Evaluation of Access Management Final Report

Safety

Mobility

Economy

Houston-Galveston Area Council

Texas A&M Transportation Institute

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Access Management is a set of techniques used to proactively manage vehicular access points to land parcels adjacent to roadways. Good access management promotes safe and efficient use of the transportation network. H-GAC previously conducted access management studies of portions of three corridors (FM 1093, FM 1960, and FM 518) in the region.

This evaluation was conducted to:

- Determine which corridor study recommendations have been implemented and which improvements are still being planned;
- Examine the effects of the recommended improvements before, during and after project implementation in the following areas:
  - Operations – including traffic flow (volumes), intersection delay, and corridor delay;
  - Safety –crash frequency, crash rates, and driveway access; and
  - Economy – changes in corridor taxable sales receipts while controlling for other economic factors occurring during those times.

Operations Summary

Detailed traffic analyses conducted as part of this evaluation revealed several notable findings. Most operational benefits were the result of roadway improvements such as turn bays, changes in traffic signal phasing, and spot widening. The list below summarizes the benefits obtained by the various access management components.

- Reduced travel times and reduced overall network delay were noted for full implementation of the recommendations as compared with the before conditions (No Build);
- Level of Service (a qualitative measure) at signalized intersections typically only changed if there were capacity improvements at the intersection.
- Increases in intersection delay are typically due to inadequate side street capacity (particularly with moderate volumes on side streets); and
- Recommended, but not yet implemented improvements to side street approaches would, in most cases, significantly reduce overall intersection delay.

Safety Summary

Average crash frequency and average crash rates are reduced in each of the three study corridors for each time period (before, during, and after improvements). Crash rates dropped in most sections 20 to 68 percent in most evaluation segments. Driveway related crashes decreased by 40 to 70 percent. Other contributing factors, including entering/exiting vehicle-related crashes were significantly reduced and rear end and intersection-related crashes were also reduced. The types and severity of crashes remained relatively unchanged, however it was found that about 90 percent of the crashes are non-injury crashes.

Economics Summary

The purpose for the economic analysis was to gain understanding on the potential impacts access management improvements had on taxable business sales and ultimately the overall effect of access management on the economic growth along a corridor. Generally, the trends from the three corridors studied suggested that business sales increased at a greater rate along these corridors than in the adjacent zip code analysis zones. However, several factors must be considered and the following events occurred during the study period that could have had an extraneous effect on business activity in the Greater Houston region:

While confounding factors and other events (hurricanes, economic recession and recovery) could have played an additional role and could have affected the results in unknown ways (otherwise known as "known unknowns", little evidence supports the theory that businesses along the access management corridors were unduly burdened by such improvements.

Evaluation Summary

Overall the access management tools studied improved mobility and safety without negatively affecting the economic growth. There are many influencing factors and it is challenging to control all influences and their combined effects. The greatest influencing factors for access management appear to be land use and density of retail and as a result, turning vehicles. The trends on the three corridors were similar despite the access to alternate routes, time of implementation, and other external influences.

Introduction

Introduction

In 2002 and 2004, the Houston-Galveston Area Council (H–GAC) commissioned access management studies of portions of three regional thoroughfare corridors: FM 1093, FM 1960, and FM 518. The studies were conducted to determine recommended access management techniques that would improve the mobility, safety, and aesthetics of these corridors. Table 1-1 presents these corridors along with the study limits and report publication dates.

Table 1-1. Corridor Studies and Publication Dates

Corridor	From*	To*	Study Publication Date
FM 1093	IH 610	SH 6	April 2002
FM 1960	Gatewick Road	Mills Road	October 2004
FM 518	SH 288	SH 146	August 2004

*See Study Reports for exact limits.

Each of the corridor studies recommended access management strategies to improve traffic flow, motorized and non–motorized user safety, air quality, and the general aesthetics of each corridor. The Texas Department of Transportation (TxDOT) has since implemented some of the recommended improvements along each corridor. This evaluation document provides an assessment of the application of access management recommendations along the three corridors with respect to traffic operations, safety, and impacts on economic activity.

Each of the three corridor study reports differed from each other relative to scope, scale, and approach. The FM 1093 (Westheimer Road) corridor was the first study corridor and the approach was more conceptual in nature than the FM 1960 and FM 518 studies. The FM 1960 and FM 518 studies were enhanced to deliver an implementation plan as opposed to only potential alternatives, so there was more detail in the FM 1960 and FM 518 as compared to the FM 1093 report.

Objective

The objective of this report is to document the evaluation and comparison of the three access management study corridors listed in Table 1-1 based on the following aspects:

- Recommended improvements implemented;
- Recommended improvements not yet implemented (which may or may not still be planned); and
- Effects of improvements before, during and after implementation in regard to the following characteristics:
    - Operation – traffic flow, intersection delay, and corridor delay;
    - Safety – crash frequency, crash rates, and comparison of driveway access in each of the study corridors; and
    - Economic – comparison of taxable sales receipts and relative to control of other economic factors occurring during those times.

Through this evaluation, the H–GAC is attempting to determine the effectiveness and feasibility of recommendations made in previous access management studies. This effort sought to determine whether or not the estimated benefits (as documented in the access management studies) from implemented improvements were actually realized. This assessment will help to determine the utility of access management studies in the region and quantify the benefits of access management projects for policy makers and local government personnel. Moreover, this assessment will ultimately help the H–GAC develop better guidance for the conduct of future access management studies.

Corridor Characteristics

The three studied roadways are located in the greater Houston area. FM 1093 and FM 1960 are characteristically similar, serving sections of dense retail and major shopping malls as well as sections of strip retail development, multifamily housing, and some undeveloped parcels. FM 518 has a mix of retail development and single family and multifamily housing, but is less dense than the other two corridors. Each corridor is described in more detail below.

FM 1093 is classified as a principal arterial. It is the major east-west arterial thoroughfare from midtown Houston to west Harris County. West of IH 610, the corridor is an eight lane facility with raised medians that separate each direction of traffic. The facility crosses three major highways (IH 610, Beltway 8, and SH 6) and has 43 signalized intersections within the study section. Major intersections typically have left turn lanes, while major driveways and unsignalized intersections may have hooded left-turn lanes. The FM 1093 study corridor is illustrated in Figure 1-1.

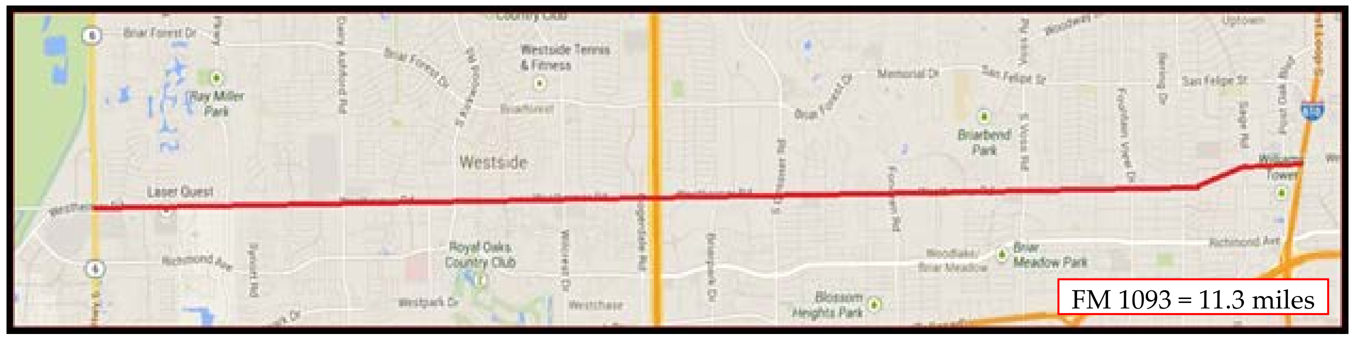


Figure 1-1. FM 1093 Access Management Study Corridor (Source Google Maps)

FM 1960 is classified as a principal arterial. It is a primary east-west thoroughfare in northwest Harris County. FM 1960 is a six lane arterial thoroughfare with raised medians that separate each direction of traffic. The facility crosses two major highways (SH 249 and IH 45) and the study section contains 36 signalized intersections. Major intersections typically have left turn bays and major driveway locations and unsignalized intersections have hooded left-turn lanes. The FM 1960 study corridor is illustrated in Figure 1-2.

FM 518 is classified as a principal arterial. It is the major east-west arterial thoroughfare in the northern portion of Brazoria and Galveston Counties and crosses several municipal jurisdictions, including Pearland, Friendswood, and League City. FM 518 is primarily a four lane facility with raised medians separating each direction of traffic, however several segments feature two-way left turn lanes. The facility crosses three major highways (SH 288, IH 45 and SH 146) and has 74 signalized intersections. Major intersections have left turn lanes and some minor driveways and unsignalized intersections have hooded left-turn lanes. The FM 518 corridor is illustrated in Figure 1-3.

Figure 1-2. FM 1960 Access Management Study Corridor (Source Google Maps)

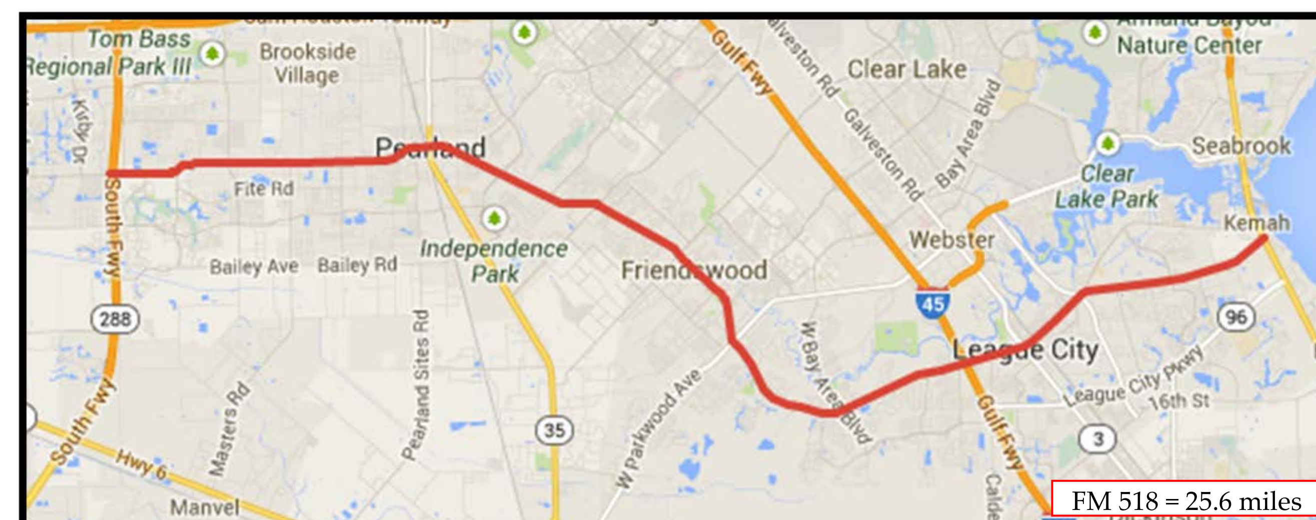


Figure 1-3. FM 518 Access Management Study Corridor (Source Google Maps)

Table 1-2 provides a description of each corridor including number of lanes, functional classification, traffic volume and other attributes.

Table 1-2. Roadway Type and Description

Roadway Name	Roadway Classification	Number of Lanes	Number of Signalized Intersections	Roadway Length	Roadway Direction	Major Highway Intersections	Traffic Volume Per Day	Level of Service Range
FM 1093	Principal Arterial	6	43	11.3 miles	East-West	3	44,000 to 71,000	D/E
FM 1960	Principal Arterial	8	36	9.3 miles	East-West	2	60,000 to 70,000	C/E
FM 518	Principal Arterial	4	74	25.6 miles	East West	3	13,000 to 56,000	C/D

Recommended Improvements and Corridor Inventory

Most of the study recommendations on the three corridors occur within the right-of-way, but some of the improvements are on private property or recommended nearby streets. Likewise, some improvements were recommended not only to the main corridor but to cross streets to improve safety and reduces delays along the corridors.

An inventory of each corridor was made using the original study recommendations, Google Earth™ aerial images, and Google Earth™ historical aerial images. Inventory items were placed on Google Earth maps and summarized into tables to make comparisons with the recommended improvements for this evaluation.

Conflict Reduction

A primary concept of access management is minimizing vehicular conflicts. Reducing conflicts can take the form of the following:

- Channelizing medians (one way and two way);
- Creating right turn bays;
- Creating left turn bays;
- Extending turn bays;
- Consolidating driveways; and
- Creating one way driveways or diverters.

Separating vehicles from the rest of the traffic stream and/or reducing the number of conflict points contribute to both increased safety and mobility by reducing the potential sources of crashes.

Mobility and Operations

Other access management concepts operational in nature, including: 1) improving traffic signal hardware and software; 2) interconnecting signals to promote progression; and 3) optimizing signal timing and phasing. These improvements assist in the efficiency of moving vehicles longer distances at higher average speeds through the corridor , and provision for alternative modes of travel.

Alternative Modes

Another access management concept is to create opportunities to reduce motorized vehicle travel through the use of multimodal alternatives. These alternative modes may include walking, biking, and increased accessibility and use of transit. Improved sidewalks and bike facilities may encourage less vehicle travel and adding amenities including bus shelters, benches, and sidewalks to bus stops can encourage use of transit.

Cross Street Improvements

Similar to the corridor improvements listed above, cross street improvements were recommended and made to improve intersecting street approaches to the main corridor. The improvements may improve overall intersection operations and improve the safety and mobility on the corridor.

Operations Evaluation

In order to evaluate the operational impacts of access management implementation along the three study corridors, a traffic operations and level of service analysis was performed using the Synchro 7.0 suite of software. The traffic analysis included comparison of operational measures of effectiveness for three conditions including:

- No-Build Conditions with 2013 Traffic Volumes;
- Current Conditions with 2013 Traffic Volumes; and
- Build-Out (Full Study Recommendations) with 2013 Traffic Volumes.

Evaluation Methodology
The evaluation methodology involved:

- Selecting representative segments within each corridor to be used for operational evaluation.
- Selecting Measures of Effectiveness (MOE's) for comparison.
- Collecting data (geometric, signal timing, and traffic data) to develop the Current Condition model.
- Developing and calibrating Current Condition traffic model using Traffic Analysis Tool Synchro 7.
- Modifying the Current Condition model to reflect "before" geometry and "before" phasing and cycle lengths to represent the No-Build Condition.
- Modifying the Current Condition model to reflect the Build-Out Condition.
- Coordinating and optimizing each model for the selected cycle length and phasing plan.
- Developing Synchro reports for selected MOE's; and
- Comparing No-Build Condition MOE's with Current Condition and Build-Out Condition MOE's.

Representative Segments
Five representative segments on the three corridors were analyzed. These segments are:

1. FM 1960 corridor: Mills Road to Cutten Road (west section);
2. FM 1960 corridor: Walters Road to Kuykendahl Road (middle section);
3. FM 1093 corridor: Wilcrest Drive to Gessner Road;
4. FM 518 corridor: SH 288 to Sunrise Lakes Boulevard (City of Pearland section); and
5. FM 518 corridor: IH 45 to SH 3 (City of League City section).

Data Collection
Traffic data for the three corridors were collected in March and April 2013. Roadway and traffic data collected to complete this analysis included:

- Current roadway geometry;
- Changes to roadway geometry and phasing plans both implemented and recommended;
- Current signal timing and phasing plans;
- Before phasing plans (identified from study reports);
- Weekday PM peak hour (5:00 pm to 6:00 pm) turning movement counts for all five representative segments;
- Weekday AM peak hour (7:00 am to 8:00 am) turning movement counts for the two FM 518 segments;
- Driveway turning movement counts at major driveways and unsignalized intersections in each segment for one 15-minute period within the peak period;
- Queuing data for left turn bays at signalized intersections and at median openings; and
- 24-hour weekday corridor volume throughput counts.

Measures of Effectiveness
Commonly employed (measures of effectiveness (MOE's) for evaluating the operational performance of an arterial corridor include travel time and/or travel speed along the corridor, level of service at signalized intersections, arterial level of service, number of stops, queues at intersections, and delay. The three selected MOE's for evaluating the operational performance of each of the study corridors included:

1. Average control delay and level of service at signalized intersections;

2. Arterial travel time and level of service; and
3. Total network delay.

Safety Evaluation

The safety evaluation analyzed the three access management projects to determine the impacts of access management on the number and severity of crashes before and after access management implementation. The following questions were posed:

- Were the facilities safer with or without access management?
    - Did crash frequency change?
    - Did crash severity change?
    - What types of crashes were reduced and what, if any, were increased?
    - What other crash characteristics are related to access management?
- Were there relative differences between sections of roadway based on the area type and land use?
- What criteria should be used to evaluate corridor safety in future studies?

Safety Evaluation Methodology

Before-, during-, and after-implementation crash data as recorded in TxDOT's Crash Record Information System (CRIS) were obtained from TxDOT for this evaluation. Crash data statistics including average crash rate per 100 million miles traveled, number of fatalities per year in the corridor, and types of crashes were computed and compared for the three time periods analyzed. A graphical representation of crash statistics was also developed. In addition, crash rates found for each of the three corridors were compared with statewide crash averages. The steps below outline the crash evaluation process:

- Divide corridor into homogeneous segments to be used for safety evaluation;
- Collect data (crash data, traffic volumes, and project implementation dates);
- Divide data into sections for analysis based on traffic volumes and sections defined in the operational analysis. These sections may be different from the original crash analyses. The researchers controlled for these differences by gathering before and after data; and
- Graphically plot data to determine crash locations and clusters to identify patterns.

Economic Impact

The impact of access management projects on business and overall economic activities are not well documented. Both factual and anecdotal examples exist regarding how access management improvements can positively or negatively affect business activity. However, few recent studies have been conducted on the economic effects of access management improvements in the Greater Houston region.

The focus of this portion of our evaluation was to investigate the potential economic effects arising from access management improvements along the three corridors. This evaluation methodology focused on collection and analysis of taxable sales data to examine the possible changes in business activity before, during, and after any implemented improvements for various classes of businesses in the corridor study areas.

Businesses within 200 feet of the center line of each corridor were identified for inclusion in the analysis using geographic information system (GIS) mapping. Those businesses were coded based on whether they could be characterized as "pass-by", "destination", or a combination of both by their nature based on the North American Industry Classification System (NAICS). This classification was done to examine taxable sales changes by business type as some business owners often note that the effects of access management projects are felt unevenly.

A "control zone" was developed from zip codes within ¼ mile of the centerline of each study corridor to compare the corridor taxable sales information with the local and regional economy. Sales tax information was requested from the Texas State Comptroller for each corridor and for the zip code control zone. For normalization purposes, taxable sales receipts were adjusted to 2012 United States

Dollars (USD) using annual Houston-Galveston-Brazoria Consumer Price Index (CPI) data. The results were tabulated and a comparative analysis was conducted for the before, during and after conditions also comparing the "pass-by", "destination", and combination NAICS business types.

Conclusions and What We Learned

Based on the three main sections of the evaluation, conclusions were made on the overall benefits of access management. The safety, mobility, and economic analyses provide insight to the types of developments and land use that most benefit from access management. Access management and corridor projects are usually planned and implemented once a problem exists with safety and/or mobility. However, there may be significant benefits to managing corridor development along emerging facilities and this evaluation reveals that establishing a framework for continuous access management has great potential to positively shape land development by reducing crashes and improving mobility before it becomes a problem.

Inventory

Introduction

This section of the evaluation report consists of the results of corridor inventories for the following access management study corridors:

- FM 1093
- FM 1960
- FM 518

Each corridor was studied to determine the status of the recommended improvements made by the original study using the following categories:

- Improvements recommended and implemented
- Improvements recommended but not implemented
- Improvements not recommended but implemented

The following attributes were plotted in Google Earth and tabulated in the inventory process:

- Raised Medians
- Turn Bay Modifications
- Traffic signals
- Driveways
- Pedestrian and Bicycle Accommodations*
- Back Streets*
- Landscaping*

*Not plotted noted

The corridor inventories served as a tool for the development of the traffic simulation models to determine the operational benefits of each project.

Inventory Method

Project inventories for FM 1093, FM 1960, and FM 518 were made using the original study recommendations, Google Earth Pro® aerial images, and Google Earth Pro® historical aerial images. A comparison was made of the historical and current Google Earth maps to determine the status of the original recommended improvements.

If the recommended improvements had not been implemented, the Google Earth Pro® map was marked and color-coded. If the recommended improvements had been implemented, the approximate date of implementation was researched by looking at the Google Earth Pro® map timeline from the current date back to when the improvement first appeared on the map. The Google Earth Pro® map was then marked, color-coded, and dated with an approximate date of implementation. These marked and color-coded maps are found in the respective appendix for each corridor.

Functional Classification

Functional classifications of roadways are based on the primary AASHTO concept with a tradeoff between mobility and access. Principal arterial roadways are developed for higher mobility than access. Their function is to gather traffic from collectors and local streets and provide the moderate long distance travel or to provide a link to the higher functional class roadways freeways and expressways.

All the corridors have a functional classification of Principal Arterial. Table 2-1 provides a description of the roadway cross section and the surrounding land use.

Table 2-1. Corridor Functional Class, Geometry and Land Use Description

Corridor	Current Corridor Description	Functional Classification	Land Use
FM 1093 IH 610 to Chimney Rock Chimney Rock to Westerland Westerland to Woodland Park Woodland Park to SH 6	Four lanes each direction, separated by raised median, most major intersections have turn bays for left turning vehicles	Principal arterial	Retail strip development with one major shopping mall, commercial office buildings ranging from 2 to 20 stories, and multifamily housing fronting FM 1093/Westheimer
FM 1960 Mills Road to Cutten Road Cutten Road to Champions Drive Champions Drive to Walters Road Walters Road to Hafer Road Hafer Road to Imperial Valley Drive	Three lanes each direction, separated by a raised median, most major intersections have turn bays for left turning vehicles,	Principal arterial	Retail strip development with one major shopping mall, commercial office buildings ranging from two to six stories and multifamily housing fronting FM 1960. Some undeveloped land still fronts FM 1960
FM 518 SH 288 to Cullen Boulevard Cullen Boulevard to Harkey Road Harkey Road to Main Street Main Street to Pearland Parkway Pearland Parkway to Sunset Meadows Sunset Meadows to Shadow Bend Drive Shadow Bend Drive to FM 528 FM 528 to League City League City to Landing Boulevard Landing Boulevard to IH 45 IH 45 to SH 3 SH 3 to FM 270/FM 2094 FM 270/FM 2094 to Meadow Parkway Meadow Parkway to Lawrence Road Lawrence Road to SH 146	Two lanes each direction, separated by two-way left-turn lane, raised median or undivided lanes, most major intersections have turn bays for left turning vehicles, some right turn bays are also provided.	Principal arterial	Retail strip development is focused around major cross streets, some commercial office buildings ranging from 2 to 5 stories, and multifamily housing fronting FM 518. Some undeveloped land still fronts FM 518 and some residential housing backs up to FM 518.

Corridor Inventory Elements

Corridor inventory elements that have been inventoried are provided in the following tables. The FM 1093, FM 1960, and FM 518 corridor access study recommended many types of improvements including:

- Cross street improvement
- Driveway improvements
- Median improvements
- Private property improvements
- Signage improvements
- Signal improvements
- Transit improvements
- Other improvements

Cross Street Improvements

- Adding dual left turn lanes
- Adding left turn lanes
- Adding right turn lanes
- Extending turn bays
- Widening streets

Driveway Improvements:

- Adding driveways
- Closing driveways
- Improving driveways

Median Improvements:

- 2 Directional channelization of lanes
- Channelizing EB left turn lanes
- Channelizing WB left turn lanes
- Closing medians

Private Property Improvements:

- Connecting adjacent properties

Signage improvements:

- Adding guide signs
- Adding no left-turn signs
- Adding overhead directional signs
- Adding overhead street name signs

Signal Improvements:

- Adding new signals
- Modifying existing signals
- Providing signal timing program
- Removing signals
- Repairing signal interconnector and vehicle detectors

Other Improvements:

- Adding dual left turn lanes
- Adding new parallel roadways
- Adding right turn lanes
- Adding sidewalks
- Converting EB through to right turn only lanes
- Converting WB through to right turn only lanes
- Extending turn bays
- Grade separating cross street/railroads

Transit Improvements:

- Adding shelter at bus stops
- Adding sidewalk from bus stops,
- Consolidating bus stops
- Removing bus stops

Summary of Corridor Improvements

Table 2-2 lists the recommended improvements based on the original reports and the inventory of improvements. More detailed information can be found in the Inventory Corridor Appendices.

Many of the recommended improvements were implemented, however most projects were designed to be low cost and quick implementation. Improvements requiring additional right of way or other jurisdictions may have been perceived to be slower and thus not included in the proposed projects.

Table 2-2 Summary of Recommended and Implemented Improvements on FM 1093, FM 1960, and FM 518

Improvement Category	FM 1093		FM 1960		FM 518		Total All Corridors	
	Recommended	Implemented	Recommended	Implemented	Recommended	Implemented	Recommended	Implemented
Capacity								
Add Dual Left Turn Lane	2	2	1	0	2	2	5	4
Add Left Turn Lane	3	1	1	0	9	4	13	5
Add Right Turn Lane	1	0	6	0	10	0	17	0
Extend Existing Turn Bay	2	2	15	0	0	0	17	2
Add Travel Lane	0	0	9	1	0	0	9	1
Driveway								
Add Driveway	2	0	9	0	0	0	11	0
Close Driveway	125	15	0	0	120	5	245	20
Improve Driveway	89	7	40	2	0	0	129	9
Median								
2 Directional Channelization	28	28	11	11	0	0	39	39
Channelize Left Turn EB	1	1	46	43	5	0	52	44
Channelize Left Turn WB	5	5	40	36	5	0	50	41
Extend Left Turn Bay	22		1	1	0	0	26	4
Close Median	38	7	3	3	6	2	48	12
Add Raised Median	0	0	0	0	182	60	182	60
Private Property								
Connect Adjacent Properties	0	0	19	0	0	0	19	0
Signage								
Add Guide Sign	0	0	2	2	0	0	2	2
Add No Left Turn Sign	0	0	1	0	0	0	1	0
Add Overhead Directional Sign	1	0	0	0	0	0	1	0
Add Overhead Street Name Sign	0	0		0	0	0		0

Table 2-2 Continued. Summary of Recommended and Implemented Improvements on FM 1093, FM 1960, and FM 518

Improvement Category	FM 1093		FM 1960		FM 518		Total All Corridors	
	Recommended	Implemented	Recommended	Implemented	Recommended	Implemented	Recommended	Implemented
Signal								
Add Signal	1	0	1	1	15	15	16	16
Improve Signal Hardware	44	0	0	0	0	0	44	0
Modify Signal	0	0	2	0	0	0	2	0
Provide Signal Timing Program	3	3	2	0	0	0	5	3
Remove Signal	0	0	4	1	1	1	5	2
Repair Signal Interconnect & Vehicle Detectors	1	1	0	0	0	0	1	1
Use Single Signal Controller	4	0	5	3	0	0	5	2
Other								
Add Dual Left Turn Lane	3	0	3	0	0	0	4	0
Add New Parallel Roadway	0	0	3	0	0	0	3	0
Add Right Turn Lane	15	0	10	0	7	1	25	1
Add Sidewalks	0	0	2	0	0	0	2	0
Convert EB Through to Right Turn Only Lane	8	0	1	0	0	0	9	0
Convert WB Through to RT Only Lane	7	0	0	0	0	0	7	0
Extend Right Turn Bay	2	0	3	0	0	0	4	0
Grade Separation of Cross Street/RR	0	0	2	0	0	0	2	0
Transit								
Add Bench at Bus Stop	0	0	18	6	0	0	18	6
Add Shelter at Bus Stop	0	0	5	2	0	0	5	2
Add Sidewalk From Bus Stop	0	0	4	0	0	0	4	0
Consolidate Bus Stop	12	0	0	0	0	0	12	0
Remove Bus Stop	17	0	0	0	0	0	5	0

Operations

Operational Analysis

In order to evaluate the operational impacts of access management implementation along the three study corridors, a traffic analysis was performed using Synchro 7.0 software. The traffic analysis included comparisons of operational measures of effectiveness (MOE's) for the following three conditions:

No-Build Condition: The No-Build Condition represents roadway characteristics before implementation of access management strategies with current (2013) traffic volumes.

Current Condition: The Current Condition represents current (2013) roadway characteristics (with or without implementation of access management recommendations) with current (2013) traffic volumes.

Build-Out: The Build-Out Condition represents roadway characteristics after full implementation of access management recommendations with current (2013) traffic volumes. This case was used for corridor segments where only some of the recommendations have been implemented. All recommendations, implemented and non-implemented recommendations, were incorporated to the model.

This section summarizes the evaluation methodology, data collection, measures of effectiveness (MOEs) used, and the operational analysis evaluation results for the three corridors evaluated.

Evaluation Methodology

Evaluation of the operational impacts of the access management implementation was completed using the following steps:

- Select representative segments within each corridor to be used for operational evaluation;
- Select MOEs for comparison;
- Collect data (geometric, signal timing, and traffic data) to develop the Current Condition model;
- Develop and calibrate Current Condition traffic model using traffic analysis tool Synchro 7;
- Modify the Current Condition model to reflect before geometry and before phasing/cycle lengths to represent the No-Build Condition;
- Modify the Current Condition model to reflect the Build-Out Condition;
- Coordinate and optimize each model for the selected cycle length and phasing plan;
- Develop Synchro reports for selected MOEs; and
- Compare No-Build Condition MOEs with Current Condition MOEs and Build-Out Condition MOEs.

Representative Segments

Previous study analyses, engineering judgment, and knowledge of the corridor operations were considered when selecting representative segments to be modeled for the evaluation of the traffic operations in each corridor with and without access management implementation. These five segments included:

1. FM 1960 corridor: Mills Road to Cutten Road;
2. FM 1960 corridor: Walters Road to Kuykendahl Road;
3. FM 1093 corridor: Wilcrest Drive to Gessner Road;
4. FM 518 corridor: SH 288 to Sunrise Lakes Blvd. (City of Pearland section); and
5. FM 518 corridor: IH 45 to SH 3 (City of League City section).

Data Collection

Traffic data for the three study corridors were collected in March and April 2013. Roadway and traffic data collected to complete this analysis included:

- Current roadway geometry;
- Changes to roadway geometry and phasing plans both implemented and recommended;
- Current signal timing and phasing plans;
- Before traffic signal phasing plans from original study;
- Weekday PM peak hour (5:00 pm to 6:00 pm) turning movement counts for all five representative segments;

- Weekday AM peak hour (7:00 am to 8:00 am) turning movement counts for the two FM 518 segments;
- Counts at major driveways and unsignalized intersections were conducted in each segment for one 15 minute period within the peak period; and
- Queuing data for left turn bays at signalized intersections and at channelized median openings.

Measures of Effectiveness

Original study recommendations for the three corridors which were anticipated to impact traffic operations included:

- Construction of raised medians to eliminate the two-way center left turn; lanes (consolidating left turning vehicles at median openings and signalized intersections);
- Improvement of turn bays (lengthening/adding) at signalized intersections;
- Improvement of signal coordination and signal phasing along the corridor; and
- Removal of unwarranted signals.

Additional recommendations regarding driveway consolidations require private property owners/developers approval and have not been implemented. The traffic analysis part of the evaluation is designed to assess the impact of all implemented recommendations except signal coordination/optimization, since optimization and coordination characteristics in the before condition (at the time of original study) are not readily available.

Commonly employed MOEs for evaluating the operational performance of an arterial corridor included:

- Travel time and/or travel speed along the corridor;
- Level of service at signalized intersections;
- Arterial level of service;
- Number of stops;
- Intersection approach and turn bay queues; and
- Delay.

The three primary MOEs for evaluating the operational performance of study corridors included:

1. Average control delay and level of service at signalized intersections;
2. Arterial travel time and level of service; and
3. Total network delay.

Analysis Results

Analysis results are summarized by representative segments for each peak hour analyzed.

FM 1093 (Westheimer Road) Corridor: Wilcrest Drive to Gessner Road
PM Peak Hour Analysis

The segment of FM 1093 between Wilcrest Drive to Gessner Road was identified as one of the two more congested sections along the study corridor and was selected as a representative segment for this evaluation. The land-use along this segment is a mixture of retail, commercial, office, and residential. Current traffic volumes in the PM peak hour are in the range of 2000 to 2300 vph in the eastbound (EB) direction and in the range of 2500 to 3300 vph in the westbound (WB) direction. The diamond interchange of Sam Houston Tollway with FM 1093 is a bottleneck and contributes significantly to overall high delays for this segment.

Geometric changes from No-Build to Current Condition included closure of raised medians at four locations (to restrict certain movements) and channelization of existing raised medians at six additional locations. Additional changes included:

- Creating double left turn bays for northbound (NB) and southbound (SB) approaches to Wilcrest Drive;
- Adding a right turn bay for the NB approach at Wilcrest Drive.

Recommended changes from the Current Condition to Build-Out Condition that have not yet been implemented included:

- Channelization treatment for the WB thru movement at the T-intersection of FM 1093 at Elmside Drive;

- Addition of right turn bay at the NB and WB approach of FM 1093 at Gessner Road; and
- Addition of a right turn bay at the EB approach of FM 1093 at Rogerdale Road.

Traffic analysis results show a 6% improvement in travel time for the WB direction and a slight increase in travel time for the EB direction when comparing the No-Build Condition with the Current Condition. In the Current Condition, due to restriction of EB left turn movements, NB left turns, and thru movements from certain driveways, there were additional U-turning vehicles at several signalized intersections, resulting in higher travel times for EB vehicles as compared to the No-Build Condition. When comparing the No-Build Conditions with the Build-Out Conditions, travel times in both EB and WB directions show improvement. Overall network delay in the Build-Out Condition was reduced by approximately 9.5% as compared to the No-Build Condition. Table 3-1 illustrates the results of the peak hour analysis for the FM 1093/Westheimer corridor from Wilcrest to Gessner.

Table 3-1. FM 1093/Westheimer Corridor: Wilcrest to Gessner Road - Results for the PM Peak Hour Analysis.

Scenario	Current Condition		No-Build Condition		Build- Out Condition	
Intersection	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service
FM 1093 at Wilcrest Dr	62.1	E	97.9	F	62.1	E
FM 1093 at Walnut Bend Ln	22.9	C	29.7	C	22.9	C
FM 1093 at Blue Willow Dr	8.2	A	4.8	A	8.2	A
FM 1093 at Rogerdale Rd	15.8	C	15.0	C	15.7	C
FM 1093 at BW 8 SB Frontage Rd	57.4	E	56.2	E	57.4	E
FM 1093 at BW 8 NB Frontage Rd	126.0	F	126.0	F	126.4	F
FM 1093 at Seagler Rd	15.4	B	15.5	B	16.5	B
FM 1093 at Briarpark Dr	21.1	C	21.1	C	17.3	B
FM 1093 at Elmside Dr	11.5	B	11.6	B	8.4	A
FM 1093 at Gessner Rd	48.9	D	48.3	D	43.6	D
Arterial Results	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**
EB FM 1093	606.9	E	594.5	E	584.5	E
WB FM 1093	555.0	D	596.7	E	547.2	D
Network	**Total Delay (Veh-hrs)**		**Total Delay (Veh-hrs)**		**Total Delay (Veh-hrs)**	
Network Delay	837.0		895.0		806.0	

FM 1960 Corridor: Mills Road to Cutten Road – PM Peak Hour Analysis

This segment of FM 1960 was identified as one of the two more congested sections along the study corridor in the 2004 study. The land use along this segment is mostly commercial with Willowbrook Mall abutting the south side of this segment. Current traffic volumes in the PM peak hour are in the range of 2100 to 2500 vehicles per hour (vph) in both the EB and WB direction.

Geometric changes from No-Build to Current Condition included construction of raised medians between Mills Road and SH 249 SB and between Breton Ridge Street and Cutten Road. The section between SH 249 NB and Breton Ridge Street had existing raised medians in the No-Build Condition. Many of the driveway or side street improvements recommended in the 2004 study have not been implemented. The study did not provide any recommendations for traffic signal phasing plan changes or removal or modification of traffic signals in this representative segment.

Table 3-2 presents the PM peak hour analysis for the FM 1960 segment from Mills Road to Cutten Road.

Table 3-2. FM 1960 Mills Road to Cutten Road PM Peak Hour Analysis.

Scenario	Current Condition		No-Build Condition		Build-Out Condition	
Intersection	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service
FM 1960 at Mills Rd	60.4	E	59.6	E	40.7	D
FM 1960 EB at SH 249 SB	37.3	D	37.2	D	28.8	C
FM 1960 EB at SH 249 NB	27.9	C	27.9	C	28.1	C
FM 1960 WB at SH 249 SB	39.9	D	39.9	D	40.0	D
FM 1960 WB at SH 249 NB	34.5	C	35.5	D	35.1	D
FM 1960 at Commons Ave	26.8	C	23.3	C	21.0	C
FM 1960 at Breton Ridge St	38.8	D	38.3	D	39.8	D
FM 1960 at Willow Center Dr	20.3	C	18.3	B	13.9	B
FM 1960 at Cutten Rd	60.0	E	59.2	E	61.0	E
Arterial Results	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**
EB FM 1960	344.1	E	341.9	E	313.7	E
WB FM 1960	386.4	E	394.2	E	368.7	E
Network	**Total Delay (Veh-hrs)**		**Total Delay (Veh-hrs)**		**Total Delay (Veh-hrs)**	
Network Delay	533.0		527.0		485.0	

Traffic analysis results showed a small improvement in travel time for the WB direction and a slight increase in travel time for the EB direction when comparing the No-Build Condition with the Current Condition. The Current Condition for this segment represents partial implementation of the access management study recommendations. When comparing No-Build Conditions with Build-Out Conditions, travel times in both EB and WB directions show improvement. Traffic modeling results suggest that total network delay for the Build-Out Condition will be approximately 8% less than the No-Build Condition. However, most of the study recommendations that have not been implemented include improvements to side streets and driveways.

Increases in delay at individual intersections and overall delay for the network when comparing the No-Build Condition with the Current Condition are due to changes in left-turning traffic patterns. The left turning vehicles using the Two Way Left Turn Lane (TWLTL) now have to travel to the next intersection or median opening and then reach their destination by making a U-turn. This travel pattern change increases the demand for the left-turn bays at signalized intersections and requires additional green time for left turn phases. This additional left turn phase allocation increases overall average delays at intersections that were near or at-capacity in the No-Build Condition.

FM 1960 Corridor -- Walters Road to Kuykendahl Road – PM Peak Hour Analysis

The land use along this segment is a mixture of commercial and residential. Geometric changes from No-Build to Current Condition that had the potential to impact operations along the corridor included:

- Construction of raised medians to replace the TWLTL;
- Grade separation of Kuykendahl Road at FM 1960; and
- Extension of Northgate Forest Drive to south of FM 1960 to modify this intersection from a T-intersection to a four-leg intersection.

The study recommendations that have the potential to impact traffic operations and have not been implemented include:

- Removal of traffic signal at Fritz Oaks at FM 1960;
- Removal of traffic signal at Terrace Oaks at FM 1960;
- Addition of turn bays on Walters Road; and
- Extension of turn bays on cross street approaches to FM 1960.

One noteworthy observation for this segment is that the grade separation of FM 1960 and Kuykendahl Road through traffic was not included in the 2004 study as a recommendation nor was it included in the operational analysis as part of improvements in the original study. The results of the PM Peak Hour Analysis for FM 1960 Segment from Walters Road to Kuykendahl Road is shown in Table 3-3.

Table 3-3. FM 1960 Walters Road to Kuykendahl Road PM Peak Hour Analysis.

Scenario	Current Condition		No-Build Condition		Build-Out Condition	
Intersection	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service
FM 1960 at Walters Road	44.5	D	43.8	D	35.2	D
FM 1960 at TC Jester Blvd	35.0	C	34.6	C	43.0	D
FM 1960 at Terrace Oak Drive	5.9	A	5.5	A	-	-
FM 1960 at Northgate Forest Drive	10.8	B	10.7	B	14.2	B
FM 1960 at Fritz Oak Place	2.9	A	2.3	A	-	-
FM 1960 at Kuykendahl Road*	45.3	D	197.1	F	44.8	D
Arterial Results	Travel Time (s)	Level of Service	Travel Time (s)	Level of Service	Travel Time (s)	Level of Service
EB FM 1960	258.9	C	269.1	C	240.6	C
WB FM 1960	300.7	D	479.2	E	286.7	C
Network	Total Delay (Veh- hrs)		Total Delay (Veh- hrs)		Total Delay (Veh- hrs)	
Network Delay	211.0		520.0		207.0	

* Assumed grade separated for Current and Build-Out Condition and at-grade for No-Build Condition.

FM 518 Corridor: SH 288 to Sunrise Lakes Boulevard (City of Pearland section) – AM and PM Peak Hour Analysis

The segment of FM 518 between SH 288 and Sunrise Lakes Boulevard was identified as one of two sections selected as a representative segment to understand the operational impacts of access management implementation. The land use along this segment is a mix of residential and commercial with a major interchange at the west end of the segment (at SH 288). The AM peak hour volumes for this segment are in the range of 950 to 1250 vehicles per hour in the WB direction and 700 to 1000 vehicles per hour in the EB direction. The No-Build Condition level of service at the signalized intersections was C or better. Very little improvement with respect to LOS was seen for the current and Build-Out Condition when compared to No-Build Condition, see a detailed comparison results for this segment in Tables 3-4 and 3-5.

Current traffic volumes in the PM peak hour are in the range of 1300 to 1750 vph in both the EB and WB direction. Major geometric changes from No-Build to Current Condition included:

- Construction of raised medians;
- Addition of a through lane in the EB and WB direction between the intersection of FM 518 at County Road 94 (South); and
- Addition of a through lane at the intersection of FM 518 at SH 288 NB Frontage Road.

Partial improvements to side streets have been implemented, however traffic signal phasing plan changes (particularly the elimination of split phasing for minor street phases) have not been implemented.

Table 3-4. FM 518: SH 288 to Sunrise Lakes Blvd AM Peak Hour Analysis.

Scenario	**Current Condition**		**No-Build Condition**		**Build-Out Condition**	
Intersection	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service
FM 518 at SH 288 SB FR	24.3	C	27.9	C	24.2	C
FM 518 at SH 288 NB FR	20.9	C	25.5	C	26.9	C
FM 518 at Silverlake Village Blvd	10.6	B	12.8	B	15.9	B
FM 518 at Wal-Mart	11.1	B	8.7	A	7.5	A
FM 518 at Home Depot	18.0	C	19.3	B	18.6	B
FM 518 at Miller Ranch Rd	18.1	B	22.0	C	18.6	B
FM 518 at Silverlake Pkwy	25.4	C	25.5	C	24.7	C
FM 518 at Sunrise Lakes *	6.7	B	-	-	6.5	A
Arterial Results	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**
EB FM 518	315.8	C	285.0	C	312.5	C
WB FM 518	305.0	C	319.2	C	324.6	C
Network	**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**	
Network Delay	76.0		86.0		78.0	

*Represents intersection that was unsignalized in the No-Build Condition, and was signalized for the Current Condition and was assumed to stay the same for the Build-Out Condition.

There is an additional signalized intersection (FM 518 at Sunrise Lakes Blvd) in this study segment that was not present at the time of the original study. The Build-Out Condition has the same geometry as the Current Condition but has different lane assignments (as were recommended in the access management study) and no split phasing at any of the intersections.

Table 3-5. FM 518: SH 288 to Sunrise Lakes Blvd PM Peak Hour Analysis.

Scenario	Current Condition		No-Build Condition		Build-Out Condition	
Intersection	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service
FM 518 at SH 288 SB FR	53.8	D	55.1	E	53.5	D
FM 518 at SH 288 NB FR	21.0	C	120.5	F	62.7	E
FM 518 at Silverlake Village Blvd	38.3	D	126.6	F	23.7	C
FM 518 at Wal-Mart	12.3	B	15.8	B	13.5	B
FM 518 at Home Depot	26.6	C	46.8	D	30.9	C
FM 518 at Miller Ranch Rd	30.9	C	32.0	C	30.7	C
FM 518 at Silverlake Pkwy	32.3	D	35.9	C	32.3	C
FM 518 at Sunrise Lakes *	10.7	B	-	-	10.7	B
Arterial Results	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**	**Travel Time (s)**	**LOS**
EB FM 518	398.2	D	511.7	E	390.9	D
WB FM 518	375.5	D	604.9	E	522.9	E
Network	**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**	
Network Delay	237.0		507.0		274.0	

*Represents intersection that was unsignalized in the No-Build Condition and was signalized for the Current Condition and was assumed to stay the same for the Build-Out Condition.

The traffic analysis results show an improvement in travel time for both directions when comparing No-Build Condition with the Current Condition on this section of FM 518. When comparing No-Build Conditions with Build-Out Conditions, travel times in both EB and WB directions show improvement, however current geometric conditions, lane assignments, and phasing plans provide the best travel times for existing volumes. The reduction noted in overall network delay and arterial travel times for the current and Build-Out Condition is due to increased capacity (addition of a lane in both EB and WB directions near SH 288) at the most congested location of the corridor.

FM 518 Corridor: IH 45 to SH 3 (City of League City Section) – AM and PM Peak Hour Analysis

Access management strategies recommended for this segment of FM 518 have not been implemented except for a few changes in lane assignments at the intersections of FM 518 at IH 45 SB Frontage Road and FM 518 at SH 3. Signal timing data for this segment was not available; as such researchers used optimized timings with signal cycle lengths taken from the previous study. One significant change from the No-Build Condition to the Current Condition is the additional signalization of the intersection at FM 518 and Wesley Drive. Tables 3-6 and 3-7 display AM and PM peak hour intersection levels of service, arterial travel times, and network delay results for the FM 518 corridor from IH 45 to SH 3. Traffic analysis results show that level of service at the segment intersections experiences no change from No-Build to Current Condition. However in the projected Build-Out Condition, delay per vehicle at the signalized intersections reduced, resulting in an overall reduction in travel times and delay for the segment.

Table 3-6. FM 518: IH 45 to SH 3 - AM Peak Hour Analysis.

Scenario	Current Condition		No-Build Condition		Build-Out Condition	
Intersection	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)	Level of Service
FM 518 at IH45 SB FR	28.9	C	28.0	C	26.8	C
FM 518 at IH45 NB FR	25.1	C	25.8	C	25.4	C
FM 518 at Wesley Drive / Church Access*	9.8	A	-	-	7.9	A
FM 518 at Calder Drive	7.3	A	10.8	B	6.9	A
FM 518 at Interurban Street	4.1	A	4.2	B	5.6	A
FM 518 at SH 3	35.6	D	34.9	D	30.5	C
Arterial Results	**Travel Time (s)**	**Level of Service**	**Travel Time (s)**	**Level of Service**	**Travel Time (s)**	**Level of Service**
EB FM 518	236.5	C	238.2	C	219.6	C
WB FM 518	240.7	C	239.7	C	243.1	C
Network	**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**	
Network Delay	94.0		91.0		79.0	

*Represents intersection that was unsignalized in the No-Build Condition, and was signalized for the Current Condition and was assumed to stay the same for the Build-Out Condition.

Table 3-7. FM 518: IH 45 to SH 3 - PM Peak Hour Analysis.

Scenario Intersection	Current Condition Delay (s/veh)	Current Condition Level of Service	No-Build Condition Delay (s/veh)	No-Build Condition Level of Service	Build-Out Condition Delay (s/veh)	Build-Out Condition Level of Service
FM 518 at IH45 SB FR	58.4	E	58.4	E	44.7	D
FM 518 at IH45 NB FR	39.4	D	39.4	D	28.3	C
FM 518 at Wesley Drive / Church Access*	18.1	B	-	-	14.6	B
FM 518 at Calder Drive	16.3	B	18.5	B	14.2	B
FM 518 at Interurban Street	9.8	A	11.9	B	7.4	A
FM 518 at SH 3	50.0	D	51.2	D	37.7	D
Arterial Results	**Travel Time (s)**	**Level of Service**	**Travel Time (s)**	**Level of Service**	**Travel Time (s)**	**Level of Service**
EB FM 518	268.1	D	258.9	C	245.6	C
WB FM 518	289.9	D	280.3	D	260.5	C
Network	**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**		**Total Delay (Veh-Hrs)**	
Network Delay	212.0		210.0		157.0	

*Represents intersection that was unsignalized in the No-Build Condition, and was signalized for the Current Condition and was assumed to stay the same for the Build-Out Condition.

Operational Analysis Results: Discussion

- Traffic analysis results suggest reduced travel times and reduced overall network delay for Build-Out Condition (full implementation of access management study recommendations) as compared to No-Build Condition (existing condition at the time of original study).
- A comparison of Current Condition with No-Build Condition shows that changes in travel times and overall delays are based on the type and scale of recommendations that have been implemented in the corridor. Capacity improvements such as turn bay additions (Wilcrest Drive at FM 1093), addition of a short thru lane at congested intersections (SH 288 NB Frontage Road at FM 518), and grade separation of a congested intersection (Kuykendahl Road at FM 1960) help improve traffic operations. However, if raised medians are the only change in the segment (for example FM 1960 West Segment) travel times and delays for the Current Condition can be somewhat higher as compared to the No-Build Condition. This higher delay is due to increase in turning traffic at the median openings and signalized intersections. Researchers hypothesize that vehicles that were using the TWLTL to turn in and out of the driveways will now travel to the nearest median opening or signalized intersection and make a left/U-turn to reach their destination. This increases left turns and the time taken within a signal cycle needed to accommodate them, incrementally increasing overall delays at the intersection as there is less time to move through vehicles.
- Phasing plans can greatly influence vehicular delays at signalized intersections and should be chosen based on traffic demand and pedestrian activity. Split phasing of the minor street has been shown to result in higher delays if a pedestrian phase needs to be served at both minor approaches. However, at locations with low pedestrian activity and high right turn volumes, it may be better to provide a split phase for the minor street by using a shared left-through lane and an exclusive right turn bay to lower total delay at the intersection.

- The level of service (qualitative measure) at signalized intersections only changed if there were significant capacity improvements at the intersection. For example, the level of service at the intersection of Kuykendahl Road at FM 1960 improved from level of service F to D for the Current Condition due to grade separation of Kuykendahl Road through movements and the addition of turn bays along FM 1960.

Throughput Analysis

Throughput (the average number of vehicles that use a roadway segment) is another measure of effectiveness that qualitatively indicates user preference for the utility of a roadway. An increase in throughput after implementation of a roadway treatment can suggest a higher user acceptance of the implemented treatment and accompanying level of service along the roadway segment. Researchers collected 24 hour traffic volume data at multiple locations along each study corridor to compare throughput in the Current Condition with the throughput reported in the original studies. These ADT volumes are shown in Tables 3-8 thru 3-10.

Table 3-8 shows throughput values for FM 1960 corridor and compares the before ADT with the after ADT. The percent difference from the 2003 TxDOT traffic maps were compared with the 2013 collected data or 2011 TxDOT traffic maps. There is an increase in throughput along the entire corridor when compared to 2003 throughput, suggesting a higher utilization of the roadway.

Table 3-8. Comparison of Throughput for FM 1960.

Location	2003 ADT	2013 ADT	Percent Difference
FM 1960 West of Cutten Rd	55,272	59,537	7.7%
FM 1960 West of Kuykendahl Rd	64,846	69,147	6.6%
FM 1960 between Hafer and IH 45 Frontage Rd	61,029	71,130	16.6%

Table 3-9 shows throughput values for FM 1093 corridor and compares the before, during with the after ADT. Katy Freeway reconstruction was completed in 2010 could be the cause of the reduction in traffic volume along the corridor.

Table 3-9. Comparison of Throughput for FM 1093.

Location	2000 AADT[1]	2003 AADT[2]	2011 AADT[3]	Percent Difference
FM 1093 West of IH 610 SB Frontage Rd	-	72,000	71,000	-1.4%
FM1093 East of BW 8 NB Frontage Rd	62,000	77,000	63,000	-18.2%
FM1093 East of SH 6	36,000	48,000	44,000	-8.3%

1. Data from access management study
2. Earliest available ADT data from traffic maps.
3. Latest available from traffic maps.

Note: Katy Freeway construction completed in 2010 and potentially ended traffic diversion
For percent difference, negative numbers suggest a decrease and positive numbers suggest an increase in traffic volumes.

Table 3-10. Throughput Comparison for FM 518.

Segment	2003 ADT	2013 ADT	Percent Difference
SH 288 to FM 865 (Cullen)	24,000	44,019	83.4%
CR 89 to FM 1128	26,000	31,107	19.6%
Harkey/Oday to Woody/Corrigan	28,000	29,823	6.5%
Halbert/McLean to SH 35/Main*	22,000	-	-
SH 35/Main to Sherwood	26,000	19,243	-26%
Westminster to Woodcreek	37,000	36,238	-2.1%
Dixie Farm to Sunset Meadows/Winding	30,000	41,748	39.2%
Sunset Meadows/Winding to Whispering Pines	21,000	56,004	166.7%
Winding Way to FM 528/Parkwood	16,100	24,538	52.4%
FM 528/Parkwood to Country Road	15,200	28,090	84.8%
Country Road to Williamsport	11,700	23,462	100.5%
Newport to Calder/Devereux	38,000	47,425	24.8%
Interurban to SH 3	38,000	30,029	-21%
Houston to FM 270/ FM 2094	31,000	30,573	-1.4%
FM 518 Split /Marina to South Shore	16,500	14,228	-13.8%
FM 1266/Columbia to Lawrence Road	9,100	13,110	44.1%
Kemah Oaks to SH 146	10,300	18,735	81.9%

*2013 data for this segment was not available. Negative numbers suggest a decrease and positive numbers suggest an increase in traffic volumes.

Safety

Purpose of Safety Evaluation

The purpose of the safety evaluation was to analyze the three projects to determine the effects of access management with respect to the number and severity of crashes before, during and after access management implementation. Specifically the following questions were addressed:

- Are the facilities safer with or without access management?
  - Was crash frequency reduced?
  - Was crash severity reduced?
  - What types of crashes were reduced and what (if any) types of crashes increased?
  - What other crash impacts may be attributable to access management?
- Were there relative differences in crash characteristics between the studied sections of roadway based on the area type and land use?
- What safety performance criteria should be used to evaluate corridor improvements?

Evaluation Objectives and Methodology

Crash data was obtained from the TxDOT's Crash Record Information System (CRIS) for before, during, and after access management implementation. The following crash data statistics were gathered:

- Average crash rate per 100 million miles traveled;
- Number of fatalities per year in the corridor; and
- Type of crashes for three time periods analyzed.

A graphical representation of crash statistics was also developed. This section presents the evaluation methodology, data collection, the various crash statistics, collision types, contributing factors and other measures. In addition, a comparison of the three corridor evaluation results to the statewide averages is included. The steps below outline the crash evaluation process used in this analysis:

- Divide corridor into homogeneous segments to be used for safety evaluation;
- Collect data (crash data, traffic volumes, and project implementation dates);
- Divide data into sections for analysis based on traffic volumes sections defined in the operational analysis. These sections may be different from the original crash analysis. The researchers controlled these differences by gathering before and after data;
- Plot crash locational data to determine and identify patterns;
- Calculate Crash Statistics; including
  - Crash Frequency;
  - Average Crash Frequency (number of crashes per year); and
  - Crash Rate (crashes per vehicle miles traveled).
- Analyze Crash Trends;
  - Crash Severity;
  - Time of Day;
  - Day of Week;
  - Number of Vehicles Involved; and
  - Contributing Factors.

During the crash analysis, the following four data issues were found and methods were employed to mitigate them as described below:

1. Multiple years of data -- crash analyses are ideally conducted with three to five years of data per time period (before, during or after) to smooth out variability in the data and reduce the influence of randomness.
2. Different number of analysis years -- in most cases, gathering the ideal three years of data for before, during, and after in the analysis period was not possible due to data limitations or limited duration of implementation. One simple metric "average crashes per year" was used to represent the crash frequency so that a comparison could be made among analysis periods.
3. Crash records database changes from 1998 to 2002 -- the TxDOT CRIS database was developed during the period from 1998 to 2002. During that time, a backlog of manual crash records was entered into CRIS. There were

anomalies noted in the data, however due to the lag time between data entry and data review some corrections were not able to be verified. For these reasons, crash data before 2003 was not requested.

4. Comparisons to previous studies -- comparisons to the crash numbers reported in the previous access management studies were not conducted since roadway study sections and crash datasets were different.

Segment Selection

Crash analysis segments were selected based on the operational analysis segments defined in the original reports. These segments also were generally aligned with most of the operational analysis segments conducted for this evaluation. Logical changes in land use, geometrics, or traffic volumes were also used to define study segments. TxDOT control section maps from the CRIS database were also used to define the segments.

Data Collection

Crash data was obtained from CRIS for each of the study corridors from 2003 to 2012. Over 250 data fields for each record were gathered to conduct the safety analysis. Characteristics about each crash included the following, but were not limited to:

- When and where the crash occurred;
- Type of collision;
- Severity of crash; and
- Contributing factors to crash.

Traffic volume data and segment lengths were also gathered from the TxDOT Roadway-Highway Inventory Network (RHiNo) data set. Project implementation dates were also obtained so that the before, during and after periods could be defined. Construction letting and completion dates were obtained from the TxDOT Houston District Planning Section. The before, during, and after time periods are shown in Table 4-1.

Table 4-1 Construction Start and Completion by Facility Study Limits

	Study Limits		Construction Letting Date	Construction Completion Date
Facility	Begin	End		
FM 1093	IH 610	Beltway 8	Mar-04	Dec-06
FM 1093	Beltway 8	SH 6	Mar-04	Dec-06
FM 1960	Milles Rd	Champions Dr	Aug-09	Jan-11
FM 1960	Champions Dr	Walters Rd	Aug-09	Jan-11
FM 1960	Walters Rd	Sugar Pine Dr	Aug-09	Jan-11
FM 1960	Sugar Pine Dr	Hafer Rd	Aug-09	Jan-11
FM 1960	Hafer Road	Imperial Valley	Aug-09	Jan-11
FM 518	SH 288 W Side	FM 865 /Cullen Blvd	2007	2007
FM 518	FM 865 Cullen Blvd	Harkey/ O'Day Rd	2007	2007
FM 518	Harkey/ O'Day Rd	SH 35 / Main St	2007	2007
FM 518	SH 35 / Main St	Pearland Parkway	None	None
FM 518	Pearland Parkway	Sunset Meadows Dr	None	None
FM 518	Sunset Meadows Dr	Shadow Bend	2002	2002
FM 518	Shadow Bend	FM 528/Parkwood Ave	2002	2002
FM 518	FM 528/Parkwood Ave	League City	None	None
FM 518	League City	Landing Blvd	None	None
FM 518	Landing Blvd	IH 45	None	None
FM 518	IH 45	SH 3	2000	2000
FM 518	SH 3	FM 270 / FM 2094	None	None
FM 518	FM 270 / FM 2094	Meadow Parkway	2007	2007
FM 518	Meadow Parkway	Lawrence Rd	2007	2007
FM 518	Lawrence Rd	SH 146	2007	2007

Crash Data Plots

The crash data was obtained and then plotted to identify spatial patterns. Multiple views were developed based on crash severity types and other characteristics. As expected, the majority of crashes occurred at or near intersections, however some patterns were identified. An example of the crash plot is shown in Figure 4-1. Crash data was plotted to determine trends.

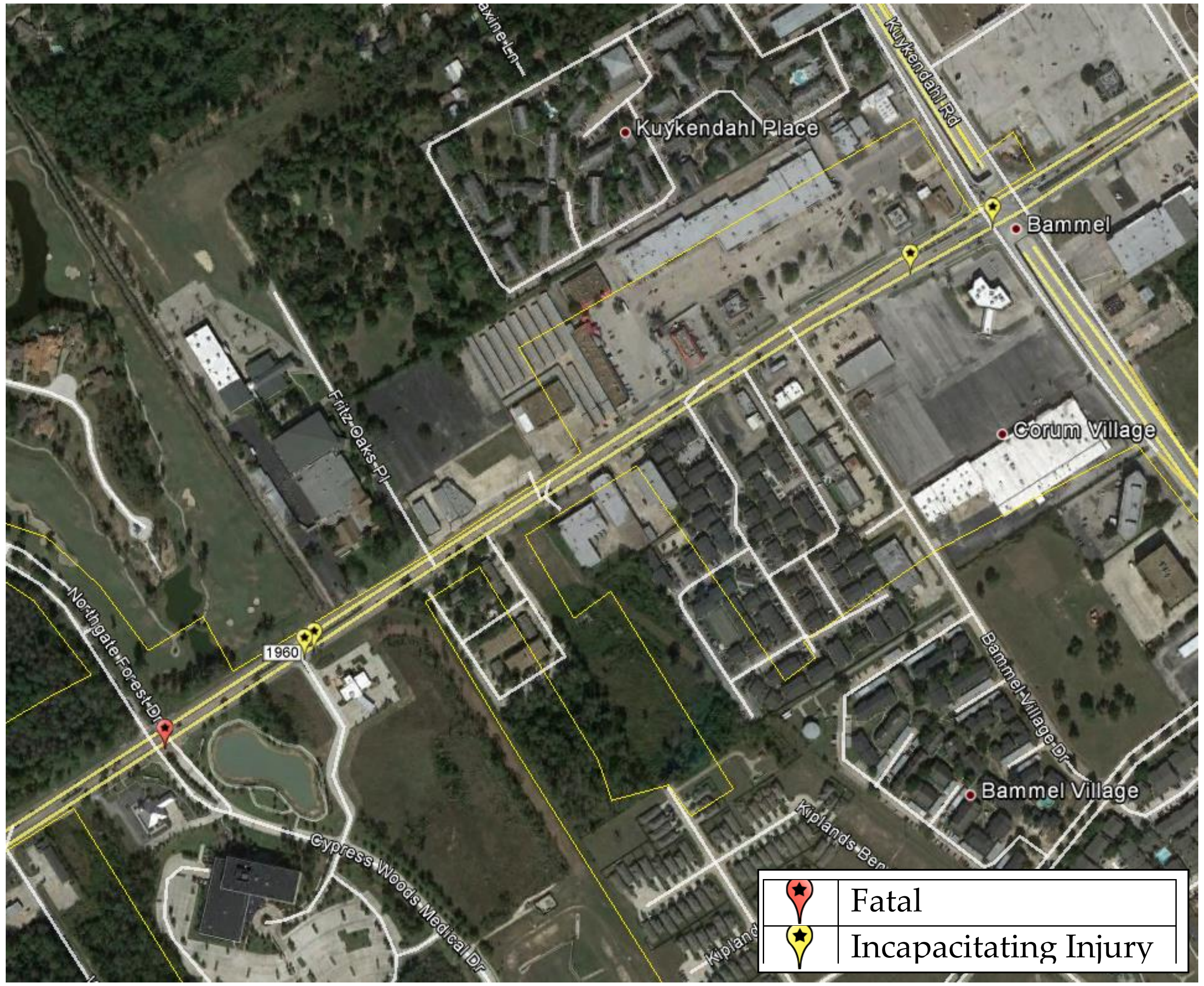


Figure 4-1. Example of Crashes Plotted by Severity

Crash Statistics and Trends

The crash data was separated into logical roadway sections and several calculations were made to analyze the data and develop charts and graphs. Corridor and section totals were calculated in an effort to make pattern observations.

A trend analysis was conducted for all sections using the following characteristics:

- Crashes by time period (before, during and after), subdivided by year;
- Crashes by number of vehicles involved by time period, subdivided by year;
- Crashes by severity by time period, subdivided by year;
- Crashes by day of week by time period, subdivided by year;
- Crashes by time of day by time period, subdivided by year;
- Crashes by month of year by time period, subdivided by year;
- Crashes by traffic control involved by time period, subdivided by year;
- Crashes by harmful event by time period, subdivided by year;
- Crashes by median width by time period, subdivided by year;
- Crashes by number of lanes by time period, subdivided by year;
- Crashes by manner of collision by time period, subdivided by year; and
- Crashes by other contributing factors by time period, subdivided by year.

Other calculations completed included normalizing the crashes to reduce the bias introduced by different lengths of analysis periods, different corridor lengths and growth in traffic. The calculations included average crash frequency and crash rates by vehicle miles traveled to normalizes the crashes based on exposure. The exposure comes from higher traffic volumes and/or longer analysis segments.

Crash Analysis Results

The analyses are presented for the three corridors followed by a section-by-section analysis. Average crash frequency and crash rates were investigated to determine the safety impact of the access management. A total of 20,664 crashes were analyzed, which included 58 fatal crashes, 431 incapacitating injury crashes, and 1,883 non-incapacitating injury crashes. Table 4-2 shows the crash frequency and average crash frequency normalized by length.

Table 4-2 Crash Frequency and Average Crash Frequency by Facility Normalized by Length

Facility	Number of Crashes (2003-2012)	Length (miles)	Average Crash Frequency (crashes/mile)
FM 1093 (IH 610 to SH 6)	9,786	11.3	866.02
FM 1960 (Mills Rd to Imperial Valley Dr)	4,243	9.3	456.24
FM 518 (SH 288 to Lawrence Rd)	6,635	25.5	260.20
Total/Average	20,664	46.1	448.24

Table 4-3 shows the crash severity by facility. The segments are not compared since the projects are of different lengths. Also the facilities have different traffic volumes so the users have different exposure rates to potential crashes.

Table 4-3 Crash Severity by Facility Normalized by Length (2003-2012)

Facility	Total Crashes	Fatal Crashes	Incapacitating Injury	Non-Incapacitating Injury	No Injury
FM 1093	9,786	33 (0.3%)	194 (2%)	843 (9%)	8,716 (89%)
FM 1960	4,243	17 (4.0%)	89 (2%)	401 (9%)	3,736 (88%)
FM 518	6,635	8 (0.1%)	148 (2%)	639 (10%)	5,840 (88%)
Total	20,664	58 (0.3%)	431 (2.1%)	1,883 (9.1%)	18,292 (88.5%)

Crash Rates

Crash rates are typically calculated as the number of crashes per 100 million vehicle miles traveled. The crash rate normalizes the crash number by distance traveled and traffic volume (both measures of exposure). In addition to the study corridors, the statewide average crash rates for urban four (or more) lane divided roadways were obtained to determine how the averages compared with the study corridors. A graph of the crash rates is presented in Figure 4-2. Additionally, the Harris county crash rates were gathered to determine the crash rate trend is consistent with the study corridor data.

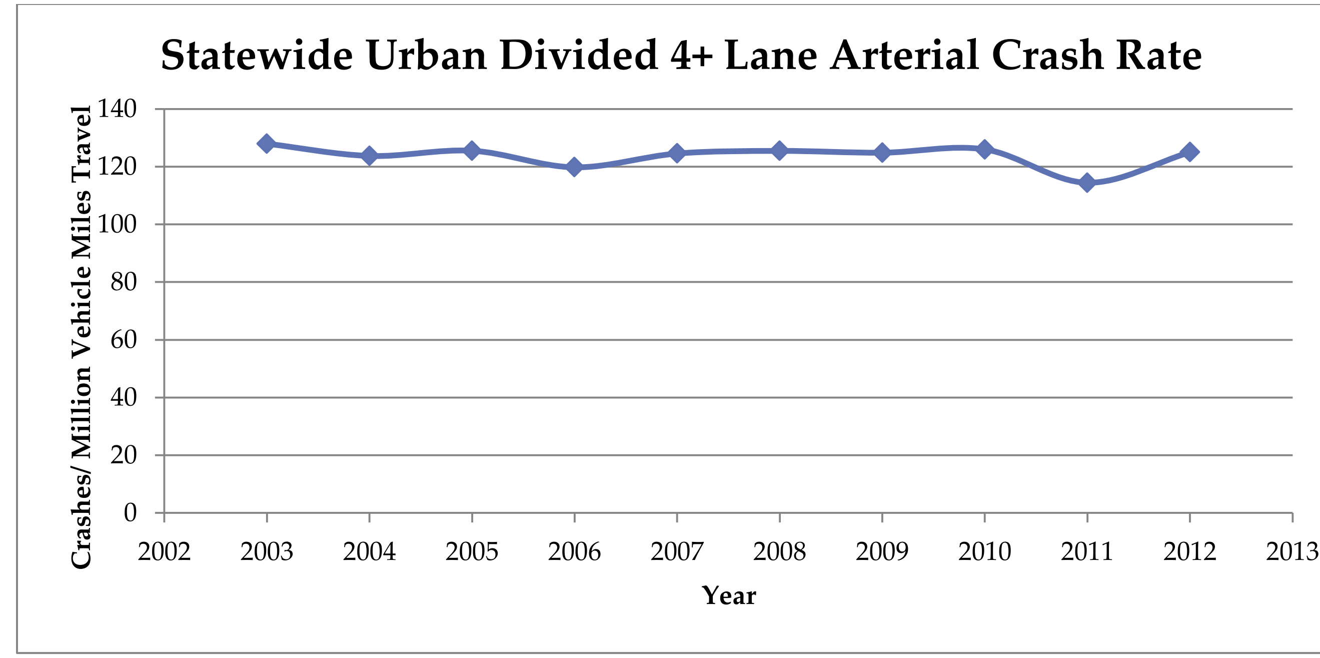


Figure 4-2. Urban Divided Four or More Lane Arterial Average Crash Rate

These results show an overall decrease in crash rates based on Harris County datawith a slight uptick in 2012 as shown in Figure 4-3. The trend of state and county-wide reduction in crash rates has been attributed to a variety of factors, of which include vehicle safety enhancements (advancements in antilock brakes, collision avoidance systems, better headlights and tires); driver training improvements, graduated drivers licenses, and alcohol awareness programs. Roadways have also improved: roadway design has advanced, improved traffic light signalization and synchronization, roadway lighting, and pavements have been modernized and improved.

Table 4-4 shows the average statewide crash rates for divided urban roadways with four or more lanes for the years defined by each project. The averages are slightly different for each corridor based on the years the crash rates were averaged. Table 4-5 shows the average crash rates per section per time period for FM 1093. The crash rates are significantly higher than the state average in the before during and after conditions.

Table 4-6 shows the same for FM 1960 and Table 4-7 shows the results for selected segments of FM 518. FM 518 had three types of sections. First, sections that have no access management treatments, second, sections that had treatments before the study period (2002) and the last type, treatments were implemented during the study periods (2007).

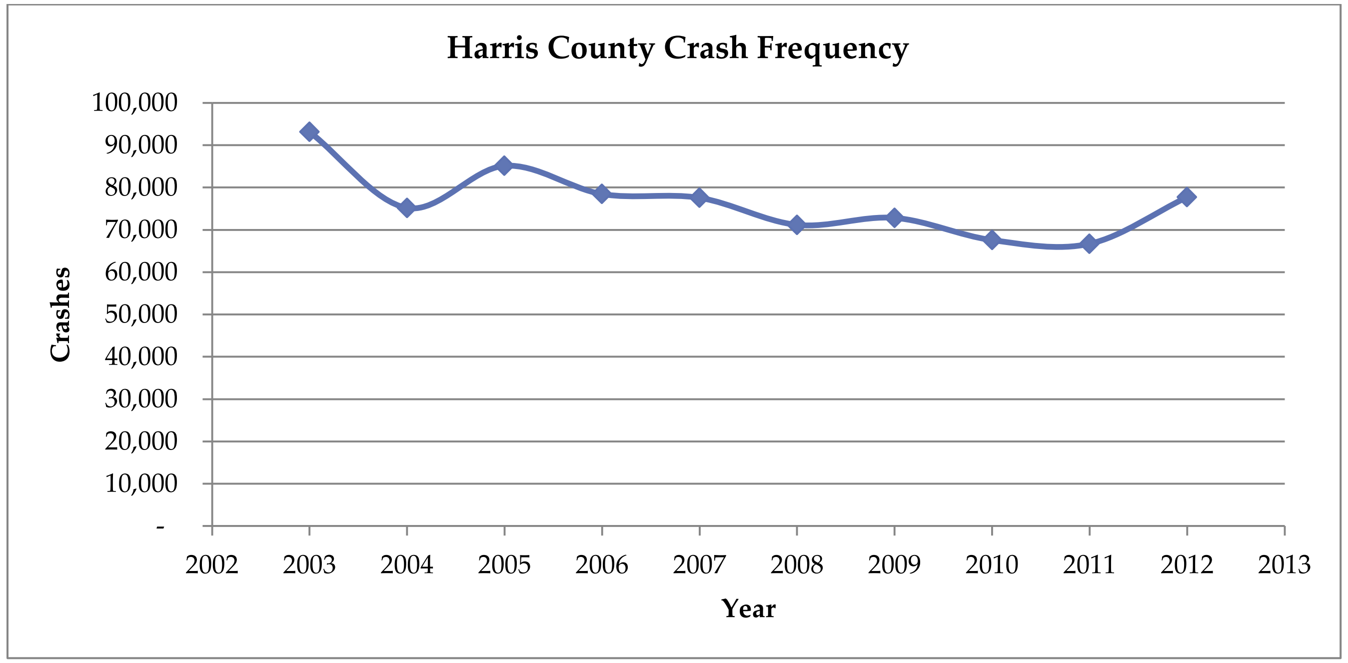


Figure 4-3. Average Crash Frequency for All Roads in Harris County

Table 4-4. Average Statewide Crash Rates (Crashes/100 Million Vehicle Miles Travel) for Divided Urban Roadways with Four or More Lanes

Facility	Before	During	After
FM 1960	124.50	125.42	119.73
FM 1093	127.95	123.01	123.39
FM 518	124.25	124.56	123.15

Table 4-5 FM 1093 Average Crash Rates (Crashes/100Million Vehicle Miles Travel) per Section per Time Period

Facility	Section	Before 2003	During 2004-2006	After 2007-2012
FM 1093	610 to BW 8	634.27	464.26	419.14
FM 1093	BW 8 to SH 6	300.02	208.77	197.14
Average		467.14	336.52	308.14

Table 4-6 FM 1960 Average Crash Rates (Crashes/100Million Vehicle Miles Travel) per Section per Time Period

Facility	Section	Before 2003-2008	During 2009-2010	After 2011-2012
FM 1960	Mills to Cutten	18.81	19.37	15.23
FM 1960	Cutten to Champions	251.03	320.71	136.99
FM 1960	Champions to Walters	118.81	107.21	37.98
FM 1960	Walters to Sugar Pine	227.15	259.20	104.61
FM 1960	Sugar Pine to Hafer	47.36	57.75	33.62
FM 1960	Hafer to Imperial Valley	78.43	55.11	47.18
Average		123.60	136.56	62.60

Table 4-7 FM 518 Average Crash Rates (Crashes/100Million Vehicle Miles Travel) per Section per Time Period*

Facility	Section	Before 2003-2006	During 2007	After 2008-20012
FM 518	SH 288 to Cullen Blvd	114.76	110.45	117.86
FM 518	Cullen Blvd to Harkey Rd	35.90	11.42	37.65
FM 518	Harkey Rd to FM 2094	36.25	30.39	44.51
FM 518	FM 2094 Meadow Parkway	25.77	39.14	31.92
FM 518	Meadow Parkway to Lawrence Rd	105.94	93.67	79.16
FM 518	Lawrence Rd to SH 146	146.48	145.42	101.85
Average		77.52	71.75	68.83

* Selected Segments that were implemented in 2007

FM 1093 Crash Experience

Crash data was obtained from the CRIS database from 2003 to 2012. A total of 9,786 crashes were analyzed for FM 1093 including 33 fatal, 194 incapacitating, and 843 non-incapacitating crashes for the before, during, and after conditions. Crash data was analyzed to determine location, severity, and crash type. The corridor was divided into two sections State Highway 6 (SH 6) to Beltway 8/Sam

Houston Tollway (BW 8). and Table 4- 10 shows the average crash frequency normalized by year for the before during and after conditions. These average frequencies have not been normalized by length or traffic volume.

Table 4-8 FM 1093 Crash Frequency from Beltway 8 to SH 6 by Time Period

Time Period	Year	Crashes Frequency/Total	Average Annual Crash Frequency
Before	2003	576	
	Total	576	576
During	2004	392	
	2005	411	
	2006	412	
	Total	1215	405
After	2007	415	
	2008	408	
	2009	324	
	2010	284	
	2011	337	
	2012	378	
Total	Total	2146	357.7

An analysis of the crash data was conducted to determine trends in the data. Various queries were conducted and the following trends were evident for both sections and all three time periods.

- More crashes occur in the PM peak period than during other times of day.
- Fridays and Saturdays have a slightly higher crash frequency than other days.
- Approximately four out of every five crashes occur between two or more vehicles.

Table 4-9 FM 1093 Crash Frequency from IH 610 to BW 8 by Time Period

Time Period	Year	Crashes Frequency/Total	Average Annual Crash Frequency
Before	2003	845	
	Total	845	845
During	2004	594	
	2005	715	
	2006	617	
	Total	1,926	642
After	2007	637	
	2008	506	
	2009	500	
	2010	410	
	2011	456	
	2012	569	
	Total	3,078	513

- The proportion of types of collision (rear end, angle, etc.) remained generally unchanged;
- Intersection and intersection related crashes went up about 10% from 30% to 40% of total;
- Vehicles leaving driveway crashes went down about 5%, from 17% to 12% of total; and
- Non-intersection crashes went down about 8%, from 55% to 47% of total.

Crash severity was also investigated to determine if there were changes in the number crashes by type. Table 4-10 shows the average yearly crashes for FM 1093 by severity or crash type. The average yearly crashes allows the comparison of time periods with different years. Crash frequency and crash severity were both reduced in the after period.

Table 4-11 shows the location or factors that contributed to the crashes. Interestingly, driveway-related crashes were reduced by half from the before to the after conditions. The only crash category that increased was "Slowing/Stopping for Traffic".

Table 4-10 FM 1093 Average Yearly Crashes by Crash Type

Crash Type	Average Crashes Before 2003	Average Crashes During 2004 to 2006	Average Crashes After 2007 to 2012
Fatality	5.0	3.3	3.0
Incapacitating Injury	29.0	20.0	17.5
Non-Incapacitating Injury	125.0	87.7	75.8
Possible Injury	539.0	425.3	278.3
Non-Injury Crashes	691.0	485.7	483.2
Unknown	32.2	25.0	12.8
Total	1421.2	1022.0	857.8

Table 4-11. FM 1093 Other Contributing Factors Average Annual Crash Frequency.

Other Contributing Factors	Average Crashes Before 2003	Average Crashes During 2004-2006	Average Crashes After 2007-2012
No Code Shown or Not Applicable	840	674	556
One Vehicle Entering Driveway	66	44	39
One Vehicle Leaving Driveway	101	55	37
Slowing/Stopping for Off, Flagman, or Traffic Ctrl.	128	88	93
Slowing/Stopping for Traffic	44	110	63
Vehicle Changing Lanes	122	79	67
Average Annual Total	1421	1047	871

FM 1960 Crash Experience

A total of 4,243 crashes were analyzed for FM 1960 corridor including 17 fatal, 89 incapacitating and, 401 non-incapacitating crashes for the before, during, and after conditions. Crash data was analyzed to determine location, severity, and crash type. Table 4-12 shows the FM 1960 crash frequency by year indicating a declining trend with a spike during construction. The average crash frequency is normalized by year for the before during and after conditions. These average frequencies have not been normalized by length or traffic volume.

Table 4-12. FM 1960 Crash Frequency by Year

Time Period	Year	Crashes Frequency/Total	Average Annual Crash Frequency
Before	2003	730	
	2004	539	
	2005	581	
	2006	429	
	2007	326	
	2008	289	
	Total	2,894	482.3
During	2009	409	
	2010	506	
	Total	915	457.5
After	2011	277	
	2012	157	
	Total	434	217.0
Grand Total		4,243	

Crash severity was also investigated to determine if there were changes in the number crashes by type. Table 4-13 shows the average yearly crashes for FM 1960 by severity or crash type. Table 4-14 shows the location or factors that contributed to the crash. The overall trend was a decrease in all periods including before, during, and after which is unusual since typically there is an increase in crashes during construction related to lane shifts, cones and barrels, sometimes narrower lanes, and shifts in lanes that occur and may not be anticipated from day to day.

Table 4-13. FM 1960 Average Annual Crashes by Crash Type

Crash Type	Average Crashes Before 2003-2008	Average Crashes During 2009-2010	Average Crashes After 2011-2012
Fatality	1.3	1.5	3.0
Incapacitating Injury	8.7	11.0	7.5
Non-Incapacitating	47.3	43.0	15.5
Possible Injury	129.8	93.0	42.5
Not Injured	295.2	309.0	148.5
Total	482.3	457.5	217.0

Table 4-14 FM 1960 Other Contributing Factors Average Annual Crash Frequency

Other Contributing Factors	Average Crashes Before 2003-2008	Average Crashes During 2009-2010	Average Crashes After 2011-2012
No Code Shown or Not Applicable	190.0	183.0	97.0
One Vehicle Entering Driveway	28.5	20.5	8.5
One Vehicle Leaving Driveway	60.8	49.5	13.0
Slowing/Stopping for Off, Flagman, or Traffic Ctrl.	62.3	66.5	21.5
Slowing/Stopping for Traffic	76.7	61.5	35.5
Vehicle Changing Lanes	33.8	48.0	27.5
Average Annual Total	482.3	457.5	217.0

FM 518 Crash Experience

FM 518 is considerably different with respect to the other two study corridors. FM 1093 and FM 1960 are more urban and have higher traffic volumes. Both FM 1093 and FM 1960 corridors have more homogeneous land use and the implementation of access management was done throughout the length of a continuous stretch of the corridor. In contrast, FM 518 has sections that are almost rural in nature with very sparse development; other sections have large retail outlets closely spaced mixed with small retail, fast food, and other high access locations. Typical weekday traffic patterns exist with weekend traffic being the most intense. FM 518 was the longest corridor of the evaluation and was divided into one to two mile segments for study. The more urban sections had higher crash frequency and rates. shows segment limits, lengths, when access management principles were implemented, and how the section was analyzed. Most of the access management principles were implemented during 2007 so a "Full" before, during and after analysis was conducted. However there are some sections that do not have medians which are considered as "Before" conditions. Other sections had medians installed prior to the analysis data so they are considered "After".

Table 4-16 shows the average annual crash frequency by crash type. The section character influences the crash frequency and rate. The distribution of crashes does not present a pattern. Both crash frequency and rate were consistent. The other contributing factors that relate to crash frequency are similar to what was stated in the previous corridors but the magnitude of the change is much smaller.

Table 4-15. FM 518 Corridor Access Implementation Status

Roadway Name	TxDOT Control Section	Starting Mile point	Ending Mile point	Starting Point	Ending Point	Length	Medians Implemented	Crash Analysis
FM 518	3416-1	0.900	3.290	SH 288 W Side	FM 865 Cullen	2.3	2007	Full
FM 518	976-2	3.290	4.000	FM 865 Cullen	Harkey/O'Day	2.2	2007	Full
FM 518	976-2	4.000	5.733	Harkey/O'Day	SH 35/Main	1.8	2007	Full
FM 518	976-2	5.733	7.600	SH 35 / Main	Pearland Parkway	1.5	None	Before
FM 518	976-2	7.600	10.441	Pearland Parkway	Sunset Meadows/Winding	2.9	None	Before
FM 518	976-2	10.441	1.186	Sunset Meadows/Winding	Shadow Bend	1.2	2002	After
FM 518	976-3	1.186	3.032	Shadow Bend	FM 528 /Parkwood	1.8	2002	After
FM 518	976-3	3.032	4.960	FM 528 /Parkwood	League City (W City Limit)	2.0	None	Before
FM 518	976-3	4.960	7.560	League City (W City Limit)	Landing Boulevard	2.6	None	Before
FM 518	976-3	7.560	8.322	Landing Boulevard	IH 45	0.8	None	Before
FM 518	976-3	8.322	9.509	IH 45	SH 3	1.2	2000	After
FM 518	976-3	9.509	10.977	SH 3	FM 270 / FM2094	1.5	None	Before
FM 518	976-3	10.977	12.300	FM 270 / FM2094	Meadow Parkway	1.4	2007	Full
FM 518	976-3	12.300	10.405	Meadow Parkway	Lawrence Road	1.3	2007	Full
FM 518	976-5	10.405	11.510	Lawrence Road	SH 146	1.1	2007	Full
Total						25.6		

Table 4-16. FM 518 (Selected Sections) Annual Average Crash Frequency by Crash Type

Crash Type	SH 288 to FM 865/Cullen			FM 865/Cullen Rd to Harkey/Oday			Harkey/Oday Rd to FM 270/FM2094			FM 270/FM2094 to Meadow Parkway			Meadow Parkway to Lawrence Road			Lawrence Road to SH 146		
Period	Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After
Years	2003 to 2006	2007	2008 to 2012	2003 to 2006	2007	2008 to 2012	2003 to 2006	2007	2008 to 2012	2003 to 2006	2007	2008 to 2012	2003 to 2006	2007	2008 to 2012	2003 to 2006	2007	2008 to 2012
Fatalities	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Incapacitating	2.0	3.0	1.0	0.0	2.0	0.6	1.8	0.0	1.4	0.5	2.0	0.6	0.3	0.0	0.2	0.8	0.0	0.0
Non-Incapacitating	9.5	7.0	10.8	1.3	2.0	1.6	6.0	8.0	8.4	3.5	2.0	1.6	1.8	2.0	1.0	2.0	0.0	1.6
Possible Injury	22.3	33.0	20.8	3.3	0.0	2.0	11.3	6.0	10.2	5.0	6.0	2.2	2.0	3.0	0.8	2.3	7.0	2.4
No Injury	77.0	86.0	95.2	7.0	0.0	7.0	32.3	34.0	34.6	15.5	15.0	9.6	5.0	3.0	4.0	5.8	10.0	7.6
Average	111.0	129.0	127.8	11.8	4.0	11.2	51.3	48.0	54.8	24.5	25.0	14.2	9.0	8.0	6.0	10.8	17.0	11.6
Avg. Crash Rate*	114.76	110.45	117.86	35.90	11.42	37.65	36.25	30.39	44.51	58.73	57.56	39.23	105.94	93.67	79.16	25.77	39.14	31.92

Conclusions

Average crash frequency and rates were reduced in each of the three study corridors comparing the before to the after time period of implementation. In some cases crashes wend down during construction. This is unusual as there is typically an increase in crashes in construction zones due to lane configuration changes, increased visual driver workload associated with construction activities, uncertainty as to roadway conditions day to day, and presence of traffic control devices.

Some of the decreases in crashes may be attributed to the overall reduction in crashes in the area and region (as shown by the Harris County crash rate reductions in Figure 4-3). The larger reductions were shown in the most congested sections and as expected, driveway related crashes decreased. The types and severity of crashes remained relatively unchanged. Other contributing factors such as entering/exiting vehicles were reduced significantly and rear end and intersection crashes were also reduced.

A review of the crash severity characteristics of all corridors indicated that almost 90 percent of the crashes are non-injury crashes. Crash rates dropped in most sections 20 to 68 percent. The FM 1093 (higher volume roadways) crash rates are still about the state average for crash rate of this facility type. There were some evaluation sections that crash rate increased, however most of those segments were four times below the statewide average for urban four lane undivided arterials. The other contributing factors section indicated that driveway crashes were reduced by 40 to 70 percent.

Recommendations

Safety is typically the top goal for each agency and should hold significant weight in project design and selection. Access management principles are valuable tools that positively affect safety by reducing the crash frequency and rate. Access management principles appear to be effective in reducing crashes and should be included in corridor safety evaluations. Crash frequencies and crash rates can be used to evaluate corridors. In future evaluations, tools such as the Highway Safety

Manual (HSM) can be used to evaluate specific sections and design elements. Currently, the HSM has a limited number of Crash Modification Factors (CMF) related to access management design features, however more are being developed and this method proves to be a valuable tool for evaluating proposed designs with respect to safety in the future.

Economics

Introduction

The effects of access management on businesses and overall economic activity are not well documented. Many factual and anecdotal examples exist regarding how access management improvements can positively or negatively impact business activity. However, few recent studies have been conducted on the economic effects of access management improvements in the Greater Houston region.

A survey of academic literature regarding access management yielded important findings. Plazak (2005), Eisele (1999), Alluri (2002), and Williams (2000) found evidence suggesting access management projects have little effect on overall business sales. If any long-term effect is seen from access management project improvements, it tends to be a small increase (rather than a decrease) in overall sales. However, these studies also found reductions in gross sales can occasionally occur during construction periods. Alluri (2012) further found business owners had a negative perception of access management improvements due to a perceived decline in business activity along an affected project corridor, despite actual property and sales tax evidence to the contrary. Studies conducted by Iowa State University (1996) and the Kansas Department of Transportation (1999) also support these findings.

Furthermore, the effect of access management on inventory shipments has raised a concern for some businesses. Alluri (2012) found this problem to be most prevalent to businesses that require large quantities of goods or frequent deliveries that could be delayed or see increased cost from access reduction, yet other studies contradict this finding.

This review also found multiple processes for quantifying economic impacts resulting from access management improvements. A study conducted by Levinson and Gluck (2000) presented a methodology for quantifying economic impacts, suggesting that economic impacts could be calculated by numbers of left turns denied relative to the percentage of pass-by trips a particular business depends on. In contrast, Eisele and Frawley (1999) analyzed economic impact through conducting surveys of local businesses and customers' perceptions.

Building on these efforts, the purpose for this study is to analyze taxable sales receipts for properties along the three access management corridors. Gross sales would have been preferable; however, those data were not publicly available. This section is intended to present the detailed process of this analysis and knowledge gaps that still persist.

Study Methodology

In 2002 and 2004, H-GAC commissioned studies of regional thoroughfare corridors. The resulting sections identified recommendations, based on access management principles and practices, to improve traffic flow, vehicular and non-motorized user safety, and general aesthetics of each corridor.

The focus of this research evaluation is to investigate the potential economic effects from access management improvements along three corridors (FM 1093, FM 1960 and FM 518). This study methodology focused on taxable sales data to examine the possible growth in business activity before, during, and after any implemented improvements for all businesses in the corridor study areas. Table 5-1 below provides a brief description of the construction periods for each of the corridors.

Table 5-1. Study Corridor Before, During, and After Construction Time Periods

Corridor	Corridor Evaluation Limits	Before Period (Years)	During Period (Years)	After Period (Years)
FM 1093	IH-610 to SH-6	2002-2004	2004-2006	2007-2009
FM 1960	US 288 to SH 146	2006-2009	2009-2011	2011-2013
FM 518	Gatewick Road to Mills Rd	2003-2005	2005-2009	2009-2011

H-GAC geocoded the businesses in the corridor zipcodes using standard ArcGIS tools. A match rate of about 70 percent was achieved and the use of a third party program was able to match about 95 percent of the business addresses. The remaining five percent of unmatched business addresses were identified manually through internet searches and other techniques. Next, researchers established an analysis zone. A geographic information system (GIS) technology was used to generate a list of businesses with property lines within 200 feet of the center line of the three access management corridors. This 200 feet analysis zone was selected because it was determined that a sample of businesses in that area would most likely be directly affected by any access management improvements. Once the subset of business were selected they were geocoded by H-GAC.

After a list of businesses were received from H-GAC, these businesses were coded based on whether they are pass-by, destination, or a combination of both by the nature of the North American Industry Classification System (NAICS).[i] This was done to examine taxable sales changes by business type as business owners often note that the effects are felt unevenly. Put another way, a common argument presented in the literature is that business owners perceive some businesses (e.g. convenience stores, gas stations, fast food and others) are more affected than other businesses (e.g. physician clinics, lawyer's offices, professional services, others) during and after access management improvements. Category descriptions are provided in Table 5-2.

A ratio of pass-by, destination, and combination businesses examined in this analysis are provided in Table 5-3.

Table 5-2. Business Corridor Category Descriptions

Category	Description
Pass-By Business	A business where it was estimated that fewer than 50 percent of trips to that business were decided upon before the trip was initiated.
Destination Business	A businesses where it was estimated that more than 50 percent of trips to that business were decided upon before the trip was initiated.
Combination Business	A trip where it was estimated that about 50 percent were decided before the trip was initiated and about 50 percent were decided after the trip was initiated.

Table 5-3 Study Corridor by Category

Corridor		Before		During		After	
		Count	%	Count	%	Count	%
FM 1093	Pass-By	390	66%	579	65%	792	64%
	Destination	107	18%	176	20%	226	18%
	Combination	91	15%	138	15%	227	18%
	Total	588	100%	893	100%	1245	100%
FM 1960	Pass-By	482	68%	531	72%	670	67%
	Destination	124	18%	108	15%	160	16%
	Combination	101	14%	101	14%	173	17%
	Total	707	100%	740	100%	1003	100%
FM 518	Pass-By	215	60%	262	59%	413	58%
	Destination	77	22%	96	22%	161	23%
	Combination	63	18%	84	19%	135	19%
	Total	355	100%	442	100%	709	100%

A control zone was developed to compare the corridor taxable sales information with the local and regional economy. During the time period when these corridors were examined, variances in economic activity may have had a significant effect on taxable sales. The Texas Comptroller of Public Accounts publishes county-level data online through its website.[ii] However, examining data at the county level would be inconclusive since distortions occurring in the local corridor area not related to access management improvements could be missed. Therefore, a local control zone was created based on local zip codes. This zone is an aggregate change of taxable sales from zip codes within ¼ mile of the centerline of the study corridor. Table 5-4 shows the zip codes analyzed for this analysis.

Table 5-4. Control Analysis Zip Codes

Corridor	Control Analysis Zip Codes
FM 1093 (IH 610 to SH 6)	77056, 77057, 77063, 77042, 77077, 77082
FM 1960 (Gatewick Rd to Mills Rd)	77073, 77090, 77068, 77014, 77069, 77066, 77064, 77070
FM 518 (SH 288 to SH 146)	77584, 77581, 77546, 77598, 77573, 77565

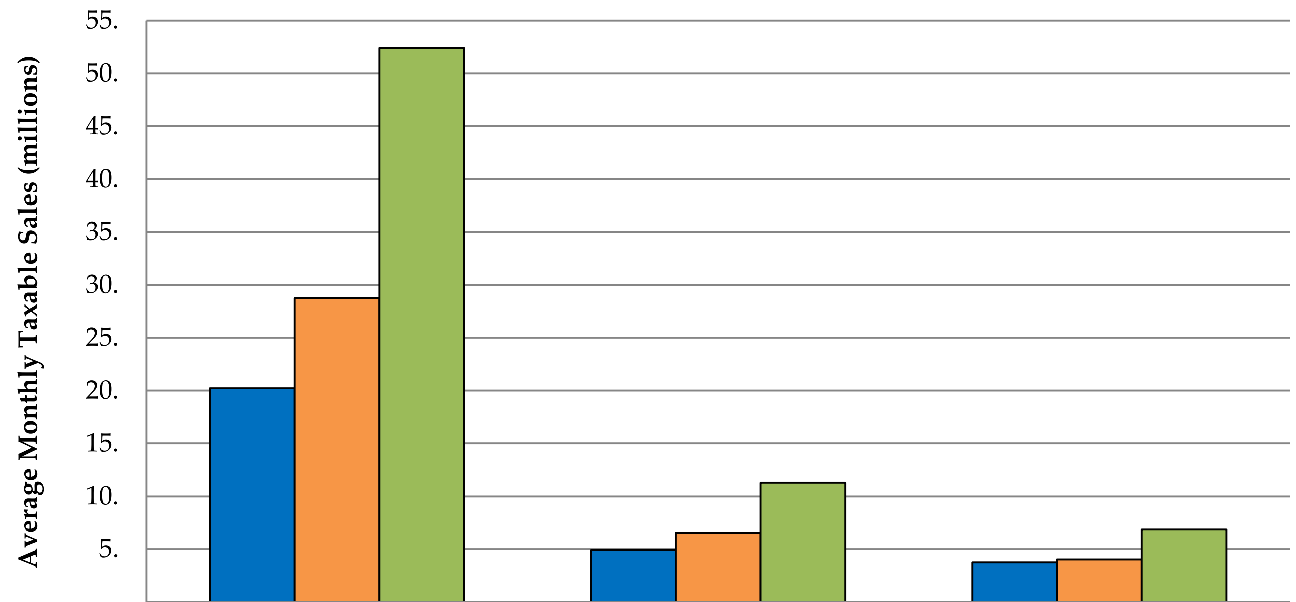
Once a tabulation of data needed was compiled, a formal information request was submitted to the Texas Comptroller of Public Accounts. Economic data were requested from the comptroller for each corridor as well as a formal request of businesses and sales tax information within the zip codes along the three corridors to include NAICS codes. Individual business activities could not be assessed based on the aggregate data provided. For normalization purposes, taxable sales receipts were adjusted to 2012 United States Dollars (USD) using annual Houston-Galveston-Brazoria Consumer Price Index (CPI) data. The results from this analysis are presented in the sections that follow.

Results: FM 1093

A comparative analysis was conducted between sections, corridors, zip codes, and county data. Results from the analysis yielded several important findings regarding FM 1093 from Interstate 610 (IH 610) to Beltway 8 (BW 8). Pass-by, destination, and combination businesses all saw increases in gross taxable sales after access management improvements were completed on FM 1093. Taxable gross sales for pass-by businesses increased from $20.2 million before access management began to $52.4 million afterward, representing a 159% growth. Businesses classified as destination saw a similar increase growing from $4.9 million before access management began to $11.3 million afterward, representing an 131% increase. Finally, businesses classified as combination saw a slight increase in gross taxable sales during construction but an increase of 86% overall from before to after. Figure 5-1 **Error! Reference source not found.**summarizes these findings.

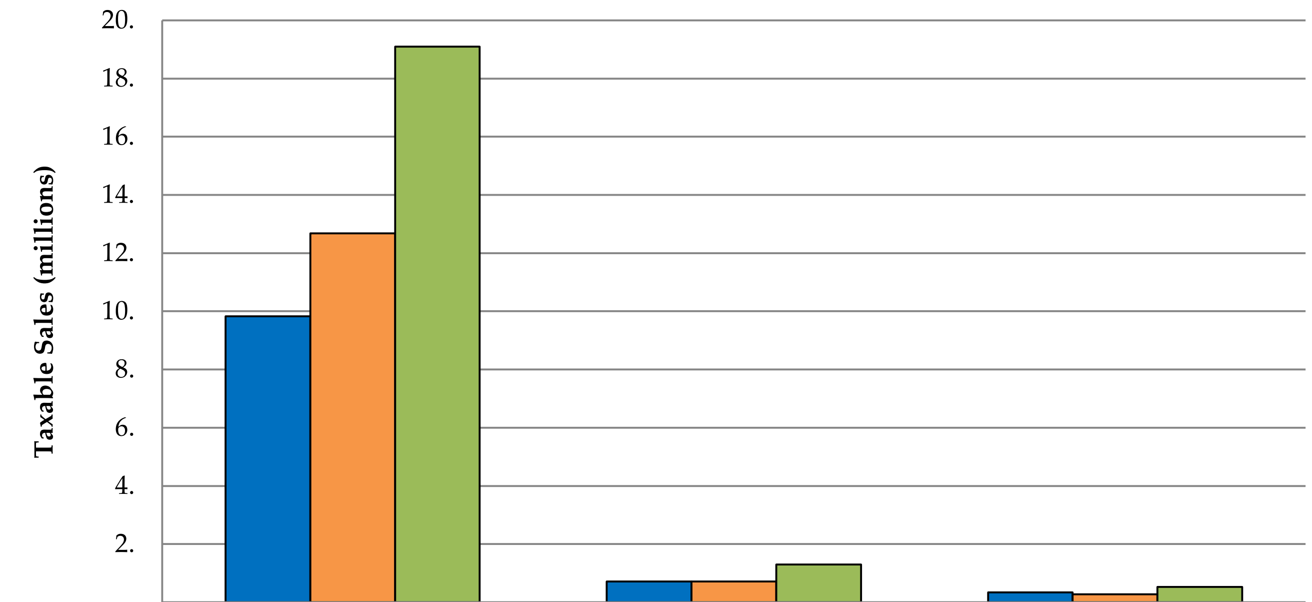
Similar results were seen for FM 1093 from BW 8 to State Highway 6 (SH 6). Pass-by designated businesses saw a 95% increase from before construction began to after improvements were completed. Destination designated businesses saw a 86% increase from before construction began to after improvements were completed, and combination designated businesses saw a 67% increase. Figure 5-2 summarizes these findings.

Data was examined based on the percent growth of taxable sales before access management improvements were made compared to after access management improvements were made, as shown in Figure 5-3. The average zip code percent changes from before to after is 41% a sizable difference from the zip code control zone to the businesses in the corridor.



	Pass-by	Destination	Combination
Before	20.2	4.9	3.7
During	28.8	6.5	4.
After	52.4	11.3	6.9

Figure 5-1. Average Monthly Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 1093 form IH 610 to BW 8



	Pass-by	Destination	Combination
Before	9.8	.7	.3
During	12.7	.7	.3
After	19.1	1.3	.5

Figure 5-2. Average Monthly Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 1093 from BW8 to SH6

Many factors could explain why FM 1093 experienced taxable sales growth that exceeded the zip code corridor. Additional corridors of similar type and further analysis could yield possible reasons for this difference.

Results: FM 1960

FM 1960 was divided into four economic analysis sections:

- Mills Road to Cutten Road
- Cutten Road to Veterans Road
- Veterans Road to Kuykendahl Road
- Kuykendahl Road to Imperial Valley

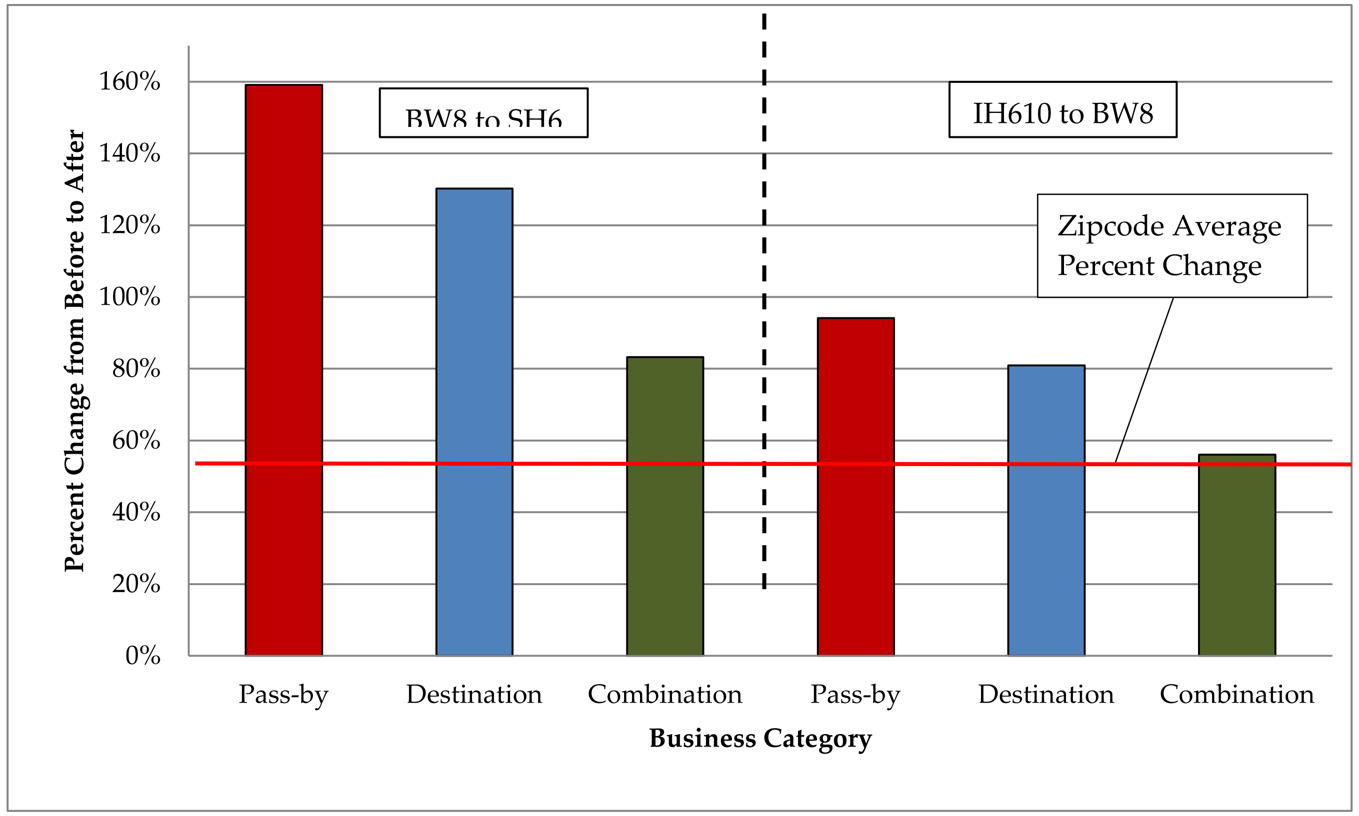


Figure 5-3. Percent Change in Taxable Sales from Before to After Implementation by Section by Category

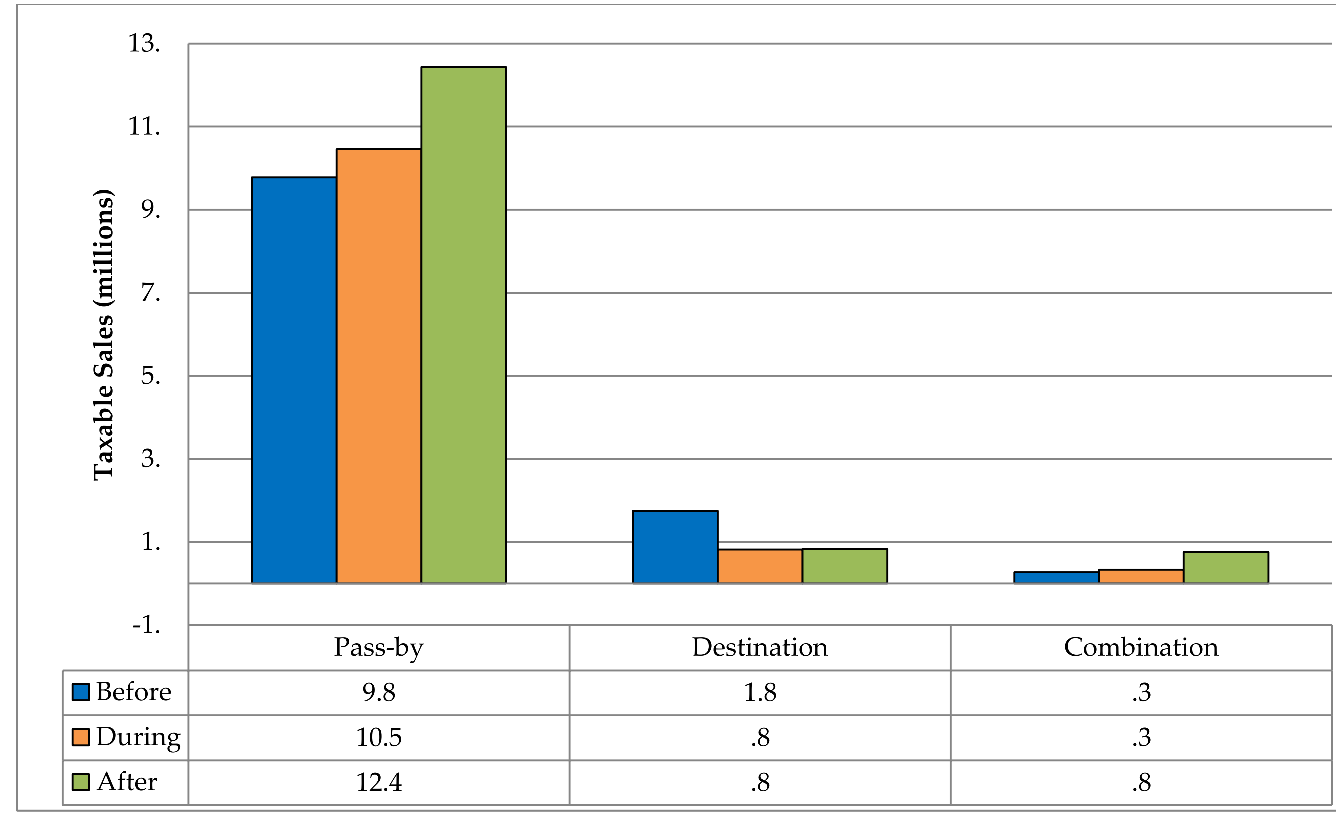


Figure 5-4. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 1960 from Mills Road to Cutten Road

While fluctuations occurred during the construction period for destination and combination businesses, overall taxable sales on the Mills Road to Cutten Road section of FM 1960 saw a net increase (before to after), as illustrated in Figure 5-4. Taxable sales for pass-by businesses increased from a monthly average of $9.8 million before access management improvements were made to $12.4 million afterward, representing a 27% increase. An increase of 166% was seen for combination businesses. Taxable sales for destination businesses saw a net average monthly decline, decreasing 56% from $1.8 million to $0.8 million.[iii]

A more consistent trend emerged for FM 1960 from Cutten Road to Veterans Road. Average monthly taxable sales for pass-by businesses increased from $14.4 million before access management improvements were made to $16.3 million after improvements, representing a 13% increase. Destination businesses saw a 40% increase in average monthly taxable sales and combination businesses remained the same. Figure 5-5 illustrates these findings.

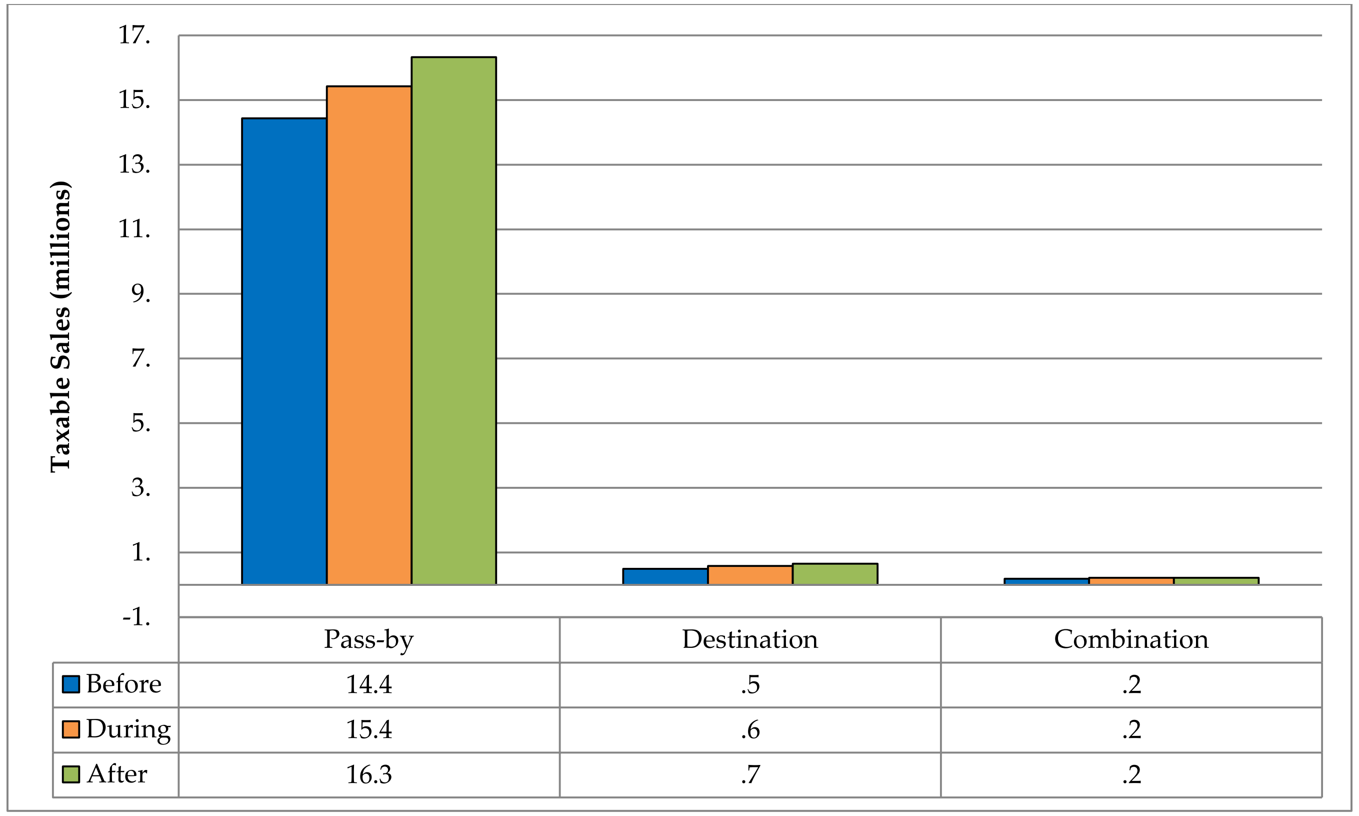


Figure 5-5. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 1960 from Cutten Road to Veterans Road

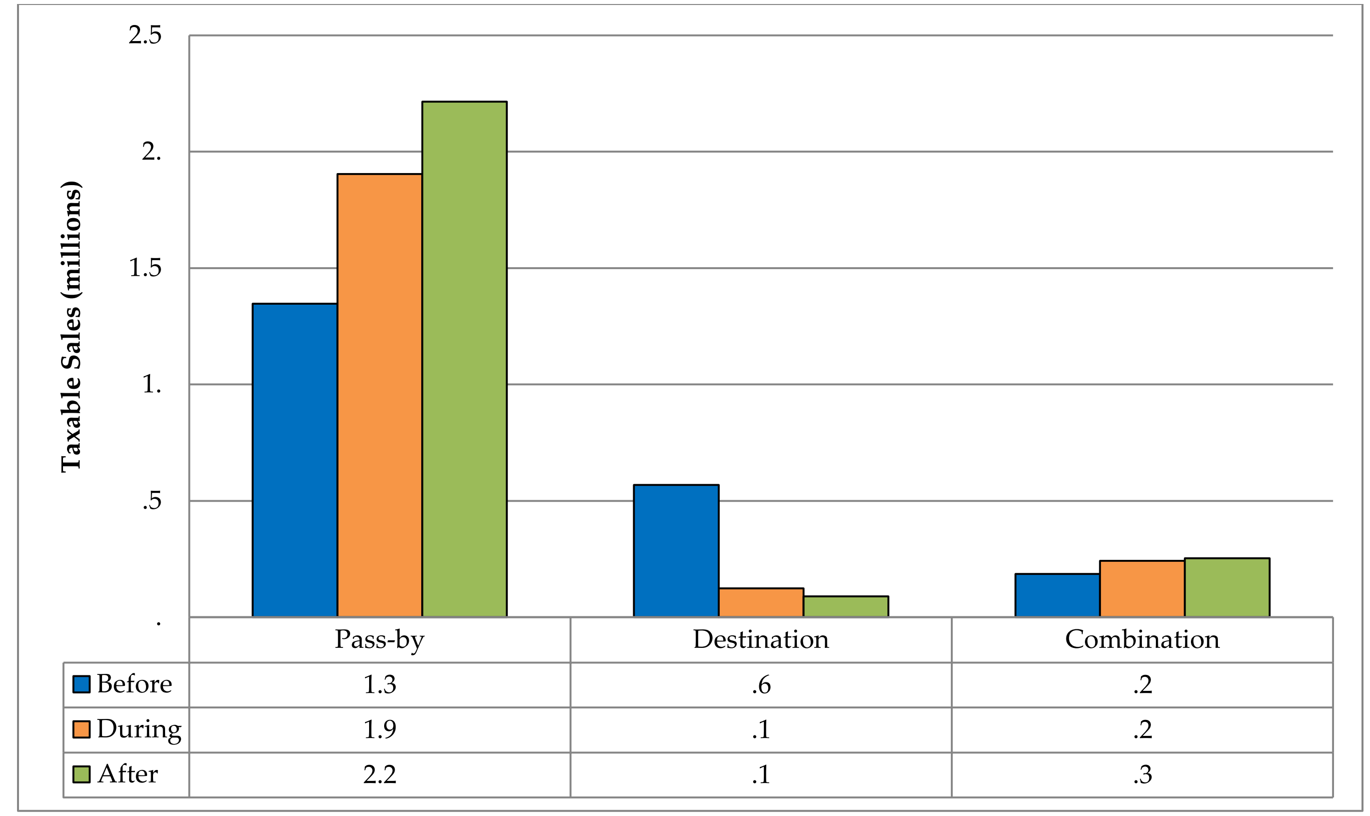


Figure 5-6. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 1960 from Veterans Road to Kuykendahl Road

FM 1960 from Veterans Road to Kuykendahl Road also demonstrates a growth trend. Average monthly taxable sales for pass-by businesses grew from $1.3 million before access management improvements were made to $2.2 million after improvements, representing a 69% increase. Destination businesses saw a significant dip in sales during and after construction while combination businesses saw an overall 50% increase. Figure 5-6 illustrates these findings.

FM 1960 from Kuykendahl Road to Imperial Valley Road saw mixed results. Average monthly taxable sales in this segment increased from $9.3 million before access management improvements to $10.6 million after improvements, representing a 14% increase. Destination businesses saw small changes in taxable sales, falling 20% and combination businesses remained unchanged at $0.3 million. Figure 5-7 illustrates these findings.

Figure 5-8 compares the rate of change from before access management improvements were made to after access management improvements were completed. The red reference line for the zip code control zone illustrates that nine out of 12 business categories outperformed the zip code comparison zone.

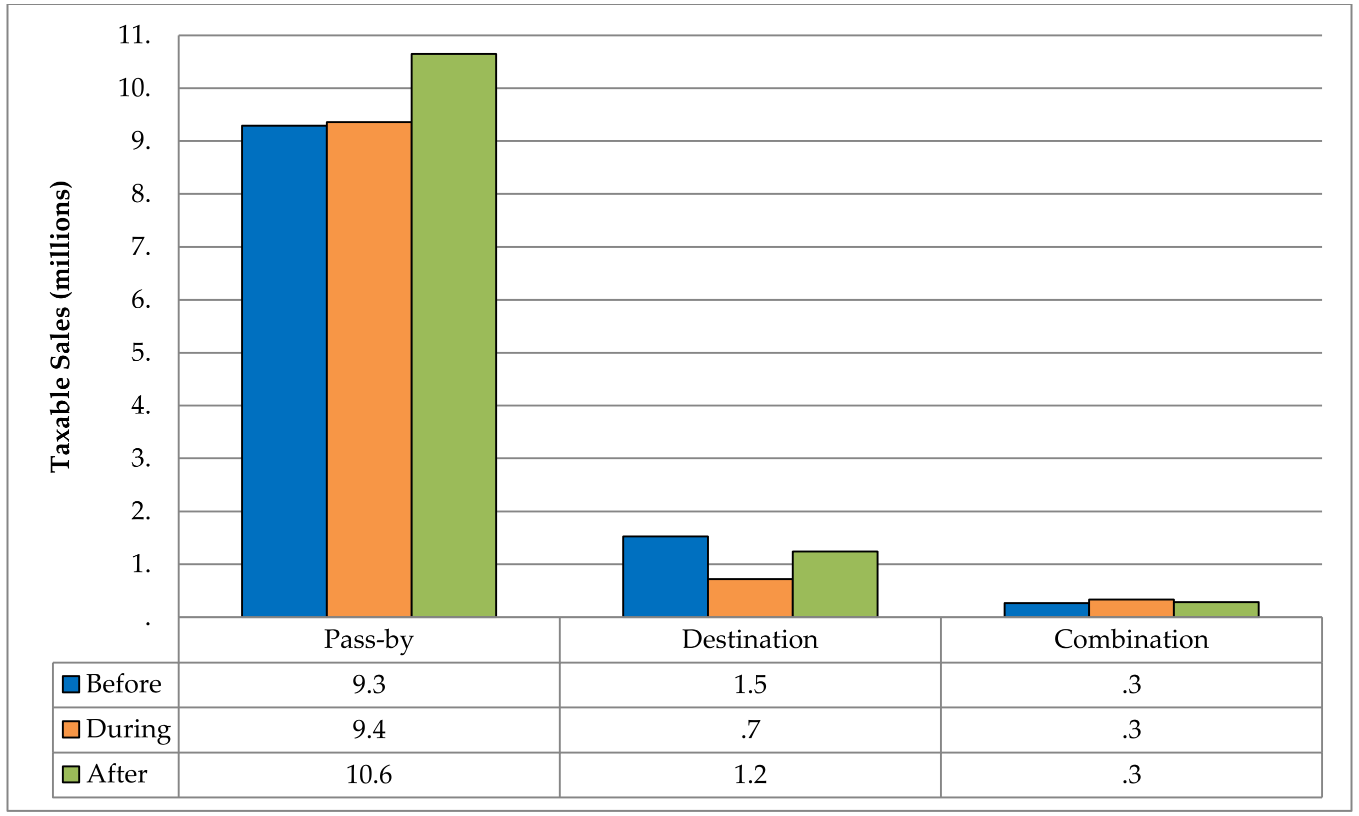


Figure 5-7. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 1960 from Kuykendahl Road to Imperial Valley Road

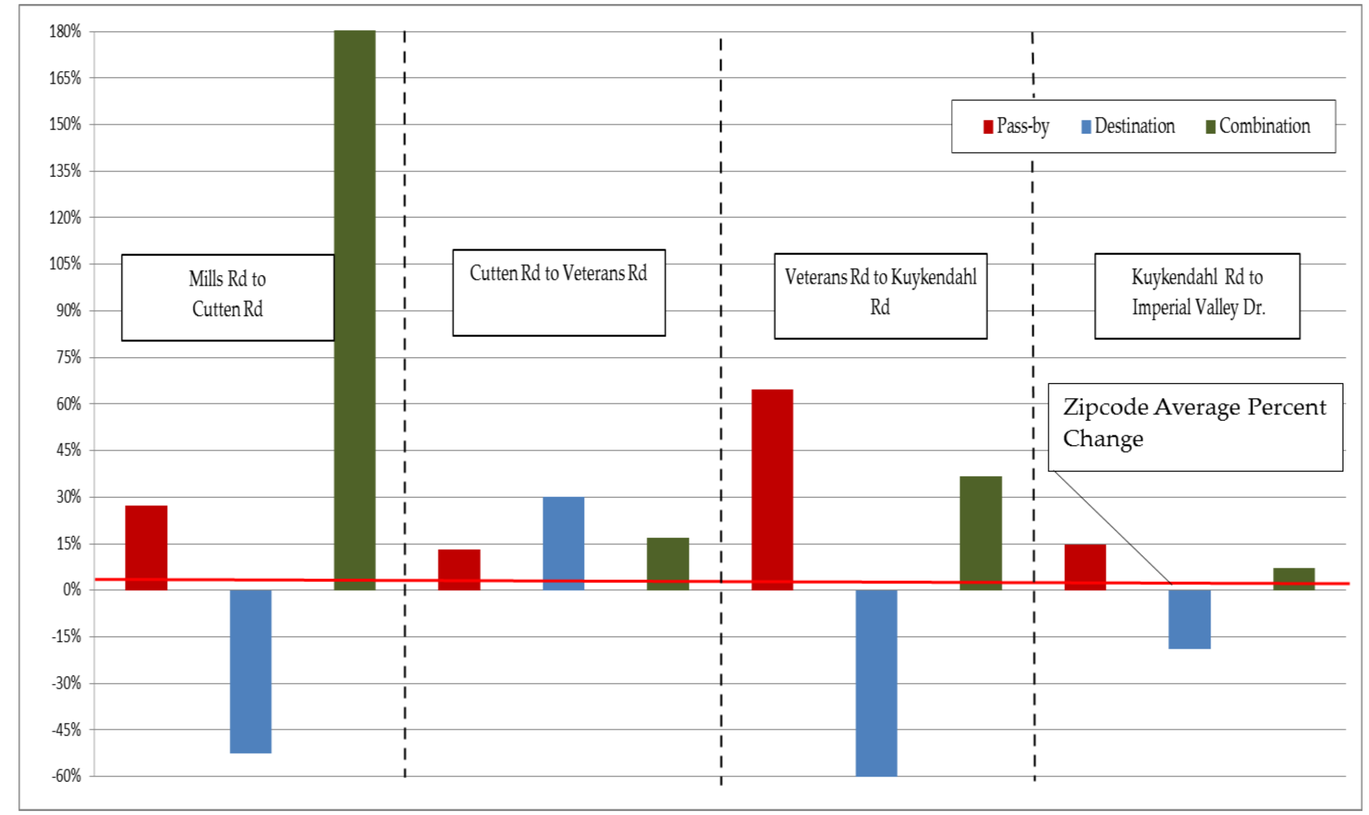


Figure 5-8. FM 1960 Percent Change in Taxable Sales from Before to After Implementation by Section and Category

Overall, positive economic impact was found on FM 1960 after access management improvements. However, while some declines in average monthly taxable sales were seen for destination and combination business, most trends point to no significant effects for all four sections of the corridor.

Results: FM 518

FM 518 was divided into 14 economic analysis sections:

- SH 288 to FM 865
- FM 865 to Harkey/Oday
- Harky/Oday to SH 35/Main
- SH 35 to Pearland Parkway
- Pearland Parkway to Sunset Meadows/Winding

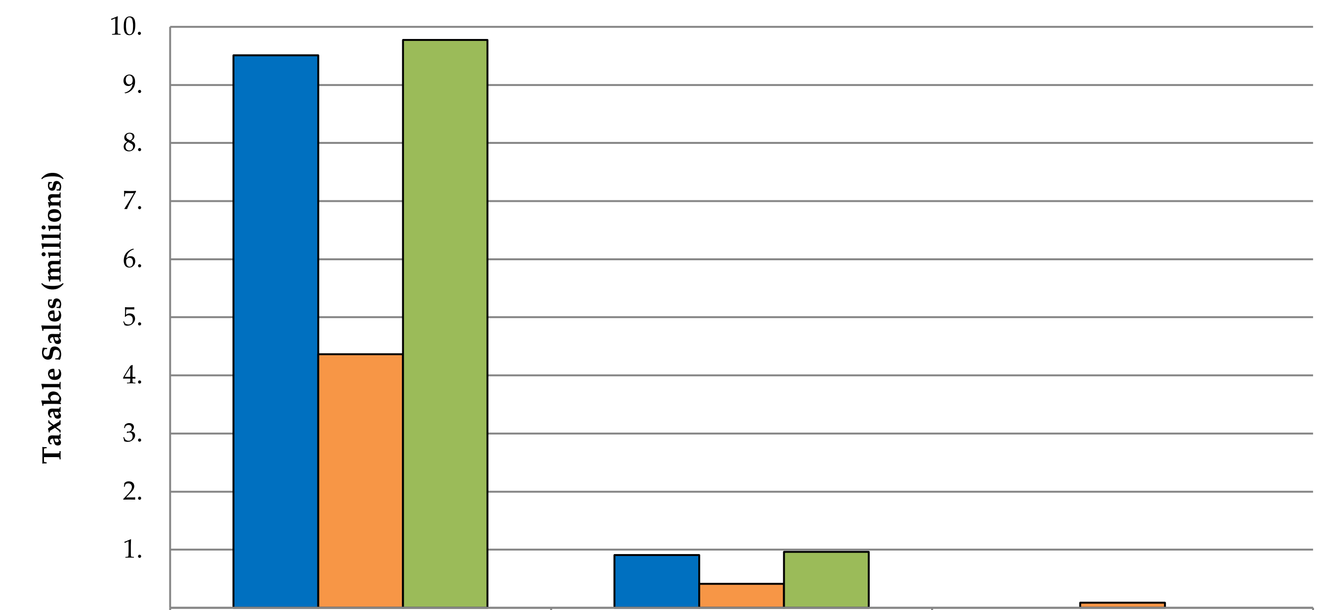
- Sunset Meadows/Winding to Shadowbend
- Shadowbend to FM 528/Parkwood
- Leage City (W City Limit) to Landing Boulevard
- Landing Boulevard to IH 45
- IH 45 to SH 3
- SH 3 to FM 270/FM 2094
- FM 270/FM2094 to Meadow Parkway
- Meadow Parkway to Lawrence Road[1]
- Lawrence Road to SH 146

Table 5-5 below provides a brief overview on the sections analyzed for this analysis.

Table 5-5. Time Periods Analyzed for FM 518 Economic Analysis.

Time Period	Start Date	End Date
Before	July 2006	July 2009
During	August 2009	January 2011
After	February 2011	September 2013

FM 518, from SH 288 to FM 865, is 2.3 miles in length and received median improvements in 2007. As shown in Figure 5-9, average monthly pass-by business taxable sales increased slightly from $9.5 before improvements to $9.8 million after improvements; average monthly destination businesses increased slightly from $0.9 million before improvements to $1.0 million after improvements. Insufficient business sales data were available for a comparison of combination classified businesses.

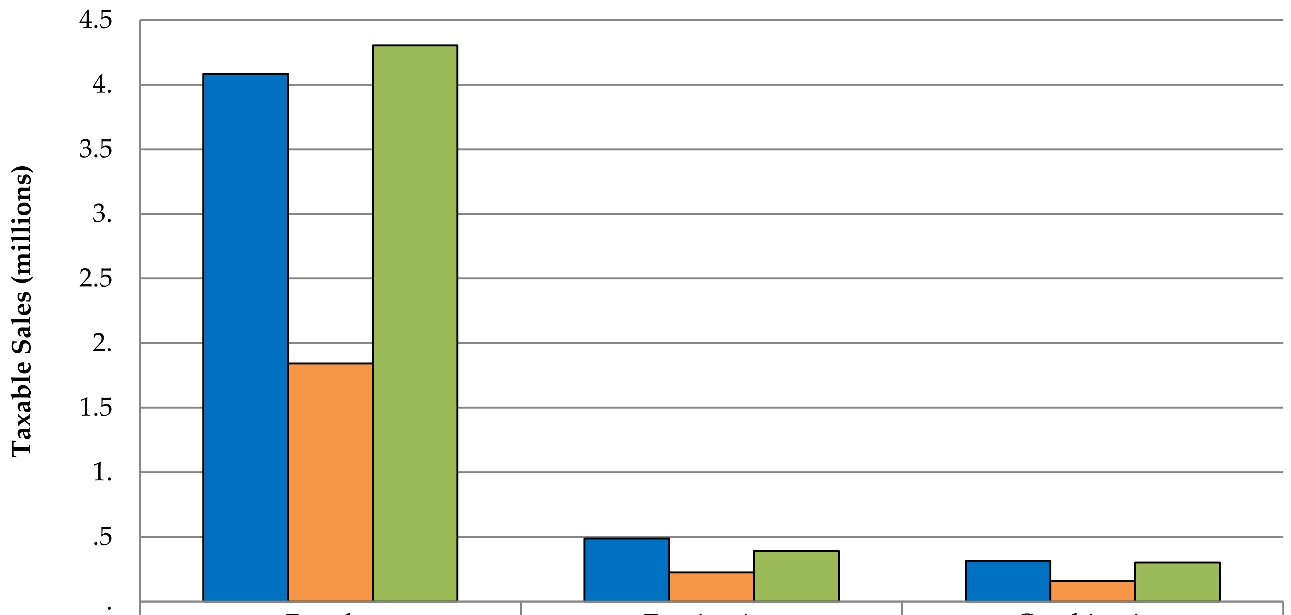


	Pass-by	Destination	Combination
Before	9.5	.9	.
During	4.4	.4	.1
After	9.8	1.	.

Figure 5-9. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from SH 288 to FM 865

FM 518, from FM 865 to Harkey/Oday Road, is 2.2 miles in length and received median improvements in 2007. As shown in Figure 5-10, this section saw a constant to slight increase in average monthly taxable sales. Average monthly pass-by business taxable sales increased 5% from 4.1million before improvements to 4.3 million after improvements were made. Destination businesses taxable sales fell slightly from $0.5 million before access management improvments to $0.4 million after improvements were made and combination businesses remained the same.

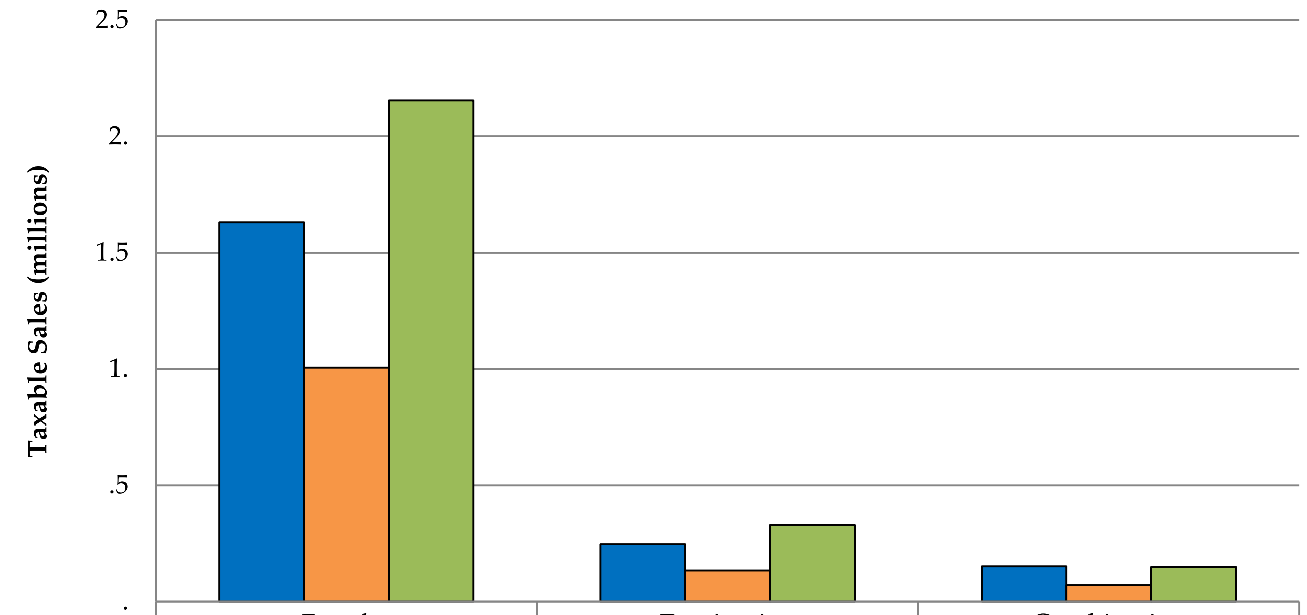
[1] Insufficient outlet data were available to evaluate average taxable sales Meadow Parkway to Lawrence Road.



	Pass-by	Destination	Combination
Before	4.1	.5	.3
During	1.8	.2	.2
After	4.3	.4	.3

Figure 5-10. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from FM 865 to Harkey/Oday Road

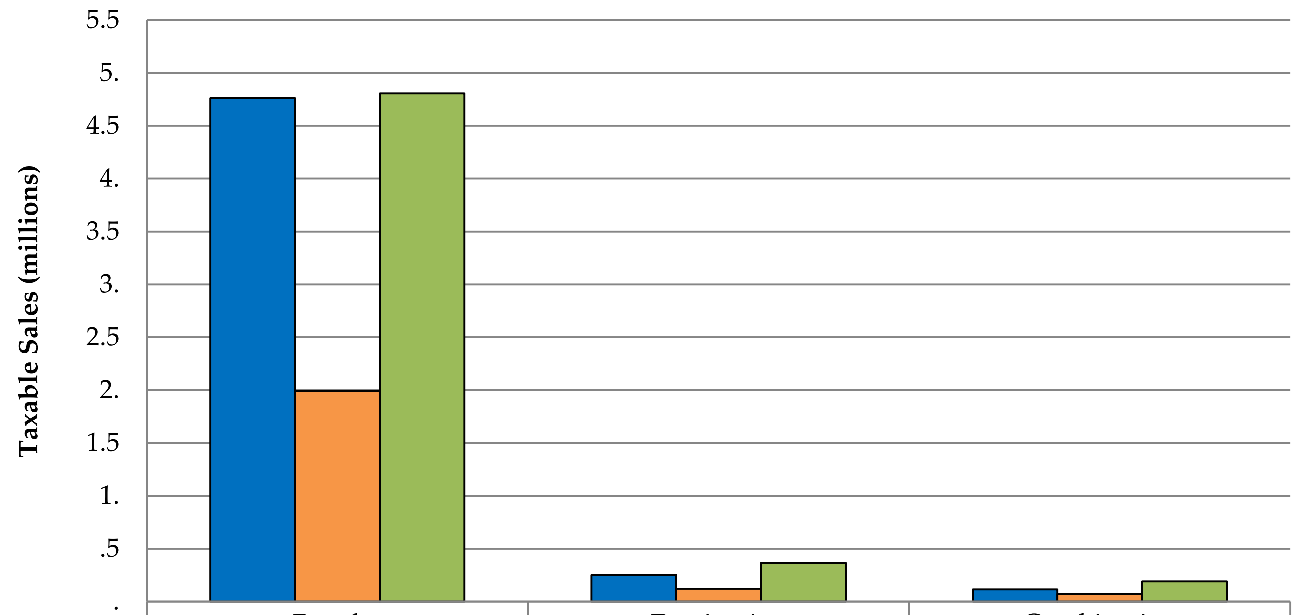
FM 518, from Harkey/Oday Rd to SH 35/Main, is 1.8 miles in length and received access management improvements in 2007. As shown in Figure 5-11, average monthly taxable sales for pass-by businesses increased from 1.6 million before access management improvements were made on other sections of 518 to $2.2 million afterward, representing a 38% increase. Destination businesses increased from 0.2 million before improvements to 0.3 million after improvements and combination businesses had a decrease of 50%.



	Pass-by	Destination	Combination
Before	1.6	.2	.2
During	1.	.1	.1
After	2.2	.3	.1

Figure 5-11. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from FM 865 to Harkey-Oday Rd to SH 35

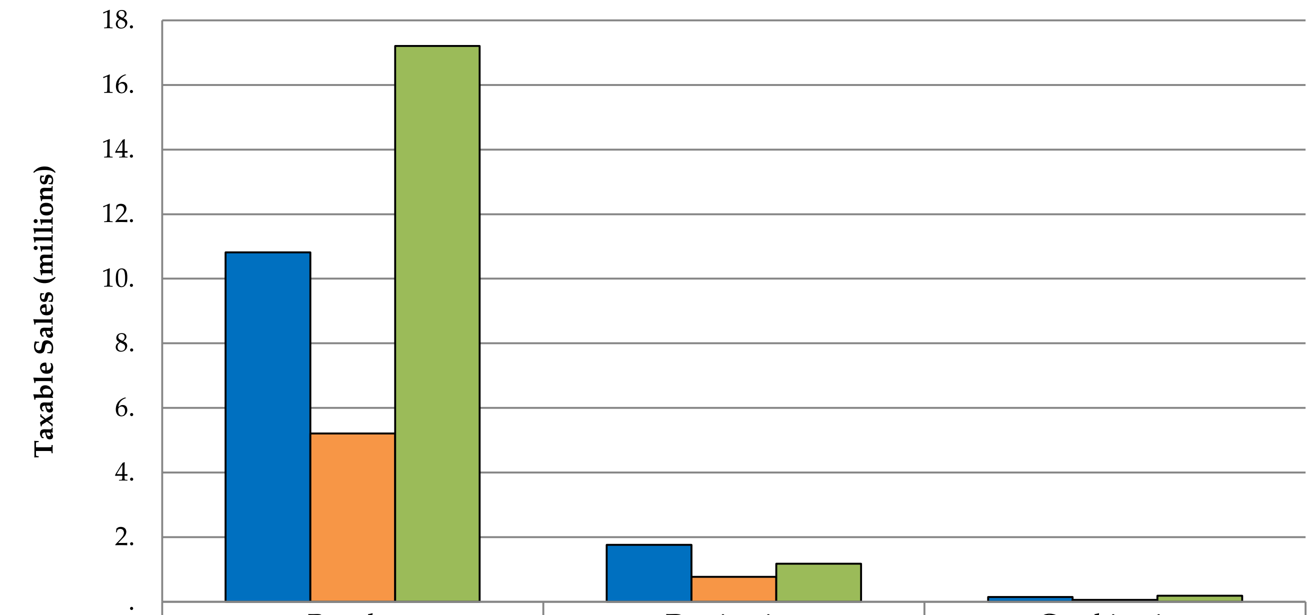
FM 518, from SH 35 (Main Street) to Pearland Parkway, is 1.5 miles in length and received no improvements during this study period. As shown in Figure 5-12, average taxable sales at pass-by business remained at $4.8 million before and after improvements were made on other sections. Destination businesses average taxable sales increased 25%. Combination businesses also saw an increase from $0.1 million before improvements were made on other sections to $0.2 million after.



	Pass-by	Destination	Combination
Before	4.8	.3	.1
During	2.	.1	.1
After	4.8	.4	.2

Figure 5-12. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from SH 35 to Pearland Parkway

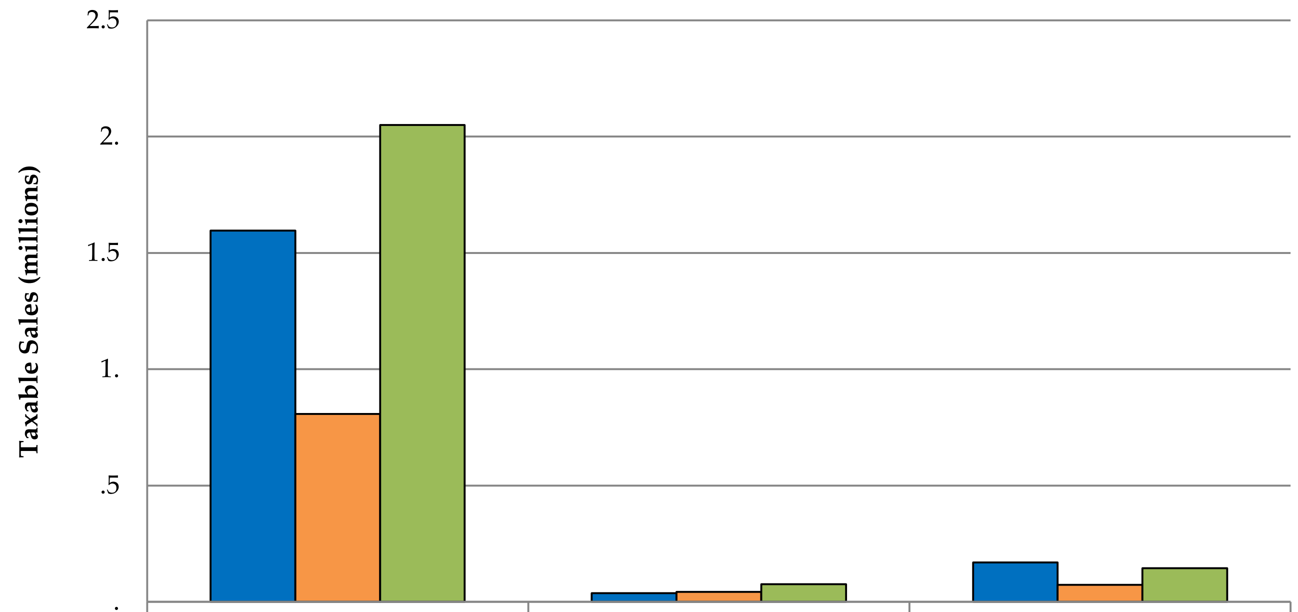
FM 518, from Pearland Parkway to Sunset Meadows, is 2.9 miles in length and received no access management improvements. As shown in Figure 5-13**Error! Reference source not found.**, average taxable sales increased from $10.8 million before improvements were made on other sections to $17.2 million afterward, representing a 59% increase during this period.



	Pass-by	Destination	Combination
Before	10.8	1.8	.1
During	5.2	.8	.1
After	17.2	1.2	.2

Figure 5-13. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from Pearland Parkway to Sunset Meadows/Winding

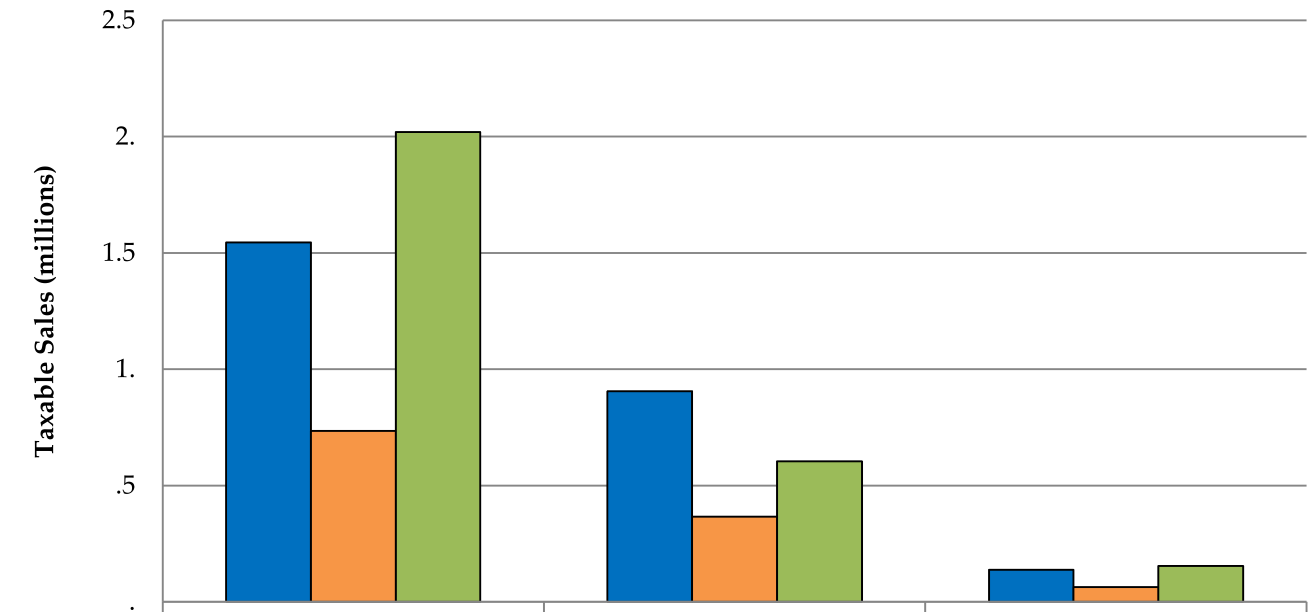
FM 518, from Sunset Meadows to Shadowbend is 1.2 miles in length and received median improvements in 2002. Since those median improvements were made, average monthly taxable sales have increased steadily. As shown in Figure 5-14**Error! Reference source not found.**, average, pass-by sales have increased from $1.6 million to $2.1 million, representing a 31% increase.



	Pass-by	Destination	Combination
Before	1.6	.	.2
During	.8	.	.1
After	2.1	.1	.1

Figure 5-14. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from Sunset Meadows/Winding to Shadow Bend

FM 518, from Shadow Bend to FM 528/Parkwood is 1.8 miles in length and received median improvements in 2002. Since those median improvements were made, average monthly taxable sales were mixed. As shown in Figure 5-15**Error! Reference source not found.**, average, pass-by sales have increased from $1.5 million to $2 million, representing a 33% increase.



	Pass-by	Destination	Combination
Before	1.5	.9	.1
During	.7	.4	.1
After	2.	.6	.2

Figure 5-15. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from Shadowbend to FM 528

FM 528 from Parkwood to League City Limits did not have the minimum number of businesses required for the Comptroller to fulfill the data request.

FM 518, from League City city limits to Landing Boulevard is 2 miles in length and received no median improvements. As shown in Figure 5-16, average taxable sales for pass-by businesses increased from $0.8 million to $1.2 million during the study period, representing a 50% increase. Insufficient tax receipt data were available for destination businesses for this corridor.

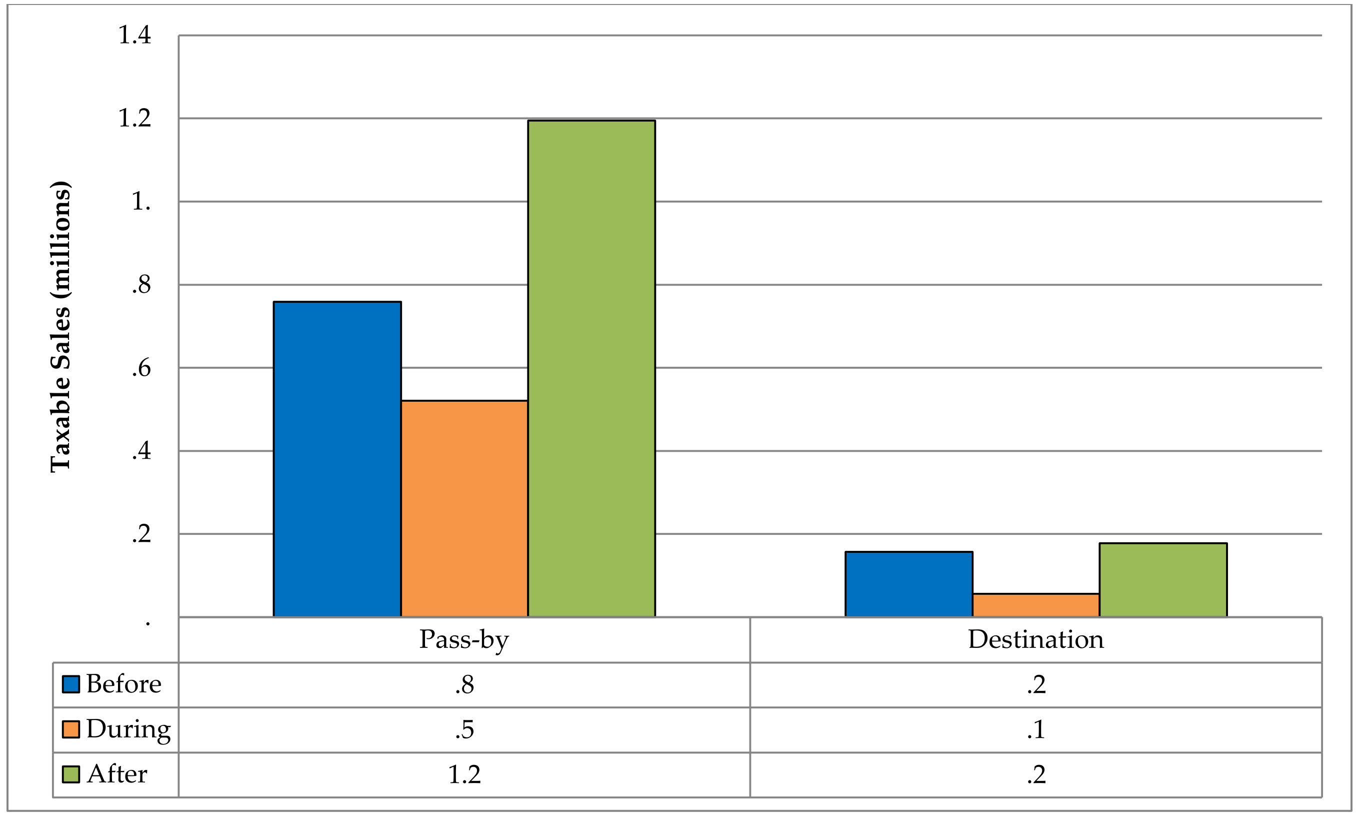


Figure 5-16. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from League City Limits to Landing

FM 518, from Landing Boulevard to IH 45, is 0.8 miles in length and received no median improvements. As shown in Figure 5-17, average taxable sales for pass-by businesses increased from $1.1 million at the beginning of the study period to $1.5 million afterward, representing a 36% increase. Insufficient tax receipt data were available for destination and combination businesses for this corridor.

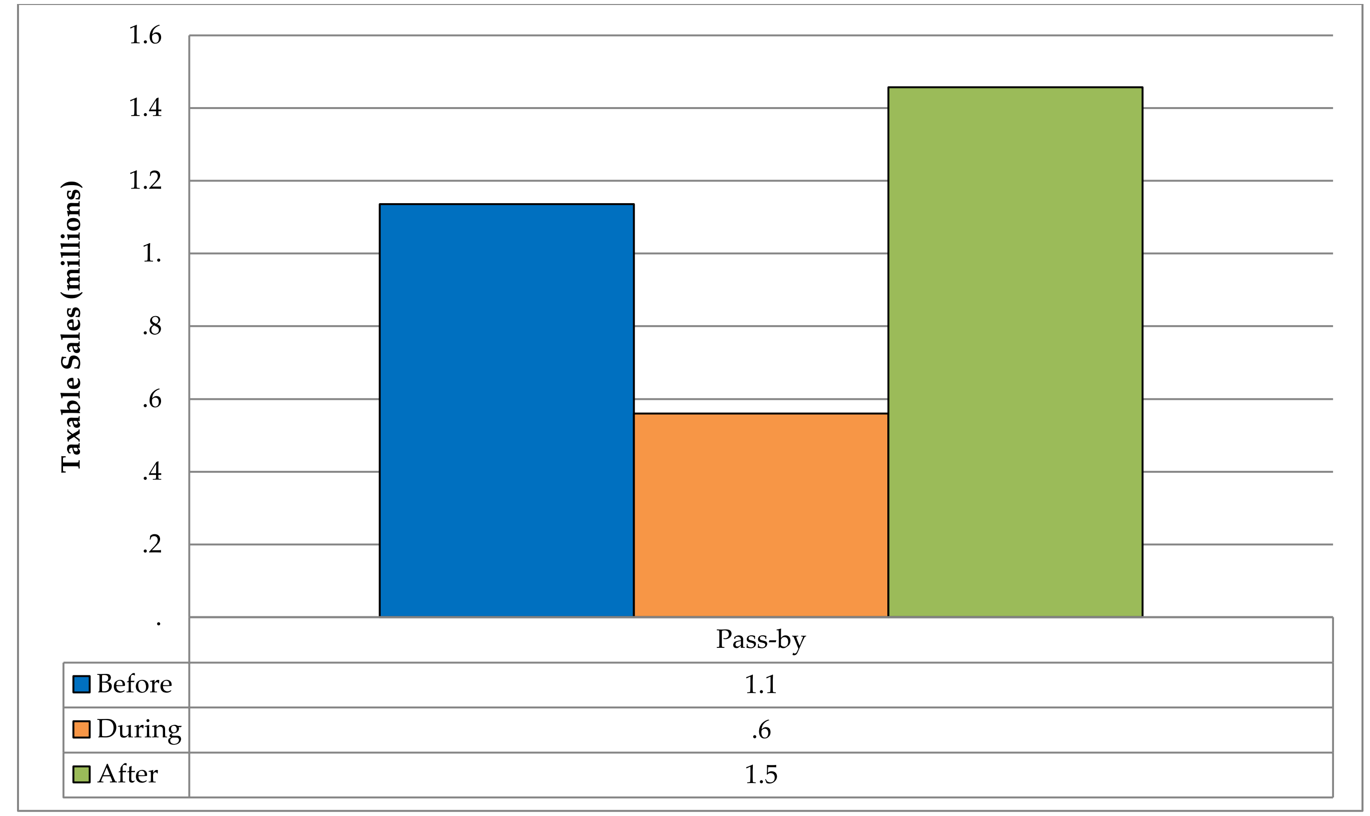
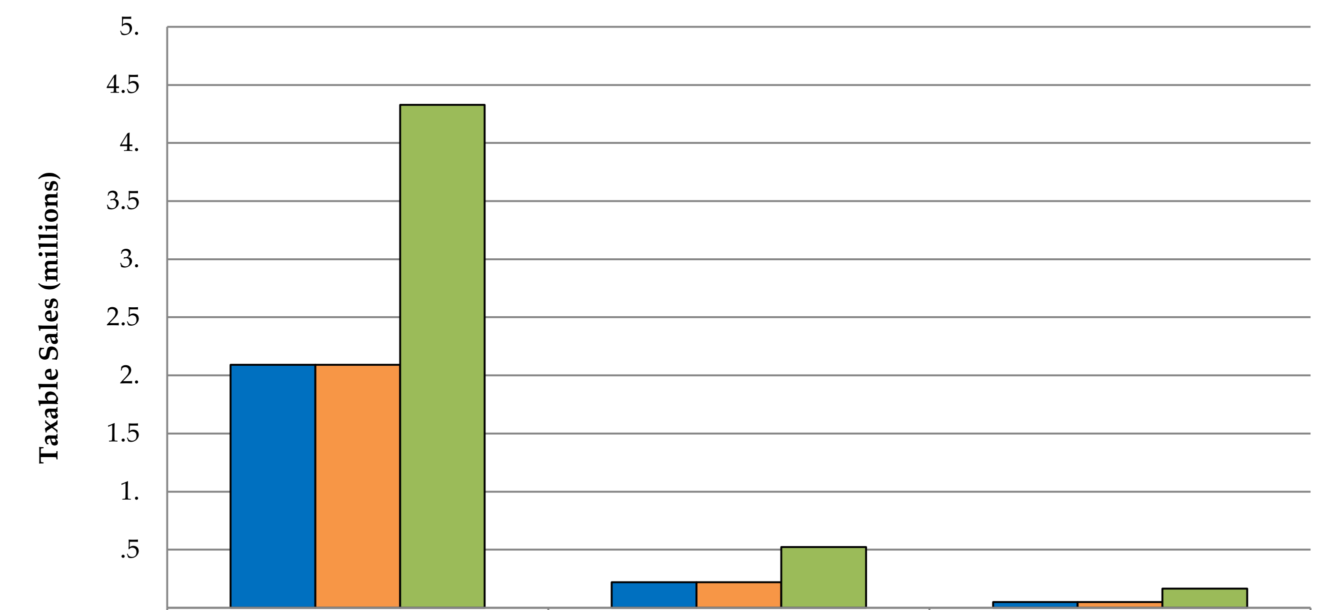


Figure 5-17. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from Landing Boulevard to IH 45

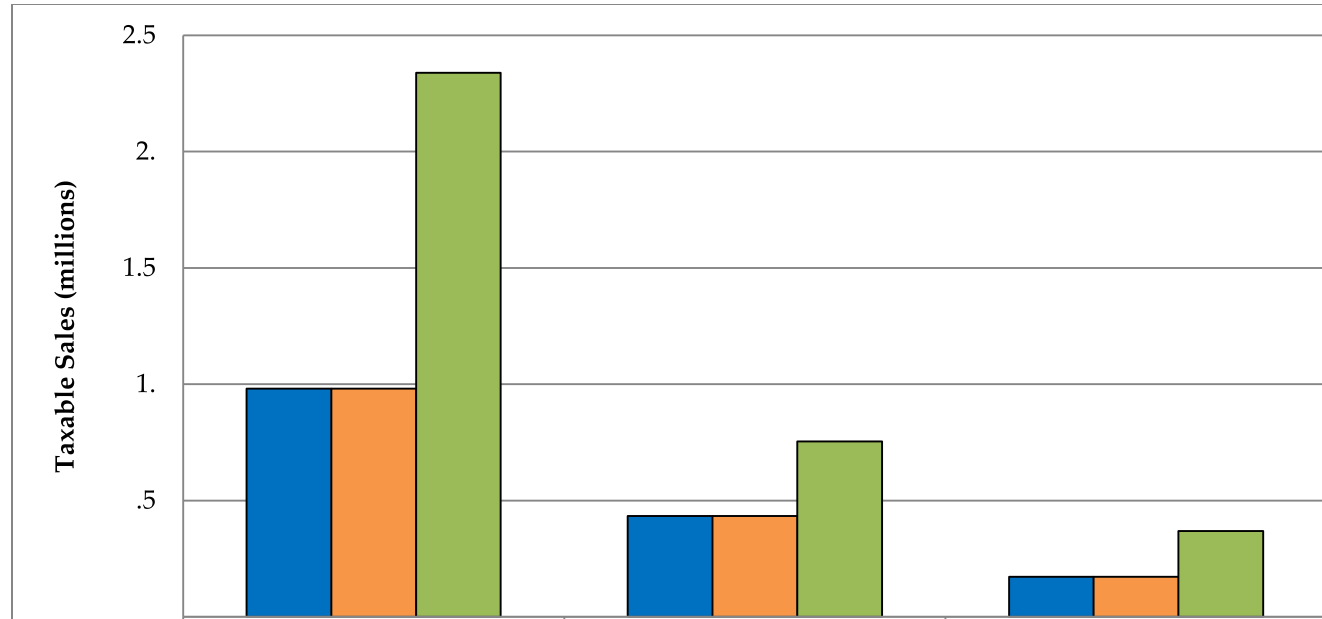
FM 518, from IH 45 to SH 3 is 1.2 miles in length and received median improvements in 2000. Therefore, the results from the study period mostly reflect after effects. As shown in Figure 5-18, average taxable sales for pass-by businesses increased from $2.1 million to $4.3 million, representing a 105% increase.



	Pass-by	Destination	Combination
Before	2.1	.2	.
During	2.1	.2	.
After	4.3	.5	.2

Figure 5-18. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from IH 45 to SH 3

FM 518 from SH 3 to FM 270/FM 2094, a 1.5 mile segment that received no median improvements, saw a fairly significant increase in average taxable sales during the study period. As shown in Figure 5-19, average taxable sales for pass-by businesses increased from $1.0 million to $2.3 million, representing an increase of 130%.



	Pass-by	Destination	Combination
Before	1.	.4	.2
During	1.	.4	.2
After	2.3	.8	.4

Figure 5-19. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from SH 3 to FM 270/FM 2094

FM 518 from FM 270/FM 2094 to Meadow Parkway, a 1.4 mile segment that received median improvements in 2007, saw an increase in average taxable sales for pass-by businesses. As shown in Figure 5-20, taxable sales increased from $0.1 million before access management improvements were made to $0.5 million afterward, representing a 400% increase. However, it is important to note that the small sample means that other factors (e.g. the relocation of one major business outlet) that could explain this significant increase.

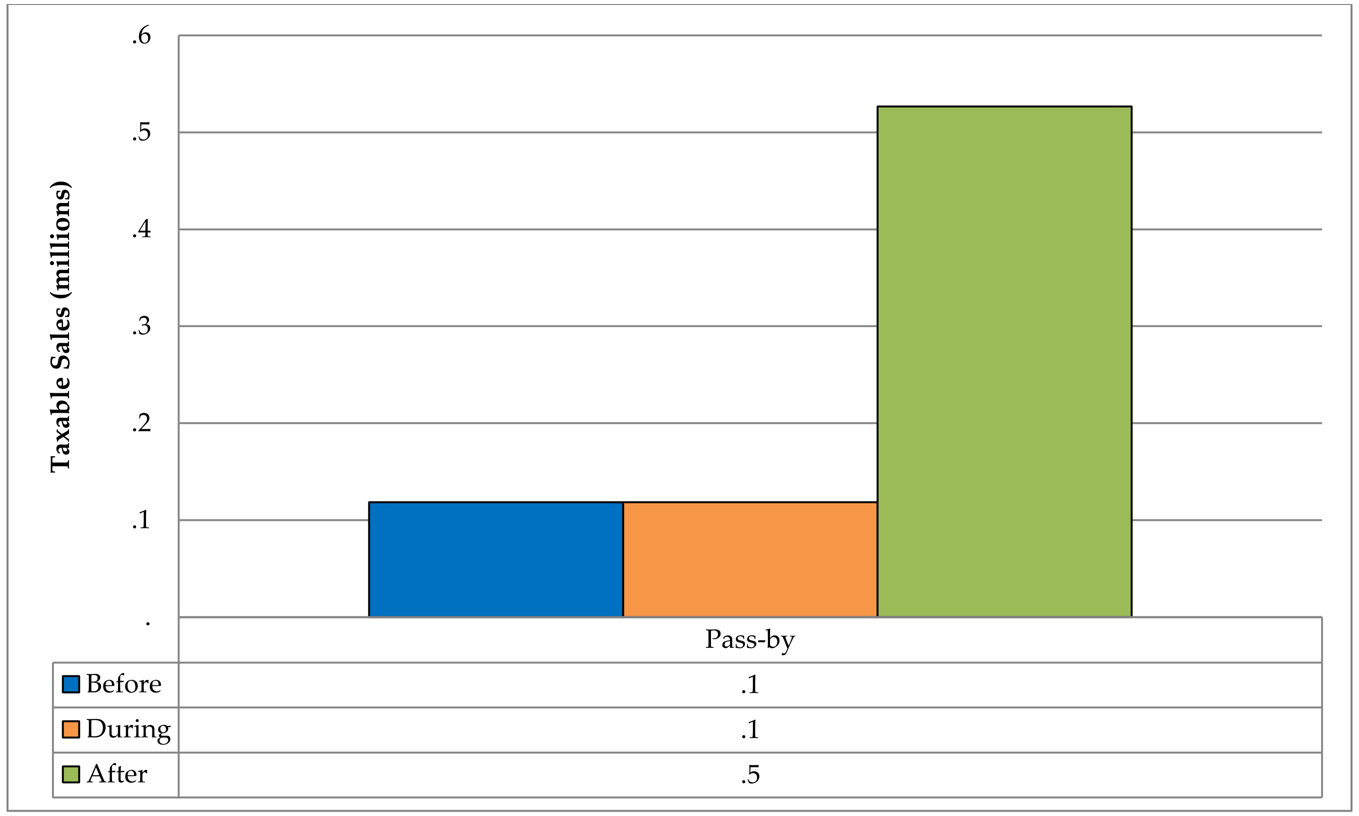


Figure 5-20. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from FM 270 to Meadow Parkway

FM 518, from Lawrence Road to SH 146, is a 1.1 mile segment that received median improvements in 2007. As shown in Figure 5-21, average taxable sales for pass-by businesses increased 64%, from $0.5 million before improvements began to $1.4 million afterward. Insufficient data were available for combination and destination business analysis.

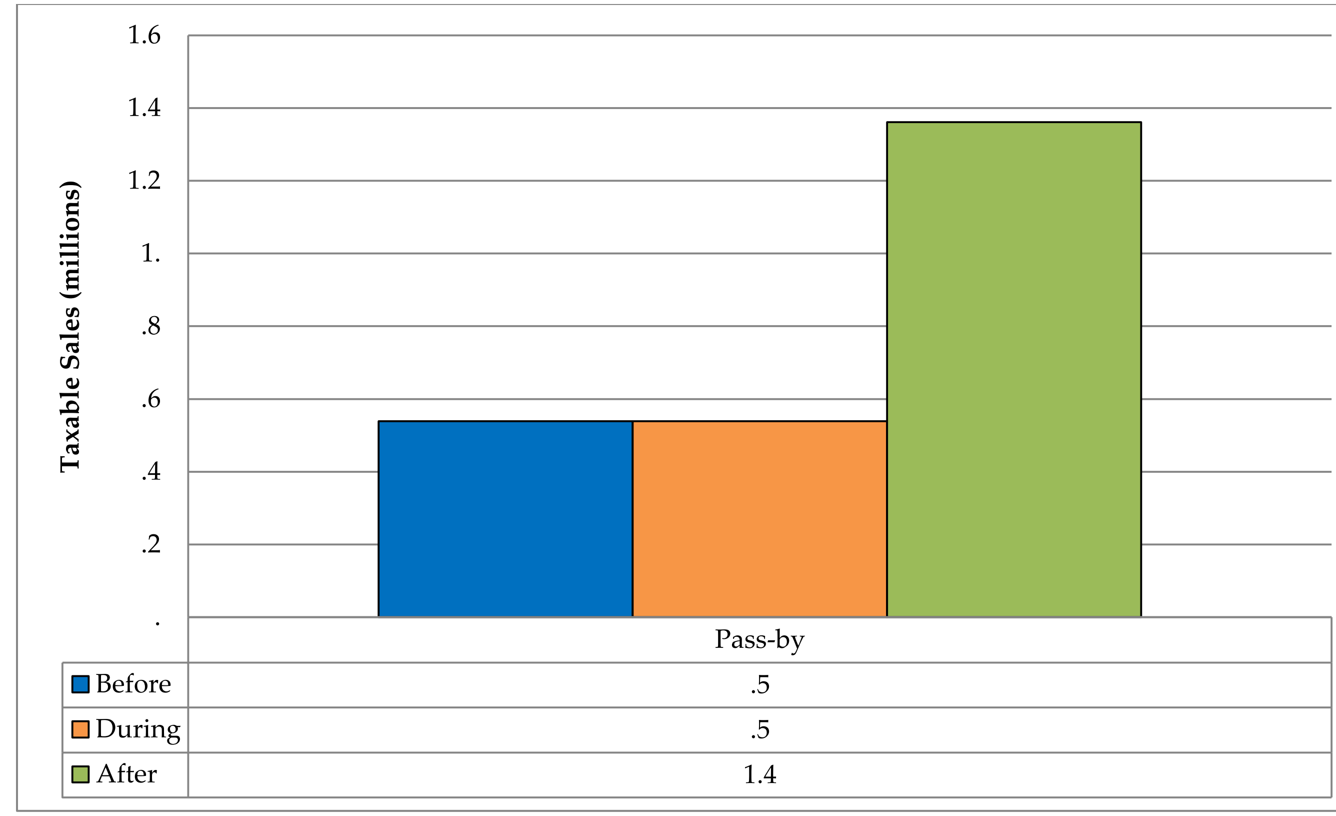


Figure 5-21. Taxable Sales by Business Category Before, During, and After Access Management Implementation for FM 518 from Lawrence to SH 146

Figure 5-22 compares the rate of change from before access management improvements were made to after access management improvements were completed. The red reference line for the zip code control zone.

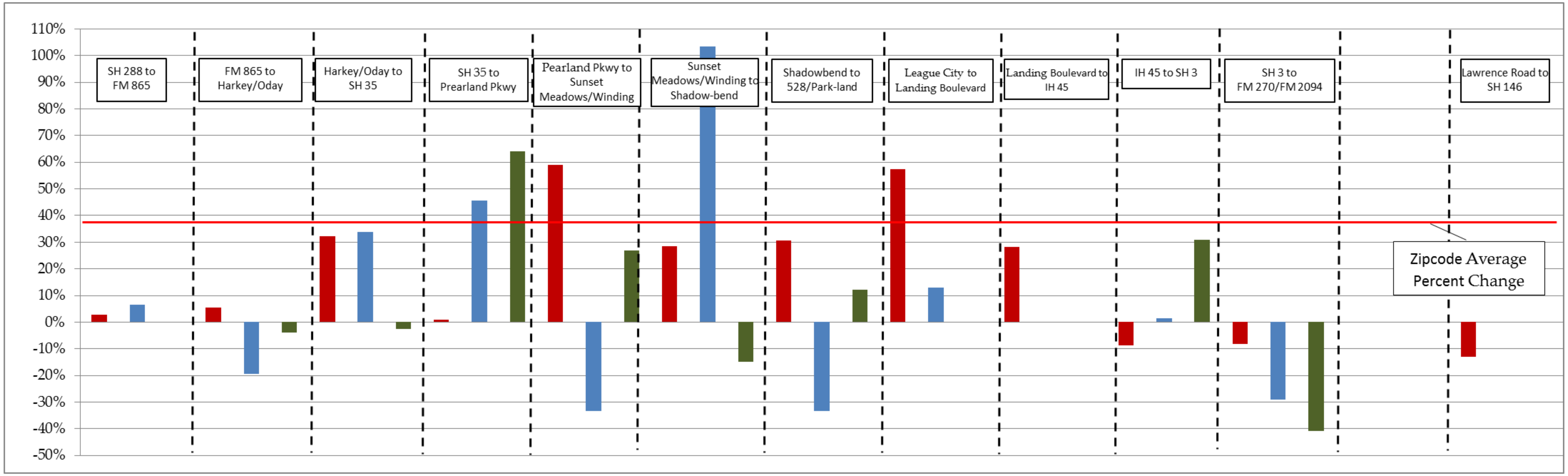


Figure 5-22. FM 518 Percent Change in Taxable Sales from Before to After Implementation by Section and Category

Corridor Comparison and Conclusions

When comparing the three corridors, interesting results emerged. When first examining county and adjacent zip code data in Houston and Harris County, it is clear that an upward trend in taxable sales was evident on a regional basis. This trend was generally mirrored in all three corrdiors studied in this analysis. For FM 1093 (Westheimer Road), pass-by, destination, and combination classified businesses far exceeded the average taxable sales growth for adjacent counties. For FM 1960, all but three business categories outperformed the zip code control zone. For FM 518, the results are a bit more mixed. Some sections that received no median improvements or that previously had medians saw large increases in average taxable sales over the study period while others saw significant decreases. Overall, while some segments saw declines in average taxable sales, the majority of segments and business categories studied for these three corridors largely mirrored taxable sales growth trends seen in the zip code control zones.

The purpose for this analysis was to gain understanding on the potential impacts access management improvements had on taxable business sales. Generally, the trends presented here suggest business sales increased at a greater rate along these corridors than in the adjacent zip code analysis zone. However, several factors must be first considered before making conclusive statements. The following events occurred during the study period that could have had an extraneous effect on business activity in the Greater Houston region:

- **Hurricane Rita (2005):** Considered the fourth-most intense Atlantic hurricane ever recorded, Hurricane Rita formed over the Bahamas and made landfall on September 24, 2005 near Sabine Pass, Texas; east of the Houston area. While this storm decimated local communities in Louisiana and Mississippi and caused large evacuations from southeast Texas, the economic damage could be considered significant. Some projections indicated that the loss of oil productivity on offshore oil rigs had been cut by 1% on an annualized basis in the second half of 2005. Due to Houston's energy-based economy, it's possible some of the economic effects were felt in Houston.
- **Hurricane Ike (2008**): On September 13, 2008, Hurricane Ike, a category 4 hurricane, made landfall near Galveston and was the costliest hurricane ever to hit Texas. Similar to Hurricane Rita, the economic effects were significant. According to the Federal Emergency Management Agency, 60,542 and 19,574 property owners reported property losses in Harris and Galveston Counties, respectively.iv On one hand, the loss of business establishments could have negatively affected taxable sales. However, the increase in spending immediately following Hurricane Ike for recovery and reconstruction could have temporarily increased taxable sales. It is unclear the extent Hurricane Ike had in affecting this study.
- **Economic Recession (2007-2009):** The global economic recession played a large role in an unprecedented but temporary decline in taxable sales from 2009 to 2010 in the Greater Houston region. While Houston and Texas fared comparatively well relative to the rest of the United.States, it is likely that a decline in economic activity during this period did have an impact in taxable sales in the study corridors. However it is difficult to fully discern the magnitude of those impacts regarding access management application.

These confounding factors and other confounding events could have played an additional role and could have affected the results in unknown ways (otherwise known as known unknowns. However, it appears from this analysis that there is little evidence to support the theory that businesses along the access management corridors were unduly burdened by such improvements activity or the resulting temporary and/or permanent mobility conditions.

As noted previously, most credible studies provide evidence that access management improvements, on the aggregate and over time, result in little to no reduced business sales along a corridor. While many studies found business outlook *perceptions* regarding access management to be negative (especially during construction), actual aggregate business sales activity along access management corridors was found to overall be positive or neutral. Cursory findings presented herein support those claims.

A few knowledge gaps exist and could require further study:

1. To what extent are transportation agencies designing access management improvements that can minimize the impact on business sales in the Greater Houston region?
2. What are the most effective ways to communicate the likely economic impacts of access management projects to local business owners in the Greater Houston area?
3. What information could be learned from follow-up stakeholder surveys and business perceptions of access management in the Greater Houston area?
4. How have the business cycles (and economic conditions) of the Greater Houston region affected sales over time?

Conclusions

Access management is a tool used to combat congestion, increase safety, and potentially influence land development and access. The application of access management can improve mobility by reducing vehicle conflict points and removing turning vehicles from the through lanes, thus improving mobility, traffic operations and safety along the corridor.

Several access management studies have been conducted in the Houston region in the past decade and the recommendations within those studies have been, in large part, implemented in those corridors. This evaluation was conducted to determine the recommendations implemented (and the benefits realized) in three of these corridors: FM 1093, FM 1960 and FM 518. The intent of this evaluation was to:

- Determine which corridor study recommendations have been implemented and which improvements are still being planned;
- Examine the effects of the recommended improvements before, during and after project implementation in the following areas:
    - Operations – traffic flow, intersection delay, and corridor delay;
    - Safety – crash frequency, crash rates, and compare those to the state averages; and
    - Economic – compare taxable sales receipts and control for other economic factors occurring during those times.

The Houston-Galveston Area Council (H–GAC) commissioned three access management studies of regional thoroughfare corridors in 2002 and 2004 on FM 1093, FM 1960, and FM 518. The studies were to determine if access management techniques could improve the mobility, safety, and aesthetics of these corridors and make recommendations to implement those which were identified to improve operations and safety. The resulting reports identified and recommended access management treatments such as:

- Raised Medians;
- Channelization;
- Turn Bays;
- Traffic Signal Improvements;
- Bus Route Amenities;
- Landscaping
- Sidewalks; and
- Other physical and operational improvements.

Most of the study report roadway recommendations have been implemented and the associated benefits have been realized. The following sections highlight the findings documented in this evaluation.

Inventory Summary

Each corridor was evaluated to determine the status of the recommended improvements made by the original study using the following categories:

- Improvements recommended and implemented;
- Improvements recommended and not implemented; and
- Improvements not recommended but implemented.

Raised medians, turn bay modifications, traffic signals, and driveways were plotted graphically and tabulated in the inventory process.

The general status of implementation, based on this evaluation, is:

- A majority, but not all, of the improvements where public agencies would be responsible (such as constructing raised medians and traffic signal improvements) have been implemented; and
- The majority of private property owner-driven recommendations (such as driveway consolidation and modifications) have not been completed.

Operations Summary

Detailed traffic analysis during the evaluation revealed several notable findings. Most operational benefits appear to be the result of capacity improvements, including the addition of turn bays, changes in traffic signal phasing (e.g., removal of split-phasing), and strategic roadway widening. The list below summarizes the benefits obtained by the various access management components.

- Reduced travel times and reduced overall network delay were realized for full implementation of the recommendations as compared with the before conditions (No Build). These benefits appear to be correlated to the type of recommendations implemented. Capacity improvements such as turn bay additions, a short thru lane at congested intersections, and grade separation of a congested intersection improve traffic operations yielded the greatest saving. Using only raised medians can result in somewhat higher delay as compared to No Build Condition with two-way left turn lanes as an increase in turning traffic at the median openings and signalized intersections is realized.

- Level of Service categories at signalized intersections typically only improved if there were significant capacity improvements at the intersection. Raised medians appear to have relatively minor operational benefits, but they certainly appear to more likely contribute to very positive safety benefits.
- In this evaluation, an increase/decrease in vehicle delay at an intersection was typically due to side street delay (typically at low to moderate volume on side streets). Improvements to the side street approaches such as turn bays could reduce green time needed to serve the side street and thus reduce intersection delay.

A comparison of network delays for the roadway sections modeled are shown in Table 6-1. The larger decreases in network delay were largely attributed to the addition of through lanes or turn bays or in the case of Kuykendahl an underpass. Total network delay ranged from 76 to 837vehicle –hours.

Table 6-1 Operational Comparison Based on Network Delay

Corridor/ Peak Hour	Segment	Total Delay (Veh- hrs) Before	Total Delay (Veh- hrs) After	Percent Change
FM 1093/PM	Wilcrest Dr to Gessner Rd	895	837	-6.9%
FM 1960/PM	Mills Road to Cutten Road	527	533	1.1%
FM 1960/PM	Walters Rd to Kuykendahl Rd	520	211	-146.4%
FM 518/AM	SH 288 to Sunrise Lakes Blvd	86	76	-13.2%
FM 518/PM	SH 288 to Sunrise Lakes Blvd	507	237	-113.9%
FM 518/AM	IH 45 to SH 3	91	94	3.2%
FM 518/PM	IH 45 to SH 3	210	212	0.9%

Safety Summary

Average crash frequency and average crash rate are reduced in each of the three study corridors for the before to after time period. Figure 6-1 shows the average crash rate for the three corridors compared with the state average for four or more lane divide arterials. Even though FM 1093 is above the state average it showed a large drop in the after conditions. Additionally FM 1093 has twice as many lanes as the state average which could contribute to the higher crash rates. Crash rates dropped between 20 to 68 percent in most evaluation segments over the three corridors. There were some evaluation sections within the three corridors that crash rate increased, however most of those segments were still three to four times lower than the statewide average for urban four-lane, undivided arterials.

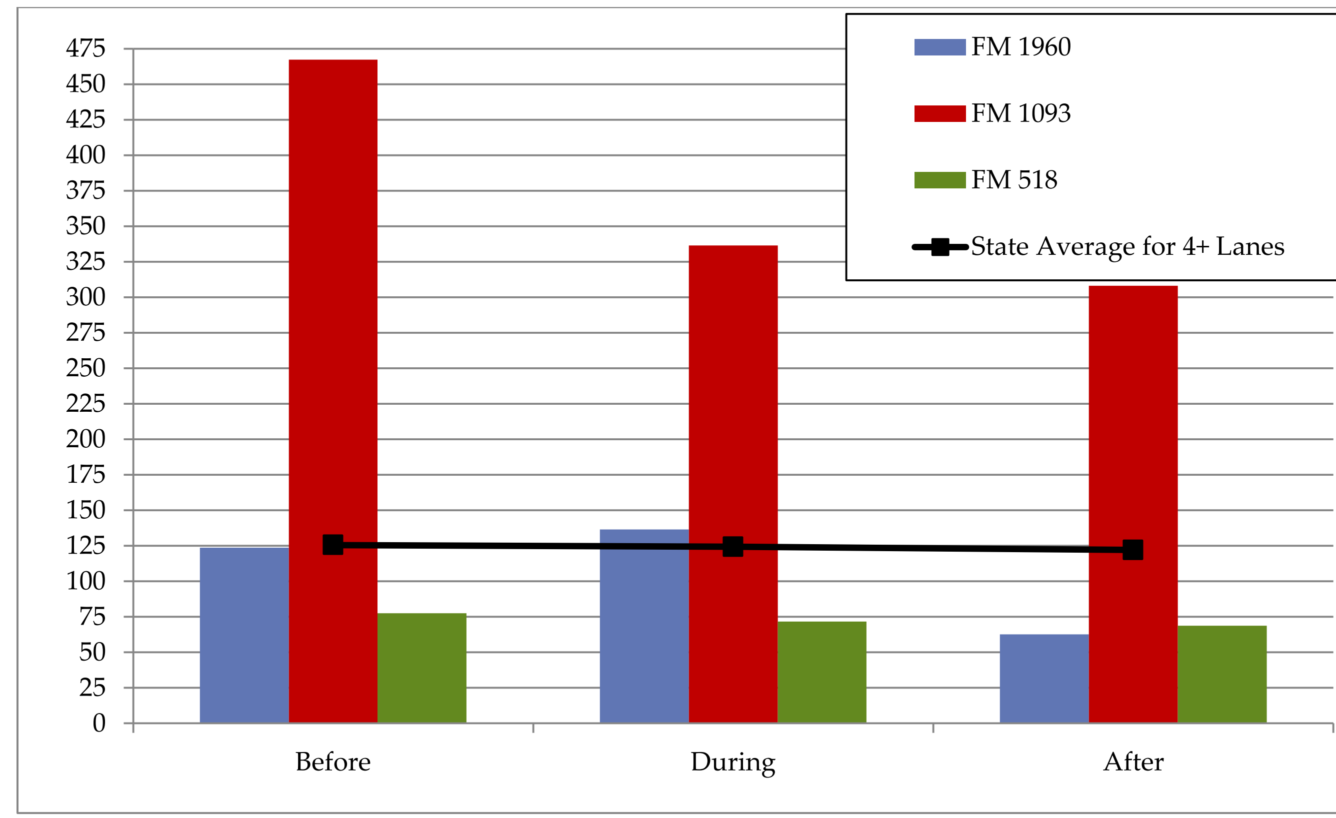


Figure 6-1. Corridor Crash Rate Compared with Statewide Average for Four Lane Divided Arterials

Some of the decreases in crashes may be attributed to the overall reduction in crashes in the region. However, the larger reductions were realized in the most congested sections. As expected, driveway-related crashes decreased by 40 to 70 percent. Other crashes attributed to certain contributing factors, including entering/exiting vehicles, rear-end and intersection-related crashes were also reduced. A review of crash severity stats indicated that almost 90 percent of the crashes on these three corridors result in non-injury crashes.

Safety is always a primary goal of all operating agencies and should hold significant weight in project design and selection. Access management principles are effective in reducing crashes and should be included in corridor safety evaluations. Crash frequency and rates can be used to evaluate corridors for potential improvements. In addition, new tools such as the Highway Safety Manual can be used to evaluate specific sections and design elements. Currently, there is a limited number of Crash Modification Factors (CMF) related to access management design features; however more are currently being developed.

To summarize, this evaluation determined the following regarding the application of access management:

- Overall, both the number of crashes and crash rates were reduced;
- Driveway-related and rear-end collisions were reduced;
- The measures of crash frequency and severity should be paired with Highway Safety Manual methodology to assess access management in future corridor studies.

Economics Summary

The purpose for the economic analysis was to gain understanding on the potential impacts access management improvements had on taxable business sales and ultimately the effects of access management on economic growth along the corridor. Generally, the trends from the three corridors studied suggest that taxable business activity increased at a greater rate along these corridors than in the adjacent zip code analysis zones. The FM 1093 corridor far out performed the control zip code (41 percent) which ranged from 81 to 142 percent. The FM 1960 corridor had mixed results ranging from 67 percent to -35 percent compared with the average control zip code four percent. FM 518 showed mixed results with a control zip code percent change from before to after of 39 percent while the sections ranged from -15 to 19 percent. The smaller sample sizes in FM 518 contributed to the high variability.

However, the following events occurred during the study period that could have had an extraneous effect on business activity in the Greater Houston region: Hurricane Rita (2005); Hurricane Ike (2008); Economic Recession (2007-2009); and oil production downturn and upturn. These confounding factors and other events could have played an additional role and could have affected the results in unknown ways, but it appears that there is very little evidence that supports the theory that businesses along the access management corridors were unduly burdened by such improvements.

Figure 6-3 shows that FM 1093 saw the largest growth in taxable sales receipts of the three corridors. FM 518 was the only corridor that exhibited a total change in taxable sales less than the zip code control zone. The small sample sizes contribute to the variability, as well as, less dense retail along the corridor. Overall the percent growth from before to after was positive in all corridors.

Figure 6-2. Access Management Improvements on FM 1960 West of Cypress Station

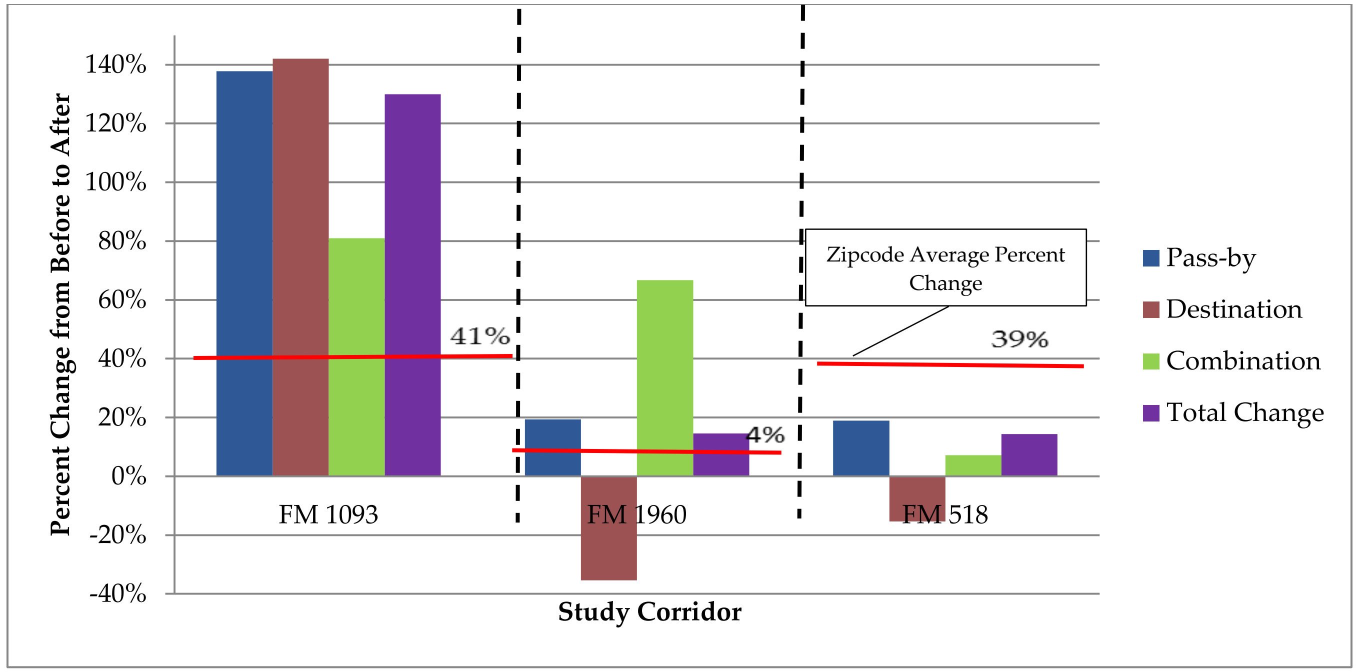


Figure 6-3. Percent Change (Before to After) of Taxable Sales Compared with Control Zone Zip Code Taxable Sales.

Access Management/Corridor Study Framework

The original studies (FM 1093) were planning level studies, while later studies (including FM 518 and FM 1960) were more specific and used by implementing agencies as working documents as guides for implementation as opposed to an alternatives or options study. Future access management studies should include:

- A stated purpose of the study – implementation (lower-level analysis and recommendations) or alternatives (higher-level and conceptual);
- If a study is geared more towards implementation, the results of the study should include more detail regarding the geometric design elements for proposed improvements which are based on traffic data collected for the study. It should also be revisited if the time elapsed between publishing and implementation is more than three years.
- The operational analyses are an important part of an access management study in order to identify intersections and other elements for improvement. However, assessing the success of an access management project solely based on operational parameters is not recommended; there should be a significant component of the assessment based on safety improvements.
- The inclusion of a crash analysis should be required in any access management study of an existing corridor which experiences recurring congestion. The results of that analysis should be carefully evaluated to formulate strategies to mitigate the existing crash characteristics in the corridor. For emerging corridors, the crash analysis can be used as a baseline to track changes in statistics as development occurs along the corridor, and as justification to implement logical access management techniques over time.
- The implementation of an access management project can be a period of uncertainty for businesses along a corridor that is changing. Even though the results of this analysis indicates an overall positive impact on business indicators, implementing agencies should provide outreach to the business community along a corridor to listen to their concerns and mitigate them where possible, both before and during construction activity.
- In summary, these access management studies can be used in two primary ways:
    - To address an existing problem (crashes and congestion); and/or
    - To guide access for development to where access points are optimally located for operations and safety to generate maximum value of return with respect to roadway user cost (through increased mobility and reduced property loss and injury) and private return on investment of development of adjacent tracts in emerging corridors.

We would also recommend that a graphical historic database of HGAC access management and mobility studies be developed. Agency staff and elected officials change periodically and having one place for stakeholders to view the breadth of corridors studied would be a valuable reference.

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[i] More information regarding NAICS code terms can be found by accessing the following link: http://www.census.gov/eos/www/naics/

[ii] The Texas Comptroller of Public Accounts historical sales tax information search tool can be found at https://ourcpa.cpa.state.tx.us/allocation/HistSales.jsp.

[iii] Researchers are unable to make any significant conclusions from this trend due to the relatively small sample size of businesses in this category.

[iv] More information on the extent of Hurricane Ike can be found here: http://www.fema.gov/pdf/hazard/hurricane/2008/ike/impact_report.pdf