M E M O R A N D U M

TO: Mayor and Council Members

FROM: Robert Spillar, P.E., Director
Austin Transportation Department

Victoria J. Li, P.E., Director
Watershed Protection Department

DATE: September 23, 2014

SUBJECT: Response to Council Resolution 20140515-063

On May 15, 2014, Council by Resolution No. 20140515-063 directed the City Manager to assess various transportation, environmental, and legal issues associated with the proposed State Highway 45 Southwest (SH45 SW). The attached report addresses each of the directives in the Council Resolution. Below is a summary of key findings and recommendations presented in the report.

Transportation
The Austin Transportation Department was directed to review and report findings and recommendations to Council regarding tasks 1-3 in the City Council Resolution.

Task 1 - *Review and report findings and recommendations to Council regarding any identified alternative transportation investments that would improve commuting between northern Hays and far southern Travis counties and Central Austin while reducing total costs, environmental harm, and impacts to MoPac commuting including but not limited to improvements to Brodie Lane.*

The following Sections under Task 1 are presented to provide additional context and address alternative transportation investments to SH 45 SW:

I. Status of Projects Completed
II. Brodie Lane, Single-Lane Roundabouts within Existing Right-of-Way
III. Upgrade Existing Roadways
IV. Active Transportation
V. Planned and/or Funded Roadway and Transit Projects

Of particular note, the series of single-lane roundabouts along Brodie Lane within existing right-of-way have not been pursued for further development as they are not deemed a viable alternative to SH 45 SW due to ROW, costs, and environmental constraints, as further described in Section II. Moreover, the roundabouts would not alleviate peak-hour demand or solve the greater mobility challenges in this area.

Similar to the Brodie Lane roundabouts, upgrading existing roadways (as described in Section III) also is constrained by environmental issues. The proposed FM 1626 to Brodie Lane to Slaughter Lane route traverses through an established neighborhood, and improvements to widen the roadway would result in displacements of these homes. The FM 1626 to Manchaca Road to Slaughter Lane, at least, would not pass through as many environmentally sensitive areas; however, it would result in residential and commercial displacements. Nonetheless, any thorough environmental analysis to ascertain the feasibility of improving mobility in the region should include an evaluation of all possible improvements.

The central theme underlying all of these components is the fact that southern Travis County and northern Hays County will continue to experience increasing population growth and development pressures. The community has been and will continue to be challenged with this growth. A combination of transportation solutions, such as bicycle and pedestrian accommodations, Transportation System Management (TSM), Travel Demand Management (TDM), along with arterial improvements are all needed in order to increase system connectivity and reduce vehicular congestion.

Task 2 - *Review and report findings and recommendations to Council regarding recent CAMPO and CTRMA traffic studies on the proposed SH45 SW.*

The following Sections under Task 2 include four traffic forecasts that have studied the proposed SH45 SW and one vehicle license plate capture survey:

I. CAMPO, SH45 SW alternative model runs
II. Center for Transportation Research, DRAFT Dynamic Traffic Study (DTS) of SH45 SW, and
III. TxDOT, DRAFT Traffic Forecasting Methodology
IV. CTRMA Level I Traffic and Revenue Forecasts
V. TTI Vehicle License Plate Capture Survey

Sections I, II, and III provide analysis on the data and reports available regarding the travel demand studies conducted for a no-build and build scenario for SH 45 SW. Section IV reports on the CTRMA Level I Traffic and Revenue Forecasts for a 4-lane tollway. The underlying methodology and assumptions vary between each product as well as the modeled output.

The CAMPO SH45 SW alternative model runs were performed using the regional travel demand model. The CAMPO model now uses a more refined four-period model (AM, Mid-day, PM, Night-time), as opposed to the previous 24-hour model. Traffic volumes were modeled for the build and no-build scenarios using the adopted 2025 transportation network and an updated 2025 demographic forecast.

The CAMPO travel demand model provided the basis for both the Dynamic Traffic Study (DTS) and the TxDOT Traffic Forecasting. The CAMPO model was used in the DTS to obtain the trip matrix used as input into the Dynamic Traffic Assignment model. The CAMPO model was also used to develop the forecasts in the TxDOT traffic forecasting. Before any of the CAMPO model or model output could be used, the DTA model and TxDOT's use of the CAMPO model needed to be calibrated to reflect observed traffic counts and travel characteristics.

The individual traffic studies utilized the CAMPO travel demand model and each has their own merit; however, there is nothing that allows comparisons to be made across the studies making it difficult to draw a conclusion as to which forecast is the most accurate.

The CTRMA Level I Traffic and Revenue Forecasts are prepared by Stantec, and represent more precise project level analysis for the proposed tollway. In a Level 1 study the consultants develop average weekday transaction projections: both Year 2025 and Year 2035 forecasts are available.
Section V is a license plate capture survey that was done in support of the TxDOT traffic forecasts. The license plate capture survey was used to analyze trips that utilized Brodie Lane between S Loop 1 and FM 1626. This section utilized the same data to draw further conclusions about traffic patterns in the study area. This study provides the most realistic travel conditions of the southwest area, finding that on average 80% of the traffic on area roadways is local.

Task 3 - *Review and report findings and recommendations to Council regarding the appropriateness of adding traffic to South MoPac by construction of SH45 SW in advance of developing and implementing a plan to address the "bottleneck" at the MoPac bridge over Lady Bird Lake.*

This section examines the Loop 1 South Environmental Study and the recent CAMPO travel demand model run scenarios to provide insight on the appropriateness of adding traffic to South MoPac by construction of SH45 SW in advance of developing and implementing a plan to address the "bottleneck" at the MoPac bridge over Lady Bird Lake.

Under the sponsorship of TxDOT and CTRMA, the Loop 1 South Environmental Study will analyze and determine the best alternatives for improving mobility from Cesar Chavez Street to Slaughter Lane. The study will also identify future needs and possible modifications to the Lady Bird Lake Loop 1 bridge. Furthermore, TxDOT and CTRMA are collaborating to conduct environmental studies on several projects in the vicinity (i.e. MoPac South, MoPac Intersections, and SH 45 SW) simultaneously.

Absent of the corridor-level traffic projections planned as part of the Loop 1 South Environmental Study, or a comparable detailed study, City Staff concludes it is difficult to evaluate how much traffic and potential additional delay or detriment will be added to the Lady Bird Lake bridge as a result of SH 45 SW construction. The available regional travel forecasts staff examined, as part of the recent CAMPO travel demand mode runs, are not a product suited to this type of corridor analysis.

Environmental

The Watershed Protection Department (WPD) and Law Department completed the requested analyses of environmental issues and the State of Texas process for environmental review for proposed roadway projects. .

Task 4 - *Review and report findings and recommendations to Council regarding any existing environmental surveys of City lands along the SH45 SW right of way, including but not limited to surveys of karst features, and subsurface flow.*

There are a large number of environmental surveys for the City-owned properties along the SH45 SW right-of-way. The City's properties are the Water Quality Protection Lands (WQPL) and the Balcones Canyonlands Preserve (BCP) Lands. Over the span of several decades, studies have been conducted by the City of Austin, state agencies and universities, and private entities. While most of these studies are not directly related to SH45 SW, they provide a substantial body of scientific information and data about the environmental conditions and sensitivity of the area. This includes information about surface and groundwater resources, karst features and other critical environmental features, and the presence and habitat of endangered species.

It is well established from the extensive body of environmental studies and surveys that the area within and in proximity to the proposed roadway has a very high concentration of karst features, including large caves and sinkholes. Many of these karst features are known to be occupied by rare karst invertebrates and provide significant recharge conduits to the Barton Springs segment of the Edwards Aquifer. Some properties have had multiple karst surveys and with each survey additional karst features have been found. A July 2014 survey by WPD staff has documented that the Tabor Crevice Cave extends 500 feet further than previously thought in the direction of the SH45 SW right-of-way and Flint Ridge Cave. A TxDOT karst survey within the SH45 SW right of way is underway and will provide important additional information that is needed for the assessment of potential impacts of the roadway. While this work is still in progress, the draft Environmental Impact Statement for the project was issued with a conclusion that there will be no significant impacts to karst features or that impacts can be largely avoided during project design. City staff believe that additional studies are needed to confirm the presence or absence of karst invertebrates in one or more caves on or near the right of way consistent with U.S. Fish and Wildlife Service (USFWS) protocols. Several dye studies have been conducted in this area of the recharge zone that demonstrate the hydraulic connectivity of the project area to the Edwards Aquifer, to nearby public water supply wells, and to Barton Springs. One dye study found a much higher recharge potential in this area than expected for areas outside of obvious recharge features like crevices, sinkholes, and caves, indicating that simply paving over soil in the area may adversely impact Edwards Aquifer recharge to a greater degree than previously thought. WPD is currently conducting a dye study to better delineate subsurface drainage to and near Flint Ridge Cave, a large portion of which underlies the proposed alignment of SH45 SW. No additional studies are recommended at this time.

There have also been many studies of surface water quantity and quality in streams in close proximity to the SH45 SW right of way, primarily Bear Creek. These studies generally have found that water quality in the area is good and that the stream is highly sensitive to pollutants from nutrients and other contaminants. Importantly, Bear Creek itself contributes significant recharge to the Edwards Aquifer.

The proposed roadway lies within and near BCCP Zones 1 and 2, which designate occupied habitat (Zone 1) or potential habitat (Zone 2) for the endangered Golden Cheek Warbler. Past surveys have found these birds near the roadway alignment on adjacent City properties. Additional surveys may be required under USFWS protocols to confirm the presence or absence of the Golden Cheek Warbler. No other protected bird species habitat is known in this area.

<u>Task 5</u> - *Review and report findings and recommendations to Council regarding any significant differences between the state environmental review process and the National Environmental Policy Act.*

After shifting federal funding out of the proposed project, TxDOT determined that it could conduct the required environmental review under state regulations and guidance rather than under the requirements of the National Environmental Policy Act (NEPA). This determination by TxDOT was also based on an expectation that no federal actions (e.g., approvals) will be necessary for construction of the roadway. Per the Council resolution, City staff have conducted a comparative analysis of state environmental review requirements and the requirements under NEPA. Generally, state environmental review requirements and process followed by TxDOT and the resultant environmental documentation (e.g., Environmental Impact Statement) mirror federal requirements and documentation. There are, however, subtle differences including:

- There is no overarching state statute similar to the federal NEPA.

- For federal reviews of projects involving state highway systems, TxDOT actually oversees the preparation and drafting of an Environmental Impact Statement in compliance with NEPA and

all other federal environmental requirements, while the Federal Highway Administration conducts an independent legal sufficiency review of the draft and final versions of the document. As a result, a project undergoing a federal review will subject to a greater number of reviews than a project conducted under state regulations.

- Federal environmental reviews must comply with the federal court's "hard look" doctrine and comply with NEPA to the "fullest extent possible". TxDOT must "consider the results" of the environmental review which must be based on "sound reasoning and accepted scientific and engineering principles."

- There is no state agency analogous to the U.S. Council on Environmental Quality (CEQ) or the U.S. Environmental Protection Agency, both of which have responsibilities for overseeing implementation of NEPA.

- Disputes between federal agencies arising through the NEPA process are resolved by the CEQ, which is not affiliated with either the project sponsor or reviewing agency. There is no similar state agency for resolving disputes between state agencies participating in a state environmental review.

- Federal agencies must ensure that their actions will not jeopardize the existence of a listed endangered species or destroy protected habitat and the federal agency <u>must consult</u> with USFWS if there is the possibility of impact. While TxDOT (or CTRMA) will have to acquire a federal incidental take permit if the project will result in "take" of a listed species, there is no requirement for consultation with USFWS nor is there any required USFWS review.

<u>Task 6</u> - *Review and report findings and recommendations to Council regarding State environmental protection measures on existing roadways and construction sites within the Barton Springs Watershed.*

Over the past year City staff has had discussions with TxDOT regarding temporary and permanent water quality protection measures on state road projects, including future improvements to U.S. Highway 290 in the Oak Hill area, improvements to MoPac South, and other planned projects in the Austin area. As a result of these discussions and site visits to area state road projects staff have concluded that:

- State environmental regulations are similar to the City's requirements for temporary erosion controls, but required implementation varies significantly and results in a disincentive for state contractors to install and maintain adequate controls.

- TxDOT has limited inspection capability locally and the Texas Commission on Environmental Quality does not routinely inspect state projects for compliance with applicable regulations.

- Temporary erosion controls at current TxDOT road projects in the Barton Springs Zone were generally limited in number and the controls that were in place were often in poor condition.

- State requirements for permanent water quality controls are similar to City of Austin requirements outside the Barton Springs Zone but are not as protective as the requirements for public infrastructure and private land development in the Barton Springs Zone.

We hope the attached report fully satisfies the intent of Council Resolution 20140515-063. If you or your staff have any questions on the transportation elements of the attached report, please contact Gordon

Derr, P.E. at (512) 974-7228; and if you have questions on the environmental elements of the report, please contact Chuck Lesniak at (512) 974-2699.

Attachment

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Response to Council Resolution 20140515-063

State Highway 45 Southwest

Transportation Alternatives/Constraints

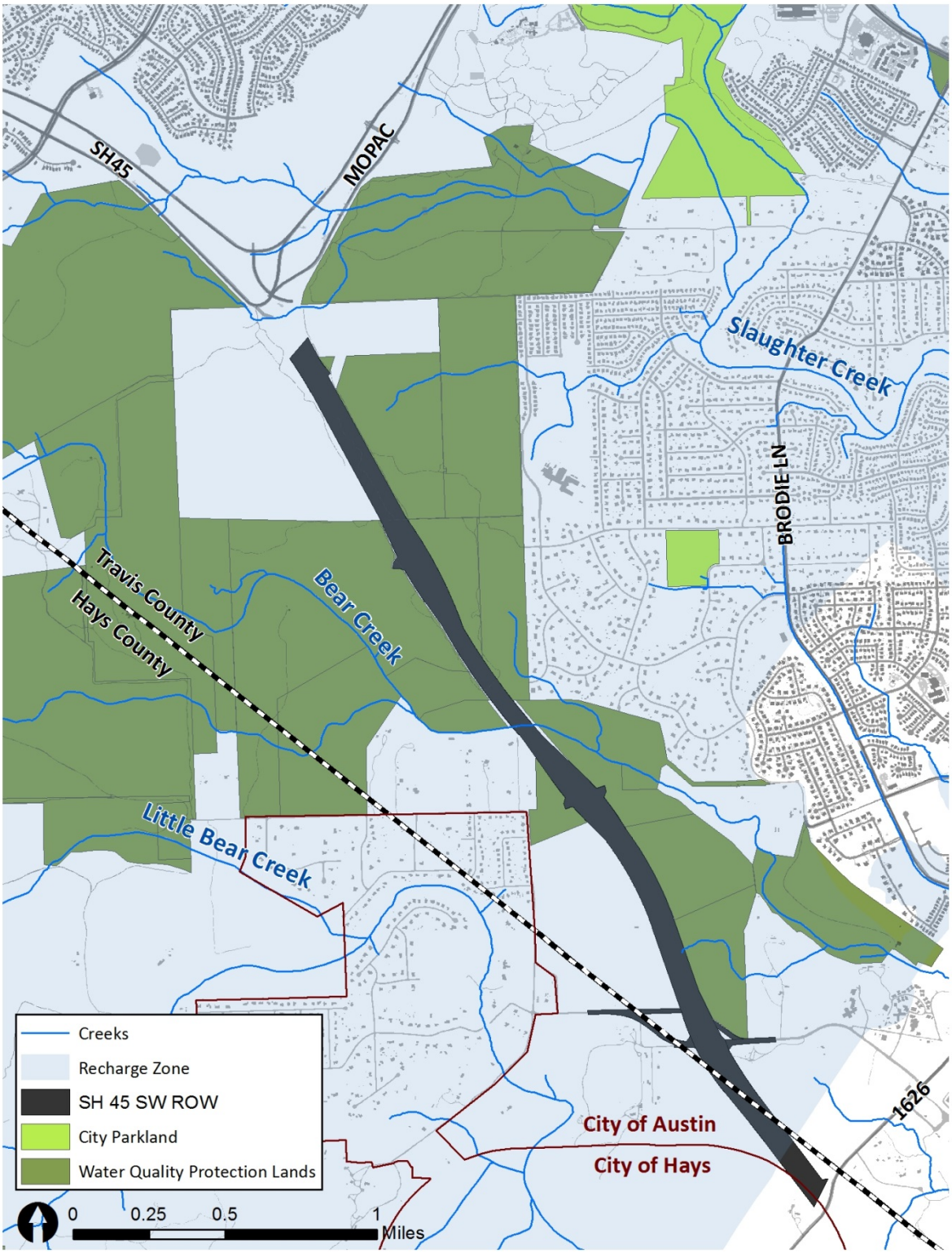
Environmental Surveys, FHWA/TxDOT EIS Review, and TxDOT Water Quality Controls in the Barton Springs Zone

Overview

On May 15, 2014 Council directed the City Manager to review and report findings and recommendations regarding State Highway 45 Southwest (SH45 SW) which is currently in the process of environmental review at the Texas Department of Transportation (TxDOT). As directed, staff from Austin Water Utility Wildlands Division (AWU), Austin Transportation Department (ATD), and the Watershed Protection Department (WPD) have compiled the following report to respond to the direction in the Council resolution.

The SH45 SW right of way is situated in the Recharge Zone of the Barton Springs Segment of the Edwards Aquifer. As shown on the following map, its route lies between Flint Ridge Cave, a cave protected under the Balcones Canyonlands Conservation Plan permit, and Bear Creek, which consistently rates as high in water quality and overall environmental integrity. Recharge from the SH45 SW project area, including Flint Ridge Cave and Bear Creek rapidly finds its way to Barton Springs. The City has provided TxDOT a significant amount of the environmental data discussed in this report that is applicable to this highly sensitive environment.

In collecting information for this report City staff have had discussions with Travis County, TxDOT and the Central Texas Regional Mobility Authority (CTRMA). The report is organized by the order of the Council questions (Tasks) in the May 15, 2014 resolution. Tasks 1-3 address transportation issues and Tasks 4-6 address environmental issues.



SH45 Southwest proposed route and surrounding area.

Task #1 Alternative Transportation Investments to SH 45 SW

Review and report findings and recommendations to Council regarding any identified alternative transportation investments that would improve commuting between northern Hays and far southern Travis counties and Central Austin while reducing total costs, environmental harm, and impacts to MoPac commuting including but not limited to improvements to Brodie Lane.

Introduction:

The following Sections are presented to provide additional context and address alternative transportation investments to SH 45 SW:

I. Status of Projects Completed

II. Brodie Lane, Single-Lane Roundabouts within Existing Right-of-Way

III. Upgrade Existing Roadways

IV. Active Transportation

V. Planned and/or Funded Roadway and Transit Projects

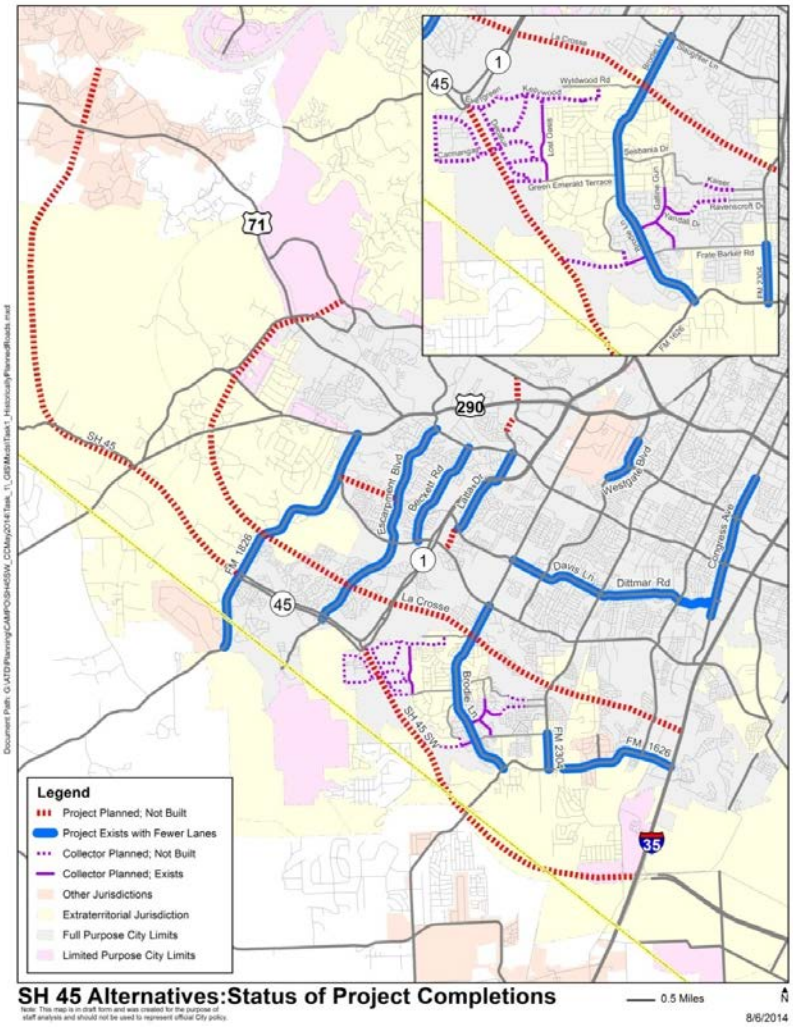
Section I provides a context for alternative transportation investments, specifically roadways with pedestrian and bicycle facilities that have been planned and completed in southwest Austin over the years, while the proceeding components (Sections II – IV) provide more information on potential alternatives to SH 45. Section V provides an in-depth review of planned and/or funded roadway and transit projects within southern Travis County and northern Hays County to relieve congestion and improve mobility.

The central theme underlying all of these components is the assumption based on demographic projections that southern Travis County and northern Hays County will continue to experience increasing population growth and development pressures. The community has been and will continue to be challenged with this growth. A combination of transportation solutions have been planned to mitigate these challenges and it will continue to take a combination of solutions to keep up with the demand.

Status of Projects Completed

Figure 1 depicts the outcomes of roadways that were planned in southwest Austin since 1984, when the SH 45 "Outer Loop Parkway" concept was adopted in the regional Transportation Plan, known as the "Austin Transportation Study". As indicated in the map legend, some of these projects were never realized or were built with a lesser capacity and number of lanes due to various environmental and community factors. Specifically, about 35 miles of major roadway projects were planned at some point but were never built, while approximately 27 miles of major roadways were built but with a lesser capacity and number of lanes. Of the collector roadways planned, about 2.4 miles were completed, while an estimated 9 miles were never built. In sum, this area of central Texas and southwest Austin has long been challenged with finding solutions to mobility and transportation connectivity, and the community has worked actively over the years to address these issues, while trying to balance protection of fragile environmental resources.

Figure 1.
Status of Project Completions



Alternative 1: Brodie Lane, Single-Lane Roundabouts within Existing Right-of-Way

Background:

In 2011, the City of Austin initiated a preliminary study to evaluate the potential for a series of intersection improvements along Brodie Lane. In consultation with Travis County staff, the goal of the preliminary study was to relieve congestion and improve mobility in the south Brodie Lane corridor. Specifically, single-lane roundabouts at major collector intersections with Brodie Lane, between Slaughter Lane and Frate Barker Road, were analyzed to identify potential operational improvements within the existing right-of-way (ROW). The intersections with Brodie included:

- Aspen Creek Parkway
- Squirrel Hollow and Indian Point Drive (roundabout pair)
- Sesbania Drive
- Sunland Drive
- Gatling Gun Lane

The initial concept for this section of Brodie Lane was a two-lane roadway, with a bio-swale median for drainage and water quality mitigation. The street would be designed to be context-sensitive to the surrounding neighborhood and include complete street-type concepts, such as shared-use paths and other accommodations. Single-lane roundabouts at strategic locations would replace existing traffic signals with connecting streets.

Roundabout Options:

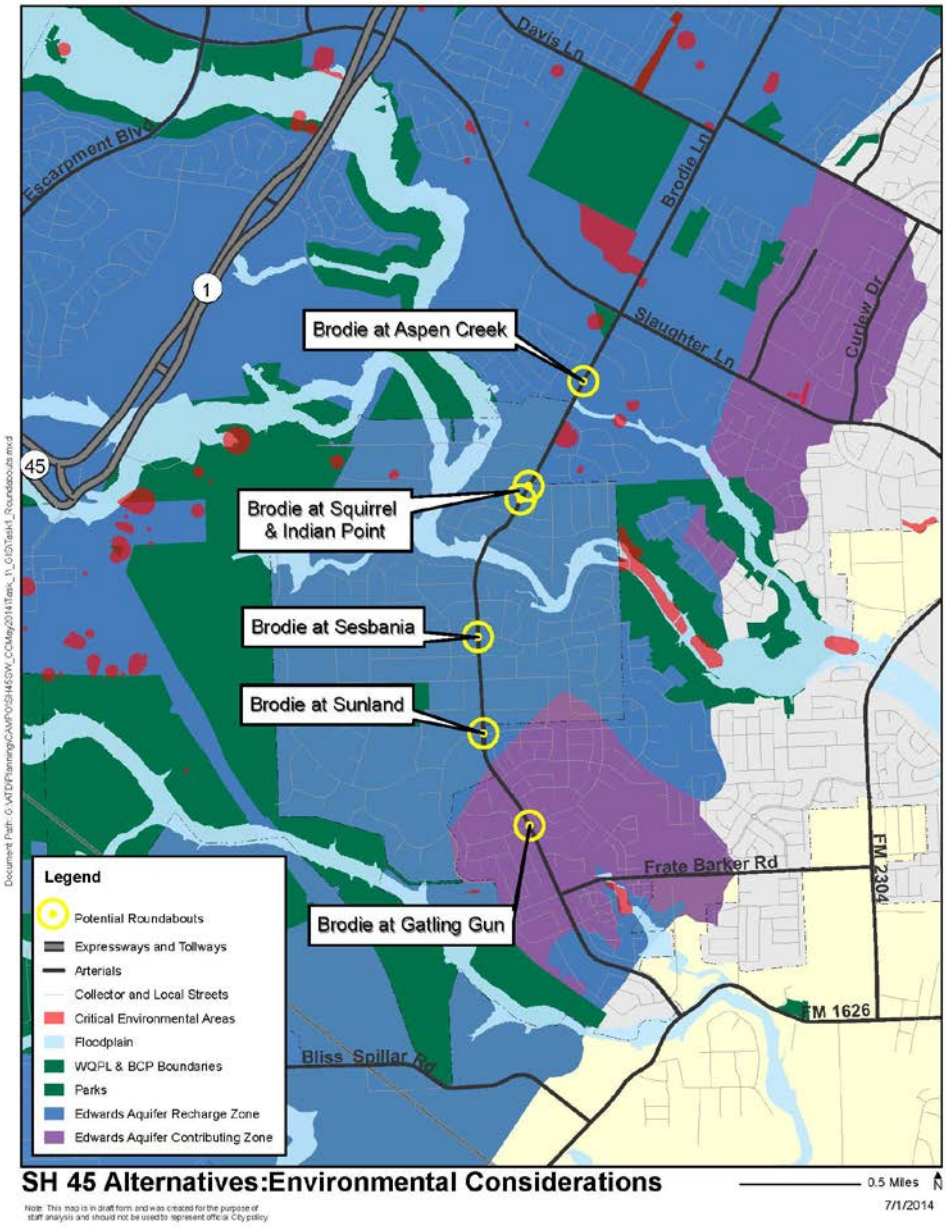
To study the feasibility of the roundabouts, intersection turning movement counts were first conducted in 2011. In 2012 and 2013, Austin Transportation Department (ATD) staff evaluated roundabouts utilizing an in-house, planning-level spreadsheet tool based on the Highway Capacity Manual (HCM). Initial, schematic designs (shown in Appendix 1) illustrate the potential roundabouts. Considering the traffic data at a planning level, single lane roundabouts were found to be generally feasible when considered singularly. However, to fully evaluate the technical feasibility of a series of roundabouts, a corridor-level model would need to be developed using an external consultant. At present, funding does not exist for such an evaluation.

ATD staff also concluded that the single-lane roundabouts could possibly be built within existing right of way with some minor ROW acquisition (e.g. minor corner clips). Both corridor-level modeling and detailed surveys are necessary to identify the most technically appropriate design for the roundabouts, which also would inform actual ROW needs. Nevertheless, a challenge would be constructing the roundabouts over the existing open drainage ditches along the west side of Brodie Lane. The intersection improvements would require significant, and costly, storm water structures to accommodate drainage. Further south, the west side of the roadway includes water quality protection appurtenances.

Environmental Constraints

The Figure 2 illustrates the locations of these roundabouts within the vicinity of Mopac and the proposed SH 45 SW and provides a larger, environmental context. It clearly demonstrates the environmental constraints, including sensitive environmental areas, floodplain, parkland, Water Quality Protection Land (WQPL) and Balcones Canyonland Preserves (BCP), as well as the Edwards Aquifer Recharge and Contributing Zones.

Figure 2
Locations of Potential Roundabouts Near Mopac and Proposed SH 45 SW



Conclusion:

The series of Brodie Lane roundabouts have not been pursued for further development as they are not a viable alternative to SH 45 SW. Besides the ROW, cost, and environmental constraints described above, the roundabouts would not alleviate peak-hour demand or solve the greater mobility challenges in this area. While a series of single-lane roundabouts may decrease travel time of through traffic along the corridor during certain periods of the day, those intersections with significant traffic loading from both Brodie Lane and the side streets may actually experience increased delays. Additionally, travelers exiting from side streets may experience significantly long wait times for acceptable gaps in traffic to exit their street and enter the flow of traffic along Brodie Lane.

The roundabouts may, however, serve to improve safety by managing vehicular access and eliminating points of conflict. They may also be more aesthetically pleasing from an urban design and built environment perspective.

Alternative 2: Upgrade Existing Roadways

As an alternative to SH 45 SW to relieve congestion and improve mobility in southern Travis County, a series of roadway improvements along existing arterials should be further evaluated. Figure 3 illustrates the limits of these alternative routes, connecting IH-35 to South Loop 1.

FM 1626 to Brodie Lane to Slaughter Lane

This proposed route would include the following urban arterial improvements for further analysis:

- Grade-separated intersection at Slaughter Lane and Brodie Lane
- Upgrade Brodie Lane from Slaughter Lane to FM 1626 to a major arterial divided (MAD) roadway with 4 lanes
- Upgrade FM 1626 from IH 35 to Brodie Lane to a MAD roadway with 4 lanes.

FM 1626 to Manchaca Road to Slaughter Lane

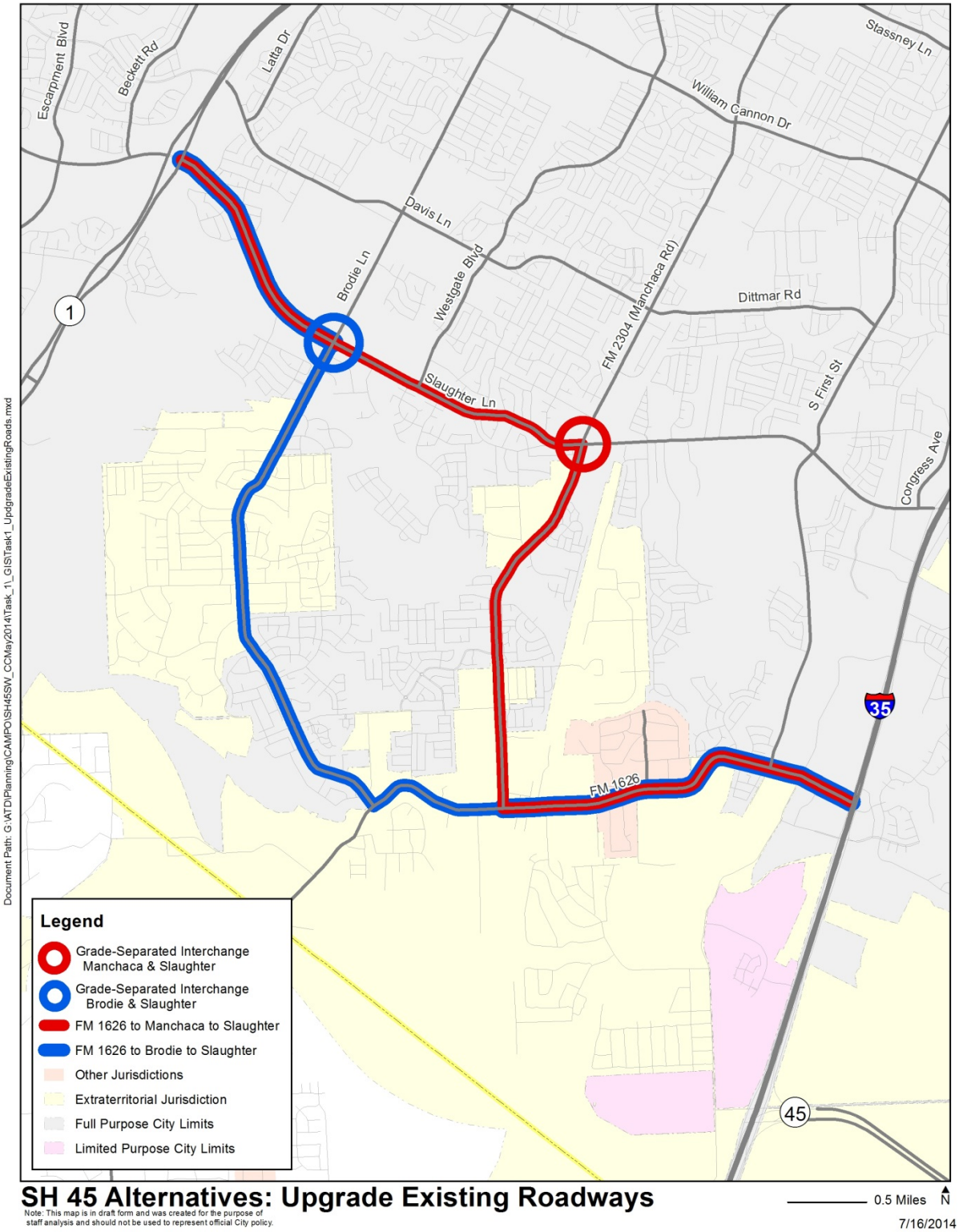
This proposed route would include the following urban arterial improvements for further analysis:

- Grade-separated intersection at Slaughter Lane and Manchaca Road
- Upgrade Manchaca Road from Slaughter Lane to FM 1626 to a MAD roadway with 6 lanes
- Upgrade FM 1626 from IH 35 to Manchaca Road to a MAD roadway with 4 lanes.

Conclusion:

These types of improvements could potentially improve mobility in the region. However, just like SH 45 SW, this proposal also comes with environmental constraints, including sensitive environmental areas, floodplain, parkland, Water Quality Protection Land (WQPL) and Balcones Canyonland Preserves (BCP), as well as the Edwards Aquifer Recharge and Contributing Zones. In addition, the Brodie Lane route traverses through an established neighborhood, and improvements to widen the roadway would result in displacements of these homes. The Manchaca Road route, at least, would not pass through as much environmentally sensitive areas, however would result in residential and commercial displacements.

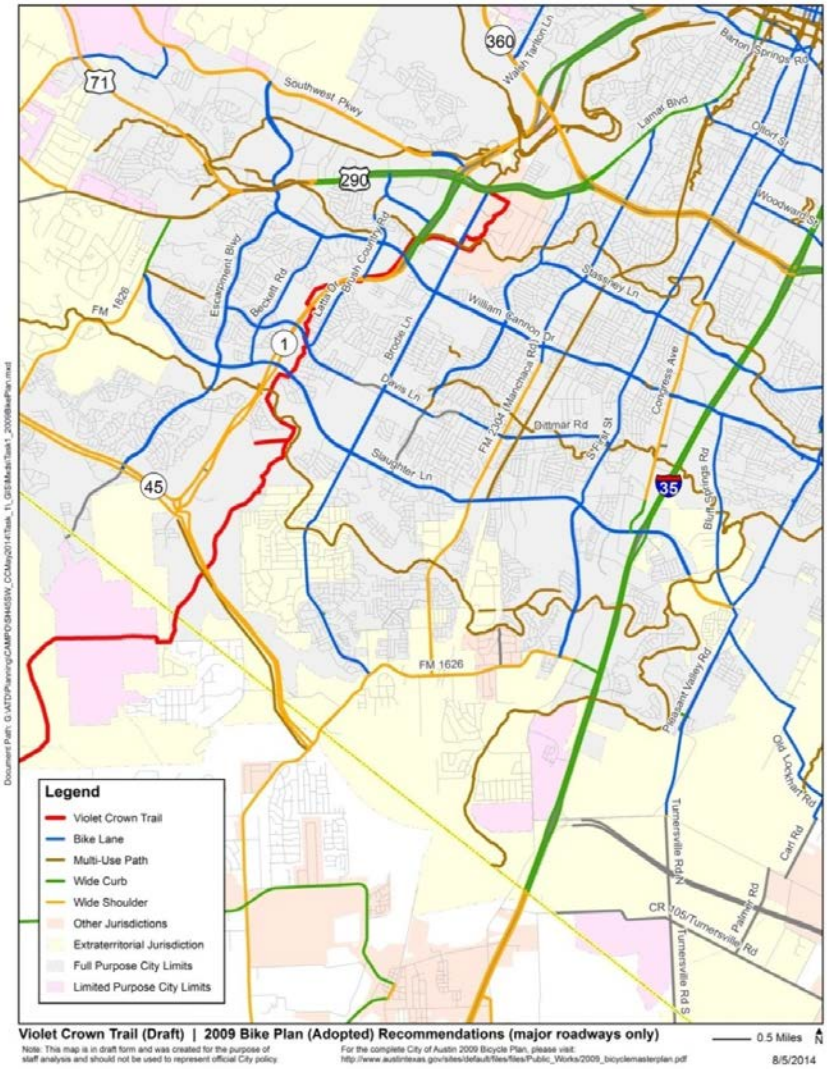
Figure 3
Location of Potential Upgrades to Existing Roadways



Alternative 3: Active Transportation (Bicycle and Pedestrian Facilities)

Figure 4 illustrates the Violet Crown Trail general location, as well as the City of Austin's 2009 Bicycle Master Plan recommendations for multi-use paths and for bicycle accommodations along major roadways. (Please note, the City of Austin's 2014 Bicycle Master Plan Update and Urban Trails Master Plan are currently in draft form.) The Violet Crown Trail is a new multi-use urban trail being planned in southwest Austin to connect south into Hays County. The recommendations presented in the 2009 Bicycle Master Plan and the Violet Crown Trail represent opportunities for encouraging active transportation, and thus potentially reducing vehicular trips in the region. These opportunities, combined with arterial improvements, Transportation System Management (TSM), and Travel Demand Management (TDM), would increase system connectivity and reduce vehicular congestion. Bicycle and pedestrian accommodations, in particular, augment the first and last miles of commutes via public transit.

Figure 4
Bicycle and Pedestrian Facilities



Alternative 4: Planned and/or Funded Roadway and Transit Projects

A series of transportation improvements within southern Travis County and northern Hays County have been planned and/or funded by TxDOT, CAMPO, the City of Austin, and Capital Metro in order to relieve congestion and improve mobility in the short-term through 2020. Table 1 below outlines these projects. Those with committed funding indicate a dollar amount; a let year (i.e. the year a project is made available for bidding) is also provided where possible. Figure 5 illustrates the general location of those projects that can be mapped.

For road projects with a let year identified, a total of approximately $456.2 million is committed for the phase(s) described in the table below. Austin Strategic Mobility Plan (ASMP) projects in SW area total an estimated $129.5 million, with a funding decision anticipated in Nov 2014.

Table 1
Transportation Projects Planned in Southern Travis and Northern Hays Counties

Project	Limits	Description	Phase	Funding	Let Year	Comment
SH 45 SW	FM 1626 – Travis County Line	Construct 4-lane turnpike with 1-lane frontage roads (Toll)	Preliminary & Construction Engineering, Construction	$7,400,000	2015	2014 UTP
SH 45 SW	Loop 1 – Hays County Line	Construct 4-lane turnpike with 1-lane frontage roads (Toll)	Preliminary & Construction Engineering, Construction	$71,712,295	2015	2014 UTP
FM 1626	FM 2770 – RM 967	Reconstruct to 4-lane road with continuous left turn lane	Preliminary & Construction Engineering, Construction	$23,053,680	2015	2014 UTP
FM 1626	West of Bear Creek bridge to – East of FM 2304	Reconstruct to 4-lane road with continuous left turn lane, paved shoulders/bike lane & sidewalk	Preliminary & Construction Engineering, ROW, Construction	$12,223,300	2016	CAMPO TIP FY 2015 - 2018
South Loop 1	.68 miles North of Davis Lane - .35 miles South of LaCrosse Blvd.	Construct roadway underpasses for a 6-lane facility	Preliminary & Construction Engineering, Construction	$45,874,993	2019	2014 UTP
Loop 1 Managed Lanes, Phase 1	.1 mile North of FM 734 – Cesar Chavez	Construction of 1 northbound and 1 southbound	Construction	$179,050,000	2013	FY 2013 of FY 2013 – 2016 TIP

Project	Limits	Description	Phase	Funding	Let Year	Comment
	Interchange	Managed Lane				
Congress Ave./Loop 275	Eberhart Lane – Foremost Dr.	Reconstruct to 4-lane divided roadway	Preliminary & Construction Engineering, Construction	$8,492,810	2014	FY 2014 of FY 2014 – 2016 CAMPO TIP
Lone Star Rail (LSTAR) District	Taylor to Seguin (CAMPO Area to Caldwell Co. Line)	Freight rail bypass study for Lone Star Rail District to relocate Union Pacific freight transport in another corridor	Study	$5,818,671	2014	2014 UTP
Slaughter Lane at First Street	Intersection	Traffic signal improvement, safety	Signal	$150,640	2015	2014 UTP
IH 35 at Slaughter Lane	Intersection	Traffic signal improvement, safety	Signal	$150,640	2015	2014 UTP
US 290 West	Circle Dr. East/ Southview Road – El Rey Blvd.	Add continuous turn lane & paved shoulders (5-feet)	Preliminary & Construction Engineering, Construction	$1,330,100	2016	2014 UTP
US 290 West	West of Scenic Brook – Joe Tanner Lane	Construct 6-lane turnpike with frontage roads (Toll)	Preliminary & Construction Engineering, Construction	$59,670,000	2018	2014 UTP
SH 71 West	US 290 West - Silvermine Drive	Construct tolled lanes & frontage roads	Preliminary & Construction Engineering, Construction	$7,800,000	2018	2014 UTP
Loop 1 South Phase II (Managed Lanes)	Cesar Chavez – Slaughter Lane	ROW acquisition and construction of managed lanes	Environmental Evaluation, Preliminary & Construction Engineering, Construction	$12,450,000	2013	Currently undergoing environmental evaluation with anticipated constructed after CAMPO FY 2015-18 timeframe; Env. FY 2013 of FY 2013 – 2016 CAMPO TIP
FM 2304	Ravenscroft – FM 1626	Reconstruct 5-lane urban roadway	Environmental Evaluation			Currently undergoing environmental evaluation with anticipated construction after

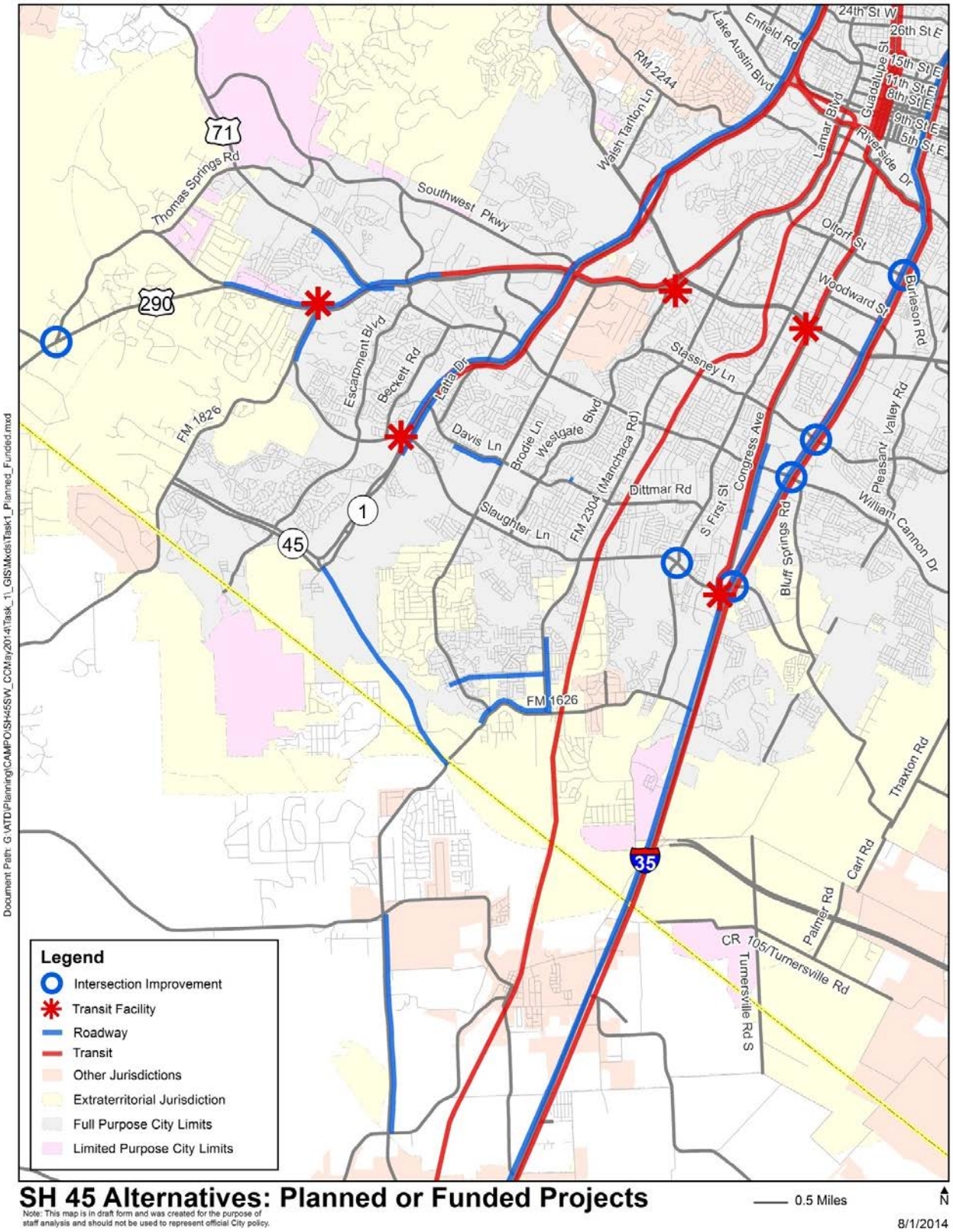
Project	Limits	Description	Phase	Funding	Let Year	Comment
						CAMPO FY 2015-18 timeframe
Frate Barker Road	East of Brodie Lane – Manchaca Road	Reconstruct to 4-lane section with continuous center left turn lane	Construction	$11,500,000	2013 - 2015	
Circle Drive/ US 290 Intersection Improvements	Realign Spring Valley Drive at Circle Drive & US 290 W	Intersection improvements to realign Spring Valley Drive	Utility Relocation and Construction		2014	
Davis Lane	Leo Street – Huebinger Drive	Gap completion project to construct 300-feet of 2-lane divided arterial with bike lanes & sidewalk; construct roundabout at existing 3-way intersection	Construction	$392,840	2014	City of Austin 2000 Bond Program
Davis Lane	Davis/Deer to Corran Ferry	Construct new section of Davis/Deer west of Brodie Lane to align with Davis Ln. east of Brodie Ln., & upgrade to 4-lane divided roadway, bike lanes & sidewalk.	Under Construction	$9,160,828	2013	Completion 2014 City of Austin 2000 Bond Program
Proposed Projects, *Austin Strategic Mobility Plan*, 2014						
IH 35 Integrated Corridor Management	TBD	Manage peak hour flow, construction, crash, weather related diversions, special event surges. Includes improved signalization & traveler information systems on parallel & feeder arterials.		$30,000,000	TBD	Proposed in ASMP, not yet funded

Project	Limits	Description	Phase	Funding	Let Year	Comment
IH 35 Interchange/Intersection Improvements	William Cannon, Stassney, Oltorf	Reconstruct frontage road access/ intersections & replace arterial overpasses; add U-turns, safety improvements. Future High Capacity Transit within Future Transportation Corridor to serve southern Travis and Hays Counties.		$90,000,000	TBD	Proposed in ASMP, not yet funded
RM 1826 Corridor Safety Program	US 290 West – Slaughter Lane	Study existing/ future safety & mobility issues; identify projects to address safety issues/ implement to extent of funds available.		$8,000,000	TBD	Proposed in ASMP, not yet funded
South/Southwest High Capacity Transit (HCT) Corridor Program	Downtown Austin – Hays County	HCT options to South and Southwest, including S. Loop 1, LSTAR, IH 35 Corridor, linkages	Corridor Study	$1,500,000	TBD	
Proposed Projects, Capital Metro's *ServicePlan2020*, 2010; and Project Connect's *Central Texas High-Capacity Transit System Plan*, 2014						
MetroRapid Route 801 North Lamar/South Congress	Tech Ridge shopping center – Southpark Meadows shopping center	First MetroRapid line to open	Operational as of January 2014	N/A	Open	MetroRapid is a new type of service that operates on two busy travel corridors. Features include limited stops with frequent service, and upgraded technology and other amenities. *Project Connect and CMTA ServicePlan2020*
MetroRapid Route 803 Burnet/South Lamar	The Domain shopping center – Westgate shopping center	Second MetroRapid line to open	Operational as of Fall 2014	N/A	Open in Fall 2014	
Bus Rapid Transit to Oak Hill	Westgate shopping center	Proposed future Bus Rapid Transit		TBD	TBD	*Project Connect*

Project	Limits	Description	Phase	Funding	Let Year	Comment
	to Oak Hill	extension				
Transit in Express Lanes	Along IH-35 and Mopac	Express buses proposed to use tolled, managed lanes free of charge	Managed lane in each direction on Mopac, between Lady Bird Lake and Parmer Lane under construction	Note: See Loop 1/Mopac Managed Lane projects above		Managed Lanes along Mopac, from Lady Bird Lake and Slaughter Lane proposed; as well as along IH-35 *Project Connect*
901 South Mopac Express	Downtown – Southwest Austin along Mopac	New express bus route would provide peak-directional service between a regional park-and-ride in Southwest Austin along Mopac to downtown Austin and UT.		TBD	TBD	Dependent upon additional parking capacity *CMTA ServicePlan2020*
945 IH-35 South Express	Downtown – South Austin along IH-35	New express bus route would provide peak-directional service between a regional park-and-ride in South Austin to downtown Austin and UT.		TBD	TBD	Dependent upon regional park-and-ride proposed. *CMTA ServicePlan2020*
Regional Park-and-Ride in Proposed Oak Hill Town Center	At proposed Oak Hill Town Center	Would have at least 400 stalls to account for future growth and allow this facility to be an intercept point for future growth south and west of Oak Hill.		Note: CAMPO FY 2013 TIP (FY 13-16 TIP) included $281,250 for Oak Hill Park-and-Ride Replacement	2013	Would replace the existing TxDOT facility on SH-71. In the interim, shared-parking would be designated at the ACC-Pinnacle campus. *CMTA ServicePlan2020 and Project Connect*
IH-35 South Corridor Park-and-Ride	Proposed in South Austin, along IH-35; no further north than Slaughter	Would have at least 400 stalls located far enough south to act as an intercept for trips coming	Note: Existing bus stops located in the Southpark Meadows shopping center	TBD	TBD	Would be served by a new route 945 and provide express service into downtown Austin.

Project	Limits	Description	Phase	Funding	Let Year	Comment
	Lane	from Kyle, Buda, and San Marcos				*CMTA ServicePlan2020 and Project Connect*
Southpark Meadows Transit Center	At Southpark Meadows shopping center	New transit center to be able to accommodate a minimum of seven buses.	Note: Existing bus stops located in the Southpark Meadows shopping center.	TBD	TBD	Proposed as separate from the "IH-35 South Corridor Park-and-Ride" *CMTA ServicePlan2020 and Project Connect*
South Mopac Park-and-Ride	Proposed in South Austin, along Mopac (potential in the vicinity of Slaughter Lane)	This may be a shared parking opportunity at some of the businesses in the vicinity of Slaughter Lane and Mopac.		TBD	TBD	A new Route 901 would provide express service from the proposed South Mopac Park-and-Ride to downtown Austin *CMTA ServicePlan2020*
Westgate Park-and-Ride	At Westgate shopping center	Shown on Project Connect vision map	Note: Existing bus stops located in the Westgate shopping center	TBD	TBD	*Project Connect*
South Congress Transit Center Park-and-Ride	At current South Congress Transit Center	Shown on Project Connect vision map		TBD	TBD	*Project Connect*
South Congress Ave. Proposed Urban Rail Phase and Corridor Study	Riverside Drive – Slaughter Lane			TBD	TBD	*Project Connect*

Figure 5
Planned Transportation Projects in Southern Travis and Northern Hays Counties



Task #2 CAMPO and CTRMA Traffic Studies on the Proposed SH45 SW

Review and report findings and recommendations to Council regarding the Recent CAMPO and CTRMA traffic studies on the proposed SH45 SW

CAMPO, Center for Transportation Research, TxDOT traffic studies and CTRMA Level I Traffic and Revenue Forecasts

Introduction:

There are four traffic forecasts available that have studied the proposed SH45 SW and one vehicle license plate capture survey:

I. CAMPO, SH45 SW alternative model runs;

II. Center for Transportation Research, DRAFT Dynamic Traffic Study (DTS) of SH45 SW;

III. TxDOT, DRAFT Traffic Forecasting Methodology;

IV. CTRMA Level I Traffic and Revenue Forecasts; and

V. TTI Vehicle License Plate Capture Survey

CAMPO, CTR, and TxDOT conducted travel demand modeling for a no-build and build scenario for SH 45 SW. CTRMA conducted a Level I Traffic and Revenue Forecasts for a 4-lane tollway. The underlying methodology and assumptions vary between each product as well as the modeled output.

The CAMPO SH45 SW alternative model runs were performed using the regional travel demand model. The CAMPO model now uses a more refined four-period model (AM, Mid-day, PM, Night-time), as opposed to the previous 24-hour model. Traffic volumes were modeled for the build and no-build scenarios using the adopted 2025 transportation network and an updated 2025 demographic forecast.

The CAMPO travel demand model provided the basis for both the Dynamic Traffic Study (DTS) and the TxDOT Traffic Forecasting. The CAMPO model was used in the DTS to obtain the trip matrix used as input into the Dynamic Traffic Assignment model. The CAMPO model was also used to develop the forecasts in the TxDOT traffic forecasting. Before any of the CAMPO model or model output could be used the DTA model and TxDOT's use of the CAMPO model needed to be calibrated to reflect observed traffic counts and travel characteristics.

The CTRMA Level I Traffic and Revenue Forecasts are prepared by Stantec, and represent more precise project level analysis for the proposed tollway. In a Level 1 study the consultants develop average weekday transaction projections: both Year 2025 and Year 2035 forecasts are available.

In addition to the four different forecasts, a license plate capture survey was done in support of the TxDOT traffic forecasts. The license plate capture survey was used to analyze trips that utilized Brodie Lane between S Loop 1 and FM 1626. The following report utilized the same data to draw further conclusions about traffic in the study area.

CAMPO SH45 SW Alternative Model Runs

Description:

Following an October 2011 meeting at TxDOT Austin District offices, CAMPO was asked to perform model runs for five SH45 SW alternative scenarios. They were;

I. Toll4 - SH45 SW with four lanes, toll, no frontage roads, and grade separation at Bliss Spillar Road.
II. Toll2 - SH45 SW with two lanes, toll, no frontage roads, and grade separation at Bliss Spillar Road.
III. NoToll4 - SH45 SW with four lanes, no-toll County Road with signal control at Bliss Spillar Road.
IV. NoToll2 - SH45 SW with two lanes, no-toll County Road with signal control at Bliss Spillar Road.
V. No-Build - without construction of SH45 SW, but improvements to other area roadways.

The model runs were performed using the updated CAMPO 2005 Interim Travel Demand Model (Figure 6) which reflected four time-of-day periods (AM peak, mid-day peak, PM peak, and off-peak) and included modifications such as a speed feedback loop. The updated model is considered to be consistent with general good practice guidelines and represents best practice for New Starts ridership forecasting. The updated model was recently reviewed and validated by Transportation Planning and Programming (TPP) Division of TxDOT making it the official CAMPO model.

The CAMPO model output from the five scenarios was used as input in the Dynamic Traffic Assignment model developed by the Network Modeling Center at the Center for Transportation Research at the University of Texas.

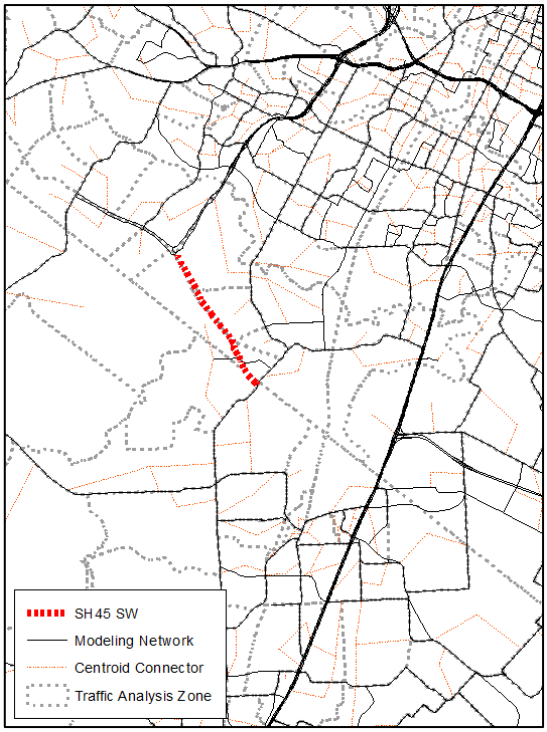


Figure 6 - CAMPO Model Network and Zone Structure

Analysis of Model Results

Demographics:

The underlying demographic assumptions for all five scenarios used an updated 2010 base year which was developed to match the 2010 Census population and 2010 employment data from the Texas Workforce Commission. The 2025 demographics used in the traffic forecasts were developed using the adopted 2035 CAMPO Plan county control totals. The forecasted growth was allocated to the 2010 base year demographics at the traffic analysis zone geography using the CAMPO Demographic Allocation Tool. Figure 7 depicts the total 2010 household density plus the household growth from 2010 to 2025 and the final 2025 household density.

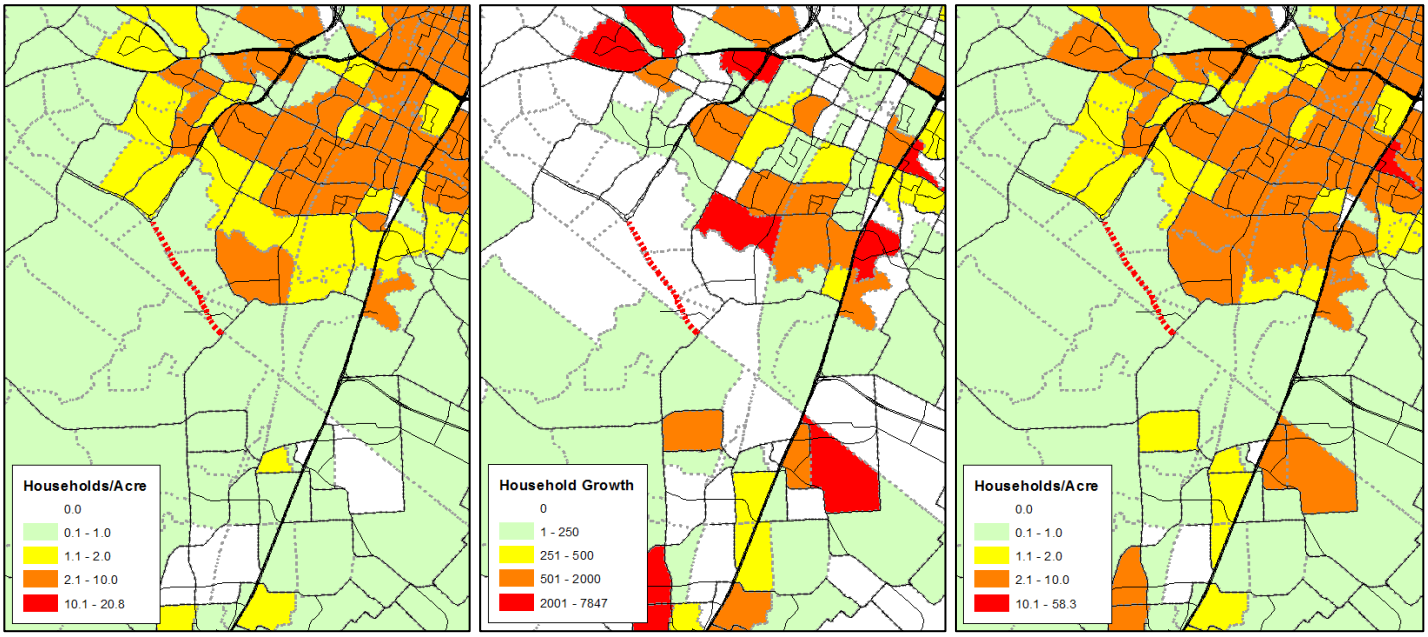


Figure 7a - 2010 Household Density, 2010 to 2025 Household Growth, 2025 Household Density (from left to right).

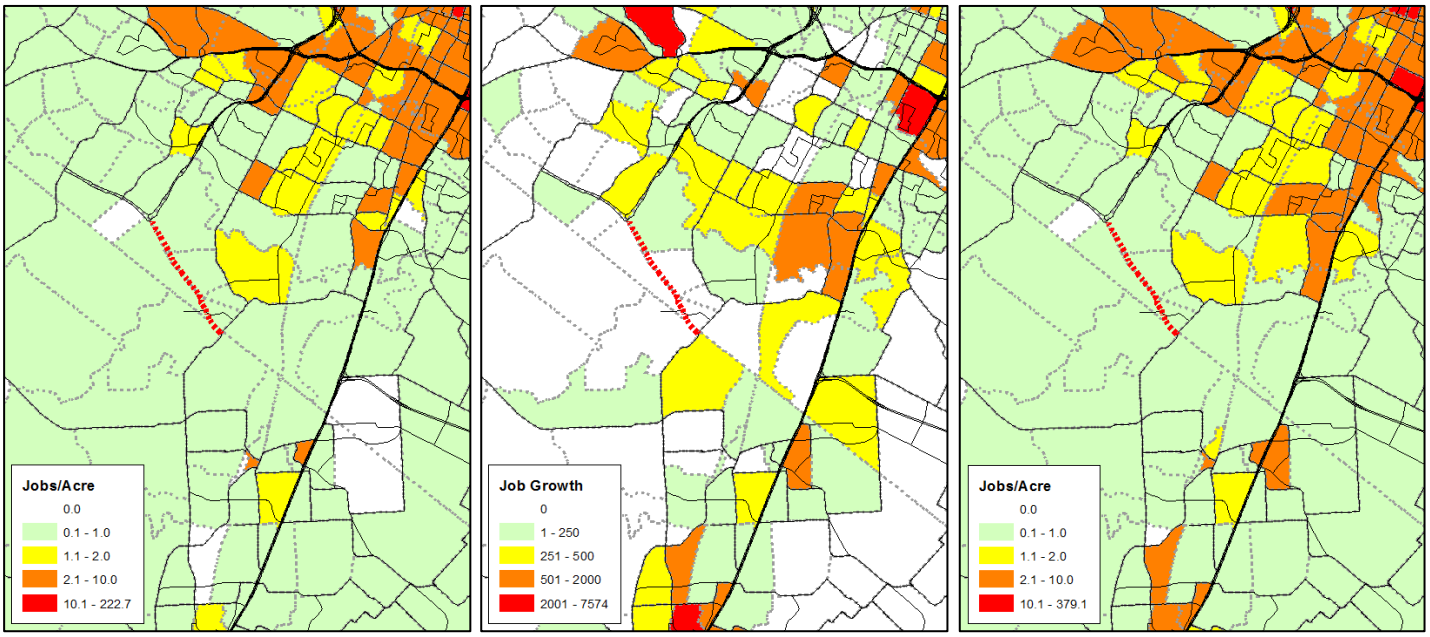


Figure 7b - 2010 Job Density, 2010 to 2025 Job Growth, 2025 Job Density (from left to right).

Some of the areas showing the highest amount of growth in Figures 7a and 7b are the Sunfield Municipal Utility Districts east of I-35 along the Hays/Travis County boundary, the Plum Creek master-planned community in Kyle, the Oak Hill Town Center area, and various infill and redevelopment opportunities within the city.

Travel Patterns:

By comparing the total origins and destinations of trips in the study area (Figure 8) it can be determined that the travel demand did not change between scenarios due to the network changes. The number of person trip and vehicle trip origins by TAZ remained nearly the same across all five scenarios, only +/- 100 trips across all origin TAZs. There was also an insignificant change to the destination of trips due to the difference in network scenarios, only shifting +/- 300 trips across all destination TAZs as compared to the no-build scenario. This can be seen during trip distribution when the model uses travel time skims to determine the end point of each trip. Any localized increase in travel demand from 2010 to 2025 can be attributed to the forecasted demographic growth in the study area, not due to the difference between network scenarios, in other words, all arterials in the study area experienced an increase in traffic volumes with or without SH45 SW. On the other hand, traffic volumes by scenario did vary by roadway based on preferable route characteristics. The SH45 SW build scenarios provide a faster alternative and therefore decreases in volume can be seen on other arterials in the study area as compared to the no-build scenario. The largest volume changes to area roadways can be seen in the 4-lane toll free scenario while fewer changes occurred in the 4-lane toll scenario (shown in Figure 9).

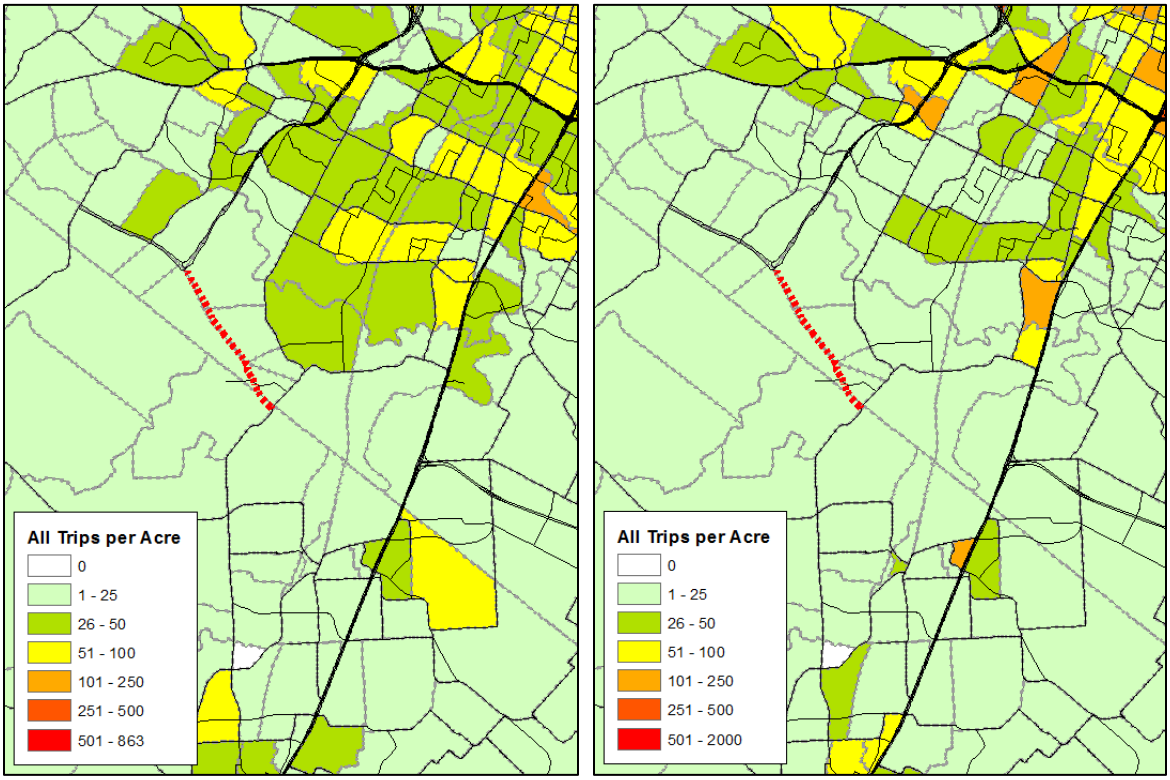


Figure 8 - All Person and Vehicle Trip Origins and Destinations by Traffic Analysis Zone (Origins, left and Destinations, right)

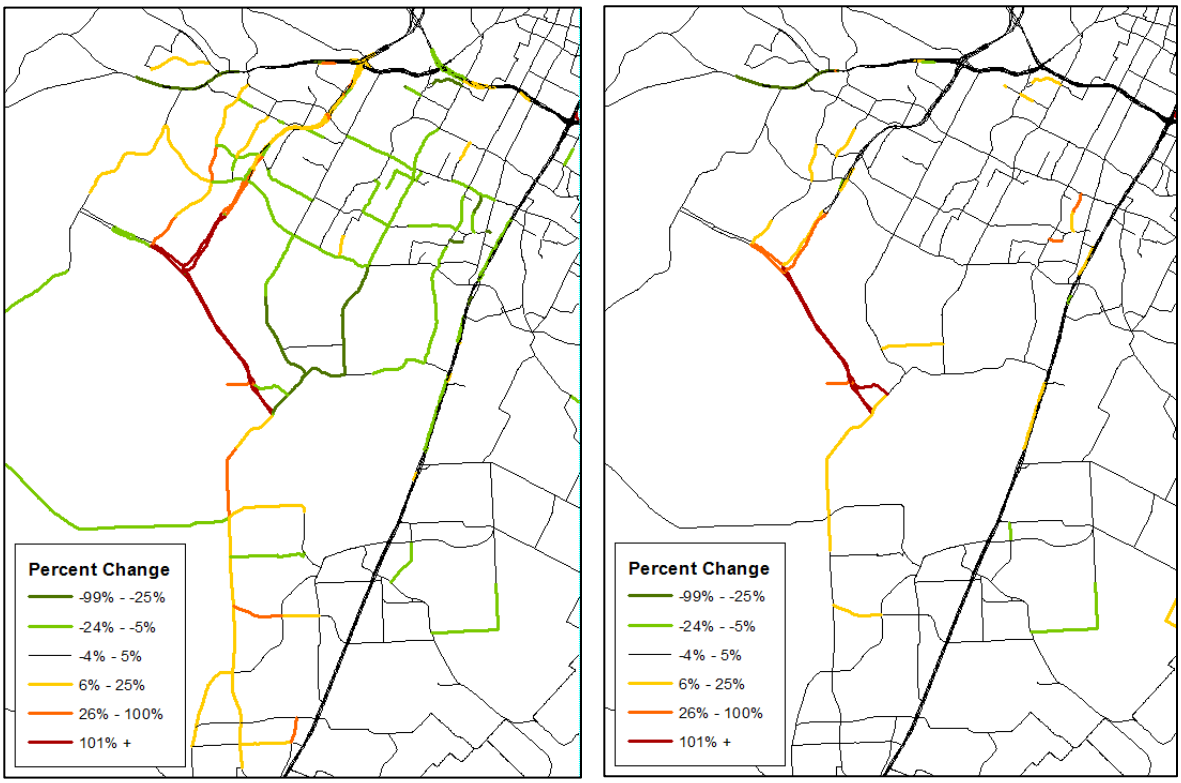


Figure 9 - Changes in Traffic Volumes from No-Build to Build Scenarios (4-lane toll free and 4-lane toll, left and right)

Traffic Volumes:

Traffic volumes were forecasted using the adopted 2025 transportation network with the only variations being the SH45 SW alternatives. With all input assumptions being the same the difference in modeled volumes can be attributed to the travel times and cost differences between each scenario. Table 2 compares the volumes in each scenario.

Table 2

Daily Traffic Volumes: Source is CAMPO "SH 45 Alternatives Analysis", 2013				
Road	**Location**	**2025 No-build**	**2025 4-lane**	**2025 4-lane toll**
SH45 SW	MoPac to FM 1626	-	24,000	5,000
MoPac	South of La Crosse Ave.	5,000	17,500	6,000
SH45	West of MoPac	5,000	16,000	9,000
FM 1626	North of proposed SH45 SW	35,000	22,500	35,000
FM 1626	South of proposed SH45 SW	35,000	42,500	38,000
FM 1626	West of I-35	11,500	11,500	11,500
Brodie Ln	North of FM 1626	12,000	8,500	12,000
Brodie Ln	South of Slaughter Ln	18,000	16,500	18,500
Slaughter Ln	East of MoPac	38,000	32,000	38,500
Manchaca Rd	North of FM 1626	24,000	16,500	25,000

Dynamic Traffic Study of SH 45(SW)

Description

CAMPO staff and the Network Modeling Center (NMC) at the Center for Transportation Research (CTR) completed a joint modeling study in December 2013 to evaluate the impact of constructing SH 45 SW, from Loop 1 to FM 1626, on traffic conditions in a specified study area in southern Travis County/northern Hays County. The study area was bounded by FM 1826 and Nutty Brown Road on the west, IH 35 on the east, US 290/SH 71 on the north, and FM 967 on the south. Five scenarios were studied, including one no-build and four build scenarios as follows in Table 3:

Table 3
Scenarios of Dynamic Traffic Study

Scenario	Description
Toll4	SH 45 SW with four lanes, toll, no frontage roads, and grade separation at Bliss Spillar Road.
Toll2	SH 45 SW with two lanes, toll, no frontage roads, and grade separation at Bliss Spillar Road.
NoToll4	SH 45 SW with four lanes, no-toll County Road with signal control at Bliss Spillar Road.
NoToll2	SH 45 SW with two lanes, no-toll County Road with signal control at Bliss Spillar Road.
No-Build	without construction of SH 45 SW, but improvements to other area roadways.

The NMC at CTR performs an advanced modeling practice called dynamic traffic assignment (DTA), a cross between regional and more microscopic models for smaller, defined areas. The idea for the DTA is to evaluate the implications of what a change in the transportation system would have on a traveler's route choices throughout the specified network.

CTR and CAMPO staff completed a draft report on the DTA modeling efforts and presented their findings to the CAMPO Policy Board at their regular meeting on December 9, 2013.[1]

The modeling approach for this study was a combination of the CAMPO travel demand model and CTR's DTA model. CAMPO staff updated the demographic forecasts and performed the CAMPO travel demand model based on the most recent 2010 population and employment estimates and on a new time-of-day component (instead of the previous, 24-hour trip-based model). The more refined outputs, based on time-of-day, were then used in the DTA model. The modeling effort was limited to study the effect of SH

[1] Originally presented in 2012, the report was pulled by CAMPO staff to address errors in land uses. The 2013 report includes quality control check assuring data accuracy.

45 SW on area roadways through the forecast year of 2025, given infrastructure improvements inherent in the 2025 CAMPO transportation network, including:

- Lane additions to Manchaca Road, FM 1626, and South Congress
- Addition of managed lanes on Loop 1 from Slaughter Road to Parmer Lane
- Addition of Lone Star Rail

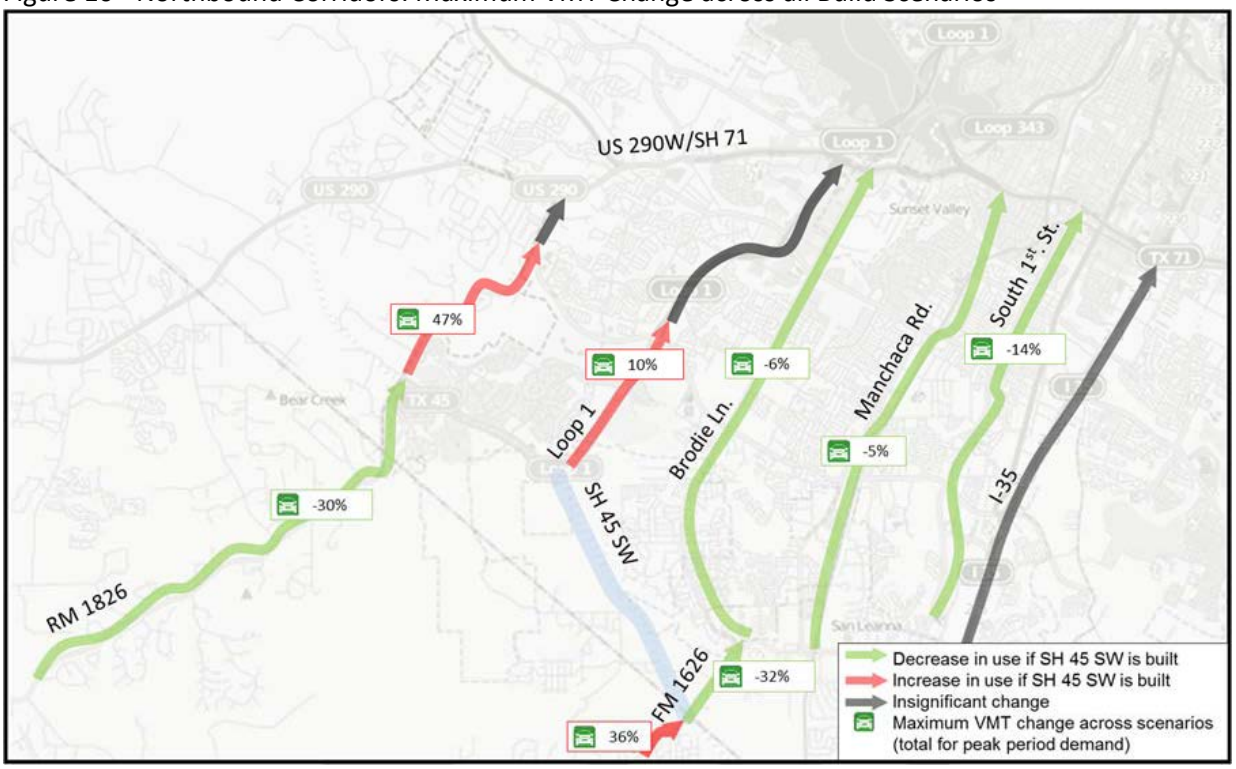
Model Results

In regard to inter-county travel patterns, some highlights from the draft report include:

- For northbound, morning peak period traffic traveling from Hays County to Travis County in a build scenario, a significant proportion of travelers are projected to use SH 45 SW and Loop 1 to reach their destinations, with travel times reduced by two to three minutes (5 to 8% reduction) and route lengths reduced by one to two miles (6 to 8% reduction).
- For southbound, morning peak period traffic traveling from Travis County to Hays County in a build scenario, a significant proportion of travelers are projected to use SH 45 SW to reach their destinations, with travel times reduced by two to three minutes (4 to 12% reduction) and route lengths reduced by 1.5 miles (7 to 9% reduction).

CTR staff also analyzed vehicle miles traveled (VMT) for certain north-south and east-west corridors to deduce how these corridors would be affected by the no-build and build scenarios. Figures 10-12, as provided in the draft DTS report, illustrate the percent change in VMT for each corridor according to the maximum change exhibited across all scenarios. Please note, the maps below highlight “significant changes”, as defined by the draft report to include those “occurring when the change in volume is greater than 3% of the roadway capacity.”

Figure 10 - Northbound Corridors: Maximum VMT Change across all Build Scenarios

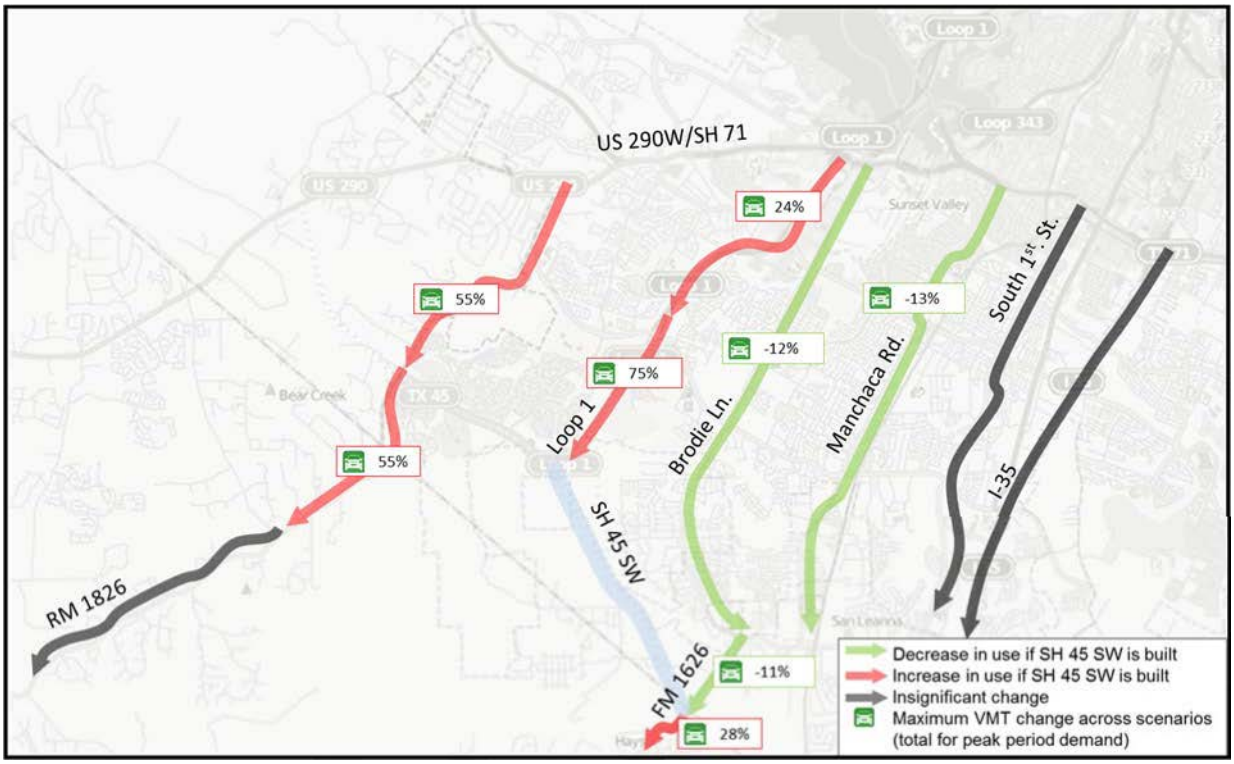


Source: *Dynamic Traffic Study of SH 45 SW* (Draft Report), CAMPO and CTR

According to the DTA analysis contained in the draft report, SH 45 SW is enabling traffic traveling northbound in the AM peak period to divert to Loop 1 from RM 1826 between FM 967 and SH 45 S; South 1st Street; Brodie Lane; Manchaca Road; and on FM 1626 north of SH 45 SW, as shown in the decrease in VMT above. In contrast, an increase in VMT can be seen on Loop 1 between SH 45 S and Slaughter Lane; RM 1826 between SH 45 S and Slaughter Lane; and FM 1626 south of SH 45 SW.

Of note, according to the draft report, Loop 1 has additional capacity between SH 45 SW and Slaughter Lane. With the addition of SH 45 SW, this additional capacity translates into an increase in VMT along that stretch of Loop 1. On the other hand, the modeling forecast showed only an "insignificant change" in VMT on Loop 1 north of Slaughter Lane. This is due, according to the draft report, to that portion of Loop 1 already being congested, resulting in insufficient space for more traffic. This indicates that the addition of SH 45 SW does not necessarily add more traffic to Loop 1 north of Slaughter Lane. However, traffic relief is exhibited on parallel corridors (e.g. Brodie Lane, Manchaca Rd, and South 1st Street).

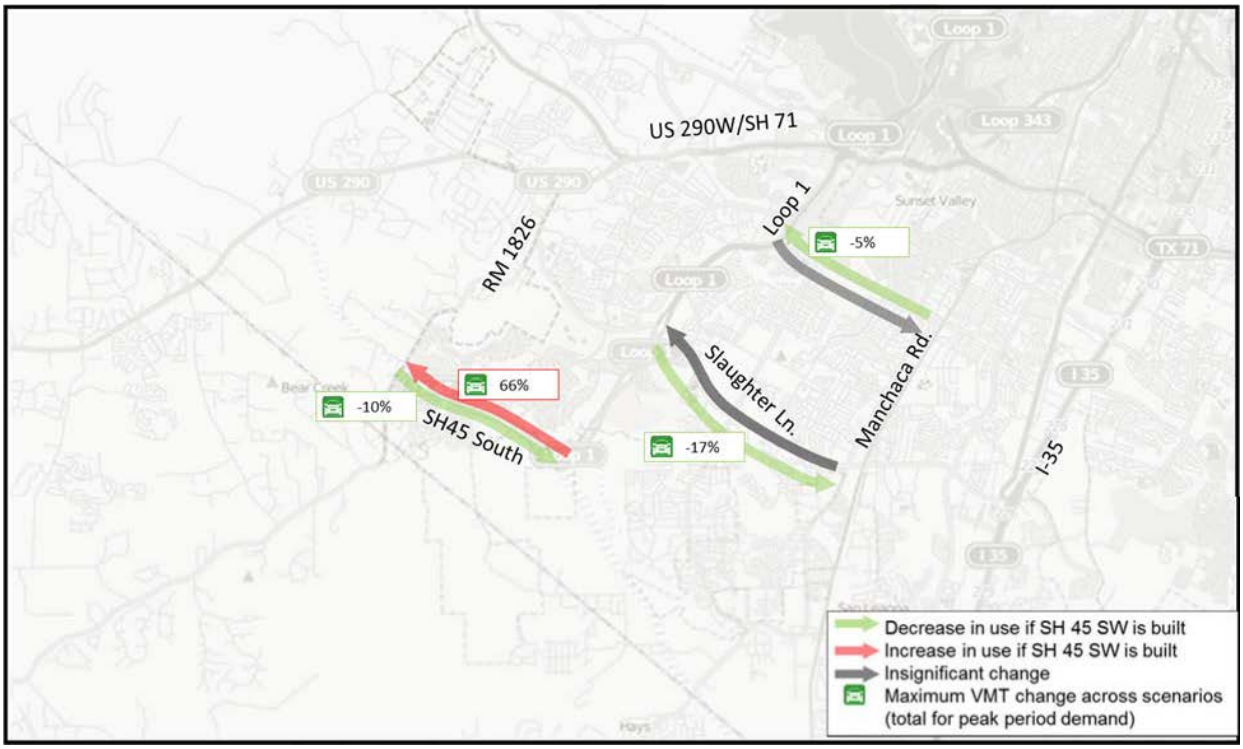
Figure 11 - Southbound Corridors: Maximum VMT Change across all Build Scenarios



Source*: Dynamic Traffic Study of SH 45 SW* (Draft Report), CAMPO and CTRM

As shown in the map above, a decrease in VMT is evidenced in the southbound direction on Brodie Lane, Manchaca Road, South 1st Street, and on FM 1626 north of SH 45 SW, with the addition of SH 45 SW. In contrast, an increase in VMT can be seen on RM 1626 between US 290 and Nutty Brown Road, Loop 1, and FM 1626 south of SH 45 SW. These patterns are consistent with the new connectivity that SH 45 SW would provide in the study area, allowing traffic to be diverted to Loop 1, RM 1826, and FM 1626 south of SH 45 SW. However, it is important to note that the map above demonstrates the travel patterns in the southbound direction, which is not necessarily the dominant travel movement for commuters during the AM peak period.

Figure 12 - Eastbound and Westbound Corridors: Maximum VMT Change across all Build Scenarios



Source*: Dynamic Traffic Study of SH 45 SW* (Draft Report), CAMPO and CTR

In regard to the eastbound and westbound corridors, the map above indicates a decrease in VMT along SH 45 S westbound and an increase in VMT along SH 45 S eastbound; Slaughter Lane eastbound; and William Cannon westbound. This is consistent with the addition of SH 45 SW, allowing traffic to divert from corridors, such as Slaughter Lane and William Cannon.

Conclusions and Report Limitations

According to the draft report, in terms of study limitations, the study did not explore the full impact of SH 45 SW reaching its full potential for highway connectivity in the region, as the network does not include the section of SH 45 SW to be built between IH 35 and Loop 1 or in the event that the southern terminus of Loop 1is upgraded to a freeway. In addition, according to the draft report, many of the northbound arterial roadways in the study are only expected to experience a “moderate relief in traffic.” However, there are no definitions of what “moderate” constitutes in the report.

Some other limitations to the overall study include the analysis of morning peak period travel patterns between select origin-destination, which provides a snapshot of select travel patterns. The results in the draft report are presented more qualitatively in terms of generalized maps and overall percentage comparisons. City staff did not have access to full model outputs and instead relied on results reported in the draft report.

In regard to the analysis of major corridors, the maps in the draft report (as included above) showed the maximum percent change in VMT across all of the build scenarios, instead of breaking each scenario

down into separate maps. Individual maps would be more useful in understanding how each corridor exhibits different travel patterns according to each build scenario and vehicle divergence overall.

TxDOT Traffic Forecasting in Support of the Draft Environmental Impact Statement

Description:

TxDOT conducted travel demand modeling for a 2035 no-build and 2035 build scenario for the proposed SH45 SW 4-lane toll road. Forecasts were developed using the CAMPO travel demand model after undergoing an extensive data collection effort and sub-area refinement. Observations of 2013 traffic conditions were used to calibrate the 2015 model before it was used to forecast 2035 traffic for both scenarios.

The 2013 observed traffic conditions compared to the 2015 model output determined that sub-area refinements were necessary. Analyzing traffic count locations across a screen line determined that the 2015 model was representing 2013 demand conditions across the study area but not at the corridor level. Sub-area refinements included splitting Traffic Analysis Zones (TAZ), adding centroid connectors, and adjusting the 2015 TAZ trip table to match the new zones. These refinements allow for trips to be loaded onto the modeling network more accurately. Additional refinements included changes to the study area's modeling network attributes. Speed and capacity adjustments were made to Brodie, Slaughter, Escarpment, SH45, and MoPac based on speed survey data collected between 2011 and 2013. These adjustments allow for trips to be assigned to the network more accurately based on travel time and capacity constraints.

The screen line analysis after the sub-area refinements showed that it more closely matched the 2013 observed distribution patterns within 7%, an acceptable margin (TxDOT Traffic Forecasting, pg 15). Once refinements were completed the 2015 model was used to estimate the no-build and build scenarios for the year 2035. Additional 2035 volume adjustments were made based on comparing historic traffic volumes and average annual growth rates. Only the bounding roadways in the study area were adjusted and reported on (MoPac, FM 1626, SH45, and SH 45 SW)

Analysis of Results

Demographics:

TxDOT traffic forecasting used the CAMPO 2035 forecasted demographics at the TAZ level to perform the no-build and build model runs. TxDOT review of the demographics in the model study area found significant developments currently underway which were not included in the forecasted demographics. Two large scale residential developments, Avana and Grey Rock Ridge, are currently approved with preliminaries just south of SH45 and west of MoPac. TxDOT estimated that there could be an additional 2,000 to 4,000 houses upon build out. Further review of the approved preliminaries shows 387 single-family homes at Grey Rock Ridge and 925 homes at Avana. Final Plats have been recorded and building permits have begun to be issued for both developments in 2013.

Travel Characteristics:

TxDOT derived K-Factor and Directional Splits from extensive count data on Mopac, SH45, and FM 1626. Based on the observed data Mopac south of Slaughter Lane and SH45 east of FM 1826 has a K-Factor of 10.5% and a directional distribution of 58%-42%. FM 1626 just south of Brodie Lane has a K-Factor of 11% and a directional distribution of 62%-38%.

Traffic Volumes:

Traffic volumes were forecasted for a 2035 no-build and 2035 build scenario for the proposed SH45 SW 4-lane toll road. The following table (Table 4) compares the scenarios and the final results:

Table 4
Traffic Volume Forecasts for SH45 SW 4-Lane Toll Road

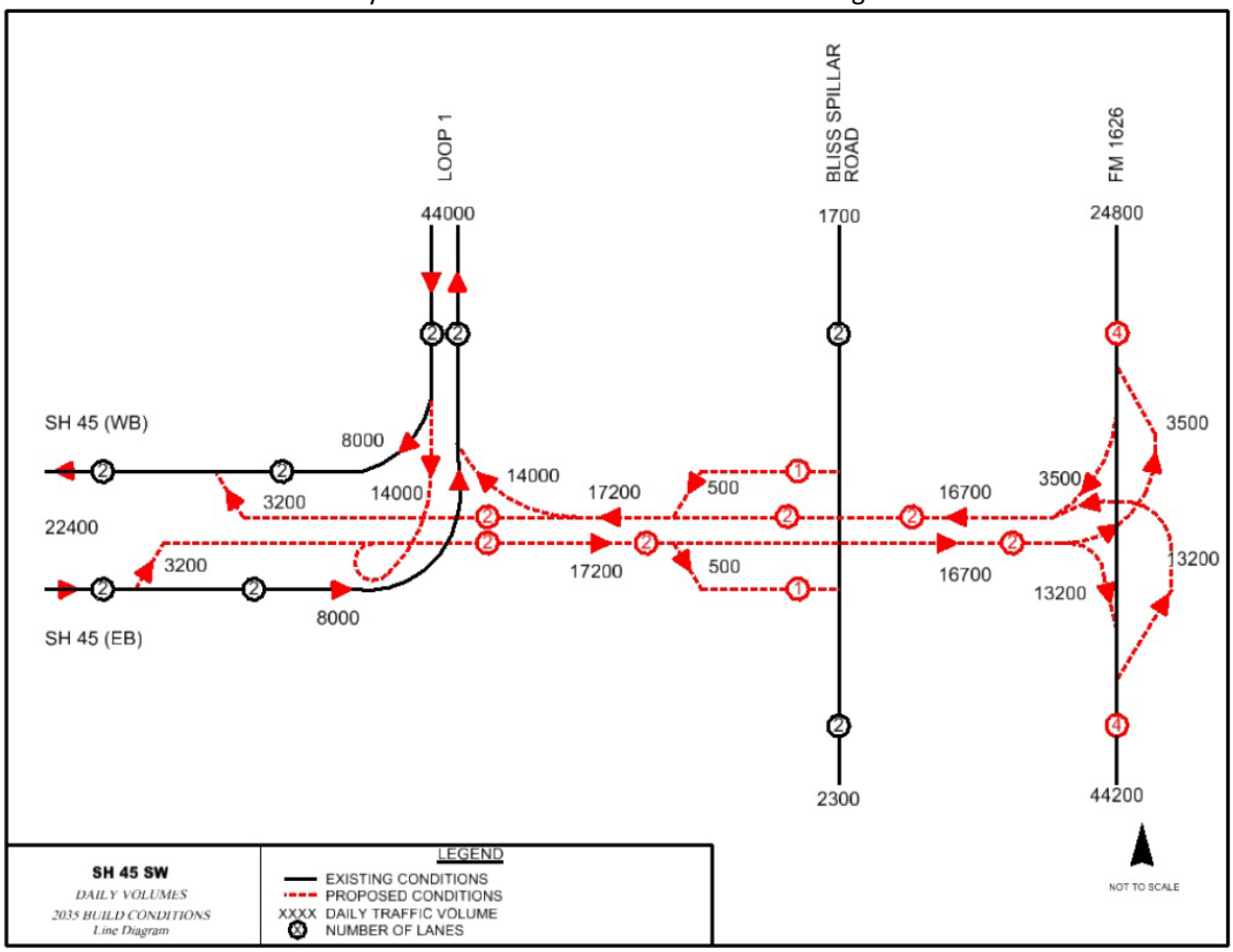
Daily Traffic Volumes: Source is TxDOT "DRAFT Traffic Forecasting Methodology", 2014				
Road	**Location**	**2013**	**2035 no-build**	**2035 build**
SH45 SW	MoPac to FM 1626	-	-	34,400
MoPac	South of La Crosse Ave.	14,866	26,600	44,000
SH45	West of MoPac	14,866	26,600	22,400
FM 1626	North of proposed SH45 SW	18,007	35,000	24,800
FM 1626	South of proposed SH45 SW	18,007	35,000	44,200

No-build – Model results for the no-build scenario were adjusted down for FM 1626 and up for MoPac and SH45 based on comparisons of historic growth rates with model growth rates. TxDOT determined the 2015 model assignment significantly over-forecasted demand on FM 1626 and applied a 3.08% average annual growth rate to the observed 2013 traffic count over a 22 year period to get the 2035 no-build volume to get 35,000. TxDOT determined the 2015 model assignment under-forecasted demand on Mopac south of Slaughter and on SH45 east of FM 1826. The last four years of traffic counts showed a positive AAGR while the model showed a decrease in traffic between 3% and 9% annually. The observed AAGR of 2.56% was applied to the observed 2013 traffic count over a 22 year period to get the 2035 no-build volumes for MoPac and SH45. It should be noted that this calculation was adjusted from 25,945 to 26,600. Bliss Spillar Rd crosses the proposed SH45 SW and in the no-build scenario is assumed to have 2,300 vehicles per day.

Build – Volumes for the build scenario were estimated using the percent difference between the no-build forecast and the build forecast applied to the adjusted no-build forecasts. The percent difference can also be described as model diversion. The model diversion indicates where traffic increases and decreases based on the changes to the modeled network. If SH45 SW is built there is resulting 26% increase in traffic in the model on FM 1626 at the proposed connection with SH45 SW. This percentage applied to the adjusted 2035 no-build volume equals 44,200. Similarly, model diversion factors were applied to MoPac south of La Crosse and SH45 west of MoPac. MoPac was adjusted by 66% to get 44,200 while SH45 was adjusted by -15% to get 22,400. The 2035 daily forecast volumes for the proposed SH45 SW were taken from the 2035 demand model and balanced to the adjusted 2035 forecast build volumes. The resulting forecast for SH45 SW is between 33, 400 and 34,400 vehicles per

day. The schematic line diagram (Figure 13) shows this forecast. Unadjusted build volumes for SH45 SW were not reported.

Figure 13
Daily Volumes 2035 Build Conditions Line Diagram



Conclusion

TxDOT forecasting methodology utilized the CAMPO travel demand model and 2013 observed traffic to forecast volumes on the proposed SH45 SW 4-lane toll road and its adjoining roadways. Adjustments to the CAMPO model were required due to the performance of the base year compared to observed 2013 traffic patterns. Even after calibrating the base year, further adjustments were required for the traffic forecasts due to the under and over forecasting of volumes as compared to historic growth rates. Due to the limited study area it is not clear what downstream effects there will be on MoPac north of Slaughter Lane or on other southwest area arterials, including Brodie Lane.

CTRMA Level I Traffic and Revenue Forecasts

Description

Of all of the traffic studies and forecasts for SH45 SW the CTRMA Level I Traffic and Revenue Forecast is the most refined and precise project level forecast. A Level I forecast is used for project screening and is based on preliminary project design and data. The project level model developed gives a rough projection of traffic and revenue generated from the project.

Results

Traffic Volumes

The forecasted volumes on SH45 SW are different compared to the previous traffic studies in this report. Differences can be attributed to the different methodologies and parameters used to model travel demand. Most notably is the inverse relationship between tolled and non-tolled in the CAMPO model versus the Level I forecast. The CAMPO model shows a preference towards non-tolled travel and therefore had a higher non-tolled forecast than the tolled scenario. Additionally, the CAMPO model is sensitive to toll costs which affects the resulting route choice even though there may be travel time savings. Both of these relationships, and other parameters, were reviewed in the DTS and TxDOT traffic studies and can explain the variation between their forecasts and the CAMPO model results. Finally, it should be noted that the access design (at-grade versus interchange) from Bliss Spillar Road to SH 45 SW could reasonably be expected to account for much of the difference between the various traffic forecasts.

Table 4
CTRMA Traffic Volume Forecasts for SH45 SW 4-Lane Toll Road

Average Weekday Transaction Projections: Source is CTRMA Level I Traffic and Revenue Forecasts			
Road	**Location**	**2025**	**2035**
SH45 SW	MoPac to FM 1626	14,388	21,003

Texas Transportation Institute Vehicle License Plate Capture Survey

Description

In October 2013 Texas Transprotation Institute (TTI) performed a vehicle license plate capture survey for the Central Texas Regional Mobility Authority (CTRMA) in the SH45 SW study area. The purpose was to fine tune the regional CAMPO travel model to better reflect travel patterns, improving predictive capability by creating better subarea corridor models. Video cameras were placed at strategic locations to identify commonly used routes for traffic entering and leaving the study area. The cameras recorded vehicle counts by direction over two 13-hour periods from 6 a.m. to 7 p.m. on separate days to capture the directional traffic, refered to as inbound and outbound traffic. These directional traffic counts can be combined to capture all traffic in a typical 13-hour period. Figure 14 shows the location of the cameras and their station location numbers.

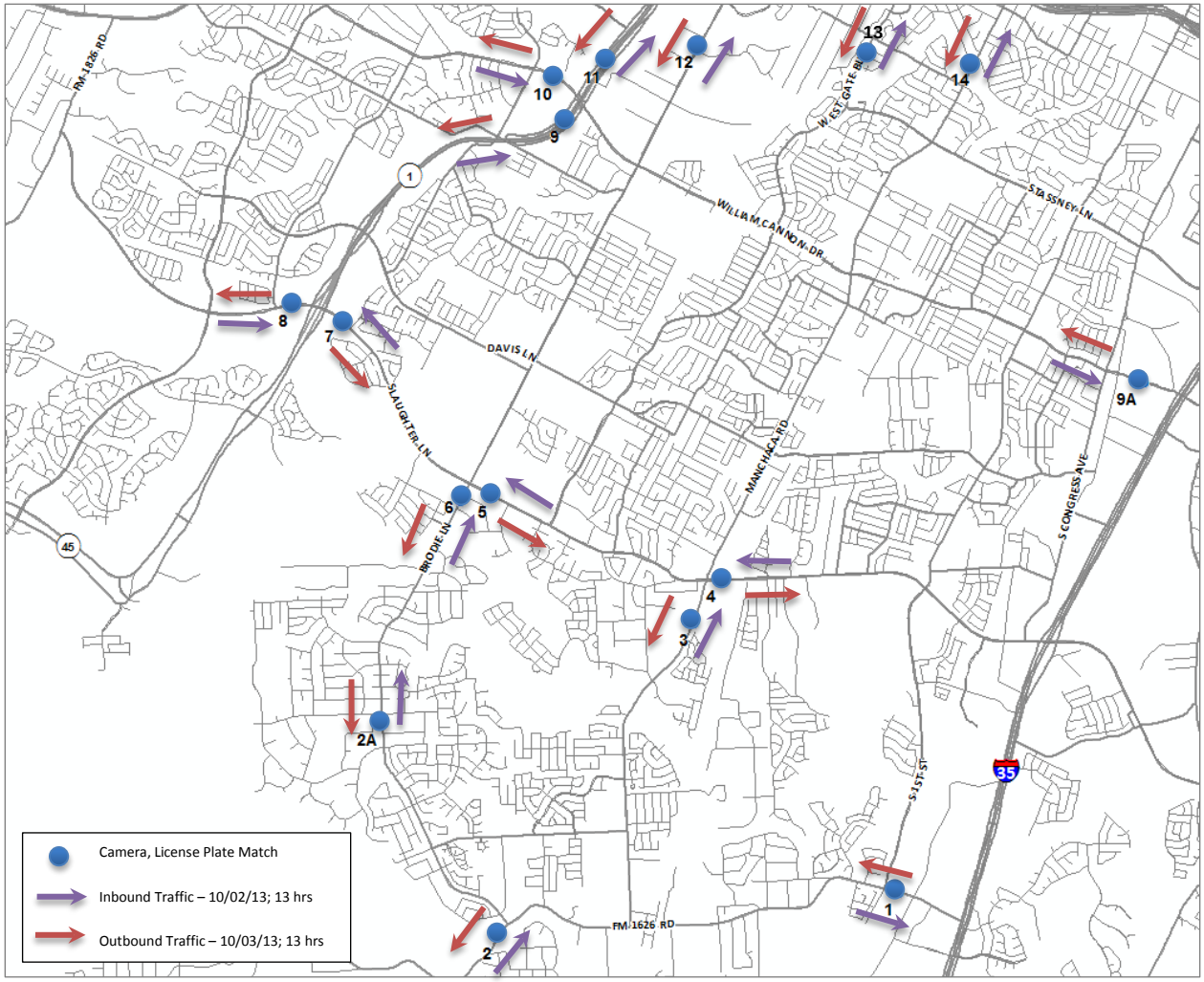


Figure 14 - Camera Locations and Inbound/Outbound Directions

Analysis

The TTI analysis primarily focused on trips that utilized FM 1626, Brodie Ln, Slaughter, and South Loop 1. The entire survey dataset however provides insight on how other trips are distributed within and through the study area. It is presented in tabular format in Appendix 2.

FM 1626, South of Brodie Lane

The video survey captured 14,660 vehicles at camera #2 on FM 1626 just south of Brodie Lane during the 13-hour period, approximately 81% of the observed daily traffic in 2013 (18,007 counts in a 24 hour period). Of those vehicles, 2,722 license plates were matched to other camera locations in the study area, which suggests 18.6% of the trips are non-local, or through trips. The remaining 81.4% of the trips not matched in another camera can be considered internal to the study area or may have utilized a route that was not monitored in the study (Figure 2).

Of the 2,722 vehicle license plates captured twice, nearly 1 out of 4 (623) traveled between FM 1626 and Slaughter via Brodie. Those 623 vehicles made up 2.9% of the 21,810 vehicles counted on Brodie just south of Slaughter. There were 152 vehicle license plates (6% of the 2,722) captured again at MoPac north of William Cannon. Alternatively, 293 vehicles were captured on FM 1626 west of I-35, and 347 on Manchaca Rd south of Slaughter (11% and 13%, respectively). This suggests trips that pass through FM 1626 south of Brodie are equally as likely to utilize these routes as Brodie Ln.

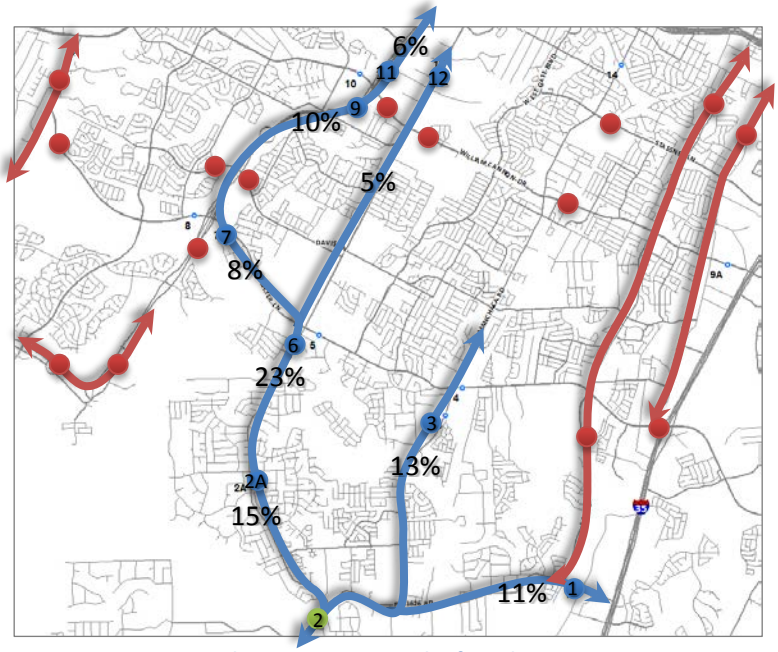


Figure 15 – Routes utilizing FM 1626 south of Brodie, site #2

How to read the map:
The routes shown in blue in Figure 15 indicate the most used routes that pass through FM 1626 south of Brodie Ln. in either direction.
The map shows the percent of trips that were matched only with site #2. For example, 23% of the trips matched with site #2 matched at site #6 (Brodie, south of Slaughter).

The routes shown in red were not monitored. The red dots denote additional camera locations that could have improved the vehicle license plate match.

Slaughter Lane, East of MoPac

Camera #7 captured the highest percentage of vehicle license plate matches by a single camera (east of MoPac on Slaughter Ln). Approximately 20.1% (4,928) of the total vehicle captures at this location were matched to other locations in the study area (24,572). These represent non-local, or through, traffic. Of those vehicles, 1,078 were captured on MoPac south of William Cannon (22% of 4,928). As shown on Figure 16, on Slaughter Ln east of Brodie Ln. at site #5 there were 920 vehicles (19%), and east of Manchaca Rd at site #4 there were 668 (14%).

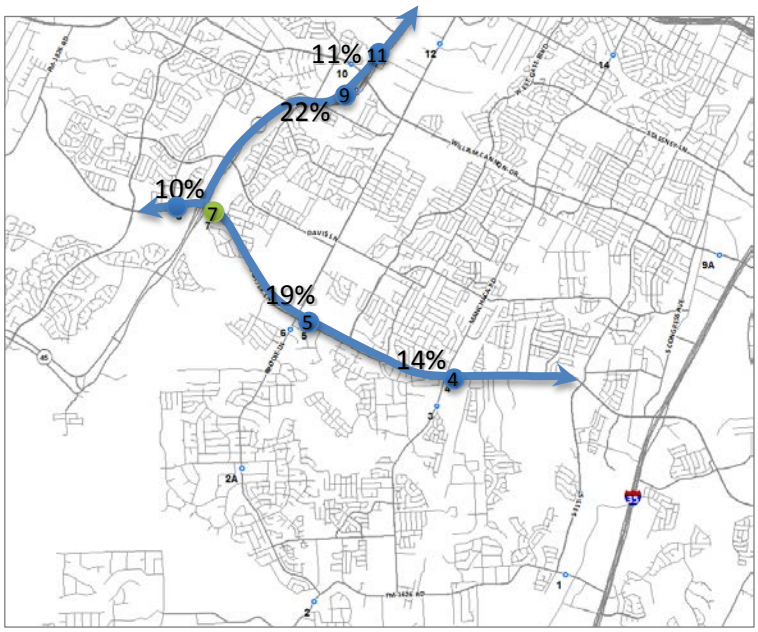


Figure 16 - Routes utilizing Slaughter Ln east of MoPac, site #7

The blue routes in Figure 16 display the most frequented routes that pass through Slaughter Ln. east of MoPac in either direction.

MoPac, South of William Cannon Drive

The highest number of vehicle license plate matches between multiple cameras occurred at site #9 with 17.6% of the 13 hour count (8,129). On the north side of William Cannon 35% of vehicles (2,838) matched at site #11. As shown on Figure 17, Slaughter Ln. west and east of MoPac accounted for 29% of the matches collectively, with 16% to the west and 13% to the east. Further east on Slaughter at site #5, 706 license plates matched while 592 matched at site #6 on Brodie, which suggests more trips passing through MoPac utilize Slaughter east of Brodie.

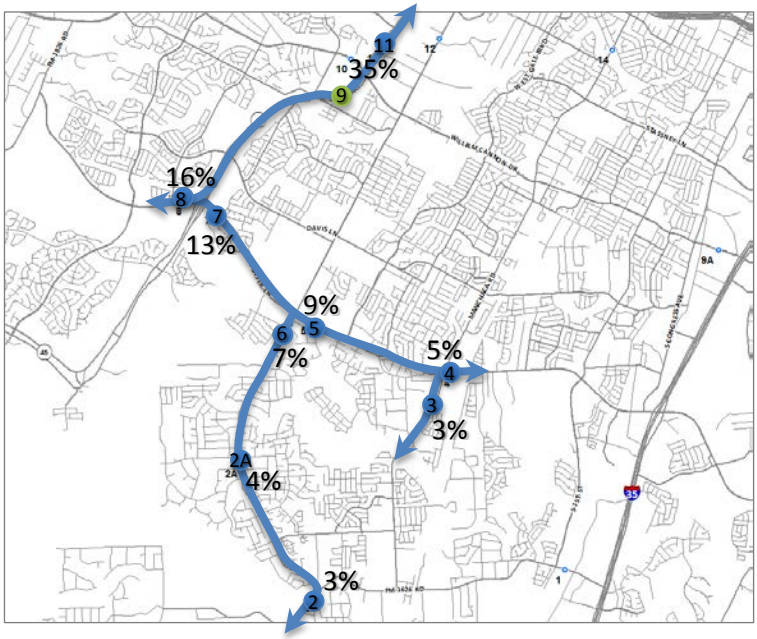


Figure 17 - Routes utilizing MoPac south of William Cannon, site #9

Manchaca Road, South of Slaughter Lane

Camera #3 captured 18,965 vehicles during the 13-hour period, with 13.2% (2,506) paired at other cameras in the study area. From this location almost equal percentages of vehicle license plates were captured in all four directions. The most-utilized route matched with site #5 on Slaughter to the west at 18% (455), while 16% (410) matched to the east on Slaughter at site #4. As shown on Figure 18, heading North/South on Manchaca a higher percentage of matched license plates occurs at site #2 on FM 1626 with 14% (347), while 12% (306) matched on Manchaca south of Ben White Blvd.

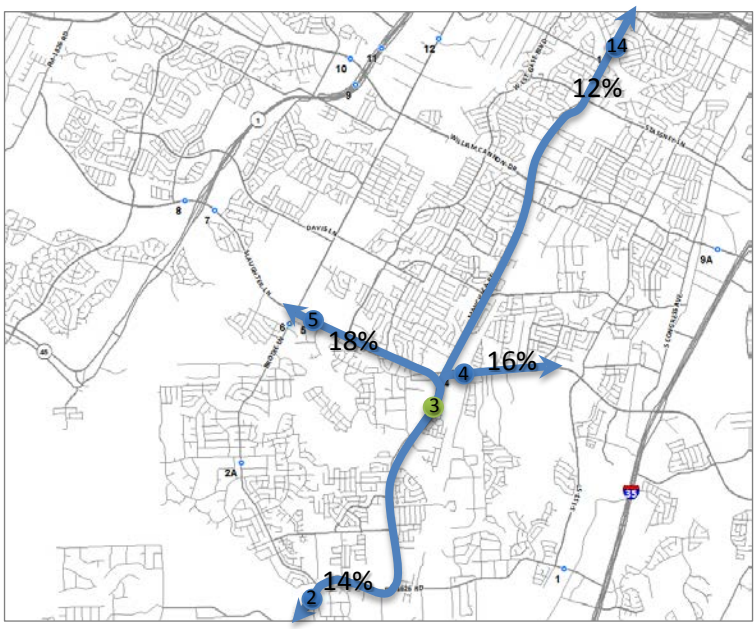


Figure 18- Routes utilizing Manchaca Rd, site #3

FM 1626, West of I-35

The camera at site #1 on FM 1626 west of I-35 had one of the lowest vehicle counts during the 13-hour period, with 12,476 vehicles, however it also exceeded the 24-hour count by 876 vehicles (11,600 in 2012). This location only had 4.8% of its counts match to other locations in the study area, 603 vehicles. As shown on Figure 19, of those vehicles, 49% of them matched with site #2 on FM 1626 south of Brodie, and 15% matched at site #4 on Slaughter east of Manchaca.

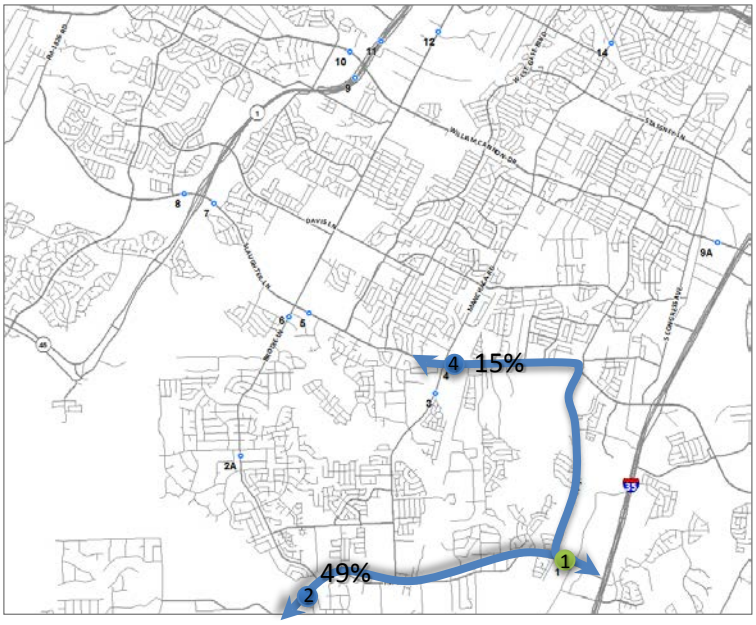


Figure 19 - Routes utilizing FM 1626 west of I-35, site #1

Conclusion:

The license plate capture survey indicates that 20% or fewer vehicle trips made in the study area were trips passing through. This also indicates that 80% or more vehicle trips made in the study area are local, or only passed through one camera location.

Traffic to MoPac and addressing the "bottleneck" bridge across Lady Bird Lake

The appropriateness of adding traffic to South MoPac by construction of SH45 SW in advance of developing and implementing a plan to address the "bottleneck" at the MoPac bridge over Lady Bird Lake

Loop 1 South Environmental Study

Under the sponsorship of TxDOT and CRTMA, the Loop 1 South Environmental Study will analyze and determine the best alternatives for improving mobility from Cesar Chavez Street to Slaughter Lane. The study will also identify future needs and possible modifications to the Lady Bird Lake Loop 1 bridge. This study began in 2013, and is anticipated to take 2-3 years to complete.

Loop 1 South was constructed in sections, similar to Loop 1 North, between 1975 and 1992 as a 4 to 6-lane divided highway. It currently attracts up to 150,000 cars and trucks per day. A brief history of South Loop 1 compiled by TxDOT is found in Table 5. The Loop 1 South Study, as well as preliminary and construction engineering, and construction phases, was included in the FY 2013 of the CAMPO FY 2013 – 2016 Transportation Improvement Program (TIP). Funds programmed for the study at that time totaled $12,450,000.

This study will examine six alternatives:

- Add General Purpose Lanes in each direction
- Add High Occupancy Vehicle (HOV) Lanes in each direction
- Add Transit Only Lanes in each direction
- Add Express Lanes in each direction
- Transportation Systems Management (TSM)/Transportation Demand Management (TDM)
- No-Build, or "do nothing" alternative

As it addresses the appropriateness of adding traffic to South Loop 1 by construction in advance of implementation of a plan to address the Lady Bird Lake Loop 1 bridge, staff provides the following quotation from TxDOT and CTRMA:

"The Texas Department of Transportation and the Central Texas Regional Mobility Authority are working together to conduct environmental studies on several projects, including MoPac South, Mopac Intersections and SH 45SW. Each of these projects is included as a stand-alone project in the Capital Area Metropolitan Organization's (CAMPO) 2035 Plan, and as such, is being studied separately. In addition, each of these projects has independent utility, meaning each would benefit drivers and would be considered a reasonable expenditure, even if no additional transportation improvements in the area are made; therefore they are being studies independent of one another. If built, these projects could function as stand-alone improvements, even if other improvements in the area do not advance, or advance at a different schedule." TxDOT/CTRMA, http://www.mopacsouth.com/about/faqs.php , accessed 8-12-2014.

Table 5

Brief History of MoPac Expressway Improvements

Planning or Construction Activity	Year
The MoPac Expressway was included as part of the 1961 City of Austin Master Plan and Circulation Plan when only 160,000 people lived in Travis County.	1961
Construction of MoPac Expressway from Lady Bird Lake to RM 2244 is completed.	1973
Construction of MoPac Expressway from RM 2244 to Loop 360 is completed.	1982
Construction of MoPac Expressway from Loop 360 to US 290 is completed.	1986
Construction of MoPac Expressway from US 290 to Slaughter Lane is completed.	1990
Construction of MoPac Expressway from Slaughter Lane to SH 45 is completed.	1991
Construction of MoPac Expressway from US 290 to William Cannon Drive (overpass over William Cannon Drive)	2005
Construction of direct connectors at MoPac Expressway/US 290	2013
The MoPac South Environmental Study was initiated to evaluate improvements south of Cesar Chavez Street to Slaughter Lane. Today, Travis County contains over one million people and the five-county region contains nearly two million. Nearly 150,000 cars and trucks drive on MoPac Expressway every day.	2013

Source: TxDOT and CTRMA, http://www.mopacsouth.com/about/project-history.php, accessed 8-12-2014.

CAMPO SH 45 SW Alternatives, Existing and Forecast Traffic on Lady Bird Lake Bridge

The CAMPO SH 45 SW Alternatives, described in detail above under Task #2, were reviewed by City staff for central Loop 1 over Lady Bird Lake, and immediately north of the lake. The 24-hour total volumes are compared in Table 6 and do not differ significantly across scenarios. This is likely due to the projected more than doubling of the region's population by 2035, and associated congestion across most of the transportation system.

Table 6

CAMPO SH45 SW Alternative Model Runs – Summary of 2012 Existing Daily Traffic and 2035 Alternatives Forecast Daily Traffic

Model Scenario	Total South of Lady Bird Lake	Total North of Lady Bird Lake (40pprox.. First to Fifth/Sixth Streets)
2012 count	174,000	-
No-build	227,240	225,800
SH45 SW 4-lane toll	227,347	226,900
SH45 SW 4-lane toll free	228,578	226,900
SH45 SW 2-lane toll	227,440	226,200
SH45 SW 2-lane toll free	228,345	226,900

After the CAMPO 2035 Plan was adopted in 2010, 2035 Plan Mobility Performance Measures showed the system "Percent Congested" in 2010 at 8.31%, with a projected increase to 22.21% by 2035. The "Average Freeway Speed" of 47.7 mph in 2010 was projected to decrease to 38.0 mph by 2035. And, most significantly, vehicle delay was projected to double: from a 2010 level of .12 hours of delay per person during a typical 24-hour period to .3 hours by 2035 (CAMPO, http://campotexas.wpengine.com/wp-content/uploads/2013/10/CAMPO2035_Appendices.pdf , p. 49.) An examination of the figure depicting "Roadway Congestion in 2035", indicates both IH 35 and Loop 1 as "Severely Congested" by 2035, with travel demand well in excess of hypothetical capacity in the future (Ibid., p. 54). Notably, all bridges crossing the Colorado River, Lake Austin, and Lady Bird Lake, and the Colorado River east of Austin are depicted as "Severely Congested", with the only exception the SH 130 tolled bridge .

Conclusion:

It is difficult to evaluate how much traffic, and potential additional delay or detriment, will be added to the Lady Bird Lake bridge as a result of SH 45 SW construction in the absence of the corridor-level traffic projections planned as part of the Loop 1 South Environmental Study, or a comparable detailed study. The available regional travel forecasts staff examined are not a product suited to this type of corridor.

Task #4 Existing Environmental Surveys

Review and report findings and recommendations to Council regarding any existing environmental surveys of City lands along the SH45 SW right of way, including but not limited to surveys of karst features, and subsurface flow.

A number of studies by the City of Austin and other entities have specifically focused on the environmental sensitivity of the right-of-way (ROW) and surrounding property over the last 30 years of planning the SH45 SW project. The geographic extent of these studies has ranged from the ROW of the segment currently under review from MoPac to FM 1626, to the segment from MoPac to IH 35, to the entire envisioned Outer Loop from the 1980's. In addition, a number of studies have been performed addressing the Barton Springs segment of the Edwards Aquifer that are pertinent to the determination of environmental impact from the present SH45 SW project. These studies have included long term monitoring, short term targeted sampling and analysis, hydrological and water quality modeling, recharge feature location and documentation, biological surveys and counts, and cave exploration and mapping.

Generally, the studies show that the proposed ROW and area surrounding SH45 SW (SH45 SW project area) is highly sensitive due to the presence of rare and endangered species (karst invertebrates, birds), karst (caves, sink holes), groundwater recharge, and strong connectivity to Barton Springs—which is home to endangered salamander habitat. A bibliography of the known relevant studies is provided in Appendix 3. The major environmental surveys completed or underway on City lands or including City lands in the SH45 SW project area are briefly discussed below. The relationship of the studies to the current project, results of the studies, staff opinion of the adequacy of the studies, and recommendations for additional work, if needed, are also provided.

Karst Surveys

Karst Feature Surveys and Assessments

A number of karst surveys have been conducted in the past in the SH45 SW project area. The first work was conducted by private citizen cavers. Flint Ridge Cave was discovered by William Russell in March 1984; Russell and a team of University of Texas grotto cave explorers descended over 150 feet below the surface to the currently known rear of the cave, located underneath the proposed SH45 SW right of way. Volunteer cavers discovered many of the known caves within the SH45 SW project area.

In July 1989, TxDOT released a "Final Environmental Impact Statement" for the Austin Outer Parkway, State Highway 45, Segment 3. The report acknowledges the sensitivity of the segment as being over the Edwards Aquifer, refers to caves and "cave dwelling organisms", but did not include a karst survey. The Draft Environmental Impact Statement from June 2014 states "Karst investigations were conducted within the state-owned ROW for TxDOT in 2007. Professional geologists identified 21 features which require some action prior to or during the construction phase of the proposed project." This statement refers to a Draft SH 45 South Karst Survey by ACI Consulting (2007). COA does not have a copy of this report; according to the latest information provided to the City by TxDOT, the report remains in draft form. In 2014, TxDOT contracted ACI and Cambrian Environmental to survey features along the

proposed SH45 SW route and excavate features to examine their nature and extent. A report of this work was not included in the DEIS as it was not yet complete; the report has not yet been released.

The TxDOT sponsored surveys conducted prior to 2014 did not systematically excavate potential cave features to further evaluate those that were not immediately obvious. By July 2014 ACI and Cambrian Environmental identified Cow Pattie, Hat, Jubilee, and two other features as known or likely caves, but had not completely cleared near surface debris, limiting their ability to enter very far into the features.

The first formal karst assessments of the SH45 SW project area involving the City of Austin began in October 1995, when the SH45 SW ROW was walked by Gary Landtrip representing TxDOT, Nico Hauwert representing the Barton Springs/Edwards Aquifer Conservation District, David Johns representing the City of Austin, and William Russell volunteer for Texas Speleological Survey. Hat and Cow Pattie Sinks were first encountered in that survey. This same team, accompanied by Willy Conrad and Mark Sanders from the City and Commissioner Todd Baxter from Travis County , conducted another pedestrian survey in the summer of 1999. Other caves within 1,000 feet of the SH45 SW ROW including Jubilee Sink, Djeridoo, Bliss Spillar, and Dunvegan caves were explored and mapped by Nico Hauwert, William Russell, and UT grotto volunteers during the mid-1990's. In 2000, Austin Water Utility Wildlands Conservation Division contracted with Dr. George Veni to assess features near SH45 SW ROW. In September and October 2005, staff from both the City of Austin Watershed Protection Department and the Barton Springs/Edwards Aquifer Conservation District walked transects across City of Austin Andrewartha, Tabor, and Edwards Crossing tracts north and east of SH45 SW ROW, finding numerous caves and other recharge features. In the Spring of 2007 the Austin Water Utility Wildlands Conservation Division contracted with Lady Bird Johnson Wildflower Center to survey a route for the Violet Crown Trail in this vicinity that identified and avoided critical environmental features. In April and May 2014, the Watershed Protection Department cave team walked transects across the entire Tabor, AARAL, and Henry WQPL tracts south and west of SH45 SW ROW finding a number of new caves and many other features.

In July 2014, the Watershed Protection Department cave team excavated an open cave at Tabor Crevice Cave, located about 1,000 feet south of the known end of Flint Ridge Cave under SH45 SW ROW, and have mapped about 500 feet of passage trending northeast toward the SH45 SW ROW and Flint Ridge Cave. Surface catchments of many of the karst features in the ROW have been estimated using LIDAR (light detection and ranging similar to RADAR) topography and field delineation of topographic slopes. The surface catchments will be reduced by the highway for several karst features including Flint Ridge and Hat. At least two features, Jubilee Sink/Cave and an un-named feature are within the existing SH45 ROW.

Adequacy and Additional Work Recommended

Karst surveys by ACI/Cambrian and the COA cave team to date provide valuable information, but many features have not been fully excavated, particularly those identified by ACI/Cambrian. Karst work contained in the DEIS was based on work conducted by ACI in 2007. COA/WPD staff have accompanied TxDOT/CTRMA consultants three times between March and June 2014 to observe karst features.

The current TxDOT/CTRMA consulting team has done an adequate job surveying the ROW for karst and potential karst features. They have excavated a number of features and potential features to evaluate the extent of their karst development and examine their potential to recharge storm water runoff. The consultants have conducted some subsurface excavation of several caves such as Hat, Cow Pattie and Jubilee. Based on the field trip on June 30,2014, all of these caves and several other features identified in the ROW should be excavated further to determine the significance of the features.

As noted previously, several features identified adjacent to SH45 SW on City WQPL should be excavated to evaluate their significance in terms of recharge potential, extent of karst development, and karst invertebrate population and composition. Additional evaluation prior to SH45 SW design and construction would assist TXDOT and CTRMA ensure that t SH45 SW minimizes impacts to the aquifer and subsurface cave fauna.

Subsurface Studies

A groundwater tracing study was conducted by the Watershed Protection Department in 2007 and 2010 to examine how accidental spills along the highways in this area might affect Barton Springs. The study involved injecting dye tracers in three caves near SH45 SW ROW and MoPac South as well as a one mile portion of Bear Creek immediately upstream of the proposed SH45 SW crossing. One tracer injected near existing SH45 SW reached wells in the nearby Shady Hollow area within hours of injection. All four tracers traveled roughly 12 miles to arrive at Barton Springs within 2 to 4 days. It was calculated that 45% of 5 pounds of dye poured into Bear Creek discharged from Barton Springs. These studies indicate a potential for rapid impacts of the SH45 SW project on nearby water supply wells and to Barton Springs.

In 2007, soil tracing, conducted cooperatively by the Watershed Protection Department and UT-Austin Department of Geological Sciences in 2007, examined the vertical movement of stormwater through soils over a cave within 500 feet of the SH45 SW ROW (Hauwert, N., and Cowan, B. 2013). Tracers poured on the surface at 6 sites traveled 100 to 300 feet to a depth of 20 feet deep in Barker Ranch #1 cave drips all within 3 to 48 hours. The rapid travel time suggest the soil's limited ability to attenuate contaminants.

The results of the aquifer wide and soil tracing studies are included in the following reports:

Hauwert, N. 2012, Dye Trace Simulation of an Accidental Spill, Phase 10: Highway 45 Southwest and MoPac South into the Barton Springs Segment of the Edwards Aquifer Travis County, Texas: City of Austin Short Report SR-13-01, 75 p.
http://www.austintexas.gov/watershed_protection/publications/document.cfm?id=196481

Hauwert, N. and Cowan, B., 2013, Delineating Source Areas To Cave Drips And Cave Streams In Austin Texas, USA: 13th Sinkhole Conference, Carlsbad, NM.
http://www.karstportal.org/node/11735?destination=node/11735

Cowan, B. and Hauwert, N., 2013, Use of Physical and Chemical Response in Cave Drips to Characterize Upland Recharge in the Barton Springs Segment of the Edwards Aquifer, Central Texas, USA: 13th Sinkhole Conference, Carlsbad, NM. http://www.karstportal.org/node/11735?destination=node/11735

Russell, W.H. 1996, "The Capital Caver, No. 3: 26." *Texas Cave Management Association.* March 1996. http://www.tcmacaves.org/news/capital.html

Additional investigation of the potential for soil transport of stormwater contaminants is part of a Flint Ridge subsurface study that is underway and expected to be complete by the summer of 2015. Tracers will be injected during rains at specific surface locations along SH45 SW ROW and monitored in cave drips within Flint Ridge and other nearby caves to determine source areas. Sampling of surface runoff and cave drips will also provide baseline water quality information to enable detection of possible highway impacts to the cave. City of Austin Watershed Protection and Austin Transportation Departments are jointly funding the 2014 Flint Ridge subsurface study.

Upland recharge may include water/rainfall that enters the aquifer by infiltrating through soils or that runs off into upland recharge features. Recharge to the aquifer through soils (upland or diffuse recharge) may be greater than previously understood. Work in the late 1980's suggested that as little as 1% of rainfall recharged the aquifer in uplands. Slade (2014), using a water balance approach and revising data from the 1980's, estimates that a little over 6% of rainfall recharges the aquifer in the uplands. Hauwert and Sharp (2014), using a direct measurement of evapotranspiration, estimate that about 28% of rainfall may recharge in the uplands. Although further study of upland recharge is needed to examine variation in recharge across the recharge zone, a compilation of Central Texas climate tower data indicates that this value is representative of average recharge as a percent of rainfall.

Creek Recharge Monitoring

Low-flow surveys of Bear Creek conducted by the Watershed Protection Department suggest 10 to 20 ft^3/s of recharge occurs downstream of proposed SH45 SW crossing. Fine-grained sediment discharging from the proposed project during construction and operation can be expected to plug downstream recharge features, including swallets in Bear Creek.

Adequacy and Additional Work Recommended

The City has not investigated water quality impacts of SH45 SW construction or operation to private or public water supply wells beyond the 2007 tracing to local wells. Similarly, TxDOT/CTRMA also have not studied possible impacts of highway construction and operation on the aquifer. During construction of SH45 SW, off-site sediment migration could plug recharge features and reduce their efficiency, block subsurface conduits inside the aquifer, cloud water in drinking water wells, and over time migrate to Barton Springs and impact water quality. For example, during construction of MoPac south of William Cannon, a large in-channel sinkhole was filled with a layer of fine white sediment several inches thick which appeared to plug the feature.

The Watershed Protection Department and U.S. Geological Survey are examining possibilities of installing creek gauging stations above proposed SH45 SW creek crossing to measure creek recharge and detect any impairment, as well as the effects of creek swallet enhancement which could effectively increase recharge to the aquifer.

Endangered Species Surveys

Karst Invertebrate Surveys along the Proposed SH45 SW ROW

City staff has been conducting rare invertebrate surveys of Flint Ridge Cave since 2002, as required by the BCCP Habitat Conservation Plan and federal permit. City staff conducted quarterly surveys from 2007 through 2010 , twice annual surveys from 2011 through 2013, and recently returned to quarterly surveys. Additional surveys are also planned 2 weeks after each dye injection during the subsurface drainage basin study discussed above.

City staff continue to observe rare troglobitic species in Flint Ridge Cave, including *Cicurina bandida* and *Rhadine austinica*, BCP species of concern (SOC), as well as other rare troglobitic species such as a cave adapted harvestman (*Texella mulaiki*), and a cave adapted millipede (*Speodesmus sp.)* none of these species are listed as endangered.

As part of a trend analysis for rare karst invertebrates on City BCP caves, an unpublished report looked at detection probabilities for *Cicurina bandida* (SOC found at Flint Ridge cave). It was determined that detection probabilities were especially high during winter surveys.

Rare karst invertebrate studies were also initiated somewhat sporadically on Barker Ranch #1 cave starting in 2005 after property containing this cave was acquired by the City. It has recently been brought to our attention that according to the USFWS, Barker Ranch #1 cave is a confirmed location for the endangered bone cave harvestman (*Texella reyesi*); however the collected specimen that led to this designation may have been misidentified. Other data suggests that this species is typically confined to locations north of the Colorado River (northern Travis and southern Williamson County).

On July 22, 2014 City staff and TxDOT contractors collected one *Texella sp.* specimen and delivered it to taxonomist Darrell Ubick. Because the specimen was a juvenile, species determination is still uncertain. Mr. Ubick suggested that this specimen more likely resembles *Texella mulaiki* than *Texella reyesi.* At a minimum, efforts to collect an adult male *Texella* from Barker Ranch #1 or adjacent caves are needed to make a final determination.

Adequacy and Additional Work Recommended

The consultants hired by TxDOT have been pursuing karst investigations in the SH45 SW ROW and those investigations are underway. A number of features have been discovered, though not completely excavated, and there has been some biological collecting done for karst species of concern. Krejca and Weckerly determined that 10 to 22 surveys are needed to determine presence/absence of rare troglobitic species. (Krejca, J. K., and B. Weckerly. 2008. Detection probabilities of Karst

invertebrates. Proceedings of the Cave and Karst Management Symposium 18:283-289). Under the current schedule it is unlikely that the TxDOT consultants will have adequate time to perform 10 to 22 surveys. Due to the low population counts and sensitivity of these species more surveys should be completed using USFWS protocols to help determine the potential impact of SH45 SW and best mitigation methods to address any impacts.

Endangered Bird Surveys on Water Quality Protection Lands (WQPL) along SH45 SW ROW

There have been a number of endangered bird surveys on portions of the WQPL surrounding the proposed SH45 SW ROW. These surveys are conducted on the WQPL as a first step in the ecological restoration process to identify where any occupied endangered species habitat is located, so that it can be avoided. The survey data were not collected on the ROW itself. For the most part the data reveals that of the two endangered bird species in the Austin area, the black-capped vireo and the golden-cheeked warbler, only the golden-cheeked warbler (GCW) is documented in the SH45 SW project area.

Over the duration of these studies (2000, 2002, 2003, 2007, 2009, 2010, 2013 and 2014) the only GCW whose habitat was found to extend to the ROW was located south of Bear Creek on the AARAL2 tract in 2013 (SWCA 2013). The 300 ft. habitat buffer for this habitat would extend into the ROW; however, it is not shown as such on the City survey reports as it was off of the WQPL proper. In this same location in 2014, an LCRA employee trained in identifying GCW reported hearing one in this area during a site visit to the LCRA power line (LCRA Email 2014). Additional GCW have been located further to the west of the proposed SH45 SW ROW on WQPL properties (Baer 2014, SWCA 2013, Baer 2009, and SWCA 2003); however, the 300 ft. habitat buffer does not extend to the ROW.

Based on the data collected over the past 14 years on the surrounding WQPL, the occupied habitat for GCW has been found to extend to the boundary of the proposed SH45 SW ROW in only one location. There is no other available documentation to confirm whether other potential GCW habitat on or adjacent to the SH45 SW ROW is occupied or not. The ROW is mapped as Zone 2, indicating potential habitat, on the 1996 BCCP GCW habitat determination maps. Portions of the study area, including areas near the SH45 SW ROW, are mapped as Zone 1, indicating known occupied habitat. USFWS regulations also define areas within 300 feet of GCW habitat as an area where actions may cause indirect effects on the species. City staff has not monitored for these indirect effects from the SH45 SW ROW on nearby occupied habitat. The limited BCP survey conducted by staff and SWCA reported no findings of either endangered species of birds along the ROW in 2014. Neither the 2014 BCP staff survey nor the TxDOT surveys reported in the DEIS were completed in accordance with US Fish and Wildlife Service (USFWS) protocol. The USFWS generally requires three years of negative surveys to confirm absence.

LCRA surveys on or adjacent to proposed SH45 SW

In 2006-2007 LCRA undertook a variety of surveys in preparation for their construction of the T420 Friendship to Manchaca power line which is immediately adjacent to the proposed SH45 SW ROW. This included a general reference of endangered species that might be found in the area (SWCA December 2006), a survey for GCW in the north stretch of proposed SH45 SW ROW (SWCA September 2007), a

karst survey (SWCA July 2007) and a study of karst anomalies detected by various geophysical remote sensing technologies (EGA March 2008).

The general reference of endangered species identifies only 3 species having the potential to occur in the T420 ROW. These include the GCW, Barton Springs salamander and Austin blind salamander. Potential habitat for GCW was postulated for the northern portion of the T420 ROW, but not on City property (though immediately adjacent to the proposed SH45 SW ROW). This was recommended for surveying which was accomplished by SWCA in 2007 with a conclusion of no GCW occupying the surveyed area. Neither the Barton Springs salamander nor the Austin blind salamander was expected to occur on the surface, but it was postulated the Austin blind salamander could occur in the subsurface below the T420 ROW. However, the study concluded that neither species was expected to be impacted by the limited project scope.

The karst survey included the 80 ft. wide alignment of the power line and a 100ft diameter around each proposed structure location. The surveys covered several alternative routes. As part of this project a total of 132 features were located, 120 were on City property. Of these, 37 were further investigated, yielding 22 that were non-karst, 10 features that were potential karst features and 4 true karst features which were then avoided by the project to avoid impacts to these features. It was noted that none of the new features were more sensitive alone or collectively as Flint Ridge Cave. This study recommended moving some pole locations and further analysis of the areas by ground penetrating radar or other geophysics to look at subsurface features that are lacking surface expression.

The EGA (March 2008) study used resistivity imaging, natural potential and some limited ground penetrating radar surveys to look for karst anomalies below the land surface and without surface expression. These studies identified several areas where karst anomalies existed, 6 out of 11 of these were in the vicinity of Flint Ridge Cave and described as both large in number and size. LCRA moved or avoided 11 pole locations to avoid these anomalies.

Adequacy and Additional Work Recommended

Based on the above discussion regarding bird surveys, additional surveys of the proposed SH45 SWROW is recommended consistent with USFWS protocol to confirm absence of endangered species.

The studies described above identified several rare and endangered (Golden Cheeked Warbler, Barton Springs salamander, and Austin Blind Salamander) species that could be impacted by work on the proposed SH45 SW ROW and demonstrated the large size and number of karst anomalies that exist underground but not expressed on the ground's surface. Additional work to identify possible impacts to these 3 endangered species would improve the understanding of how a highway vs. a power line might impact these species. It is unclear how additional studies of unexpressed karst features would help lessen the impacts of the proposed SH45 SW ROW since the highway cannot be moved as simply as power poles in the LCRA example.

Surface Water Surveys and Monitoring

Surface water surveys have not specifically targeted SH45 SW, however, data is available for Bear Creek, Little Bear Creek, and the mainstem of Slaughter Creek, but very little data is available for Danz Creek and Danz Creek Split, which are tributaries of Slaughter Creek. The bulk of the City's investigations have focused on general characterization of these waterways. In addition, the sensitivity of Bear Creek has been studied extensively to evaluate the impact of pollutant discharges from the TCEQ permitted wastewater treatment plant at the Belterra Subdivision (Hays County Water Control and Improvement District No. 1 (HCWCID No. 1)). Surveys, studies, and water quality modeling were used to examine the potential impacts of pollutants found in treated domestic wastewater to Bear Creek. The water quality and ecological reaction of the stream to these pollutants was simulated and used to negotiate conditions for settlement of a contested case hearing that were ultimately put into the TCEQ permit for the plant.

Both the general assessments of water quality, and special studies of monitoring and modeling are pertinent to SH45 SW because they show the extreme sensitivity of these streams to an increase in nutrients. Currently, the approach for design of water quality controls for the highway have used the state compliance benchmarks for Total Suspended Solids rather than evaluating treatment of nutrients or other dissolved constituents in highway runoff necessary to protect the streams. Surface water studies conducted by the City could inform TxDOT regarding the background levels of pollutants and the cumulative impact of highway runoff with the other discharges into Bear Creek or other contributing zone streams.

General Surface Water Quality Monitoring - City of Austin Environmental Integrity Index.

The Watershed Protection Department samples water quality parameters in 49 watersheds within the City's planning area to compile an Environmental Integrity Index (EII). Every other year the monitoring results are scored and assigned relative values. In addition to individual parameter scores, an overall EII score is assigned. Data are collected for dissolved oxygen, pH, conductivity, ammonia, nitrate, ortho-phosphates, total suspended solids (TSS), turbidity, E. coli, benthic macroinvertebrates, and diatoms. The scores are ranked "Very Bad", "Bad", "Poor", Marginal", "Fair", "Good", "Very Good", and "Excellent." Pertinent data to the SH45 SW project area include sampling in Bear Creek, Little Bear Creek, and Slaughter Creek (to which Danz and Danz Split are tributaries)

Data for individual watersheds including those in the SH45 SW project area were available for 2012 (Clamann, 2012), and the overall EII score for the Slaughter Creek watershed was 70 (Good). All parameters collected resulted in normal ranges except for pH which had some low values, and low concentrations of dissolved oxygen at a downstream site. The overall EII score for the Bear Creek watershed was 69 (Good). Some low values of dissolved oxygen and pH were measured. Some high values of nitrate were measured. In the latest round of surveys in 2012, the overall EII score for the Little Bear Creek watershed was 77 (Very Good). Low values of dissolved oxygen, and pH were measured. Finally, the overall EII score for the Onion Creek watershed was 80 (Very Good). Dissolved

oxygen, pH and conductivity had some values outside of the normal range at a site downstream from the SH45 SW study area. Other parameters were within normal range for these sites in 2012.

In addition to the 2012 surveys, Bear, Little Bear, and Slaughter Creeks have been sampled since about 1999 using the EII protocol and a historical rating for the last 10 years as compared to the recent 2011-2012 data can be seen in Figure 20.

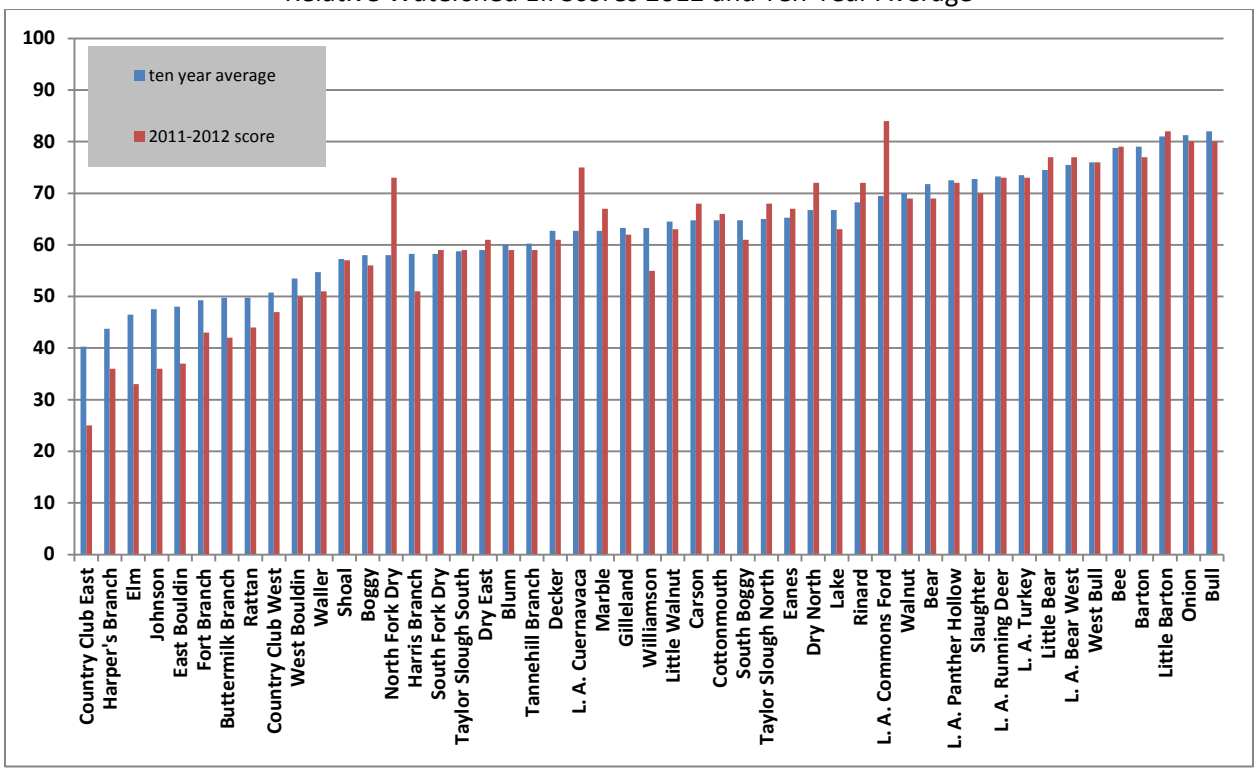
A more detailed presentation of EII results for the potentially affected streams are included in

http://www.austintexas.gov/sites/default/files/files/Watershed/eii/Bear_EII_ph2_2012.pdf

http://www.austintexas.gov/sites/default/files/files/Watershed/eii/LilBear_EII_ph2_2012.pdf

http://www.austintexas.gov/sites/default/files/files/Watershed/eii/Slaughter_EII_ph2_2012.pdf

Figure 20
Relative Watershed EII Scores 2012 and Ten-Year Average



City of Austin Special Surveys, Monitoring, and Studies – Nutrients and Algae

The City surveys and studies on Bear Creek during the TCEQ Belterra Permit negotiations focused on the sensitivity of the Bear Creek to nutrient discharges and the changes in water quality and ecology that could result (Turner 2006, Herrington 2008a,b,c, Herrington and Scoggins 2006, Turner 2009, Richter 2010). The permit was issued and the cumulative effects of the allowed discharge under the permit plus nutrient additions from SH45 SW highway runoff should be taken into consideration in the design of SH45 SW BMPs. Fortunately, the documentation provided by these surveys and studies may be useful in adaptive management decisions for both the wastewater treatment plant and SH45 SW. Field and lab experiments were conducted to assess the potential alteration of the existing algal community density and structure of Bear Creek due to increased nutrient loading. Results support that Bear Creek is highly oligotrophic and that nutrient additions from whatever source may significantly increase algal productivity and likely change their current trophic status. The weight of evidence from the City's surveys and studies support keeping nutrient loadings at or near background levels for Edwards Plateau streams.

Surveys from Other Agencies – TSU, USGS, TCEQ

Sensitivity of central Texas streams has been a subject of concern for other agencies with water quality missions. Two of these studies were completed as far back as 1986 and 1988, before the first EIS for the Outer Loop including SH45 SW was completed. The latest study was conducted in 2011 in the Barton Springs Zone, and a 2007 study analyzed 15 central Texas streams. In all of these studies the common purpose was to determine the current nutrient and algae conditions of the streams, and document their sensitivity to increases in nutrient loads from a variety of sources.

In Davis, 1986, water quality evaluations were conducted on six Colorado River tributaries including Slaughter Creek and Bear Creek. In particular, lower reaches of Slaughter Creek evidenced high levels of primary productivity (algal growth) despite very low nutrient concentrations. This indicated that the creek has a very low capacity for assimilating nutrients. "Even small point source nutrient inputs might stimulate enough additional primary productivity to induce a level of alga metabolism that would cause critically low dissolved oxygen, and thus adversely impact aquatic life in the stream." Nutrient assimilative capacity for Bear Creek was also found to be very low and "point source nutrient inputs appear to pose the primary threat to existing water quality. Even minor inputs could promote excessive plant growth and result in use impairment." In general for all of the creeks evaluated, it was found that these systems are "highly sensitive to environmental disturbance, and have low nutrient assimilative capacities. Their shallowness and high water clarity generally allows sunlight penetration to the bottom, which makes them particularly sensitive to nutrient inputs that can cause excessive proliferation of algae and associated water quality problems."

In Short, 1988, water quality and algal growth was surveyed for 20 sites among 7 different tributaries of the Colorado River, including Bear, Slaughter and Onion creeks. Sites with low phosphorous (<20 µg/L) in general had little or no apparent growth of filamentous algae (these included Bear, Slaughter, and Onion creeks). Sites with moderate phosphorous (20-50 µg/L) often had extensive growth of filamentous algae. Higher concentrations also often had heavy growth of filamentous algae. The nitrogen/phosphorous ratios determined for these streams indicated that the potential for phosphorous limitation was extremely high. However, some of the creeks studies did turn out to be nitrogen limited. In general, the study concluded that "Hill Country streams are not significantly impacted at the present time but do show the potential for water quality degradation in terms of excessive algal growth if nutrient levels are increased." In this study, the threshold for algal impacts from phosphorous

addition was proposed at between 50 and 100 µg/L of phosphorous. These levels may be useful in assessing SH45 SW over time and could be used by TxDOT/CTRMA as adaptive management triggers for upgrading water quality controls or practice during construction events or operation.

The U.S. Geological Survey, in cooperation with the Texas Commission on Environmental Quality, evaluated nutrient and biological conditions in small streams in parts of the Edwards Plateau of Central Texas (Mabe, 2007). Although none of the SH45 SW project area streams were included, the mainstem of Onion Creek was sampled for water properties, nutrients, algae, and benthic invertebrates. This study provides more documentation on the sensitivity of small central Texas streams such as those crossed by SH45 SW. Nutrient additions such as those in highway runoff may increase the amount of algae to nuisance levels and degrade aquatic habitat. Monitoring methods tested in this study may also be selected for assessments of the streams in the study areas and provide triggers for adaptive management to fix water quality problems. The USGS in cooperation with the City of Austin additionally evaluated surface water quality in the contributing zone streams including sampling in Bear and Slaughter creeks during the 2008-2010 time period with emphasis of factors affecting nutrients and bacteria. Mahler et al. (2011a, 2011b) found that baseline water quality has degraded in the contributing zone between 2001 and 2010 and that increases in nitrate may be related to land application of wastewater effluent for disposal. Additionally , Mahler et al. (2011b) concluded that water quality in the aquifer becomes more similar to surface water quality of contributing zone streams during wet periods further emphasizing the rapid communication between surface water recharge and groundwater discharge from Barton Springs.

Adequacy and Additional Work Recommended

In general, the data on representative streams and Bear Creek are adequate to help TxDOT understand the potential impact of nutrient additions from inadequately treated highway runoff. TxDOT could perform some surface water quality sampling into the future at major crossings of Danz Creek, Danz Creek Split, Bear Creek and Little Bear Creek. Flow monitoring stations should be included at sampling stations to measure streamflow over time and characterize runoff events. If possible, these sampling stations should be installed prior to breaking ground on the site to provide baseline data and included in design considerations of the roadway creek crossings. Other drainage features of the design might indicate additional useful station sites, and TxDOT may make use of the expertise of its participating agencies in selecting the station locations. Watershed modeling for Onion Creek, Slaughter Creek, Bear and Little Bear creeks could also be helpful in predicting future impacts to stream hydrology and water quality given the expected population and impervious cover growth in indirectly and cumulatively impacted areas.

Task #5 Differences Between TxDOT and NEPA Review Policies.

Review and report findings and recommendations to Council regarding any significant differences between the state environmental review process and the National Environmental Policy Act

There has been much public discussion regarding the impact of the Texas EIS review versus the Federal Highway Administration (FHWA) EIS review under the National Environmental Policy Act (NEPA)[2] for a state highway project such as SH45 SW. The basic requirements and processes for both the federal and State EIS are very similar. Consequently, the differences are subtle. Following is a listing of distinctions between the federal and Texas EIS.

Statutory Structure

Federal: Environmental review of federal projects is performed under NEPA and the administrative rules adopted by the Council on Environmental Quality (CEQ)[3]. The CEQ is an executive office under the President created to implement NEPA.

Texas: There is no broad environmental policy law in Texas analogous to NEPA, nor is there an independent reviewing agency equivalent to the CEQ. The Texas Transportation Code requires an environmental review process for transportation projects and directs the Texas Transportation Commission to establish standards by rule.[4] The rules are located in title 43 of the Texas Administrative Code.

Responsible Agency

Federal: The Federal Highway Administration (FHWA) is the agency responsible for the EIS for a transportation project subject to NEPA review. In practice, however, for a Texas transportation project subject to NEPA review , TxDOT performs most of the tasks required in the environmental review process, including preparation of the EIS documents. TxDOT does so in compliance with NEPA and all other federal environmental requirements.[5] After the EIS documents are drafted and reviewed by TxDOT, the documents are subject to an independent legal sufficiency review by FHWA; FHWA makes the final project decision.[6]

Texas: TxDOT is the agency responsible for preparing the EIS documents in a non-federal Texas transportation project. No additional review by FHWA is required and TxDOT makes the final project decision.

[2] 42 U.S.C. §§4321-4370h
[3] 40 CFR Parts 1500-1508
[4] Texas Transportation Code §201.752
[5] 23 CFR §771.109 (C) (5); 43 TAC §2.84(f); 43 TAC §2.85 (d); 43 TAC §2.86 (h); 43 TAC §2.101 (d)
[6] 23 CFR §771.127

Other Agency Review/Coordination

Federal: Under NEPA, the federal official preparing an EIS must consult with any federal agency with jurisdiction or special expertise regarding the environmental impact involved.[7] Additionally, under the federal Clean Air Act, the EPA Administrator must review and comment on every NEPA EIS. [8]

Texas: The Texas Transportation Code requires TxDOT to coordinate with the Texas Commission on Environmental Quality (TCEQ) and the Texas Parks and Wildlife Department (TPWD) in preparing an environmental review. Under the rules adopted, TxDOT coordinates with TCEQ, TPWD, and the Texas Historical Commission (THC) for projects requiring preparation of an EIS if particular triggers for coordination are met.[9]

Standard of Review

Federal: NEPA requires federal agencies "to the fullest extent possible" to act in accordance with NEPA policies. Courts have construed this language to require at a minimum that federal agencies take a "hard look" at environmental consequences, requiring that the EIS under NEPA provide a good faith analysis and sufficient information to allow a firm basis for weighing the risks and benefits of a proposed action.[10]

Texas: The Texas Transportation Code requires the Transportation Commission to "consider the results" of environmental reviews in discharging its duties.[11] The rules regarding environmental review for highway projects in the Texas Administrative Code require the review be based on "sound reasoning and accepted scientific and engineering principles".[12]

Dispute Resolution

Federal: Federal interagency disagreements concerning a project under NEPA review are submitted to the CEQ for resolution.[13] Importantly, the CEQ is an independent agency not affiliated with either the project sponsor or the federal agency in disagreement with the sponsor.

Texas: There is no process for resolving disagreements between the project sponsor and coordinating state agencies such as TCEQ, TPWD, or THC. The dispute resolution process established in the Texas

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[7] 42 USC §4332
[8] 42 USC §7609
[9] 43 TAC §2.12; 43 TAC §2.305 (TCEQ triggers for coordination); 43 TAC §2.206 (TPWD triggers for coordination); 43 TAC §2.255 (THC triggers for coordination)
[10] 42 USC §4332; *Natural Resources Defense Council v. Morton*, 458 F2d 827, 838 (D.C. Cir 1972); *County of Suffolk v. Secretary of the Interior*, 562 F2d 1368 (2nd Cir 1977), cert denied, 434 US 1064 (1978).
[11] Texas Transportation Code §201.604 (c)
[12] 43 TAC §2.49 (c)(2) (C)
[13] 42 USC §7609

Administrative Code deals exclusively with disputes between the project sponsor and department delegate.[14] In the case of a transportation project, both the sponsor and delegate are within TxDOT.

Endangered Species

Federal: Federal agencies are held to a high standard under the Endangered Species Act. They must ensure that actions they carry-out, authorize, or fund will not be likely to jeopardize the continued existence of a listed species, or destroy or adversely modify critical habitat. If SH45 SW were being federally funded, and thus an action of the Federal Highway Administration, the FHWA would be required by section 7 of the ESA to consult with the Fish and Wildlife Service before proceeding with the project if the project might affect a listed species. Consultations rarely halt a project, more commonly, they identify reasonable and prudent alternatives designed to allow the project to proceed in a manner that will not jeopardize the species.

Texas: Non-federal projects must comply with the Endangered Species Act through an incidental take permit if the project will result in take of a listed species.

[14] 43 TAC §2.52

Task #6 Existing TxDOT Roadway Best Management Practices in the Barton Springs Watershed.

Review and report findings and recommendations to Council regarding State environmental protection measures on existing roadways and construction sites within the Barton Springs Watershed

Regulatory Requirements for TxDOT

Primary State of Texas water quality requirements for SH45 SW are compliance with Texas Pollution Discharge Elimination System (TPDES) and with the State of Texas 30 TAC Chapter 213, known as Edwards Aquifer Rules under the Edwards Aquifer Protection Program (EAPP). TPDES applies to stormwater runoff for construction phase activities. EAPP contains provisions for both construction phase and post construction phase stormwater runoff.

Construction Phase Water Quality Controls

TPDES requires compliance with the Construction General Permit, issued by the TCEQ. The Construction General Permit requires the permittee to prepare and submit a Stormwater Pollution Prevention Plan (SW3P). The SW3P can be prepared by either the project owner (TxDOT) or the contractor.

The SW3P must contain a general description of the project site and proposed land disturbance activities. It requires a description of Best Management Practices (BMPs) to be used for minimization of pollution. The only performance guidance given in the Construction General Permit is: "Erosion and sediment controls must be designed to retain sediment on-site to the extent practicable…" (TPDES General Permit TXR 150000 Part III Sec. F (2) a (i)). Such guidance is difficult to apply or enforce effectively and consistently, as it relies upon individual judgment regarding "extent practicable".

The other significant requirement within the Construction General Permit (Part III F (2) b (i-iii)) is that "Erosion control and stabilization measures must be initiated as soon as practicable in portions of the site where construction activities have temporarily ceased. These measures must be initiated no more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased."

30 Texas Administrative Code, Chapter 213 establishes the Edwards Aquifer Protection Program (Edwards Aquifer Rules) which requires a Water Pollution Abatement Plan (WPAP). The WPAP requires a general description of the site and nature of the regulated activity. The rule requires a description of the BMPs to be used during construction (30 TAC 213.5) and states "BMPs and measures must prevent pollution of surface water, groundwater, or stormwater that originates on-site or flows off site, including pollution caused by contaminated stormwater runoff from the site… (30 TAC, Chapter 213, p.17)". The rule further states that "the construction-phase BMPs for erosion and sediment controls should be designed to retain sediment on site to *the extent practicable."* (emphasis added) It also requires inspection and maintenance activities. The TCEQ publishes RG-348, "Complying with the Edwards Aquifer Rules. Technical Guidance on Best Management Practices." RG-348 provides guidelines for site management and installation and maintenance of BMPs to reduce erosion and sedimentation.

In lieu of specific performance requirements (e.g. % TSS removal, effluent concentration limits or design storm sizing), complying with "to the extent practicable" many times can result in the minimum necessary erosion and sedimentation controls. Observation of TxDOT highway projects by City staff has found that these controls often allow bypass of even small storm events and are not always regularly maintained, resulting in some off-site discharge of sediment to the receiving waters. City staff have also observed that temporary soil stabilization measures are not commonly used; many times sporadic and

often insufficient temporary controls have been installed. Below (Figures 21-26) are photos of TxDOT jobsites in the Barton Springs Zone with missing or damaged erosion controls.

Figure 21 - US 290 East bound Oak Hill near Y at SH 71 5-29-14

Figure 22 - US 290 Eastbound near intersection with SH 71 5-13-14. No temporary stabilization, no controls.

Figure 24 - US 290 Eastbound near intersection with SH 71 5-29-14.

Figure 25 - US 290 Westbound 10-13-13 near ACC Pinnacle campus.

Figure 26 - US 290 Westbound 5-29-14 near ACC Pinnacle campus.

City of Austin regulations and rules (Land Development Code 25-8-181 and Environmental Criteria Manual 1.4) are very similar to both the Edwards Rules and the TPDES. In essence, all three sets of standards provide similar guidance on effective ways to minimize erosion and sedimentation. However, the City requires more detail in site planning to minimize erosion and sedimentation and provides more detailed calculations on how to size BMPs to capture and treat the 2-year design storm. A more detailed

description of the City regulations and rules are located later in this report. What makes any of the rule sets effective, however, is proper design, construction plans with specific installation details and layouts as well as regular inspection and enforcement of the rules.

State Highway 290 Construction Site

As noted above, the City of Austin has been occasionally inspecting TxDOT construction sites in the City of Austin jurisdiction since October 2013. After the first City of Austin inspection in October, COA staff met with TxDOT staff to discuss the erosion and sedimentation (E&S) controls along HWY 290 West near the ACC Pinnacle campus, which is located just west of the Edwards Aquifer Recharge inside the Edwards Aquifer Contributing Zone.

City and TxDOT staff have discussed their different approaches to fulfilling regulatory requirements for E&S control. One primary difference is the design standards used for E&S controls. The City of Austin requires the designer to calculate the runoff from a 2-year storm for the construction site, select the controls appropriate for the predicted volume and velocity of water, and demonstrate the sizing and layout of the controls is adequate to capture and treat the 2-year storm volume and velocity from all disturbed areas. Neither TxDOT plans nor TCEQ regulations require this level of design detail. This can result in inadequate controls for stormwater volume and velocity or areas of soil disturbance that do not have controls in place.

On TxDOT projects the contractor has joint responsibility with TxDOT inspectors for inspection and maintenance of those controls. Spot inspections by City staff over the last 12 months found that installation and maintenance of controls was inconsistent and controls were sometimes not installed in appropriate locations or were in poor condition.

City of Austin staff have provided information to TxDOT on the City's rules that require demonstration of the full construction phase E&S plan in the site development process. Prior to the city issuing a permit, the applicant must demonstrate via plan sheet: 1) the site management practices that will be employed to reduce soil disturbance and hence erosion; 2) the actual BMPs and their proposed layout on site to control the runoff from the 2-year design storm; 3) schedules for phasing site disturbance and for provision of temporary stabilization measures for exposed soils. After site plan approval City inspectors regularly visit construction sites to ensure the plans are being followed or whether changes are necessary to provide adequate erosion control. This level of planning and monitoring is not commonly implemented by TxDOT.

In meetings with TxDOT, City staff recommended a number of measures and erosion control approaches that are outlined in the Edwards Rules, as well as City of Austin rules, that would make the erosion and sedimentation system more effective on the TxDOT Hwy 290W site. TxDOT committed to implementing more E&S controls that would consider the City's input. Follow up monitoring by the City indicates that while some additional silt fence was employed on sites, there was no systematic upgrade of E&S systems .

Conclusion

The current state rules (TPDES and TCEQ Edwards Rules) provide the basis for the formulation of an E&S plan that could be effective. Implementation of the rules falls short through lack of performance criteria for the recommended practices, and requirements for permit or construction submittals to include the systematic plans necessary to implement the construction phase E&S control strategy. Additionally,

internal or external inspection or enforcement is needed to ensure compliance by TxDOT contractors with the TPDES or EAPP rules and guidelines.

Permanent Controls

State of Texas 30 TAC Chapter 213 requires permanent Best Management Practices (BMPs) for treatment of stormwater runoff that control pollution from development after construction is complete in areas governed by the Edwards Aquifer Rules. As noted above, these rules are enforced by TCEQ. Similarly, the City has rules for the portion of the Edwards Aquifer that contributes to and recharges the Barton Springs portion of the Edwards Aquifer, found in City Code Chapter 25-8, Subchapter A, Article 13 (*Save Our Springs Initiative*) (SOS)). As detailed below, the City's rules are more protective than the State regulations.

The proposed SH45 SW is sited in an area that is regulated by the TCEQ's Edwards Aquifer Rules. Because it is a State of Texas project, it is not subject to SOS, the City water quality regulations applicable in the Barton Springs Zone.

The following is a discussion and comparison of the state requirements for Edwards Aquifer vs. City of Austin regulations.

<u>Edwards Aquifer Rules</u>

Permanent BMPs must reduce the increase in total suspended solids (TSS) load associated with development by at least 80%. BMPs are required for development that exceeds 20% impervious cover. This means that development can increase TSS pollution loads by 20% over undeveloped conditions. There are no limits on impervious cover. The state required BMPs are not designed or intended to remove other common pollutants associated with development such as nutrients and metals.

Edwards Rules allow the following BMPs as acceptable for meeting state requirements:

- Retention-Irrigation
- Extended Detention Basin
- Grassy Swales
- Vegetated Filter Strip
- Sand Filter
- Aqualogic Cartridge system
- Wet Basins
- Constructed Wetlands
- Bioretention
- Permeable concrete

TSS removal for these BMPs range from 100% (Retention-Irrigation) to 70% (grassy swales). The method for sizing the BMP to achieve the required 80% reduction relies upon an empirical chart based on the ratio of percent load removal to load removal required. It is not clear from the state rules or criteria how

this ratio approach accounts for the volume of the control, the size of the outlet or the drawdown time in determining actual runoff capture volume on an average annual basis, which is needed to determine annual load captured. So we are not able to offer an opinion on how performance of these controls is determined. Required capture volumes are significantly lower than COA required capture volumes for SOS controls (see Table 1 for example). Lower capture volumes means that more untreated water is discharged from a developed site.

City of Austin Water Quality Regulations in the Barton Springs Zone (SOS)

Impervious Cover is limited to 15-25% net site area (NSA)in the Barton Springs Zone. BMPs must ensure that there is no increase in the annual loading of 8 pollutants (see Table 1). The limitations on impervious cover is an important part of the City's pollution prevention strategy because it maintains recharge function and reduces runoff volume.

SOS requires a treatment train approach whereby the required capture volume is sequestered in a basin then released for infiltration into undisturbed, vegetated land. Such a treatment train provides primary settling treatment and secondary infiltration treatment and allows the runoff to be discharged to an irrigation field. Stormwater that is infiltrated in the irrigation field is considered to achieve 100% removal of the pollutants within the infiltrated volume. Retention-irrigation is the only stand-alone control allowed by the Edwards rules that the City of Austin recognizes as effective pollution control in meeting the requirements of SOS.

Conclusion

City of Austin SOS permanent BMP rules provide a higher level of pollution control than the Edwards rules. Table 7 compares the primary differences in regulations and pollution control. The most significant differences between City of Austin and State of Texas regulations are that State regulations lack any limitation on impervious cover, have a smaller required capture volume, target TSS exclusively, and do not include a non-degradation standard.

Table 7. Comparison of City of Austin SOS vs. TCEQ Edwards Aquifer Post-Construction (Permanent) Water Quality Controls

	City of Austin SOS	**TCEQ Edwards Rules**
Impervious Cover Limits	15-25%	No limit
Pollutants Controlled	TSS, Phosphorus, Nitrogen, COD, Pb, Cd, Bacteria, TOC	TSS
Capture Volume*	1.32 inches	0.3 inches
Treatment Standard	No net increase in any of the listed pollutants	Allowable 20% increase in pollution for TSS. All other pollutants unregulated.
Treatment Train Required	Yes	No

*40% IC within the area draining to the control for Retention-Irrigation

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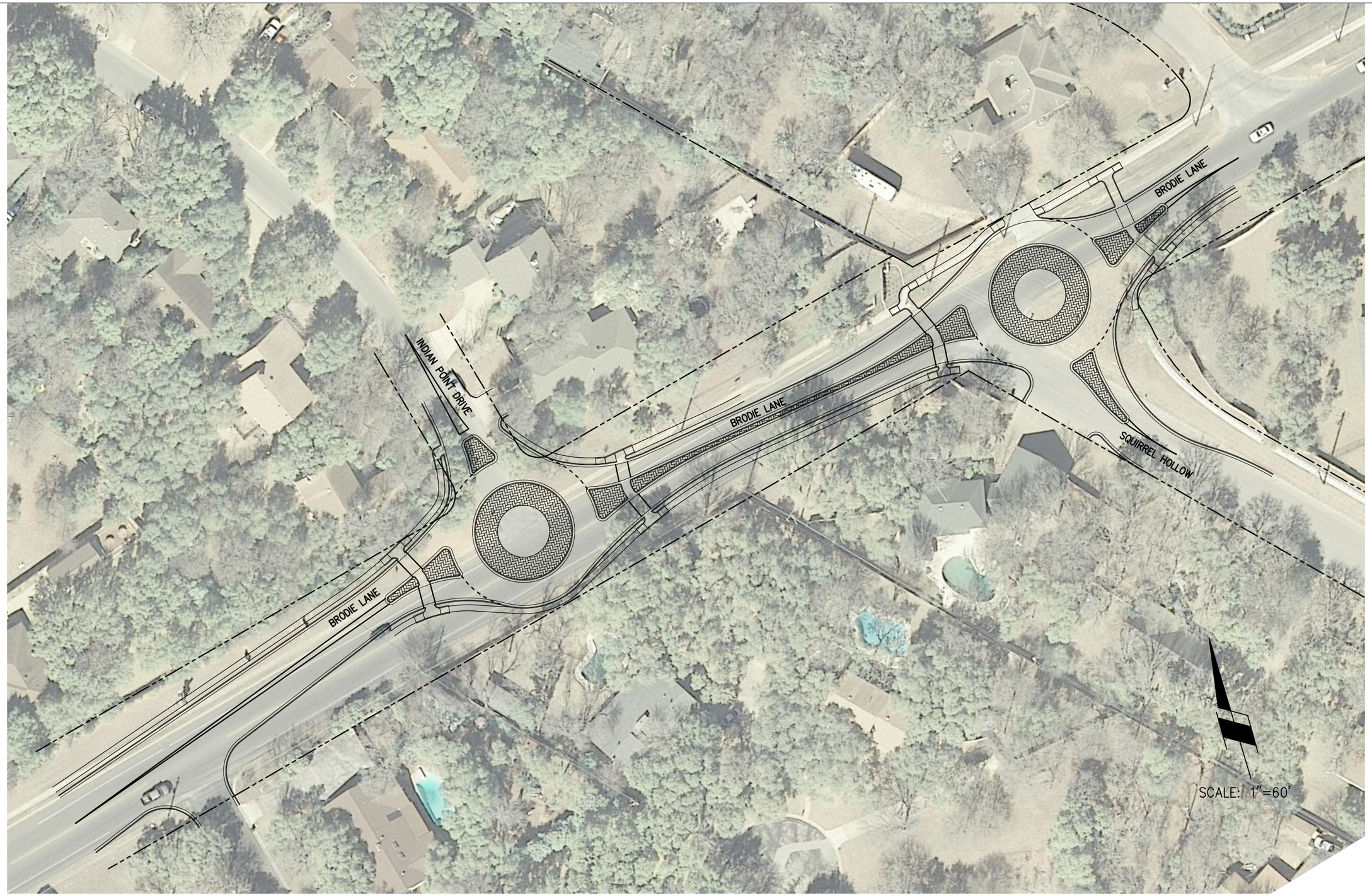
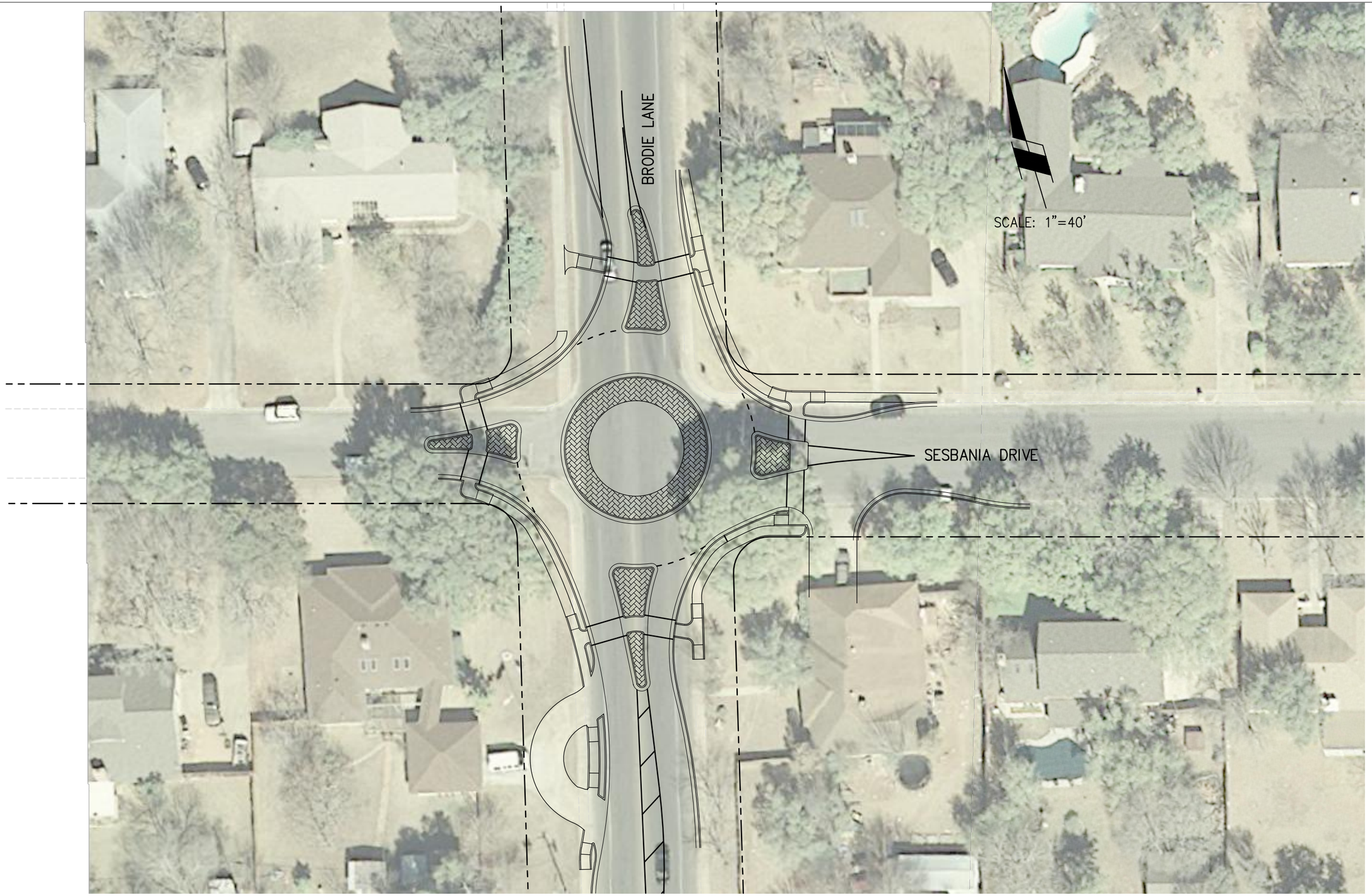
Appendix 1

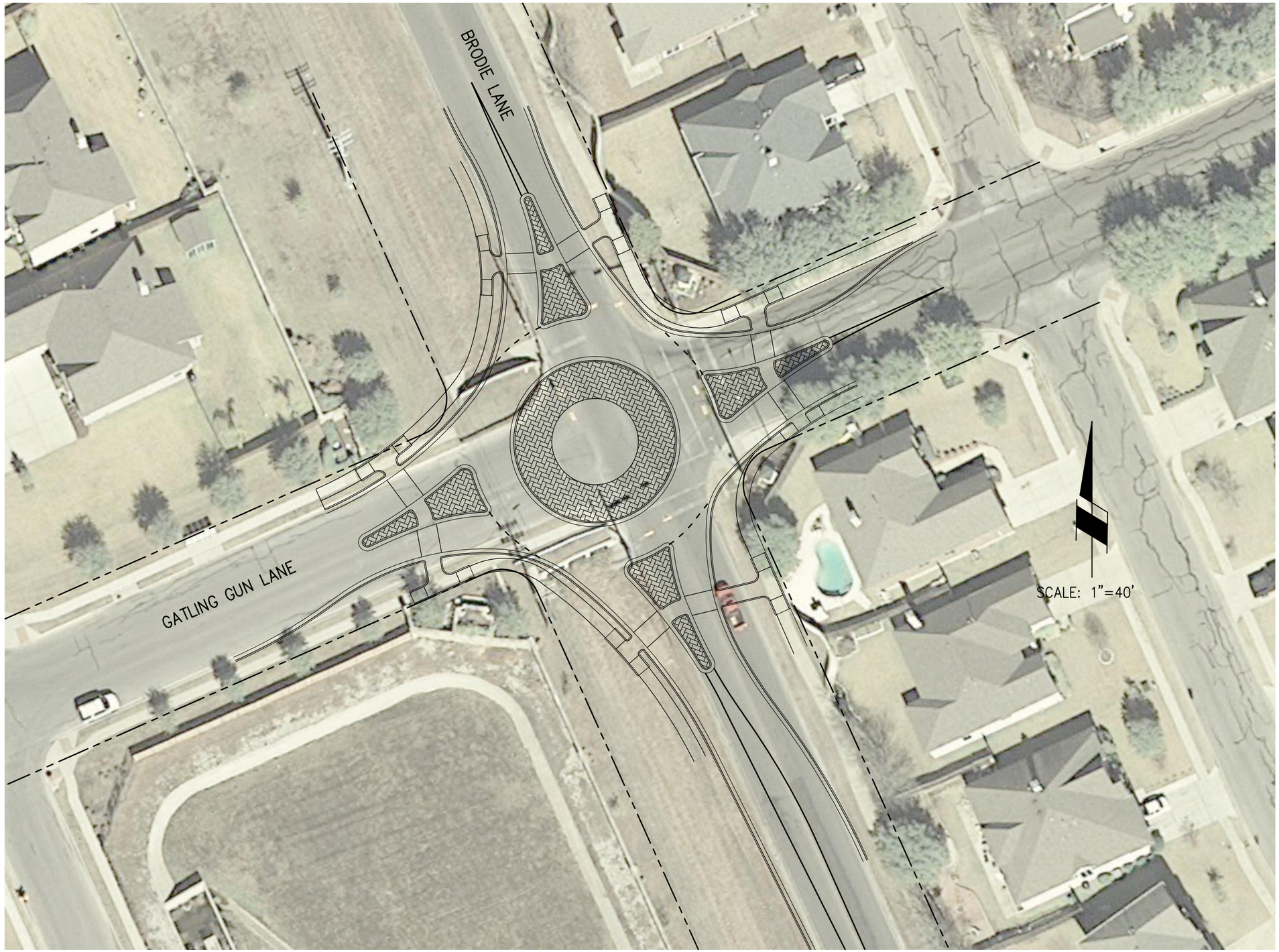
Potential Roundabouts

ASPEN CTREEK PARKWAY
BRODIE LANE
ø100'
SCALE: 1"=40'


INDIAN POINT DRIVE
BRODIE LANE
BRODIE LANE
BRODIE LANE
SQUIRREL HOLLOW
SCALE: 1"=60'


BRODIE LANE
SCALE: 1"=40'
SESBANIA DRIVE

SCALE: 1"=40'
SUNLAND DRIVE
BRODIE LANE


BRODIE LANE
GATLING GUN LANE
SCALE: 1"=40'

Appendix 2
TTI license plate capture analysis.xlsx

total captures	603	2722	2113	2506	4057	4718	3511	4928	3524	8129	573	2371	7012	1574	621	796						
from/to	1	2	2A	3	4	5	6	7	8	9	9A	10	11	12	13	14	SUM	13hr count	% captured twice	% not captured twice	Daily count	% of daily
1	0	293	18	41	93	35	18	8	23	6	18	15	7	11	8	9	603	12476	4.8%	95.2%	11600	108%
% of through	0%	49%	3%	7%	15%	6%	3%	1%	4%	1%	3%	2%	1%	2%	1%	1%	100%				^2012 count	
% of total	0.0%	2.3%	0.1%	0.3%	0.7%	0.3%	0.1%	0.1%	0.2%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	4.8%					
2	293	0	416	347	47	49	623	228	40	271	20	21	152	133	27	55	2722	14660	18.6%	81.4%	18007	81%
% of through	11%	0%	15%	13%	2%	2%	23%	8%	1%	10%	1%	1%	6%	5%	1%	2%	100%				^2013 count	
% of total	2.0%	0.0%	2.8%	2.4%	0.3%	0.3%	4.2%	1.6%	0.3%	1.8%	0.1%	0.1%	1.0%	0.9%	0.2%	0.4%	18.6%					
2A	18	416	0	22	25	35	656	209	56	302	11	21	150	160	21	11	2113	12570	16.8%	83.2%	14160	89%
% of through	1%	20%	0%	1%	1%	2%	31%	10%	3%	14%	1%	1%	7%	8%	1%	1%	100%				^2010 count	
% of total	0.1%	3.3%	0.0%	0.2%	0.2%	0.3%	5.2%	1.7%	0.4%	2.4%	0.1%	0.2%	1.2%	1.3%	0.2%	0.1%	16.8%					
3	41	347	22	0	410	455	29	231	71	204	61	45	121	58	105	306	2506	18965	13.2%	86.8%	28000	68%
% of through	2%	14%	1%	0%	16%	18%	1%	9%	3%	8%	2%	2%	5%	2%	4%	12%	100%				^2013 count	
% of total	0.2%	1.8%	0.1%	0.0%	2.2%	2.4%	0.2%	1.2%	0.4%	1.1%	0.3%	0.2%	0.6%	0.3%	0.6%	1.6%	13.2%					
4	93	47	25	410	0	1382	80	668	128	390	112	58	261	133	85	185	4057	28286	14.3%	85.7%	35620	79%
% of through	2%	1%	1%	10%	0%	34%	2%	16%	3%	10%	3%	1%	6%	3%	2%	5%	100%				^2010 count	
% of total	0.3%	0.2%	0.1%	1.4%	0.0%	4.9%	0.3%	2.4%	0.5%	1.4%	0.4%	0.2%	0.9%	0.5%	0.3%	0.7%	14.3%					
5	35	49	35	455	1382	0	183	920	216	706	36	82	374	156	46	43	4718	26118	18.1%	81.9%	34560	76%
% of through	1%	1%	1%	10%	29%	0%	4%	19%	5%	15%	1%	2%	8%	3%	1%	1%	100%				^2010 count	
% of total	0.1%	0.2%	0.1%	1.7%	5.3%	0.0%	0.7%	3.5%	0.8%	2.7%	0.1%	0.3%	1.4%	0.6%	0.2%	0.2%	18.1%					
6	18	623	656	29	80	183	0	394	132	592	21	50	358	301	48	26	3511	21810	16.1%	83.9%	24993	87%
% of through	1%	18%	19%	1%	2%	5%	0%	11%	4%	17%	1%	1%	10%	9%	1%	1%	100%				^2013 count	
% of total	0.1%	2.9%	3.0%	0.1%	0.4%	0.8%	0.0%	1.8%	0.6%	2.7%	0.1%	0.2%	1.6%	1.4%	0.2%	0.1%	16.1%					
7	8	228	209	231	668	920	394	0	493	1078	5	89	543	44	12	6	4928	24572	20.1%	79.9%	38329	64%
% of through	0%	5%	4%	5%	14%	19%	8%	0%	10%	22%	0%	2%	11%	1%	0%	0%	100%				^2013 count	
% of total	0.0%	0.9%	0.9%	0.9%	2.7%	3.7%	1.6%	0.0%	2.0%	4.4%	0.0%	0.4%	2.2%	0.2%	0.0%	0.0%	20.1%					
8	23	40	56	71	128	216	132	493	0	1309	17	64	829	105	27	14	3524	19132	18.4%	81.6%	29,309	65%
% of through	1%	1%	2%	2%	4%	6%	4%	14%	0%	37%	0%	2%	24%	3%	1%	0%	100%				^2013 count	
% of total	0.1%	0.2%	0.3%	0.4%	0.7%	1.1%	0.7%	2.6%	0.0%	6.8%	0.1%	0.3%	4.3%	0.5%	0.1%	0.1%	18.4%					
9	6	271	302	204	390	706	592	1078	1309	0	32	205	2838	138	40	18	8129	46235	17.6%	82.4%	72000	64%
% of through	0%	3%	4%	3%	5%	9%	7%	13%	16%	0%	0%	3%	35%	2%	0%	0%	100%				^2012 count	
% of total	0.0%	0.6%	0.7%	0.4%	0.8%	1.5%	1.3%	2.3%	2.8%	0.0%	0.1%	0.4%	6.1%	0.3%	0.1%	0.0%	17.6%					
9A	18	20	11	61	112	36	21	5	17	32	0	156	20	19	24	21	573	23827	2.4%	97.6%	33330	71%
% of through	3%	3%	2%	11%	20%	6%	4%	1%	3%	6%	0%	27%	3%	3%	4%	4%	100%				^2012 count	
% of total	0.1%	0.1%	0.0%	0.3%	0.5%	0.2%	0.1%	0.0%	0.1%	0.1%	0.0%	0.7%	0.1%	0.1%	0.1%	0.1%	2.4%					
10	15	21	21	45	58	82	50	89	64	205	156	0	1254	203	82	26	2371	25064	9.5%	90.5%	34980	72%
% of through	1%	1%	1%	2%	2%	3%	2%	4%	3%	9%	7%	0%	53%	9%	3%	1%	100%				^2010 count	
% of total	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.2%	0.4%	0.3%	0.8%	0.6%	0.0%	5.0%	0.8%	0.3%	0.1%	9.5%					
11	7	152	150	121	261	374	358	543	829	2838	20	1254	0	70	24	11	7012	45390	15.4%	84.6%	91000	50%
% of through	0%	2%	2%	2%	4%	5%	5%	8%	12%	40%	0%	18%	0%	1%	0%	0%	100%				^2012 count	
% of total	0.0%	0.3%	0.3%	0.3%	0.6%	0.8%	0.8%	1.2%	1.8%	6.3%	0.0%	2.8%	0.0%	0.2%	0.1%	0.0%	15.4%					
12	11	133	160	58	133	156	301	44	105	138	19	203	70	0	25	18	1574	19926	7.9%	92.1%	29810	67%
% of through	1%	8%	10%	4%	8%	10%	19%	3%	7%	9%	1%	13%	4%	0%	2%	1%	100%				^2010 count	
% of total	0.1%	0.7%	0.8%	0.3%	0.7%	0.8%	1.5%	0.2%	0.5%	0.7%	0.1%	1.0%	0.4%	0.0%	0.1%	0.1%	7.9%					
13	8	27	21	105	85	46	48	12	27	40	24	82	24	25	0	47	621	14970	4.1%	95.9%	19800	76%
% of through	1%	4%	3%	17%	14%	7%	8%	2%	4%	6%	4%	13%	4%	4%	0%	8%	100%				^2010 count	
% of total	0.1%	0.2%	0.1%	0.7%	0.6%	0.3%	0.3%	0.1%	0.2%	0.3%	0.2%	0.5%	0.2%	0.2%	0.0%	0.3%	4.1%					
14	9	55	11	306	185	43	26	6	14	18	21	26	11	18	47	0	796	21643	3.7%	96.3%	29390	74%
% of through	1%	7%	1%	38%	23%	5%	3%	1%	2%	2%	3%	3%	1%	2%	6%	0%	100%				^2010 count	
% of total	0.0%	0.3%	0.1%	1.4%	0.9%	0.2%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.0%	3.7%					

Inbound 13 Hour ALPR O-D Matrix Table (10/02/2013 Plate Collection Commenced at 6 am)

Origin Location	Destination Location 1	2	2A	3	4	5	6	7	8	9	9A	10	11	12	13	14	Total
1	0	2	0	6	11	7	3	1	2	0	2	0	1	2	1	0	38
2	134	0	356	18	23	34	434	169	21	160	7	13	98	75	11	35	1,589
2A	4	3	0	4	3	10	214	79	15	70	2	4	39	27	3	3	480
3	14	216	9	0	145	270	13	124	23	83	20	14	55	29	50	178	1,243
4	22	9	10	68	0	932	26	411	53	200	38	26	152	55	37	78	2,117
5	5	6	7	15	14	0	26	426	52	278	5	22	165	37	16	10	1,084
6	5	13	25	3	16	59	0	175	34	226	5	22	157	116	13	11	880
7	0	4	6	2	2	4	19	0	54	290	0	20	198	8	3	0	610
8	5	5	16	13	18	61	23	174	0	748	7	31	424	37	6	0	1,568
9	0	4	3	5	8	13	9	23	10	0	7	66	1,263	33	21	0	1,465
9A	0	0	1	6	18	9	0	1	0	0	0	5	5	2	3	0	50
10	6	2	3	6	5	9	5	18	8	19	70	0	548	65	22	0	786
11	0	1	0	2	1	1	1	2	1	8	0	9	0	6	2	0	34
12	1	1	2	5	4	12	2	5	3	8	4	4	11	0	9	0	71
13	1	0	0	4	4	6	2	2	1	4	8	4	10	2	0	0	48
14	3	1	0	9	11	6	0	4	3	3	16	6	6	3	13	0	84
Total	200	267	438	166	283	1,433	777	1,614	280	2,097	191	246	3,132	497	210	315	12,146

Outbound 13 Hour ALPR O-D Matrix Table (10/03/2013 Plate Collection Commenced at 6 am)

Origin Location	Destination Location 1	2	2A	3	4	5	6	7	8	9	9A	10	11	12	13	14	Total
1	0	141	12	17	41	12	8	3	14	3	7	5	3	7	4	1	278
2	16	0	13	2	4	0	4	2	2	0	1	1	0	3	0	1	49
2A	2	44	0	2	6	5	40	4	2	5	0	2	1	2	0	0	115
3	4	111	7	0	131	118	8	55	20	41	7	8	26	5	11	34	586
4	19	11	6	66	0	16	16	9	8	6	13	5	4	2	3	6	190
5	11	9	13	52	420	0	54	19	21	12	8	10	7	10	2	7	655
6	2	172	377	5	22	44	0	36	23	12	0	4	7	8	2	0	714
7	4	53	120	50	246	471	164	0	134	33	1	14	18	12	3	0	1,323
8	2	12	23	15	49	82	52	131	0	18	1	7	8	2	4	1	407
9	3	107	224	75	176	403	345	732	533	0	2	31	16	14	3	2	2,666
9A	9	12	8	28	43	14	16	3	9	23	0	78	5	8	7	0	263
10	4	5	12	17	22	41	19	37	18	89	3	0	17	6	8	0	298
11	3	53	110	38	104	201	193	325	396	1551	10	680	0	42	10	0	3,716
12	1	54	129	19	72	97	175	19	63	83	5	128	11	0	7	0	863
13	2	16	18	40	41	22	31	4	16	12	6	48	2	7	0	0	265
14	5	18	8	85	90	20	15	2	10	13	5	20	5	15	34	0	345
Total	87	818	1,080	511	1,467	1,546	1,140	1,381	1,269	1,901	69	1,041	130	143	98	52	12,733

column	287	1085	1518	677	1750	2979	1917	2995	1549	3998	260	1287	3262	640	308	367
row	316	1637	595	1829	2307	1739	1594	1933	1975	4131	313	1084	3750	934	313	429

total captures	603	2722	2113	2506	4057	4718	3511	4928	3524	8129	573	2371	7012	1574	621	796

All From/To

	1	2	2A	3	4	5	6	7	8	9	9A	10	11	12	13	14
1	0	143	12	23	52	19	11	4	16	3	9	5	4	9	5	1
2	150	0	369	20	27	34	438	171	23	160	8	14	98	78	11	36
2A	6	47	0	6	9	15	254	83	17	75	2	6	40	29	3	3
3	18	327	16	0	276	388	21	179	43	124	27	22	81	34	61	212
4	41	20	16	134	0	948	42	420	61	206	51	31	156	57	40	84
5	16	15	20	67	434	0	80	445	73	290	13	32	172	47	18	17
6	7	185	402	8	38	103	0	211	57	238	5	26	164	124	15	11
7	4	57	126	52	248	475	183	0	188	323	1	34	216	20	6	0
8	7	17	39	28	67	143	75	305	0	766	8	38	432	39	10	1
9	3	111	227	80	184	416	354	755	543	0	9	97	1,279	47	24	2
9A	9	12	9	34	61	23	16	4	9	23	0	83	10	10	10	0
10	10	7	15	23	27	50	24	55	26	108	73	0	565	71	30	0
11	3	54	110	40	105	202	194	327	397	1559	10	689	0	48	12	0
12	2	55	131	24	76	109	177	24	66	91	9	132	22	0	16	0
13	3	16	18	44	45	28	33	6	17	16	14	52	12	9	0	0
14	8	19	8	94	101	26	15	6	13	16	21	26	11	18	47	0

Appendix 3

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