
Racine	3,468	3,893	12.2
Walworth	2,452	2,888	17.8
Washington	3,442	3,617	5.1
Waukesha	9,415	9,950	5.7
Region	40,862	42,287	3.5

[a] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 2.10 presents a comparison of estimated vehicle-miles of travel from the traffic models and from actual traffic volume counts for each county within Southeastern Wisconsin. Map 2.3 presents a comparison of the modeled and estimated average weekday traffic for the freeway system and selected major arterials within Southeastern Wisconsin. The fourth-generation models calibrated with 2000 and 2001 data were able to predict year 2011 regional vehicle-miles of travel within 3.5 percent, and year 2011 freeway system and major arterial average vehicle miles traveled by county generally within 2 to 18 percent.

As presented earlier, the fourth-generation travel simulation models developed in 2005 with 2000 and 2001 data were able to predict within 2.6 percent year 2011 average weekday transit ridership within the Region. As shown in Table 2.11, year 2011 Milwaukee County Transit System unlinked boarding passenger trips estimated by the fourth-generation models are within 2.8 percent in total, and are within 0.9 percent in total for selected major routes (see Table 2.11). A comparison by route would indicate a fair amount of variability route to route as would be expected based on the best path assignment methodology employed by the transit assignment step. These selected major routes of the Milwaukee County Transit System are shown on Map 2.4.

Another test of the validity of travel simulation models is the degree to which the forecasts provided by past models are consistent with actual estimates. Table 2.12 provides the results of such a review of the validity of travel models and forecasts for the year 1990 regional plan that used the Commission's first generation models, for the year 2000 regional plan that used the second generation models, for the year 2010 and 2020 plans that used the third generation models, and for the year 2035 plans that used the fourth generation models. This test of forecast validity is a test of both the travel models and the underlying plan forecasts, including population, household, and employment levels. Commission travel forecasts have generally proven to be very accurate, with year 1990 plan travel forecasts being within about five percent of actual year 1990 travel, and year 2010, 2020, and 2035 plan forecasts being within about five to ten percent of actual year 2011 travel.

Map 2.3
Comparison of Model Estimated and Traffic Count Estimated Average Weekday Traffic Volume on Selected Arterial Streets and Highways: 2011

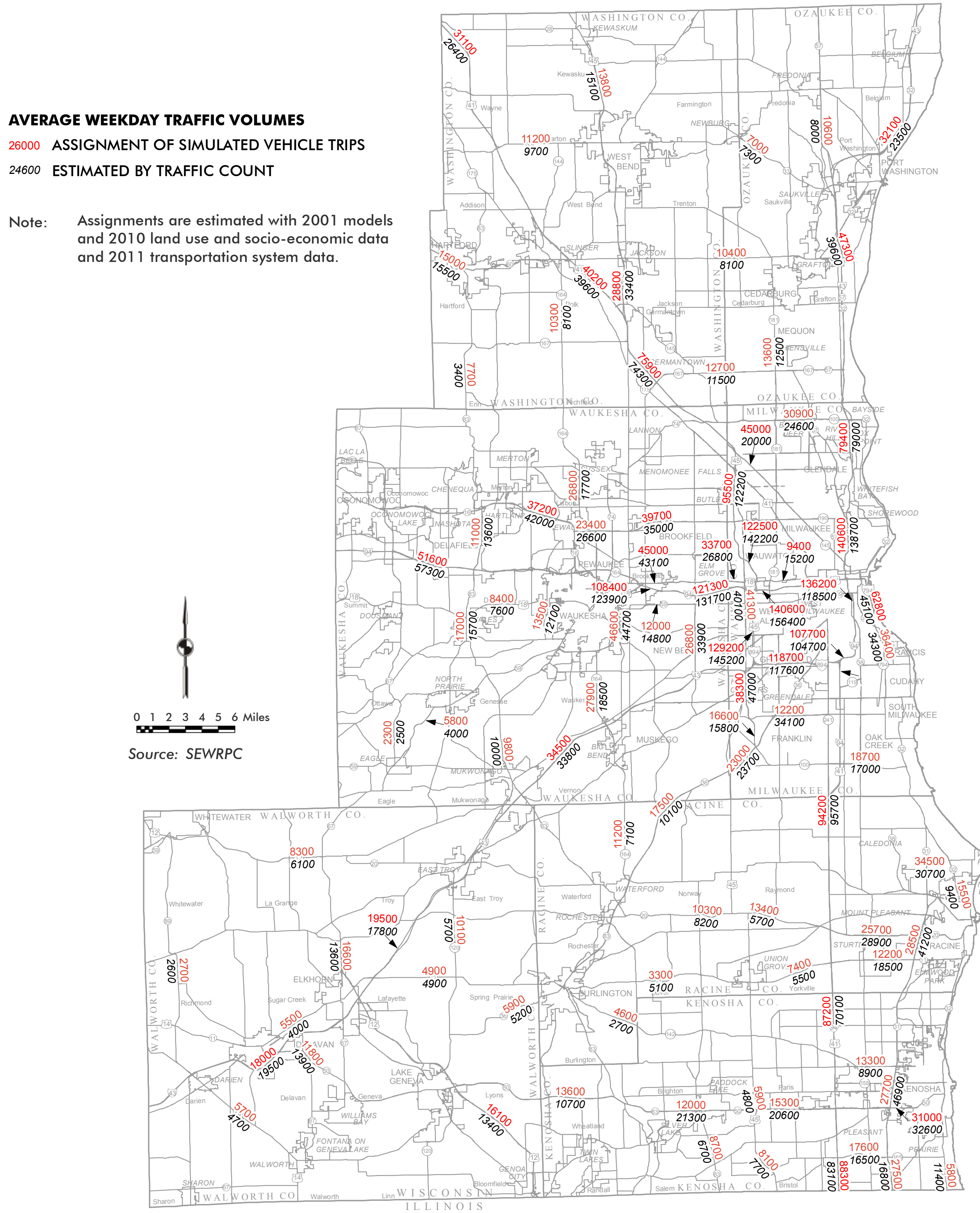


Table 2.11
Comparison of Estimated Actual Transit Ridership Boarding Passenger Counts to Fourth-Generation Model-Estimated Transit Ridership on Select Milwaukee County Transit System Bus Routes and Total System: 2011[a]

	Average Weekday unlinked Trips (Boarding Passengers)			
			Difference	
Milwaukee County Transit System	Estimated Actual[b]	2011 Model Estimated[c]	Amount	Percent
Selected Major Routes				
Route No. 10	6,890	9,750	2,860	41.5
Route No. 12	7,760	6,500	-1,260	-16.2
Route No. 15	8,410	8,870	460	5.5
Route No. 18	5,980	5,260	-720	-12.0
Route No. 19	7,700	5,090	-2,610	-33.9
Route No. 21	5,500	5,180	-320	-5.8
Route No. 23	8,760	6,110	-2,650	-30.3
Route No. 27	13,060	11,920	-1,140	-8.7
Route No. 30	14,100	18,120	4,020	28.5
Route No. 35	5,040	2,620	-2,420	-48.0
Route No. 60	4,430	3,630	-800	-18.1
Route No. 62	7,340	8,180	840	11.4
Route No. 67	4,260	5,100	840	19.7
Route No. 76	5,860	7,550	1,690	28.8
Route No. 80	7,120	7,330	210	2.9
Subtotal	112,210	111,210	-1,000	-0.9
Remainder of Routes	38,440	43,584	5,144	13.4
Total	150,650	154,794	4,144	2.8

[a] *Includes Waukesha County Transit System routes operated by the Milwaukee County Transit System*

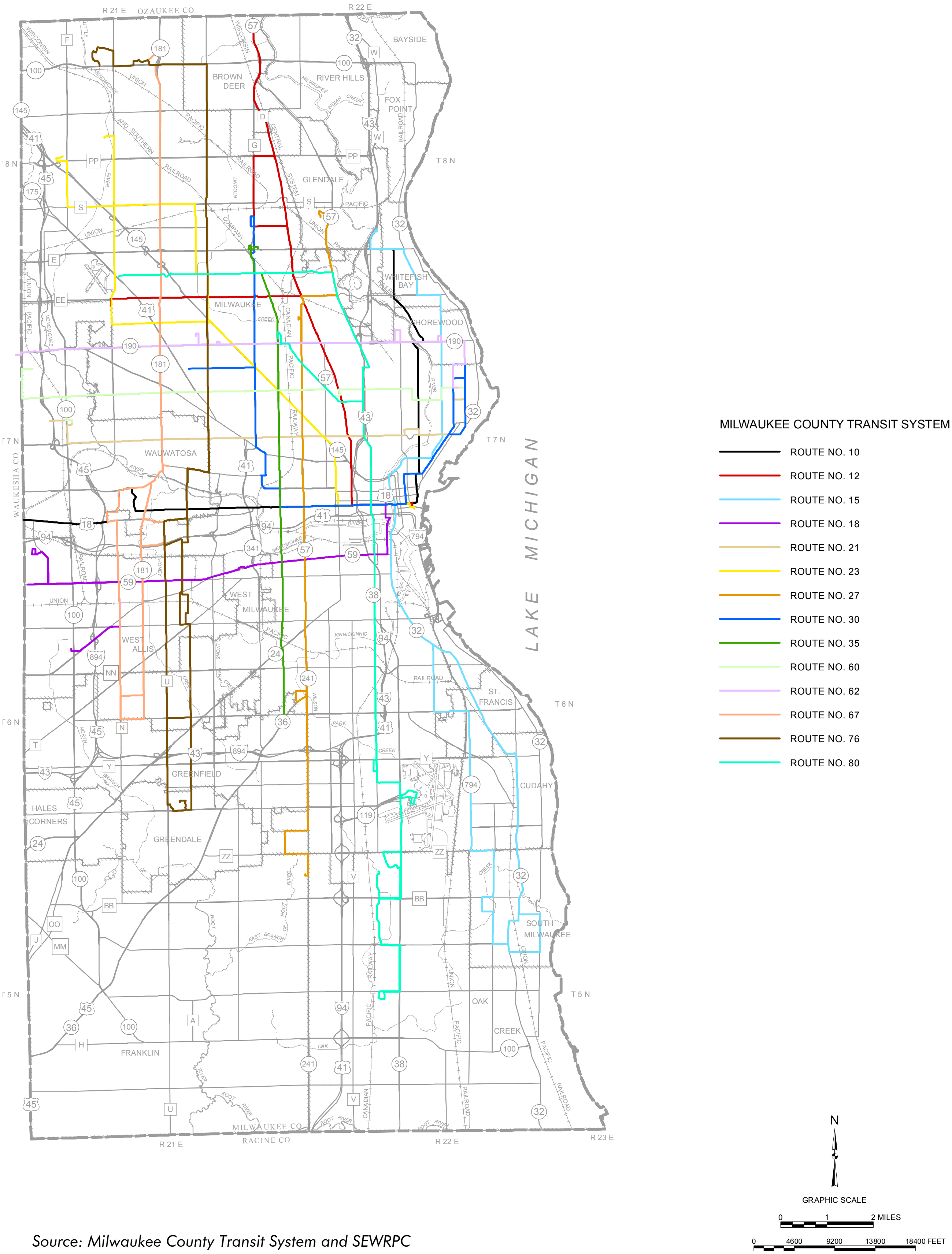
[b] *Based on actual operator counts taken during the months of March and September 2011 by the Milwaukee County Transit System*

[c] *Estimated with 2001 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

The only exception was the year 2000 plan with forecasts of vehicle trips and vehicle-miles of travel being about 20 percent less than actual estimated year 2000 travel, and forecast person trips under the year 2000 plan being about five percent less than actual year 2000 person trips. The reason for the differences between actual and forecast travel in the year 2000 was the significant decline in ridesharing and vehicle occupancy which occurred between 1972 and 1991, due to declining household size, increasing personal vehicle availability, and changing population lifestyles. The vehicle occupancy forecast under the year 2000 plan assumed no change in vehicle occupancy over the plan forecast period. Vehicle occupancy forecasts under the subsequent year 2010, 2020 and with the exception of the home-based work purpose for the 2035 plan were based upon a model which projected vehicle occupancy based upon household size and personal vehicle availability. As noted earlier, vehicle occupancy for the home-based work purpose is determined as a choice in the mode choice step. Vehicle occupancy under the 2035 plan was also further adjusted to account for a continued modest decline in vehicle occupancy expected to occur by the year 2035. While still considered reasonably accurate for the purpose of forecasting, the 2010, 2020, and 2035 plans over-predicted travel, most likely due to the decline in travel related to the recession underway in 2011. None of the socio-economic forecasts used to establish travel for the 2010, 2020, and 2035 plans anticipated the significant economic downturn experienced in the 2000's.

Map 2.4
Major Local and Express Bus Routes Operated by the Milwaukee County Transit System: 2011



Source: Milwaukee County Transit System and SEWRPC

Table 2.12
Comparison of Commission Travel Forecasts to Actual Estimated Travel: 1990, 2000, 2010, 2020 and 2035 Plans

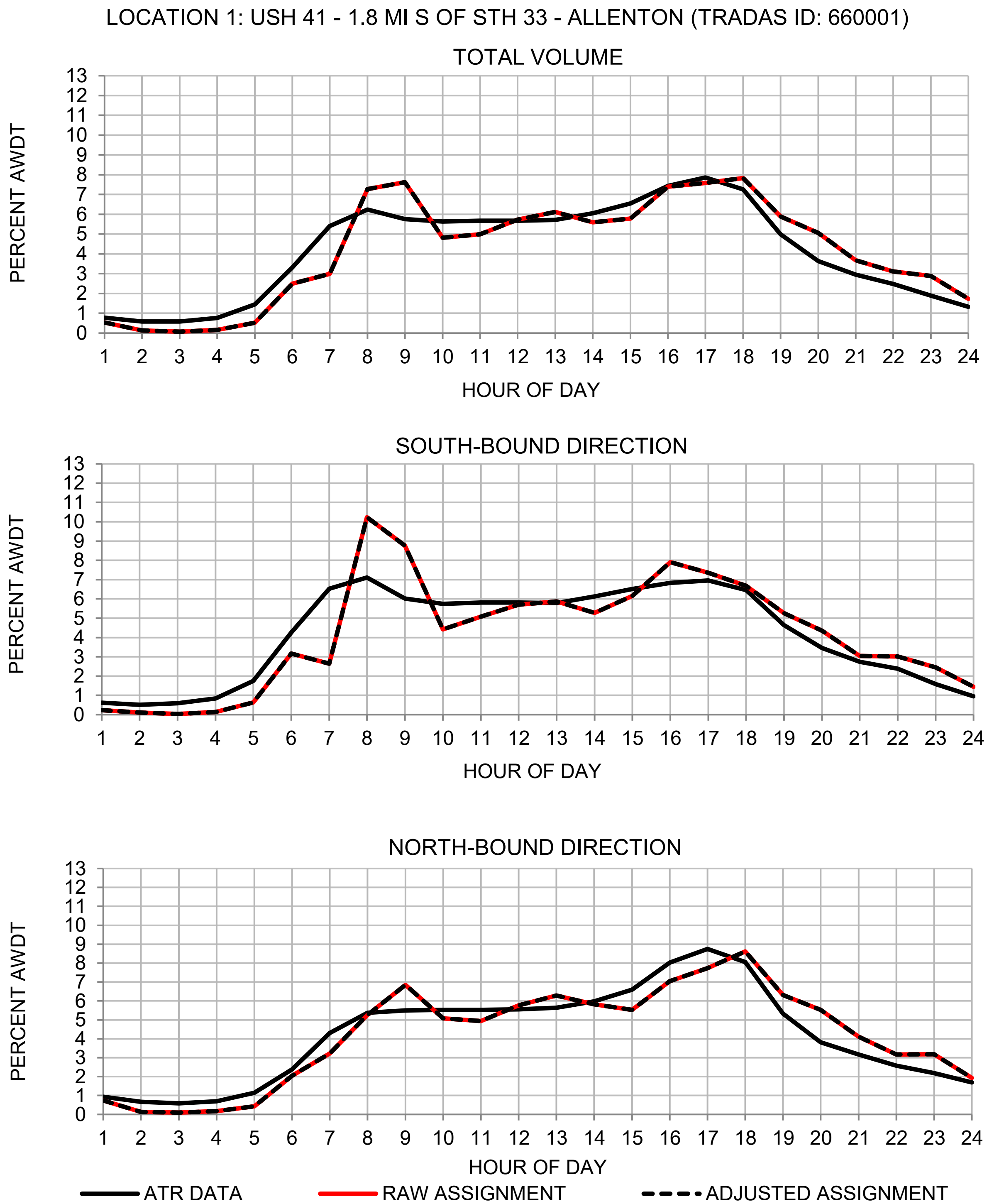
Average Weekday Travel Measure	Plan Base Year	Plan Forecast	Estimated Actual	Percent Difference: Estimated Actual and Forecast
		Year 1990 Plan		
Resident Internal Person Trips	3.60 million (1963)	6.02 million (1990)	5.59 million (1991)	+7.7 percent
Resident Internal Personal Vehicle Trips	2.17 million (1963)	3.94 million (1990)	4.08 million (1991)	-3.4 percent
Vehicle-Miles of Travel	13.1 million (1963)	32.3 million (1990)	32.4 million (1990)	-0.3 percent
		Year 2000 Plan		
Resident Internal Person Trips	4.46 million (1972)	5.75 million (2000)	6.10 million (2001)	-5.9 percent
Resident Internal Personal Vehicle Trips	2.89 million (1972)	3.77 million (2000)	4.53 million (2001)	-16.8 percent
Vehicle-Miles of Travel	20.1 million (1972)	30.1 million (2000)	39.2 million (2000)	-23.2 percent
		Year 2010 Plan		
Resident Internal Person Trips	5.59 million (1991)	6.10 million (2010)	5.80 million (2011)	+5.2 percent
Resident Internal Personal Vehicle Trips	4.08 million (1991)	4.69 million (2010)	4.20 million (2011)	+11.7 percent
Vehicle-Miles of Travel	33.1 million (1991)	42.4 million (2010)	40.9 million (2011)	+3.7 percent
		Year 2020 Plan		
Resident Internal Person Trips	5.8 million (1995)	6.16 million (2010)	5.80 million (2011)	+6.2 percent
Resident Internal Personal Vehicle Trips	4.8 million (1995)	4.86 million (2010)	4.20 million (2011)	+15.7 percent
Vehicle-Miles of Travel	35.9 million (1995)	43.9 million (2010)	40.9 million (2011)	+7.3 percent
		Year 2035 Plan		
Resident Internal Person Trips	6.10 million (2001)	6.24 million (2011)	5.80 million (2011)	+7.6 percent
Resident Internal Personal Vehicle Trips	4.53 million (2001)	4.77 million (2011)	4.20 million (2011)	+13.6 percent
Vehicle-Miles of Travel	39.7 million (2001)	43.5 million (2011)	40.9 million (2011)	+6.4 percent

Source: SEWRPC

TIME OF DAY TRAFFIC MODEL

In addition to a daily or 24-hour assignment, the fourth-generation travel model includes a time-of-day assignment model. This additional assignment model divides daily traffic data into 15-minute segments. Each time period is assigned sequentially with subsequent time periods initialized with the congested travel times and volumes from the preceding time period. In this way, the time of day model, as constructed, is more sensitive to the changing congestion levels throughout an average weekday, and can then adjust traffic assignment by time segment to reflect these changes more dynamically than the standard 24-hour daily traffic assignment. Figure 2.3 provides a comparison of the daily distribution of travel demand from the time-of-day assignment procedure to traffic count data for selected locations within Southeastern Wisconsin. These locations are shown on Map 2.5. As indicated by Figure 2.3, the time-of-day assignment model is able to replicate the daily distribution of travel.

Figure 2.3
Comparison of the Year 2011 Diurnal Distribution of Average Weekday Traffic (AWDT) Estimated by the Time-of-Day Model to WisDOT Automatic Traffic Recorder (ATR) DATA



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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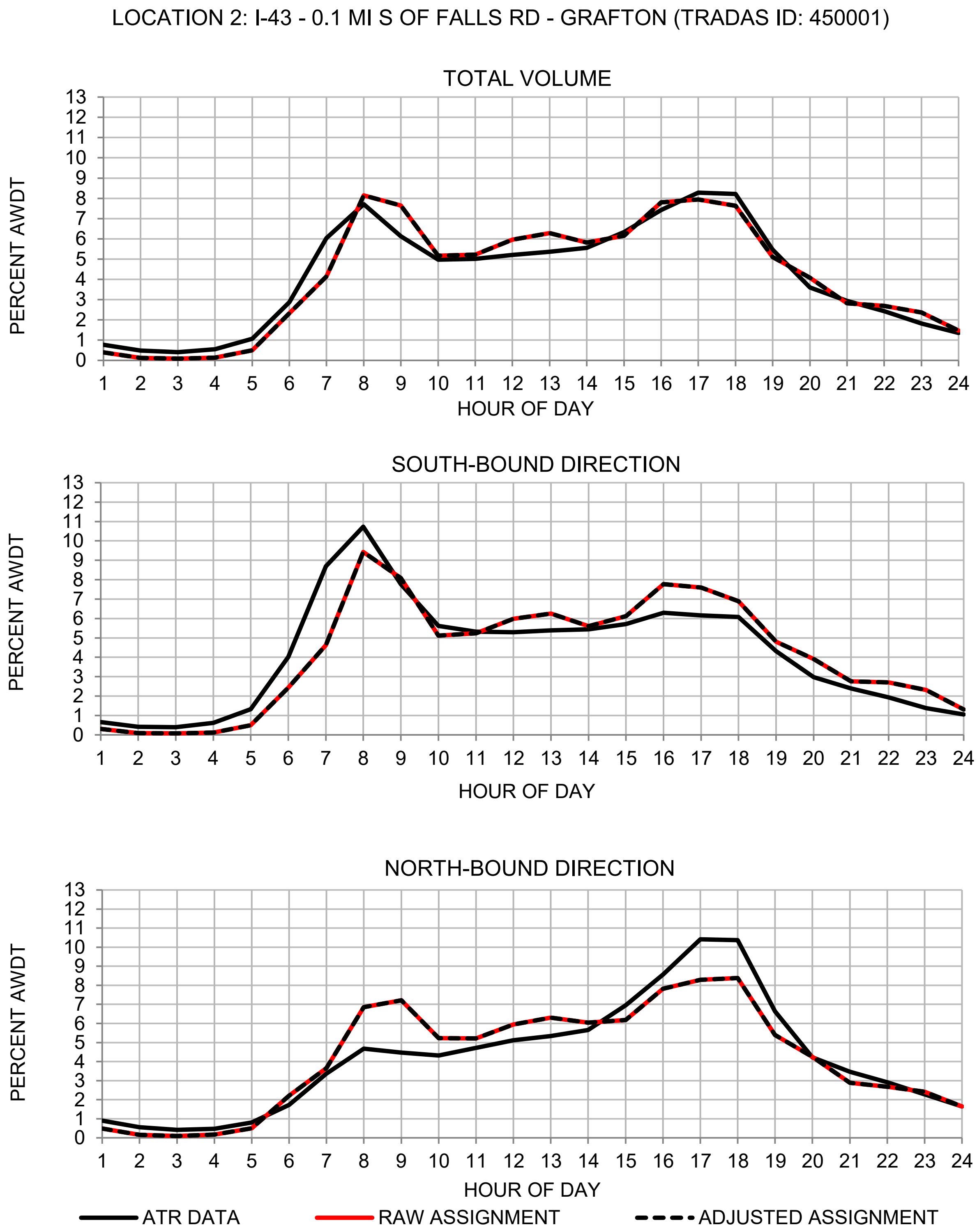
Figure 2.3 (Continued)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service “E”

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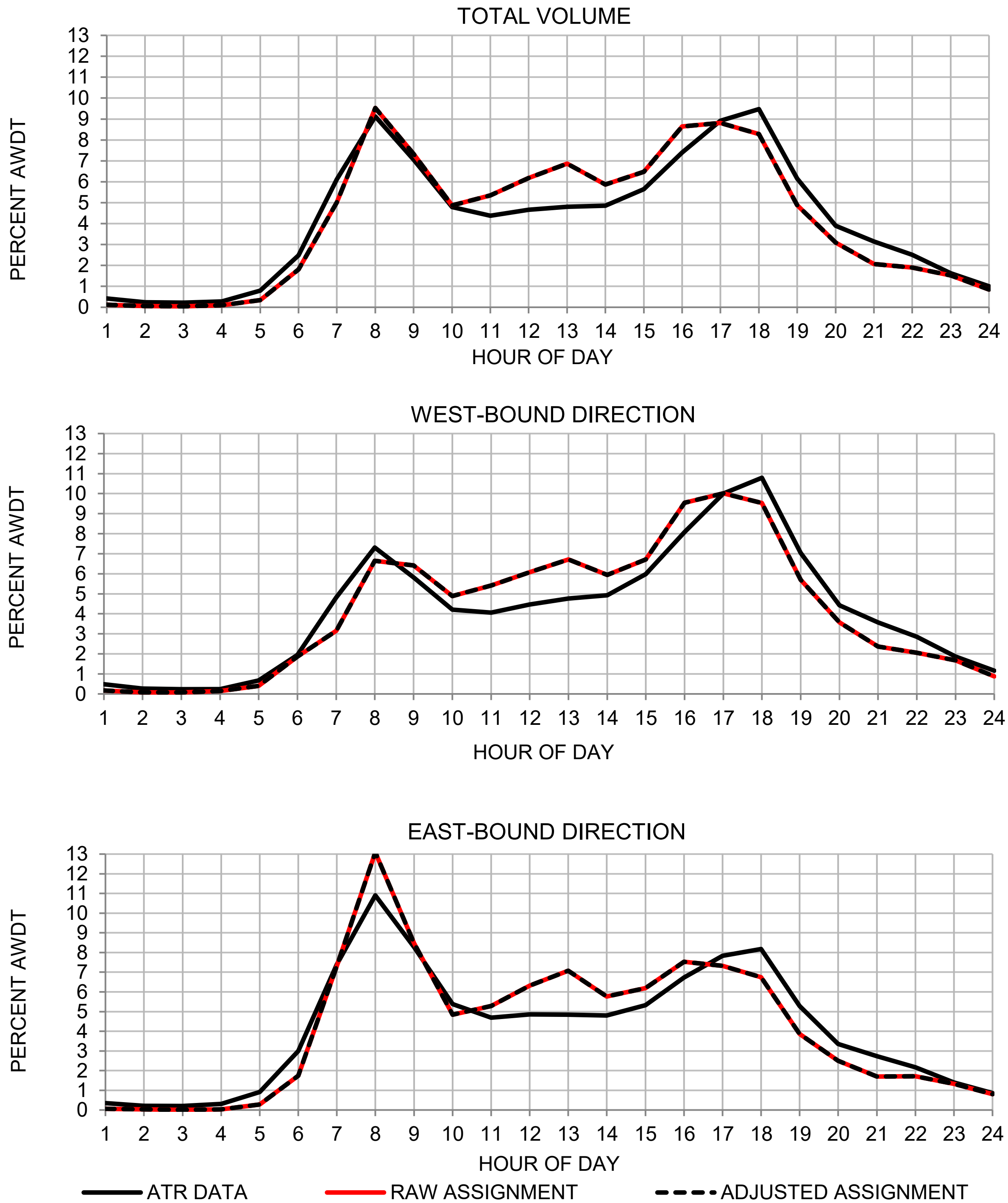
Figure 2.3 (Continued)

LOCATION 3: STH 16 -EAST OF CTH KE - PEWAUKEE #2 (TRADAS ID: 676136)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service “E”

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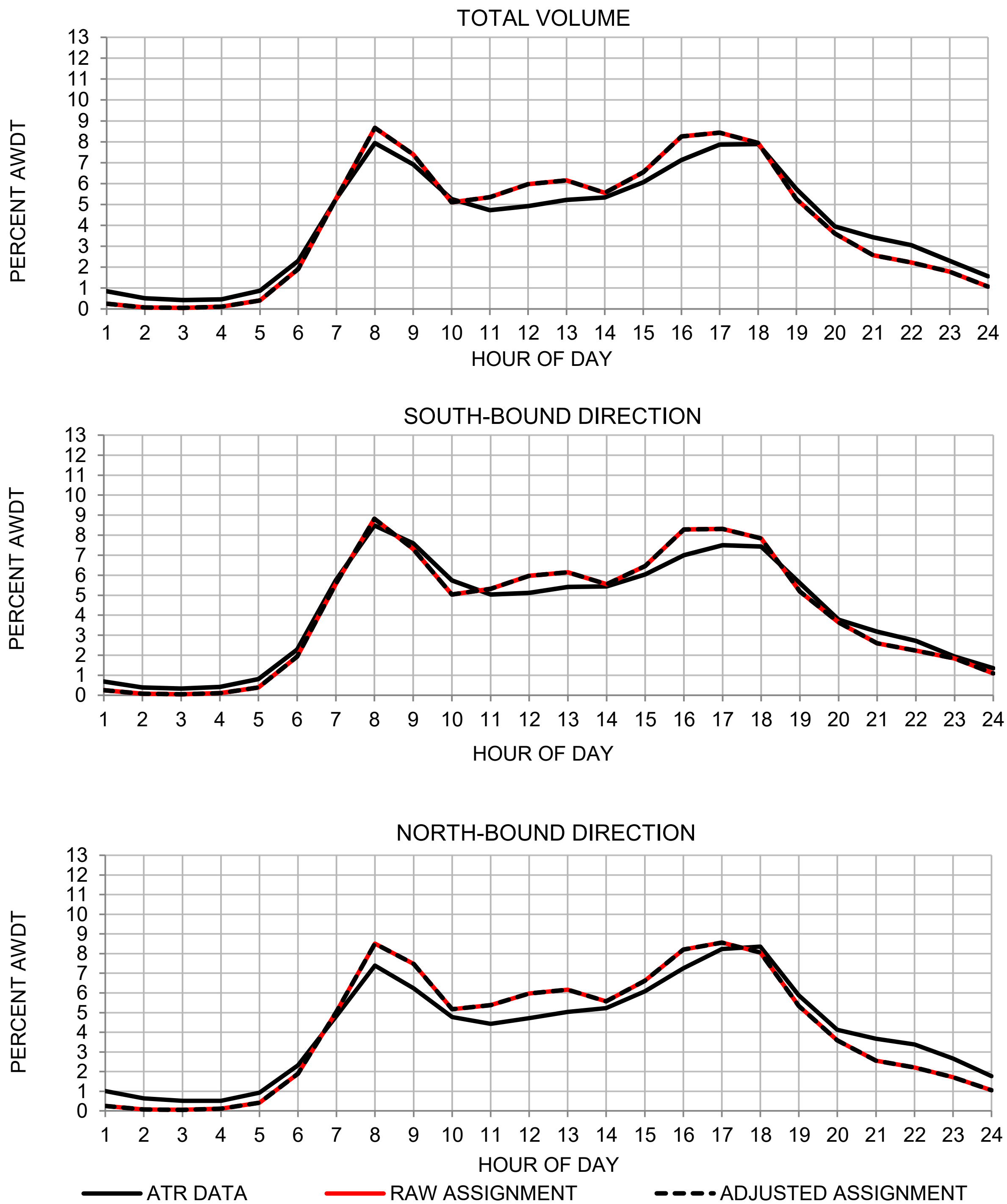
Figure 2.3 (Continued)

LOCATION 4: I-43 - AT WEST CAPITOL DR MILWAUKEE (TRADAS ID: 400018)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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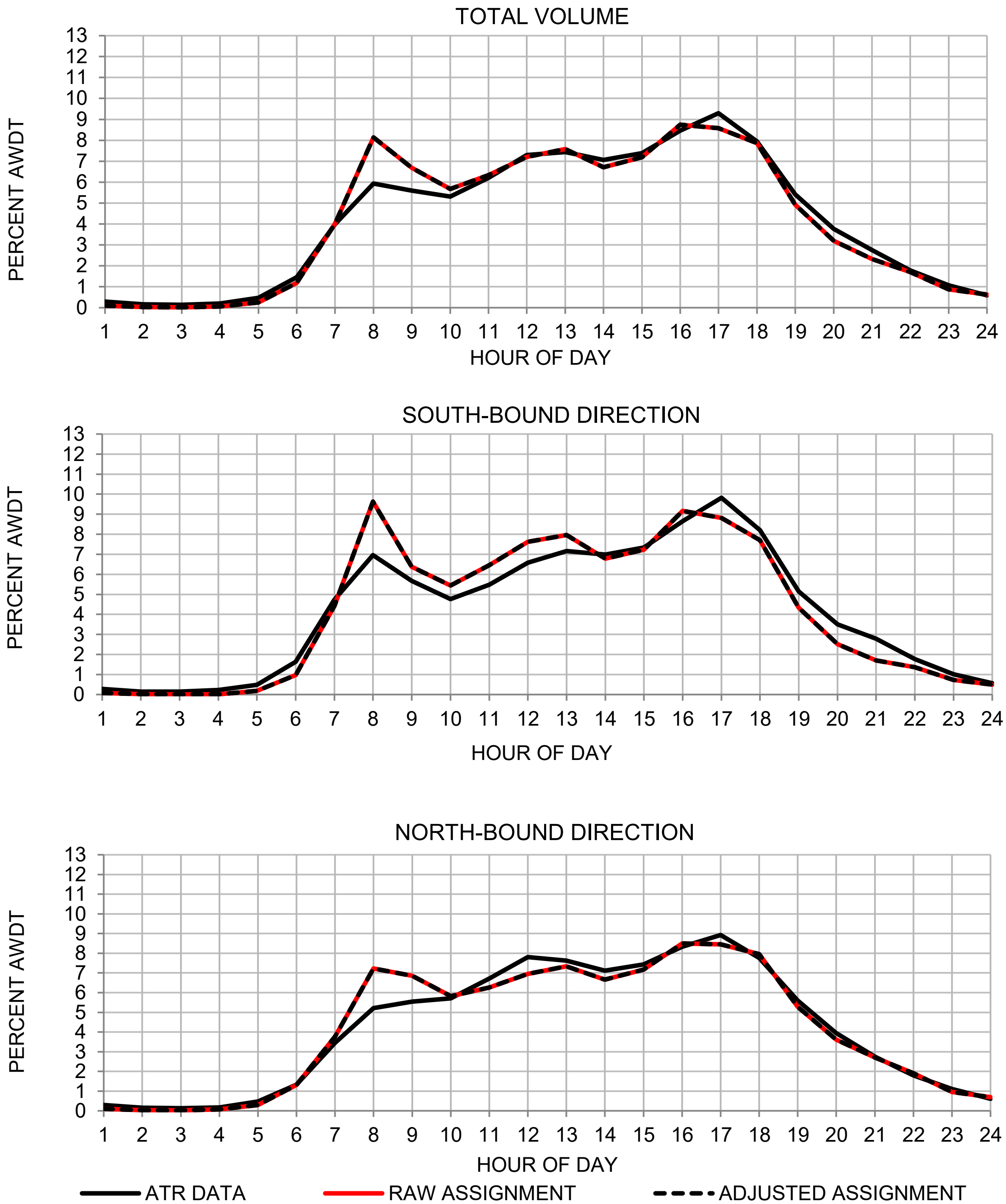
Figure 2.3 (Continued)

LOCATION 5: STH 100 MAYFAIR RD - S OF NORTH AVE - GARFIELD WAUWATOSA
(TRADAS ID: 406515)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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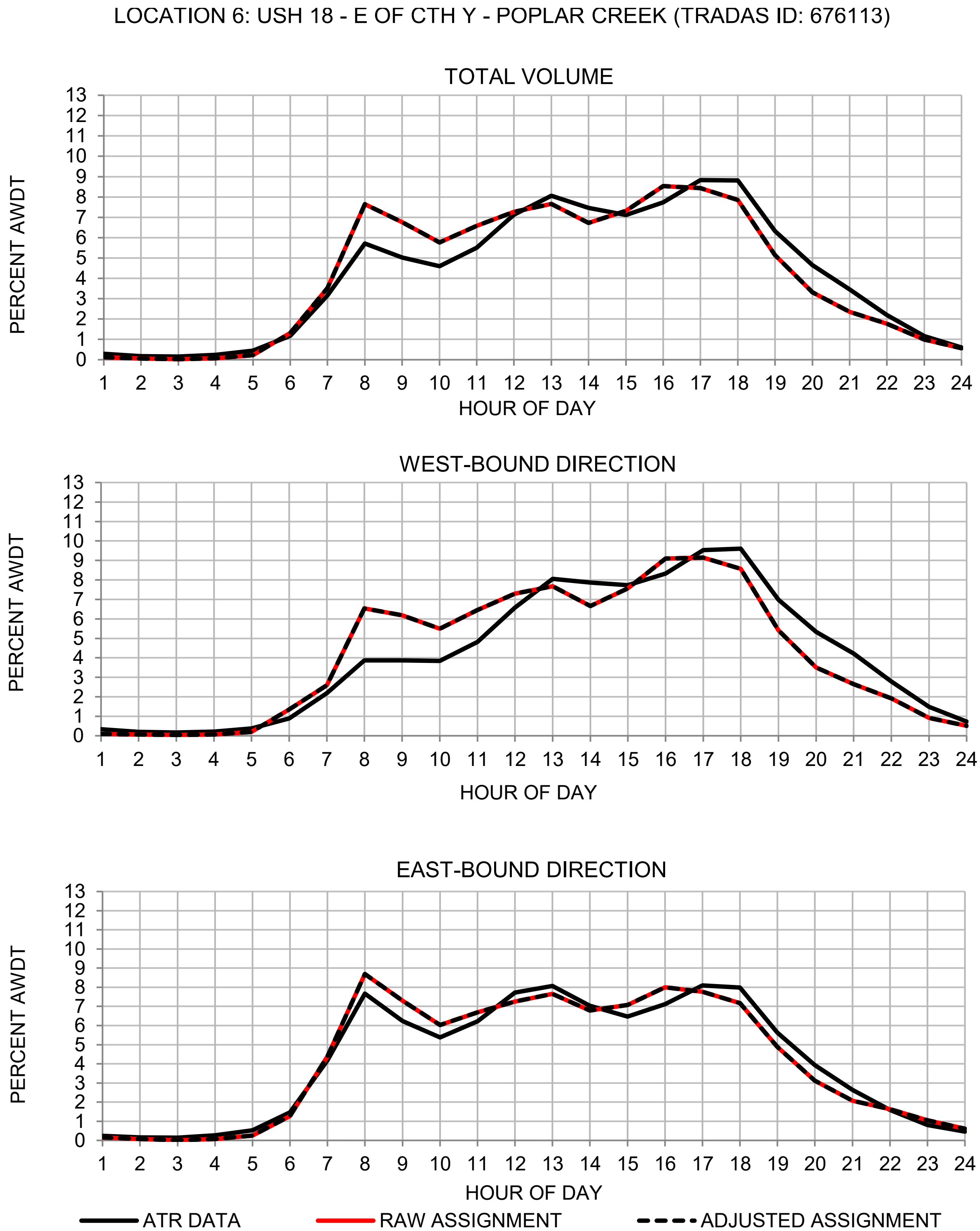

Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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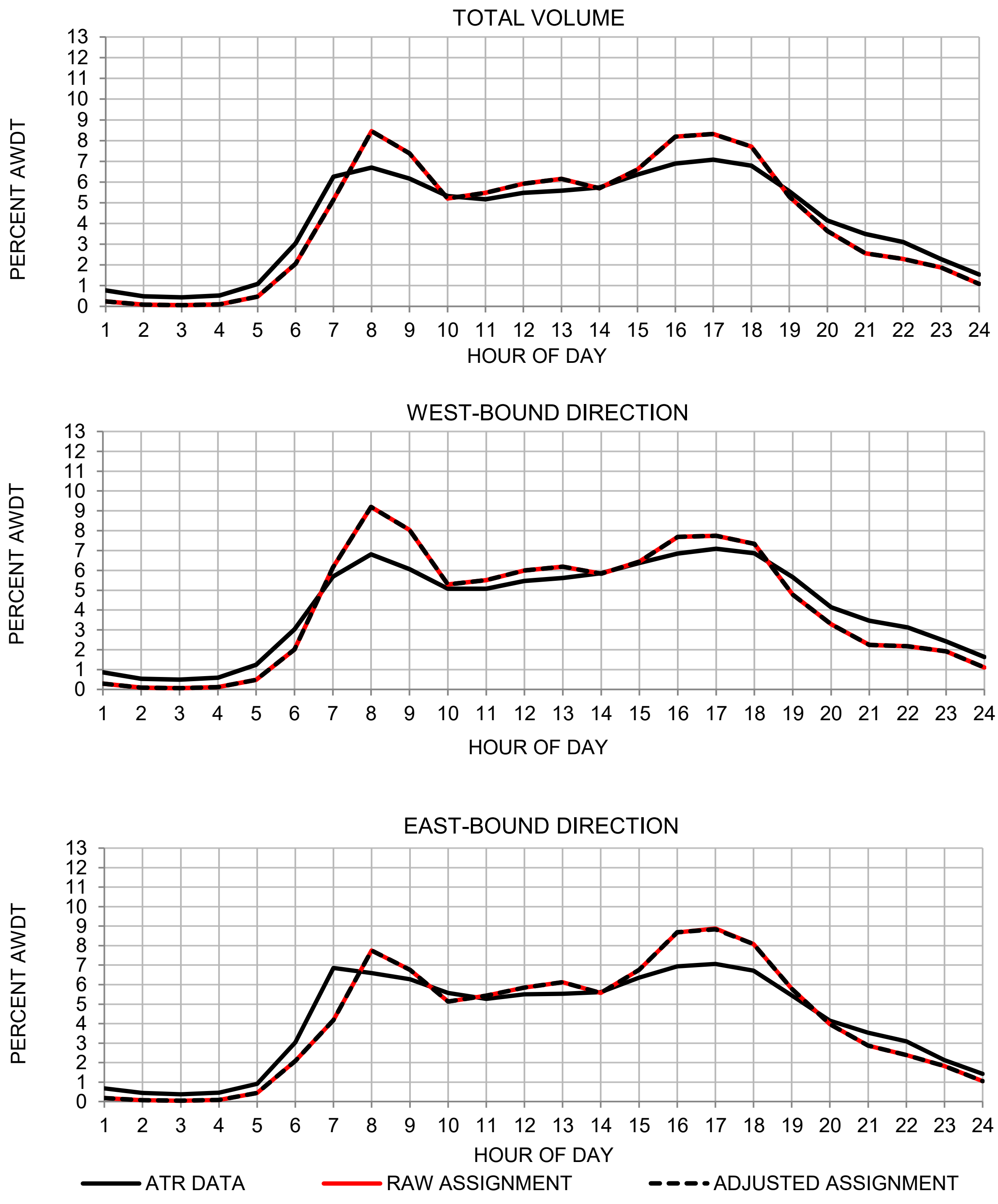
Figure 2.3 (Continued)

LOCATION 7: I-94 - AT 119TH ST WEST ALLIS (TRADAS ID: 400119)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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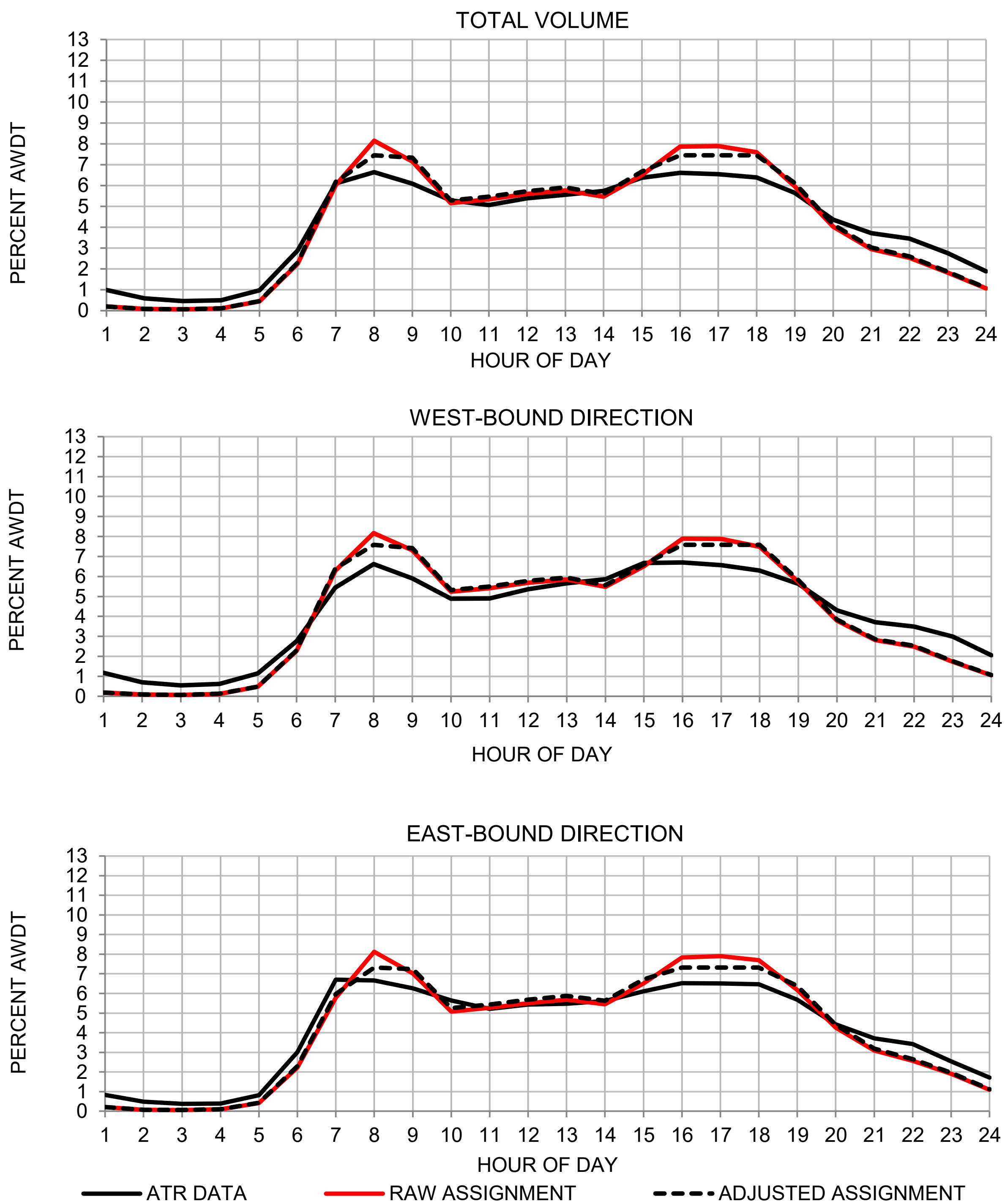
Figure 2.3 (Continued)

LOCATION 8: I-94 - BETWEEN HAWLEY & MITCHELL - CEMETERY ACCESS
(TRADAS ID: 400002)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service “E”

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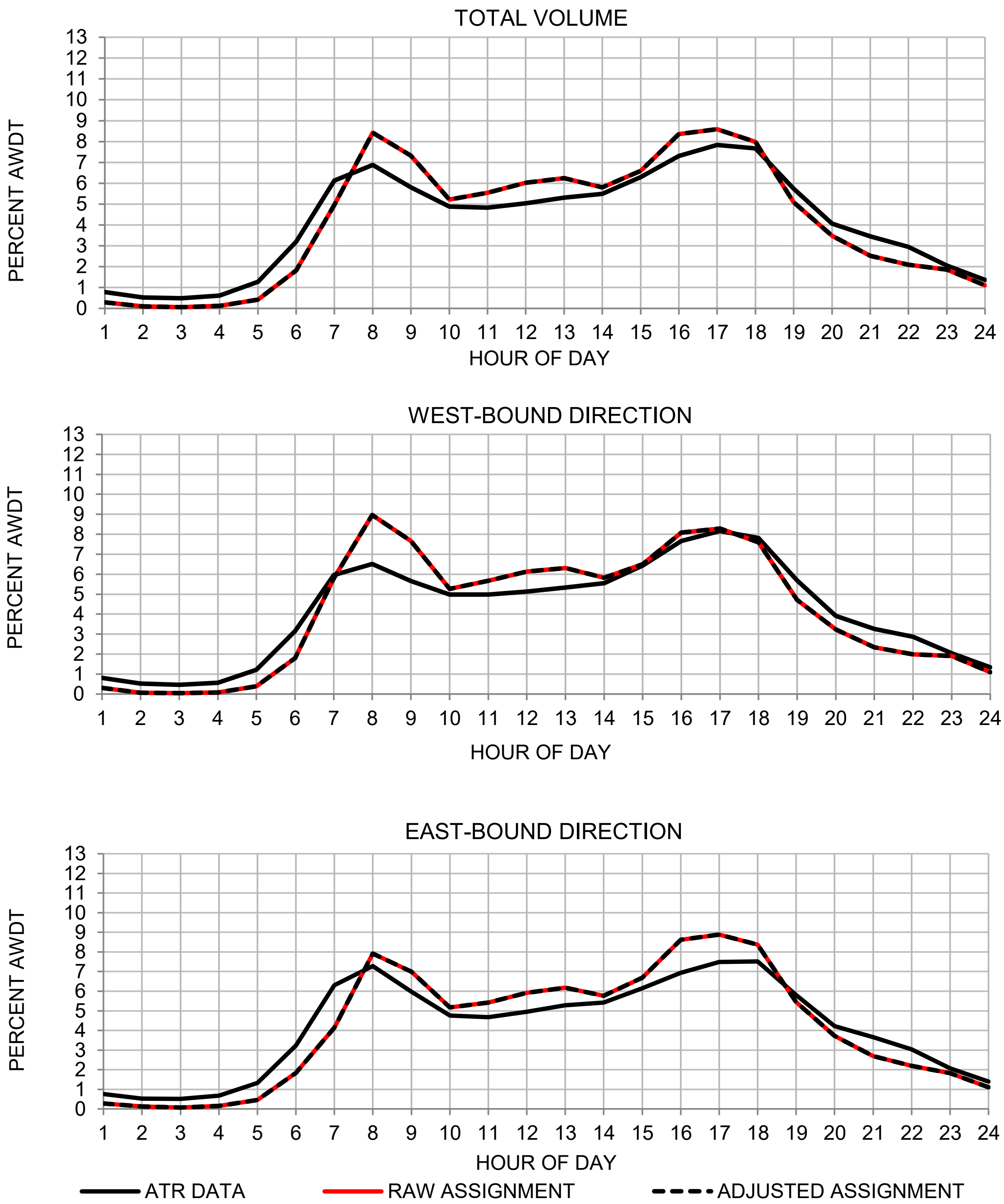
Figure 2.3 (Continued)

LOCATION 9: I-43 - E OF 68TH ST GREENFIELD (TRADAS ID: 400008)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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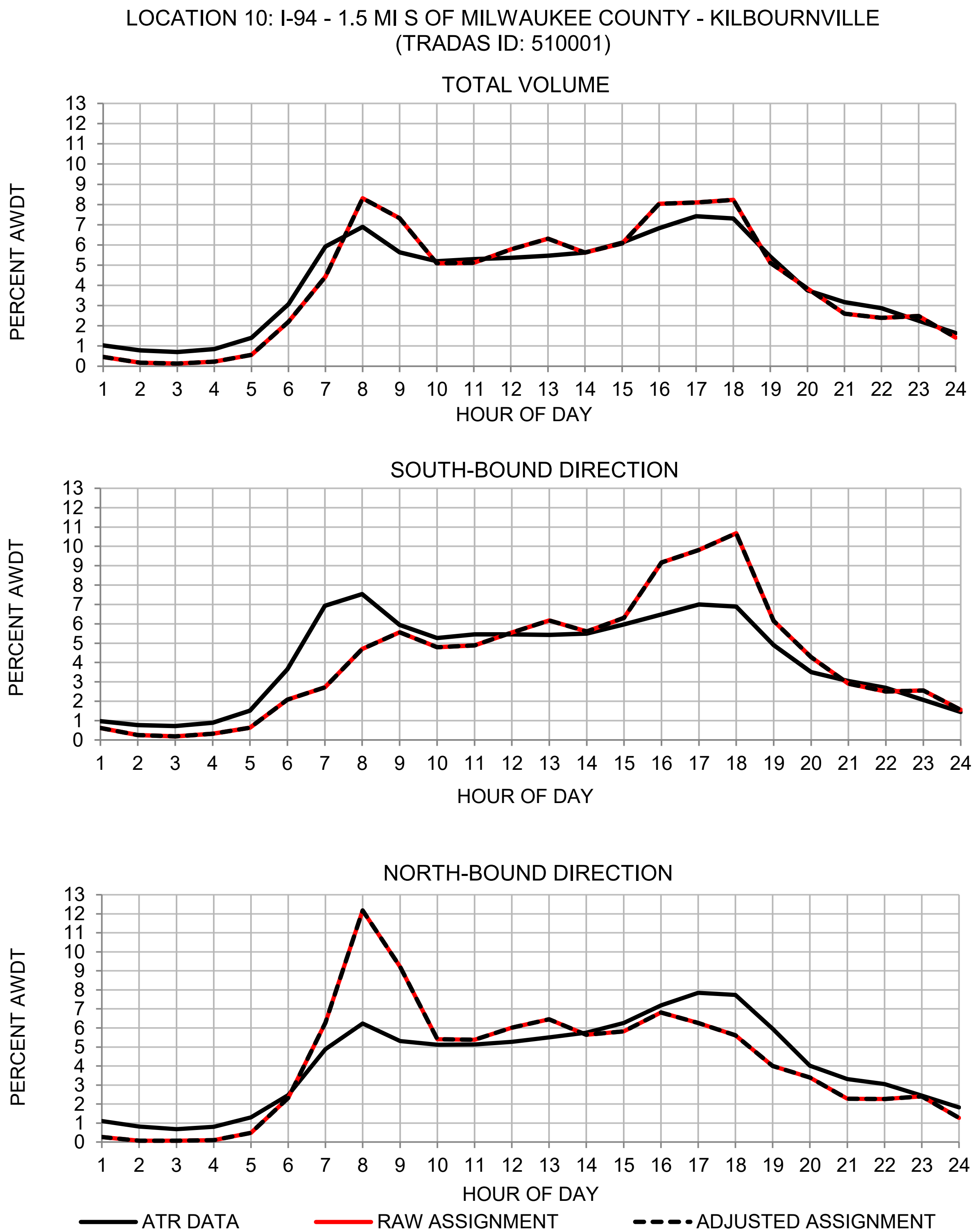
Figure 2.3 (Continued)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service “E”

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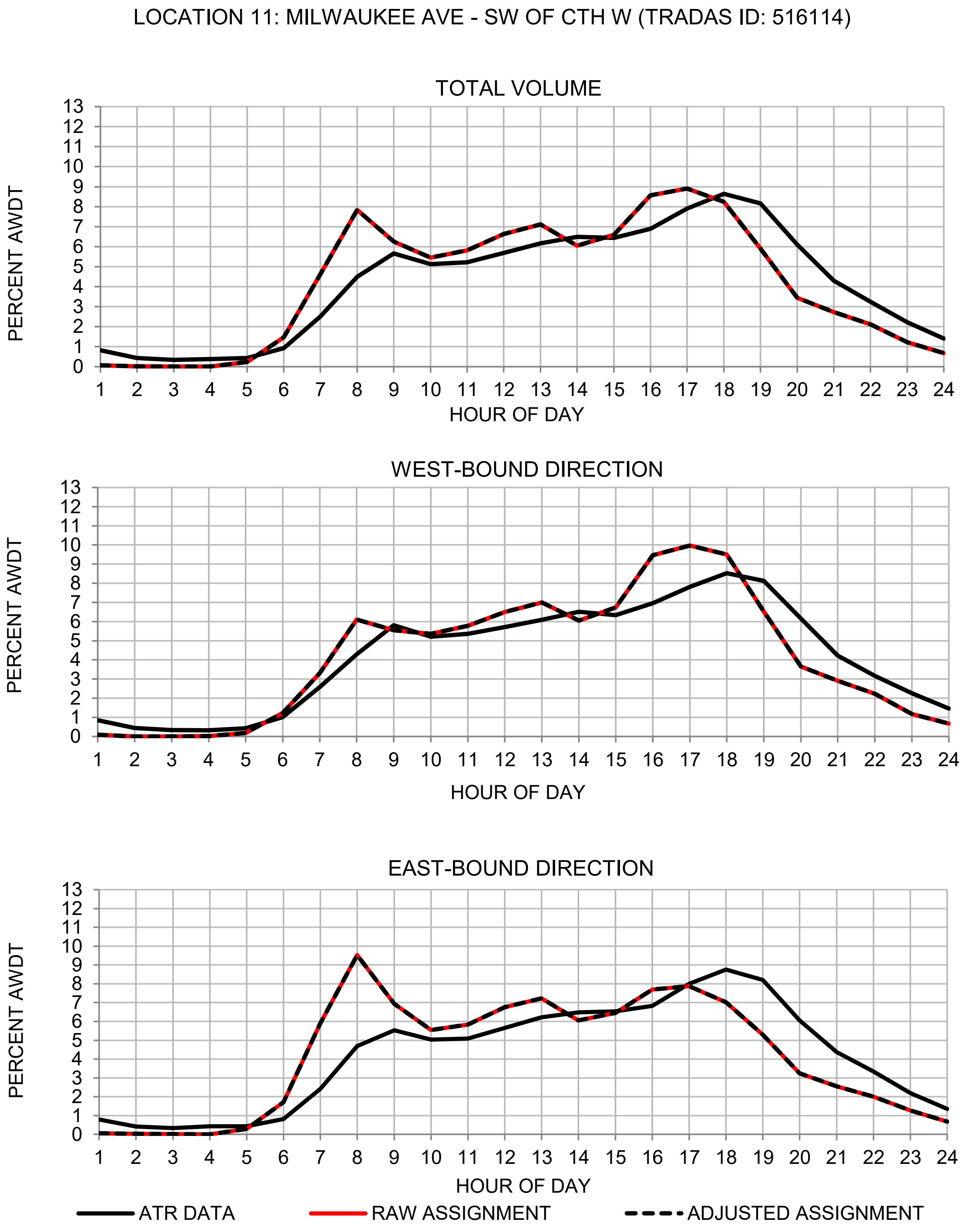
Figure 2.3 (Continued)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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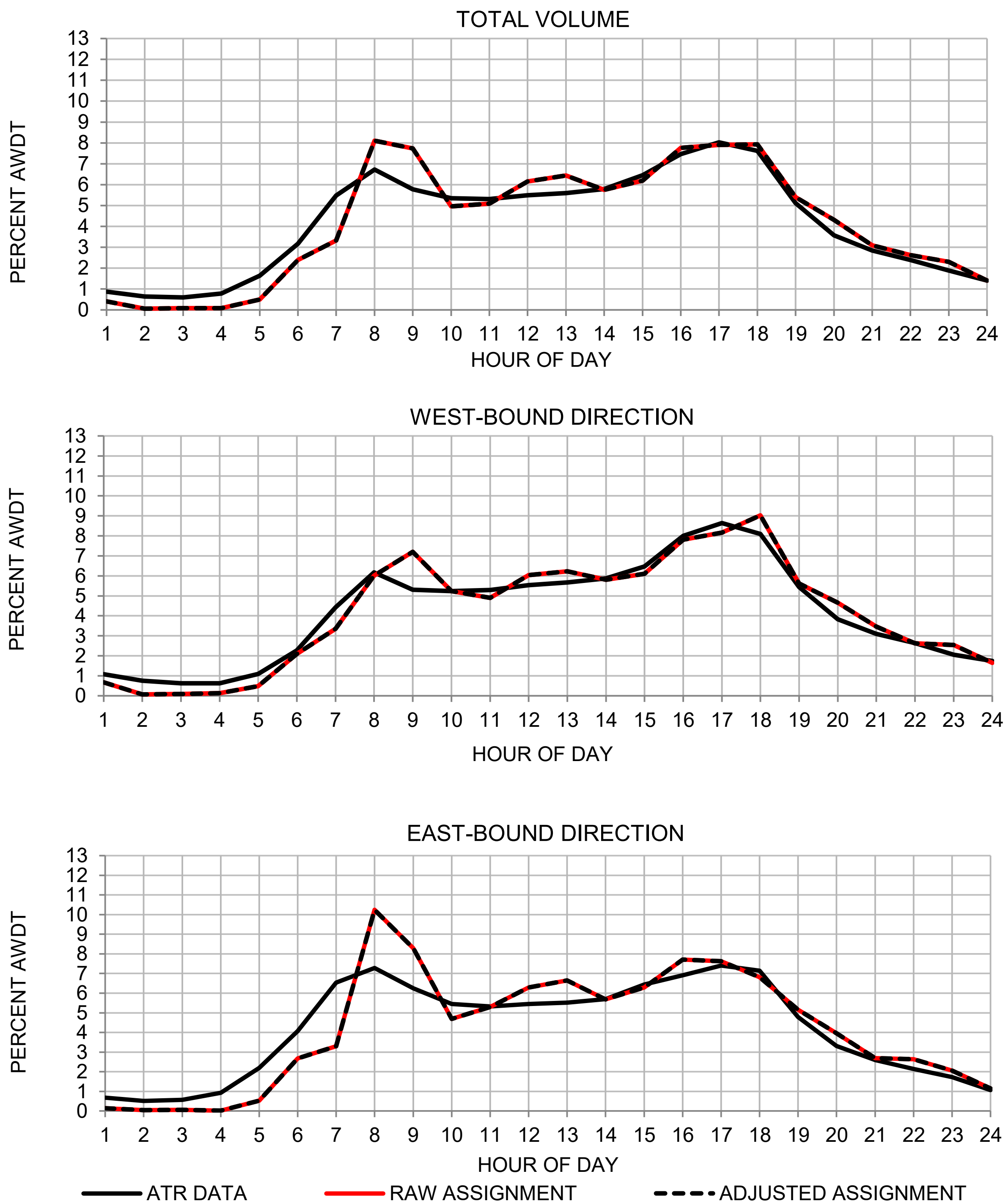
Figure 2.3 (Continued)

LOCATION 12: I-43 - 3.0 MI S OF STH 50 - DELAVAN (TRADAS ID: 640348)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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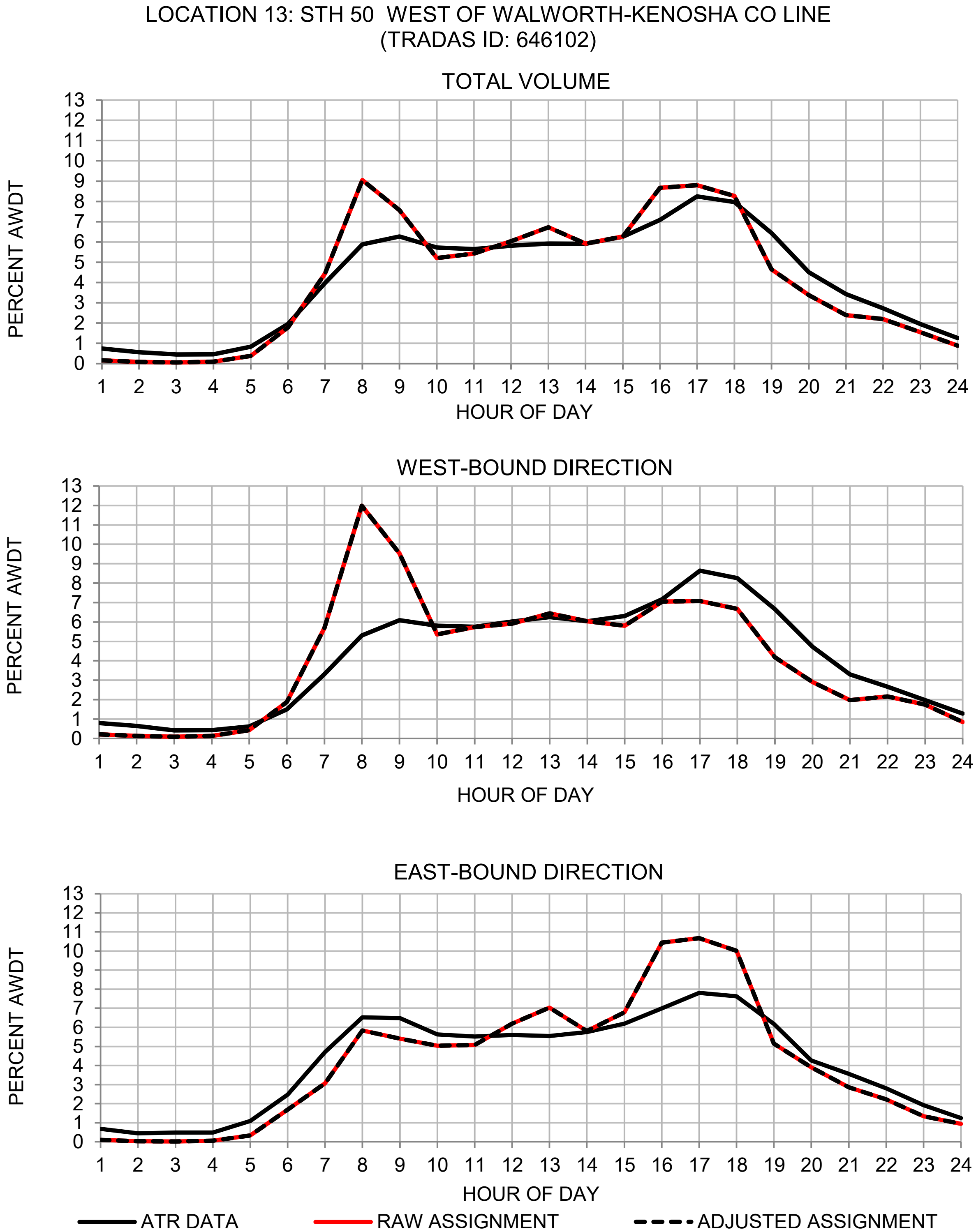
Figure 2.3 (Continued)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service "E"

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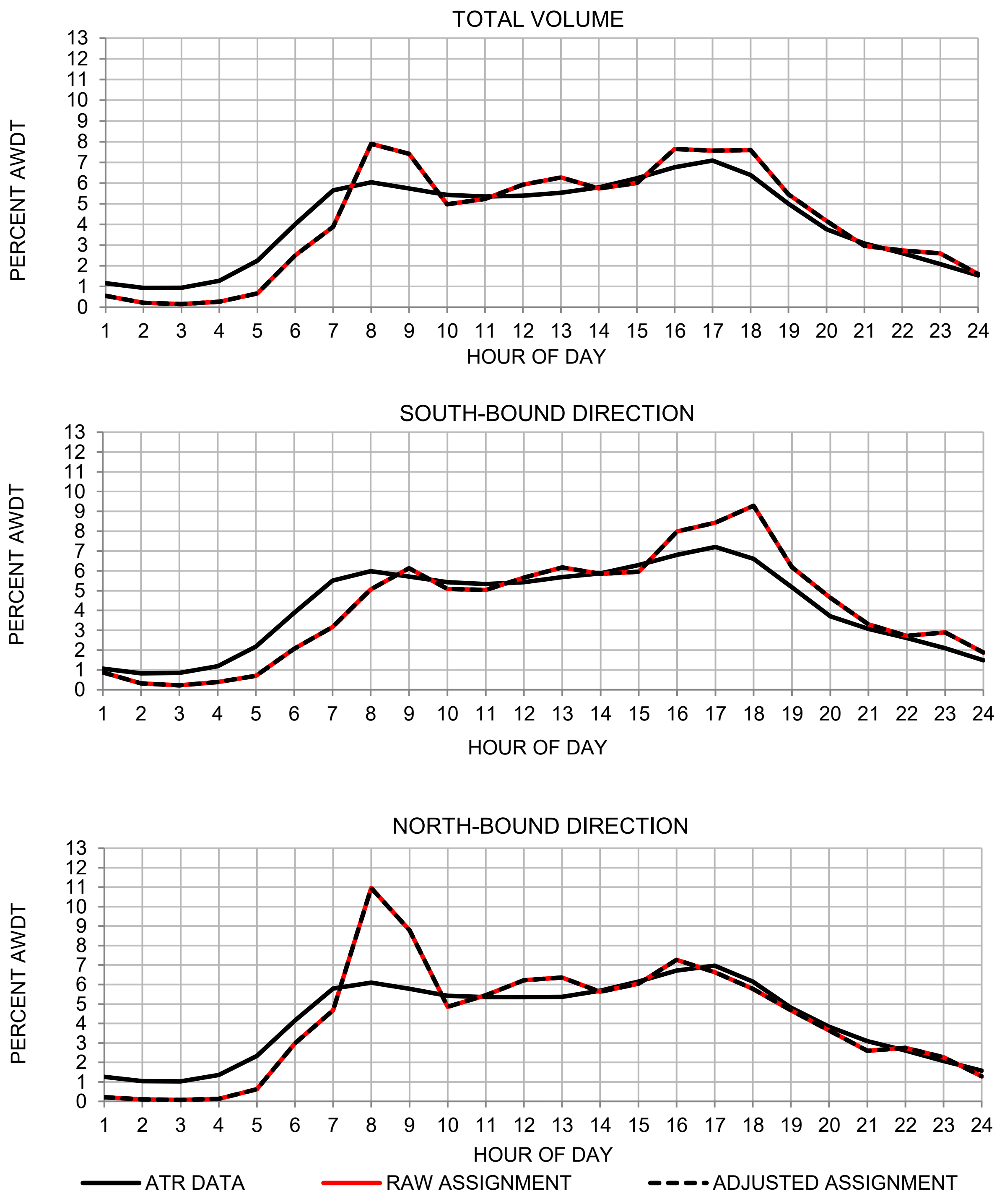
Figure 2.3 (Continued)

LOCATION 14: I-94 - 0.5 MI N OF CTH E - SOMERS (TRADAS ID: 306117)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service “E”

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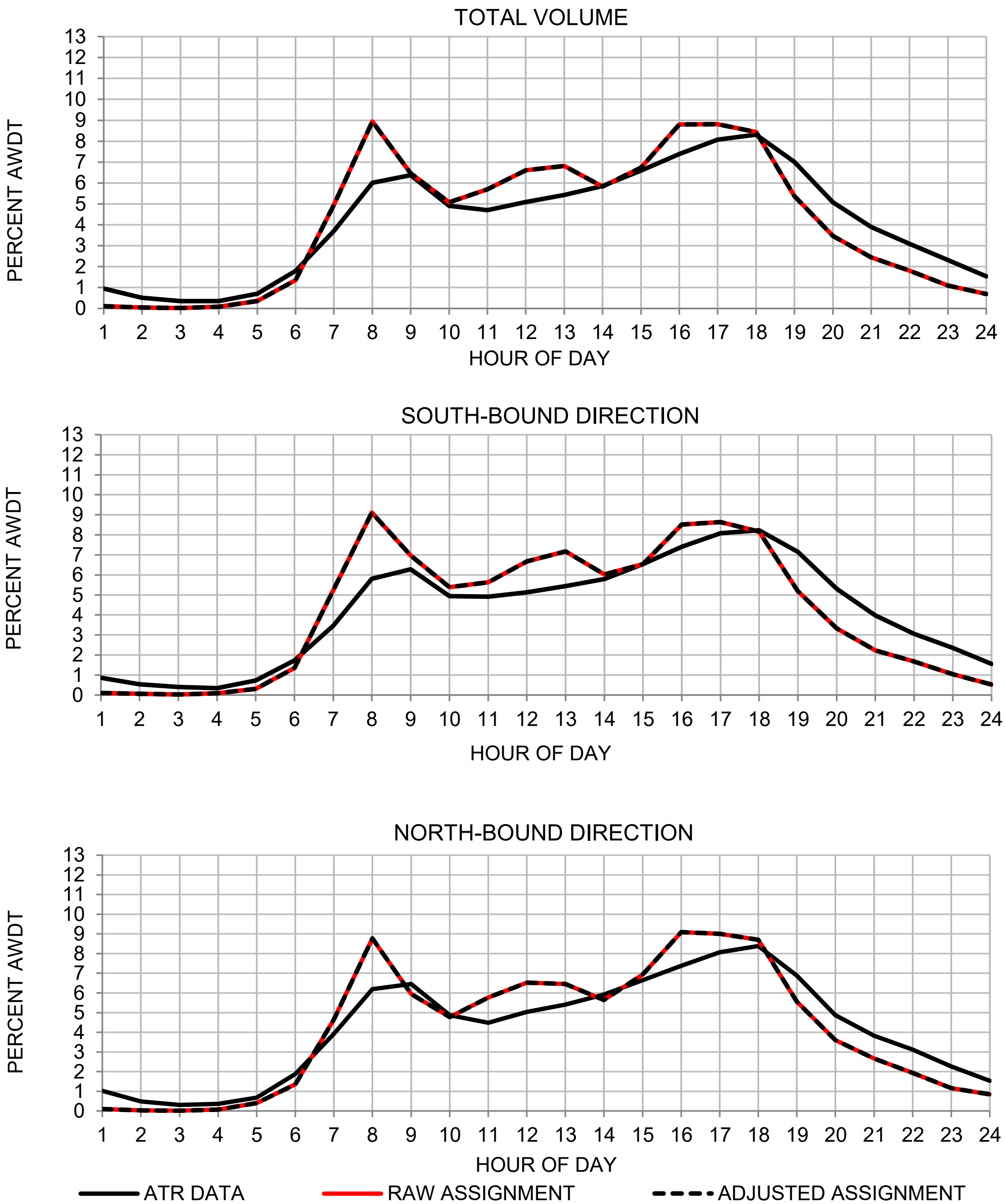
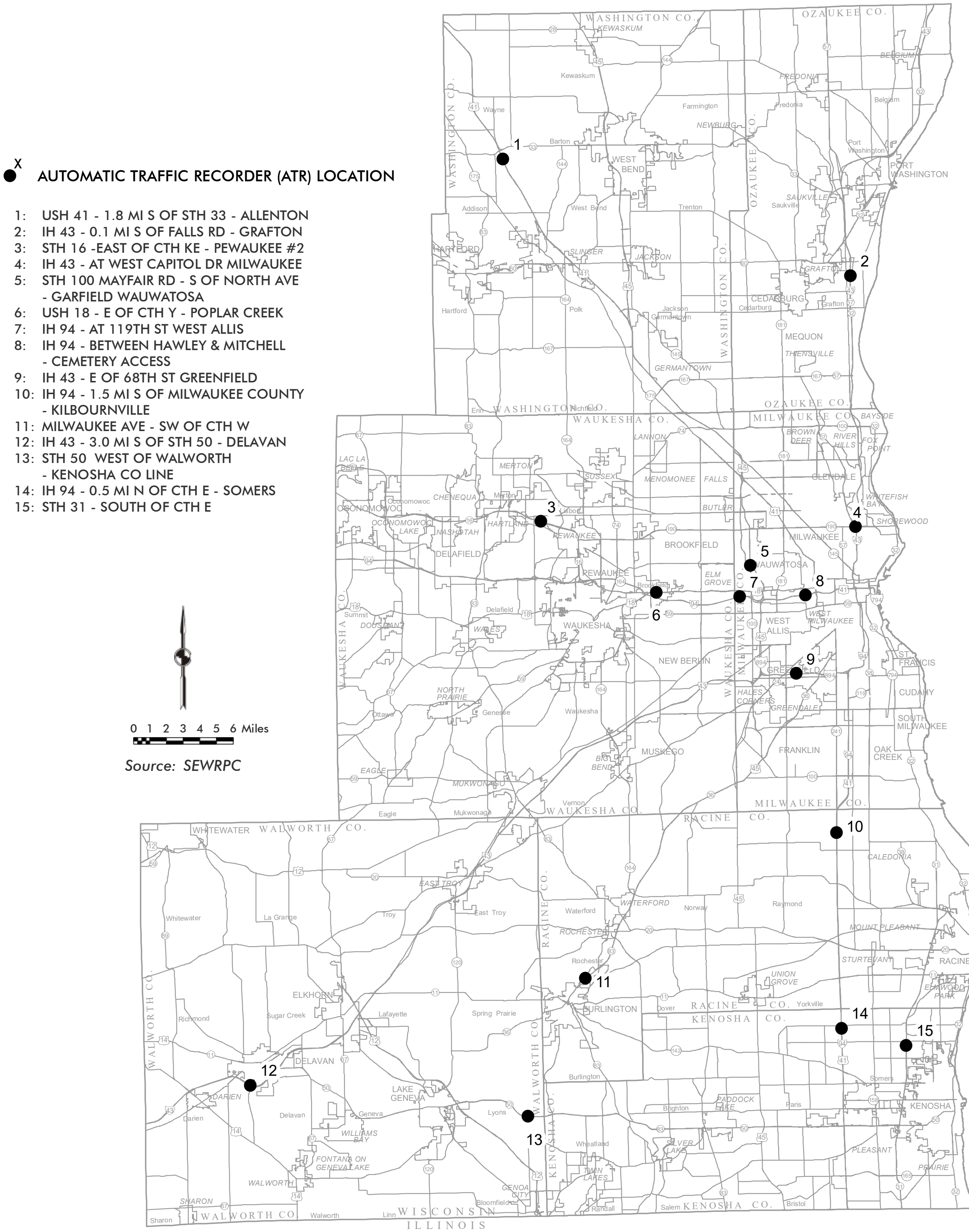
Figure 2.3 (Continued)

LOCATION 15: STH 31 - SOUTH OF CTH E (TRADAS ID: 306104)



Note: Adjusted assignment is the raw assignment capped at the capacity of the facility at a level-of-service “E”

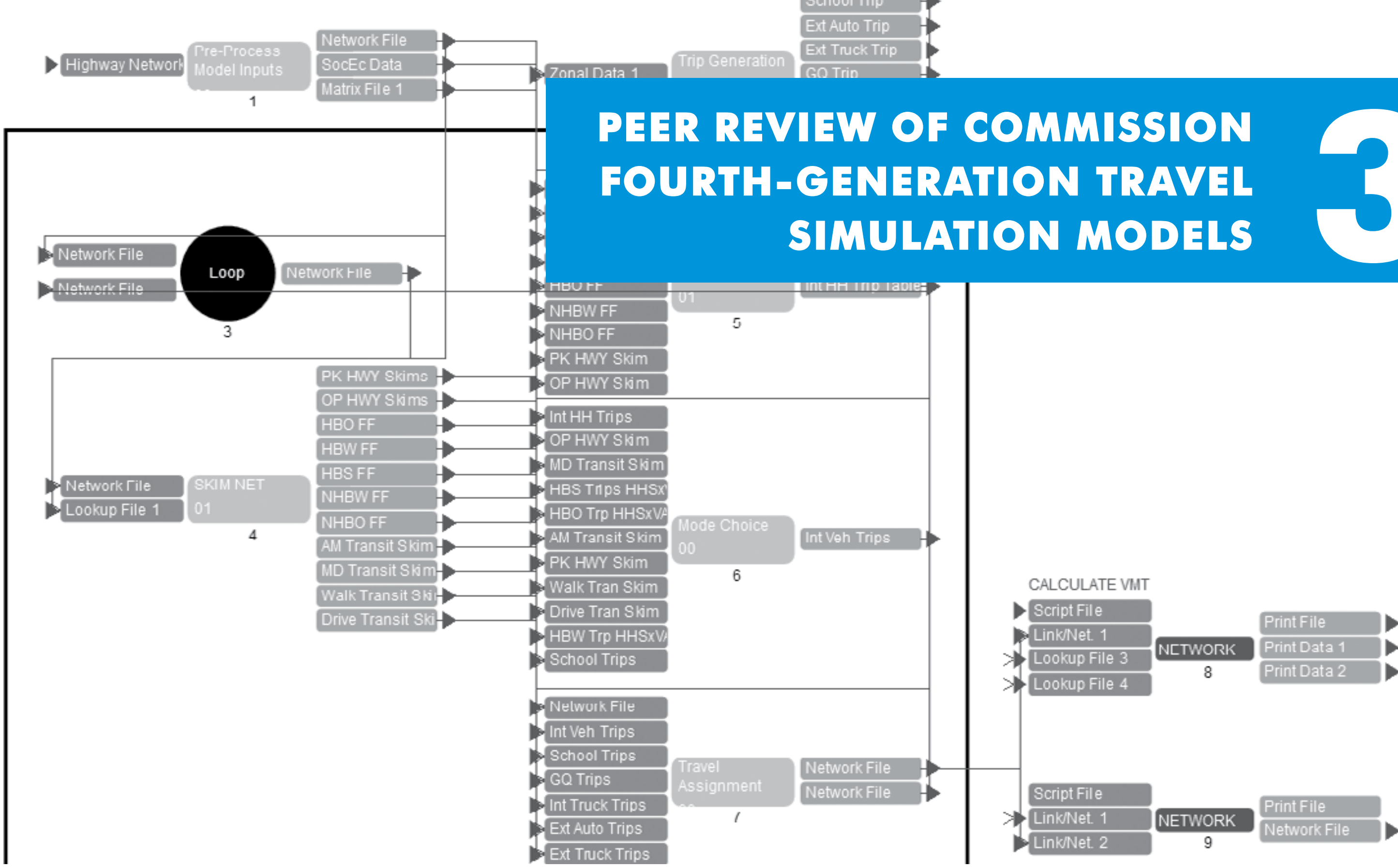
Map 2.5
Automatic Traffic Recorder (ATR) Locations Used in Validation of Time-of-Day Model



SUMMARY AND CONCLUSIONS

The fourth-generation travel simulation models developed in the early 2000s with 2000 and 2001 data were proven to forecast year 2011 travel, traffic volume, and transit ridership with a high degree of accuracy, and certainly meet the requirements for transportation planning and facility design purposes. This is particularly true when it is recognized that the year 2011 travel data are estimated based on surveys, and traffic and ridership counts are estimates themselves, with some counts having been taken over earlier and later years, and the counts reflect seasonal and daily variations in traffic flow, the impacts due to construction, which are not directly modeled, and random errors that occur in the counting process itself.

3 PEER REVIEW OF COMMISSION FOURTH-GENERATION TRAVEL SIMULATION MODELS



Credit: SEWRPC Staff

INTRODUCTION

Travel simulation models can be placed into four basic categories: outmoded methods, state-of-the-practice methods, advanced methods, and experimental methods. An outmoded method is a procedure or model which while once widely used, is no longer widely employed in travel demand models. An example of an outmoded method is the modeling of mode choice prior to destination choice. A travel demand modeling method referred to as a state-of-the-practice method is defined as a procedure or model which is in widespread use in travel demand modeling. An example of such a method is the use of the gravity model for the modeling of trip distribution. Advanced methods are those procedures or models that are not widely implemented and have only recently begun to be used and experience does not yet exist with respect to their accuracy and practical application. As experience is gained with advanced travel demand modeling methods and they become proven in terms of accuracy and practical application, they become state-of-the-practice methods. An example of an advanced practice is the use of activity-based models (ABM). Experimental methods are those methods which are currently under development and are yet to be employed in the forecast of travel by MPOs as a part of developing and testing alternative transportation system plans. An example of an experimental method was the TRANSIMS program which synthesizes and tracks individual travel behavior for the entire population of a regional study area. State-of-the-practice travel demand modeling is influenced by travel demand modeling practices required by the Federal Transit Administration for analysis of fixed guideway transit projects and by the U.S. Environmental Protection Agency and U.S. Department of Transportation for air quality conformity analysis of regional transportation plans and improvement programs.

This chapter presents the results of a review of the Commission's fourth-generation travel simulation models developed in the early 2000s with 2000 and 2001 data by experts in the field of travel simulation. Three travel simulation experts were brought in to review the Commission's current fourth-generation travel demand model battery and validation of the current model and identify potential structural and methodological improvements to consider during the development of the fifth-generation travel demand model for the Southeastern Wisconsin Region.

PEER REVIEW

The peer review of the Commission's current fourth-generation travel simulation models relative to current practice is intended to identify those travel simulation models of the Commission that should be added to, adjusted and/or changed to make sure they are using current techniques and methodology. The peer review process consisted of a moderated discussion by a panel of travel simulation experts, with the goal of reviewing the fourth-generation travel demand models in light of current modeling practice and identify potential changes to the current model structure and methods to ensure that the fifth-generation travel demand model is consistent with current modeling practice. A copy of the agenda for the meeting is included as Figure 3.1

The peer review panel consisted of three nationally recognized travel demand modeling experts: Keith Killough from Arizona Department of Transportation (ADOT), Guy Rousseau from the Atlanta Regional Commission (ARC), and Kermit Wies from the Chicago Metropolitan Agency for Planning (CMAP).

Keith Killough is the Director of Transportation Analysis for the Arizona Department of Transportation (ADOT). He holds an urban planning degree from the Massachusetts Institute of Technology and holds certification from the American Institute of Certified Planners. He is a member of several Transportation Research Board committees including the second Strategic Highway Research Program's Technical Coordinating Committee on Capacity, the Intercity Passenger Travel Policy Study Committee, and various standing and research committees.

Guy Rousseau is the Models & Surveys Manager for the Atlanta Regional Commission (ARC), the MPO for Atlanta, Georgia, which he joined in 1998. He is responsible for model development activities and travel surveys. Before coming to ARC, he was the Principal Traffic Engineer for the City of Atlanta Department of Public Works, with responsibilities for travel modeling and traffic simulation.

Kermit Wies served as Deputy Executive Director for Research and Analysis with the Chicago Metropolitan Agency for Planning (CMAP). He had over 25 years of experience in urban systems modeling and planning and is the principal author of the 2030 Regional Transportation Plan for the Chicago region.

Each of the three experts were selected specifically due to their breadth of experience in developing and implementing both trip-based and activity-based models. In addition to Commission staff, two representatives from the Wisconsin Department of Transportation were also in attendance: Jennifer Murray and Brent DesRoches. The peer review was conducted on December 18, 2014. The review and discussion was assisted by materials related to the validation of the fourth generation travel demand model provided by SEWRPC

Figure 3.1
Agenda of the Peer Review and Technical Advisory Committee for Regional Travel Demand Modeling

Agenda of the

Peer Review and Technical Advisory Committee for Regional Travel Demand Modeling

DATE: December 18, 2014

TIME: 9:00 a.m.

PLACE: Chicago Metropolitan Agency for Planning
233 South Wacker Drive, Suite 800
Chicago, Illinois 60606

AGENDA:

9:00 – 10:00	Introductions, SEWRPC Background and Overview of Vision 2050, Travel Model Applications, and Schedule for Vision 2050 Update and Model Development
10:00 – 10:15	Break
10:15 – 12:00	Presentation/Discussion of Current Fourth Generation Travel Demand Model and Year 2011 Validation Utilizing 2010/2011 Socio-Economic Inputs (Validation Tables, Figures, and Maps to be Provided prior to Meeting)
12:00 – 12:15	Break and Distribute Lunches
12:15 – 2:15	Discussion of Proposed Short-Term Model Improvements 1. Four-Step, Trip-Based Structure 2. Modeling Walk and Bicycle Trips Separately 3. Synthesizing Commercial/Freight Travel and Potential to Link to State-Wide Freight Model
2:15 – 2:30	Break
2:30 – 4:30	Discussion of Proposed Short-Term Model Improvements (continued) 4. Synthesizing Household External Travel 5. Incorporating New Transit Modes (Commuter-Rail, Light-Rail, Bus Rapid Transit) into Mode Choice
4:30 – 5:00	Continued Discussion/ Potential Long-Term Model Improvements/ Other Issues 1. Modeling Travel-Time Variability 2. Modeling Transportation System Management
5:00	Adjournment

staff, which are presented in the validation section of Chapter 2 of this report. The remainder of this chapter summarizes the recommendations of potential model improvements to consider incorporating as the fifth-generation travel demand model was being developed. Proposed improvements model identified by the expert panel to be considered during the development of the fifth-generation travel simulation model have been summarized into six categories: trip generation, trip distribution, mode choice, trip assignment, model validation and other recommendations. The recommendations made by the travel simulation peer review panel are categorized as either short or long-term, with short-term recommendations to be considered for the fifth-generation model development and the long-term recommendations to be considered for subsequent refinement of the fifth-generation model.

As indicated in Figure 3.1, Commission staff initiated the peer review with an overview of the major plan update (VISION 2050), which included the schedule for VISION 2050 and how the development of the fifth-generation travel demand model fit into the plan update and the purpose of the peer review. After the conclusion of the brief overview of VISION 2050, model development, and purpose of the peer review, Commission staff reviewed the fourth-generation travel demand model and its validation to the year 2011. A summary of the discussion and proposed model improvements from the review of the current travel demand model follows.

TRIP GENERATION

The panel indicated that the battery of trip generation models employed in the current trip generation model is consistent with current national practice. Commission staff noted that the current cross-classification models utilized to estimate trip production are relatively insensitive to demographic changes as the number of trips generated by households are only based on household size and vehicle availability. The peer review panel suggested providing additional household stratifications, such as number of workers and the presence of children in households. The panel also suggested that the Commission consider development of a population synthesizer to estimate the various household characteristics necessary to provide the additional household stratification. With regard to the vehicle availability model, the panel recommended that the Commission consider developing a logit based choice model and to also consider the presence of transit within the vehicle availability model.

During the review of the nonmotorized trip production model, the panel suggested using a different description of area type based on intersection density or street grid, rather than the density of population and employment as a measure for whether an area would be bicycle or walk friendly. One panel member noted that the method of accounting for nonmotorized travel employed by the current model was adequate, while another panel member suggested development of a choice model to determine nonmotorized travel.

TRIP DISTRIBUTION

Commission staff next provided a review of the trip distribution models employed in the current travel demand model battery. Commission staff noted that the trip distribution models take the form of gravity models and employed K-factors to constrain travel by urbanized area and major retail centers. The panel noted that the use of K-factors reduces the sensitivity of gravity models and suggested that the Commission consider not including

K-factors in the fifth generation travel demand model battery. The panel also encouraged using special generators rather than K-factors for major retail centers. The panel noted that the continued use of gravity models is consistent with current practice, and suggested that continued use of K-factors be limited to school trips in the next generation model. The panel also encouraged the Commission staff to consider developing logit based destination choice models. The use of a destination choice model would allow the trip distribution step to consider additional variables which may be significant in the choice of destination. The panel also suggested if a destination choice model is developed, that logsums from the mode choice step be included as a variable in destination choice.

MODE CHOICE

Commission staff next reviewed the mode choice step of the current travel demand model. It was noted that the Commission's use of logit based mode choice models is consistent with current practice and should be considered during the development of the fifth generation travel demand model. Commission staff noted that the current mode choice models group transit into a single transit mode. Commission staff also noted that the choice models utilize the "best" transit path from all of the available transit modes. The panel suggested that local, express, and rapid transit modes be considered separate modes during the mode choice step, and that each transit mode be skimmed separately. The panel noted that skimming and modeling each transit mode separately would assist in distinguishing between local and express bus in cases where there are two competing bus lines.

TRIP ASSIGNMENT

Commission staff reviewed the structure and methodology of the trip assignment step of the fourth-generation travel demand model battery. Staff noted that the current model assigns travel for a single 24-hour period. Staff also highlighted the time-of-day assignment procedure developed to provide peak hour travel forecasts and trip tables to the Wisconsin Department of Transportation for their corridor studies and to serve as inputs into the micro-simulation modeling conducted as part of the preliminary engineering for freeway reconstruction projects. The panel noted that the time-of-day assignment procedure would be considered advanced practice. During the discussion related to the Commission's trip assignment step, the panel recommended that the Commission capitalize on the current time-of-day assignment and consider developing skims by time of day to model mode and potentially trip distribution by time-of-day.

During the review, Commission staff noted that the current models utilize vehicle based capacities, rather than passenger car equivalents based capacities. Commission staff indicated that it would be desirable to perform trip assignment by vehicle class, to which the panel concurred and recommended that the Commission models use passenger car equivalent based rather than vehicle based capacities. The panel also recommended that heavy-duty trucks and transit vehicles be preloaded to the network as heavy-duty trucks are less likely to divert due to congestion and the facilities utilized by transit vehicles are fixed. The panel also recommended that the next travel demand model consider assigning auto trips to park-ride lots.

There was discussion relative to the volume delay functions utilized by the Commission in the current travel demand model. Commission staff noted that a single volume delay function (VDF) was utilized during the daily assignment, but that the time-of-day assignment procedure utilized eight VDFs based on the facility type and posted speed of the roadway. The panel recommended that the Commission consider utilizing multiple VDFs regardless of whether the next generation travel demand model is a daily model or incorporates time-of-day into one or more of the model steps. The panel also recommended that consideration be given to calibrating VDFs based on Akcelik or Conical functions when developing fifth-generation travel demand model. The panel noted that these forms better account for queuing than the Bureau of Public Roads (BPR) curve, especially when employing a time-of-day assignment methodology. The panel also recommended that consideration be given to utilizing generalized cost rather than travel time to determine the shortest path. Path building based on a generalized cost would allow the Commission to take into account additional variables like cost per mile or trip purpose in trip assignment.

MODEL STRUCTURE

Commission staff reviewed the general structure and operation of the current travel demand model. Staff noted that the current travel demand model was a trip-based four-step model. Commission staff noted that the next generation travel demand model would be primarily used for travel forecasting and that an activity-based model (ABM) format was not being pursued for this effort. The panel concurred that the continued use of a trip-based four-step travel demand model continues to be a valid approach to forecasting travel demand.

Commission staff also noted the current model was designed with the capability to feedback congested travel times from the trip assignment step to the destination choice step. Staff noted that feedback loop was performed once. The decision to only run a feedback loop once was determined during the development and calibration of the fourth-generation travel demand model, when it was observed that the assignment did not change significantly by performing a second or third feedback loop for the additional effort required. The panel recommended that the Commission's fifth generation travel demand model continue to include a feedback loop and that the model be allowed to iterate until it stabilizes. One suggestion for a closure criteria to determine stability was a relative gap of 0.001 based on a comparison of travel time skims from one iteration to the next.

With regard to how the current travel demand model addresses external travel, Commission staff noted the external travel at the Region's fringe, particularly at the Illinois/Wisconsin state line in Kenosha County, accounts for a significant proportion of travel generated by the Region's residents. Commission staff noted a desire to include external travel generated by resident households in the next travel demand model. The panel recommended using the trip attraction models to estimate trip attractions for the external traffic analysis zones (TAZ) with economic and demographic data from sources such as the State of Wisconsin and other metropolitan planning organizations or regional planning commissions. The trip distribution and mode choice models could then be used on the complete set of trips. With regard to freight and commercial truck travel, Commission staff indicated that conversations with the Wisconsin Department of Transportation (WisDOT) had been initiated to discuss how the State's and the Commission's modeling efforts could be coordinated. The panel supported continued cooperation between the two agencies.

Commission staff noted that forecasting of commercial truck travel under the current travel demand model is accomplished by growing the existing pattern of travel from the 2001 travel inventory using factors developed with a set of regression equations sensitive to household and employment growth. Commission staff noted that this method at the Regional level accounts for employment growth and household growth and the attendant growth in commercial truck travel. Commission staff noted that staff was considering the development of a fully synthetic commercial truck model to better distribute truck trips throughout the region and to increase the models sensitivity to changes in households and employment levels and location. The panel recommended that the Commission consider using the U.S. Department of Transportation's Quick Response Freight Manual as a potential first step in establishing trip generation rates for commercial truck travel within the Region. A second step identified by the Commission and supported by the panel was the use of WisDOT freight model results to inform the Commission's travel demand model of external commercial truck travel.

MODEL VALIDATION

During the review of the fourth-generation travel demand model and the validation statistics staff prepared related to the model's ability to simulate year 2011 travel with year 2010 socioeconomic and land use information, the panel noted that the model validation statistics looked reasonable but that additional validation statistics should be prepared. The following summarizes the additional validation statistics the panel recommended the Commission include in the validation of the next generation travel demand models.

- Consider using more screenlines to evaluate traffic flow.
- Calculating and including the coincidence ratio on the trip length frequency distribution plots which provide the comparison of modeled and estimated actual trip length frequency distributions.
- The comparison of estimates of school trips with school enrollment.
- Mapping or plotting a comparison of modeled to estimated actual zero auto households

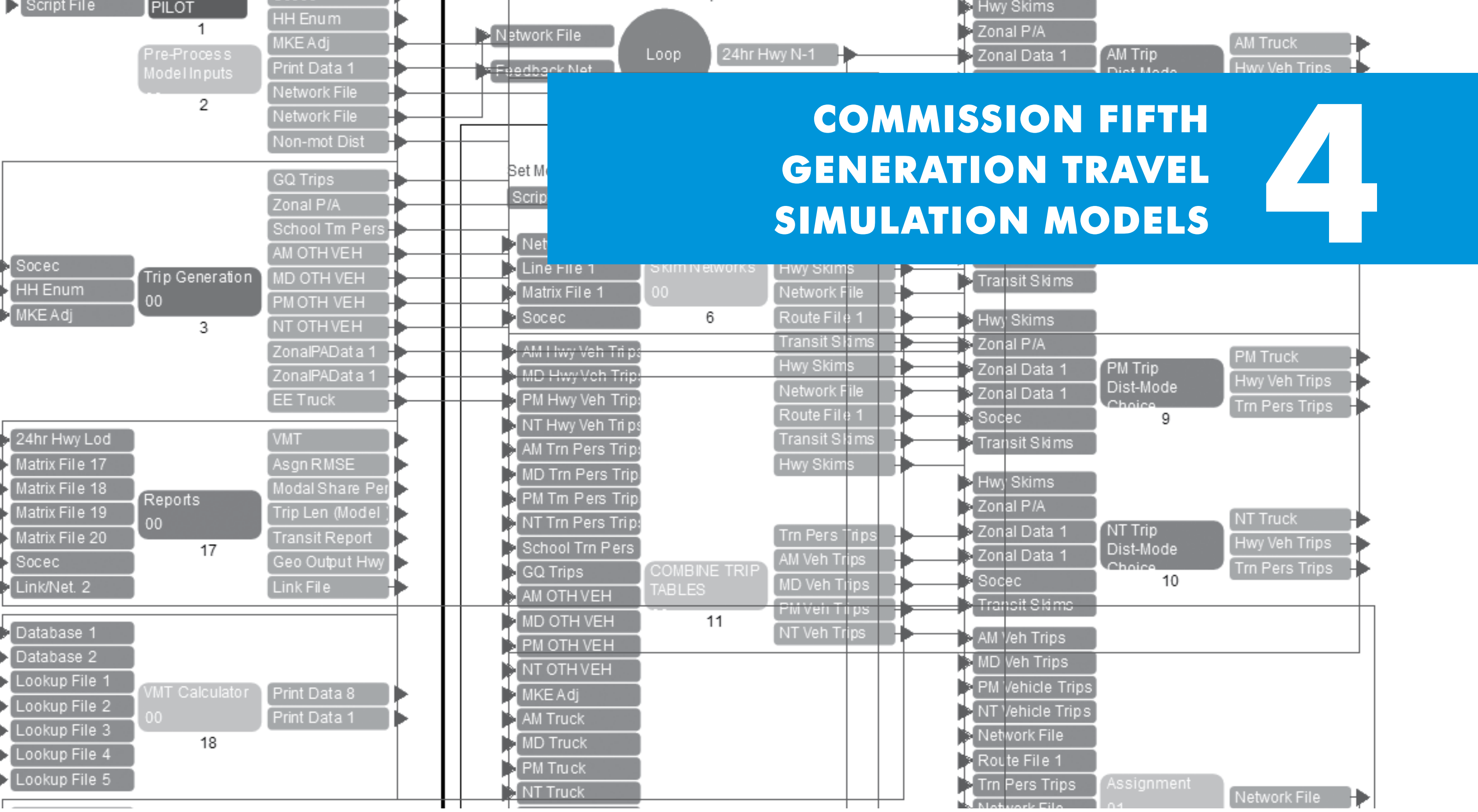
SUMMARY

Table 3.1 summarizes the panel's proposed model improvements that the Commission should consider during the development of the fifth-generation travel simulation model battery. Commission staff also considered each potential improvement and classified them into those improvements that would be considered during the initial development phase of the fifth-generation travel demand model development (short-term) for the VISION 2050 major land use and transportation plan update, and those potential improvements that would be considered as part of the ongoing update and maintenance of the fifth-generation travel demand model once the VISION 2050 planning effort is concluded.

Table 3.1
Summary of Potential Travel Demand Model Improvements Identified by the Travel Demand Modeling Peer Review and Technical Advisory Committee on December 18, 2014 to be Considered During the Development of the Commission's Fifth Generation Travel Demand Model

Model Step	Travel Demand Model Consideration	SEWRPC Priority
Trip Generation	Consider incorporating workers per household and/or the presence of children to further stratify trip generation	Short-Term
	Consider using different method to define Bicycle/Walk friendly Area Type such as intersection density or street grid	Short-Term
	Consider developing a population synthesizer. This would assist in determining the number of workers and the presence of children	Long-Term
Trip Distribution	Consider developing a destination choice logit model	Short-Term
	Consider not using K factors • Consider using special generators instead of K-factors • Consider stratifying trip distribution by income to better match high income households to high wage jobs	Short-Term
	Consider incorporating the logsum from mode choice into trip distribution	Short-Term
Mode Choice	Consider skimming for each mode modeled in mode choice	Short-Term
	Consider performing mode choice by time-of-day	Short-Term
	Consider local, express, and rapid transit modes separately	Short-Term
Trip Assignment	Consider incorporating the time-of-day assignment into four-step model and feedback period travel times to mode-choice and, potentially trip distribution	Short-Term
	Consider using passenger car equivalent (PCE) based capacities	Short-Term
	Consider pre-loading heavy-duty trucks and transit vehicles	Short-Term
	Consider using generalized cost in highway path building	Short-Term
	Consider stratifying assignment by vehicle class	Short-Term
	Consider using more than one volume-delay function stratified by facility type.	Short-Term
	Consider alternative volume delay functions such as the Akcelik or Conical functions rather than the BPR curve	Short-Term
	Consider assigning travel to park-ride lots	Short-Term
Model Structure	Consider running the feedback loop more than once and iterate the feedback loop until a relative gap of 0.001 based on travel time skims is achieved	Short-Term
	Consider a logit vehicle availability model	Short-Term
	Consider defining areas to be used in determining vehicle availability based on transit service	Short-Term
	To better address travel at the Region's fringe, consider generating total (Internal/External) travel by Region's residents and generating attractions for halo zones outside the Region. • Use socioeconomic data from other sources for halo zones such as CMAP, WisDOT, planning, state or federal agencies • Push through the trip distribution and mode choice steps	Short-Term
	Consider using Quick Response Freight Manual methods to estimate commercial vehicle travel	Short-Term
	Consider linkages between statewide freight model and external commercial vehicle travel	Short-Term
Validation	More screen lines to evaluate flows	Short-Term
	Plot trip length frequency distribution and calculate coincidence ratio for trip distribution	Short-Term
	Compare estimates of school trips with school enrollment (Advanced Practice)	Short-Term
	Compare location of zero auto households to modeled location	Short-Term

Source: SEWRPC



Credit: SEWRPC Staff

COMMISSION FIFTH GENERATION TRAVEL SIMULATION MODELS 4

This chapter presents the Commission's fifth generation of travel simulation models calibrated with year 2010 U.S. Census data, year 2010 regional land use inventory and employment data, year 2011 regional highway and transit system network data, and year 2011-12 regional travel behavior and pattern survey data.

CLASSIFICATION OF TRAVEL

The Commission's fifth generation travel simulation models, as with the Commission's previous generations of travel simulation models and travel simulation models for all urban regions, are based upon a classification of the different components of travel within an urban region. This classification of travel is necessary because the different types of trips exhibit different characteristics and, as a consequence, require different simulation techniques. In addition, some of these types of trips represent very small proportions of total travel in an urban region. The classification of trips and the determination of the relative proportion of total travel they represent allow travel simulation modeling resources to be focused on those types of trips which represent the greater proportions of travel.

As shown in Table 4.1, the first major division of trips in the Commission's fifth generation models involves the distinction between commercial truck and personal travel. The vast majority of total weekday internal travel – nearly 90 percent – belongs to the category of personal travel. Internal personal travel may be further classified into travel by resident households and group-quartered residents. Travel by group-quartered residents of the Region is separated for special consideration because of the unique travel habits and patterns exhibited by these people. Group-quartered residents are defined as those people residing in dormitories, convents, homes for the aged, and similar group residences. Group-quartered person trips have consistently

Table 4.1
Trip Classification and Fifth-Generation Travel Simulation Model Procedure

Trip Classification					Simulation Model				
					Trip Generation				
Type of Travel	Tripmaker	Internal or External	Trip Purpose	Percent of Total Trips	Production	Attraction	Trip Distribution	Modal Split	Traffic Assignment
Personal	Resident Households	Internal and External	Home-based work	19	Cross-classification analysis	Trip rate analysis (AM, Midday, PM, Night time periods)	Logit Analysis (AM, Midday, PM, Night time periods)	Logit Analysis (AM, Midday, PM, Night time periods)	Minimum path (AM, Midday, PM, Night time periods)
			Home-based shopping	10					
			Home-based other (excluding school)	26					
			Nonhome-based work	9					
			Nonhome-based other (excluding school)	11					
			School	12	Factor existing school trip levels and adjust existing patterns by mode				
	Group-Quartered Residents	Internal and External	All	1	Factor existing trip levels and adjust existing patterns by mode				
	Nonresident	External	All	2	Factor existing trip levels				
Commercial Trucks	Resident	Internal	All	9	Trip Rate Analysis	Trip rate Analysis	Gravity Model		
	Nonresident	External	All	1	Factor existing trip levels and adjust existing patterns				

Source: SEWRPC

accounted for substantially less than 1 percent of the total travel within the Region since 1963. Travel is further classified between internal and external trips. Internal trips are defined as those trips which have both ends within the Southeastern Wisconsin Region. External trips are defined as those trips which have one or both ends outside of the Region.

The primary emphasis of travel simulation models in Southeastern Wisconsin and all urban regions is on resident household travel. These trips represent nearly 90 percent of total travel made within the Southeastern Wisconsin Region on an average weekday. This group of trips may be further subdivided by trip purpose. For the fifth-generation models, the trip purposes used were home-based work (HBW); home-based shopping (HBS); home-based other (excluding school) (HBO); nonhome-based work (NHBW) and nonhome-based other (excluding school) (NHBO); and school trips. Home-based trips are defined as those trips having one end located at the residence of the tripmaker. The purpose of a home-based trip is determined by the nonhome end of the trip as either work, shopping, or other (including personal business, medical/dental, social/dining, recreation, and serving a passenger's purpose). Nonhome-based trips are defined as those trips having neither end located at the place of residence of the tripmaker and can be made for any purpose except school. Separate consideration of home-based and nonhome-based school trips is necessary because of the constraints imposed upon travel patterns by elementary, middle, and high school service area boundaries. Trips to and from elementary, middle, high, vocational, and technical schools, and colleges and universities, have consistently represented approximately 10 percent of all travel observed in the Region on an average weekday.

Table 4.1 also indicates the specific modeling techniques used for each type of trip in the Commission's fifth-generation travel simulation model battery. Following a discussion of the geographic aggregation system utilized in the Commission's fifth-generation battery of travel simulation models, each of the Commission's fifth-generation models will be described.

GEOGRAPHIC AGGREGATION SYSTEM

All travel simulation models are developed and/or applied by subarea of the region under study. The greater the degree of homogeneity of the land uses in the subareas and the closer the replication of subarea access to the transportation system, the better able the models are to accurately simulate actual travel and traffic.

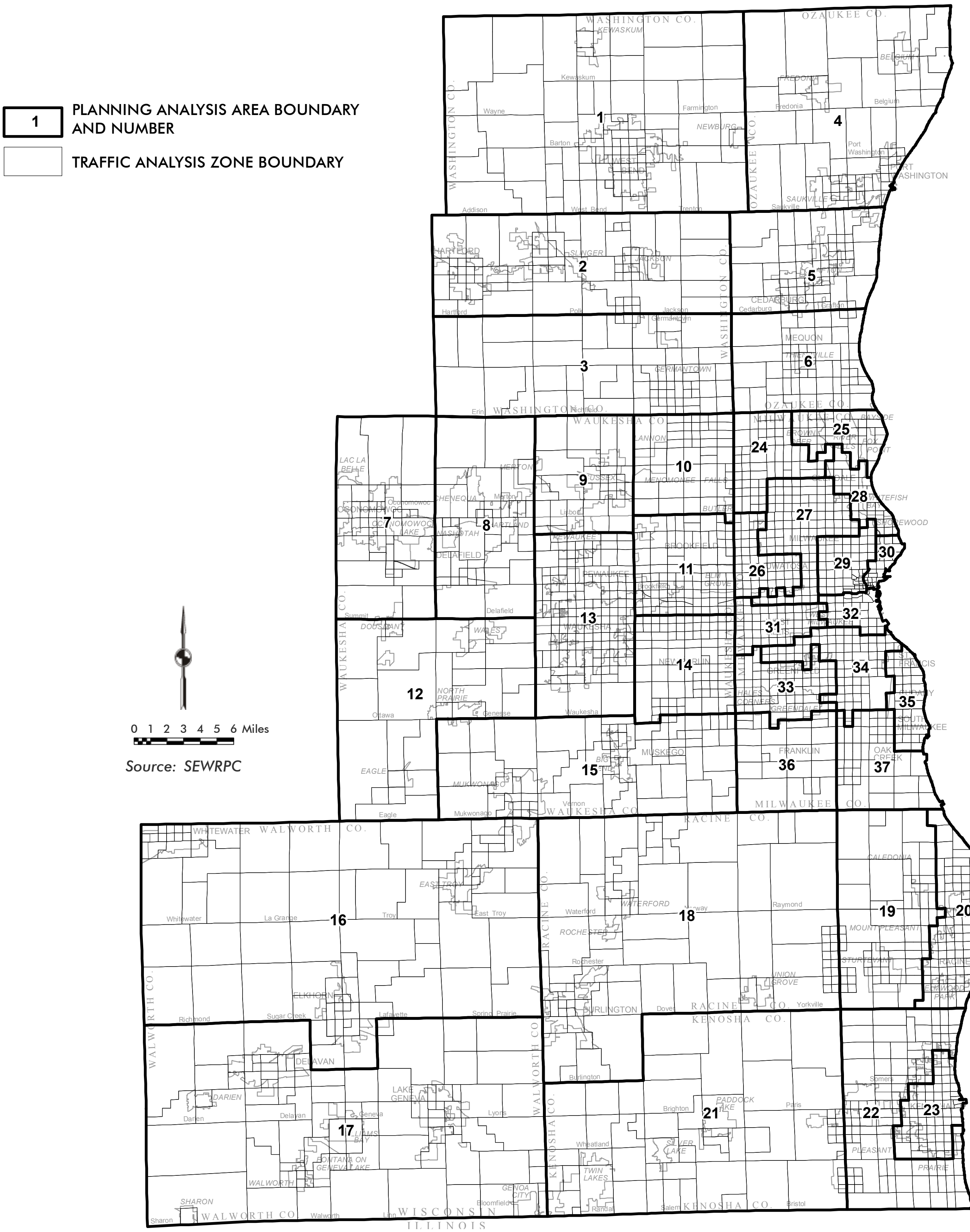
The basic unit of geographic identification used by the Commission for the collection and analysis of land use, demographic and economic, and travel inventory data is the U.S. Public Land Survey quarter-section, consisting of an approximately one-half mile on a side rectilinear area containing approximately 160 acres. There are 10,800 quarter-sections within the Region. The principal system of region subareas used in the fifth-generation travel simulation models was a system of 2,470 traffic analysis zones, composed of entire quarter-sections, combinations of quarter-sections, or groupings of city blocks smaller than a quarter-section – the latter principally in the Milwaukee, Racine, and Kenosha central business districts (CBDs). The traffic analysis zones as shown on Map 4.1, range in area from 0.04 square mile in the Milwaukee central business district to 18 square miles in the more sparsely settled portions of the Region. The fifth-generation travel simulation models also have a system of 78 external traffic analysis zones which cover the remainder of Wisconsin, Illinois, and the remainder of the continental United States. The external traffic analysis zone system is shown on Map 4.2.

Aggregations of these traffic analysis zones are used from time-to-time for planning analysis purposes, such as travel pattern analysis. One such aggregation system of planning analysis area is shown on Map 4.1. These analysis areas are intended to represent rational areas for comprehensive urban planning purposes and are generally intended to be composed of a number of "neighborhoods" grouped to form "communities," which may consist of smaller minor civil divisions—cities, villages, and towns—groupings of the smallest minor civil divisions, or subareas of the larger minor civil divisions.

HOUSEHOLD STRATIFICATION MODEL

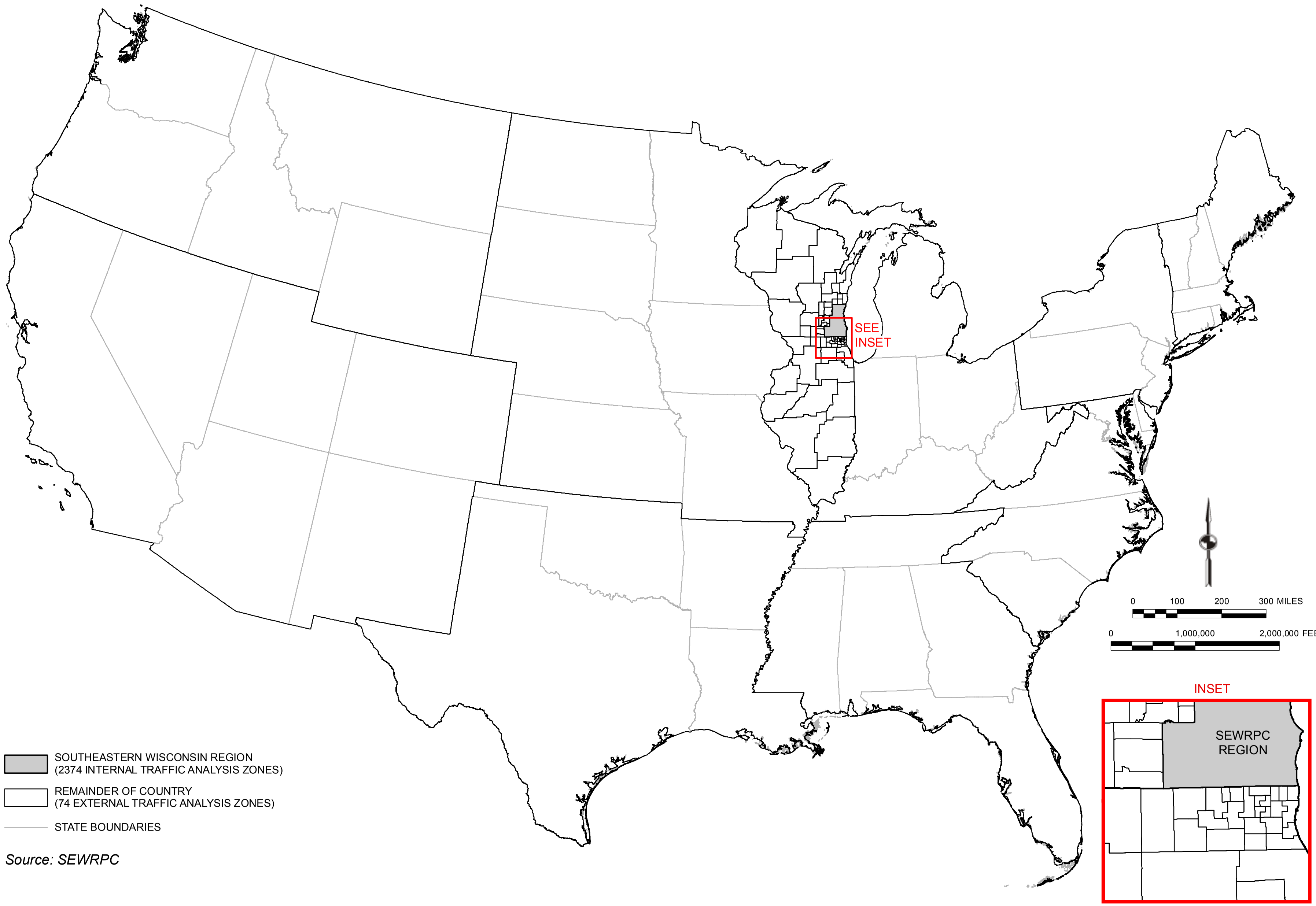
As part of the data preparation step of the Commission's fifth generation travel demand model, a series of socioeconomic models are used to estimate and stratify households based on the age of the head of household (AHOH), household size (HHSZ), number of children, number of workers, and vehicle availability. Two sets of socioeconomic models were developed. The first set of models is used to establish a regional control stratification of households, and the second set to stratify households at the traffic analysis zone level. Because the traffic analysis zone models are sensitive to income and the area type of the zone, these may over or underestimate the number of households within a given strata as compared to the Regional control totals and, as well, different land use plans would generate different household demographic distributions. The purpose of establishing Region level control totals was to eliminate this potential that alternative land use plans could develop a different distribution of household demographics related to land use plan alternatives. Since these models will be applied to different land use and transportation plan alternatives, all of which having the same regional control totals, these models were designed to constrain the household distributions estimated at the traffic analysis zone level to the regional control totals. To test the impact of different demographic conditions, changes would need to be made to the demographics input into the model.

Map 4.1
Fifth-Generation Travel Simulation Model Traffic Analysis Zones and Planning Analysis Areas in the Region



Source: SEWRPC

Map 4.2
Fourth-Generation Travel Simulation Model External Traffic Analysis Zones



Source: SEWRPC

Definition of Traffic Analysis Zone Area Type and Income Category
Both the household stratification and the trip generation models were developed to be sensitive to three area types within the Region—urban, suburban, and rural—which are defined based on population and employment density (activity density). The following formula is used to calculate first an unweighted activity density:

$$d = \frac{P + E}{L}$$

Where:

d = unweighted activity density associated with a given TAZ

P = total population in a given TAZ

E = total employment in a given TAZ

L = Net land area, excluding water in a given TAZ (acres).

To account for proximity to activities in adjacent zones, a weighted average density is calculated for a given TAZ which includes the TAZ and adjacent TAZs unweighted population and/or employment density. Individual densities were weighted using the inverse of the terminal travel time for each zone. The weighting procedure is defined by the following equation:

$$D_i = \frac{d_i t_i^{-1} + \sum_{j=1}^{n} d_j (t_i + t_j)^{-1}}{t_i^{-1} + \sum_{j=1}^{n} (t_i + t_j)^{-1}}$$

Where:

Di = weighted density at TAZ i

di = unweighted density at TAZ i

dj = unweighted density at adjacent j=1 through n TAZs

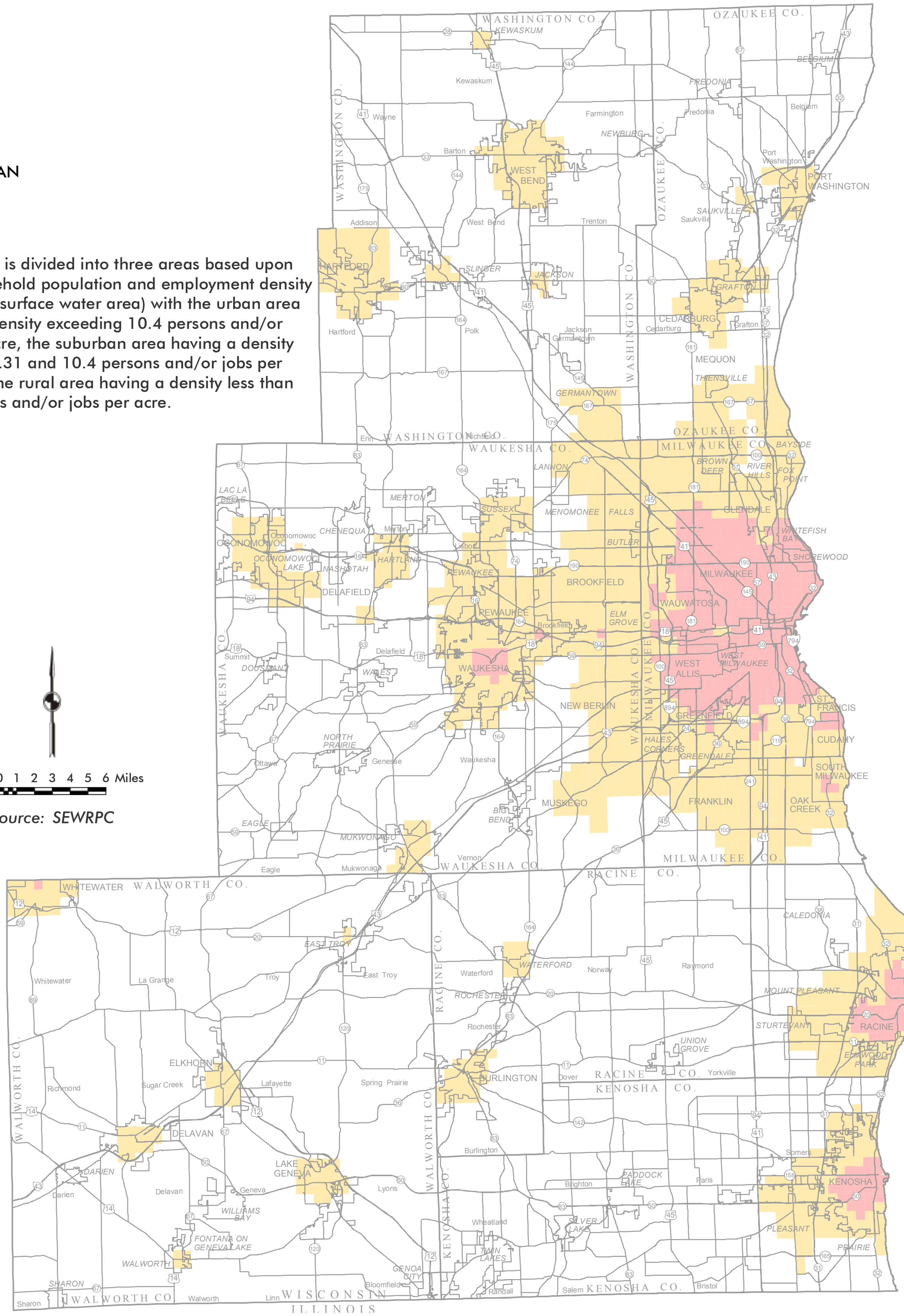
ti = terminal time associated with TAZ i (minutes)

tj = terminal times associated with adjacent j=1 through n TAZs

Using the weighted population and/or employment density (D_i), TAZs were classified as "urban" if the D_i exceeded 10.4 people and/or jobs per acre; "suburban" if D_i was between 2.31 and 10.4 people and/or jobs per acre; and "rural" if D_i is less than or equal to 2.3 people per acre. Map 4.3 shows the area types for the year 2011 based on the above definition.

TAZs were further classified as lower, moderate, or higher income areas based on the average household income for the TAZ. This household income is based on zonal income data from the 2006-2010 census transportation planning package. The income categories are based on the definitions used in the year 2035 Regional Housing Study adopted by the Commission in 2013. Using the definitions in the regional housing study, three income categories were defined: "lower income" TAZs are defined as having an average household income of less than 80 percent of the Regional mean household income; TAZs were classified as "moderate income" if the mean household income for the TAZ is between 80 and 135 percent of the regional mean household income; TAZs were classified as "higher income" where the mean household income is above 135 percent of the Regional mean household income. Map 4.4 shows the income classification by TAZ for the Region based on year 2006-2010 census transportation planning package data.

Map 4.3
Urban Area Type Model Categories: 2010



AREA TYPE

- URBAN
- SUBURBAN
- RURAL

Note: The region is divided into three areas based upon total household population and employment density (excluding surface water area) with the urban area having a density exceeding 10.4 persons and/or jobs per acre, the suburban area having a density between 2.31 and 10.4 persons and/or jobs per acre and the rural area having a density less than 2.3 persons and/or jobs per acre.

0 1 2 3 4 5 6 Miles

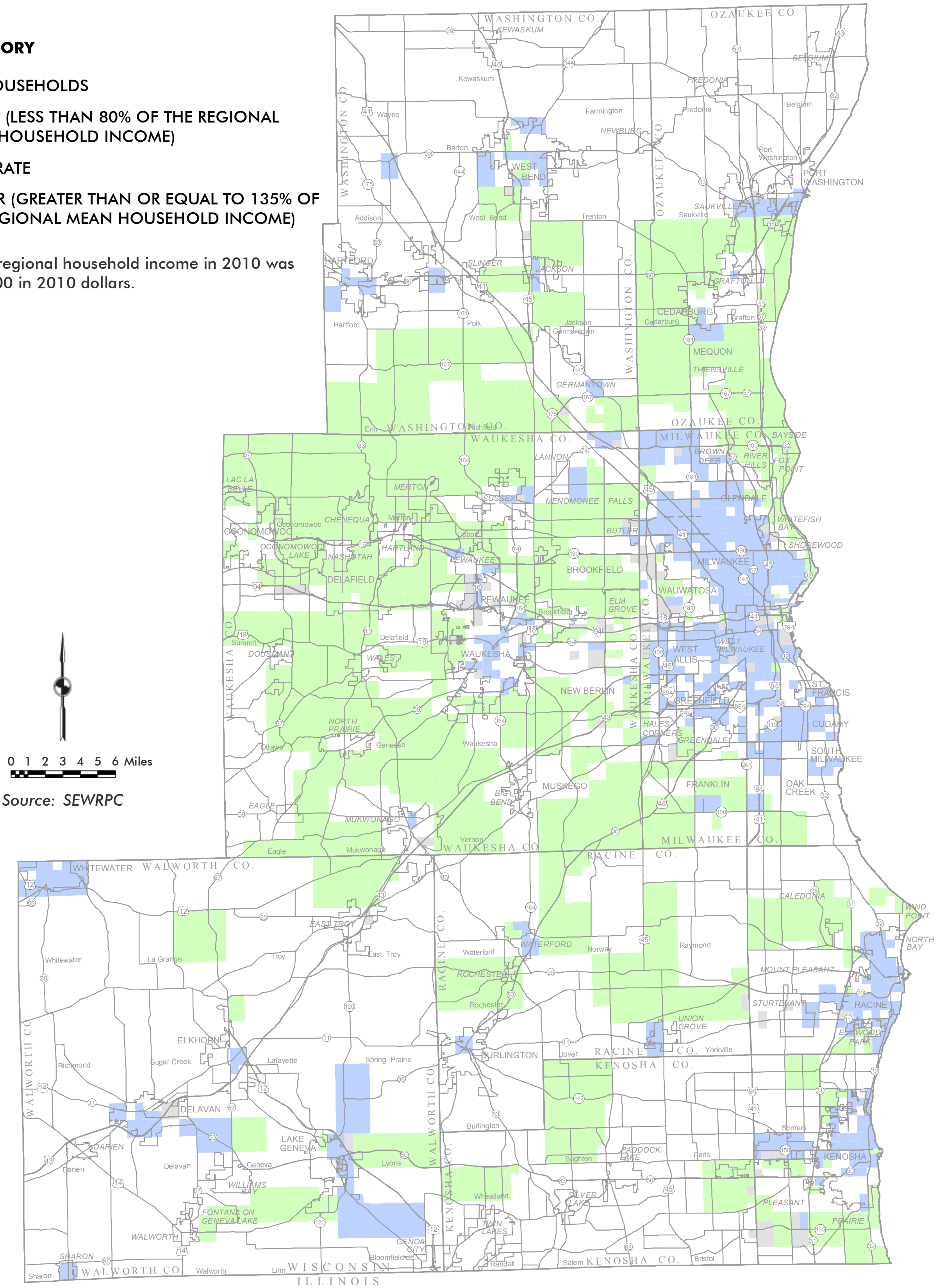
Source: SEWRPC

Map 4.4
Income Category Model Areas: 2010

INCOME CATEGORY

- NO HOUSEHOLDS
- LOWER (LESS THAN 80% OF THE REGIONAL MEAN HOUSEHOLD INCOME)
- MODERATE
- HIGHER (GREATER THAN OR EQUAL TO 135% OF THE REGIONAL MEAN HOUSEHOLD INCOME)

Note: Mean regional household income in 2010 was $65,400 in 2010 dollars.



Source: SEWRPC

Age Distribution Model
At the Regional level, the process to stratify households begins with a regional distribution of household population by age group and gender (see Table 4.2). This distribution can be modified to estimate the impacts different age distributions could have on travel within Southeastern Wisconsin. The total household population within an age category is multiplied by the attendant household formation rate, shown in Table 4.3 to estimate the total number of households by age of head of household for the Region.

Households by age band are used as a proxy for the head of household population and are subtracted from the household population within each age category to determine the remaining household population. The remaining household population is then distributed between the household age categories based on age distributions derived from the household travel inventory. Table 4.4 shows the population proportions used to distribute the household population totals by age category to households based on age of head of household. The household estimates by age of head of household are then added back into the population distribution attendant to each age of head of household category. This set of distributions will be used to estimate the number of working age children and a population weighted average workforce participation rate for each age of head of household category.

At the traffic analysis zone level the total households by TAZ are stratified into the seven age categories based on area type, and income category assigned to each zone. Table 4.5 shows the nine potential household age distributions applied at the TAZ level. These distributions were developed based on the year 2011 household travel inventory data.

Household Size Model
The next step is to stratify households at the region level into one of five household size categories (one, two, three, four, and five or more people). The process of distributing households by household size is performed by applying the household size distribution attendant to the age of head of household as shown in Table 4.6. These distributions were developed using the year 2011 household travel inventory.

At the TAZ level, the household size model distributes the households between the five household size categories utilizing a household size distribution based on the age of head of household and the zonal income category. Table 4.7 shows the 21 potential household age distributions applied at the TAZ level. These distributions are based on year 2011 household travel inventory data.

Number of Children Model
The stratification of households by number of children in developing the regional control totals and also at the traffic analysis zone level is performed after households have been distributed based on age of head of household and household size. The number of children are estimated using the distributions shown in Table 4.8 and are applied based on the age of head of household and household size. These distributions were developed using the year 2011 household travel inventory.

Employment Model
A regional control total for the total number of employed individuals is first estimated by multiplying the input household population by gender (Table 4.2) by the workforce participation rates by age and gender shown in Table 4.9. The estimated workforce by age range is then summed to create a regional control total for workforce. To then estimate the total number of workers

Table 4.2
Regional Household Population Age Distribution: 2011

Age Category	Male	Female	Total
15 and Under	209,564	201,479	411,043
16 to 24	133,483	129,083	262,566
25 to 34	129,471	132,273	261,744
35 to 44	128,322	131,420	259,742
45 to 54	149,485	154,785	304,270
55 to 64	115,537	120,728	236,265
65 to 74	57,824	68,282	126,106
75 and Older	44,307	73,260	117,567
Total	967,993	1,011,310	1,979,303

Source: 2010 U.S. Census and SEWRPC

Table 4.3
Household Formation Rates by Age of Individual: 2010

Age Category	Rate
15 and Under	--
16 to 24	0.15207
25 to 34	0.49485
35 to 44	0.55331
45 to 54	0.57584
55 to 64	0.61200
65 to 74	0.64869
75 and Older	0.74189

Source: SEWRPC

Table 4.4
Distribution of Household Population by Age Category Based on Age of Head of Household

Household Population Age Category	Proportion of Household Population Attributed to Households Based on Age of Head of Household								
	15 and Under	16 to 24	25 to 34	35 to 44	45 to 54	55 to 64	65 to 74	75 and Older	Total
4 and Under	--	0.01903	0.16420	0.12131	0.02238	0.00993	--	--	
5 to 15	--	0.00251	0.10141	0.35250	0.18210	0.02463	--	--	1.00000
16 to 17	--	--	0.01296	0.10449	0.19127	0.03294	--	--	
18 to 24	--	0.10830	0.04751	0.08226	0.28638	0.12321	0.01068	--	1.00000
25 to 34	--	0.02426	0.63444	0.14247	0.08365	0.09565	0.01953	--	1.00000
35 to 44	--	--	0.07880	0.67368	0.17344	0.04995	0.02413	--	1.00000
45 to 54	--	--	0.01350	0.08284	0.66673	0.17779	0.02956	0.02958	1.00000
55 to 64	--	--	0.01778	0.02371	0.11301	0.66165	0.14323	0.04062	1.00000
65 to 74	--	--	--	0.05037	0.03637	0.08735	0.60487	0.22104	1.00000
75 and Older	--	--	--	--	0.10163	0.11869	0.06683	0.71285	1.00000

Source: SEWRPC Household Travel Inventory

Table 4.5
Distribution of Household Population by Age of Head of Household, Area Type, and Zonal Income Category

Area Type	Zonal Income Category	Age of Head of Household							Total
		16 to 24	25 to 34	35 to 44	45 to 54	55 to 64	65 to 74	75 and Older	
Urban	Lower	0.087	0.215	0.202	0.197	0.150	0.070	0.079	1.000
	Middle	0.060	0.220	0.205	0.208	0.151	0.073	0.083	1.000
	Higher	0.009	0.217	0.229	0.168	0.172	0.110	0.095	1.000
Suburban	Lower	0.055	0.217	0.161	0.187	0.151	0.090	0.139	1.000
	Middle	0.020	0.157	0.189	0.211	0.176	0.108	0.139	1.000
	Higher	0.004	0.101	0.189	0.278	0.207	0.112	0.109	1.000
Rural	Lower	0.040	0.112	0.140	0.182	0.193	0.130	0.203	1.000
	Middle	0.016	0.118	0.202	0.269	0.202	0.115	0.078	1.000
	Higher	0.006	0.075	0.181	0.287	0.230	0.142	0.079	1.000

Source: 2006-2010 U.S. Census Transportation Planning Package and SEWRPC 2011 Household Travel Inventory

Table 4.6
Household Size Distribution by Age of Head of Household

Age of Head of Household	Household Size: One Person	Two Person	Three Person	Four Person	Five or More Person	Total
15 and Under	--	--	--	--	--	--
16 to 24	0.379	0.352	0.224	0.045	--	1.000
25 to 34	0.245	0.271	0.207	0.182	0.095	1.000
35 to 44	0.176	0.157	0.182	0.239	0.246	1.000
45 to 54	0.266	0.262	0.191	0.173	0.108	1.000
55 to 64	0.330	0.451	0.129	0.053	0.037	1.000
65 to 74	0.365	0.556	0.061	0.015	0.003	1.000
75 and Older	0.464	0.484	0.042	0.005	0.005	1.000

Source: SEWRPC 2011 Household Travel Inventory

Table 4.7
Zonal Household Size Distribution by Age of Head of Household and Zonal Household Income Category

Age of Head of Household	Zonal Income Category	Household Size: One Person	Two Person	Three Person	Four Person	Five or More Person	Total
16 to 24	Lower	0.41200	0.33000	0.19200	0.06600	--	1.00000
	Middle	0.34300	0.35600	0.29100	0.01000	--	1.00000
	Higher	--	0.92100	0.07900	--	--	1.00000
25 to 34	Lower	0.24000	0.23700	0.20800	0.20000	0.11500	1.00000
	Middle	0.25400	0.28300	0.20900	0.16200	0.09200	1.00000
	Higher	0.22700	0.34700	0.19400	0.19200	0.04000	1.00000
35 to 44	Lower	0.19600	0.19400	0.18800	0.16500	0.25700	1.00000
	Middle	0.18800	0.15200	0.17700	0.25500	0.22800	1.00000
	Higher	0.10900	0.10600	0.18400	0.33100	0.27000	1.00000
45 to 54	Lower	0.37600	0.25200	0.14500	0.11500	0.11200	1.00000
	Middle	0.27000	0.27300	0.19000	0.18400	0.08300	1.00000
	Higher	0.11600	0.24900	0.24900	0.22300	0.16300	1.00000
55 to 64	Lower	0.47000	0.31400	0.11300	0.03500	0.06799	0.99999
	Middle	0.30700	0.49200	0.12500	0.05100	0.02500	1.00000
	Higher	0.20200	0.53900	0.15700	0.08100	0.02099	0.99999
65 to 74	Lower	0.48900	0.42500	0.06400	0.02200	--	1.00000
	Middle	0.35500	0.56900	0.06100	0.01200	0.00300	1.00000
	Higher	0.24500	0.67500	0.05900	0.01500	0.00599	0.99999
75 and Older	Lower	0.53600	0.39300	0.05000	0.00800	0.01299	0.99999
	Middle	0.44200	0.51500	0.04000	0.00300	--	1.00000
	Higher	0.40000	0.56200	0.03400	0.00400	--	1.00000

Source: 2006-2010 U.S. Census Transportation Planning Package and SEWRPC 2011 Household Travel Inventory

Table 4.8
Household Distribution by Number of Children, Age of Head of Household, and Household Size

Age of Head of Household	Household Size	Number of Children					Total
		Zero	One	Two	Three	Four or More	
16 to 24	One Person	1.000	--	--	--	--	1.000
	Two People	0.846	0.154	--	--	--	1.000
	Three People	0.324	0.509	0.167	--	--	1.000
	Four People	0.230	0.252	0.518	--	--	1.000
	Five or More People	--	--	--	--	--	--
25 to 34	One Person	1.000	--	--	--	--	1.000
	Two People	0.934	0.066	--	--	--	1.000
	Three People	0.056	0.786	0.158	--	--	1.000
	Four People	0.018	0.026	0.773	0.183	--	1.000
	Five or More People	0.015	0.045	0.054	0.748	0.138	1.000
35 to 44	One Person	1.000	--	--	--	--	1.000
	Two People	0.797	0.203	--	--	--	1.000
	Three People	0.081	0.730	0.189	--	--	1.000
	Four People	0.013	0.041	0.892	0.054	--	1.000
	Five or More People	0.005	0.026	0.052	0.633	0.284	1.000
45 to 54	One Person	1.000	--	--	--	--	1.000
	Two People	0.898	0.102	--	--	--	1.000
	Three People	0.364	0.544	0.092	--	--	1.000
	Four People	0.147	0.276	0.565	0.012	--	1.000
	Five or More People	0.069	0.131	0.214	0.456	0.130	1.000
55 to 64	One Person	1.000	--	--	--	--	1.000
	Two People	0.986	0.014	--	--	--	1.000
	Three People	0.720	0.266	0.014	--	--	1.000
	Four People	0.453	0.224	0.297	0.026	--	1.000
	Five or More People	0.242	0.159	0.373	0.161	0.065	1.000
65 to 74	One Person	1.000	--	--	--	--	1.000
	Two People	0.998	0.002	--	--	--	1.000
	Three People	0.808	0.183	0.009		--	1.000
	Four People	0.722	0.192	0.086	--	--	1.000
	Five or More People	0.503	0.121	0.376	--	--	1.000
75 and Older	One Person	1.000	--	--	--	--	1.000
	Two People	0.998	0.002	--	--		1.000
	Three People	0.936	0.064	--	--	--	1.000
	Four People	0.786	0.214	--	--	--	1.000
	Five or More People	1.000	--	--	--	--	1.000

Source: SEWRPC 2011 Household Travel Inventory

Table 4.9
Workforce Participation Rates: 2010

Age Group	Male	Female
16 to 24	0.628	0.651
25 to 34	0.907	0.824
35 to 44	0.908	0.804
45 to 54	0.864	0.817
55 to 64	0.717	0.660
65 to 74	0.289	0.221
75 and Older	0.082	0.045

Source: SEWRPC Technical Report 10

within the region we adjust this number down based on the unemployment rate (10.5 percent in 2010) for the Region at the time period being modeled. This procedure establishes a control number used to constrain estimates of employed individuals during the household stratification process.

$$AWPR_i = \frac{\sum_j (HHPop_{ij} \times WPR_{ij})}{\sum_j HHPop_{ij}}$$

$$TotEmp = UE \times \sum_{ij} (HHPop_{ij} \times WPR_{ij})$$

Where:

$AWPR_i$ = Average workforce participation rate of age category i

i = age category (16 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, or 75 and older)

j = gender (male or female)

$HHPop_{ij}$ = Household population in age category i by gender j

$TotEmp$ = Total Employment

UE = Unemployment rate

WPR_{ij} = Workforce participation rate for household population in age category i and gender j

The next step is the calculation of a population weighted average workforce participation rate (HHWPR) for each household age category (AHOH) based on the population age profile calculated in the age distribution model.

$$HHWPR_k = \frac{\sum_i AWPR_i \times HHPop_i}{\sum_i HHPop_i}$$

Where:

$AWPR_i$ = Average workforce participation rate of age category i

i = age category (16 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, or 75 and older)

k = AHOH category (16 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, or 75 and older)

$HHPop_i$ = Household population in age category i

$HHWPR_k$ = Household workforce participation rate for households in AHOH category k

In order to stratify households by number of workers, the worker model was developed to distribute households into one of six categories (zero, one, two, three, four, or five or more employed individuals) based on the number of working age individuals in a household. While there is likely some dependency on whether the spouse or partner of the employed individual in a household also holds a job, this is captured in the calculation of the average workforce participation rate by age of head of household. Also, given that the loss of a job is independent of the employment status of other individuals in a household, the employment status of all working age individuals in a household are treated as independent events. The probability that an individual is either employed or unemployed is described by the following two equations:

$$P(E) = HHWPR_k \times (1 - UE)$$
$$P(NE) = 1 - P(E)$$

Where:

$P(E)$ = Probability an individual is employed

$P(NE)$ = Probability an individual is unemployed

$HHWPR_k$ = Household workforce participation rate for households in AHOH category k

UE = Unemployment rate

The two probabilities can be multiplied based on the number of working age members in a household to determine the likelihood that a household will fall into one of the six categories describing the number of workers. For example, a household with two working age individuals can have either zero, one, or two employed individuals. The probability that a household falls into one of the three categories is determined by the following equations:

Probability both are employed:

$$P(E\ and\ E) = P(E)P(E) = P(E)^2$$

Probability only one individual is employed (2 possible combinations):

$$P(E\ and\ NE) + P(NE\ and\ E) = P(E)P(NE) + P(NE)P(E) = 2[P(NE)P(E)]$$

Probability neither individual is employed:

$$P(NE\ and\ NE) = P(NE)P(NE) = P(NE)^2$$

Table 4.10 shows the set of equations used to estimate the probability that a household with one through five working age individuals will have zero to five employed individuals. This set of generalized probability equations can be used to develop regional as well as area specific household distributions by adjusting workforce participation rates and unemployment rates. The regional stratification of households by number of workers is accomplished by establishing average workforce participation rate for households based on age of the head of household category (AHOH) and the application of a regional unemployment rate. This creates seven unique sets of distributions based on the age of head of household.

At the TAZ level the average regional workforce participation rate used to establish the regional control totals is used and the regional unemployment rate is localized based on the area type (urban, suburban, and rural) and the income category for a zone (lower, middle, higher). Table 4.11 shows the adjustments to the regional unemployment rate applied based on the area type and income category of the TAZ. The application of this methodology creates 63 unique sets of household employment distributions based on age of head of household and the area type and income category of the TAZ.

Table 4.10
Probability Equations Used to Determine the Number of Employed Individuals in a Household Based on the Number of Working Age Individuals in a Household

Working Age Members	Number of Employed Individuals					
	0	1	2	3	4	5
1	$P(NE)$	$P(E)$				
2	$P(NE)^2$	$2[P(NE)P(E)]$	$P(E)^2$			
3	$P(NE)^3$	$3[P(NE)^2P(E)]$	$3[P(NE)P(E)^2]$	$P(E)^3$		
4	$P(NE)^4$	$4[P(NE)^3P(E)]$	$6[P(NE)^2P(E)^2]$	$4[P(NE)P(E)^3]$	$P(E)^4$	
5	$P(NE)^5$	$5[P(NE)^4P(E)]$	$10[P(NE)^3P(E)^2]$	$10[P(NE)^2P(E)^3]$	$5[P(NE)P(E)^4]$	$P(E)^5$

Table 4.11
Ratio of Zonal Unemployment Rate to Regional Average Unemployment Rate by Area Type and Zonal Income Category

Area Type	Zonal Income Category	Zonal Unemployment Ratio
Urban	Lower	2.09771
	Middle	0.69199
	Higher	0.32516
Suburban	Lower	1.10784
	Middle	0.66462
	Higher	0.39531
Rural	Lower	0.93618
	Middle	0.78902
	Higher	0.44122

Source: SEWRPC 2011 Household Travel Inventory

Working Age Child Model

As part of the employment model, a sub-model is used to estimate the number of working age children that should be included in the total individuals of working age for a household. The age of each child in a household with other children in a household are not completely independent events. Given the 10-year width of the head of household age bands and the use of household member age distributions in determining the proportion of working age children by age of head of household, for simplicity, the individual ages of the children in a household were considered generally independent allowing for the multiplication of the probability of independent events. The probability that a child is of working age, $P(WA)$, or not of working age, $P(NW)$, is determined based on the following two equations:

$$P(WA) = \frac{number\ of\ children\ ages\ 16\ and\ 17}{total\ number\ of\ children}$$

$$P(NW) = 1 - P(WA)$$

Table 4.12 shows the generalized probability functions used to determine the number of working age children per household that will be included in the number of working age members of a household

The two sets of household distributions are used in both the stratification of households at the Region level and the stratification of households at the traffic analysis zone level. Households are first stratified by the number of working age children. The working age members of a household are estimated by first subtracting the number of children from the size of the

Table 4.12
Probability Equations Used to Establish the Number of Working Age Children in a Household

Number of Children	Number of Working Age Children				
	0	1	2	3	4 or more
1	$P(NW)$	$P(WA)$			
2	$P(NW)^2$	$2[P(NW)P(WA)]$	$P(WA)^2$		
3	$P(NW)^3$	$3[P(NW)^2P(WA)]$	$3[P(NW)P(WA)^2]$	$P(WA)^3$	
4 or more	$P(NW)^4$	$4[P(NW)^3P(WA)]$	$6[P(NW)^2P(WA)^2]$	$4[P(NW)P(WA)^3]$	$P(WA)^4$

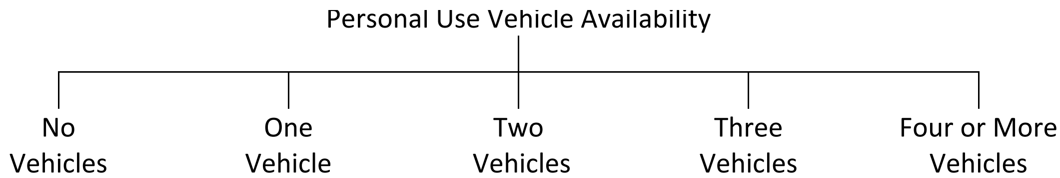
household and then adding to it the estimate of working age children. Households are then stratified by number of employed members based on the age of head of household and number of working age members.

An estimate of regional total employment is made based on the household stratification. This estimate is then compared to the regional control total that was estimated based on workforce participation rate, household population, and regional unemployment rate. If the employment estimate generated from the stratified households is more than the regional control total, households are redistributed from the employed worker categories to the no worker category. If the employment estimate generated from the stratified households is less than the regional control total, households are redistributed from the no worker category to the employed worker categories.

Balancing Zonal Stratification to Regional Control Stratification
An iterative proportional fitting (IPF) process was used to adjust the zonal household distribution to the regional controls. To balance the zonal household distributions to the regional control distributions the first step in the process sums the zonal household total for each possible combination of age of head of household, household size, number of children, and number of workers. These totals are compared to the regional controls and an adjustment factor is calculated that is then applied at the traffic analysis zone level to match that combination of household characteristics. After all of the possible combinations of household characteristics have been compared and adjusted, the procedure sums up the adjusted distribution for each traffic analysis zone and compares the adjusted household control total to the original zonal household control total. The procedure then uses this comparison to calculate a zonal adjustment factor to apply to the adjusted household distribution within each zone to match the TAZ total. This process repeats a maximum 50 times or until the root mean squared error of the current iteration compared to the regional control totals is less than or equal to 0.2. Due to the significant number of possible combinations of each of the four variables, the potential for extremely small fractions of a household being placed into any single household category is fairly high. To address this problem the IPF procedure also includes a bucket rounding procedure to carry these small fractions of a household along until they add up to an integer value. The result is that at the end of the balancing step there are only whole households assigned to any single household category.

Personal Vehicle Availability Model
The last step in the household stratification model is the estimation of vehicle availability. A multinomial logit choice model was implemented to estimate the probability that a household in a zone will have zero, one, two, three, or four or more vehicles. As shown in Figure 4.1, the probability of a household's choice in the number of vehicles is sensitive to whether a household is located in a lower income zone, the activity density of the zone, whether or not there is walk access to transit, and the number of workers and

Figure 4.1
Personal Use Vehicle Availability Model



Formula:

$$P(i) = \frac{e^{V_i}}{\sum_{j=0}^{4} e^{V_j}}$$

If household is located in a zone with walk access to transit:

$$V_0 = 1.1109\,LI + 1.6713\,ZW + 0.0176\,AD$$
$$V_1 = 3.0418\,AW1 + 3.0521\,AW2 + 2.8882\,AW3$$
$$V_2 = 1.3659\,AW1 + 4.2282\,AW2 + 3.2540\,AW3 - 0.0289\,AD$$
$$V_3 = 2.9926\,AW2 + 4.0034\,AW3 + 1.7441\,AW4 - 0.0746\,AD$$
$$V_4 = 1.7845\,AW2 + 2.9392\,AW3 + 1.8418\,AW4 - 0.0937\,AD$$

If household is located in a zone with no walk access to transit:

$$V_0 = 0.6253\,LI + 1.9171\,ZW + 0.0186\,AD$$
$$V_1 = 3.1844\,AW1 + 4.2158\,AW2 + 2.8940\,AW3$$
$$V_2 = 1.9537\,AW1 + 6.1718\,AW2 + 3.8273\,AW3 - 0.0674\,AD$$
$$V_3 = 5.3129\,AW2 + 4.8492\,AW3 + 2.7926\,AW4 - 0.1617\,AD$$
$$V_4 = 4.0234\,AW2 + 4.2040\,AW3 + 3.8227\,AW4 - 0.1963\,AD$$

Where:

$P(i)$ = Probability of owning i vehicles
V_i = Utility of owning i vehicles
i = 0 (zero vehicles) through 4 (four or more vehicles)
LI = Lower income zone (1 if true, 0 if false)
ZW = Household with zero workers (1 if true, 0 if false)
AD = Activity density of the traffic analysis zone
AW = Adult/Workers (maximum of number of adults or number of workers in a household)
$AW1$ = One Adult/Workers (1 if Adult/Workers = 1, 0 if false)
$AW2$ = Two Adult/Workers (1 if Adult/Workers = 2, 0 if false)
$AW3$ = Three Adult/Workers (1 if Adult/Workers = 3, 0 if false)
$AW4$ = Four Adult/Workers (1 if Adult/Workers = 4, 0 if false)

adults in the household. The utility of owning zero, one, two, three, or four or more vehicles is estimated for each of the vehicle availability categories. The probability that a household will be placed into one of the five vehicle ownership categories is developed based on the utility of each choice relative to the other possible choices. Because of the number of possible combinations of the five household strata and the potential for very small fractions of a household being assigned to any of the strata, a monte carlo sampling technique was used to assign each household in a zone to a single vehicle availability category.

TRIP GENERATION MODEL

The first major step in the Commission's fifth-generation travel simulation models is trip generation, whereby the total number of trip ends generated within each zone of the study area is determined through the identification and quantification of relationships between travel and land use. The fifth-generation trip generation models developed by the Commission with year 2011 travel survey data for internal regional travel by resident households of the Region use cross-classification analysis for trip productions and trip rate analyses for trip attractions for all trip purposes except school trips.

Home-based and nonhome-based trips by the resident households in the Region for all purposes except school constitute the vast majority of daily trips made within the Region, nearly 75 percent. The production of these home-based and nonhome-based trips is analyzed and forecast under the fifth-generation models through the use of cross-classification analysis. Home-based trips were stratified into trip purpose categories of home-based work, home-based shopping, and home-based other, and nonhome-based trips into nonhome-based work and nonhome-based other (excluding school) trips. Household automobile availability and household size were determined to best quantify the level of tripmaking in the fifth-generation trip production model, and the number of jobs by type and number of households were used to quantify tripmaking in the trip attraction model.

The cross-classification trip production models were developed for three areas within the Region—urban, suburban, and rural as shown on Map 4.2—based upon population and employment density. For each of these three areas, cross-classification models were developed to forecast total personal travel by all households. Table 4.13 displays the total trip cross classification production models for home-based work, home-based shopping, home-based other, nonhome-based work, and nonhome-based other trips.

While Table 4.13 includes cross-classification trip rate models for nonhome-based trip productions, the forecast of nonhome-based trip production by zone must be accomplished through an additional step that allocates the forecast regional total production of nonhome-based trips to zones. The production of nonhome-based trips cannot be directly estimated by zone with the cross-classification approach since neither end of the trip represents the place of residence of the tripmaker. Cross-classification, however, can provide an estimate of total regional nonhome-based trip productions based on the total number of regional households and their characteristics. The allocation of the regional totals of nonhome-based motorized trip productions to each zone is accomplished through equations developed through multiple regression analysis. These equations, provided below, relate the number of nonhome-based motorized trip productions in a zone to the number of households, retail employment, and other employment in a zone, based upon analyses of the 2011 household travel survey data with respect to

Table 4.13
Resident Household Total Person Trip Production Cross Classification Models

Home-Based Work Trips per Household

Area Type	Number of Workers	Age of Head of Household: 16 to 34, Vehicle Availability: None	One	Two	Three or More	35 to 64, Vehicle Availability: None	One	Two	Three or More	65 and Older, Vehicle Availability: None	One	Two	Three or More
Urban	None	--	--	--	--	--	--	--	--	--	--	--	--
	One	1.48	1.45	1.60	1.10	1.78	1.30	1.57	1.69	2.19	1.02	1.22	2.65
	Two	2.70	2.96	2.93	3.21	2.59	2.55	2.71	2.99	2.59	1.60	2.51	3.47
	Three	4.38	2.83	4.26	4.03	4.38	2.83	4.80	4.97	4.38	2.83	4.26	3.77
	Four or More	5.48	5.48	5.48	5.73	5.48	5.48	5.48	6.23	5.48	5.48	5.48	5.73
Suburban	None	--	--	--	--	--	--	--	--	--	--	--	--
	One	1.64	1.57	1.81	2.18	2.42	1.51	1.69	1.74	1.52	0.96	1.46	1.47
	Two	2.70	2.77	3.35	3.34	2.59	2.40	3.04	3.06	2.59	1.60	2.62	2.85
	Three	4.38	2.83	4.26	4.03	4.38	2.83	4.13	4.62	4.38	2.83	4.26	3.77
	Four or More	5.48	5.48	5.48	5.73	5.48	5.48	5.48	5.84	5.48	5.48	5.48	5.73
Rural	None	--	--	--	--	--	--	--	--	--	--	--	--
	One	1.64	1.76	1.82	1.46	1.89	1.41	1.69	1.74	1.52	0.94	1.36	1.55
	Two	2.70	2.80	2.86	3.00	2.59	2.54	3.12	3.39	2.59	1.60	2.43	4.42
	Three	4.38	2.83	4.26	4.03	4.38	2.83	4.29	4.51	4.38	2.83	4.26	3.77
	Four or More	5.48	5.48	5.48	5.73	5.48	5.48	5.48	6.26	5.48	5.48	5.48	5.73

Home-Based Shopping Trips per Household

Area Type	Number of Workers	Age of Head of Household: 16 to 34, Vehicle Availability: None	One	Two	Three or More	35 to 64, Vehicle Availability: None	One	Two	Three or More	65 and Older, Vehicle Availability: None	One	Two	Three or More
Urban	One	0.97	0.30	0.54	0.46	0.81	0.52	0.63	0.76	0.76	0.76	0.70	1.32
	Two	0.83	0.74	0.77	0.33	1.15	0.91	0.86	0.63	2.00	1.33	1.26	1.42
	Three	1.08	1.24	1.07	0.44	1.34	0.79	1.14	0.94	1.08	1.97	1.76	1.25
	Four	1.11	1.42	0.66	0.33	1.11	1.42	0.70	1.28	1.11	1.18	5.38	1.68
	Five or More	2.17	1.08	0.33	1.23	2.17	0.96	1.22	1.87	2.17	0.98	1.28	1.48
Suburban	One	0.91	0.43	0.65	0.46	0.48	0.50	0.40	0.69	0.33	0.72	0.70	1.32
	Two	0.73	0.67	0.78	0.65	1.11	1.09	0.90	0.86	0.63	1.18	1.33	1.40
	Three	1.08	0.81	0.65	0.49	1.28	1.29	1.06	1.22	1.08	1.47	2.43	1.59
	Four	1.11	0.89	1.22	0.34	1.11	0.95	1.09	1.05	1.11	1.18	5.38	2.12
	Five or More	2.17	1.08	0.72	1.23	2.17	0.94	1.74	1.56	2.17	0.98	1.28	1.48
Rural	One	0.91	0.13	0.52	0.46	0.76	0.53	0.61	0.33	0.34	0.68	0.65	0.63
	Two	0.73	0.72	0.48	0.17	1.11	1.09	0.76	0.87	1.21	1.36	1.09	1.19
	Three	1.08	0.95	0.53	0.74	1.28	0.95	0.88	0.94	1.08	1.67	1.46	1.35
	Four	1.11	1.30	0.62	0.33	1.11	0.25	0.90	0.93	1.11	1.18	5.38	1.68
	Five or More	2.17	1.08	0.50	1.23	2.17	0.94	1.25	1.19	2.17	0.98	1.28	1.48

Table continued on next page.

Table 4.13 (Continued)

Home-Based Other Trips per Household

Area Type	Number of Workers	Age of Head of Household: 16 to 34, Vehicle Availability: None	One	Two	Three or More	35 to 64, Vehicle Availability: None	One	Two	Three or More	65 and Older, Vehicle Availability: None	One	Two	Three or More
Urban	One	0.70	0.76	0.93	1.40	1.17	0.92	1.03	0.98	1.18	1.46	1.67	1.46
	Two	1.23	1.33	1.39	1.01	1.77	1.87	1.62	1.42	1.89	2.35	2.69	3.59
	Three	2.25	0.98	2.05	1.50	3.33	3.17	3.02	1.90	2.25	2.96	2.88	4.45
	Four	2.65	3.10	2.12	2.76	2.65	2.63	4.53	4.59	2.65	2.96	5.32	3.68
	Five or More	2.00	5.08	1.61	2.18	2.00	2.59	4.97	5.01	2.00	3.23	5.91	5.45
Suburban	One	0.65	0.73	0.03	1.40	0.59	0.90	1.02	0.77	0.90	1.46	1.69	1.46
	Two	1.18	1.29	1.66	1.97	1.78	2.17	1.83	1.95	1.03	2.57	2.88	3.09
	Three	2.25	1.58	2.15	2.92	3.19	3.43	3.39	2.97	2.25	2.95	3.33	3.47
	Four	2.65	2.25	3.39	1.40	2.65	3.69	4.94	4.00	2.65	2.96	5.32	3.15
	Five or More	2.00	5.08	4.62	2.18	2.00	2.63	7.90	6.89	2.00	3.23	5.91	5.45
Rural	One	0.65	0.16	0.42	1.40	0.98	0.89	0.87	0.50	0.36	1.38	1.37	1.03
	Two	1.18	1.35	2.43	1.17	1.78	2.38	1.52	1.55	1.03	2.21	2.52	2.68
	Three	2.25	1.14	1.22	1.91	3.19	3.24	2.91	3.03	2.25	2.89	2.40	2.85
	Four	2.65	2.78	2.63	2.76	2.65	2.94	4.27	3.61	2.65	2.96	5.32	3.68
	Five or More	2.00	5.08	6.64	2.18	2.00	2.63	5.71	4.68	2.00	3.23	5.91	5.45

Nonhome-Based Work Trips per Household

Area Type	Number of Workers	Age of Head of Household: 16 to 34, Vehicle Availability: None	One	Two	Three or More	35 to 64, Vehicle Availability: None	One	Two	Three or More	65 and Older, Vehicle Availability: None	One	Two	Three or More
Urban	None	--	--	--	--	--	--	--	--	--	--	--	--
	One	0.30	0.59	0.65	0.36	0.86	0.78	0.68	0.88	0.12	0.90	0.65	3.26
	Two	2.90	1.10	0.97	0.78	1.93	0.61	1.39	1.15	1.93	0.46	1.02	1.34
	Three	1.20	1.11	0.75	0.33	1.20	1.11	1.07	1.37	1.20	1.11	0.75	1.25
	Four or More	1.31	1.31	1.31	1.28	1.31	1.31	1.31	1.42	1.31	1.31	1.31	1.28
Suburban	None	--	--	--	--	--	--	--	--	--	--	--	--
	One	0.26	1.03	0.69	1.14	0.27	0.88	0.84	0.86	0.07	0.41	0.61	0.68
	Two	2.90	1.04	1.19	1.53	1.93	0.95	1.39	1.43	1.93	0.46	1.35	1.08
	Three	1.20	1.11	0.75	0.33	1.20	1.11	0.56	1.53	1.20	1.11	0.75	1.25
	Four or More	1.31	1.31	1.31	1.28	1.31	1.31	1.31	1.01	1.31	1.31	1.31	1.28
Rural	None	--	--	--	--	--	--	--	--	--	--	--	--
	One	0.26	0.79	0.35	0.52	0.75	0.78	0.73	0.63	0.07	0.48	0.55	1.03
	Two	2.90	1.01	0.93	0.91	1.93	1.56	1.39	1.34	1.93	0.46	1.11	1.50
	Three	1.20	1.11	0.75	0.33	1.20	1.11	0.76	1.22	1.20	1.11	0.75	1.25
	Four or More	1.31	1.31	1.31	1.28	1.31	1.31	1.31	2.21	1.31	1.31	1.31	1.28

Table continued on next page.

Table 4.13 (Continued)

Nonhome-Based Other Trips per Household

		Age of Head of Household											
		16 to 34				35 to 64				65 and Older			
		Vehicle Availability				Vehicle Availability				Vehicle Availability			
Area Type	**Number of Workers**	None	One	Two	Three or More	None	One	Two	Three or More	None	One	Two	Three or More
Urban	One	0.43	0.46	0.50	0.92	0.80	0.59	0.77	0.68	0.63	1.11	1.63	1.01
	Two	0.74	0.76	0.58	0.55	1.06	1.03	0.96	0.64	1.60	1.67	1.48	2.04
	Three	0.82	0.61	0.51	0.69	0.89	1.29	1.02	0.92	0.82	1.99	1.33	1.25
	Four	1.17	1.91	0.43	0.92	1.17	1.03	1.29	1.47	1.17	1.50	2.46	1.62
	Five or More	2.26	0.89	0.51	0.80	2.26	1.08	1.62	1.99	2.26	1.04	1.60	1.79
Suburban	One	0.38	0.36	0.74	0.92	0.48	0.76	0.69	0.93	0.48	1.11	1.39	1.01
	Two	0.74	0.54	0.50	0.32	1.00	0.81	1.00	1.09	0.45	1.64	1.54	1.73
	Three	0.82	0.51	0.73	0.47	0.90	1.05	1.27	1.11	0.82	3.68	2.37	1.65
	Four	1.17	0.76	0.99	0.36	1.17	1.78	1.42	0.92	1.17	1.50	2.46	2.15
	Five or More	2.26	0.89	1.34	0.80	2.26	1.09	2.05	2.11	2.26	1.04	1.60	1.79
Rural	One	0.38	0.22	0.54	0.92	0.68	0.64	0.79	0.39	0.15	0.91	0.87	0.95
	Two	0.74	0.68	0.29	0.09	1.00	0.83	0.80	0.97	0.94	2.19	1.61	1.64
	Three	0.82	0.52	0.33	0.53	0.90	1.10	1.13	0.99	0.82	2.57	1.56	1.05
	Four	1.17	1.59	0.68	0.92	1.17	1.80	1.27	1.31	1.17	1.50	2.46	1.62
	Five or More	2.26	0.89	1.66	0.80	2.26	1.09	1.29	1.50	2.26	1.04	1.60	1.79

Source: SEWRPC 2011 Household Travel Inventory nonhome-based motorized trip production from residential land uses, retail land uses, and other land uses.

$$NHBW = 0.589 \times REMP + 0.499 \times OEMP$$

$$NHBO = 0.227 \times HH + 3.443 \times REMP$$

Where:

$NHBW$	= Nonhome-based work trip productions
$NHBO$	= Nonhome-based other (excluding school) trip productions
HH	= Number of households
$REMP$	= Retail employment
$OEMP$	= Other (than retail) employment

The other set of trip end relationships developed in the trip generation process was for trip attraction, which is primarily a function of the nonresidential land use activity within the subareas of the Region. Person trip attraction relationships were developed through the calibration of trip rate models, representing home-based work, home-based shopping, home-based other, and nonhome-based work and nonhome-based other trip purposes. The models relate person trip attractions to employment type and households on the basis of analysis of the 2011 household travel survey and land use and employment inventories. The calibrated trip attraction equations are presented in Table 4.14.

Since the trip production models estimate total trips, which includes travel both internal and external to the Region by the resident households of the Region, the number of trip attractions for each external zone needs to be estimated. To accomplish this, an average of the existing patterns of trip attractions captured by both the internal resident household survey and external travel survey was grown based on the growth in estimated trip attractions by purpose utilizing the trip attraction equations listed in Table 4.14.

An adjustment is made to the forecast trip attractions to balance the total number of forecast trip attractions and the total number of trip productions. Because trip productions and attractions are forecast independently, the total number of forecast trip productions do not always match the total number of forecast trip attractions. For each trip purpose, the zonal trip attractions derived from application of the trip attraction model are factored so that the sum of the zonal trip attractions for each trip purpose equals the total regional cross-classification estimate of trip productions for that trip purpose. The generation—and distribution—of school trips in the fifth-generation travel models was accomplished by factoring existing school travel volumes and patterns. Such separate consideration of school trips was necessitated by the limitations imposed by fixed elementary, middle, and high school service area boundaries. Trips to and from all schools, including elementary, middle, high, vocational, and technical schools, and colleges and universities, amounted to about 12 percent of total trips generated within the Region on an average weekday in 2011. Growth factors were applied by mode—automobile, school bus, and public transit—to the observed 2011 trip tables of elementary, middle, and high school trips. The growth factors were based upon forecast changes in number of children, and were adjusted to account for potential changes in school service boundaries and the construction of new schools. With respect to trips to universities and colleges such as the University of Wisconsin-Milwaukee, Marquette University, Milwaukee

Table 4.14
Person Trip Attraction Models

Trip Purpose	Area	Variable	Trip Attraction Rate (per Job or Household)
Home-Based Work	Urban	Total Employment	1.137
	Suburban	Total Employment	1.109
	Rural	Total Employment	0.965
Home-Based Shopping	Urban	Retail Employment	2.626
	Suburban	Retail Employment	3.562
	Rural	Retail Employment	2.639
Home-Based Other (excluding school)	Urban	Households	1.209
		Retail Employment	1.285
		Other Employment	0.352
	Suburban	Households	1.417
		Retail Employment	1.997
		Other Employment	0.444
	Rural	Households	0.975
		Retail Employment	1.256
		Other Employment	0.289
Nonhome-Based Work	Urban	Households	0.231
		Retail Employment	0.781
		Other Employment	0.258
	Suburban	Households	0.227
		Retail Employment	0.907
		Other Employment	0.277
	Rural	Households	0.214
		Retail Employment	0.498
		Other Employment	0.194
Nonhome-Based Other (excluding school)	Urban	Households	0.451
		Retail Employment	1.566
		Other Employment	0.078
	Suburban	Households	0.426
		Retail Employment	2.470
		Other Employment	0.101
	Rural	Households	0.265
		Retail Employment	1.789
		Other Employment	0.094

Source: SEWRPC

Area Technical College, and Milwaukee School of Engineering, the growth factor procedure was based on the forecast growth in the number of adults.

The generation—and distribution—of personal vehicle trips by group-quartered residents is forecast in the fifth-generation travel models by the application of growth factors, reflecting the anticipated change in the number of group-quartered residents by zone of residence.

Travel within the region by commercial trucks registered within the Region constituted about 9 percent of total tripmaking within the Region on an average weekday and approximately 14 percent of total vehicle trips generated within the Region on an average weekday in 2012. In the fifth-generation travel simulation models, the generation of internal to internal (II) truck trip productions and attractions for light-duty (LD), medium-duty (MD), and heavy-duty (HD) truck trips is accomplished using internal trip rates derived from the Quick Response Freight Manual (QRFM) and localized using American Transportation Research Institute (ATRI) truck data provided

Figure 4.2
Resident Commercial Truck Trip Generation Models

Milwaukee County:

$$LD = 0.35324 \times AMC + 0.29851 \times MTW + 0.28259 \times REMP + 0.13907 \times OS + 0.07988 \times HH$$
$$MD = 0.19535 \times AMC + 0.16358 \times MTW + 0.17101 \times REMP + 0.04596 \times OS + 0.06692 \times HH$$
$$HD = 0.06568 \times AMC + 0.03926 \times MTW + 0.02454 \times REMP + 0.00340 \times OS + 0.01434 \times HH$$

Remainder of Region:

$$LD = 0.48713 \times AMC + 0.41165 \times MTW + 0.38971 \times REMP + 0.19178 \times OS + 0.11015 \times HH$$
$$MD = 0.29802 \times AMC + 0.24956 \times MTW + 0.26090 \times REMP + 0.07012 \times OS + 0.10209 \times HH$$
$$HD = 0.10077 \times AMC + 0.06023 \times MTW + 0.03765 \times REMP + 0.00521 \times OS + 0.02201 \times HH$$

Where:

LD = Number of light-duty commercial truck trip ends
MD = Number of medium-duty commercial truck trip ends
HD = Number of heavy-duty commercial truck trip ends
AMC = Number of agriculture, mining, and construction employees
MTW = Number of manufacturing, transportation/communication/utilities, and wholesale employees
$REMP$ = Number of retail employees
OS = Number of office and services employees
HH = Number of Households

by the Wisconsin Department of Transportation. The truck trip rates by vehicle class are shown in Figure 4.2. External to Internal (EI) truck trip generation is accomplished by factoring the EI commercial truck trips by vehicle class from the 2012 external travel survey using growth factors derived from Freight Analysis Framework (FAF) forecasts. External to external (EE) truck trip generation—and distribution—is accomplished by factoring ATRI derived truck trips by vehicle class using growth factors derived from FAF forecasts. External nonresident personal trips account for about 6 percent of total tripmaking and about 2 percent of total vehicle trips within the Region in 2011. In the fifth-generation travel simulation models, the generation—and distribution—of external nonresident personal travel was forecast by extrapolating the existing 2011 pattern of external tripmaking by applying growth factors to the 2011 trips on the basis of the forecast changes in households and employment at the production and attraction ends of the trips, respectively. In addition, fifth-generation model forecast external travel can be compared to, and adjusted by, statewide external travel forecasts prepared by the Wisconsin Department of Transportation if available.

The number of trip ends produced by, or attracted to, each zone as estimated by the trip generation model, the first major step of the fifth-generation travel demand model battery, is expressed in terms of 24 hour total trip ends on an average weekday. The subsequent three major steps of the fifth-generation model battery, namely, trip distribution, modal choice, and traffic assignment steps are period specific, which means each of these three major steps deals with a model process for a specific time period of an average weekday. Four time periods were considered: morning peak period (6:00 a.m. to 9:00 a.m.), Midday period (9:00 a.m. to 2:30 p.m.), evening peak period (2:30 p.m. to

6:00 p.m.), and Night period (6:00 p.m. to 6:00 a.m.). Prior to the trip distribution step daily trips are distributed between the four time periods using the factors shown in Table 4.15.

TRIP DISTRIBUTION

The second major step in the travel simulation process is trip distribution, whereby the number of trips by time period of the day between each zonal pair is determined. The input to this step from trip generation includes the number of trips ends produced by, or attracted to, each zone by resident households of the Southeastern Wisconsin Region for home-based work, home-based shopping, home-based other, nonhome-based work, and nonhome-based other trips. The fifth-generation model battery's trip distribution procedure is a combination of destination choice models and gravity models. The home-based work, home-based shopping, home-based other, nonhome-based work, and nonhome-based other trips were distributed using destination choice models. The commercial truck II and EI trips were distributed using gravity models, whereas the distribution of internal school trips, group-quartered person trips, and external nonresident personal trips and nonresident commercial truck EE trips was accomplished by factoring and adjusting the existing trip travel patterns.

The trip distribution models employed by the fifth-generation travel demand model battery for resident household home-based work, home-based shopping, home-based other, nonhome-based work, and nonhome-based other trips were destination choice models developed as multinomial logit (MNL) choice models. In destination choice models, the choices, or alternatives, are the destination zones. The destination choice models were estimated using the free, open-source software package Biogeme, version 2.2. The data used to estimate the destination choice models include trip record data collected as a part of the 2011 household travel survey carried out by the Commission, zonal data, and period-specific highway skim data obtained from the travel simulation model using estimated actual year 2011 traffic conditions. A variety of explanatory factors were considered during the development of the destination choice model including those related to destination zone size (zonal attraction ends, total population, total employment, retail employment, other employment), impedance (distance, mode-choice utility logsum), and trip context (intrazonal trip indicator, area type). The final calibrated destination choice models express the probability or attractiveness of an attraction zone as a function of distance, whether the trip is intrazonal, the logsum of the available modal choices, and the number of trip ends in each attraction zone. The destination choice models developed are not period specific. However, the estimated models are applied by time period using mode-choice utility logsums and trip distances (based on shortest time paths) attendant to each period. The models are provided in Figure 4.3.

The trip distribution model employed by the fifth-generation travel demand model battery for II and EI commercial truck travel is the gravity model, which is the most widely accepted and used trip distribution model. In the gravity model, the number of trips between two zones in the region is a function of the number of trip ends in each zone and their spacial separation measured in terms of travel time, distance, and/or cost. The model uses period-specific travel time as the measure of spatial separation. Individual gravity models were calibrated for II (LD, MD, and HD) truck trips, while for the EI trips, friction factors from the QRFM were used. The calibrated friction factors for each trip purpose are shown in Figure 4.4. Since friction factors are relative,

Table 4.15
Proportion of Person Trips Occurring Within Each Time Period of an Average Weekday in the Region: 2011

Trip Classification				Proportion of Person Trips by Period				
Type of Travel	Trip Maker	Trip Purpose	Trip Direction	Morning	Midday	Evening	Night	Total
Personal	Resident Household	Home-Based Work	From Home	0.6519	0.1805	0.0678	0.0998	1.0000
			To Home	0.0101	0.1130	0.5737	0.3032	1.0000
		Home-Based Shopping	From Home	0.0960	0.4669	0.2487	0.1884	1.0000
			To Home	0.0196	0.3340	0.3359	0.3105	1.0000
		Home-Based Other	From Home	0.2037	0.2966	0.2771	0.2226	1.0000
			To Home	0.0690	0.1983	0.2947	0.4380	1.0000
		Home-Based School	From Home	0.8084	0.1114	0.0579	0.0223	1.0000
			To Home	0.0071	0.0809	0.7787	0.1333	1.0000
		Nonhome-Based Work		0.1318	0.4436	0.3349	0.0897	1.0000
		Nonhome-Based Other		0.0507	0.4381	0.3040	0.2072	1.0000
		Nonhome-Based School		0.1700	0.2323	0.5092	0.0885	1.0000
	Group-Quartered Residents			0.1062	0.5185	0.2289	0.1464	1.0000
	Nonresident	Home-Based Work		0.2745	0.2862	0.4270	0.0123	1.0000
		Home-Based Shopping		0.0922	0.6200	0.2824	0.0054	1.0000
		Home-Based Other		0.1186	0.5645	0.3116	0.0053	1.0000
		Nonhome-Based		0.1267	0.5448	0.3234	0.0051	1.0000
		Home-Based School		0.1897	0.5028	0.3009	0.0066	1.0000
		Nonhome-Based School		0.1077	0.6423	0.2457	0.0043	1.0000
Commercial Truck	Resident	Light-Duty Truck		0.2152	0.4921	0.1862	0.1065	1.0000
		Medium-Duty Truck		0.2348	0.5480	0.1769	0.0403	1.0000
		Heavy-Duty Truck		0.2191	0.6090	0.1604	0.0115	1.0000
	Nonresident	Light-Duty Truck		0.1720	0.5678	0.2550	0.0052	1.0000
		Medium-Duty Truck		0.1369	0.6524	0.2074	0.0033	1.0000
		Heavy-Duty Truck		0.1534	0.6546	0.1849	0.0071	1.0000

Source: SEWRPC

of greater importance than their absolute magnitudes is the slope of the smoothed friction factor curve. For this reason, the friction factor curves in Figure 4.4 were normalized and plotted on logarithmic scales to facilitate a comparison between the various curves used. The friction factor curves with the smallest negative slope are for EI and II heavy-duty truck (HD) trips, indicating the smaller effects the spatial separation has on the distribution of these trips. Conversely, the curves for both EI and II light-duty truck trips show the greatest sensitivity to special separation as the travel time increases.

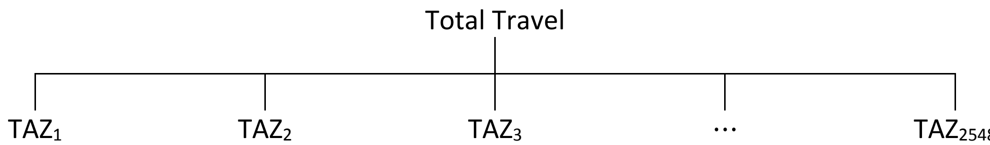
As noted earlier, the distribution of school trips, group quartered person trips, external nonresident personal trips, and EE nonresident commercial truck trips was accomplished by factoring and adjusting existing year 2011 trip travel patterns.

MODAL CHOICE

The third major step in the travel simulation process is modal choice whereby the total number of trips during each time period of the day traveling between each pair of traffic analysis zones by trip purpose is divided on the basis of travel mode used. Primarily, this step involves the division of internal person trips between the three major modes of travel: public transit, private automobile, and non-motorized trips. The determination of modal choice is essentially an evaluation of the potential demand for public transit service and for accessibility by non-motorized modes. Automobile vehicle

Figure 4.3
Destination Choice Models

Structure:



Formula:

$$P(i) = \frac{e^{V_i}}{\sum_{j=1}^{2548} e^{V_j}} \qquad LOGSUM = ln\left(\sum_m e^{V_m}\right) \qquad LOGSUM = \frac{1}{\mu} ln\left(\sum_m e^{\mu V_m}\right)$$

(For nonhome-based trips) (For home-based trips)

Home-Based Work
$V_i = 0.1083\ IZN + 0.1080\ LOGSUM - 0.0543\ DIST - 0.8986\ \ln(DIST) + 0.4080\ \ln(ATTR)$

Home-Based Shopping
$V_i = -0.9736\ IZN + 0.5920\ LOGSUM - 0.0728\ DIST - 1.7769\ \ln(DIST) + 0.4610\ \ln(ATTR)$

Home-Based Other
$V_i = -0.5219\ IZN + 0.4980\ LOGSUM - 0.0500\ DIST - 1.3970\ \ln(DIST) + 0.5910\ \ln(ATTR)$

Nonhome-Based Work
$V_i = -1.4233\ IZN + 0.0043\ LOGSUM - 0.0017\ DIST - 1.7747\ \ln(DIST) + 0.6980\ \ln(ATTR)$

Nonhome-Based Other
$V_i = -0.4619\ IZN + 0.1910\ LOGSUM - 0.0900\ DIST - 1.1340\ \ln(DIST) + 0.9260\ \ln(ATTR)$

Where:

$P(i)$	= Probability of selecting destination TAZ i
V_i	= Utility of destination TAZ i
V_m	= Utility of mode m
m	= Available mode (nonmotorized, personal vehicle, and/or transit)
i	= TAZ number 1 through TAZ number 2548
IZN	= Intrazonal trip indicator (1 if true, 0 if false)
$DIST$	= Trip distance (miles)
$ATTR$	= Number of trip ends by purpose in destination TAZ
$LOGSUM$	= Modal choice logsums
μ	= Home-based modal choice model nesting coefficient attendant to trip purpose

Figure 4.4
Internal to Internal and External to Internal Commercial Truck Trip Gravity Models

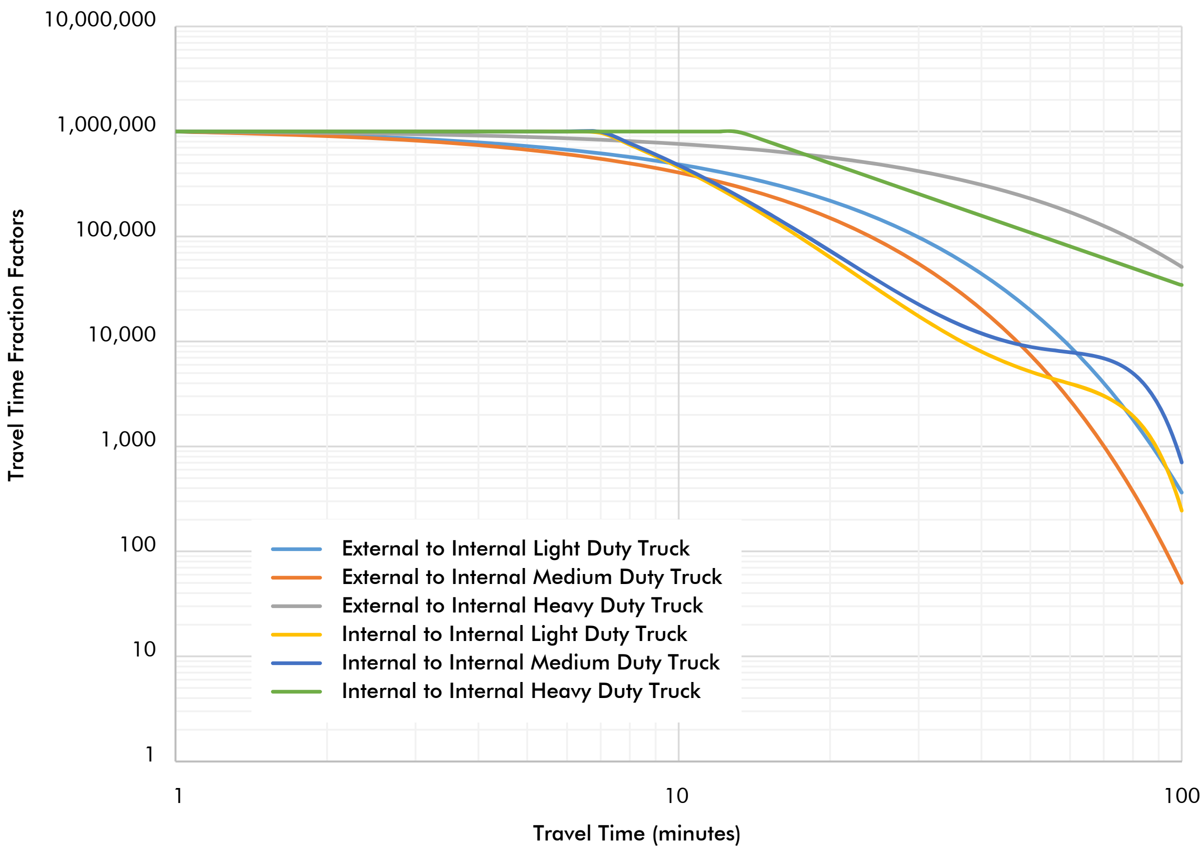
Formula:

$$P(i) = \frac{FF_i \times ATTR_i}{\sum_{j=1}^{2548} FF_j \times ATTR_j}$$

Where:

$P(i)$ = Probability of selecting destination TAZ i
i = TAZ number 1 through TAZ number 2548
FF_i = Friction factor attendant to travel time to TAZ i
$ATTR$ = number of trip ends by commercial vehicle class in destination TAZ i

Friction Factors:



Source: Quick Response Freight Manual and SEWRPC

trips and transit person trips determined in this step are taken further into the modeling process as necessary inputs to the final traffic assignment step of the travel simulation process.

The fifth-generation mode choice models were developed using data collected as a part of the 2011 travel inventory carried out by the Commission, zonal data, and period-specific network skim data obtained from the travel simulation model based on 2011 transportation system network data. The models were estimated using the free, open-source software package

Biogeme, version 2.2. A variety of explanatory factors were considered, including those related to modal alternative (in-vehicle travel time, out-of-vehicle travel time, out-of-pocket cost), impedance (distance), trip context (intrazonal trip indicator, area type, walkability score), zonal attributes (population, employment), and personal vehicle availability. The nested logit (NL) mode choice models calibrated for the home-based work, home-based shopping, and home-based other trip purposes express the probability of auto and transit mode choice as a function of personal vehicle availability, in-vehicle travel time, out-of-vehicle travel time, and out-of-pocket cost differences between these two modes; and the probability of non-motorized mode choice as a function of household vehicle availability, distance, area type, and whether the trip was an intrazonal trip—both trip ends in the same TAZ. The calibrated mode choice models for home-based work, home-based shopping, and home-based other purposes are presented in Figure 4.5. For the nonhome-based work and nonhome-based other trip purposes, multinomial logit (MNL) mode choice models were estimated, which express the probability of auto and transit mode choice as a function of in-vehicle travel time, out-of-vehicle travel time, and out-of-pocket cost differences between automobile and transit modes, and the probability of non-motorized mode choice as a function of distance, area type, and whether the trip was an intrazonal trip. The calibrated mode choice models for the nonhome-based work and nonhome-based other purposes are presented in Figure 4.6. An automobile occupancy model shown in Table 4.16 is used to convert total automobile person trips to vehicle trips for home-based work, shopping, and other trips, nonhome-based trips based on household size, number of workers in a household, and personal vehicle availability.

The non-motorized trips estimated from the calibrated mode choice models were further classified into walk and bike trips using distance-based deterministic walk share models developed from 2011 travel inventory data. Trip purposes were aggregated and walk and bike trips were classified into work related and non-work related trips. The work related trips consisted of home-based work and nonhome-based work trip purposes, whereas home-based shopping, home-based other and nonhome-based other trip purposes constituted non-work related trips. The estimated walk share models are presented below:

Non-work trips: $WT = NMT[-9.0 \times ln(DIST) + 90.0]$

$BT = NMT - WT$

Work trips: $WT = NMT[-15.0 \times ln(DIST) + 79.0]$

$BT = NMT - WT$

Where:

$DIST$ = Distance in miles (70% highway network skim distance)

NMT = Nonmotorized trips

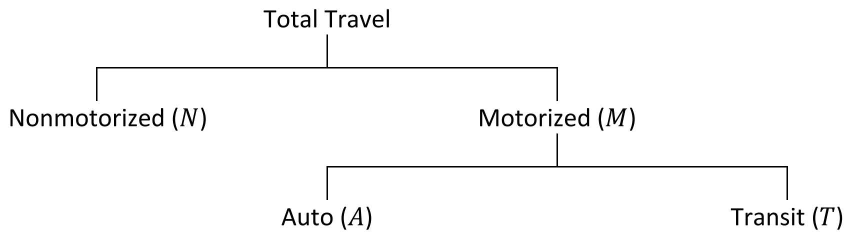
WT = Walk trips

BT = Bicycle Trips

As noted earlier, the mode choice for school trips, group quartered person trips, external nonresident personal trips was accomplished by factoring and adjusting existing year 2011 trip travel patterns based on forecast household population, by age group, and group quartered population growth.

Figure 4.5
Home-Based Mode Choice Models

Structure:



Formula:

$$P(N) = \frac{e^{\theta \ln(e^{\mu V_N})}}{e^{\theta \ln(e^{\mu V_N})} + e^{\theta \ln(e^{\mu V_A + e^{\mu V_T}})}}$$

$$P(M) = \frac{e^{\theta \ln(e^{\mu V_A + e^{\mu V_T}})}}{e^{\theta \ln(e^{\mu V_N})} + e^{\theta \ln(e^{\mu V_A + e^{\mu V_T}})}}$$

$$P(A) = P(M) \times \frac{e^{\mu V_A}}{e^{\mu V_A} + e^{\mu V_T}}$$

$$P(T) = P(M) \times \frac{e^{\mu V_T}}{e^{\mu V_A} + e^{\mu V_T}}$$

$$\theta = \frac{1}{\mu}$$

Home-Based Work

$V_A = -\,0.0119\, IVT_A - 0.0298\, OVT_A - 0.3586\, COST_A + 0.8240\, VA - 0.7050$
$V_T = -\,0.0119\, IVT_T - 0.0298\, OVT_T - 0.3586\, COST_T + 1.2915\, VA_0 - 0.4500$
$V_N = -\,0.6175\, ND + 1.5200\, IZN - 0.4720\, TPA + 1.2915\, VA_0$
$\mu = 1.5900$

Home-Based Shopping

$V_A = -0.0200\, IVT_A - 0.0500\, OVT_A - 0.5676\, COST_A + 0.6650\, VA - 0.1760$
$V_T = -0.0200\, IVT_T - 0.0500\, OVT_T - 0.5676\, COST_T + 2.8161\, VA_0 - 0.8680$
$V_N = -0.5928\, ND + 1.6200\, IZN - 0.9460\, TPA + 2.8161\, VA_0$
$\mu = 1.2200$

Home-Based Other

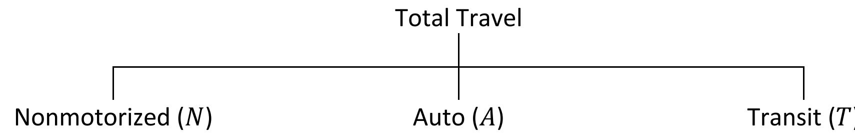
$V_A = -0.0175\, IVT_A - 0.0256\, OVT_A - 0.4948\, COST_A + 0.4330\, VA - 0.5900$
$V_T = -0.0175\, IVT_T - 0.0256\, OVT_T - 04948\, COST_T + 1.6300\, VA_0 - 1.0600$
$V_N = -0.8063\, ND + 1.5400\, IZN - 0.7950\, TPA + 1.6300\, VA_0$
$\mu = 1.7200$

Where:

$P(i)$ = Probability of choosing mode i
V_i = Utility of modal alternative i
IVT_i = In-vehicle travel time attendant to mode i (minutes)
OVT_i = Out-of-vehicle travel time attendant to mode i (minutes)
$COST_i$ = Out-of-pocket cost attendant to mode i (2011 US dollars)
VA = Household vehicle availability (0, 1, 2, or 3 for three or more)
VA_0 = Zero-vehicle household indicator variable (0 for false, 1 for true)
ND = Nonmotorized trip distance (miles)
IZN = Intrazonal trip indicator variable (1 if true, 0 if false)
TPA = Area type (1 if urban, 2 if suburban, 3 if rural)
μ = Nesting coefficient

Figure 4.6
Nonhome-Based Mode Choice Models

Structure:



Formula:

$$P(N) = \frac{e^{V_N}}{e^{V_N} + e^{V_T} + e^{V_A}} \qquad P(T) = \frac{e^{V_T}}{e^{V_N} + e^{V_T} + e^{V_A}}$$

$$P(A) = \frac{e^{V_A}}{e^{V_N} + e^{V_T} + e^{V_A}}$$

Nonhome-Based Work

$$V_A = -\,0.0474\,IVT_A - 0.0646\,OVT_A - 0.8787\,COST_A + 0.2270$$
$$V_T = -\,0.0474\,IVT_T - 0.0646\,OVT_T - 0.8787\,COST_T - 0.6790$$
$$V_N = -\,0.7280\,ND + 0.9970\,IZN - 1.4300\,TPA$$

Nonhome-Based Other

$$V_A = -0.0250\,IVT_A - 0.0597\,OVT_A - 1.2191\,COST_A + 0.0924$$
$$V_T = -0.0250\,IVT_T - 0.0597\,OVT_T - 1.2191\,COST_T + 0.1420$$
$$V_N = -0.9180\,ND + 1.4500\,IZN - 1.3500\,TPA$$

Where:

$P(i)$	= Probability of choosing mode i
V_i	= Utility of modal alternative i
IVT_i	= In-vehicle travel time attendant to mode i (minutes)
OVT_i	= Out-of-vehicle travel time attendant to mode i (minutes)
$COST_i$	= Out-of-pocket cost attendant to mode i (2011 US dollars)
ND	= Nonmotorized trip distance (miles)
IZN	= Intrazonal trip indicator variable (1 if true, 0 if false)
TPA	= Area type (1 if urban, 2 if suburban, 3 if rural)

TRAFFIC AND TRANSIT ASSIGNMENT

The fourth and final major step in the travel forecasting and analysis process is the assignment of the zone-to-zone trip volumes forecast in the trip distribution and modal split phases to specific routes of existing and proposed alternative transportation systems. The output of assignments for the arterial street and highway system is a forecast of the number of vehicles by time period on an average weekday that may be expected to use each segment of the arterial street and highway system by direction. The output of assignments for the transit system is an estimate of the number of passengers by time period on an annual average weekday that may be expected to use each segment of the transit system by direction, complete with transfers at route intersections. The period-specific assignments for the arterial street and highway system and transit system are combined to obtain the forecast of the number of vehicles and passengers respectively on a 24-hour average weekday. The assignment of travel demand to the transportation system is accomplished separately for the highway and transit systems and in several steps.

Table 4.16
Vehicle Person Trips per Vehicle Trip

Home-Based Work Person Trips per Vehicle Trip				
	Workers per Household			
Vehicles Available	One	Two	Three	Four or More
None	7.78	9.17	9.17	9.17
One	1.04	1.31	1.59	1.59
Two	1.03	1.03	1.26	1.48
Three	1.03	1.02	1.10	1.22
Four or More	1.02	1.02	1.06	1.09

Nonhome-Based Work Person Trips per Vehicle Trip				
	Workers per Household			
Vehicles Available	One	Two	Three	Four or More
None	1.52	1.25	1.25	1.25
One	1.07	1.36	2.02	4.76
Two	1.06	1.06	1.12	4.76
Three	1.06	1.06	1.06	1.11
Four or More	1.04	1.06	1.06	1.11

Home-Based Shopping Person Trips per Vehicle Trip					
	Household Size				
Vehicles Available	One	Two	Three	Four	Five or More
None	118.65	61.55	55.16	55.16	55.16
One	1.03	1.46	1.49	1.56	1.56
Two	1.02	1.21	1.25	1.30	1.39
Three	1.01	1.17	1.18	1.28	1.37
Four or More	1.01	1.13	1.14	1.18	1.35

Home-Based Other Person Trips per Vehicle Trip					
	House hold Size				
Vehicles Available	One	Two	Three	Four	Five or More
None	35.12	23.37	23.37	23.37	23.37
One	1.06	1.49	1.54	1.58	2.01
Two	1.06	1.18	1.25	1.38	1.54
Three	1.03	1.14	1.15	1.28	1.38
Four or More	1.02	1.13	1.14	1.17	1.37

Nonhome-Based Other Person Trips per Vehicle Trip					
	Household Size				
Vehicles Available	One	Two	Three	Four	Five or More
None	19.91	48.65	48.65	48.65	48.65
One	1.08	1.62	1.69	1.97	1.97
Two	1.08	1.19	1.27	1.28	1.52
Three	1.06	1.19	1.23	1.25	1.52
Four or More	1.06	1.19	1.23	1.25	1.26

Source: SEWRPC

Network Preparation

The first step in the assignment process is the preparation of highway and transit networks to provide a definitive description of the arterial street and highway and the transit system to be tested. The definitive description of the highway and transit system includes the collection, coding, and transfer to computer-usable form of data describing each link in the two networks—such as location, capacity, and operating speed—so that the operation of the overall transportation system can be simulated. Inasmuch as the transit and highway networks are the source of the zonal travel time information used in the trip distribution and modal split steps, the initial preparation of highway and transit networks must be completed near the beginning of the entire travel simulation process.

Highway Network Preparation

The first step in the preparation of the highway network is to define in detail the existing highway system and the highway system for each alternative plan to be tested, identifying all freeways and standard surface arterial streets constituting the system. The highway network includes all arterial streets in the Region, which represent about 27 percent of total street mileage and on which about 90 percent of vehicle miles of travel occur on an average weekday. The highway network is constructed using the battery of urban transportation planning programs known as Cube.

The transfer of information on the highway system to computer-usable form requires the assignment of node numbers to all intersections of, and access points to, the arterial street and highway system. Each arterial street segment between two nodes is defined as an arterial link. All freeways and freeway ramps, all surface arterial streets, and some nonarterial local roads are represented in the highway network for the Region as different types of roadway links. For each link, data are encoded. The types of data that are encoded for each arterial link are listed in Table 4.17. Link operating speeds represent estimated free-flow speed and are estimated by travel time studies for existing facilities, by speed limit, and number and type of traffic controls. Hourly, time period, and 24-hour average weekday capacities for each link are calculated based on the functional type of roadway, the operating speed of the facility, and the typical cross-section of the facility, which includes consideration of number of through traffic lanes and whether the facility is a divided or undivided facility. The hourly capacities utilized by the fifth-generation travel demand model are presented in Table 4.18.

A second type of link is used in the highway network to connect the land uses served to arterial street and highway system. For each traffic analysis zone in the Region, the center of activity is determined and marked by centroids, representing the points from which all trips originate, and to which they are destined. The centroids are connected to the access points on the highway network by access links termed centroid connector links, representing the nonarterial collector and land access street system. Access times coded on the centroid connector links are a function of the time required to access a vehicle and the time required to access the arterial system over the collector and land access streets within each zone. Map 4.5 shows the access times assigned to the centroid connectors by TAZ.

The fifth-generation travel demand model also uses a master network data structure to store the existing or "base" conditions as well as the planned future highway network conditions. In the master network all of the required geometric configurations of the highway network are encoded. This is accomplished through the encoding of both "base" and "future" geometric

Table 4.17
Type of Data Encoded for Links in the Highway Network

Type of Information	Field Name	Description
Distance	DISTANCE	Distance in miles
Speed	POST_SPD FFSPEED	Posted Speed in miles per hour Hard coded free-flow speed
Link Type	BY_FACTYPE PS_FACTYPE	Base-year (BY) and plan year (PS) link type: surface Arterial (ART), collector-distributor (CD), freeway CD (CD.FWY), centroid connector (CENT.CONN), external network link (EXT), external railroad link (EXT.RR), freeway (FWY), park-ride auto connector (PNR.AUTO), park-ride transit link (PNR.TRN), park-ride walk connector (PNR.WLK), non-freeway ramp (RMP.NF), service interchange ramp (RMP.SRV), system interchange ramp (RMP.SYS), nonarterial transit facility (TRN.CD), railroad facility (TRN.RR)
	BY_RAMP PS_RAMP	Base-year and plan year type: on-ramp (ON), off-ramp (OFF), or not applicable (NA) flag
Cross-Section Information	BY_LANE PS_LANE	Base-year and plan year number of directional lanes
	BY_DIVIDED PS_DIVIDED	Base-year and plan year cross-section: one-way (O), undivided (U), or divided (D)
	BY_TWTL PS_TWTL	Base-year and plan year two-way left-turn lane present: yes (Y) or no (N)
	BY_XSECTYPE PS_XSECTYPE	Base-year and plan year urban (U) or rural (R) cross section
Ownership	BY_JURISDICTION PS_JURISDICTION	Base-year and plan year jurisdictional ownership code: State (1), county (2), local (3)
Project ID	AIRQUAL	Project ID number used to join record to project lookup table
Plan Staging Flag	PS_XXXX	Plan staging flag used to trigger system improvements. XXXX replaced with plan stage year. Use base year geometric data BY_XXXX (B), planned geometric data PS_XXXX (P), use lookup table to determine base or plan geometry (A), link not included (N).

Source: SEWRPC

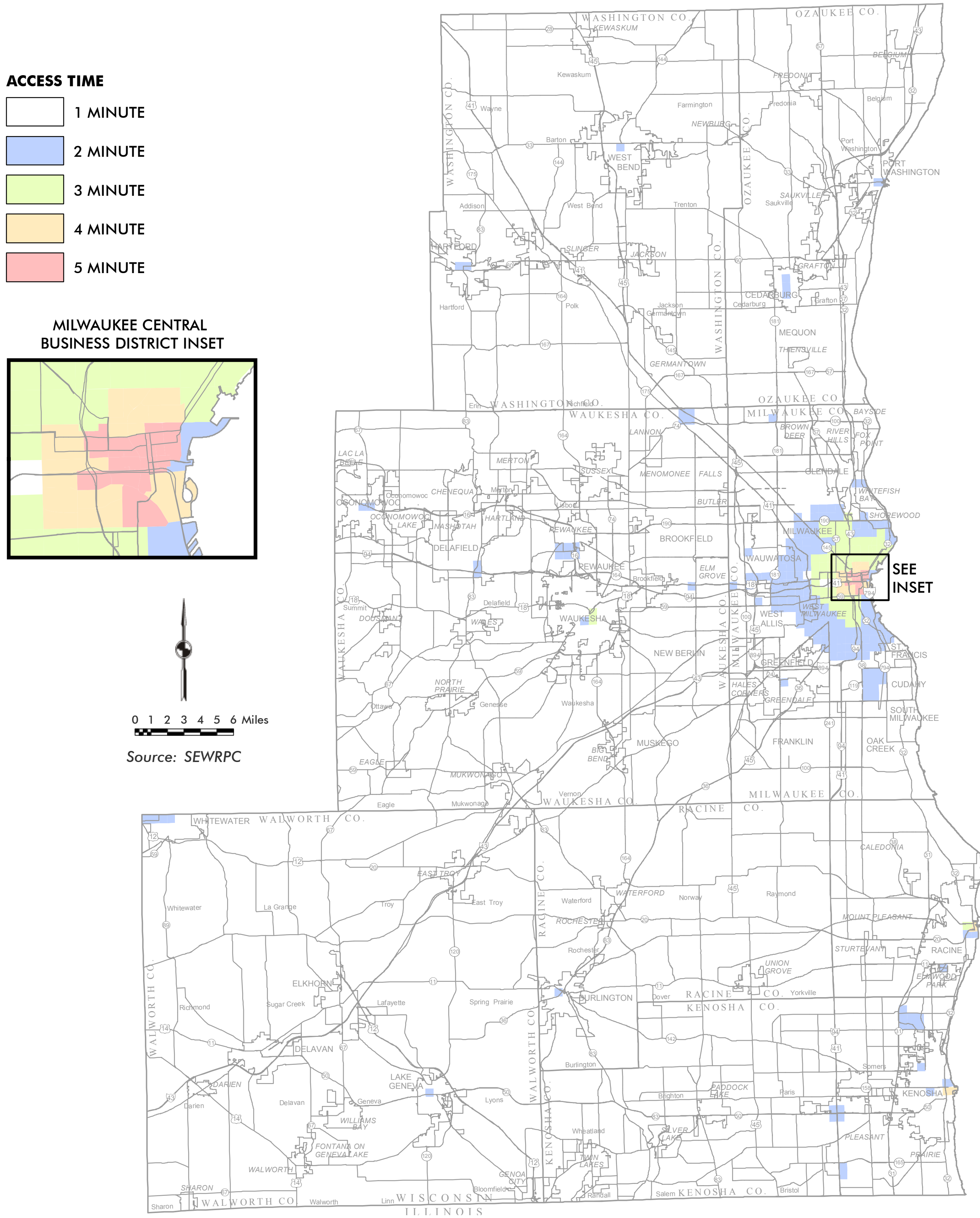
Table 4.18
Hourly Passenger Car Equivalent Capacities Used in the Fifth-Generation Travel Demand Model

Facility Type	Ramp Type	Divided/ Undivided	Directional Number of Lanes	Posted Speed Limit (mph)					
				<30	30-35	35-45	45-55	55-65	>=65
Freeway	NA	Divided	1				2,150	2,150	2,200
			2				4,300	4,300	4,400
			3				6,500	6,500	6,600
			4				8,600	8,600	8,800
			5				10,750	10,750	
			6					12,900	
Service Ramp	OFF	One-Way	1						
			2						
	ON	One-Way	1		1,140				
			2		2,280				
Standard Arterial and Nonarterial Facility Types	NA	Divided/ One-Way	1	800	850	890	1,140	1,140	
			2	1,620	1,690	1,780	2,280	2,280	
			3	2,430	2,540	2,670	3,430	3,430	
			4	3,250	3,390	3,560	4,570	4,570	
	NA	Undivided	1	800	850	890	1,140	1,140	
			2	1,620	1,690	1,780	2,280	2,280	

Note: Greyed out cells represent invalid options.

Source: SEWRPC

Map 4.5
Access Times Assigned to Centroid Connectors



Source: SEWRPC

data on every link in the network. It may also be necessary to encode additional links to account for future roadways or alignments which may not exist in the "base" conditions. Links are encoded with a unique project level code to group a set of links into a single project included in the planned "future" conditions. Each link is also encoded to indicate whether the "base" or "future" geometry of the roadways should be used or if the link should be excluded from either the base or future. A separate table with a list of future highway improvement or expansion projects includes a year open to traffic code, allowing the planned highway improvements to be staged for air quality conformity purposes or to exclude projects included in the "vision" plan from the "fiscally constrained" plan. This master network with lookup table structure allows alternative plans to be rapidly developed as well. These data are stored in a Cube geodatabase. When the model is run, a Cube binary network is generated based on the information in the lookup table.

Transit Network Preparation

The first step in the preparation of the transit network is to define in detail the transit system to be tested. This involves the identification of all existing and planned routes in the public transit system to be simulated, along with the street and highway facilities and special rapid and express transit facilities over which the routes of the system are to operate. The transit network includes all existing transit routes, with the exception of special school routes. The transit network is also constructed using the aforementioned urban transportation planning programs known as Cube.

As much of the transit network utilizes the highway network, after the transit routes and facilities have been identified, the sequence of node numbers in the highway network describing each transit route must be identified. Additionally, the highway network nodes that represent all terminal and transfer points must also be identified for each route. Special links may also be encoded into the highway network, which are not used during the highway assignment step. These different types of transit links are encoded in the network to represent the different types of transit service provided on the transit system, including local/shuttle and feeder bus transit service, rapid transit service, and commuter rail service. The types of data that are encoded in each transit route are listed in Table 4.19.

Since the transit network operates on the highway network, transit travel times for each route are determined through the relationships shown in Table 4.20 and adjusted to account for the congestion experienced in each period. If necessary, each transit route can be encoded with travel times by direction of travel for the morning, midday, evening, and night travel periods. The travel times are initially based upon maximum operating speeds for each transit mode being modeled. The transit travel time relationships identified in Table 4.20 are used to determine the actual link level travel time for each route. As highway links become congested, transit travel times are adjusted to take into account the impacts of congestion on the highway facilities transit operates over. These relationships were calibrated by comparing model estimated transit travel times by route to reported actual travel times. Some arterial streets in the urban areas of the Region may experience future increases in traffic sufficient to result in weekday traffic volumes exceeding arterial design capacity and, thereby, result in congestion severe enough to reduce transit running speeds.

The transit network is more complex than the highway network in that access to the transit system both by walking and by automobile must be allowed for in the simulation, as must the transfer between the different types of transit

Table 4.19
Mode Designations for Transit and Access Links Used in Encoded Transit Networks

Transit Lines and Non-Transit Legs	Designated Mode Number	Information Code
Non-Transit Legs		
Walk Access Link	11	Distance and time
Transfer Link	12	Distance and time
Automobile Access Link	13	Distance and time
Transit Lines		
Local Bus Transit	1	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Express Bus Transit	2	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Rapid Bus Transit	3	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Commuter Bus Transit	4	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Commuter Rail Guideway	5	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Shuttle Transit	6	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Streetcar Guideway	7	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Light Rail Guideway	8	Route Name, Operator, Period Headways, Route Nodes, Access Nodes
Metra Commuter Rail Guideway	9	Route Name, Operator, Period Headways, Route Nodes, Access Nodes

Source: SEWRPC

Table 4.20
Transit Travel Time Relationships

Mode		
Type	Number	Transit Travel Time
Walk to Transit Time	11	20 minutes per mile (3 mph)
Transfer Walk Time	12	20 minutes per mile (3 mph)
Drive Access Link	13	Congested highway network travel time
Local Bus and Shuttle Transit	1, 6	Maximum of 4.8 minutes per mile (12.5 mph) or 1.3 × non-freeway link congested travel time or 1.2 × freeway link congested travel time
Express Bus Transit	2	Maximum of 4 minutes per mile (15 mph) or 1.3 × non-freeway link congested travel time or 1.2 × freeway link congested travel time
Rapid Bus Transit	3	Maximum of 3 minutes per mile (20 mph) or 1.3 × non-freeway link congested travel time or 1.2 × freeway link congested travel time
Commuter Bus Transit	4	1.3 × non-freeway link congested travel time or 1.2 × freeway link congested travel time
Commuter Rail Guideway	5	Directly encoded to link
Streetcar	7	7.5 minutes per mile (8 mph)
Light Rail	8	3 minutes per mile (20 mph)
Metra Commuter Rail	9	Directly encoded to link

Source: SEWRPC

service. To allow for the different access methods and transfer capabilities, three different types of nontransit access links are used: walk access links, transfer links, and auto drive access links. These three types of links are generated automatically by the Cube software based on parameters discussed in the following text.

Walk access links are used to represent walk access to the transit system from the areas that each route serves. Each traffic analysis zone is directly connected by walk access only to those routes that directly serve the zone. To develop the walk access links, a set of paths, based on the shortest travel distance, is produced using the highway network between each TAZ and the access nodes for each of the transit routes. Because the network is primarily an arterial highway network the paths developed may be more circuitous than a person may actually be able to travel. As such, 70 percent of the skim distance is used. All walk connectors greater than one half of a mile are excluded from further consideration. In addition, up to four "best" or shortest connectors from each TAZ to a transit mode are retained. The resulting set of walk access links are encoded with the distance measured from the zone centroid to the access node on the network and a travel time based on an average walking speed of three miles per hour.

Transfer links are used to simulate connections between transit routes and between different transit service modes. Such links also allow for the simulation of the transfer of passengers between the different types of transit service and for simulation of "timed transfers" on routes operated with pulse scheduling in the cities of Kenosha, Racine, and Waukesha. As with the walk access links, the transfer links are generated automatically. Unlike the walk access links transfer links do not consider the distance directly and do not assume that an individual likely has a path between transit routes that is 30 percent faster than the highway network skim. The highway network is skimmed between transit access points and all paths greater than 5 minutes (based on a three mile per hour walk speed) are discarded. From that set of paths, up to four of the "best" paths are retained between routes and modes to be used for transfers. The resulting set of transfer links are encoded with the travel time.

The third type of nontransit links are auto drive access links and are used to represent access to transit service by automobile to loading points on the transit system where such access is feasible. For the existing and planned public transit system networks serving the Milwaukee area, auto drive access is limited to commuter, rapid bus, and light rail transit service at both formally designated park-ride lots, and at some stops where patrons are known to "park and ride" or "kiss and ride," although a formal park-ride lot may not be designated. Automobile drive access is only considered to be available where park and ride or kiss and ride facilities are provided unless it is known that sufficient on street parking is available in the vicinity of the transit stops. The highway network is skimmed for distance and travel time from a TAZ to the park and ride lots in the region based on the shortest distance to a park-ride lot. Travel times are read directly from the highway links. For TAZs within Milwaukee County, paths to all transit modes with a trip distance greater than two miles were discarded. Outside of Milwaukee County, paths from TAZs to a park-ride lot served by commuter rail were then limited to ten miles or less, and for all other transit modes were limited to five miles or less.

In constructing the auto drive access links to each park-ride lot, the presence of competing lots is taken into consideration, as well as the reluctance of tripmakers to "backtrack" to access a particular transit route or type of service if another route or type of service is available that would allow a more direct travel route. This is mitigated through a limitation on the number of potential park-ride lots connected to a TAZ to a single "best" path by mode of transit served, such that only the closest park-ride lot served by a mode will be connected to a TAZ.

The coding of modes of access to transit services in the transit networks utilizes all three of the above access links. Three potential access modes to transit stations served by commuter, rapid bus, and light rail transit services may be provided: walk, feeder bus (through the encoding of feeder bus services), and automobile. Walk access is provided for by encoding walk access links between the stations and the zones located within one half mile of the stations. The transfer of passengers between feeder bus lines and commuter, rapid bus, and light rail transit lines at a station is provided for by encoding transfer links between the transfer node on the feeder bus line and the station node. Finally, automobile access is provided for by encoding automobile access links between the zones served and the transit station. The automobile access connection includes the travel time of automobile access between the zone and the park-ride lot, taken directly from the highway network. The encoded travel time on the automobile access links also includes travel time associated with walking from the automobile to the boarding platform at each station, based on an average walking speed of three miles per hour.

As the final step in encoding the transit network, the routes of the transit system are converted to transit lines on the network. Where a route operates regular service with specific branches and turnback points, separate lines are encoded on the network to represent each branch or truncated portion of the route. Separate lines are also encoded where routes utilize different streets by direction of travel, where headways on a route or portion thereof vary by direction of travel or during peak periods, or where future highway network conditions may require an adjustment to the alignment of a route. All routes that regularly provide a significant level of transit service on an average weekday are encoded on the transit system.

Special routes providing a limited level of service, such as special school routes operating only one or two bus trips per day, are not included in the transit network. As was done in coding transit routes, different types of transit lines are encoded to represent the different types of transit service provided on the transit system. Operating headways are encoded for each line to reflect the level of service provided during each of four time periods: a morning peak, a midday off peak, an evening peak, and a night off peak. The routes and operating headways encoded in the transit network are defined by the operational plans prepared for each alternative.

The transit networks for the fifth-generation travel models are also stored in a master lines file. As Cube uses a text file to store the headways, mode, and operator data, in addition to the name and sequence of nodes used to describe the routes, this creates a large file that is difficult to navigate and make edits. Though there is a network editor that allows more visual editing of the network, a methodology similar to the management of the highway networks was developed to more easily control whether an alternative or plan stage includes a transit line, and also to change the headways of a route by simply updating a table. When the model is run, a lookup table is referenced that filters out the unneeded transit lines and updates the operational parameters for each line being modeled.

Network Skims

The second step in the traffic assignment process involves the computation, from the descriptions of the transportation networks, of two sets of minimum time paths from each traffic analysis zone within the Region to all other such zones, one for automobile travel and one for transit travel. For the highway network, the minimum time paths are computed by systematically comparing travel times for all links in the system in successively outward steps from the starting zone until the shortest time paths to all other zones have been computed. The minimum time paths represent the shortest door to door travel times between any two zones within the Region, including walk times at either end of the trip and park and unpark times for automobile trips.

A similar process is used to define the zone to zone travel paths for transit except that the computed time paths are weighted to reflect the different coefficients assigned to work and nonwork trips in the modal choice model. In this respect, the out of vehicle times, such as walk and drive access times, initial waiting times, and waiting times incurred in transferring between transit routes, along the transit travel path are factored by the ratio of the out-of-vehicle and in-vehicle travel time coefficients in the modal split model. The minimum time path for a particular zonal pair, consequently, reflects the path with the lowest combined in-vehicle and weighted out-of-vehicle time. While this path may not reflect the shortest absolute time path for a zonal pair on the transit network, it is believed to be more representative of the path a transit patron would take since out-of-vehicle time is viewed as the most onerous part of a transit trip.

From minimum time paths for the highway and transit networks, the zone to zone travel times for automobile and transit trips can be determined. These zone to zone travel times are used as inputs to the trip distribution and modal choice steps in the travel simulation process. Also required for the trip distribution and mode choice step is a third set of paths based on minimum nonmotorized zone-to-zone trip distance.

Trip Tables

In the third step in the traffic assignment process, matrices, or tables, of both vehicle trip interchanges and transit passenger trip interchanges for each time period of the day are prepared from the matrices of average weekday trip interchange volumes created by the process of trip generation, trip distribution, and modal split. For assignment of traffic demand to the highway network system, trip interchange tables that are direct outputs of the application of the trip generation, trip distribution, and modal split models must be combined to provide total zonal trip interchange volumes. The individual trip interchange tables that are thus combined by the four time periods include tables for internal vehicle trips by automobile for each of the five trip purposes derived from the modal choice phase plus those made for school purposes, tables for automobile trips made by people residing in group quarters, tables for external vehicle trips made by automobile, and tables for internal and external truck trips. For assignment of trips to the transit system, the trip tables for transit passenger trips for HBW, HBS, HBO, NHBW, NHBO, and school purposes by time period are combined to create tables of transit passenger trips made during specific time periods of each weekday.

As discussed previously, prior to travel assignment, trip interchanges need to be converted from "produced to attracted" format to "origin to destination". This is accomplished by taking 50 percent of the trips and distributing trips between periods using the "from home" (produced to attracted) factors. The other 50 percent of the trips are distributed between periods using the "to home" (attracted to produced). The factors are provided in Table 4.15. The "to home" trips are then "transposed" to reverse the direction of travel and added back to the remaining trips to create origin destination trip tables for each period.

Assignment

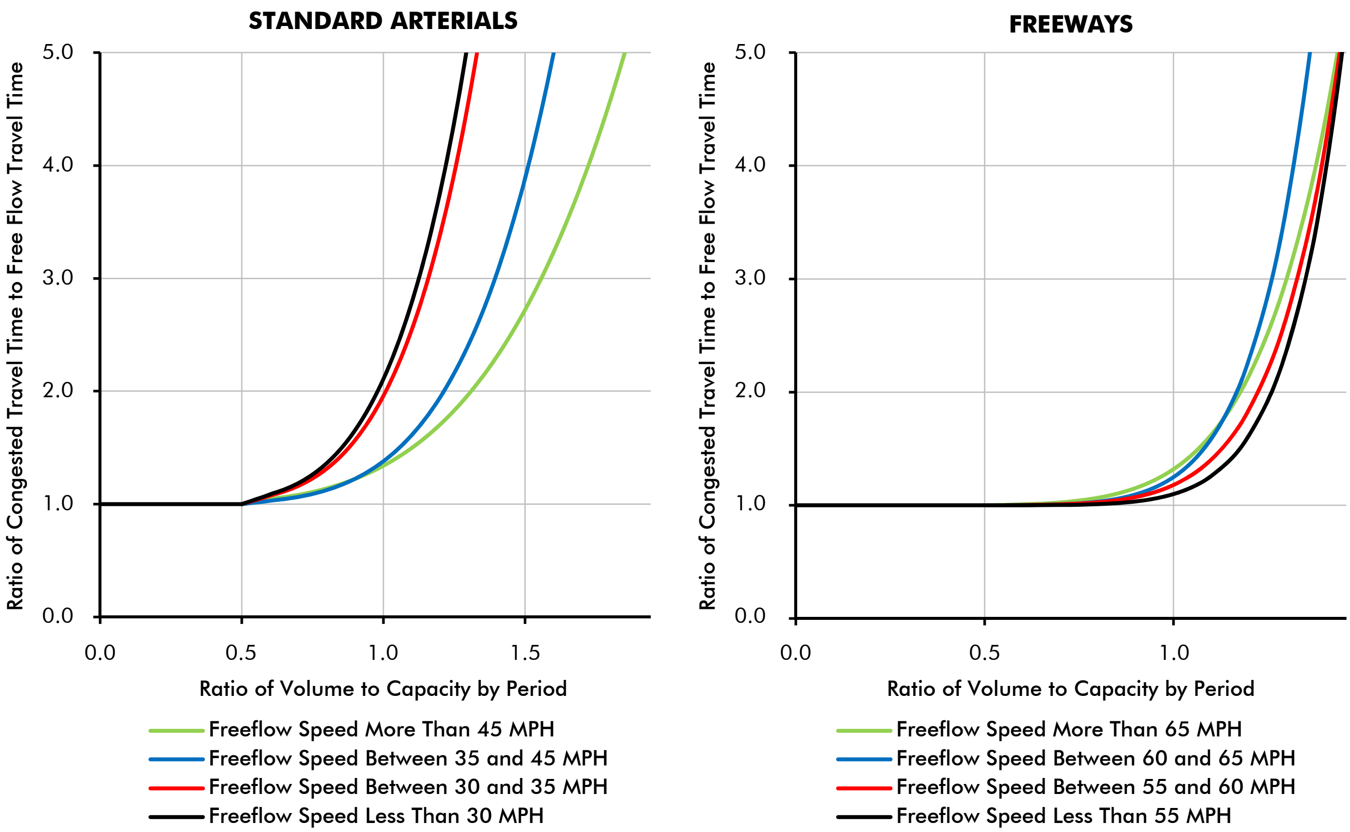
In the final step of the traffic assignment process, the tables of zone to zone trip volumes for vehicles and transit passengers created in the previous step are assigned to all the individual arterial street segments and route segments comprising the minimum time paths for all zonal interchanges on the highway and transit networks. Thus, traffic volumes are accumulated on the links for all zonal interchanges, resulting in a complete assignment of traffic demand to the network.

The transit vehicles (estimated based on the average headways) and the personal and commercial vehicles travelling through the Region are preloaded to the highway network first. The preloading of these vehicles is in recognition of the fact that these vehicles are on fixed routes or are less likely to divert to new paths due to a limited knowledge of the Region's transportation network. The assignment of the remaining travel, which has one or both ends within the Region, to the highway network is carried out next. An iterative process is used to account for the impact of assigned traffic volumes and congestion on link speeds and zone to zone travel times. In this respect, since vehicle trips are assigned to the shortest time paths on the highway network, some of the volumes on the individual links of the network may exceed the actual design capacity of the arterial street facilities being simulated, thus affecting the travel time used initially to determine the minimum time paths. The output of the assignment program at this stage is termed an "unrestrained" assignment. The ratios of the assigned volumes to the capacity of each link in the highway network are then calculated. The travel times are then increased for those links having a volume to design capacity ratio of greater than one. Minimum time paths are reassigned on the basis of the revised minimum time path through the highway network. This iterative process is continued until the assigned volumes are observed to stabilize. Thus, the operating speed at which each segment of the transportation system can be traveled is modified to simulate the effect of increasing congestion in the system. The resulting capacity restraint serves to modify the unrestrained assignment volumes and provide an accurate distribution of vehicular traffic over the highway system and accurate travel times and travel speeds by simulating the manner in which vehicle operators will seek less congested arterial routes in tripmaking.

The travel time volume to design capacity ratio relationship used to establish period travel times are shown in Figure 4.7. The fifth-generation travel assignment procedure involves the assignment of vehicles to the highway network by time period (morning peak, midday, evening peak, and night). Period-specific highway network capacities expressed in terms of passenger car equivalents (PCEs) are used to restrain the traffic loadings. Vehicle trips are assigned to the highway network by vehicle class (auto, bus, and light-, medium-, and heavy-duty truck) and converted to PCEs during the travel time adjustment step, using the factors outlined in Table 4.21. The capacities for each period were estimated using the hourly level-of-service "E" PCE capacities by facility type, shown in Table 4.18, utilizing period capacity factors, shown in Table 4.22. The period capacity factors account for temporal distribution of travel occurring within each period based on the temporal distribution of travel observed in the 2011 travel inventory. The period capacity factors are the inverse of the proportion of the travel occurring in the peak hour of the period normalized such that the sum of the four period factors is equal to 12 hours. The normalization to 12 hours is consistent with the 24-hour highway network capacities derived from the transportation system inventories conducted by the Commission. After traffic assignment is completed for each of the four periods, the vehicle traffic volumes from each of the periods were combined to obtain 24 hour average weekday vehicle traffic volumes.

The assignment of transit passenger travel to the transit network also involves the assignment of transit passenger trips by time period, using minimum time paths created for each of the time periods. Unlike the highway assignment, the capacity of the transit system is not restrained because additional transit capacity can be readily provided by the provision of additional transit vehicles and the attendant reduction of headways. The adjustment of

Figure 4.7
Travel Time to Volume/Capacity Ratio Relationships



Source: SEWRPC

headways based upon assigned passenger volumes is performed to balance the supply of transit service with the simulated demand, providing for realistic estimates of equipment requirements and operating characteristics for the transit system and consistent assumptions for ridership and cost estimation. Significant changes in operating headways require repetition of the simulation of the modal split with the modified headways.

An additional model is used to determine the access and egress modes of transit passengers at public transit stations. This special model was developed primarily to obtain estimates of parking demand at park-ride lots, utilizing information on the characteristics of transit passenger trips made using existing commuter bus services provided in the Milwaukee area. This service currently consists solely of "freeway flyer" bus service operated from outlying park-ride lots to the Milwaukee central business district. On-bus and household survey data were analyzed regarding trip purpose and the mode used by freeway flyer passengers to access freeway flyer bus service at park-ride lots.

Information was also reviewed concerning the density of residential development within the service areas of each of the existing park-ride lots and the extent and quality of local bus service to and from each park-ride lot. A model was developed to estimate the percent of total boarding passengers for trips that may be expected to use different access modes as a function of the density of residential development in the service area of the park-ride lot and the level of local bus service provided to each park-ride lot (See Table 4.23). The model projects that the percentage of passengers using the automobile for access to, or egress from, a park-ride lot will be highest

Table 4.21
Passenger Car Equivalents by Vehicle Classification

Vehicle Classification		Passenger Car Equivalents
Personal	Auto	1.0
	Bus	1.5
Commercial Truck	Light-Duty (LD)	1.0
	Medium-Duty (MD)	1.5
	Heavy-Duty (HD)	2.0

Source: SEWRPC

Table 4.22
Period Capacity Factors

Time Period	Time Range	Period Length (hours)	Capacity Factor
Morning peak	6:00 a.m. - 9:00 a.m.	3.0	1.79
Midday	9:00 a.m. - 2:30 p.m.	5.5	3.17
Evening peak	2:30 p.m. - 6:00 p.m.	3.5	2.86
Night off-peak	6:00 p.m. - 6:00 a.m.	12.0	4.18
	Total	24.0	12.00

Source: SEWRPC

Table 4.23
Percent of Boarding and Alighting Passengers by Mode of Access/Egress at Park-Ride Lots (PNR) for Non-Work Trip Purposes

	Type of Station[a]			
Access/Egress Mode	PNR Lots Serving High- to Medium-Density Residential Areas with Good Local Feeder-Bus Service	PNR Lots Serving Medium- to Low-Density Residential Areas with Poor Local Feeder-Bus Service	PNR Lots Serving Low- to Rural-Density Residential Areas with Demand-Responsive Feeder-Bus Service	PNR Lots Serving Low- to Rural-Density Residential Areas with Poor Local Feeder-Bus Service
Walk	20	15	10	10
Feeder-Bus	20	10	20	--
Auto				
Park-Ride	30	41	56	72
Kiss-Ride	30	34	14	18
Subtotal	60	75	70	90
Total	100	100	100	100

[a] *High density is 7.0 or more dwelling units per net residential acre; medium density is 2.3 to 6.9 dwelling units per net residential acre; low density is 0.7 to 2.2 dwelling units per net residential acre; and, rural density is less than 0.7 dwelling units per net residential acre.*

Poor local feeder-bus service to a transit station is considered to be bus service which has headways of 30 minutes or more, and only one to two local bus routes serve the station. Good local feeder-bus service is considered to be bus service with headways of about 15 minutes, and multiple routes serve the station, including local and express routes.

Source: SEWRPC

in areas of low residential density and poor local feeder bus service, and lowest in areas of high residential density and good local feeder bus service. The mode of access model also includes an equilibration step which assures that the automobile parking demand at any given station, as determined by the mode of access model, does not exceed the proposed parking supply at the station.

The traffic assignment process is calibrated by assigning trips from the 2011 Commission travel survey to the existing highway network and comparing link volumes with corresponding actual volumes determined by ground counts. If the comparisons so indicate, appropriate modifications are coded into the network describing the highway system so that the simulated traffic volumes correspond with the observed volumes. Such modifications include, as necessary, adjustments in link operating speeds, addition or deletion of transit access links and modification in the location of transit stop nodes.

Calibration of the transit assignment process is accomplished through a detailed analysis of the minimum time paths and associated zone to zone travel times on the simulated transit network utilizing data such as current route schedules. Where necessary, modifications are made in the transit network so that simulated travel paths reflect the most logical path followed by the trip concerned. These modifications include changes similar to those made in the highway network regarding adjustment of link speeds and location of access links, and also include adjustments made to the wait and transfer times on the network. Minimal adjustments were made to transit route segments and access links in the transit network to bring the 2011 simulated transit passenger volumes into conformance with actual 2011 transit system ridership. The minimal changes necessary included limited changes in access links to provide more direct access from selected zones to selected routes, and adjustments in route speeds for selected routes.

Feedback Methodology

As noted above, one output of the highway traffic assignment is an adjusted set of capacity restrained travel times. As travel times are also input to trip distribution and mode choice steps, the resulting travel times from traffic assignment must be reviewed and compared to those input to trip distribution and modal choice. If differences are found, then the trip distribution and modal choice steps in the simulation process must be repeated with the revised travel times. The fifth-generation travel demand model battery includes a feedback loop enabling such repetitions of the simulation process until a sufficient equilibration of travel times are achieved. The process involves iterating the trip distribution, mode choice and trip assignment steps sequentially in such a manner that the congested travel times output from the current iteration are used as the travel time inputs to the next iteration until an acceptable level of convergence is achieved. The fifth-generation travel simulation models developed by the Commission utilize a method of successive averages (MSA) feedback loop procedure to determine if an acceptable level of convergence has been reached.

The MSA link flows for the current iteration are obtained by combining the MSA link flows from the previous iteration with the current link assignments, which are inversely weighted to the number of feedback loop iterations using the relationship shown below:

$$M_{jn} = M_{j(n-1)} + \frac{1}{n}[A_{jn} - M_{j(n-1)}]$$

Where:

n = Current feedback iteration

$n-1$ = Previous feedback iteration

M_{jn} = MSA-adjusted flow on the jth link at the end of nth iteration (current iteration)

$M_{j(n-1)}$ = MSA-adjusted flow on the jth link at the end of $(n-1)$th iteration (previous iteration)

A_{jn} = Assignment on the jth link at the nth iteration obtained directly from the trip assignment step.

Next, the MSA-adjusted link flows obtained for the current feedback iteration are compared with the MSA-adjusted link flows for the previous feedback iteration in terms of root mean square error (RMSE) of MSA-adjusted flows. The RMSE provides a measure of the mean relative difference of link flows for the current iteration compared to the previous iteration, and is estimated using the relationship as follows:

$$E_n = \sqrt{\frac{\sum_{j=1}^{L}\left[M_{jn} - M_{j(n-1)}\right]^2}{L-1}}$$

Where:

E_n = RMSE of MSA-adjusted flows at the end of nth feedback iteration

L = Total number of arterial street and highway links.

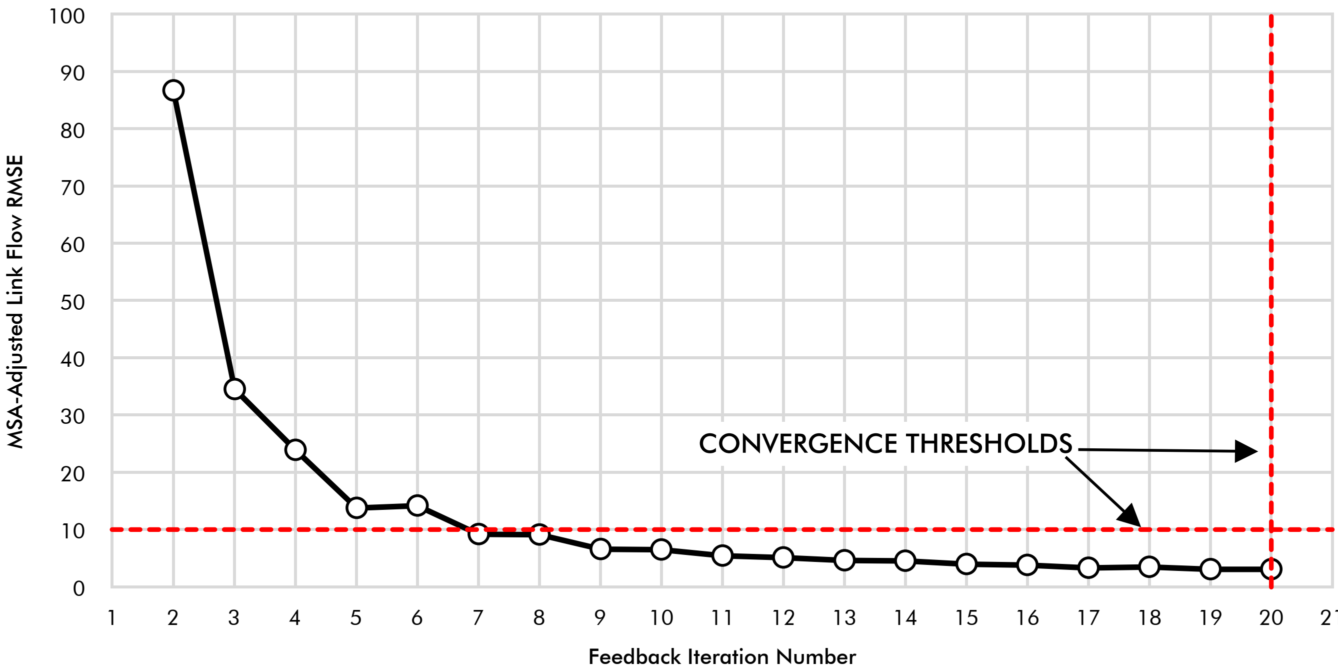
The MSA feedback procedure discussed above ensures output and input travel times converge, through the convergence of the traffic assignments. Figure 4.8 shows a typical plot of MSA-adjusted link flow RMSE relative to the number of feedback iterations. As shown in the figure, the link flows stabilize rapidly, typically in less than 10 iterations. The difference in RMSE between the end of 10th and 20th iterations is less than 5 vehicles. It is then important to specify a threshold as a stopping criterion to end the feedback loop iterations. Such a threshold should not only recognize the benefit of improved accuracy in link flows with an increase in feedback iterations, but also consider the cost of increased model run time. In the fifth-generation travel simulation models developed by the Commission, the stopping criteria specified to end the feedback loop iterations are MSA-adjusted link flow RMSE threshold of 10 or a maximum of 20 feedback iterations, whichever occurs first. It is important to note that the closure criteria does not imply accuracy with respect to observed volumes, rather the closure criteria is used to determine when the model has sufficiently stabilized.

TRAVEL SIMULATION MODEL VALIDATION

The fifth generation travel simulation models developed by the Commission using the new 2011 travel survey data to forecast design year travel demand were described in the preceding sections of this chapter. This section of the chapter presents the findings of the validation effort for the fifth generation travel simulation models.

The model validation entailed applying the full battery of simulation models with inventoried 2010 demographic, economic, and land use data and 2011 transportation system data to estimate year 2010/2011 travel demand and traffic flows. First, automobile availability and trip production and attraction models were applied to estimate total travel demand in 2010. Then, the trip distribution model was applied to estimate zone-to-zone travel demand and the mode choice model was applied to estimate zone-to-zone travel demand by individual mode. The estimated year 2010 travel demand was then assigned to the 2011 transportation system to produce simulated volumes of vehicle trips and transit passengers. The result of the transit and highway traffic assignments were then compared to observed vehicle and transit passenger counts to evaluate the performance of the travel simulation models. In this respect, it should be recognized that the observed counts of vehicle and transit trips to which the model estimates are compared represent "estimates" that contain their own errors. Many of the counts were taken on only one or two days of the entire year and, therefore, reflect

Figure 4.8
Root Mean Squared Error (RMSE) of Arterial Street and Highway Assignments of Successive Feedback Iterations



Source: SEWRPC

the effects of the daily and monthly variations in travel, required estimated adjustment to reflect average weekday conditions.

Also as part of the validation, the fifth-generation travel simulation model battery was applied with inventoried year 2000 demographic, economic, and land use data and 2001 transportation system data to estimate year 2000/2001 travel demand and traffic flows. This "back-casting" of the new travel demand model battery was performed to determine if the models, developed with year 2010/2011 data, can replicate the travel demand 10 years into the past with a reasonable degree of accuracy . Validation statistics for the year 2001 and 2011 will be presented together in the subsequent sections of this chapter.

Total Travel Demand
The year 2010/2011 and 2000/2001 were selected as the base years for model validation. Major inventories of population, employment, and land use within the Region were undertaken by the Commission in 2000 and 2010 as part of its continuing efforts to maintain an accurate and up-to-date planning data base for the Region. Also, the two latest decennial Federal censuses of population and housing were conducted in the years 2000 and 2010. Computer encoded networks representing the year 2001 and 2011 arterial street and highway system within the Region and the year 2001 and 2011 public transit systems in the Milwaukee, Racine, and Kenosha urbanized areas were also available. In addition, two comprehensive surveys of travel were conducted in the Region by the Commission during the years 2001-2002 and again during the years 2011-12.

Prior to the trip generation step, the fifth-generation travel demand model battery includes a household stratification model that distributes households by household size, vehicle availability, number of children, number of workers, and the age of head of household. The results of the household stratification model are discussed in the following text.

Tables 4.24 and 4.25 compare the model estimated year 2011 and year 2000 distributions of households by household size by county to year 2010 and year 2000 Census household distributions. As shown on the two tables the fifth-generation travel demand model is able to simulate the household size distribution to within four percent at the county level and to within 1.1 percent at the Region level for the year 2011. For the year 2000, the fifth generation travel demand model is able to replicate the Census distribution to within 5.2 percent at the county level and within 0.8 percent at the Region level.

Tables 4.26 and 4.27 compare the model estimated year 2011 and year 2000 distributions of households by vehicle availability by county to year 2010 1-year American Community Survey and year 2000 census transportation planning package (CTPP) household distributions. As shown on the two tables, the fifth generation travel demand model is able to simulate the vehicle availability distribution to within 5.9 percent at the county level and to within 0.8 percent at the Region level for the year 2011. For the year 2000, the fifth generation travel demand model is able to replicate the Census distribution to within 6.8 percent at the county level and within 3.7 percent at the Region level.

Maps 4.6 and 4.7 compare the locations of year 2011 and 2001 model estimated zero auto households to the zero auto household locations in the year 2006-2010 and year 2000 CTPP estimates. It should be noted the CTPP estimates are based on sample data and are in a different geography than the model estimates. Though the intensity of the model estimates is less than the CTPP estimates the pattern of those areas with the higher proportions of households is reasonably replicated by the fifth generation travel demand models for both 2011 and 2001.

Tables 4.28 and 4.29 compare the model estimated year 2011 and year 2000 personal use vehicle availability by county to year 2006-2010 and year 2000 CTPP vehicle availability estimates. As shown on the two tables, the fifth generation travel demand model vehicle availability estimates are within 3.7 percent at the county level and to within 0.2 percent at the Region level for the year 2011. For the year 2000, the fifth generation travel demand model estimates are within 8.6 percent at the county level and within 3.3 percent at the Region level. In addition, Tables 4.30 and 4.31 provide a comparison of the model estimated year 2011 and year 2000 household distribution by household size and vehicle availability to year 2006-2010 and year 2000 CTPP vehicle availability estimates. As shown on the two tables, the fifth-generation travel demand model compares well to the CTPP distributions for both the year 2011 and year 2000.

Tables 4.32 and 4.33 compare the model estimated year 2011 and year 2000 distributions of households by lifestyle by county to year 2006-2010 and year 2000 CTPP estimates. As shown on the two tables, the fifth generation travel demand model is within 3.7 percent at the county level and to within 2.4 percent at the Region level for the year 2011. For the year 2000, the fifth generation travel demand model is able to replicate the CTPP distribution to within 7.1 percent at the county level and within 4.2 percent at the Region level.

Tables 4.34 and 4.35 compare the model estimated year 2011 and year 2000 distributions of households by number of workers by county to year 2006-2010 and year 2000 CTPP estimates. As shown on the two tables, the

Table 4.24
Comparison of the Model Estimated Year 2011 Distribution of Households by Household Size in the Region to the 2010 Federal Census Estimate

		2010 Federal Census		Model Estimated		
	Household Size	Number of Households	Percent Distribution	Number of Households	Percent Distribution	Difference in Percent
Kenosha County	One Person	16,388	26.2	17,496	27.9	1.7
	Two People	19,968	31.9	21,349	34.0	2.1
	Three People	10,484	16.7	9,919	15.8	-0.9
	Four People	9,088	14.5	8,227	13.1	-1.4
	Five or More People	6,722	10.7	5,807	9.2	-1.5
	Total	62,650	100.0	62,798	100.0	--
Milwaukee County	One Person	129,317	33.7	115,483	30.0	-3.7
	Two People	116,827	30.5	121,576	31.6	1.1
	Three People	57,206	14.9	61,485	16.0	1.1
	Four People	42,925	11.2	47,970	12.5	1.3
	Five or More People	37,316	9.7	37,881	9.9	0.2
	Total	383,591	100.0	384,395	100.0	--
Ozaukee County	One Person	8,475	24.8	8,470	24.7	-0.1
	Two People	12,791	37.4	12,489	36.4	-1.0
	Three People	5,321	15.5	5,425	15.8	0.3
	Four People	4,802	14.0	4,801	14.0	--
	Five or More People	2,839	8.3	3,115	9.1	0.8
	Total	34,228	100.0	34,300	100.0	--
Racine County	One Person	19,958	26.4	21,540	28.4	2.0
	Two People	26,130	34.5	25,441	33.6	-0.9
	Three People	11,955	15.8	11,939	15.8	--
	Four People	10,185	13.5	9,749	12.8	-0.7
	Five or More People	7,423	9.8	7,127	9.4	-0.4
	Total	75,651	100.0	75,796	100.0	--
Walworth County	One Person	10,554	26.6	11,348	28.6	2.0
	Two People	14,008	35.3	13,744	34.6	-0.7
	Three People	6,068	15.3	6,094	15.3	--
	Four People	5,090	12.8	5,039	12.7	-0.1
	Five or More People	3,979	10.0	3,505	8.8	-1.2
	Total	39,699	100.0	39,730	100.0	--
Washington County	One Person	11,839	22.9	13,925	26.9	4.0
	Two People	19,195	37.2	18,341	35.4	-1.8
	Three People	8,336	16.2	8,048	15.5	-0.7
	Four People	7,719	15.0	6,869	13.3	-1.7
	Five or More People	4,516	8.7	4,614	8.9	0.2
	Total	51,605	100.0	51,797	100.0	--
Waukesha County	One Person	36,286	23.8	36,255	23.7	-0.1
	Two People	56,297	36.9	56,029	36.6	-0.3
	Three People	24,083	15.8	24,644	16.1	0.3
	Four People	22,846	14.9	21,931	14.3	-0.6
	Five or More People	13,151	8.6	14,235	9.3	0.7
	Total	152,663	100.0	153,094	100.0	--
Region	One Person	232,817	29.1	224,517	28.0	-1.1
	Two People	265,216	33.2	268,969	33.6	0.4
	Three People	123,453	15.4	127,554	15.9	0.5
	Four People	102,655	12.8	104,586	13.0	0.2
	Five or More People	75,946	9.5	76,284	9.5	--
	Total	800,087	100.0	801,910	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

Table 4.25
Comparison of the Model Estimated Year 2000 Distribution of Households by Household Size in the Region to the 2000 Federal Census Estimate

		2000 Federal Census		Model Estimated		
	Household Size	Number of Households	Percent Distribution	Number of Households	Percent Distribution	Difference in Percent
Kenosha County	One Person	14,269	25.5	15,460	27.6	2.1
	Two People	17,878	31.9	18,094	32.3	0.4
	Three People	9,351	16.7	9,027	16.1	-0.6
	Four People	8,645	15.4	7,771	13.8	-1.6
	Five or More People	5,914	10.5	5,703	10.2	-0.3
	Total	56,057	100.0	56,055	100.0	--
Milwaukee County	One Person	124,613	33.0	110,528	29.3	-3.7
	Two People	115,627	30.6	114,977	30.4	-0.2
	Three People	56,489	14.9	61,272	16.2	1.3
	Four People	44,143	11.7	50,705	13.4	1.7
	Five or More People	36,857	9.8	40,242	10.7	0.9
	Total	377,729	100.0	377,724	100.0	--
Ozaukee County	One Person	6,601	21.4	7,162	23.2	1.8
	Two People	11,128	36.1	10,614	34.4	-1.7
	Three People	4,948	16.0	4,976	16.1	0.1
	Four People	5,162	16.7	4,743	15.4	-1.3
	Five or More People	3,018	9.8	3,360	10.9	1.1
	Total	30,857	100.0	30,855	100.0	--
Racine County	One Person	17,349	24.5	19,398	27.4	2.9
	Two People	23,771	33.6	22,812	32.2	-1.4
	Three People	11,688	16.5	11,426	16.1	-0.4
	Four People	10,703	15.1	9,869	14.0	-1.1
	Five or More People	7,308	10.3	7,313	10.3	--
	Total	70,819	100.0	70,818	100.0	--
Walworth County	One Person	8,522	24.7	9,646	27.9	3.2
	Two People	12,165	35.2	11,351	32.9	-2.3
	Three People	5,354	15.5	5,346	15.5	--
	Four People	4,840	14.0	4,726	13.7	-0.3
	Five or More People	3,641	10.6	3,433	10.0	-0.6
	Total	34,522	100.0	34,502	100.0	--
Washington County	One Person	8,903	20.3	11,199	25.6	5.3
	Two People	15,539	35.4	14,856	33.9	-1.5
	Three People	7,425	16.9	6,964	15.9	-1.0
	Four People	7,570	17.3	6,331	14.4	-2.9
	Five or More People	4,405	10.1	4,483	10.2	0.1
	Total	43,842	100.0	43,833	100.0	--
Waukesha County	One Person	28,289	20.9	30,865	22.8	1.9
	Two People	48,488	35.9	46,573	34.4	-1.5
	Three People	22,410	16.6	22,131	16.4	-0.2
	Four People	22,921	16.9	20,842	15.4	-1.5
	Five or More People	13,121	9.7	14,810	11.0	1.3
	Total	135,229	100.0	135,221	100.0	--
Region	One Person	208,546	27.8	204,258	27.3	-0.5
	Two People	244,596	32.7	239,277	31.9	-0.8
	Three People	117,665	15.7	121,142	16.2	0.5
	Four People	103,984	13.9	104,987	14.0	0.1
	Five or More People	74,264	9.9	79,344	10.6	0.7
	Total	749,055	100.0	749,008	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

Table 4.26
Comparison of the Model Estimated Year 2011 Distribution of Households by Vehicle Availability in the Region to the 2006-2010 Census Transportation Planning Package (CTPP) Estimate

		2010 ACS		Model Estimated		
	Vehicle Availability	Number of Households	Percent Distribution	Number of Households	Percent Distribution	**Difference in Percent**
Kenosha County	No Vehicles	4,285	6.7	4,568	7.3	0.6
	One Vehicle	21,109	33.2	21,778	34.7	1.5
	Two Vehicles	25,807	40.6	24,242	38.6	-2.0
	Three Vehicles	8,170	12.9	8,725	13.9	1.0
	Four or More Vehicles	4,194	6.6	3,485	5.5	-1.1
	Total	63,565	100.0	62,798	100.0	--
Milwaukee County	No Vehicles	51,500	13.6	48,028	12.5	-1.1
	One Vehicle	164,488	43.4	156,474	40.7	-2.7
	Two Vehicles	125,798	33.2	135,232	35.2	2.0
	Three Vehicles	28,080	7.4	33,225	8.6	1.2
	Four or More Vehicles	9,010	2.4	11,436	3.0	0.6
	Total	378,876	100.0	384,395	100.0	--
Ozaukee County	No Vehicles	723	2.1	1,205	3.5	1.4
	One Vehicle	10,127	29.8	9,842	28.7	-1.1
	Two Vehicles	16,597	48.7	14,675	42.8	-5.9
	Three Vehicles	5,296	15.6	6,000	17.5	1.9
	Four or More Vehicles	1,284	3.8	2,578	7.5	3.7
	Total	34,027	100.0	34,300	100.0	--
Racine County	No Vehicles	6,582	8.8	5,858	7.7	-1.1
	One Vehicle	25,725	34.4	25,832	34.1	-0.3
	Two Vehicles	28,519	38.2	29,474	38.9	0.7
	Three Vehicles	9,386	12.5	10,368	13.7	1.2
	Four or More Vehicles	4,596	6.1	4,264	5.6	-0.5
	Total	74,808	100.0	75,796	100.0	--
Walworth County	No Vehicles	2,000	5.1	1,662	4.2	-0.9
	One Vehicle	10,163	26.0	11,706	29.5	3.5
	Two Vehicles	16,647	42.6	16,278	41.0	-1.6
	Three Vehicles	7,487	19.1	6,932	17.4	-1.7
	Four or More Vehicles	2,811	7.2	3,152	7.9	0.7
	Total	39,108	100.0	39,730	100.0	--
Washington County	No Vehicles	2,573	5.0	1,930	3.7	-1.3
	One Vehicle	12,646	24.7	15,102	29.2	4.5
	Two Vehicles	21,899	42.7	21,825	42.1	-0.6
	Three Vehicles	10,180	19.9	8,970	17.3	-2.6
	Four or More Vehicles	3,930	7.7	3,970	7.7	--
	Total	51,228	100.0	51,797	100.0	--
Waukesha County	No Vehicles	7,422	4.9	6,199	4.0	-0.9
	One Vehicle	40,396	26.7	46,008	30.1	3.4
	Two Vehicles	69,215	45.9	64,507	42.1	-3.8
	Three Vehicles	24,087	15.9	25,392	16.6	0.7
	Four or More Vehicles	9,993	6.6	10,988	7.2	0.6
	Total	151,113	100.0	153,094	100.0	--
Region	No Vehicles	75,085	9.5	69,450	8.7	-0.8
	One Vehicle	284,654	35.9	286,742	35.8	-0.2
	Two Vehicles	304,482	38.4	306,233	38.2	-0.2
	Three Vehicles	92,686	11.7	99,612	12.4	0.7
	Four or More Vehicles	35,818	4.5	39,873	5.0	0.5
	Total	792,725	100.0	801,910	100.0	--

Source: 2006-2010 Census Transportation Planning Package and SEWRPC

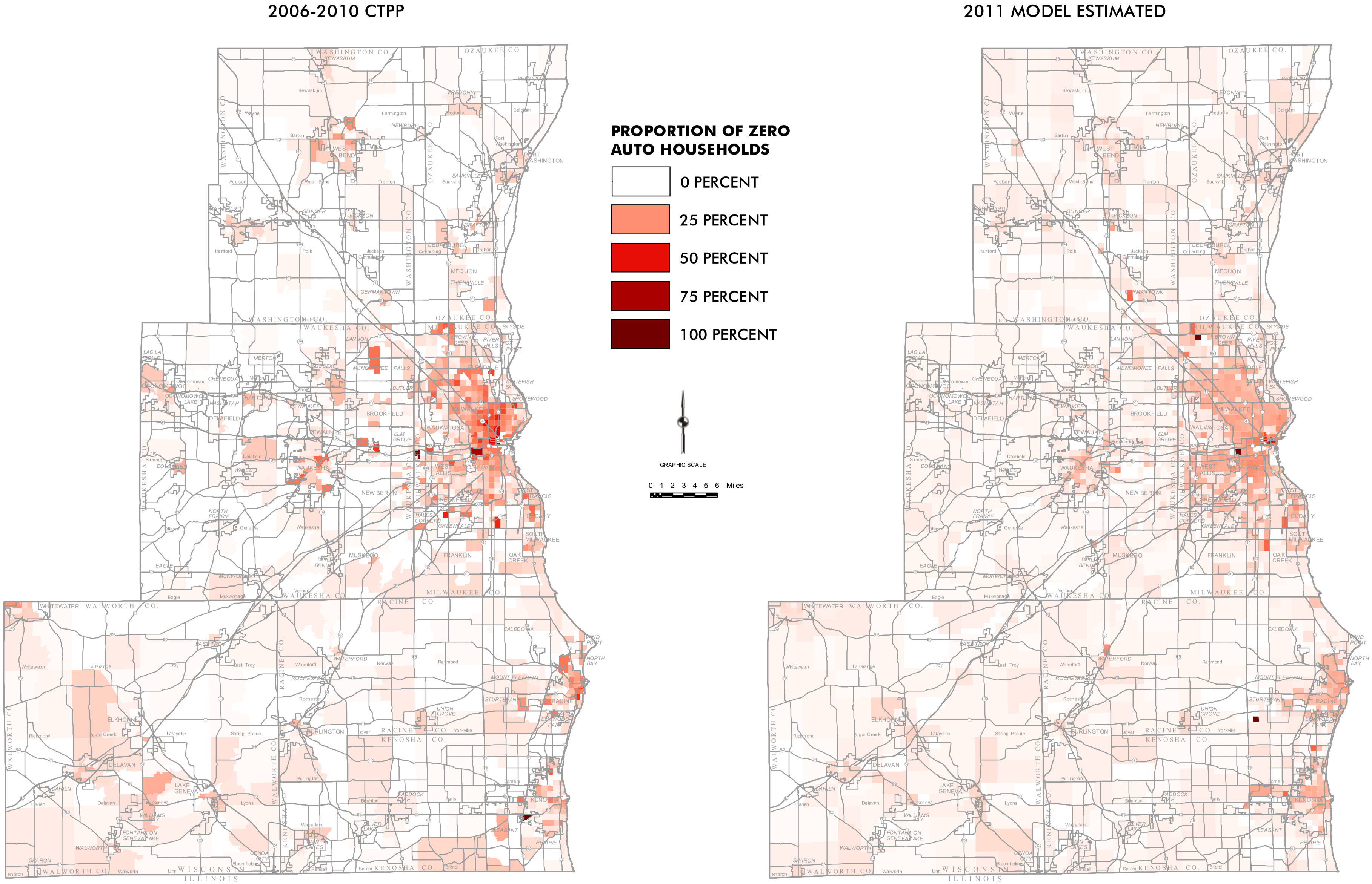
Table 4.27

Comparison of the Model Estimated Year 2000 Distribution of Households by Vehicle Availability in the Region to the 2000 Census Transportation Planning Package (CTPP) Estimate

		2000 CTPP		Model Estimated		
	Vehicle Availability	Number of Households	Percent Distribution	Number of Households	Percent Distribution	Difference in Percent
Kenosha County	No Vehicles	3,824	6.8	2,992	5.3	-1.5
	One Vehicle	19,235	34.3	20,759	37.0	2.7
	Two Vehicles	23,116	41.3	21,898	39.1	-2.2
	Three Vehicles	7,358	13.1	7,487	13.4	0.3
	Four or More Vehicles	2,524	4.5	2,919	5.2	0.7
	Total	56,057	100.0	56,055	100.0	--
Milwaukee County	No Vehicles	61,631	16.3	37,991	10.1	-6.2
	One Vehicle	156,663	41.5	161,296	42.7	1.2
	Two Vehicles	122,283	32.4	135,733	35.9	3.5
	Three Vehicles	28,131	7.4	32,011	8.5	1.1
	Four or More Vehicles	9,021	2.4	10,693	2.8	0.4
	Total	377,729	100.0	377,724	100.0	--
Ozaukee County	No Vehicles	1,039	3.4	1,027	3.3	-0.1
	One Vehicle	8,129	26.3	8,980	29.1	2.8
	Two Vehicles	15,097	48.9	13,196	42.8	-6.1
	Three Vehicles	4,970	16.1	5,380	17.4	1.3
	Four or More Vehicles	1,622	5.3	2,272	7.4	2.1
	Total	30,857	100.0	30,855	100.0	--
Racine County	No Vehicles	5,759	8.1	3,999	5.6	-2.5
	One Vehicle	22,888	32.3	25,718	36.3	4.0
	Two Vehicles	29,962	42.4	27,863	39.4	-3.0
	Three Vehicles	9,075	12.8	9,431	13.3	0.5
	Four or More Vehicles	3,135	4.4	3,807	5.4	1.0
	Total	70,819	100.0	70,818	100.0	--
Walworth County	No Vehicles	1,663	4.8	1,163	3.4	-1.4
	One Vehicle	10,778	31.2	10,503	30.4	-0.8
	Two Vehicles	14,593	42.3	14,294	41.4	-0.9
	Three Vehicles	5,319	15.4	6,005	17.4	2.0
	Four or More Vehicles	2,169	6.3	2,537	7.4	1.1
	Total	34,522	100.0	34,502	100.0	--
Washington County	No Vehicles	1,720	3.9	1,487	3.4	-0.5
	One Vehicle	11,795	26.9	13,499	30.8	3.9
	Two Vehicles	20,491	46.8	18,192	41.5	-5.3
	Three Vehicles	7,021	16.0	7,465	17.0	1.0
	Four or More Vehicles	2,815	6.4	3,190	7.3	0.9
	Total	43,842	100.0	43,833	100.0	--
Waukesha County	No Vehicles	5,689	4.2	5,073	3.8	-0.4
	One Vehicle	33,831	25.0	41,959	31.0	6.0
	Two Vehicles	65,838	48.7	56,666	41.9	-6.8
	Three Vehicles	22,616	16.7	22,184	16.4	-0.3
	Four or More Vehicles	7,255	5.4	9,339	6.9	1.5
	Total	135,229	100.0	135,221	100.0	--
Region	No Vehicles	81,325	10.9	53,732	7.2	-3.7
	One Vehicle	263,319	35.1	282,714	37.8	2.7
	Two Vehicles	291,380	38.9	287,842	38.4	-0.5
	Three Vehicles	84,490	11.3	89,963	12.0	0.7
	Four or More Vehicles	28,541	3.8	34,757	4.6	0.8
	Total	749,055	100.0	749,008	100.0	--

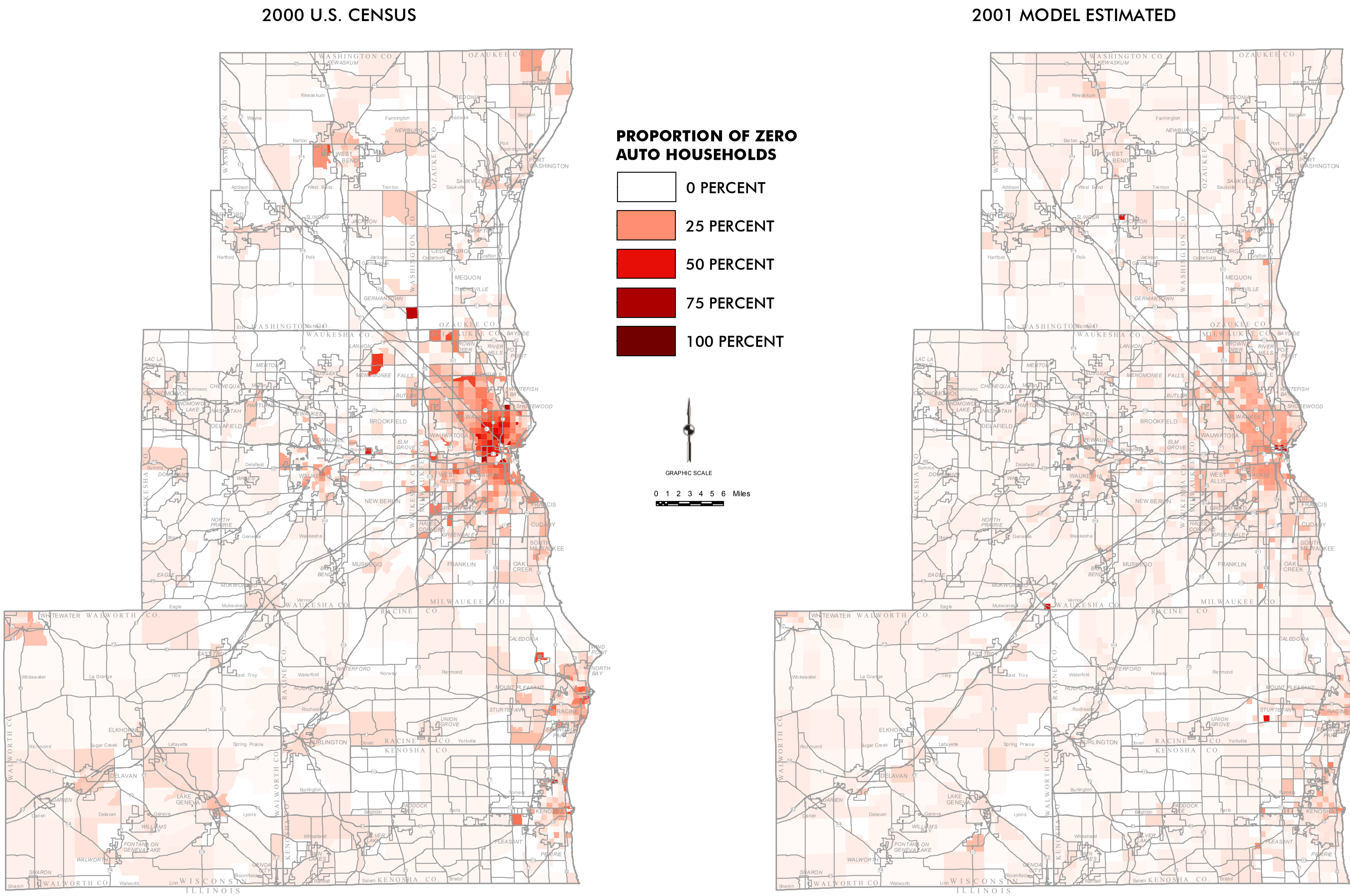
Source: 2006-2010 Census Transportation Planning Package and SEWRPC

Map 4.6
Comparison of the Location of Zero Auto Households from the Fifth Generation Travel Demand Model to the 2006-2010 Census Transportation Planning Package (CTPP) Estimates



Source: SEWRPC.

Map 4.7
Comparison of the Location of Zero Auto Households from the Fifth Generation Travel Demand Model to the 2000 Census Transportation Planning Package (CTPP) Estimates



Source: SEWRPC.

Table 4.28
Comparison of Census and Model Estimated Personal Use Vehicle Availability by County: 2011

County	2006-2010 Census Transportation Planning Package Estimate	2011 Travel Model Estimate[a]	Percent Difference 2006-2010 CTPP and Travel Model Estimates
Kenosha	114,600	110,375	-3.7
Milwaukee	553,250	572,355	3.5
Ozaukee	66,765	67,505	1.1
Racine	135,560	132,940	-1.9
Walworth	77,300	77,665	0.5
Washington	104,245	101,540	-2.6
Waukesha	303,585	295,150	-2.8
Region	1,355,305	1,357,530	0.2

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: U.S. Bureau of the Census and SEWRPC

Table 4.29
Comparison of Census and Model Estimated Personal Use Vehicle Availability by County: 2000

County	2000 Census Transportation Planning Package Estimate	2001 Travel Model Estimate[a]	Percent Difference 2000 CTPP and Travel Model Estimates
Kenosha	98,970	98,690	-0.3
Milwaukee	526,340	571,565	8.6
Ozaukee	60,440	60,600	0.3
Racine	123,940	124,965	0.8
Walworth	65,690	67,255	2.4
Washington	86,320	85,040	-1.5
Waukesha	265,350	259,200	-2.3
Region	1,227,050	1,267,315	3.3

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: U.S. Bureau of the Census and SEWRPC

fifth-generation travel demand model is within 10.0 percent at the county level and to within 5.3 percent at the Region level for the year 2011. For the year 2000, the fifth generation travel demand model is able to replicate the Census distribution to within 10.4 percent at the county level and within 7.4 percent at the Region level.

Tables 4.36 and 4.37 compare the model estimated year 2011 and year 2000 distributions of households by age of the head of household by county to year 2010 and year 2000 Census estimates. As shown on the two tables, the fifth-generation travel demand model is within 4.0 percent at the county level and to within 1.7 percent at the Region level for the year 2011. For the year 2000, the fifth generation travel demand model is able to replicate the Census distribution to within 4.5 percent at the county level and within 1.0 percent at the Region level.

Based on the results of the above comparisons of model estimates to Census and CTPP data, it can be shown that the fifth-generation travel demand

Table 4.30
Comparison of Census and Model-Estimated Percentage of Households by Vehicles Available and Household Size in the Region: 2010

Vehicles Available	2010 Census Estimate[a]					2011 Model Estimate[b]				
	Household Size					Household Size				
	One	Two	Three	Four or More	Total	One	Two	Three	Four or More	Total
None	6.0	1.7	0.9	0.9	9.5	5.0	1.5	0.7	1.4	8.7
One	20.8	8.0	3.6	3.4	35.8	19.0	7.4	4.0	5.4	35.8
Two	2.9	19.0	6.2	10.3	38.4	3.2	19.0	6.7	9.2	38.2
Three	0.5	3.4	3.7	4.1	11.7	0.4	4.5	3.3	4.2	12.4
Four or More	0.3	0.9	0.9	2.5	4.6	0.4	1.2	1.1	2.3	5.0
Total	30.5	33.0	15.3	21.2	100.0	28.0	33.5	15.9	22.6	100.0

[a] *2010 1-year American Community Survey Estimate*

[b] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: U.S. Bureau of the Census and SEWRPC

Table 4.31
Comparison of Census and Model-Estimated Percentage of Households by Vehicles Available and Household Size in the Region: 2000

Vehicles Available	2000 Census Estimate[a]					2001 Model Estimate[b]				
	Household Size					Household Size				
	One	Two	Three	Four or More	Total	One	Two	Three	Four or More	Total
None	6.0	2.0	1.1	1.6	10.7	4.1	1.2	0.6	1.3	7.2
One	18.8	9.1	3.3	3.8	35.0	19.3	7.6	4.5	6.3	37.7
Two	2.4	18.1	6.9	11.8	39.2	3.1	17.9	7.0	10.5	38.4
Three	0.4	2.7	3.6	4.6	11.3	0.4	4.2	3.1	4.3	12.0
Four or More	0.2	0.6	0.8	2.2	3.8	0.4	1.1	1.0	2.2	4.6
Total	27.8	32.5	15.7	24.0	100.0	27.3	31.9	16.2	24.6	100.0

[a] *2000 Census Transportation Planning Package Estimate*

[b] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.*

Source: U.S. Bureau of the Census and SEWRPC

model battery is able to accurately estimate household demographic characteristics used in the subsequent steps of the model.

Starting with the trip generation and trip distribution steps in the travel simulation process, the stratified households were input into the trip generation models to obtain estimates of the total number of trips made by trip purpose. The results of the application of the fifth-generation models to estimate year 2011 and 2001 travel are presented in Table 4.38 and 4.39. As shown in the tables, the fifth-generation trip generation process is able to accurately estimate total trip production to within 1.3 percent for the year 2011, though for the year 2000, the model underestimated total trip production by 7.0 percent—still within 10 percent. Travel inventory data indicate that between 2001 and 2011, average household trip generation declined. As such the fifth generation travel demand model, developed with 2011 data, would be expected to underestimate trip generation in 2001.

Tables 4.40 and 4.41 compare the distribution of model estimated year 2011 and 2001 elementary through high school trip productions to the distribution of public and private elementary through high school enrollment by county

Table 4.32
Comparison of Model Estimated Year 2011 Distribution of Households by Lifestyle in the Region to the 2010 Federal Census Estimate

	Age of Head of Household	2010 Federal Census Number	2010 Federal Census Percent Distribution	Model Estimated Number	Model Estimated Percent Distribution	Difference in Percent
Kenosha County	65 or Older	12,208	19.5	11,852	18.9	-0.6
	Under 65					
	Without Children	28,834	46.0	30,377	48.4	2.4
	with Children	21,608	34.5	20,569	32.7	-1.8
	Total	62,650	100.0	62,798	100.0	--
Milwaukee County	65 or Older	74,402	19.4	64,823	16.9	-2.5
	Under 65					
	Without Children	193,543	50.5	190,389	49.5	-1.0
	with Children	115,646	30.1	129,183	33.6	3.5
	Total	383,591	100.0	384,395	100.0	--
Ozaukee County	65 or Older	8,559	25.0	7,309	21.3	-3.7
	Under 65					
	Without Children	15,121	44.2	15,771	46.0	1.8
	with Children	10,548	30.8	11,220	32.7	1.9
	Total	34,228	100.0	34,300	100.0	--
Racine County	65 or Older	16,953	22.4	14,459	19.1	-3.3
	Under 65					
	Without Children	34,456	45.6	36,560	48.2	2.6
	with Children	24,242	32.0	24,777	32.7	0.7
	Total	75,651	100.0	75,796	100.0	--
Walworth County	65 or Older	8,981	22.6	8,330	21.0	-1.6
	Under 65					
	Without Children	18,707	47.1	19,032	47.9	0.8
	with Children	12,011	30.3	12,368	31.1	0.8
	Total	39,699	100.0	39,730	100.0	--
Washington County	65 or Older	11,377	22.0	10,833	20.9	-1.1
	Under 65					
	Without Children	23,420	45.4	24,438	47.2	1.8
	with Children	16,808	32.6	16,526	31.9	-0.7
	Total	51,605	100.0	51,797	100.0	--
Waukesha County	65 or Older	36,142	23.7	32,059	20.9	-2.8
	Under 65					
	Without Children	68,092	44.6	69,904	45.7	1.1
	with Children	48,429	31.7	51,131	33.4	1.7
	Total	152,663	100.0	153,094	100.0	--
Region	65 or Older	168,622	21.1	149,665	18.7	-2.4
	Under 65					
	Without Children	382,173	47.8	386,471	48.2	0.4
	with Children	249,292	31.1	265,774	33.1	2
	Total	800,087	100.0	801,910	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

Table 4.33
Comparison of Model Estimated Year 2000 Distribution of Households by Lifestyle in the Region to the 2000 Federal Census Estimate

	Age of Head of Household	2000 Federal Census		Model Estimated		Difference in Percent
		Number	Percent Distribution	Number	Percent Distribution	
Kenosha County	65 or Older	10,948	19.5	10,871	19.4	-0.1
	Under 65					
	Without Children	25,610	45.7	25,193	44.9	-0.8
	with Children	19,499	34.8	19,991	35.7	0.9
	Total	56,057	100.0	56,055	100.0	--
Milwaukee County	65 or Older	79,979	21.2	63,960	16.9	-4.3
	Under 65					
	Without Children	186,561	49.4	175,839	46.6	-2.8
	with Children	111,189	29.4	137,925	36.5	7.1
	Total	377,729	100.0	377,724	100.0	--
Ozaukee County	65 or Older	6,491	21.0	6,713	21.8	0.8
	Under 65					
	Without Children	13,275	43.0	12,792	41.5	-1.5
	with Children	11,091	36.0	11,350	36.7	0.7
	Total	30,857	100.0	30,855	100.0	--
Racine County	65 or Older	14,739	20.8	13,585	19.2	-1.6
	Under 65					
	Without Children	31,682	44.8	31,780	44.9	0.1
	with Children	24,398	34.5	25,453	35.9	1.4
	Total	70,819	100.1	70,818	100.0	0.1
Walworth County	65 or Older	7,314	21.2	7,167	20.8	-0.4
	Under 65					
	Without Children	16,239	47.0	15,444	44.8	-2.2
	with Children	10,969	31.8	11,891	34.4	2.6
	Total	34,522	100.0	34,502	100.0	--
Washington County	65 or Older	8,121	18.5	9,498	21.7	3.2
	Under 65					
	Without Children	19,763	45.1	18,805	42.9	-2.2
	with Children	15,958	36.4	15,530	35.4	-1.0
	Total	43,842	100.0	43,833	100.0	--
Waukesha County	65 or Older	26,763	19.8	29,216	21.6	1.8
	Under 65					
	Without Children	60,618	44.8	55,868	41.3	-3.5
	with Children	47,848	35.4	50,137	37.1	1.7
	Total	135,229	100.0	135,221	100.0	--
Region	65 or Older	154,355	20.6	141,010	18.8	-1.8
	Under 65					
	Without Children	353,748	47.2	335,721	44.8	-2.4
	with Children	240,952	32.2	272,277	36.4	4.2
	Total	749,055	100.0	749,008	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

Table 4.34
Comparison of Model Estimated Year 2011 Distribution of Households by Number of Workers in the Region to the 2006-2010 Census Transportation Planning Package Estimate

	Number of Workers	2006-2010 CTPP		Model Estimated		Difference in Percent
		Number of Households	Percent Distribution	Number of Households	Percent Distribution	
Kenosha County	None	15,679	24.7	13,280	21.1	-3.6
	One Person	23,585	37.1	27,994	44.6	7.5
	Two People	19,943	31.4	17,437	27.8	-3.6
	Three People	3,468	5.4	3,394	5.4	--
	Four or More People	890	1.4	693	1.1	-0.3
	Total	63,565	100.0	62,798	100.0	--
Milwaukee County	None	94,295	24.9	86,520	22.5	-2.4
	One Person	163,455	43.1	177,085	46.1	3.0
	Two People	100,828	26.6	99,850	26.0	-0.6
	Three People	15,867	4.2	17,483	4.5	0.3
	Four or More People	4,431	1.2	3,457	0.9	-0.3
	Total	378,876	100.0	384,395	100.0	--
Ozaukee County	None	7,346	21.6	6,984	20.4	-1.2
	One Person	12,270	36.1	14,527	42.3	6.2
	Two People	12,093	35.5	10,108	29.5	-6.0
	Three People	1,723	5.1	2,207	6.4	1.3
	Four or More People	595	1.7	474	1.4	-0.3
	Total	34,027	100.0	34,300	100.0	--
Racine County	None	18,115	24.2	16,435	21.7	-2.5
	One Person	29,010	38.8	33,869	44.7	5.9
	Two People	22,595	30.2	20,687	27.3	-2.9
	Three People	4,112	5.5	3,992	5.2	-0.3
	Four or More People	976	1.3	813	1.1	-0.2
	Total	74,808	100.0	75,796	100.0	--
Walworth County	None	8,800	22.5	8,564	21.6	-0.9
	One Person	14,370	36.7	17,499	44.0	7.3
	Two People	12,770	32.7	10,980	27.6	-5.1
	Three People	2,432	6.2	2,227	5.6	-0.6
	Four or More People	736	1.9	460	1.2	-0.7
	Total	39,108	100.0	39,730	100.0	--
Washington County	None	10,590	20.7	10,836	20.9	0.2
	One Person	17,145	33.5	22,526	43.5	10.0
	Two People	19,210	37.5	14,776	28.5	-9.0
	Three People	3,385	6.6	3,027	5.9	-0.7
	Four or More People	898	1.7	632	1.2	-0.5
	Total	51,228	100.0	51,797	100.0	--
Waukesha County	None	32,747	21.7	30,594	20.0	-1.7
	One Person	51,345	34.0	64,286	42.0	8.0
	Two People	55,025	36.4	45,904	30.0	-6.4
	Three People	9,293	6.1	10,113	6.6	0.5
	Four or More People	2,703	1.8	2,197	1.4	-0.4
	Total	151,113	100.0	153,094	100.0	--
Region	None	187,572	23.7	173,213	21.6	-2.1
	One Person	311,180	39.2	357,786	44.6	5.4
	Two People	242,464	30.6	219,742	27.4	-3.2
	Three People	40,280	5.1	42,443	5.3	0.2
	Four or More People	11,229	1.4	8,726	1.1	-0.3
	Total	792,725	100.0	801,910	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

Table 4.35
Comparison of Model Estimated Year 2000 Distribution of Households by Number of Workers in the Region to the 2000 Census Transportation Planning Package Estimate

		2000 CTPP		Model Estimated		
	Number of Workers	Number of Households	Percent Distribution	Number of Households	Percent Distribution	**Difference in Percent**
Kenosha County	None	13,162	23.4	11,229	20.0	-3.4
	One Person	20,135	35.9	24,434	43.6	7.7
	Two People	18,380	32.8	16,669	29.7	-3.1
	Three People	3,523	6.3	3,082	5.5	-0.8
	Four or More People	895	1.6	641	1.2	-0.4
	Total	56,095	100.0	56,055	100.0	--
Milwaukee County	None	107,757	28.5	75,482	20.0	-8.5
	One Person	145,635	38.5	169,756	44.9	6.4
	Two People	101,625	26.9	110,116	29.2	2.3
	Three People	17,758	4.7	18,609	4.9	0.2
	Four or More People	5,210	1.4	3,761	1.0	-0.4
	Total	377,985	100.0	377,724	100.0	--
Ozaukee County	None	5,534	17.9	6,207	20.1	2.2
	One Person	10,845	35.1	12,535	40.7	5.6
	Two People	11,988	38.8	9,574	31.0	-7.8
	Three People	2,015	6.5	2,069	6.7	0.2
	Four or More People	503	1.7	470	1.5	-0.2
	Total	30,885	100.0	30,855	100.0	--
Racine County	None	17,622	24.9	14,253	20.1	-4.8
	One Person	24,080	34.0	30,757	43.4	9.4
	Two People	23,218	32.8	21,056	29.7	-3.1
	Three People	4,650	6.6	3,935	5.6	-1.0
	Four or More People	1,225	1.7	817	1.2	-0.5
	Total	70,795	100.0	70,818	100.0	--
Walworth County	None	7,299	21.1	7,179	20.8	-0.3
	One Person	11,790	34.2	14,904	43.2	9.0
	Two People	12,280	35.6	10,062	29.2	-6.4
	Three People	2,347	6.8	1,950	5.7	-1.1
	Four or More People	799	2.3	407	1.1	-1.2
	Total	34,515	100.0	34,502	100.0	--
Washington County	None	8,001	18.2	9,055	20.7	2.5
	One Person	13,835	31.5	18,359	41.9	10.4
	Two People	17,488	39.8	13,166	30.0	-9.8
	Three People	3,580	8.2	2,684	6.1	-2.1
	Four or More People	1,006	2.3	569	1.3	-1.0
	Total	43,910	100.0	43,833	100.0	--
Waukesha County	None	25,741	19.0	27,157	20.1	1.1
	One Person	43,330	32.0	54,779	40.5	8.5
	Two People	53,503	39.5	42,128	31.2	-8.3
	Three People	10,060	7.4	9,114	6.7	-0.7
	Four or More People	2,816	2.1	2,043	1.5	-0.6
	Total	135,450	100.0	135,221	100.0	--
Region	None	185,116	24.7	150,562	20.1	-4.6
	One Person	269,650	36.0	325,524	43.5	7.5
	Two People	238,482	31.8	222,771	29.7	-2.1
	Three People	43,933	5.8	41,443	5.5	-0.3
	Four or More People	12,454	1.7	8,708	1.2	-0.5
	Total	749,635	100.0	749,008	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

Table 4.36
Comparison of Model Estimated Year 2011 Distribution of Households by Age of Head of Household in the Region to the 2010 Census Transportation Planning Package Estimate

	Age of Head of Household	2010 Census Number of Households	2010 Census Percent Distribution	Model Estimated Number of Households	Model Estimated Percent Distribution	Difference in Percent
Kenosha County	16 to 24	2,628	4.2	2,684	4.3	0.1
	25 to 34	9,611	15.3	10,088	16.1	0.8
	35 to 44	12,432	19.9	11,733	18.7	-1.2
	45 to 54	14,915	23.8	14,640	23.3	-0.5
	55 to 64	10,856	17.3	11,801	18.8	1.5
	65 to 74	6,214	9.9	6,167	9.8	-0.1
	75 and Older	5,994	9.6	5,685	9.0	-0.6
	Total	62,650	100.0	62,798	100.0	--
Milwaukee County	16 to 24	26,353	6.9	27,124	7.1	0.2
	25 to 34	75,439	19.7	75,241	19.6	-0.1
	35 to 44	68,525	17.8	72,933	19.0	1.2
	45 to 54	74,768	19.5	80,082	20.8	1.3
	55 to 64	64,104	16.7	64,192	16.7	--
	65 to 74	34,505	9.0	31,157	8.1	-0.9
	75 and Older	39,897	10.4	33,666	8.7	-1.7
	Total	383,591	100.0	384,395	100.0	--
Ozaukee County	16 to 24	792	2.3	701	2.0	-0.3
	25 to 34	3,632	10.6	4,422	12.9	2.3
	35 to 44	5,715	16.7	6,216	18.1	1.4
	45 to 54	8,387	24.5	8,587	25.0	0.5
	55 to 64	7,143	20.9	7,065	20.6	-0.3
	65 to 74	4,253	12.4	3,860	11.3	-1.1
	75 and Older	4,306	12.6	3,449	10.1	-2.5
	Total	34,228	100.0	34,300	100.0	--
Racine County	16 to 24	2,620	3.5	3,517	4.6	1.1
	25 to 34	10,833	14.3	12,452	16.4	2.1
	35 to 44	13,334	17.6	14,000	18.5	0.9
	45 to 54	17,640	23.3	17,326	22.9	-0.4
	55 to 64	14,271	18.9	14,042	18.5	-0.4
	65 to 74	8,457	11.2	7,363	9.7	-1.5
	75 and Older	8,496	11.2	7,096	9.4	-1.8
	Total	75,651	100.0	75,796	100.0	--
Walworth County	16 to 24	2,762	7.0	1,194	3.0	-4
	25 to 34	5,128	12.9	5,406	13.6	0.7
	35 to 44	6,645	16.7	7,118	17.9	1.2
	45 to 54	8,722	22.0	9,659	24.3	2.3
	55 to 64	7,461	18.8	8,023	20.2	1.4
	65 to 74	4,601	11.6	4,415	11.1	-0.5
	75 and Older	4,380	11.0	3,915	9.9	-1.1
	Total	39,699	100.0	39,730	100.0	--
Washington County	16 to 24	1,243	2.4	1,348	2.6	0.2
	25 to 34	6,729	13.0	7,183	13.9	0.9
	35 to 44	9,788	19.0	9,399	18.1	-0.9
	45 to 54	12,781	24.7	12,657	24.5	-0.2
	55 to 64	9,687	18.8	10,377	20.0	1.2
	65 to 74	5,870	11.4	5,711	11.0	-0.4
	75 and Older	5,507	10.7	5,122	9.9	-0.8
	Total	51,605	100.0	51,797	100.0	--

Table continued on next page.

Table 4.36 (Continued)

	Age of Head of Household	2010 Census Number of Households	2010 Census Percent Distribution	Model Estimated Number of Households	Model Estimated Percent Distribution	Difference In Percent
Waukesha County	16 to 24	3,435	2.3	3,233	2.1	-0.2
	25 to 34	17,844	11.7	19,902	13.0	1.3
	35 to 44	26,937	17.6	27,949	18.3	0.7
	45 to 54	37,579	24.6	38,512	25.2	0.6
	55 to 64	30,726	20.1	31,439	20.5	0.4
	65 to 74	17,709	11.6	17,014	11.1	-0.5
	75 and Older	18,433	12.1	15,045	9.8	-2.3
	Total	152,663	100.0	153,094	100.0	--
Region	16 to 24	39,833	5.0	39,801	5.0	--
	25 to 34	129,216	16.2	134,694	16.8	0.6
	35 to 44	143,376	17.9	149,348	18.6	0.7
	45 to 54	174,792	21.8	181,463	22.6	0.8
	55 to 64	144,248	18.0	146,939	18.3	0.3
	65 to 74	81,609	10.2	75,687	9.5	-0.7
	75 and Older	87,013	10.9	73,978	9.2	-1.7
	Total	800,087	100.0	801,910	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

for the 2010-2011 and 2001-2002 school years. As shown in the tables, the fifth generation travel demand model is consistent in the distribution of school trips generated by county to the distribution of students enrolled in each county to within 0.6 percent for the year 2011 and to within 0.5 percent for the year 2001.

The results of the application of the trip distribution step are presented in Tables 4.42 through 4.45 and on Figures 4.9 through 4.14, which compare model-estimated to survey-estimated trip length and travel patterns. As shown in the tables and figures the fifth generation travel demand models are able to accurately replicate trip length and the pattern of travel in both the year 2011 and year 2001.

The estimated travel demand was divided into nonmotorized, automobile, and transit person trips by applying the modal split and auto occupancy travel simulation models. Tables 4.46 through 4.49 provide the results of the application of the fifth-generation travel demand models for the years 2011 and 2001. For the year 2011, the fifth-generation travel demand model is able to project modal share to within 1.8 percent. In the year 2001, the model underestimated auto person trips by 10.2 percent and overestimated nonmotorized person trips by about 50 percent. Contributing to this difference may be the significant increase in nonmotorized travel observed between 2001 and 2011. The transit mode share estimated by the model was 6.1 percent higher than the 2001 estimate.

Transit Travel Demand

The procedure followed to validate the simulation of transit passenger travel included the model estimation of transit trips by trip purpose, the conversion of trips by purpose to trips by time period, and the assignment of trips by time period to the transit networks for the years 2011 and 2001. The transit passenger volumes derived from the transit assignment were then compared with years 2011 and 2001 passenger count information obtained from the local transit operators. The comparisons used to evaluate the transit assignment and the overall travel simulation process included systemwide

Table 4.37
Comparison of Model Estimated Year 2000 Distribution of Households by Age of Head of Household in the Region to the 2000 Census Transportation Planning Package Estimate

		2000 Census		Model Estimated		
	Age of Head of Household	Number of Households	Percent Distribution	Number of Households	Percent Distribution	**Difference in Percent**
Kenosha County	16 to 24	2,743	4.9	2,427	4.3	-0.6
	25 to 34	10,042	17.9	9,829	17.5	-0.4
	35 to 44	14,217	25.4	13,583	24.3	-1.1
	45 to 54	11,086	19.8	12,064	21.5	1.7
	55 to 64	7,021	12.5	7,281	13.0	0.5
	65 to 74	5,498	9.8	5,501	9.8	--
	75 and Older	5,450	9.7	5,370	9.6	--
	Total	56,057	100.0	56,055	100.0	-0.1
Milwaukee County	16 to 24	26,232	6.9	27,536	7.3	0.4
	25 to 34	74,320	19.7	80,416	21.3	1.6
	35 to 44	82,056	21.7	91,319	24.2	2.5
	45 to 54	71,648	19.0	71,433	18.9	-0.1
	55 to 64	43,494	11.5	43,060	11.4	-0.1
	65 to 74	38,855	10.3	30,079	7.9	-2.4
	75 and Older	41,124	10.9	33,881	9.0	-1.9
	Total	377,729	100.0	377,724	100.0	--
Ozaukee County	16 to 24	770	2.5	563	1.8	-0.7
	25 to 34	3,895	12.6	4,003	13.0	0.4
	35 to 44	7,688	24.9	7,387	23.9	-1.0
	45 to 54	7,389	24.0	7,592	24.6	0.6
	55 to 64	4,624	15.0	4,597	14.9	-0.1
	65 to 74	3,499	11.3	3,571	11.6	0.3
	75 and Older	2,992	9.7	3,142	10.2	0.5
	Total	30,857	100.0	30,855	100.0	--
Racine County	16 to 24	3,265	4.6	3,296	4.6	--
	25 to 34	11,397	16.1	12,443	17.6	1.5
	35 to 44	16,921	23.9	17,119	24.2	0.3
	45 to 54	14,976	21.2	15,190	21.4	0.2
	55 to 64	9,521	13.4	9,185	13.0	-0.4
	65 to 74	7,555	10.7	6,875	9.7	-1
	75 and Older	7,184	10.1	6,710	9.5	-0.6
	Total	70,819	100.0	70,818	100.0	--
Walworth County	16 to 24	2,529	7.3	978	2.8	-4.5
	25 to 34	5,274	15.3	5,025	14.6	-0.7
	35 to 44	7,716	22.3	8,368	24.2	1.9
	45 to 54	6,963	20.2	8,040	23.3	3.1
	55 to 64	4,726	13.7	4,924	14.3	0.6
	65 to 74	3,734	10.8	3,872	11.2	0.4
	75 and Older	3,580	10.4	3,295	9.6	-0.8
	Total	34,522	100.0	34,502	100.0	--
Washington County	16 to 24	1,439	3.3	989	2.3	-1.0
	25 to 34	7,167	16.3	6,104	13.9	-2.4
	35 to 44	11,667	26.6	10,539	24.0	-2.6
	45 to 54	9,427	21.5	10,326	23.6	2.1
	55 to 64	6,021	13.7	6,377	14.5	0.8
	65 to 74	4,244	9.7	5,044	11.5	1.8
	75 and Older	3,877	8.9	4,454	10.2	1.3
	Total	43,842	100.0	43,833	100.0	--

Table continued on next page.

Table 4.37 (Continued)

	Age of Head of Household	2000 Census Number of Households	2000 Census Percent Distribution	Model Estimated Number of Households	Model Estimated Percent Distribution	Difference In Percent
Waukesha County	16 to 24	3,736	2.8	2,904	2.1	-0.7
	25 to 34	19,547	14.5	18,227	13.5	-1.0
	35 to 44	34,237	25.3	32,287	23.9	-1.4
	45 to 54	31,323	23.2	32,670	24.2	1.0
	55 to 64	19,623	14.5	19,917	14.7	0.2
	65 to 74	14,531	10.7	15,388	11.4	0.7
	75 and Older	12,232	9.0	13,828	10.2	1.2
	Total	135,229	100.0	135,221	100.0	--
Region	16 to 24	40,714	5.4	38,693	5.2	-0.2
	25 to 34	131,642	17.6	136,047	18.2	0.6
	35 to 44	174,502	23.3	180,602	24.1	0.8
	45 to 54	152,812	20.4	157,315	21.0	0.6
	55 to 64	95,030	12.7	95,341	12.7	--
	65 to 74	77,916	10.4	70,330	9.4	-1.0
	75 and Older	76,439	10.2	70,680	9.4	-0.8
	Total	749,055	100.0	749,008	100.0	--

Source: U.S. Bureau of the Census and SEWRPC

comparisons of estimated actual and model estimated transit passengers in total, and comparisons on selected major transit routes.

A comparison of the average weekday linked passenger trips by trip purpose as determined from the Commission travel survey, with those estimated by the application of the simulation models for the Southeastern Wisconsin Region is presented in Tables 4.46 and 4.47.

Tables 4.50 and 4.51 present a comparison of years 2011 and 2001 average weekday transit ridership for selected routes as observed through passenger counts with that estimated by application of the simulation models. Maps 4.8 and 4.9 show the routes considered. The passenger count information is based upon actual weekday passenger counts taken by the transit operators in 2010 and 2011 as adjusted to account for monthly and annual variations in ridership levels so as to be representative of average weekday 2011 ridership.

Highway Travel Demand

The estimated years 2011 and 2001 arterial street system average weekday traffic (AWDT) volumes derived from application of the traffic simulation models were compared to estimated years 2011 and 2001 AWDT volumes derived from actual traffic counts. Tables 4.52 and 4.53 present a comparison of estimated vehicle-miles of travel (VMT) from the traffic models and traffic counts for each county within Southeastern Wisconsin. Maps 4.10 and 4.11 present a comparison of the estimated average weekday traffic for the freeway system and selected major arterials within Southeastern Wisconsin.

Figures 4.15 and 4.16 present percent deviation in the AWDT assignment to estimated actual AWDT counts for the years 2011 and 2001 for the cordon lines, screenlines, and cutlines shown on Map 4.12. As shown in the figures the fifth generation travel demand model is able to meet the level of accuracy Commission staff has set for the model assignment. The maximum desirable deviation, as shown on Figures 4.15 and 4.16, were based on information presented in a FHWA Travel Model Improvement Program (TMIP) document entitled, *Travel Model Validation and Reasonableness Checking Manual, Second Edition*. The maximum deviation target reflects the desire and expectation that

Table 4.38
Comparison of Travel Survey and Model Estimated Average Weekday Motorized and Non-Motorized Person Trips by Trip Purpose: 2011[a]

	2011 Total Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	1,380,100	1,426,000	45,900	3.3
Home-Based Shopping	717,600	725,700	8,100	1.1
Home-Based Other	1,838,200	1,841,600	3,400	0.2
Nonhome-Based Work	587,300	603,400	16,100	2.7
Nonhome-Based Other	809,900	814,900	5,000	0.6
School[b]	677,600	675,000	-2,600	-0.4
Total	6,010,700	6,086,600	75,900	1.3

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data, and includes trips with one end outside the Region.*

[b] *Does not include trips made by school bus.*

Source: SEWRPC

Table 4.39
Comparison of Travel Survey and Model Estimated Average Weekday Motorized and Non-Motorized Person Trips by Trip Purpose: 2001[a]

	2001 Total Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	1,555,300	1,371,700	-183,600	-11.8
Home-Based Shopping	801,700	680,200	-121,500	-15.2
Home-Based Other	2,096,500	1,757,800	-338,700	-16.2
Nonhome-Based Work	562,300	575,900	13,600	2.4
Nonhome-Based Other	715,200	767,300	52,100	7.3
School[b]	549,100	689,100	140,000	25.5
Total	6,280,100	5,842,000	-438,100	-7.0

[a] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data, and includes trips with one end outside the Region.*

[b] *Does not include trips made by school bus.*

Source: SEWRPC

Table 4.40
Comparison of the Model Estimated Distribution of School Trips to School Elementary, Middle, and High School Enrollment by County: 2010-2011 School Year

	Public and Private Elementary, Middle, and High School Enrollment		Model Estimated School Trips		
County	Number	Percent Distribution	Number	Percent Distribution	**Difference in Percent**
Kenosha	33,396	8.7	56,900	8.5	-0.2
Milwaukee	181,550	47.3	314,200	46.9	-0.4
Ozaukee	15,514	4.0	27,100	4.0	--
Racine	35,905	9.4	64,100	9.6	0.2
Walworth	17,759	4.6	31,900	4.8	0.2
Washington	23,666	6.2	45,800	6.8	0.6
Waukesha	75,972	19.8	129,700	19.4	-0.4
Total	383,762	100.0	669,700	100.0	--

Source: Wisconsin Department of Public Instruction and SEWRPC

Table 4.41
Comparison of the Model Estimated Distribution of School Trips to School Elementary, Middle, and High School Enrollment by County: 2000-2001 School Year

County	Public and Private Elementary, Middle, and High School Enrollment		Model Estimated School Trips		Difference in Percent
	Number	Percent Distribution	Number	Percent Distribution	
Kenosha	30,532	7.9	56,300	8.1	0.2
Milwaukee	190,186	49.3	340,400	48.8	-0.5
Ozaukee	15,806	4.1	28,100	4.0	-0.1
Racine	36,198	9.4	67,000	9.6	0.2
Walworth	16,727	4.3	31,400	4.5	0.2
Washington	23,344	6.0	44,100	6.3	0.3
Waukesha	73,361	19.0	130,800	18.7	-0.3
Total	386,154	100.0	698,100	100.0	--

Source: Wisconsin Department of Public Instruction and SEWRPC

Table 4.42
Comparison of Travel Survey and Model Estimated Average Trip Length for Internal Resident Household Person Travel in the Region: 2011

Trip Purpose	2011 Travel Survey Estimated Trip Length		2011 Travel Model Estimated[a] Trip Length		Percent Difference	
	Minutes	Miles	Minutes	Miles	Minutes	Miles
Home-Based Work	17.9	10.4	18.1	10.4	1.1	0.0
Home-Based Shopping	9.1	4.5	8.9	4.4	-2.2	-2.2
Home-Based Other	10.5	5.4	10.2	5.4	-2.9	0.0
Nonhome-Based Work	13.7	7.3	12.8	7.2	-6.6	-1.4
Nonhome-Based Other	9.6	4.7	9.4	4.7	-2.1	0.0
Average	12.4	6.7	12.3	6.6	-0.8	-1.5

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 4.43
Comparison of Travel Survey and Model Estimated Average Trip Length for Internal Resident Household Person Travel in the Region: 2001

Trip Purpose	2001 Travel Survey Estimated Trip Length		2001 Travel Model Estimated[a] Trip Length		Percent Difference	
	Minutes	Miles	Minutes	Miles	Minutes	Miles
Home-Based Work	18.3	9.6	17.9	10.1	-2.2	5.2
Home-Based Shopping	9.6	4.5	8.9	4.3	-7.3	-4.4
Home-Based Other	11.6	5.8	10.8	5.7	-6.9	-1.7
Nonhome-Based Work	13.9	6.9	12.5	6.8	-10.1	-1.4
Nonhome-Based Other	10.1	4.8	9.8	4.9	-3.0	2.1
Average	13.1	6.6	12.4	6.6	-5.3	0.0

[a] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.*

Source: SEWRPC

Table 4.44
Comparison of Travel Survey and Model Estimated Percent Intrazonal Trips in the Region: 2011

	2011 Travel Survey Estimated			2011 Travel Model Estimated[a]			Difference in Percent Intrazonal Trips
Trip Purpose	Total Trips	Intrazonal Trips	Percent Intrazonal Trips	Total Trips	Intrazonal Trips	Percent Intrazonal Trips	
Home-Based Work	1,343,000	37,000	2.8	1,366,200	36,200	2.6	-0.2
Home-Based Shopping	715,200	40,700	5.7	716,500	40,500	5.7	0.0
Home-Based Other	1,832,300	131,200	7.2	1,796,600	130,200	7.2	0.0
Nonhome-Based Work	579,200	32,200	5.6	586,700	32,200	5.5	-0.1
Nonhome-Based Other	804,100	84,400	10.5	799,800	83,400	10.4	-0.1
Total	5,273,800	325,500	6.2	5,265,800	322,500	6.1	-0.1

[a] Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.

Source: SEWRPC

Table 4.45
Comparison of Travel Survey and Model Estimated Percent Intrazonal Trips in the Region: 2001

	2001 Travel Survey Estimated			2001 Travel Model Estimated[a]			Difference in Percent Intrazonal Trips
Trip Purpose	Total Trips	Intrazonal Trips	Percent Intrazonal Trips	Total Trips	Intrazonal Trips	Percent Intrazonal Trips	
Home-Based Work	1,473,300	35,700	2.4	1,283,200	33,700	2.6	0.2
Home-Based Shopping	789,200	34,700	4.4	659,800	39,600	6.0	1.6
Home-Based Other	2,034,600	123,300	6.1	1,703,500	115,400	6.8	0.7
Nonhome-Based Work	542,300	32,100	5.9	556,000	30,600	5.5	-0.4
Nonhome-Based Other	701,000	55,300	7.9	749,500	69,700	9.3	1.4
Total	5,540,400	281,100	5.1	4,952,000	289,000	5.8	0.7

[a] Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.

Source: SEWRPC

as the volume and significance of the cordon lines, screenlines, and cutlines increase the maximum desirable deviation of the modeled traffic volumes from estimated actual ground count volumes should decrease.

Tables 4.54 and 4.55 provide the root mean squared error comparisons of the AWDT assignment to estimated actual AWDT counts by volume ranges for the years 2011 and 2001. The fifth-generation travel demand model is able to meet the RMSE targets Commission staff has set for accuracy in the model assignment. The RMSE targets were based on information presented in the FHWA TMIP document referenced previously. The RMSE targets reflect the desire and expectation that as the volume and significance of the roadway increases, the attendant error in the assignment should decrease. Figures 4.17 and 4.18 provide an additional comparison of AWDT assignment to estimated actual AWDT counts for the years 2011 and 2001. An R^2 is provided for each figure, which shows that for both years the model is able to exceed an R^2 of 0.88, which is considered a good indication of a model's accuracy.

It may be concluded that the traffic simulation models have the ability to forecast traffic volume with adequate accuracy for transportation planning and facility design purposes. This is particularly true when it is recognized that the actual traffic counts are estimates themselves, having been taken over a triennial period centered on the base year. As such, the counts reflect yearly as well as seasonal variations in traffic flow and random errors that occur in the counting process itself.

Figure 4.9
Comparison of Travel Survey and Model Estimated Internal Person Trip Travel Patterns by 37 Planning Areas: 2011[a]

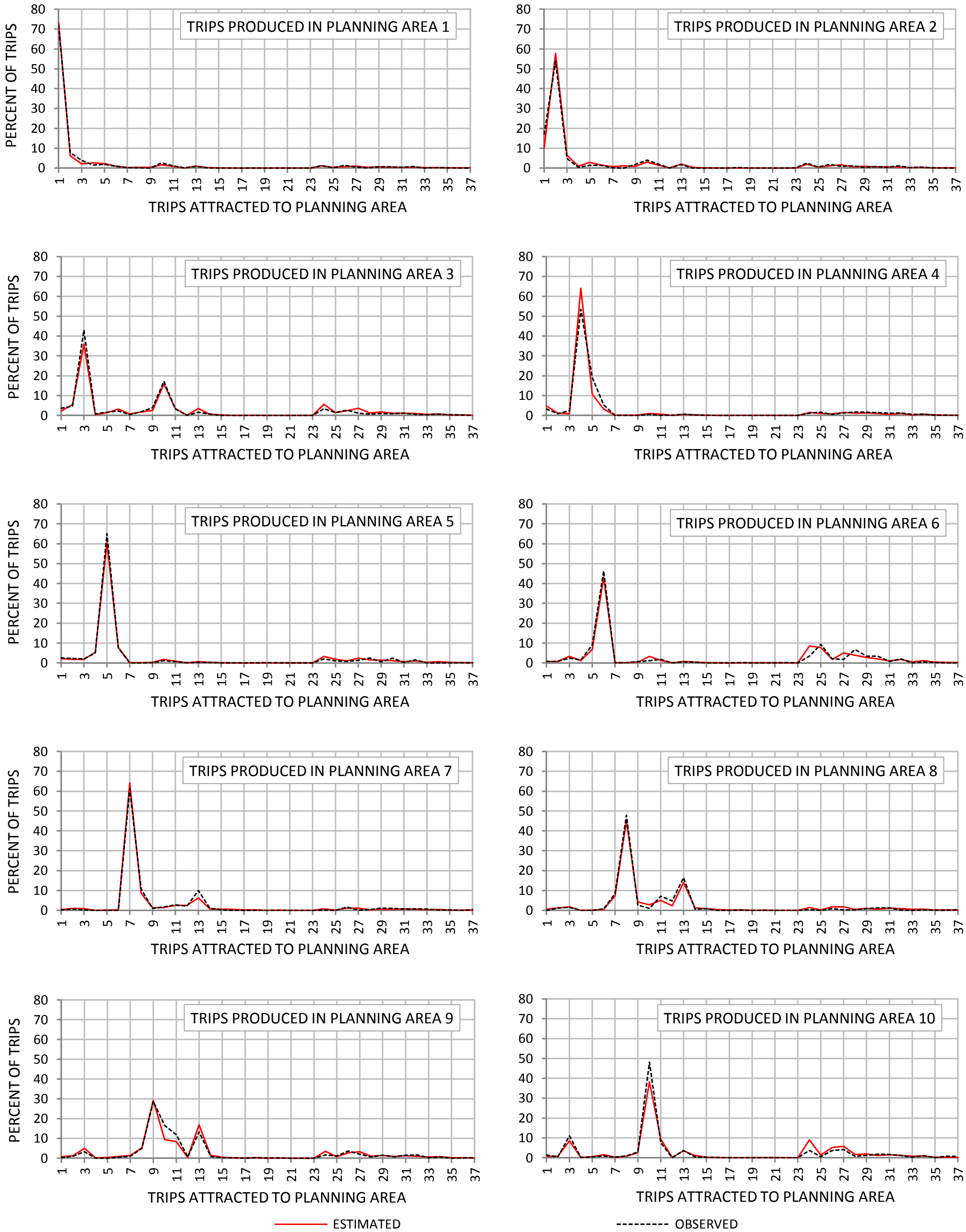


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Figure 4.9 (Continued)

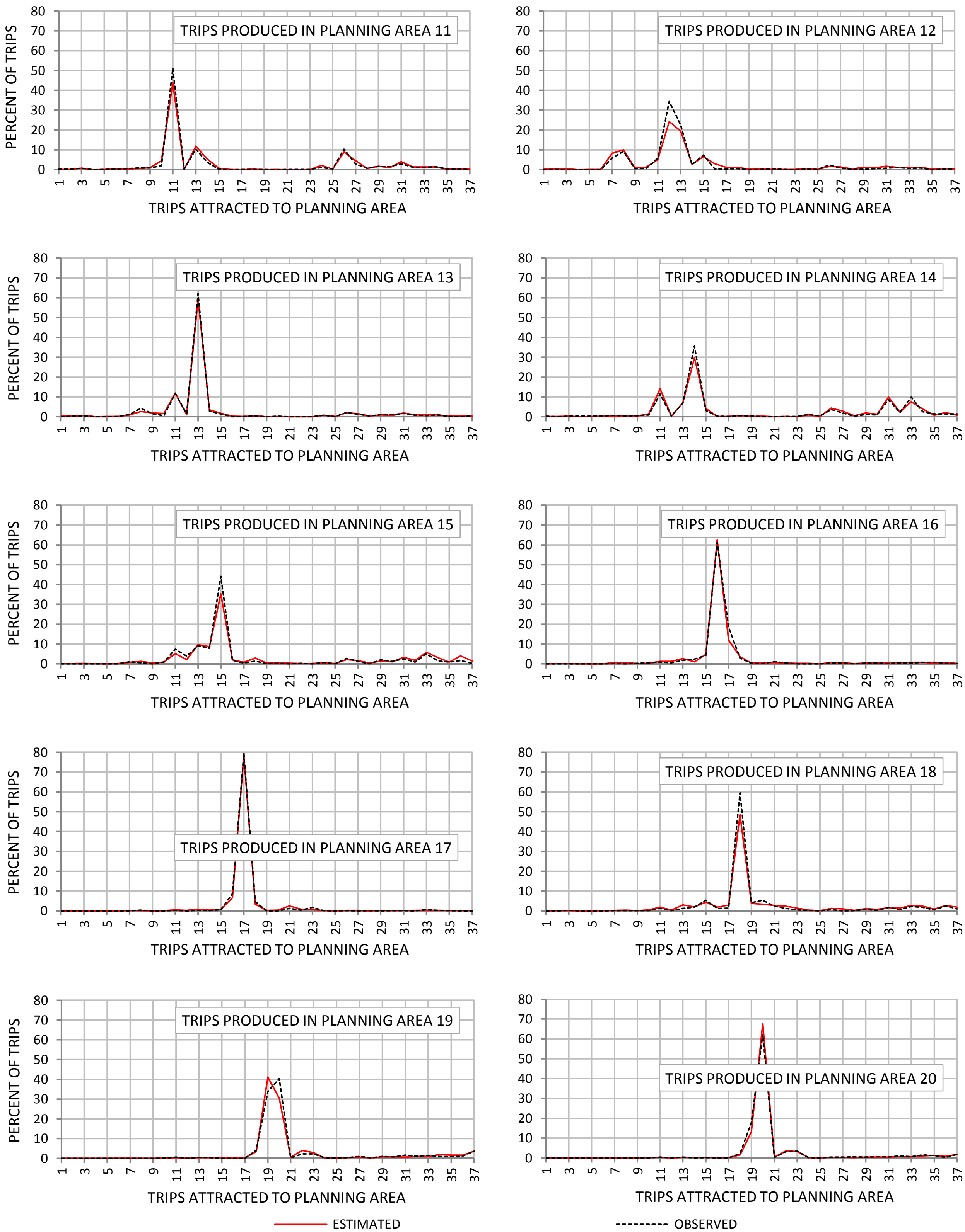

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Figure 4.9 (Continued)

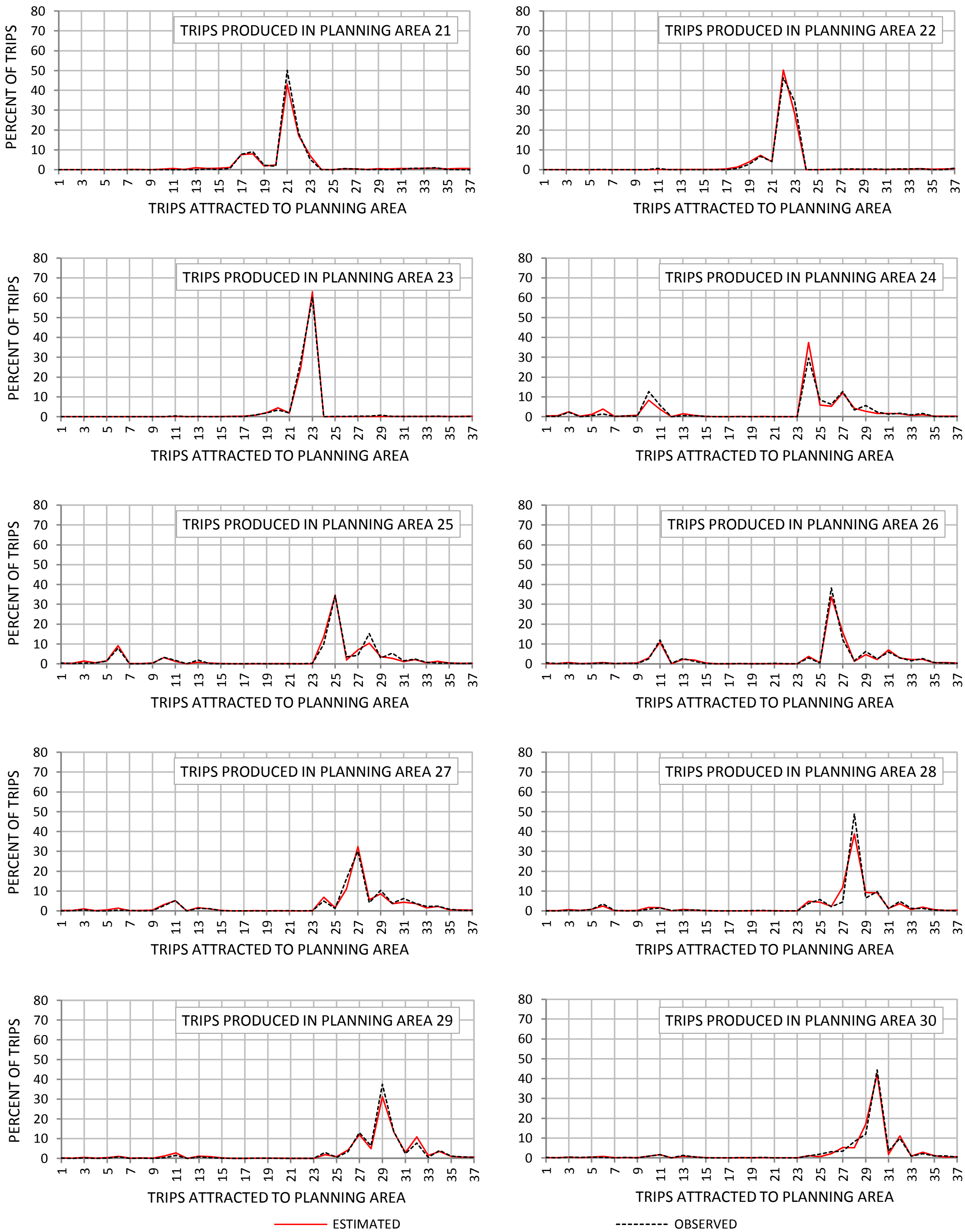

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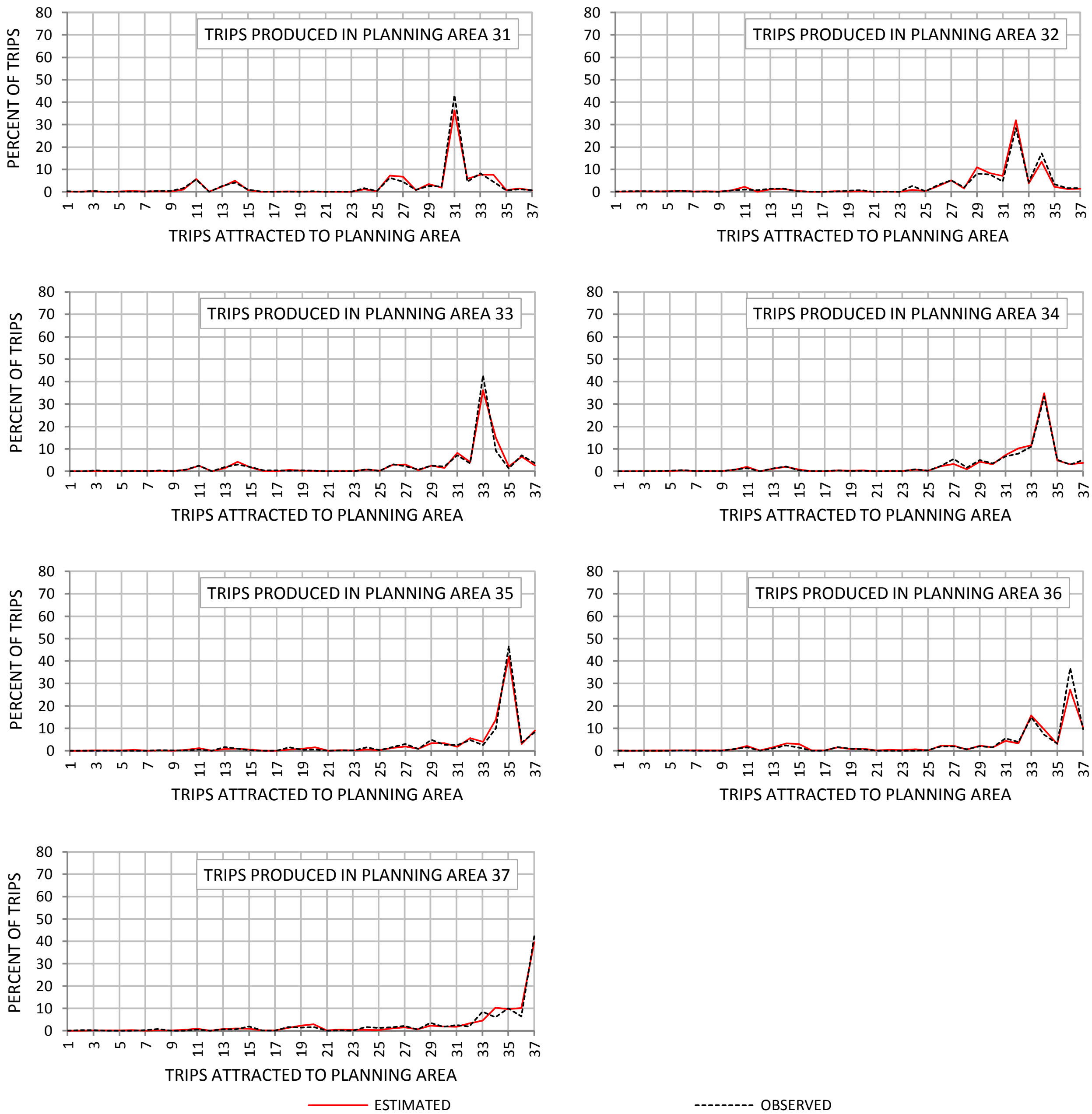
Figure 4.9 (Continued)



[a]Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.

Source: SEWRPC

Figure 4.10
Comparison of Travel Survey and Model Estimated Internal Person Trip Travel Patterns by 37 Planning Areas: 2001[a]

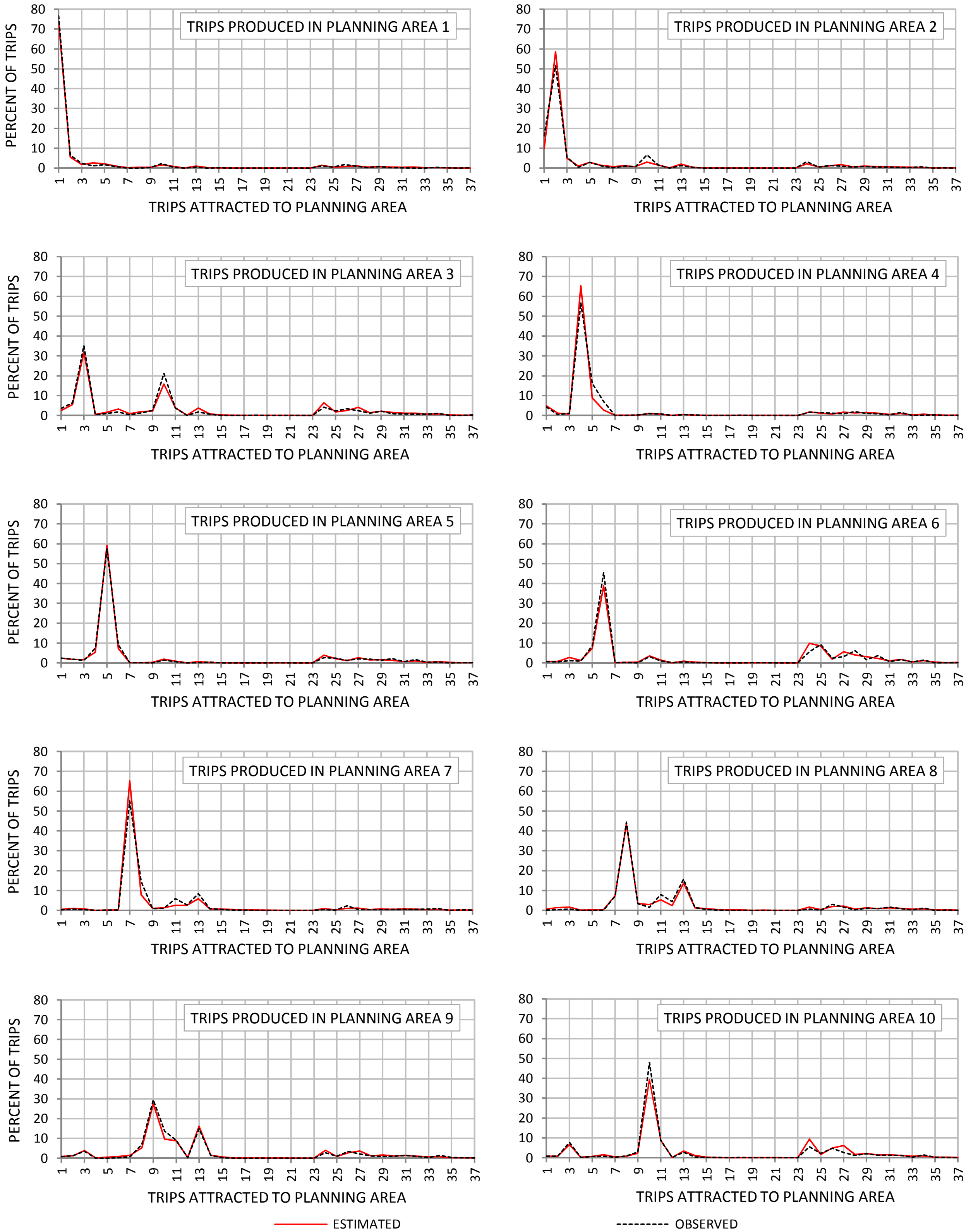


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Figure 4.10 (Continued)

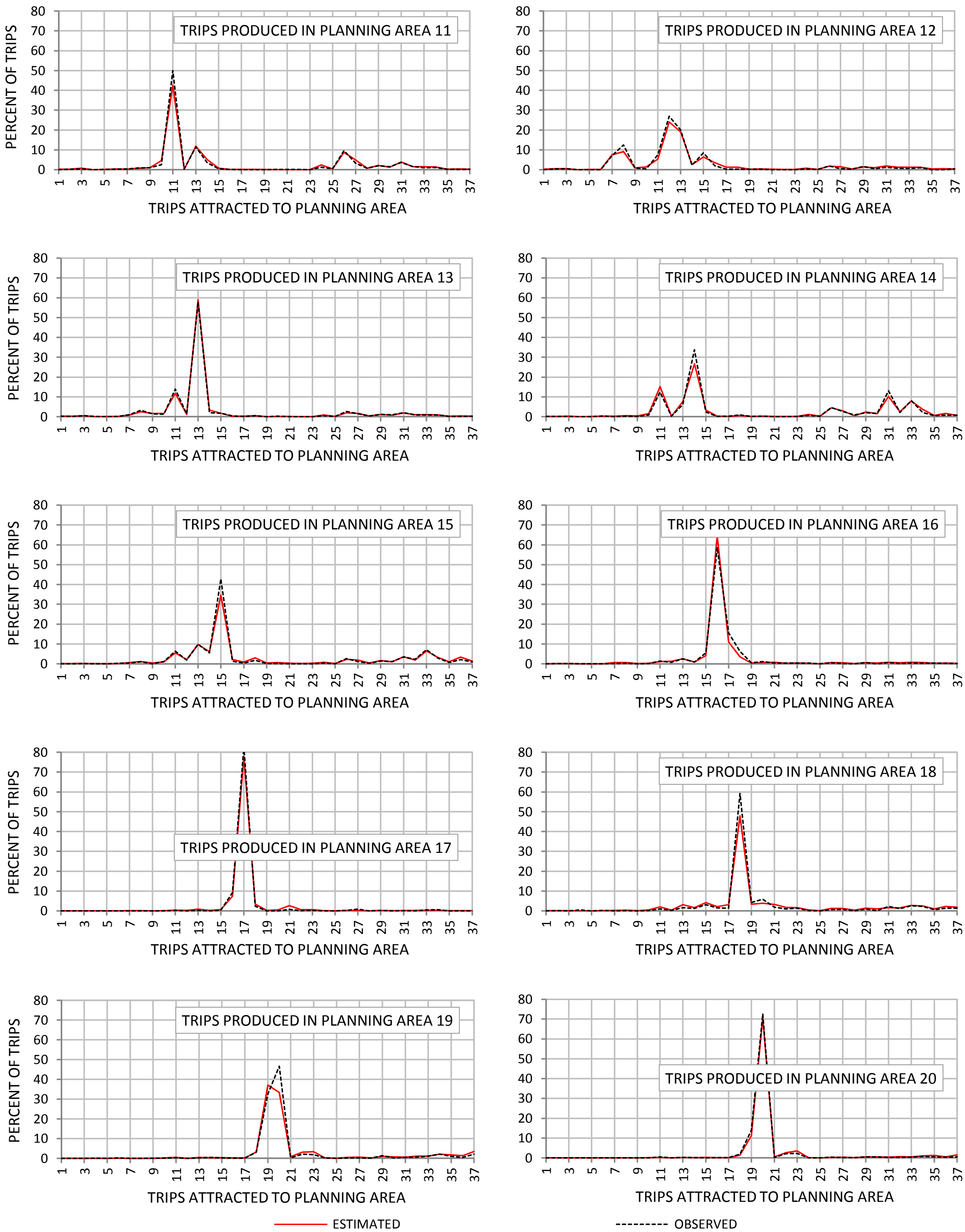

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Figure 4.10 (Continued)

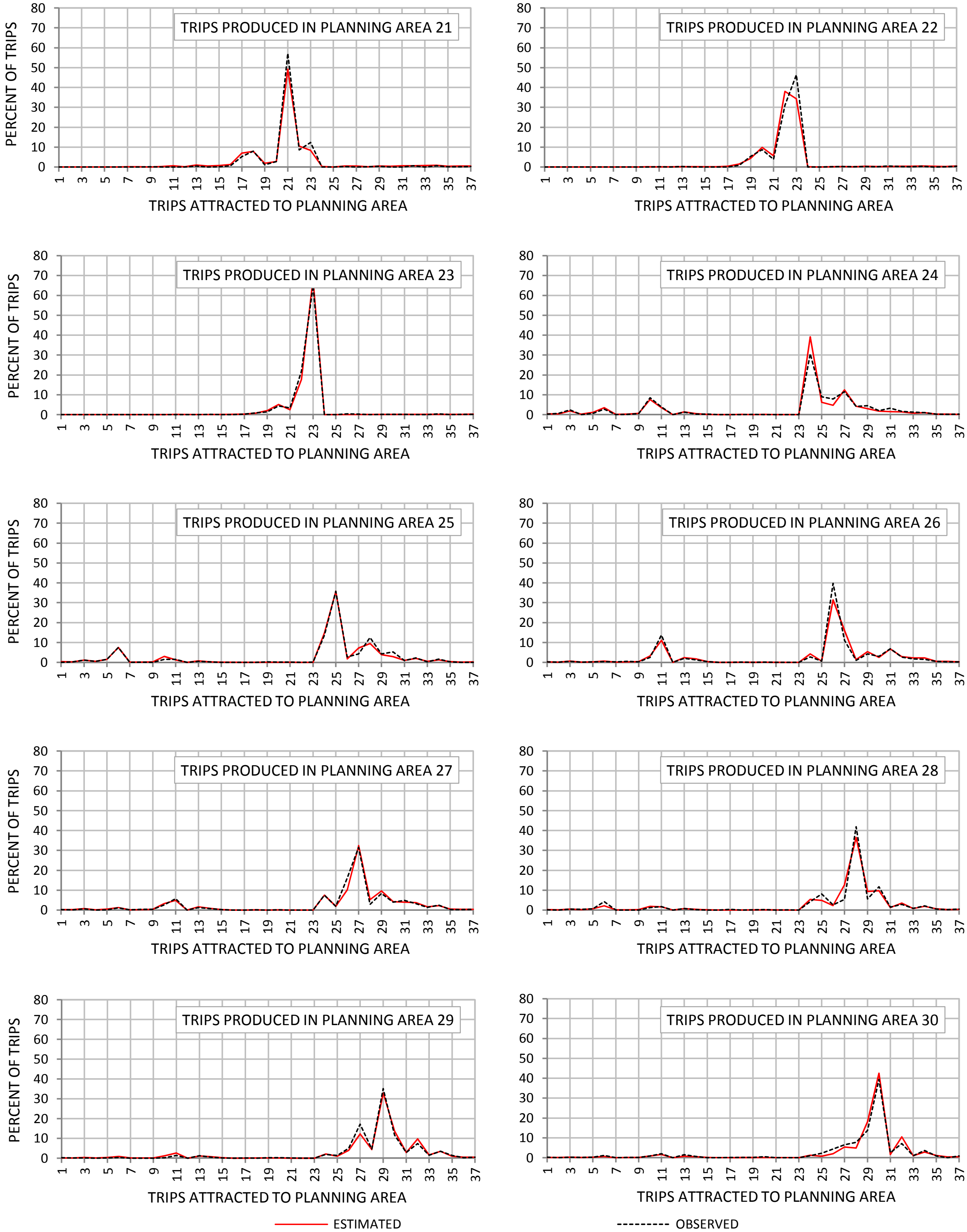

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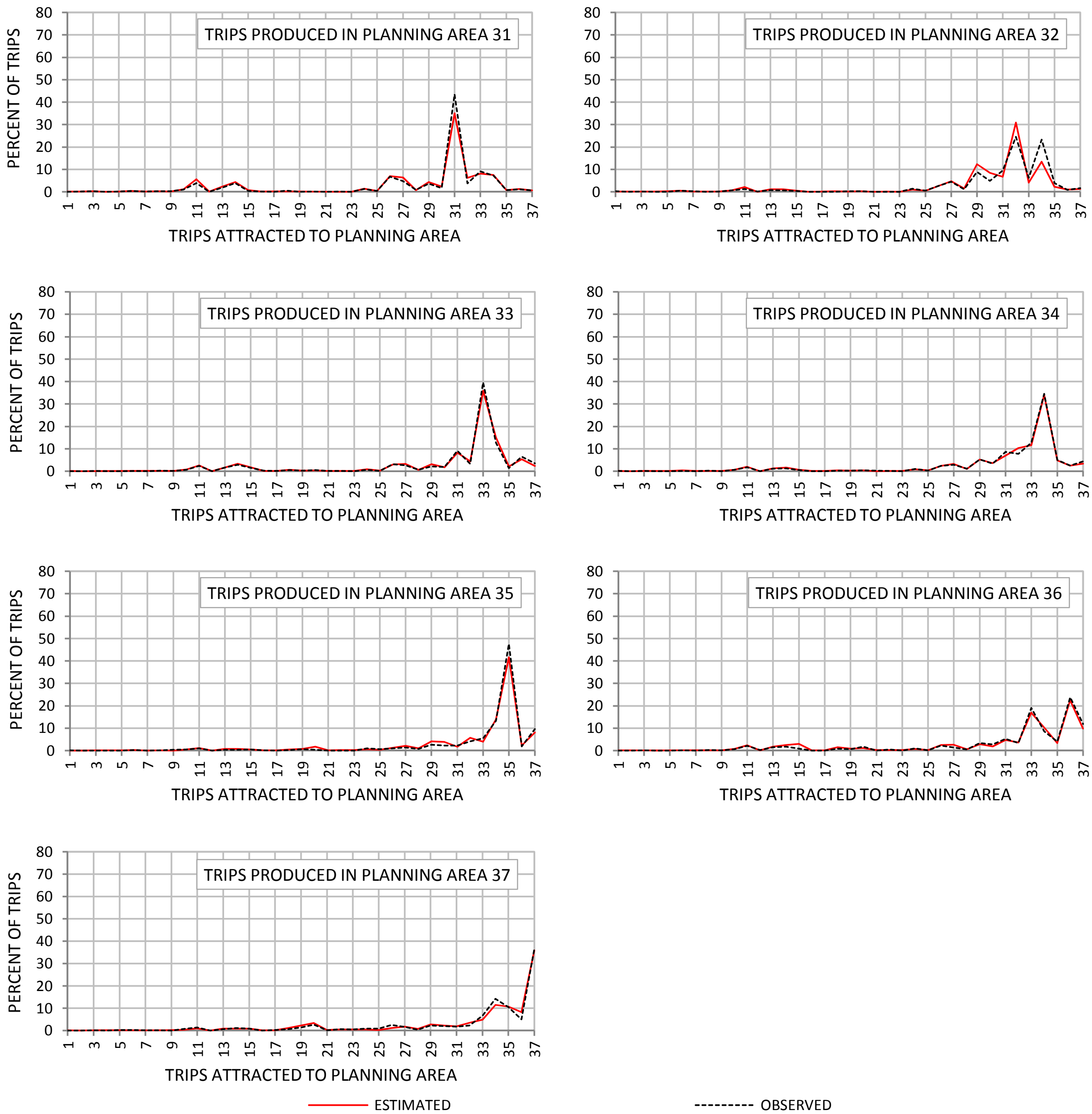
Figure 4.10 (Continued)



[a]Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.

Source: SEWRPC

Figure 4.11
Comparison of Travel Survey and Model Estimated Average Weekday Trip Length (ATL) Frequency Distribution in the Region: 2011[a]

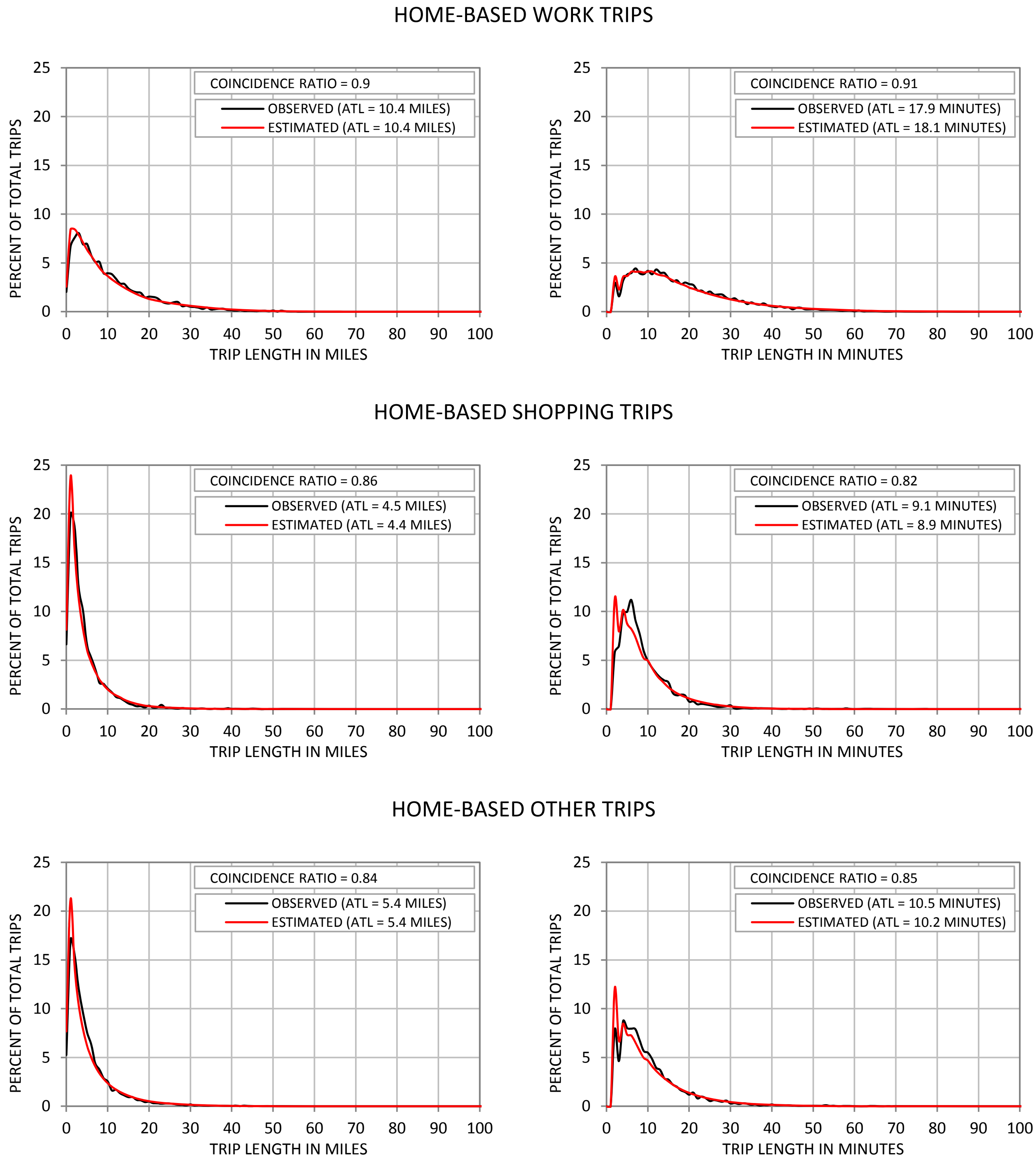


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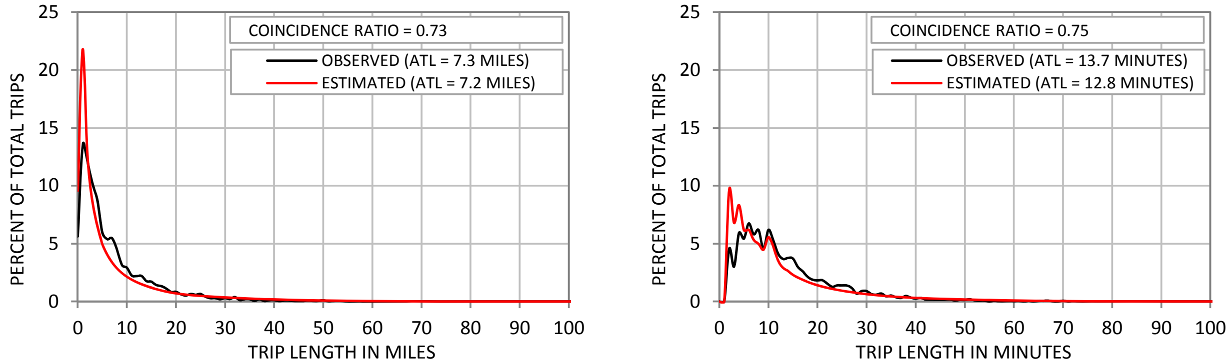
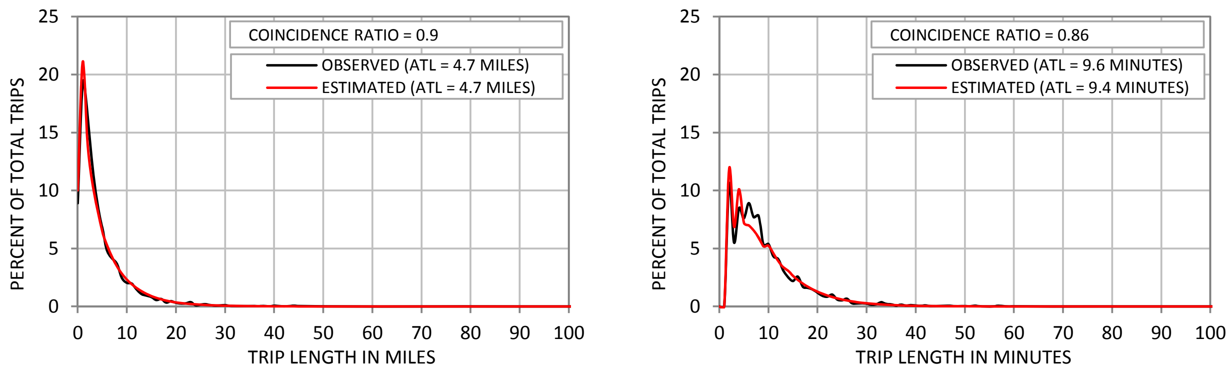
Figure 4.11 (Continued)

NONHOME-BASED WORK TRIPS



NONHOME-BASED WORK TRIPS



[a]Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.

Source: SEWRPC

Figure 4.12
Comparison of Travel Survey and Model Estimated Average Weekday Trip Length (ATL) Frequency Distribution in the Region: 2001[a]

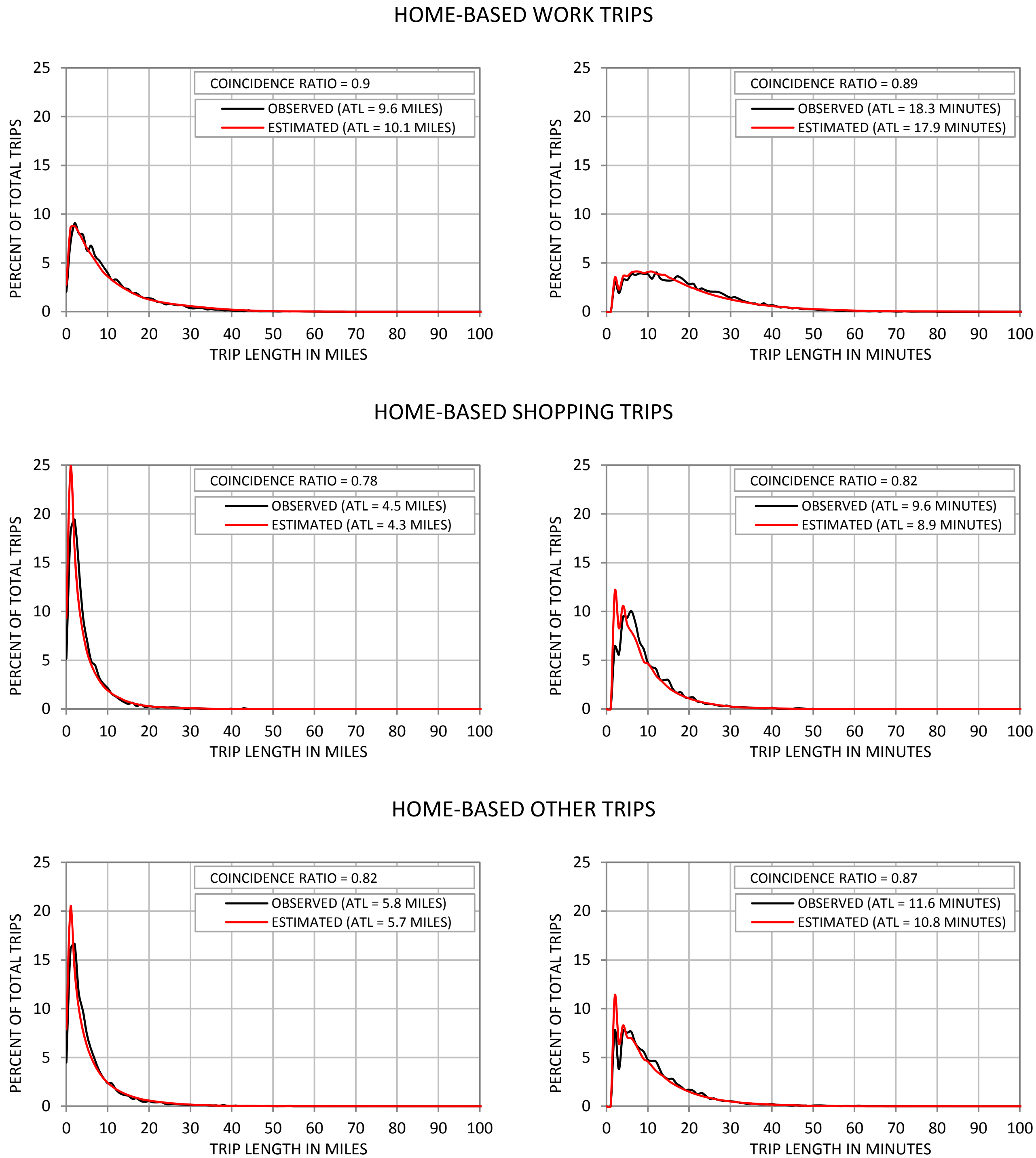


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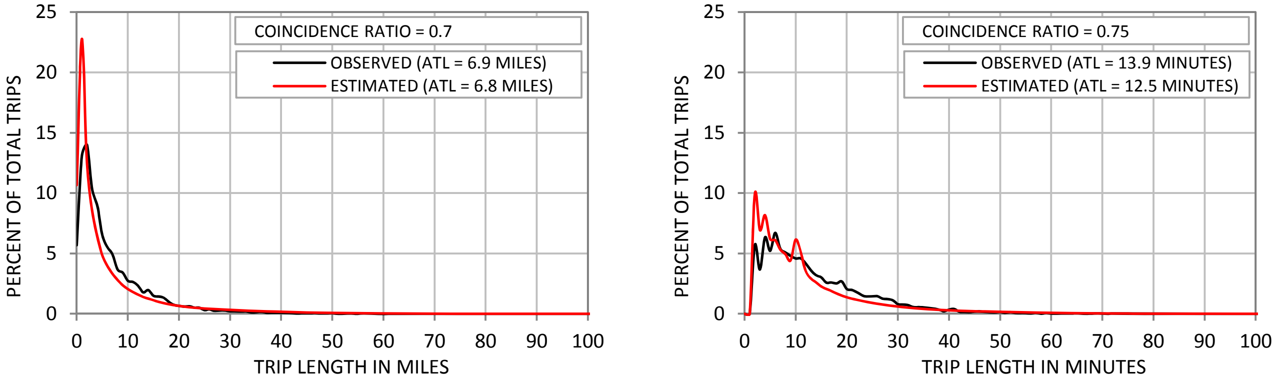
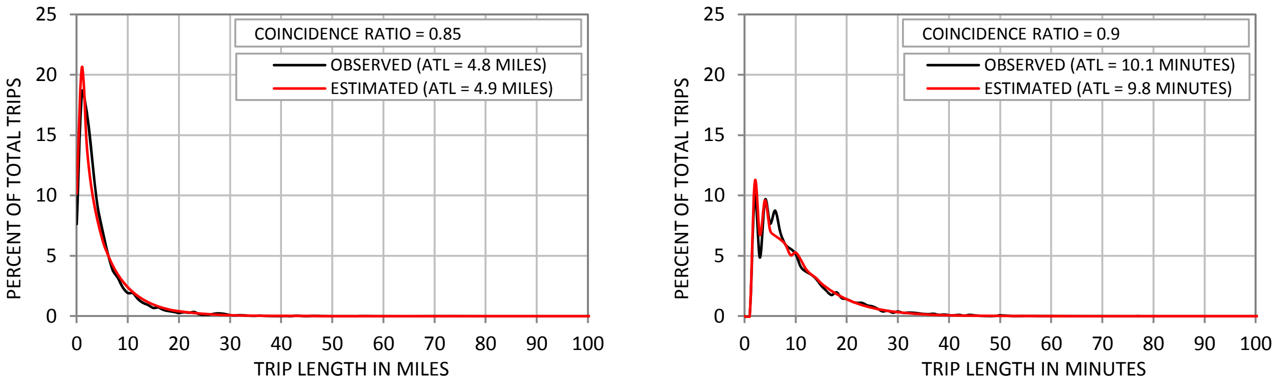
Figure 4.12 (Continued)

NONHOME-BASED WORK TRIPS



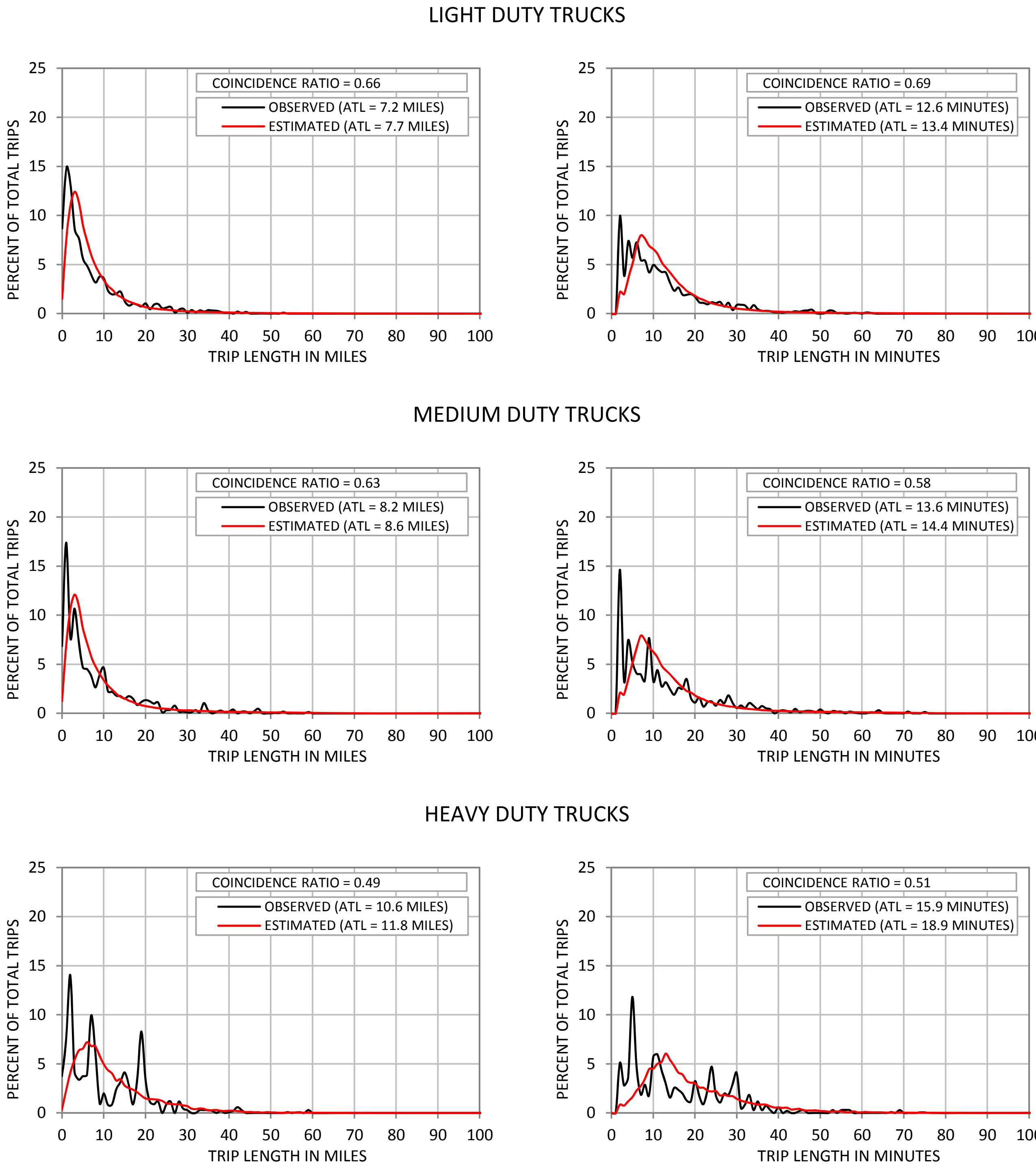
NONHOME-BASED WORK TRIPS



[a]Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.

Source: SEWRPC

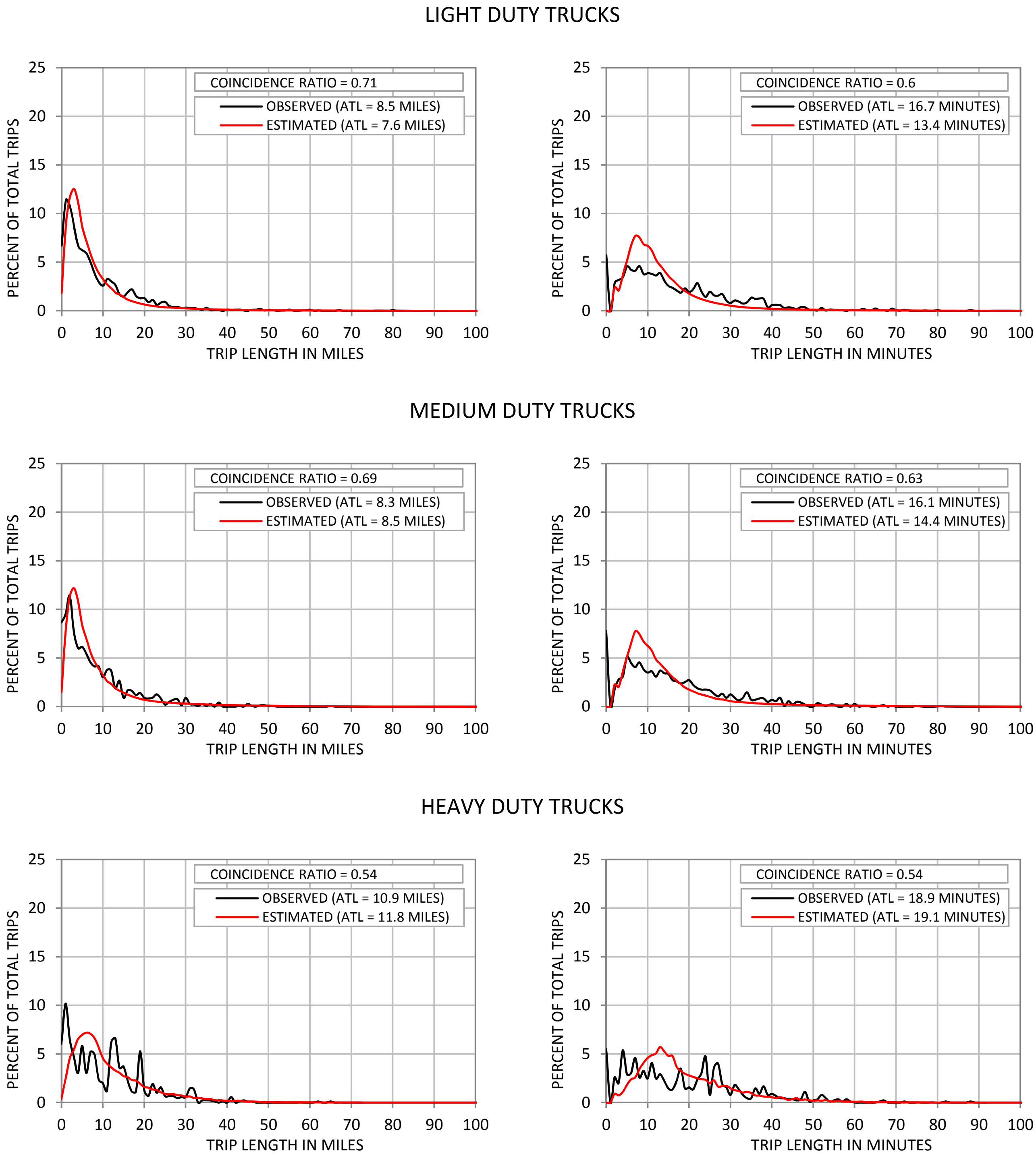
Figure 4.13
Comparison of Travel Survey and Model Estimated Average Weekday Truck Trip Length (ATL) Frequency Distribution in the Region: 2011[a]



[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Figure 4.14
Comparison of Travel Survey and Model Estimated Average Weekday Truck Trip Length (ATL) Frequency Distribution in the Region: 2001[a]



[a]Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.

Source: SEWRPC

Table 4.46
Comparison of Travel Survey and Model Estimated Average Weekday Motorized And Non-Motorized Person Trips by Trip Purpose: 2011[a]

	2011 Auto Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	1,276,700	1,317,100	40,400	3.2
Home-Based Shopping	640,800	648,000	7,200	1.1
Home-Based Other	1,683,700	1,679,600	-4,100	-0.2
Nonhome-Based Work	546,000	559,200	13,200	2.4
Nonhome-Based Other	752,900	764,900	12,000	1.6
School[b]	515,100	513,200	-1,900	-0.4
Total	5,415,200	5,482,000	66,800	1.2

	2011 Transit Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	34,200	35,400	1,200	3.5
Home-Based Shopping	12,700	12,800	100	0.8
Home-Based Other	23,500	23,600	100	0.4
Nonhome-Based Work	8,100	7,700	-400	-4.9
Nonhome-Based Other	14,200	14,200	0	0.0
School[b]	38,900	38,500	-400	-1.0
Total	131,600	132,200	600	0.5

	2011 Non-Motorized Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	69,200	73,500	4,300	6.2
Home-Based Shopping	64,100	64,900	800	1.2
Home-Based Other	131,000	138,400	7,400	5.6
Nonhome-Based Work	33,200	36,500	3,300	9.9
Nonhome-Based Other	42,800	35,800	-7,000	-16.4
School[b]	123,600	123,300	-300	-0.2
Total	463,900	472,400	8,500	1.8

	2011 Total Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	1,380,100	1,426,000	45,900	3.3
Home-Based Shopping	717,600	725,700	8,100	1.1
Home-Based Other	1,838,200	1,841,600	3,400	0.2
Nonhome-Based Work	587,300	603,400	16,100	2.7
Nonhome-Based Other	809,900	814,900	5,000	0.6
School[b]	677,600	675,000	-2,600	-0.4
Total	6,010,700	6,086,600	75,900	1.3

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data, and includes trips with one end outside the Region.*

[b] *Does not include trips made by school bus.*

Source: SEWRPC

Table 4.47
Comparison of Travel Survey and Model Estimated Average Weekday Motorized And Non-Motorized Person Trips by Trip Purpose: 2001[a]

	2001 Auto Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	1,466,300	1,266,100	-200,200	-13.7
Home-Based Shopping	758,500	611,800	-146,700	-19.3
Home-Based Other	1,984,400	1,607,900	-376,500	-19.0
Nonhome-Based Work	545,100	527,500	-17,600	-3.2
Nonhome-Based Other	687,200	711,000	23,800	3.5
School[b]	399,400	522,400	123,000	30.8
Total	5,840,900	5,246,700	-594,200	-10.2

	2001 Transit Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	49,000	37,100	-11,900	-24.3
Home-Based Shopping	14,100	14,000	-100	-0.7
Home-Based Other	27,300	26,400	-900	-3.3
Nonhome-Based Work	5,200	11,700	6,500	125.0
Nonhome-Based Other	9,400	23,600	14,200	151.1
School[b]	38,200	39,100	900	2.4
Total	143,200	151,900	8,700	6.1

	2001 Non-Motorized Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	40,000	68,500	28,500	71.3
Home-Based Shopping	29,100	54,400	25,300	86.9
Home-Based Other	84,800	123,500	38,700	45.6
Nonhome-Based Work	12,000	36,700	24,700	205.8
Nonhome-Based Other	18,600	32,700	14,100	75.8
School[b]	111,500	127,600	16,100	14.4
Total	296,000	443,400	147,400	49.8

	2001 Total Trips			
		Travel Model Estimate		
Trip Purpose	Travel Survey Estimate	Number	Difference from Survey	Percent Difference
Home-Based Work	1,555,300	1,371,700	-183,600	-11.8
Home-Based Shopping	801,700	680,200	-121,500	-15.2
Home-Based Other	2,096,500	1,757,800	-338,700	-16.2
Nonhome-Based Work	562,300	575,900	13,600	2.4
Nonhome-Based Other	715,200	767,300	52,100	7.3
School[b]	549,100	689,100	140,000	25.5
Total	6,280,100	5,842,000	-438,100	-7.0

[a] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data, and includes trips with one end outside the Region.*

[b] *Does not include trips made by school bus.*

Source: SEWRPC

Table 4.48
Walk and Bike Non-Motorized Mode Share of Person Trips: 2011[a]

Trip Type	2011 Walk Share (%) of Total Non-Motorized Trips		
	Travel Survey Estimate	Travel Model Estimate	Difference in Model Estimate
Work Related[b]	16.3	17.1	0.8
Non-work related[c]	45.3	44.6	-0.7
School[d]	23.6	23.3	-0.3
Total	85.3	85.1	-0.2

Trip Type	2011 Bike Share (%) of Total Non-Motorized Trips		
	Travel Survey Estimate	Travel Model Estimate	Difference in Model Estimate
Work Related[b]	5.7	6.2	0.5
Non-work related[c]	6.0	6.0	0.0
School[d]	3.0	2.8	-0.2
Total	14.7	14.9	0.2

Trip Type	2011 Non-Motorized (Walk and Bike) Share (%)		
	Travel Survey Estimate	Travel Model Estimate	Difference in Model Estimate
Work Related[b]	22.1	23.3	1.2
Non-work related[c]	51.3	50.6	-0.7
School[d]	26.6	26.1	-0.5
Total	100.0	100.0	--

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data, and includes trips with one end outside the Region.*

[b] *Includes home-based work, and nonhome-based work trips.*

[c] *Includes home-based shopping, home-based other, and nonhome-based other trips.*

[d] *Does not include trips made by school bus, and the estimates of walk and bike shares are based on the non-work related relationship.*

Source: SEWRPC

Table 4.49
Walk and Bike Non-Motorized Mode Share of Person Trips: 2001[a]

Trip Type	2001 Walk Share (%) of Total Non-Motorized Trips: Travel Survey Estimate	Travel Model Estimate	Difference in Model Estimate
Work Related[b]	14.9	17.7	2.8
Non-work related[c]	40.6	42.1	1.5
School[d]	35.8	25.7	-10.1
Total	91.3	85.5	-5.8

Trip Type	2001 Bike Share (%) of Total Non-Motorized Trips: Travel Survey Estimate	Travel Model Estimate	Difference in Model Estimate
Work Related[b]	2.6	6.0	3.4
Non-work related[c]	4.2	5.4	1.2
School[d]	1.9	3.0	1.1
Total	8.7	14.5	5.8

Trip Type	2001 Non-Motorized (Walk and Bike) Share (%): Travel Survey Estimate	Travel Model Estimate	Difference in Model Estimate
Work Related[b]	17.5	23.7	6.2
Non-work related[c]	44.8	47.5	2.7
School[d]	37.7	28.8	-8.9
Total	100.0	100.0	--

[a] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data, and includes trips with one end outside the Region.*

[b] *Includes home-based work, and nonhome-based work trips.*

[c] *Includes home-based shopping, home-based other, and nonhome-based other trips.*

[d] *Does not include trips made by school bus, and the estimates of walk and bike shares are based on the non-work related relationship.*

Source: SEWRPC

Table 4.50
Comparison of Estimated Actual Transit Ridership Boarding Passenger Counts to Model Estimated Transit Ridership on Select Milwaukee County Transit System Bus Routes and Total System: 2011[a]

Milwaukee County Transit System	Average Weekday Unlinked Trips (Boarding Passengers)			
	Estimated Actual[b]	2011 Model Estimated[c]	Difference	
			Amount	Percent
Selected Major Routes				
Route No. 10	6,890	8,720	1,830	26.6
Route No. 12	7,760	9,120	1,360	17.5
Route No. 15	8,410	12,870	4,460	53.0
Route No. 18	5,980	4,500	-1,480	-24.7
Route No. 19	7,700	5,530	-2,170	-28.2
Route No. 21	5,500	5,600	100	1.8
Route No. 23	8,760	6,550	-2,210	-25.2
Route No. 27	13,060	11,940	-1,120	-8.6
Route No. 30	14,100	17,630	3,530	25.0
Route No. 35	5,040	2,320	-2,720	-54.0
Route No. 60	4,430	3,420	-1,010	-22.8
Route No. 62	7,340	7,130	-210	-2.9
Route No. 67	4,260	4,000	-260	-6.1
Route No. 76	5,860	5,730	-130	-2.2
Route No. 80	7,120	10,690	3,570	50.1
Subtotal	112,210	115,750	3,540	3.2
Remainder of Routes	38,440	44,340	5,900	15.3
Total	150,650	160,090	9,440	6.3

[a] *Includes Waukesha County Transit System routes operated by Milwaukee County Transit System.*

[b] *Based on actual operator counts taken during the months of September through May during 2010 and 2011 by the Milwaukee County Transit System.*

[c] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 4.51
Comparison of Estimated Actual Transit Ridership Boarding Passenger Counts to Model-Estimated Transit Ridership on Select Milwaukee County Transit System Bus Routes and Total System: 2001[a]

Milwaukee County Transit System	Average Weekday Unlinked Trips (Boarding Passengers)			
	Estimated Actual[b]	2001 Model Estimated[c]	Difference	
			Amount	Percent
Selected Major Routes				
Route No. 10	7,500	9,600	2,100	28.0
Route No. 12	8,840	7,210	-1,630	-18.4
Route No. 14, 2	5,810	5,050	-760	-13.1
Route No. 15	8,160	15,720	7,560	92.6
Route No. 18	6,740	5,850	-890	-13.2
Route No. 19	13,080	7,150	-5,930	-45.3
Route No. 27	12,170	3,000	-9,170	-75.3
Route No. 30, 30X	20,170	23,360	3,190	15.8
Route No. 31	3,270	1,760	-1,510	-46.2
Route No. 62	8,400	6,610	-1,790	-21.3
Route No. 76	6,080	6,370	290	4.8
Route No. 80	7,960	9,250	1,290	16.2
Subtotal	108,180	100,930	-7,250	-6.7
Remainder of Routes	72,490	65,440	-7,050	-9.7
Total	180,670	166,370	-14,300	-7.9

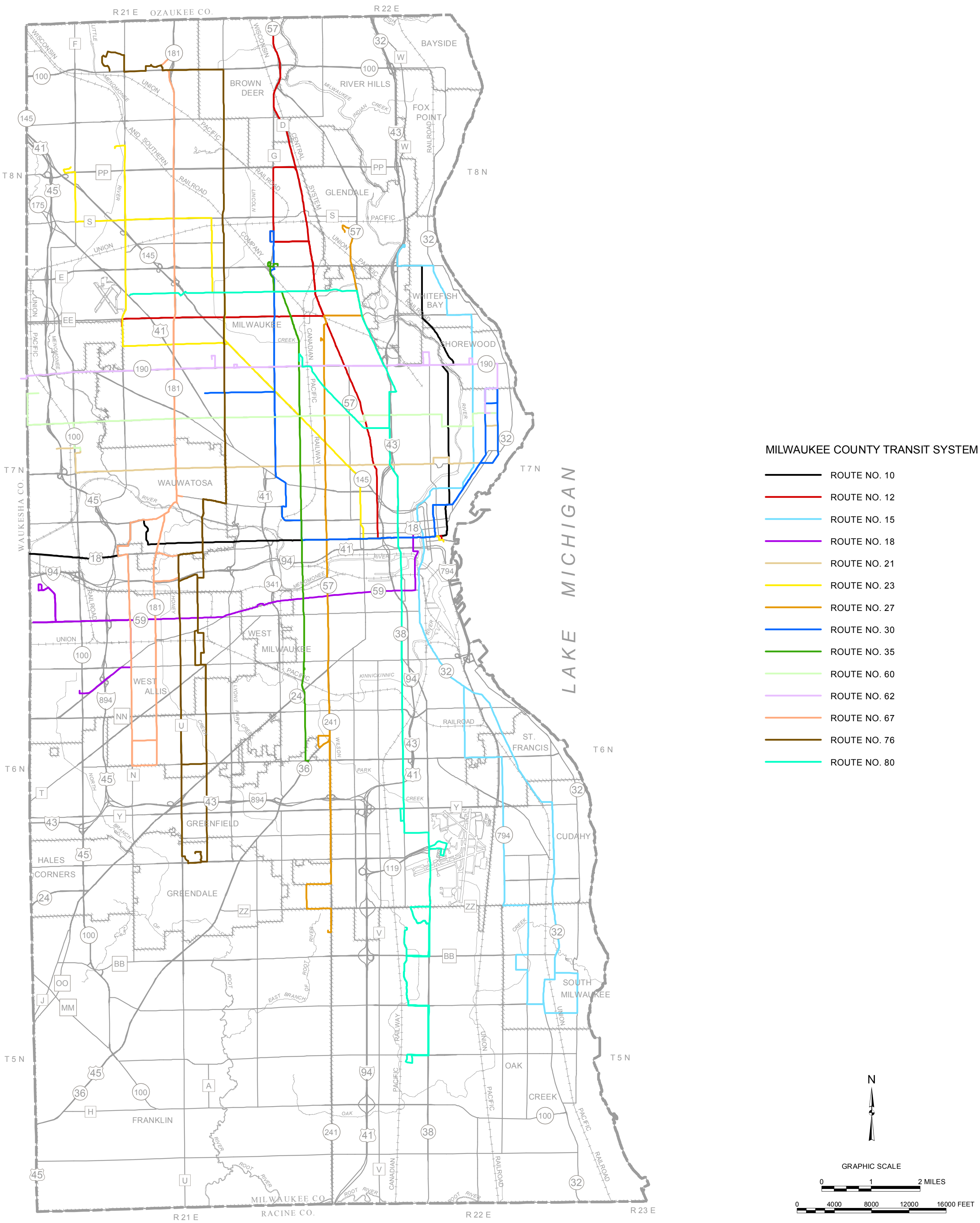
[a] *Includes Waukesha County Transit System routes operated by Milwaukee County Transit System.*

[b] *Based on actual operator counts taken during the months of September through May during 2000 and 2001 by the Milwaukee County Transit System.*

[c] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.*

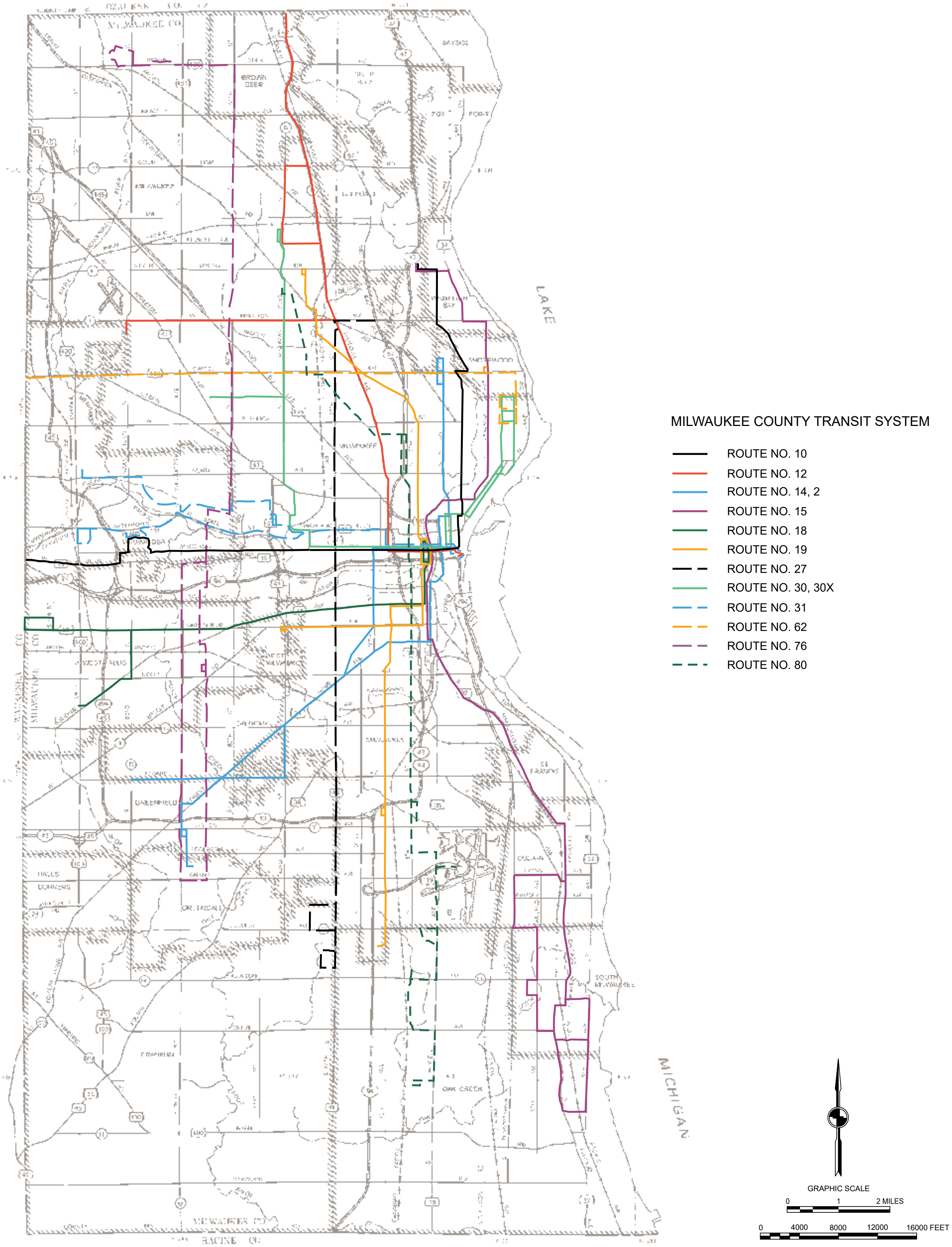
Source: SEWRPC

Map 4.8
Major Local and Express Bus Routes Operated by the Milwaukee County Transit System: 2011



Source: Milwaukee County Transit System and SEWRPC

Map 4.9
Major Local and Express Bus Routes Operated by the Milwaukee County Transit System: 2001



Source: Milwaukee County Transit System and SEWRPC.

Table 4.52
Comparison of Model Estimated and Traffic Count Estimated Arterial System Vehicle-Miles of Travel on an Average Weekday in the Region: 2011

County	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Traffic Counts (thousands)	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Travel Simulation Models[a] (thousands)	Percent Difference
Kenosha	3,497	3,112	-11.0
Milwaukee	16,210	14,672	-9.5
Ozaukee	2,378	2,310	-2.9
Racine	3,468	3,756	8.3
Walworth	2,452	2,859	16.6
Washington	3,442	3,656	6.2
Waukesha	9,415	9,883	5.0
Region	40,862	40,248	-1.5

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

Table 4.53
Comparison of Model Estimated and Traffic Count Estimated Arterial System Vehicle-Miles of Travel on an Average Weekday in the Region: 2001

County	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Traffic Counts (thousands)	Estimated 2011 Average Weekday Vehicle-Miles of Travel from Travel Simulation Models[a] (thousands)	Percent Difference
Kenosha	3,126	3,163	1.2
Milwaukee	16,377	14,966	-8.6
Ozaukee	2,259	2,274	0.7
Racine	3,383	3,731	10.3
Walworth	2,335	2,600	11.3
Washington	3,095	3,454	11.6
Waukesha	9,107	9,319	2.3
Region	39,682	39,507	-0.4

[a] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.*

Source: SEWRPC

Map 4.10
Comparison of Model Estimated and Traffic Count Estimated Average Weekday Traffic Volume on Selected Arterial Streets and Highways: 2011

AVERAGE WEEKDAY TRAFFIC VOLUMES

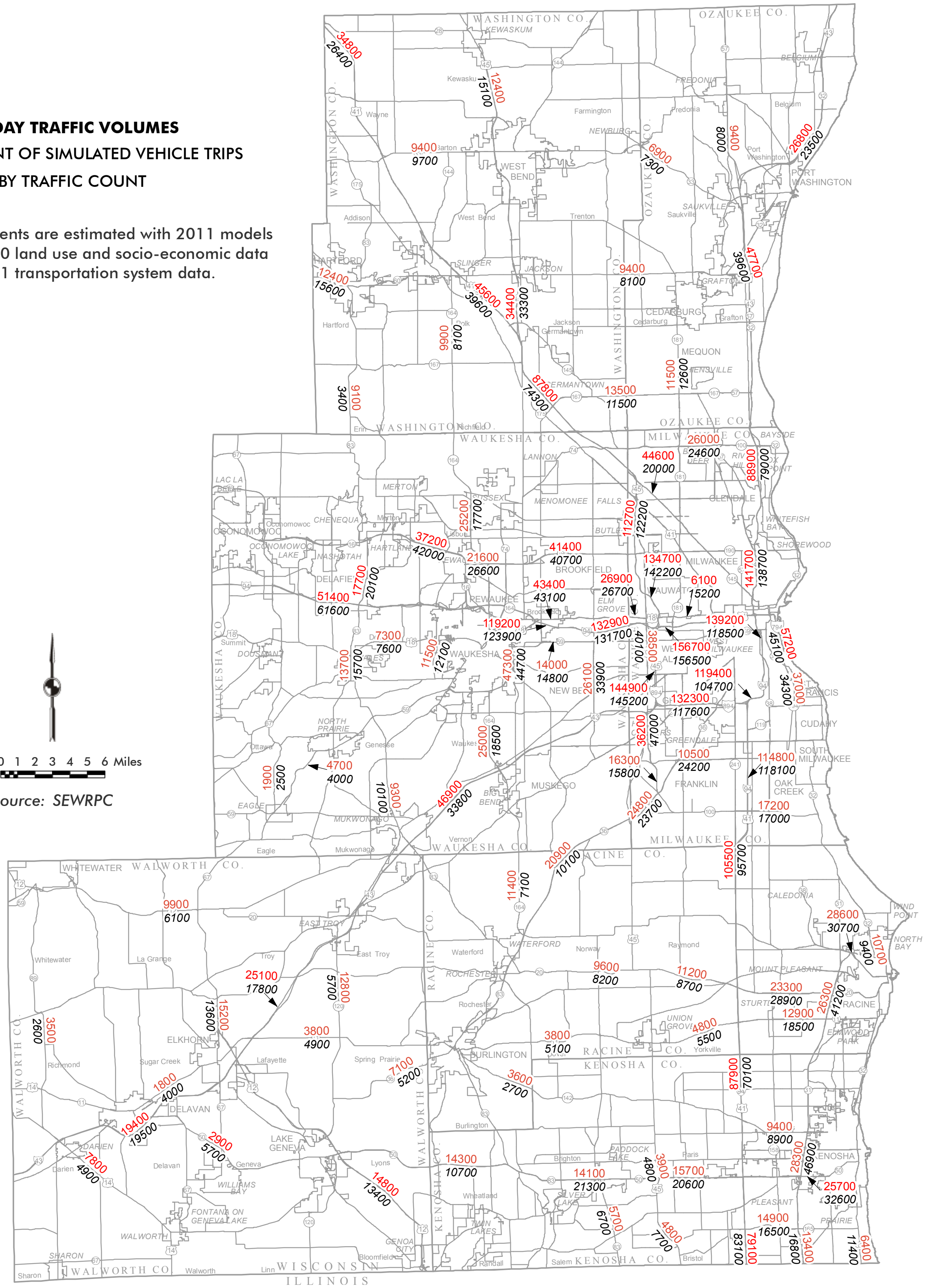
26000 ASSIGNMENT OF SIMULATED VEHICLE TRIPS

24600 ESTIMATED BY TRAFFIC COUNT

Note: Assignments are estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.

0 1 2 3 4 5 6 Miles

Source: SEWRPC



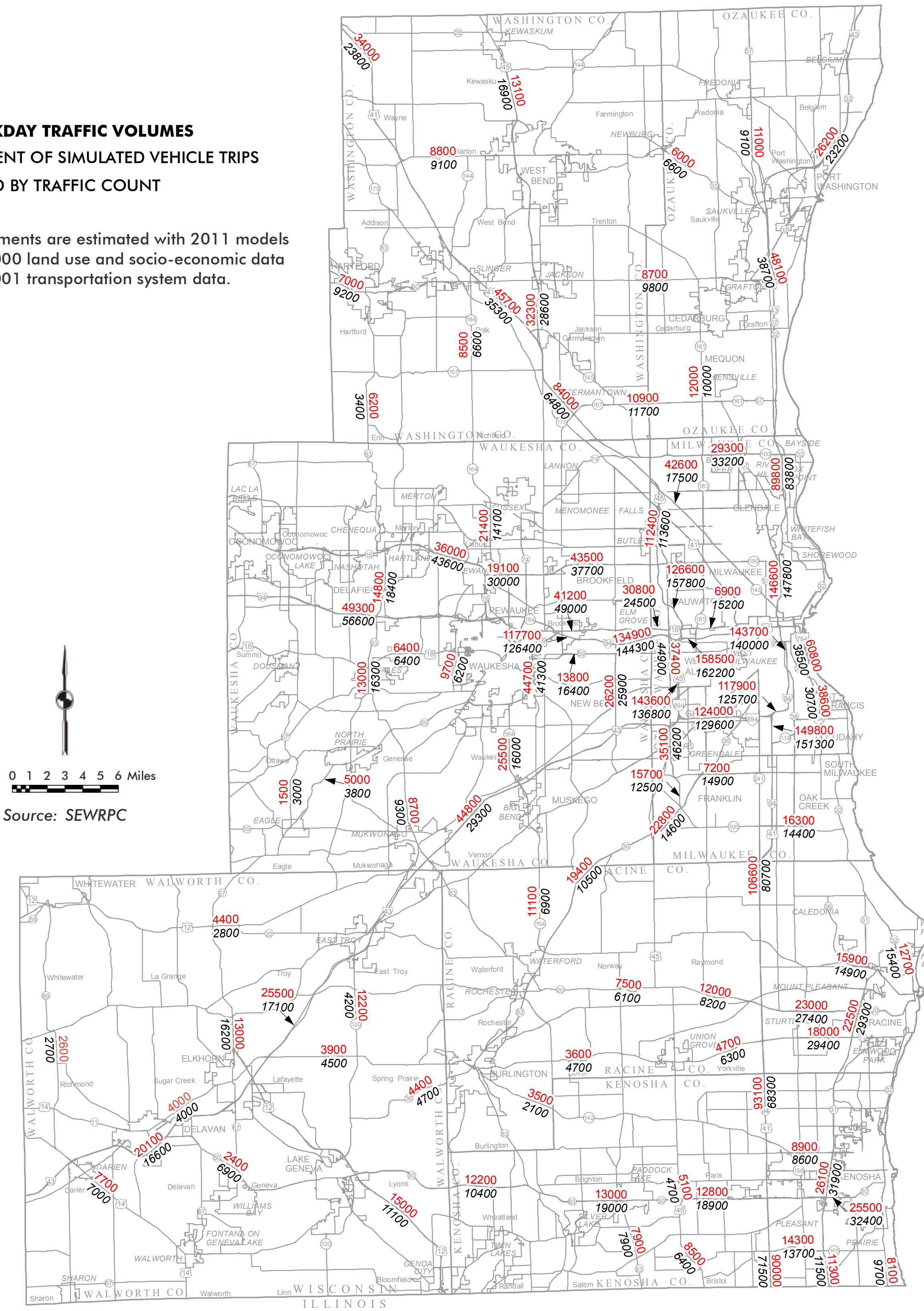
Map 4.11
Comparison of Model Estimated and Traffic Count Estimated Average Weekday Traffic Volume on Selected Arterial Streets and Highways: 2001

AVERAGE WEEKDAY TRAFFIC VOLUMES

26000 ASSIGNMENT OF SIMULATED VEHICLE TRIPS

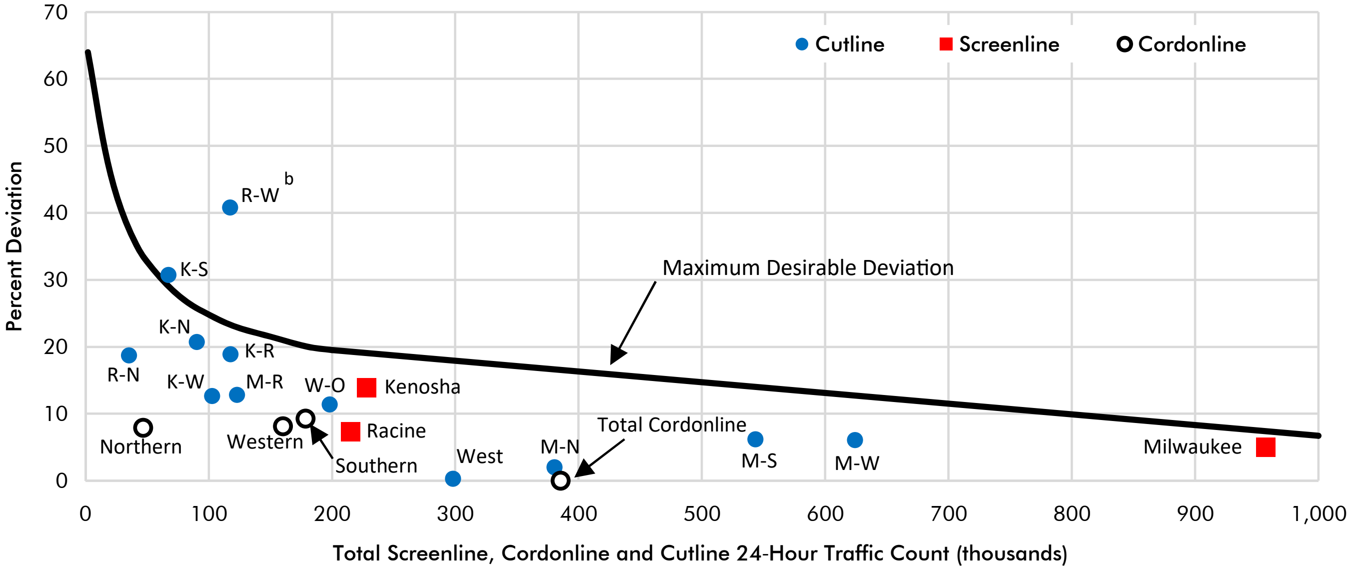
24600 ESTIMATED BY TRAFFIC COUNT

Note: Assignments are estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.



Source: SEWRPC

Figure 4.15
Maximum Desirable Deviation in Total Screenline, Cordonline, and Cutline Volumes: 2011[a]

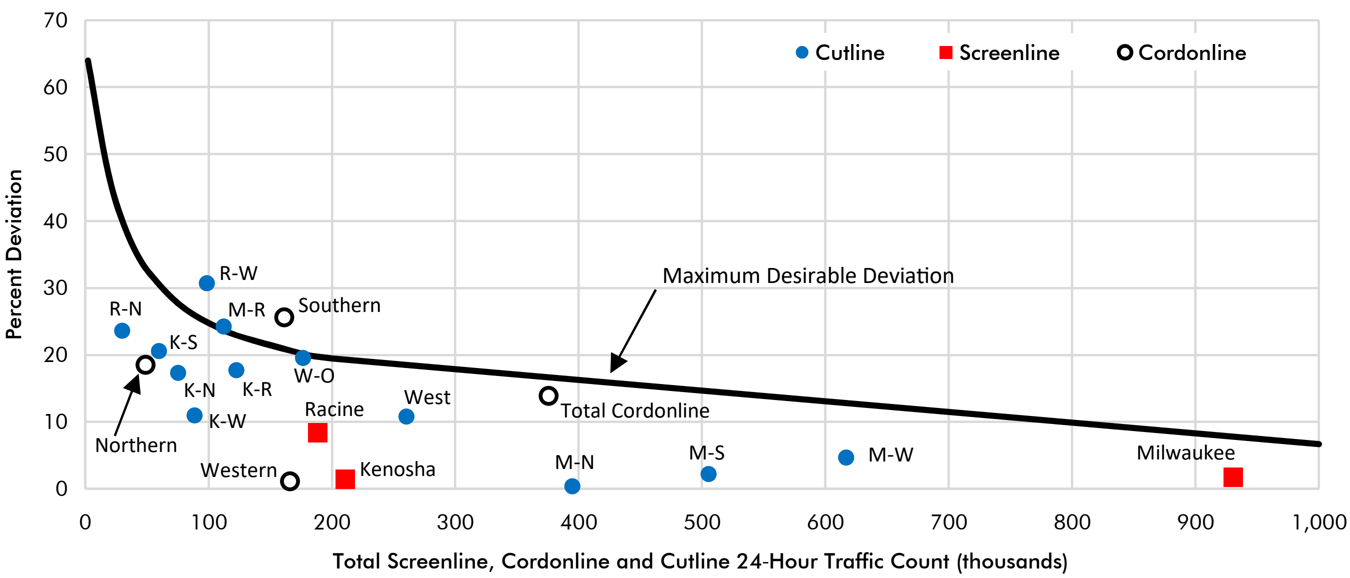


[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

[b] *A review of historical traffic count data indicates that the 2011 counts may be high by approximately 14,000 vehicles. Adjusting for this discrepancy, Commission staff estimates the actual deviation to be 31.8 percent.*

Source: Travel Model Validation and Reasonableness Checking Manual, Second Edition, Travel Model Improvement Program (TMIP), National Cooperative Highway Research Program (NCHRP) Report 255, and SEWRPC

Figure 4.16
Maximum Desirable Deviation in Total Screenline, Cordonline, and Cutline Volumes: 2001[a]

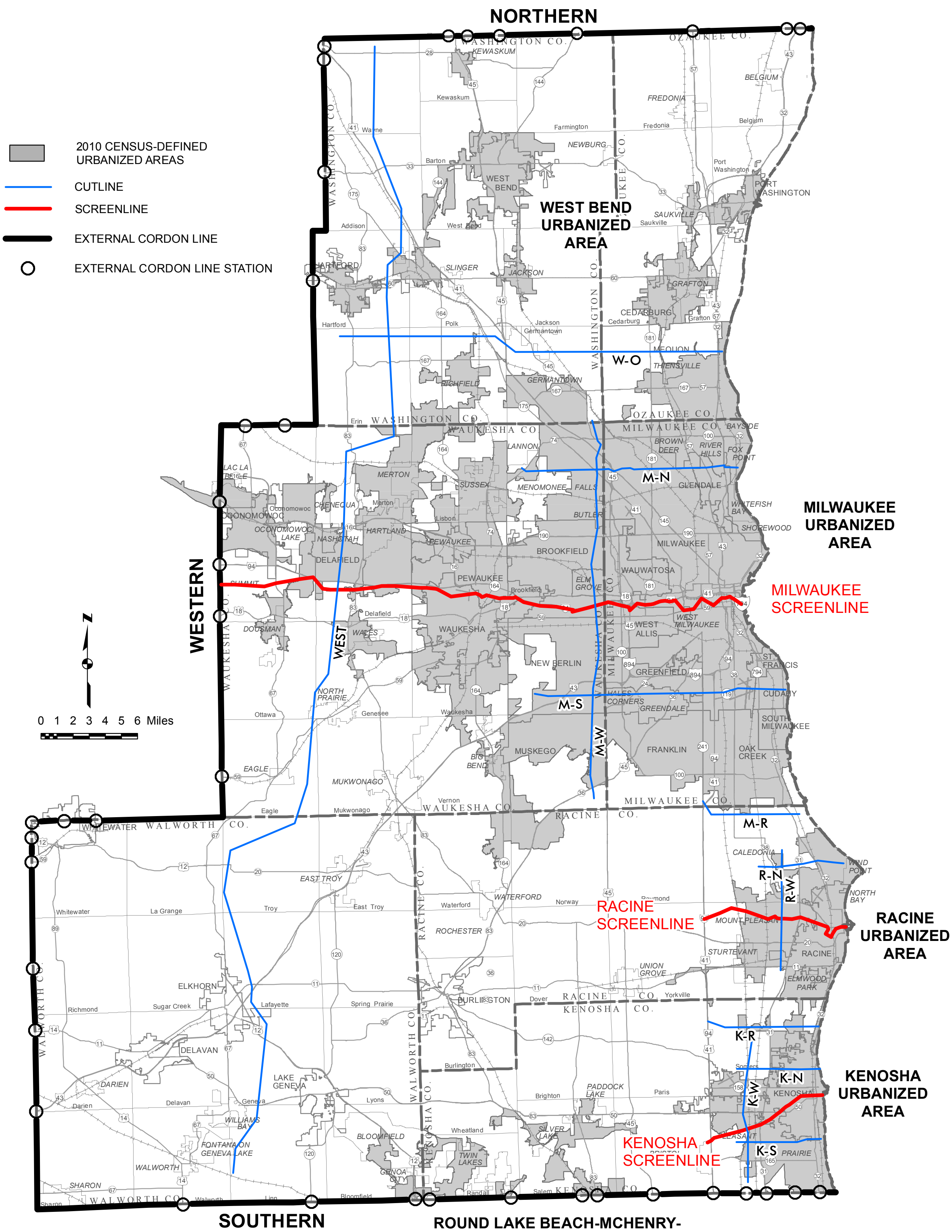


[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: Travel Model Validation and Reasonableness Checking Manual, Second Edition, Travel Model Improvement Program (TMIP), National Cooperative Highway Research Program (NCHRP) Report 255, and SEWRPC

Map 4.12

Travel Demand Model Cordonline, Cutline, and Screenline for Accuracy Checks



Source: U.S. Bureau of the Census and SEWRPC.

Table 4.54
Root Mean Squared Error Comparison of Model Estimated Average Weekday Traffic Assignment Relative to Estimated Actual Count by Count Volume Range: 2011[a]

Average Weekday Traffic Volume	Number of Links	RMSE	Percent RMSE (Target)	Percent RMSE (Actual)
0 to 4,999	3,607	1,591	100.0	63.0
5,001 to 9,999	1,743	2,938	45.0	41.8
10,000 to 14,999	500	4,076	35.0	33.6
15,000 to 19,999	210	5,272	30.0	30.9
20,000 to 29,999	95	6,887	27.0	29.6
30,000 to 39,999	43	5,893	25.0	16.6
40,000 to 49,999	35	5,701	25.0	12.8
50,000 to 59,999	25	7,387	20.0	13.4
Greater than 60,000	78	5,518	19.0	7.8
Average	6,336	2,787	45.0	40.9

[a] *Estimated with 2011 models and 2010 land use and socio-economic data and 2011 transportation system data.*

Source: SEWRPC

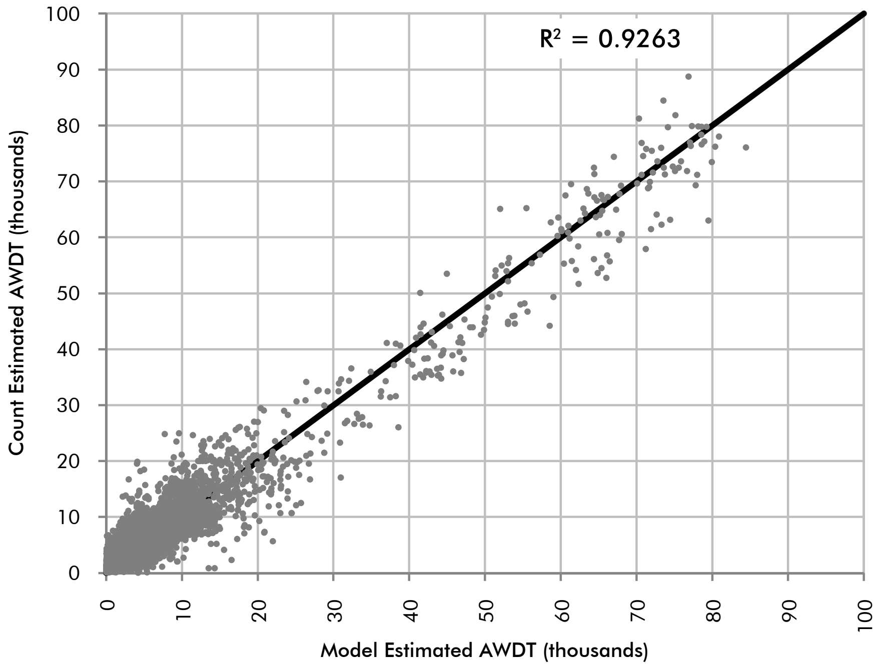
Table 4.55
Root Mean Squared Error Comparison of Model Estimated Average Weekday Traffic Assignment Relative to Estimated Actual Count by Count Volume Range: 2001[a]

Average Weekday Traffic Volume	Number of Links	RMSE	Percent RMSE (Target)	Percent RMSE (Actual)
0 to 4,999	3,509	1,602	100.0	64.0
5,001 to 9,999	2,063	2,982	45.0	42.0
10,000 to 14,999	556	4,420	35.0	36.6
15,000 to 19,999	220	4,740	30.0	28.0
20,000 to 29,999	46	5,576	27.0	23.9
30,000 to 39,999	44	9,323	25.0	27.3
40,000 to 49,999	12	7,506	25.0	17.5
50,000 to 59,999	13	3,588	20.0	6.5
Greater than 60,000	55	7,825	19.0	10.5
Average	6,518	2,841	45.0	44.3

[a] *Estimated with 2011 models and 2000 land use and socio-economic data and 2001 transportation system data.*

Source: SEWRPC

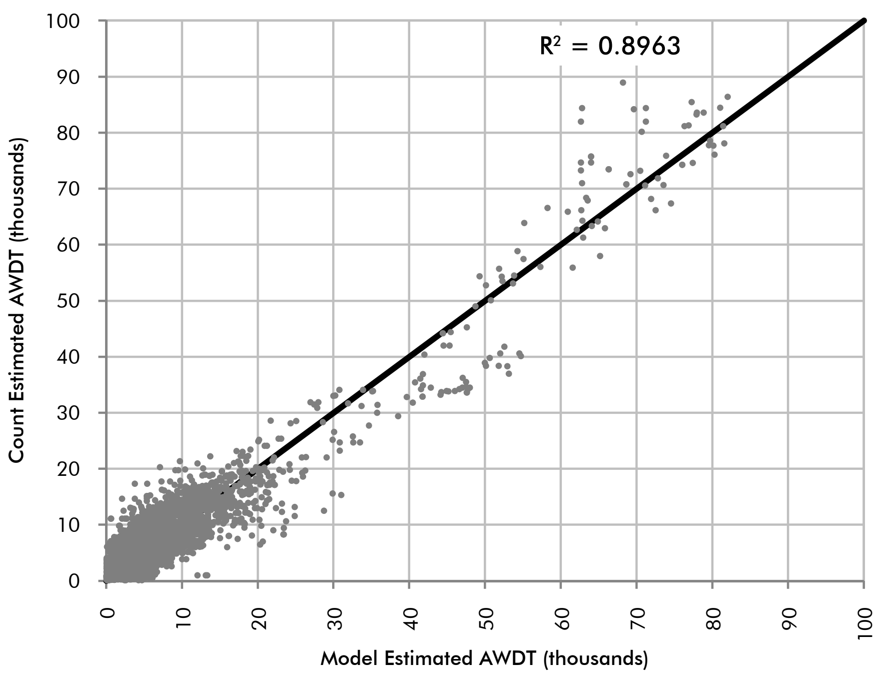
Figure 4.17
Comparison of Traffic Count and Model Estimated Average Weekday Traffic on Arterial Street and Highways in the Region: 2011[a]



[a] *Estimated with 2011 models and 2010 land use and socioeconomic data and 2011 transportation system data.*

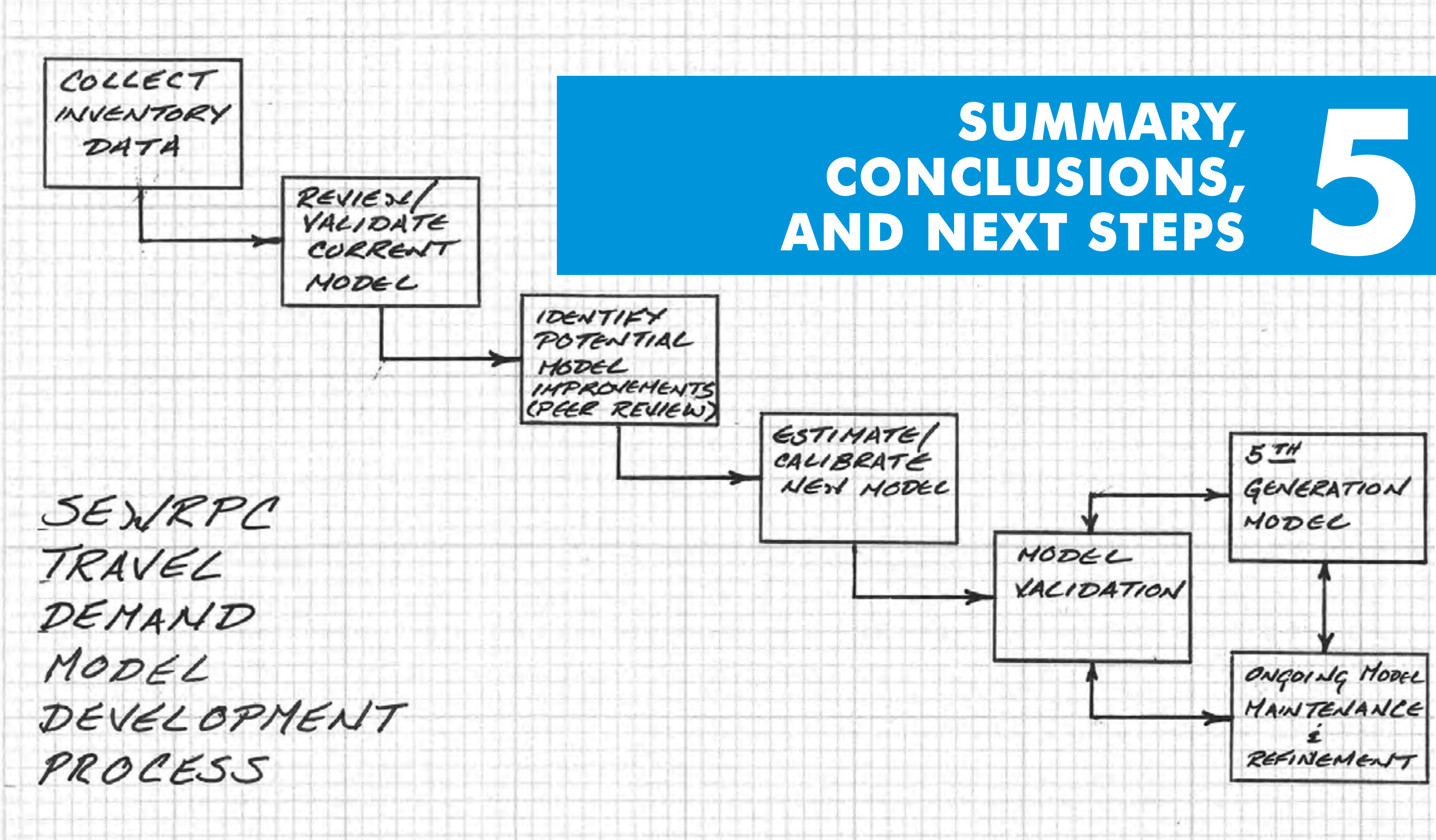
Source: SEWRPC

Figure 4.18
Comparison of Traffic Count and Model Estimated Average Weekday Traffic on Arterial Street and Highways in the Region: 2001[a]



[a] *Estimated with 2011 models and 2010 land use and socioeconomic data and 2011 transportation system data.*

Source: SEWRPC



SUMMARY, CONCLUSIONS, AND NEXT STEPS 5

Credit: SEWRPC Staff

This report describes the travel simulation models used in the design, test, and evaluation of the alternative transportation plans under the regional transportation plan preparation process. These models and the relationships and techniques incorporated in these models are important because they provide the technical basis for the design of a regional transportation plan that is properly related to the travel patterns that the planned system must serve, and they provide the necessary link between land use and transportation planning.

The Commission has over 50 years of experience in travel simulation modeling. The initial travel simulation models were developed in 1963, utilizing the findings of a comprehensive travel survey and applied in the initial regional land use-transportation study. The initial models were validated in 1972, utilizing the results of a second full-scale travel survey and demonstrated to simulate accurately 1972 travel patterns, arterial street and highway traffic volumes, and transit ridership. Some refinements were made to the models in 1972 before their application in the second-generation transportation study. A similar validation and subsequent refinement of the models occurred in 1991, 2001, and 2011, with the fifth generation of travel models produced with 2011-2012 data. The Commission staff thus has demonstrated expertise and experience in the development and application of travel simulation models, as well as intimate knowledge of the travel habits and patterns of the Region and of changes in these habits and patterns over time. The Commission believes that the most rigorous test possible of a set of travel simulation models consists of applying the full set of models to socio-economic and transportation system data from a year, be it past or future, other than the year of the data from which the models were calibrated and then comparing the model-estimated travel and traffic to survey-estimated travel and actual measured traffic counts. The Commission models have passed this test, not once, but four times, as demonstrated by comparisons indicating model-estimated traffic volumes are generally within 10 percent of ground traffic counts.

The travel simulation process used by the Commission consists of four major steps: trip generation, trip distribution, modal split, and traffic assignment. The first step in the development of these models for the fifth-generation planning effort consisted of an assessment of the models developed and used in the fourth-generation land use-transportation planning effort. Such an assessment was possible because the findings of five identical large-scale comprehensive travel surveys were available for 1963, 1972, 1991, 2001, and 2011, allowing the testing of the temporal stability of the models. Despite the changes in socio-economic conditions, in land use development, and in transportation system development that occurred, the travel simulation models from the first-, second-, third-, and fourth-generation planning efforts demonstrated an ability to simulate current travel habits and patterns with accuracy.

In spite of the excellent performance of the travel and traffic forecasting models developed under the first-, second-, third-, and fourth-generation transportation planning efforts and the conclusions that these models could continue to be used with confidence in either their original form or in a refined form through re-calibration with more recent travel survey data, certain refinements in the models were determined to be desirable.

To assist in the development of the fifth-generation travel demand model, a peer review of the fourth-generation travel demand models was conducted in December 2014. This review identified potential model enhancements to include in the fifth-generation models to ensure that the models are consistent with current modeling practice. The peer review was conducted by a panel of three nationally recognized modeling experts from across the nation. The recommendations of the peer review panel are documented in Table 3.1.

A summary description of the fifth-generation travel simulation models used in the VISION 2050 planning effort can be found in Table 4.1. Each of these models was individually validated by using travel survey data; the entire model process chain was validated by comparing the outputs of the models to observed ground counts, transit and highway. The development and validation of the fifth-generation travel demand models not only included a test of the models' ability to estimate travel in the models' base year (2011), but also a test of the models' ability to simulate travel in the year 2001. This extra test provides an extra level of confidence in the stability of the model relationships and models' ability to accurately estimate future traffic volumes. This additional test is even more significant when considering the significant economic changes that occurred between 2001 and 2011. These analyses clearly demonstrated the validity of the calibrated models to predict travel and traffic conditions with accuracies adequate for transportation system planning and engineering. The Commission models are believed to provide the Region with a technically sound transportation systems planning tool that is consistent with current modeling practice and can be used with confidence in the planning and design of surface transportation facilities within the Region.

NEXT STEPS

The new travel demand models fully incorporate all but six of the potential model improvements suggested by the peer review panel. The exclusion of the proposed model improvements from the fifth-generation travel demand model battery was primarily due to the complexity of implementing these proposed improvements within the schedule of the VISION 2050 planning effort. The discussion below details what attempts were made to estimate and calibrate these proposed model enhancements and Commission staff's justification for not including the potential model improvements in the fifth-generation travel demand model used in the VISION 2050 planning effort. Also included in the discussion is how the proposed improvement fits into the ongoing maintenance and refinement of the fifth-generation travel demand models following the conclusion of the VISION 2050 planning effort.

With regard to the recommendation to consider using a different definition of area type based on the density of intersections or street grid to define a "nonmotorized friendly" area type as an alternative to the urban, suburban, and rural definition based on population and employment, the fifth-generation travel demand moved the estimation of nonmotorized trips out of trip generation and included it as one of the potential modes in the mode choice step. As shown in Figures 4.5 and 4.6, the nonmotorized mode choice is sensitive to trip distance, whether the trip is an intrazonal trip, whether a household is a zero auto household, and the area type (urban, suburban, or rural). During the estimation of the mode choice models, intersection density and street grid were considered but a stronger correlation with the existing population and employment density based urban area type was found. No further refinement to incorporate a "nonmotorized friendly" area type is planned at this time.

With regard to the consideration of local, express, and rapid transit modes separately in the mode choice models, the fifth-generation mode choice models continue the practice of grouping all transit together. Commission staff concluded that the continued treatment of transit as a single mode in the mode choice model was appropriate since the transit service provided in the region is so heavily dominated by local service. As the Commission considers refinements to the mode-choice models in the future attendant to improvements in the transit assignment methodology this decision to group transit into a single mode will be reconsidered.

With regard to the use of generalized cost in highway path building, Commission staff has in the past considered using generalized cost with limited success. Commission staff again considered incorporating generalized cost as part of the fifth-generation trip assignment step, but based on past experience reduced the priority of this improvement. During the development of the fifth-generation travel demand model, there was insufficient time to work on this recommendation. An attempt to incorporate generalized cost into the path builder for the trip assignment step will be made in future updates to the fifth-generation travel demand model as part of the Commission's ongoing model maintenance and refinement efforts.

With regard to the consideration of the use of alternative volume delay functions (VDF) in the trip assignment step, Commission staff made an attempt to incorporate both the Akcelik and Conical VDF forms during the development of the fifth-generation travel demand model. Both VDF function forms reduced the accuracy of the traffic assignment and Commission staff concluded that continued use of the Bureau of Public Roads (BPR) based VDFs was the most appropriate. Since the Akcelik and Conical based VDFs have an improved ability to account for queuing on a link, an attempt to incorporate these VDF forms into the Commission's time-of-day assignment methodology will be made as part of a future update to this model.

With regard to the consideration of the proposed assignment of automobile travel to park-ride lots, Commission staff will incorporate it as part of the Commission's ongoing model maintenance and refinement efforts. Its exclusion from the fifth-generation travel demand model was due to the schedule required for the VISION 2050 planning effort.

With regard to the peer review panel's recommendation that the Commission consider developing linkages between the statewide freight model and commercial vehicle travel, Commission staff, as noted in Chapter 3, had already initiated coordination efforts with the Wisconsin Department of Transportation. Commission staff scheduled a workshop in 2016 to review the fifth-generation travel demand model battery with interested WisDOT, FHWA, and FTA staff. Discussion related to how the Commission and WisDOT traffic models can interact, especially with regard to freight and commercial truck travel, was reinitiated at this meeting. Future meetings will be scheduled to discuss this topic.

In addition to the above potential refinements to the fifth-generation travel simulation model battery, Commission staff has identified additional modeling efforts to be pursued over the next few years and upon conclusion of the VISION 2050 planning effort. The list of refinements is as follows:

- Update and refinement of the Commission's time-of-day assignment methodology and consideration as to how to incorporate methodology into the fifth-generation travel demand model battery.

- Refinement of the nonhome-based models to better focus changes in nonhome-based trip making to those areas of the Region where changes in household and employment levels would be expected to impact nonhome-based trip making.

- Network coding refinements and requisite model script enhancements to incorporate more directly the impacts of traffic controls on the arterial street and highway system.

- Ongoing improvements to modeling scripts to improve model run times.

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