APPENDIX D-1

Traffic Technical Report

Clarification Note: This document was completed before the development of Central Alternative 1B Modified (Selected); therefore, the alternative is not included in the document. Applicable information regarding Central Alternative 1B Modified (Selected) is provided in the FEIS.

November 2018

TRAFFIC TECHNICAL REPORT

I-69 Ohio River Crossing Project

Evansville, IN and Henderson, KY

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Traffic Technical Report

I-69 Ohio River Crossing Project
Evansville, IN and Henderson, KY

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CHAPTER 1 – INTRODUCTION

1.1 PURPOSE OF TECHNICAL REPORT

Indiana Department of Transportation (INDOT), in cooperation with Kentucky Transportation Cabinet (KYTC) and Federal Highway Administration (FHWA), is conducting a study to connect the existing segments of I-69 in Indiana and Kentucky across the Ohio River, in accordance with requirements of the National Environmental Policy Act (NEPA). A key component of the NEPA study is to estimate the impacts of a new crossing of the Ohio River on traffic patterns in the Evansville, IN metropolitan area, including the City of Henderson, KY on the south side of the river.

The Evansville Metropolitan Planning Organization (EMPO) maintains a five-county regional travel demand model (TDM) with a base year of 2010 and a forecast year of 2040. For the purposes of the I-69 Ohio River Crossing (ORX) Bridge Crossing Study, the EMPO model was obtained and updated to a new base year of 2015, which includes the recent opening of sections of I-69 to the north of I-64 and the upgrade of Edward T. Breathitt Pennyrile Parkway to I-69 south of Henderson, KY. The model has also been updated to create new 2025 and 2045 forecast horizon years compatible with the study's horizon year.

The 2015 base year update primarily consisted of a review of the existing 2015 network revisions to verify existing and recently completed roadway improvements, new socioeconomic data for use in the traffic analysis zone (TAZ) file, and current traffic count data for use in calibration and validation. The process of updating the external trip table is discussed later in this chapter.

The purpose of this technical report is to document the process, assumptions, and results of updating the EMPO model to a new base year of 2015, revalidating the model to best replicate a comprehensive set of 2015 traffic counts, and developing 2025 and 2045 forecasts including tolling scenarios and Environmental Justice (EJ) analyses. More detailed analyses using microsimulation and Highway Capacity Manual (HCM, Transportation Research Board 2016) analysis methods will be provided for a Preferred Alternative before a Final Environmental Impact Statement (FEIS) is published.

For project background, purpose and need, and further discussion of the range of alternatives under consideration, refer to the I-69 ORX *Screening Report* and *Screening Report Supplement* (INDOT and KYTC 2017 and 2018b).

CHAPTER 2 – MODEL VALIDATION

2.1 NETWORK REVIEW

The existing EMPO TDM model files included a 2010 base year network and future year networks for 2015, 2022, 2035, and 2040. The 2015 future network was used as the basis for the calibration and validation of the updated model. This network, prepared in 2012, included all programmed roadway improvements expected to occur through 2015, in effect, reflecting the existing network as of 2015. Stantec reviewed current aerial imagery and available planning documents including EMPO's 2018-2021 *Transportation Improvement Program* (TIP), to identify recently completed projects which should be present in the 2015 network (EMPO 2017; Google Earth 2018). Network edits were limited to new projects incorporating a new alignment, a change in the number of directional lanes, and/or some other improvement with an explicit change in free-flow speed or capacity. Based upon those criteria, the following projects were identified as constructed between 2012 and 2015 and verified to be present in the 2015 model network. **Figure 2.1-1** depicts the location of these projects.

1. I-69 from I-64 to the northern model external boundary within Pike County, IN
2. Oak Hill Road – realignment from Millersburg Road to Kansas Road to accommodate a runway extension at Evansville Regional Airport
3. North Green River Road – widening to four lanes between Millersburg Road and Kansas Road in east Vanderburgh County, IN
4. University Parkway – extension from Upper Mt. Vernon Road to SR 66 in western Vanderburgh County, IN
5. US 41/Lloyd Expressway – interchange modification to full cloverleaf in central Evansville, IN
6. I-69 (formerly Edward T. Breathitt Parkway)/KY 416 – interchange modification to full diamond interchange in Henderson County, KY

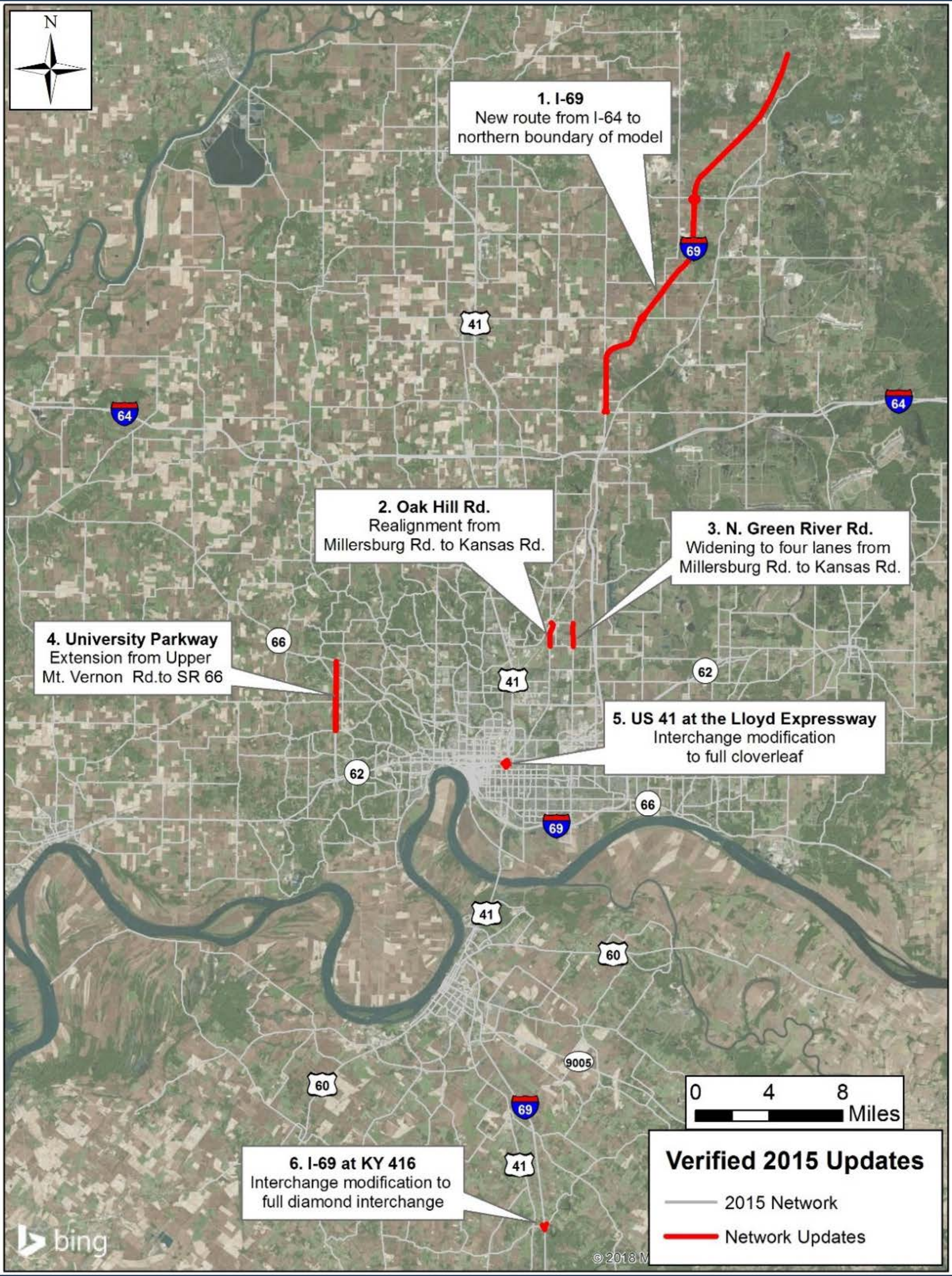


Figure 2.1-1. Recently Completed Projects within the EMPO Model Area

Sources: EMPO 2017; Bing 2018

Once the 2015 network was verified, the programmed road improvement projects with committed funding from EMPO's 2018-2021 TIP were added to the model's future year network to serve as the base Existing + Committed (E+C) network for the 2025 and 2045 alternatives analysis. The following projects were included in the E+C network; **Figure 2.1-2** depicts the location of these projects:

1. SR 61 Connector Road, Northwest Boonville Bypass – new two-lane alignment connecting SR 62 to New Harmony Road in Warrick County, IN
2. Oak Grove Road – widen to three lanes from Bell Road to SR 261 in Warrick County, IN
3. Weinbach Avenue Road Diet – reduce from four to three lanes from Walnut Street to Pollack Avenue in Evansville, IN
4. Covert Avenue Road Diet – reduce from four to three lanes from US 41 to I-69 in Evansville, IN
5. High Pointe Drive – new two-lane alignment from Grimm Road to Libbert Road in Warrick County, IN
6. Bell Road – widen to three lanes from High Pointe Road to Telephone Road in Warrick County, IN
7. Corydon Bypass – new two-lane alignment to bypass US 60 in Henderson County, KY
8. US 60 widening – widening US 60 to four lanes around Corydon, from Waverly to Corydon and from Corydon to KY 425, in Henderson and Union counties, KY

As discussed, the projects above have committed funding and are anticipated to be implemented. These are also projects that would provide for increased capacity or new routes that may affect travel patterns within the model area. While additional capacity-enhancing projects are listed in the 2040 EMPO *Metropolitan Transportation Plan*, they are subject to revision and funding uncertainty. Discussion with the EMPO staff concluded that limiting projects in the future networks to those with TIP funding certainty assured the most reasonable and predictable basis for evaluating project alternatives.

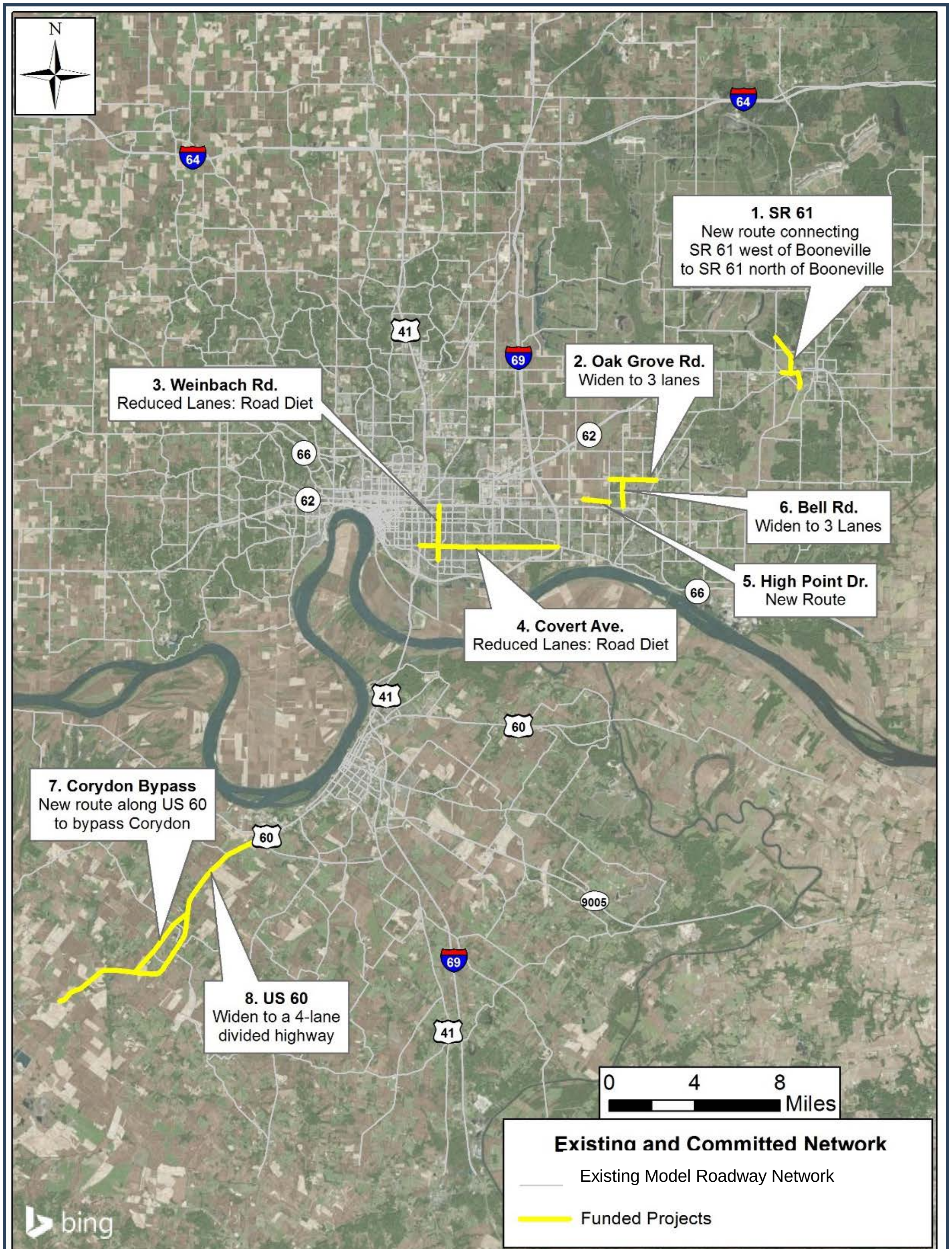


Figure 2.1-2. Planned and Committed Projects in E+C Network

Sources: EMPO 2017; Bing 2018

2.2 SOCIOECONOMIC UPDATES

The following sections summarize the process and results related to updating the socioeconomic data within the EMPO model. This effort included meetings with officials from each of the five model counties to discuss proposed socioeconomic data estimates for 2015 and projections for 2045. More discussion of these meetings is included in the Draft Environmental Impact Statement (DEIS). The general findings from these meetings are summarized below.

- **Henderson County** is expected to see negative population growth overall. There is planned residential and employment growth east of US 41 and south of US 60 and employment growth west of downtown in the vicinity of Henderson Community College.
- **Posey County** is expected to see negative population growth and little to no growth in employment. Population growth in the communities of Mt. Vernon and New Harmony is expected to remain flat and the rest of the county will experience decline.
- Continued employment growth in **Vanderburgh County** is expected near the I-69 interchanges (following the current trend), in downtown Evansville, and near University Parkway. Population growth is expected downtown and north along US 41.
- In **Warrick County**, the highest levels of growth in both population and employment are expected near the I-69 interchanges at SR 62 and SR 66 (also following current trends).
- **Gibson County's** population rate has been flat for the past 50 years as a result of the lack of sewer infrastructure and zoning. The county is promoting growth in both population and employment around the existing I-69 interchanges. The Toyota Motor Manufacturing facility south of Princeton continues to grow and will attract additional employment.

In each of these meetings, local officials were asked if the implementation of the I-69 ORX project would result in any specific changes related to land use or development trends in their county beyond those already occurring or anticipated as a result of the completion of the new sections of I-69 in southwest Indiana and the upgrade and designation of I 69 in Kentucky. This discussion included presentation of the range of alternatives (the Level 1 corridors) that were under consideration at that time. In each case, implementation of I-69 ORX project was not believed to result in changes in land use or additional development. Much of the project area is currently already developed or passes through areas with significant amounts of floodplain. The current location of I-69 in Kentucky and Indiana has already provided opportunities for development, and the development of a new Ohio River crossing would not demonstrably affect access to areas where development has not occurred or is not already planned.

2.2.1 HOUSEHOLDS

The original 2010 base year EMPO TAZ file was updated to 2015 to reflect current data estimates for population, households, and employment. The data sources for the update included the U.S. Census Bureau, STATS Indiana, and Kentucky State Data Center (KSDC) for household and population; the U.S. Bureau of Economic Analysis (BEA) for employment; local county building permit data; and interviews with local officials. Population and employment fields were directly updated in the model to reflect the county-level totals provided by the respective source data while student enrollment fields were factored to reflect the relative growth in population.

The total number of households and household population were set for each county based on the U.S. Census' estimate of population and households for 2015, as reported by KSDC and STATS Indiana (KSDC 2017, STATS Indiana 2017). Household adjustments for 2010 to 2015 were made to the individual TAZs of each county using available building permit data for new housing units in the City of Henderson, Henderson County, KY and Vanderburgh and Warrick counties, IN as a guide (Henderson et. all, 2017). Analysis using Google Earth's time-stamped aerials and interviews with local officials provided further guidance on the allocation of new households within each county (Google Earth 2018). While building permit data for Gibson and Posey counties in Indiana were not available, population growth in Posey County was slightly negative between 2010 and 2015, and was slightly positive in Gibson County. In Gibson County, local officials stated that new development occurred within the existing municipal service areas of Princeton, Haubstadt, and Fort Branch. **Table 2.2-1** presents the county level totals for household population and households from the original 2010 base year TAZ file and the new revised 2015 base year TAZ file.

Table 2.2-1. EMPO Model Household and Population

COUNTY	HOUSEHOLD POPULATION				HOUSEHOLDS			
	2010	2015	CHANGE	PERCENT CHANGE	2010	2015	CHANGE	PERCENT CHANGE
Gibson	32,765	34,114	1,349	4.1%	13,255	14,219	964	7.3%
Henderson	45,085	46,407	1,322	2.9%	18,705	19,180	475	2.5%
Posey	25,668	25,369	-299	-1.2%	10,171	9,926	-245	-2.4%
Vanderburgh	172,172	183,494	11,322	6.6%	75,248	78,599	3,351	4.5%
Warrick	58,963	62,969	4,006	6.8%	22,505	23,932	1,427	6.3%
Total	334,653	352,353	17,700	5.3%	139,884	145,856	5,972	4.3%

Sources: EMPO 2017, KSDC 2017, and STATS Indiana 2017

Figure 2.2-1 presents the allocation of household growth within the model area, as expressed by percent change from the 2010 base year to the new 2015 base year, within the model's TAZs.

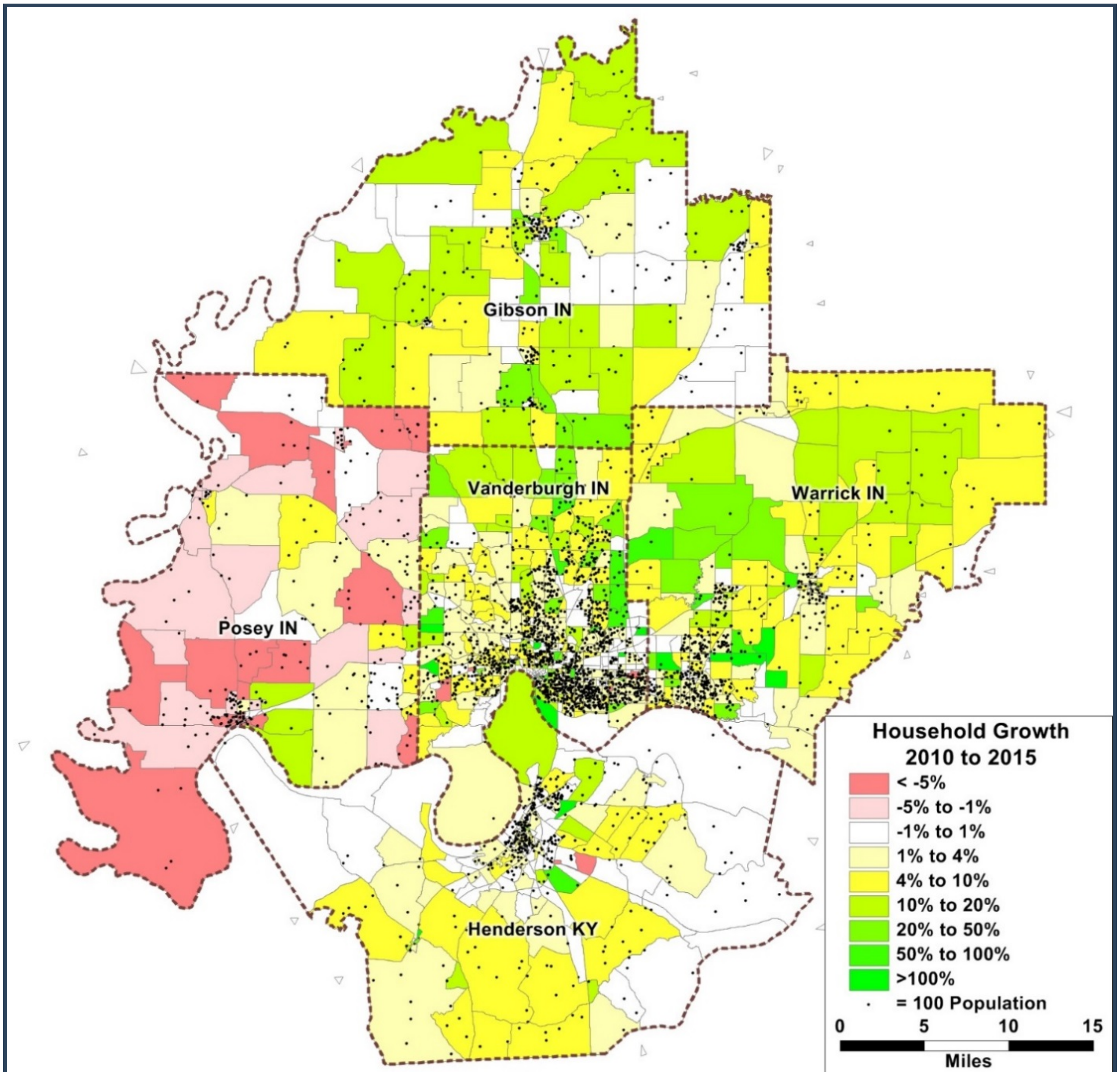
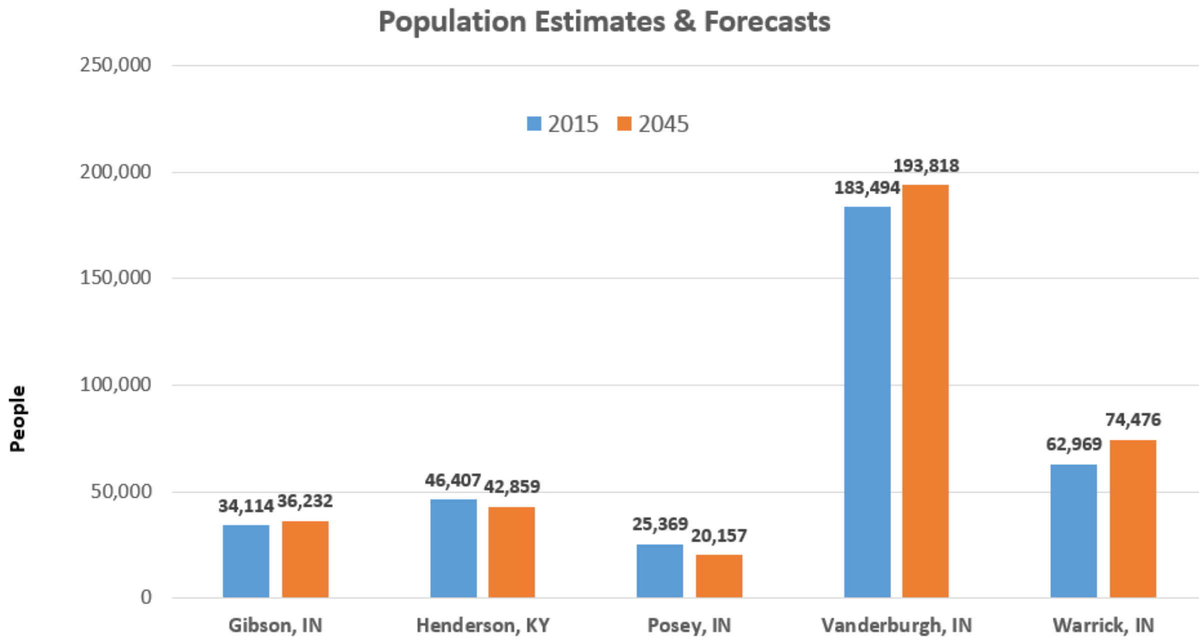


Figure 2.2-1. Percent Change of Household Growth within TAZs

Sources: EMPO 2017, KSDC 2017, and STATS Indiana 2017

Population estimates for the 2025 and 2045 TAZ files were based on the county level forecasts of KSDC and STATS Indiana (KSDC 2017, STATS Indiana 2017). **Figure 2.2-2** presents these county totals for 2015 and 2045. Growth in the EMPO model area between 2015 and 2045 is fairly flat. Henderson and Posey counties are expected to decrease in population while Gibson, Vanderburgh, and Warrick counties are expected to increase.



	Gibson, IN	Henderson, KY	Posey, IN	Vanderburgh, IN	Warrick, IN
2015	34,114	46,407	25,369	183,494	62,969
2045	36,232	42,859	20,157	193,818	74,476
DELTA	2,118	-3,548	-5,212	10,324	11,507
PERCENT CHANGE	6.2%	-7.6%	-20.5%	5.6%	18.3%

Figure 2.2-2. County Population Estimates and Forecasts

Sources: KSDC 2017 and STATS Indiana 2017

EMPO staff and local officials were consulted regarding the allocation of new population within the TAZs for each county.

In Henderson, Vanderburgh, and Warrick counties, some proposed or prospective developments were specifically identified, and the general trends of regional growth were continued going forward. Vanderburgh County is expected to grow slightly with new development located at the periphery of the county, while more rapid suburban development in Warrick County is expected to continue to expand from the southwestern corner out. Gibson County's modest growth would be located along the US 41 corridor, with some growth at its two local I-69 interchanges. In Posey and Henderson counties, where population is expected to decline, population is expected to be most stable in municipal centers while declines are expected to be greatest in rural areas.

Figure 2.2-3 presents the allocation of new households in the 2045 horizon year, within each of the models' TAZs.

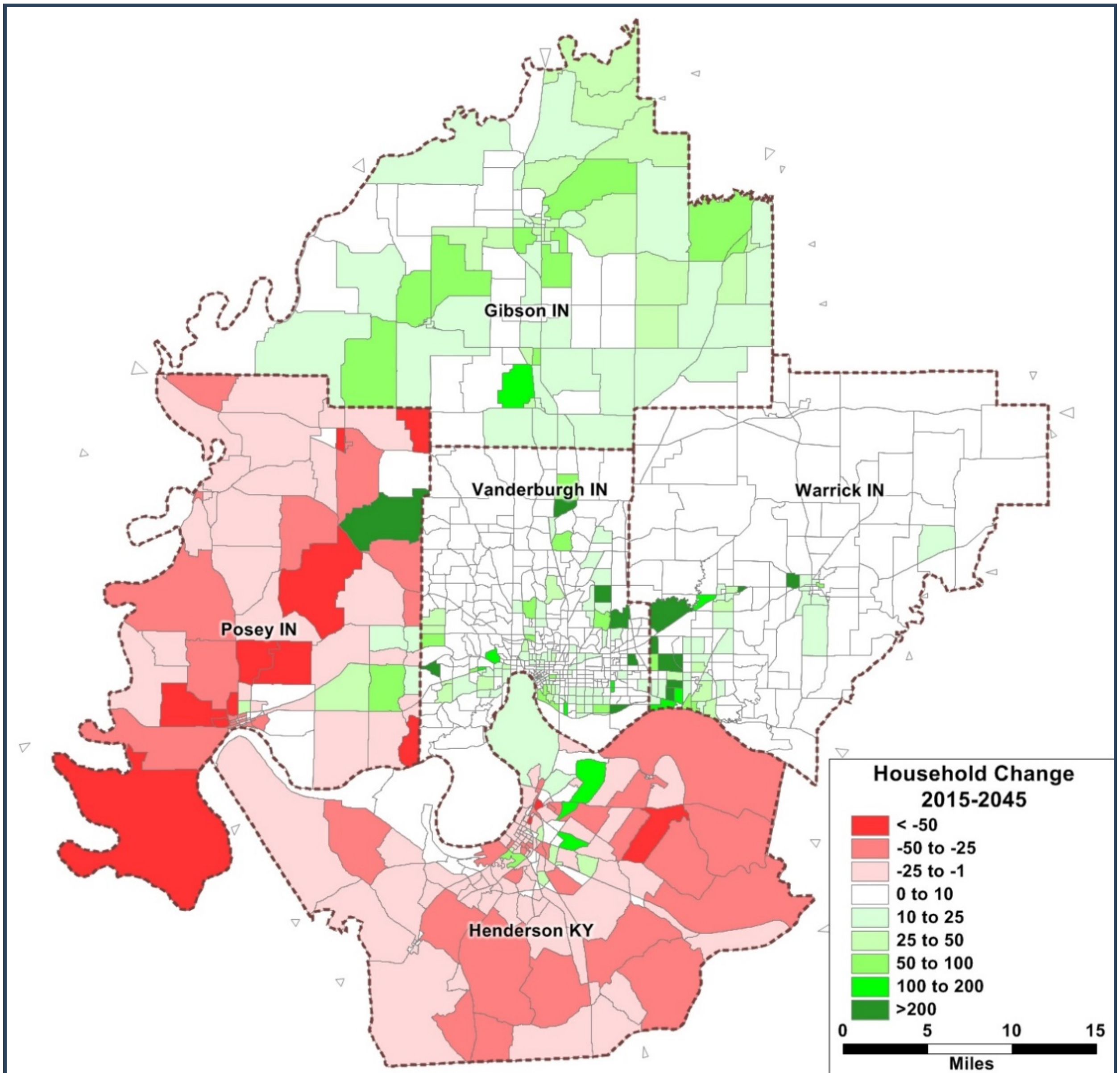


Figure 2.2-3. 2045 Household Growth Allocation per TAZ

Sources: EMPO 2017, KSDC 2017, and STATS Indiana 2017

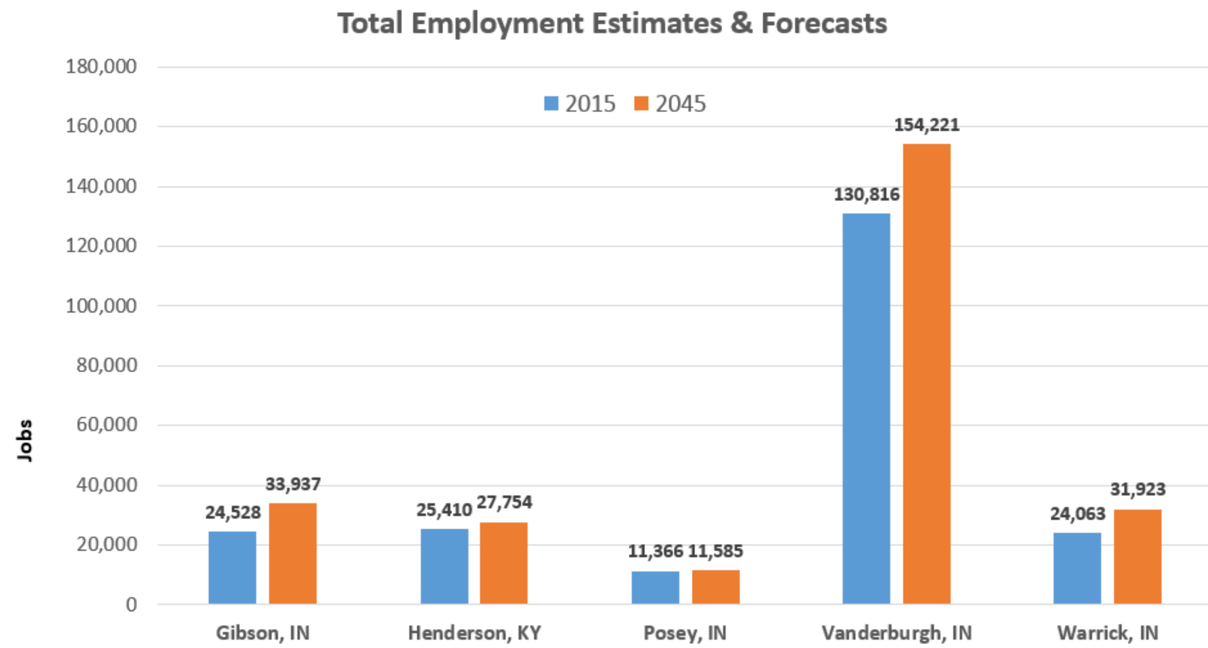
2.2.2 EMPLOYMENT

In consultation with EMPO staff, 2015 employment estimates were updated to reflect county level totals as compiled by BEA (BEA 2017). Given the economic recession beginning in 2008 and subsequent recovery through 2015, overall employment growth in the EMPO region was moderate between the 2010 and 2015 base years. Therefore, the distribution of employment within each county was generally maintained from the geographic distribution in the 2010 TAZ file, with some adjustments made in Vanderburgh and Warrick counties to reflect recent commercial development as indicated by EMPO staff and local officials.

The EMPO model includes 10 employment categories, which for the purposes of forecasting to the 2045 horizon year, were temporarily consolidated into three general categories of basic, retail, and other employment. A trendline analysis of BEA employment data from 1990 to 2015 was performed for each county for each general category. The "basic" employment category, covering agriculture, construction, manufacturing, transportation, and warehousing, is declining in all counties except Gibson, where Toyota's assembly operation has steadily expanded. In contrast, the "retail" category, which also includes restaurants, and the "other" category, which includes medical, educational, governmental, and professional service workers, have both grown steadily in each county.

The overall trends in employment continue to reflect flat to mild growth in Henderson and Posey counties and moderate growth in Vanderburgh County, the largest employment center for the regional economy. Employment in Warrick County is expected to increase more significantly in correlation with suburban expansion and Gibson County's employment growth remains tied to the growth at Toyota's assembly operation. Employment growth is expected to occur in established commercial and industrial centers in Gibson, Vanderburgh, and Warrick counties, and within new development located around I-69 interchanges northeast of Evansville.

Future county-level employment was forecast for 2025 and 2045 for each of the three general employment categories based on the linear trend lines estimated from the BEA data. Once forecast, the broad employment categories were allocated to individual TAZs and disaggregated to the smaller component employment classes used in the model. **Figure 2.2-4** compares the 2015 estimate and 2045 forecast for total employment in each county.



	Gibson, IN	Henderson, KY	Posey, IN	Vanderburgh, IN	Warrick, IN
2015	24,528	25,410	11,366	130,816	24,063
2045	33,937	27,754	11,585	154,221	31,923
DELTA	9,409	2,344	219	23,405	7,860
PERCENT CHANGE	38.4%	9.2%	1.9%	17.9%	32.7%

Figure 2.2-4. Total Employment by County

Source: BEA 2017

2.3 EXTERNAL TRIP MATRICES

With the opening of I-69 north of I-64, it was essential to be able to understand how the proposed I-69 ORX limited access highway would impact external traffic into, out of, and through the greater Evansville region. Since no recent roadside origin-destination (O/D) data surveys have been conducted in the EMPO study area, passive O/D travel data was acquired to analyze external trip-making patterns. This section of the report describes the O/D data used to assess external flows and analysis assumptions and how these data were subsequently used to update external-internal (EI) and external-external (EE) trip tables for 2015.

2.3.1 STREETLIGHT ORIGIN-DESTINATION DATA

StreetLight Data uses anonymized geographical positioning system (GPS) and location-based service (LBS) signals from personal devices and commercial fleet navigation systems to identify vehicles in traffic to establish origin-destination patterns through a designated set of network zones (StreetLight Data, Incorporated 2017). The distinct device signals, LBS and GPS, help distinguish personal vehicular travel from commercial truck patterns, which is valuable for use in validating the patterns of both vehicle classes in the model. The specific zones, temporal parameters, and aggregation methods for summarizing the O/D flows is defined through

StreetLight Data's online interface. In an effort to eliminate noise and improve confidence in the output trip patterns, eight different queries of the StreetLight database were made testing various geographic zones and time analysis periods, such as average weekday and hourly day parts. The final StreetLight dataset consisted of trips occurring during 2015 weekdays, Tuesday through Thursday only, summarized at the daily level. The regional EMPO TAZ system of 955 zones was aggregated into 60 larger zones to organize trip patterns into more manageable geographies. **Figure 2.3-1** depicts the StreetLight zone system, with the seven external zones shaded in blue that correspond to the 29 external stations in the EMPO TAZ system.

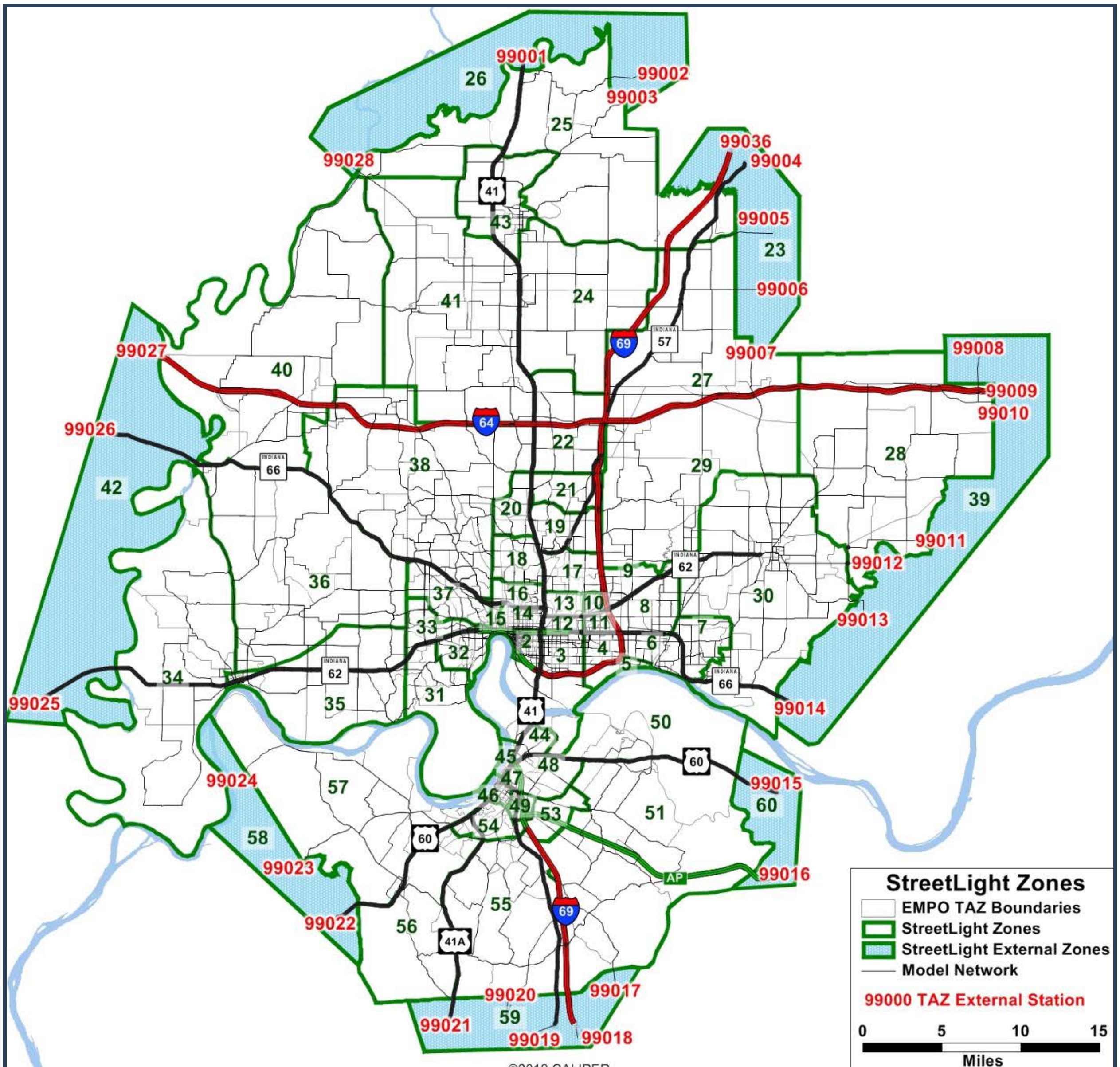


Figure 2.3-1. Origin-Destination Traffic Analysis Zones

Sources: EMPO 2017 and StreetLight Data, Incorporated 2017

The output StreetLight dataset included records of each zone to zone trip pair with an index value representing the relative flows for both autos and trucks between each pair (StreetLight Data, Incorporated 2017). A primary focus of analysis was identifying and quantifying the EE and EI/internal-external (IE) traffic patterns for current bridge traffic and making the respective volume adjustments necessary to the external zone data in the model's TAZ files and external trip tables for autos and trucks. For example, **Table 2.3-1** presents the top 10 StreetLight O/D zone pairs for auto and truck traffic crossing the US 41 bridges. **Figure 2.3-2** graphically depicts these auto zone pairs. These data indicate that, in general, the most prevalent auto crossing traffic occurs between Evansville and Henderson, while the most prevalent truck crossing traffic has at least one external component.

Table 2.3-1. Top Ten StreetLight Auto and Truck Trip Pairs Crossing the US 41 Bridge

Auto Rank	ORIGIN (StreetLight Zone)	DESTINATION (StreetLight Zone)	Percent Of Crossing Traffic
1	Newburgh, IN (6)	North Henderson (45)	3.4%
2	Evansville CBD (2)	East Henderson (48)	2.9%
3	Evansville CBD (2)	South External Zone (59)	2.0%
4	Southeast Evansville (4)	North Henderson (45)	2.0%
5	Northwest External Zone (42)	South External Zone (59)	2.0%
6	Evansville - Eastview (5)	South External Zone (59)	1.9%
7	Evansville CBD (2)	North Henderson (45)	1.7%
8	Evansville CBD (2)	Southeast External Zone (60)	1.5%
9	Evansville - Eastview (5)	North Henderson (45)	1.5%
10	Evansville Airport North (19)	West Henderson/Industrial (57)	1.4%
Truck Rank	**ORIGIN (StreetLight Zone)**	**DESTINATION (StreetLight Zone)**	**Percent Of Crossing Traffic**
1	Northwest External Zone (42)	South External Zone (59)	12.1%
2	Princeton, IN (43)	South External Zone (59)	6.2%
3	Northwest External Zone (42)	Southeast External Zone (60)	5.7%
4	Northeast External Zone (23)	Southeast External Zone (60)	4.3%
5	I-64 Central (US 41 to I-69)	South External Zone (59)	2.5%
6	Evansville - Cedar Hall (14)	South External Zone (59)	2.4%
7	Northeast Vanderburgh (21)	South External Zone (59)	2.2%
8	Princeton, IN (43)	Southeast External Zone (60)	1.9%
9	Evansville Airport South (17)	South External Zone (59)	1.8%
10	Southwest Evansville (32)	South External Zone (59)	1.3%

Source: StreetLight Data, Incorporated 2017

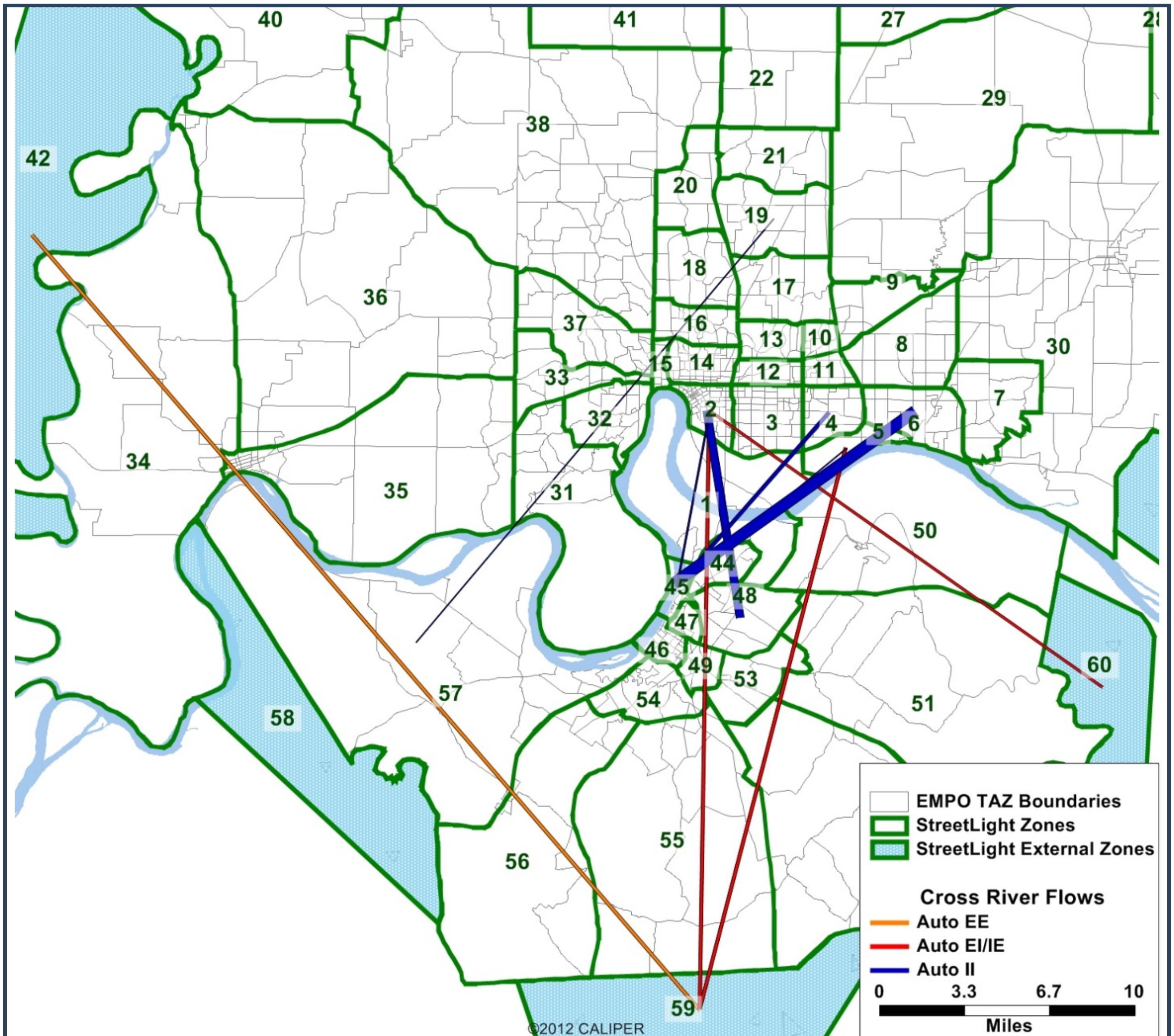


Figure 2.3-2. Top Ten StreetLight O/D Auto Crossing Trip Pairs

Sources: EMPO 2017; StreetLight Data, Incorporated 2017; ESRI

2.4 UPDATING EXTERNAL TRIPS

The StreetLight data were used in conjunction with 2015 traffic counts and the original EMPO model's trip data to update both EE and EI/IE trip patterns in the 2015 base year model (StreetLight Data, Incorporated 2017). Based on the structure of the model, these updates to EE and EI/IE trip patterns were performed separately.

2.4.1 2015 External-External Trips

The majority of the 29 external stations in the EMPO model represent low volume rural highways with daily volumes of fewer than 5,000 vehicles per day (vpd), serving almost entirely local EI/IE traffic. Partly due to the rural nature of the model's periphery and the presence of the Ohio River as a major geographic barrier with only one crossing point, the vast majority of EE trips enter and exit the model area via the higher volume interstates, parkways, and US highways. The original 2010 and 2040 EE trip matrices from the EMPO model reflected this paradigm, assigning almost all EE trips to eight high volume external stations in the model. The seven StreetLight external zones correspond with these eight major stations (I-69 and US 41A are combined within the southern StreetLight external zone in Henderson County), combining them with the surrounding lower volume external stations to create large aggregate zones which capture all trips from a general direction as they enter to exit the model area. **Table 2.4-1** presents the StreetLight external zones and the corresponding external zones from the EMPO model.

Table 2.4-1. StreetLight and EMPO External Zones

StreetLight Zone	Location	Primary EMPO External Station (ID)	Minor EMPO External Stations (ID)
42	OH - West	I-64 West (99027)	IN 62 West (99025); IN 66 West (99026)
26	OH - North	US 41 (99001)	IN 64 West (99028); IN 56 (99002); IN 65 (99003)
23	OH - Northeast	I-69 North (99036)	IN 57 (99004); IN 64 East (99005); W CR 900 S (99006); IN 61 (99007)
39	OH - East	I-64 East (99009)	IN 161 North (99008); IN 68 (99010); IN 62 East (99011); W CR 50 N (99012); IN 161 South (99013); IN 66 East (99014);
60	KY - East	KY Audubon Pkwy (99016)	US 60 East (99015)
59	KY - South	I-69 South (99018); US 41A South (99021)	KY 136 (99017); US 41 South(99019); KY 283 (99020);
58	KY - Southwest	US 60 West ((99022)	KY 359 (99023); KY 1574 (99024)

Sources: EMPO 2017, StreetLight Data, Incorporated 2017

The output StreetLight index values of auto and truck traffic between the external StreetLight zones and current count data at each EMPO external station were used to update the 2015, 2025, and 2045 EE trip matrices (EMPO 2017; StreetLight Data, Incorporated 2017). While the general presumption was that the vast majority of EE trips occur on the primary high-volume highways, additional EE trips were included to reflect the continuity and close proximity of other minor external stations. An example of the latter is the interchange between I-64 east (99009) and IN 161 north (99008), which are adjacent. Adjustments to the 2015 EE trip tables were done in an iterative process, with specific attention to maintaining accurate crossing volumes on US 41, relating to both observed counts and the relative volume of crossing trips from external zones in the StreetLight data. The model includes separate EE trip matrices for autos, single-unit trucks, and multi-unit trucks. **Table 2.4-2** depicts the EE total trip table of all trips used in the final 2015 validated model.

Table 2.4-2. 2015 External-External Total Trip Matrix

LOCATION	ZONE	US 41 N	IN 161	I-64 E	IN 68	Audubon Parkway	I-69 S	US 41A S	US 60 W	I-64 W	I-69 N	Total
		99001	99008	99009	99010	99016	99018	99021	99022	99027	99036	
US 41 N	99001			51		308	512	25	203	20	81	**1,200**
IN 161	99008			500	250							**750**
I-64 E	99009	51	500			33	50	75	125	2,597	165	**3,596**
IN 68	99010		250									**250**
Audubon	99016	308		33			100	31	750	500	424	**2,146**
I-69 S	99018	512		50		100		5	15	750	750	**2,182**
US 41A S	99021	25		75		31	5		4	20	50	**210**
US 60 W	99022	203		125		750	15	4		205	314	**1,616**
I-64 W	99027	20		2,597		500	750	20	205		500	**4,592**
I-69 N	99036	81		165		424	750	50	314	500		**2,284**
Total		**1,200**	**750**	**3,596**	**250**	**2,146**	**2,182**	**210**	**1,616**	**4,592**	**2,284**	**18,826**

Sources: EMPO 2017; StreetLight Data, Incorporated 2017

2.4.2 FUTURE YEAR EXTERNAL-EXTERNAL TRIPS

The annual growth of EE trips between the 2010 base year and the 2040 future year of the existing EMPO model was 0.6 percent, reflecting only minor growth in background traffic , and did not include an external station for the new I-69 sections between Evansville and Indianapolis. In contrast, the Indiana Statewide Travel Demand Model (ISTDM) v7 (INDOT 2017) network did reflect the upgrade of I-69 in Kentucky and the completion of I-69 in Indiana to the north, but not a new crossing.

In comparison, external through traffic in the ISTDM v7 grew at an annual rate of 2.4 percent (INDOT 2014). Analyzing growth rates from both the ISTDM and the Kentucky Statewide Traffic Model (KYSTM v17) (KYTC 2017), it was determined that the completion of I-69 within and around the project area, with the exception of the crossing itself, equates to an additional 10,000 EE trips over the existing EMPO model's relatively minor EE growth forecast.

Therefore, the 2045 EE matrix incorporates the minor growth of external background trips along with the predicted 10,000 additional trips, 5,000 in each direction, allocated to each of the primary high-volume external stations, according to the general proportions of current and projected crossing volumes at these stations. The majority of this additional traffic was assigned to I-69, with approximately 61 percent of Kentucky traffic and 68 percent of Indiana traffic. The 2025 opening year EE matrix was based on the same mild background growth rate, with the additional crossing growth interpolated. **Table 2.4-3** and **Table 2.4-4** presents the 2025 and 2045 EE total trip matrices.

Table 2.4-3. 2025 External-External Total Trip Matrix

LOCATION	ZONE	US 41 N	IN 161	I-64 E	IN 68	Audubon Parkway	I-69 S	US 41A S	US 60 W	I-64 W	I-69 N	Total
		99001	99008	99009	99010	99016	99018	99021	99022	99027	99036	
US 41 N	99001			41		382	652	17	213	16	106	1,425
IN 161	99008			500	250							750
I-64 E	99009	41	500			46	64	101	170	2643	297	3,862
IN 68	99010		250									250
Audubon	99016	382		46			96	32	777	649	853	2,835
I-69 S	99018	652		64		96		5	15	998	1204	3,033
US 41A S	99021	17		101		32	5		4	13	33	205
US 60 W	99022	213		170		777	15	4		228	439	1,845
I-64 W	99027	16		2643		649	998	13	228		772	5,319
I-69 N	99036	106		297		853	1204	33	439	772		3,704
Total		1,425	750	3,862	250	2,835	3,033	205	1,845	5,319	3,704	23,228

Sources: Summarized from the EMPO Model

Table 2.4-4. 2045 External-External Total Trip Matrix

LOCATION	ZONE	US 41 N	IN 161	I-64 E	IN 68	Audubon Parkway	I-69 S	US 41A S	US 60 W	I-64 W	I-69 N	Total
		99001	99008	99009	99010	99016	99018	99021	99022	99027	99036	
US 41 N	99001			20		528	932	0	231	6	157	1,875
IN 161	99008			500	250							750
I-64 E	99009	20	500			74	92	153	261	2736	560	4,395
IN 68	99010		250									250
Audubon	99016	528		74			88	35	830	948	1711	4,213
I-69 S	99018	932		92		88		4	14	1494	2112	4,736
US 41A S	99021			153		35	4		5			197
US 60 W	99022	231		261		830	14	5		274	689	2,304
I-64 W	99027	6		2736		948	1494		274		1317	6,774
I-69 N	99036	157		560		1711	2112		689	1317		6,546
Total		1,875	750	4,395	250	4,213	4,736	197	2,304	6,774	6,546	32,041

Sources: Summarized from the EMPO Model

2.4.3 EXTERNAL-INTERNAL TRIPS

The EMPO model sets the volume of external ends of EI-IE trips as the difference between observed counts and the estimated number of EE trips at each external station, for autos, single-unit trucks, and multi-unit trucks. Since 19 of the 29 external stations in the model do not include EE trips, the observed 2015 counts were the assigned volume for total EI-IE trips at those stations. For the 10 external stations with EE trips, EI-EI trips were calculated as the difference from the observed counts. The extrapolated growth of EI-IE trips, EE trips from the original EMPO 2010 and 2040 TAZ files, and EE trip matrices were compared to growth from the ISTDM and KYSTM as well as historic traffic counts to establish 2025 and 2045 targets for external traffic at each station. Targets for the north I-69 external station were set to be compatible with 2045 extrapolations of the 2030 forecasts for Section 2 of the I-69 corridor, which is now open. Table 2.4-5 presents the total daily EE and EI-IE trips for each external station for combined autos, single-unit trucks, and multi-unit trucks.

Table 2.4-5. External Station Counts and Total EE and EI-IE Trips

EMPO TAZ ID	Route Name/ Location	2015				2025			2045		
		ADT Count	EE Trips	EI-IE Trips	Total Trips	EE Trips	EI-IE Trips	Total Trips	EE Trips	EI-IE Trips	Total Trips
99001	US 41 N	12,219	2,398	9,821	12,219	2,850	9,892	12,742	3,751	10,000	13,751
99002	IN 56	261	0	261	261	0	307	307	0	399	399
99003	IN 65	503	0	503	503	0	502	502	0	500	500
99004	IN 57	2,695	0	2,695	2,695	0	2,430	2,430	0	1,900	1,900
99005	IN 64 E	4,493	0	4,493	4,493	0	5,062	5,062	0	6,200	6,200
99006	W CR 900 S	205	0	205	205	0	220	220	0	250	250
99007	IN 61	1,145	0	1,145	1,145	0	1,151	1,151	0	1,150	1,150
99008	IN 161	3,375	1,500	1,875	3,375	1,500	1,883	3,383	1,500	1,900	3,400
99009	I-64 E	15,803	7,192	8,611	15,803	7,725	8,741	16,466	8,791	9,000	17,791
99010	IN 68	1,136	500	636	1,136	500	858	1,358	500	1,300	1,800
99011	IN 62 E	1,841	0	1,841	1,841	0	1,861	1,861	0	1,900	1,900
99012	W CR 50 N	473	0	473	473	0	482	482	0	500	500
99013	IN 161 S	874	0	874	874	0	882	882	0	901	901
99014	IN 66 E	10,816	0	10,816	10,816	0	11,211	11,211	0	12,000	12,000
99015	US60 E	1,700	0	1,700	1,700	0	1,867	1,867	0	2,200	2,200
99016	Audubon	6,544	4,290	2,254	6,544	5,669	4,287	9,956	8,427	8,500	16,927
99017	KY 136	205	0	205	205	0	253	253	0	350	350
99018	I-69 S	11,088	4,364	6,724	11,088	6,066	8,148	14,214	9,472	10,999	20,471
99019	US 41 S	4,804	0	4,804	4,804	0	5,204	5,204	0	6,000	6,000
99020	KY 283	264	0	264	264	0	309	309	0	401	401
99021	US 41A S	2,593	418	2,175	2,593	410	2,616	3,026	394	3,500	3,894
99022	US 60 W	5,484	3,230	2,254	5,484	3,690	3,336	7,026	4,607	5,500	10,107
99023	KY 359	1,504	0	1,504	1,504	0	1,586	1,586	0	1,751	1,751
99024	KY 1574	12	0	12	12	0	25	25	0	50	50
99025	IN 62 W	4,453	0	4,453	4,453	0	4,535	4,535	0	4,700	4,700
99026	IN 66 W	1,143	0	1,143	1,143	0	1,461	1,461	0	2,100	2,100
99027	I-64 W	13,972	9,184	4,788	13,972	10,639	5,026	15,665	13,548	5,500	19,048
99028	IN 64 W	9,683	0	9,683	9,683	0	9,123	9,123	0	8,001	8,001
99036	I-69 N	7,076	4,566	2,510	7,076	7,408	9,172	16,580	13,092	22,499	35,591
	SUM	126,364	37,642	88,722	126,364	46,457	102,431	148,887	64,082	129,951	194,033

Sources: Summarized from the EMPO Model

2.5 VALIDATION PROCESS

The primary goal of the 2015 model validation was to produce traffic assignment volumes that closely matched 2015 traffic counts without substantially modifying the structure and functionality of the existing EMPO model. A total of 16 model validation runs were conducted to improve the match between available 2015 traffic counts and resulting model volumes. This followed some earlier validation testing with the 2010 EMPO model to better understand some of its shortcomings and sensitivity to model adjustments, prior to development of 2015 datasets.

The existing 2010 model was structured to output three tables with a variety of model validation performance metrics. These metrics were monitored for each model run and exported to Excel for additional computations, summaries, and commentary. A series of Volume-over-Count (V/C) plots were also made for each model run and compared with the immediate prior run as well as earlier 2010 and 2015 runs to monitor progress.

2.5.1 VALIDATION AND ADJUSTMENT OF EXTERNAL TRIPS

The earliest steps in the 2015 model validation process focused on adjusting the EE trip matrices to reflect trip patterns observed in the StreetLight data set and in overall traffic volumes reflected in new 2015 counts at the external stations and along the major high-volume corridors leading to external zones. This process involved several iterative model runs with modifications to EE trips in the EE matrices and corresponding adjustments to the EI-IE trip data fields for affected external zone locations in the TAZ file. The effects of these adjustments on traffic assignments were also monitored at the US 41 river crossing and its approaches.

2.5.2 Network Modifications

Network modifications were primarily focused on areas where model results exhibited notable deviations from observed counts particularly on facilities associated with river crossing traffic. A primary goal of these modifications was to optimize the assigned V/C ratio in the 2015 update. One universal adjustment was the modification of the model script to accept non-integer values for screenline penalty parameters, which were initially coded as a binary switch (1=penalty; null=no penalty). By allowing for a relative value, small adjustments could be made within the network database, which helped set the Ohio River crossing link to an optimum value of 0.5. Most other adjustments occurred within the model's network link layer database and were made in the following areas:

- Roadway alignments were adjusted based on a review of aerial imagery.
- Functional classification and facility type codes were checked and, if necessary, changed along limited access highway segments throughout the region to more properly reflect their actual functional designs, speeds, and capacities.
- The location and values of traffic count stations were checked and corrected by cross checking online INDOT and KYTC traffic count databases.
- Centroids and centroid connectors were modified in select instances to shift traffic among parallel facilities to better reflect actual opportunities for trips to be loaded into the network.
- The calculation of free flow speeds was adjusted to reduce speeds on centroid connectors (the theoretical links connecting zonal data to the links representing the actual roadway network) and low-volume collector/distributor roads to encourage loading to the nearest higher volume network links. Centroid connectors are imaginary roadway links that connect the zone centroid to the roadway network at nodes.
- Network attributes were adjusted to make small refinements to link capacities, such as in the case where a network link was coded with an incorrect functional classification.
- Every network link with a penalty code was checked to ensure that all penalties coded were valid and that no links were missing penalty codes.

The EMPO model includes a network parameters file (netparams) with additional penalty values and assignment volume/delay alpha and beta parameters. **Table 2.5-1** depicts these parameters and identifies where modifications were made.

Table 2.5-1. Modification to Network Parameters File

Key	Name	Modified Values			Original Values		
		Value	Min	Max	Value	Min	Max
CLEN	Cycle Length	65	60	120	63	60	120
HIGC	High Priority Green Time Ratio	0.65	0.55	0.7	0.62	0.55	0.7
HIPF	High Priority Progression Factor Ratio	0.97	0	1	0.97	0	1
MDPF	Mid Priority Progression Factor Ratio	0.93	0	1	0.93	0	1
LOPF	Low Priority Progression Factor	0.98	0.33	1	0.98	0.33	1
SGAD	Signal Accel/Decel Delay	0.2	0	1	0.42	0	1
STAD	Stop Accel/Decel Delay	0.35	0	1	0.71	0	1
STPD	Base Stop Delay	0.7	0	5	1.46	0	5
FWYA	Freeway BPR Alpha Parameter	7.25	0.1	10	8.13	0.1	10
FWYB	Freeway BPR Beta Parameter	3	3	12	3.16	3	12
PACA	Partial Access Control BPR Alpha Parameter	7.5	0.1	10	9.9	0.1	10
PACB	Partial Access Control BPR Beta Parameter	3.5	3	12	3.79	3	12
SIGA	Signal Controlled BPR Alpha Parameter	5.58	0.1	10	5.58	0.1	10
SIGB	Signal Controlled BPR Beta Parameter	3.46	3	12	3.46	3	12
STPA	Stop Controlled BPR Alpha Parameter	7	0.1	10	7.22	0.1	10
STPB	Stop Controlled BPR Beta Parameter	3.5	3	12	3.55	3	12
OTHA	Other BPR Alpha Parameter	8	0.1	10	8.99	0.1	10
OTHB	Other BPR Beta Parameter	4.5	3	12	4.89	3	12
CLTP	Car Left Turn Penalty	0.1	0.05	1	0.24	0.05	1
CRTP	Car Right Turn Penalty	0.06	0	0.5	0.14	0	0.5
CLP	Car Length Penalty	1.4	0	5	1.45	0	5
CFCP	Car Lower Functional Class Penalty	0.01	0	1	0.08	0	1
CFWYP	Car Freeway Penalty	0.68	0	1	0.05	0	1
SUPCE	Single-Unit Truck Passenger Car Equivalency	1.31	1.2	2	1.31	1.2	2
MUPCE	Multi-Unit Truck Passenger Car Equivalency	2.97	1.5	3	2.97	1.5	3
RRXP	Railroad Crossing Penalty	0.3	0	0.3	0.1	0	0.3

Sources: Summarized from the EMPO Model

2.6 VALIDATION RESULTS

As indicated earlier, a set of three model validation summary reports are produced by the EMPO model. These output summaries were used to assess model performance and determine overall validation with new 2015 counts. Specific network links and corridors were evaluated using V/C network plots, spreadsheet tables of external station volume targets, and other model outputs. The following sub-sections describe regional validation results for percent error, percent root mean square error (%RMSE), correlation coefficient (R^2), and V/C ratio for three different stratifications. The %RMSE is an overall statistical measure of the accuracy of the assignments. The lower the %RMSE value, the more accurate the model is to matching assigned volumes to observed volumes. The R^2 value provides an indication of how closely the model traffic assignments match actual count data, with higher R^2 values indicating better match (a value of 1.0 indicates a perfect match). The updated 2015 EMPO model meets state of the practice validation criteria.

2.6.1 MODEL VALIDATION SUMMARY BY FUNCTIONAL CLASSIFICATION

Table 2.6-1 depicts a series of model validation statistics by 12 functional classification categories used in the EMPO model. As indicated, the 2015 regional V/C ratio is now 1.0, which is a significant improvement over the previous 2010 model ratio of 1.04. The 2015 correlation coefficient of 0.92 exceeds the typical recommended R^2 standard of 0.90, while %RMSE, 42.67 is just slightly below the 40 percent accuracy standard targeted in the development of most regional models. The percent error is just an alternate way of stating the V/C ratio as a percentage. Results are also better than the 2010 model for the following functional classifications:

- Rural minor arterials = 6.72 percent error *(10.95 percent in 2010 model)*
- Rural major collectors = 11.92 percent error *(22.24 percent in 2010 model)*
- Rural local roads = 2.16 percent error *(21.48 percent in 2010 model)*

Table 2.6-1. Model Validation Summary by Functional Classification

Functional Class	Number of Counts	Average of Counts	Average of Assignment	Error (%)	RMSE (%)	Correlation Coefficient	Total V/C
Rural Interstate	84	4,773	4,581	-4.02	25.69	0.96	0.96
Rural Prin. Arterial	106	6,779	5,912	-12.79	27.06	0.96	0.87
Rural Minor Arterial	73	6,278	5,856	-6.72	21.84	0.93	0.93
Rural Major Collector	252	1,946	1,714	-11.92	52.80	0.78	0.88
Rural Minor Collector	43	955	582	-39.10	137.15	0.38	0.61
Rural Local Road	22	911	931	2.16	73.03	0.93	1.02
Urban Interstate	29	5,445	5,498	0.99	28.03	0.95	1.01
Urban Other Freeway	74	9,432	9,946	5.45	28.75	0.96	1.05
Urban Prin. Arterial	124	14,429	14,615	1.29	23.11	0.90	1.01
Urban Minor Arterial	158	6,001	6,670	11.14	47.42	0.87	1.11
Urban Collector	181	3,648	3,445	-5.55	56.04	0.78	0.94
Urban Local Road	18	3,028	2,804	-7.39	73.45	0.63	0.93
All	1,166	5,522	5,449	-1.31	37.83	0.94	0.99

Sources: Summarized from the EMPO Model

2.6.2 Model Validation Summary by Volume Group

Table 2.6-2 depicts a series of model validation statistics by 14 volume group categories based on average annual daily traffic (AADT). Overall statistics are the same as described in the previous subsection by functional classification. Most models perform poorest on low volume roadways where a greater percent difference tolerance is typically acceptable (e.g., 100 percent error for a volume of 500 vehicles would not result in an erroneous recommendation on lane requirements, etc.). Results are better than the 2010 model for the following volume groups:

- 2,001 to 3,000 AADT = 8.76 percent error *(27.86 percent in 2010 model)*
- 3,001 to 4,000 AADT = 6.31 percent error *(26.16 percent in 2010 model)*
- 10,001 to 12,000 AADT = 1.83 percent error *(4.25 percent in 2010 model)*
- 15,001 to 20,000 AADT = 0.48 percent error *(2.08 percent in 2010 model)*
- 20,001 to 25,000 AADT = 1.10 percent error *(1.96 percent in 2010 model)*

Table 2.6-2. Model Validation Summary by Volume Group

AADT	Number of Counts	Average of Counts	Average of Assignment	Error (%)	RMSE (%)	Correlation Coefficient	Total V/C
0 to 500	108	271	559	105.97	302.95	0.24	2.06
501 to 1,000	139	761	1,049	37.92	153.42	0.02	1.38
1,001 to 2,000	157	1,432	1,588	10.90	93.83	0.17	1.11
2,001 to 3,000	140	2,496	2,715	8.76	69.17	0.05	1.09
3,001 to 4,000	106	3,459	3,241	-6.31	49.44	0.07	0.94
4,001 to 5,000	59	5,459	4,998	-8.43	42.50	0.11	0.92
5,001 to 6,000	126	6,820	6,187	-9.29	31.54	0.19	0.91
6,001 to 8,000	62	8,817	8,079	-8.37	22.51	0.14	0.92
8,001 to 10,000	58	11,122	10,543	-5.21	25.83	0.35	0.95
10,001 to 12,000	57	13,242	13,000	-1.83	22.23	0.33	0.98
12,001 to 15,000	52	17,418	18,158	4.25	22.57	0.56	1.04
15,001 to 20,000	27	21,632	21,528	-0.48	19.50	0.48	1.00
20,001 to 25,000	10	27,489	27,792	1.10	13.62	0.25	1.01
25,001 to 30,000	6	34,622	31,126	-10.10	15.03	-0.11	0.90
All	1,166	5,522	5,449	-1.31	37.83	0.94	0.99

Sources: Summarized from the EMPO Model

2.6.3 Model Validation Summary by Corridor

Table 2.6-3 depicts a series of model validation statistics for eight key regional highway corridors. Model validation standards are toughest to meet at the corridor level as there are not as many links for averaging results. The corridors included in this table were already pre-defined in the 2010 model. Results are better than the 2010 model along the following regional corridors:

- US 41 North (Indiana) = 3.03 percent error *(8.70 percent in 2010 model)*
- I-64 = 4.65 percent error *(10.49 percent in 2010 model)*
- Ohio River Bridges (not in table) = 1.02 percent error *(19.2 percent in 2010 model)*

Table 2.6-3. Model Validation Summary by Corridor

AADT	Number of Counts	Average of Counts	Average of Assignment	Error (%)	RMSE (%)	Correlation Coefficient	Total V/C
Lloyd Expressway	28	23,059	23,029	-0.13	17.69	0.80	1.00
US 41 (IN)	83	13,751	14,167	3.03	22.15	0.84	1.03
US 41 (KY)	4	20,430	20,225	-1.00	1.59	-0.92	0.99
I-69 North (IN)	15	12,506	11,768	-5.90	14.90	0.65	0.94
I-64	21	7,717	8,076	4.65	18.16	0.88	1.05
SR 57	23	3,784	2,646	-30.08	45.59	0.89	0.70
I-69 South (KY)	10	9,959	9,491	-4.70	7.60	1.00	0.95
Audubon Pkwy	4	3,999	3,324	-16.86	23.39	0.61	0.83

Sources: Summarized from the EMPO Model

CHAPTER 3 – TOLL MODEL DEVELOPMENT

3.1 INTRODUCTION

As part of the I-69 ORX project, it was required to revise the existing EMPO model to provide a more robust toll diversion estimation process. The existing EMPO model was originally developed to estimate the travel demand in the region but the model did not include a choice-based toll diversion process due to the lack of toll facilities in the region. The existing EMPO model is summarized in a document entitled "Evansville MPO Travel Model Update 2012 – Model Development and Validation Report", dated October 2012.

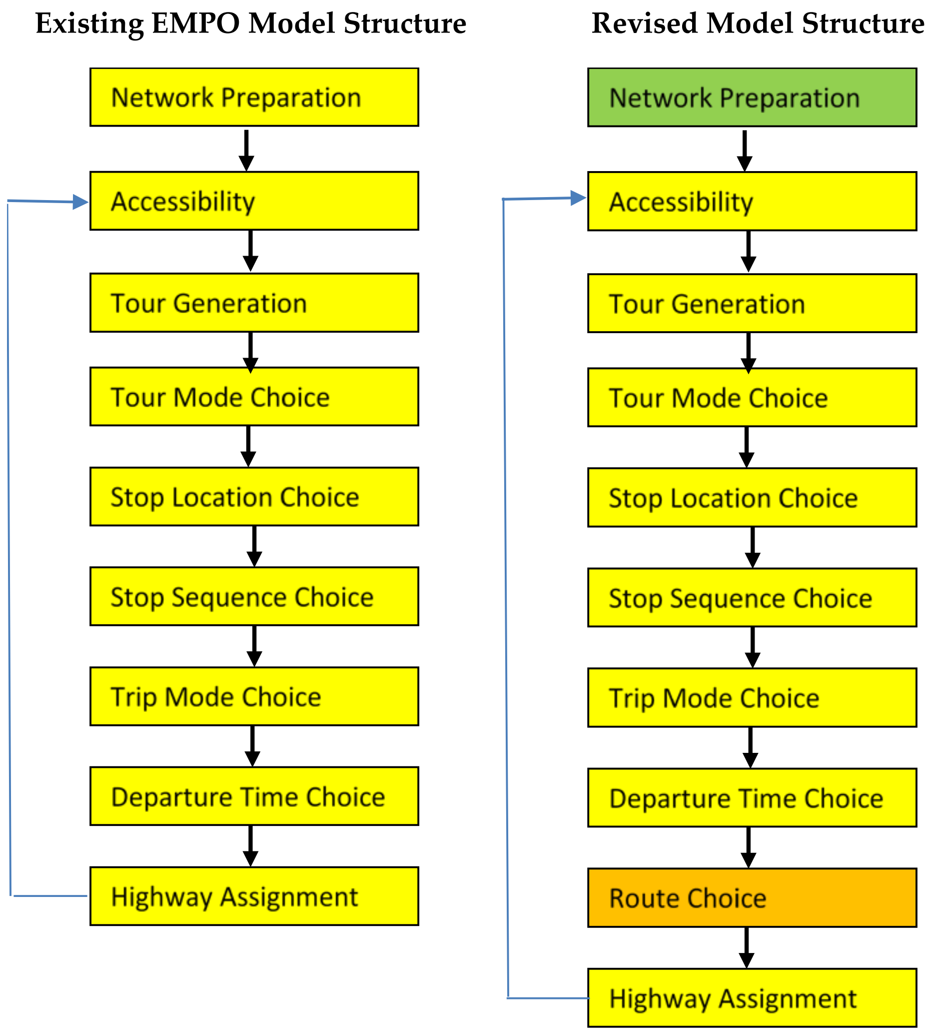
3.2 METHODOLOGY OVERVIEW

Stantec implemented a route choice toll diversion model within the tour-based model structure which included several revisions and new routines to reflect the impact of tolls both on the generation of cross-river trips and the route selected for assignment. This approach reflects an assumption that the levels of tolls being considered will, over time, influence the amount and/or frequency of trips crossing the Ohio River, particularly if all crossing points are tolled. This chapter describes the modifications made to the updated 2015 EMPO model to implement the toll diversion process. Note that modeling the assignment of traffic between the tolled and non-tolled crossing facilities with a probabilistic route choice model avoids the problems associated with standard equilibrium assignment techniques, where small changes in toll rates can cause large and unreasonable changes in diversion between competing facilities. The route choice model effectively avoids these 'cliffs' that could occur in a standard equilibrium assignment.

For the Phase 1 forecasting analysis, the adopted methodology for the project was focused on retaining all of the model components in their existing form with only minimal impacts to model processing. This required modifications to two separate model components; (1) the elements that generate and distribute trips across the region and (2) the highway assignment process that loads trips on the network among the various routes.

Within the hybrid tour-based EMPO model, travel times are used to generate and distribute trips between competing origin-destination zonal pairs. To incorporate cost sensitivity into the tour allocation routines in the model, it was necessary to convert tolls into equivalent time values suitable for use in the initial routines in the model controlling tour allocation, which is performed prior to highway assignment. These revised routines account for the burden of tolls that would potentially reduce or 'suppress' the number of river crossings.

At the latter stages of the model just prior to highway assignment, a route choice model was implemented to estimate shares of trips between tolled and non-tolled crossings as well as for scenarios where the competing crossings were both tolled, possibly with different rates. The route choice model required costs to be provided as dollar values. The original and final model structures are shown in the diagram on the following page. Note that both the existing and revised model structures incorporate a feedback loop that provides an iterative model process where congested travel times from assignment influence the generation and distribution of trips.



Note that while the refined model was being used in this project solely for estimating traffic for tolled river crossings, it was envisioned that the EMPO may in the future use this model for conventional toll road diversion estimation. To address this potential issue, the proposed approach was structured to also permit the model to forecast conventional toll roads.

As part of the model development process, extensive sensitivity analysis was performed to ensure the logic and reasonableness of the revised model's responsiveness to toll costs. This analysis is described in subsequent sections of this chapter.

3.2.1 Representing Tolls within Tour-Based Model Components

The existing EMPO model uses highway impedances in several major modeling components to control the estimation, allocation, and mode choice of trips. These model components include:

- Tour mode choice
- Stop location choice

- Stop sequence choice
- Mode choice

Note that these components are executed prior to highway assignment and do not impact the routing of trips across the network.

These procedures use units of time (minutes) rather than dollar costs as a key variable in their respective model routines. To represent the impact of tolls for these components, it is necessary to convert toll costs from dollar values into equivalent units of time. With this change, the burden of the tolls is converted directly into time for those alternatives that contain toll facilities, using the value of time (VOT, dollars per minute) computed from the coefficients in the logit formula of the toll diversion model. Note that the calculated equivalent time values from the tolls are added into the existing link travel time at the designated toll facility locations.

3.2.2 Computation of Equivalent Time from Tolls

The initial feedback iteration (e.g., zero iteration) uses free-flow time during path-building for each origin-destination pair while feedback iterations (e.g., 1st iteration, 2nd iteration, 3rd iteration, and so on) uses the average congested time weighted by both congested times and assigned link volumes for three time periods. Given that potential alternatives could include different toll rates by time of day, the toll rates are also averaged across the periods before conversion to the equivalent time values.

The highway assignment process in the EMPO model uses time values to determine assignment paths and these time values are also used in the calculation of congested times resulting from the assigned traffic. Therefore, it was necessary to ensure that the equivalent time values that represent tolls were not increased when calculating congested times after the loading in each assignment iteration. The revised model stores the toll equivalent time values in a separate time variable that is not subject to congestion adjustment.

3.3 TOLL DIVERSION MODEL STRUCTURE

As noted previously, the existing EMPO highway assignment process does not explicitly estimate the impacts of tolls on the selection of travel paths when assigning trips. In order to address this limitation, a toll diversion model was implemented. The adopted toll diversion model was developed to provide a general diversion estimation process that could be employed for typical toll road projects where competing non-tolled choices exist. The route choice model is structured to be applied by the time periods and vehicle types used in the existing highway assignment. This permits the model to reflect toll polices that might vary based on time of day and vehicle type. This diversion model is based on numerous toll diversion models that Stantec has developed as part of our nationally-recognized investment grade traffic and revenue practice.

The toll diversion routine is a logit-based route choice model that predicts the shares of trips that will choose to use the tolled crossings by vehicle type for each origin-destination zonal pair. The route choice model uses the impedance values for the two choices, normally defined as the best "toll" and "non-toll" paths. However, for the I-69 project, the routine also needed to address cases where all crossing points are tolled, possibly at different rates. It is also possible that a scenario could exist where only one bridge would exist, operating as either a tolled or non-tolled condition. This flexibility has been incorporated into the model.

The route choice model is structured as a binary logit formula for typical toll road analysis where a free option exists that competes with the tolled route. Note that the route choice model uses the actual toll costs in conjunction with the time savings to determine the estimated share of trips assigned to the toll facility. The binary logit model is defined as follows:

$$\text{Toll Share} = (1 / (1 + e^{U}))$$

Where:

Toll Share = Probability of selecting a toll road
e = Natural Logarithm
U = "Utility" of Toll Route:
$a*(Time_{TR}-Time_{FR}) + b*(Cost_{TR}-Cost_{FR}) + C_{TR}$
$Time_{TR}$ = Toll route travel time in minutes
$Time_{FR}$ = Non-toll route travel time in minutes
$Cost_{TR}$ = Toll in dollars for tolled route
$Cost_{FR}$ = Toll in dollars for non-tolled route (in this case 0.0)
C_{TR} = Constant for toll road bias (All payment methods)
a,b = Coefficients

In the equation, note that the difference in times between the tolled and "non-tolled" paths are calculated and a similar calculation is defined for differences in costs (if both bridges are tolled). In cases where one bridge is actually toll free, the cost difference is simply the toll of the competing bridge.

For situations where both bridges are tolled, the route options can be described generally as "US 41 bridge" and "I-69 bridge." In this case, the I-69 bridge would be considered the "toll" route with the US 41 bridge being the "non-tolled" route even though for this case, it is also tolled. Note that the utility formula does permit both crossings to be tolled and thus still yields the shares of trips using each crossing based on the differences between the travel times and costs for both crossings for each origin-destination zonal pair. Note that since both paths would be tolled, a link flag variable is used to restrict the path-building and assignment in each case to the particular bridge for which paths are being built. This ensures that trips predicted to use each bridge in the route choice model will be assigned properly in the highway assignment step that follows the toll diversion 'route choice' model.

The adopted coefficients and bias terms for the toll diversion model are specified in **Table 3.3-1**. The values in the model were adopted from a recently calibrated toll diversion model in Austin, TX developed for investment-grade traffic and revenue forecasting. The initial coefficients were adjusted to reflect the income differences between that region and Evansville region.

Table 3.3-1. Adapted Coefficients and Bias Terms

EMPO Model		Evansville	**Phase 1 Forecasts**				
YEAR	**2015**						
MEDIAN HOUSEHOLD INCOME			**$ 47,452**	**(EMPO counties weighted HH income (ACS 2011-2015))**			
	(ALPHA)	**(BETA)**		**BIAS TERMS**			
TRIP	**TIME**	**COST**	**VOT**	**VALUES**		**EQUIVALENT MINUTES**	
PURPOSE	**(MIN)**	**($)**	**($/HR)**	**TOLL**	**ETC**	**TOLL**	**ETC**
Auto	0.0756	0.3315	$ 13.69	0.1588	0.0000	2.1	0.0
Med Trk	0.0884	0.3372	$ 15.73	0.2740	0.0000	3.1	0.0
Hvy Trk	0.0884	0.1515	$ 35.02	0.3359	0.0000	3.8	0.0

Source: EMPO 2017

For the Evansville region, the median household income in 2015 was $47,452 which implies an hourly wage rate of $22.81. The value of time for auto travel is $13.69 per hour, which represents approximately 60 percent of the wage rate, which is within the expected range of 50 to 70 percent of the wage rate. This 'mid-point' auto value of time reflects a balanced value that represents a blending of various trip purposes. Commuter trips tend to have a higher value of time due to the urgency of travel while discretionary trip purposes such as shopping, and recreation tend to have lower values of time. Truck values of time ($15.73 per hour for medium trucks and $35.02 for heavy trucks) were adopted from a prior model in Illinois and adjusted for personal income differences between the Chicago region and the EMPO region.

3.4 MODEL VALIDATION AND SENSITIVITY ANALYSIS

As part of the development process, a series of model validation and sensitivity analysis trials were performed to verify that the model's estimates and were logical and reasonable. The initial trials were focused on assessing the reasonableness of the model's estimation of cross river trips in response to tolls. It is logical to expect that the introduction of tolls on all the river crossing points would result in a reduction of traffic. This is reasonable as some travelers would likely forego making trips or make trips less frequently due to the cost. This reduction of traffic is described as 'trip suppression'. However there is no observed data in this region to validate this expected model response. A further complication is that there are few, if any, studies that have isolated the observed impact of implementing tolls on all crossing facilities of a natural barrier, such as a river crossing. In cases where tolling was implemented on an existing toll-free facility, the observed 'near-term' diversion is at least 20%, but in these cases, there was a competing non-toll road which can attract the diverted traffic. For the I-69 crossing, most scenarios do not include a toll-free crossing. To determine a reasonable level of trip suppression, a literature review was conducted to examine the level of trip suppression due to tolls from recent research efforts. Two recent tolling studies have attempted to quantify trip suppression:

- Columbia River Investment Grade Traffic and Revenue Study, December 2013
- West Virginia Turnpike 2018 Revenue Bond Study, April 2018

Both of these studies attempted to estimate trip suppression using stated preference analysis from surveys of existing users. In the first study, toll suppression reduced trips by 9.7 percent to 14.1 percent depending upon the horizon year. In the second study, trip suppression was within a range of 2.0 to 9.2 percent depending on the market segment and payment method. While neither of these projects are fully consistent with the conditions in the I-69 corridor, their results indicated that the expected trip suppression should be within a range of approximately 5 to 10 percent.

In our initial testing of the model the resulting distribution of trips crossing the river appeared more sensitive to tolls than was expected, thus suppressing a significant amount of total cross river trips. This is likely the result of the model's distribution routines being too sensitive to the assumed value of time. To address this condition the value of time was reduced in the distribution process to provide trip suppression consistent with the recent research described above. The resulting model estimates suppressed approximately 10 percent of cross river trips, which was deemed reasonable for the purpose of the I-69 alternative analysis and environmental impact assessment.

The second phase of validation process analysis was to determine if the existing model's tour-based structure and assignment routines exhibit any variation due to the random processing techniques used in the tour-based structure and the multi-threading assignment features used in the TransCAD assignment routines. This initial evaluation was performed by repeating the same model trials multiple times. From that effort, it was determined that the limited amount of variation is not enough to alter the estimate of effects, or the decisions made about the alternatives.

The next phase of the validation testing was focused on logic and reasonableness of the revised model structure. Included in this effort were trials of the revised model and a comparison with the existing EMPO assignment process. A total of eight trials were performed using a version of the model near the end of the model calibration effort. These trials are summarized in **Table 3.4-1**.

Table 3.4-1. Model Validation and Sensitivity Trials Summary

Trial	Scenario	US-41 Bridge			I-69 Bridge			Total Crossing
		NB	SB	Total	NB	SB	Total	
1	US-41 Only, No Toll, Original Model	20,048	19,909	39,957				39,957
2	US-41 Only, No Toll, with Toll Diversion Process	20,025	19,884	39,909				39,909
3	US-41 Only, 1-Cent Toll	20,014	19,874	39,888				39,888
4	Both Bridges, 1-Cent Toll	10,224	10,131	20,355	10,266	10,220	20,486	40,841
5	US-41 Free, I-69 1$ Toll	11,411	11,304	22,715	8,837	8,802	17,639	40,354
6	US-41 Free, I-69 2$ Toll	12,668	12,550	25,218	7,552	7,530	15,082	40,300
7	US-41 Free, I-69 3$ Toll	13,846	13,717	27,563	6,363	6,352	12,715	40,278
8	US-41 Free, I-69 4$ Toll	14,916	14,777	29,693	5,292	5,290	10,582	40,275

As shown in the table, the first three trials included only the existing US 41 crossing. Trial 1 uses the existing EMPO model with US 41 as a toll-free crossing and estimates that 39,957 vehicles use the facility. Trial 2 uses the same non-tolled bridge with the revised model. Trials 1 and 2 were performed to ensure that the revised model with the route choice toll diversion process would produce comparable results to the existing EMPO model when there is only a single non-tolled crossing point. In theory, the results of these two trials should be identical, but as seen from the table, there is a minimal difference in the total volumes. Some of this variation is likely attributed to the assignment routines in the software and the random processing elements in the tour-based model structure. Trial 3, which used the revised model, assumed that the US 41 bridge was tolled, but at the 'near zero' toll rate of 1 cent. This trial estimated a trivial reduction of traffic with a value of 39,888 which indicates that the model is generally consistent if tolls are free or approach zero. Note that the range of these first three trials only varies by 69 vehicles, approximately 0.1 percent.

Trials 4 through 8 assume that two crossings exist. To perform these tests for model validation purposes, it was necessary to abstract the second bridge (I-69) in a manner that isolated the effects of its location and connections to the existing network. To achieve this, the hypothetical I-69 crossing was placed directly adjacent to the existing US 41 bridge and was connected to the remaining highway network at the exact same location as the existing terminal points of the US 41 bridge.

The expectation for these trials is that total crossing demand should increase in all cases but should gradually decline as toll rates are increased. It is also anticipated that traffic should shift from the tolled crossing to the non-tolled crossing as tolls are increased. Trial 4 demonstrates that if a second crossing is provided as a non-tolled facility, total crossing traffic would increase by approximately 900 vehicles or about 2.2 percent when compared to the single crossing trials (Trials 1–3). This is deemed reasonable as the added crossing does reduce congestion and travel times, therefore making cross-river trips more attractive. Trial 5 implements a $1.00 toll on the hypothetical I-69 crossing, which reduces total crossing trips to 40,354 and shifts a greater share of traffic back to the non-tolled US 41 bridge. Similarly, the remaining trials demonstrate a consistent pattern of declining total traffic as tolls increase with a greater share using the non-tolled US 41 Bridge. Note that total traffic under Trial 8 (40,275) with the $4.00 toll is still slightly higher than just a single non-tolled crossing point.

As a final step, an elasticity value was calculated. Elasticity is calculated as the percent change in traffic divided by the percent change in tolls. The elasticity between the $1.00 and $4.00 toll rates is -0.13 which is considered as a generally inelastic condition, consistent with our expectations for a crossing facility. Toll constraint, which measures the change between the I-69 bridge as a non-tolled crossing and the $1.00 rate is 13.9 percent which is logical given the direct proximity of the non-tolled US 41 bridge in this hypothetical comparison. In summary, the results of these trials indicate that the revised modeling process is providing logical and reasonable estimates and is deemed adequate for the initial screening analysis for the DEIS.

3.5 MODEL ALTERNATIVES AND TRAFFIC OPERATIONS

In addition to the No Build Alternative, the three build alternatives that were evaluated in the DEIS are shown in **Figure 3.5-1** and described in the following sections.

3.5.1 ALTERNATIVES

Each build alternative for the I-69 ORX project would provide access at different locations, but in each case I-69 would be a fully controlled-access facility. Proposed access at interchange locations for each build alternative is detailed in **Table 3.5-1**. A “system” interchange accommodates movements from one freeway/interstate facility to another with ramps that provide free-flow travel (i.e., no stopping). A “service” interchange accommodates movements between a freeway/interstate facility and an arterial (without access-control) or collector, and can consist of ramps that provide free-flow travel or that are regulated via traffic control devices.

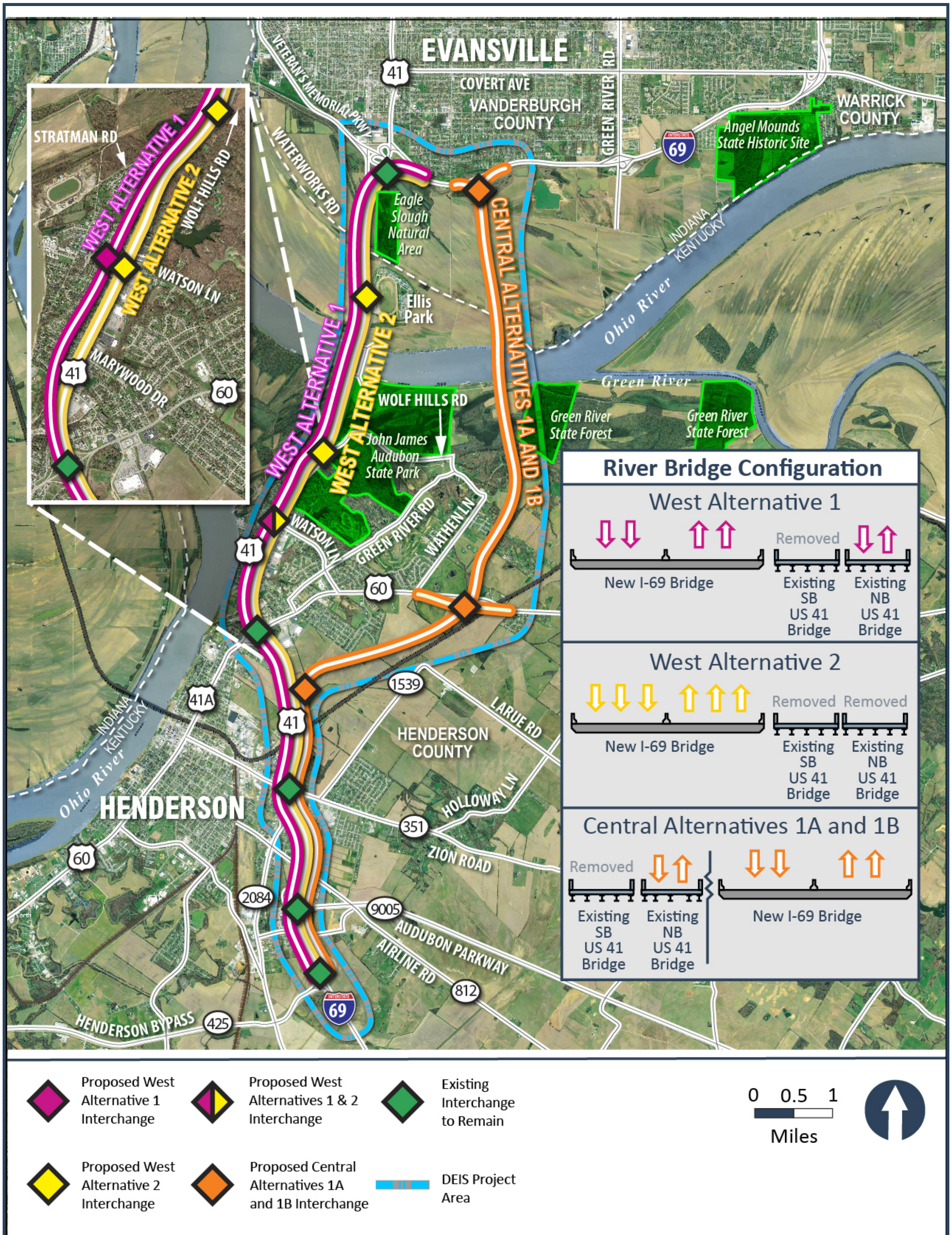


Figure 3.5-1. DEIS Alternatives

Table 3.5-1. Proposed Access for the DEIS Build Alternatives

ALTERNATIVE	INTERCHANGE LOCATIONS	EXISTING, NEW, UPGRADED, OR RECONFIGURED INTERCHANGE	INTERCHANGE TYPE
West Alternative 1	I-69/US 41/Veterans Memorial Parkway (Indiana)	Reconfigured	Service
	Watson Lane	New	Service
	US 60	Reconfigured	Service
	KY 351 (Zion Road)	Upgraded	Service
	KY 2084	Upgraded	Service
	Audubon Parkway (KY 9005)	Upgraded	System
	KY 425	Existing	Service
West Alternative 2	I-69/US 41/Veterans Memorial Parkway (Indiana)	Reconfigured	Service
	Nugent Drive	New	Service
	Stratman Road/Wolf Hills Road (KY 414)	New	Service
	Watson Lane	New	Service
	US 60	Reconfigured	Service
	KY 351 (Zion Road)	Upgraded	Service
	KY 2084	Upgraded	Service
	Audubon Parkway (KY 9005)	Upgraded	System
	KY 425	Existing	Service
Central Alternatives 1A and 1B	I-69 (approximately 1 mile east of US 41/Veterans Memorial Parkway in Indiana)	New	System
	US 60	New	Service
	US 41	New	System
	KY 351 (Zion Road)	Upgraded	Service
	KY 2084	Upgraded	Service
	Audubon Parkway (KY 9005)	Upgraded	System
	KY 425	Existing	Service

NO BUILD ALTERNATIVE

The No Build Alternative would not affect existing access.

WEST ALTERNATIVE 1

West Alternative 1 would require reconfiguration of the existing I-69/US 41/Veterans Memorial Parkway interchange in Indiana, making I-69 the through movement. The existing cloverleaf interchange would remain largely intact, but traffic connecting between northbound I-69 and US 41 to the north or south would utilize a new T-intersection to make the connections. All other connections would be free-flow movements. Because the alternative would retain one existing US 41 bridge over the Ohio River, access to Stratman Road/Wolf Hills Road and Nugent Drive would be provided via US 41 with no additional interchanges provided with I-69. The only new interchange would be at Watson Lane. The US 60 interchange would be converted from a cloverleaf interchange to a partial-cloverleaf interchange. Two of the loop ramps would be removed and replaced by intersections. The new intersection on the east side of the interchange would also provide access to and from the US 41 commercial strip. At the KY 351/KY2084 interchange, collector-distributor roadways, which separate entering and exiting traffic from through traffic, would be created to improve safety. Additionally, the southbound exit ramp to KY 2084 would be modified and a portion of KY 2084 would be converted from one-way to two-way. Minor modifications would be made to other ramps at the KY 351/KY2084 interchange and to ramps at the Audubon Parkway interchange. No changes would be required to the existing KY 425 interchange.

West Alternative 1 would provide four lanes for I-69 throughout the project area.

West Alternative 2

West Alternative 2 would require reconfiguration of the existing I-69/US 41/Veterans Memorial Parkway interchange in Indiana, making I-69 the through movement. The existing cloverleaf interchange would remain largely intact, but traffic connecting from northbound I-69 to northbound US 41 would utilize a new flyover ramp. Because the alternative would not retain either of the US 41 bridges, new interchanges would be provided at Nugent Drive north of the river and at Stratman Road/Wolf Hills Road south of the river. Through the US 41 commercial strip, US 41 would be reconstructed on the east side of the alternative to serve as a frontage road for local access. In this area, a new interchange would be provided at Watson Lane. Changes to the existing US 60, KY 351/KY 2084, and Audubon Parkway interchanges would be identical to those proposed in West Alternative 1. No changes would be required to the existing KY 425 interchange.

West Alternative 2 would provide six lanes for I-69 from south of the existing US 41 and I-69 interchange to south of Kimsey Lane. South of this area, I-69 would be four lanes.

Central Alternatives 1A and 1B

Central Alternatives 1A and 1B would both provide a new interchange at existing I-69 in Indiana approximately one mile east of US 41. At this interchange, I-69 would become the through movement. At the US 41/Veterans Memorial Parkway interchange in Indiana, the ramp from existing southbound I-69 (note: this section of roadway would no longer be designated I-69 following construction of Central Alternatives 1A or 1B) to northbound US 41 would be modified slightly to increase weaving distance between interchanges. A new interchange would be provided at US 60 east of Henderson. Central Alternatives 1A and 1B (Preferred) would also include a new system interchange with free-flow ramps at US 41 approximately one mile south of the US 60 interchange. At this interchange, I-69 would become the through movement. South of the connection between Central Alternatives 1A or 1B and I-69, changes to the existing KY 351/KY 2084 and Audubon Parkway interchanges would be identical to those proposed in West Alternative 1 and West Alternative 2. Existing interchanges that would be upgraded or reconfigured include US 60, KY 351, KY 2084, and Audubon Parkway. No changes would be required to the existing US 41/US 60 interchange or the KY 425 interchange.

Central Alternatives 1A and 1B would provide four lanes for I-69 throughout the project area.

3.5.2 Traffic Forecasts and Levels of Service

Decisions regarding toll policy and rates are not part of the NEPA process; rather, such policies must ultimately be developed by a bi-state authority (subsequent to the DEIS) and the NEPA process must examine the possible impacts related to a wide range of possible toll policies. Therefore, the traffic analysis for the I-69 ORX project focused on a range of feasible tolling scenarios. Tolling considerations included:

- Toll rates
- Tolling or not tolling the remaining US 41 bridge (where applicable)
- Tolling Ohio River crossings (i.e., US 41 and I-69) using the same or different rates
- Using the same or different toll rates based on vehicle type

The toll rate structure for the Louisville-Southern Indiana Ohio River Bridges (ORB) project was used in the analysis for the I-69 ORX project, as it is the most recent example of toll implementation in Indiana and Kentucky. The ORB project required a bi-state partnership between Indiana and Kentucky to establish toll policies to help fund the project. The project included the construction of a new Ohio River bridge to carry northbound I-65 between downtown Louisville and southern Indiana and the construction of a new eastern bridge connecting I-265 in Kentucky and SR 265 in Indiana across the river. The ORB project was completed in late 2016, and tolls were implemented in December of that year. The base toll rates in place when the project opened in December 2016 were $2.00 for cars, $5.00 for medium trucks, and $10.00 for large trucks. Given the relatively recent implementation of tolling in Louisville, the ORB project toll rates were used as a reasonable baseline for evaluating alternatives for the I-69 ORX project.

Traffic forecasts have been developed for the No Build and build alternatives based on "low traffic" and "high traffic" tolling assumptions. Low traffic assumptions were based on tolling a new I-69 crossing with no tolls or significantly reduced tolls on the remaining US 41 bridge, resulting in relatively low volumes of traffic using the new I-69 bridge. High traffic assumptions were based on tolling the new I-69 bridge and remaining US 41 bridge at the same rate, resulting in a better balance of traffic between the new I-69 bridge and the tolled US 41 bridge. Because West Alternative 2 provides a single crossing, all cross-river traffic would be tolled and there is only a high traffic scenario. Conversely, the No Build Alternative only includes a low traffic scenario because it would keep both US 41 bridges without tolls. **Table 3.5-2** shows the 2045 traffic forecasts for each alternative, and **Table 3.5-3** includes total 2045 Ohio River crossing volumes. As shown in the table, while total cross-river traffic volumes would remain relatively consistent under each build alternative and tolling scenario (47,100 to 53,300 vpd), tolling both bridges (i.e., high traffic scenario) would increase the proportion of vehicles using the I-69 bridge compared to no tolls or reduced tolls on the remaining US 41 bridge (i.e., low traffic scenario).

Table 3.5-2. 2045 Forecasted Traffic Volumes

<table>
<tr><th rowspan="2">SEGMENT</th><th rowspan="2">EXISTING (2015)</th><th rowspan="2">NO BUILD</th><th colspan="3">LOW TRAFFIC SCENARIO (VPD)</th><th colspan="3">HIGH TRAFFIC SCENARIO (VPD)</th></tr>
<tr><th>WEST ALT. 1</th><th>WEST ALT. 2</th><th>CENTRAL ALT. 1B</th><th>WEST ALT. 1</th><th>WEST ALT. 2</th><th>CENTRAL ALT. 1A</th></tr>
<tr><td>I-69 / US 41/ Veterans Memorial Parkway to KY 3522 / Nugent Drive</td><td>36,000</td><td>44,400</td><td rowspan="3">27,300</td><td rowspan="9">N/A</td><td rowspan="4">23,100</td><td rowspan="3">32,700</td><td>47,100</td><td rowspan="4">27,500</td></tr>
<tr><td>KY 3522 / Nugent Drive to Wolf Hills / Stratman Road</td><td>40,000</td><td>50,200</td><td>47,100</td></tr>
<tr><td>Wolf Hills / Stratman Road to Watson Lane</td><td>38,300</td><td>46,000</td><td>46,800</td></tr>
<tr><td>Watson Lane to US 60</td><td>35,900</td><td>41,900</td><td>48,700</td><td>49,600</td><td>46,500</td></tr>
<tr><td>US 60 to US 41 (proposed interchange)</td><td>N/A</td><td>N/A</td><td>N/A</td><td>20,300</td><td>N/A</td><td>N/A</td><td>25,500</td></tr>
<tr><td>US 60 to KY 351</td><td>30,200</td><td>40,900</td><td>40,300</td><td>42,000</td><td>42,600</td><td>40,600</td><td>36,400</td></tr>
<tr><td>KY 351 to KY 2084</td><td>26,100</td><td>41,500</td><td>41,300</td><td>42,700</td><td>42,700</td><td>41,300</td><td>40,800</td></tr>
<tr><td>KY 2084 to Audubon Parkway</td><td>22,300</td><td>38,800</td><td>38,500</td><td>39,500</td><td>39,900</td><td>38,400</td><td>38,400</td></tr>
<tr><td>Audubon Parkway to KY 425 / I-69</td><td>19,000</td><td>28,600</td><td>28,400</td><td>29,800</td><td>29,700</td><td>28,300</td><td>28,700</td></tr>
</table>

Table 3.5-3. 2045 Forecasted Ohio River Crossing Traffic Volumes

ALTERNATIVE	US 41 BRIDGES RETAINED	LOW TRAFFIC SCENARIO (VPD)			HIGH TRAFFIC SCENARIO (VPD)		
		US 41	I-69	TOTAL	US 41	I-69	TOTAL
No Build	2	50,200	N/A	50,200	N/A		
West Alternative 1	1	26,000	27,300	53,300	22,900	32,700	55,600
West Alternative 2	0	N/A			N/A	47,100	47,100
Central Alternatives 1A (High Traffic) and 1B (Low Traffic)	1	26,400	23,100	49.500	22,500	27,500	50,000

Level of Service (LOS) is a measure of the operational performance of a transportation facility commonly used by the transportation industry. It is a qualitative measure describing operational conditions within a traffic stream, based on measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. As defined in the 6th edition of the HCM (Transportation Research Board 2016), "LOS is used to translate complex numerical performance results into a simple A – F [rating] system representative of travelers' perceptions of the quality of service provided by a facility or service." In urban areas, such as where the I-69 ORX project is located, a roadway operating at LOS D is generally considered acceptable. The EMPO model presents LOS as a function of a roadway's HPMS functional classification and the maximum directional V/C ratio occurring on the roadway link for each time period: AM, PM, or off-peak. The model's process and thresholds for estimating LOS were established during the model's original development and certification by EMPO and did not change for this analysis. The existing (2015) and future (2045) No Build traffic volumes and LOS are shown on **Figure 3.5-2**.

West Alternative 1

The 2045 LOS for the low and high traffic scenarios for West Alternative 1 are shown on **Figure 3.5-3**. In the low traffic scenario, the section of US 41 from Wolf Hills Road to Watson Lane in Henderson would operate at LOS E while the Ohio River crossing would operate at LOS D. All sections of I-69 under the low traffic scenario would operate at LOS B. In the high traffic scenario, all sections of US 41 or I-69 would operate at LOS D or better.

West Alternative 2

As shown on **Figure 3.5-4**, under West Alternative 2, all sections of I-69 would operate at LOS C or better. West Alternative 2 would remove the local connectivity of the existing US 41 corridor, resulting in the lowest number of cross-river trips (47,100 vpd).

Central Alternatives 1A and 1B

The 2045 LOS for the low and high traffic scenarios is shown on **Figure 3.5-5**. In the low traffic scenario, Central Alternative 1B, the section of US 41 from Wolf Hills Road to US 60 in Henderson would operate at LOS E while the Ohio River crossing would operate at LOS D. In the high traffic scenario, Central Alternative 1A, all sections of US 41 and I-69 would operate at LOS D or better.

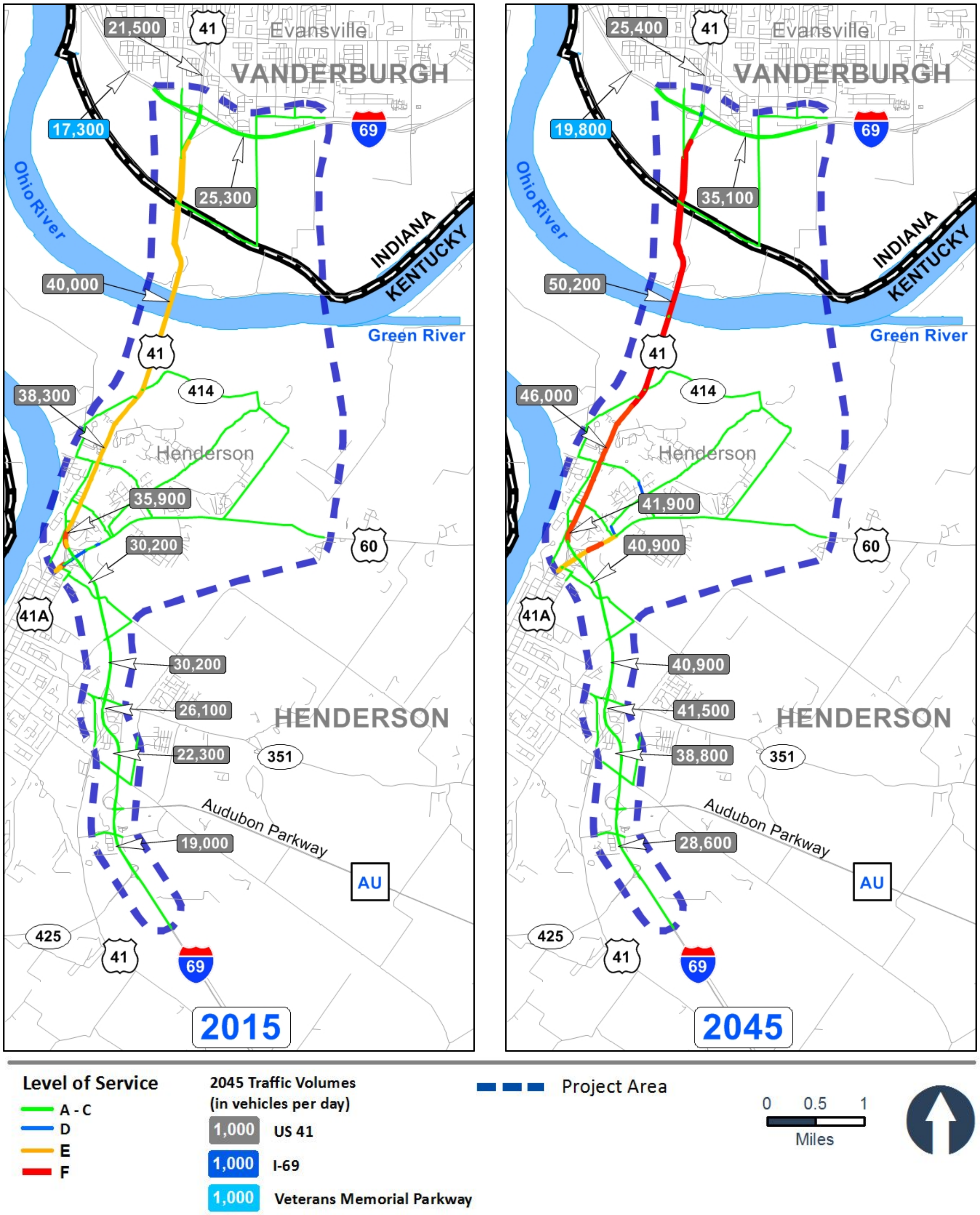


Figure 3.5-2. Level of Service – Existing (2015) and No Build (2045)

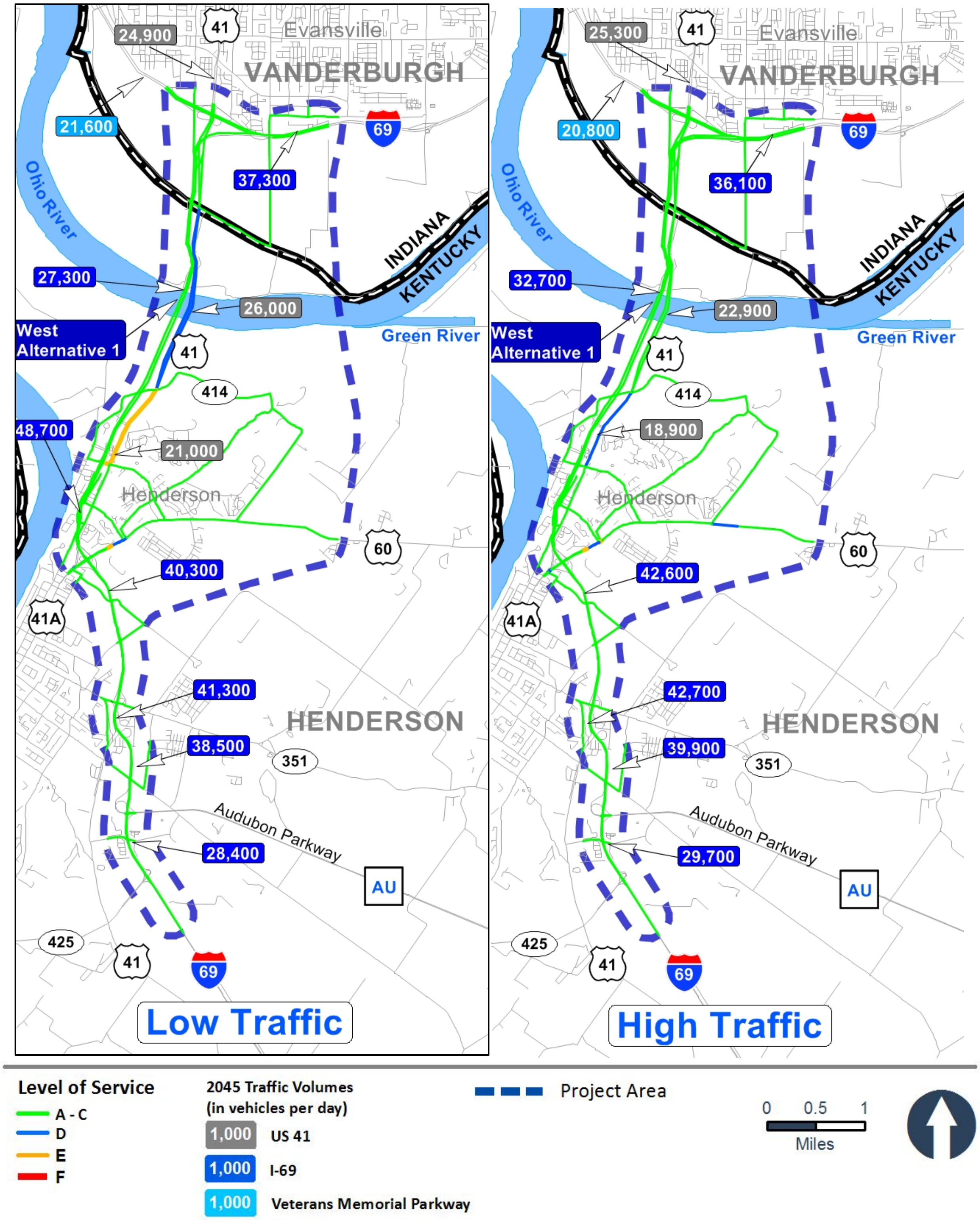


Figure 3.5-3. Level of Service (2045) – West Alternative 1

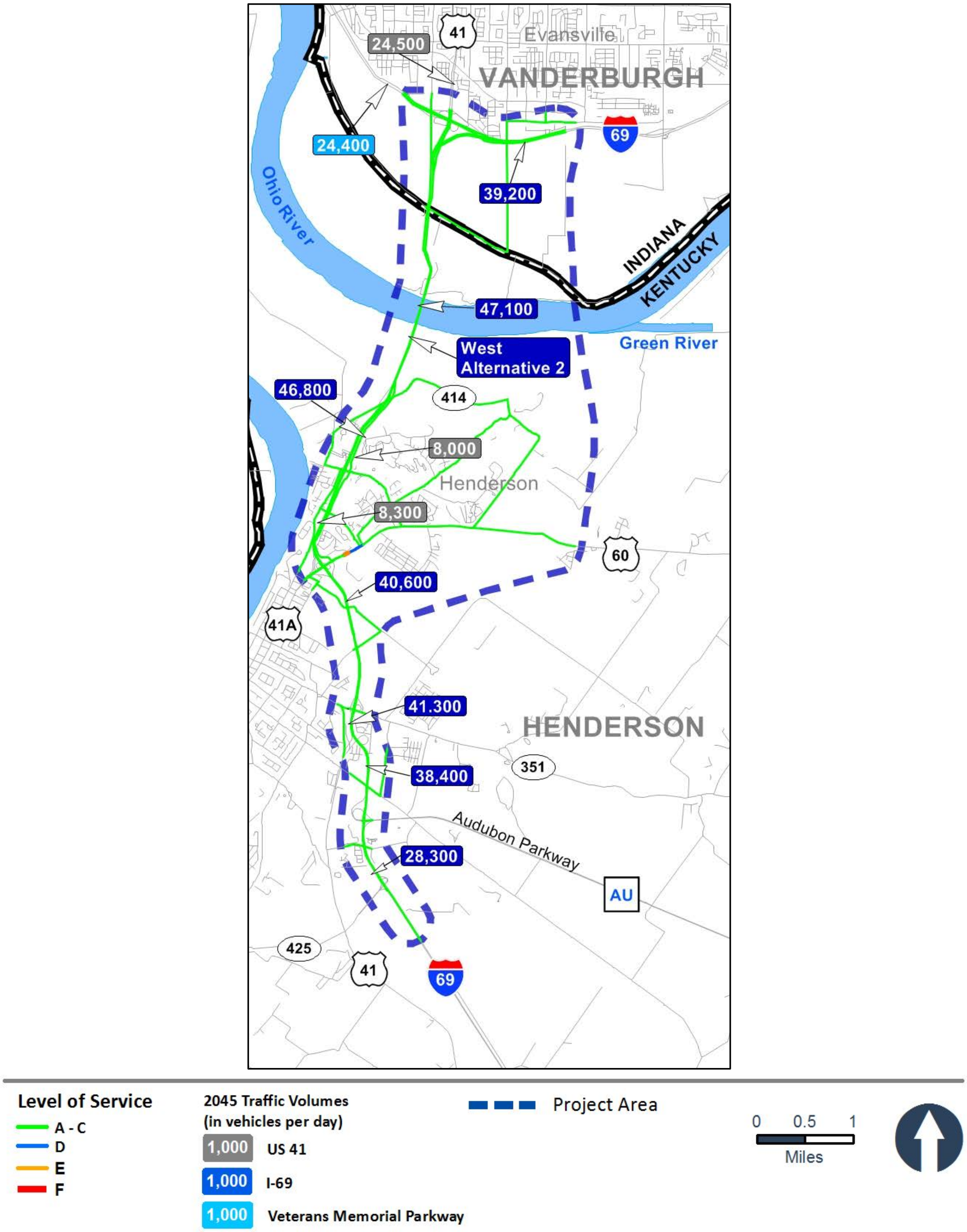


Figure 3.5-4. Level of Service (2045) – West Alternative 2

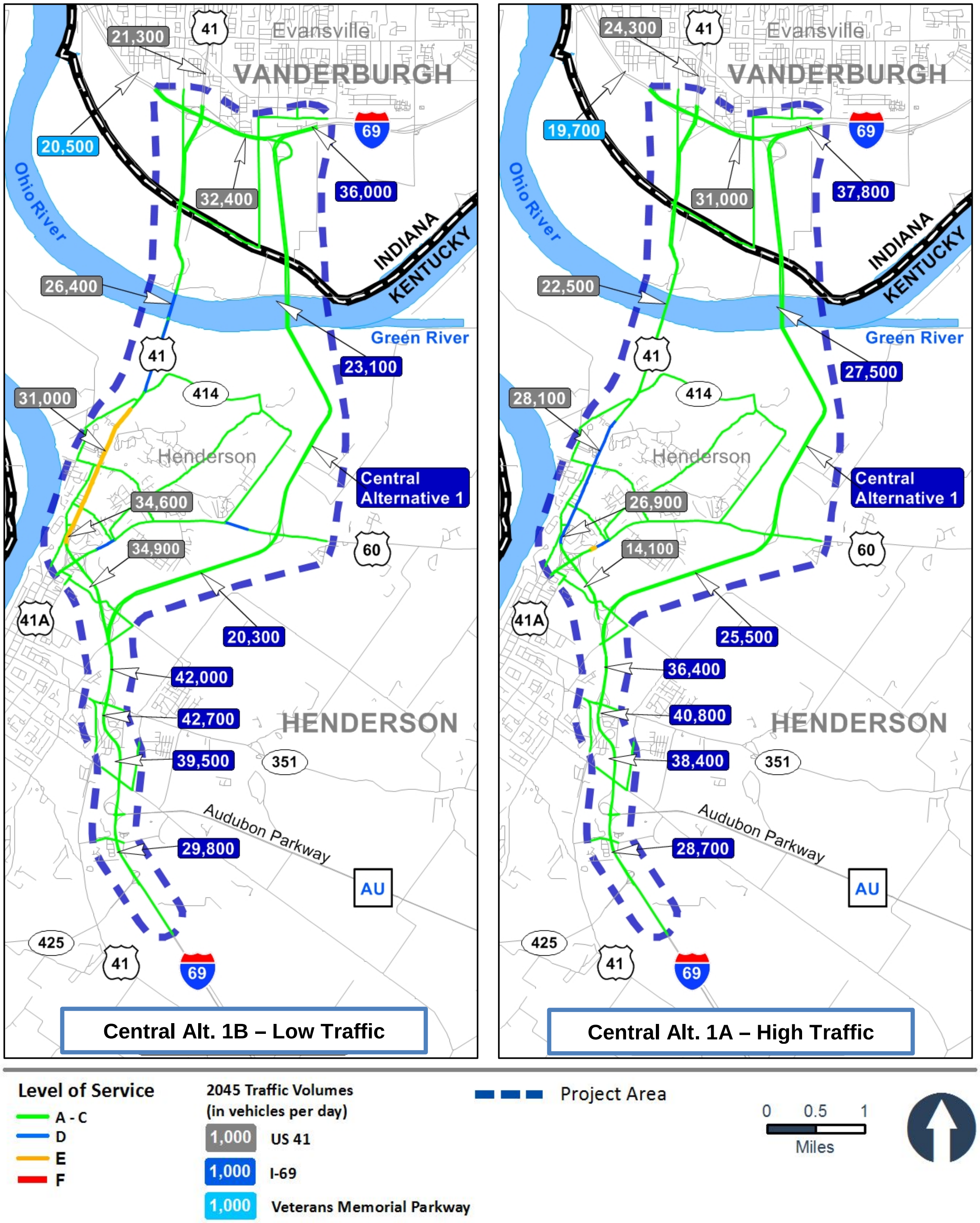


Figure 3.5-5. Level of Service (2045) – Central Alternatives 1A and 1B

The low traffic scenario, Central Alternative 1B, would have the lowest cross-river traffic volume (49,500 vpd). The high traffic scenario, Central Alternative 1A, the cross-river traffic volume of 50,000 vpd would be less than West Alternative 1 (55,600 vpd) but greater than West Alternative 2 (47,100 vpd). For Central Alternatives 1A and 1B, the proposed I-69 corridor would be farther from the existing commercial development and traffic generators along the US 41 corridor, and would therefore be somewhat less attractive as a travel alternative for trips beginning or ending near already developed areas.

The traffic forecasts developed for each build alternative support a consistent conclusion regarding the need for cross-river capacity. In every traffic scenario, no more than six total lanes of traffic crossing the Ohio River are necessary to accommodate cross-river demand through the 2045 design year at an acceptable LOS.

3.5.3 TRAVEL TIMES

Travel time, the time required to travel between two locations, provides another measure of operational performance. The highest volumes in the corridor are experienced in the northbound direction during the morning (i.e., AM) peak period and southbound during the evening (i.e., PM) peak period. **Table 3.5-4** shows the 2045 travel times for the AM and PM model peak periods for the existing, No Build, and build alternatives.

Table 3.5-4. 2045 Peak Period Through Traffic Travel Times

ALTERNATIVE	NORTHBOUND – AM PEAK[1]		SOUTHBOUND – PM PEAK[2]	
	ROUTE LENGTH (MILES)	TRAVEL TIME (MINUTES)	ROUTE LENGTH (MILES)	TRAVEL TIME (MINUTES)
Existing (via US 41)	13	16	14	20
No Build (via US 41)	13	17	14	27
West Alternative 1 Low Traffic (via I-69)	13	14	13	17
West Alternative 1 High Traffic (via I-69)	13	15	13	17
West Alternative 2 (via I-69)	13	14	13	18
Central Alternative 1B Low Traffic (via I-69)	13	13	13	15
Central Alternative 1A High Traffic (via I-69)	13	13	13	16

Notes: Travel times are based on travel between KY 425 and the I-69/Green River Road interchange.
[1] AM peak period is 6-9 a.m.
[2] PM peak period is 3-6 p.m.

Note the southbound trip lengths are longer for the Existing and No Build alternatives as they both require travel through the westbound to southbound loop ramp in the US 41/Veterans Memorial Parkway system interchange. The existing speed limit on US 41 is 45 to 50 miles per hour (mph) through the US 60 interchange and the commercial strip in Henderson and 55 mph north and south. Within the project area in Indiana, I-69 is posted 60 mph and in Kentucky it is posted 65 mph. Both of the Central Alternatives were modeled with a speed limit of 60 mph (consistent with I-69 on the south side of Evansville) and the West Alternatives were modeled with a 55 mph speed limit through the urbanized area in Henderson.

It currently takes a vehicle traveling northbound from KY 425 to the I-69/Green River Road interchange during the AM peak period approximately 16 minutes to travel the 13-mile corridor; by 2045, the travel time is expected to increase by about 1 minute. During the PM peak period, it currently takes approximately 20 minutes to make the same trip in the southbound direction; by 2045, the travel time is expected to increase by 7 minutes.

WEST ALTERNATIVE 1

West Alternative 1 would reduce AM peak period travel times from 17 minutes for the No Build Alternative to 14 and 15 minutes for the low and high traffic scenarios, respectively. PM peak hour travel times would be reduced from 27 minutes to 17 minutes for both low and high traffic scenarios.

WEST ALTERNATIVE 2

West Alternative 2 would reduce AM peak period travel times from 17 minutes for the No Build Alternative to 14 minutes and PM peak period travel times would be reduced from 27 minutes to 18 minutes.

CENTRAL ALTERNATIVES1A AND 1B

Both Central Alternatives 1A (High Traffic scenario) and 1B (Low Traffic scenario) would reduce AM peak period travel times from 17 minutes for the No Build Alternative to 13 minutes for both the low and high traffic scenarios. PM peak period travel times would be reduced from 27 minutes to 15 minutes and 16 minutes for the low and high traffic scenarios, respectively.

CHAPTER 4 – ENVIRONMENTAL JUSTICE TRAFFIC IMPACT ANALYSIS

4.1 PURPOSE OF THE ANALYSIS

As part of the I-69 ORX planning study, Stantec used the updated 2015 EMPO model to estimate the share of cross-river auto trips originating from, or destined to, TAZs identified in the *Environmental Justice Technical Memorandum: I-69 Ohio River Crossing Project* (INDOT and KYTC 2017) as containing disproportionately higher percentages of low income, minority, or both low income and minority populations (referred to as "EJ" populations).

Based upon census definitions, low income residents are those with incomes below the poverty level and minority residents are all population categories except "Not Hispanic or Latino – White Alone." To be identified as an EJ zone, the proportion of low income, minority, or the two groups in combination must be 25 percent greater than average proportion of those populations in the five-county EMPO model area. According to the American Community Survey, low income residents represent 14.8 percent of the total population within the five-county EMPO model area. Minority residents represent 11.7 percent of the total population. Therefore, the thresholds for identifying EJ zones are zones containing at least 18.5 percent low income residents and 14.8 percent for minority residents.

Parsons provided GIS maps of the identified EJ block groups for three categories: low income, minority, and low income and minority. Because census block groups generally share compatible boundary elements with the TAZ used in the EMPO model, the EJ designations from the block groups could be transferred to the respective TAZs in the EMPO model.

The model was executed for a series of alternatives under different tolling conditions and distances. Times and costs were summarized separately for both EJ and non-EJ trip categories. The costs for trips using each alternative were compared to the median income of travelers to assess the burden that travel costs and tolls would impose on EJ and non-EJ travelers making those trips.

4.2 AM PEAK HOUR

The analysis was performed using AM peak conditions to assess the impact of non-discretionary work-related trips.

Rather than using county-level income data, the model used household incomes at the TAZ level, which breaks down each county into smaller areas. The use of the AM peak period trips enabled referencing of the traveler's home TAZ and its associated average income.

4.2.1 AM TRIPS

Trips were grouped into three markets: 1) trips that began and ended in Indiana, 2) trips that began and ended in Kentucky, and, 3) trips that crossed the Ohio River. For each of these markets, the average trip distance and travel time was summarized, and the cost then calculated. Trip cost included the value of time spent traveling, fuel costs for the distance of travel, and tolls encountered along the travel route. All cost terms were calculated in 2017 dollars, which required discounting the future year 2025 toll rates with a factor estimated from assumed Consumer Price Index (CPI) growth between 2017 and 2025. The year 2025 is considered the opening year of traffic. The cost of travel time was estimated at 50 percent of the average wage rate for households at the origin (assumed home end) of the trip. Fuel costs assumed fuel at $2.50 per gallon and fuel efficiency at 20 miles per gallon. Toll rates were assumed to be consistent with the Louisville-Southern Indiana ORB project, as shown in **Figure 4.2-1** below.

CLASSIFICATION	VEHICLE DESCRIPTION	TOLL WITH TRANSPONDER	TOLL WITH REGISTERED PLATE	TOLL WITH UNREGISTERED PLATE
Passenger Vehicle	2-axle up to 7 ½ feet in height	$2	$3	$4
Medium Vehicle	2-axle more than 7 ½ feet in height (90"+); All 3-axle; All 4-axle	$5	$6	$7
Large Vehicle	5-axle or more	$10	$11	$12

Figure 4.2-1. Initial Ohio River Bridges Project Toll Rates

Source: Riverlink 2017

Table 4.2-1 displays the EJ, non-EJ and total trips across the Ohio River. Three of the alternatives (West Alternative 1 and Central Alternatives 1A and 1B) each have a low, mid-range, and high toll scenario. The No Build Alternative does not have any tolling on any roadways. West Alternative 2 has only I-69 bridge tolls. The low toll scenario is where only I-69 is tolled, which for the Central Alternative is Central Alternative 1B. The mid-range toll scenario tolls only trucks on US 41. The high toll scenario tolls all vehicles on all of the bridges, which for the Central Alternative is Central Alternative 1A.

Table 4.2-1. EJ and Non EJ Trip Shares across the Ohio River

ALTERNATIVE	TRAFFIC SCENARIO	OHIO RIVER CROSSINGS		
		EJ TRIP SHARE	NON-EJ TRIP SHARE	TOTAL
No Build Alternative	No Build	53%	47%	38,827
West Alternative 1	Alt 27 - Low	55%	45%	42,009
	Alt 40 - Mid Range	55%	45%	41,610
	Alt 32 - High	55%	45%	44,376
West Alternative 2	Alt 3	54%	46%	40,453
Central Alternatives 1A and 1B	(Central Alt. 1B) Alt 5 - Low	53%	47%	34,769
	Alt 39-Mid Range	53%	47%	39,923
	(Central Alt. 1A) Alt 28-High	52%	48%	38,969

Source: Compiled from EMPO Model

4.2.2 AVERAGE TRIP DISTANCE

For the build alternatives, the increased capacity and various alignments provide an increased share of longer distance trips as part of the cross-river market. For alternatives with two crossing facilities, note that average distances for cross-river trips are reported separately by the crossing facility. For the West Alternative 1, the average travel distance for the EJ trips is approximately 14.5 miles for both crossings since the two crossing facilities are immediately adjacent to each other. For Central Alternatives 1A and 1B, the average distance for both EJ and non-EJ crossing trips increases for those trips using the I-69 Bridge since this bridge is not adjacent to the US 41 bridge.

Table 4.2-2 shows the average trip distance, in miles, for each of the four alternatives for the 2045 AM peak hour. For the build alternatives, the increased capacity and various alignments provide an increased share of longer distance trips as part of the cross-river market. For alternatives with two crossing facilities, note that average distances for cross-river trips are reported separately by the crossing facility. For the West Alternative 1, the average travel distance for the EJ trips is approximately 14.5 miles for both crossings since the two crossing facilities are immediately adjacent to each other. For Central Alternatives 1A and 1B, the average distance for both EJ and non-EJ crossing trips increases for those trips using the I-69 Bridge since this bridge is not adjacent to the US 41 bridge.

Table 4.2-2. Average Travel Distance

Alternative			2045 A.M. Peak Average Distance (Miles)									
			EJ					Non-EJ				
			Intra-Indiana	Cross River			Intra-Kentucky	Intra-Indiana	Cross River			Intra-Kentucky
Number	Description	Toll Policy		US - 41	I -69	Overall			US - 41	I -69	Overall	
1	No-Build (US 41 Existing **4** Lanes)	No Tolls	4.6	13.8			3.9	6.4	16.6			5.4
West Corridor 1												
27	US 41 (2 lanes) & I-69 Bridge	Low Toll - US 41 Free	4.8	14.6	14.6	14.6	4.6	6.7	17.7	17.5	17.5	6.2
40		Mid Range - US 41 Auto Free	4.8	14.4	14.5	14.4	4.6	6.7	17.5	17.3	17.4	6.2
32		High Toll - All Bridges Tolled	4.7	14.3	14.7	14.5	4.5	6.7	17.2	17.5	17.4	6.2
West Corridor 2												
3	I-69 Bridge Only	Tolled	4.8	14.6			4.5	6.7	17.3			6.2
Central Corridor 1 (Central Alt. 1A – High Toll/ Central Alt. 1B – Low Toll)												
5	US 41 (2 lanes) & I-69 Bridge	Low Toll - US 41 Free	4.6	14.8	17.4	16.0	4.4	6.5	17.3	19.9	18.5	6.0
39		Mid Range - US 41 Auto Free	4.8	14.8	17.3	15.8	4.5	6.7	17.7	19.6	18.5	6.2
28		High Toll - All Bridges Tolled	4.8	14.7	17.3	16.0	4.6	6.7	17.5	19.5	18.5	6.2

Source: EMPO Model

4.2.3 AVERAGE TRAVEL TIME

Table 4.2-3 shows the average trip travel times, in minutes, for each of the four alternatives for the 2045 AM peak hour. The PM peak hour travel times have comparable differences. As shown in the table, the EJ trips have lower travel times than the non-EJ trips regardless of the corridor option, crossing bridge, or tolling option. This is likely due to amount of EJ zones along the existing US 41 alignment. When compared to the no-build alternative, the build alternatives have decreased times for both EJ and non-EJ zones for the mid-range and high toll polices. This is due to the greater share of traffic using the high speed I-69 crossing, when tolls are applied to both bridges. Only for the low toll policy, where US 41 is non-tolled, does the travel time increase over the no-build condition. This is due to the more traffic electing to use the non-tolled US 41 and traveling longer distances due to the overall increased capacity and connectivity provided by the combined system of crossings. Note that even with the low toll policy, the EJ trips have lower travel times than the non-EJ Trips.

Table 4.2-3. Average Travel Time Minutes

Alternative			2045 A.M. Peak Average Time (Minutes)									
			EJ					Non-EJ				
Number	Description	Toll Policy	Intra-Indiana	Cross River			Intra-Kentucky	Intra-Indiana	Cross River			Intra-Kentucky
				US - 41	I -69	Overall			US - 41	I -69	Overall	
1	No-Build (US 41 Existing 4 Lanes)	No Tolls	11.7	25.5			9.7	13.1	28.3			11.0
West Corridor 1												
27	US 41 (2 lanes) & I-69 Bridge	Low Toll - US 41 Free	9.5	33.2	21.9	27.2	8.1	11.1	36.4	25.1	30.4	9.5
40		Mid Range - US 41 Auto Free	9.5	28.6	21.9	25.3	8.1	11.1	31.8	25.0	28.5	9.5
32		High Toll - All Bridges Tolled	9.4	26.5	22.2	24.0	8.1	11.0	29.5	25.4	27.1	9.5
West Corridor 2												
3	I-69 Bridge Only	Tolled	9.5	22.2			8.1	11.1	25.1			9.5
Central Corridor 1							Central Alt. 1A – High Toll/ Central Alt. 1B – Low Toll					
5	US 41 (2 lanes) & I-69 Bridge	Low Toll - US 41 Free	10.2	33.1	25.9	29.8	8.7	11.7	35.7	28.5	32.3	10.1
39		Mid Range - US 41 Auto Free	9.5	25.8	23.6	24.9	8.1	11.1	29.0	26.0	27.7	9.5
28		High Toll - All Bridges Tolled	9.5	24.4	23.7	24.0	8.1	11.1	27.5	26.0	26.7	9.5

Source: EMPO Model

4.2.4 TOLL BURDEN

Table 4.2-4 contains the cost of tolls in 2017 in relation to the percentage of median household income. The median household income was derived from the American Community Survey (ACS) (U.S. Census Bureau 2017). ACS is a nationwide survey that produces demographic, social, housing, and economic estimates in increments of 1-year, 3-year, and 5-year. The median household income is being used here to understand the potential level of impact of the toll burden, not as a threshold for EJ analysis.

Average Trip Cost includes times and distances converted to equivalent costs and toll costs:

- Auto operating costs (fuel) – $0.125 per mile
- Value of time — 50 percent of zonal wage rate (annual income/2080 hours)
- All costs converted to 2017 dollar terms

Table 4.2-4. Estimating Toll Burden

TOLL COSTS (2017$)			PERCENT OF HOUSEHOLD INCOME		
			POVERTY LINE[1]	2016 MEDIAN HOUSEHOLD INCOME[2]	
1-WAY	ROUND TRIP	YEARLY COST		INDIANA	KENTUCKY
			$19,105	$49,037	$41,630
$2.00	$4.00	$960	5.0%	2.0%	2.3%

Sources: U.S.US Census Bureau 2017 and Riverlink 2017

Notes:

[1] Weighted average threshold for 3-person households

[2] Evansville Metro Area - 2016 ACS estimates (U.S. Census Bureau 2017)

4.3 CONCLUSION

The results of EJ analyses identified areas of low income and/or minority populations (INDOT and KYTC 2018a). The updated 2015 EMPO model estimated the share of cross river auto trips from the TAZs identified as EJ zones as higher than the share of cross river trips from non-EJ zones. The highest average trip length for both EJ and non-EJ trips was the West Alternative 2 crossing of the Ohio River. If tolls are implemented, the highest percentage of affected households would be those designated as low income, with tolls representing roughly two percent of affected household median incomes. Additional discussion of the overall EJ analyses can be found in Chapter 4 of the DEIS.

CHAPTER 5 – LITERATURE CITED

Bing Maps

2018 Aerial Photographs, 2010 to present.

2017 City of Henderson, Department of Building and Fire Safety

City of Henderson – source of permits (page 2 – 6).

Evansville Metropolitan Planning Organization

2012 Travel Model User's Guide (pp. 29 – pp.43).

2014 *Metropolitan Transportation Plan 2040* (amended 2016), http://www.evansvillempo.com/MTP_2040.html.

2017 *Transportation Improvement Program 2018-2021 for the Evansville-Henderson Urbanized Area*, http://www.evansvillempo.com/Docs/TIP.

Google Earth

2018 Aerial Photographs, 2010 to present.

2017 Henderson County, County Codes Department

Henderson County – source of permits (page 2 – 6).

Indiana Department of Transportation

2014 Indiana Statewide Travel Demand Model Version 7.

Indiana Department of Transportation and Kentucky Transportation Cabinet

2017 *Screening Report: I-69 Ohio River Crossing Project.*

2018a *Environmental Justice Technical Memorandum: I-69 Ohio River Crossing Project*.

2018b *Screening Report Supplement: I-69 Ohio River Crossing Project*.

Kentucky State Data Center

2017 *Population Projections | Kentucky State Data Center, University of Louisville*, http://ksdc.louisville.edu/data-downloads/projections.

Kentucky Transportation Cabinet

2017 Kentucky Statewide Travel Demand Model Version 17.

Riverlink

2017 Ohio River Bridges Toll Policy. http://riverlink.com/.

STATS Indiana

2017 *Population Topic Page: STATS Indiana, Indiana Business Research Center at Indiana University*, http://www.stats.indiana.edu/topic/population.asp.

StreetLight Data, Incorporated

2017 *Transportation Analytics on Demand | StreetLight Data*, https://www.streetlightdata.com/.

Transportation Research Board

2016 *Highway Capacity Manual, Sixth Edition*, http://hcm.trb.org.

U.S. Bureau of Economic Analysis

2017 *Regional Data, Local Area Personal Income and Employment*, https://www.bea.gov/iTable/.

U.S. Bureau of Labor Statistics

2017 Consumer Price Index, https://www.bls.gov/cpi/.

U.S. Census Bureau

2017 *American Factfinder Download Center*, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

Warrick County, Area Plan Commission

2017 Building permit data.

Vanderburgh County, Building Commission

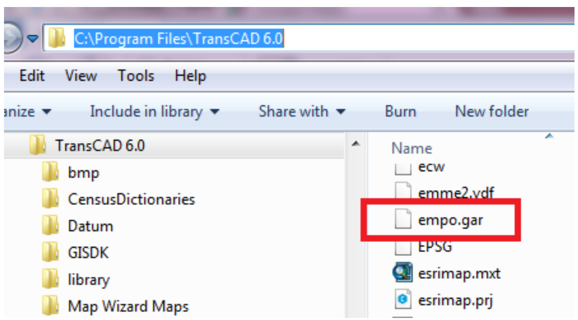
2017 Building permit data.

APPENDIX

This Appendix describes a systematic procedure to run the EMPO toll diversion model that was developed to estimate toll transactions at the Ohio River bridge crossings on US 41 and I-69. The updated EMPO model along with the toll diversion model is executed using TransCAD 6.0 Build 4295 64-bit.

Step 1: Delete 'empo.gar' in TransCAD folder

If a user is running the EMPO toll diversion model for the first time, the file 'empo.gar' (that stores the previous settings) should be deleted from TransCAD folder (e.g., 'C:\Program Files\TransCAD 6.0\') to avoid an error when opening TransCAD. Note that you don't need to delete this file again after executing the model run for the first time because the newly created settings are suitable in the next model runs.

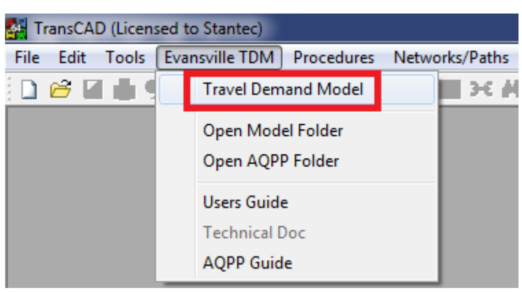


Step 2: Open the Model's User Interface

a) Open a highway network layer (e.g., '\Inputs\Network\EMPO_network.dbd')

b) Add a TAZ layer (e.g., '\Inputs\TAZ\EMPO_TAZ_2025_091417.dbd')

c) Open the model user interface by choosing the 'Travel Demand Model' option from the 'Evansville TDM' menu



Step 3: General Settings

The 'General Setting' are specified next.

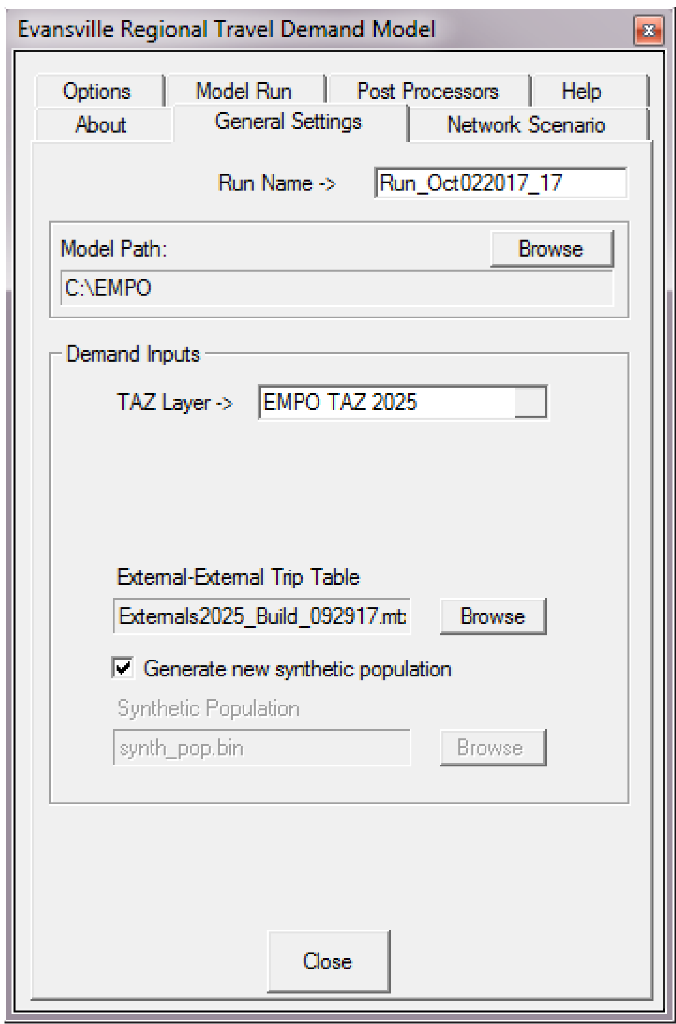
a) Run Name: (popped up automatically)

b) Model Path: (e.g., 'C:\EMPO')

c) TAZ Layer: (selection of currently opened TAZ layer)

d) External-External Trip Table: (selection of E-E matrix file)

e) Check of 'Generate new synthetic population' only if socio-economic data are changed



Step 4: Network Scenario

Then the 'Network Scenario' is specified.

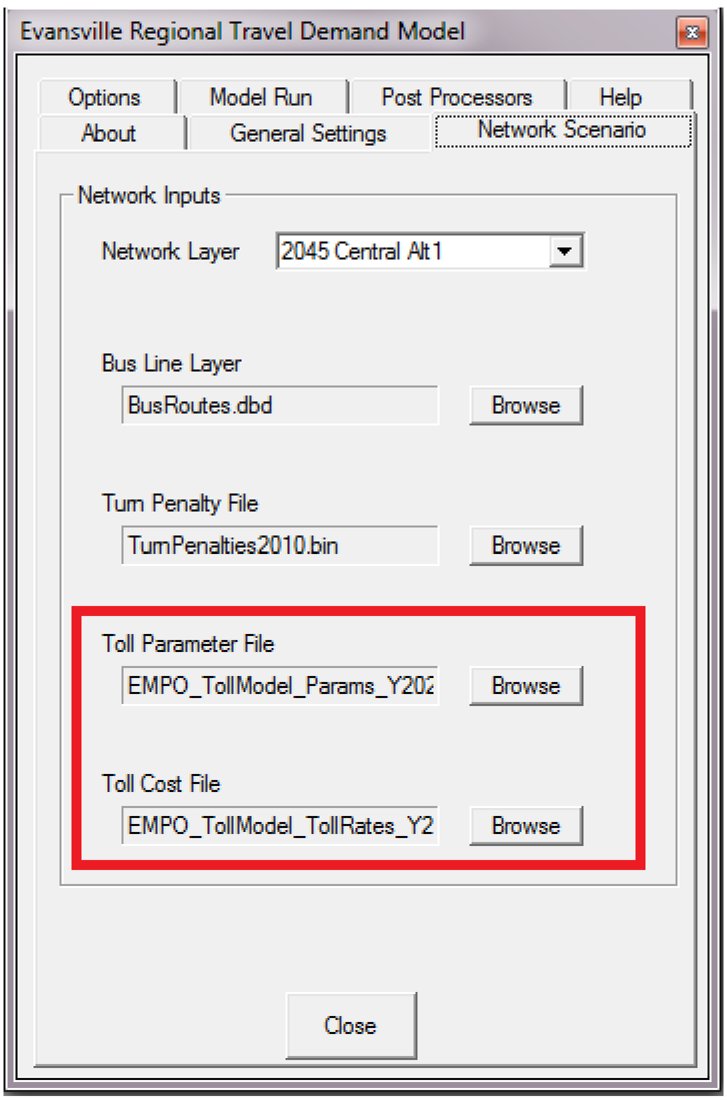
a) Network Layer: (selection of input highway network layer)

b) Bus Line Layer (e.g., 'BusRoutes.dbd')

c) Turn Penalty File (e.g., 'TurnPenalties2010.bin')

d) Toll Parameter File (e.g., 'EMPO_TollModel_Params_Y2025.dbf')

e) Toll Cost File (e.g., 'EMPO_TollModel_TollRates_Y2025.dbf')

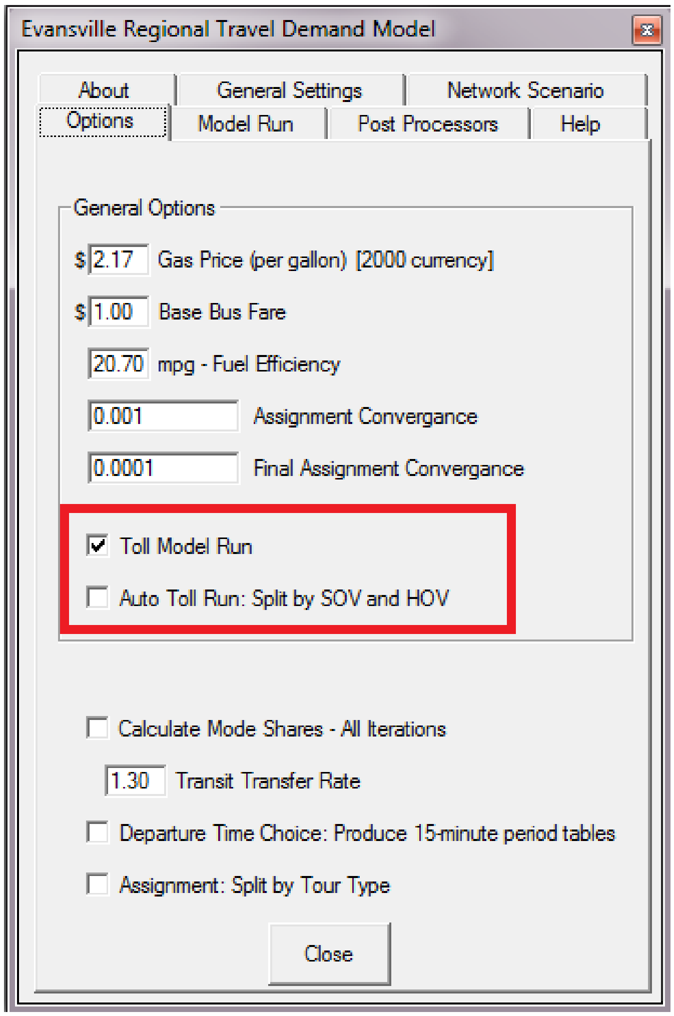


Step 5: Options

The 'Options' are specified next.

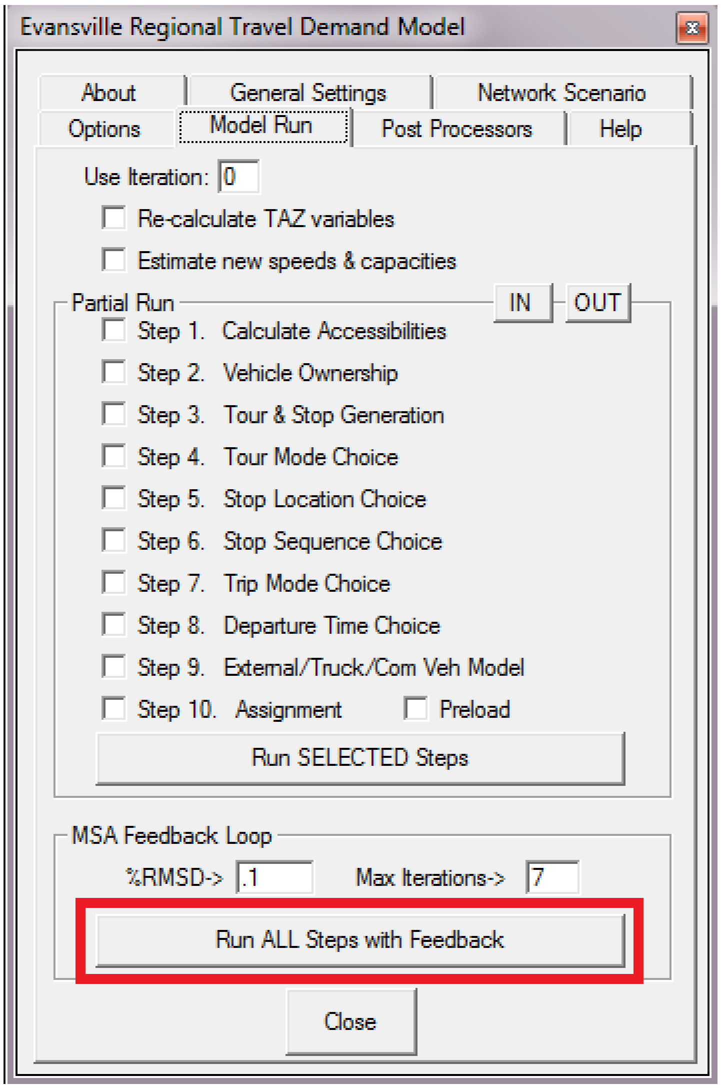
a) Check of 'Toll Model Run' if the toll diversion process is required

b) Don't check of 'Auto Toll Run: Split by SOV and HOV'; this option is only used when a HOV facility is available



Step 6: Launch the model run

Once all required settings are specified, the full model run is executed for 7 feedback iterations by clicking the 'Run ALL Steps with Feedback' button in the 'Model Run' tab. Note that this new version skips the check of RMSD condition because additional feedback iterations up to 7 are required to achieve a valid convergence.



Step 7: Output Files

The loaded volumes at the Ohio River crossing bridges (US 41 or I-69) are stored in output files located in the '\Model\tolls\' folder.

a) ***ASSN_VOL_#.bin*** (daily assigned volumes, # = the number of feedback iteration)

b) ***ASSN_VOL2_AB_#.bin*** (northbound assigned volumes by vehicle class (car, single-Unit truck, multi-unit truck) and time periods (AM, PM, OP))

c) ***ASSN_VOL2_BA_#.bin*** (southbound assigned volumes by vehicle class (car, single-Unit truck, multi-unit truck) and time periods (AM, PM, OP))

ASSN_VOL_I0.bin
ASSN_VOL_I0.DCB
ASSN_VOL_I1.bin
ASSN_VOL_I1.DCB
ASSN_VOL_I2.bin
ASSN_VOL_I2.DCB
ASSN_VOL_I3.bin
ASSN_VOL_I3.DCB
ASSN_VOL_I4.bin
ASSN_VOL_I4.DCB
ASSN_VOL_I5.bin
ASSN_VOL_I5.DCB
ASSN_VOL_I6.bin
ASSN_VOL_I6.DCB
ASSN_VOL_I7.bin
ASSN_VOL_I7.DCB
ASSN_VOL2_AB_I0.bin
ASSN_VOL2_AB_I0.DCB
ASSN_VOL2_AB_I1.bin
ASSN_VOL2_AB_I1.DCB
ASSN_VOL2_AB_I2.bin
ASSN_VOL2_AB_I2.DCB
ASSN_VOL2_AB_I3.bin
ASSN_VOL2_AB_I3.DCB
ASSN_VOL2_AB_I4.bin
ASSN_VOL2_AB_I4.DCB
ASSN_VOL2_AB_I5.bin
ASSN_VOL2_AB_I5.DCB
ASSN_VOL2_AB_I6.bin
ASSN_VOL2_AB_I6.DCB
ASSN_VOL2_AB_I7.bin
ASSN_VOL2_AB_I7.DCB

ASSN_VOL2_BA_I0.bin
ASSN_VOL2_BA_I0.DCB
ASSN_VOL2_BA_I1.bin
ASSN_VOL2_BA_I1.DCB
ASSN_VOL2_BA_I2.bin
ASSN_VOL2_BA_I2.DCB
ASSN_VOL2_BA_I3.bin
ASSN_VOL2_BA_I3.DCB
ASSN_VOL2_BA_I4.bin
ASSN_VOL2_BA_I4.DCB
ASSN_VOL2_BA_I5.bin
ASSN_VOL2_BA_I5.DCB
ASSN_VOL2_BA_I6.bin
ASSN_VOL2_BA_I6.DCB
ASSN_VOL2_BA_I7.bin
ASSN_VOL2_BA_I7.DCB