Travel Demand Model Documentation

Technical Report

Addendum to the Connect: 2050 Quad Cities Long Range Transportation Plan

August 2021

Bi-State Regional Commission

Travel Demand Model Technical Report

Addendum to Connect QC 2050: Quad Cities Long Range Transportation Plan

Approved August 24, 2021

by the Quad Cities MPO Transportation Policy Committee

Representing comprehensive, cooperative and continuing transportation planning for the Davenport, Iowa-Illinois Urbanized Area (Quad Cities) by:

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Illinois Department of Transportation
Iowa Department of Transportation
And
Local Units of Government

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ABSTRACT

TITLE:	Travel Demand Model Technical Report Addendum to Connect QC 2050: Quad Cities Long Range Transportation Plan
AUTHOR:	Bi-State Regional Commission Staff
SUBJECT:	An addendum to the Quad Cities Long Range Transportation Plan documenting the processes and procedures used by the Metropolitan Planning Organization, known as the Quad Cities MPO, as part of metropolitan travel demand forecasting for the Quad Cities metropolitan planning area.
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ABSTRACT:	A metropolitan planning organization must prepare a transportation plan in accordance with 49 USC 5303 (i) that inventories modal transportation facilities and looks at factors influencing the metropolitan transportation system over a 20-year forecast period. A travel demand model is used to forecast future traffic based on projections of land use activities in a base year (2015) and horizon years (2030 and 2050). The technical report outlines the data inputs and methodology used to project future traffic within the Quad Cities metropolitan planning area.

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1.0 Introduction

A travel demand model is designed primarily for use in transportation planning at a regional scale, such as in the development of the long-range transportation plan or for regional air quality emissions analyses. The Bi-State Regional Commission (BSRC), the Metropolitan Planning Organization (MPO) for the Davenport, Iowa-Illinois Urbanized Area, utilizes a travel demand model as a decision-making tool to assist with transportation planning, prioritizing, and coordinating roadway projects within the metropolitan area.

The *Connect 2050: Quad Cities Long Range Transportation Plan* (2050 LRTP) used a base year of 2015 and two horizon years of 2030 and 2050. The base year was selected to represent the most recently available Annual Average Daily Traffic (AADT) for the metropolitan area. The years 2030 and 2050 were selected as the short-term and long-term horizon periods for transportation system analysis and evaluations.

This model documentation technical report outlines the main steps and assumptions involved in developing the BSRC travel demand model for the metropolitan area as part of the 2050 LRTP update. The technical report assumes the audience has a general background in travel demand modeling and detailed knowledge for the Quad Cities metropolitan area.

1.1 Four-Step Travel Model

A travel demand model estimates existing and forecasted trips on the transportation system. Bi-State Regional Commission implemented the travel demand modeling process using TransCAD, an integrated transportation modeling and GIS software package developed by Caliper Corporation. The geographic area covered by the travel demand process includes part of Scott, Rock Island, and Henry Counties that represent the Quad Cities Metropolitan Planning Area (MPA).

A travel demand model is used for decision-making. It is a tool to perform a comprehensive metropolitan transportation analysis and test specific land use and roadway changes or scenarios at different periods of time. It is also used to evaluate traffic impacts resulting from changes in traveler behavior. Some of the most useful model outputs include:

- Directional link vehicle volumes
- Intersection turning movement volumes
- Network Level-of-Service (LOS)

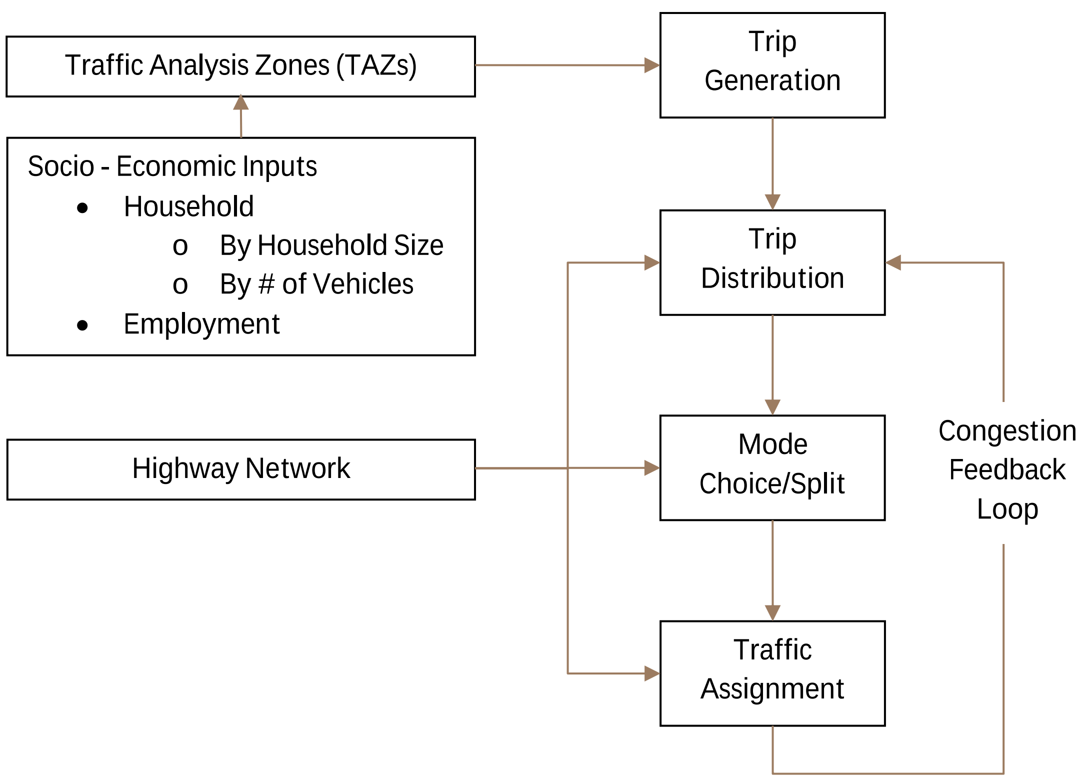
The travel demand model for the Quad Cities MPA is based on traditional four-step trip based modeling process:

- Trip Generation
- Trip Distribution
- Modal Choice (Split)

- Traffic Assignment

An overview of the basic modeling process is shown in Figure 1.1. At the start of a full model run, trip generation uses socio-economic data to calculate trip ends at the Traffic Analysis Zone (TAZ) level. These trip ends are then paired into trip tables in the distribution module, based on travel time "skimmed" from the highway network. The modal split step of the modeling process utilizes travel survey results to proportion total trips into vehicle, transit, non-motorized, and other trips. In the next step, vehicle trips are assigned to the highway network in the assignment module.

Figure 1.1 – Four Step Travel Demand Model



1.2 History of Model Development

The first generation of the BSRC travel demand model was built in TranPlan, which was a software package developed by the Urban Analysis Group. Since 2001, Bi-State Regional Commission shifted the TranPlan model platform to TransCAD in coordination with the Iowa DOT. The aim was to update the model software to be consistent with what the Iowa DOT and other MPOs in the state use.

Prior to this 2045 LRTP model, TransCAD was used to conduct the modeling process except for trip generation. The trip generation step was done in a spreadsheet program. It should be noted that the modal split step (person trips) used a different method for forecasting future travel demand.

In October 2008, the BSRC model went through a peer review as part of FHWA's Travel Model Improvement Program (TMIP). The following recommendations were made by the review panel. All of them have been achieved.

- Verify ES-202 employment data and be cautious about using labor force data in the development of demographic data inputs to the model
- Look into a second source of employment data
- Add trip rates for households without vehicle
- Add special generators for the commercial aviation airport and major regional malls
- Compare trip length frequency and average trip length against Census Transportation Planning Package (CTPP) data
- Use person trips instead of vehicle trips

A Certification Review of the transportation planning process for Quad Cities was performed by FHWA and FTA on April 16-18, 2012. The review was based on the 2040 LRTP model, and the review panel recommendations on model improvements are summarized below. All of these items have been addressed in the current 2045 LRTP model.

- Minimize using borrowed parameters
- Enhance the model document to include a description of the input data and calibration parameters for each model component and validation statistics such as RMSE
- Automate Trip Generation step in TransCAD
- Include transit mode share
- Build peak hour/time of day capabilities within the model structure
- Document how the model is used to select and prioritize projects

1.3 Iowa Standardized Model Structure (ISMS)

In November 2017, Iowa DOT released Iowa Standardized Model Structure (ISMS) Version 1.0. Taking into consideration the survey result from MTMUG and experience from other states, there are five purposes:

1. Institutionalize the use of travel demand model in the MPO planning and prioritization processes
2. Increase technical capabilities and understanding of MPO staff with respect to travel demand model development and application
3. Develop clear guidance and expectations with respect to the roles and responsibilities of travel demand modelers
4. Achieve a consistent approach to travel demand modeling across the state of Iowa's 9 MPOs

5. Implement ongoing development and maintenance practices to ensure continual readiness and currency of MPO travel demand models

As part of the *Connect 2050: Quad Cities Long Range Transportation Plan* update and with the support from Iowa DOT, Bi-State completed the transition of its Travel Demand Model into Iowa Standardized Model Structure (ISMS). The QC ISMS has been successfully applied to the planning process of the 2050 LRTP, for the 2030 and 2050 traffic forecast, on fiscally-constrained and unconstrained highway networks in the region.

2.0 Model Data Requirements

A travel demand model forecasts the movements of people and goods within the study area in the present and future. Details of local activities, socio-economic pattern, and growth trend is crucial to developing a reasonable model.

There are two primary categories of inputs essentially required to produce results for a travel demand model. These include:

- Roadway Network
- Traffic Analysis Zones (TAZs) with Socio-Economic Data

Data for Roadway Network is similar to prior modeling practice: link ID, distance, speed, number of travel lanes, capacity; however, instead of collecting information within TAZs, population, employment, school enrollment, vehicle ownership, ISMS use parcel based information to cover land use characteristics. Measurements of each land use type are collected and used for later calculation of trips. Tables 2.1 and 2.2 list all the land use types, along with their brief and detailed descriptions for each parcel.

Table 2.1: Land Use Code Brief Description

Code	Label	Description	Predictive Variable
10	RES	Residential	Housing Units
11	SFD	Single-Family Detached	Housing Units
19	MHP	Mobile Home Park	Housing Units
20	SFA	Single Family Attached	Housing Units
21	APT	Apartment Building	Housing Units
22	DOR	Dormitory	Students
23	STUD	Student Housing	Housing Units
24	RET	Retirement Community	Housing Units
25	SNF	Skilled Nursing Facility/Assisted Living	KSF
26	HOT	Hotel/Motel	KSF
27	GQ	Group Quarters/Residence Hotel	Housing Units
28	FRAT	Fraternity/Sorority	Students
30	MFG	Manufacturing	KSF
31	IPK	Industrial Park/Light Industry	KSF
32	WAR	Warehousing	KSF

Code	Label	Description	Predictive Variable
33	FTER	Freight Terminal	Acres
34	STOR	Public Storage	Acres
35	EXT	Extractive Industry	Acres
36	LF	Junkyard/Dump/Landfill	Acres
40	CAIR	Commercial Airport	Annual Enplanements
41	GAIR	General Aviation Airport	Acres
42	ROW	Right-of-way	N/A
43	UTL	Communication/Utility	N/A
44	PARK	Parking	N/A
45	TERM	Passenger Terminal	N/A
50	SFC	Street Front Commercial	KSF
51	NSC	Neighborhood Shopping Center	KSF
52	CSC	Community Shopping Center/Big Box	KSF
53	RSC	Regional Shopping Center	KSF
55	AUC	Auto Dealership	KSF
56	SS	Service Station	KSF
57	FF	Fast Food	KSF
58	SDR	Sit-down Restaurant	KSF
59	ORC	Other Commercial	KSF
60	GO	General Office	KSF
61	GOV	Government Office	KSF
62	HRO	High Rise Office	KSF
63	LIB	Library	KSF
64	PO	Post Office/Shipping Office	KSF
65	BNK	Bank	KSF
66	FS	Fire/Police Station	KSF
67	CEM	Cemetery	Acres
68	RF	Religious Facility	KSF
69	OPS	Other Public Service	KSF

Code	Label	Description	Predictive Variable
70	HOSP	Hospital	KSF
71	OHC	Other Health Care	KSF
73	REC	Recreational Use	KSF
74	CUL	Cultural Facility	KSF
75	CCEN	Convention Center	KSF
76	PA	Public Assembly	KSF
77	MIL	Military	Acres
78	JAIL	Prisons/Jails	KSF
79	TOUR	Tourist Attractions	KSF
80	PS	Day Care/Preschool	KSF
81	ELEM	Elementary School	Enrollment
82	JRHS	Junior High/Middle School	Enrollment
83	SRHS	Senior High	Enrollment
84	COLL	Post-Secondary	Enrollment
89	ORS	Other School	KSF
90	GC	Golf Course	Acres
91	CAS	Casino	KSF
92	STAD	Stadium/Arena	KSF
93	APRK	Active Park	Acres
94	PPRK	Passive Park	Acres
95	IAG	Intensive Agriculture	Acres
96	AG	Agriculture	Acres
99	VAC	Vacant	N/A
303	FPUB	Future Public/Government/Church/Recreational	Acres
304	FSPI	Future Semi-Public/Institutional	Acres
305	FOFF	Future Office	Acres
306	FCOM	Future Commercial	Acres
308	FIND	Future Industrial	Acres

Table 2.2: Land Use Code Detailed Description

Code	Label	Description
10	RES	Residential units can be coded as a generic residential use if detailed codes (11-24) are not used. Note all units should be included in totals, not only occupied units.
11	SFD	Single-family detached housing units are the most common residential use.
19	MHP	Mobile home park or manufactured home housing units are usually clustered in a single development with multiple units per parcel. These units are usually missing from parcel dwelling unit counts.
20	SFA	Single family attached housing units include duplexes where 2-3 units are on a single parcel; and condominium units which are multi-unit developments in a multi-story building, or single story buildings with shared common walls or buildings grouped around common areas.
21	APT	Apartment buildings are rental units with four or more units on a single parcel. Apartment buildings are usually included in commercial building files by tax assessor agencies.
22	DOR	Dormitory units are usually located within universities and would often not be identified as a separate use.
23	STUD	Student housing units are units occupied by college and university students without a head of household.
24	RET	Retirement communities are occupied by senior citizens and usually have multiple units on a single parcel.
25	SNF	Skilled nursing facilities, assisted living facilities, and hospices may have individual units that are included in US Census totals but whose occupants make few if any trips.
26	HOT	Hotel and motel developments may have adjoining restaurants or meeting space.
27	GQ	Group quarters are relatively rare, including transition housing, halfway housing, drug treatment residences, and long-term residence hotels. These uses are usually assigned an exempt classification code by tax assessor agencies.
28	FRAT	Fraternity and sorority houses are rare and would usually only be identified as a separate use when located off-campus; otherwise, they would be included as a university use.
30	MFG	Manufacturing uses are relatively rare and usually feature large complexes that include heavy industrial and other major manufacturing activities. There may be multiple shifts and other adjoining uses such as offices and storage areas.

Code	Label	Description
31	IPK	Industrial parks and light Industrial areas are one of the most common non-residential uses and would include a range of businesses such as small industries and contractors. These uses are often in mixed development areas with other uses such as offices and commercial.
32	WAR	Warehousing uses are relatively common and feature large buildings with truck bays.
33	FTER	Freight terminals are rare, often consisting of truck staging areas near freeways with few in any structures.
34	STOR	Public storage uses are relatively common and can be identified visually by adjoining storage sheds with small parking areas.
35	EXT	Extractive industrial uses are rare. They feature large tracts of land with few in any structures where sand a gravel mining often occurs.
36	LF	Junkyards, dumps, and landfills are rare. They feature large tracts of land with few in any structures and are usually visually easy to identify.
40	CAIR	Commercial airports have scheduled flights by commercial carriers. There is usually one commercial airport in each urban area. Parcels often include terminals, runways, parking lots, and hangers.
41	GAIR	General aviation airports and landing strips are rare. They feature large tracts of land with few in any structures and are usually visually easy to identify.
42	ROW	Road rights-of-way are not included in parcel files. Other rights-of-way for uses such as utility easements are relatively rare. These uses feature large, elongated parcels with no development.
43	UTL	Communication towers and other utility uses are rare.
44	PARK	Most parking lots are included with adjoining uses. Stand-alone parking lot uses are rare and usually only occur in downtown areas.
45	TERM	Passenger terminals for buses and railroads are rare. Commercial airport passenger terminals are included with the commercial airport use (40).
50	SFC	Street front commercial uses are one of the most common non-residential uses. They are usually stand-alone business along streets with limited on-site parking and may include businesses such as beauty shops, small hardware stores, and dry cleaners.
51	NSC	Neighborhood shopping centers are quite common and feature a single building, adjoining buildings, or multiple buildings clustered around a common parking lot. They often include a range of businesses such as grocery stores, restaurants, small shops, and offices.

Code	Label	Description
52	CSC	Community shopping centers and big box developments are usually larger in size than neighborhood shopping centers and include one or more major tenants. They feature buildings clustered around a common parking lot
53	RSC	There are usually only one or two regional shopping centers in an urban area with several anchor stores.
55	AUC	Auto dealerships feature large parcels with large parking areas. Lower-end used car dealers would usually be coded as other commercial (59).
56	SS	Service or gas stations are quite common and often include mini-markets.
57	FF	Fast food restaurants are usually located on small stand-alone parcels with a high turnover restaurant, often with drive-through facilities.
58	SDR	Sit-down restaurants are usually located on stand-alone parcels that are usually larger than fast food restaurant parcels and may have larger parking facilities.
59	ORC	Other commercial uses are meant to identify a range of commercial uses that generate fewer trips than the other commercial land uses (50-58) and may include repair shops, equipment rental shops, and stores that are in decline.
60	GO	General office uses are one of the most common non-residential uses and would include a range of businesses such as insurance agencies, legal firms, real estate agencies, tech firms, and corporate offices. These uses are often in mixed development areas with other uses such as light industrial and commercial.
61	GOV	Government offices include municipal buildings, courthouses, and Department of Motor Vehicle offices. Large state office buildings are rare and would be assigned a general or high-rise office code (60, 62). Government offices are usually assigned an exempt classification code by tax assessor agencies
62	HRO	High rise office uses are rare, usually located in downtown areas, and identify office buildings with 4 or more floors.
63	LIB	Libraries identify stand-alone libraries not affiliated with schools. Libraries are usually assigned an exempt classification code by tax assessor agencies.
64	PO	Post offices and other shipping offices such as FEDEX and UPS are relatively rare. Post offices are usually assigned an exempt classification code by tax assessor agencies.
65	BNK	Banks and credit unions are a relatively common non-residential use. These uses may be located inside shopping centers or general office buildings in which case they would not be separated out.

Code	Label	Description
66	FS	Fire and police stations are usually assigned an exempt classification code by tax assessor agencies.
67	CEM	Cemeteries feature large tracts of land with few if any structures and are usually visually easy to identify.
68	RF	Religious facilities including churches, synagogues, and mosques are usually assigned an exempt classification code by tax assessor agencies.
69	OPS	Other public service uses are relatively rare. They include a range of low generating uses such as water treatment plants and municipal storage yards. They are usually assigned an exempt classification code by tax assessor agencies.
70	HOSP	There are usually only a few hospital parcels in an urban an urban area.
71	OHC	Other health care uses are rare, most often medical office buildings near hospitals.
73	REC	Recreational uses are relatively rare and would include skating rinks and other recreational facilities housed in indoor facilities. Outdoor recreational uses would usually be categorized as active parks (93).
74	CUL	Cultural facilities are rare and would include museums, historical sites, botanical gardens, concert halls, and performance theaters.
75	CCEN	Convention centers are rare. Most urban areas would only have one and many would not have any. Convention centers that are a part of hotel uses (26) would not be separated out.
76	PA	Public assembly uses are rare, including such uses as fraternal organizations and union halls.
77	MIL	Military bases include uses such as barracks, administrative offices, airfields used by the US Army, US Airforce, or National Guards. Military bases are usually assigned an exempt classification code by tax assessor agencies.
78	JAIL	Prisons and jails uses are usually assigned an exempt classification code by tax assessor agencies.
79	TOUR	Tourist attractions are rare and may not be present in some urban areas. Uses include amusement parks, water parks, zoos, and fairgrounds.
80	PS	Day care and pre-school uses are relatively common non-residential uses. In-home child care would be assigned a residential use (10 or 11).
81	ELEM	Elementary schools can include grades kindergarten through eight, although the range of grade levels varies. In some instances, elementary schools occur on parcels with religious facilities or other schools. Those parcels should be split if possible. School parcels are usually assigned an exempt classification code by tax assessor agencies.

Code	Label	Description
82	JRHS	Junior high and middle schools can include grades six through nine, although the range of grade levels varies. In some instances, junior high schools occur on parcels with religious facilities or other schools. Those parcels should be split if possible. School parcels are usually assigned an exempt classification code by tax assessor agencies.
83	SRHS	Senior high schools can include grades nine through twelve, although the lower grade level varies. In some instances, high schools occur on parcels with religious facilities or other schools. Those parcels should be split if possible. School parcels are usually assigned an exempt classification code by tax assessor agencies.
84	COLL	Post-secondary community colleges, technical colleges and other small colleges are usually commuter colleges with limited or no campus housing. School parcels are usually assigned an exempt classification code by tax assessor agencies. Employment for Staff and Students is only needed if a University sub-model is being pursued.
89	ORS	Other schools are rare, including beauty and other post-secondary trade schools.
90	GC	Golf course and club houses are rare and feature large, irregularly shaped parcels that are usually visually easy to identify.
91	CAS	Gaming casinos are rare and may not be present is some urban areas. Casinos may have adjoining uses such as hotels and restaurants that would usually not be separated out.
92	STAD	Stadiums and arenas for viewing professional and amateur sports are rare. Stadiums that are located adjacent to schools or within universities are usually not identified as a separate use.
93	APRK	Active parks are relatively common, usually including ball fields, tennis courts or other outdoor sports facilities with few in any structures. Park parcels are usually assigned an exempt classification code by tax assessor agencies.
94	PPRK	Passive parks are rare, featuring large tracts of low intensity uses such as hiking or nature trails. Park parcels are usually assigned an exempt classification code by tax assessor agencies.
95	IAG	Intensive agriculture uses are rare, including nurseries and seed farms with few if any structures.
96	AG	Agricultural and farming uses are common in outlying parts of planning areas. Uses can Include cropland, barns, out buildings and farm houses.
99	VAC	Vacant uses are common in developing urban areas where land has been subdivided into parcels but structures have not been built. Most other inactive uses are coded as another use such as right-of-way.

Code	Label	Description
303	FPUB	Future Public/Government/Church/Recreational
304	FSPI	Future Semi-Public/Institutional
305	FOFF	Future Office
306	FCOM	Future Commercial
308	FIND	Future Industrial

2.1 Area Profile and Geographies

An area profile was prepared in Chapter 1 of the *Connect 2050: Quad Cities Long Range Transportation Plan* and is summarized here to provide an overview of the background socio-economic patterns and growth trends.

The Quad Cities Iowa/Illinois Metropolitan Planning Area (MPA) is located along the Mississippi River at the Eastern Iowa-Western Illinois border. It is defined as the Census-designated urbanized area, plus its expected growth boundary during 2050 planning horizon. The MPA covers approximately 391.12 square miles, including portions of Henry and Rock Island Counties, Illinois and Scott County, Iowa. These three counties altogether are also referred as the MPA region. According to U.S. Census data, the MPA had a population of 283,320 in 2018, which is 77.2% of the total population in MPA region (three-county area) at 367,027 in 2018.

The Quad Cities Area Profile outlines the basic socio-economic elements of population, household, employment, education, and other elements for the MPA and MPA region (three-county area). This profile is based on data from the U.S. Census, unless otherwise noted (Cross-reference Chapter 1 of the *Connect 2050: Quad Cities Long Range Transportation Plan*).

Area Population. The population of the Quad Cities MPA region (three-county area), was at its height in 1980 with a population of 383,958. As the decade closed, there was a drastic decline in population with the loss of thousands of jobs due to the devastating downturn of the farm implement industry. The 1990 Census population of the Quad Cities region was 350,855 and progressively rose to 359,062 in 2000, 363,256 in 2010, and 367,027 in 2018. Please refer to Chapter 1, Figure 1.1 in the 2050 LRTP for historical population changes in the MPA since 1950.

According to the U.S. Census Bureau 2018 ACS 5-Year Estimates, the 2018 median age of the MPA was 38.8, which was higher on average than the U.S. (38.2), Illinois State (38.3), and Iowa State (38.1). The largest age group was 55-59, accounting for 6.69% of the total population in the MPA.

Area Households. There were a total of 114,933 households in the MPA in 2018. Family households make up 60% of those households, with 26.3% having children. The average household size of the MPA is 2.39, and the average family size is 3.06. In comparison to the U.S., Illinois, and Iowa, the MPA have a lower average household size and a lower percentage of family households.

Area Employment and Economy. According to the Census Bureau's 2018 ACS 5-Year Estimates, the total employment in the MPA for civilians 16 and over in 2018 was 135,937. Employers work in a variety of industries with the top industries being manufacturing (17.1%), educational services, and health care and social assistance (22.6%), and retail trade (12.7%). Table 2.3 shows the top employers in the MPA region that coincide with the top employed industries.

Table 2.3 – Top Employers in the MPA (2020)

Rank	Company	Total Employee	Industry
1	Deere & Company (All metro locations)	7240	Manufacturing
2	Rock Island Arsenal	6163	Manufacturing
3	Trinity-Unity Point (All metro locations)	4748	Health Care
4	Genesis Medical Center (All metro locations)	2760	Health Care
5	Tyson Fresh Meats	2400	Manufacturing
6	Arconic	2000	Manufacturing
7	Tri City Engineering & Integration	1200	Manufacturing
8	Xpac (Export Packaging, Inc.)	1000	Manufacturing
9	Rhythm City Casino Resort	1000	Gaming
10	Cobham Mission Equipment	800	Manufacturing

Source: Infogroup Reference USA Gov, 2020 and individual employers

2.2 Population and Employment Growth

A fundamental component of the travel demand forecasting process is determining where people live and where they work, both in the present and future. A base year of 2015 was used to calibrate the travel demand model for present conditions, while horizon years 2030 and 2050 data are used to project future traffic. Table 2.4 summarizes the regional growth used in the travel demand model as control totals.

Table 2.4 – Population & Employment Forecasts

Planning Area Demographic Data	Year 2015 Total	Horizon Year 2030 Total	Horizon Year 2050 Total
Population	310,196	330,000	350,000
Employment (By Place of Work)	161,988	175,689	188,359

Source: Bi-State Regional Commission, 2020

Assumptions and scenarios for Population growth were narrowed down to the following three scenarios:

- Scenario 1: Growth Based on the Census Data From 1970-2010
  - Slow Growth Model (Farm Crisis)
  - Assumes 0.03% MPA Annual Growth Rate from 1970 – 2050
- Scenario 2: Historical Growth based on Scott County 1990-2015
  - Fast Growth Model (Scott County)
  - Assumes 0.56% MPA Annual Growth Rate from 1990 to 2050

- Scenario 3: Regression Analysis
    - Assumes -0.03% Growth Rate based on Excel probability plot of best fit

Future Residential Land Use Assumptions (applied to 2030 and 2050 forecasts):

- Persons Per Housing Unit – 2.42 (2015 ACS)
- Housing Units Vacancy Rate – 7.9% (2015 ACS)
- Housing Units Per Acre (Low Density) – 2.44
- Housing Units Per Acre (Medium/High Density) – 16.46

Future Land Use Projections Comparison- Population:

Year	Threshold (Decline)	Threshold (Incline High)	LU Original Population	LU Adjusted Population*
2015	306,546	306,546	310,196	310,196
2030	305,169	333,330	351,731	330,000
2050	303,344	372,718	405,750	350,000

**Adjusted population for future years accounts for a ~64% reduction in residential area projections collected from local communities.*

ISMS uses existing and forecasted socio-economic and land use data to quantify the urban activity for the planning area. The data sources for the travel demand model include:

- Parcel level land use data from Bi-State Region MPO area cities and counties
- 2013/2014 Quad Cities Household Travel Survey
- Quarterly Business data by Infogroup, Inc.
- 2015 Traffic count data from Illinois and Iowa Departments of Transportation (See LRTP Map 4.2)

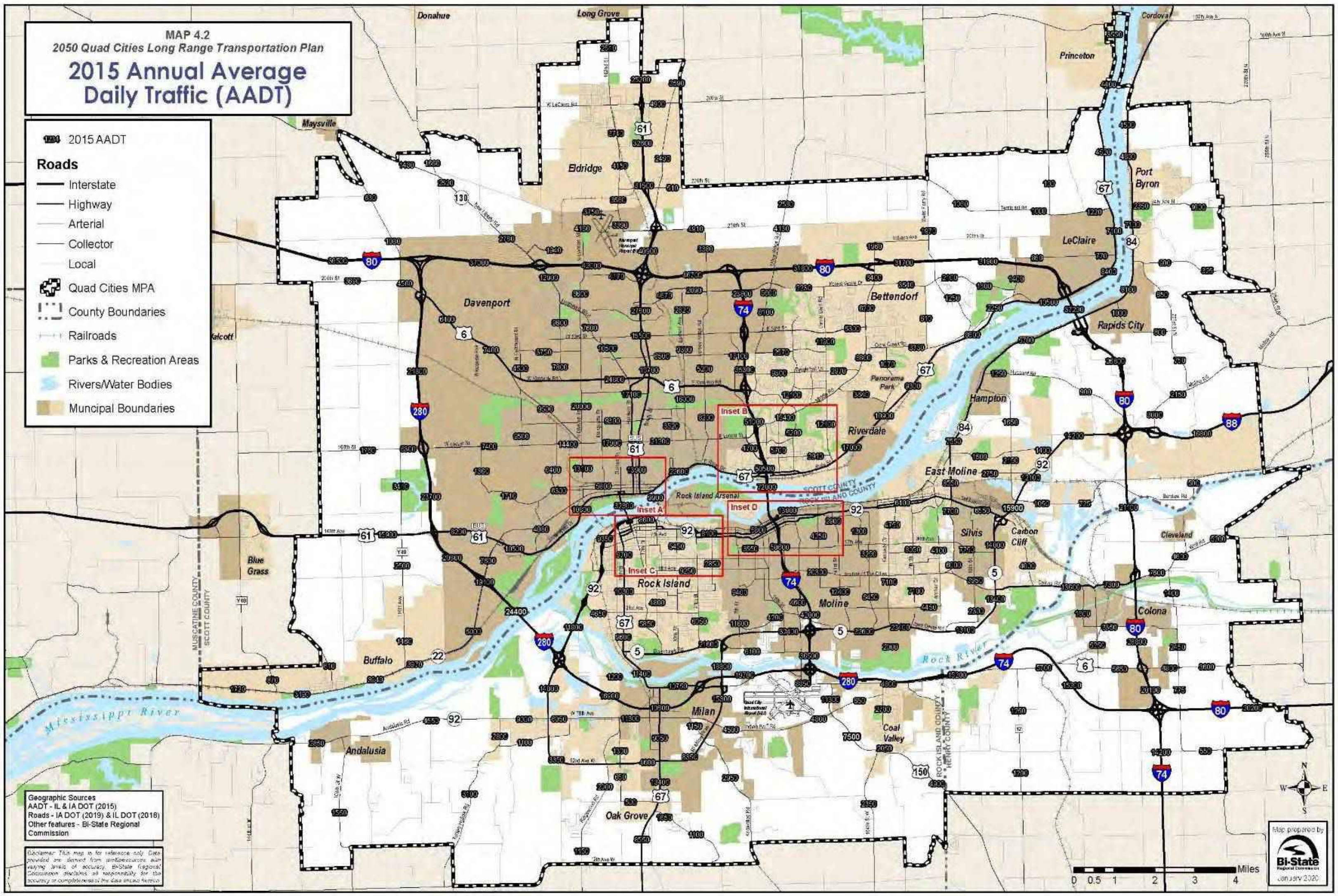
2.3 Parcel Level Housing Unit & Employment Forecast

With parcel data collected from MPO region cities and counties, total housing units and employment were estimated for each parcel following these steps:

1. Prepare housing unit regional control total forecasts.
2. Prepare non-residential regional control totals by 1) applying employment density assumptions to employment forecasts, or 2) factoring base year square footage by the change in housing units, assuming that non-residential uses grow at a similar rate as housing.
3. Identify the future land use of each parcel, which could consist of the following types:
    a. Fully developed, which would have no change in land use

   b. Scattered vacant lots within existing developed areas, which would have future land uses similar to adjacent parcels
   c. Land covered by near term subdivision plans or site specific plans, which would specify detailed future land uses
   d. Large tracts of vacant land, which would have future land uses based on general plans or other land use visioning process
   e. Redevelopment areas, which would have future land uses based on redevelopment plans
4. Calculate parcel level future housing unit and non-residential holding capacity based on future land use assumptions, residential density assumptions, and non-residential floor area ratios.
5. Determine the development year of each parcel such that the aggregate change in parcel level activity matches the regional control totals for a forecast year. Parcel phasing could be based on local knowledge or a scoring process using factors such as proximity to existing development or accessibility.

LRTP Map 4.2 – Traffic Counts with 2015 AADT



Source: Bi-State Regional Commission, 2020

2.4 Traffic Analysis Zones

Urban activities within the Quad Cities MPA are modeled and aggregated to the level of Traffic Analysis Zones (TAZs). A TAZ, in an ideal setting, is a portion of the planning or study area delineating homogeneous land use and travel purposes. TAZs are mutually exclusive (i.e. they do not overlap) and collectively exhaustive (they cover the entire model region). With ISMS model system, Land use and socio-economic data was collected at parcel level and aggregated to TAZ level, which is a step further in details in order to better predict travel in the metropolitan area. TAZs vary in size by the density or nature of the urban land use that they encompass. TAZs in this report were created to analyze traffic flow on the major streets in the MPA.

Traffic Analysis Zones are the geographical units for the travel demand model. Major land uses are defined for each TAZ. It is assumed that all travel activities and characteristics are homogeneous within each TAZ. The following principals were followed when defined the TAZs:

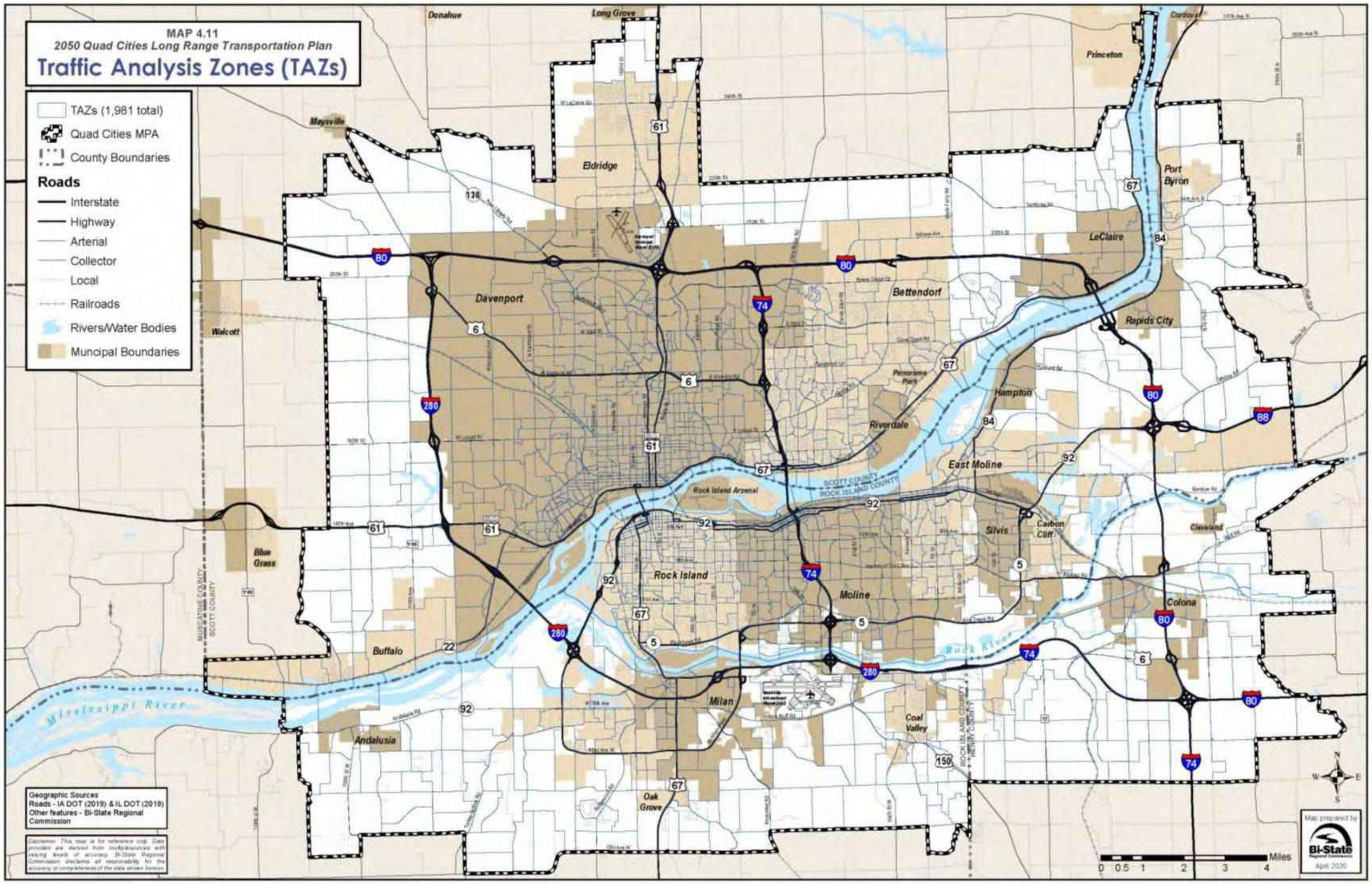
- Utilize Census and parcel geography to facilitate exchange of data.
- In cases of conflict between Census and parcel geography, review for mapping errors. Parcel data is a direct input while Census data is used to apply demographics, therefore use parcel boundaries if geographic differences persist.
- Size zones to result in similar levels of activity across most zones; consider future land use projections, which may require zones with low levels of existing activity.
- Separate housing and non-housing activity if feasible.
- Consider zones specific to special generators.
- Avoid including barriers (rivers, rail lines, major roadways, etc.) within the TAZ.
- Consider proximity to transit stops; consider developing zones within walking distance to transit.
- Consider joining areas on either side of minor roadways into one zone if land uses are similar
- Maintain continuity of a TAZ border with various administrative boundaries including but not limited to county and city areas as well as CTPP TAZ boundaries.
- Eliminate gaps and overlaps in the TAZ boundaries.
- Begin zone numbering at the externals, and then provide a gap in the numbering sequence between internal and external zones for future splits/expansion. (External trip table spreadsheets use 1 as starting zone).

The Census 2010 Traffic Analysis Zones program was initiated in 2011, and TAZs were available from the Census Bureau in 2012. The TAZs designated under the Census criteria provided the basic geography for the travel demand model to geographically reference Census data by TAZ.

For enhanced modeling purposes with ISMS, many of the TAZs were further split into smaller zones to provide higher resolution and more accurate details closely aligned with parcel data. This improves the land use type to be similar within each TAZ. After TAZ to TAZ review and recoding by planning and GIS staff at Bi-State, the total number of internal TAZs increased to 1982 (from prior 1355) and 88 external TAZs (from prior 86).

External TAZs are used for analyzing external trips. So at the "boundary" of the study area for all types of roadways going in, out and through MPA, there is a corresponding external TAZ.

LRTP Map 4.11 – Planning Boundary & Traffic Analysis Zone Map



Source: Bi-State Regional Commission, 2020

2.5 Roadway Network

Roadway network is the crucial input of a travel demand model. It provides geometric alignment and topological connectivity as well as important roadway characteristics such as number of lanes, functional classification, posted speed, etc. Roadway network is made up of centroids, external stations, centroid connectors, highway nodes, and links.

Centroids are points representing the center of activity within a TAZ. Traffic generated or attracted by zonal socio-economic data are assumed to start and end at centroids. Accordingly, centroid connectors are links to load traffic from centroids to highway network and vice versa. Centroid connectors conceptually represent the local road/ally system within each TAZ. Instead of representing internal TAZs, external stations are special centroids where external trips enter and leave the highway network. Highway links represent roadway segments, and highway nodes are the end points of links. Highway nodes typically represent intersections and access points.

Compared to previous model, several changes have been made based on ISMS. There are several new fields:

Median: Median type is obtained through Google Earth.

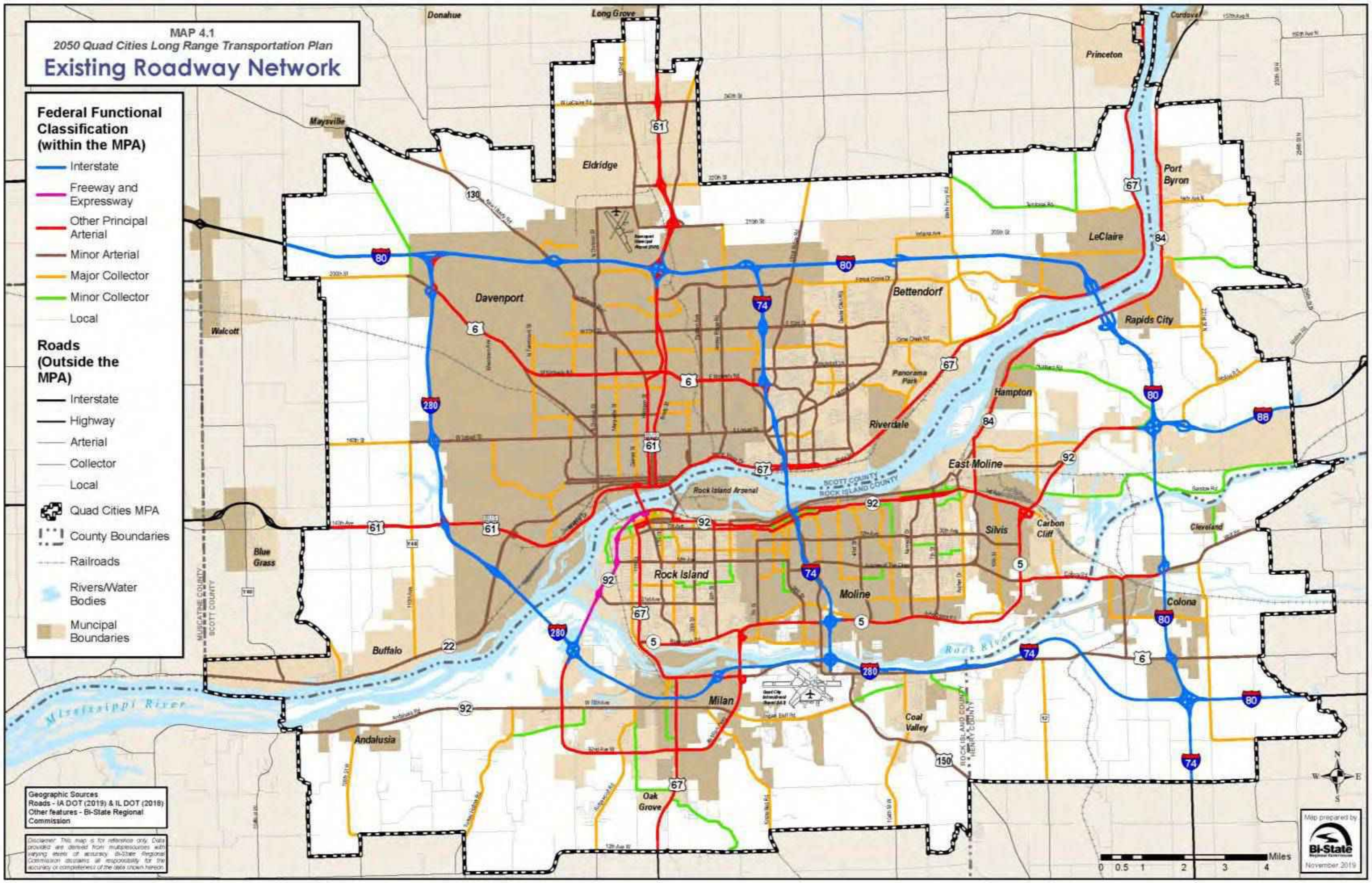
Access: Level of access along link, measured in number of mid-block access points per mile. Obtained through Google Earth.

TMC_Code: Traffic Message Channel or INRIX XD code to join link to observed travel speed from INRIX data by time and day of week.

CNT: Intersection control at end of link (directional attributes). In Quad Cities, all traffic light are assumed actuated signalized control. The data are obtained through Google Earth and cities in this region.

LRTP Map 4.1 illustrates the structure of the model network, and symbolizes the links by functional classification.

LRTP Map 4.1 – Transportation Network for Traffic Analysis



Source: Bi-State Regional Commission, 2020

Highway networks were coded in a master network file that contains both existing facilities and planned improvements. Highway networks for each scenario are "generated" from the master network, which has a set of fields describing roadway characteristics when the road is first opened, another set of fields describing proposed roadway changes, and fields describing opening and project years. For more details of the master network, see section A.1 Master Network Preparation in the Appendix (page 55).

2.6 Travel Time and Speed Data

Travel demand models use impedance values such as travel time to estimate the likelihood of selecting one option compared to other available options. Modelers should strive to develop models that estimate travel times that reasonably represent the observed conditions within the modeled area. MPO models within Iowa have INRIX travel time data as a viable resource to quantify existing travel times for major roadway corridors. The INRIX data is available through the Iowa DOT.

The 2015 Quad City Roadway INRIX data is used to calculate the speed data. In order to make the result more accurate, staff from Bi-State gathered data from every week and calculated the average value. Following ISMS, the final result shows the average speed at different time (AM, PM, OP, MD) for all the links. Then, the geographic join is used to join INRIX link to Highway Network.

2.7 Estimation of Free Flow Speed

Highway travel time and highway capacity are the two main outputs of the highway network process. Attributes used to calculate travel time, included segment length (computed by TransCAD from highway alignments), posted speed, one/two-way operation, functional classification, and area type.

Free flow speed is used by travel demand model to calculate initial uncongested travel time (T_0), which is the "starting point" of the Bureau of Public Roads (BPR) Curves to determine the congested travel time.

The BSRC model estimates free flow speed based on posted speed limits with two levels of adjustments. The first level of adjustment is multiplier factors that were applied globally. They account for intersection delay in a generalized manner based on roadway functional classification and surrounding area type. Global Speed Factors are stored in a lookup table named "spdlut.bin"

During the model calibration, a second speed adjustment was introduced to approximately 10% of all links to bring model-estimated traffic volumes into better agreement with observed traffic counts. Some of these adjustments reflect driver preferences for certain routes, while others reflect delays that are not accounted for by the speed adjustment factors. For example, a speed reduction was necessary for the Government Bridge, which is a swing-span bridge that gives right-of-way to river traffic. Delays at this river crossing can be as long as 30 minutes for barges to lock through the navigation system. These Link Speed Adjustments were hard coded in the master network link attribute field "SPEED_ADJ."

Free flow speed was calculated by following equation.

Figure 2.5 – Free-Flow Speed Calculation

$$FFS = (PSP + LAS) * GAF$$

Where: FFS – Free flow speed
PSP – Post speed limit
LAS – Link speed adjustment
GAF – Global speed adjustment factor

Table 2.5 lists Global Speed Factors applied to the network links by roadway functional classification and area type.

Table 2.5 – Global Speed Adjustment Factors

Functional	Area Type			
Classification	CBD	Urban	Suburban	Rural
Freeway	1.00	1.00	1.00	1.00
Expressway	0.95	0.95	0.95	0.95
Principal Arterial	0.75	0.75	0.85	0.85
Minor Arterial	0.75	0.75	0.85	0.95
Collector	0.75	0.75	0.85	0.95
Local	0.75	0.75	0.85	0.95

Source: Bi-State Regional Commission, 2016

2.8 Intrazonal Time Calculation

The purpose is to calculate the disutility of travel within a specific zone. Bi-State staff use non-network road segments within a TAZ to calculate the average intrazonal length, speed, and travel time for each TAZ. The theory behind this calculation rests on the propensity for longer trip times to correlate with the availability of longer, uninterrupted road segments within a TAZ.

- Utilize 2015 RAMS and IL Roadway data to represent local roads not included in the model network.
- Use the model network to select and remove segments that form TAZ boundaries.
- Tag TAZ ID to segments within each respective zone.
- Aggregate the average segment length and average speed for each TAZ based on road segment TAZ IDs.
- Convert road segment speed for each TAZ's local roads from Miles/Hour to Miles/Minute by dividing the segment value by 60.
- Multiply each segments' length by its corresponding new segment speed to calculate travel time in minutes.
- Aggregate average travel time for each TAZ based on road segment TAZ IDs.

2.9 Estimation of Link Capacity

Capacity specifies the maximum amount of traffic that can be accommodated by a roadway segment before severe congestion occurs. Traffic and roadway condition affects the capacity of a roadway. Lane width, road condition, shoulder width, and terrain of the roadway are a few factors that can determine capacity. The travel demand model uses capacity as a denominator to calculate Volume over Capacity ratio, which is used in Bureau of Public Roads (BPR) Curves to determine congested travel time.

Based on methodologies documented in Highway Capacity Manual (HCM) 2010, the criteria for measurements of the highway capacity depends on determining Level-of-Service (LOS), which ranges from A to F. In previous model versions, link capacity used to be set for LOS D. It is now based on LOS E, which is more consistent with common practice in travel demand modeling.

Table 2.10 lists the roadway capacity by number of directional lanes, functional classification, and area type.

Table 2.10 – Roadway Link Capacity

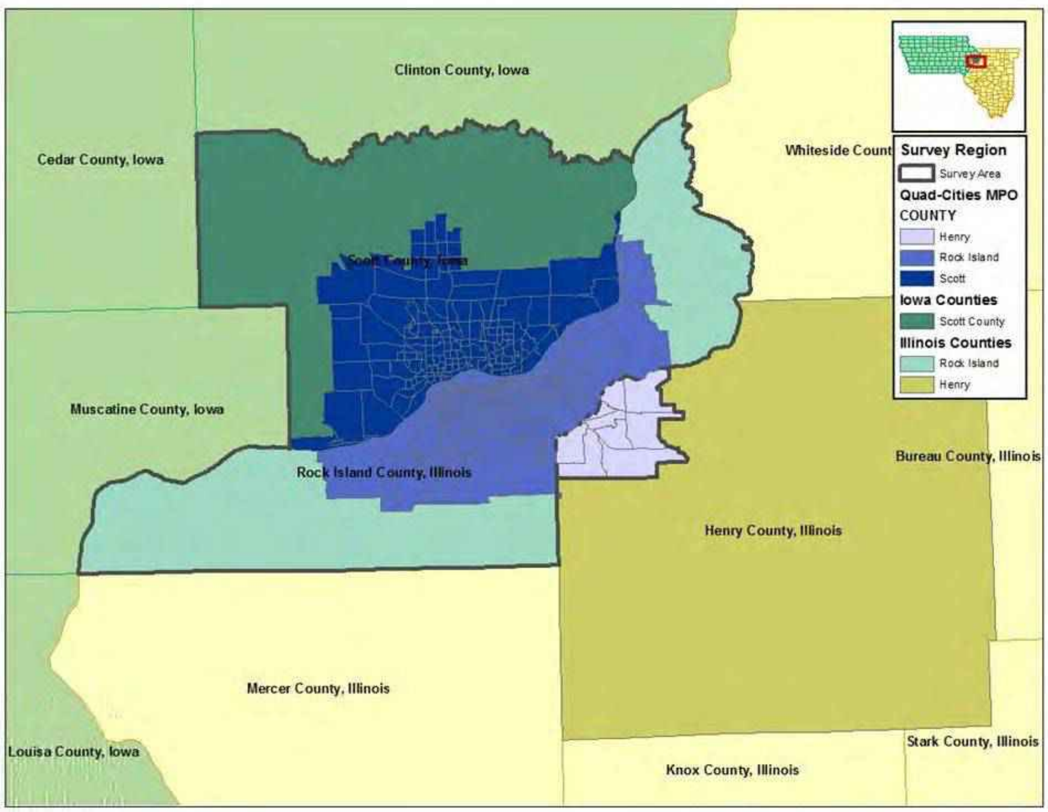
Functional Class	Lanes	CBD	Urban	Suburban	Rural
Freeway	2	3,500	3,500	3,500	3,500
	3	5,500	5,500	5,500	5,500
	4	7,500	7,500	7,500	7,500
Expressway	2	3,300	3,300	3,300	3,300
	3	5,100	5,100	5,100	5,100
	4	6,900	6,900	6,900	6,900
Principal Arterial	1	740	920	960	1,160
	2	1,480	1,840	1,920	2,320
	3	2,220	2,760	2,880	3,480
	4	2,960	3,680	3,830	4,640
Minor Arterial	1	650	760	790	950
	2	1,300	1,520	1,580	1,900
	3	1,950	2,280	2,370	2,850
	4	2,600	3,040	3,160	3,800
Collector	1	590	680	710	850
	2	1,180	1,360	1,420	1,700
	3	1,770	2,040	2,130	2,550
	4	2,360	2,720	2,840	3,400

Note: CBD = Central Business District
Source: 2010 Highway Capacity Manual

3.0 Household Travel Survey

From October 2013 to January 2014, Bi-State Regional Commission hired URS Corporation, ETC Institute, and Texas A&M Transportation Institute (TTI) to conduct the *Quad Cities Household Travel Survey (HHTS)*. This survey aimed to enhance data support for the BSRC modeling practice. It covered all of Rock Island and Scott Counties, and that portion of Henry County as captured in the MPA Boundary. By extending the study area from the MPA boundary to county borders in Rock Island and Scott Counties, the survey captured an additional 5% and 9% of populations, respectively. These populations were in the fringe city areas that exhibited strong connections to the Quad Cities MPA. Map 3.1 shows the study area within the dark boundary.

Map 3.1 – Study Area of 2013/2014 Quad Cities Household Travel Survey



Source: 2013/2014 Quad Cities Household Travel Survey

In the survey, 6,798 households were contacted, in which 1,793 households provided travel diary data. The overall response rate is 26%. It reflects a strong interest in transportation in the Quad Cities Area. Survey respondents provided a complete listing of activities made on a survey day with information such as start and end location, start and end time, trip purpose, and trip mode. Information was also collected about household, household member, and household vehicle characteristics. The survey data set contains data for all 1,793 households surveyed, 4,100 persons, 3,531 vehicles, and 13,790 trip locations.

Surveys from 168 households were determined to be unusable due to extreme weather and back in school session on survey days. It resulted in 1,625 survey households eventually used for model estimation. (See *Quad Cities Household Travel Survey* for more details. The document is available on the BSRC website at www.bistateonline.org.)

4.0 Trip Generation

Travel demand forecasting is a tool used to quantify the amount of trips on the roadway network. Trip generation is the first step in travel demand forecasting. Zonal land use, population, and economic forecasts are multiplied with trip rates to calculate how many trips will be made to and from each TAZ.

Each trip has two ends, Origin and Destination. For modelling purposes, trip ends also can be categorized as Productions or Attractions. The concept of production is associated with a trip maker's home. For instance, in a Home Based Work (HBW) trip, home is always the production, regardless of if it is the trip origin when people travel from home to work or the destination when people come back from work to home. Accordingly, attraction is the non-home end of a trip.

Trip generation model includes the following essential steps:

- Calculating trip production
- Calculating trip attraction
- Applying external trip ends
- Balancing production and attraction by trip purpose

The logic is to calculate a production rate based on different trip purposes, an attraction rate for different land use types. From CTPP data, the income level and household size for each TAZ can be gleaned; thus determining the total trips generated by each TAZ. Based on parcel data, the land use type and area for each parcel is determined. When aggregated into TAZ level, the total area for each land use type within a TAZ is rendered. As a result, they can be balanced and moved forward.

4.1 Trip Rates

The trip generation model estimates average daily trips in the following purposes:

- Home Based Work (HBW): Any trips with home at one end and work at the other end.
- Home Based School (HBSC): Any trips with home at one end and school activity at the other end (for K-12).
- Home Based Shop (HBSH): Any trips with home at one end and shopping activity at the other end.
- Home Based Other (HBO): Any trips with home at one end and the other end at an activity not included in the above categories.
- Non-Home Based (NHB): Trips that do not start or end at home.
- University (UNIV): Any trip with university activity
- Hospital (HOSP): Any trip with hospital activity

- Airport (APRT): Any trip with airport activity
- Recreation (RREC): Any trip with recreation activity
- Hotel (HOT): Hotel purpose productions are estimated based on hotel building area and not per household

The home-based work trip purpose is further disaggregated to distinguish low, medium, and high-income trips. Their trip rates were tabulated from the 2014 *Quad Cities Household Travel Survey (HHTS),* stratified by household size and auto ownership. Person trips will be converted to vehicle trips by applying vehicle occupancy in the mode split step. Also using the findings from the HHTS, daily trips will be stratified to four time-of-day periods: AM (peak), MD (Midday), PM (peak), and Night.

Commercial vehicle trips were generated as vehicle trips. For each TAZ, productions of commercial vehicle trips were set to be identical with attractions. The attractions of commercial vehicle trips were based on the number of employees in each category, school and college enrollment, and total households.

Each trip has two trip ends. The trip generation model calculates trip ends separately: one end is classified as a trip production and the other end as a trip attraction. When trips start or end at home, the home end is defined as the production end, and the other end is defined as the attraction end. Some trips are classified as non-home based trips when neither end is a home location such as a trip from a work location to a shopping center. Non-home based trip ends are split evenly into trip productions and trip attractions.

Trip generation is the process of estimating the number of trip productions and attractions at each transportation analysis zone (TAZ) based on the socio-economic activity within the zone. This process is conducted independently by trip purpose and typically done for each discrete time period. The ISMS prototype conducts trip generation separately for weekday and weekend travel.

Person trip attractions are calculated based trip rates by land use codes for each parcel, aggregated to the TAZ level. Trip attraction rates are based on commercial building area, school enrollment, site acres, or number of households depending land use. In ISMS, there are 66 land use types.

For each trip purpose, trip attraction rates were adjusted to match the total trip attraction with the total trip production. By doing this, it prevents significant scaling in the trip balancing step at the end of trip generation model.

Trip production rates shown in Table 4.1 were computed by following procedure:

The following steps were taken to convert from Bi-State 2045 Travel Demand Model (2045 TDM) to the current 2050 ISMS TDM:

1. Start with previous Bi-State model Production rates
2. Sum all vehicle ownership amounts to a single value by HH size for each trip purpose
3. Relate to ISMS trip purposes by figuring out percentages to split
   3.1. HBW to HBW by income (sum of HBWL, HBWM, and HBWH should equal the original HBW rate) - Use Census? Or Des Moines rates

3.2. HBO and HBSR to HBO, HOSP, APRT, RREC, and HOT (sum of HBO, HOSP, APRT, and RREC should equal original sum of HBO and HBSR) - Use Des Moines rates
4. Split 3+ HH to 3 and 4+ (sum of 3 and 4+ rates should equal the original 3+ rate) - Use Des Moines rates
5. Check: Sum of all cells in both original table and new table should be equal.
6. Use Des Moines Income split percentages among trip rates to split by income for final input table
7. Use Des Moines WD/WE split for each trip purpose to split to weekday and weekend rates
8. Use Des Moines TP split percentages to factor into ISMS inputs for final input table
9. Compare with Des Moines rates and total trips per household compared to 2010 model
10. Apply Census data for income adjustment and HH Survey data for time-of-day split

Table 4.1 – Time-Of-Day Trip Generation Rates

Trip Purpose	WEEKDAY				WEEKEND			
	AM	PM	NIGHT	MIDDAY	AM	PM	NIGHT	MIDDAY
HBW(L)	3.17	1.25	2.51	0.73	1.19	0.62	2.01	0.62
HBW(M)	5.61	2.21	4.42	1.28	1.07	0.56	1.83	0.57
HBW(H)	2.57	1.01	2.00	0.57	0.26	0.14	0.45	0.14
HBSCL	9.72	7.47	1.60	0.14	0.29	0.28	0.12	0.16
HBSH	0.75	3.55	4.10	4.51	2.75	4.93	4.22	9.25
HBO	4.91	4.71	10.50	2.83	5.68	5.44	11.86	6.16
NHB	5.65	10.92	8.08	12.97	3.32	11.47	8.82	10.69
HOSP	0.13	0.13	0.29	0.08	0.12	0.11	0.24	0.13
APRT	0.01	0.01	0.03	0.01	0.01	0.01	0.03	0.01
REC	0.08	0.08	0.18	0.05	0.28	0.27	0.59	0.31
HOTEL	0.10	0.09	0.21	0.06	0.09	0.08	0.18	0.09

Since Bi-State 2014 HH survey was not designed for ISMS, there are a lot of inconsistencies between the two. In general, Bi-State uses its own data to better represent local circumstances. However, staff will fill the vacancy by referencing other Midwestern MPO model and/or using the default trip rate. All school trips are limited to just school land use areas, and shopping trips to just commercial land use areas. Households is removed from all trip purposes rates. PO rates were used for LIB. The latest Census data were used for HBW income adjustment and 2014 HHTS for time period adjustment (not differentiated by land use).

Following are the steps to update the 2050 Bi-State Model Trip Attraction Rates:

1. Start with previous Bi-State model A rates shown in Table 4.2
2. Relate to ISMS trip purposes by figuring out percentages to split…
   a. HBW to HBW by income HBWL (low), HBWM (medium), and HBWH (high) - should equal original HBW total
   b. HBO and HBSR to HBO, HOSP, APRT, RREC, and HOT (sum of HBO, HOSP, APRT, and RREC should equal original sum of HBO and HBSR) - Des Moines rates applied

3. Use previous model attraction control totals (scaled to new production control total) by TAZ by trip purpose (divvied up into all ISMS trip purposes) to relate to each ISMS land use category with regression
    a. First, set the attraction control total, making sure Ps and As are balanced
    b. Dependent Variable = trip purpose control totals by TAZ
    c. Independent Variables = AMT by land use in each TAZ
    d. Reasonableness check - rates compared to Des Moines rates
    e. Leave out areas with growth in last 5 years
    f. Leave out externals
4. Divvy up into weekday vs. weekend by making WD x% higher and WE x% lower. - Des Moines rates used and adjustments were made to HBO WD/WE split due to imbalance.
5. Split by Trip Purpose using survey percentages

Table 4.2 – QC 2045 Model Trip Attraction Rates

Purpose	Industrial	Other	Retail	Casino	K-12	College	HHs
HBW	1.28	1.37	0.91	1.32	0.49	1.02	0.07
HBSCL	0.00	0.00	0.00	0.00	2.24	0.00	0.00
HBSH	0.17	0.91	5.00	0.00	0.08	0.00	0.08
HBSR	0.06	1.34	0.24	9.24	0.25	0.18	0.36
HBO	0.11	0.41	0.24	0.00	1.48	1.30	0.16
NHB	0.65	1.80	4.92	3.90	1.17	0.42	0.47
CV	0.41	0.10	0.38	0.36	0.01	0.01	0.08

Source: 2013/2014 Quad Cities Household Travel Survey

The resulting Bi-State ISMS Model trip Attraction rates, as stratified by 12 trip purposes, weekday/weekend, 4 Time-Of-Day periods and 68 land use types are saved in the Excel file "B-State_Trip_Rates-updated_for_ISMS.xlsx"

4.3 External Trips

In order to simulate the real world, 86 external stations are added to the TAZ layer. They record every single roadway to go into MPA boundary, not matter the Federal Function Class the roadway. DOT is using ITRAM to calculate the EE & EI trips.

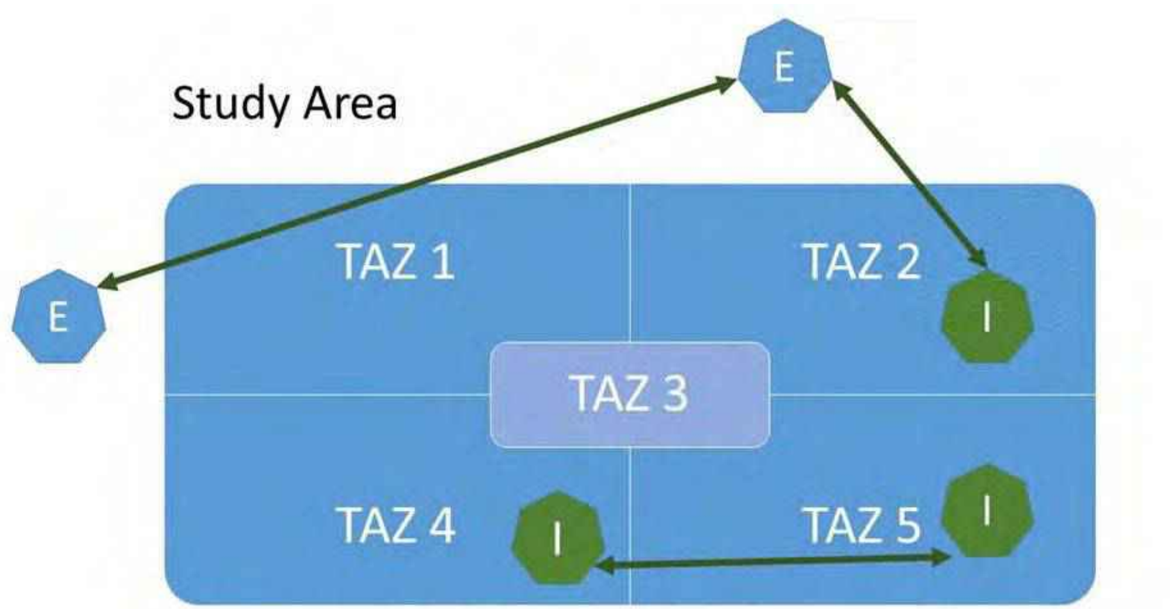
Trips having at least one end outside the planning area boundary are either called external-internal (E-I) trips (one end is outside the area) or external-external (E-E) trips (both ends are outside the area) (see Figure 4.1).

Traffic counts at the 35 external zones (TAZs that cross the planning area boundary) were used as base year control totals. Iowa DOT's Statewide Travel Demand Model (iTRAM) was used to obtain E-I trip totals by purpose at each external zone and E-E trips between zones. Outputs from the model were adjusted to match base year traffic counts at the external zones. Growth factors at each external station were calculated by comparing the 2010 and 2035 iTRAM model results. These growth factors were then applied to 2010 external trips to get projections in horizon year 2025 and 2045.

Table 4.5 summarizes base year and future traffic volumes resulting from this process at eight external zones with an Average Daily Traffic (ADT) of 5,000 or more. Map 4.1 highlights major external stations in green and other minor ones in blue.

It should be noted that E-I trips are further broken down by productions and attractions for the seven trip purposes: Home Based Work (HBW), Home Based School (HBSCL), Home Based Shop (HBSH), Home Based Social Recreation (HBSR), Home Based Other (HBO), Non-Home Based (NHB), and Commercial Vehicle (CV). The proportion was based on the percentage of each trip purpose in the 2001 *National Household Travel Survey* (NHTS).

Figure 4.1 – External Trip Types in Relation to the Study Area



Legend

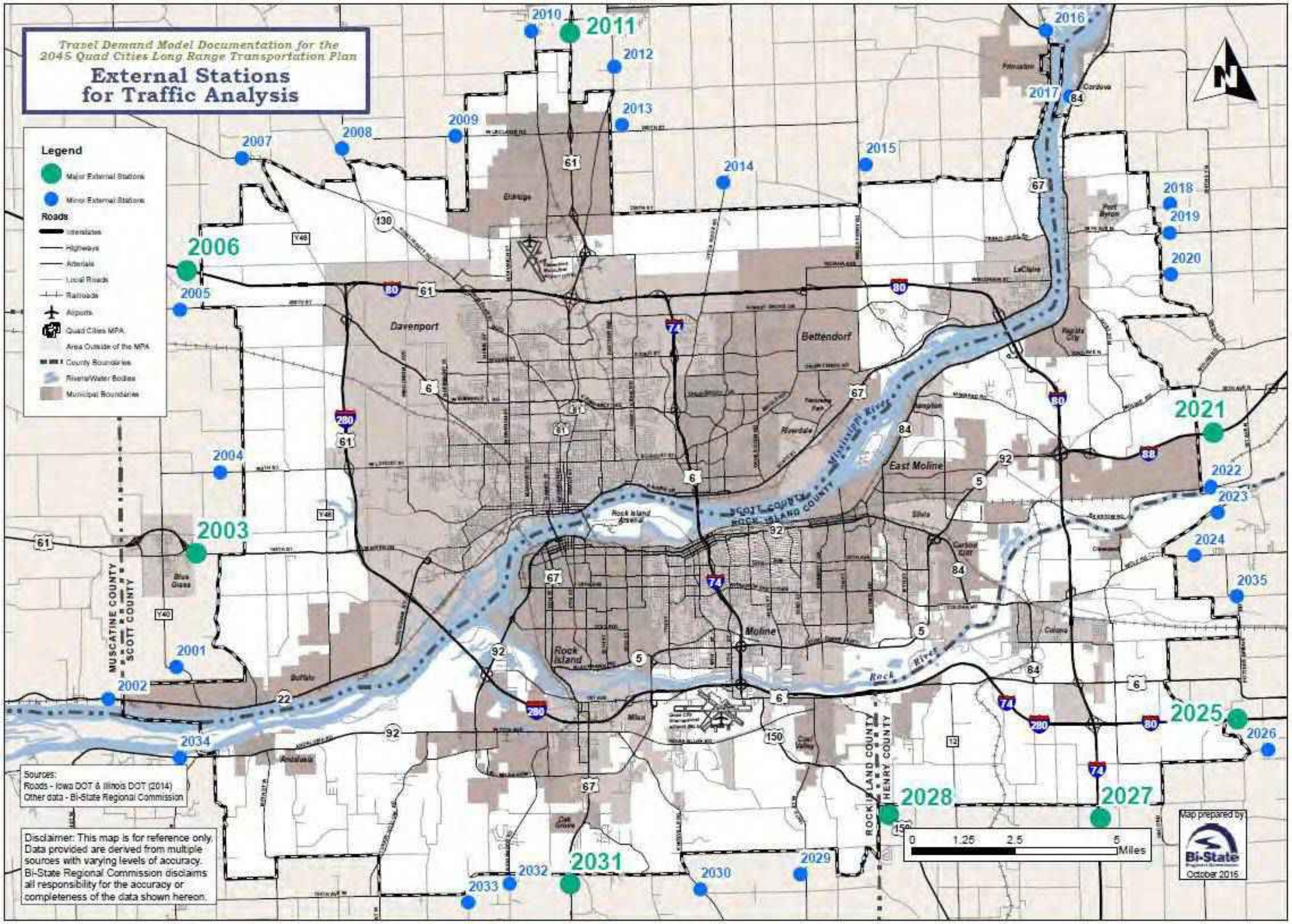
E-I	External-Internal traffic
I-I	Internal-Internal traffic
E-E	External-External (through) traffic

Table 4.3 – Traffic at Major External Stations

TAZ	Location	Total ADT		E-E Trips		E-I Trips	
		2010	2045	2010	2045	2010	2045
2003	US 61 West	14,000	24,300	1,600	3,600	12,400	20,700
2006	I-80 West	33,300	64,600	16,200	39,500	17,100	25,100
2011	US 61 North	20,700	36,400	1,300	2,900	19,400	33,500
2021	I-88	14,900	26,100	8,200	19,300	6,700	6,800
2025	I-80 East	18,900	32,100	11,500	27,200	7,400	4,900
2027	I-74	13,900	23,900	6,000	13,700	7,900	10,200
2028	US 150	5,200	7,000	40	80	5,160	6,920
2031	US 67	6,600	9,800	600	1,200	6,000	8,600

Source: Iowa Department of Transportation, 2016

Map 4.1 – External Stations for Traffic Analysis



Source: Bi-State Regional Commission, 2016

4.4 Balancing Production and Attraction Trips

Trips are balanced to ensure that trip attractions and productions are equal for each trip purpose. Trip attractions are balanced to productions for all trip purposes because there is a greater degree of confidence in household data than economic or employment data. More households in the study area will generate more trips, while more commercial places might simply grab customers from other places in the same system.

Comparing the "raw" trip production and attraction before trip balancing is a common practice to validate a trip generation model. The rule of thumb is that the production-to-attraction ratio before trip balancing should fall in the range of 0.90 to 1.10.

Table 4.4 outlines the model percentage of total trips by trip purpose versus the federal and Iowa standards. It should be noted that the HBO trips in Table 4.4 actually represent Home Based Non-work trips, which are the combination of Home Based School (HBSCL), Home Based Shopping (HBSH), Home Based Social Recreation (HBSR), and Home Based Other (HBO) trips.

Table 4.4 – Percentage of Trips by Purpose (Balanced)

Trip Purpose	TMIP Validation Manual	NCHRP 365	2009 NHTS for Iowa	Bi-State Balanced WD Trips
HBW	17.9 - 27.0%	16.0 -20.0%	12.60%	22%
HBO	47.0 - 53.8%	54.0 - 62.0%	55.80%	48%
NHB	22.6 - 31.3%	21.0 - 25.0%	31.70%	30%

Source: Bi-State Regional Commission, 2020; TMIP Model Validation and Reasonableness Checking manual, 2010

5.0 Trip Distribution

Following the trip generation process, the trip distribution model was developed to link productions with attractions. Trip distribution in the BSRC model is done using a gravity model. This step creates a matrix that allocates the number of trips going from each production to each attraction based on trip impedance, which is represented by travel time in the current BSRC model. Attraction zones with lower impedance from the production zone will exhibit a stronger attraction than those with higher impedance.

Figure 5.1 illustrates the equation of the gravity model. It is a doubly constrained model, which means that an iterative process is used to control both the productions and attractions for each zone. The process is complete when convergence criterion is met or maximum iteration is reached.

Figure 5.1 – Gravity Model

$$T_{ij} = P_i \times \left(\frac{A_j \times F_{ij} \times K_{ij}}{\sum_{j=1}^{n} A_j \times F_{ij} \times K_{ij}} \right)$$

Where:
- i – Production zone
- j – Attraction zone
- Tij – Trip produced in zone i and attracted to zone j
- Pi – Trip productions in zone i
- Aj – Trip attractions in zone j
- Fij – Friction Factor, reflecting the travel time separation between zones i and j
- Kij – An optional adjustment factor for interchanges between Zone i and Zone j
- n – The number of zones in the model area

5.1 Network Skimming

The process of calculating trip impedance between each pair of zones is called network skimming. In the current BSRC model, the impedance used in trip distribution is solely based on travel time over the shortest path between origin and destination. For each trip purpose, travel impedances are computed separately for peak and off-peak hours. No travel time impedance is calculated for External-External trips, because E-E trips are static model inputs that were generated in the O-D format in the first place.

In the previous model version, bridge penalties on travel time were introduced at the Mississippi River crossings and the Government Bridge to simulate the extra delay. They were removed in the current model and replicated by travel speed adjustment and K factors.

5.2 Trip Friction Factors

The friction factors (F_{ij}) are empirically derived travel time factors that measure the average area-wide effect of spatial separation on trip interchange between zone "i" and zone "j." They determine the likelihood of a trip being made in each impedance increment and are used in the trip distribution model to reflect the difference of trip length among trip purpose. For example, shopping trips, which are much shorter than commute trips, have friction factors that diminish more rapidly than friction factors of work trips.

Friction factors are inversely proportional to travel time. As travel time increases, the friction factor decreases. There are many ways to estimate friction factors. Some of the methods include power functions, exponential functions, or gamma functions. The friction factors of the BSRC model were generated by a gamma function illustrated in Figure 5.2 and coefficients listed in Table 5.1.

Figure 5.2 – Gamma Function

$$F = A \times T^{-B} \times e^{-CT}$$

Where:

F = Friction factor
T = Travel time in minutes
A,B,C = Coefficients
e = Base of natural logarithms

Table 5.1 – Coefficients of Gamma Function

Coefficient	HBW	HBSCL	HBSH	HBSR	HBO	NHB	CV
A	5000	2500	2500	5000	1600	1700	2000
B	0.65	2.32	1.71	1.17	2.53	1.34	0.05
C	0.08	0.00	0.04	0.09	0.01	0.05	0.09

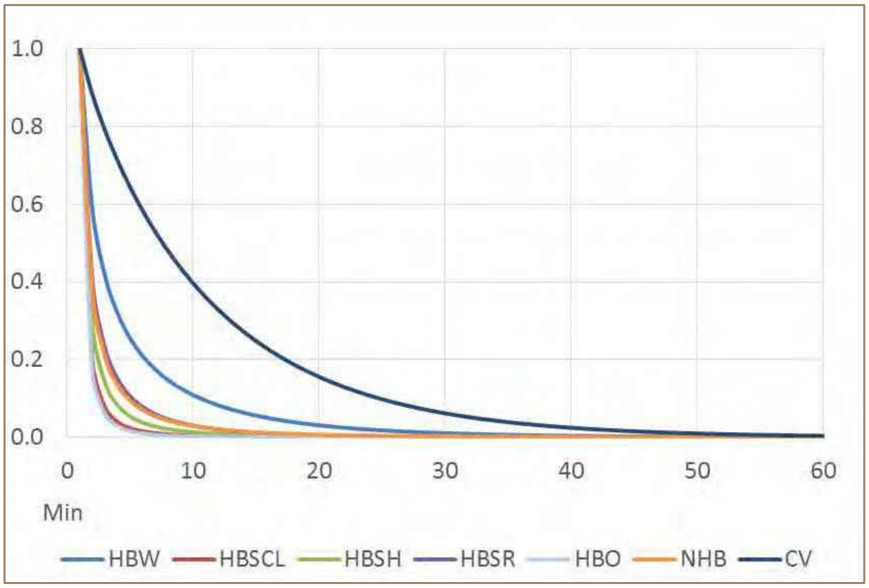
Source: Bi-State Regional Commission, 2016

Above gamma function coefficients were calibrated using the 2013/2014 *Quad Cities Household Travel Survey* data. Observed trip length distribution by trip purpose was tabulated from the survey. They were used to compare with the distribution of model trips and calibrated the friction factors in a trial-and-error process.

During the model calibration, it was determined that K-factors were needed to better represent actual travel behavior in the following circumstances:

- Mississippi River crossing impeding the amount of travel between Illinois and Iowa
- Eliminating intra-zonal trips within single use zones, such as shopping centers
- Eliminating E-E trips between external zones that are accounted for exogenously by the iTRAM model

Figure 5.3 – Friction Factor Curves by Trip Purpose

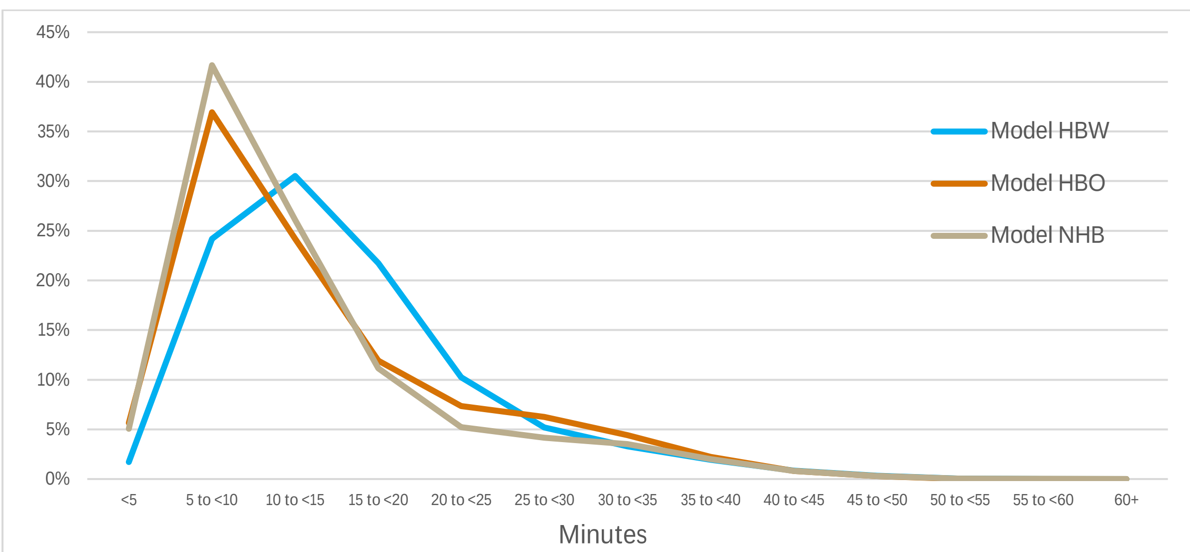


Source: Bi-State Regional Commission, 2016

5.3 Distribution Validation Statistics

Trip length distribution is an important summary of trip distribution model results. It aggregates trips for each increment of travel time in minutes or travel distance in miles. Figure 5.4 compares the trip length distributions in travel time (minutes) between trip purposes.

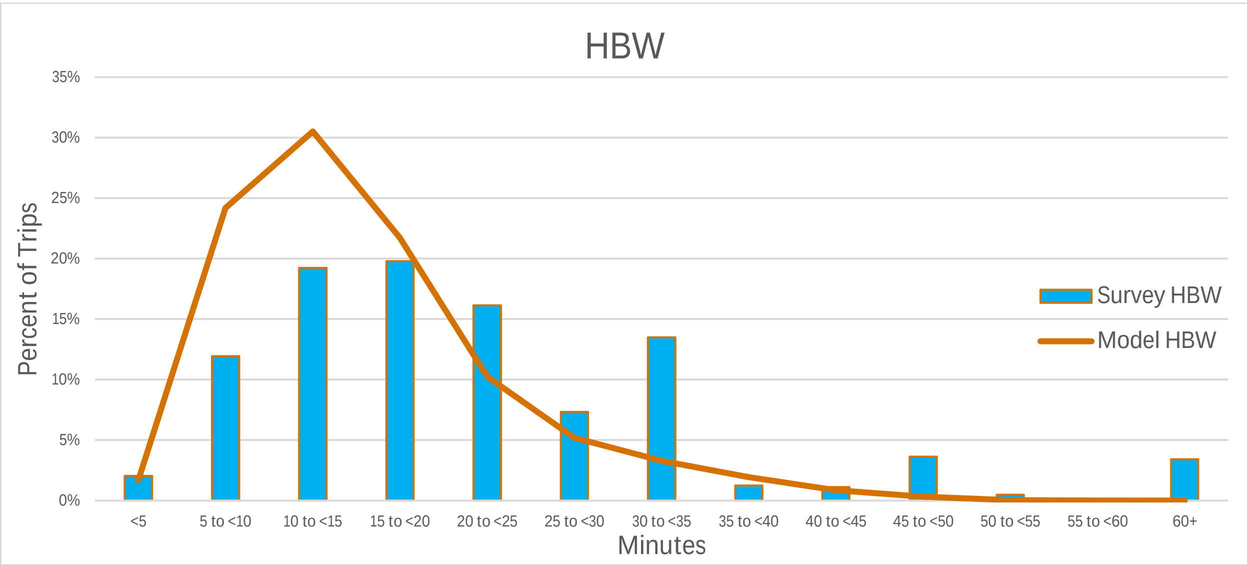
Figure 5.4 – Trip Length Distributions by Trip Purpose



Source: Bi-State Regional Commission, 2020

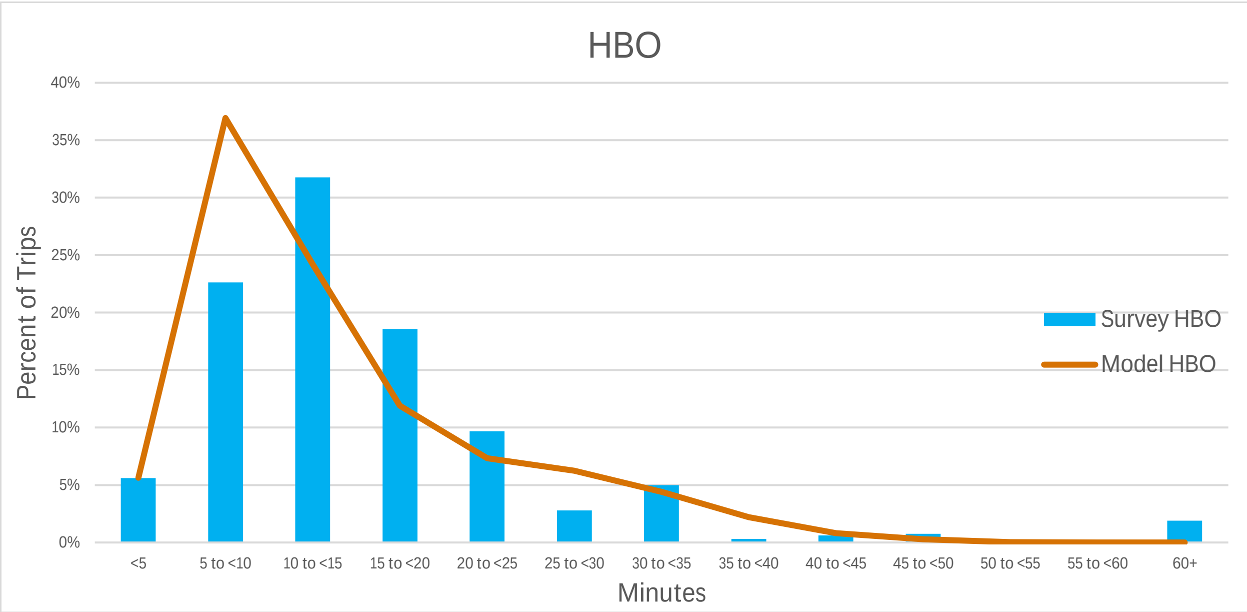
Figures 5.5, 5.6, and 5.7 compare model estimated trip length distribution in distance (miles) with observed distribution summarized from 2013/2014 Quad Cities Household Travel Survey. For each trip purpose, model results match well with observed patterns.

Figure 5.5 – Trip Length Distribution of Home Based Work Trips



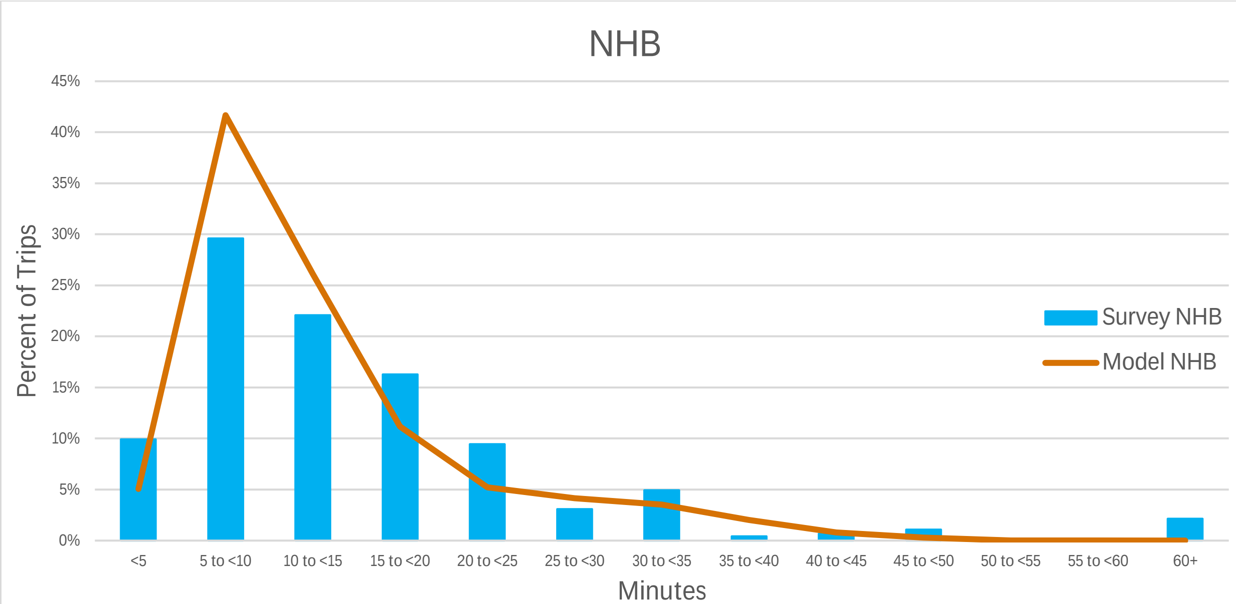
Source: Bi-State Regional Commission, 2020

Figure 5.6 – Trip Length Distribution of Home Based Other Trips



Source: Bi-State Regional Commission, 2020

Figure 5.7 – Trip Length Distribution of Non-Home Based Trips



Source: Bi-State Regional Commission, 2020

Average trip length was also summarized to evaluate the pattern of model trips. As shown in Table 5.2, model-estimated average trip lengths by distance (miles) and time (minutes) closely match survey results. In addition, FHWA published guidelines from other urban areas. Average trip lengths of BSRC model are shorter than national averages, probably because the Bi-State MPA is geographically smaller and has less traffic congestion than many other metropolitan areas. Another reason is that miscellaneous "terminal" time is often added to network time to represent out-vehicle walking time between parking lot and destination.

Table 5.2 – Average Trip Length

Trip Purpose	Minutes		
	Model	HTTS	TMIP
HBW	15.5	19.8	11-15
HBO	14.1	14.6	9.5-13
NHB	13.2	13.8	9.5-12.5

Source: Bi-State Regional Commission, 2020; 2013/2014 Quad Cities Household Travel Survey; and TMIP Model Validation and Reasonableness Checking Manual, 2010

5.4 External-External Trip Distribution

Iowa DOT's Statewide Travel Demand Model (iTRAM) and traffic count data from Iowa DOT Geographic Information Management System (GIMS) and Illinois DOT are major resources used to estimate external trips for the Bi-State model area.

Subarea extraction analysis was done to iTRAM 2010 and 2035 model runs to get base year and horizon year E-E flows for each major external station. The gap between total flows and E-E flows were E-I Flows. E-I and E-E flows from iTRAM were then scaled to 2010 traffic count data, which was used as a control total for each external station.

The iTRAM does not have every external station that the BSRC model has in it. For minor external stations that were not included in the iTRAM, an assumption was made that no E-E flows passed these externals. In other words, 2010 GIMS Counts and Illinois DOT data represent the E-I flows for these minor external stations. Count data was then split into each trip purpose by multiplying the percentage of each trip purpose to the total. A similar proportion process was applied to iTRAM trips, which were modeled at a more aggregated level than BSRC model. Then, iTRAM trips were split into the BSRC model purposes based on the proportion of trip purposes summarized from the *2013/2014 Quad Cities Household Travel Survey (HHTS)*.

The BSRC model utilizes the E-I flows in the format of PA tables. Therefore the E-I flows calculated above were tabulated for each external station. Trips entering the model area were in P's column, while trips leaving the model area were in A's column.

The BSRC model adopts the E-E flow pattern from the iTRAM model. Therefore, the trip distribution model avoids linking trip ends between externals by applying a K factor matrix to block the distribution of E-E trips. E-E flows from iTRAM were manually coded into a static matrix and directly added to the distribution results.

Single-Unit (SU) and Multi-Unit (MU) truck trips were forecasted by a similar process. However, additional tweaks were made to the iTRAM model in order to perform a subarea analysis with separate SU and MU truck trips as well as to redistribute "other" truck trips in the iTRAM model into SU and MU truck trips.

5.5 Feedback Loop and MSA

A trip distribution model is executed within a distribution-assignment feedback loop. In the first iteration, trip distribution is based on free flow time, which is calculated from free flow speed. Subsequent iterations use congested travel time, which is not a direct result of one single traffic assignment, but a weighted average of multiple feedback loop iterations.

It is called the Method of Successive Averages (MSA). "In the MSA method, output volumes from trip assignment from previous iterations are weighted together to produce the current iteration's link volumes. Adjusted congested times are then calculated based on the normal volume-delay relationship. This adjusted congested time is then fed back to the skimming procedures" (TransCAD6.0 User Manual, 2012). The MSA volume is calculated by following equation:

Figure 5.8 – Method of Successive Averages

$$MSAFlow_n = MSAFlow_{n-1} + \frac{1}{n} \times (Flow_n - MSAFLow_{n-1})$$

Where:

n – current MSA iteration number
$MSAFlow_n$ – calculated MSA flow at iteration n
$MSAFlow_{n-1}$ – calculated MSA flow at iteration n-1
$Flow_n$ – resulting flow directly from trip assignment

The distribution-assignment feedback loop ends when convergence criterion is met or the maximum iteration is reached. The number of max iteration is set to 10 by default. The measure of convergence is based on the Percent Root Mean Square Error (%RMSE) of shortest path impedance skims between current and last iterations. Its equation is shown in Figure 5.9, and the threshold was set to 0.001 to break the iteration.

Figure 5.9 – Percent RMSE of Network Skims

$$\%\text{RMSE} = \frac{\sqrt{\sum_{i \in I}\left(T_i^n - T_i^{n-1}\right)^2/(I-1)} * 100}{\left(\sum_{i \in I} T_i^{n-1}/I\right)}$$

Where:

n – current MSA iteration number;
n-1 – last MSA iteration number;
I – total number of O-D pairs;
T_i^{n-1} – Travel time of O-D pair i from last MSA iteration;
T_i^n – Travel time of O-D pair i from current MSA iteration

6.0 Mode Split

Trip distribution model produces daily person trips for the six non-commercial trip purposes. For each trip purpose, the BSRC model then applies different mode share factors to proportionate person trips into the following five travel modes: :

- Drive alone (Driver only)
- Shared ride (Carpool)
- Transit
- School bus
- Bike/Walk

As shown in Table 6.1, these mode share factors were summarized from the *2013/2014 Quad Cities Household Travel Survey (HHTS)*

Table 6.1 – Mode Share Percentages by Trip Purpose

Mode	HBW	HBSCL	HBSH	HBSR	HBO	NHB	Total
Drive Alone	93.5%	16.4%	75.7%	62.5%	77.2%	73.6%	69.4%
Shared Ride	4.1%	52.1%	20.8%	32.2%	19.0%	22.6%	24.0%
Transit	0.6%	0.2%	1.1%	0.1%	0.8%	1.6%	0.9%
School Bus	0.0%	22.5%	0.0%	0.0%	0.1%	1.1%	2.7%
Bike/Walk	1.8%	8.9%	2.3%	5.2%	2.9%	1.1%	3.1%

Source: 2013/2014 Quad Cities Household Travel Survey

Only auto trips, which include drive alone and shared ride, were left for traffic assignment. Other non-auto trips were simply ignored because of their negligible market shares. Drive alone trips were converted directly to the same amount of vehicle trips. Shared ride trips were converted to vehicle trips by applying average vehicle occupancy rates summarized from the household travel survey. The commercial truck trips were generated as vehicle trips from the beginning, so they do not need any further conversion. Table 6.2 shows the average vehicle occupancy rates by trip purpose.

Table 6.2 – Vehicle Occupancy

Trip Purpose	Occupancy
HBW	2.87
HBSCL	2.14
HBSH	2.26
HBSR	2.44
HBO	2.58
NHB	2.46

Source: 2013/2014 Quad Cities Household Travel Survey

The level of congestion varies by traffic direction and time of day. In order to reflect these conditions in the model, daily vehicle trips were allocated to the following four time periods:

- AM Peak (AM): 6:30-9:00 a.m.
- Mid-day (MD): 9:00 a.m.-3:30 p.m.
- PM Peak (PM): 3:30-6:30 p.m.
- Night (NT): 6:30 p.m.-6:30 a.m.

For each trip purpose, *2013/2014 Quad Cities Household Travel Survey* data was tabulated to estimate the diurnal distribution factors shown in Table 6.3 and directional split factors shown in Table 6.4. These factors worked together to convert daily trips in the form of PA (Production & Attraction) to period directional trips in the form of OD (Origin & Destination), which eventually can be utilized by the traffic assignment model.

Table 6.3 – Diurnal Distribution Factors

Purpose	AM Peak	Mid-day	PM Peak	Night
HBW	29%	24%	29%	18%
HBSCL	46%	36%	15%	3%
HBSH	7%	62%	20%	11%
HBSR	9%	30%	31%	30%
HBO	29%	38%	20%	13%
NHB	12%	62%	18%	8%
CV	20%	46%	22%	12%

Source: 2013/2014 Quad Cities Household Travel Survey

Table 6.4 – Percentages of Trips from Production to Attraction

Purpose	AM Peak	Mid-day	PM Peak	Night
HBW	97%	50%	10%	56%
HBSCL	100%	11%	13%	33%
HBSH	71%	47%	30%	27%
HBSR	78%	50%	58%	27%
HBO	76%	53%	45%	31%
NHB	50%	50%	50%	50%
CV	50%	50%	50%	50%

Source: 2013/2014 Quad Cities Household Travel Survey

7.0 Traffic Assignment

Traffic assignment is the last step of the travel demand model process. The vehicle trips calculated in the mode choice model are assigned to the network based on minimum impedance paths available. As congestion builds over time, the highway assignment model shifts traffic to adjacent facilities having excess capacity. Similarly, corridors where new roads or roadway improvements are planned will see traffic diversions to the new facilities from parallel facilities having slower speeds or higher congestion. These shifts in traffic between facilities are a major component of what is perceived of as induced demand.

The BSRC model assigns traffic based on a "user equilibrium" algorithm, which is an iterative process. It uses the capacity constraints on links and calculates the updated minimum impedance path for each iteration until no travelers can reduce their travel cost (in time) by switching to another route. Unless convergence criteria is met, the iterative process of assignment ends when maximum iteration is reached. The maximum iteration is set to 25 by default.

7.1 Bureau of Public Roads (BPR) Curves

The Bureau of Public Roads (BPR) curves give the change in travel time with respect to change in the Volume over Capacity (V/C) ratios on a highway link. The BPR equation is given as follows:

Figure 7.1 – BPR Function

$$T = T_0 \left[1 + a \left(\frac{v}{c} \right)^b \right]$$

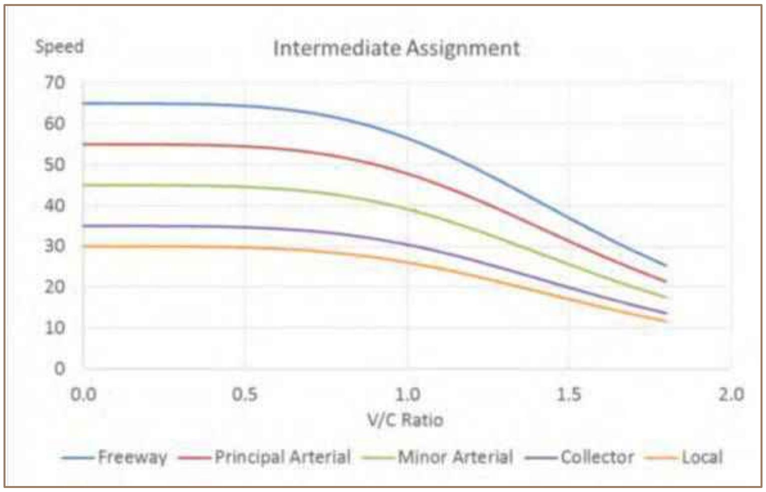
Where:

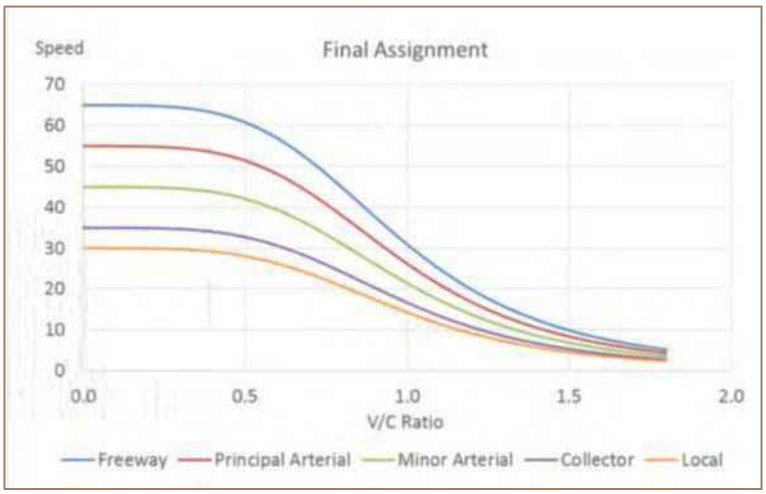
- T – Congested travel time
- T_0 – Free flow travel time
- a and b – BPR coefficients

The highway links are grouped into different link classes based on facility type, area type, number of lanes, and free flow speed. Each link class is associated with a particular BPR curve. The default coefficients of BPR curves were borrowed from the *Travel Model Improvement Program (TMIP) Model Validation and Reasonableness Checking Manual* (2010).

Figure 7.2 illustrates the Volume-Delay Function (VDF) for facilities with different functional classification and free flow speed. These curves reflect how travel speed reduces on the facility as the loading traffic increases. The upper chart shows the VDF curves that are implemented in "intermediate" assignments done for the distribution-assignment feedback loop. The lower chart shows more rigorous VDF curves that are utilized in final assignment only.

Figure 7.2 – Volume Delay Curves





Source: Bi-State Regional Commission, 2016

7.2 Turn Prohibition and Turn Penalty

Both turn prohibition and turn penalty are scenario-specific data stored in a "linktp.bin" file in the output folder. The file has three data fields including "From LinkID," "To LinkID," and "Penalty." The combination of "From LinkID" and "To LinkID" defines the turn movement.

"Penalty" fields are labeled as 9999 for prohibited turn movements, such as U-turn on a freeway or an illegal turn entering the reverse direction of a one-way street. "Penalty" fields also carry turn penalties for certain turn movements at select intersections. These penalties are extra delay in minutes that are not well represented in the travel model. One example is the left turn movements at busy intersections where people have to wait longer to cross oncoming traffic.

7.3 Convergence

As mentioned above, traffic assignment is an iterative process to approach a "user equilibrium" condition. To avoid excessive running time, model users usually stop the iteration when:

- Assignment results are within acceptable error tolerance. In this ISMS model, assignment is considered "converged" if relative gap is less than 0.0001.
- Assignment process has been running for sufficient amount of time. In this ISMS model, the maximum iteration of assignment process is set to 500.

The measure of assignment convergence is the relative gap, which is a common criteria to compare the current assignment solution to the ideal shortest-route for all O-D pairs. Its equation is shown as follows:

Figure 7.3 – Relative Gap

$$RG = \frac{\sum_i \sum_k F_{ki} * T_{ki} - \sum_i D_i * U_i}{\sum_i D_i * U_i}$$

Where:

RG – Relative gap
F_{ki} – Volume flow on link k for O-D pair i
T_{ki} – Travel time on link k for O-D pair i
D_i – The total flow for O-D pair i
U_i – The shortest route travel time for O-D pair i

7.5 Post Processing

Once traffic assignments are done for all four time periods, additional processing is needed to produce reports, data files, and maps. The four period assignment results are combined into one summary file. In this process, the peak hour volume for each period is converted back to total period volume by applying the inverse of loading multipliers (2.56 for AM, 7.14 for MD, 2.56 for PM and 4.35 for NT). Volume from the four time periods are then added up to get Annual Average Daily Traffic (AADT).

Procedures from Highway Capacity Manual (HCM) 2010 are used to compute the Level-of-Service (LOS) for each highway segment based on a Volume over Capacity (V/C) ratio as shown in Table 7.2. V/C ratio varies by time period and direction. The highest V/C ratio on a link can be used to represent the worst case condition.

Table 7.2 – Level-of-Service Standards

Volume /Capacity	Level of Service
<= 0.29	A
0.30 - 0.49	B
0.50 - 0.69	C
0.70 - 0.84	D
0.85 - 0.99	E
>= 1.0	F

Source: Highway Capacity Manual 2010

8.0 Model Validation

A systematic and iterative procedure was used to calibrate each of the four steps in the Bi-State travel model to base year 2015 travel conditions. Calibration model runs were performed to achieve the following goals:

- Bring overall trips into agreement with overall counts
- Bring model estimates into agreement with household travel survey results
- Correct traffic volume at select locations with large errors

The calibration process consists of correcting model inputs as well as adjusting parameters. The following enhancements were made during the calibration process:

- Trip Generation Model
  - Verified and corrected zonal socio-economic data in individual TAZs
  - Corrected highway network coding errors
  - Adjusted trip generation rates
- Trip Distribution Model
  - Adjusted external travel estimates
  - Adjusted trip distribution parameters and K-factors
- Modal Split Model
  - Refined modal split factors
- Traffic Assignment Model
  - Modified zone connector configurations
  - Adjusted highway capacity assumptions
  - Added link-specific speed corrections
  - Corrected turn penalty coding
  - Modified highway assignment parameters

The validation results of trip generation and distribution model have been documented in previous chapters. This chapter focuses on the final validation step that compared the 2015 model assigned volume with traffic count data from Iowa and Illinois Departments of Transportation (DOT). The validation step measures the Bi-State model's ability to replicate the actual travel characteristics on the streets. The primary goal of the validation is to ensure the model produces reasonable results and is ready for regional planning and corridor studies.

8.1 Assignment Validation Statistics

Table 8.1 summarizes regional level validation statistics after the model calibration process was finished. The "Total Traffic Volume" statistics measure how accurate the model was in replicating overall trips by functional classification.

Another model validation statistic is the Percent Root Mean Squared Error (%RMSE). The %RMSE aggregates the magnitudes of individual residuals at each count location into a single measure of model accuracy. It is calculated using the formula as follows:

Figure 8.1 – Percent RMSE of Count Validation

$$\%\mathrm{RMSE} = \frac{\sqrt{\sum_{n \in N} (M_n - C_n)^2 / (N-1)} * 100}{\left(\sum_{n \in N} C_n / N\right)}$$

Where:

M_n – Model volume on link n; C_n – Count volume on link n; N – Total number of counts

Travel demand model is a closed system. It is not able to replicate the reality, which is an open world, with 100% accuracy. The *TMIP Model Validation and Reasonableness Checking Manual, 2010* suggested the following acceptable ranges of error for roadway facilities with different functional classification. Table 8.2 compares validation statistics from the model with the TMIP guidelines. In all cases, the model is well within the acceptable limits. The total Mississippi River crossings are within 3.80% of counts.

- Interstate Freeway ± 7%
- Major arterial ± 10%
- Minor arterial ± 15%
- Collector ± 25%

Figure 8.2 is a scatter plot comparing modeled and observed volume across all traffic counts. With a slope of 0.97 and high "R Squared" of 0.9, the scatters tend to concentrate in the vicinity of the identity line (y=x). It indicates that the BSRC model consistently replicates the base year 2010 count data, and margins of error are within a satisfying tolerance.

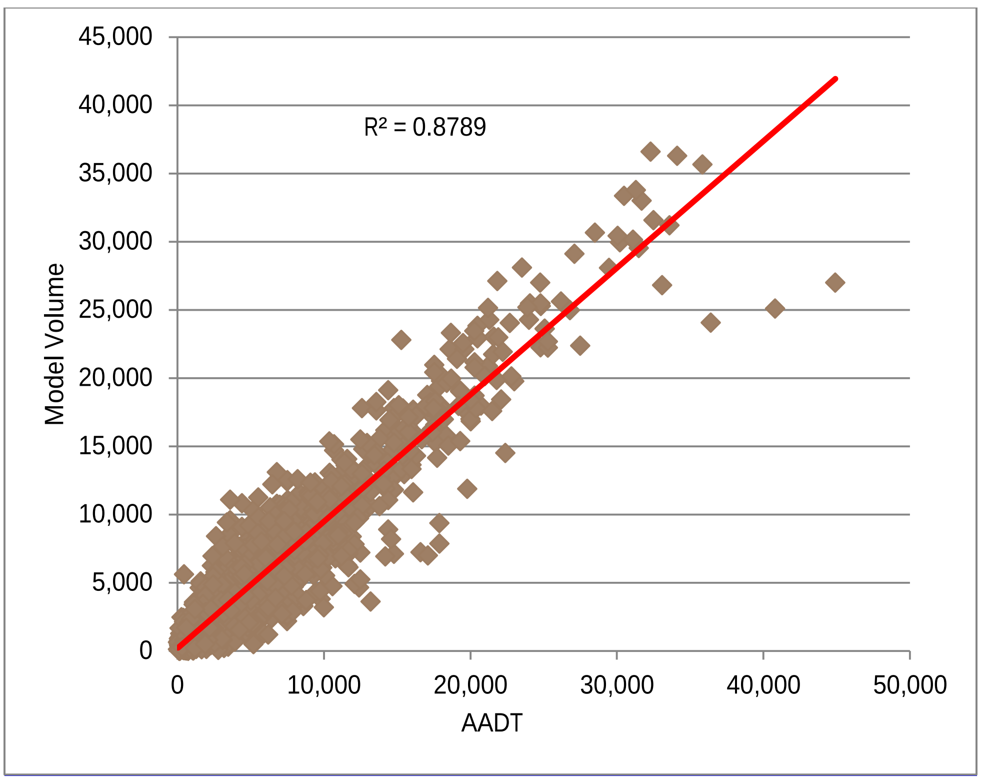
The ability of the BSRC model to accurately estimate Mississippi River bridge crossings is of particular interest in the Bi-State MPA.

Table 8.1 – Traffic Assignment Validation Statistics

Facility Type	Number of Counts	VMT		Error		Distribution		FHWA Goal
		Model	Observed	Difference	Percent	Model	Observed	
Freeways	82	1,246,403	1,263,492	-17,089	-1.40%	42%	42%	+/-7%
Principal Arterial	192	637,134	602,885	34,249	5.70%	21%	20%	+/-10%
Minor Arterial	464	618,106	694,036	-75,930	-10.90%	21%	23%	+/-15%
Collector	432	319,959	326,521	-6,563	-2.00%	11%	11%	+/-25%
Ramps	120	177,186	156,419	20,767	13.30%	6%	5%	N/A
Total	1,290	2,998,787	3,043,353	-44,565	-1.50%	100%	100%	

Source: Bi-State Regional Commission, 2020; DOT traffic counts, 2015

Figure 8.2 – Traffic Count Comparison



Source: Bi-State Regional Commission, 2020; DOT traffic counts, 2015

Table 8.2 – Mississippi River Bridges & Each State

Area Type	Number of Counts	VMT		Error		Distribution	
		Estimated	Observed	Difference	Percent	Estimated	Observed
Iowa	629	1,793,264	1,837,581	-44,317	-2.40%	60%	60%
Illinois	654	1,057,859	1,063,482	-5,623	-0.50%	35%	35%
Bridges	7	147,665	142,290	5,375	3.80%	5%	5%
Total	1290	2,998,787	3,043,353	-44,565	-1.50%	100%	100%

Source: Bi-State Regional Commission, 2020; DOT traffic counts, 2015

9.0 Alternatives Analyses for 2050 Roadway Network

Alternatives analyses for the roadway network were conducted. This analysis is one tool used by local and state jurisdictions to determine a future roadway network. In addition, pavement condition and crash history are other elements. Funding availability is another consideration. Alternatives analysis identifies existing and future congested roadway segments.

Projects are proposed and refined, based on these findings, to address the congested corridors within the roadway network. The calibrated model can demonstrate 24-hour traffic volumes, Vehicle Miles Traveled (VMT), and Vehicle Hours Traveled (VHT) for this analysis. Volume over Capacity (V/C) ratio illustrates the highest congestion levels during the day.

A detailed alternative analysis was included in the Chapter 4 of *Connect 2050: Quad Cities Long Range Transportation Plan* (2050 LRTP), which compared V/C ratios of various scenarios for future year 2030 and 2050 based on the fiscally constrained roadway/bridge improvements.

Some of the improvements are accomplished directly at the congested area, while others provide alternative routing via new roadways. In addition, not all congestion concerns could be addressed through roadway capacity expansion. Some may be addressed using alternatives in the Congestion Management Process (CMP). As a result of changing demographics, a few new congested locations are created and may need further study in the future. As the plan is reevaluated, amended, and/or updated in the future, these issues will be further studied.

10.0Future improvements

A regional travel demand model requires long-term, continuous efforts in maintenance and functional improvement to enhance its capability and reliability of traffic forecasting. A certification review of the transportation planning process for the Quad Cities MPA was performed by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) on April 26-27, 2016, and the final report was released August 29, 2016. Through the process, the following model improvements were recommended by the review team:

- Concentration on employment data accuracy
- More details on trip generation procedures
- Better representation of travel time and capacity effects at signalized intersections
- Enhanced trip distribution procedures
- Improved mode share estimates
- Better highway assignment algorithms
- Improved reporting and mapping functionality

The current trip generation model utilizes the number of employees to forecast zonal attractions. Employment data classified by North American Industry Classification System (NAICS) code are clustered into three categories: retail, industrial, and other. The same attraction rates are applied to all types of employments in each category. This treatment ignores the different nature of jobs between business types. For instance, jobs in both Finance Insurance and Food Services are labeled as "Other" employment in current model. However, places with Food Services jobs typically attract more daily trips than places with same amount of Insurance jobs. Model capability of replicating the reality may be enhanced by introducing more detailed employment categories with differentiated attraction rates.

Auto trips and truck trips are mixed up in current traffic assignment process. However, truck trips cause more congestion on roadway facilities than the same amount of auto trips. Truck drivers also behave quite differently from auto drivers in many aspects such as operating speed, changing lane, and path choice. It is common practice to treat truck trips with special speed adjustment factors, route exclusion, and Passenger Car Equivalent (PCE) factors.

It is also recommended to enhance the traffic assignment process with tighter convergence criteria. A relative gap of 0.001 rather than 0.01 would help reduce the randomness of assignment results. Volume-Delay Functions (VDF) used in traffic assignment may also be further adjusted for roadway facilities with different functional classification.

Iowa DOT is working with consultants to develop Iowa Standardized Model Structure (ISMS). This project aims to "Provide a consistent comprehensive and standard framework of best practices and application of travel demand modeling and traffic forecasting tools" (Retrieved from http://www.mtmug.org/ISMS.htm). Bi-State Regional Commission is encouraged to work with the Iowa DOT and a consultant to update the travel demand model to new policy and procedure standards.

Appendix

A.1 Master Network Preparation

The first step toward completing the Base Year 2015 roadway network dataset was to review the *2045 Quad Cities Long Range Transportation Plan (LRTP)* Master Network for the entire MPA. Some roads were added to the road network to enhance connectivity, while other roads that no longer existed in 2015 were removed, such as the Blackhawk Road and Valley View Drive intersection in Moline, and the old Tanglefoot Lane and Middle Road intersection in Bettendorf.

The 2050 LRTP model used an updated version of the adopted 2050 plan model street network. Centerline files were the source of network editing. Bi-State Regional Commission created the Rock Island and Henry Counties' spatial line data. Scott County's spatial line data was provided by Iowa DOT. The attribute data used in the travel demand model were from each state's DOT. These attribute data sets included Annual Average Daily Traffic (AADT), Federal Functional Classification (FFC), number of lanes, and speed. Wherever possible for Rock Island and Henry Counties, data values for speed were provided directly by municipalities to reflect posted speed limits. The data created by Bi-State Regional Commission include roadway capacity, direction, travel time, and link distance.

Because Iowa and Illinois DOT have different methods of organizing their data, it was necessary to have each state's data prepared separately then merged. The data for Scott County was stored in multiple shapefiles and joined by using the field name "MSLINK," which was a unique identifier. Once all the data tables had been joined to a final shapefile, then they could be exported to represent Scott County with all the needed attribute data.

For roads in Rock Island and Henry Counties, Federal Functional Classification (FFC) and area type were manually entered based upon the previous 2040 travel demand model data, using an exported TransCAD file. The final step in preparing these two Illinois Quad Cities geographies was to remove unnecessary roads that would be anything with an FFC designation below collector. Prior to merging with the Iowa Quad Cities geography, the two shapefiles were merged, and the attribute table data was combined, so a single field would contain the data values of all three counties. The last step of preparing the preliminary road network was to clip the counties' road data to the MPA boundary and also keep a quarter mile buffer outside of the MPA boundary.

Centroids represent the origins and destinations of travel activities within each Traffic Analysis Zone (TAZ). They are not necessarily physically centered in the TAZ. With the refinement of parcel based TAZs required by ISMS, Bi-State staff has more than doubled the number of TAZs in the model from the 2045 TDM. There are now 2,070 centroids in the model network. Of those 2,070, 1,982 represent internal zones, and the remaining 88 represent external stations, which are the points bordering the planning boundary that represent traffic entering, exiting, or passing through the study area.

For the geographic database, the setup of TAZ, TAZ centroids, and centroid connectors began with using an empty TAZ polygon file and assigning the proper TAZ numbers to the attribute table. Once the TAZs were given their ID number, they were overlaid on the 2010 base road network that allowed TAZ centroids to be placed. Centroids were placed in each TAZ by using 2010 aerial imagery and interpreting the single mostly likely source and destination of traffic based on ground structures and concentration. After that, the centroid connectors could be created.

Centroid connectors join centroids to the nearby road network. These connectors conceptually represent all local residential streets that are not included in the model highway network. The connectors were designated from each TAZ centroid to the most likely road that traffic would follow, typically the higher the FFC the greater the likelihood of being connected to the centroid.

Once the preliminary network data was created and combined, more in depth data manipulation could be done. This included the need to standardize FFC values from GIS files because Iowa and Illinois have slightly different ways of classifying their roads and illustrating them geographically. In addition to standardizing road classifications, highway entrance and exit ramps, and TAZ centroid connectors were also given values within the FFC data field.

Finally, once all the base network data was created in ArcMap, it could be exported for TransCAD. The first step of TransCAD preparation was to clean up the data for TransCAD to be able to be properly used. This meant making sure all intersections worked properly, dualizing divided, limited access highways, identifying one-way routes and their direction, and being sure all the network links were properly connected to allow the proper modeled flow of traffic. Network reviews were also performed when roadway capacities were generated, AADT values were entered, and number of lanes were verified.

Once the Base Year 2015 network was confirmed and verified, then roadway projects were coded into the network that are planned to be completed by 2030 and 2050. The master network file has a set of fields describing roadway characteristics when the road is first opened, another set of fields describing proposed roadway changes, and fields describing opening and project years. For example, a road that exists in 2015 as a two-lane road and will be widened by 2030 to a four-lane road would have "2030" coded in the opening year field and "1" in the opening year directional number of lane fields. The project number will be coded into the project year field and "2" in the project year directional number of lane fields. The model will then read in the project database "projlut.bin" to lookup the change year based on the project number to decide whether the project has been complete or not in the scenario year.

After the master network was completed to encompass all road projects through 2050, the network was tested again for link connectivity and any other issues. Highway network files are created from the master network for each scenario based on a listing of projects to be included in the alternative.

A.2 Network Attributes

Table A.1 describes master network attributes used in the BSRC model. It should be noted that the master network includes additional fields that are either carried over from previous versions of the model or are computed variables based on the attributes listed below.

Table A.1 – TransCAD Master Network Attribute Table

Attribute Name	Description
ID	TransCAD assigned unique link identification number
Length	TransCAD computed link length in miles
DIR	Direction code where:
0 =	Two-way operation
1 =	One-way operation in link flow direction
-1 =	One-way operation opposite link flow direction
ROUTE_NAM	Street name
AADT_2010	Final edited Iowa traffic volume
COUNTLK	Illinois count link used to interface with count volume file
DUALIZED	Where:
0 =	Not dualized
1 =	Dualized in SB/WB direction
2 =	Dualized in NB/EB direction
LRTP_FFC	Functional classification:
1 =	Freeways
2 =	Expressways
3 =	Principal arterials
4 =	Minor arterials
5 =	Collectors
6 =	Freeway-freeway ramps
7 =	On/off ramps
8 =	Local streets
9 =	Turn lanes
10 =	Zone connectors
FCNAME	Functional class name
TYPE_AREA	Area type, where:
1 =	Central Business District

2 =	Urban
3 =	Suburban
4 =	Rural
ADJSPEED	Speed adjustment needed to calibrate the highway assignment model (added to posted speed)
YRPROJ1	Opening year (9999 = not included in any year), project codes entered for LRTP projects
PSPEED1	Posted speed limit in opening year
ABLANES1	Number of lanes in the AB direction in opening year (0 when DIR = -1)
BALANES1	Number of lanes in the BA direction in opening year (0 when DIR = 1)
YRPROJ2	Year link is changed, project codes entered for LRTP projects
PSPEED2	Posted speed limit in change year (0 if same as opening year speed)
ABLANES2	Number of lanes in the AB direction in change year (0 when DIR = -1 or same as opening year, -1 = links deleted in change year)
BALANES2	Number of lanes in the BA direction in change year (0 when DIR = 1 or same as opening year)
ABCAP	Hourly level-of-service "E" capacity in the A-B direction based on functional class, area type and number of directional lanes
BACAP	Hourly level-of-service "E" capacity in the B-A direction based on functional class, area type and number of directional lanes
FFSPEED	Free-flow speed which is the sum of the posted speed and the adjusted speed multiplied by a speed adjustment factor based on functional class and area type
FFTIME	Free-flow time (minutes) based on link length and free-flow speed

Source: Bi-State Regional Commission, 2020