Texas Department of Transportation

Houston District

STATE OF TEXAS
CODY D. STONE
127924
LICENSED PROFESSIONAL ENGINEER
12-4-2020

Federal Highway Administration

INTERSTATE ACCESS JUSTIFICATION REPORT

I-45 North Houston Highway Improvement Project (NHHIP)

Limits:

Segment 2: I-45 from I-610 to I-10, I-610 from Airline Drive to Fulton Street

Segment 3: I-45 from I-10 to Scott Street, I-10 from I-45 to Waco Street, I-69 from Lyons Avenue to Spur 527

Harris County

Segment 2 CSJs: 0500-03-560, 0500-03-560, 0500-03-597

Segment 3 CSJs: 0500-08-001, 0500-03-598, 0500-03-599, 0500-03-601, 0500-08-001, 0027-13-200, 0027-13-221, 0027-13-201

Prepared by:
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This Document is released under the authority of Cody D. Stone, P.E., Texas Licensed #127924, on December 4, 2020.

Final Submittal

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EXECUTIVE SUMMARY

The Interstate 45 (I-45) North Houston Highway Improvement Project (NHHIP) is a set of improvements along six major freeway corridors in Houston, Texas. This Interstate Access Justification Report (IAJR) addresses the Federal Highway Administration's (FHWA) eight policy point requirements for access changes in Segment 2 and Segment 3 of the I-45 NHHIP.

Segment 2 and 3 of the NHHIP include over 15.3 miles of freeway facilities and include the downtown loop system in the heart of Harris County. Many of these facilities have operational and safety deficiencies and do not meet current FHWA or TxDOT design requirements.

A preferred alternative has been identified and refined through project development over the last 15 years. The proposed improvements to the project area include:

- Removal of existing Pierce Elevated (segment of I-45 from Brazos Street to Jackson Street that is above the downtown street grid) – replaced by downtown ramp connections for local access and connectivity with downtown.
- I-45 realignment to be parallel with I-10 north of downtown and parallel with I-69 east of downtown until it turns south to the existing I-45 alignment southeast of the downtown area.
- Addition of a pair of HOV/express lanes (MaX lanes) on I-10 that terminate in downtown.
- Addition of a pair of HOV/express lanes (MaX lanes) on I-45 that terminate in downtown.
- Addition of general purpose lanes on I-45 in Segment 2.
- Reconstruction of the I-45 at I-610 interchange to provide traditional right lane exits and collector-distributor parallel facilities.
- Reconstruction of the I-45 at I-10 interchange with the realignment of I-45 and improvement in direct connector facilities.
- Reconstruction of the I-69 at I-10 interchange with fully directional connectors and ultimate connections to the future Hardy Toll Road extension.
- Removal of the fourth leg of the I-69 at I-45 interchange with the Pierce Elevated section removal.
- Frontage road and local intersection improvements, like turn bays, retiming of signals, and access management at intersections, cross streets, and frontage roads.

These series of improvements aim to address existing and future transportation needs.

The satisfaction of each of the eight FHWA policy points (paraphrased) are summarized as follows:

Policy Point 1 – Need cannot be satisfied by existing interchanges and/or local roads and streets

The existing interchanges and local roads and streets need improvement to address operational and safety deficiencies. Modifications and additions of turn bays or storage alone do not address the existing and future capacity needs. The base year local intersection operational results are shown in Section 3.7.2 and show that the local network is at capacity in addition to the Interstate system, however, the existing condition analysis and field investigation revealed that the main source of congestion and safety issues in the study area was the freeway operations. Improvements to the local network would not address the safety and congestion needs in the study area.

Early studies also identified the need for capacity and lane balance on all freeways in the project area. These studies include the 2003 North-Hardy Corridor Alternatives Analysis Report, the 2004 North-Hardy Corridor Planning Studies, Alternatives Analysis Report (Transit Component), the 2005 North-Hardy Planning Studies, and Alternatives Analysis Report (Highway Component). These studies are summarized in Section 1.2 of this report. In addition, the crash rates in the project area for each freeway facility, except for I-69, are higher than the statewide crash rate for similar facility types.

Policy Point 2 – Need cannot be satisfied by transportation system management (TSM), design, and other alternative improvements without access change

TSM improvements are included in the proposed schematics with the inclusion of MaX lanes (include HOV/express), local intersection improvements, coordination with mass transit agencies, and Intelligent Transportation System (ITS) infrastructure. TSM improvements alone are not sufficient in addressing deficiencies in freeway mainlane operations, corridor capacity, and interchange design.

Policy Point 3 – An operational and safety analysis concluded the proposed change does not have significant adverse impact on safety and operations of the Interstate facility or on the local street network.

An operational and predictive safety analysis were completed with Vissim microsimulation and FHWA's Interactive Highway Safety Design Manual (IHSDM), respectively. The proposed Build alternative operational and safety results were compared to the No-Build alternative. In areas where predictive safety analysis could not be applied, a discussion of safety improvements that address deficiencies is included. Figure ES-1 shows the expected network operational improvement by reduction in total hours of delay.

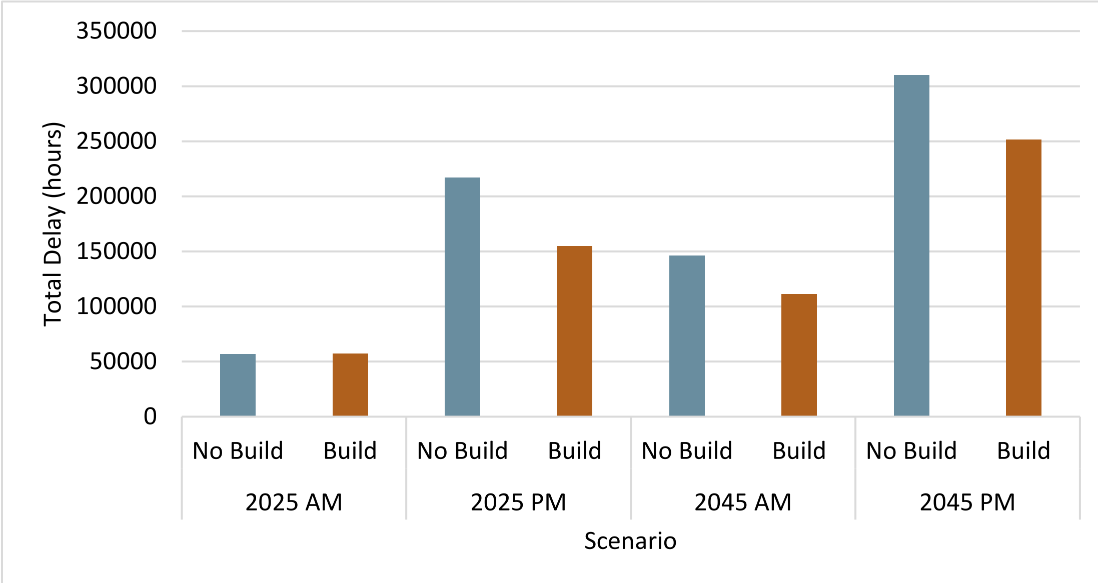


Figure ES-1: Total Delay No-Build vs. Build

Table ES-1 below summarizes the local network performance between No-Build and Build scenarios. The summary identifies intersections with greater than 55 seconds of delay because that is generally a threshold that signalized intersections exhibit slowdowns with turning vehicles requiring multiple signal cycles. Local network improvements include addition of turn bays, capacity, lane reassignment, and signal re-timings.

Table ES-1: Local Network Performance between No-Build and Build

Scenario	Number of Intersections with >55 sec/veh Average Vehicle Dealy	
	No-Build	Build
2025 AM	2	0
2025 PM	9	11
2045 AM	5	6
2045 PM	15	12

The intersection results show that the overall local network does not remove all slowdowns on the local network but also does not adversely impact operations. The Build has a similar number of intersections with greater than 55 seconds of vehicle delay. The intersections with high amount of delay were optimized to address safety and operations and are discussed in detail in Section 5.3.2. The Build network also showed improvement from the No-Build in average speed, VMT, and latent demand, which are include in Section 5.3.2 of this report.

The FHWA software, Interactive Highway Safety Design Model (IHSDM), was used for a future year safety comparison between the No-Build and Build conditions in the 2045 design year. IHSDM uses geometric and volume data to apply Highway Safety Manual Part C methodologies to predict safety outcomes including number of crashes and crash rates. The predicted crash reduction of each freeway corridor in the project area from the IHSDM software is shown in **Table ES-2** below. Note that the analysis only included the mainlanes and there are limitations in this software. The analysis length and AADT are important factors in determining expected crashes and the mainlane AADT decreased from the No-Build to the Build due to ramp reconfiguration, collector-distributor systems, and the proposed MaX lanes.

Table ES-2: Predicted Percent Reduction from No-Build to Build (2045)

	I-10	SH 288	I-45	I-69	I-610
Mainlane AADT (vpd)	20%	33%	7%	8%	22%
Effective Length (mi)	4%	21%	-8%	-9%	-3%
Predicted Crash Reduction					
Total Crashes	52%	22%	30%	28%	40%
Fatal and Injury Crashes	48%	20%	28%	22%	36%
Property-Damage Only Crashes	54%	23%	31%	31%	42%
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)					
Total Travel (100 million veh-mi)	26%	6%	4%	4%	16%
Travel Crash Rate	33%	60%	29%	29%	29%
Travel Fatal and Injury Crash Rate	30%	62%	29%	29%	30%
Travel Property-Damage Only Crash Rate	35%	59%	29%	28%	28%

As shown, the Build shows high expected safety improvement with improved lane balance, auxiliary lanes, reduction in weave sections, and improved alignment. Although the AADT reduced due to ramp reconfigurations and MaX lane additions, the crash rates show a more significant reduction than the AADT change that can be attributed to improved lane balance, design curves, and ramp configurations. There are also applicable crash modification factors associated with these improvements discussed in Section 5.4.1 of this report. Each segment of the project has a detailed discussion of safety issues in the area and the Build improvements to address those issues.

Areas where proposed improvements impact local access to and from the interstate facilities are discussed in Section 5.3.2.4. The local intersections have various improvements proposed to address safety and operations on the local network.

Policy Point 4 – The proposed access connects to a public road and will provide for all traffic movements.

At most locations, the proposed access provides for all movements and only connects to public roadways. Section 5.3.2.4 details the specific changes in access in the study area. A summary of all freeway to freeway interchange movements is shown in **Table ES-3** with the proposed design.

Table ES-3: Freeway to Freeway Interchange Movements

Freeway to Freeway Interchange	No-Build Movements	Build Movements
I-45 at I-610 – Segment 2	Full Interchange - All eight major freeway to freeway movements provided	Full Interchange - All eight major freeway to freeway movements provided
I-45 at I-10 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Partial Interchange – I-10 WB to I-45 SB and I-45 NB to I-10 EB/WB adjusted access to consolidate movements through I-69.
I-45 at I-69 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Partial Interchange – I-69 SB to I-45 NB and I-45 SB to I-69 NB adjusted access to consolidate movements through I-10.
I-69 at I-10 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Full Interchange - All eight major freeway to freeway movements provided
I-69 at SH 288 – Segment 3	Five major freeway to freeway movements provided	Five major freeway to freeway movements provided
I-69 at Spur 527 – Segment 3	Two major freeway to freeway movements provided	Two major freeway to freeway movements provided

As shown, the proposed Build has two Interstate freeway to freeway interchanges that are defined as partial interchanges. The I-45 at I-10 interchange is defined as partial because two movements from interstate to interstate are not direct. They include:

- **I-10 WB to I-45 SB** – This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-10 WB to I-69 SB, followed by a slip ramp to I-45 SB. Vehicles making this route movement would not have to change lanes between the route from I-10 WB to I-45 SB. The Build operations were reviewed in detail and show improved results from the No-Build I-10 WB to I-45 SB movement.
- **I-45 Northbound to I-10 Eastbound** - This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-45 NB to I-69 NB, followed by a direct connector from I-69 NB to I-10 EB. Once on I-69, vehicles making this route movement would not have to change lanes to continue onto the I-69 NB to I-10 EB direct

connector. The Build operations were reviewed in detail and show improved results from the No-Build I-45 NB to I-10 EB movement.

The I-45 at I-69 interchange is defined as partial because two movements from interstate to interstate are not direct. They include:

- **I-69 SB to I-45 NB** – This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-69 SB to I-10 WB, followed by a slip ramp to I-45 NB. Vehicles making this route movement would have to change four lanes over a 1.3-mile section. The traffic demand for this movement was evaluated in the microsimulation model and showed no operational issues.
- **I-45 SB to I-69 NB** - This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-45 SB to I-10 EB, followed by a direct connector to I-69 NB. Vehicles making this route movement would have to change two lanes over a 1.3-mile section. The traffic demand for this movement was evaluated in the microsimulation model and showed no operational issues.

More detailed discussion of the I-45 at I-69 and I-45 at I-10 partial interchanges are provided in Section 5.3.2.4. The partial interchanges are expected to improve operations and safety with travel time improvements and reducing conflict points that were safety issues in the Existing/No-Build condition.

In addition, Spur 527 begins at I-69, with the direct movements maintained between the Existing/No-Build and the proposed Build schematic. SH 288 ends at I-69, with five movements provided in the existing/No-Build condition, maintained in the proposed Build schematic.

All 34 urban interchanges to cross streets in the project area connect to public roads and provide for all traffic movements. Routes to and from Interstates to cross streets and local roads are impacted, but all impacted intersections were analyzed for appropriate local street improvements in safety and operations to address any access point changes.

Policy Point 5 – The proposed improvements are consistent with local and regional land use and transportation plans

The proposed improvements are in the City of Houston's Major Thoroughfare and Freeway Plan (MTFP) and the Houston-Galveston Area Council's (H-GAC) 2040 and 2045 Regional Transportation Plans. All improvements were coordinated with local and regional agencies.

Policy Point 6 – A comprehensive corridor or network study accompanies all requests for new or revised access.

Due to the urban environment of the project area, new interchanges are minimal in the project area. The extension of the Hardy Toll Road to the project area is the only anticipated new interchange as a background project and was included in all scenario analysis. This extension is expected to relieve traffic demand on the adjacent I-45 and I-69 freeway facilities.

Policy Point 7 – Request demonstrates appropriate coordination has occurred between the development and any proposed transportation system improvements.

Public meetings have been held since 2011. There have been four (4) public meetings with documentation of comments and responses to comments. There was also a public hearing in May 2017, following the release of the draft Environmental Impact Statement (DEIS). There has been continuous coordination between H-GAC, City of Houston, Harris County Toll Road Authority (HCTRA), among other impacted entities.

Policy Point 8 – The proposal includes supporting information and status of the environmental processing.

The DEIS was submitted in April 2017 and the Final Environmental Impact Statement (FEIS) was submitted in 2020. The Record of Decision (ROD) is expected in early 2021.

1.0 Introduction

1.1 *Project Background & Location*

Interstate 45 (I-45) is an interstate highway located entirely within the U.S. state of Texas. It connects the cities of Dallas and Houston, continuing southeast from Houston to Galveston over the Galveston Causeway to the Gulf of Mexico. As one of the key regional and inter-regional connections, I-45 is a critical national freight corridor and serves as an evacuation route during emergency events for the Houston-Galveston area in Harris County. According to the Houston-Galveston Area Council (H-GAC), the area metropolitan planning organization (MPO), the Houston-Galveston region is expected to increase by an estimated 3.7 million people, or 64 percent, between the years 2010 and 2040. As of the 2010 Census, the population was 4,092,459, making Harris County the most populous county in Texas and the third most populous county in the United States. Its county seat is Houston, the largest city in Texas and fourth largest city in the United States.

In order to meet the significant growth expected, the Texas Department of Transportation (TxDOT) has identified approximately 24 miles of roadway improvements, primarily along I-45 extending from Beltway 8 to SH 288 in Harris County. These improvements, known as the I-45 North Houston Highway Improvement Project (NHHIP), includes major proposed improvements to address the current and future transportation needs on I-45, US 59/I-69, I-610, and I-10. Within the project area, I-45 provides connection between North and Downtown Houston. The project includes roadway improvements to add four managed high occupancy vehicle/express (MaX) lanes to Interstate I-45 at specific segments along the project limits and reroute I-45 through downtown Houston between the existing I-45 and I-10 interchange and the existing I-45 and I-69 interchange. MaX lanes are managed lanes which use a mix of vehicle occupancy requirements and other restrictions to move the most people possible at a satisfactory speed. The project also includes roadway improvements to realign portions of I-45, I-10, and US 59/I-69 in the Downtown area to eliminate the current roadway curvature and transition the proposed roadway improvements to the interchange of US 59/I-69 and Spur 527 south of Downtown Houston. I-45 is proposed to be realigned to follow the I-10 and US 59/I-69 alignments through the downtown area. This updates roadway curvature and reduces conflict points with major traffic movements. In short, the project includes reconstruction of mainlanes and frontage roads, the addition of bicycle/pedestrian features along frontage roads, and the addition of MaX lanes on I-10 from I-45 to US 59/I-69.

The purpose of these improvements is to create additional roadway capacity to manage congestion, enhance safety, and improve mobility and operational efficiency within the project area. To facilitate in the design and analysis of alternatives, the project area was divided into three segments. **Figure 1** shows the project area map. Segment 1 extends nine (9) miles along I-45 from Beltway 8 to I-610. Segment 2 continues for three (3) miles along I-45 from I-610 to I-10. Segment 3 extends for 12.3 miles and is comprised of the Downtown Loop System which includes I-45, US 59/I-69, SH 288, I-610, and I-10. Altogether the project spans approximately 24.3 miles.

This report addresses interstate access changes in Segment 2 and Segment 3, which is approximately 15.3 miles and includes six (6) freeway to freeway interchanges. Additional details about each system to system interchange is provided in Section 3.5 of this report.

1. I-45 at I-610 – Segment 2
2. I-45 at I-10 – Segment 3
3. I-45 at I-69 – Segment 3
4. I-69 at I-10 – Segment 3
5. I-69 at SH 288 – Segment 3
6. I-69 at Spur 527 – Segment 3

Additionally, this report provides discussion of the local 34 urban interchanges, located at all major cross streets that provide access to and from Interstate freeways. These intersections were analyzed using Vissim microsimulation. These intersections are listed in section 3.5 of the report.

Segment 2 and Segment 3 have obtained some level of funding, while Segment 1 has not. Segment 1 will be the focus of a separate Interstate Access Justification Report (IAJR) upon receiving partial or full funding. **Figure 1** shows the I-45 NHHIP limits (project study area) and the IAJR limits included in this report. There is a transition from Segment 2 back to existing at the north end of the project. Details on the transition to existing are included in Section 5.3.2.4.

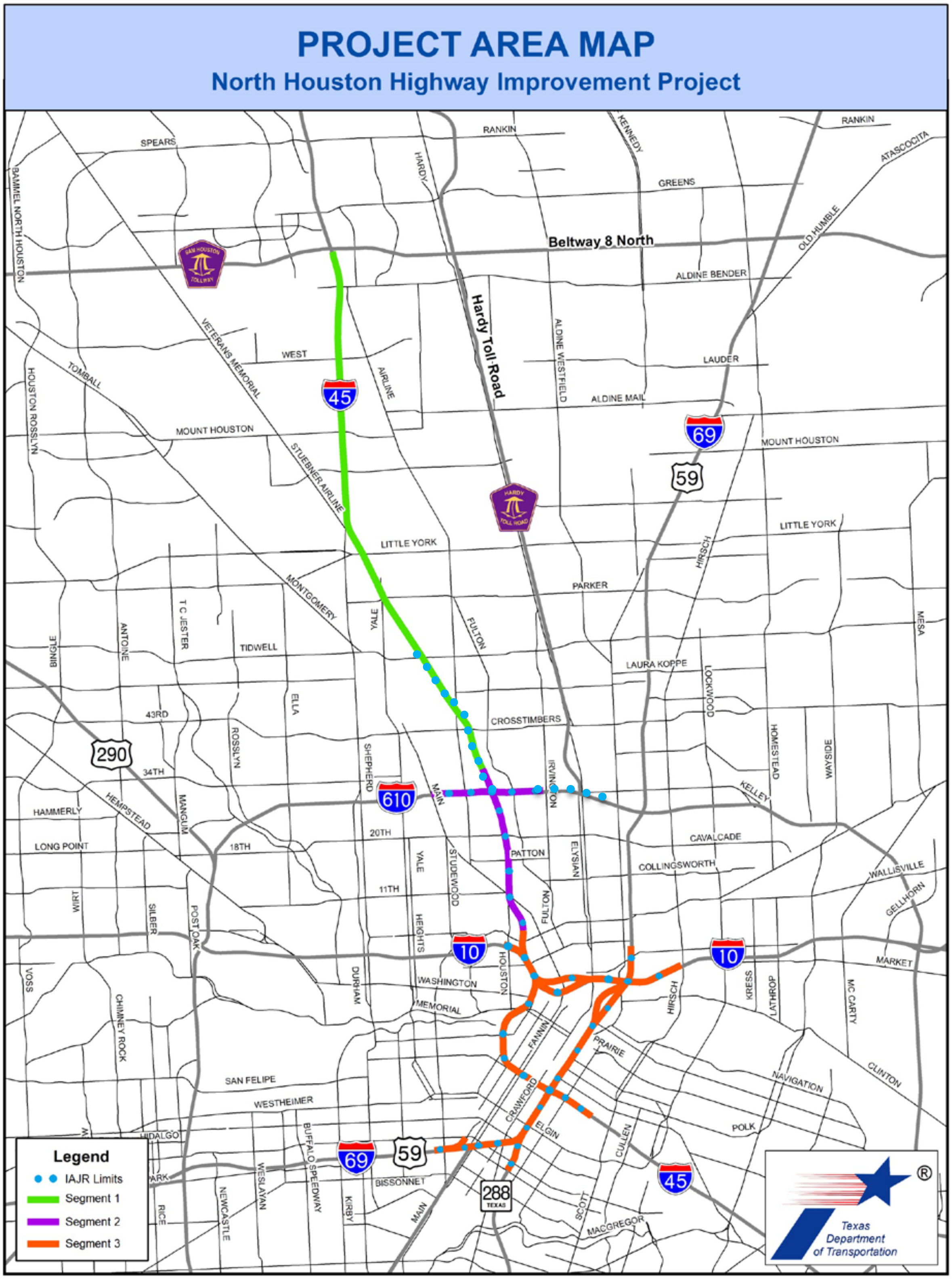
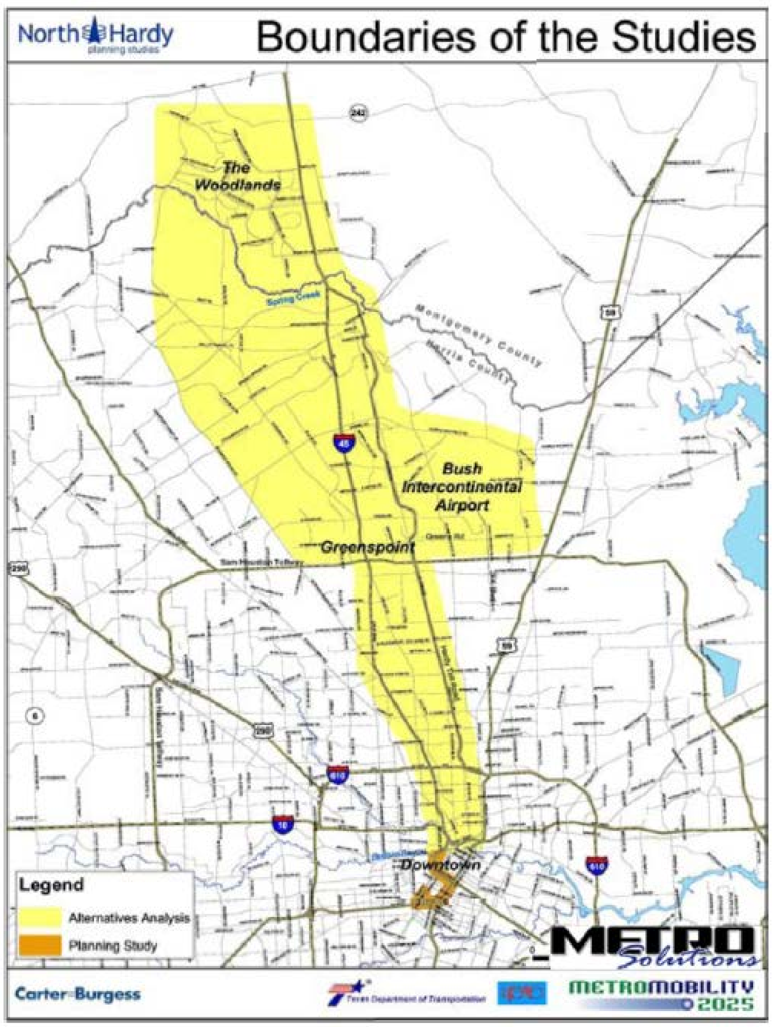


Figure 1: Project Study Area & IAJR Limits

1.2 *Previous Studies*

Previously, the Metropolitan Transit Authority of Harris County (METRO), TxDOT, and H-GAC conducted a series of planning studies to identify and address transportation needs in an area identified as the North-Hardy Corridor. The North-Hardy Corridor extended approximately 30 miles, beginning south of Downtown Houston, in Harris County, Texas, to State Highway (SH) 242 near the Woodlands in Montgomery County, Texas. North of Beltway 8 North, the corridor encompassed Hardy Toll Road and area west of I-45. A portion of the corridor extended east of Hardy Toll Road to include George Bush Intercontinental Airport. South of Beltway 8 North, the corridor generally encompassed the area between I-45 and Hardy Toll Road and included segments of United States Highway (US) 59/I-69 south of Downtown Houston. **Figure 2** shows the project area boundary for the North-Hardy Corridor alternatives analysis.



Source: METRO et al. 2005

Figure 2: Study Area for North-Hardy Planning Studies

These studies evaluated transit and highway improvement alternatives for the North-Hardy Corridor. Three reports were prepared, beginning with the North-Hardy Corridor Alternatives Analysis Report, which was completed in 2003. Two subsequent reports completed in 2004 and 2005 documented the transit component and highway component, respectively, of the Alternatives Analysis Report. The reports are described below.

1.2.1 2003 North-Hardy Corridor Alternatives Analysis Report

The 2003 North-Hardy Corridor Alternatives Analysis report initially evaluated transit and highway alternatives in the corridor. Additionally, it recommended that transit alternatives be examined prior to detailed evaluation of highway alternatives. The alternatives analysis determined that even with parallel high-capacity transit and the extension of Hardy Toll Road to Downtown Houston, additional capacity would be needed on I-45. The alternatives analysis also concluded that, at a minimum, two-way high occupancy vehicle (HOV) service would be needed in the corridor. The preferred highway alternative from the 2003 study proposed a total of 12 lanes on I-45 from I-10 to Beltway 8 North (eight general purpose lanes and four managed lanes) and 12 lanes on I-45 from Beltway 8 North to FM 1960 (10 general purpose lanes and two HOV/high occupancy toll [HOT] lanes).

This study recommended both adding capacity to general purpose lanes and adding managed lanes. General purpose lanes which are lanes on a highway that are open to all motor vehicles. Managed lanes are a set of lanes or highway facilities where operational strategies are proactively implemented and managed in response to changing conditions. Types of managed lanes include: HOV lanes, value priced lanes (including HOT lanes), and exclusive or special use lanes (such as express, bus-only, or truck-only lanes). Managed lanes are also called managed express (MaX) lanes. The primary goal of the MaX lanes are to move the maximum number of people at maximum speed, and to integrate the use of both HOV lanes and single occupancy vehicle (SOV) lanes.

1.2.2 2004 North-Hardy Corridor Planning Studies, Alternatives Analysis Report (Transit Component)

Findings from the Transit Component report were used to develop a regional Transit System Plan that combines an aggressive bus service program with Advanced High Capacity Transit (light rail). Since the study, METRO has constructed 5.2 miles of the North Corridor Light Rail Transit (LRT) project from the existing University of Houston-Downtown station in the Houston central business district (CBD) to the Northline Mall Transit Center and plans to extend the North LRT to George Bush Intercontinental Airport.

1.2.3 2005 North-Hardy Planning Studies, Alternatives Analysis Report (Highway Component)

This report examined highway alternatives within the North-Hardy Corridor. The Recommended Highway Alternative from Downtown Houston to Beltway 8 North was to add four managed lanes to the I-45/Hardy Toll Road corridor.

1.3 *Purpose*

The purpose of the proposed I-45 NHHIP is to implement an integrated system of transportation improvements with the goal of providing facilities with additional capacity to accommodate projected travel demand by incorporating transit opportunities, travel demand and management strategies, and flexible operations. Such a facility would help manage congestion, improve mobility, enhance safety, and provide travelers with options to reach their destinations.

In 2019, TxDOT released its list of Top 100 congested roadways in Texas, which is developed in coordination with the Texas Transportation Institute (TTI). **Table 1** shows lists the roadways on the Top 100 list that overlap with any portion of the proposed I-45 NHHIP.

Table 1: NHHIP Segments in TxDOT's 100 Most Congested Roadways

Rank	Roadway	From	To	Delay/Mile	Annual Congestion Cost ($Million)
3	I-69	I-610	SH 288	1,094,921	$121.9
4	I-69	SH 288	I-10	961,140	$62.6
6	I-45	I-10	I-610	770,136	$132.8
11	I-610	I-10 West	I-45	605,689	$80.2
12	I-45	Beltway 8	I-610	578,657	$112.3
13	I-10	I-45	I-69	543,269	$19.3
17	I-45	I-610	I-10	483,306	$31.2
18	I-10	I-610	I-45	466,866	$56.6
19	SH 288	I-45	I-610	459,154	$47.0
51	I-610	I-45	I-10 East	240,912	$42.8
58	I-10	I-69	I-610	221,268	$23.7
				Total	**$730.4**

As illustrated, nine segments of roadway fall within the Top 20 of the Top 100 list. The total annual cost of congestion[1] for these segments is over half a billion dollars, as seen in **Table 1**. The methods used to calculate these costs are included in the footnote below. This cost is expected to increase with urban growth and increases in traffic demand.

The American Association of State Highway and Transportation Officials (AASHTO) Interstate Access Guide designates the minimum spacing for urban interchanges as one (1) mile. System interchanges include direct connectors for continuous flow access to and from freeway segments and should be spaced further than the minimum spacing requirement. An urban interchange is defined as a road

[1] "Analysis Procedures and Mobility Performance Measures" https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2019-6.pdf

junction using grade separation with one or more ramps to permit traffic on at least one highway to pass through the junction without directly crossing any other traffic stream. There are several grade-separated cross streets in the area, however only select cross-streets have one or more ramp access points adjacent to the freeway. Operational deficiencies have been identified and often occur due to interchange and ramp spacing associated with diamond ramp configurations. This can result in frontage road traffic (local trips) backing up into the mainlanes, impacting regional traffic. The interchange spacing and associated compliancy with AASHTO standards for I-45, I-610, I-10, and US 59/I-69 are summarized in **Tables 2-5**, respectively.

Table 2: I-45 Current Interchange Spacing

From Interchange	To Interchange	Distance (miles)	Meets Current Spacing Requirements
Tidwell Rd	Airline Dr	1.0	Yes
Airline Dr	Crosstimbers St	0.4	No
Crosstimbers St	I-610	1.1	Yes
I-610	Cavalcade St	0.7	No
Cavalcade St	Patton St	0.4	No
Patton St	Main St	0.6	No
Main St	Quitman St	0.8	No
Quitman St	I-10	0.5	No
I-10	Allen Pkwy	1.1	Yes
Allen Pkwy	Brazos St	0.5	No
Brazos St	US 59/I-69	0.9	No
US 59/I-69	Dowling St (Emancipation Ave)	0.3	No
Dowling St (Emancipation Ave)	Scott St	0.8	No
Scott St	Cullen Blvd	0.4	No
Cullen Blvd	Lockwood Dr	0.4	No

Table 3: I-610 Current Interchange Spacing

From Interchange	To Interchange	Distance (miles)	Meets current spacing requirements
Main St	Airline Dr	0.6	No
Airline Dr	I-45	0.4	No
I-45	Irvington Blvd	0.9	No
Irvington Blvd	Hardy Toll Road	0.6	No

Table 4: I-10 Current Interchange Spacing

From Interchange	To Interchange	Distance (miles)	Meets current spacing requirements
Taylor St	I-45	1.1	Yes
I-45	San Jacinto St	0.8	No
San Jacinto St	McKee St	0.3	No
McKee St	US 59/I-69	0.6	No
US 59/I-69	Gregg St	0.4	No
Gregg St	Waco St	0.6	No
Waco St	Lockwood Dr	0.7	No

Table 5: I-69 Current Interchange Spacing

From Cross-street	To Cross-street	Distance (miles)	Meets current spacing requirements
Quitman Dr	Lyons Ave	0.6	No
Lyons Ave	I-10	0.4	No
I-10	Polk St	1.7	Yes
Polk St	I-45	0.4	No
I-45	McGowen St	0.3	No
McGowen St	Alabama St	0.6	No
Alabama St	San Jacinto St	0.6	No

The purpose of the proposed improvements is to decrease the levels of congestion, improve safety, and update geometric conditions to increase interchange and ramp spacing. These urban interchanges are located in developed areas with limitations on changes to geometry. Where feasible, (ex. at I-10 at San Jacinto Street), improvements were identified to improve spacing or manage access. The proposed removal of the I-45 Pierce Elevated section also addressed interchange spacing needs.

1.4 *Need*

The proposed transportation improvements are needed to address the following transportation issues in the I-45 NHHIP area (*source: NHHIP Draft Environmental Impact Statement*):

- Inadequate capacity for existing and future traffic demands.
- Average daily traffic volumes are projected to increase in the project area.

- The current single lane, reversible high-occupancy vehicle (HOV) lane along I-45 serves traffic in only one direction during peak periods.
- Evacuation effectiveness on I-45 during a hurricane or other regional emergency would be limited at its present capacity.
- Portions of I-45 do not meet current TxDOT design standards, creating a traffic safety concern. This includes inadequate weaving lengths at entrance and exit ramps, left-hand exit/entrances, and curved ramps. See Section 3.8 for further detail.
- Roadway design deficiencies include inadequate storm water drainage in some locations, potentially compromising the operational effectiveness of I-45 as an evacuation route because of high water lane closures.
- Forecasts for commuter service indicate that managed lanes would be needed on I-45 to support commuter traffic and express bus service.

1.5 *Area of Influence*

A diagrammatic representation of the project area of influence is provided in Figure 3. Due to the size of the project area, Figure 3 is shown in several pages. The figure provides the intersections included in the operational analysis and general layout of the roadway network.

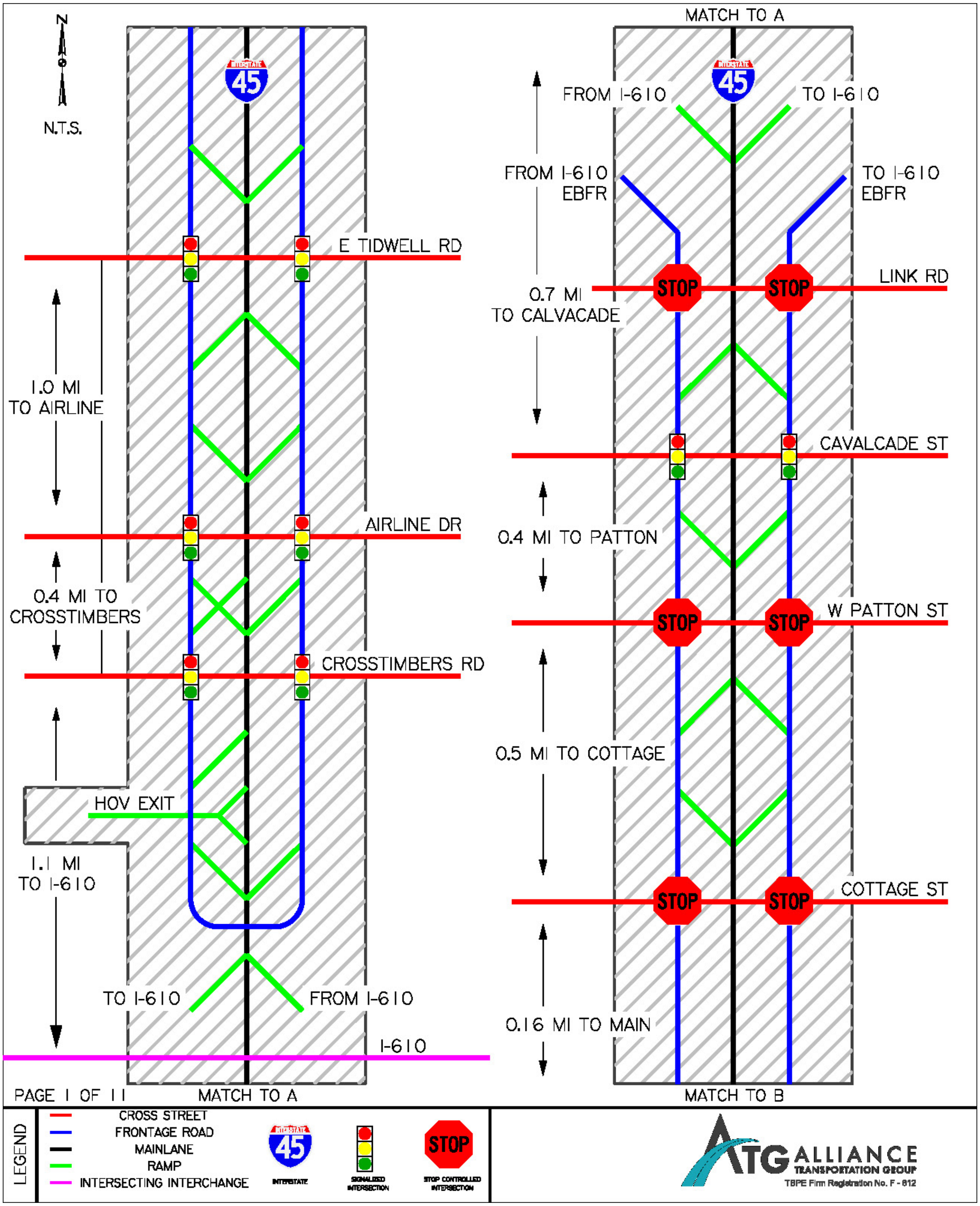
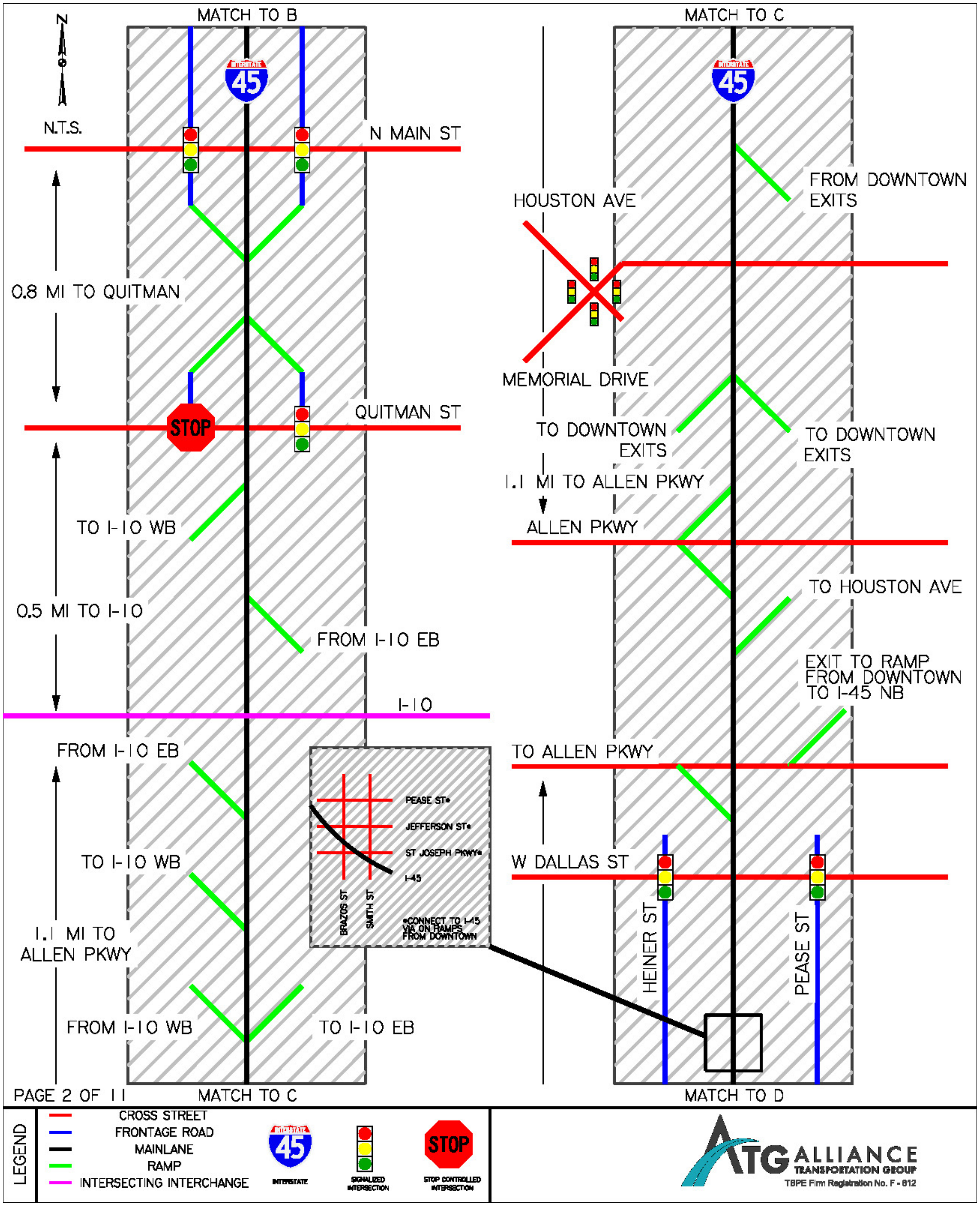


Figure 3: Existing Area of Influence



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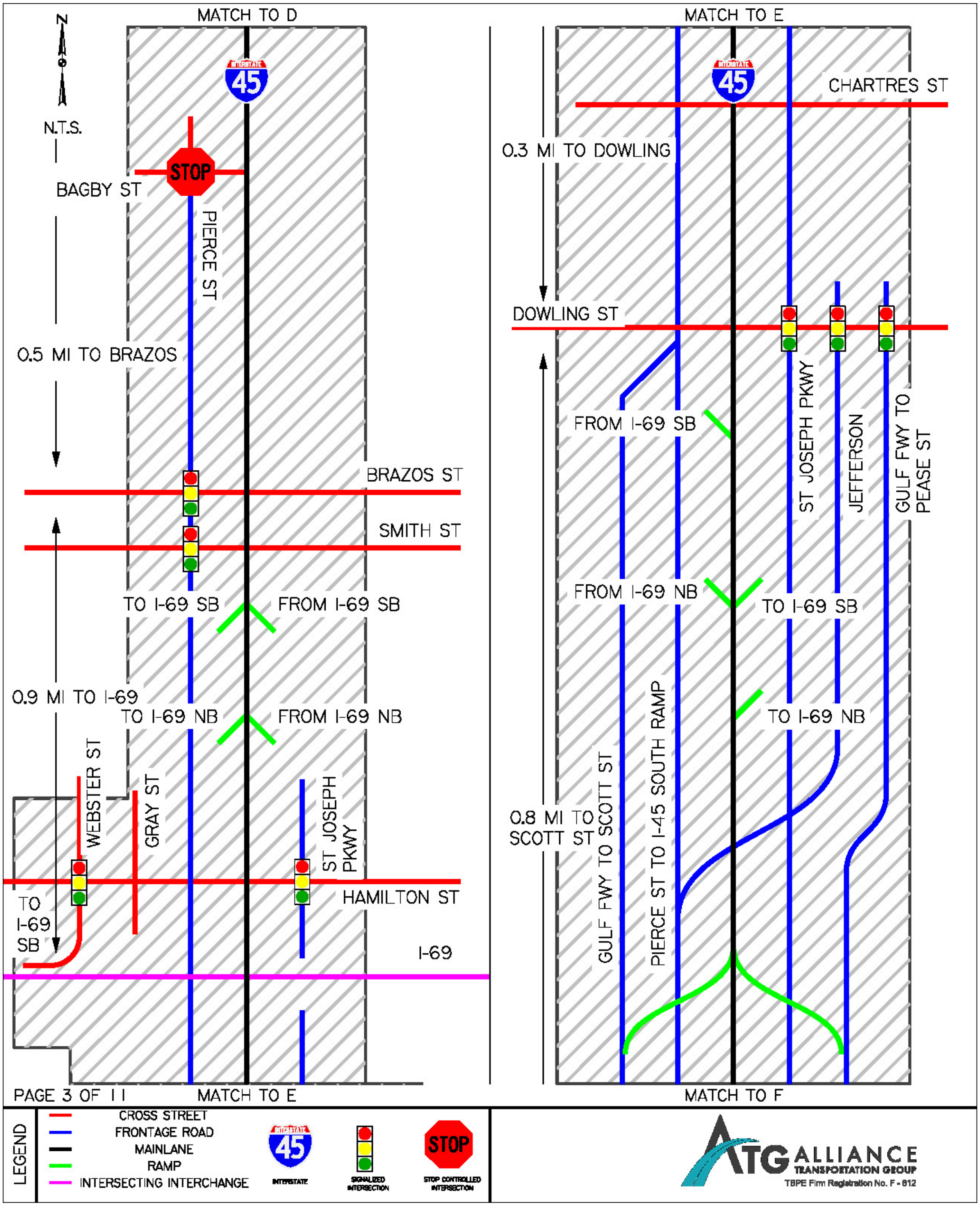

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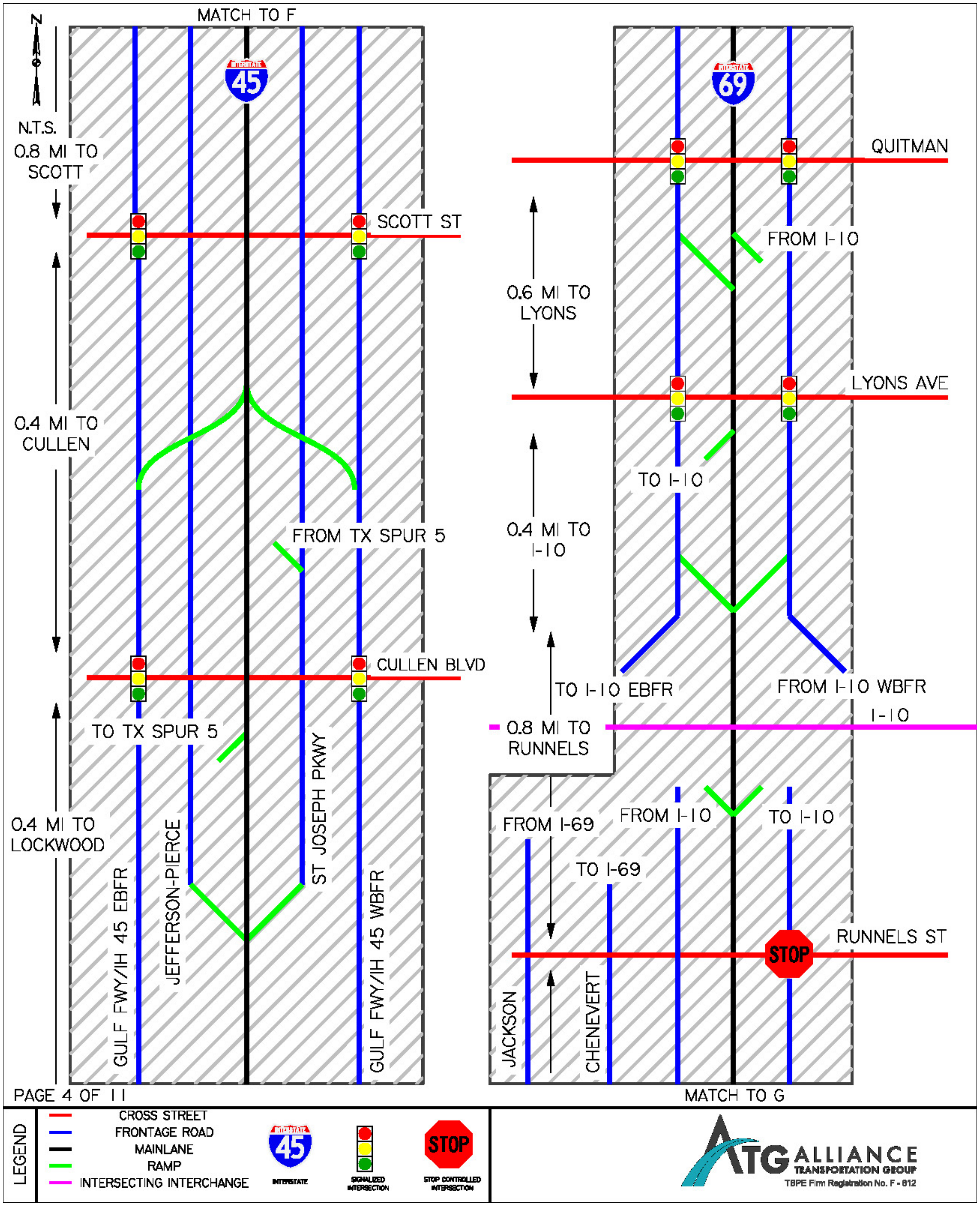

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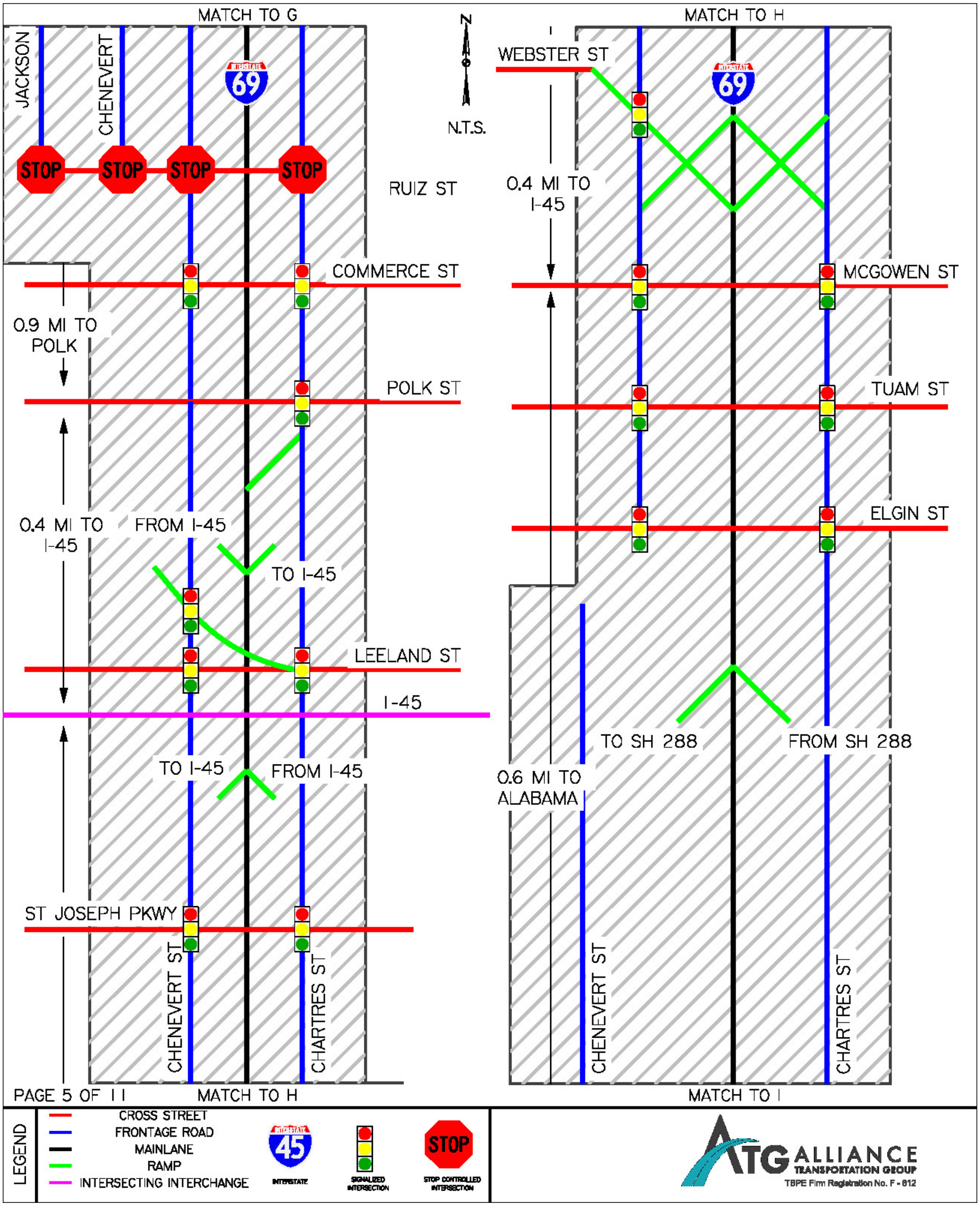

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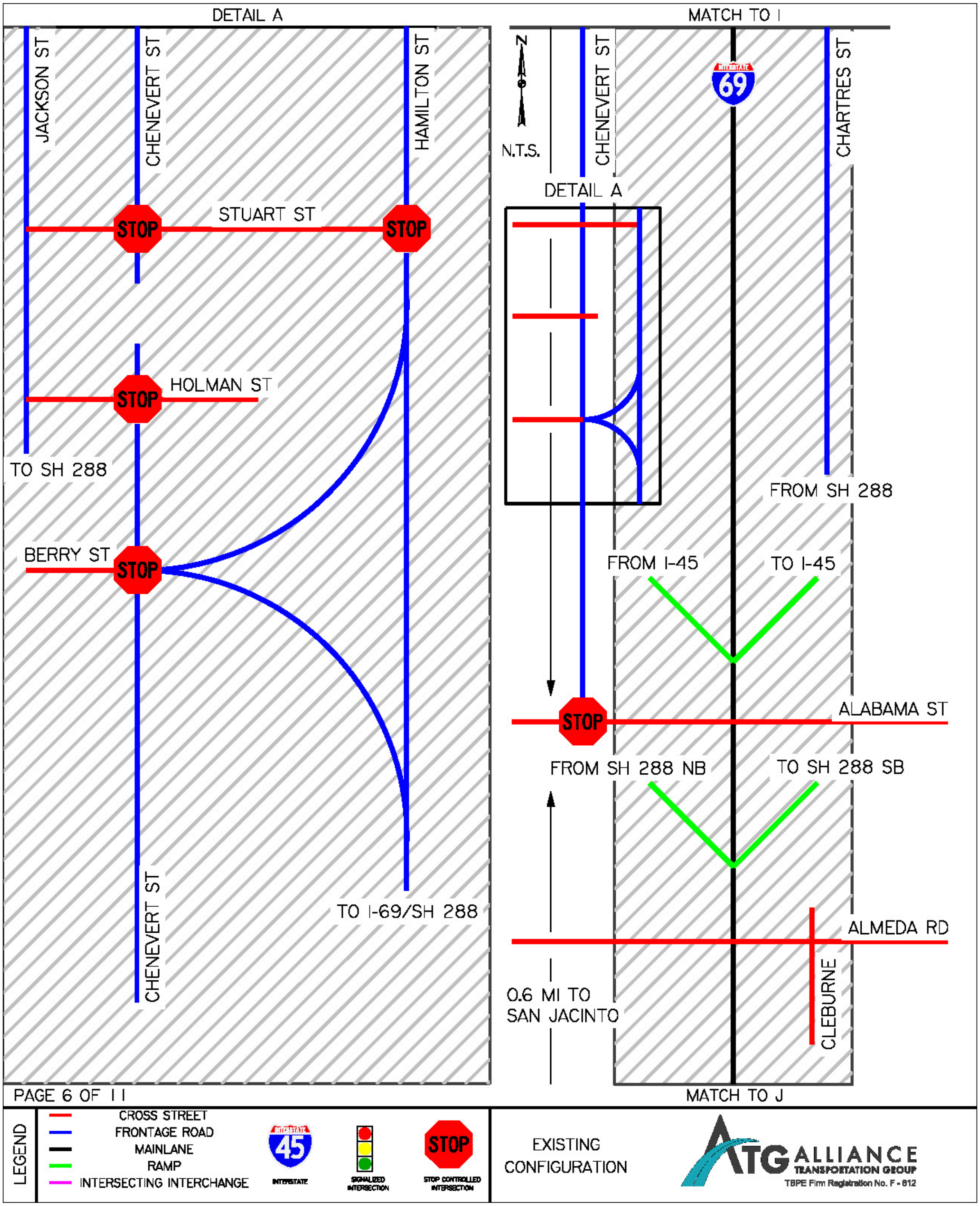

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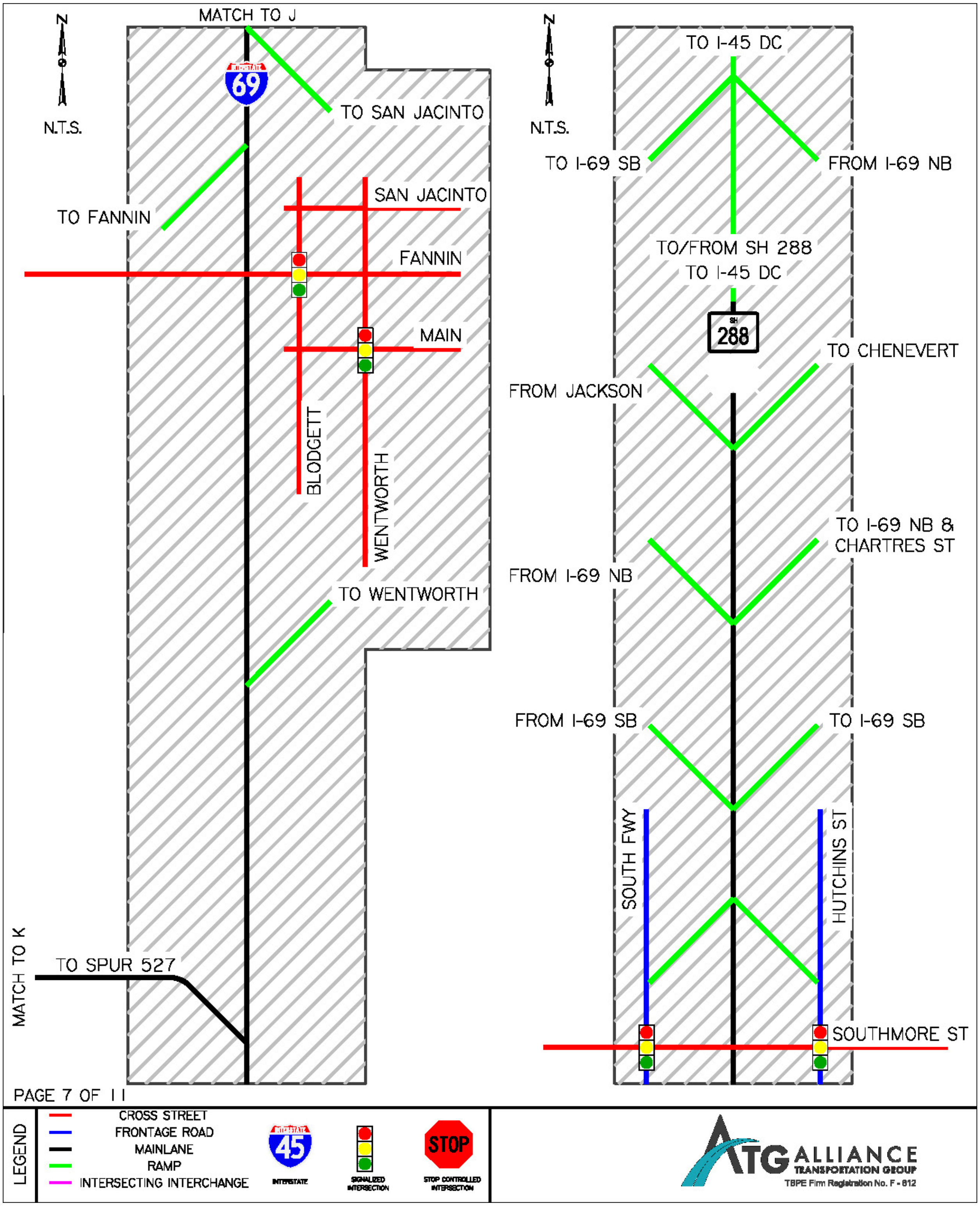

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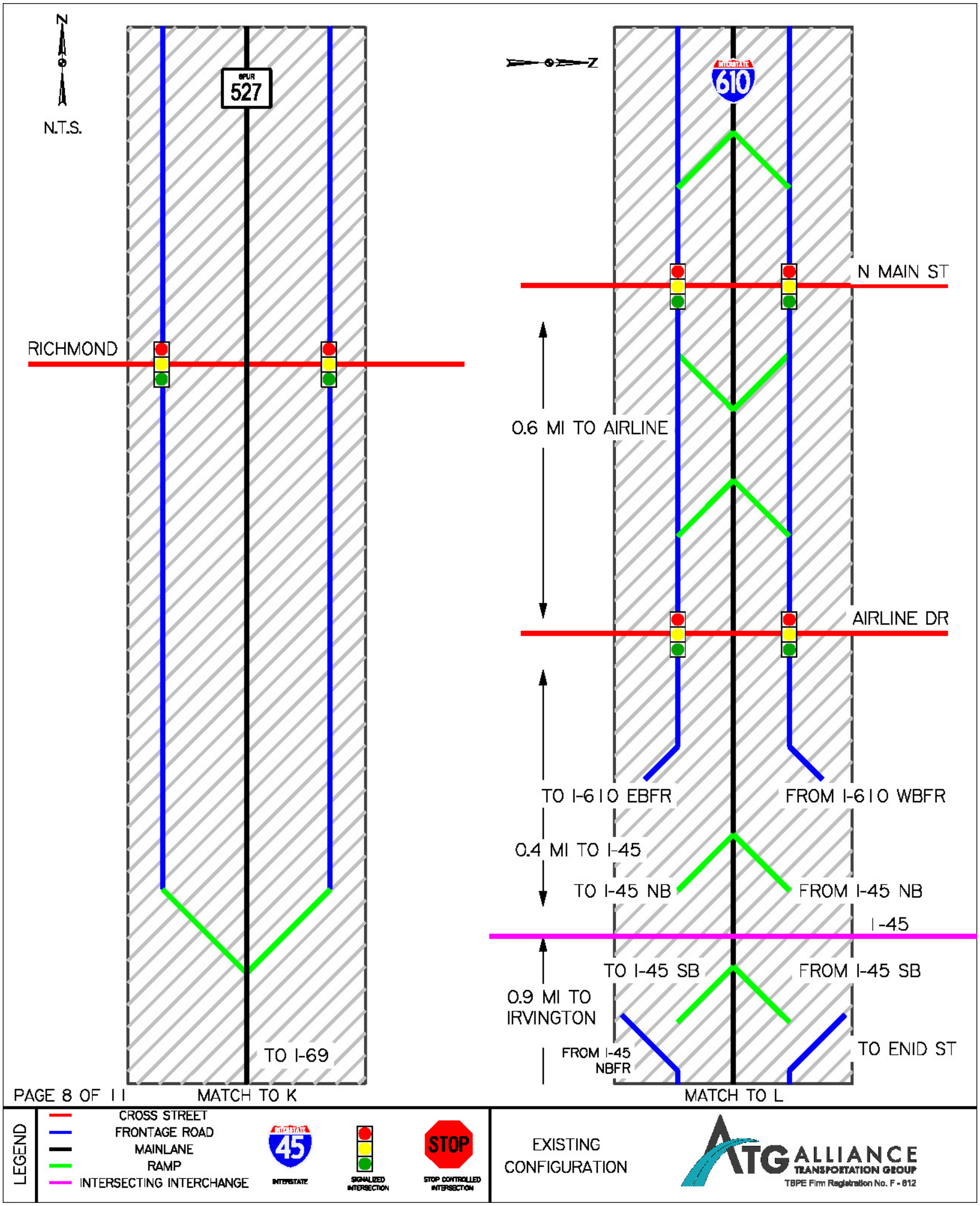

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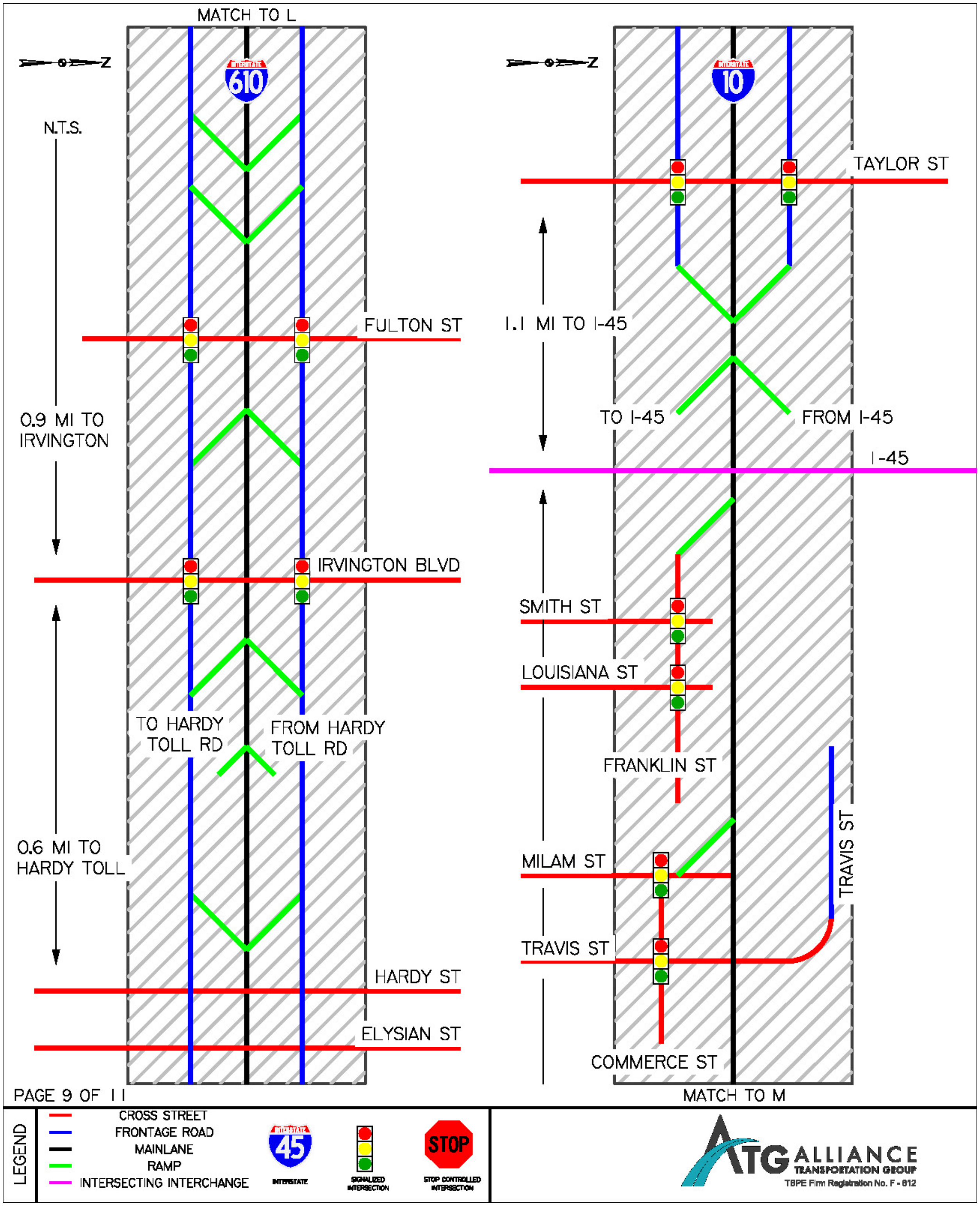

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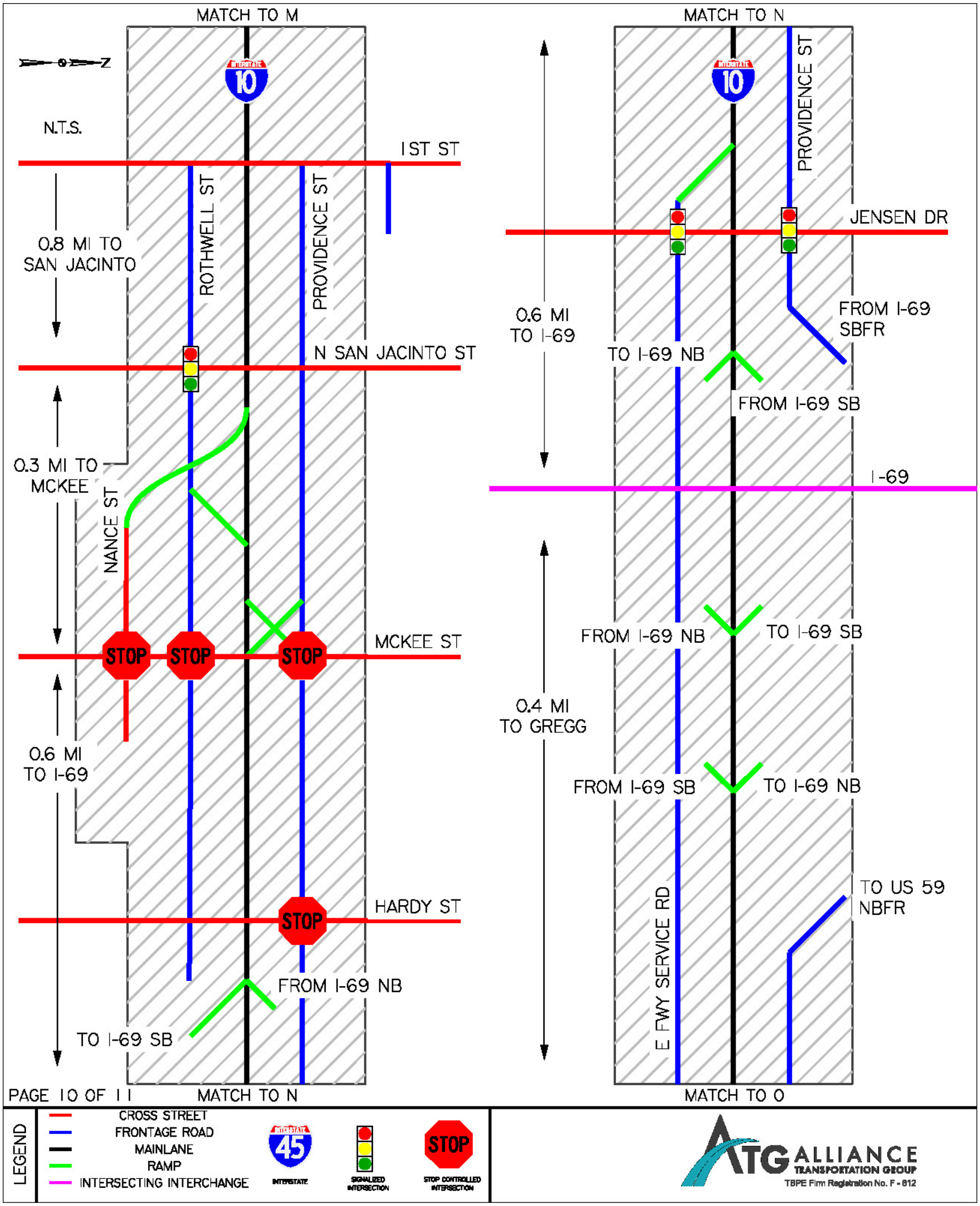

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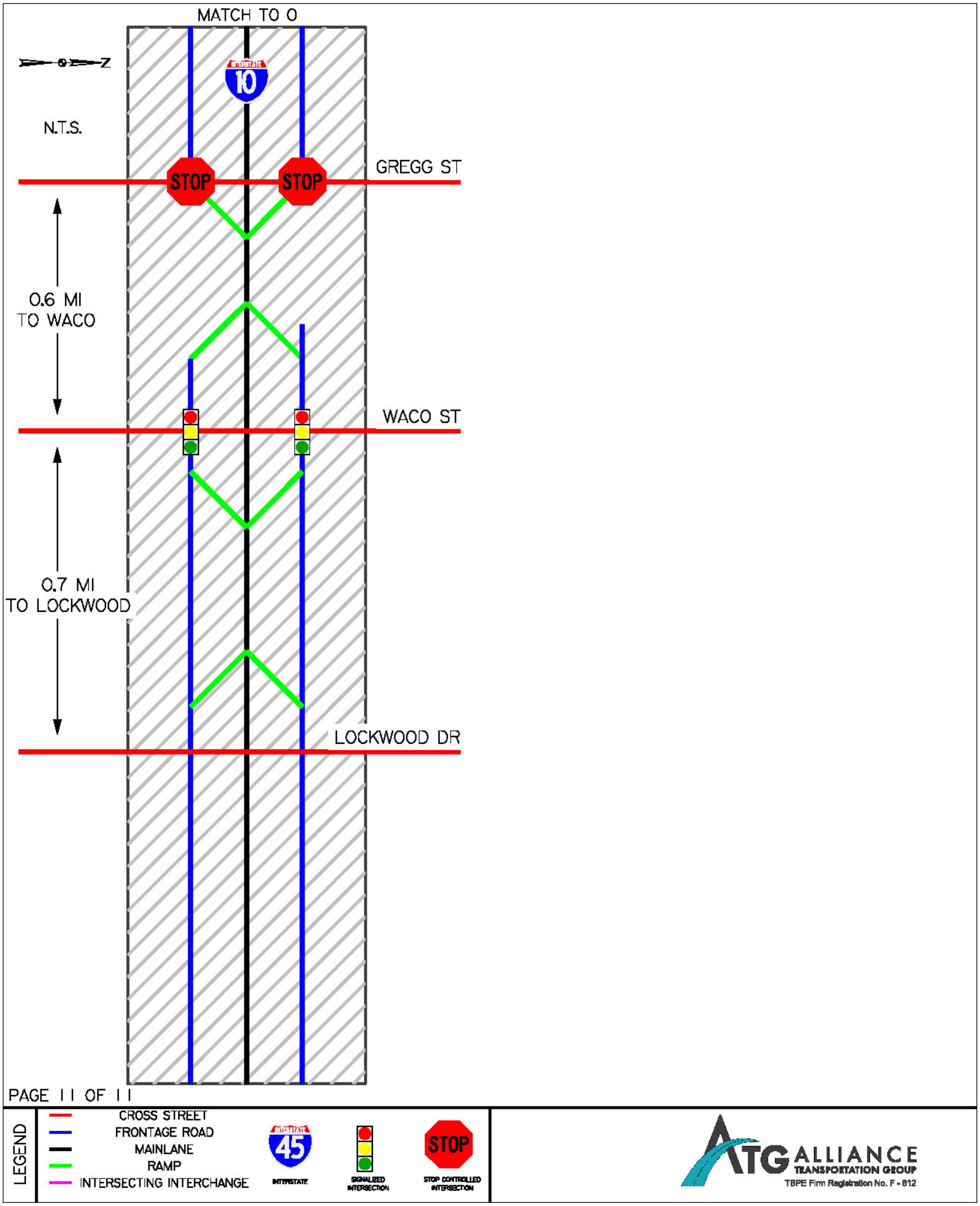

Figure 3: Existing Area of Influence

2.0 Methodology

Alliance Transportation Group, Inc. (Alliance) and HNTB met with TxDOT and the Federal Highway Administration (FHWA) on the following dates to discuss the methodology used to develop this IAJR.

- September 20, 2017
- June 19, 2018
- August 21, 2018
- December 17, 2018
- March 22, 2019

Several items were discussed, including, but not limited to, project schedule, type of software, data collection, periods of analysis, analysis years, traffic forecasting methods, calibration techniques, and alternative analysis. Meeting minutes from these discussions can be found in **Appendix A**. Alliance submitted the Methodology and Assumptions Memorandum (memo) for TxDOT and FHWA review as it is a working document intended to be commented on with refinement as the project progressed. The methods outlined in the memo are described in the sub sections below. A full version of the latest Methodology and Assumptions memo is included in **Appendix A**.

The methods and assumptions described below apply to the highway corridors along the I-45 NHHIP project area, including I-45, US 59/I-69, SH 288, I-610, Spur 527, and I-10.

2.1 *Project Schedule*

For the I-45 NHHIP, the draft environmental impact study (EIS) has been submitted and has received comments. The final EIS is being developed. One EIS is being completed for all segments. The Record of Decision (ROD) is expected in 2020. It is anticipated that the project will let starting in 2021.

A schedule and history of milestone review for the IAJR components to the study is listed in **Table 6** below. These milestone dates coincide with completion dates of the technical analysis components and have been updated based on agency comments. At each date, stakeholders met to discuss status and challenges encountered during the technical analysis.

Table 6: Milestone Review Dates

Milestone Review	Date
Review #1: Existing Conditions	June 2018
Review #2: Existing Calibration	August 2018
Review #3: Existing and Traffic Forecasts	December 2018
Review #4: Preferred Build and IAJR	April 2020

2.2 *Software*

Our team used multiple tools to perform the traffic operational analysis of the project area. Vissim (version 9.0-10) was used to evaluate network, freeway main lane, and intersection operations.

Synchro (version 10.0) was used to help develop signalized intersection timings to be incorporated into Vissim. The evaluation of the mainlane operations was completed in Vissim which included all roadway components (freeway mainlanes, ramps) within the project limits. CUBE (software produced by Citilabs) was used to review, verify, and update H-GAC model traffic forecasts. ArcGIS was utilized for analyzing crash data and creating visual maps. The project team used FHWA Interactive Highway Safety Design Model (IHSDM) version 14.1.0 (released March, 2019) for predictive analysis of crashes. Together, these tools were used to capture mainlane, ramp, and arterial operational and safety analysis necessary to assemble a complete alternative comparison.

2.3 *Data Collection*

Traffic counts and field observations were completed over two weeks on April 2018. These were completed during a typical week over three days. These counts supplemented the available 2015 base year data which was obtained at the beginning of project development. The following 2018 supplemental traffic counts, shown in **Figure 4**, were collected:

- 115, 24-hour tube counts at ramp locations
- 12, 24-hour mainlane counts
- 100, 3-hour AM and PM turning movement counts

Classification counts were collected at several 24-hour tube count locations to capture heavy vehicle percentages. Signal timings were obtained from TxDOT and City of Houston and coincide with the date counts were collected in the field.

Twenty-four hour tube counts were analyzed based on time of day in order to determine the level of congestion throughout the project area and capture traffic demand. Relatively uncongested areas were identified and used as a base point for volume balancing. Ramp volumes were smoothed from uncongested mainlane count locations to produce balanced volumes throughout the project area. This method helps mitigate the effect of congestion suppressing mainlane volumes due to decreased throughput. 2018 base year 15-minute variation was determined based on balanced demand in the project area. The 15-minute variation was used as the variation for 2025 opening year and 2045 design year model variation.

In addition, the daily variation of collected 24-hour tube counts was compared to TxDOT daily variation to ensure consistency and identify any necessary traffic volume adjustments. This was completed to help ensure that the collected data was representative of typical daily variation.

Existing and future land use and traffic information previously generated by the regional model were obtained from H-GAC. Geometric and traffic control information was obtained by the project team through field observations and from coordination with local agencies. H-GAC and TxDOT data was used in conjunction with collected data for determining future heavy vehicle percentages. Travel time and speed data from TranStar was collected in order to be used for existing Vissim calibration.

The 2018 collected traffic data was used to verify the base Travel Demand Model (TDM). Traffic volumes were compared to ensure relative consistency between data collected and TDM outputs. Any changes to the base TDM model were applied to future year TDM models, as applicable. This is explained in further detail in the sections below.

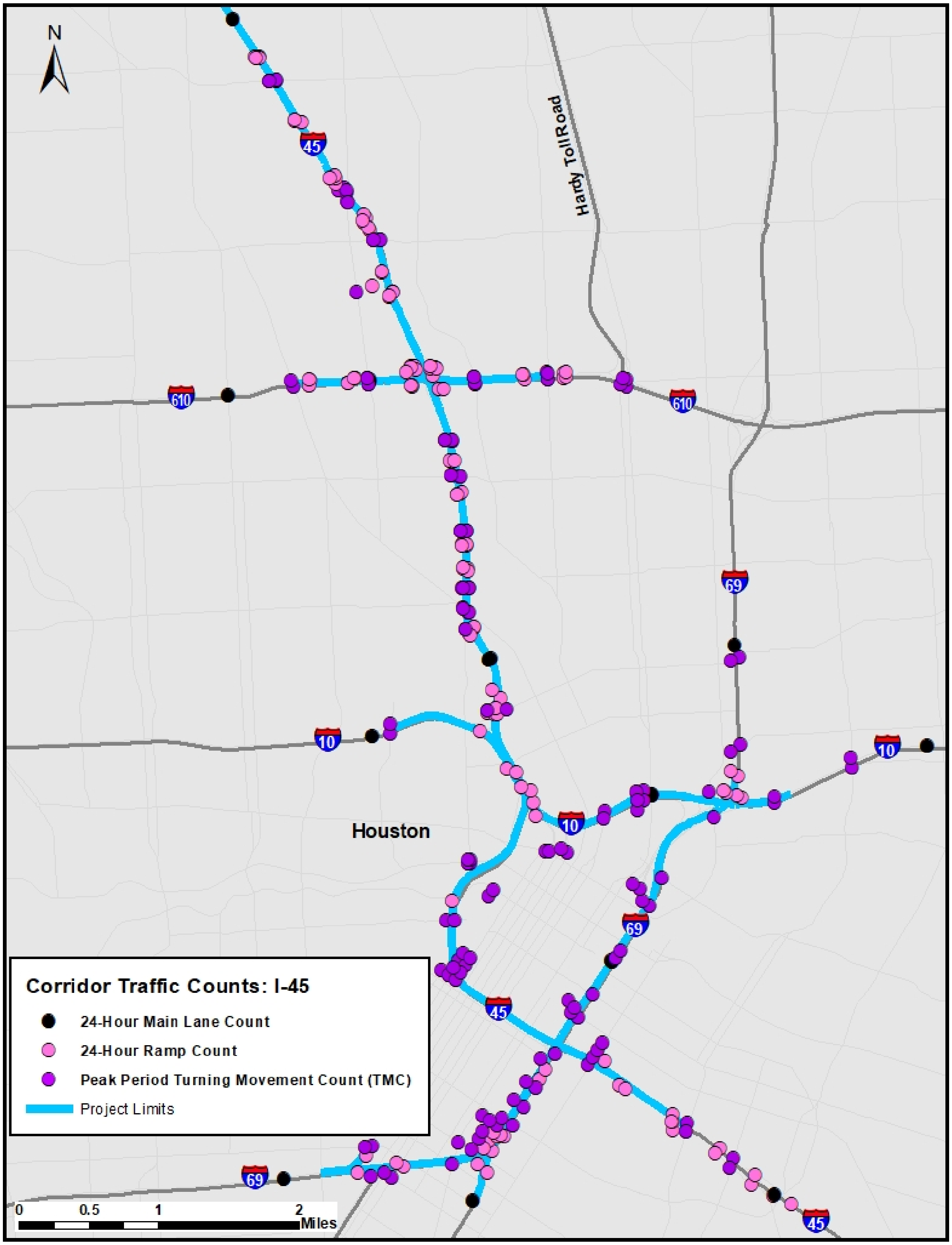

Figure 4: Traffic Count Locations

2.4 *Periods of Analysis*

At the beginning of project development, available 2016 TranStar travel time data from 5:00 AM to 7:00 PM was processed for three segments of I-45 and I-69/US 59, which contained the project area and extended slightly beyond the limits, to determine peak periods. The project scoping and development began in 2016, therefore, that was the latest data available at project onset. From the travel time data, average speed was calculated in a 24-hour period. **Figure 5** illustrates speed changes and average speed in the 24-hour period for the project area.

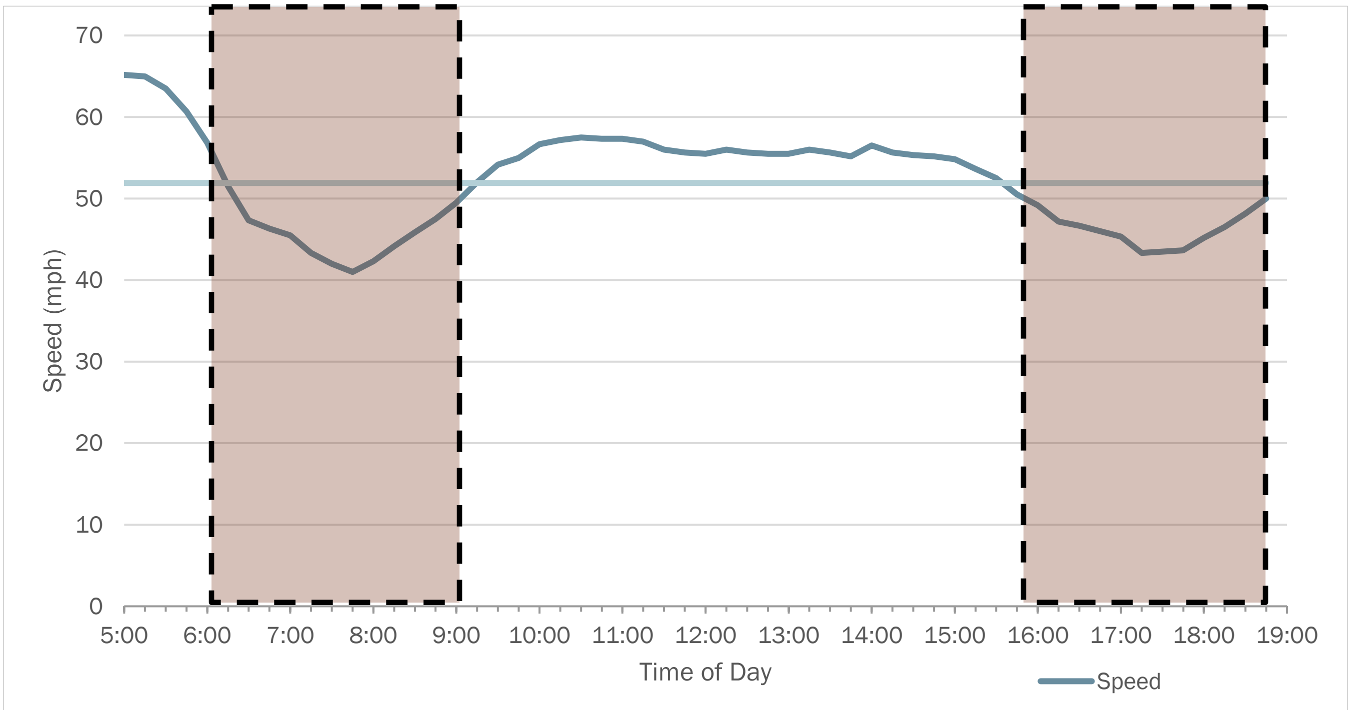

Figure 5: TranStar Speed Data

Based on the data from **Figure 5** and the existing congestion in the project area, it was determined that the traffic operational analysis in this IAJR would include two peak periods. The first peak was established to be from 6:00 to 9:00 AM and the second one from 4:00 to 7:00 PM. These peak periods were agreed upon by FHWA and TxDOT as it captures the before-and-after congestion characteristics and performance of a typical weekday.

2.5 *Analysis Years*

The base year analysis for this project was established to be 2018 and confirmed in stakeholder meetings. Field collected data, including mainlane, ramp, and intersection turning movement counts, as well as field observations, were collected in 2018. 2018 field collected and observed data was used for calibration of the Vissim microsimulation model. Opening year is expected to begin in 2025.

Therefore, to achieve the 20-year analysis requirement for this IAJR, 2045 was established as the design year (opening year + 20 years).

The existing condition operational analysis was calibrated using 2018 base year traffic demand, which incorporates 2018 traffic counts to supplement available 2015 data. The H-GAC available 2015 travel demand model was calibrated for use in future year traffic projections. TxDOT Transportation Planning and Programming (TP&P) approved methods for extrapolation were used. 2025 traffic forecasts were developed using the 2025 demographics, land use, and economics from the H-GAC model. The 2045 traffic forecasts were developed with the latest available 2040 H-GAC travel demand model and extrapolated to 2045 based on area growth. The 2045 H-GAC model is currently in development and was not available for use during the I-45 NHHIP project development.

2.6 *Travel Demand Forecasting*

Traffic volume forecasts were developed for Segment 2 and 3 to facilitate the development of this IAJR. The following sections detail the methodology used to forecast future year peak period traffic volumes. Traffic volume projections were AM and PM peak periods in 2025 and 2045. As previously mentioned, the peak periods were determined as three-hour periods that capture the congestion in the project area. The traffic projections developed were used for operational analysis and do not include 24-hour traffic volumes for the purpose of pavement or air and noise analysis. The approach was used to produce the 2025 and 2045 peak period traffic projections:

1. Inventoried and reviewed available information from data collection efforts and historical sources.
2. Developed base year traffic based on data collection and traffic demand development[2].
3. Reviewed H-GAC Travel Demand Model (TDM) scenarios.
4. Calculated H-GAC traffic assignment zone demographic forecast growth.
5. Calculated historical growth rates based on historic count data available at TxDOT count locations.
6. Selected growth rates appropriate for the segment and traffic movement. Growth rates were used in the development of future year traffic based on TDM forecasts and historical growth analysis.
7. Identified appropriate traffic diversions for both the No-Build and Build scenarios based on corridor improvements and TDM forecasts of No-Build and Build conditions.

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[2] In many cases, congested networks result in traffic counts that did not reflect overall demand. The demand is often greater than realized, and results in an observed bottleneck or backup. Traffic demand development using field observations to estimate demand at congested locations is important to accurately forecast traffic demand.

8. Applied diversions to base year traffic volumes.
9. Applied selected growth rates to base year traffic to develop future 2025 and 2045 traffic projections for both the No-Build and Build scenarios.

2.6.1 Available Data Sources

Several data sources were utilized to define growth in the project area and to aid in the development of the forecast year traffic volumes. The following sections describe the data available for use and consideration in forecasting future year volumes. As previously mentioned, an extensive effort was undertaken to collect traffic counts and perform field observations for the project in April 2018. Previously collected counts were used to supplement the April 2018 data. These counts were used to develop the 2018 base year, three-hour, peak period volumes were developed and are included in **Appendix B**.

TxDOT Permanent Count Stations on or near the corridor were used to determine the directional distribution and peak hour factor. Similarly, nearby TxDOT Vehicle Classification Count Stations were used to determine the heavy vehicle percentages along the corridor. These permanent and vehicle classification stations are depicted in **Figure 6**.

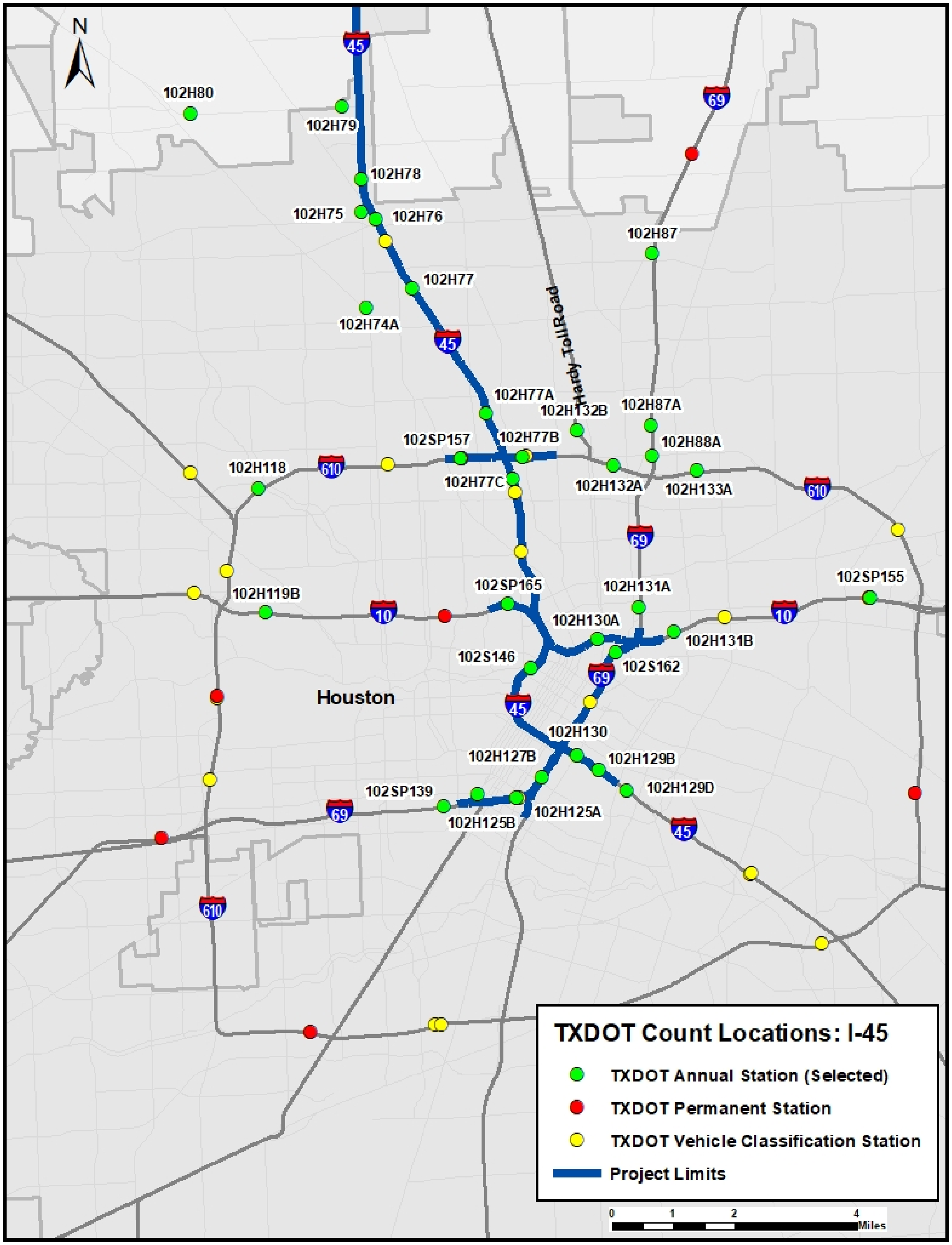

Figure 6: TxDOT Count Stations

Historical count information, between 1999 and 2017, from TxDOT's Traffic Count Database System (TCDS) at locations along the corridor and surrounding areas were used in a linear regression analysis of traffic growth. Historical average annual growth rates (AAGR) were calculated using linear regression for forty-one locations along ten different roadways in and around the project area. For the historical growth, growth rates from various historical years were calculated to ensure the recommended forecast growth rate did not represent outliers. The regression analysis was performed with an Excel tool that has been verified to match the TxDOT-Transportation Planning and Programming (TPP) Corridor Analysis Standard Operating Procedures. An I-45 NHHIP Traffic Forecasting Memorandum includes more details on historical growth and forecast growth rates. It is included in **Appendix C**.

2.6.2 Travel Demand Model Review

The 2040 H-GAC TDM used in this project was the latest adopted regional TDM available at the start of the project. The TDM includes both roadway and transit networks that reflect the adopted 2040 H-GAC Regional Transportation Plan. The H-GAC TDM includes forecast scenarios for the years 2025 and 2040. However, the 2025 TDM scenario did not include traffic forecast volumes at the time of traffic forecast development. The TDM base year validation was reviewed to affirm confidence in the TDM's ability to forecast traffic volumes for the proposed improvements. The network of each TDM forecast year was reviewed to confirm the inclusion of the proposed transportation improvements and the correct representation of roadway effecting the project area. As mentioned previously, the 2045 H-GAC model was in development and was not ready for use during this project. The following describes the focus of the review, key observations, and a summary of changes made on the I-45 corridor:

2.6.2.1 *TAZ Geography*

A thorough review of the TAZ structure was performed to ensure adequate detail existed along the corridor. TAZ geography was found to be adequate.

2.6.2.2 *Roadway Network*

Alignments, configurations, roadway characteristics (such as lanes, functional class, and speed), and proposed projects were reviewed for each scenario year.

2.6.2.3 *H-GAC Demographics*

Demographic data was reviewed and demographic growths from 2015 to 2025 and 2025 to 2040 were compared to with the Texas Demographic Center (TDC) as well as the Complete Economic and Demographic Data Source (CEDDS) forecasts. Upon review, the TDM demographic growth was found to be reasonable.

2.6.3 Travel Demand Model Validation and Consideration

The goal of the TDM validation was to confirm that the H-GAC TDM could be used with confidence to generate future traffic volumes. The process of validation compares the TDM output to known observations of travel. Our team determined that the difference between the TDM output to 2015 counts were within the accepted percentage difference range. For this reason, our team considered the TDM validated and a good available tool to generate forecasted traffic volume along the project corridor. More details are included in the Traffic Forecast Memorandum in **Appendix C**.

2.6.4 Traffic Growth Rate

2015 and 2040 H-GAC TDM traffic volumes along the project corridors were used to calculate average annual traffic growth rate. For this calculation, fifty-five locations across five roadways in the project area were selected and compared between the two models. Additional details on the comparison of growth rates by location are included in **Appendix C**.

2.6.5 Forecast Year Traffic Volume Development

Future year traffic volumes were developed utilizing accepted methodologies and guidelines in conjunction with TDM input, TxDOT TP&P standard procedures, and specific knowledge of the project area. Facility specific growth rates were based on the approach discussed in the previous section. These growth rates align with those used to develop draft daily traffic volumes, separate from this study. The daily traffic volumes are in review with TxDOT TP&P. The traffic volumes in this analysis and report are used for the sole purpose of operational analysis during peak periods. The growth rates applied for development of both the No-Build and Build forecast volumes are presented in **Table 7** below.

Table 7: Project Corridor Growth Rates

Roadway	Growth Rate (AAGR)	
	2018 - 2025	2025-2045
I-45	0.75% - 1.75%	0.5% - 1.5%
I-69	1.0% - 1.75%	0.75% - 1.5%
I-10	1.0%	0.75%
I-610	1.0% - 1.5%	0.75% - 1.0%
SH 288	1.75%	1.25% - 1.5%

The growth rate ranges presented in **Table 7** represent the range of growth rates that are applied to sections of each roadway and the direct connectors accessing each roadway for the 2025 and 2045 forecast years in the No-Build and Build scenarios. The growth rate varied by location in the project area and interaction between freeway systems. Five sets of growth rates were developed for roadway sections, shown in **Table 8** below.

Table 8: Growth Rate Application by Roadway Section

Growth Rate Combination	2018 - 2025 Growth Rate (AAGR)	2025 - 2045 Growth Rate (AAGR)	Roadway Sections
1	1.0%	0.75%	I-610, I-10, I-69 S of I-45
2	1.5%	1.0%	I-69 N of I-45, Hardy Toll, Hardy Toll to I-610 direct connectors
3	0.75%	0.5%	I-45
4	1.75%	1.5%	SH 288 (Build), SH 288 to I-45 and I-69 direct connectors
5	1.75%	1.25%	SH288 (No-Build), SH 288 to I-45 and I-69 direct connectors (No-Build)

The traffic growth on the cross streets were consistent with the rate of growth for the mainlane and frontage road growth rates in the respective roadway sections. For example, Cullen Boulevard operates perpendicular to I-45, therefore, growth rate combination 3 was applied to establish the peak period traffic forecasts for Cullen Boulevard traffic inputs and movements.

The growth rates were applied consistently between the No-Build and Build scenarios for all locations except SH 288 and I-69 direct connectors. In this area, the horizon year TDM showed different growth between the No-Build and Build scenarios. A slightly higher growth rate was used in Build scenario volume forecast to account for the expected demand in the area.

Table 9 shows the TDM scenarios and a description of the project corridor configuration included in each scenario. The completed traffic forecast for the Base, 2025, and 2045 scenarios can be found in **Appendix D**.

Table 9: Traffic Forecasting Scenarios

Forecast Year	Scenario	Corridor Configuration
2018	Base	Existing roadways including current construction underway
2025 and 2045	No-Build	Includes Hardy Connector and current construction scheduled to be completed
2025 and 2045	Build	Includes all Segment 2 and Segment 3 improvements along with Hardy Connector

The No-Build scenario included the Hardy Toll Road Downtown Connector project, expected construction beginning in 2020 with opening in 2023, which extends Hardy Toll road into Downtown Houston and provides connection to I-69. This project is described in more detail in later sections of the report. The Hardy Toll Road impacts and changes to traffic patterns were reflected in base year volume development and grown to the 2025 and 2045 No-Build forecasts.

2.7 *Measures of Effectiveness*

Six measures of effectiveness (MOEs) were agreed upon by project stakeholders, including TxDOT and FHWA, for the project area to capture the existing conditions and/or impact of proposed improvements from the selected traffic microsimulation software, Vissim. They include:

- **Segment Speed** – This MOE was output to analyze the speed of various segments, including weave segments near ingress/egress locations, over time. A speed map of the project area was created to display speeds throughout the project area over time and space. Low-speed areas were identified and considered in schematic development. Segment speeds are listed in later sections of this report comparing No-Build to Build alternatives.
- **Travel Time** – At key routes in the project area, this MOE was output for calibration of the existing model and comparison between alternatives. The travel time routes were identified at the start of the project and Houston TranStar travel times were obtained for the calibration targets.
- **Queue Lengths** – The expected queue from intersections was captured via visual inspection of microsimulation models to ensure that queue from intersections do not impact interstate operations. The queue lengths are compared to the length available to the ramp gore. Queue lengths are captured in microsimulation outputs and can be seen in speed maps found in **Appendix M** and **O**.
- **Speed Differential and Lane Change Movements** – At key merge/weave/diverge segments near ingress and egress locations, speed differential between lanes were considered. This captures the speeds by lane in high lane change locations and is used to ensure that the distance between gore points is adequate to handle the anticipated demand. The number of vehicles that are removed from the network due to inability to make lane changes is summarized to minimize expected vehicle rerouting. The speed differentials and lane change movements were noted during field observations and are documented in **Appendix E**.
- **Latent Demand** – The number of vehicles unable to access the overall network during the peak periods is represented by latent demand. This value was used to compare overall network performance of alternatives. Specific locations where this occurs were noted and discussed in the operational analysis.
- **Delay** – This quantifies the increase in travel time that a vehicle experiences due to circumstances that impede the desirable movement of traffic. It is the difference between actual travel time and free-flow travel time. Delay was used to compare intersection operational performance between alternatives. Relative delay ranges from 0 to 1 and shows the amount of time in the peak period that segments are congested. A value of 1 would mean the segment is congested for the full 3-hour peak period, while a value of 0 would mean the segment is uncongested at all times of the analysis period. It was used in freeway segment analysis to show the length of congestion.

The above MOEs were selected based on their ability to replicate existing conditions and/or compare alternative performance and efficiency from the selected traffic microsimulation software, Vissim.

2.8 *Vissim Model Development*

As mentioned, PTV Vissim version 9.0-10 was used as the operational analysis tool due to its ability to model complex freeway interchanges and corridors. It captures the impact of lane changes and includes detailed outputs.

2.8.1 Analysis Periods & Time Intervals

Both AM and PM peak period conditions were analyzed. Peak period volumes were divided into 15-minute intervals to capture peak period variation in demand. A seeding period of 30 minutes was added to the Vissim simulations prior to the peak periods, which captured the furthest travel time route on the network. Unmet demand during each peak period was noted and compared to locations where congestion was still occurring at the end of the peak periods.

2.8.2 Model Geometry & Limits

The base year Vissim model was built using aerial photographs for use in consistency in the size and scale of future scenario networks. For base year models, base year signal timing and phasing plans were used for the base and No-Build scenarios, while Build conditions included optimized signal timings from Synchro version 10.0 software. The model limits were set up to capture the initial proposed improvement impacts and all changes to the network. Additionally, the model limits included the area of influence of the project as previously discussed. Figure 7 shows the model limits based on proposed improvement impact.

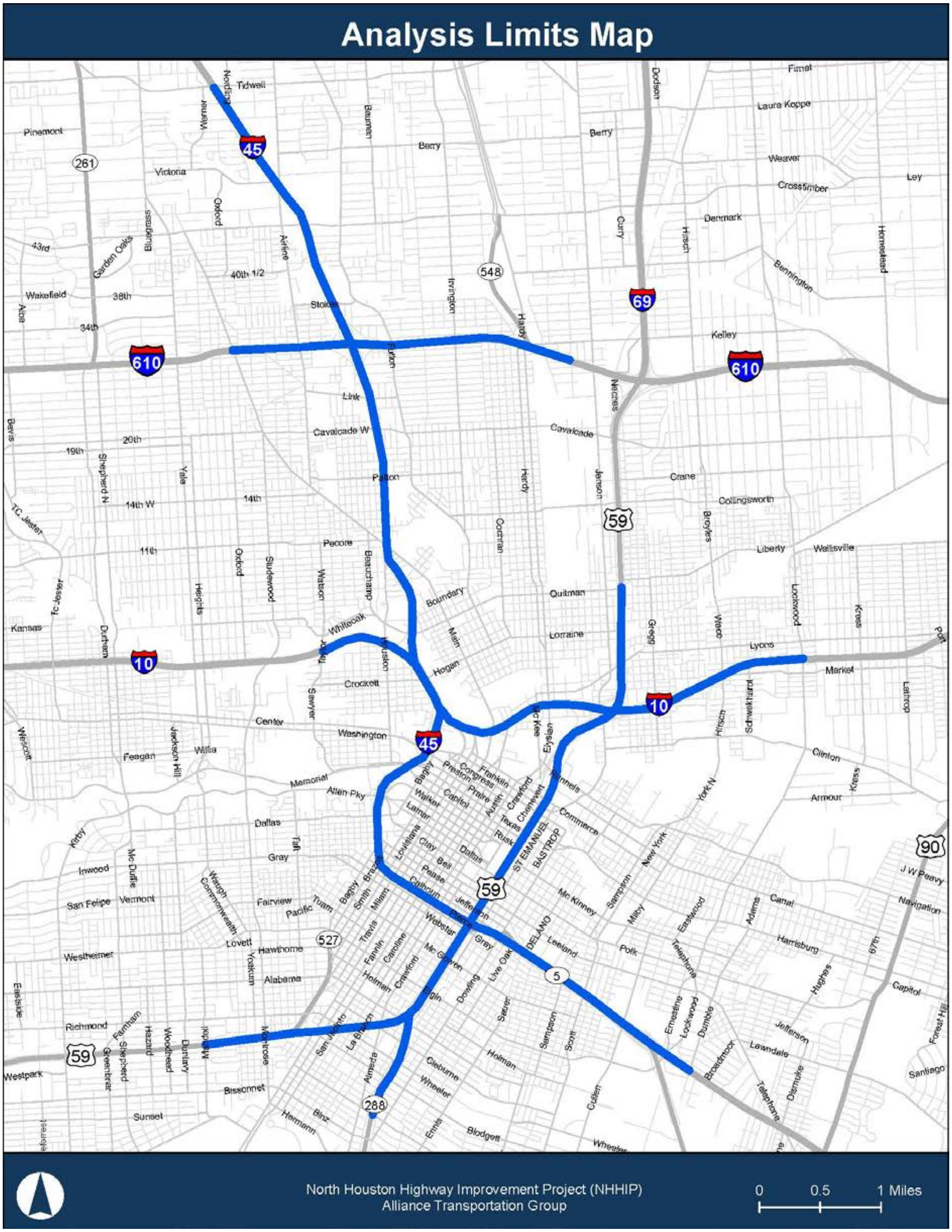

Figure 7: Vissim Model Limits

The limits were maintained for all alternatives in order to have a direct comparison in the Vissim overall network statistics. The overall network statistics used the MOEs previously discussed and was an important tool in showing the overall benefit of proposed improvements.

Future model geometry was based on the improvements that are listed in the 2040 and 2045 RTP and 2018 MTP for the region and other planned improvements from stakeholder agencies. Planned improvements scheduled to open by scenario dates, 2025 and 2040, were included in the H-GAC models.

2.8.3 Model Traffic Inputs

As stated previously, the operational analysis utilized peak period volumes for use in the traffic operational analysis. The 15-minute traffic volume data input into the existing model was obtained from the available 2015 traffic data and supplemental 2018 traffic data that was grown to the 2018 base year and balanced based on traffic demand. Each model input, where vehicles enter the network, has demand based in the 15-minute time intervals. Static route choice was used for routing by proportion over the three-hour peak periods. Exceptions were considered for calibration purposes at critical areas to meet changes in routing over 15-minute intervals. Future-year models used the forecasted traffic volumes previously discussed and applied the base year 15-minute vehicle input variation over the peak period analysis.

The Origin-Destination Matrix Estimation (ODME) tables from the H-GAC TDM scenarios were considered when inputting the routes into the models. However, critical merge/diverge/weave areas use hard-coded routes for precise volume coding and to better inform design schematic development.

Signal timings were optimized to coincide with the change in demand from forecasted volumes by using Synchro version 10 and applied into the Vissim models.

2.8.4 Model Calibration

2018 base year Vissim calibration was completed with industry-accepted calibration techniques and accepted by FHWA on February 19, 2019. Calibration was performed in accordance with FHWA’s *Traffic Analysis Toolbox Volume III* latest criteria. Travel time on the freeway segments in intervals was the focus of primary calibration. In addition, calibration was performed at critical locations for verification of field observations and queueing. Critical locations, shown in Table 10, were identified based on bottlenecks, slowdowns, and available data. An analysis was completed to assess the cause of congestion at these critical locations and to determine how the build configuration would address those operational issues.

Table 10: I-45 Critical Locations for Calibration

Location
I-10 EB merge between I-45 and I-69– Over Main St
I-10 WB merge between I-45 and I-69– Over Main St
I-69/SH 288 SB weave from I-10 to Leeland St
I-69/SH 288 NB weave from Eglin St to I-45
I-45 SB weave from I-610 to Cavalcade St
I-45 NB weave from Cavalcade St to I-610
I-10 EB weave from Nance St Exit to I-69/US 59
I-10 WB weave from Runnels St NB DC Entrance to Jackson St Exit
I-45 SB weave from I-10 WB Exit to Downtown Exits
I-45 NB weave from Downtown Entrances to I-10 EB exit

The travel times in time intervals were calibrated to within the 90% confidence interval using available Houston TranStar data and variation during the data collection period. The levels of calibration included:

- **Primary Calibration:** This level of calibration included calibration by travel time in time intervals on major routes. It was the most data intensive calibration and was performed for I-45, I-610, I-69, and I-10.
- **Secondary Calibration:** This level calibration included field observations and queueing at each critical location. All critical locations were calibrated by secondary calibration.
- **Tertiary Calibration:** This level of calibration used field observations and speed maps to verify network performance in 15-minute intervals. This level of calibration was completed for the entire analysis limits.

Additional information on detailed calibration techniques is included in **Appendix F**.

3.0 Existing Conditions

Existing conditions include several areas that were evaluated for use in assessing deficiencies and needs in the project area. The existing conditions reflect observations and data from the base year, 2018. This section includes the following sections:

- Demographics
- Land Use
- Roadway Network
- Alternative Travel Modes
- Existing Interchanges
- Existing Data
- Existing Operational Performance
- Existing Safety Conditions
- Existing Environmental Constraints

Each section outlines existing details that were considered in the development of the proposed schematic. During project development, an existing condition memorandum was also completed, and is included in **Appendix E**.

3.1 *Demographics*

The Draft EIS, available at http://www.ih45northandmore.com/draft_eis.aspx, collected community profile data for census tracts, block groups, and blocks that intersect or that are adjacent to the proposed right-of-way of the project. Collectively, this Census profile area included 42 census tracts, 69 block groups, and 1,046 blocks. *Appendix F: Community Impact Assessment Technical Report,* part of the Draft EIS being performed, includes detailed tables of population estimates, race, and ethnicity characteristics for census tracts, block groups, and blocks in the Census profile area.

Low-income populations were identified if the median household income at the Census block group level was at or below the U.S. Department of Health and Human Services (HHS) 2016 poverty guideline for a family of four persons. This was defined as an annual household income of $24,300. The number of low-income Census block groups and the median household income data are discussed in *Appendix F: Community Impact Assessment Technical Report*, also part of the Draft EIS being performed.

Segment 2 (I-45 from I-610 to I-10) of the NHHIP project area has a census profile area that consists of 10 Census tracts, 16 block groups, and 156 blocks. (Note: two Census tracts and three block groups are located in both Segments 1 and 2, and one Census tract and block group is located in both Segments 2 and 3). The population within the Segment 2 Census block area is 84.8 percent minority, of which 74.9 percent is Hispanic. Predominantly Hispanic communities are located throughout the Segment 2 Census profile area.

Segment 3 (Downtown Loop System) of the NHHIP project area has a census profile area that consists of 21 Census tracts, 33 block groups, and 602 blocks. (Note: one Census tract and one block group are located in both Segments 2 and 3). The population within Segment 3 Census profile area is 67.3 percent minority, of which 39.1 percent is Black and 22.6 percent is Hispanic.

As part of the Travel Demand Model review, demographic data and growths from 2015 to 2025 and 2025 to 2040 were reviewed and analyzed. Please refer to that section for more detail. The TDM demographic growth were found to be reasonable.

3.2 *Land Use*

The I-45 NHHIP includes several land use areas including urban and developing. There are residential, commercial, industrial, public use/institutional, parks, vacant and undeveloped land uses within the project limits. Right-of-way will be required in each segment and was required for all alternatives reviewed under the Draft EIS. The impacted land uses would be permanently converted to transportation use. The Houston-Galveston Area Council (H-GAC) Geographical Information System (GIS) data was used to denote existing land uses. Planned projects and future development is included in the 2040 H-GAC model, which is used to estimate projected travel demand.

- **Segment 2 - I-45 from I-610 to I-10 -** The Segment 2 project area is largely built-out and only four percent of property in the project area is developable vacant land. No planned developments were identified in the Segment 2 project area.
- **Segment 3 - Downtown Loop System -** The Segment 3 project area is mostly built-out and only five percent of property in the project area is developable vacant land. As the city continues to grow, Downtown and the surrounding neighborhoods are redeveloping. Several office towers, multi-family unit complexes, hotels, and mixed-use developments are under construction or planned inside of the Downtown loop. Other planned developments in the vicinity include the expansion of the Memorial Hermann Hospital located south of the Downtown area. Midtown, which was originally a commercial district, is undergoing residential redevelopment but still has significant areas of commercial development. Higher density residential land use, such as townhouses and apartment buildings, and mixed-use development are increasing in older neighborhoods to the west, east, and south of central Downtown. The area east of Downtown is experiencing high- to medium-density residential redevelopment, but this area is still comprised largely of industrial land use. The former Union Pacific railyard located two blocks north of I-10 between I-45 and US 59/I-69, is proposed to be converted to a mixed-use development known as the Hardy Yards. The Hardy Yards will include residential units, retail, and office space on a 50-acre site (Gonzalez, 2014).

3.3 *Roadway network*

The roadway network within the project area of influence was reviewed and identified by functional classification, cross section, and access control. Roadway functional classification is assigned to a corridor based on the number of lanes, daily traffic volumes, right of way, local accessibility, and character area (urban, suburban, or rural.) The character area surrounding the project area is mostly urban. The functional classifications as defined by H-GAC, surrounding the project area, are as follows:

- **Interstate** classification involves all facilities included in the Interstate Highway System. Interstate design criteria maintain strict standards for features such as clearances, sight distances, control of access, drainage, signing, lighting and maintenance of proper levels of traffic service.
- **Other Freeway and Expressway** are included in this controlled-access facilities category. They are identified by high volume type designs that allow for efficient and rapid movement of large volumes of traffic between and across urban areas.
- **Principal Arterials** allow traffic movement between large, populated areas, or across cities. The network of principal arterials, along with Interstate Highways and freeways is the primary carrier of interstate, statewide and interurban traffic.
- **Minor Arterials** link cities and larger towns as well but deliver smaller design traffic volumes. Generally high overall speeds are provided with minimum interference to through movement. In contrast, intersection treatments are expected to be less extensive than for principal arterials.

Figure 8 illustrates each facility within the project area.

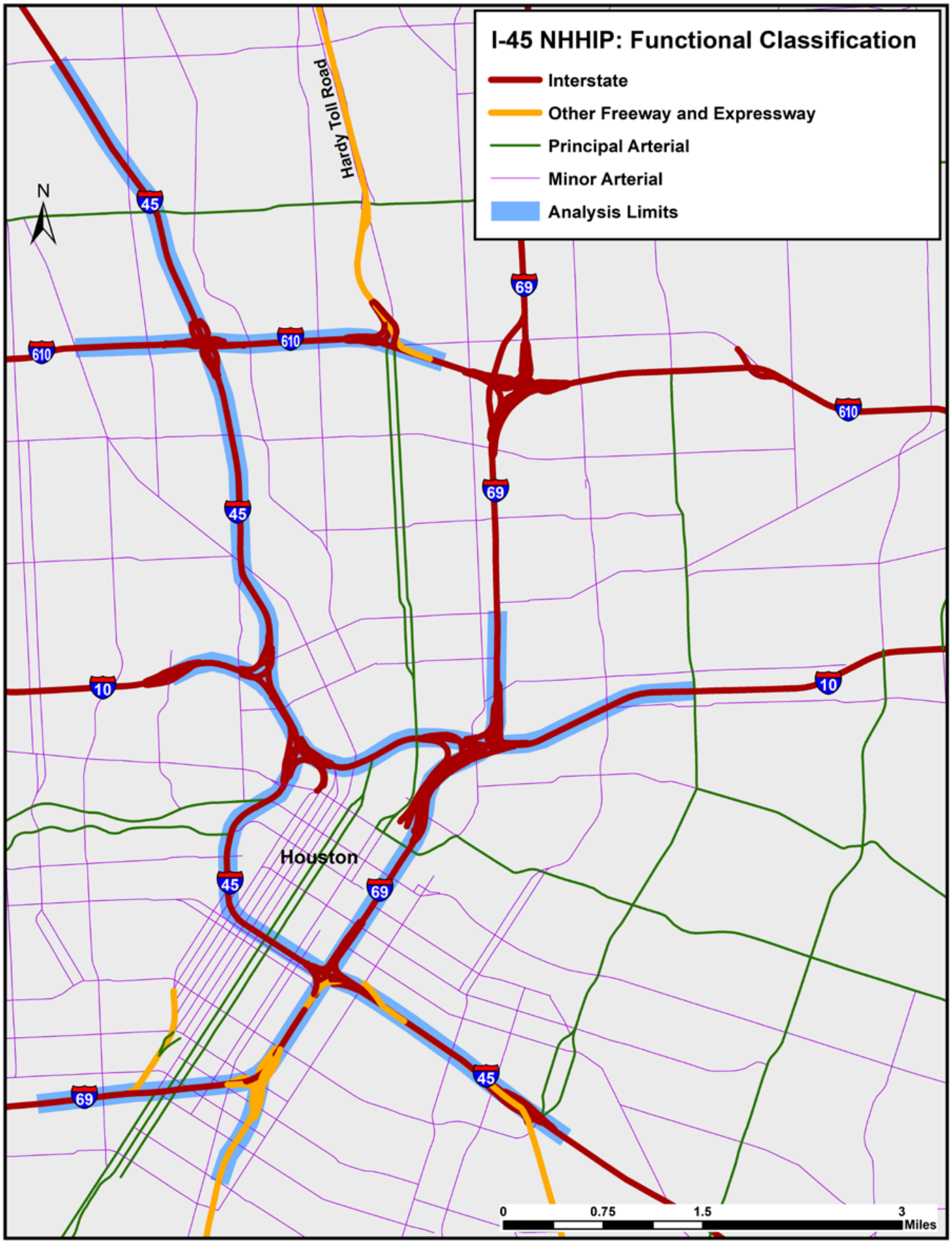

Figure 8: Functional Classifications in Project Area

3.4 *Alternative Travel Modes*

Alternative Travel Modes seek to reduce Single-Occupant Vehicle (SOV) travel and encourage travel time to be shifted outside the peak period. This section identifies the types of single occupant vehicle (SOV) alternatives that exist within the project limits, currently. Alternative Travel Modes may include:

- Heavy Occupancy Vehicle (HOV) lanes
- Transit Routes
- Park-and-Ride Facilities
- Ride Sharing
- Bicycle & Pedestrian Facilities

The alternative travel modes existing within the project limits have been identified in **Figure 9**. There are several alternatives in the project area. In addition, a bi-directional (reversible by peak direction) HOV/HOT lane operates on I-10 and I-45 on the north side of Segment 3. These facilities encourage the use of vehicles with 2+ occupancy and allow transit vehicles to operate from park and ride facilities along each corridor.

The only Park & Ride facility within the proposed project area is the METRO North Shepard Park & Ride in Segment 1, located west of I-45 near North Shepherd Drive. The METRO North Shepard Park & Ride has a direct connection with the I-45 HOV lane and provides service to the Downtown central business district and other transit center.

The METRO Light Rail Transit (LRT) has several lines that provide access within the project limits. The first portion of the Red Line travels along Main Street from NRG Park to the University of Houston-Downtown campus. The North/Red line extension connects the University of Houston-Downtown campus to the Northline Transit Center. The North/Red line extends 13 miles. The east end/green line extends 3.3 miles and travels along Harrisburg Boulevard from the Magnolia Transit Center, located east of Downtown, to the Downtown Central Station. The southeast/Purple Line extends 6.6 miles and connects the Downtown area to the Palm Center Transit Center in the Greater Third Ward. These light rail transit lines are shown in **Figure 9**.

In Segment 2 and Segment 3, sidewalks are discontinuously located along frontage roads in segments of I-45, I-10, I-69, and I-610. In Segment 2, the city's long term-bikeway vision plans include future bike paths and trails along Little White Oak Bayou and through Moody Park on the east side of I-45. In Segment 3, the city's long-term bikeway vision plan includes future off-street bike paths that connect to existing bayou trail segments and to several parks in Downtown. The Downtown District's 20-year vision plan, "Plan Downtown", includes conceptual plans for a five-mile "Green Loop" comprised of green spaces and expansive trails around the edges of central downtown. Existing bike paths are shown in **Figure 9**.

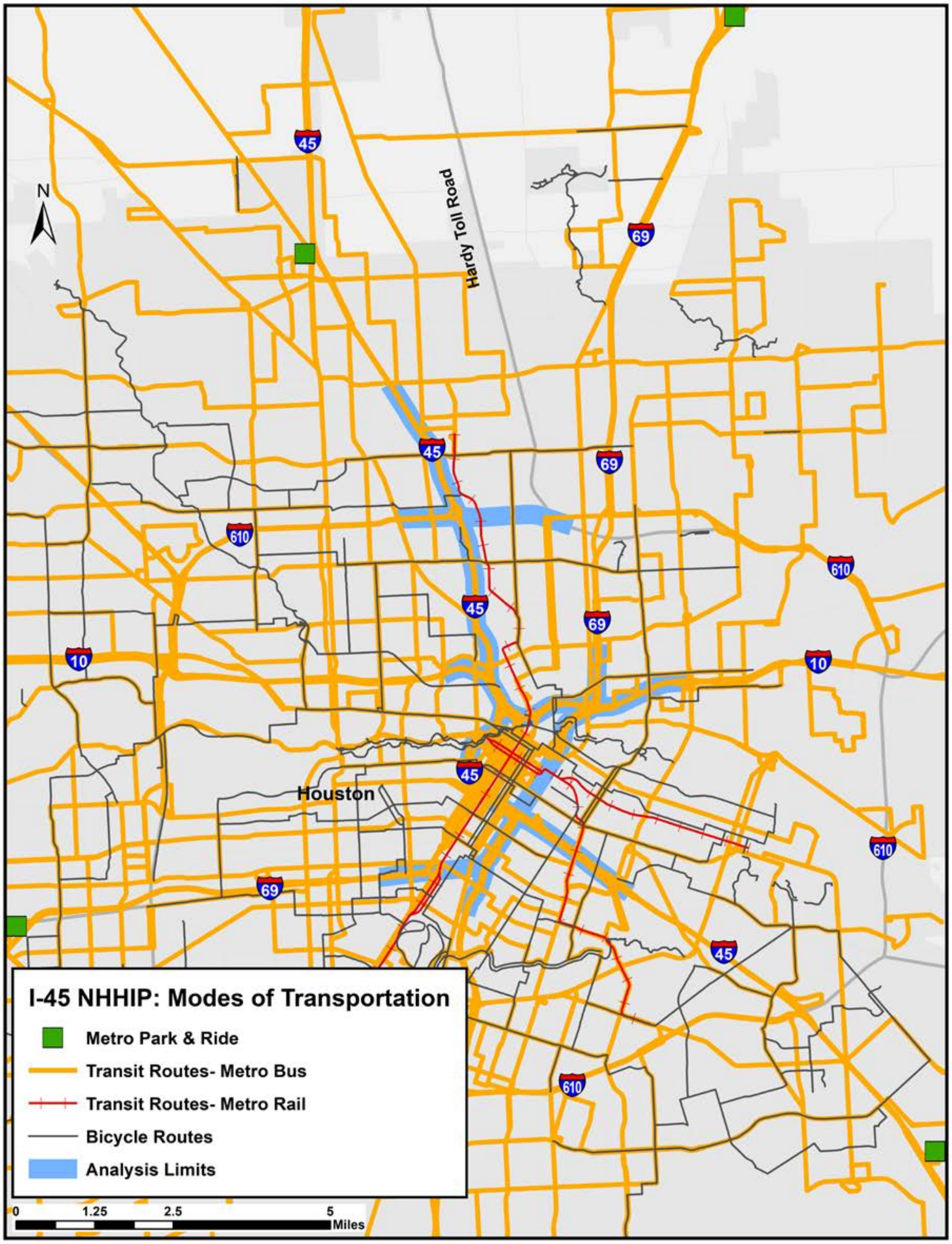

Figure 9: Alternative Travel Modes

3.5 *Existing Interchanges*

There are both arterial and freeway interchanges in the project limits. There are 34 urban interchanges, including six system to system freeway interchanges. The freeway interchanges include:

- I-45 at I-610 – Four-way, three-level, stack interchange with left and right side exits to direct connector movements. This interchange is non-basic due to the left side exits. Basic interchange configurations are defined by AASHTO in Figure 10-1 of *A Policy on Geometric Design of Highways and Streets*.
- I-45 at I-10 – Four-way, intricate, collector-distributor freeway interchange that provides uninterrupted movements to and from each freeway facility. The collector distributor system also provides access to and from the I-10 and I-45 HOV lanes. It is non-basic due to the roadway alignment geometries.
- I-45 at I-69 – Four-way, stack interchange with left and right side exits. The direct connectors utilize collector distributor systems on the northbound and westbound approaches. It is non-basic due to left exits and collector distributor systems.
- I-10 at I-69 - Four-way, three-level, freeway interchange with left and right side exits. It is non-basic due to left exits and the geometry.
- I-69 at SH 288 – Three-way freeway interchange that terminates northbound SH 288 into a collector-distributor system. The interchange also includes direct connectors to and from the downtown arterial street system.
- I-69 at Spur 527 – Three-legged interchange that provides access to and from Downtown Houston. It includes a left side exit from the eastbound approach.

The 34 urban interchanges are located at major cross streets that provide access to and from the freeways. The urban interchanges were analyzed for appropriate lane configuration and signal timing. They include the following:

1. Tidwell Road at I-45
2. Airline Drive at I-45
3. Crosstimbers Street at I-45
4. Main Street at I-610
5. Airline Drive at I-610
6. Fulton Street at I-610
7. Irvington Boulevard at I-610
8. Link Road at I-45
9. Cavalcade Street at I-45
10. Patton Street at I-45
11. Cottage Street at I-45
12. Main Street at I-45
13. White Oak Drive at I-45
14. Taylor Street at I-10
15. Quitman Street at I-69
16. Lyons Avenue at I-69

17. Memorial Way & Memorial Drive
18. Dallas Street at Gulf Freeway/Heiner Street
19. Franklin Street at Louisiana Street/Smith Street
20. Commerce Street at Milam Street/Travis Street
21. Waco Street at I-10
22. Gregg Street at I-10
23. Bagby Street at McKinney Street/Walker Street
24. McGowen Street at I-69
25. Tuam Street at I-69
26. Elgin Street at I-69
27. Ruiz Street at Jackson Street/Chenevert Street
28. Leeland Street at Hamilton Street/Chartres Street
29. Richmond Avenue at Spur 527
30. Blodgett Street at Fannin Street/San Jacinto Street
31. Emancipation Avenue at Pease Street/Jefferson Street
32. Scott Street at I-45
33. Cullen Boulevard at I-45
34. Southmore Boulevard at SH 288

The ramp configurations surrounding the urban interchanges are a mix of diamond and X-pattern configurations. Access spacing is inconsistent throughout the project area and often results in close-spacing of ramps.

3.6 *Existing Data*

Traffic counts and field observations were completed over two weeks on April 2018. These were completed during a typical week over three days. These counts supplemented the available 2015 data which was obtained at the beginning of project development. The following 2018 supplemental traffic counts were collected:

- 115, 24-hour tube counts at ramp locations
- 12, 24-hour mainlane counts
- 100, 3-hour AM and PM turning movement counts

Classification counts were collected at several 24-hour tube count locations to capture heavy vehicle percentages. Signal timings were obtained from TxDOT and City of Houston and coincide with the date counts were collected in the field.

Crash data was obtained from the TxDOT Crash Record Information System (CRIS) from 2013 – 2018. However, after initial analysis of crashes, it was determined that 2015 to 2018 data would be included in the analysis, because 2013 and 2014 data showed outliers and inconsistencies. Due to the lack of confidence in accurate data, those years were removed from analysis.

Existing land use and traffic information previously generated by the regional model were obtained from H-GAC. Geometric and traffic control information was obtained by the project team through field observations and from coordination with local agencies. H-GAC and TxDOT data was used in conjunction with collected data for determining future heavy vehicle percentages.

Travel time and speed data from TranStar was collected in order to be used for existing Vissim calibration.

3.7 *Base Year (2018) Operational Performance*

The existing operational performance was analyzed using Vissim microsimulation software. The existing models were calibrated to replicate existing operational conditions. This section includes the model calibration details and model outputs.

3.7.1 Model Calibration

The project team completed peak period calibration to the most recent FHWA Traffic Analysis Toolbox Volume III update. This calibration approach uses statistical analysis to effectively focus calibration efforts on a representative day of traffic. FHWA has been performing training seminars with state DOTs and the updated calibration methods are expected to be officially released in 2019. In discussions with TxDOT and FHWA, the latest methods for calibration were deemed acceptable. For this analysis, 2018 travel time data was obtained from Houston TranStar and aggregated to 1-hour intervals in the three-hour peak periods to aid in primary calibration methods.

Based on the updated FHWA calibration criteria, shown in **Table 11**, the existing models were calibrated with simulated travel times falling within the 90% confidence interval of the representative peak period travel times, and more than 2/3 of simulated travel times within one standard deviation of the respective data. This exceeds the minimum requirements for FHWA calibration. The 90% confidence interval was approved for use on this project by TxDOT on January 15, 2019. The calibration also includes visual observation of ten critical locations, as well as a high-level assessment of segment speeds. Finally, the number of model runs was set to three simulations based on FHWA and TxDOT guidance.

The full calibration report is included in **Appendix F** and was accepted by FHWA on February 19, 2019.

Table 11: I-45 NHHIP Primary Calibration Results

	One Standard Deviation Upper and Lower Bound		1.645 Standard Deviation Upper and Lower Bound	
	AM	PM	AM	PM
Number of 1-Hour Intervals Vissim Model Travel Time Within Range	18	17	23	22
Total Number of 1-Hour Intervals	24			
% In Range	75.0%	70.8%	95.8%	91.7%
Calibration Criteria	66.7%	66.7%	90.0%	90.0%

3.7.2 Base Year Operational Results

Base year Vissim results were output for the entire network to note general traffic patterns between AM and PM peak periods and highlight overall performance. Based on the focused MOEs discussed previously, network statistics for speed, vehicle-miles travelled, and latent demand were output and are shown in **Table 12**. These MOEs will allow a direct comparison between networks and show the potential improvement of geometric changes to the overall project area for the No-Build and Build alternatives. The remaining MOEs (segment speed, queue lengths, travel time, speed differential, and lane change movements) are the focus of specific calibration locations and will be discussed in a later section of this report. The full existing network results are included in **Appendix G**.

Table 12: Base Year (2018) Vissim Results

		Average Speed (mph)	Vehicle Miles	Latent Demand (veh)
Entire Network	AM	27.5	1,208,839	23,628
	PM	25.2	1,410,570	48,657

As shown in **Table 12**, the PM network shows a higher level of latent demand. This suggests that congestion continues beyond the peak period at certain locations. Overall, the latent demand represents 4.3% and 7.4% of the total demand in the AM and PM peak periods, respectively. The model outputs in 15-minute intervals along with TranStar speed outputs on a relevant day during data collection are provided in **Appendix H**. These outputs confirm that there were congested locations at the end of each peak period, and that the model congestion locations compare directly to actual congestion locations. The latent demand at input locations is summarized in **Table 13**. Due to the extent of the project area and the urban environment, this amount of latent demand is expected and was accepted during simulation. Source locations refer to driveway locations on the network.

Table 13: Base - Vehicles Unable to Enter Network by Location

Location	AM Peak Vehicles	PM Peak Vehicles
I-45 SB Mainlane	1,372	0
I-45 NB Mainlane	145	11,713
US 288 NB Frontage Road	0	329
US 288 NB Mainlane	5,420	7,501
I-69 NB Mainlane	0	14,233
I-10 WB Mainlane	4,492	500
I-69 SB Frontage Road	131	0
I-69 SB Mainlane	4,519	0
I-10 WB Frontage Road	0	33
I-10 EB Mainlane	5,321	9,311
I-610 EB Mainlane	0	1,479
Spur 5 NB Mainlane	0	782
Airline Rd SB	166	0
Dowling St (Emancipation Ave) WB	16	0
Cullen St WB	0	352
Southmore Blvd WB	355	696
Ruiz St EB	36	0
Brazos St WB	0	388
Memorial Dr EB	1235	60
Taylor St NB	50	0
Source North of I-45 NBFR and Crosstimbers St	0	50
Source East of Providence St and McKee St	367	0

In addition to the demand that was unable to make it onto the network in each peak period, there were approximately 660 and 1,900 vehicles during the AM and PM peak periods, respectively, that were removed from the simulations for taking greater than 60 seconds on arterial (urban) links and 120 seconds on freeway links during lane change maneuvers. This is done by the software to prevent single vehicles from getting stuck during an entire simulation and producing unrealistic model results. The removal of vehicles is acceptable to allow the microsimulation to continue to function with high levels of congestion.

Travel times for freeway routes within the project are included in **Table 14** through **Table 17**. Non-congested travel times are also provided as a point of comparison. These were derived dividing the length of the freeway segment by the posted speed limit. The tables show congestion in at least one direction or during one peak.

Table 14: I-45 (Cavalcade St to Scott St) 2018 Existing Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Northbound Non-Congested Travel Time = 387 seconds					
Northbound	6:00-7:00 AM	410	Northbound	4:00-5:00 PM	673
Northbound	7:00-8:00 AM	421	Northbound	5:00-6:00 PM	700
Northbound	8:00-9:00 AM	456	Northbound	6:00-7:00 PM	610
Southbound Non-Congested Travel Time = 355 seconds					
Southbound	6:00-7:00 AM	615	Southbound	4:00-5:00 PM	757
Southbound	7:00-8:00 AM	1033	Southbound	5:00-6:00 PM	1032
Southbound	8:00-9:00 AM	1137	Southbound	6:00-7:00 PM	479

Table 15: I-69 (Quitman St to SH 288) 2018 Existing Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Northbound Non-Congested Travel Time = 265 seconds					
Northbound	6:00-7:00 AM	282	Northbound	4:00-5:00 PM	572
Northbound	7:00-8:00 AM	287	Northbound	5:00-6:00 PM	572
Northbound	8:00-9:00 AM	286	Northbound	6:00-7:00 PM	546
Southbound Non-Congested Travel Time = 261 seconds					
Southbound	6:00-7:00 AM	761	Southbound	4:00-5:00 PM	485
Southbound	7:00-8:00 AM	1612	Southbound	5:00-6:00 PM	598
Southbound	8:00-9:00 AM	2022	Southbound	6:00-7:00 PM	449

Table 16: I-10 (1-45 to Gregg St) 2018 Existing Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Eastbound Non-Congested Travel Time = 135 seconds					
Eastbound	6:00-7:00 AM	145	Eastbound	4:00-5:00 PM	222
Eastbound	7:00-8:00 AM	146	Eastbound	5:00-6:00 PM	260
Eastbound	8:00-9:00 AM	145	Eastbound	6:00-7:00 PM	254
Westbound Non-Congested Travel Time = 145 seconds					
Westbound	6:00-7:00 AM	211	Westbound	4:00-5:00 PM	196
Westbound	7:00-8:00 AM	425	Westbound	5:00-6:00 PM	214
Westbound	8:00-9:00 AM	468	Westbound	6:00-7:00 PM	198

Table 17: I-610 (Shepherd Dr to Irvington Blvd) 2018 Existing Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Eastbound Non-Congested Travel Time = 178 seconds					
Eastbound	6:00-7:00 AM	188	Eastbound	4:00-5:00 PM	354
Eastbound	7:00-8:00 AM	222	Eastbound	5:00-6:00 PM	480
Eastbound	8:00-9:00 AM	222	Eastbound	6:00-7:00 PM	406
Westbound Non-Congested Travel Time = 179 seconds					
Westbound	6:00-7:00 AM	267	Westbound	4:00-5:00 PM	198
Westbound	7:00-8:00 AM	405	Westbound	5:00-6:00 PM	192
Westbound	8:00-9:00 AM	404	Westbound	6:00-7:00 PM	232

Segment-Level Results

There were several FHWA-approved critical locations identified during the calibration process used for segment-level MOEs. These locations were analyzed in detail to evaluate the operational conditions of the existing network. **Table 18** shows the segment results for critical locations. Critical location results were calculated based on link segment evaluation results provided in the Vissim models included with this report.

Table 18: Existing Critical Location Segment Results

		Existing AM	Existing PM
Critical Location 1: I-10 EB weave between I-45 and McKee St	**Speed (mph)**	57.2	31.5
	Density (veh/mi/ln)	12.7	58.6
	Relative Delay (s/s)	0.01	0.45
Critical Location 2: I-10 WB weave between I-45 and McKee St	**Speed (mph)**	29.4	52.4
	Density (veh/mi/ln)	61.0	25.8
	Relative Delay (s/s)	0.49	0.09
Critical Location 3: I-69 SB weave from I-10 to Dallas St	**Speed (mph)**	13.7	57.0
	Density (veh/mi/ln)	116.2	16.0
	Relative Delay (s/s)	0.76	0.02
Critical Location 4: SH 288 NB weave from Elgin St to I-45	**Speed (mph)**	15.7	55.1
	Density (veh/mi/ln)	104.1	9.6
	Relative Delay (s/s)	0.73	0.05
Critical Location 5: I-45 SB weave from I-610 to Cavalcade St	**Speed (mph)**	30.5	55.2
	Density (veh/mi/ln)	75.7	25.2
	Relative Delay (s/s)	0.47	0.04
	Speed (mph)	55.9	43.3

		Existing AM	Existing PM
Critical Location 6: I-45 NB weave from Cavalcade St to I-610	**Density (veh/mi/ln)**	24.1	48.1
	Relative Delay (s/s)	0.03	0.26
Critical Location 7: I-10 EB weave from Jackson St Entrance to I-69	**Speed (mph)**	57.3	48.5
	Density (veh/mi/ln)	13.1	42.8
	Relative Delay (s/s)	0.01	0.16
Critical Location 8: I-10 WB from I-69 to Jackson St Exit	**Speed (mph)**	35.6	57.0
	Density (veh/mi/ln)	56.6	23.4
	Relative Delay (s/s)	0.39	0.02
Critical Location 9: I-45 SB weave from I-10 WB Entrance to Downtown Exits	**Speed (mph)**	19.6	26.6
	Density (veh/mi/ln)	94.3	79.5
	Relative Delay (s/s)	0.66	0.54
Critical Location 10: I-45 NB weave from Downtown Entrances to I-10 EB Exit	**Speed (mph)**	56.8	53.9
	Density (veh/mi/ln)	22.5	33.2
	Relative Delay (s/s)	0.02	0.07

As shown in **Table 18**, critical locations 3, 4, and 9 have the highest levels of congestion. Several of the critical locations experience congestion in only one of the peak periods.

In addition to the critical locations discussed above, segment-level results for each of the four freeways spanning the entire analysis limits were compared between No-Build and Build. Speed, density, and relative delay results are shown in **Table 19** through **Table 26** below. Segments with speeds below 30 mph are highlighted in red. A threshold of 30 miles per hour (mph) was chosen to identify freeway segments with visible congestion along the network. This speed falls in the area of either level of service (LOS) E or LOS F from the Highway Capacity Manual (HCM) and represents an area where disruptions to traffic flow will create a shock wave affecting upstream traffic, incidents will create serious delays, driver comfort is poor, and vehicles may operate with frequent slowing, breakdown of flow, and higher demand than capacity. Segment results were calculated based on link segment evaluation results provided in the Vissim models included with this report.

Table 19: Existing I-45 Northbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Exit to Collector-Distributor	Speed (mph)	47.9	10.5
		Density (veh/mi/ln)	38.4	121.0
		Relative Delay (s/s)	0.18	0.82

From	To	MOE	Existing AM	Existing PM
Exit to Collector-Distributor	Entrance from TX Spur 5	Speed (mph)	55.5	11.4
		Density (veh/mi/ln)	21.6	120.6
		Relative Delay (s/s)	0.04	0.80
Entrance from TX Spur 5	Entrance from Cullen Blvd	Speed (mph)	57.2	9.1
		Density (veh/mi/ln)	17.1	131.7
		Relative Delay (s/s)	0.01	0.84
Entrance from Cullen Blvd	Entrance from Scott St	Speed (mph)	54.6	11.1
		Density (veh/mi/ln)	23.5	122.2
		Relative Delay (s/s)	0.05	0.81
Entrance from Scott St	Emancipation Ave	Speed (mph)	50.6	23.0
		Density (veh/mi/ln)	34.5	83.5
		Relative Delay (s/s)	0.13	0.60
Emancipation Ave	Entrance from I-69 SB	Speed (mph)	49.5	38.6
		Density (veh/mi/ln)	36.2	56.8
		Relative Delay (s/s)	0.15	0.33
Entrance from I-69 SB	Entrance from I-69 NB	Speed (mph)	51.8	41.3
		Density (veh/mi/ln)	31.4	53.5
		Relative Delay (s/s)	0.10	0.29
Entrance from I-69 NB	Memorial Dr	Speed (mph)	56.5	56.4
		Density (veh/mi/ln)	30.1	34.3
		Relative Delay (s/s)	0.02	0.03
Memorial Dr	Exit to I-10 WB	Speed (mph)	56.5	54.2
		Density (veh/mi/ln)	24.4	34.7
		Relative Delay (s/s)	0.03	0.07
Exit to I-10 WB	White Oak Dr	Speed (mph)	56.8	55.0
		Density (veh/mi/ln)	21.7	34.0
		Relative Delay (s/s)	0.02	0.06
White Oak Dr	Exit to Main St	Speed (mph)	57.2	51.1

From	To	MOE	Existing AM	Existing PM
		Density (veh/mi/ln)	18.0	32.9
		Relative Delay (s/s)	0.01	0.12
Exit to Main St	Patton St	Speed (mph)	56.9	48.1
		Density (veh/mi/ln)	20.8	41.9
		Relative Delay (s/s)	0.02	0.18
Patton St	Exit to I-610	Speed (mph)	56.1	43.7
		Density (veh/mi/ln)	23.2	49.1
		Relative Delay (s/s)	0.03	0.25
Exit to I-610	Crosstimbers St	Speed (mph)	54.8	35.6
		Density (veh/mi/ln)	23.4	61.6
		Relative Delay (s/s)	0.05	0.39
Crosstimbers St	Airline Dr	Speed (mph)	54.4	43.2
		Density (veh/mi/ln)	28.1	51.7
		Relative Delay (s/s)	0.06	0.26
Airline Dr	Tidwell Rd	Speed (mph)	55.9	45.7
		Density (veh/mi/ln)	26.6	47.8
		Relative Delay (s/s)	0.04	0.21
Tidwell Rd	End	Speed (mph)	56.6	55.0
		Density (veh/mi/ln)	26.4	38.1
		Relative Delay (s/s)	0.02	0.05

Table 20: Existing I-45 Southbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Tidwell Rd	Speed (mph)	26.0	41.3
		Density (veh/mi/ln)	91.1	50.2
		Relative Delay (s/s)	0.55	0.29
Tidwell Rd	Airline Dr	Speed (mph)	27.0	54.9
		Density (veh/mi/ln)	87.1	26.9

From	To	MOE	Existing AM	Existing PM
		Relative Delay (s/s)	0.53	0.05
Airline Dr	Crosstimbers St	Speed (mph)	26.6	55.0
		Density (veh/mi/ln)	85.4	26.3
		Relative Delay (s/s)	0.54	0.05
Crosstimbers St	I-610	Speed (mph)	26.8	55.2
		Density (veh/mi/ln)	83.1	26.9
		Relative Delay (s/s)	0.54	0.05
I-610	Patton St	Speed (mph)	30.3	53.8
		Density (veh/mi/ln)	78.1	28.3
		Relative Delay (s/s)	0.48	0.07
Patton St	Main St	Speed (mph)	30.7	47.0
		Density (veh/mi/ln)	75.3	42.3
		Relative Delay (s/s)	0.47	0.19
Main St	White Oak Dr	Speed (mph)	26.7	43.0
		Density (veh/mi/ln)	83.7	44.9
		Relative Delay (s/s)	0.54	0.26
White Oak Dr	I-10	Speed (mph)	22.8	36.0
		Density (veh/mi/ln)	95.4	61.5
		Relative Delay (s/s)	0.61	0.38
I-10	Memorial Dr	Speed (mph)	19.3	25.9
		Density (veh/mi/ln)	96.5	81.5
		Relative Delay (s/s)	0.67	0.55
Memorial Dr	W Dallas St	Speed (mph)	15.0	17.8
		Density (veh/mi/ln)	113.3	98.5
		Relative Delay (s/s)	0.74	0.69
W Dallas St	Exit to I-69	Speed (mph)	24.9	29.8
		Density (veh/mi/ln)	86.1	68.8
		Relative Delay (s/s)	0.57	0.49

From	To	MOE	Existing AM	Existing PM
Exit to I-69	St Joseph Pkwy	Speed (mph)	53.1	56.6
		Density (veh/mi/ln)	35.5	22.9
		Relative Delay (s/s)	0.08	0.02
St Joseph Pkwy	Scott St	Speed (mph)	55.5	56.9
		Density (veh/mi/ln)	26.4	19.0
		Relative Delay (s/s)	0.04	0.02
Scott St	Cullen Pkwy	Speed (mph)	47.3	55.8
		Density (veh/mi/ln)	26.9	16.2
		Relative Delay (s/s)	0.18	0.04
Cullen Pkwy	End	Speed (mph)	56.1	57.0
		Density (veh/mi/ln)	25.0	18.4
		Relative Delay (s/s)	0.03	0.02

Table 21: Existing I-69 Northbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Exit Main St	Speed (mph)	57.6	7.2
		Density (veh/mi/ln)	18.9	143.1
		Relative Delay (s/s)	0.01	0.88
Exit Main St	Exit US 288	Speed (mph)	57.2	9.5
		Density (veh/mi/ln)	17.2	125.8
		Relative Delay (s/s)	0.01	0.84
Exit US 288	McGowen St	Speed (mph)	56.7	13.9
		Density (veh/mi/ln)	17.2	105.4
		Relative Delay (s/s)	0.02	0.76
McGowen St	Leeland St	Speed (mph)	55.1	32.3
		Density (veh/mi/ln)	24.8	69.5
		Relative Delay (s/s)	0.05	0.44
Leeland St	Entrance from Ruiz St	Speed (mph)	57.3	56.0
		Density (veh/mi/ln)	14.2	30.4
		Relative Delay (s/s)	0.01	0.03
Entrance from Ruiz St	End	Speed (mph)	57.7	56.5
		Density (veh/mi/ln)	9.0	24.5
		Relative Delay (s/s)	0.00	0.02

Table 22: Existing I-69 Southbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Lyons St	Speed (mph)	27.5	57.5
		Density (veh/mi/ln)	82.7	16.8
		Relative Delay (s/s)	0.53	0.01
Lyons St	Entrance from I-10	Speed (mph)	13.3	55.8
		Density (veh/mi/ln)	121.8	19.7
		Relative Delay (s/s)	0.77	0.04

From	To	MOE	Existing AM	Existing PM
Entrance from I-10	Leeland St	Speed (mph)	10.1	39.7
		Density (veh/mi/ln)	125.6	53.1
		Relative Delay (s/s)	0.83	0.32
Leeland St	McGowan St	Speed (mph)	10.8	31.0
		Density (veh/mi/ln)	117.5	68.3
		Relative Delay (s/s)	0.81	0.47
McGowan St	Elgin St	Speed (mph)	20.8	29.8
		Density (veh/mi/ln)	73.5	57.7
		Relative Delay (s/s)	0.64	0.49
Elgin St	Entrance from Spur 527	Speed (mph)	54.6	55.2
		Density (veh/mi/ln)	33.0	31.5
		Relative Delay (s/s)	0.05	0.05
Entrance from Spur 527	End	Speed (mph)	56.9	56.9
		Density (veh/mi/ln)	22.7	22.1
		Relative Delay (s/s)	0.02	0.02

Table 23: Existing I-10 Eastbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Taylor St	Speed (mph)	22.7	18.8
		Density (veh/mi/ln)	102.6	102.7
		Relative Delay (s/s)	0.61	0.68
Taylor St	I-45 Exit Ramp	Speed (mph)	18.7	18.7
		Density (veh/mi/ln)	100.4	93.9
		Relative Delay (s/s)	0.68	0.68
I-45 Exit Ramp	NB I-45 Overpass	Speed (mph)	39.2	20.2
		Density (veh/mi/ln)	34.2	91.0
		Relative Delay (s/s)	0.32	0.65
NB I-45 Overpass		Speed (mph)	55.1	38.1

From	To	MOE	Existing AM	Existing PM
	NB I-45 Entrance (No-Build)/SB I-45 Entrance (Build)	Density (veh/mi/ln)	11.6	56.2
		Relative Delay (s/s)	0.03	0.33
NB I-45 Entrance (No-Build)/SB I-45 Entrance (Build)	SB I-69 Exit Ramp	Speed (mph)	57.1	41.4
		Density (veh/mi/ln)	13.6	50.2
		Relative Delay (s/s)	0.01	0.28
SB I-69 Exit Ramp	NB I-69 Entrance Ramp	Speed (mph)	57.6	53.1
		Density (veh/mi/ln)	9.9	33.4
		Relative Delay (s/s)	0.01	0.08
NB I-69 Entrance Ramp	East Freeway Entrance Ramp	Speed (mph)	57.0	56.6
		Density (veh/mi/ln)	12.9	26.2
		Relative Delay (s/s)	0.01	0.02
East Freeway Entrance Ramp	Schweikhardt St	Speed (mph)	57.2	54.9
		Density (veh/mi/ln)	14.7	29.3
		Relative Delay (s/s)	0.01	0.05
Schweikhardt St	End	Speed (mph)	57.4	56.5
		Density (veh/mi/ln)	15.1	30.2
		Relative Delay (s/s)	0.01	0.02

Table 24: Existing I-10 Westbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Waco St	Speed (mph)	31.4	14.1
		Density (veh/mi/ln)	77.2	105.3
		Relative Delay (s/s)	0.46	0.76
Waco St	East Fwy Service Road (No-Build)/Benson St (Build)	Speed (mph)	29.3	18.2
		Density (veh/mi/ln)	88.8	102.6
		Relative Delay (s/s)	0.49	0.69
East Fwy Service Road (No-Build)/Benson St (Build)	NB I-69 Exit Ramp	Speed (mph)	27.3	35.4
		Density (veh/mi/ln)	79.2	57.9

From	To	MOE	Existing AM	Existing PM
		Relative Delay (s/s)	0.53	0.39
NB I-69 Exit Ramp	SB I-69 Exit Ramp (Build)	Speed (mph)	27.0	51.4
		Density (veh/mi/ln)	84.5	33.9
		Relative Delay (s/s)	0.54	0.11
SB I-69 Exit Ramp (Build)	SB I-69 Entrance Ramp	Speed (mph)	39.4	55.3
		Density (veh/mi/ln)	48.5	24.6
		Relative Delay (s/s)	0.32	0.05
SB I-69 Entrance Ramp	NB I-69 Entrance Ramp	Speed (mph)	38.1	56.4
		Density (veh/mi/ln)	56.3	25.3
		Relative Delay (s/s)	0.34	0.03
NB I-69 Entrance Ramp	N. Main St	Speed (mph)	34.0	56.4
		Density (veh/mi/ln)	62.7	26.7
		Relative Delay (s/s)	0.41	0.03
N. Main St	NB I-45 Exit Ramp	Speed (mph)	30.6	50.3
		Density (veh/mi/ln)	54.6	26.0
		Relative Delay (s/s)	0.47	0.13
NB I-45 Exit Ramp	NB I-45 Entrance Ramp	Speed (mph)	52.7	53.8
		Density (veh/mi/ln)	30.7	32.7
		Relative Delay (s/s)	0.09	0.07
NB I-45 Entrance Ramp	Taylor St	Speed (mph)	56.3	54.7
		Density (veh/mi/ln)	24.7	29.2
		Relative Delay (s/s)	0.03	0.06
Taylor St	End	Speed (mph)	56.8	56.1
		Density (veh/mi/ln)	24.4	26.7
		Relative Delay (s/s)	0.02	0.03

Table 25: Existing I-610 Eastbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Main St	Speed (mph)	55.3	19.0
		Density (veh/mi/ln)	32.7	95.8
		Relative Delay (s/s)	0.05	0.67
Main St	IH-45	Speed (mph)	47.7	40.7
		Density (veh/mi/ln)	38.1	48.3
		Relative Delay (s/s)	0.18	0.30
IH-45	Irvington Blvd Exit Ramp	Speed (mph)	56.6	55.7
		Density (veh/mi/ln)	17.3	20.3
		Relative Delay (s/s)	0.01	0.03
Irvington Blvd Exit Ramp	Hardy Toll Rd	Speed (mph)	57.0	56.5
		Density (veh/mi/ln)	17.2	19.8
		Relative Delay (s/s)	0.02	0.03
Hardy Toll Rd	End	Speed (mph)	56.2	55.2
		Density (veh/mi/ln)	20.4	22.5
		Relative Delay (s/s)	0.03	0.05

Table 26: Existing I-610 Westbound Segment Results

From	To	MOE	Existing AM	Existing PM
Start	Hardy Toll Rd	Speed (mph)	54.6	54.5
		Density (veh/mi/ln)	23.4	27.4
		Relative Delay (s/s)	0.06	0.06
Hardy Toll Rd	Irvington Blvd	Speed (mph)	37.1	54.8
		Density (veh/mi/ln)	56.6	23.1
		Relative Delay (s/s)	0.35	0.05
Irvington Blvd	Fulton St	Speed (mph)	20.4	43.6
		Density (veh/mi/ln)	83.5	37.9

From	To	MOE	Existing AM	Existing PM
		Relative Delay (s/s)	0.65	0.25
Fulton St	IH-45	Speed (mph)	38.0	46.2
		Density (veh/mi/ln)	53.1	40.4
		Relative Delay (s/s)	0.34	0.20
IH-45	Main St	Speed (mph)	56.1	56.1
		Density (veh/mi/ln)	26.4	24.7
		Relative Delay (s/s)	0.03	0.03
Main St	End	Speed (mph)	55.6	56.5
		Density (veh/mi/ln)	31.3	27.6
		Relative Delay (s/s)	0.04	0.02

As illustrated, each freeway contains segments which operate below 30 mph in at least one direction or one peak period. The following locations, highlighted in red above and summarized below, were the considered with the critical location points as focal areas of operational improvements in schematic development.

- I-45 Northbound
    - Existing PM: Between the southern entrance to the I-45 network through Emancipation Avenue.
- I-45 Southbound
    - Existing AM: Between the northern entrance to the I-45 network through the interchange with I-610 and between Main Street and exit to I-69. I-45 is modeled as tying back to the existing cross-section at the project limits. The completion of NHHIP Segment 1 will alleviate the congestion in this area.
    - Existing PM: Between the interchange with I-10 and exit to I-69
- I-69 Northbound
    - Existing PM: Between the southern entrance to the I-69 network through McGowen Street. I-69 is modeled as tying back to the existing cross-section at the project limits.
- I-69 Southbound
    - Existing AM: Between the northern entrance to the I-69 network through Elgin Street. I-69 is modeled as tying back to the existing cross-section at the project limits.
    - Existing PM: Between McGowen Street and Elgin Street

- I-10 Eastbound
    - Existing AM: Between the western entrance to the I-10 network through the I-45 exit ramp. I-10 is modeled as tying back to the existing cross-section at the project limits.
    - Existing PM: Between the eastern entrance to the I-10 network and the northbound I-45 overpass. I-10 is modeled as tying back to the existing cross-section at the project limits.
- I-10 Westbound
    - Existing AM: Between Waco Street and the southbound I-69 exit build ramp (location noted from the build network)
    - Existing PM: Between the eastern entrance to the I-10 network through the East Freeway Service Road. I-10 is modeled as tying back to the existing cross-section at the project limits.
- I-610 Eastbound
    - Existing PM: Between the western entrance to the I-610 network through Main Street. I-610 is modeled as tying back to the existing cross-section at the project limits.
- I-610 Westbound
    - Existing AM: Between Irvington Boulevard and Fulton Street

In addition to identifying freeway deficiencies, the local street network intersections that provide access to the Interstate were analyzed. **Table 27** shows the average delay for the intersections in the study area from Vissim microsimulation software. Average vehicle delay can be compared to the level of service (LOS) thresholds within the HCM to gauge which intersections are expected to fail (operate with LOS E or LOS F). The threshold for LOS E is 55 seconds per vehicle. Intersections with average vehicle delay over 55 seconds are highlighted in red.

Table 27: 2018 Intersection Delay - Base Year Results

Intersection	Average Vehicle Delay (sec/veh)	
	2018 AM	2018 PM
Tidwell St at I-45 NBFR	24.4	24.1
Tidwell St at I-45 SBFR	22.0	22.6
Airline Dr at I-45 SBFR	20.1	24.6
Airline Dr at I-45 NBFR	27.2	46.2
Crosstimbers St at I-45 NBFR	30.4	34.0

Table 27: 2018 Intersection Delay - Base Year Results

Intersection	Average Vehicle Delay (sec/veh)	
	2018 AM	2018 PM
Crosstimbers St at I-45 SBFR	17.7	44.7
Airline Dr at 40 1/2 Street	17.7	10.1
Airline Dr at I-610 WBFR	36.3	12.8
Airline Dr at I-610 EBFR	21.2	24.4
Main St at I-610 EBFR	18.3	23.5
Main St at I-610 WBFR	34.6	22.8
Fulton St at I-610 EBFR	9.5	21.7
Fulton St at I-610 WBFR	30.2	19.4
Irvington Blvd at I-610 EBFR	13.3	22.0
Irvington Blvd at I-610 WBFR	31.6	22.0
Link St at I-45 NBFR	22.3	7.3
Link St at I-45 SBFR	7.4	7.1
Cavalcade St at I-45 SBFR	19.5	26.2
Cavalcade St at I-45 NBFR	33.4	21.1
Patton St at I-45 NBFR	31.9	9.8
Patton St at I-45 SBFR	16.4	8.5
Cottage St at I-45 NBFR	2.5	2.5
Cottage St at I-45 SBFR	1.2	1.9
Main St at I-45 NBFR	3.4	6.4
Main St at I-45 SBFR	27.8	34.2
Houston Ave at I-45 S from Main St Ramp	1.8	3.7
White Oak Dr at I-45 SB Ramp	8.4	9.8
White Oak Dr at I-45 N Ramp	15.2	8.0
Taylor St at I-10 EBFR	41.8	57.6
Taylor St at I-10 WBFR	18.9	19.6
Quitman St at I-69 SBFR	43.5	30.0

Table 27: 2018 Intersection Delay - Base Year Results

Intersection	Average Vehicle Delay (sec/veh)	
	2018 AM	2018 PM
Quitman St at I-69 NBFR	31.0	32.5
Lyons St at I-69 NBFR	8.5	4.4
Lyons St at I-69 SBFR	26.8	22.1
Gregg St at I-10 EBFR	6.2	6.7
Gregg St at I-10 WBFR	8.7	1.6
Waco St at I-10 EBFR	10.5	15.7
Waco St at I-10 WBFR	30.6	69.5
Chartres St at Commerce St	15.5	21.0
Commerce St at Hamilton St	16.0	15.1
Ruiz St at Chenevert St	15.5	5.0
Ruiz St at Jackson St	15.2	1.1
Chartres St at Capitol St	9.2	6.1
Runnels St at Chartres St	2.6	4.3
Nance St at McKee St	3.1	3.1
Rothwell St at McKee St	2.5	1.3
Providence St at McKee St	21.4	18.9
N San Jacinto St at Providence St	4.6	3.8
N San Jacinto St at Rothwell St	13.4	45.2
Hamilton St at Stuart St	0.9	4.7
Chenevert St at Holman St	6.8	6.6
Berry St at Chenevert St	3.2	24.2
Alabama St at Chenevert St	1.0	2.4
Elgin St at I-69 NBFR	21.3	20.8
Elgin St at I-69 SBFR	6.7	18.9
Tuam St at I-69 NBFR	16.6	9.5
Tuam St at I-69 SBFR	13.5	13.6

Table 27: 2018 Intersection Delay - Base Year Results

Intersection	Average Vehicle Delay (sec/veh)	
	2018 AM	2018 PM
McGowen St at I-69 NBFR	12.4	23.1
McGowen St at I-69 SBFR	16.2	18.5
Webster St at I-45 SBFR	17.3	15.7
St Joseph Pkwy at Emancipation Ave	17.0	20.6
Jefferson St at Emancipation Ave	26.0	23.0
Pease St at Emancipation Ave	31.4	29.5
Chartres St at Leeland St	16.9	18.1
Hamilton St at Leeland St	9.5	13.0
Hamilton St at Bell Street	21.4	22.3
St. Emanuel St at Polk St	22.1	15.0
Scott St at I-45 SBFR	26.2	31.9
Scott St at I-45 NBFR	12.0	10.1
Cullen Blvd at I-45 SBFR	15.9	17.5
Cullen Blvd at I-45 NBFR	27.3	36.3
Pierce St at Bagby St	2.0	1.6
Pierce St at Brazos St	41.5	27.9
Pierce St at Smith St	6.6	7.6
St Joseph Pkwy at Brazos St	5.9	4.4
St Joseph Pkwy at Smith St	11.4	11.8
Jefferson St at Smith St	13.2	9.1
Jefferson St at Brazos St	16.6	18.4
Pease St at Smith St	14.8	35.9
Pease St at Brazos St	21.7	104.7
W Dallas St at Gulf Fwy	4.7	46.3
W Dallas St at Heiner St	20.7	10.5
McKinney St at Bagby St	26.0	35.7

Table 27: 2018 Intersection Delay - Base Year Results

Intersection	Average Vehicle Delay (sec/veh)	
	2018 AM	2018 PM
Walker St at Bagby St	31.6	44.2
Memorial Dr at Houston Ave NB	1.2	7.5
Memorial Dr at Houston Ave SB	5.3	52.6
Memorial Way at Houston Ave NB	3.6	27.1
Memorial Way at Houston Ave SB	3.2	7.2
Franklin St at Smith St	13.1	15.2
Louisiana St at Franklin St	6.9	20.7
Milam St at Commerce St	18.4	17.3
Commerce St at Travis St	18.0	20.0
Jensen Dr at Providence St	0.8	0.3
Main St at Wentworth St	4.5	3.9
Fannin St at Blodgett St	1.5	2.7
Richmond St at Spur 527 NBFR	27.2	42.0
Richmond St at Spur 527 SBFR	28.7	30.3
Southmore Blvd at SH 288 NBFR	73.5	199.8
Southmore Blvd at SH 288 SBFR	21.9	57.8
Chartres St at Rusk St	25.0	54.8

As shown in **Table 27**, the Existing AM network had one intersection with average vehicle delay above 55 seconds and the Existing PM network had five. The locations of Southmore Boulevard at SH 288, Pease Street at Brazos Street, Taylor Street at I-10, and Waco Street at I-10 were either considered for local improvements or improved by freeway congestion relief.

Network 15-Minute Variation

A critical component to the analysis was capturing the change in network performance over 15-minute intervals. The AM and PM peak periods had varying traffic characteristics and fluctuating levels of congestion. The AM peak period begins with highways at free flow conditions throughout the project area, then begins to breakdown as demand exceeds capacity from 6:30 AM to 9:00 AM. By 9:00 AM, the speeds begin to increase. In the PM peak period, demand is high with spot-location congestion at the start of the peak period, 4:00 PM, and the congestion continues to about 6:30 PM. After 6:30 speeds begin to increase. The overall network speed begins to recover in both peak periods in the late stages of the peak period.

Each 15-minute demand at entry locations was analyzed to ensure that the variation in congestion through the network adequately replicated general traffic conditions. Mainlane volumes were estimated by obtaining counts at uncongested points of the network and calculating adjacent traffic volumes forwards and backwards through the network to estimate input demand. In addition, video of count locations were reviewed to ensure that ramps with congestion or metering had adequate traffic demand estimates. Speed maps in 15-minute intervals are included in **Appendix H**, along with TranStar speed maps corresponding to the elected calibration date.

3.8 *Existing Safety Conditions*

The Texas Strategic Highway Safety Plan's mission is to reduce human and societal costs of highway traffic crashes, deaths, and injuries by implementing effective highway safety countermeasures and by changing the driving culture in the state. As such, historical crash records were obtained from the Crash Records Information System (CRIS) query by TxDOT and a crash rate per 100 million vehicles miles travelled for the corridors were determined. The CRIS query is an application available from TxDOT which allows the public to obtain traffic crash details for all reported crashes within the state of Texas. CRIS data included specific information for all recorded crashes including: location, date, time, crash severity, crash type, crash injury classification, as well as various roadway and environmental factors. There were a total of 11,965 categorized and reported crashes from January 1, 2015 to December 31, 2018 in the project area.

The crash rate for each year was calculated using the following formula:

$$R = \frac{C\ x\ 100{,}000{,}000}{V\ x\ 365\ x\ L}$$

Where,

- R = Roadway crash rate for the road segment expressed as crashes per 100 million vehicle-miles of travel
- C = Total number of roadway crashes in the study period
- V = Traffic volumes using Average Annual Daily Traffic (AADT) volumes
- L = Length of the roadway segment in miles

Crash rates between 2015 and 2018 were compared to statewide averages for urban interstate systems. **Table 28** shows the project area crash rates compared to the statewide average for each of the urban interstate systems within the project area. A graphical representation of this data is shown in **Figure 10.**

Crashes along I-69 and SH 288 were grouped together due to close proximity to one another and inconsistencies in crash reporting in the CRIS database. There were multiple instances where a crash along SH 288 and I-69 were documented as one highway, but the coordinates show the opposite. The graphical representation of data within GIS shows this with many crashes along I-69 and SH 288 being applied to the same location. The large amount of weaving is likely the source of confusion within this area for police officers completing crash reports, leading to the mis-represented data. Therefore, the data from I-69 and SH 288 near the system interchange was grouped to provide an overall representation of what is happening between this location and the interchange of I-45 and I-69.

Additionally, it was noted that most crashes at the I-45 and I-69 interchange were assigned to I-45. This attributes to the lower number of crashes along I-69 within the project area which consequently lowered the crash rate compared to the other interstates within the project limits.

Table 28: Crash Rates 2015-2018

Roadway	Year	Crashes	AADT	Crash Rates *	Statewide Average (Urban Interstate)
I-45 (North of I-610)	2015	525	244,962	264.49	141.20
	2016	457	253,697	222.31	145.88
	2017	433	236,910	225.56	141.29
	2018	447	250,224	220.46	135.95
I-45 (South of I-610)	2015	1,216	211,054	211.31	141.20
	2016	1,178	223,512	193.30	145.88
	2017	1,114	213,124	191.71	141.29
	2018	1,004	213,543	172.44	135.95
I-69	2015	329	197,775	68.64	141.20
	2016	348	203,687	70.49	145.88
	2017	371	193,655	79.05	141.29
	2018	450	194,557	95.43	135.95
I-10	2015	557	197,976	150.55	141.20
	2016	545	172,412	169.15	145.88
	2017	594	174,036	182.64	141.29
	2018	508	188,978	143.84	135.95
I-610	2015	458	161,014	183.80	141.20
	2016	468	185,221	163.27	145.88
	2017	496	190,446	168.29	141.29
	2018	467	188,072	160.45	135.95

* expressed as crashes per 100 million vehicle-miles of travel

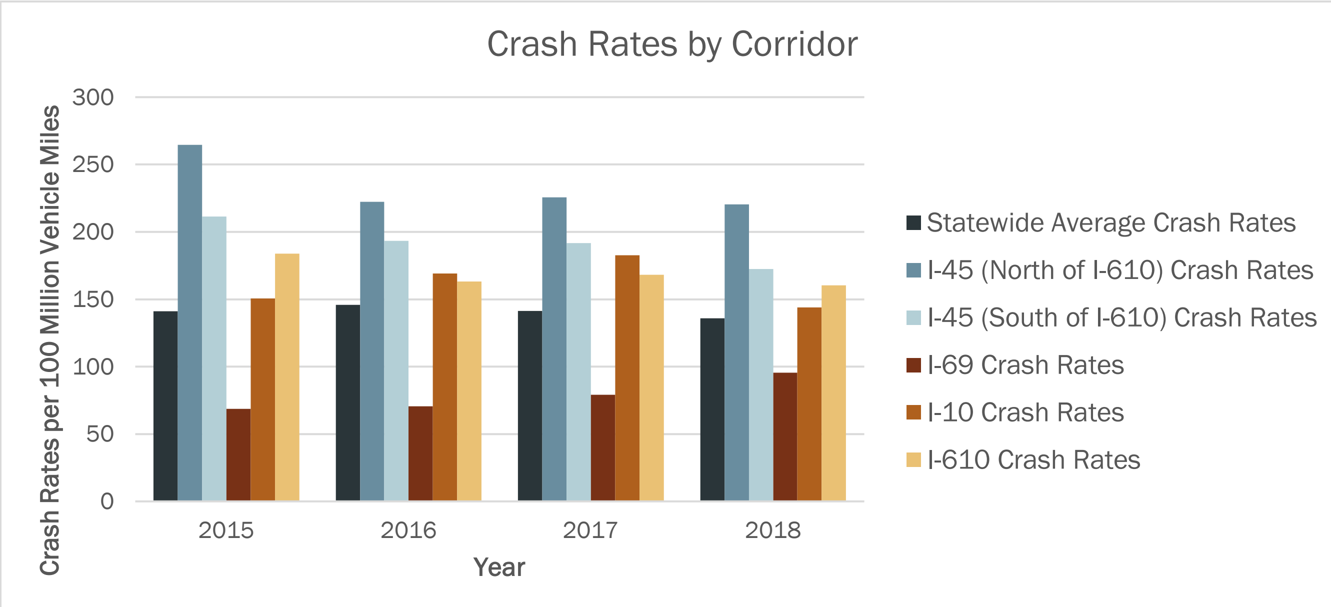

Figure 10: Corridor Average Crash Rates by Year (2015-2018)

As shown in **Table 28** and **Figure 10**, the crash rates of the interstates within the project area are higher than the Statewide average crash rates for the four (4) years, with the exception of I-69.

The crash severities within the project limits were also analysed. Crashes were classified as: non-injury crashes (69% - 8,248 crashes total within the project limits) or possible injury crashes (21% - 2,486 crashes total within the project limits). The remaining crash injuries (10%) include fatalities, incapacitating injuries, and non-incapacitating injury crashes. Of the total 11,965 crashes, 47 were reported as fatalities, 141 were reported as incapacitating injury crashes, and 788 were reported as non-incapacitating injury crashes. **Tables 29** and **30** show crash severity by year and by facility type, respectively. **Table 31** shows the percentages of types of crashes along each segment for each year.

Table 29: Crash Severity by Year (2015-2018)

Roadway	Year	Fatal	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	Not Injured	Unknown	Total
I-45 (North of I-610)	2015	0	7	32	119	357	10	525
	2016	3	5	31	94	319	5	457
	2017	2	4	21	96	303	7	433
	2018	2	1	18	93	322	11	447
I-45 (South of I-610)	2015	7	12	69	280	827	21	1,216
	2016	5	12	78	250	821	12	1,178
	2017	3	10	77	222	774	28	1,114
	2018	4	9	52	232	686	21	1,004
I-69	2015	5	6	32	72	207	7	329
	2016	1	7	23	66	245	6	348
	2017	1	6	36	61	259	8	371
	2018	2	6	35	87	312	8	450
I-10	2015	1	5	22	119	389	21	557
	2016	0	13	38	103	373	18	545
	2017	3	7	38	104	429	13	594
	2018	0	6	35	97	355	15	508
I-610	2015	3	8	39	106	292	10	458
	2016	3	8	43	92	312	10	468
	2017	1	5	44	90	346	10	496
	2018	1	4	25	103	320	14	467
Total	Grand Total	47	141	788	2,486	8,248	255	11,965

Table 30: Crash Severity by Facility Type

Roadway	Facility Type	Fatal	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	Not Injured	Unknown	Total on Segment
I-45 (North of I-610)	Main Lane	5	15	75	329	1040	24	1488
	Frontage Road	1	2	25	67	232	9	336
	Entrance/ Exit Ramp	1	0	2	6	29	0	38
	Total	7	17	102	402	1301	33	1862
I-45(South of I-610)	Main Lane	15	30	247	903	2779	63	4037
	Frontage Road	1	11	19	58	229	14	332
	Entrance/ Exit Ramp	3	2	10	23	100	5	143
	Total	19	43	276	984	3108	82	4512
I-69	Main Lane	8	18	111	232	845	22	1236
	Frontage Road	0	3	7	25	72	1	108
	Entrance/ Exit Ramp	1	4	8	29	106	6	154
	Total	9	25	126	286	1023	29	1498
I-10	Main Lane	3	31	124	394	1426	58	2036
	Frontage Road	0	0	6	16	81	6	109
	Entrance/ Exit Ramp	1	0	3	13	39	3	59
	Total	4	31	133	423	1546	67	2204
I-610	Main Lane	8	20	112	307	1019	23	1489
	Frontage Road	0	4	35	78	216	16	349
	Entrance/ Exit Ramp	0	1	4	6	35	5	51
	Total	8	25	151	391	1270	44	1889
Total	Grand Total	47	141	788	2,486	8,248	255	11,965

Table 31: Crash Severity by Facility Type (Percentage)

Roadway	Year	Fatal	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	Not Injured	Unknown	Total on Segment
I-45 (North of I-610)	2015	0.00%	1.33%	6.10%	22.67%	68.00%	1.90%	100.00%
	2016	0.66%	1.09%	6.78%	20.57%	69.80%	1.09%	100.00%
	2017	0.46%	0.92%	4.85%	22.17%	69.98%	1.62%	100.00%
	2018	0.45%	0.22%	4.03%	20.81%	72.04%	2.46%	100.00%
	Total	0.38%	0.91%	5.48%	21.59%	69.87%	1.77%	100.00%
I-45 (South of I-610)	2015	0.58%	0.99%	5.67%	23.03%	68.01%	1.73%	100.00%
	2016	0.42%	1.02%	6.62%	21.22%	69.69%	1.02%	100.00%
	2017	0.27%	0.90%	6.91%	19.93%	69.48%	2.51%	100.00%
	2018	0.40%	0.90%	5.18%	23.11%	68.33%	2.09%	100.00%
	Total	0.42%	0.95%	6.12%	21.81%	68.88%	1.82%	100.00%
I-69	2015	1.52%	1.82%	9.73%	21.88%	62.92%	2.13%	100.00%
	2016	0.29%	2.01%	6.61%	18.97%	70.40%	1.72%	100.00%
	2017	0.27%	1.62%	9.70%	16.44%	69.81%	2.16%	100.00%
	2018	0.44%	1.33%	7.78%	19.33%	69.33%	1.78%	100.00%
	Total	0.60%	1.67%	8.41%	19.09%	68.29%	1.94%	100.00%
I-10	2015	0.18%	0.90%	3.95%	21.36%	69.84%	3.77%	100.00%
	2016	0.00%	2.39%	6.97%	18.90%	68.44%	3.30%	100.00%
	2017	0.51%	1.18%	6.40%	17.51%	72.22%	2.19%	100.00%
	2018	0.00%	1.18%	6.89%	19.09%	69.88%	2.95%	100.00%
	Total	0.18%	1.41%	6.03%	19.19%	70.15%	3.04%	100.00%
I-610	2015	0.66%	1.75%	8.52%	23.14%	63.76%	2.18%	100.00%
	2016	0.64%	1.71%	9.19%	19.66%	66.67%	2.14%	100.00%
	2017	0.20%	1.01%	8.87%	18.15%	69.76%	2.02%	100.00%
	2018	0.21%	0.86%	5.35%	22.06%	68.52%	3.00%	100.00%
	Total	0.42%	1.32%	7.99%	20.70%	67.23%	2.33%	100.00%
	2015	0.52%	1.23%	6.29%	22.56%	67.16%	2.24%	100.00%

Roadway	Year	Fatal	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	Not Injured	Unknown	Total on Segment
Project Area	2016	0.40%	1.50%	7.11%	20.19%	69.09%	1.70%	100.00%
	2017	0.33%	1.06%	7.18%	19.05%	70.18%	2.19%	100.00%
	2018	0.31%	0.90%	5.74%	21.28%	69.37%	2.40%	100.00%
	Total	0.39%	1.18%	6.59%	20.78%	68.93%	2.13%	100.00%

As shown, the total percentage of KA crashes (fatal and incapacitating injury) for each segment are all under four percent. The segment with the highest percentage of KA crashes was I-69 with 2.27 percent of crashes. In 2015, 3.34% of crashes were classified as KA crashes. There was no major construction along I-69 during this time, however there were several flooding events that affected the project area and contributed to the total number of KA crashes in 2015, 2016, and 2017 (Hurricane Harvey). It was found that 13% of KA crashes occurred in standing water or wet conditions along the roadways.

Appendix I includes figures which show the location of the incapacitating and fatal injuries along all roadways within our project limits. Two locations stood out for the amount of fatal and incapacitating crashes that occurred;

1. Westbound I-610 at and downstream of the I-45 northbound/southbound to WB I-610 merge
2. Northbound I-45 approaching the I-69 interchange

Westbound I-610 is being addressed in the Build alternative with the reconstruction of direct connectors, addition of collector distributors and removal of 1,300-foot weave. NB I-45 is being addressed in the proposed Build alternative with the realignment of I-45 and reconstruction of the I-45 to I-69 direct connectors with increased curve radii.

According to the CRIS data, 11,965 crashes were recorded within the project area over the four (4) year period from 2015-2018. **Figure 11** shows crash type by facility for all analysis years. **Figure 12** shows a comparison of the crash types for all facilities within the project limits.

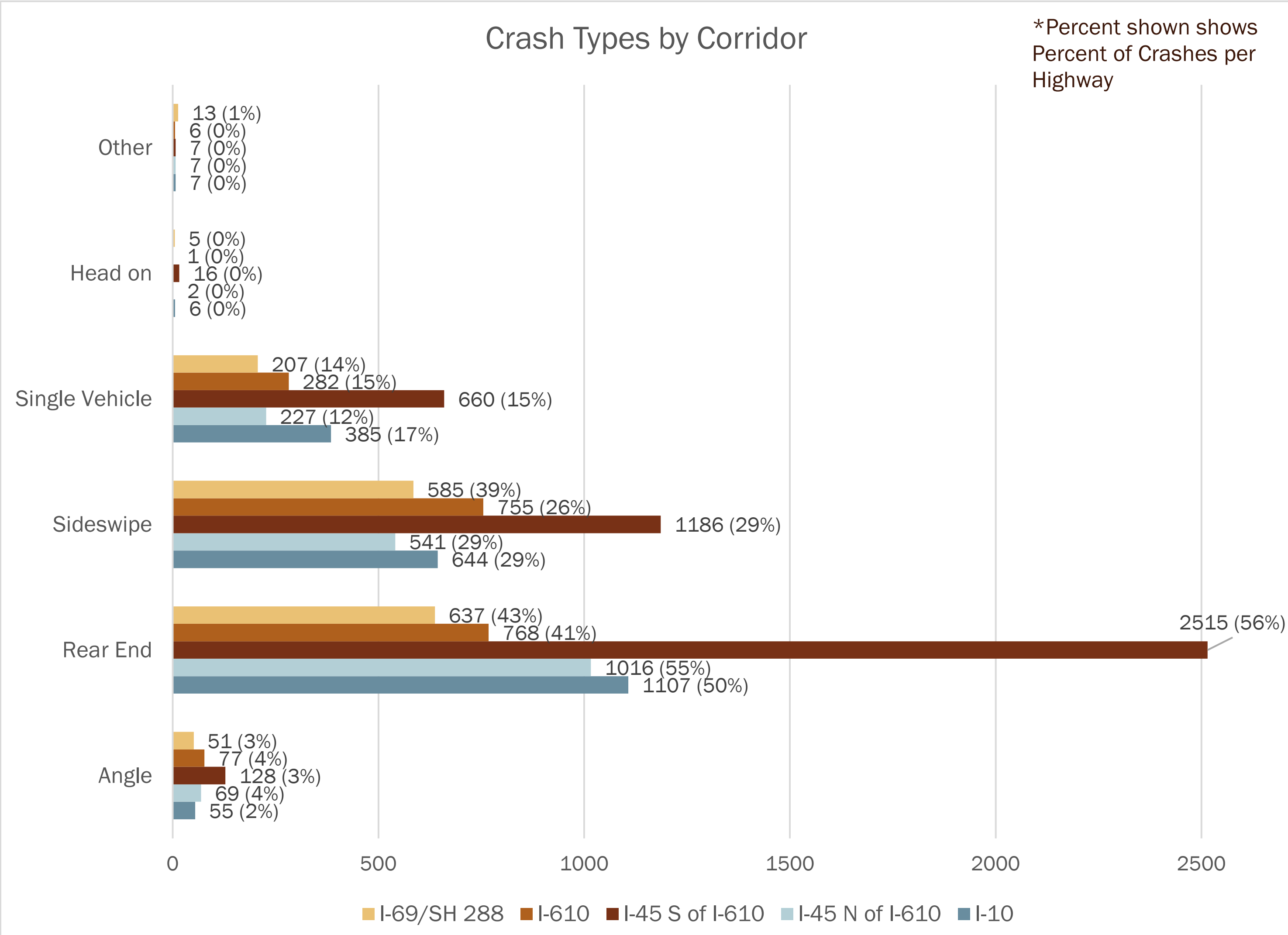

Figure 11: Crash Type by Corridor

As shown in **Figure 11**, I-45 south of I-610 contains the most crashes, as it has the longest limits (7.74 miles). I-45 also has the highest proportion of rear-end crashes compared to the other interstates. This is likely due to large amounts of congestion noted during existing conditions. I-69 and SH 288 show the highest proportion of sideswipe collisions, likely due to the weave segments to and from I-45 and I-10. **Table 32** and **Figure 12** show the crash types for all facilities.

Table 32: Crash Type for all Facilities

Crash Type	I-45 N of I-610	I-45 S of I-610	I-69	I-10	I-610	Total
Angle	4%	3%	3%	2%	4%	3%
Rear End	55%	56%	43%	50%	41%	51%
Sideswipe	29%	26%	39%	29%	40%	31%
Single Vehicle	12%	15%	14%	17%	15%	15%
Head On	0%	0%	0%	0%	0%	0%
Other	0%	0%	1%	0%	0%	0%
Total	100%	100%	100%	100%	100%	-

As shown in **Table 32**, rear end crashes are most common along I-45 (56%), south of I-610 with a higher average than the entire network (51%). Sideswipe crashes are most common along I-69 and I-610 at 39% and 40%, respectively in comparison to the entire network average of 31%. This could be due to the large amount of weaving or merging in these sections. Single vehicle, angle, and head on crashes are relatively the same along all facilities in comparison to the network average.

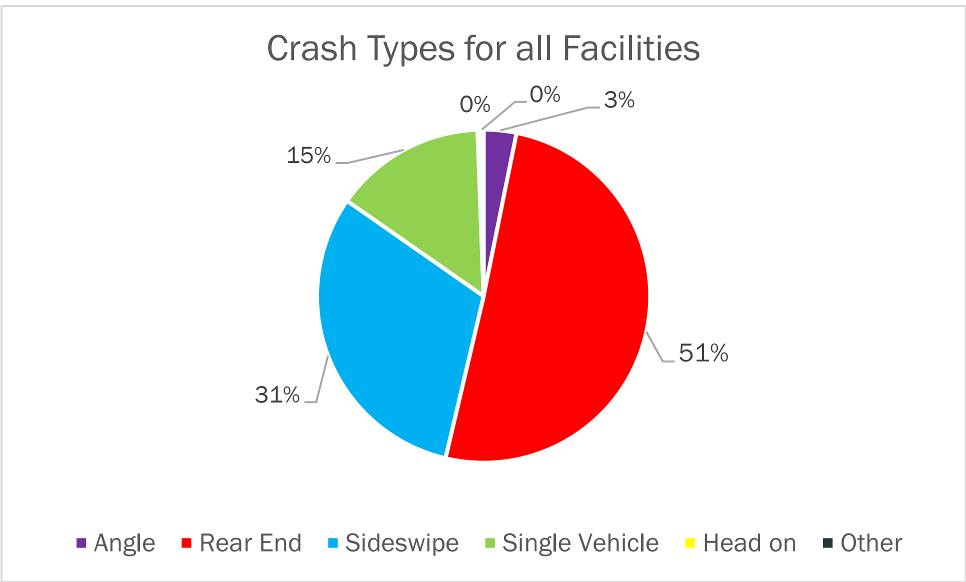

Figure 12: Crash Type by all Facilities

As shown in **Figure 12**, the most common type of crash along all facilities is rear end (51%). This is likely due to the large amount of congestion along the entire network. The second most common type of crash is sideswipe. Sideswipe crashes are caused by a number of reasons including congestion, weaving and merging, or a vehicle attempting to avoid a rear-end crash. Details about the crashes per roadway within the project area are shown in the following sections.

Nighttime crashes categorized as no illumination were also reviewed to identify any trends in the project area. There was a consistent 3-4% occurrence of these crashes, which could be attributed to areas with poor lighting, lack of safety lighting, missing underpass illumination, or lack of intersection illumination. Illumination is included in Build improvements which should reduce or eliminate these crashes.

Figure 13 and **Figure 14** are crash heat maps for Segment 2 and Segment 3, respectively. These maps show a high concentration of crashes at the following areas

- I-610 at Main Street
- I-45 at I-610 Interchange
- I-45 near Cavalcade Street – weave sections with existing ramp configurations
- I-45 at I-10 Interchange
- I-45 at I-69 Interchange
- I-69 at SH 288 Interchange
- I-45 at Cullen Boulevard
- I-45 from Buffalo Bayou to Pierce Elevated Section

The list above shows that the highest concentration of crashes are at the freeway to freeway interchange segments. Each of these locations are discussed for Build improvements in Section 5.5.2.

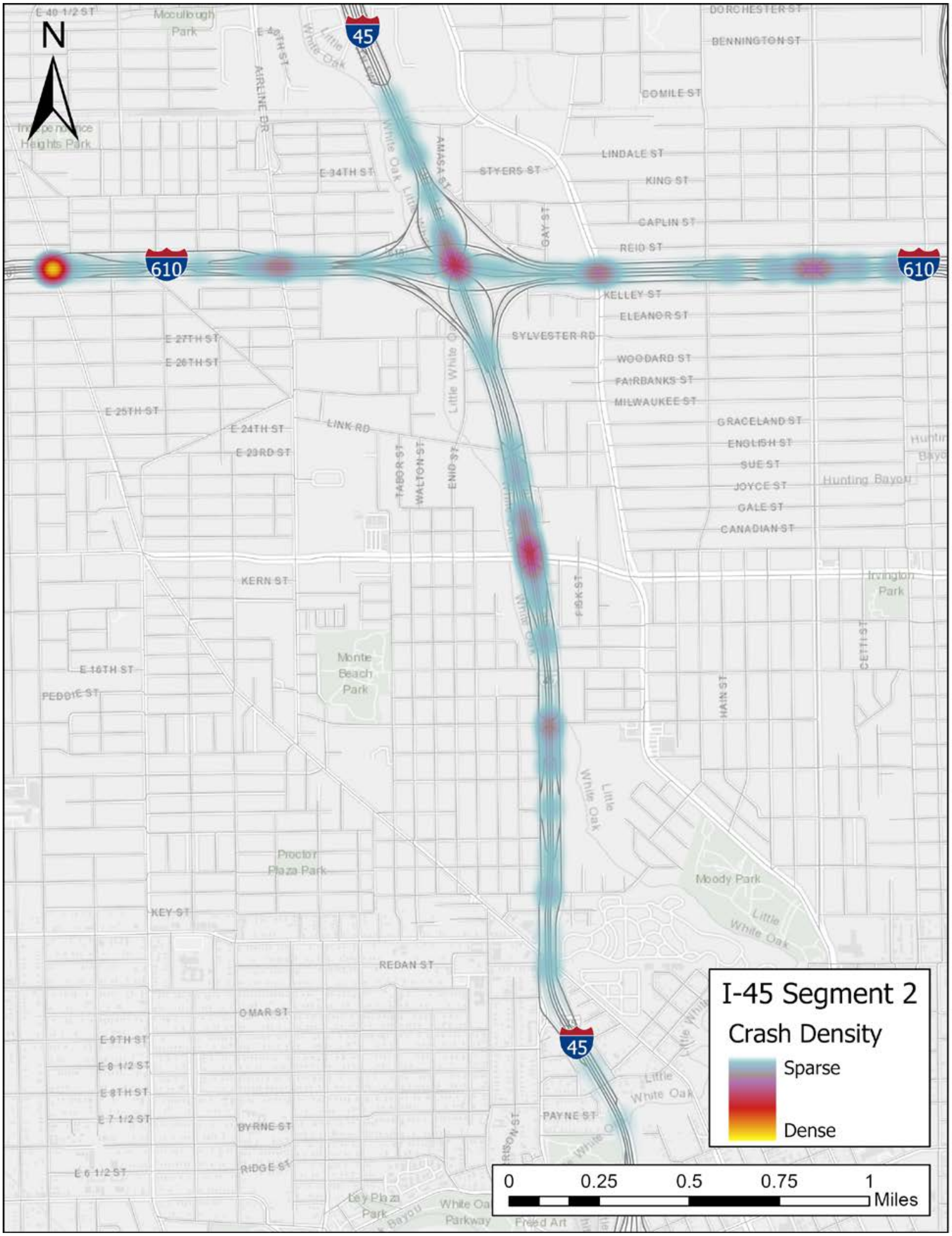

Figure 13: Segment 2 Crash Heat Map

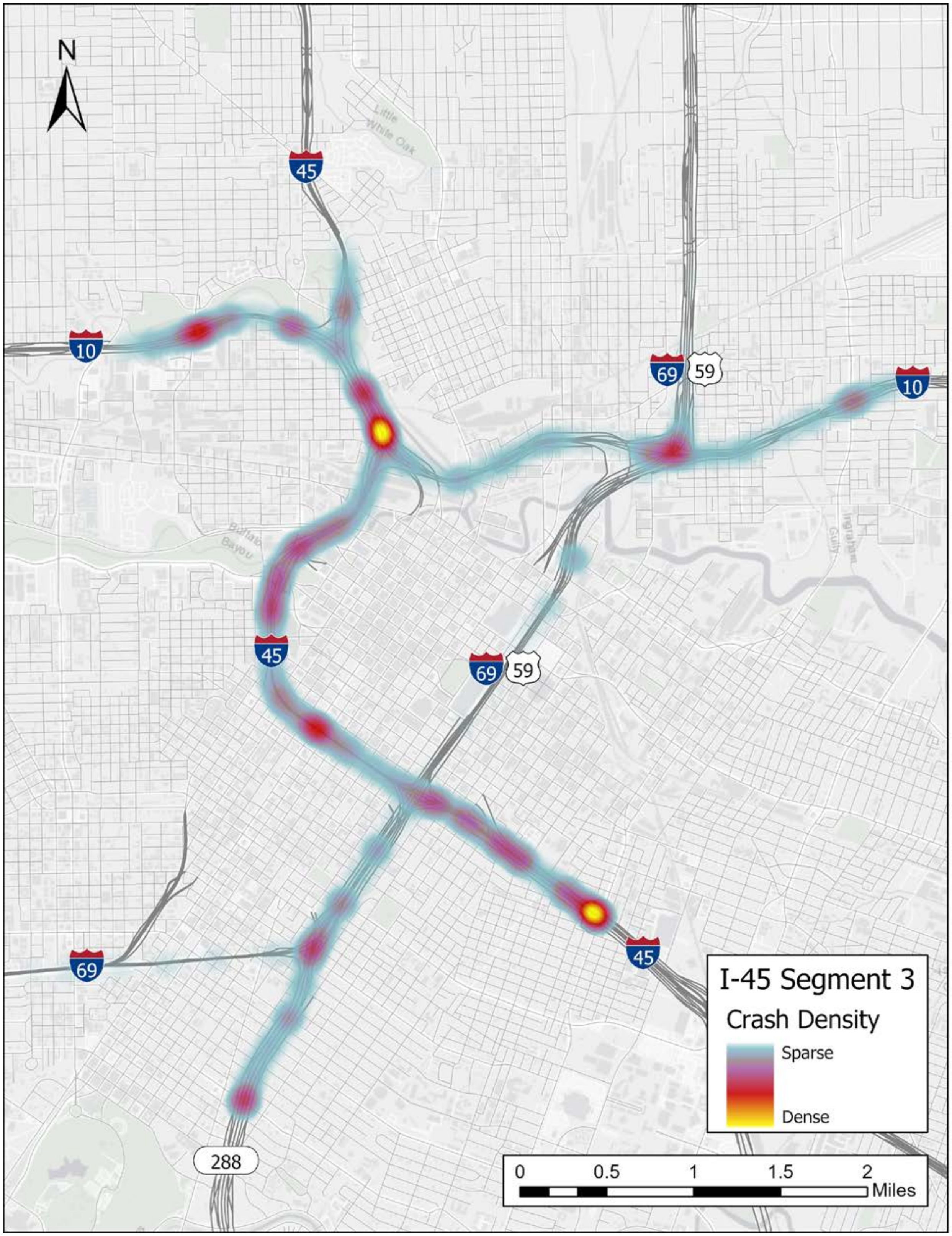

Figure 14: Segment 3 Crash Heat Map

3.8.1 I-45 North of I-610

The I-45 North of I-610 section limits span from Tidwell Road to I-610. The most common crash type for this area were rear end, sideswipe, and single vehicle crashes. Causes for these types of crashes include lane changing, congestion, and weaving behavior. Crash hot spots in this area were identified along the south side of Crosstimbers Street, south of Patton Street, and N. Main Street.

A total of 1,862 mainlane, frontage road, and ramp crashes were documented along I-45 north of I-610 within the project limits. **Tables 33** and **34** show the crash types along this area by facility type and year.

Table 33: Crash Types for I-45 North of I-610

Crash Type	ML	FR	Ramps	I-45 North of I-610	Total Project Area
Angle	0%	17%	0%	3%	2%
Head On	0%	0%	0%	0%	0%
Other	1%	8%	0%	2%	2%
Rear End	61%	28%	42%	54%	50%
Sideswipe	28%	33%	26%	29%	31%
Single Vehicle	10%	14%	32%	11%	14%
Total	100%	100%	100%	100%	100%

Table 33 shows that there are more crashes along the mainlanes for rear ends along I-45 North of I-610 compared to the project area. This is likely due to the hotspot areas identified previously as along the south side of Crosstimbers Street, south of Patton Street, and N. Main Street. Additionally, compared to the project area, there are far more angle crashes along the frontage roads compared to the entire facility. This is likely due to vehicles entering the frontage road from driveways and crashing with vehicles traveling through on the frontage roads.

Table 34: Crash Types along I-45 N of I-610 vs Project Area

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Angle	0	0%	11	3%	0	0%	11	1%	51	0%
	Head-On	1	0%	0	0%	0	0%	1	0%	10	0%
	Other	6	0%	4	1%	0	0%	10	1%	44	0%
	Rear End	226	15%	22	7%	10	26%	258	14%	1579	13%
	Sideswipe	127	9%	37	11%	9	24%	173	9%	900	8%
	Single Vehicle	59	4%	11	3%	2	5%	72	4%	501	4%
	Total	419	28%	85	25%	21	55%	525	28%	3085	26%
2016	Angle	1	0%	12	4%	0	0%	13	1%	74	1%
	Head-On	1	0%	0	0%	0	0%	1	0%	3	0%
	Other	3	0%	12	4%	0	0%	15	1%	56	0%
	Rear End	250	17%	20	6%	0	0%	270	15%	1530	13%
	Sideswipe	93	6%	24	7%	0	0%	117	6%	916	8%
	Single Vehicle	27	2%	12	4%	2	5%	41	2%	417	3%
	Total	375	25%	80	24%	2	5%	457	25%	2996	25%
2017	Angle	1	0%	21	6%	0	0%	22	1%	86	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	10	0%
	Other	1	0%	6	2%	0	0%	7	0%	65	1%
	Rear End	205	14%	24	7%	3	8%	232	12%	1474	12%
	Sideswipe	88	6%	27	8%	0	0%	115	6%	947	8%
	Single Vehicle	37	2%	15	4%	5	13%	57	3%	426	4%
	Total	332	22%	93	28%	8	21%	433	23%	3008	25%
2018	Angle	2	0%	12	4%	0	0%	14	1%	76	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	7	0%
	Other	2	0%	4	1%	0	0%	6	0%	45	0%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Rear End	222	15%	29	9%	3	8%	254	14%	1454	12%
	Sideswipe	106	7%	23	7%	1	3%	130	7%	904	8%
	Single Vehicle	30	2%	10	3%	3	8%	43	2%	390	3%
	Total	362	24%	78	23%	7	18%	447	24%	2876	24%
Avg 2015 - 2018	Angle	1	0%	14	4%	0	0%	15	1%	72	1%
	Head-On	1	0%	0	0%	0	0%	1	0%	8	0%
	Other	3	0%	7	2%	0	0%	10	1%	53	0%
	Rear End	226	15%	24	7%	4	11%	254	14%	1509	13%
	Sideswipe	104	7%	28	8%	3	7%	134	7%	917	8%
	Single Vehicle	38	3%	12	4%	3	8%	53	3%	434	4%
	Total	373	25%	85	25%	10	26%	467	25%	2993	25%
Total		1488	100%	336	100%	38	100%	1862	100%	11965	100%

As shown in **Table 34**, there are consistently slightly more rear end crashes along I-45 north of I-610 compared to the project area. This can be attributed to congestion along this segment. There was no major construction between 2015 and 2018 in this segment. All other crash types are consistent with the project area. **Figures 15-17** show the crash types along I-45 N of I-610 by facility type.

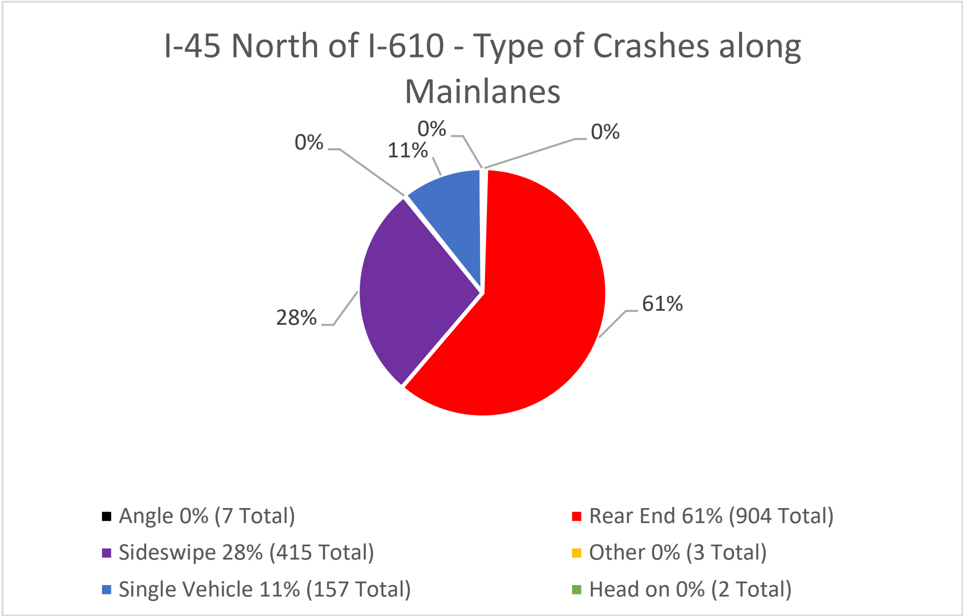

Figure 15: I-45 North of I-610 – Type of Crashes along Mainlanes

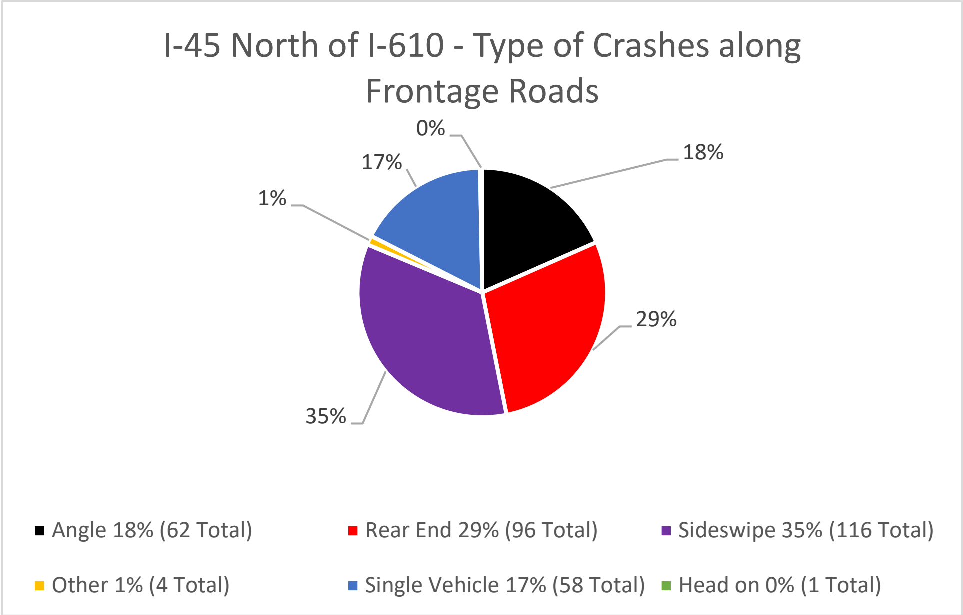

Figure 16: I-45 North of I-610 – Types of Crashes along Frontage Roads

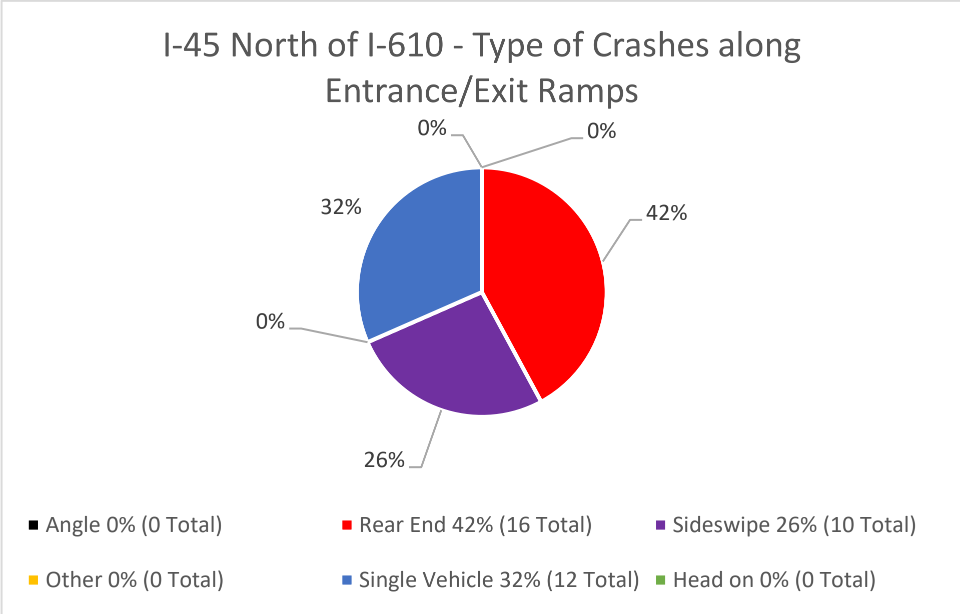

Figure 17: I-45 North of I-610 – Type of Crashes along Entrance/Exit Ramps

Figures 18-20 show the crash severity occurring along this roadway. Each crash is categorized based upon the most severe injury recorded for each crash. Of the 1,862 crashes within the project area, the majority were reported as non-injuries on all facility types (mainlanes, frontage roads, entrance/exit ramps.) Over the four (4) year study period, 7 fatalities and 17 incapacitating injuries were recorded.

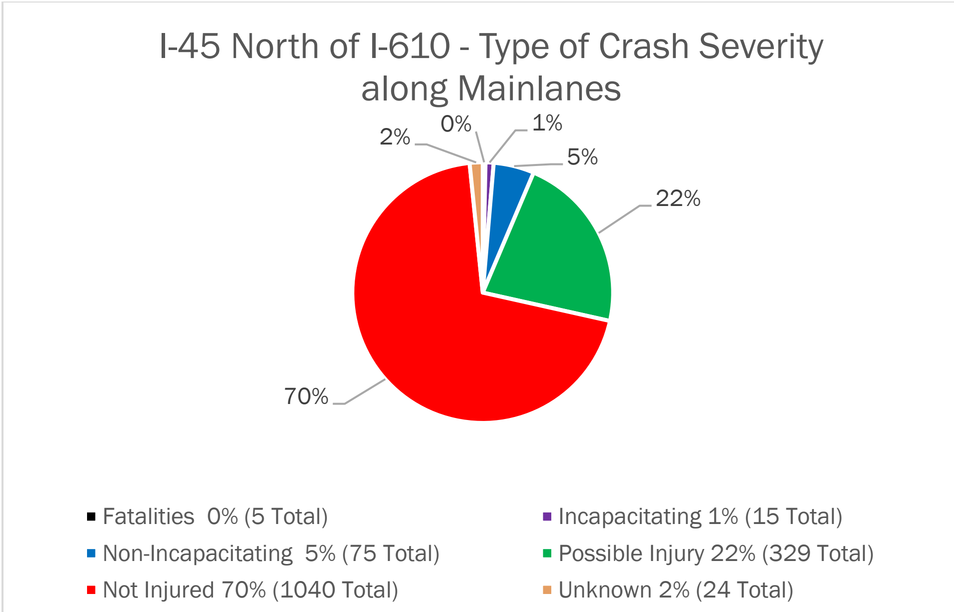

Figure 18: I-45 North of I-610 – Type of Crash Severity along Mainlanes

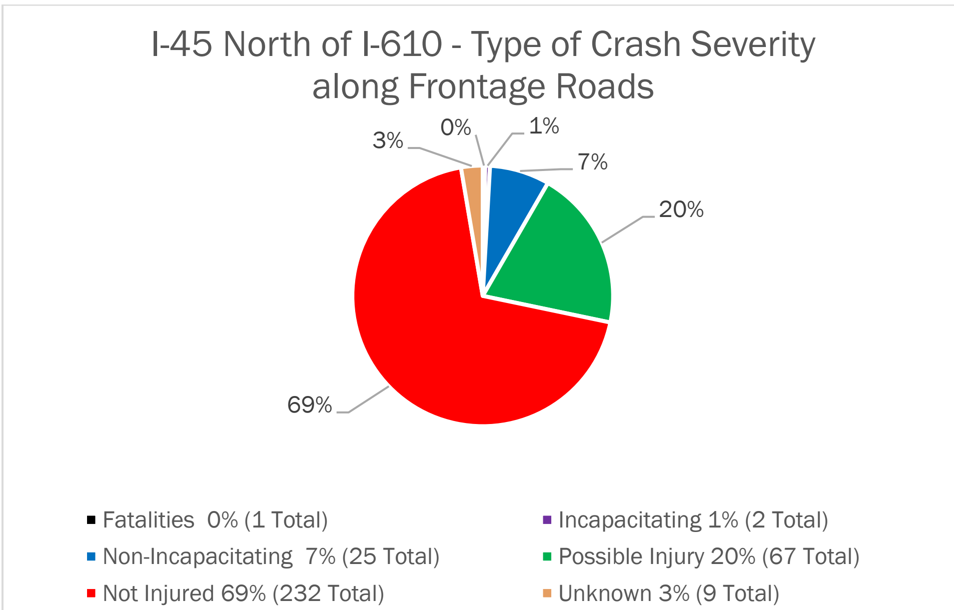

Figure 19: I-45 North of I-610 – Type of Crash Severity along Frontage Roads

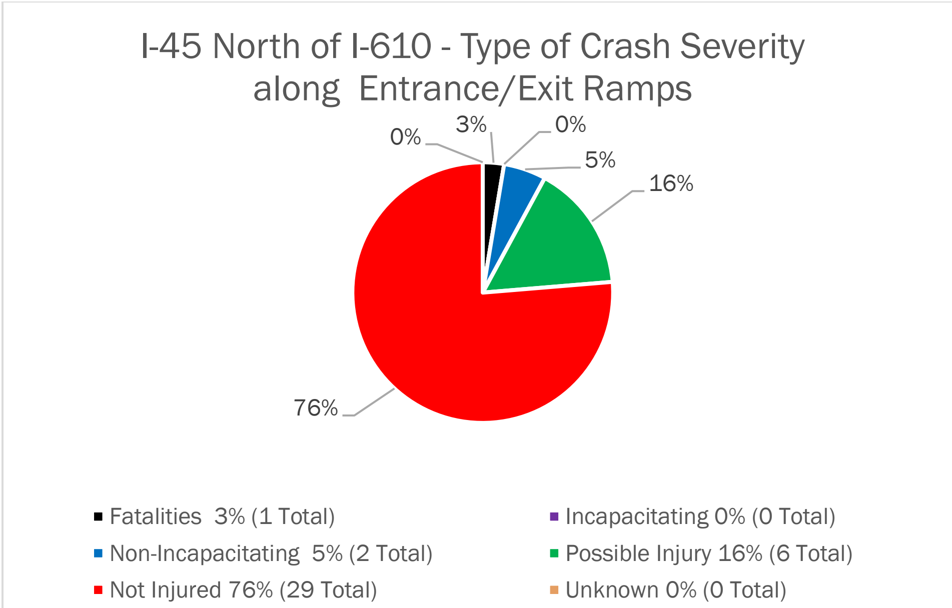

Figure 20: I-45 North of I-610 – Type of Crash Severity along Entrance/Exit Ramps

Table 35 show the crash severity along I-45 N of I-610 compared to the project area.

Table 35: Crash Severity along I-45 N of I-610 vs Project Area

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Unknown	7	0%	3	1%	0	0%	10	1%	69	1%
	Suspected Serious Injury	5	0%	2	1%	0	0%	7	0%	38	0%
	Non Incap	27	2%	5	1%	0	0%	32	2%	194	2%
	Possible Inj	100	7%	15	4%	4	11%	119	6%	696	6%
	Killed	0	0%	0	0%	0	0%	0	0%	16	0%
	Not Injured	280	19%	60	18%	17	45%	357	19%	2072	17%
	Total	419	28%	85	25%	21	55%	525	28%	3085	26%
2016	Unknown	4	0%	1	0%	0	0%	5	0%	51	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Suspected Serious Injury	5	0%	0	0%	0	0%	5	0%	45	0%
	Non Incap	25	2%	6	2%	0	0%	31	2%	213	2%
	Possible Inj	81	5%	13	4%	0	0%	94	5%	605	5%
	Killed	2	0%	1	0%	0	0%	3	0%	12	0%
	Not Injured	258	17%	59	18%	2	5%	319	17%	2070	17%
	Total	375	25%	80	24%	2	5%	457	25%	2996	25%
2017	Unknown	6	0%	1	0%	0	0%	7	0%	66	1%
	Suspected Serious Injury	4	0%	0	0%	0	0%	4	0%	32	0%
	Non Incap	13	1%	7	2%	1	3%	21	1%	216	2%
	Possible Inj	75	5%	20	6%	1	3%	96	5%	573	5%
	Killed	1	0%	0	0%	1	3%	2	0%	10	0%
	Not Injured	233	16%	65	19%	5	13%	303	16%	2111	18%
	Total	332	22%	93	28%	8	21%	433	23%	3008	25%
2018	Unknown	7	0%	4	1%	0	0%	11	1%	69	1%
	Suspected Serious Injury	1	0%	0	0%	0	0%	1	0%	26	0%
	Non Incap	10	1%	7	2%	1	3%	18	1%	165	1%
	Possible Inj	73	5%	19	6%	1	3%	93	5%	612	5%
	Killed	2	0%	0	0%	0	0%	2	0%	9	0%
	Not Injured	269	18%	48	14%	5	13%	322	17%	1995	17%
	Total	362	24%	78	23%	7	18%	447	24%	2876	24%
	Unknown	6	0%	2	1%	0	0%	8	0%	64	1%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
Avg 2015 - 2018	Suspected Serious Injury	4	0%	1	0%	0	0%	4	0%	35	0%
	Non Incap	19	1%	6	2%	1	1%	26	1%	197	2%
	Possible Inj	82	6%	17	5%	2	4%	101	5%	622	5%
	Killed	1	0%	0	0%	0	1%	2	0%	12	0%
	Not Injured	260	18%	58	17%	7	19%	325	18%	2062	17%
	Total	372	25%	84	25%	10	26%	466	25%	2992	25%
Total		1488	100%	336	100%	38	100%	1862	100%	11965	100%

Table 35 shows that there are no significant trends year to year for crash severity. All crash severities for all years along I-45 north of I-610 are comparable to the project area.

The TxDOT Roadway Design manual designates minimum spacing and guidelines for ramps with and without auxiliary lanes. According to the TxDOT Roadway Design Manual, the minimum weaving length between an entrance ramp followed by an exit ramp without an auxiliary lane is 2,000 ft and with an auxiliary lane is 1,500 ft. The minimum length between an exit ramp followed by an exit ramp is 1,000 ft. **Table 36** identifies ramps where updating existing conditions to meet design criteria could be effective in improving safety and operations.

Table 36: Critical Merge/Weave Locations (I-45 North of I-610)

Between		Travel Direction	Gore to Gore Length (ft)	Has Auxiliary Lane?
Ramp 1	Ramp 2			
Entrance from Airline Dr	Exit to Riggs St	SB	1,270	Yes

In review of the crash data, there is a high percentage of rear end crashes along the weave location between the entrance from Airline Drive and the exit to Riggs Street. This could be attributed to the short geometric weave distance between the entrance and exit ramps that leaves less space for gap acceptance and lane changes.

The proposed Build schematic addresses the critical weave location between the entrance from Airline Drive and exit to Riggs Street by removing the exit to Riggs Street in the Build scenario. **Table**

37 and **Figure 21** show the time of day in which crashes occurred along I-45 North of I-610 in addition to comparing the number of crashes within this segment to the entire facility.

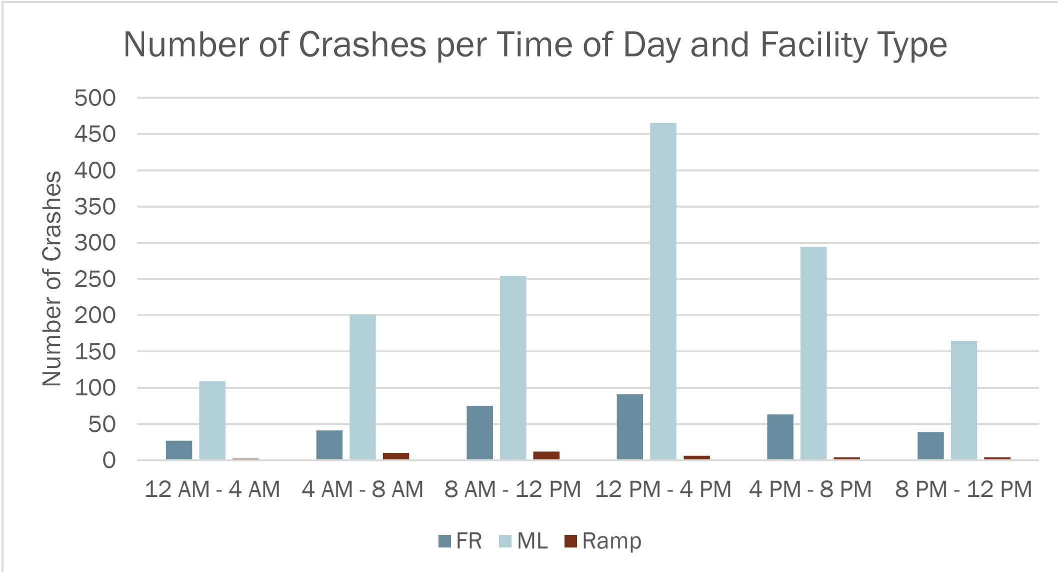

Figure 21: Number of Crashes per Time of Day and Facility Type along I-45N of I-610

Table 37: Time of Day Crashes along I-45 N of I-610 vs Project Area

Time of Day	I-45 North of I-610 (#, %)		Project Area (#, %)	
12 AM - 4 AM	138	7%	936	8%
4 AM - 8 AM	252	14%	1605	13%
8 AM - 12 PM	341	18%	2412	20%
12 PM - 4 PM	562	30%	2876	24%
4 PM - 8 PM	361	19%	2818	24%
8 PM - 12 PM	208	11%	1318	11%
Total	1862	100%	11965	100%

As shown in **Table 37**, there are more crashes between 12 PM and 4 PM along I-45 North of I-610 compared to the project area. This can be attributed to commercial development attracting midday demand and heavy congestion in this segment.

A total of 1,862 mainlane, frontage road, and ramp crashes were documented along I-45 north of I-610 within the project limits. 69% (1,276 of 1,862) of those crashes occurred during daylight conditions and 30% (556 of 1,862) during nighttime conditions. 3% (50 of 1862) were reported to be nighttime crashes in areas where there was limited to no illumination.

Table 38 shows the time of day crashes and severity along I-45 N of I-610 compared to the project area for the shared respective time period.

Table 38: Time of Day Crashes and Severity along I-45 N of I-610

Time of Day	Segment and Project Area Crashes and Percentages	Unknown	Suspected Serious Injury	Non-Incapacitating Injury	Possible Injury	Killed	Not Injured	Total
12 AM - 4 AM	Segment Crashes	11	2	10	14	3	98	138
	Segment %	8%	1%	7%	10%	2%	71%	100%
	Project Area Crashes	100	29	87	130	17	573	936
	Project Area %	11%	3%	9%	14%	2%	61%	100%
4 AM - 8 AM	Segment Crashes	5	2	12	48	1	184	252
	Segment %	2%	1%	5%	19%	0%	73%	100%
	Project Area Crashes	42	16	100	353	11	1083	1605
	Project Area %	3%	1%	6%	22%	1%	67%	100%
8 AM - 12 PM	Segment Crashes	1	6	19	97	1	217	341
	Segment %	0%	2%	6%	28%	0%	64%	100%
	Project Area Crashes	26	20	182	577	4	1603	2412
	Project Area %	1%	1%	8%	24%	0%	66%	100%
12 PM - 4 PM	Segment Crashes	3	2	35	136	0	386	562
	Segment %	1%	0%	6%	24%	0%	69%	100%
	Project Area Crashes	30	23	171	652	3	1997	2876
	Project Area %	1%	1%	6%	23%	0%	69%	100%
4 PM - 8 PM	Segment Crashes	5	1	10	71	1	273	361
	Segment %	1%	0%	3%	20%	0%	76%	100%
	Project Area Crashes	24	22	150	562	2	2058	2818
	Project Area %	1%	1%	5%	20%	0%	73%	100%
8 PM - 12 PM	Segment Crashes	8	4	16	36	1	143	208
	Segment %	4%	2%	8%	17%	0%	69%	100%
	Project Area Crashes	33	31	98	212	10	934	1318
	Project Area %	3%	2%	7%	16%	1%	71%	100%

Table 38 shows that there were 24 total KA crashes (killed or suspected serious injury). There were fewer KA crashes between 12 AM and 4 AM compared to the rest of the network. This is likely because I-45 North of I-610 is not located downtown near late night traffic generators. **Table 38** also shows that the most severe crashes occur between 8 PM and 8 AM (54%) of total crashes.

13 of these crashes occurred between 8 PM and 8 AM (54%) of total crashes. The period with the most KA crashes was 8 AM to 12 PM with a total of 7 crashes.

3.8.2 I-45 South of I-610

The I-45 South of I-610 limits span from I-610 to Cullen Boulevard. There were 4,512 crashes between years 2015-2018 in this area. The most common crash types for the I-45 South of I-610 were rear end, sideswipe, and single vehicle crashes. Upon review of the crash data, it was noted that rear end crashes were caused due to queue spillback along interchange ramps, left exits, or entrances. The queue spillback resulted in driver confusion causing vehicles to slow down which resulted in a speed differential. Hotspot crash locations were located north of the I-45 and I-10 interchange, along the connector of I-10 at I-45, along the Allen Parkway exits of Pierce-Elevated, and west of Leeland Street, past the I-45 and I-69 interchange.

There was a total of 4,512 mainlane, frontage road, and ramp crashes in this area. **Tables 39** and **40** show the crash types along this area by facility type and year.

Table 39: Crash Types along I-45 South of I-610

Crash Type	ML	FR	Ramps	All I-45 South of I-610	Project Area
Angle	1%	16%	1%	2%	2%
Head On	0%	0%	1%	0%	0%
Other	1%	6%	1%	1%	2%
Rear End	59%	25%	42%	56%	50%
Sideswipe	25%	34%	22%	26%	31%
Single Vehicle	14%	19%	32%	14%	14%
Total	100%	100%	100%	100%	100%

Table 39 shows that there were more rear end crashes along I-45 south of I-610 compared to the project area. This is likely due to heavy congestion along this entire segment, especially in hotspot areas such as north of the I-45 and I-10 interchange, along the connector of I-10 at I-45, along the Allen Parkway exits of Pierce-Elevated, and west of Leeland Street, past the I-45 and I-69 interchange. Additionally, compared to the project area, there are less sideswipe crashes compared to the project area. This is likely due to the Pierce elevated section along I-45. This stretch has no ramp entrances or ramp exits so less vehicles change lanes to exit within this stretch.

Table 40 shows the crash types for all years along I-45 S of I-610 compared to the project area.

Table 40: Crash Types along I-45 S of I-610 vs Project Area

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 S of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Angle	7	0%	11	3%	1	1%	19	0%	51	0%
	Head-On	3	0%	0	0%	1	1%	4	0%	10	0%
	Other	8	0%	7	2%	0	0%	15	0%	44	0%
	Rear End	668	17%	23	7%	10	7%	701	16%	1579	13%
	Sideswipe	257	6%	22	7%	10	7%	289	6%	900	8%
	Single Vehicle	163	4%	15	5%	10	7%	188	4%	501	4%
	Total	1106	27%	78	23%	32	22%	1216	27%	3085	26%
2016	Angle	12	0%	14	4%	1	1%	27	1%	74	1%
	Head-On	1	0%	0	0%	0	0%	1	0%	3	0%
	Other	14	0%	3	1%	0	0%	17	0%	56	0%
	Rear End	596	15%	27	8%	19	13%	642	14%	1530	13%
	Sideswipe	287	7%	40	12%	7	5%	334	7%	916	8%
	Single Vehicle	121	3%	22	7%	14	10%	157	3%	417	3%
	Total	1031	26%	106	32%	41	29%	1178	26%	2996	25%
2017	Angle	8	0%	18	5%	0	0%	26	1%	86	1%
	Head-On	6	0%	0	0%	1	1%	7	0%	10	0%
	Other	13	0%	6	2%	1	1%	20	0%	65	1%
	Rear End	564	14%	18	5%	17	12%	599	13%	1474	12%
	Sideswipe	262	6%	28	8%	7	5%	297	7%	947	8%
	Single Vehicle	141	3%	13	4%	11	8%	165	4%	426	4%
	Total	994	25%	83	25%	37	26%	1114	25%	3008	25%
2018	Angle	12	0%	9	3%	0	0%	21	0%	76	1%
	Head-On	4	0%	0	0%	0	0%	4	0%	7	0%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 S of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Other	7	0%	5	2%	1	1%	13	0%	45	0%
	Rear End	543	13%	15	5%	14	10%	572	13%	1454	12%
	Sideswipe	219	5%	24	7%	7	5%	250	6%	904	8%
	Single Vehicle	121	3%	12	4%	11	8%	144	3%	390	3%
	Total	906	22%	65	20%	33	23%	1004	22%	2876	24%
Avg 2015 - 2018	Angle	10	0%	13	4%	1	0%	23	1%	72	1%
	Head-On	4	0%	0	0%	1	0%	4	0%	8	0%
	Other	11	0%	5	2%	1	0%	16	0%	53	0%
	Rear End	593	15%	21	6%	15	11%	629	14%	1509	13%
	Sideswipe	256	6%	29	9%	8	5%	293	7%	917	8%
	Single Vehicle	137	3%	16	5%	12	8%	164	4%	434	4%
	Total	1011	25%	84	25%	38	27%	1129	25%	2993	25%
Total		4037	100%	332	100%	143	100%	4512	100%	11965	100%

As shown in **Table 40**, there are more rear end crashes along I-45 south of I-610 compared to the project area. This can be attributed to congestion along this segment. There was no major construction between 2015 and 2018 in this segment. There are consistently fewer sideswipe crashes along this segment. This is likely due to the Pierce elevated section. This stretch has no ramp entrances or ramp exits so less vehicles change lanes within this stretch.

There were 80 crashes that occurred within a construction zone. 47 of these crashes (59%) resulted in rear ends. 24 of these crashes (30%) resulted in sideswipes, and 9 (11%) resulted in a single vehicle crash. **Figures 22 – 24** show the crash types along I-45 S of I-610 by facility type.

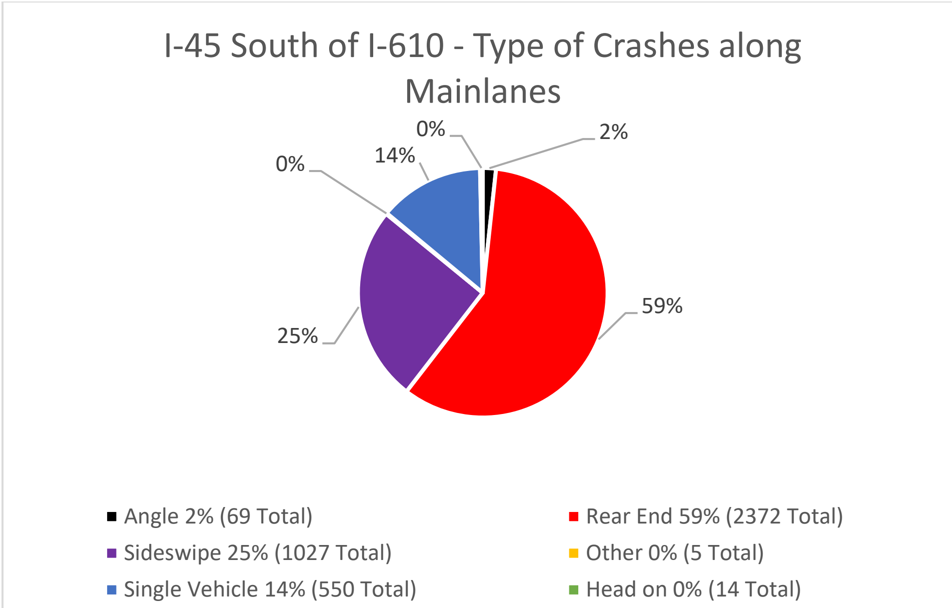

Figure 22: I-45 South of I-610 – Type of Crashes along Mainlanes

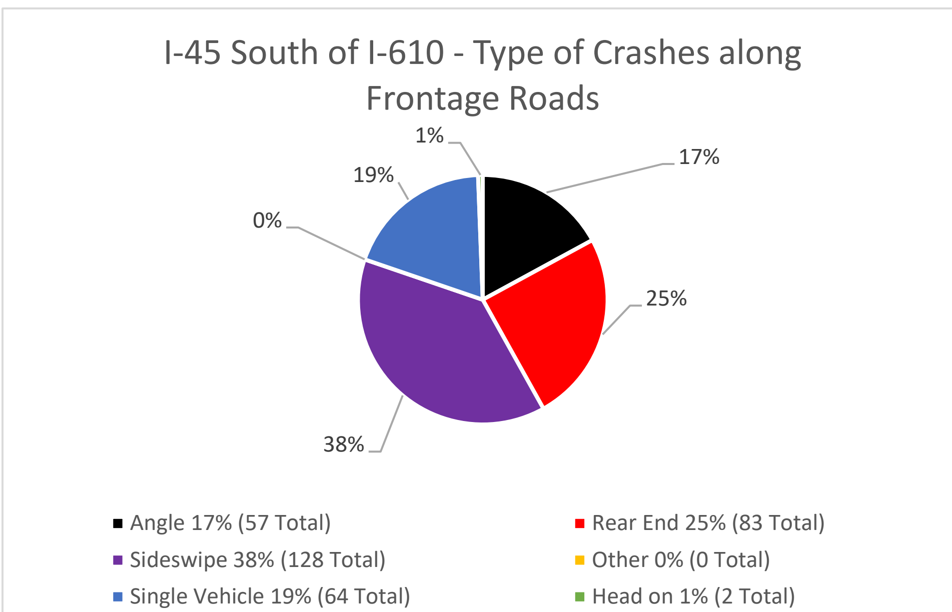

Figure 23: I-45 South of I-610 – Type of Crashes along Frontage Roads

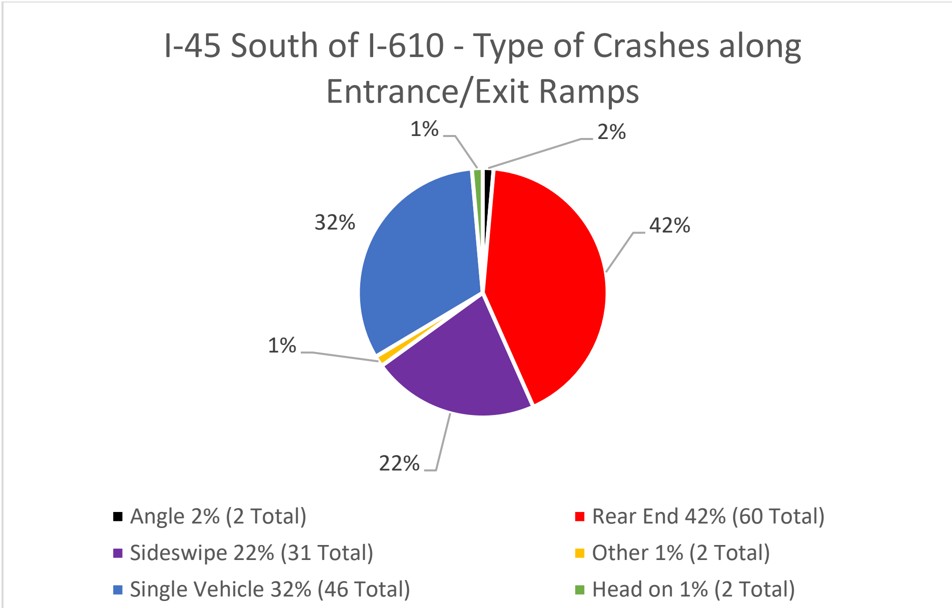

Figure 24: I-45 South of I-610 – Type of Crashes along Entrance/Exit Ramps

Figures 25-27 show the crash severity occurring along this roadway. Each crash is categorized based upon the most severe injury recorded for each crash. Of the total 4,512 crashes within the project area, the majority were reported as non-injuries on the mainlanes, frontage roads, and entrance/exit ramps. Over the four (4) year study period, 19 fatalities and 43 incapacitating injuries were recorded.

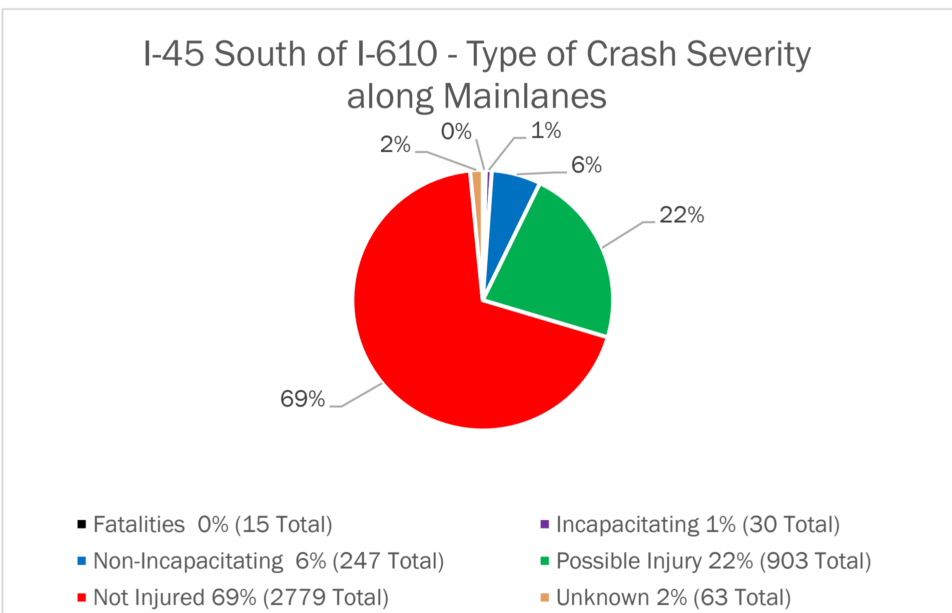

Figure 25: I-45 South of I-610 – Type of Crash Severity along Mainlanes

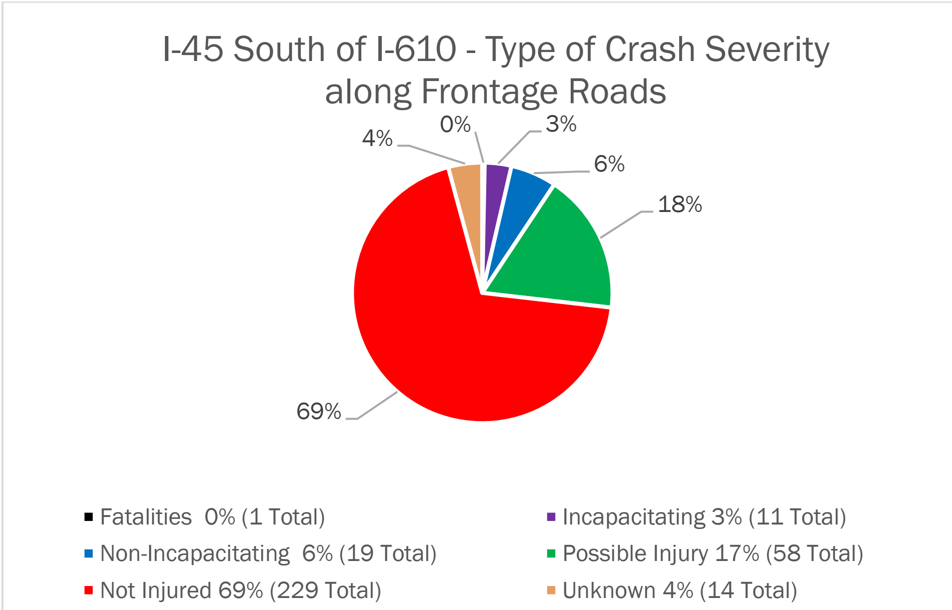

Figure 26: I-45 South of I-610 – Type of Crash Severity along Frontage Roads

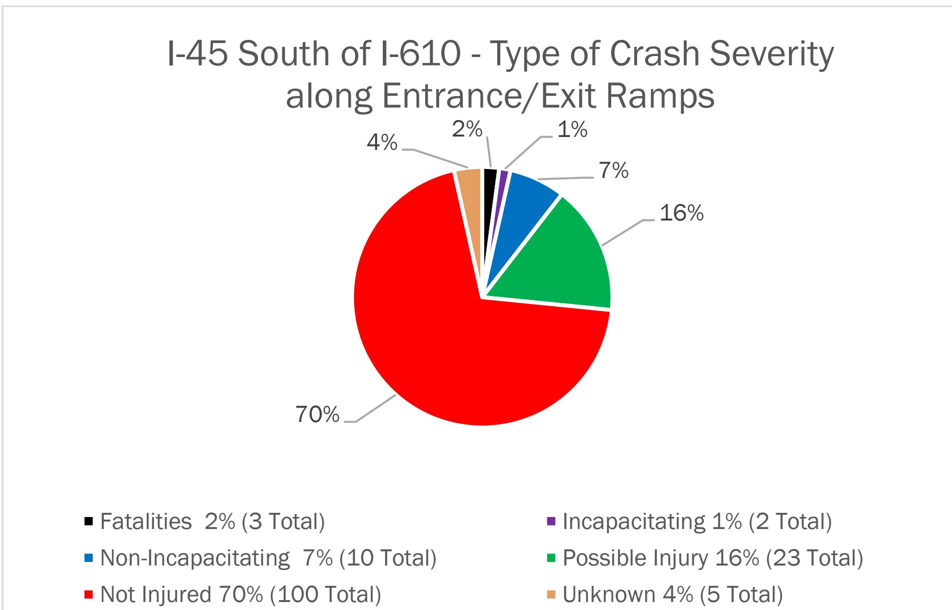

Figure 27: I-45 South of I-610 – Type of Crash Severity along Entrance/Exit Ramps

Table 41 shows the crash severity along I-45 S of I-610 across all years compared to the project area.

Table 41: Crash Severity along I-45 S of I-610 vs Project Area

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Unknown	16	0%	4	1%	1	1%	21	0%	69	1%
	Suspected Serious Injury	9	0%	3	1%	0	0%	12	0%	38	0%
	Non Incap	64	2%	4	1%	1	1%	69	2%	194	2%
	Possible Inj	267	7%	10	3%	3	2%	280	6%	696	6%
	Killed	7	0%	0	0%	0	0%	7	0%	16	0%
	Not Injured	743	18%	57	17%	27	19%	827	18%	2072	17%
	Total	1106	27%	78	23%	32	22%	1216	27%	3085	26%
2016	Unknown	8	0%	3	1%	1	1%	12	0%	51	0%
	Suspected Serious Injury	9	0%	2	1%	1	1%	12	0%	45	0%
	Non Incap	68	2%	7	2%	3	2%	78	2%	213	2%
	Possible Inj	218	5%	22	7%	10	7%	250	6%	605	5%
	Killed	4	0%	0	0%	1	1%	5	0%	12	0%
	Not Injured	724	18%	72	22%	25	17%	821	18%	2070	17%
	Total	1031	26%	106	32%	41	29%	1178	26%	2996	25%
2017	Unknown	22	1%	4	1%	2	1%	28	1%	66	1%
	Suspected Serious Injury	5	0%	4	1%	1	1%	10	0%	32	0%
	Non Incap	69	2%	3	1%	5	3%	77	2%	216	2%
	Possible Inj	201	5%	16	5%	5	3%	222	5%	573	5%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-45 N of I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Killed	2	0%	0	0%	1	1%	3	0%	10	0%
	Not Injured	695	17%	56	17%	23	16%	774	17%	2111	18%
	Total	994	25%	83	25%	37	26%	1114	25%	3008	25%
2018	Unknown	17	0%	3	1%	1	1%	21	0%	69	1%
	Suspected Serious Injury	7	0%	2	1%	0	0%	9	0%	26	0%
	Non Incap	46	1%	5	2%	1	1%	52	1%	165	1%
	Possible Inj	217	5%	10	3%	5	3%	232	5%	612	5%
	Killed	2	0%	1	0%	1	1%	4	0%	9	0%
	Not Injured	617	15%	44	13%	25	17%	686	15%	1995	17%
	Total	906	22%	65	20%	33	23%	1004	22%	2876	24%
Avg 2015 - 2018	Unknown	16	0%	4	1%	1	1%	21	1%	64	1%
	Suspected Serious Injury	8	0%	3	1%	1	0%	11	0%	35	0%
	Non Incap	62	2%	5	1%	3	2%	69	2%	197	2%
	Possible Inj	226	6%	15	4%	6	4%	246	6%	622	5%
	Killed	4	0%	0	0%	1	1%	5	0%	12	0%
	Not Injured	695	17%	57	17%	25	18%	777	17%	2062	17%
	Total	1011	25%	84	25%	37	26%	1129	25%	2992	25%
Total		4037	100%	332	100%	143	100%	4512	100%	11965	100%

Table 41 shows that all crash severities for all years along I-45 north of I-610 are comparable to the project area.

During field visits, four (4) locations were identified where updating the geometric configuration to meet design criteria would improve safety and operations. The first location is the entrance ramp from Patton Street in the southbound direction. The entrance ramp is 300 feet long with no acceleration lane onto I-45. The entrance ramp should be redesigned to AASHTO and TxDOT Roadway Design Manual standards in accordance with tapered or parallel entrance ramp design criteria. In review of the crash data, there is a concentration of rear end and sideswipe crashes in this location. The proposed Build alternative addresses this safety issue by removing the entrance and exit ramps between Patton Street and Cottage Street. In the Build scenario, access to Patton Street and Cottage Street from I-45 southbound is served by an exit ramp just south of the I-610 interchange. Access to I-45 southbound from Patton Street and Cottage Street is served by an entrance ramp south of Main Street in the Build scenario. The increased spacing from the existing configuration between to the ramps improves traffic flow on this segment of I-45.

The second location is the direct connector from I-69 southbound onto I-45 northbound. The merge has no acceleration or taper length. The entrance should be redesigned to AASHTO and TxDOT Roadway Design Manual standards in accordance with tapered or parallel entrance ramp design criteria. In review of the crash data, there is a concentration of sideswipe crashes, being the most common, and rear end, being the second most common type of crash in this area. The proposed Build alternative removes this direct connector and converts to a partial interchange with rerouted traffic using a direct connector from I-69 to I-10 followed by a direct connector from I-10 to I-45 northbound, which meet design standards. The direct connector in the Build network exits on the right side of I-69 and enters a direct connector which feeds into I-45 on the right side, removing the safety risk presented in the existing network.

The third location is the I-45 southbound downtown exit providing access to McKinney Street and Allen Parkway. The rapid succession of exits in addition to left-side exits which violate driver expectation when intermixed with right-side entrances and exits, are shown in Figure 28. In review of the crash data, there is a large concentration of sideswipe crashes in this area. The proposed Build alternative addresses this with the realignment of the I-45 freeway mainlanes and providing extended ramps into downtown as the exit to McKinney Street and Allen Parkway.

Figure 28: Left Exits along I-45 SB

In the fourth location, it was noted that several low bridges along I-45, in the downtown loop, were struck by large trucks, as shown in **Figure 29**. The I-45 NHHIP schematic was originally designed with a 16.5-foot vertical clearance prior to implementation of the 18.5-foot vertical clearance requirement for bridges. However, an 18.5-foot vertical clearance will be accommodated as part of the detailed design phase on the project. In review of the crash data, it was found that 66 crashes occurred when there was hitting of a support at underpass, tunnel, overhead sign bridge, or top of underpass or tunnel. These crash occurrences often require multiple or all lane closures along the interstate. The proposed Build alternative address all low-clearance bridges so that they meet clearance criteria with reconstruction of bridges and mainlanes.

Figure 29: Bridge Strikes along I-45

A map showing these four locations and how the proposed Build schematic addresses the corresponding safety and operational concerns is shown in **Figure 30**.

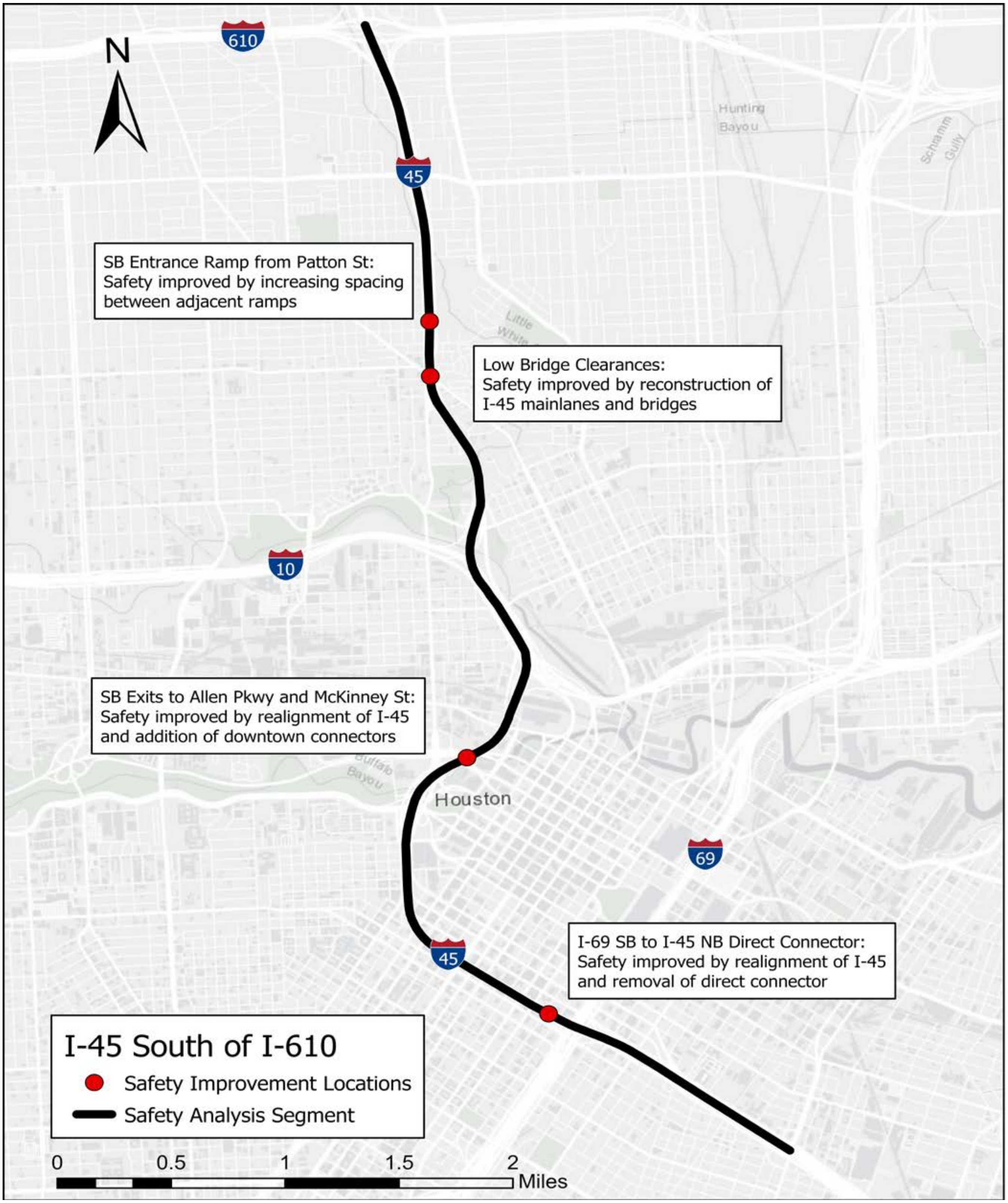

Figure 30: I-45 South of I-610 Safety Improvement Locations

According to the TxDOT Roadway Design Manual, the minimum weaving length between an entrance ramp followed by an exit ramp without an auxiliary lane is 2,000 ft and with an auxiliary lane is 1,500 ft. The minimum weaving length between an exit ramp followed by an exit ramp is 1,000 ft. **Table 42** denotes ramps where updating the existing conditions to meet design criteria could be effective in improving safety and operations. In review of the crash data, there is a concentration of sideswipe and rear end crashes in this area.

Table 42: Critical Merge/Weave Locations (I-45 South of I-610)

Between		Travel Direction	Gore to Gore Length (ft)	Has Auxiliary Lane?
Ramp 1	Ramp 2			
Exit to White Oak Dr	Exit from I-45 S to I-10 W	SB	620	N/A

The proposed Build schematic addresses the critical weave location between the exit to White Oak Drive and exit to I-10 westbound from I-45 southbound by realigning the White Oak Drive exit ramp and moving the I-10 westbound north exit ramp. The weave location increases between distance between the two ramps to an acceptable distance from 620 feet in the No-Build alternative to 2,000 feet in the Build alternative.

Table 43 and **Figure 31** show the time of day in which crashes occurred along I-45 south of I-610 in addition to comparing the number of crashes within this segment to the entire facility.

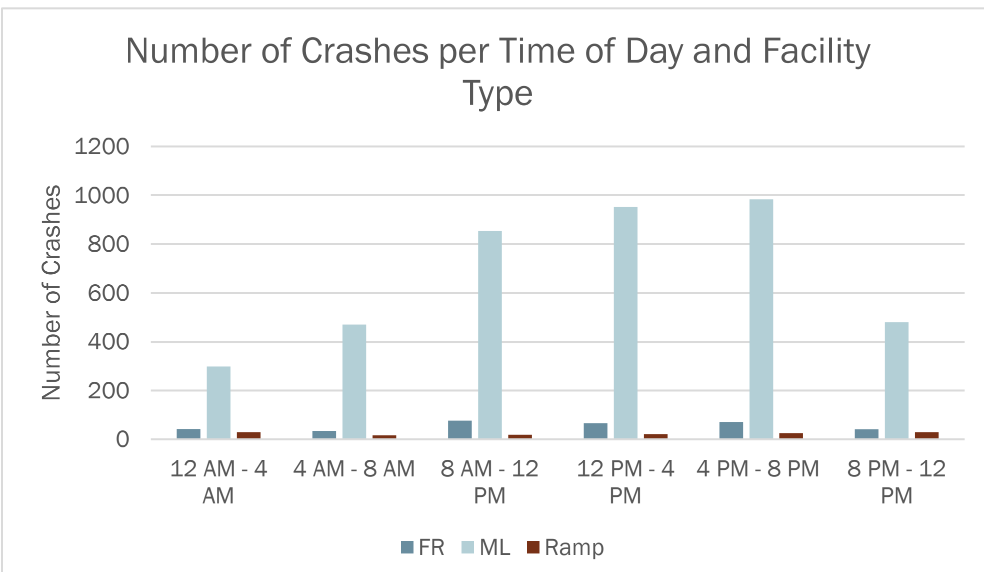

Figure 31: Number of Crashes per Time of Day and Facility Type along I-45

Table 43 shows the time of day crashes and severity along I-45 S of I-610 compared to the project area for the shared respective time period.

Table 43: Time of Day Crashes along I-45 S of I-610 vs Project Area

Time of Day	All I-45 South of I-610 (#, %)		Project Area (#, %)	
12 AM - 4 AM	371	8%	936	8%
4 AM - 8 AM	520	12%	1605	13%
8 AM - 12 PM	950	21%	2412	20%
12 PM - 4 PM	1040	23%	2876	24%
4 PM - 8 PM	1080	24%	2818	24%
8 PM - 12 PM	551	12%	1318	11%
Total	4512	100%	11965	100%

As shown in **Table 43**, the number of crashes per time period is comparable to the project area.

A total of 4,512 mainlane, frontage road, and ramp crashes were documented along I-45 south of I-610 within the project limits. 69% (3106 of 4,512) of those crashes occurred during daylight conditions and 29% (1324 of 4,512) during nighttime conditions. 3% (134 of 4,512) of crashes were reported to be nighttime crashes in areas where there was limited to no illumination.

Table 44 shows the time of day crashes and severity along I-45 S of I-610 compared to the project area for the shared respective time period.

Table 44: Time of Day Crashes and Severity along I-45 S of I-610

Time of Day	Segment and Project Area Crashes and Percentages	Unknown	Suspected Serious Injury	Non-Incapacitating Injury	Possible Injury	Killed	Not Injured	Total
12 AM - 4 AM	Segment Crashes	33	14	33	51	7	233	371
	Segment %	9%	4%	9%	14%	2%	63%	100%
	Project Area Crashes	100	29	87	130	17	573	936
	Project Area %	11%	3%	9%	14%	2%	61%	100%
4 AM - 8 AM	Segment Crashes	10	4	28	114	6	358	520
	Segment %	2%	1%	5%	22%	1%	69%	100%
	Project Area Crashes	42	16	100	353	11	1083	1605
	Project Area %	3%	1%	6%	22%	1%	67%	100%
8 AM - 12 PM	Segment Crashes	9	5	63	239	0	634	950
	Segment %	1%	1%	7%	25%	0%	67%	100%

Time of Day	Segment and Project Area Crashes and Percentages	Unknown	Suspected Serious Injury	Non-Incapacitating Injury	Possible Injury	Killed	Not Injured	Total
	Project Area Crashes	26	20	182	577	4	1603	2412
	Project Area %	1%	1%	8%	24%	0%	66%	100%
12 PM - 4 PM	Segment Crashes	8	6	57	253	1	715	1040
	Segment %	1%	1%	5%	24%	0%	69%	100%
	Project Area Crashes	30	23	171	652	3	1997	2876
	Project Area %	1%	1%	6%	23%	0%	69%	100%
4 PM - 8 PM	Segment Crashes	12	8	56	233	0	771	1080
	Segment %	1%	1%	5%	22%	0%	71%	100%
	# of Crashes on Network	24	22	150	562	2	2058	2818
	% of Time Period in Network	1%	1%	5%	20%	0%	73%	100%
8 PM - 12 PM	# of Crashes on Hwy	10	6	39	94	5	397	551
	% of Time Period on Hwy	2%	1%	7%	17%	1%	72%	100%
	# of Crashes on Network	33	31	98	212	10	934	1318
	% of Time Period in Network	3%	2%	7%	16%	1%	71%	100%

Table 44 shows a total of 62 total KA crashes (killed or suspected serious injury). 42 of these crashes occurred between 8 PM and 8 AM (68% of crashes). The period with the most KA crashes was between 12 AM and 4 AM with 21 total crashes (31% of crashes). The segment includes Downtown Houston and is similar to the project area for KA percentages by time of day.

3.8.3 I-69

The I-69 limits span from Mandell Street to Quitman Street There were 1,498 crashes between years 2015-2018. Crashes are heavily concentrated at the weave locations before the direct connectors entering and exiting the I-69 and I-45 interchange. Additionally, other hotspot locations include the weave before the direct connectors approaching the I-69 interchange with SH 288 and the area to the north and south of the Spur 527 interchange. **Tables 45** and **46** show the crash types along this area by facility type and year.

Table 45: Crash Types along I-69

Crash Type	ML	FR	Ramps	I-69	Project Area
Angle	1%	13%	2%	2%	2%
Head On	0%	0%	0%	0%	0%
Other	2%	7%	1%	2%	2%
Rear End	44%	27%	39%	43%	50%
Sideswipe	38%	46%	41%	39%	31%
Single Vehicle	14%	6%	17%	14%	14%
Total	100%	100%	100%	100%	100%

Table 45 shows that there are more sideswipe crashes along I-69 compared to the project area. This is likely due to the large merge sections with SH 288, I-45, and I-10 within the project area.

Table 46 shows the crash types for all years along I-69 compared to the project area.

Table 46: Crash Types along I-69 vs Project Area

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-69 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Angle	5	0%	2	2%	0	0%	7	0%	51	0%
	Head-On	1	0%	0	0%	0	0%	1	0%	10	0%
	Other	10	1%	2	2%	0	0%	12	1%	44	0%
	Rear End	129	10%	5	5%	8	5%	142	9%	1579	13%
	Sideswipe	90	7%	16	15%	8	5%	114	8%	900	8%
	Single Vehicle	49	4%	1	1%	3	2%	53	4%	501	4%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-69 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Total	284	23%	26	24%	19	12%	329	22%	3085	26%
2016	Angle	4	0%	4	4%	2	1%	10	1%	74	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	3	0%
	Other	7	1%	0	0%	0	0%	7	0%	56	0%
	Rear End	122	10%	7	6%	11	7%	140	9%	1530	13%
	Sideswipe	117	9%	9	8%	22	14%	148	10%	916	8%
	Single Vehicle	31	3%	2	2%	10	6%	43	3%	417	3%
	Total	281	23%	22	20%	45	29%	348	23%	2996	25%
2017	Angle	4	0%	3	3%	0	0%	7	0%	86	1%
	Head-On	2	0%	0	0%	0	0%	2	0%	10	0%
	Other	4	0%	3	3%	0	0%	7	0%	65	1%
	Rear End	143	12%	8	7%	16	10%	167	11%	1474	12%
	Sideswipe	111	9%	11	10%	18	12%	140	9%	947	8%
	Single Vehicle	36	3%	4	4%	8	5%	48	3%	426	4%
	Total	300	24%	29	27%	42	27%	371	25%	3008	25%
2018	Angle	5	0%	5	5%	1	1%	11	1%	76	1%
	Head-On	2	0%	0	0%	0	0%	2	0%	7	0%
	Other	5	0%	3	3%	2	1%	10	1%	45	0%
	Rear End	154	12%	9	8%	25	16%	188	13%	1454	12%
	Sideswipe	150	12%	14	13%	15	10%	179	12%	904	8%
	Single Vehicle	55	4%	0	0%	5	3%	60	4%	390	3%
	Total	371	30%	31	29%	48	31%	450	30%	2876	24%
	Angle	5	0%	4	3%	1	1%	9	1%	72	1%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-69 (#,% of total crashes)		Project Area (#,% of total crashes)	
Avg 2015 - 2018	Head-On	1	0%	0	0%	0	0%	1	0%	8	0%
	Other	7	1%	2	2%	1	0%	9	1%	53	0%
	Rear End	137	11%	7	7%	15	10%	159	11%	1509	13%
	Sideswipe	117	10%	13	12%	16	10%	145	10%	917	8%
	Single Vehicle	43	4%	2	2%	7	4%	51	3%	434	4%
	Total	310	25%	28	26%	40	26%	374	25%	2993	25%
Total		1236	100%	108	100%	154	100%	1498	100%	11965	100%

As shown in **Table 46**, there are more sideswipe crashes along I-69 due to the many merge/weaves along the segment. There were more sideswipe crashes compared to the project area in 2018. There was no major construction along this segment during the years of analysis.

There were 19 crashes that occurred within a construction zone. 4 of these crashes (21%) resulted in rear ends. 8 of these crashes (42%) resulted in sideswipes, and 5 (26%) resulted in a single vehicle crash. The remaining crashes were classified as angle and other crashes.

Figure 32 shows the type of crashes occurring along I-69. The most common crash types for I-69 include: rear end, sideswipe, and single vehicle crashes. Causes for these crashes include: lane changing, congestion and weaving behavior throughout the corridor. **Figures 33-35** show the crash types along I-69 by facility type.

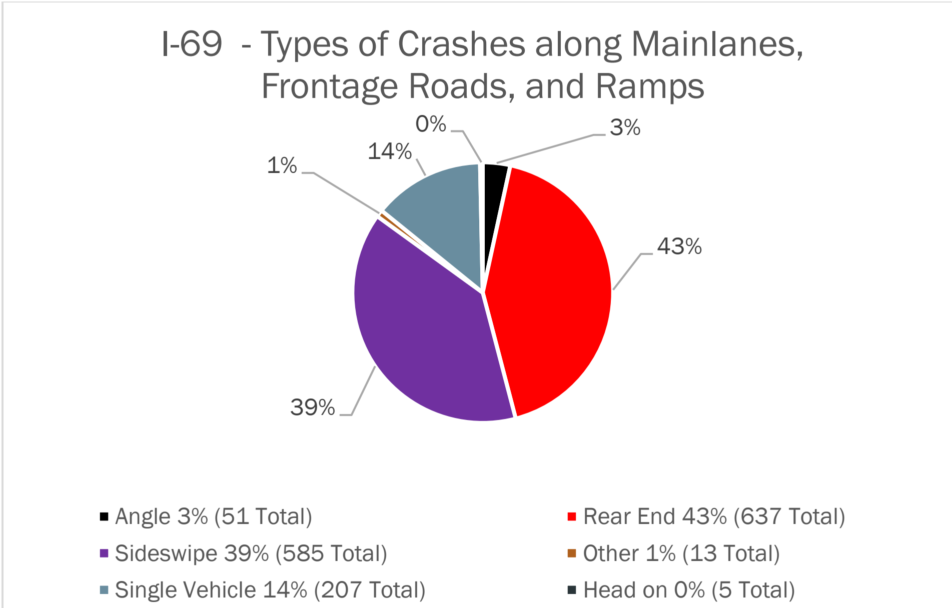

Figure 32: I-69 – Types of Crashes along Mainlanes, Frontage Roads, and Ramps

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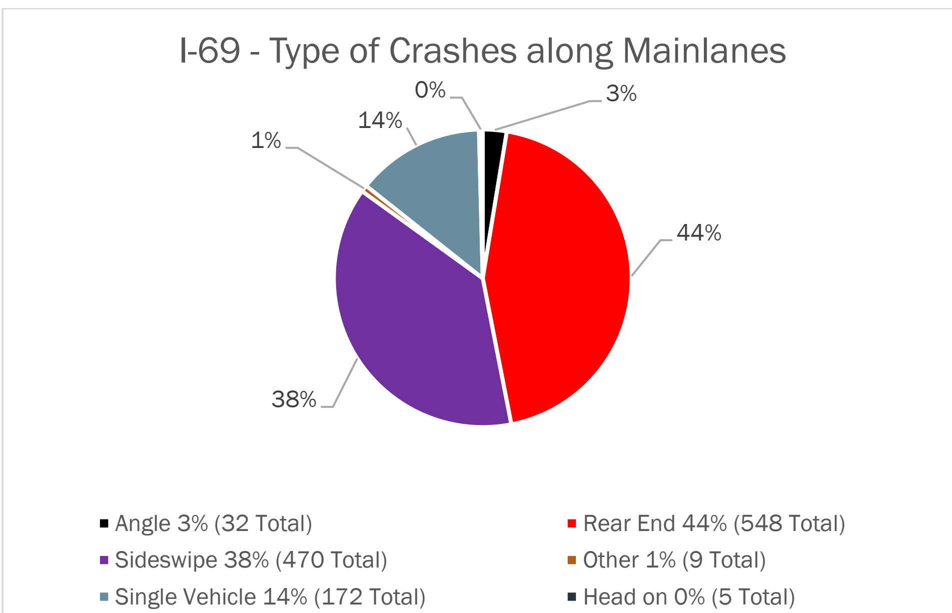

Figure 33: I-69 - Type of Crashes along Mainlanes

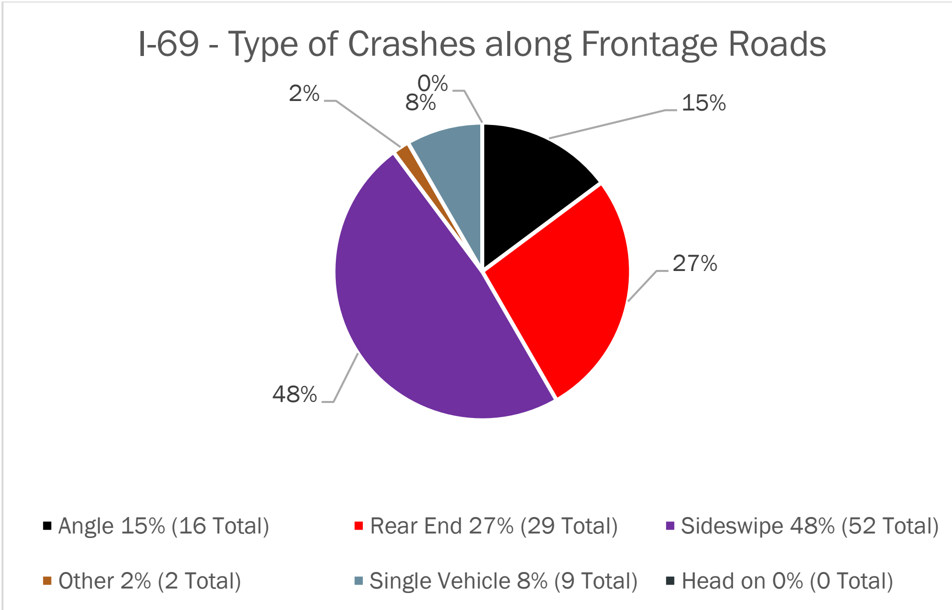

Figure 34: I-69 – Type of Crashes along Frontage Roads

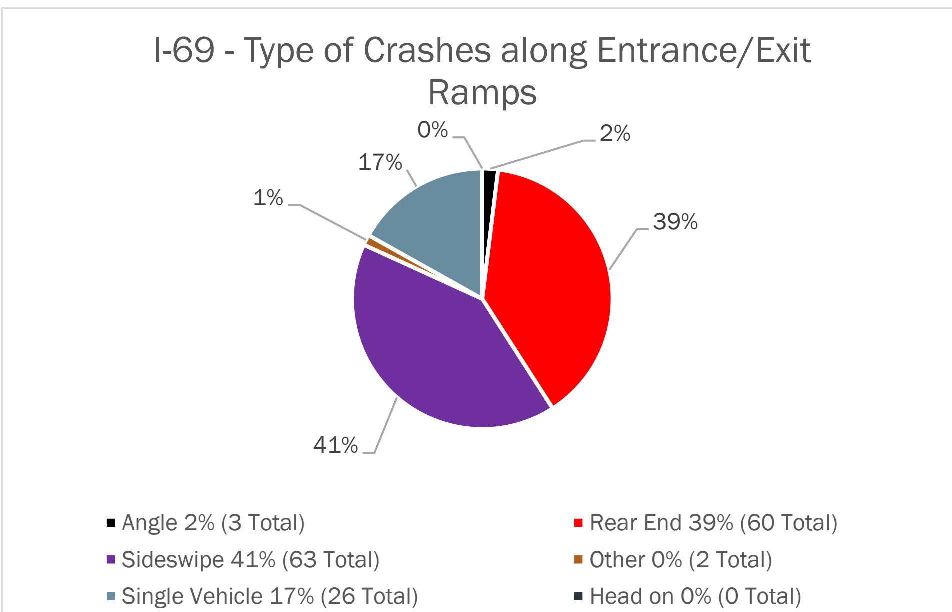

Figure 35: I-69 – Type of Crashes along Entrance/Exit Ramps

As illustrated in **Figure 32**, the most common crash types for I-69 include: rear end, sideswipe, and single vehicle crashes. **Figures 33-35** show the type of crashes by facility type that occur in this area.

Figures 36-38 illustrates the breakdown of crashes by severity along I-69. Each crash is categorized based upon the most severe injury recorded. Of the 1,498 crashes within the project area, 68% were reported as non-injuries. Over the five-year study period, 9 fatalities and 25 incapacitating injuries were recorded.

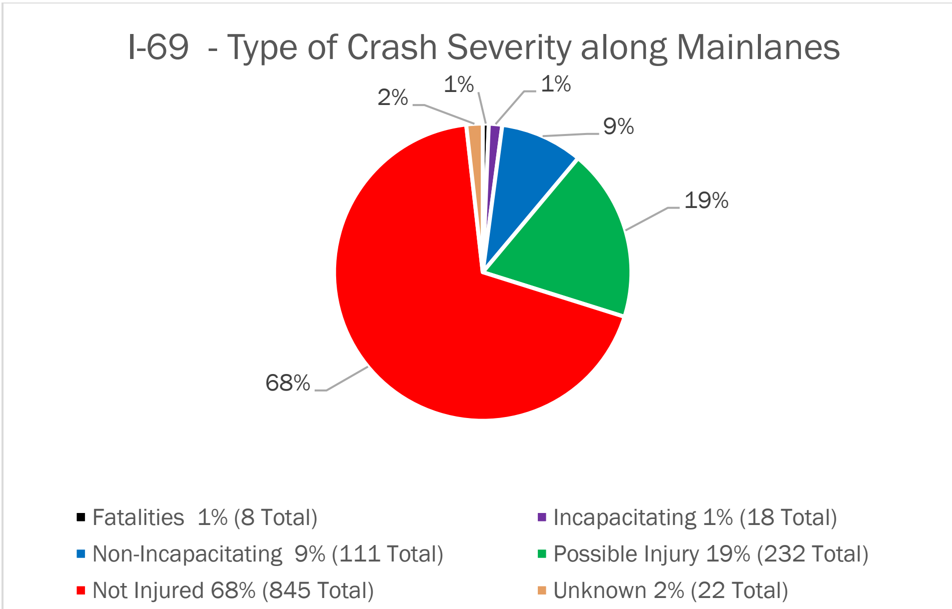

Figure 36: I-69 – Type of Crash Severity along Mainlanes

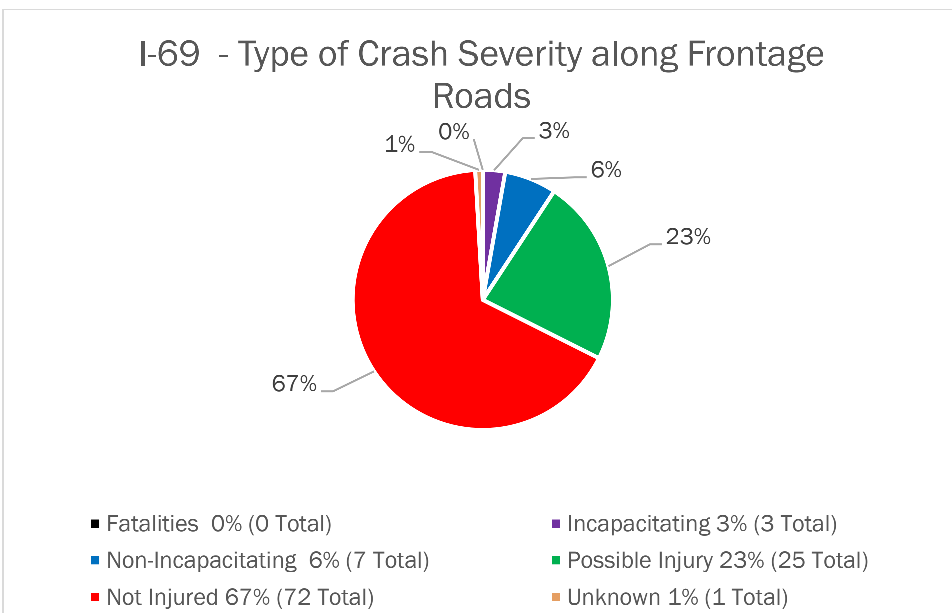

Figure 37: I-69 – Type of Crash Severity along Frontage Roads

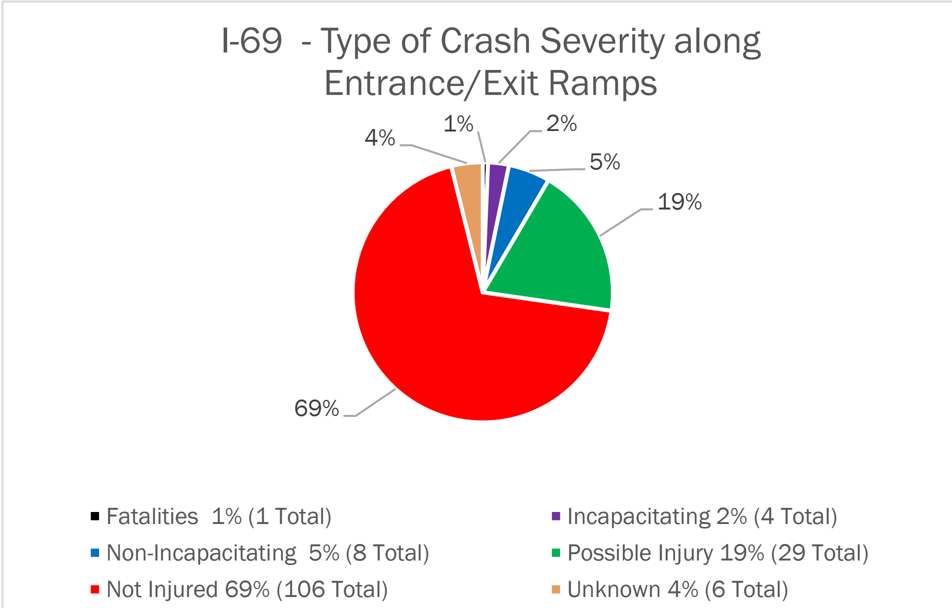

Figure 38: I-69 – Type of Crash Severity along Entrance/Exit Ramps

Table 47 show the crash severity along I-69 across all years compared to the project area.

Table 47: Crash Severity along I-69 vs Project Area

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-69 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Unknown	7	1%	0	0%	0	0%	7	0%	69	1%
	Suspected Serious Injury	5	0%	0	0%	1	1%	6	0%	38	0%
	Non Incap	29	2%	2	2%	1	1%	32	2%	194	2%
	Possible Inj	59	5%	9	8%	4	3%	72	5%	696	6%
	Killed	5	0%	0	0%	0	0%	5	0%	16	0%
	Not Injured	179	14%	15	14%	13	8%	207	14%	2072	17%
	Total	284	23%	26	24%	19	12%	329	22%	3085	26%
2016	Unknown	3	0%	0	0%	3	2%	6	0%	51	0%
	Suspected Serious Injury	4	0%	1	1%	2	1%	7	0%	45	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-69 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Non Incap	22	2%	0	0%	1	1%	23	2%	213	2%
	Possible Inj	52	4%	4	4%	10	6%	66	4%	605	5%
	Killed	1	0%	0	0%	0	0%	1	0%	12	0%
	Not Injured	199	16%	17	16%	29	19%	245	16%	2070	17%
	Total	281	23%	22	20%	45	29%	348	23%	2996	25%
2017	Unknown	5	0%	1	1%	2	1%	8	1%	66	1%
	Suspected Serious Injury	3	0%	2	2%	1	1%	6	0%	32	0%
	Non Incap	31	3%	3	3%	2	1%	36	2%	216	2%
	Possible Inj	53	4%	1	1%	7	5%	61	4%	573	5%
	Killed	0	0%	0	0%	1	1%	1	0%	10	0%
	Not Injured	208	17%	22	20%	29	19%	259	17%	2111	18%
	Total	300	24%	29	27%	42	27%	371	25%	3008	25%
2018	Unknown	7	1%	0	0%	1	1%	8	1%	69	1%
	Suspected Serious Injury	6	0%	0	0%	0	0%	6	0%	26	0%
	Non Incap	29	2%	2	2%	4	3%	35	2%	165	1%
	Possible Inj	68	6%	11	10%	8	5%	87	6%	612	5%
	Killed	2	0%	0	0%	0	0%	2	0%	9	0%
	Not Injured	259	21%	18	17%	35	23%	312	21%	1995	17%
	Total	371	30%	31	29%	48	31%	450	30%	2876	24%
Avg 2015 - 2018	Unknown	6	0%	0	0%	2	1%	7	1%	64	1%
	Suspected Serious Injury	5	0%	1	1%	1	1%	6	0%	35	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-69 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Non Incap	28	2%	2	2%	2	1%	32	2%	197	2%
	Possible Inj	58	5%	6	6%	7	5%	72	5%	622	5%
	Killed	2	0%	0	0%	0	0%	2	0%	12	0%
	Not Injured	211	17%	18	17%	27	17%	256	17%	2062	17%
	Total	310	25%	27	25%	39	25%	375	25%	2992	25%
Total		1236	100%	108	100%	154	100%	1498	100%	11965	100%

Table 47 shows that there are no significant trends year to year for crash severity. All crash severities for all years along I-69 are comparable to the project area.

The proposed Build schematic addresses the critical weave location before the direct connectors entering and exiting the I-69 and I-45 interchange by realigning I-45 to be parallel with I-10 north of downtown and parallel with I-69 east of downtown until it turns south to the existing I-45 alignment southeast of the downtown area and the removal of the fourth leg of the I-69 at I-45 interchange with the Pierce Elevated section removal. The proposed Build schematic addresses the critical weave location the weave before the direct connectors approaching the I-69 interchange with SH 288 and the area to the north and south of the Spur 527 interchange with the realignment of SH 288 and I-69 and removal of exits giving access to Jackson Street and Chenevert Street

1,044 of 1,498 mainlane, frontage road, and ramp crashes (70%) were reported during daylight conditions. 28% (416 of 1,498) crashes occurred during nighttime. 55 crashes (4%) were reported to be nighttime crashes in areas where there was limited to no illumination.

Table 48 and **Figure 39** show the time of day in which crashes occurred along I-69 in addition to comparing the number of crashes within this segment to the project area.

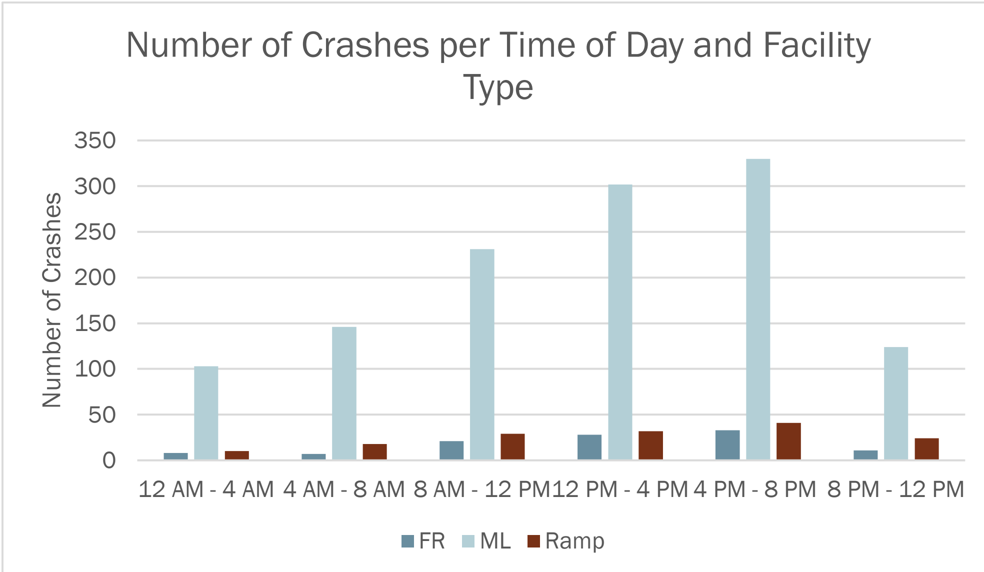

Figure 39: Number of Crashes per Time of Day and Facility Type along I-69

Table 48: Time of Day Crashes along I-69 vs Project Area

Time of Day	I-69 (#, %)		Project Area (#, %)	
12 AM - 4 AM	121	8%	936	8%
4 AM - 8 AM	171	11%	1605	13%
8 AM - 12 PM	281	19%	2412	20%
12 PM - 4 PM	362	24%	2876	24%
4 PM - 8 PM	404	27%	2818	24%
8 PM - 12 PM	159	11%	1318	11%
Total	1498	100%	11965	100%

As shown in **Table 48**, there are more crashes between 4 PM to 8 PM compared to the project area. This is likely due to the increased number of vehicles on the segment during this time period.

Table 49 shows the time of day crashes and severity along I-69 compared to the project area.

Table 49: Time of Day Crashes and Severity along I-69

Time of Day	Segment and Project Area Crashes and Percentages	Unknown	Suspected Serious Injury	Non-Incapacitating Injury	Possible Injury	Killed	Not Injured	Total
12 AM - 4 AM	Segment Crashes	10	3	13	20	3	72	121
	Segment %	8%	2%	11%	17%	2%	60%	100%
	Project Area Crashes	100	29	87	130	17	573	936
	Project Area %	11%	3%	9%	14%	2%	61%	100%
4 AM - 8 AM	Segment Crashes	5	5	15	42	2	102	171
	Segment %	3%	3%	9%	25%	1%	60%	100%
	Project Area Crashes	42	16	100	353	11	1083	1605
	Project Area %	3%	1%	6%	22%	1%	67%	100%
8 AM - 12 PM	Segment Crashes	3	1	27	59	0	191	281
	Segment %	1%	0%	10%	21%	0%	68%	100%
	Project Area Crashes	26	20	182	577	4	1603	2412
	Project Area %	1%	1%	8%	24%	0%	66%	100%
12 PM - 4 PM	Segment Crashes	3	6	31	70	1	251	362
	Segment %	1%	2%	9%	19%	0%	69%	100%
	Project Area Crashes	30	23	171	652	3	1997	2876
	Project Area %	1%	1%	6%	23%	0%	69%	100%
4 PM - 8 PM	Segment Crashes	3	5	28	77	1	290	404
	Segment %	1%	1%	7%	19%	0%	72%	100%
	Project Area Crashes	24	22	150	562	2	2058	2818
	Project Area %	1%	1%	5%	20%	0%	73%	100%
8 PM - 12 PM	Segment Crashes	5	5	12	18	2	117	159
	Segment %	3%	3%	8%	11%	1%	74%	100%
	Project Area Crashes	33	31	98	212	10	934	1318
	Project Area %	3%	2%	7%	16%	1%	71%	100%

Table 49 shows that 20 of the 34 total KA crashes (killed or suspected serious injury) occurred between 8 PM and 8 AM (58% of crashes). The least KA crashes occurred during 8 AM to 12 PM with one crash. The other time periods were consistent with either 6 or 7 KA crashes per period.

3.8.4 I-10

The I-10 limits span from Taylor Street to Lockwood Drive There were 2,204 total crashes on this corridor from 2015 to 2018. **Tables 50 – 51** show the crash types along this area by facility type and year.

Table 50: Crash Types along I-10

Crash Type	ML	FR	Ramps	I-10	Project Area
Angle	1%	8%	0%	2%	2%
Head On	0%	0%	0%	0%	0%
Other	1%	6%	0%	1%	2%
Rear End	51%	33%	37%	50%	50%
Sideswipe	29%	38%	19%	29%	31%
Single Vehicle	17%	16%	44%	17%	14%
Total	100%	100%	100%	100%	100%

Table 50 shows less sideswipe crashes and greater single vehicle crashes compared to the project area. **Table 51** shows the crash types for all years along I-10 compared to the project area.

Table 51: Crash Types along I-10 vs Project Area

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-10 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Angle	4	0%	3	3%	0	0%	7	0%	51	0%
	Head-On	3	0%	0	0%	0	0%	3	0%	10	0%
	Other	2	0%	1	1%	0	0%	3	0%	44	0%
	Rear End	277	14%	9	8%	7	12%	293	13%	1579	13%
	Sideswipe	134	7%	15	14%	1	2%	150	7%	900	8%
	Single Vehicle	92	5%	1	1%	8	14%	101	5%	501	4%
	Total	512	25%	29	27%	16	27%	557	25%	3085	26%
2016	Angle	4	0%	3	3%	0	0%	7	0%	74	1%
	Head-On	1	0%	0	0%	0	0%	1	0%	3	0%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-10 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Other	3	0%	2	2%	0	0%	5	0%	56	0%
	Rear End	267	13%	6	6%	5	8%	278	13%	1530	13%
	Sideswipe	129	6%	12	11%	2	3%	143	6%	916	8%
	Single Vehicle	96	5%	6	6%	9	15%	111	5%	417	3%
	Total	500	25%	29	27%	16	27%	545	25%	2996	25%
2017	Angle	12	1%	1	1%	0	0%	13	1%	86	1%
	Head-On	1	0%	0	0%	0	0%	1	0%	10	0%
	Other	14	1%	2	2%	0	0%	16	1%	65	1%
	Rear End	269	13%	9	8%	5	8%	283	13%	1474	12%
	Sideswipe	170	8%	8	7%	7	12%	185	8%	947	8%
	Single Vehicle	86	4%	4	4%	6	10%	96	4%	426	4%
	Total	552	27%	24	22%	18	31%	594	27%	3008	25%
2018	Angle	8	0%	2	2%	0	0%	10	0%	76	1%
	Head-On	1	0%	0	0%	0	0%	1	0%	7	0%
	Other	5	0%	1	1%	0	0%	6	0%	45	0%
	Rear End	235	12%	12	11%	5	8%	252	11%	1454	12%
	Sideswipe	156	8%	6	6%	1	2%	163	7%	904	8%
	Single Vehicle	67	3%	6	6%	3	5%	76	3%	390	3%
	Total	472	23%	27	25%	9	15%	508	23%	2876	24%
Avg 2015 - 2018	Angle	7	0%	2	2%	0	0%	9	0%	72	1%
	Head-On	2	0%	0	0%	0	0%	2	0%	8	0%
	Other	6	0%	2	1%	0	0%	8	0%	53	0%
	Rear End	262	13%	9	8%	6	9%	277	13%	1509	13%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-10 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Sideswipe	147	7%	10	9%	3	5%	160	7%	917	8%
	Single Vehicle	85	4%	4	4%	7	11%	96	4%	434	4%
	Total	509	25%	27	25%	16	27%	552	25%	2993	25%
Total		2036	100%	109	100%	59	100%	2204	100%	11965	100%

Table 51 shows a slightly higher proportion of single vehicle crashes than the project area. There were no major observed construction improvements between 2015 and 2018.

Figure 40 shows the type of crashes occurring along I-10. **Figures 41-43** show the types of crashes by freeway type.

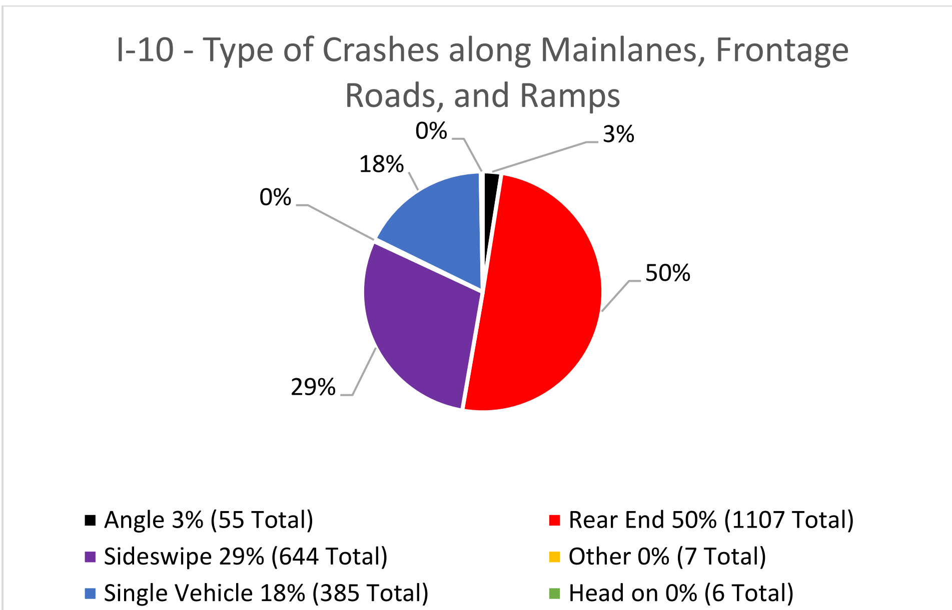

Figure 40: I-10 - Type of Crashes along Mainlanes, Frontage Roads, and Ramps

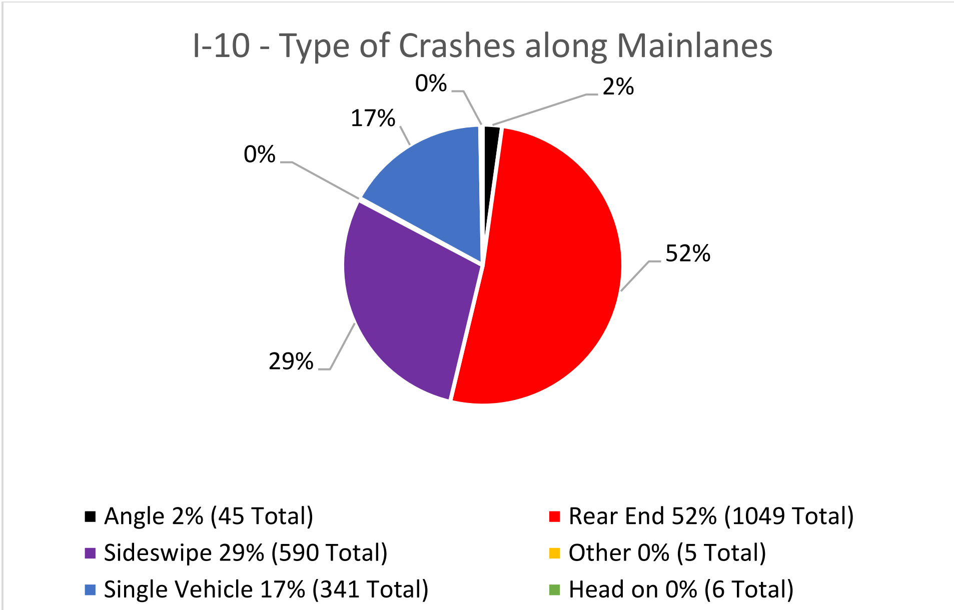

Figure 41: I-10 – Type of Crashes along Mainlanes

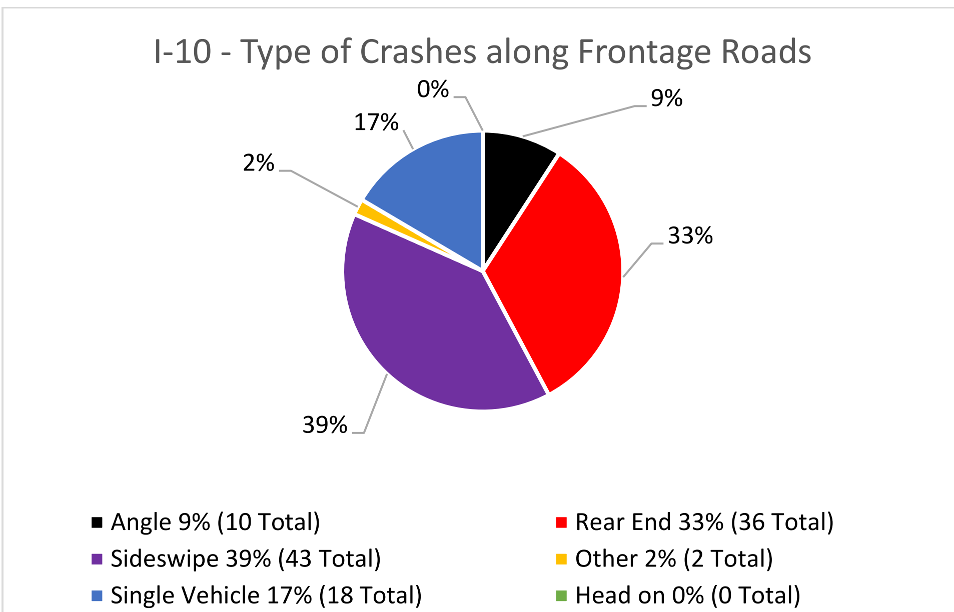

Figure 42: I-10 – Type of Crashes along Frontage Roads

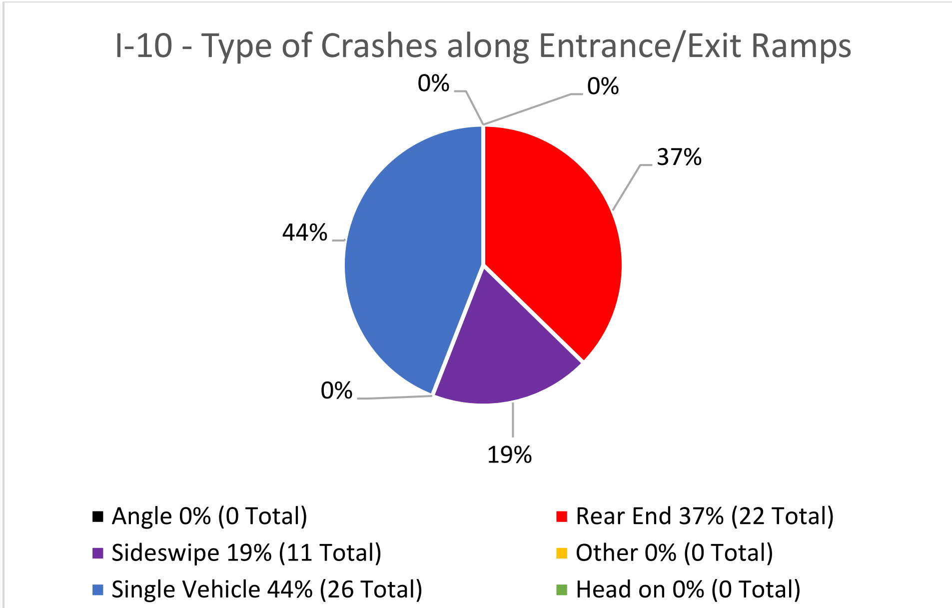

Figure 43: I-10 – Type of Crashes along Entrance/Exit Ramps

As shown in **Figure 40**, the most common crash types for I-10 include: rear end, sideswipe, and single vehicle crashes. Causes for these types of crashes included: lane changing, congestion and weaving behavior. Crash hotspot locations included the areas along Taylor Street, Houston Avenue, and Waco Street.

Figures 44-46 show the crash severity occurring along this roadway. Each crash is categorized based upon the most severe injury recorded for each crash. Of the 2,204 crashes within the project area, the majority were reported as non-injuries on the mainlanes, frontage roads, and entrance/exit ramps. Over the four (4) year study period, 4 fatalities and 31 incapacitating injuries were recorded.

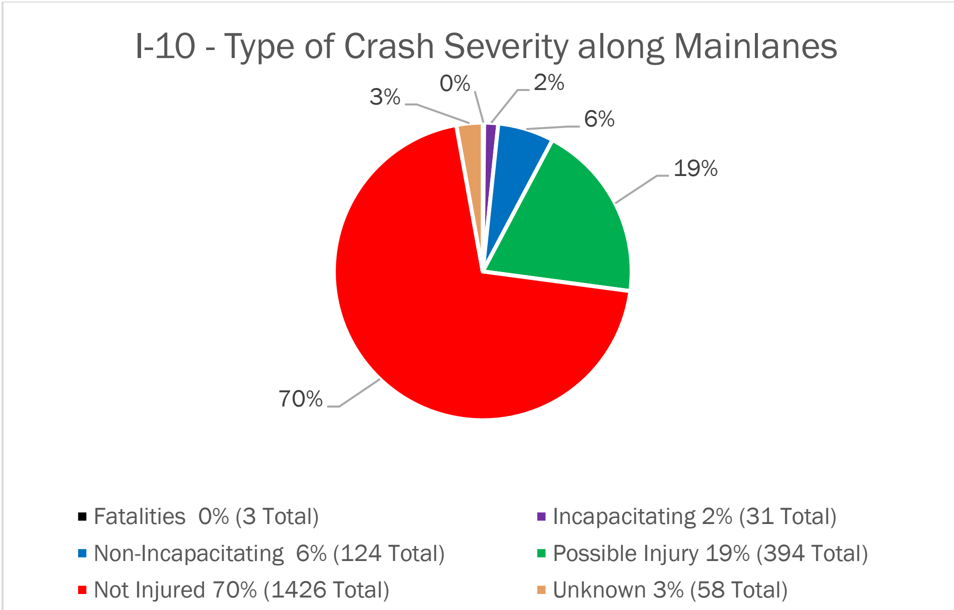

Figure 44: I-10 - Type of Crash Severity along Mainlanes

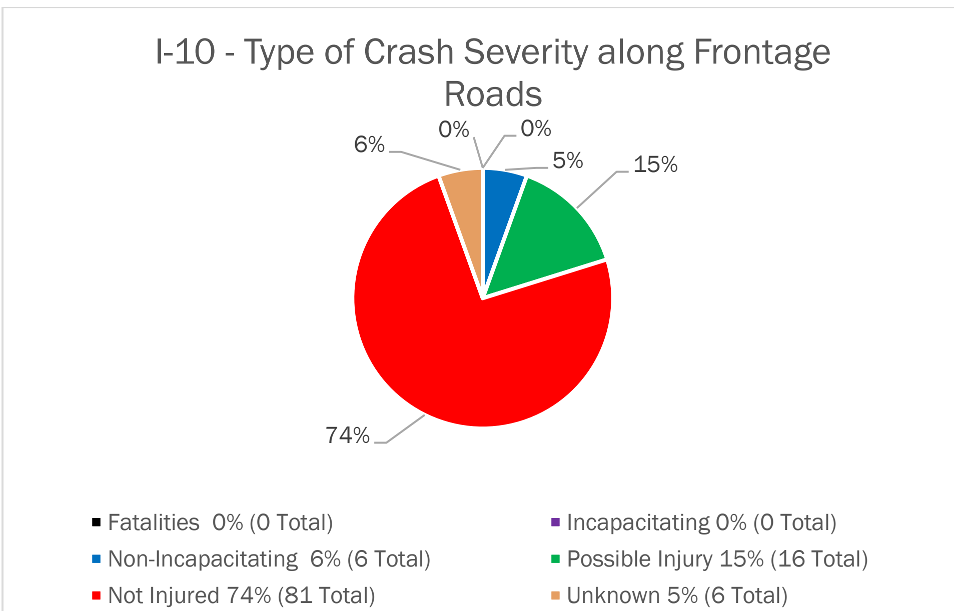

Figure 45: I-10 – Type of Crash Severity along Frontage Roads

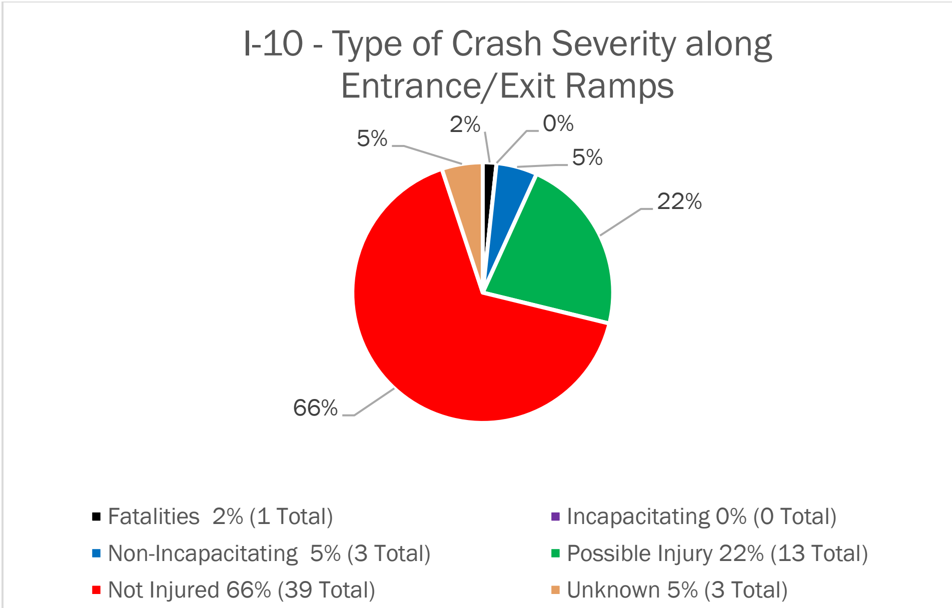

Figure 46: I-10 – Type of Crash Severity along Entrance/Exit Ramps

Table 52 shows the crash severity along I-10 compared to the project area.

Table 52: Crash Severity along I-10 vs Project Area

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-10 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Unknown	20	1%	0	0%	1	2%	21	1%	69	1%
	Suspected Serious Injury	5	0%	0	0%	0	0%	5	0%	38	0%
	Non Incap	18	1%	2	2%	2	3%	22	1%	194	2%
	Possible Inj	112	6%	3	3%	4	7%	119	5%	696	6%
	Killed	1	0%	0	0%	0	0%	1	0%	16	0%
	Not Injured	356	17%	24	22%	9	15%	389	18%	2072	17%
	Total	512	25%	29	27%	16	27%	557	25%	3085	26%
2016	Unknown	15	1%	2	2%	1	2%	18	1%	51	0%
	Suspected Serious Injury	13	1%	0	0%	0	0%	13	1%	45	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-10 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Non Incap	34	2%	3	3%	1	2%	38	2%	213	2%
	Possible Inj	96	5%	4	4%	3	5%	103	5%	605	5%
	Killed	0	0%	0	0%	0	0%	0	0%	12	0%
	Not Injured	342	17%	20	18%	11	19%	373	17%	2070	17%
	Total	500	25%	29	27%	16	27%	545	25%	2996	25%
2017	Unknown	11	1%	1	1%	1	2%	13	1%	66	1%
	Suspected Serious Injury	7	0%	0	0%	0	0%	7	0%	32	0%
	Non Incap	37	2%	1	1%	0	0%	38	2%	216	2%
	Possible Inj	97	5%	4	4%	3	5%	104	5%	573	5%
	Killed	2	0%	0	0%	1	2%	3	0%	10	0%
	Not Injured	398	20%	18	17%	13	22%	429	19%	2111	18%
	Total	552	27%	24	22%	18	31%	594	27%	3008	25%
2018	Unknown	12	1%	3	3%	0	0%	15	1%	69	1%
	Suspected Serious Injury	6	0%	0	0%	0	0%	6	0%	26	0%
	Non Incap	35	2%	0	0%	0	0%	35	2%	165	1%
	Possible Inj	89	4%	5	5%	3	5%	97	4%	612	5%
	Killed	0	0%	0	0%	0	0%	0	0%	9	0%
	Not Injured	330	16%	19	17%	6	10%	355	16%	1995	17%
	Total	472	23%	27	25%	9	15%	508	23%	2876	24%
Avg 2015 - 2018	Unknown	15	1%	2	1%	1	1%	17	1%	64	1%
	Suspected Serious Injury	8	0%	0	0%	0	0%	8	0%	35	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-10 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Non Incap	31	2%	2	1%	1	1%	33	2%	197	2%
	Possible Inj	99	5%	4	4%	3	6%	106	5%	622	5%
	Killed	1	0%	0	0%	0	0%	1	0%	12	0%
	Not Injured	357	18%	20	19%	10	17%	387	18%	2062	17%
	Total	511	25%	28	26%	15	25%	552	25%	2992	25%
Total		2036	100%	109	100%	59	100%	2204	100%	11965	100%

Table 52 shows that all crash severities for all years along I-69 are comparable to the project area.

The entrance ramp from Taylor Street is a location where updating to meet design criteria would improve safety and operations. The entrance ramp from Taylor Street to I-10 eastbound has no acceleration lane. The entrance ramp should be redesigned to AASHTO and TxDOT Roadway Design Manual standards in accordance with tapered or parallel entrance ramp design criteria. In addition to the short taper length, vehicles entering the I-45 northbound direct connector have a short weaving length (2,000 ft) and are required to perform four lane changes before reaching the exit. In review of the crash data, there is a concentration of sideswipe crashes in this area.

The proposed Build schematic does not address the entrance ramp from Taylor Street since this location is slightly beyond the limits of this project and constrained by a retaining wall. In regards to the weave, the lane changes from Taylor Street entrance are still needed, but an additional lane of capacity is provided for vehicles accessing I-45 northbound, and access from Quitman Street is maintain which should be a route considered for vehicles in the Taylor Street vicinity. These will be considered as part of I-10 improvements that are under development from I-610 to I-45 under a separate project.

1,555 of the 2,204 mainlane, frontage road, and ramp crashes (71%) were reported during daylight conditions. 27% (594 of 2204) crashes occurred during nighttime conditions. 63 crashes (3%) were reported to be nighttime crashes in areas where there was limited to no illumination.

Table 53 and **Figure 47** show the time of day in which crashes occurred along I-10 in addition to comparing the number of crashes within this segment to the entire facility.

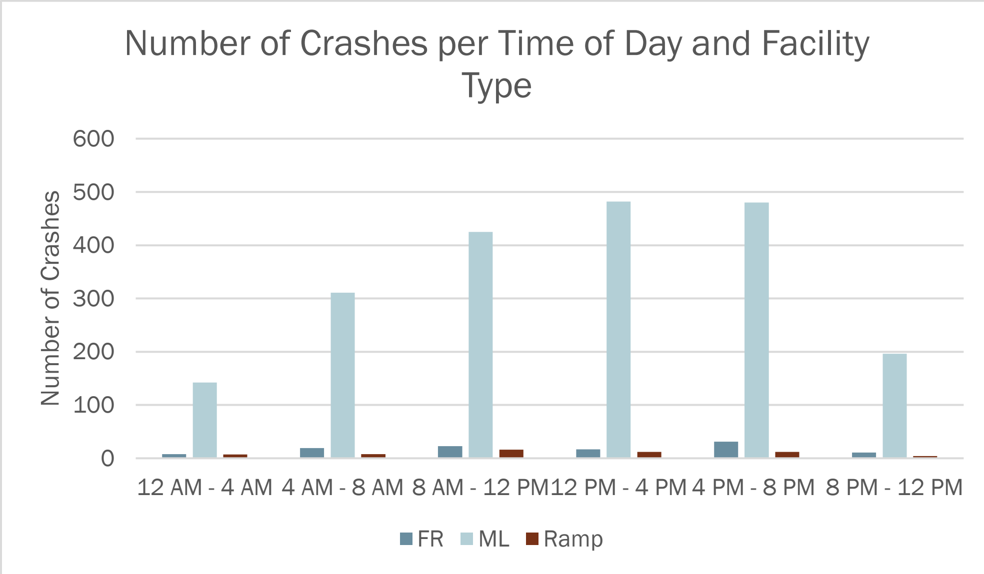

Figure 47: Number of Crashes per Time of Day and Facility Type along I-10

Table 53: Time of Day Crashes along I-10 vs Project Area

Time of Day	I-10 (#, %)		Project Area (#, %)	
12 AM - 4 AM	157	7%	936	8%
4 AM - 8 AM	338	15%	1605	13%
8 AM - 12 PM	464	21%	2412	20%
12 PM - 4 PM	511	23%	2876	24%
4 PM - 8 PM	523	24%	2818	24%
8 PM - 12 PM	211	10%	1318	11%
Total	2204	100%	11965	100%

Table 53 shows that the number of crashes per time period are comparable to the project area. **Table 54** shows the time of day crashes and severity along I-10 compared to the project area.

Table 54: Time of Day Crashes and Severity along I-10

Time of Day	Segment and Project Area Crashes and Percentages	Unknown	Suspected Serious Injury	Non-Incapacitating Injury	Possible Injury	Killed	Not Injured	Total
12 AM - 4 AM	Segment Crashes	24	7	11	22	1	92	157
	Segment %	15%	4%	7%	14%	1%	59%	100%
	Project Area Crashes	100	29	87	130	17	573	936
	Project Area %	11%	3%	9%	14%	2%	61%	100%
4 AM - 8 AM	Segment Crashes	14	3	24	77	1	219	338
	Segment %	4%	1%	7%	23%	0%	65%	100%
	Project Area Crashes	42	16	100	353	11	1083	1605
	Project Area %	3%	1%	6%	22%	1%	67%	100%
8 AM - 12 PM	Segment Crashes	10	4	39	101	2	308	464
	Segment %	2%	1%	8%	22%	0%	66%	100%
	Project Area Crashes	26	20	182	577	4	1603	2412
	Project Area %	1%	1%	8%	24%	0%	66%	100%
12 PM - 4 PM	Segment Crashes	11	2	26	95	0	377	511
	Segment %	2%	0%	5%	19%	0%	74%	100%
	Project Area Crashes	30	23	171	652	3	1997	2876
	Project Area %	1%	1%	6%	23%	0%	69%	100%
4 PM - 8 PM	Segment Crashes	2	6	20	93	0	402	523
	Segment %	0%	1%	4%	18%	0%	77%	100%
	Project Area Crashes	24	22	150	562	2	2058	2818
	Project Area %	1%	1%	5%	20%	0%	73%	100%
8 PM - 12 PM	Segment Crashes	6	9	13	35	0	148	211
	Segment %	3%	4%	6%	17%	0%	70%	100%
	Project Area Crashes	33	31	98	212	10	934	1318
	Project Area %	3%	2%	7%	16%	1%	71%	100%

Table 54 shows a total of 35 KA crashes (killed or suspected serious injury). 21 of these crashes occurred between 8 PM and 8 AM (60% of crashes). The period with the least KA crashes is 12 PM – 4 PM with 2 crashes.

3.8.5 I-610

The I-610 limits span from Main Street to Hardy Toll Road. There are 1,889 crashes from years 2015-2018. **Tables 55** and **56** show the crash types along this area by facility type and year.

Table 55: Crash Types along I-610

Crash Type	ML	FR	Ramps	All I-610	Project Area
Angle	2%	11%	2%	3%	2%
Head On	0%	0%	0%	0%	0%
Other	1%	5%	0%	2%	2%
Rear End	46%	16%	37%	41%	50%
Sideswipe	37%	52%	25%	39%	31%
Single Vehicle	14%	15%	35%	15%	14%
Total	100%	100%	100%	100%	100%

Table 55 shows there were far less rear end crashes compared to the rest of the project area. This is likely because I-610 had the least amount of congestion relative to the other segments. **Table 56** shows the crash types for all years along I-610 compared to the project area.

Table 56: Crash Types along I-610 vs Project Area

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Angle	3	0%	4	1%	0	0%	7	0%	51	0%
	Head-On	1	0%	0	0%	0	0%	1	0%	10	0%
	Other	2	0%	2	1%	0	0%	4	0%	44	0%
	Rear End	169	11%	8	2%	8	16%	185	10%	1579	13%
	Sideswipe	132	9%	37	11%	5	10%	174	9%	900	8%
	Single Vehicle	72	5%	11	3%	4	8%	87	5%	501	4%
	Total	379	25%	62	18%	17	33%	458	24%	3085	26%
2016	Angle	8	1%	8	2%	1	2%	17	1%	74	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	3	0%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Other	6	0%	6	2%	0	0%	12	1%	56	0%
	Rear End	180	12%	15	4%	5	10%	200	11%	1530	13%
	Sideswipe	130	9%	44	13%	0	0%	174	9%	916	8%
	Single Vehicle	42	3%	13	4%	10	20%	65	3%	417	3%
	Total	366	25%	86	25%	16	31%	468	25%	2996	25%
2017	Angle	4	0%	14	4%	0	0%	18	1%	86	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	10	0%
	Other	10	1%	5	1%	0	0%	15	1%	65	1%
	Rear End	169	11%	20	6%	4	8%	193	10%	1474	12%
	Sideswipe	151	10%	55	16%	4	8%	210	11%	947	8%
	Single Vehicle	45	3%	13	4%	2	4%	60	3%	426	4%
	Total	379	25%	107	31%	10	20%	496	26%	3008	25%
2018	Angle	8	1%	12	3%	0	0%	20	1%	76	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	7	0%
	Other	4	0%	6	2%	0	0%	10	1%	45	0%
	Rear End	172	12%	14	4%	2	4%	188	10%	1454	12%
	Sideswipe	132	9%	46	13%	4	8%	182	10%	904	8%
	Single Vehicle	49	3%	16	5%	2	4%	67	4%	390	3%
	Total	365	25%	94	27%	8	16%	467	25%	2876	24%
Avg 2015 - 2018	Angle	6	0%	10	3%	0	1%	16	1%	72	1%
	Head-On	0	0%	0	0%	0	0%	0	0%	8	0%
	Other	6	0%	5	1%	0	0%	10	1%	53	0%
	Rear End	173	12%	14	4%	5	9%	192	10%	1509	13%

Year	Crash Type	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Sideswipe	136	9%	46	13%	3	6%	185	10%	917	8%
	Single Vehicle	52	4%	13	4%	5	9%	70	4%	434	4%
	Total	373	25%	88	25%	13	25%	473	25%	2993	25%
Total		1489	100%	349	100%	51	100%	1889	100%	11965	100%

As shown in **Table 56**, there are less rear end crashes and more sideswipe crashes compared to the project area. This is likely because of the short weave distances, left side exits and entrances at the I-45 interchange, and speed differential.

Figure 48 shows the type of crashes occurring along I-610.

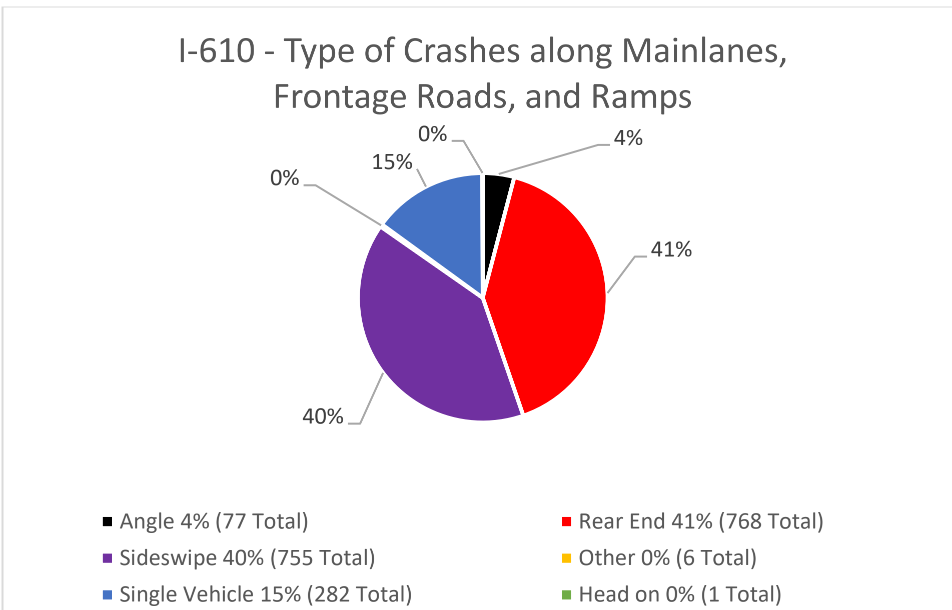

Figure 48: I-610 - Type of Crashes along Mainlanes, Frontage Roads, and Ramps

As shown in **Figure 48**, the most common crash types for I-610 were rear end, sideswipe, and single vehicle crashes. Causes for these types of crashes include: lane changing, congestion and weaving behavior throughout the corridor. Hotspot locations included Airline Drive, Irvington Blvd, and Hardy Toll Road.

The direct connectors serving I-45 northbound and I-45 southbound are located 2,800 feet from the Main Street entrance ramp, providing appropriate weaving distance for vehicles wishing to access the I-45 interchange from I-610 eastbound. However, due to heavy congestion during the AM and PM peak periods at this location, weaving maneuvers along I-610 eastbound are difficult.

Figures 49-51 illustrates the breakdown of crashes by severity. Each crash is categorized based upon the most severe injury recorded for each crash. Of the 1,889 crashes within the project area, the majority were reported as non-injuries. Over the five-year study period, 8 fatalities and 25 incapacitating injuries were recorded.

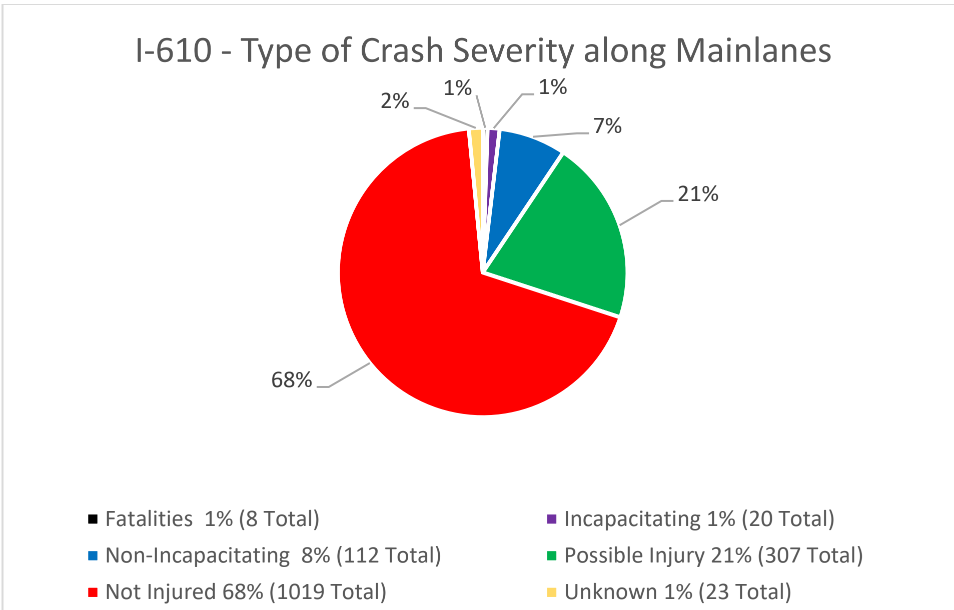

Figure 49: I-610 – Type of Crash Severity along Mainlanes

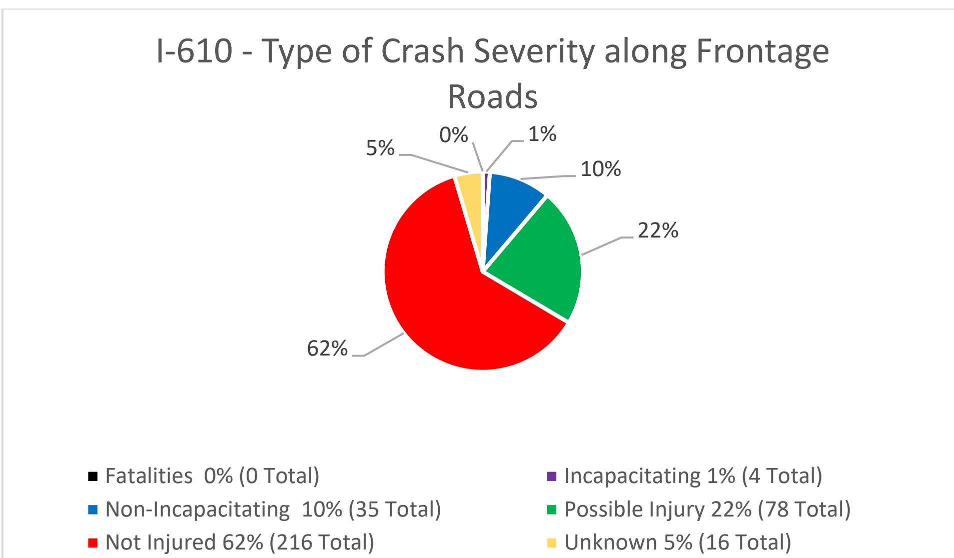

Figure 50: I-610 – Type of Crash Severity along Frontage Roads

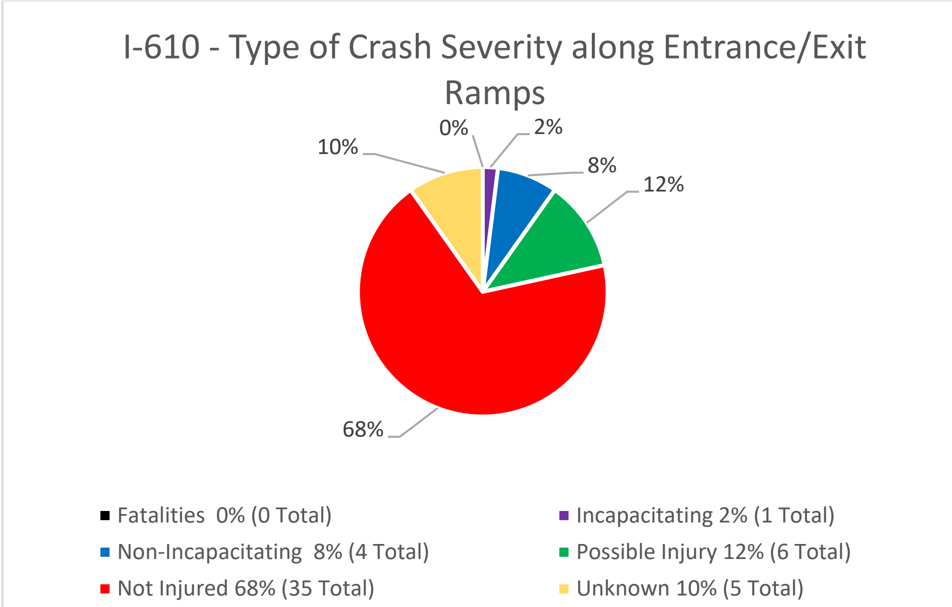

Figure 51: I-610 – Type of Crash Severity along Entrance/Exit Ramps

Table 57 shows the crash severity along I-610 compared to the project area.

Table 57: Crash Severity for all years along I-610 vs Project Area

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
2015	Unknown	7	0%	3	1%	0	0%	10	1%	69	1%
	Suspected Serious Injury	7	0%	0	0%	1	2%	8	0%	38	0%
	Non Incap	31	2%	8	2%	0	0%	39	2%	194	2%
	Possible Inj	83	6%	21	6%	2	4%	106	6%	696	6%
	Killed	3	0%	0	0%	0	0%	3	0%	16	0%
	Not Injured	248	17%	30	9%	14	27%	292	15%	2072	17%
	Total	379	25%	62	18%	17	33%	458	24%	3085	26%
2016	Unknown	3	0%	3	1%	4	8%	10	1%	51	0%
	Suspected Serious Injury	6	0%	2	1%	0	0%	8	0%	45	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Non Incap	30	2%	12	3%	1	2%	43	2%	213	2%
	Possible Inj	73	5%	17	5%	2	4%	92	5%	605	5%
	Killed	3	0%	0	0%	0	0%	3	0%	12	0%
	Not Injured	251	17%	52	15%	9	18%	312	17%	2070	17%
	Total	366	25%	86	25%	16	31%	468	25%	2996	25%
2017	Unknown	8	1%	2	1%	0	0%	10	1%	66	1%
	Suspected Serious Injury	4	0%	1	0%	0	0%	5	0%	32	0%
	Non Incap	31	2%	10	3%	3	6%	44	2%	216	2%
	Possible Inj	69	5%	20	6%	1	2%	90	5%	573	5%
	Killed	1	0%	0	0%	0	0%	1	0%	10	0%
	Not Injured	266	18%	74	21%	6	12%	346	18%	2111	18%
	Total	379	25%	107	31%	10	20%	496	26%	3008	25%
2018	Unknown	5	0%	8	2%	1	2%	14	1%	69	1%
	Suspected Serious Injury	3	0%	1	0%	0	0%	4	0%	26	0%
	Non Incap	20	1%	5	1%	0	0%	25	1%	165	1%
	Possible Inj	82	6%	20	6%	1	2%	103	5%	612	5%
	Killed	1	0%	0	0%	0	0%	1	0%	9	0%
	Not Injured	254	17%	60	17%	6	12%	320	17%	1995	17%
	Total	365	25%	94	27%	8	16%	467	25%	2876	24%
Avg 2015 - 2018	Unknown	6	0%	4	1%	1	3%	11	1%	64	1%
	Suspected Serious Injury	5	0%	1	0%	0	1%	6	0%	35	0%

Year	Crash Severity	ML (#, % of total crashes)		FR (#, % of total crashes)		Ramps (#,% of total crashes)		I-610 (#,% of total crashes)		Project Area (#,% of total crashes)	
	Non Incap	28	2%	9	3%	1	2%	38	2%	197	2%
	Possible Inj	77	5%	20	6%	2	3%	98	5%	622	5%
	Killed	2	0%	0	0%	0	0%	2	0%	12	0%
	Not Injured	255	17%	54	16%	9	17%	318	17%	2062	17%
	Total	373	25%	88	25%	13	25%	473	25%	2992	25%
Total		1489	100%	349	100%	51	100%	1889	100%	11965	100%

Table 57 shows that there are no significant trends year to year for crash severity. All crash severities for all years along I-610 are comparable to the project area.

The TxDOT Roadway Design Manual designates minimum spacing and guidelines for ramps with and without auxiliary lanes. According to the TxDOT Roadway Design Manual, the minimum weaving length between an entrance ramp followed by an exit ramp without an auxiliary lane is 2,000 ft and with an auxiliary lane is 1,500 ft. The minimum weaving length between an exit ramp followed by an exit ramp is 1,000 ft. **Table 58** denotes ramps where updating existing conditions to meet design criteria could be effective in improving safety and operations in this area. In the review of the crash data, there were rear end and sideswipe crashes noted in this area.

Table 58: Critical Merge/Weave Locations (I-610)

Between		Travel Direction	Gore to Gore Length (ft)	Has Auxiliary Lane?
Ramp 1	Ramp 2			
Entrance from Main St.	Exit to Airline Dr.	EB	1,120	Yes
Entrance from Airline Dr.	Exit to Main St.	WB	1,120	Yes

The proposed Build schematic addresses the critical merge locations with the removal of the eastbound entrance ramp from Main Street and the westbound exit ramp to Main Street on I-45.

1,330 of the 1,889 mainlane, frontage road, and ramp crashes (70%) were reported during daylight conditions. 28% (525 of 1889) of crashes occurred during nighttime conditions. 57 crashes (3%) were reported to be nighttime crashes in areas where there was limited to no illumination.

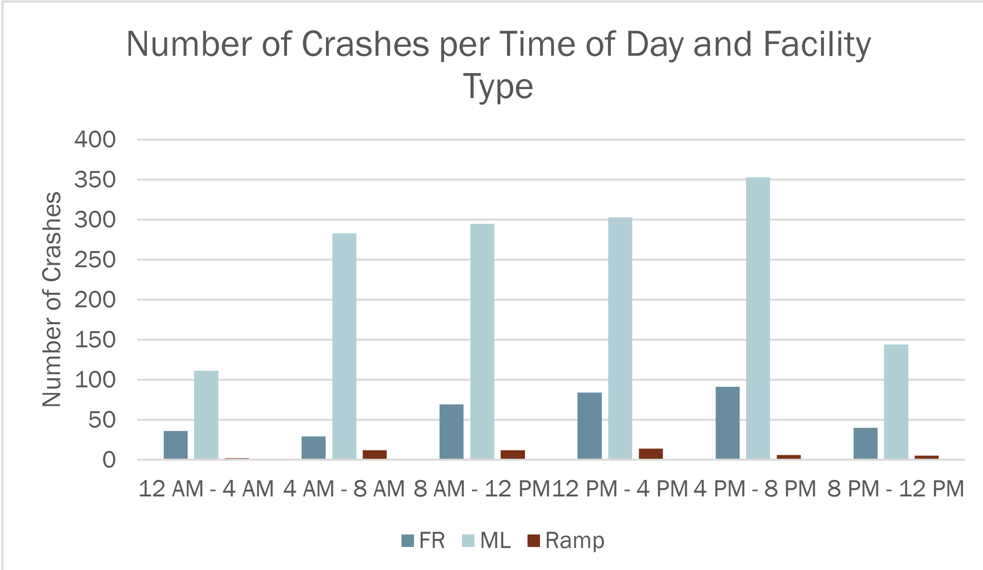

Figure 52: Number of Crashes per Time of Day and Facility Type along I-610

Table 59 and **Figure 52** show the time of day in which crashes occurred along I-610 in addition to comparing the number of crashes within this segment to the entire facility.

Table 59: Time of Day Crashes along I-610 vs Project Area

Time of Day	I-610 (#, %)		Project Area (#, %)	
12 AM - 4 AM	149	8%	936	8%
4 AM - 8 AM	324	17%	1605	13%
8 AM - 12 PM	376	20%	2412	20%
12 PM - 4 PM	401	21%	2876	24%
4 PM - 8 PM	450	24%	2818	24%
8 PM - 12 PM	189	10%	1318	11%
Total	1889	100%	11965	100%

As shown in **Table 59**, there are more crashes between 4 AM and 8 AM compared to the project area. This could be due to higher demand for morning commuters along this segment than the project area, as many vehicles are traveling to Downtown Houston.

Table 60 shows the time of day crashes and severity along I-610 compared to the project area.

Table 60: Time of Day Crashes and Severity along I-610

Time of Day	Segment and Project Area Crashes and Percentages	Unknown	Suspected Serious Injury	Non-Incapacitating Injury	Possible Injury	Killed	Not Injured	Total
12 AM - 4 AM	Segment Crashes	22	3	20	23	3	78	149
	Segment %	15%	2%	13%	15%	2%	52%	100%
	Project Area Crashes	100	29	87	130	17	573	936
	Project Area %	11%	3%	9%	14%	2%	61%	100%
4 AM - 8 AM	Segment Crashes	8	2	21	72	1	220	324
	Segment %	2%	1%	6%	22%	0%	68%	100%
	Project Area Crashes	42	16	100	353	11	1083	1605
	Project Area %	3%	1%	6%	22%	1%	67%	100%
8 AM - 12 PM	Segment Crashes	3	4	34	81	1	253	376
	Segment %	1%	1%	9%	22%	0%	67%	100%
	Project Area Crashes	26	20	182	577	4	1603	2412
	Project Area %	1%	1%	8%	24%	0%	66%	100%
12 PM - 4 PM	Segment Crashes	5	7	22	98	1	268	401
	Segment %	1%	2%	5%	24%	0%	67%	100%
	Project Area Crashes	30	23	171	652	3	1997	2876
	Project Area %	1%	1%	6%	23%	0%	69%	100%
4 PM - 8 PM	Segment Crashes	2	2	36	88	0	322	450
	Segment %	0%	0%	8%	20%	0%	72%	100%
	Project Area Crashes	24	22	150	562	2	2058	2818
	Project Area %	1%	1%	5%	20%	0%	73%	100%
8 PM - 12 PM	Segment Crashes	4	7	18	29	2	129	189
	Segment %	2%	4%	10%	15%	1%	68%	100%
	Project Area Crashes	33	31	98	212	10	934	1318
	Project Area %	3%	2%	7%	16%	1%	71%	100%

Table 60 shows a total of 33 KA crashes (killed or suspected serious injury). 18 of these crashes occurred between 8 PM and 8 AM (55% of crashes). The period with the most KA crashes is 8 PM – 12 AM with 9 crashes. This is significant as it is higher than the project area proportion. This could be due to sight distance at night with the short weaves and lane changes in the vicinity of the I-45 interchange.

3.9 *Existing Environmental Constraints*

There are several environmental constraints in the project area, including; residential communities, water resources, floodplains, wetlands and other waters of the United States, vegetation and wildlife, threatened and endangered species, archaeological, historic resources, and section 4(f) resources. Each constraint is briefly described below. More information can be found in the Draft Environmental Impact Statement (EIS) that was released in April 2017. An existing environmental constraint map is provided in **Appendix J**.

Residential Communities

Communities are adjacent to the freeway facilities and required consideration in development of alternatives.

Water Resources

Within the proposed project area, the City of Houston operates and maintains the public water system that distributes public drinking water to end users. 15 registered water wells are located within the proposed project area. Wells that have unavoidable impacts with the proposed Build schematic will be plugged and abandoned according to Texas Commission on Environmental Quality (TCEQ) regulations to eliminate the potential for impacts to groundwater resources.

Floodplains

Portions of the proposed project traverse areas designated by the Federal Emergency Management Agency (FEMA) as special flood hazard areas (regulatory floodways, 100-year floodplains, and 500-year floodplains). Approximately 70 percent of the project area is outside the 100-year floodplains and other flood hazard areas as determined by FEMA. Specifically, the Buffalo Bayou traverses the project area in Segment 3, the Little White Oak Bayou runs adjacent to I-45 in Segment 2, and the White Oak Bayou runs adjacent to I-10 on the western portion of Segment 3. A detailed hydrologic and hydraulic study will be performed for the proposed project during the design phase to determine the appropriate location and sizes for required bridges, culverts, and other structures, to meet or exceed FHWA and TxDOT standards.

Wetlands and Other Waters of the United States

The Buffalo Bayou and a portion of the White Oak Bayou within Segment 3 are identified as navigable waters of the United States. Project construction activities involving discharges of dredged or fill material into navigable waters will require a permit from the U.S. Army Corps of Engineers (USACE) under Section 10 of the Rivers and Harbors Act. Coordination with the U.S. Coast Guard under Section 9 of the Rivers and Harbors Act will be required for bridge structures over the navigable waters of the Buffalo Bayou and White Oak Bayou.

The majority of the water bodies in the project area are streams or drainages, as opposed to wetlands. Impacts to the jurisdictional waters of the United States, including wetlands, are minimized with the proposed project. Coordination with the USACE will be conducted for Section 404 of the Clean Water

Act and Section 10 of the Rivers and Harbors Act permit authorization for unavoidable impacts to jurisdictional waters/wetlands.

Vegetation and Wildlife

Vegetation is not a significant environmental constraint since the project is in an urbanized area with less than 0.4 percent having riparian or open water characteristics. Native wildlife populations in the general region of the proposed project have been largely displaced by the development and urbanization of Houston, leaving remaining habitat areas highly fragmented. No essential fish habitat is identified in the proposed project area.

Threatened and Endangered Species

The U.S. Fish and Wildlife Service's Information and Planning and Conservation website lists five species as potentially occurring within the project area. None of the species would be impacted by the proposed project since three are bird species, and the remaining two do not have existing suitable habitats in the project area. There are one state-listed threatened species and three Species of Greatest Conservation Need (SGCN) that may be impacted by construction of the proposed project. Surveys will be conducted prior to construction to see if preferred habitats are present within the proposed right-of-way.

Archaeological

Archaeological studies are ongoing and have identified some areas within the right-of-way that are classified as high probability and moderate probability areas. On site surveys will be performed for parcels within the right-of-way for the proposed schematic.

Historic Resources

Segment 2 does not have any locations impacted by National Register of Historic Places (NRHP)-eligible properties, however, Segment 3 includes impacts to historic resources. An individual Section 4(f) evaluation is being prepared for all properties that will be adversely affected by the proposed schematic.

Section 4(f) Resources

Public parks and recreational facilities within 500 feet of the proposed project right-of-way were evaluated for potential Section 4(f) effects. Historic resources evaluated were those within the area of potential impact for the proposed project or immediately adjacent to the proposed right-of-way.

4.0 **Future Conditions**

Future conditions were assessed with the use of several data sources, including the 2040 H-GAC model, draft traffic projections developed by others for use in pavement, air, and noise analyses, future transportation plans, and background projects. This section is organized with the following sub-sections:

- Future Land Use
- Future Forecast Traffic Volume
- Future Plans and Background Projects

Each of these subsections relate to items that have impacts on the alternative operational and safety analyses.

4.1 *Future Land Use*

Future land use was evaluated using the 2040 H-GAC model and identifying any major developments in the project area. The redevelopment east of the project area on the Buffalo Bayou was considered, along with redevelopment in the downtown area. The project is currently in an urban area, therefore, land use changes are not expected to change significantly from existing.

Table 61 depicts the population and employment growth rates calculated for the neighboring areas included in **Figure 53**. The population growth in the project area, northeast, southeast, south, and west regional areas appear reasonable. The project area is experiencing lower employment and population growth that can be attributed to the higher absolute values of the population and employment in the area. Higher population growth in the north, northeast and west neighboring areas reflect the larger potential for future growth in these areas that are currently less developed. Employment growth rates are higher in the northeast and west neighborhood areas. The northeast area consists of the area between Hardy Toll Road, I-69, and SL 8, which has the potential to attract large future employment growth. In summary, the H-GAC TDM socioeconomic growth pattern for the neighboring areas was found to be reasonable.

Table 61: Neighboring Growth (AAGR)

Location	2015 to 2025 Annual Pop (%)	2025 to 2040 Annual Pop (%)	2015 to 2025 Annual Emp (%)	2025 to 2040 Annual Emp (%)
Project Area	0.9%	0.8%	0.9%	1.8%
North	2.5%	1.3%	1.3%	0.9%
Northeast	1.7%	1.4%	3.1%	0.8%
Southeast	1.3%	2.7%	1.1%	1.9%
South	1.6%	1.6%	1.2%	0.7%
West	2.1%	1.4%	2.6%	2.0%

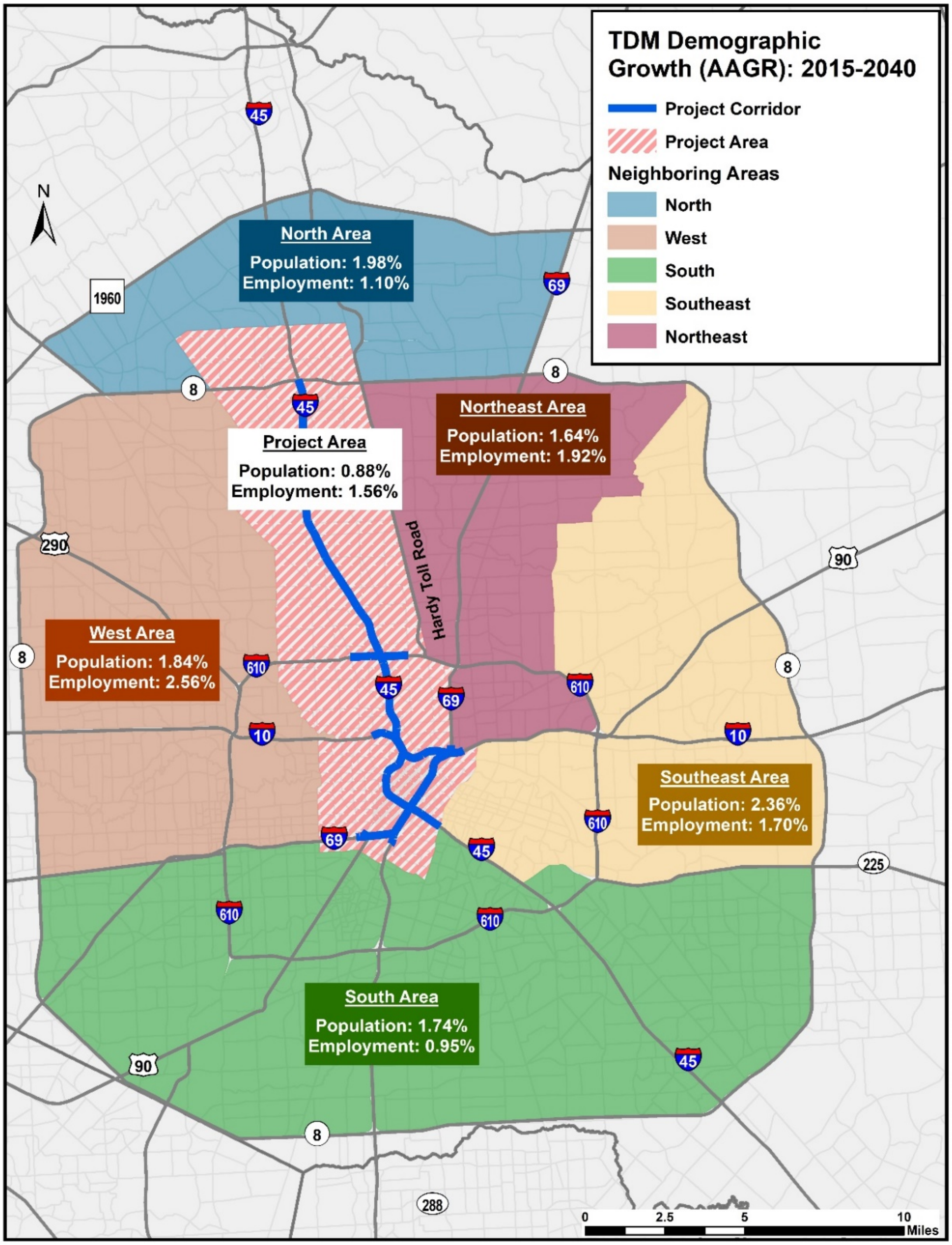

Figure 53: Project and Neighboring Area Population and Employment Annual Growth

4.2 *Future Forecast Traffic Volume*

As discussed in the methodology section of the report, future year traffic volumes were developed utilizing accepted methodologies and guidelines in conjunction with TDM input, TxDOT TP&P standard procedures and specific knowledge of the project area. Facility specific growth rates were based on the approach discussed in the previous section. The growth rates applied for development of both the No-Build and Build peak period forecast traffic volumes are presented in **Table 62** below.

Table 62: Project Corridor Growth Rates

Roadway	Growth Rate (AAGR)	
	2018 - 2025	2025-2045
I-45	0.75% - 1.75%	0.5% - 1.5%
I-69	1.0% - 1.75%	0.75% - 1.5%
I-10	1.0%	0.75%
I-610	1.0% - 1.5%	0.75% - 1.0%
SH 288	1.75%	1.25% - 1.5%

The growth rate ranges presented in **Table 62** represent the range of growth rates that are applied to different sections of each roadway and the connectors accessing each roadway for the 2025 and 2045 forecast years in the No-Build and Build scenarios. The growth rates were applied in five combinations to the roadway sections shown in **Table 63** below.

Table 63: Growth Rate Application by Roadway Section

Growth Rate Combination	2025 Growth Rate (AAGR)	2045 Growth Rate (AAGR)	Roadway Sections
1	1.0%	0.75%	I-610, I-10, I-69 S of I-45
2	1.5%	1.0%	I-69 N of I-45, Hardy Toll, Hardy Toll to I-610 Connectors
3	0.75%	0.5%	I-45
4	1.75%	1.5%	SH 288 (Build), SH 288 to I-45 and I-69 Connectors
5	1.75%	1.25%	SH288 (No-Build), SH 288 to I-45 and I-69 Connectors (No-Build)

After the No-Build traffic volumes and patterns where finalized, No-Build and Build scenarios from the TDM and standard procedures documented by TxDOT-TPP were used to identify changes in traffic patterns resulting from project improvements. The TDM helped identify changes to traffic patterns, which were then used to develop forecast year traffic volumes. The approach for changes in travel patterns included first identifying system level changes, and, subsequently, applying local level changes. System level changes to traffic patterns include traffic that is moving through the project area and influenced by capacity changes on major freeway facilities and new/relocated facilities. These traffic pattern changes were informed by TDM comparisons between the Base, No-Build, and Build scenarios at key locations in the project corridor. Local level changes to traffic patterns consist of route changes contained within the project area at urban interchanges and are influenced by access restrictions or additions.

Figure 54 depicts changes in traffic patterns effecting the No-Build and Build traffic volumes due to the proposed Hardy Connector. In the figure, the dashed lines show the original route used by traffic in the base scenario and the solid lines show the diversion to the proposed facility. These diversions were determined by TDM volume comparisons between the Base and No-Build scenarios and knowledge of traffic patterns. During traffic volume development, volumes maintained balanced total ingress and egress between the Base and No-Build configurations, meaning that the total number of vehicles entering and exiting the network is consistent between scenarios of the same analysis years. In the No-Build scenario traffic pattern changes diverted traffic from I-45 to the Hardy Toll Connector that either accessed downtown or continued through the project area on I-45.

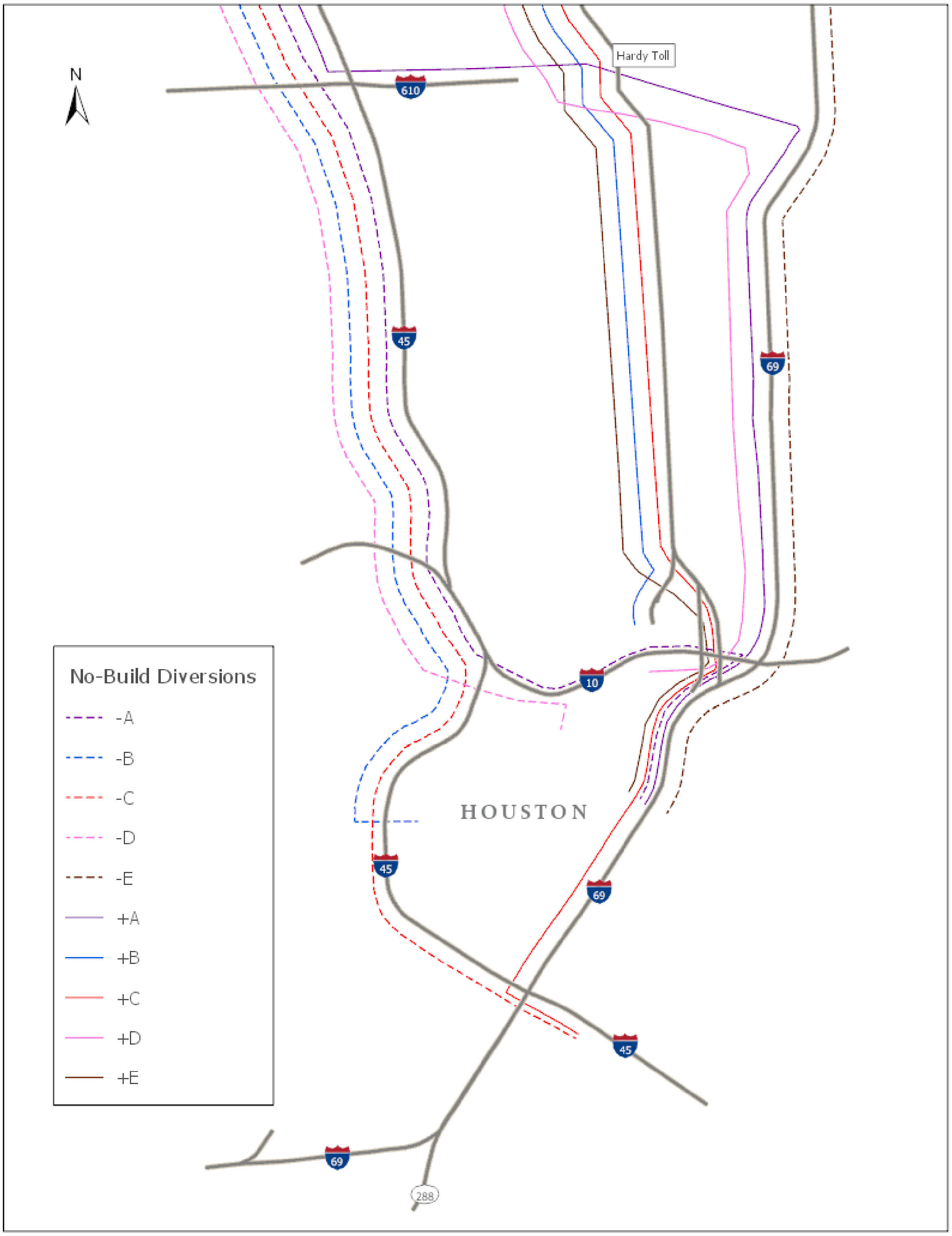

Figure 54: No-Build Traffic Pattern Changes

The Build scenario forecast was developed with a similar methodology as the No-Build scenario. Key traffic pattern changes resulting from the relocation of I-45 to the north and east side of downtown, the downtown connector system on the northwest side of downtown, the addition of MAX lanes in the corridor, and frontage road/ramp reconfigurations throughout the project area were identified.

The completed traffic forecast for the Base, 2025, and 2045 scenarios are included in **Appendix D**. It is important to note that these traffic forecasts are three-hour periods, so the lane capacity should not be compared to a typical one-hour peak hour lane capacity.

The traffic patterns in the downtown area were impacted by the revision from full interchanges to partial interchanges for I-45 at I-10 and I-45 at I-69. A full description of the updated routes is provided in Section 5.3.2.

4.3 *Future Plans and Background Projects*

The project team discussed future plans and background projects with stakeholders to identify and incorporate into to the Build schematics. Various agencies, including Houston METRO, City of Houston, H-GAC, and Harris County Toll Road Authority (HCTRA), have future plans and projects that impact the project area. The most significant plans are briefly discussed in this section, with reference to locations where more detail can be found.

4.3.1 Future Plans

Several future transportation plans were identified to identify accommodations needed for the design schematics. The following are key future plans in the project area that were considered in schematic development.

- Houston METRO Reimagining – This transit plan was approved in 2015 and includes restructuring of bus routes throughout the Houston area. The plan has a series of proposed changes that are being implemented in stages throughout the region. More information can be found at https://www.ridemetro.org/Pages/Reimagining.aspx.
- City of Houston Bike Plan – The Houston Bike Plan was adopted by City Council in March 2017. It includes short term implementation routes and a long-term improvement map for bike facilities in the Houston region. The City is in the process of prioritizing and implementing the bike facilities included in the plan. More information on the report is included at http://houstonbikeplan.org/documents/.
- City of Houston Thoroughfare and Freeway Plan (MTP) – The City of Houston updates this plan annually and it identifies sections of roadways (either thoroughfares or major collectors) that are in need of expansion, either by lengthening or widening. More information and maps of proposed expansions are included at https://www.houstontx.gov/planning/transportation/MTFP.html.

- H-GAC 2040 Pedestrian and Bicycle Plan – The 2045 Pedestrian and Bicycle Plan is under development as part of the 2045 Regional Transportation Plan. This plan was completed in 2015 and is a long-range planning document that describes our region's vision for enhancing pedestrian and bicycle infrastructure within the eight-county Transportation Management Area (TMA). It supports the 2040 Regional Transportation Plan (RTP), a long-range, multi-modal transportation plan that guides investment in all types of transportation infrastructure throughout the Houston-Galveston area. More information is at the plan website, https://www.h-gac.com/pedestrian-bicyclist-planning/regional-plan.aspx.
- H-GAC 2045 Regional Transportation Plan (RTP) – The 2045 draft RTP has been released and is currently under public comment period. The plan includes recommended improvements for the 2045 regional vision. More information can be found at the 2045 draft RTP website, http://2045rtp.com/documents.aspx.

Each of these plans were considered in the production of project area alternatives. The proposed design schematics incorporate or do not inhibit the execution of these plans as part of network mobility throughout the Houston area.

4.3.2 Background Projects

There are two background projects that were included in future year alternative analysis. The background projects included had a direct impact on the roadway infrastructure for operational analysis and traffic patterns in the project area. The background projects include

- I-45 northbound to I-69 northbound direct connector reconstruction project – This project reconstructed the direct connector to utilize a collector-distributor system and distribute traffic demand upstream of the existing gore point location. It is expected to be completed by the end of 2019 and is included in all 2025 and 2045 analysis year microsimulation models.
- Hardy Toll Road Downtown Connector Project – As discussed in previous sections of this report, the North Hardy Toll Road is proposed to be extended to the I-10 at I-69 interchange. This project is expected to substantially impact traffic patterns and is expected to be completed in 2023. It is included in both the 2025 and 2045 analysis year microsimulation models.

These background projects are included in the TDM development and were considered in development of traffic projections. Project plans were reviewed and incorporated into the microsimulation traffic operation models.

5.0 Alternatives

The alternatives for I-45 NHHIP have gone through an iterative process over the last 15 years. There was initial, planning level, screening of alternatives using the H-GAC travel demand models, following by a more robust evaluation of alternatives for the environmental impact statement. The alternatives have been refined with public and stakeholder input throughout the project development. For this report's alternative analysis, the operational and safety analyses are performed with the No-Build and Build (preferred alternative) scenarios. This section includes discussion of the initial alternatives, the preliminary preferred alternative, and the analysis of the scenarios for the design period (2025 to 2045).

5.1 *Initial Alternatives*

The universe of alternatives for Segments 2 and 3 were developed in a comprehensive, multi-year process. The process undertaken to develop these alternatives is summarized below and a detailed report, NHHIP Alternatives Analysis: Engineering and Traffic Criteria is available in **Appendix K**.

The process included the following steps:

- Identify the Universe of Alternatives
    - Alternatives from prior Studies
    - Develop Alternatives via Public and Stakeholder Meeting
    - Study Team developed additional Alternatives
- Evaluate Alternatives
    - Develop Methodology to screen the alternatives
    - Initial Screening: Reduce the Universe of Alternatives to six (6) per segment
    - Develop the six Alternatives to conduct a more detail screening
    - Detailed screening to develop three (3) Preliminary Alternatives:
    - Structural feasibility
    - Evaluate using Houston-Galveston Area Council (H-GAC) Traffic Demand Model (TDM)
    - Seek Input on the Preliminary Alternatives from various Stakeholders
        - Public Meetings
        - Agency meetings
- Determine the Proposed Recommended Alternative

The first step undertaken to identify the Universe of Alternatives was to review studies previously completed in the project area. The prior studies were: 2004 North-Hardy Corridor Alternatives

Analysis Report (Transit Component), 2005 North-Hardy Planning Studies, Alternatives Analysis Report (Highway Component), Downtown District Study, 2005 US 59/I-69/SH 288 Corridor Feasibility Study (from Spur 527 to I-45), and the 2012 I-45N Alternative Analysis. Next, Stakeholder and Public Meetings were held to seek additional ideas and better inform the alternative development. Using this stakeholder and public input, the project team developed a set of 15 alternatives for Segment 2 and 10 alternatives for Segment 3 to further analyze.

To develop additional Alternatives, the design team followed the latest design standards and methodologies from TxDOT and AASHTO. The alternatives were focused on project purpose and need. The alternatives ranged from alignment of freeways, number of lanes by segment, and types of facilities to serve the users.

The universe of alternatives were evaluated with methodologies agreed upon by stakeholders to screen alternatives. Alternatives were removed based on constraints, including environmental and physical, along with evaluation of mobility improvement. Detailed screening was continued with seven alternatives for both Segment 2 and Segment 3.

The remaining preliminary alternatives were evaluated by constructability, functionality requirements, operational and maintenance, Managed Lane Utilization, Travel Demand along I-45, Vehicle Hours Traveled (VHT) along I-45, VHT along Project area Freeway System, VHT along the Downtown Street System, and Volume to Capacity Ratio along I-45. This level of analysis was completed as part of the draft Environmental Impact Statement (DEIS). It included H-GAC model runs and preliminary Vissim model development.

A preferred alternative was selected as part of the DEIS. This alternative combined several alternative components and met both stakeholder and public purpose and need.

5.2 *Alternative Scenarios*

The preferred alternative was moved forward to analysis at the detailed microsimulation and safety level. This report analyzes the preferred alternative (Build) and No-Build scenarios for 2025 and 2045. The scenarios analyzed include:

- 2025 No-Build
- 2025 Build
- 2045 No-Build
- 2045 Build

An iterative process of Build refinement was completed to improve the schematic upon detailed analysis.

5.3 *Operational Analysis of Alternatives*

One of the main needs that spurred the I-45 NHHIP is the inadequate existing and future capacity to accommodate traffic demand. With the expected traffic growth over the coming years, a "Do-Nothing" scenario was expected to result in greater deficiencies on the existing facilities. An operational analysis of the No-Build and Build alternatives was completed to compare operational results.

5.3.1 No-Build Alternative

The 2025 and 2045 No-Build scenarios, as mentioned previously, included two major background projects; I-45 northbound to I-69 northbound direct connector reconstruction and the Hardy Toll Road Downtown Connector projects. Traffic projections were developed for AM and PM peak periods and incorporated updates to land use, demographics, and background projects. The No-Build is commonly referred to as the "Do-Nothing" scenario. If we were to do-nothing and maintain the existing infrastructure with future changes to traffic patterns, these are the expected operational results.

No-Build Vissim results were output for the entire network for AM and PM peak periods and highlight overall performance. Based on the focused MOEs discussed previously, network statistics for speed, vehicle-miles travelled, and latent demand were output and are shown in **Table 64**. The remaining MOEs (segment speed, queue lengths, travel time, speed differential, and lane change movements) are the focus of specific calibration locations. The full 2025 and 2045 No-Build network results are included in **Appendix L** and **Appendix N**, and speed maps in 15-minute increments in **Appendix M** and **Appendix O**, respectively.

Table 64: Existing 2018, No-Build 2025, and No-Build 2045 Vissim Results

		Average Speed (mph)	Vehicle Miles	Latent Demand (veh)
2018	AM	27.5	1,208,839	23,628
	PM	25.2	1,410,570	48,657
2025	AM	25.6	1,200,562	29,436
	PM	19.8	1,318,645	86,684
2045	AM	19.7	1,190,301	85,724
	PM	17.7	1,361,786	134,994

As shown in **Table 64**, both the AM and PM networks show a higher level of latent demand. In addition, the MOEs show deterioration in average speed from 2018 to 2045, as expected with increased traffic demand. The vehicle miles traveled from the Existing to No-Build alternative decreases due to diversion of traffic to the Hardy Toll Road and the network being currently at capacity. These outputs confirm that there were congested locations at the end of each peak period. The latent demand at input locations is summarized in **Table 65** below. Due to the extent of the project area and the urban environment, this amount of latent demand is expected. A description of the locations of the latent demand and potential projects to address latent demand at the edges of the study area is included in the discussion of Build operational results in Section 5.3.2.

In addition to recording the latent demand on a network-level, Vissim outputs were analyzed to identify which input locations at had latent demand. **Table 65** shows these locations for the No-Build networks. A majority of the latent demand occurs at the mainlane inputs, especially I-45 northbound, SH 288 northbound, I-69 northbound, I-10 westbound, and I-10 eastbound.

Table 65: No-Build - Vehicles Unable to Enter Network by Location

Location	2025 AM Peak Vehicles	2025 PM Peak Vehicles	2045 AM Peak Vehicles	2045 PM Peak Vehicles
I-45 NB Mainlane	2,757	14,568	5,648	19,332
SH 288 NB Frontage Rd	125	474	595	1,432
SH 288 NB Mainlane	8,636	10,533	12,345	12,770
I-69 NB Mainlane	0	23,165	2,627	29,321
I-10 WB Mainlane	5,306	7,267	13,170	10,683
I-10 WB Frontage Rd	49	434	1,182	892
I-69 SB Frontage Rd	594	0	1,597	0
I-69 SB Mainlane	1,685	121	12,834	5,299
I-10 EB Mainlane	1,642	5,922	8,112	10,764
I-610 WB Mainlane	851	10,140	6,355	18,230
I-610 EB Mainlane	151	1,717	4,667	4,935
Hardy Toll Rd SB	2,562	1,371	7,448	1,526
I-45 SB Frontage Rd	182	0	454	0
40 ½ St EB	0	1,876	0	0
Main St SB	0	0	35	0
Airline Rd SB	394	0	884	0
Irvington St SB	502	0	829	0
Cavalcade St WB	0	0	122	0
Patton St WB	0	0	33	0
Main St to I-45 EB	0	0	63	41
Scott St WB	155	0	320	0
Dowling St WB (Emancipation Ave)	363	261	565	394
Southmore Blvd WB	574	701	1,035	1,320
Southmore Blvd EB	0	0	169	230
Richmond St WB	35	128	381	591

Table 65: No-Build - Vehicles Unable to Enter Network by Location

Location	2025 AM Peak Vehicles	2025 PM Peak Vehicles	2045 AM Peak Vehicles	2045 PM Peak Vehicles
McGowen St WB	0	0	0	109
Waco St SB	0	0	286	0
Chenevert St NB	0	1,735	0	4,024
Ruiz St EB	0	0	0	4
N San Jacinto St NB	0	0	0	33
N Main St SB to Rothwell	0	0	0	72
Louisiana St NB	0	0	0	404
Smith St WB	0	1,096	0	1,942
Pease St NB	0	0	0	43
Brazos St EB	0	0	347	1,651
Brazos St WB	55	612	0	881
Allen Pkwy SB	0	982	13	712
Allen Pkwy NB	0	0	0	67
Memorial Dr WB	0	0	15	1
Memorial Dr EB	2,260	3,484	2,208	3,189
Houston Ave SB	3	0	0	0
Houston Ave SB 2	91	0	55	0
Taylor St NB	0	7	435	433
Source North of Chartres St and Capitol St	0	89	0	494
Source South of Chartres St and Rusk St	0	0	0	293
Source East of Providence St and McKee St	464	0	686	0

In addition to the demand that was unable to make it onto the network in each peak period, there were approximately 1,060 and 2,330 vehicles during the 2025 AM and PM peak periods, respectively, that were removed from the simulations for taking excessive time during lane change maneuvers. During the 2045 AM and PM peak periods, there were approximately 1,500 and 3,510 vehicles, respectively, removed from the simulation for taking excessive time during lane change maneuvers. This is done by the software to prevent single vehicles from getting stuck during an entire simulation and producing unrealistic model results. The removal of vehicles is acceptable to allow the microsimulation to continue to function with high levels of congestion.

Travel times for freeway routes within the project area are included in **Tables 66-73**. Travel times generally increase from the Existing condition, however bottleneck locations at ramps as well as an increase in latent demand cause some routes to experience a decrease in travel time from Existing to No-Build. The tables show increases in travel time from 2025 to 2045 along almost all routes. Each route experiences congestion in at least one direction or during one peak.

Table 66: I-45 (Cavalcade St to Scott St) 2025 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Northbound Non-Congested Travel Time = 387 seconds					
Northbound	6:00-7:00 AM	405	Northbound	4:00-5:00 PM	401
Northbound	7:00-8:00 AM	406	Northbound	5:00-6:00 PM	398
Northbound	8:00-9:00 AM	407	Northbound	6:00-7:00 PM	396
Southbound Non-Congested Travel Time = 355 seconds					
Southbound	6:00-7:00 AM	426	Southbound	4:00-5:00 PM	585
Southbound	7:00-8:00 AM	653	Southbound	5:00-6:00 PM	816
Southbound	8:00-9:00 AM	712	Southbound	6:00-7:00 PM	807

Table 67: I-45 (Cavalcade St to Scott St) 2045 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Northbound Non-Congested Travel Time = 387 seconds					
Northbound	6:00-7:00 AM	405	Northbound	4:00-5:00 PM	596
Northbound	7:00-8:00 AM	407	Northbound	5:00-6:00 PM	445
Northbound	8:00-9:00 AM	408	Northbound	6:00-7:00 PM	402
Southbound Non-Congested Travel Time = 355 seconds					
Southbound	6:00-7:00 AM	639	Southbound	4:00-5:00 PM	656
Southbound	7:00-8:00 AM	970	Southbound	5:00-6:00 PM	805
Southbound	8:00-9:00 AM	1158	Southbound	6:00-7:00 PM	798

Table 68: I-69 (Quitman St to SH 288) 2025 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Northbound Non-Congested Travel Time = 265 seconds					
Northbound	6:00-7:00 AM	280	Northbound	4:00-5:00 PM	426
Northbound	7:00-8:00 AM	324	Northbound	5:00-6:00 PM	433
Northbound	8:00-9:00 AM	383	Northbound	6:00-7:00 PM	425
Southbound Non-Congested Travel Time = 261 seconds					
Southbound	6:00-7:00 AM	646	Southbound	4:00-5:00 PM	640
Southbound	7:00-8:00 AM	1326	Southbound	5:00-6:00 PM	886
Southbound	8:00-9:00 AM	1531	Southbound	6:00-7:00 PM	887

Table 69: I-69 (Quitman St to SH 288) 2045 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Northbound Non-Congested Travel Time = 265 seconds					
Northbound	6:00-7:00 AM	302	Northbound	4:00-5:00 PM	399
Northbound	7:00-8:00 AM	366	Northbound	5:00-6:00 PM	400
Northbound	8:00-9:00 AM	377	Northbound	6:00-7:00 PM	403
Southbound Non-Congested Travel Time = 261 seconds					
Southbound	6:00-7:00 AM	879	Southbound	4:00-5:00 PM	1116
Southbound	7:00-8:00 AM	1651	Southbound	5:00-6:00 PM	1267
Southbound	8:00-9:00 AM	1859	Southbound	6:00-7:00 PM	1336

Table 70: I-10 (1-45 to Gregg St) 2025 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Eastbound Non-Congested Travel Time = 135 seconds					
Eastbound	6:00-7:00 AM	141	Eastbound	4:00-5:00 PM	182
Eastbound	7:00-8:00 AM	141	Eastbound	5:00-6:00 PM	192
Eastbound	8:00-9:00 AM	141	Eastbound	6:00-7:00 PM	159
Westbound Non-Congested Travel Time = 145 seconds					
Westbound	6:00-7:00 AM	329	Westbound	4:00-5:00 PM	1260
Westbound	7:00-8:00 AM	917	Westbound	5:00-6:00 PM	1216
Westbound	8:00-9:00 AM	1077	Westbound	6:00-7:00 PM	1152

Table 71: I-10 (1-45 to Gregg St) 2045 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Eastbound Non-Congested Travel Time = 135 seconds					
Eastbound	6:00-7:00 AM	141	Eastbound	4:00-5:00 PM	156
Eastbound	7:00-8:00 AM	141	Eastbound	5:00-6:00 PM	150
Eastbound	8:00-9:00 AM	141	Eastbound	6:00-7:00 PM	151
Westbound Non-Congested Travel Time = 145 seconds					
Westbound	6:00-7:00 AM	719	Westbound	4:00-5:00 PM	1106
Westbound	7:00-8:00 AM	1503	Westbound	5:00-6:00 PM	1262
Westbound	8:00-9:00 AM	1911	Westbound	6:00-7:00 PM	1130

Table 72: I-610 (Shepherd Dr to Irvington Blvd) 2025 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Eastbound Non-Congested Travel Time = 178 seconds					
Eastbound	6:00-7:00 AM	194	Eastbound	4:00-5:00 PM	349
Eastbound	7:00-8:00 AM	232	Eastbound	5:00-6:00 PM	390
Eastbound	8:00-9:00 AM	379	Eastbound	6:00-7:00 PM	383
Westbound Non-Congested Travel Time = 179 seconds					
Westbound	6:00-7:00 AM	372	Westbound	4:00-5:00 PM	380
Westbound	7:00-8:00 AM	393	Westbound	5:00-6:00 PM	388
Westbound	8:00-9:00 AM	380	Westbound	6:00-7:00 PM	388

Table 73: I-610 (Shepherd Dr to Irvington Blvd) 2045 No-Build Travel Times

Direction	Time Interval	Travel Time (s)	Direction	Time Interval	Travel Time (s)
Eastbound Non-Congested Travel Time = 178 seconds					
Eastbound	6:00-7:00 AM	207	Eastbound	4:00-5:00 PM	387
Eastbound	7:00-8:00 AM	432	Eastbound	5:00-6:00 PM	396
Eastbound	8:00-9:00 AM	458	Eastbound	6:00-7:00 PM	391
Westbound Non-Congested Travel Time = 179 seconds					
Westbound	6:00-7:00 AM	395	Westbound	4:00-5:00 PM	386
Westbound	7:00-8:00 AM	401	Westbound	5:00-6:00 PM	395
Westbound	8:00-9:00 AM	408	Westbound	6:00-7:00 PM	396

There were several critical locations identified during calibration that were the focus of segment level MOEs. These locations were analyzed in detail to compare the alternatives and ensure that issues at the critical locations are resolved in the Build configuration. **Table 74** shows the segment results for critical locations. Critical location results were calculated based on link segment evaluation results provided in the Vissim models included with this report.

Table 74: No-Build Critical Location Segment Results

		2025 No-Build AM	2025 No-Build PM	2045 No-Build AM	2045 No-Build PM
Critical Location 1: I-10 EB weave between I-45 and McKee St	**Speed (mph)**	57.3	41.4	57.3	54.7
	Density (veh/mi/ln)	12.7	46.1	11.4	26.9
	Relative Delay (s/s)	0.01	0.28	0.01	0.05
	Speed (mph)	53.7	57.1	56.6	57.0
	Density (veh/mi/ln)	16.2	10.4	11.9	11.2

Table 74: No-Build Critical Location Segment Results

		2025 No-Build AM	2025 No-Build PM	2045 No-Build AM	2045 No-Build PM
Critical Location 2: I-10 WB weave between I-45 and McKee St	**Relative Delay (s/s)**	0.07	0.01	0.02	0.01
Critical Location 3: I-69 SB weave from I-10 to Dallas St	**Speed (mph)**	19.5	12.2	11.8	10.1
	Density (veh/mi/ln)	99.1	96.7	116.6	101.7
	Relative Delay (s/s)	0.66	0.79	0.80	0.83
Critical Location 4: SH 288 NB weave from Elgin St to I-45	**Speed (mph)**	13.1	5.7	8.1	5.6
	Density (veh/mi/ln)	111.8	142.3	126.0	143.2
	Relative Delay (s/s)	0.77	0.90	0.86	0.90
Critical Location 5: I-45 SB weave from I-610 to Cavalcade St	**Speed (mph)**	55.3	55.8	39.0	56.1
	Density (veh/mi/ln)	26.3	19.5	56.2	20.0
	Relative Delay (s/s)	0.04	0.03	0.32	0.02
Critical Location 6: I-45 NB weave from Cavalcade St to I-610	**Speed (mph)**	56.7	55.4	56.6	55.1
	Density (veh/mi/ln)	16.0	26.9	15.9	23.5
	Relative Delay (s/s)	0.02	0.04	0.02	0.05
Critical Location 7: I-10 EB weave from Jackson St Entrance to I-69	**Speed (mph)**	57.3	45.7	57.4	52.9
	Density (veh/mi/ln)	12.9	46.5	11.9	35.3
	Relative Delay (s/s)	0.01	0.21	0.01	0.08
Critical Location 8: I-10 WB from I-69 to Jackson St Exit	**Speed (mph)**	57.5	57.3	57.5	57.2
	Density (veh/mi/ln)	10.9	9.7	8.6	10.1
	Relative Delay (s/s)	0.01	0.01	0.01	0.01
Critical Location 9: I-45 SB weave from I-10 WB Entrance to Downtown Exits	**Speed (mph)**	26.2	18.6	18.0	12.7
	Density (veh/mi/ln)	80.4	100.9	97.6	113.6
	Relative Delay (s/s)	0.55	0.68	0.69	0.78
Critical Location 10: I-45 NB weave from Downtown Entrances to I-10 EB Exit	**Speed (mph)**	57.0	53.0	57.0	54.2
	Density (veh/mi/ln)	16.3	29.4	17.2	27.3
	Relative Delay (s/s)	0.01	0.08	0.01	0.06

As illustrated, critical locations 3, 4, 5, and 9 have the highest levels of congestion. As expected, the level of congestion increases from the 2025 No-Build to the 2045 No-Build.

No-Build Intersection Results

Intersection delay from Vissim microsimulation software for the No-Build scenarios were compared to Build scenarios. The intersection results are presented in section 5.3.2.5. The intersections that showed delay greater than 55 seconds/vehicle include:

- Taylor Street at I-10 Eastbound Frontage Road
- Gregg Street at I-10 Westbound Frontage Road
- Pease Street at Emancipation Avenue
- Pierce Street at Brazos Street
- Pease Street at Smith Street
- Pease Street at Brazos Street
- Richard Street at Spur 527 Northbound Frontage Road
- Southmore Boulevard at SH 288 Northbound Frontage Road
- Southmore Boulevard at SH 288 Southbound Frontage Road
- Main Street at I-45 Southbound Frontage Road
- N San Jacinto Street at Rothwell Street
- McGowen Street at I-69 Northbound Frontage Road
- Jefferson Street at Brazos Street
- W Dallas Street at Gulf Freeway
- Chartres Street at Rusk Street

Network 15-Minute Variation

A critical component to the analysis was capturing the change in network performance over 15-minute intervals. The AM and PM peak periods had varying traffic characteristics and fluctuating levels of congestion. Speed maps in 15-minute intervals are included in **Appendix M** and **O**.

5.3.2 Preferred Alternative (Build)

The preferred alternative includes the complete reconstruction and reconfiguration of the highways that comprise the "Downtown Loop" in Segment 3, and the widening and reconfiguration of highways in Segment 2. The major improvements in the preferred alternative include the following:

- Removal of existing I-45 Pierce Elevated – replaced by downtown ramp connections for local access and connectivity with downtown.
- I-45 realignment to be parallel with I-10 north of downtown and parallel with I-69 east of downtown until it turns south to the existing I-45 alignment southeast of the downtown area.
- Addition of a pair of HOV/express lanes (MaX Lanes) on I-10 that terminate in downtown.
- Addition of a pair of HOV/express lanes (MaX Lanes) on I-45 that terminate in downtown.
- Addition of general-purpose lanes on I-45 in Segment 2.
- Reconstruction of the I-45 at I-610 interchange to provide traditional right lane exits and collector-distributor parallel facilities along I-610.
- Reconstruction of the I-45 at I-10 interchange with the realignment of I-45 and improvement in direct connector facilities.
- Reconstruction of the I-69 at I-10 interchange with fully directional connectors and connections to the future Hardy Toll Road extension.
- Removal of the fourth leg of the I-69 at I-45 interchange with the Pierce Elevated section removal.
- Frontage road and local intersection improvements, like turn bays, retiming of signals, and access management at intersections, cross streets, and frontage roads.

In addition to the major improvements, there are a series of access changes related to local ramp access. Each station change is presented in later sections and was considered to improve ramp spacing, while maintaining an adequate level of access to the freeway facilities. The proposed Build schematics are provided in **Appendix P**.

5.3.2.1 *Area of Influence*

A diagrammatic representation of the proposed Build area of influence is provided in **Figure 55.** Due to the size of the project area, **Figure 55** is shown in several pages. The figure provides the intersections included in the operational analysis and general layout of the roadway network.

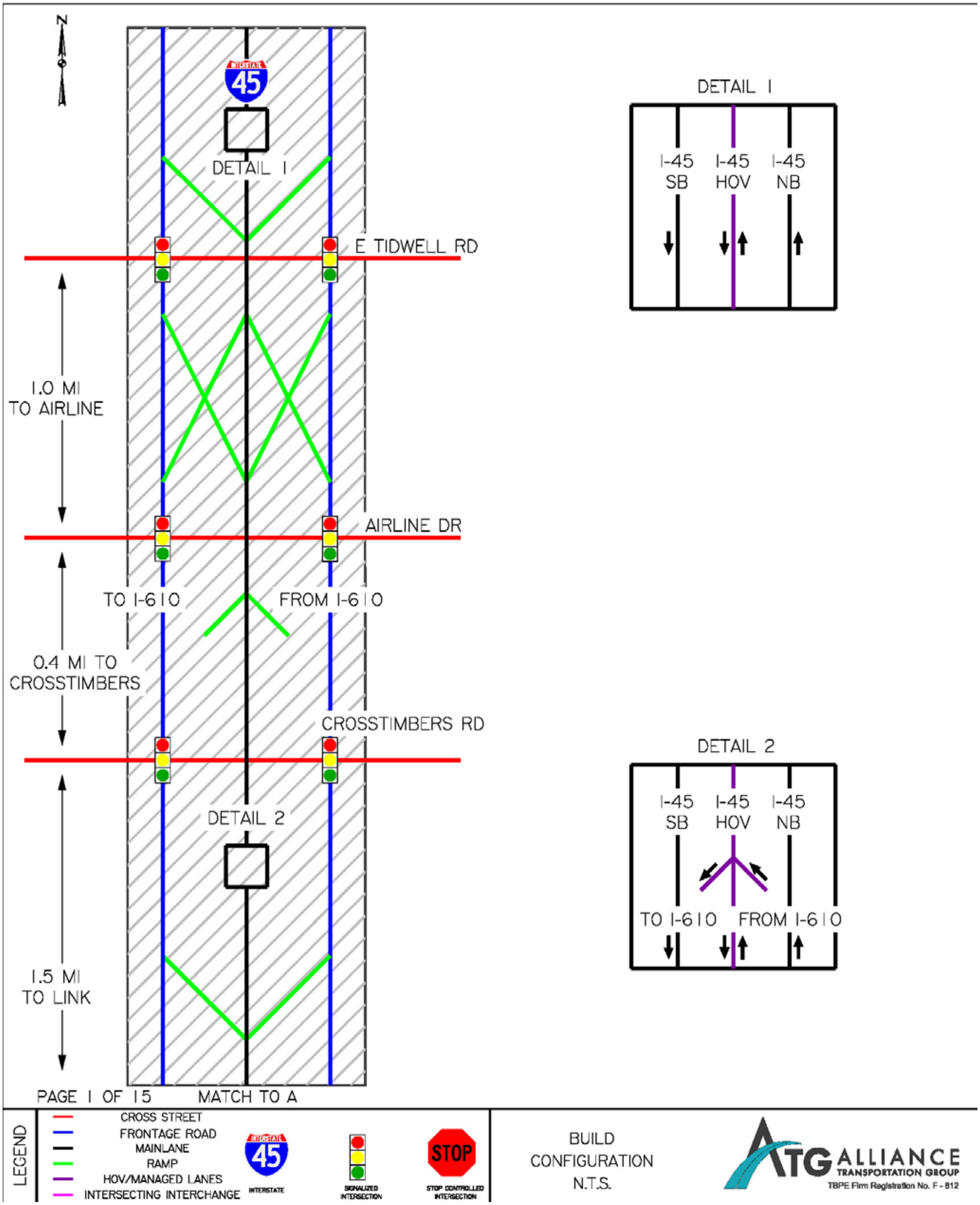

Figure 55: Build Area of Influence

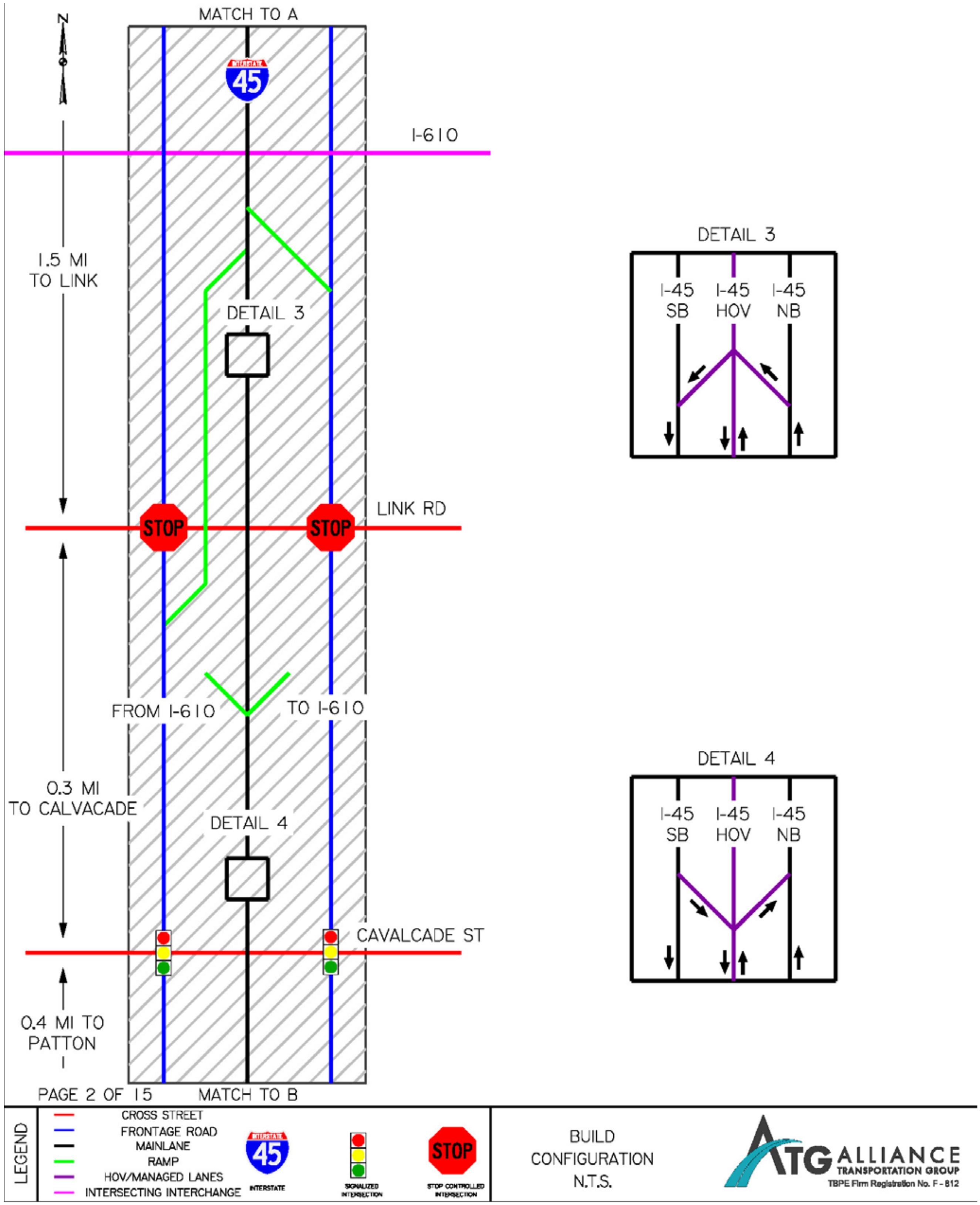

Figure 55: Build Area of Influence

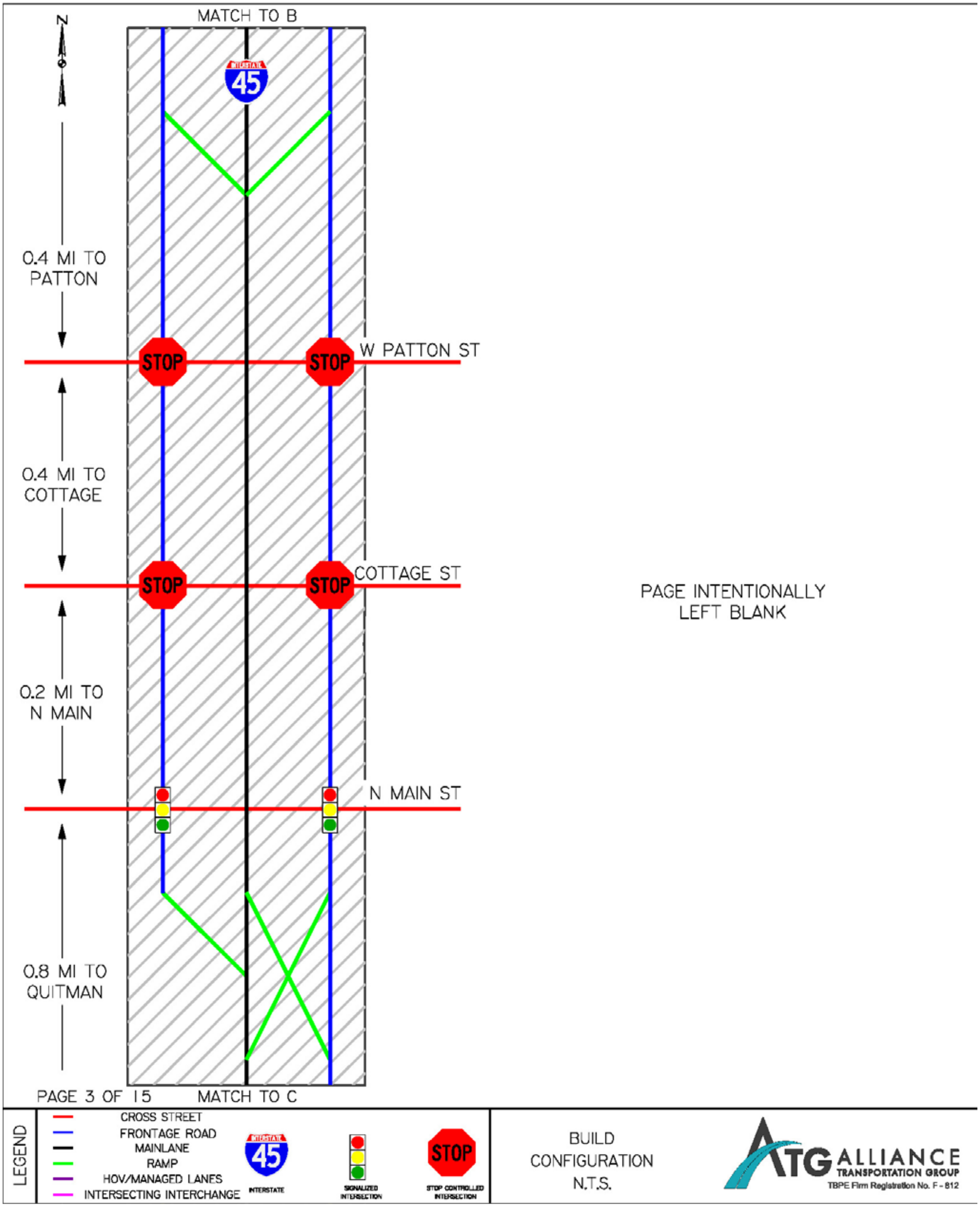

Figure 55: Build Area of Influence

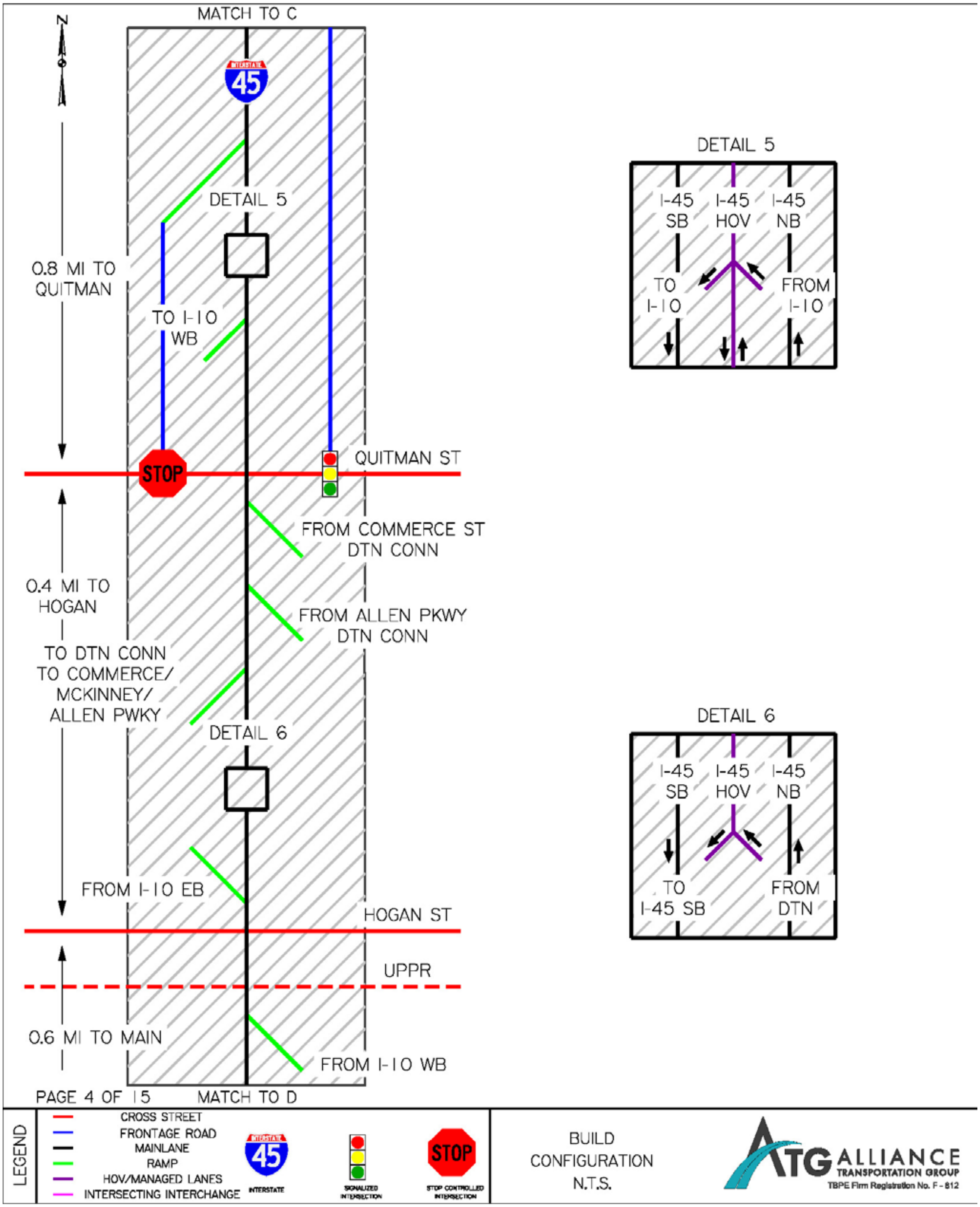

Figure 55: Build Area of Influence

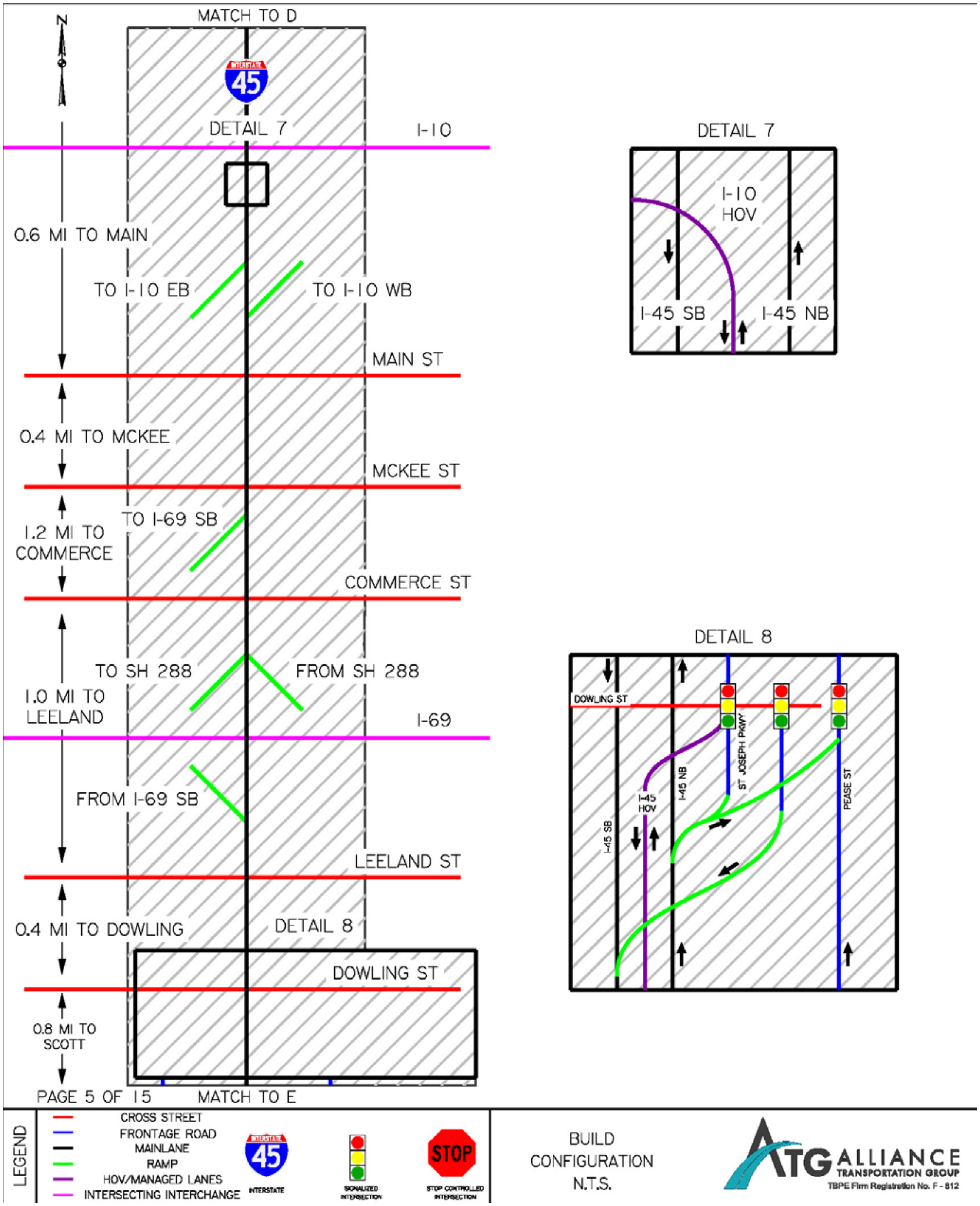

Figure 55: Build Area of Influence

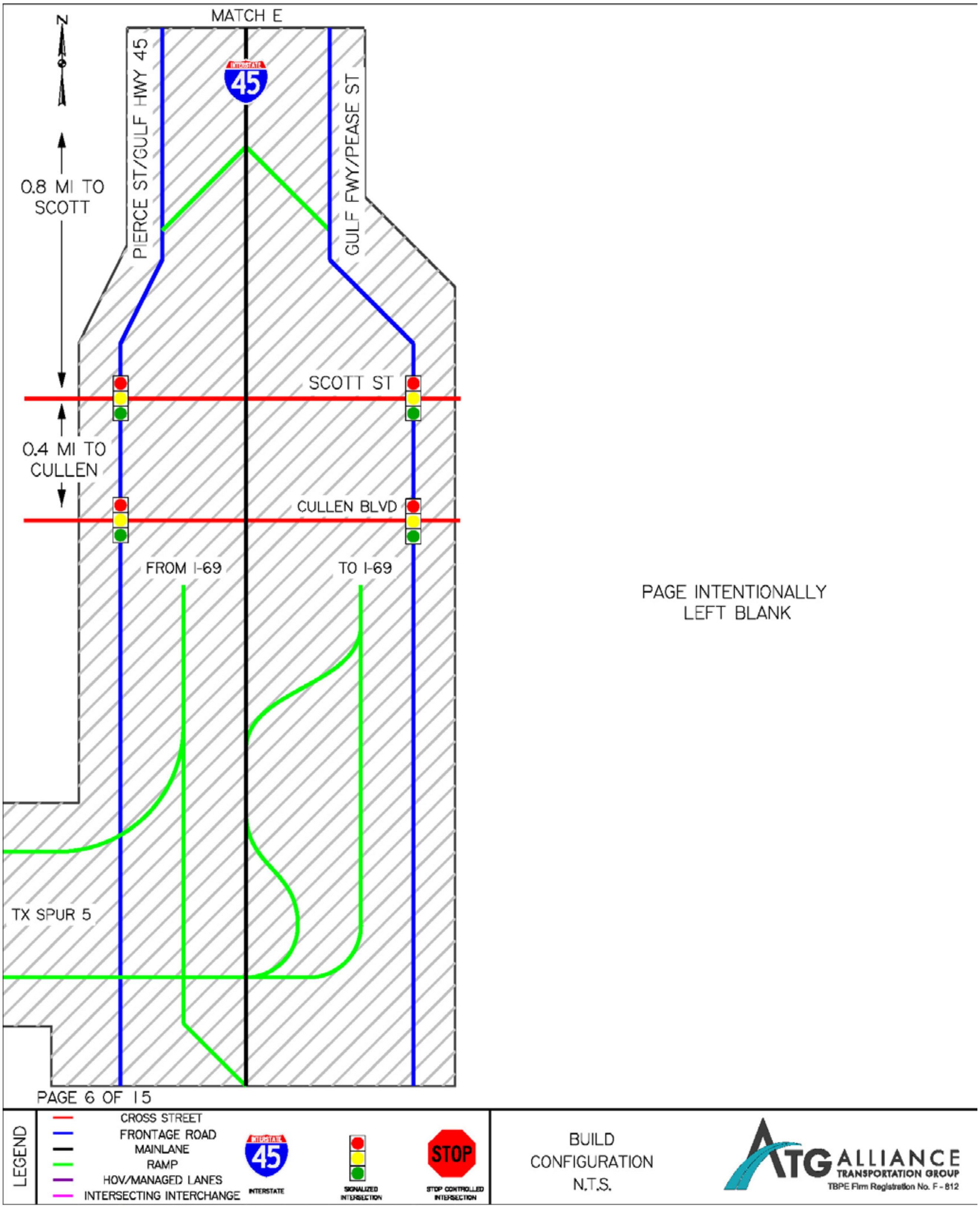

Figure 55: Build Area of Influence

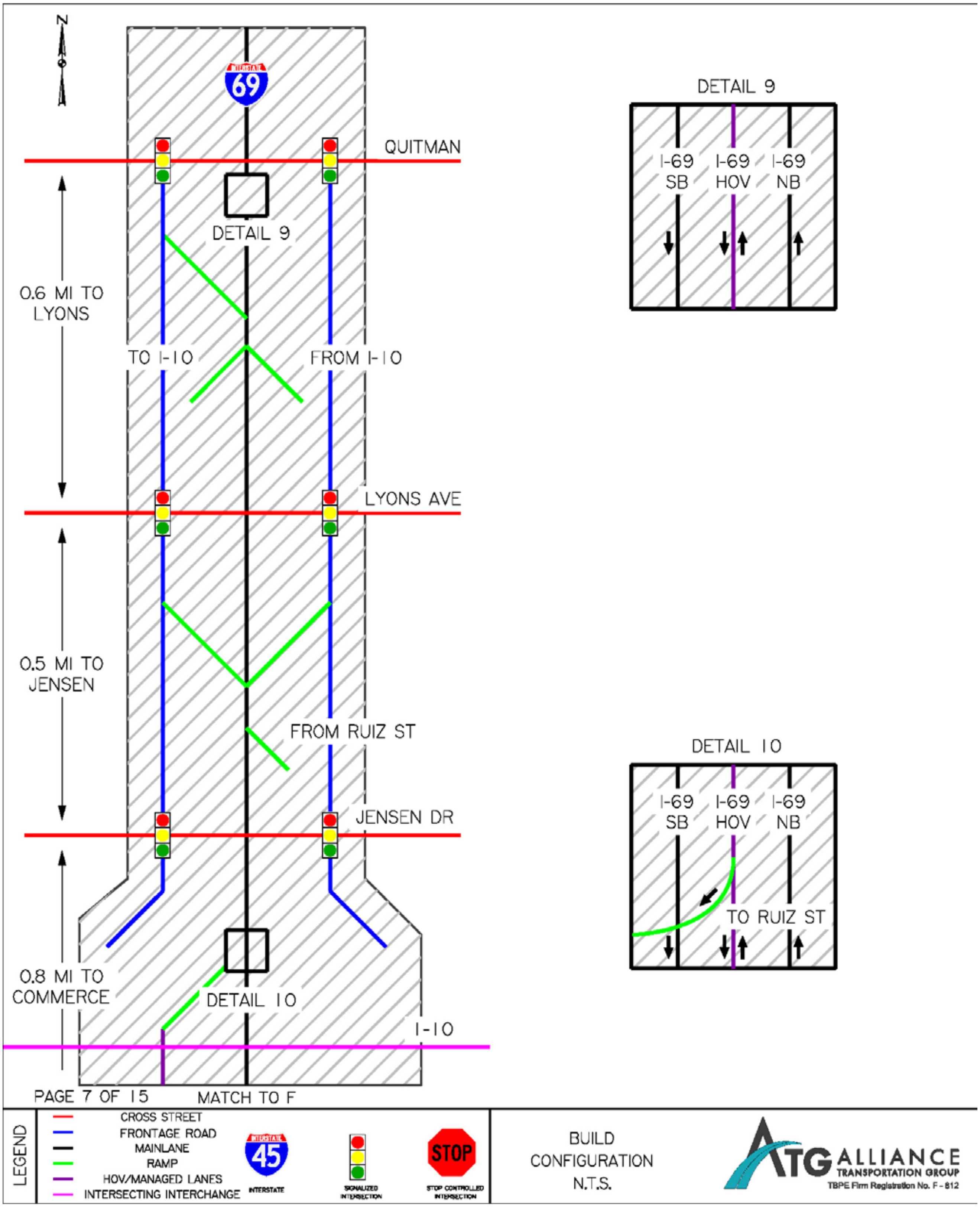

Figure 55: Build Area of Influence

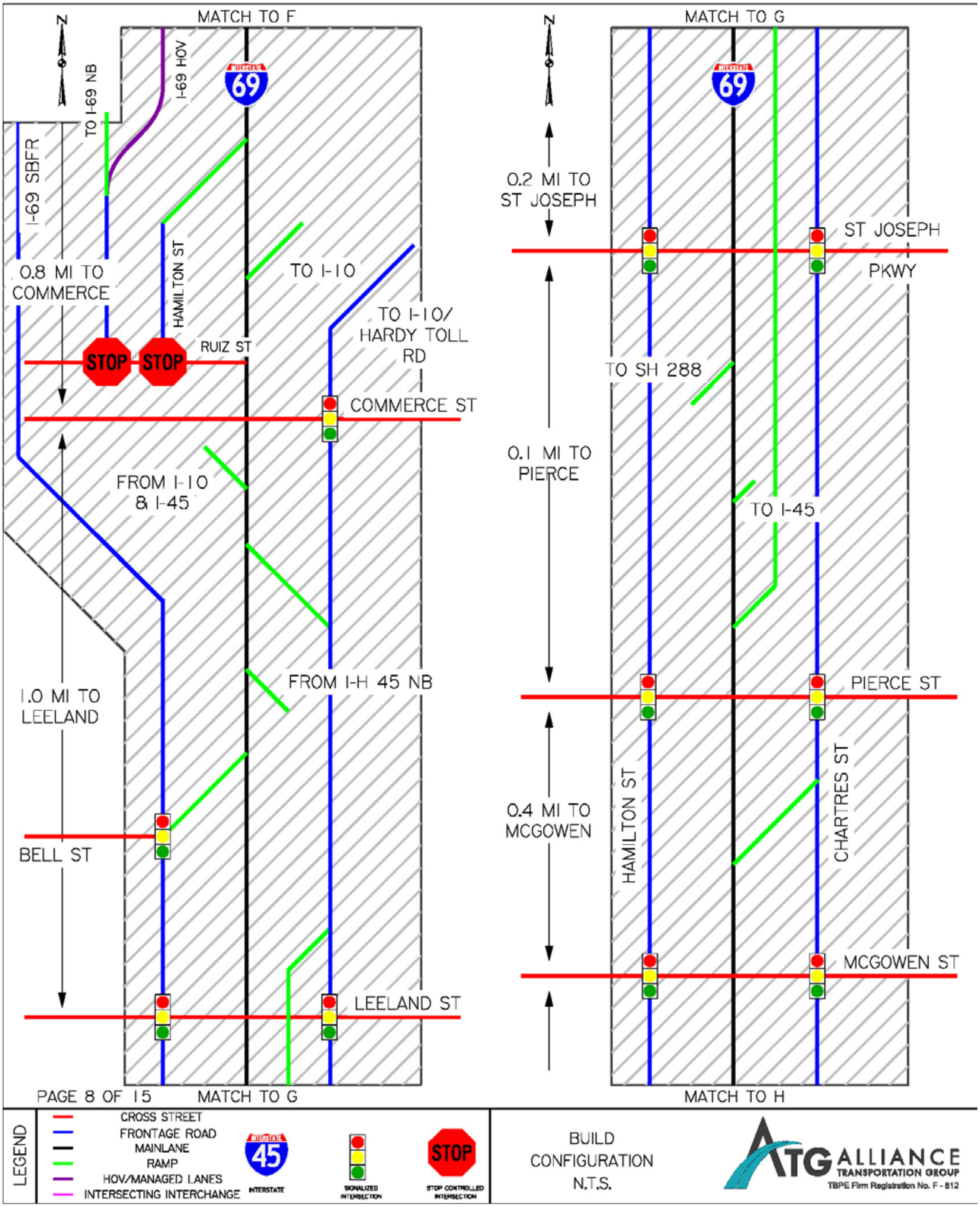

Figure 55: Build Area of Influence

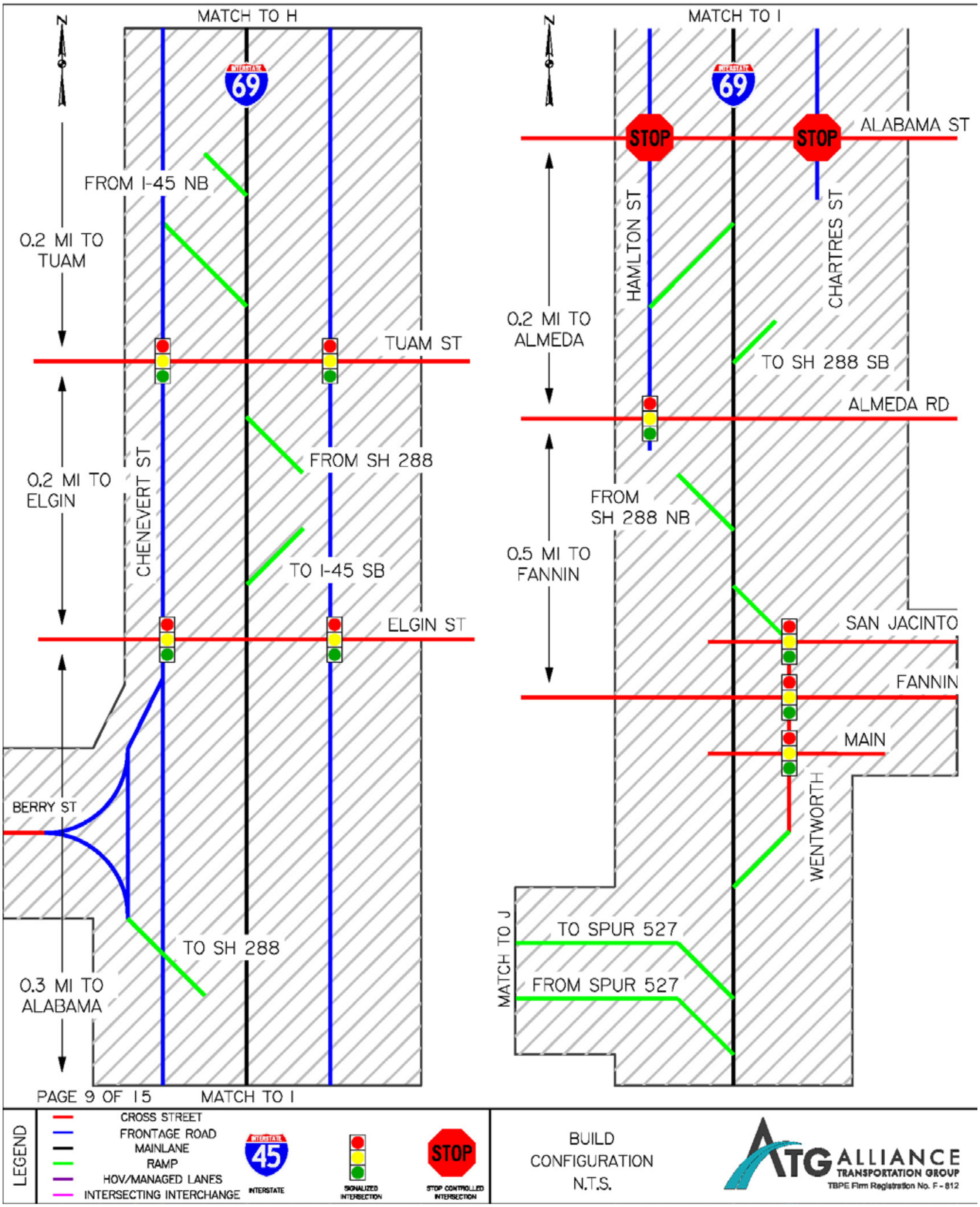

Figure 55: Build Area of Influence

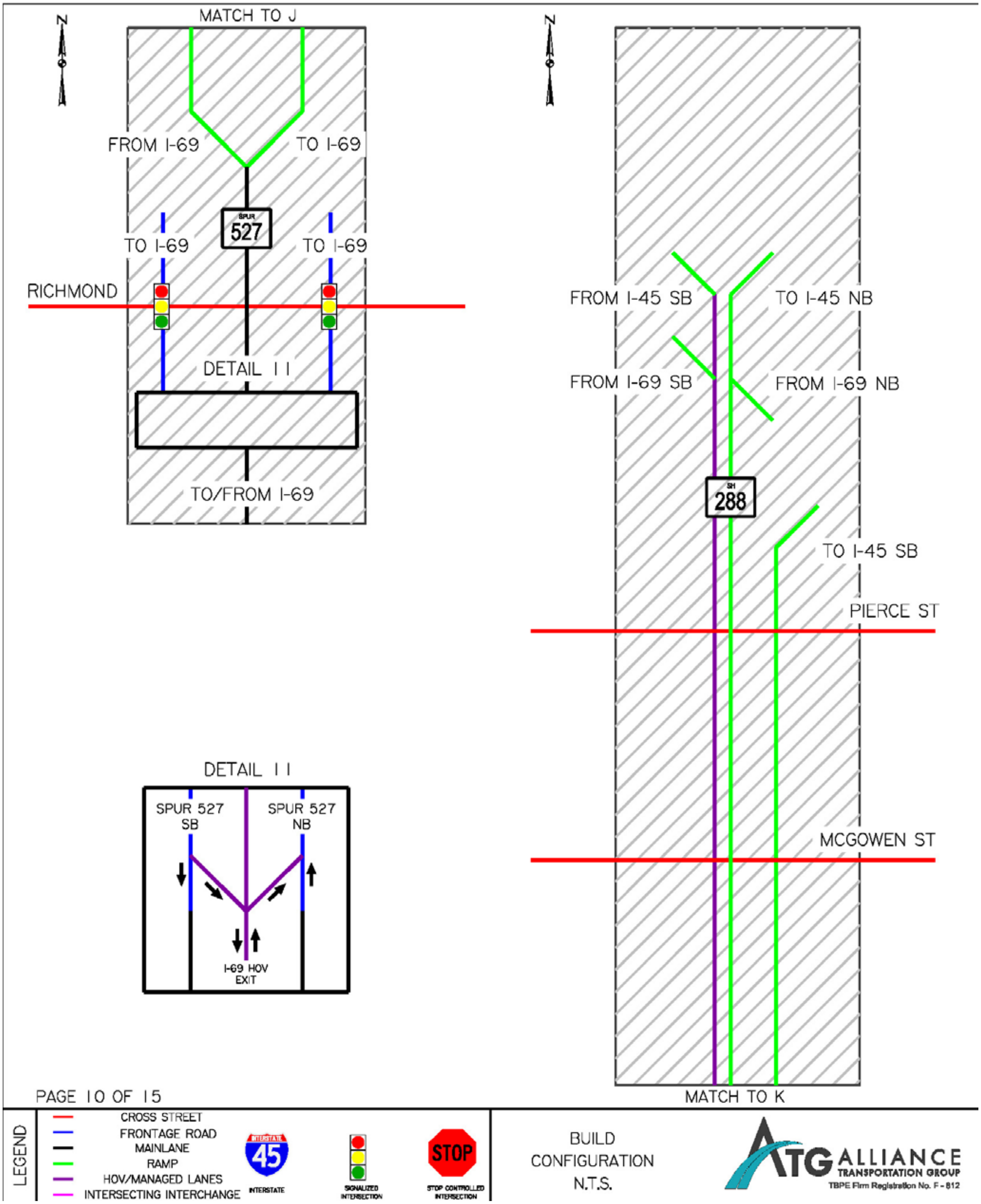

Figure 55: Build Area of Influence

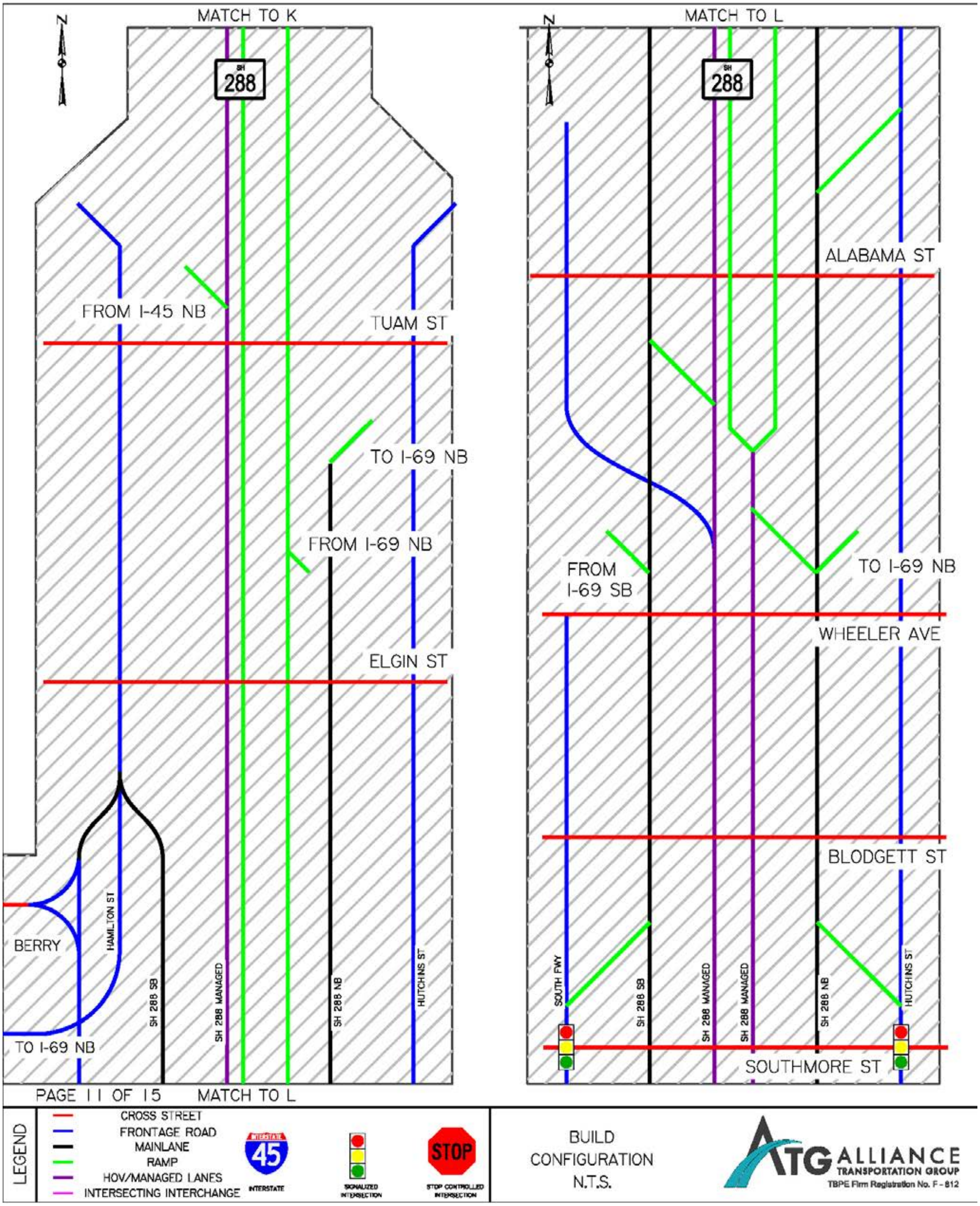

Figure 55: Build Area of Influence

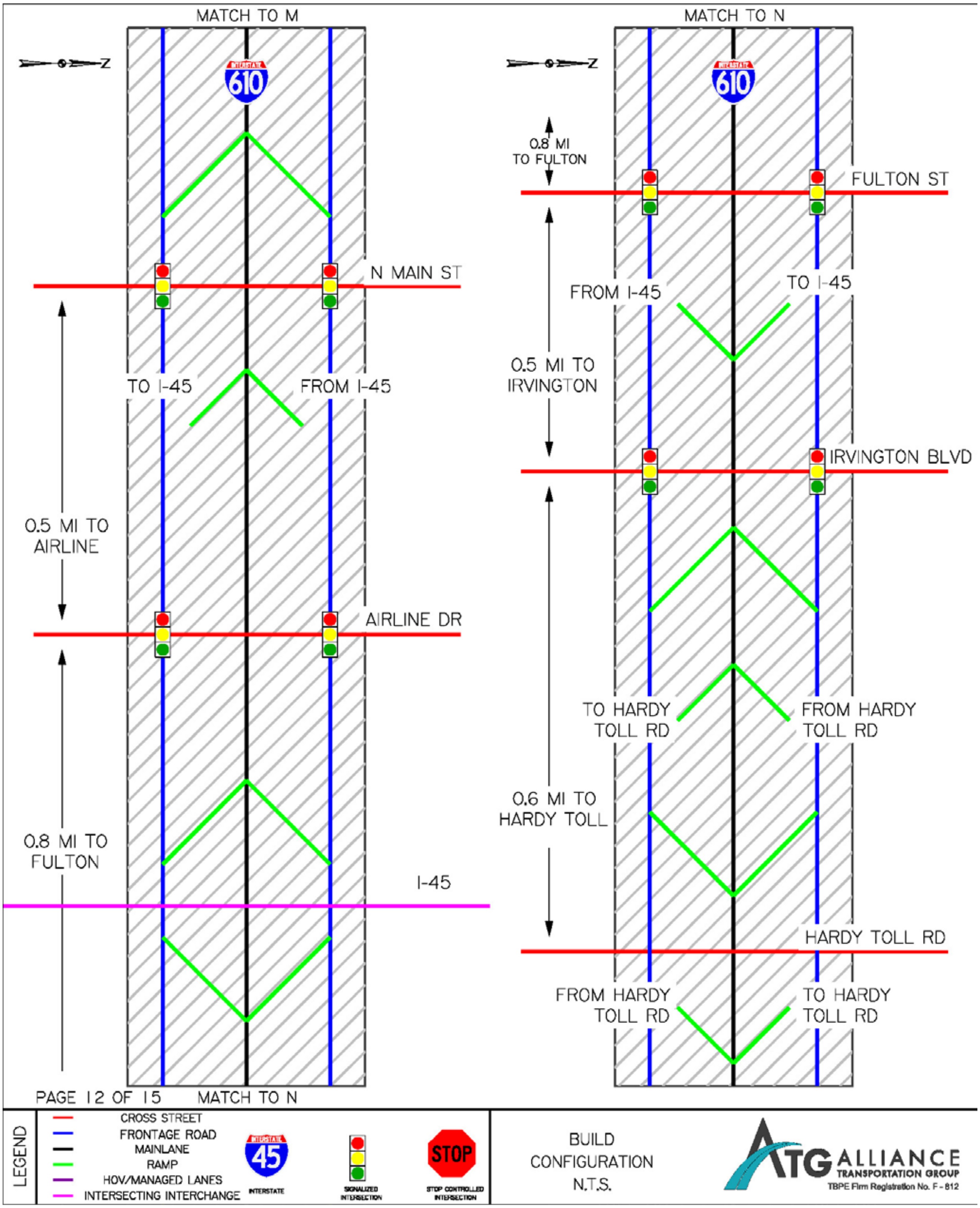

Figure 55: Build Area of Influence

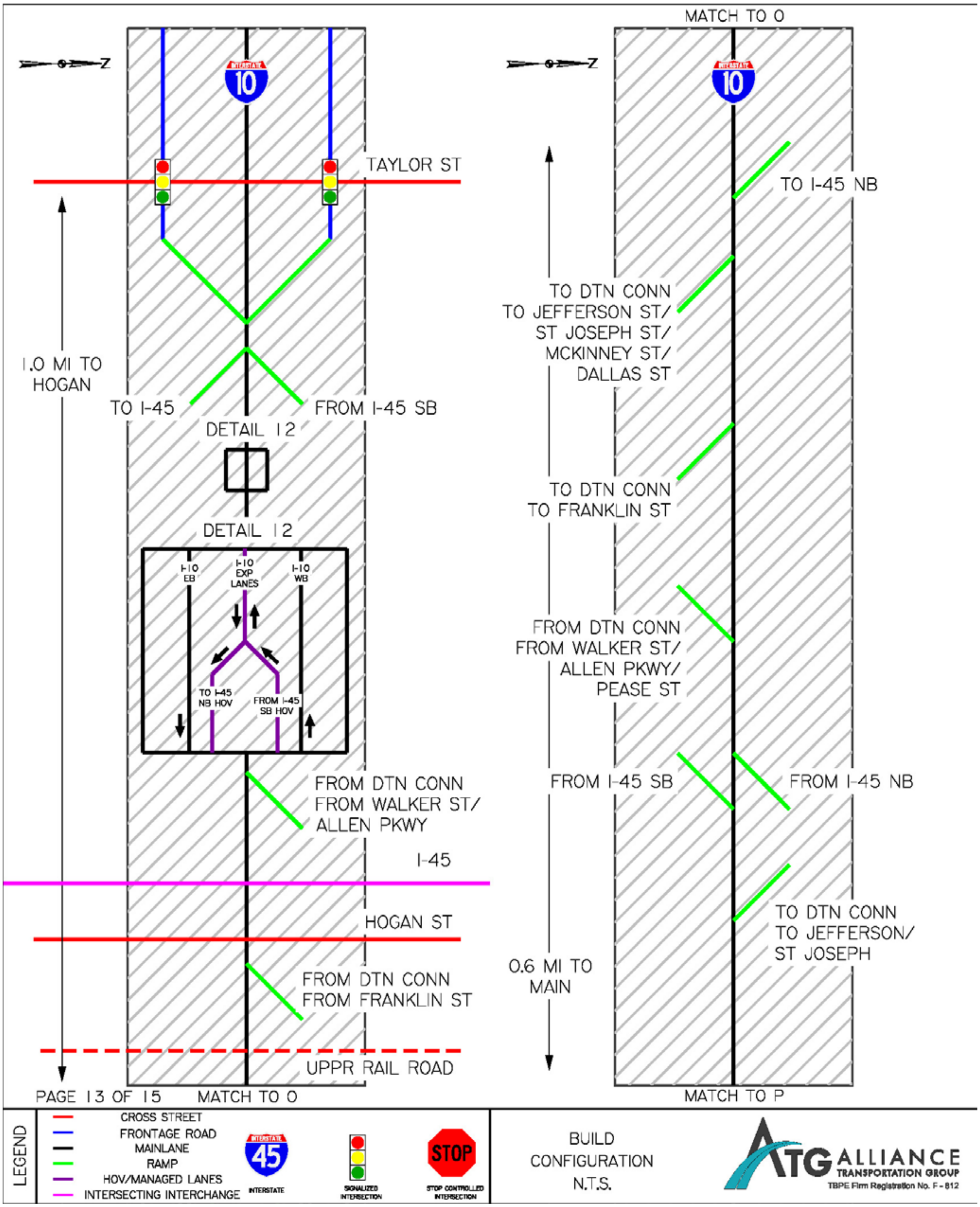

Figure 55: Build Area of Influence

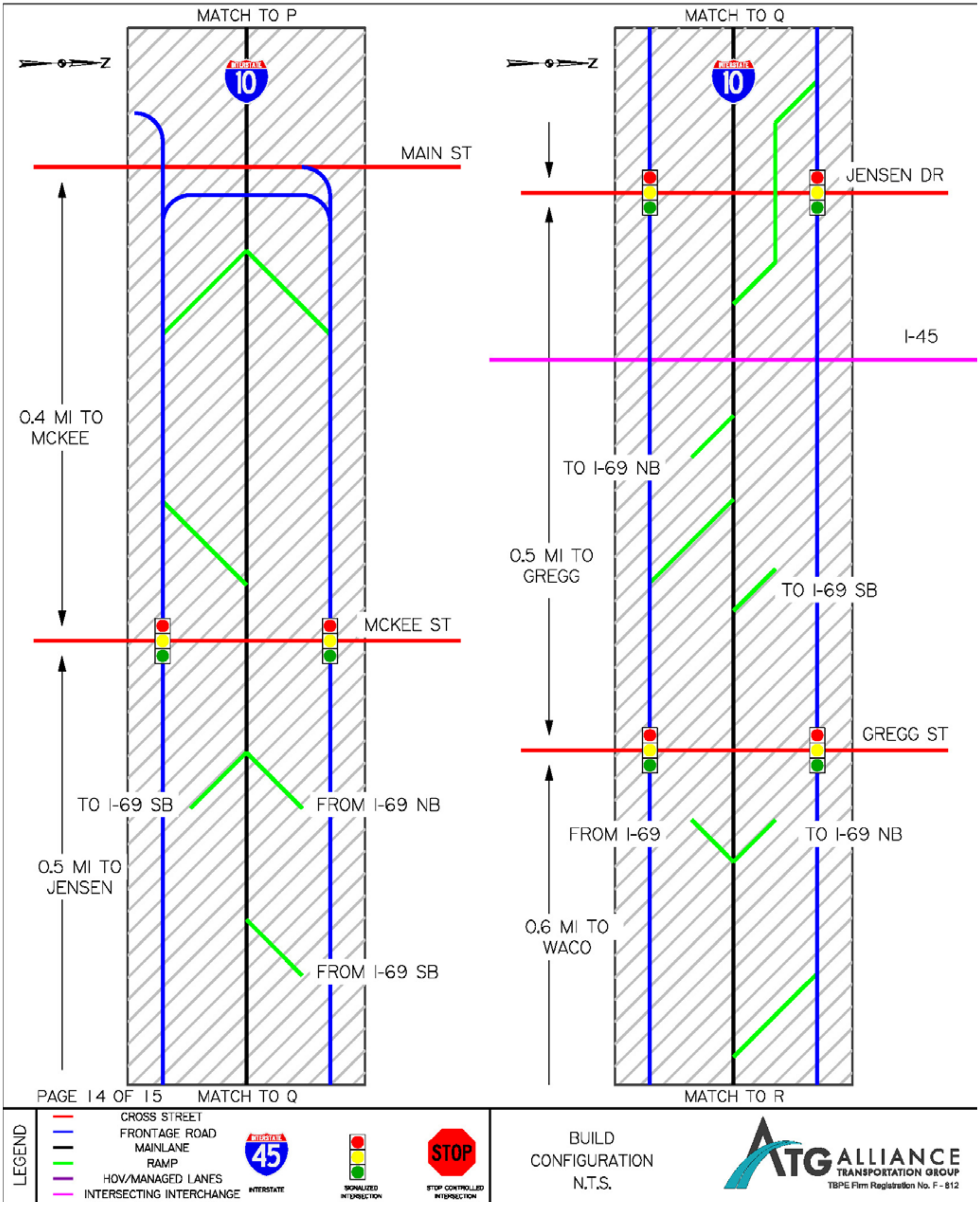

Figure 55: Build Area of Influence

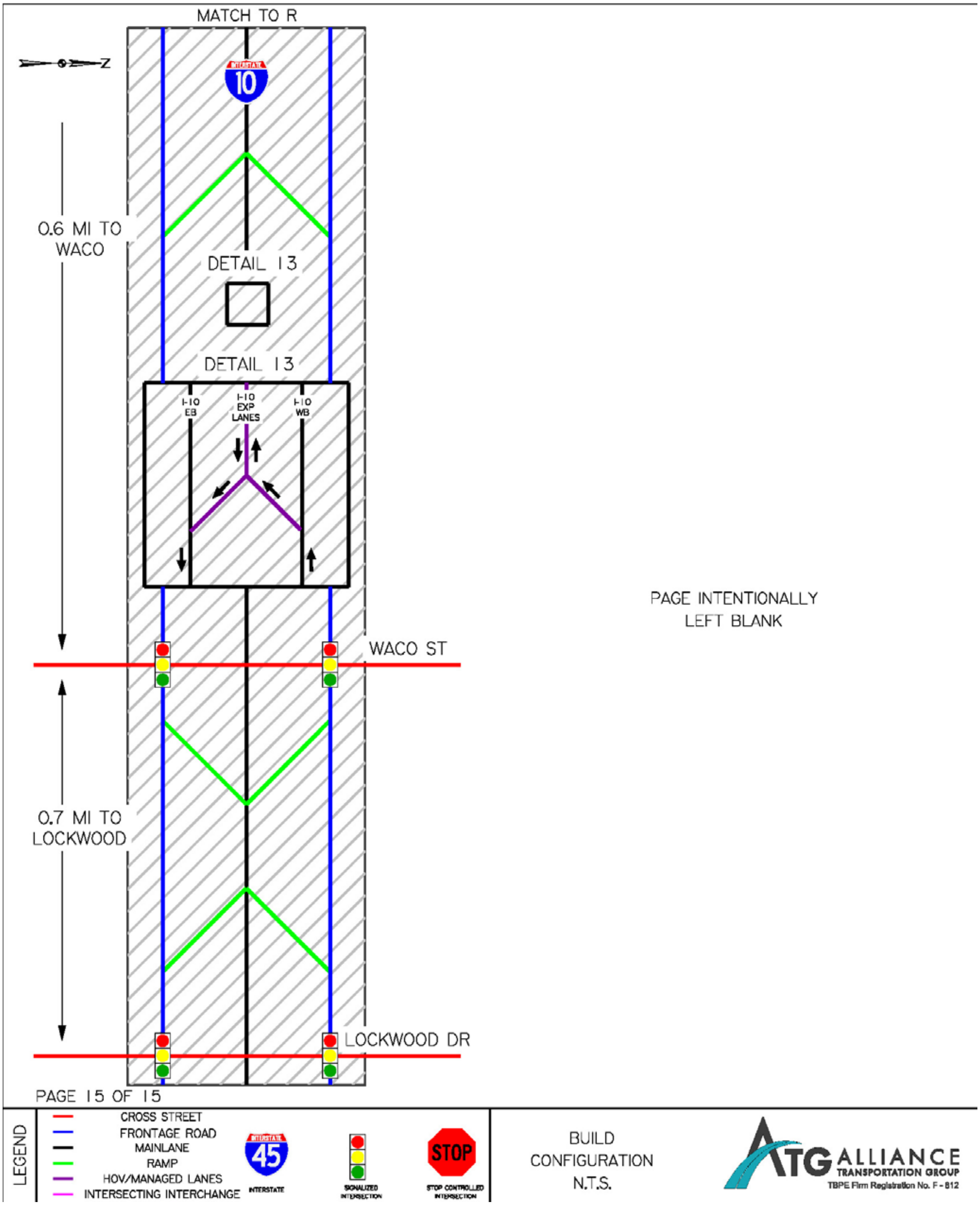

Figure 55: Build Area of Influence

5.3.2.2 *Transportation Improvements to Alternate Interchanges*

Each of the urban interchanges was considered for local intersection and interchange improvements, which include turn bays, lane assignments, and signal timing/phasing improvements. These improvements were identified by the public, stakeholders, and iterative microsimulation traffic analysis. **Table 75** summarizes the improvements along the local street network.

Table 75: Summary of Intersection Improvements

List of Improvements	I-45 N of I-610	I-45 S of I-610 to I-10	I-45 from I-10 to Cullen Blvd	I-69	I-10	I-610
Total Number of Intersections	3	5	4	17	3	2
Realign Frontage Road	3	5	3	17	3	2
Signal Retiming	3	2	1	2	0	2
Add U-turn	1	2	0	0	0	0
Add Through Lane	1	1	2	2	1	0
Add Right Turn Bay	2	0	1	0	0	0
Add Left Turn Bay	2	0	0	3	0	0
Add Signal	0	0	2	0	0	0

In addition to intersection improvements, freeway-to-freeway interchanges were the focus of major improvements. This includes the addition of collector-distributor systems, integration of express lane facilities, and realignment of ramps at freeway interchanges, and conversion to traditional, right-side exit ramps. The freeway reconstruction is included in the list of major improvements above and are shown in the proposed Build schematic.

5.3.2.3 *Transportation System Management*

Transportation System Management (TSM) improvements are sets of techniques used to improve traffic operations without increasing the physical size of transportation infrastructure. These improvements were considered at all urban interchanges to enhance the mobility at arterials throughout the project area. This project requires major reconstruction and ROW acquisition; therefore, all feasible arterial needs were considered that connect to the freeway system.

In addition, the improvements are expected to include the addition of Intelligent Transportation Systems (ITS) infrastructure and express lane facilities. ITS infrastructure aims at informing travelers of dynamic traffic conditions, thus more efficiently managing the existing transportation infrastructure. The proposed express lane facilities aim at managing a reliable transportation corridor, and effectively allow transit and emergency vehicles to operate throughout the project area.

5.3.2.4 *Change in Access*

The Build schematic includes several changes in access to the 15.3 miles of urban freeway facilities in the project area. Changes in access in the proposed Build schematic were designed to improve operational efficiency and safety throughout the project area. All freeway-to-freeway movements are maintained with continuous movements at major interchanges. Each ramp is summarized in **Tables 76-79** with the Existing versus Proposed station number and by freeway facility.

Table 76: I-45 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
Northbound	Entrance from Spur 5	None	949+00	949+00	Seg 3, I-45, 1/9
	Entrance from Cullen Blvd	None	958+00	958+00	Seg 3, I-45, 1/9
	Entrance from Scott St	None	976+00	976+00	Seg 3, I-45, 1/9
	Exit to St Joseph Pkwy	*Ramp serves all I-45 NB traffic instead of only I-45 HOV*	*N/A*	*998+25*	*Seg 3, I-45, 1/9*
	Exit to I-69 NB from I-45	*Moved South, Combined with I-69 SB and SH 288 SB Exit*	*1009+00*	*918+25*	*Seg 3, I-45, 1/9*
	Exit to I-69 SB from I-45	*Moved South, Combined with I-69 NB Exit*	*1014+50*	*918+25*	*Seg 3, I-45, 1/9*
	Entrance from I-69 SB	Ramp from I-69 SB to I-45 NB Removed. Combined with Exit to I-10 WB and then routed to use Exit to I-45 NB from I-10 WB	159+00	N/A	Seg 3, I-45, 1/9
	Entrance from I-69 NB	I-45 Relocated with Entrance Ramp Moved North and East	158+18	1048+00	Seg 3, I-45, 2/9
	Exit to Allen Pkwy	Ramp Removed in Build with I-45 realignment	459+00	N/A	Seg 3, I-45, 9/9
	Exit to Houston/Memorial Ave	Ramp Removed in Build with I-45 realignment	458+25	N/A	Seg 3, I-45, 9/9
Northbound	Entrance from Allen Pkwy	Ramp Moved to Collector-Distributor Accessing I-45	475+50	464+25	Seg 3, I-45, 9/9
	Entrance from Walker St	Ramp Moved to Collector-Distributor Accessing I-45	475+50	480+25	Seg 3, I-45, 9/9
	Exit to I-10 WB	Ramp Relocated with I-45 Realignment	520+50	1164+00	Seg 3, I-45, 3/9
	Entrance from Travis St	Ramp Relocated North	545+00	1220+00	Seg 3, I-45, 3/9
	Entrance from I-10 WB	Ramp Relocated with I-45 Realignment	545+00	1192+00	Seg 3, I-45, 3/9
	Entrance from I-10 EB to I-45 NB Express	Ramp Moved North	1221+00	1231+25	Seg 2, I-45

Table 76: I-45 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Entrance from I-10 EB	Ramp Moved North	1221+00	1254+50	Seg 2, I-45
	Entrance from White Oak Dr/Quitman St	Ramp Reconfigured to connect to DC Entrance Ramp from I-10 EB	1228+00	1254+50	Seg 2, I-45
	Exit to Main St	Ramp Moved South	1249+75	1242+00	Seg 2, I-45
	Exit to Patton St	Combined with Exit Ramp to Main St	1276+50	N/A	Seg 2, I-45
	Entrance from Cottage St./ Main St.	Combined with Entrance Ramp from Cavalcade St	1288+25	N/A	Seg 2, I-45
	Exit to Cavalcade St	Ramp Moved South	1305+50	1296+00	Seg 2, I-45
	Access to and from Managed Lanes	Add Access to Managed Lanes	N/A	1322+00-1337+00	Seg 2, I-45
	Entrance from Cavalcade	Ramp Moved North and Provides Access from Link St	1321+75	1346+00	Seg 2, I-45
	Exit to I-610	Ramp Moved South	1339+00	1325+50	Seg 2, I-45
	Exit to Crosstimbers	Ramp Moved South	1385+50	1381+00	Seg 1, I-45
	Exit to Airline	Ramp Removed in Build	1417+00	N/A	Seg 1, I-45
	Entrance from I-610	Ramp Moved North	1365+00	1419+50	Seg 1, I-45
	Exit to Tidwell	Ramp Moved North	1434+50	1453+50	Seg 1, I-45
	Entrance from Airline	Ramp Moved North	1463+50	1473+50	Seg 1, I-45
	Ramps built/proposed as background projects				
	Exit to Airline	Ramp Moved North	1463+50	1470+00	Seg 1, I-45
	Entrance from Tidwell	Ramp Moved North	1435+00	1452+50	Seg 1, I-45
Southbound	Exit to I-610	Ramp Moved North	1365+00	1418+50	Seg 1, I-45
	Entrance from Crosstimbers	Ramp moved South	1384+50	1381+00	Seg 1, I-45
	Access to and from Managed Lanes	Add Access to Managed Lanes	N/A	1337+00-1322+00	Seg 2, I-45
	Entrance from I-610	Ramp Moved South	1339+00	1323+00	Seg 2, I-45

Table 76: I-45 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Exit to Cavalcade St	Ramp Moved North	1322+00	1345+00	Seg 2, I-45
	Entrance from Cavalcade St	Ramp Moved South	1305+00	1298+00	Seg 2, I-45
	Exit to Main St	Combined with Exit Ramp to Cavalcade St	1287+50	N/A	Seg 2, I-45
	Entrance from Patton St	Combined with Entrance Ramp from Main St	1277+00	N/A	Seg 2, I-45
	Entrance from Main St	Ramp Realigned	1248+25	1246+50	Seg 2, I-45
	Exit to White Oak Drive	Ramp Realigned	1233+50	1235+25	Seg 2, I-45
	Exit to I-10 WB	Ramp Moved South	1227+50	1222+00	Seg 3, I-45, 3/9
	Exit to I-10 EB	Ramp Moved South	1202+00	1169+00	Seg 3, I-45, 3/9
	Entrance from I-10 EB	Ramp Moved North	1191+00	1202+00	Seg 3, I-45, 3/9
	Entrance from I-10 WB	Direct Ramp from I-10 WB to I-45 SB removed. Combined with Exit to I-69 SB and Entrance Ramp from I-69 SB	260+25	N/A	Seg 3, I-45, 2/9
	Exit to Dallas St	Combined with Exit Ramp to McKinney St and Allen Pkwy	142+00	148+00	Seg 3, DTN, 9/9
	Exit to McKinney St	Combined with Exit to Dallas St and Allen Pkwy	141+00	148+00	Seg 3, DTN, 9/9
	Exit to Allen Pkwy	Combined with Exit to Dallas St and McKinney St	133+50	148+00	Seg 3, DTN, 9/9
	Entrance from Allen Pkwy	Ramp Removed in Build	118+50	N/A	Seg 3, DTN, 9/9
	Entrance from Houston Ave/Memorial Dr	Ramp Removed in Build	118+00	N/A	Seg 3, DTN, 9/9
	Exit to I-69 SB	Ramp Moved North	1011+00	1126+50	Seg 3, I-45, 2/9
	Exit to SH 288	Ramp Moved North	1011+00	1049+00	Seg 3, I-45, 2/9
	Exit to I-69 NB	Combined with Exit Ramp to I-10 EB and then I-69 NB	1012+00	N/A	Seg 3, I-45, 3/9
	Entrance from I-69 SB	Ramp Moved North	1011+00	1044+00	Seg 3, I-45, 2/9
	Entrance from I-69 NB/ SH 288 NB	Ramp Moved South	1008+00	913+00	Seg 3, I-45, 1/9
	Exit to Scott St	None	978+50	978+50	Seg 3, I-45, 1/9

Table 76: I-45 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Exit to Cullen St	None	956+50	956+50	Seg 3, I-45, 1/9
	Exit to Spur 5	None	939+50	939+50	Seg 3, I-45,1/9

Table 77: I-69 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
Northbound	Exit to Main St	Ramp Realigned	1013+00	1019+00	Seg 3, I-69, 4/9
	Exit to Spur 527	Ramp Realigned	1016+00	1012+00	Seg 3, I-69, 4/9
	Entrance from San Jacinto	Ramp Realigned	1046+00	1048+00	Seg 3, I-69, 4/9
	Exit to SH 288 SB	Ramp Realigned	1060+00	1060+50	Seg 3, I-69, 4/9
	Exit to I-45	Ramp Moved North	1076+00	1084+50	Seg 3, I-69, 4/9
	Entrance from SH 288 NB	Ramp Moved North	1086+00	1088+00	Seg 3, I-69, 4/9
	Exit to Gray St	Ramp Realigned	1104+00	1103+50	Seg 3, I-69, 4/9
	Entrance from McGowen St.	Combined with Entrance from Leeland	1118+50	N/A	Seg 3, I-69, 4/9
	Exit to Polk St	Ramp Realigned to Exit to Lamar St in Build	1135+00	1125+00	Seg 3, I-69, 5/9
	Entrance from I-45	Ramp Moved North	1146+00	1149+50	Seg 3, I-69, 5/9
	Entrance from Leeland St	Ramp Added in Build	N/A	1157+50	Seg 3, I-69, 5/9
	Exit to I-10	Ramp Moved North	1186+50	1188+50	Seg 3, I-69, 5/9
	Entrance from Downtown	Ramp Moved North	1217+00	1226+50	Seg 3, I-69, 5/9
	Exit to Lyons Ave	Ramp Moved North	1241+00	1242+00	Seg 3, I-69, 5/9
	Entrance from I-10	Ramp Realigned	1262+50	1262+00	Seg 3, I-69, 5/9
Southbound	Exit to I-10	Ramp Moved North	1242+00	1246+50	Seg 3, I-69, 5/9
	Entrance from Lyons St	Ramp Moved North	1224+00	1229+50	Seg 3, I-69, 5/9

Table 77: I-69 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Exit to Downtown	Ramp Realigned and Moved South	1204+00	1195+00	Seg 3, I-69, 5/9
	Entrance from I-10	Ramp Realigned and Moved South	1179+00	1169+00	Seg 3, I-69, 5/9
	Exit to I-45 SB	Moved North with the relocation of I-45	1140+00	1148+00	Seg 3, I-69, 5/9
	Exit to Bell St	Ramp Added in Build	N/A	1141+50	Seg 3, I-69, 5/9
	Exit to McGowen St	Combined with Exit to Bell St	1109+00	1141+50	Seg 3, I-69, 5/9
	Entrance from Webster St	Ramp Moved South	1095+00	1088+00	Seg 3, I-69, 4/9
	Exit to Almeda Rd	Ramp Added in Build	N/A	1069+00	Seg 3, I-69, 4/9
	Exit to SH 288 SB	Ramp Moved North	1077+00	1119+00	Seg 3, I-69, 5/9
	Entrance from I-45	Ramp Moved North	1071+00	1090+50	Seg 3, I-69, 4/9
	Entrance from SH 288 NB	Ramp Moved South	1053+00	1049+00	Seg 3, I-69, 4/9
	Exit to Fannin St.	Ramp Removed in Build	1035+50	N/A	Seg 3, I-69, 4/9
	Ramp from Blodgett St (Closed)	Ramp Removed in Build	1014+00	N/A	Seg 3, I-69, 4/9
	Entrance from Spur 527	Ramp Realigned	1010+00	1009+00	Seg 3, I-69, 4/9

Table 78: I-10 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
Eastbound	Exit to Taylor St	No Change	964+50	964+50	Seg 3, I-10, 6/9
	Entrance from Taylor St	No Change	986+00	986+00	Seg 3, I-10, 6/9
	Exit to I-45 NB	Ramp Moved West	1007+00	1000+00	Seg 3, I-10, 6/9
	Exit to I-45 SB	Ramp Moved West and Combined with Exit to I-45 NB	1026+50	1000+00	Seg 3, I-10, 6/9
	Exit to DT Connectors	Proposed Ramp in Build	N/A	1037+00	Seg 3, I-10, 6/9
	Exit to Smith St	Ramp Realigned	1045+00	1042+00	Seg 3, I-10, 6/9

Table 78: I-10 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Entrance from DT Connectors	Proposed Ramp in Build	N/A	1054+00	Seg 3, I-10, 6/9
	Entrance from I-45 SB	Ramp Realigned due to Relocation of I-45	1050+00	1059+50	Seg 3, I-10, 6/9
	Entrance from I-45 NB	Ramp Removed in Build due to Realignment of I-45 and Addition of DT Connectors	1055+00	N/A	Seg 3, I-10, 6/9
	Entrance from Rothwell St	Ramp Realigned	1083+00	1084+50	Seg 3, I-10, 6/9
	Exit to McKee St	Ramp Realigned	1073+00	1072+00	Seg 3, I-10, 6/9
	Exit to I-69 SB	Ramp Moved West	1094+00	1092+00	Seg 3, I-10, 7/9
	Exit to Jensen Dr	Ramp Removed in Build	1107+00	N/A	Seg 3, I-10, 7/9
	Exit to I-69 NB	Ramp Moved East	1112+50	1114+00	Seg 3, I-10, 7/9
	Entrance from I-69 NB	Ramp Moved East	1127+00	1143+00	Seg 3, I-10, 7/9
	Entrance from I-69 SB	Ramp Moved East and Combined with Entrance from I-69 NB	1130+00	1143+00	Seg 3, I-10, 7/9
	Entrance from Gregg St	Ramp Removed in Build	1151+50	N/A	Seg 3, I-10, 7/9
	Exit to Waco St	No Change	1161+00	1161+00	Seg 3, I-10, 7/9
	Entrance from Waco St	No Change	1181+00	1181+00	Seg 3, I-10, 7/9
Westbound	Exit to Waco St	No Change	1179+00	1179+00	Seg 3, I-10, 7/9
	Entrance from Waco St	No Change	1156+50	1156+50	Seg 3, I-10, 7/9
	Exit to Gregg St	Ramp Moved West	1149+00	1148+00	Seg 3, I-10, 7/9
	Exit to I-69 NB	Ramp Moved East	1132+00	1137+25	Seg 3, I-10, 7/9
	Exit to I-69 SB	Ramp Moved East	1124+50	1126+00	Seg 3, I-10, 7/9
	Entrance from I-69 SB	Ramp Realigned and Moved West	1110+00	1108+50	Seg 3, I-10, 7/9
	Entrance from I-69 NB	Ramp Moved West	1093+50	1089+50	Seg 3, I-10, 7/9

Table 78: I-10 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Exit to Providence St	Ramp Moved East	1082+50	1125+00	Seg 3, I-10, 7/9
	Entrance from Providence St	Ramp Realigned	1071+00	1071+50	Seg 3, I-10, 6/9
	Exit to I-45 SB	Ramp Removed in Build due to Realignment of I-45 and Addition of DT Connectors	1051+00	N/A	Seg 3, I-10, 6/9
	Exit to I-45 NB	Ramp Moved West	1047+00	1042+00	Seg 3, I-10, 6/9
	Entrance from Louisiana St	Ramp Moved West	1044+00	1031+50	Seg 3, I-10, 6/9
	Exit to DT Connector	Proposed Ramp in Build	N/A	1057+00	Seg 3, I-10, 6/9
	Entrance from I-45 NB	Ramp Moved West	1031+00	1056+00	Seg 3, I-10, 6/9
	Entrance from DT Connector	Proposed Ramp in Build	N/A	1006+00	Seg 3, I-10, 6/9
	Entrance from I-45 SB	Ramp Moved West	1006+00	1004+00	Seg 3, I-10, 6/9
	Exit to Taylor St	No Change	986+50	986+50	Seg 3, I-10, 6/9

Table 79: I-610 Existing Versus Proposed Access Locations

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
Eastbound	Exit to Main St	No Change	1484+00	1484+00	Seg 2, I-610
	Entrance from Main St	Ramp Moved East, Connects to C-D	1511+00	1566+00	Seg 2, I-610
	Exit to Airline Dr	Ramp Removed in Build	1520+00	N/A	Seg 2, I-610
	Exit to I-45 NB	Ramp Moved West	1541+00	1518+00	Seg 2, I-610
	Exit to I-45 SB	Ramp Moved West and Combined with Exit to I-45 NB	1545+50	1518+00	Seg 2, I-610
	Entrance from I-45 NB	Ramp Moved East	1560+50	1577+50	Seg 2, I-610
	Entrance from I-45 SB	Ramp Moved East and Combined with Entrance from I-45 NB	1564+50	1577+50	Seg 2, I-610
	Exit to Irvington Blvd	Ramp Moved West, Connects to C-D	1586+00	1543+00	Seg 2, I-610

Direction	Ramp	Action	Existing Station	Proposed Station	Schematic Page Number
	Exit to Hardy St	No Change	1600+00	1600+00	Seg 2, I-610
	Exit to Hardy Toll Rd	No Change	1612+50	1612+50	Seg 2, I-610
	Entrance from Irvington Blvd	No Change	1629+00	1629+00	Seg 2, I-610
	Entrance from Hardy Toll Rd	No Change	1646+00	1646+00	Seg 2, I-610
Westbound	Entrance from Hardy Toll Road	No Change	1611+00	1611+00	Seg 2, I-610
	Entrance from Hardy Street	No Change	1598+50	1598+50	Seg 2, I-610
	Entrance from Irvington Blvd	Ramp Moved West, Connects to C-D	1584+50	1541+50	Seg 2, I-610
	Exit to I-45 NB	Ramp Moved East	1568+00	1579+00	Seg 2, I-610
	Exit to I-45 SB	Ramp Moved East and Combined with Exit to I-45 NB	1557+00	1579+00	Seg 2, I-610
	Entrance from I-45 SB	Ramp Moved West	1541+00	1511+50	Seg 2, I-610
	Entrance from I-45 NB	Ramp Moved West and Combined with Entrance from I-45 SB	1538+00	1511+50	Seg 2, I-610
	Entrance from Airline Dr	Ramp Removed in Build	1522+00	N/A	Seg 2, I-610
	Exit to Main St	Ramp Moved East, Connects to C-D	1511+00	1565+50	Seg 2, I-610

In summary, there are 51 ramp access location changes along I-45, 30 on I-69, 26 on I-10, and 14 on I-610. I-45 includes the greatest number of ramp changes due to the capacity additions and realignment of the downtown loop freeway system. These changes focused on increasing weave lengths, providing improved lane balance, and addressing capacity needs.

Downtown Ramp Connections

The proposed realignment of the I-45 downtown loop system includes downtown connector ramps to and from I-45 and I-10 and resulted in multiple impacts to the existing Downtown access points for I-45 Northbound and I-45 Southbound. The changes in access resulted in conversion of I-45 at I-10 and I-45 at I-69 to partial interchanges and new travel paths being required to enter and exit the Downtown area. **Table 80** summarizes the changes in access along I-45 in the downtown area. The I-45 NHHIP team has coordinated with City of Houston on the implementation of signage and wayfinding along appropriate arterial streets to identify paths to the interstate.

Table 80: I-45 Downtown Access Impacts

Movement	Existing/No-Build	Build	Traffic Demand and Operations
Downtown to I-45 Southbound	Entrance from Allen Pkwy	▪ Option 1 - Allen Pkwy to Downtown Connector to I-10 Eastbound to I-69 Southbound to I-45 Southbound ▪ Option 2 - Allen Pkwy to Jefferson St to I-45 Southbound	There are 950 veh/hr in the 2045 AM peak period and 1,790 veh/hr in the 2045 PM peak period split between Option 1 and Option 2 by a 70/30 split
	Entrance from Houston Ave/Memorial Dr	▪ Option 1 - Houston Ave to Allen Pkwy to Downtown Connector to I-10 Eastbound to I-69 Southbound to I-45 Southbound ▪ Option 2 - Memorial Dr to Walker St to Downtown Connector to I-10 Eastbound to I-69 Southbound to I-45 Southbound ▪ Option 3 - Houston Ave to Jefferson St to I-45 SB	There are 1,900 veh/hr in the 2045 AM peak period and 2,280 veh/hr in the 2045 PM peak period split between Option 1, Option 2, and Option 3 by a 50/30/20 split
	Via I-10 Eastbound and I-69 Southbound	▪ Main St to I-10 Eastbound to I-69 Southbound to I-45 Southbound	There are 1,900 veh/hr in the 2045 AM peak period and 1,840 veh/hr in the 2045 PM peak period shifting to use the Build movement
Downtown to I-45 Northbound	Entrance from St Joseph Pkwy	▪ St Joseph Pkwy to Pease St to Downtown Connector to I-45 Northbound	There are 1,310 veh/hr in the 2045 AM peak period and 1,220 veh/hr in the 2045 PM peak period shifting to use the Build movement
	Via I-69 Northbound and I-10 Westbound	▪ Option 1 - Commerce St to I-69 Northbound/I-10 Westbound connector to I-10	There are 10 veh/hr in the 2045 AM peak period and 30 veh/hr in the 2045 PM peak period split

Movement	Existing/No-Build	Build	Traffic Demand and Operations
		Westbound to I-45 Northbound ▪ Option 2 - Leeland St to I-69 Northbound to I-10 Westbound to I-45 Northbound	between Option 1 and Option 2 by an 80/20 split
I-45 Northbound to Downtown	Exit to Allen Pkwy	▪ Option 1 - Exit to St Joseph Pkwy/Pease St to Allen Pkwy via Downtown streets ▪ Option 2 - I-45 Northbound to I-69 Northbound to I-10 Westbound to Downtown Connector to Exit to Bagby St to Allen Pkwy via local streets ▪ Option 3 - I-45 Northbound to I-10 Westbound to Exit to Taylor St to Allen Pkwy via local streets	There are 560 veh/hr in the 2045 AM peak period and 470 veh/hr in the 2045 PM peak period split between Option 1, Option 2, and Option 3 by a 10/20/70 split
	Exit to Houston Ave/Memorial Dr	▪ Option 1 - Exit to St Joseph Pkwy/Pease St to Houston Ave/Memorial Dr via Downtown streets ▪ Option 2 - I-45 Northbound to I-69 Northbound to I-10 Westbound to Downtown Connector to Jefferson St to Houston Ave/Memorial Dr via Downtown streets ▪ Option 3 - I-45 Northbound to I-10 Westbound to Exit to Taylor St to Houston Ave/Memorial Dr via local streets	There are 970 veh/hr in the 2045 AM peak period and 690 veh/hr in the 2045 PM peak period split between Option 1, Option 2, and Option 3 by a 10/10/80 split

Interchange Movements

At most locations, the proposed access provides for all movements and only connects to public roadways. A summary of all freeway to freeway interchange movements is shown in **Table 81** below with the proposed design.

Table 81: Freeway to Freeway Interchange Movements

Freeway to Freeway Interchange	No-Build Movements	Build Movements
I-45 at I-610 – Segment 2	Full Interchange - All eight major freeway to freeway movements provided	Full Interchange - All eight major freeway to freeway movements provided
I-45 at I-10 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Partial Interchange – I-10 WB to I-45 SB and I-45 NB to I-10 EB/WB adjusted access to consolidate movements through I-69.
I-45 at I-69 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Partial Interchange – I-69 SB to I-45 NB and I-45 SB to I-69 NB adjusted access to consolidate movements through I-10.
I-69 at I-10 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Full Interchange - All eight major freeway to freeway movements provided
I-69 at SH 288 – Segment 3	Five major freeway to freeway movements provided	Five major freeway to freeway movements provided
I-69 at Spur 527 – Segment 3	Two major freeway to freeway movements provided	Two major freeway to freeway movements provided

The I-45 at I-10 interchange is defined as partial because two movements from interstate to interstate are not direct. They include:

- **I-10 WB to I-45 SB** – This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-10 WB to I-69 SB, followed by a slip ramp to I-45 SB. Vehicles making this route movement would not have to change lanes between the route from I-10 WB to I-45 SB. The Build operations were reviewed in detail and show improved results from the Existing/No-Build I-10 WB to I-45 SB movement.
- **I-45 NB to I-10 EB** - This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-45 NB to I-69 NB, followed by a direct connector from I-69 NB to I-10 EB. Once on I-69, vehicles making this route movement would not have to change lanes to continue onto the I-69 NB to I-10 EB direct connector. The Build operations were reviewed in detail and show improved results from the Existing/No-Build I-45 NB to I-10 EB movement.

Table 82 summarizes the operational and safety impacts of the partial interchange. In addition, these movements are illustrated in **Figure 56**.

Table 82: I-45 at I-10 Partial Interchange Movements Operations and Safety

Movement	Change	Operational Results (min)	Safety Impact
I-10 WB to I-45 SB	Accommodated via I-10 WB to I-69 SB to I-45 SB	No-Build 2045 Travel Time (AM/PM) – (14.1/15.4 min) Build 2045 Travel Time (AM/PM) – (2.4/2.6 min)	Eliminates low design speed direct connector and Build improves design speed for movement. No weave lane changes required in Build schematic.
I-45 NB to I-10 EB	Accommodated via I-45 NB to I-69 NB to I-10 EB	No-Build 2045 Travel Time (AM/PM) – (6.1/8.6 min) Build 2045 Travel Time (AM/PM) – (5.8/6.4 min)	Eliminates direct connector that has merge on the structure followed by left lane addition. No weave lane changes required in Build schematic.

The I-45 at I-69 interchange is defined as partial because two movements from interstate to interstate are not direct. They include:

- **I-69 SB to I-45 NB**– This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-69 SB to I-10 WB, followed by a slip ramp to I-45 NB. Vehicles making this route movement would have to change four lanes over a 1.3-mile section. The traffic demand for this movement was evaluated in the microsimulation model and showed no operational issues.
- **I-45 SB to I-69 NB** - This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-45 SB to I-10 EB, followed by a direct connector to I-69 NB. Vehicles making this route movement would have to change two lanes over a 1.3-mile section. The traffic demand for this movement was evaluated in the microsimulation model and showed no operational issues.

Table 83 summarizes the operational and safety impacts of the partial interchange. In addition, these movements are illustrated in **Figure 57**.

Table 83: I-45 at I-69 Partial Interchange Movements Operations and Safety

Movement	Route Change	Operational Results	Safety Impact
I-69 SB to I-45 NB	Accommodated via I-69 SB to I-10 WB to I-45 NB	No-Build 2045 Travel Time (AM/PM) – (14.6/13.8 min) Build 2045 Travel Time (AM/PM) – (3.0/2.6 min)	Eliminates low design speed direct connector with merge identified as safety issue in crash analysis. Build will require weave lane changes for this low traffic demand movement.
I-45 SB to I-69 NB	Accommodated via I-45 SB to I-10 EB to I-69 NB	No-Build 2045 Travel Time (AM/PM) – (9.0/ 9.6 min) Build 2045 Travel Time (AM/PM) – (3.1/2.9 min)	Eliminates low design speed direct connector that has merge with I-45 NB to I-69 NB direct connector. Build will require weave lane changes for this low traffic demand movement.

For both the I-45 at I-10 and I-45 at I-69 interchange, the signage and wayfinding will be provided in accordance with MUTCD and the Texas Freeway Signage Manual. The I-45 NHHIP team has coordinated with City of Houston on the implementation of signage and wayfinding along appropriate arterial streets to identify paths to the interstate.

In addition, Spur 527 starts at I-69, with the direct movements maintained between the existing/No-Build and the proposed Build schematic. SH 288 ends at I-69, with five movements provided in the existing/No-Build condition, maintained in the proposed Build schematic.

The I-45 to I-610 westbound and I-610 eastbound to I-45 direct connectors have slip ramps to and from N Main Street. This concept was developed to improve lane balance and due to public comment regarding needed access to low income communities. It was reviewed and considered in operational and safety analysis.

There are three direct connectors that have two lanes merge to one lane, due to lane balance with downstream connections at the I-610 at I-45 interchange; I-45 northbound to I-610 westbound, I-610 westbound to I-45 southbound, and I-610 eastbound to I-45 southbound. Two lanes of capacity were provided at diverge points to maximize operational efficiency. The merge to one lane on each direct connector will be signed appropriately with option lanes and provides additional space for vehicle gaps in lane changes. They were reviewed to ensure operational efficiency and safety. The direct connectors will have appropriate distance to merge with signage.

All 34 urban interchanges to cross streets in the project area connect to public roads and provide for all traffic movements. Routes are impacted on cross streets, but all impacted intersections were analyzed for appropriate local street improvements in safety and operations to address any access point changes.

Figure 56: I-45 at I-10 Partial Interchange Movements

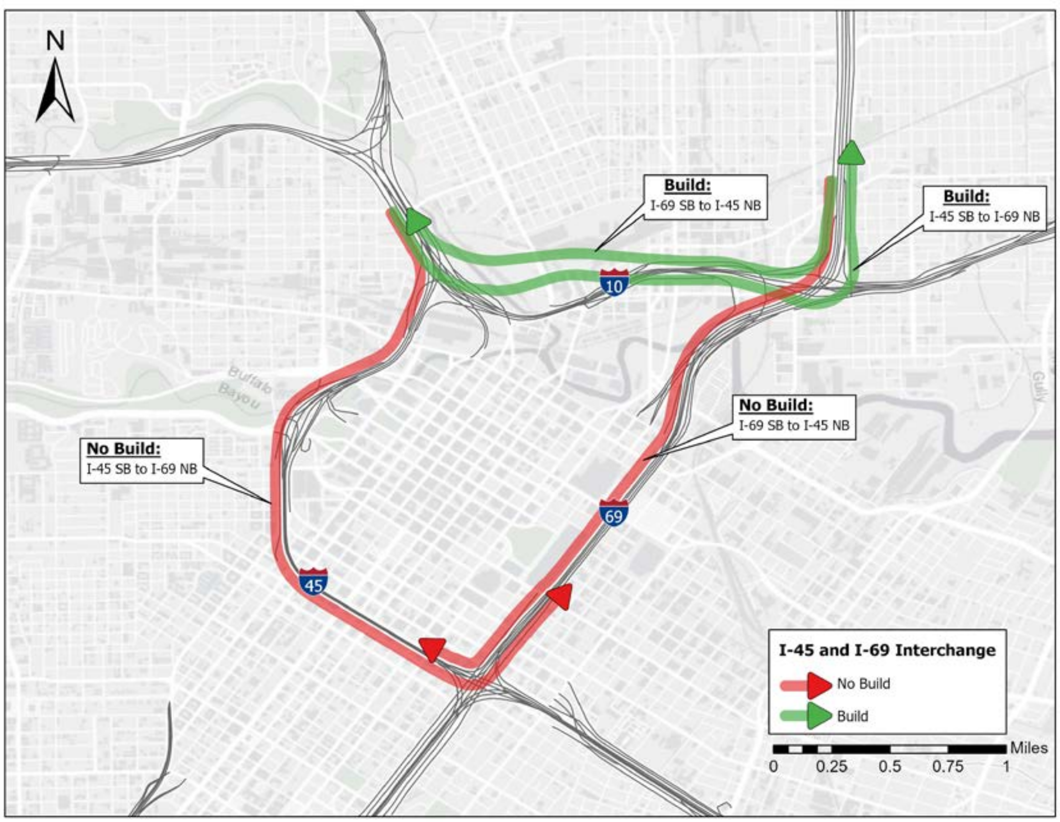

Figure 57: I-45 at I-69 Partial Interchange Movements

I-45 Transition from Segment 2 to Existing

The proposed Build configuration was modeled assuming a transition from the proposed Segment 2 Build configuration back to the existing configuration. This transition takes place along I-45 directly north of where the I-610 direct connectors tie in with the I-45 mainlanes. The transition includes extending the proposed improvements of Segment 1 past Victoria Drive. All improvements in the Segment 1 schematic, **Appendix P; page 12**, were included as part of the safety and operational analysis. North of Victoria Drive, the configuration transitions back to existing. The entrance and exit ramps between Tidwell Avenue and Airline Drive are maintained with the existing gore points. The transition plan including number of lanes can be seen in **Figure 58**.

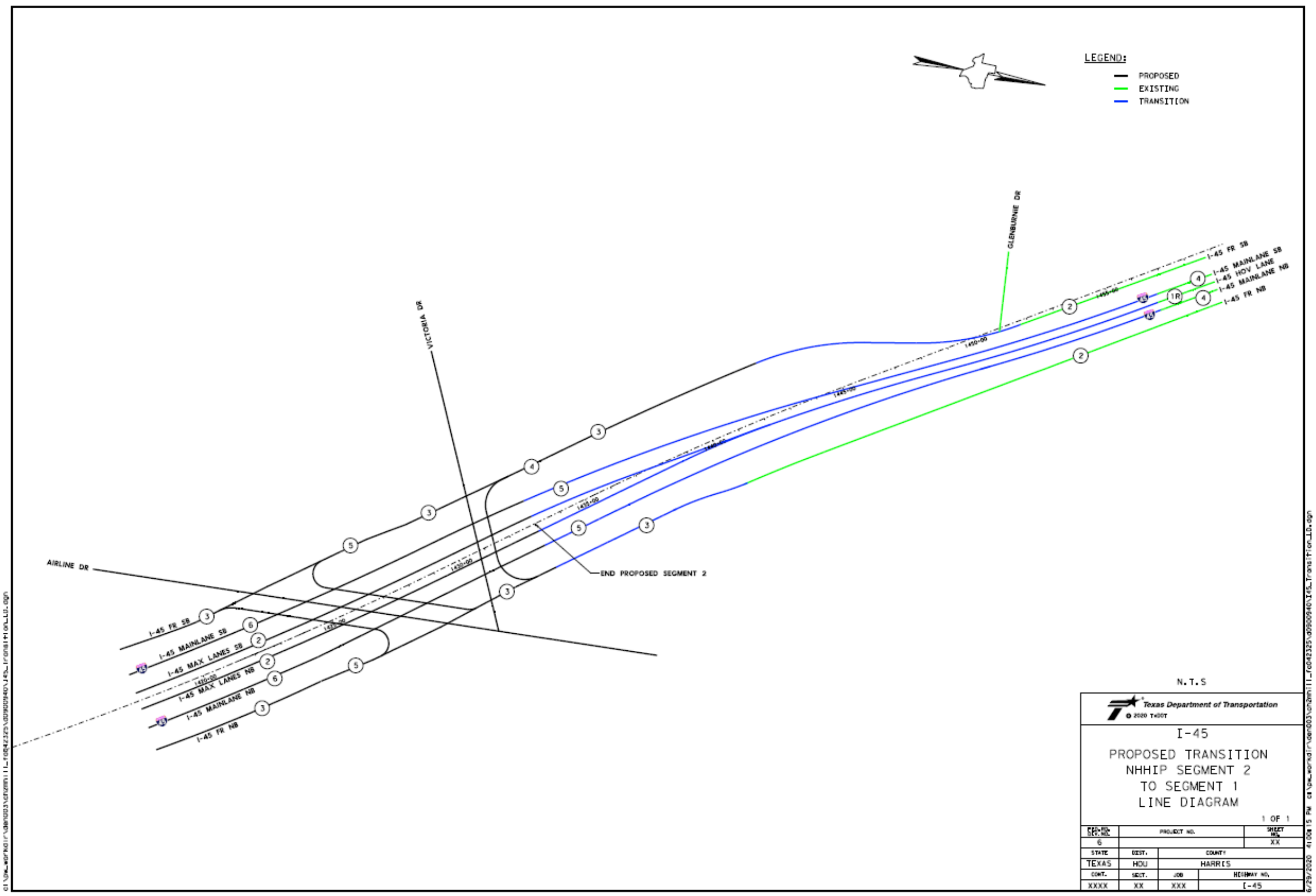

Figure 58: I-45 Transition from Proposed Build to Existing

As seen in **Figure 58**, the 2x2 MaX Lanes will merge to the single reversible lane north of Airline Drive The transition impacts the time of day entrance and exit points to the proposed MaX lanes. In the morning, vehicles traveling on the I-45 northbound MaX lanes will exit at the I-610 interchange to the I-45 northbound general purpose lanes. In the afternoon, vehicles traveling southbound will not be able to enter the I-45 MaX lanes until the I-610 interchange entrance location.

MaX Lane Access Points

The MaX lane system are proposed on the I-10 and I-45 corridors to provide HOV/Express lane capacity through the project area. Transit vehicles would be able to operate on the Max lanes and they provide direct access to and from Downtown Houston. The I-45 MaX lanes begin at the project start south of Tidwell Avenue and end in Downtown Houston. The I-10 MaX lanes operate through the project area from Houston Avenue to west of Waco Street. There are two direct connections from I-10 MaX lanes to I-45 MaX lane, including:

- I-10 EB MaX lane to I-45 NB MaX lane
- I-45 SB MaX lane to I-10 WB MaX lane

An I-10 project west of the project area is being studied and would potentially extend the I-10 MaX lanes in the future. The project is unfunded.

The access on the I-10 MaX lanes includes:

- I-10 EB/WB MaX lane start and end point west of Houston Ave
- I-10 EB/WB MaX lane start and end point west of Waco St
- I-10 EB MaX exit to Smith St (downtown)
- I-10 WB MaX entrance from Smith St (downtown)

The access on the I-45 MaX lanes includes:

- I-45 SB MaX lane exit to Milam St – terminates I-45 SB MaX lanes
- I-45 NB MaX lane entrance from Travis St – begins I-45 NB MaX lanes
- I-45 SB MaX lane weave section (entrance/exit) at I-610 interchange north of I-610 to I-45 SB direct connector merge
- I-45 NB MaX lane weave section (entrance/exit) at I-610 interchange north of I-45 NB to I-610 direct connector diverge
- I-45 SB MaX lane exit to I-45 SB to I-610 direct connector
- I-45 NB MaX lane entrance from I-610 to I-45 NB direct connector
- I-45 NB/SB MaX lane start and end point north of Victoria Drive

The I-45 northbound traffic in the morning peak exits at I-610, prior to the transition back to the reversible lane near Victoria Drive.

These access points were included in operational and safety analysis. The gore points were considered with weave lengths in the Vissim model, while the ramp gore points were included in the predictive safety analysis.

Design Exceptions

The proposed design for Segments 2 and 3 includes three potential design exceptions necessitated by geometric and ROW constraints. These potential exceptions are described in Table 84 below. They will be vetted during final design and, if it is determined that any of the design exceptions are still required, a formal request for design exception will be submitted to the Design Division for review to be submitted to FHWA for review and approval. These are the current statuses of the design exceptions.

Table 84: I-45 NHHIP – Design Exception Summary

Location	Exception Type	NHHIP Project Criteria	Solution	Explanation
Entrance from Travis St to I-45 N MaX	Shoulder Width	10 ft inside shoulder for three plus lanes	4 ft Shoulder	The third lane heading north from Girard Street to the exit ramp to I-45 NB General purpose lanes is an auxiliary lane. This is a transition to the existing downtown urban streets. There is a retaining wall and building constraint adjacent to the east side of the entrance ramp.
Exit from I-45 S MaX to Milam St	Shoulder Width	10 ft inside shoulder for three plus lanes	4 ft Shoulder	I-45 SB MaX Lane becomes Milam Street as it approaches Girard Street intersection. Therefore, I-45 SB Max Lane can be classified as a local street as it approaches Girard Street. Distance from I-45 SB MaX Gore to the beginning of Girard Street intersection is currently 545 ft. There is a drainage culvert bridge constraint limiting the shoulder width in this transition to existing.
US59/I69 NB General Purpose Lanes	Shoulder Width	4 ft inside shoulder and 8 ft outside shoulder on DC / 10 ft outside shoulder on GP	6 ft shoulder	The mainlanes outside shoulder is adjusted to 10 ft. The I-45 NB DC to I-69 NB outside shoulder can be increased from 6 ft to 8 ft but decrease the inside shoulder width from 4 ft to 2 ft, for the roadway portion of the DC. The DC structural section will have 4 ft inside shoulder. This design is to fit within downtown constraints, right of way, and retaining walls.

5.3.2.5 *Operational Analysis Results*

The 2025 and 2045 Build scenarios were analyzed in Vissim 9.0-10 for traffic operation results. Traffic projections were developed for AM and PM peak periods and incorporated updates to land use, demographics, and background projects. The No-Build and Build traffic volume inputs are approximately equal in each scenario, to provide a direct comparison. Traffic projections considered the proposed improvements, which include diversions with the proposed access changes.

Build Vissim results were output for the entire network for AM and PM peak periods and highlight overall performance. Based on the focused MOEs discussed previously, network statistics for speed, vehicle-miles travelled, and latent demand were output and are shown in **Table 85** and compared to No-Build operations in **Figures 59-61**. The remaining MOEs (segment speed, queue lengths, travel time, speed differential, lane changes, and delay) are the focus of specific calibration locations. The 2025 and 2045 Build network results are included in **Appendix Q** and **Appendix R**, respectively.

Table 85: Build 2025 and 2045 Vissim Results

		Average Speed (mph)	Vehicle Miles	Latent Demand (veh)
2025	AM	35.3	1,403,276	27,728
	PM	27.9	1,584,787	56,771
2045	AM	31.7	1,501,503	59,399
	PM	26.0	1,636,937	107,027

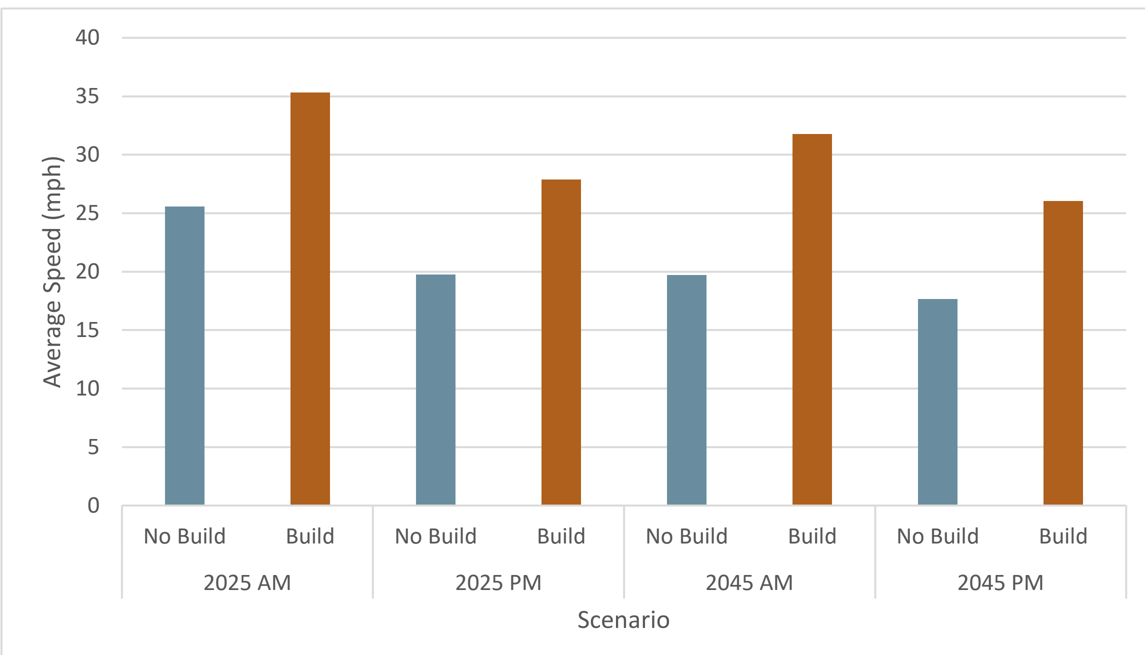

Figure 59: Average Speed No-Build vs. Build

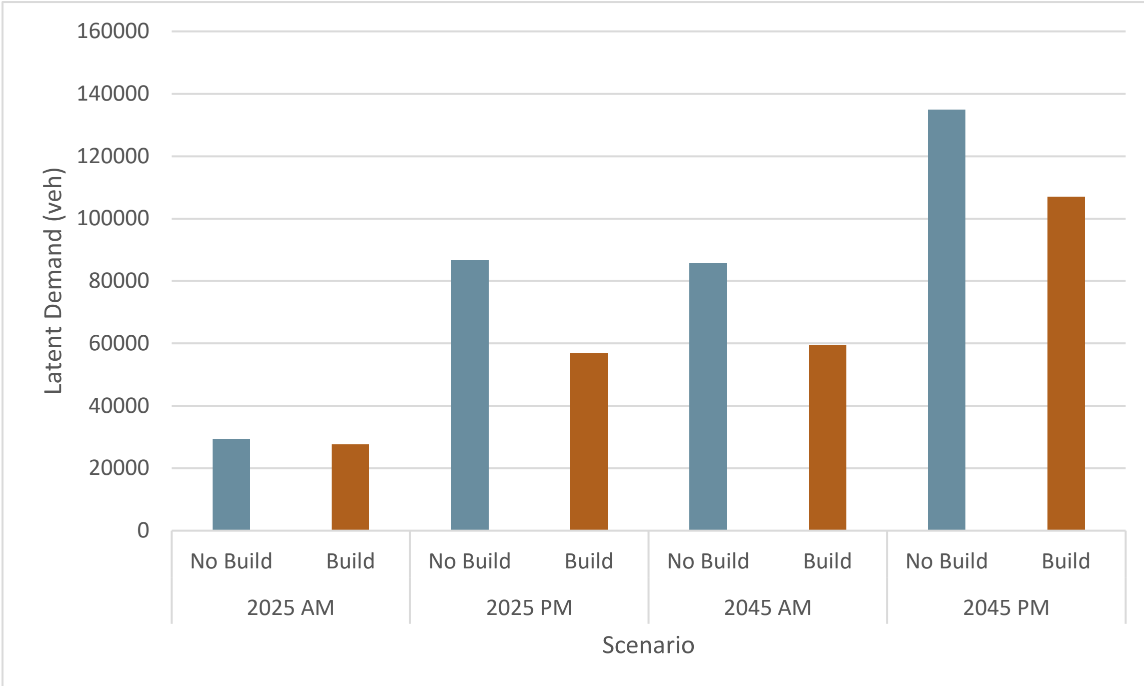

Figure 60: Latent Demand No-Build vs. Build

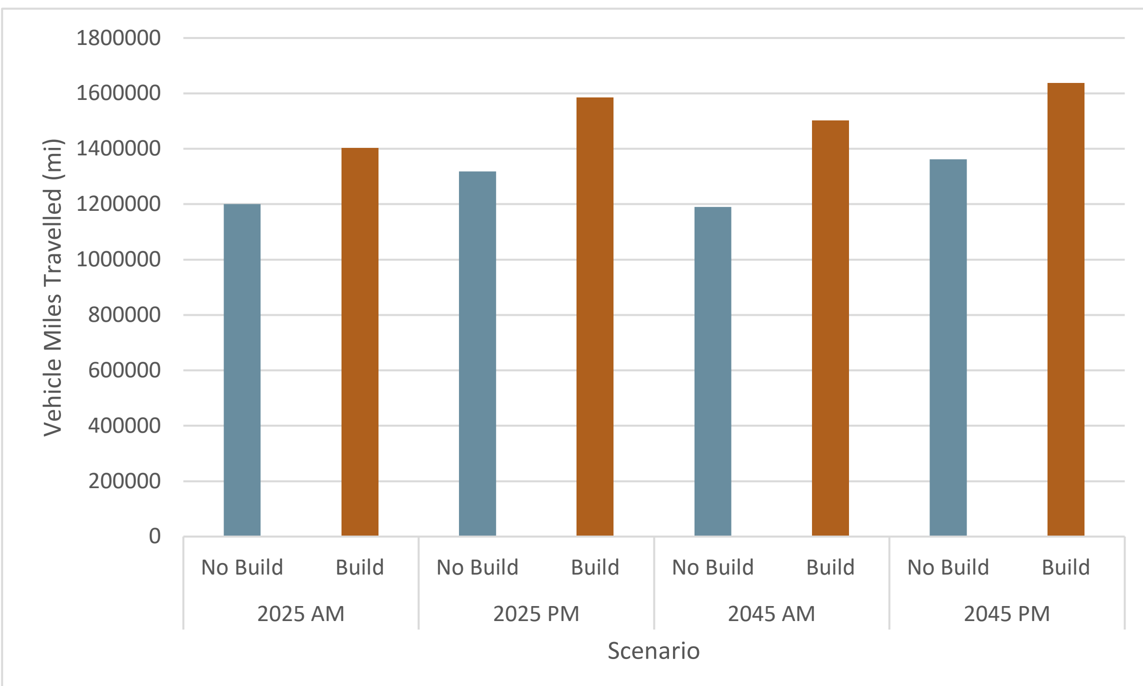

Figure 61: Vehicle Miles Traveled No-Build vs. Build

As shown in **Table 85**, the PM network shows a higher level of latent demand. **Figures 59-61** show the improvement in average speed, VMT, and latent demand across all scenarios from No-Build to Build. There is also a reduction in total delay from the proposed Build compared to No-Build of over 50,000 and 70,000 hours in the 2025 and 2045 scenarios, respectively. The latent demand at input locations is summarized in **Table 86** below. Due to the extent of the project area and the urban environment, this amount of latent demand is expected and was accepted during simulation. Furthermore, the latent demand increases at I-45 southbound mainlanes due to an increase in demand as a result of the proposed improvements.

Table 86: 2025 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
I-45 ML SB	0	1058	0	3076
I-45 ML NB	2757	4020	14568	5527
US 288 NBFR	125	0	474	0
US 288 ML NB	8636	9221	10533	958
I-69 ML NB	0	0	23165	12591
I-10 ML WB	5306	0	7267	0
I-10 WBFR	49	201	434	0
I-69 SBFR	594	14	0	0
I-69 ML SB	1685	163	121	0
I-10 ML EB	1642	374	5922	2257
I-610 ML WB	851	0	10140	8185
I-610 ML EB	151	144	1717	3166
Hardy Toll Rd SB	2562	0	0	0
I-45 SBFR N of Tidwell	182	0	0	0
40.5 St EB to Airline	0	0	1876	0
Spur 527 ML SB	0	871	0	1698
Main NB to I-610	0	6	0	0
Main SB to I-610	0	267	0	0
Airline NB to I-610	0	15	0	0
Airline SB to I-610	394	1682	0	0
Irvington SB	502	481	0	0

Table 86: 2025 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
Link WB	0	8	0	0
Cottage WB	0	0	0	17
Main to I-45 EB	0	76	0	0
Houston Ave to Main St	0	0	0	28
Hadley to Jefferson-Pierce SB	0	121	0	1103
Jefferson SB	0	0	0	1011
Scott WB	155	60	0	0
Emancipation WB	363	472	261	804
Southmore WB	574	31	701	0
Richmond WB	35	24	128	109
Chenevert NB	0	0	1735	362
McKee SB	0	459	0	0
Commerce WB	0	0	0	188
Smith WB	0	0	1096	2
Pease NB	0	31	0	1092
St Joseph Pkwy NB	0	0	0	1975
Brazos EB	55	2	0	1606
Brazos WB	0	0	612	0
W Dallas WB	0	0	0	594
W Dallas EB	0	333	0	348
Allen Pkwy EB	0	578	982	2715
Allen Pkwy WB	0	77	0	5056
Memorial Way WB	0	17	0	335
Memorial Dr EB	2260	1083	3484	1550
Houston Ave SB	3	0	0	0
Houston Ave SB 2	91	185	0	0
Taylor NB	0	0	7	0
146: 45 SBFR to Webster	0	2473	0	4152

Table 86: 2025 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
Hardy Toll SB	0	0	1371	0
SB Ramp from Main	0	74	0	0
I-10 EBFR East of McKee St	0	0	0	0
Source North of Chartres St and Capitol St	0	0	89	0
Source North of Chartres St and Leeland Ave	0	0	0	156
Source East of Providence St and McKee St	464	0	0	0
Source South of I-45 SBFR and Cottage St	0	0	0	13
Source East of Main St and I-610 WBFR	0	58	0	0
Source North of St Emanuel St @ McKinney St	0	0	0	2618

In addition to the demand that was unable to make it onto the network in each peak period, there were approximately 1,408 and 3,097 vehicles during the Build AM and PM peak periods, respectively, that were removed from the simulations for taking excessive time during lane change maneuvers. This is done by the software to prevent single vehicles from getting stuck during an entire simulation and producing unrealistic model results. The removal of vehicles is acceptable to allow the microsimulation to continue to function with high levels of congestion.

Table 87 lists the latent demand by vehicle input for the 2045 Build network. Similar to 2025, the latent demand increases at I-45 southbound mainlanes due to an increase in demand as a result of the proposed improvements.

Table 87: 2045 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
I-45 ML SB	0	7303	0	5777
I-45 ML NB	5648	4728	19332	11210
US 288 NBFR	595	295	1432	595

Table 87: 2045 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
US 288 ML NB	12345	15278	12770	9782
I-69 ML NB	2627	470	29321	19573
I-10 ML WB	13170	801	10683	197
I-10 WBFR	1182	338	892	0
I-69 SBFR	1597	946	0	0
I-69 ML SB	12834	6648	5299	0
I-10 ML EB	8112	1870	10764	8105
I-10 EBFR	0	0	399	0
I-610 ML WB	6355	3286	18230	12595
I-610 ML EB	4667	2134	4935	4952
I-45 NBFR	0	21	0	0
Hardy Toll Rd SB	7448	3449	1526	1337
I-45 SBFR N of Tidwell	454	0	0	0
Tidwell EB	0	1	0	165
Airline EB to I-45	0	15	0	0
Crosstimbers EB	0	0	0	25
Spur 527 ML SB	0	1347	0	2736
Main SB to 610	35	0	0	0
Airline SB to I-610	884	803	0	0
Irvington SB	829	862	0	0
Link WB	0	102	0	0
Cavalcade WB	122	0	0	0
Patton WB	33	0	0	0
Main to I-45 EB	63	225	41	227
Houston Ave to Main St	0	0	0	64
Cullen WB	0	386	0	0
Hadley to Jefferson-Pierce SB	0	318	0	1478
Scott WB	320	596	0	419

Table 87: 2045 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
Jefferson SB	0	0	0	1565
Emancipation WB	565	892	394	1012
Southmore WB	1035	725	1320	410
Southmore EB	169	0	230	0
Richmond WB	381	289	591	843
Richmond EB	0	32	0	66
Elgin WB	0	0	0	362
Tuam EB	0	0	0	19
McGowen WB	0	0	109	0
Chenevert NB	0	0	4024	2005
Ruiz EB	0	0	4	0
Waco SB	286	48	0	0
McKee SB	0	730	0	0
N San Jacinto NB	0	0	330	0
N Main St SB to Rothwell	0	0	72	0
Commerce WB	0	0	0	389
Travis NB	0	0	0	867
Louisiana NB	0	0	404	1111
Smith WB	0	0	1942	113
Pease NB	0	782	43	2456
St Joseph Pkwy NB	0	437	0	1887
Brazos EB	347	91	1651	1083
Brazos WB	0	0	881	0
W Dallas WB	0	0	0	753
W Dallas EB	0	431	0	505
Allen Pkwy SB	13	451	712	2720
Allen Pkwy WB	0	19	67	5716
Memorial Way WB	15	42	1	0

Table 87: 2045 No-Build vs. Build - Vehicles Unable to Enter Network by Location

Location	No-Build AM Peak Vehicles	Build AM Peak Vehicles	No-Build PM Peak Vehicles	Build PM Peak Vehicles
Memorial Dr EB	2208	1537	3189	2530
Houston Ave SB 2	55	369	0	0
Taylor NB	435	0	433	0
45 SBFR to Webster	126	3606	0	5855
69 NBFR to Leeland	0	0	0	278
SB Ramp from Main	0	104	0	0
Hardy Toll SB	0	0	2184	0
Hardy Toll SB	82	0	0	0
I-10 HOV EB	0	0	0	77
Source North of Chartres St and Leeland Ave	0	0	0	541
Source North of Cottage St and I-45 SBFR	0	0	0	7
Source South of I-45 SBFR and Cottage St	0	0	0	135
Source South of I-69 SBFR and McGowan St	0	0	0	311
Source North of Chartres St and Capitol St	0	0	494	3702
Source South of Chartres St and Rusk St	0	0	293	0
Source East of Providence St and McKee St	686	0	0	0

In addition to the demand that was unable to make it onto the network in each peak period, there were approximately 2,268 and 4,127 vehicles during the Build AM and PM peak periods, respectively, that were removed from the simulations for taking excessive time during lane change maneuvers. This is done by the software to prevent single vehicles from getting stuck during an entire simulation and producing unrealistic model results. The removal of vehicles is acceptable to allow the microsimulation to continue to function with high levels of congestion.

A description of major latent demand locations of the Build networks including details of planned future projects and potential mitigation strategies are as follows:

- **I-45 SB:** Additional traffic demand is projected at this location compared to the No-Build configuration due to Build improvements. Furthermore, I-45 is modeled as transitioning back to the existing cross-section at the project limits. The completion of NHHIP Segment 1 will alleviate the congestion at this input.
- **I-45 NB:** In all scenarios except for 2025 AM, latent demand decreased from the No-Build condition. The latent demand at this location can be attributed to tying back to the existing configuration.
- **SH 288 NB:** The excess traffic demand at US 288 is attributed to higher growth expected south of the project area. No additional projects are currently planned on this roadway, but there are planning projects that are examining capacity expansion on adjacent roadways, like SH 35, to alleviate traffic demand on the SH 288 corridor.
- **I-69 NB/SB:** Latent demand due to high traffic demand entering Houston area. This location experienced a significant decrease in latent demand compared to the No-Build condition.
- **I-10 EB:** Latent demand is primarily a result of congestion from the eastbound Taylor Street intersection backing up onto the mainlanes. Future projects will address I-10 including Taylor Street.
- **I-610 EB/WB:** Latent demand due to high traffic demand entering Houston area. In addition, the mainlanes were modeled as tying back to the existing configuration at the model limits. I-610 is being considered for future schematic development projects.
- **Allen Parkway:** Latent demand due to competing movements with high traffic demand at a four-approach signal. Potential future mitigation can include grade separation such as direct connectors to/from Allen Parkway.

Travel times for freeway routes within the project area are compared to No-Build travel times in **Figures 62-77**.

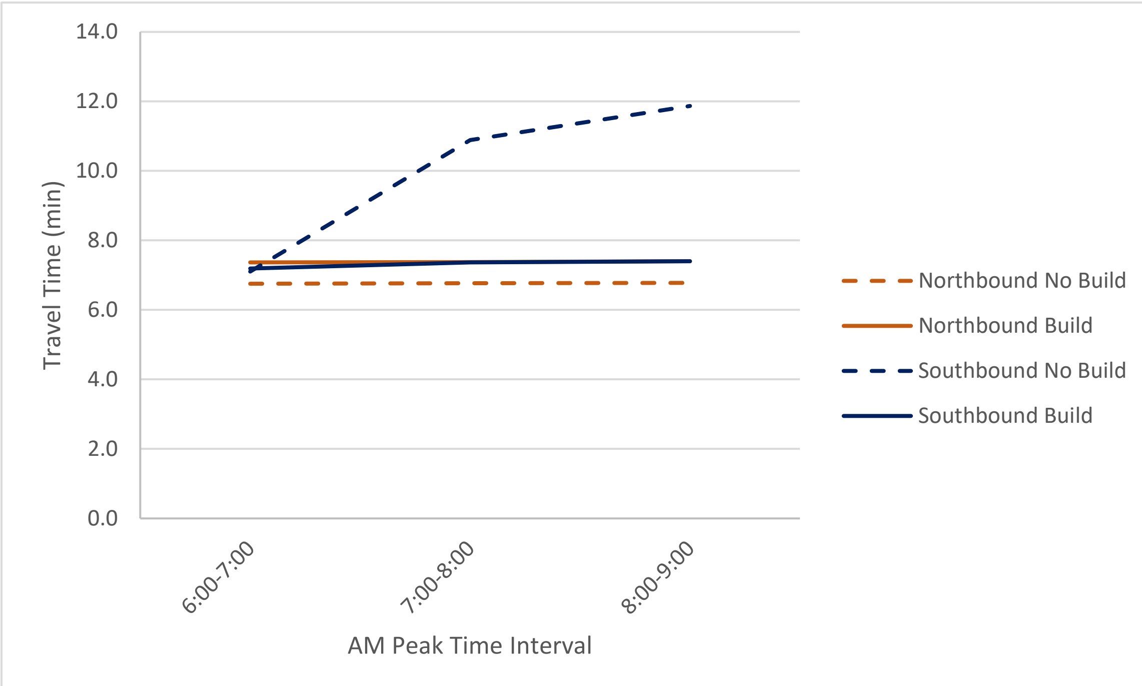

Figure 62: I-45 2025 AM No-Build vs. Build Travel Times

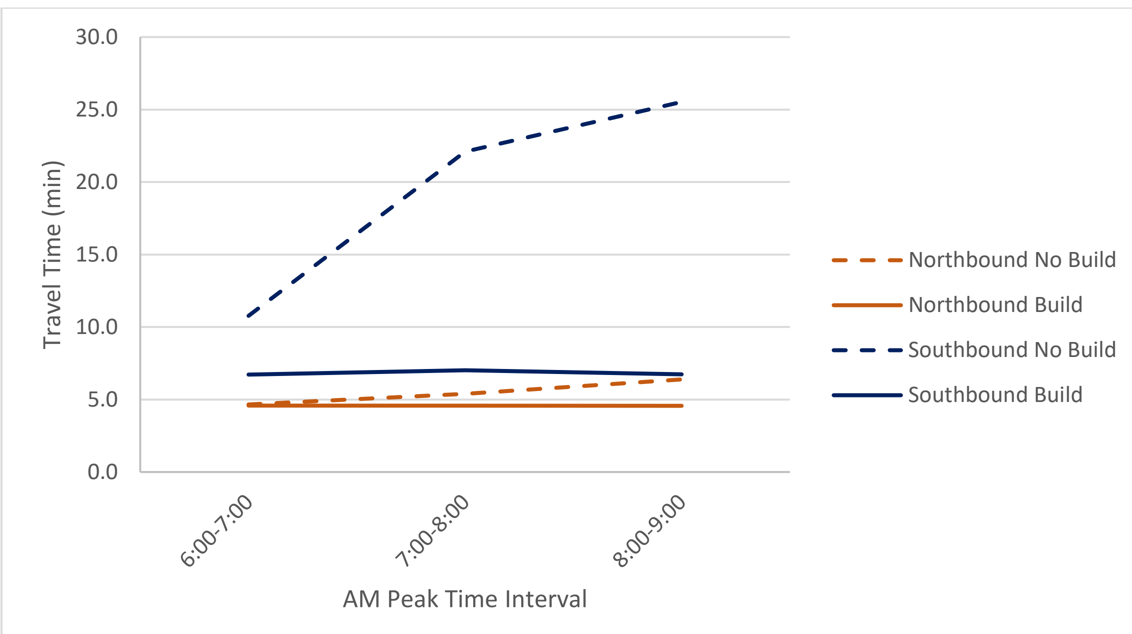

Figure 63: I-69 2025 AM No-Build vs. Build Travel Times

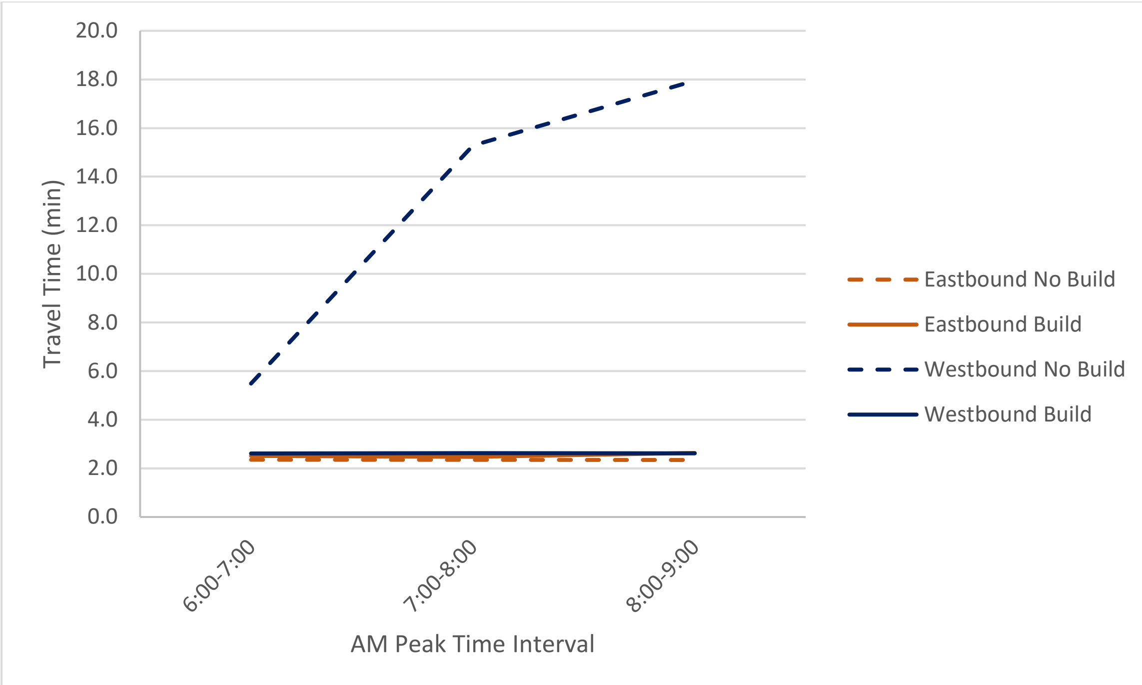

Figure 64: I-10 2025 AM No-Build vs. Build Travel Times

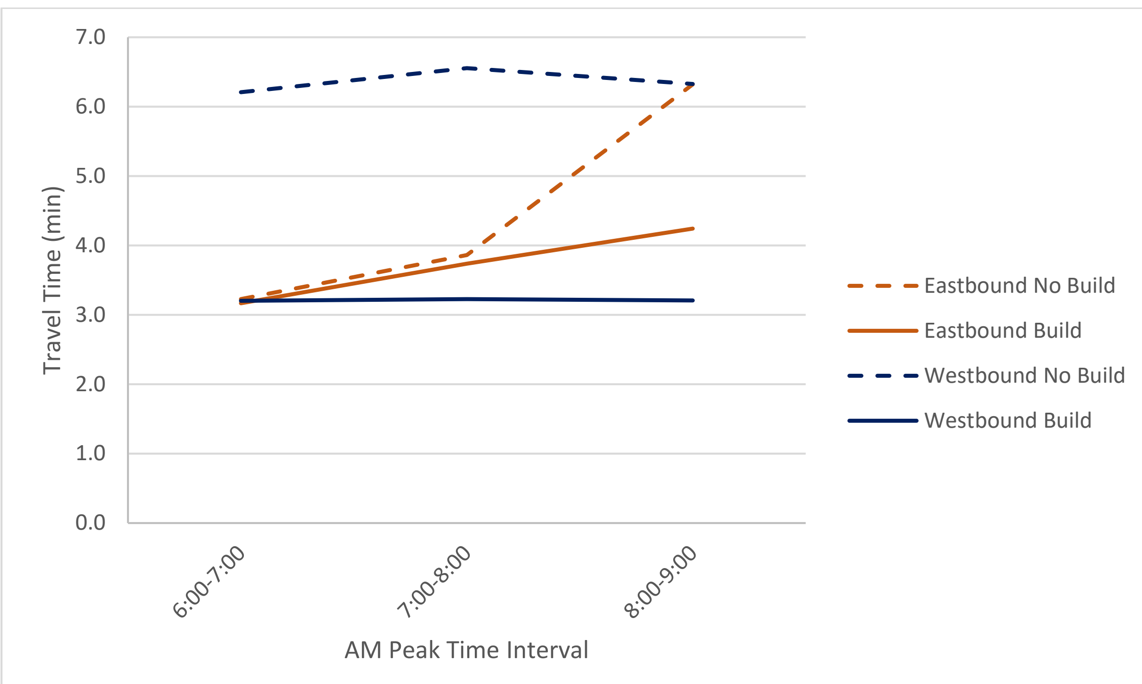

Figure 65: I-610 2025 AM No-Build vs. Build Travel Times

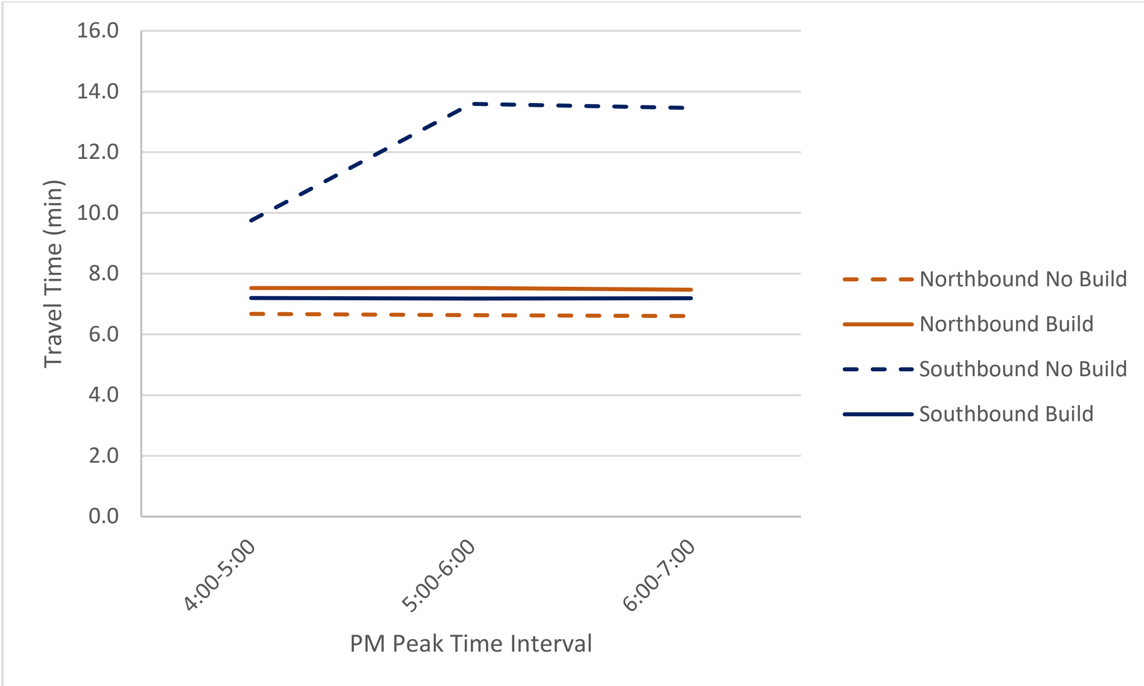

Figure 66: I-45 2025 PM No-Build vs. Build Travel Times

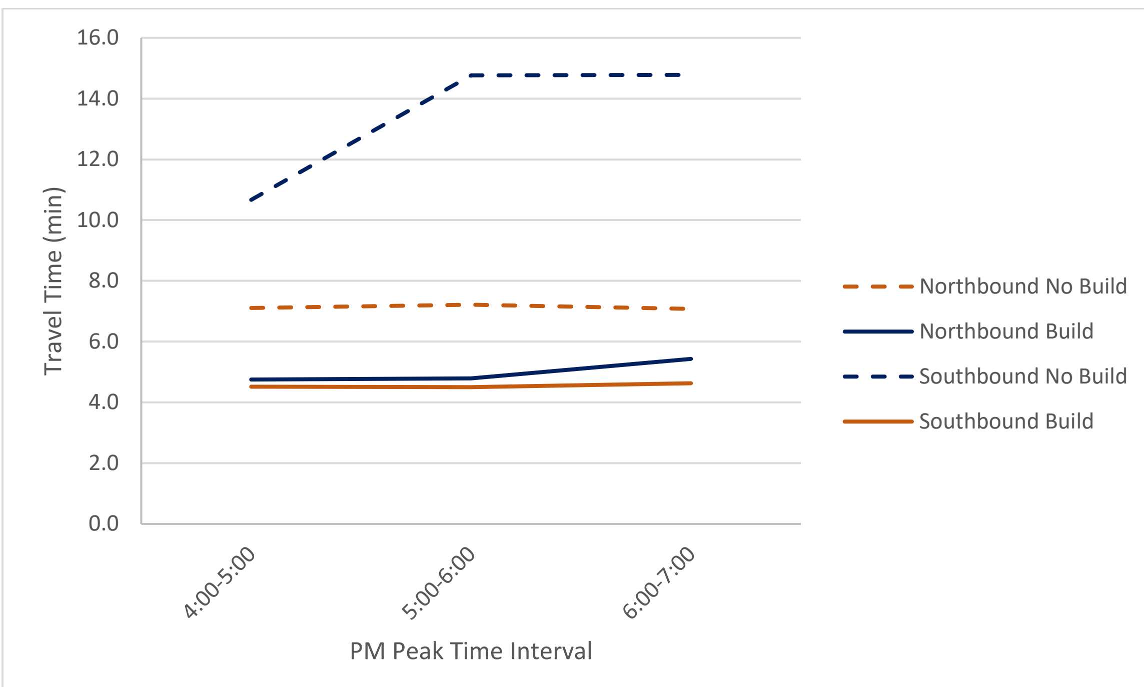

Figure 67: I-69 2025 PM No-Build vs. Build Travel Times

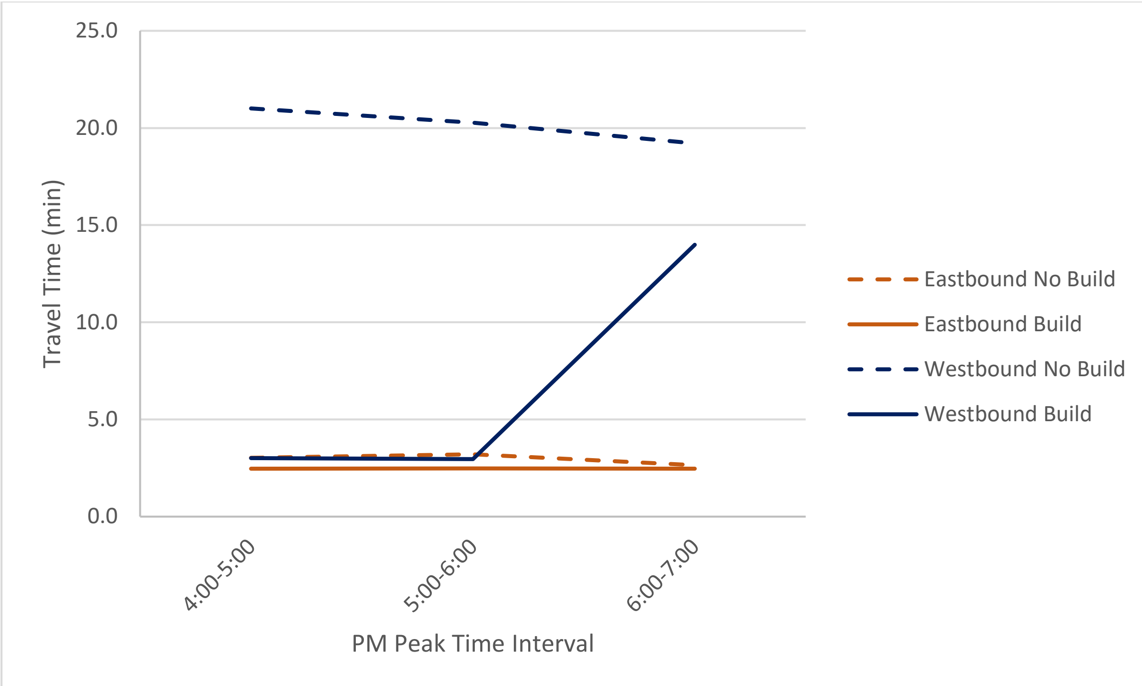

Figure 68: I-10 2025 PM No-Build vs. Build Travel Times

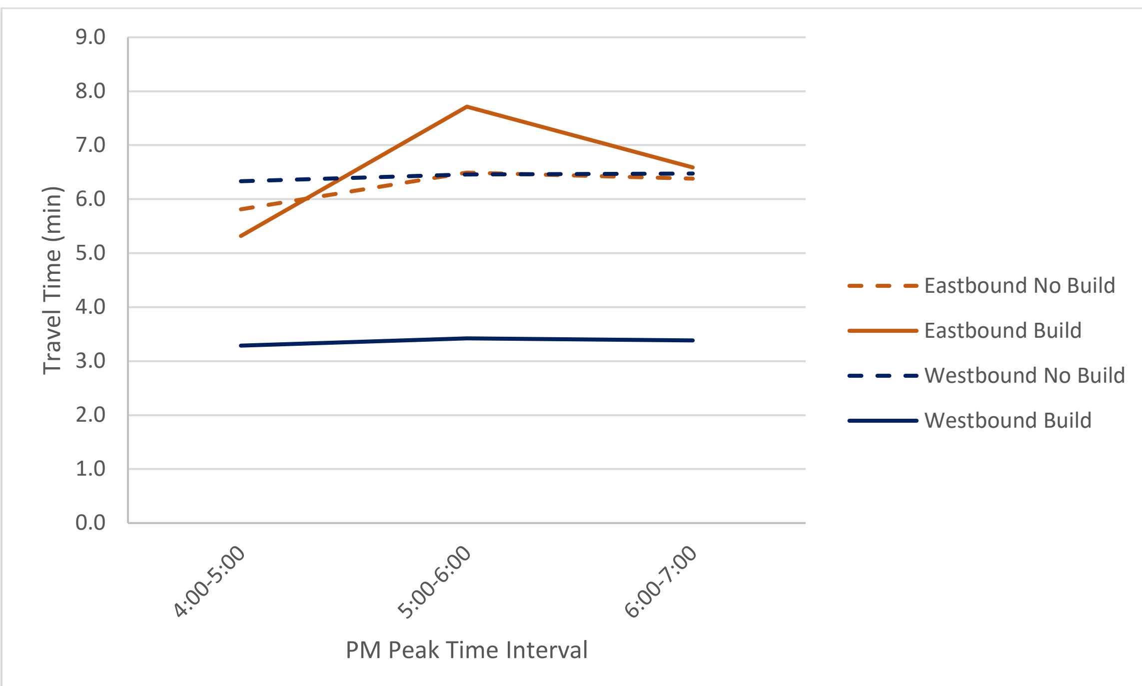

Figure 69: I-610 2025 PM No-Build vs. Build Travel Times

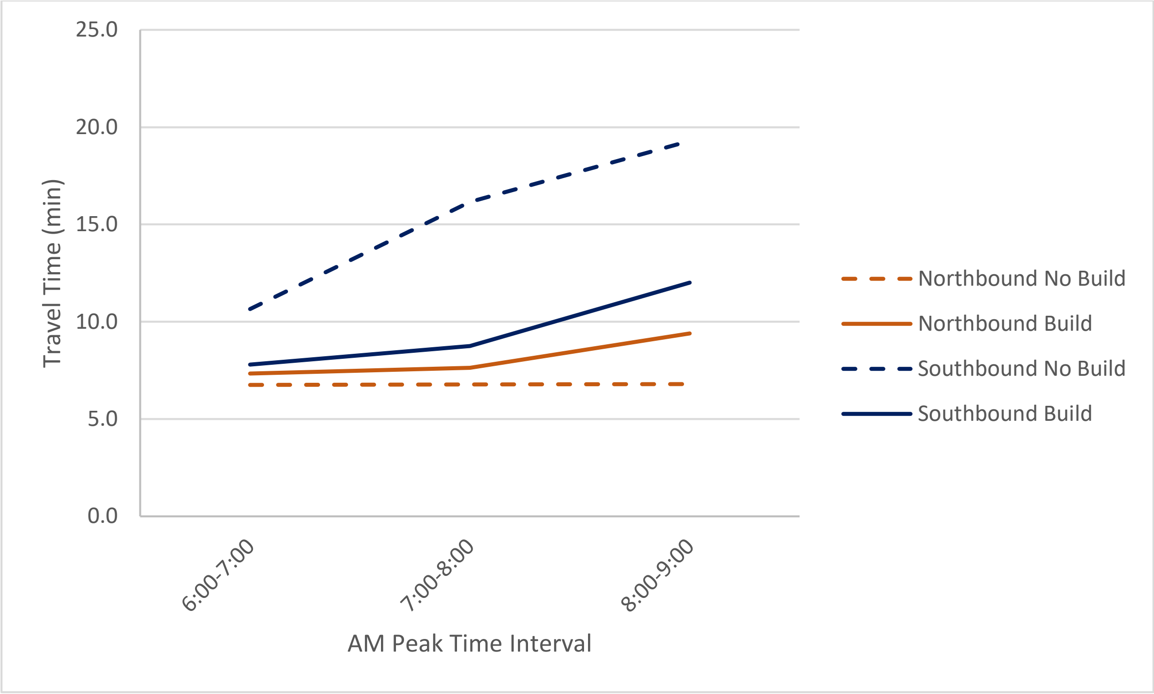

Figure 70: I-45 2045 AM No-Build vs. Build Travel Times

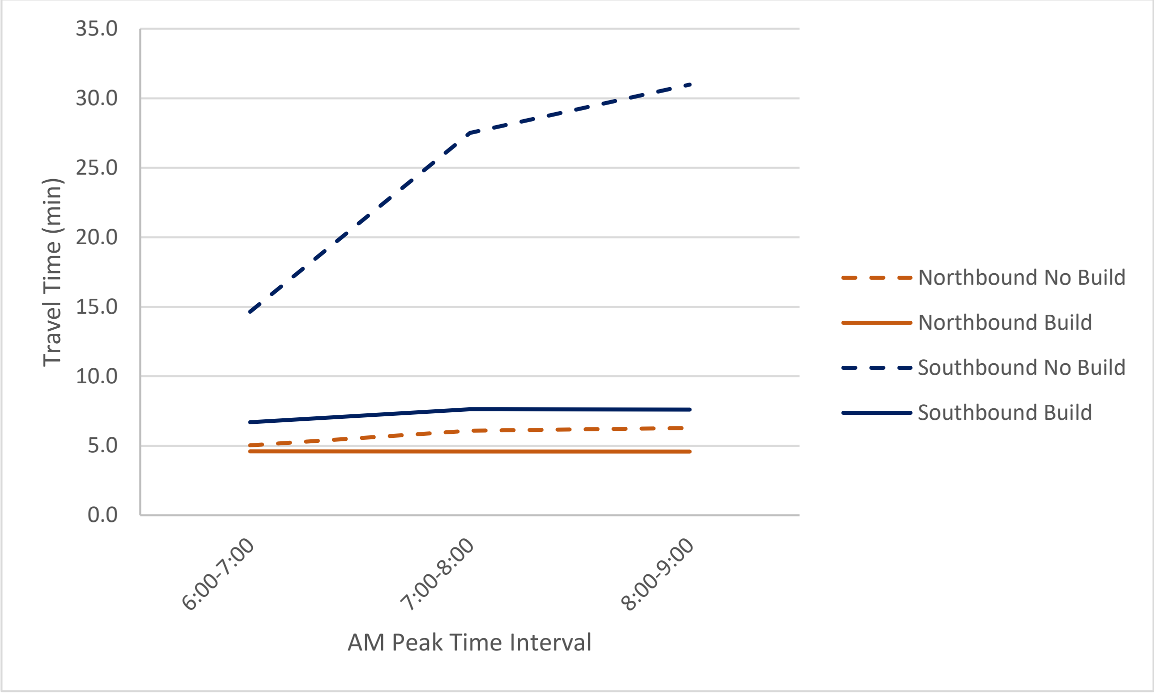

Figure 71: I-69 2045 AM No-Build vs. Build Travel Times

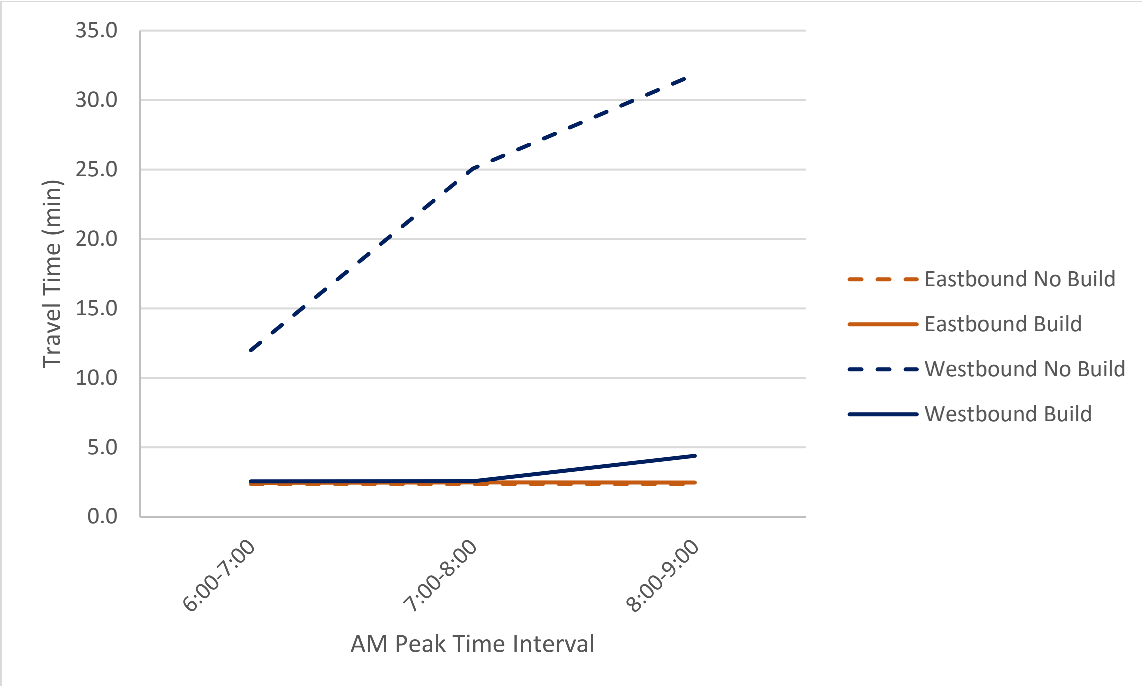

Figure 72: I-10 2045 AM No-Build vs. Build Travel Times

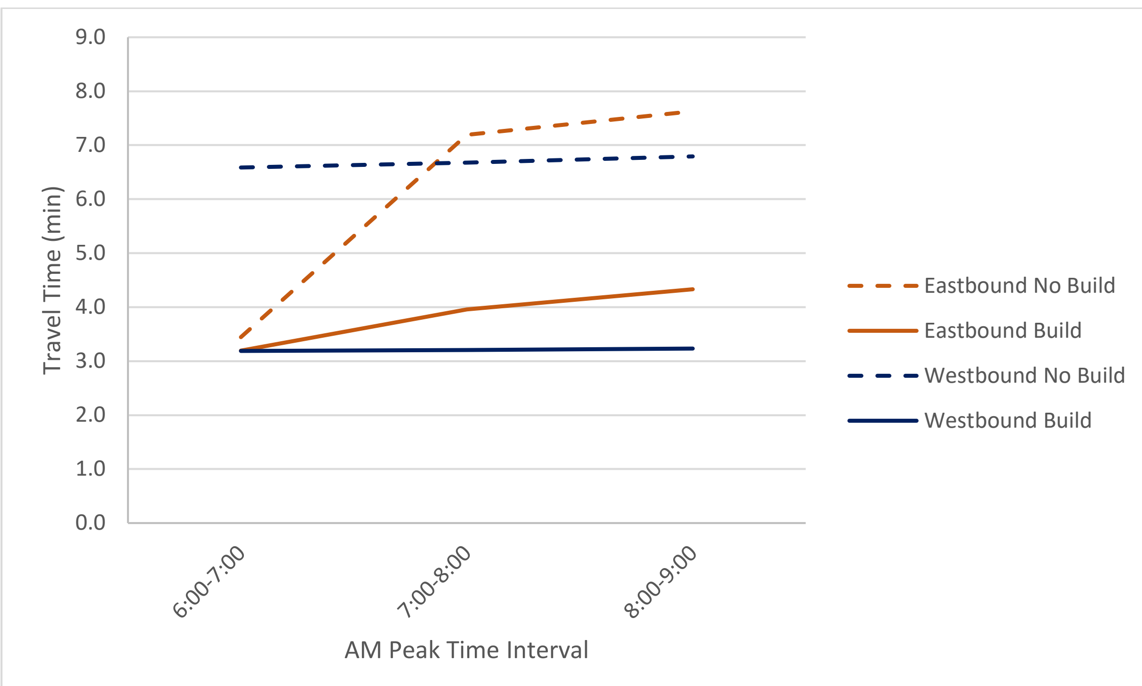

Figure 73: I-610 2045 AM No-Build vs. Build Travel Times

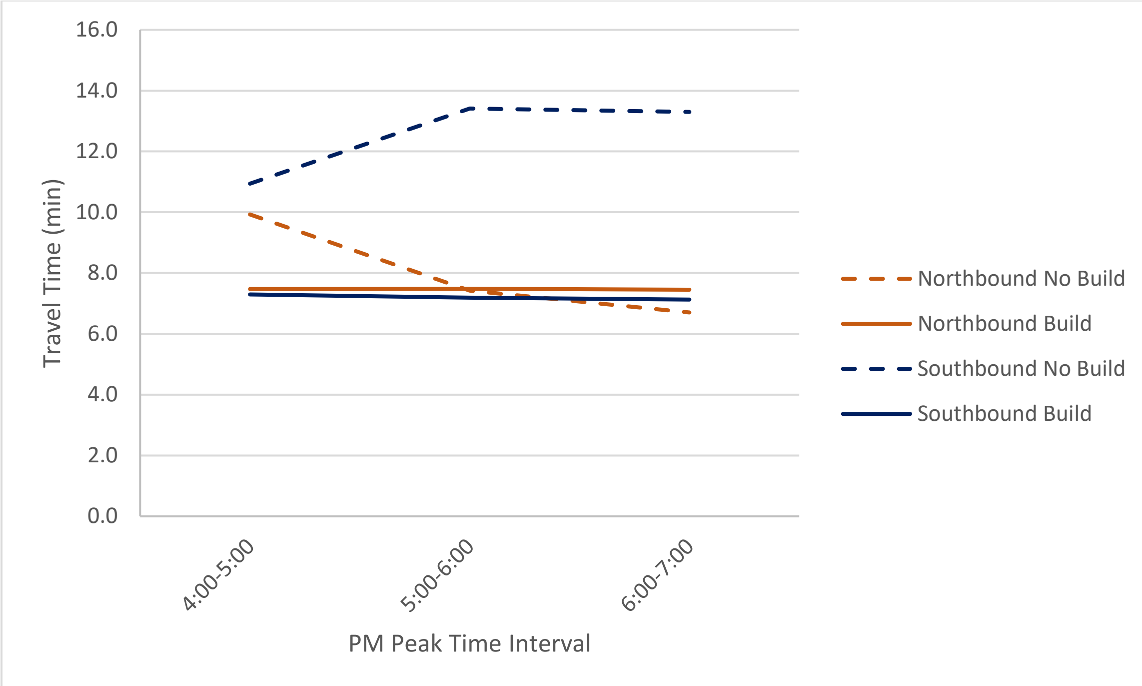

Figure 74: I-45 2045 PM No-Build vs. Build Travel Times

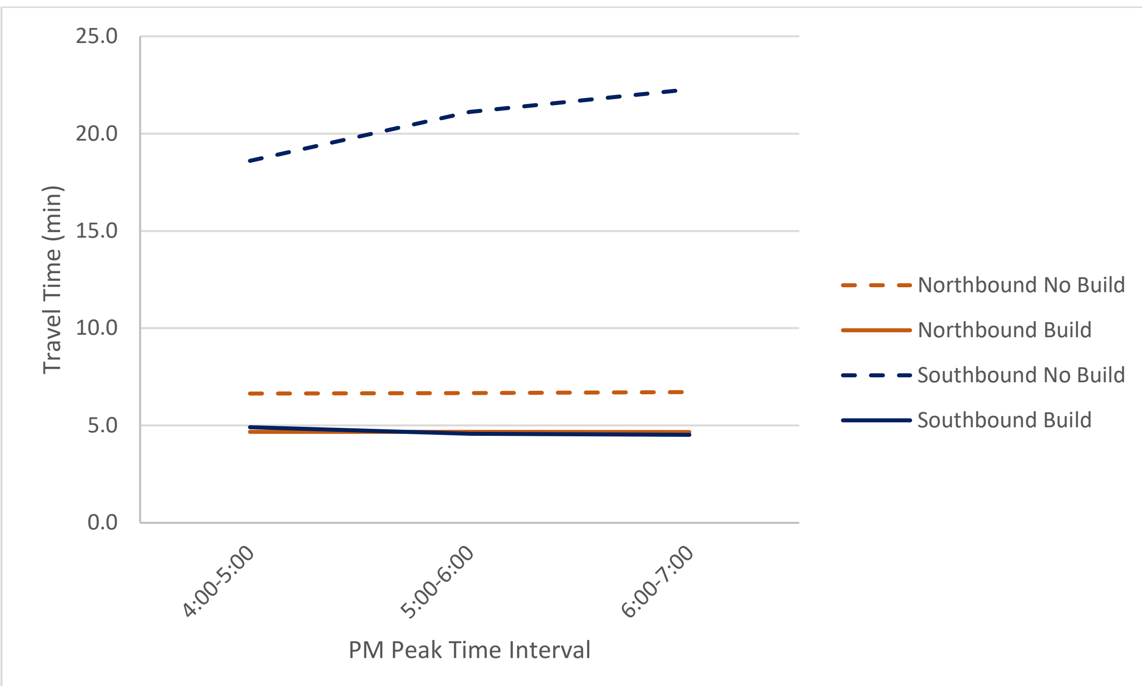

Figure 75: I-69 2045 PM No-Build vs. Build Travel Times

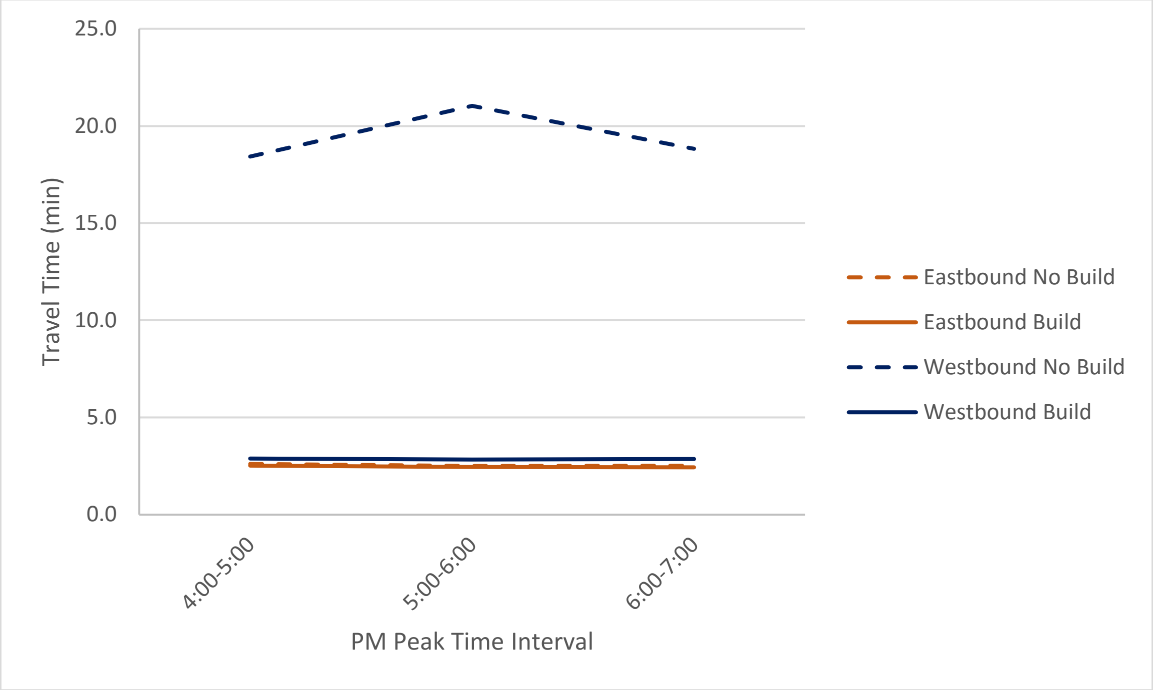

Figure 76: I-10 2045 PM No-Build vs. Build Travel Times

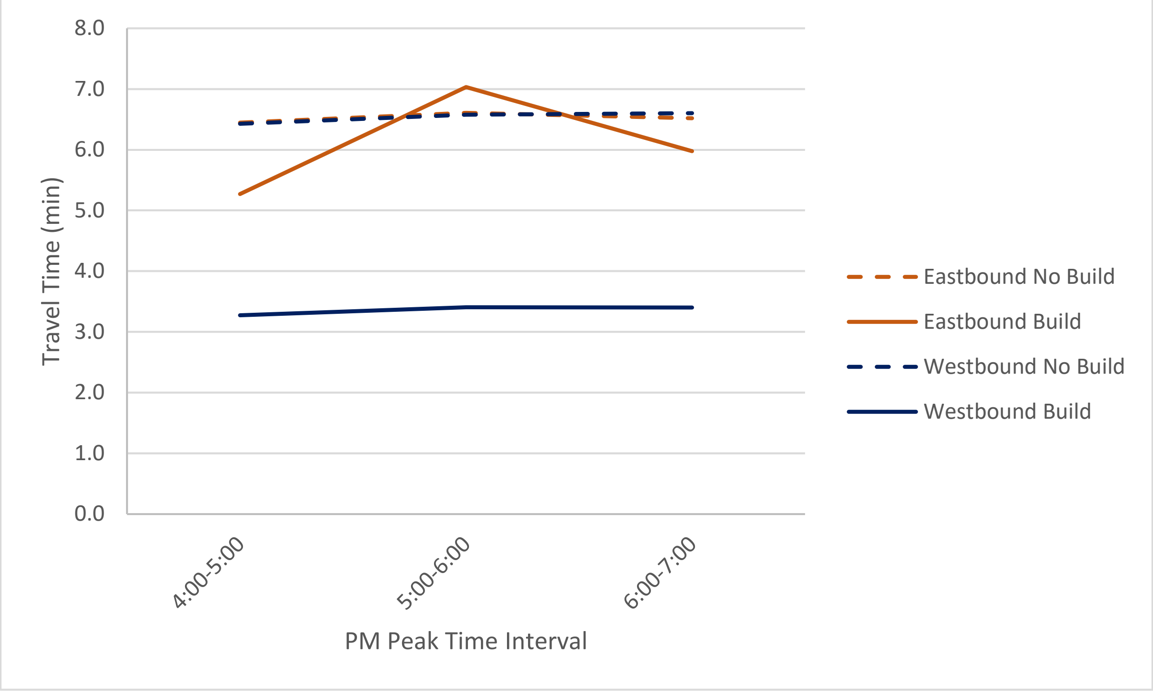

Figure 77: I-610 2045 PM No-Build vs. Build Travel Times

As shown in **Figures 62-77**, most corridors show significant travel time improvements in the Build from the No-Build. The few exceptions include:

- **I-45 Northbound (NB)** – all scenarios except 2045 PM – The I-45 No-Build and Build scenarios both do not exhibit significant levels of congestion in the project area. The slowdowns occur at the start and end of the study area. The I-45 NB Build travel times are slightly greater than the No-Build in all scenarios due to the increase in length and number of vehicles that can enter the network. In all scenarios, more vehicles are able to enter at I-45 NB in the Build than the No-Build with improved operations at the southern limit of I-45.
- **I-610 Eastbound (EB)** – 2025 PM and 2045 PM scenarios – I-610 EB experiences a slight increase in travel time from No-Build due to more vehicles being able to enter the freeway system. This leads to an increase in vehicles lane changing to access the direct connectors. The congestion proceeds upstream and impacts the I-610 travel time. Despite the increase in travel time, more vehicles are being served with lower overall delay.

For all scenarios, average networks speed increases, vehicle miles traveled increases, and latent demand decreases in the Build networks compared to the No-Build. This indicates that the roadway network is operating more efficiently as a whole, despite the slight increase in travel times for I-45 northbound and I-610 eastbound.

In addition to travel times for each freeway corridor, the travel times of several major movements within the project area were compared between No-Build and Build. **Figure 78** and **Figure 79** illustrate the travel time comparison for 2025 and 2045, respectively.

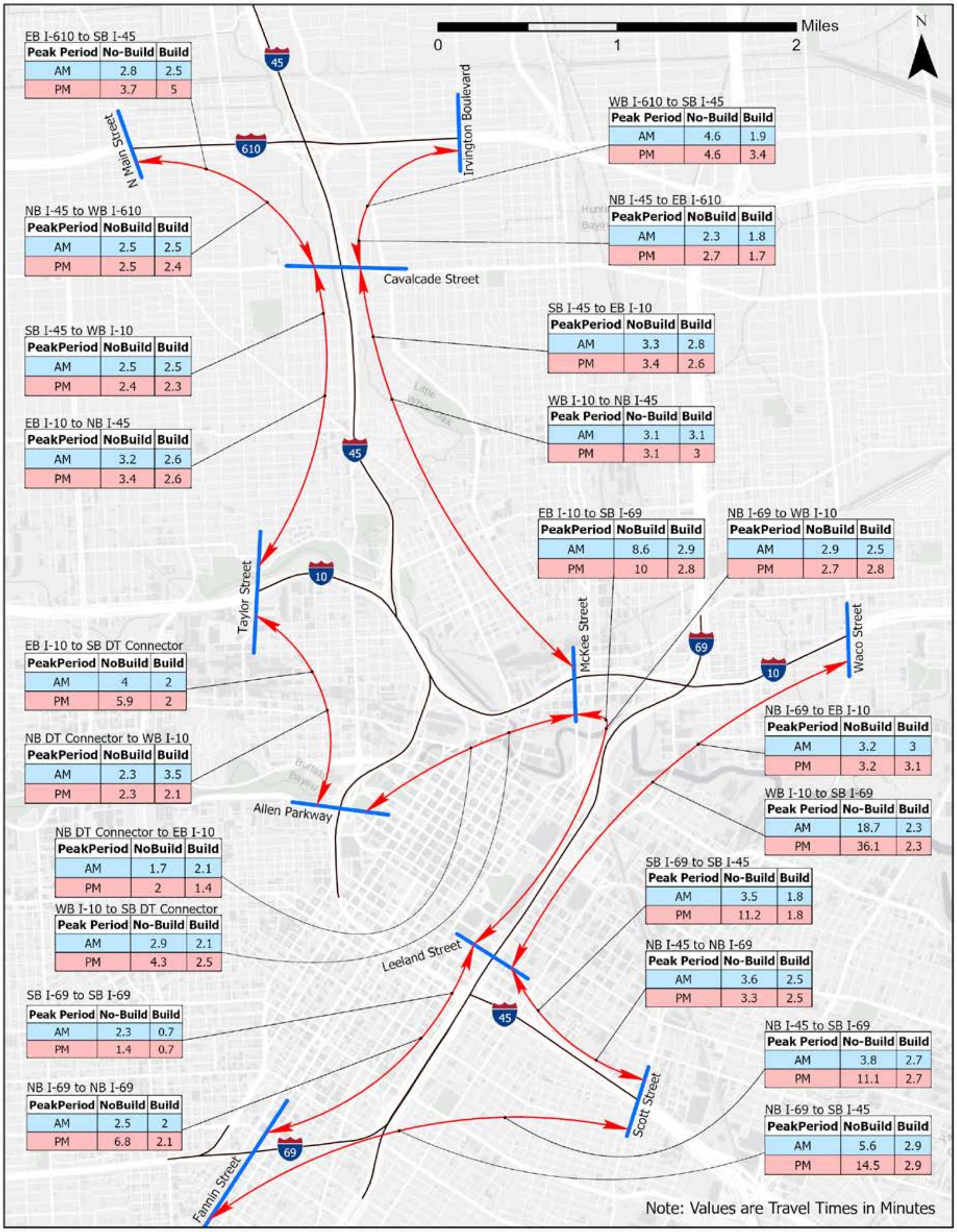

Figure 78: 2025 Major Movements Travel Time Comparison

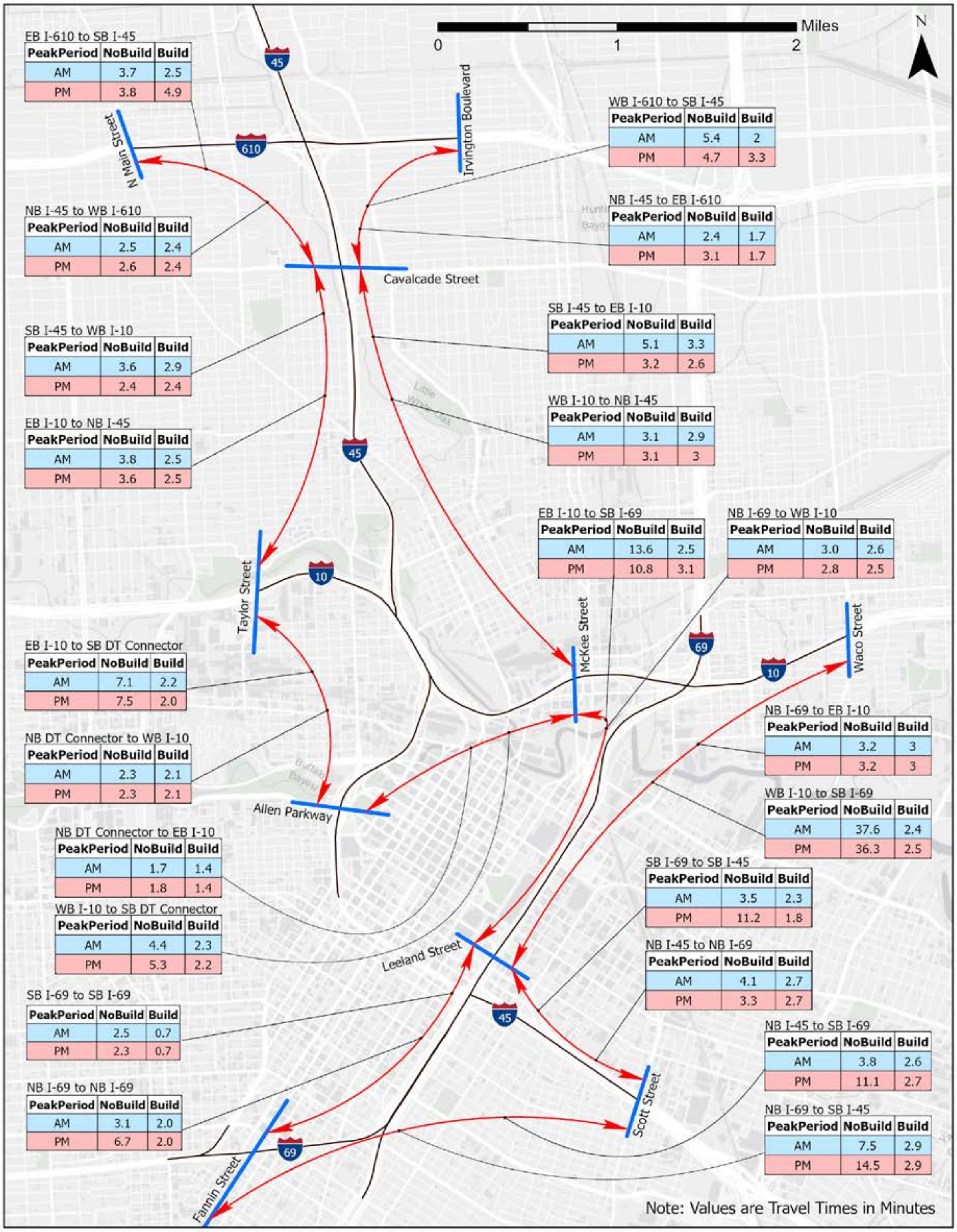

Figure 79: 2045 Major Movements Travel Time Comparison

There were several critical locations identified in the during calibration that were the focus of segment level MOEs. These locations were analyzed in detail to compare the alternatives and ensure that issues at the critical locations are resolved in the Build configuration. Table 88 shows the comparison of segment results for critical locations between the Build configuration and the No-Build configuration, as shown previously in Table 74. Critical location results were calculated based on link segment evaluation results provided in the Vissim models included with this report.

Table 88: Build Segment Results at Critical Locations									
		2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Critical Location 1: I-10 EB weave between I-45 and McKee St	**Speed (mph)**	57.3	42.2	41.4	55.4	57.3	54.8	54.7	55.4
	Density (veh/mi/ln)	12.7	11.1	46.1	21.1	11.4	9.3	26.9	17.4
	Relative Delay (s/s)	0.01	0.17	0.28	0.63	0.01	0.05	0.05	0.05
Critical Location 2: I-10 WB weave between I-45 and McKee St	**Speed (mph)**	53.7	56.6	57.1	47.6	56.6	50.9	57.0	56.9
	Density (veh/mi/ln)	16.2	14.8	10.4	39.4	11.9	28.3	11.2	12.3
	Relative Delay (s/s)	0.07	0.02	0.01	2.12	0.02	0.12	0.01	0.02
Critical Location 3: I-69 SB weave from I-10 to Dallas St	**Speed (mph)**	19.5	40.1	12.2	55.7	11.8	37.5	10.1	44.5
	Density (veh/mi/ln)	99.1	50.2	96.7	21.6	116.6	55.0	101.7	38.4
	Relative Delay (s/s)	0.66	0.31	0.79	0.45	0.80	0.35	0.83	0.23
Critical Location 4: SH 288 NB weave from Elgin St to I-45	**Speed (mph)**	13.1	47.5	5.7	47.0	8.1	47.3	5.6	46.9
	Density (veh/mi/ln)	111.8	15.5	142.3	22.8	126.0	19.9	143.2	24.2
	Relative Delay (s/s)	0.77	0.01	0.90	0.26	0.86	0.02	0.90	0.02
Critical Location 5: I-45 SB weave from I-610 to Cavalcade St	**Speed (mph)**	55.3	56.6	55.8	57.6	39.0	47.8	56.1	57.5
	Density (veh/mi/ln)	26.3	26.8	19.5	13.2	56.2	32.8	20.0	15.6
	Relative Delay (s/s)	0.04	0.03	0.03	0.10	0.32	0.12	0.02	0.01

Table 88: Build Segment Results at Critical Locations									
		2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Critical Location 6: I-45 NB weave from Cavalcade St to I-610	**Speed (mph)**	56.7	50.6	55.4	55.0	56.6	57.5	55.1	55.4
	Density (veh/mi/ln)	16.0	13.5	26.9	24.7	15.9	12.9	23.5	22.9
	Relative Delay (s/s)	0.02	0.06	0.04	0.68	0.02	0.02	0.05	0.05
Critical Location 7: I-10 EB weave from Jackson St Entrance to I-69	**Speed (mph)**	57.3	38.9	45.7	46.3	57.4	51.6	52.9	44.9
	Density (veh/mi/ln)	12.9	11.8	46.5	29.2	11.9	9.8	35.3	29.9
	Relative Delay (s/s)	0.01	0.24	0.21	2.39	0.01	0.10	0.08	0.22
Critical Location 8: I-10 WB from I-69 to Jackson St Exit	**Speed (mph)**	57.5	57.1	57.3	49.7	57.5	54.2	57.2	57.3
	Density (veh/mi/ln)	10.9	11.9	9.7	32.4	8.6	18.5	10.1	9.6
	Relative Delay (s/s)	0.01	0.01	0.01	1.66	0.01	0.07	0.01	0.01
Critical Location 9: I-45 SB weave from I-10 WB Entrance to Downtown Exits	**Speed (mph)**	26.2	57.6	18.6	56.2	18.0	43.7	12.7	57.7
	Density (veh/mi/ln)	80.4	10.9	100.9	7.9	97.6	32.8	113.6	4.7
	Relative Delay (s/s)	0.55	0.01	0.68	0.40	0.69	0.23	0.78	0.01
Critical Location 10: I-45 NB weave from Downtown Entrances to I-10 EB Exit	**Speed (mph)**	57.0	36.3	53.0	58.1	57.0	58.3	54.2	57.9
	Density (veh/mi/ln)	16.3	20.0	29.4	21.6	17.2	12.8	27.3	23.8
	Relative Delay (s/s)	0.01	0.14	0.08	0.24	0.01	0.01	0.06	0.02

The majority critical locations show improved segment MOEs from the No-Build scenarios. A few critical locations show a slight decrease in speed compared to the No-Build condition. This can be attributed to upstream bottlenecks in the No-Build condition improving the performance of the critical locations. In the Build scenarios, the bottlenecks are alleviated, and these segments process more vehicles which results in a reduction in speed.

Network 15-Minute Variation

A critical component to the analysis was capturing the change in network performance over 15-minute intervals. The AM and PM peak periods had varying traffic characteristics and fluctuating levels of congestion. Speed maps for 2025 and 2045 Build networks in 15-minute intervals are included in **Appendix M** and **O**, respectively.

Segment-Level Comparison

In addition to the critical locations discussed above, segment-level results for each of the four freeways spanning the entire analysis limits were compared between No-Build and Build. Speed, density, and relative delay results are shown in **Tables 89-104** below. Segments which operate at under 30 mph are highlighted in each table. Segments where a direct comparison between No-Build and Build cannot be made due to a change in highway alignment will have "N/A" where that segment does not exist. Segment results were calculated based on link segment evaluation results provided in the Vissim models included with this report.

Table 89: 2025 I-45 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Exit to Collector-Distributor	Speed (mph)	33.8	35.2	13.0	24.1
		Density (veh/mi/ln)	69.3	55.3	107.3	77.2
		Relative Delay (s/s)	0.42	0.39	0.78	7.02
Exit to Collector-Distributor	Entrance from TX Spur 5	Speed (mph)	56.3	57.1	55.5	56.4
		Density (veh/mi/ln)	6.7	8.5	16.3	21.2
		Relative Delay (s/s)	0.03	0.02	0.04	0.33
Entrance from TX Spur 5	Entrance from Cullen Blvd	Speed (mph)	57.9	57.7	57.5	57.3
		Density (veh/mi/ln)	6.5	8.0	16.0	17.2
		Relative Delay (s/s)	0.00	0.01	0.01	0.15
Entrance from Cullen Blvd	Entrance from Scott St	Speed (mph)	57.1	57.1	56.8	56.9
		Density (veh/mi/ln)	9.6	11.1	19.1	20.2
		Relative Delay (s/s)	0.01	0.01	0.02	0.18

Table 89: 2025 I-45 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Entrance from Scott St	Exit to St Joseph Pkwy	Speed (mph)	56.5	56.1	54.9	56.3
		Density (veh/mi/ln)	11.5	13.2	22.0	22.6
		Relative Delay (s/s)	0.02	0.03	0.05	0.33
Exit to St Joseph Pkwy	Entrance from I-69 NB	Speed (mph)	N/A	53.3	N/A	52.3
		Density (veh/mi/ln)	N/A	2.9	N/A	21.4
		Relative Delay (s/s)	N/A	0.00	N/A	0.20
Exit to St Joseph Pkwy	Entrance from I-69 SB	Speed (mph)	57.5	N/A	56.1	N/A
		Density (veh/mi/ln)	11.2	N/A	23.3	N/A
		Relative Delay (s/s)	0.01	N/A	0.03	N/A
Entrance from I-69 SB	Entrance from I-69 NB	Speed (mph)	56.0	N/A	54.0	N/A
		Density (veh/mi/ln)	13.8	N/A	28.5	N/A
		Relative Delay (s/s)	0.03	N/A	0.07	N/A
Entrance from I-69 NB	Memorial Dr.	Speed (mph)	57.2	N/A	56.5	N/A
		Density (veh/mi/ln)	20.1	N/A	30.5	N/A
		Relative Delay (s/s)	0.01	N/A	0.02	N/A
Memorial Dr.	Exit to I-10 WB	Speed (mph)	57.1	N/A	54.8	N/A
		Density (veh/mi/ln)	17.5	N/A	28.7	N/A
		Relative Delay (s/s)	0.01	N/A	0.06	N/A
Entrance from I-69 NB	Exit to I-10 WB	Speed (mph)	N/A	52.3	N/A	52.3
		Density (veh/mi/ln)	N/A	10.5	N/A	24.2
		Relative Delay (s/s)	N/A	0.01	N/A	0.31
Exit to I-10 WB	White Oak Dr	Speed (mph)	57.6	57.7	56.5	57.0
		Density (veh/mi/ln)	12.4	9.6	28.4	21.5
		Relative Delay (s/s)	0.01	0.01	0.03	0.21
White Oak Dr	Exit to Main St	Speed (mph)	57.3	49.7	56.7	56.5
		Density (veh/mi/ln)	11.6	10.2	21.4	22.5

Table 89: 2025 I-45 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
		Relative Delay (s/s)	0.01	0.04	0.02	0.39
Exit to Main St	Patton St	Speed (mph)	57.5	51.2	56.5	56.2
		Density (veh/mi/ln)	13.1	13.8	23.3	25.0
		Relative Delay (s/s)	0.01	0.04	0.03	0.43
Patton St	Exit to I-610	Speed (mph)	57.0	49.5	56.1	53.6
		Density (veh/mi/ln)	15.1	14.9	25.8	26.3
		Relative Delay (s/s)	0.02	0.08	0.04	0.97
Exit to I-610	Crosstimbers St	Speed (mph)	55.5	51.3	51.3	55.9
		Density (veh/mi/ln)	17.4	14.9	29.5	25.1
		Relative Delay (s/s)	0.04	0.06	0.12	0.47
Crosstimbers St	Airline Dr	Speed (mph)	55.5	50.5	48.8	41.5
		Density (veh/mi/ln)	22.8	18.0	39.7	47.6
		Relative Delay (s/s)	0.04	0.09	0.16	3.44
Airline Dr	Tidwell Rd	Speed (mph)	56.7	49.4	51.7	38.6
		Density (veh/mi/ln)	21.5	28.3	36.1	48.6
		Relative Delay (s/s)	0.02	0.13	0.11	4.03
Tidwell Rd	End	Speed (mph)	57.0	50.6	55.5	48.4
		Density (veh/mi/ln)	21.4	31.9	32.4	44.7
		Relative Delay (s/s)	0.02	0.11	0.04	1.99

Table 90: 2025 I-45 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Tidwell Rd	Speed (mph)	54.1	18.1	38.0	12.1
		Density (veh/mi/ln)	31.8	100.8	57.1	115.6
		Relative Delay (s/s)	0.07	0.69	0.35	9.50
Tidwell Rd	Airline	Speed (mph)	55.3	15.4	36.5	31.3

Table 90: 2025 I-45 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
		Density (veh/mi/ln)	27.6	105.3	56.0	61.3
		Relative Delay (s/s)	0.05	0.73	0.37	5.54
Airline	Crosstimbers St	Speed (mph)	56.2	41.3	31.2	41.5
		Density (veh/mi/ln)	26.4	50.2	67.4	48.6
		Relative Delay (s/s)	0.03	0.29	0.46	3.43
Crosstimbers St	I-610 SB	Speed (mph)	54.6	56.8	46.0	53.2
		Density (veh/mi/ln)	27.5	25.2	33.6	20.1
		Relative Delay (s/s)	0.06	0.02	0.21	0.99
I-610 SB	Patton St	Speed (mph)	55.9	56.6	56.6	57.6
		Density (veh/mi/ln)	27.1	26.8	19.5	13.2
		Relative Delay (s/s)	0.03	0.02	0.02	0.10
Patton St	Main St	Speed (mph)	N/A	56.3	N/A	57.1
		Density (veh/mi/ln)	N/A	28.9	N/A	16.1
		Relative Delay (s/s)	N/A	0.03	N/A	0.18
Main St	White Oak Dr	Speed (mph)	55.0	51.1	56.6	57.0
		Density (veh/mi/ln)	27.9	30.2	19.1	15.1
		Relative Delay (s/s)	0.05	0.12	0.02	0.20
White Oak Dr	I-10	Speed (mph)	42.9	55.5	44.0	57.4
		Density (veh/mi/ln)	49.5	25.6	44.9	13.1
		Relative Delay (s/s)	0.26	0.04	0.24	0.14
I-10	I-69	Speed (mph)	N/A	52.0	N/A	53.3
		Density (veh/mi/ln)	N/A	31.1	N/A	26.6
		Relative Delay (s/s)	N/A	0.10	N/A	0.97
I-10	Memorial Dr	Speed (mph)	27.6	N/A	18.1	N/A
		Density (veh/mi/ln)	78.7	N/A	101.4	N/A
		Relative Delay (s/s)	0.52	N/A	0.69	N/A

Table 90: 2025 I-45 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Memorial Dr	W Dallas St	Speed (mph)	30.4	N/A	11.0	N/A
		Density (veh/mi/ln)	81.2	N/A	120.5	N/A
		Relative Delay (s/s)	0.47	N/A	0.81	N/A
W Dallas St	Exit to I-69	Speed (mph)	32.6	N/A	28.4	N/A
		Density (veh/mi/ln)	71.1	N/A	71.9	N/A
		Relative Delay (s/s)	0.44	N/A	0.51	N/A
I-69	Rusk St	Speed (mph)	N/A	51.9	N/A	53.2
		Density (veh/mi/ln)	N/A	31.2	N/A	24.3
		Relative Delay (s/s)	N/A	0.04	N/A	0.29
Exit to I-69	St Joseph Pkwy	Speed (mph)	53.8	51.5	56.3	51.5
		Density (veh/mi/ln)	32.3	21.4	27.6	20.2
		Relative Delay (s/s)	0.07	0.02	0.03	0.19
St Joseph Pkwy	Scott St	Speed (mph)	53.2	55.9	56.1	56.6
		Density (veh/mi/ln)	29.5	18.6	27.1	18.0
		Relative Delay (s/s)	0.08	0.03	0.03	0.22
Scott St	Cullen Blvd	Speed (mph)	48.1	51.5	46.7	51.5
		Density (veh/mi/ln)	26.5	11.1	28.9	12.7
		Relative Delay (s/s)	0.17	0.02	0.19	0.18
Cullen Blvd	End	Speed (mph)	56.2	56.7	55.8	56.1
		Density (veh/mi/ln)	25.1	17.3	28.2	22.4
		Relative Delay (s/s)	0.03	0.02	0.04	0.37

Table 91: 2025 I-69 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Exit Main St	Speed (mph)	49.8	57.1	7.1	31.3
		Density (veh/mi/ln)	36.1	22.7	143.8	62.9

Table 91: 2025 I-69 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
		Relative Delay (s/s)	0.14	0.02	0.88	5.53
Exit Main St	Exit US 288	Speed (mph)	38.9	57.7	5.2	57.5
		Density (veh/mi/ln)	53.7	12.2	151.9	16.5
		Relative Delay (s/s)	0.33	0.01	0.91	0.11
Exit US 288	McGowen St	Speed (mph)	46.2	57.4	39.2	54.5
		Density (veh/mi/ln)	38.9	12.9	51.1	20.8
		Relative Delay (s/s)	0.20	0.01	0.33	0.73
McGowen St	Leeland St	Speed (mph)	55.0	56.6	55.1	51.2
		Density (veh/mi/ln)	23.8	14.8	19.8	34.0
		Relative Delay (s/s)	0.05	0.02	0.05	1.41
Leeland St	Entrance from Ruiz St	Speed (mph)	57.0	57.5	56.8	54.0
		Density (veh/mi/ln)	17.4	13.4	21.5	33.4
		Relative Delay (s/s)	0.02	0.01	0.02	0.81
Entrance from Ruiz St	End	Speed (mph)	57.6	57.6	57.0	54.5
		Density (veh/mi/ln)	11.5	12.0	19.2	32.1
		Relative Delay (s/s)	0.01	0.01	0.02	0.72

Table 92: 2025 I-69 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Lyons St	Speed (mph)	18.7	27.6	24.8	53.1
		Density (veh/mi/ln)	93.0	73.6	76.9	30.6
		Relative Delay (s/s)	0.68	0.52	0.57	1.02
Lyons St	Entrance from I-10	Speed (mph)	18.5	34.5	14.5	56.1
		Density (veh/mi/ln)	104.1	60.3	101.0	22.2
		Relative Delay (s/s)	0.68	0.41	0.75	0.39
	Leeland St	Speed (mph)	14.2	55.7	34.0	54.8

Table 92: 2025 I-69 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Entrance from I-10		Density (veh/mi/ln)	113.6	25.7	58.5	20.3
		Relative Delay (s/s)	0.76	0.03	0.41	0.50
Leeland St	McGowen St	Speed (mph)	11.8	56.8	56.5	56.9
		Density (veh/mi/ln)	114.0	18.4	20.1	10.7
		Relative Delay (s/s)	0.80	0.02	0.02	0.09
McGowen St	Elgin St	Speed (mph)	22.0	56.7	42.5	57.1
		Density (veh/mi/ln)	71.2	19.7	34.9	14.8
		Relative Delay (s/s)	0.62	0.02	0.27	0.12
Elgin St	Entrance from Spur 527	Speed (mph)	54.3	56.5	55.7	56.8
		Density (veh/mi/ln)	34.4	26.0	29.7	20.7
		Relative Delay (s/s)	0.06	0.02	0.04	0.18
Entrance from Spur 527	End	Speed (mph)	56.8	56.0	57.0	56.0
		Density (veh/mi/ln)	23.6	30.0	21.2	27.6
		Relative Delay (s/s)	0.02	0.03	0.02	0.37

Table 93: 2025 I-10 Eastbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Taylor St	Speed (mph)	33.1	45.9	22.7	34.7
		Density (veh/mi/ln)	70.1	24.9	92.1	57.9
		Relative Delay (s/s)	0.43	0.21	0.61	4.83
Taylor St	I-45 Exit Ramp	Speed (mph)	28.8	56.8	24.5	49.6
		Density (veh/mi/ln)	73.1	16.3	78.6	27.4
		Relative Delay (s/s)	0.50	0.02	0.58	1.69
I-45 Exit Ramp	NB I-45 Overpass	Speed (mph)	45.0	57.0	36.4	56.5
		Density (veh/mi/ln)	30.7	11.6	50.0	15.7
		Relative Delay (s/s)	0.22	0.02	0.37	0.32

Table 93: 2025 I-10 Eastbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
NB I-45 Overpass	NB I-45 Entrance (No-Build)/SB I-45 Entrance (Build)	Speed (mph)	55.6	53.1	45.4	57.3
		Density (veh/mi/ln)	13.6	5.4	43.7	18.1
		Relative Delay (s/s)	0.02	0.05	0.21	0.18
NB I-45 Entrance (No-Build)/SB I-45 Entrance (Build)	SB I-69 Exit Ramp	Speed (mph)	57.2	41.4	45.2	53.2
		Density (veh/mi/ln)	13.4	11.3	45.5	23.0
		Relative Delay (s/s)	0.01	0.19	0.22	1.05
SB I-69 Exit Ramp	NB I-69 Entrance Ramp	Speed (mph)	57.6	50.9	51.9	56.8
		Density (veh/mi/ln)	10.8	5.4	36.3	20.9
		Relative Delay (s/s)	0.01	0.02	0.10	0.33
NB I-69 Entrance Ramp	East Freeway Entrance Ramp	Speed (mph)	57.0	54.7	56.6	57.3
		Density (veh/mi/ln)	14.8	11.4	26.9	20.3
		Relative Delay (s/s)	0.01	0.03	0.02	0.18
East Freeway Entrance Ramp	Schweikhardt St	Speed (mph)	57.1	54.9	54.7	49.8
		Density (veh/mi/ln)	16.9	17.5	30.4	34.9
		Relative Delay (s/s)	0.01	0.03	0.06	1.70
Schweikhardt St	End	Speed (mph)	57.3	55.6	56.5	55.3
		Density (veh/mi/ln)	17.3	18.9	31.3	33.9
		Relative Delay (s/s)	0.01	0.02	0.02	0.56

Table 94: 2025 I-10 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Waco St	Speed (mph)	15.5	49.9	1.6	57.6
		Density (veh/mi/ln)	126.0	26.0	179.6	13.3
		Relative Delay (s/s)	0.73	0.14	0.97	0.08
Waco St	East Fwy Service Road (No-	Speed (mph)	8.5	56.7	1.7	57.3
		Density (veh/mi/ln)	156.7	20.1	186.2	16.2

Table 94: 2025 I-10 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
	Build)/Benson St (Build)	Relative Delay (s/s)	0.85	0.02	0.97	0.14
East Fwy Service Road (No-Build)/Benson St (Build)	NB I-69 Exit Ramp	Speed (mph)	7.0	56.7	2.2	56.9
		Density (veh/mi/ln)	142.7	14.1	165.0	10.5
		Relative Delay (s/s)	0.25	0.02	0.96	0.22
NB I-69 Exit Ramp	SB I-69 Exit Ramp (Build)	Speed (mph)	5.2	56.6	1.8	56.7
		Density (veh/mi/ln)	143.2	12.9	162.3	8.2
		Relative Delay (s/s)	0.91	0.02	0.97	0.28
SB I-69 Exit Ramp (Build)	SB I-69 Entrance Ramp	Speed (mph)	53.2	57.9	50.9	56.0
		Density (veh/mi/ln)	5.0	5.7	2.3	4.3
		Relative Delay (s/s)	0.08	0.00	0.12	0.42
SB I-69 Entrance Ramp	NB I-69 Entrance Ramp	Speed (mph)	56.8	55.5	57.1	47.8
		Density (veh/mi/ln)	10.1	11.4	6.5	30.4
		Relative Delay (s/s)	0.02	0.02	0.02	1.66
NB I-69 Entrance Ramp	N. Main St	Speed (mph)	56.6	56.7	57.4	49.2
		Density (veh/mi/ln)	11.5	15.1	10.3	38.8
		Relative Delay (s/s)	0.02	0.02	0.01	1.82
N. Main St	NB I-45 Exit Ramp	Speed (mph)	54.3	57.1	57.1	52.3
		Density (veh/mi/ln)	14.1	12.3	9.6	25.8
		Relative Delay (s/s)	0.06	0.01	0.01	1.16
NB I-45 Exit Ramp	NB I-45 Entrance Ramp	Speed (mph)	57.0	57.6	56.3	57.3
		Density (veh/mi/ln)	13.3	12.1	16.9	16.7
		Relative Delay (s/s)	0.01	0.01	0.02	0.16
NB I-45 Entrance Ramp	Taylor St	Speed (mph)	56.9	49.8	57.3	57.1
		Density (veh/mi/ln)	16.2	19.2	17.3	20.6
		Relative Delay (s/s)	0.02	0.09	0.01	0.21
Taylor St	End	Speed (mph)	57.2	51.9	57.2	57.0

Table 94: 2025 I-10 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
		Density (veh/mi/ln)	16.9	20.7	17.2	21.6
		Relative Delay (s/s)	0.01	0.06	0.01	0.23

Table 95: 2025 I-610 Eastbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Main St	Speed (mph)	43.3	43.5	20.2	18.1
		Density (veh/mi/ln)	55.3	47.3	91.8	95.2
		Relative Delay (s/s)	0.25	0.25	0.65	8.27
Main St	IH-45/Frontage Entrance Ramp	Speed (mph)	44.6	56.0	46.7	49.3
		Density (veh/mi/ln)	45.4	23.0	40.3	26.6
		Relative Delay (s/s)	0.23	0.04	0.19	1.81
IH-45/Frontage Entrance Ramp	Irvington Blvd Exit Ramp	Speed (mph)	56.6	56.8	54.3	56.5
		Density (veh/mi/ln)	19.8	18.8	21.4	16.6
		Relative Delay (s/s)	0.02	0.02	0.05	0.32
Irvington Blvd Exit Ramp	Hardy Toll Rd	Speed (mph)	57.0	56.3	56.1	55.4
		Density (veh/mi/ln)	20.4	21.2	19.5	19.6
		Relative Delay (s/s)	0.02	0.03	0.03	0.53
Hardy Toll Rd	End	Speed (mph)	55.2	56.3	55.6	56.1
		Density (veh/mi/ln)	24.7	24.7	21.5	21.2
		Relative Delay (s/s)	0.05	0.03	0.04	0.37

Table 96: 2025 I-610 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Irvington Blvd Frontage Exit	Speed (mph)	19.7	34.2	16.6	18.0
		Density (veh/mi/ln)	90.7	54.6	98.7	97.7
		Relative Delay (s/s)	0.66	0.41	0.71	8.28

Table 96: 2025 I-610 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Irvington Blvd Frontage Exit	Irvington Blvd	Speed (mph)	22.3	54.2	12.0	20.8
		Density (veh/mi/ln)	87.4	27.7	119.6	91.0
		Relative Delay (s/s)	0.61	0.06	0.79	7.67
Irvington Blvd	Fulton St	Speed (mph)	12.5	56.4	12.5	30.8
		Density (veh/mi/ln)	104.4	25.5	102.0	63.7
		Relative Delay (s/s)	0.79	0.03	0.78	5.62
Fulton St	Airline	Speed (mph)	37.4	57.2	36.7	57.3
		Density (veh/mi/ln)	54.2	23.7	55.0	21.4
		Relative Delay (s/s)	0.35	0.01	0.36	0.14
Airline	Main St	Speed (mph)	55.9	56.4	55.1	56.7
		Density (veh/mi/ln)	26.7	26.7	27.2	23.7
		Relative Delay (s/s)	0.04	0.03	0.05	0.26
Main St	End	Speed (mph)	55.3	55.4	56.3	55.6
		Density (veh/mi/ln)	31.9	31.6	29.9	28.9
		Relative Delay (s/s)	0.04	0.04	0.03	0.48

Table 97: 2045 I-45 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Exit to Collector-Distributor	Speed (mph)	30.9	37.5	11.2	23.7
		Density (veh/mi/ln)	73.5	53.1	112.9	76.4
		Relative Delay (s/s)	0.47	0.35	0.81	0.59
Exit to Collector-Distributor	Entrance from TX Spur 5	Speed (mph)	56.4	56.8	55.3	56.5
		Density (veh/mi/ln)	6.3	16.0	14.2	19.7
		Relative Delay (s/s)	0.03	0.02	0.05	0.03
Entrance from TX Spur 5	Entrance from Cullen Blvd	Speed (mph)	57.9	42.5	51.4	57.4
		Density (veh/mi/ln)	6.5	29.4	23.1	16.2

Table 97: 2045 I-45 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
		Relative Delay (s/s)	0.00	0.27	0.11	0.01
Entrance from Cullen Blvd	Entrance from Scott St	Speed (mph)	57.0	34.8	44.4	56.9
		Density (veh/mi/ln)	9.8	58.9	42.4	19.5
		Relative Delay (s/s)	0.01	0.40	0.23	0.01
Entrance from Scott St	Exit to St Joseph Pkwy	Speed (mph)	56.5	36.4	40.2	56.1
		Density (veh/mi/ln)	11.8	43.0	45.3	22.1
		Relative Delay (s/s)	0.02	0.37	0.30	0.03
Exit to St Joseph Pkwy	Entrance from I-69 NB	Speed (mph)	N/A	53.0	N/A	52.3
		Density (veh/mi/ln)	N/A	5.2	N/A	20.9
		Relative Delay (s/s)	N/A	0.00	N/A	0.02
Exit to St Joseph Pkwy	Entrance from I-69 SB	Speed (mph)	57.6	N/A	42.8	N/A
		Density (veh/mi/ln)	11.2	N/A	44.7	N/A
		Relative Delay (s/s)	0.01	N/A	0.26	N/A
Entrance from I-69 SB	Entrance from I-69 NB	Speed (mph)	56.2	N/A	45.6	N/A
		Density (veh/mi/ln)	13.7	N/A	45.3	N/A
		Relative Delay (s/s)	0.03	N/A	0.21	N/A
Entrance from I-69 NB	Memorial Dr.	Speed (mph)	57.2	N/A	56.0	N/A
		Density (veh/mi/ln)	20.0	N/A	36.8	N/A
		Relative Delay (s/s)	0.01	N/A	0.03	N/A
Memorial Dr.	Exit to I-10 WB	Speed (mph)	57.0	N/A	54.3	N/A
		Density (veh/mi/ln)	18.4	N/A	33.6	N/A
		Relative Delay (s/s)	0.02	N/A	0.07	N/A
Entrance from I-69 NB	Exit to I-10 WB	Speed (mph)	N/A	52.5	N/A	52.7
		Density (veh/mi/ln)	N/A	12.4	N/A	22.0
		Relative Delay (s/s)	N/A	0.01	N/A	0.02
Exit to I-10 WB	White Oak Dr	Speed (mph)	57.6	57.7	55.4	57.1

Table 97: 2045 I-45 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
		Density (veh/mi/ln)	13.1	10.1	30.8	19.8
		Relative Delay (s/s)	0.01	0.01	0.05	0.02
White Oak Dr	Exit to Main St	Speed (mph)	57.3	58.1	56.5	56.6
		Density (veh/mi/ln)	11.3	9.1	22.5	22.4
		Relative Delay (s/s)	0.01	0.01	0.03	0.03
Exit to Main St	Patton St	Speed (mph)	57.5	57.7	56.3	56.3
		Density (veh/mi/ln)	12.8	12.9	24.4	24.5
		Relative Delay (s/s)	0.01	0.01	0.03	0.03
Patton St	Exit to I-610	Speed (mph)	56.9	57.2	55.9	54.5
		Density (veh/mi/ln)	14.9	13.8	27.0	25.2
		Relative Delay (s/s)	0.02	0.02	0.04	0.07
Exit to I-610	Crosstimbers St	Speed (mph)	55.8	57.3	51.8	56.0
		Density (veh/mi/ln)	16.6	14.9	29.2	24.8
		Relative Delay (s/s)	0.04	0.01	0.11	0.04
Crosstimbers St	Airline Dr	Speed (mph)	56.0	53.4	49.4	40.9
		Density (veh/mi/ln)	21.4	18.6	38.5	48.7
		Relative Delay (s/s)	0.03	0.08	0.15	0.30
Airline Dr	Tidwell Rd	Speed (mph)	56.9	53.7	51.9	34.4
		Density (veh/mi/ln)	20.3	26.9	35.7	54.2
		Relative Delay (s/s)	0.02	0.07	0.11	0.41
Tidwell Rd	End	Speed (mph)	57.1	56.4	55.5	47.2
		Density (veh/mi/ln)	20.3	28.7	32.1	46.7
		Relative Delay (s/s)	0.01	0.03	0.04	0.19

Table 98: 2045 I-45 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Tidwell Rd	Speed (mph)	42.5	17.3	26.9	10.5
		Density (veh/mi/ln)	51.6	103.2	80.9	127.1
		Relative Delay (s/s)	0.27	0.70	0.54	0.82
Tidwell Rd	Airline	Speed (mph)	44.2	15.5	22.3	9.0
		Density (veh/mi/ln)	47.1	104.3	86.5	132.2
		Relative Delay (s/s)	0.24	0.73	0.62	0.85
Airline	Crosstimbers St	Speed (mph)	47.3	41.3	16.9	40.8
		Density (veh/mi/ln)	44.3	50.2	98.3	46.5
		Relative Delay (s/s)	0.18	0.29	0.71	0.30
Crosstimbers St	I-610 SB	Speed (mph)	42.0	47.7	40.3	55.1
		Density (veh/mi/ln)	51.4	31.2	43.4	14.1
		Relative Delay (s/s)	0.27	0.09	0.30	0.02
I-610 SB	Patton St	Speed (mph)	37.0	47.7	56.7	57.5
		Density (veh/mi/ln)	62.9	33.0	20.0	13.5
		Relative Delay (s/s)	0.36	0.12	0.02	0.01
Patton St	Main St	Speed (mph)	N/A	45.5	N/A	57.0
		Density (veh/mi/ln)	N/A	37.4	N/A	16.5
		Relative Delay (s/s)	N/A	0.17	N/A	0.02
Main St	White Oak Dr	Speed (mph)	29.4	40.6	56.4	56.8
		Density (veh/mi/ln)	78.6	40.7	19.9	15.6
		Relative Delay (s/s)	0.49	0.26	0.02	0.02
White Oak Dr	I-10	Speed (mph)	22.7	48.2	41.7	57.4
		Density (veh/mi/ln)	95.6	29.9	50.5	13.2
		Relative Delay (s/s)	0.61	0.13	0.28	0.01
I-10	I-69	Speed (mph)	N/A	44.1	N/A	54.8
		Density (veh/mi/ln)	N/A	38.0	N/A	22.4

Table 98: 2045 I-45 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
		Relative Delay (s/s)	N/A	0.21	N/A	0.05
I-10	Memorial Dr	Speed (mph)	17.5	N/A	12.5	N/A
		Density (veh/mi/ln)	100.8	N/A	113.9	N/A
		Relative Delay (s/s)	0.70	N/A	0.78	N/A
Memorial Dr	W Dallas St	Speed (mph)	11.9	N/A	10.2	N/A
		Density (veh/mi/ln)	124.5	N/A	122.8	N/A
		Relative Delay (s/s)	0.79	N/A	0.82	N/A
W Dallas St	Exit to I-69	Speed (mph)	24.8	N/A	28.8	N/A
		Density (veh/mi/ln)	86.9	N/A	71.3	N/A
		Relative Delay (s/s)	0.57	N/A	0.50	N/A
I-69	Rusk St	Speed (mph)	N/A	50.5	N/A	53.4
		Density (veh/mi/ln)	N/A	33.2	N/A	21.1
		Relative Delay (s/s)	N/A	0.07	N/A	0.02
Exit to I-69	St Joseph Pkwy	Speed (mph)	54.2	52.1	56.4	51.5
		Density (veh/mi/ln)	29.6	27.0	25.9	19.3
		Relative Delay (s/s)	0.06	0.08	0.02	0.02
St Joseph Pkwy	Scott St	Speed (mph)	54.6	48.0	56.2	56.7
		Density (veh/mi/ln)	26.6	34.3	26.0	17.4
		Relative Delay (s/s)	0.06	0.17	0.03	0.02
Scott St	Cullen Blvd	Speed (mph)	50.2	50.7	47.4	51.6
		Density (veh/mi/ln)	23.5	10.8	27.5	12.3
		Relative Delay (s/s)	0.13	0.03	0.18	0.01
Cullen Blvd	End	Speed (mph)	56.4	56.6	55.7	56.2
		Density (veh/mi/ln)	23.5	17.6	27.5	22.3
		Relative Delay (s/s)	0.03	0.02	0.04	0.03

Table 99: 2045 I-69 Northbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Exit Main St	Speed (mph)	15.9	53.5	6.6	32.7
		Density (veh/mi/ln)	109.1	31.8	146.8	61.8
		Relative Delay (s/s)	0.73	0.08	0.89	0.44
Exit Main St	Exit US 288	Speed (mph)	22.2	57.5	5.1	57.4
		Density (veh/mi/ln)	98.3	15.8	152.7	18.1
		Relative Delay (s/s)	0.62	0.01	0.91	0.01
Exit US 288	McGowen St	Speed (mph)	42.8	56.8	39.2	55.9
		Density (veh/mi/ln)	47.8	16.2	51.6	18.5
		Relative Delay (s/s)	0.26	0.02	0.32	0.04
McGowen St	Leeland St	Speed (mph)	53.3	55.7	54.0	55.5
		Density (veh/mi/ln)	26.5	18.0	23.2	23.1
		Relative Delay (s/s)	0.08	0.04	0.07	0.04
Leeland St	Entrance from Ruiz St	Speed (mph)	56.8	57.2	56.6	56.6
		Density (veh/mi/ln)	18.2	15.1	23.9	26.8
		Relative Delay (s/s)	0.02	0.01	0.02	0.02
Entrance from Ruiz St	End	Speed (mph)	57.5	57.5	56.7	55.5
		Density (veh/mi/ln)	12.1	13.7	21.4	31.0
		Relative Delay (s/s)	0.01	0.01	0.02	0.04

Table 100: 2045 I-69 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Start	Lyons St	Speed (mph)	9.9	18.2	8.6	56.6
		Density (veh/mi/ln)	127.9	93.9	129.7	25.5
		Relative Delay (s/s)	0.83	0.69	0.85	0.02

Table 100: 2045 I-69 Southbound - No-Build vs. Build Segment Results

From	To	MOE	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Lyons St	Entrance from I-10	Speed (mph)	11.4	31.6	10.7	48.6
		Density (veh/mi/ln)	122.5	65.6	113.1	36.1
		Relative Delay (s/s)	0.80	0.46	0.82	0.16
Entrance from I-10	Leeland St	Speed (mph)	9.9	53.9	17.9	45.8
		Density (veh/mi/ln)	127.0	29.3	92.3	34.5
		Relative Delay (s/s)	0.83	0.06	0.69	0.20
Leeland St	McGowen St	Speed (mph)	10.1	56.5	11.5	56.8
		Density (veh/mi/ln)	121.6	20.5	113.4	13.4
		Relative Delay (s/s)	0.83	0.02	0.80	0.01
McGowen St	Elgin St	Speed (mph)	20.1	56.4	21.1	56.9
		Density (veh/mi/ln)	76.0	21.2	72.4	17.1
		Relative Delay (s/s)	0.65	0.02	0.64	0.01
Elgin St	Entrance from Spur 527	Speed (mph)	53.4	56.1	54.9	56.6
		Density (veh/mi/ln)	36.8	28.1	32.6	23.3
		Relative Delay (s/s)	0.07	0.03	0.05	0.02
Entrance from Spur 527	End	Speed (mph)	56.8	55.3	56.9	55.9
		Density (veh/mi/ln)	24.9	32.5	23.0	29.7
		Relative Delay (s/s)	0.02	0.04	0.02	0.03

Table 101: 2045 I-10 Eastbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Taylor St	Speed (mph)	20.0	40.6	17.0	21.3
		Density (veh/mi/ln)	113.1	39.1	111.4	98.3
		Relative Delay (s/s)	0.66	0.30	0.71	0.63

Table 101: 2045 I-10 Eastbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Taylor St	I-45 Exit Ramp	Speed (mph)	17.3	56.5	19.5	54.0
		Density (veh/mi/ln)	105.2	18.4	88.5	19.6
		Relative Delay (s/s)	0.70	0.02	0.66	0.06
I-45 Exit Ramp	NB I-45 Overpass	Speed (mph)	38.5	55.2	33.7	56.7
		Density (veh/mi/ln)	36.0	14.0	53.3	12.6
		Relative Delay (s/s)	0.34	0.05	0.42	0.02
NB I-45 Overpass	NB I-45 Entrance (No-Build)/SB I-45 Entrance (Build)	Speed (mph)	55.5	57.9	53.3	57.4
		Density (veh/mi/ln)	11.1	5.5	32.3	15.5
		Relative Delay (s/s)	0.02	0.01	0.07	0.01
NB I-45 Entrance (No-Build)/SB I-45 Entrance (Build)	SB I-69 Exit Ramp	Speed (mph)	57.3	54.0	54.4	52.9
		Density (veh/mi/ln)	12.1	9.4	31.4	21.9
		Relative Delay (s/s)	0.01	0.06	0.06	0.09
SB I-69 Exit Ramp	NB I-69 Entrance Ramp	Speed (mph)	57.6	57.6	54.3	56.9
		Density (veh/mi/ln)	9.8	4.9	31.5	19.2
		Relative Delay (s/s)	0.01	0.00	0.06	0.02
NB I-69 Entrance Ramp	East Freeway Entrance Ramp	Speed (mph)	57.0	56.2	56.3	57.2
		Density (veh/mi/ln)	13.8	11.6	25.7	20.2
		Relative Delay (s/s)	0.01	0.03	0.03	0.02
East Freeway Entrance Ramp	Schweikhardt St	Speed (mph)	57.2	56.4	54.3	50.4
		Density (veh/mi/ln)	15.8	18.4	28.5	34.4
		Relative Delay (s/s)	0.01	0.03	0.06	0.13
Schweikhardt St	End	Speed (mph)	57.4	57.0	56.5	55.3
		Density (veh/mi/ln)	16.3	20.0	29.4	34.1
		Relative Delay (s/s)	0.01	0.02	0.02	0.05

Table 102: 2045 I-10 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Waco St	Speed (mph)	6.7	44.6	1.2	57.5
		Density (veh/mi/ln)	165.2	39.3	185.8	15.9
		Relative Delay (s/s)	0.88	0.23	0.98	0.01
Waco St	East Fwy Service Road (No-Build)/Benson St (Build)	Speed (mph)	2.3	56.2	1.7	57.0
		Density (veh/mi/ln)	184.4	22.4	185.5	19.4
		Relative Delay (s/s)	0.96	0.03	0.97	0.02
East Fwy Service Road (No-Build)/Benson St (Build)	NB I-69 Exit Ramp	Speed (mph)	2.4	55.2	2.2	56.2
		Density (veh/mi/ln)	166.9	16.6	164.4	12.8
		Relative Delay (s/s)	0.96	0.05	0.96	0.03
NB I-69 Exit Ramp	SB I-69 Exit Ramp (Build)	Speed (mph)	2.3	53.0	1.9	55.0
		Density (veh/mi/ln)	162.8	16.9	163.4	10.4
		Relative Delay (s/s)	0.96	0.09	0.97	0.05
SB I-69 Exit Ramp (Build)	SB I-69 Entrance Ramp	Speed (mph)	52.1	56.9	51.5	58.1
		Density (veh/mi/ln)	3.2	5.0	2.4	1.4
		Relative Delay (s/s)	0.10	0.02	0.11	0.00
SB I-69 Entrance Ramp	NB I-69 Entrance Ramp	Speed (mph)	56.8	54.2	57.1	54.8
		Density (veh/mi/ln)	7.9	16.9	6.5	8.3
		Relative Delay (s/s)	0.02	0.07	0.02	0.01
NB I-69 Entrance Ramp	N. Main St	Speed (mph)	57.4	52.7	57.2	57.2
		Density (veh/mi/ln)	8.9	24.2	12.0	12.3
		Relative Delay (s/s)	0.01	0.09	0.01	0.01
N. Main St	NB I-45 Exit Ramp	Speed (mph)	56.7	54.2	57.0	57.0
		Density (veh/mi/ln)	10.7	19.6	10.4	12.7
		Relative Delay (s/s)	0.02	0.07	0.02	0.02
NB I-45 Exit Ramp	NB I-45 Entrance Ramp	Speed (mph)	57.0	57.5	55.8	57.1
		Density (veh/mi/ln)	13.0	13.9	20.1	17.7

Table 102: 2045 I-10 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
		Relative Delay (s/s)	0.01	0.01	0.03	0.02
NB I-45 Entrance Ramp	Taylor St	Speed (mph)	56.8	57.1	56.8	56.9
		Density (veh/mi/ln)	16.3	18.2	22.3	22.0
		Relative Delay (s/s)	0.02	0.01	0.02	0.02
Taylor St	End	Speed (mph)	57.2	57.0	56.9	56.9
		Density (veh/mi/ln)	17.1	20.5	16.2	23.0
		Relative Delay (s/s)	0.01	0.02	27.62	0.02

Table 103: 2045 I-610 Eastbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Main St	Speed (mph)	29.6	42.0	18.4	18.9
		Density (veh/mi/ln)	82.9	51.6	95.6	91.7
		Relative Delay (s/s)	0.49	0.28	0.68	0.68
Main St	IH-45/Frontage Entrance Ramp	Speed (mph)	38.5	54.7	46.4	49.1
		Density (veh/mi/ln)	54.0	26.1	41.3	27.8
		Relative Delay (s/s)	0.34	0.06	0.20	0.15
IH-45/Frontage Entrance Ramp	Irvington Blvd Exit Ramp	Speed (mph)	56.5	56.6	53.5	53.9
		Density (veh/mi/ln)	20.4	20.5	23.1	17.6
		Relative Delay (s/s)	0.02	0.02	0.06	0.03
Irvington Blvd Exit Ramp	Hardy Toll Rd	Speed (mph)	56.6	55.8	55.4	55.3
		Density (veh/mi/ln)	21.3	23.2	21.0	20.7
		Relative Delay (s/s)	0.02	0.04	0.05	0.05
Hardy Toll Rd	End	Speed (mph)	55.4	55.9	56.0	55.9
		Density (veh/mi/ln)	25.0	26.8	22.1	22.9
		Relative Delay (s/s)	0.04	0.03	0.03	0.03

Table 104: 2045 I-610 Westbound - No-Build vs. Build Segment Results

From	To	MOE	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Start	Irvington Blvd Frontage Exit	Speed (mph)	13.3	17.6	14.9	20.3
		Density (veh/mi/ln)	107.7	95.6	103.6	91.6
		Relative Delay (s/s)	0.77	0.70	0.74	0.65
Irvington Blvd Frontage Exit	Irvington Blvd	Speed (mph)	13.2	53.9	11.0	23.2
		Density (veh/mi/ln)	110.1	28.1	123.7	84.7
		Relative Delay (s/s)	0.77	0.06	0.81	0.60
Irvington Blvd	Fulton St	Speed (mph)	11.3	56.4	12.2	31.9
		Density (veh/mi/ln)	109.2	26.0	102.2	62.5
		Relative Delay (s/s)	0.80	0.03	0.79	0.45
Fulton St	Airline	Speed (mph)	36.8	57.1	36.6	57.2
		Density (veh/mi/ln)	55.7	24.7	55.0	23.8
		Relative Delay (s/s)	0.36	0.02	0.37	0.01
Airline	Main St	Speed (mph)	55.0	56.3	54.5	56.5
		Density (veh/mi/ln)	28.1	27.8	28.4	26.2
		Relative Delay (s/s)	0.05	0.03	0.06	0.02
Main St	End	Speed (mph)	55.1	56.3	56.0	55.9
		Density (veh/mi/ln)	33.1	30.1	31.2	30.6
		Relative Delay (s/s)	0.05	0.03	0.03	0.03

As seen in **Tables 89-104**, there is expected to be considerable operational improvement in most freeway segments from the No-Build condition to the Build condition in both 2025 and 2045. Despite the improvement from No-Build, the Build networks still have some freeway segments which operate at under 30 mph. A majority of these segments are at the very beginnings and ends of the analysis limits, where the Build configuration ties into the existing roadway network. In the case of the northern end of I-45, the construction of NHHIP Segment 1 will likely alleviate the congestion. Similarly, future added capacity projects along I-10, I-69, and I-610 adjacent to the analysis limits will help improve operations at these locations.

As mentioned in the change of access section, the I-45 to I-610 westbound and I-610 eastbound to I-45 direct connectors have slip ramps to and from N Main Street. This concept was developed to improve lane balance and due to public comment regarding needed access to low income communities. It was reviewed and considered in operational and safety analysis. The results showed that the access did not create a slowdown on the direct connectors and vehicles have appropriate space to make lane changes. The I-610 eastbound to I-45 northbound direct connector does exhibit slowdown, but that is due to the downstream merge back to existing condition, north of Victoria Drive.

Intersection Analysis

The node evaluation feature within Vissim was used to conduct an intersection comparison between the No-Build and Build networks. Within Vissim, nodes are polygons drawn around intersections for data analysis. Vissim records data including average vehicle delay during the analysis period. Vissim outputs were analyzed to determine the average vehicle delay at each study intersection in each scenario. The Vissim intersection results are presented in Table 105 and Table 106 for 2025 and 2045, respectively. Due to changes in alignment and subsequent changes in access, some intersections are unique to only the No-Build or Build scenarios. Where an intersection is not applicable based on realignment, an "N/A" was used in the tables. Intersections with average vehicle delay above 55 seconds are highlighted in red.

Table 105: 2025 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Tidwell St at I-45 NBFR	26.7	23.0	22.8	22.8
Tidwell St at I-45 SBFR	39.5	23.2	27.7	29.4
Airline Dr at I-45 SBFR	22.0	14.6	22.9	20.9
Airline Dr at I-45 NBFR	28.0	31.6	29.5	34.6
Crosstimbers St at I-45 NBFR	36.1	31.8	25.8	28.4
Crosstimbers St at I-45 SBFR	18.4	21.7	23.9	29.6
Airline Dr at 40 1/2 St	14.6	N/A	34.5	N/A
Airline Dr at I-610 WBFR	38.2	25.0	13.0	18.2
Airline at I-640 EBFR	21.0	17.4	27.8	19.6
Main St at I-610 EBFR	19.0	24.1	24.5	26.7
Main St at I-610 WBFR	36.8	48.3	23.4	28.6
Fulton St at I-610 EBFR	9.2	24.5	22.6	31.7

Table 105: 2025 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Fulton St at I-610 WBFR	33.0	20.3	18.7	16.9
Irvington Blvd at I-610 EBFR	13.4	14.5	28.9	30.9
Irvington Blvd at I-610 WBFR	42.2	45.1	20.3	20.8
Link St at I-45 NBFR	23.8	25.8	7.5	15.3
Link St at I-45 SBFR	7.3	15.2	7.8	26.5
Cavalcade St at I-45 SBFR	19.1	21.5	27.2	41.2
Cavalcade St at I-45 NBFR	47.3	47.7	21.4	28.5
Patton St at I-45 NBFR	41.4	47.0	8.9	46.4
Patton St at I-45 SBFR	19.6	30.3	7.9	34.6
Cottage St at I-45 NBFR	2.2	1.5	2.7	3.0
Cottage St at I-45 SBFR	1.2	4.3	2.2	0.9
Main St at I-45 NBFR	6.0	7.1	7.2	8.4
Main St at I-45 SBFR	34.3	9.5	51.2	21.7
Houston Ave at I-45 S from Main St Ramp	1.2	N/A	4.2	N/A
White Oak Dr at I-45 SB Ramp	8.8	3.2	10.2	3.8
White Oak Dr at I-45 N Ramp	17.5	11.7	8.7	5.9
Taylor St at I-10 EBFR	33.0	30.5	70.9	56.3
Taylor St at I-10 WBFR	16.1	13.0	15.1	16.2
Quitman St at I-69 SBFR	45.0	40.2	32.4	35.7
Quitman St at I-69 NBFR	31.0	30.3	33.7	32.5
Lyons St at I-69 NBFR	10.8	8.6	5.7	5.2
Lyons St at I-69 SBFR	27.3	13.0	22.9	14.8
Gregg St at I-10 EBFR	6.2	6.6	5.7	6.9
Gregg St at I-10 WBFR	54.4	4.0	93.7	3.7
Waco St at I-10 EBFR	11.4	21.1	15.8	24.6

Table 105: 2025 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Waco St at I-10 WBFR	26.4	41.1	29.0	21.4
Chartres St at Commerce St	15.6	N/A	23.0	N/A
Commerce St at Hamilton St	15.2	N/A	17.6	N/A
Ruiz St at Chenevert St	4.9	1.6	48.0	44.7
Ruiz St at Jackson St	2.0	0.6	31.8	5.0
Chartres St at Capitol St	9.9	N/A	6.1	N/A
St Emanuel St at Leeland St	N/A	0.2	N/A	12.0
Hamilton St at Rusk St	N/A	0.2	N/A	0.3
Hamilton St at Capitol St	N/A	0.2	N/A	0.1
Ruiz St at Hamilton St	N/A	0.6	N/A	0.3
St Emanuel St at Commerce St	N/A	5.1	N/A	32.3
Runnels St at Chartres St	2.5	N/A	11.0	N/A
Nance St at McKee St	3.1	N/A	3.2	N/A
Rothwell St at McKee St	2.5	2.2	1.3	1.2
Providence St at McKee St	21.7	12.9	19.8	110.0
Providence St at Hardy St	N/A	1.2	N/A	135.4
N San Jacinto St at Providence St	0.5	N/A	0.5	N/A
N San Jacinto St at Rothwell St	13.7	N/A	30.6	N/A
Hamilton St at Stuart St	0.7	N/A	0.5	N/A
Chenevert St at Holman St	6.9	6.1	6.7	9.2
Berry St at Chenevert St	2.7	2.3	5.9	3.1
Alabama St at Chenevert St	0.8	0.8	0.8	0.7
Elgin St at I-69 NBFR	22.2	22.6	22.5	25.7
Elgin St at I-69 SBFR	7.5	9.8	17.9	43.3
Tuam St at I-69 NBFR	15.8	11.0	10.2	13.3

Table 105: 2025 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
Tuam St at I-69 SBFR	13.6	12.9	13.1	13.9
McGowen St at I-69 NBFR	12.4	14.0	35.0	15.3
McGowen St at I-69 SBFR	16.4	5.7	18.4	8.6
Webster St at I-45 SBFR	18.5	39.3	15.8	52.3
St Joseph Pkwy at Emancipation Ave	16.8	16.5	21.2	22.9
Jefferson St at Emancipation Ave	29.6	23.3	32.0	50.5
Pease St at Emancipation Ave	34.4	16.5	57.4	19.0
Chartres St at Leeland St	17.4	N/A	19.5	N/A
Hamilton St at Leeland St	10.3	N/A	14.1	N/A
Hamilton St at Bell Street	21.5	N/A	22.1	N/A
St. Emanuel St at Polk St	22.5	0.4	14.6	4.1
Scott St at I-45 SBFR	17.9	18.7	24.8	24.3
Scott St at I-45 NBFR	18.8	5.4	39.5	6.6
Cullen Blvd at I-45 SBFR	14.5	10.7	15.3	10.7
Cullen Blvd at I-45 NBFR	12.2	7.4	20.3	6.7
Pierce St at Bagby St	1.5	9.3	1.1	4.0
Pierce St at Brazos St	68.0	29.6	24.9	121.3
Pierce St at Smith St	7.5	14.0	7.5	22.3
St Joseph Pkwy at Brazos St	6.5	40.7	5.2	164.3
St Joseph Pkwy at Smith St	11.9	35.0	13.8	108.4
Jefferson St at Smith St	12.9	24.9	8.9	52.2
Jefferson St at Brazos St	17.1	31.2	15.9	61.9
Pease St at Smith St	14.8	21.8	73.1	80.3
Pease St at Brazos St	22.2	16.5	123.1	25.1
W Dallas St at Gulf Fwy	4.7	31.5	45.8	91.5

Table 105: 2025 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2025 No-Build AM	2025 Build AM	2025 No-Build PM	2025 Build PM
W Dallas St at Heiner St	23.4	52.1	9.7	58.5
McKinney St at Bagby St	26.3	37.7	32.6	17.1
Walker St at Bagby St	31.8	33.4	33.9	29.8
Memorial Dr at Houston Ave NB	1.2	5.3	7.7	4.4
Memorial Dr at Houston Ave SB	14.4	16.7	24.1	21.9
Memorial Way at Houston Ave NB	9.5	7.3	41.0	16.2
Memorial Way at Houston Ave SB	6.0	9.5	8.6	11.3
Franklin St at Smith St	13.7	15.0	14.8	15.2
Louisiana St at Franklin St	7.5	8.4	33.2	31.0
Milam St at Commerce St	17.6	20.5	16.2	20.4
Commerce St at Travis St	18.8	18.3	17.2	47.5
Allen Pkwy at I-45	N/A	45.4	N/A	113.5
Jensen Dr at Providence St	0.8	19.4	0.3	17.3
Main St at Wentworth St	5.3	3.6	5.2	5.4
Fannin St at Blodgett St	1.7	N/A	2.7	N/A
Richmond St at Spur 527 NBFR	39.4	35.0	56.6	52.7
Richmond St at Spur 527 SBFR	31.7	24.6	34.4	29.1
Southmore Blvd at SH 288 NBFR	105.7	33.1	175.1	22.6
Southmore Blvd at SH 288 SBFR	42.1	15.1	58.7	18.9
Chartres St at Rusk St	25.5	N/A	60.7	N/A
Rothwell St at Hardy St	N/A	0.0	N/A	0.0
I-610 EBFR at 45 SBFR	N/A	11.0	N/A	10.7
I-610 EBFR at 45 NBFR	N/A	3.1	N/A	1.9
I-610 WBFR at 45 SBFR	N/A	3.5	N/A	5.4
I-610 WBFR at 45 NBFR	N/A	5.6	N/A	9.2

Table 106: 2045 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Tidwell St at I-45 NBFR	34.1	26.3	26.7	27.6
Tidwell St at I-45 SBFR	41.1	31.6	35.7	41.2
Airline Dr at I-45 SBFR	22.8	19.9	25.1	20.7
Airline Dr at I-45 NBFR	33.2	41.0	28.9	34.9
Crosstimbers St at I-45 NBFR	41.4	31.7	31.8	29.7
Crosstimbers St at I-45 SBFR	18.5	20.7	24.7	36.5
Airline Dr at 40 1/2 St	14.5	N/A	10.8	N/A
Airline Dr at I-610 WBFR	42.6	40.7	13.5	19.4
Airline at I-640 EBFR	18.9	17.2	28.4	20.0
Main St at I-610 EBFR	24.2	24.4	24.9	26.5
Main St at I-610 WBFR	51.8	46.7	24.0	28.3
Fulton St at I-610 EBFR	9.3	25.1	22.3	33.7
Fulton St at I-610 WBFR	37.0	19.8	19.7	17.1
Irvington Blvd at I-610 EBFR	14.1	15.8	33.0	43.5
Irvington Blvd at I-610 WBFR	42.4	47.0	22.7	22.6
Link St at I-45 NBFR	27.0	27.6	7.6	15.9
Link St at I-45 SBFR	7.4	16.7	7.4	23.0
Cavalcade St at I-45 SBFR	20.5	29.7	33.7	29.8
Cavalcade St at I-45 NBFR	50.6	41.9	21.4	25.0
Patton St at I-45 NBFR	47.1	50.6	9.2	45.8
Patton St at I-45 SBFR	21.1	30.6	8.2	29.8
Cottage St at I-45 NBFR	2.4	1.6	2.7	3.8
Cottage St at I-45 SBFR	1.3	4.8	2.3	1.1
Main St at I-45 NBFR	7.1	9.2	7.9	10.7

Table 106: 2045 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Main St at I-45 SBFR	41.6	11.3	63.2	21.5
Houston Ave at I-45 S from Main St Ramp	2.7	N/A	4.4	N/A
White Oak Dr at I-45 SB Ramp	9.1	3.8	11.4	4.2
White Oak Dr at I-45 N Ramp	24.0	13.5	10.1	7.0
Taylor St at I-10 EBFR	65.5	37.4	84.9	57.4
Taylor St at I-10 WBFR	18.4	13.7	16.5	20.1
Quitman St at I-69 SBFR	46.3	42.7	42.5	46.4
Quitman St at I-69 NBFR	31.6	31.2	34.2	33.6
Lyons St at I-69 NBFR	12.8	8.7	6.7	6.0
Lyons St at I-69 SBFR	28.9	14.8	23.4	7.4
Gregg St at I-10 EBFR	6.2	6.7	6.7	7.1
Gregg St at I-10 WBFR	88.7	4.1	86.9	3.6
Waco St at I-10 EBFR	12.8	25.0	23.6	26.0
Waco St at I-10 WBFR	47.6	55.0	24.3	35.8
Chartres St at Commerce St	16.6	N/A	39.5	N/A
Commerce St at Hamilton St	16.1	23.2	17.3	N/A
Ruiz St at Chenevert St	4.8	1.7	50.6	45.0
Ruiz St at Jackson St	2.7	0.7	35.3	5.0
Chartres St at Capitol St	11.8	N/A	7.0	N/A
St Emanuel St at Leeland St	N/A	0.3	N/A	30.8
Hamilton St at Rusk St	N/A	13.0	N/A	0.3
Hamilton St at Capitol St	N/A	0.9	N/A	2.9
Ruiz St at Hamilton St	N/A	4.1	N/A	0.4
St Emanuel St at Commerce St	N/A	20.6	N/A	7.3
Runnels St at Chartres St	3.6	N/A	26.1	N/A

Table 106: 2045 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Nance St at McKee St	3.4	N/A	3.4	N/A
Rothwell St at McKee St	2.7	1.9	1.4	1.3
Providence St at McKee St	22.5	39.0	20.4	7.2
Providence St at Hardy St	N/A	10.1	N/A	1.2
N San Jacinto St at Providence St	0.2	N/A	2.8	N/A
N San Jacinto St at Rothwell St	14.6	N/A	80.9	N/A
Hamilton St at Stuart St	0.7	N/A	0.8	N/A
Chenevert St at Holman St	7.0	6.4	6.8	10.1
Berry St at Chenevert St	2.7	2.8	4.4	4.5
Alabama St at Chenevert St	0.8	0.9	0.7	0.9
Elgin St at I-69 NBFR	22.7	23.0	27.3	37.1
Elgin St at I-69 SBFR	7.4	9.0	19.3	48.8
Tuam St at I-69 NBFR	15.9	10.8	12.4	14.4
Tuam St at I-69 SBFR	12.7	13.5	13.7	14.3
McGowen St at I-69 NBFR	13.0	13.9	55.3	18.9
McGowen St at I-69 SBFR	16.4	5.9	23.3	9.6
Webster St at I-45 SBFR	30.7	41.9	37.1	79.0
St Joseph Pkwy at Emancipation Ave	16.9	21.5	21.0	23.9
Jefferson St at Emancipation Ave	30.2	24.8	30.7	67.9
Pease St at Emancipation Ave	36.3	19.7	58.0	24.4
Chartres St at Leeland St	18.0	N/A	38.7	N/A
Hamilton St at Leeland St	10.0	N/A	48.0	N/A
Hamilton St at Bell Street	21.5	N/A	21.7	N/A
St. Emanuel St at Polk St	22.6	0.4	28.7	0.7
Scott St at I-45 SBFR	18.9	19.1	27.3	27.2

Table 106: 2045 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Scott St at I-45 NBFR	16.4	6.2	39.6	6.4
Cullen Blvd at I-45 SBFR	13.8	12.1	19.1	10.5
Cullen Blvd at I-45 NBFR	11.2	17.3	25.3	6.3
Pierce St at Bagby St	1.5	23.1	1.4	3.8
Pierce St at Brazos St	80.9	96.0	161.6	93.7
Pierce St at Smith St	7.6	13.2	7.8	25.9
St Joseph Pkwy at Brazos St	8.8	103.1	13.6	128.5
St Joseph Pkwy at Smith St	12.4	58.7	27.3	107.3
Jefferson St at Smith St	12.6	24.5	9.8	48.7
Jefferson St at Brazos St	17.3	25.5	115.6	58.2
Pease St at Smith St	15.1	25.0	154.2	60.6
Pease St at Brazos St	22.8	12.6	210.1	18.2
W Dallas St at Gulf Fwy	4.8	27.3	57.6	80.9
W Dallas St at Heiner St	23.7	65.4	9.0	53.7
McKinney St at Bagby St	25.7	39.1	33.9	27.3
Walker St at Bagby St	31.8	34.5	37.6	56.5
Memorial Dr at Houston Ave NB	1.1	5.8	6.6	5.4
Memorial Dr at Houston Ave SB	10.4	19.3	24.1	18.3
Memorial Way at Houston Ave NB	9.1	8.4	52.3	20.4
Memorial Way at Houston Ave SB	8.4	10.0	8.2	11.5
Franklin St at Smith St	13.5	17.0	15.4	18.2
Louisiana St at Franklin St	7.7	8.9	49.7	35.2
Milam St at Commerce St	17.9	20.2	16.9	20.8
Commerce St at Travis St	19.8	18.3	17.7	53.0
Allen Pkwy at I-45	N/A	57.8	N/A	108.8

Table 106: 2045 Intersection Delay - No-Build vs. Build Results

Intersection	Average Vehicle Delay (sec/veh)			
	2045 No-Build AM	2045 Build AM	2045 No-Build PM	2045 Build PM
Jensen Dr at Providence St	0.8	19.9	0.4	17.0
Main St at Wentworth St	5.1	4.3	3.2	5.6
Fannin St at Blodgett St	1.6	N/A	3.3	N/A
Richmond St at Spur 527 NBFR	39.5	42.1	58.5	52.9
Richmond St at Spur 527 SBFR	33.8	28.3	44.3	32.9
Southmore Blvd at SH 288 NBFR	121.1	59.1	175.1	92.3
Southmore Blvd at SH 288 SBFR	65.0	18.8	70.9	26.6
Chartres St at Rusk St	33.2	N/A	100.6	N/A
Rothwell St at Hardy St	N/A	0.0	N/A	0.0
I-610 EBFR at 45 SBFR	N/A	10.6	N/A	12.0
I-610 EBFR at 45 NBFR	N/A	2.7	N/A	5.8
I-610 WBFR at 45 SBFR	N/A	3.6	N/A	5.0
I-610 WBFR at 45 NBFR	N/A	5.7	N/A	8.4

As seen in **Table 105** and **Table 106**, the intersections in the Build network in general operate at similar levels or better compared to the No-Build network. Intersections with high vehicle delay in the Build scenarios are primarily located in the downtown region and Allen Parkway. Future coordination with the City of Houston in recommended to ensure the signal timings in the downtown grid are optimized for smooth traffic flow.

The locations in the Build scenario that operate with delay greater than 55 seconds per vehicle in 2045 are summarized below with discussion of No-Build comparison.

- Taylor Street at I-10 EB Frontage Road – Improved from the No-Build condition by over 25 seconds per vehicle in both AM and PM peak periods.
- Webster Street at I-45 SB Frontage Road – Serves higher traffic demand than No-Build with access changes. Operates as two-phase signal but is geometrically constrained by residential community west of frontage road.
- Jefferson Street at Emancipation Avenue – Serves higher traffic demand than No-Build with access changes. Operates to serve southbound entrance to I-45, but is limited by entrance ramp

needing to merge to a single lane for lane balance on the I-45 southbound collector-distributor system.

- Pierce Street at Brazos Street – Improved from the No-Build condition by over 50 seconds per vehicle in the PM peak period.
- St Joseph Parkway at Brazos Street - Serves higher traffic demand than No-Build with access changes. Operates as two-phase signal but is geometrically constrained by commercial and residential downtown buildings.
- St Joseph Parkway at Smith Street - Serves higher traffic demand than No-Build with access changes. Operates as two-phase signal but is geometrically constrained by commercial and residential downtown buildings.
- Jefferson Street at Brazos Street – Improved from the No-Build condition by over 50 seconds per vehicle in the PM peak period.
- Pease Street at Smith Street – Improved from the No-Build condition by over 90 seconds per vehicle in the PM peak period.
- W Dallas Street at Gulf Freeway - Serves higher traffic demand than No-Build with access changes. This intersection is geometrically constrained with the adjacent Downtown Club building.
- W Dallas Street at Heiner Street - Serves higher traffic demand than No-Build with access changes. The intersection signal timing phasing was optimized, but peak periods see queues due to high traffic demands.
- Walker Street at Bagby Street - Serves higher traffic demand than No-Build with access changes. This intersection is geometrically constrained by multiple downtown buildings.
- Allen Parkway at I-45 Frontage Road – Intersection does not currently exist, but location has high crash rates with congestion and short weaves. The signal timing was optimized but serves very high traffic demand in the peak periods.
- Southmore Boulevard at SH 288 NB Frontage Road – Improved from the No-Build condition by over 60 seconds per vehicle in both AM and PM peak periods.

Additionally, the Patton Street and Link Road were changed from stop-controlled in the No-Build to signalized in the Build. This change was warranted due to high volume of competing traffic. At the Cavalcade Street and I-45 Northbound Frontage Road intersection, the eastbound left was changed from a single left to a dual left to better serve that high demand movement.

Average vehicle delay can be compared to the LOS thresholds within the HCM to gauge which intersections are expected to fail (operate with LOS E or LOS F). The threshold for LOS E is 55 seconds per vehicle. Table 107 shows how many study intersections are above 55 vehicles per second in each scenario.

Table 107: 2045 Intersection Summary Results - No-Build vs. Build

Scenario	Number of Intersections with >55 sec/veh Average Vehicle Delay	
	No-Build	Build
2025 AM	2	0
2025 PM	9	11
2045 AM	5	6
2045 PM	15	12

As seen in Table 107, the number of intersections with average vehicle delay greater than 55 seconds is similar between the No-Build and Build networks. This result indicates that the Build configuration does not adversely impact the local network. Additionally, the Build intersections are able to operate at similar levels even with the greater VMT experienced in each Build network compared to the No-Build.

I-45 Operational Results with Segment 1 Completed

The network was also modeled with a scenario that assumes Segment 1 is completed alongside Segments 2 and 3. Segment 1 does not have funding, but this scenario was run to determine the operational performance with additional capacity to the north of the project area, which may be constructed in the future.

Network performance results from the Vissim models can be seen in **Table 108** below. Note that the intersection of Pierce St at Brazos St was not included in this model because added traffic demand created a software issue in the circular pattern of intersections.

Table 108: 2045 Segment 1 Transition vs. Transition to Existing – 2025 and 2045 Vissim Results

	Scenario	Peak	Average Speed (mph)	Vehicle Miles	Latent Demand (veh)
Segment 1 Transition	2025	AM	34.7	1,440,385	20,512
		PM	30.2	1,650,676	43,851
	2045	AM	30.7	1,517,925	55,009
		PM	27.8	1,690,022	94,757
Transition to Existing	2025	AM	35.3	1,403,276	27,728
		PM	27.9	1,584,787	56,771
	2045	AM	31.7	1,501,503	59,399
		PM	26.0	1,636,937	107,027

As seen in **Table 108**, the Vissim results for the networks with the Segment 1 transition are similar to the networks with the proposed transition to existing. The largest difference in performance between the two transition plans is the reduction in latent demand and increase in vehicle miles for the Segment 1 transition networks. This is due to the additional I-45 lanes along allowing more vehicles to enter the network at the I-45 southbound mainlanes. In addition, a portion of the traffic demand from I-45 southbound mainlanes in the PM peak period is diverted to the 2x2 MaX Lanes north of the project area.

5.4 *Proposed Alternative Travel Modes*

Alternative travel modes seek to reduce Single-Occupant Vehicle (SOV) travel and encourage travel to be shifted outside the peak period. This section identifies the types of single occupant vehicle (SOV) alternatives that improve upon existing alternatives travel modes within the project limit. Proposed improvements to alternative travel modes include improved transit routes and bicycle & pedestrian facilities.

In the proposed Build Alternative, the improvements to the bicycle and pedestrian facilities include the addition of continuous sidewalks at the following locations, where the sidewalk is discontinuous or incomplete under Existing/No-Build conditions:

- North of Houston Belt & Terminal Railroad Line
- I-45 and I-610 interchange (continuous bicycle and pedestrian connection provided through interchange)
- North of I-10/I-45 and West of I-69
- South of I-45 from I-69 to Neddleton Street
- North of SH 288 to I-45 interchange
- I-10 to Waco Street
- I-10 to Bringhurst Street
- I-610 from Airline Drive to East of Fulton Street
- I-45 downtown frontage road connections, including an added crossing at Allen Parkway

In addition to the above improvements, dedicated bicycle and pedestrian space was included at the following cross streets:

- Quitman Street, Hogan Street, McKee Street, Hardy Road, Commerce Street, Franklin Street, Congress Street, Preston Street, Texas Avenue, Capitol Street, Rusk Street, McKinney Street, Lamar Street, Leeland Street, Pease Street, Jefferson Street, St Joseph Parkway, Jensen Drive, Main Street, Fannin Street, San Jacinto Street, Caroline Street, Austin Street, La Branch Street, Almeda Road, Alabama Street, Elgin Street, Tuam Street, McGowen Street, Gray Street, Pierce Street, Meadow Street, Houston Street, Dallas Street, and Cleburne Street.

The trail connection at White Oak Bayou was maintained and a pedestrian bridge was proposed at Mary Street. There are options for the City of Houston to reuse I-45 Pierce Elevated section for cultural/art space, bicycle and pedestrian use, or other forms, transforming this area away from single occupancy vehicle and freight use.

In the proposed Build Alternative, the Houston Metro will be able to operate on the MaX lanes, which provide bidirectional express lanes at all times of the day. This allows more buses to run throughout the day and adjust routes to take advantage of the operational improvements provided by the proposed alternative. Transit routes are being considered as the I-45 NHHIP project moves into implementation.

5.5 Future Conditions Crash Analysis

The proposed improvement's impact on crashes were evaluated using the AASHTO Highway Safety Manual (HSM) published in 2010 along with the Freeways and Interchange supplement which was published in 2014. The HSM is a proven analysis tools for crash frequency prediction per FHWA. It facilitates integrating quantitative crash frequency and severity performance measures into roadway planning, design, operations, and maintenance decisions. In this section, we will discuss the crash modification factors (CMFs) identified for the proposed improvements, the Interactive Highway Safety Design Model (IHSDM) used for analysis and other safety factors that were taken into consideration.

5.5.1 Crash Modification Factors (CMFs)

A CMF is the measure of the safety effectiveness of a design element and is used to calculate the anticipated change in the number of crashes after implementing a countermeasure on a road or intersection. Countermeasures may include geometric and/or operational improvements such as adding auxiliary lanes along freeway mainlanes or adding a right/left turn lane at an intersection.

The Crash Modification Factors Clearinghouse, funded by U.S. Department of Transportation Federal Highway Administration (FHWA), provides a searchable online database of CMFs included in the HSM along with guidance and resources on using CMFs in road safety practice. In addition to providing the CMFs, a "confidence level" is provided for each CMF. This confidence level is determined by both the HSM and CMF Clearinghouse and is represented by the star quality rating. This rating is based on a scale of 1 to 5 with 5 indicating the highest level of confidence.

Some CMF's were identified for the proposed improvements. The improvement type and applicable CMFs for this project include:

- Improvement 1 - Add a continuous auxiliary lane for weaving between entrance ramp and exit ramp
    - CMF = 0.79
    - Crash Reduction Expected = 21%
    - Star Rating = ***
    - CMF Clearinghouse ID #7440
    - CMF Improvement 1 applies to I-45 at Airline Drive, I-45 north of I-10 interchange, I-610 between I-45 and Hardy Toll Road, I-69 between I-10 and I-45, and I-69 between I-45 and SH 288.

- Improvement 2 – Provide a deceleration lane on one-lane freeway exit ramp
  - CMF = e^2.198(Y-X)
    - Y = new deceleration length
    - X = prior deceleration length
  - Crash reduction expected = varies
  - Star Rating = ***
  - CMF Clearinghouse ID #3042
- Improvement 3 – Currently, there are existing concrete guardrails in some project areas. Due to the positive safety impacts of the existing concrete guardrail, our team proposes to keep the guardrail and perform maintenance on them. The CMFs to install a concrete guardrail in a median, include:
  - CMF = 0.80
  - Crash reduction expected = 20%
  - Star Rating = ****
  - CMF Clearinghouse ID #2255
- Improvement 4 – Increase inside paved shoulder width from 4 ft to 10 ft
  - CMF = 0.665
  - Crash reduction expected = 33.5%
  - Star Rating = ***
  - CMF Clearinghouse ID #4244
- Improvement 5 - Modify two-lane-change to one-lane-change merge/diverge area –
  - CMF = 0.68
  - Crash reduction expected = 32%
  - Star Rating = *****
  - CMF Clearinghouse ID #476
  - CMF Improvement 5 applies to I-69 between I-10 and I-45, and I-69 between I-45 and SH 288
- Improvement 6 – Provide a right-turn on one major road approach
  - CMF = 0.91
  - Crash reduction expected = 28%

- Star Rating = *****
- CMF ID = #288
- CMF Improvement 6 applies to Airline Road at I-45 Frontage Road, Crosstimbers Street at I-45 Frontage Road and Allen Parkway at I-45 Frontage Road,

- Improvement 7 – Provide a left-turn lane on one major road approach
  - CMF = 0.72
  - Crash reduction expected = 28%
  - Star Rating = *****
  - CMF ID = #260
  - CMF Improvement 7 applies to Tidwell Road and I-45 Frontage Road, Airline Drive and I-45 Frontage Road, Leeland Street and I-69 Frontage Road, Elgin Street and I-69 Frontage Road, and Almeda Road and I-69 Frontage Road.

The proposed improvements are anticipated to reduce the number of crashes in the corridor. The anticipated crash reduction varies from 21% to 45% depending on the improvement. The HSM predictive analysis equations utilized by IHSDM do not evaluate urban freeways which are greater than ten lanes. Locations that are not able to be analysed in IHSDM due to limitations in number of freeway lanes are summarized with the applicable CMFs and discussion of safety issues in the following section.

5.5.2 Summary of Safety Improvements by Section

This section summarizes safety improvements from each section of the overall network. These improvements are outlined by discussing No-Build safety areas of concern, identifying the proposed Build changes, and outlining expected safety improvement.

5.5.2.1 I-45 - Tidwell to I-610

Table 109 shows a summary of No-Build safety concerns along I-45 from Tidwell Road to I-610 and how the Build network addresses these issues.

Table 109: Addressed Safety Issues along I-45 from Tidwell Rd to I-610

No-Build Safety Concerns	Build Improvement
Heavy congestion contributing to a large amount of rear end crashes	Added HOV Lanes beginning north of Crosstimbers Street Expanded existing ROW Frontage Roads added at the I-610 and I-10 intersection continuous frontage roads along I-45

No-Build Safety Concerns	Build Improvement
Heavy congestion contributing to sideswipe crashes for vehicles attempting to enter/exit to direct connectors	Direct Connectors enter and exit mainlanes north of Crosstimbers Street gaining 1000 additional feet for weaving between the DC's and upstream entrance and exit ramps instead of the direct connectors beginning south of Stokes Street
Short weave length between Entrance from Airline Drive and Exit to Riggs Street	Removal of Exit to Riggs Street
Victoria Drive high number of conflict points with full access	Access management to convert to Victoria Drive to one-way operations westbound and add separated southbound to northbound U-turn

One of the improvements along I-45 from Tidwell Road to I-610 includes the additional 1,000 feet of weaving length north of the I-610 direct connectors. Per the "Safety Performance for Freeway Weaving Segments" by Yi Qi, states that weaving sections with longer lengths will have lower crash frequency per 1,000 feet. This is because weaving vehicles need to make required lane changes in the space and time limited by the length of the weaving section. Longer lengths mean weaving vehicles have more time and more moving distance to find safe gaps to make lane changes. **Table 110** shows a numeric summary of geometric improvements of safety benefits for I-45 from Tidwell Road to I-610. There are no left side entrances or exits in the No-Build or Build configurations for this section.

Table 110: Geometric Improvement Safety Benefits for I-45 (from Tidwell Rd to I-610) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	0	0	-
Number of Merges	2	1	50%
Number of Diverge Points without a Deceleration Lane	3	1	67%
Number of Left-Side Exits/Entrances	0	0	-

As shown in **Table 110**, the number of merges and number of diverge points without a deceleration lane decreased from the No-Build network to the build network.

5.5.2.2 I-45 from I-610 to I-10

Table 111 shows a summary of No-Build safety concerns along I-45 between I-610 and I-10 and how the Build network addresses these issues.

Table 111: Addressed Safety Issues along I-45 from I-610 to I-10

No-Build Safety Concerns	Build Improvement
Rear End crashes due to queue spillback along interchange ramps	Decreased congestion along mainlanes and interchange ramps due to added capacity and downstream operational improvements
The interchange of I-45 and I-610 shows a high concentration of crashes in the historical crash analysis	Addition of one mainlane in each direction, Expansion of HOV lanes from one lane (direction depending on peak period) to two lanes per direction, and DC entrance and exits from I-610 moved north and south of the I-45 and I-610 interchange. There is improved lane balance in the area and improved alignment.
The I-45 mainlanes over Cavalcade Street show a high concentration of crashes in the historical analysis due to the weave sections with existing ramp configurations	The northbound ramp from Cavalcade Street and the southbound ramp to Cavalcade Street are removed to eliminate the northbound and southbound weave sections.
Entrance ramp from Patton Street with short merge	Change of access shifts volume entering I-45 from Patton street to use the entrance ramp south of Main Street in the Build scenario. This removes the entrance ramp and associated short merge.
Entrance slip ramp connecting from frontage road to eastbound I-610 to southbound I-45 direct connector	Entrance ramp removed to eliminate conflict point on high speed direct connector that has poor sight distance
Houston Ave at I-45 SBFR stop-control intersection close to southbound Main Street entrance ramp	Converted stop-control intersection to roundabout to address public need for access from Houston Ave and improve safety with traffic calming

The addition of continuous frontage roads between Main Street and Quitman Street connects the local roadways and addresses access needs local residents commented on at public meetings.

There was one location where safety is being addressed as part of final design and construction. The northbound frontage road connection north of Quitman Street merges with the I-10 eastbound to I-45 northbound ramp. **Figure 80** shows this location.

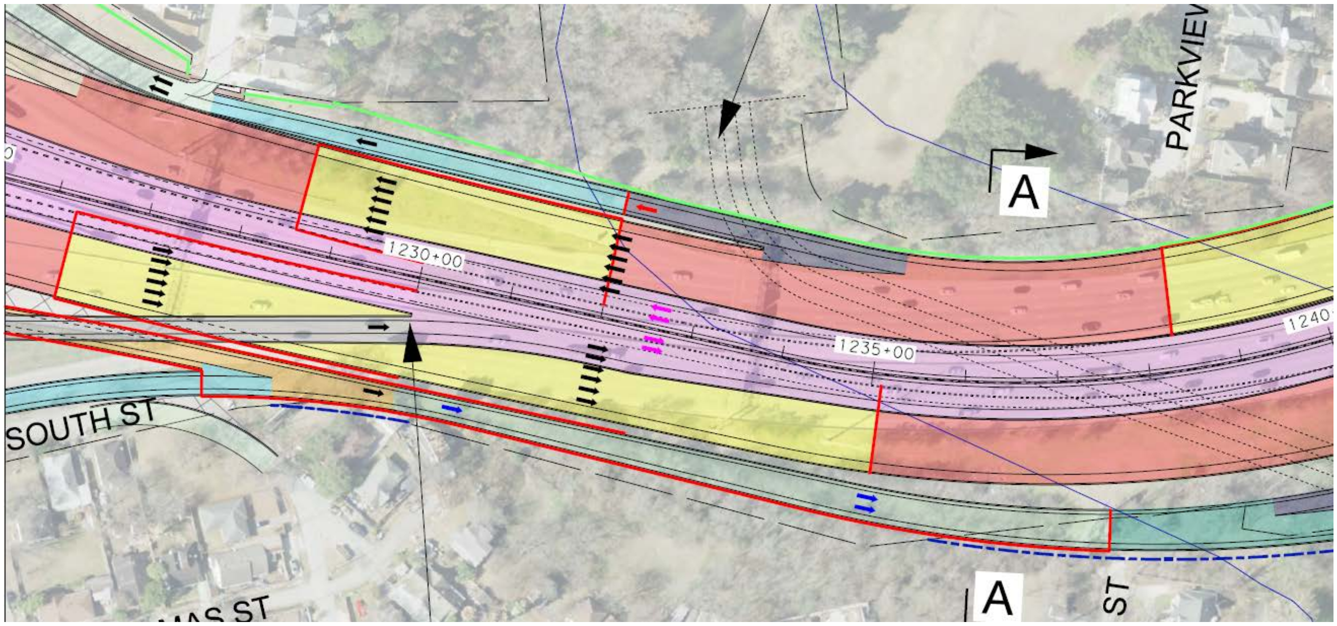

Figure 80: Local Access from Quitman St to I-45 Northbound Frontage Road

There were multiple alternatives considered at this location. Public comment showed a need for access to I-45 northbound in the area. A two-lane weave was reviewed for feasibility, however, the additional width needed would result in a historic building removal. The operations showed low traffic demand along the direct connector due to the access provided in the I-10 MaX lanes and did not show a slowdown in operations in the microsimulation model. Therefore, the merge was moved forward in schematic design. The final design will include consideration of sight distance, advisory speed of ramp, rumble strips, and advanced warning.

Table 112 shows a list of the No-Build and Build left-side exits/entrance ramp locations along I-45 from I-610 to I-10. As shown, the locations only include MaX lane access.

Table 112: No-Build and Build Left-Side Exits along I-45 from I-610 to I-10

Exiting Left-Side/Entrance Ramp Location	Build Left-Side/Entrance Ramp Location
Ramp does not exist in No-Build configuration	Added Left Exit I-45 SB to MaX Lanes – weave with auxiliary lane
Ramp does not exist in No-Build configuration	Added Left Entrance from I-45 SB MaX Lanes – weave with auxiliary lane
Ramp does not exist in No-Build configuration	Added Left Exit I-45 NB to MaX Lanes – weave with auxiliary lane
Ramp does not exist in No-Build configuration	Added Left Entrance from I-45 NB MaX Lanes – weave with auxiliary lane

Table 113 shows a numeric summary of geometric improvements of safety benefits for I-45 from I-610 to I-10.

Table 113: Geometric Improvement Safety Benefits for I-45 from (I-610 to I-10) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	1	1	0%
Number of Merges	3	2	33%
Number of Diverge Points without a Deceleration Lane	1	0	100%
Number of Left-Side Exits/Entrances	0	4 (MaX Lanes)	-

As shown in **Table 113**, the number of merges and the number of diverge points without a deceleration lane decreased and the number of left-side exits/entrances increased due to the MaX lane entrance and exits from the no-build network to the build network.

5.5.2.3 *I-45 from I-10 to I-69*

Table 114 shows a summary of No-Build safety concerns along I-45 between I-10 and I-69 and how the Build network addresses these issues.

Table 114: Addressed Safety Issues along I-45 from I-10 to I-69

No-Build Safety Concerns	Build Improvement
Rear end crashes were due to queue spillback along interchange ramps	Decreased congestion along mainlanes and interchange ramps
The interchange of I-45 and I-69 shows a high concentration of crashes in the historical crash analysis. There are a large number of left entrances and exits to/from I-69 to I-45. Additionally, the direct Connector from I-69 SB to I-45 NB merge has no acceleration or taper length	I-45 at I-69 interchange converted to a partial interchange with traffic is diverted to use the direct connector from I-69 SB to I-10 EB and then the direct connector from I-10 EB to I-45 NB both meeting design standards. Many of the left-side entrances and exits are eliminated in the build configuration or replaced with right-side exits.
Rapid succession of left exits violates driver expectancy when intermixed with right-side entrances and exits	Decrease in number of left entrances and exit.
The interchange of I-45 and I-10 shows a high concentration of crashes in the historical crash analysis	I-45 SB to I-10 EB Left exit is replaced by right exit, I-45 NB left exit to I-10 WB is changed to a two-lane right-side exit, and HOV exit to Franklin Street removed

No-Build Safety Concerns	Build Improvement
I-45 from Buffalo Bayou to Pierce Elevated Section shows a high concentration of crashes in the historical crash analysis.	Removal of existing I-45 Pierce Elevated – replaced by downtown ramp connections for local access and connectivity with downtown and the realignment of I-45 to be parallel with I-10 north of downtown and parallel with I-69 east of downtown until it turns south to the existing I-45 alignment southeast of the downtown area.

Table 115 shows a list of the No-Build and Build left-side exits/entrance ramp locations along I-45 from I-10 to I-69.

Table 115: No-Build and Build Left-Side Exits along I-45 from I-10 to I-69

Exiting Left-Side/Entrance Ramp Location	Build Left-Side/Entrance Ramp Location
Left-side I-45 NB exit to I-10 WB	Changed to a two-lane right-side exit
Left-side I-45 SB exit to I-10 EB/Commerce St	Changed to both right-side exits. Exits to I-10 EB and Commerce St occur at two separate ramps.
Left-side I-45 SB exit to McKinney St	Changed to a right-side exit from Downtown Connector
Left-side I-45 SB exit to Allen Pkwy	Changed to a right-side exit from Downtown Connector
Left-side I-45 NB exit to Allen Pkwy	Ramp does not exist in Build configuration
Left-side I-45 NB exit to I-69 SB/SH 288 SB	Changed to a right-side exit (background project)
Left-side I-45 SB exit to I-69 NB	Ramp does not exist in Build configuration
Left-side I-45 SB entrance from I-69 SB	Changed to be realigned as right-side entrance
Left-side I-45 NB entrance from I-69 NB	Ramp remains as a left-side entrance in realignment
Ramp does not exist in No-Build configuration	Added Left Exit I-45 SB exit to SH 288 SB – lane add with no merge

Table 116 shows a numeric summary of geometric improvements of safety benefits for I-45 from I-10 to I-69.

Table 116: Geometric Improvement Safety Benefits for I-45 (from I-10 to I-69) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	0	0	-
Number of Merges	4	2	50%
Number of Diverge Points without a Deceleration Lane	4	1	75%
Number of Left-Side Exits/Entrances	8	2	75%

As shown in **Table 116,** the number of merges, number of diverge points without a deceleration lane, and the number of left-side exits/entrances all decreased from the No-Build to Build network.

5.5.2.4 I-45 from I-69 to Cullen Boulevard

Table 117 shows a summary of No-Build safety concerns along I-45 between I-10 and Cullen Boulevard and how the Build network addresses these issues.

Table 117: Addressed Safety Issues along I-45 from I-69 to Cullen Blvd

No-Build Safety Concerns	Build Improvement
Rear end crashes were due to queue spillback along interchange ramps	Decreased congestion along mainlanes and interchange ramps due to the re-alignment of the I-45 and I-69 interchange
I-45 at Cullen Boulevard shows a high concentration of crashes in the historical crash analysis.	The limits of improvements ends west of Cullen Blvd and Scott St. Crashes in 2015-2018 occurred mainly on the frontage road and there have been intersection improvements completed separate from the NHHIP proposed Build.

Table 118 shows a numeric summary of geometric improvements of safety benefits for I-45 from I-69 to Cullen Boulevard. There are no left side entrances or exits in the no-build or build configurations for this section. As mentioned, Cullen Boulevard has had separate intersection improvements to address safety issues noted in our crash analysis.

Table 118: Geometric Improvement Safety Benefits for I-45 (from I-69 to Cullen Blvd) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	0	0	-
Number of Merges	2	1	50%
Number of Diverge Points without a Deceleration Lane	2	1	50%
Number of Left-Side Exits/Entrances	0	0	-

As shown in **Table 118**, the number of merges and the number of diverge points without a deceleration lane decreased from the No-Build to Build network.

5.5.2.5 I-69 from South of SH 288 to North of I-10

Table 119 shows a summary of No-Build safety concerns along I-69 between south of SH 288 and north of I-10 and how the Build network addresses these issues.

Table 119: Addressed Safety Issues along I-69 from S of SH 288 to N of to I-10

No-Build Safety Concerns	Build Improvement
Large amount of rear end and sideswipe crashes concentrated heavily at the weave locations before the DCs entering and exiting the I-69 and I-45 interchange due to heavy congestion.	Realignment of I-45 to be parallel with I-10 north of downtown and parallel with I-69 east of downtown until tying into the existing I-45 alignment southeast of the downtown area and removal of the fourth leg of the I-69 at I-45 interchange with the pierce elevated section removal. Improved lane balance and operations with fewer direct merge points.
Large amount of rear end and sideswipe crashes concentrated heavily at the weave before the direct connectors approaching the I-69 and SH 288 interchange due to heavy congestion.	Realignment of SH 288 and I-69 and removal of the exits to Jackson St and Chenevert St to improve lane balance.
I-45 left entrance violates driver expectancy when intermixed with right-side entrances and exits	Removal of left entrance from I-45 NB/I-45 SB
The interchange of I-69 and SH 288 shows a high concentration of crashes in the historical crash analysis.	Additional lane added in both directions along I-69 mainlanes, re-alignment of DC ramps to/from SH 288, less weaving along I-69 between Alabama Street and the I-69 and I-45 interchange

Table 120 shows a list of the No-Build and Build left-side exits/entrance ramp locations along I-45 from I-10 to I-69. The left side entrance from Chenevert Street is a lane add and has been reviewed to ensure no operational deficiency and low traffic weave demand for lane changes in the area.

Table 120: No-Build and Build Left-Side Exits along I-69 from S of SH 288 to N of to I-10

Exiting Left-Side/Entrance Ramp Location	Build Left-Side/Entrance Ramp Location
Left-side I-69 NB entrance from I-45 NB/I-45 SB	Changed to be realigned as right-side entrance
Right-side entrance from Chenevert St	Changed to left entrance from Chenevert St to I-69 NB – entrance is lane add with no merge

Table 121 shows a numeric summary of geometric improvements of safety benefits for I-45 from I-10 to I-69.

Table 121: Geometric Improvement Safety Benefits for I-69 (from S of SH 288 to N of I-10) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	5	2	60%
Number of Merges	4	1	75%
Number of Diverge Points without a Deceleration Lane	3	1	67%
Number of Left-Side Exits/Entrances	1	1	0%

As shown in **Table 121**, the number of weaves with distances less than 1,500 feet, number of merges, and number of diverge points without a deceleration lane decreased between the No-Build and Build network. The number of left-side exits/entrances remained the same between the No-Build and Build network.

5.5.2.6 *I-10 – West of I-45 to East of I-69*

Table 122 shows a summary of No-Build safety concerns along I-10 between west of I-45 and east of I-69 and how the Build network addresses these issues.

Table 122: Addressed Safety Issues along I-10 between West of I-45 and East of I-69

No-Build Safety Concerns	Build Improvement
Large amount of rear end and sideswipe crashes near Taylor St, Houston Ave, and Waco St. due to lane changing, congestion, and weaving behavior.	Decreased congestion along mainlanes and interchange ramps
Left entrances and exits violate driver expectancy when intermixed with right-side entrances and exits	Removal and realignment of left side entrances
Entrance ramp from Taylor Street to I-10 EB has no acceleration lane.	The build schematic does not address this entrance ramp since the ramp is slightly out of the project limits
Vehicles that enter I-10 from Taylor Street and wishing to enter the I-45 NB direct connector must cross 4 lanes very quickly creating a hotspot for sideswipe and rear end crashes in this area	The build schematic does not address this weave distance since the entrance ramp from Taylor street is outside of the project limits

Table 123 shows a list of the No-Build and Build left-side exits/entrance ramp locations along I-10 between west of I-45 and east of I-69.

Table 123: No-Build and Build Left-Side Exits along I-10 between West of I-45 and East of I-69

Exiting Left-Side/Entrance Ramp Location	Build Left-Side/Entrance Ramp Location
Left-side I-10 EB exit to I-45 NB	Ramp remains as a left-side exit in realignment – option lane from two lane exit collector distributor
Left-side I-10 EB exit to I-69 NB	Changed to realign as right-side exit
Left-side I-10 WB entrance from Franklin St	Changed to realign as right-side entrance
Left-side I-10 EB exit to I-45 SB	Ramp remains as a left-side exit in realignment - includes lane add and no merge
Left-side I-10 WB exit to I-45 SB	Changed to realign as right-side exit
Left-side I-10 EB entrance from I-69 SB	Changed to realign as right-side exit
Left-side I-10 WB exit to I-69 SB	Ramp remains as a left-side exit in realignment – lane drop with downstream lane add

Exiting Left-Side/Entrance Ramp Location	Build Left-Side/Entrance Ramp Location
Left-side I-10 EB entrance from I-45 SB	Ramp remains as a left-side exit in realignment – lane add with no merge
Ramp does not exist in No-Build configuration	Added left entrance to I-10 EB from MaX Lanes – includes lane add with right side merge
Ramp does not exist in No-Build configuration	Added left exit from I-10 WB to MaX Lanes – lane drop with lane add upstream of location
Right-side entrance from I-45 NB	Changed to left entrance to I-10 WB from I-45 NB – lane add with no merge
Right-side exit to I-45 NB	Changed to left exit from I-10 WB to I-45 NB – lane drop and lane add to I-45 with no merge or diverge

Table 124 shows a numeric summary of geometric improvements of safety benefits along I-10 between west of I-45 and east of I-69. Although there are still left side exits and entrances in the Build for this area, all of the locations avoid direct merge or diverge conditions.

Table 124: Geometric Improvement Safety Benefits along I-10 (from West of I-45 to East of I-69) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	5	4	20%
Number of Merges	4	3	25%
Number of Diverge Points without a Deceleration Lane	4	0	100%
Number of Left-Side Exits/Entrances	8	8	0%

As shown in **Table 124**, the number of weaves with distances less than 1,500 feet, number of merges, and number of diverge points without a deceleration lane decreased between the No-Build and Build network. The number of left-side exits/entrances remained the same between the No-Build and Build network.

5.5.2.7 *I-610 – Main St to Hardy Toll*

Table 125 shows a summary of No-Build safety issues along I-610 between Main Street and Hardy Toll Road and how the Build network addresses these issues.

Table 125: Addressed Safety Issues along I-610 between Main Street and Hardy Toll Road

No-Build Safety Concerns	Build Improvement
The merge and weave locations between the entrance from Main St and the exit to Airline Dr in addition to the entrance from Airline Dr to the exit to Main St do not meet design criteria – this area shows a high concentration of crashes in the historical crash analysis	The Build Schematic addresses the critical merge locations with the removal of the eastbound entrance ramp from Main St and the westbound exit ramp to Main St on I-610 and addition of those ramps as lane adds and drops from the I-45 direct connectors for more space and lane balance.

Table 126 shows a list of the No-Build and Build left-side exits/entrance ramp locations along I-610 between Main Street and Hardy Toll Road.

Table 126: No-Build and Build Left-Side Exits along I-610 between Main St and Hardy Toll Rd

Exiting Left-Side/Entrance Ramp Location	Build Left-Side/Entrance Ramp Location
Left-side exit from I-610 EB to I-45 NB	Changed to realign as right-side exit
Left-side exit from I-610 WB to I-45 SB	Changed to realign as right-side exit
Left-side entrance to I-610 EB from I-45 SB	Changed to realign as right-side entrance
Left-side entrance to I-610 WB from I-45 NB	Changed to realign as right-side entrance

Table 127 shows a numeric summary of geometric improvements of safety benefits along I-610 between Main Street and Hardy Toll Road.

Table 127: Geometric Improvement Safety Benefits for I-610 (from Main St to Hardy Toll Rd) No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	2	0	100%
Number of Merges	3	3	0%
Number of Diverge Points without a Deceleration Lane	0	2	-
Number of Left-Side Exits/Entrances	4	0	100%

As shown in **Table 127**, the number of weaves with distances less than 1,500 feet and the number of left-side exits/entrances decrease. The number of merges stay the same and the number of diverge points without a deceleration lane increased between the No-Build and Build network. The diverge points are below the interchange, where mainlane traffic volumes are lower with the removal of traffic demand to and from I-45.

Other Safety Design Elements

Many other safety elements are being considered at specific locations throughout the project area. They each have associated CMFs below 1.0, but the safety impact will be dependent on the specific location. These design elements include:

- Advisory Speed Signs
- Advanced Warning Signs
- Rumble Strips
- Providing Left and Right Turn Bays
- Intersection Illumination
- Backplates on Signal Heads
- Leading Pedestrian Intervals in Downtown Houston Area
- Chevrons for Horizontal Curves

These elements are expected to improve safety throughout the project area and the specific locations are being determined in final design with coordination with City of Houston.

5.5.3 Interactive Highway Safety Design Model (IHSDM)

Prior to the start of the safety analysis, a meeting was held between TxDOT, FHWA, and the consultant team to discuss an approach to predictive crash analysis and software available to perform such analysis. The discussion considered the use of IHSDM, ISATe, or microsimulation trajectory data from Vissim. Based on confidence in the software and applicable project type, IHSDM was chosen as the software for modelling predictive safety. There are limitations with the software, but the team decided that areas where IHSDM could not be applied would have crash modification factor and general safety issue discussion.

The IHSDM is a suite of software analysis tools used to evaluate the safety and operational effects of geometric design decisions on highways per FHWA. IHSDM is a predictive model that can be used as a decision-support tool that provides estimates of a highway design's expected safety, operational performance, and checks existing or proposed highway designs against relevant design policy values. IHSDM includes crash prediction capabilities for two-lane rural highways, multilane rural highways, urban/suburban arterials, freeways, and interchanges/ramps as specified in Part C (Predictive Method) of the 1st Edition Highway Safety Manual (HSM). For the purpose of this safety analysis, mainlane segments and ramp connections were analysed, while frontage road sections were not included. MaX lanes were modelled as left side ramp gore points in the safety analysis models.

IHSDM has analysis limitations that applied to all No-Build and Build models. These limitations include:

- Analysis of cross-sections greater than 10 lanes of capacity - Auxiliary lanes less than 4,500 feet and acceleration/deceleration lanes less than 800 feet are not considered lanes of capacity according to HSM methodology.
- Decrease in crash prediction reliability for freeway segments with AADT greater than 150,000 vehicles/day – This applies to many freeway segments, although results are still reported and able to be directly compared between No-Build and Build.
- Analysis of managed lanes – Ramps to and from managed lanes are included in analysis, but the straight segments are unable to be included in analysis.

Figure 81 and **Figure 82** display the locations within the study area where there are more than 10 lanes in the No-Build and Build models. The denoted section along I-10 cannot be analyzed by IHSDM because it is a proposed 11-lane cross-section in the Build condition. This section of I-10 was also removed from the No-Build IHSDM model to provide more direct effective length comparisons. Segments where the AADT is greater than 150,000 vehicles/day can be analyzed although the reliability of the results decreases. It is important to note that portions of I-45, I-610, I-10, and I-69 had AADTs greater than 150,000.

Furthermore, changes in freeway alignment, the addition of MaX lanes, and ramp sequence reconfiguration resulted in changes of effective length and average AADT between the No-Build and Build. Our technical team worked to provide the most direct comparison possible by effective length, however there are AADT shifts based on ramp reconfigurations and addition of MaX lanes. Average AADT and effective length are two primary drivers of crash rate, so an accurate safety comparison between the No-Build and Build were challenging due to these differences. TxDOT has not yet developed calibration factors for the safety performance functions (SPFs) used in freeway crash prediction models, therefore, the IHSDM models are not calibrated to local conditions.

The Empirical Bayes (EB) Method was considered for this analysis, to be used as a means to combine an estimate from the predictive model (IHSDM results) with CRIS crash history data in order to obtain a more reliable estimate of the expected average crash frequency. The EB Method applies the reliability of the estimate of expected average crash frequency by pooling the estimate from the predictive model with the project area observed crash data. The model estimate describes the safety of the typical site with attributes matching those of the subject site. However, it has some level of statistical uncertainty due to unexplained differences among the set of similar sites used to calibrate the predictive model. Similarly, an average crash frequency computed from crash data has uncertainty because of the random variability inherent to crash data. After a meeting between FHWA and the consultant, it was determined that the EB Method was not a viable option for this project as there are major differences between the No-Build and Build alignments, which could skew results. Due to the changes in alignment, the crash history data may no longer be applicable to the Build.

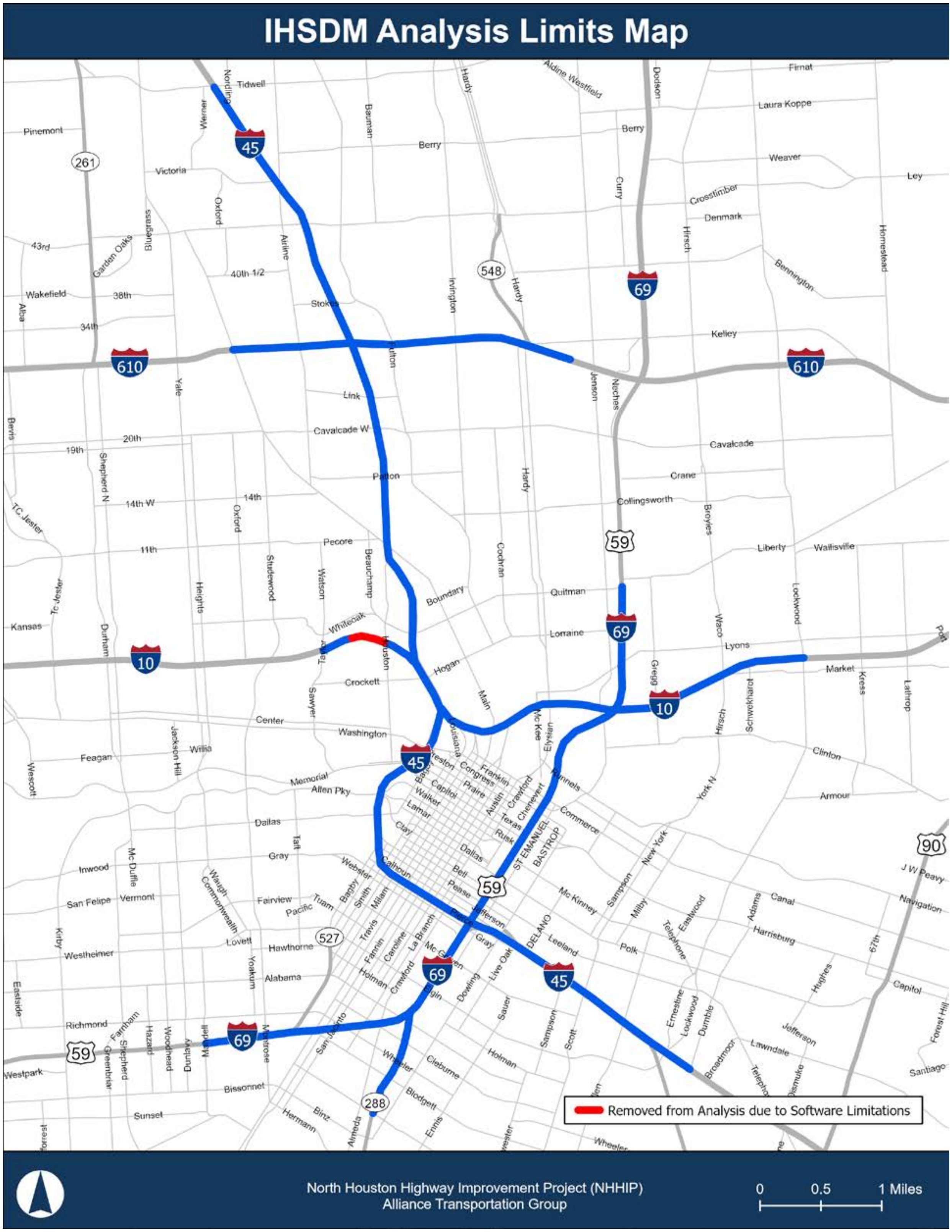

Figure 81: No-Build IHSDM Analysis Limits

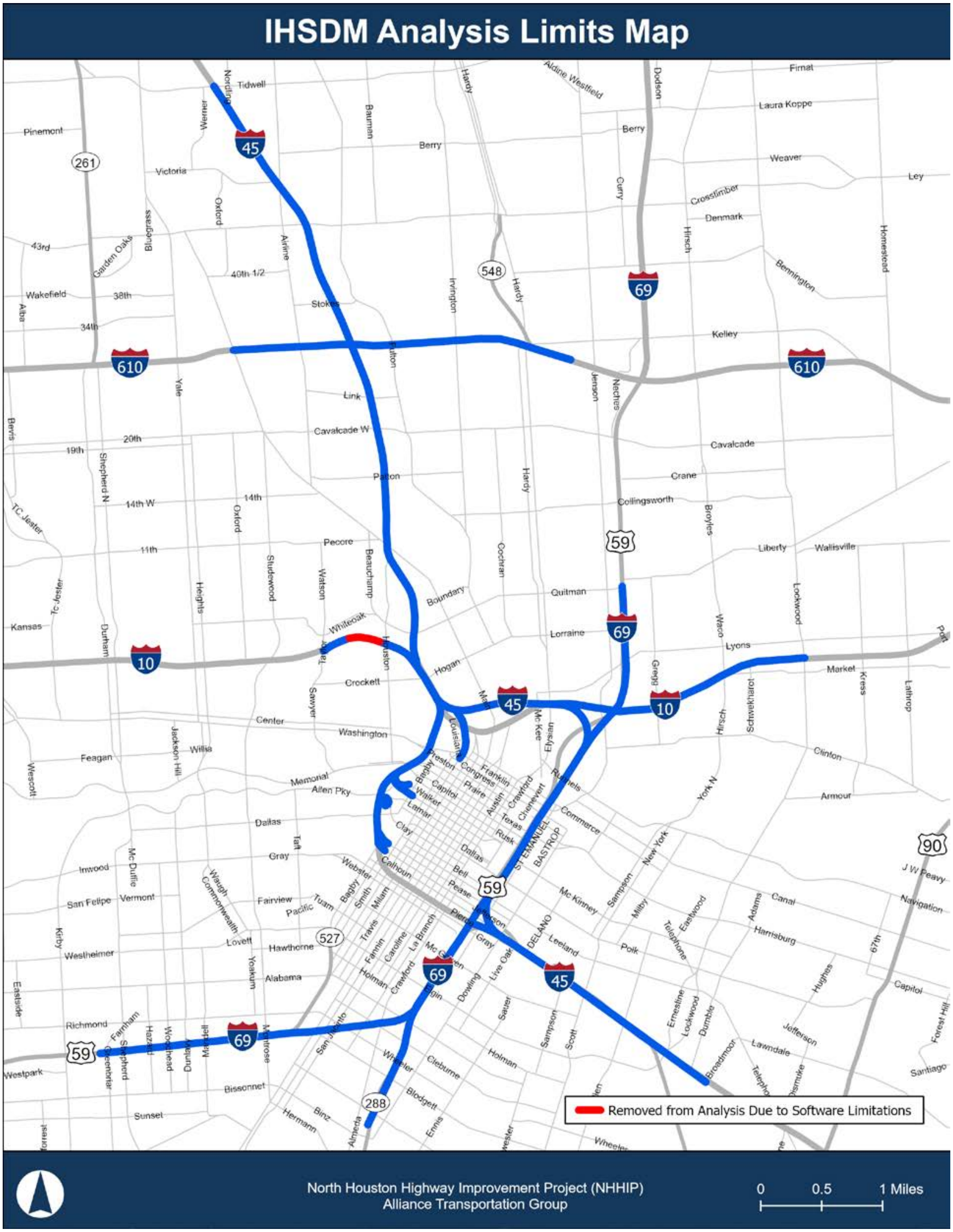

Figure 82: Proposed Build IHSDM Analysis Limits

As illustrated in **Figure 81** and **Figure 82**, the segment of I-10 between Taylor Street and the I-45 interchange could not be analyzed by the IHSDM software. This is due to the fact that in the Build condition, the freeway segment has more than ten lanes of capacity. In the No-Build condition, the on-ramp from Taylor Street joins the freeway with an acceleration lane of approximately 200 feet. Then, 2,100 feet downstream of the on-ramp, there is a left-side exit for a direct connector to I-45 northbound. The Build condition has a similar configuration except the left-side exit is moved upstream approximately 700 feet compared to the No-Build condition. This reduction in weave length for the Build condition may result in more aggressive lane changes. This location is being considered for improvement as part of project development in the adjacent I-10 corridor and should be addressed in future projects. Project constraints and the overall limits inhibited major reconstruction in this area.

In this analysis, the year of interest is the future year, 2045. It is important to note that 2045 was selected as the comparison year although the available future year draft 24-hour traffic forecasts were 2040. Draft 24-hour year 2040 traffic forecasts have been submitted for approval with TxDOT Transportation Planning and Programming (TP&P) division. Growth rates consistent with those used to develop 2040 AADT were applied to forecast 2045 numbers used in the safety analysis. AADT for No-Build and Build were consistent. Although the operational analysis shows an increase in VMT, that is for a peak period, while the safety analysis incorporates daily traffic. Operational and safety results are separate and should not be directly compared.

For the purposes of this analysis, each freeway was analyzed separately. **Tables 128-132** summarize the results of the IHSDM analysis for I-45, I-69, I-10, I-610 and SH 288 comparing the 2045 No-Build versus Build Conditions. The percent difference between the 2045 No-Build and Build was calculated in order to quantify the predicted safety improvement by crash and in crash rate. The detailed results can be found in **Appendix S.**

Table 128 shows the results of the IHSDM analysis for I-45 freeway. Reduction in average AADT in the Build condition is a result of vehicles diverting to the MaX lanes and to the downtown ramp connectors. The increase in effective length in the Build condition is due to the realignment of I-45 from I-10 to I-69. The predictive crash analysis shows a 30% reduction in total crashes and a 29% reduction in the travel crash rate per 100 million vehicle-miles. Additionally, the travel crash rate is projected to reduce from 285 to 203 crashes per 100 million vehicle-miles and the number of expected fatal and injury crashes reduces from 286.16 to 205.01 crashes. The crash rate for the fatal and injury crashes also reduced from 83 to 59 per million vehicle-miles travelled.

The safety improvements in the Build condition is attributed to a reduction in average AADT, the reduction in left-side exits, and improved lane balance. For example, the No-Build IHSDM analysis shows the freeway segments with the highest crash rates are located between the on-ramps and off-ramps for McKinney Street, Dallas Street, and Allen Parkway and the I-45/I-10 direction connectors. This was a location identified in the existing safety evaluation as a safety concern (see **Figure 28**) due to the rapid succession of exits including left-side exits. In the Build condition, this segment of I-45 is removed from the interstate and is served by downtown connectors with an improved ramp configuration design to improve spacing and reduce left-side ramps.

Table 128: Predicted Crash Rates on I-45 for No-Build and Build Alternatives

	2045		Percent Reduction (%)
	No-Build	Build	
Average AADT (vpd)	341,537	316,069	7
Effective Length (mi)	8.9252	9.6232	-8
Predicted Crashes			
Total Crashes	1025.42	713.20	30
Fatal and Injury Crashes	286.16	205.01	28
Property-Damage Only Crashes	739.26	508.18	31
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)			
Total Travel (100 million veh-mi)	6.98	6.71	4
Travel Crash Rate	285	203	29
Travel Fatal and Injury Crash Rate	83	59	29
Travel Property-Damage Only Crash Rate	202	144	29

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 129 shows the results of the IHSDM analysis for the I-69 freeway. Reduction in average AADT along I-69 in the Build condition is due to changes in ramp sequencing as a result of the proposed freeway alignment changes in the project area. An increase in effective length in the Build condition is due to a combination of mainlane and ramp realignments. The crash prediction results indicate that the travel crash rate will reduce from 264 to 188 crashes per 100 million vehicle-miles and the number of expected fatal and injury crashes reduces from 121.10 to 94.49 crashes. The crash rate for the fatal and injury crashes also reduce from 85 to 60 per million vehicle-miles travelled. With the proposed improvements, there is a 28% reduction in the total crashes and a 29% reduction in the travel crash rate per 100 million vehicle-miles.

The safety improvements in the Build condition is attributed to a reduction in average AADT, the removal of the reverse curve along the I-69 mainlane near the I-10 interchange, and improved lane balance. Furthermore, the removal of the existing reverse curve alignment of I-69 near the I-10 interchange improves safety outcomes. According to the IHSDM analysis of I-69 from just south to north of the I-10 interchange, the realignment from a reverse curve to a single horizontal curve alone results in a 13% reduction of total crashes and a 20% reduction in crash rate.

Table 129: Predicted Crash Rates on I-69 for No-Build and Build Alternatives

	2045		Percent Reduction (%)
	No-Build	Build	
Average AADT (vpd)	318,431	294,526	8
Effective Length (mi)	4.5014	4.9290	-9
Predicted Crashes			
Total Crashes	430.58	308.31	28
Fatal and Injury Crashes	121.10	94.49	22
Property-Damage Only Crashes	309.47	213.82	31
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)			
Total Travel (100 million veh-mi)	3.43	3.29	4
Travel Crash Rate	264	188	29
Travel Fatal and Injury Crash Rate	85.00	60	29
Travel Property-Damage Only Crash Rate	179	129	28

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 130 shows the results of the IHSDM analysis for the I-10 freeway. Reduction in average AADT in the Build condition is primarily due to vehicles diverting from the mainlanes to the MaX lanes. The slight difference in effective length is due to the realignment of I-10 from I-45 to I-69. According the IHSDM analysis, there is projected to be a 52% reduction in total crashes and a 33% reduction in the travel crash rate per 100 million vehicle-miles. Additionally, the travel crash rate is projected to reduce from 228 to 153 crashes per 100 million vehicle-miles and the number of expected fatal and injury crashes reduces from 92.51 to 47.84 crashes. The crash rate for the fatal and injury crashes also reduce from 70 to 49 per million vehicle-miles travelled.

The safety improvements in the Build condition is attributed to the reduction in average AADT, improved mainlane horizontal alignment between I-45 and I-69, eliminating diverges without a deceleration lane, and improved weaving distances. Additionally, the smoothing out of the horizontal alignment just east of the I-45 appears to provide safety improvements according to the IHSDM segment results. In the No-Build, the segment of I-10 where the degree of curvature is highest shows one of the highest crash rates of the freeway overall. In the Build condition, this same location (Station 1060+00 to 1065+00) have predicted crash rates that are generally lower than the other segments of the freeway.

Table 130: Predicted Crash Rates on I-10 for No-Build and Build Alternatives

	2045		Percent Reduction (%)
	No-Build	Build	
Average AADT (vpd)	274,128	219,988	20
Effective Length (mi)	3.4857	3.3311	4
Predicted Crashes			
Total Crashes	309.34	148.64	52
Fatal and Injury Crashes	92.51	47.84	48
Property-Damage Only Crashes	216.82	100.79	54
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)			
Total Travel (100 million veh-mi)	2.29	1.70	26
Travel Crash Rate	228	153	33
Travel Fatal and Injury Crash Rate	70.00	49	30
Travel Property-Damage Only Crash Rate	158	103	35

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 131 shows the results of the IHSDM analysis for the I-610 freeway. Traffic diverting from the mainlanes to collector-distributor ramps in the Build condition causes a reduction in average AADT compared to the No-Build. Effective length is slightly different between the No-Build and Build due to realignment near the I-45 interchange. The IHSDM results indicate that the travel crash rate will reduce from 232 to 165 crashes per 100 million vehicle-miles and the number of expected fatal and injury crashes reduce from 62.91 to 40.13 crashes. The crash rate for the fatal and injury crashes also reduces from 71 to 50 per million vehicle-miles travelled. With the proposed improvements, there is a 40% reduction in the total crashes and a 29% reduction in the travel crash rate per 100 million vehicle-miles.

The safety improvements in the Build condition is attributed to the reduction in average AADT, eliminating left-side exits and entrances, and improved weaving distances. Furthermore, the IHSDM analysis shows that the locations with the highest crash rates in the No-Build condition are near the I-45 interchange area, where the alignment curves around the direct connectors. In the Build, the alignment straightens out these horizontal curves with the redesign of the of the I-610/I-45 interchange. IHSDM segment results show relatively low predicted crash rates at this location (Station 1554+00 to 1559+00).

Table 131: Predicted Crash Rates on I-610 for No-Build and Build Alternatives

	2045		Percent Reduction (%)
	No-Build	Build	
Average AADT (vpd)	319,825	249,650	22
Effective Length (mi)	2.4419	2.5237	-3
Predicted Crashes			
Total Crashes	222.82	132.76	40
Fatal and Injury Crashes	62.91	40.13	36
Property-Damage Only Crashes	159.92	92.63	42
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)			
Total Travel (100 million veh-mi)	1.83	1.54	16
Travel Crash Rate	232	165	29
Travel Fatal and Injury Crash Rate	71	50	30
Travel Property-Damage Only Crash Rate	161	116	28

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 132 shows the results of the IHSDM analysis for the SH 288 freeway. Reduction in average AADT in the Build condition is primarily due to managed lanes in the Build condition which carry more traffic than the No-Build condition. This is a result of capacity added to the southbound direction beginning with the on-ramp near Stuart Street. The difference in effective length between No-Build and Build is due to freeway and ramp realignment within the project limits. Additionally, the effective length in the Build condition does not include any speed change lanes since all ramps connect with the freeway as a lane add or lane drop. The IHSDM results show that the travel crash rate is projected to reduce from 277 to 112 crashes per 100 million vehicle-miles and the number of expected fatal and injury crashes reduce from 18.58 to 14.79 crashes. The crash rate for the fatal and injury crashes also reduce from 84 to 32 per million vehicle-miles travelled. Additionally, the Build condition shows a 22% reduction in the total crashes and a 60% reduction in the travel crash rate per 100 million vehicle-miles is seen on SH 288.

The safety improvements in the Build condition can be attributed to the reduction in average AADT, and improved lane balance. For example, the No-Build I-69 northbound to SH 288 southbound direct connector is added with an acceleration lane of approximately 300 feet. This occurs at the same location as a two-lane add from the I-69 southbound direct connector which results in many simultaneous lane change movements. In the Build condition, both ramp connections at this freeway segment are lane adds and they are spaced 550 feet apart. IHSDM results for the Build condition in this area show lower predicted crash rates in the Build compared to the No-Build for these freeway segments (Station 1013+00 to 1022+00).

Table 132: Predicted Crash Rates on SH 288 for No-Build and Build Alternatives

	2045		Percent Reduction (%)
	No-Build	Build	
Average AADT (vpd)	273,641	182,569	33
Effective Length (mi)	0.8712	0.6862	21
Predicted Crashes			
Total Crashes	65.38	51.02	22
Fatal and Injury Crashes	18.58	14.79	20
Property-Damage Only Crashes	46.80	36.23	23
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)			
Total Travel (100 million veh-mi)	0.49	0.46	6
Travel Crash Rate	277	112	60
Travel Fatal and Injury Crash Rate	84	32	62
Travel Property-Damage Only Crash Rate	193	79	59

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 133 shows the percent reduction results of all the roadways where an IHSDM analysis was completed. All corridors showed an improvement from No-Build to Build conditions, with I-10 showing an over 50% reduction in total crashes and an almost 50% reduction in fatal and injury crashes. Overall, in comparison of the 2045 No-Build versus the 2045 Build, the 2045 Build improves safety along the corridors in the project area.

Table 133: Percent Reduction by Corridor

	Percent Reduction (%)				
	I-45	I-69	I-10	I-610	SH 288
Average Mainlane AADT (vpd)	7	8	20	22	33
Effective Length (mi)	-8	-9	4	-3	21
Total Crashes	30	28	52	40	22
Fatal and Injury Crashes	28	22	48	36	20
Property-Damage Only Crashes	31	31	54	42	23
Total Travel (100 million veh-mi)	4	4	26	16	6
Travel Crash Rate (crashes per 100 million vehicle-miles)	29	29	33	29	60
Travel Fatal and Injury Crash Rate (crashes per 100 million vehicle-miles)	29	29	30	30	62
Travel Property-Damage Only Crash Rate (crashes per 100 million vehicle-miles)	29	28	35	28	59

The safety improvements shown in the IHSDM analysis are partly due to a reduction in average AADT in the Build condition for each freeway corridor. This reduction in average AADT can be attributed to the addition of managed lanes, the downtown connector, and collector-distributor roadways. Because AADT is one of the primary causes of crashes, it follows that a reduction in volume would result in improved safety outcomes on the freeway. A portion of those reduction in crashes would be shifted to the managed lanes, downtown connector, and collector-distributor roadways which cannot be analyzed with the IHSDM software. On these facilities, TxDOT design standards were applied wherever feasible to ensure safe operations. Additionally, operations on these facilities were reviewed in the Vissim models to ensure that congestion did not cause potential safety issues by queueing to the mainlanes. This was reviewed in detail at the I-610 collector-distributors, where two ramps combine and then two ramps split off resulting in many lane change movements. Differences in average AADT will have a greater impact on the number of predicted total crashes compared to the predicted crash rate. However, crash rates will be affected as well based on AADT thresholds within the CMF formulas found in the HSM. The reduction in crashes and crash rate shown in the model results are greater than the percent reduction in AADT.

5.5.4 Other Safety Benefits

In addition to the safety improvements listed above, the proposed improvements will increase the safety within the project limits by reducing the number of merge points, weaves with distances less than 1,500 feet, the number of diverge points without a deceleration lane, and eliminating left-side exits and entrances. **Table 134** compares the number of merges, weaves with distances less than 1,500 feet, the number of diverge points without a deceleration lane, and the number of left-side exits and entrances in the No-Build and Build Conditions.

Table 134: Geometric Improvement Safety Benefits No-Build vs. Build

Geometry Change	No-Build	Build	Percent Reduction
Weaves with Distances less than 1,500 feet	13	7	46%
Number of Merges	22	12	45%
Number of Diverge Points without a Deceleration Lane	17	6	65%
Number of Left-Side Exits/Entrances	21	15 (4 for MaX lane)	29%

The TxDOT Roadway Design Manual requires weaving distances to be greater than 1,500 feet. FHWA prefers weaves greater than 2,000 feet. The proposed improvements increase the weaving distances greater than 2,000 feet at all locations except for seven locations which are less than 1,500 feet and an additional ten locations which are between 1,500 and 2,000 feet.

There are 21 left-hand exits and entrances in the No-Build condition. Section 5.5.2 describes each of these left-hand ramp locations and how they are addressed in the Build condition.

6.0 **Compliance with Policy Point # 1**

The need being addressed by the request cannot be adequately satisfied by existing interchanges to the Interstate, and/or local roads and streets in the corridor can neither provide the desired access, nor can they reasonably be improved (such as access control along surface streets, improving traffic control, modifying ramp terminals and intersections, adding turn bays or lengthening storage) to satisfactorily accommodate the design-year traffic demand (23 CR 625.2(a)).

There is not a reasonable alternative to the proposed improvements, as there is not comparable facilities to the I-45, I-10, I-69, I-610, and SH 288 corridors, which could satisfactorily accommodate the 2045 design year traffic demand. Modifications and additions of turn bays or storage are included in the proposed Build, but those improvements alone do not address the base year (2018) and future (2045) capacity needs.

The proposed project serves a regional need by providing improved operations through the regional area. This improved operation facilitates access to I-45, one of the key regional and inter-regional connections, by providing additional capacity and increasing movement along the corridor. Early studies identified the need for capacity on all freeways in the project area. The improvements proposed in this project are consistent with H-GAC's 2040 and 2045 Regional Transportation Plan. Additionally, the future year analyses for the proposed project utilize information from the H-GAC's 2040 and 2045 Regional Transportation Plans, which includes all known projects in the planning horizon.

Current traffic volumes are expected to increase within the project limits according to the Houston-Galveston Area Council (H-GAC) 2040 and 2045 Regional Transportation Plan, making the corridors within the project limits congested. Parallel facilities are already built out and operational improvements on the surface streets cannot accommodate projected traffic volumes. There are several reasons this set of improvements is proposed, which focus around the project area purpose and need.

6.1 *Purpose and Need*

The purpose of the proposed I-45 NHHIP improvements is to implement an integrated system of transportation improvements with the goal of providing facilities with additional capacity to accommodate projected travel demand by incorporating transit opportunities, travel demand and management strategies, and flexible operations. Such a facility would help manage congestion, improve mobility, enhance safety, and provide travellers with options to reach their destinations. Improvements include:

- Realignment of I-45 to be parallel with I-10 and US 59/I-69.
- Depression of US 59/I-69 from Spur 527 to Downtown.
- Addition of I-10 MaX Lanes from I-45 to US 59/I-69.

- Removal of the existing elevated portion of I-45 parallel to Pierce Street

These features will result in improved access to and from Downtown, the Hardy Toll Road, and SH 288.

The proposed project is needed to reduce/eliminate current interstate operational issues. The existing congestion is a result of the combination of the following components:

- High number of lane changes and ramp merging.
- Queue spillbacks into mainlanes, as the current frontage road configuration minimizes available queue storage on frontage roads at cross-streets.
- Weaving operations between entering and exiting traffic on the mainlanes.

The proposed transportation improvements are also needed to address the following transportation issues:

- Inadequate capacity for existing and future traffic demands.
- Average daily traffic volumes are projected to increase.
- The current single lane, reversible high-occupancy vehicle (HOV) lane along I-45 serves traffic in only one direction during peak periods.
- Evacuation effectiveness on I-45 during a hurricane or other regional emergency would be limited at its present capacity.
- Roadway design deficiencies include inadequate storm water drainage in some locations, potentially compromising the operational effectiveness of I-45 as an evacuation route because of high water lane closures.
- Forecasts for commuter service indicate that managed lanes would be needed on I-45 to support commuter traffic and express bus service.

6.2 *Interest of the Public*

This proposed project is in the best interest of the public as it will result in improved overall mobility and safety within the corridor.

There are several grade-separated cross streets in the project area, however only select cross streets have one or more ramp access points adjacent to the freeway. Operational deficiencies have been identified and often occur due to interchange and ramp spacing associated with diamond ramp configurations. This can result in frontage road traffic (local trips) backing up into the mainlanes, impacting regional traffic.

Statistics from the Vissim operational traffic model runs and predictive safety analyses indicate that the proposed improvements are expected to:

- Improve level of service by producing a reduction in average vehicle delay through the project area.
- Improve intersection operations through implementation of the X-pattern ramp configuration, lane balance, and addition of transportation system management improvements in several locations throughout the corridor.
- Provide operational measures of effectiveness that exceed the No-Build condition for projected 2045 traffic demand due to the combination of additional mainlane, auxiliary lanes, reconfiguration of freeway interchanges with collector-distributor systems, and addition of express (HOV) lanes.
- Reduction in crashes with the improved freeway alignment, ramp spacing, and safety features in the project area.

6.3 *Regional Transportation Needs*

The proposed project serves a regional need by providing improved operations through the regional area. This improved operation facilitates access to I-45 by providing continuous routes and increasing north-south movement along the corridor.

6.4 *Regional Long-Range Plan Compliance*

The future year analyses for the proposed project utilize information from the Houston-Galveston Area Council (H-GAC) 2040 and 2045 Regional Transportation Plan (RTP), which includes all known projects in the planning horizon. This proposed I-45 NHHIP is included in the H-GAC RTP.

6.5 *Cross Street Impact*

The proposed change in access includes upgrades to frontage road intersections and cross streets for the projects area of influence identified in the operational improvements analysis. The improvements were coordinated with the City of Houston and optimized with proposed intersection geometry. The City of Houston operate the cross-street traffic signals.

7.0 Compliance with Policy Point # 2

The need being addressed by the request cannot be adequately satisfied by reasonable transportation system management (such as ramp metering, mass transit, and HOV facilities), geometric design, and alternative improvements to the Interstate without the proposed change(s) in access (23 CFR 6.25.2(a))

Transportation system management and geometric design concepts are included in the proposed set of improvements. Alternative improvements to the Interstate facilities would not address the current and 2045 design-year traffic demand and safety needs. A range of alternatives were considered within the project limits. These included the No-Build, Transportation System Management (TSM) and Transportation Demand Management (TDM) alternatives, and non-freeway improvements. These alternatives were analyzed to arrive at the preferred Build alternative. Stakeholder coordination was performed during this process to receive feedback on alternatives considered and selected. The schematic design plans reflecting the preferred alternative selected by TxDOT was utilized for this analysis. The proposed Build schematic is included in **Appendix P**.

7.1 *No-Build Alternative*

The No-Build Alternative represents the case where the proposed project improvements are not constructed. There would be no geometric changes to the I-45, I-69, I-10, I-610 and SH 288 corridors and only maintenance/repair work would occur in the project limits. The No-Build Alternative is carried forward in this document as the baseline against which the Build Alternatives are compared.

Though the No-Build alternative avoids ROW, environmental, and other construction-related impacts, it does not rectify the operational and safety deficiencies along the corridors. The growth projected in Harris County and surrounding areas is expected to generate traffic which would exceed the capacity of I-45, I-69, I-10, I-610 and SH 288 corridor. The expected congestion would also result in degraded safety. For this reason, the No-Build Alternative would not satisfy the purpose and need for the project.

7.2 Transportation System Management

Transportation System Management (TSM) improvements were included in the preferred alternative. However, TSM improvements alone are not sufficient due to the deficiencies in mainlane operations, corridor capacity, and the decreased ability of the ramp pattern and spacing to handle weaving traffic. TSM improvements were incorporated into the preferred alternative which included signal timing optimization, lengthening merge areas, added turn bays, lane assignment adjustments, and revised signage.

The proposed project does not preclude ramp metering, Intelligent Transportation System (ITS) and additional TSM strategies from being applied on future projects. ITS TSM strategies such as active traffic management and dynamic message signs are not precluded from this project or future projects. The Houston ITS Master Plan proposes several ITS projects which include adding and consideration of new ITS equipment such as CCTV's, DMS (including lane assignment) and fiber throughout the Houston area. The proposed ITS improvements seek to mitigate the non-recurring congestion caused by incidents such as stalled vehicles and crashes. They enable authorities to identify and resolve incidents more quickly and provide travelers with information regarding alternate travel routes, times, or modes in the event of an incident, evacuation or other emergency. These ITS projects will be considered during the detailed design. However, ITS improvements alone would not address the recurring congestion anticipated in the corridor.

7.3 *Transportation Demand Management*

Transportation Demand Management (TDM) alternatives mitigate congestion by reducing vehicular travel and accommodating and/or increasing transit, bicycle, and pedestrian travel. The proposed project provides sidewalks adjacent to the frontage roads and accommodates bicycles on the frontage roads and cross-street crossing which is consistent with H-GAC's 2040 Regional Pedestrian & Bicycle Plan.

The project is located within limits of the Houston METRO Transit service with routes servicing the following cities and locations:

- Bellaire
- Bunker Hill Village
- El Lago
- Hedwig Village
- Hilshire Village
- Houston
- Humble
- Hunters Creek
- Katy
- Missouri City
- Piney Point
- Southside Place
- Spring Valley
- Taylor Lake Village
- West University Place
- Major portions of unincorporated Harris County are also included

Existing transit service lines will be maintained within the project limits. In addition, the proposed MaX lanes (HOV and express lanes) provide additional capacity and expected travel time improvements to Houston METRO routes. The proposed lanes add bidirectional 24-hour use, where there is currently only capacity for commuter directions.

TDM strategies would continue being pursued as part of the regional Congestion Mitigation Process, and as part of the regional plan to achieve air quality attainment. However, TDM strategies are not expected to result in a significant improvement in congestion or safety. Due to the expected growth along the project corridor, TDM strategies were eliminated as a stand-alone alternative.

7.4 Alternatives Considered

The alternatives for I-45 NHHIP have gone through an iterative process over the last 15 years. There was initial, planning level, screening of alternatives using the H-GAC travel demand models, following by a more robust evaluation of alternatives for the environmental impact statement. The alternatives have been refined with public and stakeholder input throughout the project development. For this report's alternative analysis, the operational and safety analyses are performed with the No-Build and Build (preferred alternative) scenarios.

The universe of alternatives for Segments 2 and 3 were developed in a comprehensive, multi-year process. The process undertaken to develop these alternatives is summarized below and a detailed report, NHHIP Alternatives Analysis: Engineering and Traffic Criteria is available in Appendix K. Additionally, Chapter 5.0 of this IAJR report details the alternative analysis procedures and results. In summary, the alternative analysis process included the following steps:

- Identify the Universe of Alternatives
    - Alternatives from prior Studies
    - Develop Alternatives via Public and Stakeholder Meeting
    - Study Team developed additional Alternatives
- Evaluate Alternatives
    - Develop Methodology to screen the alternatives
    - Initial Screening: Reduce the Universe of Alternatives to six (6) per segment
    - Develop the six Alternatives to conduct a more detail screening
    - Detailed screening to develop three (3) Preliminary Alternatives:
    - Structural feasibility
    - Evaluate using Houston-Galveston Area Council (H-GAC) Traffic Demand Model (TDM)
    - Seek Input on the Preliminary Alternatives from various Stakeholders
        - Public Meetings
        - Agency meetings
- Determine the Proposed Recommended Alternative

The scenarios analyzed during the alternative analysis included:

- 2025 No-Build
- 2025 Build
- 2045 No-Build

- 2045 Build

An iterative process of Build refinement was completed to improve the schematic upon detailed analysis.

7.5 Preferred Alternative

The major improvements in the preferred alternative include the following:

- Removal of existing I-45 Pierce Elevated – replaced by downtown ramp connections for local access and connectivity with downtown.
- I-45 realignment to be parallel with I-10 north of downtown and parallel with I-69 east of downtown until it turns south to the existing I-45 alignment southeast of the downtown area.
- Addition of a pair of HOV/express lanes (MaX) on I-10 that terminate in downtown.
- Addition of a pair of HOV/express lanes (MaX) on I-45 that terminate in downtown.
- Addition of general purpose lanes on I-45 in Segment 2.
- Reconstruction of the I-45 at I-610 interchange to provide traditional right lane exits and collector-distributor parallel facilities.
- Reconstruction of the I-45 at I-10 interchange with the realignment of I-45 and improvement in direct connector facilities.
- Reconstruction of the I-69 at I-10 interchange with fully directional connectors and connections to the future Hardy Toll Road extension.
- Removal of the fourth leg of the I-69 at I-45 interchange with the Pierce Elevated section removal.
- Frontage road and local intersection improvements, like turn bays, retiming of signals, and access management at intersections, cross streets, and frontage roads.

In addition to the major improvements, there are a series of access changes related to local ramp access. Each station change is presented in **Tables 76-79** and was considered to improve ramp spacing, while maintaining an adequate level of access to the freeway facilities. The proposed Build schematic is provided in **Appendix P**.

8.0 Compliance with Policy Point # 3

An operational and safety analysis has concluded that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facility (which includes main lane lanes, existing, new, or modified ramps, and ramp intersections with crossroad) or on the local street network based on both the current and the planned future traffic projections. The analysis should, particularly in urbanized areas, include at least the first adjacent existing or proposed interchange on either side of the proposed change in access (23 CFR 625.2(a), 655.603(d), and 777.111(f)). The crossroads and the local street network, to at least the first major intersection on either side of the proposed change in access, should be included in this analysis to the extent necessary to fully evaluate the safety and operational impacts that the proposed change in access and other transportation improvements may have on the local street network (23 CFR 625.2(a) and 655.603(d)). Requests for proposed change in access should include a description and assessment of the impacts and ability of the proposed changes to safely and efficiently collect, distribute, and accommodate traffic on the Interstate facility, ramps, intersection of ramps with crossroad, and local street network (23 CFR 625.2(a) and 655.603(d)). Each request must also include a conceptual plan of the type and location of the signs proposed to support each design alternative (23 U.S.C. 109(d) and 23 CFR 655.603(d)).

An operational and safety analysis was performed for the proposed changes in access for the project area. The operational analysis was performed using Vissim (version 9.0-10) to evaluate network and freeway mainlane operations and signalized intersection operations. The evaluation of the mainlane operations was completed in Vissim which included all roadway components (freeway mainlanes, ramps) within the project limits. The safety analysis was performed using the Highway Safety Manual to identify CMFs and FHWA 's Interactive Highway Safety Design Model (IHSDM) for predictive analysis of crashes. Together, these tools were used to capture mainlane, ramp, and arterial operational and safety analysis necessary to assemble a complete alternative comparison. A detailed safety review of each project segment was also completed for items that addressed safety deficiencies. For details on the methodology followed, please refer to Chapter 2.0.

8.1 *Summary of Operational & Safety Analysis*

The operational and safety analysis has concluded that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facilities or on the local street network based on both the current and the planned future traffic projections. For details on the existing and future condition analysis, please refer to Chapter 3.0 and Chapter 4.0, respectively. The proposed improvements are expected to improve the operational and safety characteristics of the project area. **Figure 83** shows the improvement in total system delay between No-Build and Build for each analysis scenario.

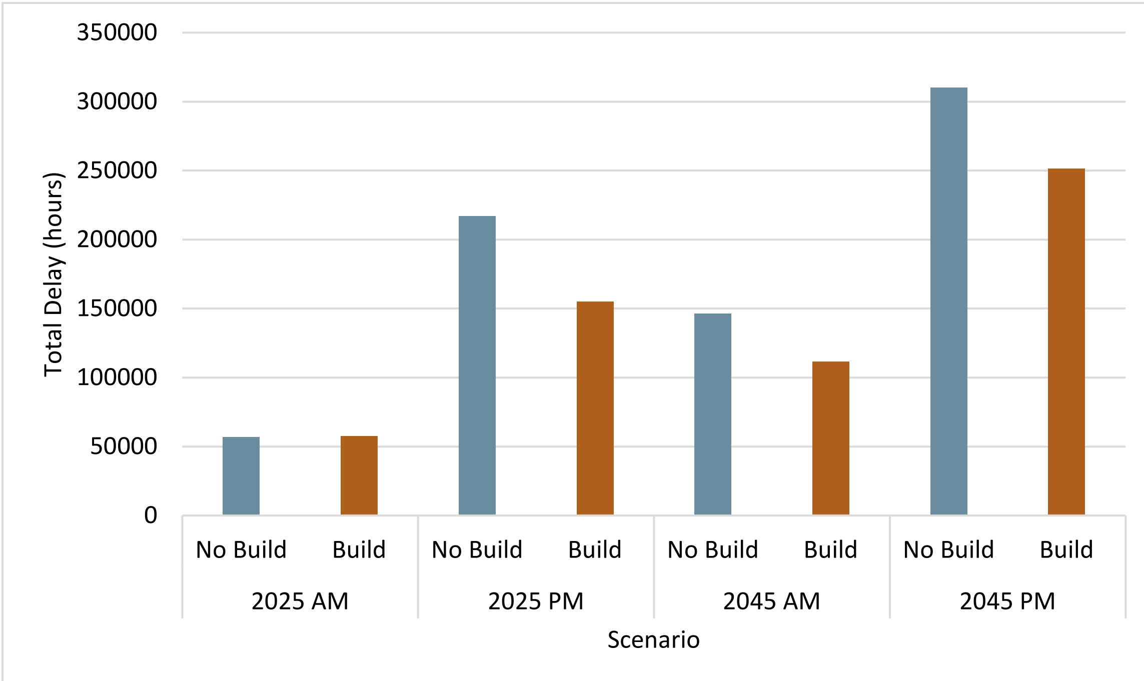

Figure 83: No-Build vs. Build Total Delay

Table 135 shows the Build network results. **Figures 84-86** compare the No-Build and Build network results for comparison by scenario. As shown, the network average speed increases, VMT increases, and latent demand decreases across all scenarios. **Chapter 5.0** includes detailed travel time and segment speed comparisons between No-Build and Build alternatives. The results show general improvement at a majority of locations. The cause for areas in the Build networks having some MOEs show a lack of improvement is due to the metering of traffic in the No-Build simulations, which is apparent in the latent demand and VMT differences.

Table 135: Build 2025 and 2045 Vissim Results

		Average Speed (mph)	Vehicle Miles	Latent Demand (veh)
2025	AM	35.3	1,403,276	27,728
	PM	27.9	1,584,787	56,771
2045	AM	31.7	1,501,503	59,399
	PM	26.0	1,636,937	107,027

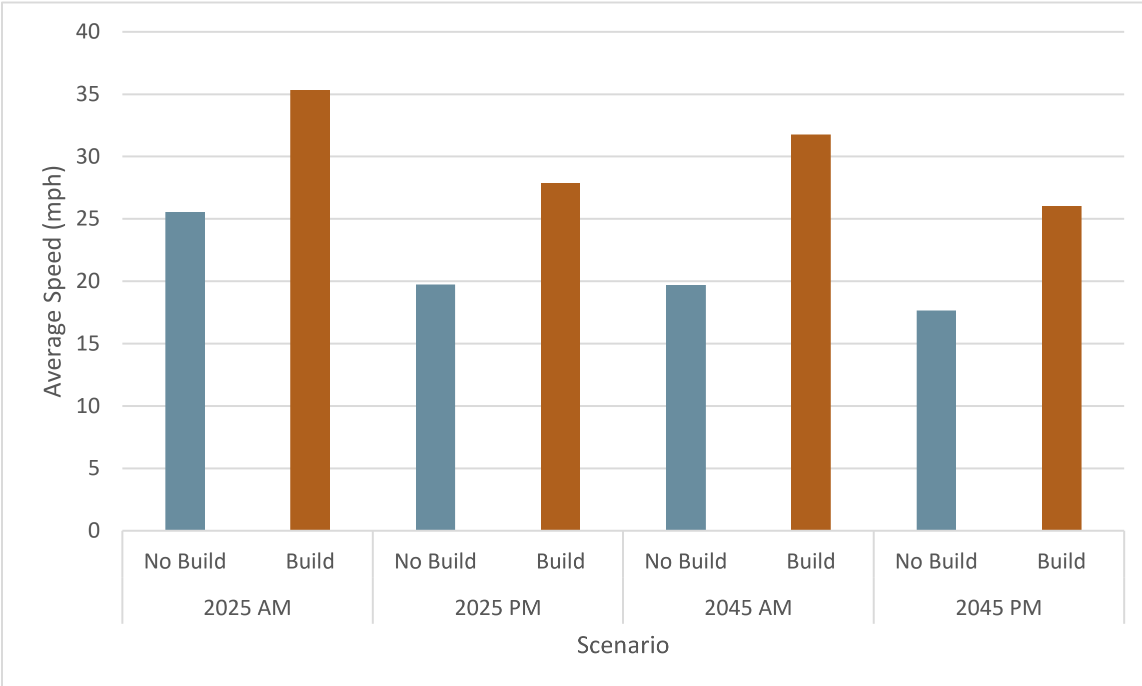

Figure 84: Average Speed No-Build vs. Build

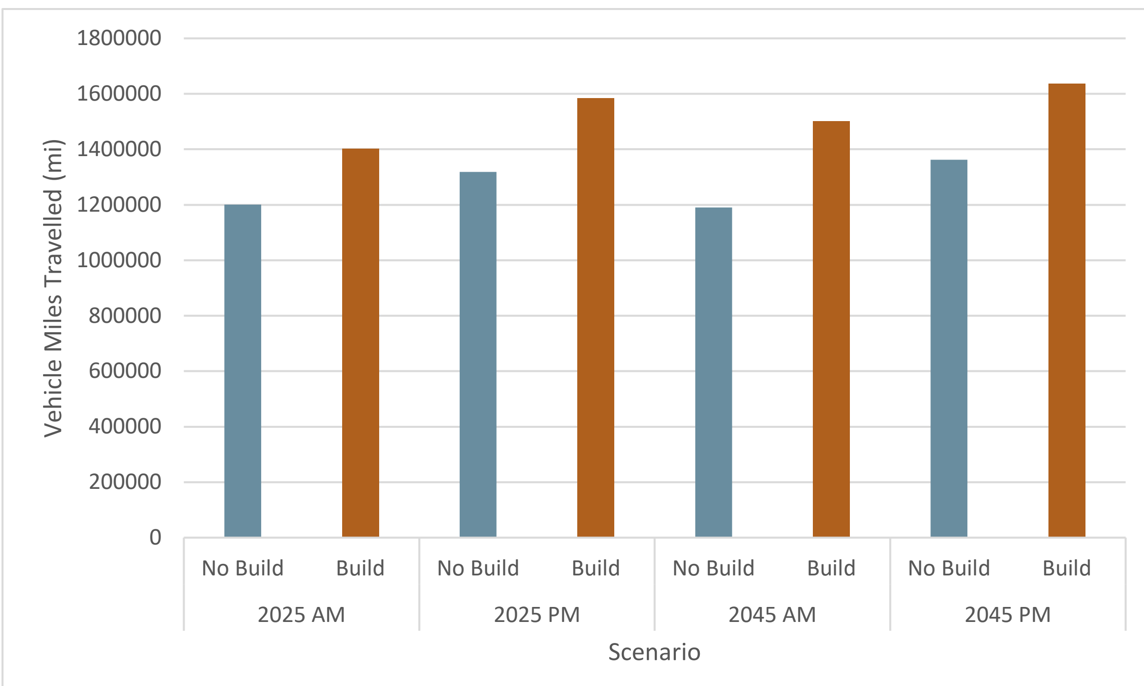

Figure 85: Vehicle Miles Travelled No-Build vs. Build

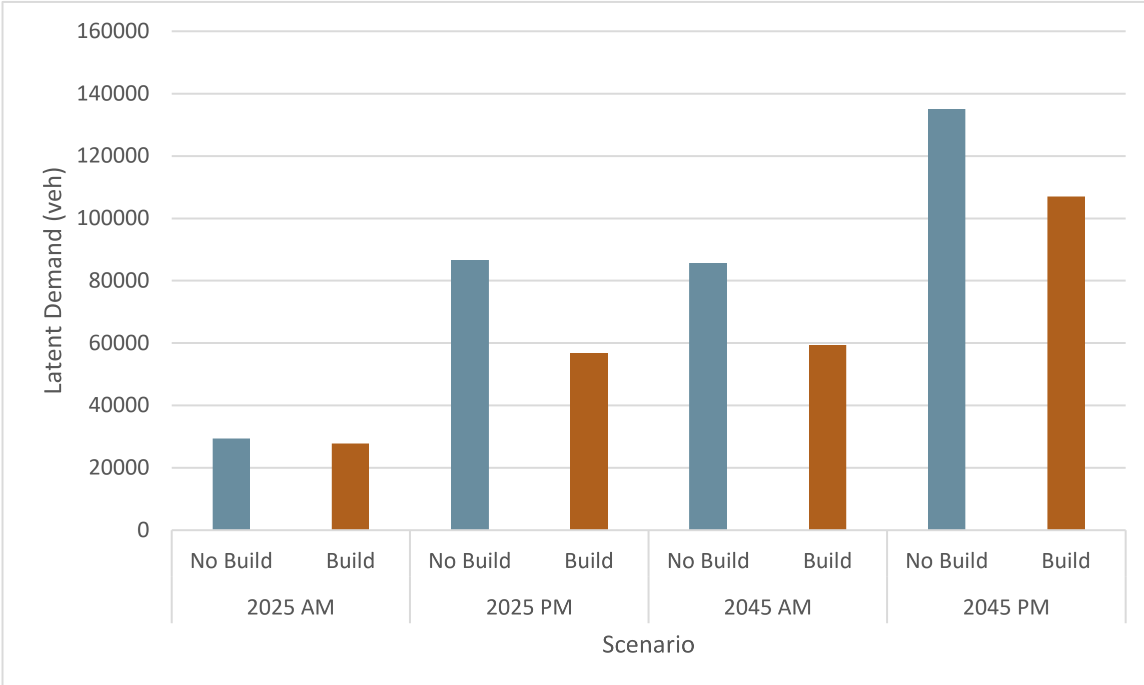

Figure 86: Latent Demand No-Build vs. Build

Substantial congestion would be expected at most project locations by 2045 in the No-Build Alternative, with high vehicle density anticipated at several locations. The 2045 Build network reduces the total network delay of a typical AM and PM peak period day by over 70,000 hours. This analysis demonstrates the adjacent street network would not be negatively impacted by the Build Alternative, and local traffic operations would substantially improve.

In addition to the network results presented above, **Table 136** and **Table 137** show the 2025 and 2045 travel time comparison and percent improvement between No-Build and Build for each freeway corridor.

Table 136: 2025 Vissim Travel Time Results – No-Build vs. Build

	Average No-Build AM Peak Period Travel Time (min)	Average Build AM Peak Period Travel Time (min)	Percent Improvement	Average No-Build PM Peak Period Travel Time (min)	Average Build PM Peak Period Travel Time (min)	Percent Improvement
I-45 Southbound (Cavalcade St to Scott St)	10.0	7.3	26%	12.3	7.2	41%
I-45 Northbound (Scott St to Cavalcade St)	6.8	7.4	-9%	6.6	7.5	-13%
I-69 Southbound (Quitman St to SH 288)	19.5	6.8	65%	13.4	4.6	66%
I-69 Northbound (SH 288 to Quitman St)	12.3	7.2	41%	12.3	7.2	41%
I-10 Eastbound (I-45 to Greg St)	2.3	2.5	-7%	3.0	2.5	17%
I-10 Westbound (Greg St to I-45)	12.9	2.6	80%	20.2	6.7	67%
I-610 Eastbound (Shepherd Dr to Irvington Blvd)	4.5	3.7	17%	6.2	6.5	-5%
I-610 Westbound (Irvington Blvd to Shepherd St)	6.4	3.2	50%	6.4	3.4	48%

Table 137: 2045 Vissim Travel Time Results – No-Build vs. Build

	Average No-Build AM Peak Period Travel Time (min)	Average Build AM Peak Period Travel Time (min)	Percent Improvement	Average No-Build PM Peak Period Travel Time (min)	Average Build PM Peak Period Travel Time (min)	Percent Improvement
I-45 Southbound (Cavalcade St to Scott St)	15.4	8.9	42%	12.6	7.2	43%
I-45 Northbound (Scott St to Cavalcade St)	6.8	8.1	-20%	8.0	7.5	7%
I-69 Southbound (Quitman St to SH 288)	24.4	7.4	70%	20.7	5.0	76%
I-69 Northbound (SH 288 to Quitman St)	12.6	7.2	43%	12.6	7.2	43%
I-10 Eastbound (I-45 to Greg St)	2.3	2.5	-5%	2.5	2.5	3%
I-10 Westbound (Greg St to I-45)	23.0	3.2	86%	19.4	2.9	89%
I-610 Eastbound (Shepherd Dr to Irvington Blvd)	6.1	3.8	38%	6.5	6.1	7%
I-610 Westbound (Irvington Blvd to Shepherd St)	6.7	3.2	52%	6.5	3.4	49%

As shown in **Table 136** and **Table 137**, travel times improve for nearly every corridor in both peak periods, travel times improve in the Build condition compared to the No-Build condition. The only corridors that show increases in travel time are I-45 northbound, I-10 eastbound, and I-610 eastbound. The increase is caused by several contributing factors. The first is that the I-45 and I-10 corridors increase in total length in the Build configuration, so travel time at free-flow speed will increase. Next, for these three corridors, the Build configuration allows more vehicles to be processed compared to the No-Build configuration. More vehicles can operate on these corridors with less latent demand. Finally, I-45 northbound and I-10 eastbound experienced bottlenecks at the beginning and end areas of the travel routes in the Vissim simulation, where the corridor tied to the existing roadway network. Future added capacity projects adjacent to the project limits would improve operational efficiency.

In addition to analysis of Interstate operations, the local intersections impacted by access to and from the interstate were analyzed. **Table 138** summarizes the intersection analysis results.

Table 138: 2045 Intersection Summary Results - No-Build vs. Build

Scenario	Number of Intersections with >55 sec/veh Average Vehicle Delay	
	No-Build	Build
2025 AM	2	0
2025 PM	9	11
2045 AM	5	6
2045 PM	15	12

As seen in **Table 138**, the number of intersections with average vehicle delay greater than 55 seconds is similar between the No-Build and Build networks. This result indicates that the Build configuration does not adversely impact the local network. Detailed discussion of each Build network intersection with greater than 55 seconds of delay is included in Section 5.3.2.5, with most less than the delay from the No-Build scenario. Additionally, the Build intersections are able to operate at similar levels even with the greater VMT experienced in each Build network compared to the No-Build.

Table 139 summarizes the percent reduction in crashes that is predicted for year 2045 along each I-10, SH 288, I-45, I-69 and I-610. Sections 5.5.1 and 5.5.2 also describe applicable crash modification factors and detailed safety issue discussion, respectively.

Table 139: Predicted Percent Reduction from No-Build to Build (2045)

	I-10	SH 288	I-45	I-69	I-610
Mainlane AADT (vpd)	20%	33%	7%	8%	22%
Effective Length (mi)	4%	21%	-8%	-9%	-3%
Predicted Crashes					
Total Crashes	52%	22%	30%	28%	40%
Fatal and Injury Crashes	48%	20%	28%	22%	36%
Property-Damage Only Crashes	54%	23%	31%	31%	42%
Predicted Travel Crash Rate (crashes per 100 million vehicle-miles)					
Total Travel (100 million veh-mi)	26%	6%	4%	4%	16%
Travel Crash Rate	33%	60%	29%	29%	29%
Travel Fatal and Injury Crash Rate	30%	62%	29%	29%	30%
Travel Property-Damage Only Crash Rate	35%	59%	29%	28%	28%

The analysis included the limits as described in the Area of Influence (**Chapter 1.0- Section 1.5**) which has at least the first adjacent existing or proposed interchange on either side of the proposed change in access. Also included in the operational analysis were the crossroads and the local street network and the build network, to at least the first major intersection on either side of the proposed change in access, as seen in **Figure 3** and **Figure 55**. This was done to fully evaluate the operational impacts that the proposed change in access and other transportation improvements may have on the local street network. Crash analysis at the cross street intersections and frontage roads were included and considered in the safety analysis.

Chapter 5.0 (Alternatives) includes a detailed description and assessment of the impacts and ability of the proposed changes to safely and efficiently collect, distribute and accommodate traffic on the Interstate facilities, ramps, intersection of ramps with crossroad, and local street network. Within **Chapter 5.0**, there is a description on the alternative analysis methodology followed and how the preferred alternative (build), which details the proposed access changes, was chosen.

The proposed guide and small signs proposed to support the proposed improvements design alternative will comply with the Texas Manual of Uniform Traffic Control Devices (MUTCD).

9.0 Compliance with Policy Point # 4

The proposed access connects to a public road only and will provide for all traffic movements. Less than “full interchanges” may be considered on a case-by-case basis for applications requiring special access, such as managed lanes (e.g., transit, HOVs, HOT lanes) or park and ride lots. The proposed access will be designed to meet or exceed current standards (23 CFR 625.2(a), 625.4(a)(2), and 655.603(d)). In rare instances where all basic movements are not provided by the proposed design, the report should include a full-interchange option with a comparison of the operational and safety analyses to the partial-interchange option. The report should also include the mitigation proposed to compensate for the missing movements, including wayfinding signage, impacts on local intersections, mitigation of driver expectation leading to wrong-way movements on ramps, etc. The report should describe whether future provision of a full interchange is precluded by the proposed design.

At most locations, the proposed access provides for all movements and only connects to public roadways. A summary of all freeway to freeway interchange movements is shown in **Table 140** below with the proposed design.

Table 140: Freeway to Freeway Interchange Movements

Freeway to Freeway Interchange	No-Build Movements	Build Movements
I-45 at I-610 – Segment 2	Full Interchange - All eight major freeway to freeway movements provided	Full Interchange - All eight major freeway to freeway movements provided
I-45 at I-10 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Partial Interchange – I-10 WB to I-45 SB and I-45 NB to I-10 EB/WB adjusted access to consolidate movements through I-69.
I-45 at I-69 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Partial Interchange – I-69 SB to I-45 NB and I-45 SB to I-69 NB adjusted access to consolidate movements through I-10.
I-69 at I-10 – Segment 3	Full Interchange - All eight major freeway to freeway movements provided	Full Interchange - All eight major freeway to freeway movements provided
I-69 at SH 288 – Segment 3	Five major freeway to freeway movements provided	Five major freeway to freeway movements provided
I-69 at Spur 527 – Segment 3	Two major freeway to freeway movements provided	Two major freeway to freeway movements provided

The I-45 at I-10 interchange is defined as partial because two movements from interstate to interstate are not direct. They include:

- **I-10 WB to I-45 SB** – This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-10 WB to I-69 SB, followed by a slip ramp to I-45 SB. Vehicles making this route movement would not have to change lanes between the route from I-10 westbound to I-45 SB. The Build operations were reviewed in detail and show improved results from the Existing/No-Build I-10 WB to I-45 SB movement.
- **I-45 NB to I-10 EB** - This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-45 NB to I-69 NB, followed by a direct connector from I-69 NB to I-10 EB. Once on I-69, vehicles making this route movement would not have to change lanes to continue onto the I-69 NB to I-10 EB direct connector. The Build operations were reviewed in detail and show improved results from the Existing/No-Build I-45 NB to I-10 EB movement.

Table 141 summarizes the operational and safety impacts of the partial interchange.

Table 141: I-45 at I-10 Partial Interchange Movements Operations and Safety

Movement	Change	Operational Results (min)	Safety Impact
I-10 WB to I-45 SB	Accommodated via I-10 WB to I-69 SB to I-45 SB	No-Build 2045 Travel Time (AM/PM) – (14.1/15.4 min) Build 2045 Travel Time (AM/PM) – (2.4/2.6 min)	Eliminates low design speed direct connector and Build improves design speed for movement. No weave lane changes required in Build schematic.
I-45 NB to I-10 EB	Accommodated via I-45 NB to I-69 NB to I-10 EB	No-Build 2045 Travel Time (AM/PM) – (6.1/8.6 min) Build 2045 Travel Time (AM/PM) – (6.8/6.4 min)	Eliminates direct connector that has merge on the structure followed by left lane addition. No weave lane changes required in Build schematic.

The I-45 at I-69 interchange is defined as partial because two movements from interstate to interstate are not direct. They include:

- **I-69 SB to I-45 NB** – This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-69 SB to I-10 WB, followed by a slip ramp to I-45 NB. Vehicles making this route movement would have to change four lanes over a 1.3-mile section. The traffic demand for this movement was evaluated in the microsimulation model and showed no operational issues.
- **I-45 SB to I-69 NB** - This movement is altered from a direct connector in the Existing/No-Build condition to being provided by direct connection from I-45 SB to I-10 EB, followed by a direct connector to I-69 NB. Vehicles making this route movement would have to change two lanes over a 1.3-mile section. The traffic demand for this movement was evaluated in the microsimulation model and showed no operational issues.

Table 142 summarizes the operational and safety impacts of the partial interchange.

Table 142: I-45 at I-69 Partial Interchange Movements Operations and Safety

Movement	Route Change	Operational Results	Safety Impact
I-69 SB to I-45 NB	Accommodated via I-69 SB to I-10 WB to I-45 NB	No-Build 2045 Travel Time (AM/PM) – (14.6/13.8 min) Build 2045 Travel Time (AM/PM) – (3.0/2.6 min)	Eliminates low design speed direct connector with merge identified as safety issue in crash analysis. Build will require weave lane changes for this low traffic demand movement.
I-45 SB to I-69 NB	Accommodated via I-45 SB to I-10 EB to I-69 NB	No-Build 2045 Travel Time (AM/PM) – (9.0/9.6 min) Build 2045 Travel Time (AM/PM) – (3.1/2.9 min)	Eliminates low design speed direct connector that has merge with I-45 NB to I-69 NB direct connector. Build will require weave lane changes for this low traffic demand movement.

In addition, Spur 527 starts at I-69, with the direct movements maintained between the existing/No-Build and the proposed Build schematic. SH 288 ends at I-69, with five movements provided in the existing/No-Build condition, maintained in the proposed Build schematic.

All 34 urban interchanges to cross streets in the project area connect to public roads and provide for all traffic movements. Routes are impacted on cross streets, but all impacted intersections were analyzed for appropriate local street improvements in safety and operations to address any access point changes

In existing conditions, the ramp configurations surrounding the urban interchanges are a mix of diamond configuration and X-pattern. Access is inconsistent throughout the project area and often results in close-spacing of ramps. The Build schematic includes several changes in access to the 15.3 miles of urban freeway facilities in the project area to improve lane balance. Each ramp is summarized in **Table 76** through **Table 79** with the No-Build versus Build station number and by freeway facility.

9.1 *Meet or Exceed Standards*

As noted previously, FHWA supports the design control/criteria and desired operational goals of this project and supports the 20-year design parameters. Every reasonable attempt was made to meet TxDOT and AASHTO standard and criteria throughout the project area. The project currently requires three design exceptions at select locations where the proposed design fails to satisfy TxDOT standards and criteria. These locations are identified and discussed on page 205 of this report.

As indicated on the attached schematic (**Appendix P**), updates to geometry to meet design criteria have been addressed, except for design exceptions at select locations, and lane continuity and lane balance has been improved throughout the project area. Many left side entrances and exits were removed. All movements have been evaluated through operational analyses performed for the study using Vissim microsimulation software.

The existing length of access control along the cross-streets will remain in the proposed condition and will provide for acceptable operations and safety. Sufficient ROW is available or is being acquired to provide for all proposed improvements. TxDOT has used appropriate design standards set forth by FHWA and AASHTO, however design exceptions are likely required. The design exceptions include select locations for shoulder width reductions.

10.0 Compliance with Policy Point # 5

The proposal considers and is consistent with local and regional land use and transportation plans. Prior to receiving final approval, all requests for new or revised access must be included in an adopted Metropolitan Transportation Plan, in the adopted Statewide or Metropolitan Transportation Improvement Program (STIP or TIP), and the Congestion Management Process within transportation management areas, as appropriate, and as specified in 23 CFR part 450, and the transportation conformity requirements of 40 CFR parts 51 and 93.

The analysis for the proposed improvements utilized information from the H-GAC 2040 and 2045 Regional Transportation Plan (RTP) and inputs from H-GAC's 2040 regional travel demand model, the model available during development of traffic projections that includes locally adopted demographics that capture local land use plans in the region. As such, the analysis of this proposed project incorporates all other projects contained in the H-GAC 2040 and 2045 RTPs, and is consistent with the Plan's goals and objectives. The project is located in a non-attainment area for air quality. The proposed project is included in the H-GAC 2040 RTP project map and travel demand model and the released (May 2019) H-GAC 2045 RTP. Sections of the proposed project are also included in the 2019-2022 STIP. Although the general CSJ is 0912-00-146, there are several CSJs in the STIP that acquire funding for the Build alternative. There is no funding for Segment 1. Segment 2 includes Contract CSJ: 0500-03-560 which contains CSJ 0500-03-560 and CSJ 0500-03-597. Segment 3 includes CSJ: 0500-08-001 which contains Contract CSJ: 0500-03-598, CSJ: 0500-03-599, CSJ: 0500-03-601, CSJ: 0500-08-001, CSJ: 0027-13-200, CSJ: 0027-13-221 (all Design Build) and Contract CSJ: 0027-13-201 (Design-Bid-Build).

All proposed improvements were coordinated and approved by TxDOT with input from H-GAC. Furthermore, traffic volumes that were used in this study utilized TxDOT's TP&P office and the local MPO's planning model to provide guidance to obtain/develop traffic volumes. The MPO's model includes all proposed improvements currently identified in the state and regional long-range plan along with land development growth patterns for the future year and is consistent with the traffic and air quality models the MPO uses to develop their current Transportation Plan (20-year) and TIP. Other projects, studies or planned actions that may influence the report analysis were included in the design and analysis.

Houston has a population of approximately 2.3 million which places this project within a Transportation Management Area (TMA). Houston currently operates as a non-attainment area.

There was a draft Mobile Source Air Toxics (MSAT) Quantitative Report submitted May 2018 that show MSAT emissions are expected to decrease compared to the base year. There is a minor increase in MSAT emissions expected between No-Build and Build due to higher VMT.

11.0 Compliance with Policy Point # 6

In corridors where the potential exists for future multiple interchange additions, a comprehensive corridor or network study must accompany all requests for new or revised access with recommendations that address all of the proposed and desired access changes within context of a longer-range system or network plan (23 U.S.C. 109(d), 23 CFR 625.2(a), 655.603(d), and 771.111).

Due to the urban environment of the project area, new interchanges are minimal in the project area. The extension of the Hardy Toll Road to the project area is the only anticipated new interchange as a background project and was included in each scenario analyses. This extension is expected to relieve traffic demand on the adjacent I-45 and I-69 freeway facilities.

As discussed in Section 4.3, several future transportation plans were identified to develop accommodations needed for the design schematics. The following are key future plans in the project area that were considered in schematic development.

- Houston METRO Reimagining
- City of Houston Bike Plan
- City of Houston Thoroughfare and Freeway Plan (MTP)
- H-GAC 2040 Pedestrian and Bicycle Plan
- H-GAC 2040 Regional Transportation Plan (RTP)
- H-GAC 2045 Regional Transportation Plan (RTP)

Each of these plans were considered in the production of project area alternatives. The proposed design schematics incorporate or do not inhibit the execution of these plans as part of network mobility throughout the Houston area.

There are two background projects that were included in future year alternative analysis. The background projects include:

- I-45 northbound to I-69 northbound direct connector reconstruction project – This project reconstructed the direct connector to utilize a collector-distributor system and distribute traffic demand upstream of the existing gore point location. It was completed by the end of 2019 and is included in all 2025 and 2045 analysis year microsimulation models.
- Hardy Toll Road Downtown Connector Project – As discussed in previous sections of this report, the North Hardy Toll Road is proposed to be extended to the I-10 at I-69 interchange. This project is expected to substantially impact traffic patterns and is expected to be completed in 2023. It is included in both the 2025 and 2045 analysis year microsimulation models.

These background projects are included in the TDM development and were considered in development of traffic projections. Project plans were reviewed and incorporated into the microsimulation traffic operation models.

12.0 **Compliance with Policy Point # 7**

When a new or revised access point is due to a new, expanded, or substantial change in current or planned future development or land use, requests must demonstrate appropriate coordination has occurred between the development and any proposed transportation system improvements (23 CFR 625.2(a) and 65.603(d)). The request must describe the commitments agreed upon to assure adequate collection and dispersion of the traffic resulting from the development with the adjoining local street network and Interstate access point (23 CFR 625.2(2) and 655.603(d)).

During the schematic development, public meetings were held since 2011 to encourage coordination and input from the public within the project area. There have been four public meetings with documentation of comments and responses. There was also a public hearing in May 2017, following the release of the draft Environmental Impact Statement (DEIS). There has been coordination between H-GAC, City of Houston, Harris County Toll Road Authority (HCTRA), and FHWA, among other impacted entities. City of Houston has held public meetings as well and there has been coordination for the local street network for operations and safety.

The proposed project will not require the local street network to be improved prior to the beginning of this project. Necessary local street improvements required by this project are incorporated into the proposed schematic.

The improvements made in the I-45 NHHIP are part of the long-range planning process as improvements to the overall transportation system. Access to and from existing and future development will be improved by the proposed additions. The work was coordinated and approved by TxDOT, along with input from the H-GAC. There are no pre-condition requirements before the proposed improvements can be constructed.

Funding for this project is discussed in Section 15.0.

13.0 Compliance with Policy Point # 8

The proposal can be expected to be included as an alternative in the required environmental evaluation, review and processing. The proposal should include supporting information and current status of the environmental processing (23 CFR 771.111).

The environmental clearance for the I-45 NHHIP is underway as a Draft Environmental Impact Statement (DEIS), which was submitted in April 2017, and was updated based on comments received. The Final Environmental Impact Statement (FEIS) was released October 2020, and the Record of Decision (ROD) is expected in early 2021. The social, economic, and environmental impacts of the proposed NHHIP were evaluated for land use, soils and geology, social, economics, air quality, noise, wetlands, floodplains, water quality, biological resources, cultural resources, parklands, hazardous/regulated materials, and visual aesthetics. The proposed Build schematic was selected as the preferred alternative in the DEIS based on its ability to best accomplish the need for and purpose of the transportation improvements, while minimizing impacts to social, economic, and environmental resources. A Section 4(f) evaluation was completed as part of the FEIS.

14.0 Compliance with Engineering Standards

This project was performed in compliance with the following Engineering Standards:

- TxDOT's Roadway Design Manual
- TxDOT's Hydraulic Design Manual
- Texas Manual on Uniform Traffic Control Devices (TMUTCD)
- Standard Specifications for Construction and Maintenance of Highways
- Streets and Bridges
- PS&E Preparation Manual
- TxDOT's Traffic Signals Manual
- TxDOT' s Highway Illumination Manual
- Transportation Research Board (TRB) Highway Capacity Manual
- American with Disabilities Act Accessibility Guidelines (ADAAG)
- Texas Accessibility Standards (TAS)
- AASHTO Guide for the Development of Bicycle Facilities
- National Electrical Code (NEC)
- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Street (latest edition).
- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Design Standards – Interstate System (latest edition).

15.0 **Funding Plan**

The general construction cost of the overall NHHIP project for Segments 1, 2 and 3 is estimated to be approximately $7 Billion, which does not account for estimated right-of-way costs. It is anticipated that the project will be paid for with a mix of state and federal funds and construction will span over seven (7) years. TxDOT anticipates funding the proposed improvements by advertising Design-Build advertisements for each of the three (3) segments. As this IAJR is focused on Sections 2 & 3, this section will only focus on those two (2) sections. It should be noted, that throughout the length of the project, there are several locations that have open space. These open spaces have been identified as having the potential of private funding and development. Per December 2019, segments of the proposed project are funded as follows:

15.1 *Segment 2*

Segment 2 is expected to be funded by a Design-Build contract in fiscal year 2026.

15.2 *Segment 3*

The Texas Department of Transportation (TxDOT) is currently contemplating use of a Base Scope and Deferred Work Components (DWCs) as defined in the Request for Information (RFI) for this segment of the NHHIP project. As of December 2019, this segment is fully funded based on TxDOT's cost estimates (approximately $3 billion in construction costs, $3.6 billion Design-Build (DB) contract cost).

It is anticipated that the Base Scope plus DWCs approach may be used to address project phasing and bonding considerations. Schematics for the Base Scope and DWCs, including preliminary design and operational considerations, will be included with the reference information documents (RIDs). TxDOT anticipates overlapping the construction of the Base Scope and DWCs. Funding has been secured for the base scope and two DWCs as follows:

15.2.1 Base Scope

The base scope for this segment of the project extends along the I-10 Corridor and I-10/I-45/I-69 interchanges and has an estimated construction value of approximately $1.5 billon. It is anticipated that construction will span over four (4) years.

The Base Scope will require temporary connections to the Downtown Connectors and to existing elevated I-69 south of Buffalo Bayou alongside Minute Maid Park. It is anticipated that the I-45 mainlanes will be constructed in this phase alongside I-10 and I-69 but will not be opened to traffic in the Base Scope condition. However, I-45 traffic will remain operational on the Pierce Elevated section. Additionally, TxDOT is contemplating the release of all right-of-way (ROW) support and utility adjustments for the entire Segment 3 DB limits with Base Scope notice to proceed (NTP) 2.

15.2.2 DWC #1: I-69 Corridor from Runnels Street south of Buffalo Bayou to Elgin

DWC#1 has an estimated construction value of approximately $1.1 billon with an anticipated construction duration of three (3) years. I-45 is anticipated to be opened to traffic in stages during this phase, which will allow the removal of traffic from the Pierce Elevated section and completion of the I-69/I-45 South interchange. Coordination with the Convention Center and the cut and cover Tunnel Section will be ongoing during the duration of this DWC. TxDOT is working closely with Houston First, operator of the Convention Center. There will be a Special Specification concerning requirements of working around the Convention Center and coordinating demolition of the existing I-69 elevated facilities adjacent to the Convention Center.

15.2.3 DWC #2: Downtown Connectors, decommission Pierce Elevated, and complete SH 288 Interchange

DWC#2 has an estimated construction value of approximately $400 million with an anticipated construction duration of two (2) years. During this phase, I-45 will be re-routed to its new alignment. Interface with TxDOT Design-Bid-Build (DBB) project along I-69 from Montrose to SH 288 and with SH 288 Comprehensive Development Agreement project at the I-69/SH288 Interchange will be required. It is anticipated that a up to 15-year Capital Maintenance Contract (CMC) consisting of three five-year terms as solicited on recent TxDOT DB projects will be utilized. The first five-year term will begin at Final Acceptance for each applicable scope component and will be independent of maintenance terms for other scope components. The limits of the CMC will be well defined to exclude transition zones between applicable scope components.

15.3 *Segment 1*

Segment 1 is unfunded, but is being reviewed for feasibility and schematic development. Once funded, a separate IAJR for this segment will be developed.

16.0 Recommendation

The I-45 NHHIP is recommended for approval based on compliance with the eight FHWA policy points. The project has been developed through alternative analysis over several years, with consideration of operational, safety, and environmental impacts. The operational and safety analysis included in the report show substantial improvements in operational efficiency and expected crash reduction. The assessment of operational and safety impacts was closely coordinated with the development of the ultimate schematic in an iterative process. Informed by the analyses, potential bottleneck locations and potential safety risks were communicated to the design team to further improve the schematic. The final environmental impact statement was complete in October 2020, with a record of decision expected in early 2021.