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16. Abstract

To answer questions being raised by abutting residents and businesses about proposed elevated and/or depressed freeway improvements in the urban and suburban areas of Texas, a four-year study has been conducted to estimate the social, economic and environmental effects of such freeway designs. Eight existing, two under construction and one approved for construction freeway sections have been studied on a before-, during- and after-construction basis. The sections selected for study range from being in predominately residential suburban areas to predominantly commercial-industrial downtown areas. The specific effects of the three types estimated for each study section are as follows: (1) social impacts: population changes, neighborhood accessibility, neighborhood cohesion and community services; (2) economic impacts: relocation and mitigation costs, business sales, property uses and values, tax revenues, employment and income and user costs; and (3) environmental impacts: aesthetics, drainage and erosion, noise and air pollution, vibration and hazardous spills. The literature review and a survey of highway agencies in other states were used to determine the appropriate procedures or models and mitigation measures to implement in estimating the social, economic and environmental impacts of elevated and depressed freeways.

The results of the study, presented in six separate reports according to types of effect, can be used by highway planning and designing engineers to prepare environmental statements and documents of the expected social, economic and environmental impacts of proposed elevated and depressed freeway projects. Also, the results can be disseminated at the public hearings for a proposed project. This report presents the findings of the drainage, erosion, hazardous spill, vibration and aesthetic effects of elevated, depressed and at-grade level freeways. The findings indicate that the grade level differences are significant for almost all of the factors studied. Therefore, the maintenance costs varied accordingly. The specific grade level designs of each freeway study section also affected maintenance costs.

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DRAINAGE, EROSION AND OTHER ENVIRONMENTAL IMPACTS OF ELEVATED, DEPRESSED AND AT-GRADE LEVEL FREEWAYS IN TEXAS

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Research Report 1327-5
Research Study Number 0-1327
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Sponsored by the
Texas Department of Transportation
In Cooperation with
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IMPLEMENTATION STATEMENT

The findings of this study can be used by TxDOT to improve its procedures for estimating and evaluating drainage, erosion, hazardous spill, vibration and aesthetic effects from proposed elevated, depressed and at-grade freeways. The findings indicate that the grade level differences are significant for almost all of the factors studied. Therefore, the maintenance costs varied accordingly. The specific grade level designs of each freeway study section also affected maintenance costs. Some adjustments may need to be made to minimize these maintenance cost differences.

The study findings can be implemented immediately to be presented at public hearings and to be used in preparing environmental impact statements.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented within. The contents do not necessarily reflect the views or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. It is not intended for construction, bidding, or permit purposes. This report was prepared by Wayne G. McCully, Research Scientist and Jesse L. Buffington, Research Economist.

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Dallas District:

Richard H. Rawles, Jr., Former Director of Construction; Gary W. Taylor, Project Manager of North Central Project Office; and Terry L. May, District Right-of-Way Engineer.

Houston District:

Hans C. Olavson, Director of District Transportation Planning; Dennis W. Warren, Director of Construction; and Thomas N. Lou, Assistant to Director of Transportation and Planning.

Harris County Toll Road Authority:

Wesley E. Freise, Executive Director.

Lubbock District:

Carl R. Utley, District Engineer; V. G. Chetty, Former Deputy District Engineer; John E. Rantz, Director of Operations and Construction; Steven P. Warren, Director of Transportation Planning and Development; Ted Copeland, Traffic Engineer; Mike Craig, Assistant District Design Engineer; Davis Melton, Environmental Coodinator; and Claude C. Kneisley, Right-of-way Supervisor.

San Antonio:

John P. Kelly, District Engineer; Julie Brown, Director of Transportation Planning and Development; Mary T. Richards, Environmental Coordinator; Gilbert G. Gavia, District Design Engineer; Felix A. Lemra, District Design Section; and Herbie L. Belvin, District Right-of-Way Administrator.

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SUMMARY

Transportation agencies are faced with an ever-increasing responsibility to accommodate a progressively greater traffic volume with minimal impact on the associated natural and built environments. This study looks at impacts generated by various grade levels utilized in urban freeway design. The various grade levels are constructed at ground level (at-grade), below ground level (depressed), and above ground level (elevated).

The following environmental factors were studied:

- Traffic noise (Research Report 1327-3)
- Air quality (Research Report 1327-4)
- Aesthetics (visual quality)
- Drainage
- Erosion
- Hazardous spills

In an effort to assist highway designers, a combined approach was employed which utilized a review of existing literature and visits to selected study sites to assess impacts before, during and after construction. At-grade conditions were used as a base line for comparison with elevated and depressed sections. Traffic noise and air quality are examined in detail in other reports; the remaining factors were evaluated qualitatively.

Researchers found that relative impacts of the designated environmental factors were specific for each of the three vertical alignments. At-grade sections offered the greatest amount of green space, but accent plantings can be installed in wall planters, in gore areas and around supports for overhead structures in depressed sections. Maintenance of vegetation used in depressed sections is more intensive, particularly where green space is not available. Elevated sections also do not offer green space and are considered visually obtrusive in residential neighborhoods.

Drainage is a greater concern in both elevated and depressed sections than in at-grade sections. Management of storm water in at-grade sections can usually be accomplished by

gravity flow, but depressed and elevated sections require special handling for collection and transport of runoff. Innovative techniques for pumping, siphoning and monitoring flow have been used with depressed sections. Curb-side gutters have been used on elevated sections, but lateral slope must fit close tolerances for crossfall to ensure pavement drainage for safety.

Treatment of hazardous spills is addressed by designating hazardous cargo routes and development of trained response teams for cleanup. Since most spills result from an accident, alternate routing of traffic may be required. The first requirement is to minimize human exposure. Subsequent actions should contain spillage, neutralize the affected area and provide for environmental protection.

TxDOT has employed some innovative procedures for planning and monitoring the mitigation of these impacts. Environmental responsibilities are codified in the Clean Water Act, Clean Air Act, the Intermodal Surface Transportation Efficiency Act and its successors, and the National Environmental Policy Act, numerous judgments and policies of various regulatory agencies. Environmental requirements to alleviate impacts from highway design, construction, operation and maintenance can be assigned to trained specialists or addressed by team action. TxDOT functions well in both of these areas.

INTRODUCTION

BACKGROUND

Study Problem Statement

The Texas Department of Transportation (TxDOT) is continually upgrading the existing highway system in the state, especially in urban and suburban areas. This upgrading involves improving existing highways or freeways on the existing route or on a new route paralleling the old route or bypassing the central city. Such freeway improvements are made at varying grade levels, i.e, at-grade, elevated grade and depressed grade, depending on the terrain, land use and other factors. The choice of grade level at a particular point may be an attempt to mitigate negative noise and aesthetics impacts on a residential neighborhood. The current trend in design is toward elevated and depressed sections to gain additional travel lanes. The elevated sections may be either earthen or bridge in form. Many sections of each type of grade level have been built over the years since the late 1950s. Many are more than 20 years old. However, quite a few sections have been built during last five to 10 years, and some sections are either under construction or in the planning stages.

Even though many sections of elevated and depressed freeways have been built over the years in the state, more and more questions are being raised by abutting or nearby residents and businesses about the possible negative impacts of such freeways. In recent years, stiff resistance has been given to the proposed elevated section of the Dallas North Central Expressway and more recently to the proposed elevated or depressed section of U.S. Highway 287 in Wichita Falls. Also, the elevated sections of U.S. Highway 183 now under construction in Austin have caused similar concerns.

Any highway improvement, regardless of grade level, not only impacts users but also impacts abutting and nearby property owners, businesses and residents in some manner. Even the whole city or community is impacted in some way during and after construction. Elevated and depressed freeway designs raise particular questions concerning noise and air quality impacts, but vibration in moving vehicles and in structures adjacent to the freeway and flooding of depressed freeways are additional concerns. The recent flooding of a depressed section of IH 10 in Houston dramatized the latter problem. Soil erosion at the point of drainage discharge may present a problem. Finally, aesthetic qualities of elevated and depressed sections may be matters of concern.

Impacts that result from elevated and depressed freeway improvements can be classified into three major types: (1) social, (2) economic and (3) environmental. A partial list of the specific impacts of each of the major types is given below. The social impacts are: population changes, neighborhood accessibility, neighborhood cohesion and community services. The economic impacts are: relocation and mitigation costs, business sales, land uses and proper values, tax revenues, employment and income and user costs. The environmental impacts are: aesthetics, drainage and erosion, air quality, noise and vibration, and hazardous spills.

A preliminary search of the literature reveals very few case studies that have measured many of the social, economic and environmental impacts of depressed and elevated freeways, especially those in Texas. Therefore, the highway decision-makers have very little relevant impact data to write and support the environmental assessment statements and to present at public hearings for proposed elevated and depressed sections of existing or proposed freeway.

Study Objectives

The general objectives of the study are to determine the social, economic and environmental effects of elevated and depressed freeways in urban and suburban areas. The more specific objectives of the study are as follows:

1. Determine the appropriate estimating procedures or models and mitigation measures to be used in this study to estimate the social, economic and environmental effects of elevated and depressed freeways.
2. Estimate the social, economic and environmental effects of several existing, contracted and proposed elevated and depressed freeway sections situated in urban areas in Texas and recommend a final set of impact-estimating procedures for use by TxDOT.

Selection of Freeway Study Sections

At the beginning of this study, a survey was conducted in all of TxDOT's districts to locate elevated and depressed freeway sections at least 0.805 km (0.5 mi) long that were planned, under construction or recently constructed during the last 10 years. (Copies of the survey forms appear in Appendix A.) Also, the survey asked for TxDOT to indicate the location (downtown or suburban), abutting land use and age (less than five years or more than five years) of each qualifying freeway section. Later, a determination was made whether each freeway section was on an existing highway route or a new location. These were considered primary characteristics to be used in selecting the freeway study sections.

A total of 30 freeways (11 elevated and 19 depressed) were identified and reported by the TxDOT districts. A total of 12 (six elevated and six depressed) were planned; three (one elevated and two depressed) were under construction; and 15 (four elevated and 11 depressed) were recently constructed. Each of the 30 candidate study sections were personally inspected by TTI researchers accompanied by a TxDOT district official.

With the help of TxDOT's study panel members, a total of 11 freeway sections were selected for study. Of those selected, two (one elevated and one depressed) were planned; two (one elevated and one depressed) were under construction; and seven (three elevated and four depressed) were built. Of the seven already built, three (two elevated and one depressed) were less than four years old and four (one elevated and three depressed) were over four years old.

Location and Characteristics of Study Freeway Sections

Table 1 shows the selected study sections; type of grade level, location, abutting land use and age. As can be seen, an attempt was made to have a fairly good mix of study sections representing different types of location, stages of construction and ages and land uses for each of the study grade levels.

The 11 study sections are located in four Texas cities: one depressed section on U.S. Highway 75 in Dallas; one depressed section on the Sam Houston Tollway in Houston; and four sections in Lubbock. Two of these were located on IH 27 (one elevated and one depressed) and two are located on the planned East-West Freeway (U.S. Highways 62/82), one elevated and one depressed. Figures 1-4 show the specific location of the study sections within Dallas, Houston, Lubbock and San Antonio, respectively.

Table 1. Freeway Sections Selected for Study by Type of Grade Level Design and Key Characteristics

TYPE OF DESIGN/ Number/STATUS	CITY & HIGHWAY Type/Number	ROUTE LOCATION	SECTION LOCATION	ABUT LAND USE
Elevated Sections				
No. 11- Planned	Lubbock-US 62/82	Existing	Suburban	Res/Com
No. 8-Built Under 4Yrs	Lubbock-IH 27	New	Downtown	Com/Ind
Depressed Sections				
No. 10-Planned	Lubbock-US 82	Existing	Downtown	Com/Pub/ Res
No. 7-Under Contruction	Dallas-US 75	Existing	Downtown & Suburban	Com/Res
No. 9-Built Under 4 Yrs	Lubbock-IH 27	New	Suburban	Res/Com
No. 5-Built Under 4 Yrs	San Antonio-US 281	Existing	Suburban	Vacant/ Res/Com
No. 1-Built Over 4 Yrs[1]	San Antonio-IH 35	Existing	Downtown	Res/Com
No. 6-Built Over 4Yrs	Houston-Beltway 8	New	Suburban	Res/Com
Combination Elevated & Depressed Sections				
No. 2-Built Under 4 Yrs	San Antonio-IH 35	Existing	Downtown	Res/Com
No. 3-Built Under 4 Yrs	San Antonio-IH 10	Existing	Downtown	Res/Com
No. 4-Built Over 4 Yrs	San Antonio-IH 10/35	Existing	Downtown	Com/Ind

[1]No basic grade level change in this section, but adjacent to a new elevated/depressed section having feeder ramps extending into this section.

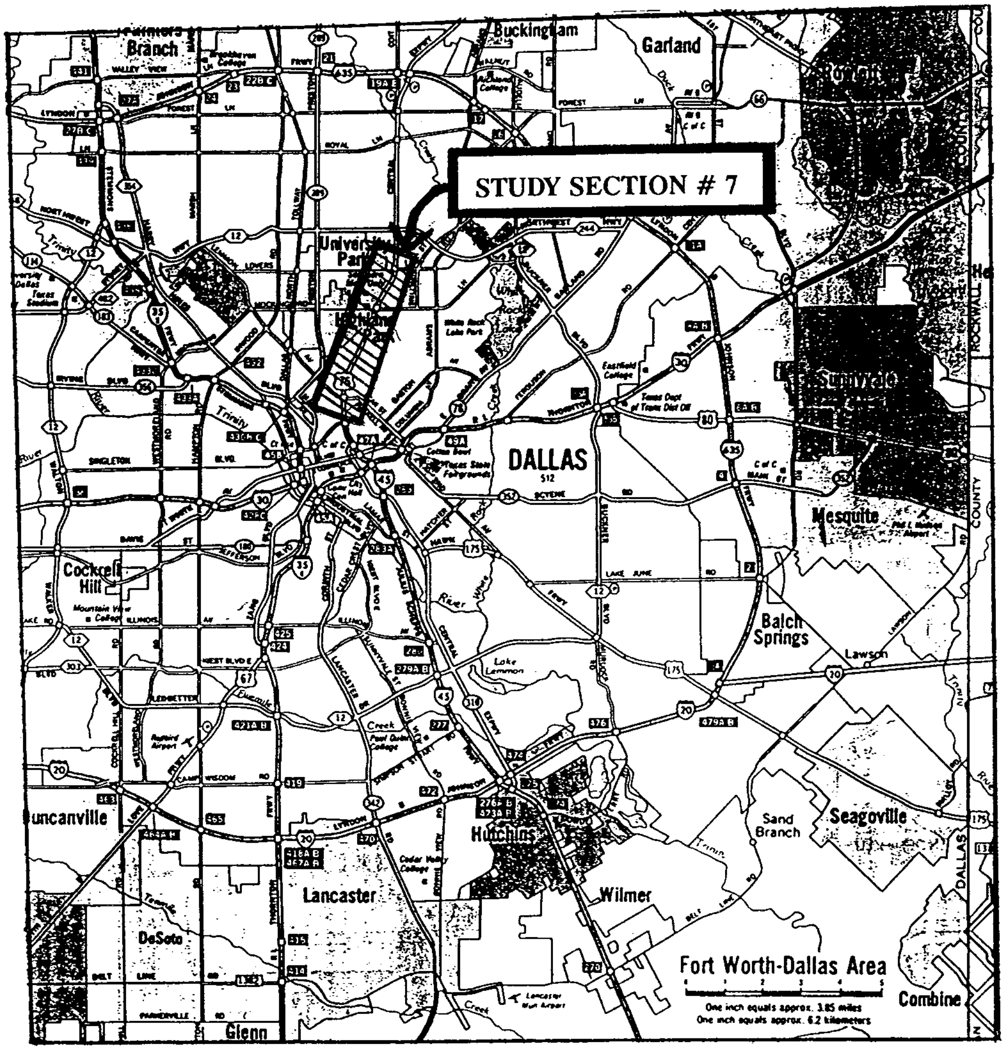


Figure 1. Location of the Study Section 7 on U.S. Highway 75 (Central Expressway) Near Downtown Dallas

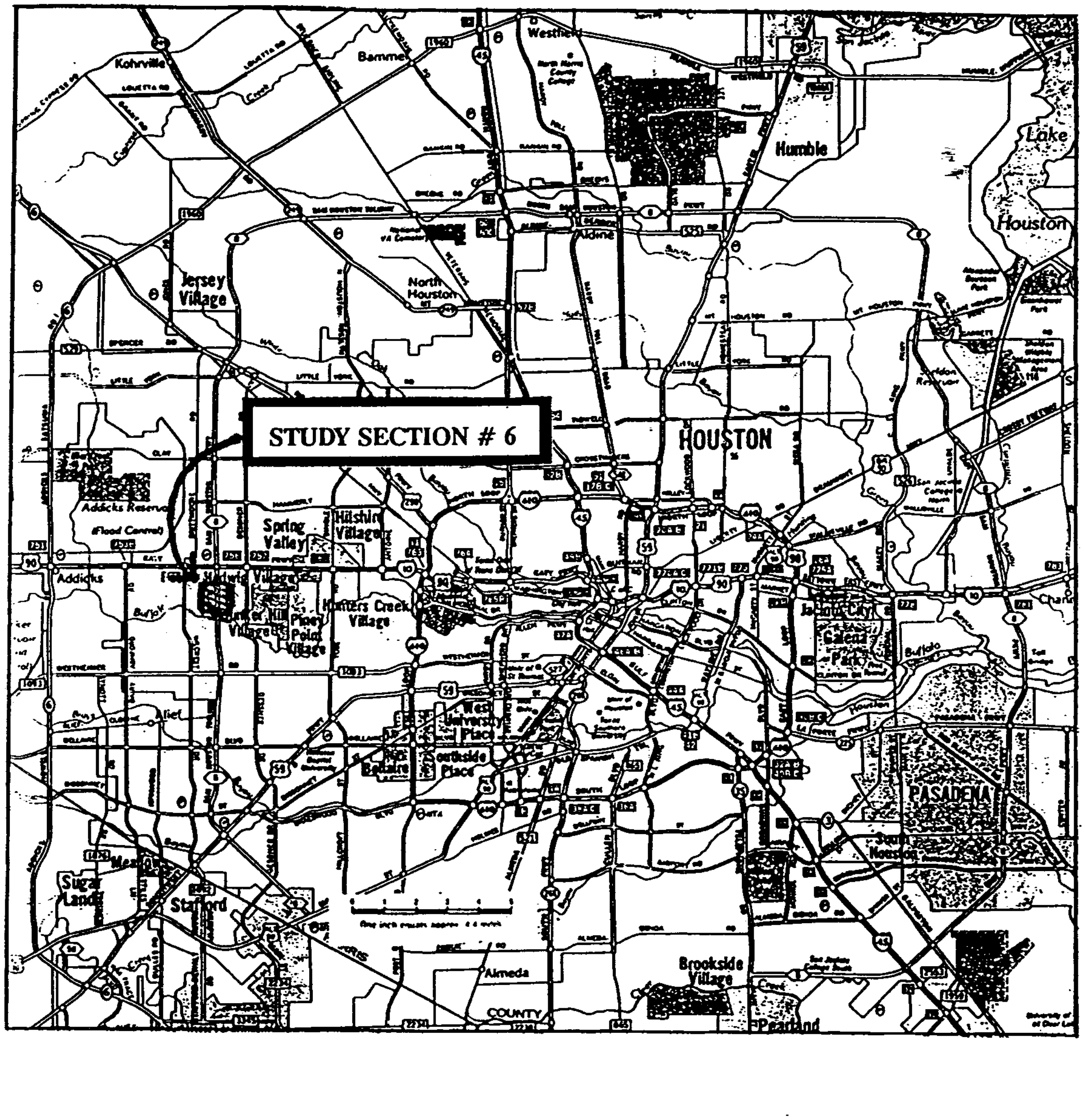


Figure 2. Location of Study Section 6 on the Sam Houston Tollway in Southwestern Part of Houston

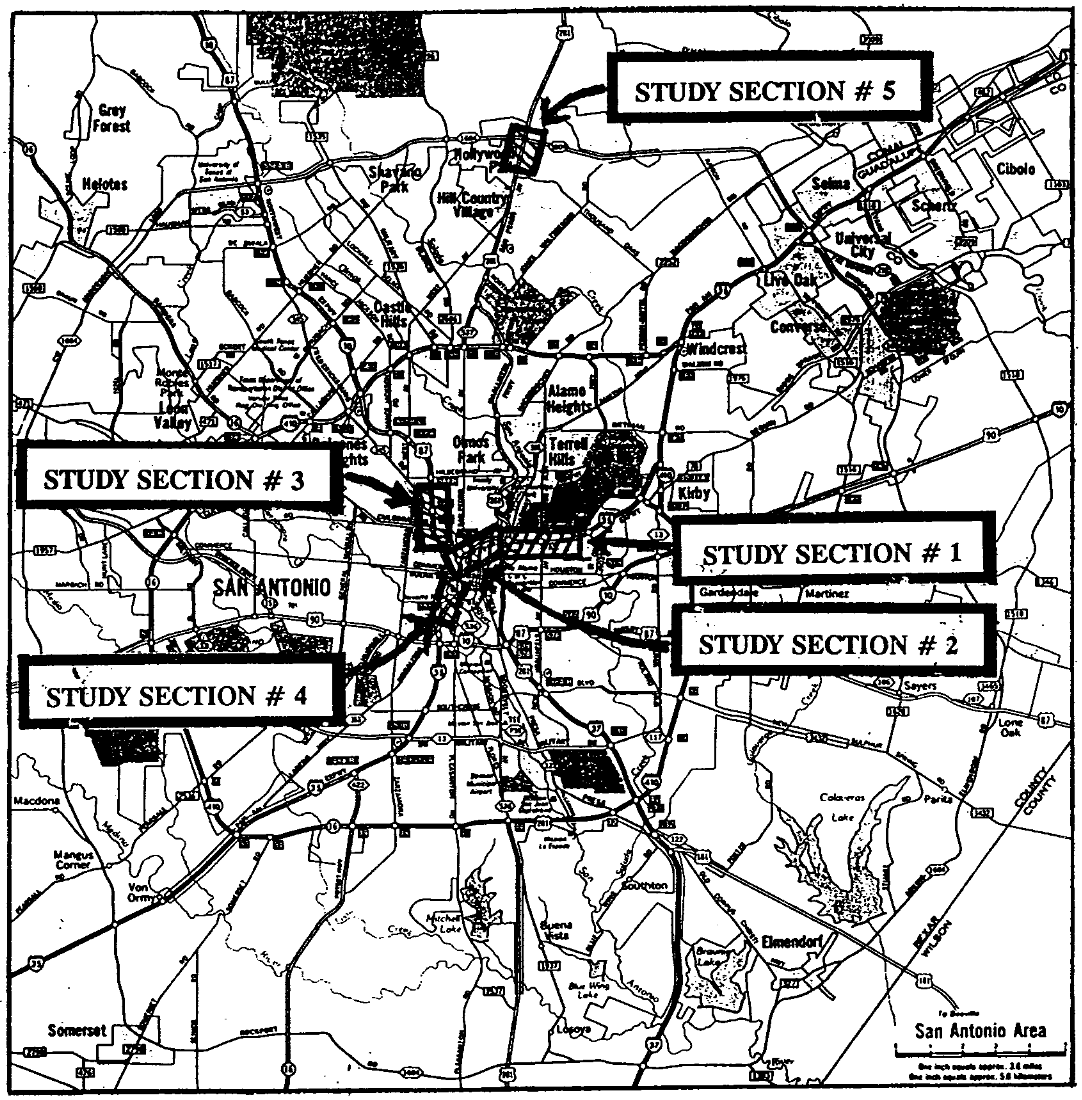


Figure 3. Location of Study Sections 1-5 on IH 10, 10/35, 35 and U.S. Highway 281 in San Antonio

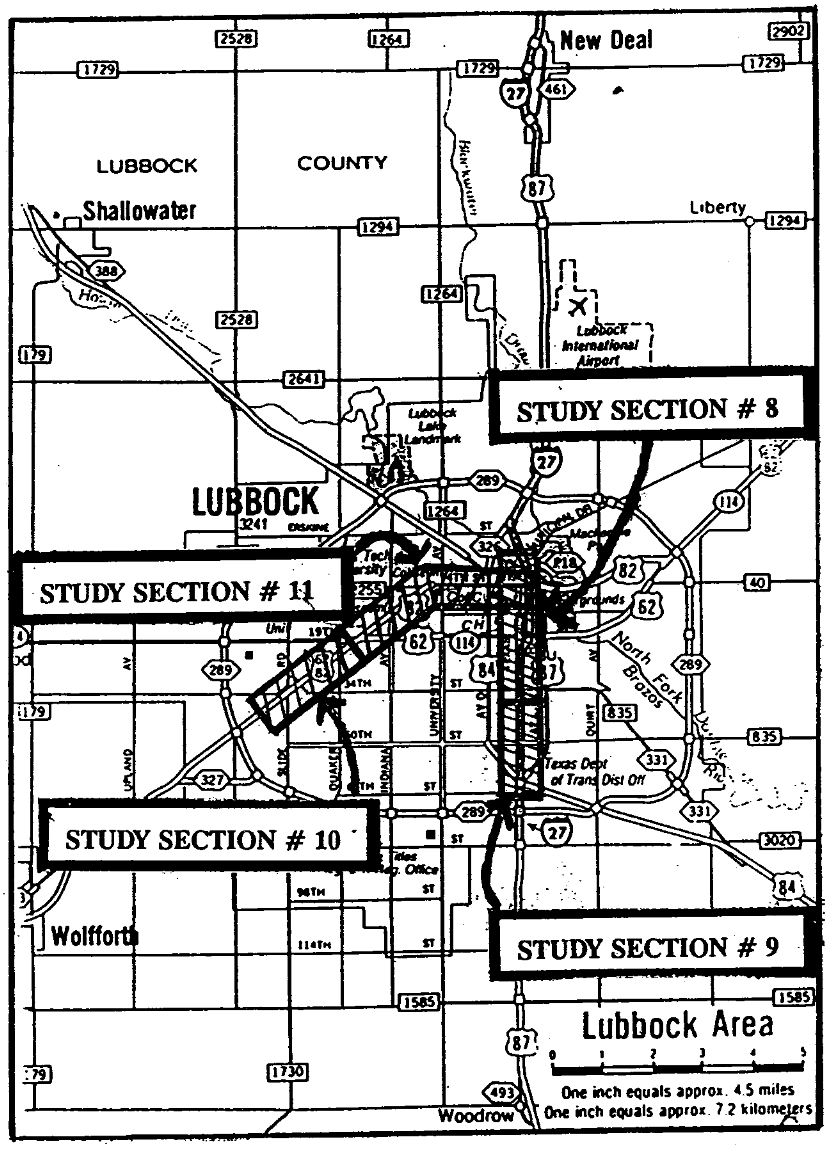


Figure 4. Location of Study Sections 8-11 on IH 27 and U.S. Highways 62/82 (Proposed East-West Freeway) in Lubbock

Tables 2 and 3 show other important characteristics of each study section by study grade level. Some of these characteristics are used in evaluating the different impacts considered under this study.

Typical Cross-sectional Design of Study Freeway Sections

Figures 5-9 show the typical cross-sectional designs of the study freeway sections. There are some variations in cross-sectional design through each study section, depending on the specific location. For instance, only one of the cross-sections show the on and off ramp designs or the variation in the number of main lanes or frontage road lanes throughout the study section.

General Methodology and Data Sources

The general methodology planned for this study was to conduct a "before and after" construction period comparative analysis across time supplemented with a cross-sectional analysis at one point-in-time. The eight completed freeway study sections lend themselves easily to both analyses. The three others can be used to provide current before and/or after construction period data to supplement these analyses. For instance, the two study sections still under construction, at time of selection, can be used to study some of the construction effects of each grade level. The two planned study sections can be used to estimate anticipatory effects by grade level.

The before and after analysis can compare the elevated freeway sections with depressed freeway sections to ascertain any significant differences in various types of impact elements, i.e., air pollution, noise pollution, business activity, neightborhood cohesian, etc. The one point-in-time analysis can compare current level unit values of each impact element to determine significant differences between elevated and depressed freeway grade levels. For either of these analytical approaches, you can compare elevated study sections with depressed study sections and also compare these two grade levels with adjacent or nearby at-grade level sections. The at-grade sections, when available, can serve as a control or base section.

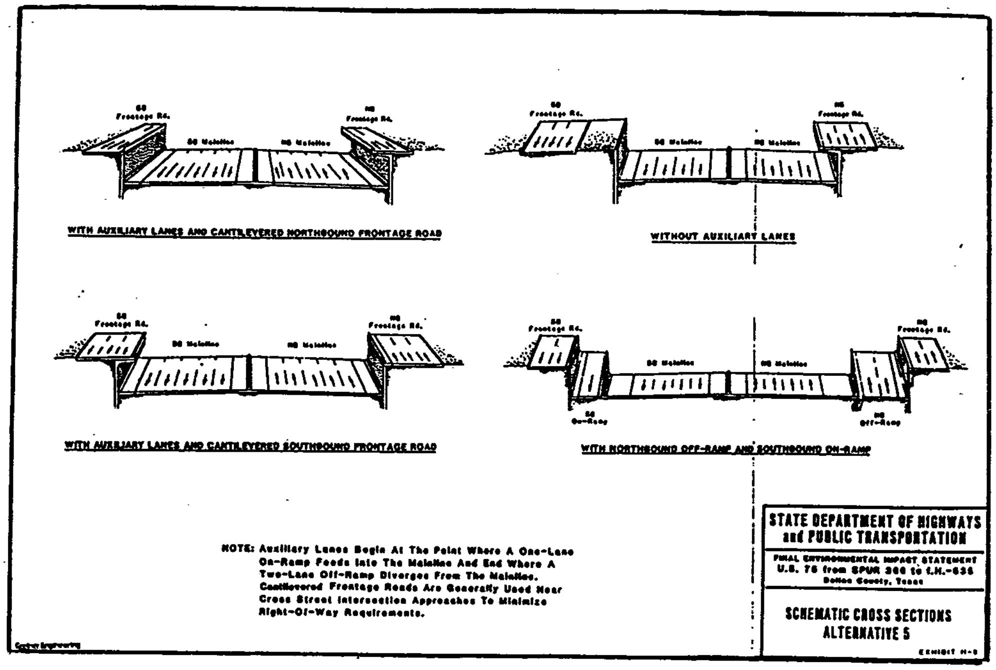
Sources of data used in the study ranged from a review of the literature to "on-site" data collection. The prior studies found in the literature, as well as data obtained from a national survey of state transportation agencies, helped to determine the different methodologies

Table 2. Study Freeway Sections by Age, Grade Level Before, Length, Grade Level Depth, Right-of-Way Width, Type of Main Lane Access and ADT

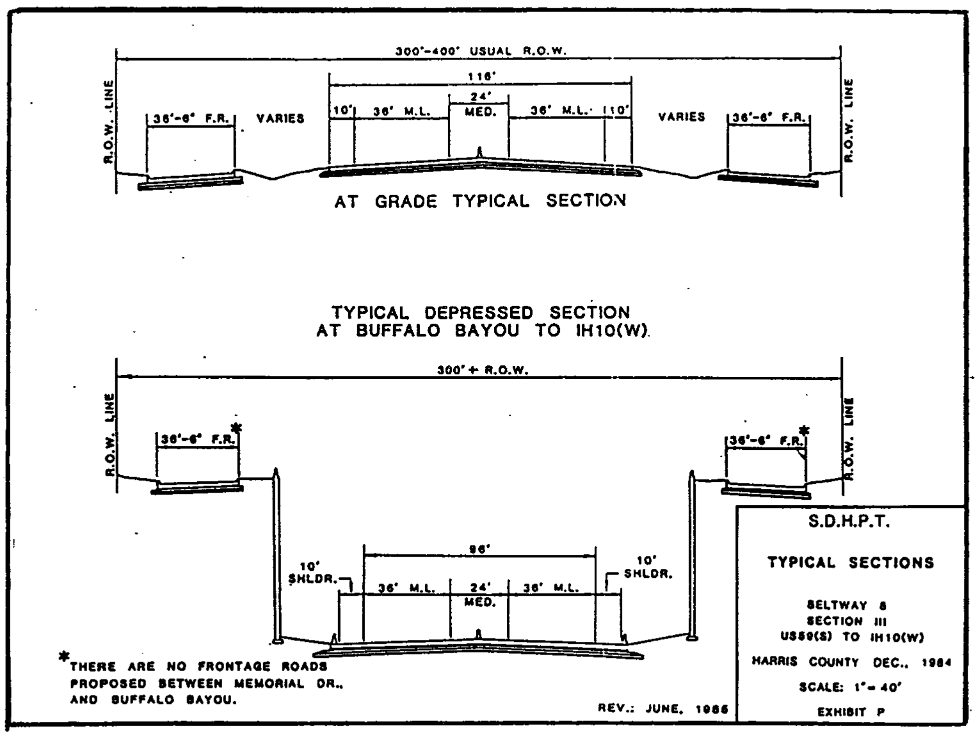
STUDY NO./ TYPE OF GRADE LEVEL AFTER CONSTRUCTION	AGE AFTER (yrs)	GRADE LEVEL BEFORE	LENGTH AFTER km(mi)	GRADE LEVEL HEIGHT/DEPTH m(ft)		RIGHT-OF-WAY WIDTH m(ft)		TYPE OF ACCESS TO MAIN LANES		ADT	
				BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Elevated/Combination Elevated & Depressed											
No. 2 IH 35-San Antonio	1	depressed	2.01(1.25)	-4.6(-15)	+6.1(+20)	64.0(210)	70.7(232)	full	limited	75,600	188,300
No. 3 IH 10-San Antonio	3	depressed	2.96(1.84)	0(0)	+6.1(+20)	65.5(215)	74.7(245)	limited	limited	94,100	198,500
No. 4 IH 10/35-San Antonio	6	elevated/ depressed	2.28(1.42)	+6.1(+20)	+6.1(+20)	61.0(200)	76.2(250)	limited	limited	79,800	186,500
No. 8 IH 27-Lubbock	3	at-grade	3.02(1.88)	0(0)	5.5(+18)	38.1(125)	121.9(400)	full	limited	42,352	77,350
No. 10 U.S.H. 62/82-Lubbock	0	at-grade	2.32(1.44)	0(0)	+6.4(+21)	53.6(176)	97.5(320)	full	limited	22,493	52,533
Depressed											
No. 6 Sam Houston Beltway-Houston	6	at-grade	2.09(1.30)	0(0)	-5.2(-17)	91.4(300)	91.4(300)	full	limited	84,000	168,000
No. 7 U.S.H. 75-Dallas	0	at-grade	6.47(4.02)	0(0)	-6.7(-22)	67.1(220)	85.3(280)	limited	limited	155,000	217,700
No. 9 IH 27-Lubbock	3	at-grade	4.84(3.01)	0(0)	-5.2(-17)	38.1(125)	121.9(400)	full	limited	42,356	77,350
No. 11 U.S.H. 62/82-Lubbock	0	at-grade	2.56(4.12)	0(0)	-6.7(-22)	53.7(176)	102.1(335)	full	limited	22,656	34,483
No. 1 IH 35-San Antonio	10	depressed	2.22(1.38)	-4.6(-15)	-4.6(-15)	91.4(300)	91.4(300)	limited	limited	50,000	150,000
No. 5 U.S.H. 281-San Antonio	5	at-grade	2.85(1.77)	0(0)	-6.4(-21)	91.4(300)	91.4(300)	full	limited	12,700	94,000

Table 3. Study Freeway Sections by Number of Structures, Crossing Streets, Main Lanes, On Ramps and Off Ramps

STUDY NO./ TYPE OF GRADE LEVEL AFTER CONSTRUCTION	STRUCTURES (NO.)		CROSSING STREETS (NO.)		MAIN LANES (NUMBER)		ON RAMPS (NUMBER)		OFF RAMPS (NUMBER)	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Elevated/Combination Elevated & Depressed										
No. 2 IH 35-San Antonio	11	12	11	11	4	10	4	8	6	8
No. 3 IH 10-San Antonio	9	11	6	6	4	10	3	6	5	6
No. 4 IH 10/35-San Antonio	6	8	8	8	6	10	4	6	4	3
No. 8 IH 27-Lubbock	2	6	21	6	4	6	0	4	0	3
No. 10 U.S.H. 62/82-Lubbock	2	4	5	3	4	6	0	3	0	3
Depressed										
No. 6 Sam Houston Beltway-Houston	0	3	7	3	4	6	0	2	0	2
No. 7 U.S.H. 75-Dallas	13	14	13	13	4	8	16	5	16	5
No. 9 IH 27-Lubbock	0	7	11	4	4	6	0	2	0	2
No. 11 U.S.H. 62/82-Lubbock	4	21	22	15	4	6	0	8	0	8
No. 1 IH 35-San Antonio	9	9	7	7	6	6	3	3	3	3
No. 5 U.S.H. 281-San Antonio	1	2	2	2	4	6	0	3	0	3

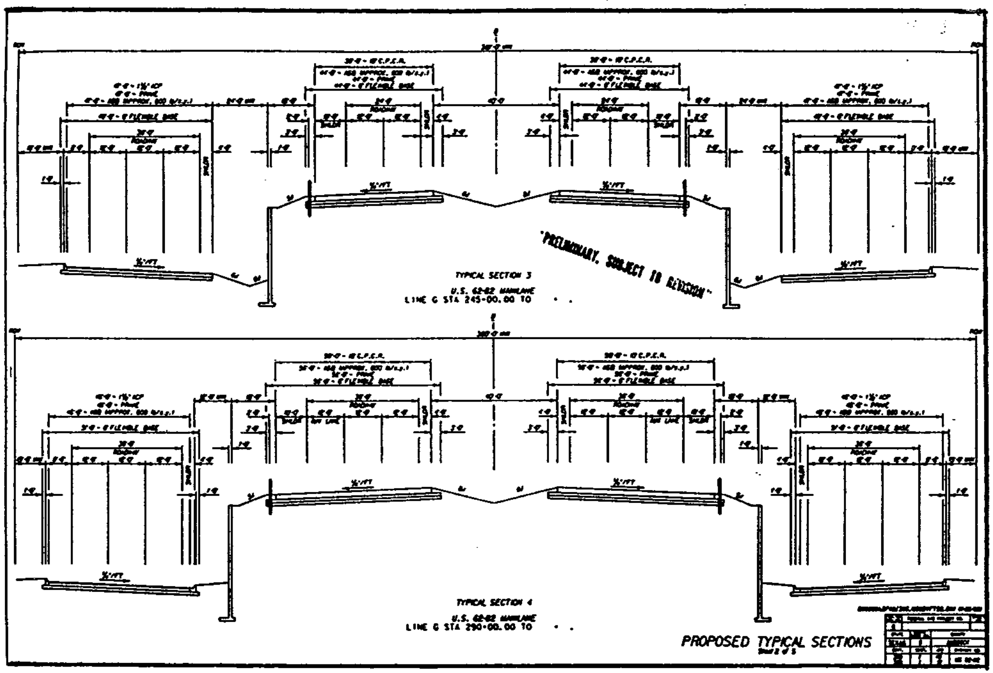


U. S. Highway 75 Section # 7, Dallas

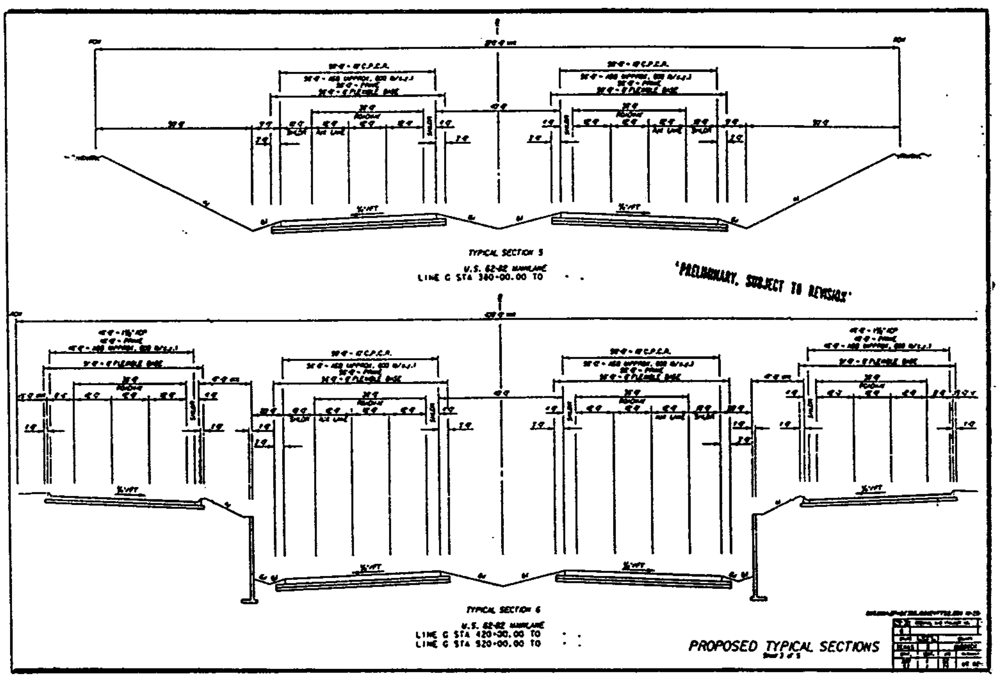


Sam Houston Tollway Section # 6, Houston

Figure 5. Typical Cross-sectional Design of Depressed Study Sections on U. S. Highway 75 in Dallas, Texas and Sam Houston Tollway in Houston, Texas

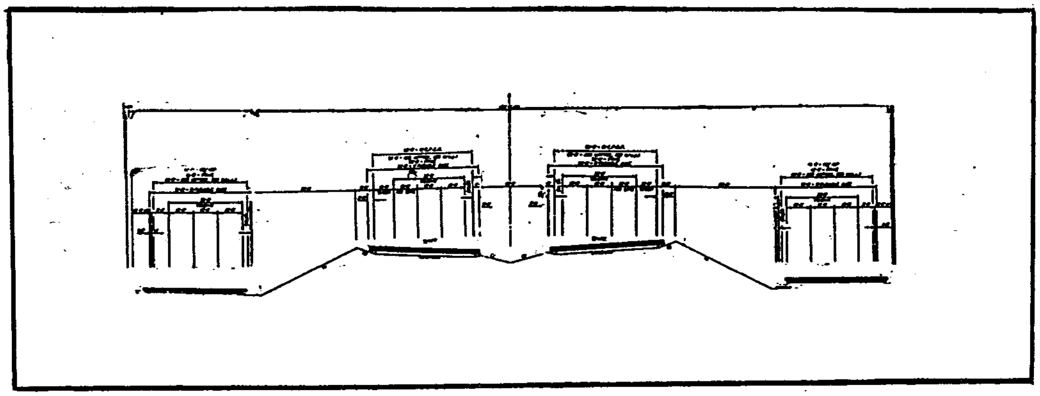


Elevated Section # 10

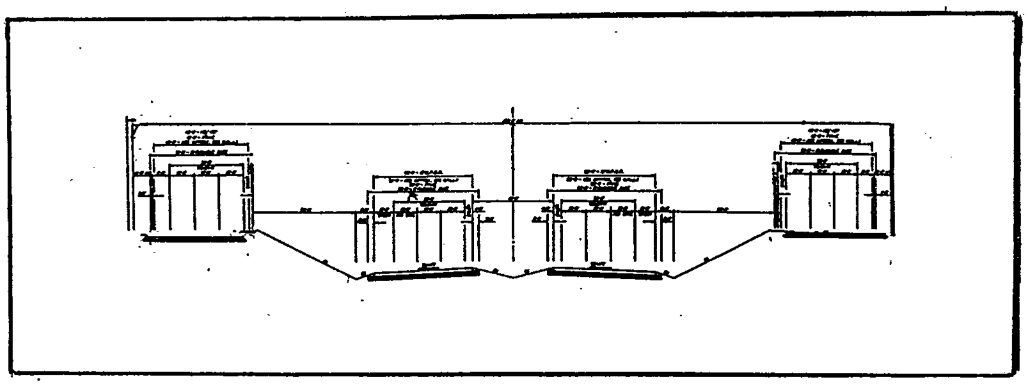


Depressed Section # 11

Figure 6. Typical Cross-sectional Design of the Depressed and Elevated Study Sections on the Planned East-West Freeway in Lubbock, Texas

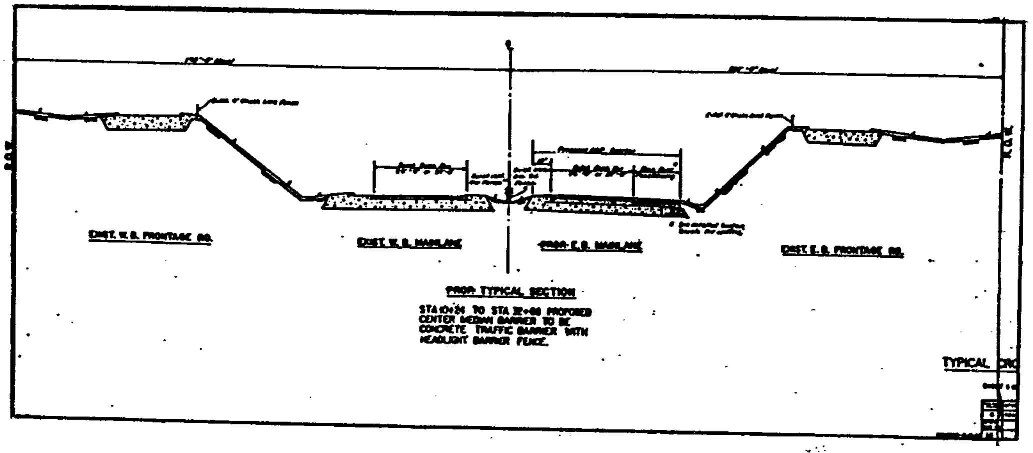


Elevated Section # 8

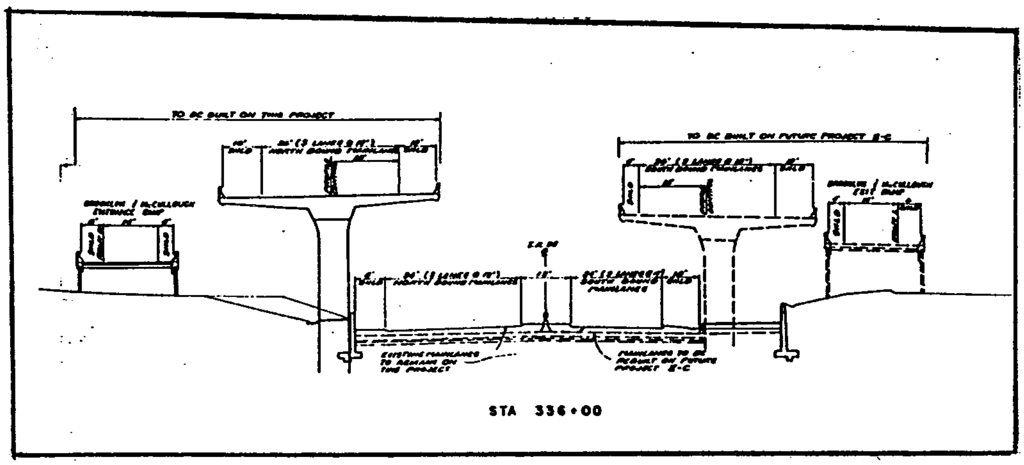


Depressed Section # 9

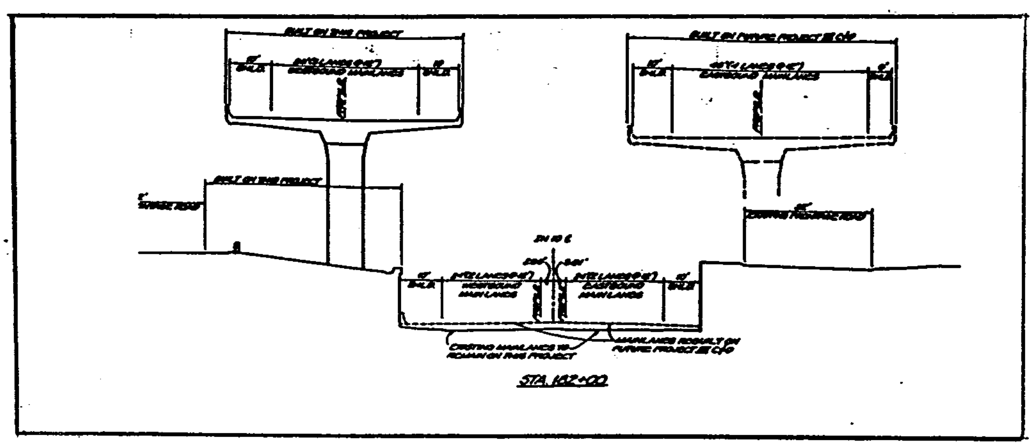
Figure 7. Typical Cross-sectional Design of the Elevated and Depressed Study Sections on the I.H. 27 in Lubbock, Texas



I.H. 35 Section # 1

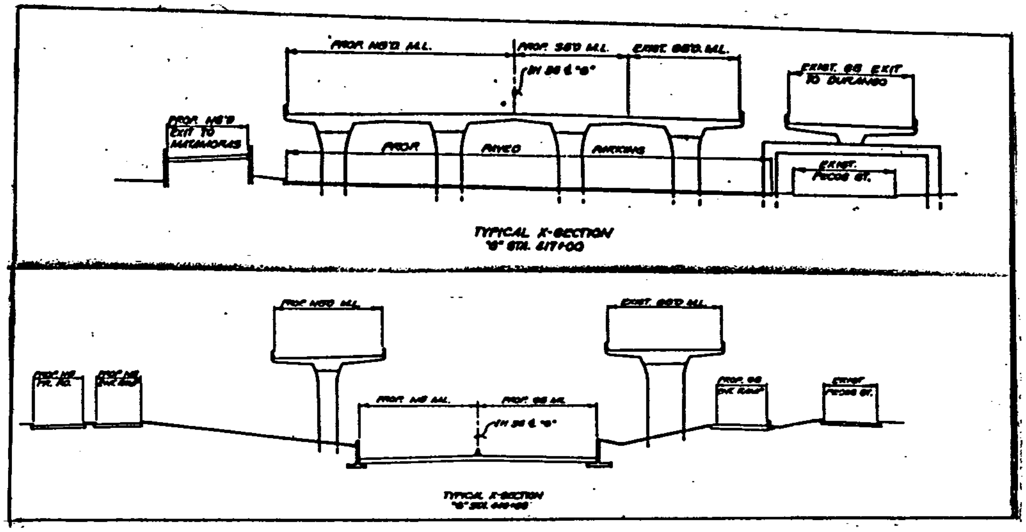


I.H. 35 Section # 2

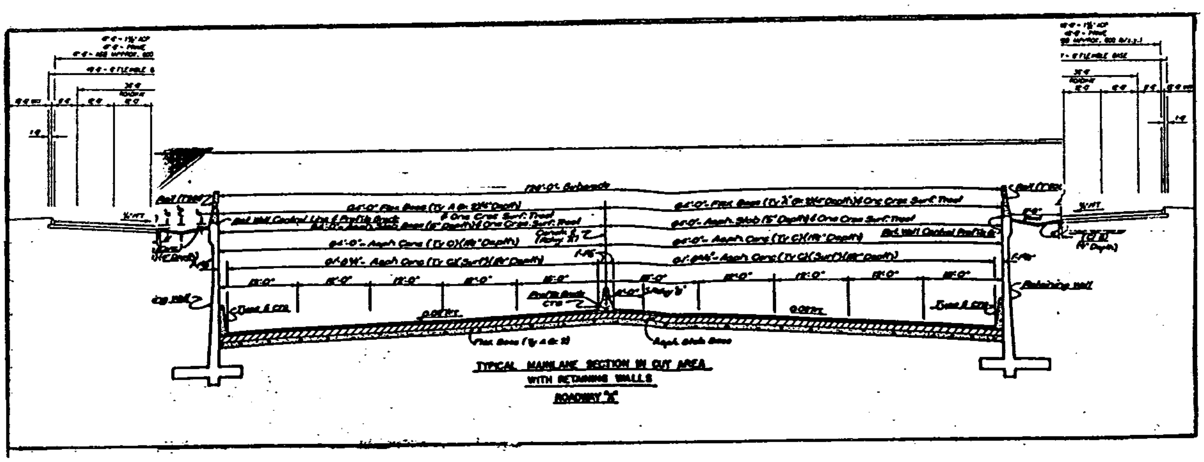


I.H. 10 Section # 3

Figure 8. Typical Cross-sectional Design of the Combination Elevated/Depressed Study Sections on I.H. 10 and 35 in San Antonio, Texas



I.H. 35 Section # 4



U. S. Highway 281 Section # 5

Figure 9. Typical Cross-sectional Design of the Depressed Study Sections on U. S. Highway 281 and I.H. 35 in San Antonio, Texas

methodologies used in the study. The data obtained to estimate the effects of the different impact elements came from the literature, national survey, United States Census Bureau, Texas State Comptroller and Employment Commission, TxDOT, Environmental Impact Statements (EIS) of each study section, city criss-cross directories, site surveys of businesses and residents, traffic volumes and composition, air and noise levels and drainage, erosion and other environmental conditions.

Reports of Findings

Since this study involves the study of many different impacts elements, the findings are presented in several reports by type of impact. The reports are as follows:

- Research Report 1327-1:
  Social and Economic Effects of Elevated and Depressed Freeways in Texas
- Research Report 1327-2:
  Land Value and Use Effects of Elevated and Depressed Freeways in Texas
- Research Report 1327-3:
  Noise Pollution Effects of Elevated and Depressed Freeways in Texas
- Research Report 1327-4:
  Air Pollution Effects of Elevated and Depressed Freeways in Texas
- Research Report 1327-5:
  Drainage, Erosion and Other Environmental Impacts of Elevated and Depressed Freeways in Texas
- Research Report 1327-6F:
  Social, Economic and Environmental Effects of Elevated and Depressed Freeways in Texas

Research Report 1327-1 contains a summary of the findings from the national survey of state transportation agencies and the Texas survey of TxDOT districts, and a description of the cities and areas of the cities where the freeway study sections are located. This report, Research Report 1327-5, contains the findings on the effects of elevated and depressed freeways on drainage, erosion, hazardous spills, vibration and aesthetics.

REVIEW OF PREVIOUS WORK

The highway environment, as visualized within TxDOT, is an extensive system of corridor rights-of-way and adjacent facilities throughout Texas (Hauser and McCully 1996). Urban sections of freeways often encroach upon densely populated areas which are particularly sensitive to environmental impacts generated by freeway infrastructures and associated traffic.

Each incremental increase in freeway traffic loading results in alternative design concepts to counter the impacts. It was recognized early by the ITE Technical Council Committee 6A9 (Traffic Engineering 46(2):38-41, 1976) that impacting environmental factors for analysis included air, noise, visual quality, vibration, vegetation and ground water. Air, noise and visual quality had a high level of importance, and the remaining factors were rated medium to low in importance.

Recently, design engineers evaluating infrastructure deployment issues associated with automated highway systems (AHSs) in urban metropolitan areas (Yim et al. 1995) have delineated three environmental concerns: (1) compatibility of design with adjacent development, (2) land-use considerations and (3) traffic impacts on neighborhood arterials.

An elevated, automated facility introduces a new structural element to neighborhoods along the freeway corridor. If lighter construction material were used, the facility's visual impact could be considerable. However, if the structure borders dense clusters of high-rise buildings, its visual impact would be less significant than if the structure borders an area with residences or other low-rise buildings. Landscaping and soundwalls are used currently as noise buffers, but specific measures will be needed to mitigate adverse noise and air quality impacts of urban freeways in residential neighborhoods.

Lateral expansion of an existing corridor may be needed to secure land for additional traffic lanes, elevated structures, or for entry and exit facilities. In some cases, lateral expansion may be costly and politically undesirable because of a need to encroach on existing neighborhoods, demolish buildings, or the presence of retaining walls, soundwalls and bridge supports.

Vehicles entering or exiting a freeway need to queue on local streets, large parking lots, or undeveloped areas to avoid interrupting local traffic. Another potential problem is the construction of fly-over ramps on high-cost land.

Elevated and depressed (including tunnels) freeway sections continue to offer viable alternatives to those at-grade. Design engineers utilize innovative designs and ingenuity to overcome problems on a site-specific basis. The impacts of these innovative procedures on the local environment need to be addressed and accommodated during the planning and design phases of a specific project.

RESEARCH APPROACH/PROCEDURES

It was recognized early (Traffic Engineering 46(2):38-41, 1976) that environmental factors for analysis should include at least air, noise, visual quality, vibration, vegetation and ground water. Air, noise and visual quality had a high level of importance and the remaining factors were of medium to low importance. In current studies, Yim et al. 1995 also voiced concern for visual, noise and air quality impacts of urban freeways.

The ITE Technical Council Committee 6A9 (Traffic Engineering 46(2):38-41, 1976) evaluated only air and noise factors quantitatively; the other factors were rated qualitatively. For this study, noise and air quality were measured quantitatively and reported in Research Reports 1327-3 and 1327-4, respectively. Visual quality, drainage and erosion were noted qualitatively due to a lack of objective procedures. The procedures used included visual inspection, conferences with TxDOT personnel, EIS reports, project plans and literature reviews using TRIS sources. At-grade sections constituted the norm for comparison.

FINDINGS/DISCUSSION

Except for Beltway 8 in Houston and IH 27 in Lubbock where new locations were involved, the basic infrastructure and drainage protocols were established earlier for each location. However, the additional impacts generated by the improvements to each route may result in some alteration of existing mitigative practices.

The freeway sections are characterized in Tables 1-3. Study sections are mapped in Figures 1-4, and typical cross-sections are shown in Figures 5-9.

DALLAS

Case 7 is a depressed section of North Central Expressway (U.S. 75) in Dallas extending north 6.47 km from the junction with Spur 366 to IH 635. The initial four main lanes at-grade were increased to eight lanes in the modification with cantilevered frontage roads at-grade.

Landscaping in the median and in planters in the side walls of the freeway provide beauty and variety to the roadway and offer subtle reminders of off-ramps from the freeway. Vertical sidewalls of the freeway are formed from textured panels.

The main roadway is paved over the full width and bordered with vertical concrete walls. Consequently, there is no soil erosion from the right-of-way. Storm drainage from the facility is channeled into one of three systems for disposal. The planning document anticipated only a modest increase in drainage volume, at best.

The area south of Haskell Avenue is served by the drainage system of the Woodall-Rodgers Freeway. The central drainage basin, extending from Haskell Avenue to Lovers Lane, drains into the Turtle Creek system which empties into the Trinity River. The project area north of Lovers Lane is drained by White Rock Creek and its tributaries aggregating 14 separate stormwater sewer systems.

The design team for this project has incorporated a number of visual quality items into the finished corridor to enhance the driving experience. The concrete walls are textured, contrasting colored paving makes route selection on frontage roads easier, wall planters draw attention to freeway exits and foliage and flowering plants soften concrete walls and highlight structural elements.

HOUSTON

Case 6 is a depressed section of Beltway 8 in Houston which extends south 2.1 km from the Katy Freeway (IH 10). The original seven cross streets were reduced to three in the modification from the original at-grade facility. The previous four travel lanes were increased to six main lanes supplemented by two frontage roads.

Erosion control is not a concern because all of the elements within the vertical walls are paved. Vegetation is restricted to a very narrow strip along the frontage road.

Drainage is collected and pumped into Buffalo Bayou. Visual quality is tastefully addressed with textured vertical panels.

LUBBOCK

Case 11 is an elevated section of U.S. 62/82 in Lubbock which has not been contracted.

Case 8 is an elevated section of IH 27 which connects IH 27 coming into Lubbock from the north with the section which exits to the south. Originally an at-grade corridor with four lanes and 21 crossing streets in downtown Lubbock, it was modified to six lanes and six cross streets. There are four on-ramps and three off-ramps within 3 km. Grass was planted on the median, and soil blankets were installed between the main lanes and frontage roads. Storm drains are coordinated with the system for the city of Lubbock.

Case 9 is a depressed section of IH 27 extending south from the section above to Loop 289. Modified from an at-grade section having a right-of-way width of 38 m to a width of 122 m, the main travelway was increased from four to six lanes. The number of crossing streets decreased from 11 to four, and two each off- and on-ramps service the exit and entrance to the main lanes.

Grass was sodded on the narrow median and additional erosion control was to be installed locally. Some natural vegetation is volunteering on non-mow areas, and erosion is evident on areas without a vegetative cover. Small trees (cedar elms) have been installed at strategic locations. The area between main lanes is difficult to mow because spacing between retaining walls impedes mower entrance.

Surface drainage is collected into existing natural channels. Ground water is 8.7 m to 11.4 m below the constructed grade and contamination is not expected. Deicing is not required every year, and any salt residue after sweeping is carried in lined channels to a collector channel for disposal.

Visual quality ranges from good for structures and pedestrian walkways, to poor for eroded areas and those bare of vegetative cover.

SAN ANTONIO

Case 5 is a depressed modification of U.S. 281 extending from Bitters Road to Bulverde Road. U.S. 281 is a major urban arterial highway in San Antonio. The finished facility is a six-lane divided freeway with added frontage roads on either side.

All trees were retained within the right-of-way. Side slopes along the main lanes are vertical cuts from native limestone, an attractive visual quality. Undisturbed areas support a cover of native grasses, scattered oak, mesquite and hackberry trees, together with assorted native shrubs.

Most of the project lies over a recharge zone for the Edwards Aquifer, a major source of culinary and irrigation water. This sensitive area is closely monitored by the Edwards Underground Water District and the U.S. Geological Service to maintain the integrity of the aquifer.

Case 1 is a depressed section if IH 35 which has been in place for more than 10 years. The only modification was to facilitate entry to added elevated sections of IH 35.

The facility is a six-lane divided freeway with adjacent frontage roads. Sideslopes are stabilized with grass turf or paved riprap, and the freeway shows no sign of active erosion.

Case 2, 3 and 4 are similar in that they have been modified to 10-lane freeways and are combined depressed/elevated sections in downtown San Antonio. The concrete structural elements are aesthetically pleasing. The rights-of-way are paved, so green features are lacking. Consequently, erosion is not a problem. Drainage on elevated sections is collected in gutters at the outer edge and consolidated through a collector system.

CONCLUSIONS

Transportation and environment are closely linked through current environmental laws and regulation, and transportation plans should be compatible with environmental laws and mandates. Impacts are similar but vary in degree for at-grade, elevated and depressed freeway sections for erosion, drainage, visual quality, noise, air quality, and hazardous spills. These impacts should be minimized for adjacent properties as well as for the travel environment.

Perhaps the most acute problem facing regulators and design/operations alike is the matter of definition for each of the several impacts.

DRAINAGE

The dichotomy of definition is illustrated by the dual functionality of runoff devices such as wetlands and wet ponds. The primary hydraulic consideration is to size a basin to mitigate downstream flooding, and local drainage criteria are basic to the hydraulic design. Conversely, the ideal conditions for environmental mitigation may be to store the water for an extended period to facilitate settling and physical/chemical/biological processes.

EROSION

Computation of sediment yields from erosion is not yet an exact science, but equations are available for estimating potential soil loss from relatively flat agricultural lands. These relationships should be determined for steeper slopes in construction zones.

Slope areas supporting a thin stand of plants may suffer soil loss as evidenced by scattered accumulations of plant parts, erosion pavements of fine gravel on the soil surface or deltaic fans of fine sediments at the toe of a slope. Flatter slopes support a denser, more effective vegetative cover than steeper slopes, but the degree of slope has not been quantified for its protection potential.

The following are basic:

- Prevention of erosion is generally more effective than sediment control.
- Minimal runoff velocities retain the maximum amount of sediment onsite with a corresponding reduction in erosion.
- Channelized flows usually have higher flow velocities and are more damaging.

VIBRATION

Neither local highway offices nor any of the recent literature reported any complaints of vibration. Either this stress has been mitigated by improved technology in structures and/or foundations or it is not differentiated from noise.

AESTHETICS AND VISUAL QUALITY

An urban freeway is usually perceived as an intrusion into a landscape. Visual quality can be evaluated on a situation-specific basis by integrating an estimate of vividness, intactness, unity and compatibility. These judgments can be modified by travel conditions:

- Speed of travel - more details are noticeable at slower speeds.
- Traffic volume - high-volume traffic may detract attention from visual resources more evident at slower rush-hour speeds.
- Views - vegetation can frame or enhance specific views or it can screen adjacent property or unsightly views. Views made more vivid with accent plants soften concrete walls.
- Safety - vegetation can be a unifying element to emphasize pavement edges and exit ramps.

NOISE AND AIR QUALITY

These elements are combined because they share the concept of a defined threshold value. Noise mitigation is based on perception of sounds, but air quality mitigation regulations reflect a clinical reaction. Even the P10 standard is presently being subjected to scrutiny as a standard particle size.

GROUNDWATER

The impact of groundwater on subsurface aquifers is a function of specific soil type, nature of the contaminant, movement of the solvent front and depth to the permanent water table. These parameters can be used to assign risk for a contaminant to invade a specific groundwater stratum.

The challenge to an operations agency is to find viable and usable definitions of threshold values for each environmental factor and integrate these into the design, construction and maintenance of an engineering product.

RECOMMENDATIONS FOR IMPLEMENTATION

Consideration of environmental impact is a relatively new concept to design engineers. Close review of plans and conferences with operations personnel during the course of this study revealed that most design engineers possess a superb knowledge of engineering. However, not all designs develop a seamless connection between design and environment. Ideally, with the close oversight by regulations, harmonization between environment and highway design should begin early in the design phase and be evaluated continuously in planning review.

IMPACTS AND MITIGATION

Except in special cases, width right-of-way is fixed, which requires greater use of a vertical dimension in designed modifications.

- Depressed sections, in many cases, are bordered by vertical walls. Visual quality is attained by using textured concrete. U.S. 281 in San Antonio is located on a limestone foundation, so the fractured rock faces of vertical cuts present a varied texture of natural stone.
- In most cases the entire width of right-of-way is paved. This eliminates the need to maintain vegetation, but it imposes a greater drainage load.

Modifications should be designed for maintenance. At one location mowing equipment cannot easily access median areas behind retaining walls. This requires alternative hand treatment (expensive) or designation of no-mow areas (undesirable in urban settings). This situation may result because:

- The project was overdesigned with fixtures (retaining walls).
- Access requirements were not anticipated in the design.
- Step-downs to more level areas or landscape designs which eliminate vegetated areas are possible alternatives to a grassed median.

The features incorporated into freeway design in Dallas show the results which can be achieved with team designs and reviews. Innovative solutions are common in handling drainage and other problems peculiar to at-grade, depressed, and elevated sections. Generally, the same needs may be encountered in these sections, but the magnitude may vary by type of section.

HAZARDOUS SPILLS

Treatment of hazardous spills is a developing technology. A continuing sequence of training is presented to all operations levels, and procedures are modified with each new development.

Spills of hazardous materials used in operations, resulting from a roadway accident, or uncovered during installation should be addressed in the following manner:

- Ensure personal safety by wearing protective clothing, goggles and gloves, as needed.
- Stop the flow or leak.
- Contain the spillage to prevent contamination of the local environment. Liquids may be absorbed with soil, kitty litter, wood shavings or similar material; dry materials should be covered with plastic and/or moistened to prevent drift.
- Place the contaminated debris in non-leak containers. Check the intended use; materials meant to be soil applied may still be usable for that purpose. If the quantity of hazardous waste exceeds 90.7 kg, the Dangerous Waste Regulations will then apply.
- Direct traffic around the spill area.
- Notify your office or supervisor for further instructions.

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APPENDIX

Recent Construction

Estimate the number of **recently constructed** (within the past 10 years) elevated and depressed freeway sections in your District [City].

☐ Number of elevated sections.

☐ Number of depressed sections.

Note: Please list only sections that would be viable for study, that is, sections that involve at least two over/underpasses, or are at least 1/4 mile long.

Give the location and check the descriptive characteristics for each section.

Section Location (Hwy/Frwy Name or Number)*	Elevated	Depressed	Downtown	Suburban	Residential	Commercial	Age of Facility		Facility Length (Miles)	Land Use Map Available	Aerial Map Available
							<5yrs	6-10yrs			

*Please attach map with section identified.

Under Construction

Estimate the number of elevated and depressed freeway sections in your District [City] that are currently **under construction.**

☐ Number of elevated sections.

☐ Number of depressed sections.

Note: Please list only sections that would be viable for study, that is, sections that involve at least two over/underpasses, or are at least 1/4 mile long.

Give the location and check the descriptive characteristics for each section.

Section Location (Hwy/Frwy Name or Number)*	Elevated	Depressed	Downtown	Suburban	Residential	Commercial	Construction Start Date	Facility Length (Miles)	Land Use Map Available	Aerial Map Available

*Please attach map with section identified.

Planned Construction

Estimate the number of **planned** elevated and depressed freeway sections in your District [City].

☐ Number of elevated sections.

☐ Number of depressed sections.

Note: Please list only sections that would be viable for study, that is, sections that involve at least two over/underpasses, or are at least 1/4 mile long.

Give the location and check the descriptive characteristics for each section.

Section Location (Hwy/Frwy Name or Number)*	Elevated	Depressed	Downtown	Suburban	Residential	Commercial	Construction Start Date	Facility Length (Miles)	Land Use Map Available	Aerial Map Available

*Please attach map with section identified.