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16. Abstract

In the research documented here, researchers develop information to communicate the safety and economic impacts of converting frontage roads from two-way to one-way. Researchers studied five locations in Texas where frontage roads were converted from two-way operation to one-way operation. Researchers identified a comparison site in Texas that remained two-way for comparison to four of the treatment (conversion) sites.

Researchers developed accident modification factors (AMFs) related to frontage road conversion segments that roadway designers can use to guide frontage road conversion project planning. Researchers developed AMFs based on non-property-damage-only (non-PDO) crashes for segments and interchange intersections. Researchers developed 12 AMFs and provide confidence intervals around the estimates. Researchers describe how the AMFs were developed, associated caveats, and how to apply the AMFs. Researchers also document the process used to build the safety database from electronic data-sets and printed crash reports. Finally, researchers provide recommendations to facilitate and expedite future crash analyses.

Researchers attempted to investigate the economic impacts of frontage road conversion by analyzing gross sales data, appraisal data, employment data, and surveys of business owners/managers and customers. Only the appraisal data and survey information were at the parcel level along the corridors and survey sample size was limited.

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SAFETY AND ECONOMIC IMPACTS OF CONVERTING TWO-WAY FRONTAGE ROADS TO ONE-WAY: METHODOLOGY AND FINDINGS

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was William Eisele, P.E. #85445.

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- Mr. Robert Appleton, P.E., TxDOT Bryan District;
- Mr. Heath Bozeman, P.E., TxDOT Lubbock District;
- Mr. Stephen Gbur, P.E., TxDOT Beaumont District;
- Mr. Chris Hehr, P.E., TxDOT Design Division; and
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CHAPTER 1: INTRODUCTION

INTRODUCTION

Frontage roads have been the primary design solution for providing access along Texas rural freeways and access-controlled principal arterials. In rural and lesser developed urban areas, TxDOT typically operates the frontage roads as two-way facilities, due to relatively long distances between interchanges. As areas with two-way frontage roads become more urban in nature and adjacent land develops, traffic volumes increase, and safety and operational issues become concerns. When this occurs, TxDOT begins to consider frontage road conversion to one-way. Frequently, the conversion projects occur at the urban fringe areas of rapidly growing communities. The motoring public is typically concerned about safety and mobility related to frontage road conversion, while business and property owners are concerned with economic impacts associated with access, business activity, and property values. This research will fill the need for updated information on the safety and economic impacts of frontage road conversion.

Project Objectives

This research effort addressed four objectives:

1. Develop accurate information that can be used to communicate the types of safety impacts that have been experienced and can be expected.
2. Develop accident modification factors (AMFs) that roadway designers and decision-makers can use to guide frontage road conversion project planning.
3. Develop accurate information that can be used to communicate the types of economic impacts that have been experienced and can be expected.
4. Identify any issues identified in crash data obtained as a result of this analysis.

Research Methodology

This research primarily has two tracks—a safety component and an economic component. Pursuing the safety component included evaluating crash data (historical electronic data and printed crash reports) and performing both a statistical analysis and a “hot-spot” safety analysis. Chapter 3 documents the data collection and the reduction of the crash data into a consistent dataset for analysis. Chapter 4 documents the safety analysis.

Researchers also performed an economic analysis that included investigating gross sales, appraisal values, and employment data, as well as distributing surveys to business owners/managers. Chapter 5 contains data collection and findings of the economic analysis.

Researchers performed six tasks to satisfy the objectives listed above. The tasks were:

1. Examine related material, practices, and Texas experiences.
2. Develop experimental design and select case study corridors.
3. Develop surveys.
4. Perform data collection.
5. Perform data reduction and analysis, document crash data "lessons learned," and develop accident modification factor(s).
6. Develop deliverables.

Organization of Report

This report is organized into six chapters and nine appendices, as described below:

- Chapter 1—Introduction: Provides an introduction to the research topic and presents project objectives, methodology, and report organization.
- Chapter 2—Literature Review: Provides a summary of previous research relevant to the topic.
- Chapter 3—Site Selection, Data Collection, and Data Reduction: Provides an overview of site selection and the data collection and data reduction performed for the safety analysis.
- Chapter 4—Safety Analysis and Findings: Provides a discussion of the findings and conclusions related to the safety analysis.
- Chapter 5—Economic Data Analysis and Findings: Provides a discussion of the data collection, data reduction, findings, and conclusions related to the economic analysis.
- Chapter 6—Conclusions and Future Work: Summarizes the key conclusions of the work as well as future opportunities.
- Appendix A—Contains maps and photographs of key operational and geometric characteristics from conversion and comparison sites.

- Appendix B—Includes all crash variables used in the electronic database.
- Appendix C—Contains control section and milepoint information for all case study locations provided by TxDOT.
- Appendix D—Illustrates crash data discrepancies between printed and electronic data.
- Appendix E—Contains maps showing analysis units for each site for the safety analysis.
- Appendix F—Provides supporting discussion of statistical analyses.
- Appendix G—Includes gross sales tables and figures.
- Appendix H—Contains business owner/manager and customer survey instruments.
- Appendix I—Provides additional data analysis for surveys.

CHAPTER 2: LITERATURE REVIEW

INTRODUCTION

In Texas, frontage roads typically exist in rural and urban environments along state highway corridors. Their primary function is to distribute and collect traffic between local streets and interchanges. They also serve other purposes, depending on the type of facilities they serve and the characteristics of the surrounding areas. For instance, frontage roads control access, provide access to adjacent properties, and maintain circulation on each side of the highway (*1*). In general, they usually run parallel to the main traveled way and are typically on both sides of the roadway. Depending on the characteristics of the adjacent land, frontage roads can operate as one-way or two-way.

Frontage roads have been the primary design solution for providing access along Texas rural freeways and access-controlled principal arterials. The Texas Department of Transportation (TxDOT) has developed several guidelines for designing rural frontage roads (*2*). The guidelines address various important design elements, such as selecting the proper design speed, lane and shoulder widths, and type of operation (i.e., one-way or two-way).

Despite their benefit of providing access control, there are circumstances where the use of frontage roads can become problematic. For instance, on high-speed roadways, closely spaced intersections could increase the likelihood of crashes (*1*). In addition, drivers could potentially turn left from a connecting local street onto a one-way frontage road. Limiting access along frontage roads is also imperative, as increased access density is directly related to increased crashes (*3,4*).

In rural and lesser developed urban areas, the frontage roads are usually operated as two-way facilities, due to relatively long distances between interchanges. As areas with two-way frontage roads become more urban in nature and adjacent land develops, traffic volumes increase, and safety and operational issues become concerns. When this occurs, TxDOT begins to consider frontage road conversion to one-way. The challenge is to effectively communicate to stakeholders and interested parties the benefits provided by converting frontage roads and what types of impacts may reasonably be expected. Historically, frontage road conversions have been made with the objective of improving traffic operations and safety. Operations are improved by removing conflicts at entrance and exit ramps where opposing traffic must yield to traffic entering and exiting the mainlanes. Signalization is also more efficient. When conversions are implemented, conflicts for traffic entering and exiting the mainlanes are reduced (i.e., no crossing conflicts remain) (*5*).

The next section of the literature review summarizes the literature on the safety and operational performance of frontage roads and AMFs and crash reduction factors (CRFs). Then the literature discusses the economic impacts of frontage road conversions. Finally, the last section summarizes the highlights of this review.

SAFETY AND OPERATIONAL IMPACTS

This section describes the literature review on the safety and operational impacts related to frontage road operations. The first subsection describes studies that document the safety performance of one-way and two-way frontage roads. The second subsection provides details about existing AMFs. The last section deals with statistical methods with respect to safety impacts.

Safety and Operational Performance

This subsection is divided into two parts. The first part describes previous studies that examined the safety effects of converting frontage road operations. The second part describes factors affecting frontage roads.

Safety Effects of Frontage Road Conversion

Researchers document four relevant studies here. Woods et al. performed the first study in 1983 for TxDOT (*6*). The authors identified operational and safety problems associated with two-way frontage roads. In this study, problems related to two-way operations included the number of conflict points and possible movements that are higher for two-way operations than for one-way. Two-way frontage roads can also be subjected to operational problems such as increases in delay and reduction in capacity. Crash and operational data were collected at 22 study sites, and the analysis of crash frequency and rate was performed on frontage road segments and ramps. Woods et al. reported that slip ramps had the most frequent erratic driving maneuvers, and the average daily traffic (ADT) and level of area development had a significant effect on crashes at ramp-frontage road intersections.

In the follow-up study, Woods and Chang evaluated crash frequency and severity after converting two-way frontage road operations to one-way (*7*). Nine frontage roads with segment lengths varying between 0.9 and 9.5 miles were selected for evaluation. Researchers collected data for a minimum of two years for each site for those that were converted between 1975 and 1981. Using the Wilcoxon matched-pairs signed rank test for their analysis, the authors found a reduction of about 20 percent in crash frequency after conversion. They did not find any statistically significant reduction in crash severity.

This naïve before-and-after analysis (i.e., no comparison sites that remained two-way frontage roads were used) was based on short periods of before-and-after data (at most, two years for each period). Such an analysis fails to distinguish the effect of treatment (conversion) from the effects of other factors that might have also changed from the "before" to the "after" period (*8*). As a result, the validity of the conclusion that there is a significant reduction (of about 20 percent) in crashes after the conversion to one-way operation seems questionable. Transportation safety analysts no longer consider the method used by the authors reliable (*8*).

In 1984, Woods summarized the results of a series of Texas Transportation Institute (TTI) reports (report series 288) regarding the safety and efficiency of frontage roads and proposed warrants for converting two-way frontage roads to one-way (*9*). He examined the data collected in the previous studies. From the data, he reported that the factors affecting crash rates were not the type of ramps but the roadside development and the volume of traffic traveling on the frontage road. Consequently, he proposed two warrants, depending on frontage road volumes and crash experience, based on the crash analysis and erratic driving maneuver for two-way frontage roads. The primary limitation of the analysis is the aforementioned fact that comparison sites were not included in the analysis to account for site selection and regression-to-the-mean biases.

Another study, performed by the Texarkana Metropolitan Planning Organization in 2001, examined the feasibility of converting two-way frontage roads in Texarkana (*10*). The study was performed because operational problems had appeared due to the increase in traffic volumes along the study corridors. This study did not analyze crash data. Field investigations were conducted to identify the geometric configurations of interchanges, and traffic volume data were collected at nine interchanges in Texarkana. The study concluded that traffic volume would increase at key interchanges in the IH 30 corridor due to the commercial development in the future and operational problems would arise when the traffic volume reached moderate levels. Based on previous TTI studies, the study noted that one-way operations would be safer and more efficient than two-way operations. At the time of this documentation, construction is underway to convert the frontage roads in Texarkana from two-way to one-way and to connect discontinuous frontage roads in the area along IH 30.

A recent study examined six characteristics before and after frontage road conversion in Arkansas (*11*). Researchers investigated the number of crashes, traffic volumes, speeds, travel times between nodes, land use, sales tax for selected businesses, and business owner opinions. For crash data, researchers used two years of crash data (2000–2001) as the before period and two years of crash data (2005–2006) as the after period. Researchers did not include the construction years (2003 and 2004) in the analysis. Researchers found that mainlane crashes decreased 40 percent (by 235 crashes), frontage road crashes decreased 30 percent (by 235 crashes), and ramp crashes increased 20 percent (by 6 crashes) after the conversion. Researchers did not have comparison sites in the analysis. Twenty percent to 40 percent of crash reports were located incorrectly in the summary database. Researchers did a detailed review of individual crash reports to correct this error. As for other operational characteristics, there was an approximately 1 percent increase in traffic volume and a 5 mph increase in speed. The researchers did not observe economic impacts on businesses based on lane use type and taxable revenue when comparing before and after the conversion.

Another study compared the crash frequency of different types of urban roadway segments, and the results show that frontage roads with diamond interchanges have higher crash rates (4.59 crashes per million vehicle-miles of travel [VMT]) than frontage roads without diamond interchanges (2.19 crashes per million VMT) and also higher crash rates than mainlane (2.49 crashes per million VMT). This study hypothesized the possible reasons as more traffic conflicting points, turning movements, frequent lane changing, and pedestrians (*12*).

Factors Influencing Frontage Road Operations

This section describes studies that have examined factors associated with operations on frontage roads. There have been several studies performed on factors related to frontage road operations.

In 1981, Stockton et al. evaluated the 1979 law that required drivers on frontage roads of a controlled-access highway to yield the right-of-way to drivers using ramps in the interest of driver safety and travel efficiency (*13*). To assess public awareness and perception of the new law, researchers conducted a survey at ramps and frontage sections in Austin and Bryan/College Station. Researchers interviewed a total of 471 drivers. The authors found that uniformity had been improved in some instances since the law was introduced. Researchers found that for ramp terminals on one-way frontage roads, the law had an overall positive effect, while on two-way frontage roads, the results depended upon ramp type. Therefore, the authors recommended the law be amended to address one-way frontage roads only.

In 1987, Stover and Gattis evaluated attitude of drivers toward the conversion of two-way to one-way frontage roads (*14*). The authors conducted 121 interviews in 15 small and medium-sized Texas communities. Researchers conducted in-person interviews (Bryan/College Station) or by telephone or mail (other cities). The interviewees included city staffs, council members, real estate appraisers, real estate and development interests, and owners of abutting businesses. According to the analysis of survey responses, staff and council members were strongly in favor of one-way frontage roads. On the other hand, business owners, real estate representatives, and developers favored two-way frontage roads because they thought converting two-way operations to one-way was detrimental to their business. Most individuals (85 percent of respondents) thought one-way frontage roads were safer than two-way frontage roads from a traffic safety perspective.

In a subsequent study sponsored by TxDOT, Gattis et al. derived relationships between delay and traffic volume on frontage roads and freeway ramps connecting to these roads (*15*). The authors evaluated four case study types:

- one-way frontage road intersection with exit ramp converging movement,
- two-way frontage road intersection with exit ramp converging movement,
- two-way frontage road intersection with exit ramp with contraflow movement, and
- two-way frontage road intersection with entry ramp with contraflow movement.

"Contraflow movement" refers to traffic flow traveling in opposite directions between the ramp and the intersection. Researchers collected the data at ramps located in the Texas cities of San Marcos, College Station, and Bryan. With the volume and delay data collected, researchers calculated and used several parameters for developing the relationships to estimate delay using queuing theory. Finally, for the four case studies, researchers derived a delay model as a function of ramp volume, frontage road volume, and gap acceptance characteristics. Analysts can use the derived model to estimate overall delay of frontage road traffic, and when combined with measurements of travel speed and distance, it will help to evaluate effects of travel time for operational strategies of frontage roads.

Messer et al. developed numerical operational warrants for converting two-way frontage roads to one-way and applied these warrants to five case studies in Texas (*5*). Researchers established these warrants to provide the most efficient possible traffic flow on a one-way or two-way frontage road. They categorized the warrants in three levels based on different traffic volume characteristics.

Jacobson et al. evaluated frontage road operations and developed guidelines for recommended distance between an exit ramp and driveways located downstream of a ramp (*16*). They analyzed crash data at existing frontage roads, collected onsite geometric design characteristics, and preformed simulation studies. Researchers collected crash data for a six-year period at 32 ramps located on five urban freeways. Jacobson et al. reported that crash rates decreased as the distance between the exit ramp and the first driveway downstream increased (*16*). The authors suggested guidelines for the non-freeway weaving section (i.e., before the driveway so the driver can safely decelerate to turn), in which the minimum weaving distance should be 460 ft. In addition, the desirable weaving distance was based on the total volume, downstream driveway volume, and number of weaving lanes considering the level-of-service (LOS) of frontage road operation.

To determine the distance to safely access the ramp from an upstream driveway, Jacobson et al. collected data including the distance between the driveway and the entrance ramp, frontage road traffic volume, frontage road vehicular speed, minimal variability in vertical and/or horizontal curvature of roadway geometry, frontage road driveway (access) density, and the number of lanes at five sites located in San Antonio and Austin (*17*). Using crash data from 1995 to 1998, they reported that the crash rate significantly increased (by a magnitude of two or three) on sections where driveways were located within 100 ft or less downstream of an entrance ramp and recommended that the desirable distance should be 200 ft upstream and 100 ft downstream of the entrance ramp.

Another important factor related to the operations and safety of frontage roads is the yield treatments and associated geometric design (merging and weaving). TxDOT-sponsored project 0-4986, "An Assessment of Frontage Road Yield Treatment Effectiveness," developed guidance for choosing exit ramp/U-turn yield treatments by building the Frontage Road Yield Treatment Analysis Tool (FRYTAT). The software tool can determine appropriate yield treatments at exit ramp/U-turn and frontage road merge areas by the measures of effectiveness (MOEs) collected during simulation. Measures used include a performance index for the countermeasure, which is a function of delay, speed, and total crashes (*18*).

Two studies have documented regression models for estimating the safety performance of frontage roads. In the first study, Kockelman et al. briefly examined the safety performance of frontage roads near Austin (*19*). This study was part of a much broader analysis of frontage roads, which is described in the next section. Through multivariate linear regression analysis, they found that higher access densities and speed variations had a negative effect on safety. This work examined a limited number of sites and the approach used is not appropriate for analyzing crash data because crash data are non-negative discrete count events and linear regression models cannot be used for such data (*20*).

Accident Modification Factors and Crash Reduction Factors

An AMF represents the change in safety when a particular geometric design element changes in size from one value to another. An AMF greater than 1.0 represents the situation where the design change is associated with more crashes, while an AMF less than 1.0 indicates fewer crashes. Below are some relevant studies on AMFs.

Lord and Bonneson described the role and application of AMFs within the highway design process (*21*). They first described the concepts and characteristics associated with the AMFs and provided a framework to include them in the design process for safety evaluation and analysis. Furthermore, the authors proposed three applications where these factors could be used: during the preliminary design stage, for assessing design consistency, and for evaluating design exceptions. Finally, the authors showed how to apply the AMFs for application using a series of examples.

Researchers developed the *Roadway Safety Design Workbook* for TxDOT that contains methods for predicting crashes on freeway segments, rural highway segments, and frontage roads (*22*). The methods include AMFs for grade, lane width, outside shoulder width, inside shoulder width, median width, shoulder rumble strip presence, and utility pole density and offset. As part of this project, Lord and Bonneson developed AMFs based on the Poisson regression model described above (*23*). AMFs were developed for lane width, shoulder width, and edge marking delineation for rural two-way frontage roads. Researchers did not investigate AMFs for frontage road conversion.

Similar to AMFs, crash reduction factors are sometimes used. A CRF is the estimated percent crash reduction of some specific countermeasure(s). The term CRF has historically been used, and it includes the word "reduction" because there was an expectation that improvement would result in reduced crashes. Sometimes, however, a reduction is not found, and the term AMF gained some popularity. Several studies document the CRF calculation process and its application (*24,25*). An FHWA report documents current CRF values of various countermeasures, and two items are related to frontage roads (*26*). The CRF of installing a frontage road is 40 percent, and the CRF of converting a roadway from two-way to one-way is 26 percent (not specific to frontage road conversion). These values are based on Agent et al. (*27*) and Gan et al. (*28*).

RELATED ECONOMIC IMPACTS LITERATURE

This section covers the literature on the economic impacts associated with frontage road conversions or studies that are relevant to this research. The studies include literature where frontage roads were converted from two-way to one-way.

Eisele and Frawley (*29*) conducted a study on the economic impacts on adjacent businesses that result from the construction of raised medians. They developed a methodology for estimating the economic impacts for designing raised medians in urban areas. They proposed an eight-step process and evaluated their methodology using case studies. To accomplish the study objectives, researchers collected data on corridor characteristics, median installation, and business information in College Station, Texas, and other cities. Researchers used mail-out surveys, personal interviews, and customer surveys to obtain the data from respondents. The authors analyzed the data using stratified samples divided by sizes and business types. Furthermore, they produced aggregate statistics of gross sales, employment trend, and property value trend data compared to state, cities, and counties.

The study provided business and property owners with information regarding potential economic impacts of raised median installation on businesses and properties. The key results of the research effort are as follows: 1) about 90 percent of business owners showed that their regular customers were as likely or more likely to endorse their business after the median installations; and 2) most business types, with the exception of gas stations and automotive repair shops, observed an increase in the daily numbers of customers and in gross sales. The construction activities generally had a negative effect on adjacent businesses. The methodology developed from this research investigating the economic impacts of raised median installation was valuable for adoption and use on this project.

Kockelman et al. (*19,30*) comprehensively evaluated frontage road design policies and financial, operational, legal, and land development issues related to the policies. They surveyed 19 state departments of transportation (DOTs) to obtain information about the process for building frontage roads. In addition, they collected data on frontage roads located in or near Austin, Texas. The data collected included vehicle miles traveled, access density, and vehicle speeds. Using a geographic information system (GIS) and demographic data, a corridor pair analysis was conducted to know whether frontage roads encourage commercial development of moderate to high intensity alongside freeway corridors. For the operational analysis, researchers used CORridor SIMulation (CORSIM) to analyze the effects of one-way frontage roads. The results indicated that non-frontage road configurations performed as well, if not better, than frontage roads.

In the second part of the study, Kockelman et al. (*19,30*) compared freeway corridors that had frontage roads with freeway corridors that did not include frontage roads. They reported that frontage roads improved the operations of the freeway mainlanes in markedly developed areas compared to corridors with no frontage roads. They also found that the construction, land, and access costs of freeway corridors that included frontage roads were higher than those that did not include frontage roads.

Hanning (*31*) and Gattis et al. (*11*) studied the effects of converting frontage roads on the road network, land use, and traffic safety. To accomplish the objective of the study, researchers examined changes in travel time, land use, tax, and volume data along the frontage roads located between Little Rock and Benton, Arkansas. Researchers performed a before-and-after study for the operational effects. Researchers collected tax and business data and public opinion surveys for evaluating the economic effects of the conversion. Researchers collected the opinions of business owners about the conversion separately. According to the results, it was difficult to clearly define the impacts of traffic volumes on frontage roads before and after conversion.

The authors investigated roadway volume along the frontage roads, overpasses, and parallel roadways before and after conversion. After conversion, the volume on the frontage roads decreased, but the volume on the overpasses and parallel roadways increased and the overall average daily volume increased. Therefore, it was not possible to identify the effect of frontage road conversions on traffic volumes. Researchers found one-way operations to have lower travel times between fixed nodes before and after the conversion. One-way operations had more opportunity for traffic flow to operate under free-flow conditions between nodes, with an associated decrease in vehicle delay, compared to frontage roads with two-way operations.

In terms of land use, the impacts were mixed following the conversion. Some sites had positive impacts, while others had negative impacts. Some business owners felt the construction phase of the conversion may have a bigger effect on business than the conversion. Researchers also found that taxable revenues were significantly lower after conversion. Although the business owners perceived that one-way operation was safer than two-way, they anticipated their sales to be reduced due to the conversion. Researchers measured the business impact by tax amount for restaurants and motels only in Little Rock, Arkansas. Stover et al. documented a similar result that while most people acknowledge the safety improvement of one-way operation, individuals do not understand the capacity and operational advantages of one-way operation (*14*).

In 2004, TxDOT contracted with Kimley-Horn and Associates to analyze the business vitality and evaluate economic impacts after conversion of frontage roads from two-way to one-way operation (*32*). To meet the objective, researchers identified five study corridors in San Marcos, Hillsboro, Huntsville, Sulphur Springs, and Mansfield. Researchers conducted an analysis of local, regional, and state economic trends focusing on the differences between two-way and one-way conversion to examine whether economic characteristics of properties located adjacent to converted frontage roads were different. Frontage road business owners felt that one-way frontage roads reduced traffic congestion and increased traffic safety. However, they felt that the conversion reduced access to their property. The study revealed that business owners that were subjected to frontage road conversions in 2000 or 2001 were more satisfied than those whose frontage roads were converted more recently to being interviewed (i.e., 2002 or 2003). This implies that it may take customers some time to become accustomed to the frontage road conversion. Overall, it seems that there were no adverse economical impacts for businesses that were surveyed three years after the conversion.

CONCLUDING REMARKS

This review summarizes the literature on the safety and operational impacts of converting two-way operations to one-way, on statistical methods, and on the economic impacts of frontage road operations. The review has shown that converting two-way frontage roads to one-way is usually associated with a reduction in crashes, although the methods previously used to estimate the safety effects suffer from important methodological problems. In general, researchers found the operational characteristics of one-way frontage roads to be superior to those of two-way frontage roads.

This chapter identified three key studies on the economic aspects of frontage road conversion. In the first one, researchers found that the construction, land, and access costs of freeway corridors that included frontage roads were higher than those that did not include frontage roads (*19*,*30*). In the second study, the conversion of frontage roads in Arkansas showed that some businesses were affected positively, while others were influenced negatively (*11*,*31*). In the last study, Texas businesses where the conversion occurred three or four years prior to being surveyed were, in general, not negatively affected by the conversion of frontage roads (*32*).

CHAPTER 3:
SITE SELECTION, DATA COLLECTION, AND DATA REDUCTION

SITE SELECTION

Case Study Characteristics Summary

Table 3-1 includes the characteristics of the selected case study corridors where frontage roads were converted. Researchers investigated possible conversion study corridors throughout Texas and performed site visits. The prioritized sites shown in Table 3-1 provide different highway types, geographic representation throughout Texas, and an adequate amount of economic development. Most were converted in the last five to seven years (at the time of site selection), and most have a representative comparison site. Table 3-2 shows the characteristics of the comparison sites that will be compared to the conversion sites. The comparison sites currently have two-way frontage road operation. At the time of this writing, the Huntsville comparison corridor in Table 3-2 has been mostly converted to one-way operation. Appendix A shows photographs and maps of each conversion and comparison corridor used in the subsequent analysis.

Table 3-1. Characteristics of Selected Case Study Sites where Frontage Roads Were Converted.

City	TxDOT District	Road	From	To	Length (miles)	Conversion Year
Sulphur Springs	PAR	IH 30	SH 19	SL 301	5.0	2001
Huntsville	BRY	IH 45	Ave S/Smither	FM 1791	2.8	2001
Wolfforth	LBB	US 62/82	CR 1300/ Quitsna Ave	82nd St/ CR 7100	2.5	2001
Hillsboro	WAC	IH 35	SH 22	FM 286	0.6	2001
Burleson	FTW	IH 35W	Ricky Lane	Alsbury Blvd	3.7	2004
Rockwall	DAL	IH 30	FM 3097/Horizon Rd/Village Rd	FM 549	3.4	See Note
Seguin	SAT	IH 10	N. Guadalupe St	SH 123	1.2	See Note

Note: The Rockwall and Seguin conversion year dates were not exactly known by TxDOT officials. After investigation, the conversion year was found to be too long ago to be an effective corridor for analysis. See chapter text for further details.

Table 3-2. Characteristics of Selected Case Study Corridors for Comparison to Conversion Sites in Table 3-1.

City Where Comparison Is Located	Comparison for What City?	TxDOT District	Road	From	To	Length (miles)
Greenville	Sulphur Springs	PAR	IH 30	SH 34	Division	2.8
Huntsville	Huntsville	BRY	IH 45	Ave S/ Smither	Park Road 40	5.8
Plainview	Wolfforth	LBB	IH 27	Bus IH 27 North	Bus IH 27 South	7.6
West	Hillsboro	WAC	IH 35	Wiggins Rd	McLennan Co. Line	5.9

Note: An appropriate comparison site for Burleson was not available.

Case Studies Not Used for Economic or Safety Analysis

Two of the case studies listed in Table 3-1 were not used in subsequent analysis. The reasons are documented below.

Seguin, Texas (IH 10)

There are two segments of IH 10 in Seguin with frontage roads. One of these segments has two-way frontage roads, and the other segment has one-way frontage roads. The original information provided to the researchers was that the one-way frontage road segment had been converted in 2005. The research team set up interview appointments with business owners and managers along the conversion corridor and began conducting interviews for the economic analysis. Interviewees told the researchers, however, that the conversion had taken place well over 10 years ago. Conversions that occurred that long ago do not lend themselves to being case studies due to the lack of previous crash and economic data. Therefore, after conducting a few interviews, the researchers decided to discontinue the interview process in Seguin.

Rockwall, Texas (IH 30)

Initial information provided to researchers indicated that the IH 30 frontage roads in Rockwall had been converted in 2007. A researcher visited the local Chamber of Commerce to inquire about obtaining a letter of support to send to businesses. The Chamber of Commerce representative indicated that only a short segment on the north (westbound) side of IH 30 had been converted recently. Researchers began investigating the conversion date further, making several contacts with the Dallas District, Area Office, and Rockwall County Maintenance Office.

An employee of the Rockwall County Maintenance Office informed the research team that only a short (less than one-quarter mile) segment had been converted on the south (eastbound) side. This segment does not contain enough businesses to perform an economic impact analysis. Therefore, the IH 30 corridor in Rockwall was not selected as a case study for the project.

Case Study Used for Safety Analysis Only

Burleson, Texas (IH 35W)

The frontage roads along IH 35W in Burleson were converted to one-way in 2004. This time span works very well for a case study in most instances. As the research team was attempting to schedule interviews with business owners and managers, a much higher than typical percentage of potential interviewees refused to meet with researchers. Many of those refusing to be interviewed stated that the researchers needed to contact their corporate offices. Although researchers did not perform thorough comparisons with other corridors, they did note that some of the businesses that referred the scheduler to corporate offices were from the same chains that participated in interviews in other cities. This corridor has experienced substantial growth in the years since the conversion, meaning that many of the businesses would have no pre-conversion economic data to offer. While the recently opened businesses do not provide interviewees and economic data, their presence seems to indicate that the frontage road conversion has not impeded commercial development along the corridor. While this corridor was not used as an economic impacts case study, the research team did use it for the safety analysis.

DATA COLLECTION

Obtaining Electronic Crash Records for Safety Analysis

Researchers obtained the electronic records of all crashes relevant to each study site from two different sources. One source was the TxDOT Crash Records Information System (CRIS) database, which contains all the information recorded on peace officers' crash reports for the years 2002–present, with the exception of narratives and diagrams, coded into fields. Researchers obtained crash records from the CRIS database for the years 2005–2007 initially, and then for 2003–2004 at a later date in the project. TxDOT informed the research team that the 2002 data were incomplete and should be omitted from analysis.

The research team obtained further crash records for the years 1998–2001 from a second source: the Department of Public Safety (DPS) historical (electronic) crash database. This database is composed of coded information obtained from the peace officer crash reports for crashes in Texas through the end of 2001. At that time, the database was maintained by DPS and updates were sent to various agencies in Texas, including TTI. The research team obtained the data for this project from the historical data in TTI's archives of the crash record database.

All told, both databases contain more than 200 information fields pertaining to data about the crash itself, the drivers and vehicles involved, any casualties as a result of the crash, and roadway information. From this list of information fields, researchers selected approximately 53 that were determined to be relevant to this study and created 13 additional variables that they used in the data reduction phase. Appendix B provides the list of all variables, as well as their relationship to the information on the printed crash records.

Researchers then searched the electronic crash database for all of the crashes occurring anywhere on the control sections containing the study corridors (discussed further in the next section). They then extracted the records of those crashes from the database (each record composed of over 50 fields, as listed in Appendix B) and stored the records in a spreadsheet. Researchers formatted the electronic crash records into spreadsheets showing each crash as one row of data in the spreadsheet; researchers saved the data into separate files by city and organized by the year in which the crash occurred. Table 3-3 shows a sample of crash record data extracted from the database.

Table 3-3. Sample of Electronic Crash Record Data with Selected Columns.

ACC_NO	CNTYCITY	MILE1	MILE2	OTHERFAC	CONTSEC1	CONTSEC2	ACC_YR
8000097	9403	16.0		0	0535-01		1998
8000686	23601	12.7		0	0675-07		1998
8000701	11600	3.0		0	0009-13		1998
8000853	11600	11.3		0	0009-13		1998
8000921	19901	4.7		0	0009-12		1998
8001057	4601	9.6		46	0016-05		1998
8001064	5798	1.2		0	0009-12		1998
8001489	4601	10.1		0	0016-05		1998
8001628	11600	7.5		34	0009-13		1998
8001630	11603	13.9	2.4	5	0009-13	0173-07	1998

Identification of Study Corridors Using Control Section Milepoints

Researchers already had physical descriptions of the conversion and comparison sites, based on route number, county, and limits usually bounded by crossing streets or highways. However, to fully utilize the electronic database and accurately identify crashes at the study sites, researchers had to further describe the sites by control section and milepoint.

Researchers began by reviewing the TxDOT district control section maps and locating the control sections containing all the study sites. They then obtained the electronic records of all crashes on those control sections from 1998 through 2001, using the TTI database archive (discussed in previous section). Overall, researchers identified 7,174 total crashes occurring in the specified control sections during calendar years 1998–2001. Note that the control section was typically much longer than the actual case study location. In some cases, the case study corridor included portions of more than one control section.

All crashes in the electronic database are located through the use of control section and milepoint. While other descriptors may be used to identify some crashes (e.g., names of intersecting streets or highways), the only descriptor that can be applied to all crashes is milepoint. Typically, milepoint values increase from south to north and from west to east. To keep the crashes that occurred within the limits of the study sites, researchers had to determine the limits based on the control section and milepoint.

Initially, researchers used a multi-step process to determine the control section and milepoint values. This process included resolving the TxDOT control section maps (using a "map measuring wheel") with the Google Earth® ruler tool and the TxDOT Roadway Inventory (RHiNo). Researchers also verified control section and milepoint values by checking with crashes at intersections in the crash database.

Researchers identified some discrepancies between the CRIS system milepoints and printed crash reports and between the CRIS system and DPS system milepoint values. Based upon these discrepancies, the TTI research team and members of the Project Monitoring Committee (PMC) met with TxDOT Traffic Operations Division staff to better understand the possible reasons for the discrepancies.

Researchers learned that the DPS database references crashes to the centerline miles from the 1992 roadway inventory roadbed data and CRIS crashes are located from the 2003 roadway inventory file. As a result, there are differences in some milepoints between the two datasets.

Researchers and members of the PMC learned that one must use the control section and milepoint values in DPS and CRIS and not another data source (e.g., RHiNo, Google Earth®, TxDOT district control section maps, etc.) to ensure that the correct control section and milepoint values are used. Subsequent to the meeting, TxDOT Traffic Operations staff provided researchers with the control section and milepoint information for all case study locations. Appendix C shows this information. Note that the information in Appendix C goes beyond the limits of each case study to ensure no crashes were missed.

Using the control section and milepoint information contained in Appendix C, researchers examined the electronic crash records to determine which crashes actually occurred within the study corridors.

Obtaining Printed Crash Reports

Due to the electronic crash records lacking more specific details, such as the narrative and diagram of the crash, researchers requested printed crash reports to aid in the project analyses. Researchers also discovered that the CRIS data did not include key "positional" data that identified on which frontage road the vehicle was traveling or the direction. Therefore, the printed reports were necessary to validate this key information. This is discussed later in this chapter as well.

Initial Reports Request

The research team first requested printed crash reports in March 2008. TxDOT has a site on the Internet (http://www.txdot.gov/contact_us/?id=trf-cdr-email) through which one may request crash reports for specific locations. Per TxDOT suggestion, TTI requested reports using the highway numbers and did not specify "just for frontage roads." TxDOT staff had indicated that specifying frontage roads may inadvertently cause an omission of reports for frontage road crashes. TTI also bracketed the case study segments by requesting crashes between points beyond either end of the case study segments. These bracketed areas were typically to the next exit beyond either end of the case study segment. The bracketing was intended to ensure that the research team received all crash reports for the conversion corridor. In past projects, the research team has observed crash reports that have incorrect locations noted. Sometimes, the incorrect locations led to crash reports being recorded as happening on a study corridor when the crash actually occurred outside of the study limits, and vice versa.

The research team requested crash reports for the Rockwall and Seguin corridors prior to determining that they would not be actual case studies due to the dates of the conversions. Researchers received over 4,500 printed crash records (mainlanes and frontage roads) from TxDOT for all case studies for the years 2001 to 2007.

As in previous studies, the research team also found that printed crash data are generally available for a 10-year historical period. After receiving the initial crash reports, TxDOT instructed the research team that in the future, TTI would need to make requests for specific crash reports based upon the crash numbers used in the electronic database ("ACC_NO" in Table 3-3). It appears the TTI research team was very fortunate to have placed the request when they did, given the change in the report request process.

Second Printed Crash Reports Request

Along three of the test corridors, the variable ROADPART in the electronic crash records for 2005–2007 was miscoded as "mainlane," when it should have been "frontage road," approximately 36 percent of the time (74 of 205 crashes). Without the printed report to confirm the details of the crash, the dataset might have missed crashes that actually took place on the frontage roads. This was a main reason why a project modification was requested. The project modification provided more time to obtain additional crash reports, verify their accuracy, and enter them into the updated project database. For the same three test corridors, researchers did not identify this problem for the DPS database in 2001. Appendix D documents this further.

In early April 2009, the research team submitted a second request for 1,269 specific crash reports for the nine conversion and comparison sites due to this discrepancy of the ROADPART variable. The research team received 1,185 of the 1,269 requested reports in late April 2009. Only 84 reports (approximately 7 percent) were missing. Of all the reports received, researchers determined 241 relevant for analysis (i.e., crash was within the corridor limits and involved a vehicle on the frontage road). Property-damage-only (PDO) crashes were also entered into the database.

Third and Final Printed Crash Reports Request

As part of the modification, researchers added 2003–2004 data to the analysis. In early July 2009, TTI requested 1,493 reports from the TxDOT Traffic Operations Division for the years 2003 and 2004 for the nine conversion and comparison sites. Of the 1,493 crash reports requested, researchers received 1,468 crash reports in late September 2009. Only 25 reports (less than 2 percent) were missing.

Of the reports received, 76 total reports were relevant for analysis and were entered into the final database. The relevant crashes include those that were non-property-damage-only (non-PDO) crashes, were within the corridor limits, and involved a vehicle on the frontage road. Researchers expected that a large number of the crash reports would not ultimately end up in the final dataset, but it was necessary to request the large number of crash reports to ensure that the most relevant crashes were retained for inclusion in the final electronic dataset.

During the research, the research team learned that the definition of a PDO crash changed in 2003, resulting in more PDO crashes in the database after 2003. Because of this change in PDO crashes in trend analyses, the research team focused on retaining only those crashes that were not PDO crashes in 2003 and 2004 (i.e., the 76 total reports retained). The non-PDO crashes include all crashes with fatalities, incapacitating injuries, non-incapacitating injuries, and possible injuries. The definitions of these types of crashes remain consistent over time, and they provide more consistent before-after and trend analyses.

DATA REDUCTION

Reconciliation of Data

Years and Formats of Data

The crash dataset consisted of an electronic crash database for the years 1998–2007 (excluding 2002) and printed crash reports for the years 2001–2007 (excluding 2002). DPS managed the electronic database from 1998–2001 and by TxDOT from 2002–2007. There were some changes in crash variable names and numbering code, some new variables that were added to the 2002–2007 dataset, and some variables that were missing in the 2002–2007 dataset as a result of not being carried over from the 1998–2001 DPS data. In the beginning stages of this project, only 2001–2002 and 2005–2007 crash records were available in the electronic format.

Later on, the 2003–2004 electronic data became available for analysis in this project, and they were incorporated after the project modification.

The printed crash reports were in a form format, with blank fields that an officer hand wrote or typed information into. The electronic records were set up in a dataset format with many crash variables that contained varying numerical coded options per variable. For instance, the weather condition at the time of the crash was handwritten in a box on the printed crash report based on a list of choices on the form. Researchers identified weather-related changes made in the printed report formats between the years 2005 and 2006. For example, for printed reports completed in the years 2001–2005, snowing weather conditions would have been written as a number three, whereas the electronic dataset (2006 and later) would show this weather condition as a number four. Appendix B shows all variable names and values.

Screening of the Printed Crash Data

It was the goal of the research team to collect a consistent and thorough crash dataset for the safety analysis portion of the project based on reported crashes. To organize the printed crash reports, the research team sorted the reports into subgroups based on the following criteria:

- Mainlane: the crash took place on the mainlanes of the interstate or highway.
- Not in the corridor: the crash took place outside the limits of the case study corridors.
- Parking lot: the crash took place in a parking lot or on private property.
- Frontage road only: the crash took place on the frontage road (within the corridor limits) but not at an intersection with another street, driveway access, or ramp.
- Frontage road intersection: the crash took place at, near, or because of a frontage road intersection with another street.
- Frontage road driveway: the crash took place at, near, or because of a frontage road intersection with a driveway access point.
- Ramp: the crash took place at, near, on, or because of a frontage road intersection with an entrance or exit ramp.

Note that the only categories of crash reports above that were relevant to the project based on the location of the crash were the last four. In the analysis, researchers did not consider crashes that took place strictly on an entrance or exit ramp and had no vehicles involved in the crash on the frontage road itself.

Data Translation of All Variables

Because the electronic and printed records were in different formats and did not always match, researchers developed a process of reconciling the printed crash reports with the other variables in the electronic records, as well as reconciling the historic DPS electronic data with the new CRIS electronic data to form a consistent electronic dataset across years. Researchers denoted whether each crash number was available in electronic format only, printed format only, or both. This aided researchers in compiling a list of specific crash numbers to request printed reports the research team was missing.

Researchers analyzed each crash report relevant to the project and verified that each variable in the electronic crash database was accurate, and they made changes in the electronic dataset as needed.

There were some variables that researchers filled in for the 2003–2007 CRIS electronic data that were previously used in the 1998–2001 DPS data. These variables indicated which side of the interstate or highway the crash took place on (east versus west frontage road, for example). These "position" variables were essential in determining which crash records were relevant to the project. These variable names are POSFROM1, POSIMPCT, and DIR2VEH1. The POSFROM1 variable describes where the vehicles were located just prior to the collision, the POSIMPCT variable describes where the collision itself took place, and the DIR2VEH1 variable describes the directions the vehicles were traveling just prior to the collision. This direction was based on knowing in which direction the milepoint values were increasing at a particular study site. This means that a vehicle traveling north might have a different numerical code depending on which study site it was located in because the milepoint values increased in different directions at the study sites.

Researchers found these three variables so important for this research that they went through every relevant crash report for the years 2003–2007 to fill in the values for these variables. Since researchers could only determine the values of these three variables based on analyzing a printed crash report, they were unable to fill in the three variables for the electronic-only crash records, which were missing a corresponding printed report. There were only eight crash records across all study sites that fell into this category. All eight of these crash reports were coded as occurring on the mainlanes, so it is likely they would not have been used in the analysis. Therefore, the researchers hypothesize that missing these eight crash reports did not affect the results. See Appendix B for a full description of all the crash variables.

Without these position variables, the research team could not perform this frontage road safety analysis. Researchers recommend that consideration be given to adding these position variables to the database to aid future safety analyses.

Electronic Crash Record Data Reduction

As mentioned previously, the research team screened the electronic dataset and extracted the crash records that occurred within the case study corridors of the conversion and comparison sites. The team primarily used the control section number, the crash variable ROADPART, and the milepoint variable to identify relevant crash records within the study corridor limits. The variable ROADPART denotes the part of the roadway where the crash took place (e.g., frontage road or mainlane).

Other Crash Data Discrepancies

In addition to the ROADPART issues identified above, researchers identified further discrepancies while working with the printed and electronic crash records. Researchers identified the following items, which are noted below and described in further detail in Appendix D, to provide awareness of these discrepancies to those performing future crash analyses. Appendix D, and the list below, provide details about how the research team updated the final reported crash electronic database for the safety analysis performed in this report.

- Several fields in the electronic crash records were left blank. For crashes that had an available printed report, researchers filled in the blank fields.
- The printed crash reports changed format between 2005 and 2006, effectively changing the meaning of the numbering code for the crash variables. The electronic crash records often did not match the newest numbering code, so researchers converted them to keep all variables consistent.
- The variable denoting the hour the crash took place (TIME) was occasionally incorrect by one hour. Researchers did not perform a time-of-day analysis as part of this research but simply made this observation.
- There were apparent changes in the identifiers used on printed crash reports. The printed reports showed both a crash ID and a crash number, whereas the electronic

dataset only showed the crash number. The reports seemed dependent on using the crash ID as the main identifier, which made it difficult to reconcile the reports with the electronic dataset. Further, the crash number did not always appear on the printed reports, making it difficult for researchers to identify which electronic record matched up to the report, especially if the crash ID was not provided on the cover page handout received with the crash reports. The cover pages were provided to the researchers by TxDOT and included the crash ID, county, and crash date.

- The county and city numbers sometimes changed between years in the electronic records. Though researchers did not use the county and city number variables but rather located crashes with the control section and milepoint, they made this observation.

Preparing the Electronic Dataset for Statistical Analysis

To facilitate locational crash analysis along each case study corridor, the research team identified different roadway classifications called "unit types." Each analysis unit along each corridor was assigned a unit type. The main purpose of the unit types was to separate the later statistical analysis into appropriate groups (e.g., segment and interchange). The following list describes each unit type in more detail.

- Interchange intersection:
    - Interchange intersections occur where the frontage road intersects a cross street.
    - More specifically, researchers defined the intersection as the physical area of the intersection within the rectangular shape when tracing the curb lines of the intersection.
    - They can be either signalized (Figure 3-1) or stop-sign controlled (Figure 3-2).

Figure 3-1. Example of a Signalized Interchange Intersection.

Figure 3-2. Example of a Stop-Sign Controlled Interchange Intersection.

- Segment:
  - A segment unit type is the section of frontage road between two intersection unit types.
  - It includes driveway access points, interstate highway entrance and exit ramps, U-turn turnarounds, and side streets. See Figure 3-3.

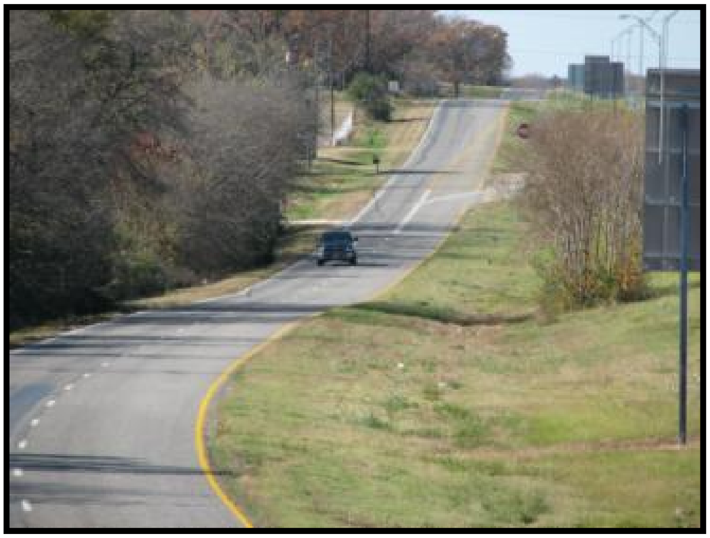

Figure 3-3. Segment Unit Type That Shows Driveways and an Exit Ramp.

- Ramp intersection:
  - This unit type occurs where the frontage road intersects an access ramp for a cross street. Note that the cross street itself does not intersect the frontage road—only the access ramps do. See Figures 3-4 and 3-5.
  - There can be either one or two "ramp intersections" associated with a cross street.

Figure 3-4. Bird's Eye View of a Cross Street with Two Access Ramps That Intersect the Frontage Road.
(Source: ©2009 Google Maps)

Figure 3-5. Ground Level View of a Ramp Intersection.

- Ramp segment:
    - A ramp segment is the short section of frontage road in between two ramp intersections. In Figure 3-4, it is the section of frontage road that runs below the cross street.
    - A ramp segment often travels underneath an overpass bridge, so it does not include driveways, ramps, or side streets but may have bridge supports, guardrails, or other overpass characteristics.
    - If a cross street has only one access ramp and therefore only one ramp intersection with the frontage road, then the segment unit type would be on either side of the single ramp intersection.
- Multiple intersection:
    - This unit type refers to the situation where a frontage road intersects with a cross street in the form of multiple intersections due to a divided highway (Figures 3-6 and 3-7).
    - This only occurred at one intersection out of all study sites (City of Greenville at Joe Ramsey and the NW frontage road).

Figure 3-6. Multiple Intersection Unit Type in Greenville at Joe Ramsey and NW Frontage Road. (Source: ©2009 Google Maps)

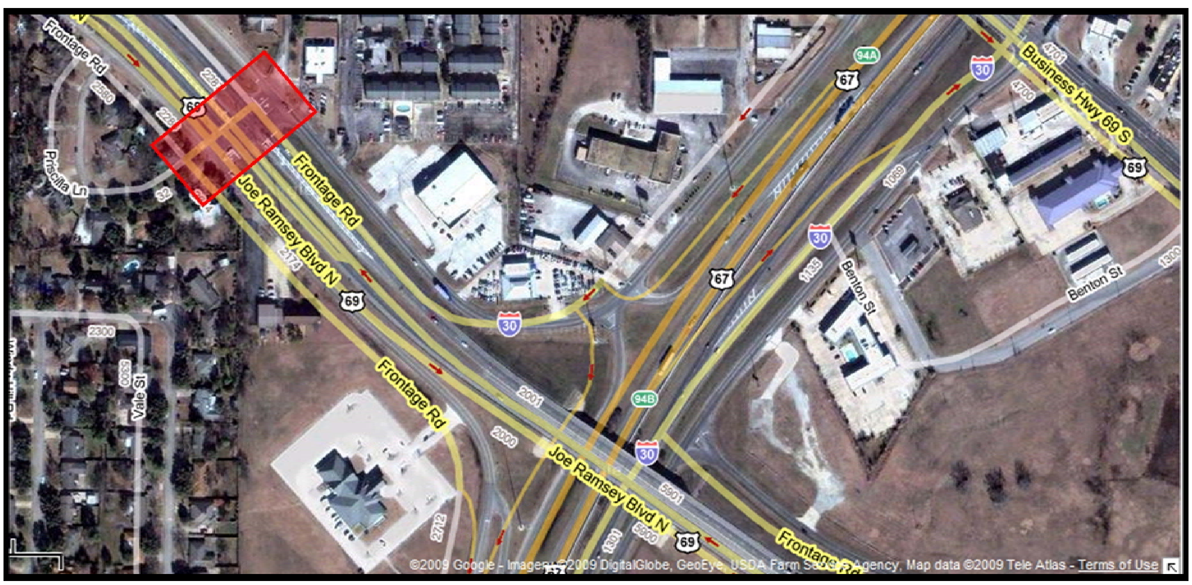

Figure 3-7. Same Intersection as Figure 3-6, Showing How the Frontage Road Intersects with the Divided Highway Cross Street. (Source: ©2009 Google Maps)

- Transition intersection:
  - A transition intersection occurs where the frontage road changes from two-way to one-way (Figure 3-8).
  - Signs and pavement markings communicate this transition to motorists (Figure 3-9).

Figure 3-8. Example of a Transition Intersection Unit Type.

Figure 3-9. Sign Displayed at a Transition Intersection.

Once researchers had identified unit types based on roadway characteristics, they sequentially numbered every unit type along all study corridors and called them "analysis units." Analysis units (AUs) were used to narrow down a crash location. The analysis unit changed when the unit type changed. As shown in the example in Figure 3-10, the beginning point of the study corridor was a segment unit type, which was labeled as analysis unit #1. Then moving north along the east frontage road of this corridor, the next unit type was an interchange intersection (analysis unit #2). Analysis unit #3 was another segment. This sequential analysis unit numbering continued to the north along the study corridor until the end point. Then the numbering continued southbound back toward the beginning point again. Figure 3-10 shows the final analysis units (#6, #7, and #8) of the Huntsville (conversion) site. Appendix E shows maps of all the analysis units labeled along the corridor for each site.

Figure 3-10. Example Showing How Analysis Units Were Assigned along a Study Corridor.
(Source: ©2009 Google Maps)

Frequency of Crashes by Analysis Unit

Once researchers labeled all analysis units and the electronic crash dataset was complete for each site, they classified each crash into one of the analysis units for that site. In other words, if seven crashes took place at the same interchange intersection at one site, all seven crashes were assigned the same analysis unit.

For the DPS data, the following are the key variables researchers used to sort crashes into the appropriate analysis units:

- control section (CONTSEC1);
- milepoint (MILE1);
- position prior to accident (POSFROM1, POSFROM2) and position of point of impact (POSIMPCT);
- month and year (MONTH, YEAR);
- severity (SEVERITY);
- type of collision (COLISION);
- part of roadway (ROADPART);
- intersection related (INTERSECT);

- intersection road type (INTERRD);
- intersection type/entering roads (ENTERRD);
- direction of travel of vehicles (DIR2VEH1, DIR2VEH2);
- vehicle location prior to accident (FROMVEH1, FROMVEH2); and
- location of point of impact (IMPACT).

Appendix B further defines these variables. For crashes during the years when crash reports were available (2001, 2003–2007), researchers used the crash reports to sort crashes into the appropriate analysis units.

Analysis Unit Considerations for Final Analysis

Because the DPS data milepoints were reported to the 0.1 mile (±528 ft), it was sometimes difficult to identify crashes that may have occurred at ramp intersections. Therefore, researchers combined any ramp intersection crashes into the adjacent segment. Similarly, ramp segments were added to adjacent segments as well.

The only transition intersections (analysis units #9 and #10 in the Huntsville comparison site) were removed from the analysis dataset because they are not similar to the other interchange intersections that have a consistent operation at the frontage road intersection. Similarly, the only multiple intersection analysis unit, which occurred in Greenville, was removed because it is not similar to the interchange intersections.

After screening the dataset for these unique locations, researchers had the most reliable and consistent (across years) dataset of reported crashes possible for the subsequent analyses.

Volume Data

Researchers obtained traffic volume data from TxDOT. Researchers used the volume data to adjust crash frequencies relative to volume. Researchers received count data for the available locations along the state facilities and also at cross streets.

Construction Periods

Researchers classified each month and year of the conversion sites as either the "before," "after," or "buffer" time periods relative to the frontage road conversion. The buffer time period indicated that there was construction taking place either on the frontage road itself or related ramps and intersections in the process of converting the frontage roads from two-way to one-way. Once researchers determined these time periods for each conversion site from TxDOT staff, researchers used the same periods on each respective comparison site to consistently compare the before-and-after effects of converting frontage roads from two-way to one-way. When it was not possible to distinguish the beginning and end of conversion construction to specific months, researchers used the entire year in which the conversion occurred as the buffer period. Table 3-4 shows the number of months used in the analysis for the before, buffer, and after periods. The note in Table 3-4 indicates the construction, or buffer, time periods researchers used for all sites.

Table 3-4. Number of Months Used in the Before, Construction Buffer, and After Periods.

Conversion-Comparison City Pair	Before	Construction Buffer	After
Sulphur Springs-Greenville	44	4	60
Huntsville-Huntsville	43	5	60
Wolfforth-Plainview	36	12	60
Hillsboro-West	36	12	60
Burleson	60	12	36

Note: The “Construction Buffer” is the number of months removed because they were assumed to be affected by the construction due to the frontage road conversion. The construction buffer for Hillsboro and Wolfforth is 2001, for Huntsville is 8/2001 to 12/2001, for Sulphur Springs is 9/2001 to 12/2001, and for Burleson is 2004. DPS data are available for 1998–2001, and CRIS data are available for 2003–2007.

Measuring Segments and Number of Access Points

Researchers used Google Earth® to measure the length of each frontage road segment and to count the number of driveways, side streets, U-turns, and ramps that intersected each segment. To measure the length of a frontage road segment, researchers used the ruler tool in Google Earth® to trace along the segment.

Researchers also conducted visual counts of the number of ramps, driveways, U-turns, and side streets along each frontage road segment. To accomplish this, researchers used the historical imagery tool in Google Earth® to view historical maps of each site when available. This historical imagery tool displays a timeline with a slider that can be moved forward or backward to view older or newer maps. The limitations of this tool are that historical images are not available for every year, only a few select years. Furthermore, not all sites have the same years of historical images available, making it difficult to compare them on the same timeframe across sites. Also, the historical images are of poorer clarity than more recent images, which made it more difficult for researchers to clearly see the fine details along the roadways. Ultimately, these limitations precluded the use of this geometric data in the safety analysis.

CONCLUDING REMARKS

This chapter described the selected sites as well as the data collection and data reduction performed on the crash data to develop the final dataset of reported crashes used for subsequent analyses. Researchers identified several crash data discrepancies when comparing the electronic crash data to actual printed crash reports. Awareness of the issues summarized in this chapter and Appendix D will assist future safety data analysts in ensuring they have a complete dataset for analysis and decision-making.

Critical position variables were removed from the electronic database in the CRIS database (2002 and after). Researchers manually created and filled these variables into the final electronic database for use in the analysis by reviewing the diagrams on the crash reports. Future safety analysis will be facilitated with the addition of these position variables into the CRIS dataset.

Finally, electronic records lack the narrative descriptions and diagrams that were filled out at the scene of the crash. These two pieces of information were vital in helping researchers identify what events took place in the crash. Printed crash reports were invaluable for this research effort to identify position on the highway (frontage road or mainlane) and milepoint location of the crash, and to provide an understanding of what caused the crash. The printed reports allowed the research team to verify and correct locational discrepancies in the electronic crash reports.

The cause of some of the discrepancies identified in this chapter between the printed reports and the electronic crash records is not clear to the research team. Human error could be introduced when officers complete the crash reports and/or when the reports are coded into the electronic database system. While the extent of human error is not understood because it was not specifically studied in this effort, researchers suggest that additional training of officers completing crash reports and those individuals entering the crash data into CRIS might reduce similar discrepancies in the future.

CHAPTER 4: SAFETY ANALYSIS AND FINDINGS

INTRODUCTION

This chapter describes the safety analysis and associated findings. The chapter begins by describing some basic exploratory analysis, then includes the statistical before-after comparison group analysis with comparison sites to develop the AMFs, and concludes with a hot-spot analysis.

EXPLORATORY ANALYSIS

Identifying Percentage of Relevant Crashes

Researchers began the statistical analysis by investigating all crashes in the DPS data (1999–2000) for the control sections and milepoints of interest for the case studies. Researchers created the pie chart shown in Figure 4-1, which identifies the percentage of crashes that occurred on the mainlanes, frontage roads, or other locations (e.g., ramps, connections). Researchers performed this analysis by summarizing the ROADPART variable in the DPS data. The pie chart indicates that 51 percent of the crashes occurred on the frontage roads.

Researchers then investigated the percentage of crashes that were non-PDO (i.e., incapacitating injury, non-incapacitating injury, possible injury, and fatality) on frontage roads and non-frontage roads. Figure 4-2 shows a pie chart that divides the frontage road crashes (from Figure 4-1) by injury type. Figure 4-2 shows that 68 percent of crashes were non-PDO on frontage roads.

Because the subsequent research only focuses on the non-PDO crashes, and because the definition of a PDO crash changed in 2003, only about 35 percent (51 percent multiplied by 68 percent) of crashes occurring at these sites in the before period are applicable to this research. This stratification helps explain the relatively low sample sizes and numbers of crashes that remain in the final dataset.

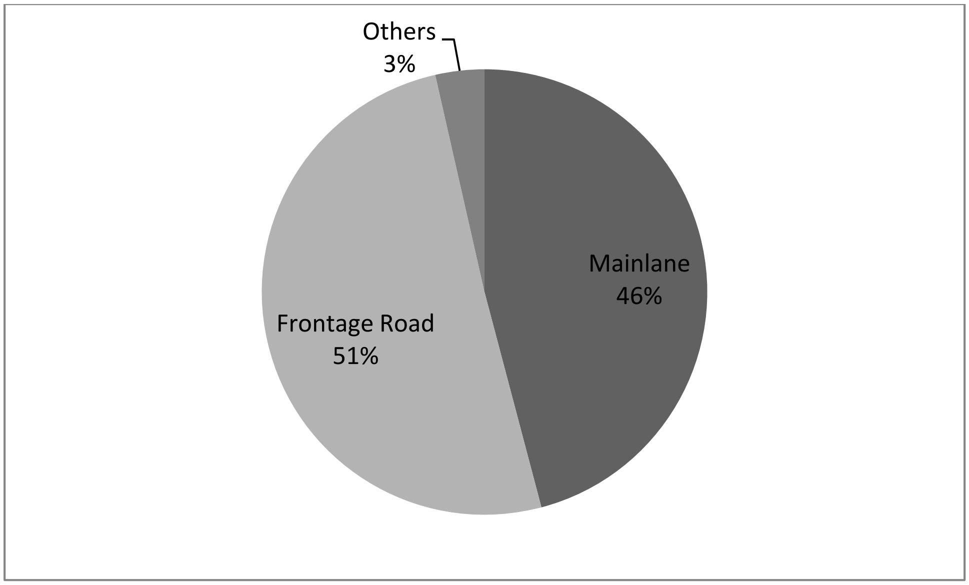

Figure 4-1. Percent of Crashes by Location from 1998 to 2000 (All Case Study Locations).

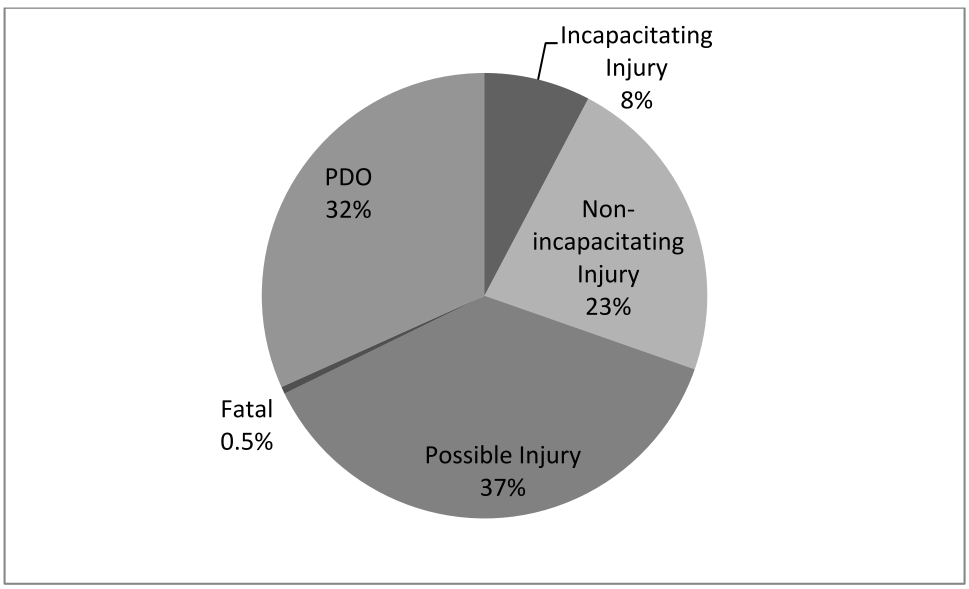

Figure 4-2. Percent of Frontage Road Crashes by Injury Type from 1998 to 2000 (All Case Study Locations).

Number of Crashes per Year by Time Period

Table 4-1 shows the number of crashes per time period for each conversion and comparison site. The values in the left side of Table 4-1 are the total crashes for the entire before or after time period at either the conversion (treatment) site or the comparison site. The values on the right side of Table 4-1 are computed on a per-year basis.

According to the numbers on the right side of Table 4-1, the number of crashes per year decreased at each of the conversion (treatment) sites. In some cases (Huntsville and West), Table 4-1 illustrates that the number of crashes at the comparison site also decreased.

Table 4-1. Crashes per Year by Conversion-Comparison Sites and Time Period.

Conversion-Comparison City Pair	Total Crash Number by Time Period				Average Crash Number by Time Period[1]			
	BT	AT	BC	AC	BT	AT	BC	AC
Sulphur Springs-Greenville	53	32	40	66	14.5	6.4	10.9	13.2
Huntsville-Huntsville	68	17	42	18	19.0	3.4	11.7	3.6
Wolfforth-Plainview	4	2	22	52	1.3	0.4	7.3	10.4
Hillsboro-West	5	3	7	8	1.7	0.6	2.3	1.6
Burleson	56	13	n.a.	n.a.	11.2	4.3	n.a.	n.a.

[1]Values are converted from totals for the time period (left side of Table 4-1) to crashes per year using the number of months in the before and after periods at each conversion site as shown in Table 3-6.
Note: BT = before period of treatment (conversion) site, AT = after period of treatment (conversion) site, BC = before period of comparison site, AC = after period of comparison site.

COMPARISON GROUP STATISTICAL SAFETY ANALYSIS

Researchers determined the safety effectiveness of frontage road conversion by reviewing crash data before and after a conversion took place. The statistical method used to evaluate the effectiveness of the conversion was a before-after evaluation with comparison groups (C-G). See Hauer (*33*) and Harwood et al. (*34*) for detailed explanations of the C-G method. The C-G method assumes that the change in crash frequency between the before and after periods for a comparison group is representative of the change in crash frequency that would have occurred for the corresponding treatment group had the conversion at the treatment site not been made. It can account for the change in crashes due to extraneous factors (e.g., weather, driving behavior, reporting practice) between the before and after periods in the safety effectiveness estimate. One popular measure of safety effectiveness is the safety effectiveness index (θ), which is defined to be the ratio of the expected number of crashes after the treatment to what it would have been without the treatment. Appendix F shows the detailed theorem and calculation procedures of the C-G analysis used in this study to obtain the estimate of $\theta\left(\hat{\theta}\right)$.

Segment Crash Analysis Findings

The following provides the results of the C-G analysis for all non-PDO crashes along segments for the study sites of interest. Each conversion-comparison group is compared to each other, and weighted averages (where more weights are given to a pair of cities with more crashes) are produced. Note that the term “treatment site” is used in the statistical analyses here to denote the locations where a conversion of the frontage roads has taken place. As discussed previously, only non-PDO crashes are used in analysis because there was a change in what constituted PDO crashes in 2003, which resulted in an increase in the number of PDO crashes. Therefore, an unbiased trend analysis of PDO crashes was not possible. Note that the segment analysis here was performed on analysis units where the unit type was a segment or ramp segment.

The analyses that follow in table form contain the estimates of the safety effectiveness index and the percent crash reduction for each pair of treatment-comparison groups (cities) by total crashes, crash impact types, and crash severity. Appendix F describes the theorem of the C-G method and calculation procedures. The descriptions for the column headings of subsequent tables in this section are as follows:

- BT = $\frac{Crash_{BT}}{\#\, months} \times 12$ (where $Crash_{BT}$ is the sum of crashes during the before period over treatment sites): annual crash frequency in the before period at the treatment site;
- AT = $\frac{Crash_{AT}}{\#\, months} \times 12$: annual crash frequency in the after period at the treatment site;
- BC = $\frac{Crash_{BC}}{\#\, months} \times 12$: annual crash frequency in the before period at the comparison site;
- AC = $\frac{Crash_{AC}}{\#\, months} \times 12$: annual crash frequency in the after period at the comparison site;
- w: the weight for each treatment group for calculating the overall effectiveness;
- $\hat{\theta}_T$: safety effectiveness index estimate accounting for traffic volume differences between before and after periods;

- w_T: the weight for each treatment group accounting for traffic volume differences between before and after periods; and
- PCR_T = percent crash reduction accounting for traffic volume differences between before and after periods $100(1 - \hat{\theta}_T)$.

The estimates for "Burleson-only" in the analyses and tables that follow are obtained by using the naïve before-after evaluation without any comparison group. Appendix F describes this method as the "naïve before-after evaluation method."

Table 4-2 shows that the annual crash frequency per year goes down from the before to after periods for all of the conversion (treatment) sites. As for the comparison sites, the number of crashes per year goes down for West and Huntsville, and the number of crashes per year goes up for Greenville and Plainview.

From Table 4-2, researchers found a statistically significant 57 percent reduction in the expected number of non-PDO crashes along the segments converted from two-way to one-way. Researchers found a statistically significant reduction of 64 percent at the Burleson site. Note that the confidence intervals are provided for $\hat{\theta}_T$, and if the computed confidence interval does not include 1.00, the results are statistically significant. If it includes 1.00, this implies that the crash reduction at the treatment sites as compared to that at the comparison sites is not statistically significant.

Table 4-2. Safety Effectiveness of Frontage Road Conversion for Segment Crashes: All Non-PDO Crashes, Total Crashes.

Conversion-Comparison Pair	BT	AT	BC	AC	$\hat{\theta}_T$	w_T	PCR_T
Total Non-PDO Crashes							
Hillsboro-West	1.7	0.6	2.3	1.6	0.3019	1.3547	69.81
Huntsville-Huntsville	19.0	3.4	11.7	3.6	0.5234	6.7507	47.665
Sulphur Springs-Greenville	14.5	6.4	10.9	13.2	0.3846	10.32	61.536
Wolfforth-Plainview	1.3	0.4	7.3	10.4	0.6996	0.7526	30.041
Overall					0.431 (0.276, 0.675)		**57%**
Burleson only	11.2	4.3			0.365 (0.149, 0.58)		**64%**

Notes: BT = annual crash frequency in the before period at the treatment (conversion) site, AT = annual crash frequency in the after period at the treatment (conversion) site, BC = annual crash frequency in the before period at the comparison site, AC = annual crash frequency in the after period at the comparison site, and PCR_T = percent crash reduction for the treatment (conversion) weighted by traffic volume. Bold implies statistical significance at the 95% confidence interval. The confidence intervals for the safety effectiveness index are provided in parentheses. Estimates are based upon those segment analysis units with non-missing traffic volumes. The percentages of analysis units with non-missing traffic volumes for each city are shown in Table 4-6, presented later. C-G analysis does not consider the effect of a conversion-comparison pair when either the before or after period has zero crashes. When this occurs, the columns are indicated as "n.a." (not applicable). The estimates for Burleson have been obtained by before-after evaluation without any comparison group. The procedure is provided in Appendix F. Segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which PCRs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the PCRs inherently include some impact of the ramp configurations that occur with the conversion. It was not possible to separate these effects.

Researchers also investigated specific types of crashes. Table 4-3 provides the statistically significant results by crash type, including:

- non-PDO angle and opposite-direction crashes including a left turn (94 percent reduction overall);
- non-PDO angle crashes (83 percent reduction overall); and
- non-PDO rear-end crashes (73 percent reduction overall, 75 percent reduction in Burleson).

Another crash type of interest is the opposite-direction crash. Table 4-3 documents the statistical significance for angle and opposite-direction crashes that included a left-turning vehicle. Intuitively, one would expect reductions in opposite-direction crashes because of the limited opportunity for opposite-direction crashes on segments after frontage roads are converted from two-way to one-way.

Table 4-4 illustrates that opposite-direction crashes did decrease. In fact, in Hillsboro, Sulphur Springs, and Wolfforth, there was zero in the after period. Therefore, the C-G analysis provided inconclusive results. As a result, researchers analyzed the opposite-direction crashes using the naïve method without comparison groups, documented in Appendix F. This is the same method used previously to develop estimates from the Burleson site, which does not include a comparison site. Table 4-4 indicates that a statistically significant 96 percent reduction in opposite-direction crashes was identified. Note that wrong-way movements in the after period constituted the crashes that are identified in the "AT" column of Table 4-4.

Researchers also investigated crash reductions by crash severity. Table 4-5 shows the statistically significant results, including:

- non-PDO non-incapacitating injury crashes (68 percent reduction overall, 59 percent reduction in Burleson);
- non-PDO possible injury crashes (54 percent reduction overall, 77 percent reduction in Burleson); and
- incapacitating injury, non-incapacitating injury, and fatal non-PDO crashes (68 percent reduction overall, 57 percent reduction in Burleson).

Table 4-3. Safety Effectiveness of Frontage Road Conversion for Segment Crashes: All Non-PDO Crashes, by Crash Type.

Conversion-Comparison Pair	BT	AT	BC	AC	$\hat{\theta}_T$	w_T	PCR_T
Non-PDO Angle and Opposite-Direction Crashes Including a Left Turn							
Hillsboro-West	0.0	0.0	1.0	0.0	n.a.	n.a.	n.a.
Huntsville-Huntsville	5.9	0.0	4.2	0.6	n.a.	n.a.	n.a.
Sulphur Springs-Greenville	5.2	0.4	2.2	3.2	0.0594	1.321	94.064
Wolfforth-Plainview	0.0	0.0	1.7	1.2	n.a.	n.a.	n.a.
Overall					0.059 (0.011,0.327)		**94%**
Burleson only	4.2	0.0			n.a.	n.a.	n.a.
Non-PDO Angle Crashes							
Hillsboro-West	0.3	0.0	0.3	0.0	n.a.	n.a.	n.a.
Huntsville-Huntsville	4.2	0.2	4.2	0.6	0.3153	0.6911	68.468
Sulphur Springs-Greenville	2.2	0.4	1.6	2.6	0.1089	1.0722	89.114
Wolfforth-Plainview	0.3	0.0	0.7	0.8	n.a.	n.a.	n.a.
Overall					0.165 (0.038, 0.723)		**83%**
Burleson only	0.8	0.3			0.376 (0.0, 1.026)		62%
Non-PDO Rear-End Crashes							
Hillsboro-West	1.3	0.2	0.3	0.2	0.1666	0.3233	83.345
Huntsville-Huntsville	8.1	2.0	2.5	1.4	0.426	2.7378	57.4
Sulphur Springs-Greenville	5.7	1.8	4.4	6.0	0.2005	3.5258	79.946
Wolfforth-Plainview	0.3	0.0	3.0	5.2	n.a.	n.a.	n.a.
Overall					0.272 (0.127, 0.583)		**73%**
Burleson only	4.6	1.3			0.253 (0.0, 0.509)		**75%**

Notes: BT = annual crash frequency in the before period at the treatment (conversion) site, AT = annual crash frequency in the after period at the treatment (conversion) site, BC = annual crash frequency in the before period at the comparison site, AC = annual crash frequency in the after period at the comparison site, and PCR_T = percent crash reduction for the treatment (conversion) weighted by traffic volume. Bold implies statistical significance at the 95% confidence interval. The confidence intervals for the safety effectiveness index are provided in parentheses. Estimates are based upon those segment analysis units with non-missing traffic volumes. The percentages of analysis units with non-missing traffic volumes for each city are shown in Table 4-6, presented later. C-G analysis does not consider the effect of a conversion-comparison pair when either the before or after period has zero crashes. When this occurs, the columns are indicated as "n.a." (not applicable). The estimates for Burleson have been obtained by before-after evaluation without any comparison group. The procedure is provided in Appendix F. Segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which PCRs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the PCRs inherently include some impact of the ramp configurations that occur with the conversion. It was not possible to separate these effects.

Table 4-4. Safety Effectiveness of Frontage Road Conversion for Segment Crashes: All Non-PDO Crashes, without Comparison Sites.

Conversion-Comparison Pair	BT	AT	$\hat{\theta}_T$	PCR_T
Non-PDO Opposite-Direction Crashes				
Hillsboro-West	0.0	0.0	n.a.	n.a.
Huntsville-Huntsville	3.3	0.2	0.055	94%
Sulphur Springs-Greenville	4.1	0.0	0	100%
Wolfforth-Plainview	0.0	0.0	n.a.	n.a.
Burleson	4.4	0.3	0.072	93%
Overall			0.037 (0.0, 0.089)	**96%**

Notes: BT = annual crash frequency in the before period at the treatment (conversion) site, AT = annual crash frequency in the after period at the treatment (conversion) site, and PCR_T = percent crash reduction for the treatment (conversion) weighted by traffic volume. Bold implies statistical significance at the 95% confidence interval. The confidence intervals for the safety effectiveness index are provided in parentheses. Estimates are based upon those segment analysis units with non-missing traffic volumes. The percentages of analysis units with non-missing traffic volumes for each city are shown in Table 4-6, presented later. Estimates have been obtained using before-after evaluation without any comparison group. The procedure is provided in Appendix F. Segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which PCRs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the PCRs inherently include some impact of the ramp configurations that occur with the conversion. It was not possible to separate these effects.

Table 4-5. Safety Effectiveness of Frontage Road Conversion for Segment Crashes: All Non-PDO Crashes, by Crash Severity.

Conversion-Comparison Pair	BT	AT	BC	AC	$\hat{\theta}_T$	w_T	PCR_T
Non-PDO Non-Incapacitating Injury Crashes							
Hillsboro-West	0.0	0.2	0.7	0.6	n.a.	n.a.	n.a.
Huntsville-Huntsville	3.9	0.4	3.9	1.2	0.2627	1.2573	73.733
Sulphur Springs-Greenville	5.7	2.2	4.1	5.4	0.3429	3.9738	65.715
Wolfforth-Plainview	0.3	0.2	4.3	2.2	n.a.	n.a.	n.a.
Overall					0.322 (0.136, 0.758)		**68%**
Burleson only	4.4	2.0			0.41 (0.057, 0.762)		**59%**
Non-PDO Possible Injury Crashes							
Hillsboro-West	1.7	0.4	1.0	1.0	0.265	0.80	73.5
Huntsville-Huntsville	11.7	2.8	6.4	1.8	0.842	3.00	15.8
Sulphur Springs-Greenville	6.5	2.8	5.2	6.2	0.405	4.22	59.5
Wolfforth-Plainview	1.0	0.2	3.0	7.6	0.172	0.52	82.8
Overall					0.456 (0.247, 0.839)		**54%**
Burleson only	4.0	1.0			0.234 (0.0, 0.504)		**77%**
Incapacitating Injury, Non-Incapacitating Injury, and Fatal Non-PDO Crashes							
Hillsboro-West	0.0	0.2	1.3	0.6	n.a.	n.a.	n.a.
Huntsville-Huntsville	7.3	0.4	5.3	1.6	0.1596	1.4181	84.041
Sulphur Springs-Greenville	7.9	3.6	5.7	7.0	0.3878	5.5688	61.224
Wolfforth-Plainview	0.3	0.2	4.3	3.0	n.a.	n.a.	n.a.
Overall					0.324 (0.154, 0.68)		**68%**
Burleson only	7.2	3.3			0.427 (0.137, 0.718)		**57%**

Notes: BT = annual crash frequency in the before period at the treatment (conversion) site, AT = annual crash frequency in the after period at the treatment (conversion) site, BC = annual crash frequency in the before period at the comparison site, AC = annual crash frequency in the after period at the comparison site, and PCR_T = percent crash reduction for the treatment (conversion) weighted by traffic volume. Bold implies statistical significance at the 95% confidence interval. The confidence intervals for the safety effectiveness index are provided in parentheses. Estimates are based upon those segment analysis units with non-missing traffic volumes. When traffic volumes are missing, the columns are indicated as "n.a." (not applicable). The percentages of analysis units with non-missing traffic volumes for each city are shown in Table 4-6, presented later. C-G analysis does not consider the effect of a conversion-comparison pair when either the before or after period has zero crashes. When this occurs, the columns are indicated as "n.a." (not applicable). The estimates for Burleson have been obtained by before-after evaluation without any comparison group. The procedure is provided in Appendix F. Segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which PCRs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the PCRs inherently include some impact of the ramp configurations that occur with the conversion. It was not possible to separate these effects.

Volume Data Used for Segment Statistical Analysis

The estimates incorporating traffic volumes ($\hat{\theta}_T$, PCR_T) in Tables 4-2 through 4-5 are based on the data from analysis units with non-missing traffic volumes. Table 4-6 shows the percentages of analysis units with non-missing traffic volumes for each city. Table 4-6 shows the average analysis unit (AU) traffic volume that was used for adjusting crashes per year by traffic volume. Table 4-7 shows traffic volume and the percent change from the before to the after period.

Table 4-6. Percentage of Analysis Units with Non-Missing Volumes Used in Segment Analysis.

City	Total # Analysis Units	# of Units with Missing Volumes	Units with Missing Volumes	Percentage of Units with Non-Missing Volumes
Sulphur Springs	14	2	2, 29	86
Greenville	7	3	4, 6, 13	57
Huntsville (Conversion)	4	0	n.a.	100
Huntsville (Comparison)	7	3	2, 4, 15	57
Wolfforth	5	3	2, 7, 11	40
Plainview	8	0	n.a.	100
Hillsboro	2	0	n.a.	100
West	8	2	7, 9	75
Burleson	17	4	17, 20, 22, 24	76

Table 4-7. Segment Traffic Volume by Case Study City and Time Period.

City	Period	Average ADT[1]	Percent Change from Before to After Time Period
Sulphur Springs	Before	2200	-18
Sulphur Springs	After	1800	-18
Greenville	Before	1800	22
Greenville	After	2200	22
Huntsville (Conversion)	Before	4600	20
Huntsville (Conversion)	After	5500	20
Huntsville (Comparison)	Before	3600	31
Huntsville (Comparison)	After	4700	31
Wolfforth	Before	2600	23
Wolfforth	After	3200	23
Plainview	Before	1200	8
Plainview	After	1300	8
Hillsboro	Before	3100	77
Hillsboro	After	5500	77
West	Before	1900	11
West	After	2100	11
Burleson	Before	2200	45
Burleson	After	3200	45

[1]ADT = average daily traffic. Values are rounded and represent the statistical average of ADT values for all available years in the before or after period.

Intersection Crash Analysis Findings

Researchers separated those crashes that were in the physical area of the intersection from segment crashes. Researchers also investigated the development of safety effectiveness estimates for different types of crashes within the intersections. Researchers defined the intersections as the physical area of the interchange intersections. The intersection analysis included unit types of interchange intersections only. The crash was classified as an intersection crash if the first point of collision took place within the physical area of the intersection. Because an estimate of traffic volume entering the interchange intersections was not available and could not be reasonably estimated with available traffic volume data, the percent crash reduction values for the intersection crash analysis are not weighted by traffic volume.

Table 4-8 summarizes the results of the intersection crash safety analysis. Table 4-8 shows the statistically significant results, including:

- non-PDO opposite-direction crashes (80 percent reduction overall, 89 percent reduction in Burleson);
- non-PDO opposite-direction crashes including a left turn (85 percent reduction overall);
- non-PDO angle and opposite-direction crashes including a left turn (77 percent reduction overall); and
- non-PDO possible injury crashes (87 percent reduction overall, 76 percent reduction in Burleson).

Table 4-8. Safety Effectiveness of Frontage Road Conversion for Intersection Crashes: Non-PDO Crashes.

Conversion-Comparison Pair	BT	AT	BC	AC	$\hat{\theta}$	w_T	PCR_T
Non-PDO Opposite-Direction Crashes							
Hillsboro-West	1.0	1.2	0.0	0.0	n.a.	n.a.	n.a.
Huntsville-Huntsville	7.0	3.0	1.1	2.4	0.2	2.2727	80
Sulphur Springs-Greenville	0.3	0.0	0.8	1.6	n.a.	n.a.	n.a.
Wolfforth-Plainview	0.0	0.4	2.7	0.6	n.a.	n.a.	n.a.
Overall					0.2 (0.054, 0.734)		**80%**
Burleson only	2.8	0.3			0.111 (0.0, 0.322)		**89%**
Non-PDO Opposite-Direction Crashes Including a Left Turn							
Hillsboro-West	1.0	1.2	0.0	0.0	n.a.	n.a.	n.a.
Huntsville-Huntsville	7.0	3.0	0.8	2.4	0.15	1.9108	85
Sulphur Springs-Greenville	0.3	0.0	0.8	1.6	n.a.	n.a.	n.a.
Wolfforth-Plainview	0.0	0.4	2.3	0.6	n.a.	n.a.	n.a.
Overall					0.15 (0.036, 0.619)		**85%**
Burleson only	2.8	0.0			n.a.		n.a.
Non-PDO Angle and Opposite-Direction Crashes Including a Left Turn							
Hillsboro-West	1.0	1.2	0.0	0.0	n.a.	n.a.	n.a.
Huntsville-Huntsville	7.5	3.4	1.1	2.6	0.1937	2.3653	80.627
Sulphur Springs-Greenville	0.3	0.2	1.4	1.6	0.625	0.4301	37.5
Wolfforth-Plainview	0.0	0.4	2.7	1.0	n.a.		n.a.
Overall					0.232 (0.072, 0.749)		**77%**
Burleson only	3.0	0.0			n.a.		n.a.
Non-PDO Possible Injury Crashes							
Hillsboro-West	0.7	1.0	0.3	0.6	0.8333	0.4918	16.667
Huntsville-Huntsville	7.5	3.6	0.3	2.8	0.0476	0.8591	95.238
Sulphur Springs-Greenville	0.0	0.6	1.4	1.2	n.a.	n.a.	n.a.
Wolfforth-Plainview	0.0	0.0	3.7	1.6	n.a.	n.a.	n.a.
Overall					0.135 (0.025, 0.729)		**87%**
Burleson only	2.6	0.67			0.238 (0.0, 0.567)		**76%**

Notes: BT = annual crash frequency in the before period at the treatment (conversion) site, AT = annual crash frequency in the after period at the treatment (conversion) site, BC = annual crash frequency in the before period at the comparison site, AC = annual crash frequency in the after period at the comparison site, and PCR_T = percent crash reduction for the treatment (conversion) weighted by traffic volume. Note that volume data are not available for the intersections, so these values are not weighted by traffic volume. Bold implies statistical significance at the 95% confidence interval. The confidence intervals for the safety effectiveness index are provided in parentheses. C-G analysis does not consider the effect of a conversion-comparison pair when either the before or after period has zero crashes. When this occurs, the columns are indicated as "n.a." (not applicable). The estimates for Burleson have been obtained by before-after evaluation without any comparison group. The procedure is provided in Appendix F. Interchange intersections are adjacent to segments that include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which PCRs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the PCRs inherently include some impact of the ramp configurations that occur with the conversion. It was not possible to separate these effects.

AMFs for Frontage Road Conversion

The text and tables in the previous section highlight cases in which a statistically significant percent reduction in crashes was identified where two-way frontage roads were converted to one-way frontage roads. A percent reduction can be expressed as a crash reduction factor, as defined in Chapter 2 (Literature Review) of this report. An accident modification factor is computed as 1-(CRF/100) if CRF is given. AMF is the estimate of the index of effectiveness (θ). Table 4-9 shows AMFs associated with the percent change values discussed above. Table 4-9 also provides the corresponding uncertainty estimates (95 percent confidence intervals) for AMFs in parentheses.

This report documents fully the methodology, assumptions, and site characteristics upon which these AMFs are computed. These AMFs are computed for segments between interchange intersections and for the interchange intersections. The segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which these AMFs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the AMFs here inherently include some impact of the ramp configurations that occur with the conversion as well. It was not possible to separate these effects.

With these caveats in mind, the AMFs shown in Table 4-9 provide transportation engineers and planners an estimate of the possible impacts of converting frontage roads from two-way to one-way.

Table 4-9. Summary of Segment and Interchange Intersection AMFs Related to Frontage Road Conversion from Two-Way Operation to One-Way Operation.

Item of Interest	Accident Modification Factor (AMF) Value (Confidence Interval)	Table for More Information
Segment Crashes by Crash Type		
Total non-PDO crashes	0.43 (0.28, 0.68)	Table 4-2
Non-PDO opposite-direction crashes	0.04 (0.00, 0.09)	Table 4-4
Non-PDO angle and opposite-direction crashes including a left turn	0.06 (0.01, 0.33)	Table 4-3
Non-PDO angle crashes	0.17 (0.04, 0.72)	Table 4-3
Non-PDO rear-end crashes	0.27 (0.13, 0.58)	Table 4-3
Segment Crashes by Crash Severity		
Non-PDO non-incapacitating injury crashes	0.32 (0.14, 0.76)	Table 4-5
Non-PDO possible injury crashes	0.46 (0.25, 0.84)	Table 4-5
Non-PDO incapacitating injury, non-incapacitating injury, and fatality crashes	0.32 (0.15, 0.68)	Table 4-5
Interchange Intersection Crashes by Crash Type		
Non-PDO opposite-direction crashes	0.20 (0.05, 0.73)	Table 4-8
Non-PDO opposite-direction crashes including a left turn	0.15 (0.04, 0.62)	Table 4-8
Non-PDO angle and opposite-direction crashes including a left turn	0.23 (0.07, 0.75)	Table 4-8
Interchange Intersection Crashes by Crash Severity		
Non-PDO possible injury crashes	0.14 (0.03, 0.73)	Table 4-8

Notes: Includes only non-PDO crashes. All values are statistically significant. See report text for full methodology, assumptions, and site characteristics upon which these AMFs are computed. AMFs are computed for segments between interchange intersections and for interchange intersections. Segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which these AMFs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the AMFs here inherently include some impact of the ramp configurations that occur with the conversion as well. It was not possible to separate these effects. An uncertainty estimate (confidence interval) associated with each AMF is provided in parentheses.

Application of AMFs

The following example demonstrates the application of the AMFs in Table 4-9. Assumptions for this example include the following: Frontage roads along an interstate in Texas are planned for conversion from two-way operation to one-way operation. The conversion project will include the removal of "button-hook" ramps and the reconfiguration of some ramps. TxDOT transportation planners and engineers would like to estimate the impacts on crashes based upon the conversion.

Table 4-10 summarizes the average number of crashes per year, over the last three years, experienced along the segments of frontage road and at the interchange intersections along the frontage road, which is currently two-way. TxDOT would like to estimate the number of crashes that might be expected after the construction project based upon the findings of this research project.

Table 4-10. Sample Crash History at Example to Demonstrate Application of AMFs.

Item of Interest	Crashes per Year over Historical Three-Year Period
Segment Crashes by Crash Type	
Total non-PDO crashes	32
Non-PDO opposite-direction crashes	17
Non-PDO angle and opposite-direction crashes including a left turn	21
Non-PDO angle crashes	9
Non-PDO rear-end crashes	5
Segment Crashes by Crash Severity	
Non-PDO non-incapacitating injury crashes	3
Non-PDO possible injury crashes	8
Non-PDO incapacitating injury, non-incapacitating injury, and fatality crashes	14
Interchange Intersection Crashes by Crash Type	
Non-PDO opposite-direction crashes	10
Non-PDO opposite-direction crashes including a left turn	4
Non-PDO angle and opposite-direction crashes including a left turn	6
Interchange Intersection Crashes by Crash Severity	
Non-PDO possible injury crashes	12

The expected number of crashes with the conversion is estimated using the AMF as shown in Equation 4-1. Equation 4-2 shows the calculations to determine the expected number of total non-PDO crashes with the conversion based on the AMF in Table 4-9 and the example crash history in Table 4-10.

$$\begin{matrix} Expected\ Crashes \\ With\ Conversion \end{matrix} = \begin{pmatrix} Expected\ Crashes \\ Without\ Conversion \end{pmatrix} \times AMF \qquad \text{Equation 4-1}$$

$$\begin{matrix} Expected\ Crashes \\ With\ Conversion \end{matrix} = \begin{pmatrix} 32\ Crashes \\ Per\ Year \end{pmatrix} \times 0.43 = 14\ Crashes\ per\ Year \qquad \text{Equation 4-2}$$

Table 4-11 presents the expected crashes per year and confidence intervals of the results and associated calculations for all AMFs provided in Table 4-9 along with the associated confidence interval. Note that the same caveats shown in Table 4-9 are replicated in Table 4-11. Mainly that these results are estimates of the true expected crashes per year. It can be concluded that with 95 percent confidence the true expected crashes per year will be between the confidence limits provided.

Table 4-11. Results of AMF Sample Application.

Item of Interest	Crashes per Year over Historical Three-Year Period	Expected Crashes per Year (Applying AMFs)	AMF 95% Confidence Interval of Expected Crashes per Year
Segment Crashes by Crash Type			
Total non-PDO crashes	32	32 x 0.43 = 13.8	9.0 to 21.8
Non-PDO opposite-direction crashes	17	17 x 0.04 = 0.7	0 to 1.5
Non-PDO angle and opposite-direction crashes including a left turn	21	21 x 0.06 = 1.3	0.2 to 6.9
Non-PDO angle crashes	9	9 x 0.17 = 1.5	0.4 to 6.5
Non-PDO rear-end crashes	5	5 x 0.27 = 1.4	0.7 to 2.9
Segment Crashes by Crash Severity			
Non-PDO non-incapacitating injury crashes	3	3 x 0.32 = 1.0	0.4 to 2.3
Non-PDO possible injury crashes	8	8 x 0.46 = 3.7	2.0 to 6.7
Non-PDO incapacitating injury, non-incapacitating injury, and fatality crashes	14	14 x 0.32 = 4.5	2.1 to 9.5
Interchange Intersection Crashes by Crash Type			
Non-PDO opposite-direction crashes	10	10 x 0.20 = 2.0	0.5 to 7.3
Non-PDO opposite-direction crashes including a left turn	4	4 x 0.15 = 0.6	0.2 to 2.5
Non-PDO angle and opposite-direction crashes including a left turn	6	6 x 0.23 = 1.4	0.4 to 4.5
Interchange Intersection Crashes by Crash Severity			
Non-PDO possible injury crashes	12	12 x 0.14 = 1.7	0.4 to 8.8

Notes: Rounded values are shown. The same caveats indicated in Table 4-9 apply, which includes the following. Results apply only to non-PDO crashes. All values are statistically significant. See report text for full methodology, assumptions, and site characteristics upon which these AMFs are computed. AMFs are computed for segments between interchange intersections and for interchange intersections. Segments include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. The projects upon which these AMFs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the AMFs here inherently include some impact of the ramp configurations that occur with the conversion as well. It was not possible to separate these effects.

HOT-SPOT ANALYSIS

Researchers also performed a hot-spot statistical analysis. The objective of the hot-spot analysis was simply to identify segments and/or interchange intersections by analysis unit along the study corridors where there was a number of crashes in either the before or after period that was relatively higher than all other analysis units at that study corridor. In this analysis, the conversion sites were not compared directly to a comparison site to address the effects of regression to the mean or other local factors (e.g., roadway design, driver behavior, weather). Researchers did not control for traffic volume in this analysis. Researchers performed this analysis to give an indication of performance at the local analysis unit level so that local TxDOT and transportation agency staff could identify the possible local effects of the frontage road conversion (or the lack of a conversion in the comparison sites).

To perform the hot-spot analysis, researchers used a very practical method for identifying hot-spots in a study corridor. Researchers identified a fixed threshold number of crashes at the analysis unit level such that if a location had more crashes than the threshold (across all years in either the before or after period), it was considered to be a hot-spot. If the location had less than the threshold, researchers did not consider it a hot-spot. This hot-spot analysis was meant to identify the locations along each corridor that observed the largest (relative) increases or decreases in the number of crashes. Because the total number of crashes varied so much across sites, the fixed threshold number of crashes changed depending on the site. Therefore, if a site had a relatively high fixed threshold number, then that particular site also had an overall relatively large number of total crashes. Table 4-12 shows the fixed threshold numbers of crashes for each corridor.

Table 4-12. Threshold Numbers of Crashes for All Sites That Determine Hot-Spot Locations.

City	Threshold Number of Crashes in "Before" or "After"
Sulphur Springs	7
Greenville	7
Huntsville (Conversion)	11
Huntsville (Comparison)	6
Wolfforth	2
Plainview	4
Hillsboro	5
West	3
Burleson	8

Once researchers identified all analysis units that exceeded the fixed threshold number (across all time period years), they took a closer look at those analysis units. Researchers analyzed crash reports, the narratives and diagrams, milepoint values, and collision type to determine if the analysis unit actually contained a hot-spot location. Recall that one analysis unit could be a frontage road segment consisting of multiple items like ramps, driveways, side streets, etc. It was important to look more closely at exactly where these "above threshold" crashes were taking place to determine if several crashes occurred at a particular milepoint location (a hot-spot), or if that particular segment had several crashes spread out over the distance of its length, implying that it was not an actual hot-spot location. Researchers used their best judgment in the process of identifying hot-spots.

Hot-Spot Maps

Once researchers identified where hot-spot locations were along each site, they created maps showing the details of each hot-spot. The maps identify the frontage road of interest, the associated analysis unit number, the number of non-PDO crashes (and non-PDO crashes per year) in the before and after periods, the type of crashes (when notable), and the severity of crashes (when notable). Figure 4-3 through Figure 4-18 provide maps of hot-spot locations for all of the study corridors. Researchers identified hot-spots in Sulphur Springs (Figure 4-3 through Figure 4-5), Greenville (Figure 4-6 and 4-7), Huntsville (conversion; Figure 4-8), Huntsville (comparison; Figure 4-9 through Figure 4-11), Wolfforth (Figure 4-12), Plainview

(Figure 4-13 and Figure 4-14), Hillsboro (Figure 4-15), West (Figure 4-16), and Burleson (Figure 4-17 and Figure 4-18).

Sulphur Springs

In most cases, the hot-spot locations identified in Sulphur Springs indicated a slight decrease in the number of crashes per year. In analysis unit #25 (Figure 4-4), the number of crashes per year increased slightly in the after period. In general, by reviewing Figure 4-3 through Figure 4-5, it is clear where the opposite-direction crashes appear to be reduced by the frontage road conversion (and associated ramp reconfiguration).

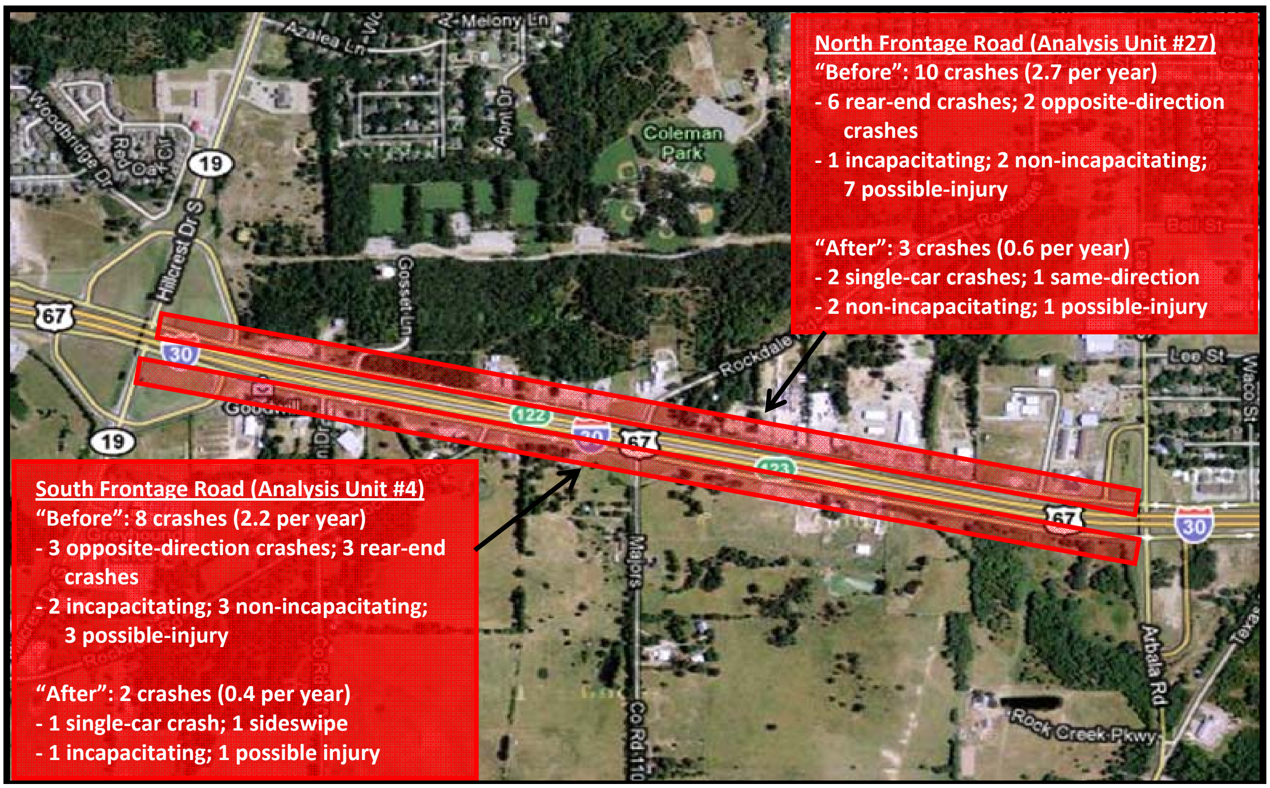

Figure 4-3. Selected Hot-Spot Location #1—Sulphur Springs. (Source: ©2010 Google Maps)

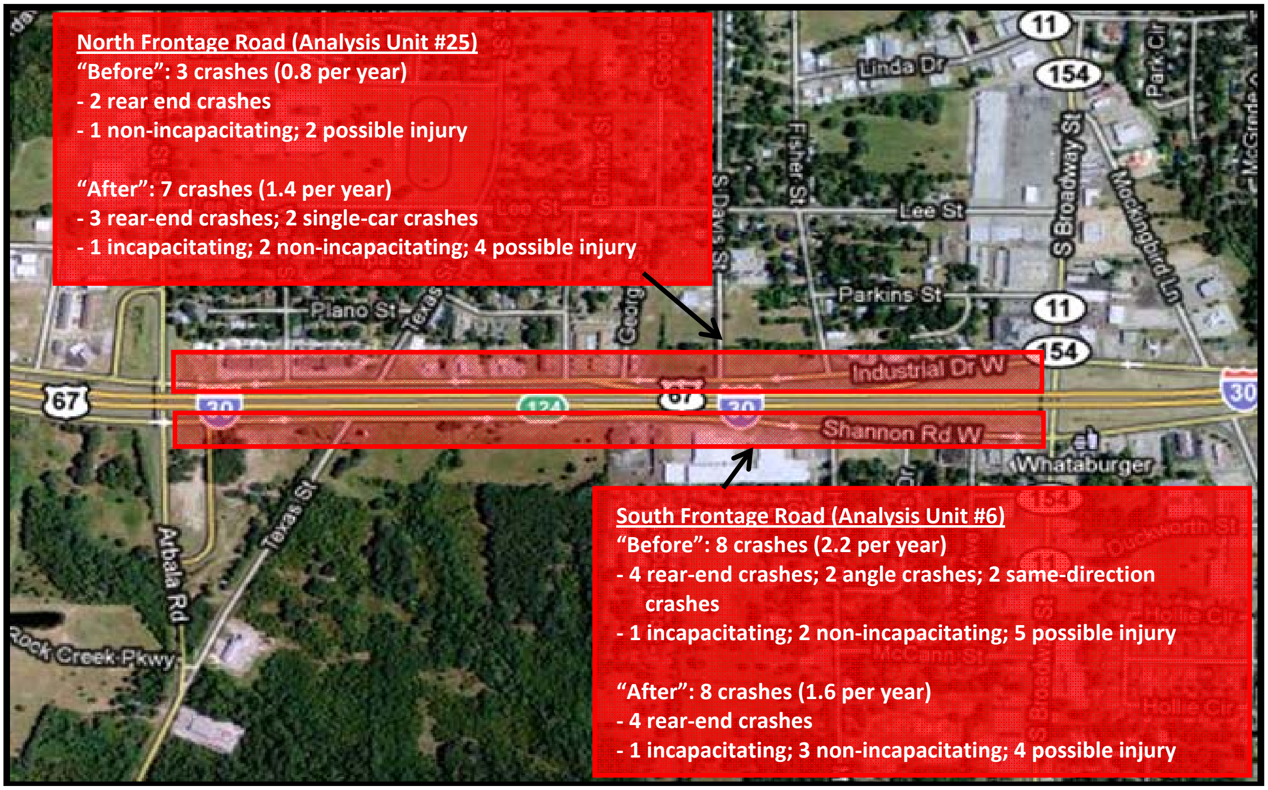

Figure 4-4. Selected Hot-Spot Location #2—Sulphur Springs.
(Source: ©2010 Google Maps)

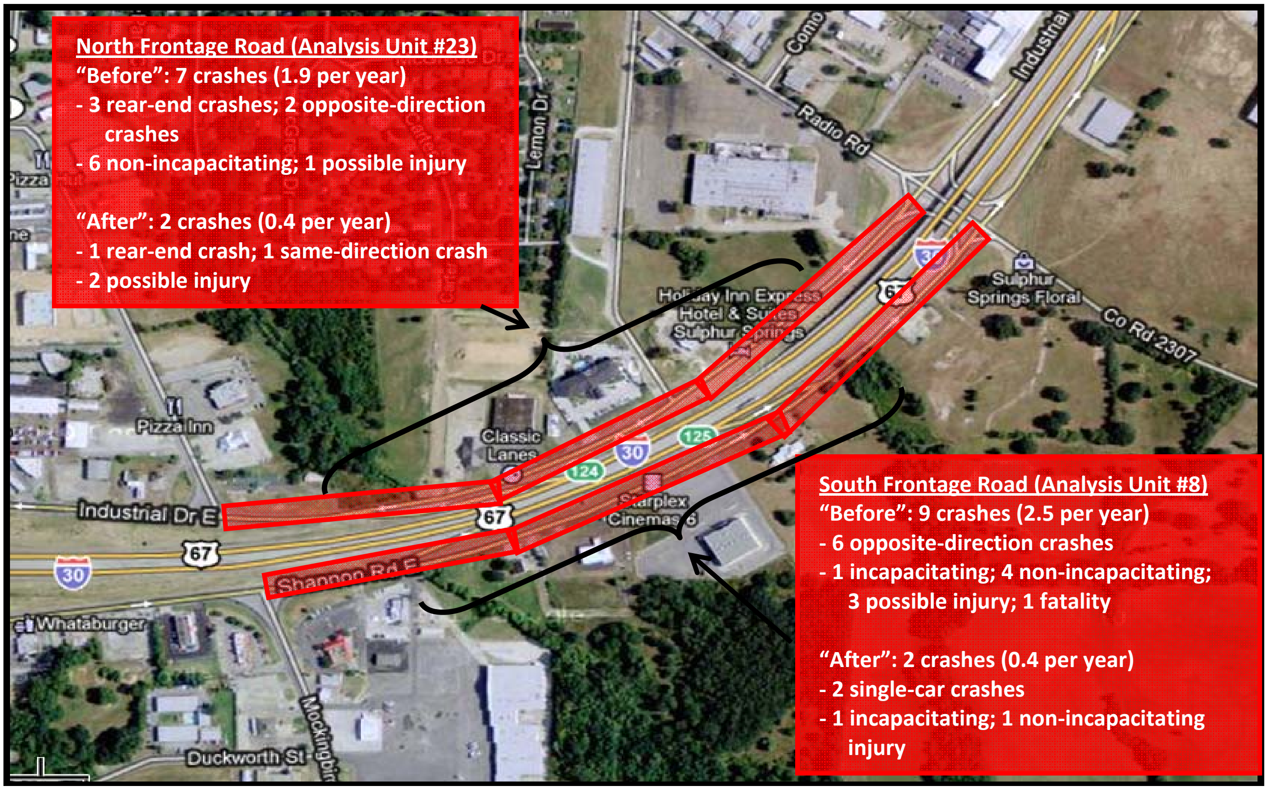

Figure 4-5. Selected Hot-Spot Location #3—Sulphur Springs.
(Source: ©2010 Google Maps)

Greenville

Figure 4-6 and Figure 4-7 display the maps for the hot-spots associated with the comparison site in Greenville. These figures generally indicate that the number of crashes in each of the hot-spot locations either remained approximately the same or increased. Only analysis unit #7 (Figure 4-7) indicates a reduction in the number of crashes.

Huntsville (Conversion)

The hot-spot locations along the Huntsville conversion site were all located around the intersection of the frontage roads of IH 45 with SH 30 (11th Street locally; Figure 4-8). In all cases, the number of crashes per year in the after period was lower than the before period. These crash reductions appear to be due to the frontage road conversion, especially since opposite-direction crashes were also reduced in the segments (see analysis unit #8 in particular).

Huntsville (Comparison)

There were three hot-spot location figures for the Huntsville comparison site (Figure 4-9 through Figure 4-11). Notably, in all of the hot-spot locations that were interchange intersections, there was an increase in crashes per year, and in all of the hot-spot locations that were segments, there was a decrease in crashes per year. Researchers hypothesize that some of the reduction in the crashes per year along the segments could be due to the conversion of the frontage roads on the adjacent segment of frontage roads to the north. Increases in crashes per year at the interchange intersections could be due to increases in traffic volume.

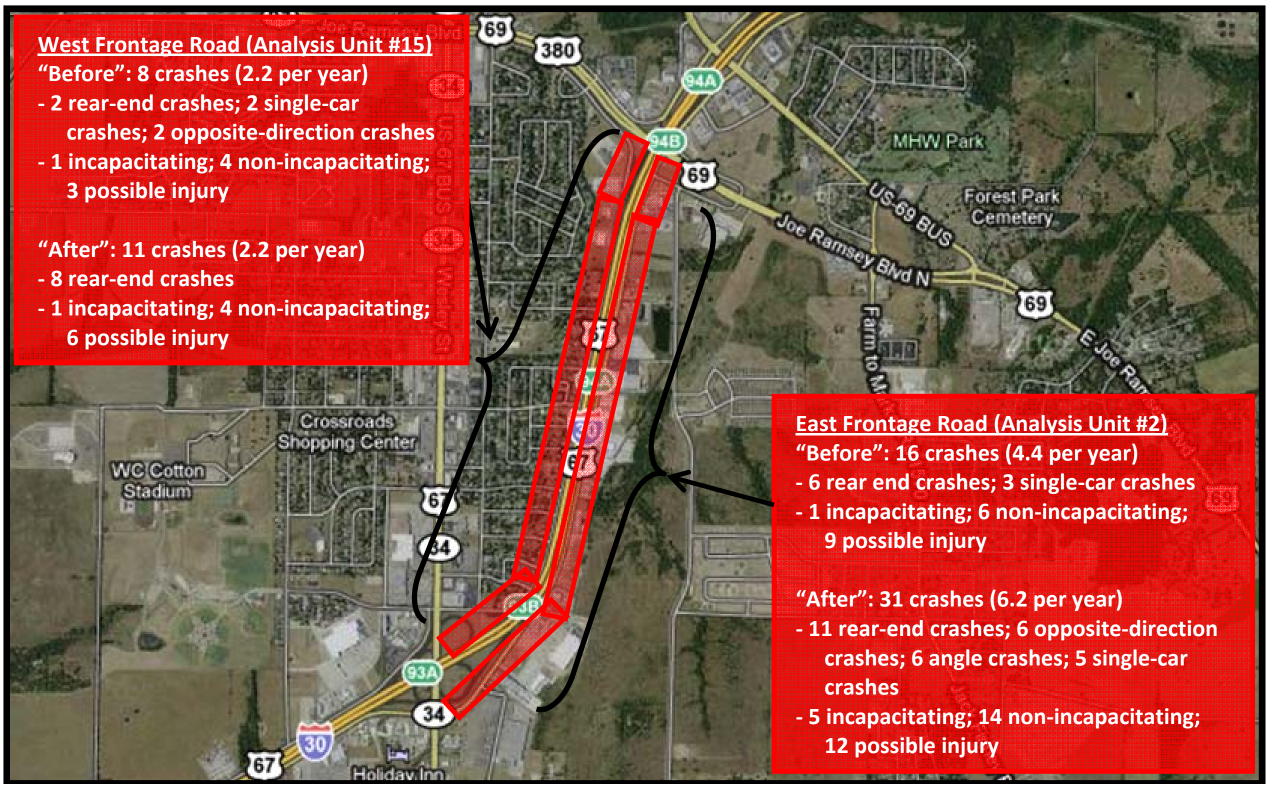

Figure 4-6. Selected Hot-Spot Location #1—Greenville.
(Source: ©2010 Google Maps)

Figure 4-7. Selected Hot-Spot Location #2—Greenville.
(Source: ©2010 Google Maps)

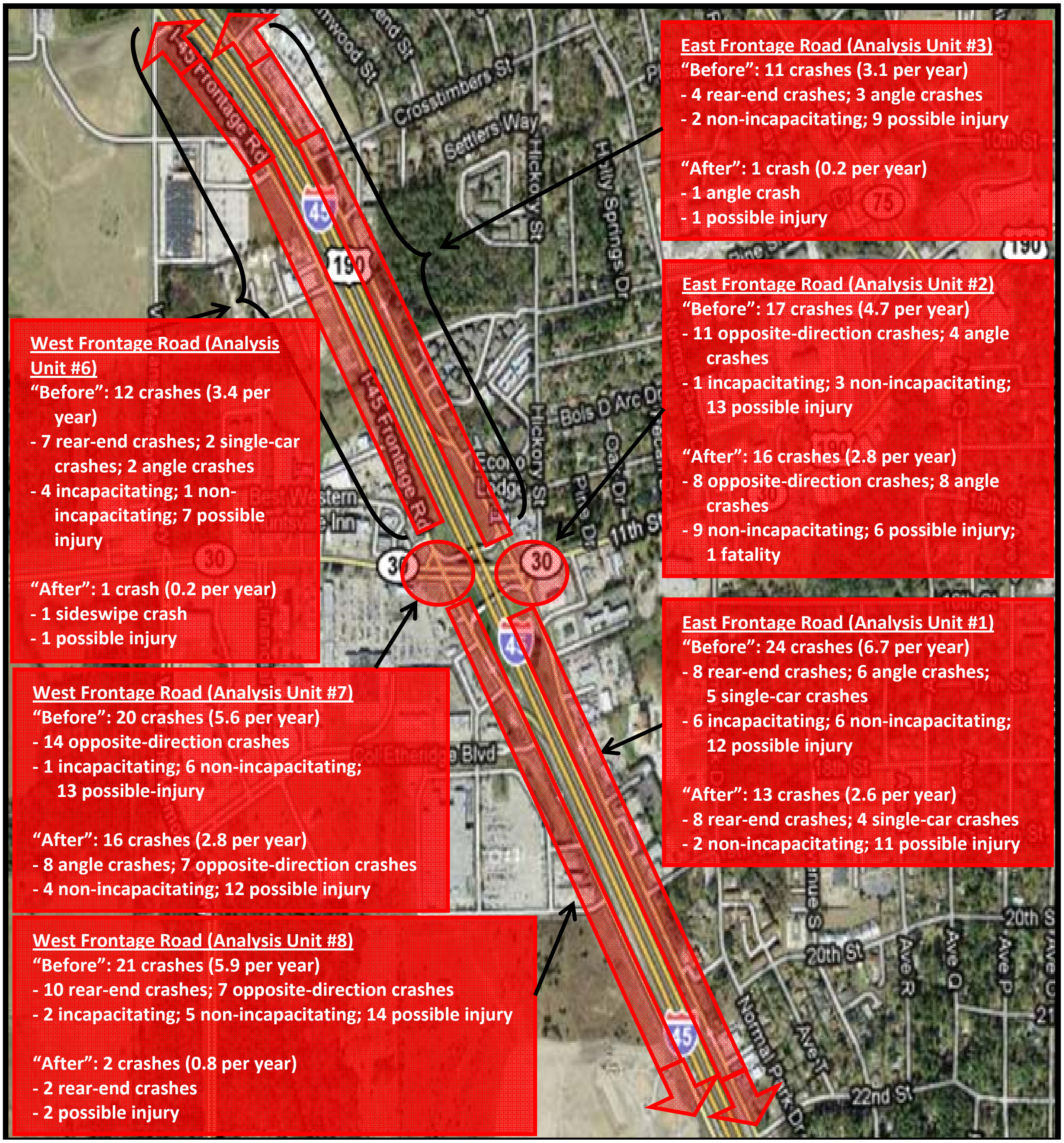

Figure 4-8. Selected Hot-Spot Location #1—Huntsville (Conversion).
(Source: ©2010 Google Maps)

Figure 4-9. Selected Hot-Spot Location #1—Huntsville (Comparison).
(Source: ©2010 Google Maps)

Figure 4-10. Selected Hot-Spot Location #2—Huntsville (Comparison).
(Source: ©2010 Google Maps)

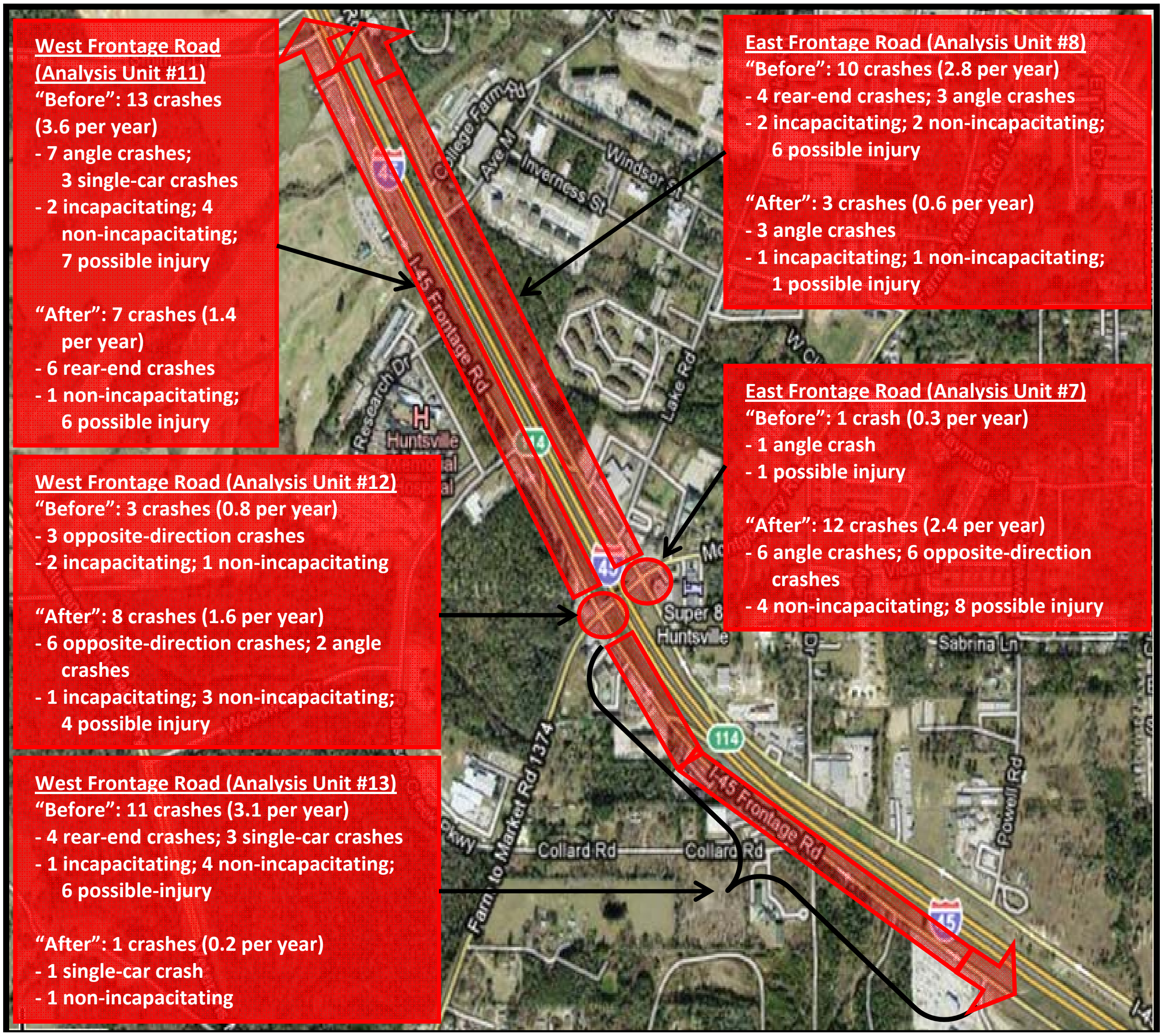

Figure 4-11. Selected Hot-Spot Location #3—Huntsville (Comparison). (Source: ©2010 Google Maps)

Wolfforth

The case study in the City of Wolfforth had the lowest threshold value, as shown in Table 4-12, to identify hot-spot locations. Researchers identified two crashes in the before period and none in the after period along analysis unit #2 (see Figure 4-12).

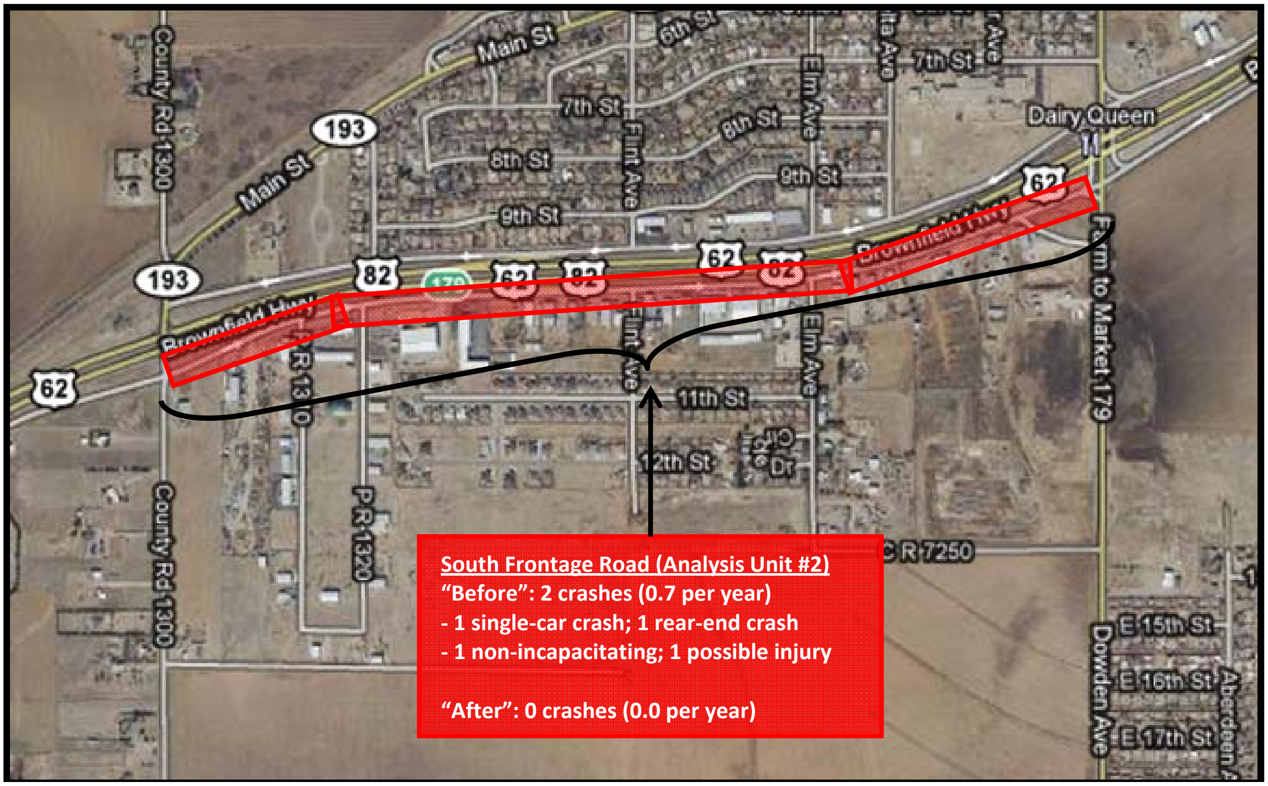

Figure 4-12. Selected Hot-Spot Location #1—Wolfforth.
(Source: ©2010 Google Maps)

Plainview

Figure 4-13 and Figure 4-14 contain the hot-spot locations for the Plainview comparison site. All of the analysis units identified as hot-spots in Plainview decreased in crashes per year in the after period except analysis unit #13. Analysis unit #13 increased from 1.3 crashes per year to 8.0 crashes per year. Review of the crash reports seems to indicate numerous crashes near the entrance of a large discount department store that was built along the segment.

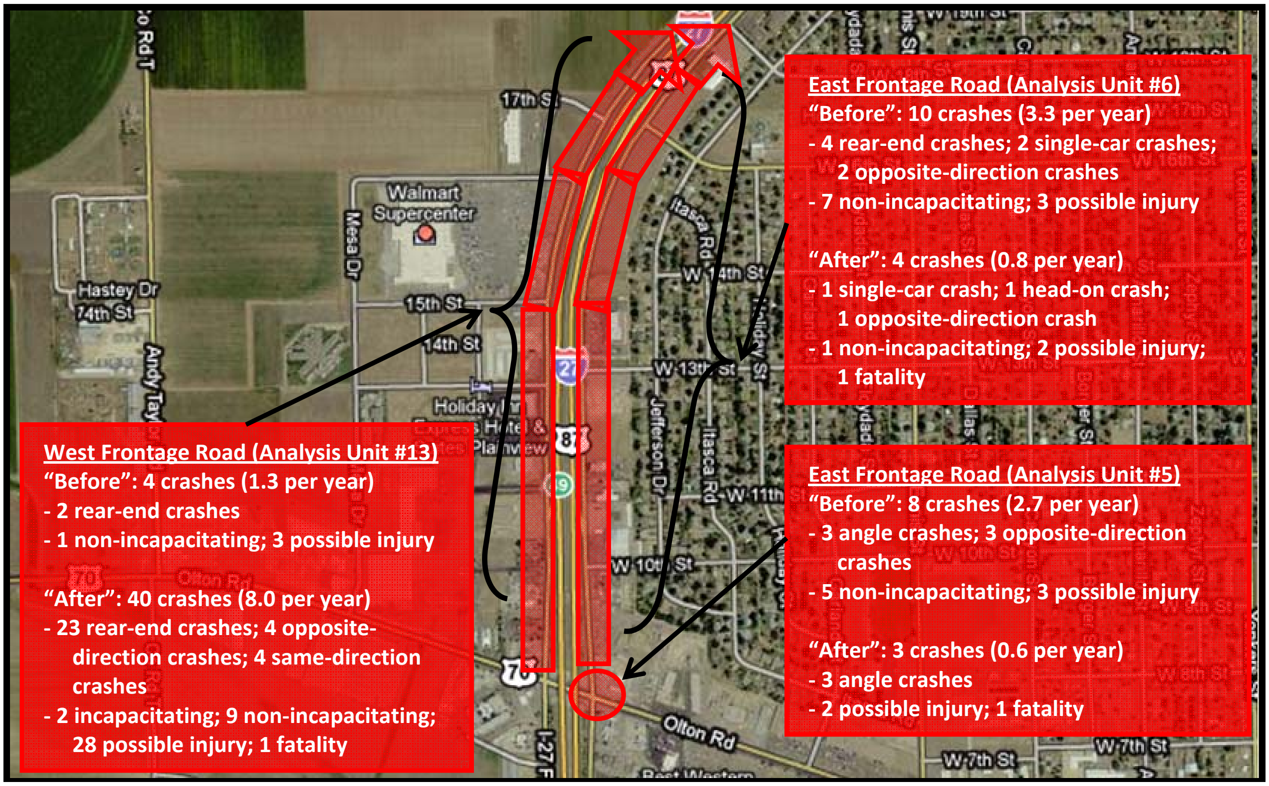

Figure 4-13. Selected Hot-Spot Location #1—Plainview.
(Source: ©2010 Google Maps)

Figure 4-14. Selected Hot-Spot Location #2—Plainview.
(Source: ©2010 Google Maps)

Hillsboro

Researchers identified two hot-spot locations, shown in Figure 4-15, for the Hillsboro conversion site. The segment along analysis unit #5 decreased in crashes per year, while the interchange intersection of analysis unit #1 increased from 0.3 crashes per year to 1.4 crashes per year. Researchers hypothesized that the reason, in part, for the increase in crashes at analysis unit #1 is due to the increase in traffic volume. The Hillsboro conversion site had the largest increase in traffic volume of any of the case study locations (see Table 4-7).

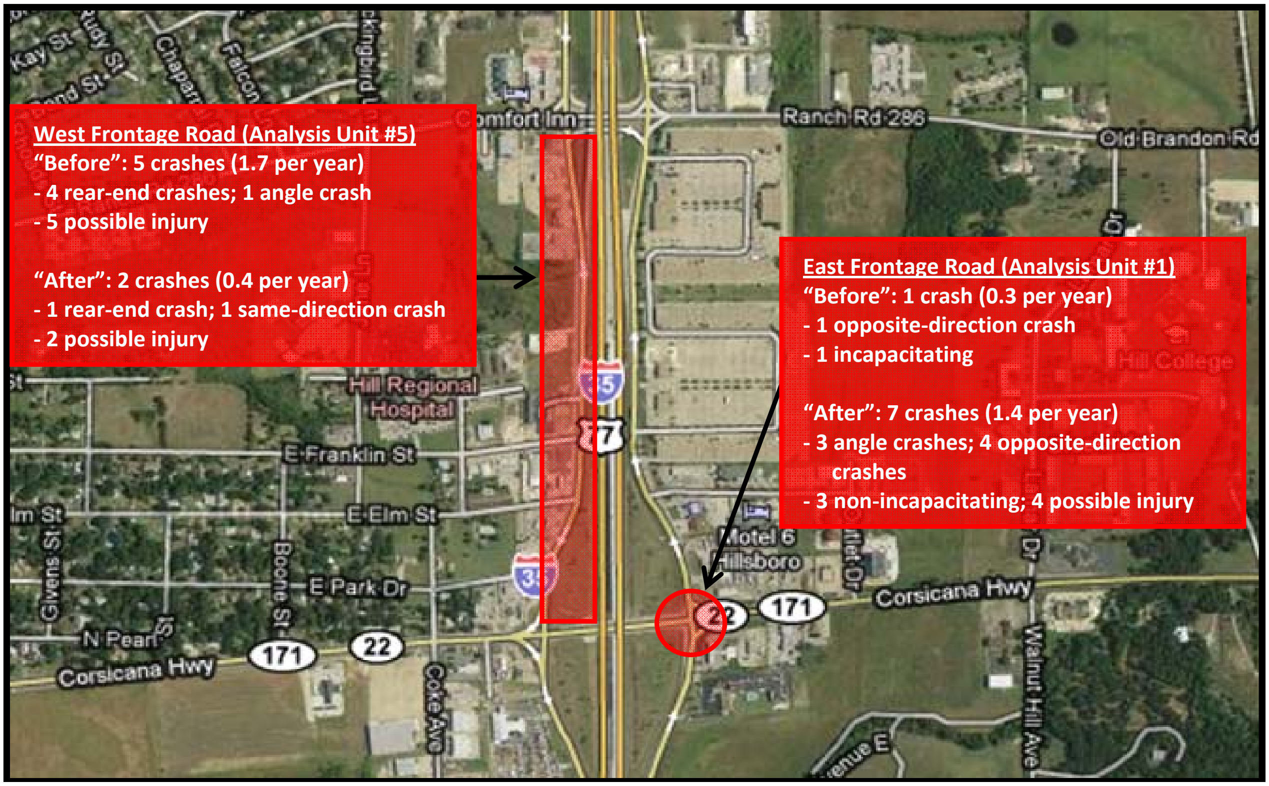

Figure 4-15. Selected Hot-Spot Location #1—Hillsboro. (Source: ©2010 Google Maps)

West

There were very few crashes along the city of West comparison site, as shown in Table 4-1. One hot-spot location was identified along the west frontage road south of Tokio Road, where there was a crash reduction from 1.0 crash per year to 0.4 crash per year (see Figure 4-16).

Figure 4-16. Selected Hot-Spot Location #1—West. (Source: ©2010 Google Maps)

Burleson

Figure 4-17 and Figure 4-18 contain the hot-spot locations for the case study in Burleson. All of the interchange intersection and segment analysis units in this case study identified as hot-spot locations had a decrease in the number of crashes per year. There were numerous opposite-direction crashes in the segments of the hot-spot locations that appear to be mitigated with the conversion of the frontage roads.

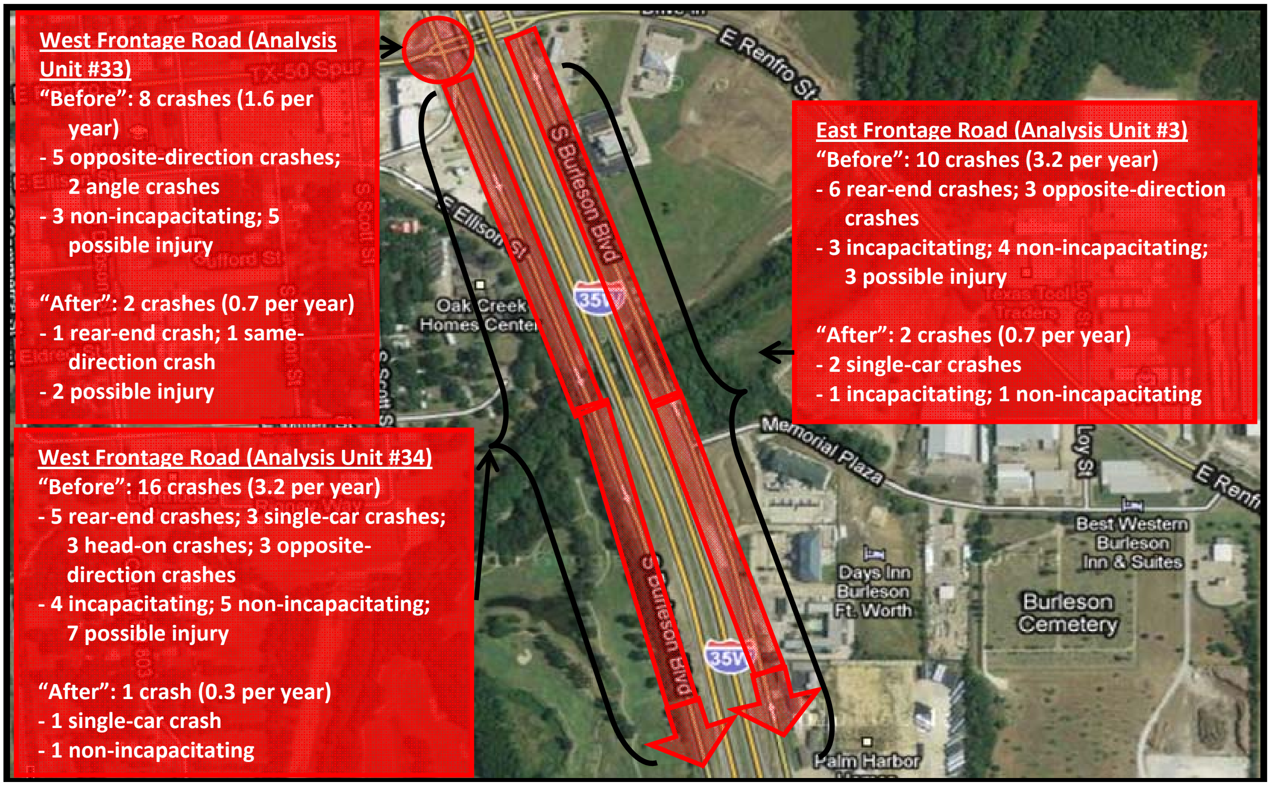

Figure 4-17. Selected Hot-Spot Location #1—Burleson.
(Source: ©2010 Google Maps)

Figure 4-18. Selected Hot-Spot Location #2—Burleson.
(Source: ©2010 Google Maps)

CONCLUDING REMARKS

This chapter includes three types of safety analyses: 1) exploratory analysis, 2) statistical comparison-group analysis (AMF development), and 3) hot-spot analysis. In the exploratory analysis, researchers identified that about 35 percent of crashes occurring at the case study sites in the before period were applicable to this research (i.e., non-PDO crashes on frontage roads). This stratification helps explain the relatively low sample sizes and numbers of crashes that remained in the final dataset for analysis.

Researchers performed a statistical analysis in the form of a comparison-group analysis along segments and interchange intersections of converted frontage roads. Researchers developed 12 AMFs for different crash types or severity along segments and interchange intersections (see Table 4-9).

The segments upon which the researchers developed AMFs include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. Typically, the projects upon which these AMFs are based included other improvements such as ramp improvements in addition to the frontage road conversion. Therefore, the AMFs here inherently include some impact of the ramp configurations that occur with the conversion as well. It was not possible to separate these effects. Researchers expect that these AMFs will be valuable for transportation planners and engineers interested in estimating the safety impacts of converting frontage roads from two-way to one-way.

Researchers then performed a hot-spot analysis, which was intended to provide a practical, corridor-specific evaluation of some of the impacts of the frontage road conversion from the before to the after period. Several locations along conversion sites where the number of crashes decreased from the before period to the after period were identified. Researchers hypothesized that these changes are due, in large part, to the conversion of the frontage roads to one-way. In several other cases, researchers identified crashes increasing or remaining relatively constant at associated comparison sites.

CHAPTER 5:
ECONOMIC DATA ANALYSIS AND FINDINGS

INTRODUCTION

This chapter describes the data collection, data reduction, analysis, and findings of four types of economic data:

- gross sales,
- appraisal values,
- employment, and
- business owner/manager surveys.

GROSS SALES ANALYSIS

The Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) are common economic data classification systems reflecting all components of the economy (e.g., retail, manufacturing). Researchers investigated the use of both classification systems to evaluate gross sales trends in cities and counties where frontage roads were converted from two-way to one-way, as well as locations still operating as two-way (comparison sites for each conversion site).

The intention of the research team was to ultimately compare the aggregate (city-level and county-level) sales data to the findings from the business owner/manager surveys and to provide an assessment of the economy in each area. As discussed in a later section of this chapter, however, researchers received limited responses to survey questions related to actual gross sales. Therefore, the sales analysis provided here primarily provides an indication of the general economic trends of gross sales in each city/county by the “before” and “after” time periods of the conversion projects. It is not prudent, or is it the intent, to attribute changes in this city-level or county-level gross sales data to the frontage road conversion specifically.

Researchers obtained sales data from the Texas Comptroller of Public Accounts. Beginning in 2002, the Texas Comptroller of Public Accounts discontinued using SIC and started using NAICS. Table 5-1 shows the corridors investigated for the gross sales analysis, including related data characteristics.

Table 5-1. Cities and Data Characteristics for Estimating Gross Sales Trends.

Conversion City	County	Conversion Year	Comparison City	Comparison County	Data Used[1]
Sulphur Springs	Hopkins	2001	Greenville	Hunt	SIC (Gross Sales)
Hillsboro	Hill	2001	West	McLennan	SIC (Gross Sales)
Wolfforth	Lubbock	2001	Plainview	Hale	SIC (Amount Subject to Tax)
Huntsville	Walker	2001	N/A	N/A	SIC (Gross Sales)
Burleson	Johnson	2004	N/A	N/A	SIC (Amount Subject to Tax)

[1]SIC data range from 1992 to 2006, while NAICS data range from 2002 to 2007. Given the conversion years of the corridors studied, the SIC data source was selected to provide trend data both before and after the conversion. All data were collected from the Texas Comptroller of Public Accounts. Generally, gross sales data were used, but in some cases "amount subject to tax" data were analyzed (if data anomalies were found in gross sales data). Additional detail is provided in the body of the report.

Background to SIC and NAICS

The federal government developed SIC in the 1930s. The SIC system uses a four-digit hierarchical coding system. The first two digits categorize all economic activity into 10 industry sectors: 1) agriculture, forestry, and fisheries; 2) mining; 3) construction; 4) manufacturing; 5) wholesale trade; 6) retail trade; 7) transportation, communications, and utilities; 8) finance, insurance, and real estate; 9) service industries; and 10) public administration. The third and fourth digits divide the 10 industry sectors into 99 major groups. This allows analysts to gather a comprehensive disaggregate picture of economic activity within each sector. However, the SIC system does not handle some newer business types including many previously unclassified business activities (e.g., information services, new health care provision, high-tech manufacturing) (*35*).

NAICS replaced the SIC system in the United States, Canada, and Mexico beginning in 2002 because it allows for classification of these new businesses. Moreover, the SIC system was discontinued after 2005 (*36*,*37*). NAICS has a six-digit coding structure that allows greater coding flexibility than the four-digit structure of SIC. NAICS classifies all economic activity into 20 industry sectors. Among these sectors, five are mostly goods-producing sectors and 15 are service sectors. NAICS identifies about 1,170 industries, while SIC identifies 1,004 industries (*38*).

Although NAICS provides an improved method to classify the economy for current industries, there are time-series inconsistencies between the two methods when attempting to plot both SIC and NAICS data together. Recognizing this difficulty, researchers were cautious to select the appropriate data source (NAICS or SIC) when investigating trend data for the conversion and comparison cities and counties. Researchers considered the appropriateness of each data series carefully before simply combining them.

In an effort to carefully examine each data source and their consistency with each other, researchers selected three Texas counties with relatively high population and three Texas counties with relatively low population. The relatively high population counties were Tarrant, Bell, and Lubbock, and the counties with relatively low population were Franklin, Grimes, and Titus. In theory, the data of NAICS may be compared with SIC data by restructuring and redefining each sector appropriately. However, because of the limitation of the SIC categories and because some NAICS data do not include disaggregate categories similar to SIC, it was difficult to equivalently match the two datasets with the correspondence tables on the U.S. Census Bureau Internet site (e.g., "1997 NAICS Matched to 1987 SIC Retail Trade") (*39*).

Table 5-2 shows an example of how selected two-digit SIC classifications compare to the three-digit NAICS classification. For example, item 55 in the SIC system (automotive dealers and gasoline service stations) was defined as the sum of similar items in the NAICS system, including item 441 (motor vehicle and parts dealers) and item 447 (gasoline stations).

Results of the analysis show that the gross sale values of SIC and NAICS were different in several sectors (automotive dealers and gasoline service stations, general merchandise stores, and food stores), while some sectors were similar. Figure 5-1a and Figure 5-1b show some typical differences between NAICS and SIC, and Figure 5-1c and Figure 5-1d show examples of similarities. Considering the unavoidable time series break between SIC data and NAICS data, researchers selected one data series for each study corridor analysis rather than attempting to match two inconsistent data series.

SIC data (1992–2006) were used to investigate the gross sales economic trends for the relatively "older" conversion sites (and associated comparison sites), while researchers decided to use NAICS data (2002–2007) for the "newer" conversion sites (and associated comparison sites). Only the Seguin and Rockwall sites were considered newer. The research team originally understood that they were both converted in the mid-2000s, but later determined that the roads were converted many years ago (see Chapter 3 and Table 3-1 for additional information). Therefore, researchers did not study these corridors, and only the SIC data were used for analysis for the remaining sites.

The SIC data included the conversion year for each site. For some cities or counties with gross sales data anomalies (i.e., data appearing to "spike" from very high to low), researchers investigated "amount subject to tax" data as well. Amount subject to tax data do not include all purchases (i.e., government tax-exempt purchases are not included).

Given the retail/service business interest of this research, there are 12 applicable industry sectors in the SIC system. Generally, when graphs for each complete sector were developed, it was hard to recognize more disaggregate changes that might be occurring. For improved presentation of these changes, researchers grouped the different industries into two subgroups. Table 5-2 shows these subgroups (group A and group B). In general, group A businesses are related to retail (building materials, home furniture, miscellaneous retail), and group B businesses are non-retail (hotels, restaurants, bars, groceries, gasoline). Therefore, for every study site, there are two trends on each group representing group A and group B, and another trend line showing the total for group A and group B.

Table 5-2. Sample Data Contents Comparing SIC and NAICS.

GROUP	SIC	TITLE	NAICS	TITLE
A (Retail)	52	Building Materials, Hardware, Garden Supply, and Mobile Home Dealers	444	Building Material and Garden Equipment and Supplies Dealers
	53	General Merchandise Stores	452	General Merchandise Stores
	56	Apparel and Accessory Stores	448	Clothing and Clothing Accessories Stores
	57	Home Furniture, Furnishings, and Equipment Stores	442	Furniture and Home Furnishings Stores
			443	Electronics and Appliance Stores
			451	Sporting Goods, Hobby, Book, and Music Stores
	59	Miscellaneous Retail	446	Health and Personal Care Stores
			451	Sporting Goods, Hobby, Book, and Music Stores
			453	Miscellaneous Store Retailers
			454	Non-Store Retailers
	72	Personal Services	812	Personal and Laundry Services
	75	Automotive Repair, Services, and Parking	811	Repair and Maintenance
	76	Miscellaneous Repair Services	443	Electronics and Appliance Stores
			811	Repair and Maintenance
B (Non-Retail)	54	Food Stores	445	Food and Beverage Stores
			454	Non-Store Retailers
	55	Automotive Dealers and Gasoline Service Stations	441	Motor Vehicle and Parts Dealers
			447	Gasoline Stations
	58	Eating and Drinking Places	722	Food Services and Drinking Places
	70	Hotels, Rooming Houses, Camps, and Other Lodging Places	721	Accommodation

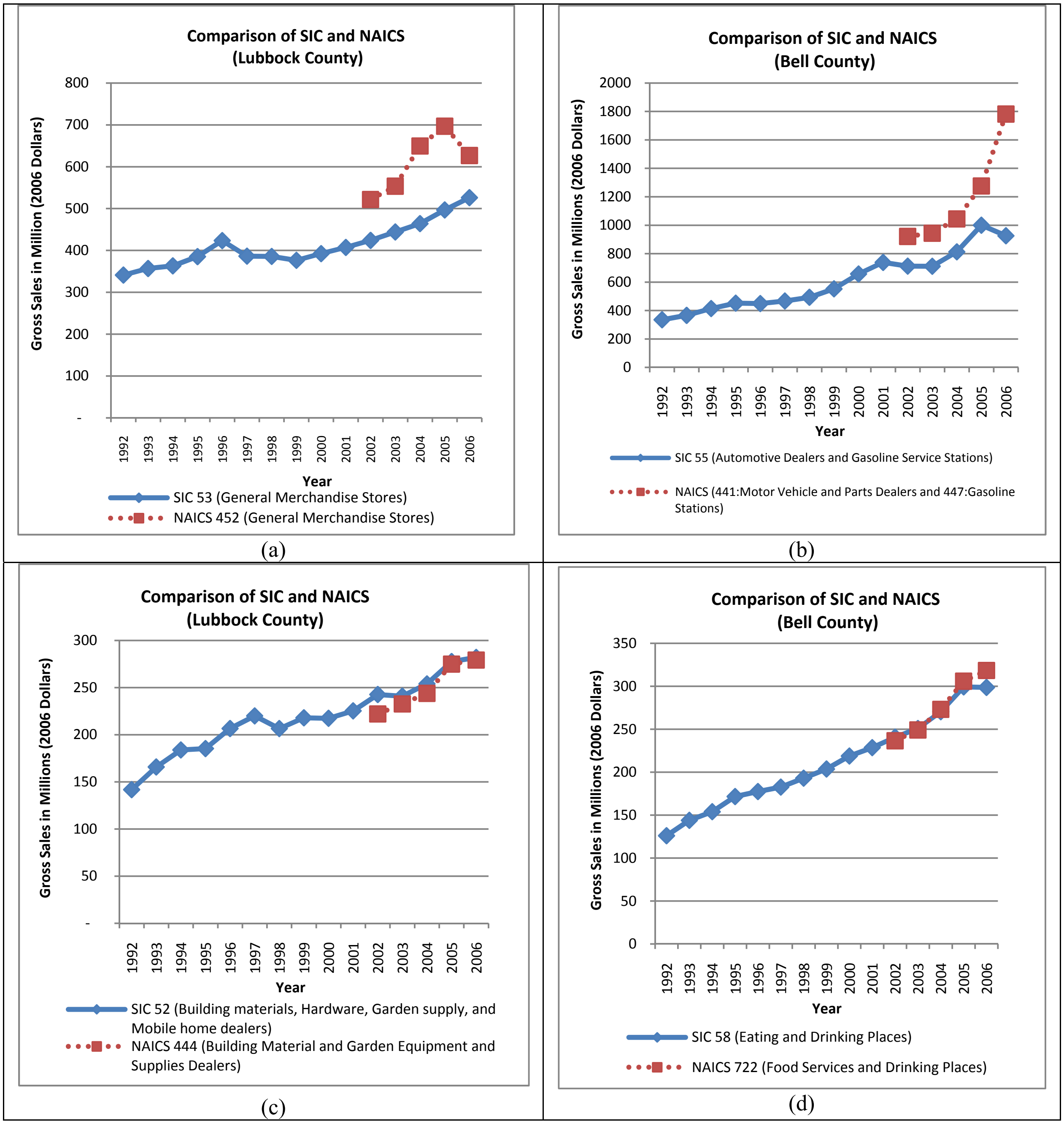

Figure 5-1. SIC and NAICS Gross Sales Data for Selected Counties.

Analysis Procedures, Assumptions, and Data Reporting

The following bulleted list highlights assumptions made and graphs created by the research team:

- It is important for the reader to understand that these gross sales values are for the entire city, not just the frontage road of interest; therefore it is not prudent to attribute sales differences to the frontage road conversion specially. The intent is to identify the general economic trends in each area with these data.
- Researchers used consumer price index (CPI) values to inflation-adjust all sales values to the most recent year of available data (2006). CPI values were obtained from the Bureau of Labor Statistics (*40*).
- "Gross Sales" in millions were adjusted to 2006 using the CPI and SIC data. Researchers created graphs of both the city and county where the conversion and comparison sites were located.
- "Amount Subject to Tax" in millions of dollars (in 2006 dollars) with SIC data were used for analysis when gross sales data seemed to spike from high to low or vice-versa.
- For a more disaggregate analysis, researchers also developed the same graphs to show the trends for specific industries including automotive dealers and gasoline, hotel, and food store/eating and drinking places.
- Appendix G shows all of these graphics. State of Texas relationships are shown first, followed by each conversion and comparison site in the order shown in Table 5-1. To create these graphics, researchers made necessary assumptions. The key assumptions, data notes, and procedure highlights follow in this bulleted list.
- Group A and group B include the following SIC groupings: group A businesses are related to retail (building materials [SIC code 52], general merchandise stores [SIC code 53], apparel and accessory stores [SIC code 56], home furniture [SIC code 57], miscellaneous retail [SIC code 59], personal services [SIC code 72], automotive repair, service, and parking [SIC code 75], and miscellaneous repair services [SIC code 76]); and group B businesses are non-retail (hotels [SIC code 70], eating and

drinking places [SIC code 58], food stores [SIC code 54], and automotive dealers and gasoline service stations [SIC code 55]).

- Gross sales and amount subject to tax are made available on a quarterly basis from the Texas Comptroller of Public Accounts. The number of businesses in each quarter varies. Therefore, it is not possible to track the gross sales of a specific business, or even a specific group of the same businesses, over time.
- Gross sales and amount subject to tax are only provided when the number of establishments is four or more. For example, if there are only three hotels in the city for a given quarter, no data will be provided for "hotel." This limitation on disclosure is intended to protect private sales data when sample sizes are low.
- The dashed vertical line in all of the graphics in Appendix G refers to the year of the conversion in the conversion city. If it is a comparison city, the vertical line relates to the conversion study for which the site is a comparison (see Table 5-1 to identify the comparison sites for each conversion site).
- For locations and annual time periods with no reported data because the number of establishments was fewer than four, researchers used the average value of adjacent years (before/after) (e.g., average of 1994 and 1996 to estimate 1995 yearly data). This assumption was implemented only in Wolfforth (SIC=57 [1994], SIC=54 [1995, 1997–1999], SIC=76 [1999]).
- In some cases, researchers could not create graphs if the data were lacking for many years. This occurred in several instances, including Greenville (hotel), Wolfforth (auto Dealers and gas), Hale County (hotel), Huntsville (hotel), and Walker County (hotel).
- The reader is encouraged to review the graphics and discussion shown in Appendix G. Appendix G provides more information about sales at the city and county level as well as by business type.

Findings for State of Texas and by City for Each Case Study Location

State of Texas

For the State of Texas, the gross sales for all businesses together and for specific businesses (auto dealer and gas, hotel, food store, and eating and drinking) increased overall from 1992 through 2006 (see Appendix G, Figures G-1 through G-8). There was a small drop from 2000 through 2003, but the gross sales value increased after 2003 and remained relatively flat from 2005 through 2006. Figure 5-2 shows three important indicators of the before and after periods (assuming a conversion year of 2001): 1) the percent change between the average value from the before period (1996 through 2000) and the after period (2002 through 2006); 2) the percent change (trend) in the before period (1996 through 2000); and 3) the percent change (trend) in the after period (2002 through 2006). The average percent change in the after period (12 percent) was lower than the average percent change of the before period (24 percent), but this indicator did remain positive. In addition, the average gross sales value of the before and after periods increased 13 percent.

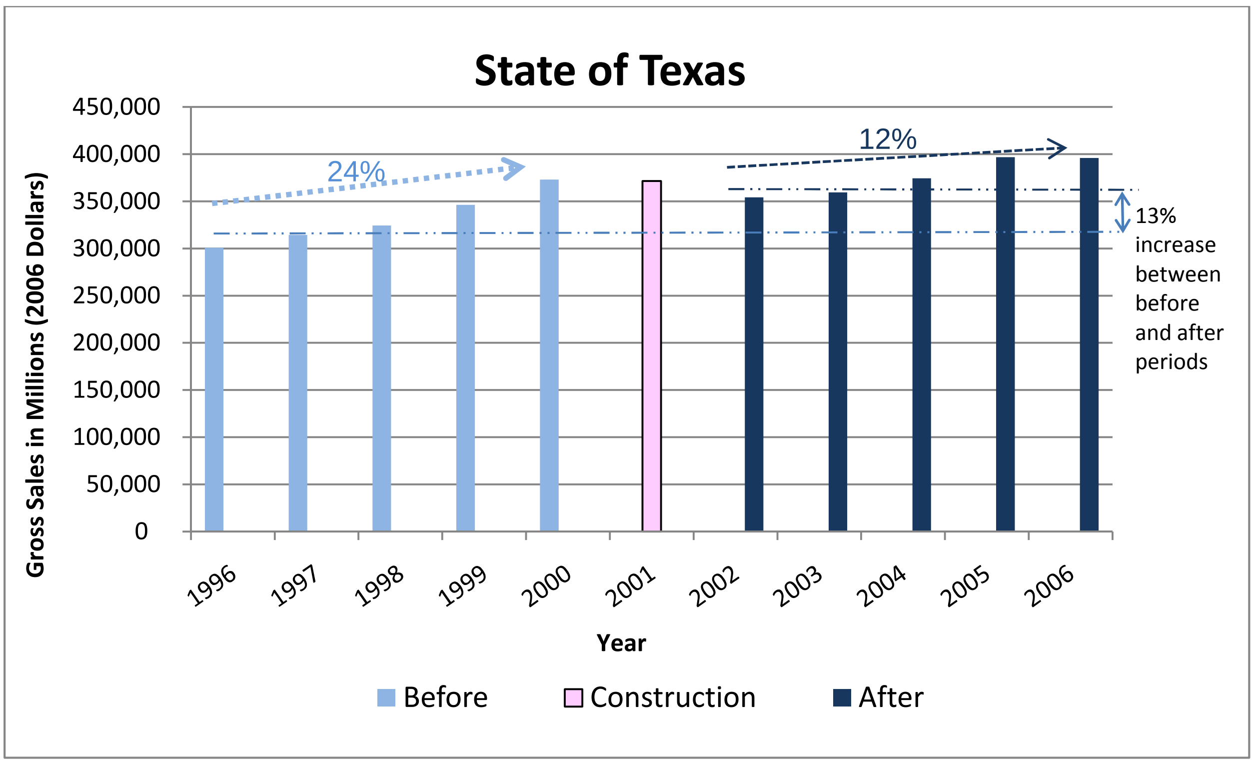

Figure 5-2. The Average Percent Change of Before and After Periods of the State of Texas.

City of Sulphur Springs and City of Greenville Gross Sales

To demonstrate the trend in gross sales relative to the conversion, researchers separated gross sales data into three periods (before, construction, and after) and performed a before-and-after analysis. Figure 5-3 and Figure 5-4 show the gross sales percentage change in different periods for Sulphur Springs and Greenville, respectively. Table G-1 and Figures G-9 through G-21 in Appendix G show the detailed information. The following observations are made:

- As seen in Figure 5-3, the average percent change of the after period (7 percent) was higher than the average percent change of the before period (3 percent), which indicates that gross sales were increasing at a higher rate than they were before conversion of the frontage roads. However, the percent changes of Sulphur Springs were lower than the average percent changes of the State of Texas for the same time periods (see Figure 5-2 for comparison).
- The average gross sales value of before and after periods decreased 14 percent, and this change is significantly different. This reduction of Sulphur Springs is different from the up-trend in the State of Texas.
- In Greenville (see Figure 5-4), the average percent change of the after period was down 3 percent and the average percent change of the before period was up 20 percent. In comparison to Figure 5-2, these trends of percent changes in Greenville were different from the average percent changes of the State of Texas. The average gross value of before and after periods increased 26 percent.
- It is important to recall that these gross sales values are for the entire city, not just the frontage road of interest; therefore it is not prudent to attribute sales differences to the frontage road conversion specifically. The intent is to just see the general economic trends in each area with these data. Because Greenville is only approximately 30 minutes west of Sulphur Springs along IH 30, it is possible that Greenville was an alternative for some sales activity after the conversion. However, it appears that long-term outlook is relatively positive, as the percent change after the construction to present is higher in Sulphur Springs.

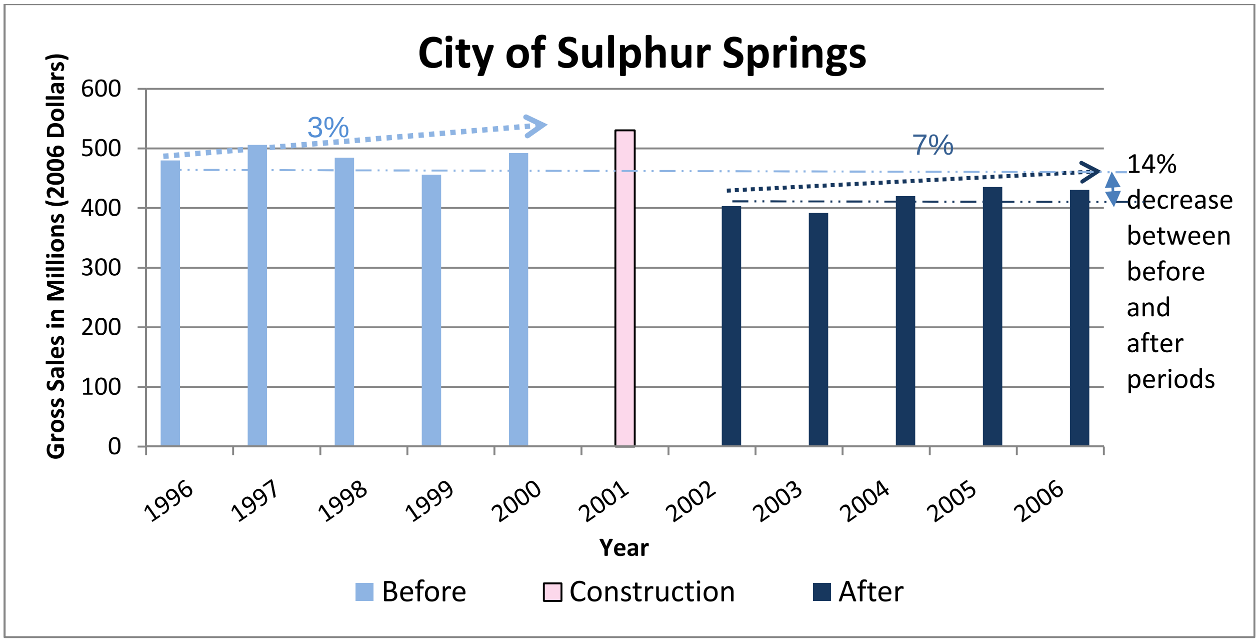

Figure 5-3. Average Percent Change of Before and After Periods in Sulphur Springs.

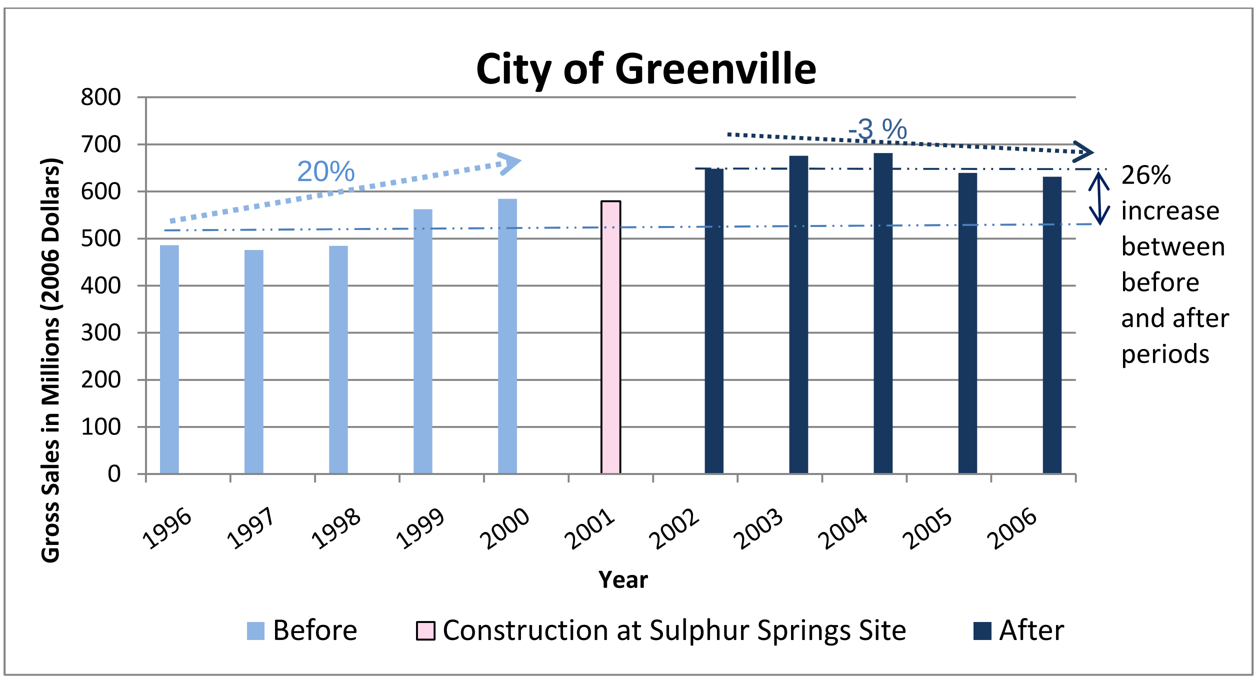

Figure 5-4. Average Percent Change of Before and After Periods in Greenville.

City of Hillsboro and City of West Gross Sales

Figures 5-5 and 5-6 show the gross sales percentage change in the before and after periods for Hillsboro and West, respectively. Table G-2 and Figures G-22 through G-35 in Appendix G show the detailed information. The following observations are made:

- In Hillsboro, the growth rate of gross sales was positive in the after period, although its average gross sales value decreased slightly (2 percent) after construction. The percent changes of Hillsboro were lower than the average percent changes of the State of Texas for the same time periods, and the reduction of average gross sales value in Hillsboro was also different from the up-trend in the State of Texas (see Figure 5-2 for comparison).
- In West, the growth rate of gross sales was negative in the after period, and its average gross sales value also decreased slightly (5 percent). The percent changes of West were lower than the average percent changes of the State of Texas for the same time periods, and the reduction of average gross sales value in West was also different from the up-trend in the State of Texas (see Figure 5-2 for comparison).
- After the conversion year of 2001, the gross sales of Hillsboro remained relatively unchanged, while the gross sales of West decreased slightly. The difference between these two cities was mostly caused by the reduction in group B (non-retail) business sales in the city of West. As for retail businesses (group A), the gross sales of these two cities remained relatively unchanged. Hence, based on the above data, there appear to be long-term increases in gross sales in Hillsboro.
- As mentioned previously, it is not prudent to attribute changes in this city-level gross sales data to the frontage road conversion specifically. The intent is to identify the general economic trends in each area with these data.

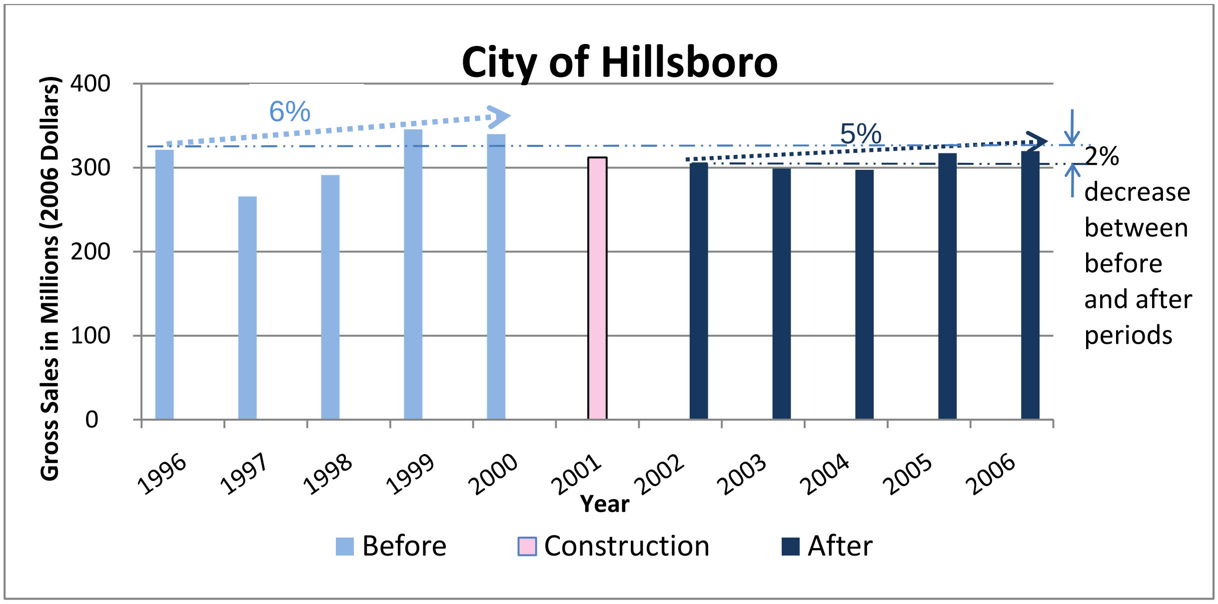

Figure 5-5. Average Percent Change of Before and After Periods in Hillsboro.

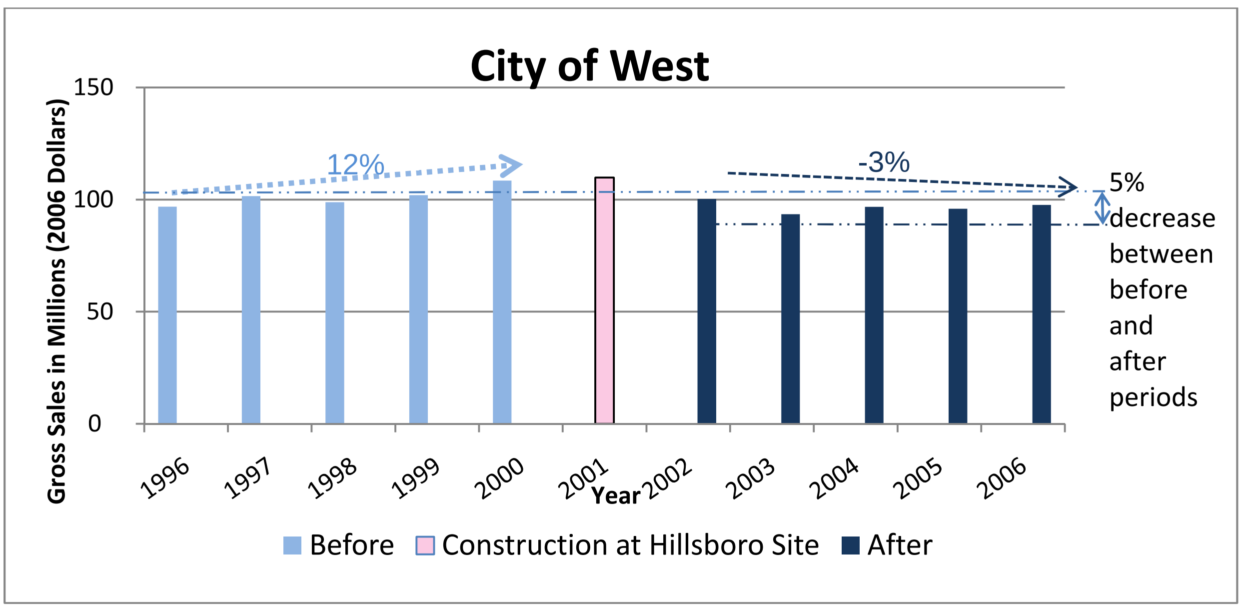

Figure 5-6. Average Percent Change of Before and After Periods in West.

City of Wolfforth and City of Plainview Gross Sales

Figures 5-7 and 5-8 show the percentage change of the amount-subject-to-tax sales in the before and after periods for Wolfforth and Plainview, respectively. Table G-3 and Figures G-36 through G-47 in Appendix G provide detailed information. The following observations are made:

- In Wolfforth, the growth rate became smaller in the after period (10 percent), and the average value of the amount subject to tax decreased statistically when comparing the before and after periods (30 percent decrease). The percent changes of Wolfforth were higher than the average percent changes of the State of Texas for the same time periods, and the reduction of average gross sales value in Wolfforth was also different from the up-trend in the State of Texas (see Table B-3 for comparison).
- In Plainview, the gross sales decreased in the after period (2002 through 2006) by 2 percent, and there was a 22 percent decrease between the before and after periods. The percent changes of Plainview were lower than the average percent changes of the State of Texas for the same time periods, and the reduction of average gross sales value in Wolfforth was also different from the up-trend in the State of Texas (see Table B-3 for comparison).
- In Wolfforth, there did seem to be a decrease in 2003, but the total gross sales values are the smallest of the three areas analyzed, and any impacts can be accentuated in small areas, as such economics can be more sensitive to anything that may affect the local economy. However, in the after period (2002 through 2006), the percent change was an increase of 10 percent in Wolfforth and a decrease of 2 percent in Plainview.
- As mentioned previously, it is not prudent to attribute changes in this city-level gross sales data to the frontage road conversion specifically. The intent is to identify the general economic trends in each area with these data.

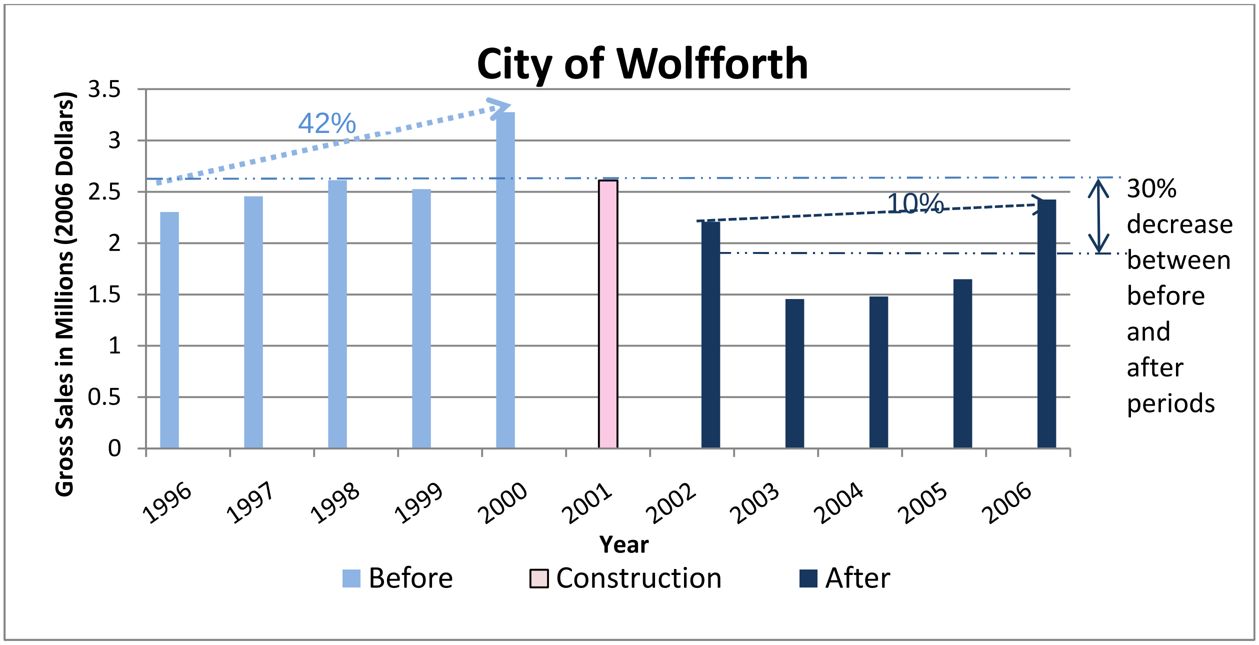

Figure 5-7. Average Percent Change of Before and After Periods in Wolfforth.

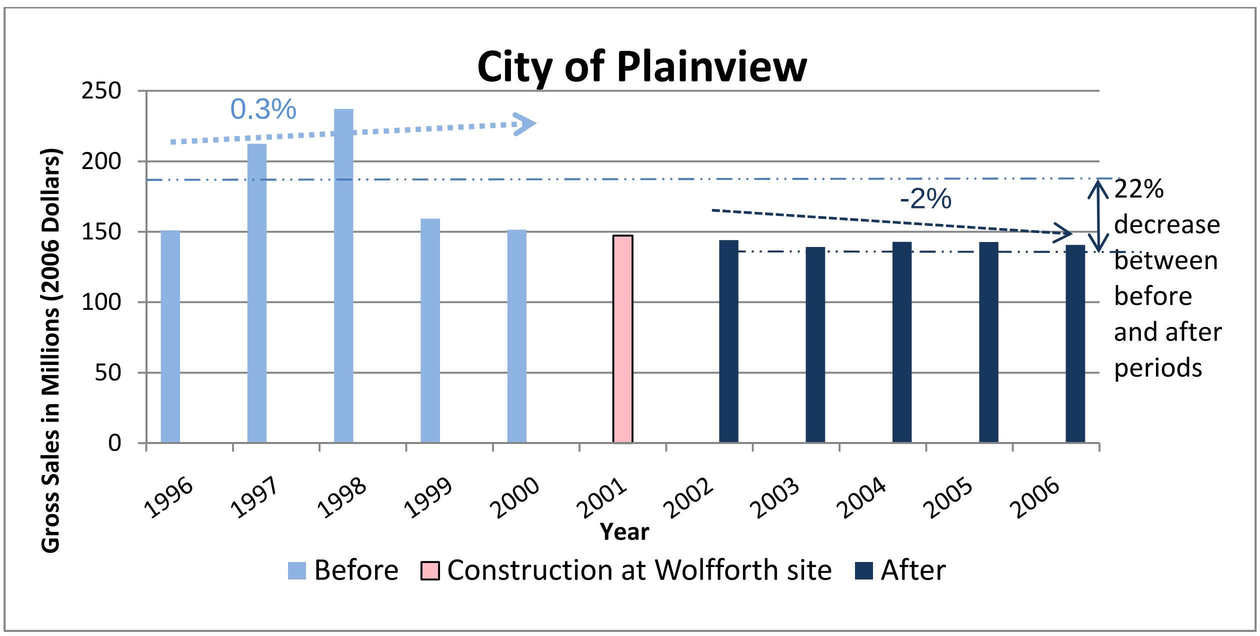

Figure 5-8. Average Percent Change of Before and After Periods in Plainview.

City of Huntsville Gross Sales

The Huntsville site is in Walker County. The conversion and comparison sites are adjacent to one another along the Huntsville corridor. The northern segment is the conversion site, while the southern segment is the comparison site. The gross sales data are aggregate information by city. Therefore, there is no detailed information for each specific segment or locations. For completeness, researchers provide the trends of the City of Huntsville here. Figure 5-9 shows the percent change of the gross sales in the before and after periods. In Huntsville, the growth rate became smaller in the after period (28 percent), but the average value of gross sales increased when comparing the before and after periods (15 percent increase). Figures G-48 through G-53 in Appendix G provide additional information.

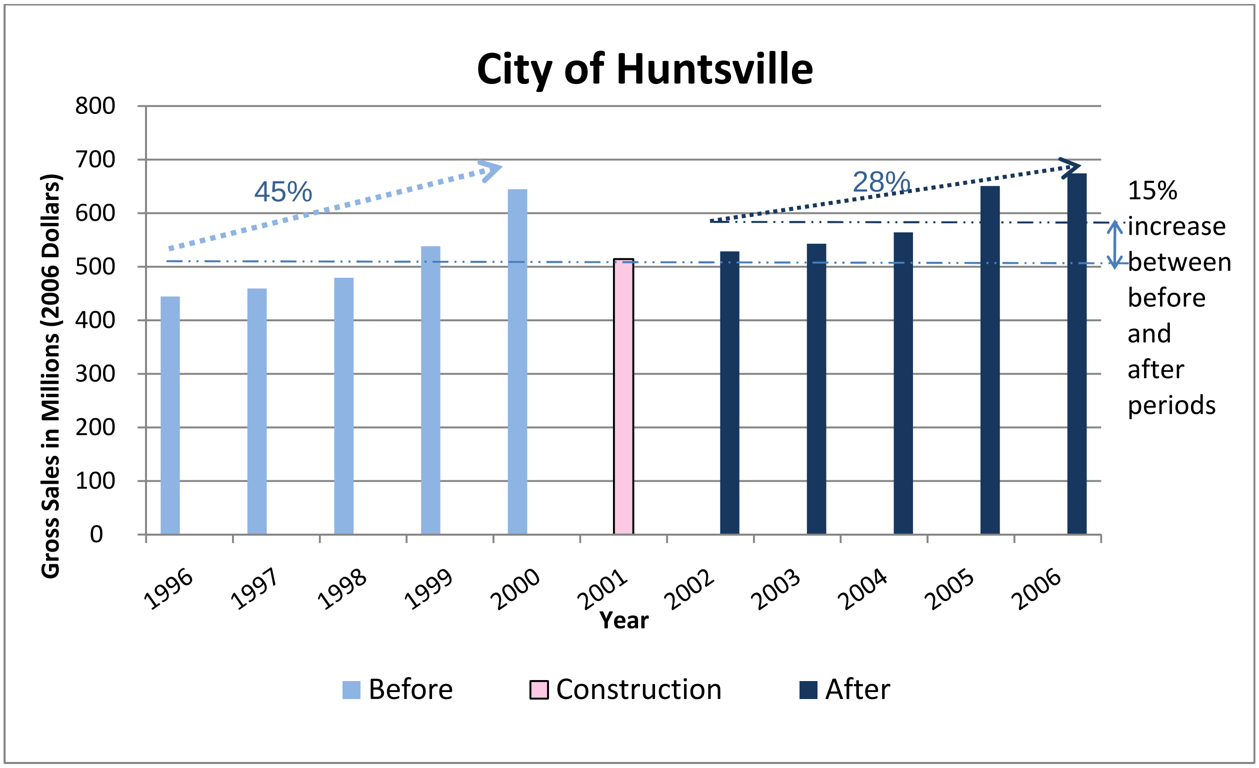

Figure 5-9. Average Percent Change of Before and After Periods in Huntsville.

City of Burleson Gross Sales

The next conversion corridor is in the city of Burleson along IH 35W (Tarrant and Johnson Counties). The north segment (milepoint 42-37) is in Tarrant County, and the south segment (milepoint 37-36) is in Johnson County. Figure G-54 through Figure G-63 of

Appendix G show the trends. Recall that there is not a comparison corridor for the Burleson conversion site. The following observations are made:

- Figure 5-10 shows the percentage change of the gross sales in the before and after periods. In Burleson, the growth rate became smaller in the after period (4 percent), and the average value of gross sales increased when comparing the before and after periods (38 percent increase).
- As mentioned previously, it is not prudent to attribute changes in this city-level gross sales data to the frontage road conversion specifically. The intent is to identify the general economic trends in each area with these data.

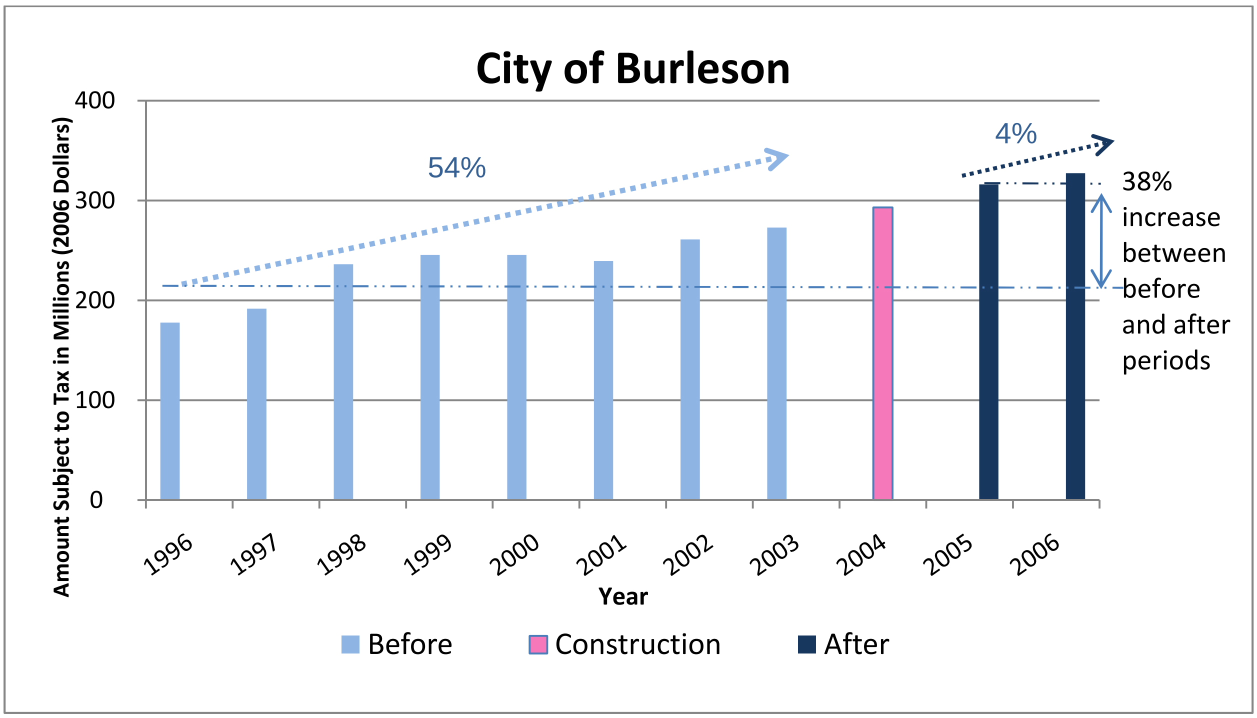

Figure 5-10. Average Percent Change of Before and After Periods in Burleson.

Summary of Gross Sales Findings

Table 5-3 shows the change of gross sales (or amount subject to tax) for each city, including more detailed statistics about the before and after periods. As mentioned previously, it is important to note that it is not prudent to attribute changes in these city-level gross sales data to the frontage road conversion specifically. The intent is to identify the general economic trends in each area with these data. The observations made below are in terms relative to the "before" and “after” period relative to conversion dates, but it is not intended to indicate causality between these trends and the frontage road conversion. These data are too aggregate for such analysis.

The cities with conversion sites had growth in the after period at a higher rate than the associated city of the comparison sites. In fact, all comparison sites had a negative gross sales trend in the after period. The average value of gross sales decreased in most conversion and comparison cities (except Greenville, Huntsville, and Burleson), and this was different from the up-trend in the State of Texas.

Table 5-3. Gross Sales Characteristics of Cities with Conversion and Comparison Sites.

Groups and Cities[1]		Gross Sales Data[2]		
		Percent Change of Before Period[3]	Percent Change of After Period[4]	Percent Change of After Period Compared to Before Period
Texas (Gross Sales A)		24%	12%	13%
Texas (Amount Subject to Tax)		16%	5%	9%
Group 1	Sulphur Springs	3%	7%	−14%
	Greenville	20%	−3%	26%
Group 2	Hillsboro	6%	5%	−2%
	West	12%	−3%	−5%
Group 3	Wolfforth	42%	10%	−30%
	Plainview	0%	−2%	−22%
Group 4	Huntsville	45%	28%	15%
Texas (Gross Sales B)		19%	0%	16%
Group 5	Burleson	54%	4%	38%

[1]Texas (Gross Sales A), Texas (Amount Subject to Tax), and Texas (Gross Sales B) provide the gross sales value and the amount subject to tax of Texas for reference. The difference between Texas (Gross Sales A) and Texas (Gross Sales B) is their before period and after period. Because the Burleson site was converted in 2004 (different than the others), gross sales at the State of Texas level (Gross Sales B) were computed for comparison.

[2]The data for Group 1, 2, 3 and 4 are gross sales, and the data for Group 5 is amount subject to tax.

[3]Computed as the percent difference between the gross sales value in the last year and in the first year in the before period. Texas (Gross Sales A), Texas (Amount Subject to Tax), and Group 1, 2, 3, and 4 are from 1996 to 2000. Texas (Gross Sales B) and Group 5 are from 1996 to 2003.

[4]Computed as the percent difference between the gross sales value in the last year and in the first year in the after period. Texas (Gross Sales A, Texas (Amount Subject to Tax), and Group 1, 2, 3, and 4 are from 2002 to 2006. Texas (Gross Sales B and Group 5 are from 2005 to 2006.

Concluding Remarks on Gross Sales Analysis

The following observations are made:

- It is not prudent, nor is it the intent, to attribute changes in this city-level gross sales data to the frontage road conversion specifically. Rather, the intent is to identify the general economic trends in each area with these data using the before and after time periods of the conversions.
- In the after period, all cities with conversion sites showed increases in gross sales at a higher rate than the corresponding city of the comparison site. In fact, all comparison sites showed negative gross sales after the conversion date in the conversion city.
- When comparing the percent change of the after period with the before period, researchers found a decrease in gross sales in the city of each conversion site except Burleson and Huntsville. The decrease ranged from 2 percent in Hillsboro to 30 percent in Wolfforth. The State of Texas experienced a 13 percent increase during the same time period.
- Generally, the trends of the gross sales of all businesses together were similar to the trends of group B (non-retail) businesses, while the gross sales of retail businesses (group A) remained relatively flat (unchanged). This detailed analysis and discussion is shown in Appendix G. The changes in gross sales trends of the group B (non-retail) businesses were mostly caused by auto dealers and gas stations, while the trends of food stores and eating and drinking places remained relatively flat. The auto dealers and gas stations generally accounted for more gross sales activity, and changes in this category had more influence on gross sales trends.
- It is reasonable to assume that some additional factors could have been influencing the sales of auto dealers and gas stations, and these factors may not have been related to the frontage road conversion. The State of Texas data showed a noticeable drop between 2000 and 2002 that was caused by auto dealers, gas stations, and hotels. It is possible that the cost of gas was influencing spending during 2000 to 2002. The historical gas price from 2000 to 2002 was higher than the previous 10 years, and it also became much higher after 2004 (*41*). Another possibility for the relatively lower values in 2000 to 2002 is the September 11 attacks in New York City. There were

economic effects of the attacks on transportation, and many economic activities were closed temporarily, including the United States Stock Exchange.

There were many other economic factors affecting gross sales values that the research team did not control for in this analysis. Among those factors were general economic conditions in the local area as well as state and national economic trends. The study also did not control for access to new retail outlets in other locales that might have resulted in locational shifts in buying patterns. While these factors may have skewed data for a specific year, the research team believes the general long-term trends reflected in the data are valid.

APPRAISAL DATA ANALYSIS AND FINDINGS

Appraisal Data Collection

Land owners adjacent to frontage roads that may be converted from two-way operation to one-way operation are often concerned about property value impacts. Researchers collected appraisal data for parcels adjacent to all of the conversion and comparison sites. Researchers also added the City of Cibolo case study for this analysis, which will be discussed in detail later in this chapter.

For the conversion and comparison sites, researchers contacted the county appraisal districts to obtain land and improvement values for parcels adjacent to the interstates or highways studied. Specifically, researchers asked all appraisal districts for key data elements including parcel identification, address, legal description, "doing business as," owner name, year, land value, improvement value, and total appraised value. Ideally, researchers desired appraisal data from three to five years prior to the conversion year up to the most current year of data available. Researchers collected these data for each conversion site and its associated comparison site. Some county appraisal districts were not able to provide appraisal values for three years or more prior to the conversion year. Often, this was due to the electronic or Internet-accessible database not including all years. In these cases, researchers requested hardcopies or electronic historical appraisal data for each parcel to supplement the online data. In some cases, additional data were not available back to the desired years.

Many county appraisal districts had online appraisal data search engines that provided separated land and improvement values by year for each parcel. These county appraisal districts were able to provide researchers with a list of the parcels adjacent to the study sites and the associated property identification (property ID) number. This enabled researchers to perform online searches to gather the land and improvement values for all the years available on the Internet site. For county appraisal districts that did not have an online property search website, the appraisal districts provided researchers with hardcopy and sometimes electronic data of the appraised values.

Methodology

After obtaining the appraisal district data, researchers attempted to identify current business type for each parcel. Researchers used Google maps®, Google Earth®, Bing®, and schematics from the field investigations to assist in identifying the business type information. In some cases, the county appraisal district had "doing business as" (DBA) information to identify the business. Researchers performed trend analyses for all available parcels and for specific groups of businesses. "All available parcels" included vacant (undeveloped) land, residential parcels with frontage road access, and all other parcels adjacent to the frontage road. Researchers did not keep state or city parcels in the dataset because they are exempt from full property taxes. Researchers investigated trends for other selected business types including gas, restaurant, hotel, etc. Researchers could not always identify the current business type for each parcel; therefore, researchers included those only where it could be determined.

Researchers developed graphs for the years of data available that show the appraised value in each year. In many cases, some parcels of appraisal data were not available for a given parcel throughout the entire time series. For example, a parcel that is subdivided out from a "parent" parcel will "suddenly" appear in the trend as having a land value when the parcel comes under new ownership. Often, county appraisal districts indicated that it was difficult to trace the history back on a particular parcel to identify the parent track, especially because parcels can be subdivided, and then subsequently subdivided again. In these cases, researchers removed these parcels from the analysis. More than likely, this means that there is physical property included in the earlier years (prior to being subdivided) that is not included in the later years. Therefore, this provides a conservative estimate in later years of the appraised values. When this occurs, researchers mention all the additional appraised value along the corridor that is not included in the trend analysis. Researchers considered leaving the additional parcel values in the analysis, but because it was difficult to know the exact parent tract, which could even be from a property that is not adjacent to the frontage road, it was determined to proceed with the conservative trend analysis.

Researchers initially performed the appraisal data collection and analysis early in the first year of the project. Researchers took the opportunity to update some of the graphics with more recent data at the end of the project when it was readily available and as time allowed. Therefore some of the graphics have trend information for more recent years.

Appraisal Data Considerations

As previously discussed, researchers collected land and improvement appraisal values for all parcels adjacent to the conversion and comparison sites. Researchers began with the goal of investigating the trend in land value and improvement value from before and after the conversion (and similar trend years in the comparison sites). After reviewing the data, and speaking with several appraisers, researchers identified several nuances and external factors that affect the data. For those reviewing the trend data, it is important to understand these factors that affect appraisal data. A sampling of the nuances and factors encountered by the research team are identified as follows:

- As mentioned in the prior section, in all study locations researchers identified some parcels that would appear in later years of the trend analysis. Researchers learned that these were typically, but not always, property replats, or subdivisions. It was often time-prohibitive for researchers to go historically back to identify parent tracks for such subdivisions. In some cases, the appraisers themselves indicated that this could be a time-consuming process and the history of parcels was not always easy to obtain. Therefore, researchers often removed such parcels to provide a more conservative trend analysis of the values.
- Researchers identified relatively high increases in appraisal values along a couple of the corridors in a particular year. After investigating, researchers learned that the adjustments were made across the board in these cases to bring the land and improvement values up to market value. In one case, because of this, researchers began the trend analysis after that year of data. In some cases, these increases are a

function of the local economic climate and are included in the trend analysis. The point to the reader is that such adjustments can occur.

- In more than one location, the research team learned that values are frequently contested by property owners or tax consultants, and adjustments are made to values based upon these hearings. Likewise some property owners may not contest values on a similar property, causing variation in appraised values on properties that are relatively similar.
- Researchers learned that certified values are due by July 25 for the tax year by law. Researchers identified one location where the Appraisal Review Board (ARB) hearings occurred after the July 25 date, and the adjusted values were not inserted into the historical online values. Rather, a note was kept on the record. It is possible that there are more locations and/or parcels where this may have occurred, particularly in locations where there are numerous appraisal hearings.
- Researchers learned that, by law, appraisers can use three acceptable methods to appraise property: 1) market by looking at sales, 2) income for income-producing properties, and 3) replacement cost. Depending upon the type of parcel, economic activity, sales, etc., it is possible that parcels are appraised with different methods in a given location.
- Researchers learned that land values are typically held relatively constant and adjustments in appraised value are typically made to improvements to avoid any inequities in land value.
- In some cases, researchers received only total market values; therefore, the graphs in this section contain only total market value information.

Considering all of these nuances with appraisal data, researchers developed aggregate percentage differences in appraised values over the range of time that was available for each study site.

Appraisal Data Analyses and Findings

After reducing the data in Excel® spreadsheets, researchers created figures that show the land value (when available), improvement value (when available), and total appraised value for each conversion and comparison site. Researchers computed the percent change from the first year of available data to the last year of available data and placed these values in the figures. This section presents these figures, along with observations.

Sulphur Springs Conversion Site

Researchers received parcel data for 101 parcels in Sulphur Springs along IH 30. Figure 5-11 illustrates the trend in land value, improvement value, and total appraised value from 2000 to 2010. All values are relatively flat from 2000 to 2003. Beginning in 2004, improvement values and total values increase and then flatten out in 2008. Land values remain relatively constant throughout the entire trend. It should be noted that nine parcels representing five million dollars in total appraised value in 2010 were removed from this analysis because they were likely subdivisions; therefore, in the later years this trend of values should be considered conservative.

Researchers identified 20 businesses along the corridor (hotel, restaurant, gas, and retail). As shown in Figure 5-12, the trend with these 20 businesses is similar to the larger group, with declines in recent years (2008 and later) impacting these businesses more than the larger group of all parcels. Over the entire trend of years, total appraised values are down 1 percent (Figure 5-12) compared to being up 24 percent for all businesses (Figure 5-11).

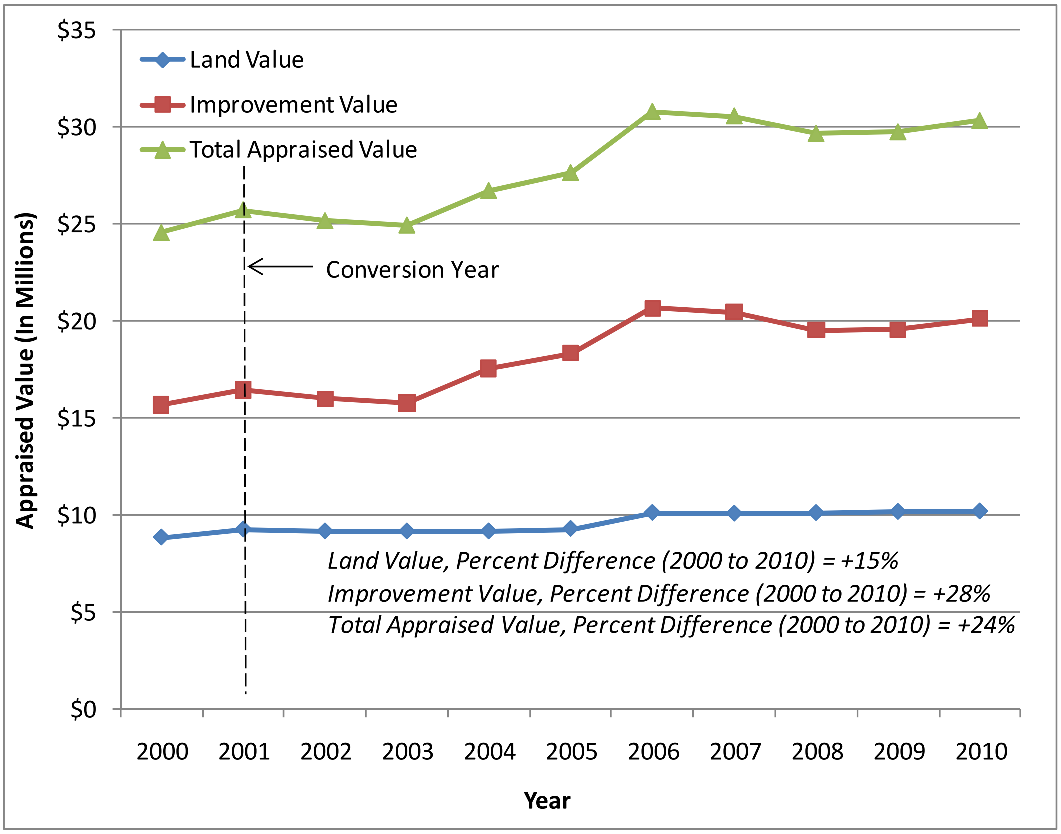

Figure 5-11. Appraised Value along Sulphur Springs Corridor.

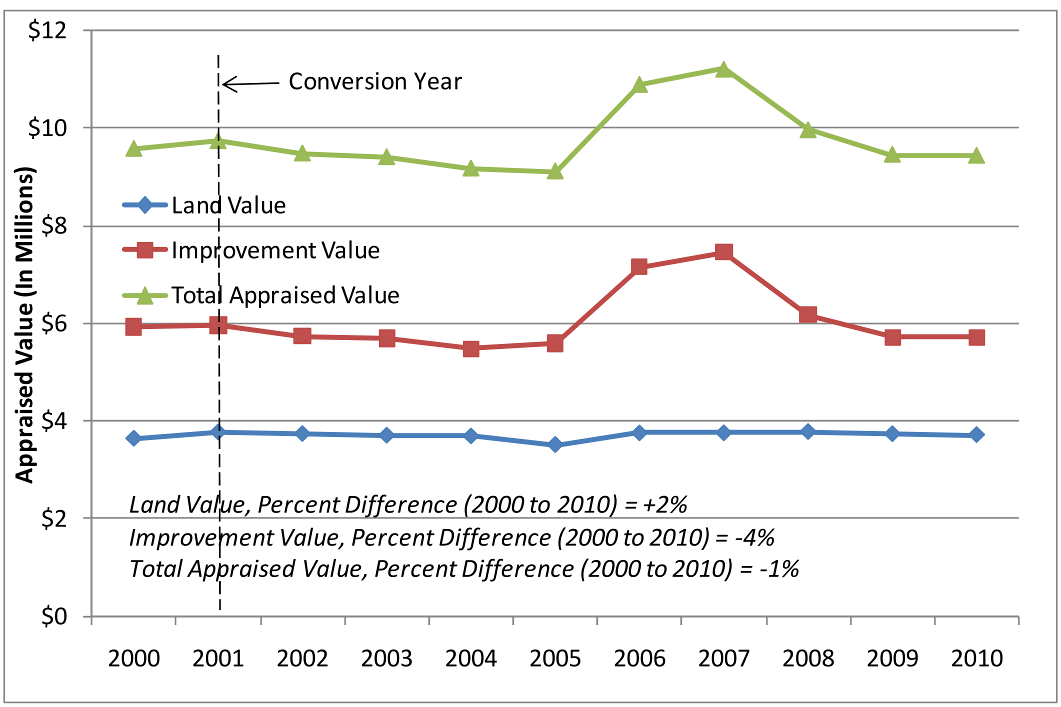

Figure 5-12. Appraised Value along Sulphur Springs Corridor, Selected Businesses.

Greenville Comparison Site

Researchers received parcel data for 107 parcels in Greenville along IH 30. Figure 5-13 shows the trend in land value, improvement value, and total appraised value from 2000 to 2008. Over the time series, land values increase by 52 percent and total appraised values increased 70 percent. Generally, there appear to be long-term increases through 2008. It should be noted that four parcels representing three million dollars in total appraised value in 2008 were removed from this analysis because they were likely subdivisions; therefore, in the later years this trend of values should be considered conservative. Researchers investigated selected business types and found similar trends.

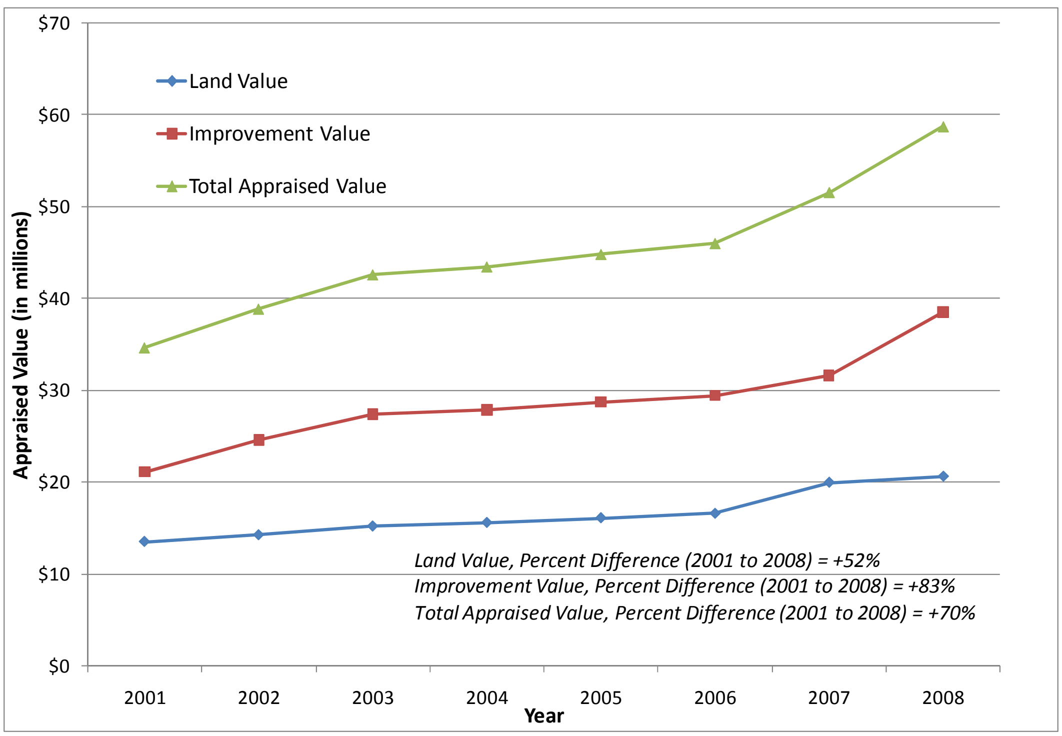

Figure 5-13. Appraised Value along Greenville Corridor.

Huntsville Conversion Site

Researchers received parcel data for 53 parcels along IH 45 along the Huntsville conversion site. Figure 5-14 illustrates the trends in appraised values. Trends are relatively increasing, with a slight decline from 2009 to 2010. Overall, there is a 32 percent increase in total appraised values from 1999 to 2010. As before, researchers removed some parcels from the trend that were likely subdivisions. There were numerous parcels with a total value of eight million dollars in 2010 removed. Therefore, in the later years, the value trends are conservative. Approximately four million dollars was developed in 2002, the year after the conversion. Figure 5-15 shows the trend of 18 selected gas, retail, restaurant, and hotel properties along the corridor. While land values remained relatively flat and increased only 11 percent over the time period from 1999 to 2010, total appraised value increased by 56 percent.

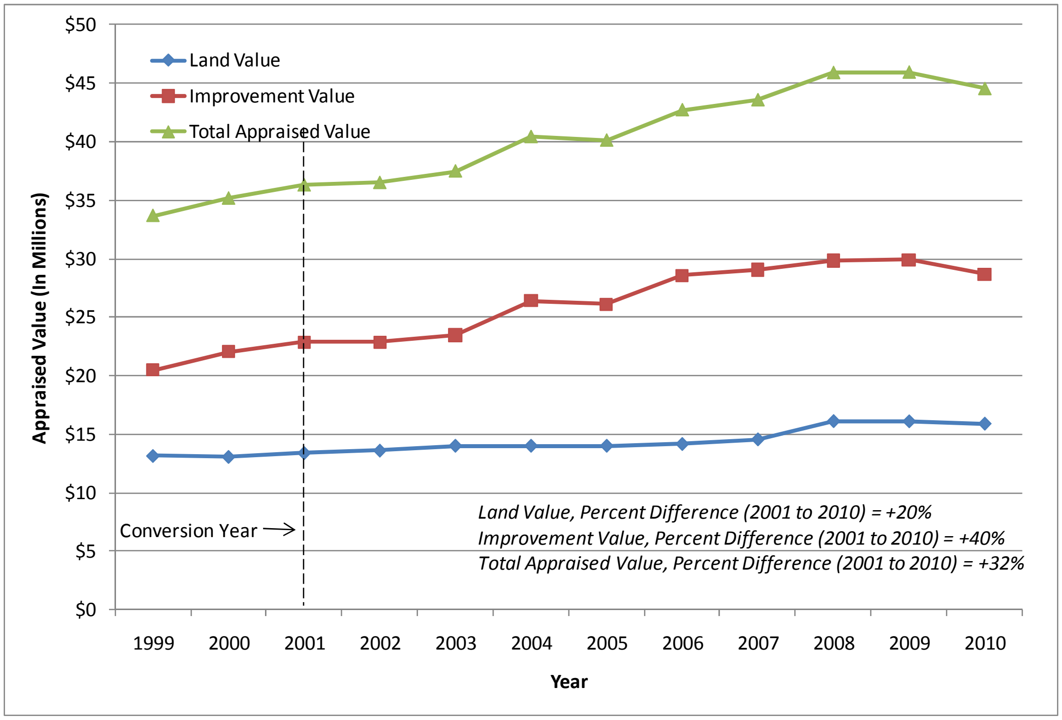

Figure 5-14. Appraised Value along Huntsville Conversion Corridor.

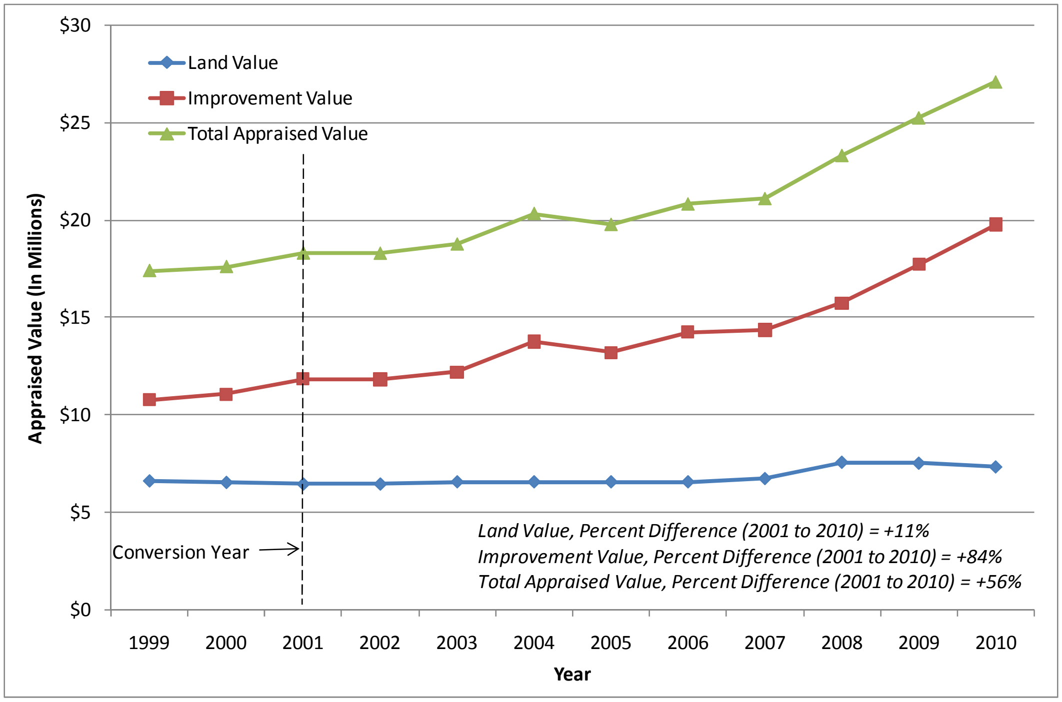

Figure 5-15. Appraised Value along Huntsville Conversion Corridor, Selected Businesses.

Huntsville Comparison Site

Researchers received parcel data for 43 parcels along the Huntsville comparison site along IH 45. It should be noted that while this site was used as a comparison site to the Huntsville conversion site, it too was converted to one-way in early 2009. The appraisal trend data are shown from 1999 to 2010 in Figure 5-16. The trend is similar to the conversion site, showing increases and then relative flattening of values from 2008 to 2010. Over the 11-year period, the total appraised values increased 154 percent. There were also eight parcels valued at slightly over four million dollars in 2010 that were removed from the analysis because they were likely subdivisions, but that could not be clarified; therefore, in the later years this trend of values should be considered conservative. Researchers investigated nine selected gas, retail, restaurant, and hotel parcels and found a similar trend in appraisal values, as shown in Figure 5-17.

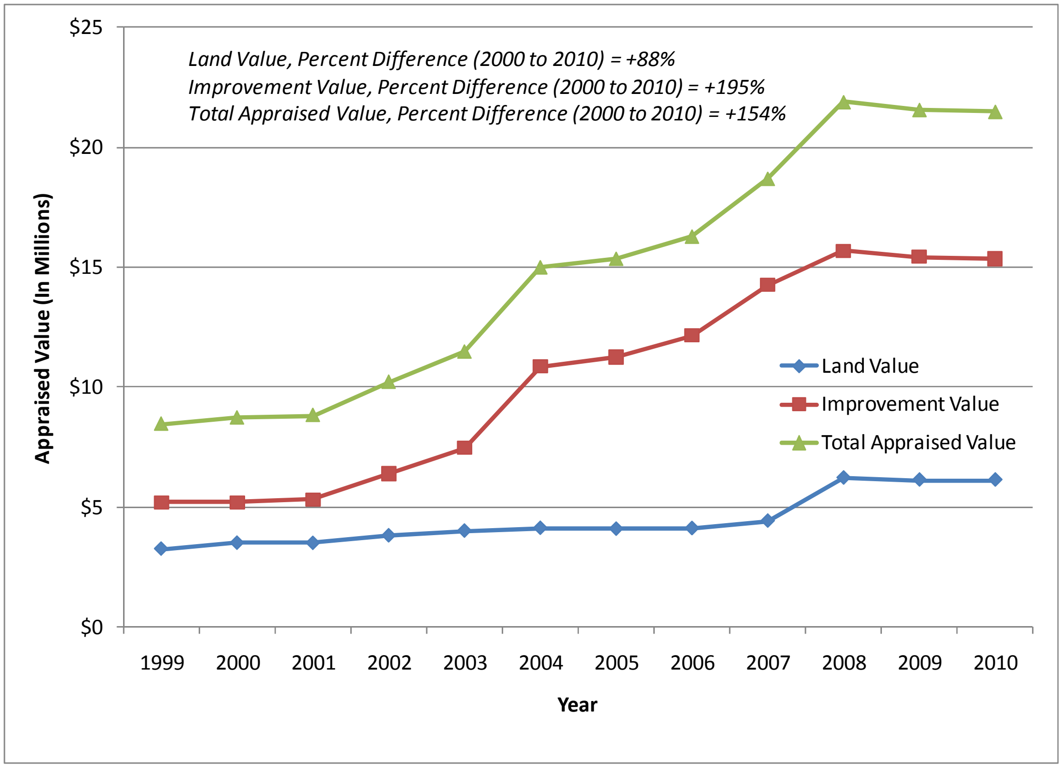

Figure 5-16. Appraised Value along Huntsville Comparison Corridor.

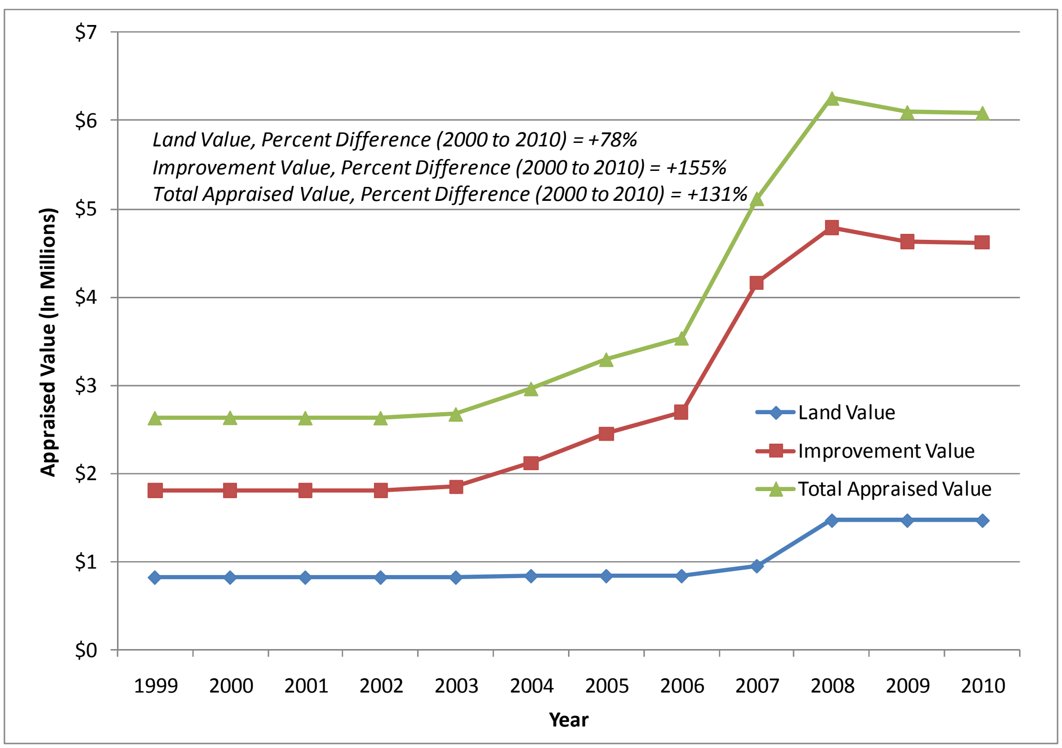

Figure 5-17. Appraised Value along Huntsville Comparison Corridor, Selected Businesses.

Wolfforth Conversion Site

Researchers obtained parcel data for 58 parcels along US 62/82. Figure 5-18 shows the trend from 2003 to 2008. For this trend, researchers started in 2003 because there were several parcels that did not go back through the entire time period, and researchers did not want to have to remove all of them. To get the trend from 2003 to 2008, researchers removed five parcels with a total value of just over one million dollars in 2008. Therefore, as before, this trend should be considered conservative. Figure 5-18 shows general increases from 2003 to 2008 and total appraised values were up 84 percent during this time period.

Researchers investigated five parcels (retail, restaurant, gas) that had appraisal data back to 2000. Though it is a very small sample size, the trend for these five parcels shown in Figure 5-19 is similar to the trend for all parcels shown in Figure 5-18.

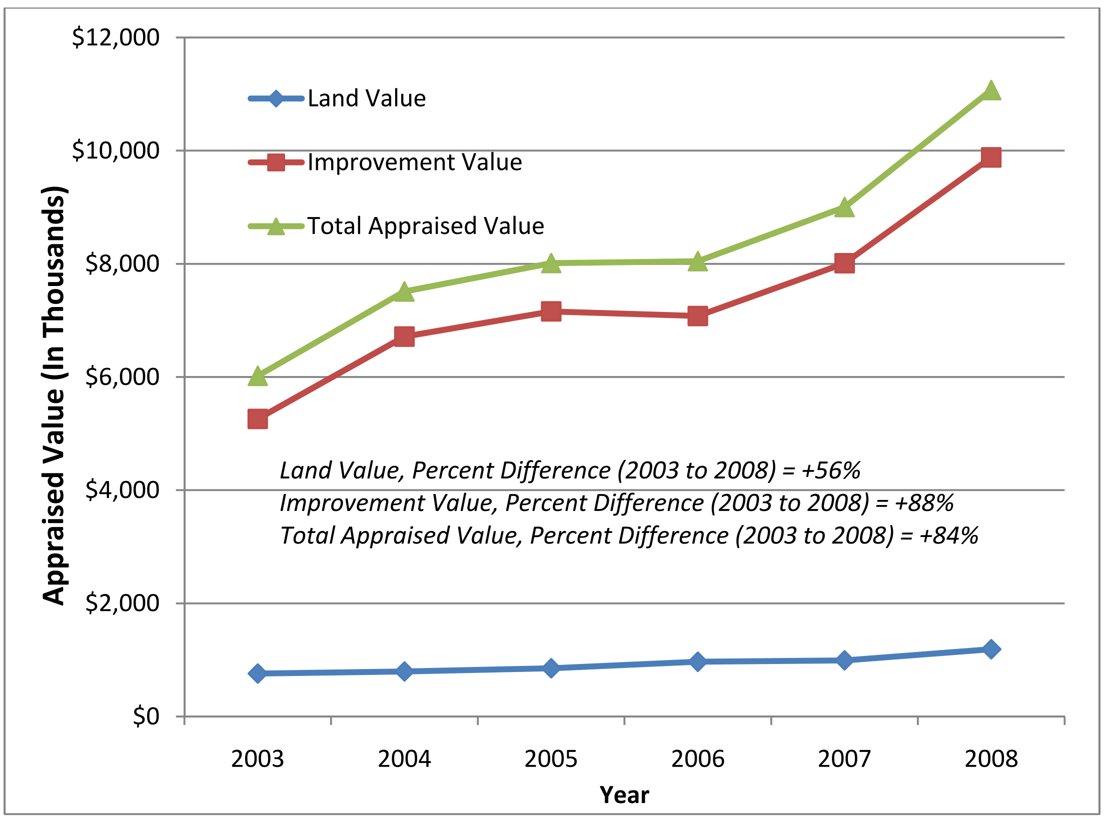

Figure 5-18. Appraised Value along Wolfforth Conversion Corridor.

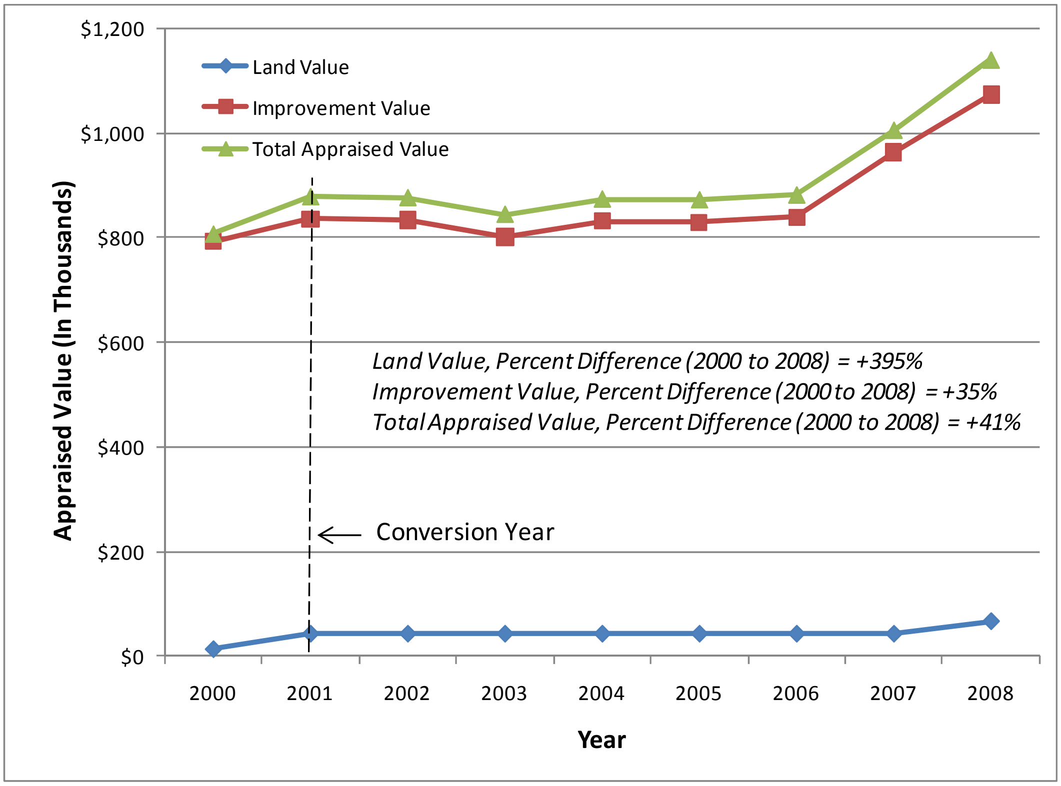

Figure 5-19. Appraised Value along Wolfforth Conversion Corridor, Selected Businesses.

Plainview Comparison Site

Researchers obtained parcel data for 102 parcels along IH 27. Similar to Wolfforth, researchers performed the trend analysis back to 2005 to avoid losing substantial numbers of parcels that did not have trend data back to 1999. As shown in Figure 5-20, appraised values are relatively flat over the period from 2005 to 2008. Total appraised values are up 19 percent and land values are up 84 percent.

Researchers investigated 13 selected businesses (restaurants, hotels, retail) to analyze the trends from 1999 to 2008. For these selected businesses, the trend is shown in Figure 5-21. Improvement and total appraised values decreased from 1999 to 2004 and then increased to near their 1999 values by 2008. Land values remained relatively flat over the time period. The trend from 2005 to 2008 for these 13 selected parcels is similar to the trend for all parcels shown in Figure 5-20. In recent years, the 13 selected parcels are increasing in total appraised value.

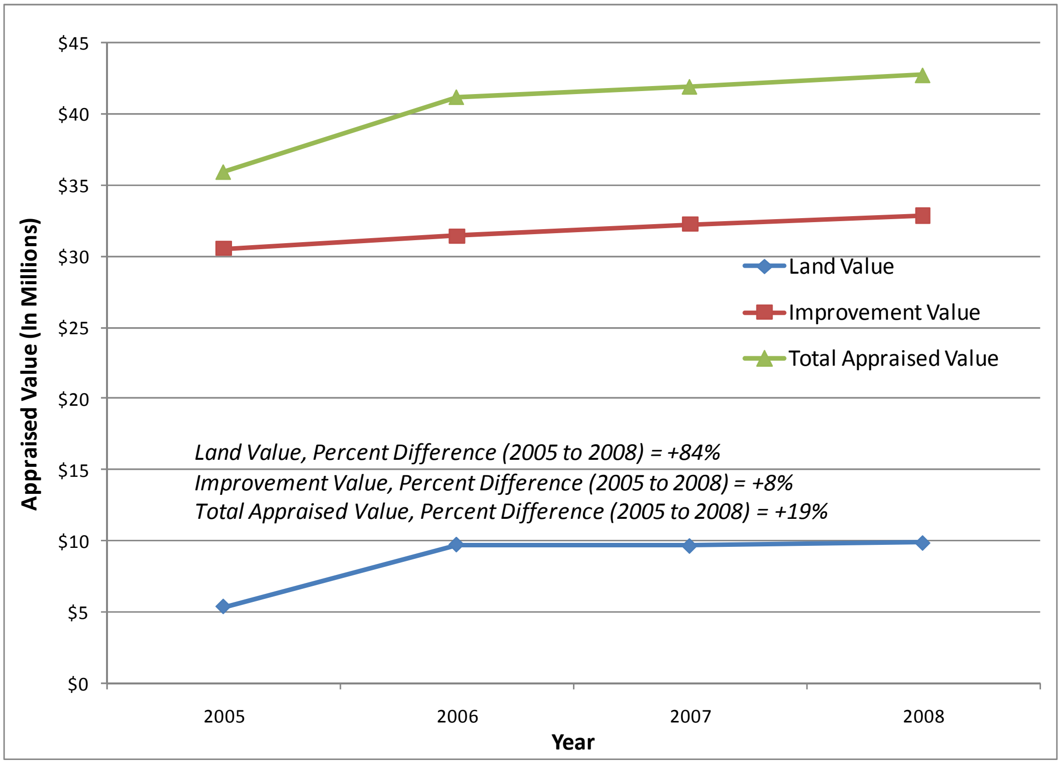

Figure 5-20. Appraised Value along Plainview Comparison Corridor.

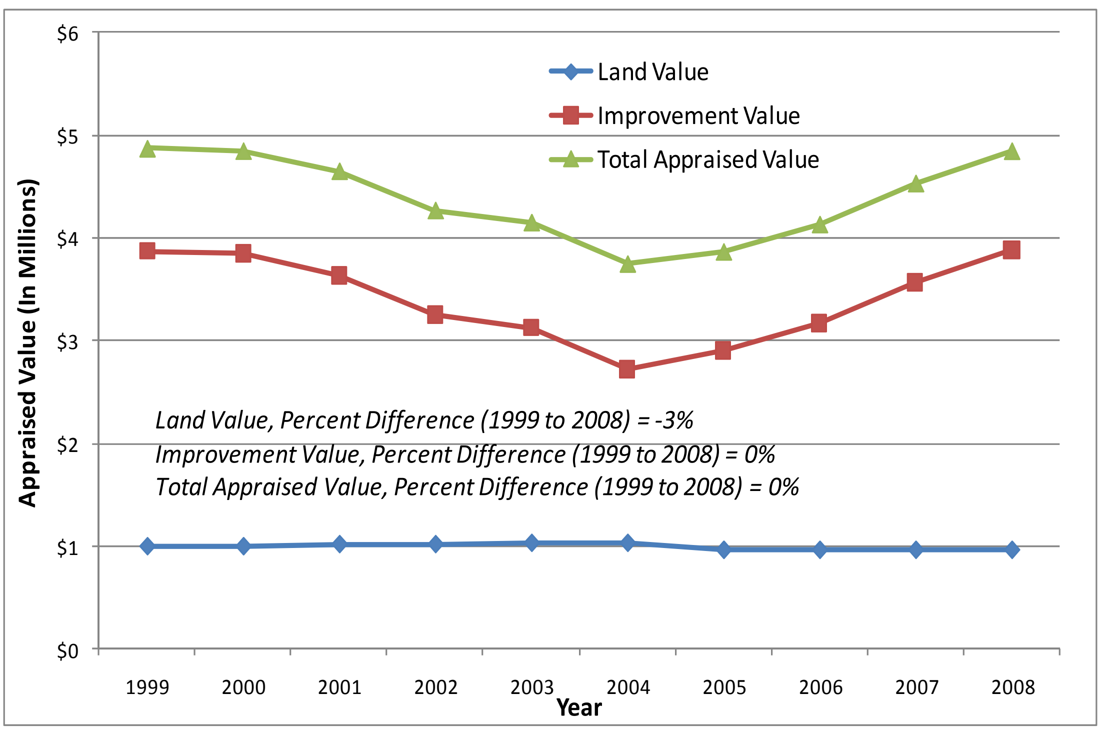

Figure 5-21. Appraised Value along Plainview Comparison Corridor, Selected Businesses.

Hillsboro Conversion Site

Researchers received parcel data for 21 parcels along IH 35 in Hillsboro. Because most of the parcels were identified as hotel, restaurant, gas, or retail, researchers did not further break down the 21 parcels. Researchers removed three parcels that did not have history back to the start of the historical trend. These parcels added another 1.2 million dollars of value in 2010. Reviewing Figure 5-22 shows a large increase in improvement and total appraised values in 2007, then values level off and then decrease from 2009 to 2010.

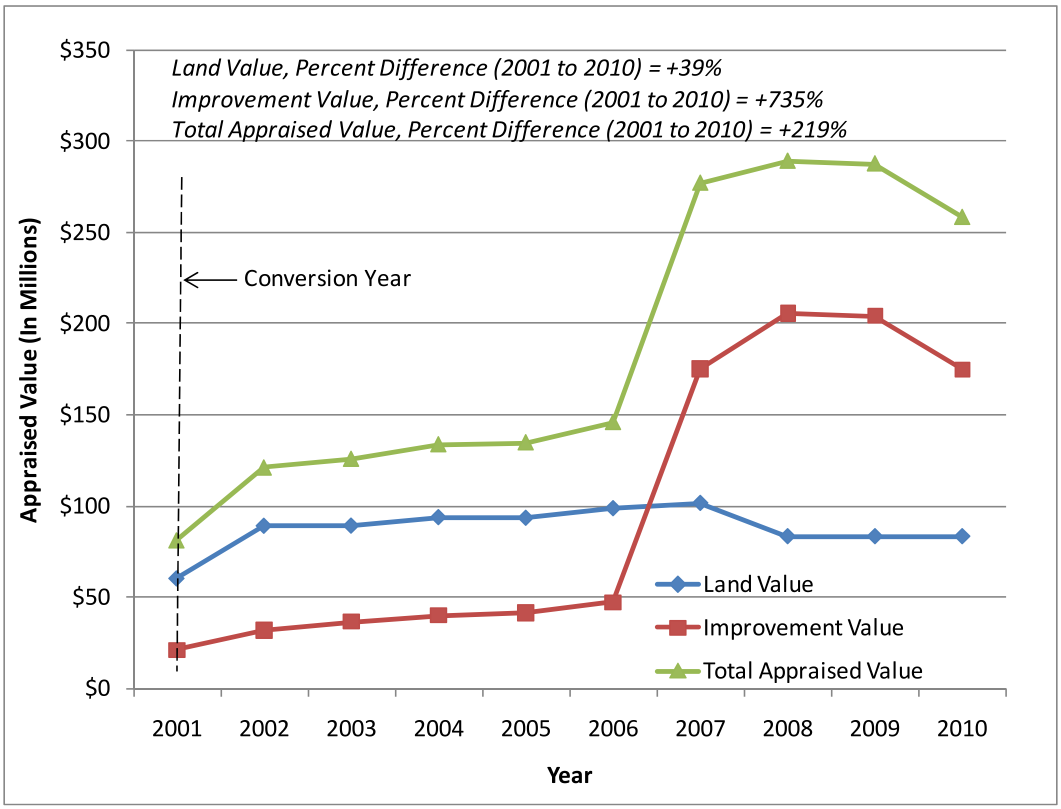

Figure 5-22. Appraised Value along Hillsboro Conversion Corridor.

West Comparison Site

Researchers obtained appraisal data for 51 parcels along IH 35 in West. Figure 5-23 shows the general increases in appraised values from 2006 through 2010. To avoid losing substantial numbers of parcels, researchers only investigated the trend from 2006 to 2010. Removing the parcels would have resulted in not showing nearly 3.5 million dollars worth of value in 2010.

Researchers further investigated restaurants, gas, and retail stores at 10 selected parcels that could be identified. Note that there are relatively high increases in value over the 10-year period of the 10 selected parcels. There is a 233 percent increase in total appraised value shown in Figure 5-24.

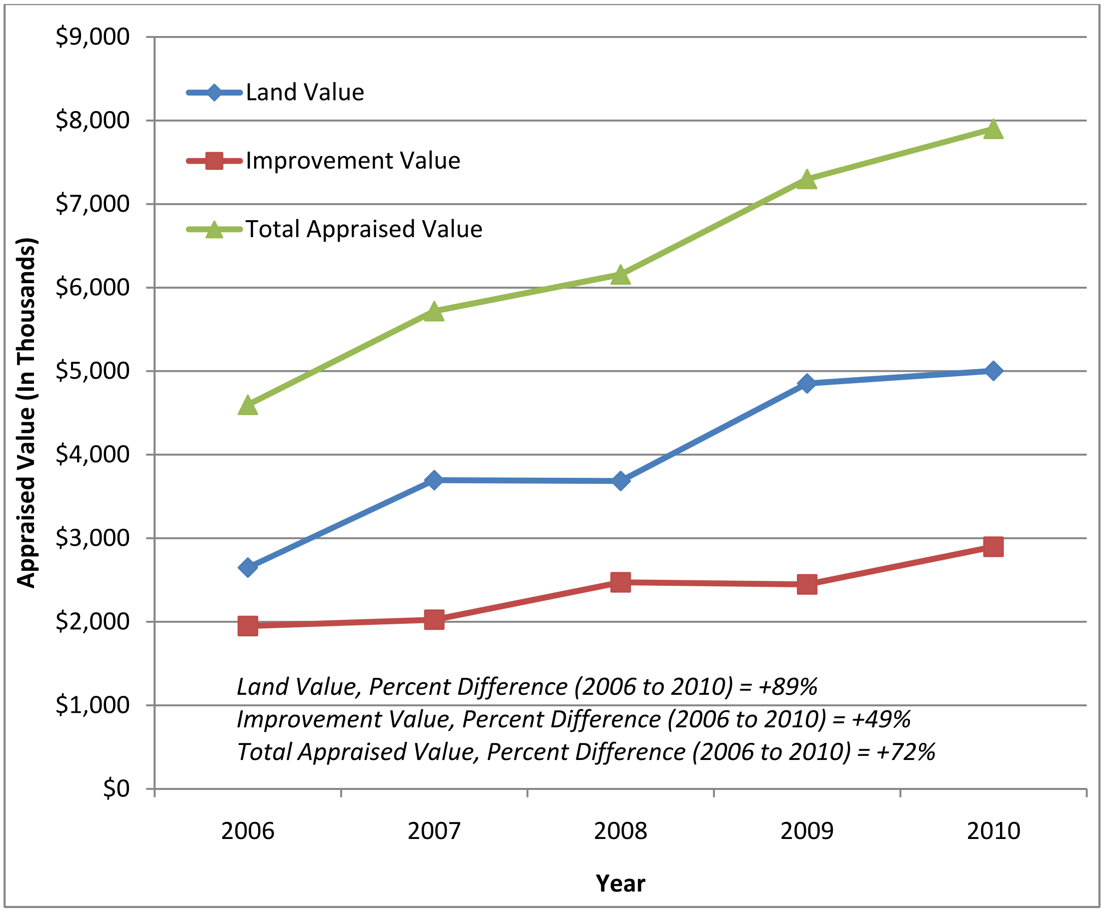

Figure 5-23. Appraised Value along West Comparison Corridor.

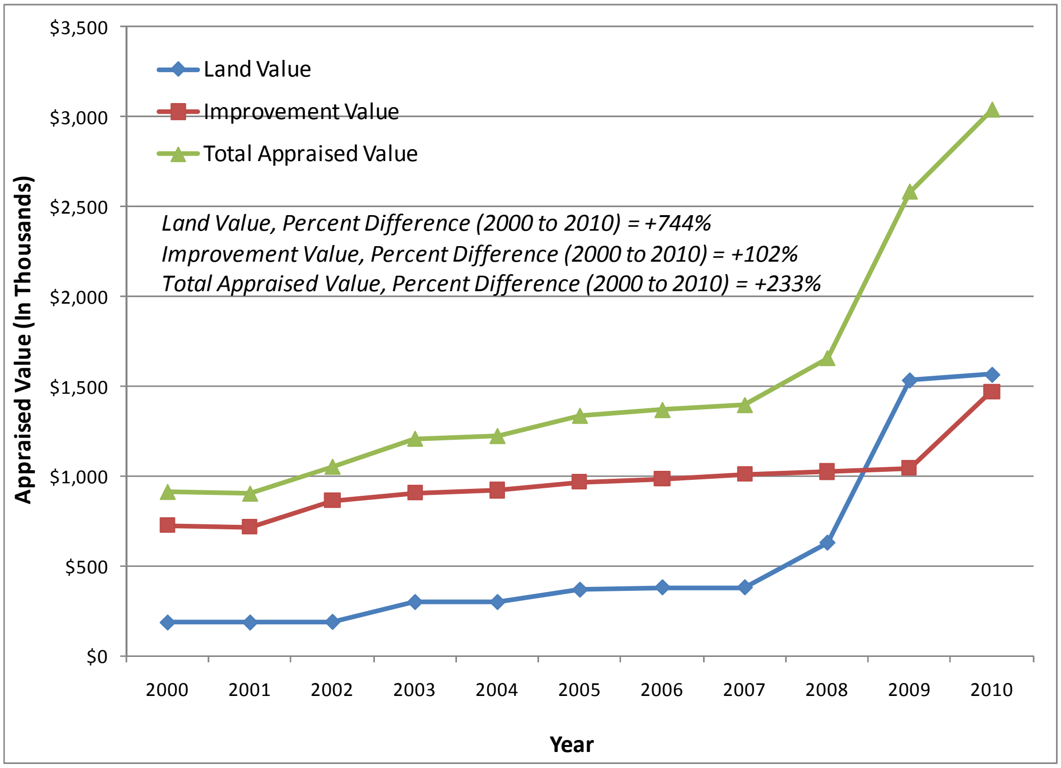

Figure 5-24. Appraised Value along West Comparison Corridor, Selected Businesses.

Burleson Conversion Site

The Burleson corridor along IH 35W includes two counties—Tarrant County and Johnson County. These are discussed in the sections that follow.

Tarrant County. Researchers obtained total appraised values for 30 parcels along IH 35W in Tarrant County. Researchers received only total appraised values for Tarrant County, so the trend shown in Figure 5-25 is not disaggregated by land and improvement values. There is a general increase in total appraised values shown in Figure 5-25. The percent difference from 1997 to 2008 is 133 percent. Researchers removed three parcels valued at an additional 5.2 million dollars in 2008 because the parent subdivision could not be identified. Therefore, the trend values shown in Figure 5-25 are conservative. There is also a relatively high increase in total appraised values from 1997 to 1998 because of a big-box store being built.

Researchers investigated eight locations identified as restaurants, fast-food, or convenience stores that had parcel data from 1997 to 2008. The result of this trend analysis is shown in Figure 5-26, and it demonstrates a similar trend as shown in Figure 5-25.

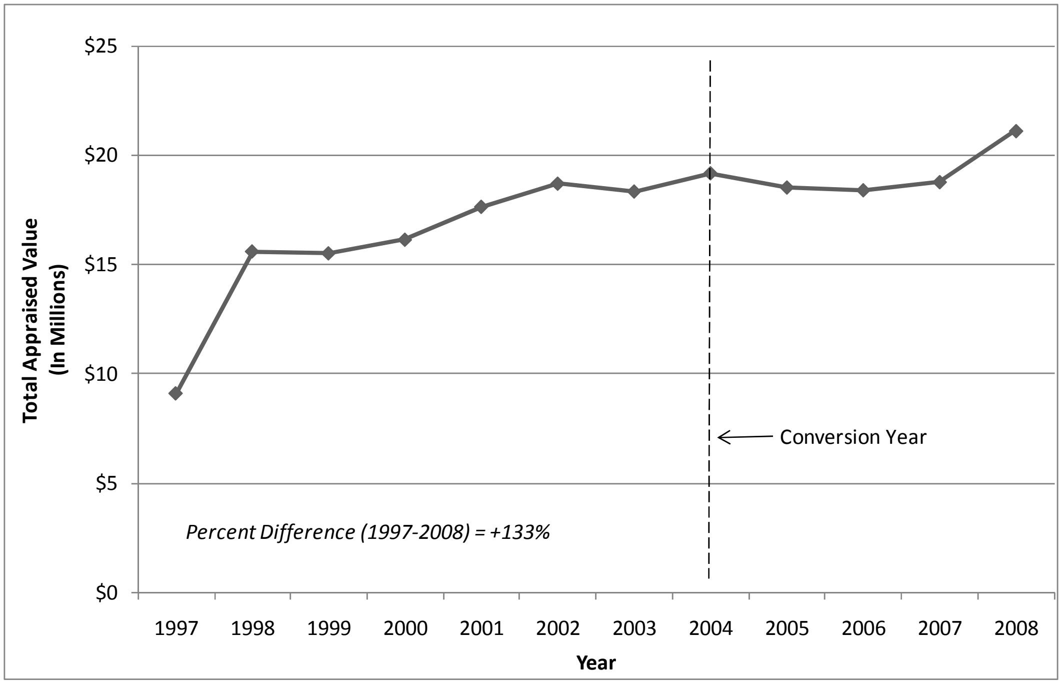

Figure 5-25. Appraised Value along Burleson Conversion Corridor (Tarrant County).

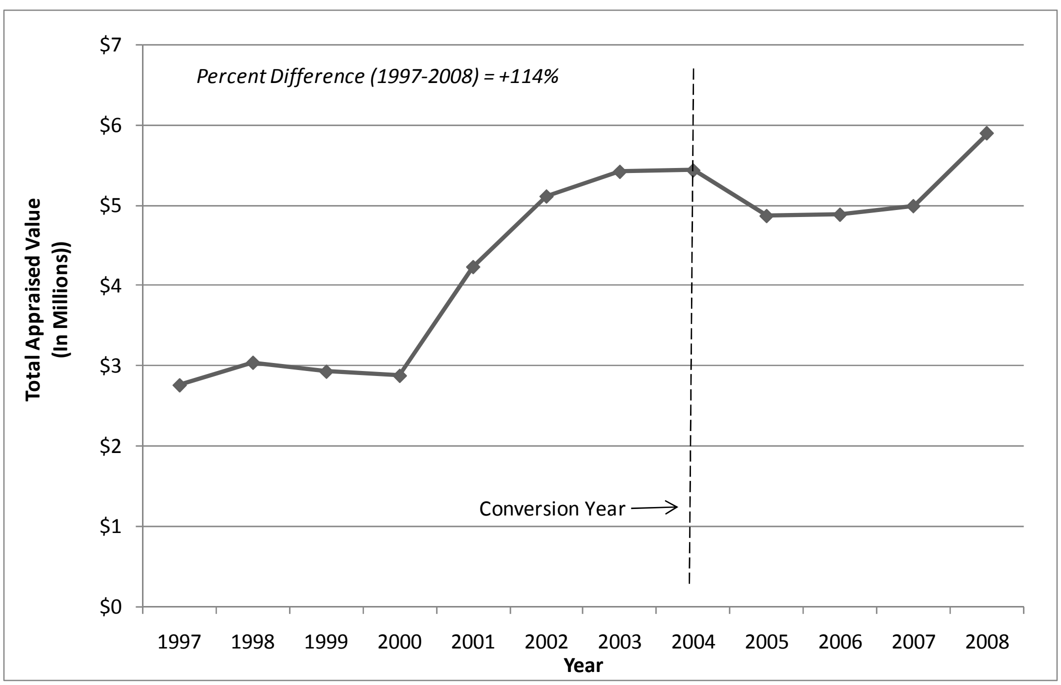

Figure 5-26. Appraised Value along Burleson Conversion Corridor (Tarrant County), Selected Businesses.

Johnson County. Researchers obtained appraisal data in Johnson County along the IH 35W corridor for 86 parcels. The trend data are shown in Figure 5-27 from 1999 to 2010. As with previous figures, the trend shown in Figure 5-27 is relatively conservative because researchers removed nine parcels valued at 12 million dollars in 2010. The trend is generally increasing, and there is a 108 percent increase from 1999 to 2010 in total appraised value.

Researchers investigated the trend for 13 selected parcels with current businesses of restaurant, hotel, gas, and retail. As shown in Figure 5-28, the general trend is relatively flat from 1999 to 2007 and then increasing in 2008, with reduced total appraised values since 2008. Overall, there is a 57 percent increase in total appraised values from 1999 to 2010.

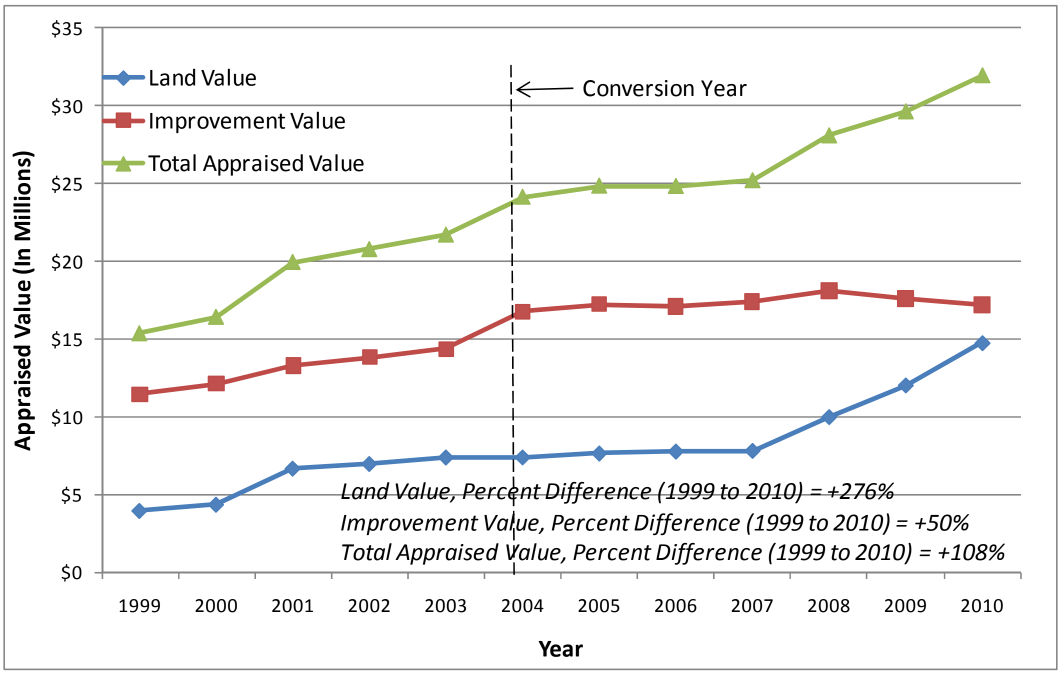

Figure 5-27. Appraised Value along Burleson Conversion Corridor (Johnson County).

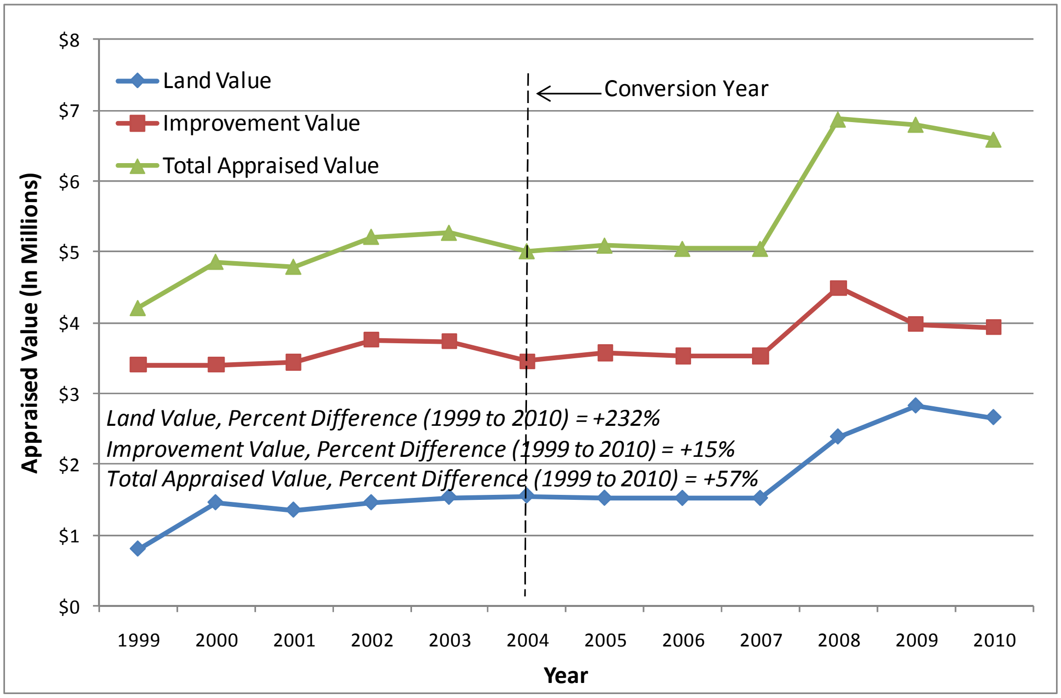

Figure 5-28. Appraised Value along Burleson Conversion Corridor (Johnson County), Selected Businesses.

City of Cibolo Site

Researchers studied one development along a roadway segment on IH 35 in the City of Cibolo that was not an original part of the study. During the public involvement process along this corridor, the residents of the Northcliffe subdivision in Cibolo had expressed concern that their home property values would decrease if frontage roads were converted from two-way to one-way. They suspected there would be increased traffic due to drivers trying to reach FM 1103 in order to travel southbound on IH 35. The subdivision is located approximately 6 miles southwest of New Braunfels on the southeast side of IH 35. Figure 5-29 shows a map of the subdivision's location. The frontage road along IH 35 was converted to one-way in 2004. This site was not selected as a case study corridor for an economic and safety analysis because it is primarily residential with only a few businesses, and most of them are industrial.

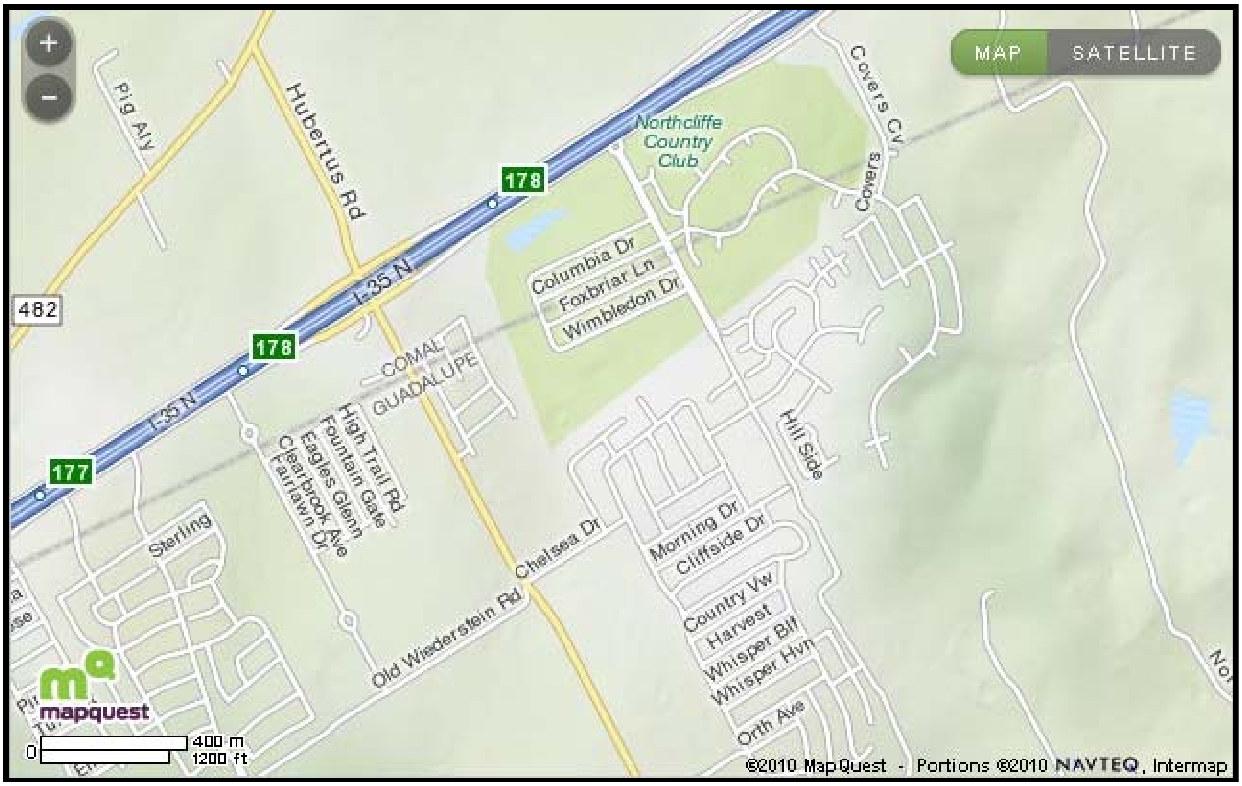

Figure 5-29. Location of the Northcliffe Subdivision in the City of Cibolo. (Map provided by MapQuest.com, Inc.).

To evaluate this concern, researchers randomly selected 51 parcels in the subdivision that the researchers hypothesized might be most affected by the conversion. The Northcliffe subdivision resides in two counties: Guadalupe and Comal. Researchers collected land and improvement values from several neighborhood streets in Northcliffe using each county's online property search engine on the county appraisal districts' Internet sites. Comal County's Internet site provided data for the years 2000 through 2007, while Guadalupe County's site provided data for only 2005 through 2007. Researchers hypothesized which roadways would most likely be affected by perceived cut-through traffic, and they selected Charleston Lane, Columbia Drive, Foxbriar Lane, Wimbledon Drive, Fairways Drive, Mayfair Drive, Cherry Tree Drive, Wedgewood Drive, and Meadowhead Drive. Researchers analyzed approximately six samples of home resident addresses from each street studied and gathered the land and improvement value for each year available.

Figure 5-30 shows the results of this study in Comal County. In Comal County, researchers selected 12 parcels and total appraised values were relatively "flat" until 2005. From 2005 through 2007, there were appraised value increases. Total appraised value was up

27 percent from 2000 to 2007. The land value did not change for any of the parcels during this time period. The research team did not look at any comparison corridors, and it is possible that the property value changes in other areas from year-to-year could be higher or lower than those experienced in this area.

Figure 5-31 shows the results of the City of Cibolo site in Guadalupe County. In Guadalupe County, researchers selected 39 parcels and total appraised values were up 17 percent from 2005 to 2007. As with Comal County, there was no change in the land values of the parcels.

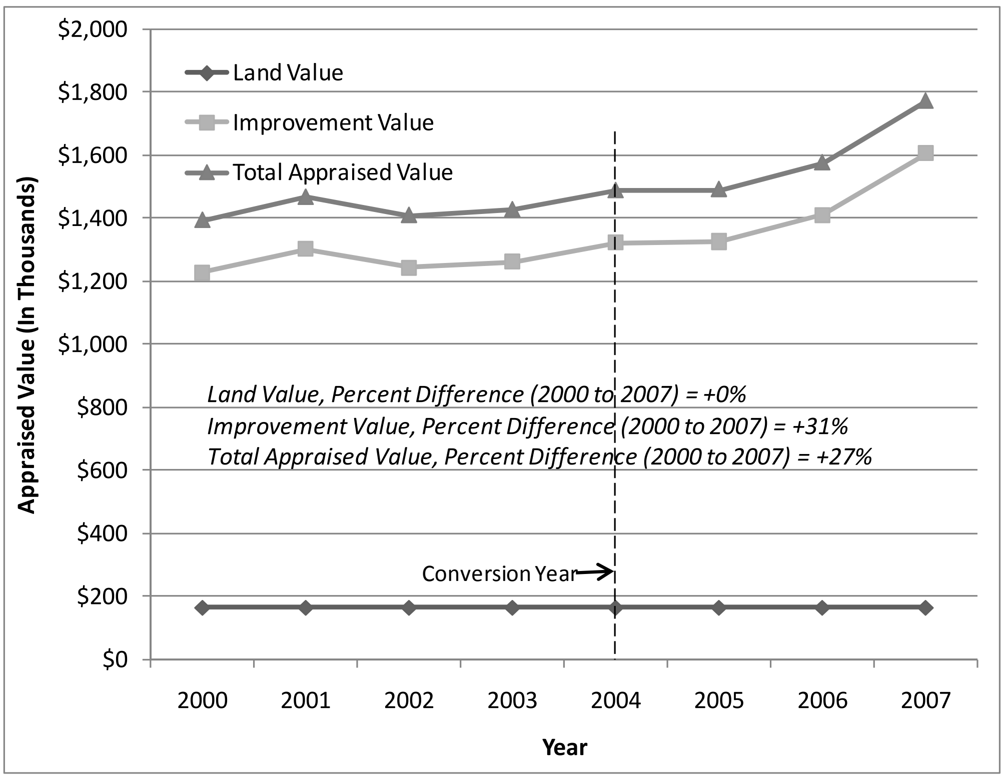

Figure 5-30. Appraised Value along City of Cibolo Site (Comal County).

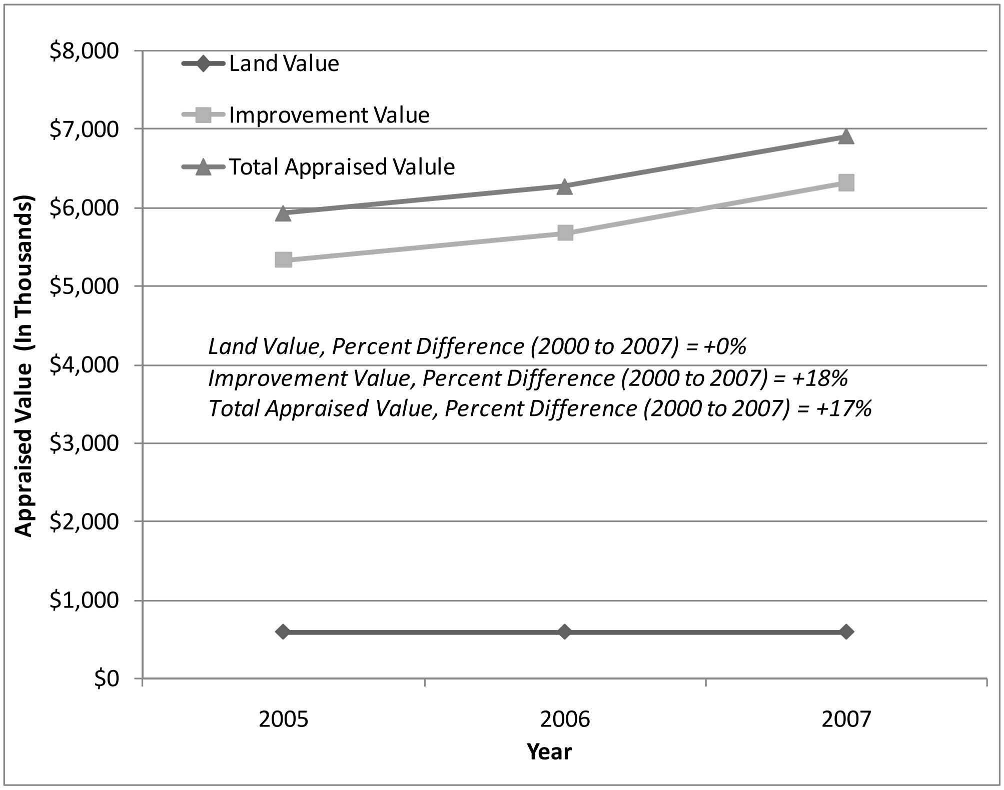

Figure 5-31. Appraised Value along City of Cibolo Site (Guadalupe County).

Concluding Remarks on Appraisal Data Findings

Researchers obtained appraisal data for parcels along all the conversion and comparison sites and an additional site in the City of Cibolo. Researchers documented several nuances and factors encountered by the research team that affect appraisal data. Researchers developed trend analysis graphics showing land appraised value, improvement appraised value, and total appraised value. In general, the graphs indicate overall increases in appraised values over the historical trends shown. From the aggregate appraisal data documented here, it does not appear there are substantial overall negative effects on appraisal values along conversion sites in the long term.

It should be noted that the research team did not look at any comparison sites for the Burleson or Cibolo corridors. Further, there are many other economic factors affecting appraised values that the research team did not control for in this analysis. Among those factors were several economic conditions in the local area (e.g., local real estate market, economic vitality of the area) as well as state and national economic trends. While these factors may have skewed data for a specific year, the research team believes the general trends reflected in the data are insightful in the long term.

EMPLOYMENT DATA ANALYSIS AND FINDINGS

Employment Data Collection

Similar to the gross sales data, researchers collected employment data in each conversion and comparison site city (by zip code) with the intention of comparing the results to the business survey responses from business owner/managers and to provide an assessment of the economy in each area. Because limited survey samples were obtained, discussed in the next section of this chapter, the employment data here primarily provides an indication of the general economic trends of employment in each city/county by the "before" and "after" time periods of the conversion projects. It is not prudent, or is it the intent, to attribute changes in this zip-code level employment data to the frontage road conversion specifically.

In this study, researchers collected employment data for each conversion and comparison city from U.S. Census Bureau Internet site (*42*). Researchers entered the corresponding zip codes of each city to obtain the annual employment data. The data were extracted from the Business Register (BR), which is a database that contains a record for each establishment located in the United States. Data are available beginning in 1998. The BR contains the most complete, current, and consistent data for U.S. business establishments. There are several main resources for updating this database, including the annual company organization survey, annual survey of manufacturers, current business surveys, and other Census Bureau programs. The data do not contain self-employed individuals, private household employees, railroad employees, agricultural production employees, and most government employees.

Some small cities' employment data are not available for every year on the U.S. Census Bureau Internet site. For Huntsville, there are no available data for 1998 or 2002, so researchers used the average value of 2001 and 2003 to estimate the 2002 data. For Plainview, there is no exact number of employees in 1998.

Employment Data Analyses and Findings

Researchers separated the employment data into two periods (before and after) and calculated the corresponding average number of employees in each period and the percent change from the before to after period. The duration of before and after period in each group of cities was different because the employment data were not available in some years. Researchers tried to keep the duration of before and after periods equal. However, in some cases, the researchers chose the most recent years as the after period when the time period after the conversion was much longer than the time period before conversion.

State of Texas

For the State of Texas, the number of employees increased overall from 1998 through 2007. There was a small drop from 2002 through 2003, but the employment number increased after 2003. Figure 5-32 and Figure 5-33 show three important indicators of the before and after periods: 1) the percent change between the average value from the before period and the after period, 2) the percent change (trend) in the before period, and 3) the percent change (trend) in the after period. The construction years shown in Figure 5-32 and Figure 5-33 are 2001 and 2004, respectively. As seen in Figure 5-32, the percent change of the after period increased 13 percent, and there was a 7 percent difference in the number of employees in the before and after periods. As Figure 5-33 illustrates, the percent change of the after period was 9 percent, and the percent change of the number of employees when comparing the before and after periods was 10 percent.

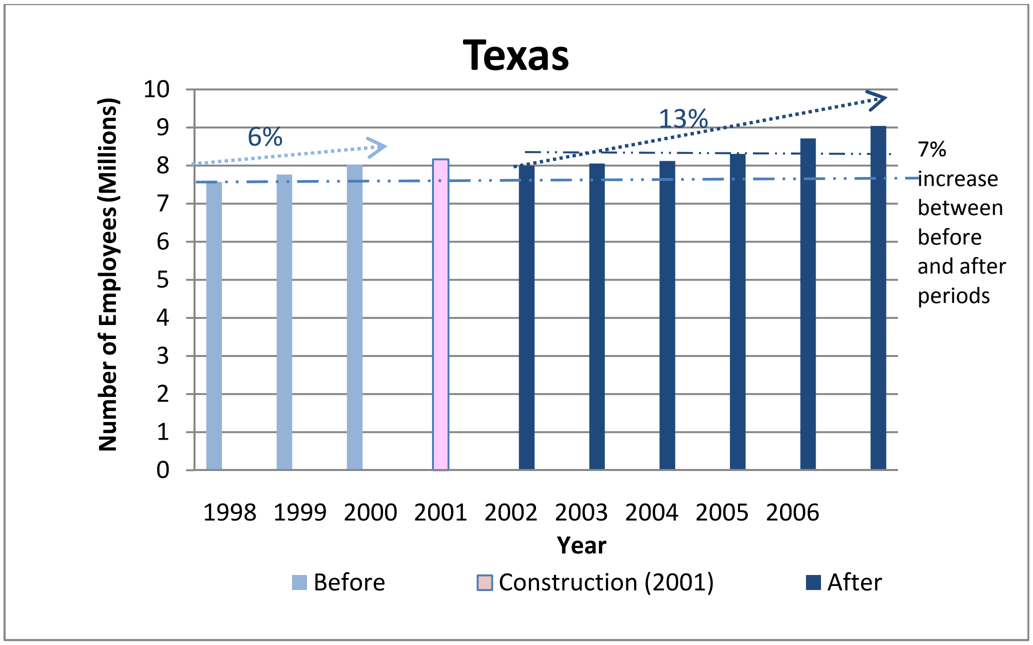

Figure 5-32. The Number of Employees in Texas (Construction Year = 2001).

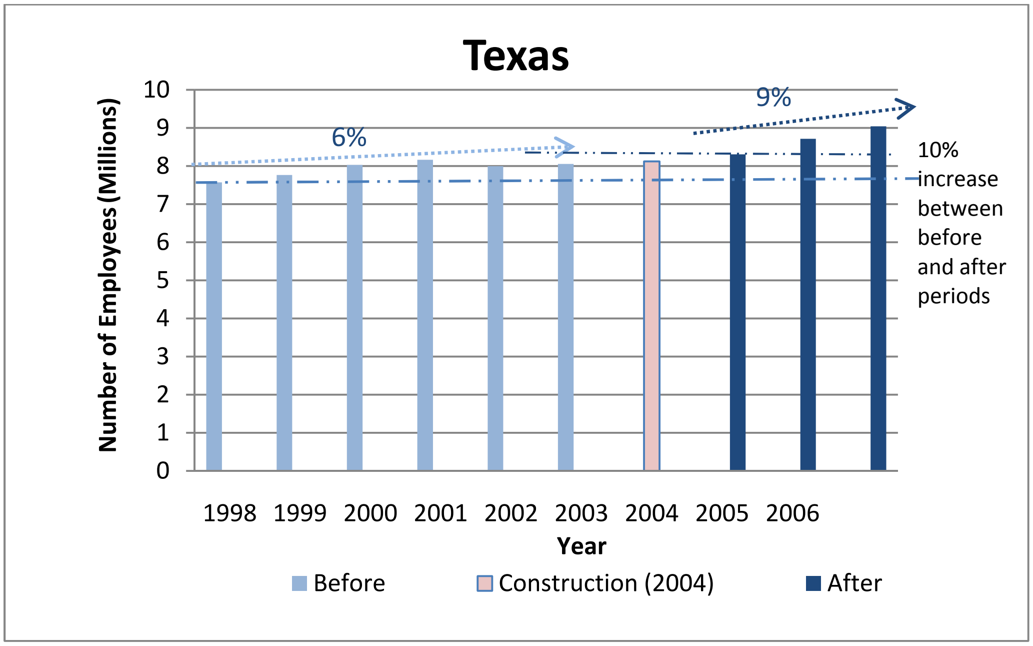

Figure 5-33. The Number of Employees in Texas (Construction Year = 2004).

City of Sulphur Springs and City of Greenville Employment Data

The first conversion site and comparison site are in the city of Sulphur Springs and the city of Greenville. The Sulphur Springs corridor is contained in the 75482 zip code. The Greenville corridor is contained in the 75402 zip code. Figure 5-34 and Figure 5-35 show the number of employees of these two cities by year. The following observations are made about their employment data:

- In Sulphur Springs, the number of employees was relatively flat. There was a small decrease in 2001 and 2005.
- In Greenville, the number of employees increased substantially from 2002 to 2003, and it remained relatively flat from 2003 through 2005. In 2006, the trend decreased.

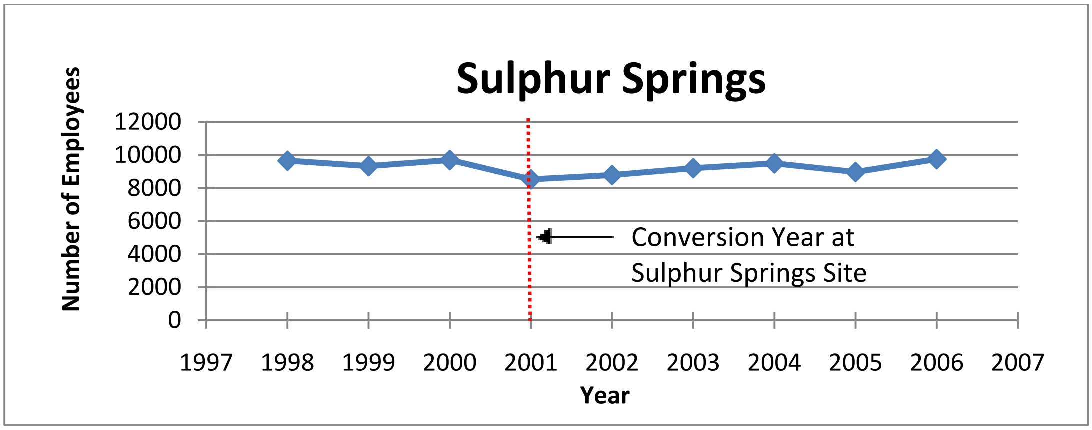

Figure 5-34. The Number of Employees in Sulphur Springs.

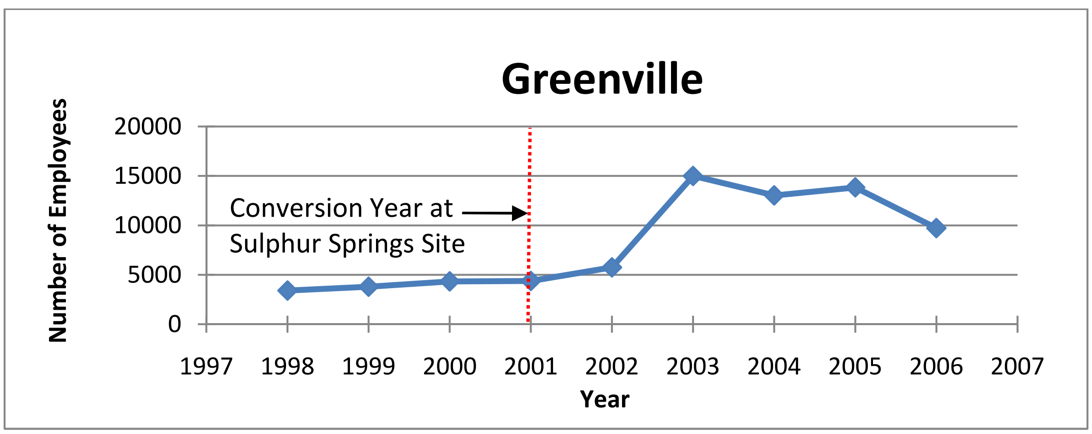

Figure 5-35. The Number of Employees in Greenville.

In Sulphur Springs (Figure 5-36), the percent change of the after period was an increase of 11 percent, and the percent change of the before period was an increase of 0.4 percent. There was a decrease between the number of employees in the before and after periods. It is a 3 percent difference. In Greenville (Figure 5-37), the percent change of the after period was 69 percent, and the average percent change of the before period was 27 percent. The percent change of the number of employees when comparing the before and after periods was 198 percent. Researchers identified one large manufacturing employer that opened in 2003 and contributed to the large increase in the number of employees.

Researchers contacted the Development Board of the City of Greenville to inquire about the large increase in the number of employees from 2002 to 2003 and beyond. Researchers learned that there were no annexations or other probable reasons for the very large increase. One possibility brought to the attention of the research team was that one of the large employers has a large number of employees and contractors, and those employees might be counted differently from year to year (employer versus contractor); however, this was only a speculation, and it would not account for all of the increase in the number of employees. The large number of employees from 2003 through 2006 in the City of Greenville appears suspiciously high.

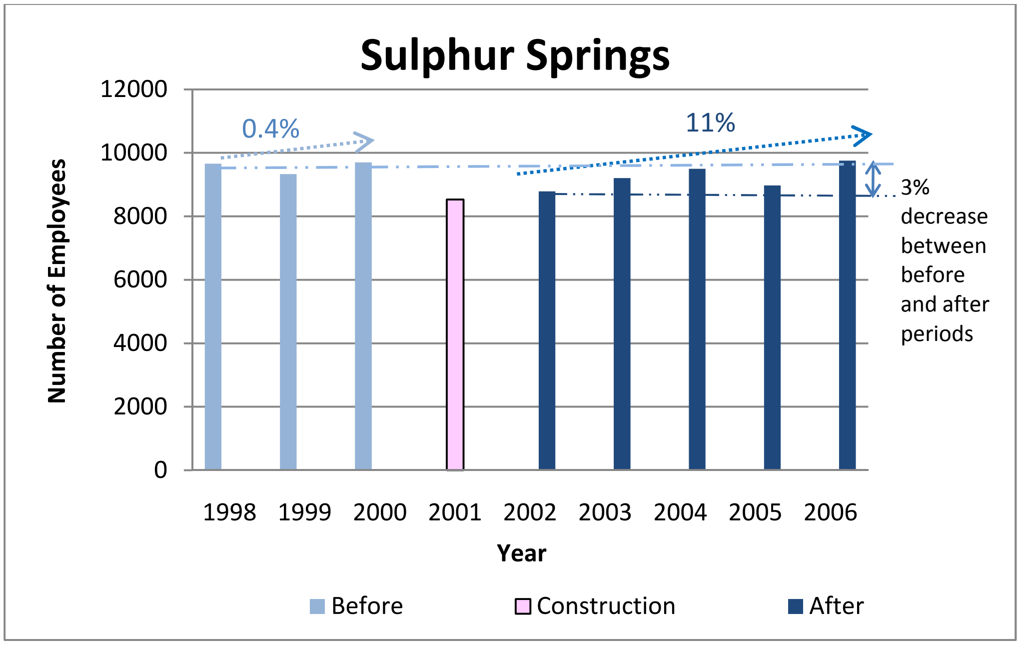

Figure 5-36. Average Percent Change of Before and After Periods in Sulphur Springs.

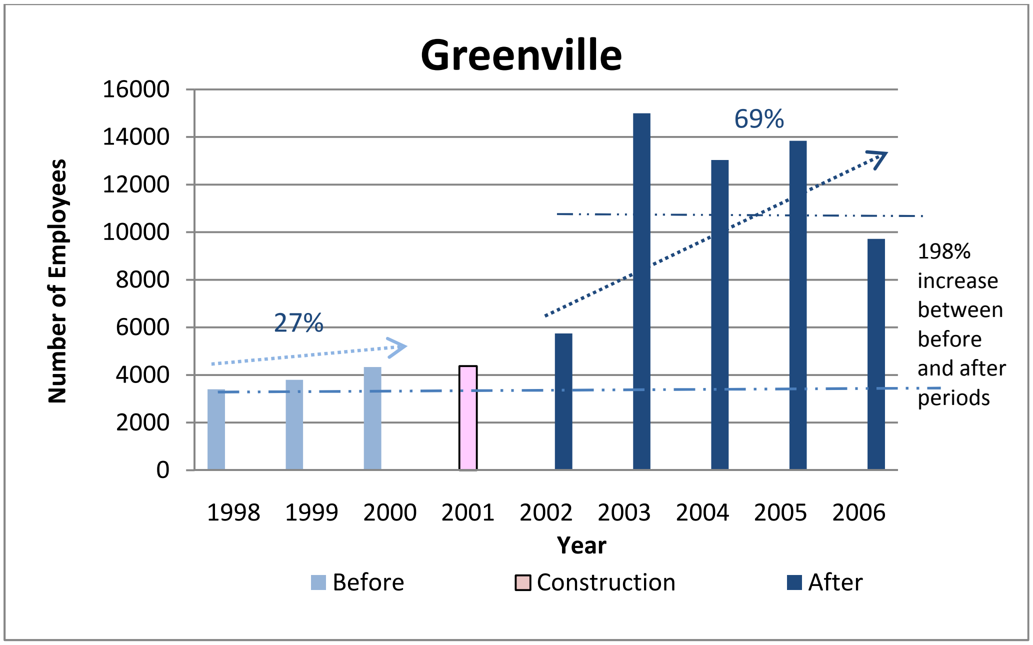

Figure 5-37. Average Percent Change of Before and After Periods in Greenville.

City of Hillsboro and City of West Employment Data

The next conversion and comparison sites are in the city of Hillsboro and the city of West, respectively. The Hillsboro corridor is contained in the 76645 zip code. The West corridor is contained in the 76691 zip code. Figures 5-38 and 5-39 show the employment trends. The following observations are made about these trends:

- In Hillsboro, the number of employees increased from 1998 to 2001, and there was a down trend between 2001 and 2003. The number remained relatively flat in recent years.
- In West, the number of employees remained relatively flat, and there was a decrease from 1998 to 1999. It was difficult to directly compare the employment data from West to Hillsboro because the number of employees in Hillsboro was approximately three times the number in West.

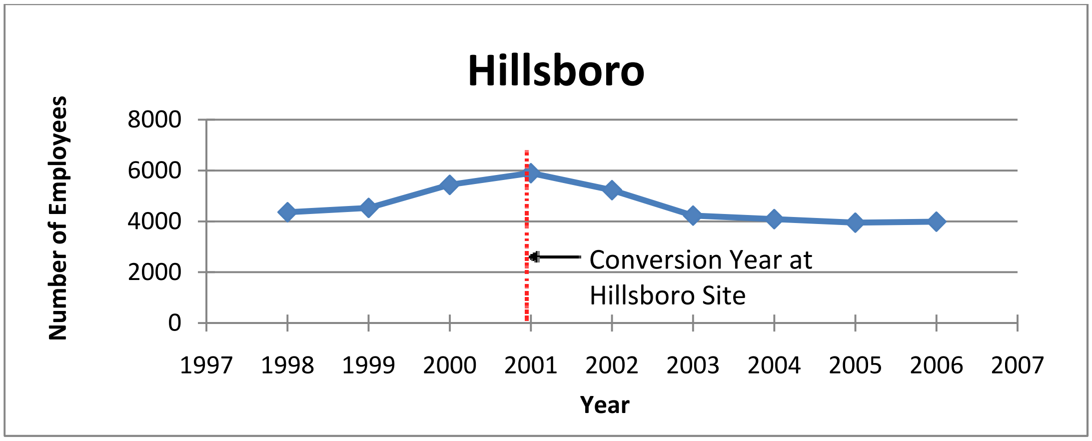

Figure 5-38. Number of Employees in Hillsboro.

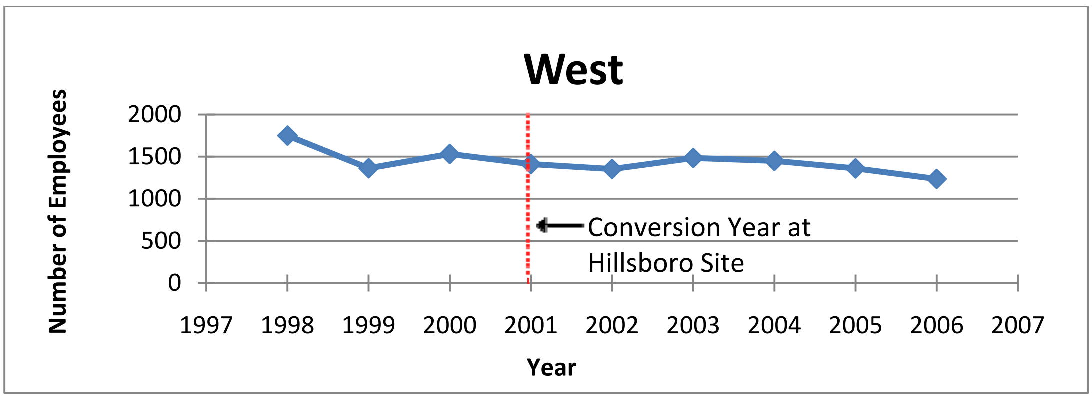

Figure 5-39. Number of Employees in West.

In Hillsboro (Figure 5-40), the percent change of the after period was a decrease of 24 percent, and the percent change of the before period was an increase of 25 percent. There was a slightly higher number of employees in the before period than the after period. In West (Figure 5-41), the percent change of the after period was a decrease of 9 percent, and the percent change of the before period was a decrease of 13 percent. The average number of employees in the before period compared to the after period decreased 11 percent.

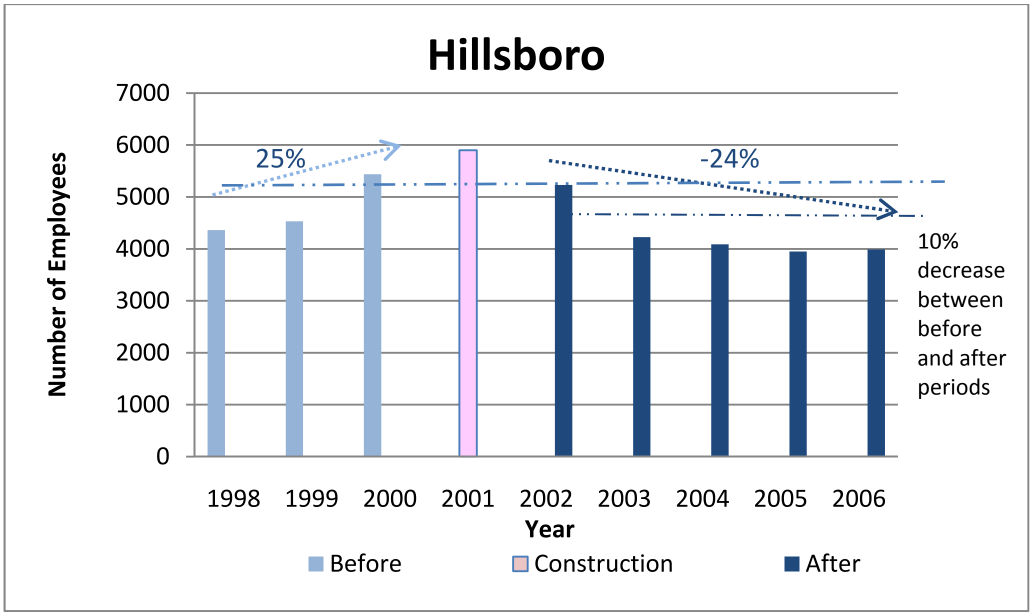

Figure 5-40. Average Percent Change of Before and After Periods in Hillsboro.

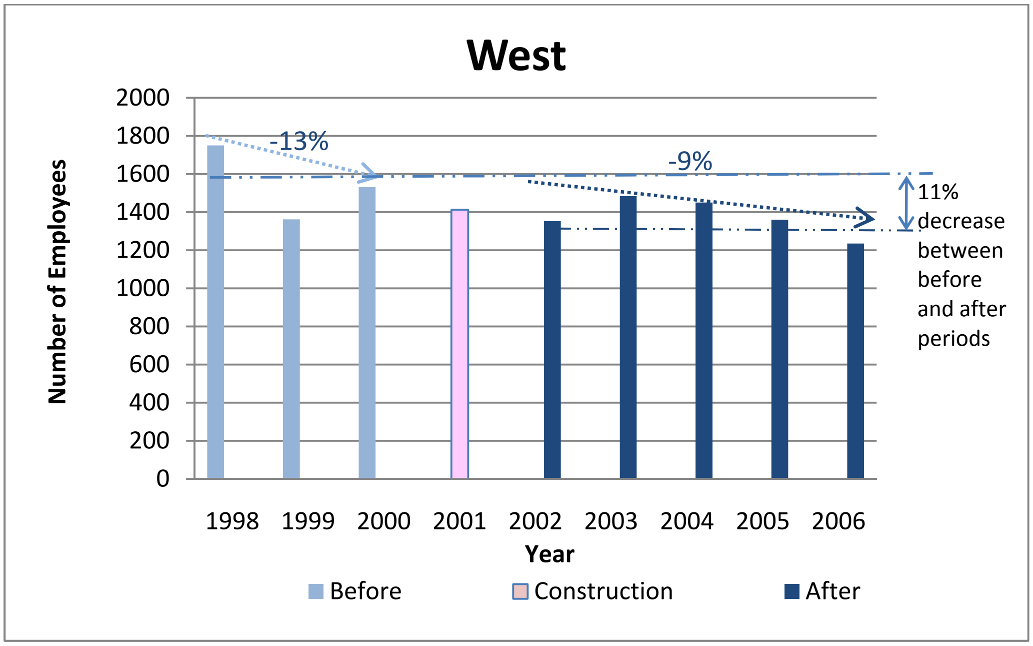

Figure 5-41. Average Percent Change of Before and After Periods in West.

City of Wolfforth and City of Plainview Employment Data

The next conversion and comparison sites are in the city of Wolfforth and the city of Plainview, respectively. The Wolfforth corridor is contained in the 79382 zip code. The Plainview corridor is contained in the 79072 zip code. Figures 5-42 and 5-43 show the employment trends. The following observations are made about these employment data:

- In Wolfforth, the number of employees increased from 1999 to 2001, and there was a down trend between 2001 and 2004. The number has been increasing in recent years.
- In Plainview, the number of employees remained relatively flat, and the number of employees in Plainview was about 10 times the number in Wolfforth.

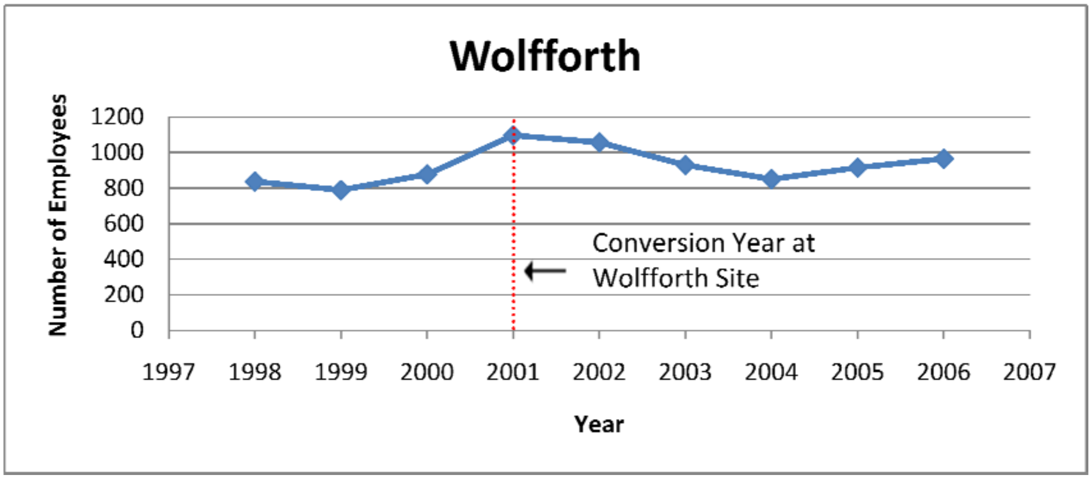

Figure 5-42. Number of Employees in Wolfforth.

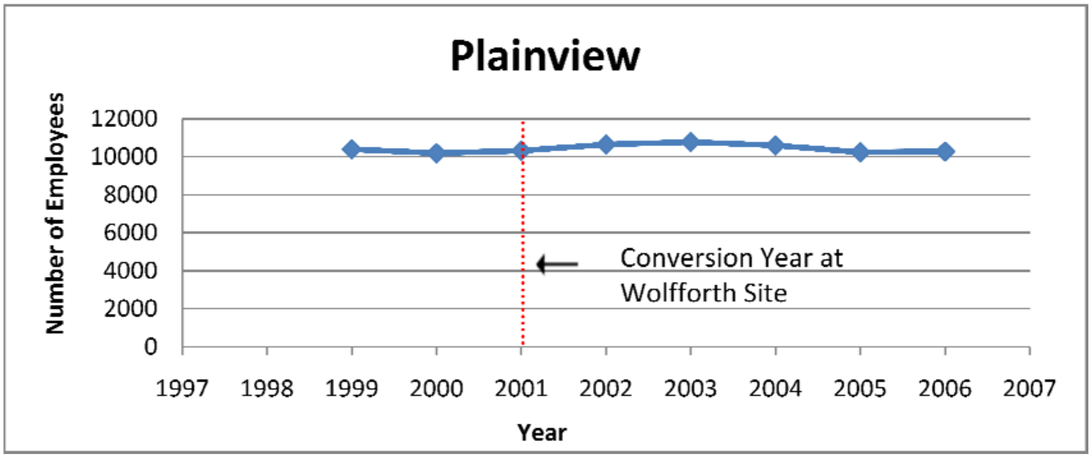

Figure 5-43. Number of Employees in Plainview.

In Wolfforth (Figure 5-44), the percent change of the after period was a decrease of 9 percent, and the percent change of the before period was an increase of 5 percent. There were 13 percent more employees in the after period compared to the before period. In Plainview (Figure 5-45), the percent change of the after period was a decrease of 3 percent, and the average percent change of the before period was a decrease of 2 percent. The average number of employees between the before and after periods increased 2 percent.

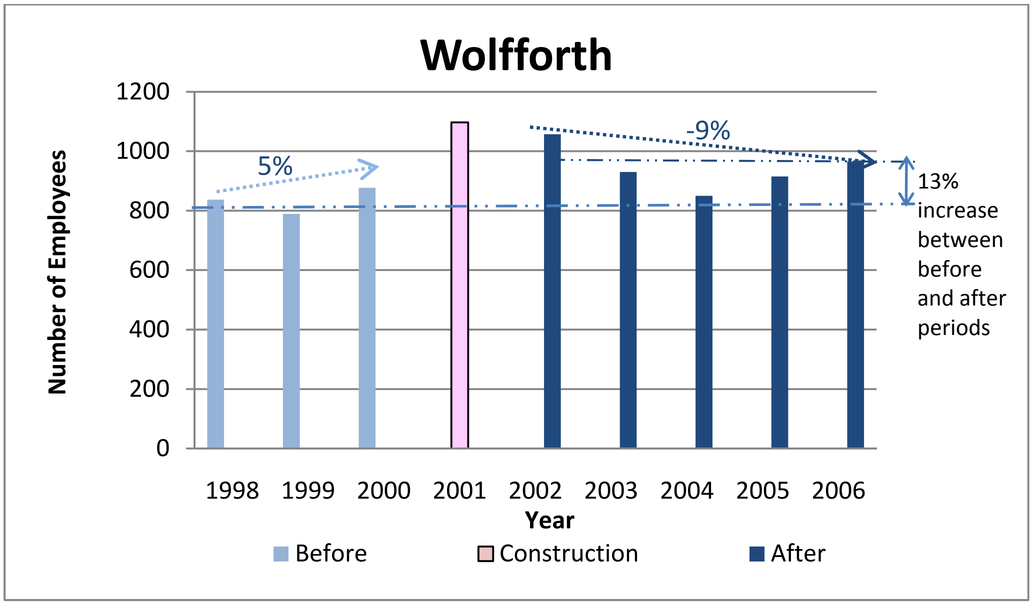

Figure 5-44. Average Percent Change of Before and After Periods in Wolfforth.

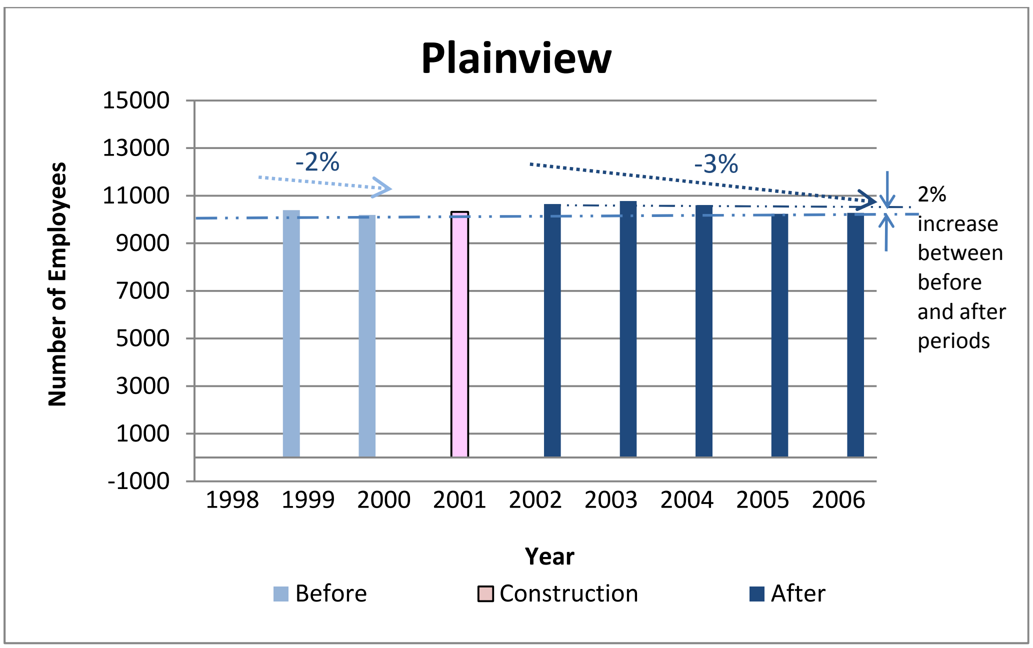

Figure 5-45. Average Percent Change of Before and After Periods in Plainview.

City of Huntsville Employment Data

The next conversion and comparison sites are both in the city of Huntsville. The Huntsville corridor is contained in the 77340 and 77320 zip codes. For completeness, the number of employees for the city of Huntsville is included here. Figure 5-46 shows the trend of the number of employees. The following observations are made about these employment data:

- There were no data on the number of employees in Huntsville in 1998 or 2002.
- In Huntsville, the number of employees increased from 1999 to 2000, and there was a down trend between 2000 and 2001. Since the conversion year (2001), the number of employees has been increasing.

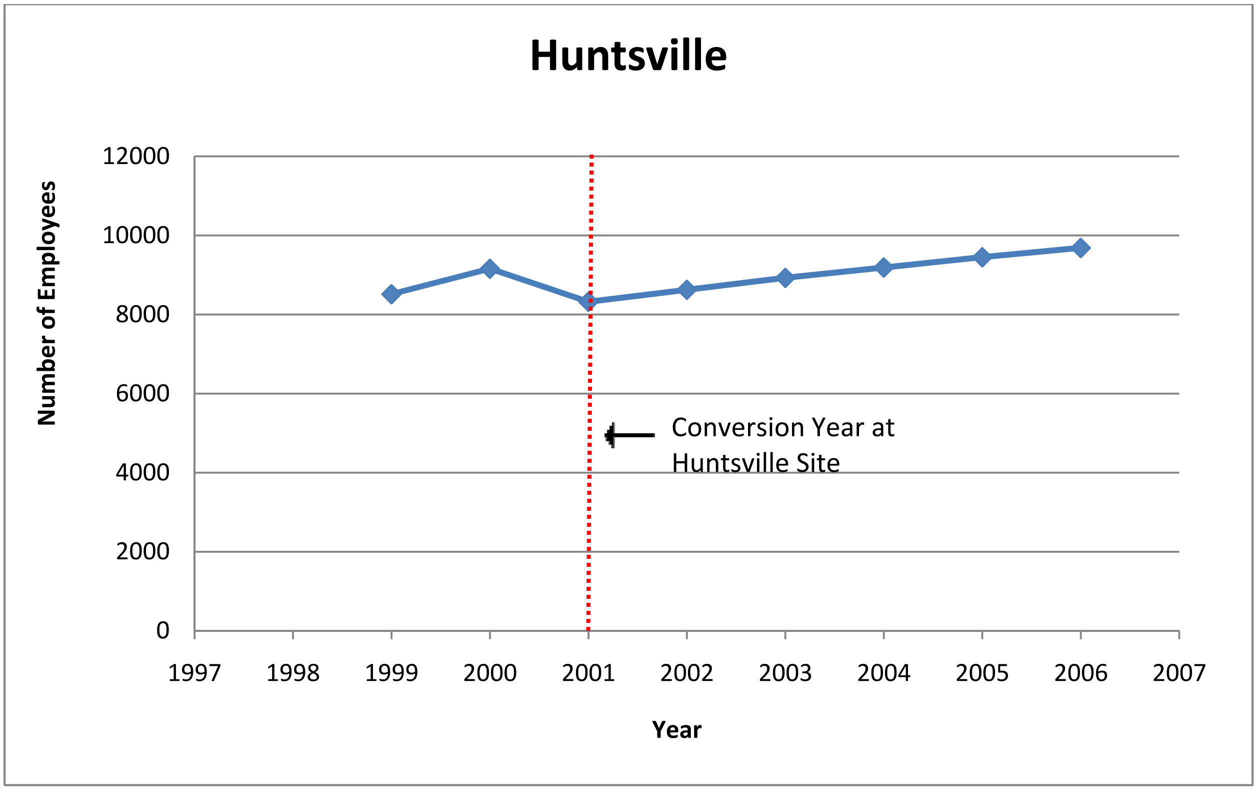

Figure 5-46. Number of Employees in Huntsville.

In Huntsville (Figure 5-47), the percent change of the after period was 12 percent, and the percent change of the before period was 8 percent. There was a 4 percent increase in the after period compared to the before period. The number of employees in 2002 was computed by linear interpolation of 2001 and 2003.

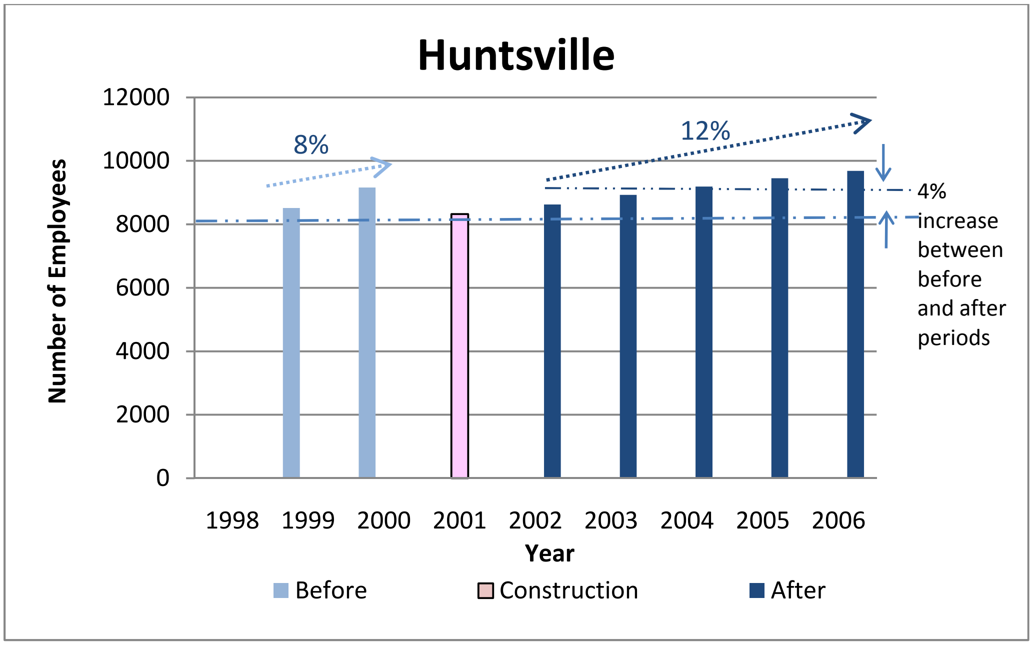

Figure 5-47. Average Percent Change of Before and After Periods in Huntsville.

City of Burleson Employment Data

The last conversion site is the city of Burleson. The Burleson corridor is contained in the 76028 zip code. Figure 5-48 shows the trend of the number of employees. The following observations are made about these employment data:

- Generally, the number of employees in Burleson increased from 1998 through 2004. After the conversion year (2004), the number of employees increased further.

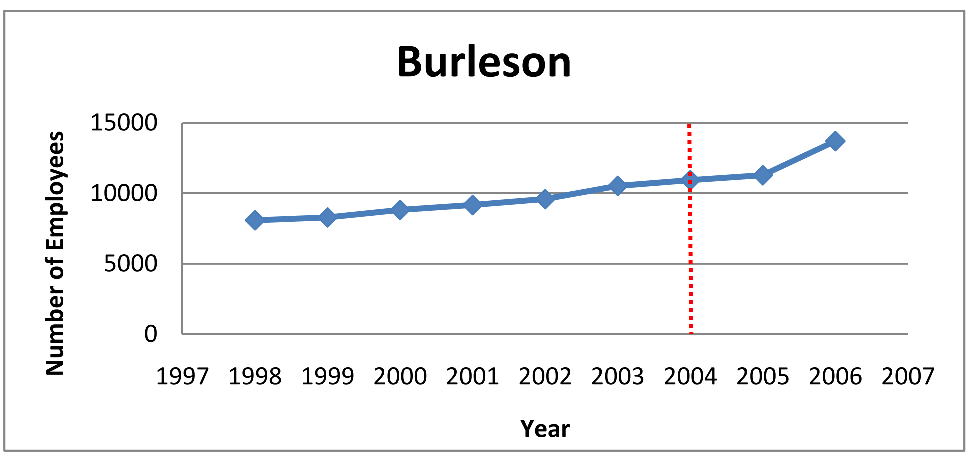

Figure 5-48. Number of Employees in Burleson.

In Burleson (Figure 5-49), the percent change of the after period was 22 percent, and the percent change of the before period was 30 percent. There was a higher number (38 percent) of employees in the after period than the before period.

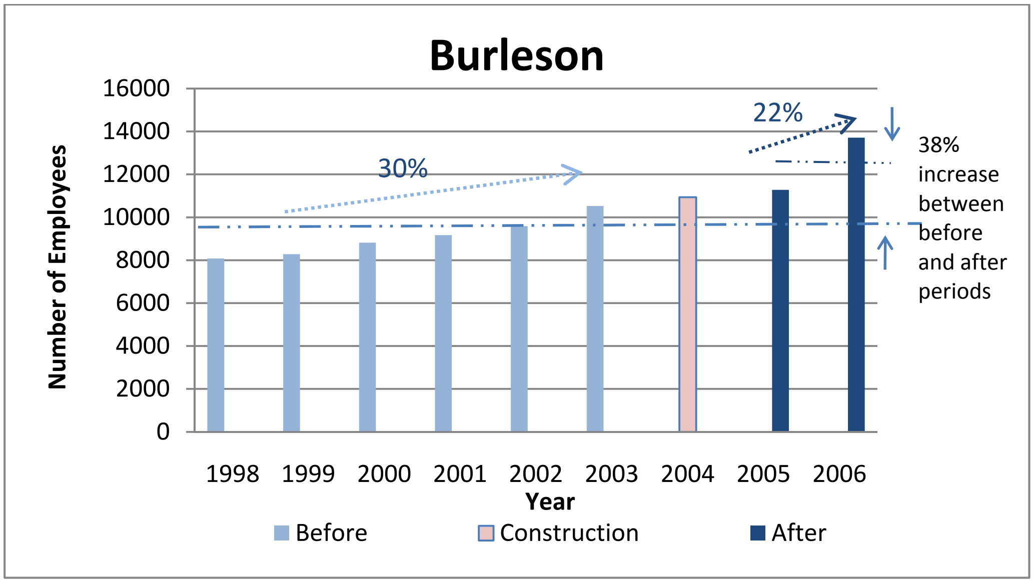

Figure 5-49. Average Percent Change of Before and After Periods in Burleson.

Summary of Employment Findings

Table 5-4 shows the changes in employment data for each city and the State of Texas, including statistics about the before and after periods. Note that the employment data provided here only provides an indication of the general economic trends of employment in each city/county by the “before” and “after” time periods of the conversion projects. It is not prudent, or is it the intent, to attribute changes in this zip-code level employment data to the frontage road conversion specifically.

Based on the most recent two years of data, the trends of employment numbers were generally increasing (except Greenville and West). However, researchers found it difficult to compare the number of employees from each conversion and comparison city because of the site-specific characteristics (e.g., the number of employees in Hillsboro and Plainview were much higher than West and Wolfforth). Another difficulty for making comparison was the large increase in 2003 in Greenville. Further, with the zip code-level data here, there was no way to break out the Huntsville comparison and conversion sites.

The most notable observation of this analysis is that in recent years, the trends of employment numbers are generally increasing (except Greenville and West) based on the trend data (Figures 5-34, 5-35, 5-38, 5-39, 5-42, 5-43, 5-46, and 5-48). Overall, the trend in the number of employees in the State of Texas is increasing.

Table 5-4. Employment Statistics by Conversion and Comparison City.

Group	City	Percent Change of Before Period[1]	Percent Change of After Period[2]	Percent Change of After Period Compared to Before Period[3,4]
State of Texas—A[4]		6%	13%	7%
Group 1	Sulphur Springs	0.4%	11%	−3%
	Greenville	27%	69%	198%
Group 2	Hillsboro	25%	−24%	−10%
	West	−13%	−9%	−11%
Group 3	Wolfforth	5%	−9%	13%
	Plainview	−2%	−3%	2%
State of Texas—B[4]		3%	13%	6%
Group 4	Huntsville (Conversion & Comparison)	8%	12%	4%
State of Texas—C[4]		6%	9%	10%
Group 5	Burleson (Conversion site only)	30%	22%	38%

[1]Computed as the percent difference between the number of employees in the last year and in the first year in the before period. Each group of cities has a different before period. Group 1 is from 1998 to 2000. Group 2 is from 1998 to 2000. Group 3 is from 1998 to 2000. Group 4 is from 1999 to 2000. Group 5 is from 1999 to 2003.
[2]Computed as the percent difference between the number of employees in the last year and in the first year in the after period. Each group of cities has a different after period because of the data limitation. Groups 1, 2, 3, and 4 are from 2002 to 2006. Group 5 is from 2005 to 2006.
[3]Computed as the percent difference between the average number of employees from the after period (defined in footnote #2) and the average number of employees in the before period (defined in footnote #1).
[4]To make a consistent comparison with each grouping, the before and after periods were made the same. The before period of the State of Texas—A is from 1998 to 2000. The before period of the State of Texas—B is from 1999 to 2000. The before period of the State of Texas—C is from 1998 to 2003. The after period of the State of Texas—A and the State of Texas—B is from 2002 to 2006. The after period of the State of Texas—C is from 2005 to 2006.

Concluding Remarks on Employment Findings

Researchers provide the following conclusions related to employment trends:

- The employment data analyzed in this chapter only provides an indication of the general economic trends of employment in each city/county by the before and after time periods of the conversion projects. It is not prudent, nor is it the intent, to attribute changes in this zip-code level employment data to the frontage road conversion specifically.

- Researchers found it difficult to compare the number of employees from each conversion and comparison city because of the site-specific characteristics (e.g., the number of employees in Hillsboro and Plainview were much higher than West and Wolfforth).
- The most notable observation of the employment analysis is that in the most recent two years of data, the trends of employment numbers generally increased for all conversion sites and most comparison sites (except in Greenville and West).
- The trend in the number of employees in the State of Texas also generally increased over the years investigated.
- Regarding the employment data, there were many other economic factors affecting the numbers of employees that the researchers could not control for in this research. Among those factors were several economic conditions in the local area (e.g., job opportunity, local real estate market, economic vitality of the area) as well as state and national economic trends.

SURVEYS OF BUSINESS OWNERS/MANAGERS AND CUSTOMERS

Background

The business community often has concern that frontage road conversions will negatively impact their businesses. To identify their concerns and to assist in the development of mitigation strategies, researchers surveyed business owners/managers and customers along both one-way and two-way frontage roads. Researchers conducted eighty business owner/manager surveys and 74 customer surveys in seven cities. Researchers conducted 36 of the business owner/manager surveys and 49 of the customer surveys at businesses along one-way frontage roads converted in 2001. Researchers conducted the remaining surveys at businesses along two-way frontage roads in cities with similar characteristics to the cities with converted (one-way) frontage roads. Appendix H includes surveys for the business owner/manager at conversion sites (pages 276–281), business owner/manager at comparison sites (pages 282–287), customer at conversion sites (page 288), and customer at comparison sites (page 289). In the sections that follow, the reader is referred to the questions asked in these surveys prior to the results being provided.

Survey Methods

Prior to conducting the business owner/manager and customer surveys, the research team performed a windshield survey by driving along the selected corridors and videotaping and noting useful information. Researchers called all businesses along the corridor in an attempt to make appointments with business owners/managers to conduct the business owner/manager surveys. If a business participated in the business survey, it was later contacted to determine willingness to participate in the customer survey portion of this study.

Researchers at TTI collected survey data using Institutional Review Board (IRB)-approved materials (see http://researchcompliance.tamu.edu/irb). Researchers read questions to the business owners/managers, and a member of the research team recorded their response. Customer surveys were handed out to the customers by a member of the research team or left at the business to be handed out by the business owners/managers.

Data Reduction and Analysis Methods

It was important that conversion years be such that a business owner at the establishment would remember pre-conversion economic trends. As described in the safety analysis, researchers selected only conversion projects that occurred during or after 2001. Researchers chose comparison cities to provide a comparison of trends in locations similar to the conversion cities (e.g., similar drivers, same TxDOT district).

After removing business owner/manager surveys for businesses that opened post-conversion, researchers conducted Chi-square tests to determine if there were statistically significant differences in responses. If the expected count was less than five for more than 20 percent of all cells, researchers performed a Fisher-Freeman-Halton Exact (FFHE) test instead of a Chi-square test. Researchers performed the FFHE test using StatsDirect (http://www.statsdirect.com). Researchers investigated two significance levels, p-values of 0.05 and 0.01, in all cases. Tables 5-5 and 5-6 show the business owner/manager and customer survey sample sizes.

Table 5-5. Business Owner/Manager Survey Sample Size by Conversion and Comparison City.

Group	Conversion City	Conversion Year	Useable Surveys	Comparison City	Useable Surveys
A	Hillsboro	2001	10	West	10
B	Sulphur Springs	2001	10	Greenville	14
C	Wolfforth	2001	12	Plainview	16
D	Huntsville	2001	4	Huntsville	4
Column Total =			36		44

Note: Huntsville contains both one-way and two-way frontage roads.

Table 5-6. Customer Survey Sample Size by Conversion and Comparison City.

Group	Conversion City	Number	Comparison City	Number
A	Hillsboro	43	West	-
B	Sulphur Springs	6	Greenville	25
Column Total =		49		25

Data Analyses and Findings

Researchers conducted a number of analyses. Highlights of the six most meaningful results are included in the body of the report. Additional results are also included in Appendix I. Researchers describe the following in this chapter:

- criteria customers use when selecting a place to do business,
- customer likelihood of stopping at a business,
- operational and economic impacts,
- business location and access,
- impacts upon different business types, and
- owner/manager perception affecting frontage road operation (two-way or one-way) preference.

Criteria Customers Use when Selecting a Place to Do Business

Six business selection criteria (distance to travel, hours of operation, customer service, product quality, product price, and access to store) were ranked by business owners/managers and customers. This was asked in question #7 of the business owner/manager survey on page 276 (conversion site) and page 282 (comparison site). It was question #10 of the customer survey on page 288 (conversion site) and question #8 of the customer survey on page 289.

Researchers averaged individual responses and determined overall rankings for conversion and comparison business owners/managers and customers. The results of this investigation show that store access and travel distance rank lower than items business owners/managers have control over, such as product quality and customer service. Table 5-7 shows the rank of all selection criteria; Appendix I shows the detailed results.

Table 5-7. The Priority of All Criteria of Customer and Business Surveys from Conversion Site and Comparison Site.

Rank	Conversion (One-Way) Corridors		Comparison (Two-Way) Corridors	
	Customers	Business Owners/Managers	Customers	Business Owners/Managers
1	Product Quality	Product Quality	Customer Service	Customer Service
2	Customer Service	Customer Service	Product Quality	Product Quality
3	Product Price	Product Price	Store Access	Product Price
4	Store Access	Store Access	Product Price	Store Access
5	Travel Distance	Travel Distance	Hours Of Operation	Travel Distance
6	Hours Of Operation	Hours Of Operation	Travel Distance	Hours Of Operation

Note: Shading identifies "store access" and "travel distance" by category.

Customer Likelihood of Stopping at a Business

To further estimate the possible impacts of reducing access, customers were asked the following: If the frontage road were converted, would you be more likely, less likely, or have the same likelihood of stopping at this business? This was asked in question #9 of the customer survey on page 288 (conversion site) and question #7 of the customer survey on page 289 (comparison site). Researchers computed results to their need to make U-turns (question #7, page 288 for conversion site and question #5, page 289 for comparison site), having to travel in the opposite direction than desired (question #4, page 288 for conversion site and question #2, page 289 for comparison site), trip type (pass-by or planned) (question #5, page 288 for conversion site and question #3, page 289 for comparison site), and whether it is a conversion or comparison site. Table 5-8 shows the statistically significant differences.

Table 5-8. Likelihood of Customers Stopping.

Is it a Conversion Site? (P-value = 0.018)				
Group	Less	Same	More	Responses
Comparison	71%	29%	0%	14
Conversion	29%	67%	3%	58
Have to Leave Opposite Direction? (P-value = 0.0001)				
Group	Less	Same	More	Responses
No	10%	87%	3%	30
Yes	61%	37%	3%	38
Was it a Pass-by or Planned Trip? (P-value = 0.049)				
Group	Less	Same	More	Responses
Pass-by	24%	68%	8%	25
Planned	46%	54%	0%	46
Need to Make U-Turn to Arrive? (P-value = 0.008)				
Group	Less	Same	More	Responses
No	25%	75%	0%	40
Yes	55%	41%	3%	29

Notes: Differences are statistically significant. Percentages may not add up to 100% due to rounding.

Researchers further reviewed the initial findings that a significantly higher portion of planned customers were less likely to stop at a business after conversion. By investigating question #6 on page 288 (conversion site) and question #4 on page 289 (comparison site), researchers found that most planned stops were local customers (see Table 5-9). A high proportion of customers making planned trips also needed to leave the business in the opposite direction from which they desired.

Table 5-9. Investigation of Local Trips Leaving in the Opposite Direction.

Local or Non-Local? (P-value = 0.001)			
Group	Pass-by	Planned	Responses
Local	14%	86%	43
Non-Local	63%	37%	30
Have to Leave Opposite Direction? (P-value = 0.001)			
Group	Pass-by	Planned	Responses
No	56%	44%	32
Yes	13%	87%	38

Note: Differences are statistically significant.

While access and travel distance are ranked third or lower by customers in the investigation of customer business-selection criteria, it seems these variables still have a significant impact on the likelihood of a customer stopping at a business. Due to a small sample size in the variety of business types where customers were interviewed, further confirmation is still needed. However, these findings suggest frontage road conversion may have an impact on the number of local customers doing business at businesses with primarily planned stops along frontage roads if additional travel is needed. Appendix I shows the detailed results.

Operational and Economic Impacts

The next analysis investigated a number of operational and economic factors asked of business owners/managers about frontage road conversion. Table 5-10 shows the survey results of eight variables (number of customers, property access, number of crashes, business opportunities, traffic congestion, customer satisfaction, traffic safety, and delivery convenience). Table 5-11 shows the responses that are significantly different by comparison and conversion site.

Researchers compared economic impact variables within the business owners and customer groups, and the results of that comparison are shown in Appendix I. There were no significant differences between the comparison and conversion groups within the business owner/manager survey results. There were also no significant differences between the comparison and conversion groups within the customer survey results. Researchers found statistical differences when comparing conversion-site business owners/managers to conversion customers and comparing comparison business owners/managers to comparison customers. Some differences may have occurred due to a customer self-selection bias where customers selecting to do business along a converted frontage road have more favorable views.

Along converted sites, survey respondents could indicate that these eight operational and economic factors were "better," "worse," or "about the same" in question #18 on page 280 of the business owner/manager survey and question #11 on page 288 of the customer survey. Similar questions were asked of business owners/managers (question #18, page 286) and customers (question #9, page 289) at the comparison sites.

Table 5-10. Operational and Economic Effects of Frontage Road Conversion.

Number of Customers?			Property Access?		
Decrease	No Change	Increase	Worse	Same	Better
50%	29%	21%	75%	16%	9%
Number of Crashes?			Business Opportunities?		
Decrease	No Change	Increase	Worse	Same	Better
31%	46%	23%	48%	43%	9%
Traffic Congestion?			Customer Satisfaction?		
Worse	Same	Better	Worse	Same	Better
26%	25%	49%	51%	41%	8%
Traffic Safety?			Delivery Convenience?		
Worse	Same	Better	Worse	Same	Better
20%	32%	48%	61%	29%	11%

Notes: Shaded cells indicate the highest percent of business owner/manager response. Percentages may not add up to 100% due to rounding.

Table 5-11. Economic Effects of Frontage Road Conversion with Statistical Differences.

Property Value? (P-value = 0.002)			
Group	Decrease	No Change	Increase
Comparison	40%	40%	21%
Conversion	12%	24%	64%
Total	29%	33%	38%
Gross Sales Along Converted Section? (P-value = 0.021)			
Group	Decrease	No Change	Increase
Comparison	52%	34%	14%
Conversion	76%	7%	17%
Total	62%	23%	15%

Notes: Differences are statistically significant. Percentages may not add up to 100% due to rounding.

These findings suggest business owners/managers have a fear of losing customers post-conversion. These findings also suggest that customer satisfaction, a portion of customer service, may be negatively affected by frontage road conversion. Further confirmation is necessary to determine if this is a long-standing trend or just a short-term issue that would occur with any change of this magnitude.

Business Location and Access

Differences in the location of the conversion-site business along the converted frontage road may have an influence on business owner/manager perceptions. To investigate any possible difference, researchers developed an additional access-level variable. Researchers gave businesses a "high," "medium," or "low" access level based upon the following:

- High Access: Businesses on the corner or with direct access to the major cross street.
- Medium Access: Businesses with access to back streets or onsite cross access that runs parallel to the frontage road and behind, or in front of, the business, allowing vehicles access to the business without traveling along the frontage road.
- Low Access: Businesses where the only access point lies on the frontage road (i.e., mid-block).

Researchers found no significant differences when comparing location and access.

Business Type Investigation

Researchers investigated business type in three different ways. One way involved grouping businesses according to their survey response aggregated to seven categories: convenience stores and gas stations, fast food, other restaurants, hotels, medical services, other services, and retail. Survey respondents were asked the primary business type in question #2, page 276 (conversion site) and question #2, page 282 (comparison site). Additionally, researchers aggregated the data by businesses that have higher proportions of pass-by customers (fast food, convenience stores, and gas stations) and those that are mainly planned stops (the remaining businesses). Finally, researchers aggregated responses by "retail" and "non-retail" based upon the business categories used for the gross sales analysis from the State of Texas Comptroller's Office using the Standard Industrial Classification business codes.

Using the above method, researchers found one statistically significant difference in Table 5-12. In most cases, business type had little effect on business owners'/managers' perceptions. An exception to this was retail business owners/managers. Retail business owners/managers were more concerned about delivery convenience than non-retail business owners/managers. They also felt their property value increased post-conversion. Appendix I shows additional detail on these three aggregation methods and this analysis.

Table 5-12. Statistically Significant Differences between Retail and Non-Retail for All Business Owners/Managers.

Delivery Convenience? (P-value = 0.019)				
Group	Worse	Same	Better	Responses
Non-Retail	51%	37%	12%	41
Retail	84%	5%	11%	19

Note: Differences are statistically significant.

Investigation of Frontage Road Preference

Researchers hypothesized that business owners/managers bias against one-way frontage roads may have an effect on the results in the previous sections. For this reason, they asked business owners/managers, "How do you classify your preference for one-way compared to two-way traffic on freeway frontage roads in urban areas?" This is question #20a, page 280 (conversion site) and question #19a, page 286 (comparison site).

Researchers compared responses to all economic and operational categories previously investigated. Table 5-13 show the statistically significant differences based upon business owners'/managers' preference for frontage road operation. Those business owners/managers who indicated they "strongly favor one-way" or "somewhat favor one-way" are in the "1-Way" group (row) of Table 5-13. If they indicated "strongly favor two-way" or somewhat favor two-way," they are in the "2-Way" group (row).

Business owners'/managers' perception of operational and economic impacts seem to influence their frontage road operation (one-way or two-way) preference. Appendix I shows more detailed information.

Table 5-13. Statistically Significant Differences between Business Owner/Manager Preferences for Frontage Roads Operating One-Way or Two-Way.

Number of Customers? (P-value = 0.005)				Traffic Congestion? (P-value = 0.007)				Business Opportunities? (P-value = 0.033)			
Group	Decrease	No Change	Increase	Group	Worse	Same	Better	Group	Worse	Same	Better
1-Way	28%	44%	28%	1-Way	15%	12%	73%	1-Way	28%	60%	12%
2-Way	64%	18%	18%	2-Way	33%	33%	33%	2-Way	60%	32%	9%
Property Value? (P-value = 0.018)				Traffic Safety? (P-value = 0.007)				Customer Satisfaction? (P-value = 0.037)			
Group	Decrease	No Change	Increase	Group	Worse	Same	Better	Group	Worse	Same	Better
1-Way	14%	52%	33%	1-Way	8%	15%	77%	1-Way	36%	60%	4%
2-Way	38%	20%	43%	2-Way	27%	44%	29%	2-Way	60%	29%	10%
Number of Crashes? (P-value = 0.002)				Property Access? (P-value = 0.007)				Delivery Convenience? (P-value = 0.001)			
Group	Decrease	No Change	Increase	Group	Worse	Same	Better	Group	Worse	Same	Better
1-Way	44%	52%	4%	1-Way	54%	27%	19%	1-Way	32%	40%	28%
2-Way	20%	46%	35%	2-Way	88%	8%	4%	2-Way	73%	25%	2%

Notes: Differences are statistically significant. Percentages may not add up to 100% due to rounding.

Concluding Remarks on Surveys

Findings related to the surveys are based upon very small sample sizes. Further, the survey data are perceptions of customers and business owners/managers. Researchers were not able to obtain actual gross sales or employment data to compare to the gross sales and employment data described earlier in this chapter. With these caveats in mind, researchers offer the following conclusions based upon the survey analysis and responses on the surveys:

- There is interest from the business community in doing conversions as quickly as possible once construction starts and constructing the support infrastructure before the frontage road conversion (bridges, U-turns, signage). Identifying opportunities for property access (e.g., cross access, shared access, alternate streets) along the two-way frontage road before the frontage road conversion is important. It is further important to engage all stakeholders and the business community early and often regarding a possible project.
- Customers would rather not travel in the "opposite" direction when leaving a business and may be less likely to stop at a business if this is necessary.
- Customer satisfaction may be negatively affected by frontage road conversion. Customer satisfaction may be considered part of customer service, which is an element of customer business selection.

- Business owners/managers seem to be concerned about the number of customers they will receive and possible reductions in gross sales along the converted corridor post-conversion. This is despite indications of their property value increasing.
- When asked if they generally prefer one-way or two-way frontage roads, there is a connection between frontage road operation preference (one-way or two-way) response and business owner/manager concerns. Those business owners/managers that prefer one-way frontage roads generally indicate they believe there is a decrease in crashes, increase in traffic safety, and improvement in traffic congestion.
- Most business owners/managers feel the frontage road conversion will harm their business. In general, business owner/manager concerns revolve around access, gross sales, customer satisfaction, construction, secondary infrastructure, ramp locations, and freeway signage. It appears perceived economic impacts may be related to timing of additional infrastructure placement and construction.
- Access level did not affect business owner/manager responses in this study. Business owners/managers on corners with cross-street access and business owners/managers with only frontage road access all shared the same concerns.
- Retail business owners/managers are more concerned about delivery convenience than non-retail business owners/managers.
- Business owners/managers do a reasonable job estimating the considerations customers make when selecting a business.

CHAPTER 6:
CONCLUSIONS AND FUTURE WORK

The research team undertook this research effort to address four objectives:

1. Develop accurate information that can be used to communicate the types of safety impacts that have been experienced and can be expected.
2. Develop accident modification factors that roadway designers and decision-makers can use to guide frontage road conversion project planning.
3. Develop accurate information that can be used to communicate the types of economic impacts that have been experienced and can be expected.
4. Identify any issues identified in crash data obtained as a result of this analysis.

The fourth objective was added as a result of a project modification caused, in part, because of issues identified with the coding of some crash variables in the Crash Records Information System in comparison to printed crash reports.

Researchers evaluated the safety and economic impacts of frontage road conversion at five sites in Texas where conversions were implemented. Comparison sites in Texas where frontage roads remained two-way were identified for four of the five conversion sites.

In summary, researchers found a reduction in non-PDO crashes when frontage roads are converted from two-way to one-way operation. Further, it does not appear there are substantial overall negative effects on appraisal values along the conversion sites in the long term. These findings and additional conclusions are described in more detail in the sections that follow.

SAFETY ANALYSIS (OBJECTIVES 1 AND 2)

Researchers performed three types of safety analyses: 1) exploratory analysis, 2) statistical comparison-group analysis, and 3) hot-spot analysis. In the exploratory analysis, researchers identified that about 35 percent of crashes occurring at the case study sites in the before period were applicable to this research (i.e., non-PDO crashes on frontage roads). This stratification helps explain the relatively low sample sizes and numbers of crashes that remained in the final dataset for analysis.

Researchers performed a statistical analysis in the form of a comparison-group analysis along segments and interchange intersections of converted frontage roads. Researchers developed 12 AMFs for different crash types or severity along segments and interchange intersections (see Table 4-9). Chapters 3 and 4 (and associated appendices) discuss the data collection, data reduction, and analyses performed to develop the AMFs shown in Table 4-9.

The segments upon which the AMFs were developed include a variety of exit/entrance ramps, access densities, lengths, and geometric characteristics. Typically, the projects upon which these AMFs are based included other improvements, such as ramp improvements, in addition to the frontage road conversion. Therefore, the AMFs here inherently include some impact of the ramp configurations that occur with the conversion as well. It was not possible to separate these effects. With these caveats in mind, researchers developed the AMFs shown in Table 4-9. Researchers expect these AMFs will be valuable for transportation planners and engineers interested in estimating the safety impacts of converting frontage roads from two-way to one-way.

Researchers then performed a hot-spot analysis, which was intended to provide a practical, corridor-specific evaluation of some of the impacts of the frontage road conversion from the before to the after period. Researchers identified several locations along conversion sites where the number of crashes decreased from the before period to the after period. Researchers hypothesized that these changes are due, in large part, to the conversion of the frontage roads to one-way. In several other cases, researchers identified crashes increasing or remaining relatively constant at associated comparison sites.

ECONOMIC ANALYSIS (OBJECTIVE 3)

Researchers evaluated the following four data sources to perform the economic analysis of frontage road conversion:

- gross sales data from the Texas Comptroller of Public Accounts,
- appraisal data from county appraisal districts,
- employment data from the U.S. Census Bureau, and
- surveys of business owners/managers and customers.

The following sections highlight conclusions of analyzing these data sources.

Gross Sales Data and Analysis

Researchers provide the following conclusions related to gross sales:

- It is not prudent, nor is it the intent, to attribute changes in this city-level gross sales data to the frontage road conversion specifically. Rather, the intent is to identify the general economic trends in each area with these data using the before and after time periods of the conversions.
- In the after period, all cities with conversion sites showed increases in gross sales at a higher rate than the corresponding city of the comparison site. In fact, all comparison sites showed negative gross sales after the conversion date in the associated conversion city.
- When comparing the percent change of the after period with the before period, researchers found a decrease in gross sales in the city of each conversion site except Burleson and Huntsville. The decrease ranged from 2 percent in Hillsboro to 30 percent in Wolfforth. The State of Texas experienced a 13 percent increase during the same time period.
- There were many other economic factors affecting gross sales values that the research team did not control for in this analysis. Among those factors were general economic conditions in the local area as well as state and national economic trends. The study also did not control for access to new retail outlets in other locales that might have resulted in locational shifts in buying patterns.

Appraisal Data and Analysis

Researchers obtained appraisal data for parcels along all the conversion and comparison sites and an additional site in the City of Cibolo. Researchers documented several nuances and factors encountered by the research team that affect appraisal data. Researchers developed trend analysis graphics showing land appraised value, improvement appraised value, and total appraised value. In general, the graphics indicate overall increases in appraised values over the historical trends shown. From the aggregate appraisal data documented here, it does not appear there are any substantial overall negative effects of the conversion sites in the long term.

It should be noted that the research team did not look at any comparison sites for the Burleson or Cibolo corridors. Further, there are many other economic factors affecting appraised values that the research team did not control for in this analysis. Among those factors were several economic conditions in the local area (e.g., local real estate market, economic vitality of the area) as well as state and national economic trends. While these factors may have skewed data for a specific year, the research team believes the general trends reflected in the data are insightful in the long term.

Employment Data and Analysis

Researchers provided the following conclusions related to employment trends:

- The employment data analyzed provides only an indication of the general economic trends of employment in each city/county by the before and after time periods of the conversion projects. It is not prudent, nor is it the intent, to attribute changes in this zip-code level employment data to the frontage road conversion specifically.
- Researchers found it difficult to compare the number of employees from each conversion and comparison city because of the site-specific characteristics (e.g., the number of employees in Hillsboro and Plainview were much higher than West and Wolfforth).
- The most notable observation of the employment analysis is that in the most recent two years of data, the trends of employment numbers generally increased for all conversion sites and most comparison sites (except in Greenville and West).
- The trend in the number of employees in the State of Texas also generally increased over the years investigated.
- Regarding the employment data, there were many other economic factors affecting the numbers of employees that the researchers could not control for in this research. Among those factors were several economic conditions in the local area (e.g., job opportunity, local real estate market, economic vitality of the area) as well as state and national economic trends.

Business Owner/Manager Surveys

Findings related to the surveys are based upon very small sample sizes. Further, the survey data are perceptions of customers and business owners/managers. Researchers were not able to obtain actual gross sales or employment data to compare to the gross sales and employment data described earlier in Chapter 5. With these caveats in mind, researchers offer the following conclusions based upon the survey analysis and responses on the surveys:

- There is interest from the business community in doing conversions as quickly as possible once construction starts and constructing the support infrastructure before the frontage road conversion (bridges, U-turns, signage). Identifying opportunities for property access (e.g., cross access, shared access, alternate streets) along the two-way frontage road before the frontage road conversion is important. It is further important to engage all stakeholders and the business community early and often regarding a possible project.
- Customers would rather not travel in the "opposite" direction when leaving a business and may be less likely to stop at a business if this is necessary.
- Customer satisfaction may be negatively affected by frontage road conversion. Customer satisfaction may be considered part of customer service, which is an element of customer business selection.
- Business owners/managers seem to be concerned about the number of customers they will receive and possible reductions in gross sales along the converted corridor post-conversion. This is despite indications of their property value increasing.
- When asked if they generally prefer one-way or two-way frontage roads, there is a connection between frontage road operation preference (one-way or two-way) response and business owner/manager concerns. Those business owners/managers that prefer one-way frontage roads generally indicate they believe there is a decrease in crashes, increase in traffic safety, and improvement in traffic congestion.
- Most business owners/managers feel the frontage road conversion will harm their business. In general, business owner/manager concerns revolve around access, gross sales, customer satisfaction, construction, secondary infrastructure, ramp locations,

and freeway signage. It appears perceived economic impacts may be related to timing of additional infrastructure placement and construction.

- Access level did not affect business owner/manager responses in this study. Business owners/managers on corners with cross-street access and business owners/managers with only frontage road access all shared the same concerns.
- Retail business owners/managers are more concerned about delivery convenience than non-retail business owners/managers.
- Business owners/managers do a reasonable job estimating the considerations customers make when selecting a business.

Summary of Economic Analysis

Other than appraisal data and survey information, the economic data sources evaluated here are not disaggregated to the parcel corridor level. From the aggregate appraisal data documented in this report, it does not appear there are any substantial overall negative effects of the conversion sites in the long term. The survey results from local business owners/managers reflect common concerns of the business community when conversions are possible. As stated above, there is interest from the business community in doing conversions as quickly as possible once construction starts and constructing the support infrastructure before the frontage road conversion (bridges, U-turns, signage). Chapter 5 (and associated appendices) discuss the data collection, data reduction, and analysis performed to develop the selected economic impact concluding remarks.

CRASH DATA QUALITY (OBJECTIVE 4)

Researchers identified some crash data discrepancies when comparing the electronic crash data to actual printed crash reports. Awareness of the issues summarized in this report, and specifically in Appendix D, will assist future safety data analysts in ensuring they have a complete dataset for analysis.

One variable in the electronic crash records is ROADPART, which identifies the part or type of roadway where a crash occurred. Researchers discovered that for three selected case study locations, there was an average of approximately 36 percent of reports miscoded as having taken place on the mainlane when they actually took place on the frontage road. Researchers had to manually verify all printed crash reports (mainlane and frontage road) to ensure that all applicable frontage road crash reports were kept.

Researchers noted that critical position variables were removed from the electronic database in 2002 and after. Researchers manually created and filled these variables into the final electronic database used for analysis by reviewing the diagrams on the crash reports. The crash reports, and associated narratives and location diagrams, were key for locating crashes in the correct analysis unit along each study corridor. The addition of these position variables into the CRIS dataset would facilitate future safety analyses.

Electronic records lack the narrative descriptions and diagrams that were filled out at the scene of the crash. These two pieces of information were vital in helping researchers identify what events took place in the crash. Printed crash reports were invaluable for this research effort to identify position on the highway (frontage road or mainlane) and milepoint location of the crash, and to provide an understanding of what caused the crash.

The cause of some of the discrepancies identified between the printed reports and the electronic crash records is not clear to the research team. Human error could be introduced when officers complete the crash reports and/or when the reports are coded into the electronic database system. While the extent of human error is not understood because it was not specifically studied in this effort, researchers suggest that additional training of officers completing crash reports and those individuals entering the crash data into CRIS might reduce similar discrepancies in the future.

FUTURE RESEARCH NEEDS

Researchers identified several future research needs, as discussed below.

Safety Analysis

There is a need to expand the frontage road analysis performed here to additional sites. Researchers were limited by the fact that traffic volume data were not available for many of the frontage road segments and for the interchange intersections. For three cities, nearly half of the frontage road segments did not have volume data available. Additional sites and more traffic data would facilitate more powerful statistical techniques (e.g., Empirical Bayes methods), which may provide more robust estimation of frontage road conversion AMFs.

A comparison site was not available for the Burleson conversion corridor. Evaluating additional conversion and comparison sites could provide more insight into frontage road conversion impacts.

Economic Analysis

Additional sites would also benefit the economic analysis. Additional conversion sites would provide a greater sample of opportunity for business owner/manager surveys and customer surveys as well as more opportunity to investigate gross sales, appraised values, and employment impacts of conversion.

In future work, it would be valuable to investigate the possibility of getting corridor-specific gross sales data, if available. It would also be valuable if future work could control for the economic factors related to gross sales, appraised values, and employment data analyses that were not controlled for in this study. These items appeared in a prior bulleted list of this chapter.

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APPENDIX A:
MAPS AND PHOTOGRAPHS OF FRONTAGE ROAD STUDY SITES

This appendix contains maps of each conversion comparison site. It also includes photographs of selected geometric and operational characteristics.

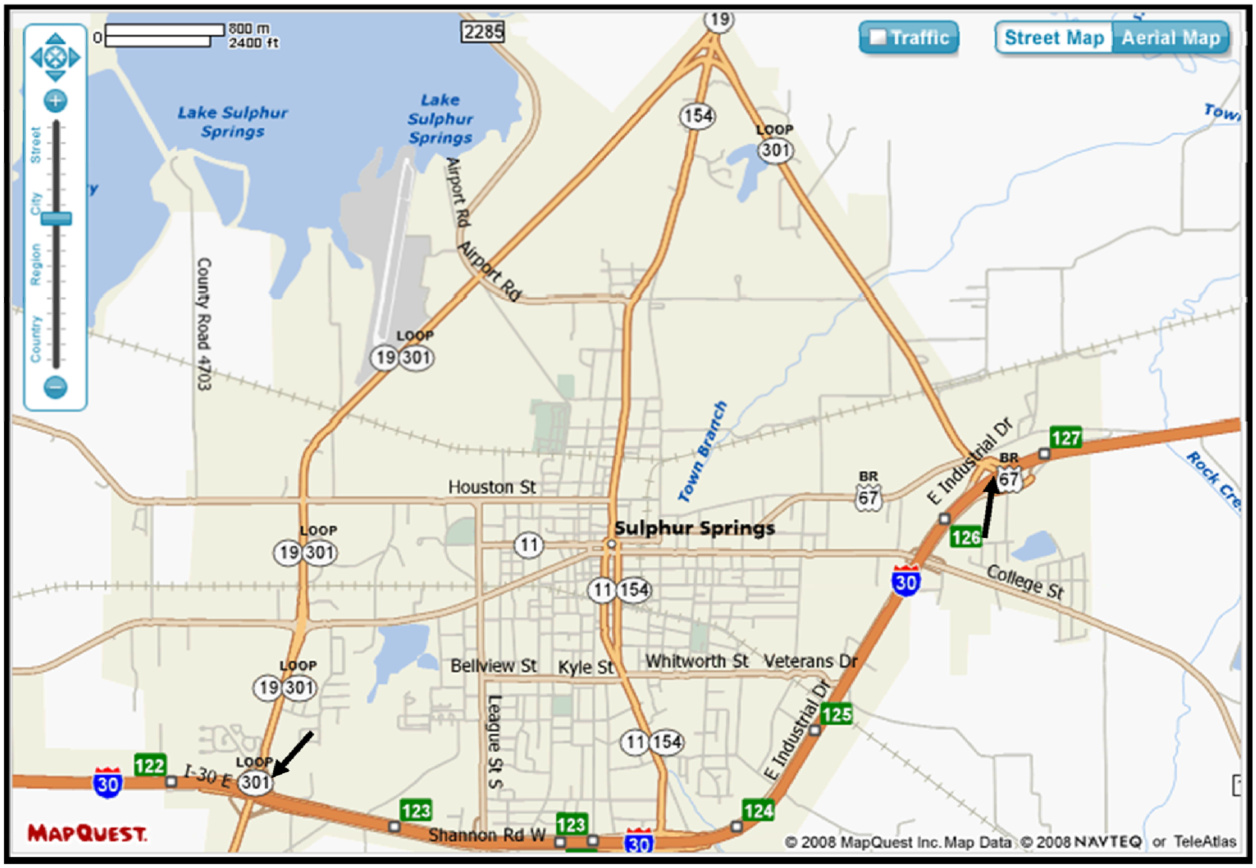


Figure A-1. Sulphur Springs, Case Study Location (Conversion Site)
(Map from MapQuest.com, Inc.).

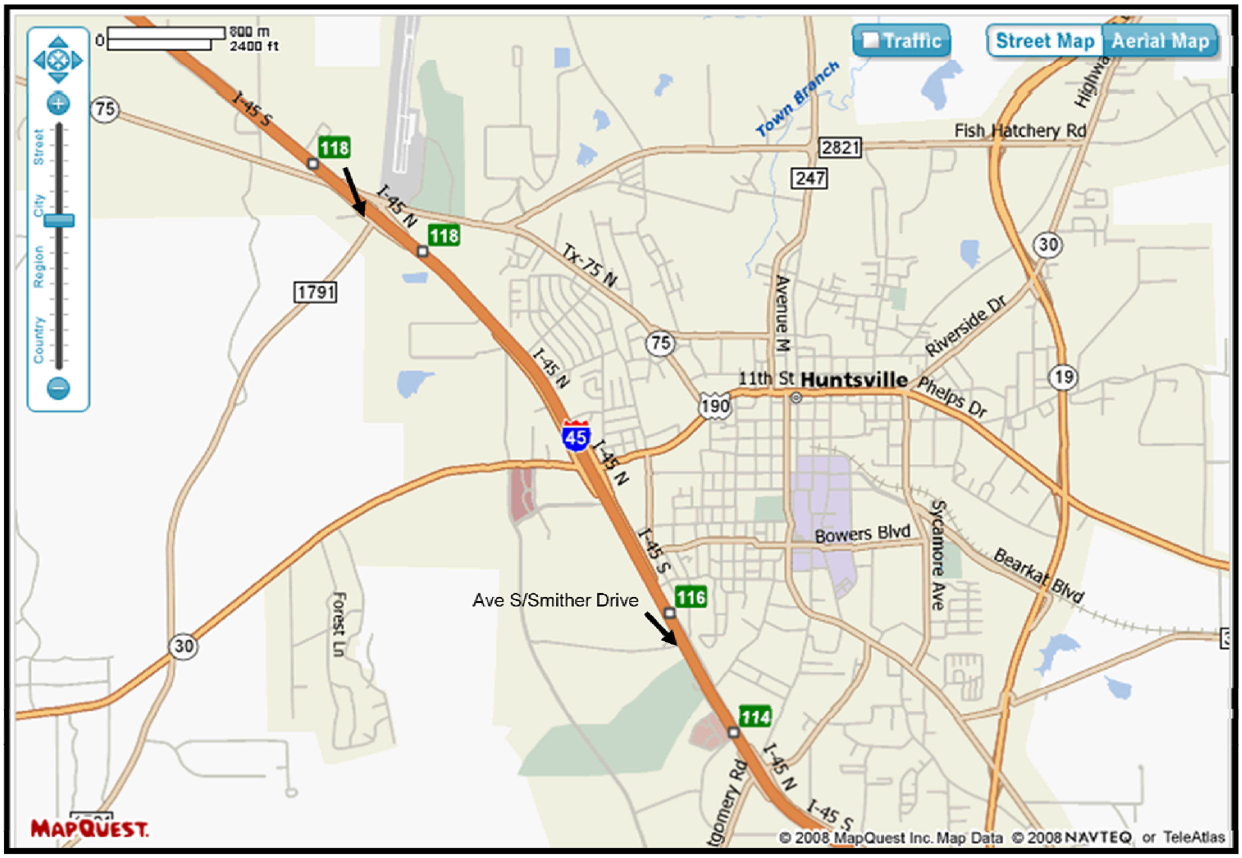


Figure A-2. Huntsville, Case Study Location (Conversion Site) (Map from MapQuest.com, Inc.).

Figure A-3. Wolfforth, Case Study Location (Conversion Site)
(Map from MapQuest.com, Inc.).

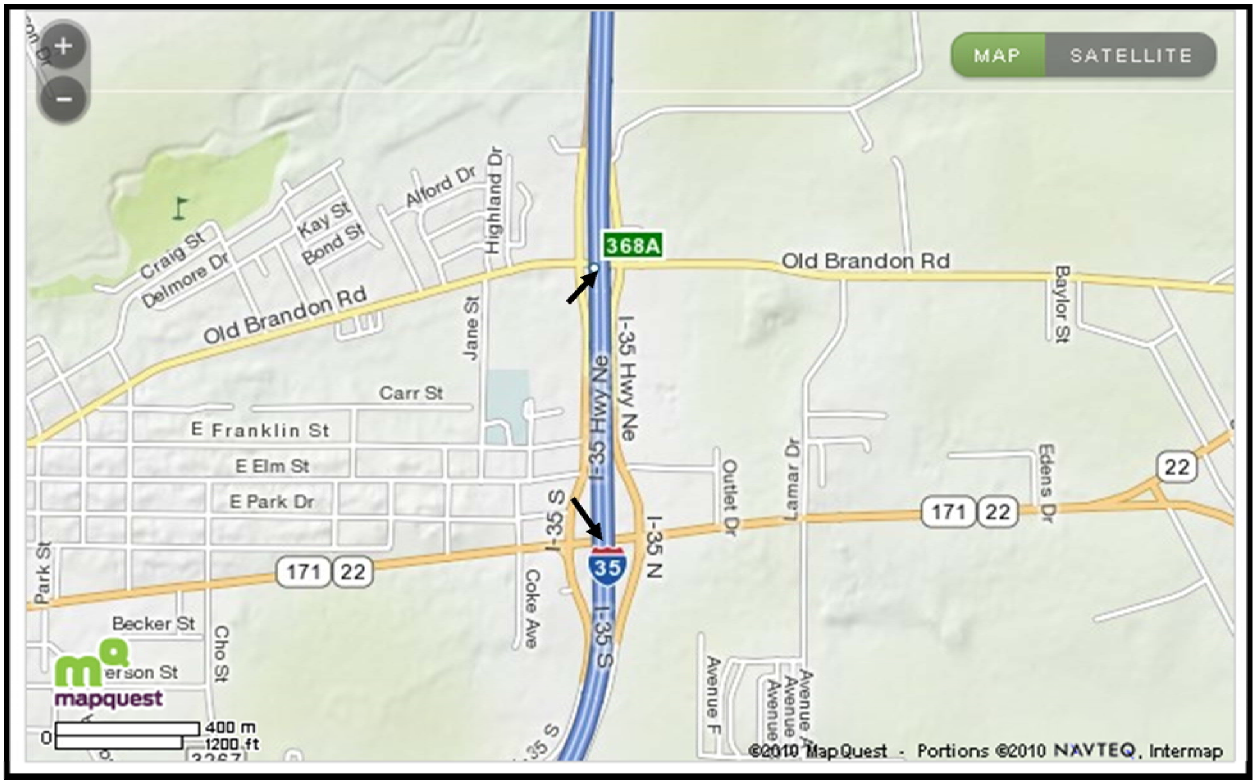


Figure A-4. Hillsboro, Case Study Location (Conversion Site) (Map from MapQuest.com, Inc.).

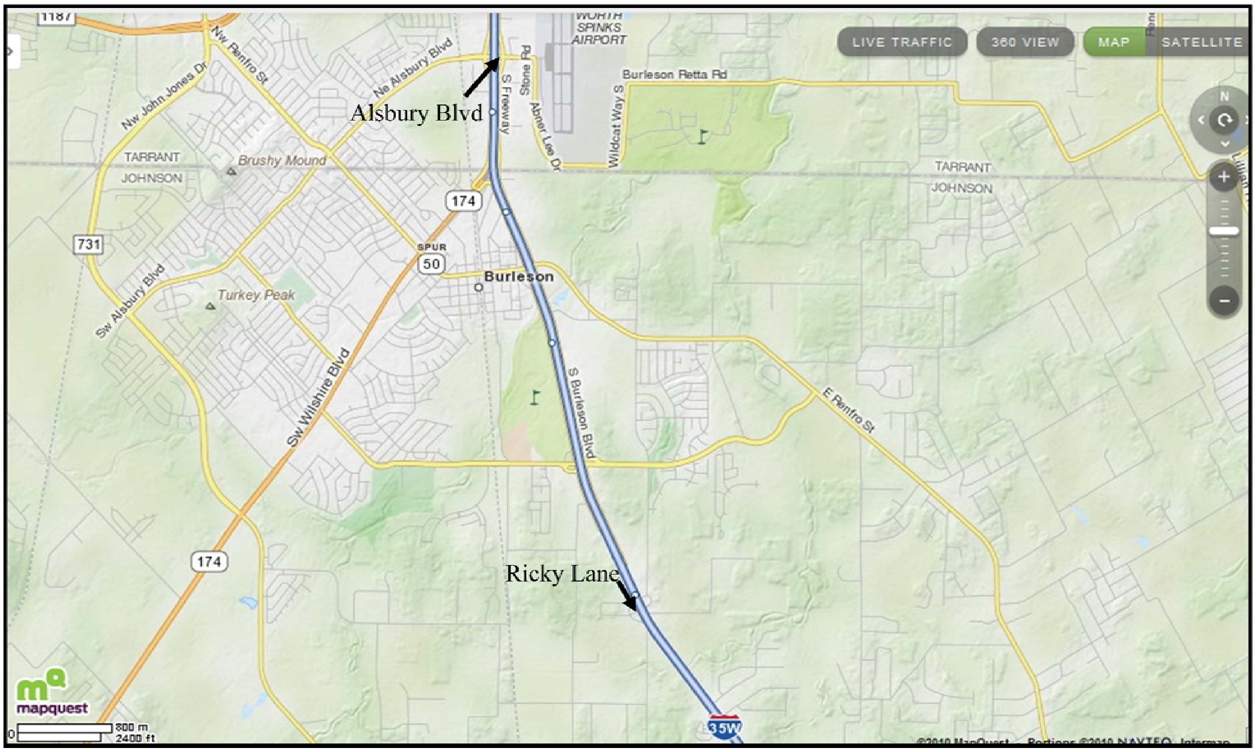


Figure A-5. Burleson, Case Study Location (Conversion Site)
(Map from MapQuest.com, Inc.).

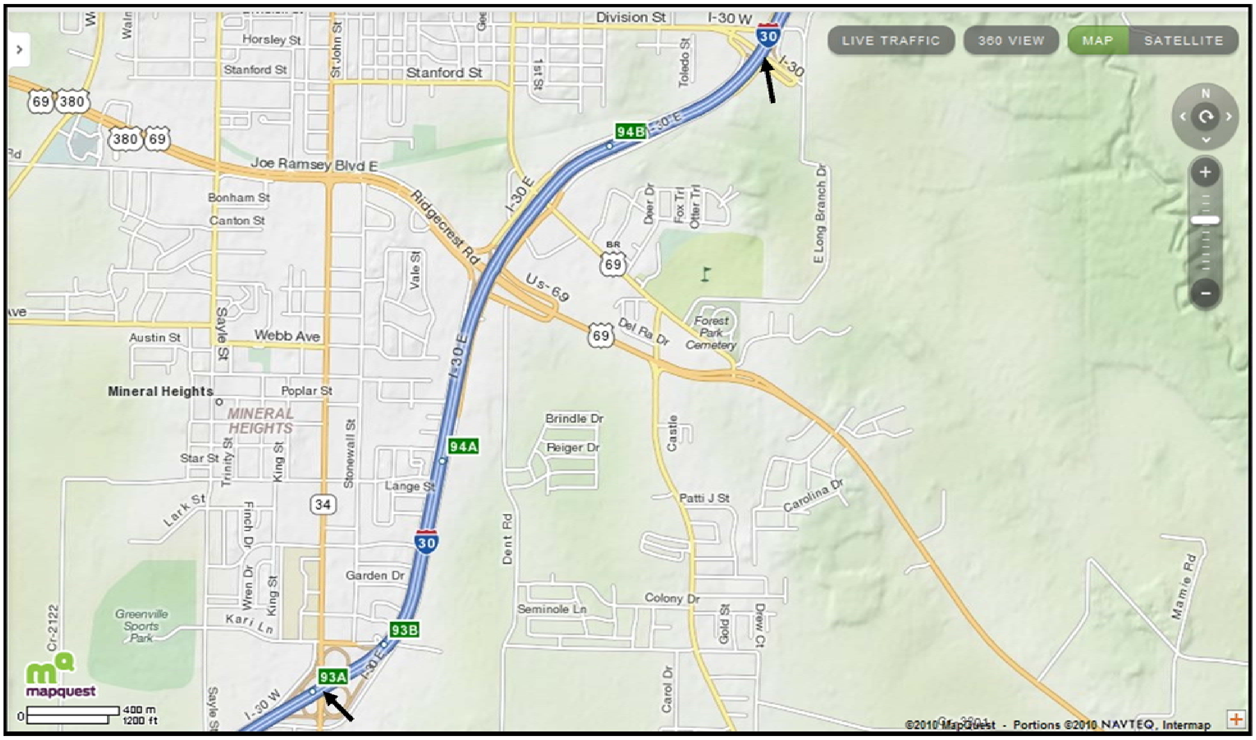


Figure A-6. Greenville, Case Study Location (Comparison Site)
(Map from MapQuest.com, Inc.).

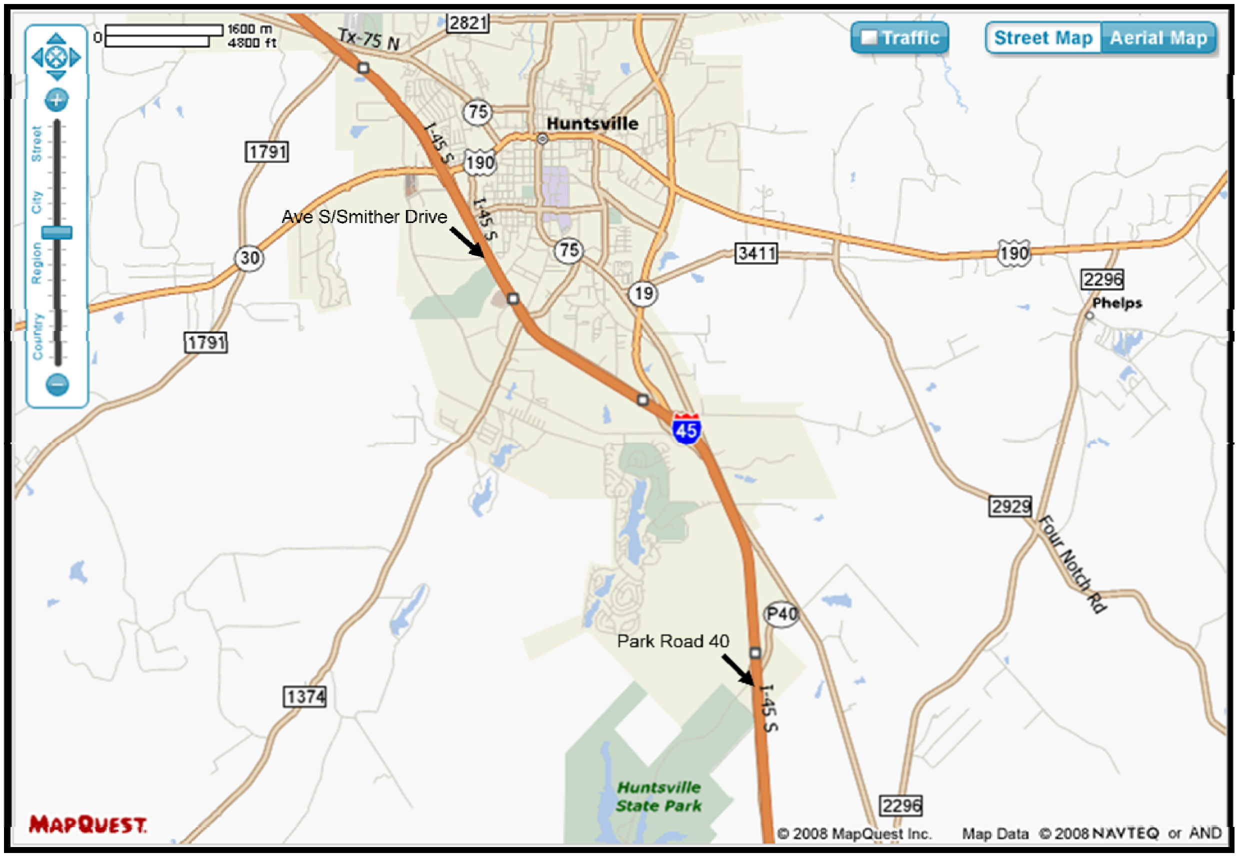


Figure A-7. Huntsville, Case Study Location (Comparison Site)
(Map from MapQuest.com, Inc.).

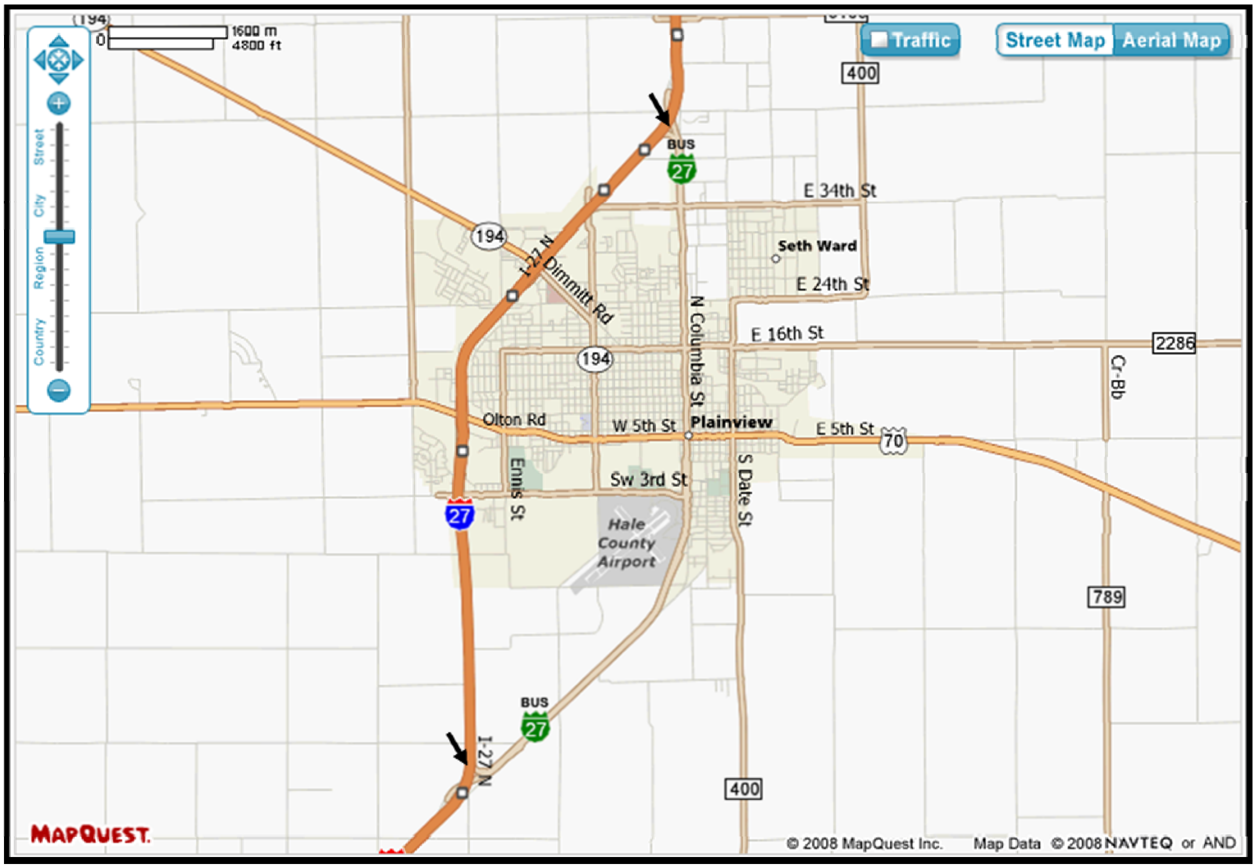


Figure A-8. Plainview, Case Study Location (Comparison Site)
(Map from MapQuest.com, Inc.).

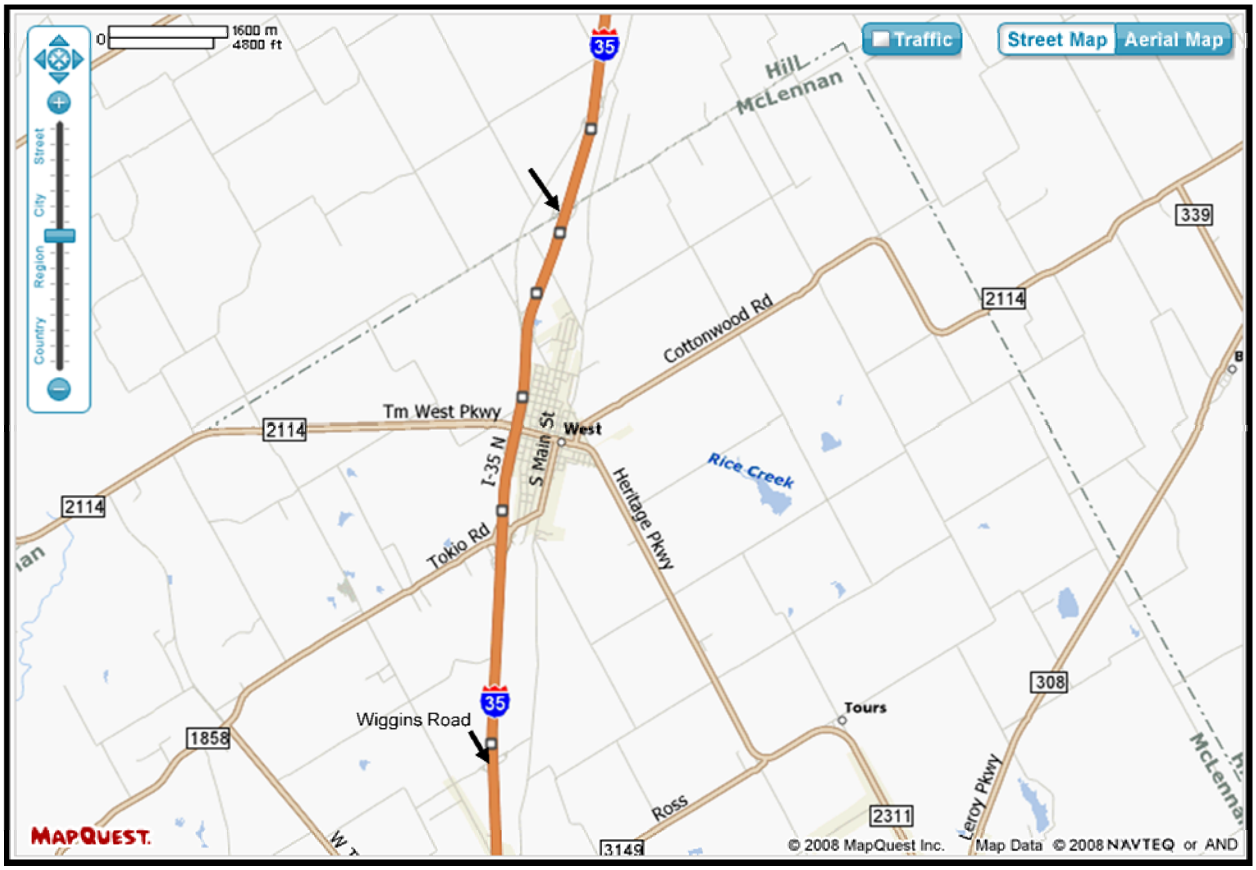


Figure A-9. West, Case Study Location (Comparison Site)
(Map from MapQuest.com, Inc.).

Figure A-10. Ramp Intersection with Frontage Road (Sulphur Springs—Example 1).

Figure A-11. Ramp Intersection with Frontage Road (Sulphur Springs—Example 2).

Figure A-12. Ramp Intersection with Frontage Road (Greenville).

Figure A-13. Transition Intersection from One-Way to Two-Way Operation Showing "Do Not Enter" Signing (Sulphur Springs).

Figure A-14. Transition Intersection from One-Way to Two-Way Operation (Sulphur Springs).

Figure A-15. Signing at Transition Intersection (Burleson).

Figure A-16. Exit Ramp Where Frontage Road Reduces to One Lane (Sulphur Springs).

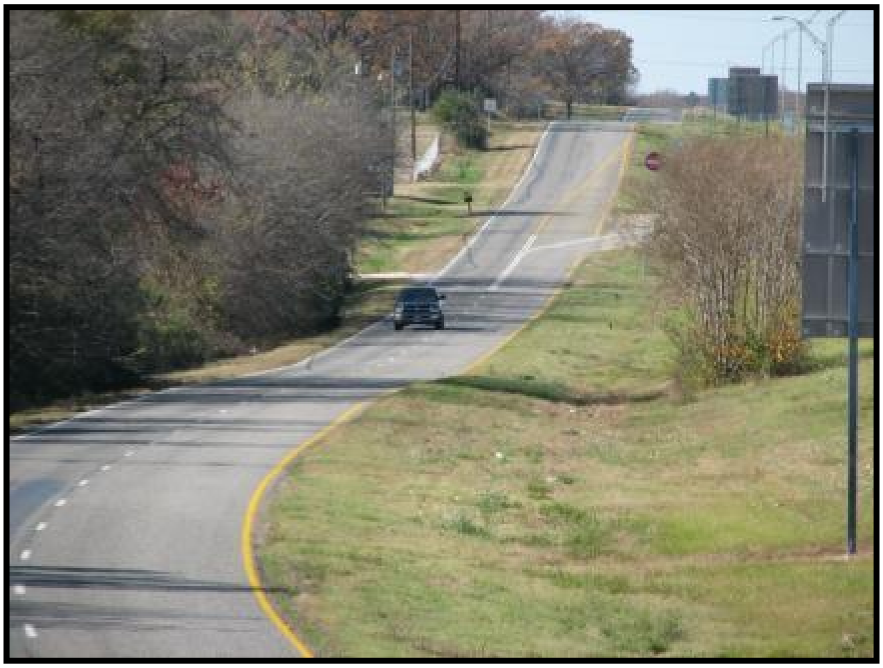


Figure A-17. Exit Ramp Where Frontage Road Reduces to One Lane (Sulphur Springs).

Figure A-18. Exit Ramp Where Frontage Road Reduces to One Lane (Wolfforth).

Figure A-19. Exit Ramp Where Frontage Road Continues with Two Lanes (Hillsboro).

Figure A-20. One-Way Entrance Ramp Design with Arrow Pavement Markings (Sulphur Springs).

Figure A-21. One-Way Entrance Ramp Design without Arrow Pavement Markings (Sulphur Springs).

Figure A-22. Two-Way Frontage Road Exit Ramp with "Yield" Treatment (Greenville).

Figure A-23. Two-Way Frontage Road Exit Ramp with "Yield" and "No Left Turn" Treatment (Greenville).

Figure A-24. Two-Way Frontage Road Exit Ramp with "Yield" Treatment (Plainview).

Figure A-25. Two-Way Entrance Ramp (Greenville).

Figure A-26. Two-Way Entrance Ramp at Right (Plainview).

Figure A-27. “Stop” Controlled Interchange Intersection (Hillsboro).

Figure A-28. "Stop" Controlled Interchange Intersection (Burleson).

Figure A-29. Signalized Interchange Intersection (Wolfforth).

Figure A-30. Signalized Interchange Intersection—No Retaining Wall (Burleson).


Figure A-31. Signalized Interchange Intersection—Retaining Wall (Burleson).

APPENDIX B: CRASH VARIABLES USED IN ANALYSIS

This appendix contains variables used in the final reported crashes electronic database for analysis. It also provides notes to those coding in the variables. Some of the figures below are scanned from the DPS Crash Records Code Manual. Not all of these variables were available in the CRIS data (2003–2007), so researchers coded them based upon printed crash reports.

Accident Number (ACC_NO)
From report, number should start with the last digit of the year the crash occurred in. (7 digits, sometimes 8)

County, City
County and City number from tables

Control Sectio1, MilePoint1—for primary roadway
Control Sectio2, MilePoint2—for secondary/intersecting highway

ROAD CLASS,Column 19

ROAD NUM 2 RDCLASS14.
ROAD CLASS

1. Interstate	5. City Street
2. US & State Highways	6. Tollway
3. Farm to Market	7. Other Roads (Alley)
4. County Road	8. Beltway 8 (East) Tollbridge

PART OF ROADWAY No. 1, INVOLVED,Column 56

ROADPART CHAR 1 ROADPART13.
PART OF ROADWAY 1 INVOLVED

Part of Roadway will be the highest priority part of the roadway involved in the accident.

1. Main Lane	6. Detour
2. Frontage road	7. Other
3. Entrance ramp	8.
4. Exit ramp	9.
5. Connection	+. Unknown

**Ask yourself, "On what type of road did this crash occur?"

Accident Year
Use full four-digit year.
Month

January	1	July	7
February	2	August	8
March	3	September	9
April	4	October	10
May	5	November	11
June	6	December	12

Date
Use the day of the month.

DAY OF WEEK,Column 24

```
DAY        NUM        2    DAYFMT9.
  DAY OF WEEK

1.  Sunday                        5.  Thursday
2.  Monday                        6.  Friday
3.  Tuesday                       7.  Saturday
4.  Wednesday
```

TIME,Columns 25-26

```
TIME       NUM        2    TIMEFMT16.
  TIME

 0.  Midnight to 12:59 AM        12.  Noon to 12:59 PM
 1.  1:00 AM to 1:59 AM          13.  1:00 PM to 1:59 PM
 2.  2:00 AM to 2:59 AM          14.  2:00 PM to 2:59 PM
 3.  3:00 AM to 3:59 AM          15.  3:00 PM to 3:59 PM
 4.  4:00 AM to 4:59 AM          16.  4:00 PM to 4:59 PM
 5.  5:00 AM to 5:59 AM          17.  5:00 PM to 5:59 PM
 6.  6:00 AM to 6:59 AM          18.  6:00 PM to 6:59 PM
 7.  7:00 AM to 7:59 AM          19.  7:00 PM to 7:59 PM
 8.  8:00 AM to 8:59 AM          20.  8:00 PM to 8:59 PM
 9.  9:00 AM to 9:59 AM          21.  9:00 PM to 9:59 PM
10.  10:00 AM to 10:59 AM        22.  10:00 PM to 10:59 PM
11.  11:00 AM to 11:59 AM        23.  11:00 PM to 11:59 PM
```

Light Condition (from 2007 accident report—USE CODES HERE, NOT ON REPORT)

Daylight	1
Dark Not Lighted	2
Dark Lighted	3
Dark Unknown Lighting	4
Dawn	5
Dusk	6
Other	8
Unknown	9

FIRST HARMFUL EVENT,Column 28

```
_1STHARM  CHAR     1    HARM16.
 FIRST HARMFUL EVENT
```

Collision of a motor vehicle with:

1. Pedestrian
2. Another motor vehicle in transport
3. RR Train
4. Parked Car
5. Pedalcyclist
6. Animal
7. Fixed Object
8. Other Object

Other than collision:

0. Overturned
-. Other non-collision

Weather (from 2007 accident report—USE CODES HERE, NOT ON REPORT)

Clear/Cloudy	1
Rain	2
Sleet/Hail	3
Snow	4
Fog	5
Blowing Sand/Snow	6
Severe Crosswinds	7
Other	8
Unknown	9

Surface Condition (from 2007 accident report—USE CODES HERE, NOT ON REPORT)

Dry	1
Wet	2
Standing Water	3
Snow	4
Slush	5
Ice	6
Sand Mud Dirt	7
Other	8
Unknown	9

ROAD CONDITION,Column 32

```
ROAD_CON  CHAR     1    ROADCON17.
 ROAD CONDITION
```

0. No defects
1. Holes, ruts, etc., in surface
2. Defective shoulders
3. Foreign material on surface
4. High water or flood debris
5. Slick surface
6. Obstruction in road not lighted (night)
7. Obstruction in road not marked (day)
8. Narrow bridge, overpass or underpass
9. Road under construction
-. Maintenance or repair activity affecting traffic
+. Defects unknown

```
INVESTIGATION,Column 33

    INVEST    CHAR      1    INVEST16.
      INVESTIGATION

    1.  Investigated by DPS - arrest
    2.  Investigated by DPS - no arrest
    3.  Investigated by city police - arrest
    4.  Investigated by city police - no arrest
    5.  Investigated by sheriff's department - arrest
    6.  Investigated by sheriff's department - no arrest
    7.  Reported by other agency
    8.  Driver report only
```

Traffic Control (from 2007 accident report—USE CODES HERE, NOT ON REPORT)

None	1
Inoperative	2
Officer	3
Flagman	4
Signal Light	5
Flashing Red Light	6
Flashing Yellow Light	7
Stop Sign	8
Yield Sign	9
Warning Sign	10
Center Stripe/Divider	11
No Passing Zone	12
RR Gate/Sign	13
School	14
Crosswalk	15
Bike Lane	16
Other	17

Roadway Relation (from 2007 accident file—USE CODES HERE, NOT ON REPORT)

On Roadway	1
Off Roadway	2
Shoulder	3
Median	4

```
INTERSECTION RELATED,Column 37

    INTRSECT  CHAR      1    INTER16.
      INTERSECTION RELATED

    1.  Intersection
    2.  Intersection related
    3.  Driveway access
    4.  Non intersection
```

**Ask yourself, "Did this occur in/at an intersection (#1), because of an intersection (#2), at a driveway entrance/exit (#3), or none of the above (#4)?"

INTERSECTION ROAD TYPE,Column 38

INTERRD CHAR 1 INTERRD16.
INTERSECTION ROAD TYPE

0. No intersection

INTERSECTION AT GRADE

1. With main lanes of a numbered highway
2. With frontage road of a numbered highway
3. With wye connection
4. With ramp
5. With county road or city street

GRADE SEPARATION

6. With main lanes of a numbered highway
7. With frontage road of a numbered highway
8. With wye connection
9. With county road or city street
-. With crossover from one frontage road to another
+. Unknown

**If you picked 1 or 2 for INTRSECT, ask yourself, "What type of road is the ROADPART I selected earlier intersecting with?" --"At Grade" means on the same plane; "Separation" is not on same plane, like an overpass, for example.

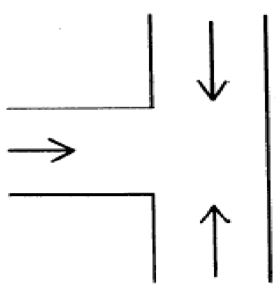
INTERSECTION TYPE/ENTERING ROADS,Column 39

ENTERRD CHAR 1 ENTER14.
INTERSECTION TYPE / ENTERING ROADS

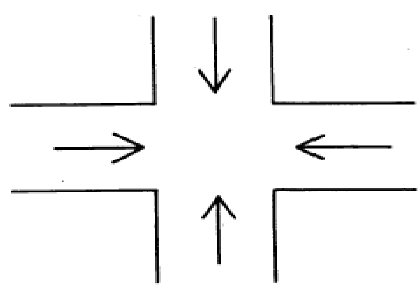
0. Not applicable
2. Channelized T or Y
3. Three entering roads - T or Y
4. Four entering roads - crossing or other
5. Five entering roads
6. Six entering roads
7. Traffic Circle (at intersection or within)
8. Cloverleaf

EXAMPLE OF ENTERING ROADS

3 entering roads



4 entering roads (even if one-way)



VEHICLE MOVEMENTS/MANNER OF COLLISION, Columns 40-41

COLISION NUM 2 COL16.
VEHICLE MOVEMENTS / MANNER OF COLLISION

This variable shows the manner of collision and vehicular movements in accidents involving collisions between two motor vehicles and vehicular movements in all other accidents.

TWO MOTOR VEHICLES APPROACHING AT AN ANGLE

10. Both going straight
11. #1 straight - #2 backing
12. #1 straight - #2 stopped
13. #1 straight - #2 right turn
14. #1 straight - #2 left turn
15. Both right turn
16. #1 right turn - #2 left turn
17. #1 right turn - #2 stopped
18. Both left turn
19. #1 left - #2 stopped

TWO MOTOR VEHICLES - GOING SAME DIRECTION

20. Both going straight - rear end
21. Both going straight - sideswipe
22. #1 straight - #2 stopped
23. #1 straight - #2 right turn
24. #1 straight - #2 left turn
25. Both right turn
26. #1 right turn - #2 left turn
27. #1 right turn - #2 stopped
28. Both left turn
29. #1 left turn - #2 stopped

TWO MOTOR VEHICLES - GOING OPPOSITE DIRECTIONS

30. Both going straight
31. #1 straight - #2 backing
32. #1 straight - #2 stopped
33. #1 straight - #2 right turn
34. #1 straight - #2 left turn
35. #1 backing - #2 stopped
36. #1 right turn - #2 left turn
37. #1 right turn - #2 stopped
38. Both left turn
39. #1 left turn - #2 stopped

TWO MOTOR VEHICLES - OTHER

40. #1 straight - #2 entering or leaving parking space
41. #1 right turn - #2 entering or leaving parking space
42. #1 left turn - #2 entering or leaving parking space
43. #1 entering or leaving parking space - #2 stopped
44. Both entering or leaving parking space
45. Both vehicles backing
46. All others

MOVEMENT OF VEHICLE IN OTHER THAN MOTOR WITH MOTOR ACCIDENTS

1. Vehicle going straight
2. Vehicle turning right
3. Vehicle turning left
4. Vehicle backing
5. Other

OBJECT STRUCK,Columns 42-43

```
OBJECT     NUM       2    OBJECT16.
  OBJECT STRUCK
```

This variable used in conjunction with the First Harmful Event and Vehicle Movements/Manner of Collision variables will give a more detailed picture of the accident. The value of Object Struck variable may indicate either the first or second impact or collision, depending on the first harmful event. For example: If the First Harmful Event variable shows collision with a fixed object, then this variable will indicate the first impact. If the First Harmful Event variable shows collision between two motor vehicles, then this variable may indicate a second impact, or may be used to show vehicle movement or specifically:

0. No code shown is applicable
1. Vehicle overturned
2. Vehicle hit hole in road
3. Vehicle jack-knifed
4. Person fell or jumped from vehicle
9. Vehicle hit train on tracks parallel to road - no crossing **(Since January 1, 1980)**
10. Vehicle hit train moving forward
11. Vehicle hit train backing
12. Vehicle hit train standing still
13. Vehicle hit train - action unknown
20. Vehicle hit highway sign
21. Vehicle hit curb
22. Vehcile hit culvert - headwall or marker post
23. Vehicle hit guard post, guard rail or delineator
24. Vehicle hit railroad signal pole or post
25. Vehicle hit railroad crossing gates
26. Vehicle hit traffic signal pole or post
27. Vehicle hit overhead obstruction (signal light, wires, etc.)
28. Vehicle hit construction barricade, cones, warnings signs, or material
29. Vehicle hit luminaire pole
30. Vehicle hit utility pole
31. Vehicle hit mail box
32. Vehicle hit tree or shrub
33. Vehicle hit fence
34. Vehicle hit house, building or building fixture
35. Vehicle hit commercial sign
36. Vehicle hit other fixed object
37. Vehicle hit maintenance barricade, cones, or materials **(Since January 1, 1981)**
38. Vehicle hit maintenance machinery **(Since January 1, 1981)**
39. Vehicle hit median barrier (divider) **(Since January 1, 1981)**
40. Vehicle hit end of bridge (abutment or rail end)
41. Vehicle hit side of bridge (bridge rail)
42. Vehicle hit pier or support at underpass or tunnel
43. Vehicle hit top of underpass or tunnel
44. Vehicle hit bridge crossing gate
45. Vehicle hit attenuation device
49. Vehicle hit by falling/blowing rocks from a truck **(Since January 1, 1980)**
50. Vehicle hit fallen trees or debris on road
51. Vehicle hit object from another vehicle in road
52. Vehicle hit previously wrecked vehicle
53. Vehicle hit construction or maintenance machinery
54. Vehicle hit other machinery
55. Vehicle hit other object

TRAFFIC CONTROL,Column 35

```
TRAF_CON  CHAR      1    CONT16.
  TRAFFIC CONTROL
```

0. No traffic control shown or traffic control inoperative
1. Officer, flagman, or watchman
2. Stop and go signal
3. Stop sign
4. Flashing red light
5. Flashing yellow light
6. Warning sign
7. RR gates or signal
8. Yeild sign
9. Center stripe or divider

-. No passing zone

+. Other traffic control

(For alternative formats, see $TRAFFIC in Appendices H and I)

```
*------------------------------------------------------------------------*
|     FORMAT NAME: $CONT     LENGTH:   16   NUMBER OF VALUES:   12       |
|  MIN LENGTH:   4  MAX LENGTH:  40  DEFAULT LENGTH:  16  FUZZ: N/A      |
*------------------------------------------------------------------------*
|          START |               END | LABEL                            |
*------------------------------------------------------------------------*
|+               |+                  |OTHER TRAF CON                    |
|-               |-                  |NO PASSING ZONE                   |
|0               |0                  |NONE OR INOP                      |
|1               |1                  |OFFICER, FLAGMAN                  |
|2               |2                  |STOP/GO SIGNAL                    |
|3               |3                  |STOP SIGN                         |
|4               |4                  |FLASH RED LITE                    |
|5               |5                  |FLASH YEL LITE                    |
|6               |6                  |WARNING SIGN                      |
|7               |7                  |RR GATES OR SIG                   |
|8               |8                  |YIELD SIGN                        |
|9               |9                  |CENTER LINE                       |
*------------------------------------------------------------------------*

*------------------------------------------------------------------------*
|     FORMAT NAME: $CONT     LENGTH:   29   NUMBER OF VALUES:   12       |
|  MIN LENGTH:   4  MAX LENGTH:  40  DEFAULT LENGTH:  29  FUZZ: N/A      |
*------------------------------------------------------------------------*
|          START |               END | LABEL                            |
*------------------------------------------------------------------------*
|+               |+                  |OTHER TRAFFIC CONTROL             |
|-               |-                  |NO PASSING ZONE                   |
|0               |0                  |NONE OR INOPERATIVE               |
|1               |1                  |OFFICER, FLAGMAN, OR WATCHMAN     |
|2               |2                  |STOP/GO SIGNAL                    |
|3               |3                  |STOP SIGN                         |
|4               |4                  |FLASHING RED LIGHT                |
|5               |5                  |FLASHING YELLOW LIGHT             |
|6               |6                  |WARNING SIGN                      |
|7               |7                  |RR GATES OR SIGNAL                |
|8               |8                  |YIELD SIGN                        |
|9               |9                  |CENTER STRIPE OR DIVIDER          |
*------------------------------------------------------------------------*
```

Other Factors (Written in the boxes for Units 1 and 2—in no particular order)

Animal on Road – Domestic	1
Animal on Road – Wild	2
Backed Without Safety	3
Changed Lane When Unsafe	4
Defective or no Head Lamps	5
Defective or no Stop Lamps	6
Defective or no Tail Lamps	7
Defective or no Turn Signal Lamps	8
Defective or no Trailer Brakes	9
Defective or no Vehicle Brakes	10
Defective or no Steering Mechanism	11
Defective or Slick Tires	12
Defective Trailer Hitch	13
Disabled in Traffic Lane	14
Disregard Stop and Go Signal	15
Disregard Stop Sign or Light	16
Disregard Turn Marks at Intersection	17
Disregard Warning Sign at Construction	18
Distraction in Vehicle	19
Driver Inattention	20
Drove Without Headlight	21
Failed to Control Speed	22
Failed to Drive in Single Lane	23
Failed to Give Half of Roadway	24
Failed to Heed Warning Sign	25
Failed to Pass to Left Safely	26
Failed to Pass to Right Safely	27
Failed to Give Signal or Wrong Signal	28
Failed to Stop at Proper Place	29
Failed to Stop for School Bus	30
Failed to Stop for Train	31
Failed to Yield ROW – Emergency Vehicle	32
Failed to Yield ROW – Open Intersection	33
Failed to Yield ROW – Private Drive	34
Failed to Yield ROW – Stop Sign	35
Failed to Yield ROW – To Pedestrian	36
Failed to Yield ROW – Turning Left	37
Failed to Yield ROW – Turn on Red	38
Failed to Yield ROW – Yield Sign	39
Fatigued or Asleep	40
Faulty Evasive Action	41
Fire in Vehicle	42
Fleeing or Evading Police	43
Followed too Closely	44

Had Been Drinking	45
Handicapped Driver	46
Ill	47
Impaired Visibility	48
Improper Start from Parked Position	49
Load Not Secured	50
Opened Door into Traffic Lane	51
Oversize Vehicle or Load	52
Overtake and pass Insufficient Clearance	53
Parked and Failed to Set Brakes	54
Parked in Traffic Lane	55
Parked Without Lights	56
Passed in no Passing Zone	57
Passed on Right Shoulder	58
Ped/PedalCyc/MOT CONL FTYROW to Vehicle	59
Speeding Unsafe (Under Limit)	60
Speeding Over Limit	61
Taking Medication	62
Turned Improperly – Cut Corner on Left	63
Turned Improperly – Wide Right	64
Turned Improperly – Wrong Lane	65
Turned When Unsafe	66
Under Influence – Alcohol	67
Under Influence – Drug	68
Wrong Side – Approach or in Intersection	69
Wrong Side – Not Passing	70
Wrong Way – One Way Road	71
Cell/Mobile Phone Use	72
Road Rage	73
Other Factor (Write In)	74

Total Vehicles Involved

Use number of total vehicles involved, even after initial crash. Be careful of 18-wheelers; sometimes officers count them as two units.

SEVERITY,Column 29

```
SEVERITY  CHAR      1    SEVER15.
  SEVERITY

The highest degree of injury suffered in the accident:

1.  Incapacitating injury - not able to walk, drive, etc.(A)
2.  Nonincapacitating injury - bump on head, abrasions, minor
                              lacerations (B)
3.  Possible injury - limping, complaint of pain (C)
4.  Fatal (K)
5.  Non-injury
```

**On the same page as the diagram and other factors.

Number of Casualties
Total Number of People with Injury Code C, B, A, K (Total of “C” or greater)

Non-Injured
Total Number of Occupants with Injury Code = N

Possibly Injured
Total Number of Occupants with Injury Code = C

Non-Incapacitating Injuries
Total Number of Occupants with Injury Code = B

Incapacitating Injuries
Total Number of Occupants with Injury Code = A

Fatal
Total Number of Occupants with Injury Code = K
---------------- VARIABLES BELOW WERE CREATED BY THE RESEARCHERS-------------
Drugs
Operating Under the Influence (Specify alcohol, DWI, drugs, etc., if true; leave blank if false)

2-Way Related?
1 = Yes; 0 = No

Weather/Construction
Only when the officer’s written description or “Other Factors” clearly states one of these contributed to the crash: 0 = Weather related; 1 = Construction related (Leave blank otherwise)

Crash Type

1	Rear-end	4	Sideswipe
2	Angle crash	5	Right-angle crash
3	Head-on	6	Single vehicle ran off road

Vehicle Turning
For “T” intersections/driveway access points only. If a car was turning in/out, which way? 1 = Left; 2 = Right; 3 = Straight (like they were trying to cross to get to a ramp or something—won’t be used often, if at all); (Leave blank for non-T intersections or non-driveway access points).

In/Out Turning
For “T” intersections/driveway access points only: 1 = Turning into; 2 = Out of; (Leave blank otherwise).

The following pages are for the POSFROM1, P0SIMPCT, and DIR2VEH1 variables.

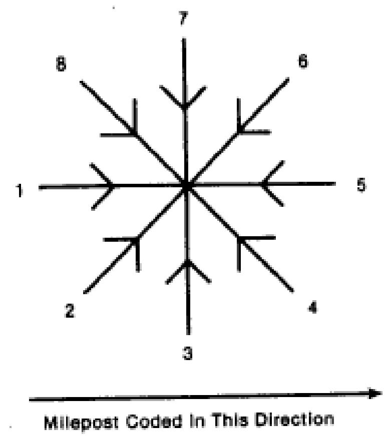
DIRECTION OF TRAVEL (A2 RECS),Columns 62-63

```
DIR2VEH1  CHAR      1    TRAVDIR16.
  DIRECTION OF TRAVEL, VEHICLE 1 (A2 RECS)

DIR2VEH2  CHAR      1    TRAVDIR16.
  DIRECTION OF TRAVEL, VEHICLE 2 (A2 RECS)
```

For accidents occurring in a city not participating in the Urban Project or accidents in rural areas (TYPECON = A2), the Direction of Travel will be in relation to the direction of milepoints (MILEDIR) and will show direction of actual movement of a moving vehicle or the direction headed in the case of a stopped vehicle. DIR2VEH1 is for the vehicle no. 1 and DIR2VEH2 is for the vehicle no. 2. For accidents occurring in a city participating in the Urban Project (TYPECON = A1), DIR2VEH1 and DIR2VEH2 will be stored as missing.

1. With Milepoint Direction
2. Right rear
3. Right
4. Opposite right
5. Opposite Milepoint Direction
6. Opposite left
7. Left
8. Left rear
9.
0. No second vehicle
+. Unknown direction



FORMAT NAME: $TRAVDIR	LENGTH: 16	NUMBER OF VALUES: 10
MIN LENGTH: 4 MAX LENGTH: 40	DEFAULT LENGTH: 16	FUZZ: N/A

START	END	LABEL
+	+	UNKNOWN DIR
0	0	NO 2ND VEHICLE
1	1	W/ MILEPOST DIR
2	2	RIGHT REAR
3	3	RIGHT
4	4	OPPOSITE RIGHT
5	5	OPP MILEPOST DIR
6	6	OPPOSITE LEFT
7	7	LEFT
8	8	LEFT REAR

POSITION PRIOR TO ACCIDENT, Columns 65-66 71-72 and
POSITION OF POINT OF IMPACT, Columns 68-69

```
POSFROM1  CHAR     2    POSITN2.
  VEHICLE 1 POSITION PRIOR TO ACCIDENT

POSFROM2  CHAR     2    POSITN2.
  VEHICLE 2 POSITION PRIOR TO ACCIDENT

POSIMPCT  CHAR     2    POSITN2.
  POSITION OF POINT OF IMPACT
```

For those accidents occurring in a city not participating in the Urban Project or accidents occurring in rural areas (TYPECON = A2), Vehicle Position Prior to Accident will be the position of the vehicle or vehicles immediately prior to the accident. POSFROM1 is for the vehicle no. 1 and POSFROM2 is for the vehicle no. 2. If no second vehicle was involved, POSFROM2 will be stored as missing. For accidents occurring in a city participating in the Urban Project (TYPECON = A1), POSFROM1 and POSFROM2 will be stored as missing.

For those accidents occurring in a city not participating in the Urban Project or accidents occurring in rural areas (TYPECON = A2), Position of Point of Impact will be the position of the first harmful event, stored in _1STHARM. For accidents occurring in a city participating in the Urban Project (TYPECON = A1), POSIMPCT will be stored as missing.

SHOULDERS & PARKING LANES

01. Outer shoulder or parking lane on Milepoint Left Frontage
02. Inner shoulder or parking lane on Milepoint Left Frontage
03. Outer shoulder or parking lane on Milepoint Left Main Lanes
04. Inner shoulder or parking lane on Milepoint Left Main Lanes
05. Inner shoulder or parking lane on Milepoint Right Main Lanes
06. Outer shoulder or parking lane on Milepoint Right Main Lanes
07. Inner shoulder or parking lane on Milepoint Right Frontage Road
08. Outer shoulder or parking lane on Milepoint Right Frontage Road
09. Center parking area

MAIN DRIVING LANES

10. 3rd or more lane on Milepoint Left
11. 2nd lane on Milepoint Left
12. 1st lane on Milepoint Left
13. Center stripe
14. Center lane of three lane road
15.
16. 1st lane on Milepoint Right
17. 2nd lane on Milepoint Right
18. 3rd or more lane on Milepoint Right

FRONTAGE ROAD DRIVING LANES

20. Outer driving lane on Milepoint Left Frontage Road
21. Center driving lane on Milepoint Left Frontage Road
22. Inner driving lane on Milepoint Left Frontage Road
23. Center stripe on Milepoint Left Frontage Road
24.
25.
26. Inner driving lane on Milepoint Right Frontage Road
27. Center driving lane on Milepoint Right Frontage Road
28. Outer driving lane on Milepoint Right Frontage Road
29. Center stripe on Milepoint Right Frontage Road

TURN SLOTS / RAMPS

30. Right turn slot or ramp to left main lane
31. Right turn slot or ramp from left main lane
32.
33. Left turn slot or ramp for traffic moving opposite to milepoint
34. Right turn slot or ramp to left frontage road
35. Right turn slot or ramp from left frontage road
36. Right turn slot or ramp to right main lanes
37. Right turn slot or ramp from right main lanes
38.
39. Left turn slot or ramp from traffic moving with milepoint
3-. Right turn slot or ramp to right frontage road
3+. Right turn slot or ramp from right frontage road

RAMPS AND OPENINGS IN MEDIANS

40. On Ramp to Left Main Lane - Regardless of length or origin
41. Off Ramp from Left Main Lane - Regardless of length or termination
42. Opening in median between Left Main Lanes and frontage road
43. Opening in median between Main Lanes
44.
45.
46. On Ramp to Right Main Lane - Regardless of length or origin
47. Off Ramp from Right Main Lane - Regardless of length or termination
48. Opening in median between Right Main Lane and frontage road
49.

CHANNELIZING ISLANDS

50. Channelizing island for 30 above
51. Channelizing island for 31 above
52. Channelizing island in Left Frontage Road
53. Channelizing island in 43 above
54. Channelizing island for 34 above
55. Channelizing island for 35 above
56. Channelizing island for 36 above
57. Channelizing island for 37 above
58. Channelizing island in Right Frontage Road
59.
5-. Channelizing island for 3- above
5+. Channelizing island for 3+ above

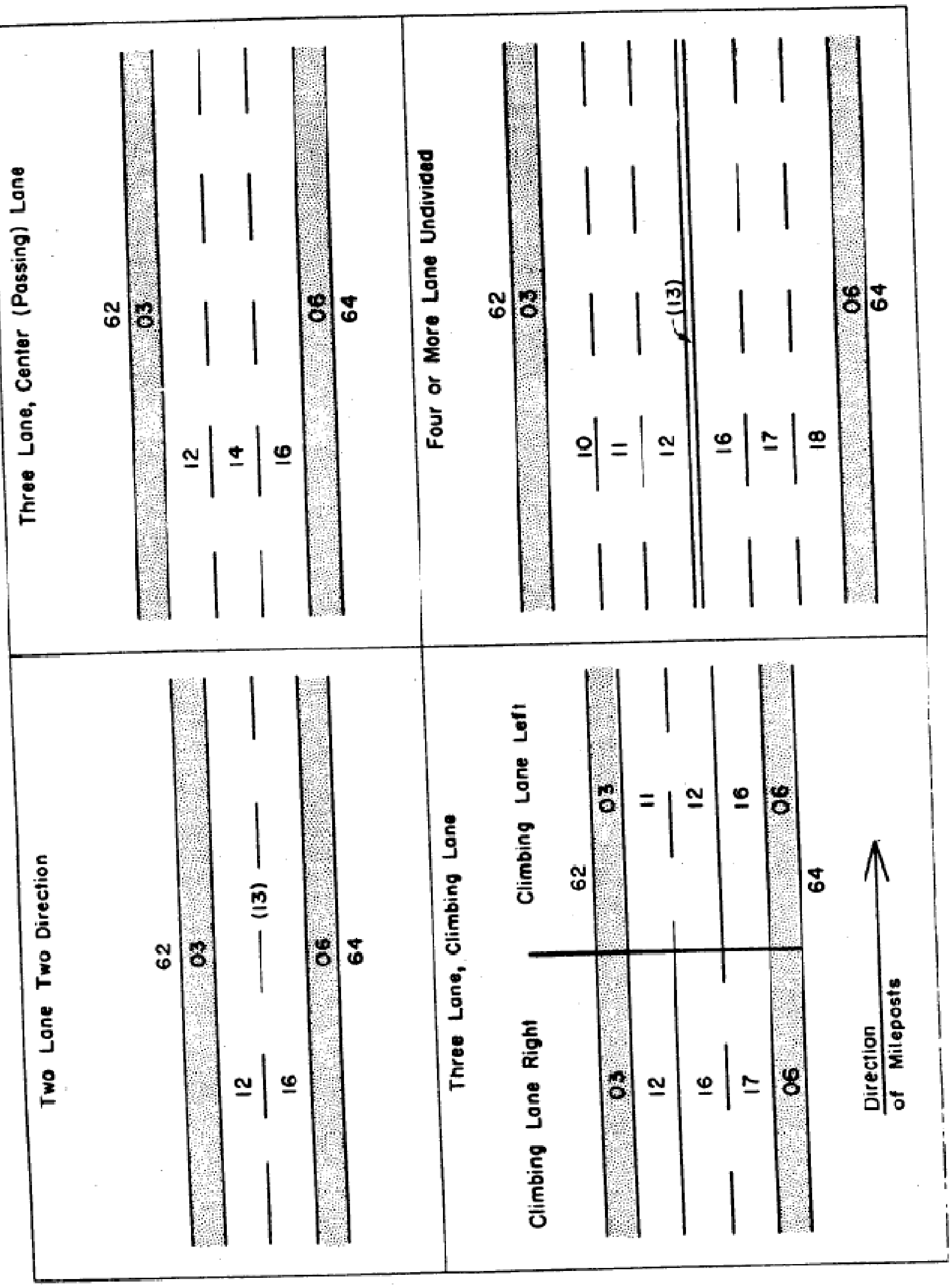
AREAS TO LEFT AND RIGHT

61. Area to left of Left Frontage Road
62. Area to left of Main Lanes
63. Area between Main Lanes
64. Area to right of Main Lanes
65. Area to right of Right Frontage Road
66. Attenuation device (normally between right main lanes and off ramp)

OTHER

70. Location shown in column 59
71. Location shown in column 60

TYPES OF ROADS



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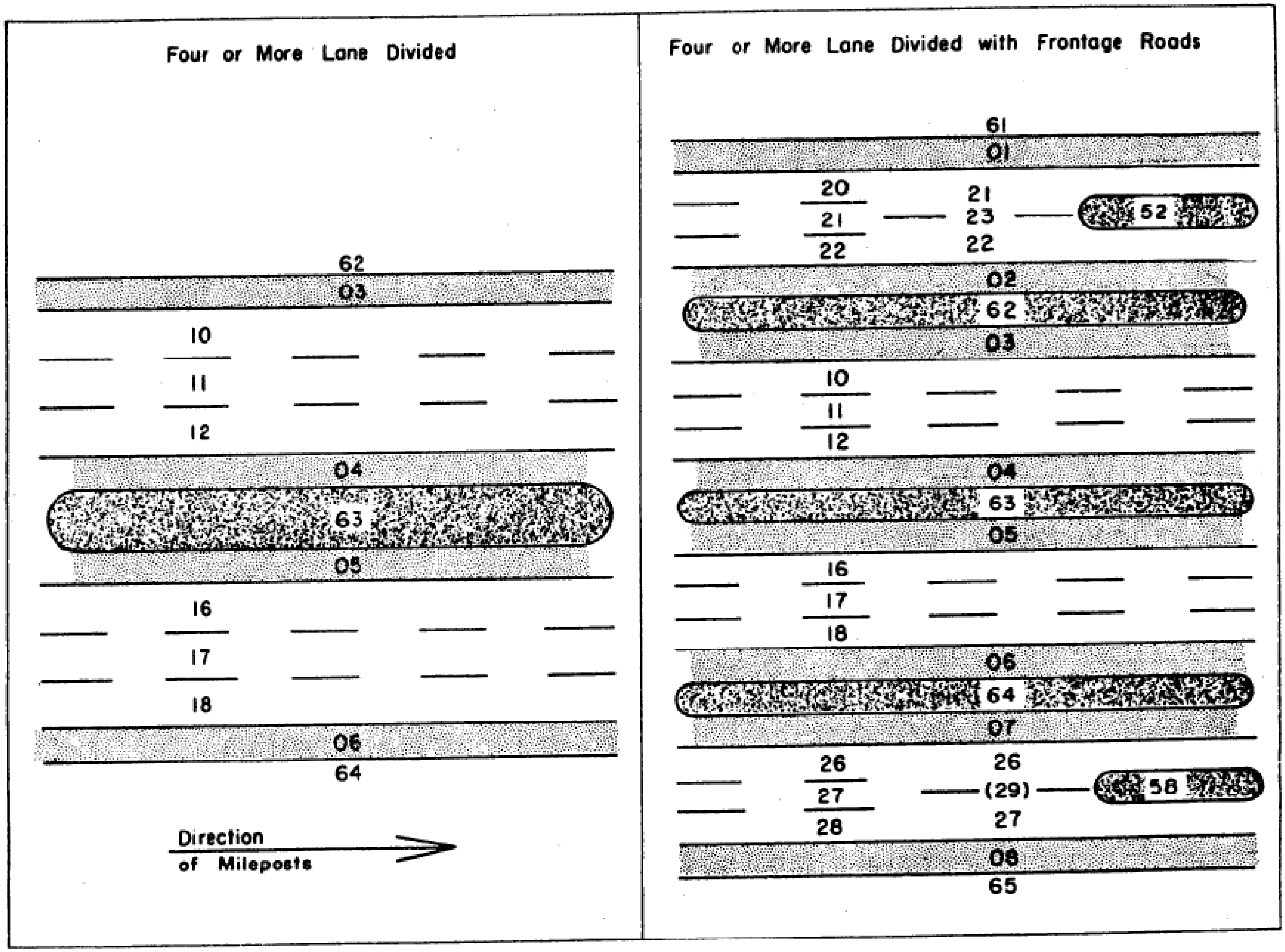
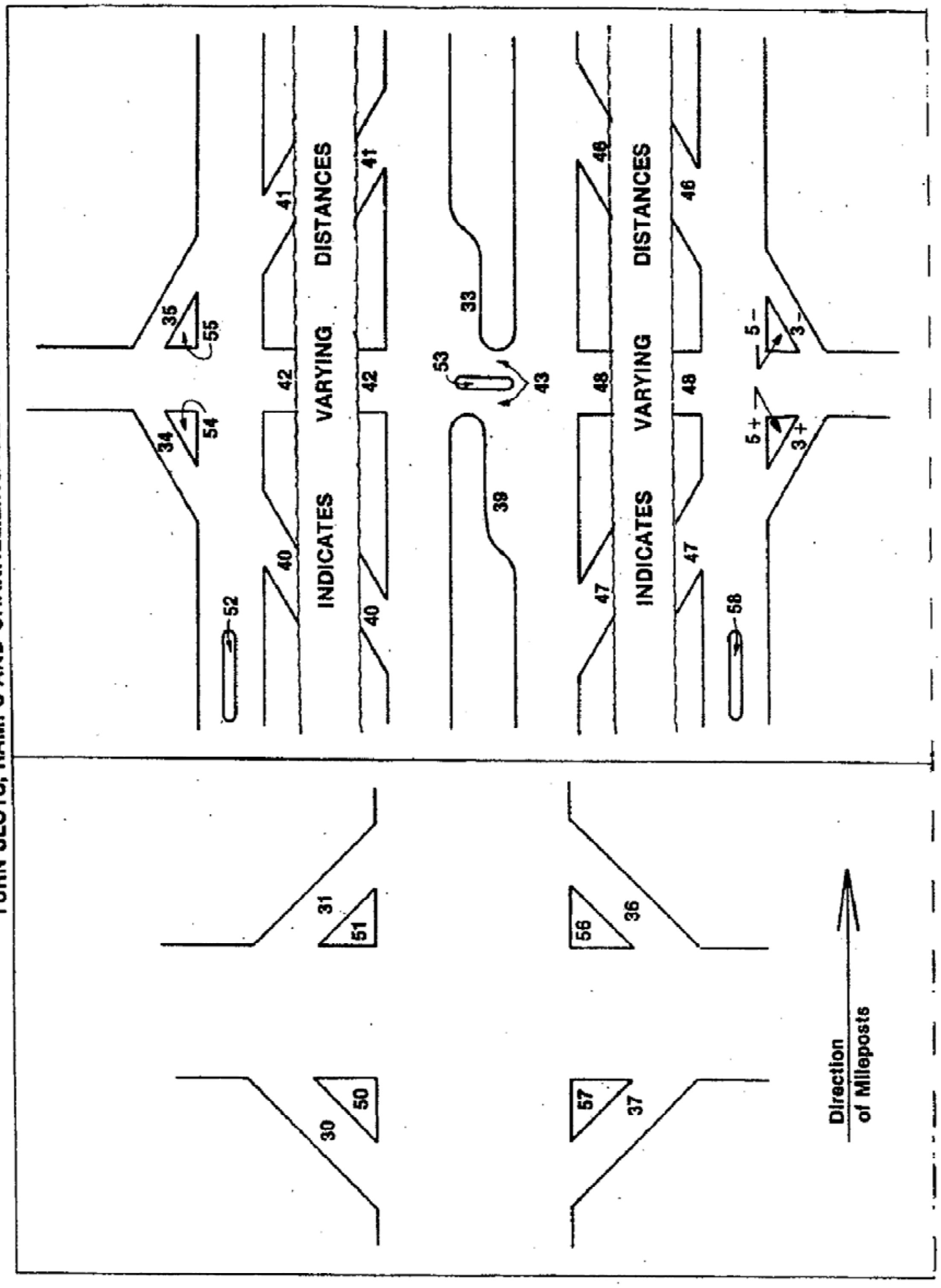
TYPES OF ROADS



TURN SLOTS, RAMPS AND CHANNELIZING ISLANDS



VEHICLE LOCATION PRIOR TO ACCIDENT,Columns 64 and 70

```
FROMVEH1  NUM      2    HWY15.
  VEHICLE 1 LOCATION PRIOR TO ACCIDENT

FROMVEH2  NUM      2    HWY15.
  VEHICLE 2 LOCATION PRIOR TO ACCIDENT
```

For those accidents occurring in a city not participating in the Urban Project or accidents occurring in rural areas (TYPECON = A2), Vehicle Location Prior to Accident will be the highway which the vehicle or vehicles were on immediately prior to the accident. FROMVEH1 is for the vehicle no. 1 and FROMVEH2 is for the vehicle no. 2. If no second vehicle was involved, FROMVEH2 will be stored as missing. For accidents occurring in a city participating in the Urban Project (TYPECON = A1), FROMVEH1 and FROMVEH2 will be stored as missing.

1. Highway no. 1
2. Highway no. 2
3. Highway no. 3
4. Connection
5. Detour
6. County road or city street

FORMAT NAME: HWY LENGTH: 15 NUMBER OF VALUES: 6		
MIN LENGTH: 4 MAX LENGTH: 40 DEFAULT LENGTH: 15 FUZZ: STD		
START	END	LABEL
1	1	HWY NO. 1
2	2	HWY NO. 2
3	3	HWY NO. 3
4	4	CONNECTION
5	5	DETOUR
6	6	CNTY RD,CITY ST

FORMAT NAME: HWY LENGTH: 23 NUMBER OF VALUES: 6		
MIN LENGTH: 4 MAX LENGTH: 40 DEFAULT LENGTH: 23 FUZZ: STD		
START	END	LABEL
1	1	HWY NO. 1
2	2	HWY NO. 2
3	3	HWY NO. 3
4	4	CONNECTION
5	5	DETOUR
6	6	COUNTY ROAD,CITY STREET

LOCATION OF POINT OF IMPACT,Column 67

IMPACT NUM 2 HWY15.
LOCATION OF POINT OF IMPACT

For those accidents occurring in a city not participating in the Urban Project or accidents occurring in rural areas (TYPECON = A2), Location of Point of Impact will be the highway which the first harmful event, stored in _1STHARM, occurred on. For accidents occurring in a city participating in the Urban Project (TYPECON = A1), IMPACT will be stored as missing.

1. Highway no. 1
2. Highway no. 2
3. Highway no. 3
4. Connection
5. Detour
6. County road or city street

FORMAT NAME: HWY LENGTH: 15 NUMBER OF VALUES: 6
MIN LENGTH: 4 MAX LENGTH: 40 DEFAULT LENGTH: 15 FUZZ: STD

START	END	LABEL
1	1	HWY NO. 1
2	2	HWY NO. 2
3	3	HWY NO. 3
4	4	CONNECTION
5	5	DETOUR
6	6	CNTY RD,CITY ST

FORMAT NAME: HWY LENGTH: 23 NUMBER OF VALUES: 6
MIN LENGTH: 4 MAX LENGTH: 40 DEFAULT LENGTH: 23 FUZZ: STD

START	END	LABEL
1	1	HWY NO. 1
2	2	HWY NO. 2
3	3	HWY NO. 3
4	4	CONNECTION
5	5	DETOUR
6	6	COUNTY ROAD,CITY STREET

APPENDIX C: CONTROL SECTION AND MILEPOINT INFORMATION

The table in this appendix provides the control section and milepoint information provided by the TxDOT Traffic Operations Division to identify the intersecting cross-street locations in both the DPS (1998–2001) and CRIS (2003–2007) datasets. In many cases, the milepoint values differ between the systems, and in some cases even the control sections differ.

County	Roadway	City (Area)	Cross Street	Control Section (DPS Data)	Cross-Street MP 1998–2001 (DPS Data)	Control Section (CRIS Data)	Cross-Street MP 2003–2007 (CRIS Data)
Tarrant	IH 35W	Burleson	McAllister Road	0014-02	2.3	0014-02	2.317
Tarrant	IH 35W	Burleson	Alsbury	0014-02	1.7	0014-02	1.716
Johnson	IH 35W	Burleson	Renfro/TX-50 Spur/FM 3391	0014-03	22.5	0014-03	22.480
Johnson	IH 35W	Burleson	Ricky Lane/County Road 601	0014-03	20.2	0014-03	20.193
Johnson	IH 35W	Burleson	Bethesda	0014-03	18.0	0014-03	17.920
Hopkins	IH 30	Sulphur Springs	State Loop 313/Business US 67	0009-09	11.2	0009-09	11.300
Hopkins	IH 30	Sulphur Springs	SH 19/Hillcrest Dr	0009-09	13.4	0009-09	13.501
Hopkins	IH 30	Sulphur Springs	League St/Arbala Rd	0009-09	14.7	0009-09	14.774
Hopkins	IH 30	Sulphur Springs	SH 11/SH 154/Broadway	0010-02	15.6	0010-02	15.723
Hopkins	IH 30	Sulphur Springs	Radio Rd/Bill Bradford/County Rd 2307	0010-02	16.4	0010-02	16.441
Hopkins	IH 30	Sulphur Springs	FM 1870/College St	0010-02	17.7	0010-02	17.686
Hopkins	IH 30	Sulphur Springs	State Loop 301/ Business US 67	0010-02	18.4	0010-02	18.263
Hopkins	IH 30	Sulphur Springs	County Road 3451	0010-02	20.7	0010-02	20.621
Hunt	IH 30	Greenville	County Road 2124/County Road 2122	0009-13	12.8	0009-13	12.554
Hunt	IH 30	Greenville	SH 34/Wesley St	0009-13	13.9	0009-13	13.612
Hunt	IH 30	Greenville	Joe Ramsey Blvd/US 69	0009-13	15.4	0009-13	15.020
Hunt	IH 30	Greenville	Moulton/Business US 69	0009-13	15.7	0009-13	15.298
Hunt	IH 30	Greenville	Division Street	0009-13	16.6	0009-13	16.199
Hunt	IH 30	Greenville	Lee Street/Business US 67	0009-13	17.5	0009-13	17.056
Hill	IH 35	Hillsboro	N Waco Street/Spur 579/US 77	0014-24	15.0 – 15.1	0014-24	14.995
Hill	IH 35	Hillsboro	FM 286/Old Brandon Road	0014-24	13.2	0014-24	13.145

County	Roadway	City (Area)	Cross Street	Control Section (DPS Data)	Cross-Street MP 1998–2001 (DPS Data)	Control Section (CRIS Data)	Cross-Street MP 2003–2007 (CRIS Data)
Hill	IH 35	Hillsboro	SH 171/SH 22/Corsicana Highway	0014-24	12.6	0014-24	12.577
Hill	IH 35	Hillsboro	FM 3267/Old Bynum Road	0014-24	11.9	0014-24	11.898
Hill	IH 35	West	County Road 3102 W	0014-07	1.1	0014-07	1.036
Hill/ McLennan	IH 35	West	Russels Branch/East County Line Road E	0014-07	0.0	0014-07	0.000
McLennan	IH 35	West	Marable St	0014-08	9.1	0014-08	9.094
McLennan	IH 35	West	FM 2114/TM West Pkwy/W Oak St	0014-08	8.0	0014-08	8.062
McLennan	IH 35	West	FM 1858/Tokio Rd	0014-08	6.9	0014-08	6.910
McLennan	IH 35	West	Wiggins Road	0014-08	4.5	0014-08	4.606
McLennan	IH 35	West	FM 3149/Tours Road	0014-08	2.8	0014-08	2.897
Walker	IH 45	Huntsville	FM 1696/Pinedale Rd	0675-06	22.3	0675-06	22.008
Walker	IH 45	Huntsville	FM 1791	0675-06	17.7	0675-06	17.289
Walker	IH 45	Huntsville	Veterans Memorial Parkway (WFR intersection)	0675-06	16.5	0675-06	16.255
Walker	IH 45	Huntsville	SH 30/11th St/US 190	0675-06	16.0	0675-07	15.521
Walker	IH 45	Huntsville	Smither Dr/Avenue S	0675-07	15.0	0675-07	14.383
Walker	IH 45	Huntsville	FM 1374/Montgomery Rd	0675-07	14.1	0675-07	13.647
Walker	IH 45	Huntsville	SH 19	0675-07	12.3	0675-07	11.708
Walker	IH 45	Huntsville	Crossover at SH 75 and Veterans Memorial Parkway	0675-07	11.7	0675-07	11.212
Walker	IH 45	Huntsville	Park Road 40 (at WFR)	0675-07	9.1 & 9.2	0675-07	8.680
Lubbock	US 62/US 82	Wolfforth	FM 1585/114th St	0380-01	3.5	0380-01	3.482
Lubbock	US 62/US 82	Wolfforth	County Road 1300/Loop 193/Main Street	0380-01	4.7	0380-01	4.591
Lubbock	US 62/US 82	Wolfforth	FM 179/Dowden Ave	0380-01	5.7	0380-01	5.654

County	Roadway	City (Area)	Cross Street	Control Section (DPS Data)	Cross-Street MP 1998–2001 (DPS Data)	Control Section (CRIS Data)	Cross-Street MP 2003–2007 (CRIS Data)
Lubbock	US 62/US 82	Wolfforth	82nd Street	0380-01	7.2	0380-01	7.063
Lubbock	US 62/US 82	Wolfforth	66th Street	0380-01	8.9	0380-01	8.717
Hale	IH 27	Plainview	FM 3183	0067-04	33.1	0067-04	33.689
Hale	IH 27	Plainview	County Road 60	0067-04	32.0	0067-04	32.192
Hale	IH 27	Plainview	North Business US 27/Columbia Street	0067-04	31.8 & 32.3	0067-04	32.142
Hale	IH 27	Plainview	FM 194/Dimmitt Rd	0067-04	29.8	0067-04	29.828
Hale	IH 27	Plainview	US 70/Olton Rd	0067-04	28.0	0067-04	27.918
Hale	IH 27	Plainview	FM 3466/SW 3rd St	0067-05	27.1	0067-05	27.117
Hale	IH 27	Plainview	South Business US 27	0067-05	24.2	0067-05	23.775
Hale	IH 27	Plainview	County Road-T (CR-T)/FM 2337	0067-05	22.6 & 22.7	0067-05	22.694

APPENDIX D:
CRASH DATA DISCREPANCIES

DISCREPANCIES IDENTIFIED WITH TXDOT CRASH RECORDS

Researchers received electronic and printed crash records for several years to be analyzed for this project. Electronic crash records were available for the years 1998–2001 and 2005–2007 initially, and 2003–2004 were added later in the project per the project modification. Printed crash records were available for the years 2001–2007, but the year 2002 was omitted from analysis per TxDOT instruction.

Researchers encountered several discrepancies while working with these crash records, as discussed in further detail below. These discrepancies are documented in this appendix to provide awareness to those performing future crash analyses.

ROADPART Coding

One variable in the electronic crash records is called ROADPART, which means the part or type of roadway where the crash occurred. Researchers often found that the ROADPART field was incorrectly entered when comparing crash reports with the electronic dataset. Researchers originally began with the entire file of electronic records and then reduced the data into a smaller file consisting of the records relevant to this study (in particular, ROADPART = 2 for frontage roads). For three selected case study locations, researchers found that there was an average of approximately 36 percent that were miscoded from 2005–2007. In other words, the printed report stated that the crash took place on a frontage road (ROADPART should equal 2), but the electronic record from the original main file indicated the ROADPART was equal to 1 (mainlane), meaning that it had been overlooked in the first sorting step where researchers only retrieved ROADPARTs equal to 2.

Table D-1 shows the results of this analysis along the three selected sites, as well as the city name, the year, the fraction of miscoded ROADPART crashes to total crashes, and the percentages of miscoded ROADPART crashes. If researchers had not had printed reports, a couple of fatalities would have been missed as a result of the discrepancies. Researchers did not identify the miscoding problem in 2001 (see Table D-1).

Table D-1. Investigation of Miscoded Electronic Data.

Greenville				Sulphur Springs				Wolfforth			
DPS Data	*CRIS Data*			*DPS Data*	*CRIS Data*			*DPS Data*	*CRIS Data*		
2001	2005	2006	2007	2001	2005	2006	2007	2001	2005	2006	2007
0 of 40 0%	19 of 50 38%	10 of 41 24%	12 of 38 32%	0 of 22 0%	19 of 22 86%	6 of 21 29%	7 of 28 25%	0 of 5 0%	1 of 1 100%	0 of 1 0%	0 of 3 0%
Total:	41 of 129 = 32% (2005–2007)			Total:	32 of 71 = 45% (2005–2007)			Total:	1 of 5 = 20% (2005–2007)		
Total:	74 of 205 = 36% (across three sites from 2005–2007)										

Notes: Numbers above indicate the number/percent of crashes coded in the electronic database as mainlanes that should have been coded as frontage roads. This is a comparison of those years/crashes when both the electronic and printed datasets are available.

There are three possibilities that may explain the ROADPART variable discrepancies. The first case may be due to which street is listed first on the crash report. To clarify, the printed reports have two lines that can be filled out—"Road on which accident occurred" and "Intersecting street"—and both are filled out if the crash took place at an intersection. Sometimes the report would have the cross street (non-frontage road) listed as the "Road on which accident occurred," but the crash description and diagram would show the crash to have actually taken place on the frontage road. This was one case where researchers would observe the ROADPART coded as a 1 for mainlane (if the cross street is a highway) instead of a 2 (for frontage road). Second, in some cases, there was a pure miscode, meaning that the frontage road was listed as the "Road on which accident occurred," but the electronic record variable ROADPART was erroneously coded as a 1 instead of a 2. This occurred less often.

Third, there may be some confusion about the variable itself. The description for how to code ROADPART (see Figure D-1) does mention coding the "highest priority" road as the ROADPART, but there is some confusion about whether the highest priority means the roadway that was most involved in the crash or the more important type of roadway at the intersection, regardless of its involvement in the crash. For instance, if a crash occurs at the intersection of a state highway and an interstate frontage road, and the crash physically occurs on the frontage road, how should those coding the crashes interpret the term "highest priority?" For this work, the research team called the roadway most involved, meaning the roadway on which the crash physically occurred, as the higher priority.

```
PART OF ROADWAY No. 1, INVOLVED,Column 56

    ROADPART  CHAR     1    ROADPART13.
      PART OF ROADWAY 1 INVOLVED

    Part of Roadway will be the highest priority part of the
    roadway involved in the accident.

    1.  Main Lane                      6.  Detour
    2.  Frontage road                  7.  Other
    3.  Entrance ramp                  8.
    4.  Exit ramp                      9.
    5.  Connection                     +.  Unknown
```

Figure D-1. Description of How to Code the Variable "ROADPART."

Fields Left Blank

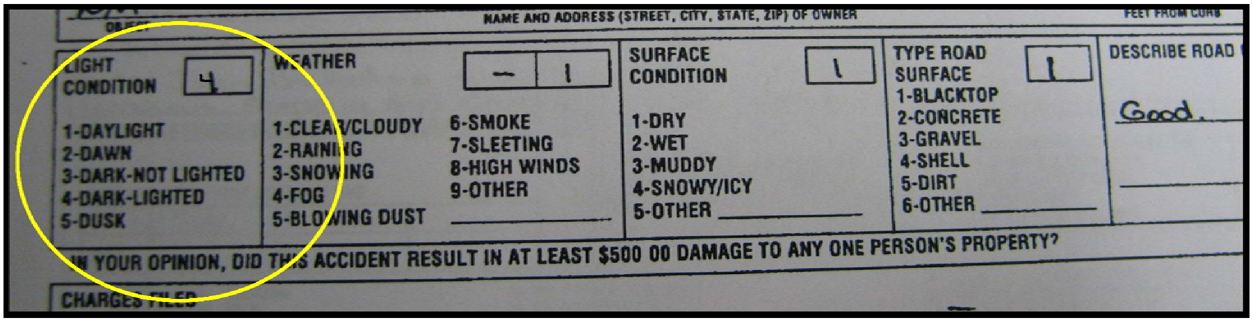
Researchers noticed that some fields for the years 2005–2007 were left blank (see Figure D-2) in the electronic records for the variables ROAD_CON (road condition), INVEST (investigating party), INTERRD (intersection road type), and NUMCAS (number of casualties). Researchers filled in these fields for crashes when printed reports were available but were unable to fill them in for the electronic-only records (i.e., no crash report was available). The variable NUMCAS (number of casualties) refers to the number of occupants/drivers that had an injury of "C" (possible injury) or greater, in other words, the sum of the number of people who were anything other than "not injured."

Source	ACC_YR	ROAD_CON	INVEST	ROADWAY	INTRSECT	INTERRD	ENTERRD	TOTALVEH	SEVERITY	NUMCAS	NONINJ	POSSINJ	NONINC	INCINJ	FATAL
Electronic	2005	0		1	4		0	2	2		1	0	2	0	0
Electronic	2005	0		2	4		0	1	3		0	1	0	0	0
Electronic	2005	0		5	2		0	2	3		1	1	0	0	0
Electronic	2005	0		1	2		2	2	3		1	1	0	0	0
Electronic	2006		3	1	1		4	2	2		1	0	1	0	0
Electronic	2006		3	2	2		0	2	3		1	1	0	0	0
Electronic	2006		3	2	4		0	1	1		0	0	0	1	0
Electronic	2006		5	1	4		0	2	5		1	0	0	0	0
Electronic	2006		5	2	4		0	2	5		1	0	0	0	0
Electronic	2006		5	2	4		0	2	5		2	0	0	0	0
Electronic	2007		3	2	3		0	2	3		2	1	0	0	0
Electronic	2007		5	1	4		0	2	1		2	0	1	1	0
Electronic	2007		5	2	2		4	2	5		1	0	0	0	0
Electronic	2007		5	1	2		2	2	5		2	0	0	0	0
Electronic	2007		5	1	2		3	2	5		4	0	0	0	0
Electronic	2007		5	1	4		0	3	2		0	0	1	0	0

Figure D-2. Example from City of Greenville Showing Blank Fields in Electronic Data.

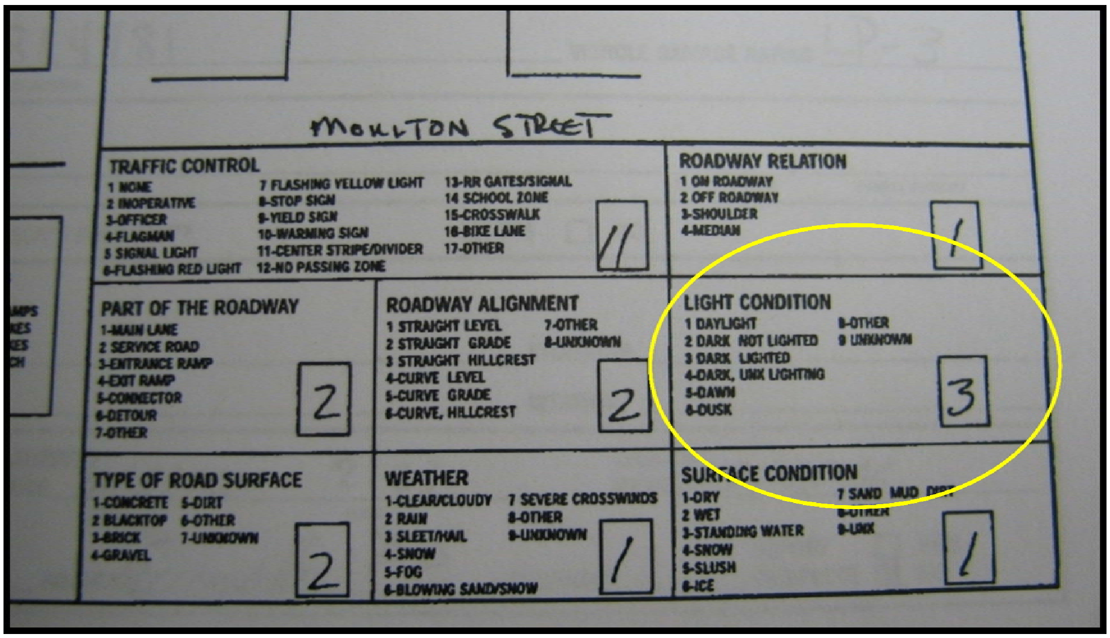
Crash Report Format Changes

The reports changed format between 2005 and 2006, also changing the numbering code for variables LIGHT, WEATHER, SURF_CON (surface condition), TRAF_CON (traffic control), 1STHARM (1st harmful event), and OBJECT. For example, for the variable LIGHT, what was coded as a 4 (dark-lighted) in the 2001–2005 reports became a 3 in the 2006–2007 reports (see Figures D-3 and D-4).



NAME AND ADDRESS (STREET, CITY, STATE, ZIP) OF OWNER
FEET FROM CURB
LIGHT CONDITION 4
1-DAYLIGHT
2-DAWN
3-DARK-NOT LIGHTED
4-DARK-LIGHTED
5-DUSK
WEATHER – 1
1-CLEAR/CLOUDY
2-RAINING
3-SNOWING
4-FOG
5-BLOWING DUST
6-SMOKE
7-SLEETING
8-HIGH WINDS
9-OTHER
SURFACE CONDITION 1
1-DRY
2-WET
3-MUDDY
4-SNOWY/ICY
5-OTHER
TYPE ROAD SURFACE 1
1-BLACKTOP
2-CONCRETE
3-GRAVEL
4-SHELL
5-DIRT
6-OTHER
DESCRIBE ROAD
Good.
IN YOUR OPINION, DID THIS ACCIDENT RESULT IN AT LEAST $500 00 DAMAGE TO ANY ONE PERSON'S PROPERTY?
CHARGES FILED

Figure D-3. Example of Older Crash Report Format, Years 2001–2005.



MOULTON STREET
TRAFFIC CONTROL
1 NONE
2 INOPERATIVE
3-OFFICER
4-FLAGMAN
5 SIGNAL LIGHT
6-FLASHING RED LIGHT
7 FLASHING YELLOW LIGHT
8-STOP SIGN
9-YIELD SIGN
10-WARNING SIGN
11-CENTER STRIPE/DIVIDER
12-NO PASSING ZONE
13-RR GATES/SIGNAL
14 SCHOOL ZONE
15-CROSSWALK
16-BIKE LANE
17-OTHER
11
ROADWAY RELATION
1 ON ROADWAY
2 OFF ROADWAY
3-SHOULDER
4-MEDIAN
1
PART OF THE ROADWAY
1-MAIN LANE
2 SERVICE ROAD
3-ENTRANCE RAMP
4-EXIT RAMP
5-CONNECTOR
6-DETOUR
7-OTHER
2
ROADWAY ALIGNMENT
1 STRAIGHT LEVEL
2 STRAIGHT GRADE
3 STRAIGHT HILLCREST
4-CURVE LEVEL
5-CURVE GRADE
6-CURVE, HILLCREST
7-OTHER
8-UNKNOWN
2
LIGHT CONDITION
1 DAYLIGHT
2 DARK NOT LIGHTED
3 DARK LIGHTED
4-DARK, UNK LIGHTING
5-DAWN
6-DUSK
8-OTHER
9 UNKNOWN
3
TYPE OF ROAD SURFACE
1-CONCRETE
2 BLACKTOP
3-BRICK
4-GRAVEL
5-DIRT
6-OTHER
7-UNKNOWN
2
WEATHER
1-CLEAR/CLOUDY
2 RAIN
3 SLEET/HAIL
4-SNOW
5-FOG
6-BLOWING SAND/SNOW
7 SEVERE CROSSWINDS
8-OTHER
9-UNKNOWN
1
SURFACE CONDITION
1-DRY
2 WET
3-STANDING WATER
4-SNOW
5-SLUSH
6-ICE
7 SAND MUD DIRT
8-OTHER
9-UNK
1

Figure D-4. Example of New Crash Report Format, Years 2006–2007.

Time Variable Inaccuracies

There were infrequent electronic files that had the incorrect TIME variable (the hour the crash occurred) entered. Usually, it was off by one hour. Researchers simply wrote over the electronic record entry if it was incorrect, but this did not occur very often.

Change in the Way Crash Records Are Identified

One particular issue that arose during the comparison of crash data was the apparent change in the way crash records were identified. Through at least 2001, each crash record was given a distinct seven-digit identifying number, the first digit of which was the last digit of the year in which the crash occurred (e.g., all of the 1998 crashes have a crash number that begins with 8). This seven-digit number is called ACC_NO (i.e., accident number) in the DPS database and is simply called DPS NO or crash number on the printed records. The DPS crash number is noted in the DPS NO box in the right margin of the upper portion of the first page of each printed record (see Figure D-5).

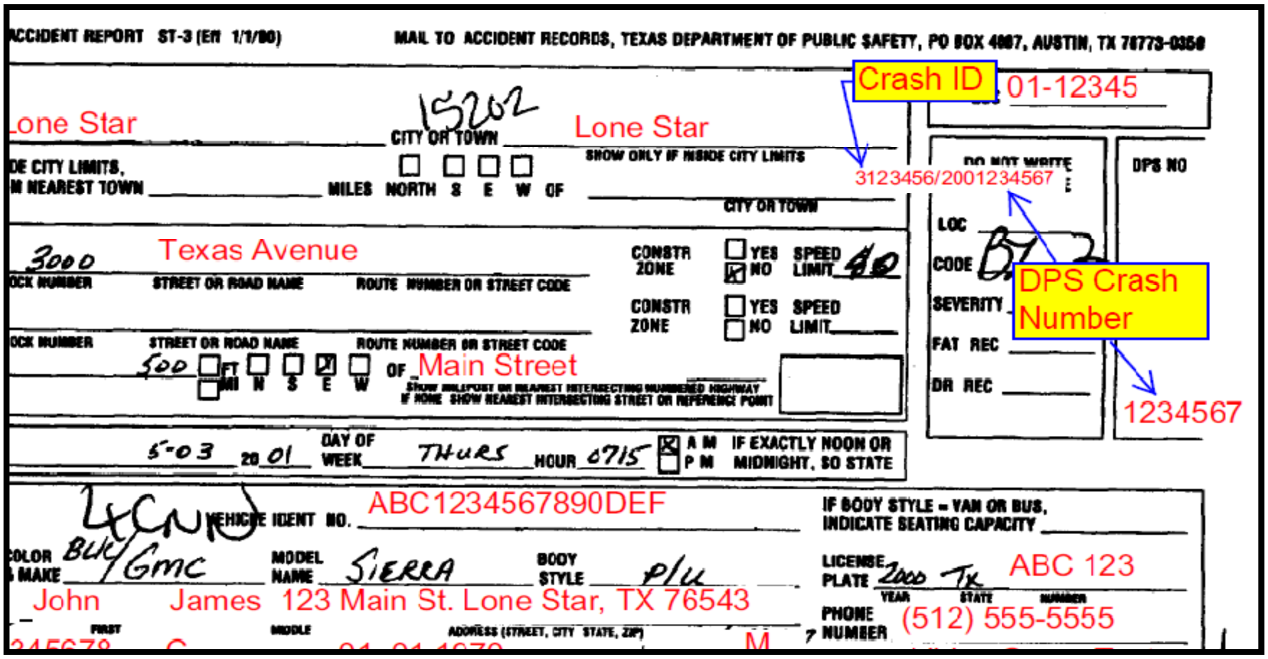


Figure D-5. Crash Identifiers Used in Printed Crash Reports.

However, sometime after 2001, a new numbering system that has run concurrently with the DPS numbering system was apparently instituted. This new system uses a separate seven-digit number called a crash ID. Researchers could not identify a pattern between these numbers. On the printed records, it appears that the crash number and crash ID have been retroactively reapplied on the form, as there is no blank or line designated for recording the crash ID. As shown in Figure D-6, the new designator is a seven-digit number corresponding to the crash ID, followed by a 10-digit crash number (apparently expanded to include all four digits of the year) and separated by a slash.

The printed crash records obtained by the research team were bundled and were summarized in cover letters that listed the crash number, crash ID, county, and crash date within the bundle. There was a preference by the research team to use only the crash number for identification because it is the only identifier given in the electronic database, and it is provided in the printed records as well. However, as described in the next section, an issue was that the crash number was absent from some of the later printed records, which showed only the crash ID.

Crash Number Missing on Reports

The ACC_NO (crash number) did not always appear on the printed crash reports; sometimes only the crash ID would appear, so researchers would have to locate a cover-page packet to then get the ACC_NO to find the associated electronic crash record for that particular printed report (see Figures D-6 through D-8). Furthermore, on printed reports for 2003 and on, sometimes a stamped number with the same number of digits as the crash number would appear on the upper right-hand side (see Figure D-7). This stamped number did not match the crash number assigned to the crash ID on the cover page.

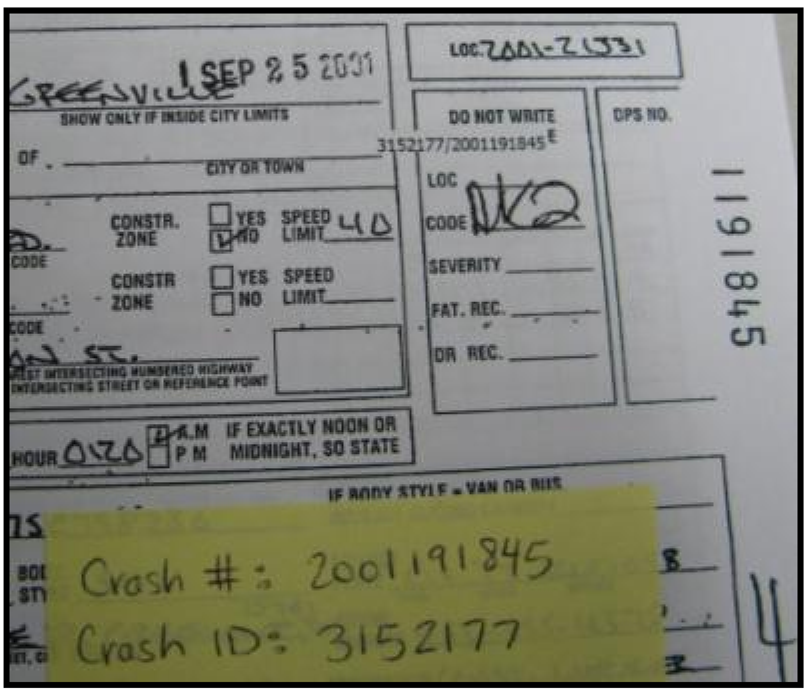


Figure D-6. Printed Report That Shows Both ACC_NO (Crash Number) and Crash ID.

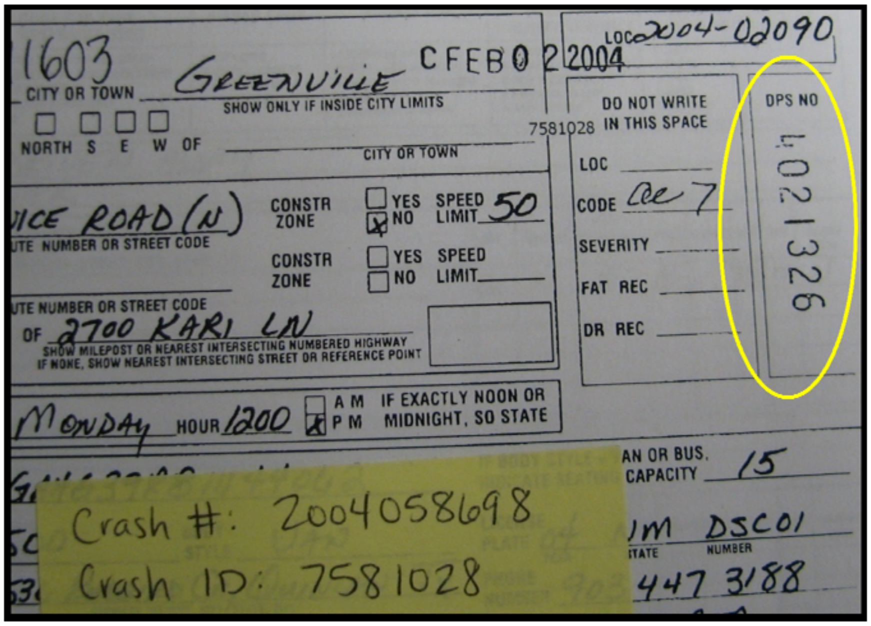
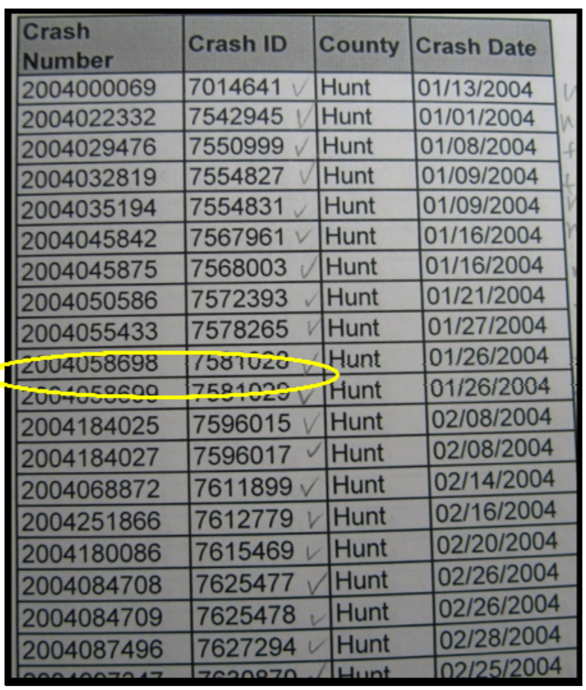


Figure D-7. Printed Report That Does Not Show ACC_NO (Crash Number), Only Crash ID.



Crash Number	Crash ID	County	Crash Date
2004000069	7014641	Hunt	01/13/2004
2004022332	7542945	Hunt	01/01/2004
2004029476	7550999	Hunt	01/08/2004
2004032819	7554827	Hunt	01/09/2004
2004035194	7554831	Hunt	01/09/2004
2004045842	7567961	Hunt	01/16/2004
2004045875	7568003	Hunt	01/16/2004
2004050586	7572393	Hunt	01/21/2004
2004055433	7578265	Hunt	01/27/2004
2004058698	7581028	Hunt	01/26/2004
2004058699	7581029	Hunt	01/26/2004
2004184025	7596015	Hunt	02/08/2004
2004184027	7596017	Hunt	02/08/2004
2004068872	7611899	Hunt	02/14/2004
2004251866	7612779	Hunt	02/16/2004
2004180086	7615469	Hunt	02/20/2004
2004084708	7625477	Hunt	02/26/2004
2004084709	7625478	Hunt	02/26/2004
2004087496	7627294	Hunt	02/28/2004
[illegible]	[illegible]	Hunt	02/25/2004

Figure D-8. Cover-Page Packet That Matches Crash ID to ACC_NO (Crash Number).

Changes in CNTYCITY Variable

The CNTYCITY numbers sometimes changed between years in the electronic records for the same city and same control section (CONTSEC1). The cause of this change is not clear (see Figure D-9).

Source	ACC_NO	CNTYCITY	CONTSEC1	ACC_YR
Printed	4456310	11603	0009-13	2004
Printed	4464865	11603	0009-13	2004
Printed	4488372	11603	0009-13	2004
Printed	4502828	11603	0009-13	2004
Printed	4518634	11603	0009-13	2004
Printed	4558148	11603	0009-13	2004
Both	2005018115	180	0009-13	2005
Both	2005018116	180	0009-13	2005
Both	2005019020	180	0009-13	2005
Both	2005021941	180	0009-13	2005
Both	2005034671	180	0009-13	2005
Both	2005036124	180	0009-13	2005
Both	2005045313	180	0009-13	2005

Figure D-9. Example from City of Greenville Showing Change in CNTYCITY from 2004 to 2005.

APPENDIX E:
ANALYSIS UNIT MAPS

This appendix contains maps showing the analysis units along all case study corridors. Corridors are shown from north to south or from west to east.

For the Burleson site, after determining the analysis unit numbers, researchers discovered that the entire corridor was not converted in 2004 but rather only the segment from Alsbury south to Ricky Lane. This is why there is a disconnect in the analysis unit numbers shown in this appendix—only the relevant analysis unit values remain.

Sulphur Springs

Figure E-1. Sulphur Springs, Analysis Unit Map 1 of 7.
(Source: ©2009 Google Maps)

Figure E-2. Sulphur Springs, Analysis Unit Map 2 of 7.
(Source: ©2009 Google Maps)

Figure E-3. Sulphur Springs, Analysis Unit Map 3 of 7. (Source: ©2009 Google Maps)

Figure E-4. Sulphur Springs, Analysis Unit Map 4 of 7. (Source: ©2009 Google Maps)

Figure E-5. Sulphur Springs, Analysis Unit Map 5 of 7. (Source: ©2009 Google Maps)

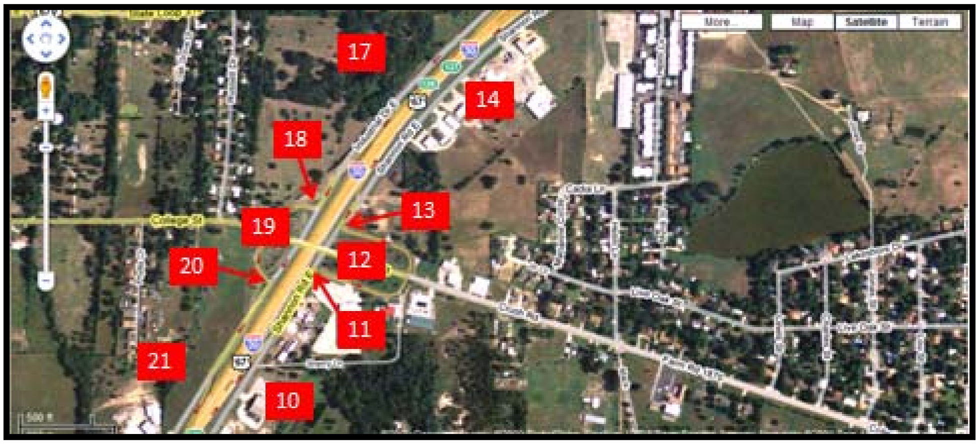


Figure E-6. Sulphur Springs, Analysis Unit Map 6 of 7.
(Source: ©2009 Google Maps)

Figure E-7. Sulphur Springs, Analysis Unit Map 7 of 7.
(Source: ©2009 Google Maps)

Greenville

Figure E-8. Greenville, Analysis Unit Map 1 of 6.
(Source: ©2009 Google Maps)

Figure E-9. Greenville, Analysis Unit Map 2 of 6.
(Source: ©2009 Google Maps)

Figure E-10. Greenville, Analysis Unit Map 3 of 6.
(Source: ©2009 Google Maps)

Figure E-11. Greenville, Analysis Unit Map 4 of 6.
(Source: ©2009 Google Maps)

Figure E-12. Greenville, Analysis Unit Map 5 of 6.
(Source: ©2009 Google Maps)

Figure E-13. Greenville, Analysis Unit Map 6 of 6.
(Source: ©2009 Google Maps)

Huntsville (Conversion Site)

Figure E-14. Huntsville (Conversion Site), Analysis Unit Map 1 of 5.
(Source: ©2009 Google Maps)

Figure E-15. Huntsville (Conversion Site), Analysis Unit Map 2 of 5. (Source: ©2009 Google Maps)

Figure E-16. Huntsville (Conversion Site), Analysis Unit Map 3 of 5. (Source: ©2009 Google Maps)

Figure E-17. Huntsville (Conversion Site), Analysis Unit Map 4 of 5. (Source: ©2009 Google Maps)

Figure E-18. Huntsville (Conversion Site), Analysis Unit Map 5 of 5. (Source: ©2009 Google Maps)

Huntsville (Comparison Site)

Figure E-19. Huntsville (Comparison Site), Analysis Unit Map 1 of 10. (Source: ©2009 Google Maps)

Figure E-20. Huntsville (Comparison Site), Analysis Unit Map 2 of 10. (Source: ©2009 Google Maps)

Figure E-21. Huntsville (Comparison Site), Analysis Unit Map 3 of 10. (Source: ©2009 Google Maps)

Figure E-22. Huntsville (Comparison Site), Analysis Unit Map 4 of 10. (Source: ©2009 Google Maps)

Figure E-23. Huntsville (Comparison Site), Analysis Unit Map 5 of 10. (Source: ©2009 Google Maps)

Figure E-24. Huntsville (Comparison Site), Analysis Unit Map 6 of 10. (Source: ©2009 Google Maps)

Figure E-25. Huntsville (Comparison Site), Analysis Unit Map 7 of 10. (Source: ©2009 Google Maps)

Figure E-26. Huntsville (Comparison Site), Analysis Unit Map 8 of 10. (Source: ©2009 Google Maps)

Figure E-27. Huntsville (Comparison Site), Analysis Unit Map 9 of 10.
(Source: ©2009 Google Maps)

Figure E-28. Huntsville (Comparison Site), Analysis Unit Map 10 of 10.
(Source: ©2009 Google Maps)

Wolfforth

Figure E-29. Wolfforth, Analysis Unit Map 1 of 4.
(Source: ©2009 Google Maps)

Figure E-30. Wolfforth, Analysis Unit Map 2 of 4.
(Source: ©2009 Google Maps)

Figure E-31. Wolfforth, Analysis Unit Map 3 of 4.
(Source: ©2009 Google Maps)

Figure E-32. Wolfforth, Analysis Unit Map 4 of 4.
(Source: ©2009 Google Maps)

Plainview

Figure E-33. Plainview, Analysis Unit Map 1 of 8. (Source: ©2009 Google Maps)

Figure E-34. Plainview, Analysis Unit Map 2 of 8. (Source: ©2009 Google Maps)

Figure E-35. Plainview, Analysis Unit Map 3 of 8. (Source: ©2009 Google Maps)

Figure E-36. Plainview, Analysis Unit Map 4 of 8.
(Source: ©2009 Google Maps)

Figure E-37. Plainview, Analysis Unit Map 5 of 8.
(Source: ©2009 Google Maps)

Figure E-38. Plainview, Analysis Unit Map 6 of 8.
(Source: ©2009 Google Maps)

Figure E-39. Plainview, Analysis Unit Map 7 of 8.
(Source: ©2009 Google Maps)

Figure E-40. Plainview, Analysis Unit Map 8 of 8.
(Source: ©2009 Google Maps)

Hillsboro

Figure E-41. Hillsboro, Analysis Unit Map 1 of 1.
(Source: ©2009 Google Maps)

West

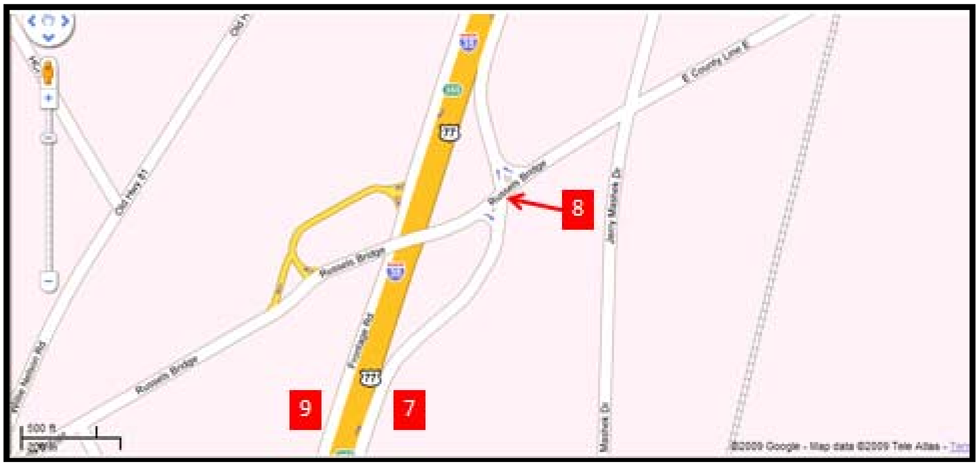


Figure E-42. West, Analysis Unit Map 1 of 5.
(Source: ©2009 Google Maps)

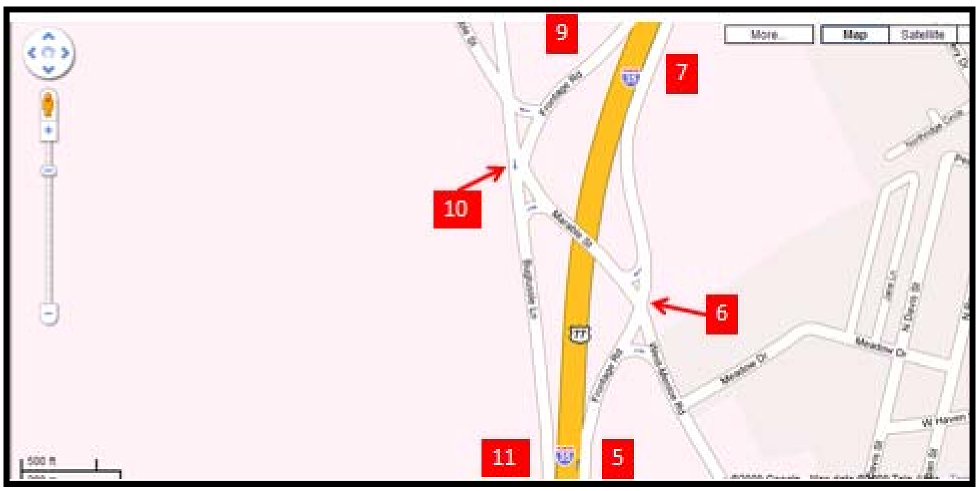


Figure E-43. West, Analysis Unit Map 2 of 5.
(Source: ©2009 Google Maps)

Figure E-44. West, Analysis Unit Map 3 of 5.
(Source: ©2009 Google Maps)

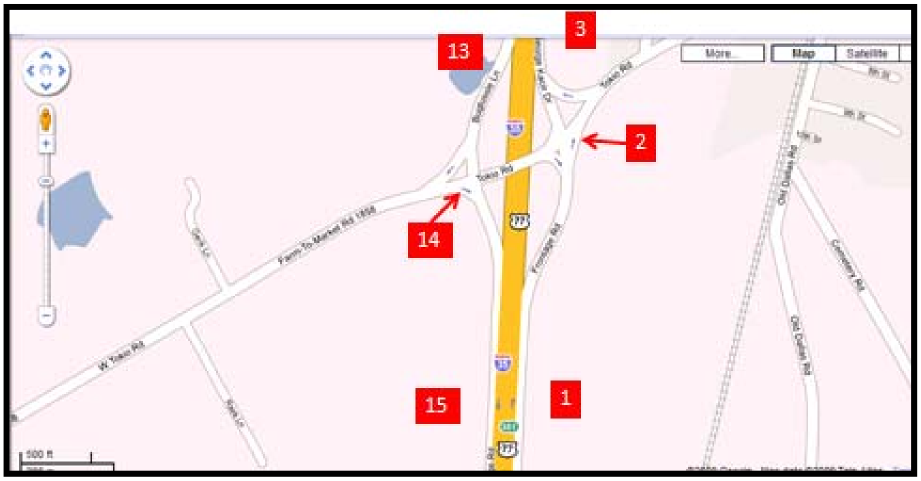


Figure E-45. West, Analysis Unit Map 4 of 5.
(Source: ©2009 Google Maps)

Figure E-46. West, Analysis Unit Map 5 of 5.
(Source: ©2009 Google Maps)

Burleson

Figure E-47. Burleson, Analysis Unit Map 1 of 6.
(Source: ©2009 Google Maps)

Figure E-48. Burleson, Analysis Unit Map 2 of 6.
(Source: ©2009 Google Maps)

Figure E-49. Burleson, Analysis Unit Map 3 of 6.
(Source: ©2009 Google Maps)

Figure E-50. Burleson, Analysis Unit Map 4 of 6. (Source: ©2009 Google Maps)

Figure E-51. Burleson, Analysis Unit Map 5 of 6. (Source: ©2009 Google Maps)

Figure E-52. Burleson, Analysis Unit Map 6 of 6. (Source: ©2009 Google Maps)

APPENDIX F:
ADDITIONAL DISCUSSION OF STATISTICAL ANALYSES AND SUMMARY STATISTICS

BEFORE-AFTER EVALUATION WITH COMPARISON GROUPS (C-G)

The C-G method assumes that the change in crash frequency between the before and after periods, *M(j)* and *N(j)*, for a comparison group is representative of the change in crash frequency that would have occurred for the corresponding treatment group if the conversion had not been made. Figure F-1 shows the relationship between j treatment groups. The researchers used the ratio of crash numbers during the before and after periods $\left(\frac{N(j)}{M(j)} \times K(j)\right)$ to estimate the crash number in the treatment site without conversion (π *(j)*).

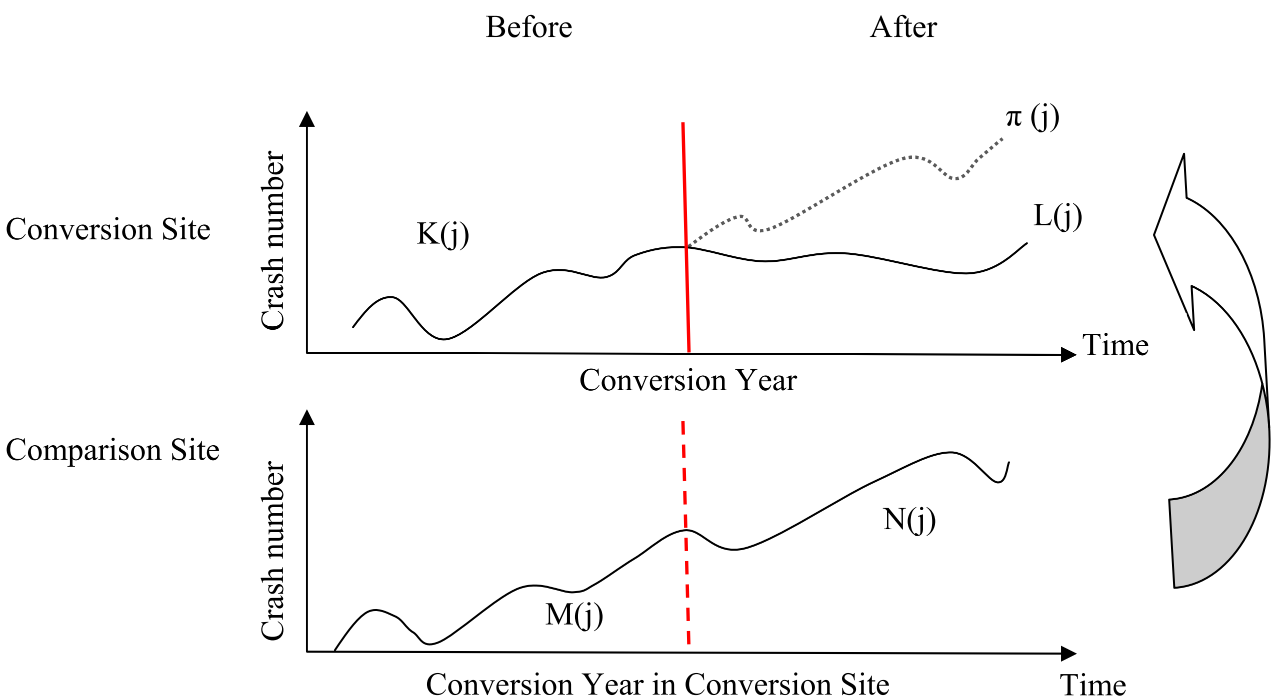


Figure F-1. Illustration of Crash Number Variables.

Step 1. Identify a group of comparison sites that are similar to the treatment sites in the *j*th treatment group ($j = 1,\cdots,J$) in terms of geometric characteristics and traffic volume.
Step 2. Let $\lambda(j)$ be the expected number of crashes after the treatment and $\pi(j)$ be the predicted number of crashes that would have been without the treatment for the *j*th treatment group. Let $K(j)$ and $L(j)$ be the number of before crashes and the number of after crashes for the *j*th treatment group, respectively, and $M(j)$ and $N(j)$ be the number of before crashes and the number

of after crashes for the *j*th comparison group, respectively. That is, $K(j) = \sum_{i=1}^{I_j} K_i$ where K_i is the number of before crashes at analysis unit *i* in the *j*th treatment group and *L(j)*, *M(j)*, and *N(j)* are also defined similarly, i.e., as the sum of the number of after crashes over all sites in the *j*th treatment group, the sum of the number of before crashes over all sites in the *j*th comparison group, and the sum of the number of after crashes over all sites in the *j*th comparison group, respectively. Find estimates of $\lambda(j)$ and $\pi(j)$ for each of the *J* treatment groups.

$$\hat{\lambda}(j) = L(j)$$

$$\hat{\pi}(j) = \frac{N(j)}{M(j)} \times K(j).$$

Step 3. Find an estimate of the index of effectiveness $\theta(j)$:

$$\hat{\theta}(j) = \hat{\lambda}(j) / \hat{\pi}(j) = \frac{L(j)M(j)}{K(j)N(j)}.$$

Step 4. Compute the log odds ratio, R_j, as follows:

$$R_j = \ln\left(\frac{L(j)M(j)}{K(j)N(j)}\right) = \ln \hat{\theta}(j).$$

Step 5. Compute the squared standard error for R_j by:

$$\left\{s.e.\left(R_j\right)\right\}^2 = Va\hat{r}\left(R_j\right) = \frac{1}{K(j)} + \frac{1}{L(j)} + \frac{1}{M(j)} + \frac{1}{N(j)}.$$

Step 6. Compute an overall average odds ratio as a weighted average log odds ratio across all *J* treatment groups where the weight for each treatment group represents the reciprocal of the squared standard error of the log odds ratio.

$$R = \frac{\sum_{j=1}^{J} w_j R_j}{\sum_{j=1}^{J} w_j}$$

where $w_j = 1 \big/ \left\{s.e.\left(R_j\right)\right\}^2$.

Step 7. Compute the standard error and the approximate 95 percent confidence interval for R.

$$s.e.(R) = 1 \Big/ \sqrt{\sum_{j=1}^{J} w_j}\ ,$$

$$R_{upper} = R + 1.96 s.e.(R),$$

and:

$$R_{lower} = R - 1.96 s.e.(R)$$

where R_{upper} and R_{lower} stand for the upper and lower limit of the approximate 95 percent confidence interval, respectively.

Step 8. Obtain the estimate of the index of effectiveness of the countermeasure and the corresponding 95 percent confidence interval by exponentiating R, R_{upper}, and R_{lower}, respectively, as:

$$\hat{\theta} = e^{R},$$

$$\theta_{upper} = e^{R_{upper}},$$

and:

$$\theta_{lower} = e^{R_{lower}}.$$

The average percent crash reduction can be estimated as $100\left(1-\hat{\theta}\right)$.

Remark 1: The above procedure is applicable if both the treatment and comparison groups have approximately the same (in terms of magnitude and direction) traffic volume change from before to after period. Otherwise, the traffic volume changes from the before to the after periods need to be incorporated into θ. In that case, the before crash count at treatment site i (K_i) in the jth treatment group will need to be replaced by $K_i \times \frac{ADT_i^{AT}}{ADT_i^{BT}}$ where ADT_i^{BT} and ADT_i^{AT} are the average traffic volume during the before period at treatment site i and the average traffic volume during the after period at site i. Likewise, the before crash count at comparison site k (M_k) in the jth comparison group will need to be replaced by $M_k \times \frac{ADT_k^{AC}}{ADT_k^{BC}}$ where ADT_k^{BC} and ADT_k^{AC} are the average traffic volume during the before period at site i and the average traffic volume during the after period at comparison site k. The interested reader can find more information on this procedure elsewhere (*34*).

NAÏVE BEFORE-AFTER EVALUATION METHOD

The naïve before-after (BA) evaluation is valid only when it can be assured that there are no before-after differences caused by any other changes over time that may confound the effect of treatment. The following section summarizes the naïve before-after evaluation method described in Hauer (*33*). The original method can account for only an unequal number of before and after crash data years. Researchers used this method for analyses when there was no comparison site available (e.g., analyses using the Burleson data).

Suppose that a treatment has been implemented on sites numbered 1, 2, *…, i, … , n.* The following notations are adapted from Hauer (*33*):

K(1), K(2),…, K(n): observed crash counts from *n* sites during the before periods;

L(1), L(2),…, L(n): observed crash counts from *n* sites during the after period;

$r_d(i)$: ratio of durations for site *i* ($i = 1, \cdots, n$) defined by

$r_d(i)$ = (# of after crash data years for site *i*) / (# of before crash data years for site *i*);

π: expected number of crashes on the roadway in the after period had the countermeasure not been implemented; and

λ: expected number of crashes on the roadway in the after period after the countermeasure has been implemented.

The effect of the treatment on safety can be assessed by estimating the index of effectiveness, $\theta \,(= \lambda / \pi)$.

The naïve before-after evaluation method described in Hauer (*33*) estimates the measures of effectiveness θ by:

$$\hat{\theta} = \frac{\hat{\lambda} / \hat{\pi}}{1 + Var(\hat{\pi}) / \hat{\pi}^2}$$

where $\hat{\pi}$ and $\hat{\lambda}$ are estimates of π and λ, given respectively by:

$$\hat{\lambda} = \sum_{i=1}^{n} L(i)$$

and:

$$\hat{\pi} = \sum_{i=1}^{n} r_d(i) K(i).$$

Because $\widehat{\theta}_1 = \frac{\hat{\lambda}}{\hat{\pi}}$ is a biased estimate of θ even if $\hat{\pi}$ and $\hat{\lambda}$ are unbiased estimates of π and λ, an estimate $\hat{\theta}$ that is (approximately) unbiased for θ is preferred to $\hat{\theta}_1$.

The variances of $\hat{\delta}$ and $\hat{\theta}$ are given respectively by:

$$Var(\hat{\delta}) = Var(\hat{\pi}) + Var(\hat{\lambda}),$$

and:

$$Var(\hat{\theta}) = \theta^2 \left[\left(Var(\hat{\lambda}) / \lambda^2 \right) + \left(Var(\hat{\pi}) / \pi^2 \right) \right] \Big/ \left[1 + Var(\hat{\pi}) / \pi^2 \right]^2.$$

If $\hat{\theta}$ is less than 1, then the countermeasure has a positive effect on safety. The percent reduction of crashes can be computed as $100(1-\hat{\theta})$.

The steps for the naïve before-after evaluation method can be summarized as follows:

Step 1. Find estimates of λ and π.

$$\hat{\lambda} = \sum_{i=1}^{n} L(i)$$

$$\hat{\pi} = \sum_{i=1}^{n} r_d(i) K(i)$$

Step 2. Find estimates of $Var(\hat{\lambda})$ and $Var(\hat{\pi})$.

$$V\hat{a}r(\hat{\lambda}) = \sum_{i=1}^{n} L(i)$$

$$V\hat{a}r(\hat{\pi}) = \sum_{i=1}^{n} r_d(i)^2 K(i)$$

Step 3. Find estimates of θ.

$$\hat{\theta} = \frac{\hat{\lambda}/\hat{\pi}}{1 + V\hat{a}r(\hat{\pi})/\hat{\pi}^2}$$

Step 4. Find estimates of $Var(\hat{\theta})$.

$$V\hat{a}r(\hat{\theta}) = \hat{\theta}^2 \left[\left(1/\hat{\lambda} \right) + \left(V\hat{a}r(\hat{\pi}) / \hat{\pi}^2 \right) \right] \Big/ \left[1 + V\hat{a}r(\hat{\pi}) / \hat{\pi}^2 \right]^2$$

Step 5. Obtain the approximate 95 percent confidence intervals for θ as follows:

$$\hat{\theta} \pm 1.96 \cdot \sqrt{V\hat{a}r\left(\hat{\theta}\right)}$$

As a matter of fact, the assumption that there have been no changes from before to after periods other than the treatment is often violated. There will almost always be changes over time in traffic volume, vehicle mix, weather, etc., when the crash data of multiple years are analyzed. Because the naïve before-after evaluation does not control for those changes, the effect of treatment cannot be separated from those changes.

Remark 2: Among several potential changes between before and after periods, the changes in traffic volumes are often non-ignorable and almost always need to be incorporated into the analysis. To incorporate traffic volume changes in B-A analysis, the before crash count at treatment site i , $K(i)$, can be replaced by $K(i) \times \frac{\mathrm{ADT}(i)^{AT}}{\mathrm{ADT}(i)^{BT}}$ where $\mathrm{ADT}(i)^{BT}$ and $\mathrm{ADT}(i)^{AT}$ are the average traffic volume during the before period at treatment site i and the average traffic volume during the after period at site i, as in Remark 1. The estimates for Burleson from the B-A method with incorporated traffic volumes ($\hat{\theta}_T$, PCR_T) were obtained by substituting $K(i) \times \frac{\mathrm{ADT}(i)^{AT}}{\mathrm{ADT}(i)^{BT}}$ for K(i) in the above steps.

APPENDIX G:
GROSS SALES TABLES AND FIGURES

This appendix includes additional observations and discussion about each conversion site city and comparison site city (if available), followed by supporting tables of summary statistics and the graphics of trends by city, county, and business type. Note that group A businesses are retail-related and group B are non-retail. See "Analysis Procedure, Assumptions, and Data Reporting" in Chapter 5 for further information about the data source and assumptions made to generate these figures.

The vertical line on all graphics indicates the conversion year of the roadway in the city of interest (conversion site) for the conversion or comparison site location.

Comparison of Sulphur Springs Conversion Site and Greenville Comparison Site

Figures G-9 through G-23 show the gross sales trends in more detail. Table G-1 shows the results in table form. The research team made the following observations about the Sulphur Springs gross sales trends:

- Gross sales for all businesses in Sulphur Springs slightly increased overall from 1992 to 2006. During this period, the gross sales of group A (retail) businesses slightly increased, while group B (non-retail) businesses slightly decreased.
- Gross sales values after the conversion in Sulphur Springs (2003–2006) increased after a reduction from 2001 to 2003. This reduction was most likely caused by the reduction observed in group B (non-retail) business sales.
- Gross sales values in recent years (2005–2006) remained relatively constant in the city of Sulphur Springs.
- Auto dealers and gas: The gross sales of auto dealers and gas stations in Sulphur Springs decreased during 2001 to 2003 but increased slightly after 2003.
- Hotels: The gross sales of hotels in Sulphur Springs were lacking in 1992 to 1995 and 2004 to 2006 because the number of establishments was fewer than four. However, based on available data, the gross sales of hotels continuously decreased from 1998 to 2003.

- Food stores and eating and drinking places: The gross sales of food stores in Sulphur Springs increased after the conversion (2002), and the gross sales of eating and drinking establishments increased slightly.

The following observations are made about the Greenville gross sales trends:

- Gross values in the city of Greenville (comparison site) increased overall from 1992 to 2006. During this period, the gross sales of group A (retail) and group B (non-retail) businesses increased.
- Auto dealers and gas: The gross sales of auto dealers and gas stations in Greenville increased from 1996 to 2006 overall and were relatively constant from 2005 to 2006.
- Hotels: The gross sales of hotels in Greenville were limited after 1998 because the number of establishments was fewer than four. Therefore, no figure was available.
- Food stores and eating and drinking places: The gross sales of food stores decreased and eating and drinking places increased from 1992 to 2006.

The following observations are made about the Hopkins County and Hunt County gross sales trends:

- The gross sales values of Hopkins County had the same general trend as the city of Sulphur Springs, and the gross sales values of Hunt County had the same general trend as the city of Greenville. The likely reason is that both cities represented a high percentage of the whole gross sales value of their corresponding counties.
- Auto dealers and gas: For both counties, the trend was the same as the corresponding city.
- Hotels: The Hopkins County hotel values were very similar to the city of Sulphur Springs. The gross sales value of hotels in Hunt County decreased from 1998 to 2006.
- Food stores and eating and drinking places: For both counties, the trend was the same as each corresponding city.

The following observations are made comparing the gross sales trends from the city of Sulphur Springs and the city of Greenville:

- All gross sales data trends: After the conversion year (2001), the gross sales values of Sulphur Springs decreased, while the gross sales values of Greenville increased. However, the difference between these two cities was mostly caused by the reduction in group B (non-retail) business sales, especially in auto dealers and gas. As for retail businesses (group A), the gross sales values of these two cities stayed relatively flat.

Comparison of Hillsboro Conversion Site and West Comparison Site

Figure G-22 through Figure G-35 show the comparison of the trends in gross sales data. Table G-2 shows the results in table form. The following observations are made about the Hillsboro gross sales trends:

- Gross sales values of all businesses in the city of Hillsboro were higher overall in 2006 than 1992. There was a decrease during 1997 and 1998. Gross sales values after the conversion year of 2001 remained relatively unchanged. In recent years (2005–2006), gross sale values increased slightly. During this period (1992–2006), the gross sales of group A (retail) and group B (non-retail) businesses also had the same trends as the gross sales of all businesses.
- Auto dealers and gas: The gross sales of auto dealers and gas stations in Hillsboro reduced during 1995 to 1997 and 2000 to 2004 but increased slightly in recent years. There was a large reduction in gross sales in 1997, which is a suspicious point.
- Hotels: The gross sales data of hotels in Hillsboro were unavailable because the number of establishments was fewer than four.
- Food stores and eating and drinking places: The gross sales of food stores and eating and drinking places in Hillsboro remained relatively unchanged but did increase slightly overall.

The following observations are made about the city of West gross sales trends:

- Gross sales values in West increased slightly from 1992 to 2006, and there was a small jump during 1994 and 1995. During this period (1992–2006), the gross sales of group A (retail) and group B (non-retail) businesses also had similar trends. Gross sales values in West decreased slightly after 2001.
- Auto dealers and gas: The gross sales of auto dealers and gas stations in West increased continuously before 2001 but decreased after 2001.
- Hotels: The gross sales data of hotels in West were unavailable because of the few establishments.

- Food stores and eating and drinking places: The gross sales of food stores and eating and drinking places in West increased slightly.

The following observations are made about the Hill County and McLennan County gross sales trends:

- The gross sales values of Hill County had the same trend as the city of Hillsboro. The gross sales values of McLennan County had a different trend than the city of West. The likely reason is that the city of West only represents a small percentage (about 5 percent) of the whole gross value of its corresponding county.
- Auto dealers and gas: Hill County had the same trend as the city of Hillsboro, but McLennan County had a different trend than the city of West.
- Hotels: The gross sales values of hotels in Hill County increased after 2003, while the gross sales of hotels in McLennan County decreased after 1999, especially in 2006.
- Food stores and eating and drinking places: Hill County values increased slightly as did the not capital city of Hillsboro. McLennan County values increased more than the city of West, especially for food stores.

The following observations are made comparing the gross sales trends from the city of Hillsboro and the city of West:

- All gross sales data trends: After the conversion year of 2001, the gross sales of Hillsboro remained relatively unchanged, while the gross sales of West decreased slightly. The difference between these two cities was mostly caused by the reduction in group B (non-retail) business sales in the city of West. As for retail businesses (group A), the gross sales of these two cities remained relatively unchanged.

Comparison of Wolfforth Conversion Site and Plainview Comparison Site

Figure G-36 through Figure G-47 show the trends based upon the available gross sales data. Table G-3 shows the results in table form.

The following observations are made about the Wolfforth gross sales trends (amount-subject-to-tax sales):

- The tax values of many business types were unavailable between 1992 and 1993 because the number of establishments was fewer than four. Researchers used the average data of adjacent years in place of unavailable data for the trends of food stores (1995, 1997–1999), home furniture (1994), and miscellaneous retail (1999).

- Amount-subject-to-tax sales in Wolfforth were higher in 2006 than 1994, and the value increased from 1993 to 2000 and decreased until 2003. During this period, the gross sales of group B (non-retail) businesses also had the same trends, while the trends of group A (retail) businesses remained relatively unchanged up to 2004, increased in 2005, and decreased in 2006. The value of group B was higher than the value of group A.
- Auto dealers and gas: The amount-subject-to-tax sales of auto dealers and gas stations in Wolfforth were unavailable from 1992 to 1995 and 2001 to 2006 because of the limited number of establishments.
- Hotels: The amount-subject-to-tax sales of hotels in Wolfforth were also unavailable because of the limited number of establishments.
- Food stores and eating and drinking places: The amount-subject-to-tax sales of food stores in Wolfforth decreased after 2000. The amount-subject-to-tax sales of eating and drinking places are not shown in Appendix G because data were missing for 1992–1999 and 2003–2005.

The following observations are made about the Plainview gross sales trends (amount-subject-to-tax sales):

- Amount-subject-to-tax sales in Plainview were relatively unchanged from 1992 to 2006. There was a jump between 1996 and 1998, and researchers identified these data as suspicious points and did not consider them in further analysis. Amount-subject-to-tax sales remained relatively constant after 1999. During this period (1992–2006), the gross sales of group A (retail) businesses had the same trend, while the trend of group B (non-retail) businesses remained relatively unchanged. The value of group A was higher than the value of group B.
- Auto dealers and gas: The amount-subject-to-tax sales of auto dealers and gas stations in Plainview increased from 1992 to 2006.
- Hotels: The amount-subject-to-tax sales of hotels in Plainview were unavailable because of the few establishments.

- Food stores and eating and drinking places: The gross sales of food stores in Plainview decreased, while the gross sales of eating and drinking places increased.

The following observations are made about the Lubbock County and Hale County amount-subject-to-tax trends:

- The amount-subject-to-tax sales in Hale County had the same trend as the city of Plainview, but the amount-subject-to-tax sales in Lubbock County had a different trend than the city of Wolfforth. The likely reason is that Wolfforth represents only a small percentage (about 10 percent) of the whole gross sales of Lubbock County. Another relatively large city, Lubbock, is also in Lubbock County, accounting for a majority of gross sales.
- Auto dealers and gas: The amount-subject-to-tax sales of auto dealers and gas stations in Lubbock County increased, and in Hale County they remained relatively unchanged.
- Hotels: The amount-subject-to-tax sales of hotels in Hale County were unavailable because there were fewer than four establishments. In Lubbock County, there were three drops in the amount-subject-to-tax sales of hotels in Plainview in 1997, 2000, and 2004.
- Food stores and eating and drinking places: The amount-subject-to-tax sales of food stores decreased in Lubbock County and Hale County, and the amount-subject-to-tax sales of eating and drinking places increased in Lubbock County and Hale County.

The following observations are made comparing the gross sales trends from the city of Wolfforth and the city of Plainview:

- Amount-subject-to-tax data trends: After the conversion year of 2001, amount-subject-to-tax sales in Wolfforth decreased for three years and then increased back to the same value as 2001, while the value of Plainview remained unchanged. The difference between these two cities was mostly caused by the group B (non-retail) business sales. As for retail businesses (group A), the gross sales of these two cities remained relatively unchanged.

City of Huntsville Gross Sales

Figures G-48 through G-53 illustrate the related Huntsville graphics. The following observations are made about the Huntsville gross sales trends:

- Gross sales values generally increased from 1992 to 2006. There was a small jump in the gross sales values of group B businesses in 2000. After the conversion year (2001), the gross sales values of all businesses together continuously increased, especially in 2005 and 2006. In the same period, group B had a similar trend as all businesses, while group A remained relatively flat.
- Auto dealers and gas: The gross sales of auto dealers and gas stations in Huntsville jumped in 2000, came back down in 2001, and then increased in more recent years.
- Hotels: The gross sales data of hotels in Huntsville were unavailable from 1992 to 2006 because the number of establishments was fewer than four.
- Food stores and eating and drinking places: The gross sales of food stores in Huntsville increased after 2003, and the gross sales of eating and drinking places remained relatively unchanged.

The following observations are made about the Walker County gross sales trends:

- The gross sales values of Walker County had the same trend as the city of Huntsville. The likely reason is that Huntsville represents about 90 percent of the gross sales in Walker County.
- Auto dealers and gas: The trend was the same as the city of Huntsville.
- Hotels: The gross sales data of hotels in Walker County were unavailable because the number of establishments was fewer than four.
- Food stores and eating and drinking places: The gross sales trend was the same as the city of Huntsville.

City of Burleson Conversion Gross Sales

Figures G-54 through G-63 display related Burleson graphics. The following observations are made about the Burleson gross sales trends (amount-subject-to-tax sales):

- Amount-subject-to-tax sales of all businesses in Burleson continuously increased from 1992 to 2006. During this period, the amount-subject-to-tax sales of group A (retail) businesses had the same trend as all businesses, while the trend of group B (non-retail) remained relatively flat. The value of group A was higher than the value of group B.

- Auto dealers and gas: The amount-subject-to-tax sales of auto dealers and gas stations in the city of Burleson decreased after the conversion year of 2004 but increased from 2005 to 2006.
- Hotels: The amount-subject-to-tax sales data of hotels in Burleson were unavailable because there were fewer than four establishments.
- Food stores and eating and drinking places: The amount-subject-to-tax sales of food stores in Burleson decreased overall (1992 compared to 2006), while the amount-subject-to-tax sales of eating and drinking places increased overall.

The following observations are made about the Tarrant and Johnson Counties amount-subject-to-tax trends:

- The amount-subject-to-tax sales values of Johnson County had the same trend as the city of Burleson. The amount-subject-to-tax sales of Tarrant County had a slightly different trend, although there were increases in sales. The reason for the similarity is that most of Burleson is located in Johnson County rather than Tarrant County, and Tarrant County also includes a portion of Fort Worth.
- Auto dealers and gas: The amount-subject-to-tax sales in Johnson County had the same trend as the city of Burleson, but the amount-subject-to-tax sales in Tarrant County had a different trend than the city of Burleson.
- Hotels: The amount-subject-to-tax sales of hotels in Johnson County were unavailable because there were fewer than four establishments, and the amount-subject-to-tax sales data of hotels in Tarrant County increased substantially from 2003 to 2004 and decreased after 2004.
- Food stores and eating and drinking places: The amount-subject-to-tax sales of food stores in the city of Burleson, Johnson City, and Tarrant County all increased. The amount-subject-to-tax sales of drinking places decreased in the city of Burleson, Johnson County, and Tarrant County.

Table G-1. Average Percent Change of Before and After Periods and the Percent Difference of Before Period Compared to After Period of Sulphur Springs and Greenville (Gross Sales).

Business	Percent Change in Before Period (from 1996 to 2000)[1]			Percent Change in After Period (from 2002 to 2006)[2]			Percent Difference of Before Period Compared to After Period[3]		
	Sulphur Springs	Greenville	State	Sulphur Springs	Greenville	State	Sulphur Springs	Greenville	State
All Gross Sales	3%	20%	24%	7%	−3%	12%	−14%	26%	13%
Group A (Retail)	−4%	11%	29%	−1%	−4%	18%	−18%	10%	16%
Group B (Non-Retail)	10%	31%	17%	16%	−2%	3%	−9%	44%	10%
Auto Dealer and Gas	8%	58%	23%	−5%	2%	1%	−31%	94%	10%
Hotel	−7%	-	19%	-	-	−4%	-	-	−2%
Food Store	17%	7%	9%	55%	−3%	7%	45%	−2%	8%
Eating and Drinking Place	2%	18%	19%	5%	−12%	3%	4%	3%	12%

[1]Computed as the percent difference between the 2000 gross sales values and the 1996 gross sales values.
[2]Computed as the percent difference between the 2006 gross sales values and the 2002 gross sales values.
[3]Computed as the percent difference between the five-year average value in gross sales from the after period (2002 through 2006) and the five-year average value in the gross sales from the before period (1996 through 2000).
Note: "-" indicates there were fewer than four establishments for the category and gross sales data were not provided.

Table G-2. Average Percent Change of Before and After Periods and the Percent Difference of Before Period Compared to After Period of Hillsboro and West (Gross Sales).

Business	Percent Change in Before Period (from 1996 to 2000)[1]			Percent Change in After Period (from 2002 to 2006)[2]			Percent Difference of Before Period Compared to After Period[3]		
	Hillsboro	West	State	Hillsboro	West	State	Hillsboro	West	State
All Gross Sales	6%	12%	24%	5%	−3%	12%	−2%	−5%	13%
Group A (Retail)	2%	−21%	29%	−1%	27%	18%	−8%	8%	16%
Group B (Non-Retail)	11%	22%	17%	12%	−10%	3%	6%	−8%	10%
Auto Dealer and Gas	8%	28%	23%	18%	−21%	1%	8%	−13%	10%
Hotel	-	-	19%	-	-	−4%	-	-	−2%
Food Store	16%	12%	9%	10%	35%	7%	5%	12%	8%
Eating and Drinking Place	19%	−31%	19%	−12%	7%	3%	−1%	2%	12%

[1]Computed as the percent difference between the 2000 gross sales values and the 1996 gross sales values.
[2]Computed as the percent difference between the 2006 gross sales values and the 2002 gross sales values.
[3]Computed as the percent difference between the five-year average value in gross sales from the after period (2002 through 2006) and the five-year average value in the gross sales from the before period (1996 through 2000).
Note: "-" indicates there were fewer than four establishments for the category and gross sales data were not provided.

Table G-3. Average Percent Change of Before and After Periods and the Percent Difference of Before Period Compared to After Period of Wolfforth and Plainview (Amount Subject to Tax).

Business	Percent Change in Before Period (from 1996 to 2000)[1]			Percent Change in After Period (from 2002 to 2006)[2]			Percent Difference of Before Period Compared to After Period[3]		
	Wolfforth	Plainview	State	Wolfforth	Plainview	State	Wolfforth	Plainview	State
All Gross Sales	42%	0%	16%	10%	−2%	5%	−30%	−22%	9%
Group A (Retail)	−34%	−1%	18%	−70%	−1%	6%	28%	−29%	10%
Group B (Non-Retail)	53%	4%	14%	22%	−6%	1%	−36%	−3%	6%
Auto Dealer and Gas	-	11%	17%	-	−9%	1%	-	8%	4%
Hotel	-	-	16%	-	-	2%	-	-	−4%
Food Store	13%	3%	4%	−29%	−21%	−3%	−35%	−19%	−6%
Eating and Drinking Place	-	3%	21%	-	4%	4%	-	5%	15%

[1]Computed as the percent difference between the 2000 gross sales values and the 1996 gross sales values.
[2]Computed as the percent difference between the 2006 gross sales values and the 2002 gross sales values.
[3]Computed as the percent difference between the five-year average value in gross sales from the after period (2002 through 2006) and the five-year average value in the gross sales from the before period (1996 through 2000).
Note: "-" indicates there were fewer than four establishments for the category and gross sales data were not provided.

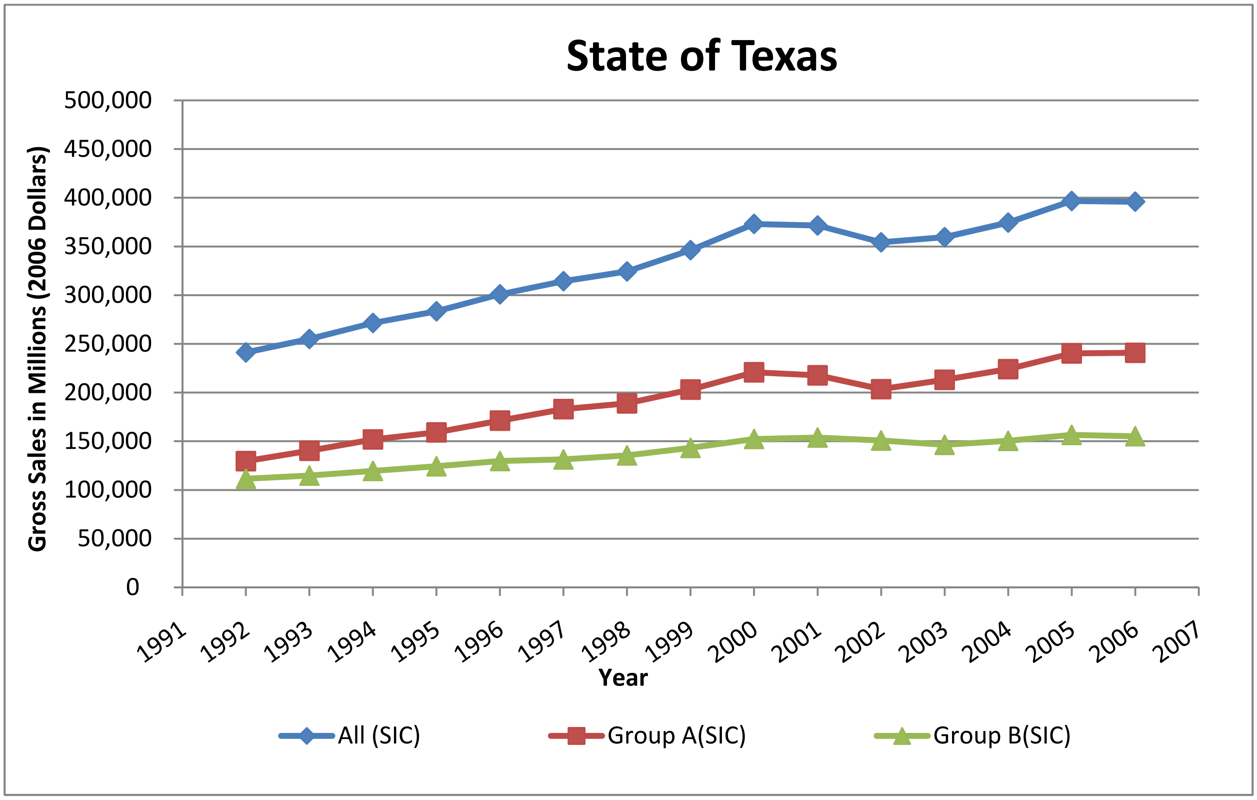


Figure G-1. State of Texas Total Gross Sales.

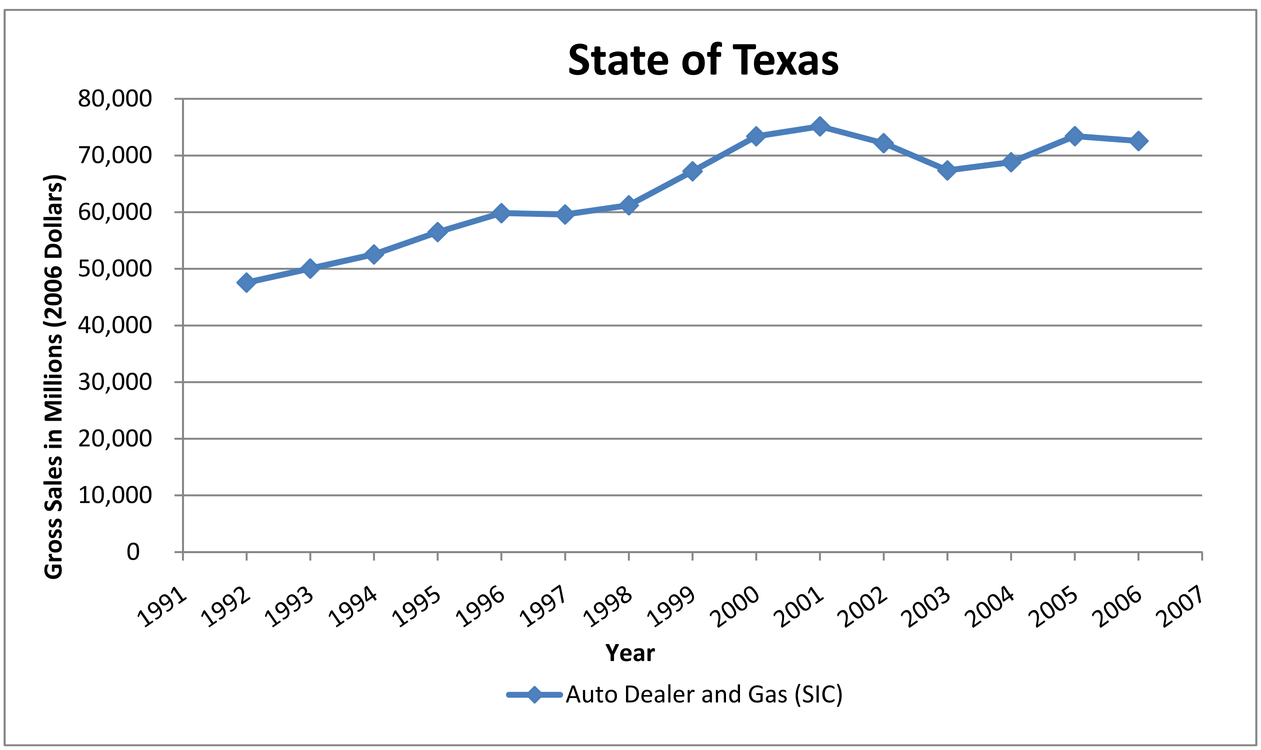


Figure G-2. State of Texas Gross Sales of Auto Dealers and Gas.

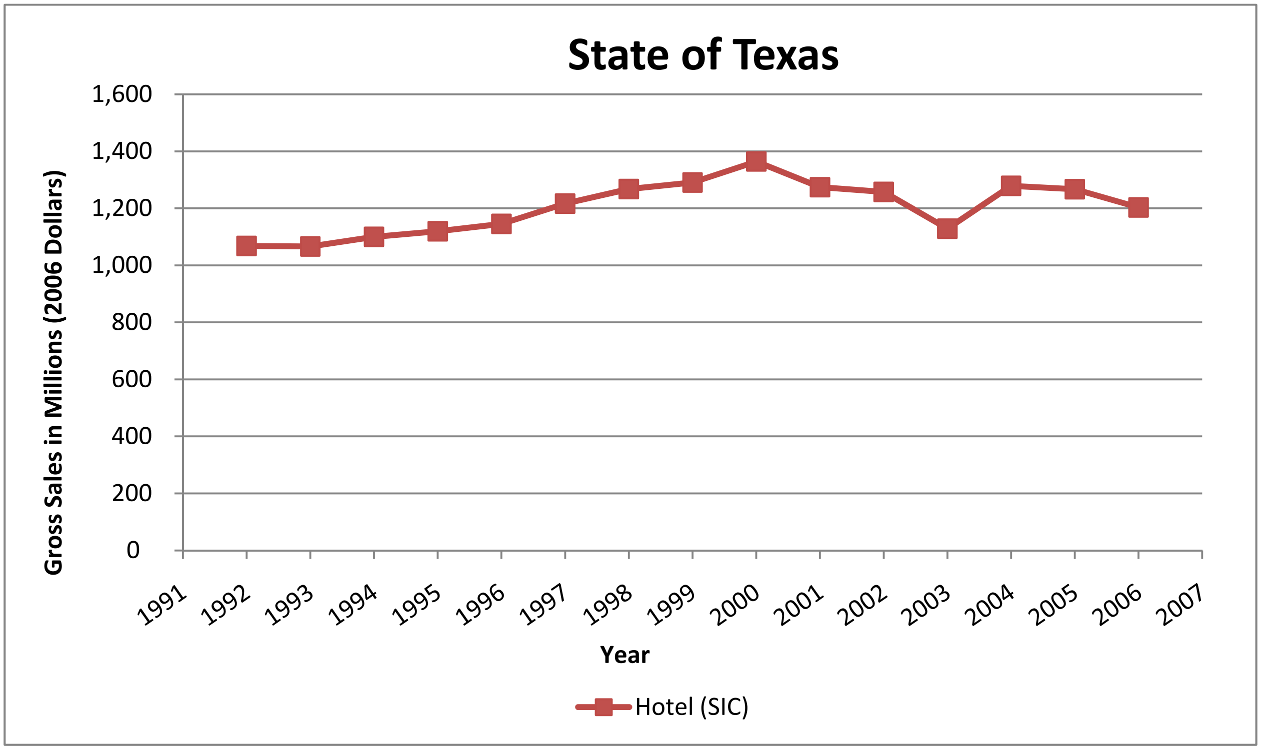


Figure G-3. State of Texas Gross Sales of Hotels.

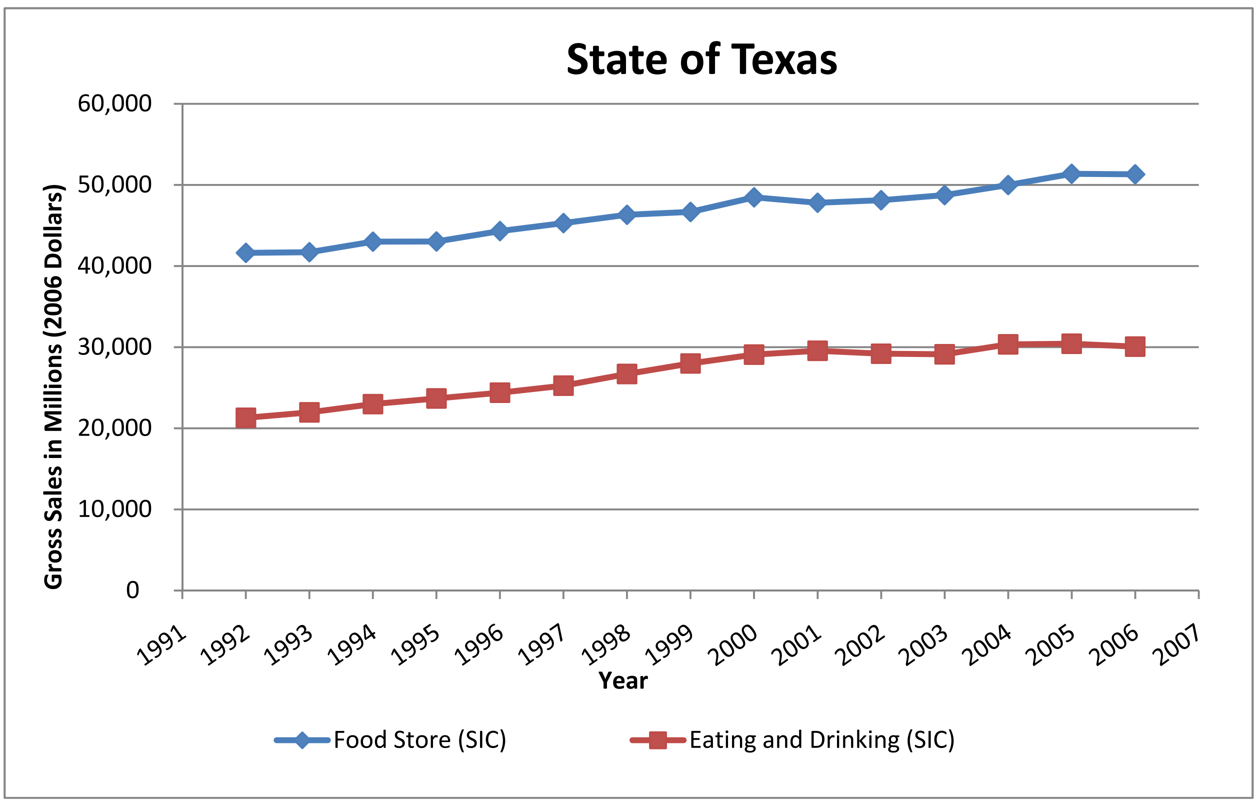


Figure G-4. State of Texas Gross Sales of Food Stores and Eating and Drinking Places.

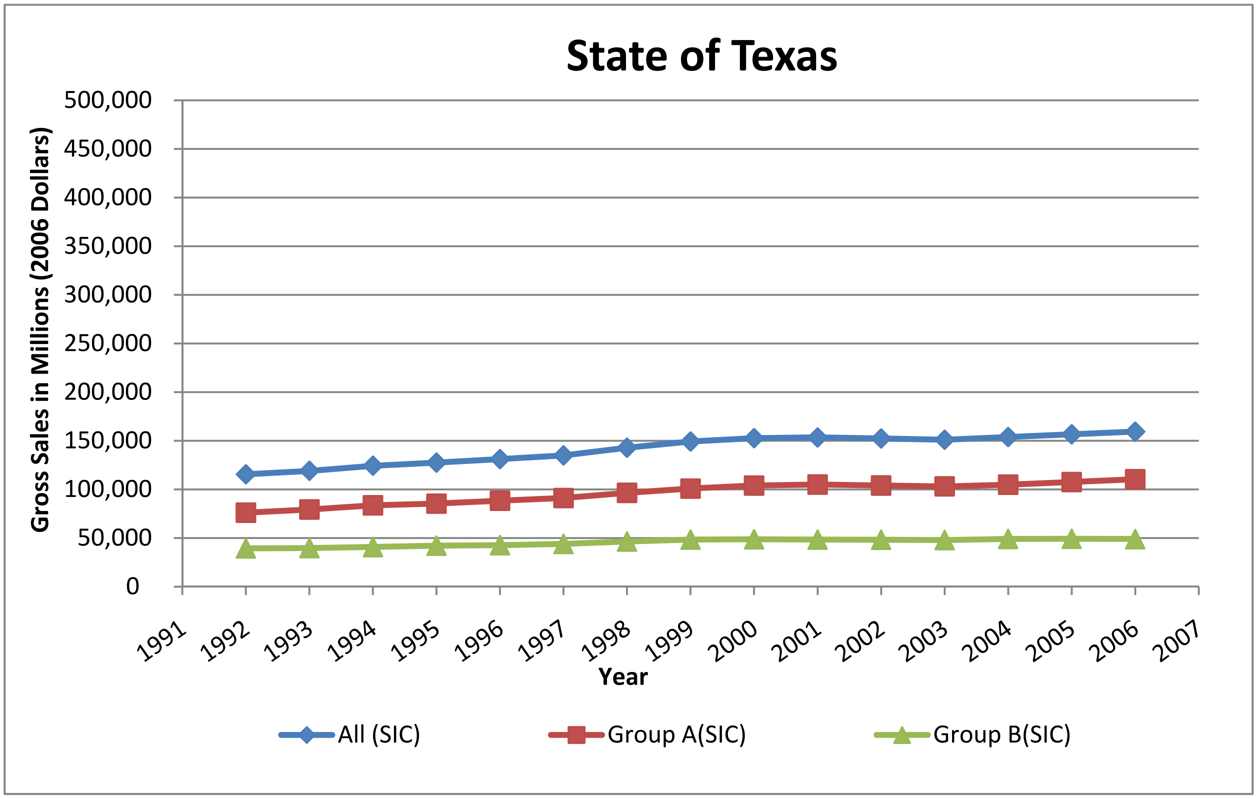


Figure G-5. State of Texas Total Gross Sales (Amount Subject to Tax).

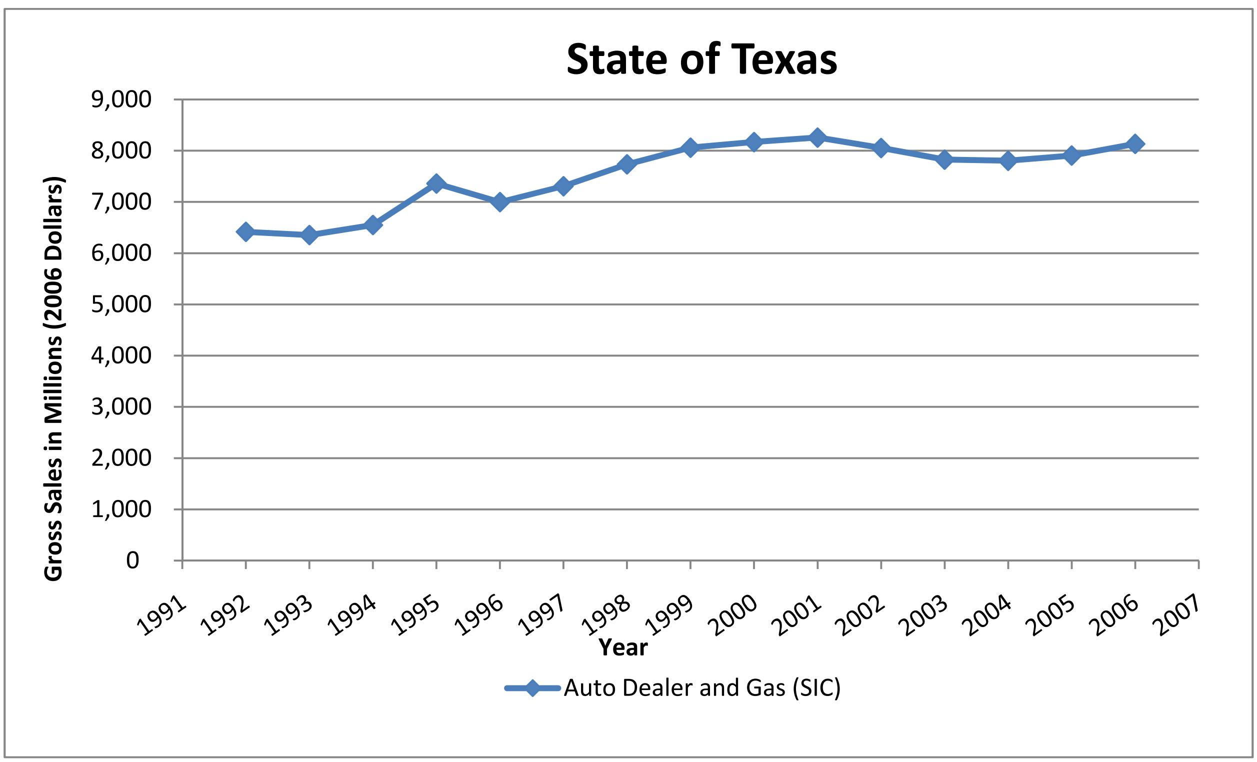


Figure G-6. State of Texas Gross Sales of Auto Dealers and Gas (Amount Subject to Tax).

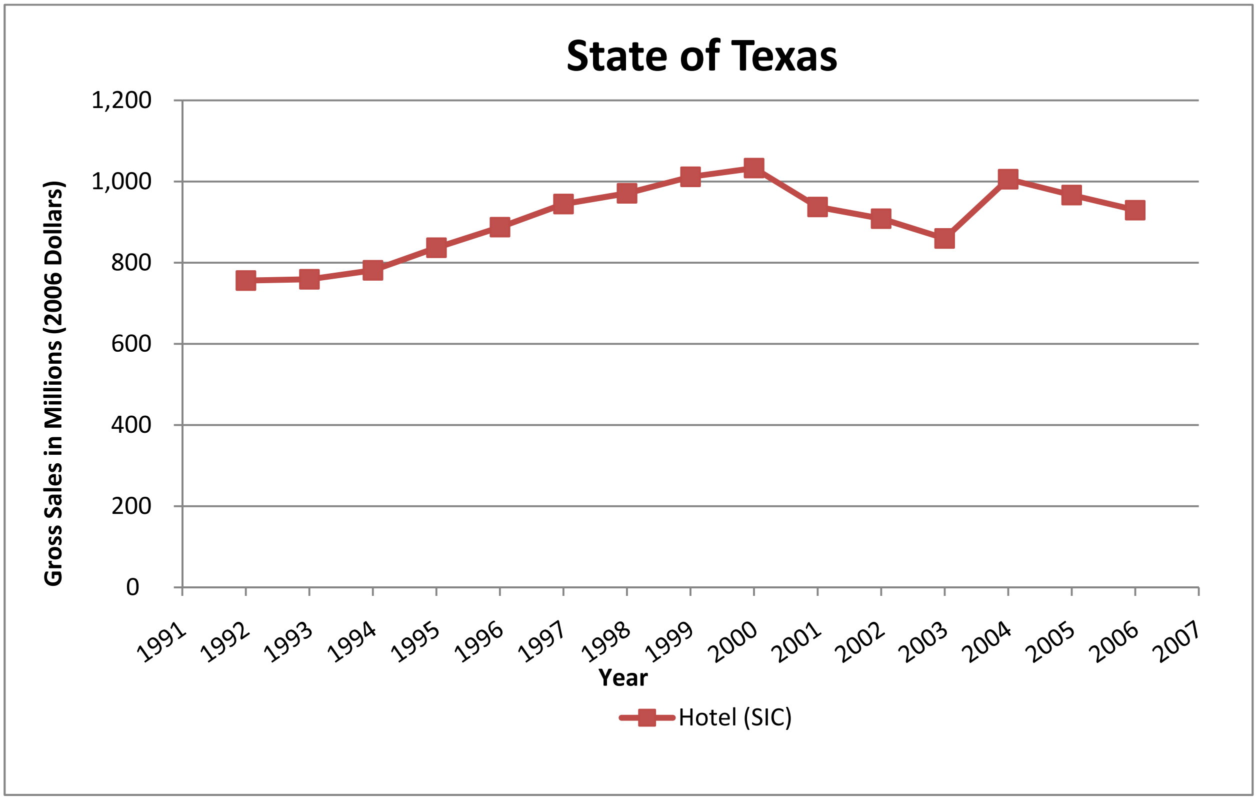


Figure G-7. State of Texas Gross Sales of Hotels (Amount Subject to Tax).

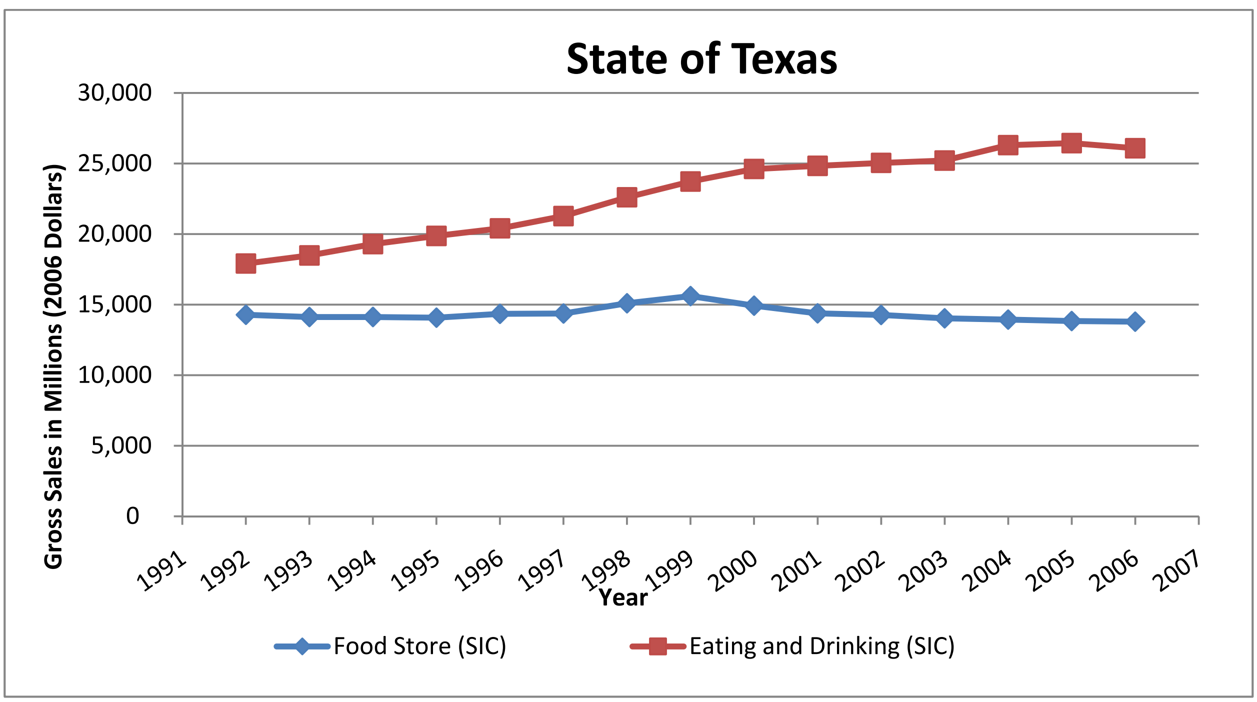


Figure G-8. State of Texas Gross Sales of Food Stores and Eating and Drinking Places (Amount Subject to Tax).

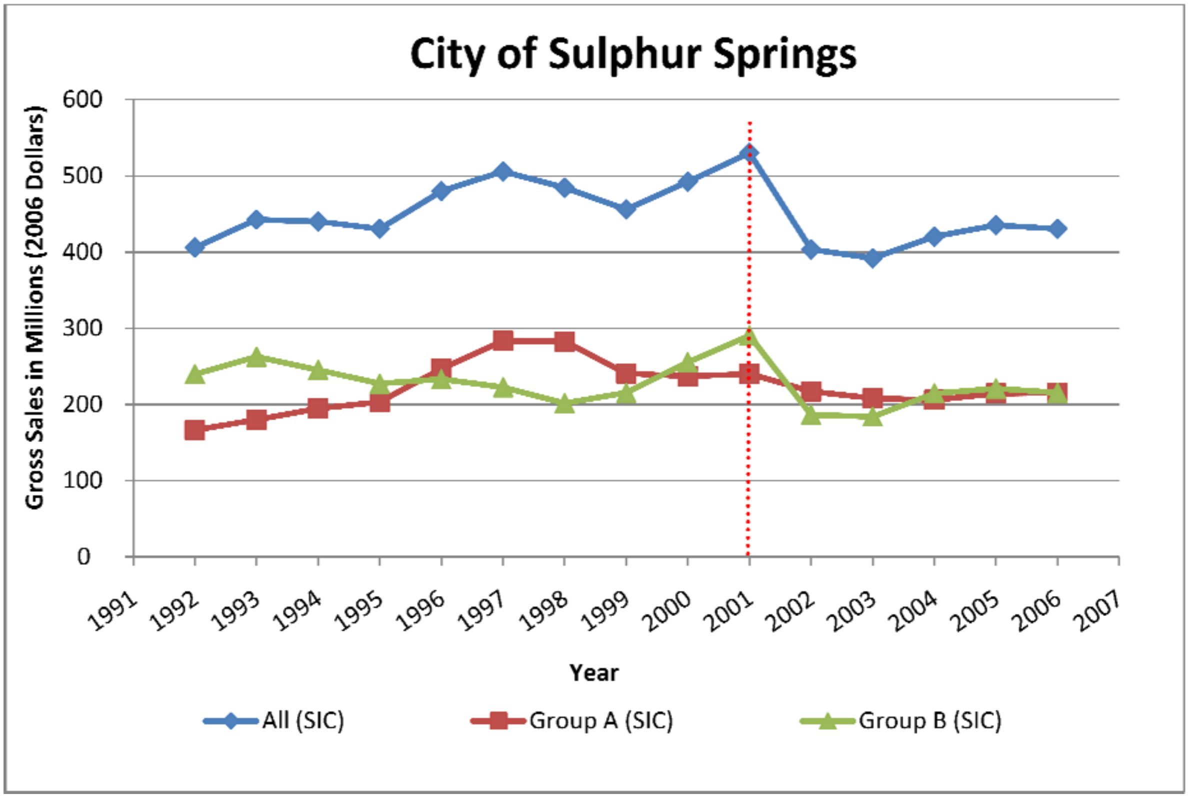


Figure G-9. City of Sulphur Springs Total Gross Sales.

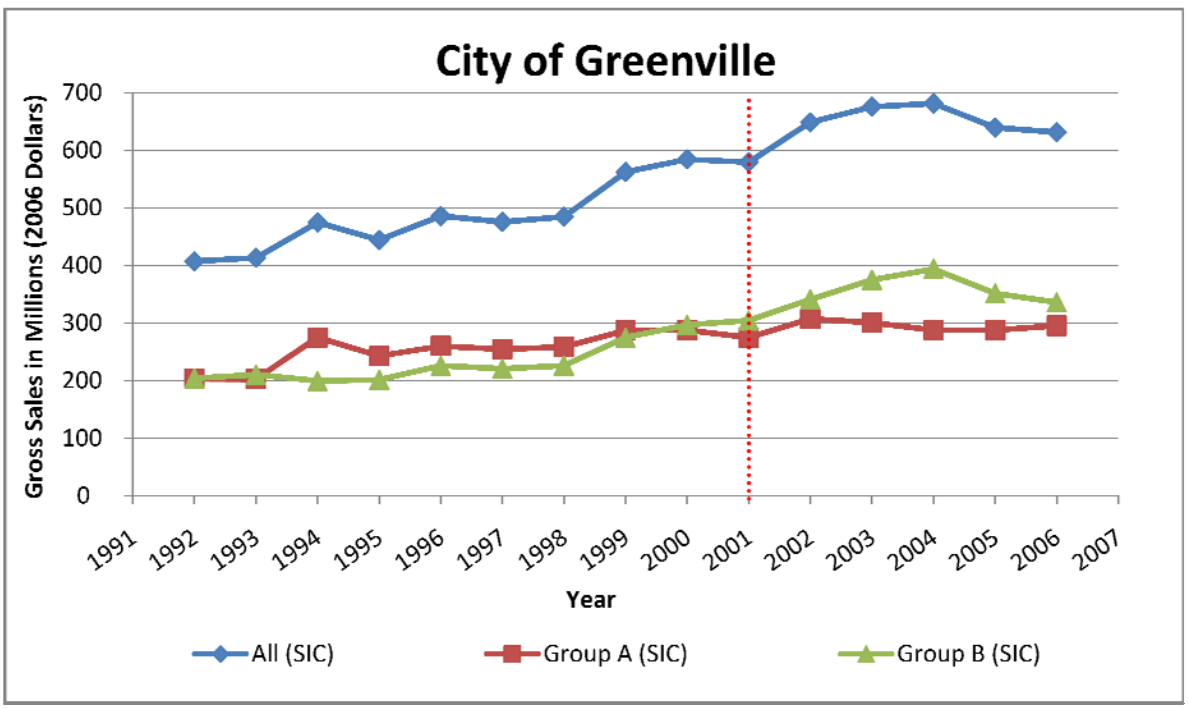


Figure G-10. City of Greenville Total Gross Sales.

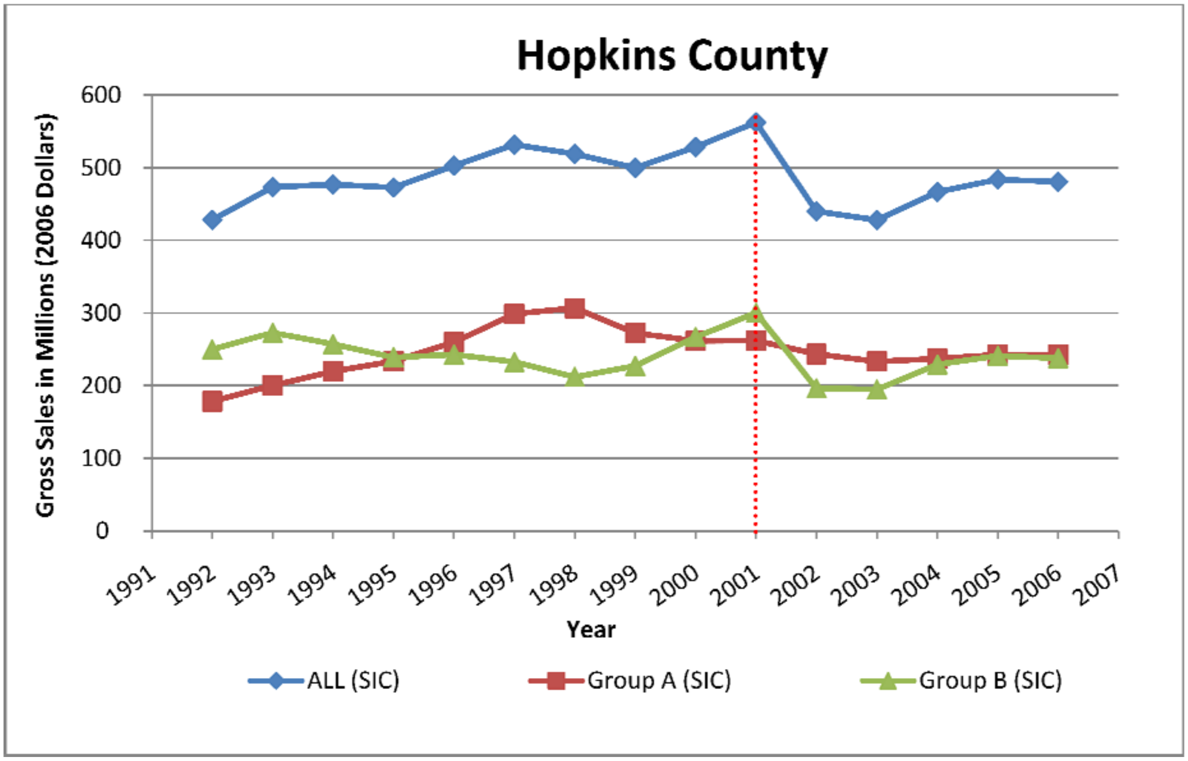


Figure G-11. Hopkins County Total Gross Sales.

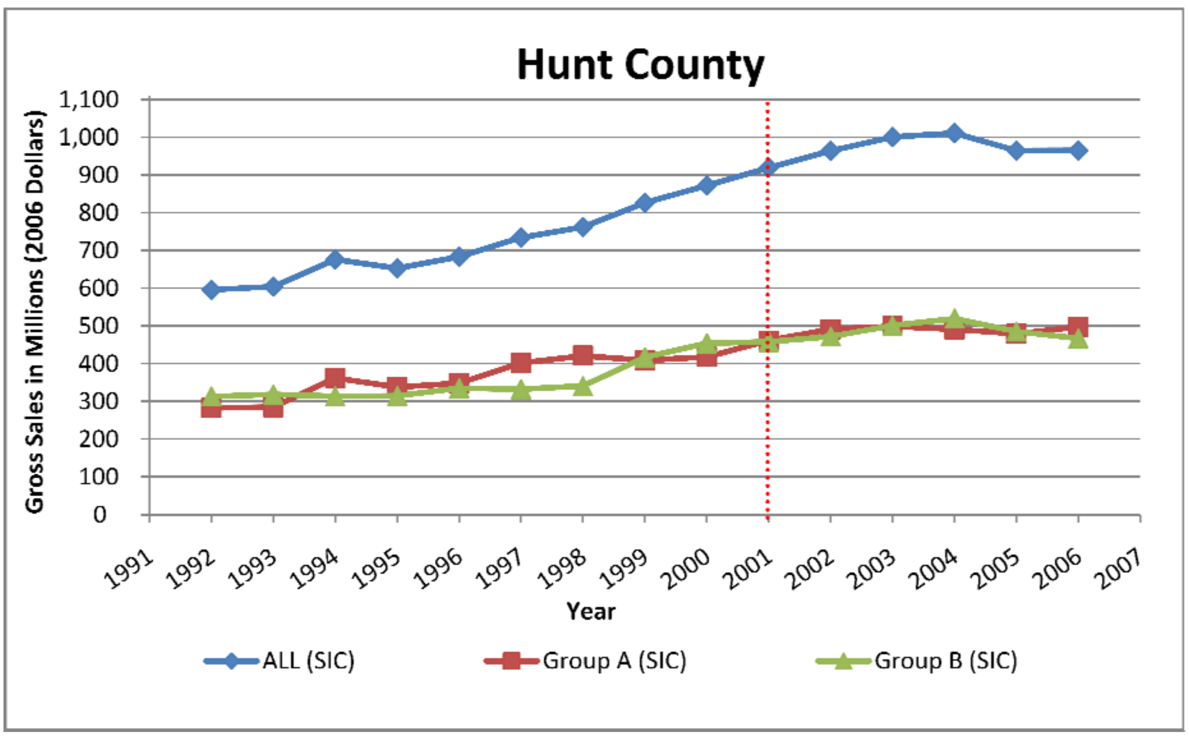


Figure G-12. Hunt County Total Gross Sales.

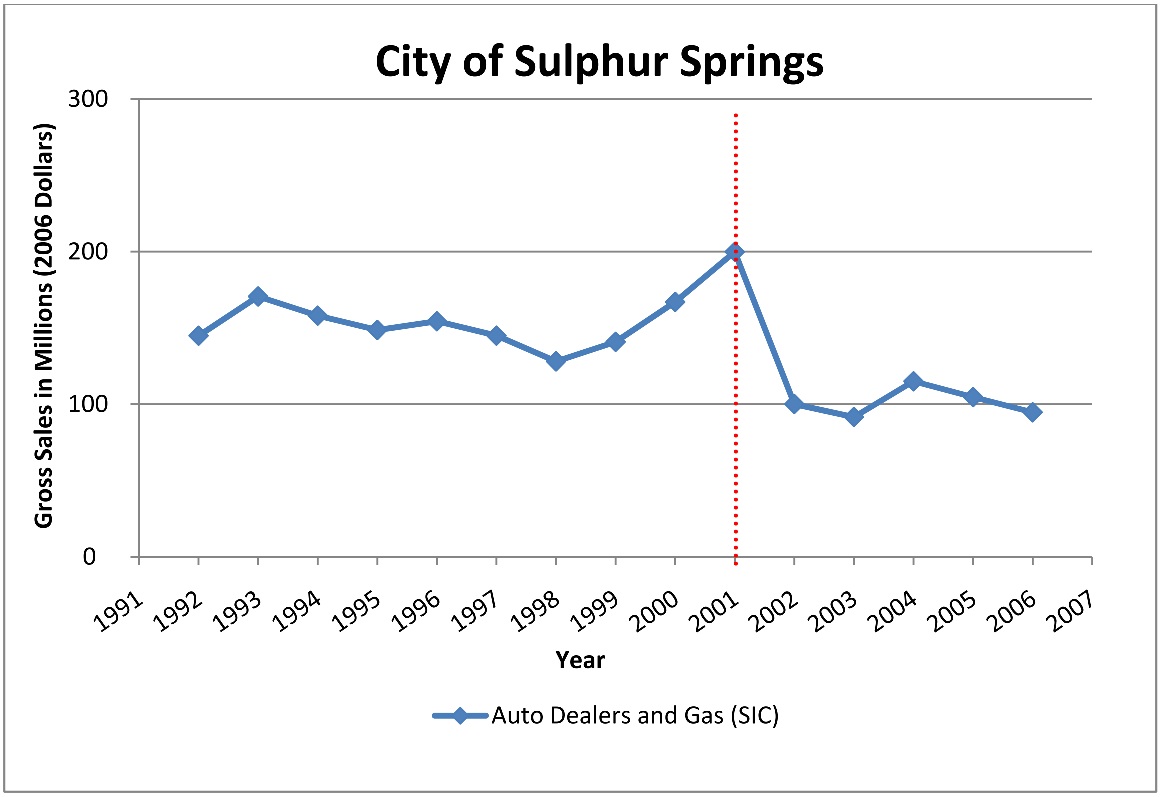


Figure G-13. City of Sulphur Springs Gross Sales of Auto Dealers and Gas.

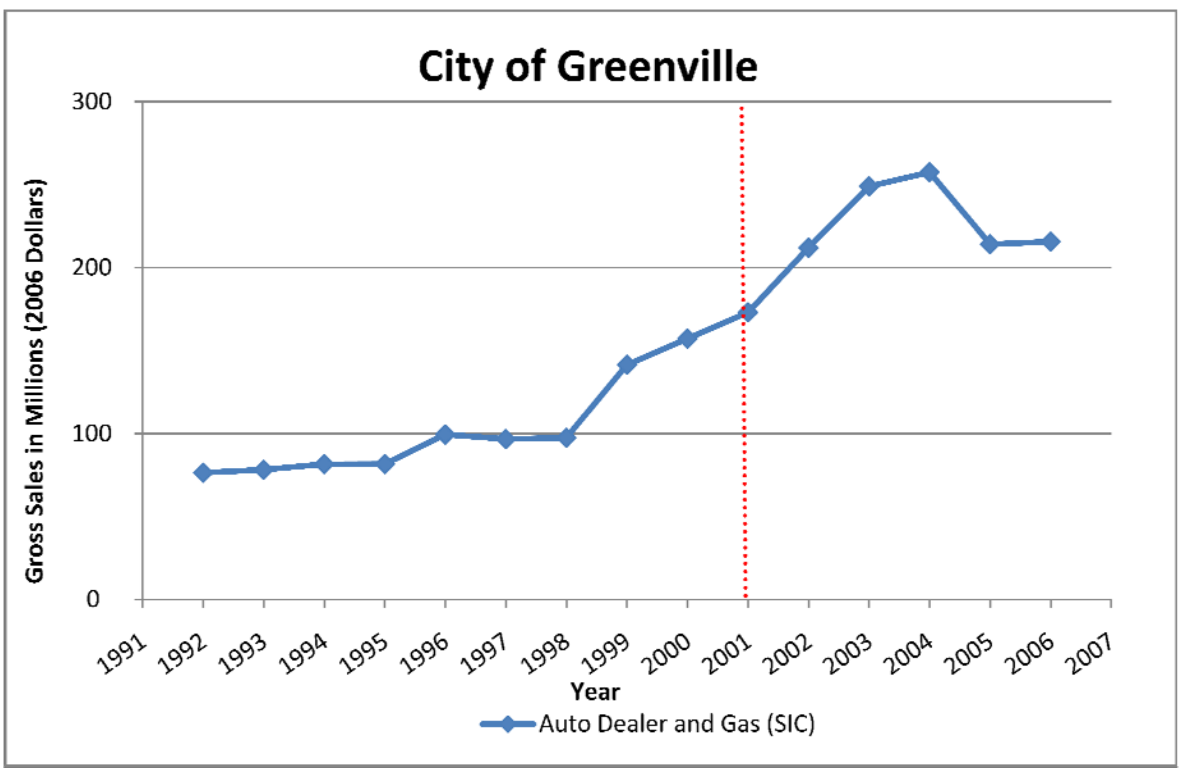


Figure G-14. City of Greenville Gross Sales of Auto Dealers and Gas.

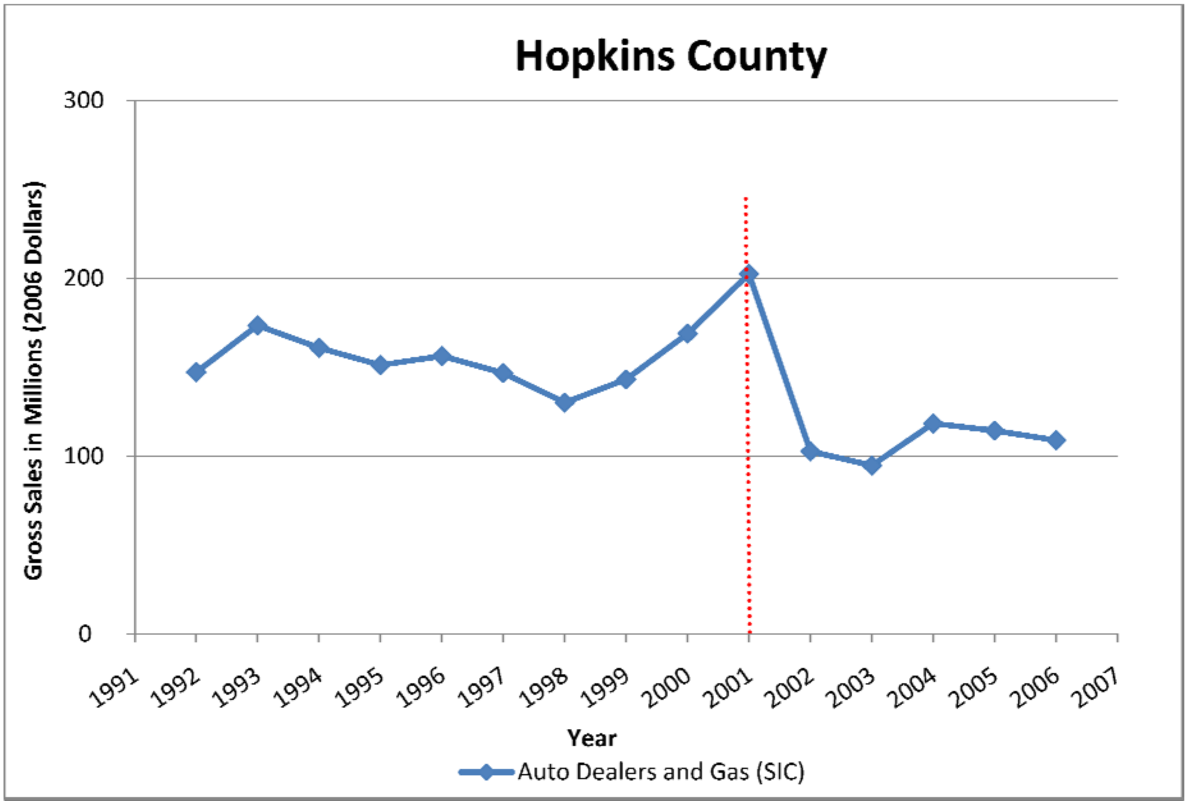


Figure G-15. Hopkins County Gross Sales of Auto Dealers and Gas.

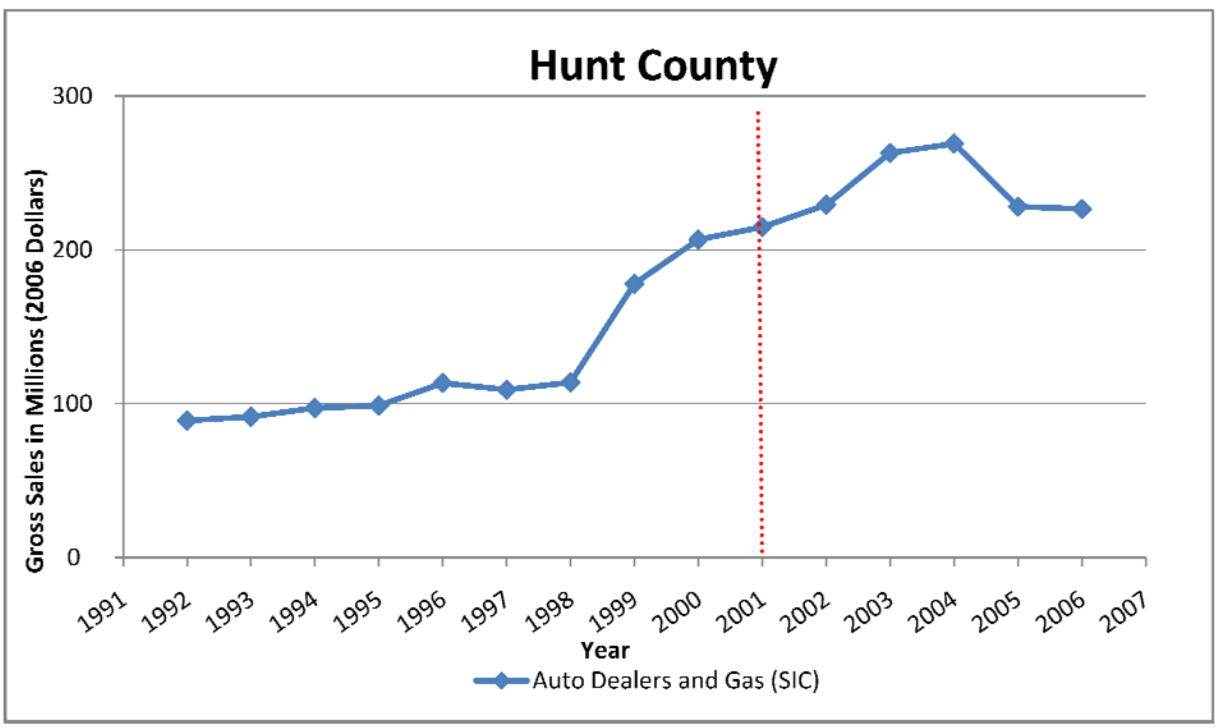


Figure G-16. Hunt County Gross Sales of Auto Dealers and Gas.

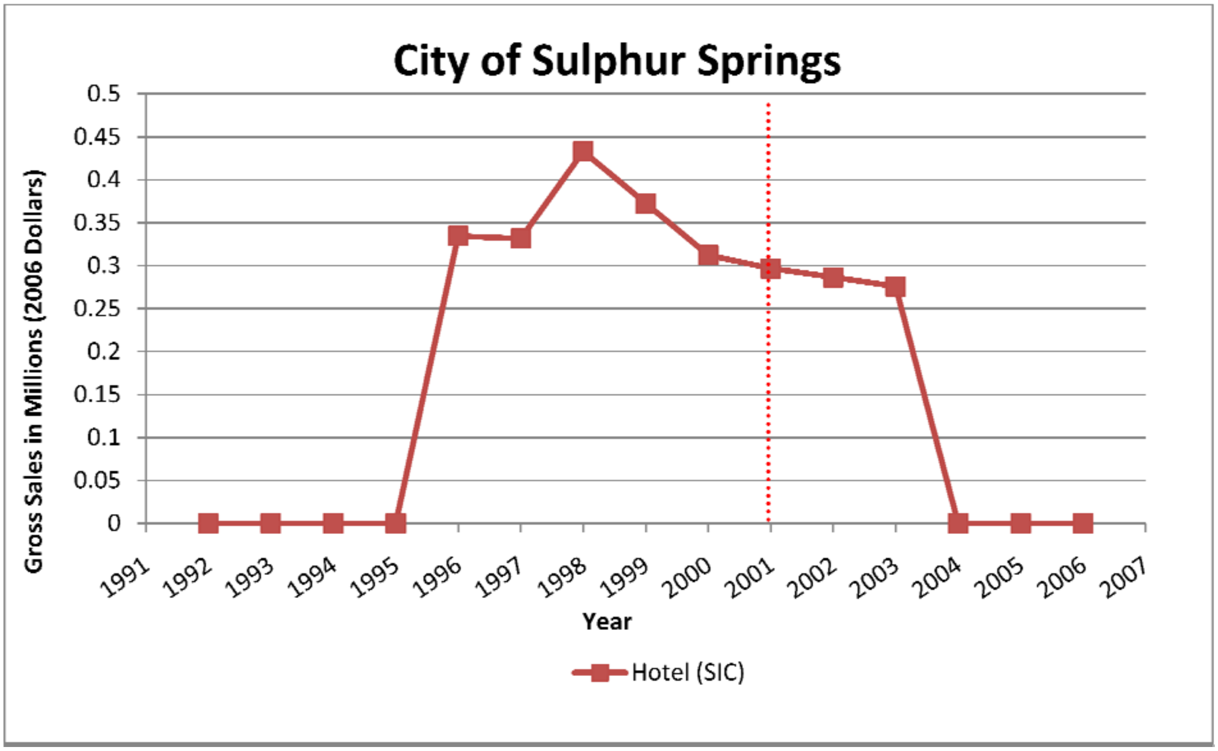


Figure G-17. City of Sulphur Springs Gross Sales of Hotels.

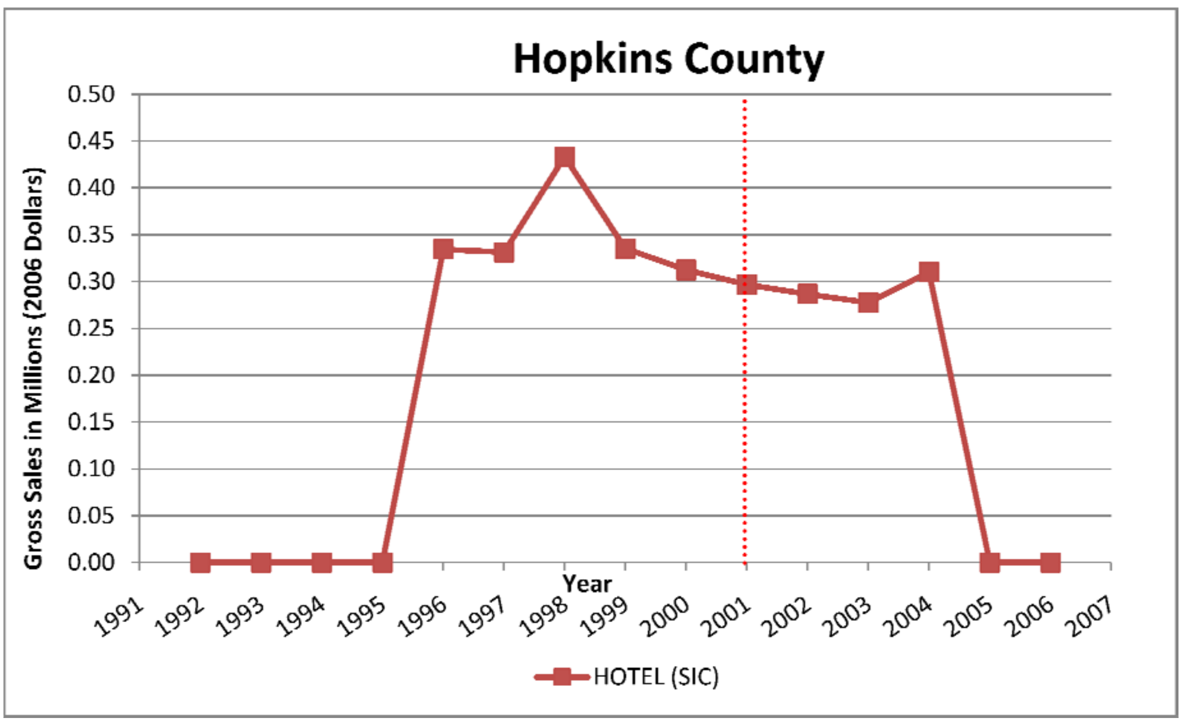


Figure G-18. Hopkins County Gross Sales of Hotels.

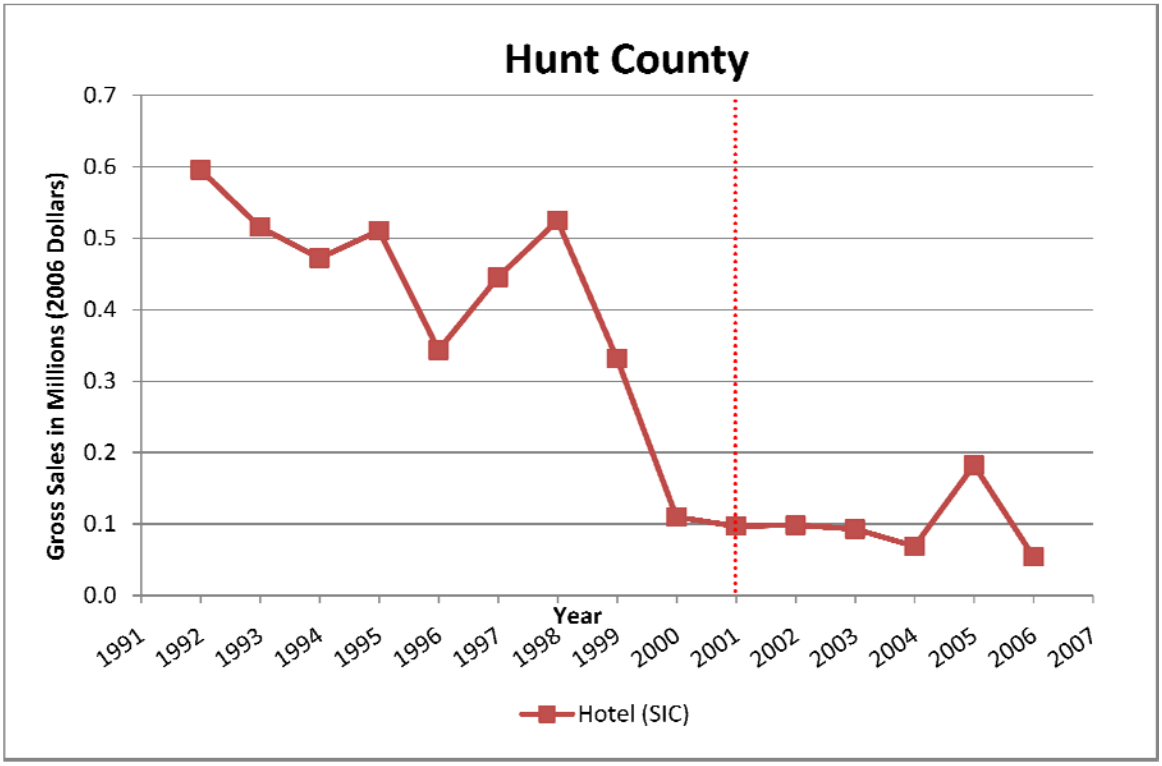


Figure G-19. Hunt County Gross Sales of Hotels.

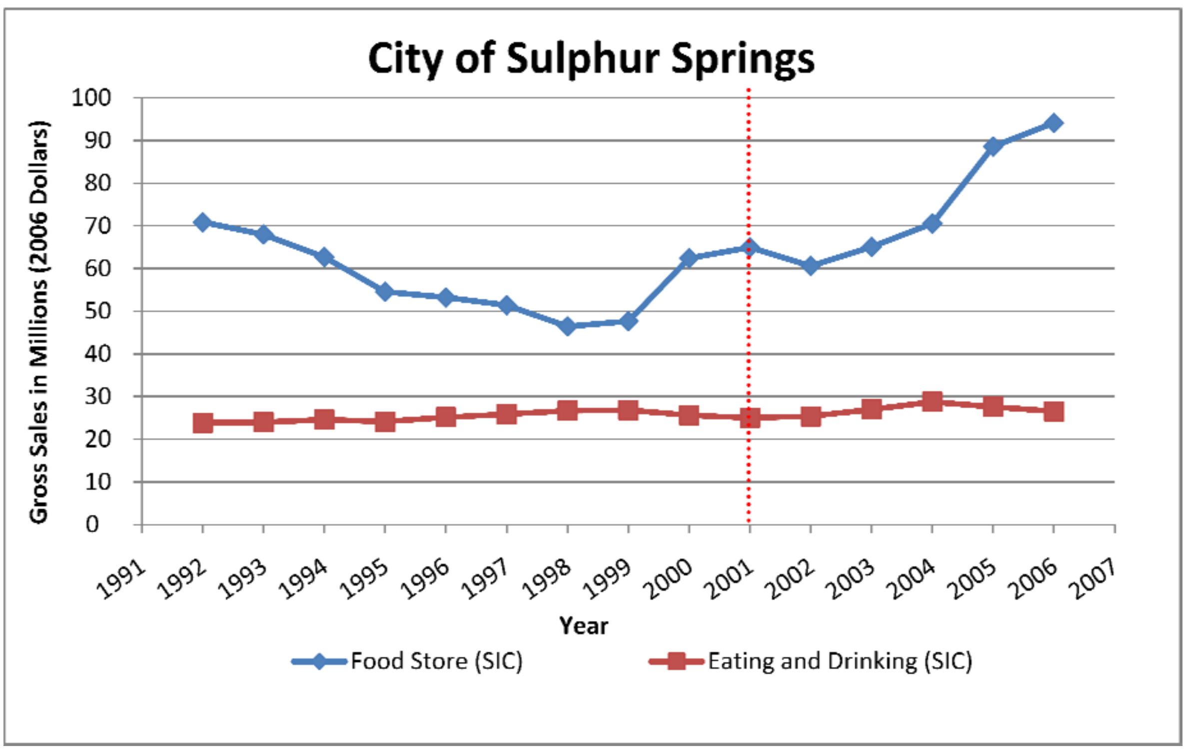


Figure G-20. City of Sulphur Springs Gross Sales of Food Stores and Eating and Drinking Places.

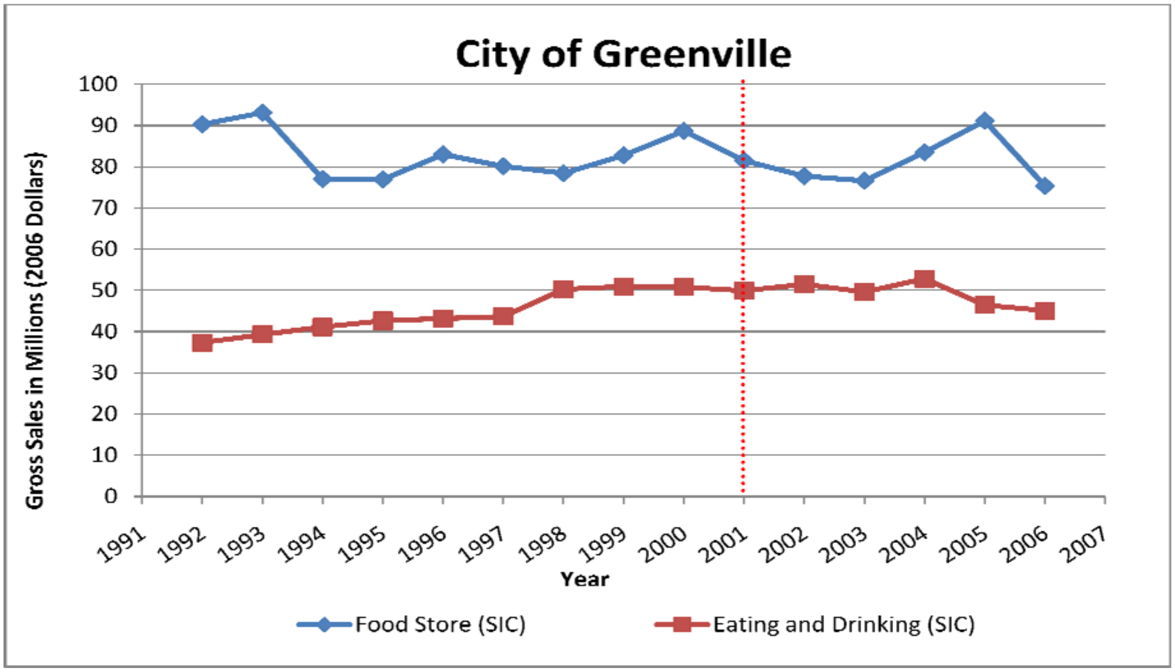


Figure G-21. City of Greenville Gross Sales of Food Stores and Eating and Drinking Places.

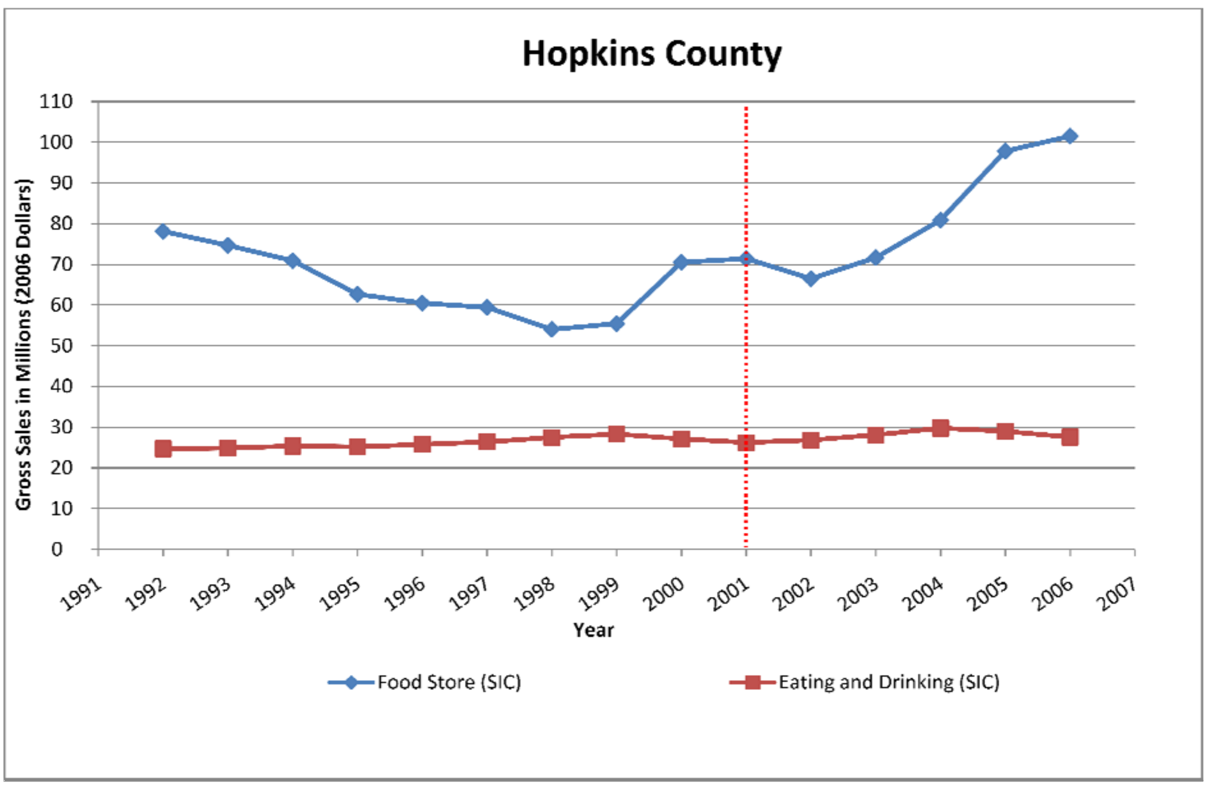


Figure G-22. Hopkins County Gross Sales of Food and Eating and Drinking Places.

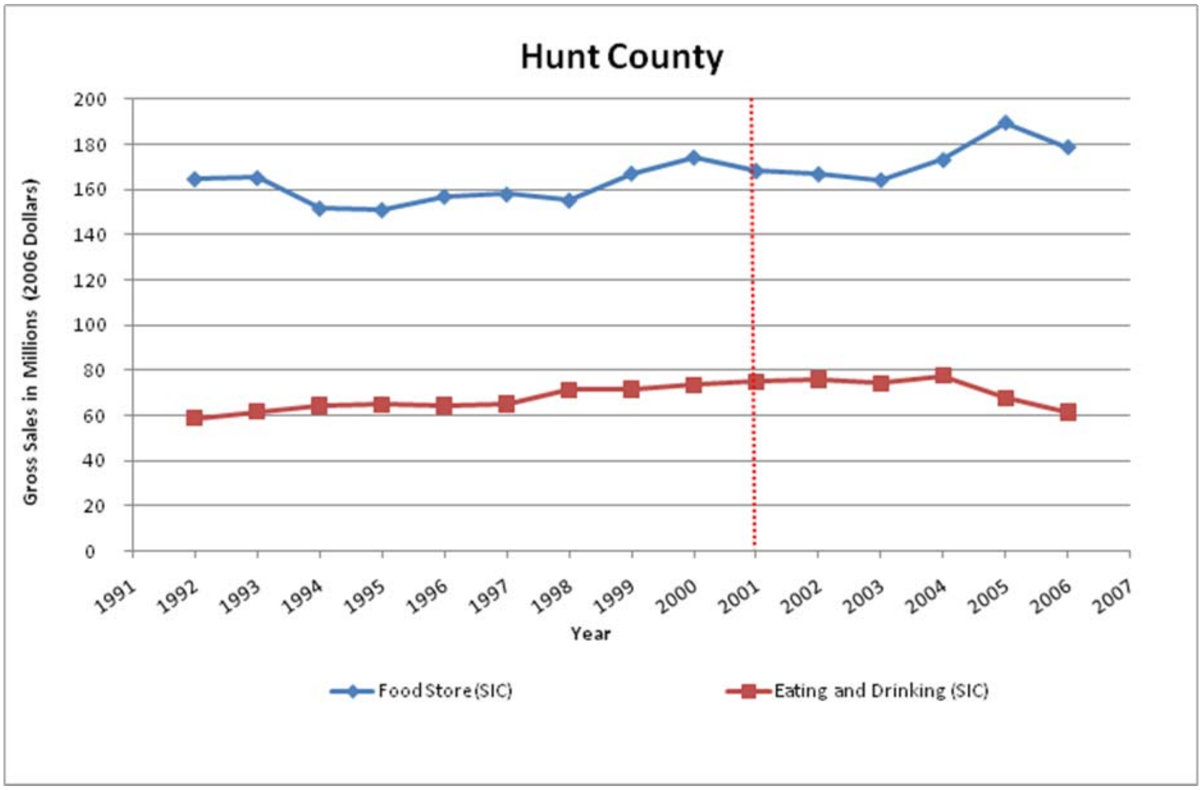


Figure G-23. Hunt County Goss Sales of Food Stores and Eating and Drinking Places.

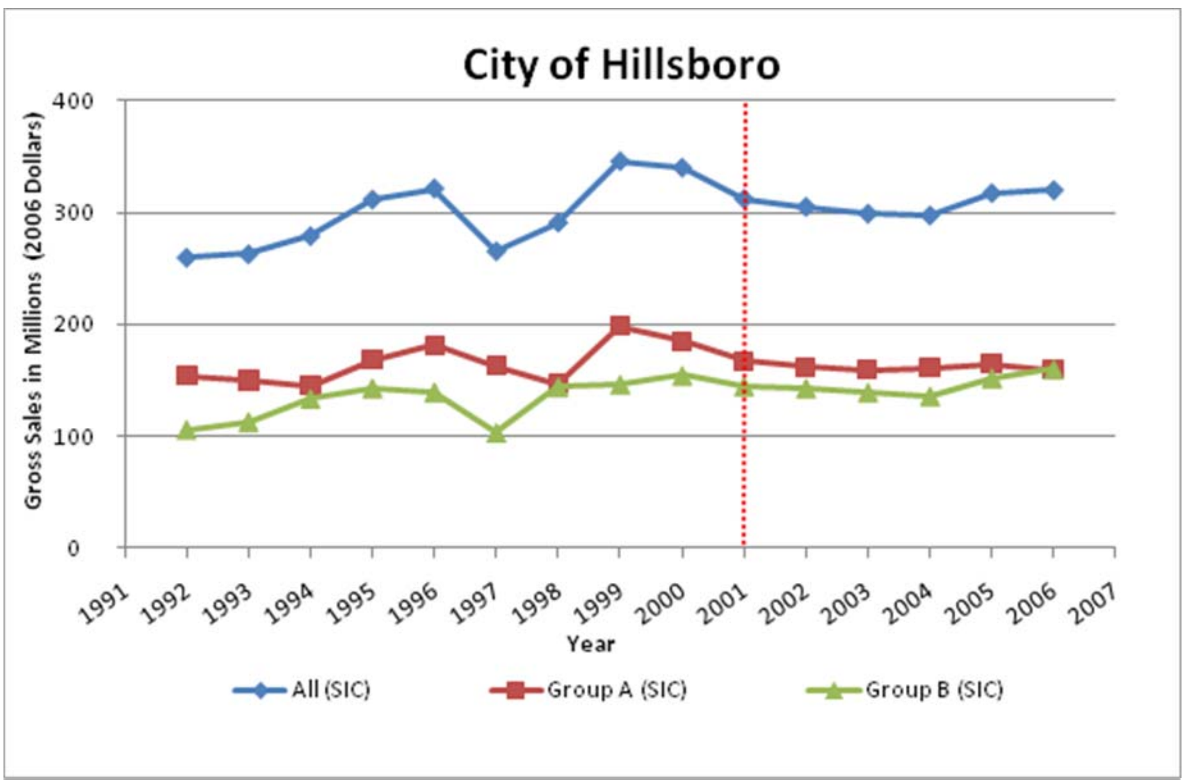


Figure G-24. City of Hillsboro Total Gross Sales.

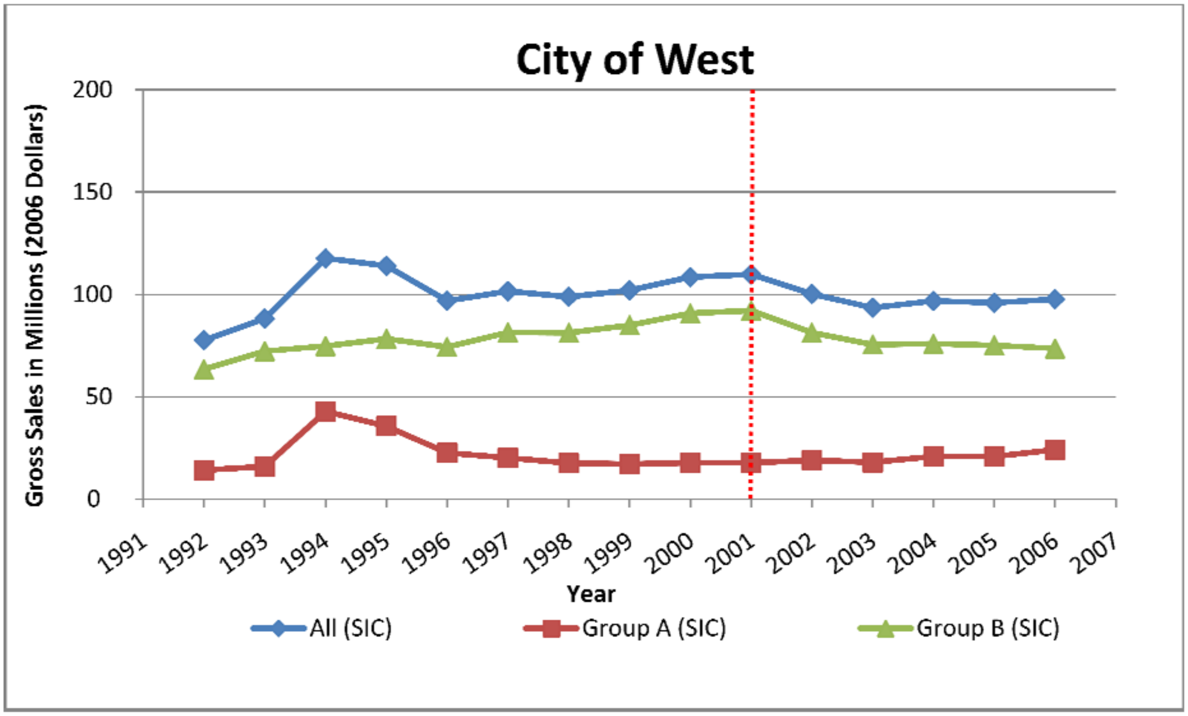


Figure G-25. City of West Total Gross Sales.

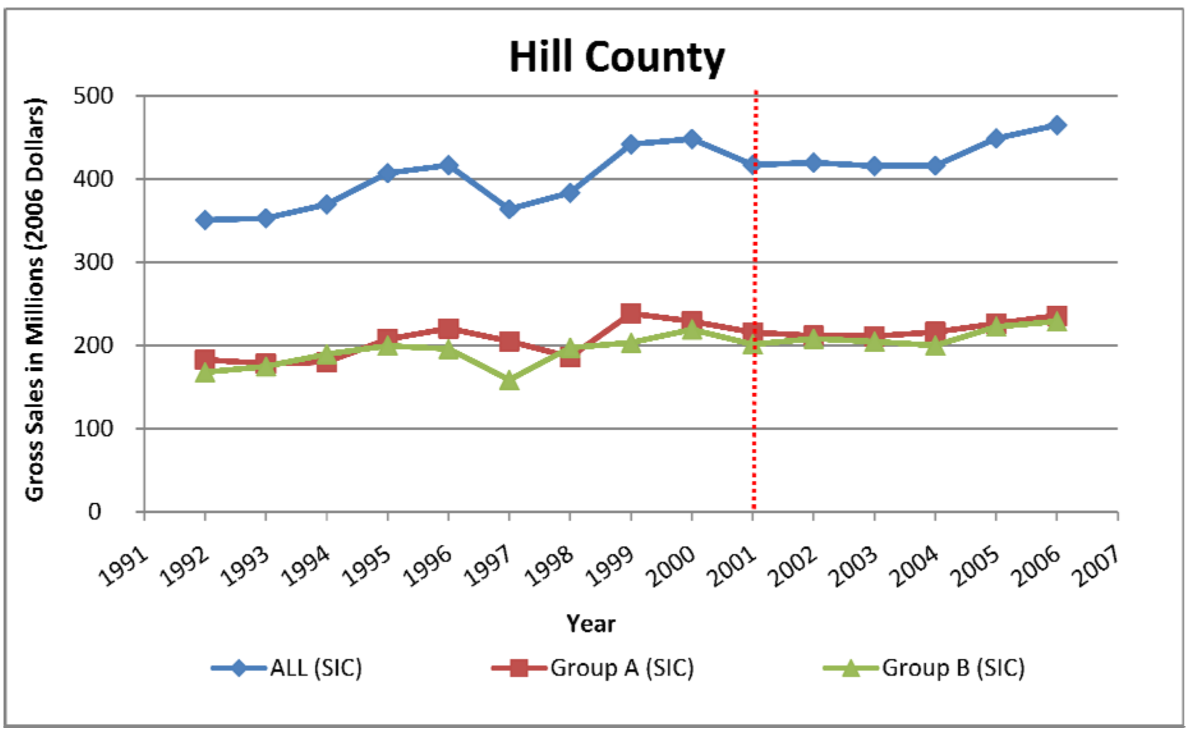


Figure G-26. Hill County Total Gross Sales.

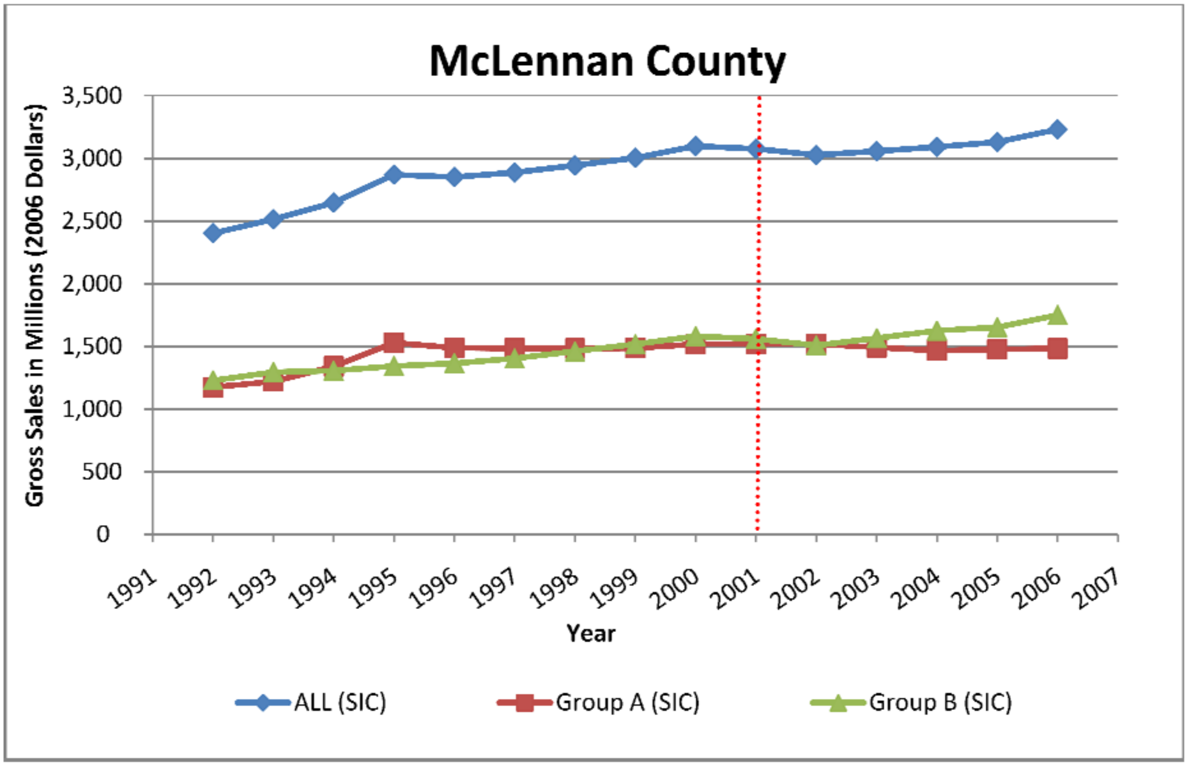


Figure G-27. McLennan County Total Gross Sales.

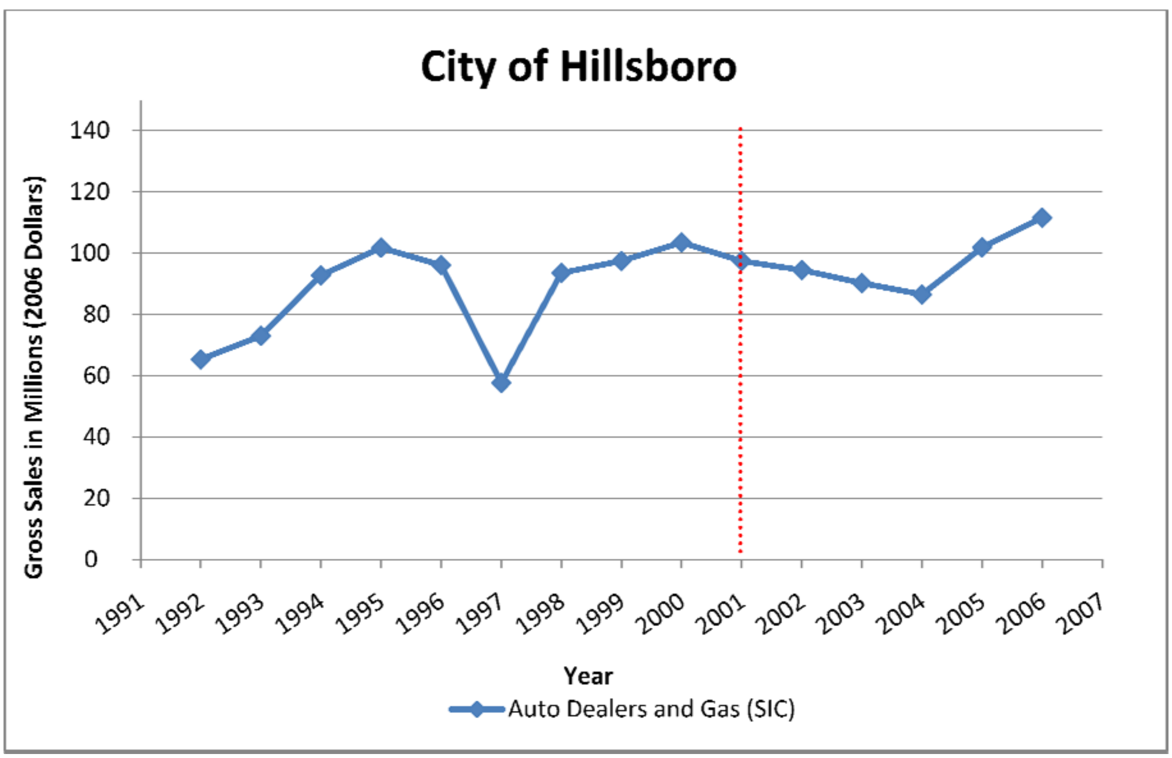


Figure G-28. City of Hillsboro Gross Sales of Auto Dealers and Gas.

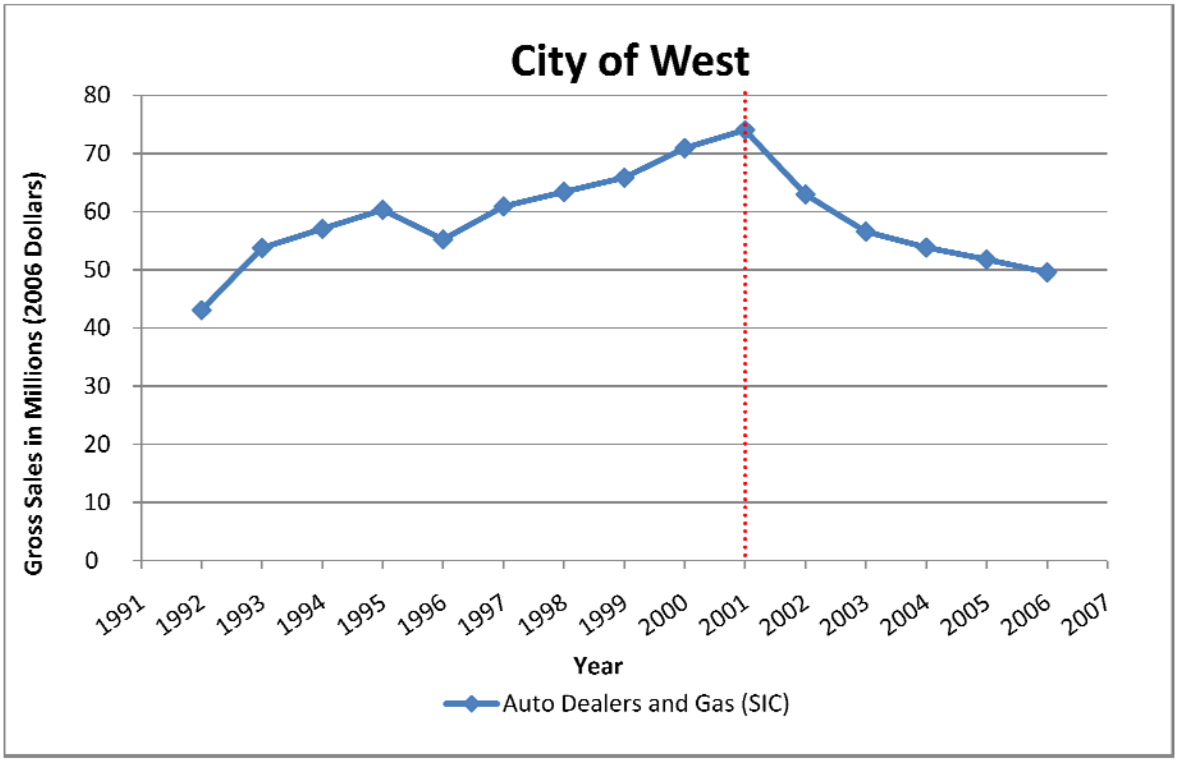


Figure G-29. City of West Gross Sales of Auto Dealers and Gas.

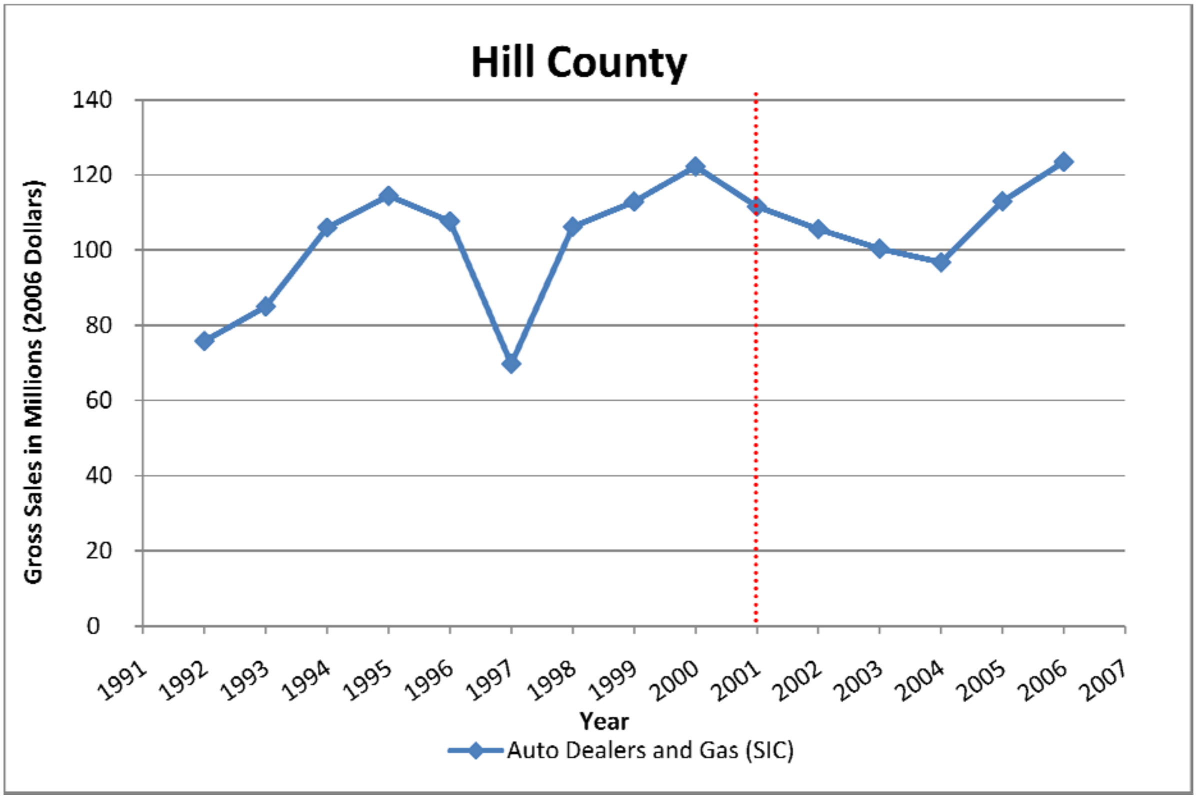


Figure G-30. Hill County Gross Sales of Auto Dealers and Gas.

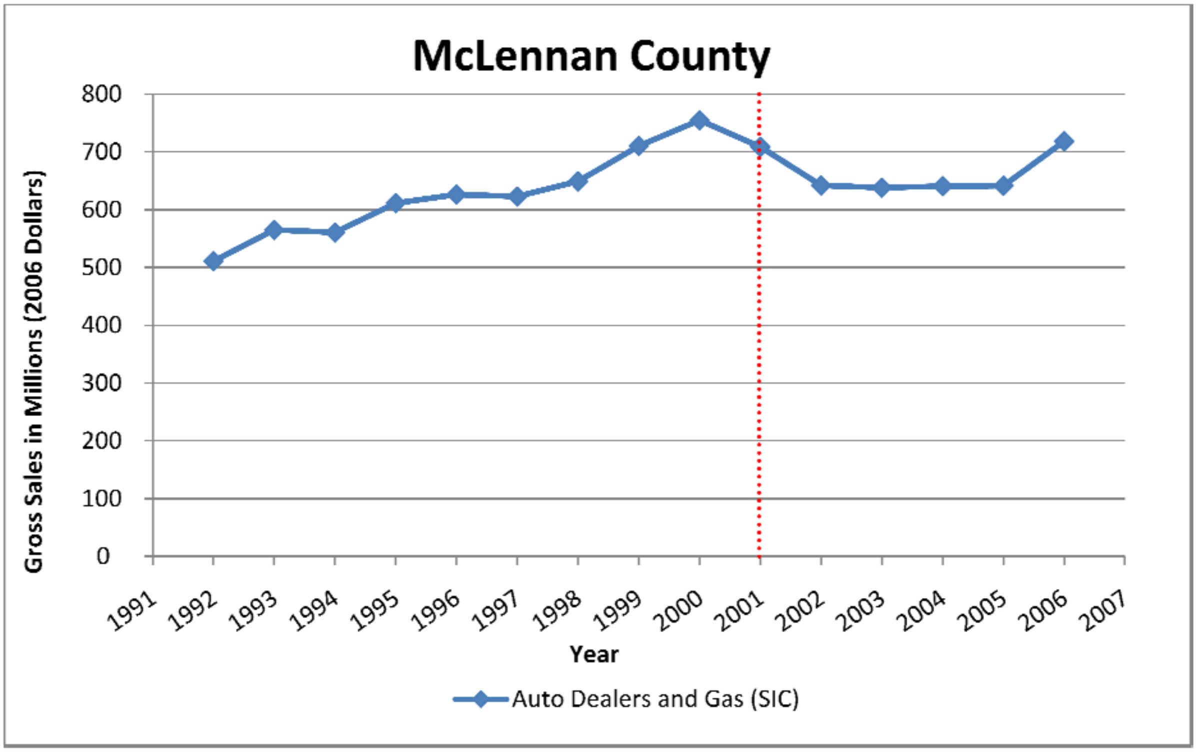


Figure G-31. McLennan County Gross Sales of Auto Dealers and Gas.

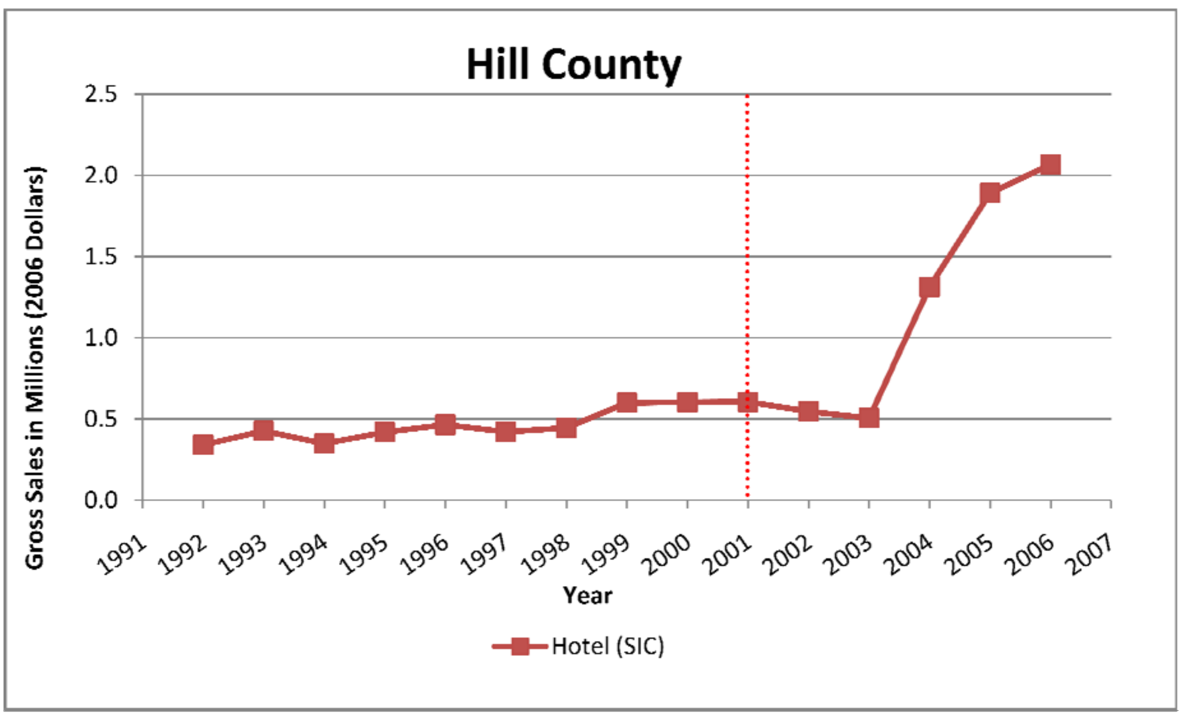


Figure G-32. Hill County Gross Sales of Hotels.

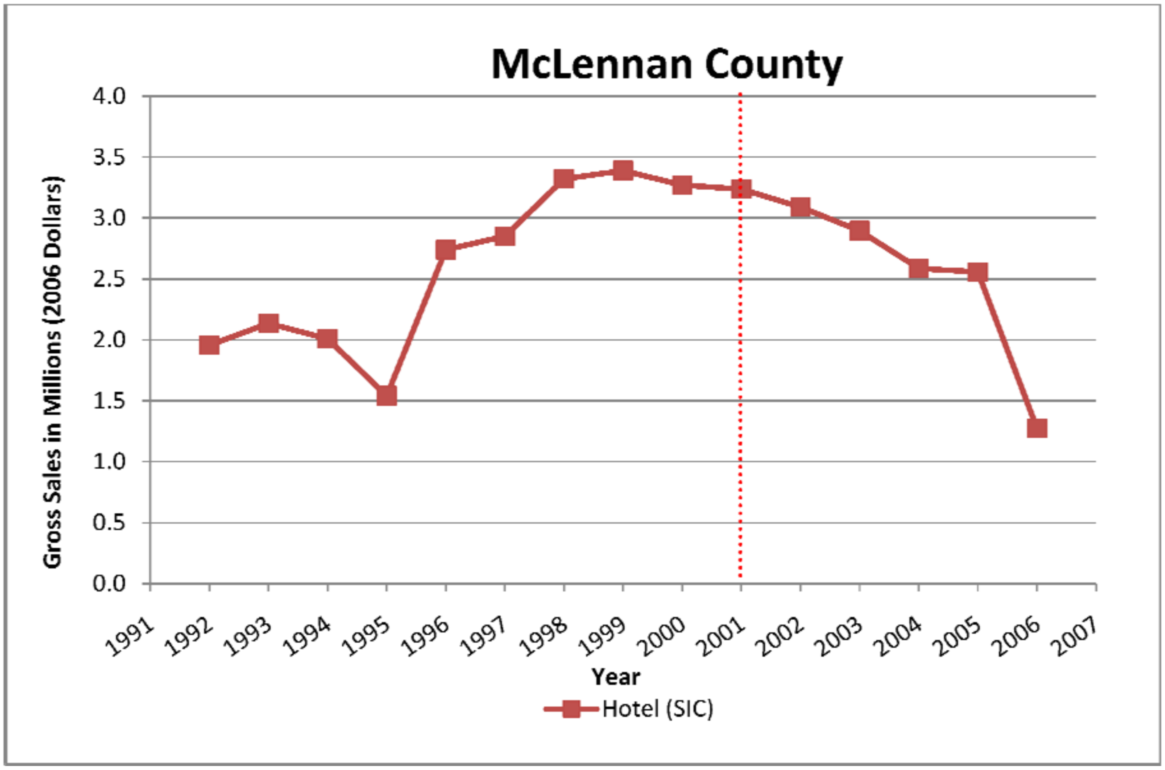


Figure G-33. McLennan County Gross Sales of Hotels.

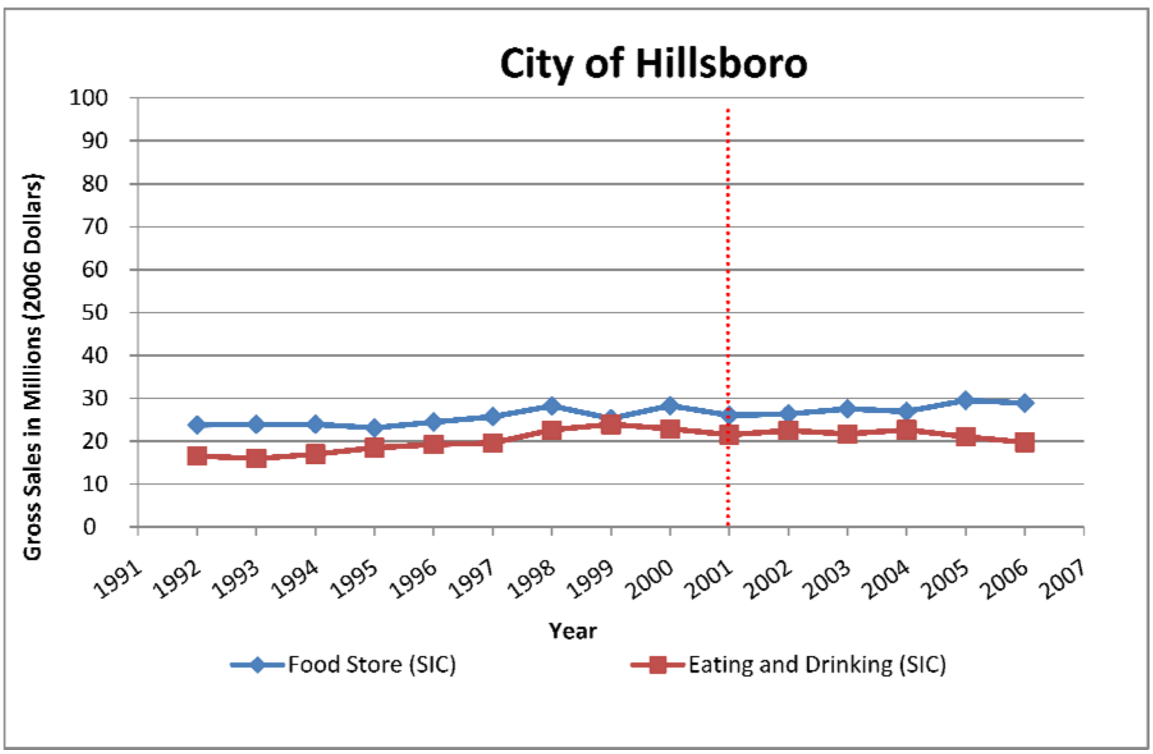


Figure G-34. City of Hillsboro Gross Sales of Food Stores and Eating and Drinking Places.

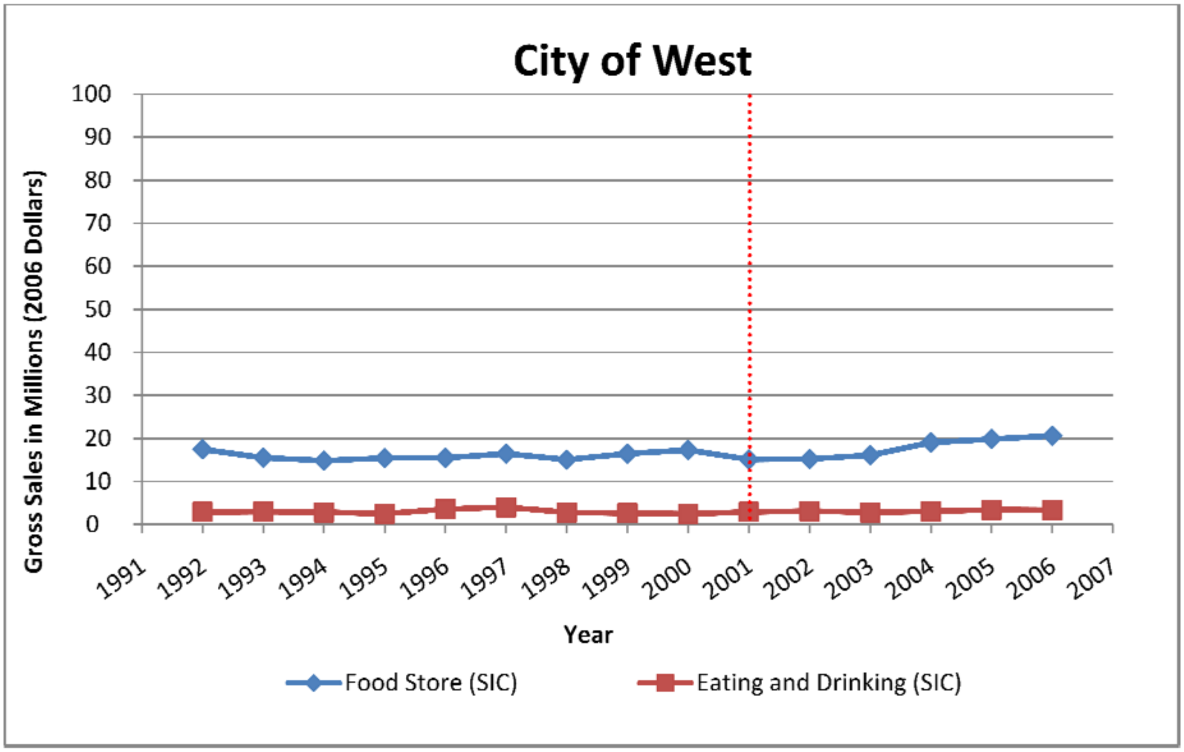


Figure G-35. City of West Gross Sales of Food Stores and Eating and Drinking Places.

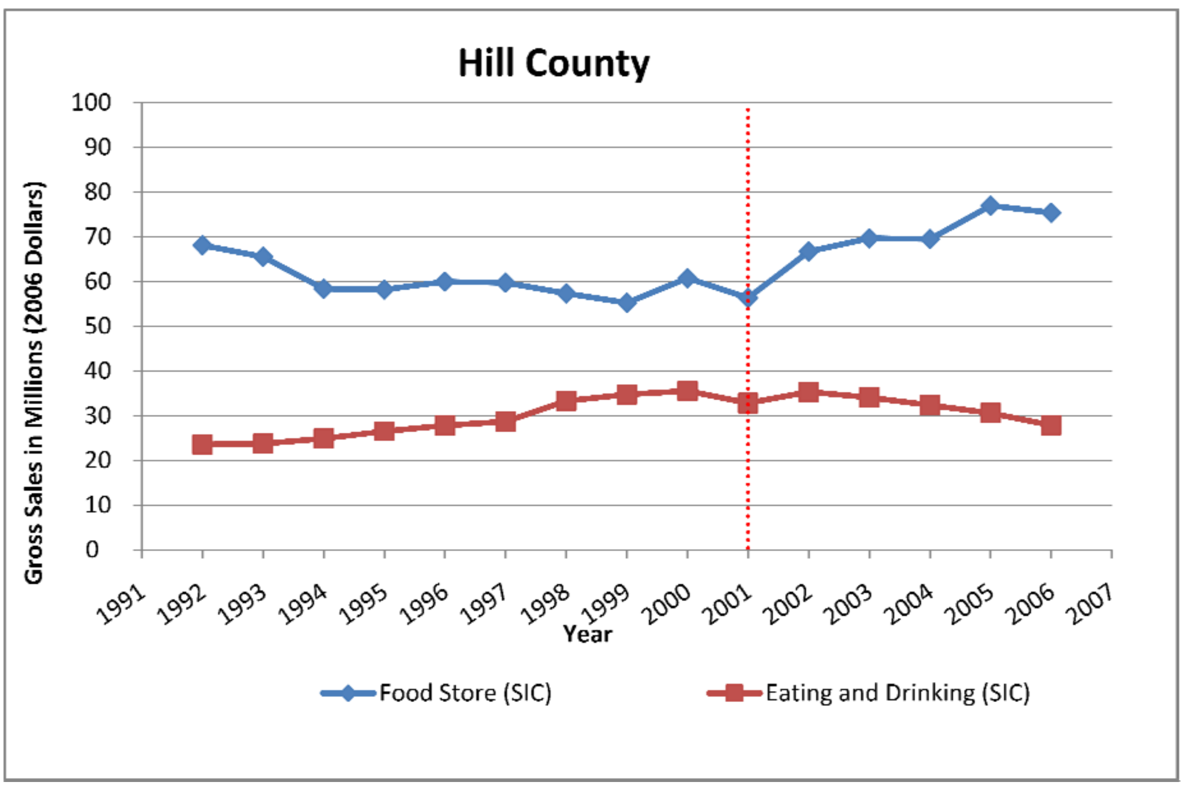


Figure G-36. Hill County Gross Sales of Food Stores and Eating and Drinking Places.

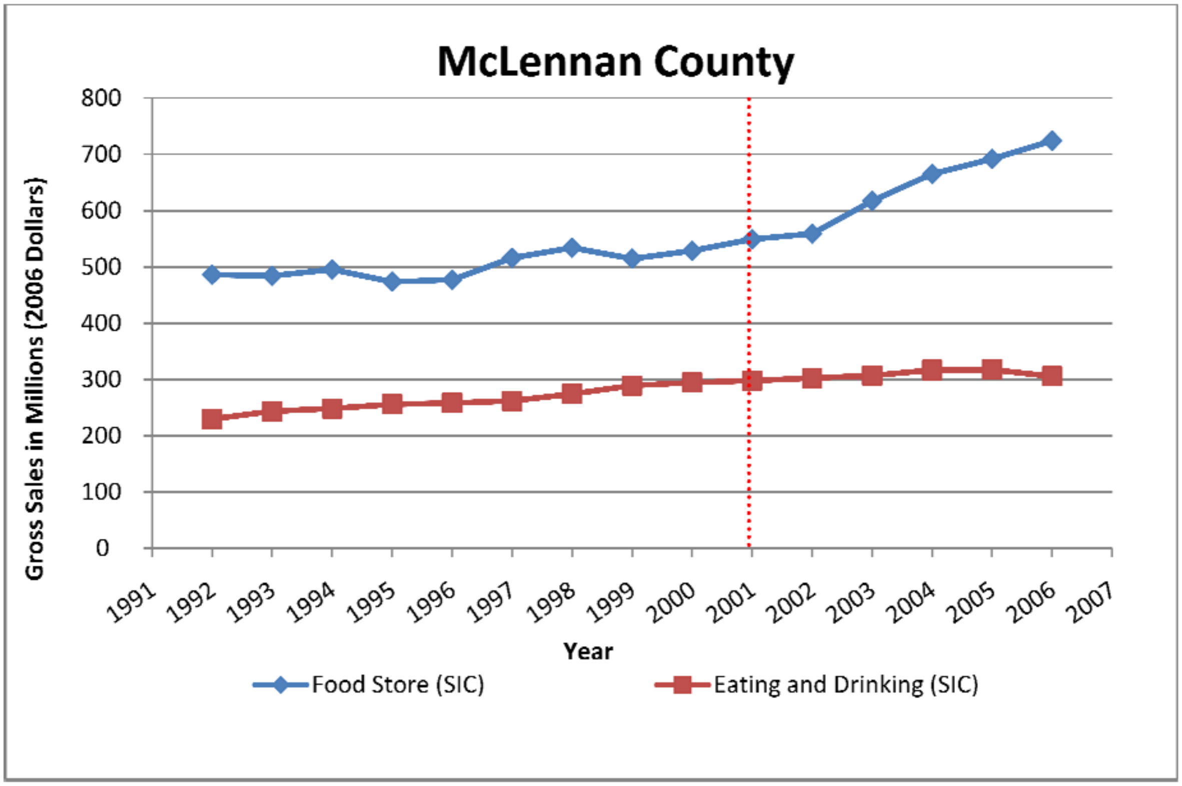


Figure G-37. McLennan County Gross Sales of Food Stores and Eating and Drinking Places.

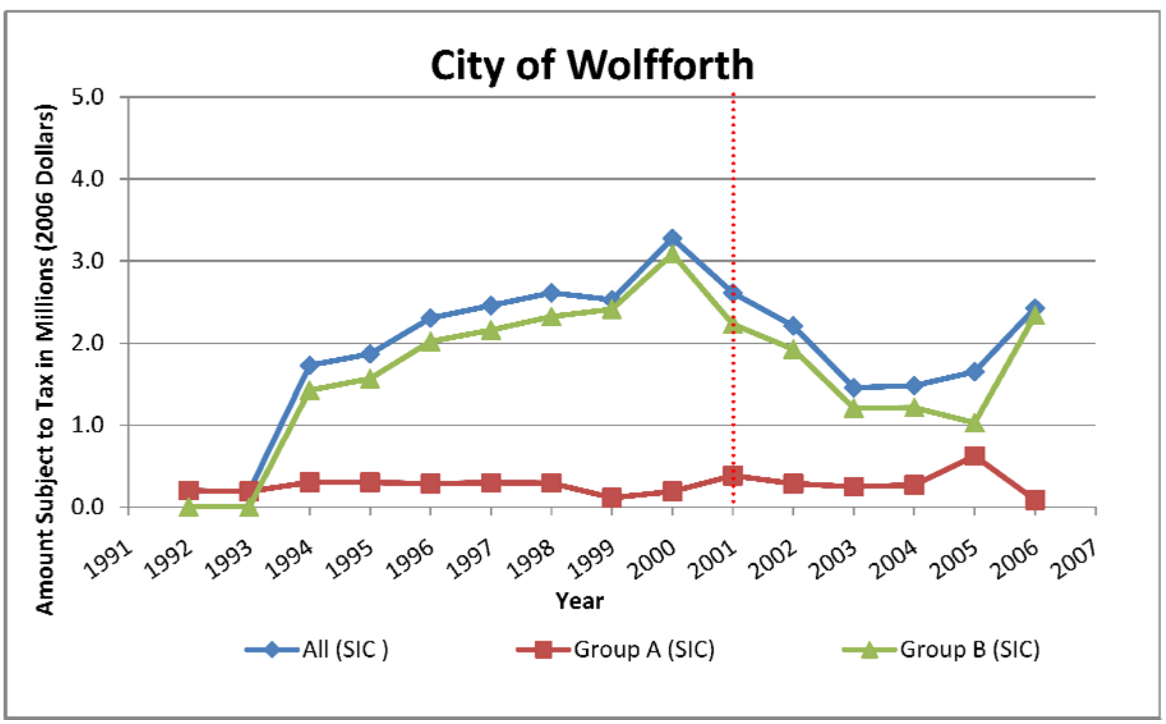


Figure G-38. City of Wolfforth Total Gross Sales.

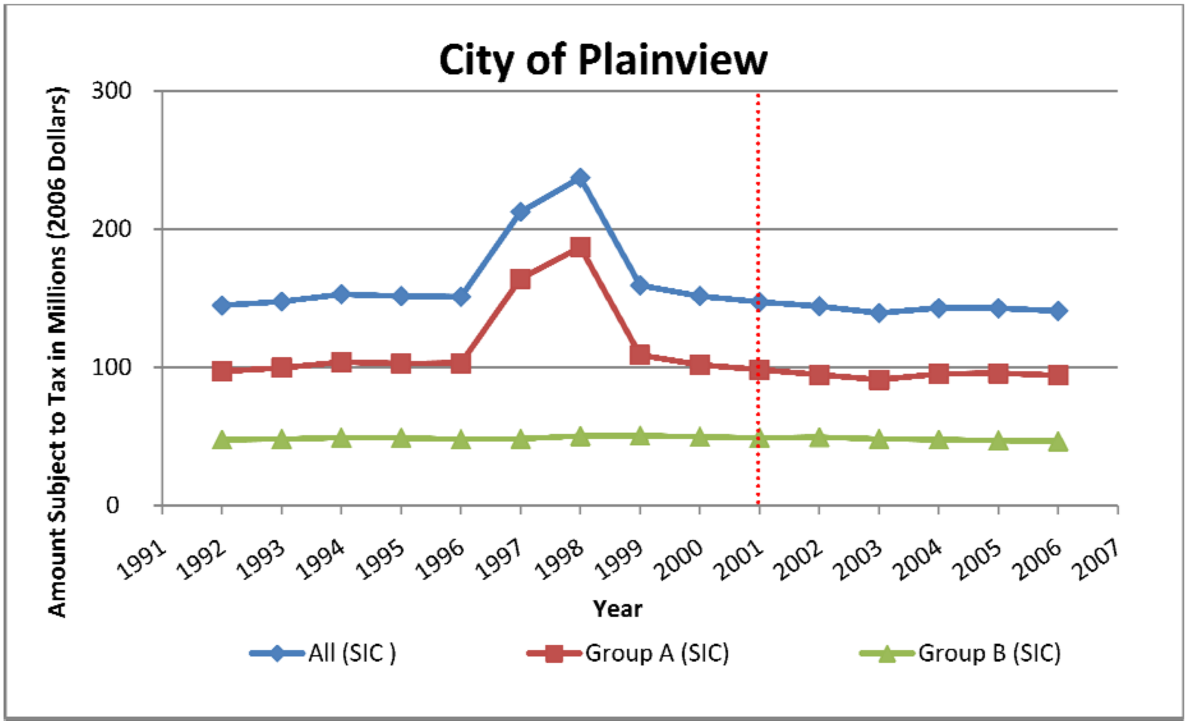


Figure G-39. City of Plainview Total Gross Sales.

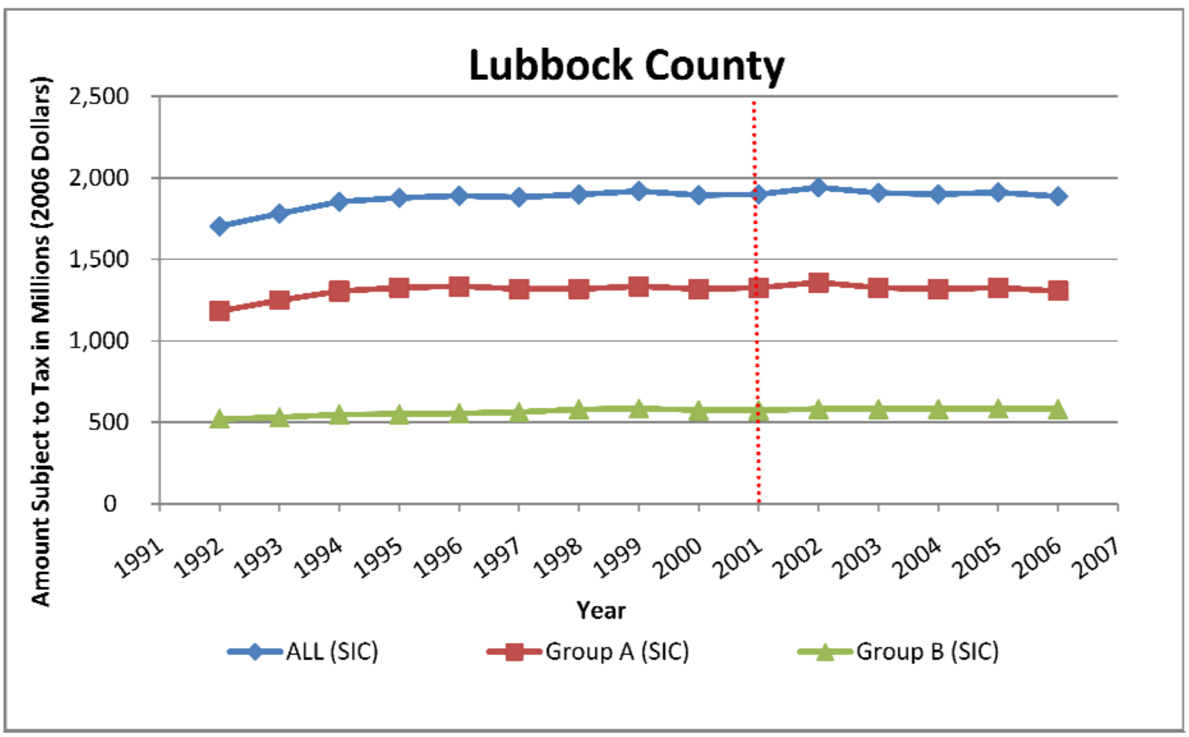


Figure G-40. Lubbock County Total Gross Sales.

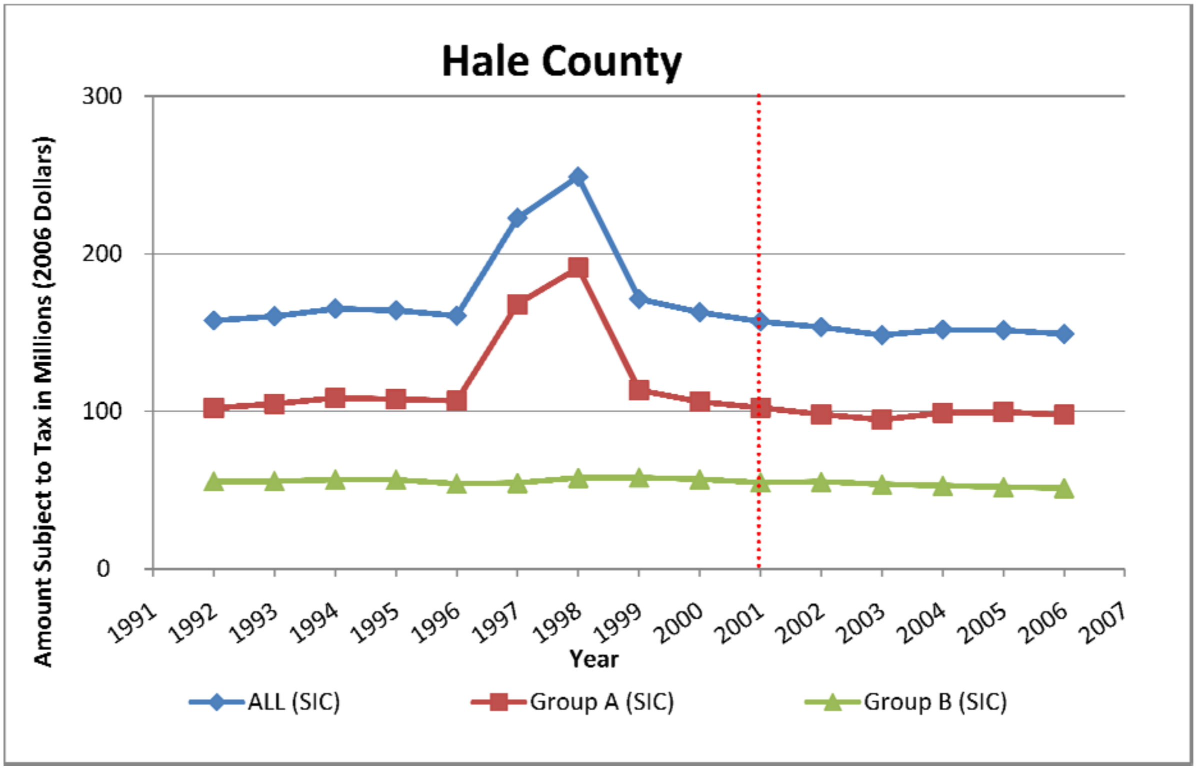


Figure G-41. Hale County Total Gross Sales.

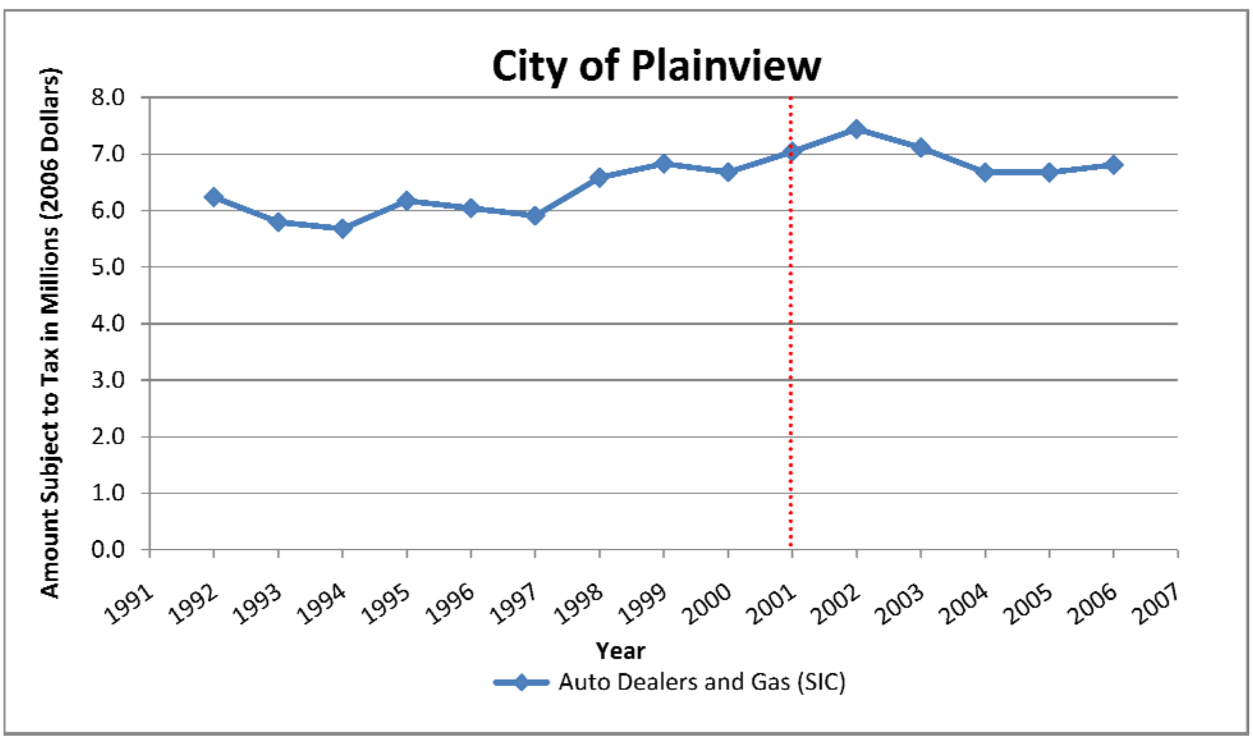


Figure G-42. City of Plainview Gross Sales of Auto Dealers and Gas.

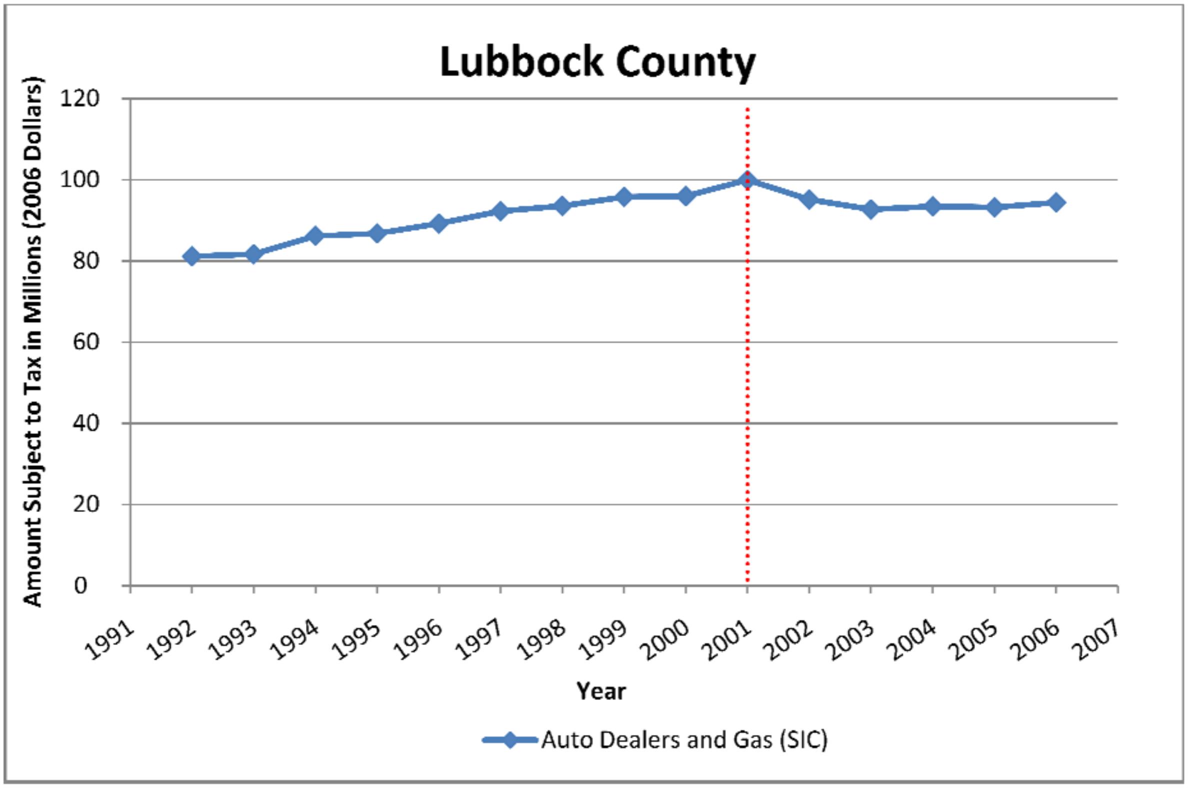


Figure G-43. Lubbock County Gross Sales of Auto Dealers and Gas.

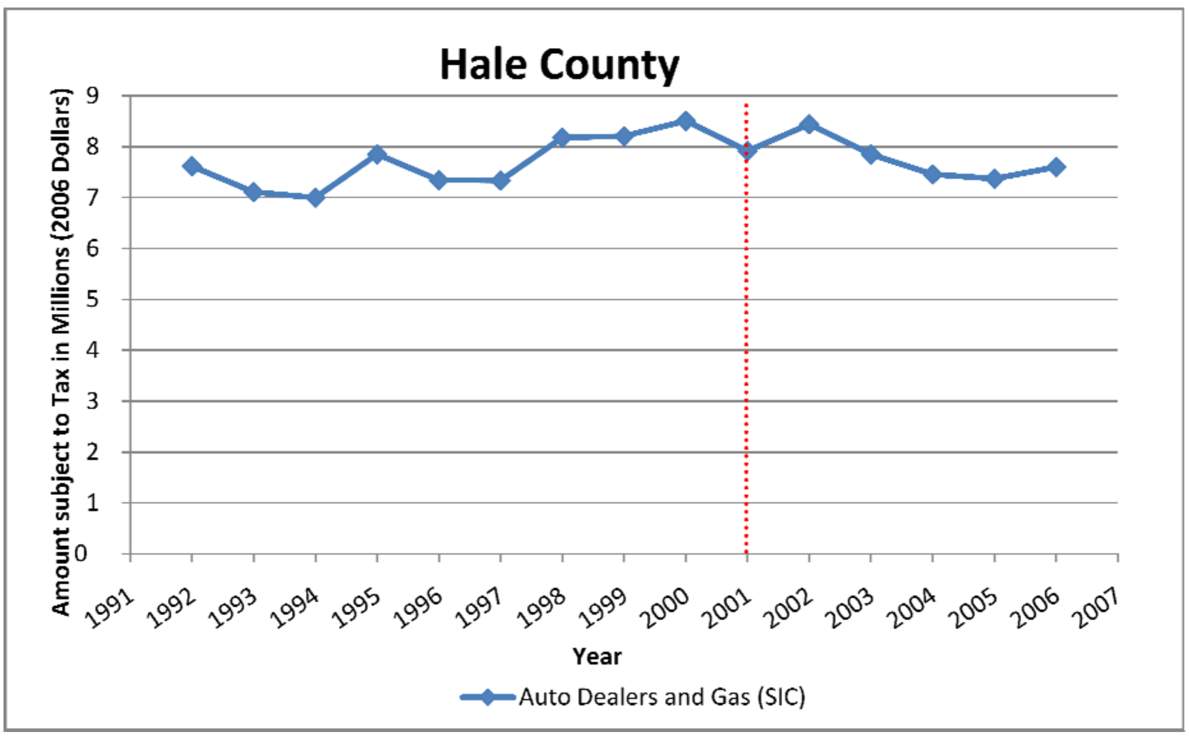


Figure G-44. Hale County Gross Sales of Auto Dealers and Gas.

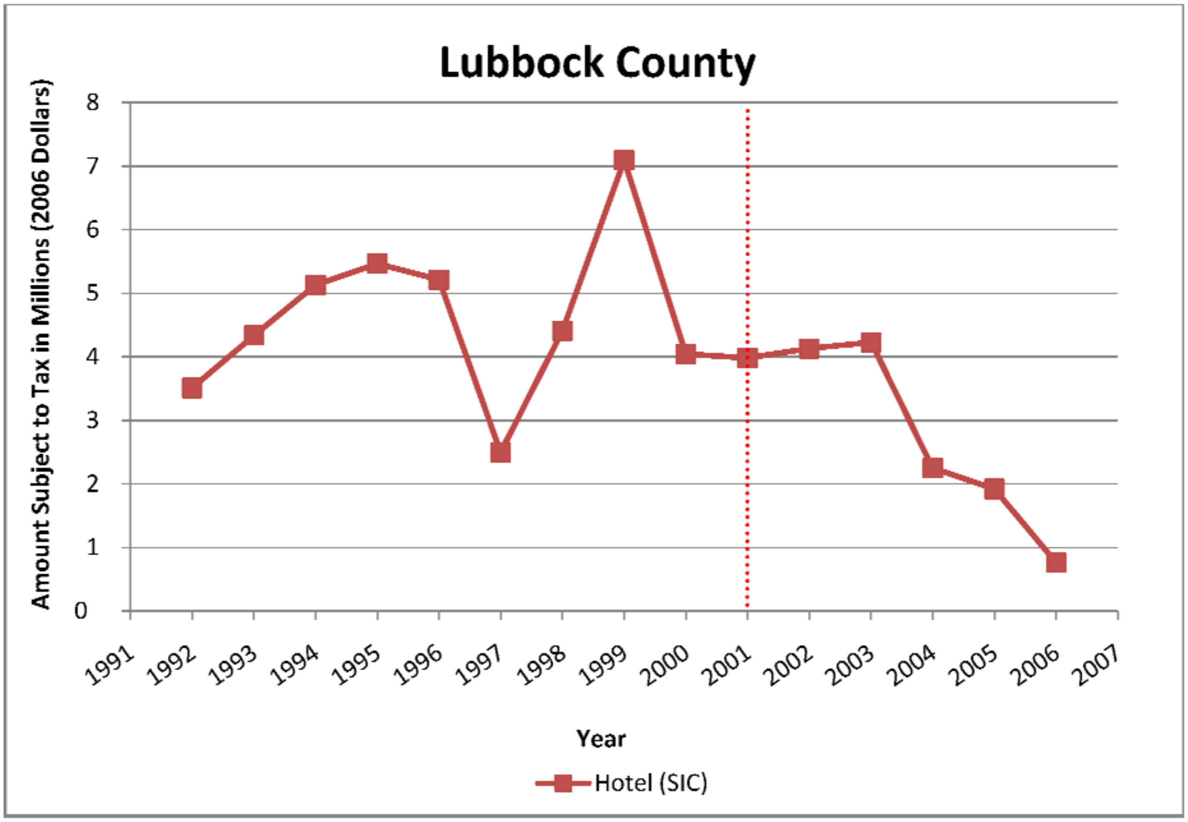


Figure G-45. Lubbock County Gross Sales of Hotels.

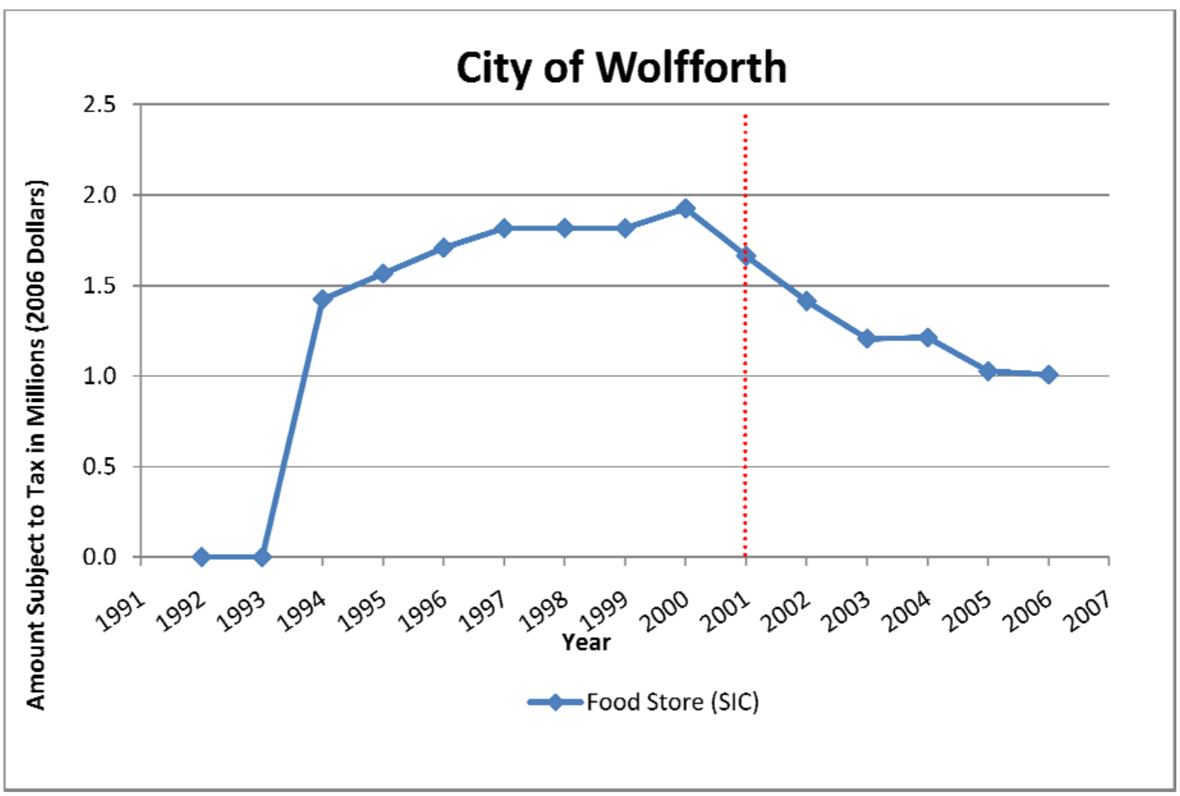


Figure G-46. Wolfforth Gross Sales of Food Stores and Eating and Drinking Places.

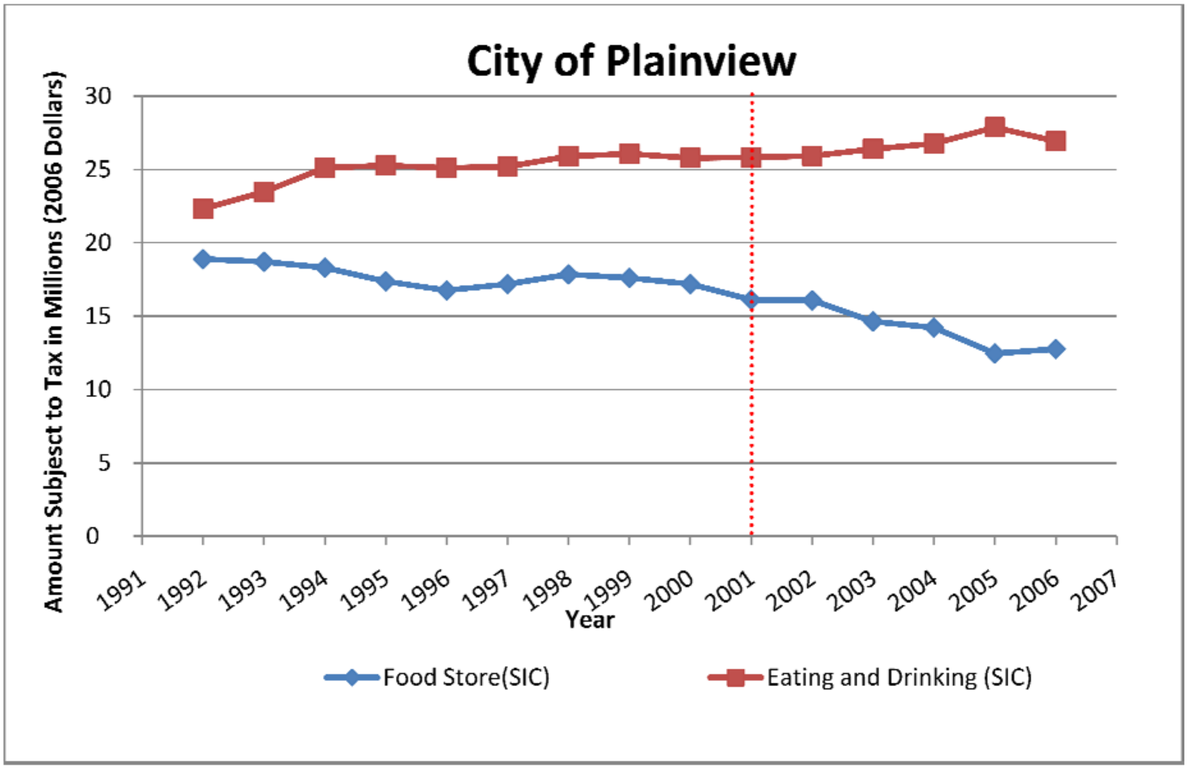


Figure G-47. Plainview Gross Sales of Food Stores and Eating and Drinking Places.

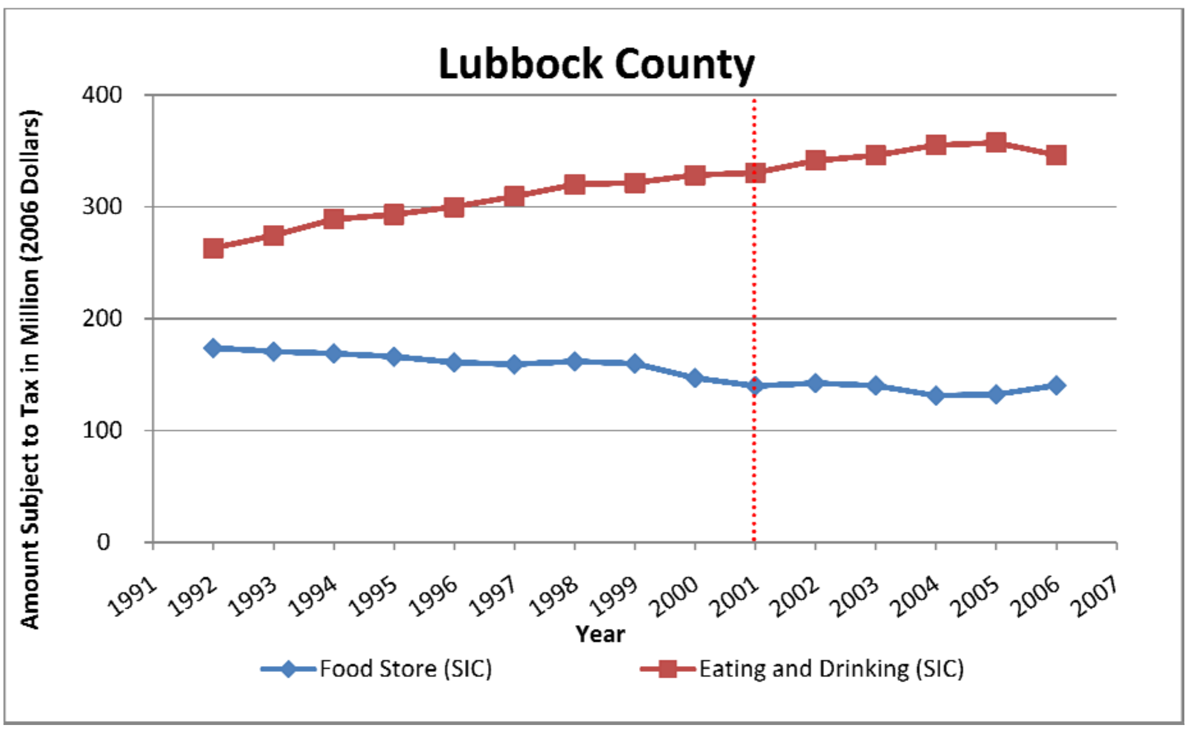


Figure G-48. Lubbock County Gross Sales of Food Stores and Eating and Drinking Places.

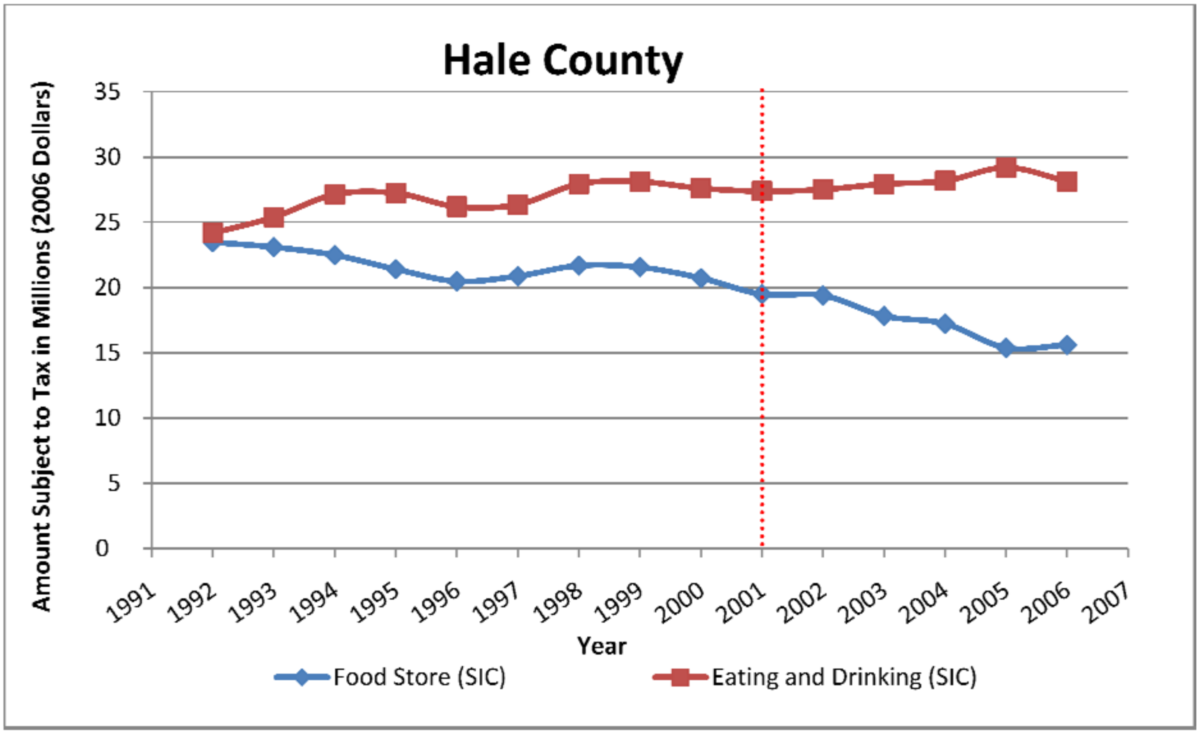


Figure G-49. Hale County Gross Sales of Food Stores and Eating and Drinking Places.

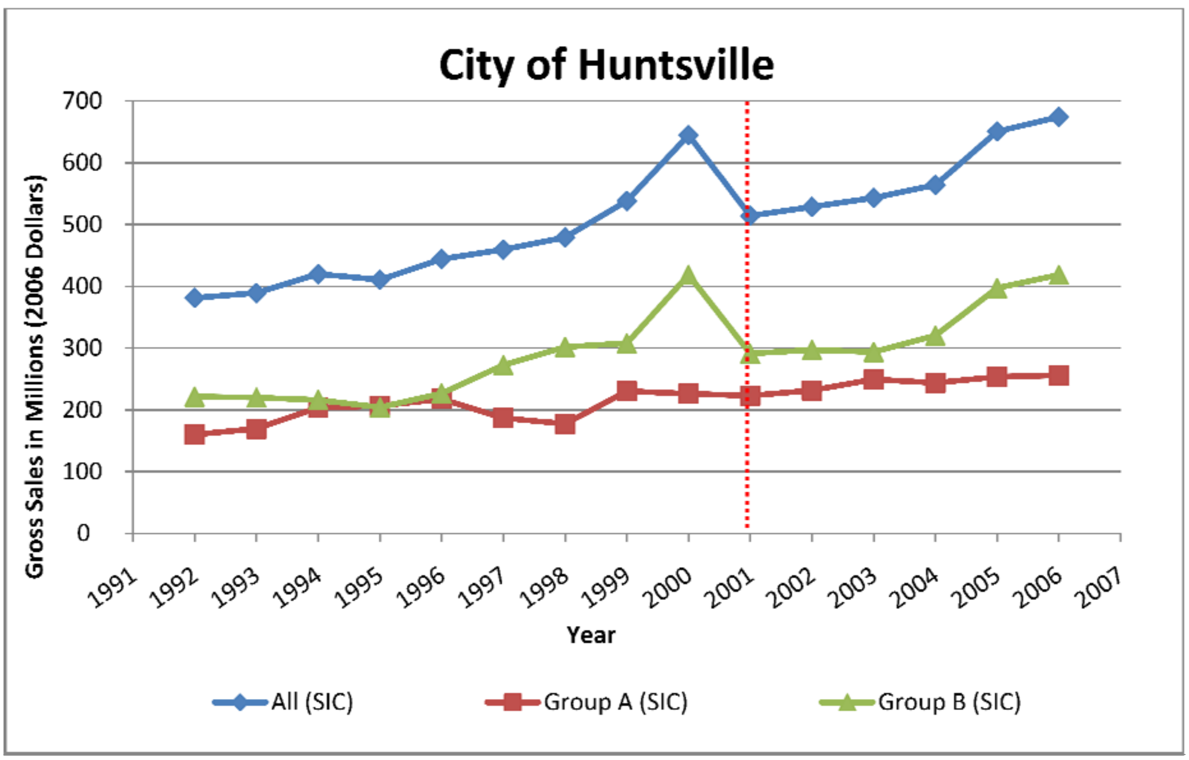


Figure G-50. City of Huntsville Total Gross Sales.

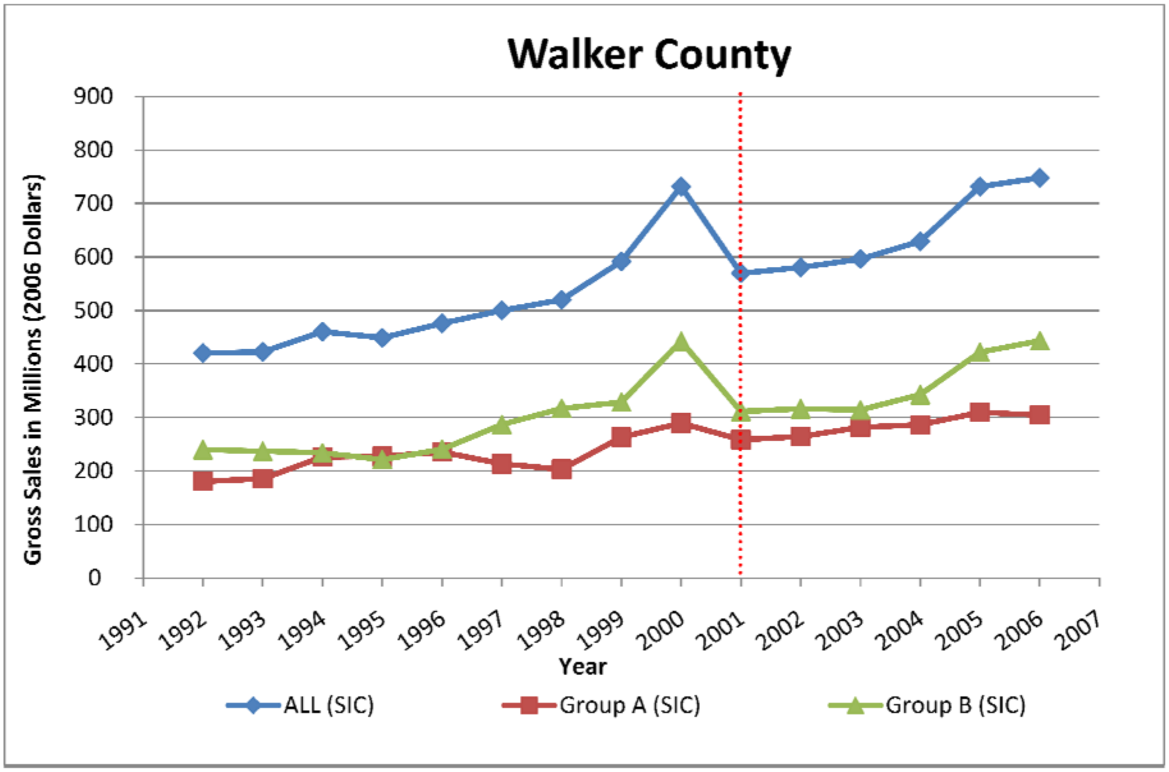


Figure G-51. Walker County Total Gross Sales.

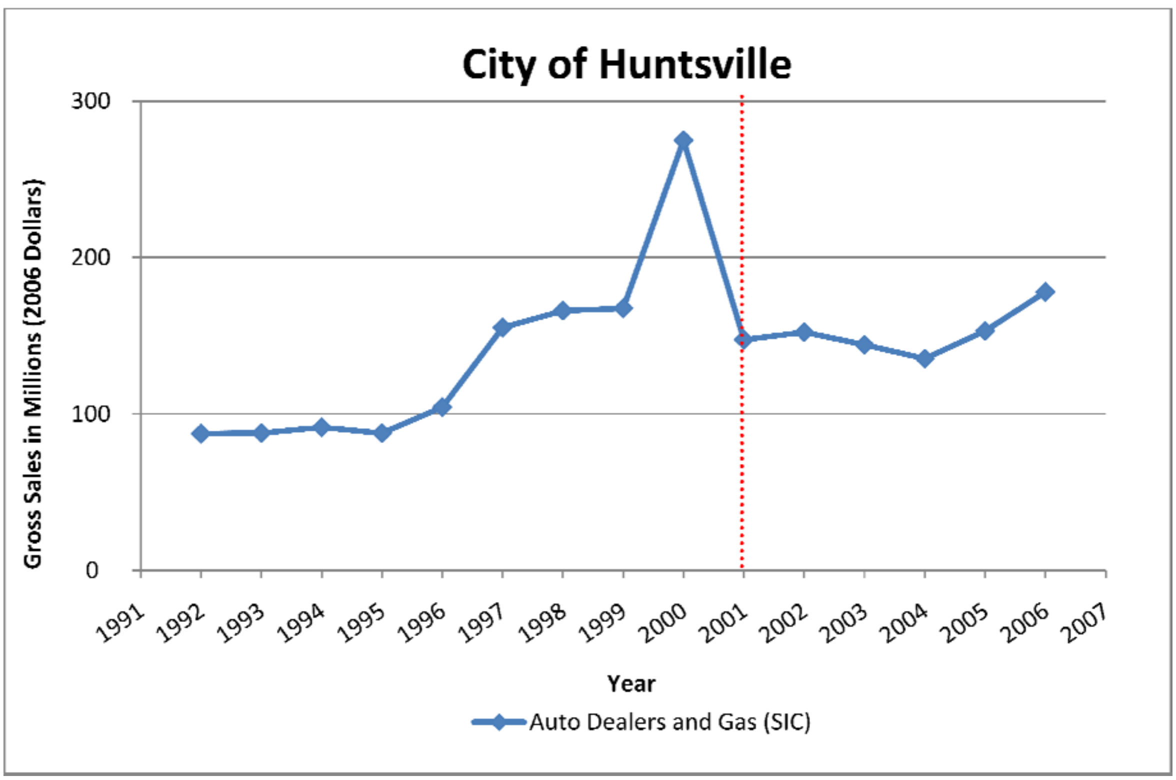


Figure G-52. City of Huntsville Gross Sales of Auto Dealers and Gas.

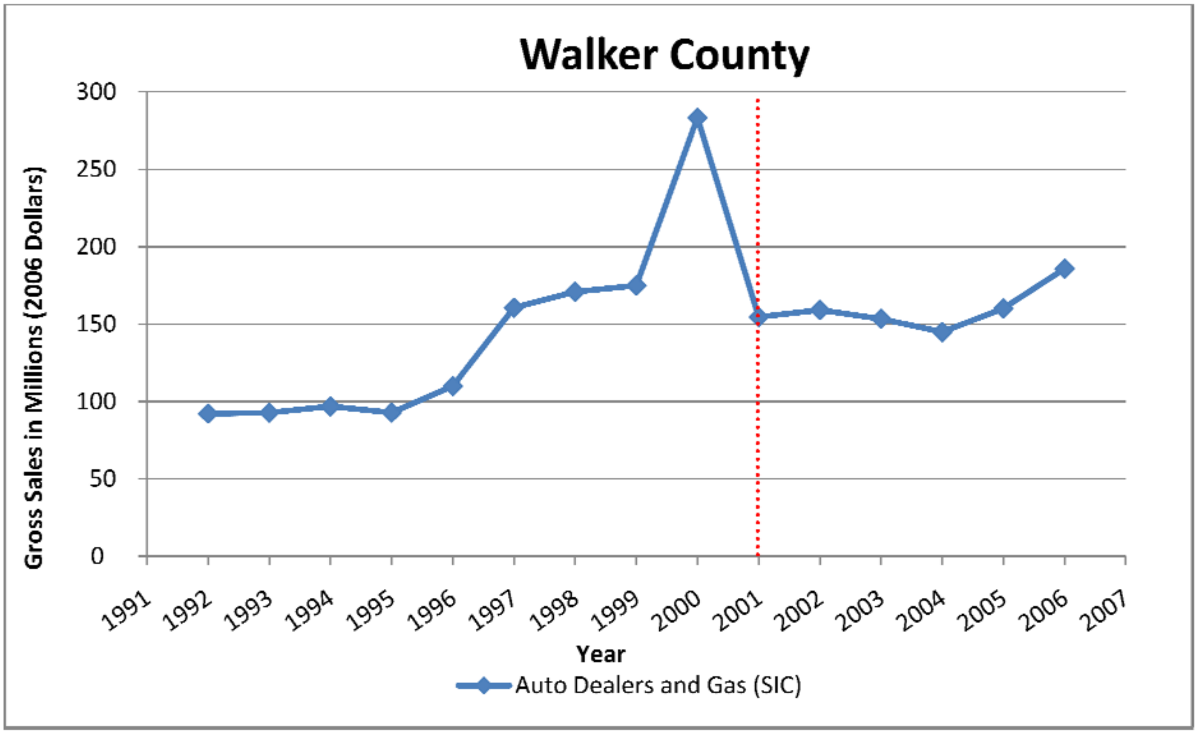


Figure G-53. Walker County Gross Sales of Auto Dealers and Gas.

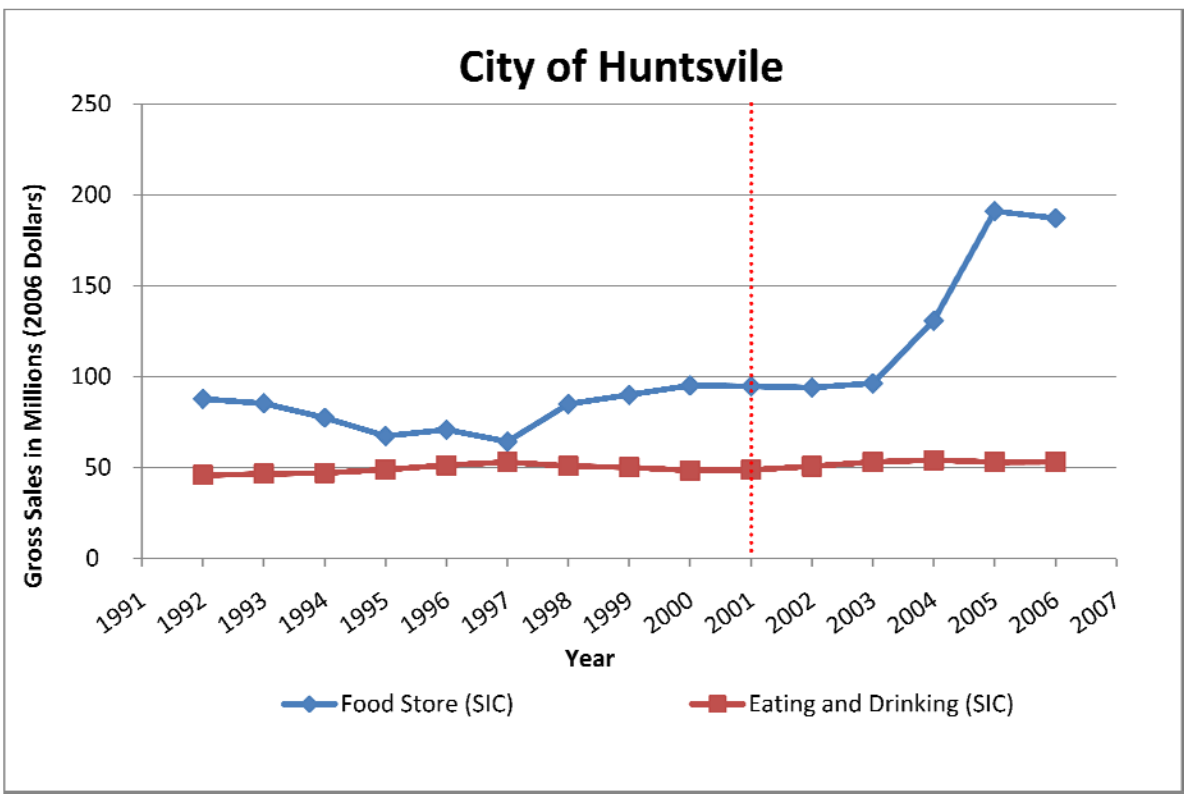


Figure G-54. City of Huntsville Gross Sales of Food Stores and Eating and Drinking Places.

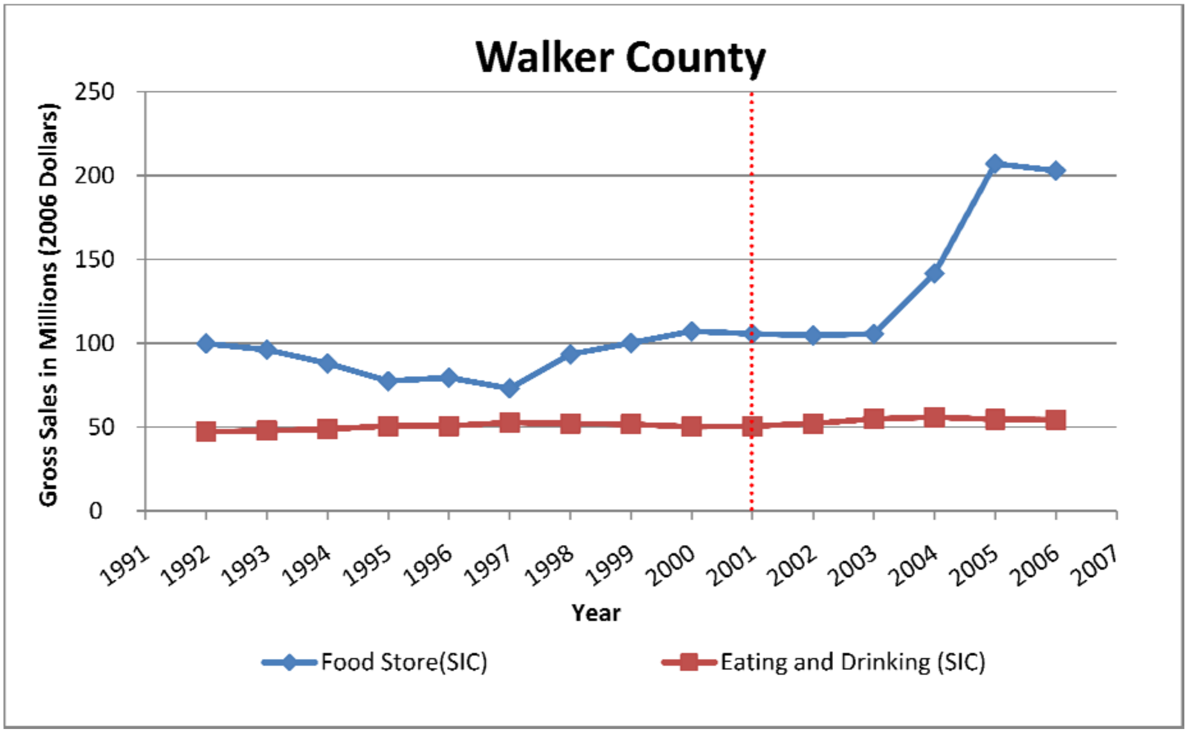


Figure G-55. Walker County Gross Sales of Food Stores and Eating and Drinking Places.

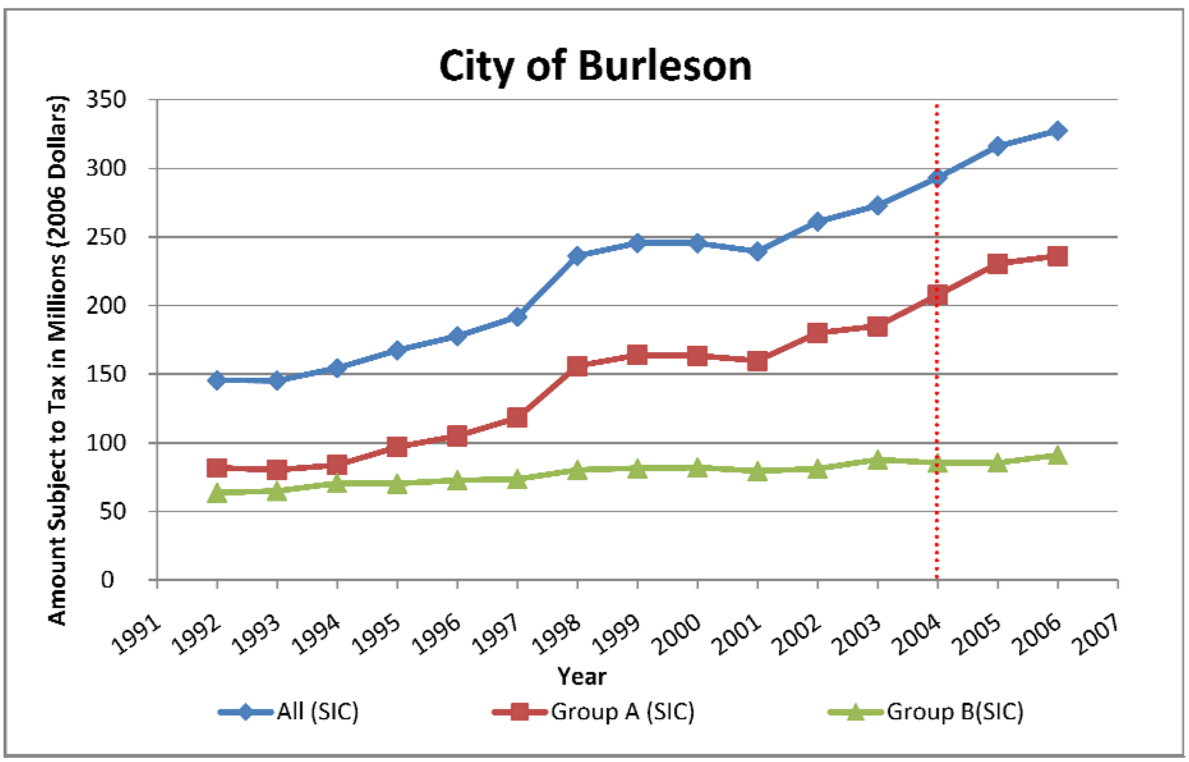


Figure G-56. City of Burleson Total Gross Sales.

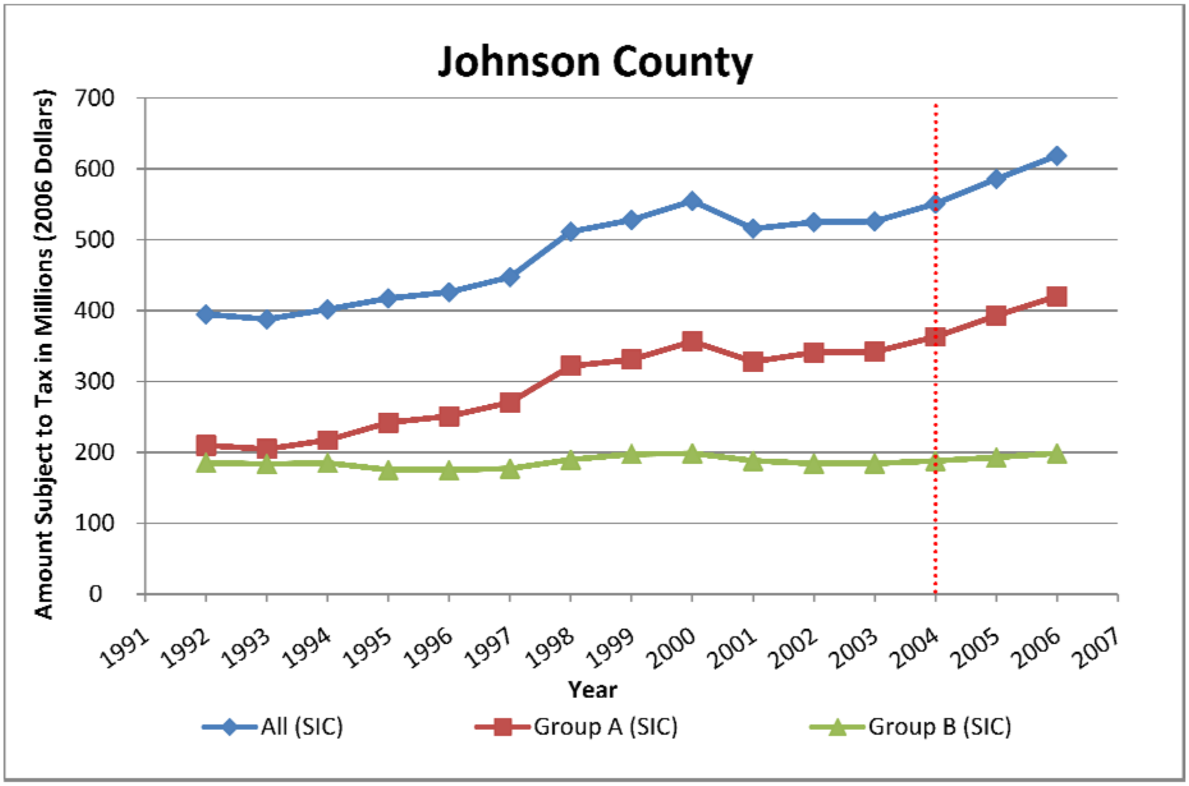


Figure G-57. Johnson County Total Gross Sales.

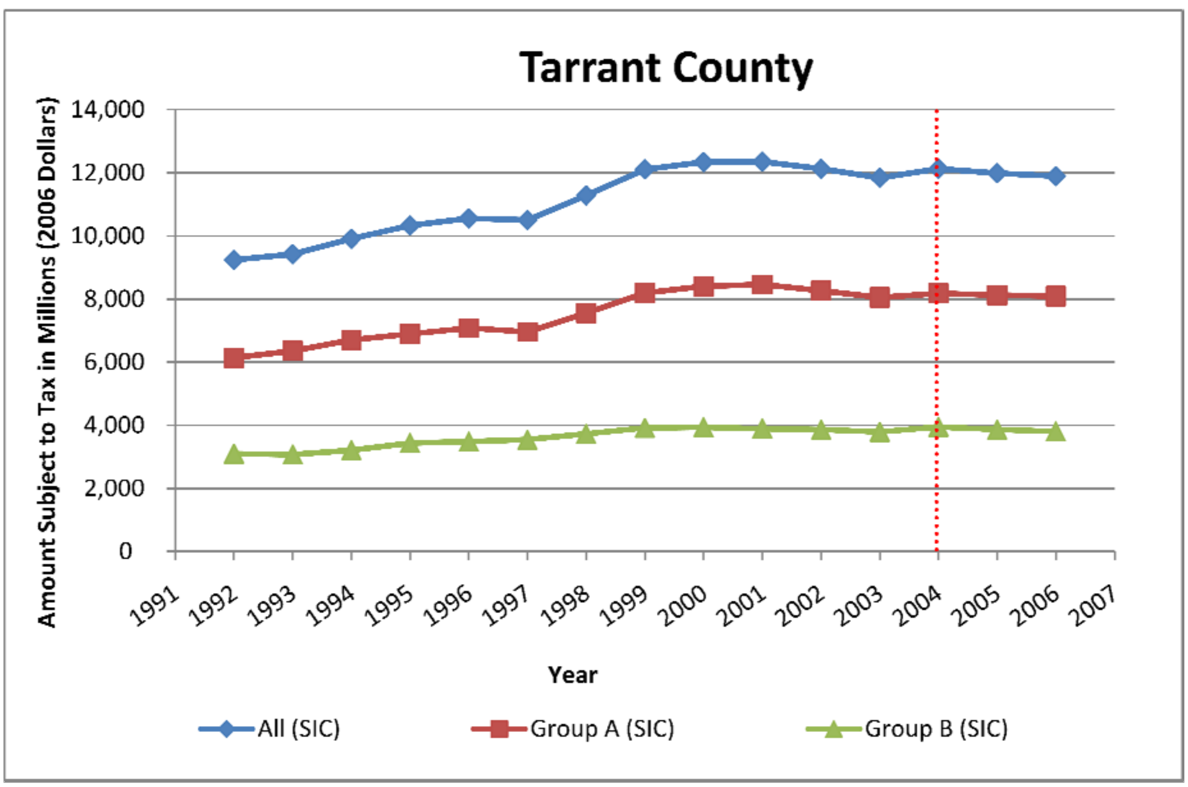


Figure G-58. Tarrant County Total Gross Sales.

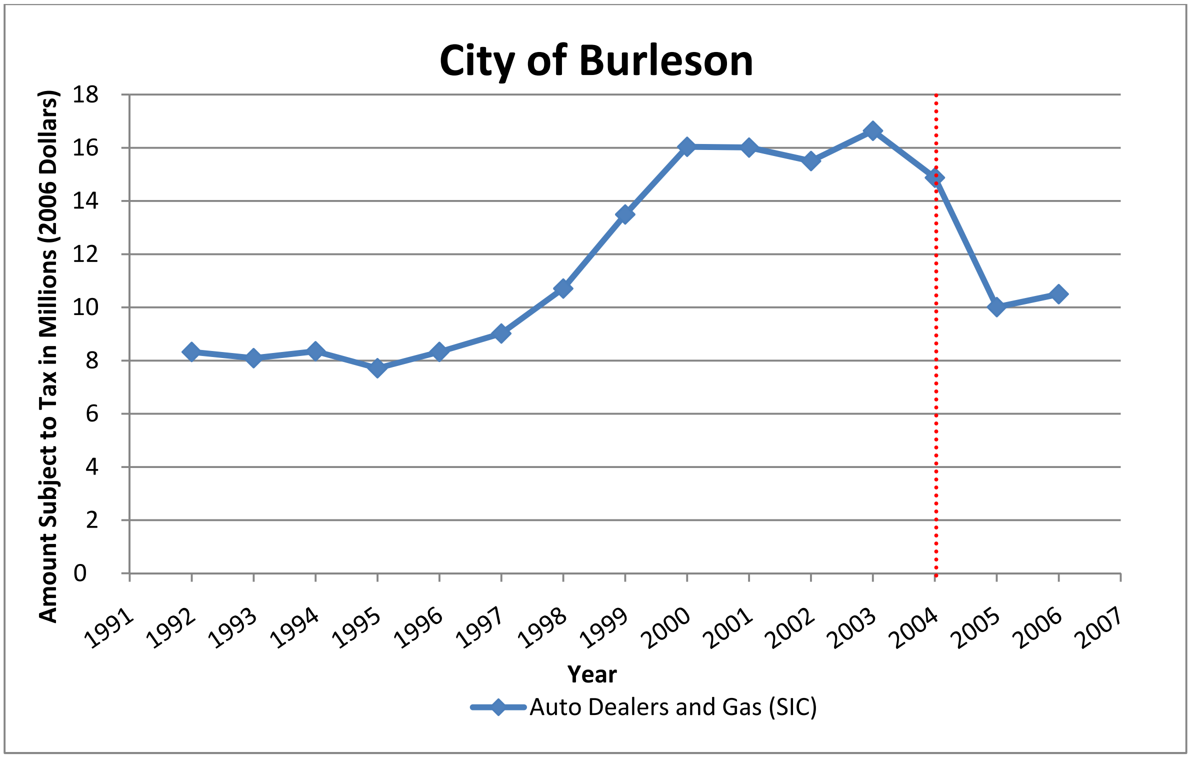


Figure G-59. City of Burleson Gross Sales of Auto Dealers and Gas.

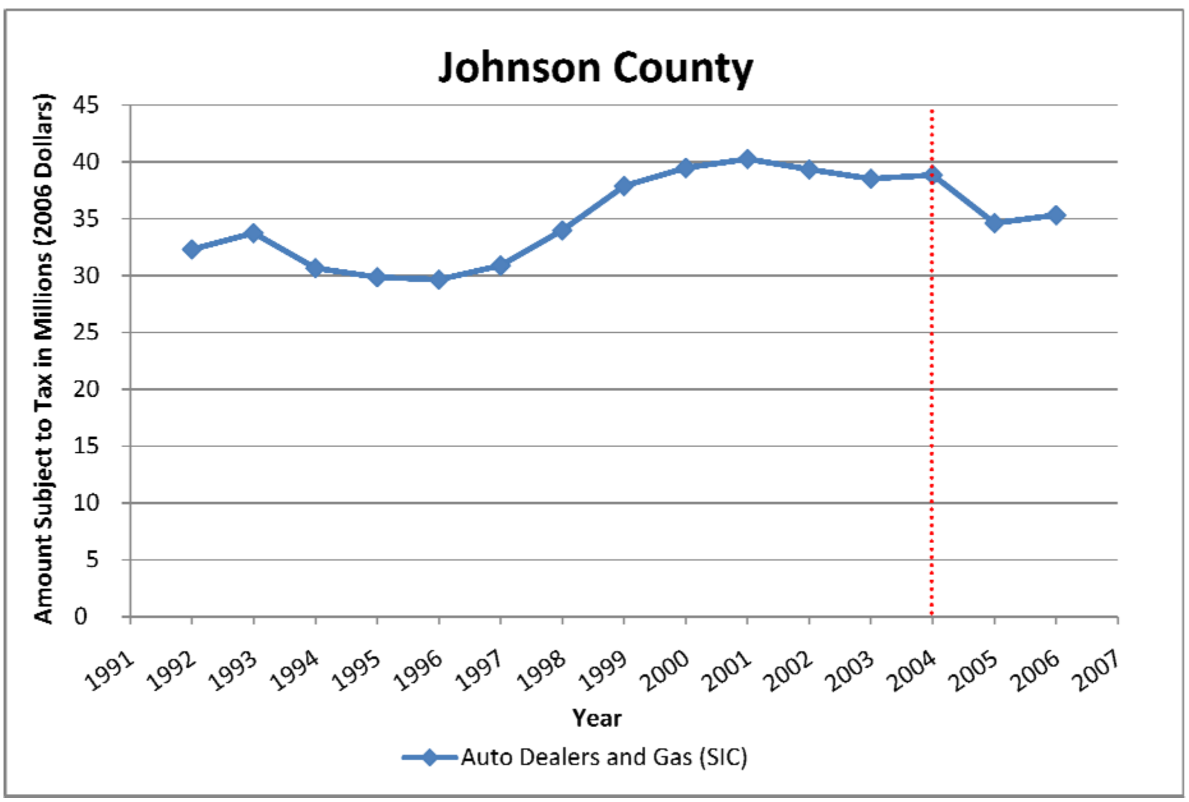


Figure G-60. Johnson County Gross Sales of Auto Dealers and Gas.

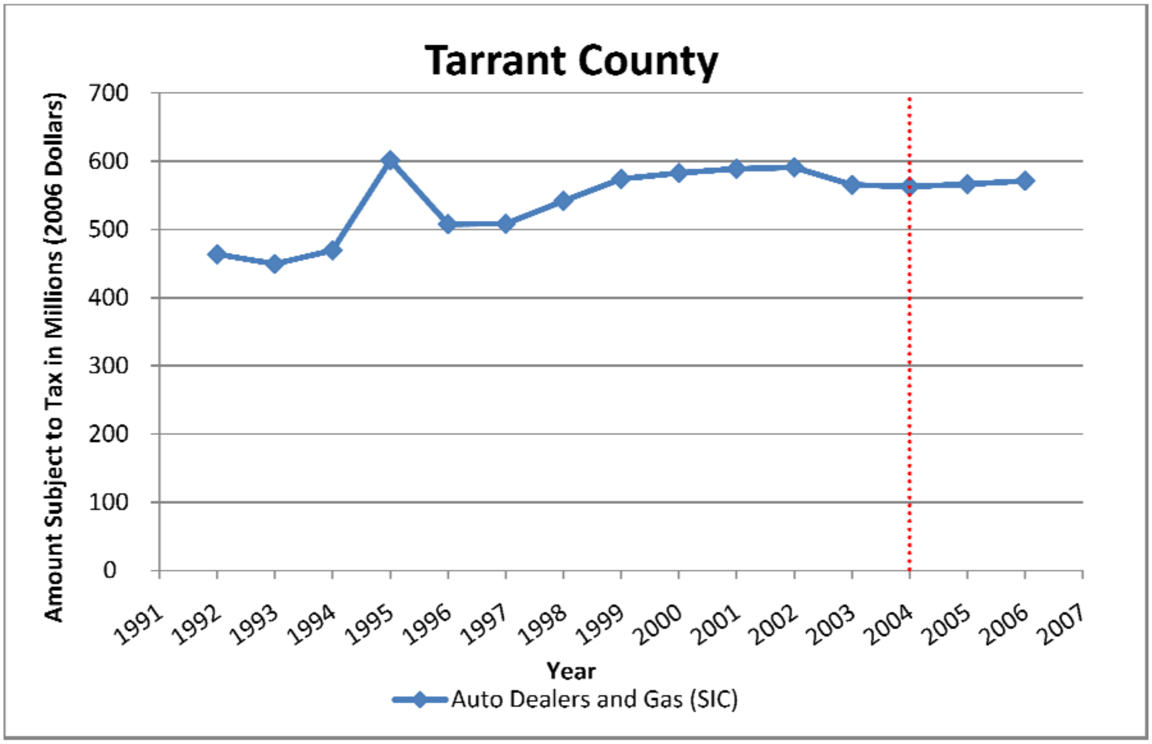


Figure G-61. Tarrant County Gross Sales of Auto Dealers and Gas.

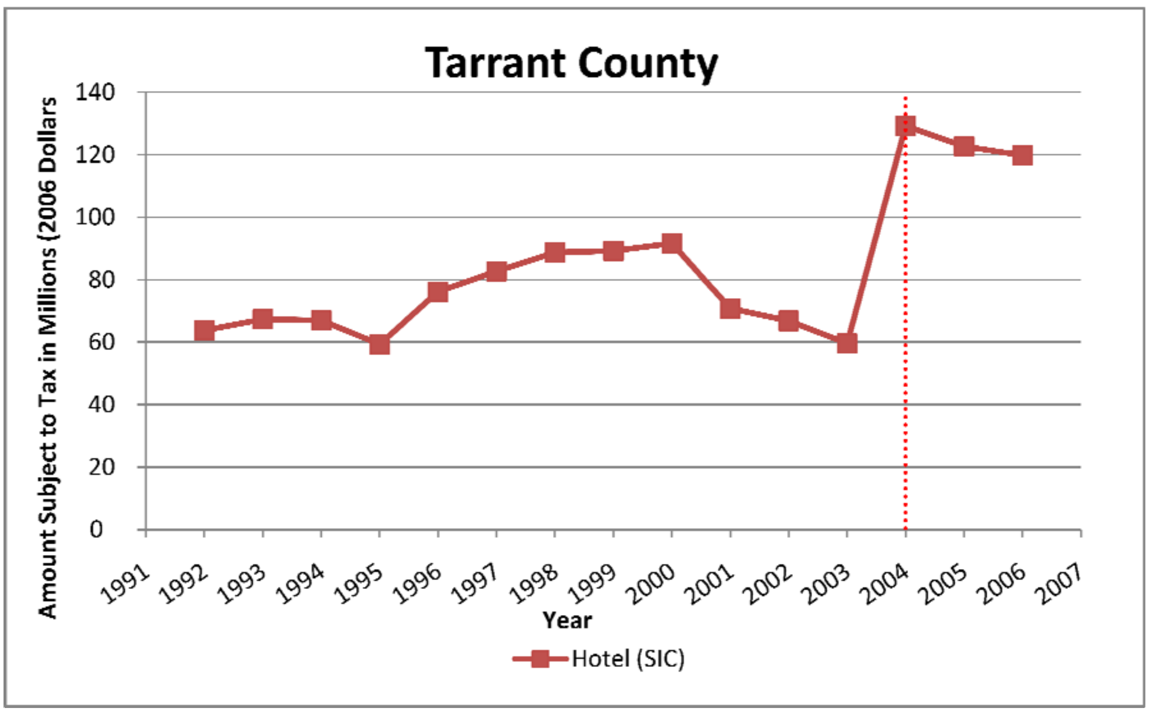


Figure G-62. Tarrant County Gross Sales of Hotels.

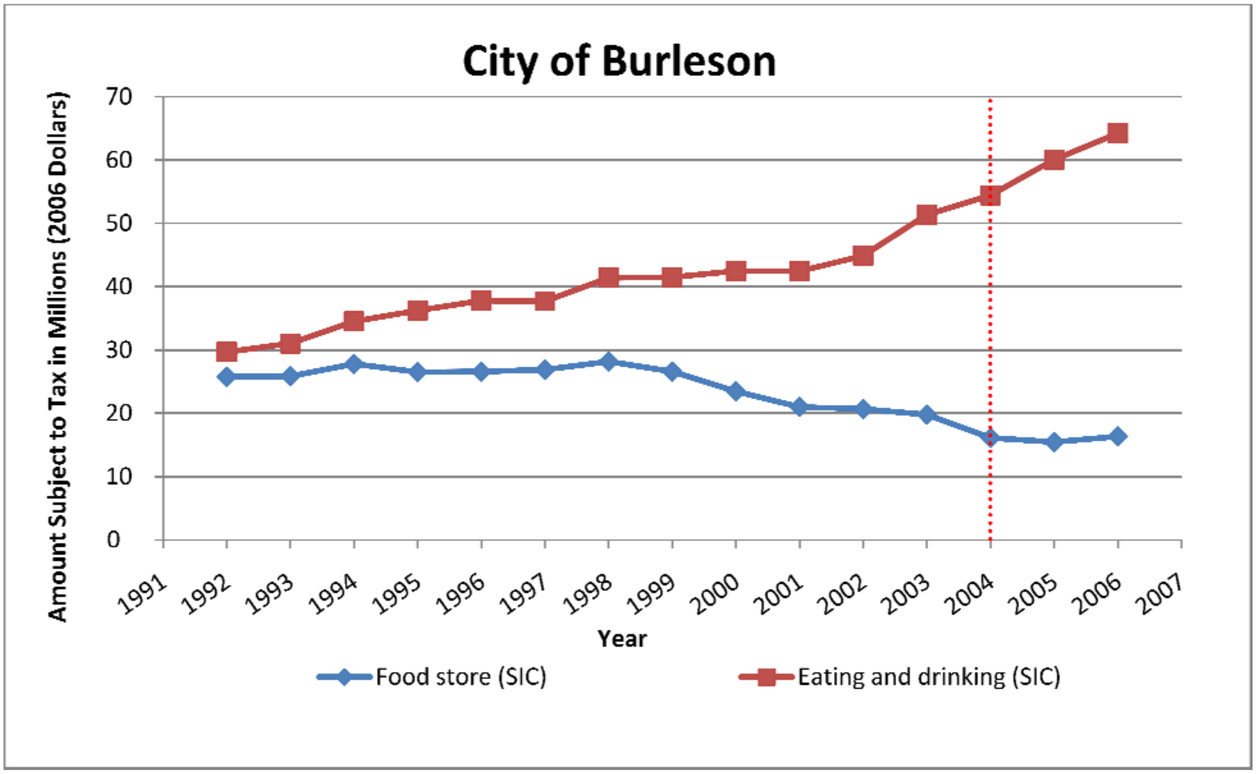


Figure G-63. Burleson Gross Sales of Food Stores and Eating and Drinking Places.

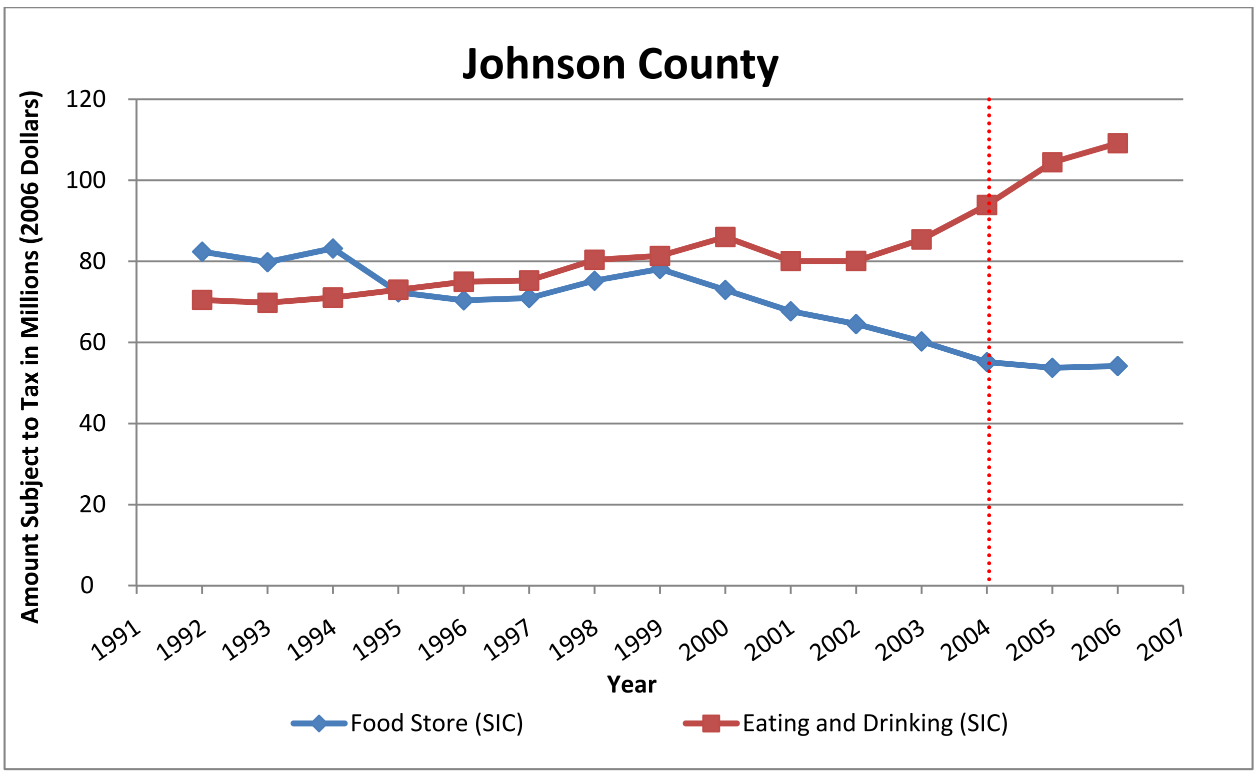


Figure G-64. Johnson County Gross Sales of Food Stores and Eating and Drinking Places.

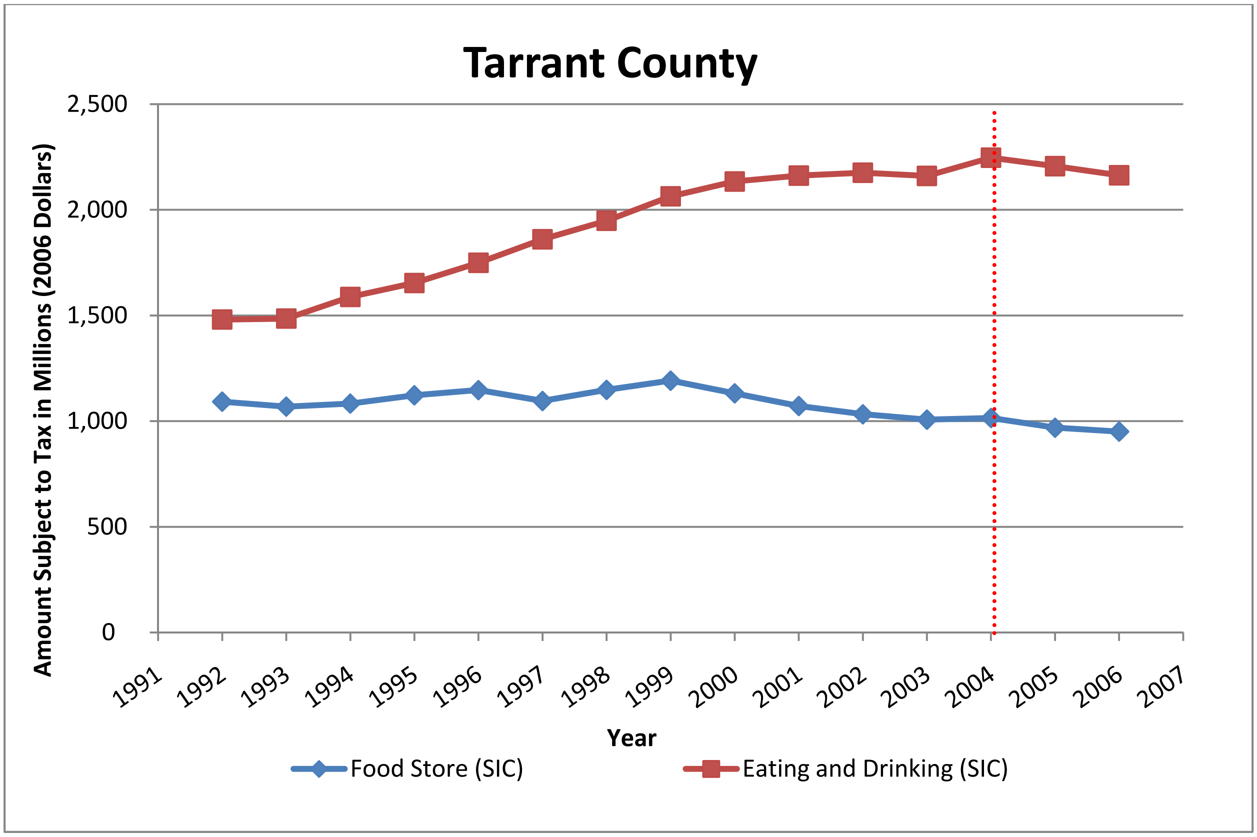


Figure G-65. Tarrant County Gross Sales of Food Stores and Eating and Drinking Places.

APPENDIX H:
BUSINESS OWNER/MANAGER AND CUSTOMER SURVEY INSTRUMENTS

1. Business owner/manager survey—conversion site
2. Business owner/manager survey—comparison site
3. Customer survey—conversion site
4. Customer survey—comparison site

1. **Business owner/manager survey—conversion site**

City______________________ CONFIDENTIAL
FRs currently one-way (conversion site) Code No._____

Thank you very much for your time in filling out this important survey!

1. When did this business open at this location?
   Month__________ Year____________
2. What is the primary type of business?
   ☐ Durables Retail ☐ Specialty Retail ☐ Grocery
   ☐ Convenience Store
   ☐ Gas Station ☐ Conv/Gas Station ☐ Fast-food Restaurant ☐ Sit-down Restaurant
   ☐ Bar/Tavern ☐ Hotel ☐ Medical ☐ Other Services
   ☐ Other (please describe):________
3. What do you believe is the percentage of your customers who are "passer-by" customers versus those who intend on stopping at your business? "Passer-by" customers are those customers that are not intending to stop at your particular business (i.e., impulse customers) as opposed to planned stops by customers that had intended on stopping at your business.
   ____Percent passer-by traffic_____Percent planned stop
4. Prior to the frontage road conversion to one-way, what do you believe was the percentage of your customers who were passer-by customers and those that intended on stopping at your business?
   _____Percent passer-by traffic______Percent planned stop
5. What do you believe is the reason(s) for the difference, if any, in the percentages you reported in question 3 and question 4?
   ____
   ____
   ____
6. Do you believe your regular customers have remained about the same, are more likely, or are less likely to visit your business due to the frontage road conversion?
   ☐ Less likely ☐ More likely ☐ Stay about the same
7. Please rank the following considerations <u>in ascending order</u> from "1" to "6" (with "1" being the most important) that consumers use when selecting a business of your type. Note: You should use each number from 1 to 6 only once.

Distance to Travel	Hours of Operation	Customer Service	Product Quality	Product Price	Access to Store
_____	_____	_____	_____	_____	_____

8. Please indicate with an “X” the appropriate range of annual gross sales for each year of this business. This information provides the researchers with a range by which to evaluate the trend in economic activity due to the frontage road conversion. Conversion year is shown in **bold**.

	1995	1996	1997	1998	1999	2000	**2001**	2002	2003	2004	2005	2006	2007
Less than $100,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$100,000 to $250,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$250,000 to $500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$500,000 to $1,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$1,000,000 to $1,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$1,500,000 to $2,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$2,000,000 to $2,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$2,500,000 to 3,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$3,000,000 to $3,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$3,500,000 to $4,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$4,000,000 to $4,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$4,500,000 to $5,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
More than $5,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9a. Please indicate below the change in percentage of business sales activity that occurred at this business between the years shown. Conversion year is shown in **bold**.

- Please give your best estimate of the percentage impacts, up or down, on your business.
- If you do not think there was a change, please mark an “X” for “No Change.”
- Please place an “X” for “Not Sure” if you are uncertain about what the change was.

	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–**2001**	**2001**–2002	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007
Percentage Increase	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%
No Change	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Percentage Decrease	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%
Not Sure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9b. What do you believe is the reason for the changes from year to year as you have indicated in question 9a?

____
____
____
____
____

9c. For any decreases noted in question 9a, what percentage of the "lost" customers do you believe are local customers and what percentage are from out of town?
_____% Local _____% Out of town

9d. What percentage of your customers are local and what percentage are from out of town?
_____% Local _____% Out of town

For questions 10 to 17, please identify whether you feel each of the following items has "increased," "decreased," or "not changed" (no change) as compared to before the frontage roads were converted.

10. Your number of customers per day?
☐ Increased ☐ Decreased ☐ No Change

11. Your number of full-time employees?
☐ Increased ☐ Decreased ☐ No Change

12. Your number of part-time employees?
☐ Increased ☐ Decreased ☐ No Change

13. Your property values?
☐ Increased ☐ Decreased ☐ No Change

14. The effect on the number of crashes along the portion of IH 45 where the frontage road was converted?

☐ Increased ☐ Decreased ☐ No Change

15. The effect on the traffic volumes along the portion of IH 45 where the frontage road was converted?

☐ Increased ☐ Decreased ☐ No Change

16. The effect on gross sales for all businesses along the portion of IH 45 where the frontage road was converted?

☐ Increased ☐ Decreased ☐ No Change

17. The effect on gross sales for all other businesses in this area of Wolfforth due to the frontage road conversion?

☐ Increased ☐ Decreased ☐ No Change

18. Please indicate below whether you feel the frontage road conversion has made the following items "Better," "Worse," or about "The Same" as before the frontage road was converted.

	Better	Worse	The Same
a. Traffic Congestion	☐	☐	☐
b. Traffic Safety	☐	☐	☐
c. Property Access	☐	☐	☐
d. Business Opportunities	☐	☐	☐
e. Customer Satisfaction	☐	☐	☐
f. Delivery Convenience	☐	☐	☐

19. Please indicate the extent of your involvement in the public hearing and public meeting process for this frontage road conversion project by placing an "X" next to the appropriate category below.

☐ High (attended several meetings)
☐ Somewhat high involvement
☐ Moderate involvement
☐ Somewhat low involvement
☐ Low involvement

20a. How do you classify your preference for one-way compared to two-way traffic on freeway frontage roads in urban areas?

Strongly favor one-way	Somewhat favor one-way	No preference	Somewhat favor two-way	Strongly favor two-way
☐	☐	☐	☐	☐

20b. Why?____

____

____

21. Frontage roads in urban areas should be one-way when first constructed.

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

22. What other comments do you have concerning freeway frontage roads?

Once again, thank you very much for your time in completing this important survey!

2. Business owner/manager survey—comparison site

City ____________________ CONFIDENTIAL
FRs currently two-way (comparison site) Code No._____

Thank you very much for your time in filling out this important survey!

1. When did this business open at this location?
   Month
2. What is the primary type of business?
   ☐ Durables Retail ☐ Specialty Retail ☐ Grocery ☐ Convenience Store
   ☐ Gas Station ☐ Conv/Gas Station ☐ Fast-food Restaurant
   ☐ Sit-down Restaurant
   ☐ Bar/Tavern ☐ Hotel ☐ Medical☐ Other Services
   ☐ Other (please describe):
3. What do you believe is the percentage of your customers who are “passer-by” customers versus those who intend on stopping at your business? “Passer-by” customers are those customers that are not intending to stop at your particular business (i.e., impulse customers) as opposed to planned stops by customers that had intended on stopping at your business.
   _____Percent passer-by traffic _____Percent planned stop
4. If the frontage road were converted to one-way, what do you believe would be the percentage of your customers who are passer-by customers and those that intended on stopping at your business?
   _____Percent passer-by traffic _____Percent planned stop
5. What do you believe is the reason(s) for the difference, if any, in the percentages you reported in question 3 and question 4?
   ____
   ____
   ____
6. If the frontage roads were converted to one-way, do you believe your regular customers would remain about the same, be more likely, or be less likely to visit your business due to the frontage road conversion?
   ☐ Less likely ☐ More likely ☐ Stay about the same
7. Please rank the following considerations in ascending order from “1” to “6” (with “1” being the most important) that consumers use when selecting a business of your type. Note: You should use each number from 1 to 6 only once.

Distance to Travel	Hours of Operation	Customer Service	Product Quality	Product Price	Access to Store
_____	_____	_____	_____	_____	_____

8. Please indicate with an “X” the appropriate range of annual gross sales for each year of this business. This information provides the researchers with a range by which to evaluate the trend in economic activity due to the frontage road conversion.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Less than $100,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$100,000 to $250,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$250,000 to $500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$500,000 to $1,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$1,000,000 to $1,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$1,500,000 to $2,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$2,000,000 to $2,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$2,500,000 to 3,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$3,000,000 to $3,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$3,500,000 to $4,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$4,000,000 to $4,500,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
$4,500,000 to $5,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
More than $5,000,000	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9a. Please indicate below the change in percentage of business sales activity that occurred at this business between the years shown.

- Please give your best estimate of the percentage impacts, up or down, on your business.
- If you do not think there was a change, please mark an “X” for “No Change.”

Please place an “X” for “Not Sure” if you are uncertain about what the change was.

	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007
Percentage Increase	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%
No Change	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Percentage Decrease	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%	___%
Not Sure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9b. What do you believe is the reason for the changes from year to year as you have indicated in question 9a?

____
____
____
____
____

9c. For any decreases noted in question 9a, what percentage of the “lost” customers do you believe are local customers and what percentage are from out of town?
_____% Local _____% Out of town

9d. What percentage of your customers are local and what percentage are from out of town?
_____% Local _____% Out of town

For questions 10 to 17, please identify whether you feel each of the following will “increase,” “decrease,” or “not change” (no change) if the frontage roads were converted.

10. Your number of customers per day?
☐ Increase ☐ Decrease ☐ No Change

11. Your number of full-time employees?
☐ Increase ☐ Decrease ☐ No Change

12. Your number of part-time employees?
☐ Increase ☐ Decrease ☐ No Change

13. Your property values?
☐ Increase ☐ Decrease ☐ No Change

14. The number of crashes along the portion of IH 45 where the frontage road would be converted?
☐ Increase ☐ Decrease ☐ No Change

15. Traffic volumes along the portion of IH 45 where the frontage road would be converted?
☐ Increase ☐ Decrease ☐ No Change

16. The gross sales for all businesses along the portion of IH 45 where the frontage road would be converted?
☐ Increase ☐ Decrease ☐ No Change

17. The gross sales for all other businesses in this area of Huntsville due to the frontage road conversion?
☐ Increase ☐ Decrease ☐ No Change

18. Please indicate below whether you feel a frontage road conversion would make the following items "Better," "Worse," or about "The Same" as before the frontage road was converted.

	Better	Worse	The Same
a. Traffic Congestion	☐	☐	☐
b. Traffic Safety	☐	☐	☐
c. Property Access	☐	☐	☐
d. Business Opportunities	☐	☐	☐
e. Customer Satisfaction	☐	☐	☐
f. Delivery Convenience	☐	☐	☐

19a. How do you classify your preference for one-way compared to two-way traffic on freeway frontage roads in urban areas?

Strongly favor one-way	Somewhat favor one-way	No preference	Somewhat favor two-way	Strongly favor two-way
☐	☐	☐	☐	☐

19b. Why?____
____
____

20. Frontage roads in urban areas should be one-way when first constructed.

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

21. What other comments do you have concerning freeway frontage roads?

Once again, thank you very much for your time in completing this important survey!

3. Customer survey—conversion site

City______________ CONFIDENTIAL

FRs currently one-way (conversion site) Code No.______

Thank you very much for your time in filling out this survey!

1. Did you notice that TxDOT converted the frontage roads to one-way in 2001 in front of this business? Yes ☐ No ☐
2. Did you come here before the frontage road conversion? Yes ☐ No ☐
3. Have you changed your overall shopping habits or store loyalty because of the conversion?
   Yes ☐ No ☐
4. When leaving this business, will you have to go the opposite way than you would like (because of the conversion) and make a U-turn (or series of right turns)?
   Yes ☐ No ☐
5. Did you make a special trip to visit this business or just stop here because it is convenient on the way to somewhere else?
   ☐ Special trip just to this business (or went out of way to stop here)
   ☐ Passing by/convenient (did not plan to stop here)
6. Are you a local customer (live nearby) or just passing through town?
   Local ☐ Passing through town ☐
7. Did you make a U-turn (or two left turns) at the interchange to get here?
   Yes ☐ No ☐
8. Did you come to this business to avoid U-turns (or two left turns)? Yes ☐ No ☐
9. If you visited this business before the frontage road conversion, do you believe you are now "more likely" or "less likely" to visit this business because of the frontage road conversion, or is it about the same?
   Less likely ☐ More likely ☐ About the same ☐
10. Please rank the following considerations in increasing order from "1" to "6" (with "1" being the most important) that you use when selecting a business of this type. Note: You should use each number from 1 to 6 only once.

Distance to Travel	Hours of Operation	Customer Service	Product Quality	Product Price	Access to Store
_____	_____	_____	_____	_____	_____

11. Please indicate below whether you feel the frontage road conversion has made the following items "better," "worse," or about "the same" as before the conversion.

	Better	Worse	The Same
a. Traffic Congestion	☐	☐	☐
b. Traffic Safety	☐	☐	☐
c. Property Access	☐	☐	☐
d. Business Opportunities	☐	☐	☐
e. Customer Satisfaction	☐	☐	☐

12. Do you have any other comments regarding the frontage road conversion? Please use back of page for any comments.

4. Customer survey—comparison site

City______________ CONFIDENTIAL

FRs currently two-way (comparison site) Code No.______

Thank you very much for your time in filling out this survey!

1. If the frontage roads were converted to one-way in front of this business, would you change your overall shopping habits or store loyalty because of the conversion?
   Yes ☐ No ☐
2. If the frontage roads were converted to one-way when leaving this business, would you have to go the opposite way than you would like (because of the conversion) and make a U-turn (or series of right turns)? Yes ☐ No ☐
3. Did you make a special trip to visit this business or just stop here because it is convenient on the way to somewhere else?
   ☐ Special trip just to this business (or went out of way to stop here)
   ☐ Passing by / convenient (did not plan to stop here)
4. Are you a local customer (live nearby) or just passing through town?
   Local ☐ Passing through town ☐
5. If the frontage roads were converted to one-way, would you make a U-turn (or two left turns) at the interchange to get here? Yes ☐ No ☐
6. If the frontage roads were converted to one-way, would you come to this business to avoid U-turns (or two left turns)? Yes ☐ No ☐
7. If the frontage roads were converted to one-way, do you believe you would be "more likely" or "less likely" to visit this business, or would it be about the same?
   Less likely ☐ More likely ☐ About the same ☐
8. Please rank the following considerations in increasing order from "1" to "6" (with "1" being the most important) that you use when selecting a business of this type. Note: You should use each number from 1 to 6 only once.

Distance to Travel	Hours of Operation	Customer Service	Product Quality	Product Price	Access to Store
_____	_____	_____	_____	_____	_____

9. If the frontage roads were converted to one-way, please indicate below whether you feel the frontage road conversion would make the following items "better," "worse," or about "the same" as before the conversion.

	Better	Worse	The Same
a. Traffic Congestion	☐	☐	☐
b. Traffic Safety	☐	☐	☐
c. Property Access	☐	☐	☐
d. Business Opportunities	☐	☐	☐
e. Customer Satisfaction	☐	☐	☐

10. Do you have any other comments regarding the frontage road conversion? Please use back of page for any comments.

APPENDIX I:
ADDITIONAL DATA ANALYSES FOR SURVEYS

Following are additional analyses details for:

1. criteria customers use when selecting a place to do business,
2. customer likelihood of stopping at a business,
3. operational and economic impacts,
4. impact upon different business types, and
5. business owners'/managers' frontage road operation (two-way or one-way) preferences.

CRITERIA CUSTOMERS USE WHEN SELECTING A PLACE TO DO BUSINESS

Question #7, page 276 (business owner/manager, conversion site), question #7, page 282 (business owner/manager, comparison site), question #10, page 288 (customer, conversion site), and question #8, page 289 (customer, comparison site) asked survey respondents to rank customer service, access to store, distance to travel, product quality, product price, and hours of operation.

Researchers averaged the values found for the business owners/managers and customers and ranked from lowest to highest value. Table I-1 shows the resulting average, sample standard deviation, and rank for each item. The research team broke down these values by customer and business owner/manager and then subdivided them by comparison city, conversion city, and all cities.

These values show that, in general, customer service and product quality are the most important factors according to both the customers and the business owners. These results have access to store ranked either third or fourth. These results also show travel distance as the fifth-ranked value for all but comparison customers, which had a rank of sixth for this category. These results suggest access to the store may not be as important as product quality and customer service, items business owners/managers have control over.

Table I-1. Business Owner/Manager and Customer Ranking of Items Related to Customer Business Selection.

Customer Service						Product Quality					
Group	Subgroup	Average	S	n	Rank	Group	Subgroup	Average	S	n	Rank
Customer	Comparison	2.33	1.44	12	1	Customer	Comparison	2.42	1.68	12	2
	Conversion	3.06	1.37	33	2		Conversion	2.55	1.56	33	1
	All	2.87	1.41	45	2		All	2.51	1.58	45	1
Business Owner/ Manager	Comparison	2.02	1.14	42	1	Business Owner/ Manager	Comparison	2.55	1.38	42	2
	Conversion	2.73	1.53	33	2		Conversion	2.61	1.30	33	1
	All	2.33	1.36	75	1		All	2.57	1.34	75	2
Access to Store						Product Price					
Group	Subgroup	Average	S	n	Rank	Group	Subgroup	Average	S	n	Rank
Customer	Comparison	3.42	1.78	12	3	Customer	Comparison	3.83	1.19	12	4
	Conversion	3.61	1.95	33	4		Conversion	3.55	1.86	33	3
	All	3.56	1.89	45	3		All	3.62	1.70	45	4
Business Owner/ Manager	Comparison	3.83	1.56	42	4	Business Owner/ Manager	Comparison	3.36	1.61	42	3
	Conversion	3.42	1.70	33	4		Conversion	3.27	1.75	33	3
	All	3.65	1.62	75	4		All	3.32	1.66	75	3
Distance to Travel						Hours of Operation					
Group	Subgroup	Average	S	n	Rank	Group	Subgroup	Average	S	n	Rank
Customer	Comparison	4.67	1.67	12	6	Customer	Comparison	4.33	1.30	12	5
	Conversion	4.09	1.70	33	5		Conversion	4.30	1.29	33	6
	All	4.24	1.69	45	5		All	4.31	1.28	45	6
Business Owner/ Manager	Comparison	4.36	1.39	42	5	Business Owner/ Manager	Comparison	4.88	1.33	42	6
	Conversion	4.15	1.62	33	5		Conversion	4.82	1.31	33	6
	All	4.27	1.49	75	5		All	4.85	1.31	75	6

S = sample standard deviation, n = number of respondents

CUSTOMER LIKELIHOOD OF STOPPING AT A BUSINESS

Researchers asked customers if they would be more likely, less likely, or have the same likelihood of stopping at the business if the frontage road were converted. This was asked in question #9, page 288 (conversion site) and question #7, page 289 (comparison site).

Researchers found significant differences concerning the likelihood of stopping based upon the following criteria:

- Was the survey being conducted at a converted site?
- Did the customer need to travel in the opposite direction than they would like to when leaving the business? (question #4, page 288, conversion site and question #2, page 289, comparison site)
- Was the trip pass-by or planned? (question #5, page 288, conversion site and question #3, page 289, comparison site)
- Is the customer a local or passing through town? (question #6, page 288, conversion site and question #4, page 289, comparison)
- Did the customer make a u-turn to arrive? (question #7, page 288, conversion site and question #5, page 289, comparison site)
- Did they come to the business to avoid a U-turn? (question #8, page 288, conversion site and question #6, page 289, comparison site)

Table I-2 shows the results of the surveys, considering all bulleted categories identified above. The four significant results are discussed individually.

Table I-2. Customer Responses to Their Likelihood of Stopping Based upon Access, Trip Purpose, and Residency.

Is it a Conversion Site?					**Are You a Local or Non-Local?**				
Group	Less	More	Same	Responses	Group	Less	More	Same	Responses
Comparison	71%	0%	29%	14	Local	43%	5%	52%	42
Conversion	29%	3%	67%	58	Non-Local	28%	0%	72%	29
All	38%	3%	60%	72	All	37%	3%	61%	71
Fisher-Freeman-Halton Exact Test P =				**0.018**	Fisher-Freeman-Halton Exact Test P =				0.208
Would You/Do You Have to Leave Opposite?					**Did/Would You Make a U-Turn to Arrive?**				
Group	Less	More	Same	Responses	Group	Less	More	Same	Responses
No	10%	3%	87%	30	No	25%	0%	75%	40
Yes	61%	3%	37%	38	Yes	55%	3%	41%	29
All	38%	3%	59%	68	All	38%	1%	61%	69
Fisher-Freeman-Halton Exact Test P =				***0.0001***	Fisher-Freeman-Halton Exact Test P =				***0.008***
Was it a Pass-by or Planned Trip?					**Did/Would You Come Here to Avoid U-Turn?**				
Group	Less	More	Same	Responses	Group	Less	More	Same	Responses
Pass-by	24%	8%	68%	25	No	33%	2%	65%	49
Planned	46%	0%	54%	46	Yes	47%	0%	53%	15
All	38%	3%	59%	71	All	36%	2%	63%	64
Fisher-Freeman-Halton Exact Test P =				**0.049**	Fisher-Freeman-Halton Exact Test P =				0.520

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100% due to rounding.

Conversion vs. Comparison (Confidence Level = 0.95)

Seventy-one percent of customers at comparison-site businesses felt they were less likely to stop at that business if the frontage road were converted as compared to only 29 percent saying this at the conversion businesses. This result is highly biased in the sense that converted business customers had already decided to do business at the location where they were surveyed. However, it is still important to note that customers did feel they would be less likely to stop if a frontage road conversion were to occur.

Need to Leave in the Opposite Direction (Confidence Level = 0.99)

Sixty-one percent of customers who would need to leave in the opposite direction also felt they were less likely to stop at that business. Eighty-seven percent of customers felt that if they did not have to leave in the opposite direction, their likelihood of stopping would not be any different. This suggests that ease of access is important for customers and that customers would rather stop at locations they can get to more easily.

Need to Make a U-Turn to Arrive (Confidence Level = 0.99)

Fifty-five percent of the customers surveyed that needed to make or would need to make a U-turn to arrive at a business felt they were less likely to go to that business post-conversion. Seventy-five percent of the customers surveyed indicated that if they did not need to make a U-turn, they would have the same likelihood of stopping. This is further evidence that ease of access is important for customers and thus important to business owners/managers.

Planned vs. Pass-By Stop

Forty-six percent of motorists of planned stops felt they were less likely to stop if a conversion occurred (see Table I-2). To further investigate this finding, researchers conducted a comparison between planned and pass-by trips in relation to customers being local or non-local, the need to make a U-turn, and the need to leave in the opposite direction if there was a one-way frontage road. Table I-3 shows the results.

Table I-3. Planned or Pass-By Compared to Access and Residency Variables.

Are You a Local or Non-Local?				**Did/Would You Come Here to Avoid U-Turn?**			
Group	Pass-by	Planned	Responses	Group	Pass-by	Planned	Responses
Local	14%	86%	43	No	37%	63%	49
Visiting	63%	37%	30	Yes	27%	73%	15
All	34%	66%	73	All	34%	66%	64
Fisher-Freeman-Halton Exact Test P =			***0.0001***	Fisher-Freeman-Halton Exact Test P			0.549
Did/Would You Make a U-Turn to Arrive?				**Would You/Do You Have to Leave Opposite?**			
Group	Pass-by	Planned	Responses	Group	Pass-by	Planned	Responses
No	40%	60%	40	No	56%	44%	32
Yes	23%	77%	30	Yes	13%	87%	38
All	33%	67%	70	All	33%	67%	70
Fisher-Freeman-Halton Exact Test P =			0.200	Fisher-Freeman-Halton Exact Test P			***0.0002***

Note: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance.

As expected, there is a statistically significant difference between the quantity of local and visiting customers making planned or pass-by trips. Locals make more planned stops than visiting customers. Further, it seems that 87 percent of the customers that would need to leave in the opposite direction due to a conversion were also planned customers. As seen in Table I-3, customers that needed to leave in the opposite direction would be less likely to do business at that location.

OPERATIONAL AND ECONOMIC IMPACTS

The following question was asked of business owners, managers, and customers to investigate their perception of the operational effects of frontage road conversion:

Please indicate below whether you feel a frontage road conversion would make the following items "better," "worse," or about "the same" as before the frontage road was converted.

- *Traffic Congestion*
- *Traffic Safety*
- *Property Access*
- *Business Opportunities*
- *Customer Satisfaction*
- *Delivery Convenience*

This is question #18, page 280 (business owner/manager, conversion site), question #18, page 286 (business owner/manager, comparison site), question #11, page 288 (customer, conversion site), and question #12, page 289 (customer, comparison site).

In the case of comparison cities, researchers investigated the same items but the question was changed such that it investigated what the business owners/managers and customers thought might happen if the frontage road were converted. Customers were not asked about delivery convenience, and thus business owner/manager perceptions could not be compared to customer perceptions concerning delivery convenience.

Results and Discussion

Researchers compared the variables above within the business owner and customer groups, and the results of that comparison are shown in Table I-4. The null hypothesis for all tests is that the responses for each group are the same. The alternative hypothesis is that the responses for each group are not the same.

There were no significant differences between the comparison and conversion groups within the business owner/manager survey results. There were also no significant differences between the comparison and conversion groups within the customer survey results. However, when comparing comparison business owners/managers to comparison customers, there were significant differences, and the same was true for conversion business owners/managers and customers as well. Table I-5 shows these differences.

From Table I-4, we can see that 49 percent of all business owners/managers felt congestion would get better or was better post-conversion. Table I-4 also shows that 48 percent of all business owners/managers felt safety would get better or was better post-conversion. Seventy-five percent of business owners/managers felt property access would be worse or was worse post-conversion. Forty-eight percent, 51 percent, and 61 percent of business owners/managers felt business opportunities, customer satisfaction, and delivery convenience, respectively, were worse or would be worse post-conversion. A lack of difference between comparison and conversion groups suggests that the fears businesses owners/managers have pre-conversion are the same issues faced by businesses owners and managers post-conversion.

Table I-4. Conversion Business Owners/Managers Compared to Comparison Business Owners/Managers and Conversion Customers Compared to Comparison Customers.

Business Owners & Managers				
Traffic Congestion?				
Group	Same	Better	Worse	Responses
Comparison	27%	52%	20%	44
Conversion	22%	44%	34%	32
All	25%	49%	26%	76
Fisher-Freeman-Halton Exact Test P =				**0.391**
Traffic Safety?				
Group	Same	Better	Worse	Responses
Comparison	25%	55%	20%	44
Conversion	42%	39%	18%	33
All	32%	48%	19%	77
Fisher-Freeman-Halton Exact Test P =				**0.265**
Property Access?				
Group	Same	Better	Worse	Responses
Comparison	14%	11%	75%	44
Conversion	18%	6%	76%	33
All	16%	9%	75%	77
Fisher-Freeman-Halton Exact Test P =				**0.681**
Business Opportunities?				
Group	Same	Better	Worse	Responses
Comparison	45%	14%	40%	42
Conversion	39%	3%	58%	33
All	43%	9%	48%	75
Fisher-Freeman-Halton Exact Test P =				**0.160**
Customer Satisfaction?				
Group	Same	Better	Worse	Responses
Comparison	40%	9%	51%	43
Conversion	42%	6%	52%	33
All	41%	8%	51%	76
Fisher-Freeman-Halton Exact Test P =				**0.941**
Delivery Convenience?				
Group	Same	Better	Worse	Responses
Comparison	30%	12%	58%	43
Conversion	27%	9%	64%	33
All	29%	11%	61%	76
Fisher-Freeman-Halton Exact Test P =				**0.890**

Customers				
Traffic Congestion?				
Group	Same	Better	Worse	Responses
Comparison	64%	21%	14%	14
Conversion	47%	30%	23%	57
All	51%	28%	21%	71
Fisher-Freeman-Halton Exact Test P =				**0.573**
Traffic Safety?				
Group	Same	Better	Worse	Responses
Comparison	57%	14%	29%	14
Conversion	36%	34%	30%	56
All	40%	30%	30%	70
Fisher-Freeman-Halton Exact Test P =				**0.292**
Property Access?				
Group	Same	Better	Worse	Responses
Comparison	86%	14%	0%	14
Conversion	55%	30%	14%	56
All	61%	27%	11%	70
Fisher-Freeman-Halton Exact Test P =				**0.137**
Business Opportunities?				
Group	Same	Better	Worse	Responses
Comparison	86%	14%	0%	14
Conversion	52%	38%	11%	56
All	59%	33%	9%	70
Fisher-Freeman-Halton Exact Test P =				**0.072**
Customer Satisfaction?				
Group	Same	Better	Worse	Responses
Comparison	71%	29%	0%	14
Conversion	41%	39%	20%	56
All	47%	37%	16%	70
Fisher-Freeman-Halton Exact Test P =				**0.070**

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100% due to rounding.

In general, customers tended to feel things would not change post-conversion or had not changed post-conversion, as evidenced by higher percentages of similar responses throughout the categories. The significant differences, as shown in Table I-5, are discussed individually.

Table I-5. Comparison Customers Compared to Comparison Business Owners/Managers and Conversion Customers Compared to Conversion Business Owners/Managers.

Comparison Business Owners, Managers, & Customers					**Conversion Business Owners, Managers, & Customers**				
Traffic Congestion?					**Traffic Congestion?**				
Group	Same	Better	Worse	Responses	Group	Same	Better	Worse	Responses
Comparison	64%	21%	14%	14	Comparison	47%	30%	23%	57
Conversion	27%	52%	21%	44	Conversion	22%	44%	34%	32
All	36%	45%	19%	58	All	38%	35%	27%	89
Fisher-Freeman-Halton Exact Test P =				**0.044**	Fisher-Freeman-Halton Exact Test P =				**0.056**
Traffic Safety?					**Traffic Safety?**				
Group	Same	Better	Worse	Responses	Group	Same	Better	Worse	Responses
Comparison	57%	14%	29%	14	Comparison	36%	34%	30%	56
Conversion	25%	55%	21%	44	Conversion	42%	39%	18%	33
All	33%	45%	22%	58	All	38%	36%	26%	89
Fisher-Freeman-Halton Exact Test P =				**0.018**	Fisher-Freeman-Halton Exact Test P =				**0.470**
Property Access?					**Property Access?**				
Group	Same	Better	Worse	Responses	Group	Same	Better	Worse	Responses
Comparison	86%	14%	0%	14	Comparison	55%	30%	14%	56
Conversion	14%	11%	75%	44	Conversion	18%	6%	76%	33
All	31%	12%	57%	58	All	42%	21%	37%	89
Fisher-Freeman-Halton Exact Test P =				**0.0001**	Fisher-Freeman-Halton Exact Test P =				**0.0001**
Business Opportunities?					**Business Opportunities?**				
Group	Same	Better	Worse	Responses	Group	Same	Better	Worse	Responses
Comparison	86%	14%	0%	14	Comparison	52%	38%	11%	56
Conversion	45%	14%	41%	42	Conversion	39%	3%	58%	33
All	55%	14%	30%	56	All	47%	25%	28%	89
Fisher-Freeman-Halton Exact Test P =				**0.006**	Fisher-Freeman-Halton Exact Test P =				**0.0001**
Customer Satisfaction?					**Customer Satisfaction?**				
Group	Same	Better	Worse	Responses	Group	Same	Better	Worse	Responses
Comparison	71%	29%	0%	14	Comparison	41%	39%	20%	56
Conversion	40%	9%	51%	43	Conversion	42%	6%	52%	33
All	47%	14%	39%	57	All	42%	27%	32%	89
Fisher-Freeman-Halton Exact Test P =				**0.0006**	Fisher-Freeman-Halton Exact Test P =				**0.0003**

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100%.

Researchers found statistically significant differences between comparison customers and comparison business owners/managers for all five categories: traffic congestion, traffic safety, property access, business opportunities, and customer satisfaction. Researchers found significant differences between conversion customers and conversion business owners/managers for property access, business opportunities, and customer satisfaction. Each category and the differences found are discussed individually.

Traffic Congestion (Confidence Level = 0.95, Comparison Only). Sixty-four percent of customers felt traffic congestion would be the same post-conversion, whereas 52 percent of business owners/managers felt it would be better post-conversion. These same differences were not found to be significant when looking at the conversion business owners/managers and customers.

These findings suggest that customers both pre- and post-conversion may not recognize benefits to congestion that are associated with frontage road conversion. However, approximately half of business owners/managers at converted and unconverted locations did feel there would be some reduction in congestion. This feeling did not change significantly post-conversion. This lack of change between comparison and conversion business owners/managers suggests that business owners/managers at converted locations may not be changing their opinion between pre- and post-conversion.

Traffic Safety (Confidence Level = 0.95, Comparison Only). Fifty-seven percent of customers felt that traffic safety would remain the same post-conversion, while 55 percent of business owners/managers felt that traffic safety would get better post-conversion. These same differences were not found when comparing conversion business owners/managers to conversion customers. These findings suggest business owners/managers feel there is a safety benefit to converting frontage roads and that customers feel things will remain the same.

Even though it was not a significant difference, fewer conversion business owners/managers felt safety was improved post-conversion and that more conversion customers thought safety had improved. This is likely due to driver expectation of one-way frontage road in urban areas and business owners/managers recalling occurrences of drivers going the wrong way on recently converted frontage roads.

Property Access (Confidence Level = 0.99, Both). Eighty-six percent of comparison customers and 55 percent of conversion customers felt property access would, or did, remain the same after a conversion. Thirty percent of conversion customers thought access was better post-conversion. Zero percent of comparison customers felt it would be worse, and only 14 percent of conversion customers felt it was worse. These findings were significantly different from comparison and conversion business owners/managers, of whom 75 percent and 76 percent, respectively, felt property access would be worse.

These differences are potentially the result of customers not recognizing the need to make U-turns or travel the opposite direction when leaving a business at comparison sights. As shown in the customers' likelihood of stopping, this has an effect on customer driving behavior. Differences between conversion customers and conversion business owners/managers are potentially the result of selection bias of customers at converted locations. Namely, customers had already decided to do business at that location and thus had a more positive view of the access level for that business. They likely did not need to make a U-turn, travel in the opposite direction to get to the business, or travel in the wrong (opposite) direction when leaving the business.

The business owners'/managers' views likely indicate that business owners/managers fear that access will be worse post-conversion. This could potentially contribute to the selection bias observed in the conversion customer surveys if fewer customers were visiting the businesses where surveys were performed.

Business Opportunities (Confidence Level = 0.99, Both). The business opportunities category results are similar to those found in the property access category. These numbers suggest that comparison customers did not recognize the possible effects of frontage road conversion and that there was selection bias among conversion customers. There was an increase between comparison business owners/managers feeling opportunities would be worse and conversion business owners/managers feeling they did get worse. The increase was from 41 percent to 58 percent and was not found to be statistically significant.

Customer Satisfaction (Confidence Level = 0.99, Both). The customer satisfaction category numbers are similar to those of the property access and business opportunities categories. These numbers suggest that comparison customers did not recognize the possible effects of frontage road conversion and that there was selection bias among conversion customers. Approximately 50 percent of business owners/managers felt customer satisfaction would go down or had gone down post-conversion. As found previously, customer service ranked either first or second of the six categories shown in Table I-1.

Discussion

When conversion business owners/managers were compared to conversion customers and comparison business owners/managers were compared to comparison customers, researchers found statistically significant differences between their responses. Some differences may have occurred due to self-selection bias among customers. This is when customers selecting to do business along a converted frontage road have more favorable views.

These findings suggest business owners/managers have a concern of losing customers post-conversion. These findings also suggest that customer satisfaction, a portion of customer service, may be impacted by frontage road conversion. Customer service is an element of customer business selection, as shown in Table I-1.

IMPACT UPON DIFFERENT BUSINESS TYPES

All Seven Business Types

Researchers found statistically significant differences between the different business types when looking at their estimation of the number of full-time employees post-conversion. Full-time employees were included in question #11, page 279 (conversion site) and question #11, page 285 (comparison site). Table I-6 shows the results of this investigation.

In general, fast food and other restaurant business owners/managers felt the number of full-time employees would or had decreased post-conversion. In general, the remaining business owners/managers felt there was or would be no change in the number of full-time employees.

Pass-By or Planned

There were no statistically significant differences between business owners/managers at primarily pass-by trip businesses and business owners/managers at primarily planned trip businesses. This indicates that business owners/managers of both primarily pass-by and planned businesses share the same concerns about frontage road conversions.

Table I-6. Statistically Significant Differences when Investigating All Seven Business Types: All Business Owners/Managers.

Number of Full-Time Employees?				
Group	Decrease	No Change	Increase	Responses
Conv/Gas	20%	80%	0%	5
Fast Food	40%	30%	30%	10
Hotel	20%	60%	20%	5
Medical	0%	67%	33%	3
Other Restaurant	50%	45%	5%	20
Other Services	0%	80%	20%	15
Retail	27%	53%	20%	15
All	27%	56%	16%	73
Fisher-Freeman-Halton Exact Test P =				**0.047**

Notes: Bold = 0.0500 significance, and italicized with old = 0.0100 significance. Percentages may not add up to 100% due to rounding.

Retail or Non-Retail

Researchers compared the retail and non-retail groups between comparison business owners/managers, conversion business owners/managers, and all business owners/managers. Statistically significant differences for each group are discussed individually.

Non-Retail Comparison and Retail Comparison. Table I-7 shows the only statistically significant difference found when comparing non-retail comparison business owners/managers to retail comparison business owners/managers. Retail business owners/managers in comparison groups were significantly more concerned about delivery convenience than non-retail business owners/managers. This makes sense because retail businesses typically get more deliveries than non-retail businesses.

Table I-7. Statistically Significant Differences between Non-Retail Comparison and Retail Comparison Business Owners/Managers.

Delivery Convenience?				
Group	Same	Better	Worse	Responses
Non-Retail	42%	13%	46%	24
Retail	0%	8%	92%	12
All	28%	11%	61%	36
Fisher-Freeman-Halton Exact Test P =				**0.010**

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100% due to rounding.

Non-Retail Comparison and Non-Retail Conversion. Table I-8 shows a statistically significant difference found between non-retail comparison business owners/managers and non-retail conversion business owners/managers. Comparison non-retail business owners were a large portion of the group that felt pass-by customers would go up post-conversion.

Questions #3 and #4, page 279 (conversion site) and questions #3 and #4, page 282 (comparison site) asked business owners/managers about pass-by traffic shown in Table I-8.

Table I-8. Statistically Significant Differences between Non-Retail Comparison and Non-Retail Conversion Business Owners/Managers.

Number of Pass-by Customers?				
Group	Same	Up	Down	Responses
Comparison	28%	67%	6%	18
Conversion	31%	15%	54%	13
All	29%	45%	26%	31
Fisher-Freeman-Halton Exact Test P =				***0.003***

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentage may not add up to 100% due to rounding.

Retail Comparison and Retail Conversion. Researchers found two statistically significant differences between retail comparison business owners/managers and retail conversion business owners/managers, as shown in Table I-9. Researchers found a statistically significant difference when looking at the number of pass-by customers post-conversion.

Another statistically significant difference was between 100 percent of retail conversion businesses owners/managers feeling that their property value was going up compared to 10 percent of all retail comparison business owners/managers feeling this way. This suggests that retail business owners feel their property value does increase after a conversion.

Question #13, page 279 (conversion site) and question #13, page 285 (comparison site) asked business owners/managers about property values shown in Table I-9.

Table I-9. Statistically Significant Differences between Retail Comparison and Retail Conversion Business Owners/Managers.

Property Value?				
Group	No Change	Increase	Decrease	Responses
Comparison	60%	10%	30%	10
Conversion	0%	100%	0%	5
All	40%	40%	20%	15
Fisher-Freeman-Halton Exact Test P =				**.0004**
Number of Pass-by Customers?				
Group	Same	Up	Down	Responses
Comparison	50%	50%	0%	10
Conversion	40%	0%	60%	5
All	47%	33%	20%	15
Fisher-Freeman-Halton Exact Test P =				**0.023**

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100% due to rounding.

All Retail and Non-Retail. When looking at differences between retail and non-retail for business owners/managers, the only statistically significant difference was found when looking at the delivery convenience category, as shown in Table I-10. The finding suggests retail business owners/managers are concerned about their ability to get products into their store to sell.

Table I-10. Statistically Significant Differences between Retail and Non-Retail for All Business Owners/Managers.

Delivery Convenience?				
Group	Same	Better	Worse	Responses
Non-Retail	37%	12%	51%	41
Retail	5%	11%	84%	19
All	28%	12%	62%	60
Fisher-Freeman-Halton Exact Test P =				**0.019**

Note: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100% due to rounding.

Findings and Discussion

In most cases, business type had little effect on business owners'/managers' perceptions. An exception to this was retail business owners/managers. Retail business owners/managers were more concerned about delivery convenience than non-retail business owners/managers. They also felt their property value increased post-conversion.

BUSINESS OWNERS'/MANAGERS' FRONTAGE ROAD OPERATION (TWO-WAY OR ONE-WAY PREFERENCES)

Table I-11 shows the statistically significant differences based upon business owners'/managers' preference for frontage road operations on economic and operational categories. This is question #20a, page 280 (conversion site) and question #19a, page 286 (conversion site). Those business owners'/managers' who indicated they "strongly favor one-way" or "somewhat favor one-way" are in the "1-Way" group (row) of Table I-11. If they indicated "strongly favor two-way" or "somewhat favor two-way," they are in the "2-Way" group (row). Sixty-three percent of all respondents indicated they preferred two-way frontage roads.

The following are highlighted differences at confidence levels of 0.99; these results indicate preference may have influenced the previous results in these categories:

- number of customers (64 percent with two-way preference thought it would decrease);
- number of crashes (34 percent with two-way preference thought it would increase);
- traffic congestion (73 percent with one-way preference thought it would be better);
- traffic safety (77 percent with one-way preference thought it would be better);
- property access (88 percent with two-way preference thought it would be worse); and
- delivery convenience (73 percent with two-way preference thought it would be worse).

The following are highlighted differences at a confidence level of 0.95; these results indicate preference may have influenced the previous results in these categories:

- property value (38 percent with two-way preference thought it would decrease);
- number of pass-by customers (61 percent with one-way preference thought there would be no change);
- business opportunities (60 percent with two-way preference thought they would be worse); and
- customer satisfaction (60 percent with two-way preference thought it would be worse).

These findings suggest that any conclusions reached while using the above categories may have been influenced by the business owners' or managers' preference for two-way frontage roads. Another possibility could be that all the issues business owners/managers have with frontage road conversion may have influenced their frontage road preference.

Table I-11. Statistically Significant Differences between Business Owners' and Managers' Preferences for Frontage Roads Being One-Way or Two-Way.

Number of Customers?					**Traffic Safety?**				
Group	Decrease	No Change	Increase	Responses	Group	Worse	Same	Better	Responses
1-Way	28%	44%	28%	25	1-Way	8%	15%	77%	26
2-Way	64%	18%	18%	45	2-Way	27%	44%	29%	48
No Pref	0%	100%	0%	2	No Pref	0%	0%	100%	2
All	50%	29%	21%	72	All	20%	33%	47%	76
Fisher-Freeman-Halton Exact Test P =				***0.005***	Fisher-Freeman-Halton Exact Test P =				***0.007***
Property Value?					**Property Access?**				
Group	Decrease	No Change	Increase	Responses	Group	Worse	Same	Better	Responses
1-Way	14%	52%	33%	21	1-Way	54%	27%	19%	26
2-Way	38%	20%	43%	40	2-Way	88%	8%	4%	48
No Pref	0%	100%	0%	2	No Pref	50%	50%	0%	2
All	29%	33%	38%	63	All	75%	16%	9%	76
Fisher-Freeman-Halton Exact Test P =				**0.018**	Fisher-Freeman-Halton Exact Test P =				***0.007***
Number of Crashes?					**Business Opportunities?**				
Group	Decrease	No Change	Increase	Responses	Group	Worse	Same	Better	Responses
1-Way	44%	52%	4%	25	1-Way	28%	60%	12%	25
2-Way	20%	46%	35%	46	2-Way	60%	32%	9%	47
No Pref	100%	0%	0%	2	No Pref	0%	100%	0%	2
All	30%	47%	23%	73	All	47%	43%	9%	74
Fisher-Freeman-Halton Exact Test P =				***0.002***	Fisher-Freeman-Halton Exact Test P =				**0.033**
Number of Pass-by Customers?					**Customer Satisfaction?**				
Group	Decrease	No Change	Increase	Responses	Group	Worse	Same	Better	Responses
1-Way	17%	61%	22%	23	1-Way	36%	60%	4%	25
2-Way	35%	24%	41%	37	2-Way	60%	29%	10%	48
No Pref	0%	50%	50%	2	No Pref	0%	100%	0%	2
All	27%	39%	34%	62	All	51%	41%	8%	75
Fisher-Freeman-Halton Exact Test P =				**0.0348**	Fisher-Freeman-Halton Exact Test P =				**0.037**
Traffic Congestion?					**Delivery Convenience?**				
Group	Worse	Same	Better	Responses	Group	Worse	Same	Better	Responses
1-Way	15%	12%	73%	26	1-Way	32%	40%	28%	25
2-Way	33%	33%	33%	48	2-Way	73%	25%	2%	48
No Pref	0%	0%	100%	2	No Pref	100%	0%	0%	2
All	26%	25%	49%	76	All	60%	29%	11%	75
Fisher-Freeman-Halton Exact Test P =				***0.007***	Fisher-Freeman-Halton Exact Test P =				***0.001***

Notes: Bold = 0.0500 significance, and italicized with bold = 0.0100 significance. Percentages may not add up to 100% due to rounding.