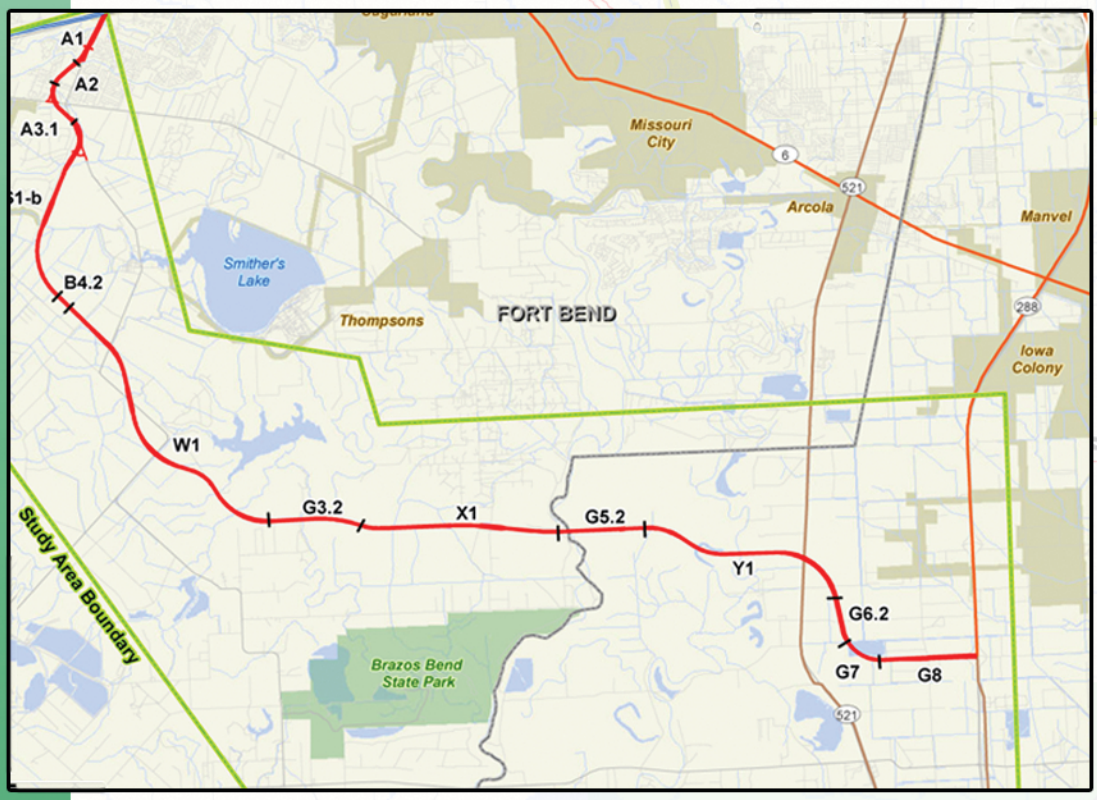
From US 59 to SH 288
Fort Bend County, Texas
Brazoria County, Texas

FHWA-TX-EIS-99-06-F

Final Environmental Impact Statement

Grand Parkway State Highway 99 Segment C



U.S. Department of Transportation
Federal Highway Administration

Texas Department of Transportation

U.S. Army Corps of Engineers
Cooperating Agency

06233/WH/10

CSJ's:
3510-02-002
3510-02-901
3510-03-001
3510-03-002
3510-03-004

August 2012

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FHWA-TX-EIS-99-06-F
CSJ (control-section-job) Nos. 3510-02-002, 3510-02-901, 3510-03-001, 3510-03-002, 3510-03-004

GRAND PARKWAY (STATE HIGHWAY 99) SEGMENT C
FROM UNITED STATES HIGHWAY (US) 59 TO STATE HIGHWAY (SH) 288
FINAL ENVIRONMENTAL IMPACT STATEMENT

Submitted Pursuant to the

NATIONAL ENVIRONMENTAL POLICY ACT
42 U.S.C. 4332 (2) (c)
49 U.S.C. 303

by the

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION *and*
TEXAS DEPARTMENT OF TRANSPORTATION

In Cooperation with

U.S. ARMY CORPS OF ENGINEERS

8/8/2012
Date of Approval

Gregory S. Punske
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8/7/12
Date of Approval

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Volume 1

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ABSTRACT

The proposed State Highway 99 (SH 99) (Grand Parkway) is a planned scenic highway, which would form a 180+mile circumferential highway around the Houston metropolitan area. Segment C of Grand Parkway, a 26-mile segment in Fort Bend and Brazoria counties, traverses from U.S. Highway 59 to SH 288. The Grand Parkway will be constructed as a four-mainlane controlled-access freeway in a minimum 300-foot right-of-way (ROW) width, expanding to a 400-foot ROW at ramps and isolated frontage road locations. It would provide access to radial freeways and would serve as a third loop around metropolitan Houston at a radial distance of approximately 25 to 30 miles outside the downtown Houston area. Transportation improvements are needed in the Segment C study area to relieve local congestion, which has resulted from high population growth, increased residential development, and increased commercial development within and adjacent to the study area. In addition, this facility is needed to relieve regional congestion, which has resulted from increasing regional development associated with strong Houston, Texas, and U.S. economies throughout the 1990s. The Grand Parkway will play a significant and greatly needed role for providing additional hurricane evacuation capacity for residents of Galveston and Brazoria counties. Many alternative design concepts were considered during the project's comprehensive screening process. The process included an evaluation of the No-Build Alternative, Transportation System Management Alternative, Travel Demand Management Alternative, Modal Alternatives, and Added Single-Occupied Vehicle Capacity Alternatives. Each of the alternative design concepts were evaluated relative to the project's need and purpose. Following a public hearing and further consideration of agency and public comments, the Representative Alternatives were slightly adjusted, and a Preferred Alternative was identified. The Preferred Alternative is comprised of a combination of alignments investigated during the study process as documented in this Final Environmental Impact Statement. The Preferred Alternative that has emerged from the study was proposed based on its ability to best fulfill the need for and purpose of the project while minimizing impacts to the natural, physical, and social environments. The Preferred Alternative for Segment C would require the acquisition of new ROW (approximately 1,131 acres), the adjustment of utility lines, and the filing of aquatic resources including jurisdictional wetlands. A total of 6 commercial displacements and 14 residential displacements would occur. No known archeological resources or nonarcheological historic-age resources listed in or eligible for the National Register of Historic Places are expected to be impacted. No listed threatened or endangered species would be impacted. A total of 20 noise receiver locations representing 67 impacted residences would be impacted by traffic noise.

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Public Meeting (August 2007)

Summary Sheet
Comments
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Table 2: Proposed Grand Parkway Segment C 2007 Public Meeting Comments and Responses
Materials

ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ADT	Average Daily Traffic
AFT	American Farmland Trust
AOI	Area of Influence
APAR	Affected Property Assessment Report
APE	area of potential effect
AST	aboveground storage tanks
ASTM	American Society for Testing and Materials
ATL	average trip length
BA	Biological Assessment
BCTRA	Brazoria County Toll Road Authority
BGEPA	Bald and Golden Eagle Protection Act
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe Railway
BO	Biological Opinion
BRA	Brazos River Authority
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CALF	Closed and Abandoned Landfill Inventory
CAMS	Continuous Air Monitoring Stations
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIA	Cumulative Impact Analysis
CISD	Consolidated Independent School District
CMA	Congestion Mitigation Analysis
CMSA	Consolidated Metropolitan Statistical Area
CMZ	Coastal Management Zone
CO	carbon monoxide
CR	County Road
CRT	Commuter Rail Transit
CWA	Clean Water Act
dB(A)	Decibels adjustment made to high and low frequencies to approximate the way a person hears traffic sounds
dbh	diameter at breast height
DCR	Dry Cleaner Registration Database
DEIS	Draft Environmental Impact Statement
DPM	diesel particulate matter

EFH	essential fish habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice
ENV	TxDOT Environmental Affairs Division
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERNS	Emergency Response Notification Systems
ESA	Endangered Species Act
ESA	Environmental Site Assessment
ETJ	extraterritorial jurisdiction
FBCTRA	Fort Bend County Toll Road Authority
FBSD	Fort Bend Subsidence District
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FM	Farm-to-Market Road
FPPA	Farmland Protection Policy Act
FR	Federal Register
FRS	Facility Registry System
FTA	Federal Transit Administration
FY	Fiscal Year
GIS	Geographic Information System
GLO	General Land Office
GPA	Grand Parkway Association
GPS	Global Positioning System
HAP	Hazardous Air Pollutant
HBNW	home-based nonwork trip
HBW	home-based work trip
HCTRA	Harris County Toll Road Authority
HES	Hurricane Evacuation Study
H-GAC	Houston-Galveston Area Council
HGB	Houston-Galveston-Brazoria
HGM	hydrogeomorphic
HHS	Department of Health and Human Services
HOT	high-occupancy tolled lanes
HOV	high-occupancy vehicle
HPA	high-probability area
IH	Interstate Highway
IHW	Industrial and Hazardous Waste Sites
IRIS	EPA's Integrated Risk Information System

ISD	Independent School District
LEP	limited English proficiency
L_{eq}	average or equivalent sound level
LID	Levee Improvement District
LOM	Level of Mobility
LPST	Leaking Petroleum Storage Tanks
LUST	leaking underground storage tank
LRT	Light Rail Transit
MBTA	Migratory Bird Treaty Act
METRO	Metropolitan Transit Authority
mgd	million gallons per day
MIS	Major Investment Study
MLS	Multiple Listing Service
mph	miles per hour
MPO	Metropolitan Planning Organization
MS4	Municipal Separate Storm Sewer Systems
MSA	Metropolitan Statistical Area
MSAT	mobile source air toxics
msl	mean sea level
MSWLF	Municipal Solid Waste Landfill Sites
MUD	Municipal Utility District
NAAQS	National Ambient Air Quality Standards
NAC	Noise Abatement Criteria
NCHRP	National Cooperative Highway Research Program
NDD	Natural Diversity Database
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NORM	naturally occurring radioactive material
NOV	Notice of Violation
NO_x	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
O_3	ozone
Pb	lead

PEM	Palustrine emergent
PFO	Palustrine forested
PJD	preliminary jurisdictional determination
PL	Public law
PM	particulate matter
PM_{10} and $PM_{2.5}$	particulate matter of 10 and 2.5 microns and less
PMSA	Primary Metropolitan Statistical Areas
ppb	parts per billion
ppm	parts per million
PSS	Palustrine scrub/shrub
PST	Petroleum Storage Tanks
RFG	reformulated gasoline
ROW	right-of-way
RRC	Railroad Commission of Texas
RSA	resource study area
RTP	Regional Transportation Plan
SAL	State Archeological Landmark
SCS	Soil Conservation Service
SH	State Highway
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SO_2	sulfur dioxide
SOV	single occupancy vehicle
SPILL	TCEQ Spills Database
STIP	Statewide Transportation Improvement Plan
SW3P	Storm Water Pollution Prevention Plan
TAC	Texas Administrative Code
TARL	Texas Archeological Research Laboratory
TAZ	Traffic Analysis Zone
TCAA	Texas Clean Air Act
TCEQ	Texas Commission on Environmental Quality
TCMP	Texas Coastal Management Program
TDCJ	Texas Department of Criminal Justice
TDM	Travel Demand Management
TEA-21	Transportation Equity Act for the 21st Century
Th-232	thorium-232
THC	Texas Historical Commission
TIERII	Tier II Chemical Reporting Program Facilities
TIP	Transportation Improvement Program
TOS	Texas Ornithological Society

TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSM	Transportation System Management
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
U-238	uranium-238
US	U.S. Highway
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDOT	U.S. Department of Transportation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
VCP	Voluntary Cleanup Program List
VHT	vehicle hours traveled
VMT	vehicle miles traveled
VOC	volatile organic compound
vpd	vehicles per day

SUMMARY

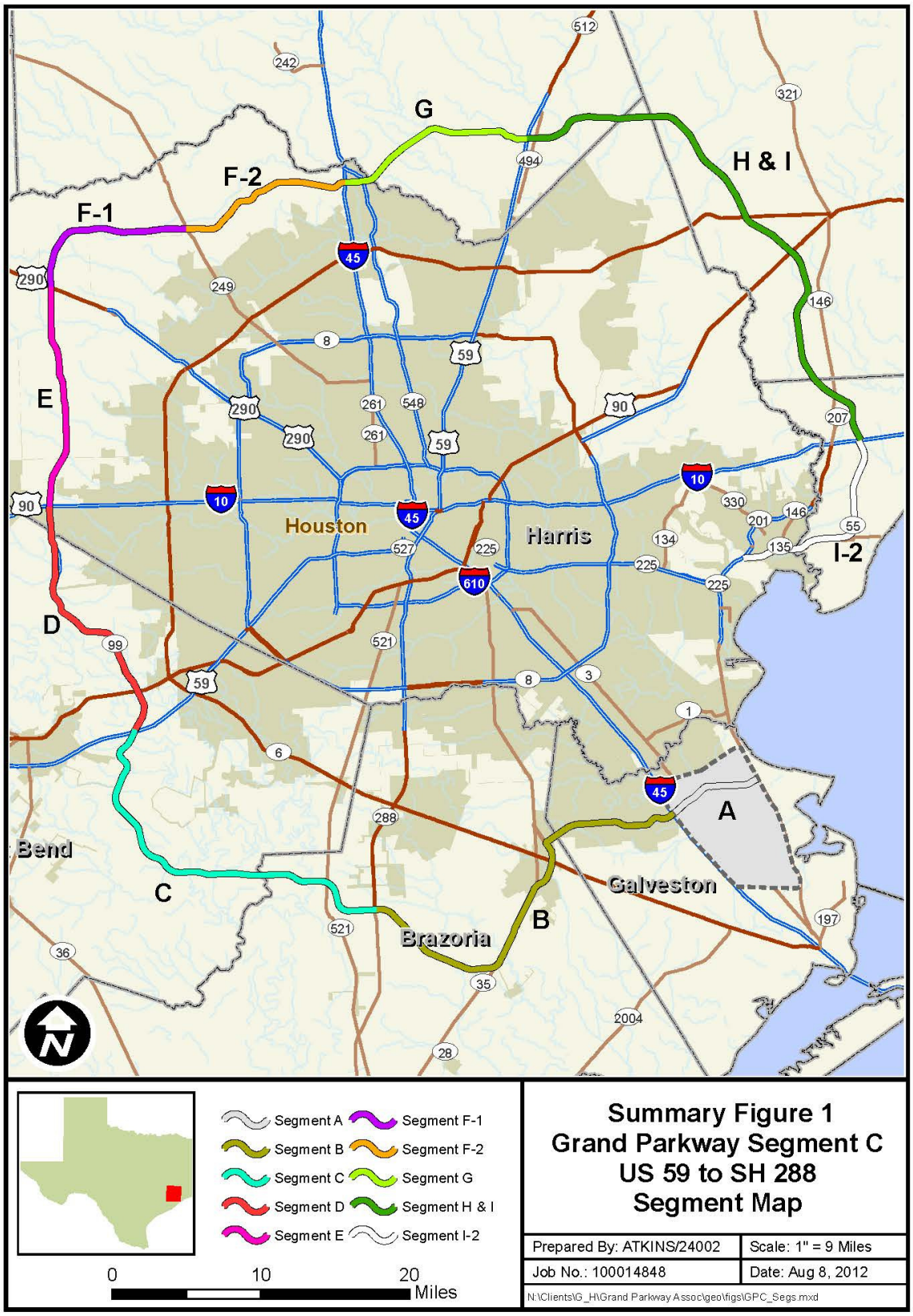
INTRODUCTION

The proposed State Highway (SH) 99 (Grand Parkway) is a planned highway that would form a 180+ mile circumferential facility around the Houston metropolitan area. The Grand Parkway would be a new location facility built to accommodate a 70-mile-per-hour (mph) design speed. The main lanes would be posted at 65 mph and the frontage roads would be posted at 40 to 45 mph. The Grand Parkway would be constructed as a four-mainlane, controlled-access toll road in a minimum 300-foot right-of-way (ROW) width, expanding to approximately 400-foot ROW at ramps and isolated frontage road locations. The 400-foot ROW can accommodate one of the following typical roadway sections: four-mainlane section without frontage roads, four-mainlane section with frontage roads, and four-mainlane section with exit and entrance ramps. It would provide access to various radial freeways (such as U.S. Highway [US] 59 and SH 288) and would serve as a third loop around Houston at a distance of approximately 25 to 30 miles outside of the downtown area (see Summary Figure 1). The Grand Parkway design would also account for the additional ROW required at each of the logical termini radii to construct direct connector ramps resulting in a fully directional interchange. The proposed facility would traverse Harris, Montgomery, Liberty, Chambers, Galveston, Brazoria, and Fort Bend counties.

This Final Environmental Impact Statement (FEIS) incorporates responses to comments received regarding the Segment C Draft Environmental Impact Statement (DEIS) on May 2000. This document also incorporates updates from the DEIS Reevaluation approved in July 2011. The Grand Parkway Association (GPA), in coordination with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA), has prepared this FEIS to include updated land use, indirect and cumulative impacts, environmental constraints analyses, and the selection of the Preferred Alternative Alignment (Preferred Alternative).

DESCRIPTION OF THE PROPOSED ACTION

This document addresses the proposed Grand Parkway Segment C, an approximately 26-mile segment in Fort Bend and Brazoria counties, which traverses from US 59 to SH 288. The project's northern terminus is near the intersection of existing Segment D of the Grand Parkway at US 59 in Fort Bend County. The project's southeastern terminus is approximately 26.9 miles southeast of US 59 at SH 288 in Brazoria County. The Preferred Alternative would be a new location, four-lane, controlled-access toll road with intermittent frontage roads within a 300–400-foot ROW. Traversing parts of Fort Bend and Brazoria counties, the proposed new toll road would provide access to US 59 and SH 288 (radial freeway). The proposed Segment C project would involve the construction of direct connector ramps at US 59 and SH 288 to provide fully directional interchanges. The roadway would be designed to accommodate a 70-mph design speed. The preliminary construction cost estimate for the Segment C Preferred Alternative is $625,110,107. This project cost includes estimated construction, ROW, and utilities costs, escalation, and inflation.


G
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I-2
Houston
Harris
Galveston
Brazoria
Bend
Segment A
Segment B
Segment C
Segment D
Segment E
Segment F-1
Segment F-2
Segment G
Segment H & I
Segment I-2
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10
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Miles
Summary Figure 1
Grand Parkway Segment C
US 59 to SH 288
Segment Map
Prepared By: ATKINS/24002
Scale: 1" = 9 Miles
Job No.: 100014848
Date: Aug 8, 2012
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Construction funding was determined for this project to be a toll road facility. This FEIS includes analyses of environmental consequences that may change as a result of the proposed facility, such as economic impacts, noise, air quality, and environmental justice (EJ).

PROJECT HISTORY

This document addresses the need and purpose, alternatives considered, Preferred Alternative, environmental impacts, and public involvement for the proposed construction of Segment C of SH 99 in Brazoria and Fort Bend counties, Texas. In 1998, the Houston District of TxDOT, assisted by the GPA, initiated a Major Investment Study (MIS) for the proposed Grand Parkway Segment C-1 of the Grand Parkway. Grand Parkway Segment C-1 was a proposed transportation facility located in east-central Fort Bend County from US 59 to Farm-to-Market Road (FM) 762. The MIS process was approximately 50 percent complete when two events changed the scope of the MIS and the approach to preparing the MIS:

- The limits for the study area were extended beyond FM 762 to the east into Brazoria County in 1998, resulting in project limits from US 59 in Fort Bend County to SH 288 in Brazoria County.
- The Transportation Equity Act for the 21st Century (TEA-21) was signed on June 9, 1998. TEA-21 eliminated the MIS as a separate requirement and directed that design scope decisions should be integrated into the planning process, which is a part of the National Environmental Policy Act (NEPA). In accordance with the FHWA input and recommendations, it was determined that the proposed Grand Parkway Segment C-1 MIS should be stopped.

In May 1998, the proposed Grand Parkway Segment C-1 MIS was stopped by agreement of TxDOT and FHWA, and a combined Environmental Impact Statement (EIS) and MIS for proposed Segment C of the Grand Parkway was initiated. Information obtained and concepts developed during the proposed Grand Parkway Segment C-1 MIS have been incorporated into the DEIS/MIS for the proposed Grand Parkway Segment C.

A DEIS was prepared and released for public review and comment on May 13, 2000. A 60-day public comment period was provided in accordance with the requirements of NEPA. Two identical public hearings were held on June 13, 2000. The Preferred Alternative was selected by the project team based on the results of an alternatives analysis (Section 2) and input received from the public and from local, state, and federal agencies. Two public workshops were held on November 14, 2000, to present and receive comments on the Preferred Alternative. A DEIS Reevaluation, dated May 2011 was prepared and approved on July 21, 2011. This FEIS documents the process that was used to evaluate and select the Preferred Alternative.

NEED AND PURPOSE

The Grand Parkway was conceived in the 1960s as a controlled-access highway and was included in regional planning studies since the 1980s. The purpose of the proposed Grand Parkway Segment C is to relieve congestion and increase mobility on local and regional transportation facilities and to supplement existing roadways by providing an additional emergency evacuation route. The proposed Grand Parkway Segment C is currently identified in the following county and the Houston-

Galveston Area Council (H-GAC) transportation plans as a needed highway to address existing and future traffic demand in the region:

- Fort Bend County Mobility Plan Update (1996) – Identified as one of the top five needed transportation projects.
- H-GAC 2035 Regional Transportation Plan (RTP) Update – Identified on the Fiscal Year (FY) 2011–2014 Transportation Improvement Program (TIP).
- H-GAC Congestion Management System Plan – Identified as a needed added capacity project for the region.
- Brazoria County Thoroughfare Plan (2005) – Identified as a priority project.

Mobility and Congestion

The proposed Grand Parkway Segment C is needed to relieve local congestion, which has resulted from high population growth, increased residential development, and increased commercial development within and adjacent to the study area. In addition, this facility is needed to relieve regional congestion that has resulted from increasing regional development associated with strong Houston, Texas, and U.S. economies throughout the 1990s. Fort Bend County's population has grown dramatically from 354,452 in 2000 to 585,375 in 2010, and Brazoria County's has grown from 241,767 in 2000 to 313,166 in 2010. The Texas Water Development Board (TWDB) forecasts that Fort Bend County's population will reach 1,090,710 by the year 2040, and Brazoria County's will reach 444,981 by 2040.

Residential and commercial development has also increased with the growth in population with several new residential subdivisions located in the study area. There is also a great demand for office space and manufacturing facilities in Fort Bend County. Consequently, a number of developers have announced and begun construction of new office buildings and new speculative manufacturing and warehouse buildings in eastern Fort Bend County.

The H-GAC's regional travel demand model of the Houston metropolitan area was used as a basis for determining the projected traffic, which would utilize the proposed Grand Parkway Segment C and existing roadway facilities in the study area. The H-GAC's model provides projected traffic forecasts on roadway facilities based on population and employment forecasts. Major traffic generators in the vicinity of the proposed facility include:

- The University of Houston, Sugar Land campus, located south of US 59 at University Boulevard
- The cluster of residential development located south of US 59 at SH 99 (Grand Parkway) and Crabb River Road
- The Sienna Plantation residential development located north of the eastern portion of the proposed Grand Parkway Segment C
- The W.A. Parish Power Plant, operated by NRG Energy, near Smither's Lake, and the Brazos Valley Power Plant, operated by Calpine Energy
- The George Ranch Historic Park located off FM 762 in the central portion of the proposed Grand Parkway Segment C

- The Brazos Bend State Park located near the Brazos River south of the eastern portion of the proposed Grand Parkway Segment C
- Thompson's Oilfield located west of the Brazos River north of the eastern portion of the proposed Grand Parkway Segment C
- Reading Junior High School and George Ranch High School, located along FM 762 east of Bridlewood Estates.

The H-GAC projected traffic on the proposed Grand Parkway Segment C for the Build scenario ranges from 4,112 to 48,562 vehicles daily in year 2019, 9,975 to 51,499 in year 2022, and from 8,352 to 87,738 vehicles daily in year 2035. An average daily traffic (ADT) of 5,000 vehicles is set forth as a minimum by TxDOT to justify a four-lane highway. For the year 2035 traffic projections, all portions of the proposed facility (except the eastern terminus at SH 288) satisfy these minimum requirements.

Analysis of the estimated traffic volumes for the Build and No-Build scenarios for year 2009 (base year) and year 2035 indicate that construction of the proposed Grand Parkway Segment C would not change daily traffic volumes on the majority of roadway facilities in the study area. A comparison of future year 2035 daily traffic estimates at 23 roadway segments within the study area showed a ±10 percent change in traffic volumes at four locations. In addition, the change in traffic volumes at 10 of these locations is below 1,000 vehicles. This difference in traffic volumes is within a reasonable uncertainty range for the traffic estimation procedure. The four locations with more than 10 percent traffic difference occur at US 59 west of the proposed Grand Parkway Segment C, FM 762 between FM 2759 and the proposed Grand Parkway Segment C, FM 762 between the proposed Grand Parkway Segment C and FM 1462, and FM 521 from SH 6 to the proposed Grand Parkway Segment C. Two of the locations (US 59 west of the proposed Grand Parkway Segment C and FM 762 from FM 2759 to the proposed Grand Parkway Segment C) exhibit decreases in daily vehicles of 32,512 and 2,017, respectively, while two locations, FM 762 from the proposed Grand Parkway Segment C to FM 1462 and FM 521 from SH 6 to the proposed Grand Parkway Segment C exhibit increases in daily vehicles of 1,599 and 3,223, respectively, in the Build scenario. The shift in larger volumes of traffic between the Build and No-Build scenarios from FM 762 and US 59 is due to the availability of the proposed Grand Parkway Segment C.

Overall, construction of the proposed Grand Parkway Segment C would be necessary to maintain efficient traffic operations throughout the region. The projected traffic on the proposed Grand Parkway Segment C in the year 2035 warrants the consideration of a four-lane highway per TxDOT's guidelines for the entire limits of the proposed Grand Parkway Segment C. Additionally, the H-GAC projected growth in the study area through year 2035 and associated traffic volume increases would increase congestion and delays already experienced by motorists on existing roadways in the study area. As traffic on these roadways exceeds capacity, the proposed Grand Parkway Segment C would be an alternative route for many of these motorists.

Hurricane Analysis

The Grand Parkway would play a potentially significant role in the evacuation of residents and tourists from the surge of vulnerable areas of Galveston and Brazoria counties in Texas. The location of the proposed facility would provide an additional means for evacuees to reach intended destinations. The magnitude of the role that the Grand Parkway may play is a function of how many evacuees would logically use the route given their location and intended destination and the relief that the Grand Parkway provides to expected evacuation bottlenecks in the area. Given the location of the Houston-Galveston-Brazoria (HGB) metropolitan areas along the northwest Gulf Coast and the intense recent hurricane activity, hurricane evacuation is a critical public safety issue.

If planned improvements on each evacuation route and the proposed Grand Parkway Segments B and C are not built, clearance time in the year 2035 is expected to increase to greater than 50 hours for the Galveston zones. If planned improvements to each evacuation route are built but the proposed Grand Parkway Segments B and C are not built, clearance times would be approximately 34 hours for the Galveston zones. With the Grand Parkway and the planned improvements to each evacuation route, evacuation times fall to 29 hours or greater. As the clearance time calculations indicate, the Grand Parkway would save 4 to 6 hours of evacuation clearance time for the Galveston zones. For Brazoria evacuees who are leaving to go out of the county, Grand Parkway can save over 4 hours of clearance time.

The second substantial timesaving effect due to the Grand Parkway is that it allows evacuation clearance time plus prelandfall hazards time to drop below 24 hours, which is a key warning timeframe of the National Hurricane Center. This would be a scenario where the Grand Parkway is in place, and Interstate Highway (IH) 45 is placed under a reverse-lane strategy. Communities that can reduce their times below 24 hours have the ability to issue evacuation advisories with much more confidence in projected landfall location and time of arrival.

The last evacuation benefit that must be mentioned is that the Grand Parkway provides another access-controlled evacuation route for Galveston and Brazoria counties in the case of a major accident on IH 45 or SH 288 south of the Sam Houston Tollway.

Evacuation alternatives such as the reverse laning of IH 45, the use of public transit, and widening of existing routes were considered in the analysis. The benefits and problems associated with each were clearly analyzed and discussed in light of local and national evacuation experience and research. None of the alternatives provides the evacuation relief afforded by the proposed Grand Parkway facility.

ALTERNATIVES CONSIDERED

Many alternative design concepts were considered during the comprehensive screening process of this project. The process included an evaluation of the following alternative design concepts:

1. No-Build Alternatives

2. Transportation System Management (TSM) Alternatives
3. Travel Demand Management (TDM) Alternative
4. Modal Alternatives
5. Added Single Occupancy Vehicle (SOV) Capacity Alternatives

Each of the alternative design concepts were evaluated relative to the stated need and purpose for this project. A preferred design concept was selected and alternatives for the preferred design concept were identified and evaluated. Each of the alternatives was evaluated based on its ability to meet the need and purpose for the project, in addition to its impacts on the human and natural environment. The following discussion summarizes the evaluation of each of these alternatives.

No-Build Alternative

The No-Build Alternative consists of the existing transportation system plus projects that are committed. The No-Build Alternative does not include the construction of the proposed Grand Parkway Segment C. The No-Build Alternative would cost less and cause less disruption to the existing human and natural environment than the other build alternatives. However, the No-Build Alternative would also result in higher maintenance costs and additional travel time for local and regional traffic. Existing roadways in the study area would continue to deteriorate due to an increase in local traffic volumes. Traffic disruptions for maintenance purposes would be more frequent with the No-Build Alternative.

The No-Build Alternative does not adequately address the issues (congestion relief and additional hurricane evacuation) that define the need for this transportation facility. However, the No-Build Alternative remains a baseline alternative throughout this study.

Transportation System Management Alternatives

TSM is used to improve existing transportation facilities using low-cost transportation improvements in place of, or in addition to, large-scale changes. TSM alternatives include park-and-ride lots, ridesharing, high-occupancy vehicle (HOV) lanes, traffic signal coordination, and intersection improvement. This approach enhances the operation of existing facilities, while minimizing capital outlay. Depending upon the improvements chosen, this approach can have minimal or major effects on traffic.

Under this alternative, the only important facility that could receive low-cost transportation improvements is SH 6. A Congestion Mitigation Analysis (CMA) for the proposed Grand Parkway Segment C was conducted, which evaluated improvements to the existing SH 6. The CMA evaluated SH 6 with TSM improvements assuming the proposed Grand Parkway Segment C would not be built. It determined that by implementing the proposed Transportation Control Measures along SH 6, the level of mobility improved by 0.02 percent, which does not result in enough improvement as compared with added capacity alternatives. The construction of the Grand Parkway from US 59 to SH 288 provides the additional capacity needed to accommodate the forecasted travel demand. The Grand Parkway is a project that is necessary in order to achieve acceptable levels of mobility in the area.

Travel Demand Management Alternatives

TDM involves actions or programs that encourage people to travel at alternative times or use fewer vehicles in order to reduce congestion. TDM focuses on the reasons travelers make trips. People today usually travel alone in a car, but they can be encouraged to change their route or time of departure, share a ride in a carpool, use the bus, or not make the trip. Although the TDM alternative should be implemented as much as possible, it was determined that it alone would not meet the need and purpose of this project.

Modal Alternatives

Modal alternatives considered in the analysis include improved bus transit, HOV lanes, rail, bicycle, and pedestrian. These alternatives are described below.

Houston's Metropolitan Transit Authority (METRO) is not authorized to provide service in Fort Bend or Brazoria counties, but could provide service in the future through intercounty agreements. METRO's recommended concept for future service is to continue the implementation of the Regional Bus Plan. However, METRO has never evaluated expansion of its Regional Bus Plan into Fort Bend and Brazoria counties. Also, the Fort Bend County Mobility Plan Update study found that a bus transit system would not be financially feasible in Fort Bend County because of low ridership projections. The Fort Bend County study suggested implementation of a demand-response bus transit system in Fort Bend County. Connect Transportation, operated by the Gulf Coast Center, and Colorado Valley Transit provides demand-response bus transit in suburban and rural areas of Brazoria County. However, demand-response bus transit would not be expected to significantly reduce demand and congestion on roadways or address hurricane evacuation within the corridor. Therefore, it would not satisfy the need for transportation improvements in the study area.

The HOV lane concept is used on existing roadways that experience high traffic congestion. HOV lanes are most effective when potential ride-sharers have common geographic trip origins and destinations within similar timeframes. The HOV lane concept does not meet the project's need and purpose because a congested freeway corridor, which could be improved with the addition of an HOV lane, does not exist in the study area. Only 1½ miles of US 59 are within the study area, and HOV lanes are already proposed within that corridor. SH 6, while a congested highway, is not a likely candidate for HOV improvements due to the trip characteristics utilizing SH 6. Also, an HOV lane would not provide additional capacity for hurricane evacuation purposes. HOV lanes are designed to relieve congestion by offering capacity for carpools; this is inadequate capacity to alleviate congestion during hurricane evacuation.

METRO has conducted numerous rail feasibility studies within the region and has no plans to construct a rail facility within the proposed Grand Parkway Segment C study area. One such study concluded that commuter rail along US 90A would not be feasible because of the combination of low population density and high income levels.

The feasibility of bicycle and pedestrian alternatives is heavily dependent on trip length. The trip lengths that would occur as this facility satisfied its need and purpose are greater than feasible bicycle or pedestrian trip lengths. Therefore, bicycle and pedestrian alternatives do not satisfy the need and purpose requirements of this study.

Added Single Occupancy Vehicle Capacity Alternatives

Three types of added SOV capacity alternatives were included in the analysis:

1. Widen existing arterials – Several farm-to-market roads in the study area could be widened and improved to four-lane arterial standards. However, this action alone would not provide enough additional capacity to effectively reduce congestion, nor would it provide an additional hurricane evacuation route. Widening existing SH 6, beyond the committed six-lane facility, could cause considerable impacts to existing residential and commercial development and would not meet the need and purpose for the project.
2. Construct new arterials – The construction of these new four-lane arterials in the study area would not improve regional mobility and would not provide additional hurricane evacuation capacity; therefore, it would not meet the need and purpose of the project. Several new arterials are shown on the current Fort Bend County Mobility Plan. Each of these serves a purpose of relocating traffic from the local collector street network to the regional highway network. In and of themselves, they would not meet the need and purpose for the proposed Grand Parkway Segment C.
3. Construct a new controlled-access highway – A new location controlled-access highway, as conceived by TxDOT and the GPA, and as included in the various regional planning documents, would meet the need for transportation improvements in the study area. A new location controlled-access highway would relieve local and regional congestion, and provide a substantial amount of additional capacity during hurricane evacuation.

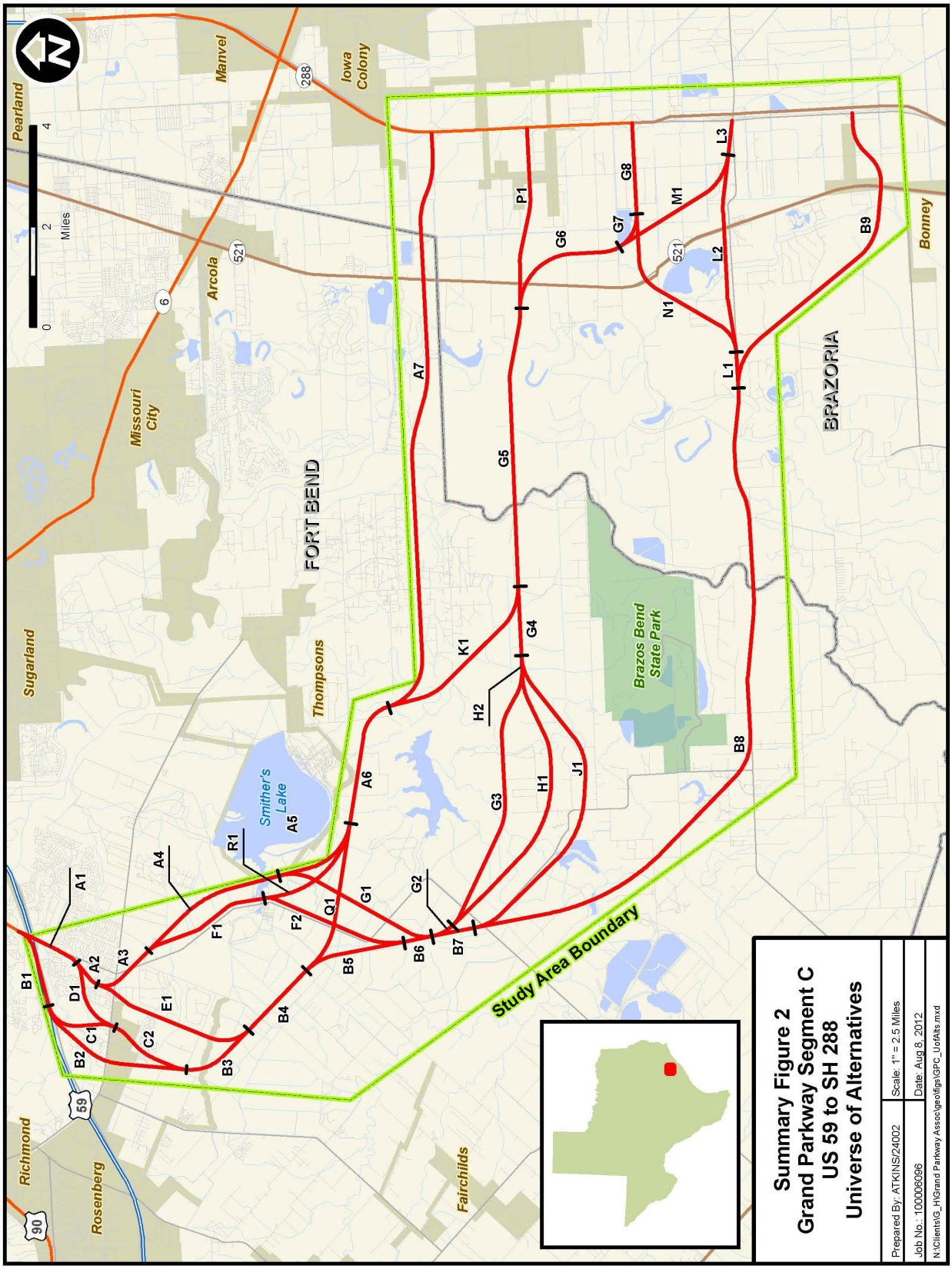
Preferred Design Concept

The preferred design concept for a transportation facility in this study area is a new location four-lane, controlled-access tolled facility beginning at US 59 and extending 26.9 miles to SH 288. The preferred design also includes construction of direct connector ramps at US 59 and SH 288 to provide fully directional interchanges. The proposed action begins just north of the US 59 interchange and heads in a southerly direction along existing Crabb River Road/FM 2759 for approximately 1 mile toward FM 762, with an interchange with Sansbury Boulevard. This portion of the facility comprises mainlanes and frontage roads. The facility continues on new location, without frontage roads, in a southerly direction for 11 miles, with interchanges at three crossings of FM 762, a Reading Road extension, and the future extension of Peters Road. The remaining 14 miles would continue in an easterly direction toward SH 288 on new location with interchanges at FM 521, CR 48, and SH 288. The facility includes frontage roads between CR 48 and SH 288. In addition to the interchanges, the proposed facility would bridge the following waterbodies: Rabbs Bayou, Dry Creek, Big Creek (two crossings), Big Creek diversion channel, Waters Lake Bayou, Brazos River, Cow Lake, and Oyster Creek. The proposed ROW is typically 300 feet in areas with mainlanes only. The ROW expands to approximately 400 feet at cross-street interchanges and in areas with frontage roads. This type of facility is the

design concept that would best satisfy the need and purpose of the project: congestion relief, increased local and regional mobility, and increased capacity for hurricane evacuation needs.

The consideration of controlled-access highway alternatives, hereafter referred to as alternatives, involved a three-phase screening process. All of the alternatives included in each phase are evaluated with equal levels of effort. As alternatives are screened and eliminated, more-detailed levels of study are performed. Each of the alternatives identified are evaluated with respect to the planning and design criteria described below.

- **Phase 1** included data collection, constraints map development, identification of the Universe of Alternatives (Summary Figure 2), a Public Scoping Meeting/MIS Initiation Meeting, screening of the Universe of Alternatives, selection of the group of Reasonable Alternatives (Summary Figure 3), and a Public Workshop. The screening of the Universe of Alternatives and the selection of the group of Reasonable Alternatives was performed on October 16, 1998, with input from agencies, TxDOT's Houston District, and the FHWA. The screening was performed based on all project data, including input from the agencies, local officials, and the public. The Reasonable Alternatives were presented to the public at the Public Workshop on October 27, 1998.
- **Phase 2** included a detailed evaluation of the group of Reasonable Alternatives. This involved developing diagrammatic designs and performing environmental field investigations of each of the Reasonable Alternatives. The Reasonable Alternatives were screened and reduced to a smaller group of alternatives called Representative Alternatives (Summary Figure 4) at a meeting on August 23, 1999, with staff from TxDOT's Houston District, TxDOT's Environmental Affairs Division, and FHWA. A DEIS was prepared and public hearings were held on June 13, 2000, to present the findings of the DEIS. The public comments were evaluated and a Preferred Alternative was recommended. The Preferred Alternative was presented to the public at two Public Workshops held simultaneously on November 14, 2000.
- **Phase 3** included the evaluation of the Preferred Alternative (Summary Figure 5) in order to measure impacts, develop mitigation measures, and address issues raised by other agencies or the public. During this phase, it was determined that the Grand Parkway would be constructed as a toll road; therefore, the appropriate toll road analyses were conducted for construction of the proposed Grand Parkway Segment C. This FEIS was prepared during Phase 3. A detailed schematic design of the Preferred Alternative was prepared as well as ROW documents.


Pearland
Manvel
Iowa Colony
Missouri City
Arcola
Sugarland
Thompsons
Richmond
Rosenberg
Fairchilds
Bonney
FORT BEND
BRAZORIA
Smither's Lake
Brazos Bend State Park
Study Area Boundary
0 2 4 Miles
A1
A2
A3
A4
A5
A6
A7
B1
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B3
B4
B5
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B8
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C2
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K1
L1
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L3
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Q1
R1
6
59
90
288
521
Summary Figure 2
Grand Parkway Segment C
US 59 to SH 288
Universe of Alternatives
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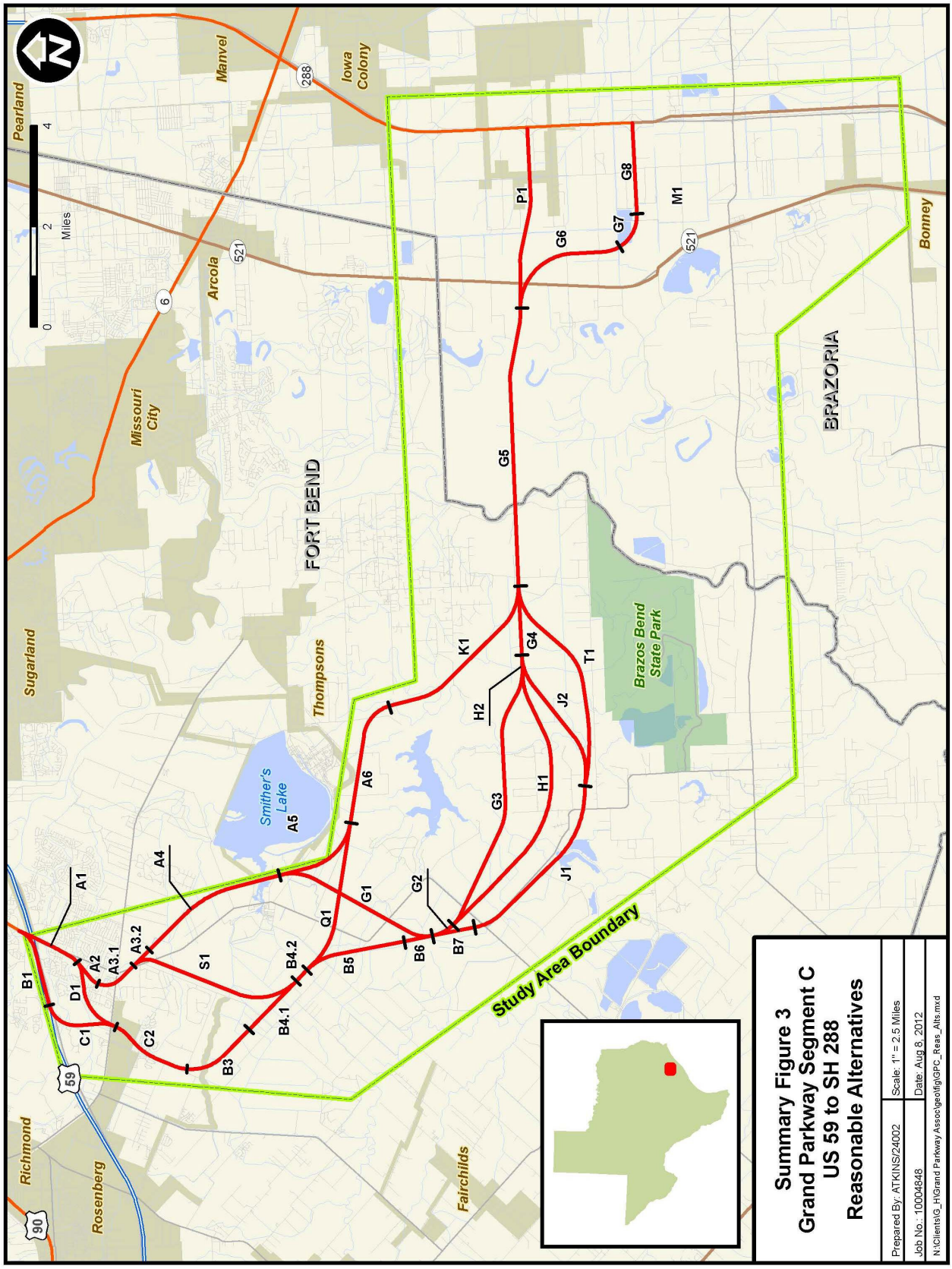
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Smither's Lake
Brazos Bend State Park
BRAZORIA
Bonney
Richmond
Rosenberg
Fairchilds
Study Area Boundary
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B4.2
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T1
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Summary Figure 3
Grand Parkway Segment C
US 59 to SH 288
Reasonable Alternatives
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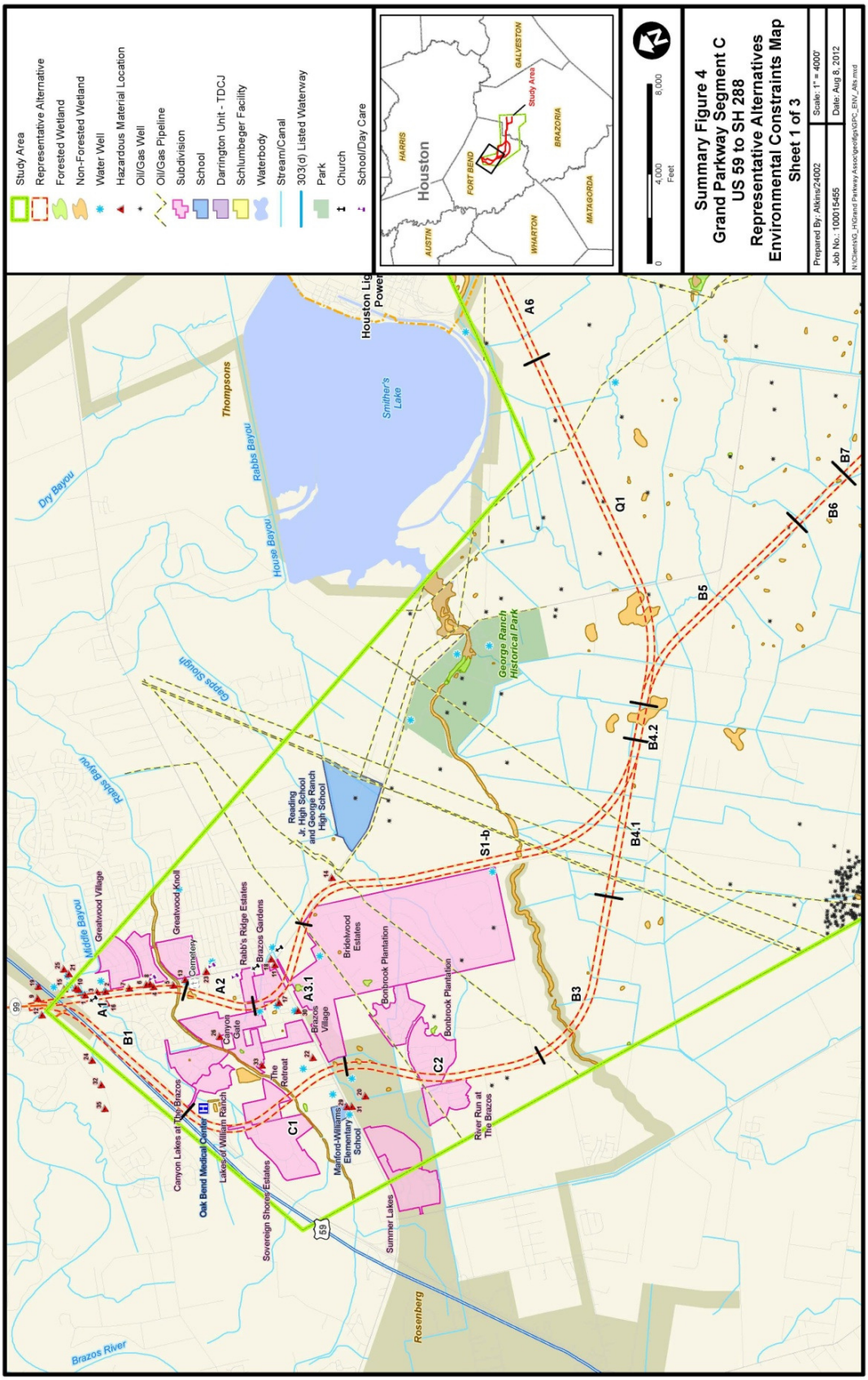
Study Area
Representative Alternative
Forested Wetland
Non-Forested Wetland
Water Well
Hazardous Material Location
Oil/Gas Well
Oil/Gas Pipeline
Subdivision
School
Darrington Unit - TDCJ
Schlumbeger Facility
Waterbody
Stream/Canal
303(d) Listed Waterway
Park
Church
School/Day Care
Houston
HARRIS
AUSTIN
FORT BEND
WHARTON
MATAGORDA
BRAZORIA
GALVESTON
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Summary Figure 4
Grand Parkway Segment C
US 59 to SH 288
Representative Alternatives
Environmental Constraints Map
Sheet 1 of 3
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Houston Lig
Power
Smither's Lake
Thompsons
Rabbs Bayou
House Bayou
Dry Bayou
Gapps Slough
Rabbs Bayou
Middle Bayou
Brazos River
Rosenberg
George Ranch Historical Park
Greatwood Village
Greatwood Knoll
Cemetery
Rabb's Ridge Estates
Brazos Gardens
Reading Jr. High School and George Ranch High School
Canyon Gate
Brazos Village
The Retreat
Bridelwood Estates
Bonbrook Plantation
Bonbrook Plantation
River Run at The Brazos
Canyon Lakes at The Brazos
Oak Bend Medical Center
Lakes of William Ranch
Sovereign Shores Estates
Manford-Williams Elementary School
Summer Lakes
A1
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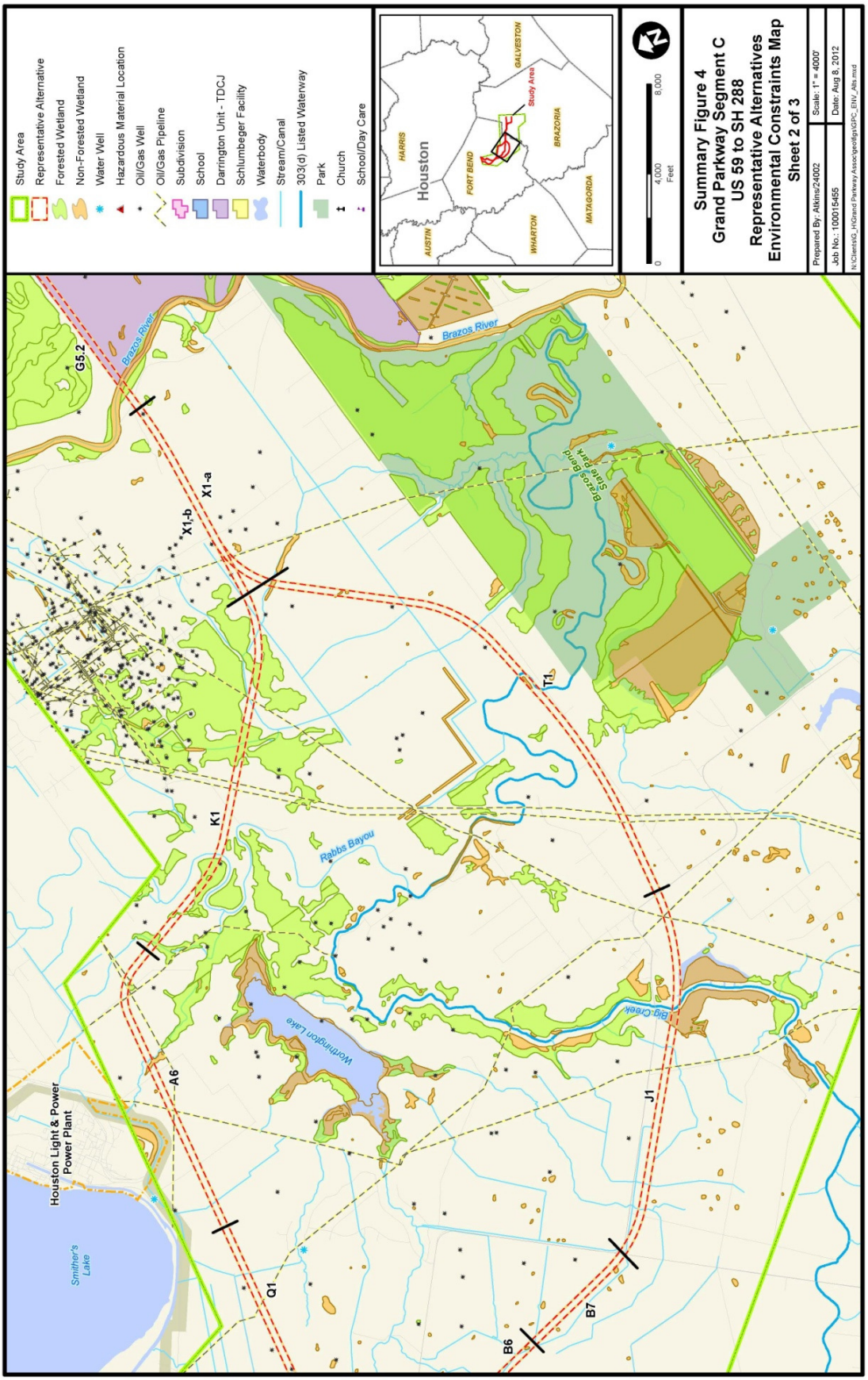
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Darrington Unit - TDCJ
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GALVESTON
Study Area
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Summary Figure 4
Grand Parkway Segment C
US 59 to SH 288
Representative Alternatives
Environmental Constraints Map
Sheet 2 of 3
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Brazos River
Brazos River
Brazos Bend State Park
Rabbs Bayou
Big Creek
Worthington Lake
Houston Light & Power Power Plant
Smither's Lake
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X1-a
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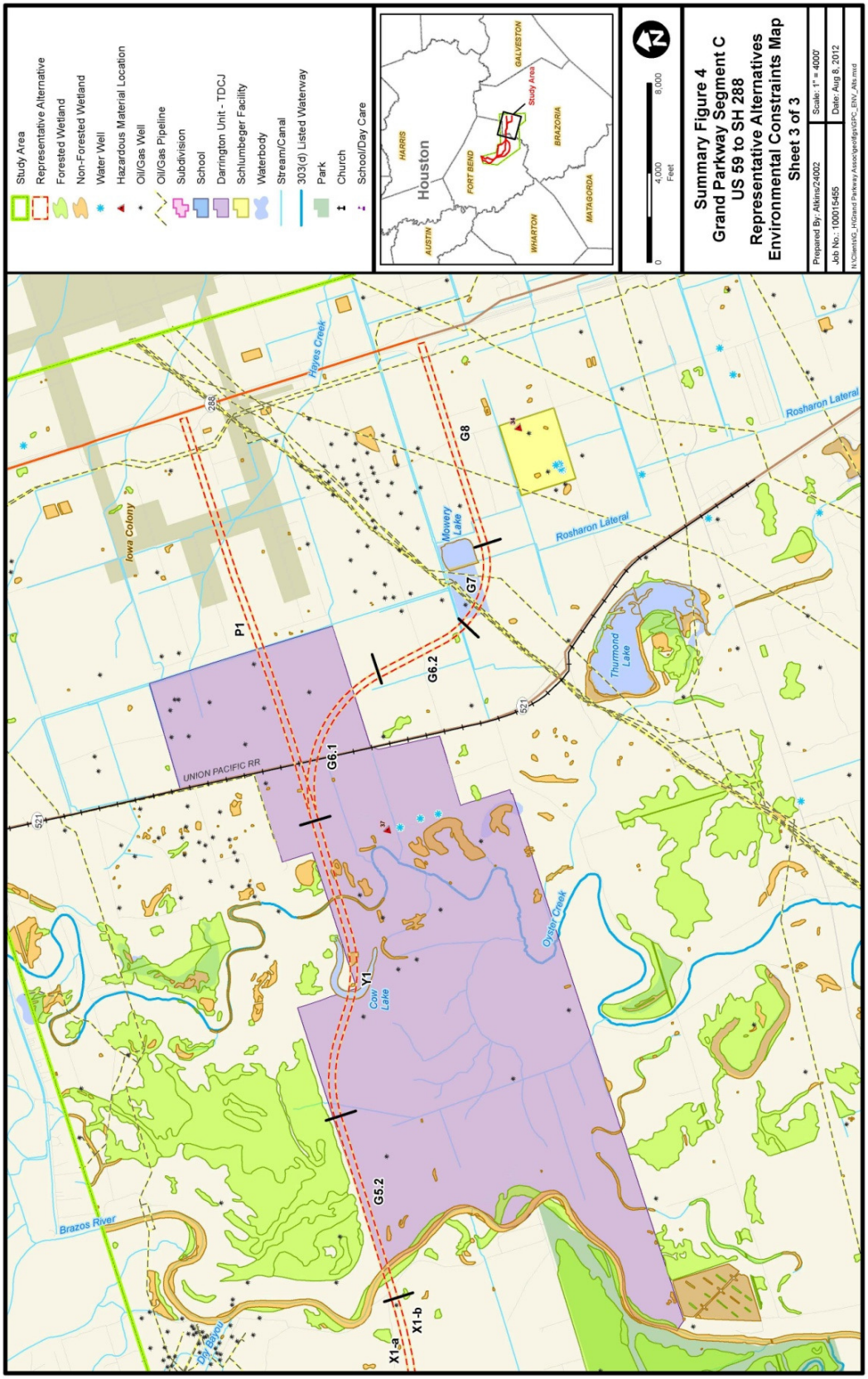
T1
J1
B6
B7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Study Area
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Summary Figure 4
Grand Parkway Segment C
US 59 to SH 288
Representative Alternatives
Environmental Constraints Map
Sheet 3 of 3
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Hayes Creek
Iowa Colony
P1
G8
Mowery Lake
G7
Rosharon Lateral
Rosharon Lateral
Thurmond Lake
G6.2
G6.1
UNION PACIFIC RR
Y1
Cow Lake
Oyster Creek
G5.2
Brazos River
X1-a
X1-b
Dry Bayou

Pearland
Manvel
Iowa Colony
288
521
6
Arcola
Missouri City
Sugarland
Thompsons
FORT BEND
Smither's Lake
Richmond
Rosenberg
90
59
99
Fairchilds
Brazos Bend State Park
BRAZORIA
Bonney
Miles
0
2
4
A1
A2
A3.1
S1-b
B4.2
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G3.2
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Y1
G6.2
G7
G8
Study Area Boundary
Summary Figure 5
Grand Parkway Segment C
US 59 to SH 288
Alignment of the
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Phase 1

An environmental constraints map was prepared for the study area, which was developed with the use of secondary source data such as National Wetlands Inventory maps, U.S. Geological Survey (USGS) maps, subdivision plat information, current aerial photographs, windshield surveys from public ROW, and input from local residents, businesses, officials, and agencies. The Universe of Alternatives was developed as 500- to 1,000-foot-wide corridors for the full length of the project, and impacts were quantified through the entire width of the corridor.

The Universe of Alternatives comprised 41 independent segments, each with a unique alphanumeric name, which connect to one another at nodes. The total number of possible alternatives for getting from one terminus of the project to the other terminus of the project was 96. The evaluations resulted in the elimination of 11 segments and 40 possible alternatives traveling from 1 terminus of the project to the other terminus of the project. These alternatives are referred to as the Reasonable Alternatives.

Phase 2

The Phase 2 screening included the preparation of preliminary schematic designs for each of the Reasonable Alternatives. Environmental fieldwork was performed within the 500- to 1,000-foot-wide corridors for each Reasonable Alternative, and impacts were quantified through the entire width of the corridor. Also, during Phase 2 work, two segments were added to the study.

The Reasonable Alternatives were composed of 32 segments. The number of possible Reasonable Alternatives for getting from one terminus of the project to the other terminus of the project totaled 40. The evaluation of Reasonable Alternatives provided the study team with data that led to decisions regarding the elimination of some of the possible 40 alternatives within the Reasonable Alternatives. Those alternatives remaining for consideration are called the Representative Alternatives. There are eight Representative Alternatives, and their potential environmental consequences are discussed in detail in Section 4 of this FEIS. Ultimately, Phase 2 concluded with the recommendation of a Preferred Alternative. The selection of a Preferred Alternative was based on an evaluation of social, economic, and environmental impacts for each of the Representative Alternatives. Ultimately, the FHWA and TxDOT chose a Preferred Alternative that best meets the need and purpose of the project and also avoids or causes minimal impacts to the human and natural environment. Public input was also evaluated prior to the final selection of the Preferred Alternative.

Phase 3

Phase 3 includes a detailed environmental evaluation of the Preferred Alternative. The FEIS was completed during this phase. A Biological Assessment (BA) was prepared for a protected species found near the Preferred Alternative, and formal Section 7 consultation with the U.S. Fish and Wildlife Service (USFWS), including a Biological Opinion (BO), was completed. Detailed wetland delineations of the Preferred Alternative have been completed and verified by the U.S. Army Corps of Engineers (USACE). The boundaries of all wetlands that would be impacted by the Preferred Alternative were verified by the USACE

(February 3, 2003). The verification expired; therefore, a request for a reverification with the USACE was made. As stated in a letter dated April 1, 2010, the USACE has completed its preliminary jurisdictional determination but is awaiting the permit application to continue the review process.

ENVIRONMENTAL ISSUES

While developing and screening alternatives, environmental impacts were either avoided or minimized to the maximum extent practicable at the level of analysis presented in this document. Environmental impacts attributable to the selection of the Representative Alternatives have been measured and are summarized in Section 4. Impacts were measured within a 300-foot-wide corridor for each Representative Alternative using secondary data sources as well as field data generated from detailed studies (e.g., wetland surveys). Where rights-of-entry for individual properties were not granted, the impacts were measured using the best available information and supplemented with surveys conducted by helicopter utilizing differentially corrected Global Positioning Systems (GPS). There are two significant ecological issues that warrant explicit mention: (1) forested wetland impacts, and (2) protected species. Columbia Bottomland Forests (a.k.a., Austin's Woods) are not specifically regulated under the Clean Water Act (CWA) but may contain forested wetlands. The Preferred Alternative would impact forested wetlands and Columbia Bottomland Forest in the Rabbs Bayou-Big Creek corridor, and the Preferred Alternative would encroach on the secondary management zone of the Bald Eagle nest located north of Brazos Bend State Park. The project team worked closely with the USFWS and other resource agencies to develop a synergistic plan for wetland and Bald Eagle habitat mitigation.

Land Use

All project segments would result in the loss of existing land uses within the proposed roadway ROW. In more-developed areas, impacts may also include visual and access-related issues relative to residences and communities. In rural areas, the decrease in farmland acreage and disruption of the physical fabric of farms would be the primary issues. Additional impacts to the entire study area may involve the expansion of residential and commercial development, especially in the vicinity of newly created intersections.

Geology, Soils, and Farmland Impacts

The Preferred Alternative would cross soils and geology similar in nature to the other Representative Alternatives. The conversion of prime farmland soils to the proposed highway ROW ranges from 704 acres for Representative Alternative 1 to 868 acres for Representative Alternative 8. The Preferred Alternative would convert approximately 955 acres of prime farmland soils to proposed highway ROW. A Natural Resources Conservation Service (NRCS) Form CPA-106 was completed for the Preferred Alternative, and a score of 149 points was received in a letter dated January 19, 2012.

Social Impacts

Social impacts that would occur as a result of construction of the proposed Grand Parkway Segment C may involve changes in community cohesion, impacts to community facilities, changes in traffic patterns, and short-term construction-related impacts involving noise, dust, and traffic. Mount Moriah Church (in Segment A1* [an asterisk indicates that a particular segment is part of the Preferred Alternative]), located in Representative Alternatives 1–4 and the Preferred Alternative, would need to be relocated. Impacts to community facilities would be primarily visual and access related to the Sandberry Cemetery, Southwest Church of the Nazarene, Brown Cemetery, Reading Junior High School, and George Ranch High School. Impacts to recreation areas may relate to changes in the landscape and increased ease of access to the George Ranch Historical Park and Brazos Bend State Park. Changes in traffic patterns would result in a decrease in commute times and an improvement to regional public safety. Associated increases in residential land use could accelerate growth of population in the area. Although some segments traverse minority and low-income census blocks, impacts to these populations are not disproportionate.

Several residential and commercial structures would be impacted by the eight Representative Alternatives and Preferred Alternative. The Preferred Alternative would displace 6 businesses, 14 residences, 1 church, and 1 Municipal Utility District (MUD) facility. Based on the number and type of relocations, adverse impacts to minorities and low-income populations are not disproportionate.

Economic Impacts

In addition to temporary economic impacts from the construction of the project, additional long-term impacts would result from the operation of the proposed Grand Parkway Segment C, primarily from maintenance activities. However, operational impacts are not addressed because costs for operation are not known at this time.

The total output impact, which includes the direct and indirect impact of the construction of the proposed Grand Parkway Segment C on the Texas economy, as well as direct non-Texas impacts, is estimated to be $743 million (estimates do not include the construction of the direct connector ramps). This includes indirect impacts as goods and services are provided to the sectors that provide the goods and services directly for the construction of the highway. The total employment impact, which shows the number of construction-related jobs that would be created, is estimated to be 3,893.

Overall, the proposed Grand Parkway Segment C project would encourage economic growth and jobs in Brazoria and Fort Bend counties, and the entire Houston area. Tax revenues would increase, and residential and commercial property values would likely increase over time. According to the Uniform Relocation Assistance and Real Properties Acquisitions Act of 1970 (amended in 1987), property owners will receive compensation for properties acquired for transportation projects, and nondiscriminatory ROW policies will be followed with regard to appraisals and acquisitions of homes and businesses.

Pedestrian and Bicyclist Impacts

The 2035 RTP Update includes a Regional Bikeway Plan update that contains a listing of current and proposed bicycle facilities for the Houston area. The Grand Parkway Segment C project is not identified in the plan to receive a future bicycle facility. None of the alternatives considered in this FEIS cross bicycles lanes. However, the proposed Grand Parkway Segment C project would accommodate (where practical) future crossings for both pedestrians and bicyclists at intersections, bridges, and over/underpasses affecting or providing direct access to designated pedestrian and bicycle facilities.

Air Quality Impacts

The Houston area is in attainment for all the criteria pollutants except for 8-hour ozone (O_3). The U.S. Environmental Protection Agency (EPA) classified the Houston-Galveston area, which includes Fort Bend and Brazoria counties, as a severe O_3 nonattainment area. The EPA regulations require that a nonattainment area demonstrate that its RTP and TIP conform to the intent of the State Implementation Plan (SIP) to attain the 8-hour O_3 standard by the year 2010.The proposed Grand Parkway Segment C is included in H-GAC's 2035 RTP Update and FY 2011–2014 TIP, as amended. This 2035 RTP Update and the 2011–2014 TIP, as amended, were found to conform with the SIP on July 21, 2010.

The analysis of Mobile Source Air Toxics (MSATs) was modeled and forecasted to be lower in the future (2019 and 2035) than the existing conditions (2009). The EPA's MOBILE6.2 model estimates much smaller benefits in MSATs after 2019. This estimation, in combination with a 77 percent growth in vehicle miles traveled (VMT), results in 2035 Build emissions being 31 percent lower than the 2009 base year. Diesel particulate matter (DPM), 1-3-Butadiene, and benzene are the only priority MSATs that are expected to decrease in that timeframe. MSATs will continue to improve over time due to dramatic improvements in vehicle technology and fuels and traffic flow improvements.

Emissions from diesel-powered and other construction equipment would occur under the Build Alternative for Segment C. These construction emissions would be temporary in nature. As each task is completed, the equipment would move out of the immediate area.

Noise Impacts

The Preferred Alternative and eight Representative Alternatives were analyzed in detail utilizing the FHWA's most current Traffic Noise Model (TNM version 2.5) and TxDOT's *2011 Guidelines for Analysis and Abatement of Roadway Traffic Noise*. For the detailed analysis of the Preferred Alternative, predicted traffic noise levels were modeled at 24 receiver locations that represent the land-use activity areas adjacent to the proposed project that might be impacted by traffic noise and potentially benefit from feasible and reasonable noise abatement. Results of the traffic noise analysis for the Preferred Alterative indicated that 20 representative receivers, representing a total of 67 residences, would be impacted by the traffic noise. The full noise barrier analysis determined that one noise barrier would be both reasonable and feasible and is proposed for incorporation into the project.

Water Quality Impacts

The construction of the proposed Grand Parkway Segment C would produce changes in the quantity and quality of runoff from the paved area. However, since the proposed ROW is only a small fraction of the watershed for each stream crossing considered, any changes are expected to have minimal impact on the receiving waters. Grassy swales are recommended to mitigate the effect of runoff directly from the ROW, as they have been demonstrated as an effective and low-maintenance measure for highway runoff. Water quality in the study area is not expected to be detrimentally affected by construction and highway usage. However, some localized reduction in water quality may occur if siltation and turbidity are not adequately controlled, especially during construction. The adverse impacts to water quality are expected to be slight. Mitigation for all impacts mentioned above will include TxDOT Best Management Practices (BMPs) designed to limit water quality degradation from construction activities. Permanent BMPs will mitigate effects by reducing roadway pollutants before they reach the stream system.

Permits

A CWA Section 404 permit would be required by the USACE for the Preferred Alternative. Water quality certification from the Texas Commission on Environmental Quality (TCEQ) would also be necessary per Section 401 of the CWA prior to filling wetlands. The Segment C Preferred Alternative crosses the Brazos River. At its crossing of the Brazos River, it is a navigable waterway (according to correspondence with the USACE Galveston District) and is included in the federal programs for channel navigation improvements, although ultimate design has not been funded, initiated, or completed. Because the crossing is above the currently maintained federal navigation project, a letter of permission (or Section 9 permit) will be required from the U.S. Coast Guard (USCG).

Since the project would disturb more than 1 acre of land, TxDOT would be required to comply with the TCEQ Texas Pollutant Discharge Elimination System (TPDES) General Permit for Construction Storm Water Runoff, which requires development of a Storm Water Pollution Prevention Plan (SW3P) in order to avoid adverse impacts potentially resulting from construction stormwater runoff discharges. In addition, because the project would disturb more than 5 acres of land, TxDOT would issue a Notice of Intent (NOI) prior to construction stating that the SW3P has been developed and filed. Additionally, in accordance with CWA Section 402 where stormwater from the proposed construction project will discharge to a Municipal Separate Storm Sewer System (MS4), the MS4 Permittee would be notified of the construction activity.

Wetlands and Vegetative Community Impacts

Wetlands

None of the alternatives completely avoids impacts to wetlands. Through the screening and evaluation process, wetland impacts would be avoided and minimized as much as possible. Representative Alternatives potentially impact between 15 and 55 acres of wetlands. The boundaries of all wetlands that would be impacted by the Preferred Alternative were verified by the USACE (February 3, 2003). The verification expired; therefore, a request for a reverification with the USACE was requested. In

a letter dated April 1, 2010, the USACE has completed the preliminary jurisdictional determination (PJD), but is awaiting the permit application to continue the review process. The USACE provided a PJD that indicated the ROW for the Preferred Alternative contains 32.92 acres of aquatic resources. Additionally 3.26 acres of potential impacts to aquatic resources were identified within additional ROW evaluated for the US 59 and SH 288 interchanges (addition of direct connector ramps) subsequent to the USACE verification. A letter requesting an updated PJD was sent to the USACE by TxDOT Houston District on February 16, 2012 (Appendix I). Project correspondence will be updated once a response is received by the USACE. A draft compensatory wetland mitigation plan has been recommended, but has not been finalized with the appropriate agencies.

Vegetative Communities

The Preferred Alternative encompasses approximately 1,356 acres of ROW (1,131 new and 225 existing ROW). With respect to pastureland/grassland/cropland impacts, the Preferred Alternative would impact approximately 872 acres. With respect to forest impacts, the Preferred Alternative Alignment would impact approximately 53 acres.

TABLE S-1
SUMMARY OF PREFERRED ALTERNATIVE VEGETATIVE COMMUNITY IMPACTS

Community Type			
Pastureland/ Grassland/ Cropland (acres)	Forestland (acres)	Nonforested Wetlands (acres)	Forested Wetlands (acres)
1,024	110	17	9

Floodplains

The proposed Grand Parkway Segment C crosses the 100-year floodplains of the Brazos River and its tributaries. Each of the 100-year floodplains would need to be crossed with a major hydraulic structure, the majority of which would be bridges. The hydraulic design practices for this project would be in accordance with current TxDOT and FHWA design policies and standards. The highway drainage facility would permit the conveyance of the 100-year flood without causing substantial impacts to the roadway, stream, or adjacent property. With these design criteria, the drainage structures are not expected to impact the existing floodplain. All fill used to create the bridge embankments would be fill in the floodplain, which would require mitigation with floodplain storage adjacent to the roadway.

Other impacts to the 100-year floodplains include increased flow due to the roadway being constructed and its associated increased percent of impervious cover. The increase in flow must be mitigated with detention facilities within the proposed ROW. These detention facilities would offset increase in flows as well as add additional floodplain storage to the watershed, which would restore and preserve the natural and beneficial floodplain values.

Threatened and Endangered Species

Four of the Representative Alternatives and the Preferred Alternative include a segment that encroaches upon the secondary management zone of a Bald Eagle nest. The occurrence of the nest was complicated by the fact that Brazos Bend State Park is located to the south. While sufficient room for the proposed ROW exists between the maximum extent of the nest's secondary management zone and the park's boundary, the project team and resource agency staff, including the USFWS, worked closely together to avoid perceived impacts to Brazos Bend State Park while minimizing impacts to the Bald Eagle nest management zones at this location. A BA was provided to the USFWS in 2004 in order for them to issue a BO, which includes management, mitigation, and compensation recommendations, as well as a jeopardy opinion. The BA was updated to reflect the movement of the nest location. The issuance of a BO was completed in March 2007, therefore satisfying Section 7 consultation.

The proposed Grand Parkway Segment C includes the preservation of a tract of bottomland hardwood forest in Austin's Woods to ensure the long-term protection and preservation of suitable Bald Eagle nesting habitat. Ultimately, approximately 500 acres of Austin's Woods will be preserved through acquisition, donation to a conservation entity, or through protection under a conservation easement.

Cultural Resources

Archeological Resources

After review of the Intensive Archaeological Survey of the Proposed Grand Parkway Segment C Preferred Alternative (Sherman et al., 2006) and Rural Historic District and Landscape Assessment for the Darrington Prison Farm (Foster, 2007), TxDOT and the Texas State Historic Preservation Officer (SHPO) determined that the Darrington Plantation/Prison Farm landscape is not eligible for listing in the National Register of Historic Places (NRHP) for its architectural and associative qualities. However, three archeological sites (41BO212, 41BO213, and 41BO218) and their associated high-probability areas (HPAs) within the Darrington Plantation/Prison Farm property should be avoided until final determinations of archeological significance have been made. Pending final investigation and assessment of these sites and areas, TxDOT has stipulated that impacts and disturbances caused by clearing, grubbing, construction activity, staging and storage of equipment, borrowing of soils, soil disposal, or other ground-disturbing activities of any kind shall be avoided in the following designated areas:

- Site 41BO212 at the Brazos River, extending out from the centerline of the existing roadway for a distance of 200 feet to each side of the centerline;
- Site 41BO218 at Cow Lake, extending out from the centerline of the existing roadway for a distance of 200 feet to each side of the centerline; and
- Site 41BO213 at Oyster Creek, extending out from the centerline of the existing roadway for a distance of 200 feet to each side of the centerline.

No work of any kind shall be conducted within the above-designated areas without obtaining written documentation and approval from the TxDOT Environmental Affairs Division (ENV) stating that avoidance issues have been resolved.

Historic Nonarcheological Resources

In accordance with the Programmatic Agreement among the FHWA, Texas Historical Commission (THC), Advisory Council on Historic Preservation (ACHP), and TxDOT and the Memorandum of Understanding between TxDOT and the THC, TxDOT consulted with the Texas SHPO regarding the project's potential to affect significant sites. The results of the Section 106 coordination have been utilized in the selection of the Recommended Alternative Alignments that avoid or minimize to the greatest extent possible any potentially adverse effects from the project on historic nonarcheological resources.

Hazardous Materials

There are six registered hazardous material sites identified within the proposed ROW. All of these sites are considered low risk to the proposed project; however, prior to ROW acquisition it is recommended that a Phase I Environmental Site Assessment (ESA) (in accordance with the most current American Society for Testing and Materials [ASTM] Standards) be conducted at each site and/or facility that has known, or the potential for, hazardous waste impacts to the existing environment. All tanks should be removed from the ground, and proper closure activities conducted prior to acquisition.

Indirect Effects

The Study Team followed a seven-step approach to evaluate indirect effects based on the 2010 TxDOT *Guidance on Preparing Indirect and Cumulative Impact Analyses*. Using this guidance, the Study Team established an Area of Influence (AOI) based on the H-GAC's Traffic Analysis Zone (TAZ) boundary and a 15-minute travel contour. A TAZ is a special area delineated by state or local transportation officials for tabulating traffic-related data, especially journey-to-work and place-of-work statistics. A TAZ usually consists of one or more census blocks, block groups, or census tracts.

Potential indirect effects could include the following:

- Development and land-use changes due to improved access;
- Decrease in amount of prime farmland soils as a result of potential development;
- Increase in commercial development, increased income, employment and earnings opportunities; additional tax revenues; increased and/or improved community services, improvement of local roadways, and improved public recreational opportunities;
- Increased effects to water resources through degradation of surface water and groundwater, more rapid discharge to stormwater, and additional pollutant loadings of waterways;
- Loss of wildlife habitat and decreased habitat value in areas of increased land development spurred by the proposed toll facility; and

- Impacts to cultural resource sites from development projects on private property.

Where possible, the Study Team quantitatively determined the induced or indirect growth effect of the Build Alternative compared with the No-Build Alternative based on mapping developed by the Expert Panel. Unless otherwise noted, the anticipated growth and development under the No-Build Alternative would have similar indirect impacts to resources and issues as the Build Alternative.

Cumulative Effects

The Study Team followed an eight-step approach to evaluate cumulative effects based on the 2010 TxDOT's *Guidance on Preparing Indirect and Cumulative Impact Analyses*. Using this guidance, the Study Team established resource study areas (RSAs) for each resource identified in the indirect effects analysis for further study. Five resources were carried through the cumulative effects analysis: Land Use, Prime Farmland Soils, Water Quality, Waters of the U.S. including Wetlands, and Vegetation and Wildlife Habitat.

Cumulative effects to these resources under the No-Build Alternative and Build Alternative would be similar as new residential subdivisions and associated infrastructure continue to develop within the AOI. Approximately 11,395 acres of new development would likely occur within the AOI as a result of the Build Alternative. Under the No-Build Alternative, development would still occur but would likely be residential in nature, and would occur at a slower rate. This new development would potentially convert approximately 9,159 acres of prime farmlands compared with the No-Build Alternative. New development as a result of the Build Alternative would result in an increase in impervious cover and greater volumes of runoff during storm events, potentially affecting an additional 20 miles of streams and 513 acres of wetlands as compared with the No-Build Alternative. Under the Build Alternative, an additional 4,424 acres of vegetation could be affected as compared with the No-Build Alternative.

COORDINATION AND PUBLIC INVOLVEMENT

There have been several opportunities to date for the public to receive information regarding the issues associated with the proposed Grand Parkway Segment C, including the opportunity to submit comments at the project internet website (www.grandpky.com). In addition to public meetings, coordination meetings with regulatory agencies have been held. Section 7 details and lists each of the public meetings and discussions with the general public, agencies, and local public officials to date. Below is a summary of these meetings.

Public Involvement

- The Public Scoping Meeting/MIS Initiation Meeting for the proposed Grand Parkway Segment C was held on August 20, 1998, at the Guy Lodge Hall at the George Ranch.
- On October 27, 1998, a Public Workshop for the proposed Grand Parkway Segment C was held at the George Ranch.

- Two public hearings were held simultaneously on June 13, 2000, at the Sacred Heart Catholic Church in Brazoria County and Dickinson Elementary School in Fort Bend County to present the findings of the DEIS. Information on the two public hearings is available in Volume 3.
- Two public workshops were held simultaneously on November 14, 2000, at the Sacred Heart Catholic Church in Brazoria County and Manford-Williams Elementary School in Fort Bend County to present a Build Alternative for the proposed Grand Parkway Segment C (Volume 3).
- A third public meeting was held to receive comments regarding the construction of the proposed Grand Parkway Segment C as a toll facility. The meeting was held on August 30, 2007, at Guy Lodge Hall/Beasley Post Office on the George Ranch Historical Park in Richmond, Texas (Volume 3).

Local Official Involvement

Throughout this proposed Grand Parkway Segment C study, local officials provided input that was considered in the development and screening of alternatives. Input was requested from and provided by these local officials on a regular basis, as necessary, via telephone conversations and meetings. Concerns of several local officials are noted below.

Agency Coordination

Throughout this proposed Grand Parkway Segment C study, various agency officials from the Texas Parks & Wildlife Department (TPWD), USFWS, USACE, THC, EPA, and TCEQ provided input that was considered in the development and screening of alternatives and evaluation of the Grand Parkway Segment C project. Input was requested from and provided by these agencies on a regular basis, as necessary, via telephone conversations, meetings, and letters.

TABLE S-2
SUMMARY OF IMPACTS FOR REPRESENTATIVE AND PREFERRED ALTERNATIVES

	Item	Unit	1	2	3	4	5	6	7	8	P*
1	**Wetlands**										
1.1	Nonforested	acres	17	17	13	13	18	18	14	14	21
1.2	Forested	acres	38	38	2	3	38	38	2	3	6
2	**Endangered Species Occurrence within 1 mile**										
2.1	Animals	# sites	0	0	0	0	0	0	0	0	0
2.2	Plants	# sites	0	0	0	0	0	0	0	0	0
3	**Vegetative Communities**										
3.1	Forestland	acres	129	129	81	81	150	150	102	102	110
3.2	Pastureland/Grassland/ Cropland	acres	640	720	777	858	744	824	881	962	1,024
3.3	Habitat Fragmentation	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes
4	**Geologic**										
4.1	Geologic Sites	# sites	0	0	0	0	0	0	0	0	0
4.2	Prime Farmland	acres	704	749	792	836	734	780	823	868	955
5	**Water Resources**										
5.1	River Crossings	# of	1	1	1	1	1	1	1	1	1
5.2	Major Stream Crossings	# of	8	7	8	7	8	7	8	7	7
5.3	Minor Stream Crossings	# of	8	7	10	9	7	6	9	8	8
5.4	Irrigation Canal/Ditch Crossings	# of	13	15	16	18	21	23	24	26	17
5.6	Stock Ponds	# of	3	4	4	5	4	4	4	5	6
5.7	Floodplains	acres	420	373	447	400	467	420	494	447	349
5.8	Floodways	acres	21	19	21	19	22	20	21	20	21
6	**Hazardous Materials**	# sites	6	6	6	6	0	0	0	0	6
7	**Relocations**										
7.1	Commercial	# of	6	6	6	6	4	4	4	4	6
7.2	Single Family (Site Built)	# of	5	12	8	15	88	95	91	98	12
7.3	Single Family (Mobile Homes)	# of	1	2	1	2	1	2	1	2	2
7.4	Single Family (Platted)	# of	0	0	0	0	0	0	0	0	0
7.5	Schools	# of	0	0	0	0	0	0	0	0	0
7.6	Churches	# of	1	1	1	1	0	0	0	0	1
7.7	Cemeteries	# of	1	1	1	1	0	0	0	0	0
8	**Historic and Archeological Resources**										
8.1	Previously Recorded Archeological Sites (within ROW)	# of	3	3	3	3	0	0	1	1	3
8.2	Historic Nonarcheological Resources (within APE)	# of	12	12	16	17	6	7	11	12	9
8.3	High-Probability Areas	LF	28,200	28,200	37,500	37,500	27,575	27,575	36,875	36,875	40,900
8.4	Newly Recorded Archeological Sites (within ROW)	# of	3	3	5	5	3	3	4	4	3

TABLE S-2, CONT'D

	Item	Unit	1	2	3	4	5	6	7	8	P*
9	**Environmental Justice Considerations**	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes
10	**Noise and Air**										
10.1	Noise Receivers	# of	59	64	62	67	31	36	34	39	67
10.2	Air Quality	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	**Engineering and Mobility**										
11.1	Length	miles	24.9	26.1	27.4	28.6	26.4	27.6	28.9	30.1	26.9
11.2	Terminated County Roads	# of	2	2	2	2	1	1	1	1	2
11.3	Railroad Grade Separations	# of	1	1	1	1	1	1	1	1	1
11.4	Grade Separations	# of	9	11	9	11	10	12	10	12	13
11.5	Ramps	# of	22	22	22	22	20	20	20	20	26
11.6	Construction Sequencing Impacts	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes
11.7	Utility Crossings	# of	17	20	13	16	16	19	12	15	16
12	**ROW**										
12.1	Required ROW	acres	916	961	1006	1051	969	1013	1059	1103	1,131
12.2	Existing ROW	acres	6.6	13.4	30.0	36.8	0.0	6.8	23.4	30.2	225
12.3	Donated ROW	acres	369.4	370.5	275.2	276.3	373.4	374.5	279.2	280.3	468.3
13	**Other Environmental Issues**										
13.1	Visual Impacts and Aesthetics	high/ low	low	low	low	low	low	low	low	low	low
13.2	Follows Existing Roadway ROW	miles	0.90	1.8	1.3	2.2	0.00	0.9	0.4	1.3	1.8
13.3	Observatory Dark Northern Skies Impact	y/n	no	no	no	no	no	no	no	no	no
13.4	George Ranch Historical Park (private) Impacts	y/n	no	no	no	no	no	no	no	no	no
13.5	Potential 4f Issue (Cultural Resources)	y/n	no	no	no	no	no	no	no	no	no
13.6	Potential 4f/6f Issue (Parks and Public Lands)	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes

Source: Study Team (2011).
*Preferred Alternative
y/n = yes/no
LF = Linear Feet
NA = Not Applicable

INTRODUCTION

PROJECT DESCRIPTION

The proposed State Highway (SH) 99 (Grand Parkway) is a planned highway that would form a 180+ mile circumferential facility around the Houston metropolitan area (see Exhibit 1). The Grand Parkway would be a new location facility built to accommodate a 70 miles per hour (mph) design speed. The main lanes would be posted at 65 mph, and the frontage roads would be posted at 40 to 45 mph. The Grand Parkway would be constructed as a four-mainlane controlled-access toll road in a minimum of a 300-foot right-of-way (ROW) width, expanding to approximately 400-foot ROW at ramps and isolated frontage road locations. The 400-foot ROW can accommodate one of the following typical roadway sections: four-mainlane section without frontage roads, four-mainlane section with frontage roads, and four-mainlane section with exit and entrance ramps. It would provide access to various radial freeways (such as U.S. Highway [US] 59 and SH 288) and would serve as a third loop around Houston at a distance of approximately 25 to 30 miles outside of the downtown area. The Grand Parkway design would also account for the additional ROW required at each of the logical termini radii to construct direct connector ramps resulting in a fully directional interchange. The proposed facility would traverse Harris, Montgomery, Liberty, Chambers, Galveston, Brazoria, and Fort Bend counties.

PROJECT HISTORY

This document addresses the need and purpose, alternatives considered, Preferred Alternative, environmental impacts, and public involvement for the proposed construction of Segment C of SH 99 in Brazoria and Fort Bend counties, Texas. In 1998, the Houston District of the Texas Department of Transportation (TxDOT), assisted by the Grand Parkway Association (GPA), initiated a Major Investment Study (MIS) for the proposed Grand Parkway Segment C-1 of the Grand Parkway. Grand Parkway Segment C-1 was a proposed transportation facility located in east central Fort Bend County from US 59 to Farm-to-Market Road (FM) 762. The MIS process was approximately 50 percent complete when two events changed the scope of the MIS and the approach to preparing the MIS:

- The limits for the study area were extended beyond FM 762 to the east into Brazoria County in 1998, resulting in project limits from US 59 in Fort Bend County to SH 288 in Brazoria County.
- The Transportation Equity Act for the 21st Century (TEA-21) was signed on June 9, 1998. TEA-21 eliminated the MIS as a separate requirement, and directed that design scope decisions should be integrated into the planning process that is a part of the National Environmental Policy Act (NEPA). In accordance with the Federal Highway Administration (FHWA) input and recommendations, it was determined that the proposed Grand Parkway Segment C-1 MIS should be stopped.

In May 1998, the proposed Grand Parkway Segment C-1 MIS was stopped by agreement of TxDOT and FHWA, and a combined Environmental Impact Statement (EIS) and MIS for proposed Segment C of the Grand Parkway was initiated.

Information obtained and concepts developed during the proposed Grand Parkway Segment C-1 MIS have been incorporated into the DEIS/MIS for the proposed Grand Parkway Segment C.

A DEIS was prepared and released for public review and comment on May 13, 2000. A 60-day public comment period was provided in accordance with the requirements of the NEPA. Two identical public hearings were held on June 13, 2000. The Preferred Alternative was selected by the project team based upon the results of an alternatives analysis (Section 2) and input received from the public and from local, state, and federal agencies. Two public workshops were held on November 14, 2000, to present and receive comments on the Preferred Alternative. A Reevaluation of the DEIS, dated May 2011, was prepared and approved on July 21, 2011. This Final Environmental Impact Statement (FEIS) documents the process that was used to evaluate and select the Preferred Alternative.

CURRENT STATUS

The current status of each segment of the Grand Parkway is show in Table 1. Locations of these segments are illustrated in Exhibit 1.

Segment	Proposed Location	Approx. Length (miles)	Counties	Status
A	SH 146 west to IH 45	6.5	Galveston	Corridor Feasibility Study completed 2010
B	IH 45 west to SH 288	28.2	Galveston, Brazoria	FEIS anticipated publication in Spring 2013
C	SH 288 west to US 59	26.9	Brazoria, Fort Bend	FEIS anticipated publication in Spring 2012
D	US 59 north to IH 10	18.2	Fort Bend, Harris	Reevaluation for tolling approved in September 2008
E	IH 10 north to US 290	15.2	Harris	Under construction; Open to traffic in 2013
F-1	US 290 east to SH 249	11.9	Harris	ROD issued in June 2009
F-2	SH 249 east to IH 45	12.1	Harris	ROD issued in December 2009
G	IH 45 east to US 59	13.6	Harris, Montgomery	ROD issued in December 2010
H&I-1	US 59 south to US 90/US 90 south to IH 10	37.3	Montgomery, Harris, Liberty, Chambers	FEIS anticipated publication in Fall 2012
I-2	IH 10 south to SH 146	14.5	Chambers, Harris	Open to traffic 2008

Source: www.grandpky.com (2012).

SECTION 1: PROJECT NEED AND PURPOSE

The proposed State Highway (SH) 99 (Grand Parkway) is a planned scenic highway, which would form a 180+ mile circumferential highway around the Houston metropolitan area. The Grand Parkway would be constructed as a four-mainlane controlled-access highway in a minimum 300-foot right-of-way (ROW) width, expanding to approximately 400-foot ROW at ramps and isolated frontage road locations. It would provide access to radial freeways and would serve as a third loop around metropolitan Houston at a radial distance of approximately 25 to 30 miles outside the downtown Houston area. The proposed facility would traverse Harris, Montgomery, Liberty, Chambers, Galveston, Brazoria, and Fort Bend counties. This document addresses the proposed Grand Parkway Segment C, a 26.9-mile segment in Fort Bend and Brazoria counties, which traverses from U.S. Highway (US) 59(S) to SH 288 (Exhibit 2).

This section presents the needs (or problems) found in the study area (study area depicted in Exhibit 3) and the purpose (or goals) of the proposed project. Section 1.1 presents a summary of the local need for transportation improvements and the purpose of the proposed Grand Parkway Segment C. Section 1.2 presents a detailed transportation needs analysis of the proposed Grand Parkway Segment C.

1.1 NEED FOR AND PURPOSE OF THE PROPOSED PROJECT

Transportation improvements are needed in the proposed Grand Parkway Segment C study area because there are inefficient connections between suburban communities and major radial roadways, and there is an increasing demand on transportation infrastructure from projected population and economic growth. For planning and design purposes, SH 99 (Grand Parkway) was divided into 11 segments—A through I-2.

Per the U.S. Department of Transportation (USDOT) and Related Agencies Appropriations Bill, 1993 (adopted in July 1993) as well as H.R. 5518 (Report accompanying the Bill, Page 103) signed by President Bush October 6, 1992, Congress accepted that the Grand Parkway be studied and developed on a segment-by-segment basis and specifically instructed the Federal Highway Administration (FHWA) to prepare Environmental Impact Studies (EISs) for each segment of the Grand Parkway. In August 1992 (revised June 1993), an Environmental Overview was prepared for the Grand Parkway as a whole. In 1998, the Houston District of Texas Department of Transportation (TxDOT), assisted by the Grand Parkway Association (GPA), initiated a Major Investment Study (MIS) for the proposed Grand Parkway Segment C-1 of the Grand Parkway. Proposed Grand Parkway Segment C-1 was a proposed transportation facility located in east central Fort Bend County from US 59 to Farm-to-Market Road (FM) 762. The MIS process was approximately 50 percent complete when two important events changed the scope of the MIS and the approach to preparing the MIS:

- The limits for the study area were extended beyond FM 762 to the east into Brazoria County in 1998, resulting in project limits from US 59 in Fort Bend County to SH 288 in Brazoria County.

- The Transportation Equity Act for the 21st Century (TEA-21) was signed on June 9, 1998. TEA-21 eliminated the MIS as a separate requirement, and directed that design scope decisions should be integrated into the planning process that is a part of the National Environmental Policy Act (NEPA). In accordance with FHWA input and recommendations, it was determined that the proposed Grand Parkway Segment C-1 MIS should be stopped.

Subsequently, in May 1998, the proposed Grand Parkway Segment C-1 MIS was stopped by agreement of TxDOT and FHWA, and a combined Draft Environmental Impact Statement (DEIS) and MIS for the proposed Grand Parkway Segment C of the Grand Parkway was initiated. Information obtained and concepts developed during the proposed Grand Parkway Segment C-1 MIS have been incorporated into this Final Environmental Impact Statement (FEIS) for the proposed Grand Parkway Segment C.

Consistent with the April 2003 Texas Transportation Commission Minute Order 109226 that states, "The completion of the Grand Parkway is essential and urgent, as construction of the projects would alleviate congestion and improve traffic flow in the Houston metropolitan area and the surrounding region…" and "The commission has determined that constructing the Grand Parkway as a toll facility is the most efficient and expeditious means of ensuring its development, and encourages the development of partnerships and the employment of innovative methods for its financing and construction." Houston-Galveston Area Council's (H-GAC) 2035 Regional Transportation Plan (RTP) Update (Appendix A) identifies the addition of tolled facilities, including the Grand Parkway, as necessary to address current congestion and future growth in the Houston region. The local needs for the proposed Grand Parkway Segment C are further detailed in the following:

- System Linkage: The current transportation system does not allow for efficient circumferential traffic movement, i.e., it does not provide efficient connections, or linkage, between major suburban communities and major roadways that radiate outward from Houston such as US 59 and SH 288.
    - The transportation system does not provide efficient connections between suburban communities such as Richmond, Rosenberg, Needville, and Angleton.
- Only collector roadways connect US 59 and SH 288 within the study area. To accomplish circumferential trips, travelers must make trips that include SH 6 or Beltway 8 north of the study area. Expanded Capacity: Transportation demand exceeds the current and future capacity of existing transportation infrastructure:
    - The collector roadways that provide partial circumferential movement in the traffic study area (Crabb River Road, Sandy Point Road, and FM 1462) will face increased levels of congestion. The circumferential roadways that lie within the traffic study area (SH 6 and Beltway 8) are expected to face increases in traffic and congestion.
    - Construction of the proposed Grand Parkway Segment C would be necessary to maintain efficient traffic operations throughout the region. If the proposed Grand Parkway Segment C is not constructed by 2035, an average daily traffic (ADT) range from 8,352 to 87,738 vehicles would have to utilize alternate roadways to

complete their journey. This would lead to increased travel times, limiting regional mobility, and forcing the expansion and/or improvement of existing facilities throughout the area. Additionally, as stated above, it was determined a toll facility is the most efficient and expeditious means of ensuring the development of Grand Parkway, and encourages the development of partnerships and the employment of innovative methods for its financing and construction.

- Safety: Traffic movement on many roadways in the proposed Grand Parkway Segment C study area such as US 59, SH 288, SH 6, and Crabb River Road are controlled by intersections, traffic signals and/or stop signs, and multiple access points, all of which contribute to stop-and-go conditions and congestion during peak travel times and emergency events.
  - The proposed Grand Parkway Segment C is needed to relieve local congestion that has resulted from high population growth, increased residential development, and increased commercial development within and adjacent to the study area as well as the Houston metroplex.
  - Since radial facilities are congested during an evacuation, there is a need to connect them with an efficient circumferential roadway. As an example, when as many as 2 million people fled the Houston metroplex before Hurricane Rita on September 22, 2005, evacuees followed roadways leading to Austin, San Antonio, and Dallas. Severe congestion ensued, and contra-flow lanes were eventually opened. This evacuation prompted the creation of a task force to study evacuation from coastal areas in Texas.
- Economic Development: The expected growth would continue to strain existing transportation infrastructure, creating a barrier to businesses, commuters, and economic development. For those areas outside the Interstate Highway (IH) 610 Loop (and within the eight-county H-GAC region), the H-GAC predicts a 67.5 percent growth in population and a 62.7 percent growth in employment from the year 2005 to 2035. The eight-county region is divided into five zones. Grand Parkway Segment C is within Zone 4, which is defined as a 20- to 35-mile radius from Houston. Within Zone 4, the population is projected to increase 44 percent, 11 percent more than next highest projected zone (H-GAC, 2011a).

The purpose of the proposed transportation improvements in the proposed Grand Parkway Segment C study area is to efficiently link the suburban communities and major roadways, enhance mobility and safety, and respond to economic growth. The goal is to improve system linkage, address current and future transportation demand, improve safety, and accommodate population and economic growth. The goals of the proposed Grand Parkway Segment C are further detailed in the following:

- System Linkage: Improve system linkage, or connectivity within the existing transportation network. There currently is no primary east-west thoroughfare in the proposed Grand Parkway Segment C traffic study area. The proposed project would provide circumferential linkage between US 59 and SH 288, the two major radial facilities in the proposed Grand Parkway Segment C study area, and provide direct linkage for traffic engaged in circumferential traffic movement.

- Expanded Capacity: Address transportation demand, reduce traffic congestion, and provide travel options.
- Safety: Improve regional and local safety for the traveling public by minimizing conditions that contribute to stop-and-go conditions and congestion during peak travel times and emergency events The Grand Parkway would provide an additional hurricane and emergency evacuation route (Exhibit 4) for the Houston metroplex consistent with Minute Order No. 82325 signed October 25, 1984. Grand Parkway could alleviate a portion of the congestion during mass evacuations, thus creating safer and more efficient evacuation conditions.
- Economic Development: Accommodate demographic and economic growth by improving the movement of persons and goods, thereby minimizing barriers between businesses, consumers, and transportation infrastructure.

This section was prepared in accordance with the FHWA's Technical Advisory T 66480.8A, "Guidance for Preparing and Processing Environmental and Section 4(f) Documents" (FHWA, 1987), FHWA's memorandum entitled, "Purpose and Need in Environmental Documents" (FHWA, 1990), FHWA's and Federal Transit Administration's (FTA) joint memorandum entitled "Integration of Planning and NEPA Processes" (FHWA and FTA, 2005), and TxDOT's memorandum entitled, "Guidance on Purpose and Need" (TxDOT, 2001). The FHWA (1990) indicates that the need for and purpose of the project may, and probably should, evolve during the project development process as information is gathered and more is learned about the study. Studies conducted for the proposed Grand Parkway included interaction with project stakeholders, including the general public, local businesses, landowners, local officials, community leaders, regulatory agencies, FHWA, and TxDOT.

1.2 DETAILED TRANSPORTATION NEEDS ANALYSIS

A transportation needs analysis, or traffic analysis, was performed to assess the need for (1) additional transportation improvements for circumferential travel, and (2) improved system linkage between suburban communities and major roadway facilities. The area used for this traffic analysis is referred to as the traffic study area and is larger than the proposed Grand Parkway Segment C study area shown in Exhibit 3 because it includes all major roadways potentially affected by the proposed transportation facility. The traffic study area for the proposed Grand Parkway Segment C is generally bounded by Beltway 8 (Sam Houston Tollway) to the north, US 59 to the west, SH 288 to the east, and various existing rural roadways to the south. It was assumed that the traffic would remain the same regardless of alternative used.

The H-GAC's regional travel demand model of the Houston metropolitan area was used as a basis for determining the current and future traffic, which would utilize the proposed Grand Parkway Segment C of the Grand Parkway. The H-GAC's model provides current and future traffic forecast on roadway facilities based upon population and employment forecasts. For this study, the H-GAC provided traffic forecasts for several scenarios. These scenarios include a Build and No-Build where Build and No-Build refers to the construction status of the proposed Grand Parkway Segment C for years 2009 and 2035. An additional analysis was conducted in June 2010 to determine 2019 traffic projections. No-Build scenarios for all years assume that none of the 11 segments of Grand Parkway are constructed. The 2009 and 2019 Build

scenarios assumed that only the proposed Grand Parkway Segment C is open to traffic while the 2035 Build scenario assumes all 11 segments of 180+ mile Grand Parkway are open to traffic as a toll road.

Two different traffic analyses were conducted to evaluate the need and benefits of the proposed Grand Parkway Segment C. The primary focus of the proposed Grand Parkway Segment C analysis is to compare the projected traffic volumes on the proposed Grand Parkway Segment C to the minimum requirements of a rural multi-lane highway as defined by Part IV of TxDOT's *Operations and Procedures Manual*. The area roadway analysis would evaluate the traffic benefits to roadways within the study area by comparing projected traffic volumes with and without the proposed Grand Parkway Segment C. It is assumed that the study area, the regional geographic area affected by the construction of the proposed Grand Parkway Segment C, is located within US 59, SH 288, Beltway 8 (Sam Houston Tollway), and the Fort Bend and Brazoria county line.

Table 1-1 presents the 2019 and 2035 Build scenario traffic volume projections for the proposed Grand Parkway Segment C. The estimated ADT on the proposed Grand Parkway Segment C exceeds the threshold for a four-lane multilane rural highway in both short-term (2019) and long-term (2035) scenarios. However, as illustrated in Table 1-1, the traffic demand on the western portion of the proposed Grand Parkway Segment C is much higher than the portion to the east of the Brazos River. The traffic estimate on the proposed Grand Parkway Segment C, east of the Brazos River to SH 288, is, however, on the lower range of four-lane rural highway requirements. According to the "Standards of Design for Multilane Rural Highways" in the *Highway Design Division Operations and Procedures Manual* as published by TxDOT (1992), a four-lane rural highway requires an ADT of 5,000 to 20,000 vehicles.

TABLE 1-1
PROPOSED GRAND PARKWAY SEGMENT C PROJECTED TRAFFIC VOLUMES

Limits	Year 2019	Year 2022*	Year 2035	Change (2019 to 2035) (%)	Distance (miles)
US 59 to FM 2759	48,562	51,499	87,738	80.7	1.93
FM 2759 to FM 762	13,335	24,062	28,612	114.6	5.29
FM 762 to FM 1994	13,335	22,618	28,612	114.6	2.17
FM 1994 to Ft. Bend Tollway	6,722	10,925	11,771	75.1	0.45
Ft. Bend Tollway to Brazos River	6,722	9,975	11,771	75.1	7.54
Brazos River to FM 521	4,350	9,975	8,352	92.0	4.37
FM 521 to CR 48	4,136	10,307	8,429	103.8	3.38
CR 48 to SH 288	4,112	10,307	8,388	104.0	0.87

Source: H-GAC (2010).
*From previous H-GAC model.

1.2.1 System Linkage

The interstate and regional highway systems are predominantly oriented in either an east-west or a north-south direction. Circumferential transportation infrastructure would link the interstate and state highway systems. Information obtained from

public involvement activities (see Section 7 of this volume) indicated that citizens would use the proposed project as a link to the existing interstate or state highways for travel to areas outside Houston.

- US 59 and SH 288 are two radial highways connecting Houston to its suburbs and beyond. No reasonable freeway alternative connecting major radial facilities exists in the proposed Grand Parkway Segment C study area. There currently is no primary east-west thoroughfare in the proposed Grand Parkway Segment C traffic study area, and travelers are forced to access SH 6 or Beltway 8 to move east-west. Secondary roads include Crabb River Road, Sandy Point Road, FM 762, FM 521, Thompson Highway, and FM 1462; however, none provide a continuous connection from US 59 to SH 288 and the majority of study area land is undeveloped and lacks transportation infrastructure. For example, with construction of the proposed Grand Parkway Segment C, the travel distance from County Road (CR) 60/SH 288 to US 59/SH 99 (Grand Parkway) would be reduced by 10 percent (from 29 to 26.9 miles). Furthermore, the proposed Grand Parkway Segment C would decrease the travel time between these two locations. Currently, the shortest route from CR 60/SH 288 to US 59/SH 99 (Grand Parkway) utilizes SH 288, SH 6, and US 59. The proposed Grand Parkway Segment C would improve connectivity of the surrounding roadway network, improve access, and reduce travel circuity.

The purpose of the Area Roadway Analysis is to evaluate the traffic effect of the proposed Grand Parkway Segment C on the major roadways in the study area. Evaluation of the estimated traffic volumes on the major roadways indicate that construction of the proposed Grand Parkway Segment C would not create an adverse traffic condition. As shown in Table 1-2, daily traffic comparison between Build and No-Build scenarios (for analysis year 2035) shows that there is a 10 percent change in daily traffic at 4 of the 23 locations. Furthermore, the change in daily traffic at 10 of these locations is below 1,000 vehicles. This difference in traffic volumes are not substantial based on traffic estimation procedures.

Table 1-2 summarizes the years 2009, 2019, and 2035 traffic volumes for the No-Build and Build scenarios for these roadways and also provided in Exhibit 5. Table 1-2 presents examples of base year and future No-Build traffic data. The No-Build Alternative represents a condition in which all planned improvements in the 2035 RTP Update are in place, except the Grand Parkway. Exhibit 5 depicts traffic data for all roadway segments in the proposed Grand Parkway Segment C traffic study area in graphical form.

Overall, construction of the proposed Grand Parkway Segment C would be necessary to maintain efficient traffic operations throughout the region. If the proposed Grand Parkway Segment C is not constructed, the 8,352 to 87,738 daily vehicles projected for the year 2035 would utilize alternate roadways in order to complete their journey. As such, the increase in traffic volume on these roadways would increase travel times and delays for motorists, limiting regional mobility, and forcing the expansion and/or improvement of existing facilities throughout the area at great expense and inconvenience to the public.

TABLE 1-2
PROJECTED AREA ROADWAY TRAFFIC VOLUMES

Roadway	Limits	Year 2009	Year 2019			Year 2035		
		Existing	No-Build	Build	Change (%)	No-Build	Build	Change (%)
US 59	West of Grand Parkway	105,303	152,746	140,542	-8.0	216,522	184,010	-15.0
	Grand Parkway to SH 6	132,813	160,807	163,195	1.5	224,191	226,707	1.1
	SH 6 to Sam Houston Tollway	236,634	268,401	270,150	0.7	312,030	313,640	0.5
	Sam Houston Tollway to IH 610	191,253	217,590	216,342	-0.6	255,037	255,026	0.0
Sam Houston Tollway	US 59 to US 90A	69,599	99,960	99,679	-0.3	113,745	109,395	-3.8
	US 90A to FM 521	71,139	89,121	87,554	-1.8	110,479	108,765	-1.6
	FM 521 to SH 288	67,414	79,191	77,349	-2.3	99,973	97,954	-2.0
SH 6	US 59 to Settlers Way	39,290	40,114	40,441	0.8	57,661	58,255	1.0
	Settlers Way to FM 1092	47,459	47,217	47,351	0.3	65,814	66,298	0.7
	FM 1092 to SH 122	39,228	53,249	52,884	-0.7	83,122	82,358	-0.9
	SH 122 to FM 521	25,515	29,790	30,020	0.8	42,517	43,683	2.7
	FM 521 to SH 288	28,033	36,280	36,228	-0.1	28,886	29,777	3.1
FM 1462	West of FM 762	2,509	4,153	4,057	-2.3	11,678	11,042	-5.5
	FM 762 to FM 521	5,699	8,414	7,838	-6.8	17,979	16,897	-6.0
	FM 521 to SH 288	5,487	7,697	7,047	-8.4	16,524	15,582	-5.7
FM 762	FM 2759 to Grand Parkway	3,910	5,734	4,315	-24.7	10,949	8,932	-18.4
	Grand Parkway to FM 1462	2,235	3,645	3,996	9.6	8,802	10,401	18.2
FM 521	Sam Houston Tollway to SH 6	13,196	24,378	24,322	-0.2	38,479	37,854	-1.6
	SH 6 to Grand Parkway	4,770	14,011	14,471	3.3	19,721	22,944	16.3
	Grand Parkway to FM 1462	3,331	6,291	5,596	-11.0	9,327	9,393	0.7
SH 288	Sam Houston Tollway to SH 6	92,601	117,946	117,800	-0.1	150,522	148,212	-1.5
	SH 6 to Grand Parkway	31,739	37,887	37,424	-1.2	42,397	43,098	1.7
	Grand Parkway to FM 1462	32,383	37,464	38,973	4.0	52,254	56,495	8.1

Source: H-GAC (2010).

1.2.2 Expanded Capacity

The H-GAC regional travel demand model of the Houston metropolitan area was used to determine the base year traffic (2009) and future years 2019 and 2035 traffic projections (Exhibit 5). Base year and future traffic were compared to determine the change in traffic volumes over time. The H-GAC's model determines traffic volumes on roadway facilities based upon current and projected population and employment data as well as the transportation network available to travelers. In the 2035 No-Build scenario between US 59 and SH 288, a large portion of the Sam Houston Tollway and approximately 50 percent of SH 6 would operate at or near capacity. Exhibit 5 illustrates the traffic estimates for the Build and No-Build scenarios for 2009, 2019, and 2035, respectively. The traffic analysis was conducted for the following facility types defined by the FHWA:

- Interstate Highways/Freeways: These are divided highways with two or more lanes designated for the exclusive use of traffic in each direction. These roadways are intended to provide uninterrupted flow. There are no signalized or stop-controlled at-grade intersections. Direct access from adjacent properties is not permitted.

Access is limited to ramp locations and opposing directions are separated by a raised barrier, a median, or a raised traffic island. An example of an interstate highway is IH 10.

- Principal Arterials: These roadways provide an integrated network of roads that connect principal metropolitan areas and serve virtually all urban areas with a population greater than 25,000. Principal arterials can be grouped into two separate categories:
  - Freeway Principal Arterial: These principal arterials have complete access control. Much like an interstate facility, they are designed to have an unimpeded traffic flow. Examples include Beltway 8 and US 290. The proposed Grand Parkway is an example of a freeway principal arterial.
  - Non-Freeway Principal Arterial: These principal arterials do not exhibit access control. At-grade intersections and impeded traffic flow are common. US 90A and SH 6 are examples of a nonfreeway principal arterial.
- Minor Arterials: These roadways interconnect and supplement the principal arterial system with a greater emphasis on land access and a lower level of traffic mobility. They provide intra-community service and connect rural collector roadways to the urban highway system. An example of a minor arterial is FM 762 Thompson Highway.
- Collector Roadways: These roadways provide service to any county seat, large towns, or other major traffic generators not served by the arterial system. They provide links to the higher classified routes and serve as important intra-county travel corridors. Examples of collector roadways are Crabb River Road and Sandy Point Road.

Access Management: The Smart Street Program, a concept developed as part of the 2025 RTP, was also described in the 2035 RTP. The Smart Street Program was a tool developed to increase mobility and improve transit access and safety by providing operational improvements along strategic regional thoroughfares. Since the adoption of the 2035 RTP, the Smart Street program was redefined as the Access Management program. As explained in the 2035 RTP, "Access Management is the same concept as Smart Street but defines specific improvements in corridors through planning studies and the implementation of recommended solutions, and is part of a ["complete street"], where priorities among all modes of street users has been rebalanced." Access Management would improve mobility through a range of alternatives such as traffic light synchronization; deployment of roundabouts; medians; constructing or extending (as needed) turn bays; consolidation of duplicate driveways, as appropriate; and partial grade separation of some traffic lanes at major intersections (H-GAC, 2011b).

Expected future benefits of the Access Management program include:

- Opportunities for economic development along select arterials;
- Improvements to transportation and land use access through the use of back access roads to major traffic generators;
- Increased travel options due to improved arterials and connectivity; and

- Enhanced regional evacuation routes.

This growth in traffic is consistent with the projected future population and employment growth.

1.2.3 Safety

The proposed project would improve regional and local safety for the traveling public by minimizing conditions that contribute to stop-and-go conditions and congestion during peak travel times and emergency events.

The Grand Parkway would play a potentially significant role in the evacuation of residents and tourists from the surge vulnerable areas of Galveston and Brazoria counties in Texas. The location of the proposed facility would provide an additional means for evacuees to reach intended destinations. The magnitude of the role that the Grand Parkway may play is a function of how many evacuees would logically use the route given their location and intended destination and the relief that the Grand Parkway would provide to expected evacuation bottlenecks in the area. Given the location of the Houston/Galveston/Brazoria (HGB) Metropolitan area along the northwest Gulf Coast and the intense recent hurricane activity, hurricane evacuation is a critical public safety issue.

1.2.3.1 Evacuation Trip Generation

For Galveston, Brazoria, and Harris counties, a number of evacuation vehicles were developed relevant to the analysis for the current year (2008) and year 2035. The Hurricane Evacuation Study (HES) model developed for the Galveston region study area (from the recent U.S. Army Corps of Engineers [USACE]/Federal Emergency Management Agency [FEMA] HES) was used as a starting point and major modifications were made based on new zip code-based evacuation zones delineated by the counties. Exhibit 4 shows the blue, yellow, and red surge based evacuation zones delineated in the USACE/FEMA study and the additional county delineated zip code-based areas in green that would also be asked to evacuate for a major hurricane. Numbers of evacuating vehicles were generated and projected forward using growth factors developed for each county. Evacuation zones form the basis of areas contributing evacuation traffic to the existing and future evacuation routes.

Using census data for year 2000, which is the current state estimate, and a H-GAC projection for 2035, the growth factors developed for each county are as follows (Table 1-3).

TABLE 1-3
ESTIMATED POPULATION GROWTH

	2000 Census Population	2008 Population Estimate	2008 Growth Factor	2035 Population Projection	2035 Growth Factor
Galveston County	250,158	286,987	1.15	412,000	1.65
Brazoria County	241,767	296,691	1.23	496,000	2.05
Harris County	3,400,578	3,922,115	1.15	5,840,000	1.72

Source: Study Team (2008).

Evacuation vehicles leaving the area from designated evacuation zones were then generated by applying the growth factors to the year 2000 baseline figures developed from the zip code modified USACE/FEMA HES traffic model (Table 1-4).

TABLE 1-4
ESTIMATED TOTAL EVACUATION VEHICLES

	Total Out Evac. Vehicles Year 2000 Generated from Zip Code Zones	Est. Total Out Evac. Vehicles Year 2008 Generated from Zip Code Zones	Est. Total Out Evac. Vehicles Year 2035 Generated from Zip Code Zones
Galveston Zones	117,235	134,495	193,081
Harris Zones	184,799	213,141	317,365
Brazoria Zones	72,077	88,451	147,870
Totals	**374,111**	**436,087**	**658,316**

Source: Study Team (2008).

1.2.3.2 Behavioral Data

Of critical importance to determining which evacuation zones might use each existing evacuation route and the proposed Grand Parkway Segments B and C (and to what degree), all available behavioral information was collected and reviewed. The American Red Cross was able to conduct approximately 4,000 telephone surveys in the early 1980s to learn what Gulf Coast residents did during Hurricane Allen. Texas A&M conducted a series of behavioral interviews in 1990, which were more hypothetical in nature, but presumably allowed residents to reflect on Hurricane Alicia in 1983. More recently, Dr. Michael Lindell and Carla Prater of the Hazard Reduction and Recovery Center of Texas A&M published a report entitled "Behavioral Analysis Texas Hurricane Evacuation Study, February 2008," which provided a wealth of behavioral parameters for each coastal region of Texas. Various newspaper articles from the *Houston Chronicle* provided anecdotal behavioral information for the Hurricane Rita and Ike evacuations.

Data regarding direction of travel and intended destinations were of primary significance to this analysis. A composite of all available behavioral information led to these estimated percentages (Table 1-5).

TABLE 1-5
EVACUATION DESTINATIONS

Direction of Evacuation Traffic	Average (%)	Destination Cities	Average (%)
North	45	Austin	15
Northeast	10	Dallas/Fort Worth	25
West	15	Houston	20
Northwest	30	San Antonio	15
		Other	25
Total	**100**	**Total**	**100**

Source: Study Team (2008).

1.2.3.3 Potential Grand Parkway Evacuation Traffic

Using the generated evacuation vehicle and behavioral data, it was concluded that a number of evacuating vehicles would potentially use the proposed Grand Parkway Segments B and C as evacuation routes. Segment C would be a more effective evacuation route if Segment B were in place. Evacuation vehicle figures for both segments were developed for the year 2035. Assumptions regarding what portion of each evacuation zone's directional traffic is using each segment are as follows:

- Grand Parkway Segments B and C in place.
- Harris County zones would not use the Grand Parkway given location and proximity to other regional roadways.
- Galveston Zones (including tourists) would comprise approximately 90 percent of westbound evacuation traffic and up to one-third of northwestbound evacuation traffic using the proposed Grand Parkway Segments B and C.
- Brazoria Zones – half of westbound and half of northwestbound evacuation traffic would use the proposed Grand Parkway Segment C, and up to one-fifth of northbound traffic would use the proposed Grand Parkway Segment C if Segments D, E, F, and G are in place.

Using these key assumptions, the evacuation vehicle data (generated by zone), and the directional travel percentages (listed previously), the following maximum potential evacuation vehicle volumes were generated by segment for the year 2035 (Table 1-6).

TABLE 1-6
2035 POTENTIAL VEHICLE VOLUMES

Contributing Area	Proposed Grand Parkway Segment B	Proposed Grand Parkway Segment C
Galveston Zones	45,181	45,181
Brazoria Zones	0	46,579
Harris Zones	0	0
Total by Segment	**45,181**	**91,760**

Source: Study Team (2008).

1.2.3.4 Evacuation Route Capacities

Route characteristics were examined to ascertain the existing number of lanes by direction that would be used in evacuations. Route characteristics, including number of lanes by direction, were used to develop hourly flow rates for each evacuation route in the study area. The H-GAC future year model parameters were then reviewed to ascertain the planned/future number of lanes by direction on each route. Data from post-storm evacuation assessment work for FEMA and the USACE contain actual hour-by-hour traffic counts during major evacuations over the last 20 years, and this data

helped in developing appropriate service volumes for this analysis. The estimated average hourly rate volumes of evacuated vehicles are as follows (Table 1-7).

TABLE 1-7
HOURLY SERVICE VOLUMES

	Current Year 2008 (vehicles/hr)	Future Year 2035 (vehicles/hr)
Galveston Routes		
SH 6	1,000	1,800
SH 146	1,200	2,100
IH 45	4,800	6,500
Grand Parkway Segment B/C	not in place	3,000
Brazoria Routes		
SH 288	1,850	1,850
SH 36	800	800
Route 521	800	800
SH 35	800	800

Source: Study Team (2008).

1.2.3.5 Evacuation Clearance Times With and Without the Project

For evacuation traffic desiring to go out of county, the proposed Grand Parkway Segments B and C would provide additional capacity to both Galveston and Brazoria evacuation zones attracting evacuation traffic that might otherwise clog Harris County evacuation routes. The clearance times provided in Table 1-8 reflect these benefits. A simplified method was used for calculating overall clearance time, whereby evacuating vehicles from an area are divided by the total hourly average evacuation route capacities serving that area. However, to add a degree of realism and accuracy regarding the Grand Parkway role in evacuation, vehicles identified (above) as potentially using the Grand Parkway were subtracted out and the resulting calculations were made (see Table 1-8).

If planned improvements on each evacuation route and the proposed Grand Parkway Segments B and C are not built, clearance time in the year 2035 would increase to greater than 50 hours for the Galveston zones. If planned improvements to each evacuation route are built but the proposed Grand Parkway Segments B and C are not built, clearance times would be approximately 34 hours for the Galveston zones. With the Grand Parkway and the planned improvements to each evacuation route, evacuation times fall to 29 hours or greater. As the clearance time calculations indicate, the Grand Parkway would save 4 to 6 hours of evacuation clearance time for the Galveston zones. For Brazoria evacuees who are leaving to go out of county, Table 1-8 shows that the Grand Parkway can save over 4 hours of clearance time.

TABLE 1-8
EVACUATION TIMES

Year 2035 Gross Out of County Clearance Time Estimates Based on Zip Code Zones	2035 Total Evac. Vehicles	2035 Planned Hourly Route Capacities	2035 Clearance Time WITH Planned Widenings	2035 Route Capacities WITHOUT Planned Widenings	2035 Clearance Time WITHOUT Planned Widenings
Galveston Zones Exiting Evacuation Traffic/Routes					
w/Grand Parkway SH 6, SH 146, IH 45	306,582	10,400	**29.5 hours**	7,000	**43.8 hours**
Grand Parkway Segment B	45,181	3,000	15.1 hours	3,000	15.1 hours
w/o Grand Parkway (No-Build) SH 6, SH 146, IH 45	351,764	10,400	**33.8 hours**	7,000	**50.3 hours**
w/Reverse Lane on IH 45 and w/Grand Parkway SH 6, SH 146, IH 45	306,582	15,400	**19.9 hours**	10,000	**20.5 hours**
Grand Parkway Segment B	45,181	3,000	15.1 hours	3,000	9.5 hours
w/Reverse Lane on IH 45 and w/o Grand Parkway (No-Build) SH 6, SH 146, IH 45	351,764	15,400	**22.8 hours**	10,000	**35.2 hours**
Brazoria Zones Exiting Evacuation Traffic/Routes					
w/Grand Parkway SH 288, SH 36, Route 521, SH 3	101,291	4,250	**23.8 hours**	4,250	**23.8 hours**
Proposed Grand Parkway Segment C **with** Galveston County traffic	91,760	3,000	**30.6 hours**	3,000	**30.6 hours**
w/o Grand Parkway (No-Build) SH 288, SH 36, Route 521, SH 3	147,870	4,250	**34.8 hours**	4,250	**34.8 hours**

Source: Study Team (2008).

Clearance times are also provided for an IH 45 reverse-lane strategy as local officials are likely to implement this as a result of the difficult evacuation experienced with Hurricane Rita. Even with a reverse-lane strategy on IH 45, the Grand Parkway saves an additional 3 to 4 hours of clearance time.

This savings in time is significant in three respects. First, in situations (like Hurricane Opal) where the storm rapidly increases in forward speed and intensity, the Grand Parkway may give over 50,000 evacuees the opportunity to evacuate who would not have been able to evacuate otherwise. (Emergency management officials have to add a block of what is called prelandfall hazards time to clearance time to come up with the total number of hours before eye landfall at which to start evacuating the public. Pre-landfall hazards time is the number of hours before eye landfall at which either wind or flooding conditions make it impossible to continue traveling on the roadways.) Depending on the size and meteorological characteristics of the hurricane, prelandfall hazards could be anywhere from 3 to 8 hours. With prelandfall hazards times added to the 50- and 34-hour times calculated without the Grand Parkway, an event like Hurricane Opal could easily happen where there is not enough existing roadway capacity to handle the needed evacuation movements.

The second significant timesavings effect due to the Grand Parkway is that it allows evacuation clearance time plus prelandfall hazards time to drop below 24 hours, which is a key warning timeframe of the National Hurricane Center. This would be a scenario where the Grand Parkway is in place, and IH 45 is placed under a reverse-lane strategy. Communities

that can reduce their times below 24 hours have the ability to issue evacuation advisories with much more confidence in projected landfall location and time of arrival.

The last evacuation benefit that must be mentioned is that the Grand Parkway provides another access-controlled evacuation route for Galveston and Brazoria counties in the case of a major accident on IH 45 or SH 288 south of the Sam Houston Tollway.

1.2.3.6 Evacuation Alternatives

In the past, a few organizations have set forth several alternatives that they believe would relieve the need for the proposed project to be built at least in regards to hurricane evacuation. Those alternatives are as follows:

- use of public transit
- widening of existing routes

The use of public transit has been suggested as an evacuation alternative to building the proposed Grand Parkway Segments B and C. Public transit has been used in a very limited fashion in other parts of the coastal United States for evacuation purposes. It has been used in resort areas such as Atlantic City, New Jersey, and Hilton Head, South Carolina, where there is a large tourist population without personal vehicles. Transit has also been used to evacuate migrant farm workers from substandard housing in hurricane-vulnerable areas in selected rural communities. Southeast Florida counties, such as Dade and Broward, have circulated transit vehicles along their barrier islands during major hurricane events such as Hurricane Andrew. However, very few residents have been willing to use the service even though pick-up points have been well planned and advertised.

Public transit use for evacuations by its very nature takes evacuees to designated public shelters. Most people do not want to go to public shelters and do not like the idea of leaving their residence with no personal freedom to come back on their own. Most pre- and post-storm hurricane behavioral analyses indicate no more than about 1 percent of the evacuating population intending to use or actually using public transit during an evacuation. To significantly reduce clearance times, transit use would need to be at least 15 to 20 percent of evacuee's mode choice, and that is not realistic in a private auto dominant community like the Houston-Galveston metropolitan area.

The second suggested alternative of widening existing routes has already been factored into this analysis. The 2035 model for the area incorporates a number of lane additions. In many cases the lane additions are the maximum that can be implemented within existing or available ROW. As shown previously, with these roadway widenings and without the Grand Parkway, clearance times can drop to roughly 34 hours. However, when adding a prelandfall hazards time of 3 to 8 hours to this figure, the area still is in the difficult dilemma of having to start evacuation outside the National Hurricane Center's 24-hour warning threshold. Implementing the Grand Parkway project, coupled with the widenings and IH 45 reverse-lane strategy, allow the communities to fall within the warning capabilities of the National Hurricane Center.

1.2.4 Economic Development

The H-GAC predicts population and economic growth for southern Harris County, northern Fort Bend and Brazoria counties through the year 2035. Increased population combined with increased traffic and congestion could make it more difficult for businesses to function efficiently. The rate and distribution of population and employment growth influence travel demand, creating the need for transportation improvements and alternative solutions. The H-GAC predicts that because of increased traffic, existing plans for transportation and traffic management improvements will not relieve future congestion. The proposed project would provide necessary additional roadway capacity to help alleviate this problem.

The proposed Grand Parkway Segment C would increase transportation efficiency for many commuters. The proposed project would provide an alternative circumferential route that would avoid local traffic conflicts and connect local communities, thus addressing and accommodating existing and future growth.

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SECTION 2: ALTERNATIVES CONSIDERED

Initially, alternative design concepts were identified and evaluated relative to the stated need and purpose for this project. A preferred design concept was selected. Next, alternatives for the preferred design concept were identified and evaluated. The evaluations resulted in the identification of a group of Representative Alternatives for the preferred design concept. Additional evaluations eventually resulted in the designation of the Preferred Alternative.

Section 4 of this FEIS addresses in detail the environmental consequences of the Representative Alternatives and the Preferred Alternative.

2.1 ALTERNATIVE DESIGN CONCEPTS

A full range of design concepts (highway, arterial, transit, pedestrian, bicycle) were defined and considered. Other concepts considered included the No-Build Alternative, Transportation System Management (TSM) alternatives, and Travel Demand Management (TDM) alternatives.

2.1.1 No-Build Alternative

The No-Build Alternative consists of not constructing the proposed Grand Parkway Segment C. However, it does consist of all the existing transportation facilities including the construction of planned and/or committed roadways in the study area. Committed improvements are those projects included in the 2035 RTP Update excluding the proposed Grand Parkway Segment C.

The No-Build Alternative would not reduce existing and future traffic volumes on roadways within the study area. Section 1 contains several detailed traffic analyses that result in traffic volumes for various Build alternatives and the No-Build Alternative. The No-Build Alternative results in much higher traffic volumes, which would result in higher travel times on other roadways within the study area. As also discussed in Section 1, the Houston region needs additional hurricane evacuation routes. The No-Build Alternative does not provide an additional hurricane evacuation route for the Houston region.

Additionally, although the No-Build Alternative would cost less to construct than build design concepts, the No-Build Alternative would result in higher maintenance costs to existing roadways in the study area due to increased traffic volumes on those facilities. The No-Build Alternative would also require additional short-term restoration and safety improvements to enhance the operation of the existing roadways in the study area. Further, traffic disruptions on existing roadways for maintenance purposes would be more frequent with the No-Build Alternative.

For the reasons stated above, the No-Build Alternative does not adequately address the need and purpose for the project. It would not reduce congestion or improve mobility on existing roadways within the study area and does not provide the

needed hurricane evacuation for the Houston region. However, the No-Build Alternative remains a baseline alternative throughout this study.

2.1.2 Transportation System Management Alternatives

TSM alternatives include those actions, which maximize the efficiency of the present roadway system. TSM alternatives include park & ride lots, ridesharing, high-occupancy vehicle (HOV) lanes, traffic signal coordination, intersection improvements, and other operational improvements.

- Park & Ride Lots – Encourage ridesharing and HOV lane usage.
- Ridesharing – Reduces vehicles on the existing roadway network by combining trips of common origin and destination. Ridesharing is most effective in areas of high-density residential development and employment.
- HOV Facilities – As a TSM improvement, would involve restriction of lanes on existing roadways for nonsingle occupancy vehicle use during peak traffic periods. Existing roadways in the study area on which HOV facilities could reasonably be implemented are US 59, SH 288, and SH 6.
- Traffic Signal Coordination – Results in increased traffic capacity of existing roadways by optimizing traffic signal phasing of individual intersections and coordination of successive signalized intersections along a thoroughfare. Candidate roadways for traffic signal coordination are limited to SH 6.
- Intersection Improvements – Consist of additional turn lanes, added through lanes through restriping, and traffic signal optimization.

Local agencies are currently evaluating and implementing TSM measures that are most feasible in the study area. The City of Sugar Land is currently implementing traffic signal coordination along SH 6. TxDOT is extending the US 59 HOV lane to just north of SH 6. The Westpark Tollway Park & Ride is located in Fort Bend County, west of Sugar Land.

TxDOT conducted a feasibility study for a SH 6 bypass around Sugar Land in 1997. The feasibility study also included investigations of TSM alternatives along SH 6 from US 90A to McKeaver Road. TxDOT concluded that TSM improvements along the SH 6 corridor would not reduce congestion considerably. The study also concluded that a relief route for SH 6 (south of Sugar Land and north of the Brazos River) would not be built (Brown & Gay, 2000).

A Congestion Mitigation Analysis (CMA) for the proposed Grand Parkway Segment C evaluated SH 6, a parallel facility that is currently experiencing congestion. The CMA concludes that TSM improvements along SH 6, as discussed earlier in Section 2.1.2, would not adequately relieve congestion.

The TSM alternatives described above do not completely address the issues (congestion relief, improved mobility, and additional hurricane evacuation) that define the need for this transportation facility. Park & ride lots, ridesharing, and HOV facilities have limited opportunities in the study area due to the geographic and time diversity of trip origins and

destinations. Traffic signal coordination opportunities are currently being implemented along SH 6. Intersection improvements would not adequately reduce congestion levels on roadways in the study area. While TSM measures should still be evaluated and implemented where feasible, additional transportation improvements in the corridor are needed to address congestion, mobility, and hurricane evacuation.

2.1.3 Travel Demand Management Alternatives

TDM measures consist of behavioral changes to commuters' travel habits, which result in fewer vehicles during the peak hours. The TDM measures improve mobility and reduce congestion during the peak hours. Six examples of TDM measures are described below:

1. Carpooling/Van Pooling – Combining multiple commuters into a single vehicle, resulting in fewer peak hour trips.
2. Employee Trip Reduction Programs – Programs that require major employers to reduce the average vehicular occupancy of their work force, resulting in fewer peak hour trips.
3. Compressed Work Weeks – Working full time in fewer days, resulting in some reduction in peak hour trips.
4. Telecommuting – Working from home, resulting in few or no peak hour trips.
5. Flex-Time – Working nontypical schedules resulting in a shift in commute trips from the peak hours to nonpeak hours.
6. Employer Incentives – Incentives that encourage employees to carpool or vanpool.

TDM alternatives 1 and 2 described above require modification to the behavioral patterns of individual commuters. Generally, behavioral changes have not been found to be effective when they are voluntary and only slightly effective when they are mandatory. Currently, none of these TDM measures are mandatory. Making these TDM alternatives mandatory could require action by a governing agency. TDM alternatives 3 through 5 described above result from employers allowing employees to vary their typical work schedules. Employers are hesitant to voluntarily implement these TDM measures because of concerns of lost productivity and profitability.

TDM alternatives were eliminated from further consideration. TDM measures have no effect on needed capacity during a hurricane evacuation, and as described above, they do not sufficiently relieve congestion or improve mobility.

2.1.4 Modal Alternatives

Modal alternatives considered in the analysis include improved bus transit, HOV lanes, rail, bicycle, and pedestrian. These alternatives are described below.

2.1.4.1 Bus Transit

There is currently no provider of bus transit within the study area. Within the study area, the Fort Bend County Mobility Plan Update found that a bus transit system would not be financially feasible in Fort Bend County because of low ridership

projections. The Fort Bend County study suggested implementation of a demand-response bus transit system in Fort Bend County. Connect Transportation, operated by the Gulf Coast Center, and Colorado Valley Transit provides demand-response bus transit in suburban and rural areas of Brazoria County. However, because demand-response bus transit does not adequately increase capacity or address hurricane evacuation within the corridor, it does not satisfy the need for transportation improvements in the study area.

2.1.4.2 High-Occupancy Vehicle Lanes

The HOV lane concept is used in conjunction with an existing roadway, which is experiencing considerable traffic congestion. HOV lanes are most effective when potential ride-sharers have common geographic trip origins and destinations within similar timeframes.

There are currently no HOV lanes within the study area. Houston's Metropolitan Transit Authority (METRO) operates HOV lanes in Houston on several radial freeway corridors: US 59 North and South, IH 45 North and South, US 290, and IH 10 West. METRO could provide HOV lane service in Fort Bend and Brazoria counties in the future through intercounty agreements. US 59 currently has HOV lanes that end just north of SH 6, north of the study area.

The HOV lane concept does not meet the project's need and purpose because a congested freeway corridor, which could be improved with the addition of an HOV lane, does not exist in the study area.

2.1.4.3 Rail Transit

The rail transit concept is also most effective where commuters have common geographic trip origins and destinations. There is currently no operator of rail transit within the study area. METRO has performed many rail feasibility studies within the region and has no plans to construct a rail facility within the proposed Grand Parkway Segment C study area.

Rail transit does not meet the project's need and purpose because the anticipated low ridership makes rail transit infeasible to construct and operate in the study area. Also, even if rail transit were feasible to construct, it would not meet the project's need and purpose as it relates to hurricane evacuation.

2.1.4.4 Bicycle and Pedestrian

The feasibility of bicycle and pedestrian alternatives is heavily dependent upon trip length. The trip lengths, which would occur as this facility satisfies its need and purpose, are greater than feasible bicycle or pedestrian trip lengths. Therefore, bicycle and pedestrian alternatives do not satisfy the need and purpose requirements of this project.

2.1.5 Added Single Occupancy Vehicle Capacity Alternatives

Three alternatives were considered for adding single occupancy vehicle (SOV) capacity in the study area.

2.1.5.1 Widen Existing Arterials

FM 762, FM 2759, FM 1994, and FM 1462 could be widened. Currently, each of these FM roadways is a two-lane facility with shoulders. The geometrics of each of these roadways are substandard, including several low-speed, 90-degree turns. Widening and realigning these roadways to four-lane rural arterial standards would increase capacity in the study area and address local mobility and congestion. However, these would not relieve regional congestion or provide additional hurricane evacuation capacity, and therefore do not meet the need for transportation improvements in the study area.

SH 6, located northeast of the study area, could be widened. Although the widening of SH 6 would slightly improve regional congestion, the SH 6 widening would not address the congestion in the study area, nor would it provide adequate hurricane evacuation capacity.

2.1.5.2 Construct New Arterials

Similar to the discussion in the section above, new location arterial roadways (divided four-lane sections) would increase capacity in the study area and somewhat address local mobility and congestion. As discussed in Section 2.1.2, the SH 6 bypass study concluded that TxDOT would preserve existing TxDOT ROW along the SH 6 bypass study route from US 59 to Ditch H and from the intersection of US 90A/SH 6 to US 59 for the purpose of the City of Sugar Land and/or Fort Bend County constructing a thoroughfare.

The City of Sugar Land has plans to construct University Boulevard, from US 59 to Ditch H. However, University Boulevard would not relieve congestion in the study area because it is designed to serve a new university and does not form a complete loop or provide adequate additional hurricane evacuation capacity, and therefore does not meet the need for transportation improvements in the study area.

2.1.6 Build Alternatives

As conceived by TxDOT and GPA, and as included in various regional planning documents, including the H-GAC 2035 RTP Update, the Build Alternative consists of a controlled-access toll road constructed on a new location. The Build Alternative is being proposed in additional to, not in lieu of, the commitments identified in the No-Build Alternative, including continuation of the improvements to existing facilities, incorporating the execution of planned and/or committed roadway improvements, TSM, TDM, bus transit, HOV lanes, rail feasibility, and new construction in the study area. The GPA would consider any and all future TSM, TDM, and modal transportation improvements, including future rail park-and-ride lots and/or stations. Committed improvements are those projects included in the 2035 RTP Update (H-GAC, 2011b). This alternative transportation mode would relieve local and regional congestion, improve mobility and system linkage, and improve safety on congested roadways within the region. The Build Alternative meets the need for and purpose of the project.

A free or non-toll Build Alternative (controlled access, four-lane freeway on new location) was considered, but eliminated from further study. The non-toll Build Alternative would not be consistent with the 2035 RTP Update that identifies the addition of tolled facilities, including the Grand Parkway, as necessary to address current congestion and future growth in the H-GAC planning region. The 2035 RTP Update is consistent with 2001 Texas Legislation Senate Joint Resolution 16 that, upon voter approval, amended the Texas State Constitution to create Texas Mobility Fund and authorized grants and loans of money and issuance of obligations for financing the construction, reconstruction, acquisition, operation, and expansion of state highways, turnpikes, toll roads, toll bridges, and other mobility projects. Given the new financing strategies available under this amendment, and the growth of regional toll authorities like the Texas Turnpike Authority, Fort Bend County Toll Road Authority (FBCTRA), Brazoria County Toll Road Authority (BCTRA), Harris County Toll Road Authority (HCTRA), and H-GAC, the 2035 RTP Update has included tolling as an integral part of its financial planning strategy and the Grand Parkway as a component of this plan.

2.2 PREFERRED DESIGN CONCEPT (PROPOSED ACTION)

The design concepts considered (i.e., No-Build, TSM, TDM, Modal Alternatives, and Added SOV Capacity Alternatives) were all evaluated in terms of their ability to satisfy the need and purpose of the project (see Section 2.1). The preferred design concept for a transportation facility in this study area is a new location four-lane controlled-access tolled facility beginning at US 59 and extending 26.9 miles to SH 288. As stated in Section 1.1, a toll facility is the most efficient and expeditious means of ensuring development of Grand Parkway, and encourages the development of partnerships and the employment of innovative methods for its financing and construction. The proposed action begins at the US 59 interchange and heads in a southerly direction along the existing Crabb River Road/FM 2759 for approximately 1 mile toward FM 762, with an interchange with Sansbury Boulevard. This portion of the facility is comprised of mainlanes and frontage roads. The facility continues on new location, without frontage roads, in a southerly direction for 11 miles, with interchanges at three crossings of FM 762, a Reading Road extension, and the future extension of Peters Road. The remaining 14 miles would continue in an easterly direction towards SH 288 on new location with interchanges at FM 521, CR 48, and SH 288. The facility includes frontage roads between CR 48 and SH 288. In addition to the interchanges, the proposed facility would bridge the following waterbodies: Rabbs Bayou, Dry Creek, Big Creek (two crossings), Big Creek diversion channel, Waters Lake Bayou, Brazos River, Cow Lake, and Oyster Creek. Exhibit 6 illustrates the conceptual typical section for the proposed facility. The proposed ROW is typically 300 feet in areas with mainlanes only. The ROW expands to approximately 400 feet at cross street interchanges and in areas with frontage roads. This type of facility is the design concept that would best satisfy the need and purpose of the project: congestion relief, increased local and regional mobility, and increased capacity for hurricane evacuation needs.

2.3 SCREENING OF THE NEW LOCATION HIGHWAY ALTERNATIVES

The consideration of four-lane controlled-access highway alternatives, hereafter referred to as alternatives, involves a three-phase screening process. This screening process is consistent with the NEPA and TEA-21. All of the alternatives included in each phase are evaluated with equal levels of effort. As alternatives are screened and eliminated, more-

detailed levels of study are performed. Ultimately, a detailed design will be developed for the Preferred Alternative. Each of the alternatives identified are evaluated with respect to the planning and design criteria previously established and described below.

- Phase 1 included data collection, constraints map development, identification of the Universe of Alternatives, a Public Scoping Meeting/MIS Initiation Meeting, screening of the Universe of Alternatives, selection of the group of Reasonable Alternatives, and a Public Workshop. The Public Scoping Meeting/MIS Initiation Meeting was held on August 20, 1998. It included input from the public that increased the size of the study area and added alternatives to the Universe of Alternatives. A project newsletter was produced and distributed, which documented the Public Scoping Meeting/MIS Initiation Meeting and announced an upcoming Public Workshop. The screening of the Universe of Alternatives and the selection of the group of Reasonable Alternatives was performed on October 16, 1998, with input from agencies, TxDOT's Houston District, and the FHWA. The screening was performed based on all project data, including input from the agencies, local officials, and the public (see Section 7). The Reasonable Alternatives were presented to the public at the Public Workshop on October 27, 1998. A second project newsletter was produced and distributed. This newsletter documented the Public Workshop and included revisions to the Reasonable Alternatives, which resulted from public input at the Public Workshop (see Section 7 and volumes 3–5 for more information on Public Involvement).
- Phase 2 included a detailed evaluation of the Reasonable Alternatives. This involved developing preliminary schematic designs and performing environmental field investigations of each of the Reasonable Alternatives during the first 6 months of 1999. The Reasonable Alternatives were screened and reduced to a smaller group of alternatives called Representative Alternatives at a meeting on August 23, 1999, with TxDOT's Houston District, TxDOT's Environmental Affairs Division (ENV), and FHWA. The screening was performed based upon all project data, including input from agencies, local officials, and the public (see Section 7). The public had an opportunity to comment on the DEIS during a comment period, which included a public hearing June 13, 2000, when the findings of the DEIS were presented to the public (Volume 3). Based on comments received at the June 2000 public hearing, some of the Representative Alternatives were revised slightly. Additionally, a Preferred Alternative was developed as a result of the comments received during the June 2000 public hearing. The Preferred Alternative was presented to the public at a Public Workshop, November 14, 2000 (Volume 3). A Reevaluation for the eight Representative Alternatives was prepared and approved in 2011.
- Phase 3 included a detailed analysis of the Preferred Alternative and a few other slight shifts in the eight Representative Alternatives. Additional analysis of the Preferred Alternative was conducted to avoid and minimize impacts to environmental resources to the greatest extent practicable, and ultimately compensate for the impacts that cannot be avoided. The evaluation process was reverified in 2007 and 2009. During the reverification, constraints, project data, and land use evaluated in 2000 were reviewed. Many of the planned residential subdivisions have since been constructed and additional subdivisions have been planned and developed. These now developed residential subdivisions are located in areas of various alternatives not

selected as part of the Preferred Alternative. Also, other engineering and environmental constraints were generally shown to be the same during the reverification for all the alternatives. This evaluation confirmed that the selection of the preferred alternative would remain the same and that no additional analysis is warranted. Phase 3 also includes the FEIS, which will be provided at a Public Workshop (meeting) if approved. The detailed schematic will also be presented at a Public Workshop.

2.3.1 Phase 1 Screening Process – Universe of Alternatives to Reasonable Alternatives

2.3.1.1 Phase 1 Engineering Design and Environmental Analysis

An environmental constraints map was prepared for the study area. The constraints map was developed with the use of secondary source data such as National Wetlands Inventory maps, U.S. Geological Survey (USGS) maps, subdivision plat information, current aerial photographs, windshield surveys from public ROW, and input from local residents, businesses, officials, and agencies.

The Universe of Alternatives was developed as 500- to 1,000-foot-wide corridors for the full length of the project, and impacts were quantified through the entire width of the corridor. Corridor widths were generally 1,000 feet but were narrowed to 500 feet in the northern section of the study area because of already higher density development. The 500-foot-wide corridor was applied to all alternatives within a certain reach of the northern portion of the study area so that alternatives being compared with one another would be equal in corridor width. The concept of the different corridor widths was reviewed and approved by the FHWA.

2.3.1.2 Phase 1 Screening of the Universe of Alternatives

The Universe of Alternatives was composed of 41 independent segments, each with a unique alphanumeric name (Exhibit 7), which connects to one another at nodes. The total number of possible alternatives for getting from one terminus of the project to the other terminus of the project was 96. Appendix B displays a summary of Phase 1 environmental impacts and engineering factors within the entire corridor by segment.

The segments in the Universe of Alternatives were grouped into subalternatives within three project sections (northern, middle, and southern) for evaluation purposes. The evaluation of subalternatives provided the study team with data that led to decisions regarding the elimination of some of the possible 96 alternatives within the Universe of Alternatives.

Phase 1 evaluations were numbered 1 through 10. The following paragraphs give brief descriptions of the 10 evaluations of subalternatives and discuss why subalternatives were discarded. Appendix C displays the summary of the environmental impacts and engineering factors by Phase 1 subalternative for each of the 10 evaluations. Exhibit 8 provides a graphical summarization of each of the 10 evaluations.

Phase 1 – Evaluation 1

Evaluation 1 included comparison of four subalternatives (1-A to 1-D) from US 59 at Crabb River Road to Rice Field Road.

- **Subalternative 1-A** was eliminated due to large impacts to forested wetlands and prairie vegetative communities.
- **Subalternative 1-D** was eliminated due to impacts to the community of Crabb and the planned Bridlewood subdivision.
- **Subalternatives 1-B and 1-C** were retained for further evaluation in Phase 2.

Phase 1 – Evaluation 2

Evaluation 2 included comparison of three subalternatives (2-A to 2-C) from Whaley's Corner to north of Brazos Bend State Park. None of the three various subalternatives in this area were eliminated. All three subalternatives were retained for further evaluation in Phase 2.

Phase 1 – Evaluation 3

Evaluation 3 included comparison of three subalternatives (3-A to 3-C) from the Texas Department of Criminal Justice (TDCJ) Darrington Unit to SH 288.

- **Subalternative 3-C** was eliminated from future evaluations, because of impacts to forested and nonforested wetlands, prairie vegetative communities, and 100-year floodplains.
- **Subalternatives 3-A and 3-B** were retained for further evaluation in Phase 2.

Phase 1 – Evaluation 4

Evaluation 4 included comparison of three subalternatives (4-A to 4-C) from FM 1462 to SH 288.

- **Subalternative 4-B** was eliminated because of impacts to commercial and residential properties in the vicinity of Rosharon and along FM 1462.
- **Subalternative 4-C** was eliminated because of large impacts to historic plantations in the vicinity of China Grove and Bonney.
- **Subalternative 4-A** was retained for further evaluation in Phase 2.

Phase 1 – Evaluation 5

Evaluation 5 included comparison of three subalternatives (5-A to 5-C) from US 59 at Crabb River Road to northeast of Lake Worthington.

- **Subalternative 5-B** was eliminated due to impacts to a historic landscape on the George Ranch and because of its proximity to the George Ranch Historical Park. A Texas Historical Commission (THC) assessment determined that an intact group of George Ranch tenant farm dwellings along FM 762 had local historic significance, including their associated agricultural landscape (see sections 3.18 and 4.17 for more detailed information).
- **Subalternatives 5-A and 5-C** were retained for further evaluation in Phase 2.

Phase 1 – Evaluation 6

Evaluation 6 included comparison of three subalternatives (6-A to 6-C) from Crabb River Road to Whaley's Corner.

- **Subalternative 6-B** was eliminated due to its proximity to the George Ranch Historical Park and impacts to a historic landscape on the George Ranch. A THC assessment determined that an intact group of George Ranch tenant farm dwellings along FM 762 had local historic significance, including their associated agricultural landscape (see sections 3.18 and 4.17 for more-detailed information).
- **Subalternatives 6-A and 6-C** were retained for further evaluation in Phase 2

Phase 1 – Evaluation 7

Evaluation 7 included comparison of four subalternatives (7-A to 7-D) from the San Jacinto Gas Compression Station to north of the Brazos Bend State Park.

- **Subalternatives 7-B and 7-D** were eliminated due to high impacts to historic structures on the George Ranch and because of their proximity to the George Ranch Historical Park. A preliminary assessment of the George Ranch found that an intact group of tenant farm dwellings had locally historic significance (see sections 3.18 and 4.17 for more detailed information).
- **Subalternatives 7-A and 7-C** were retained for further evaluation in Phase 2.

Phase 1 – Evaluation 8

Evaluation 8 included comparison of two subalternatives (8-A to 8-B) from Rice Field Road to north of the Brazos Bend State Park. Neither of the two subalternatives in this area were eliminated. Both subalternatives were retained for further study in Phase 2.

Phase 1 – Evaluation 9

Evaluation 9 included comparison of two subalternatives (9-A to 9-B) from Whaley's Corner to SH 288.

- **Subalternative 9-B** was eliminated due to impacts to hazardous material sites, nonforested wetlands, one church, residential properties along FM 1462, need for dark skies south of the George Observatory, and high construction costs.
- **Subalternative 9-A** was retained for further evaluation in Phase 2.

Phase 1 – Evaluation 10

Evaluation 10 included comparison of two subalternatives (10-A to 10-B) from northeast of Lake Worthington to SH 288.

- **Subalternative 10-A** was eliminated due to impacts to nonforested wetlands, Thompsons Oil Field, and nonconformity with local planning.
- **Subalternative 10-B** was retained for further evaluation in Phase 2.

2.3.1.3 Phase 1 Screening Summary

The 10 evaluations resulted in the elimination of 12 segments and resulted in 40 possible alternatives going from one terminus of the project to the other terminus of the project. These alternatives are referred to as the Reasonable Alternatives and are shown in Exhibit 9.

2.3.2 Phase 2 Screening Process – Reasonable Alternatives to Representative Alternatives

2.3.2.1 Phase 2 Additional Engineering Design and Environmental Analysis

Preliminary schematic designs were prepared for each of the Reasonable Alternatives. Environmental fieldwork was performed where access was available within the 500- to 1,000-foot-wide corridors for each Reasonable Alternative, and impacts were quantified through the entire width of the corridor. Also, during Phase 2 work, two segments were added to the study.

- **Segment S1** was added because of the possibility that remaining alternatives in the northern portion of the study area (C2 and A4) might be eliminated. The proposed Grand Parkway Segment C2 had recently become greatly impacted by residential development. Segment A4 had recently become less desirable because of public input related to potential impacts to the George Ranch Historical Park.
- **Segment T1** was added because of the elimination of three similarly located segments due to the location of a Bald Eagle's nest.

2.3.2.2 Phase 2 Screening of the Reasonable Alternatives

The Reasonable Alternatives were composed of 32 segments. Appendix D displays a summary of Phase 2 environmental impacts and engineering factors by segment. The number of possible Reasonable Alternatives for getting from one

terminus of the project to the other terminus of the project totaled 40. From this point forward, the remaining alternatives are referred to as Reasonable Alternatives 1 through 40.

The segments within the Reasonable Alternatives were also grouped into subalternatives for evaluation purposes. The subalternatives again covered only a portion of the project limits, and were less complicated to compare to one another. The evaluation of subalternatives provided the study team with data that led to decisions regarding the elimination of some of the possible 40 alternatives within the Reasonable Alternatives.

Phase 2 evaluations were numbered 11 through 15. The following paragraphs give brief descriptions of the five evaluations of subalternatives and discuss why nonviable subalternatives were discarded. Appendix E displays the summary of the environmental impacts and engineering factors by Phase 2 subalternative for each of the five evaluations. Exhibit 10 provides a graphical summarization of Evaluation 11 through 15.

Phase 2 – Evaluation 11

Evaluation 11 included comparison of four subalternatives (11-A to 11-D) between Crabb River Road and northwest of Lake Worthington.

- **Subalternative 11-B** was eliminated due to the potential relocation of residents of 29 single-family (platted) site-built homes. For the purposes of this analysis, it was assumed that these 29 platted lots contained 29 occupied homes (competed or under construction) by the end of 2000. Therefore, for the purposes of impacts, it was assumed that residents of 29 homes would be impacted by subalternative 11-B.
- **Subalternative 11-D** was eliminated due to impacts to the George Ranch Historical Park.
- **Subalternatives 11-A and 11-C** were retained for further evaluation in Phase 2.

Phase 2 – Evaluation 12

Evaluation 12 included comparison of four subalternatives (12-A to 12-D) between Crabb River Road and Whaley's Corner.

- **Subalternative 12-B** was eliminated due to the potential relocation of residents of 29 single-family (platted) site-built homes. For the purposes of this analysis, it was assumed that these 29 platted lots contained 29 occupied homes (competed or under construction) by the end of 2000. Therefore, for the purposes of impacts, it was assumed that residents of 29 homes would be impacted by subalternative 12-B.
- **Subalternative 12-D** was eliminated due to impacts to the George Ranch Historical Park.
- **Subalternatives 12-A and 12-C** were retained for further evaluation in Phase 2.

Phase 2 – Evaluation 13

Evaluation 13 included comparison of five subalternatives (13-A to 13-E) from northwest of Lake Worthington to FM 521.

- **Subalternatives 13-B, 13-C, and 13-E** were eliminated due to impacts to a Bald Eagle's nest.
- **Subalternatives 13-A and 13-D** were retained for further evaluation in Phase 2.

Phase 2 – Evaluation 14

Evaluation 14 included comparison of five subalternatives (14-A to 14-E) from Whaley's Corner to FM 521.

- **Subalternatives 14-B, 14-C, and 14-E** were eliminated due to impacts to a Bald Eagle's nest.
- **Subalternatives 14-A and 14-D** were retained for further evaluation in Phase 2.

Phase 2 – Evaluation 15

Evaluation 15 included comparison of two subalternatives (15-A to 15-B) from FM 521 to SH 288. Neither of the two subalternatives in this area were eliminated. Both subalternatives were retained for further study in Phase 2.

2.3.2.3 Phase 2 Screening Status

Appendix F summarizes the impacts of the 40 Reasonable Alternatives. The five evaluations did not result in the recommendation of a Preferred Alternative. Instead, the five evaluations resulted in the elimination of 32 of the Reasonable Alternatives. From this point forward, the eight remaining Reasonable Alternatives are referred to as Representative Alternatives. They are numbered as follows:

Representative Alternative 1 = Reasonable Alternative 11
Representative Alternative 2 = Reasonable Alternative 12
Representative Alternative 3 = Reasonable Alternative 19
Representative Alternative 4 = Reasonable Alternative 20
Representative Alternative 5 = Reasonable Alternative 31
Representative Alternative 6 = Reasonable Alternative 32
Representative Alternative 7 = Reasonable Alternative 39
Representative Alternative 8 = Reasonable Alternative 40

A preliminary schematic design was developed for each of the Representative Alternatives as listed above. Environmental field investigations were performed for each Reasonable Alternative within the 500- to 1,000-foot-wide corridors. Impact analysis resulted in the following changes:

- Segment C2 would have impacted a residential development and A4 would have impacted the George Ranch Historical Park. Therefore, Segments C2 and A4 were eliminated and Segment S1 was added in their place.
- Three segments were located in proximity to a Bald Eagle nest; therefore, Segment T-1 was added.

The eight Representative Alternatives were a combination of 23 segments, as described below:

Representative Alternative 1: A1, A2, A3.1, S1, B4.2, Q1, A6, K1, G5, P1
Representative Alternative 2: A1, A2, A3.1, S1, B4.2, Q1, A6, K1, G5, G6, G7, G8
Representative Alternative 3: A1, A2, A3.1, S1, B4.2, B5, B6, B7, J1, T1, G5, P1
Representative Alternative 4: A1, A2, A3.1, S1, B4.2, B5, B6, B7, J1, T1, G5, G6, G7, G8
Representative Alternative 5: B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, G5, P1
Representative Alternative 6: B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, G5, G6, G7, G8
Representative Alternative 7: B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, G5, P1
Representative Alternative 8: B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, G5, G6, G7, G8

Exhibit 11 depicts a graphical representation of the eight Representative Alternatives on an environmental constraints map. Appendix G summarizes the Representative Alternatives (Phase 2 Representative Alternatives) impacts by Segment and then by Alternative.

2.3.2.4 Draft Environmental Impact Statement

A DEIS was approved and signed by TxDOT and FHWA and was published in May 2000. The DEIS concluded with the identification of eight Representative Alternatives that were found to be feasible because they meet the need and purpose for this project and avoided or minimized impacts to the human and natural environment. A Preferred Alternative was not identified in the DEIS.

2.3.2.5 Public Hearing

On June 13, 2000, two Public Hearings for the proposed Grand Parkway Segment C were held—one in the northern part of the study area and another in the eastern part. The northern hearing was held at the Dickinson School in Sugar Land, Texas, and the eastern hearing was held at the Sacred Heart Catholic Church in Manvel, Texas. There were 215 individuals in attendance at the northern hearing and 127 individuals at the eastern hearing. Formal presentations were made by the project team regarding the alternatives presented in the DEIS. Approximately 43 individuals provided oral comments at these two hearings. A summary report is included in Volume 3. Comments received during other public hearings/workshops where the Representative Alternatives were presented (as described in Section 2.3.3.1) also contributed to shifts of Representative Alternative segments to avoid/minimize environmental impacts.

2.3.2.6 Shift in Representative Alternatives Since the 2000 DEIS Circulation and Public Hearings

Based on input obtained during the public hearings and potential environmental impacts determined during environmental analysis, shifts have occurred within the Representative Alternatives, and the derived segments listed in Table 2-1 resulted from the shifts to address public comment and further minimize impacts. These shifts have occurred in previously defined Segments A1, A2, A3.1, S1, G7, and G8, and Segments X1-a/X1-b, G5.2, Y1, and G6.2, which derived post-May 2000 DEIS circulation. Table 2-2 lists and Exhibit 12 shows the location of the Representative Alternatives with newly derived segments as a result of Phase 2 screening that were presented in the 2011 DEIS Reevaluation.

TABLE 2-1
POST-2000 DEIS CIRCULATION DERIVED SEGMENTS

New Segment	Change	Explanation
X1-a/X1-b	Replaced western portion of G5	G5 divided into G5.1 and G5.2 so that the northern boundary of George Ranch would be avoided and the original eastern terminus of G5 would remain in place. X1-a/X1-b replaced G5.1 based on further refinements to avoid George Ranch property limits.
Y1	Replaced eastern portion of G5	Eastern portion of original G5 shifted south at the request of a landowner to avoid crossing a livestock pond.
G6.2	Newly added segment	Derived as result of a shift in Segment Y1.
S1-b	Modification of S-1	S-1 shifted as a result of comments received from the public and elected officials after the November 14, 2000, Public Workshop and redesignated as Segment S1-b. The alignment adjustment was done to minimize ROW acquisition and resulted in fewer wetland impacts.

Source: Study Team (2011).

TABLE 2-2
POST-2000 DEIS CIRCULATION (DEIS REEVALUATION) REPRESENTATIVE ALTERNATIVES

Representative Alternative	Segments
1	A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1
2	A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8
3	A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1
4	A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2, G7, G8
5	B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1
6	B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8
7	B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1
8	B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2, G7, G8

2.3.3 Phase 3 Screening Process – Representative Alternative to Preferred Alternative

The process used to identify, evaluate, and screen the alternatives was found to be consistent with the requirements of the NEPA and approved for use on this project by the FHWA. This Preferred Alternative selection process included consideration of the alternative's ability to meet the need and purpose; impacts to the human and natural environment; and comments received from resource agencies, elected officials, and the public.

2.3.3.1 Public Hearings and Public Meetings/Workshops

On November 14, 2000, two Public Workshops for the proposed Grand Parkway Segment C were held in Manvel, Texas, and Richmond, Texas. The two meetings were attended by approximately 257 persons combined. The meetings were conducted in an open-house format with exhibit boards displaying all previous alternatives and the Preferred Alternative. A copy of the approved DEIS along with the project schedule were available for review. Written comments were received at these meetings. A summary report is included in Volume 3.

Approximately 2,000 comments were received from both the general public as well as resource agencies. Table 2-3 summarizes the comments received at both meetings.

TABLE 2-3
PUBLIC COMMENTS RECEIVED

Comment	Number Received
Avoid farmland impacts	10
Build Proposed Grand Parkway Segment C	125
DEIS does not adequately address hurricane evacuation	20
Ensure flooding problems are adequately addressed	60
Grand Parkway will cause urban sprawl	175
Grand Parkway will improve mobility and reduce congestion	90
Identify secondary development impacts	85
Keep alignment away from Brazos Bend State Park	1,800
Keep alignment away from Iowa Colony	115
Keep alignment away from the George Observatory	100
Minimize the construction cost	475
Proposed Grand Parkway Segment C would be an effective hurricane evacuation route	70
Protect the Bald Eagles and other species	100
Use Crabb River Road alignment	400
Use the “No-Build” option	200

The Preferred Alternative was identified based on an evaluation of the environmental impacts and comments received at the November 14, 2000, Public Workshop. The reasons for selecting the Preferred Alternative are summarized below:

- Public comments were received suggesting that the proposed Grand Parkway Segment C not directly impact the Brazos Bend State Park. The Preferred Alternative is now located approximately 1.5 miles from the park. Traffic noise impacts to the park are minimized with the Preferred Alternative.
- Public comments were received requesting the proposed Grand Parkway Segment C stay far away from the George Observatory. The Preferred Alternative is located about 3 miles from the observatory.
- The Preferred Alternative minimizes impacts to the Bald Eagle’s nest that is located within the project’s study area. The Preferred Alternative is located approximately 1,678 feet from the nest and is not within the primary

management zone as defined by the U.S. Fish and Wildlife Service (USFWS). A Section 7 consultation process is complete to ensure impacts to the eagle are avoided.

- Impacts to the community of Iowa Colony are avoided.
- The Preferred Alternative utilizes existing Crabb River Road, which reduces the amount of undisturbed ROW that would be required to construct the proposed Grand Parkway Segment C.
- The Preferred Alternative minimizes the bisecting of private property.
- The Preferred Alternative utilizes a "straighter" horizontal alignment, which results in a lower construction costs along the eastern project limits.
- The Preferred Alternative avoids existing residential and commercial development.

The Preferred Alternative was also presented to the public during Public Meetings held in August 30, 2007, at Guy Lodge Hall/Beasley Post Office on the George Ranch Historic Park in Richmond, Texas. The meeting was held to receive comments regarding the construction of the proposed Grand Parkway Segment C as a toll facility. There were a total of 269 in attendance. Eighteen verbal comments were received. Throughout the meeting, attendees had the chance to submit written comments or mail their comments by September 13, 2007. A total of 934 written comments were received.

2.3.3.2 Phase 3 Results – Preferred Alternative

During the Phase 3 Preferred Alternative selection process, some of the Representative Alternative segments were shifted to better avoid and minimize impacts and address comments received at the public hearings and workshops. Additionally some new segments of the Preferred Alternative were created. The alignment adjustments are described below and shown Exhibit 13. The Preferred Alternative Alignment is shown in Exhibit 14.

- **A3.1 and S1-b (far northern portion)** shifted slightly east.
- **Segment W1** was created after Segment G3.2 had been revised (see below). W1 provides for a direct connection between Segment B4.2 and Segment G3.2.
- **Segment G3.2** had previously not been included as a Representative Alternative due to its proximity to a protected species. However, the USFWS has since accepted the location of G3.2 and does not believe that a protected species is impacted by this segment. Therefore, Segment G3.2 was added back to the Preferred Alternative.
- **Segment X1** (replaces X1-a/X1-b and connects to G3.2) shifted slightly north of former X1-a and X1-b.
- **Y1** shifted slightly north.
- **G6.2 and G7** shifted slightly west.

- **G8** (far western portion) shifted slightly south.
- Addition of Direct Connectors at US 59 and SH 288.

2.4 ESTIMATED CONSTRUCTION COSTS

Cost estimates were prepared for each one of the individual segments, which made up the Universe of Alternatives, Reasonable Alternatives, and Preferred Alternative, and are included in the tables in Appendices C through G. Total construction cost values for different alternatives were determined by the summation of the proposed Grand Parkway Segment costs that make up the alternative.

These construction costs were based upon the conceptual design plans for the project and include preparation of ROW, excavation and embankment, construction traffic control, pavement, signing, pavement markings, bridge structures, guardrails, frontage roads, interchange ramps and signals, and drainage. Unit prices were developed for each of these cost items, either per mile or per each, based on current construction costs in Texas for highway projects in the Houston metropolitan area. The conceptual design was then used to enumerate the mileage and quantities of each item for the individual segments. Also, a factor of 10 percent was applied for construction mobilization and a factor of 15 percent was applied for contingencies to each segment. These costs were updated periodically to reflect changes made during the study.

The approximate total construction costs for each of the eight Representative Alternatives (as presented in the 2000 DEIS) and the Preferred Alternative (as calculated under current day conditions) are listed below. These costs are preliminary in nature and are based on conceptual design only. These costs have been used only for “order of magnitude” comparisons, and in actuality, the final construction costs may vary.

Representative Alternative 1 =$139,000,000
Representative Alternative 2 =$157,000,000
Representative Alternative 3 =$146,000,000
Representative Alternative 4 =$163,000,000
Representative Alternative 5 =$142,000,000
Representative Alternative 6 =$160,000,000
Representative Alternative 7 =$149,000,000
Representative Alternative 8 =$167,000,000

A preliminary schematic design of the Preferred Alternative has been prepared. A more-detailed construction cost estimate of the Preferred Alternative was prepared using the schematic and more current costs than at the time the Representative Alternatives preliminary costs were prepared. The current project cost (construction and agency) estimate for the Preferred Alternative is $625,110,107. This project cost includes estimated construction cost, estimated ROW cost, estimated utilities cost, escalation, and inflation costs.

2.5 ROW REQUIREMENTS

ROW requirements were also developed for each of the eight Representative Alternatives and the Preferred Alternative. Several factors were considered in developing ROW requirements:

- **ROW Footprint** – The conceptual designs, which were prepared for the eight Representative Alternatives, identified ROW requirements. The conceptual designs defined approximate limits of roadway sections with ramps and frontage roads (resulting in a 400-foot-wide ROW) and roadway sections without ramps and frontage roads (resulting in a 300-foot-wide ROW).
- **Donated ROW** – Several property owners (e.g., The George Foundation, the TDCJ) have indicated a willingness to donate ROW, if necessary.

The total ROW requirements for each of the eight Representative Alternatives and the Preferred Alternative are listed below. These ROW requirements for Representative Alternatives 1–8 are preliminary in nature and are based on conceptual designs. These ROW requirements have been used only for "order of magnitude" comparisons, and in actuality, the final ROW requirements may vary.

Representative Alternative 1 = 916 acres
Representative Alternative 2 = 961 acres
Representative Alternative 3 =1,006 acres
Representative Alternative 4 = 1,051acres
Representative Alternative 5 = 969 acres
Representative Alternative 6 =1,013 acres
Representative Alternative 7 =1,059 acres
Representative Alternative 8 =1,103 acres

The proposed ROW required for the Preferred Alternative, based upon the current schematic (variable 300- to 400-foot ROW to limit environmental impacts) is 1,131 acres. The project would also utilize approximately 225 acres of existing ROW. It was also assumed that the proposed ROW footprint for the Preferred Alternative would not be increased for any construction of toll collection booths. At this time, it is assumed that tolls would be collected by electronic toll collection, which would be constructed within the current proposed ROW footprint.

2.6 FUNDING

In the Texas Transportation Commission Minute Order authorizing the study of this project, the Commission included a requirement that toll road issues be "considered" in the study. As conceived by TxDOT and the GPA, and as included in various regional planning documents, including the H-GAC's 2035 RTP Update, the Build Alternative (Preferred Alternative) consists of a controlled-access toll road constructed on new location. The RTP recognizes that as the region's travel demands increase, federal and state revenues for building and maintaining highways will need to be supplemented through the creation of toll facilities to expand the area transportation system. The 2035 RTP Update is consistent with

2001 Texas Legislation Senate Joint Resolution 16 that, upon voter approval, amended the Texas State Constitution to create Texas Mobility Fund and authorized grants and loans of money and issuance of obligations for financing the construction, reconstruction, acquisition, operation, and expansion of state highways, turnpikes, toll roads, toll bridges, and other mobility projects. Given the new financing strategies available under this amendment, and the growth of regional toll authorities like the Texas Turnpike Authority, FBCTRA, BCTRA, HCTRA, and H-GAC, the 2035 RTP Update has included tolling as an integral part of its financial planning strategy and the Grand Parkway as a component of this plan.

This FEIS assesses and documents the environmental consequences of the facility being a toll road instead of a free road as discussed in the DEIS, and the public will be allowed to have input. Generally, the operation of the facility as a toll road would have minimal environmental effects. A limited number of environmental consequences potentially impacted by the Preferred Alternative being a toll road include traffic volumes, which is a function for traffic noise and air quality impacts. Other considerations include environmental justice (EJ) and acceleration of construction. The details of these environmental consequences are discussed in Section 4.

SECTION 3: AFFECTED ENVIRONMENT

This section discusses the affected environment of the proposed Grand Parkway Segment C.

3.1 LAND USE AND TRANSPORTATION PLANNING

Municipal governments in the State of Texas are granted broad authority to regulate land use within their respective jurisdictions. This authority allows considerable flexibility in the adoption of zoning and subdivision ordinances and land use and transportation plans. This section provides a description of historical and existing land uses and municipal and transportation plans in the proposed Grand Parkway Segment C study area.

Existing land uses within the study area were identified from aerial photography, TxDOT county maps, and USGS topographic maps. The resulting Environmental Constraints Map (Exhibit 15) was verified with field reconnaissance efforts conducted in June 2010. Supplemental information was also obtained from municipal planning documents, other pertinent documents, and interviews with municipal and state agency staff.

3.1.1 Historical Development Patterns

The study area falls within the Houston-Galveston-Brazoria Consolidated Metropolitan Statistical Area (HGB CMSA), which is made up of three Primary Metropolitan Statistical Areas (PMSA): the Houston PMSA (Chambers, Fort Bend, Harris, Liberty, Montgomery, and Waller counties), the Galveston – Texas City PMSA (Galveston County), and the Brazoria PMSA (Brazoria County).

Primarily rural until the 1970s, the suburban growth of Fort Bend and Brazoria counties has been closely tied to the economic prosperity of Houston. The lower cost of land in Fort Bend and other counties surrounding Houston has drawn residential development away from the central city to areas more affordable for the developer and homeowner. As bedroom communities increased through the 1980s, decentralization of Houston continued as jobs and retail sales began to follow homeowners to the suburbs. Over time, the Houston region has become a central city surrounded by smaller edge cities, large enough to support shopping and labor markets.

Much of the area in the Houston vicinity has been developed in a “leap frog” pattern. New subdivisions are built in outlying areas when land closer to the city is still undeveloped. Fitting this growth model, land in the region is developed if it is relatively close to existing subdivisions, is near transportation arteries and is large enough to make the private construction of stand-alone infrastructure economically efficient (Fort Bend Parkway Toll Road Traffic and Revenue Study, 1999).

This type of growth, master-planned communities developed by private entities, is rapidly occurring in the study area. Such communities are large enough to lower the per-unit costs of private development of capital infrastructure while at the same time offering open space and community facilities. Often, such communities are annexed by surrounding cities in efforts to

improve that city's tax base, providing the residents of the affected area approve it by referendum. Houston and its surrounding edge communities have typically expanded in this way (Fort Bend Parkway Toll Road Traffic and Revenue Study, 1999).

3.1.2 Existing Land Use

Located on the Gulf Coastal Plain, the study area covers 107,980 acres within two counties. The majority of the study area is located in the southeast portion of Fort Bend County. A smaller portion is located in northwest Brazoria County. The area falls within Gulf Coast State Planning Region 16 and is governed by the H-GAC of Governments. The study area is least utilized for commercial and industrial uses. Most commercial uses within the study area are concentrated along Crabb River Road, with the majority of the land utilized for agricultural, scattered residential clusters (particularly in the northern study area), Brazos Bend State Park, the Darrington Unit of the TDCJ, and George Ranch Historical Park. The bulk of the industrial uses include Thompsons Oil Field. The State of Texas owns two large land operations within the study area: Brazos Bend State Park and the Darrington Unit of the TDCJ. Sections 3.3.2.3 and 3.3.2.4 include discussions of Brazos Bend State Park.

The Darrington Unit is a prison farm located entirely within the Brazoria County portion of the study area. This 6,770-acre facility houses 1,836 prisoners at medium, minimum, and administrative segregation custody levels. Although the prison farm would seem to be a considerable constraint due to the security requirements of the facility, the TDCJ, in coordination with TxDOT (Exhibits 11 and 15), indicated that prison farm property could be considered in evaluating alternatives under the following conditions:

- Routes should only be considered that would not bisect the prison farm (i.e., follow the northern boundary or follow the southern boundary of the prison farm)
- Only prison farm land could be impacted
- Prison facilities could not be impacted
- Prison security must be maintained (i.e., buffer zone, illumination)
- Prison farm drainage in low-lying areas is a regular problem and must be considered

3.1.2.1 Urban Development

The most intensive development is found in the rapidly growing northern third of the proposed Grand Parkway Segment C study area. Suburban residential and commercial growth has occurred along Crabb River Road near US 59. The Memorial Hermann Sugar Land Hospital complex is located on the northwest corner of the US 59/Grand Parkway interchange, and the Riverpark Shopping Center is located on the northeast corner of the interchange. Newer and planned urban development extends to the south and west. Subdivisions are currently under construction on both the east and west sides of Crabb River Road, south and west of the intersection of Crabb River Road and FM 762 along the western edge of

Berdett Road and south of Smithers Lake along FM 762. Commercial uses are concentrated along Crabb River Road. The remainder of the study area is characterized by agricultural land uses, primarily rice farms, scattered small residential clusters, parklands, and the TDCJ as discussed above. The Brazos River and numerous tributaries cross the primarily level study area as well as the extensive irrigation system implemented by rice farmers.

Recent development, primarily in the northern third of the study area, is in the form of suburban style master-planned communities consisting of fairly high-density, single-family homes along curvilinear streets. Subdivisions within the study area include Greatwood, Greatwood Village, Greatwood Knoll, Bridlewood, Bridlewood Estates, Canyon Gate, Crestwood Tara, Brazos Crossing, Brazos Village, Canyon Lakes at the Brazos, Lakes of Williams Ranch, Brazos Village, Ridge Estates, Brazos Gardens, River Run at the Brazos, Bonbrook Plantation, Sovereign Shores Estates, Summer Lakes, and The Retreat (Exhibit 15).

Reading Jr. High School and George Ranch High School are located along FM 762 east of Bridlewood Estates (Exhibit 16).

The residential pattern of recent developments contrasts sharply with the rural nature of the traditional housing stock of the area where small clusters of homes or individual farm homesteads dot FM roads. Many of the residences in more rural settings include farm-related structures such as garages, barns, storage building, and other agricultural outbuildings. Many also appear to be smaller than the new homes more recently built in the northern portion of the study area.

Commercial and industrial land uses in the study area are minimal. The bulk of the commercial land uses are in the northern third of the study area near residential communities. Travel-related gas stations and fast food restaurants are concentrated near US 59. Extending south along Crabb River Road are additional community services including auto mechanic shops, dry cleaners, storage areas, and mini-markets.

The primary industrial land uses in the study area include Thompsons Oil Field. Much of this area is wooded or used as pasture. Industry-related dirt roads and buildings owned by various oil companies course through this property.

3.1.2.2 Agricultural Land Uses

Agriculture dominates the land uses within the study area. While Fort Bend and Brazoria counties are characterized by numerous crops including cotton, grain sorghum, corn, rice, hay, and soybeans, cultivation within the study area appears to be dominated by irrigated rice fields. Data from the Natural Resources Conservation Service (NRCS) indicate that agricultural land use decreased while urban land use increased in Fort Bend County between 1987 and 1992. Cropland decreased from 39 percent to 32 percent and pasture decreased from 31 percent to 27 percent, while rangeland increased from 12 to 21 percent and urban land use increased from 12 to 15 percent. Brazoria County saw similar decreases in cropland, which dropped from 25 to 21 percent; and pasture, which fell from 44 to 39 percent. Rangeland decreased from 13 to 11 percent and urban land use decreased slightly from 13 percent in 1987 to 12 percent in 1992 (Soil Conservation Service [SCS], 1987, 1992).

The 2007 Census of Agriculture reports that the amount of land in farms in Fort Bend County decreased approximately 9 percent from 415,251 acres in 2002 to 382,740 acres in 2007, and the average size of farms increased from 266 acres in 2002 to 273 acres in 2007. Total market value of land and buildings purchased for farming in Fort Bend County increased from approximately 72.7 million in 2002 to $88.5 million in 2007. In Brazoria County, land in farms decreased from 613,891acres in 2002 to 528,957 acres in 2007. The average size of farms decreased from 250 acres in 2002 to 205 acres in 2007. Total market value of land and buildings purchased for farming in Brazoria County increased from approximately $97.3 million in 2002 to $115.7 million in 2007 (U.S. Department of Agriculture [USDA], 2007).

3.1.2.3 Transportation Land Uses

The study area falls between two major interstate-type highways, which serve as spokes in the wheel of highways connecting the City of Houston to its suburbs and provide for interstate commerce. On the western edge is US 59, which runs northeast to southwest. On the eastern edge is US 288, which runs north to south. The primary road through the study area is FM 762. Except for Crabb River Road in the northernmost section, the remainder of the area consists of a network of sparsely developed farm-to-market and county roads.

The Union Pacific Railroad and the Burlington Northern Santa Fe Railway (BNSF) provide rail service for the Houston metroplex. Only the BNSF has a facility in the study area. This is a freight line from Rosenberg to Galveston. There is no passenger rail service within the study area.

Four landing strips are located entirely or partially within the study area (National Oceanic and Atmospheric Administration [NOAA], 1997, 1998; TxDOT, 1994). All of these are private airstrips. Three of these airstrips are located southwest of the Lake Worthington Conservation Area. The fourth airstrip is located northeast of Rosharon.

3.1.3 Land-Use Planning

As described in Section 3.1.1, large-scale residential development in the Houston region occurs through the development of master-planned communities by private entities. There is very little land in the study area under municipal jurisdiction, although a larger percentage of land does fall within the extraterritorial jurisdiction (ETJ) of neighboring cities. Typically, these types of master-planned communities are eventually annexed by a city.

As shown in Exhibit 17, there are a number of cities and smaller incorporated areas that exist within or extend into the study area. The city limits of Rosenberg, population 30,618 extend into the northwest section of the study area, encompassing the southern ROW of FM 762 as well as a corridor along Dry Creek up to Berdett Road. Rosenberg's ETJ includes the portion of study area bordered by Berdett Road and Rice Field Road. Rosenberg has adopted a comprehensive plan but has no zoning ordinance in place. The city has adopted a standard subdivision ordinance that governs development within its ETJ.

Richmond, population 11,679 is the county seat of Fort Bend County. Its southern city limits abut the northeast side of Rosenberg. Richmond's ETJ also extends into the northwest portion of the study area, just north of Rosenberg's ETJ. Richmond has no zoning ordinance and no comprehensive plan in effect, although development within its ETJ is subject to Richmond's subdivision ordinance.

Richmond is the largest general-law city in Texas, which means that it cannot annex voluntarily, only through petition. As a result, the city has not annexed and expanded to the same degree and rate as some of its neighbors. However, Richmond is currently involved in a number of capital improvement projects, which include improvement of 7,904 square feet of the existing 28,201-square-foot Fort Bend Family Health Center, Inc., totaling over $600,000 provided by a federal grant (Recovery.Gov, 2011).

The City of Sugar Land is located northeast of the study area with a population of 78,817. The city limits of Sugar Land extend along the ROW of US 59 just inside the northeast boundary of the study area. This strip is not zoned. The Sugar Land ETJ extends well into the study area, encompassing much of the land east of Crabb River Road between US 59 and FM 2759. As with the cities mentioned above, development must adhere to the city's subdivision regulations and design standards as well as county standards. The city's comprehensive plan was adopted in 1993, and a comprehensive plan update was approved in 2005.

Additionally, there are a number of small, incorporated cities within the study area. Iowa Colony, 2010 population 1,170, is located in Brazoria County. Incorporated in 1973, this city consists of farms and rural homes. Iowa Colony's city boundaries extend into the northeastern corner of the study area 400 to 600 feet in width along either side of east/west CR 64, 382, 62 and 49 and north/south along CR 65. The ETJ of Iowa Colony extends ½ mile beyond its city limits. Ordinances, which govern development within the city's ETJ, include a subdivision ordinance, a mobile home ordinance, and a mobile home park ordinance.

The town of Sandy Point, with the 2000 population (U.S. Census does not provide 2010 population) of approximately 250, is located on both sides of FM 521 and extends north of CR 54 to south of Sandy Point Road. There are no ordinances that govern development within the town's ETJ in place at this time (Mowery, 2006).

The town of Thompsons, 2010 population 246, is located north of the study area. Its town limits abut the study area, encircling Smithers Lake Exhibit 17). The ETJ of Thompsons extends into the study area to Brazos Bend State Park. The town follows the subdivision and design standards of Fort Bend County. Bonney, 2000 population (U.S. Census does not provide 2010 population) of approximately 384, is located in the southeast section of the study area. Rosharon is a small, unincorporated community located in the southeastern corner of the study area at the intersection of FM 521 and FM 1462.

3.1.4 Transportation Planning

The H-GAC has been designated by the Governor of Texas as the Metropolitan Planning Organization (MPO) for transportation planning in the Gulf Coast State Planning Region. The Transportation Policy Committee provides policy

guidance and overall coordination for multi-modal transportation planning and development within the eight-county Houston-Galveston Transportation Management Area (H-GAC, 1989).

According to TxDOT, an MIS has been completed that examines widening US 59 from SH 6 to the Wharton county line. The segment of this project, which stretches from SH 6 to the future Grand Parkway, has been constructed and is open to traffic. The segment from Grand Parkway to the Wharton county line is a Priority II (Hunt, 1999). Additional plans include elevating sections of FM 521, as it is classified as a hurricane evacuation route. No capacity will be added to this roadway (Mackhart, 1999).

The FBCTRA has constructed a toll road (Fort Bend Parkway), which connects the Sam Houston Tollway and SH 6 in northeastern Fort Bend County. It opened on August 30, 2004, to approximately 6,000 commuters taking advantage of a new travel option (FBCTRA, 2009). A second leg of the toll road will extend 18 miles from SH 6 south across the Brazos River to the intersection with the proposed Grand Parkway. Transportation planning and environmental studies are underway for this section. A third leg, on the long-range-planning horizon, would extend from the proposed Grand Parkway southwest to SH 36 (Meyers, 1999).

The City of Rosenberg has included Grand Parkway and an extension of Reading Road on its city map. The segment of Reading Road would intersect with the proposed Grand Parkway and falls within the city's 10-year planning horizon (Braun, 1999).

3.2 GEOLOGY, SOILS, AND FARMLANDS

3.2.1 Physiography

The study area is located in the Gulf Coastal Plain physiographic province of Texas. The province ranges in character from a nearly smooth, featureless depositional plain bordered by shallow bays, barrier islands, and beaches along the Gulf of Mexico, to low, rolling hills extending inland to the Balcones Fault Zone. The plain rises gradually from sea level to an elevation of 200 feet above mean sea level (msl) within 50 to 100 miles of the coast. The generally flat relief of the Gulf Coastal Plain is broken by narrow valleys of small streams and broad valleys of larger streams that drain the region. At some locations, this topographical pattern is interrupted by the presence of such features as salt domes and fault scarps. Some scattered salt domes have surface expression in the form of broad mounds having as much as 100 feet of relief. Faults are common in the region but generally have little or no surface expression.

The land surface within the study area is characterized as broad, nearly level and gently sloping with poorly defined drainage patterns. The Brazos River and smaller headward-eroding streams cut the coastal plain. These streams flow through shallow, incised valleys that provide the most notable relief in topography. An extensive network of ditches and levees cross portions of the study area. The natural ground surface of the study area slopes coastward and ranges in elevation from about 85 feet msl near the northwestern corner of the study area to about 45 feet msl near the southeastern corner. Water surface elevations along the banks of the Brazos River range from 35 to 65 feet msl.

3.2.2 Geology

The study area is located on the northern flank of the Gulf Coast Geosyncline, a major center of sediment deposition since the middle to late Jurassic Period. The sedimentary rock and unconsolidated sediment beneath the study area are more than 30,000 feet thick and are differentiated into named stratigraphic units (i.e., formations) that dip and thicken towards the Gulf of Mexico from their landward margins. The younger formations crop out progressively coastward of the older formations and they dip Gulfward at angles slightly greater than the slope of the land surface. The result is a vertically stacked sequence of offlapped wedges whose outcrops occur as concentric bands that generally parallel the Texas coast.

The thick sequence of sedimentary rocks and unconsolidated sediments beneath the present day Gulf Coastal Plain reflect cyclic marine and continental deposition in the region through the Jurassic, Cretaceous, and Tertiary periods, culminating with predominantly fluvial deposits at the end of the Tertiary period. This pattern continued through the Pleistocene Epoch (i.e., early Quaternary period), during which sedimentation was largely controlled by sea level fluctuations associated with repeated, glacial and interglacial episodes (McGowen et al., 1976). The past 18,000 years (i.e., Holocene Epoch) has been characterized by erosion of the Pleistocene sediments and the deposition of alluvial sediments in the stream valleys of the region.

Examination of the “Geologic Atlas of Texas, Houston Sheet” (Bureau of Economic Geology, 1982), indicates the geologic units recognized within the study area are Miocene through Holocene in age and include, from oldest to youngest: the Fleming Formation of Miocene age; the Goliad Sand of Pliocene age; the Willis Sand, Bentley Formation, Montgomery Formation, and Beaumont Formation of Pleistocene age; and the alluvium of the Holocene age. Generally, each of these units is composed of sedimentary deposits of gravel, sand, silt, and clay. With the exception of Quaternary alluvial deposits, the Pleistocene-age Beaumont Formation is the only stratigraphic unit that crops out in the study area. Extensive deposits of Quaternary alluvium are unconformably deposited over the Beaumont within the Brazos River valley, which crosses the eastern portion of the study area.

As mentioned previously, faulting is common in the Texas Coastal Zone and is a product of natural geologic processes. Coastal faults are related to the gradual subsidence and tilting of the underlying strata and the adjustment of the overlying sediment. Radiating faults frequently occur above salt domes, which are common to the Texas Coastal Zone. These features have existed for thousands of years; however, there is clear indication that certain man-made activities have increased the activity of surface fault movement. Most of the documented active faults are located in areas of heavy withdrawal of groundwater, oil, and gas. These areas are also the areas that have experienced the greatest surface subsidence (Fisher et al., 1972). Fluid withdrawal can activate movement along faults by depressurizing subsurface sediments, which reduce the buoyancy and increases the overburden pressure on the aquifer. Coincidentally, the areas of the most active faults occur in areas of high groundwater withdrawal. According to the Natural Hazards of the Texas Coastal Zone (Brown et al., 1974), there are several active or potentially active faults located in the study area. Further interpretation of aerial photographs of the Texas Coastal Zone has identified linear features, topographic scarps, and/or anomalies in natural patterns, which have resulted in the inference of numerous active or potentially active faults.

Land-surface subsidence is another natural geologic process that is a function of the depositional environment of the Texas Coastal Basin. The natural rate of subsidence has been greatly accelerated due to increased utilization of groundwater resources. Excessive groundwater withdrawal is the primary cause of land-surface subsidence. As groundwater is removed the artesian pressure and piezometric surface declines allowing the water-saturated clay beds in the aquifer to become compressed. As the clay beds are compacted and dehydrated, they undergo a volume reduction that results in subsidence of the overlying land surface. Land subsidence already experienced is irreversible.

According to studies performed by the Harris-Galveston and Fort Bend counties Subsidence Districts, the land-surface at the study area has subsided approximately 1 to 2 feet between 1906 and 1995 (Exhibit 18). The rate of subsidence of the study area from 1987–1995 is estimated to be slightly less than 0.25 foot. Exhibit 19 illustrates predicted subsidence rates through year 2030. There are no subsidence maps for Brazoria County.

Salt domes are common throughout the Texas Coastal Zone. These subsurface features frequently have little or no surface expression, but create amenable conditions for the mining of sulfur and/or salt, and the production of oil and gas. Four salt domes have been identified within a 5-mile radius of the study area. The Thompsons Salt Dome, which is located beneath the Thompsons Oil and Gas Field, is the only salt dome within the study area. This salt dome is located west of the Brazos River near the Fort Bend-Brazoria county line. There are no documented radial faults associated with any of the salt domes near the study area.

3.2.3 Soils

Examination of the Soil Surveys for Fort Bend and Brazoria counties (SCS, 1960, 1979, 1981) reveals that a total of five general soils map classifications within the proposed Grand Parkway Segment C study area: (1) Lake Charles- Bernard-Edna; (2) Pledger-Brazoria-Norwood; (3) Edna-Bernard-Verland; (4) Asa-Norwood Brazoria; and (5) Edna-Aris-Kemah (Exhibit 20). The following is a description of each soil series located within the study area (SCS 1960; NRCS, 2010).

Fort Bend County

Asa Series

Soils of the Asa series are fertile and highly productive. They occupy the nearly level rarely overflowed bottom lands mainly along the Brazos River.

Beaumont Series

The soil of this series is fertile, moderately productive, and imperfectly drained. It occupies the nearly level to slightly depressed areas on the prairies.

Bernard Series

Soils of the Bernard series are dark, fertile, and productive. They occupy nearly level to sloping upland. Slopes exceeding 1 percent in gradient are susceptible to erosion when cultivated.

Edna Series

Soils of the Edna series are sandy and crusty and have a compact blocky subsoil. Their productivity is low. They occur on level, nearly level, and gently sloping areas.

Fulshear Series

Soils of the Fulshear series are moderately productive. They occupy gently sloping uplands and are susceptible to erosion when cultivated.

Hockley Series

Soils of the Hockley series are on gentle slopes, and they are well drained. They have low productivity but respond to management.

Katy Series

Soils of the Katy series are sandy, light colored, and of moderate to low fertility. They are mostly in the northern part of the county on nearly level areas. Small areas, however, are on slopes that are as much as 4 percent.

Kaufman Series

Soils of the Kaufman series are dark heavy soils of the bottom lands. They occur on frequently overflowed flood plains of large creeks and of the San Bernard River. Kaufman soils are fertile, but they are too often flooded to be used for crops. If cleared of trees, these soils would be very good for pasture.

Lake Charles Series

Soils of the Lake Charles series are dark clays occurring in the level to nearby level prairies. They are the most extensive soils in the county. The surface of these soils has a characteristic hog-wallowed microrelief.

Miller Series

The Miller series consists of reddish calcareous bottom-land soils with a heavy clay substratum. These soils are productive and drought resistant. They occur mostly in level and nearby level areas, but in a few places the surface is undulating and sloping.

Novasota-luke Series

The soils in this complex occur in an intricate pattern and are not mappable as separate units.

Norwood Series

The Norwood series consists of calcareous soils on the flood plain of the Brazos River. Most areas are nearly level, but a few consist of low parallel ridges and shallow swales. Norwood soils are well suited for field crops and pasture.

Pledger Series

The Pledger series consist of dark clay soils. They occupy level to nearly level flood plains of the Brazos and the lower San Bernard Rivers. Drainage of the surface improves this soil for cultivation.

Roebuck Series

The Roebuck series consists of brownish poorly drained soils occupying the natural depressions of the Brazos River flood plain. These soils have to be drained before they can be cultivated or used as improved pasture.

Waller Series

The Waller series consists of grayish acid wet soils occurring in small shallow rounded depressions on the Gulf Coastal Prairie. These depressions range from less than 1 acre to 25 or 30 acres in size, and they are generally from 6 to 10 inches lower than the surrounding prairie. Water stands in the depressions for long periods.

Yahola Series

The Yahola series consists of reddish sandy calcareous soils. They generally occur on natural levees along the present and old channels of the Brazos River. The surfaces are convex, and in places the slopes are as much as 1 percent.

Brazoria County

Aris Series

The Aris series consists of nearly level, somewhat poorly drained soils. These soils formed in ancient fluvial deposits. Slopes range from 0.2 percent to 1 percent.

Asa Series

The Asa series consists of nearly level to sloping, well drained, nonsaline soils. These soils formed in recent loamy fluvial deposits. Slopes range from 0.2 to 8 percent.

Beaumont Series

The Beaumont series consists of nearly level, poorly drained, nonsaline soils. These soils formed in ancient clayey coastal deposits. Slopes range from 0.1 to 0.3 percent.

Bernard Series

The Bernard series consists of nearly level, somewhat poorly drained, nonsaline soils. These soils formed in clayey ancient coastal deposits. Slopes range from 0.1 to 0.4 percent.

Brazoria Series

The Brazoria series consists of nearly level to gently sloping, somewhat poorly drained, nonsaline soils. These soils formed in recent clayey fluvial deposits. Slopes range from 0.1 to 5 percent.

Clemville Series

The Clemville series consists of nearly level somewhat poorly drained, nonsaline soils. These soils formed in recent loamy fluvial deposits that are underlain by clayey deposits. Slopes range from 0.2 to 0.5 percent.

Edna Series

The Edna series consists of nearly level and gently sloping, poorly drained, nonsaline soils. These soils formed in clayey ancient coastal deposits. Slopes range from 0.1 to 5 percent.

Kenney Series

The Kenney series consists of nearly level and gently sloping, well drained, nonsaline, sandy soils. These soils formed in ancient sandy fluvial deposits under prairie.

Lake Charles Series

The Lake Charles series consists of nearly level to sloping, somewhat poorly drained, nonsaline soils. These soils formed in ancient clayey coastal deposits. Slopes range from 0.1 to 8 percent.

Norwood Series

The Norwood series consists of deep, nearly level to sloping, well drained, nonsaline soils. These soils formed in recent loamy fluvial deposits. Slopes range from 0.2 to 8 percent.

Pledger Series

The Pledger series consists of deep, nearly level, somewhat poorly drained, nonsaline soils. These soils formed in recent clayey fluvial deposits. Slopes range from less than 0.1 to 0.6 percent.

Sumpf Series

The Sumpf series consists of nearly level, very poorly drained, nonsaline soils. These soils formed in recent clayey fluvial deposits. Slopes range from 0.1 to 0.5 percent.

The engineering properties of most of the soils located within the study area are similar. Variations occur as a result of the presence of coarser grained material associated with recent alluvial deposition along streams. The potential of these soils for urban uses is classified as medium, due in part to limiting features including high shrink-swell potential, wetness, clayey texture, and the susceptibility to flooding. Most of the soils typically consist of moderately to poorly drained fat clays and sandy clays with slow permeabilities. Within the study area, only the Norwood, Waller, Asa, Bernard, Hockley, Katy, Fulshear, Kenney, Clemville, and Edna soils are classified as not having a high shrink-swell potential or a wet, clayey texture. These well-drained soils developed on coarser, alluvial parent material, and as a result, these soils are also susceptible to flooding.

Soil erodibility is dependent on soil properties, the slope of the land, precipitation, and vegetation cover. The soil properties important in determining potential for erosion are three interrelated factors: permeability, structure, and consistency of the soil composition (Brady, 1990; Sopher and Baird, 1979). Each of these is dependent on particle size and chemical composition, including the amount of organic matter present, to determine the amount of soil loss (Brady, 1990; SCS, 1981). The slope will determine the velocity and volume of runoff. The impact of precipitation is determined by the amount and intensity of the rainfall, and vegetation cover determines the exposure of the soil to the erosive action by wind and rainfall. Based on these criteria, the erosion factor due to sheet and rill action, K (Universal Soil Loss Equation), is moderate for the soils in the study area (SCS, 1981; Wiedenfeld, 2001).

3.2.4 Farmlands

Many parts of the study area are farmed, but not all areas in agricultural use are considered for protection under the Farmland Protection Policy Act (FPPA). The FPPA, as detailed in Subtitle I of Title XV of the Agricultural and Food Act of 1981, provides protection to prime and unique farmlands, all of which are classified into four distinct types. The four types of farmland as defined by the FHWA Technical Advisory are (1) prime, (2) unique, (3) other than prime or unique and of statewide importance, and (4) other than prime or unique that is of local importance (FHWA, 1987). The State of Texas recognizes two of these categories: prime and statewide important farmland soils. Prime farmland soils, as defined by the USDA, are soils that are best suited to producing food, feed, forage, and oilseed crops. Such soils have properties that are favorable for the production of sustained high yields. Prime farmland soils typically produce the highest yields with a minimum input of energy and economic resources, and farming these soils has been found to keep damage to the

environment at a minimum. Prime farmland soils usually exist where adequate precipitation is available, and where mean temperature and length of growing season are favorable. The pH level of prime soils is neither extremely acidic nor extremely alkali. These soils are fairly permeable to water and air, contain very few rocks and are not excessively erodible by wind or water. Prime soils are not saturated for long periods, nor are they subject to frequent flooding during the growing season. Slopes are generally less than 6 percent. Prime farmland can include cropland, pastureland, rangeland, or forestland, but does not include land converted to urban, industrial, transportation, or water uses.

Statewide important farmlands are defined by the appropriate state or county agency as important for the production of food, feed, fiber, and forage or oilseed crops, but are lacking in one or more criteria to be classified as prime farmland. Each county in Texas in which a soil survey has been developed has a grouping system for classifying the relative suitability of soils for growing crops. These capability classes rank all soils including their limitations for crop production. Generally, the higher the suitability class, the better it is for cultivation.

The five general soil types in the project area each include prime and statewide important farmland components. The soil series within the study area recognized as prime or statewide important farmland by the state NRCS office are presented in Table 3-1. Each of the soil series is further identified in the table by the soils associations discussed in Section 3.2.3.

TABLE 3-1
PRIME AND STATEWIDE IMPORTANT FARMLAND SOILS WITHIN THE STUDY AREA

Soil Series	Prime Farmland	Fort Bend County Soils	Brazoria County Soils
Aris soils	X		X
Asa soils	X	X	
Asa-Pledger complex	X	X	
Beaumont clay soils	X	X	
Bernard soils	X	X	X
Brazoria soils	X		X
Clemville soils	X		X
Edna soils		X	X
Fulshear soils	X	X	
Hockley soils		X	
Katy soils	X	X	
Kaufman soils		X	
Kenney soils			X
Lake Charles soils	X	X	X
Miller soils	X	X	
Navasota-juka complex		X	
Norwood soils	X	X	X
Pledger soils	X	X	X
Roebuck soils		X	
Sumpf soils			X
Yohola soils	X	X	

Source: NRCS (2011).

3.3 SOCIAL CHARACTERISTICS

3.3.1 Population Characteristics

Reflective of the growth pattern of Houston and its environs as discussed in Section 3.1.1, over the last 30 years the population of the HGB CMSA has increased dramatically as shown in Table 3-2. Although the rate of growth has slowed since 1970 when the population increased by 43.0 percent over that decade, growth is still relatively high, at 19.7 percent during the 1980s and 25.1 percent during the 1990s.

Population within the study area has increased. Although in 1960 Brazoria County contained almost twice as many people as Fort Bend County and was growing faster, the 1970s proved to be a boom for Fort Bend County. During this decade, Fort Bend's population increased by 150.3 percent from 52,314 to 130,962. Brazoria County grew 56.6 percent over the same period from 108,312 to 169,587. Fort Bend County has continued to outpace Brazoria County but at a slower rate since that time. Between 1980 and 1990, Fort Bend County and Brazoria County grew 72.1 percent and 13.0 percent, respectively. In the 1990s, Brazoria County's growth rate has increased 26.1 percent while Fort Bend County's growth has slowed 57.2 percent for the decade. However, over the last decade, the growth rate in Brazoria and Fort Bend counties increased to 29.5 and 65.2 percent, respectively. Overall, from 1960 to 2010, Fort Bend County's average annual rate of growth is more 4 times that of Brazoria County.

The cities of Richmond (population 11,679) and Rosenberg (population 30,618), located north of the study area, grew steadily through the 1960s and at a faster rate through the 1970s. While their rates of growth slowed in the 1980s, population in the 1990s did increase once again. The City of Sugar Land (population 78,817), in the northern portion of the study area but closer to the City of Houston, grew very rapidly between 1970 and 2000 with growth of at least 158 percent each decade. Between 2000 and 2010, growth continued (24.5 percent), however, at a slower rate than the previous decades. Although these three cities lie primarily outside of the study area, their population growth patterns reflect those of the region.

Population in the study area is expected to continue increasing. As shown in Table 3-3, projections suggest that between 2010 and 2040, Brazoria and Fort Bend counties will increase 45.6 and 98.3 percent, respectively. These percentages are only slightly less than the projected percentage change of the State of Texas for the same time frame.

Population of Sugar Land is anticipated to increase by approximately 28.4 percent between 2010 and 2020; however, population growth is anticipated to slow to 3.5 percent between 2020 and 2030, then plateau over the next 20 years. Richmond is expected to increase by 5.3 percent between 2010 and 2020, and by 21.4 percent between 2020 and 2030. Rosenberg is expected to increase at 5.5 percent between 2010 and 2020 and 27.0 percent between 2020 and 2030.

TABLE 3-2
POPULATION GROWTH BY CITY, COUNTY, AND STATISTICAL AREA

	Population						Percent Change					Average Annual Growth Rate (%)
	1960	1970	1980	1990	2000	2010	1960–1970	1970–1980	1980–1990	1990–2000	2000–2010	1960–2010
Fort Bend County	40,527	52,314	130,962	225,421	354,452	585,375	29.1	150.3	72.1	57.2	65.2	26.9
City of Richmond	3,668	5,777	9,692	10,042	11,081	11,679	57.5	67.8	3.6	10.3	5.4	4.4
City of Rosenberg	9,698	12,098	17,995	20,183	24,043	30,618	24.7	48.7	12.2	19.1	27.4	4.3
City of Sugar Land	2,802	3,318	8,826	24,549	63,328	78,817	18.4	166.0	178.1	158.0	24.5	54.3
Brazoria County	76,204	108,312	169,587	191,707	241,767	313,166	42.1	56.6	13.0	26.1	29.5	6.2
HGB CMSA	NA	2,181,316	3,118,481	3,732,919	4,669,571	NA	NA	43.0	19.7	25.1	NA	NA
State of Texas *(1,000s)*	9,579	11,196	14,229	16,986	20,852	25,146	16.9	27.1	19.4	22.8	20.6	3.3

Source: U.S. Census Bureau (1960, 1970, 1980, 1990b, 2000, 2010).
NA – Not Available
HGB CMSA Average Annual Growth Rate is for 1960–2000 due to lack of information found for this geography on the 2011 Census website.

In Table 3-4, projected population for the year 2040 is identified for the study area, using Traffic Analysis Zones (TAZs) that were provided by the H-GAC. Also, Exhibit 21 shows the 31 TAZs that overlap into the study area. Portions of some TAZs overlap into areas that are outside the project study area, so the projected population is likely an over-estimation of the true 2040 population. Based on the H-GAC's projections, the study area population is expected to reach 158,096 by 2040.

As shown in Table 3-5, Fort Bend County, the white population is the largest ethnic grouping, representing 36.2 percent of the population. In Brazoria County, the white is also the largest ethnic grouping representing 53.2 percent of the population. Fort Bend has almost double the black population than Brazoria County. The Hispanic population percentages in Fort Bend County and Brazoria County are similar, 23.7 and 27.7 percent, respectively. As shown in Table 3-6, per capita incomes range from $20,021 to $24,985, both greater than the Texas average of $19,617. Fort Bend County has a higher population density of 405.3 persons per square mile than Brazoria, which contains 174.4 per square mile.

Table 3-7 displays 1999 and 2010 population and housing characteristics for the study area. The data are based on U.S. Census Bureau enumerations for census tracts (CTs), which together provide a social and economic representation of area population. Exhibits 22 and 23, respectively, show the location of the study area in relation to the 2000 and 2010 CTs. The study area covers large portions of nine CTs with a combined 2010 population of 67,771 persons. In 2010, there were approximately 21,056 residential housing units within the study area's CTs. Median household incomes of study area CTs within Fort Bend County range from $57,021 to $117,853. The median household incomes of study area block groups within Brazoria County range from $55,550 to $68,882. The study area's average median household income for CTs within Fort Bend County and Brazoria counties is $81,839. This is consistent with the Fort Bend County's overall median income of $79,845 and greater than Brazoria County's median household income of $65,607. Additionally, all CTs in the study area display median household incomes that are greater than the Texas state average ($49,646).

3.3.2 Social/Community Resources

Sensitive social and community facilities (schools, churches, and cemeteries), parks, and recreation areas were identified through a compilation of existing mapping sources (USGS topographic maps, TxDOT county maps), aerial photography, field reconnaissance surveys, and information provided by local and state agencies. The resulting site location information was mapped and is shown in Exhibit 15 (see Section 3.3.2.4, Public Lands, for additional information on public parks and recreation areas located in the study area).

TABLE 3-3
POPULATION PROJECTIONS BY CITY, COUNTY, AND STATISTICAL AREA

	Actual	Projected			Percentage Change			
Place	**2000/2010+***	**2020**	**2030**	**2040**	**2000/2010–2020**	**2020–2030**	**2030–2040**	**2000/2010–2040+**
City of Richmond	13,493	14,212	17,257	20,334	5.3	21.4	17.8	50.7
City of Rosenberg	37,420	48,048	61,043	74,405	5.5	27.0	21.9	98.8
City of Sugar Land	83,819	101,422	105,000	105,000	28.4	3.5	0.0	25.3
Brazoria County	305,649	354,708	401,684	444,981	16.1	13.2	10.8	45.6
Fort Bend County	550,121	719,737	893,875	1.090,710	30.8	24.2	22.0	98.3
Houston CMSA	4,669,571	6,377,118	7,312,270	8,259,915	36.6	14.7	13.0	76.9
HGB CMSA**+**	4,715,407	6,443,005	7,400,720	8,398,069	36.6	14.9	13.5	78.1
State of Texas (*1,000s*)	25,388	29,650	33,712	37,734	16.8	13.7	11.9	48.6

Sources: U.S. Census Bureau (2010), Texas Water Development Board (TWDB, 2011a).
+2010 data is available and presented for all Places listed except for Houston CMSA and HGB CMSA; therefore, 2000 data is presented for Houston CMSA and HGB CMSA.
*TWDB was used as the primary source of data for this table; therefore, the estimated populations presented may differ from those estimate presented in Table 3-2 where U.S. Census Bureau was used as the primary source of data.

TABLE 3-4
STUDY AREA POPULATION PROJECTIONS BY TRAFFIC ANALYSIS ZONES (TAZ)

Fort Bend County		Brazoria County	
TAZ	Projected Population 2045	TAZ	Projected Population 2025
2134	14,192	1961	3,155
2135	7,811	1963	791
2255	7,247	1964	330
2256	6,875	1965	3,500
2257	5,864	1966	792
2258	23,527	1967	747
2265	6,044	1969	4,420
2266	11,051	1970	8,803
2267	946	1972	1,272
2274	15,879	1973	941
2275	5,624	1974	880
2308	2,711	1975	328
2311	5,785	1976	6,552
2314	5,919	1977	611
2315	1,870	1978	2,185
		1981	1,444
Subtotal	121,345		36,751
Study Area Total	158,096		

Source: H-GAC (2011).

TABLE 3-5
POPULATION ETHNICITY PROFILE FOR 2010

Place	Total Population	Number White	% White	Number Black	% Black	Number Hispanic	% Hispanic	Number Other	% Other
Fort Bend County	585,375	211,680	36.2	123,267	21.1	138,967	23.7	111,461	19.0
Brazoria County	313,166	166,674	53.2	36,880	11.8	86,643	27.7	22,969	7.3
Texas	25,145,561	11,397,345	45.3	2,886,825	11.5	9,460,921	37.6	1,400,470	5.6

Source: U.S. Census Bureau (2010).

TABLE 3-6
SOCIOECONOMIC PROFILE FOR 1999 AND 2010

Place	2010 Median Household Income ($)	2010 Per Capita Income ($)	Number of Housing Units	Persons Per Household+	Median Age	Population Density Persons per square mile+	% Below Poverty Level*	Limited English Population++
Fort Bend County	79,845	32,016	197,030	3.14	35.0	405.3	6.8	5.9
Brazoria County	65,607	27,529	118,336	2.82	35.1	174.4	9.4	4.5
Texas	49,646	24,870	9,977,436	2.74	33.6	79.6	14.1	8.4

Source: U.S. Census Bureau (2000, 2010).
* Percentage of people above 18 years of age.
+This U.S. Census information is not available for 2010; therefore, 2000 U.S. Census information is provided.
++Percentage of people above 5 years of age.

TABLE 3-7
DETAILED 1999 AND 2009 POPULATION CHARACTERISTICS BY STUDY AREA CENSUS TRACT**

Census Area	Population	Number of Housing Units	# White	% White	# Black	% Black	Hispanic Origin	% Hispanic	# Other	% Other	Per Capita Income ($)	Median Household Income ($)	% Below Poverty***	LEP[1] Population****
CT 6746* (CY 2000)	-		-	-	-		-	-						
BG 1	-	-	-	-	-	-	-	-						
BG 2	-	-	-	-	-	-	-	-						
CT 6746.01	3,762	1,429	2,739	72.8	252	6.7	304	8.1	467	12.4	62,863	115,417	0.5	0.1
BG 1	2,521	-	1,793	71.1	195	7.7	189	7.5	344	13.6				
BG 2	1,241	-	946	76.2	57	4.6	115	9.3	123	9.9				
CT 6746.02	7,641	2,543	5,021	65.7	717	9.4	980	12.8	923	12.1	45,255	117,853	1.5	1.0
BG 1	2,991	-	1,909	63.8	306	10.2	416	13.9	360	12.0				
CT 6746.03	5,999	2,060	3,045	50.8	877	14.6	1,707	28.5	370	6.2	27,149	71,529	8.3	3.1
BG 1	1,037	-	744	71.7	82	7.9	135	13.0	76	7.3				
BG 2	2,079	-	934	44.9	362	17.4	661	31.8	122	5.9				
BG 3	2,883	-	1,367	47.4	433	15.0	911	31.6	172	6.0				
CT 6746.04	4,607	1,415	1,118	24.3	1,529	33.2	901	19.6	1,059	23.0	35,761	98,285	7.0	1.5
BG 1	4,607	-	1,118	24.3	1,529	33.2	901	19.6	1,059	23.0				
CT 6747	11,165	3,551	3,555	31.8	2,978	26.7	2,213	19.8	2,419	21.7	28,473	81,691	7.3	4.9
BG 1	4,272	-	861	20.2	1,194	28.0	573	13.4	1,644	38.5				
BG 2	742	-	191	25.7	96	12.9	443	59.7	12	1.6				
BG 3	6,151		2,503	40.7	1,688	27.4	1,197	19.5	763	12.4				
CT 6755	11,151	3,874	4,027	36.1	2,215	19.9	3,986	35.7	923	8.3	31,198	70,321	7.2	3.3
BG 1	7,080	-	2,856	40.3	1,507	21.3	1,947	27.5	770	10.9				
BG 2	4,071	-	1,171	28.8	708	17.4	2,039	50.1	153	3.8				
CT 6756	5,808	2,152	3,920	67.5	89	1.5	1,697	29.2	102	1.8	25,307	57,021	6.2	2.9
BG 2	2,099	-	1,515	72.2	30	1.4	522	24.9	32	1.5				
CT 6618	5,385	1,866	2,896	53.8	341	6.3	1,489	27.7	659	12.2	26,579	68,882	11.4	8.1
BG 1	2,445	-	1,552	63.5	209	8.6	608	24.9	76	3.1				
BG 2	2,940	-	1,344	45.7	132	4.5	881	30.0	583	19.8				
CT 6619	12,253	2,166	4,380	35.7	3,483	28.4	4,106	33.5	284	2.3	10,485	55,550	12.8	3.5
BG 1	2,889	-	984	34.1	449	15.5	1,287	44.5	169	5.8				
BG 4	1,986	-	369	18.6	1,011	50.9	586	29.5	20	1.0				
Total/Avg for Census Tracts	67,771	21,056	30,701	48.7	12,481	16.3	17,383	23.9	7,206	11.1	32,563	81,839	6.9	3.2
Total/Avg for Block Groups	-	-	20,364	44.9	9,793	17.3	13,2220	27.7	6,134	10.2	-	-	-	

Source: U.S. Census Bureau (2000, 2010).

[1]LEP = Limited English Proficiency; CY = Census Year; BG = Block Group; CT = Census Tract

* Census Tract 6746 was subdivided into 4 subsets for 2010 data; however, the 2000 6746 Census Tract is included in the table so to present census data that was not available in 2010.

+ 2000 Data is presented because Census information was not available for 2010.

**CT 6747 BG3 did not exist in 2000 and was developed for the 2010 Census Data. Because poverty, income, and LEP Census Data are not available for 2010 BGs, this information is not presented above for the 2010 CT 6747 BG 3.

*** Percentage of people above 18 years of age.

****Percentage of people above 5 years of age.

3.3.2.1 Schools

Five independent school districts (ISD) exist within the study area, Lamar Consolidated Independent School District (CISD), Fort Bend, Angleton, Needville, and Alvin. Five schools exist within the study area, Reading Jr. High School, George Ranch High School, Susanna Dickinson Elementary, William Velasquez Elementary, and Manford-Williams Elementary School. The location of schools and school district boundaries are shown on Exhibits 15 and 16.

3.3.2.2 Churches and Cemeteries

The locations of churches and cemeteries in the study area are shown in Exhibit 15. In rural areas, local churches often serve as focal points for community interaction.

3.3.2.3 Parks and Recreation

A search of the Texas Parks and Wildlife Department (TPWD), Texas Outdoor Recreation Inventory database and field reconnaissance efforts revealed a number of parks and recreation areas in the study area. Parks and recreation areas range in size from small golf courses to large state parks and are owned and managed by a variety of entities including local development corporations, state and federal agencies, and private and nonprofit groups.

There are a number of parklands in the study area. Brazos Bend State Park covers 4,897 acres, with an eastern boundary of 3.2 miles fronting the Brazos River on the southeast border of Fort Bend County. This area was purchased by the state in 1976 and opened to the public in 1984. The George Observatory, owned and operated by the Houston Museum of Natural Science, is located here and houses a 36-inch telescope built primarily for public viewing and education. The George Ranch Historical Park, which is open to the public, is owned by the George Foundation (privately owned) and encompasses 500 acres. It is located within the 23,000-acre George Ranch. The Fort Bend Museum Association operates the outdoor living history exhibit on the park grounds.

Other recreation facilities in the area include a paintball course located just south of US 59 at Williams Way. There are a number of private recreational parks and trails within the planned communities of Greatwood, Riverpark, Canyon Gate, and Bridlewood.

The Lake Worthington Conservation Area, also within Fort Bend County, is a privately owned tract of land. The landowners have negotiated a conservation easement with the USFWS, which restricts development of the property. It is not open to the public.

No lands included in the National Park System or the National Trails System are located in the study area (National Park Service [NPS], 1999a). Additionally, no rivers classified as wild and scenic occur within the proposed Grand Parkway Segment C study area (NPS, 1999b).

3.3.2.4 Public Lands

In addition to small community parks, a few places are considered public lands. Included is the Brazos Bend State Park. Small parks located far from the alternative routes (discussed in Section 2) were not mapped, as the project is not anticipated to impact these areas.

Brazos Bend State Park, referred to in Section 3.3.2.3, is part of the state park system owned and managed by the TPWD. Prior to the state's purchase, most of the land was used for cattle grazing, pecan harvesting, and private hunting. Open to the public since 1984, the park has facilities for campers, a 21.6-mile hike/bike trail, group picnic pavilions, and a ½-mile wheelchair accessible nature trail. While most of the park is in the Brazos River floodplain, there are also areas of flat upland coastal prairies. In addition to the Brazos River, Big Creek runs diagonally through the park and creates, in combination with man-made levees, numerous lakes, sloughs and bayous (TPWD, 1999).

The George Observatory, dedicated in 1989, is owned and operated by the Houston Museum of Natural Science. Located in the Brazos Bend State Park because of the area's dark night skies and proximity to Houston, the observatory houses one of the largest telescopes consistently available for public viewing in the nation.

3.3.2.5 Institutional

The Darrington Unit is a large state-owned prison (6,770 acres) with large tracts of lands used for agricultural and farming operations (TDCJ, 2010).

3.3.3 Limited English Proficiency

Executive Order (EO) 13166, Improving Access to Services for Persons with Limited English Proficiency (LEP) required federal agencies to examine the services they provide and identify any need to services to those with LEP. The EO requires federal agencies to work to ensure that recipients of federal financial assistance provide meaningful access to their LEP applicants and beneficiaries. Failure to ensure that LEP persons can effectively participate in or benefit from federally assisted programs and activities may violate the prohibitions under Title VI of the Civil Rights Restoration Act of 1987 and Title VI regulations.

As indicated in Tables 3-6 and 3-7, the average percentage of population (5 years of age and older) within the study area CTs that is considered LEP is 3.2 percent, lower than Brazoria County (5.9 percent), Fort Bend County (4.5 percent), and the state (8.4 percent). CT 6618 has the greatest LEP population (8.1 percent) of the CTs; however, this is less than the state's average of 8.4 percent. During the public involvement process, as described in the Executive Summary, efforts, in accordance with policies at the time of involvement, were made to accommodate non-English speaking populations. Therefore, the requirements of EO 13166 have been satisfied.

3.4 ECONOMICS

3.4.1 Economic Conditions

Economic characteristics were examined for the greater HGB and more specifically for Brazoria and Fort Bend counties for a region-wide portrayal of the economic environment in which the proposed project is located. At a more local level, study area CTs were also examined. Nearby communities of Richmond, Rosenberg and Sugar Land are also profiled below.

3.4.1.1 Economic Characteristics of Area Population

The economic characteristics of the study area were derived from the 2010 Census where information was available; however, where 2010 information was not available, 2000 data was used. This is based on consistent availability of data for study area counties, municipalities, and CTs. Updates to the 2000 Census are currently not available for all of the study area municipalities and CTs; however, some updates (2005–2007 American Community Survey 3-Year Estimates) are available for study area counties and Metropolitan Statistical Areas (MSA) and have been updated accordingly.

Work Location

In the greater HGB CMSA, 81.6 percent of the working population is employed in the same county as their place of residence (Table 3-8). However, large numbers of Brazoria and Fort Bend County residents work outside their home counties. In Brazoria County, 59.7 percent work in the same county as their residence and 40.3 percent work in another county or outside the state. In Fort Bend County, more persons work outside their home county than within their home county. Among Fort Bend County residents, 36.6 percent work inside the county and 63.4 percent work outside Fort Bend County. For the two counties combined, 45.0 percent work inside their home counties and 54.4 percent work in other counties or outside the state.

For the nearby cities of Richmond and Rosenberg, 66.7 percent and 72.2 percent of workers, respectively, are employed in their home counties. In the City of Sugar Land, only 35.5 percent are employed inside Fort Bend County.

Table 3-8 shows comparable figures for the primary CTs within the study area, including tract 6619 in Brazoria County and tracts 6746, 6755, and 6756 in Fort Bend County. For these study area tracts, 48.4 percent work in their home counties, while 51.6 percent work outside their resident counties.

Median Travel Time to Work

Median travel time to work is consistent with the work location of area residents. As indicated in Table 3-8, for the HGB CMSA, median travel time to work is 28.8 minutes. Reflecting the suburban location of the study area, workers from that area have a longer commute to work, averaging 35.6 minutes daily. This is similar to travel time for Fort Bend County residents, of which almost two-thirds work outside of their home counties, and who have a median travel time of 32.3 minutes. Brazoria County residents, 59.7 percent of which are employed in their home counties, have a shorter travel time to work (28.0 minutes). The

TABLE 3-8
ECONOMIC CHARACTERISTICS OF REGIONAL AND STUDY AREA POPULATIONS 1999+

Characteristic	HGB CMSA		Brazoria County		Fort Bend County		Both Counties		City of Richmond		City of Rosenberg		City of Sugar Land		Study Area*	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Work Location																
Same County as Residence	1,698,933	81.6	62,594	59.7	59,932	36.6	122,526	45.0	2,942	66.7	7,398	72.2	10,836	35.5	5,555	48.4
Different County	368,206	17.7	41,346	39.4	102,513	62.7	143,859	53.6	1,455	33.0	2,844	27.8	19,391	63.6	5,836	50.9
Out of State	14,468	0.7	892	0.9	1,169	0.7	2061	0.8	11	0.2	4	0.1	283	0.9	84	0.7
Work At Home	51,644	2.5	2,264	2.2	4,731	2.9	6995	2.6	58	1.3	146	1.4	1,258	4.1	414	3.6
Median Travel Time to Work (Minutes)	28.8	NA	28.0	NA	32.3	NA	30.6	NA	26.7	NA	27.0	NA	29.6	NA	35.6	NA
Occupation																
Managerial & Professional	746,560	35.2	34,840	32.7	73,741	44.4	78,581	28.8	833	18.7	2,176	20.7	17,506	56.8	4,793	41.2
Tech., Sales, Adm. Supp.	289,480	13.6	13,661	12.8	16,534	9.9	30,195	11.1	1,070	24.0	2,109	20.1	2,288	7.4	1,494	12.9
Service	580,083	27.3	26,035	24.4	45,986	27.7	72,021	26.4	1,177	26.4	2,625	25.0	8,364	27.1	2,814	24.2
Farming, Forestry, Fishing	4,462	0.2	423	0.4	454	0.3	877	0.3	39	0.9	124	1.2	47	0.2	38	0.3
Precision Prod, Craft, Repair	235,483	11.1	15,755	14.8	12,559	7.6	28,314	10.4	743	16.6	1796	17.1	1072	3.5	1243	10.7
Operators, Fabricators, Laborers	265,547	12.5	15,948	15.0	14,792	8.9	30,740	11.3	602	13.5	1,672	15.9	1,532	5.0	1,239	10.7
Class of Workers																
Private for Profit	1,567,312	73.9	76,860	72.1	116,296	70.0	193,156	70.8	3,180	71.2	7,573	72.1	21,802	70.8	8,772	75.5
Private, Not for Profit	110,905	5.2	5,500	5.2	10,047	6.0	15,547	5.7	256	5.7	464	4.4	2,002	6.5	445	3.8
Local Government	130,583	6.2	7,785	7.3	11,458	6.9	19,243	7.1	324	7.3	924	8.8	1,858	6.0	854	7.3
State Government	89,550	4.2	6,102	5.7	8,178	4.9	14,280	5.2	340	7.6	496	4.7	1,135	3.7	786	6.8
Federal Government	38,003	1.8	1,712	1.6	3,107	1.9	4,819	1.8	23	0.5	61	0.6	321	1.0	129	1.1
Self-Employed	127,471	6.0	3,702	3.5	10,136	6.1	13,838	5.1	196	4.4	744	7.1	2,194	7.1	767	6.6
Unpaid Family Workers	5,494	0.3	308	0.3	484	0.3	792	0.3	6	0.1	12	0.1	124	0.4	24	0.2
Median Household Income 1999 ($)	44,761	NA	48,632	NA	63,831	NA	57,661	NA	34,888	NA	35,510	NA	81,767	NA	62,369	NA
Poverty Status	628,385	13.50	24,660	10.20	25,166	7.10	49,826	8.40	2,129	19.20	3,861	16.10	2,372	3.70	1,465	4.80

Source: U.S. Census Bureau (2000).
*Includes Brazoria County Tract 6619; Fort Bend County Tracts 6746, 6755, and 6756.
+2000 Census Bureau information was used because 2010 Census data is not yet available for this type of information.

same pattern is shown for the cities examined. Richmond and Rosenberg, with a relatively higher percentage of home-county workers, have median travel times of 26.7 and 27.0 minutes, respectively. In Sugar Land, where only 35.5 percent of residents work in their home county, the median travel time to work is 29.6 minutes.

Occupation

As compared with the HGB CMSA, the rest of the study area workers are more likely to be employed in technical/sales/administrative support and less likely to be employed as operators, fabricators, and laborers.

For the HGB CMSA, the greatest number of workers (35.2 percent) are employed in managerial and professional positions. This occupational category is followed by service occupations (27.3 percent) and technical, sales, and administration support occupations (13.6 percent). Operators, fabricators, and laborers account for 12.5 percent of workers, while precision production, craft, and repair professions account for 11.1 percent of workers.

In the study area CTs, the greatest number of workers (41.2 percent) are employed in managerial and professional positions. This occupational category is followed by service occupations (24.2 percent of workers) and technical, sales, and administrative support occupations (12.9 percent). Precision production, craft and repair professions, and operators, fabricators, and laborer occupations each employ 10.7 percent of the workforce. The two-county Brazoria/Fort Bend region reflects generally the same occupational characteristics as the more limited study area tracts, although Fort Bend County shows a slightly higher percentage of managerial professions (44.4 percent) and Brazoria County has a greater percentage of operators, fabricators and laborers and precision production, and craft occupations, at 15.0 and 14.8 percent, respectively.

Examining occupational distributions for area cities, Sugar Land is preponderantly oriented toward managerial and professional occupations (56.8 percent) and service occupations (27.1 percent). Compared with the study area tracts, Richmond and Rosenberg have a greater percentage of service workers and technical, sales, and administrative support workers.

Class of Worker

Private, for-profit enterprises employ 73.9 percent of HGB CMSA workers; this percentage is roughly the same for the two-county region, for the various cities in the area, and for the study area. Also, in the HGB CMSA, the two-county region, the cities in the area, and the study area, state and local governments employ an average of 12.5 percent of workers.

Median Household Income

In 1999, median household income for the HGB CMSA was $44,761. Median household incomes for Brazoria and Fort Bend counties were higher, at $48,632 and $63,831, respectively. Median household income for the combined two-county

area was $57,661, which is 28.8 percent higher than the HGB CMSA income. Study area median household income was 39.3 percent higher than for the HGB CMSA at $62,369.

In contrast, the area cities of Richmond and Rosenberg had median household incomes below that of the HGB CMSA, at $34,888 and $35,510, respectively. On the other hand, the City of Sugar Land has a median household income almost double that for the HGB CMSA at $81,767.

Poverty Status

The percent of residents with poverty-level income corresponds to the differences in household incomes. The study area has a very low percentage of poverty status persons (at 4.8 percent), when compared with the HGB CMSA (at 13.5 percent), and Brazoria and Fort Bend counties, at 10.2 and 7.1 percent, respectively. The cities of Richmond and Rosenberg have higher percentages of poverty status persons, at 19.2 and 16.1 percent, respectively. The City of Sugar Land has a smaller proportion of poverty status persons than the study area at 3.7 percent.

Summary

Compared with the population in the HGB CMSA, the study area population in 2000 had a greater tendency to work outside their home counties, and had longer commute times to work. In both the study area and the HGB CMSA, managerial and professional positions are the most dominant occupations for the workforce. However, the study area has a slightly greater proportion of workers (than the HGB CMSA) who are employed in these occupations. The study area workforce and that of the HGB CMSA are roughly equal in their tendency to be employed in service occupations, technical, sales, and administrative support occupations. The class of workers in the study area is similarly structured as in the HGB CMSA. In both cases, private, for-profit workers are the dominant grouping, with roughly two-thirds of all workers in this category. State and local government workers are the second greatest grouping in both cases, representing roughly 11 percent in both cases. The study area populations have relatively higher median incomes and lower levels of poverty than the population of the HGB CMSA.

3.4.1.2 Leading Economic Sectors

Regional

Table 3-9 provides an area economic profile regarding the leading economic sectors for the years 2000, 2002, 2004, 2006, and 2008. Since 2000, Brazoria County is experiencing growth within the information; finance and insurance; and real estate and rental and leasing as well as educational services; health care and social assistance; and accommodation and food services. Fort Bend County is experiencing growth in educational; heath care and social assistance; and accommodation and food services as well as finance and insurance; professional, scientific and technical; and administrative and support and waste management and remediation services. Within Brazoria County, finance and insurance services showed the most growth between 2000 and 2008, a 67.49 percent increase, with the addition of 567

TABLE 3-9
COUNTY ESTABLISHMENTS AND EMPLOYEES
BRAZORIA AND FORT BEND COUNTIES

County/Industry	Total Number of Establishments						Number of Employees					
	Year					2000–2008 % Change	Year					2000–2008 % Change
	2000	2002	2004	2006	2008		2000	2002	2004	2006	2008	
Brazoria County												
Forestry, Fishing & Agric. Support	10	8	10	7	6	-40.00	20-99	30	51	20-99	48	-
Mining	32	33	24	28	35	9.38	659	663	542	590	776	17.75
Utilities	28	29	20	18	14	-50.00	238	275	244	203	NA	-
Construction	382	371	381	396	403	5.50	9,515	11,685	10,174	12,397	13268	39.44
Manufacturing	224	221	212	216	220	-1.79	15,005	12,501	12,526	12,650	13369	-10.90
Wholesale Trade	215	207	197	206	211	-1.86	2,531	2,494	1,650	2,099	2243	-11.38
Retail Trade	652	683	683	683	764	17.18	9,089	9,603	10,783	11,502	12613	38.77
Transportation & Warehousing	123	132	137	147	163	32.52	1,453	1,411	2,230	2,230	2848	96.01
Information	46	54	63	66	67	45.65	549	586	558	559	1358	147.36
Finance and Insurance	203	215	241	282	340	67.49	1,413	1,401	1,664	1,858	1980	40.13
Real Estate, Rental & Leasing	173	208	231	241	267	54.34	1,314	1,517	1,543	1,618	1468	11.72
Professional, Sci, & Tech. Services	302	348	358	396	414	37.09	1,607	1,959	1,970	2,295	2246	39.76
Mgmt. of Companies & Enterprise	-	10	13	20	14	-	-	209	229	237	239	-
Admin, Support, Waste Mgt, Remediation Services	182	166	168	194	191	4.95	3,439	3,123	4,474	4,042	3361	-2.27
Educational Services	-	32	45	51	65	-	-	251	503	517	575	-
Health Care & Social Services	-	391	421	476	536	-	-	5,105	5,708	5,890	6914	-
Arts, Entertainment & Recreation	-	63	63	75	76	-	-	567	875	940	1013	-
Accommodation & Food Services	-	313	336	364	414	-	-	5,110	5,449	6,600	7642	-
Other Services	-	508	521	499	497	-	-	3,275	3,606	3,565	3897	-
Unclassified	53	26	17	16	7	-86.79	77	21	21	0-19	25	-67.53
Totals*	3,837	4,018	4,141	4,381	4,704	22.6	60,876	61,786	64,800	69,839	76,051	24.93

TABLE 3-9, CONT'D

County/Industry	Total Number of Establishments						Number of Employees					
	Year					2000–2008 % Change	Year					2000–2008 % Change
	2000	2002	2004	2006	2008		2000	2002	2004	2006	2008	
Fort Bend County												
Agric. Serv., Forestry & Fishing	10	13	8	6	9	-10.00	20-99	20-99	55	61	45	-
Mining	68	65	71	79	82	20.59	999	512	1,096	1,429	1827	82.88
Utilities	16	39	39	31	19	18.75	1,000–2,499	1,357	1,535	1,104	NA	-
Construction	473	509	565	608	677	43.13	5,237	6,140	6,252	7,156	7583	44.80
Manufacturing	313	301	317	321	330	5.43	11,542	10,916	10,451	11,980	12997	12.61
Wholesale Trade	458	503	512	568	609	32.97	4,285	4,873	5,367	5,491	6091	42.15
Retail Trade	1,008	1,059	1,087	1,098	1224	21.43	14,781	15,722	16,517	17,820	20315	37.44
Transportation & Warehousing	87	83	92	117	136	56.32	479	497	1,807	1,999	2515	425.05
Information	95	99	113	110	100	5.26	2,156	1,798	1,419	1,290	1189	-44.85
Finance and Insurance	359	431	456	560	623	73.54	2,061	2,603	3,144	3,460	3985	93.35
Real Estate, Rental & Leasing	256	290	335	368	397	55.08	1,312	1,406	1,384	1,597	1577	20.20
Professional, Sci, & Tech. Services	742	931	988	1,067	1220	64.42	6,008	6,621	6,620	7,719	6186	2.96
Mgmt. of Companies & Enterprise	-	40	35	54	49	-	-	3,082	4,142	3,316	3293	-
Admin, Support, Waste Mgt, Remediation Services	306	323	360	423	491	60.46	3,656	3,934	4,551	6,087	7544	106.35
Educational Services	69	83	103	118	132	91.30	745	988	1,080	1,184	1381	85.37
Health Care & Social Services	568	672	759	897	1069	88.20	6,646	7,208	8,735	10,695	11741	76.66
Arts, Entertainment & Recreation	64	73	76	78	97	51.56	1,771	1,599	1,713	2,441	2485	40.32
Accommodation & Food Services	396	444	522	595	696	75.76	7,814	8,263	9,873	12,019	13891	77.77
Other Services	570	617	623	662	710	24.56	4,782	4,941	4,869	5,169	5706	19.32
Unclassified	109	33	44	30	25	-77.06	175	0-19	39	18	NA	-
Totals*	6,008	6,615	7,105	7,790	8,695	44.72	78,648	82,953	90,649	102,035	112,606	43.18

Source: U.S. Census Bureau (2011).
*Some information withheld to avoid disclosing data for individual companies
Note: NA is Not Available
Note: 2010 data is not yet available for the information provided in this table; therefore, 2008 data is the last year provided.

establishments (40.1 percent increase). Real estate and rental and leasing services grew by 53.3 percent. There was a 50.0 percent decrease in utilities and a 40 percent decrease in agriculture, forestry, fishing, and hunting. Manufacturing and construction had the highest number of employees in 2000 and maintain the highest number of employees in 2008 with 13,369 and 13,268, respectively, in 2008. Within Fort Bend County, educational services and health care and social assistance showed the most growth 91.3 and 88.2 percent, respectively. Accommodation and food services as well as finance and insurance services also showed growth with 78.7 and 73.5 percent, respectively. Retail trade and Manufacturing services had the highest number of employees in 2000 and maintained the highest number of employees in 2008 with 20,315 and 12,997, respectively. There was a 10 percent reduction in agriculture, forestry, fishing and hunting in Fort Bend County. Also, the number of employees in field of information services decreased by 44.9 percent.

Construction sector activity is further illustrated in Table 3-10 and shows the number of housing units permitted from 1996 to 2008. During that period of time, over almost 45,000 new housing units were permitted in Brazoria and Fort Bend counties. Of those, 19,611 were permitted in the Brazoria County, and 25,341 were permitted in Fort Bend County.

Study Area

In the study area, the major businesses appear to be community retail and services, based on a windshield survey. Residential construction has also been heavy in the northernmost portion of the study area.

3.4.1.3 Labor Force and Employment

Table 3-11 contains data for the decade on the region's labor force estimates, employment, and unemployment rates, as compared with the same figures for the entire state.

The Houston metropolitan area constitutes a considerable portion of the state's labor force, with over 20 percent of all workers in the state. Generally, trends in the Houston area are reflected in statewide employment and labor force statistics.

The metropolitan labor force increased between 2000 and 2010 by 576,444 workers, or 27.8 percent. Unemployment has increased from 4.1 percent in 2000 to 8.5 percent in 2010. These figures are comparable to activity throughout the state, where unemployment in 2000 was 4.2 percent and 8.2 percent in 2010. Unemployment in the metropolitan area is slightly higher than statewide unemployment.

Of the two counties in the study area, Fort Bend County's labor force grew at a slightly more accelerated pace than Brazoria County, 48.9 percent compared to 40.1 percent, respectively, over the 2000–2010 period. The two area cities experienced increases in labor force; however, the City of Rosenberg's labor force only increase slightly by 0.9 percent, while the City of Sugar Land's labor force increased by 98.6 percent. There were also differences between area counties in terms of unemployment rates. Brazoria County has generally tended to have higher unemployment rates than the Houston metropolitan area, while Fort Bend County has experienced lower rates than the region as a whole. The 2010

TABLE 3-10
NEW PRIVATELY OWNED HOUSING UNITS
STUDY AREA COUNTIES
2000–2010

	Units							
Units per Structure	**2000**	**2002**	**2004**	**2006**	**2008**	**2010**	**2000–2010 New Structures (Number)**	**2010 % of Total within County**
Brazoria County								
1 Unit	1,903	2,738	3,288	3,287	1,977	1,647	14,840	99.5
2 Units	2	0	0	4	0	0	6	0.0
3 and 4 Units	0	0	28	0	0	0	28	0.0
5 Units and More	180	343	1,051	298	150	9	2,031	0.5
Total Units	2,085	3,081	4,367	3,589	2,127	1,656	16,905	
Fort Bend County								
1 Unit	1,063	1,130	3,858	7,910	5,689	4,724	23,374	99.7
2 Units	0	0	2	2	6	0	10	0.0
3 and 4 Units	0	0	0	155	0	0	155	0.0
5 Units and More	250	0	292	729	192	16	1,479	0.13
Total Units	1,313	1,130	4,152	8,796	5,887	4,740	26,018	
Total for Both Counties	3,398	4,211	8,519	12,385	8,014	12,792	49,319	

Source: U.S. Census Bureau (2010).

TABLE 3-11
REGIONAL CIVILIAN LABOR FORCE AND EMPLOYMENT ESTIMATES
ANNUAL AVERAGE, 2000–2010

Factor Area	Year											2000–2010 Change	
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Number	%
Civilian Labor Force													
Texas	10,324,527	10,462,712	10,803,187	10,964,756	11,051,912	11,170,574	11,348,147	11,474,987	11,701,585	11,906549	12,136,384	1,811,857	17.6
Houston-Sugar Land-Baytown MSA	2,163,502	2,201,442	2,519,885	2,557,767	2,577,349	2,613,896	2,674,420	2,723,348	2,781,315	2,840,477	2,895,737	732,235	33.8
Brazoria County	106,312	106,660	127,036	129,859	131,993	134,096	134,940	138,430	141,773	146,087	148,943	42,631	40.1
Fort Bend County	189,472	192,818	206,947	217,182	225,687	235,978	244,977	253,919	259,044	276,683	282,100	92,628	48.9
Both Counties	295,784	299,478	333,983	347,041	357,680	370,074	379,917	392,349	400,817	422,770	431,043	135,259	45.7
City of Rosenberg	15,973	16,262	NA	NA	NA	14,350	14,719	15,297	15,639	15,761	16,113	140	0.9
City of Sugar Land	21,306	21,674	NA	NA	NA	39,650	40,869	40,937	41,627	41,487	42,302	20,996	98.6
Employment													
Texas	9,887,039	9,955,270	10,115,299	10,228,640	10,385,318	10,568,414	10,787,397	10,972,152	11,126,436	11,006,179	11,141,903	1,254,864	12.7
Houston-Sugar Land-Baytown MSA	2,074,164	2,107,065	2,367,554	2,385,219	2,417,074	2,468,010	2,540,012	2,606,101	2,646,966	2,625,636	2,650,608	576,444	27.8
Brazoria County	99,685	100,336	118,938	120,353	122,839	126,408	128,157	132,264	134,338	134,282	135,559	35,874	36.0
Fort Bend County	183,995	186,914	196,216	203,879	213,190	223,641	233,293	243,532	247,350	256,987	259,430	75,435	41.0
Both Counties	283,680	287,250	315,154	333,543	336,029	350,049	361,450	375,796	381,688	391,269	394,989	111,309	39.2
City of Rosenberg	15,391	15,635	NA	NA	NA	13,630	14,039	14,689	14,919	14,634	14,773	-618	-4.0
City of Sugar Land	20,797	21,126	NA	NA	NA	37,924	39,253	39,530	40,149	39,220	39,593	18,796	90.4
Unemployment Rate (Percent)													
Texas	4.2	4.9	6.4	6.7	6.0	5.4	4.9	4.4	4.9	7.6	8.2	NA	NA
Houston MSA	4.1	4.3	6.0	6.7	6.2	5.6	5.0	4.3	4.8	7.6	8.5	NA	NA
Brazoria County	6.2	5.9	6.4	7.3	6.9	5.7	5.0	4.5	5.2	8.1	9.0	NA	NA
Fort Bend County	2.9	3.1	5.2	6.1	5.5	5.2	4.8	4.1	4.5	7.1	8.0	NA	NA
Both Counties	9	9	5.6	5.4	6.1	5.4	4.9	4.2	4.8			NA	NA
City of Rosenberg	3.6	3.9	NA	NA	NA	5.0	4.6	4.0	4.6	7.2	8.3	NA	NA
City of Sugar Land	2.4	2.5	NA	NA	NA	4.4	0.0	3.4	3.6	5.5	6.4	NA	NA

Source: Texas Workforce Commission (2011).

Note: Data for City of Richmond was unavailable for years 2000–2010.

unemployment rate for Brazoria County was 9.0 percent, while Fort Bend's unemployment rate was 8.0 percent. There is considerable variation among area cities as well; in 2010, unemployment for Rosenberg and Sugar Land was 8.3 and 6.4 percent, respectively.

3.4.1.4 Personal Income

Personal income for the region and the state are shown in Table 3-12. Personal income in the metropolitan area has consistently been approximately 15–25 percent higher than that of the state as a whole. Brazoria County's per capita income has stayed fairly consistent with the state since 1970. Fort Bend County's per capita income has exceeded the state since 1980. Brazoria County has had lower per capita income that the metropolitan area since 2007; however, Fort Bend County has had per capita incomes greater than metropolitan area since 1980.

TABLE 3-12
PERSONAL INCOME IN STUDY AREA REGION

Factor/Location	1970	1980	1990	2000	2009/2010*
Total Personal Income ($000)					
Texas	40,819,997	141,658,500	297,146,169	593,139,424	952,338,721
HSBMSA	9,236,168	38,910,447	77,166,397	161,397,579	273,246,563
Brazoria County	406,011	1,842,833	3,341,252	6,573,637	11,602,475
Fort Bend County	167,984	1,634,128	4,506,056	12,088,185	25,503,482
Population Estimates					
Texas	11,236,772	14,338,208	17,044,605	20,946,049	25,257,114
HSBMSA	2,213,853	3,184,357	3,792,007	4,739,625	5,867,489
Brazoria County	108,854	170,849	192,581	243,140	309,208
Fort Bend County	52,894	133,267	228,359	358,758	556,870
Per Capita Personal Income ($)					
Texas	3,633	9,880	17,421	28,317	37,706
HSBMSA	4,172	12,219	20,350	34,053	46,570
Brazoria County	3,730	10,786	17,344	27,038	37,523
Fort Bend County	3,176	12,262	19,747	33,695	45,798
Per Capita Personal Income as Percent of National Average					
Texas	100.00	100.00	100.00	100.00	94.0
HSBMSA	113.90	123.67	116.81	120.26	117.0
Brazoria County	102.67	109.17	99.56	95.48	97
Fort Bend County	87.42	124.11	113.35	118.99	116

Source: U.S. Department of Commerce, Bureau of Economic Analysis (2011).
*Houston-Sugar Land-Baytown Metropolitan Statistical Area (HSBMSA), Brazoria and Fort Bend County data was not available for 2010; therefore, 2009 data is presented.

3.4.1.5 Financial Conditions

Table 3-13 shows tax rate information for the major governmental bodies in the vicinity of the study area. Neither the Brazoria County Central Appraisal District nor the Fort Bend County Central Appraisal District had maps to indicate all the taxing entities within the study area, but the major entities were identified from examination of a sample of property tax

records in the area. In addition to current taxing entities, it is possible that nearby entities, such as the City of Sugar Land and the City of Richmond, may be affected by the proposed project as these cities experience expansion in the vicinity of the roadway.

3.5 PEDESTRIANS AND BICYCLISTS

A Regional Bicycle Plan was approved by the H-GAC in April 1996 and revisions and updates have been made since that time. Some of the updates and revisions were made as part of the 2002–2004 Transportation Improvement Program (TIP), in the 2006–2008 TIP, 2011–2014 TIP and H-GAC's 2035 RTP Update. No existing or proposed bike facilities fall within the study area.

TABLE 3-13
TAX RATE FOR MAJOR TAXING JURISDICTIONS IN STUDY AREA REGION

Jurisdiction	2010 Tax Rate ($)
Brazoria County	
Brazoria County	0.40
Brazoria Co. Road & Bridge	0.06
Alvin ISD	1.30
Alvin Community College	0.20
Iowa Colony Drainage District	0.19
Fort Bend County	
Fort Bend County	0.48
Fort Bend Drainage District	0.02
City of Richmond	0.79
City of Rosenberg	0.50
City of Sugar Land	0.30
Fort Bend ISD	1.34
Lamar CISD	1.36
Needville ISD	1.52
Wharton County Jr. College	0.14

Source: Brazoria County Appraisal District (2011); Fort Bend County Appraisal District (2011).

3.6 AIR QUALITY

Air pollution may contribute to adverse human health effects and ecosystem degradation. Motor vehicles, industries, construction equipment, and some commercial operations are among the sources of air pollution in the Houston area. The main air pollutants emitted from motor vehicles are volatile organic compounds (VOCs), nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide, particulate matter (PM), and a class of compounds called mobile source air toxics (MSATs). VOCs and NO_x can react in the air in sunlight to form ground-level O_3. Because the reactions take place over several hours, maximum concentrations of O_3 are often far downwind of the precursor sources. Thus, O_3 is a regional problem and not a local condition.

3.6.1 National Ambient Air Quality Standards

The U.S. Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) for seven air pollutants to protect public health and the environment, with an adequate margin of safety. NAAQS exist for the seven pollutants: CO, O_3, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), PM for both 10 and 2.5 microns and less (PM_{10} and $PM_{2.5}$), and lead (Pb). The Clean Air Act Amendments (CAAA) of 1990 establishes specific milestones toward attaining the NAAQS, depending on the severity of the air pollution problem in the region.

VOCs in motor vehicle emissions are created by incomplete combustion. Some of these VOCs contribute to O_3 and smog formation, while others, such as benzene and formaldehyde, are toxic or carcinogenic. Trucks and older cars emit much more VOCs than newer cars.

NO_x is created inside the combustion chambers of motor vehicles when, under high heat and pressure, nitrogen molecules in air are split into reactive nitrogen atoms, which then combine with oxygen. NO_x also reacts with oxygen and organic compounds in the atmosphere to form O_3 and smog. Motor vehicles produce the least emissions of NO_x per mile between 20 and 30 miles per hour (mph). NO_x emissions per mile increase as vehicles go slower or faster, so simply increasing or decreasing average traffic speed can increase NO_x emissions.

CO is a very reactive gas that can cause asphyxiation. Because of its high reactivity, it does not persist in the air long after it is emitted, and therefore, CO is a local problem where it occurs. Current CO emissions are estimated for 2017 (the year construction is estimated to be completed) and 2035 (the horizon year for project planning) for this project with a computer model that is approved by the FHWA as discussed in Section 4.6.2. Estimated CO levels along SH 99 are below the national standard.

PM consists of tiny particles that are emitted by vehicle engines (especially the diesel engines of trucks), brake pads, tires, and other moving parts of motor vehicles. These particles contribute to smog and haze, and are dangerous to human health, especially to people with respiratory conditions. The EPA provides health criteria for particles smaller than 10 microns (about one-seventh the width of a human hair) and for particles smaller than 2.5 microns.

The NAAQS for the seven pollutants are listed in Table 3-14. The EPA delegated authority for monitoring and enforcing air quality regulations in Texas to the Texas Commission on Environmental Quality (TCEQ) Office of Air Quality. The TCEQ may adopt other, more stringent, air quality standards than those of the EPA; however, the TCEQ observes the same air quality standards as the EPA.

Motor vehicles are the primary source of air pollution emissions associated with the proposed project. The impact of such emissions varies with the region's total CO emissions from motor vehicles, weather conditions, and topography of the region. In addition to CO, motor vehicles also produce VOCs and NO_X, which can react under certain conditions to form O_3. Determining the cause of O_3 through modeling requires long-term meteorological data and detailed area-wide emission rates for all potential sources (industry, business, and transportation).

TABLE 3-14
NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Primary Standard (Public Health)		Secondary Standard (Public Welfare)	
	Level	Averaging Times	Level	Averaging Times
Nitrogen Dioxide	100 ppb	1-hour(1)	No secondary standard	
	53 ppb	Annual (Arithmetic Mean)(2)	Same as primary standard	
Carbon Monoxide	35 ppm	1-hour(3)	No secondary standard	
	9 ppm	8-hour(3)		
Particulate Matter 10 microns or smaller (PM_{10})	150 µg/m^3	24-hour(4)	Same as Primary Standard	
Particular Matter 2.5 microns or smaller ($PM_{2.5}$)	15 µg/m^3	Annual (Arithmetic Mean)(5)	Same as Primary Standard	
	35 µg/m^3	24-hour(6)	Same as Primary Standard	
Ozone	0.075 ppm (2008 Std)	8-hour(7)	Same as Primary Standard	
	0.08 ppm (1997 Std)	8-hour(8)		
	0.12 ppm	1-hour(9)		
Sulfur Dioxide	75 ppb	1-hour(10)	0.5 ppm	3-hour(3)
Lead	0.15 µg/m^3	Rolling 3-Month Average(11)	Same as primary standard	

Source: 40 CFR 50.

ppb = parts per billion ppm = parts per million; µg/m^3 = micrograms per cubic meter

(1) The 1-hour primary standard is met when the 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentration is less than or equal to 100 ppb.

(2) The annual primary standard is met when the annual average concentration in a calendar year is less than or equal to 53 ppb.

(3) Not to be exceeded more than once per calendar year.

(4) Not to be exceeded more than once per year on average over 3 years.

(5) To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.

(6) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).

(7) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).

(8) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

(9) (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1; (b) As of June 15, 2005, the EPA revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonattainment Early Action Compact Areas. On April 15, 2009, the EPA revoked the 1-hour ozone standard in the remaining Early Action Compact areas.

(10) The 1-hour primary standard is met at an ambient air quality monitoring site when the 3-year average of the annual (99th percentile) of the daily maximum 1-hour average concentrations is less than or equal to 75 ppb. Final rule signed June 2, 2010. The 1971 annual and 24-hour SO2 standards were revoked in that same rulemaking. However, these standards remain in effect until 1 year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

(11) Not to be exceeded in a calendar quarter. Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m^3 as a quarterly average) remains in effect until 1 year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

The EPA designates the status of a county's ambient air with respect to compliance to the NAAQS. The designations are as follows:

- Attainment – meets or is better than requirements
- Nonattainment – did not meet requirements
- Unclassifiable – cannot be classified

This proposed project is located within Brazoria and Fort Bend counties that are part of the HGB and have been designated by the EPA as a "severe" nonattainment area for O_3; therefore, the transportation conformity rule does apply.

The EPA regulations require that a nonattainment area demonstrate that its RTP and TIP conform to the intent of the State Implementation Plan (SIP) to attain the 8-hour O_3 standard by the year 2019. Under the regulations, added capacity projects may advance to construction only if they are part of the RTP and TIP, which has been determined to conform to the SIP. The proposed SH 99 Segment C is included in the H-GAC 2035 RTP Update, approved on January 25, 2011, and Fiscal Year (FY) 2011–2014 TIP, as amended and proposed by H-GAC. The RTP and TIP were found to conform to the SIP on July 21, 2010.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP Update (such as traffic volumes, population, employment, number of households, and vehicle miles traveled [VMT]) have been evaluated to determine whether any additional analysis is warranted before the FHWA takes final environmental action. This evaluation confirmed that the changes in the modeled parameters were minor, and therefore, no additional analysis is warranted. The analysis of 2025–2035 RTP Update modeled parameters can be found in the Administrative Record.

Existing background CO concentrations, attributable to emissions in the general community and to CO transported into that community, for the vicinity of the project area are estimated to be 4.5 and 2.8 parts per million (ppm) for the existing one-hour and eight-hour concentrations, respectively. These estimated background CO concentrations were obtained from TxDOT's 2006 *Air Quality Guidelines*. TCEQ has several Continuous Air Monitoring Stations (CAMS) located throughout the state that monitor air quality in Texas. These sites measure different parameters such as, but not limited to, CO, NO_x, NO_2, and O_3. The closest stations to the project area that measure CO are CAMS C35 and C403, which are located on Durant Street in Deer Park and Clinton Drive in Houston, respectively. For the month of December 2009, these stations measured an average 0.20 and 0.30 ppm, respectively, for existing 1-hour CO concentrations, which are below the NAAQS and the 4.5 ppm for 1-hour background concentrations obtained from TxDOT's 2006 *Air Quality Guidelines*.

3.6.2 Air Toxics

3.6.2.1 Introduction

Controlling air toxic emissions became a national priority with the passage of the CAAA, whereby Congress mandated that the EPA regulate 188 air toxics, also known as hazardous air pollutants (HAPs). The EPA has assessed this expansive list in their latest rule on the Control of Hazardous Air Pollutants from Mobile Sources (*Federal Register* [FR], Vol. 72, No. 37, page 8430, February 26, 2007) and identified a group of 93 compounds emitted from mobile sources that are listed in their Integrated Risk Information System (IRIS) (http://www.epa.gov/ncea/iris/index.html). In addition, EPA identified seven compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers from their 1999 National Air Toxics Assessment (http://www.epa.gov/ttn/atw/nata1999/). These are:

- *acrolein,*
- *benzene,*
- *1,3-butadiene,*
- *diesel particulate matter plus diesel exhaust organic gases (diesel PM),*
- *formaldehyde,*
- *naphthalene,*
- *and polycyclic organic matter*.

While FHWA considers these the priority MSATs, the list is subject to change and may be adjusted in consideration of future EPA rules. Air toxics analysis is a continuing area of research. While much work has been done to assess the overall health risk of air toxics, many questions remain unanswered. In particular, the tools and techniques for assessing project-specific health outcomes as a result of lifetime MSATs exposure remain limited. These limitations impede the ability to evaluate how the potential health risks posed by MSAT exposure should be factored into project-level decision-making within the context of NEPA.

Nonetheless, air toxics concerns continue to be raised on highway projects during the NEPA process. Even as the science emerges, we are duly expected by the public and other agencies to address MSAT impacts in our environmental documents. The FHWA, EPA, the Health Effects Institute, and others have funded and conducted research studies to try to more clearly define potential risks from MSAT emissions associated with highway projects. The FHWA will continue to monitor the developing research in this emerging field.

3.6.2.2 Health Effects of Air Toxics

In FHWA's view, information is incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with a proposed set of highway alternatives. The outcome of such an assessment, adverse or not, would be influenced more by the uncertainty introduced into the process through assumption and

speculation rather than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action.

The EPA is responsible for protecting the public health and welfare from any known or anticipated effect of an air pollutant. They are the lead authority for administering the CAAA and have specific statutory obligations with respect to HAPs and MSAT. The EPA is in the continual process of assessing human health effects, exposures, and risks posed by air pollutants. They maintain IRIS, which is "a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects" (EPA, http://www.epa.gov/ncea/iris/index.html). Each report contains assessments of noncancerous and cancerous effects for individual compounds and quantitative estimates of risk levels from lifetime oral and inhalation exposures with uncertainty spanning perhaps an order of magnitude.

Because of the limitations in the methodologies for forecasting health impacts described, any predicted difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with predicting the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against project benefits, such as reducing traffic congestion, accident rates, and fatalities plus improved access for emergency response, which are better suited for quantitative analysis.

3.6.2.3 Monitored Levels of MSATs

The TCEQ and other local entities operate air quality monitors for the criteria pollutants and air toxics. This network of monitors measures the air quality and determines the levels of the various pollutants in the air. However, not all monitors measure for all criteria pollutants and air toxics. The closest air quality monitors to Segment C are 9 miles (CAMS 84), 13 miles (CAMS 410), and 15 miles (CAMS 409) away as shown in Table 3-15. The official data from these monitors are found on the EPA's maintained web site (www.epa.gov/air/data). Not all monitors sample for the same pollutants. Of the monitors in the vicinity of Segment C, only the air toxics 1,3-butadiene and benzene are reported for the more distant monitor locations in Texas City (CAMS 100 and 1022).

Figure 3-1 illustrates a 10-year trend (1998-2008) of 1,3-butadiene and benzene mean concentrations (parts per billion or ppb) at the Texas City monitor locations. The results indicate a general downward trend in emission concentrations at these locations. There are currently no NAAQS established for any of the priority MSATs. Thus, the monitored values cannot be compared to any specific standards at this time.

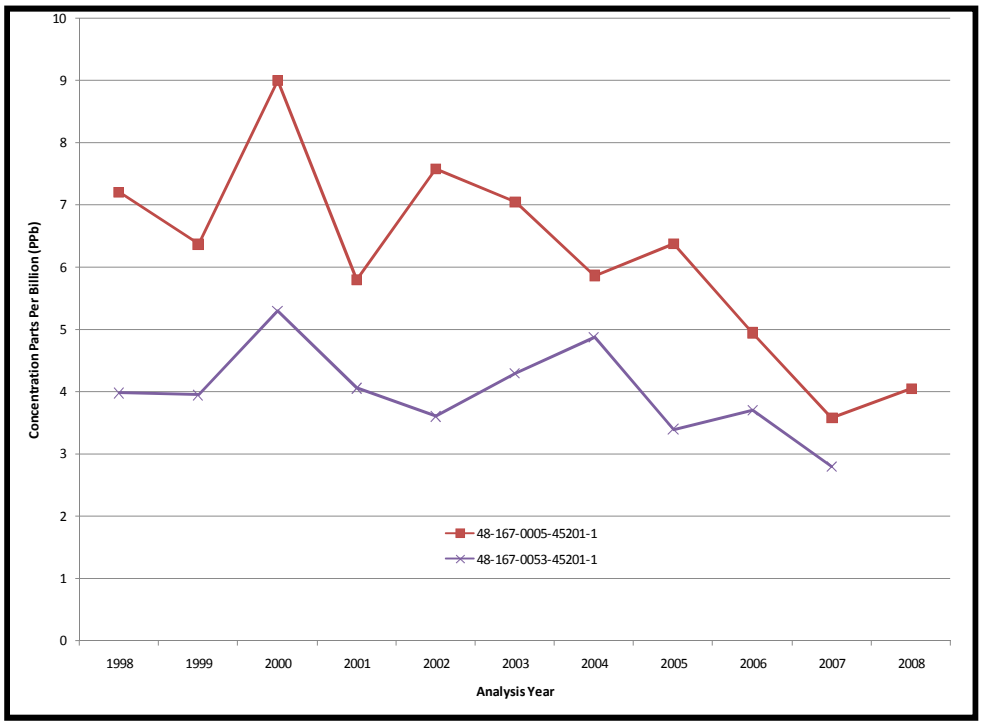
TABLE 3-15
MONITOR LOCATIONS IN THE VICINITY OF SEGMENT C

EPA Monitor ID (TCEQ ID)	Location	Distance from Preferred Alternative	MSATs Monitored
48-039-1004 (CAMS 84)	Brazoria County, Manvel	9 miles	N/A
48-167-0053 (CAMS 100)	Galveston County, Texas City	30 miles	1,3-Butadiene, Benzene
48-201-0051 (CAMS 409)	Harris County, Houston	15 miles	N/A
48-201-0066 (CAMS 410)	Harris County, Houston	13 miles	N/A
48-167-0005 (CAMS 1022)	Galveston County, Texas City	30 miles	1,3-Butadiene, Benzene

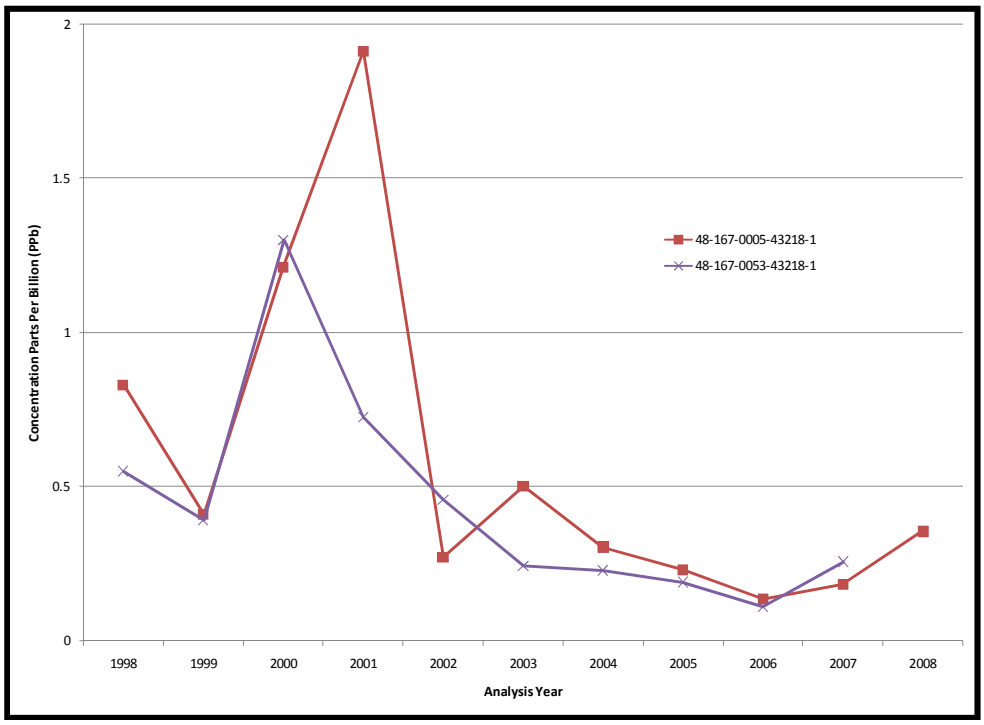
Source: EPA AirData; Study Team (2011).

Readers are cautioned not to infer a qualitative ranking order of geographic areas based on EPA AirData reports. Air pollution levels measured near a particular monitoring site may not be representative of the prevailing air quality of a county or urban area. Pollutants emitted from a particular source may have little impact on the immediate geographic area, and the amount of pollutants emitted does not indicate whether the source is complying with applicable regulations.

Figure 3-1
EPA Monitored Values for Air Toxics in Vicinity of Segment C
(Benzene)



(1,3-Butadiene)



Source: EPA AirData: www.epa.gov/air/data annual mean concentrations in ppb; Study Team (2011).

3.7 EXISTING NOISE ENVIRONMENT

3.7.1 Characteristics of Noise

Sound from highway traffic is generated primarily from a vehicle's tires, engine, and exhaust. It is commonly measured in decibels and is expressed as "dB."

Sound occurs over a wide range of frequencies. However, not all frequencies are detectable by the human ear; therefore, an adjustment is made to the high and low frequencies to approximate the way an average person hears traffic sounds. This adjustment is called A-weighting and is expressed as decibels (dB(A)). Also, because traffic sound levels are never constant due to the changing number, type, and speed of vehicles, a single value is used to represent the average or equivalent sound level and is expressed as "L_{eq}." Table 3-16 compares some common sounds and noise levels for indoor and outdoor situations.

TABLE 3-16
COMMON SOUND NOISE LEVELS

OUTDOOR	dB(A)	INDOOR
Air horn	110	Rock/blues band
Jet flyover at 1,000 feet		Baby crying
Leaf Blower	100	Subway
Gas Weed Eater		Fire alarms
Riding lawn mower	90	Blender
Gas edger		Crowded restaurant
Police whistle	80	Disposal at 3 feet
Air conditioner compressor		Shouting at 3 feet
	70	
		Normal conversation at 3–5 feet
Normal conversation at 3 feet	60	Clothes dryer at 3 feet
Babbling brook		Large business office
Quiet urban (daytime)	50	Refrigerator
Quiet urban (nighttime)	40	Quiet Office, Library
Wilderness	30	
	20	Recording studio
	10	Threshold of hearing

Source: TxDOT (2010).

3.7.2 Existing Noise Levels

Existing noise levels were measured at 14 sites (sites 1–14) within the proposed Grand Parkway Segment C study area in November 2010 and January 2012 using a Bruel & Kjaer 2238D sound level meter. A summary of the ambient noise measurement sites and results is presented in Table 3-17, and the locations are shown on (Exhibit 24). Short-term (15 minutes in duration) noise measurements were made at each of these sites.

TABLE 3-17
AMBIENT NOISE MEASUREMENT DATA
PROPOSED GRAND PARKWAY SEGMENT C

Site	Location	Description	Noise Level (dB(A), L_{eq})
1.	Greatwood Subdivision (near US 59), Fort Bend County	Single-family Residence	68.5
2.	Canyon Gate Subdivision, Fort Bend County	Single-family Residence	57.3
3.	The Retreat Subdivision (south of SH 59), Fort Bend County	Single-family Residence	50.2
4.	Brazos Gardens Subdivision, Fort Bend County	Single-family Residence	56.1
5.	Bridlewood Estates (at west end of Grande Gables Drive)	Single-family Residence	50.8
6.	Bridlewood Estates (at Crabb River Road), Fort Bend County	Single-family Residence	63.0
7.	Bonbrook Subdivision, Fort Bend County	Single-family Residence	47.2
8.	Windham Banks Subdivision, Fort Bend County	Single-family Residence	55.9
9.	FM 762 (west of Oak Lake Village Drive), Fort Bend County	Single-family Residence	68.9
10.	West Brazos Bend, Fort Bend County	Single-family Residence	37.8
11.	Sawmill Road (west of Big Creek), Fort Bend County	Single-family Residence	37.0
12.	CR 53 (east of FM 521), Brazoria County	Single-family Residence	40.8
13.	CR 55/Airline (west of SH 288), Brazoria County	Single-family Residence	44.3
14.	CR 60 (west of SH 288), Brazoria County	Single-family Residence	52.2

Dominant noise sources within the proposed Grand Parkway Segment C study area included traffic on existing roads, various kinds of local activity, and sounds created by animals. Measured noise levels varied from a high L_{eq} of 68.9 dB(A) at Site No. 9, at FM 762 west of Oak Lake Village Drive, to a low L_{eq} of 37.0 dB(A) at Site No. 11, located near Sawmill Road. These measured noise levels characterize the existing (ambient) noise levels within the proposed Grand Parkway Segment C study area and include representative peak-hour traffic conditions in urban areas as well as rural isolated traffic conditions.

In Section 4, Environmental Consequences, predictions of traffic-generated noise using forecasted peak hour traffic volumes are compared with ambient noise levels to assess preliminary impacts resulting from the eight Representative Alternatives. The detailed analysis of the Preferred Alternative is also discussed in Section 4.

3.8 WATER QUALITY

3.8.1 Surface Water Quality

The watersheds within the region of influence of the project are located in the Brazos River Basin in Fort Bend and Brazoria counties. The area consists of undeveloped acreage such as farmlands and wooded areas. Major channels in this area are the Brazos River, Rabbs Bayou, Dry Creek, Big Creek, and Oyster Creek. Major lakes in this area are Lake Worthington and Smithers Lake.

The TCEQ Permanent Rules Chapter 307, Texas Surface Water Quality Standards Subsections 307.2–307.10, April 30, 1997, presents surface water quality standards, which apply to all surface waters in the state. The major surface waters of the state are classified in the Texas Surface Water Quality Standards as "segments" for the purposes of water quality management and designation of site-specific standards.

Two classified segments transverse the study area. The first classified segment is Segment 1202J of the Brazos River Watershed. This segment of the Brazos River starts at a point 330 feet upstream of SH 332 in Brazoria County and continues upstream to the confluence of the Navasota River in Grimes County. The second classified segment is Segment 1110 of the San Jacinto-Brazos Coastal Watershed. This is the Oyster Creek segment, which begins at a point 330 feet upstream of FM 2004 in Brazoria County and continues upstream to the Brazos River Authority (BRA) diversion dam 1.1 miles upstream of SH 6 in Fort Bend County. According to the 2010 TCEQ Texas Surface Water Quality Standards, Segments 1202J and 1110 are reported to have elevated levels of fecal coliform. Segment 1110 is reported to have depressed dissolved oxygen levels, while Segment 1202J is reported to be within a normal range for dissolved oxygen.

Water quality data in the study area are available at two stations of the Surface Water Quality Monitoring Program of the TCEQ. Table 3-18 summarizes the ambient water quality data at these two stations.

Big Creek at Big Creek Road has a limited number of annual observations, which appear to have been made at a range of flow and environmental conditions. The maximum temperature observation during the sample period was 33.1 degrees Celsius (°C) (91.6 degrees Fahrenheit [°F]), approximately 1.9 °C below the criterion of 35 °C (95 °F). Five of the 19 samples for fecal coliform exceed the contact recreation criterion, an improvement since previous observations, and most dissolved oxygen values appear satisfactory.

The data for the Brazos River at US 90A in Richmond are somewhat different and more extensive. The station is on the TCEQ Segment 1202, Brazos River below its confluence with the Navasota River. The dissolved oxygen levels are more uniform than those of Big Creek, reflecting a larger waterbody. The conductivity and dissolved solids values tend to be substantially higher, reflecting a larger number of low-flow samples. The fecal coliform values have a long-term geometric mean that is within the existing contact recreation criterion. At this time, Segment 1202 is not on the 303(d) list. The 303(d) list is named after the relevant section of the federal Clean Water Act (CWA) and is a list of waterbodies that do not meet or are not expected to meet applicable water quality standards.

TABLE 3-18
AMBIENT WATER QUALITY CONDITIONS

Station	Parameter	Storet Code	Unit	Data Period From	Data Period To	Number of Samples	Mean [1]	Max	Min	Stdev [2]
ID 11518 Big Creek at Gless/Big Creek Road 12.9 km (8 miles) NE Fairchilds	Water Temperature	00010	deg C	08/24/98	02/19/02	28	21.9	33.1	9.7	6.2
	Conductivity	00094	mmhos/cm	10/20/98	02/19/02	27	534.9	1829	85.7	434.7
	Dissolved Oxygen	00300	mg/L	08/24/98	02/19/02	28	7.2	11.3	2.5	2.7
	pH	00400	std. unit	08/24/98	04/16/02	28	7.6	8.8	7.0	0.5
	Total Suspended Solids	00530	mg/L	08/24/98	04/16/02	27	76.8	743.0	6.0	142.9
	Nitrite + Nitrate	00630	mg/L	09/24/97	12/23/97	2	0.475	0.865	0.085	0.552
	Ortho Phosphorus	00660	mg/L	09/24/97	12/23/97	2	0.324	0.387	0.260	0.090
	Chloride	00940	mg/L	08/24/98	02/19/02	27	78.4	578.5	6.2	123.1
	Fecal Coliform	31616	cfu/dL	08/24/98	02/19/02	19	602.4	>1200	24.0	474.8
ID 11846 Brazos River at US90A in Richmond	Water Temperature	00010	deg C	06/23/99	10/25/07	29	23.6	33.4	10.2	7.9
	Conductivity	00095	mmhos/cm	06/23/99	10/25/07	26	701.2	1170.0	240.0	262.7
	Dissolved Oxygen	00300	mg/L	06/23/99	10/25/07	18	7.8	11.8	1.5	2.5
	pH	00400	std. unit	06/23/99	10/25/07	18	8.0	8.5	7.5	0.3
	Total Dissolved Solids	70300	mg/L	12/19/07	09/20/07	2	371.0	452.0	290.0	114.6
	Biochemical Oxygen Demand	00310	mg/L	01/26/93	09/07/95	15	2.0	6.0	1.0	1.2
	Alkalinity	00410	mg/L	01/26/93	09/08/93	5	138	191	80	48
	Hardness	00900	mg/L	02/12/02	08/06/02	3	176.7	200.0	160.0	20.8
	Ammonia Nitrogen	00608	mg/L	06/23/99	09/25/02	11	0.1	0.4	<0.1	0.1
	Total Kjeldahl Nitrogen	00625	mg/L	01/26/93	09/07/95	15	0.593	1.20	0.30	0.252
	Nitrite + Nitrate	00631	mg/L	06/23/99	09/25/02	13	0.4	1.3	0.1	0.5
	Phosphorus	00665	mg/L	01/26/93	09/07/95	15	0.209	0.81	0.04	0.207
	Ortho Phosphorus	00671	mg/L	06/23/09	10/25/07	14	0.044	0.091	0.010	0.030
	Chloride	00940	mg/L	06/23/99	10/25/07	18	85.5	182.3	27.5	49.0
	Sulfate	00945	mg/L	06/23/99	10/25/07	18	54.9	97.1	27.6	22.8
	Fecal Coliform	31625	cfu/dL	01/26/93	07/31/95	14	121	1100	32	0.46

TABLE 3-18, CONT'D

Station	Parameter	Storet Code	Unit	Data Period		Number of Samples	Mean [1]	Max	Min	Stdev [2]
				From	To					
	Aluminum	01106	mg/L	01/26/93	09/07/95	9	31.1	60	< 10	20.9
	Arsenic	01000	mg/L	08/23/99	02/12/02	5	3.2	4.7	1.2	1.3
	Cadmium	01025	mg/L	08/23/99	02/12/02	7	0.4	1.0	<0.1	0.4
	Chromium	01030	mg/L	08/23/99	02/12/02	7	0.9	1.0	0.8	0.1
	Copper	01040	mg/L	08/23/99	02/12/02	7	3.3	7.4	1.1	2.7
	Iron	01046	mg/L	08/23/99	02/12/02	7	23.5	54.0	10.0	20.9
	Lead	01049	mg/L	08/23/99	02/12/02	4	<1.0	<1.0	<1.0	0
	Nickel	01065	mg/L	01/26/93	06/28/96	11	2.82	< 10	< 1	3.57
	Silver	01075	mg/L	08/23/99	02/12/02	5	0.7	1.0	<0.1	0.5
	Zinc	01090	mg/L	08/23/99	02/12/02	7	21.4	24.0	18.0	2.5

Source: TCEQ (2009).

[1]Geometric mean for Fecal Coliform

[2]Standard deviation of log data for Fecal Coliform

Concentration reported as less than a certain value is assigned that value when calculating mean and standard deviation.

3.8.2 Groundwater

Recognized aquifers in the study area that contain freshwater (i.e., water having not more than 1,000 milligrams per liter [mg/l] total dissolved solids) include the Chicot and Evangeline aquifers (Wesselman, 1972). Quaternary alluvial deposits along the Brazos River may also be a source of fresh groundwater, but no published or open-file information on hydraulic characteristics or use of this water-bearing unit were identified.

The Chicot Aquifer is the shallowest major aquifer of the lower Gulf Coastal Plain, and consists of all strata between ground surface and the top of the Evangeline Aquifer. Wesselman (1972) subdivided the Chicot into upper and lower units in southeastern Fort Bend County based on the occurrence of an intervening clay stratum at a depth of about 200 feet. Sand strata constitutes about 40 to 75 percent of the unit, with the rest consisting of less permeable clays, sandy clays, and muds (Wesselman, 1972). The boundaries of the Chicot Aquifer are not distinct, but the upper Chicot is generally correlated to the Beaumont Formation, and the lower Chicot generally correlated to the Montgomery, Bentley, and Willis formations. Groundwater in the upper Chicot may exist under confined (i.e., artesian) or unconfined (i.e., water table) conditions, while groundwater in the lower part is under confined or leaky confined conditions. The elevation of the base of the Chicot Aquifer is estimated to be about 700 feet below msl at the study area.

The Evangeline Aquifer underlies the Chicot Aquifer and is generally correlated with the Pliocene-age Goliad Formation. The Evangeline Aquifer is estimated to be about 1,850 feet thick beneath the study area with the base level of 1,055 feet and upper level of 1 foot. Sand strata constitute about 33 to 40 percent of the aquifer. Wesselman (1972) also concluded there is hydrologic communication between sands of the Evangeline and sands of the lower Chicot in some areas of eastern Fort Bend County.

Recharge to the Chicot and Evangeline aquifers occurs predominantly by infiltration of precipitation through permeable portions of the aquifers that crop out at the land surface, and by leakage from overlying aquifers. Recharge to the Chicot Aquifer occurs mainly on the outcrops of the Montgomery, Bentley, and Willis formations, in Waller, Austin, and Colorado counties (Gabrysch, 1977). Little or no recharge by precipitation occurs where the outcrop of the Chicot corresponds to the outcrop of the low-permeability upper Beaumont Formation. Accordingly, there is likely little recharge to the Chicot Aquifer by direct precipitation in the study area. However, recharge to the upper Chicot likely occurs by leakage from saturated alluvium deposits where the Brazos River valley is deeply incised into the Beaumont Formation. The Goliad Formation, which comprises most of the Evangeline Aquifer, is overlain by the Willis Formation in the study area and in Austin and Waller counties to the north, so recharge to the Evangeline is presumed to occur mainly by leakage from the overlying Chicot Aquifer (Wesselman, 1972).

According to data supplied by the Texas Water Development Board (TWDB), 6,492 acre-feet of groundwater was pumped from the Gulf Coast Aquifer in the project area in 1960. In 1970, a total of 12,418 acre-feet of groundwater was pumped from this aquifer. The total pumpage increased to 36,780 acre-feet in 1980 and to 59,936 acre-feet in 1990.

According to the 19th Annual Ground Water Report of the Fort Bend Subsidence District (FBSD), the 2008 groundwater pumpage from the regional aquifers within the district totaled 101.7 million gallons per day (mgd) (312 acre-feet), compared with 79.1 mgd (243 acre-feet) in 2007. This is a 29 percent increase in 1 year. In 2008, 76 percent of the total pumpage was used in public supply, 8 percent was used for industrial purposes, and 10 percent was used for agricultural purposes. Total public supply has increased 22 percent since 2007, while industrial use has decreased slightly by 6 percent. Total irrigation use varies considerably from year to year.

In 1990, groundwater constituted 59 percent of the total water demand, and surface water sources constituted 40 percent of the total. Treated effluent, used solely for the irrigation of a golf course, made up nearly 0.5 percent. In 2008, groundwater use made up 65 percent of the total water demand, and surface water use constituted 35 percent of the total water demand. In 2008, the Brazos River was the sole source of surface water within the district's boundaries and is currently used only for industrial and irrigation uses. No treated effluent uses have been reported for the past 2 years.

3.8.2.1 Water Well Review

Well records and published groundwater reports of the TWDB were reviewed to provide information on water wells in the study area. The well records were obtained from TCEQ and TWDB (TCEQ, 2011; TWDB, 2011b).

The results of the water well review indicated that a total of 140water-supply wells lie within the study area. There are 20 public and 11 private water supply wells within ¼ mile of the Preferred Alternative. Seventeen of the 20 public wells are completed in the Chicot Aquifer, and total depths range from 185 to 810 feet below ground surface. Three of the wells are completed in the Evangeline Aquifer and total depths range from 594 to 1,942 feet below ground surface. Eight of 11 private wells are completed in the Chicot Aquifer, and the remainder are completed in the Evangeline Aquifer. Total depths range from 50 to 1,942 feet. Private wells are utilized for domestic, livestock, industrial, or irrigation purposes.

3.9 PERMITS

3.9.1 Waters of the U.S., Including Wetlands

Section 404 of the CWA authorizes the USACE to regulate discharges of dredged or fill material into waters of the U.S., including wetlands. As part of the USACE approval process, the state environmental agency (TCEQ) must certify, pursuant to Section 401 of the CWA, that the discharge of dredged or fill material to be licensed or permitted by the USACE will comply with the applicable state effluent limitations and water quality standards. Placement of dredged of fill material within Waters of the U.S., including wetlands, requires a permit from the USACE under Section 404 and water quality certification from the TCEQ under Section 401. The result of the Section 404 evaluations and potential impacts are discussed in Section 3.10 (Wetlands and Vegetative Communities) and Section 4.9 (Wetlands and Vegetative Communities) of this volume.

Section 402 of the CWA prohibits the discharge of any pollutant to Waters of the U.S. from a point source unless the discharge is authorized by a Texas Pollutant Discharge Elimination System (TPDES) permit. Construction activity is considered a point source discharge. Permit authorization may be given under an Individual Permit or an existing General Permit. Currently, coverage under TPDES permit is required in Texas for construction activity that disturbs 5 or more acres, provided an Notice of Intent (NOI) is filed with the TCEQ and EPA (40 CFR 122); even though the TCEQ has assumed authority for the stormwater program from the EPA as part of TPDES authorization.

The TPDES permit requires the completion of a Storm Water Pollution Prevention Plan (SW3P). The SW3P requirements are designated to allow maximum flexibility when selecting Best Management Practices (BMPs) at the construction site. As part of the SW3P, inspections are required of both stabilized and unstabilized areas in the construction site for evidence of, or the potential for, pollutants entering Waters of the U.S. via stormwater runoff. Summary report to these inspections must be written and retained as part of the SW3P. Once construction has been completed, a Notice of Termination must be filed per permit requirements. Additional coordination with Fort Bend Coty local government relative to stormwater pollution prevention may also be required prior to project construction.

3.9.2 Navigable Waters of the U.S.

The General Bridge Act of 1946 and Section 9 and 10 of the Rivers and Harbors Act of 1899 prohibit the unauthorized obstruction, including bridge construction, or alteration of any navigable water of the U.S. unless the work has been authorized by permit from the U.S. Coast Guard (USCG) and the USACE. As defined in 33 CFR 329.4, “Navigable waters of the U.S. are those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events that impede or destroy navigable capacity.” The Brazos River is considered navigable from the Gulf of Mexico to the town of Navasota in Grimes County, Texas. The study area occurs in this navigable reach of the Brazos River.

3.9.3 Endangered Species Act, Sections 7 and 9

When an action or authorization of one federal agency may result in a take (“take” is a specific legal term as defined in 50 CFR 3 and 17), the federal agency (in this case the FHWA) will consult with the USFWS under Section 7 procedures of the Endangered Species Act (ESA). A previously federally threatened species (Bald Eagle) (prior to its August 2007 delisting) occurs within the project vicinity. 50 CFR 402.12 requires the preparation of a Biological Assessment (BA) to establish a baseline of environmental conditions and forecast potential impacts resulting from the project. Under formal Section 7 consultation guidelines, the USFWS may decide to issue a Biological Opinion (BO) and Section 9 Permit for incidental take.

Although the Bald Eagle is no longer protected under the ESA, it is still protected under the Bald and Golden Eagle Protection Act (BGEPA). Per discussions with the USFWS in December 2009, the terms and conditions of existing BOs issued under Section 9 of the ESA would be “grandfathered” in under the BGEPA, therefore, eliminating the need for a

second permit unless project impacts or species information were updated. Therefore, the terms and conditions issued in the BO for Segment C, dated March 7, 2007, remain valid and in effect.

While it is the opinion of the project team and resource agencies that the project would not constitute a take for the Bald Eagles, the Section 9 permit is a precautionary measure to ensure that an illegal take (i.e., take without a permit) does not occur. The project modifications discussed in 1 below compensate for the risk of the potential take.

Two additional points merit discussion in relation to this permit obligation:

1. The ESA does not allow compensation for impacts. The ESA does provide opportunities for the project to be modified to, in effect, mitigate for potential impacts to species or their habitats. In the case of the proposed Grand Parkway Segment C, one option for project modification is for 500 acres (representing one Bald Eagle nest territory) of Austin's Woods to be protected by conservation easement, acquisition or some combination thereof. Other options include land swaps between interested landowners, working within the context of larger conservation initiatives within the area, or monetary contributions in lieu of outright acquisition or easement payment. All options are being considered at this time. In addition, no construction activities may occur within 1 mile of the nest during the eagle nest season (approximately October to May). Vegetation clearing would be minimized and screening vegetation would be conserved or replanted within this 1-mile zone.
2. Detailed information regarding the location of the eagle nest is not available to the public under the TPWD and USFWS policy and private property rights of landowners.

Sections 3.17 and 4.16 provide additional information on threatened and endangered species.

3.10 WETLANDS AND VEGETATIVE COMMUNITIES

3.10.1 Wetlands

The wetland communities present in the study area are typical of palustrine emergent (PEM) and palustrine forested (PFO) areas within southeast Texas as described by Cowardin et al. (1979). Nonforested wetlands may include wet meadows, sloughs, depressions, and pond fringes. Forested wetlands typically occur in depressional areas and along the study area's streams. Descriptions of the nonforested and forested wetland communities in the study area are presented below.

Nonforested Wetlands

According to McMahan et al. (1984), commonly associated plants found in freshwater, nonforested wetlands include water hyacinth (*Eichhornia crassipes*), cattail (*Typha* sp.), water-pennywort (*Hydrocotyle* sp.), pickerelweed (*Pontederia cordata*), arrowhead, white waterlily (*Nymphaea odorata*), cabomba (*Cabomba caroliniana*), coontail (*Ceratophyllum* sp.), and duckweed (*Lemna* sp.). These vegetation communities can be found in hydric lowlands landward of brackish marsh,

coastal prairies, and marshes. This vegetation type corresponds with McMahan et al. (1984) vegetation type 43 (Marsh/Barrier Island).

Nonforested wetlands or PEM (Cowardin et al., 1979) are scattered throughout the study area. A detailed wetland delineation report has been prepared for the Preferred Alternative. Although the nonforested wetlands in the study area are not identical, the following list represents the majority of the vegetation observed in this habitat type during field investigations in the area. Typical vegetation includes eastern gamagrass (*Tripsacum dactyloides*), Arkansas dogshade (*Limnosciadium pinnatum*), bristleleaf eryngo (*Eryngium yuccifolium*), big-headed rush (*Juncus megacephalus*), canna (*Canna glauca*), spatulate leaved frog-fruit (*Phyla nodiflora*), Timothy canarygrass (*Phalaris angusta*), green flatsedge (*Cyperus virens*), bermudagrass (*Cynodon dactylon*), sedge (*Carex* sp.), Drummond's rattlebush (*Sesbania drummondii*), curly dock (*Rumex crispus*), sand spikerush (*Eleocharis montevidensis*), smooth water primrose (*Ludwigia peploides*), jointed flatsedge (*Cyperus articulatus*), hairy hydrolea (*Hydrolea ovata*), flatsedge (*Cyperus* sp.), soft rush (*Juncus effusus*), arrowhead (*Sagittaria* sp.), spiderlily (*Hymenocallis caroliniana*), grassleaf rush (*Juncus marginatus*), Brazilian vervain (*Verbena brasiliensis*), swamp smartweed (*Polygonum hydropiperoides*), Chinese tallow-tree saplings (*Sapium sebiferum*), morning glory (*Ipomoea leptophylla*), bushy bluestem (*Andropogon glomeratus*), St. John's wort (*Hypericum* sp.), thin paspalum (*Paspalum setaceum*), and camphor pluchea (*Pluchea camphorata*).

The majority of the nonforested wetlands observed are considered early successional communities experiencing secondary succession. Many of the nonforested wetlands may have been forested wetlands prior to conversion of the forests to pastureland or agricultural lands. Although these areas may have been forested wetlands in the past, the length of time these wetlands have been converted indicates that the community observed represents the new normal circumstances or community type expected. Due to the ongoing agricultural practices and increasing urban development within the project area, the probability for these areas to revert to forested wetland communities is remote.

In addition to the areas considered to be converted nonforested wetlands, several of the wetlands observed are likely remnant prairie-pothole wetlands that are known to have occurred historically in portions of the study area. Due to the conversion of the land to agricultural uses, these wetlands are also considered early successional wetlands. Continual agricultural practices and other urban development within the majority of the project area make the potential for these wetlands to reach a climax community stage remote.

Forested Wetlands

Forested wetlands, or PFO (Cowardin et al., 1979) are concentrated in the northern and southern regions of the study area. In the northern portion of the study area, forested wetlands are associated with the Rabbs Bayou-Big Creek drainages and the Brazos River floodplain in Thompsons Oil Field. Forested wetlands in the southern portion of the study area are associated with the Big Creek-Brazos River floodplain and Pilant Lake wetland complex, both of which are primarily located in Brazos Bend State Park.

According to McMahan et al. (1984), the plant species associated with forested wetlands include beech (*Fagus americana*), swamp chestnut oak (*Quercus michauxii*), elms (*Ulmus* spp.), sweetgum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), bald cypress (*Taxodium distichum*), hawthorn (*Crataegus* sp.), dwarf palmetto (*Sabal minor*), poison ivy (*Toxicodendron radicans*), trumpet creeper (*Campsis radicans*), Alabama supplejack (*Berchemia scandens*), and greenbriar (*Smilax* spp.). These wetland areas correspond with McMahan et al. (1984) vegetation type 31 and can be found in forested depressional areas throughout Texas.

Forested wetland communities are generally located south and west of Smithers Lake and north and east of the Brazos River. Several small, forested wetlands can also be observed south of the Brazos River, near Oyster Creek. Vegetation within these areas typically includes water oak (*Quercus nigra*), American sycamore, black willow (*Salix nigra*), planertree (*Planera aquatica*), cottonwood (*Populus deltoides*), sugar hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), dwarf palmetto, seedbox (*Ludwigia* spp.), maidencane (*Panicum hemitomon*), and peppervine (*Ampelopsis arborea*).

The majority of the forested wetlands are considered mid-late successional forested wetland communities. The overstory trees observed were typically between 40 and 60 feet tall, with average diameter at breast height (dbh) ranging from 8 to 12 inches. Typical canopy coverage ranges between 60 and 80 percent.

In addition to the mid-late successional forested wetland communities, several of the forested wetlands appear to be early successional forested wetlands or herbaceous wetlands being converted to forested wetlands. These wetlands are dominated by Chinese tallow, green ash, and black willow trees that range in height from 30 to 50 feet. The average diameter at breast height ranges from 4 to 8 inches and the canopy coverage is typically approximately 50 to 60 percent.

Wetlands provide a variety of ecological functions to the natural ecosystem and to humans. Some of the functions that wetland habitats may provide include wildlife and aquatic habitat, removal of sediment and toxicants, removal or transformation of nutrients, flood and storm damage protection, erosion control, water storage, groundwater recharge and discharge, and natural area buffers. In general, the wetland sites within the project area provide some flood storage, sediment trapping, groundwater recharge, and wildlife habitat.

An important function of wetlands along the proposed Grand Parkway within the Brazos River floodplain and areas adjacent to the floodplain is flood abatement. Typically, wetlands are located in relatively lower topographic positions than nonwetland areas and provide storage capacity for floodwater. In addition to storing the floodwater, the reduction in water volume moving across the land decreases runoff potential and erosion.

Sediment retention is another important wetland function provided by study area wetlands. The sediments that are carried across the land into the wetlands eventually fall out into the wetland, reducing the sediment and nutrient load into the local streams and waterways. As the sediments drop out of the flowing water, various plants act as filters either by absorbing the nutrients or chemicals from the sediments, or by trapping the nutrients/sediments in the soil through the root system of the wetland vegetation. The net result is a reduction of sediments in the waterways and improved water quality.

In addition to their functions related to surface water, wetlands may act as a catch basin for groundwater recharge. As water fills the wetlands, it percolates through the soil to the water table, becoming part of the groundwater. During recharge, as the water percolates through the soil, sediments and nutrients are filtered out by the soils and root zone of the vegetation, cleansing the water before it reaches the water table. This function is probably more pronounced for wetlands within the floodplain of the study area's streams and river. It may be even more pronounced in floodways.

In addition to the surface and groundwater functions, wetlands provide habitat for many wildlife species. For wildlife species that utilize the wetlands, the wetlands provide secure areas with an abundance of food and shelter during different life stages and environmental and climatic conditions. Different guilds or groups of wildlife species may use one or more types of wetlands in the study area.

Human recreational and commercial uses are important functions/values of wetlands. Wetland areas provide multiple recreational uses, such as hiking, wildlife viewing, hunting, and fishing. Of particular interest in the study area is Brazos Bend State Park. The park provides excellent opportunities to view wildlife in typical floodplain forests and wetlands (forested and nonforested) of southeastern Texas. Although hunting is not allowed on park property for typical wetland game animals (e.g., waterfowl), the TPWD does manage a public deer hunt on park grounds during the winter. Fishing opportunities are also provided at the park where piers and bank access have been established on many of the oxbows and naturally occurring lakes.

3.10.2 Vegetative Communities

The study area for the proposed Grand Parkway Segment C is situated in the Texas ecological region known as the Gulf Coast Prairies and Marshes (Gould, 1975). This ecological region is characterized by nearly level topography with precipitation averaging 48 inches per year. The regional elevation extends from sea level along the coast up to 250 feet msl in the uplands of Fort Bend and Brazoria counties with little topographic relief within the study area (Hatch et al., 1990).

The native vegetation of this region originally consisted of tall grass prairies intermixed with post oak savannahs and forested riparian corridors (Hatch et al., 1990; SCS, 1960). Where there has been disturbance or alterations to the landscape, such as farming and ranching and urbanization, various shrubs, exotic trees, and undesirable herbaceous species have invaded. Most of this region is very productive farmland for growing row crops and rice, and because of the urbanization and agricultural activities, very little native prairie remains. The remnant prairie that does exist is dominated by climax grasses such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and gulf muhly (*Muhlenbergia capillaris*). Most of these grasses have been replaced by invaders such as johnsongrass (*Sorghum halepense*), great ragweed (*Ambrosia trifida*), Brazilian vervain, and woody species such as eastern baccharis (*Baccharis halimifolia*) and Chinese tallow-tree.

The northern portion of Fort Bend County and western portion of Brazoria County that would be affected by the proposed Grand Parkway Segment C form an area of increasing urban development. The vegetative communities that are present

include wetland and nonwetland forestlands, pastureland/grassland/cropland, and nonforested wetlands (see site photographs in Appendix H). Forested and nonforested wetlands are described in Section 3.10.1, Wetlands. The following vegetative community descriptions are based on McMahan et al. (1984) and were adjusted to reflect site-specific conditions based on field observations.

Forestlands

Forestlands in the study area may include upland, riparian, and floodplain forests. Species overlap is common and an effort has not been made to differentiate between these forest communities. Forestlands that meet the technical criteria for wetlands (Environmental Laboratory, 1987) are described in Section 3.10.1.

Based on field observations, the majority of the nonwetland forests in the study area are considered late successional or climax forested communities, relative to adjacent or nearby forests. Typical overstory trees are approximately 50 to 70 feet tall with average dbh ranging between 10 and 15 inches. In areas where the forested vegetation has not been cleared, canopy coverage ranges between 80 and 100 percent.

Typical overstory vegetation species found along fencerows and in upper elevations within the study area include cedar elm (*Ulmus crassifolia*), winged elm (*U. alata*), live oak (*Quercus virginiana*), sugarberry (*Celtis laerigath*), and pecan (*Carya illinoiensis*). Lower elevations typically support water oak, black gum (*Nyssa sylvatica*), green ash, and Chinese tallow-tree. These trees are found within floodplains and along streambanks. Understory and shrub species include yaupon (*Ilex vomitoria*), dwarf palmetto, Chinese privet (*Ligustrum sinense*), flowering dogwood (*Cornus florida*), and Chinese tallow. Common vine species include common and laurel greenbriar (*Smilax rotundifolia* and *S. laurifolia*), southern dewberry (*Rubus trivialis*), trumpet creeper, peppervine, Japanese honeysuckle (*Lonicera japonica*), and Alabama supplejack (*Berchemia scandens*). The herbaceous layer includes narrowleaf woodoats (*Chasmanthium sessiliflorum*), Cherokee sedge (*Carex cherokeensis*), maidencane, and curly dock. Many species listed above are typical of forested wetlands (USFWS, 1988) bottomland hardwood forests (McMahan et al., 1984) in the area.

Pastureland/Grassland/Cropland

The pastureland/grassland/cropland community type usually results from the clearing of woody vegetation with the intent of growing a mixture of native and/or introduced grasses and forbs. This clearing practice is common throughout many parts of Texas, and may result in a community that resembles the early stages of a young forest (McMahan et al., 1984). This community type corresponds with McMahan et al. (1984) vegetation type 45. Cropland is defined by McMahan et al. (1984) as any “cultivated cover crop or row crop providing food and/or fiber for either man or domestic animals.” McMahan et al. designates this vegetation type 44.

Typical vegetation associated with this community includes eastern gamagrass, snow-on-the-prairie (*Euphorbia bicolor*), annual sumpweed (*Iva annua*), bermudagrass, bahiagrass (*Paspalum notatum*), broomsedge bluestem (*Andropogon virginicus*), little bluestem, indiangrass, dallisgrass (*Paspalum dilatatum*), vasey grass (*Paspalum urvillei*), knotroot bristle

grass (*Setaria geniculata*), southern carpet grass (*Axonopus affinis*), johnsongrass, rescuegrass (*Bromus unioloides*), western ragweed (*Ambrosia psilostachya*), curly dock, Brazilian vervain, smutgrass (*Sporobolus indicus*), bull thistle (*Cirsium horridulum*), honey mesquite (*Prosopis glandulosa*), wild onion (*Allium canadense*), false garlic (*Allium bivalve*), huisache (*Acacia smallii*), sedge, big bluestem, giant ragweed (*Ambrosia artemssiifolia*), giant goldenrod (*Solidago gigantea*), grassleaf rush, perennial ryegrass (*Lolium perenne*), southern dewberry, Macartney rose (*Rosa bracteata*), narrowleaf sumpweed (*Ira annua*), common greenbriar (*Smilax rotundifolia*), gerardia (*Agalinus* sp.), dwarf palmetto, flatsedge (*Cyperus* spp.), Chinese tallow-tree, yaupon, pecan, winged elm, cedar elm, green wild indigo (*Baptisia sphaerocarpa*), green flatsedge, and eastern baccharis.

The pastureland and grassland communities within the area are heavily disturbed, or in some cases, under rotational grazing. Due to intense grazing and the lack of a natural fire regime, these communities are dominated by less desirable grasses and forbs. The grasses within the study area include perennial ryegrass, bermudagrass, southern carpet grass, smutgrass, dallisgrass, vasey grass, bahiagrass, and johnsongrass. Some native species such as indiangrass, little bluestem, and brownseed paspalum (*Paspalum plicatulum*) still exist. Forbs present in the study area include curly dock, giant ragweed, Canada goldenrod, Brazilian vervain, narrowleaf sumpweed, and western ragweed. Commonly occurring shrubs on disturbed pastureland include honey mesquite and Macartney rose.

During the field evaluations, the pastureland/grassland communities were described as early successional communities as a result of past indicators of rotation farming practices. In the majority of the pasturelands/grasslands observed, old rice levees or indicators of ground leveling were documented.

Cropland in the study area is normally used to grow corn, rice, grain sorghum, and soybeans, but cotton and alfalfa are also present. In the abandoned fields, various invading species such as those mentioned above become common. Refer to Section 3.2.4 for a complete description of prime and important farmland soils within the study area.

3.10.3 Natural Areas

For purposes of this document, natural areas are ecologically sensitive areas, including portions of certain important habitats such as bottomland hardwood forest, wetlands, and native tall grass prairie. Forested wetlands are considered one of the more sensitive natural areas in this part of the state. The Brazos River floodplain is centered on a riparian corridor that commonly contains both wetland and nonwetland forests. These forested complexes in Brazoria and Fort Bend counties are referred to by the USFWS as the Austin's Woods (Exhibit 25). These woods succeeded the region's last major timber harvests in the 1930s, thus they are approximately 70-year-old forest stands. This physiographic region originally consisted of coastal bottomland hardwood forests within the 500-year floodplains approximately located south of US 59, east of the Colorado River, and west of SH 6 to the coast. A large forested corridor in the study area connects Thompsons Oil Field and the riparian zones of Big Creek, Waters Lake Bayou, and Rabbs Bayou. The corridor continues through the Pilant Lake wetland complex (located in the park) and out of the study area. Forests in this corridor are considered Austin's Woods.

Three dedicated natural areas were identified within the study area, the Lake Worthington Conservation Area, Brazos Bend State Park, and George Ranch Historical Park (Exhibits 11 and 15). Brazos Bend State Park, Lake Worthington Conservation Area, and the George Ranch Historical Park were described previously in Section 3.3.2.3, Parks and Recreation. George Ranch is also described further in Section 3.18.

3.11 FLOODPLAINS

3.11.1 Hydrology and Drainage

The study area is located within the Brazos River Basin in Fort Bend and Brazoria counties. This basin occurs in the central to southeastern portions of the state. It is bordered by the San Jacinto River Basin on the east and the San Bernard and Colorado River Basins on the west. The Brazos River Basin has a drainage area of over 45,000 square miles (USGS, 1999). The study area receives an average of 48 inches of precipitation annually (Hershfield, 1961). With the project being located in the coastal plain, the grades of the streams are small; therefore, velocities within the channels are slow. The overland slopes in the study area are approximately 4 feet/mile (0.08 percent). The study area consists primarily of undeveloped acreage such as farmlands and wooded areas.

The study area contains numerous major streams, minor streams, irrigation canals, stock ponds, and rivers. Major channels in the study area are Rabbs Bayou, Dry Creek, Big Creek, Brazos River, and Oyster Creek. One unique drainage feature is the Big Creek Diversion Channel recently constructed by the Fort Bend County Drainage District.

3.11.2 Floodways and Floodplains

3.11.2.1 Principle Characteristic of the Project Area

The Segment C study area includes mostly suburban and rural areas southwest of Houston. The topography of the region varies from nearly flat terrain immediately along the Gulf Coast to a gently undulating plain that extends inland approximately 50 to 100 miles (Stutzenbaker, 1999). Floodplains associated with the watercourses in most of the region are typically characterized as wide, flat, and wooded. Each of the major streams within the Segment C study area has floodplains, as identified by FEMA (Exhibit 26).

3.11.2.2 Community Status in the National Flood Insurance Program

The National Flood Insurance Program (NFIP), established by FEMA, has enabled counties and local government agencies the opportunity to map and define the base (100-year) floodplains and special flood hazard areas. The NFIP is administered and enforced through the counties and/or local communities. Under the authority of the NFIP, some communities establish permit requirements for all development within the base floodplain zone. As a result, a community's participation status in the NFIP dictates what type of map is available for estimating potential floodplain encroachments. A community's participation and status in the NFIP is based on one of two programs. The two programs are the Regular Program and the Emergency Program.

Communities participating in NFIP's Regular Program generally have quantitative flood hydraulic studies performed on each floodway. In these communities, the NFIP map is a Flood Insurance Rate Map and in the majority of the cases, a regulatory floodway is in effect. Communities participating in NFIP's Emergency Program generally possess qualitative flood hydraulic data for the floodway. In the Emergency Program, the community's NFIP map is a Flood Hazard Boundary Map showing only approximate base floodplain boundaries.

FEMA, Q3 (electronic) flood data was used for Fort Bend and Brazoria counties (FEMA 2007a, 2007b) to determine 100-year floodplain impact calculations as described in Section 4-10 (Exhibit 26).

3.11.2.3 Segment C Study Area Floodways and Floodplains

The Segment C study area is located within the Brazos River Basin between the San Jacinto River Basin on the east and the San Bernard and Colorado River Basins on the west. The project crosses several FEMA 100-year floodplains. FEMA, Q3 (electronic) flood data Bend and Brazoria counties (FEMA 2007a, 2007b) were referenced to determine the location of 100-year floodplains. The designated flood hazard boundaries in the study area consist of land adjacent to the defined drainage channels for Rabbs Bayou, Dry Creek, Big Creek, Brazos River, and Oyster Creek. The base flood elevation has been determined for most areas located within the 100-year flood zone. In backwater and tributary areas, due to a lack of precise hydraulic information, these base flood elevations have been estimated. The Brazos River floodplain extends from Big Creek on the west to Oyster Creek on the east. The 100-year floodplain is approximately 42.1 percent of the study area, and the 500-year floodplain is approximately 48.8 percent of the study area. Exhibit 26 shows the limits of the floodplains in the study area.

For the Brazos River and upper reaches of Dry Creek, a floodway has been delineated using FEMA, Q3 (electronic) flood data (FEMA, 2007a, 2007b). The floodway is defined as the area within the floodplain where the water is likely to be deep and have high velocities. The floodway is indicated by the area within the floodplain in which if the base flood is encroached equally on both banks, the base flood elevation is increased 1 foot.

The number of insurance claims and total dollars paid since the beginning of the NFIP are shown in Tables 3-19 and 3-20. Although specific locations were not available, only the unincorporated areas listed in the tables are potentially in the study area of the proposed Grand Parkway Segment C.

The floodplain administrators for Brazoria and Fort Bend counties and flood control district officials for areas affected by the proposed Grand Parkway Segment C, including Drainage District #5 (Iowa Colony) in Brazoria County and Fort Bend County Drainage District, were also consulted regarding this project.

TABLE 3-19
TOTAL HISTORICAL NUMBER OF INSURANCE CLAIMS AND TOTAL DOLLARS PAID FOR FLOOD DAMAGES SINCE 1978 IN FORT BEND COUNTY

City/Town	Total Losses (claims)	Total Dollars Paid (historical)
Big Oaks Municipal Utility District (MUD)	1	0
Chelford City MUD	6	23,341
Cities MUD	9	15,725
First Colony	10	5,661
Fort Bend County*	238	3,147,346
Fort Bend County*	20	89,983
Fort Bend County*	10	3,737
Fort Bend County*	14	160,352
Fort Bend County*	3	5,265
Fort Bend County*	2	0
Fort Bend County*	1	0
Fort Bend County*	1	0
Fort Bend County*	3	1,877
Fort Bend County*	2	4,107
Fulshear	14	199,761
Houston	40,972	931,491,355
Katy	45	218,699
Kingsbridge MUD	3	25,941
Meadow Place	16	33,995
Mission Bend MUD	10	47,152
Missouri City	456	1,989,904
Needville	7	140,065
Pecan Grove MUD	12	60,024
Pleak	3	1,703
Richmond	31	322,358
Rosenburg	45	437,848
Simonton	202	4,550,957
Stafford	55	218,096
Sugar Land	179	623,655
Thompsons	0	0
West Keegan Bayou	4	6,619
Willow Fork Drainage Divide	8	35,468
Total	**42,382**	**943,860,994**

Source: NFIP (2009).
*Unincorporated areas

TABLE 3-20
TOTAL HISTORICAL NUMBER OF INSURANCE CLAIMS AND TOTAL DOLLARS PAID FOR FLOOD DAMAGES SINCE 1978 IN BRAZORIA COUNTY

City/Town	Total Losses (claims)	Total Dollars Paid (historical)
Alvin	1,244	12,687,994
Angleton	821	5,837,322
Baileys Prairie	40	289,654
Bonney	0	0
Brazoria County*	6,179	69,912,483
Brazoria City	220	2,540,165
Brookside	190	4,137,295
Clute	308	2,525,578
Danbury	65	482,153
Freeport	924	7,457,266
Hillcrest	53	776,020
Holiday Lakes	8	17,802
Iowa Colony	28	434,723
Jones Creek	102	858,100
Lake Jackson	440	2,008,379
Liverpool	40	409,737
Manvel	259	3,320,355
Oyster Creek	116	873,675
Pearland	2,566	45,344,145
Quintana	15	140,564
Richwood	100	517,679
Surfside Beach	1,289	15,605,424
Sweeny	106	1,923,378
West Columbia	94	1,145,944
Total	**15,207**	**179,245,835**

Source: NFIP Loss Statistics (2009).
*Unincorporated areas

3.11.2.4 Historical Data

A summary of maximum flow measurements is shown in Table 3-21. The historical data for the Brazos River Basin were recorded by two USGS gauging stations located near Richmond and Rosharon, Texas (USGS, 2009). The Richmond gauge has 77 years of recorded data and the Rosharon gauge has around 39 years of recorded data. The gauge station identification numbers are 8114000 and 8116650, respectively. The maximum peak flow rate for the Richmond gauge station was 123,000 cubic feet per second (cfs) on June 6, 1929, and the Rosharon gauge station had its highest flow of 83,900 cfs on October 22, 1994. Water quality properties are also available for the Brazos River at these gauging stations. Physical and field measurements taken at these locations include dissolved oxygen, pH, suspended sediment, turbidity, and instantaneous stream flow. Other water quality properties available are major ions, nutrients, biological measurements, and inorganic trace elements.

TABLE 3-21
MAXIMUM FLOW MEASUREMENTS ALONG THE BRAZOS RIVER

Water Year	Date	Gage Height (feet)	Streamflow (cfs)
Station 08114000 Brazos River at Richmond			
1929	6-Jun-29	N/A	123,000
1941	28-Nov-41	38.4	117,000
1957	5-May-57	37.13	119,000
1961	16-Jan-61	29.66	78,800
1965	25-May-65	34.72	98,800
1968	14-May-68	32.43	89,600
1973	15-Jun-73	31.62	72,500
1977	22-Apr-77	34.05	80,500
1979	8-Jun-79	35.29	88,100
1981	14-Jun-81	29.67	64,700
1982	7-Nov-82	28.8	61,300
1987	17-Jun-87	32.18	67,800
1992	1-Jan-92	49.68	94,000
1995	21-Oct-95	50.3	88,100
1999	22-Oct-99	47.08	80,300
2000	6-May-00	20.76	14,600
2001	17-March-01	35.46	46,700
2002	21-Dec-02	37.52	52,300
2003	7-Nov-03	45.22	74,800
2004	2-Jun-04	43.10	68,300
2005	29-Nov-05	45.84	76,700
2006	10-May-06	18.50	11,900
2007	20-July-07	45.04	72,100
2008	19-May-08	26.54	25,500

TABLE 3-21, CONT'D

Water Year	Date	Gage Height (feet)	Streamflow (cfs)
Station 08116650 Brazos River at Rosharon			
1968	14-May-68	50.74	79,900
1973	15-Jun-73	50.49	79,300
1977	23-Apr-77	48.75	73,000
1979	9-Jun-79	48.56	76,500
1985	26-Oct-85	37.24	45,200
1986	8-Feb-86	37.86	46,700
1987	17-Jun-87	46.6	63,300
1992	3-Jan-92	51.89	82,700
1995	22-Oct-95	51.82	84,400
1999	17-Nov-99	49.42	76,400
2000	10-Jun-00	20.39	13,600
2001	18-March-01	38.66	45,700
2002	21-Dec-02	40.52	43,300
2003	9-Nov-03	47.66	63,700
2004	3-July-04	47.49	64,400
2005	29-Nov-05	49.88	71,100
2006	11-May-06	16.64	11,000
2007	6-Jun-07	48.89	67,800
2008	19-May-08	27.81	25,400

Source: USGS (2009).

3.12 WILDLIFE

3.12.1 Aquatic Habitat

Aquatic habitats in the proposed Grand Parkway Segment C study area support a diverse assemblage of biotic communities characteristic of the Gulf Coast Plain. In addition to the Brazos River and its major tributaries, several small streams, oxbow lakes, wetlands, ponds, and ditches are found within the study area. Waterbodies in this area are typically slow moving or ponded.

The Brazos River in the study area drains approximately 44,000 square miles. The geomorphology of the Brazos River is typical of other Gulf Coast Plains Rivers. Its immediate drainage area has little relief and consists of sandy loam, clay, and sandy soils (BRA, 2001). The river is deep, wide, slow-moving, and typically carries a heavy silt load. Common habitat types include woody debris, overhanging vegetation, undercut banks, cobble, leaf packs, and artificial cover (i.e., broken cement, tires, etc.). Numerous aquatic and semi-aquatic organisms occur in this reach of the river. The TPWD has listed the segment of the Brazos River from Austin/Waller County to the Gulf of Mexico as an "Ecologically Significant River" (TPWD, 2001). Common fish species include catfish (*Ictalurus* spp. and *Pylodictis olivaris*), gar (*Lepisosteus* spp.), crappie (*Pomoxis* spp.), freshwater drum (*Aplodinotus grunniens*), and minnows (*Notropis* and *Cyprinella* spp.) (Hubbs, 1982;

TPWD, 2001). This segment of river is used by anglers who target its catfish and freshwater drum fishery (Simmons, 1986).

Macroinvertebrates in this area include those species typically found in pools or, deep, slow-moving streams. Examples include dragonflies (*Odanata*), crayfish (*Cambaridae*), caddisflies (*Trichoptera*), snails (*Gastropoda*), true bugs (*Hemiptera*), and midge flies (*Chironomidae*). Due to the size and low velocity of the river, various zooplankton (*microcrustacea*) are abundant. The Brazos River also supports mussels including paper pondshell (*Anodonta imbecillis*), giant floater (*A. grandis*), yellow sandshell (*Lampsilis teres*), and washboard (*Megalonaias nervosa*) (Howles et al., 1996).

All other waterbodies in the study area ultimately drain into the Brazos River and support much of the same fauna. These habitats are either ponded (wetlands, ponds, ditches, backwaters, etc.) or are slow-moving streams. Dominant habitat features include emergent aquatic plants, overhanging vegetation, leaf packs, woody debris, and, in streams, undercut banks. Many fish species in the Brazos River use these tributaries, backwaters, and floodplain impoundments as spawning grounds and nursery areas. Other species characteristic of small streams and quiescent backwaters are also found in the project area.

These include sunfish (*Lepomis* spp.), largemouth bass (*Micropterus salmoides*), pirate perch (*Aphredoderus sayanus*), topminnows (*Fundulus* spp.), bowfin (*Amia calva*), and numerous other species. These habitats also support diverse aquatic invertebrate communities including mayflies (*Ephemeroptera*), crayfish, caddisflies, dragonflies, midge flies, snails, water scorpions (*Nepidae*), beetles (*Coleoptera*), aquatic worms (*Oligocheata*), and zooplankton.

Waterbodies within the study area also provide important habitat and services to other semi-aquatic organisms such as the American alligator (*Alligator mississippiensis*); American beaver (*Castor canadensis*); turtles, such as the red-eared slider (*Trachemys scripta elegans*), Midland smooth softshell turtle (*Trionyx muticus*); wading birds; and waterfowl. These and other organisms are dependent upon these areas for food, water, and refuge.

Brazos Bend State Park is included in the study area and contains extensive aquatic habitats including wetlands, oxbow lakes, and ponds. Many of the aquatic and semi-aquatic life that occur in the study area can also be found here. Common sport fish in the park are crappie, largemouth bass, and channel catfish (*Ictalurus punctatus*). The proximity of the park to the Houston metropolitan area makes it a popular recreation area. The park offers opportunities for the public to camp, fish, hike, bird watch and a number of other outdoor activities, many of which are centered around its aquatic habitats.

3.12.2 Terrestrial Wildlife

Brazoria and Fort Bend counties occur within the Texan Biotic Province as described by Blair (1950). The Texan Biotic Province represents a transitional area between the forested province to the east and grassland provinces to the west. The integration of forests and grasslands in the area results in a mixture of vertebrate species typical of the two general habitats. The majority of the native vegetation in the province has been replaced by cultivated crops, improved pasture

grasses, invasive brush, or urban development. Consequently, numerous native wildlife populations have declined. Many habitat specialists, including the least shrew (*Cryptotis parva*), Texas horned lizard (*Phrynosoma cornutum*), and northern bobwhite (*Colinus virgianus*) have undergone significant reductions in numbers and had their distributions severely altered, while other more generalistic species such as the coyote (*Canis latrans*), eastern meadowlark (*Sturnella magna*), and mourning dove (*Zenaida macroura*) apparently have increased in number and habitat occupation.

Approximately 49 species of mammals occur (or have historically occurred) in the Texan Province, of which only 8 are grassland species encroaching from the west, southwest, or north. Two species of land turtles occur in the Texan Province. Nine of the 16 lizard species occurring in the Texan Province are eastern forest species, and the remaining 7 are western grassland affiliates. Of the 39 species of snakes documented in the Texan Province, 27 are eastern forest species and 12 are western. Five salamanders (all eastern forest species) and 18 species of frogs and toads (15 of which are eastern forest species) occur in the Texan Biotic Province (Blair, 1950).

The terrestrial wildlife habitats within the study area correspond to the vegetation types presented in Section 3.10.2, and include grassland/pastureland/cropland, forestland, forested wetlands, and nonforested wetlands. The distribution of habitat types in the study area and the activity patterns of many wildlife species result in some overlapping of faunal communities. Forest-dwelling species may occasionally occur in open areas around forest stands, and species particular to nonforested habitats may occasionally be found in forested areas. Edge areas, or ecotones, between major habitats are often preferred by wildlife species because of the diversity of food and cover usually provided by the overlap of vegetative communities. Literature reviewed to identify species of potential occurrence within the study area habitats include Tennant (1998) and Bartlett and Bartlett (1999) for reptiles and amphibians, Texas Ornithological Society (TOS, 1995) for avian species, and Manning and Jones (1998) for mammals.

3.12.3 Migratory Birds

The Migratory Bird Treaty Act (1918) (MBTA) protects migratory birds, active nests, eggs, and/or young. In the event that migratory birds are encountered on site during project construction, every effort would be made to avoid harm to migratory birds, their eggs, nests, and young. If necessary, old migratory bird nests would be removed from structures after the nesting season. For upcoming construction, preventative measures would be taken to prevent birds from building new nests on the proposed construction area.

3.12.4 Pastureland/Grassland/Cropland

The pastureland/grassland/cropland habitat type is the most abundant habitat found in the study area. Although the general purpose of this habitat is to grow crops or graze livestock, much of this habitat is out of production at any given time as farmers and ranchers rotate their stock to allow the land to recover before returning the land to its intended use. This results in a mixture of native and/or introduced grasses and forbs with early successional woody vegetation in many areas. Due to the agricultural aspect of the study area, some tracts are inundated with water for extended periods that contribute to habitat for mid-continental waterfowl, wading birds, and other water-dependent vertebrate species.

Between 350 and 400 species of birds occur as migrant and winter resident species in the study area and include many species of waterfowl (Smeins, 1994). In autumn, following crop production, migratory birds arrive to the area for wintering grounds and remain until March. Some of the common waterfowl associated with the study area's inundated agricultural fields include the green-winged teal (*Anas crecca*), northern pintail (*Anas acuta*), common gadwall (*Anas strepera*), American widgeon (*Anas americana*), lesser scaup (*Aythya affini*), northern shoveler (*Anas clypeata*), snow goose (*Chen caerulescens*), and greater white-fronted goose (*Anser albifrons*). Year-round residents that may occur include such species as the great blue heron (*Ardea herodias*), great egret (*Ardea alba*), white-faced ibis (*Plegadis chihi*), killdeer (*Charadrius vociferous*), black vulture (*Coragyps atratus*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), northern bobwhite, mourning dove, American crow (*Corvus brachyrhynchos*), northern mockingbird (*Mimus polyglottos*), European starling (*Sturnus vulgaris*), northern cardinal (*Cardinalis cardinalis*), red-winged blackbird (*Agelaius phoeniceus*), eastern meadowlark, and savannah sparrow (*Passerculus sandwichensis*). Other avian migrant/winter resident species expected to occur in the study area include the American robin (*Turdus migratorius*), chipping sparrow (*Spizella passerina*), Brewer's blackbird (*Euphagus cyanocephalus*), and the savannah sparrow (*Passerculus sandwichensis*). Avian species, which may nest in the study area during spring and summer, include the common nighthawk (*Chordeiles minor*) and the eastern kingbird (*Tyrannus tyrannus*).

The Gulf Coast toad (*Bufo valliceps valliceps*) and Woodhouse's toad (*Bufo woodhousii*) are the most likely amphibians to occur in the study area's inundated agricultural fields. Other amphibians found in drier pastures and grasslands include the spotted chorus frog (*Pseudacris clarkii*) and southern leopard frog (*Rana utricularia*). One terrestrial turtle species, the ornate box turtle (*Terrapene ornata ornata*), could occur in this habitat type. Common lizard species that may occur throughout the study area include the green anole (*Anolis carolinensis*) and ground skink (*Scincella lateralis*). Snake species that may occur in the study area include the Texas rat snake (*Elaphe obsolete lindheimeri*), Gulf Coast ribbon snake (*Thamnophis proximus orarius*), and the rough earth snake (*Virginia striatula*). Several venomous species of snakes may also occur within the study area, including the southern copperhead (*Agkistrodon contortrix contortrix*) and western cottonmouth (*Agkistrodon piscivorus leucostoma*).

Mammal species that may occur throughout the pastureland/grassland/cropland habitat include the Virginia opossum (*Didelphis virginiana*), common raccoon (*Procyon lotor*), house mouse (*Mus musculus*), eastern cottontail (*Sylvilagus floridanus*), swamp rabbit (*S. aquaticus*), striped skunk (*Mephitis mephitis*), marsh rice rat (*Oryzomys palustris*), hispid cotton rat (*Sigmodon hispidus*), northern pygmy mouse (*Baiomys taylori*), coyote, common gray fox (*Urocyon cinereoargenteus*), feral pig (*Sus scrofa*), and white-tailed deer (*Odocoileus virginianus*).

3.12.5 Forestlands

The nonwetland forested areas (Austin's Woods) include mixed hardwood woodlands found in uplands and floodplains (including riparian edges) within the study area. This habitat type is widespread throughout the study area and provides cover and edge habitat for a variety of wildlife. Wildlife movement patterns are variable due to the amount of food, cover, and water provided in a particular area.

Amphibians likely to occur within the study areas wooded habitats include the northern cricket frog (*Acris crepitans crepitans*), upland chorus frog (*Pseudacris triseriata feriarum*), bronze frog (*Rana clamitans clamitans*), northern spring peeper (*Pseudacris crucifer*), and the smallmouth salamander (*Ambystoma texanum*). One terrestrial species of turtle that may occur in upland (nonwetland) forest habitat is the three-toed box turtle (*Terrapene carolina triunguis*). Common lizard species that may occur include the five-lined skink (*Eumeces fasciatus*) and the northern fence lizard (*Sceloporus undulatus hyacinthinus*). Snake species that may occur in this habitat type include the eastern hognose snake (*Heterodon platirhinos*), rough earth snake (*Virginia striatula*), and rough green snake (*Opheodrys aestivus*). Venomous species of snakes that may occur within the study area include the Texas coral snake (*Micrurus fulvius tener*) and western pigmy rattlesnake (*Sistrurus miliarius streckeri*).

Avian residents likely to occur in these forested areas include the white-eyed vireo (*Vireo griseus*), red-shouldered hawk (*Buteo lineatus*), Carolina chickadee (*Poecile carolinensis*), tufted titmouse (*Baeolophus bicolor*), red-bellied woodpecker (*Melanerpes carolinus*), blue jay (*Cyanocitta cristata*), Carolina wren (*Thryothorus ludovicianus*), barred owl (*Strix varia*), and eastern screech owl (*Otus asio*) in addition to those found in pastureland/grassland/cropland habitat. Seasonal nesting species include the yellow-billed cuckoo (*Coccyzus americanus*), red-eyed vireo (*Vireo olivaceus*), Swainson's warbler (*Limnothlypis swainsonii*), summer tanager (*Piranga rubra*), and great crested flycatcher (*Myiarchus crinitus*). The forested areas in the study area also provide important habitat for neotropical species during fall and winter migrations, such as the yellow-bellied sapsucker (*Sphyrapicus varius*), northern flicker (*Colaptes auratus*), eastern phoebe (*Sayornis phoebe*), ruby-crowned kinglet (*Regulus calendula*), hermit thrush (*Catharus guttatus*), cedar waxwing (*Bombycilla cedrorum*), orange crowned warbler (*Vermivora celata*), yellow-rumped warbler (*Dendroica coronata*), and white-throated sparrow (*Zonotrichia albicollis*).

Mammal species that may occur throughout the forested areas include species found in the pastureland/ grassland/cropland habitat, as well as the eastern fox squirrel (*Sciurus niger*), eastern gray squirrel (*Sciurus carolinensis*), and eastern red bat (*Lasiurus borealis*).

3.12.6 Nonforested Wetlands

Nonforested wetlands tend to provide habitat for more water-dependent species, such as wading birds, waterfowl, and other aquatic species similar to those commonly occurring in the inundated agricultural fields described above. Additional aquatic species favoring this habitat type include the American alligator (*Alligator mississippiensis*), diamondback water snake (*Nerodia rhombifer*), broad-banded water snake (*Nerodia fasciata confluens*), green tree frog (*Hyla cinerea*), bull frog (*Rana catesbeiana*), nutria (*Myocastor coypus*), and American beaver.

3.12.7 Forested Wetlands

Many of the wildlife species likely to occur in this habitat type are the same as those found in nonwetland forest habitats since these habitats are so closely associated within the study area. Forested wetlands also support American alligators; water snakes including the broad-banded water snake (*Nerodia fasciata confluens*) and western mud snake (*Farancia*

abacura reinwardtii); common turtle species including the Mississippi mud turtle (*Kinosternon subrubrum hippocrepis*) and red-eared slider (*Trachemys scripta elegans*); and amphibians including Blanchard's cricket frog (*Acris crepitans blanchardi*), Cope's gray treefrog (*Hyla chrysoscelis*), and gray tree frog (*Hyla versicolor*).

In addition to wildlife, several species of domesticated animals are found within the region. Those commonly observed are cats (*Felix domesticus*), dogs (*Canis familiaris*), cattle (*Bos taurus* and *B. indicus*), horses (*Equus caballus*), and feral pigs (*Sus scrofa*).

3.13 WILD AND SCENIC RIVERS

The Wild and Scenic Rivers Act describes those river areas eligible to be included in a system afforded protection under the Act as free flowing and possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values.

The study area is not situated in the vicinity of any river on the National Inventory of river segments included in the National Wild and Scenic River System (NPS, 1999b).

The study area does include a listed unique stream segment. The portion of Big Creek within the Brazos Bend State Park was nominated as a stream of unique ecological value by the Region H Water Planning Board. The stream segment was recommended because the bottom hardwoods and associated wetlands provide valuable water quality; part of the Great Texas Coastal Birding Trail; and, designated as an Ecoregion Reference Stream by the TPWD River Studies Program for high dissolved oxygen and diversity of benthic macro invertebrates.

3.14 COASTAL BARRIERS

Coastal barriers are undeveloped areas on barrier islands and peninsulas or otherwise protected areas, as mapped by the United States Department of the Interior, General Land Office (GLO, 1994) Texas Coastal Management Program (TCMP). Coastal barriers can include coastal natural resources that provide sediment utilized in coastal processes and provide food and/or habitat for numerous faunal species. The landward boundaries of coastal barriers are distinct at the shoreline of bays and estuaries.

Part of the TCMP is to ensure the protection and/or restoration of these coastal barriers. City and county governments located in counties with barrier islands implement the TCMP policies related to preservation of beach access and dune protection. This is accomplished through development of Beach Access and Dune Protection Plans consistent with the TCMP policies per the Open Beaches Act, Dune Protection Act, and floodplain requirements. Participating agencies that review these protection plans include the Texas GLO, School Land Board, and the Office of the Attorney General. In addition, the TCEQ and TxDOT implement policies related to managing undeveloped areas of barrier islands through approval of special districts and transportation projects on barrier islands.

Fort Bend County does not have any coastal barrier resources. Brazoria County does have coastal barrier resources in the southern portion of the county. However, the study area is wholly outside any coastal barrier systems.

3.15 COASTAL ZONE MANAGEMENT

The Coastal Zone Management Act of 1972, as amended, provides for preservation, protection, development, and where feasible, restoration and enhancement of the nation's coastal zone resources. The State of Texas now has an approved TCMP (approved by the NOAA on December 23, 1996, as published in the FR [Volume 62, Number 7] on January 10, 1997).

The GLO is the state's designated lead agency that coordinates the development and implementation of the TCMP. Prior to the TCMP, various state and federal agencies, cities, and counties managed the state's coastal resources as dictated by regional issues or other state and federal regulatory mechanisms (e.g., the CWA). These entities will continue to implement the TCMP through ongoing programs where appropriate. However, existing programs are required to ensure consistency with the TCMP.

The boundary of the Texas Coastal Management Zone (CMZ) was delineated in accordance with the requirements of the Federal Coastal Zone Management Act, federal program development and approval regulations, and Texas Coastal Coordination Act. Requirements dictate that a state's coastal zone boundaries include four elements: inland boundary, seaward boundary, interstate boundaries, and federal lands excluded from the boundary.

No portion of Fort Bend County is included in the CMZ. Although the southern portion of Brazoria County is included in the CMZ, the study area for the proposed Grand Parkway Segment C lies approximately 13.5 miles north of the Texas CMZ. Coastal wetlands within the Chocolate Bayou riparian corridor in Brazoria County are approximately 6.5 miles from the study area (GLO, 1996).

3.16 ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act, as amended on October 11, 1996, directs that all federal agencies whose actions will impact essential fish habitat (EFH) must consult with the National Marine Fisheries Service (NMFS) regarding potential adverse effects. As a result, any project receiving federal funding must address potential impacts to EFH. The proposed project is outside the limits of tidally influenced, coastal waters and would not impact EFH; therefore, coordination with the NMFS is not required.

3.17 THREATENED AND ENDANGERED SPECIES

Table 3-22 includes those plant and wildlife species that are considered by the USFWS and TPWD to be federally and state-listed endangered, threatened or a candidate species and have a potential of occurrence in the project area. Sources reviewed to develop the list include the USFWS online database (2011), Poole et al. (2000), the TPWD's online Annotated

TABLE 3-22
ENDANGERED AND THREATENED PLANTS AND WILDLIFE OF POTENTIAL OCCURRENCE IN BRAZORIA AND FORT BEND COUNTIES

Common Name	Scientific Name	State Status	Federal Status	Habitat Description	County	Habitat Present within Study Area	Effect/Impact
AMPHIBIANS							
Houston Toad	*Bufo houstonensis*	E	E†	Sandy soil, breeds in ephemeral pools	Fort Bend	No	No
BIRDS							
American Peregrine Falcon	*Falco peregrinus anatum*	E	DM†	Potential migrant	Both	Yes	No
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	SOC	DM†	Potential migrant	Both	Yes	No
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	E	E†	Open prairies of mostly thick grass 1 to 3 ft tall; from near sea level to 200 ft along coastal plain on upper 2/3 of Texas coast	Fort Bend	No	No
Bald Eagle (Nesting)	*Haliaeetus leucocephalus*	T	DM	Near water areas, in tall trees	Both	Yes	No
Black Rail	*Laterallus jamaicensis*	SOC		Marshes, pond borders, wet meadows, and grassy swamps	Brazoria	No	No
Brown Pelican (Nesting)	*Pelecanus occidentalis*	E	DM	Island near coastal areas	Brazoria	No	No
Eskimo Curlew	*Numenius borealis*	E	E†	Grasslands, pastures, plowed fields, marshes, mudflats	Brazoria	No	No
Henslow Sparrow (winterin)	*Ammodramus henslowii*	SOC		weedy fields, fields with bunch grass, vines, and brambles, need bare ground	Both	Yes	No
Interior Least Tern	*Sterna antillarum athalassos*	E	E†	Nests along sand and gravel bars within streams and rivers, only listed when 50 miles inland.	Fort Bend	No	No
Piping Plover (Wintering)	*Charadrius melodus*	T	E, T	Beach and bayside mud or salt flats	Brazoria	No	No
Reddish Egret	*Egretta rufescens*	T	*	Brackish marshes and tidal flats	Brazoria	No	No
Snowy Plover	*Charadrius alexandrinus*	SOC		Coastal winter migrant	Brazoria	No	No
Southeastern Snowy Plover	*Charadrius alexandrinus tenuirostris*	SOC		Winter migrant on Texas coast beaches, bayside mud or salt flats	Brazoria	No	No
Sooty Tern	*Sterna fuscata*	T	*	Maritime bird	Brazoria	No	No
Sprague's Pipit	*Anthus spragueii*	--	C†**	Migrant, upland prairie, coastal grasslands	Both	Yes	No
Western Burrowing Owl	*Athene cunicularia hypugaea*	SOC		Open grasslands, prairie, plains, and savannahs	Fort Bend	No	No
Western Snowy Plover	*Charadrius alexandrinus nivosus*	SOC		Coastal winter migrant	Brazoria	No	No
White-faced Ibis	*Plegadis chihi*	T	†*	Freshwater marshes, but some brackish or salt marshes	Both	Yes	No
White-tailed Hawk	*Buteo albicaudatus*	T	*	Coastal Prairies	Both	Yes	No
Whooping Crane	*Grus americana*	E	E, EXPN	Winters in Aransas National Wildlife Refuge	Both	Yes	No
Wood Stork	*Mycteria americana*	T	*, E†	Prairie ponds and flooded pastures	Both	Yes	No
MAMMALS							
Jaguarundi	*Herpailurus yaguarondi*	E	E†	Thick brushland near water	Brazoria	No	No
Louisiana Black Bear	*Ursus americanus*	T	T†	Bottomland hardwoods; large, undisturbed forested areas	Both	No	No
Ocelot	*Leopardus pardalis*	E	E†	Dense chaparral; mesquite-thorn scrub and live oak mottes	Brazoria	No	No

TABLE 3-22, CONT'D

Common Name	Scientific Name	State Status	Federal Status	Habitat Description	County	Habitat Present within Study Area	Effect/Impact
Plains Spotted Skunk	*Spilogale putoria interrupta*	SOC	*	Open fields, prairies, croplands, fence rows, farm yards, brushy areas, and tall grass prairies	Brazoria	Yes	No
Red Wolf	*Canis rufus*	E	E†*	Extirpated, brushy, forested areas, coastal prairies	Both	No	No
West Indian Manatee	*Trichechus manatus*	E	E††	Gulf and bay system	Brazoria	No	No
FISH							
American Eel	*Anguilla rostrata*	SOC		Coastal waterways below reservoirs to gulf	Both	No	No
Sharpnose Shiner	*Notropis oxyrhynchus*	SOC	C, C†	Large turbid river, sand, gravel, and clay-mud bottom	Both	Yes	No
Smalltooth Sawfish	*Pristis pectinata*	E	E†	Sheltered bays, shallow banks, estuaries and river mouths	Brazoria	No	No

Source: USFWS (2011); Poole et al. (2000); TPWD (2011a, 2011b).
*These species occur on the state listing of threatened or endangered species; however, they are not federally listed at this time by the U.S. Fish and Wildlife Service (2011).
†These species are listed by the U.S. Wildlife Service; however, they are not listed to occur within this county by the Clear Lake office of the U.S. Fish and Wildlife Service (2011).
--Not listed for Texas Parks and Wildlife Department for this county.
E = endangered T = threatened H = historical occurrence I = introduced population C = candidate species SOC = species of concern DM = delisted taxon, recovered, being monitored first 5 years SAT = similarity of appearance to a threatened taxon, EXPN=Experimental population, Nonessential.

County List of Rare Species for Fort Bend and Brazoria counties (2011a), and Texas Natural Diversity Database [NDD]) (TPWD, 2011b). It should be noted that inclusion on the list does not imply that a species is known to occur in the study area for the proposed project, but only acknowledges the potential for occurrence. Only those species listed as endangered or threatened by the USFWS are afforded complete federal protection and are therefore discussed individually here.

In December 2011, a literature review of the Texas NDD, a continually updated data source, was conducted to identify known occurrences of threatened/endangered species within the study area for the proposed project. Based on a review of the Texas NDD (TPWD, 2011b), there are three documented occurrences of the Bald Eagle within the study area. No other documented occurrences of federally or state-listed endangered, threatened, or candidate species were present within the study area; however, it should be noted that a lack of documented occurrences does not mean listed species or their habitat are absent from the study area (TPWD, 2011b).

According to the USFWS, currently there are 106 species in the State of Texas federally listed threatened, endangered, or candidates for listing as threatened or endangered (USFWS, 2011). Of these, 13 species are listed by the USFWS (2011) as potentially occurring in Brazoria and Fort Bend counties. Additionally, 29 state-listed threatened or endangered species are included on the Annotated County List of Rare Species (TPWD, 2011a). Below are brief descriptions of the federally and state listed threatened and endangered species.

Amphibians

Houston Toad

The Houston toad (*Bufo houstonensis*), a federally and state-listed endangered species is included within the TPWD Annotated County List for Fort Bend County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. According to the Texas NDD (TPWD, 2011b), there are no occurrences of the Houston toad recorded within 1 mile of the Representative Alternatives. Loose sandy soil habitats required to provide habitat for the Houston toad are not present within the study area; therefore, the proposed project would have no effect on the Houston toad

Birds

American and Arctic Peregrine Falcon

The American peregrine falcon, state-listed threatened species, is a rare migrant statewide, and nests in the mountains of Trans-Pecos Texas, while the Arctic peregrine falcon is an uncommon migrant statewide and an uncommon winter resident on the Coastal Prairies and coast, where it typically occurs near bays and estuaries (Lockwood and Freeman, 2004). The USFWS recently removed the peregrine falcon from its list of endangered and threatened species, but the American and Arctic subspecies retain their state-listed status. Suitable nesting or wintering habitat is present in the project area; however, there are no documented occurrences of the American or Arctic peregrine falcon within 1 mile of the Representative Alternatives. The proposed project would have no impact on the American peregrine or Arctic peregrine falcon or their preferred habitats within the vicinity of the project.

Attwater's Prairie-chicken

The Attwater's prairie-chicken a federally and state-listed endangered species is included within the TPWD Annotated County List for Fort Bend County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. Attwater's prairie-chickens live on coastal prairie grasslands with tall grasses, such as little bluestem, indiangrass, and switchgrass. The birds like a variety of tall and short grasses in their habitat. They gather to choose a mate in an area of bare ground or short grass where the males can be easily seen by the females. Hens build their nest in tall grass and usually lay 12 eggs during nesting season. The eggs hatch in April or May. Small green leaves, seeds, and insects form the diet of the Attwater's prairie-chicken. Attwater's prairie-chickens live about 2 to 3 years in the wild (TPWD, 2011b). Based on a review of NDD files (TPWD, 2011b) and field investigations, no preferred habitat for the Attwater's prairie-chicken occurs within the Representative Alternatives. The proposed project would have no effect on the Attwater's prairie-chicken.

Bald Eagle

The Bald Eagle was delisted by the USFWS on August 8, 2007. The health of the Bald Eagle population will be monitored for the next 5 years, and the eagle could be reclassified after the 5-year monitoring period. The Bald Eagle is still listed as threatened by the TPWD. Additionally, the Bald Eagle is protected by the MBTA and the BGEPA. As described in Section 3.17, under the MBTA it is illegal to pursue, hunt, take, capture, kill, possess, sell, barter, purchase, export, or import migratory birds, their parts, nests or eggs, except as permitted by regulation. Additionally, "take" is defined under the MBTA as "pursue, hunt, shoot, wound, kill, trap, capture, possess, or collect" (USFWS, 2007a). The BGEPA prohibits the take, possession, sale, purchase, barter, offer to sell, purchase, or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit. "Take" is defined as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb" a bald or golden eagle. The term "disturb" under the BGEPA was recently defined by a final rule published in the FR on June 5, 2007. "Disturb" means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior (USFWS, 2007b).

Three Bald Eagle nests are known to exist within the study area vicinity. Two nests are located north of Smithers Lake and appear to be utilized by the same nesting pair. The other nest is located southeast of Lake Worthington. All three nests were observed in the field by study team ecologists during the 2000 DEIS field studies. An adult and an immature Bald Eagle were observed near the southern nest during field surveys conducted in February, March, and April 1999; an adult pair was observed near the newest nest location (February 2005). Observations from field visits between 2000 and 2005 confirmed the nest sites originally reported in the DEIS are still intact. In February 2005, during another field visit, it appeared that a branch supporting the nest had broken, and the nest had fallen to the ground. During the same field visit another nest was observed approximately 1,350 feet southwest of the previously documented nest and was assumed to have been constructed by the same nesting pair. The proposed project would have no effect on the Bald Eagle.

Brown Pelican

The federally and state-listed endangered Brown pelican (*Pelecanus occidentalis*) is primarily a coastal species that rarely ventures very far out to sea or inland. In Texas, it occurs primarily along the lower and middle coasts, but occasional sightings are reported on the upper coast and inland to central, north-central, and eastern Texas, usually on large freshwater lakes (TOS, 1995); however, such occurrences are relatively uncommon. The Brown pelican has been recorded from Brazoria County (Oberholser, 1974); however, coastal habitats and/or large freshwater lakes are not present within the study area. Impacts to the Brown pelican are not expected as a result of the proposed project; therefore, the project would have no effect on the Brown pelican.

Eskimo Curlew

The Eskimo curlew (*Numenius borealis*), a federally and state-listed endangered species is included within the TPWD Annotated County List for Brazoria County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The species is considered to be extinct, or nearly so. The last few observations on the Texas coast were in the 1960s (Linam et al., 1994). Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the Eskimo curlew recorded within 1 mile of the Representative Alternatives; therefore, impacts to the Eskimo curlew are not expected as a result of the proposed project. The proposed project would have no effect on the Eskimo curlew.

Piping Plover

The federally listed endangered and federally and state-listed threatened Piping plover (*Charadrius melodus*) is a regular post-breeding migrant along the Texas coast, where it overwinters (Oberholser, 1974; TOS, 1995), potentially occurring in Brazoria County. The Piping plover can be found along Texas beaches and tidal flats generally from mid-July through April. Preferred habitat for the Piping plover is larger expanses of coastal, intertidal sand or mud flats. This species has been observed in Brazoria County (Oberholser, 1974); however, preferred habitats for the Piping plover are not present within the study area. Impacts to the Piping plover are not expected as a result of the proposed project; therefore, the proposed project would have no effect on the Piping plover.

Interior Least Tern

The Interior least tern, a federally listed and state-listed endangered species, is included within the TPWD Annotated County List for Fort Bend County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. In Texas, the state-listed endangered Interior least tern historically nested on sandbars of the Colorado River, Red River, and Rio Grande. At present time, small breeding populations exist at isolated locations within the species' historic range, although the species' winter range includes the entire Texas Gulf Coast. The Interior least tern's preferred nesting habitat is unvegetated, frequently flooded sand flats, salt flats, sand and gravel bars, and sand, shell, and/or gravel beaches (Campbell, 1995; Thompson et al., 1997). The habitats described above are not present within the vicinity of proposed project, and according to the Texas NDD (TPWD, 2011b), there are no occurrences of the Interior least tern within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the Interior Least Tern.

Reddish Egret

The Reddish egret, a state-listed threatened species, typically inhabits salt bays and marshes. Its breeding range is restricted to the Gulf Coast where it commonly nests in yucca-pricklypear thickets (Oberholser, 1974). The Reddish egret may occur within the project area during post-breeding visits. Based on a review of NDD files (TPWD, 2011b) and field

investigations, no preferred habitat for the Reddish egret occurs within the Representative Alternatives. The proposed project would have no impact on the Reddish egret.

Sooty Tern

The state-listed threatened Sooty tern is a largely pelagic (open ocean) species that nests on isolated tropical and subtropical islands (Schreiber et al., 2002). The species is a rare and local summer resident along the middle and lower Texas Gulf Coast from Matagorda County to Cameron County, where they nest in small numbers on natural and spoil islands, particularly in the Laguna Madre (Oberholser, 1974; Lockwood and Freeman, 2004). Sooty terns are rare in summer along the upper Texas Coast (Richardson et al., 1998). Because there are no coastal waters present within the project area, potential habitats for the Sooty tern would not be present in the project area. Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the Sooty tern within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the Sooty tern.

Sprague's Pipit

Sprague's pipit is a federal candidate for listing as threatened or endangered within the counties crossed by the project. Sprague's pipit would be considered a wintering migrant, potentially occurring in native upland prairie grasslands (Jones, 2010). Because native prairie grasslands are not common within the vicinity of the project, occurrences of this species are unlikely; therefore, the proposed project would have no effect on Sprague's pipit.

White-faced Ibis

The White-faced ibis, a state-listed threatened species, forages bays, marshes, lakes, and ponds (Rappole and Blacklock, 1994). The proposed project would have a negligible impact on marshes and is not likely to adversely impact any White-faced ibis that might be present in the vicinity of the project.

White-tailed Hawk

The state-listed threatened White-tailed hawk is an uncommon local resident on the Gulf coastal plain, from Harris County south to the Rio Grande (Lockwood and Freeman, 2004). White-tailed hawks inhabit coastal prairies and brushlands, as well as inland mesquite and oak savannahs (Farquhar, 1992). This species may occur in the general vicinity of the project area. The proposed is not likely to adversely impact any White-tailed hawk that might be present in the vicinity of the project.

Whooping Crane

The proposed project lies within the historic wintering range and within the migration corridor of the Whooping crane, a federally and state-listed endangered species. Each fall, the entire population from the Wood Buffalo National Park in northern Canada migrates primarily to the Aransas National Wildlife Refuge and adjacent areas of the central Texas coast

in Aransas, Calhoun, and Refugio counties to overwinter (USFWS, 1995). During migration, these birds may stop at small stock ponds or other waterbodies occurring in pastureland and feed in cultivated fields such as sorghum or corn. The Whooping crane is a potential migrant through the project area, since it has been recorded from both counties, including Fort Bend County at Brazos Bend State Park (Oberholser, 1974); however, the proposed project would not impact critical habitats for the whooping crane. The proposed project would have no effect on the Whooping crane.

Wood Stork

The Wood stork, a state-listed threatened species, is an uncommon to common post-breeding visitor to the central and upper coastal prairies and a regular visitor of lakes and reservoirs in central and east Texas. The Wood stork forages in shallow standing water, including saltwater, and usually roosts communally in tall snags; however, the Wood stork has not been known to nest in Texas since 1960. The proposed project would have a negligible impact wood stork habitat and not likely to adversely impact the Wood stork.

Mammals

Jaguarundi

The jaguarundi (*Herpailurus yagouaroundi*), a federally and state-listed endangered species is included within the TPWD (2011a) Annotated County List for Brazoria County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The jaguarundi is considered to have historically resided in the study area counties; however, the project area is not within its current range of occurrence. Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the jaguarondi within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the jaguarondi.

Louisiana Black Bear

The Louisiana black bear (*Ursus americanus*), a federally and state-listed threatened species is included within the TPWD (2011a) Annotated County List for both counties crossed by the project; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The Louisiana bear is considered to have historically resided in the study area counties; however, the project area is not within its current range of occurrence. Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the Louisiana black bear within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the Louisiana black bear.

Ocelot

The ocelot (*Leopardus pardalis*), a federally and state-listed endangered species included within the TPWD (2011a) Annotated County List for Brazoria County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The ocelot is considered to have historically resided in the study area counties; however, the project area is not within its current range of occurrence. Furthermore, according to the Texas NDD (TPWD,

2011b), there are no occurrences of the ocelot within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the ocelot.

Red Wolf

The red wolf (*Canis rufus*), a federally and state-listed endangered species included within the TPWD (2011a) Annotated County List for both counties crossed by the project; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The red wolf historically occurred throughout the eastern half of the state but is now extinct in the wild in Texas, having been extirpated by the 1970s (Schmidly, 2004). Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the red wolf within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the red wolf.

West Indian Manatee

The West Indian manatee (*Trichechus manatus*), a federally and state-listed endangered species, is included within the TPWD Annotated County List for Brazoria County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The West Indian manatee occurs in coastal waters along the Texas Gulf Coast. Because there are no coastal waters present within the project area, potential habitats for the West Indian manatee would not be present in the project area. Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the West Indian manatee within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the West Indian Manatee.

Fish

Smalltooth Sawfish

The smalltooth sawfish (*Pristis pectinata*), a federally and state-listed endangered species, is included within the TPWD Annotated County List for Brazoria County; however, this species is not listed as potentially occurring within either of the two counties crossed by the USFWS. The smalltooth sawfish occurs in coastal waters along the Texas Gulf Coast. Because there are no coastal waters present within the project area, potential habitats for the smalltooth sawfish would not be present in the project area. Furthermore, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the smalltooth sawfish within 1 mile of the Representative Alternatives; therefore, the proposed project would have no effect on the smalltooth sawfish.

Sharpnose Shiner

The sharpnose shiner, a federally listed candidate species, is a small, slender minnow, endemic to the Brazos River Basin in Texas. Historically, the sharpnose shiner existed throughout the Brazos River and several of its major tributaries within the watershed. They generally feed on aquatic invertebrates while also consuming a large amount of sand/silt, which indicates foraging behavior occurs among the sediment, as well as on drift in the water column (Marks et al., 2001). In the

1960s, samples taken from a Fort Bend County location on the Brazos River identified a small population of sharpnose shiners; however, samples taken in the 1990s and 2001 indicated that no sharpnose shiners were present within this portion of their historical range (Center for Biological Diversity, 2002). In another Brazos River study within Fort Bend County, three individuals of sharpnose shiner were collected in the confluence of Allens Creek during September 20–23, 2001 (Gelwick and Li, 2002). Other current information indicates that the population within the Upper Brazos River drainage (upstream of Possum Kingdom Reservoir) is apparently stable, while the population within the Middle and Lower Brazos River Basins may only exist in remnant areas of suitable habitat, or may be completely extirpated (USFWS, 2006). Because the project area is located in the Middle and Lower River Basin area, the presence of the sharpnose shiner within the Brazos River of the project area is not likely. Furthermore, large perennial water sources crossed by the proposed project (Brazos River and Oyster Creek) will be crossed by spanning, and direct impacts to those potential habitats would be avoided; therefore, the proposed project would have no effect on the sharpnose shiner.

Mollusks

False spike mussel

The false spike mussel (*Quadrula mitchelli*) is a state-listed threatened species in Brazoria County, Texas. The false spike mussel is possibly extirpated in Texas, with historic populations in the Rio Grande, Brazos, Colorado, and Guadalupe River Basins (TPWD, 2011a). According to the Texas NDD (TPWD, 2011b), there are no occurrences of the false spike mussel within 1 mile of the Representative Alternatives. Large perennial water sources crossed by the proposed project (Brazos River and Oyster Creek) will be crossed by spanning, and direct impacts to those potential habitats would be avoided; therefore, the proposed project would have no impact on the false spike mussel.

Smooth Pimpleback

The smooth pimpleback (*Quadrula houstonensis*) is a state-listed threatened and federally listed as a candidate species for both counties crossed by the project. The smooth pimpleback is native to the central and lower Brazos and Colorado Rivers with recent observations in 2006 as close as the mainstem Brazos River in Grimes, Waller, and Austin counties (50 CFR Part 17). According to the Texas NDD (TPWD, 2011b), there are no occurrences of the smooth pimpleback within 1 mile of the Representative Alternatives. Large perennial water sources crossed by the proposed project (Brazos River and Oyster Creek) will be crossed by spanning, and direct impacts to those potential habitats would be avoided; therefore, the proposed project would have no effect on the smooth pimpleback.

Texas Fawnsfoot

The Texas fawnsfoot (*Truncilla macrodon*) is a state-listed threatened and federally listed as a candidate species for both counties crossed by the project. The Texas fawnsfoot is native to the Brazos and Colorado rivers in central Texas, with historic populations from Fort Bend County upstream to the lower reaches of the Clear fork Brazos River in Shackelford county (50 CFR Part 17); very few live individuals have been found in recent decades. According to the Texas NDD

(TPWD, 2011b), there are no occurrences of the smooth pimpleback within 1 mile of the Representative Alternatives. Large perennial water sources crossed by the proposed project (Brazos River and Oyster Creek) will be crossed by spanning, and direct impacts to those potential habitats would be avoided; therefore, the proposed project would have no effect on the Texas fawnsfoot.

Reptiles

Alligator Snapping Turtle

The state-listed threatened alligator snapping turtle is the largest North American freshwater turtle species. Alligator snapping turtles inhabit deep rivers, lakes, and large streams of the southeastern U.S. (Garrett and Barker, 1987). Documented records exist from nearby Harris County (Dixon, 2000) and northward, but the species could occur in the project area where suitable habitat exists. The proposed project is not likely to adversely impact any alligator snapping turtle that might be present in the vicinity of the project.

Sea Turtle Species

The five species of sea turtles that, according to the USFWS, that could potentially occur in Brazoria County are the state-listed endangered Atlantic hawksbill sea turtle (*Eretmochelys imbricata*), federally and state-listed threatened green sea turtle (*Chelonia mydas*), federally and state-listed endangered Kemp's Ridley turtle (*Lepidochelys kempii*), federally and state-listed endangered leatherback sea turtle (*Dermochelys coriacea*), and federally and state-listed threatened loggerhead sea turtle (*Caretta caretta*). These sea turtles occur in coastal waters along the Texas Gulf Coast. Because there are no coastal waters present within the project area, potential habitats for the sea turtle species listed above would not be present in the project area; therefore, the proposed project would have no effect on sea turtle species.

Texas Horned Lizard

The Texas horned lizard (*Phrynosoma cornutum*) is a state-listed threatened species that typically occurs in open, semi-arid regions with bunchgrasses that are not present within the study area (TPWD, 2011b). The proposed project will have no impact on the Texas horned lizard.

Timber/Canebrake Rattlesnake

The state-listed threatened timber/canebrake rattlesnake (*Crotalus horridus*) occurs in the eastern third of the state, where it typically inhabits bottomland forests, mesic woodlands, palmetto groves, cane thickets, and brushy fields, especially where dense vegetation grows just above ground level (Werler and Dixon, 2000). The species may occur in the project area in appropriate habitat types; however, no individuals were encountered during the field investigations. The proposed project is not likely to adversely impact the timber/canebrake rattlesnake.

Vascular Plants

Texas Prairie Dawn-Flower

Of the federally listed threatened and endangered plant species in Texas, only one, Texas prairie dawn-flower (*Hymenoxys texana*), is known to exist within the Fort Bend County portion of the Study Area. There are no federally threatened or endangered plant species known to occur in Brazoria County.

The Texas prairie dawn-flower is an annual sunflower (Asteraceae) and ranges in height from 3.5 to 18 centimeters. The bracts conceal the minute ray flowers; the yellow disk flowers are 3 to 4 millimeters long. Texas prairie dawn-flower habitat consists of small, sparsely vegetated areas of fine-sandy saline soil. Competition within these poorly drained depressions is limited due to saline conditions tolerated by the Texas prairie dawn-flower. These sparsely vegetated areas commonly occur on the lower sloping portion of pimple (mima) mounds or on the level to slightly concave areas around the mound's base. Pimple mounds are typically 10 to 50 feet in diameter and less than 12 inches high; the soil is usually sandier than the surrounding flat areas. The Texas prairie dawn-flower is also found in bare spots at locations that endure continuous disturbance over a period of time (e.g., overgrazing), but which have been allowed to revegetate naturally. In the absence of continued disturbance, colonies of Texas prairie dawn-flower are usually out-competed by other vegetation until the continued disturbance resumes and favorable conditions return to the site. The preferred bare spots are usually wet to moist during the winter and early spring but lose all traces of hydrology by summer. These low-lying locations may or may not be considered jurisdictional wetlands. The Texas prairie dawn-flower flowers and fruits from mid-March to mid-April and senescence are usually complete by May (USFWS, 1995). About 50 population sites of this species survive in Fort Bend and Brazoria counties; however, according to the Texas NDD (TPWD, 2011b), there are no occurrences of the Texas prairie dawn-flower within 1 mile of the Representative Alternatives. Due to the potential for occurrence of the Texas prairie dawn in the adjacent proposed Grand Parkway Segment C project area, field surveys were conducted to determine the presence or absence of populations and suitable habitat within the alternative alignments for the proposed project. Ground surveys conducted for the Texas prairie dawn during the flowering period found no populations within alternative alignments. The majority of the study area traversed by the Representative Alternatives and Preferred Alternative consists of improved pasture, agricultural (row crop) fields, woodlands, or developed areas. The proposed project would have no effect to the Texas prairie dawn.

State-Listed Species

Based on a review of the habitat descriptions of each state-listed endangered, threatened, or rare bird species potentially occurring within the study area (see Table 3-22), the following species may potentially occur within the study area at various periods throughout the year: American Peregrine Falcon, Arctic Peregrine Falcon, White-faced Ibis, White-tailed Hawk, Wood Stork, false spike mussel, and alligator snapping turtle. None of the state-listed species have any known documented occurrences within the study area (TPWD, 2011b).

State-listed bird species (American Peregrine Falcon, Arctic Peregrine Falcon, White-faced Ibis, White-tailed Hawk, and Wood Stork) would likely occur within the study area to forage, roost, or migrate through the region. Direct mortality impacts are not anticipated to any state-listed threatened, endangered, or rare bird species as a result of the proposed project.

Other state-listed threatened, endangered, or rare species in Table 3-22 (false-spike mussel and alligator snapping turtle) may be present within the study area; however, their presence would be limited to the bed and banks of perennial water sources such as the Brazos River or Oyster Creek. Because such water sources would be spanned by bridging, direct impacts to these state-listed species are not anticipated as a result of the proposed project. Additionally, potential habitats for the timber/canebrake rattlesnake would be crossed by the proposed project; however, direct mortality impacts are not anticipated as result of the proposed project.

Overall, the proposed project would have no impact on any of the above-listed state species.

Federally Listed Species

Based on a review of the habitat descriptions of federally listed species potentially occurring within the Fort Bend and Brazoria counties, habitat capable of supporting the whooping crane, Sprague's pipit, the sharpnose shiner, and the Texas prairie dawn-flower, smooth pimpleback, and Texas fawnsfoot may be present within the project area. None of the federally listed species above have known documented occurrences within the study area (TPWD, 2011b). Additionally, the Bald Eagle, although delisted, federally is still afforded federal protection under the MBTA and BGEPA. According to the TPWD NDD (2011), three Bald Eagle nests are known to exist within the study area vicinity.

Federally listed bird species (Whooping crane, Sprague's pipit) may occur within the study area to forage, roost, or migrate through the region. Direct mortality impacts are not anticipated to any federally listed threatened, endangered, or candidate for listing bird species as a result of the proposed project. Additionally, the project alignment would not cross in close enough proximity to nest locations of the federally delisted Bald Eagle to interfere with normal breeding, feeding, or sheltering behavior of nesting eagles in the study area and therefore would not "disturb" the Bald Eagle under BGEPA guidelines.

Other federally listed threatened, endangered, or rare species in Table 3-22 (sharpnose shiner, smooth pimpleback, and Texas fawnsfoot) may be present within the study area; however, their presence would be limited to the bed and banks of perennial water sources such as the Brazos River or Oyster Creek. Because such water sources would be spanned by bridging, direct impacts to these state-listed species are not anticipated as a result of the proposed project.

3.18 HISTORIC AND ARCHEOLOGICAL RESOURCES

3.18.1 Cultural Environment

The study area is located in Fort Bend and Brazoria counties, which are within the THC's Southeast Texas Archeological Study Region of the Eastern Planning Region (Kenmotsu and Perttula, 1993). The following discussion of local cultural history is based on the location of the study area within the Southeast Texas Archeological Study Region and more specifically the Brazos River basin and the Coastal Prairie physiographic zone. In general, the Coastal Prairie environment is relatively resource poor, lacking the silicious gravels of the more-inland Outer Coastal Plain and the concentration of food resources that characterize the Coastal Littoral Zone. Although not a severe limiting factor, surface waters within the Coastal Prairie are not as potable as less-clayey inland sources and are not augmented by springs that occur in both Outer Plain and Coastal Littoral environments. Relatively abundant food resources, however, can be found in the riparian hardwood forests that grow along area streams. The habitats associated with oxbow lakes, which currently show up as meander scars and are present within the study area, represent an especially favorable environment for human habitation.

3.18.2 Prehistoric Period

The earliest generally accepted culture of the Americas, the Paleoindian, ranged over most of North America by the close of the Pleistocene. Several types of well-made, lanceolate projectile points diagnostic of this culture, including Scottsbluff, Clovis, Plainview, and Angostura, and possibly San Patrice, have been recovered from archeological contexts in the vicinity of the study area. The sites in the study area vicinity yielding this information include 41HR5 and 41HR7 (Wheat, 1953), and 41HR85 (Aten et al., 1976).

Evidence is scarce of the Early Archaic cultures. Aten (1983) sees a continuation during the Early Archaic of a generalized technology and minimum band level of social organization established during the Paleoindian period. Dart points that suggest Early Archaic activity in this area are primarily central Texas types, including Baird, Bell, Andice, and Wells points.

At sites dating to the Middle Archaic, more regional variation in artifact assemblages has been noted (Aten, 1983). The potential for occupation of the study area before and during the Middle Archaic is felt to be low, except between 2000 B.C. and A.D. 1000 when Oyster Creek Meander Belt was active. Along the Brazos River at the inland boundary of the Coastal Prairie (Hall, 1981), a variety of both central and east Texas point types occur, including Bulverde, Trinity, and Carrollton points.

The Late Archaic extends from the approximate period when the sea level attained its current state until the introduction of the bow and arrow along the Brazos River in ca. A.D. 900 (Hall, 1981). Regional cultural variations, and possibly population as well (Fields et al., 1983), are greatest during the Late Archaic. Aten (1983) cites Story (1980) in her recognition of two broad adaptive patterns that coexisted within different geographic regions of east Texas during the Late Archaic. The pattern that may be applicable to the study area and to the preferred alternative is Story's eastern strategy, which "was designed for the humid woodlands and prairies of the upper coast," and included a seasonal round with group dispersal in

coastal areas during the summer and consolidation in inland areas in the winter months. The systematic exploitation of coastal resources increased the potential for occupation of the study area, most likely by groups based along the Brazos River. Projectile points diagnostic of Late Archaic occupations are the eastern types, Gary, Kent, Yarbrough, and Ellis, but also include Palmillas and Refugio types characteristic of the Coastal Bend (Patterson, 1979).

The Late Prehistoric period is a time of relatively static environmental conditions that lasted until European contact. Population during the Late Prehistoric tended to increase until European-introduced disease decimated the aboriginal inhabitants. Patterson (1979) observed an increase in numbers of Late Prehistoric sites while individual sites exhibited fewer cultural remains. He interprets this as evidence of a more mobile lifestyle. Projectile points diagnostic of Late Prehistoric occupations include Perdiz and Scallorn, and ceramics may include Goose Creek Plain variety Anahuac, O'Neal Plain variety Conway, Mandeville Plain, Tchefuncte Plain, Goose Creek variety unspecified, and Tchefuncte Stamped, for the earlier part of the period, and San Jacinto Incised and Baytown Plain, varieties Phoenix Lake and San Jacinto (Aten, 1983). It should be noted that these ceramic sequences were developed for the Galveston Bay area and may or may not apply to any archeological remains in the study area.

The Historic Indian period occupation of the project vicinity by aboriginal people has been previously described by Wheat (1953) and Fields et al. (1983); therefore, further elaboration will not be made at this time. However, it is important to note that Aten (1983) places this area within a buffer zone between the known territories of the Coco, Akokisa, and Tonkawa, and occupation of the study area by these groups could have been possible.

3.18.3 Historic Period

The historic period for the area now known as Fort Bend and Brazoria counties and the vicinity of the proposed Grand Parkway Segment C Preferred Alternative begins with Cabeza de Vaca's account of his survival as a member of the ill-fated Narvaez expedition of 1527. Marooned by a hurricane that destroyed the fleet, Cabeza de Vaca and a handful of companions are believed to have landed at the mouth of Oyster Creek during their journey to find the Spanish colonies in Mexico. Cabeza de Vaca is said to have remained in the area for a while and traveled with the local native groups up and down Oyster Creek (Wharton, 1939). The area remained under Spanish control, occupied by native groups and only a few remote Spanish missionary and military outposts, until the early nineteenth century when Mexico established its claim to the region. Occupation of this region by Native American groups was limited, although areas on either side of Big Creek were a favorite campground for local groups. This area is noted to have been within a buffer zone between the known territories of the Coco, Akokisa, and Tonkawa, suggesting occupation by any of these groups at some time may have been possible (Aten, 1983).

In the early decades of the nineteenth century, Anglo-American immigration into this area began under the leadership of *empresario* Stephen F. Austin, who was empowered by the Mexican government to promote settlement and grant lands in the fertile Brazos River Valley. Native groups were not prevalent around the Brazos River at this time, although occasional encounters with them did occur. The Brazos River was too far south and east for the Comanches, and only a single camp

of Karankawas was known to be located on Big Creek, about 15 miles below the town of Richmond. Colonization by Stephen F. Austin's "Old Three Hundred" began when the first of the settlers were dropped off at the mouth of the Brazos River in January of 1822. They then traveled upriver to a large bend in the Brazos River, where the City of Richmond is currently located, and constructed a log shelter known as the "Fort." Each of the Old Three Hundred settlers was granted a league and a labor of land by the Mexican government in 1824 (Wharton, 1939). They established homesteads along the fertile agricultural lands of the Brazos River, along the banks of Big Creek to the south, and along Oyster Creek to the east. The earliest houses were of hand-hewn logs, typically two rooms in size with an open central hallway known as a "dog run." Although Stephen F. Austin's father, Moses Austin, envisioned the colonists developing commercial-scale agriculture based on sugar and cotton as the principal crops, corn was the crop raised initially as subsistence for the families and their livestock. After 1824, the Mexican government authorized the granting of additional lands, and more settlers continued to arrive.

As settlers moved into the area, there were two recorded encounters with the Karankawas living along Big Creek in Fort Bend County. A significant event in local history was the "Big Creek Campaign" in 1824. Several Karankawas were pursued in retaliation for stealing some horses (Wharton, 1939). Another battle with Karankawas occurred on Jones Creek in adjacent Brazoria County in 1824. As more settlers arrived, typically from the deep southern states of the United States (Jordan et al., 1984), a cotton gin, general store, and trading post were established at Richmond. A ferry also operated across the Brazos River at Thompsons Crossing.

During this period, cotton was grown as a commercial crop. Sugar was also cultivated, but on a more experimental level by relatively few farmers (Creighton, 1975). Although the Mexican government prohibited the importation of slaves from Africa, both cotton and sugar cultivation required intensive labor commitments throughout most of the year. To meet the labor requirements, some of the more wealthy planters brought slaves into the region when they originally settled there. The prohibition against importation of slaves was flagrantly violated by several of the larger cotton growers who participated in the illicit slave trade (Wharton, 1939).

Growing resentment toward the Mexican government's control over the settlers stirred revolutionary sentiments. Recommendations for Texas's declaration of independence emanated from the towns of Columbia and Brazoria in the months before the Mexican army began its advance into Texas (Creighton, 1975). When news of the massacres of Texan forces at Goliad and San Antonio reached Austin's colonies, many local residents abandoned their homesteads and fled eastward in an event known as the "Runaway Scrape." Some individuals hid in the woods along the way, while others fled as far as Louisiana (Wharton, 1939).

In April 1836, General Santa Anna and his Mexican troops left San Felipe and traveled south to a homestead near present-day Kendleton on Turkey Creek. From there he marched to the Thompsons ferry on the Brazos River. He captured the ferry, the west side of the river, and ransacked and burned every house in Richmond. Santa Anna then divided his troops, taking only a portion of them to Harrisburg. The remaining troops were left to camp in the river bend at

Richmond for 3 days. Santa Anna's defeat and capture at San Jacinto left the rest of his Mexican force to retreat by way of Turkey Creek (Wharton, 1939).

After the Texans' victory over Santa Anna, Austin's colonies experienced a period of tremendous growth and prosperity. Many new towns were established; Fort Bend and Brazoria counties were formed with Richmond and Brazoria as their respective county seats. The defeat of Mexican rule also enabled the open practice of non-Catholic religions, which in turn led to the establishment of numerous churches.

In the period between the Texas Revolution and the Civil War, sugar quickly became the dominant cash crop, and large sugar plantations using slave labor developed along the banks of the Brazos River and Oyster Creek. As the plantations prospered and expanded their production, small sugar mills were quickly replaced by larger steam-powered mills. Within the current project vicinity, Francis Bingham and Sterling McNeel each had large brick sugarhouses that served the Bingham and Darrington plantations as well as other local planters. Early accounts document that sugarcane was brought in from the field by slaves using horse-drawn carts and in some cases on small rail cars (Armstrong, 1991).

Prior to the arrival of commercial rail transportation, the Brazos River not only provided fertile land for cultivation, but also provided a vital means of transporting crops to market. Steamboats regularly traveled the Brazos River with cargoes of cotton and sugar. Landings were located at plantations in Big Creek, Waters, Richmond, Gaston, and Randoon. However, a bar at the mouth of the Brazos River sometimes hindered transportation, and steamers began to abandon the Brazos River in favor of Buffalo Bayou and the growing town of Houston. Efforts to improve navigation on the Brazos River were made in the 1850s. The Galveston and Brazos Navigation Company secured a charter to construct a canal from the mouth of the Brazos River to West Galveston Bay. This canal was dug by hand and was completed sometime between 1854 and 1857 (Meyers, 1998).

The first chartered railroad in the area was built from Harrisburg to Richmond through Sugar Land. It was chartered in 1850 and was called the Buffalo Bayou, Brazos and Colorado Railroad. In 1856, the Houston Tap and Brazoria Railway Company was established. Nicknamed the "Sugar Road" or the "Sugar Land Express," this railway ran east of the Brazos River along Oyster Creek, stopping at various plantations, including the Darrington and Bingham plantations, along the way. It was later purchased by Missouri Pacific, which eventually abandoned the line south of Arcola. The abandoned line was still noted, however, on both the 1963 Juliff and 1953 Thompsons USGS 7.5-minute quadrangle maps.

In order to secure certain economic and political advantages, Texans voted to join the United States in 1845. However, by 1861, amid increasing tensions between northern and southern states, the residents of Fort Bend and Brazoria counties strongly favored secession as a way to preserve their cultural and economic interests. Locally, Terry's Texas Rangers was formed under the direction of Colonel B.F. Terry. Many men from Fort Bend and Brazoria counties joined the Confederate districts of Texas, New Mexico, and Arizona, headquartered in Houston. The 26th Texas Calvary and other regiments were camped outside Richmond for purposes of patrolling the Brazos River. Confederate blockade-runners also operated on the Brazos River, exporting cotton and sugar in exchange for supplies to support the Southern war effort.

The end of the Civil War marked the beginning of a difficult time for the people of Fort Bend and Brazoria counties. The federal government seized crops and Texas was placed under military rule with federal troops camped at Velasco and Sandy Point (Creighton, 1975). When local slaves learned of their emancipation on June 19, 1865, more than a year after President Lincoln had proclaimed their freedom, many of the former slaves had few options but to stay on at the plantations and work for meager wages or a share of the crop. Continued black settlement on the Levi Jordan Plantation in Brazoria County is one documented example of this type of by former slaves during the postbellum period (Brown et al., 1974; Brown and Cooper, 1990; Freeman, 2004). Others moved into small ethnic enclaves, often on the land of a failed plantation, and eventually developed self-reliant communities with their own churches and schools. However, most former slaves left the rural plantations and moved into developing "Freedmen" communities in and around major market centers, like the Fourth Ward of Houston.

In the Reconstruction years, many former plantation owners were forced to subdivide their land into smaller parcels and offer them either for sale or lease as a means to recover some of their lost investment and to generate income. Over time a viable postbellum pattern of agriculture developed that included several variations on the theme of smaller-scale farms operated by individuals or single-family units. One of these variations came to be known as sharecropping because the landowner provided housing, tools, and grain for planting in exchange for one-half to two-thirds of the crop produced by the sharecropper, an individual who was often a former slave of the landowner. Another variation, called tenant farming, required that the tenant be somewhat better off financially and thereby able to provide his own tools and grain (Moore, 2001). Under tenant farming, the landowner was usually paid a fee at harvest time for leasing the land to the tenant. Certain plantation owners were known to abuse their position by evicting the sharecroppers or tenants at harvest time and seizing all of the crops (Wharton, 1939).

Gradually, sharecropping and tenant farming in the Reconstruction period developed into a pervasive system that continued well into the late nineteenth and early twentieth centuries. However, another agricultural system that more closely resembled the antebellum pattern of forced gang labor also developed during Reconstruction to cultivate large tracts of land. In an attempt to address agricultural labor shortages, the state instituted a program in 1871 that allowed for the leasing of imprisoned convicts as farm laborers on large private plantations (Armstrong, 1991; Wharton, 1939). The convicts were also leased out to construct railroads. This system worked so well that in 1886 the legislature authorized the state's penitentiary system to purchase farmlands and operate them with convict labor. This was the beginning of the Texas prison farm system. Many of the state's prison farm units are located in Fort Bend and Brazoria counties, including the Darrington Prison Farm within the proposed Grand Parkway Segment C Preferred Alternative.

The Darrington State Prison Farm, formerly known as the Darrington Plantation, was one of the old plantations acquired by the state under the prison farm program. The land was initially granted to Achilles McFarland, one of Austin's Old Three Hundred settlers, but later became a large sugar plantation owned by Sterling McNeel. Years later, in his early-twentieth-century recollection of Brazoria County's most prominent plantations, Strobel (1926) describes the Darrington Plantation as having slave cabins and a large main residence, as well as a brick sugarhouse with a double set of kettles. According to

Strobel's account, pre–Civil War improvements had long since disappeared from the plantation. The Houston Tap and Brazoria Railway at one time ran through the plantation/prison en route to Sugar Land. According to Jimmy Hawkins (2001), Farm Manager of the Darrington Prison Farm, the rail line carried inmates to the various prisons. The remains of it today can be seen as a dirt road running through the farm.

To a great extent, the success of Reconstruction in the South was dependent on the rebuilding and expansion of rail transportation, particularly in areas of agricultural production. For Brazos River farms and ranches, rail connections to Houston and Galveston were of vital importance. In 1867 a yellow fever epidemic in Galveston caused the City of Houston to prohibit rail service between the two cities. With the realization that this embargo was an asset to the Port of Houston, subsequent embargoes were imposed. In order to survive, the City of Galveston built the Gulf, Colorado and Santa Fe Railroad to bypass the City of Houston. This line came under the control of the Atchison, Topeka, and Santa Fe Railroad in 1886, which is now part of the Burlington, Northern and Santa Fe Railroad that still operates today. Starting in the 1880s, railroad promoters and land speculators brought German, Irish, Czech, and Polish immigrants to the area. These immigrants established small farmsteads across the area and founded numerous ethnic communities. Fairchild, Needville, and Guy are each examples of the type of small rural farming communities founded in the late nineteenth and early twentieth centuries along the rail lines. Another such community at the eastern end of the proposed Grand Parkway Segment C Preferred Alternative is Iowa Colony.

While cattle ranching had long been an integral part of agricultural operations in Fort Bend and Brazoria counties, the introduction of barbed wire and selective breeding practices in the 1880s gave ranchers better control over their cattle and allowed them to increase the size and quality of the herds. Several meat-packing plants were constructed in the area, and as railroads were established, ranchers began to ship their cattle to market by rail. The hurricane of September 1900 that destroyed Galveston also devastated farms and communities across much of Fort Bend and Brazoria counties. Although many people lost their lives and their livelihoods in the storm, people quickly began to rebuild, and the early twentieth century became a time of prosperity for Fort Bend and Brazoria counties. Cars, electricity, and telephone service were introduced to the counties. Land speculators attracted new immigrants, and new communities were formed.

The region's economy began to change with the advent of oil and mineral extraction. Shortly after substantial oil and gas deposits were discovered at Spindletop and Galveston Bay, sulfur was discovered at Bryan Mound in 1901. Subsequent sulfur discoveries in the area include Big Creek Community (1922) and the Orchard Dome (1924). By 1928, the Gulf Coast of Texas was producing over 90 percent of the world's consumption of sulfur. None of these finds are within the preferred alternative.

In response to increasing mineral exploitation, the Damon branch of the Gulf, Harrisburg, and San Antonio Rail line was constructed from Rosenburg through Damon in 1917. In 1931, the Thompsons branch of the Gulf, Colorado and Santa Fe Railroad was constructed from Thompsons southwest to Cane Jet, and joined with the Atchison, Topeka, and Santa Fe at SH 60 just below Wharton. This may have been a Works Progress Administration project. Both rail lines were abandoned in 1985.

During World War I, the demand for sulfur greatly increased and production levels increased accordingly. Local participation in the war effort included the formation of local home guard units. Draft boards were formed and men were selected to join the service. Company D, 5th Texas Infantry was organized in Brazoria County and deployed to France. Federal troops were sent to guard the sulfur plant at Freeport. Coincident increases in shipbuilding also raised the demand for live oak treenails, wooden pegs used in shipbuilding at the time. Brazoria County factories located at Brazoria, Sweeney, and Hasima were the primary source of this product, much of which was used at Texas's shipbuilding centers at Galveston and Orange.

The demand for sulfur decreased with the end of World War I, and oil exploration became more profitable. Although the first oil gusher in Brazoria County occurred in 1902, a long and prosperous series of discoveries was made after the war. A complete listing of local oil fields includes Blue Ridge (1919), Big Creek Fields (1922), Orchard Field (1926), Sugar Land Field (1927), Long Point (1924), Clodine (1929), Thompsons (1931), Katy (1935), and Needville (1941). The oil boom brought a surge in population and was good for the local economy.

In the project vicinity, the Thompson Oilfield was discovered on the Jones Plantation in the 1920s. Originally founded by one of Austin's Old Three Hundred colonists, Henry Jones's plantation survived the Civil War as a combined cattle-ranching and farming operation that was less dependent on slaves for labor and financial collateral. By the time of the oil discovery, the operation had been passed down from Jones through a series of heirs and was known as the George Ranch. While oil provided a substantial portion of the family's wealth, much of which was used for philanthropic pursuits, the George Ranch continued its traditional interests in farming and ranching, albeit in a modernized manner greatly differing from the ranch's antebellum origins. By the 1920s, a substantial portion of the George Ranch was being farmed by tenants who leased houses and attended a school that belonged to the George Ranch. A significant and distinctive collection of surviving tenant farmhouses, set amid an expansive agricultural landscape extending east to the Brazos River, was recognized and avoided along FM 762 during the initial route selection process for the proposed Grand Parkway Segment C.

By 1928, rice farming had become an important industry in the Brazoria-Fort Bend area, and the Richmond rice canal system was constructed. At Crabb Switch, a local stop along the Gulf, Colorado and Santa Fe Railway, a large rice drying, storage, and shipping facility developed to serve local area rice growers. Located within the original Joseph Kuykendall Survey, this agricultural industrial facility and its associated general store were both recognized and avoided during route selection for the current project.

During the 1930s, the Great Depression had substantially less of an impact upon the Texas Gulf Coast than elsewhere, although a significant drought made grain prices prohibitive, which in turn made it difficult for farmers to feed their herds. As a result, the quality of cattle was poor, and buyers for the United States government purchased starving cattle and sent them to the Houston Cattle Company in Missouri City for slaughter. There the company boned, processed, cooked, and canned the beef to help feed the destitute.

During the 1940s, local area residents again contributed to the war effort. Local militia groups were formed to protect the home front. Farming and manufacturing, as well as oil and mineral production, were increased in response to the war effort. A prisoner of war camp was established in Richmond to house German, Italian, and Japanese prisoners who were expected to work within the local community. Following locally familiar prison-farming practices, a Fort Bend County family could hire up to 10 prisoners at a time to help with planting and harvesting. Rice farmers paid prisoners 40 cents a hour for 10-hour days. The farmers provided the transportation and the U.S. Army provided the guards and food. Prisoners also worked at the meat-packing plants and built the Clodine rice dryer. Other structures in the area may have also been constructed by the prisoners of war. In Brazoria County, prisoner of war camps were located at Camp Angleton and Alvin, supplying cheap labor to the communities there as well.

3.18.4 Archeological Resources

Archeological Resources

Various laws and regulations require consideration of the impacts of the proposed project on cultural resources such as archeological sites and historic structures. TxDOT operates under several formal agreements that expedite its compliance with these laws and regulations.

Not all cultural resources are afforded equal treatment in the planning process under applicable cultural resources laws. Historic (NRHP-listed or -eligible) properties and State Archeological Landmarks (SALs) are those objects, sites, and structures that have characteristics that require those resources to be given further consideration in the project planning process. Projects should avoid and minimize impacts to historic properties and SALs when possible. They should resolve the effects of impacts, usually through some mitigation measures, when avoidance is not possible.

Consideration of possible impacts to cultural resources is required under the Antiquities Code of Texas because the project is being planned as a public transportation facility with TxDOT. Cultural resource impacts must also be considered under Section 106 of the National Historic Preservation Act, as amended, because the project is being planned with federal funding provided by the FHWA. The purpose of the intensive survey was to identify NRHP-eligible sites within the existing and proposed ROW for the proposed Grand Parkway Segment C Preferred Alternative and involved archival research and fieldwork conducted in 2001 and 2003 under Texas Antiquities Permit No. 2553.

The investigations (as discussed in Section 3.18 and 4.18) were performed in compliance with the National Historic Preservation Act of 1966 (Public Law [PL] 89-665), as amended in 1974, 1976, 1980, and 1992; the NEPA of 1969 (PL 91-190. 83 Stat. 915, 42 USC 4321, 1970); the Procedures of the Advisory Council on Historic Preservation (ACHP) (36 *Code of Federal Regulations* [CFR] 800); and other appropriate cultural resources legislation and guidelines, as well as the guidelines set forth by the Register of Professional Archaeologists and the Council of Texas Archeologists.

3.18.4.1 Previous Archeological Investigations

Numerous cultural resource management studies have been conducted in Fort Bend and Brazoria counties, including large-scale archeological surveying, testing, and mitigation conducted in association with the construction of Barker and Addicks reservoirs. Reviews of previous research along the upper Texas coast have been presented by Aten (1983), Fields et al. (1983), and Stokes (1985). In addition, Moore et al. (1989) and Patterson (1995) have compiled extensive bibliographies for the archeology of this region. This section briefly summarizes previous archeological investigations in the region through the Grand Parkway Segment C surveys in 2003.

The earliest professional investigations in the upper Texas Gulf Coast region were conducted by J.E. Pearce under the sponsorship of the Bureau of American Ethnology. Between 1918 and 1932, Pearce, then Chairman of the Department of Anthropology at the University of Texas, conducted or directed numerous reconnaissance and excavation projects throughout East Texas (Pearce, 1932). Pearce seems to have been largely concerned with the relationship between Texas cultures and the high cultures of the Mississippi Valley, the American Southwest, and Mesoamerica, as well as the role of eastern Texas as a route for diffusion between these cultures. His interest in the upper coast area must be considered somewhat marginal. With the exception of excavation at the Caplen site, a prehistoric cemetery in Galveston County, little of his investigations in the region were ever published (Campbell, 1957).

Addicks Reservoir

The next major investigation in the vicinity of the study area and the proposed Grand Parkway Segment C Preferred Alternative was conducted in Addicks Reservoir for the Smithsonian Institution River Basin Surveys by Joe Ben Wheat (1953). Wheat conducted surveys in the late 1940s, along Langham, South Mayde, and Bear creeks and Buffalo Bayou recording nine archeological sites. Wheat performed excavations at several sites where he obtained data that resulted in the development of a chronological sequence for the area based on lithic typology (Suhm et al., 1954).

Considerable research effort has also been expended in the Addicks area by members of the Houston Archeological Society. Numerous surveys and excavations conducted by the Houston Archeological Society have contributed to our understanding of prehistoric settlement patterns, chronology, and technological change (Patterson, 1972, 1973a, 1973b, 1974, 1975, 1976, 1977, 1980a, 1980b). Most of this information has been published in the *Houston Archeological Society Newsletter*.

A comprehensive investigation conducted in this area was a survey in Addicks Reservoir, conducted under the auspices of the Cullen Foundation for the City of Houston (Fields et al., 1983). In the course of this investigation, Fields et al. surveyed all high-site-probability areas and sampled low-probability areas (1983). They investigated 46 prehistoric and 18 historic sites. The preferred location for historic settlement was found to be in upland situations, while all but two of the prehistoric sites were confined to pimple mounds in the floodplains (Fields et al., 1983).

Shortly after the completion of the Addicks Reservoir survey, Prewitt & Associates, Inc., was contracted by the USACE to perform a survey at Bear Creek Park, which lies within Addicks Reservoir. This investigation included the survey of approximately 37.8 percent of the 2,920-acre park and resulted in the recording of five prehistoric and seven historic sites. Three of the prehistoric sites were found to be clustered in a group of at least 26 natural pimple mounds. The fourth site is located on a relatively isolated pimple mound, while the fifth is on an upland margin. Two of the prehistoric sites provided temporally diagnostic artifacts, which suggested occupation during the Early and/or Late Ceramic periods. The remaining sites yielded only nondiagnostic lithic debitage (Howard and Freeman, 1983).

In early spring 1983, one of the sites (41HR436) recorded during the Addicks Reservoir survey was tested (Kotter and Fields, 1983). The testing was directed toward the assessment of the site's eligibility for the NRHP. Site 41HR436 is one of only a few known upland prehistoric sites in Addicks Reservoir. The site was recommended for nomination to the NRHP (Kotter and Fields, 1983) and was nominated by the USACE Galveston District.

Another archeological investigation within Addicks Reservoir was a survey for improvements to Eldridge Road (Voellinger and James, 1984). Two sites previously reported by Fields et al. (1983) (41HR473 and 41HR188) were revisited, but no additional cultural resources were identified.

Barker Reservoir

Texas A&M University conducted a survey in 1983 on portions of Barker Reservoir, where a total of 17 archeological sites were recorded. Of those sites, 5 are historic and 12 are prehistoric. Ten of the 12 prehistoric sites are located on pimple mounds or terrace remnants (Ensor et al., 1987).

Other work by Texas A&M in Barker Reservoir included an additional archeological survey and test excavations (Ensor et al., 1987). The archeological survey resulted in the location of five prehistoric sites and one historic site. The prehistoric sites are all located on small pimple mounds in the floodplain. They were found to contain information potentially significant to area prehistory. The historic site, a twentieth-century farmhouse, was not considered to be eligible for the NRHP.

This survey was followed by the NRHP eligibility testing of three of the sites recorded during the survey: 41FB70, 41FB71, and 41FB72 (Ensor et al., 1987). Two of these sites (41FB71 and 41FB72) were found to contain cultural materials relating to the Late Archaic or Early Ceramic and Late Ceramic periods. The third site, 41FB70, exhibited material relating to a Late Ceramic period of occupation. All three sites were recommended for nomination to the NRHP and were subsequently excavated and reported by Ensor in 1987.

Additional inventories and assessments of cultural resources were conducted at Barker Reservoir (Fields et al., 1986). This work included a survey of 3,122 acres along the floodplains of Buffalo Bayou and its tributaries, as well as 1,293 acres in the adjacent uplands. During this effort, 31 prehistoric and 21 historic sites were documented. All of the prehistoric sites were located on natural rises and mounds on the floodplain of Buffalo Bayou.

Other Work

The Texas Archeological Survey of The University of Texas at Austin conducted an archeological survey along Clear Creek pursuant to a flood control project in Brazoria County. This effort located 76 prehistoric sites and 2 historic sites (McGuff and Cox, 1973).

Following the Clear Creek survey, a comprehensive investigation within the East Texas Coastal Plain was reported by Hall (1981). In 1974 and 1975, investigations of 15 archeological sites were conducted in Austin County along Allens Creek, a tributary of the Brazos River approximately 115 kilometers from the Gulf Coast. Excavations at one site, 41AU36, revealed 236 burials that could be segregated into four cemeteries, dating from the Middle Archaic through the Late Prehistoric period.

In November and December 1983, an archeological survey of the First Colony Levee Improvement District (LID) was conducted (Scott and Freeman, 1984). Four historic sites and one prehistoric site were recorded during the survey and a previously recorded prehistoric site was also revisited. All of the newly recorded prehistoric sites were located on the Oyster Creek floodplain, most on low rises or pimple mounds. Further archival research and informant interviews were recommended for the four historic sites to adequately assess them in terms of the NRHP eligibility. The prehistoric sites were not considered eligible for the NRHP, and no further work was recommended. In early spring 1984, a second phase of the cultural resource work of the First Colony LID was conducted (Ragsdale and Fields, 1984). This phase, a historical assessment, consisted of an informant, archival, and literature search as well as an architectural evaluation on one historic site. As a result of the records search, the location of a cemetery and a turn-of-the-twentieth-century farmstead, as well as the probable locations of a second earlier farmstead and a plantation, were identified. However, only the farmstead and the cemetery could be located in the field. Neither of these sites, nor the locations of the earlier farmstead and plantation, were judged to be eligible for the NRHP.

The USACE, Galveston District conducted an archeological survey along Oyster Creek and located five prehistoric sites (Good, 1985) in oxbow cutbank exposures and plowed portions of floodplain rises. A historical and archeological assessment for the Sienna Plantation development was conducted in summer 1984 (Glander, 1984). One prehistoric site and several historic structures relating to the plantation era were documented. A cultural resources survey of the 1,300-acre Riverbrook Associates property was conducted during 1986, which identified eight previously unrecorded sites—seven historic housesites and one disused cemetery (Hudson, 1986).

During January and February 1986, the NRHP testing was conducted on site 41FB99, the Flat Bank Creek site, located along a channel of the Oyster Creek meanderbelt. The testing program revealed midden deposits and several pit features. Radiocarbon dating and artifact analysis indicated that the site was occupied between about A.D. 800 and 1600. An earlier preceramic component was possibly present as well. Due to the site's considerable research potential, it was judged to be eligible for the NRHP (Kelly et al., 1994).

During spring 1987, an archeological survey of Cinco Ranch identified one historic site and four prehistoric sites (Voellinger et al., 1987). The four prehistoric sites were later subjected to a program of archeological testing designed to determine their NRHP eligibility status. The testing revealed that three of the sites contained substantial quantities of buried cultural debris and were therefore potentially eligible for the NRHP. The fourth site, however, yielded no artifactual remains during the testing phase of the project and thus did not contain enough retrievable information to warrant the NRHP nomination.

An archeological survey of Natchez, a 1,200-acre development in Fort Bend County, was conducted in late fall 1987 and winter 1988 (Voellinger et al., 1988). As a result of that survey, 15 previously unrecorded cultural resource sites were located: 13 historic sites, 1 prehistoric site, and 1 multicomponent historic/prehistoric site. The prehistoric components appeared to offer scant cultural deposits and were not likely to yield significant information. Of the historic components, one site was thought to be related to an early-nineteenth-century occupation. A second site, an industrial site, appeared eligible for the NRHP due to its direct association with the development of rice farming, an important trend in the local history. The remaining historic sites appeared to be related to the sharecropper occupation of the area.

A survey was conducted of the Joseph S. and Lucie H. Cullinan Park (Moore and Moore, 1991). Data recovery was eventually conducted (Moore et al., 1996) at two prehistoric sites (41FB199 and 41FB200) located during the original survey of the park.

Survey and trenching (Sherman, 1998) and data recovery (Rogers et al., 2000) were conducted at site 41FB255, a Late Prehistoric site located on a natural levee of an abandoned channel of Oyster Creek. This site appears to represent multiple occupations during the Late Prehistoric period. Seven radiometric samples were submitted with returned dates ranging between A.D. 979 and 1598. This project also conducted a DNA study, which was the first time any DNA had been sampled and tested from prehistoric human skeletal remains from Texas (Rogers et al., 2000).

Data recovery was conducted at old Velasco (41BO125) (Earls and Tomka, 1994) at the mouth of the Brazos River. Previous work conducted at 41BO125 includes that conducted by Fox et al. (1981). This effort also included research on the Quintana site of the Brazos River. An archeological survey of the Quintana Beach County Park included the reassessment of site 41BO116 (Corbin, 1987).

Archeological excavations were conducted at the Varner-Hogg Plantation State Historical Park in Brazoria County (Earls and Tomka, 1994). Earlier work conducted at the park examined the historic occupation of the plantation and included the documentation of building foundations and construction monitoring (Crouch, 1982).

Other investigations within the two counties include a cultural resources survey of an 18-acre development project on Clear Creek in Brazoria County, which assessed the integrity of prehistoric site 41BO182 (Moore, 1994); a survey along a proposed pipeline corridor in the Brazoria National Wildlife Refuge, which yielded negative results (Booth et al., 1994); and a cultural resource survey of a well pad in Brazoria County, also yielding negative results (Moore et al., 1996). Numerous

other surveys, typically limited in size and scope, have been conducted in the area by the USACE. These reports are on file as letter reports at the THC.

Reconnaissance survey, archival research, and informant interviews for the proposed Grand Parkway Segment C were conducted previously in 1999 (Sherman et al., 2003) to assess archeological high-probability areas (HPAs) within the Universe of Alternatives and identify any cultural resource sites through their surface expression. This work resulted in the identification of four newly recorded archeological sites (41FB271, 41FB272, 41BO203, and 41BO204). Of these sites, only 41FB272 is located within the proposed Grand Parkway Segment C Preferred Alternative. Five previously recorded sites (41FB114, 41FB127, 41FB128, 41FB133, and 41FB134) were also visited and assessed based on surface expression. Of these sites, only 41FB127, 41FB128, and 41FB134 are located within the proposed Grand Parkway Segment C Preferred Alternative. All three of these are historic sites have been negatively impacted by suburban encroachment.

3.18.4.2 Recorded Archeological Site Locations

At the time of the official archeological records review (1999), approximately 32 previously recorded archeological sites had been recorded within the study area. Most of the known site locations were identified from the official site file records at the Texas Archeological Research Laboratory (TARL), which revealed more than 190 previously recorded archeological sites in Brazoria County and more than 250 sites in Fort Bend County. In Brazoria County, nine sites were NRHP listed, two were determined eligible for the NRHP, and eight were identified as SAL properties. In Fort Bend County, the NRHP and the SAL publications each listed two sites. None of the NRHP or SAL properties were located in the study area, and none were located within the final proposed Grand Parkway Segment C Preferred Alternative because all such sites had been avoided through project planning and design adjustments. Of the 32, Several previously recorded archeological sites for which the NRHP eligibility determinations have not been made are located within the proposed Grand Parkway Segment C Preferred Alternative. These include historic sites 41FB127, 41FB128, and 41FB134, and prehistoric/historic site 41FB272. All four of the historic and prehistoric/historic sites have been negatively impacted by suburban encroachment.

3.18.4.3 Reconnaissance Survey of High-Probability Areas

In addition to these approximately 32 previously recorded archeological site locations, it was recognized that the study area likely contained other archeological sites of potential historical significance. To assess the potential for locating additional archeological resources, efforts were made to predict and ground-truth accessible areas with a high probability for locating additional archeological sites. HPAs for prehistoric and historic cultural resource sites were predicted using 7.5-minute topographic maps of the study area and available soils data. The HPAs were defined as areas in proximity to major drainage areas, on natural levees, and in proximity to previously recorded cultural resource sites. Previous research has shown that the majority of the previously recorded prehistoric sites in this region are located on rises within floodplain

settings. Historic sites are located within both floodplain and upland settings. The field reconnaissance to ground-truth the HPAs was limited to accessible tracts within the study area.

About one-third of the HPAs examined are located in the Brazos River Valley in areas where fluviate and deltaic deposits date to the Holocene. The bordering upland areas represent older Late Pleistocene, fluviate and deltaic deposits that predate human occupation in the region. Previous archeological investigations in the region have demonstrated that historic and some prehistoric sites exist in upland regions. It was expected that sites located on older geological landforms would not be found in deeply buried contexts. For this reason, upland prehistoric sites were expected to be found close to the ground surface. Likewise, historic sites in upland areas were expected to be found close to the ground surface. The integrity of these sites most probably would depend on the range of historic transformations to which they have been subjected, such as agricultural and housing development.

The portion of the study area that is located within the Brazos River floodplain has the potential to contain deeply buried archeological sites. Previous research has demonstrated that sandy floodplain rises located in areas where Holocene deposits outcrop, such as natural levees and pimple mounds, have a high probability of containing prehistoric sites, some of which could be deeply buried and maintain a high degree of integrity. A high occurrence of historic sites was not expected for such landforms. However, if such sites are located there, it was expected that they could maintain a high degree of integrity. Floodplain settings not on rises were considered to have some potential for containing cultural resources. However, identification of buried sites in this setting was hampered because such areas were obscured by dense clay at the ground surface, as observed during the field reconnaissance.

To ground-truth the predicted HPA predictions, a complete pedestrian walkover of accessible portions of each HPA was undertaken in 1999 (under Antiquities Permit 2173). Two archeologists traversed each HPA two times following a serpentine pattern to search for surficial evidence of cultural occupation. Particular attention was paid to areas where the ground surface was visible, such as roadcuts, rodent burrow spoil piles, cut banks, treefalls, cattle trails, and dirt roads.

Five previously recorded sites were revisited and four cultural resources sites were newly recorded during the reconnaissance survey. Together, the previously recorded and newly recorded archeological site locations amounted to a total of 32 recorded site locations within the study area at the conclusion of the reconnaissance survey.

3.18.4.4 Intensive Survey of High-Probability Areas for the Preferred Alternative

A TxDOT archeologist evaluated the potential for the proposed undertaking to affect archeological historic properties (36 CFR 800.16(l)) or SALs (13 Texas Administrative Code [TAC] 26.12) in the area of potential effect (APE). The APE comprises the existing ROW within the project limits (and any areas of new ROW or easements). The APE extends to the maximum depth of impact below the modern ground surface. Current schematic designs for the project estimate that depth to extend 25–50 feet below current ground surface. Section 106 review and consultation proceeded in accordance with the First Amended Programmatic Agreement among the FHWA, TxDOT, the Texas State Historic Preservation Officer (SHPO), and ACHP regarding the Implementation of Transportation Undertakings, as well as the Memorandum of

Understanding between the THC and TxDOT. The following documentation presents TxDOT's findings and explains the basis for those findings.

An intensive survey of the APE was performed under Texas Antiquities Permit No. 2553. On the basis of these investigations, four recorded sites were revisited, 41FB272, 41FB127, 41FB128, and 41FB134; all were historic-age sites, though 41FB272 also had a possible prehistoric component. Based on the revisits, it was determined that all of the sites were extensively disturbed by modern urban development and were not considered NRHP eligible under the criteria of 36 CFR 60.4. No further research was recommended at these site locations.

The intensive survey of previously identified HPAs resulted in the recording of three historic-age sites:

- 41BO212 – a historic-age site of unidentified use or function. Cultural materials observed on the surface included red brick fragments, iron fragments, and clear glass fragments. Four shovel-tests and a single backhoe trench were excavated. The shovel-tests yielded a metal hinge, two clear glass fragments, and an unidentified animal bone. The trench yielded clear glass fragments (some from a modern bottle), decomposed unidentifiable nails, fence staples, a thick brown ceramic sherd, white porcelain sherds, and faunal remains. All excavated cultural materials were encountered at 10–20 centimeters below the surface. According to an informant from the Darrington Prison unit, local accounts suggest that the location of this site may be associated with an African-American antebellum and postbellum occupation, possibly former slave quarters.
- 41BO213 – a known historic-age dump. According to an informant from the Darrington Prison unit, this site has been in use as a dump since the existence of the prison. The close proximity of this dump to 41BO203 (the Mary Bingham residence – within the Francis Bingham plantation) and 41BO204 (a structure possibly associated with the Bingham house), may indicate a possible association with the Bingham Plantation. Numerous cultural materials were observed during the pedestrian survey on the ground surface including porcelain toilet sherds, brick fragments, plastic, metal fragments, glass, rubber, and clothing pieces. A single trench was excavated within the boundaries of 41BO213; no cultural materials were observed.
- 41BO218 – the reported location of a "brick-lined well" and structure. An informant from the Darrington Prison unit reported that the site is possibly associated with a watering station for the Houston, Tap, and Brazoria Railroad, constructed in 1854 and continuing in use until about the Great Depression under the Houston and Great Northern line, the Gulf, Colorado, and Santa Fe line, and the Atchison, Topeka, and Santa Fe line. The informant reported that the prison had excavated the well to a depth of 2.4 meters below the surface and capped the remnant of the well. Six shovel tests were excavated, no cultural materials were encountered, nor were any observed on the surface. No evidence of a structure was observed.

The NRHP eligibility of these three sites has not been determined. Eligibility testing at the three sites was recommended to determine significance if these sites cannot be avoided.

Based on archival research, two additional HPAs were identified:

- An area of the Preferred Alternative adjacent to the Mary Bingham residence, which is recorded as 41BO203 and 41BO204, both of which are outside of the preferred alignment (east of Oyster Creek and adjacent to Willow Lake); this area is also the same HPA where 41BO213 was encountered.
- The area within the Preferred Alternative between 41BO212 and the Brazos River and 100 meters to the east of 41BO212.

It was recommended that these areas should be systematically surveyed by metal detectors and auger testing to identify any cultural materials that may be associated with Old Three Hundred and plantation-era sites and may yield information regarding historic plantation settlement patterns. It was further recommended that if 41BO212, 41BO213, and 41BO218 cannot be avoided, by adjustments in final design (or depth of impact in the case of 41BO218), each of these sites should be tested for NRHP eligibility. TxDOT suggests that the sites be formally tested to determine eligibility in order to determine whether redesign is necessary.

TxDOT completed its review on September 18, 2006 (Bettis, 2006; Appendix I), and the Texas SHPO concurred with all findings and recommendations on October 10, 2006. As of August 31, 2002, TxDOT had received no objection to the project from federally recognized Native American tribes with a demonstrated historic interest in the project area, although all asked to be kept apprised of progress.

3.18.5 Historic Resources

The information reported in this section generally describes nonarcheological historic resources, or buildings, structures, objects, sites and districts that are 50 years of age or older, within the study area and how they relate to the major periods of historic development discussed above in the Cultural Chronology. A more detailed discussion of these resources as they occur in relation to the alternatives considered for this project is presented in Section 4.17.

3.18.5.1 Nonarcheological Historic Properties

A search of official cultural resource agency records and site listings at the outset of the original nonarcheological historic resource investigations indicated that no historic properties (NRHP-listed, NRHP-eligible, Recorded Texas Historic Landmarks, nonarcheological SALs, or Official Texas Historical Markers) had been recorded in the study area. However, it was anticipated that other historic resources in the study area might be eligible for NRHP listing and could be subject to impacts as a result of this project. Following completion of the nonarcheological historic resource surveys, the George Ranch Historical Park was determined eligible for the NRHP listing and one building within the park, the Pickens House, was designated as an Recorded Texas Historic Landmark.

3.18.5.2 Historic Resources Survey Results

To identify historic-age resources in the study area, research was conducted of historical maps of Fort Bend and Brazoria counties, TxDOT's Historic Bridges Inventory, local historical literature, and knowledgeable informants before a historic resources survey was conducted. Review of the 1930s and 1950s State Highway Department maps for the study area revealed that the study area was still largely undeveloped agricultural land into the mid-twentieth century, with a typical pattern of house sites located along the edges of the county and state roadways. It was also apparent from historical maps that concentrations of historic buildings could occur, particularly in the vicinity of older railroad towns, such as Bonney, Rosharon, and Crabb. Other historic building sites and cemeteries were also anticipated across the study area, but in more remote locations, such as the Big Creek area in the south-central portion of the study area. While suburban development in the study area is having an increasingly destructive impact on the older buildings and occupation sites, particularly in the northern part of the study area, land use in the study area is still dominated by farms and ranches.

In general, the array of residential, commercial, agricultural, industrial and ecclesiastical building types observed in the study area represent patterns of rural agricultural and community development that were typical of Texas and the Brazos Valley in the late nineteenth to mid-twentieth century period. Individual family dwellings were the most common building type, with virtually all examples representing common "national folk" house styles that spread across the United States after the arrival of railroads. These styles include late nineteenth century "Victorian" farmhouses, early twentieth century Bungalows, and mid-twentieth century Ranch houses. One factor that contributed to the nationwide distribution of these house types was the widespread availability of mass-produced building materials after the arrival of the railroad (McAlester and McAlester, 1984).

Generally, surviving examples of the more recent building types and styles are more abundant than examples of the older types and styles. Notably, very little architectural evidence remains in the study area to represent the earlier period of immigration, settlement, and agricultural development in the early to mid-nineteenth century. For example, the only hand-crafted Anglo-American log cabins observed by the research team are located in the George Ranch Historical Park, and evidence of mid-nineteenth-century plantation houses has been limited largely to archeological foundation elements. Instead of log cabins and grand plantation homes that characterized the area in the early to mid-nineteenth century period, it is the individual farmstead site of the late nineteenth to early twentieth century period that has survived and characterizes historic architectural development patterns of the study area today.

A particularly intact group of tenant farmhouses associated with the George Ranch was identified along FM 762, outside of the George Ranch Historical Park boundaries. These houses retain their architectural integrity both as individual building sites and as a group of related tenant farmsteads situated within intact agricultural lands still owned and cultivated by the George Ranch. Coordination of these architectural resource sites with Texas SHPO resulted in their being determined eligible for NRHP listing (Sadowski, 2000; Appendix I). Elsewhere in the study area, tenant farmsteads still exist either as individual dwellings or as intact groups of buildings, often within a relatively small tract of agricultural land. Most, however,

have lost much of their original land and architectural integrity, leaving only an isolated house or barn within a few acres that may or may not be actively used for agricultural production.

Several communities were identified that reflect the study area's civic development patterns, particularly after the arrival of the railroads in the latter nineteenth century. The most recognizable communities include Bonney, Rosharon, and Crabb (originally called Crabb Switch). Bonney and Rosharon each contain substantial numbers of potentially historic buildings that reflect residential, commercial, and agricultural developments typical of small, rural town sites in the late nineteenth to early twentieth century period. Additionally, Bonney and Rosharon each contain concentrations of buildings that may represent African American settlements that occurred frequently in such communities. Otherwise, Crabb has lost many of its historic period buildings but still retains two core commercial elements: the Old Crabb Store and the Crabb Rice-Drying Plant. Both of these resources have been determined eligible for NRHP listing and are located adjacent to the two primary transportation routes through Crabb, FM 2785 and the Atchison, Topeka, and Santa Fe Railway.

Historic maps of the study area indicate that some early agricultural communities also existed in the study area, but were more dispersed and lacked a typical town center. For example, a dispersed group of older buildings was identified along Big Creek in the south-central portion of the study area. Review of historical records and maps does indicate the presence of an early to mid-nineteenth century "Big Creek" community in this general area. However, very few of the buildings in this area appear to date to the nineteenth century, and several of the older building sites appear to have been moved in from other locations. Local informants confirm this interpretation for a church building formerly located in Arcola.

3.19 HAZARDOUS MATERIALS

A GeoSearch™ Report, dated May 4, 2011, was ordered to identify potential hazardous materials sites within the proposed ROW of Representative Alternatives 1-8 and the majority of the Preferred Alternative. Additionally, another GeoSearch™ Report, dated November 9, 2011, was ordered to identify potential hazardous materials sites for the remaining portion of the Preferred Alternative that was not covered in the May 4, 2011, Report. GeoSearch™ is an environmental database company that provides a list of available federal, state, and local databases of known or potential hazardous waste or petroleum product facilities, landfills, and facilities currently under investigation for environmental violations in the surrounding area. A field survey was also conducted in May 2010 for the entire project area and June 2011 for the segments. Some of the database information that is included in the GeoSearch ™ Report is as follows:

Federal

- Aerometric Information Retrieval System/Air Facility Subsystem
- Biennial Reporting System
- Clandestine Drug Laboratory Locations
- EPA Docket Data

- Federal Engineering Institutional Control Sites
- Emergency Response Notification System (ERNS)
- Facility Registry System (FRS)
- Hazardous Materials Incident Reporting System
- Integrated Compliance Information System (formerly Dockets)
- Integrated Compliance Information System National Pollutant Discharge Elimination System
- Material Licensing Tracking System
- National Pollutant Discharge Elimination System
- PCB Activity Database System
- Permit Compliance System
- Comprehensive Environmental Response, Compensation, and Liability Information System Liens
- Section Seven Tracking System
- Toxics Release Inventory
- Toxic Substance Control Act Inventory
- No Longer Regulated Resource Conservation and Recovery Act (RCRA) Generator Facilities
- Resource Conservation & Recovery Act – Generator Facilities
- Brownfields Management System
- Comprehensive Environmental Response, Compensation and Liability Information System
- Land Use Control Information System
- No Further Remedial Action Planned Sites
- No Longer Regulated RCRA non-CORRACTS Treatment, Storage or Disposal Facilities
- Open Dump Inventory
- Resource Conservation & Recovery Act – Treatment, Storage & Disposal Facilities
- Delisted National Priorities List
- Department of Defense Sites
- Formerly Used Defense Sites
- No Longer Regulated RCRA Corrective Action Facilities

- National Priorities List
- Proposed National Priorities List
- Resource Conservation & Recovery Act – Corrective Action Facilities
- Record of Decision System

State

- Groundwater Contamination Cases
- Historic Groundwater Contamination Cases
- TCEQ Liens
- Municipal Setting Designations
- Notice of Violations (NOVs)
- State Institutional/Engineering Control Sites
- Spills Listing
- Dry Cleaner Registration Database (DCR)
- Industrial and Hazardous Waste Sites
- Permitted Industrial Hazardous Waste Sites
- Petroleum Storage Tanks (PST)
- Affected Property Assessment Reports (APAR)
- Brownfields Site Assessments
- Closed and Abandoned Landfill Inventory (CALF)
- Innocent Owner/Operator Database
- Leaking Petroleum Storage Tanks (LPST)
- Municipal Solid Waste Landfill Sites (MSWLF)
- Railroad Commission Voluntary Cleanup Program and Brownfield Sites
- Radioactive Waste Sites
- Tier II Chemical Reporting Program Facilities (TIERII)
- Voluntary Cleanup Program
- Recycling Facilities

- State Superfund
- Texas Railroad Commission data on oil wells
- Underground Storage Tanks on Tribal Lands
- Leaking Underground Storage Tanks on Tribal Lands
- Open Dump Inventory on Tribal Lands
- Indian Reservations

(Note: acronyms listed above are not listed in the acronyms list for the document.)

3.19.1 Hazardous Material Sites

A total of 37 potentially hazardous material sites were listed in the GeoSearch™ Reports (Exhibit 15 and Table 3-23). It should be noted that orphan or unmappable sites listed in the database review were reviewed and included, if applicable.

Of the 37 hazardous materials sites listed, 12 sites contain PSTs. Three LPSTs were located within the study area at A Plus Cleaners, KMS Kwik Stop Food Mart, and Gonyos Service Station. Three landfills were identified within the study area, one listed as MSWLF and two listed on CALF. One IHW were located within the study area. Six facilities are listed in the Facility Registry System (FRS). Eight dry-cleaning facilities were listed on the DCR. Sixteen facilities are classified under TIERII. Five NOVs have been given to five facilities. One APAR has been filed for the TDCJ in Rosharon. One facility contains ERNS.

3.19.2 Oil/Gas Well Sites

A search of publicly available records for oil/gas well sites was conducted for the study area. The following Railroad Commission of Texas (RRC) records were reviewed for this study.

RRC Oil and Gas Division county base maps, field maps, Geographic Information System (GIS) maps, and Well-Bore Database – The RRC issues permits and approval for drilling of oil and/or gas wells within the State of Texas. All permitted wells are plotted on various RRC maps and placed in a Well-Bore Database maintained by the RRC.

Approximately 825 oil and/or gas well sites were identified within the study area. The majority of these wells are located in the Thompsons Oil & Gas Field, which is located in the northeastern portion of the study area. The remaining wells are sparsely scattered throughout the study area. The RRC records indicate that approximately 156 wells are currently producing oil and/or gas within the study area. Sixty-five well sites are classified as sidetrack well surface locations and should be considered as active. One well is currently reported as temporarily shut-in, and 15 wells are used as injection wells. A total of 256 of the well sites within the study area are classified as dry holes, and 223 are formerly production wells

TABLE 3-23
HAZARDOUS MATERIAL SITES LISTED IN GEOSEARCH™ REPORT

Site Name	Map ID[1]	Address	Facility Type	Potential for Impacts
Handi Stop 33	1	1750 Crabb River Road	PST, FRSTX (2), NOV	No
Z Bar	2	1612 Crabb River Road	NOV	Low
Greatwood	3	1720 Crabb River Rd.	FRSTX, TIERII	No
Pilgrim Cleaners 162	4	1270 Crabb River Road	FRSTX, DCR	No
Fort Bend County MUD 116	5	1003 Crabb River Road	TIERII, ERNSTX, FRSTX, NOV	Low
Timewise Foodstore 3301	6	1274 Crabb River Road	PST, FRSTX, NOV	Low
Crystal Cleaners	7	1510 Crabb River Road	NOV, FRSTX (2), DCR	No
Buc-ee's 31	8	1243 Crabb River Road	PST	No
My Favorite Cleaners	9	17436 West Grand Parkway South	DCR	No
A Plus Cleaners	10	20335 Southwest Freeway	LPST, PST, DCR	Low
County Cleaners	11	103 Crabb River Road, Suite B	PST, DCR	No
Memorial Hermann Sugar Land Hospital	12	17500 West Grand Parkway South	TIERII (2)	No
KMS Kwik Stop Food Mart	13	909 Crabb River Road	PST, LPST	Low
Booth Compressor Station	14	7431 FM 762	TIERII	No
Plus Cleaners	15	20107 Southwest Freeway	DCR	No
Fort Bend County Mud 116 W1	16	1643 Brazos Gate Drive	TIERII	No
Road And Bridge Crabb	17	201 Payne Lane	PST (2)	No
Crabb River Shell	18	110 Crabb River Road	PST	No
HEB 563	19	19988 Southwest Freeway	PST	No
Rosenberg	20	235 Benton Road	PST	No
Fort Bend County MUD 106 W1	21	6660 Greatwood Parkway	TIERII	No
Archie Lee West Estate	22	5.0 miles Southeast of Richmond on Left of Highway 762	CALF	Low
Crabb River Cleaners	23	738 Crabb River Road	IHW, DCR	Low
Plant 3	24	5200 Ranson Road	PST (2), TIERII (2)	No
Pilgrim Cleaners 179	25	6560 Greatwood Parkway, Suite 400	DCR	No
Lowen Garcia	26	0.25 mile East of Crabb on Highway 762	CALF	Low
River Road Animal Clinic Landfill	27	401 Crabb River Road	MSWLF	Low
Fort Bend County LID 10	28	5955 East Riverpark	TIERII	No
Lamar CISD S1	29	5111 FM 762	TIERII (2)	No
Gonyos Service Station	30	6107 Thompson	LPST	Low
Lamar CISD W1	31	5112 FM 762	TIERII	No
Richmond Plant #2018	32	4815 Ranson Road	TIERII	No
Fort Bend County MUD 116 S2	33	5323 ½ Carta Valley Lane	TIERII	No
Schlumberger Reservoir Completions	34	14910 Airline Road	TIERII	No
Gulf Coast Concrete and Shell Inc.	35	4713 Ransom Road	TIERII	No
Fort Bend County MUD 1 L2	36	2526 Sparrow Branch Court	TIERII	No
Texas Dept of Criminal Justice Rosharon	37	59 Darrington Road	TIERII, APAR	Low

that are now reported to be plugged and abandoned. The remaining well sites are classified as either permitted (41) or cancelled (68) drilling locations. Exhibit 15 depicts the location of the Thompsons Oil & Gas Field.

3.20 VISUAL AND AESTHETIC QUALITIES

Aesthetic quality refers to an individual's subjective perception of natural beauty in a landscape. It can be determined by the presence of designated scenic areas, overlooks along trails or roadways, or by a positive endorsement of a particular view by the public. Aside from these general descriptors, a number of factors may be taken into account when considering the aesthetic quality of a certain feature or landscape. Among these are the following:

- Uniqueness of the landscape in relation to the region as a whole
- Whether the scenic area is a foreground, middle-ground or background view
- Focus of the view
- Scale of elements in the scene
- Number of potential viewers
- Duration of the view
- Amount of previous modifications or disturbance to the landscape

Based on these criteria, the corridor is considered to exhibit a low to medium degree of aesthetic quality, with few unique or necessarily spectacular views. Although a majority of the land in the corridor is in agricultural use, many areas, primarily within the northern third, are undergoing rapid conversion to urban uses, and still other areas are dominated by large, wooded expanses. As a result of this conversion, the landscape is characterized by varying degrees of human influence.

The region is characterized by flat terrain, vegetated with several large tracts of mature hardwoods, grasslands, and cropland. Numerous creeks and streams, wetlands, man-made stock ponds and irrigation canals, and the Brazos River course through the area. Most of the existing vegetation is low and consists of cultivated crops during the growing season. Inundated agricultural fields within the area can serve as migratory bird viewing sites. In addition, Brazos Bend State Park and George Ranch Historical Park are two publicly accessible natural and historic attractions within the study area.

TxDOT has mapped 10 separate "Travel Trails" throughout Texas to provide travel routes that highlight natural, cultural, and scenic attractions within different areas of the state. These routes are described in pamphlets distributed by TxDOT offices and tourist information centers, and marked by special signs along designated highways. The "Texas Independence Trail" encompasses 40 distinct sites throughout southeastern Texas that mark locations and events pivotal to the fight for Texas freedom. The section of US 59 that delimits the northernmost end of the study area is part of this scenic highway loop. This portion of the drive does not indicate any designated scenic views or landmarks (TxDOT, n.d.).

SECTION 4: ENVIRONMENTAL CONSEQUENCES

The following section describes the potential environmental consequences associated with the eight Representative Alternatives and the Preferred Alternative (Exhibits 11 and 15). The Preferred Alternative is a combination of segments from the eight Representative Alternatives and derived segments during development of the Preferred Alternative. The eight Representative Alternatives are discussed in Section 4 at the recommendation of the FHWA to illustrate the potential environmental consequences compared with those of the Preferred Alternative. The evaluation of the eight Representative Alternatives was completed during the May 2011 DEIS Reevaluation process. This document (FEIS) presents the findings of the DEIS Reevaluation again and discusses the Preferred Alternative and its detailed analyses and subsequent potential impacts. The No-Build Alternative is discussed in Section 2 of this FEIS, which documents the corridor level screening process that led to the selection of the Preferred Alternative. The Preferred Alternative was selected because of its overall superiority in minimizing impacts to the human and natural environment while providing the improved traffic service needed to meet existing and future demand.

The impacts of the Representative Alternatives as presented in the DEIS Reevaluation were calculated using a 300-foot ROW width. However, because the Preferred Alternative is at a more-detailed design stage, the Preferred Alternative impacts were calculated using the most detailed design, which is a 300- to 400-foot ROW width. The Representative Alternatives diverge from one common beginning (US 59 at the Grand Parkway) and one common ending point (SH 288). The eight Representative Alternatives have an average length of 27.5 miles, with the longest being 30.1 miles and the shortest being 24.9 miles. Each Alternative consists of a series of individual roadway segments. Exhibit 15 identifies the segments making up each alternative. In many instances, several different Representative Alternatives include overlapping segments. To address this issue, the discussion of impacts for each environmental category begins with a general description of the impacts throughout the corridor, a detailed summary of the impacts along all segments, and a summary of the segment impacts for each Representative Alternative and the Preferred Alternative. The segments of the Preferred Alternative are distinguished to ease the identification of the Preferred Alternative. In some cases an asterisk is used after the name of the segment (e.g., A1*) to denote that a particular segment is part of the Preferred Alternative. Table 4-1 summarizes all impacts within the ROW for each of the Representative Alternatives as well as the Preferred Alternative. A multistep process for the recommendation of a Preferred Alternative was followed after circulation of the DEIS and completion of a public review period and public hearing, followed by the circulation of the DEIS Reevaluation. Data contained in the DEIS and DEIS Reevaluation, review comments from regulatory agencies, and comments from the public hearing process were used to further screen the Representative Alternatives, leading to the recommendation of the Preferred Alternative. This FEIS documents the process used to identify the Preferred Alternative.

TABLE 4-1
SUMMARY OF IMPACTS FOR REPRESENTATIVE AND PREFERRED ALTERNATIVES

	Item	Unit	1	2	3	4	5	6	7	8	P*
1	**Wetlands**										
1.1	Nonforested	acres	17	17	13	13	18	18	14	14	21
1.2	Forested	acres	38	38	2	3	38	38	2	3	6
2	**Endangered Species Occurrence within 1 mile**										
2.1	Animals	# sites	0	0	0	0	0	0	0	0	0
2.2	Plants	# sites	0	0	0	0	0	0	0	0	0
3	**Vegetative Communities**										
3.1	Forestland	acres	129	129	81	81	150	150	102	102	110
3.2	Pastureland/Grassland/ Cropland	acres	640	720	777	858	744	824	881	962	1,024
3.3	Habitat Fragmentation	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes
4	**Geologic**										
4.1	Geologic Sites	# sites	0	0	0	0	0	0	0	0	0
4.2	Prime Farmland	acres	704	749	792	836	734	780	823	868	955
5	**Water Resources**										
5.1	River Crossings	# of	1	1	1	1	1	1	1	1	1
5.2	Major Stream Crossings	# of	8	7	8	7	8	7	8	7	7
5.3	Minor Stream Crossings	# of	8	7	10	9	7	6	9	8	8
5.4	Irrigation Canal/Ditch Crossings	# of	13	15	16	18	21	23	24	26	17
5.6	Stock Ponds	# of	3	4	4	5	4	4	4	5	6
5.7	Floodplains	acres	420	373	447	400	467	420	494	447	349
5.8	Floodways	acres	21	19	21	19	22	20	21	20	21
6	**Hazardous Materials**	# sites	6	6	6	6	0	0	0	0	6
7	**Relocations**										
7.1	Commercial	# of	6	6	6	6	4	4	4	4	6
7.2	Single Family (Site Built)	# of	5	12	8	15	88	95	91	98	12
7.3	Single Family (Mobile Homes)	# of	1	2	1	2	1	2	1	2	2
7.4	Single Family (Platted)	# of	0	0	0	0	0	0	0	0	0
7.5	Schools	# of	0	0	0	0	0	0	0	0	0
7.6	Churches	# of	1	1	1	1	0	0	0	0	1
7.7	Cemeteries	# of	1	1	1	1	0	0	0	0	0
8	**Historic and Archeological Resources**										
8.1	Previously Recorded Archeological Sites (within ROW)	# of	3	3	3	3	0	0	1	1	3
8.2	Historic Nonarcheological Resources (within APE)	# of	12	12	16	17	6	7	11	12	9
8.3	High-Probability Areas	LF	28,200	28,200	37,500	37,500	27,575	27,575	36,875	36,875	40,900
8.4	Newly Recorded Archeological Sites (within ROW)	# of	3	3	5	5	3	3	4	4	3

TABLE 4-1, CONT'D

	Item	Unit	1	2	3	4	5	6	7	8	P*
9	**Environmental Justice Considerations**	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes
10	**Noise and Air**										
10.1	Noise Receivers	# of	59	64	62	67	31	36	34	39	67
10.2	Air Quality	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	**Engineering and Mobility**										
11.1	Length	miles	24.9	26.1	27.4	28.6	26.4	27.6	28.9	30.1	26.9
11.2	Terminated County Roads	# of	2	2	2	2	1	1	1	1	2
11.3	Railroad Grade Separations	# of	1	1	1	1	1	1	1	1	1
11.4	Grade Separations	# of	9	11	9	11	10	12	10	12	13
11.5	Ramps	# of	22	22	22	22	20	20	20	20	26
11.6	Construction Sequencing Impacts	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes
11.7	Utility Crossings	# of	17	20	13	16	16	19	12	15	16
12	**ROW**										
12.1	Required ROW	acres	916	961	1006	1051	969	1013	1059	1103	1,131
12.2	Existing ROW	acres	6.6	13.4	30.0	36.8	0.0	6.8	23.4	30.2	225
12.3	Donated ROW	acres	369.4	370.5	275.2	276.3	373.4	374.5	279.2	280.3	468.3
13	**Other Environmental Issues**										
13.1	Visual Impacts and Aesthetics	high/ low	low	low	low	low	low	low	low	low	low
13.2	Follows Existing Roadway ROW	miles	0.90	1.8	1.3	2.2	0.00	0.9	0.4	1.3	1.8
13.3	Observatory Dark Northern Skies Impact	y/n	no	no	no	no	no	no	no	no	no
13.4	George Ranch Historical Park (private) Impacts	y/n	no	no	no	no	no	no	no	no	no
13.5	Potential 4f Issue (Cultural Resources)	y/n	no	no	no	no	no	no	no	no	no
13.6	Potential 4f/6f Issue (Parks and Public Lands)	y/n	yes	yes	yes	yes	yes	yes	yes	yes	yes

*Preferred Alternative
y/n = yes/no
LF = Linear Feet
NA = Not Applicable

4.1 LAND-USE IMPACTS

4.1.1 Land-Use Segment Analysis

Numerous criteria were used to measure potential impacts for each Representative Alternative and Preferred Alternative. From a land use perspective, the critical criteria include (1) the number of residential and nonresidential structures located within the ROW (see Section 4.1.1.1, Relocations) as well as residential and nonresidential land use beyond, but in proximity to the proposed project; and (2) current development trends and state and/or local governmental plans and policies on land use and growth in the study area. Primary considerations are proximity of the project to habitable structures, compatibility of adjacent land uses and municipal or state land-use plans, and the amount of displaced land use. Table 4-2 lists potentially affected land uses by segment, Representative Alternative, and Preferred Alternative.

TABLE 4-2
LAND-USE IMPACTS BY SEGMENT AND ALTERNATIVE

Affected Segment	Affected Alternative	Impact
A3.1*, C1	1, 2, 3, 4, 5, 6, 7, 8, P	Alternative crosses active rail line
A1*,A2*, A3.1*, A3.2, B1, C1, C2, J1, T1, G7*, G8*, P1, W1*, G3.2*	1, 2, 3, 4, 5, 6, 7, 8, P	Visual and potential access-related impacts to existing residences and communities
J1	3, 4, 7, 8	Separation of farmland from farm homestead
All except A1*, A2*, A3.1*	1, 2, 3, 4, 5, 6, 7, 8, P	Decrease in farmland acreages
All segments	1, 2, 3, 4, 5, 6, 7, 8, P	Continued conversion of existing land use to residential development
P1, G6, G8*, C1, A1*, A3.1*, Q1, G1, J1	1, 2, 3, 4, 5, 6, 7, 8, P	Continued conversion of existing land use to commercial land use at highway interchanges
All except A1*, A2*, A3.1*	1, 2, 3, 4, 5, 6, 7, 8, P	Potential disruption of the physical fabric of farms
C2, B4.1, J1, G6.2, G8*, P1	1, 2, 3, 4, 5, 6, 7, 8, P	Potential termination of local and/or residential roadways

*Segment included in Preferred Alternative.

The northern segments are located within proximity of existing or planned MUDs. Segments B1 and A1 border the northern and eastern boundaries of Canyon Gate. Segment A1 borders the western edge of Greatwood. However, since these segments are located on existing roadways, the visual, noise and access-related impacts resulting from selection of these segments would be lessened relative to the impacts of road construction on new location.

Segments A3.1*, A3.2, S1, and S1-b* parallel the northern and eastern edges of Bridlewood and selection of these segments would create potential noise, visual and access-related impacts to this community. Segments C1 and C2 bisect a section of Bridlewood. Construction of the proposed facility on these segments would likely influence the structure and cohesion of future neighborhoods and create noise and visual impacts for future residents.

All of the segments in the northern third of the study area fall under some form of municipal jurisdiction. Segments A3.1*, B3, C1, and C2 traverse slices of Rosenberg's incorporated area and ETJ; Segment P1 bisects the city limits and ETJ of

Iowa Colony. Neither incorporated area is zoned. Additionally, Segments B1 and C1 fall within the City of Richmond's ETJ; Segments A1*, A2*, and A3.1* cross the City of Sugar Land's ETJ; Segments S1, S1-b*, B4, B4-2*, B5, Q1, and P6 fall within the Town of Thompsons' ETJ.

The segments located primarily in the northern and eastern portions of the study area intersect with existing local roadways. While it is evident that the proposed Grand Parkway Segment C would increase accessibility to this area, the potential termination of local roads could reduce ease of access to local enclaves. Typically, such impacts are mitigated by the use of bridges or access ramps. Proposed segments cross the BNSF rail line, which is currently active, and the Union Pacific Railroad, which is abandoned. Adequate bridging of active railroad lines would be provided to ensure no interruption of service.

4.1.1.1 Relocation and Displacement of Existing Land Uses

All project segments would change land use within the ROW of the proposed project. Direct impacts would be related to the relocation of residential and business structures (see Section 4.1.1.) and the loss of existing land use within the ROW. Impacts potentially include loss of access to land across the proposed Grand Parkway Segment C; localized pressure for business development in the vicinity of interchanges; and the disruption of the physical fabric of neighborhoods and farms.

The majority of the ROW required for the Representative Alternatives consists of nonurban land uses. With the exception of Segments A1*, A2*, and A3.1* located within the vicinity of Crabb River Road, all segments traverse agricultural acreage. Therefore, construction of most of the segments would result in a decrease of farmland acreage. A segment may cut through a farm or individual field in such a way as to hamper the access or transport of livestock and/or equipment. As a result, agricultural land use may be decreased further if the additional costs in travel time outweigh the revenue gained by utilizing the separated section. Farms appear to be disrupted on every alternative, especially on the southwestern segments. Segment J1 falls just south of a farm homestead separating the household and barns from its corresponding farmland. Due to the nature of current land use in the area, the physical fabric of farms will be disrupted to a greater degree than the physical fabric of neighborhoods.

There are a number of residential areas within the proximity of the Representative Alternatives (Exhibit 15). Potential impacts to these neighborhoods include noise, visual effects, and a change in access across the facility.

The Preferred Alternative would parallel Crestwood, Tara, and Bridlewood in the northern study area primarily along existing road corridors. The Preferred Alternative departs from existing roadways at FM 762 near the Brazos Lakes subdivision. Beyond Brazos Lakes, the Preferred Alternative traverses primarily agricultural property 2,000 feet north of Brazos Bend State Park. The Preferred Alternative parallels the northern portion of the Darrington Prison Farm and concludes utilizing existing roadway along CR 60. This alternative could create visual and access-related impacts to existing residences and communities, decrease total farmland acreages and production, and disrupt the physical fabric of farms.

Property values could increase near proposed interchanges and grade separated intersections as land becomes more desirable for commercial development. Commercial development and associated property value increases are more likely to occur at interchanges and intersections, which are already near existing and proposed communities. The value of residential units and property adjacent to the proposed highway is difficult to predict. Individual home values are based on each owner's and potential buyer's perception of the benefits of an adjacent highway and would vary on a case-by-case basis.

4.1.2 Summary of Impact

All Representative Alternatives and the Preferred Alternative are consistent with state and local government plans and policies on land use and growth that are relevant within the project area.

As described in Section 4.1, all of the Representative Alternatives and the Preferred Alternative would result in the reduction of mostly agricultural land. All of the Representative Alternatives would require relocations of homes and commercial businesses. Representative Alternatives 1–4 and the Preferred Alternative would require relocation of a church. Representative Alternatives 1-4 would require relocation of cemetery. Representative Alternative 8 would result in the most residential relocations. Representative Alternatives 1–3 and the Preferred Alternative would have the least number of residential impacts. Representative Alternatives 1–4 and the Preferred Alternative would impact six commercial facilities whereas Representative Alternatives 4–8 would impact 4 commercial facilities.

Under the No-Build Alternative, suburban growth within the proposed project area is expected to continue at a rate similar to historical trends. New subdivisions would lead to loss of agricultural land. Commercial development would likely occur along existing arterial roadways that run through the Segment C project area. Existing arterial roadways through the Segment C project area would likely become more heavily traveled without the proposed project and may become more congested over time. Potential short-term noise and visual effects and construction-related traffic delays would not occur under the No-Build Alternative. Access-related effects and construction-related traffic delays would not occur under the No-Build Alternative, as none of the roads within the Segment C project area would be affected. Induced development associated with entrance/exit ramps and short sections of frontage roads under the proposed project would not occur under the No-Build Alternative.

4.1.3 Indirect Impacts

The proposed Segment C project would likely induce indirect development in the Segment C study area regardless of the Alternative selected. The actual extent and type of indirect development is influenced greatly by many variables, including the local and regional economic climate, the size of and distance to nearby communities and the existing local services offered. This indirect development would likely include convenience stores, gas stations, retail strip malls, restaurants, office buildings, and residences, including apartments. Residential development may result because of community growth and improved access to nearby job markets.

Nodes of indirect development are expected to occur at highway interchanges (US 59) and at FM 521, along frontage roads, and at grade-departed intersections where entrance/exit ramps to the proposed Segment C project would be constructed.

4.1.4 Mitigation

Avoidance and minimization of impacts to land use were used as techniques in the selection of the Preferred Alternative. Grade separations would be provided for all major arterial roadways that cross the Preferred Alternative to avoid termination of through-travel, and intermittent frontage roads would be provided for adjacent property access and connectivity to major highways. Additionally, opportunities to reduce the amount of ROW would be identified during the final stage design.

4.2 GEOLOGY, SOILS, AND FARMLAND IMPACTS

4.2.1 Physiography, Soils, and Geology

Although impacts to soils would be unavoidable, the Representative and Preferred Alternatives within the study area (i.e., inclusive of the Brazos River floodplain) cross similar topography and soils consisting of broad, flat plains on predominantly clayey substrate of the Beaumont Formation and alluvial deposits. Where unavoidable impacts do occur, such as at localized cut and fill areas, mitigative measures would offset the impact to these resources. However, the geologic resources (i.e., faults) in the study area are influenced by regional conditions that have the potential to impact the proposed project.

Most soil groups traversed by the alternatives are characterized by the NRCS as having high shrink-swell potential. This is a measure of the potential volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. If the shrink-swell potential is rated moderate to high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special consideration should be given to the selection of materials for fill, and the design of the roadbed. Increased costs and special designs required will not be unlike those encountered on other roadway projects within the study area counties. Table 4-3 depicts selected engineering properties of the soils crossed by each of the Representative and Preferred Alternatives.

Construction of a roadway involves compaction of soils and removal of vegetation, which can increase the amount of erosion and subsequent sedimentation. Slope, soil texture, and precipitation during construction will determine the soil loss potential. Erosion and sediment control measures, such as reseeding and phasing vegetation removal, will effectively minimize erosion and soil loss during construction. See Section 4.7.1, Surface Water Quality, for a description of additional erosion control and slope stabilization techniques.

TABLE 4-3
ENGINEERING CRITERIA FOR SOILS

Map Unit	Prime Farmland	Statewide Important Farmland	Suitability for Road Construction	Corrosiveness		Potential for Erosion		Depth of Water Table (feet)	Shrink-Swell Potential
				Uncoated Steel	Concrete	K*	T**		
Fort Bend County									
Asa fine sandy loam	X		severe	high	low	0.32	5	none listed	low
Asa silty clay loam+	X		severe***	high	low	0.32	5	none listed	low
Asa-Pledger complex+	X		severe	high	low	0.32	5	none listed	mod-very high
Bernard clay loam, 0–1%+	X		severe	high	low	0.32	5	0.5–2.0	moderate
Bernard-Edna clay loam, 1–4%+	X		severe	high	low	0.32	5	0.5–2.0	high
Bernard-Edna clay loam, 4–8%	X		severe	high	low	0.32	5	none listed	moderate
Bernard-Edna complex, 0–1%+	X		severe	high	low	0.32	5	0.5–2.0	high
Edna fine sandy loam, 0–1%+		X	severe	high	low	0.37	5	none listed	low
Edna fine sandy loam, 1–4%+		X	severe	high	low	0.37	5	none listed	low
Kaufman clay+		X	severe	high	low	0.32	5	1.5–6.0	high
Lake Charles, 0–1%+	X		severe	high	low	0.32	5	none listed	very high
Lake Charles, 1–4%+	X		severe	high	low	0.32	5	none listed	very high
Miller clay+	X		severe	high	low	0.32	5	none listed	high
Miller silt loam+	X		severe	high	low	0.43	5	none listed	low
Miller silty clay loam+	X		severe	high	low	0.37	5	none listed	very high
Norwood clay+	X		severe	high	low	0.32	5	none listed	high
Norwood silty clay loam+	X		severe	high	low	0.43	5	none listed	mod-low
Pledger clay+	X		severe	high	low	0.32	5	none listed	very high
Roebuck clay+		X	severe	high	low	0.32	5	0–>6.0	high
Waller soils+		X	severe	high	moderate	0.43	5	0–>6.0	low

Source: SCS (1960, 1979, 1981); Wiedenfeld (2001); NRCS (2012).
+Soil found within the Preferred Alternative.
* Value represents average annual rate of soil loss by sheet and rill erosion by water in tons per acre per year. Values range from 0.05 (low potential) to 0.69 (high potential)
** Value is an estimate of the maximum average annual rate of soil erosion by wind or water in tons per acre per year that can occur without affecting crop productivity over a sustained period
***Severe – Has one or more properties unfavorable for the rated use. The limitation generally requires major soil reclamation, special design, or intensive maintenance

To the maximum extent possible, material excavated from roadway cuts would be used as fill material where required. If suitable soils are not found within the ROW, they would be obtained from other sites within a reasonable haul distance of the project. Detailed investigation of soils for construction should be conducted during design of the Preferred Alternative.

Faults in the Texas Coastal Zone are products of natural geologic processes. Geologic evidence suggests that fault activity in the present time should be a relatively minor process. However, the frequency and activity of fault movement is increasing. There is clear indication that man's activities, including groundwater withdrawal and oil and gas production, are causing this increase in fault activation. Nearly all fault reactivation has occurred where the piezometric surface has dropped over 100 feet and where there has been at least a 1-foot drop of land surface subsidence (Brown et al., 1974). Therefore, aquifer management is crucial to minimizing the impacts of fault activation and land surface subsidence.

Impacts of these development-induced natural processes include loss of ground elevation (which increases incidents of flooding), saltwater encroachment in freshwater aquifers, increased groundwater pumping costs, and changes in land slopes and stream drainage patterns. Impacts associated with construction include unstable foundations, broken underground utilities, and cracked sidewalks and roadways, which can result in expensive repairs. However, modification of the historical pattern of groundwater withdrawal can effectively mitigate subsidence, fault reactivation, and associated problems. Such a plan will require significantly less withdrawal of groundwater, but a variety of other mitigating factors should be considered. Different levels of subsidence and related problems can be tolerated; for example, subsidence in a low-lying developed area is a greater problem than in less developed areas at higher elevations. Aquifers, which contain overcompacted clays, can sustain greater withdrawals than aquifers containing undercompacted clays (Brown et al., 1974). Detailed analysis and mapping of the hydrologic character of the coastal aquifer may provide useful information to determine the maximum amount of withdrawal and the density of producing wells that can exist within prescribed acceptable levels of subsidence.

Fort Bend, Harris, and Galveston counties' Subsidence Districts are actively pursuing a regional program that reduces future groundwater withdrawals by encouraging a conversion from groundwater use to surface water use. Brazoria County currently does not have a Subsidence District. Projections from the districts' land surface subsidence modeling indicate that if no further groundwater reductions occur within the region, then subsidence in the region of the study area would likely be 2.5 feet by the year 2030 (Exhibit 27). But if both districts can reduce excessive groundwater withdrawals under their groundwater management plan, then subsidence in the region of the study area could be limited to 1 to 1.5 feet by the year 2030 (Exhibit 19).

Subsidence and faults in the Texas Coastal Zone are unavoidable, but with awareness of these natural processes, they need not be a problem. Proper engineering design can accommodate for the low rates of differential movement along faults and in areas of subsidence. Decreased groundwater usage will minimize subsidence and may actually deactivate many of the faults. The study area has remained relatively undeveloped and the regional aquifers beneath the project have not experienced a significant drop of the piezometric surface. The groundwater management plan of the region's

subsidence districts will likely have a measurable effect on future land surface subsidence. However, project design should account for the future subsidence of 1.5 to 2.5 feet to continue to occur within the project area.

The Preferred Alternative would not provide any unique impacts to the region's topography, soils, or geologic resources.

4.2.2 Farmland Impacts

This section outlines the impacts to farmland soils protected under the FPPA and does not include non-FPPA protected soils that are in existing agricultural use. Bisection of farms would not only convert existing farmland or prime and statewide important farmland soils (potential farmland) to highway ROW, but would also result in the disruption of some operations. However, this proposed project may result in positive impacts to local farming operations as well. The proposed Grand Parkway Segment C would increase accessibility to FM roads. An improved transportation system in Fort Bend and Brazoria counties would improve highway safety for the transport of farm products and equipment.

Prime and statewide important farmland should be avoided where practicable; however, due to the large acreage of these soils in Fort Bend and Brazoria counties, each Representative Alternative and Preferred Alternative would have an unavoidable effect on some prime and statewide important farmland soils. The Preferred Alternative would be placed along and close to existing property lines where possible to minimize the splitting or fragmentation of farms. Table 4-4 below shows the acreage of prime and statewide important farmland soils for each of the eight Representative Alternatives and the Preferred Alternative:

TABLE 4-4
PREFERRED ALTERNATIVE ACREAGES OF PRIME AND STATEWIDE IMPORTANT FARMLAND SOILS BY SEGMENT

Alternative	Prime and Statewide Farmland Soils (acres)
Representative Alternative 1	704
Representative Alternative 2	749
Representative Alternative 3	792
Representative Alternative 4	836
Representative Alternative 5	736
Representative Alternative 6	780
Representative Alternative 7	823
Representative Alternative 8	868
Preferred Alternative	955

Table 4-5 summarizes the amount of prime and statewide important farmland soils that would be impacted by the Preferred Alternative. Exhibit 28 shows the location of prime and statewide important farmland soils in relation to the Preferred Alternative.

TABLE 4-5
PREFERRED ALTERNATIVE ACREAGES OF PRIME AND STATEWIDE IMPORTANT FARMLAND SOILS BY SEGMENT

Segment	Soil Association	Prime Farmland Soil Acreage
A1*	Miller/Norwood/Pledger	63.3
A2*	Lake Charles/Bernard	20.1
A3.1*	Lake Charles/Bernard	39.1
B4.2*	Lake Charles/Bernard	7.8
G3.2*	Brazoria/Pledger	63.2
G5.2*	Norwood/Brazoria/Asa	50.3
G6.2*	Lake Charles	40.3
G7*	Lake Charles/Bernard	26.2
G8*	Lake Charles/Bernard	92
S1.b*	Lake Charles/Bernard	155.5
W1*	Edna/Bernard	112.7
X1*	Brazoria/Pledger	122.7
Y1*	Lakes Charles	162

Source: NRCS (2011); Study Team (2011).
*Segment included in Preferred Alternative; NA = Not Applicable

As indicated in the DEIS Reevaluation, Form CPA-106 (specifically for linear transportation projects) was submitted to the NRCS on January 27, 2011, for the eight Representative Alternatives (Appendix I). A letter from the NRCS was received on March 22, 2011, indicating the farmland conversion impact rating for the eight Representative Alternatives received a score less than 160 points and that no further consideration for farmlands was necessary (Appendix I). A letter and associated Form CPA-106, dated December 13, 2011, was also submitted to NRCS for the Preferred Alternative. Since the Preferred Alternative impacts were calculated using the most detailed 300- to 400-foot ROW (not available for the eight Representative Alternatives), the impacts to the Preferred Alternative seem greater than the eight Representative Alternatives. In a letter dated January 19, 2012, the Preferred Alternative also received a score of less than 160 points from the NRCS (149 points). Therefore, project-related impacts to prime farmland in the two counties are determined minimal according to the land evaluation and site assessment scoring used by the NRCS, and this proposed project is exempt from the FPPA requirements.

4.2.3 Summary of Impacts

The Representative Alternatives as well as the Preferred Alternative cross soils and geology similar in nature. The prime farmland impacts of the Preferred Alternative are slightly greater than the impacts of the Representative Alternatives; however, the reasoning for this is the Representative Alternative impacts were calculated based on a 300-foot ROW, whereas the most-detailed design (300- to 400-foot ROW) was used to calculate the Preferred Alternative impacts. While the impacts resulting from removal of topsoil, compaction, and removal of vegetation would cause temporary to permanent loss to these resources, these are anticipated to be minor as rated and scored by the NRCS. Mitigation measure to be implemented during and after construction would help restore a portion of these resources. Under the No-Build Alternative,

no new ground disturbances would occur; therefore, no impacts to existing geological or farmland soil resources would take place.

4.2.4 Indirect Impacts

Indirect impacts to geologic resources, including soils, would occur because of induced development, although these impacts are expected to be minimal.

4.2.5 Mitigation

Measures to minimize overall disturbance to the environment have already been taken as the 400-foot ROW was reduced to a 300- to 400-foot ROW. The use of silt fences and other erosion control measure during construction would prevent erosion of native soils and reduce the runoff of soil particles into area streams. Furthermore, implementing revegetation of native species along constructed ROW would prevent future erosion and would thereby increase the success rate of revegetation efforts. The need for mitigation of geologic resources is not anticipated. Mitigation for prime farmlands is not anticipated to be necessary, per the anticipated NRCS ranking. If mitigation is necessary per the NRCS response, all required mitigation would be conducted in accordance with the NRCS.

4.3 SOCIAL IMPACTS

4.3.1 Social and Community Impacts Analysis

4.3.1.1 Community Cohesion

As defined in FHWA Technical Advisory T6640.8A, changes in community cohesion as a result of highway construction and improvements may be beneficial or adverse. Changes in community cohesion may include splitting neighborhoods, isolating a portion of a neighborhood or an ethnic group, generating new development, changing property values, terminating residential roads, and separating residents from community facilities. Table 4-6 lists social and community-related impacts by segment and alternative, specifically for the Preferred Alternative.

During construction, short-term impacts, especially in the northern section (Segments A1*, A2,* and A3.1*), would occur due to the movement of workers and materials through the area and construction activities. Construction noise and dust as well as temporary disruption of traffic on local roads may also temporarily affect residents, businesses, and farming operations in the vicinity of the project. Some construction activities may occur at night, which would minimize its effects on daytime traffic using existing facilities. Coordination between TxDOT and landowners regarding construction scheduling and access to the construction sites and ROW should help to minimize such temporary disruptions.

TABLE 4-6
SOCIAL IMPACTS BY SEGMENT AND ALTERNATIVE

Affected Segment	Affected Alternative	Impact
C1	5, 6, 7, 8	Manford-Williams Elementary School: Potential impacts to school bus and pedestrian routes
A2*	1, 2, 3, 4, P	Visual related impacts to Sandberry Cemetery
A1*, A2*, A3.1*, B3, C1, C2, J1, G3.2*, G6, P1, T1, S1 (version 2)*, W1*	1, 2, 3, 4, 5, 6, 7, 8, P	Aesthetic impacts to residences
A3.1*, A3.2	1, 2, 3, 4, P	Impact to southwestern corner of the Triumph Christian Center
C1	5, 6, 7, 8	Alternative bisects paintball course
C1	5, 6, 7, 8	Visual and access-related impacts to Zion Hill Missionary Church
A2*, A3.1*	1, 2, 3, 4, P	Visual impacts to Southwest Church of the Nazarene
J1, T1	3, 4, 7, 8	Visual impacts to Brown cemetery
G5.2*, J1, T1, X1*	1, 2, 3, 4, 5, 6, 7, 8, P	Increase in exposure of Brazos Bend State Park/George Observatory
S1-b*	1, 2, 3, 4, P	Increase in exposure of the George Ranch Historical Park
All segments	1, 2, 3, 4, 5, 6, 7, 8, P	Potential decrease in commute times
All segments	1, 2, 3, 4, 5, 6, 7, 8, P	Potential increase in commuters
All segments	1, 2, 3, 4, 5, 6, 7, 8, P	Overall improvement in public safety
All segments	1, 2, 3, 4, 5, 6, 7, 8, P	Potential increase in value of property adjacent to highway (primarily at interchanges)
All segments	1, 2, 3, 4, 5, 6, 7, 8, P	Construction impacts: noise, dust, rerouting traffic

P = Preferred Alternative
*Segment included in Preferred Alternative

4.3.1.2 Environmental Justice

This document is in compliance with the FHWA policies to determine whether a proposed project will have disproportionate effects on minority or low–income populations and meets the requirements of EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low–Income Populations*. The EO, signed February 11, 1994, requires all federal agencies to address the impact of their programs with respect to EJ. The EO requires that federal agencies identify and appropriately address disproportionately high and adverse human health and environmental effects on minority and low-income populations, and requires that such populations that could be affected by the proposed project be involved in the community participation and public involvement process.

The proposed project is also in compliance with EO 13166, *Improving Access to Services for Persons with Limited English Proficiency.* This EO requires federal action to examine the services provided to LEP communities and to identify the need for services for people with LEP. This EO requires federal agencies to work to ensure that recipients of federal financial assistance provide meaningful access to the LEP applicants and beneficiaries. According to 2010 U.S. Census data, within the study area CTs, the average percent of persons (population 5 years of age and older) that speak English “not well” or

"not at all" was 2.5 percent, which is lower when compared with Brazoria County (4.5 percent), Fort Bend County (5.9 percent), and the state (8.4 percent).

For this analysis, the population is considered to be a minority population if the percentage of minority persons in a census tract is greater than 50 percent. USDOT Order 5610.2 defines low income as "a person whose median household income is at or below the Department of Health and Human Services (HHS) poverty guidelines." The poverty guideline for a family of four in 2012 is $23,050 (HHS, 2012).

Tables 3-6 and 4-7 provide block level and CT data for all blocks and CTs that intersect any of the eight Representative Alternatives or the Preferred Alternative.

Median household income of CT 6619 ($55,550) was less than Brazoria County ($65,607). Median household income of CTs 6746.03 ($71,529), CT 6755 ($70,321), and 6756 ($57,021) was less than Fort Bend County's median household income ($79,845). Although the median household income of several CTs intersecting the eight Representative Alternatives or the Preferred Alternative are less than the counties they are within, all CTs have a higher median household income than Texas ($49,646).

Brazoria County's CT 6619 has a minority population that exceeds 50 percent (64.3 percent). Brazoria County overall has a minority population of 46.8 percent. Therefore, CT 6619 has a slightly greater minority population than that of the county as a whole. CT 6619 has a lower percentage of population living in poverty than Brazoria County.

Fort Bend's CTs 6746.04 and 6755 have minority populations that exceed 50 percent (65.7, and 63.9 percent, respectively). However, CTs 6746.04 and 6755 have minority populations similar to their respective county (Fort Bend County, 63.8 percent). Additionally, all CTs within Fort Bend County have a lower percentage of population living in poverty than Fort Bend County.

All CT median household incomes are above the 2012 HHS poverty guidelines of $23,050 (HHS, 2012).

The residents in these communities appear to maintain similar incomes with their immediate neighbors. All of the alternatives were analyzed, and it has been determined that no minority or low-income populations have been identified that would be disproportionately affected.

As indicated in Table 4-7, there are several blocks with over 50 percent minority populations. Those blocks include CT 6746.04, BG 1, blocks 1006, 1010, 1018, 1033, 1043, 1044, and 1049; CT 6755, BG 1, blocks 1039, 1069, 1071, 1080, 1086, 1127, and 1285; CT 6756, BG 2, block 2019; CT 6618, BG 2, blocks 2062 and 2063.; and CT 6619, BG 1, blocks 1096, 1099, 1120, and 1136.

TABLE 4-7
DETAILED 1999 AND 2009 POPULATION CHARACTERISTICS BY CENSUS TRACT, BLOCK GROUP, AND BLOCK

Census Tract, BG and Block	Alternatives Included	Population	Number White	% White	Number Black	% Black	Hispanic Origin	% Hispanic	Number Other	% Other
CT 6746.01		3,762	2,739	72.8	252	6.7	304	8.1	467	12.4
BG 1	1-8, P	2.521	1,793	71.1	195	77.4	189	7.5	344	13.6
Block 1000	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1002	1-8, P	4	4	100.0	0	0.0	0	0.0	0	0.0
Block 1008	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
BG 2		1,241	946	76.2	57	4.6	115	9.3	123	9.9
Block 2001	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2003	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2004	1,2,3,4,P	12	9	75.0	1	8.3	0	0.0	2	16.7
Block 2006	1-8, P	100	83	83.0	2	2.0	11	11.0	4	4.0
Block 2010	1,2,3,4,P	42	32	76.2	0	0.0	3	7.1	7	16.7
Block 2011	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2012	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2013	1,2,3,4,P	139	95	68.4	8	5.8	10	7.2	26	18.7
Block 2016	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2017	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
CT 6746.03		5,999	3,045	50.8	877	14.6	1,707	28.5	370	6.2
BG 1		1,037	744	71.7	82	7.9	135	13.0	76	7.3
Block 1004	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0.0	0.0
Block 1005	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0.0	0.0
Block 1006	P	80	54	67.5	8	10.0	12	15.0	6.0	7.5
Block 1029	P	0	0	0.0	0	0.0	0	0.0	0.0	0.0
CT 6746.04		4,607	1,118	24.3	1,529	33.2	901	19.6	1,059	23.0
BG 1		4,607	1,118	24.3	1,529	33.2	901	19.6	1,059	23.0
Block 1001	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1002	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1003	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1004	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1005	1,2,3,4,P	7	4	57.1	0	0.0	1	14.3	2	28.6
Block 1006	1,2,3,4,5,6,7, 8,P	1028	213	20.7	387	37.7	124	12.1	304	29.6
Block 1010	1,2,3,4,P	22	8	36.4	8	36.4	6	27.3	0	0.0
Block 1016	5,6,7	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1018	5,6,7,8	44	16	36.4	9	20.5	0	0.0	19	43.2
Block 1019	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1023	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1024	5,6,7,8	119	100	84.0	3	2.5	14	11.8	2	1.7
Block 1032	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1033	1,2,3,4	287	66	23.0	127	44.3	33	11.5	61	21.3
Block 1042	P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1043	1,2,3,4,P	149	46	30.9	60	40.3	35	23.5	8	5.4
Block 1044	1,2,3,4,P	181	72	39.8	49	27.1	59	32.6	1	0.6
Block 1048	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1049	5,6,7,8	11	0	0.0	9	81.8	0	0.0	2	18.2

TABLE 4-7, CONT'D

Census Tract, BG and Block	Alternatives Included	Population	Number White	% White	Number Black	% Black	Hispanic Origin	% Hispanic	Number Other	% Other
CT 6747		11,165	3,555	31.8	2,978	26.7	2,213.	19.8	2,419	21.7
BG 1	1-8, P	4,272	861	20.2	1,194	28.0	573	13.4	1,644	38.5
Block 1033	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
BG 3		6151	2,503	40.7	1,688	27.4	1,197	19.5	763	12.4
Block 3078	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 3079	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 3080	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 3081	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 3084	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 3100	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
CT 6755		11,151	4,027	36.1	2,215	19.9	3,986	35.7	923	8.3
BG 1		7080	2,856	40.3	1,507	21.3	1,947	27.5	770	10.9
Block 1020	P	380	196	51.6	103	27.1	38	10.0	43	11.3
Block 1036	P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1038	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1039	1,2,3,4,5,6,7, 8,P	85	30	35.3	7	8.2	32	37.7	16	18.8
Block 1053	5,6,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1069	5,6,7,8	1,312	508	38.7	309	23.6	309	23.6	186	14.2
Block 1071	5,6,7,8	157	61	38.9	44	28.0	41	26.1	11	7.0
Block 1077	1,2,3,4,P	52	26	50.0	13	25.0	7	13.5	6	11.5
Block 1078	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1080	1,2,3,4	47	8	17.0	20	42.6	19	40.4	0	0.0
Block 1081	1,2,3,4,5,6,7, 8,P	2	2	100.0	0	0.0	0	0.0	0	0.0
Block 1082	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1084	1,2,3,4,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1086	5,6,7,8	112	39	34.8	15	13.4	58	51.8	0	0.0
Block 1087	5,6,7,8	1	1	100.0	0	0.0	0	0.0	0	0.0
Block 1126	6,7,8	13	10	76.9	3	23.1	0	0.0	0	0.0
Block 1127	5,6,7,8	2	0	0.0	0	0.0	2	100.0	0	0.0
Block 1134	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1190	1,2,3,4,5,6,7, 8,P	231	127	55.0	34.00	14.7	35	15.2	35	15.2
Block 1192	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1200	1,5,6,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1209	P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1210	1,5,6	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1259	1,3,4,5,6,7,8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1261	1,5,6	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1269	1,4,5,6,7,8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1285	1,3,4,5,6,7,8, P	2	0	0.0	2	100.0	0	0.0	0	0.0
Block 1291	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1293	1,3,4,5,6,7,8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1294	P	0	0	0.0	0	0.0	0	0.0	0	0.0

TABLE 4-7, CONT'D

Census Tract, BG and Block	Alternatives Included	Population	Number White	% White	Number Black	% Black	Hispanic Origin	% Hispanic	Number Other	% Other
Block 1367	1,4,5,6	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1402	3,4,7,8	3	3	100.0	0	0.0	0	0.0	0	0.0
Block 1403	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1406	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1407	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1408	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1409	3,4,7,8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1440	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1444	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
CT 6756		5,808	3,920	67.5	89	1.5	1,697	29.2	102	1.8
BG 2		2,099	1,515	72.2	30	1.4	522	24.9	32	1.5
Block 2002	P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2003	P	275	167	60.7	14	5.1	85	30.9	9	3.3
Block 2005	P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2006	P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2007	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2008	3,4,7,8	94	86	91.5	3	3.2	2	2.1	3	3.2
Block 2019	3,4,7,8	132	27	20.5	0	0.0	105	79.6	0	0.0
Block 2023	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2025	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 2026	3,4,7,8	0	0	0.0	0	0.0	0	0.0	0	0.0
CT 6618	1-8, P	5,385	2,896	53.8	341	6.3	1,489	27.7	659	12.2
BG 1	1-8, P	2,445	1,552	63.5	209	8.6	608	24.9	76	3.1
Block 1125	1-8, P	30	16	53.3	12	40.0	0	0.0	2	6.7
Block 1134	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 1135	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
BG 2	1-8, P	2,940	1,344	45.7	132	4.5	881	30.0	583	19.8
Block 2010	1-8, P	17	14	82.4	0	0.0	3	17.7	0	0.0
Block 2062	1-8, P	40	12	30.0	19	47.5	5	12.5	4	10.0
Block 2063	1-8, P	5	0	0.0	0	0.0	0	0.0	5	100.0
Block 2064	1-8, P	0	0	0.0	0	0.0	0	0.0	0	0.0
CT 6619		12,253	4,380	35.7	3,483	28.4	4,106	33.5	284	2.3
BG 1		2,889	984	34.1	449	15.5	1,287	44.5	169	5.8
Block 1081	1,3,5,7	8	6	75.0	0	0.0	2.0	25.0	0	0.0
Block 1082	1,3,5,7	22	18	81.8	0	0.0	4.0	18.2	0	0.0
Block 1093	1,3,4,6,8,P	42	24	57.1	6	14.3	12.0	28.6	0	0.0
Block 1096	1,3,5,7	13	4	30.8	0	0.0	5.0	38.5	4	30.8
Block 1099	1,3,5,7	74	14	18.9	7	9.5	20.0	27.0	33	44.6
Block 1100	1,3,5,7	6	6	100.0	0	0.0	0.0	0.0	0	0.0
Block 1101	1,3,5,7	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1102	1,3,5,7	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1108	2,3,6,8,P	3	3	100.0	0	0.0	0.0	0.0	0	0.0
Block 1110	1-8, P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1117	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1118	2,3,6,8,P	0	0	0.0	0	0.0	0.00	0.0	0	0.0
Block 1120	2,3,6,8,P	90	32	35.6	20	22.2	36.0	40.0	2	2.2
Block 1121	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0

TABLE 4-7, CONT'D

Census Tract, BG and Block	Alternatives Included	Population	Number White	% White	Number Black	% Black	Hispanic Origin	% Hispanic	Number Other	% Other
Block 1122	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1123	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1124	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1127	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1128	2,3,6,8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1136	2,3,6,8,P	38	9	23.7	17	44.7	11.0	29.0	1	2.6
Block 1181	1-8, P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1192	P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1193	P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1196	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0.0	0.0	0	0.0
Block 1200	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0.00	0.0	0	0.0
BG 4		1,986	369	18.6	1,011	50.9	586	29.5	20	1.0
Block 4000	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 4001	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 4005	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 4010	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Block 4012	1,2,3,4,5,6,7, 8,P	0	0	0.0	0	0.0	0	0.0	0	0.0
Brazoria County	1-8 and Preferred	313,166	166,674	53.2	36,880	11.8	86,643	27.7	22,969	7.3
Fort Bend County	1-8 and Preferred	585,375	211,680	36.2	123,267	21.1	138,967	23.7	111,461	19.0
State of Texas	1-8 and Preferred	25,145,561	11,397,345	45.3	2,886,825	11.5	9,460,921	37.6	1,400,470	5.6

Source: U.S. Census Bureau (2000 and 2010).
CY = Census Year; BG = Block Group; CT = Census Tract
* Segment is included in the Preferred Alternative
Note: Median household income and percent below poverty was not provided by the U.S. Census Bureau for the block level 2010 data.

The blocks within CT 6746.04 with minority populations greater than 50 percent are as follows: block 1006 with 79.3 percent minorities, block 1010 with 63.6 percent minorities; block 1018 with 63.6 percent minorities; block 1033 with 77 percent minorities, block 1043 with 69.1 percent minorities, block 1044 with 60.2 minorities, and block 1049 with 100 percent minorities. Blocks 1010 (Representative Alternatives 1, 2, 3, 4 and Preferred Alternative); block 1018 (Representative Alternatives 5, 6, 7, and 8); block 1043 (Representative Alternatives 1, 2, 3, 4, and Preferred Alternative); block 1044 (Representative Alternatives 1, 2, 3, 4, and Preferred Alternative) have fewer minorities than the associated BG (75.8 percent) and are consistent with the percentage of minority population within Fort Bend County. Blocks 1006 (Representative Alternatives 1, 2, 3, 4, 5, 6, 7, 8 and Preferred Alternative) and 1033 (Representative Alternatives 1, 2, 3, and 4) have a slightly greater percentage of minorities than the associated BG (75.8 percent). Block 1049 (Representative Alternatives 5, 6, 7, and 8) has the highest percent minority; however, there are only 11 residents within this block representing less than 1 percent of the BG population (4,607 residents).

The blocks within CT 6755 with minority populations greater than 50 percent and where block residents consist of over 1 percent of the BG population are as follows: block 1039 with 64.7 percent minorities, block 1069 with 61.2 percent minorities, block 1071 with 61.2 percent, block 1080 with 83 percent, block 1086 with 65.2 percent and block 1285 with 100 percent minorities. Blocks 1039 (Representative Alternatives 1, 2, 3, 4, 5, 6, 7, 8, and Preferred Alternative); block 1069 (Representative Alternatives 5, 6, 7, and 8), block 1071 (Representative Alternatives 5, 6, 7 and 8), and block 1086 (Representative Alternatives 5, 6, 7 and 8) are slightly higher than the BG minority population percentage (59.7 percent). Block 1080 (Representative Alternatives 1, 2, 3 and 4) has a 39 percent more minorities than the BG (59.7 percent). Block 1285 (Representative Alternatives 1, 2, 3, 4, 5, 6, 7, 8, and Preferred Alternative) has 39 percent more minorities than the associated BG; however, there are only 2 residents within this block representing less than 1 percent of the BG population (7,080 residents).

The only block within CT 6756 with a minority population greater than 50 percent is block 2019 with 79.6 percent minorities. Block 2019 (Representative Alternatives 3, 4, 7, and 8) has more than double the minority population than that of the associated BG (27.8 percent).

The blocks within CT 6618 with minority populations greater than 50 percent and where block residents consists of over 1 percent of the BG population are as follows: block 2010 with 54.3 percent minorities and block 2063 within 100 percent minorities. Block 2010 (Representatives 1–8 and Preferred Alternative) consisted of a greater minority population (70 percent) than the associated BG (54.3 percent) and a Brazoria County (46.8 percent). CT 6618, BG 2, block 2063 has a minority population of 100 percent; however, the population of this block is only 5, which accounts for less than 1 percent of the total BG population. Additionally, the work to be conducted within CT 6618 is limited to the construction of direct connectors that are proposed within the existing ROW.

The blocks within CT 6619 with minority populations greater than 50 percent and where block residents consist of over 1 percent of the BG population are as follows: block 1096 with 69.2 percent minorities, block 1099 with 81.1 percent minorities, block 1120 with 64.4 percent minorities, and block 1136 with 76.3 percent minorities. Block 1096 (Representative Alternatives 1, 3, 5, and 7) consist of slightly greater percentage of minorities than the associated BG (65.8 percent). Block 1120 (Representative Alternatives 2, 3, 6, 8, and Preferred Alternative) consists of slightly fewer minorities compared to the BG (65.8 percent). Blocks 1099 (Representative Alternatives 1, 3, 5 and 7) and block 1136 (Representative Alternatives 2, 3, 6, 8, and Preferred Alternative) consist of greater percentages of minorities than the BG (65.8 percent) and Brazoria County (46.8 percent).

Of the blocks listed in Table 4-7 with minority population greater than 50 percent and the where the block population represented larger than 1 percent of the total BG, 6 intersected the Preferred Alternative. Two (CT 6746.04 block 1006, CT 6755 block 1039) of the six blocks were intersected by all alternatives; two (CT 6746.04 blocks 1043 and 1044) were also intersected by Representative Alternatives 1, 2, 3, and 4; and two (CT 6619 blocks 1120 and 1136) were also intersected by Representative Alternatives 2, 3, 6, 8.

The list below provides the number of minorities (per block data from U.S. Census Bureau) within the blocks that intersect the proposed ROW per each Alternative. The Preferred Alternative would impact fewer minorities than any of the Representative Alternatives. The Representative Alternative with the next fewest minority impacts is Representative Alternative 1 with 1,427 minorities impacted. The Preferred Alternative has approximately 20 percent fewer minority impacts than Alternative 1.

Alternative 1:	1,427
Alternative 2:	1,445
Alternative 3:	1,619
Alternative 4:	1,463
Alternative 5:	1,953
Alternative 6:	1,971
Alternative 7:	2,058
Alternative 8:	2,076
Preferred Alternative:	1,185

Additionally, all alternatives, including the Preferred, intersect two blocks (CT 6619, BG 2, blocks 2062 and 2063), which include approximately 1,624 minorities; however, the proposed construction in these two blocks occur within existing ROW.

As indicated previously, 2010 block level information is not available for data pertaining to per capita income, median household income, percent below poverty, and LEP populations. However, the following analysis of the 2010 CT data as presented in Tables 3-6 and 3-7 was conducted in order to compare these socioeconomic characteristics within the study area with the county and state.

As indicated in Tables 3-6 and 3-7, CTs 6746.01, 6746.02, 6746.04, and 6747 have a higher median household income than Fort Bend County and Texas. CTs 6746.03, 6755 and 6756 have lower average household incomes than Fort Bend County; however, all three have higher average household income than Texas. The percent population below poverty within CT 6746.01, 6746.02, and 6756 are lower than Fort Bend County and Texas. CT 6746.03, 6746.04, 6747, and 6755 have a greater percentage of impoverished populations than Fort Bend County; however, all have a fewer percentage of impoverished populations than Texas. CT 6619 has a lower average household income than Brazoria County; however, higher than Texas. CTs 6618 and 6619 have higher percentages of impoverished populations than Brazoria County; however, lower than Texas.

Persons with Limited English Proficiency

The proposed project is in compliance with EO 13166, *Improving Access to Services for Persons with Limited English Proficiency*. This EO requires federal action to examine the services provided to persons with LEP and to identify the need for services for those people with LEP. (LEP is defined in the Elementary and Secondary Education Act of 1965 as

amended by the Improving America's Schools Act of 1934.) This EO requires federal agencies to work to ensure that recipients of federal financial assistance provide meaningful access to the LEP applicants and beneficiaries.

LEP populations within Fort Bend County and the study area are all below Fort Bend County's LEP population percentage of 5.9 and the state (8.4 percent). CT 6618 has a greater percentage of LEP population than Brazoria County; however, less than the state (8.4 percent). CT 6619 LEP population percentage is less than Brazoria County and Texas.

Two public involvement meetings were held for the proposed Grand Parkway Segment C. These events, a Public Workshop and a Public Scoping Meeting/MIS Initiation Meeting, took place in the Guy Lodge Hall of the George Ranch Historical Park in August and October 1998. Public involvement, as discussed in Section 7, was inclusive of all residents and population groups in the study area and did not exclude low–income groups or any persons because of race, color, religion, national origin, sex, age, or handicap. However, the meeting hall used was not readily wheelchair accessible. Relevant information was brought outside to individuals unable to enter the building due to disability. All subsequent and future meetings were and will be held at wheelchair-accessible locations.

Advertisements for the public meetings were placed in local and regional newspapers; general notices were posted at city halls and county seats; and individual notices were mailed to local agencies, organizations and interested citizens. Both a project website (www.grandpky.com) and mailers included a statement indicating that Spanish-speaking interpreters were available upon request, although none were requested.

As discussed in Section 2, this project would be partially funded by toll revenue and users of the road would have to pay a toll. Therefore, the impacts to ethnic minority populations and low-income populations were assessed (separately from the EJ analysis in Section 4.3.1.2) as part of the Project Level EJ Toll Analysis (Section 4.3.1.3).

4.3.1.3 Project Level Environmental Justice Toll Analysis

A project-level toll analysis was conducted to determine the potential impact that tolling would have on the EJ community within the project area. To complete this study, H-GAC utilized a travel demand model to identify potential toll road users and to conduct a travel-time analysis for persons residing in EJ TAZs and non-EJ TAZs. In addition, an evaluation of toll policies, toll rates, and available free facilities was conducted to fully evaluate the potential for disproportionate impacts to EJ communities.

Nontoll Facilities

The new location 26.9-mile toll road with intermittent frontage roads would extend from US 59 to SH 288 through Brazoria and Fort Bend counties. The main lanes are proposed to be tolled and there are no existing parallel arterials within the study area. The free roadway network that connects US 59 to SH 288 within the study area comprises local and farm-to-market roads that are generally two-lane facilities. The approximately 33-mile route entails traveling along Crabb River

Road south to FM 762, FM 762 south to FM 1462, and FM 1462 north to SH 288 (Exhibit 29). There are no toll facilities or transit service within the study area.

Toll Policies

The FBCTRA sets the toll policies for all toll roads within their jurisdiction. However, they have entered into an agreement with the HCTRA to operate and maintain toll roads within Fort Bend County. Likewise, Brazoria County defers to HCTRA policies. As such, the toll policies as set forth by HCTRA are assumed to be applicable for both Fort Bend and Brazoria counties toll road projects, including the Grand Parkway Segment C. HCTRA's toll policies have identified various circumstances for which free passage on area toll roads is allowed to individuals, certain types of vehicles, and under special circumstances. The categories of free passage for toll roads are explained in Table 4-8.

In addition, consistent with Texas Transportation Commission Minute Order No. 82325, signed October 25, 1984, the entire Grand Parkway would serve as an additional hurricane and emergency evacuation route for the Houston metroplex. In order to alleviate congestion during mass evacuations and create safer, more efficient evacuation conditions, tolls on the Grand Parkway would be suspended during hurricane evacuation.

Anticipated Toll Rate

The anticipated toll rate for the Grand Parkway project would be a schedule of rates that would not exceed the average per-mile toll rates for electronic toll transactions in force and effect for the HCTRA-operated toll road system. The toll rates identified in Table 4-9 were in effect on October 1, 2011. Toll rate increases would need to be approved by the Commissioners Court.

Methods of Toll Collection

Tolls would be collected using a completely electronic toll collection (ETC) system. No toll booths are proposed and, therefore, no cash payment would be accepted. The ETC system requires that users of the roadway have a toll tag that registers on the ETC system as the vehicles pass under the toll gantry. The ETC equipment would be placed on toll gantries positioned at specific locations along the mainlanes and at certain ramps.

The ETC allows participating motorists to prepay their tolls using a major credit/debit card or direct debit payment option. A small adhesive transponder (toll tag) that communicates electronically with a computer via radio frequencies is affixed to the inside of the windshield. As motorists use the facility, tolls are electronically deducted from their prepaid account. When an account reaches the minimum balance level, it automatically charges (debits) the customer's credit card or bank account to bring it back to the original deposit amount.

TABLE 4-8
CATEGORIES OF FREE PASSAGE ON TOLL ROADS

Category	Description
Vehicles	1. Marked police vehicles, fire department vehicles, and ambulances.
	2. Authorized emergency vehicles identified in Texas Transportation Code § 541.201
	3. Vehicles designated by the Department of Public Safety as emergency vehicles during disasters declared by the governor of Texas (Texas Transportation Code § 546.006).
	4. Individual military vehicles and convoys (considering the technological and personnel limitations of operating the toll project) (Texas Transportation Code § 362.901). • Clearly identifiable military vehicles may use the electronic tolling lanes. • Military vehicles that are not clearly identifiable should use the collector lane and "sign through" on a log maintained by the collector. • Military vehicles that are not clearly identifiable will not be allowed free passage on toll roads where there are no collector lanes.
	5. Vehicles that are part of a funeral procession, provided that: • HCTRA is notified at least 24 hours in advance; • HCTRA's Director determines that it is in the interest of public safety that the procession be routed onto the toll road system; • the procession is escorted by certified peace officers; and • the procession enters and exits the toll road system outside of these hours: Monday through Friday – 6:00 AM to 9:00 AM and 4:00 PM to 7:00 PM
	6. Processions and motorcades for heads-of-state and dignitaries (if the procession/motorcade is escorted by the United States Secret Service, Texas Department of Public Safety, or other law enforcement agency responsible for safety and security).
	Harris County owned/leased vehicles while used in the performance of county business.
Individuals	1. Current federal and state military members with Military ID are permitted free passage through collector lanes. • Requires presenting valid military ID and signing a nonrevenue sheet. • Free passage not available on Toll Roads with no collector lanes or through combination collector/electronic tolling lanes if vehicle is equipped with an EZ TAG device.
	2. HCTRA employees who must incur a toll to access or depart their duty stations at Hardy North Toll Plaza, Hardy South Toll Plaza, Sam Houston North Toll Plaza, and Sam Houston South Toll Plaza.
	3. HCTRA employees assigned to the Sam Houston Toll Bridge or Sam Houston East Plaza, whose route to work includes crossing the Toll Bridge are permitted sign through privileges for the Toll Bridge.
	4. HCTRA employees who must use the Toll Roads on HCTRA-related business (during working hours) in their private vehicles are permitted sign-through privileges upon presentation of proper authorization.

TABLE 4-8, CONT'D

Category	Description
Circumstances	The Commissioners Court authorizes free passage on the Toll Roads when there is sufficient notice of an impending catastrophic event. When the emergency or event is unexpected or unforeseen, authority is delegated to persons in the best position to exercise informed judgment as outlined below: • **Large-scale emergency or calamity:** The county judge is authorized to permit free passage on part or all of the toll roads when a large-scale emergency or calamity (natural or man-made) threatens public safety and necessitates the immediate evacuation or relocation of large numbers of people that may obstruct or impede rapid movement on the toll roads. • **Localized emergency or condition:** In the event of a localized emergency or condition (such as refinery explosions, gas leaks, hazardous material spills, flooding, traffic accidents, lane closures, etc.) that substantially threatens public safety and mobility, an on-site Incident Management certified peace officer may permit limited free passage for a period of no more than 1 hour. Approval of the county judge, Executive Director of Harris County Public Infrastructure, or the Director of HCTRA must be obtained to extend free passage beyond the initial one-hour period. • **Lane and/or road closures:** When closures required for construction and maintenance of the Toll Roads are expected to substantially and adversely affect traffic flow and/or threaten public safety, free passage may be permitted by the Director of HCTRA, the Executive Director of Harris County Public Infrastructure, or their designee. • **Ramp tolls:** HCTRA may elect to not collect tolls at ramps on dates or during hours where the Director concludes that the amount of vehicle traffic at those ramps and the tolls likely to be collected do not justify the cost of assigning collectors during those times. • **Opening a new road project or segment:** HCTRA's Director may designate a time period where free passage may be permitted to allow for testing of the infrastructure supporting the toll collection process. If the test period needs to exceed 45 days, HCTRA's Director should obtain authorization from Commissioners Court to extend the test period.

Source: HCTRA (n.d.).

TABLE 4-9
HCTRA TOLL RATES

Vehicle Axles	Mainline Plaza
2	$1.30 EZ Tag $1.50 Cash
3	$3.00
4	$4.50
5	$6.00
6	$7.50

Source: https://www.hctra.org/tollroads_rates, and http://www.gpprocurement.com/system/file_download.ashx?pg=148dver=3.

Motorists using the toll road without a toll tag would be charged via the video tolling system. The ETC video records a photograph of the vehicle's license plate and a (monthly) invoice would be mailed to the registered owner of the vehicle. The assessed toll fee for these motorists is higher than that for toll tag users, and an additional collection fee is included on the monthly invoices. This tolling program allows infrequent users without a transponder/toll tag to travel the toll road without having to stop and pay. The video tolling method is more expensive for users who do not have an active toll account because fees associated with billing and handling of the periodic billing statements are added to the costs.

Any EZ TAG account set up with a toll facility operator in Texas would be able to access toll roads or managed lanes in any of the toll authority areas while having the tolls charged to the user's home account. To achieve this objective, toll tags or transponders issued by a toll authority in one area of the state would be capable of registering toll transactions to the user's home toll account. Users from other states or international drivers would be billed similarly to users without toll tags.

The EZ TAG program requires an initial prepayment of $40 for credit/debit card payment and $80 for funds directly deducted from a bank, plus a $15 per-tag activation fee for the first three TAGs, and $10 per tag thereafter. Monthly statements for the previous 18 months of an account usage are available at no charge with an online account, or printed statements may be mailed. The associated fees for enrolling in the EZ TAG program are shown in Table 4-10.

TABLE 4-10
EZ TAG FEES

Number of Vehicle(s)	Prepaid Deposit	Balance at which Replenishment Required (¼ of Deposit)	Activation Fee (per EZ TAG)
1–3	$40	$10	$15
4-6	$80	$20	$10
7-9	$120	$30	$10
etc.	Maximum $600 (or optional higher balance)	Maximum $150 (or ¼ of optional higher balance)	$10

Source: https://www.hctra.org/about_forms/.

The user would be required to set up a prepaid account that would automatically transfer funds from their credit card or bank account to the toll account. The minimum account balance is determined by the type of payment used for the account as well as the number of EZ TAGs on the account. The typical credit card-backed account with one to three EZ TAGs has a required replenishment amount of $40 and a low balance amount of $10. This means that as a motorist travels through the EZ TAG lanes and the account goes to $10 or below, the credit/debit card will automatically be charged $40 per the EZ Agreement.

The typical bank account EZ account with one to three EZ TAGs has a required replenishment amount of $80 and a low balance amount of $20. Similarly, if the balance falls below $20, the system will automatically replenish the EZ TAG account to the $80 minimum. Frequent toll road users would therefore see multiple replenishment charges on their bank account in a month. A $25 fee is applied to each rejected withdraw from the bank account. If a bank charge fails after three consecutive attempts or three times in a 12-month period, a credit card would be required as the primary form of payment. Currently, cash accounts are not accepted to maintain an EZ TAG. Toll accounts issued by other Texas transportation entities such as the TxTag and Texas Toll Tag would be accepted on the EZ TAG system.

Toll Booths Locations

Since the Grand Parkway is proposed as an all-electronic toll road with no cash payments, no toll booths are proposed. The mainlane toll gantries would span both directions of travel on a structure similar to a typical sign bridge. The gantry would support ETC reader units, video enforcement system cameras, illumination devices, automatic vehicle identification antennae, communications gear, and other necessary equipment. This equipment would be supported approximately 20 feet above the roadway surface and would be used to collect electronic toll data. Similar, smaller gantries would be needed at some ramps as well, except these would only span the width of the particular entrance or exit ramp. The exact location of toll gantry locations (ramps and mainlane) would be determined during final design. Advantages of the ETC system include the following:

- The system minimizes the amount of ROW needed for the proposed toll collection facilities because additional lanes for cash toll booths and parking and other facilities for toll attendants would not be required.
- The gantry minimizes the acceleration and deceleration of traffic that usually accompanies toll booth collections because cash would not be accepted.
- Last-minute lane changes between toll and cash lanes would not occur, providing smoother traffic conditions at toll collection locations.
- Lighting impacts would be minimized because the gantries would not require any lighting beyond typical roadway-specific lighting for the video enforcement cameras.

Since the ETC system does not require the installation of toll booths, there would be no disproportionate impact to EJ communities regarding toll booth placement.

Environmental Justice Analysis

The H-GAC evaluation to determine the effects of the Grand Parkway Segment C on EJ populations utilized the travel demand model in conjunction with those 2000 Census block groups, which contained 51 percent or more of minority and/or low income populations. Once the EJ block groups were identified, EJ TAZs were identified if 50 percent or more of its area was identified as an EJ population. Exhibit 30 shows the EJ-related demographic data for the TAZs within the Segment C Study Area. There are 31 TAZs within the Segment C study area. Of these, 14 are identified as EJ zones (9 in Brazoria County and 5 in Fort Bend County). The proposed Segment C alignment traverses through 4 EJ zones in Brazoria County and borders one EJ zone in Fort Bend County. Following the identification of the EJ TAZs, two regional roadway network scenarios were utilized, the 2035 RTP Update Build Scenario and the 2035 RTP Update No-Build Scenario, to conduct an analysis on travel time for persons within the EJ TAZs and non-EJ TAZs. The Build Scenario includes the new tolled lanes, managed lanes, and high-occupancy tolled lanes (HOT) projects identified in the 2035 RTP Update. The No-Build Scenario includes the current roadway network, the fiscally constrained 2035 RTP Update roadway

network along with the existing plus the committed managed lane system (e.g., BW 8) but excludes the Grand Parkway Segment C project.

Travel Demand Assumptions and Methodology

The region's travel demand model does not provide a means for tracking travel at an individual household level, but does provide a means for tracking travel at a zonal level. For purposes of the analyses, the zones are specified as either EJ zones or non-EJ zones, based on the socioeconomic characteristics of the zonal populations. Some regional travel models employ a generalized cost assignment procedure for toll analyses. The H-GAC models perform toll analyses at the mode choice level. Hence, the H-GAC travel model uses a multiclass assignment procedure rather than a generalized cost procedure.

The mode choice models are applied by trip purpose. For the mode choice toll analyses, two travel time estimates are developed from each zone to all other zones: (1) the travel time using both toll and nontoll links (commonly referred to as "toll path" travel times), and (2) the travel time using only nontoll links (commonly referred to as the "free path" travel time). In the mode choice model, if the toll path does not offer a shorter travel time between two zones than the free path travel time, the trip is not considered a "candidate" for the toll facility. If a trip can save travel time using a toll path over a free path then it is considered a "candidate" trip. Of course, not all candidate trips will choose to use a tolled path. The probability of a candidate trip using a tolled path is a function of a number of variables such as the magnitude of the potential travel time savings, the toll costs, and the income characteristics of the zones residents. Aspects of this approach are employed in the analyses presented.

In mode choice model applications, there is a single highway network that is used to estimate the travel times for toll paths and free paths. For the regional toll analyses, there are two networks: the "Build" network (i.e., the forecasted roadway network containing the subject toll facilities) and the "No-Build" network (i.e., the network containing all the forecasted roadways except the Grand Parkway Segment C). Existing and committed toll facilities are contained in both networks. In this analytical setting, simply comparing the toll path versus free path option will not identify the candidate trips for only the new toll facilities being studied. Indeed, such a grouping would include trips using both existing and proposed toll facilities.

To focus on candidate trips for the new toll facility, the travel time for toll paths in the Build network is compared with the toll path travel time in the No-Build network. Trips that have a shorter toll path travel time in the Build network than the toll path travel time in the No-Build network are defined as candidate trips for the new toll facilities. The trips for a given trip purpose are segmented into four groups:

- Trips produced by EJ zones that are classified as "Candidate" trips
- The remaining trips produced by EJ zones are classified as non-"Candidate" trips
- Trips produced by non-EJ zones that are classified as "Candidate" trips

- The remaining trips produced by non-EJ zones are classified as non-"Candidate" trips.

In summary, assumptions and limitations specifically for the Grand Parkway Segment C project-level toll analysis are as follows:

1. The model is based on the latest adopted H-GAC 2035 household and employment forecast as of November 2011 (household and employment numbers are used for Trip Generation only, not population).
2. The model was validated to 2005 traffic counts within acceptable industry and H-GAC standards.
3. The model includes all system expansions as listed in the Houston 2035 RTP; the "No-Build" scenario removes only the segment being tested.
4. The model uses the same H-GAC 2035 household and employment forecast for all scenarios, both "Build" and "No-build."
5. For this analysis, an EJ zone is any TAZ that meets the minimum criteria as defined under Title VI. The model does not use separate individual households. All travels in the model from households in an EJ zone are assumed to be EJ, regardless of their individual income levels or composition. The model's Trip Generation step does consider household's income level as a factor for trip generation. (The general assumption is that higher income households tend to make more trips.)

This modeling analysis includes only direct home-based work (HBW) and home-based nonwork (HBNW) trips. Nonhome-based trips, i.e., "trip chains," are not included in this analysis. (The H-GAC model includes nonhome-based trips for travel demand forecasting; however, for the project level EJ analysis, only HBW and HBNW trips are used.)

Results

To determine the time analysis for the different types of trip scenarios, trips were divided into HBW and HBNW for both tolled and free facilities. The number of HBW and HBNW trips for the Grand Parkway Segment C project is depicted in Table 4-11.

TABLE 4-11
POTENTIAL PERSON TRIPS IN THE EJ AND NON-EJ ZONES

	2035 HBW Person Trips			2035 HBNW Person Trips		
	Toll Candidate	Non-Candidate	Total	Toll Candidate	Non-Candidate	Total
EJ Zone	472,931	2,178,048	2,650,979	288,982	6,122,041	6,411,023
Percent of Total	17.8	82.2		4.5	95.5	
Non-EJ Zone	654,686	2,452,412	3,107,098	421,684	6,408,515	6,830,199
Percent of Total	21.1	78.9		6.2	93.8	

Source: H-GAC (2011).

Using toll path travel times and free path travel times from the Build and the No-Build networks, there are four travel times for each type of trip (e.g., HBW, HBNW): (1) Build network-toll path option, (2) Build network-free path option, (3) No-Build network-toll path option, and (4) No-Build network – free path option. By computing the average trip lengths (ATLs) for each of the options, the impacts of the two networks on the choice options can be quantified, compared, and analyzed.

As shown in Table 4-11, approximately 18 percent of the HBW trips identified within EJ zones were toll candidates. Additionally, nearly 21 percent of the HBW trips identified within non-EJ zones were toll candidates. Of the HBNW trips, approximately 5 percent of the trips identified within EJ zones were toll candidates and nearly 6 percent of the HBNW trips identified within non-EJ zones were toll candidates.

Utilizing this data, further evaluation was conducted to determine the free path travel and tolled travel path for both the Build and No-Build Network Scenarios. The ATL in minutes was the measure used in this evaluation for both types of trips within the EJ and non-EJ zones.

The results of the HBW and HBNW trips analysis for the proposed Grand Parkway Segment C are presented in Tables 4-12 and 4-13, respectively.

TABLE 4-12
AM PEAK HOME-BASE WORK TRIPS

			AM Peak Average Trip Length (ATL) in minutes for Free and Tolled Facilities under the Build and No-Build Network Scenarios					
			Build Network Scenario		No-build Network Scenario		Difference in AM Peak ATL in minutes	
Zones	**2035 HBW Trip Scenarios**	**Number of 2035 HBW Person Trips**	**ATL Using Tolled Facility**	**ATL Using Free Facility**	**ATL Using Tolled Facility**	**ATL using Free Facility**	**Difference in ATL for the Tolled Facility (No-Build – Build)**	**Difference in ATL for Free Facility (No-Build – Build)**
EJ Zone	Trips that save 0+ minutes using a new tolled facility	472,931	46.42	52.23	47.21	52.30	0.79	0.07
	Trips that cannot save 0+ minutes using a new tolled facility	2,178,048	29.06	30.05	29.01	29.99	-0.05	0.06
Non-EJ Zone	Trips that save 0+ minutes using a new tolled facility	654,686	60.33	68.41	61.42	68.28	1.09	-0.13
	Trips that cannot save 0+ minutes using a new tolled facility	2,452,412	37.23	38.70	37.14	38.55	-0.09	-0.15

Source: H-GAC (2011).

TABLE 4-13
AM PEAK HOME-BASE NONWORK TRIPS

			AM Peak Average Trip Length (ATL) in minutes for Free and Tolled Facilities under the Build and No-Build Network Scenarios					
			Build Network Scenario		No-build Network Scenario		Difference in AM Peak ATL in minutes	
Zones	2035 HBNW Trip Scenarios	Number of 2035 HBNW Person Trips	ATL Using Tolled Facility	ATL Using Free Facility	ATL Using Tolled Facility	ATL using Free Facility	Difference in ATL for the Tolled Facility (No-Build – Build)	Difference in ATL for Free Facility (No-Build – Build)
EJ Zone	Trips that save 0+ minutes using a new tolled facility	288,982	33.79	35.91	34.97	36.57	1.18	0.66
	Trips that cannot save 0+ minutes using a new tolled facility	6,122,041	15.87	15.95	15.83	15.91	-0.04	-0.04
Non-EJ Zone	Trips that save 0+ minutes using a new tolled facility	421,684	55.06	58.85	57.08	60.25	2.02	1.4
	Trips that cannot save 0+ minutes using a new tolled facility	6,408,515	24.69	24.84	24.63	24.79	-0.06	-0.05

Source: H-GAC (2011).

The results for the HBW and HBNW trips analysis indicate:

- The addition of the Grand Parkway Segment C project to the regional roadway network under the Build Scenario results in a minor reduction of travel time in the EJ and non-EJ Zones (0.79 and 1.09 minutes, respectively, for HBW trips, and 1.18 and 2.02 minutes for HBNW, respectively).
- While the users of the toll facility in the Build Network Scenario within the EJ Zones would receive a greater time savings benefit than the users on the free network, there is no appreciable change in travel time on the free network in the EJ and non-EJ Zones. As a result, there is no potential for a disproportionate negative effect to the EJ populations from the proposed Grand Parkway Segment C project. In fact, the entire region, including the EJ Zones, would recognize a benefit in travel time savings because of the added capacity the entire toll roadway network facilities provide to the regional roadway network.

Potential Economic Impact

Potential economic impacts to individuals using the proposed Grand Parkway Segment C can be illustrated using the 2010 HCTRA toll rates and the median household income for the study area. Currently, the low, mid-range, and high toll rates are 12.3, 20.0, and 33.6 cents per mile, respectively. The potential cost per household calculations assumes that a toll road user makes 500 trips (250 round-trips) per year along the 26.9-mile tollway from US 59 to SH 288. As shown in Table

4-14, the annual cost for low, mid-range, and high toll rates would be approximately $1,654, $2,690, and $4,519, respectively.

A user with an annual household income that equals the 2009 median Brazoria County household income of $67,644 would spend 2.4, 4.0, and 6.7 percent of their household income on tolls. Fort Bend County users with a 2009 median household income of $80,623 would spend 2.1, 3.3, and 5.6 percent of their income on tolls. Users with an annual household income that falls within the 2012 HHS poverty level of $23,050 would spend 7.2, 11.7, and 19.6 percent of their household income on tolls.

TABLE 4-14
POTENTIAL ECONOMIC IMPACT

					Brazoria County	Fort Bend County	Percent of Poverty Level Income[4]
Toll Range	**Toll Rate per Mile[1]**	**Trips per Year**	**Miles per Trip**	**Total Cost per Year**	**Percent of Median HH Income[2]**	**Percent of Median HH Income[3]**	
Low	$0.123	500	26.9	$1,654	2.4	2.1	7.24
Mid-range	$0.20	500	26.9	$2,690	4.0	3.3	11.7
High	$0.336	500	26.9	$4,519	6.7	5.6	19.6

Source: H-GAC (2011).
[1]Per HCTRA 2010 toll rates
[2]Median household income for Brazoria County is $67,644.
[3]Median household income for Fort Bend County is $80,623.
[4]2012 HHS poverty guideline level is $23,050 for a family of four.

Assuming the same level of use, low-income populations would pay a larger percentage of their income in tolls when compared with the general population. If toll costs are beyond the affordability of low-income travelers, they have the alternative of using the existing nontolled transportation network. As a result, potential users who are unable to afford the toll or maintain a toll tag would be denied the travel benefit (reduced travel time) associated with using the tolled facility.

Availability of Tolling Information

The HCTRA website provides information regarding the EZ TAG, toll road network, toll charges or violations, and safety on the toll roads. Currently this information is available in English and no information is provided regarding the availability of translation services or hearing impaired assistance.

Conclusions

This analysis of EJ impacts for the proposed project indicates that the potential for disproportionately high and adverse impacts on the minority and/or low–income population are low.

4.3.1.4 Community Services and Facilities

The Representative Alternatives were selected in order to avoid and minimize the impacts to sensitive community facilities. Exhibit 11 indicates the locations of sensitive residential and community facilities relative to the eight Representative Alternatives. Table 4-15 lists the impacts to these community facilities by segment and by alternative, including the Preferred Alternative. Indirect impacts due to changes in traffic patterns could disrupt pedestrian corridors and bus routes of schools and churches in the general vicinity of the alternatives. Potential mitigation measures to reduce the effects of the proposed project on schools, churches, and cemeteries include the use of signalized intersections with pedestrian controls at the interchange ramps, the construction of pedestrian overpasses across the roadway facility, and the construction of noise and visual barriers between the community facility grounds and the proposed Grand Parkway Segment C.

Schools

No school property would be taken by the Preferred Alternative. Indirect impacts due to increased traffic or changes in traffic patterns could be experienced by schools in the general vicinity of the proposed interchanges. The proposed Grand Parkway Segment C (Representative Alternatives 5–8) is approximately 0.5 mile from Manford-Williams Elementary School. Alternatives 1–4 are located approximately 0.75 mile from Reading Junior High School and George Ranch High School. Two additional schools (Susanna Dickinson Elementary and William Velasquez Elementary) are located in the study area but farther away from the Preferred Alternative. Potential impacts to these schools include the increased traffic volume on FM 762 and the disruption of pedestrian routes. School bus routes may also require some alteration to accommodate roadway system changes. Travel time along routes may decrease due to reduced congestion, higher speeds, and more direct access provided by the proposed project. Safety along school bus routes should improve as traffic is drawn from congested arterial roads to the new facility.

Potential mitigation measures to reduce the impacts on nearby schools include the use of signalized intersections with pedestrian controls at the interchange ramps and the construction of noise and visual barriers (if needed) between the school grounds and the proposed Grand Parkway Segment C.

Churches and Cemeteries

As shown in Exhibit 11, numerous churches and cemeteries are located in the study area. The Representative Alternatives have been selected to minimize the impacts to these sensitive community facilities. Utilization of Segment A1* (Representative Alternatives 1–4 and Preferred Alternative) would require the relocation of Mount Moriah Baptist Church, located at 1707 Crabb River Road (2011 assessed value of $343,600). This church is located within the proposed ROW and would require relocation. Segment A2* (Representative Alternatives 1–4 and Preferred Alternative) is within the vicinity of Sandberry Cemetery and may have a visual impact, but would not affect access or the cemetery itself. The proposed Grand Parkway Segment C1 (Representative Alternatives 5–8) is located near Zion Hill Missionary Church,

TABLE 4-15
POTENTIAL COMMERCIAL RELOCATIONS BY SEGMENT

					Tax Values (where known) ($)				Census Tract Socioeconomics			
Segment	Affected Alternative	Location	Type	Acres (if known)	Land	Productivity	Improvement	2011 Assessed Value	Tract	% Black or African American	% Hispanic or Latino	% Below Poverty
A1*	1–4, P	1750 Crabb River Road	Commercial	1.43	607,400	N/A	909,720	1,517120	6746.01	6.7	8.1	2.4
A1*	1–4, P	1520 Crabb River Road	Commercial	N/A	N/A	N/A	16,800	16,800	6746.01	6.7	8.1	2.4
A1*	1–4, P	1510 Crabb River Road	Commercial	N/A	N/A	N/A	139,410	139,410	6746.01	6.7	8.1	2.4
C1	5–8	N/A	Commercial	N/A	N/A	N/A	N/A	N/A	6755	19.9	35.7	6.5
US 59 Direct Connector	1–8, P	17550 West Grand Parkway	Commercial	N/A	N/A	N/A	N/A	64,910	6747	26.7	19.8	8.6
US 59 Direct Connector	1–8, P	17480 West Grand Parkway	Commercial	N/A	N/A	N/A	N/A	101,180	6747	26.7	19.8	8.6
US 59 Direct Connector	1–8, P	20030 Southwest Freeway	Commercial	N/A	N/A	N/A	N/A	90,290	6747	26.7	19.8	8.6

Sources: Brazoria County Central Appraisal District (2011); Fort Bend County Central Appraisal District (2011); U.S. Census Bureau (2010).

+ Where there are two census tracts listed, the associated data in the columns that follow are listed in respective order.

∞ 2010 household income values are not yet available for census tracts within Fort Bend County; therefore, 2000 data for percent below poverty is presented. Also CT 6746 was subdivided into four CTs in 2010; therefore, multiple CTs are referred to where 2010 data is available, however, where 2010 data was not available, only one CT (CT 6746) is referenced.

*P – Preferred Alternative

while Segment A3.1* (Representative Alternatives 1–4 and Preferred Alternative) crosses near Southwest Church of the Nazarene. Brown Cemetery and a relocated church are located north and south of Segments J1 and T1 (Representative Alternatives 3, 4, 7, and 8). Mitigation measures to reduce the indirect effects of the project on churches and cemeteries could include pedestrian overpasses to maintain access and the construction of noise and visual barriers between the facility and the proposed Grand Parkway Segment C.

Parks and Recreation

Impacts to parks are also listed in Table 4-15. Concern has been raised in public meetings regarding the impacts of Segments T1 and X1 on the George Observatory, located within Brazos Bend State Park, and the park itself. In response to public and agency comments concerning the proximity of these segments to Brazos Bend State Park, the Preferred Alternative was moved northward, thus contributing to the development of the Preferred Alternative segments W1, G3.2, and X1. The Preferred Alternative is approximately 7,000 feet from Brazos Bend State Park property. Moving the Preferred Alternative 1.3 miles from the Brazos Bend State Park boundary would avoid any direct affects to the park. All commitments between the GPA and Brazos Bend State Park would be honored for the Preferred Alternative. Users of the George Observatory fear that secondary development due to the construction of the proposed Grand Parkway Segment C could alter the darkness of the area and in turn decrease the visibility of stars by visitors. However, no studies have been performed to confirm these effects. The GPA has made a commitment to the George Observatory to expand its scenic easement to shield the lighting to the maximum extent possible.

The Preferred Alternative is located approximately 4,200 feet from the George Ranch Historical Park. There would be no direct impacts to this private facility. The Preferred Alternative would also lie within 1,000 feet of the Lake Worthington Conservation Area. Impacts to this private easement were addressed during the Section 7 consultation.

The improved exposure and access to the George Ranch Historical Park, Brazos Bend State Park, and the George Observatory brought about by the proximity of these sites to the proposed Grand Parkway Segment C could result in an increase in numbers of visitors.

Representative Alternatives 1–4 and the Preferred Alternative would require ROW from the southwestern corner of The Triumph Christian Center. No impact to the function of the church is anticipated.

4.3.1.5 Public Lands

Impacts to schools and parks are discussed in the section above. No publicly owned recreation areas or parks would be directly affected by or are directly adjacent to the Representative Alternatives or the Preferred Alternative. Therefore, no Section 4(f) or Section 6(f) public land takes are anticipated for any of the alternatives. However, as stated in Section 4.17, those sites where access is necessary for Section 4(f) evaluations but has not yet been granted will be surveyed and evaluated for Section 4(f) impacts in greater detail once access is granted.

4.3.1.6 Public Safety

The proposed project, including all Representative Alternatives and the Preferred Alternative, would have a beneficial impact on the level of public safety in the study area. This improvement would be attributable to the diversion of drivers from local roads, as many opt for the greater convenience and faster travel time of the new roadway. It is likely that the proposed highway facility would reduce congestion and facilitate the reduction in response time for police, fire protection, and medical services. However, it is also likely that the proposed Grand Parkway Segment C would ease commutes and in turn increase travelers through the area.

4.3.2 Relocations

Potential relocation impacts are detailed in the following section and summarized in Table 4-15.

4.3.2.1 Relocation Analysis

A windshield survey of structures that may potentially be relocated by the proposed project was conducted in June 2009, with a follow-up survey conducted in June 2010. Aerial maps were also consulted in an attempt to identify structures that were not clearly visible from public roadways. Although no record searches were formally performed regarding the various properties, and no interviews were conducted with the owners or occupants, some information was readily available through an address search of county tax records. This sample of tax records was used to approximate property values and to identify, when possible, farm properties as distinct from nonfarm rural properties. Table 4-15 contains information on each potentially relocated commercial business based on readily available information, to the extent it could be obtained without intrusion on the subject properties.

For the purposes of assessing availability of alternative housing, a property search was performed of properties listed by members of the Houston Association of Realtors. This search was limited to properties offered through the Multiple Listing Service (MLS) that were in the general location of the subject properties, which approximated the assessed valuation or estimated valuation of each property.

Although no intrusive interviews were conducted, the socioeconomic characteristics of the occupants may be surmised from the values of the properties. Additional information is included in Table 4-15 regarding CT characteristics of tracts in which the properties are located as a proxy for the general socioeconomic characteristics of affected neighborhoods.

Segment A1*, in the vicinity of Crabb River Road, is in the most urbanized portion of the study area; however, there are only three commercial establishments, one church, and a Municipal Utility District (MUD) facility, that appear to be located in the proposed ROW of Segment A1* and subject to potential displacement by Representative Alternatives 1–4 and the Preferred Alternative. There are three additional commercial properties located within the ROW of the US 59 interchange, associated with the direct connectors, on the northeast side of US 59. Exxon, Greatwood Auto Collision and Detail, and $1.89 Crystal Cleaner are the three commercial properties located within the ROW of Segment A1*. Bank of America,

Whataburger, and Mattress Firm are located within the ROW at the US 59 interchange. The three commercial establishments within the ROW required for the direct connector ramps would be relocated for any of the alternatives.

Exxon (located at 1750 Crabb River Road) has a 2011 assessed value of $1,517,120; Greatwood Auto Collision and Detail (located at 1520 Crabb River Road) have a 2011 assessed value of $16,800; $1.89 Crystal Cleaner (located at 1510 Crabb River Road) has a 2011 assessed value of $139,410; Bank of America (located at 17550 W. Grand Parkway) has a 2011 assessed value of $64,910; Whataburger (located at 17480 W. Grand Parkway) has a 2011 assessed value of $101,180; and Mattress Firm has a 2011 assessed value of $90,290. All of these businesses appear to have high activity, perhaps due to their locations at busy intersections. Given the likelihood that the Grand Parkway corridor would gradually convert to commercial uses along its length, these businesses may be able to relocate to another, equally attractive site. However, this may involve an interruption of business.

The Fort Bend MUD #116 is located on the north side of Rabbs Bayou along Crabb River Road. This facility is located within the proposed ROW and would require relocation. Additionally, the northeastern portion of the garden center located on the corner of US 59 and Crabb River Road is within the ROW; however, this parking area is not expected to be taken since this area of ROW is proposed as a bridge.

Table 4-16 provides the number of residential relocations by Alternative.

TABLE 4-16
RESIDENTIAL RELOCATIONS BY ALTERNATIVE

	Alternative								Preferred Alternative
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Single Family (Site Built)	5	12	8	15	88	95	91	98	12
Single Family (Mobile Homes)	1	2	1	2	1	2	1	2	2
Single Family (Platted)	0	0	0	0	0	0	0	0	0
Total Residential	**6**	**14**	**9**	**17**	**89**	**97**	**92**	**100**	**14**

Source: Study Team (2011).

Availability of Comparable Housing

For purposes of assessing availability of alternative housing, a property search was performed of properties listed by members of the Houston Association of Realtors through the MLS in 2011. The search was limited to housing (1) in the general location (all or portion of the resident county) of the subject properties, and (2) which approximated the assessed valuation or estimated valuation of each property.

The relocations within the Representative Alternatives as well as the Preferred Alternative are located in the following zip codes: 77469, 77430, and 77515. Realtos.com Multiple Listing indicates that over 250 single-family homes were listed in the 77469 zip code; 10 in 77430; and 170 in 77515. Of the homes listed in the 77469 zip code, there were 2 properties listed under $50,000; 14 properties listed between $50,000–$80,000; 14 properties listed between $80,000–$100,000; 51

properties listed between $100,000–$150,000; 61 properties listed between $150,000–$200,000; and 114 properties listed above $200,000.

Of the homes listed in the 77430 zip code, there was one property listed under $50,000; six properties listed between $50,000–$80,000; none above $80,000–$100,000; none between $100,000–$150,000; one property listed between $150,000–$200,000; and two properties listed above $200,000.

Of the homes listed in the 77515 zip code, there were 9 properties listed under $50,000; 37 properties listed between $50,000–$80,000; 20 properties above $80,000–$100,000; 55 properties listed between $100,000–$150,000; 29 property listed between $150,000–$200,000; and 41 properties listed above $200,000.

While it appears that replacement housing can be found for all of the properties within the general area, replacement housing supplemental payments may be required to relocate some of the displaced property owners into comparable housing.

Relocation Assistance by the Texas Department of Transportation

According to the Uniform Relocation Assistance and Real Properties Acquisitions Act of 1970 (amended in 1987), property owners will receive compensation for properties acquired for transportation projects under nondiscriminatory ROW policies with regard to appraisals and acquisitions of homes and businesses.

TxDOT offers relocation counseling and financial assistance to residences and businesses that are displaced by the acquisition of highway ROW. Those who are displaced will be contacted by a relocation counselor who will provide information, answer questions, and assist the occupant in applying for relocation benefits. Benefits are provided to eligible tenants and owners of relocated properties. Relocation services provided include provision of listings of comparable housing, transportation to inspect the housing (especially for elderly or disabled persons), and referral services to other agencies that provide assistance for relocated persons.

In general, relocated persons are provided at least a 90-day notice of the displacement. Prior to the move, displaced persons apply to TxDOT for relocation benefits, which are intended to reimburse the costs of moving and related expenses incurred in the move. Displaced persons may chose either to engage a professional mover and be reimbursed for actual costs (limited to a move of 50 miles from the original property), or be paid directly on the basis of a fixed moving cost schedule, which is based on the number of rooms in the dwelling.

Replacement housing payments are based on the cost of a comparably functioning dwelling (in terms of the number of rooms, living space, location, and square footage), which is currently available, and within the financial means of the occupant. The replacement housing must be “decent, safe, and sanitary” (TxDOT, 1999), meeting all the minimum requirements established by the state and conforming to local building codes. Depending on particular circumstances,

assistance may be offered as a purchase supplement, rental assistance, or down payment on a loan. Potentially displaced persons will not be forced to move unless at least one comparable replacement dwelling is made available to them.

Relocation benefits have no adverse effect on Social Security eligibility, welfare eligibility, or income tax liability.

In addition to residential relocation assistance, TxDOT also provides assistance to relocated businesses, farms, and nonprofit organizations. Moving benefits may be in the form of reimbursements of reasonable moving expenses, or fixed payments under specified circumstances.

4.3.3 Summary of Impacts

Representative Alternatives 1–4 and the Preferred Alternative would result in the relocation of six commercial facilities, one church, and one MUD facility. Representative Alternatives 5–8 would result in the relocation of four commercial facilities.

Representative Alternatives 5–8 would result in the greatest number of residential relocations, ranging from 89 to 100. Alternatives 1–4 and the Preferred Alternative would result in the least number of residential relocations, ranging from 6 to 17, with the Preferred Alternative resulting in 14 relocations. Housing is available within the impacted zip codes of the residential relocations. Additionally, some possible impacts that may occur as a result of tolling the proposed project may be that low-income persons who cannot afford toll tags would be forced to use longer alternative routes to access emergency services. Low-income persons may not have credit cards with which to purchase toll passes. Low-income persons who do not own vehicles would not benefit from the toll-road system, leading them to be forced to use alternative routes, resulting in longer commutes than higher-income persons. However, those who would use the toll road and those who would choose not to use the toll road would both experience benefits. If local residents use the toll road, benefits would include increased access to job markets and services, and decreased travel time to destinations. Local residents that choose to not use the toll road may benefit by reduced traffic on local roadways, thereby decreasing their commuting times.

All alternatives would likely have a beneficial effect on public safety, reduce traffic congestions, improve school bus transportation, and improve response times overall for police, fire protection, and medical services in the Segment C project area. No fire stations would be displaced by any Alternative. Generally, all of the Alternatives are anticipated to increase property values in the Segment C project area, particularly in areas adjacent to entrance/exist ramps, interchanges, and frontage roads.

Under the No-Build Alternative, community cohesion impacts from the proposed project would not occur. However, anticipated future development in the Segment C project area would continue to alter the land use patterns in the area, changing the character from semi-rural suburban to urbanized suburban. As arterial roadways in the Segment C project area take on additional traffic volume over time (without the proposed project), traffic congestion on these roadways would increase in the area. Eventually, these arterial roadways would have to be widened and/or improved to accommodate this increase in traffic volume. Temporary construction effects and relocations of residences and businesses would result as

roadway improvements are made on these arterial roadways. Increased future traffic congestion on these arterial roadways would likely affect school bus routing and would likely increase emergency response times.

4.3.4 Indirect Impacts

Indirect development may occur because of the proposed highway and could affect the daily lives of residents in nearby communities. Potential indirect development would be similar for all alternatives' alignments. The degree to which indirect development may occur is dependent on many variables and is difficult to precisely predict. Existing residential areas may become more densely populated, utility and social service responsibility may increase, and forest, farmland, and/or undeveloped land may be converted to other urban forms of land use.

All of the proposed project alternative alignments would provide an impetus for indirect development at or near entrance/exit ramps and highway interchanges, and adjacent to the short sections of highway frontage roads. This indirect development would likely include gas stations, convenience stores, retail strip-malls, restaurants, office buildings, and apartments. In the long-term, these new developments would provide services, office space, and some housing for residents of the Segment C project area, but would not have any disproportionate effects on minority or low-income populations. This growth is likely to occur over an extended period of time and is likely to follow current residential growth patterns observed in the project area.

Indirect development and potential community change can be perceived as positive or negative. To some, this change is unwanted and the conversion of farmland and/or undeveloped land to residential and commercial uses is undesirable; however, for others, new development often means new jobs and increased economic vitality.

The No–Build Alternative would not likely result in indirect development or associated change in communities beyond the current development trends. Current development trends would affect increased traffic with the No-Build Alternative; however, the No-Build Alternative would not provide the congestion relief afforded by the Build Alternative.

4.3.5 Mitigation

Community and Relocations

Every effort has been made in the selection of the Preferred Alternative to avoid or minimize adverse effects to sensitive resources. Opportunities to reduce the amount of ROW would be identified during the final design stage. During the construction phase, short-term effects related to noise and dust would be minimized (see Section 4.6.7). Traffic delays would be minimized through coordination among TxDOT, contractors, and affected neighborhoods or landowners (in the areas immediately adjacent to the proposed ROW), and by developing a construction schedule that would allow for a minimum delay for movement across the proposed ROW. Also, efforts would be made to provide appropriate construction detours, informative signage, and access to residences, farms, businesses, and community facilities where practicable.

Grade separations would be incorporated into the design of the Preferred Alternative, allowing adequate movement of school buses and emergency vehicles across the proposed Segment C project area.

There would be a low potential for disproportionate effects associated with the Preferred Alternative to minorities or low-income populations within the Segment C project area; therefore, no mitigation related to EJ would be necessary.

Tolls

Mitigation for low-income populations within the proposed Grand Parkway Segment C may include:

- Offering cash-purchasing alternatives, such as vending machines at local retailers for applying credit to the EZ Tag that is used to access the toll road.
- Offering reduced toll fares for low-income populations.
- Buses may be allowed to use the toll road for free to allow those low-income populations toll-road access.

4.4 ECONOMIC IMPACTS

The following sections address economic impacts from the construction of the proposed Grand Parkway Segment C. In addition to temporary economic impacts from the construction of the project, additional long-term impacts would result from the operation of the proposed Grand Parkway Segment C, primarily from maintenance activities. However, operational impacts are not addressed because costs for operation are not known at this time.

4.4.1 Texas Economy (Total Demand) Segment Analysis

Table 4-17 shows the direct and indirect impact of the construction of the proposed Grand Parkway Segment C on the Texas economy, as well as direct non-Texas impacts. For each segment, total construction cost is shown in the second column. Direct impacts, as derived from the Texas Input-Output Model (Texas Comptroller of Public Accounts, 2000) are shown in the third and fourth columns, disaggregated into imports (impacts on the economy outside the State of Texas) and Texas impacts.

The far right column of Table 4-17 shows the total final demand impact of each segment on the Texas economy. This is obtained from the final demand multiplier for new roadway and highway construction of 3.6885 times the construction cost. This includes indirect impacts as goods and services are provided to the sectors that provide the goods and services directly for the construction of the highway. Also included are impacts on households in the form of personal income.

According to the Uniform Relocation Assistance and Real Properties Acquisitions Act of 1970 (amended in 1987), property owners will receive compensation for properties acquired for transportation projects under nondiscriminatory ROW policies with regard to appraisals and acquisitions of homes and businesses.

TABLE 4-17
TOTAL ECONOMIC IMPACT OF PROPOSED GRAND PARKWAY SEGMENTS: CONSTRUCTION PHASE AND PERCENT OF PROJECTED STATE GROSS PRODUCT 2003–2006 ($ MILLIONS) +

Segment	Construction Cost	Direct Impacts		Total Impact	Percent
		Impact Outside Texas	Texas Direct Impact		
A1*	13.90	2.60	11.30	51.30	0.001
A2*	4.50	0.90	3.70	16.60	0.000
A3.1*	8.90	1.70	7.20	32.80	0.001
A6	11.10	2.10	9.00	40.90	0.001
B1	5.00	1.00	4.10	18.40	0.001
B3	3.60	0.70	2.90	13.30	0.000
B4.1	7.00	1.30	5.70	25.80	0.001
B4.2*	1.30	0.20	1.00	4.80	0.000
B5	11.50	2.20	9.30	42.40	0.001
B6	1.80	0.30	1.50	6.60	0.000
B7	3.10	0.60	2.50	11.40	0.000
C1	14.50	2.80	11.80	53.50	0.001
C2	13.10	2.50	10.60	48.30	0.001
G3.2*	9.70	1.90	7.90	35.80	0.001
G5.2*	22.00	4.20	17.90	81.10	0.002
G6.2*	5.80	1.10	4.70	21.40	0.001
G7*	3.20	0.80	3.60	11.80	0.000
G8*	13.50	2.10	8.90	49.80	0.001
J1	16.00	3.00	12.90	59.00	0.002
K1	16.00	3.00	12.90	59.00	0.002
P1	17.30	3.30	14.00	63.80	0.002
Q1	18.00	3.40	14.60	66.40	0.002
S1-b*	23.60	4.50	19.10	87.00	0.002
T1	19.60	3.70	15.90	72.30	0.002
W1*	38.10	7.20	30.90	140.50	0.004
X1*	31.70	6.00	25.70	116.90	0.003
Y1*	25.30	4.80	20.50	93.30	0.002

Source: Texas Comptroller of Public Accounts (1989, 2000).

*Segment included in Preferred Alternative

+Some segments were revised since the estimates in the table above were conducted; therefore, the estimates are considered approximate. For example, G4 and G5 were replaced by other segments, therefore not presented in the table. X1-a and X1-b were replaced with X1. G6.1 shifted slightly and is now included in Y1. S1 shifted slightly and is now called S1-b.

4.4.1.1 Major Economic Sectors

Table 4-18 shows the relative economic impact to various major economic sectors from the construction of each segment. These are the relative portions of the Total Texas Impact figures (total demand) from Table 4-17. The remaining demand impact, household sector, and income impacts are discussed below and shown in Table 4-19.

4.4.1.2 Retail and Wholesale Trade

Table 4-20 provides more-specific data on the impacts of construction on retail and wholesale trade. Retail and wholesale trade are some of the components of "Trade" from Table 4-20.

4.4.1.3 Established Business Districts and Public and Private Sectors

Established central business districts of area communities are not located within the study area and would not likely be affected by the conversion of land uses in the proposed ROW. There is, however, an established commercial area in Segments A1* and A3*, which would likely be considerably affected by being located along a major highway ROW rather than along a major local arterial. It should be noted, however, that the potentially affected businesses lie along existing Crabb River Road, near the intersection with US 59. This intersection is currently heavily traveled, and US 59 is a major highway through the region; therefore, the change in the commercial nature of this area is likely to be one of magnitude rather than a quantitative change in commercial function. Several businesses would likely be relocated (see Section 4.3), while others would perhaps benefit from greater traffic volumes. It is also possible that there may be some intensification of commercial uses in this area and that there may be some changes in businesses in this area as traffic volumes increase.

Although local jurisdictions will ultimately control land-use patterns and intensity of development, it is likely that there would be an intensification of commercial and office uses along the already-commercial Crabb River Road area near US 59. Currently, there is some residential development along Crabb River Road. Potentially, undeveloped land could become commercial development, which would create economic benefits, including additional economic production, employment, personal income, and governmental revenues from property, franchise, sales, and other appropriate taxes. However, the magnitude of such changes is dependent both on local regulatory controls and market forces, which will affect such factors as type of land use permitted, allowable densities, structure heights, etc.

TABLE 4-18
TOTAL DIRECT TEXAS IMPACT OF GRAND PARKWAY SEGMENTS, BY MAJOR ECONOMIC SECTOR AND PERCENT OF PROJECTED STATE GROSS PRODUCT 2003–2006 ($ MILLIONS) +

	Agriculture		Mining		Construction		Manufacturing		Transportation Communication Utilities		Trade		Finance Insurance Real Estate		Services	
Segment	$	%	$	%	$	%	$	%	$	%	$	%	$	%	$	%
A1*	0.40	0.001	0.80	0.000	16.20	0.010	5.40	0.001	2.40	0.001	4.10	0.001	4.90	0.001	5.00	0.001
A2*	0.10	0.000	0.30	0.000	5.30	0.003	1.80	0.000	0.80	0.000	1.30	0.000	1.60	0.000	1.60	0.000
A3.1*	0.30	0.001	0.50	0.000	10.40	0.006	3.50	0.001	1.60	0.000	2.60	0.000	3.10	0.001	3.20	0.001
A6	0.30	0.001	0.60	0.000	13.00	0.008	4.30	0.001	2.00	0.000	3.30	0.001	3.90	0.001	4.00	0.001
B1	0.10	0.000	0.30	0.000	5.80	0.004	1.90	0.000	0.90	0.000	1.50	0.000	1.80	0.000	1.80	0.000
B3	0.10	0.000	0.20	0.000	4.20	0.003	1.40	0.000	0.60	0.000	1.10	0.000	1.30	0.000	1.30	0.000
B4.1	0.20	0.000	0.40	0.000	8.20	0.005	2.70	0.000	1.20	0.000	2.10	0.000	2.50	0.000	2.50	0.000
B4.2*	0.00	0.000	0.10	0.000	1.50	0.001	0.60	0.000	0.20	0.000	0.40	0.000	0.50	0.000	0.50	0.000
B5	0.30	0.001	0.70	0.000	13.40	0.008	4.50	0.001	2.00	0.000	3.40	0.001	4.00	0.001	4.10	0.001
B6	0.10	0.000	0.10	0.000	2.10	0.001	0.70	0.000	0.30	0.000	0.50	0.000	0.60	0.000	0.70	0.000
B7	0.10	0.000	0.20	0.000	3.60	0.002	1.20	0.000	0.50	0.000	0.90	0.000	1.10	0.000	1.10	0.000
C1	0.40	0.001	0.80	0.000	16.90	0.010	5.60	0.001	2.50	0.001	4.30	0.001	5.10	0.001	5.20	0.001
C2	0.40	0.001	0.70	0.000	15.20	0.009	5.10	0.001	2.30	0.000	3.90	0.001	4.60	0.001	4.70	0.001
G3.2*	0.30	0.001	0.60	0.000	11.40	0.007	3.80	0.001	1.70	0.000	2.90	0.000	3.40	0.001	3.50	0.001
G5.2*	0.70	0.002	1.20	0.001	25.70	0.016	8.50	0.001	3.90	0.001	6.50	0.001	7.70	0.001	7.90	0.001
G6.2*	0.20	0.000	0.30	0.000	6.70	0.004	2.20	0.000	1.00	0.000	1.70	0.000	2.00	0.000	2.10	0.000
G7*	0.10	0.000	0.20	0.000	3.80	0.002	1.30	0.000	0.60	0.000	1.00	0.000	1.10	0.000	1.20	0.000
G8*	0.40	0.001	0.80	0.000	15.80	0.010	5.20	0.001	2.40	0.001	4.00	0.001	4.80	0.001	4.80	0.001
J1	0.50	0.001	0.90	0.000	18.60	0.011	6.20	0.001	2.80	0.001	4.70	0.001	5.60	0.001	5.70	0.001
K1	0.50	0.001	0.90	0.000	18.60	0.011	6.20	0.001	2.80	0.001	4.70	0.001	5.60	0.001	5.70	0.001
P1	0.50	0.001	1.00	0.001	20.10	0.012	6.70	0.001	3.00	0.001	5.10	0.001	6.10	0.001	6.20	0.001
Q1	0.50	0.001	1.00	0.001	20.90	0.013	7.00	0.001	3.10	0.001	5.30	0.001	6.30	0.001	6.40	0.001
S1-b*	0.70	0.002	1.30	0.001	27.50	0.017	9.20	0.002	4.10	0.001	7.00	0.001	6.30	0.001	6.40	0.001
T1	0.60	0.001	1.10	0.001	22.80	0.014	7.60	0.001	3.40	0.001	5.80	0.001	6.90	0.001	7.00	0.001
W1*	1.10	0.002	2.20	0.001	44.40	0.027	14.80	0.003	6.70	0.001	11.30	0.002	13.40	0.002	13.70	0.002
X1*	0.90	0.002	1.80	0.001	37.00	0.022	12.30	0.002	5.60	0.001	9.40	0.001	11.20	0.002	11.40	0.002
Y1*	0.80	0.002	1.40	0.001	29.50	0.018	9.80	0.002	4.40	0.001	7.50	0.001	8.90	0.002	9.10	0.001

Source: Texas Comptroller of Public Accounts (1989, 2000).

*Segment included in Preferred Alternative

+Some segments were revised since the estimates in the table above were conducted; therefore, the estimates are considered approximate. For example, G4 and G5 were replaced by other segments, therefore, not presented in the table. X1-a and X1-b were replaced with X1. G6.1 shifted slightly and is now included in Y1. S1 shifted slightly and is now called S1-b.

TABLE 4-19
INCOME IMPACTS OF GRAND PARKWAY SEGMENTS AND PERCENT OF PROJECTED STATE PERSONAL INCOME 2003–2006 ($ MILLIONS) +

Segment	Direct Impacts		Indirect Impacts		Total Impacts	
	$	%	$	%	$	%
A1*	4.00	0.000	8.10	0.000	12.10	0.000
A2*	1.30	0.000	2.60	0.000	3.90	0.000
A3.1*	2.60	0.000	5.20	0.000	7.80	0.000
A6	3.20	0.000	6.50	0.000	9.70	0.000
B1	1.40	0.000	2.90	0.000	4.30	0.000
B3	1.00	0.000	2.10	0.000	3.10	0.000
B4.1	2.00	0.000	4.10	0.000	6.10	0.000
B4.2*	0.40	0.000	0.80	0.000	1.20	0.000
B5	3.30	0.000	6.70	0.000	10.00	0.000
B6	0.50	0.000	1.10	0.000	1.60	0.000
B7	0.90	0.000	1.80	0.000	2.70	0.000
C1	4.20	0.000	8.40	0.000	12.60	0.000
C2	3.80	0.000	7.60	0.000	11.40	0.000
G3.2*	2.80	0.000	5.70	0.000	8.50	0.000
G5.2*	6.40	0.000	12.80	0.000	19.20	0.001
G6.2*	1.70	0.000	3.30	0.000	5.00	0.000
G7*	0.90	0.000	1.90	0.000	2.80	0.000
G8*	3.90	0.000	7.80	0.000	11.70	0.000
J1	4.60	0.000	9.30	0.000	13.90	0.000
K1	4.60	0.000	9.30	0.000	13.90	0.000
P1	5.00	0.000	10.00	0.000	15.00	0.001
Q1	5.20	0.000	10.40	0.000	15.60	0.001
S1-b*	6.80	0.000	13.70	0.000	20.50	0.001
T1	5.70	0.000	11.40	0.000	17.10	0.001
W1*	11.00	0.000	22.10	0.001	33.10	0.001
X1*	9.20	0.000	18.40	0.001	27.60	0.001
Y1*	7.30	0.000	14.70	0.000	22.00	0.001

Source: Texas Comptroller of Public Accounts (1989, 2000).

*Segment included in Preferred Alternative

+Some segments were revised since the estimates in the table above were conducted; therefore, the estimates are considered approximate. For example, G4 and G5 were replaced by other segments, therefore, not presented in the table. X1-a and X1-b were replaced with X1. G6.1 shifted slightly and is now included in Y1. S1 shifted slightly and is now called S1-b.

TABLE 4-20
RETAIL AND WHOLESALE SALES IMPACT OF GRAND PARKWAY SEGMENTS AND PERCENT OF PROJECTED STATE GROSS PRODUCT 2003–2006 ($ MILLIONS) +

Segment	Retail Sales		Wholesale Sales	
	$	%	$	%
A1*	1.90	0.001	1.80	0.001
A2*	0.60	0.000	0.60	0.000
A3.1*	1.20	0.000	1.20	0.000
A6	1.60	0.000	1.50	0.000
B1	0.70	0.000	0.70	0.000
B3	0.50	0.000	0.50	0.000
B4.1	1.00	0.000	0.90	0.000
B4.2*	0.20	0.000	0.20	0.000
B5	1.60	0.000	1.50	0.000
B6	0.30	0.000	0.20	0.000
B7	0.40	0.000	0.40	0.000
C1	2.00	0.001	1.90	0.001
C2	1.80	0.001	1.70	0.001
G3.2*	1.40	0.000	1.30	0.000
G5.2*	3.10	0.001	2.90	0.001
G6.2*	0.80	0.000	0.80	0.000
G7*	0.50	0.000	0.40	0.000
G8*	1.90	0.001	1.80	0.001
J1	2.20	0.001	2.10	0.001
K1	2.20	0.001	2.10	0.001
P1	2.40	0.001	2.30	0.001
Q1	2.50	0.001	2.40	0.001
S1-b*	3.30	0.001	3.10	0.001
T1	2.70	0.001	2.60	0.001
W1*	5.30	0.002	5.10	0.002
X1*	4.40	0.001	4.20	0.001
Y1*	3.50	0.001	3.40	0.001

Source: Texas Comptroller of Public Accounts (1989, 2000).
*Segment included in Preferred Alternative
+Some segments were revised since the estimates in the table above were conducted; therefore, the estimates are considered approximate. For example, G4 and G5 were replaced by other segments, therefore, not presented in the table. X1-a and X1-b were replaced with X1. G6.1 shifted slightly and is now included in Y1. S1 shifted slightly and is now called S1-b.

4.4.1.4 Employment

As shown in Table 3-9, there has been considerable growth in jobs, the labor force, and employment in the Houston metropolitan area over the past decade, especially in Fort Bend County. Employment in Brazoria County, while it has also experienced growth, has not increased as rapidly as the labor force. Table 4-21 shows the number of jobs expected to be generated by the construction of the project, both directly in the construction sector and indirectly in all other sectors. These figures were derived from the Texas Input-Output Model, using factors for the number of jobs per $1,000,000 of construction cost. These factors were adjusted from the 1986 cost figures used in the Input-Output Model to 1999 costs by applying ENR Construction Cost Indices (*Engineering News-Record*, 1999).

Given the size of the Houston metropolitan area, it is likely that the construction workforce could be drawn from the general region without causing considerable population relocations for construction. Thus the indirect impacts resulting from the construction of the project are likely to be negligible. However, it is possible that the construction workforce would not be available exclusively from Fort Bend and Brazoria counties.

Table 4-22 shows historical and current construction-related workforce, historical employment by sector, and unemployment patterns.

Table 4-22 shows the projected local construction workforce trends that would have occurred in the two-county area between 1990 and 2010 if the proposed Grand Parkway Segment C had been constructed during that timeframe. According to the projection, the construction workforce of Fort Bend and Brazoria County would have steadily increased between 1990 and 2010. This was a conservative (low) figure that assumed the proposed project would draw from the work force that would have otherwise been unemployed construction workers. Only a portion of those workers was likely to have the skills required for roadway construction. These figures can be compared with the workforce needs of the various alternatives, which indicate that approximately 2,800 to 3,900 jobs would be created over the 30-month construction timeframe. This comparison suggests that the construction workforce is likely to be drawn from the larger Houston metropolitan area, which is of sufficient size to provide the necessary workers.

4.4.1.5 Personal Income

Table 4-23 shows the impacts on households from the construction phase of the roadway. This table represents the increases to household income due to the construction of the roadway.

4.4.1.6 Impacts on Local Tax Revenues

Table 4-23 shows the potential impact of each segment of the roadway construction on local government revenues, based on the Texas Input-Output Model. These are temporary impacts during the construction phase of the project. In the longer term, land purchased for the ROW would be removed from local tax rolls, thus potentially decreasing property tax

TABLE 4-21
EMPLOYMENT IMPACT OF GRAND PARKWAY SEGMENTS AND PERCENT OF PROJECTED STATE GROSS PRODUCT 2003–2006 +

Number of Jobs from Construction Phase						
	Direct Jobs (Construction)		Indirect Jobs (All Sectors)		Total Jobs (All Sectors)	
Segment	#	%	#	%	#	%
A1*	269	0.012	261	0.001	530	0.001
A2*	88	0.004	85	0.000	173	0.000
A3.1*	172	0.007	167	0.000	340	0.001
A6	215	0.009	208	0.001	423	0.001
B1	97	0.004	94	0.000	191	0.000
B3	70	0.003	67	0.000	137	0.000
B4.1	136	0.006	132	0.000	267	0.001
B4.2*	25	0.001	24	0.000	49	0.000
B5	222	0.010	215	0.001	437	0.001
B6	35	0.002	34	0.000	70	0.000
B7	60	0.003	58	0.000	118	0.000
C1	280	0.012	272	0.001	552	0.001
C2	252	0.011	245	0.001	497	0.001
G3.2*	188	0.008	182	0.000	370	0.001
G5.2*	425	0.018	412	0.001	837	0.002
G6.2*	111	0.005	108	0.000	219	0.001
G7*	63	0.003	61	0.000	123	0.000
G8*	261	0.011	253	0.001	514	0.001
J1	308	0.013	299	0.001	607	0.001
K1	308	0.013	299	0.001	607	0.001
P1	333	0.014	323	0.001	656	0.002
Q1	346	0.015	336	0.001	683	0.002
S1-b*	456	0.020	442	0.001	898	0.002
T1	378	0.016	367	0.001	745	0.002
W1*	735	0.032	713	0.002	1,448	0.003
X1*	612	0.026	594	0.001	1,206	0.003
Y1*	488	0.021	473	0.001	961	0.002

Source: Texas Comptroller of Public Accounts (1989, 2000).

*Segment included in Preferred Alternative

+Some segments were revised since the estimates in the table above were conducted; therefore, the estimates are considered approximate. For example, G4 and G5 were replaced by other segments, therefore, not presented in the table. X1-a and X1-b were replaced with X1. G6.1 shifted slightly and is now included in Y1. S1 shifted slightly and is now called S1-b.

TABLE 4-22
LOCAL CONSTRUCTION WORKFORCE

Factor /Location	Year		
	1990	2000	2010
Population			
HGB CMSA	3,732,919	4,002,777	4,820,501
Brazoria County	191,707	225,358	260,865
Fort Bend County	225,421	332,865	476,530
Both	417,128	558,223	737,395
Work Force as % of Population			
HGB CMSA	48.51	48.50	48.50
Brazoria County	51.16	51.16	51.16
Fort Bend County	54.27	54.27	54.27
Both	52.84	53.01	53.17
Work Force			
HGB CMSA	1,810,651	1,941,546	2,338,182
Brazoria County	98,079	115,295	133,461
Fort Bend County	122,334	180,643	258,609
Both	220,413	295,938	392,069
Unemployment Rate (%)			
HGB CMSA	5.00	5.00	5.00
Brazoria County	5.64	6.88	6.88
Fort Bend County	3.48	3.15	3.15
Both	4.44	4.60	4.42
Unemployed			
HGB CMSA	90,499	97,077	116,909
Brazoria County	5,527	7,927	9,175
Fort Bend County	4,256	5,690	8,146
Both	9,783	13,617	17,322
Projected Percent Construction			
HGB CMSA		N/A	N/A
Brazoria County		16.23	16.23
Fort Bend County		7.02	7.02
Both		12.38	11.90
Projected Unemployed Construction			
HGB CMSA		N/A	N/A
Fort Bend County		399	572
Brazoria County		1,286	1,489
Both		1,686	2,061

Source: Texas Comptroller of Public Accounts (1989, 2000).

TABLE 4-23
LOCAL GOVERNMENT REVENUES IMPACT OF GRAND PARKWAY SEGMENTS AND PERCENT OF PROJECTED STATE GROSS PRODUCT 2003–2006 ($ MILLIONS) +

Segment	Revenues	
	$	%
A1*	0.04	0.0001
A2*	0.01	0.0000
A3.1*	0.03	0.0001
A6	0.03	0.0001
B1	0.02	0.0001
B3	0.01	0.0000
B4.1	0.02	0.0001
B4.2*	0.00	0.0000
B5	0.04	0.0001
B6	0.01	0.0000
B7	0.01	0.0000
C1	0.04	0.0001
C2	0.04	0.0001
G3.2*	0.03	0.0001
G5.2*	0.07	0.0002
G6.2*	0.02	0.0001
G7*	0.01	0.0000
G8*	0.04	0.0001
J1	0.05	0.0001
K1	0.05	0.0001
P1	0.05	0.0001
Q1	0.06	0.0002
S1-b*	0.07	0.0002
T1	0.06	0.0002
W1*	0.12	0.0003
X1*	0.10	0.0003
Y1*	0.08	0.0002

Source: Texas Comptroller of Public Accounts (1989, 2000).

*Segment included in Preferred Alternative

+Some segments were revised since the estimates in the table above were conducted; therefore, the estimates are considered approximate. For example, G4 and G5 were replaced by other segments, therefore, not presented in the table. X1-a and X1-b were replaced with X1. G6.1 shifted slightly and is now included in Y1. S1 shifted slightly and is now called S1-b.

revenues. However, it is likely that land along the ROW would be converted to more urbanized uses, particularly commercial uses, thus increasing the revenue potential from property taxes from these properties. Also, as land-use conversions occur, there would likely be additional local revenues from sales taxes and various miscellaneous fees and taxes assessed by municipal government. Those governments most likely to be affected by these impacts are the municipalities of Rosenberg, Sugar Land, and Richmond. Also likely to be affected are the revenues of Brazoria and Fort Bend counties and revenues of the taxing entities currently within the study area (see Table 3-13).

4.4.1.7 Commercial and Residential Development

As discussed in Section 3.1.1, the general region of the study area has experienced considerable growth in recent years, especially in Fort Bend County. Moreover, that growth is expected to continue (see Table 3-3). With the increase in residential development, commercial development will follow. The proposed project would likely continue the conversion of land uses in the vicinity of the roadway, from the suburban and rural land uses currently existing through much of the area, to more urbanized uses. The area is likely to be somewhat more attractive for residential location with the completion of the proposed project, in part because the current, relatively long commute times to employment centers may be lessened, both because of the access provided by the proposed Grand Parkway Segment C and because urbanization in the region would bring more employers to the area.

Urbanized land conversion would be anticipated as a secondary effect of construction of any of the proposed project alternatives. Since the proposed Grand Parkway Segment C would be developed as a limited access road, commercial development is likely to occur near major intersections and where frontage roads are incorporated into highway design. New opportunities for commercial development along the proposed Grand Parkway Segment C (all alternatives) would raise property values over their current value (No-Build Alternative), as similar opportunities for highly accessible, high-visibility commercial sites would not be available without the proposed project. Commercial uses along the proposed Grand Parkway Segment C are considered the highest and greatest use of the land, in terms of land values, and hence the greatest property value increase is anticipated adjacent to the proposed project in areas where the limited access roadway design facilitates access. Although substantial residential development is not anticipated beyond the planned communities already underway, those properties within the corridor that are likely to be developed as residential subdivisions would also increase in property value, as access to the proposed Grand Parkway Segment C would be considered an amenity.

4.4.2 Summary of Impacts

Overall, the proposed Grand Parkway Segment C project would encourage economic growth and increase job availability in Brazoria County, Fort Bend County, and the entire Houston region. Tax revenues would increase and residential and commercial property values would likely increase over time.

4.4.3 Indirect Effects

Indirect economic impacts would be tied to potential indirect development. The economic impacts of that development are summarized as follows:

- Provide improved access to US 59 and FM 521 and other local arterials within the project area vicinity, which could provide increased employment opportunities and additional tax revenues.
- Growth in residential/commercial development would increase the demand for consumer services, including retail, banking, medical, and recreational.
- Commercial development at frontage roads, entrance/exit ramps, and interchanges would have varying economic effects on the local economy, depending on the extent of this development.

4.4.4 Mitigation

Economic effects related to the proposed Segment C project are considered to be beneficial; therefore, no mitigation would be necessary.

4.5 PEDESTRIAN AND BICYCLIST IMPACTS

Segments A3.1*, B1, B7, C1, D1, Q1, G1, G3, G6, H1, J1, P1, W1*, and Y1* intersect with existing local roadways. While it is evident that the proposed Grand Parkway Segment C would increase accessibility to this area, the potential termination of local roads could reduce ease of access to local enclaves for drivers as well as bicyclists. Some of these impacts would be mitigated by the use of bridges and grade separations, allowing vehicles and bicycles to maintain traditional routes upon heeding signalized intersections. Bicycle lanes and/or pedestrian access may be proposed for the proposed Grand Parkway Segment C away from the main travel lanes to ensure safety.

4.5.1 Summary of Impacts

None of the Alternatives considered in this FEIS cross bicycles lanes. However, the proposed Grand Parkway Segment C project would accommodate (where practical) future crossings for both pedestrians and bicyclists at intersections, bridges, and over/underpasses affecting or providing direct access to designated pedestrian and/or bicycle facilities.

4.5.2 Indirect Impacts

Pedestrian and bicycles could benefit from the indirect development of residential and commercial streets in conjunction with this project because of the congestion relief the proposed Segment C would provide and the increased availability of community resources such as shopping. Benefits would be greater if pedestrian walkways and bicycle facilities were incorporated into transportation plans within the project area. However, there would likely be increased congestion,

specifically at grade separations, because of traffic entering and exiting the proposed Segment C project and inducted development anticipated at these locations.

4.5.3 Mitigation

The proposed Segment C project would minimize adverse effects to bicyclists and pedestrians by providing crosswalks, walk signals, and appropriate signage at grade-separated intersections (entrance/exit ramp access points). In the event that a bicycle or pedestrian facility is in place prior to the proposed project, the facility would be reconstructed to maintain continuity and function.

4.6 AIR QUALITY IMPACTS

The primary pollutants from motor vehicles are VOCs, CO, and NO_x. Motor vehicles also emit particulate matter (PM) and diesel-powered vehicles emit oxides of sulfur.

4.6.1 National Ambient Air Quality Standards

The proposed project is located within Brazoria and Fort Bend counties, which are designated as “severe” nonattainment areas for O_3 within the H-GAC’s Transportation Management Area; therefore, the transportation conformity rule does apply. The HGB area is in attainment for all NAAQS, except O_3.

All projects in the H-GAC TIP that are proposed for federal or state funds were initiated in a manner consistent with federal guidelines in Section 450, of Title 23 CFR and Section 613.200, Subpart B, of Title 49 CFR. Energy, environment, air quality, cost, and mobility considerations are addressed in the programming of the TIP. The proposed Grand Parkway Segment C is included in the H-GAC’s 2035 RTP Update approved on January 25, 2011, and FY 2011–2014 TIP, as amended and proposed by H-GAC. The RTP and TIP were found to conform to the SIP on July 21, 2010.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP Update (such as traffic volumes, population, employment, number of households, and VMT) have been evaluated to determine whether additional analysis is warranted before the FHWA takes final environmental action. This evaluation confirmed that the changes in the modeled parameters were minor and, therefore, no additional analysis is warranted. The analysis of 2025–2035 RTP Update modeled parameters can be found in the Administrative Record.

The modeling procedures of O_3 require long-term meteorological data and detailed area-wide emission rates for all potential sources (industry, business, and transportation) and are normally too complex to be performed within the scope of an environmental analysis for a highway project. Accordingly, concentrations of O_3 for the purpose of comparing the results of the NAAQS are modeled by H-GAC for the SIP. However, concentrations for CO are readily modeled for highway projects and are required by federal regulations.

Design year traffic data is estimated to be 41,681 vehicles per day (vpd), less than the 140,000 vpd threshold that would require a Traffic Air Quality Analysis. The 140,000-vpd threshold is based on a TxDOT modeling study, which demonstrated that it is highly unlikely that the NAAQS for CO would ever be exceeded on any project with traffic numbers below this level (TxDOT, 2006).

4.6.2 MSATs Modeling

4.6.2.1 MSAT Analysis Overview

FHWA has developed interim guidance for the analysis of MSATs within the NEPA process for highways. The guidance was originally developed in February 2006 (FHWA, 2006) and updated in a September 30, 2009, memorandum (FHWA, 2009). Much of FHWA's MSATs guidance has been incorporated into TxDOT's *Air Quality Guidelines Addendum* (TxDOT, 2011) and serves as the guide for the MSATs technical report (see Administrative Record for Tech Report). Per the guidelines, a conference call was conducted to determine the methods and assumptions for the MSATs analysis in consultation with key partners, including TxDOT's Division of Environmental Affairs, FHWA, and the GPA.

FHWA has developed, as adopted by TxDOT, a tiered approach for analyzing MSATs in NEPA documents. Depending on the specific project circumstances, three levels of analysis are identified:

1. No analysis for projects with no potential for meaningful MSAT effects;
2. Qualitative analysis for projects with low potential MSAT effects; or
3. Quantitative analysis to differentiate alternatives for projects with higher potential MSAT effects.

A Technical Report by Michael Baker Corporation, *Grand Parkway (SH 99) Segment C, Mobile Source Air Toxics, NEPA document and Technical Report* (2011) was prepared for the proposed project. Based on forecast traffic volumes, Segment C of the Grand Parkway is considered a project with low potential MSAT effects since the project falls under the criteria examples provided in TxDOT's guidelines, specifically that the projected design year traffic is not expected to exceed 140,000 average annual daily traffic. However, the interagency consultation process has recommended a more rigorous assessment of project impacts, including a quantitative analysis of the seven priority MSATs for each alternative.

The technical report provides an assessment of the project impacts that includes the following elements:

- A brief MSAT description and discussion of national trend data projecting substantial overall reductions in emissions due to stricter engine and fuel regulations issued by EPA;
- A discussion of information that is incomplete or unavailable for a project-specific assessment of MSAT impacts, in compliance with Council on Environmental Quality (CEQ) regulations (40 CFR 1502.22(b));
- A comparison of the expected effect of the project on traffic volumes, vehicle mix, or routing of traffic, and the associated assumed changes in MSATs; and

- An analysis methodology completed in consultation with federal and state partners using the latest available traffic information.

National MSATs Trends

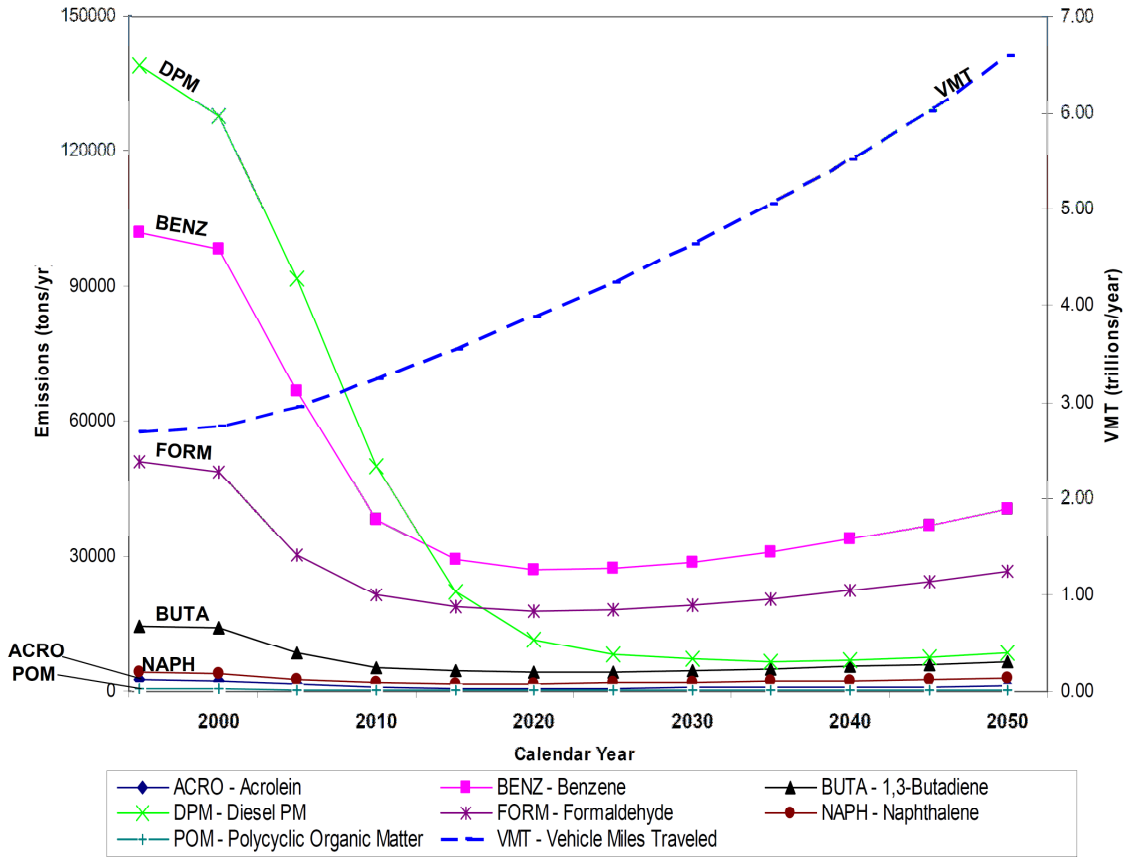
As automotive design technology continues to improve, older, higher-polluting vehicles continue to be retired and replaced with newer, cleaner vehicles. Newer-technology vehicles are becoming cleaner with each subsequent model year (EPA, 1999). The following items will also have significant effects on reducing future levels of MSAT emissions:

- Fuels are becoming cleaner. EPA has adopted new requirements to substantially lower emissions of benzene and other MSAT toxics by lowering benzene content in gasoline, reducing evaporative emissions that permeate through portable fuel containers, and reducing nonmethane hydrocarbon exhaust emissions from passenger vehicles operating at cold temperatures (under 75 degrees Fahrenheit) (EPA, 2007).
- Reid vapor pressure and reformulated gasoline (RFG) requirements have lowered toxic emissions of gasoline.
- The EPA's 2004 nonroad diesel sulfur rules have reduced sulfur levels in diesel fuel down to 15 ppm, further reducing PM and other MSAT emissions from diesel powered vehicles. Low-sulfur gasoline enables better emission controls and can lead to further emission reductions from present catalyst-equipped fleet (EPA, 1999), and low-sulfur diesel will enable new diesel emission reduction technology (EPA, 2000).
- RFG was implemented in the Houston area in 1995 and has resulted in reductions of MSATs.
- Over the period 2007–2010, the EPA's light-duty Tier 2 emission and fuel standards were fully implemented.

TxDOT's *Air Quality Guidelines Addendum* (TxDOT, 2011) provides national MSAT trends based on FHWA analyses using EPA's MOBILE6.2 emission model. Figure 4-1 illustrates the trend graph provided in the guidelines. According to FHWA analyses, even if vehicle activity (VMT) increases by 145 percent, a combined reduction of 72 percent in total annual emissions for the priority MSATs is projected from 1999 to 2050. The most significant decreases in MSATs occur in the 2000–2015 timeframe.

As indicated in TxDOT's guidelines, air toxics analysis is a continuing area of research. While much work has been done to assess the overall health risk of air toxics, many questions remain unanswered. In particular, the tools and techniques for assessing project-specific health outcomes as a result of lifetime MSAT exposure remain limited. These limitations impede the ability to evaluate how the potential health risks posed by MSAT exposure should be factored into project-level decision making within the context of the NEPA. The FHWA, EPA, Health Effects Institute, and others have funded and conducted research studies to more clearly define potential risks from MSAT emissions associated with highway projects. The FHWA will continue to monitor the developing research in this emerging field.

Figure 4-1
FHWA MSAT Analysis: National MSAT Emission Trends 1990–2050 Using Mobile6.2



Source: TxDOT's Air Quality Guidelines Addendum (TxDOT, 2011).

4.6.2.2 MSATs Analysis Results

The MSATs analysis included selection of roadway links for air quality analysis, collection of relevant environmental, fuel, and control strategy data, estimation of emission factors from MOBILE6.2, and application of those emission factors based on regional VMT and speeds produced from the regional travel model.

The study area for air quality analysis includes the entire H-GAC travel model region. An affected transportation network (roadway links used for air quality analyses) was derived by comparing the modeled 2035 No-Build scenario traffic volumes to the 2035 Build scenario and selecting roadway links where there was a ±5 percent volume change. These same roadway links were also extracted from the 2009 and 2019 travel model networks. As a result, the affected network is the same for all analysis scenarios allowing for direct comparison of emission results. Due to the traffic diversions estimated by the travel model's assignment module, some of the roadway links contained in the affected network are not directly adjacent to the Segment C corridor.

The most recent version of EPA's MOBILE6.2 emission model has been used to estimate MSAT emission factors for each pollutant and analysis year. Key inputs to the emission model are consistent with those used for other modeling purposes

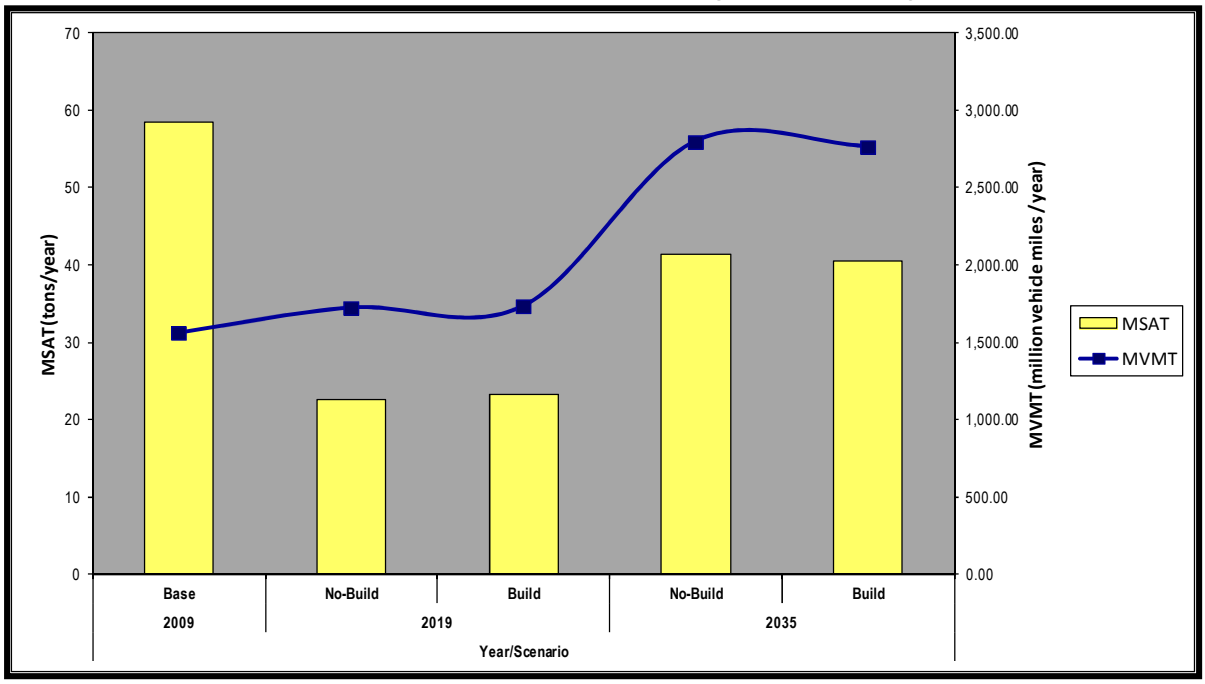
in the area (e.g., SIP inventories from TCEQ, H-GAC conformity analyses, etc.). The resulting emission inventory for the seven priority MSATs for the Grand Parkway Segment C affected transportation network is summarized in Table 4-24 and Figure 4-2.

TABLE 4-24
SEGMENT C MSAT EMISSIONS BY ALTERNATIVE (TONS/YEAR)

Compound	Year/Alternative						
	2009	2019		2035			
	Base Year	No-Build	Build	No-Build	% Change from Base Year	Build	% Change from Base Year
Naphthalene	0.618	0.678	0.678	1.183	91	1.169	89
Acrolein	0.480	0.277	0.277	0.496	3	0.496	3
Benzene	21.653	9.914	9.914	20.923	-3	20.346	-6
1,3-Butadiene	3.438	1.460	1.460	3.226	-6	3.073	-11
Formaldehyde	10.797	5.840	6.205	11.468	6	11.315	5
Diesel Particulate Matter (DPM)	21.441	4.380	4.745	4.015	-81	4.104	-81
Polycyclic Organic Matter	0.0035	0.0046	0.0046	0.0078	123	0.0077	120
Total MSAT	***58.431***	***22.553***	***23.283***	***41.319***	***-29***	***40.510***	***-31***
Vehicle Miles of Travel (VMT/Year)	***1,565***	***1,726***	***1,737***	***2,798***	***79***	***2,765***	***77***

Source: EPA Model6.2 and Study Team (2010).

Figure 4-2
Comparison of MSAT Emissions vs. VMT by Scenario for Segment C



Source: EPA MOBILE6.2 model; Study Team (2010).

VMT for the affected transportation network was estimated to increase by 11 percent between 2009 and 2019 and 77 percent between 2009 and 2035. Despite increasing VMT, the analysis indicates that forecasted 2035 total MSAT emissions, under the Segment C Build Alternative, are not expected to significantly worsen over that estimated for the 2009 base year.

The analysis indicates nearly a 60 percent decrease in MSAT emissions between the 2009 base year and 2019 Build conditions. The reasons for these dramatic improvements are two-fold: a change in vehicle fuels (both gasoline and diesel fuel) and a change in emission standards for both light-duty and heavy-duty on-highway motor vehicles. The EPA predicts substantial future air emission reductions as the agency's new light-duty and heavy-duty on-highway fuel and vehicle rules come into effect. These include Tier 2 light-duty vehicle standards, Heavy Duty Diesel Vehicle standards, low sulfur diesel fuel, and EPA's off-road diesel engine and fuel standards.

EPA's MOBILE6.2 model estimates much smaller benefits in MSATs after 2019. This estimation, in combination with a 77 percent growth in VMT, results in 2035 Build emissions being 31 percent lower than the 2009 base year. DPM, 1-3-Butadiene and benzene are the only priority MSATs that are expected to decrease in that timeframe.

The fate of MSATs and the concentrations at any specific receptor are unknown due to the current technical shortcomings of emission and dispersion models; therefore, the health effects of MSATs on the public cannot be determined at this time. The above emission computations have been included in this qualitative analysis to illustrate potential trends of emissions related to projected traffic volumes for the Grand Parkway Segment C Build Alternative and the expected effects of future vehicle and fuel standards, in combination with vehicle turnover.

4.6.2.3 MSATs Analysis Conclusions

Research has found that the ability to discern differences in MSAT emissions among transportation alternatives is difficult given the uncertainties associated with forecasting travel activity and air emissions 25 years or more into the future. When evaluating the future options for upgrading a transportation corridor, the major mitigating factor in reducing MSAT emissions is the implementation of the EPA's new motor vehicle emission control standards. Decreases in MSAT emissions will be realized from the base year (2009) through an estimated time of completion for a planned project and its design year some 30 years in the future. Accounting for anticipated increases in VMT and varying degrees of efficiency of vehicle operation, total forecast 2035 MSAT emissions were predicted to not worsen over existing base year conditions. In fact, forecast estimates are 31 percent lower than the base year. Substantial reductions (81 percent) are expected in DPM over that timeframe.

The most important factors affecting emission differences among the available options are VMT and levels of traffic congestion, as manifested by speeds. When evaluating transportation network alternatives operating substantially under capacity, the difference in VMTs is more important than the difference in congested vehicle speeds. The excess capacity would accommodate an increase in traffic volumes without adversely affecting travel speeds and related MOBILE6.2

emission factors. Conversely, where one transportation network alternative is operating substantially over its capacity, the difference in congested vehicle speeds may be more influential than the difference in VMT. MOBILE6.2 emission factors are very sensitive to vehicle speeds in the slow, congested speed range. Mitigating this congestion may have more of an effect on reducing emissions than the offset due to a potential increase in VMT. For transportation network alternatives operating slightly under or over capacity, the differences in VMT and differences in congested speeds are equally substantial.

The Houston area is in attainment for both PM_{10} and $PM_{2.5}$. The major air toxics from mobile sources, especially benzene, have dropped dramatically since 1995 and are expected to continue dropping. The introduction of RFG has lead to a substantial part of this improvement. In addition, Tier 2 automobiles introduced in model year 2004 will continue to help reduce MSATs. Diesel exhaust emissions have been falling since the early 1990s with the passage of the CAAA. The CAAA provided for improvement in diesel fuel through reductions in sulfur and other diesel fuel improvements. In addition, the EPA has further reduced the sulfur level in diesel fuel, effective in 2006. The EPA also has called for dramatic reductions in NO_X emissions and PM from on-road and off-road diesel engines.

4.6.3 Air Quality Construction Impacts

Emissions from diesel powered and other construction equipment would occur under the Build Alternative for Segment C. These construction emissions would be temporary in nature. As each task is completed, the equipment would move out of the immediate area. In addition, emissions would be mitigated through improvements in diesel fuel for both the Texas Low Emission Diesel program started on October 31, 2005, and the federal low-sulfur diesel program, which took effect in Texas on October 15, 2006. In addition to tailpipe emissions, fugitive dust may be generated during project construction. Because the variables affecting construction emissions (e.g., type of construction vehicles, timing and phasing of construction activities, haul routes, etc.) cannot be identified until the project is ready for construction, no estimate of construction emission can be undertaken. However, project construction would be conducted in accordance with all federal, state, and local regulations that govern construction activities and emissions. Specific dust suppression mitigation measure that can be utilized would be identified in a dust control plan prepared prior to project construction.

4.6.4 Summary of Impacts

Pollutants required to be evaluated included CO and O_3. As modeled, the Grand Parkway will not lead to increases in either of these pollutants. The Houston area is in attainment for all the criteria pollutants except for 8-hour O_3. The EPA classified the Houston-Galveston area, which includes Harris County, as a severe O_3 nonattainment area. The EPA regulations require that a nonattainment area demonstrate that its RTP and TIP conform to the intent of the SIP to attain the 8-hour O_3 standard by the year 2010. The most recent SIP revision to EPA requested the area be revised to severe with an attainment date of June 15, 2019. Under the regulations, added capacity projects may advance to construction only if they are part of the RTP and TIP, which has been determined to conform to the SIP. The proposed SH 99

Segment C is included in the H-GAC 2035 RTP Update, approved on January 25, 2011, and FY 2011–2014 TIP, as amended and proposed by H-GAC. The RTP and TIP were found to conform to the SIP on July 21, 2010.

MSATs were modeled and were found to be lower in the future (2019 and 2035) than the existing conditions (2009). MSATs will continue to improve over time due to dramatic improvements in the vehicle technology and fuels and traffic flow improvements.

Other potential air quality impacts could occur with the continued existence of industrial complexes in the Houston area. Generally, industrial facilities that emit air pollutants are governed and permitted through TCEQ. MSATs, as a result of the proposed Grand Parkway, are not expected to increase overall in the Houston area in the future years. Under the No-Build Alternative, MSATs are expected to decline at nearly the same rate as the Build Alternatives, with no direct effect to air quality in the Houston area.

4.6.5 Indirect Impacts

The network of future roadways and subdivision streets within the Area of Influence (AOI) are expected to contribute to further traffic improvements from the base year (2009). In addition, modeling shows a decrease in overall emissions. This decrease is due to the rapidly improving fuel and vehicle technology and the turnover between the base year (2009) and the future year of 2035, which is expected to be the case for both criteria pollutants, including CO and MSAT.

Besides undergoing a conformity analysis to assume compliance with the NAAQS, proposed TxDOT highway projects in the Houston metropolitan area would have to be part of a RTP and TIP that have been determined to conform to the SIP. Other potential air quality impacts could occur with increased industrial development in the area. Generally, industrial facilities that emit air pollutants would be governed and permitted through the TCEQ.

Improved traffic flow in areas of existing congestion may also result in improved air quality. Time will also contribute to substantial and ongoing improvements in air quality as older technology vehicles are retire and newer cleaner vehicles replace them.

4.7 NOISE MODELING ANALYSIS

This analysis conforms to the FHWA Regulation 23 CFR 772, “Procedures for Abatement of Highway Traffic Noise and Construction Noise,” and TxDOT’s 2011 *Guidelines for Analysis and Abatement of Roadway Traffic Noise*. Preliminary noise analyses were conducted for the eight Representative Alternatives. The Preferred Alternative was further analyzed in greater detail utilizing the FHWA’s most current Traffic Noise Model. The details are discussed below.

The traffic noise analysis typically includes the following elements:

- Identification of land-use activity areas that might be impacted by traffic noise
- Determination of existing noise levels

- Prediction of future noise level
- Identification of possible noise impacts
- Consideration and evaluation of measures to reduce noise impacts

4.7.1 Noise Abatement Criteria

Table 4-25 outlines the noise abatement criteria (NAC) established by the FHWA and TxDOT for various land-use activity areas that are used as one of two means to determine when a traffic noise impact will occur.

TABLE 4-25
FHWA AND TXDOT NOISE ABATEMENT CRITERIA

Activity Category	FHWA [dB(A) L_{eq}]	TxDOT [dB(A) L_{eq}]	Description of Land-Use Activity Areas
A	57 (exterior)	56 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	66 (exterior)	Residential
C	67 (exterior)	66 (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52 (interior)	51 (interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 (interior)	71 (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A-D or F.
F	--	--	Agricultural, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	--	--	Undeveloped lands that are not permitted.

NOTE: Primary consideration is given to exterior areas (Categories A, B, or C) where frequent human activity occurs. However, interior areas (Category D or E) are used if exterior areas are physically shielded from the roadway or if there is little or no human activity in exterior areas adjacent to the roadway.

4.7.2 Impacts to Noise Receivers

A noise impact occurs when either the absolute or relative criterion is met:

Absolute criterion: the predicted noise level at a receiver approaches, equals, or exceeds the NAC. “Approach” is defined as 1 dB(A) below the NAC. For example, a noise impact would occur at a Category B residence if the noise level is predicted to be 66 dB(A) or above.

Relative criterion: the predicted noise level substantially exceeds the existing noise level at a receiver even though the predicted noise level does not approach, equal, or exceed the NAC. "Substantially exceeds" is defined as more than 10 dB(A). For example, a noise impact would occur at a Category B residence if the existing level is 50 dB(A) and the predicted level is 61 dB(A) (11 dB(A) increase).

Preliminary results (Table 4-26) determined that all eight Representative Alternatives would result in noise impacts to one or more modeled sites, which represent a much larger number of actual receivers (i.e., individual residences or businesses), because either the absolute or relative criterion has been met at a particular modeled receiver. The Representative Alternative impacting the fewest receivers is Representative Alternative 5 (31 receivers).

TABLE 4-26
PRELIMINARY NOISE IMPACTS

Alternative	Number of Modeled Sites Impacted	Total Number of Represented Receivers Impacted
1	8	59
2	8	64
3	9	62
4	9	67
5	5	31
6	5	36
7	6	34
8	6	39

Source: Study Team (2011).

When a traffic noise impact occurs, noise abatement measures must be considered. A noise abatement measure is any positive action taken to reduce the impact of traffic noise on an activity area.

The FHWA Traffic Noise Model 2.5 software was used to calculate predicted traffic noise levels. The model primarily considers the number, type, and speed of vehicles; highway alignment and grade; cuts, fills, and natural berms; surrounding terrain features; and the locations of activity areas likely to be impacted by the associated traffic noise.

For the detailed analysis of the Preferred Alternative, predicted traffic noise levels were modeled at 24 receiver locations (Table 4-27 and Exhibit 24), which represent the land-use activity areas adjacent to the proposed project that might be impacted by traffic noise and potentially benefit from feasible and reasonable noise abatement.

As indicated in Table 4-27, the proposed project would result in a traffic noise impact, and the following noise abatement measures were considered: traffic management, alteration of horizontal and/or vertical alignments, acquisition of undeveloped property to act as a buffer zone, and the construction of noise barriers.

Before any abatement measure can be incorporated into the project, it must be both feasible and reasonable. In order to be feasible, the abatement measure must be able to reduce the noise level by greater than 50 percent of impacted, first

row receivers by at least 5 dB(A); and to be reasonable, it must not exceed the cost-effectiveness criterion of $25,000 for each receiver that would benefit by a reduction of at least 5 dB(A), and the abatement measure must be able to reduce the noise level of at least one impacted, first row receiver by at least 7 dB(A).

TABLE 4-27
TRAFFIC NOISE LEVELS (DB(A) L_{EQ})

Receiver	Description	NAC Category	NAC Level	Existing	Predicted	Change (+/-)	Noise Impact
R1	Commercial	D	52	43	45	+2	No
R2	Commercial	D	52	43	43	0	No
R3	Residential	B	67	57	69	+12	Yes
R4	Residential	B	67	57	72	+15	Yes
R5	Residential	B	67	57	69	+12	Yes
R6	Residential	B	67	57	73	+16	Yes
R7	Residential	B	67	57	69	+12	Yes
R8	Commercial	D	52	32	46	+14	Yes
R9	Residential	B	67	57	66	+9	Yes
R10	Residential	B	67	57	67	+10	Yes
R11	Residential	B	67	57	66	+9	Yes
R12	Residential	B	67	56	66	+10	Yes
R13	Residential	B	67	56	70	+14	Yes
R14	Residential	B	67	56	71	+15	Yes
R15	Residential	B	67	56	67	+10	Yes
R16	Residential	B	67	56	70	+14	Yes
R17	Residential	B	67	56	69	+13	Yes
R18	Residential	B	67	56	72	+16	Yes
R19	Residential	B	67	56	69	+13	Yes
R20	Residential	B	67	56	71	+15	Yes
R21	Residential	B	67	56	75	+19	Yes
R22	Residential	B	67	55	61	+6	No
R23	Residential	B	67	55	66	+11	Yes
R24	Residential	B	67	55	65	+10	No

Source: Study Team (2012).

Traffic management: Control devices could be used to reduce the speed of the traffic; however, the minor benefit of 1 dB(A) per 5 mph reduction in speed does not outweigh the associated increase in congestion and air pollution. Other measures, such as time or use restrictions for certain vehicles, are prohibited on state highways.

Alteration of horizontal and/or vertical alignments: The horizontal alignment was altered to the greatest extent possible given the urban development adjacent to the existing ROW. Further alteration of the alignment would displace additional residences and/or business and therefore would not be cost effective or reasonable.

Buffer zone: The acquisition of sufficient undeveloped land adjacent to the highway project to preclude future development that could be impacted by highway traffic noise would not be cost effective or reasonable.

Noise barriers: This is the most commonly used noise abatement measure. Noise barriers were evaluated at each of the impacted receivers, and the results are discussed below.

R3–R5: These receivers represent residences in the Canyon Gate subdivision. A total of 25 receivers were modeled at this subdivision. A noise barrier analysis was performed at this location and a noise barrier that would achieve the minimum feasible reduction of 5 dB(A) would cost $574,748 and benefit 20 receivers. This exceeds the reasonable, cost-effectiveness criterion of $25,000 per receiver and is therefore not proposed for incorporation.

R6–R7: These receivers represent seven residences in Greatwood Village. One noise barrier was determined to be both feasible and reasonable for these receivers, and is therefore proposed for incorporation into the project (Table 4-28).

TABLE 4-28
NOISE BARRIER PROPOSAL (PRELIMINARY)

Barrier	Subdivision	# Benefited Receivers	Length (feet)	Height (feet)	Total Cost ($)	$/Benefited Receiver
1	Greatwood Village	6	588	14	148,176	24,696

Source: Study Team (2012).

R8: This receiver is a retail business. A noise barrier would have a detrimental effect on this receiver by restricting views and access by potential customers.

R9–R11: These receivers represent seven residences within Greatwood Knoll. A noise barrier analysis was performed at this location and a noise barrier that would achieve the minimum feasible reduction of 5 dB(A) at each of the impacted residences would exceed the reasonable, cost-effectiveness criterion of $25,000 per receiver.

R12–R14: These receivers represent residences within Brazos Village. A total of 12 residences were impacted within this subdivision. A noise barrier that would achieve the minimum feasible reduction of 5 dB(A) at 10 of these residences would cost $316,362, which would exceed the reasonable, cost-effectiveness criterion of $25,000, and therefore is not proposed for incorporation.

R15–17 and R19: These receivers represent a single residence. A noise barrier that would achieve the minimum feasible reduction of 5 dB(A) at this residence would exceed the reasonable, cost-effectiveness criterion of $25,000, and therefore is not proposed for incorporation.

R18 and R20–R21: These receivers represent residences within Brazos Gardens. A total of nine residences were impacted within this subdivision. A noise barrier that would achieve the minimum feasible reduction of 5 dB(A) at each of these residences would cost $403,083, which would exceed the reasonable, cost-effectiveness criterion of $25,000, and therefore is not proposed for incorporation.

R23: This receiver represents residences within Windham Banks. A total of two residences were impacted within this subdivision. A noise barrier that would achieve the minimum feasible reduction of 5 dB(A) at this residence would cost $419,259, which would exceed the reasonable, cost-effectiveness criterion of $25,000, and therefore is not proposed for incorporation.

Any subsequent project design changes may require a reevaluation of this analysis. The final decision to construct the proposed noise barriers will be made upon completion of the project design and the public involvement process.

Much of the land-use activity areas adjacent to the proposed project are currently Category G, undeveloped land. There is no NAC for undeveloped land; however, to avoid noise impacts that may result from future development of properties adjacent to the project, local officials responsible for control programs should ensure, to the maximum extent possible, that no new activities are planned or constructed along or within the following predicted noise contours (Table 4-29).

TABLE 4-29
NOISE IMPACT CONTOURS

Undeveloped Areas	Land Use	Impact Contour (dB(A))	Approximate Distance from ROW (feet)
FM 2759 to FM 762	Residential	66	125
	Commercial	71	128
FM 762 to FM 1994	Residential	66	164
	Commercial	71	92
FM 1994 to Big Creek	Residential	66	161
	Commercial	71	75
Big Creek to FM 521	Residential	66	152
	Commercial	71	70
FM 521 to SH 288	Residential	66	154
	Commercial	71	72

Source: Study Team (2012).

Noise associated with the construction of the project is difficult to predict. Heavy machinery, the major source of noise in construction, is constantly moving in unpredictable patterns. However, construction normally occurs during daylight hours when occasional loud noises are more tolerable. None of the receivers are expected to be exposed to construction noise for a long duration; therefore, any extended disruption of normal activities is not expected. Provisions would be included in the plans and specifications that require the contractor to make every reasonable effort to minimize construction noise through abatement measures such as work-hour controls and proper maintenance of muffler systems.

A copy of this traffic noise analysis would be provided to local officials to assist in future land-use planning. As of the date of approval of this document (Date of Public Knowledge), the GPA, FHWA, and TxDOT are no longer responsible for providing noise abatement for new development adjacent to the project.

4.7.3 Summary of Impacts

Results of the traffic noise analysis for the Preferred Alternative indicated that 20 representative receivers, representing a total of 67 residences, would be impacted by the traffic noise. Noise abatement measures were evaluated for each of the impacted representative receivers (see Section 4.6.8).

Under the No-Build Alternative, increases in population and employment growth are projected throughout the project area. It is expected that ambient noise levels would increase within areas of concentrated development associated with project growth.

4.7.4 Indirect Impacts

Future increases in ambient noise levels associated with projected development is anticipated, especially in proximity to the Segment C project area. The network of future roadways and subdivision streets, in conjunction with this project, would be expected to contribute to increased ambient noise levels. The density and type of future development within the project area would contribute to the overall changes in noise levels.

4.7.5 Mitigation

Noise abatement measures were analyzed for receiver locations impacted by the Preferred Alternative. In determining and providing abatement measures for traffic noise impacts, primary consideration is given to exterior areas where frequent human use occurs and lower noise levels would be of benefit. The evaluation indicated that noise barriers would be feasible and reasonable at one location and therefore are proposed for incorporation into the project subject to the completion of the project design, utility evaluation, and polling of adjacent owners. This location is shown on Exhibit 24.

4.8 WATER QUALITY IMPACTS

4.8.1 Surface Water Quality

Surface water quality effects of the Preferred Alternative and the eight Representative Alternatives are addressed in this section. As with most projects there are two broad categories of effects: one from construction and one from long-term operation.

Construction in the immediate area of stream crossings can be expected to generate additional sediment loads to the streams if bare or unvegetated earth is exposed to rainfall for an extended period of time. Because all alternatives being considered involve a proposed ROW area well in excess of 5 acres, TxDOT will be required to comply with the TCEQ TPDES General Permit for Construction Storm Water Runoff. An NOI for coverage under the TPDES will be sent to the TCEQ by TxDOT for the project prior to construction activities, which will be accomplished by filing an NOI with the TCEQ stating that TxDOT will have an SW3P in place during construction.

In accordance with NPDES/TPDES requirements and TxDOT policies, an SW3P will be prepared before the submission of the NOI. Once the SW3P and NOI are accepted by the TCEQ, the project will be covered by the General Permit and construction can then begin. The SW3P should be closely followed and updated according to site conditions during construction. Pollution from stormwater will be minimized through adherence to measures in the project's SW3P. Construction of the proposed action would include temporary erosion control measures to minimize impacts to water quality during construction as specified in the TxDOT manual *Storm Water Management & Guidelines for Construction Activities*. These may include the use of silt fencing, inlet protection barriers, hay bales, seeding or sodding of bare areas, or other suitable means of containment. Temporary erosion control structures will be specified in the SW3P, built before construction begins (where appropriate), inspected, maintained, and updated during construction. The SW3P will also include nonstructural measures such as construction phasing and good housekeeping to minimize impacts to stormwater quality. Vegetation will be cleared only as needed, and clearing may be phased to maintain soil integrity and minimize exposure of an erosive surface. When construction is completed, disturbed areas will be restored and reseeded according to the TxDOT specification "Seeding for Erosion Control." Specific erosion control measures will be selected during the development of SW3P.

The long-term operational effects on surface water quality include changes in the nature and timing of rainfall runoff and changes in the constituents carried in the runoff. For example, runoff from a paved surface will carry particulate material from tire wear and oils and greases from vehicles in addition to urban litter such as paper, plastic bags, and Styrofoam. Because the land would be paved, there would be a reduction in natural organic matter such as leaf litter and branches in the runoff.

To quantify the changes in rainfall runoff, the primary variable is the change in impervious cover. Other changes might include the elevation and grading of the proposed ROW in particular reaches that might alter the timing and distribution of runoff between watersheds. However, this information tends to only be available after detailed designs have been produced.

To quantify the changes in impervious cover, the length of the proposed Grand Parkway Segment C draining into each stream for the Preferred Alternative and each Representative Alternative was delineated and the corresponding area of the ROW was calculated. Table 4-30 presents the lengths and areas for all the alternatives. The length shown in the table is the length of the portion of the proposed Grand Parkway Segment C draining directly to the corresponding stream and does not include the contribution from an upstream watershed. For example, Rabbs Bayou (above Smithers Lake) and Dry Creek drain into Rabbs Bayou (below Smithers Lake), which in turn drains into Big Creek. In Table 4-30, the length shown for Big Creek is the length draining directly to Big Creek.

TABLE 4-30
ACREAGE OF ROW OF PROPOSED GRAND PARKWAY SEGMENT C DRAINING INTO INDIVIDUAL STREAMS

Alternative	Watershed [1]	Length of Proposed Grand Parkway Segment C Grand Parkway (feet)	Average ROW (feet)	Area (acres)
Preferred	Rabbs 1	10,000	400	92
Preferred	Rabbs 2	14,200	300	98
Preferred	Dry Creek	30,530	300	210
Preferred	Big Creek	14,860	300	102
Preferred	Waters Lake Bayou	16,510	300	114
Preferred	Brazos River	19,700	300	136
Preferred	Oyster Creek	8,950	300	62
Preferred	Hayes Creek	26,510	300	183
1	Rabbs Bayou[1]	10,000	400	92
1	Rabbs Bayou[2]	24,000	300	165
1	Dry Creek	34,000	300	234
1	Big Creek	2,000	300	14
1	Walters Lake Bayou	9,000	300	62
1	Brazos River	20,000	300	138
1	Oyster Creek	10,000	300	69
1	Hayes Creek	16,000	300	110
2	Rabbs Bayou1	10,000	400	92
2	Rabbs Bayou[2]	24,000	300	165
2	Dry Creek	34,000	300	234
2	Big Creek	2,000	300	14
2	Walters Lake Bayou	9,000	300	62
2	Brazos River	20,000	300	138
2	Oyster Creek	10,000	300	69
2	Hayes Creek	21,000	300	145
3	Rabbs Bayou[1]	10,000	400	92
3	Rabbs Bayou[2]	0	0	0
3	Dry Creek	41,000	300	282
3	Big Creek	38,000	300	262
3	Walters Lake Bayou	12,000	300	83
3	Brazos River	20,000	300	138
3	Oyster Creek	10,000	300	69
3	Hayes Creek	16,000	300	110
4	Rabbs Bayou1	10,000	400	92
4	Rabbs Bayou[2]	0	0	0
4	Dry Creek	41,000	300	282
4	Big Creek	38,000	300	262
4	Walters Lake Bayou	12,000	300	83
4	Brazos River	20,000	300	138
4	Oyster Creek	10,000	300	69

TABLE 4-30, CONT'D

Alternative	Watershed[1]	Length of Proposed Grand Parkway Segment C Grand Parkway (feet)	Average ROW (feet)	Area (acres)
4	Hayes Creek	21,000	300	145
5	Rabbs Bayou[1]	5,000	400	46
5	Rabbs Bayou[2]	24,000	300	165
5	Dry Creek	37,000	300	255
5	Big Creek	2,000	300	14
5	Walters Lake Bayou	9,000	300	62
5	Brazos River	20,000	300	138
5	Oyster Creek	10,000	300	69
5	Hayes Creek	16,000	300	110
6	Rabbs Bayou[1]	5,000	400	46
6	Rabbs Bayou[2]	24,000	300	165
6	Dry Creek	37,000	300	255
6	Big Creek	2,000	300	14
6	Walters Lake Bayou	9,000	300	62
6	Brazos River	20,000	300	138
6	Oyster Creek	10,000	300	69
6	Hayes Creek	21,000	300	145
7	Rabbs Bayou[1]	5,000	400	46
7	Rabbs Bayou[2]	0	0	0
7	Dry Creek	41,000	300	282
7	Big Creek	32,000	300	220
7	Walters Lake Bayou	12,000	300	83
7	Brazos River	20,000	300	138
7	Oyster Creek	10,000	300	69
7	Hayes Creek	16,000	300	110
8	Rabbs Bayou[1]	5,000	400	46
8	Rabbs Bayou[2]	0	0	0
8	Dry Creek	41,000	300	282
8	Big Creek	32,000	300	220
8	Walters Lake Bayou	12,000	300	83
8	Brazos River	20,000	300	138
8	Oyster Creek	10,000	300	69
8	Hayes Creek	21,000	300	145

Source: Study Team (2011).
[1]Rabbs Bayou: Above Smithers Lake
[2]Rabbs Bayou: Below Smithers Lake

Table 4-31 shows the acreage of the ROW that would drain to the streams. The areas shown include contributions from an upstream area. For example, the area for the Brazos River includes the areas of ROW draining to Rabbs Bayou, Dry Creek, Big Creek, and Walters Lake Bayou. Since the changes are related to the extent of the area drained, a comparison of the areas of the ROW draining to each stream for different alternatives would be effectively a comparison of the relative impact of each alternative on each stream. Table 4-32 shows the comparison based on Table 4-31. Overall, it appears that Alternative 4 would have the biggest impact and Alternative 5 would have the least impact in terms of change in impervious cover upstream of a stream crossing. In this regard, the Preferred Alternative ranks third among the alternatives.

TABLE 4-31
AREAS (IN ACRES) OF ROW DRAINING TO STREAMS

	Alternative								
	Preferred	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rabbs Bayou[1]	92	92	92	92	92	46	46	46	46
Rabbs Bayou[2]	400	491	491	374	374	466	466	328	328
Dry Creek	210	234	234	282	282	255	255	282	282
Big Creek	616	567	567	719	719	542	542	631	631
Walters Lake Bayou	114	62	62	83	83	62	62	83	83
Brazos River	752	705	705	856	856	680	680	769	769
Oyster Creek	62	69	69	69	69	69	69	69	69
Hayes Creek	183	110	145	110	145	110	145	110	145
TOTAL	2,429	2,330	2,365	2,585	2,620	2,230	2,265	2,318	2,353

Source: Study Team (2011).
Note: This includes upstream drainage.

TABLE 4-32
COMPARISON OF IMPACTS DUE TO DIFFERENT ALTERNATIVES

	Alternative	
	with most impact	**with least impact**
Rabbs Bayou[1]	1, 2, 3, 4, P	5, 6, 7, 8
Rabbs Bayou[2]	1, 2	7, 8
Dry Creek	3, 4, 7, 8	P
Big Creek	3, 4	5, 6
Walters Lake Bayou	P	1, 2, 5, 6
Brazos River	3, 4	5, 6
Oyster Creek	1, 2, 3, 4, 5, 6, 7, 8	P
Hayes Creek	P	1, 3, 5, 7
OVERALL	4	5

Source: Study Team (2011).
P: Preferred Alternative
[1]Rabbs Bayou: Above Smithers Lake
[2]Rabbs Bayou: Below Smithers Lake

The load of particulate matter as well as dissolved constituents carried to a stream is related to the runoff volume. Using data in the Houston metropolitan area, Liscum (in press) derived the following expression for estimating the amount of runoff for a storm:

$$RO = 0.613\ ABDF^{-0.268}\ RF^{1.22}\ APT^{0.213}$$

Where RO = storm runoff volume (inches), ABDF = basin development factor, RF = storm rainfall amount (inches), and APT = antecedent precipitation index (inches). The basin development factor is a characterization of the percentage development of the watershed, which in turn is related to the percentage of impervious cover. Before construction of the proposed Grand Parkway Segment C, the percent impervious cover of the ROW is zero, corresponding to an ABDF of 12. After construction, the ROW would have a 30 percent impervious cover, corresponding to an ABDF of 3. From the above equation, the change from 0 percent impervious cover to 30 percent impervious cover would result in a 45 percent increase in the runoff volume from the ROW. Table 4-33 gives the estimated runoff volume for 1-inch and 4-inch rainfall events, assuming an antecedent precipitation index of 1 inch. The runoff coefficient is the ratio of the runoff volume to the rainfall amount.

TABLE 4-33
ESTIMATED RUNOFF VOLUMES

	0% impervious cover		30% impervious cover	
	Runoff volume (inches)	Runoff Coefficient (%)	Runoff volume (inches)	Runoff Coefficient (%)
1-inch rain	0.31	31	0.46	46
4-inch rain	1.71	43	2.48	62

The above calculations show that the increase in impervious cover due to the construction of the proposed Grand Parkway Segment C would result in a substantial increase in runoff from the proposed ROW. However, it should be noted that for all alternatives, the proposed ROW represents a very small fraction of the total area of each watershed. While the percentage increase in runoff volume contributed by the proposed ROW itself would be high, the percentage increase in total runoff volume in the watershed would be small.

An increase in the peak runoff rate may increase the scouring of the streambed downstream of a crossing, which would lead to an increase in suspended sediments and associated constituents downstream. Based on the site runoff curve developed by Harris County Flood Control District (1988), Table 4-34 shows the estimates of the peak runoff rate from the proposed ROW of each alternative before and after the construction of the proposed Grand Parkway Segment C for a 25-year frequency storm and a 100-year frequency storm, assuming no detention ponds are built. Impervious covers of 0 percent and 30 percent are assumed for the pre- and post-construction conditions, respectively. For all alternatives, the peak runoff rate from the proposed ROW is approximately doubled after construction of the proposed Grand Parkway Segment C. As discussed earlier, the proposed ROW represents a small area of the entire watershed. Even doubling the

TABLE 4-34
EXISTING AND PROPOSED SITE RUNOFF FROM ROW OF PROPOSED GRAND PARKWAY SEGMENT C

Alternative	Watershed[1]	Area (acres)	Runoff (25-year freq)[2]		Runoff (100-year freq)[2]	
			Existing[3] (cfs)	Proposed[4] (cfs)	Existing[3] (cfs)	Proposed[4] (cfs)
Preferred	Rabbs Bayou[1]	92	100	190	140	270
Preferred	Rabbs Bayou[2]	98	105	205	150	290
Preferred	Dry Creek	210	200	380	280	540
Preferred	Big Creek	102	105	205	150	290
Preferred	Walters Lake Bayou	114	120	240	170	320
Preferred	Brazos River	136	140	270	200	380
Preferred	Oyster Creek	62	70	140	100	190
Preferred	Hayes Creek	183	170	350	260	480
1	Rabbs Bayou[1]	92	100	190	140	270
1	Rabbs Bayou[2]	165	160	320	220	400
1	Dry Creek	234	220	420	320	600
1	Big Creek	14	20	40	30	56
1	Walters Lake Bayou	62	70	140	100	190
1	Brazos River	138	140	270	200	380
1	Oyster Creek	69	80	150	110	210
1	Hayes Creek	110	115	220	160	300
2	Rabbs Bayou[1]	92	100	190	140	270
2	Rabbs Bayou[2]	165	160	320	220	400
2	Dry Creek	234	220	420	320	600
2	Big Creek	14	20	40	30	56
2	Walters Lake Bayou	62	70	140	100	190
2	Brazos River	138	140	270	200	380
2	Oyster Creek	69	80	150	110	210
2	Hayes Creek	145	140	270	200	380
3	Rabbs Bayou[1]	92	100	190	140	270
3	Rabbs Bayou[2]	0	0	0	0	0
3	Dry Creek	282	250	500	360	700
3	Big Creek	262	230	460	340	650
3	Walters Lake Bayou	83	90	170	130	250
3	Brazos River	138	140	270	200	380
3	Oyster Creek	69	80	150	110	210
3	Hayes Creek	110	115	220	160	300
4	Rabbs Bayou[1]	92	100	190	140	270
4	Rabbs Bayou[2]	0	0	0	0	0
4	Dry Creek	282	250	500	360	700
4	Big Creek	262	230	460	340	650
4	Walters Lake Bayou	83	90	170	130	250
4	Brazos River	138	140	270	200	380
4	Oyster Creek	69	80	150	110	210
4	Hayes Creek	145	140	270	200	380
5	Rabbs Bayou[1]	46	54	105	75	145
5	Rabbs Bayou[2]	165	160	320	220	400

TABLE 4-34, CONT'D

Alternative	Watershed[1]	Area (acres)	Runoff (25-year freq)[2]		Runoff (100-year freq)[2]	
			Existing[3] (cfs)	Proposed[4] (cfs)	Existing[3] (cfs)	Proposed[4] (cfs)
5	Dry Creek	255	230	460	330	620
5	Big Creek	14	20	40	30	56
5	Walters Lake Bayou	62	70	140	100	190
5	Brazos River	138	140	270	200	380
5	Oyster Creek	69	80	150	110	210
5	Hayes Creek	110	115	220	160	300
6	Rabbs Bayou[1]	46	54	105	75	145
6	Rabbs Bayou[2]	165	160	320	220	400
6	Dry Creek	255	230	460	330	620
6	Big Creek	14	20	40	30	56
6	Walters Lake Bayou	62	70	140	100	190
6	Brazos River	138	140	270	200	380
6	Oyster Creek	69	80	150	110	210
6	Hayes Creek	145	140	270	200	380
7	Rabbs Bayou[1]	46	54	105	75	145
7	Rabbs Bayou[2]	0	0	0	0	0
7	Dry Creek	282	250	500	360	700
7	Big Creek	220	200	400	290	560
7	Walters Lake Bayou	83	90	170	130	250
7	Brazos River	138	140	270	200	380
7	Oyster Creek	69	80	150	110	210
7	Hayes Creek	110	115	220	160	300
8	Rabbs Bayou[1]	46	54	105	75	145
8	Rabbs Bayou[2]	0	0	0	0	0
8	Dry Creek	282	250	500	360	700
8	Big Creek	220	200	400	290	560
8	Walters Lake Bayou	83	90	170	130	250
8	Brazos River	138	140	270	200	380
8	Oyster Creek	69	80	150	110	210
8	Hayes Creek	145	140	270	200	380

Source: Study Team (2011).

[1] Rabbs Bayou: Above Smithers Lake, [2]Rabbs Bayou: Below Smithers Lake.

[2] From Harris County Flood Control District Site Runoff Curves, Harris County (1988).

[3] 0% Impervious.

[4] 30% Impervious.

runoff contribution from the proposed ROW would only result in a marginal increase in the peak runoff rate of the entire watershed. Therefore, a substantial increase in scouring of the streambed is not expected.

The Center for Research in Water Resources of The University of Texas at Austin performed a detailed study of highway runoff in an urban area (Barrett et al., 1995b). One of the major tasks of the study was the characterization of highway runoff in the Austin area (Barrett et al., 1998). Their monitoring program included three sites where rain events over a 2-year period were monitored. In addition, an artificial rain system was constructed along a highway that allowed highway runoff to be collected and analyzed in controlled circumstances. Monitoring involved characterization of runoff flows and concentrations and measurements of the effectiveness of several alternative runoff treatment methods.

The concentrations of constituents in runoff at the studied sites were found to be similar to median values reported in a nationwide study of highway runoff quality, and similar to urban runoff. Barrett et al. concluded that highway runoff should have little adverse effect on all but the most sensitive receiving waters. Moreover, they confirmed the effectiveness of grassy swales in the reduction of pollutant loads of many constituents in highway runoff that have been reported in several previous studies. Swales promote settling of suspended solids and infiltration of runoff into the soil. The reduction in pollutant load is due to reduced runoff volume and, for some constituents, due to reduced concentrations as well.

Another significant task of the Center for Research in Water Resources study was a literature review on the control of pollution from highway runoff (Barrett et al., 1995a). It was found that most design references specified vegetated controls as their first choice because of their wide adaptability, low costs, and minimal maintenance requirements. Wet ponds are recommended when site conditions are not conducive to vegetated controls. Infiltration practices (e.g., infiltration trenches and basins) seem to offer excellent treatment potential but are the least desirable because of their high maintenance requirements. In a field filtration study, Barrett et al. (1995b) found that the hydraulic performance of vertical sand filters was uneven, resulting in little apparent improvement in runoff quality.

The construction of the proposed Grand Parkway Segment C would produce changes in the quantity and quality of the runoff from the paved area. However, since the proposed ROW is only a small fraction of the watershed for each stream crossing considered, any changes are expected to have minimal impact on the receiving waters. Grassy swales are recommended to mitigate the effect of runoff directly from the ROW, as they have been demonstrated as an effective and low-maintenance measure for highway runoff.

In summary, water quality in the study area is not expected to be detrimentally affected by construction and highway usage. However, some localized reduction in water quality may occur if siltation and turbidity are not adequately controlled, especially during construction. The adverse impacts to water quality are expected to be slight. Mitigation for all impacts mentioned above will include TxDOT BMPs designed to limit water quality degradation from construction activities. Permanent BMPs will mitigate effects by contributing to eliminating roadway pollutants before they reach the stream system.

The TCEQ is responsible for water quality certification required for obtaining a USACE Section 404 permit. The reviews for such certification are referred to as Section 401 certification reviews. The TCEQ has developed a tiered system of review based on project size and the amount of state water affected. Tier I projects are those that affect less than 3 acres of waters in the state, or less than 1,500 linear feet of streams. For these small projects, the TCEQ has determined that incorporating certain BMPs and other requirements into the project will generally be adequate to maintain water quality at the desired level. No further Section 401 review will be necessary if the permittee agrees to include those BMPs and requirements into the project as part of their Section 404 permit. Any project that does not qualify for a Tier I review, or for which the applicant elects not to incorporate Tier I criteria, or prefers to use alternatives, will be considered a Tier II project. Tier II projects are subject to an individual certification review by the TCEQ. The applicant needs to complete a Tier II 401 Certification Questionnaire and an Alternative Analysis Checklist. Since the proposed Grand Parkway Segment C would affect more than 3 acres of wetlands, the project would be subject to Tier II review.

4.8.2 Groundwater

Construction and operation of the proposed Grand Parkway Segment C facility would have a nominal impact to regional groundwater resources. A review of well records and published groundwater reports of the TWDB indicate that a total of 20 public water supply wells and 11 private water wells are located within ¼ mile of the proposed ROW of the Preferred Alternative. One of the public water supply wells and two private water wells lie directly within the proposed ROW of the Preferred Alternative and would be directly impacted. As a result, each of these wells must be plugged according to TCEQ regulations (16 TAC 76.1004). While the public and private use of groundwater from these wells will be impacted, plugging of these five wells will eliminate the potential impact to groundwater resources.

The Source Water Protection Program is a voluntary pollution prevention program created by the 1996 Safe Drinking Water Act Amendments (Section 1453). It is an expansion of the existing Wellhead Protection Program and was implemented to protect public groundwater sources from possible surface and subsurface source contamination. All public water supply systems are eligible to participate in the program. Under the program, a wellhead protection area is established around each public supply well. This area is a ½-mile-diameter protective buffer zone within which certain development is excluded to prevent possible contamination of the groundwater. According to data reviewed from the Public Water Supply Section of the TCEQ, none of the adjacent wells are enrolled in the Wellhead Protection Program. However, due to the proximity of the alternatives, each of the wells identified could be potentially impacted. Appropriate precautions, such as established BMPs, should be taken to divert surface runoff from entering the aquifers in the wellhead protection area.

The results of the water well review indicate that a total of 20 public water supply wells lie within ¼ mile of the alternatives. These wells are located adjacent to Segments A1, A2, A3.1, and S1-B. One public water well appears to be located within the proposed ROW of the Preferred Alternative. Table 4-35 summarizes the impacted public water supply wells.

TABLE 4-35
PUBLIC WATER SUPPLY WELLS LOCATED WITHIN
ONE-QUARTER MILE OF THE REPRESENTATIVE AND PREFERRED ALTERNATIVES

Public Well ID	Well Owner	Segment Impacted	Aquifer	Well Depth (feet)	Approximate Distance from ROW of Preferred Alternative (feet)
0790350	Bridlewood Estates	S1-B*	Chicot	262	292
0790350	Bridlewood Estates	A3.1*	Chicot	242	1082
0790350	Bridlewood Estates	A3.1*	Chicot	460	1018
0790365	Triumph Christian Center	A3.1*	Chicot	463	746
0790398	CBI	A3.1*	Chicot	190	493
0790350	Bridlewood Estates	A3.1*	Chicot	242	1082
0790243	Fort Bend County PCT 2 Road & Bridge	A3.1*	Chicot	214	239
790243	Fort Bend County PCT 2 Road & Bridge	A3.1*	Chicot	310	469
0790242	Fort Bend County PCT 3 Road & Bridge	A2*	Chicot	185	217
790177	Parkway Crossing	A2*	Chicot	185	217
790177	Parkway Crossing	A2	Chicot	185	235
0790305	Z Bar	A1*	Chicot	300	390
0790367	Fort Bend County MUD 116 Canyon Gate	A1*	Evangeline	825	301
0790367	Fort Bend County MUD 116 Canyon Gate	A1*	Evangeline	592	312
0790361	Crabb River Road Exxon	A1*	Chicot	315	0
0790196	USA RV PARK	A1*	Chicot	325	397
0790196	USA RV PARK	A1*	Chicot	325	328
0790112	Plantation MUD	A2*	Chicot	810	1300
0790296	Fort Bend County MUD 106	A1*	Evangeline	1942	825
0790418	Jiffy Lube 2879	A1*	Chicot	260	433

Source: TCEQ (2011) and TWDB (2011b).

The results of the water well review also indicated that a total of 11 private water supply wells lie within ¼ mile of the alternatives. Available information indicates that none of the wells are used for domestic purposes. Two of the wells lie within the proposed ROW of the Preferred Alternative and may be directly impacted. If possible, alignments would be adjusted to minimize impacts to area private water wells. If adjustments are not feasible, those wells within the proposed ROW of the Preferred Alternative would need to be plugged and abandoned according to TCEQ regulations to eliminate the potential of impacts to groundwater resources. Appropriate precautions, such as the use of established BMPs, should be taken to divert surface runoff from entering the aquifer at wellheads within a minimum of ¼ mile from the proposed ROW. Table 4-36 summarizes the impacted private water supply wells.

TABLE 4-36
PRIVATE WATER SUPPLY WELLS LOCATED WITHIN ONE-QUARTER MILE OF THE REPRESENTATIVE ALTERNATIVES AND PREFERRED ALTERNATIVE

Private Well ID	Well Owner	Segment Impacted	Aquifer	Well Depth (feet)	Primary Use	Approximate Distance from ROW of Preferred Alternative (feet)
6527505	Plantation MUD #2	A2*	Evangeline	840	Unknown	899
6527704	Fort Bend County Road Maintenance	A3.1*	Chicot	245	Unknown	717
6527703	Richmond Rice Association	A3.1*	Chicot	50	Unknown	857
6527506	Fort Bend County MUD #106	A1*	Evangeline	1942	Unknown	616
6527510	SWWC Fort Bend Co.	A1*	Evangeline	592	Unknown	449
6536901	Texas Department of Corrections	Y1*	Chicot	123	Irrigation	75
6535603	Eugene Garlin	W1*	Chicot	240	Unknown	993
6536509	George Estate	X1*	Chicot	87	Stock	106
6535601	Martin Thompson	W1*	Chicot	160	Unused	0
6527801	August Meyers	S1-B*	Chicot	79	Unused	441
6527803	Tex. Eastern Trans.	S1-B*	Chicot	614	Industrial	0

Source: TCEQ (2011), TWDB (2011b).

Potential adverse impacts to groundwater could occur as a result of the spill of hazardous or toxic material during transport after completion of the project. During construction, spills would be mainly limited to fuels (i.e., gasoline, diesel) and lubricants used by construction equipment. Such spills and their adverse impacts can be controlled through proper maintenance of equipment and management of these materials, and by prompt response and cleanup of spills and leaks. In either case, impacts to the groundwater quality as a result of surface spills would be greatly minimized by the characteristically low permeability of the clayey soils and clay substrate, and existing surface features, which may prohibit surface recharge. Additionally, the use of established BMPs, including grassy swales, may reduce pollutants that could impact surface water and the aquifer by filtering pollutants from surface water runoff. Appropriate spill response actions will ensure such impacts are localized and remediated. Descriptions of the aquifers in the region can be found in the Groundwater discussion in Section 3.8.2.

The wells within the Preferred Alternative ROW would require plugging; however, the owners of these wells would be fairly compensated according to the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (49 CFR 24). The compensation will be negotiated during ROW acquisition and may involve either the drilling of a new well or connection to a local municipal water source.

4.8.3 Summary of Impacts

Effect to surface water runoff and groundwater from the Representative Alternatives as well as the Preferred Alternative would be minimal. Quality and quantity of stormwater runoff would be altered by the Representative Alternatives and the Preferred Alternative in two ways: (1) direct effects from construction, and (2) effects from long-term operation of the

roadway. Well records indicate that groundwater pollution prevention measures might be required for one public well and two private wells within the Preferred Alternative ROW.

4.8.4 Indirect Impacts

Future increases in stormwater runoff levels and effects to groundwater associated with project regional and local developments are anticipated, especially in proximity to the Segment C access points where indirect growth may occur. The network of future roadways and subdivision streets, in conjunction with this project, would be expected to contribute to increased runoff as impermeable surface area increases. The density and type of future development within the project area would contribute to the overall changes in runoff. Development with the watershed near the highways may result in additional impacts to private and public water wells; however, an estimate cannot be determined.

4.8.5 Mitigation

Surface Water

A SW3P will be prepared prior to construction and followed throughout the construction phases to minimize the discharge of sediment laden stormwater to the Segment C project area streams. The project SW3P will be prepared pursuant to the TxDOT manual *Storm Water Management Guidelines for Construction Activities* (TxDOT, 2000). Also prior to construction, opportunities to reduce the width of the ROW would be considered during final design, which would have the effect of reducing the amount of cleared vegetation and, therefore, the potential for erosion.

Mitigation for unavoidable impacts would incorporate the following BMPs at appropriate stages during construction. For erosion control, sod would be utilized and remain in place until the area has been stabilized. For sedimentation, a combination of silt fencing and hay bale dikes would be utilized and would remain in place until project completion. The existing ditches would be used for retention storage during construction. For post-construction BMPs, a combination of retention and vegetative filter strips would be utilized to control total suspended solids after construction. Vegetation within the existing ditches would be replanted after construction and would act as vegetative filter strips. Other areas of the ROW would be seeded with native species of grasses, shrubs, or trees as needed. At the completion of construction, the TxDOT specification *Seeding for Erosion Control* would be followed to restore and reseed all disturbed areas.

Additionally, in accordance with CWA Section 402, where stormwater from the proposed construction project would discharge to a Municipal Separate Storm Sewer System (MS4), the MS4 permittee would be notified of the construction activity. See Section 4.7.1 for further discussion of permitting of stormwater discharge.

Groundwater

Avoidance and minimization of impacts to the public and private water supply wells have been incorporated in the preliminary design of the Preferred Alternative and would be performed during final design of the project. Measures would include minor alignment shifts to minimize the impact to sources water protection areas and/or avoid direct impact to the

public and private water supply wells. Any water supply wells affected by construction would be mitigated using measures such as providing a new well or connection to the public water system, if feasible. Wells taken out of service would be sealed in accordance with the specifications outlined by the Water Well Drillers Board of the Texas Department of Licensing and Regulation.

A stormwater management plan would be developed in accordance with FHWA and TxDOT criteria to reduce the risk of contaminating local aquifers. The stormwater management basins would collect and control spills of hazardous materials, sediments, and other particulates found in highway runoff. The use of established BMPs would be employed to prevent highway stormwater runoff from entering the aquifer at wellheads.

An emergency spill control pollution prevention plan would be developed and coordinated with local official for the Preferred Alternative. Special stormwater management measures would be designated to isolate potentially hazardous spills, for treatment and removal, before entering an aquifer. The BMPs listed in the previous section would be considered and incorporated into the plans during the final design of the proposed project.

4.9 PERMITS

4.9.1 Waters of the U.S., Including Wetlands

The location (Exhibits 11 and 15) and extent of dredged or fill material into waters of the U.S. have been identified. Alternatives to the Preferred Alternative are discussed in Section 2. A detailed evaluation of impacts by alternatives is discussed in this section. While impacts to resources regulated by the CWA could not be avoided, they have been minimized to the maximum extent practicable for the Preferred Alternative. Further minimization would require deviation from the Preferred Alternative and increases in impacts to other resources. All impacts to waters of the U.S. will be coordinated with the USACE and other applicable resource agencies through the CWA individual permit application process. Permittable activities are proposed for the Preferred Alternative under Section 10 of the Rivers and Harbors Act and Section 404 of the CWA. Although isolated wetlands are not regulated under Section 404, impacts to isolated wetlands have been identified and included in the alternatives analysis and the USACE Permit Application. The alternatives evaluation process fully considered mitigation sequencing for isolated wetlands in the development of the Preferred Alternative.

In general, all wetland areas that would be crossed by the Preferred Alternative would be permanently impacted. These wetlands and waters of the U.S. would most likely be impacted by the placement of fill material in the wetland to elevate the road or by secondary impacts from the road construction. All wetlands that would be impacted have been identified. Measures to minimize and/or mitigate for any adverse impacts have been developed in conjunction with the USACE and resource agencies.

Potential adverse impacts to waters of the U.S., including wetlands, are reduced floodwater storage, decreased surface water quality (due to loss of sediment trapping, nutrient removal, and chemical detoxification functions) near the proposed

road alignment, reduction in wildlife habitat, and possibly a decrease in groundwater recharge. Mitigation measures will be implemented to reduce the potential adverse impacts from the unavoidable impacts. A complete mitigation plan, currently being developed, will address mitigative measures for those impacts to resources that could not be avoided and further minimized. Proposed potential mitigation measures are presented in Section 4.10.6, Recommendations for Mitigation.

Since the project would disturb more than 1 acre of land, TxDOT would be required to comply with the TCEQ TPDES General Permit for Construction Storm Water Runoff, which requires development of an SW3P in order to avoid adverse impacts potentially resulting from construction stormwater runoff discharges. In addition, because the project would disturb more than 5 acres of land, TxDOT would issue an NOI prior to construction stating that the SW3P has been developed and filed. The NOI would be filed with the TCEQ and EPA (40 CFR 122) prior to the issuance of a TPDES construction stormwater discharge permit as per Section 402 of the CWA. Additionally, in accordance with CWA Section 402, where stormwater from the proposed construction project will discharge to an MS4, the MS4 Permittee would be notified of the construction activity.

TxDOT has its own stormwater management guidelines and BMPs for construction activities (TxDOT, 2000), which will be used in the development of the SW3P. As part of the SW3P, TxDOT staff or a designee will be required to inspect both stabilized and unstabilized areas of the construction site for evidence of, or the potential for, pollutants entering waters of the U.S. via stormwater runoff through a drainage system. Summary reports of these inspections will be written and retained as part of the SW3P. Once construction has been completed and the disturbed areas achieve 70 percent stabilizing vegetative cover, a Notice of Termination will be filed per permit requirements. No other point source discharges that may require additional authorizations under Section 402 of the CWA are anticipated at this time.

Water quality certification from the TCEQ will also be necessary per Section 401 of the CWA prior to filling wetlands. The USACE will initiate the Water Quality Certification for permit applicants. However, applicants may negotiate directly with the TCEQ staff to address issues regarding Section 401 Water Quality Certification. A CWA Section 404 permit for the disturbance of more than 3 acres of waters of the U.S. is subject to individual review by TCEQ as Tier 2 project impacts.

4.9.2 Navigable Waters of the U.S.

Segment G5.2* crosses the Brazos River. The Brazos River at this location is a navigable waterway (according to correspondence with the USACE Galveston District) and is included in the federal programs for channel navigation improvements, although ultimate design has not been funded, initiated, or completed. Because the Segment G5 crossing, included in all Representative Alternatives and the Preferred Alternative, is above the currently maintained federal navigation project, a letter of permission (or Section 9 permit) will be required from the USCG. According to the USACE, Galveston District, no other waterway in the study area is deemed navigable.

The General Bridge Act of 1946 and Section 10 of the Rivers and Harbors Act of 1899 prohibit the unauthorized obstruction, including bridge construction, or alteration of any navigable water of the U.S.; therefore, coordination and permit approval must occur with the USCG and the USACE. As defined in 33 CFR 329.4, “Navigable waters of the United

States are those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce."

4.9.3 Summary of Impacts

Implementation of any of the alternative alignments would require Section 404 and Section 10 permits from the USACE, Section 401 water quality certification, and an appropriate mitigation plan. The proposed project would also require a TPDES construction stormwater discharge permit and completion of an SW3P and NOI. Additionally, a Section 9 permit from the USCG would be required. Under the No-Build Alternative, no permits would be required.

4.9.4 Indirect Impacts

Wetlands and waterbodies requiring Section 404 and Section 10 permits for the proposed project are discussed in Section 4.9.1 (Indirect Impacts, Wetlands), and the indirect impacts requiring the TPDES permit are presented in Section 4.7.4 (Indirect Impacts, Water Quality).

4.9.5 Mitigation

Mitigation options associated with the wetland impacts requiring Section 404 and Section 10 permits are discussed in Section 4.9.5 (Mitigation, Wetlands), and the mitigation discussion for the activities requiring the TPDES permit are presented in Section 4.7.5 (Mitigation, Water Quality). The Section 404 and 10 permits and the TPDES permit will be obtained prior to construction.

4.10 WETLANDS AND VEGETATIVE COMMUNITY IMPACTS

4.10.1 Wetlands

EO 11990, "Protection of Wetlands," established a national policy "to avoid to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative." Federal Highway Technical Advisory T 6640.8A (FHWA, 1987) provides guidelines for addressing wetland impacts in environmental documents, including identification of the extent of wetlands impacted, their type, quality and function. Alternatives for avoidance and practicable measures to minimize harm to wetlands should be addressed. The importance of the wetland areas such as relative importance of the wetland resource and its function to the area, and any uniqueness that may contribute to the wetland's importance, should be presented.

All proposed construction activities will impact wetlands and aquatic systems to varying degrees. The initial clearing of the land during construction activities will remove the vegetative cover. These activities whether taking place in grassland or forested communities will increase the surface runoff and could lead to erosion. If the runoff is allowed to flow into streams without soil surface protection, erosion will increase sedimentation and turbidity. Water chemistry could be modified due to

the entrainment of sediments, nutrients, and pollutants in the water column while also diminishing suitable habitat for aquatic species, including plants. To mitigate these potential impacts, placement and monitoring of erosion control measures at the beginning of, during, and after construction will be incorporated into the plans according to TxDOT SW3P guidelines, which will aid in minimizing impacts from erosion and sedimentation. Preparation of the SW3P will coincide with final design of the roadway. Revegetation along the ROW will be performed according to TxDOT revegetation guidelines.

The effects of construction will primarily fall into two categories: (1) the immediate impacts that will occur during the construction phase; and (2) the long-term effects or permanent changes caused by the roadway itself, or through management practices related to the roadway (Darnell et al., 1976). The degree of impacts construction activities will have on the environment depends largely on construction practices and on the design of highway and bridge structures. Conservative construction practices can reduce the effects on the physical environment. The long-term effects of man-made landforms on ecosystems are less predictable than the immediate impacts of construction on the specific sites, as changes to the wetland/aquatic system can take place over a longer period of time.

Wetland functions/values will be permanently impacted by filling the wetlands during road construction. Various mitigation measures will be employed to offset the permanent impacts. All mitigation measures will be designed to replace the lost wetland functions and values. Short- and long-term effects of wetland impacts include loss of the functions and values (described in Section 3.10.1). Short-term losses will most likely include temporary water quality losses, wildlife habitat loss, and a decrease in some recreational uses. Impacts to the flood control function will be avoided by design measures (e.g., detention facilities).

Since the impacts to the wetlands will be mitigated, long-term impacts will be eliminated by the replacement of the impacted wetlands and their function and value. Formal mitigation measures will be discussed and developed to ensure wetland function and value are not permanently lost by the proposed project.

Following development of the constraints map, 500- and/or 1,000-foot corridors were selected that avoided or minimized impacts to those known constraints. With an average proposed ROW width of 300 to 400 feet, the actual footprint of the project could be “meandered” within the corridor (with geometry and design requirements noted) to avoid or minimize impacts to constraints identified or refined during the field effort (e.g., wetlands unmapped by National Wetlands Inventory). Refer to Section 2 for a discussion on applied screening methodologies that narrowed down the Universe of Alternatives to the Representative Alternatives.

Three major steps or levels of investigation were employed to identify jurisdictional wetlands as defined by the USACE, *Wetland Delineation Manual* (Environmental Laboratory, 1987) for the Representative Alternatives. The first level of investigation included reviewing color infrared aerial photographs and published soil survey maps. All potential wetland areas were delineated on the maps and classified as either forested or nonforested wetlands.

The second level of investigation utilized the above maps during a helicopter survey of the Representative Alternatives. During the flight, all the potential wetlands identified from the aerial photos were qualified as either forested or nonforested and the boundaries confirmed and corrected by the project team, if necessary.

The third level of investigation included a ground survey of all properties on the Representative Alternatives to which the field team had access. During the ground survey, all areas that were dominated by hydrophytic vegetation had at least one primary or two secondary hydrology indicators, and had hydric soils that were mapped as potential jurisdictional wetlands (Environmental Laboratory, 1987). Where access was granted for on-site investigations, the boundaries of the potential wetland areas were flagged and mapped with real-time differentially corrected Global Positioning Systems (GPS) equipment. Properties without access required evaluation of aerial photographs and digital area calculations to determine acreage. Additional areas for the US 59 and SH 288 interchanges to incorporate direct connectors were added to the proposed project following completion of ground surveys. These areas were investigated from existing easements, and potential waters of the U.S. were evaluated using aerial photographs and digital area calculations to determine acreage. The wetland delineation data for the Preferred Alternative was supplemented by additional field data to be consistent with the delineation methodology agreement in place between the USACE and the Houston District of TxDOT.

The potential acreage of wetlands impacted by the Representative Alternatives ranges from approximately 15 acres (Alternative 3) to 56 acres (Representative Alternative 6). Table 4-37 lists the impacts by wetland type for each Representative Alternative. Note that impacts for the Representative Alternatives were kept at the same level of analysis and measured prior to the USACE verification while impacts for the Preferred Alternative were identified using a greater detail of analysis. Refer to Table 4-38 for a list of the jurisdictional wetlands, wetland types, and acreages identified within the Preferred Alternative ROW.

Each wetland community type has been identified (Cowardin et al., 1979) and quantified for potential impacts within the ROW. The location of each wetland area in relation to the Preferred Alternative and Representative Alternatives are mapped in Exhibits 31 and 32, respectively. As indicated in a letter dated April 1, 2010, the USACE completed the preliminary jurisdictional determination (PJD) of the project area (Appendix I). According to the PJD completed by the USACE, 32.92 acres of waters of the U.S., including wetlands, occur within the Preferred Alternative. Total preliminary jurisdictional wetland acreage within the Preferred Alternative is 25.96 acres. Additionally, 6.96 acres of open water was documented as a result of the more-extensive studies completed for the preferred analysis. Open waters were not analyzed for the Representative Alternative segments, and thus the 6.96 acres of open water within the Preferred Alternative is not included in the comparative analysis as shown in Table 4-38. Additionally, the January 2012 field studies and wetland determination for the US 59 and SH 288 interchanges (Exhibit 32) are also not included in the comparative analysis for the Representative Alternatives and only evaluates the Preferred Alternative. Thus, the acreages in Table 4-38 reflect an additional 2.21 acres of jurisdictional wetlands and 1.05 acres of jurisdictional open waters for the Preferred Alternative. Per the letter from the USACE dated April 1, 2010, the USACE has completed the PJD (which is valid for 5 years from the date of the letter) but is awaiting the permit application to continue the review process. A subsequent letter

to the USACE was submitted by TxDOT Houston District on February 16, 2012, to update the proposed project with the US 59 and SH 288 interchanges. Final concurrence from the USACE will be included with the FEIS upon receipt.

TABLE 4-37
WETLAND AND RESOURCE IMPACTS BY ALTERNATIVE

Alternative No.	Wetland Type	
	Nonforested Wetlands (ac)	Forested Wetlands (ac)
1 (A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1)	17	38
2 (A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8)	17	38
3 (A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1)	13	2
4 (A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2,G7, G8)	13	3
5 (B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1)	18	38
6 (B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8)	18	38
7 (B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1)	14	2
8 (B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2, G7, G8)	14	3
Preferred Alternative (A1, A2, A3.1, S1-b, B4.2, W1, G3.2, X1, G5.2, Y1, G6.2, G7, G8)	17*	9*

Source: Study Team (2011).
*Impacts shown for the Preferred Alternative for comparative analysis do not contain more detailed surveys outside of the scope of what was evaluated for the other alternatives, including impacts to open water and impacts associated with the US 59 and SH 288 direct connectors.

TABLE 4-38
JURISDICTIONAL WETLANDS FOR THE PREFERRED ALTERNATIVE

Map Name	Description	Wetland (ac)	Open Water (ac)	Classification	USACE Jurisdiction
Stream Crossings					
STR 1B	Middle Bayou	–	0.15	Intermittent	404
STR 2	Rabbs Bayou	–	0.41	Perennial (PEM)	404
STR 3	Gapps Slough	–	0.10	Perennial	404
STR 4	Dry Creek	–	0.08	Perennial (PEM)	404
STR 5	Tributary of Worthington Lake	–	0.13	Intermittent	404
STR 6	Secondary Tributary of Worthington Lake	–	0.05	Intermittent	404
STR 7	Tributary of Worthington Lake	–	0.05	Intermittent	404
DRN HD1	Unnamed Tributary	–	0.01	Ephemeral	404
STR 8	Big Creek	–	0.22	Perennial	404
STR 9	Big Creek	–	0.26	Perennial	404
STR 10	Waters Lake Bayou	–	0.04	Intermittent	404
STR 12	Unnamed Drainage	0.04	–	Intermittent (PEM)	404
STR 17	Brazos River	–	2.43	Perennial	10/404
STR 18	Cow Lake	–	2.14	Open Water	404
STR 19	Oyster Creek	–	0.35	Perennial	404
STR 20	Willow Lake drainage	–	0.02	Intermittent	404
STR 21	Dry Creek Tributary	–	0.05	Intermittent	404
STR 22	Unnamed drainage	–	0.19	Intermittent	404
MM 17	Tributary to Big Creek	–	0.04	Intermittent	404
MM 18	Tributary to Big Creek	–	0.07	Intermittent	404
MM-31	Unnamed Drainage	–	0.09	Intermittent	404
MM-32	Unnamed Drainage	–	0.08	Intermittent	404
Ditch DC1*	Tributary to Brazos River	–	0.02	Ephemeral	404
Ditch DC2*	Tributary to Middle Bayou	–	0.05	Intermittent	404
Ditch DC3*	Tributary to Middle Bayou	–	0.01	Intermittent	404
Hayes Creek*	Hayes Creek	–	0.16	Intermittent	404
Canal DC1*	South Texas Water Company Canal	–	0.24	Intermittent	404
Canal DC2*	South Texas Water Company Canal	–	0.27	Intermittent	404
Canal DC3*	South Texas Water Company Canal	–	0.30	Intermittent	404
Wetlands					
MMHD2	Wetland	0.02	–	PEM	404
MMHD3	Wetland	0.16	–	PEM	404
MM-22	Wetland	0.07	–	PEM	404
MM-33	Wetland	0.11	–	PEM	404
MM-34	Wetland	0.30	–	PEM	404

TABLE 4-38, CONT'D

Map Name	Description	Wetland (ac)	Open Water (ac)	Classification	USACE Jurisdiction
MM-35	Wetland	0.64	–	PEM	404
MM-36	Wetland	0.08	–	PEM	404
MM-37	Wetland	0.10	–	PEM	404
STR7 WET	Wetland	0.06	–	PEM	404
WET 1	Wetland	0.31	–	PEM	404
WET 2	Wetland	0.02	–	PEM	404
WET 3	Wetland	0.13	–	PEM	404
WET 4	Wetland	0.15	–	PEM	404
WET 5	Wetland	0.22	–	PEM	404
WET 6	Wetland	0.05	–	PEM	404
WET 9	Wetland	0.06	–	PSS	404
WET 10	Wetland	3.99	–	PFO	404
WET 10A	Wetland	0.32	–	PFO	404
WET 11	Wetland	1.14	–	PFO	404
WET 12	Wetland	3.39	–	PEM	404
WET 13	Wetland	0.03	–	PEM	404
WET 14	Wetland	0.46	–	PEM	404
WET 15	Wetland	0.02	–	PEM	404
WET 16	Wetland	0.83	–	PEM	404
WET 16A	Wetland	0.49	–	PEM	404
WET 16B	Wetland	0.06	–	PEM	404
WET 17	Wetland	3.09	–	PFO	404
WET 18	Wetland	0.35	–	PEM	404
WET 19	Wetland	0.45	–	PEM	404
WET 20	Wetland	0.31	–	PEM	404
WET 21	Wetland	0.07	–	PSS	404
POND AA	Wetland	3.24	–	PEM	404
WET 1 JRM	Wetland	0.75	–	PEM	404
WET HD2	Wetland	0.03	–	PEM	404
WET 2 JRM	Wetland	0.42	–	PEM	404
Missed Wet 1	Wetland	0.90	–	PEM	404
Missed Wet 2	Wetland	0.50	–	PEM	404
Missed Wet 3	Wetland	0.70	–	PEM	404
Missed Wet 4	Wetland	1.90	–	PEM	404
WET DC1*	Wetland	0.99	–	PEM	404
WET DC2*	Wetland	0.74	–	PFO	404
WET DC3*	Wetland	0.48	–	PEM	404
WET DC4*	Wetland	–	–	PFO	404
WET DC5*	Wetland	–	–	PFO	404
Stream Crossings Subtotal		**0.04**	**8.01**		
PEM Wetland		**0.04**	–		
Open Water		–	**8.01**		
Wetlands Subtotal		**28.17**	–		

TABLE 4-38, CONT'D

Map Name	Description	Wetland (ac)	Open Water (ac)	Classification	USACE Jurisdiction
PEM Total		**18.72**			–
PFO Total		**9.28**			–
PSS Total		**0.13**			–
Total Jurisdictional Wetlands and Waters of the U.S. within the Preferred Alignment		**28.17**	**8.01**	**36.18 ac (Waters of U.S.)**	

Source: Study Team (2012).
*= photo-interpreted waters/wetlands from the 2012 interchange surveys.
PEM = palustrine emergent
PFO = palustrine forested
PSS = palustrine scrub/shrub

The USACE provided a preliminary verification that indicated the ROW for the Preferred Alternative contains 32.92 acres of aquatic resources to illustrate the utility of design considerations in avoidance and minimization measures. Additionally 3.26 acres of potential impacts to aquatic resources were identified within additional ROW evaluated for the US 59 and SH 288 interchanges subsequent to the USACE verification. These aquatic resources include both isolated and adjacent PEM, PFO, and palustrine scrub/shrub (PSS) wetlands, fringe wetlands along stream banks, natural and modified-natural streams, bayous and drainages, and open-water areas (e.g., Brazos River, oxbows, etc.). However, approximately 40 to 50 percent of those wetlands and other waters of the U.S. will be impacted by construction of the Preferred Alternative. The fact that some degree of impact is often unavoidable, regardless of the care applied during the planning design and construction of a highway, necessitates a plan for compensatory mitigation to replace function, values, and features or habitat that may be disturbed. This is required for unavoidable impacts that remain after appropriate and practicable minimization has been achieved. Mitigation or replacement of unregulated habitat (habitat not under the USACE jurisdiction where legal compensation is required or under the ESA where project modification may be required) within transportation corridors may not be practical or safe. On occasion, on-site restoration of degraded wetland habitat or creation of man-made wetland habitat within the highway ROW through creative use of swales, borrow pit areas, detention basins, or drainage runoff channels may be appropriate.

On-site mitigation measures are not always practical or feasible within a highway ROW. In addition, such measures may not effectively restore resource values; thus, off-site mitigation measures may be more appropriate. Off-site mitigation projects for wetlands must be designed to reestablish, to the extent reasonable, similar wetland functions and type as the preexisting site. Off-site mitigation should be conducted in the same geographic vicinity or in proximity, and most likely within the same watershed as the project, particularly for wetlands. Mitigative action may include expanding existing wetlands, restoration with hydrophytic species, or regulating water levels in impoundments or streams. Construction or improvement of the wetland habitat mitigation should not be considered unless post-project monitoring of the sites can be arranged.

Due to the spatial arrangement of some resources and a finite number of alternatives, impacts to wetlands (as a regulated resource) are addressed in a compensatory mitigation plan (Section 4.9.5). However, it is important to note that alternative evaluations involving avoidance and minimization of wetland impacts where possible have been a continual part of this planning process. Similarly, nonwetland resources (e.g., Austin's Woods), while not regulated under current laws, were avoided to the maximum extent practicable. Nonregulated resources are often included as part of a wetland mitigation plan, on a case-by-case basis. Identification of valued nonregulated resources was a collaborative effort between the project team and resource agencies.

The primary focus of the mitigation plan for the proposed Grand Parkway Segment C would provide compensation for unavoidable impacts to jurisdictional waters of the U.S., including wetlands, and impacts to the secondary management zone for the Bald Eagle nest (Section 4.16.1). It has been proposed that a nonwetland component be incorporated into the mitigation plan to compensate for unavoidable impacts to nonregulated natural resources.

The jurisdictional wetland delineation data obtained for the Preferred Alternative was finalized and submitted to and verified by the USACE in April 2010 (Appendix I). A subsequent letter to the USACE was submitted by TxDOT Houston District on February 16, 2012, to update the proposed project with the US 59 and SH 288 interchanges. The updated data from this wetland determination is included in Table 4-37; therefore, this section has been updated pending any future amendments from the USACE that might be received. The FEIS will be updated with the final jurisdictional determination received from the USACE. The verified delineation was used to calculate impacts to waters of the U.S., including wetlands, associated with the proposed roadway. Mitigation alternatives that were evaluated for this project have included wetland/habitat restoration, enhancement, creation, and/or preservation. In the evaluation of mitigation concepts, preference was given to potential mitigation opportunities located within the Brazos River basin of Fort Bend and Brazoria counties. Natural resource agencies have been closely involved in decisions regarding appropriate mitigation ratios, and the location, size and character of mitigation opportunities.

Use of TxDOT's Coastal Bottomlands Mitigation Bank was also considered as a means of providing compensatory wetland mitigation for the proposed Grand Parkway Segment C. A likely funding source for compensatory mitigation for the proposed Grand Parkway Segment C is a trust fund that has been established by the GPA in conjunction with The Nature Conservancy of Texas. The purpose of the trust fund is mitigation of wetland impacts that may result from the construction of the Grand Parkway. The funds will be utilized by The Nature Conservancy of Texas in accordance with USACE guidelines to mitigate impacted wetlands, including recovery and restoration of historically degraded wetlands and habitat. Most current efforts have focused on the Austin's Woods in the vicinity of Brazos Bend State Park and the proposed Lake Worthington Conservation Area.

Specific mitigation measures have been recommended by resource agencies (USFWS and TPWD) and have been considered for inclusion in the final mitigation plan. The USFWS recommendations were made relative to potential impacts to the secondary management zone of the Bald Eagle. Recent past efforts have included seasonal restrictions on

construction activities and equipment use, work intensity zones, and replacement of up to one Bald Eagle nest territory (approximately 500 acres) with appropriate habitat.

In a meeting held in January 2000, the TPWD identified several mitigation measures that will be considered.

- Span major drainages along the Preferred Alternative (e.g., Big Creek and Brazos River)
- Create wildlife underpasses that also accommodate sheet flow of water, specifically in the vicinity of Big Creek and Brazos Bend State Park
- Construct "drift fences" along the roadway in high wildlife use areas to direct wildlife to underpasses
- Reduce facility width to 300 feet
- Mitigate for all regulatory wetland impacts
- Direct lighting downward to attenuate light pollution to dark skies around Brazos Bend State Park
- Buffer sound impacts with screening vegetation along the ROW within the Bald Eagle nest management zone

The social, technical, and regulatory merit of these recommendations will be evaluated and discussed with resource agency staff and the project team.

A conceptual compensatory mitigation plan will be submitted to the USACE as part of the Section 404 permit review process. The mitigation plan will include (by reference) a discussion of the avoidance and minimization measures (mitigation sequencing) used in the routing and design of the proposed roadway. In addition, the plan includes specifications for accomplishing the proposed compensatory mitigation measures. A monitoring program has been included in the mitigation plan to ensure the successful implementation of the compensatory mitigation measures. If a USACE Section 10/404 permit is issued for the proposed Grand Parkway Segment C, the approved mitigation plan will become a condition of the permit.

4.10.1.1 Conceptual Compensatory Mitigation Plan

A formal compensatory mitigation plan will be developed as part of the USACE's Section 10/404 permit process. This section has been developed to foster a sense of commitment by TxDOT to providing compensatory mitigation for those impacts that are not avoidable and cannot be further minimized. A summary of issues relative to the development of the conceptual mitigation plan is provided below.

There are essentially three elements to the conceptual mitigation plan that will be discussed in this section. The first element that will be discussed is the compensation for impacts to wetlands (for purposes of this discussion, "wetlands" includes both isolated and adjacent wetlands as verified by the USACE in February 2003). Isolated and adjacent wetlands were evaluated and "treated" the same throughout the mitigation sequencing process. The Preferred Alternative includes

32.92 acres of wetlands and other waters of the U.S., including 22 stream crossings and 39 wetlands. There are 18.76 acres of PEM, 9.28 acres of PFO, 0.13 acre of PSS, 8.01 acres of open water. In addition, mitigation for stream impacts may be required by the USACE per the Interim Galveston District Stream Condition Assessment Standard Operating Procedure for Compensatory Stream Mitigation released in a special public notice on July 12, 2011. Stream mitigation would be determined based on USACE guidance and/or upon the release of a final rule following the interim period.

The second element for discussion is the 500 acres (approximately) of Bald Eagle habitat (Austin's Woods) that will be protected in order to offset potential impacts to the secondary management zone of the Bald Eagle nest. The target area for acquisition is in the Big Creek-Rabbs Bayou-Brazos River corridor that exists in the vicinity of the Lake Worthington Conservation Area and Brazos Bend State Park. The GPA has been working closely with the George Foundation and other landowners in the vicinity to facilitate a preservation opportunity that would provide some synergy for the conservation initiative in this area.

The third element is an amalgamation of mitigation elements that the GPA has committed to with resource agencies.

- Span major drainages along the Preferred Alternative (e.g., Big Creek and Brazos River)
- Create wildlife underpasses that also accommodate sheet flow of water, specifically in the vicinity of Big Creek and Brazos Bend State Park
- Construct "drift fences" along the roadway in high wildlife use areas to direct wildlife to underpasses
- Reduce facility width to 300 feet
- Mitigate for all wetland impacts
- Direct lighting downward to attenuate light pollution to dark skies around Brazos Bend State Park
- Buffer sound impacts with screening vegetation along the ROW within the Bald Eagle nest management zone

4.10.1.1.1 Conceptual Wetland Mitigation Plan

Wetland restoration/creation within the approximate 500-acre eagle nest tract along the Brazos River floodway, north of Brazos Bend State Park, is the preferred method of compensatory wetland mitigation. This element of the overall mitigation plan will be in conjunction with the establishment of on-site detention as required for highway design and local floodplain administration. Elevation for detention pond outfalls will be designed to retain some water to facilitate the establishment of wetland vegetation within the basins.

In order to effectively develop a conceptual plan and determine replacement values for impacted wetlands, the Coastal Bottomlands Mitigation Bank acreage replacement values were used as guidelines. Considerable study and evaluation by TxDOT and resource agency staff was expended to develop the ratios over a period of several years. Ratios developed for

habitats within the mitigation bank's service area include low-, medium-, and high-quality wetlands; the project occurs within the mitigation bank's service area. Impacts to PEM, PSS, and PFO wetlands would be mitigated separately in order to achieve a balance between the types of habitats impacted and the types of habitats restored, created, or preserved within the mitigation bank. PSS wetlands are generally successional transition wetlands between PEM and PFO wetlands. Typically Gulf Coastal Plain and river floodplain PSS wetlands are more or less comprised of young trees and some species of shrubs. It is thought that the replacement PSS wetlands will eventually develop into PFO wetlands. PFO wetlands can be difficult to create and can take as long as 5 years to ensure that the appropriate tree species are beginning to take hold within the vegetative community. Once site design is finalized, impacts to PEM, PSS, and PFO wetlands would be quantified utilizing the USACE Hydrogeomorphic (HGM) approach to provide the appropriate mitigation ratio of impacts to mitigation credits. Given the calculated impacts to the wetlands within the ROW, the resulting replacement acreages of each wetland type is as follows:

PEM Wetlands – 18.76 acres of impact to low-quality wetlands. Assuming restoration or creation credits would be utilized and similarity of wetland quality at the impact site versus the mitigation site, a replacement ratio of 1:1 would be expected for the mitigation bank; however, mitigation ratios may be adjusted based on the results of HGM analysis.

PSS Wetlands – 0.13 acre of impact to medium-quality wetlands. Assuming restoration or creation credits would be utilized and similarity of wetland quality at the impact site versus the mitigation site, a replacement ratio of 1:1 would be expected for the mitigation bank; however, mitigation ratios may be adjusted based on the results of HGM analysis.

PFO Wetlands – 9.28 acres of impact to high-quality wetlands. A replacement ratio of 6:1 was developed for the mitigation bank. Assuming restoration or creation credits would be utilized and similarity of wetland quality at the impact site versus the mitigation site, a replacement ratio of 1:1 would be expected for the mitigation bank; however, mitigation ratios may be adjusted based on the results of HGM analysis.

Stream Impacts – Stream impacts, including 8.01 acres of open-water impacts within the stream channel and 0.04 acre of impacts to fringe wetlands would be determined upon evaluation of the final roadway design, and mitigation ratios determined based upon USACE guidance and/or upon the release of a final rule for stream mitigation following the interim period. Approximately 1,400 acre-feet of floodplain mitigation and detention will be required based on the conclusions provided in the Drainage and Impact Analysis Report (2002). Once the surface acreage of detention is designed, those acres will be incorporated into the mitigation ratio.

In lieu of outright design, construction, and monitoring of the wetland acreages, TxDOT may elect to pursue an in lieu fee donation to a nonprofit organization (e.g., National Fish and Wildlife Foundation). Resource agency staff have expressed an interest in this approach as it provides some fiscal flexibility in the acquisition and protection of key conservation properties and/or resources that might otherwise be unattainable within the timeframe necessary to afford complete protection for the entire initiative. The in lieu fee approach is offered as an option. The amount of the donation would be similar to the cost of implementing a compensatory wetland mitigation plan as described above.

4.10.1.1.2 Bald Eagle Nest Habitat Preservation

As discussed in Section 4.16, Threatened and Endangered Species, approximately 500 acres of Austin's Woods will be preserved through acquisition and donation to a conservation entity or through protection under a conservation easement. It is the intent of the project team to develop the mitigation plan within the context of a larger conservation initiative in the project vicinity. Resource agency staff have been involved in discussions regarding mitigation opportunities within the Big Creek-Rabbs Bayou-Brazos River corridor situated in the vicinity of the Lake Worthington Conservation Area and Brazos Bend State Park. This area represents a solid opportunity for Austin's Woods conservation and is located largely within the combined 100-year floodplains of the three waterways.

A commitment has been received from the George Foundation to dedicate approximately 500 acres of Brazos River floodway north of Brazos Bend State Park. This floodway habitat constitutes a portion of the riparian corridor and Austin's Woods and would be necessary to link the Lake Worthington Conservation Area with Brazos Bend State Park.

In lieu of a donation from the George Foundation, TxDOT may elect to contribute a donation to a nonprofit organization (e.g., National Fish and Wildlife Foundation). Resource agency staff have expressed an interest in this approach as it provides some fiscal flexibility in the acquisition and protection of key conservation properties that might otherwise be unattainable within the timeframe necessary to afford complete protection for the entire initiative. The in lieu fee approach is offered as an option. The amount of the donation would be similar to the cost of acquiring or restricting development of an approximate 500-acre parcel within the Brazos River floodway.

4.10.1.1.3 Nonregulatory Mitigation

As per Provision (4) (A) (ii) of the TxDOT-TPWD Memorandum of Understanding, impacts to the following should be considered for compensatory mitigation: (1) habitat for federal candidate species (impacted by the project) if mitigation would assist in the prevention of the listing of the species, (2) rare vegetation series (S1, S2, or S3) that also locally provide habitat for a state-listed species (refer to "Plant Communities of Texas (Series Label)" by the TPWD for series designations), (3) all vegetation communities listed as S1 or S2, regardless of whether the series in question provide habitat for state-listed species, (4) bottomland hardwoods, native prairie and riparian sites, and (5) any other habitat feature considered to be locally important that the TxDOT Houston District chooses to consider.

Span major drainages along the preferred alternative (e.g., Big Creek and Brazos River). Major drainages along the Preferred Alternative would be spanned to allow 100-year rainfall events and flooding to pass through the structures unimpeded. State and federal laws require that roadway designs consider 100-year water surface elevations. Those elevations are not allowed to increase.

Create wildlife underpasses that also accommodate sheet flow of water, specifically in the vicinity of Big Creek and Brazos Bend State Park. Wildlife underpasses would be developed in conjunction with spans of major drainages in

the Big Creek-Rabbs Bayou-Brazos River corridor. Detailed design would dictate where major spans (and wildlife underpasses) would be developed.

Construct "drift fences" along the roadway in high wildlife use areas to direct wildlife to underpasses. The concept of drift fences is to "funnel" wildlife to a specific location to alleviate, to the extent possible, traffic mortality. However, drift fences can also be detrimental to some forms of wildlife as predators are likely to be more successful in the vicinity of drift fence travel lanes and outlets. In concert with escape and travel cover in the vicinity of the wildlife openings, drift fences might be the BMP to attenuate wildlife-traffic mortality. The feasibility of incorporating drift fences and escape-travel cover into the final design will be evaluated. Some form of wildlife road-crossing controls will be implemented through Thompsons Bottom (area of concern between Lake Worthington Conservation Area and Brazos Bend State Park).

Reduce facility width (the 1,000-foot ROW originally considered was reduced to 300 feet). The facility width was reduced to 300 feet where only main lanes are located and approximately 400 feet where on-off ramps, intersections, and grade separations are required.

Mitigate for all wetland impacts. As described above, all wetlands impacted within the ROW are proposed for mitigation at an overall ratio of 1:1.

Direct lighting downward to attenuate light pollution to dark skies around Brazos Bend State Park. Lighting specifications will be developed during the detailed design. Lighting will be directed downward to attenuate light pollution.

Buffer sound impacts with screening vegetation along the ROW within the Bald Eagle nest management zone. Screening vegetation will be provided according to TxDOT specifications for screening traffic noise from sensitive use areas.

4.10.2 Vegetative Communities

The primary impact to vegetation resulting from site preparation and construction of the proposed project is the removal of existing vegetation from the ROW and any construction staging areas. Four vegetation community types would be impacted by the Preferred Alternative: pastureland/grassland/cropland, nonforested wetland, forested wetland, and forestland (photos in Appendix H). Although each of these communities would be impacted, only the wetland communities are regulated by federal regulations. Refer to Table 4-39 for a list of the community types and accompanying potential impacts by each of the eight Representative Alternatives and the Preferred Alternative. Table 4-38 reflects potential impacts to nonforested and forested wetlands prior to the USACE verification.

In addition to the four vegetation communities potentially impacted by the Representative and Preferred Alternatives, additional mature woody and pastureland vegetation would be impacted by a proposed channel relocation located on Segment K1 for Representative Alternatives 1, 2, 5, and 6. The channel relocation is approximately 2,000 feet in length and 100 feet in width, for a total additional ROW or easement requirement of 4.6 acres. Aerial photos were inspected and

the amount of additional ROW that would impact the mature woody vegetation is 2.3 acres. The remainder of the additional ROW is pastureland. Other than this proposed channel relocation, it is not anticipated that any stream or river crossings will require any additional clearing outside the ROW. The Preferred Alternative does not require any channel relocations.

TABLE 4-39
CUMULATIVE VEGETATION COMMUNITY TYPE
ACREAGE OF POTENTIAL IMPACTS BY ALTERNATIVE

Alternative No.	Community Type			
	Pastureland/ Grassland/ Cropland (ac)	Forestland (ac)	Nonforested Wetlands (ac)	Forested Wetlands (ac)
1 (A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1)	630	137	17	38
2 (A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8)	724	137	17	38
3 (A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1)	753	97	13	2
4 (A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2,G7, G8)	847	97	13	3
5 (B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1)	732	160	18	38
6 (B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8)	827	160	18	38
7 (B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1)	856	120	14	2
8 (B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2, G7, G8)	950	120	14	3
Preferred Alternative (A1, A2, A3.1, S1-b, B4.2, W1, G3.2, X1, G5.2, Y1, G6.2, G7, G8)	1024	110	17	9

Source: Study Team (2011).

For all of the Representative Alternatives and the Preferred Alternative, impacts would be direct and indirect, temporary and long term. Direct impacts would entail the alteration of the vegetation, soils, and hydrology. Vegetation may be mowed or removed in preparation for construction. Depending on construction needs, soils would be graded or amended with fill, and heavy equipment would compact soils, which often alters their drainage capability. As the topography and vegetation are altered, hydrologic conditions associated with runoff and drainage flow would also change, although appropriate design measures would minimize these impacts. Disturbed areas will be revegetated. BMPs may call for plowing, seeding and/or sodding of disturbed areas. An SW3P will be prepared in conjunction with the final design for the project. The SW3P will utilize BMPs and other practices to avoid and minimize the impacts of removing ROW vegetation and more-quickly restore vegetative functions in the ROW.

The construction of a new roadway affects the environment at various levels of geographic scale, from the microscopic to the landscape level. On a landscape level, the ecological communities currently existing along the Representative Alternatives and the Preferred Alternative would be fragmented to some degree. It is difficult to quantify this effect, primarily because there are numerous dynamic variables involved. Many generalizations regarding the concept of habitat fragmentation are well accepted, but specific processes and functional relationships are site specific, dynamic, and interrelated at various scales of both time and space. From this macro-perspective, the study area has already suffered from fragmentation in a broad sense. Forest clearing, agriculture, roadways, irrigation systems, land use, and human encroachment have all contributed to fragmentation over time. In areas where fragmentation is known to have detrimental impacts (e.g., large stream and river corridors), structures would be provided to pass design flood events and allow movement of animals and processes along the corridor.

The direct effects of construction, operation, and maintenance of the new ROW add an element of disturbance to the ecosystem. The cumulative effects of numerous secondary developments resulting from roadway developments could continue to displace existing species from an area, or potentially alter important migratory routes for others. The vegetation communities occurring along the Preferred Alternative would be directly impacted by construction-related activities. The inevitable fragmentation of contiguous habitat blocks, the severance of riparian forest corridors, and the potential modifications of hydrologic and nutrient cycling and transfer processes are also likely to have some impact on natural communities. Wetland and aquatic systems are impacted in a similar fashion through direct disturbance by heavy machinery compaction and scarification, placement of fill and construction materials, and the disruption of hydrological and nutrient cycling. As with other elements of the ecosystem, wildlife communities are impacted by the permanent loss of habitat. In addition to direct construction-related mortality or injury, wildlife populations tend to suffer impacts associated with displacement into adjacent habitats, which may be at carrying capacity (i.e., the maximum sustainable level) for that species.

Composition of vegetative communities may also be impacted by the spread of exotic species (such as nonnative grass, shrub, and tree species planted in the ROW and/or the locally invasive Chinese tallow-tree). In addition, unintentional and/or illegal introductions of exotic plant species may be facilitated by human access provided by the new roadway,

potentially impacting biodiversity. EO 13112 requires federal agencies to prevent introduction of invasive species and provide for their control and then to minimize the economic, ecological, and human health impacts that invasive species cause. Native plant species of grasses, shrubs, or trees would be used in the landscaping and in the seed mixes. No invasive species would be used to revegetate the ROW, and soil disturbance would be minimized to ensure that invasive species do not establish within the ROW.

The following discussion for the nonwetland vegetation community types is relative to the proposed ROW. Wetland community impacts are discussed in Section 4.9.1 and presented in Tables 4-37 through 4-40. For purposes of converting community types from corridors to ROW, acreage figures for each community type were reduced to 30 percent to reflect a more realistic impact for each community type. There may be minor fluctuations in the ROW depending on the number and location of grade separations, curve radii, and other detail design considerations. As a regulated resource, potential jurisdictional wetland acreages were calculated by field methodologies (Environmental Laboratory, 1987) and differentially corrected GPS or by review of 1995 series color infrared aerial photographs (for properties with no ground access) and digitized. Wetland acreages were generated by developing a layer in CADD and overlaying with the schematic design of the Preferred Alternative. All field-delineated wetlands and photo-interpreted wetlands were inspected by helicopter in April 1999 and verified by the USACE in February 2003.

Forestlands

Deciduous upland and bottomland forest is typically isolated to the segments located south and northwest of Smithers Lake and north and east of Oyster Creek. Although these forested communities are not regulated by state or federal agencies (unless they are forested wetlands), the forest community type is considered part of the Austin's Woods, a sensitive natural community found within Brazoria and Fort Bend counties. Section 4.9.2 provides additional information for Columbia Bottomland forests. Potential acreage impacted in the proposed ROW ranges from 97 acres (Representative Alternatives 3 and 4) to 160 acres (Representative Alternatives 5 and 6). The Preferred Alternative would impact 110 acres of forest.

Pastureland/Grassland/Cropland

Pastureland/Grassland/Cropland is the most common vegetation type in the study area. Potential acreage impacts to these vegetation types range from 630 acres (Representative Alternative 1) to 1,024 acres (Preferred Alternative); Representative 8 would have the second greatest impacts (950 acres) to pastureland/grassland/cropland. Cropland represents the majority of this category for the Representative Alternatives and the Preferred Alternative. Cropping history in both study area counties is tied closely to federal farm programs, and the agricultural base for both counties is dwindling as urban encroachment continues and farm programs trend towards a market driven supply-demand economic model.

Natural Areas

All Representative Alternatives have been routed to avoid the proposed Lake Worthington Conservation Area, Brazos Bend State Park, and the George Foundation's George Ranch Historical Park (also discussed in Section 4.17). Representative Alternatives 1, 2, 5, and 6 and the Preferred Alternative would come within 1,000 feet of the boundary of Lake Worthington Conservation Area, a privately owned conservation initiative with the USFWS. Representative Alternatives 3, 4, 7, and 8 are approximately 1,500 feet north, at the closest point, of the boundary to the TPWD's Brazos Bend State Park. The Preferred Alternative is approximately 7,250 feet north of Brazos Bend State Park.

Other natural areas of special concern include blocks of Columbia Bottomland forest. The USFWS considers any coastal plain bottomland hardwood forest within a 500-year floodplain south of US 59, east of the Colorado River and west of SH 6 to the coast as Austin's Woods. All eight of the Representative Alternatives and the Preferred Alternative traverse some of the Austin's Woods. However, Representative Alternatives 1, 2, 5, and 6 would cross the most important block of Austin's Woods (in the study area) east of Lake Worthington. This block of woods was avoided by the Preferred Alternative. An almost unbroken corridor of Austin's Woods adjacent to Rabbs Bayou, Waters Lake Bayou, and the Brazos River originates around Thompsons Oil Field arching to the west and south and terminating in the Pilant Lake wetland complex of Brazos Bend State Park. Due to the rapid urbanization of southeast Texas, wildlife resource agency staff have identified forested community types as a priority for protection, restoration, and creation.

Beneficial Landscape Practices

In response to the Executive Memorandum of April 26, 1994, the EPA developed guidelines to promote the use of environmentally beneficial landscaping practices and design. The Executive Memorandum directs that where cost effective and to the extent practicable, agencies will:

(a) use regionally native plants for landscaping;

(b) design, use, or promote construction practices that minimize adverse effects on the natural habitat;

(c) seek to prevent pollution by, among other things, reducing fertilizer and pesticide use, using integrated pest management techniques, recycling green waste, and minimizing runoff. Landscaping practices that reduce the use of toxic chemicals provide one approach for agencies to reach reduction goals established in EO No. 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements";

(d) implement water-efficient practices, such as the use of mulches, efficient irrigation systems, audits to determine exact landscaping water-use needs, recycled or reclaimed water, and the selecting and siting of plants in a manner that conserves water and controls soil erosion. Landscaping practices, such as planting regionally native shade trees around buildings to reduce air conditioning demands, can also provide innovative measures to meet the energy consumption reduction goal established in EO No. 12902, "Energy Efficiency and Water Conservation at Federal Facilities"; and

(e) create outdoor demonstrations incorporating native plants, as well as pollution prevention and water conservation techniques, to promote awareness of the environmental and economic benefits of implementing this directive. Agencies are encouraged to develop other methods for sharing information on landscaping advances with interested nonfederal parties.

In accordance with EO 13112, native plant species of grasses, shrubs, and/or trees would be used in the landscaping and in the seed mixes where practicable. No invasive or noxious species would be used to revegetate the ROW, and soil disturbance would be minimized to ensure that invasive species do not establish in the ROW.

4.10.3 Summary of Impacts

Wetlands

Wetland impacts are summarized in Table 4-37. Impacts from the alternative alignments ranged from 15 to 56 acres of wetlands, including 13 to 18 acres nonforested wetland impacts and 2 to 38 acres of impacts to forested wetlands. The Preferred alternative would result in 26 acres of wetland impacts, including 17 acres of nonforested wetlands and 9 acres of forested wetlands.

The No-Build Alternative would avoid impacts to larger wetlands (forested and nonforested, but could result in smaller wetland impacts associated with short-term, minor restoration activities (e.g., resurfacing, bridge repairs, road widening) to existing transportation facilities.

Vegetative Communities

Vegetative community impacts are summarized in Table 4-39. With respect to pastureland/grassland/cropland impacts, Alternative 1 would have the least impact (630 acres) and Preferred Alternative would have the greatest impact (1,024 acres), followed by Representative Alternative 8 with 950 acres of impacts. With respect to forest impacts, Representative Alternatives 5 and 6 would have the most impact (160 acres), and Representative Alternatives 3 and 4 would have the least impact (97 acres). The Preferred Alternative Alignment would result in 110 acres of forest impact.

Alternative Alignments 1 and 2 would have the greatest impact to wetlands more specifically, forested wetlands; while Alternative 7 would impact the fewest forested wetlands, and the least impact to wetlands overall. The Preferred Alternative Alignment would impact an intermediate amount of wetlands relative to the other alternative alignments.

The No-Build Alternative would avoid impacts to larger wetlands (forested and nonforested), but could result in smaller wetland impacts associated with short-term, minor restoration activities (e.g., resurfacing, bridge repairs, road widening) to existing transportation facilities. The No-Build Alternative would also avoid impacts to other vegetative communities (farmland, rangeland, riparian habitat, upland forest, etc.). The No-Build Alternative would likely avoid impacts to larger vegetative communities, but could result in smaller community impacts associated with improvements to existing transportation facilities.

4.10.4 Indirect Impacts

Wetlands

Indirect impacts to wetlands from the construction of Grand Parkway Segment C are considered likely based on the existing land use of the Segment C project area and the general growth pattern of the Houston metropolitan area. Construction of the new location roadway would likely facilitate new development in proximity to proposed access points resulting in a gradual decrease of nonforested and forested wetlands.

Development and subsequent impacts to wetlands at any location would require coordination with the USACE and other permitting agencies. While additional wetlands are associated with and adjacent to Segment C of the Grand Parkway, no indirect development would occur for any of the alternative alignments except at access points/frontage roads required to serve existing access needs. No access to adjacent property is to be provided along the majority of these alignments.

Vegetative Communities

Indirect impacts to wetlands and vegetative communities resulting from the construction of Segment C are considered likely based on the existing land use of the Segment C project area and general growth pattern of the Houston metropolitan area. Construction of the new location roadway would likely facilitate new development in proximity to proposed access points resulting in a gradual decrease of nonforested wetlands and forested wetlands (bottomland hardwood communities), thus potentially leading to the removal or fragmentation of wildlife habitat.

Development and subsequent impacts of any aquatic resource at any location would require coordination with the USACE and other permitting agencies. While additional wetlands are associated with and adjacent to Segment C of the Grand Parkway, no indirect development would occur for any of the alternative alignments except at access points/frontage roads required to serve existing access needs. No access to adjacent property is to be provided along the majority of these alignments.

4.10.5 Mitigation

Wetlands

Mitigation includes measures that avoid, minimize, eliminate, or compensate for impacts to resources. Initial mitigation measures in the planning or alignment of highway projects minimize the probable occurrence of habitat (vegetation communities) and wetland impacts through route location (avoidance) and construction practices. Activities to minimize the impacts to habitats from highway construction include minimizing devegetation of the construction area wherever safety allows, decreasing the amount of fill placement, and implementation of BMPs, including an erosion and sedimentation control plan. Specific impact minimization to wetland areas may include the design (use of bridge crossings instead of filled embankment); the use of retention basins and vegetated swales to minimize runoff, sedimentation, turbidity, leaching of

soil nutrients, and leaching of chemicals from petroleum products, pavement, and waste material; and alleviating flow alterations due to structures, which change established wetland drainage or flooding patterns.

Vegetative Communities

Preliminary mitigation options for impacts to wetlands and vegetative communities that cannot be avoided or further minimized include on-site mitigation and off-site mitigation. On-site mitigation may include the creation or enhancement of wetlands within the Segment C proposed ROW. Such mitigation would primarily involve development of shallow emergent wetland potholes and shallow forested wetlands very similar in function and value to the emergent and forested wetlands impacted during roadway construction. Potential off-site areas considered for enhancement, restoration, and/or preservation include tracts of land within and adjacent to the Brazos River floodplain that may be placed under conservation easement or purchased and placed under perpetual deed restriction. Other options may include use of the Coastal Bottomlands Mitigation Bank, wetland creation, and/or enhancement on property owned and/or managed by the George Ranch Foundation.

Mitigation alternatives associated with on-site mitigation and off-site mitigation will continue to be investigated and evaluated by the GPA, TPWD, USFWS, EPA, and USACE. A compensatory mitigation plan will be submitted to the USACE as part of the Section 404 and Section 10 permit review process. It is anticipated that a nonwetland component would be incorporated, at the discretion of the TxDOT Houston District, into the mitigation plan to compensate for unavoidable impacts to nonregulated natural resources (riparian habitat, upland forest, etc.).

4.11 FLOODPLAINS AND WATERBODY MODIFICATIONS

4.11.1 Hydrology and Drainage

The proposed Grand Parkway Segment C would not substantially alter rainfall drainage patterns, contaminate, or otherwise adversely affect the public water. Each of the proposed highway alternatives would increase the amount of impervious area within the watersheds, resulting in increased surface runoff. The increased surface runoff due to construction of the proposed roadway would not be considered substantial because of the required drainage (mitigation) facilities that would be incorporated into the project designs. The planned drainage facilities (including detention) will be constructed in compliance with guidelines of the affected cities and flood control districts.

The Brazos River is the only river within the Segment C project area. Major streams that flow through the project area include Rabbs Bayou, Dry Creek, Big Creek, and Oyster Creek. The number of crossings of the Brazos River, major streams, minor streams, and irrigation canals; number of stock ponds; area of floodplains and floodways; and linear feet of stream and irrigation canal relocations are shown in Table 4-40 for each segment. Each of the Representative Alternatives has approximately the same number of river crossings.

TABLE 4-40
CUMULATIVE WATER RESOURCES TYPE PER ALTERNATIVE

Representative Alternative	River Crossings (# of)	Major Stream Crossings (# of)	Minor Stream Crossings (# of)	Irrigation Canals/ Ditch Crossing (# of)	Total River, Stream, and Irrigation/ Canal Crossings	Pond/Lake (# of)	Floodplains (acres)	Floodway (acres)
1 (A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1)	1	8	8	13	30	3	420	21
2 (A1, A2, A3.1, S1-b, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8)	1	7	7	15	30	4	373	19
3 (A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1)	1	8	10	16	35	4	447	21
4 (A1, A2, A3.1, S1-b, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2,G7, G8)	1	7	9	18	35	5	400	19
5 (B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, P1)	1	8	7	21	37	4	467	22
6 (B1, C1, C2, B3, B4.1, B4.2, Q1, A6, K1, X1-a, G5.2, Y1, G6.1, G6.2, G7, G8)	1	7	6	23	37	4	420	20
7 (B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, P1)	1	8	9	24	42	4	494	21
8 (B1, C1, C2, B3, B4.1, B4.2, B5, B6, B7, J1, T1, X1-b, G5.2, Y1, G6.1, G6.2, G7, G8)	1	7	8	26	42	5	447	20
Preferred Alternative (A1, A2, A3.1, S1-b, B4.2, W1, G3.2, X1, G5.2, Y1, G6.2, G7, G8)	1	7	8	5	33	1	349	21

Source: Study Team (2011).
LF – linear feet

Alternatives 7 and 8 would have the most river, stream, and irrigation/canal crossings, with 42. Alternatives 1 and 2 would have the least river, stream, and irrigation/canal crossings, with 30. The remaining alternative alignments, including the Preferred Alternative, would range between 33 and 37 crossings.

Due to flat slopes in the area and the lack of drainage features, sheet flow patterns should be considered when designing the drainage structures. For example, the staff at Brazos Bend State Park has commented that sheet flow is an important hydrology source for the Pilant Lake wetland complex. Although Pilant Lake is within the park, it is evident that the watershed lies to the northwest of the park. Sheet flow interruption should therefore be a consideration in project design. Representative Alternatives 3, 4, 7, and 8 could possibly affect the sheet flow into Brazos Bend State Park. Adversely impacting sheet flow could cause negative impacts to natural resources. Sheet flow patterns should be acknowledged for certain portions of the Preferred Alternative during design. Mitigation measures may include cross drainage structures or long, elevated bridge structures to allow the sheet flow to be unchanged relative to existing conditions.

The orientation of the existing streams and irrigation canals to the Representative Alternatives creates a necessity for alternative engineering solutions. If the irrigation canal or stream flows parallel with, instead of perpendicular to, the Representative Alternatives, the irrigation canal or stream is to be relocated outside the proposed ROW. No stream relocations are anticipated for the Preferred Alternative.

Exhibit 26 shows the floodplains of the Brazos River and its tributaries covering portions of the Representative Alternatives and the Preferred Alternative for the proposed Grand Parkway Segment C. Tables 4-40 and 4-41 show the area of floodplains and floodway crossed for each segment and Representative or Preferred Alternative, respectively. Each of the floodplains would need to be crossed with a major hydraulic structure. The majority of these hydraulic structures would be bridges. The majority of the floodplain area is due to the extensive Brazos River floodplain. Other floodplains along the Representative and Preferred Alternatives for the proposed Grand Parkway Segment C have relatively narrow floodplain widths (less than 700 feet) (FEMA, 2007a, 2007b).

4.11.2 Floodways and Floodplains

4.11.2.1 Assessment Methodology

The floodplains assessment follows the guidance of FHWA's Technical Advisory T 6640.8A, Guidance for Preparing and Processing Environmental and Section 4(f) Documents (FHWA, 1987). The assessment methodology is based on the requirements provided in EO 11988 Floodplain Management, Federal-Aid Highway Program Manual 6-7-3-2, *Location and Hydraulic Design of Encroachments on Floodplains*, and USDOT's EO 5650.2, *Floodplain Management and Protection*.

Federal-Aid Highway Program Manual 6-7-3-2 essentially references 23 CFR § 650 Subpart A, *Location and Hydraulic Design of Encroachment on Floodplains*. The floodplain regulations require that final drainage and mitigation analyses be preformed to address and discuss the following items for each of the proposed alternative alignments:

- The risk of flooding associated with the implementation of the highway facility;
- The impacts on natural and beneficial floodplain values;
- The support of incompatible development within the floodplains; and
- Measures to minimize floodplain encroachments.

Floodplain regulations also require the utilization of NFIP maps to identify the limits of the base (100-year) floodplain. The NFIP was established by FEMA and is administered and enforced through communities affected by floodplains. FEMA Q3 (electronic) flood data was used to map the limits of 100-year floodplains and floodplain floodways (Exhibit 26).

The intent of these regulations is to avoid or minimize transportation encroachments within the base floodplain, where practicable, and to avoid supporting land use development that is incompatible with floodplain values. Sections 60.3(c), 65.3, 65.6, and 65.12 of FEMA's NFIP and related regulations, Revised October 1, 2005, specify that "…the cumulative effect of the proposed development, when combined with all other existing and anticipated development in this area, will not increase the water surface elevation of the base flood more than 1 foot at any point within the community" (44 CFR 60.3(c)(10)). Section 60.3 states that "when the Administrator has provided a notice of final base flood elevations…and has provided data from which the community shall designate its regulatory floodway, the community shall prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses…that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge" (44 CFR 60.3(d)(3)).

4.11.2.2 Local Jurisdiction

The TCEQ coordinates the NFIP with local communities and FEMA. Texas Water Code (§ 16.311–16.323) requires that each city or county adopt ordinances (for cities) or orders (for counties) necessary for the municipality to be eligible to participate in the NFIP, as well as the authority to regulate activity in the base floodplain. The local floodplain management program, under direction of the floodplain administrator, is responsible for managing the NFIP.

4.11.2.3 Natural and Beneficial Floodplain Values

Floodplains provide several natural and beneficial values. Floodplains provide floodwater detention, water quality maintenance, and groundwater discharge. Many types of aquatic and terrestrial plants and animals find their habitats on floodplains. Archeological and historical resources, as well as recreation sites, are often located on floodplains. Floodplains are often utilized for agriculture because they contain rich, fertile soil and are typically flat to gently sloping. The following discussions describe the functions and values that floodplains provide.

Flood Flow Moderation

Floodplains serve a flood detention function by temporarily storing water from a flood event. By temporarily storing floodwaters, they reduce peak flows by extending flood durations. Encroachments within a floodplain tend to diminish the flood flow detention capability of a floodplain by reducing the floodwater storage volume in the floodplain, causing it to pass through the floodplain in a shorter time period. Because of the diminished flood flow detention capability, flood peaks increase downstream.

Water Quality

Floodplain vegetation maintains the chemical and biological integrity of water by reducing the flow velocity and allowing impurities, such as sediment, to settle and be removed from the water column. Sediment and toxicant retention in floodplains can reduce the impurity concentrations in downstream watercourses. However, sediment and toxicant retention can also destroy biological communities supported on floodplains by overloading nutrients, decreasing dissolved oxygen, and increasing water temperature. When undisturbed, these water quality values exist in a state of equilibrium. Floodplain encroachments modify these values until a new equilibrium is achieved.

Groundwater Recharge

As floodplain vegetation reduces water flow velocity, more water has the ability to infiltrate and recharge the groundwater table. In addition to the surface storage of a floodplain, groundwater recharge provides subsurface storage, which contributes to the reduction of downstream flood flows. Floodplain encroachments increase the water flow velocity, thus, reducing groundwater infiltration/recharge rates.

4.11.2.4 Analysis of Floodplain Impact

EO 11988 seeks to avoid adverse impacts associated with the use and modification of floodplains and to avoid direct or indirect support of floodplain development. This order directs federal agencies to evaluate the potential effects of its actions on floodplains. For actions located in a regulatory floodplain, the agency is required to consider alternatives to avoid adverse effects and incompatible development. This order specifically requires that a floodplain evaluation be included in any EIS prepared in accordance with NEPA.

The floodplain assessment compares the amount of floodplain encroachment anticipated by each alternative alignment and includes a discussion of the flooding risks, impacts to the beneficial functions and values, support of incompatible development within the floodplain, measures taken to minimize the impact, and the measures to restore and preserve the beneficial functions and values, as required by FHWA's Technical Advisory T 6640.8A.

All alternative alignments including the Preferred Alternative Alignment were quantitatively examined for encroachments on the Segment C study area's watercourses and associated floodplains. The No-Build Alternative would not result in direct impacts to floodways or floodplains. Table 4-41 shows the amount of both floodway and 100-year floodplain with the ROW

of each alternative alignment. The totals in Table 4-41 represent substantially more acreage than would be impacted by the project because final design would include bridging most, if not all, of the floodways and much of the 100-year floodplain acreage found within the ROW.

Table 4-41 presents a worst-case scenario for 100-year floodplain encroachments by showing the total amount of 100-year floodplain encroachment if no bridging occurred in the final design. Table 4-41 also shows the percentage of each alternative compared to the total amount of floodplains within the study area.

TABLE 4-41
FLOODPLAIN ENCROACHMENT (ASSUMING NO BRIDGING) SUMMARY FOR EACH STUDY AREA WATERSHED

Representative Alternative	100-year Floodplain Encroachment (acres)	Encroachment as Percent of Total 100-year Floodplain within the Study Area
1	420	0.4
2	373	0.3
3	447	0.4
4	400	0.4
5	467	0.4
6	420	0.4
7	494	0.5
8	447	0.4
Preferred Alternative (A1, A2, A3.1, S1-b, B4.2, W1, G3.2, X1, G5.2, Y1, G6.2, G7, G8)	348	0.3

Source: Study Team (2011).

4.11.2.5 Flooding Risks

Because of the flat topography in the area and the low number of natural drainage features, the floodplains associated with the watercourses in the region are typically characterized as wide and flat. These wide floodplains cover thousands of acres of mostly rural land within the Segment C study area, where the risk of flooding in generally high.

The majority of highways constructed in the Houston area are very near to at-grade facilities. Highways are typically elevated on 1 to 3+ feet of fill to ensure no road closures from local flooding during heavy rainfalls. The highways/roadways are raised on fill material and structures in order to cross over other roadways and/or streams and rivers. While the cuts/fills for the proposed highway are not determined at this time, the hydraulic design for this project would be in accordance with current FHWA and TxDOT design policies. The facility would permit the conveyance of the 100-year flood, inundation of the roadway being acceptable, without causing significant damage to the facility, stream, or other property. The proposed project would not increase the base flood elevation to a level that would violate applicable floodplain regulations and ordinances. Coordination with the local floodplain administrator for Brazoria and Fort Bend counties, local affected flood control officials, and TPWD would occur.

Detention facilities would be constructed within the ROW to mitigate the increase of flows within the floodplains associated with the increase of impervious cover. The detention facilities would offset increased flows as well as add floodplain storage to the watershed. If needed, additional floodplain fill mitigation basins would be constructed to offset any floodplain storage volume that was lost due to fill in the floodplain caused by the construction of the project. This would help to restore and preserve the natural and beneficial floodplain values.

4.11.2.6 Impacts to the Natural and Beneficial Values

Preliminary design of the Preferred Alternative Alignment includes the bridging or culverting of all regulatory floodways within the ROW. For floodplain crossings that are not bridged, the alternative alignment ROW would represent a 300- to 400-foot-wide band through the broad floodplains, with the actual proposed roadway footprint covering just a portion of that width. Table 4-41 shows the percentage of floodplains within the study area that would be crossed, either by bridge or not, by each of the alternative alignments. These percentages represent a very small portion of the total floodplain within the entire study area. Without bridging, the Preferred Alternative Alignment would encroach upon 0.3 percent of all 100-year floodplains in the study area. The bridging developed in final design may reduce this percentage. The small percentage of anticipated floodplain impacts in conjunction with the implementation of the mitigation measures would result in unsubstantial impacts to the natural and beneficial values of the Segment C study area floodplains.

4.11.2.7 Support of Incompatible Development within the Floodplain

For all alternative alignments, interchanges and grade-separated intersections would be provided at roadway crossings to maintain access across the Grand Parkway. It is likely that development would occur in the areas of intersections as an indirect result of the project; however, development within the floodplains would be regulated.

4.11.2.8 Measures Taken to Minimize Floodplain Impacts

The alternative alignments were designed to avoid impacts to floodplains to the maximum extent feasible and practicable. All eight Representative Alternatives were located to minimize encroachment on regulatory floodways and floodplains and maintain a transverse encroachment to the extent possible. Preliminary design of the Preferred Alternative Alignment includes bridging or culverting all of the regulatory floodways. During final design of the selected Preferred Alternative Alignment, opportunities to reduce the width of the ROW and to include further bridging to avoid and minimize floodplain encroachments would be considered. Final drainage and mitigation analyses would be conducted during final project design.

4.11.2.9 Measures Taken to Restore and Preserve the Natural and Beneficial Values

Restoration and preservation of the natural and beneficial values associated with the floodplains would include a final hydraulic analysis, minor alignment modifications during final design, and the implementation of BMPs during construction. Some of the BMPs may include:

- Vegetative fencing to restrict contractor access to sensitive areas;
- Limit construction staging areas to locations outside the floodplains, or minimize the size of the staging area;
- Implementation of a SW3P to protect water quality;
- Implementation of a stormwater management plan to prohibit increases in water velocity;
- Revegetation of cleared areas within the floodplains that are needed for construction; and
- Analyze the use of other BMPs on a location-by-location basis.

The hydraulic design practices for this project would be in accordance with current TxDOT and FHWA design policies and standards. The highway drainage facility should permit the conveyance of the 100-year flood without causing significant impacts to the roadway, stream, or adjacent property. The proposed project would not increase the base flood elevation to a level that would violate applicable floodplain regulations and ordinances. Coordination with the local floodplain administrator for Brazoria and Fort Bend counties, local affected flood control officials, and TPWD would occur. All minor streams will be crossed with culverts, and all major streams and rivers will be bridged. No channel improvements, which could possibly change the hydrology parameters of the watershed, are planned in the areas of the crossings. All culverts and bridges will be designed so as not to impact water levels or hydrograph timing of the channels.

All Representative Alternatives and Preferred Alternative cross the extensive Brazos River floodplain. The limits of the Brazos River floodplain extend from Big Creek on the west to Oyster Creek on the east, for over 40,000 linear feet of floodplain. Just outside the Brazos River top of banks, the floodplain is very wide and very shallow with small velocities. The floodway of the Brazos River is also very extensive (approximately 9,600 linear feet of the proposed crossing). The Brazos River floodplain crossing would consist of a large bridge over the river and several relief structures to help pass the flow in the overbanks and not affect the floodplain or floodway. With these types and number of structures, velocity and water surface elevation impacts will be minimal to none. This is an important consideration since the proposed Grand Parkway Segment C would be designated as a hurricane evacuation route. Compliance with the requirements of local entities, including drainage districts, is necessary; therefore, detention facilities would need to be constructed to offset the slight increase in flow due to the construction of the project. These detention facilities will be utilized to offset the peak flow rates and the time to peak of the proposed roadway. All fill within the floodplains of the proposed project would be offset with mitigating excavation.

The Brazos River floodway would also be crossed by each of the alternatives. The floodway is the area of floodplain that should be reserved to allow the water to move downstream. The floodway, in most cases, is just outside the top of banks or the channel. In this area the bridge should span past the top of the banks. The Brazos River floodway should be checked and modified if necessary to correctly represent its limits. This process should be completed after the issuance of the Record of Decision by the FHWA.

Other potential impacts to the floodplains include increased flows due to the roadway being constructed and its associated increased impervious cover. The increase in flow would be mitigated with detention facilities within the proposed ROW. These detention facilities will offset increases in flows as well as add additional floodplain storage to the watershed, which will restore and preserve the natural and beneficial floodplain values.

4.11.3 Preferred Alternative Impacts to Hydrology, Drainage, and Floodplains

A detailed hydrologic and hydraulic analysis was completed for the Preferred Alternative. The report is entitled Draft Drainage and Impact Analysis Report, Proposed Grand Parkway Segment C, dated September 2002 (Impact Report). A copy of the report is on file at the TxDOT Houston District office. The report identifies all stream crossings and the structures needed to pass the 100-year flows, including the Brazos River, sheet flow structures to offset any impacts due to change in sheet flow patterns, and impact analyses to determine the mitigation necessary to offset impacts due to change in percent imperviousness and floodplain storage. The remainder of this section summarizes the conclusions and recommendations from the Impact Report.

The Brazos River floodplain crossing will be designed to be passable during extreme flooding events. The roadway is to be a minimum of 1 foot above the 100-year water surface. Bridges will be set with the low chord a minimum of 2 feet above the 100-year water surface to allow debris passage. The Impact Report presents the detailed hydrologic and hydraulic analysis to determine the water surface elevations of the three main streams within the Brazos River floodplain. Placement of fill for roadway embankments in the floodplain will reduce floodwater storage and must be compensated by offsetting excavation below the 100-year water surface. Therefore, compensatory storage excavation requirements were determined to offset any fill volumes placed in the floodplain.

Three alternatives were analyzed to cross the Brazos River floodplain. Included in each analysis is the impact to the Brazos River 100-year water surface elevation and compensatory floodplain storage volumes. FEMA provided existing conditions HEC-2 models of the Brazos River and Oyster Creek. These HEC-2 models were used to determine the optimum bridge crossing over the Brazos River.

- Option 1 – Span the entire Brazos River floodplain with a continuous bridge system. No fill will be placed in the floodplain; therefore, no excavation for compensatory floodplain storage is required. (The volume of bridge piers was considered negligible.)
- Option 2 – Span only the floodway for each of the three major streams in the Brazos River floodplain, with the remainder of the floodplain crossing on earthen embankments. A net volume of over 1,500 acre-feet of fill will be placed in the floodplain for the roadway embankment. This fill volume is to be offset by compensatory storage excavation in the floodplain.
- Option 3 (Recommended Option) – Span only the floodway of the three major streams as in Option 2, with the addition of large cross-drainage structures at multiple locations across the floodplain. The fill volumes for

embankments and compensatory storage requirements are essentially the same as for Option 2. With this alternative, there is no impact to the water surface elevation outside the Grand Parkway ROW.

Other streams are crossed by the proposed Grand Parkway Segment C. The Impact Report details the hydrologic and hydraulic analyses required to complete the preliminary design of each of the major stream and minor stream crossings. The flows were calculated using TxDOT approved Regression Equations and the stream crossings were designed with either the Texas Hydraulic System Culvert Design program for culvert crossings or HEC-2 for bridge crossings. All stream crossings were designed to pass the 100-year frequency flows without any head loss through the culvert or bridge structure. The locations of the proposed culverts and bridges are shown in the Impact Report.

In addition to hydraulic structures at the minor and major stream crossings, additional hydraulic structures are needed to allow localized sheet flow to cross the proposed roadway. Approximately 11 sheet flow structures were designed and placed. The locations and design calculations of the proposed sheet flow structures are shown in the Impact Report.

In order to avoid impacts (increased flow rates), stormwater detention is required to reduce peak flow rate from developed conditions to predevelopment rates. The detention volumes for each subarea necessary to mitigate potential increases in flow rates due to the additional pavement were determined based on the 100-year frequency storm event. Drainage areas were determined for the roadway ROW, including 150 feet of area beyond the ROW, in order to perform a preliminary roadside ditch sizing. Existing and proposed peak flows were developed. No offsite sheet flow was included in the 100-year peak flow calculations. Future development of those areas will require detention if allowed to continue to drain to the Grand Parkway ROW. The peak flow and total rainfall depth are used to derive a hydrograph and volume of runoff. A comparison of the existing and proposed conditions hydrograph was used to determine a volume of detention that would mitigate potential increases to the peak runoff.

Runoff from proposed development exceeds the runoff from existing conditions. Therefore, to prevent impacts on the receiving streams, the excess flows from roadway development must be restricted. Estimated mitigation volumes were calculated for each subarea based on the difference between the hydrographs of existing and proposed conditions. The calculated mitigated volume is the detention volume necessary to offset the increase in peak flows due to the construction of the proposed Grand Parkway Segment C. The total detention volume required to offset the construction of the entire proposed Grand Parkway Segment C is over 200 acre-feet. The calculations used to design the proposed detention facilities are shown in the Impact Report.

Based on the FEMA Q3 (electronic) data for the area, a major portion of this project would be constructed within the 100-year floodplain of the Brazos River and other tributaries. The volume that would be displaced by fill from proposed improvements was computed as the area below the 100-year floodplain elevation and above the existing ground elevation. This area is multiplied by the length of roadway within this area to obtain a volume that is equal to the volume of water that would be displaced and therefore require mitigation.

Within the Brazos River floodplain is where the majority of floodplain fill would occur. For Brazos River crossing Alternate 1, the bridge piers' volumes are assumed to be negligible and no compensatory storage excavation is required. For Brazos River Options 2 and 3 (Recommended Option), there is a gross estimated volume of 1,500 acre-feet of fill within the 100-year floodplain that would need to be mitigated with compensating excavation. Therefore, the gross total amount of mitigation that would be necessary to compensate for the proposed roadway is approximately 1,500 acre-feet. To keep the floodplain volume constant, additional excavation is proposed to compensate for the fill that would be placed in the floodplain. All compensatory storage must be excavated below the 100-year water surface elevations with means for the floodwaters to enter and exit the area as floodwaters rise and recede.

4.11.4 Summary of Impacts

4.11.4.1 Hydrology and Drainage

All of the alternative alignments would cross rivers and streams. Representative Alternatives 7 and 8 would have the most river and stream crossings, with 42. Alternatives 1 and 2 would have the least stream crossings, with 30. The remaining alternative alignments, including the Preferred Alternative, would range between 33 and 37 crossings. Preliminary design of the Preferred Alternative Alignment includes spanning the floodways of major streams. Other stream crossings would be culverted, although further bridging would be considered in final design. Each of the proposed highway alternatives would increase the amount of impervious area within the watersheds, resulting in increased surface runoff. The increased surface runoff would not be considered substantial because of the required drainage (mitigation) facilities that would be incorporated into the project designs (see Section 4.10.1). The No-Build Alternative would not impact hydrology and drainage.

4.11.4.2 Floodways and Floodplains

Of the 107,978 acres within the Segment C study area, 46 percent, or 49,237 acres, are within floodways and floodplains. Avoidance of this resource during the development of the alternative alignments was carefully balanced with avoidance of other sensitive resources in the study area. All of the alternative alignments would encroach on the following streams and their associated regulatory floodways and floodplains: Rabbs Bayou, Dry Creek, Big Creek, Brazos River, and Oyster Creek. The proposed project would have little to no impact to regulatory floodways, as these would be bridged.

All alternative alignments are similar with respect to potential encroachment of the study area floodplains, ranging from 0.3 to 0.5 percent of the study area floodplains. The Preferred Alternative Alignment would potentially encroach upon 0.3 percent of the floodplains in the study area. Further avoidance and minimization of floodplain encroachments would be considered during final design.

Natural and beneficial floodplain values would not be altered because of the implementation of mitigation measures determined from final drainage and mitigation analyses conducted during final project design (see Section 4.10.6 for more detail).

Under the Build Alternative, rainfall runoff rates would be expected to increase slightly because of an increase in impervious pavement surface area; however, the increased runoff would be mitigated and would not alter or affect the natural and beneficial floodplain functions, values, or characteristics. The No-Build Alternative would not impact floodway or floodplains.

4.11.5 Indirect Impacts

Commercial and/or residential development is likely to result from the Grand Parkway, particularly near intersections, which may or may not be in the floodplain. However, any construction or development in a floodplain is regulated and requires a development permit from the Fort Bend and Brazoria County floodplain administrator. Access points to the Grand Parkway have been located outside of the floodplains to the greatest extend practicable to minimize potential for future floodplain development.

4.11.6 Mitigation

4.11.6.1 Hydrology and Drainage

Because of flat topography and the low number of natural drainage features within the study area, sheet flow patterns will be considered when designing the drainage structures. Final drainage and mitigation analyses would be conducted during final project design. Mitigation measures may include cross drainage structures or elevated bridge structures to allow sheet flow to be unchanged relative to existing conditions. Hydraulic structures would be designed pursuant to TxDOT and FHWA standards to accommodate periods of high flows without impacting downstream areas. Mitigation of impacts will include BMPs during construction and detention facilities to offset increased flows.

4.11.6.2 Floodways and Floodplains

Final drainage and mitigation analyses would be performed during the final design of the highway. The studies would provide detailed hydraulic information necessary to determine the use of culverts or a bridge at each stream crossing. The structures would be designed according to FHWA and TxDOT standards. These studies would be reviewed by local, state, and federal regulatory agencies to confirm that adequate measures have been taken to ensure that floodplain encroachment does not increase the risk of flooding to adjacent property. Areas sensitive to local flooding will be identified during the final design phase of the project. If areas of severe flooding are identified, design criteria may be more restrictive than those specified in county orders. The project will comply with the Fort Bend and Brazoria County “floodplain program.” Any proposed construction or development in a special flood hazard area would be coordinated with the Fort Bend and Brazoria County floodplain administrator to receive a development permit.

The proposed alternative alignments were designed to avoid impacts to floodplains to the maximum extend feasible and practicable. All alignments were located to minimize encroachment on regulatory floodways. All floodways would be

bridged or culverted by the selected Preferred Alternative alignment, and further avoidance and minimization of floodplain encroachments would be considered during final design.

The BMPs listed in Section 4.10.2.8 would be considered and incorporated into the plans during the final design of the highway. The proposed roadway and drainage improvements would be designed to handle a 100-year flood event without affecting the floodways. Inundation of the roadway without causing substantial damage to the roadway, stream, or other property is considered acceptable. The hydraulic design practices on this proposed project would be in accordance with current TxDOT and FHWA design policies and standards. The proposed project would not increase the base flood elevation to a level that would violate applicable floodplain regulations or ordinances.

In some cases, the Preferred Alternative does not cross the floodplain of a specific watercourse at the point of least potential impact. However, the Preferred Alternative was developed such that it represented the least amount of potential floodplain impact throughout the entire project area while minimizing impacts to other environmental concerns. Avoidance of floodplains for both the corridor analysis and the alternative alignment analysis, with the exception of the No-Build Alternative, is not possible because the watercourses in the project area traverse the entire study area. In order to avoid these watercourse crossings, the alternative alignments would need to be located outside of the headwaters of the watercourses. An alternative located outside of the headwaters of the watercourses would not meet the purpose and need of the project.

Because the floodplain boundaries of the watercourses in the study area traverse the entire study area and the Preferred Alternative minimizes floodplain encroachment, the Preferred Alternative alignment is the only practicable alternative for limiting floodplain encroachment.

4.12 WILDLIFE

4.12.1 Aquatic Habitat

The study area is located within an area of warm freshwater fisheries. Neither tidal influence nor cold water fishery conditions exist under normal circumstances. There are three general categories of potential impacts to aquatic habitats and fisheries resulting from construction and use of the proposed roadway. First, the waterways may be physically altered as a result of construction activities. Second, sedimentation from the construction activities may impact the aquatic habitat. Third, water quality may be impacted due to increased vehicular traffic and nonpoint source runoff or point source toxic spills draining into the waterway.

Physical alteration can occur when a waterway is crossed, when the existing channel is modified by relocation or the installation of a culvert, and/or where sufficient passage is given to accommodate flood events. Channel relocation may impede stream flow or entirely curtail flow for a short period during the placement of a culvert. Channel relocation may also result in the removal of trees and other vegetation, which can contribute to wind and water erosion. Primary measures to

mitigate adverse impacts due to channel relocation include minimizing the area to be disturbed, replanting the areas cleared, and optimizing stream diversions to include low-flow augmentation of intermittent streams.

On small waterways, pipe and box culverts are used to allow the passage of water. In addition to modifying the natural channel, culverts inevitably change the flow characteristics of the waterway and eventually alter the nearby channel morphology. However, these effects are quite limited in extent, generally occurring immediately upstream and/or downstream of the crossing. If the formation of a deep pool occurs, a beneficial provision of habitat will be available for aquatic life during dry periods. The proper culvert design will maintain adequate water depth and incorporate a rough bottom to simulate a rock/gravel substrate. The use of properly designed culverts and low-flow augmentation will enhance fish passage.

The typical short-term construction impacts are associated with excess turbidity and siltation. These impacts differ in their effect on turbid lowland streams relative to clear upland streams. Typically, the species found in lowland waters are those with a high tolerance for turbidity. Short periods of high turbidity are not considered lethal to fish (Hamilton and Nelson, 1984). The high turbidity is either tolerated by many species or the fish simply move away and return when acceptable levels are restored. However, high levels of turbidity can clog the gills of fish and reduce their ability to extract oxygen from the water. Turbidity and sedimentation may also affect food supplies. High turbidity levels can clog the gills of fish species feeding on plankton, thus preventing such species from actual food intake. In addition, high turbidity can interfere with the ability of a fish to locate prey. While fish normally recover quickly from such stresses, such circumstances during spawning seasons may reduce reproductive success until turbidity levels return to normal.

More typically, sedimentation can bury the food supplies of benthic feeders. This is of limited concern in segments of streams with mud or silt bottoms. If the degree of siltation is minimal, the benthic species often survive. In addition, many benthic species living in mud bottoms are very opportunistic and recolonization of such habitats is often quite rapid.

In general, oil and grease are the petroleum products that are washed into a stream from a roadway. Such chemicals accumulate on the road during dry periods and are flushed to receiving waters when rain occurs. However, the most lethal fraction of petroleum products is the volatiles, which rapidly evaporate. Therefore, the most lethal fraction of the petroleum is rarely included in the oil and grease washed into a stream. Flows are generally higher after a rain; the oil and grease are often diluted and washed away. Greater details of potential water quality impacts are included in Section 4.7.1 of this document.

In summary, the physical alterations to the waterway would be confined to and limited by the construction of adequately sized and designed drainage structures. Hydraulic structures designed in accordance with TxDOT standards will ensure that sufficient passage is provided to accommodate periods of high water flow, limiting periodic siltation of stream channels. Proper planning and execution of the construction should ensure only short-term, minor impacts to the aquatic habitat.

Adverse impacts to aquatic species are expected to be slight, since there would be minimal habitat conversion. During construction, however, some individual mortality could occur when species are present at creek and river crossings, and there could be some localized reduction in population size if siltation and turbidity are not adequately controlled. In addition, unintentional and/or illegal introductions of exotic aquatic plant species may be facilitated by human access provided by the new roadway, potentially impacting biodiversity. Mitigation for all impacts mentioned above will include TxDOT BMPs designed to limit water quality degradation from construction activities. These practices will minimize fill washing into streams, wetlands, and the Brazos River; limit movement of machinery in the construction corridor at stream and wetlands crossings; provide adequate erosion control; and ensure adherence to proper cleanup procedures.

The potential impacts to the aquatic environment caused by the Representative Alternatives will differ in response to the number and type of roadway crossings present, aquatic habitat area, major stream channel relocations required, and culverts used on each of the eight Representative Alternatives. The following Table 4-42 lists the number of river crossings and stream crossings by alternative. Major crossings include the Brazos River, Rabbs Bayou, Gapps Bayou, Big Creek, Water Lake Bayou, Oyster Creek, and Hayes Creek. Many of the segments intersect the same stream several times.

TABLE 4-42
STREAM AND RIVER CROSSING BY ALTERNATIVE

Alternative	Major Stream Crossings	Minor Stream Crossings	Brazos River
Representative Alternative 1	8	8	Yes
Representative Alternative 2	7	7	Yes
Representative Alternative 3	8	10	Yes
Representative Alternative 4	7	9	Yes
Representative Alternative 5	8	7	Yes
Representative Alternative 6	7	6	Yes
Representative Alternative 7	8	9	Yes
Representative Alternative 8	7	8	Yes
Preferred Alternative	7	8	Yes

Source: Study Team (2011).

4.12.2 Terrestrial Wildlife

Construction of the proposed Grand Parkway Segment C would directly affect those animals that reside within the path of the Preferred Alternative. Impacts on wildlife from the construction of the Preferred Alternative for the project can be divided into short-term effects resulting from physical disturbance during construction and long-term effects resulting from habitat modification. Clearing and construction would directly and/or indirectly affect most animals that reside or wander within the proposed highway ROW. Larger, more mobile species such as deer, foxes, and squirrels may avoid the initial clearing and construction activities and move into adjacent areas outside the proposed ROW. Some small, low-mobility forms may be killed by the heavy machinery. These include several species of amphibians, reptiles, and mammals. Fossorial animals (i.e., those that live underground, such as moles and shrews) may similarly be negatively impacted as a result of soil compaction caused by heavy machinery. The increased noise and activity levels during construction could

disturb breeding or other activities of species inhabiting the areas adjacent to the proposed ROW. Although the normal behavior of many wildlife species could be disturbed during construction, the long-term damage to those species may be less severe.

The carrying capacity of habitat for any particular species is dependent on the availability of limited resources such as food, shelter, water, territory, and nesting sites (Dempster, 1975). For the purpose of impacts analysis, available habitats are assumed to be at their carrying capacity for the species that occur there. Highway construction would likely displace individuals in the vicinity of the proposed ROW, forcing them into competition with residents of adjacent habitat for the available resources. The inevitable result of this increased pressure would be the eventual decrease in birthrate and/or increase in mortality until populations are reduced to levels that the habitat can support (Dempster, 1975). The initial stress created by displaced wildlife on adjacent habitat may also produce changes in species composition and community dynamics (Adams and Geis, 1981), potentially resulting in long-term effects.

Once construction is completed and the vegetation has recovered, some wildlife species may move back into vegetated portions of the proposed ROW. Species diversity of small mammals may be greater within the ROW than in adjacent habitats (Adams and Geis, 1983). This increase in diversity may be attributed to the change and maintenance of the successional stages of vegetation in the proposed ROW that would produce a greater abundance of forage and/or cover for many species. Highway construction, while producing largely temporary negative impacts to some wildlife, generally increases the habitat for ecotonal or edge species, such as the eastern cottontail, white-tailed deer, indigo bunting, Virginia opossum, and grassland species, particularly the white-footed mouse, hispid cotton rat, and eastern harvest mouse (Adams and Geis, 1983). Although mortality of small mammals, white-tailed deer, amphibians, and reptiles would be expected, studies indicate that, with the exception of rare, endangered, and threatened species, the majority of wildlife populations are not detrimentally affected (Adams and Geis, 1983; Leedy, 1977).

Several potential impacts of nonpoint source pollution on terrestrial plant and animal life from construction and use of the roadway may occur according to current literature. These impacts may include direct and indirect effects from the addition of heavy metals (especially lead), salts, organic molecules, oil and grease, O_3, nutrients, dust, and suspended solids to roadside environments (Trombulak and Frissell, 2000). However, impacts from pollutants such as oil and grease originating from machinery and construction-related activities are expected to be minimized by the implementation of erosion control methods. Measures used to minimize water quality impacts are discussed in Section 4.7; air quality impacts are discussed in Section 4.6.

Any escaping pollutant may adversely affect surrounding plant and animal species and possibly affect the value of wildlife habitat. Dust resulting from construction and spread by road traffic could also detrimentally impact plants and wildlife habitat (Farmer, 1993). In addition, chemical composition of some woody plants changes in response to pollution, including increased concentrations of terpenoids and salts, and decreased production of soluble protein and chlorophyll, which are necessary for plant function (Akimov et al., 1989; Banerjee et al., 1983; Bogemans et al., 1989). Organisms (especially those contained in the soil) may suffer mortality or be displaced due to chemical exposure (Gunter and Wilke, 1983;

Krzusztofiak, 1991; Muskett and Jones, 1981). Growth and vitality (including resistance to pathogens) of many plants can be depressed (Fleck et al., 1988; Flueckiger et al., 1984; Moritz and Breitenstein, 1985; Northover, 1987; Petersen et al., 1982). Plants and animals may accumulate toxins at levels that pose health hazards, which may be passed on to humans that consume contaminated organisms (Dickinson et al., 1987; Graham and Kalman, 1974; Guttormsen, 1993; Nasralla and Ali, 1985). Also, increased concentrations of some pollutants, particularly salts used in deicing, may attract large mammals, putting them at risk of being killed by vehicles (Fraser and Thomas, 1982), though use of salts for deicing in the proposed study area is not expected to frequently occur due to the area's mild climate. On a very broad scale, evolutionary processes may be affected through altered selection pressures that result in local differentiation of plant and animal populations (Kiang, 1982; Minoranskii and Kuzina, 1984).

Additional terrestrial wildlife impacts may occur due to increased spread of exotic and/or noxious species (such as nonnative grass, shrub, and tree species planted in the proposed ROW, the locally invasive Chinese tallow-tree, and brown-headed cowbird [*Molothrus ater*]) into previously undisturbed portions of the study area. In addition, unintentional and/or illegal introductions of exotic terrestrial and aquatic plant and animal species may be facilitated by human access provided by the new roadway.

Roadway construction can have positive effects on many generalistic wildlife species. The mowed zone adjacent to the highway would not be particularly productive as wildlife habitat, but would provide a feeding area for some birds such as the American robin (*Turdis migratorius*), sparrows (*Passer* spp.), and some small mammals, depending on the mowing regime (Leedy, 1977). Less frequently mowed grassy areas and shrubby or forested areas along the edge of the ROW would provide feeding and nesting areas for some bird species and cover for a variety of wildlife (Adams and Geis, 1983; Leedy, 1977). Road cuts may provide habitat for bank swallows (*Riparia riparia*), and bridges may accommodate nesting rock doves (*Columba livia*), cliff swallows (*Petrochelidon pyrrhonota*), barn swallows (*Hirundo rustica*), and roosting bat species.

However, negative impacts to other wildlife species may occur due to habitat fragmentation caused by the proposed roadway. Contiguous unfragmented forested tracts (the Austin's Woods, for example) are important habitat for area-sensitive species. Area-sensitive species, particularly forest-nesting, neotropical migrants, requiring forest interior habitat are typically more sensitive to fragmentation than edge-adapted species and are particularly affected by predation, brood-parasitism, and other impacts on nesting success (Brittingham and Temple, 1983; Faaborg et al., 1992; Terborgh, 1989). Numerous studies of breeding bird communities in large versus fragmented habitats have shown that fragmented habitats are less diverse than nonfragmented habitats (Askins et al., 1990). Recent studies indicate that forest habitat fragmentation has a detrimental effect on numerous avian species that show a marked preference for large undisturbed forested tracts (Robbins et al., 1989; Terborgh, 1989). Recent literature suggests that nesting success of neotropical migrant birds is lower in areas of low forestation than in areas of higher forestation (Robinson et al., 1995; Rosenberg et al., 1986), although results vary between different geographic regions. In particular, forest fragmentation has a greater negative impact to nesting success in geographic regions dominated by agricultural land uses (e.g., Midwest) relative to

regions dominated by a forested landscape (e.g., Northeast) (Robinson et al., 1995; Rosenberg et al., 1999). Research shows that the incidence of nest parasitism by the brown-headed cowbird and nest predation typically increases when forest fragment size decreases (Robinson et al., 1995).

Considering potential impacts to wildlife discussed above, the primary concerns are impacts caused by habitat fragmentation, especially relative to forest and wetland habitats. Forests, particularly, are relatively static environments that require greater regenerative time after clearing compared with farmland, pasture/grassland, or emergent wetlands. Acreage impacts to vegetative communities that occur within the study area provide a method of quantifying and comparing terrestrial wildlife habitat impacts, including habitat fragmentation, potentially incurred by construction of each segment. Tables 4-1, 4-2, and 4-39 summarize the potential impacts to vegetative communities.

Migratory Birds

The MBTA (1918) protects migratory birds, active nests, eggs, and/or young. It should be noted that the project will be implemented in full compliance with all provisions and regulations outlined in and pursuant to the MBTA (16 USC 703-711).

Trees observed within the project area may provide potential migratory bird habitat. A cursory nest survey was conducted during initial environmental investigations. No nests were observed during the survey. To avoid effects to migratory birds and their habitat, construction should be avoided during the peak-nesting season. In the event that migratory birds are encountered on site during project construction, every effort would be made to avoid harm to migratory birds, their eggs, nests, and young. If necessary, old migratory bird nests would be removed from structures after the nesting season. For upcoming construction, preventative measures would be taken to prevent birds from building new nests on the proposed construction area.

Terrestrial Wildlife Impacts by Alternative

Linear projects by their very nature fragment natural habitats. The alternative evaluation process for this project has endeavored to minimize habitat fragmentation, particularly to forests and wetlands, to the maximum extent practicable. Acreage impacts to vegetative communities that occur within the study area were used to evaluate the extent of terrestrial wildlife habitat impacts, including fragmentation that could result from each of the Representative Alternatives and the Preferred Alternative, and are listed below. Tables 4-2 and 4-39 summarize impacts to community types by alternative.

Representative Alternatives 1, 2, 5, and 6 impact more forested uplands than do the southerly Representative Alternatives. Representative Alternatives 1, 2, 5, and 6 impact more forested wetlands than the other alternatives. Representative Alternatives 3, 4, 7, and 8 and the Preferred Alternative do not utilize Segment K1, a major contributor to forest impacts. Segment K1 increases the resource impact substantially for forested areas due to its relative location in the Big Creek, Waters Lake Bayou, and Rabbs Bayou corridor between Thompsons Oil Field and the Pilant Lake wetland complex. Representative Alternatives 3, 4, 7, and 8 cross the corridor but at the southerly extent. This area has been subjected to

habitat changes (e.g., forested to pasture) over the recent past and larger land holdings have been subdivided and sold for acreage home sites. Consequently, the forested corridor is effectively fragmented.

The southerly Representative Alternatives (3, 4, 7, and 8) and the Preferred Alternative seek to capitalize on existing habitat conversion and fragmentation by utilizing existing habitat breaks between Pilant Lake and Big Creek. From a terrestrial wildlife impact standpoint, more natural habitats are impacted by Representative Alternatives 1, 2, 5, and 6. The remaining Representative Alternatives and the Preferred Alternative are easily ordered from least to most terrestrial wildlife impacts: Preferred Alternative, then Alternatives 3, 4, 7, and 8. The Preferred Alternative is favored from a wildlife perspective because it avoids perceived impacts to Brazos Bend State Park and minimizes encroachment on the secondary management zone for the Bald Eagle nest (see Section 4.16). Although nonforested wetland impacts for the Preferred Alternative are more than the rest of the Alternatives, the greatest acreage difference in impact is 7 acres with impact difference of 4 acres for the majority of the other Alternatives.

4.12.3 Summary of Impacts

The Preferred Alternative is favored from a wildlife perspective because it avoids perceived impacts to Brazos Bend State Park and minimizes encroachment on the secondary management zone for the Bald Eagle nest (see Section 4.16). Although nonforested wetland impacts for the Preferred Alternative are more than the Representative Alternatives, the greatest acreage difference in impact between all these Alternatives analyzed is 7 acres, with impact difference of 4 acres for the majority of the other Alternatives. The Preferred Alternative would impact 6 acres of forested wetlands compared to Alternatives 1, 2, 5, and 6 with 38 acres of impacts. Alternative 3 and 7 would have the least forested wetlands impacts (2 acres). The Preferred Alternative would have the least forestlands impacts (53 acres) compared to Alternatives 3 and 4 with the next least impacts resulting in 81 acres of forestland loss. Additionally, as indicated previously, the impact analysis for the Representative Alternatives were conducted using a 300-foot ROW, whereas the Preferred Alternative impact analysis was conducted using the most detailed design, which is a 300- to 400-foot ROW.

The potential impacts to the aquatic environment caused by the Preferred Alternative would differ in response to the number and type of roadway crossing present, aquatic habitat area, major stream channel relocations required, and culverts used on each of the proposed alignments. Representative Alternatives 2, 4, 6, and 8 and the Preferred Alternative would cross six major streams, whereas, Representative Alternatives 1, 3, 5, and 7 would cross eight major streams. Alternative 3 would cross the most minor stream (10) and Representative Alternative 3 would cross the least number of minor streams (7). The Preferred Alternative would cross 8 minor streams.

The No-Build Alternative would avoid impacts to wildlife associated with the removal of terrestrial and aquatic habitats, but could result in impacts adjacent to existing transportation facilities where suitable habitat for wildlife exists. Although improvement activities associated with existing transportation facilities could also result in impacts to many wildlife species, the impacts would likely be considered less substantial since there would be a relatively small area of habitat removed and there would be no new fragmentation of habitat.

4.12.4 Indirect Impacts

Indirect impacts to wildlife resulting from the construction of the proposed Segment C project are considered likely based on the existing land use of the project area and general growth pattern of the Houston metropolitan area. Construction of the new roadway would likely facilitate new development resulting in a gradual decrease of wildlife habitat. Any removal or fragmentation of habitat due to the development of farmlands, forests, and wetlands would adversely impact the foraging, breeding, and roosting activities of many terrestrial wildlife species. New development resulting from the proposed highway facility would impact aquatic species by increasing sedimentation in streams and natural waterbodies. Water quality would likely be impacted because of increased vehicular traffic and nonpoint source runoff or point source toxic spills draining into the aquatic habitats.

4.12.5 Mitigation

Initial mitigation measures in the planning process of the project minimized the probable occurrence of habitat (vegetation communities) and wetland impacts through route location (avoidance). Construction of the proposed alternative alignments would directly impact vegetative communities (riparian habitat, upland forests, etc.) that provide wildlife habitat. For impacts that cannot be avoided or further minimized, a mitigation plan would be developed to compensate for unavoidable impacts to regulated natural resources (e.g., jurisdictional wetlands). It is anticipated that the mitigation plan would also include a component to compensate for unavoidable impacts to nonregulated natural resources, such as isolated wetlands. Refer to Section 4.9 for a discussion of habitat mitigation. TxDOT BMPs, designed to limit water quality degradation from construction activities, would be included in the mitigation plan. These practices would minimize fill washing into perennial streams, intermittent drainages, and wetlands; limit movement of machinery in the construction corridor at stream and wetland crossings; provide adequate erosion and siltation control; and ensure adherence to proper cleanup procedures.

4.13 WILD AND SCENIC RIVERS

The study area is not situated in the vicinity of any river on the National Inventory of river segments included in the National Wild and Scenic River System (NPS, 1999b); therefore, no impacts to Wild and Scenic Rivers would occur. However, a segment of Big Creek within Brazos Bend State Park in Fort Bend County was nominated by the TPWD as an ecologically significant stream segment. Big Creek is listed as a Stream of Unique Ecological Value in the Region H Water Planning Group. This segment of Big Creek within Brazos Bend State Park would not be impacted by the proposed Grand Parkway Segment C because it does not traverse Big Creek within the ecologically significant stream segment.

4.14 COASTAL BARRIER RESOURCES

The Coastal Barrier Resources Act requires that no new federal expenditures or financial assistance may be made available for various construction projects within the boundaries of the Coastal Barrier Resources System. The

Representative Alternatives and the Preferred Alternative are not within the boundaries of the Coastal Barrier Resource System.

4.15 COASTAL ZONE MANAGEMENT

The Coastal Zone Management Act of 1972, as amended, provides for preservation, protection, development, and where feasible, restoration or enhancement of the resources of the nation's coastal zone. The State of Texas now has an approved Coastal Management Program (approved by the NOAA on December 23, 1996, as published in the FR [Volume 62, Number 7] on January 10, 1997). The Representative and Preferred Alternatives are not within the Coastal Zone Boundary (GLO, 1996).

4.16 ESSENTIAL FISH HABITAT

The proposed project does not intersect tidally influenced coastal waters and would have no impact on EFH. Coordination with the NMFS is not required.

4.17 THREATENED AND ENDANGERED SPECIES

Upon review of information and maps provided by the TPWD, NDD, and USFWS regional office in Clear Lake, it was determined that three species could potentially be impacted by the project: the Bald Eagle, the Texas prairie dawn-flower, and the sharpnose shiner (see Appendix H for photos).

4.17.1 Bald Eagle

As discussed in Section 3.17, three Bald Eagle nests are known to exist within the study area vicinity. Two nests are located north of Smithers Lake and appear to be occupied by the same nesting pair. The other nest is located southeast of Lake Worthington. All three nests were observed in the field by study team ecologists. An adult and an immature Bald Eagle were observed near the southern nest during field surveys conducted in February, March, and April 1999; an adult pair was observed near the newest nest location (February 2005; Appendix H).

The Bald Eagle was delisted by the USFWS on August 8, 2007. The health of the Bald Eagle population will be monitored for the next 5 years, and the eagle could be reclassified after the 5-year monitoring period. The Bald Eagle is still listed as threatened by the TPWD. Additionally, the Bald Eagle is protected by the MBTA and the BGEPA. Under the MBTA it is illegal to pursue, hunt, take, capture, kill, possess, sell, barter, purchase, export, or import migratory birds, their parts, nests or eggs, except as permitted by regulation. "Take" is defined under the MBTA as "pursue, hunt, shoot, wound, kill, trap, capture, possess, or collect (USFWS, 2007a)." The BGEPA Act prohibits the take, possession, sale, purchase, barter, offer to sell, purchase, or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit. "Take" is defined as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb" a bald or golden eagle. The term "disturb" under the BGEPA was recently defined by a final rule published in the FR on June 5, 2007. "Disturb" means to agitate or bother a bald or golden eagle to a degree that causes,

or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior (USFWS, 2007b).

The Project Team is required to fulfill the terms and conditions for the Bald Eagle as stated in the BO issued by the USFWS (March 2007) (Appendix I), regardless of its delisting. For this reason, all pertinent information discussed below regarding impacts within the management zones is still being considered for this project.

None of the Representative Alternatives or the Preferred Alternative occur within any primary management zones for Bald Eagle nests, as defined by the USFWS Bald Eagle Management Guidelines (USFWS, 1995). The primary management zone extends from a minimum radius of 750 feet outward to a maximum of 1,500 feet surrounding the nest. The USFWS recommends that the following activities not occur within the primary management zone:

- Alteration of habitat or change in land use
- Tree cutting, logging, or removal of trees
- Use of chemicals toxic to wildlife
- Placement of aboveground electrical transmission or distribution lines
- Helicopter or fixed-wing aircraft operating within 500 feet vertical distance or 1,000 feet horizontal distance of the nest site, except during the nonnesting season
- Most types of human entry, except minimal disturbance activities

Minimal disturbance activities would include hiking, fishing, camping, and bird watching. Also included as a minimal disturbance activity would be farming, ranching, and hunting if they are existing practices and have occurred historically on the site.

Farming, ranching and hunting can be carried out safely during the breeding season if:

- A change or increase in the form or level of disturbance from historic levels would not result.
- Physical alteration of the primary zone would not result.
- Landowners are made aware of the most critical portions of the eagle-nesting season (October–April) so that these activities can be avoided or minimized during this time as much as possible.
- The activity will be modified as much as possible if impact to Bald Eagles becomes apparent.

Segment T1 (Representative Alternatives 3, 4, 7, and 8) would pass within the secondary management zone of the southernmost Bald Eagle nest if the USFWS applies the maximum distance for the secondary management zone. However, the limits of the secondary management zone are discretionary (as discussed below). For these Representative

Alternatives, there is sufficient width between constraints (i.e., Bald Eagle's secondary management zone and Brazos Bend State Park) to accommodate the proposed design ROW of 300 feet. The Preferred Alternative would also pass within the secondary management zone of the southernmost Bald Eagle nest, but to the north of the nest. This alignment moves the proposed ROW approximately 1.5 miles to the north of the state park and approximately 2,750 feet north of the nest. The 2,750 feet increases the distance between the nest and the Preferred Alternative due to the relocation of the previously documented southern-most nest, which was approximately 1,678 feet from the Preferred Alternative. The secondary management zone encompasses an area extending outward from the boundary of the primary zone an additional distance of at least 750 feet (but a possible maximum of 1 mile). The restrictions in this zone are intended to preserve the integrity of the primary zone and to protect important Bald Eagle use areas, particularly feeding areas, within the secondary zone. The secondary zone should be contiguous with feeding areas and should protect Bald Eagle access to them. The following activities are likely to be detrimental to Bald Eagles at any time and in most cases should be avoided within the secondary zone. These activities include:

- Development of new commercial or industrial sites
- Construction of multi-story buildings or high-density housing developments between the nest and the eagle's feeding area
- Placement of electrical transmission or distribution lines between the nest site and the eagle's feeding area
- Construction of new roads, trails, canals, or ROWs, which would tend to facilitate human access to the eagle nest
- Use of chemicals toxic to wildlife

Certain activities that involve only minimal alteration or disturbance of habitat can be carried out safely in the secondary zone during the nonnesting season. Examples of such activities include minor logging or land clearing, minor construction, seismographic exploration employing explosives, oil well drilling, and low-level aircraft operations. However, the following guidelines are recommended:

- Such activities should avoid alteration or loss of Bald Eagle habitat as much as possible.
- If logging occurs, it should be done so that as many large trees as possible, but at least 10 to 15 live trees per acre, are retained as roost and perch trees. Generally, the trees left uncut should be the largest trees in the stand, and preferably with open crowns and stout lateral limbs. Selective forestry practices (such as seedtree, shelterwood, and single tree-selection) are recommended over clear-cutting (USFWS, 1995).

Certain minimal-disturbance activities (such as hiking, birdwatching, fishing, camping, picnicking, and hunting) and other similar land-use activities that involve no new alteration of habitat (farming, ranching) can be safely carried out in the secondary management zone at any time.

In addition to the restricted activities detailed in the USFWS Bald Eagle Management Guidelines (USFWS, 1995), certain buffers must be in place per the revised National Bald Eagle Management Guidelines (USFWS, 2007a).

- Since the roadway construction activities are not anticipated to be seen from the nest, a minimum of a 330-foot buffer should be in place around the nest site.
- For clearing, external construction, and landscaping activities, a buffer between 330 and 660 feet from the nest should be in place and activities conducted outside of the breeding season.
- All trees or overstory trees within 330 feet of an eagle nest should not be removed at any time.
- There should be a 660-foot buffer for chain saw use near a nest in use.
- Blasting and other activities that produce extremely loud noises within ½ mile of an active nest should be avoided.
- Explosives should not be used within ½ mile of communal roosts when eagles are congregating, or within 1 mile in open areas.
- Forests of natural areas should be maintained in areas between the construction activity and the nest trees (landscape buffers).

Project team and resource agencies' concerns were used to develop the Preferred Alternative to avoid perceived impacts to Brazos Bend State Park while minimizing impacts to the Bald Eagle nest management zones. The Preferred Alternative completely avoids impacts to the primary management zone. However, due to other constraints in the vicinity (e.g., proposed Lake Worthington Conservation Area, Austin's Woods, land ownership patterns, etc.), the secondary management zone could not be entirely avoided. This alignment puts the edge of the proposed ROW approximately 2,750 feet from the eagle nest currently in use. This compromise moved the Preferred Alternative more than 1.5 miles from the park and outside the maximum primary management zone of the eagle nest.

It is anticipated that the construction and operation of the Preferred Alternative would not directly impact the subject eagles considering current traffic volumes on nearby county and state roadways and the active ranch management practices occurring within the vicinity of the nests. No roadways are proposed to occur within the maximum primary eagles nest management zone. Measures, as discussed above, would be taken to avoid any adverse impacts to the Bald Eagles during the time of nesting activity from October 1 through May 31. During this seasonal period, a 1-mile radius from the nest site (079-1-I, as identified in the BA) will strictly prohibit:

- All heavy equipment use
- All survey crews (on foot and vehicles)
- All construction vehicle traffic
- Clearing of woody vegetation

As a result of these restrictions, no habitat modifications, such as the removal of trees or shrubs, would occur within the seasonal exclusion zone during this time period. Construction within the 1-mile seasonal exclusion zone will be strategically planned during the nonnesting season, and routes will be identified outside the 1-mile radius for progression beyond the seasonal exclusion zone. Contract specifications will prohibit the locations of borrow pits, stormwater detention ponds, equipment yards, and other disturbances within the 1-mile exclusion zone throughout the year.

The project team worked closely with the USFWS and other resource agencies to develop a compensatory mitigation plan similar to those developed for other projects in the area (e.g., SH 35). The project team and resource agency staff worked toward a synergistic plan that included wetland mitigation and Bald Eagle habitat.

The project team notified the USFWS in August 1999 that a Bald Eagle nest had been discovered within the proposed alignments of some alternative segments for the proposed Grand Parkway Segment C. The project team initiated formal Section 7 consultation with the USFWS in December 2000. A BA was provided to the USFWS in 2004 to facilitate the USFWS's issuance of a BO that includes general project information, effects of the proposed project, a conclusion on impacts to the Bald Eagle, statements regarding take, reasonable and prudent measures, and terms and conditions for exemption from Section 9 of the ESA. In March 2007, the USFWS concluded that the construction and operation of the proposed Grand Parkway Segment C is not likely to jeopardize the continued existence of the Bald Eagle provided reasonable and prudent measures are followed and terms and conditions of the BO are implemented; therefore, Section 7 consultation is complete. Due to the sensitive nature of the data in the BA and BO, the consultation documents are not included in this document by specific request of the TPWD and USFWS. Reasonable and Prudent Measures include:

1. Implementation of seasonal restrictions on construction activities within the nesting territory to reduce the likelihood of the adult eagles abandoning the territory while eggs or young are present in the nest.
2. Determination of the locations of any new nests with[in] the action area to ensure that the proposed project does not result in direct take of a Bald Eagle nest.

In order to be exempt from the prohibitions of Section 9 of the [Endangered Species] Act, the following nondiscretionary terms and conditions, which implement the reasonable and prudent measure[s] described above and outline required reporting/monitoring requirements, [must] be complied with:

1. Implement all clearing of vegetation within the action area during the period of June 1 to September 1. Any clearing of vegetation that is ongoing as of September 1 may continue until finished.
2. Implement all heavy equipment use within the action area during the period of June 1 to September 1. Any heavy equipment use that is ongoing as of September 1 may continue until finished.
3. Survey the action area annually to determine the location and status of all Bald Eagle nests within the action area. The best time to conduct the surveys is during the month of December.

4. Conduct a training class for project employees each October. The training should include a description of Bald Eagles and their nests and information on who they should contact if a new nest or injured eagle is discovered.

During discussions with resource agencies regarding the Bald Eagle nest and alternatives for avoidance and minimization of impacts (even within the Bald Eagle nest's secondary management zone), both federal and state agency staff stated that it appeared that this nesting pair were perhaps moving their nesting activities northward from the original nest location. Although this assumption was consistent with the landowner's observations and the documented tendency of this Bald Eagle pair to relocate their nest (maybe as many as eight or nine times) (Erfling, 1999), the latest nest relocation (observed in February 2005) is approximately 1,350 feet southwest of the location documented in 1999. However, it appears that suitable nesting areas are available in all directions from the previous and current nest locations. Many variables appear to influence the selection of a nest site and relocation of the nest may or may not happen again. The proposed Grand Parkway Segment C includes the preservation of a tract of bottomland hardwood forest in Austin's Woods to ensure the long-term protection and preservation of suitable Bald Eagle nesting habitat. This preservation will be achieved through acquisition, conservation easement, or monetary donation to an approved conservation entity. Any property acquired will be obtained from a willing seller and approved by the USFWS. Ultimately, approximately 500 acres of Austin's Woods will be preserved through acquisition, donation to a conservation entity or through protection under a conservation easement. The parcel size is based on the acreage included in a maximum Bald Eagle management zone (USFWS, 1995), inclusive of the maximum primary (1,500 feet) and maximum secondary management zones (1 mile from the edge of the primary management zone). It is the intent of the project team to develop the acquisition plan within the context of a larger conservation initiative in the project vicinity. Resource agency staff has been involved in discussions regarding acquisition opportunities within the Big Creek-Rabbs Bayou-Brazos River corridor situated in the vicinity of the Lake Worthington Conservation Area and Brazos Bend State Park. This area represents a solid opportunity for Austin's Woods conservation and is located largely within the combined 100-year floodplains of the three waterways.

A commitment has been received from the George Foundation to dedicate approximately 500 acres of Brazos River floodway north of Brazos Bend State Park. This floodway habitat constitutes a portion of the riparian corridor and Austin's Woods and would be necessary to link the Lake Worthington Conservation Area with Brazos Bend State Park.

In lieu of a donation from the George Foundation, TxDOT may elect to contribute a donation to a nonprofit organization (e.g., National Fish and Wildlife Foundation). Resource agency staff has expressed an interest in this approach as it provides some fiscal flexibility in the acquisition and protection of key conservation properties that might otherwise be unattainable within the timeframe necessary to afford complete protection for the entire initiative. The in lieu fee approach is offered as an option. The amount of the donation would be similar to the cost of acquiring or restricting development of an approximate 500-acre parcel within the Brazos River floodway.

4.17.2 Texas Prairie Dawn-Flower

The Texas prairie dawn is a federally and state-listed endangered plant. Due to the potential for occurrence of the Texas prairie dawn in the adjacent proposed Grand Parkway Segment C project area, field surveys were conducted to determine the presence or absence of populations and suitable habitat within the alternative alignments for the proposed project. Ground surveys conducted for the Texas prairie dawn during the flowering period found no populations within alternative alignments. The majority of the study area traversed by the Representative Alternatives and Preferred Alternative consists of improved pasture, agricultural (row crop) fields, woodlands, or developed areas. The proposed project would have no effect to the Texas prairie dawn.

4.17.3 Sharpnose Shiner

The sharpnose shiner is a small, slender minnow, endemic to the Brazos River Basin in Texas. Historically, the sharpnose shiner existed throughout the Brazos River and several of its major tributaries within the watershed. Samples taken from a Fort Bend County location on the Brazos River in the 1960s identified a small population of sharpnose shiners; however, samples taken in the 1990s and 2001 indicated that no sharpnose shiners were present within this portion of their historical range (Center for Biological Diversity, 2002). In another Brazos River study within Fort Bend County, three individuals of sharpnose shiner were collected in the confluence of Allens Creek during September 20–23, 2001 (Gelwick and Li, 2002). Other current information indicates that the population within the Upper Brazos River drainage (upstream of Possum Kingdom Reservoir) is apparently stable, while the population within the Middle and Lower Brazos River Basins may only exist in remnant areas of suitable habitat, or may be completely extirpated (USFWS, 2006). Therefore, the presence of the sharpnose shiner within the Brazos River of the project area is not likely; the proposed project would have no effect to the sharpnose shiner.

Standard TxDOT BMPs for erosion control/maintenance of stream quality should be sufficient to prevent excess turbidity/adverse impacts to water quality in the event that the sharpnose shiner would be present. During construction, water flow in the streams would be maintained by installing properly sized flumes within the construction crossing. The construction crossing and flumes would be removed at the earliest practicable time, after construction is completed in this work area.

4.17.4 Smooth Pimpleback

The smooth pimpleback is a small mollusk native to the central and lower Brazos and Colorado Rivers with recent observations in 2006 as close as the mainstem Brazos River in Grimes, Waller, and Austin counties (50 CFR Part 17). According to the Texas NDD (TPWD, 2011b), there are no occurrences of the smooth pimpleback within 1 mile of the Representative Alternatives. Large perennial water sources crossed by the proposed project (Brazos River and Oyster Creek) will be crossed by spanning, and direct impacts to those potential habitats would be avoided; therefore, the proposed project would have no effect on the smooth pimpleback. In addition, standard TxDOT BMPs for erosion control/maintenance of stream quality should be sufficient to prevent excess turbidity/adverse impacts to water quality in

the event that the smooth pimpleback would be present. During construction, water flow in the streams would be maintained by installing properly sized flumes within the construction crossing. The construction crossing and flumes would be removed at the earliest practicable time, after construction is completed in this work area.

4.17.5 Texas Fawnsfoot

The Texas fawnsfoot is a small mollusk native to the Brazos and Colorado Rivers in central Texas, with historic populations from Fort Bend County upstream to the lower reaches of the Clear fork Brazos River in Shackelford county (50 CFR Part 17); very few live individuals have been found in recent decades. According to the Texas NDD (TPWD, 2011b), there are no occurrences of the smooth pimpleback within 1 mile of the Representative Alternatives. Large perennial water sources crossed by the proposed project (Brazos River and Oyster Creek) will be crossed by spanning, and direct impacts to those potential habitats would be avoided; therefore, the proposed project would have no effect on the Texas fawnsfoot. In addition, standard TxDOT BMPs for erosion control/maintenance of stream quality should be sufficient to prevent excess turbidity/adverse impacts to water quality in the event that the Texas fawnsfoot would be present. During construction, water flow in the streams would be maintained by installing properly sized flumes within the construction crossing. The construction crossing and flumes would be removed at the earliest practicable time, after construction is completed in this work area.

4.17.6 Summary of Impacts

Potential impacts to threatened and endangered species are summarized by species in sections 4.16.1 through 4.16.5. The project team initiated formal Section 7 consultation with the USFWS in December 2000 regarding a Bald Eagle nest discovered within the proposed alignments of some alternative segments for the proposed Grand Parkway Segment C. A BA was provided to the USFWS in 2004 to facilitate the USFWS's issuance of a BO that includes general project information, effects of the proposed project, a conclusion on impacts to the Bald Eagle, statements regarding take, reasonable and prudent measures, and terms and conditions for exemption from Section 9 of the ESA. In March 2007, the USFWS concluded that the construction and operation of the proposed Grand Parkway Segment C is not likely to jeopardize the continued existence of the Bald Eagle provided reasonable and prudent measures are followed and terms and conditions of the BO are implemented; therefore, Section 7 consultation is complete. Additionally, the proposed Segment C project would preserve 500 acres of Austin's Woods through a conservation easement as part of mitigation measures. No further effects or impacts to threatened and endangered species are anticipated for the proposed Grand Parkway Segment C Project.

Under the No-Build Alternative, no effect to threatened and endangered species would be anticipated.

4.17.7 Indirect Impacts

Indirect impacts to threatened and endangered species would include the removal of some large open-canopy trees that would provide suitable nesting habitat for the Bald Eagle; however, removal of trees within the ROW would be offset by the

preservation of approximately 500 acres of bottomland forest within the Austin's Woods, which would result in the permanent protection of suitable Bald Eagle nesting habitats as the result of the proposed Grand Parkway Segment C Project.

Under the No-Build Alternative, no impacts to threatened and endangered species would occur; however, approximately 500 acres of bottomland forest within Austin's Woods would not be afforded protection and would be potentially subject to development activities not associated with the proposed Grand Parkway Segment C Project.

4.17.8 Mitigation

Mitigation requirements established through correspondence with the USFWS associated with the Bald Eagle management zones are discussed in Section 4.16.1 (Bald Eagle [Threatened and Endangered Species]). No further mitigation requirements are anticipated for threatened and endangered species associated with the proposed Grand Parkway Segment C Project.

4.18 CULTURAL RESOURCES

Historic properties, as defined by the Secretary of the Interior, include those cultural resources (sites, buildings, structures, districts, objects, etc.) that are state or locally designated, listed in the NRHP, or that are eligible for such listing. However, before project-related impacts to both archeological and nonarcheological historic resources are discussed in detail, the following information is presented to summarize the consideration that was given to them during project planning and analysis for each of the eight Representative Alternatives. A discussion of impacts and efforts to avoid, minimize, or mitigate those impacts along the Preferred Alternative is presented in Section 4.18.4.

4.18.1 Archeological Resources

4.18.1.1 Known Archeological Resource Sites

As noted previously in Section 3.18.4.1, the site file and records reviewed at the TARL and THC (last updated in April of 2010) revealed more than 440 previously recorded archeological sites in Brazoria and Fort Bend counties. Approximately 32 previously recorded and newly recorded sites occur within the study area, but none are currently recognized as NRHP listed or NRHP eligible. Of these 32, only 7 sites are located within the proposed ROW limits of segments that make up the eight Representative Alternatives and the Preferred Alternative.

In January 2012, an archeologist conducted a records review for the US 59 and SH 288 interchanges accommodating the addition of the direct connector ramps that were not included in the original archeological investigations The review identified four previously recorded archeological sites and one previously recorded cemetery within 1,300 feet of the proposed centerline at these locations. All of the resources were associated with the direct connectors at US 59, and none of the sites were within the proposed ROW limits. However, surveys of HPAs within the ROW at US 59 direct connectors are recommended.

To aid the reader in their understanding of the individual cultural resource sites, Table 4-43 presents more-detailed identification and evaluation data for each resource located within the proposed ROW of one of the Representative Alternatives and/or the Preferred Alternative, including the NRHP eligibility assessments where sufficient information is available to make such an assessment. The table also includes information about nonarcheological historic-age resources recorded within a broader APE. In addition, coordination of NRHP eligibility with the Texas SHPO is pending for several HPAs where survey-level investigations have not been completed due to lack of right of entry and for several recorded archeological resources that require NRHP eligibility testing after property acquisition has been completed. The results of that coordination will be used to avoid or minimize to the greatest extent possible any potentially adverse effects from the project on archeological resources.

4.18.1.2 Archeological High-Probability Areas

As noted in Section 3.18.4.3, the archeological HPAs were predicted to identify areas where additional archeological resources, both prehistoric and historic, could occur and would thus be subject to impact by the project. Table 4-1, at the beginning of Section 4, lists the linear length of HPAs predicted within each segment. In addition to these HPAs, the results of the HPA assessment and the field surveys suggested that a number of historic period resources occur within or near the eight Representative Alternatives and Preferred Alternative. Each of these resources is described below with reference to the nearest segment that could impact related archeological deposits if they exist.

Darrington Prison Farm

The Darrington Prison Farm was formerly known as the Darrington Plantation. The land was originally granted to Achilles McFarland, one of Stephen F. Austin's "Old 300" colonists. During its original development and operation as a sugar plantation, the property was owned by Sterling McNeel. In this period, the plantation had a large main residence, slave cabins, and a brick sugarhouse with a double set of kettles (Strobel, 1926). According to an anonymous informant cited in Strobel (1926), pre-Civil War improvements have long since disappeared, including the sugarhouse that was burned. The Darrington Plantation became a State Prison Farm in 1918. Segments G5.2* and Y1* follow or are in proximity to the northern property line of the prison farm as well as to two historic archeological sites that may be associated with the Darrington Plantation, the Darrington prison farm, or possibly the adjacent Bingham Plantation.

Site 41BO212 is a historic site that was identified during the initial phase of the Phase I survey. This site was located roughly 0.16 mile east of the Brazos River. The origins of this site remain ambiguous. Due to the potential industrial significance of the Brazos River to the Darrington Plantation, the area between the river and site 41BO212, as well as the area between 41BO212 and 330 feet to the east, is considered to be a HPA for the presence of plantation era-related facilities.

TABLE 4-43
CULTURAL RESOURCE IMPACTS BY ALTERNATIVE

Site No./Name	Site Type	Segment/Proximity	Alternative(s)	NRHP Assessment	Impact
41FB127, 41FB128, and 41FB134	historic period archeological	A1/in ROW	1,2,3,4, & P	N/A	Direct
41FB272	historic/prehistoric archeological	S1-b/in APE	1,2,3,4,P	No	Direct
1-1/Mount Moriah MB Church	early 20th C. ecclesiastical	A1/in ROW; B1/in APE	1,2,3,4,5,6,7,8, & P	No	Direct (Segment A1); Indirect (Segment B1)
Sandberry Cemetery	late 19th to late 20th C. funerary	A2/in APE	1,2,3,4, & P	No	Indirect
5-1	early 20th C. farmstead with renovated house	A2/in APE	1,2,3 4, & P	No	Indirect
5-3	late 19th C. dwelling	A3.1/in APE	1,2,3,4, & P	No	Indirect
5-5	early 20th C. dwelling	A3.1/in APE	1,2,3,4, & P	No	Indirect
1-11	early 20th C. dwelling	A3.1/in APE	1,2,3,4, & P	No	Indirect
1-13	early 20th C. dwelling	A3.1/in APE	1,2,3,4, & P	No	Indirect
1-18a	early 20th C. commercial	A3.1/in APE	1,2,3,4, & P	No	Indirect
1-18b	early 20th C. dwelling	A3.1/in APE	1,2,3,4, & P	No	Indirect
1-21	late 19th to early 20th C. industrial	A3.1/in APE	1,2,3,4, & P	No	Indirect
5-16	early 20th C. dwelling	C1/in APE	5,6,7, & 8	No	Indirect
5-15	early 20th C. dwelling	C1/in APE	5,6,7, & 8	No	Indirect
1-17	early 20th C. dwelling	C1/in APE	5,6,7, & 8	No	Indirect
5-18	late 19th C. farmstead	A6/in APE	1,2,5, & 6	No	Indirect
3-9	late 19th C. farmstead with renovated house	J1/in APE	3,4,7, & 8	No	Indirect
3-11	ca. 1950 dwelling	J1/in APE	3,4,7, & 8	No	Indirect
6-5	early 20th C. farm with modern house	J1/in APE	3,4,7, & 8	No	Indirect
41FB11	prehistoric archeological	J1/ in ROW	3,4,7 & 8	N/A	Direct
3-10	early 20th C. dwelling	J1/in APE	3,4,7, & 8	No	Indirect
6-14	late 19th C. farm with intact array of buildings	T1/in APE	3,4,7, & 8	No	Indirect
6-21	late 19th/early 20th C. church	T1/in APE	3,4,7, & 8	No	Indirect
41BO203	historic period archeological	G5.2/in APE	1,2,3,4,5,6,7,8, & P	Unknown	Indirect
41BO204	historic period archeological	G5.2 in APE	1,2,3,4,5,6,7,8, & P	Unknown	Indirect
41BO212*	historic archeological	G5.2/in ROW	1,2,3,4,5,6,7,8, & P	Unknown	Direct
41BO213*	historic archeological	Y1/in ROW	1,2,3,4,5,6,7,8 & P	Unknown	Direct
41BO218*	historic well site	Y1/in ROW	1,2,3,4,5,6,7,8 & P	Unknown	Direct
6-23	early 20th C. farmhouse	G6/in APE	2,4,6, & 8	No	Indirect
7-8	late 19th C. farmhouse	P1/in APE	1,3,5, & 7	No	Indirect
7-2	early 20th C. farm	G8/in ROW	2,4,6, & 8	No	Direct
41FB015	possibly late prehistoric archeological	T1	3,2,7, & 8	No	Indirect

Source: Study Team (2011).

*Insufficient data are currently available to make NRHP assessments for the identified archeological resources

**The five recorded sites found to be located in the vicinity of the US 59 direct connectors are not included in the table

C – Century, N/A – All sites appear to be destroyed by previous development

Bingham Plantation

The Bingham Plantation was located just north of the Darrington Plantation. The plantation was established in 1824 by Francis Bingham, one of the earliest cattlemen in Brazoria County (one of Austin's "Old 300"), who controlled a herd of some 600 cattle. Bingham reportedly constructed a home of lumber planed at his own mill on the plantation. A "house of entertainment" was also located on the property (Wharton, 1939). Frances Bingham was instrumental in the placement of the Fort Bend-Brazoria County Line. His protests against being included in Fort Bend County led to the location of the county line along the northern boundary of his Plantation. Segments G5.2* and Y1* follow or are in proximity to the southern property line of the Bingham Plantation as well as two historic archeological sites (Bingham residences) that may be associated with the Bingham Plantation or the adjacent Darrington Plantation/Prison Farm complex.

The original Bingham residence (Bowling Green) was reportedly located near the southern margin of the Francis Bingham league on land owned by Milam Caldwell since the start of the twentieth century. This area is located a minimum 0.42 mile from the Preferred Alternative. No facilities associated with the original Bingham residence are predicted to be within the Preferred Alternative.

The second Bingham residence (Providence Plantation) was located roughly 1.74 miles to the north of the Preferred Alternative. No facilities associated with this plantation are predicted to occur within the Preferred Alternative.

The Mary Bingham residence (Terry) was identified during the reconnaissance survey (site 41BO203). This site is roughly 0.31 mile from the Preferred Alternative. An additional site that is potentially associated with the Mary Bingham residence (41BO204) is located roughly 0.1 mile from the Preferred Alternative. Both of these sites are located in proximity to Willow Lake, which is about 279 feet from the Preferred Alternative. Due to the potential importance of Willow Lake and Oyster Creek to industrial operations on the Bingham plantation, the portion of the preferred alignment adjacent to Willow Lake and east of Oyster Creek is considered to be a HPA for the presence of plantation-era facilities.

Houston Tap and Brazoria Railroad

This railroad was originally chartered in 1858, and was one of the earliest commercial rail operations in the state. It operated from Houston to the City of Columbia in Brazoria County, with numerous stops at various sugar plantations along the way. It was nicknamed the "Sugar Road" because its primary purpose was to transport sugar to Houston. Today, a portion of the old rail line crosses Segment Y1* along the northern boundary of the Darrington Prison Farm.

A potential well site (41BO218) was identified between Cow Lake and the rail bed of the Houston Tap and Brazoria Railroad. Due to the potential importance of Cow Lake and the Houston Tap and Brazoria Railroad to industrial facilities associated with the Mary Bingham residence, the area between the rail bed on the west and Oyster Creek on the east might have contained plantation-era remains. However, construction activities by the prison are thought to have disturbed the integrity of such potential remains. This area is consequently not considered to be a HPA.

Gulf, Colorado and Santa Fe Railroad

This railroad was constructed in 1875 and operated from Galveston through Rosenberg in Fort Bend County to Brenham in Washington County. In 1867 a yellow fever epidemic in Galveston caused the City of Houston to prohibit rail service between the two cities. With the realization that this embargo was an asset to the Port of Houston, subsequent embargoes were imposed at the hint of fever. In order to survive, the City of Galveston built the Gulf, Colorado, and Santa Fe Railroad to bypass the City of Houston. This line came under the control of the Atchison, Topeka, and Santa Fe system in 1886, which still operates today as the BNSF and crosses Segments A3.1* and C1 near Crabb.

An additional section of the Gulf Coast & Santa Fe Railroad was constructed in 1931 from Thompsons southwest through Guy. The exact history of this portion of the railroad could not be determined. However, it appears that it may have been a Works Progress/Work Projects Administration project, and its purpose was most likely to serve the various oil and sulfur fields in the area. This rail line was abandoned in 1985 but still crosses Segments J1 and A6 located to the southwest of Thompsons Oil Field.

Sandberry Cemetery

This African American Cemetery located on the west side of FM 2759 between US 59 and FM 762 may be related to one of several plantations that operated in the area during the antebellum period. In particular, it may maintain associations with the plantations of Abner Jackson, Joseph Kuykendall, and/or Henry Jones. The core of the Kuykendall plantation later developed into the community of Crabb located south of the Sandberry Cemetery along the Atchison, Topeka, and Santa Fe Railroad near the intersection of FM 2759 and FM 762. The cemetery is located to the east of the node separating Segments A1* and A2*. The proposed ROW limits are located approximately 180 feet beyond the fenced and maintained boundary of the cemetery.

Big Creek

The areas on either side of Big Creek were a favorite campground for local Indian groups. Historically, Karankawas are known to have camped along Big Creek, and the “Big Creek Campaign” of 1824 was an important event in local history. Joseph H. Polley was the only one of the “Old 300” to settle along Big Creek. Subsequent settlers inhabited the area in 1828 and 1831. Big Creek presents a high probability for potentially important Native American sites, as well as sites related to the early colonization of the area, particularly where it is crossed by Segment J1.

Sandy Point

Federal troops were stationed at Sandy Point during Reconstruction after the Civil War. Several Confederate graves are located in the cemetery at Sandy Point and it is possible that this area has additional Civil War–era sites as well.

Lewis (or Louis) Cumings Site

The prehistoric archeological site 41FB015 was originally recorded in 1950 and 1951 by Raymond Walley. Very little is recorded about the site. At least two prehistoric potsherds were collected from the site suggesting it dates, at least in part, to the Late Prehistoric period. Site 41FB15, also known as the Lewis (or Louis) Cumings site, is shown on a map in a 1955 *Bulletin of the Texas Archeological Society* article concerning the nearby Albert George site. Both the Albert George site, located north of 41FB015, and prerecorded archeological site 41FB016, located approximately 150 meters south of 41FB015, contain prehistoric burials.

4.18.2 Historical Resources

As noted in Section 3.18.5, a windshield reconnaissance was conducted to identify historic-age nonarcheological resources located in the study area that could be impacted by the project. The ca. 1957 USGS 7.5-minute topographic quadrangle maps of the study area were used as the best available information source for identifying historic building sites that would be 50 years old or older at the time of project construction. Table 4-43 identifies the building sites recorded within an APE extending out approximately 1,300 feet in each direction from the proposed ROW of each Representative Alternative.

Of the 23 ca. 1957 or older building sites and cemeteries with standing structural remains recorded in the APE, two have been determined eligible for NRHP listing (Sadowski, 2000; Appendix I). Those two properties include the Old Crabb Store (Site No. 1-18a) and the Old Crabb Rice-Drying Plant (Site No. 1-21), located in Crabb along FM 2759 and the Atchison, Topeka, and Santa Fe Railway. Four additional tenant-farmer houses that are part of the George Ranch were also determined eligible, but they are located outside of the APE for all eight Representative Alternatives and the recommended Preferred Alternative. All other recorded historical resources have been determined not eligible for NRHP-listing (Sadowski, 2000). Discussion of efforts to avoid, minimize, or mitigate impacts to the two NRHP-eligible historic properties is presented in Section 4.18.4.

George Ranch

In the period of time since the historic nonarcheological resource survey was conducted, a portion of the present-day George Ranch has been determined eligible for NRHP listing. Formerly known as the Jones Plantation, the George Ranch dates from the first half of the nineteenth century. In 1899, A.P. and Mamie George became the fourth generation to operate the plantation. Aside from their successful cultivation of crops, they also became very successful ranchers. The discovery of oil on the property in the 1920s provided the bulk of the family's wealth, which they used for philanthropic pursuits.

Today the George Ranch Historical Park is a branch of the Fort Bend Museum Association. It serves as a living history museum and has been determined eligible for NRHP listing. It is likely that Segments Q1 and S1 cross property that was once part of the plantation but all elements within the park complex are located outside the APE of all alternatives. Within

the larger George Ranch, a small group of tenant farmhouses located along FM 762 was determined eligible as part of a rural agricultural district, as noted above in connection with the historic nonarcheological resources survey, but all elements within this district are located outside the APE of all alternatives.

4.18.3 Representative Alternatives Analysis

Representative Alternative 1 contained a cumulative total of 28,200 feet (5.34 miles) of HPA. Segment A1 contains previously recorded archeological sites 41FB127, 41FB128, and 41FB134, which appear to have been destroyed in recent years by modern developments. TxDOT and the THC have determined that these three sites require no further archeological investigation. The NRHP eligibility of these sites, however, remains undetermined. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Architecturally, this Representative Alternative presented no impacts to NRHP-eligible architectural resources. Overall, this Representative Alternative presents both direct and indirect impacts to 12 historic-age nonarcheological resources. Of these 12 resources, 2 are NRHP-eligible historic properties located in the Crabb Community that would be indirectly, nonadversely impacted by Representative Alternative 1. Additionally, one cemetery is located within the APE of Representative Alternative 1.

Representative Alternative 2 contained a total of 28,200 feet (5.34 miles) of HPA. Segment A1 contains previously recorded archeological sites 41FB127, 41FB128, and 41FB134, which appear to have been destroyed in recent years by modern developments. TxDOT and the THC have determined that these three sites require no further archeological investigation. The NRHP eligibility of these sites, however, remains undetermined. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Overall, this Representative Alternative presents both direct and indirect impacts to 12 historic-age nonarcheological resources. Of these 12 resources, two are NRHP-eligible historic properties located in the Crabb Community that will be indirectly, nonadversely impacted by Representative Alternative 2. Additionally, one cemetery is located within the APE of Representative Alternative 2.

Representative Alternative 3 contained about 31,500 feet (5.96 miles) of HPA. Segment A1 contains previously recorded archeological sites 41FB127, 41FB128, and 41FB134, which appear to have been destroyed in recent years by modern developments. TxDOT and the THC have determined that these three sites require no further archeological investigation. The NRHP eligibility of these sites, however, remains undetermined. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Site 41FB11 is a previously recorded prehistoric site within Segment J1. Site 41FB015 is a newly recorded site located within Segment T-1. Overall, this Representative Alternative presents both direct and indirect impacts to 16 historic-age nonarcheological resources. Of these 16 resources, 2 are NRHP-eligible historic properties located in the Crabb Community that will be indirectly, nonadversely impacted by Representative Alternative 3. Additionally, one cemetery is located within the APE of Representative Alternative 3.

Representative Alternative 4 contained about 31,500 feet (5.96 miles) of HPA. Segment A1 contains previously recorded archeological sites 41FB127, 41FB128, and 41FB134which appear to have been destroyed in recent years by modern developments. TxDOT and the THC have determined that these three sites require no further archeological investigation. The NRHP eligibility of these sites, however, remains undetermined. Site 41FB11 is a previously recorded prehistoric site on Segment J1. Site 41FB11 warrants further consideration. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Site 41FB015 is a newly recorded site located on Segment T-1. Overall, this Representative Alternative presents both direct and indirect impacts to 17 historic-age nonarcheological resources. Of these 17 resources, 2 are NRHP-eligible historic, properties located in the Crabb Community that will be indirectly, nonadversely impacted by Representative Alternative 4. Additionally, one cemetery is located within the APE of Representative Alternative 4.

Representative Alternative 5 contained about 27,575 feet (5.20 miles) of HPA. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Overall, this Representative Alternative presents both direct and indirect impacts to six historic-age nonarcheological resources. None of the resources have been determined eligible for NRHP inclusion.

Representative Alternative 6 contained about 27,575 feet (5.20 miles) of HPA. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Overall, this Representative Alternative presents both direct and indirect impacts to seven historic-age nonarcheological resources. None of the resources have been determined eligible for NRHP inclusion.

Representative Alternative 7 contained about 28,875 feet (5.5 miles) of HPA. Segment J1 contains a previously recorded prehistoric archeological site, 41FB11. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Site 41FB015 is a newly recorded site located on Segment T-1. Overall, this Representative Alternative presents both direct and indirect impacts to 11 historic-age nonarcheological resources. None of the resources have been determined eligible for NRHP inclusion.

Representative Alternative 8 contained about 28,875 feet (5.5 miles) of HPA. Segment J1 contains a previously recorded prehistoric archeological site, 41FB11. Segment G5.2 contains one newly recorded site, 41BO212. Segment Y1 contains two newly recorded sites, 41BO213 and 41BO218. Sites 41BO212, 41BO213, and 41BO218 warrant further consideration (see below). Site 41FB015 is a newly recorded site located on Segment T-1. Overall, this representative alternative presents both direct and indirect impacts to 12 historic-age nonarcheological resources. None of the resources have been determined eligible for NRHP inclusion.

4.18.4 Summary of Impacts

4.18.4.1 Archeological Resources

Cultural resources work for the proposed Grand Parkway Segment C is set forth chronologically below.

- In 1998, the GPA approved the preparation of a DEIS and FEIS and all supporting technical reports, including the cultural resources reports.
- In 1999, a reconnaissance survey of the proposed Grand Parkway Segment C Universe of Alternatives was conducted under Texas Antiquities Permit No. 2173. The results of that survey aided in selection of the proposed Grand Parkway Segment C Preferred Alternative from a wide array of possible component segments.
- In March 2001, subsequent to acceptance of the reconnaissance report by TxDOT and the THC, Texas Antiquities Permit No. 2553 was issued for an intensive survey of the Preferred Alternative. An intensive archeological survey was conducted of roughly 14.7 kilometers (9.1 miles), including 1,090 acres (441 hectares) of HPAs. These areas were located along Segments A1, A2, A3.1, S1, B4.2, W1, G3.2, X1, G5.2, and Y1. Deep testing along selected waterways was also conducted in 2001. A draft report of investigations was submitted to the THC.

During an August 26, 2002, Project Team meeting (see Appendix I, meeting notes) with the THC, TxDOT, and FHWA, and subsequent comments provided by the THC (see Appendix I, letter dated October 15, 2002, from Sergio Iruegas representing the THC), unresolved issues were identified and means to address these were suggested. These communications led to an amendment to the scope of work for the Phase I survey, Antiquities Permit #2553 (see Appendix I). This scope was approved by the THC on November 1, 2002 (Martin, 2001). This work included additional archeological fieldwork and intensive archival investigation. The amended scope of work also called for limiting any additional field investigation to (1) historic archeological sites with a demonstrable association to antebellum and postbellum plantation-related settlement patterns, (2) shovel testing at previously identified site 41FB272, and (3) additional geomorphological trenching along landforms with the potential to harbor buried archeological resources based on the predictions outlined in the Houston Potential Archeological Liability Mapping that were not previously subjected to backhoe trenching. The amended scope of work also mandated that any additional archeological fieldwork determined to be necessary as a result of the historical research would be conducted under a new Antiquities Permit and a new scope of work to be reviewed and approved by the THC.

Three previously recorded archeological sites are located within the proposed ROW of the Preferred Alternative. All three sites—41FB127, 41FB128, and 41FB134—are located near Crabb, Texas. Field reconnaissance of these sites suggests that all three have been destroyed by encroachment of development in the area. TxDOT and the Texas SHPO have concurred that no further consideration of these sites is required.

The intensive archeological survey conducted within the proposed ROW of the Preferred Alternative in March, May, and June 2001, and July 2003 yielded evidence of four previously unrecorded archeological sites, including sites 41BO212, 41BO213, 41BO218, and 41FB272. Site 41BO212 is a historic site that lies within Segments G5.2. Site 41BO213 is a historic dumpsite within Segment Y1. Site 41BO218 is a historic well site within Segment Y1. Site 41FB272 is a historic/prehistoric archeological site within Segment S1-b. All of these sites are associated with the 1820s to 1870s plantation-era settlement patterns.

The possible prehistoric component at site 41FB272 is ephemeral, restricted to the ground surface, and appears to lack the information potential that would warrant listing in the NRHP. The historic component at this site appears to represent the remains of a sharecropper or tenant residence, though no intact structural elements remain. The site lacks the information potential that would warrant listing in the NRHP.

The historic well at site 41BO218 appears to have been disturbed by aboveground surface facilities. However, the portion of the well below approximately 8 feet may remain undisturbed. The well may contain cultural deposits relevant to understanding the operation of the Bingham and/or Darrington plantations, and such deposits may warrant the inclusion of this site in the NRHP. TxDOT has recommended avoidance of the site and its vicinity until a final determination can be made regarding its archeological significance, if any.

The NRHP eligibility status of sites 41BO212 and 41BO213 remain unknown. The potential significance of these sites depends in part on their ability to provide important archeological information regarding antebellum and postbellum settlement within Stephen F. Austin's first colony and occupation of Brazoria County. The proximity of these sites also suggests possible association to plantations and historic resources in the area. TxDOT has recommended avoidance of these sites and their vicinity until a final determination can be made regarding its archeological significance, if any.

Sites 41BO212, 41BO213, and 41BO218 also lie within the Darrington Prison Farm. The archival research strongly suggests that the prison farm system in Texas evolved from the earlier plantations, and that prison farms are likely to contain many features (historical and archeological) important to understanding that pattern of agricultural development along the lower Brazos River.

The intensive archeological report (Sherman et al., 2006) and an amendment to the historical structures report (Foster, 2007) outlines the details of these investigations.

From their review of these reports, TxDOT and the Texas SHPO determined that the Darrington Plantation/Prison Farm landscape is not NRHP eligible for its architectural and associative qualities (Goodson, 2007); however, three archeological sites (41BO212, 41BO213, and 41BO218) and their associated HPAs within the Darrington plantation/prison farm property should be avoided until final determinations of archeological significance have been made. Pending final investigation and assessment of these sites and areas, TxDOT has stipulated that impacts and disturbances caused by clearing, grubbing, construction activity, staging and storage of equipment, borrowing of soils, soil disposal, or other ground-disturbing activities of any kind shall be avoided in the following designated areas:

- Site 41BO212 at the Brazos River, extending out from the centerline of the existing roadway for a distance of 200 feet to each side of the centerline;
- Site 41BO218 at Cow Lake, extending out from the centerline of the existing roadway for a distance of 200 feet to each side of the centerline; and
- Site 41BO213 at Oyster Creek, extending out from the centerline of the existing roadway for a distance of 200 feet to each side of the centerline.

No work of any kind shall be conducted within the above-designated areas without obtaining written documentation and approval from the ENV that avoidance issues have been resolved. Additionally, archeologists are in direct coordination with the project design team and will follow TxDOT standards for survey and documentation in areas not previously subject to archeological investigation, including those areas to which archeologists did not have permissible access during the intensive survey.

More specifically, additional work will be required at the proposed US 59 interchange area. The additional investigation would likely include preconstruction trenching at the proposed overpass locations and at any other areas subject to deep impacts. Due to the proposed construction depths at these locations (estimated to reach up to 50 to 60 feet), any deeply buried cultural resources present within the Brazos River floodplain could be directly impacted by project construction.

4.18.4.2 Historic Nonarcheological Resources

Two NRHP-eligible architectural resources are located within the APE of the Preferred Alternative near its crossing of FM 2759 and the Atchison, Topeka, and Santa Fe Railroad in Crabb, Texas. The route of the Preferred Alternative was refined to avoid any direct impact to these two historic properties. The Preferred Alternative would have no effect on the character-defining features of these two historic properties in Crabb. The proposed route is sufficiently distant from these properties that the project will not diminish their ability to continue commercial service to the local community (Appendix I). Thus, there is no need to provide further efforts to avoid, minimize, or mitigate impacts to these two historic properties.

4.18.5 Indirect Impacts

4.18.5.1 Nonarcheological Resources

Potential indirect impacts to nonarcheological historic resources may include visual, noise, or other types of effects at distances well removed from the area of project construction. Increased development could increase incidences of looting and vandalism of historic resources. With the construction of the Grand Parkway Segment C project, the addition of commercial development near interchanges could have an indirect impact on nonarcheological historic resources. There would be no indirect effects as a result of the No-Build Alternative.

4.18.5.2 Archeological Resources

Indirect development could increase incidences of looting, vandalism, and nonscientific collecting of archeological resources. However, based on assumptions made by the Expert Panel, indirect project impacts would not be located within the AOI 100-year floodplains, which have a high probability for archeological resources. Under the Grand Parkway Segment C project, the addition of commercial development near interchanges could have an indirect impact on archeological resources. There would be no indirect effects as a result of the No-Build Alternative.

4.18.6 Mitigation

If any site identified by archeological field survey within the Preferred Alternative is found to be eligible for the NRHP, actions and consultation would be initiated to avoid, minimize, or mitigate adverse effects to that site. If an NRHP-eligible site could not be avoided in the final design process, consultation would include development of a mitigation plan. This mitigation plan would be developed and reviewed by TxDOT in consultation with the THC and FHWA. Design modifications may be sufficient to reduce the severity of the effect to a nonadverse level. Mitigation of unavoidable adverse effects typically includes archeological data recovery and full archival documentation. Section 4(f) coordination will only be performed for archeological sites warranting preservation in place. The unsurveyed portions of the APE will be surveyed once access is obtained (Appendix I).

4.19 SECTION 4(f)/6(f)

As indicated in Section 4.18.4.1, the Preferred Alternative was refined to avoid any direct impacts to two NRHP-eligible historic properties located in the Crabb Community. Regardless of which Alternative was selected, this avoidance measure would have occurred; therefore, the potential 4(f) issues as they relate to NRHP-eligible historic properties would have been the same.

All Representative Alternatives and the Preferred Alternative contained historic period archeological sites 41BO212, 41BO213, and 41BO218. Regardless of which Alternative was selected, the potential 4(f) issues as they relate to archeological resources would have been the same. NRHP determinations have not been finalized for these sites as of the date of this FEIS. If any of these sites are determined eligible, actions and consultation would be initiated to avoid, minimize, or mitigate adverse affects to the resources. As described above in Section 4.18.4.2, avoidance of these archeological sites has been recommended and TxDOT has accepted the avoidance measures as outlined in Section 4.18.4.2 if possible during the final design. The need for a Section 4(f) impact assessment as it relates to archeological resources will be determined once the NRHP eligibility determinations and design specifications are finalized.

No publicly owned recreation areas or parks would be directly affected by, or are directly adjacent to, the Representative Alternatives or the Preferred Alternative. Therefore, no Section 4(f) or Section 6(f) public land takes are anticipated for any of the alternatives.

4.20 HAZARDOUS MATERIALS IMPACTS

4.20.1 Regulated Hazardous Material Sites

An initial site assessment including a visual survey of the project limits and surrounding area, research of existing and previous land use, and limited review of federal and state regulatory databases/lists was performed by Atkins (formerly PBS&J) in 2010 and 2011. The purpose of the initial site assessment was to identify possible hazardous materials within the project limits. Although partially undeveloped, commercial businesses exist along Crabb River Road, the northern portion of the project limits. Sections 3.1.2 and 4.1.1 provide land use descriptions of this area.

Of the 37 sites identified by the GeoSearch™ reports (see Table 3-25), 6 hazardous materials sites were listed within the proposed ROW of Segment A-1 (Alternatives 1-4 and the Preferred Alternative). Table 4-44 indicates the site name and distance from the Segment A-1 and Alternative impacted. The RCRA-G site, TIER II sites, SPILLS site, and DCR sites are not discussed in these paragraphs as they were considered to pose NO risk to the proposed project. There were no additional hazardous materials sites identified within 100 feet of the proposed ROW for Alternatives 1–8 or the Preferred Alternative.

Of the six hazardous material sites with registered USTs, two are also listed as the location of a leaking underground storage tank (LUST). All six sites are located within Segment A1 (Exhibits 11 and 15). Below are descriptions of the six hazardous materials site identified within Alternatives 1–4 and the Preferred Alternative.

- #1: Handi Stop 33/Crabb River Road Exxon, 1750 Crabb River Road, Richmond, Texas

There are three 12,000-gallon PSTs in use at this site: two underground gasoline tanks and one underground diesel tank installed on June 1, 1998, and registered August 17, 1998. Two NOVs were issued to this site on February 23, 2007: one minor waste violation for failure to maintain daily inspection logs according to 115.244 (Inspection Requirements), and one moderate waste violation for failure to conduct a monthly inspection of the components listed in 115.242(3)(J). Both violations are noted to be resolved. Based on the best available information, no known or suspected release of petroleum from the PSTs and the resolution of the two NOVs, this site was designated as a LOW risk to the proposed project.

- #2: Z Bar, 1612 Crabb River Road, Richmond, Texas

One NOV was issued to this site on May 3, 2010: minor water violation for failure to provide a minimum pressure tank capacity of 220 gallons. This violation has not been resolved and remains active. Based on the best available information and the active status of the NOV, this site was designated as a LOW risk to the proposed project.

- #3: Greatwood/Cellco – Greatwood, 1720 Crabb River Road, Sugar Land, Texas

This site is designated at a TIER II. There are 578.4 units of sulfuric acid stored at this site. No violations have been filed on this site. Based on the best available information, this site was designated as a LOW risk to the proposed project.

TABLE 4-44
HAZARDOUS MATERIALS SITES IN THE PROJECT AREA

	Site Information	Database – Site ID#	Petroleum Storage Tank(s)	Potential Contaminant Parameters	Distance from Project Alignment (miles)	Risk Evaluation	Alternatives
1	Handi Stop 33 1750 Crabb River Rd. Richmond, TX 77469	PST – 0070920	• One 12,000-gallon gasoline fuel underground storage tank (UST) in use • One 12,000-gallon gasoline fuel UST in use • One 12,000-diesel gasoline fuel UST in use	Petroleum Involvement	SW (0.01)	Low	1, 2, 3, 4, and Preferred
	Crabb River Road - Exxon 1750 Crabb River Rd. Richmond, TX 77469	FRSTX – 110034539159	None	None			
	Handi Stop 33 1750 Crabb River Rd. Richmond, TX 77469	FRSTX – 110034013680	None	None			
	Handi Stop 33 1750 Crabb River Rd. Richmond, TX 77469	NOV – RN102026895	None	• 02/23/2007: Minor waste violation - Resolved • 02/23/2007: Moderate waste violation - Resolved			
2	Z Bar 1612 Crabb River Rd. Richmond, TX 77469	NOV – RN101192169	None	• 05/03/2010: Minor waste violation - Active	SW (0.01)	Low	1, 2, 3, 4, and Preferred
3	Cellco - Greatwood 1720 Crabb River Rd. Richmond, TX 77469	FRSTX – 110040425359	None	None	S (0.01)	Low	1, 2, 3, 4, and Preferred
	Greatwood 1720 Crabb River Rd. Sugar Land, TX 77469	TIERII – 101346	None	Storage of Sulfuric Acid			
4	Fort Bend County MUD 116 S1 1003 Farm Road 2759 Richmond, TX 77469	TIERII – 48NV3N08J4PN	None	Storage of calcium hypochlorite granular & chlorine gas	NW (0.02)	Low	1, 2, 3, 4, and Preferred
	Fort Bend 1003 Farm Road 2759 Richmond, TX 77469	ERNSTX – 1156348354	None	09/25/2001: Equipment Failure (Regulator) - 25-pound Chlorine Spill			
	Fort Bend County MUD 116 1003 Farm Road 2759 Richmond, TX 77469	FRSTX – 110033938880	None	None			

TABLE 4-44, CONT'D

	Site Information	Database – Site ID#	Petroleum Storage Tank(s)	Potential Contaminant Parameters	Distance from Project Alignment (miles)	Risk Evaluation	Alternatives
	Fort Bend County MUD 116 1003 Farm Road 2759 Richmond, TX 77469	NOV – RN102943131	None	• 09/30/2009: Minor water violation - Resolved • 05/13/2008: Minor water violation - Resolved • 08/08/2007: Minor water violation - Resolved • 08/08/2007: Minor water violation - Active • 06/19/2007: Minor water violation - Resolved • 06/19/2007: Minor water violation - Resolved • 09/30/2006: Moderate water violation - Active • 07/07/2006: Minor water violation - Resolved			
5	Greatwood Auto Collision 1500 Crabb River Rd. Richmond, TX 77469	NOV – RN104713359	None	09/07/2005: Moderate air violation - Resolved	SW (0.02)	Low	1, 2, 3, 4, and Preferred
	Greatwood Auto Collision 1500 Crabb River Rd. Richmond, TX 77469	FRSTX – 110033998360	None	None			
	Crystal Cleaners 1500 Crabb River Rd. Richmond, TX 77469	FRSTX – 110034565450	None	None			
	Crystal Cleaners 1500 Crabb River Rd. Richmond, TX 77469	DCR – RN103962031	None	Solvent: Perchloroethylene (Tetrachloroethylene)			
6	Buc-ee's 31 1243 Crabb River Rd. Richmond, TX 77469	PST – 0079441	• One 40,000-gallon gasoline fuel UST in use • One 40,000-gallon diesel fuel UST in use	Petroleum Involvement	W (0.04)	Low	1, 2, 3, 4, and Preferred

Source: Study Team (2012).

- #4: Fort Bend County MUD 116, 1003 Crabb River Road, Richmond, Texas

This site is designated at TIERII. Chlorine gas and calcium hypochlorite granular are stored at this facility. This site contains an ERNSTX. On September 25, 2001, there was an incident caused by equipment failure; 25 pounds of chlorine was released from a 150-pound chlorine cylinder due to a failed regulator. The material did not reach water. The system was shut down and repairs were made. Eight NOVs were issued to this site ranging from July 7, 2006, to September 30, 2009. Six of the eight violations have been resolved. The two active violations were issued September 30, 2006 (failure to meet the limit for one or more permit parameters), and August 8, 2007 (failure to initiate engineering and financial planning for an expansion and/or upgrading of the wastewater treatment plant or collection system when the plant has reached 75 percent of the permitted daily average for 3 consecutive months). Based on the best available information and the active status of the two NOVs, this site was designated as a LOW risk to the proposed project.

- #5: Crystal Cleaners/Greatwood Auto Collision, 1510 Crabb River Road, Richmond, Texas

One NOV was issued to this site on September 7, 2005: one minor air violation for operating without being registered with the commission and having no authorization to construct a new facility. The violation has been resolved. This site is also listed on the DCR. Solvents used on this site include perchlorethylene (tetrachlorethylene). Based on the best available information and the resolution of the NOV, this site was designated as a LOW risk to the proposed project.

- #6: BUC-EE'S 31, 1243 Crabb River Road, Richmond, Texas

There are two 40,000-gallon PSTs in use at this site: one underground gasoline tank and one underground diesel tank, installed on May 16, 2008, and registered August 20, 2008. Based on the best available information and no known or suspected release of petroleum from the PSTs, this site was designated as a LOW risk to the proposed project.

4.20.2 Oil/Gas Well Sites

Numerous oil and/or gas wells have been drilled within the study area, particularly in the Thompsons Oil & Gas Field located in the northern portion of the study area and west of the Brazos River. Based on the review of the RRC records, 17 oil and/or gas well locations are within the Representative Alternatives. All 15 are reported to be plugged or abandoned, except one active well in Segment B5. Three oil and/or gas wells are located within the Preferred Alternative. All three wells are located within Segment X1*; one is plugged, one is a cancelled location, and the other is a dry hole. The operator of the well, as identified by the RRC records, is responsible for the plugging of any abandoned wells and/or the remediation of polluted well sites associated with their exploration activities. However, if a well is damaged during construction of the proposed project, then the responsible party would be required to correct the damage and remediate any pollution resulting from the damage.

Naturally occurring radioactive material (NORM) is commonly associated with the production of oil and gas. The source of most of the radioactivity in petroleum industry wastes are the isotopes formed from radioactive decay of uranium-238

(U-238) and thorium-232 (Th-232), which are naturally present in the subsurface formations from which oil and gas are extracted (NORM Technology Connection). The primary radionuclide of concern in NORM wastes is radium-226 (Ra-226) of the U-238 decay series. Ra-226 of the Th-232 decay series also occurs in NORM wastes, but is usually at lower concentrations.

The petroleum industry waste streams most likely to contain elevated radium concentrations include produced water, scale, and sludge. Radium, which is highly soluble, can be mobilized in the liquid phases of a subsurface formation and transported to the surface in the produced water stream. As the produced water is brought to the surface some of the dissolved radium precipitates out in solid form. The radium coprecipitates with barium sulfate, a hard and relatively insoluble scale deposit. Generally, radium concentrations tend to be highest closest to the wellhead where the scale tends to form. Scale also tends to form within pipelines and tanks, and sludge is commonly found in pits used during the drilling of wells. Wells that do not have significant associated scale formation generally do not have a NORM problem. As previously mentioned, all of the wells located within the proposed ROW of the Representative Alternatives are reported to be plugged and abandoned. As a result, the possibility of exposure to elevated levels of NORM at these well sites is quite small. Additionally, there are no reported wells within the project area that are used for the disposal of NORM wastes.

According to RRC, 27 petroleum pipelines were identified within the project area of Segment C. Representative Alternatives 2 and 6 cross the most pipelines (27). Representative Alternatives 3 and 7 cross the fewest number of pipelines (15). Alternatives 1 and 5 cross 19 pipelines. Representative Alternatives 4, 8, and the Preferred Alternative cross 23 pipelines. In Segment G7 in Brazoria County there is a location where 8 pipelines intersect each other. Alternatives 2, 4, 6, and 8 cross this major pipeline intersection.

The potential for a petroleum pipeline to impact the project area is minimal. The absence of any TCEQ records of a pipeline rupture from within the project area of Segment C suggests that there have been no reported incidents of pipeline ruptures or spills. The presence of these petroleum pipelines does not appear to have negatively impacted the project area

4.20.3 Hazardous Waste Impacts to the Existing Environment from Project Construction Activities

The impacts from hazardous material use and handling during construction activities associated with the proposed project pose a minimal risk of impacts to the environment. Temporary aboveground storage tanks (ASTs) and equipment, vehicles, and machinery that contain oil and use diesel fuel are typically used during major construction projects. Typical impacts may include leaking valves, hoses, or small spills that may occur during refueling activities associated with ASTs or small leaks that may occur from equipment, vehicles, and/or machinery. However, these impacts would be minimal and typically do not pose a significant risk to the environment. The contractor will take appropriate measures to prevent, minimize, and control the spill of hazardous materials in the construction area. The use of construction equipment within sensitive areas should be minimized or eliminated entirely. All construction materials used for this project should be removed as soon as work schedules permit. Should any leaks or spills occur, they will be handled according to applicable state and federal regulations and TxDOT standard specifications.

4.20.4 Summary of Impacts

The construction of the alternatives poses very little risk of hazardous waste impacts to the environment. Hazardous waste impacts associated with the proposed project would more likely be associated with currently operating sites and facilities or historical sites and facilities, which have already impacted the existing environment or have the potential to impact the existing environment. Facilities such as these that are located within the proposed ROW would be acquired by the project owner through ROW acquisition. The acquisition of hazardous material sites and facilities does present a liability risk to the project owner. Therefore, prior to ROW acquisition it is recommended that a Phase I ESA (in accordance with the most current American Society for Testing and Materials [ASTM] Standards), be conducted at each site and/or facility that has known, or the potential for, hazardous waste impacts to the existing environment. If deemed appropriate, an asbestos inspection would be performed at each structure prior to demolition to determine the presence of asbestos. Based on the results of the Phase I ESA and asbestos inspection, a possible Phase II including remedial and abatement activities may be warranted at certain sites or facilities. Asbestos inspections, analysis, abatement, and disposal would be performed in compliance with applicable federal and state regulations. Issues related to the presence of hazardous materials would be addressed during the ROW acquisition process. Any unanticipated hazardous materials and/or petroleum contamination encountered during construction should be handled according to applicable state and federal regulations and TxDOT standard specifications. All USTs identified within the proposed ROW would need to be removed from the ground per TxDOT specifications prior to construction activities in accordance with the TCEQ guidelines.

RRC records indicate that 15 wells sites are located within the ROW of the Representative Alternatives. The Preferred Alternative would cross 23 pipelines; however, impacts related to these pipelines are anticipated to be negligible.

Under the No-Build Alternative, development within the Segment C project area is expected to continue in a similar fashion as before and at a rate similar to historical trends. Further exploration and production of oil and gas could occur; however, suburban growth would eventually reduce the availability of land to lease for oil and gas production. Commercial development would likely occur along existing arterial roadways that occur within the project area. This commercial development will likely increase the number of most common hazardous material sites, and retail gasoline sites.

4.20.5 Indirect Impacts

Potential indirect impacts to hazardous materials locations could occur as a result of land disturbance from development, infrastructure, or utility improvements. The risk could be minimized or avoided by conducting a Phase I ESA to identify hazardous materials prior to property acquisition and development. Many lenders require a Phase I ESA prior to lending money for property acquisition.

4.20.6 Mitigation

Mitigation of these impacts may come in the form of compensation to relocate the wells identified within the ROW. Other mitigation is not applicable. If a well could not be avoided, it would need to be plugged and abandoned as per RRC and

TxDOT guidelines. Active wells located within the ROW would be required to be relocated or avoided by construction activities. If oil and gas wells would be affected within the proposed ROW, applicable plugging and supervision requirements would be provided in the TAC, Title 16, Part 1, Chapter 3, Section 3.14 under the jurisdiction of the RRC. Well plugging would need to be performed by cementing companies, service companies, or operators approved by the RRC. Arrangements with the responsible well operator for proper plugging according to applicable regulations would be addressed during the ROW acquisition and negotiation process. If not plugged prior to construction, the wells would be addressed per TxDOT standard specification Item 103, Disposal of Wells.

The relocation of existing pipelines does not appear necessary. However, the depths of the pipelines and their locations would be clearly marked prior to construction to prevent an accidental rupture.

The proposed project includes the demolition and/or relocation of building structures. The buildings may contain asbestos containing materials. Asbestos inspections, specification, notification, license, accreditation, abatement, and disposal, as applicable, would be in compliance with federal and state regulations. Asbestos issues would be addressed during the ROW process prior to construction.

4.21 VISUAL AND AESTHETIC IMPACTS

This analysis of visual and aesthetic impacts is limited to addressing publicly accessible views of the landscape, which are confined primarily to roadways and public lands. Viewer groups include those with views from the project (road-users) and those with views of the project (landowners). Vehicular passengers with views from the project may originate from the local area, statewide, other states, or other countries.

The same roadway design is proposed for all eight Representative Alternatives and the Preferred Alternative, and all would incorporate a 300- to 400-foot ROW at the construction phase of the project. The proposed highway, characterized by gentle curves and extensive bridging, would most likely provide some scenic views of the area's natural features. Construction of the roadway along the alternatives, however, would require the removal of linear tracts of vegetation, which lend to the area's scenic atmosphere. Rich soils and flat topography have made this area ideal for agricultural purposes, but the opportunities for vistas are thus limited due to the flat terrain.

Road users would most likely benefit from viewing the study area's undeveloped sections where inundated agricultural fields provide migratory bird viewing and 80-year-old hardwood forests, known as the Austin's Woods. A scenic easement agreement was developed for property owners who grant a scenic easement that restricts and limits certain uses for the purpose of preserving open space for the public's scenic enjoyment of the proposed Grand Parkway Segment C. Groups who would be the most adversely impacted by highway development are primarily those using adjacent tracts of land. Groups with a view of the road would include adjacent property owners (especially those near overpasses or bridges), recreational users, single-family residential and suburban residents, and commercial owners. The Representative and Preferred Alternatives would pass in proximity to residential subdivisions in the ETJ of Sugar Land, Richmond,

Thompson's, Needville, Rosharon, and Iowa Colony. The roadway would diminish the rural, pastoral atmosphere of many of these residential areas.

Varying degrees of adverse impacts to neighborhood aesthetics are expected. Segments A1, A2, A3.1, B1, C1, C2, G5.2, G6.2, G8, J1, Q1, P1, X1-a/X1-b, and S1-b along the Representative Alternatives would each be visible to some degree from residential developments (see Exhibits 11 and 15). Along the Preferred Alternative, visual impacts can be expected along segments A1, A2, A3.1, G3.2, G5.2, G6.2, G8, X1, S1-b, and W1 in the study area. The proposed roadway alternatives pass close to several established neighborhoods in the western half of the study area.

The adverse impacts to the visual and aesthetic qualities of the local area, however, could be reduced through consideration of landscaping and design variations (vegetation screening, earthen berms, variable profiles, variable medians) during project design. Existing vegetation could screen many of the visual impacts along A1, A2, G3.2, K1, T1, G5.2, the southern portion of W1, and north of G5.2 and X1.

In addition, the project team has proposed to erect cut-off luminaires to reduce radiant light emissions generated by the parkway where passive light measures (reflective striping, road markers, warning, or informational signs) are inadequate. Signs, billboards, and outdoor advertising structures would be limited. The construction of the facility as a parkway with limited access points and frontage roads is intended to prevent strips of commercial development along the roadway, which some individuals may not find aesthetically pleasing.

4.21.1 Summary of Impacts

Construction of any of the alternatives, including the Preferred Alternative, would have a visual impact on adjacent areas. In areas where the Grand Parkway would be a new location roadway, adjacent landowners would be exposed to increased glare from vehicle traffic and lighted intersections. However, landowners would experience a decrease in the amount of regional traffic currently using the existing arterial system.

The proposed Segment C project would be constructed predominately at grade with vegetated shoulders, ROW, and medians. As currently proposed, grade separations are limited to areas where the proposed roadway would cross another roadway or a perennial stream, and frontage roads do not run the full length of the alignment. The roadway lighting system is restricted to those areas where entrance/exit ramps or toll collection facilities are located. Where residential areas are located near the collection facilities and ramps, the presence of roadway illumination light fixtures as well as additional light cast from these fixtures could be considered additional negative visual and aesthetic impacts.

The No-Build Alternative would not directly alter any visual resources; however, increased traffic congestion associated with the No-Build Alternative and the current development pressures in the region could lead to short-term and long-term impacts on the visual quality of the area road network and landowners adjacent to roads in the network.

4.21.2 Indirect Impacts

It is likely that commercial and/or residential development resulting from the proposed Segment C project would occur near intersections where access to the new roadway has been provided. These developments would likely include streetlights and/or security lighting that would be expected to result in incremental and localized increases in ambient light levels, glare, and nightglow.

4.21.3 Mitigation

Aesthetic quality will be taken into consideration during the design process to minimize perceived visual intrusions. The Preferred Alternatives is expected to have minimal impacts to the visual and aesthetic quality due to the project's low vertical profile, the existing low to medium degree of aesthetic quality, and the potential for incorporating aesthetically pleasing elements into the final design.

The impacts on visual quality of the environment would be minimized by:

- Design specifications to blend into the landscape; and
- Landscape planting and revegetation of natural areas impacted by construction.

4.22 ENERGY IMPACTS

The proposed project is expected to lower total energy utilization, no matter which alternative is selected. Both the construction and operational energy requirements of each alternative were considered. The energy required during construction would increase proportionally with the length of the alternative. Completion of the facility, however, would more than compensate for the energy used during construction by increasing the efficiency of vehicles traveling on the new facility, some of which will divert from current travel routes distant from the new corridor. This project would increase access, decrease travel times, and ease congestion in nearby areas, thereby resulting in long-term operational energy savings, which would offset the initial construction energy requirements.

Increased energy efficiency on the new roadway would be attributed to its free-flow, controlled-access features and would result in decreased vehicle delays and more efficient vehicle operating speeds. The project is considered consistent with the Federal Energy Policy and Conservation Act.

4.22.1 Summary of Impacts

The Build Alternative would require short-term energy consumption during construction activity. The short-term construction-related energy consumption could be offset by the operational energy efficiencies gained with the use of an improved transportation facility over many decades.

4.22.2 Indirect Impacts

The increase in access, decrease of travel times, and ease of congestion in nearby areas would result in long-term operational energy savings.

4.22.3 Mitigation

The construction of the project Segment C project would result in the reduction of energy consumption by relieving congestion on the existing roadway network. As stipulated in Section 1 (Project Need and Purpose), the proposed Segment C project would be destined to:

- improve system linkage or connectivity within the existing transportation network
- address transportation demand, reduce traffic congestion, and provide travel options
- improve regional and local safety for the traveling public

In addition, the Grand Parkway would result in reduced traffic congestion, and thus a reduction of energy consumption (see Section 4.6, Air Quality).

SECTION 5: INDIRECT EFFECTS

This section analyzes and discusses the potential indirect effects of the Grand Parkway Segment C project. This analysis was conducted in accordance with FHWA, CEQ, and TxDOT guidance. As defined by CEQ, indirect effects are:

> "…effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8).

Indirect effects can be placed in three broad categories. These categories include (1) alteration of the behavior and functioning of the physical environment caused by project encroachment alteration; (2) access-alteration effects; and (3) effects related to project-influenced development. Examples of this include fragmentation of a habitat and functional effects to water quality. The quantitative analysis for indirect effects focused on the induced changes to land use that would potentially result from the construction of the proposed Grand Parkway Segment C.

5.1 METHODOLOGY

The methodology for the indirect impact analysis is based on the findings in the TxDOT's *Guidance on Preparing Indirect and Cumulative Impact Analyses* (September 2010). Table 5-1 describes TxDOT's seven-step method that was utilized.

TABLE 5-1
SEVEN STEPS FOR CONDUCTING AN INDIRECT IMPACT ANALYSIS

Step 1	Scoping
Step 2	Identify the Study Area's Goals and Trends
Step 3	Inventory the Study Area's Notable Features
Step 4	Identify Impact-Causing Activities of Proposed Action and Alternatives
Step 5	Identify Potentially Substantial Indirect Effects for Analysis
Step 6	Analyze Indirect Effects and Evaluate Results
Step 7	Assess Consequences and Consider/Develop Mitigation (when appropriate)

5.2 STEP 1 – SCOPING

Analyzing the likelihood of development in the study area once construction is completed is a key component to evaluating the potential for indirect impacts. To accomplish this, an Expert Panel comprised of local land-use planners and people with firsthand knowledge of planning or development in the government, education, and private sectors was established. An Expert Panel convened in January 2007 and provided information regarding past, current, and reasonably foreseeable future developments; however, based on new indirect and cumulative guidance, the FHWA requested that the Expert Panel be expanded and reestablished in February 2009. The 2009 Expert Panel was contacted to solicit their input on what land-use changes they anticipate that would potentially result from the construction of the proposed Grand Parkway

Segment C. Each member of the Expert Panel received a letter, which included a project description, a location map, historic aerials showing land-use patterns, and a questionnaire requesting their input on past, current, and future development within the area. The 2009 Expert Panel included the following participants.

- David Gornet – GPA
- Manny Francisco – TxDOT, Houston District
- Perri D'Armond – Greater Fort Bend Economic Development Council
- L.M. "Matt" Sebesta, Jr. – Brazoria County Commissioner Precinct 2
- Gerald Roberts, PE – Brazoria County Engineer
- Tom D. Stavinoha – Fort Bend County Commissioner Precinct 1
- Mary Ruth Rhodenbaugh – Brazoria County Commissioner Precinct 4
- Patti Worfe – Angleton Economic Development Director
- Patrick O'Day – Brazoria County Groundwater Conservation District Director
- Richard Hurd – Brazoria County Parks Department Director
- Marilynn Kindell – Fort Bend County Community Development Director
- Nathan Hatcher – Fort Bend County Engineering
- Michael Davis – Fort Bend County Parks Department Director
- Ron Neighbors – The Fort Bend Subsidence District General Manager
- Frank Simpson – Missouri City's City Manager
- James Callaway – City of Sugar Land Executive Director of Community Development
- Theresa Grahmann – City of Rosenberg Planning Director
- Curtis Rhodes – Needville ISD Superintendent
- Brenda Teykl – City of Needville
- Hilmar Moore – Mayor, City of Richmond
- Dr. Robby McGowen – Alvin ISD Superintendent
- Dr. Heath Burns – Angleton ISD Superintendent
- Dr. Timothy Jenney – Fort Bend ISD Superintendent
- Dr. Thomas Randle – Lamar CISD Superintendent
- Jamie Schubert – TPWD

- Casey Cutler – USACE
- Edith Erfling – USFWS
- Glen Gilmore – City of Richmond City Manger
- Delores Martin – City of Manvel Mayor
- Kevin Sherrodd – Brazoria County Assistant County Engineer

The Expert Panel was contacted to determine what they perceived the development trends would be within their jurisdiction with (Build Alternative) and without (No-Build Alternative) construction of the proposed Grand Parkway Segment C.

For this analysis, the Grand Parkway Segment C project includes existing land use and all projects programmed in the H-GAC 2035 RTP Update (H-GAC, 2011b), the Fort Bend Tollway. The No-Build Alternative includes all existing land use and projects in the H-GAC 2035 RTP Update without the proposed Grand Parkway Segment C. The Expert Panel was asked to consider where future development would be expected to occur within their jurisdictions under each of these two scenarios through 2035, which equates to the planning year for the project (future temporal boundary for the indirect and cumulative impact analyses [CIA]). Development would continue past 2035; therefore, these scenarios do not represent the ultimate development for these jurisdictions.

The National Cooperative Highway Research Program (NCHRP) Report 466, Desk Reference for Estimating Indirect Effects of proposed Transportation Projects (NRC, 2002), states "…linear projects (e.g., new highways or fixed transit guideways) typically have the most extensive effects when compared with new interchanges, transit stations, or bridges, or with new ports, airports and related facilities." The NCHRP Report 466 goes on to say that there are certain general circumstances that may influence the likelihood of induced development shifts (NRC, 2002). These general circumstances include the extent and maturity of existing transportation infrastructure, land availability, and price, state of the regional economy, area vacancy rates, location attractiveness, local political/regulatory conditions, and land-use controls.

5.2.1 AREA OF INFLUENCE

For this analysis, the geographic boundary for which possible indirect impacts could occur has been identified as the AOI. In order to establish the AOI, the Expert Panel recommended a multi-step process. This multi-step process is as follows:

Step 1: Calculate the 15-minute travel distance on the radial network from the proposed project traveling away from Houston (Outer AOI) and traveling towards Houston (Inner AOI). This distance is then marked as an initial boundary point. The travel time output from the H-GAC regional travel demand model 2035 Build Scenario was utilized to develop the travel time contours.

Step 2: Repeat Step 1 for two additional 15-minute increments (30 and 45 minutes).

Step 3: Connect the boundary points for each increment to establish each incremental boundary line. The area between each 15-minute boundary line is then defined as the 15-minute travel contour. (Note: Where a radial roadway is not available to establish a boundary point, boundary lines are kept parallel to the proposed Grand Parkway Segment C corridor alignment.)

Step 4: Refine the boundary for both the Inner and Outer AOI based on the H-GAC's TAZ boundary (Exhibit 21) and the 15-minute boundary line. A TAZ is a special area delineated by state and/or local transportation officials for tabulating traffic-related data, especially journey-to-work and place-of-work statistics. A TAZ usually consists of one or more census blocks, block groups, or CTs.

This four-step process initially produced a reasonable Outer AOI (Exhibit 33). However, the northern boundary of this Inner AOI incorporated large portions of a geographical area north of SH 6 and south of Beltway 8 that was already developed. Therefore, any development in this area is likely the result of existing land use patterns, and not the proposed project. As a result of the evaluation on the existing roadway network and current development the Inner AOI stops at SH 6 (Exhibit 34). Additionally, the 30- and 45- minute travel contours cover and extend beyond the H-GAC travel demand model area and the Houston region; therefore, both travel contours were eliminated from the AOI.

After an evaluation of the roadway system within the project vicinity and an analysis of whether any induced development-shifting circumstances were present, the proposed Grand Parkway Segment C 15- minute travel shed (AOI) incorporates about 588 square miles (376,900 acres) including the communities of Needville, Fairchilds, Pleak, Thompsons, portions of Missouri City, parts of Sugar Land, and Arcola (Exhibit 35). The majority of subdivisions within the AOI are located in the northern portion with some scattered subdivisions on the outside edges of this boundary (Exhibit 35). Additionally, the majority of these subdivisions were developed after 2006. Travel contours in the project area for the 2035 No-Build scenario remained unchanged with respect to the Build 2035 scenario, and therefore, the AOI for the Build and No-Build remains constant. The study area previously identified to determine direct effects was approximately 108,000 acres, while the AOI is 376,900 acres. The previous study area was the geographic boundary within which alternative corridor locations were developed and direct effects were assessed, while the AOI is the geographic boundary within which possible indirect effects could occur.

The Expert Panel was presented with a land-use map, which presents historic snapshots of residential and other development from 1985 through 2006 (Exhibit 35). This map summarizes land development over the past 24 years. The Expert Panel was also presented with a year 2008 base map showing existing residential and commercial development, parks, wetlands, and floodplains, as well as planned developments.

The Expert Panel's goal was to provide a basis for the Study Team's assessment of future land-use changes by predicting where, when and in what manner land within the AOI might develop under both the No-Build and Build Alternative. From this, the Study Team could then determine what growth, and hence, what indirect impacts could be attributed to the development of the proposed Grand Parkway Segment C. The Expert Panel and Study Team determined that land within

the AOI that was already developed would not change, planned developments would continue as planned, and parks, wetlands, and floodplains would not develop due to the additional cost, difficulty, and regulatory constraints associated with their development. The remaining undeveloped land free from constraints comprised approximately 190,200 acres within the AOI. This undeveloped land was analyzed for development potential and land uses were allocated under both the No-Build and Build Alternative.

During public involvement activities (see Section 7 of this volume), citizens indicated that they would use the proposed project as a link to the existing interstate or state highways for travel to areas outside Houston. Major roadways located within or bordering the AOI include US 59, SH 6, FM 2759 (Crabb River Road), FM 762, FM 521, FM 1462, and SH 288. US 59 and SH 288 are two radial highways connecting Houston to its suburbs and beyond. No reasonable freeway alternative connecting major radial facilities exists in the AOI and travelers are forced to access SH 6 or Beltway 8 for east-west travel. Secondary roads include FM 2759, FM 762, FM 521, and FM 1462; however, none provide a continuous connection from US 59 to SH 288 and the majority of AOI lacks transportation infrastructure.

To refine the evaluation to identify the potential for indirect effects attributed to the Grand Parkway Segment C project in a partially developing area, the guidance in NCHRP Report 466, Desk Reference for Estimating Indirect Effects of Proposed Transportation Projects (NRC, 2002) was utilized as a second evaluation. NCHRP Report 466 states, "development effects are most often found up to 1 mile around a freeway interchange, up to 2 to 5 miles along major feeder roadways to the interchange, and up to ½ mile around a transit station." Based on this development scenario, the Area of Potential Indirect Effect was developed for the Grand Parkway Segment C project that included a 1-mile buffer around the Grand Parkway Segment C interchanges with US 59, and SH 288 and a 5-mile buffer placed along major feeder roadways with new intersections/interchanges (Sansbury Boulevard, FM 762, FM 521, and CR 48) (Exhibit 36). The Area of Potential Indirect Effect was then refined and other major roadways such as the remaining portion of US 59, SH6, and the remaining portion of SH 288 were not included due to the difficulty in discerning the effects of these established roadways from Grand Parkway Segment C. These roadways already have substantial development and are continuing to develop. Once the basic area was defined, further refinement was conducted based on the factors such as the potential for an area to support development considering existing and planned utilities and other infrastructure and availability of developable land. Consideration was also given to general access and mobility opportunity based on the inclusion of frontage roads associated with the proposed Grand Parkway Segment C project. The resulting Area of Potential Indirect Effect (Exhibit 36) is approximately 83,918 acres. For evaluation of the potential for indirect effects attributed to the Grand Parkway Segment C project, both the AOI, which is based on the 15-minute travel shed, and the Area of Potential Indirect Effect will be provided for each resource.

The land-use categories used by the Expert Panel are described in Table 5-2. They were evaluated in terms of their response to change; stresses imposed and their capacity to withstand these stresses; pertinent regulations, standards, and development plans that establish thresholds; and their current status.

TABLE 5-2
LAND-USE CATEGORIES

Land-Use Category	Definition
R1	High-density single family
R2	Low-density single family
R3	Multifamily
Master Planned Community	A suburban plan that includes homes and commercial, work, educational, and community facilities
Commercial	Retail, office, or industrial
Undeveloped	Would remain undeveloped due to a lack of demand
Undeveloped/Constrained	Would remain undeveloped due to a form of an environmental constraint (e.g., parks, wetlands, and floodplains)

Source: Study Team (2012).

Transportation improvements often reduce the time-cost of travel, enhancing the attractiveness of surrounding land to developers and consumers. Development on undeveloped land, or conversion of the built environment to more intensive uses, is often a consequence of highway projects (NRC, 2002). Changes in the traffic patterns and alteration of accessibility to the proposed Grand Parkway Segment C could influence the location of residential and commercial growth; subsequently, making the AOI more attractive to development.

Subsequently, the linear form of transportation corridors can result in a unique impact on ecosystems. Linear corridors may function as specialized habitats, conduits of movement, barriers or filters to movement, or sources of effects on surrounding habitats. Indirect effects of transportation projects that can have important consequences for ecosystems include (1) habitat fragmentation; (2) lethal, sublethal, and reproduction effects from pollution; (3) disruption of ecosystem functioning from direct mortality impacts; and (4) disruption of natural processes from altered energy flows (NRC, 2002).

5.3 STEP 2 – IDENTIFY THE STUDY AREA'S GOALS AND TRENDS

Existing zoning, future land use plans, and comprehensive plans identify the goals for the cities within the AOI. The cities of Needville, Rosenberg, and Arcola; villages of Fairchilds and Pleak; town of Thompsons; as well as portions of Missouri City and Sugar Land (**Exhibit 35**) lie within the AOI for the project. Many of these entities have developed plans that identify goals and objectives for the area and some include provisions for the proposed project.

5.3.1 City Goals

City of Sugar Land

The City of Sugarland has adopted the first five chapters of the "Vision 2025 City of Sugarland Comprehensive Plan" (July 2012). These chapters document the economic and demographic baseline, history of the city and planning initiatives, as wells as the goals and objectives for the city. These goals and objectives support the Vision 2025, which was approved by Council in 2009. In general, they desire to have an attractive community that is safe and environmentally friendly and provides a living environment for citizens, which contains business, education, cultural, and recreational activities.

Additionally, they recognize that superior mobility is an important goal. They want to effectively move traffic through and to and from the city. While their land use section of the plan (Chapter 6) has yet to be approved by the Council, the past "Sugar Land 2021 – Our Vision" (City of Sugar Land, 2003) included a land use plan that provided for the consideration of the Grand Parkway project.

Missouri City

The City of Missouri City has adopted the "Missouri City Comprehensive Plan" (September 2009). The Comprehensive Plan provides information on the history and demographic trends of Missouri City, as well as addresses land use and community character, growth capacity, parks and recreation, mobility, and an overall strategy for executing the Comprehensive Plan. The Comprehensive Plan serves as a guide for the development of the City with respect to land use, thoroughfares and streets within the city and its ETJ as well as advocates mobility within the region. Key planning considerations for area's mobility include:

- Achieving long-term solutions to traffic along regional corridors given continued population growth and development around the greater Houston area.
- Coordinating with other entities including other area cities, Fort Bend County, Harris County, the Fort Bend and Harris County Toll Road Authorities, and TxDOT to ensure that regional roadways can adequately accommodate projected future traffic volumes in the area.
- Developing and maintaining a system of arterial and collector streets that provide for multiple connections and travel options within and through the community versus concentrating traffic on only a few primary roadways.
- Maximizing flow and reducing traffic conflicts on existing roadways and ensuring carrying capacity is preserved on any future facilities through access management and other TSM strategies.

Although the Grand Parkway Segment C project is not within the City of Missouri ETJ, the implementation of the Grand Parkway Segment C appears to be consistent with the key planning considerations as discussed above.

City of Manvel

The City of Manvel has adopted a visionary future Comprehensive Development Plan (2007). This plan addresses future land use, transportation, utilities, drainage, governance, economic development, public facilities, and open space, as well as community image. As the city is located outside of the Grand Parkway Segment C construction area, the city plan does mention the Grand Parkway within the drainage section, which suggests that storm drain systems associated with the Grand Parkway would outfall into primary drainage systems in the area. The plan also notes that in the past, the City of Manvel has relied heavily on the state and county for planning of its transportation corridors.

Village of Pleak

The Village of Pleak Comprehensive Plan was published in March of 2009. The plan focuses on project growth, land use, infrastructure, transportation, roadway planning, and parks. The Village of Pleak is located at the intersection of the proposed Spur 10 extension, proposed Fort Bend Parkway extension and SH 36. The plan defers roadway infrastructure and transportation to Fort Bend County and TxDOT, since they maintain or control most major roadways within the village. The Grand Parkway is referenced throughout the Comprehensive Plan.

Village of Fairchilds

The Village of Fairchilds does not currently have a comprehensive plan or thoroughfare plan available for review.

City of Arcola

The City of Arcola does not currently have a comprehensive plan or thoroughfare plan available for review. They do provide ordinance relating to platting and development within the city.

City of Rosenberg

The City of Rosenberg does not currently have a comprehensive plan available for review. They have developed a thoroughfare plan that depicts the existing city limits and roadways along with the proposed ETJ for the city and area roadways. The Grand Parkway Segment C is included on the thoroughfare plan map.

City of Needville

The City of Needville does not currently have a comprehensive plan or thoroughfare plan available for review.

Town of Thompsons

The town of Thompsons does not currently have a comprehensive plan or thoroughfare plan available for review.

Regional Planning Efforts - Houston Galveston Area Council

The H-GAC 2035 RTP Update defines transportation systems and services in the area containing the boundaries of the AOI. The RTP Update addresses regional transportation needs that are identified through forecasting current and future travel demand, developing and evaluating system alternatives, and selecting those options, which best meet the mobility needs of the region. The proposed facility is included in this plan.

5.3.2 Trends

The majority of the AOI is located in the southeast portion of Fort Bend County with a smaller portion located in northwest Brazoria County. The area falls within Gulf Coast State Planning Region 16 and is governed by the H-GAC. Based on the

review of aerial photography from the years 1985 to 2006, the northern reaches of the AOI have seen elements of new residential growth from the Houston metropolitan area, while much of the area is still characterized by sparse commercial and residential development, with the bulk of the land being level farmland.

Primarily rural until the 1970s, the suburban growth of Fort Bend and Brazoria counties has been closely tied to the economic prosperity of Houston. The lower cost of land in Fort Bend and other counties surrounding Houston has drawn residential development away from the central city to areas more affordable for the developer and homeowner. As bedroom communities increased throughout the 1980s, decentralization of Houston continued as jobs and retail sales began to follow homeowners to the suburbs. Over time, the Houston region has become a central city surrounded by smaller edge cities, large enough to support shopping and labor markets.

As shown in Exhibit 35, in 1985 there were only nine residential developments within the AOI. These included Brazos Landing, Colony Meadows, Crescent Lakes, First Colony, Greatwood, Lake Point, Laurel Oaks, Sandy Point Estates, and Williams Glen. By 1996, residential development included the following subdivisions: Alcorn Bend, Austin Meadows, Brazos Town Center, Avalon Villages of Avalon, Belgrand Estates, Bridgewater, Clairmont Acres, Commonwealth Estates, Dove Meadows, Fairchild Estates, Fairchild Manor, New Territory, Oaks of Rosenberg, Palmcrest, Plantation Lakes, Rivers Mist, Royal Meadow Lakes, Sandy Point Estates, Schlumberger, Seven Oaks, Sovereign Shores Estates, Sunrise Meadows, Sutton Forest, Sweetwater, Villages at Rosenberg, and Villages at Town Center. By 2006, expansion of residential development among the existing developments included Benton Park, Brazos Bend Oaks, Brazos Lake, Bridlewood Estates, Canyon Gate at the Brazos, Double M Ranch, The Lakes, Lincoln Park, Oak Lake Village, Randy Ridge, River Park, River Park West, Royal Lakes Estates, Royal Lakes Manor, Sienna Point, Sterling Lakes, Summer Lakes, Suncreek Ranch, and Valley Vistas Estates.

The residential pattern of recent developments, master-planned communities, contrasts sharply with the rural nature of traditional residences, clusters of homes or individual farm homesteads along FM roads located within the southern and eastern portions of the AOI. Many of the residences in more rural settings include farm-related structures such as garages, barns, storage buildings, and other agricultural outbuildings. Many also appear to be smaller than the new homes more recently built in the northwestern portion of the AOI. Commercial and industrial land uses in the AOI are minimal and the bulk of the commercial land uses are in the northern portion of the AOI near US 59 and FM 762. Travel-related gas stations and fast food restaurants are concentrated near US 59 and along Crabb River Road. Extending south along Crabb River Road are additional commercial services including auto mechanic shops, dry cleaners, storage areas, and mini-markets.

An important aspect of this growth is the conversion of rural land to developed land, a shift that is readily apparent within the AOI. As previously described in Section 3.3.1, the population growth forecasted over the next 30 years (98.3 percent for Fort Bend County and 45.6 percent for Brazoria County) suggests that the trend toward urbanization within the AOI would likely continue in the foreseeable future thereby continue to convert agricultural land and open space land to more urban land uses.

The H-GAC 2035 RTP Update defines transportation systems and services in the area containing the boundaries of the AOI. The RTP addresses regional transportation needs that are identified through forecasting current and future travel demand, developing and evaluating system alternatives and selecting those options, which best meet the mobility needs of the region. The proposed facility is included in this plan.

5.4 STEP 3 – INVENTORY THE STUDY AREA'S NOTABLE FEATURES

Indirect effects to resources outside the project area could occur within the AOI. Of these resources, the indirect effects analysis requires an assessment of potential indirect effects of the Grand Parkway Segment C project on the area's notable features. Notable features are generally described as sensitive species or habitats, valued environmental components that we seek to use, protect, or enhance, unique or unusual resources, or vulnerable elements of the human population, such as elderly, children disabled, low-income or minority populations.

Below is a list of notable features within the study area followed by a more detailed discussion of the features:

- Manford Elementary School
- Reading Jr. High School
- George Ranch High School
- Brazos Bend State Park
- The George Observatory
- A paintball course
- Private recreational parks and trails within the planned communities of Greatwood, Riverpark, Canyon Gate, and Bridlewood
- The Lake Worthington Conservation Area
- The Brazos River
- Austin's Woods
- Prime farmlands
- Wetlands
- Vegetation
- Wildlife habitat (including Bald Eagle and the Texas prairie dawn-flower habitat)
- Floodplains.

There are a number of schools in the study area. Manford Elementary School, located approximately 0.25 mile west of US 59 on FM 762, is in the Lamar CISD. Manford Elementary School serves grades pre-K through 5 and enrolled 632 students in 2011 (Great School, 2012). Reading Jr. High School and George Ranch High School, located along FM 762 east of Bridlewood Estates, both also in Lamar CISD, enrolled 1,540 and 1,783 students in 2011, respectively (Lamar CISD, 2012). The University of Houston Sugarland is located south of US 59 at University Boulevard. The University of Houston Sugarland enrolled 2,626 students in the fall semester of 2011 (University of Houston Sugarland, 2012).

There are a number of parklands in the study area. Brazos Bend State Park covers 4,897 acres, with an eastern boundary of 3.2 miles fronting the Brazos River on the southeast border of Fort Bend County. Open to the public since 1984, the park has facilities for campers, a 21.6-mile hike/bike trail, group picnic pavilions, and a ½-mile wheelchair accessible nature trail. While most of the park is in the Brazos River floodplain, there are also areas of flat upland coastal prairies. In addition to the Brazos River, Big Creek runs diagonally through the park and creates, in combination with man-made levees, numerous lakes, sloughs and bayous (TPWD, 1999).

The George Observatory, owned and operated by the Houston Museum of Natural Science, is located here and houses a 36-inch telescope built primarily for public viewing and education. The George Ranch Historical Park, which is open to the public, is owned by the George Foundation (privately owned) and encompasses 500 acres. It is located within the 23,000-acre George Ranch. Located in the Brazos Bend State Park, because of the area's dark night skies and proximity to Houston, the observatory houses one of the largest telescopes consistently available for public viewing in the nation.

Other recreation facilities in the area include a paintball course located just south of US 59 at Williams Wire Boulevard. There are a number of private recreational parks and trails within the planned communities of Greatwood, Riverpark, Canyon Gate, and Bridlewood.

The Lake Worthington Conservation Area, also within Fort Bend County, is a privately owned tract of land. The landowners have negotiated a conservation easement with the USFWS, which restricts development of the property. It is not open to the public.

Austin's Woods is considered a sensitive natural community found within Brazoria and Fort Bend counties. These coastal bottomland hardwoods are approximately 70-year old forest stands and are located throughout the study area. Due to the rapid urbanization of southeast Texas, wildlife resource agency staff have identified forested community types as a priority for protection, restoration and creation. Due to the rural nature of the AOI, prime farmlands would be considered a notable feature as would the Brazos River, wetlands, vegetation and wildlife habitat (including Bald Eagle and the Texas prairie dawn-flower habitat), and floodplains.

5.5 STEP 4 – IDENTIFY IMPACT-CAUSING ACTIVITIES OF THE PROPOSED ACTION AND ALTERNATIVES

Steps 2 and 3 of the indirect effects assessment have focused on the identification of trends, goals, and notable features. The next steps involve identification and assessment of impacts that may come into conflict with these goals and features. This step consists of listing the impact-causing actions of the project, the general types of impact-causing activities, and a description as to how they relate to the project (Table 5-3).

TABLE 5-3
IMPACT CAUSING ACTIVITIES

Type of Activity	Project Specific Activity	Relevant Details
Modification of Regime	Alteration of Ground Cover	Approximately 1,117 acres of existing land uses including approximately 955 acres of prime farmland converted to roadway ROW. Ground cover adjacent to the proposed project would be temporarily disturbed because of construction activities. BMPs would be in place to control soil erosion. When construction is complete, ground cover would be reestablished according to EO 13116 – Invasive Species.
Modification of Regime	Modification of Habitat	Approximately 26 acres of jurisdictional wetlands and waters of the U.S. would potentially be permanently impacted. These wetlands would most likely be impacted by the placement of fill material in the wetland to elevate the road. 872 acres of pastureland/grassland/ cropland and 153 acres of forestland would be directly affected by roadway ROW.
Modification of Regime: Resource Extraction	Flow Modification	Increase of impervious cover due to the construction of roadway ROW would result in an increase in runoff. Approximately 997 acres draining into individual streams. In addition, 349 acres of 100-year floodplains affected by proposed project.
Land Transformation and Construction: Land Alteration Access Alteration	New or Expanded Transportation Facility	New location four-lane controlled access highway with interchanges at US 59, FM 521, FM 762, and SH 288. Total ROW required is 1,117 acres. The air quality in the AOI is currently considered in poor health, because it is within the nonattainment area for ozone. In addition, the proposed project will result in changes in land use designations/increase mobility and access. All such actions can result in changes of traffic patterns and thus have the potential to indirectly impact air quality in the area.
Processing	Storage of Construction Materials	The contractor is responsible for all impacts to project specific locations, which may include storage areas, waste sites, and material sources outside the project limits. In addition, the contractor must certify compliance with all applicable laws, rules, and regulations pertaining to the preservation of cultural resources, natural resources, and the environment as directed in the TxDOT Standard Specification for Construction of Highways, Streets, and Bridges (2004). If the contractor chooses to use undeveloped land or another site for the storage of materials, impacts to natural resources may increase.

TABLE 5-3, CONT'D

Type of Activity	Project Specific Activity	Relevant Details
Land Alternation	Pavement Placement	The primary impact to vegetation resulting from site preparation and construction of the proposed project is the removal of existing vegetation from the ROW and any construction staging areas. Four vegetation community types would be impacted by the Preferred Alternative: pastureland/grassland/cropland, nonforested wetland, forested wetland, and forestland.
Resource Renewal	Revegetation	Seeding and replanting would be conducted in accordance with EO 13112 – Invasive Species. Other mitigation alternatives associated with on-site mitigation and off-site mitigation would continue to be investigated and evaluated by the GPA, TPWD, USFWS, EPA, and USACE. A compensatory mitigation plan will be submitted to the USACE as part of the Section 404 and Section 10 permit review process. It is anticipated that a nonwetland component would be incorporated, at the discretion of the TxDOT Houston District, into the mitigation plan to compensate for unavoidable impacts to nonregulated natural resources (riparian habitat, upland forest, etc.).
Changes in Traffic	Traffic Patterns/Environmental Justice	A Build Alternative would increase capacity and improve mobility throughout the project area. With these improvements, travel time on the local roadway network would also improve. In addition, mainlines and access roads provide motorist with new commute options as well as provide for changes in access on the existing roadway network. As such, some traffic patterns would change in the project area. The EJ communities would not experience a highly adverse disproportionate impact based on the project; but the proposed changes may be considered disproportionate.
Waste Emplacement and Treatment	Land fill	No impact or displacement of waste material is anticipated.
Chemical Treatment	Chemical Usage	No use of fertilizer is anticipated during revegetation. Periodic use of herbicide may occur during routine maintenance for the Build Alternative, as necessary.
Access Alteration	Travel	The Build Alternative would improve travel between US 59 and SH 288. Access throughout the area would be improved with the Build Alternative as there is currently no major transportation facility in the area.

Source: Study Team (2012).

5.6 STEP 5 – IDENTIFY POTENTIALLY SUBSTANTIAL INDIRECT EFFECTS FOR ANALYSIS

This step summarizes the methods used to identify indirect impacts and presents the framework for determining which impacts merit further analysis, or conversely, which impacts require no further analysis. The methods used to identify indirect impacts are primarily qualitative. This technique focused on the elements or indicators that characterize the AOI using ecological and social data from the baseline investigations. The discussion of indirect impacts is organized by three different types of impacts: encroachment-alteration impacts, induced growth impacts, and impacts related to induced growth.

5.6.1 Encroachment-Alterations Impacts

There are two major types of direct encroachment impacts as a result of transportation projects: changes in travel patterns and access, and direct relocation of homes, businesses, or public facilities. Indirect effects are commonly related to changes in land use, including conversion of land to transportation use. Changes in travel patterns may also occur in conjunction with transportation projects, including those where tolling is involved. When a transportation project is constructed, improved accessibility (direct effect) and the availability of undeveloped land may make an area more attractive for development.

The increased access anticipated to be provided by the project could be a sufficient condition for the intensification of development already occurring or planned. This might be especially true of the central and eastern portion of the AOI, which has a lower density of development, and therefore, the greatest potential for additional growth. However, based on the current economic conditions, the opportunity for project-caused intensification of development already occurring is minimal.

Ecological impacts may also occur with the increases in development. Vegetation and wildlife habitat would be replaced by urban development through a continuing net loss of established, late successional woody and herbaceous vegetation, fragmentation of remaining vegetation resources, and reduction of habitat connectivity in the larger area. Although the upland woods are less diverse and of lower value than riparian woods, they provide the important wildlife habitat component of cover for escape and concealment, particularly in areas subject to fragmentation due to development.

Furthermore other ecological effects to area waterways could occur with any increase in development. The area waterways could face water quality degradation from increased impermeable surface and increased nonpoint source pollution. Increased stormwater runoff could potentially introduce pollutants leading to toxicity and behavioral effects of various species resulting in degradation of habitats, which could elicit changes in reproductive behavior and rates, as well as changes in food sources. Ultimately, this trend could result in changes in ecosystem structure and function. The alteration of natural hydrological processes would indirectly alter energy flows, which would potentially change immigration and emigration of species and change the vegetative structure of the AOI.

While the location of the Grand Parkway Segment C was designed to minimize impacts to existing neighborhoods and residential subdivisions during the planning phases of the project, the proposed project could influence the perceived “rural nature” of the certain areas of the AOI. The rural portions of the AOI may have a more “suburban feel,” which may be a concern to the existing residential communities.

5.6.2 Induced Growth Impacts

As previously discussed, indirect impacts related to land use that may occur within the AOI include development within the central and eastern portion of the AOI, which has a lower density of development, and therefore, the greatest potential for additional growth.

The research is mixed as to whether transportation improvements spur development, or if development creates the need for transportation improvements (Handy, 2002). For widening of existing roadways, as in the case of US 183, studies conducted by the University of Texas Center for Transportation Research and University of California at Davis found little relationship between this type of activity and local development permitting (Handy, 2002; Kockelman et al., 2000). Real estate professionals interviewed for the University of Texas Center for Transportation Research study agree in their assertions that accessibility provided by roadway projects is a necessary, but not sufficient condition for development of surrounding land. They state that other factors such as zoning and development regulations play a much more important role in the timing and location of development. However, the researchers caution that ". . . it would not be prudent to conclude that highway expansions have no impact on development." Similarly, the University of California at Davis study concluded that urban highway expansion shows no evidence of generating new growth; however, it affects the pattern or distribution of existing growth.

Factors such as transportation access, visibility, utility availability, and zoning and development regulations provide a foundation for determining the timing and location of development. Within the AOI local land use planning efforts reflect the ongoing local transition from rural to suburban land use. However, the information gathered in chapter 3 and 4 and steps 1 and 2 indicate that the project area and AOI are developing and will continue to develop. Because the Grand Parkway project has been in the planning stages for several years, the study area cities have developed land use plans to accommodate the Build Alternative.

Local land use planning reflects the ongoing local rural to urban land use transition. Commercial and industrial land uses are influenced by transportation improvements as mobility and accessibility are key factors in the determination of transportation costs for businesses. Industrial and commercial land uses do not represent a substantial percentage of developed land within the AOI and the transition of rural areas to commercial and industrial uses along Grand Parkway Segment C would not be expected to be substantial.

The anticipated regional growth and new accessibility may bring economic benefits to the AOI cities in the form of new employment opportunities, which in turn may increase the local tax base. However, the development would change the land use patterns and may affect the current rural to suburban landscape.

According to the Urban Land Institute, transportation improvements are factored into planning but are not the driving force in these processes (Urban Land Institute, 2004). The general consensus is that regional economics is the primary driving force for regional development. The major effect of highways is seen in the distribution of the development within a region (FHWA, 2004). The proposed project would enhance mobility, potentially enhancing the rate at which planned development occurs; however, this would not constitute inducement of substantial net new growth. If improvements were not implemented, development within the area would likely continue, but at a potentially slower rate.

5.6.3 Effects Related to Induced Growth

The third type of indirect impact is related to induced growth. These are similar to encroachment-alteration effects, but occur as a result of induced growth. An example would be habitat fragmentation as a result of development induced by the proposed project. As previously discussed, no substantial induced development is anticipated based on historical development patterns and the current economic recession. As described in Step 2, residential and commercial development is consistent with area goals; therefore, the increased access and mobility of Grand Parkway Segment C is expected to compliment and facilitate the area's goals.

The third type of indirect impacts is the impacts that project-influenced land development and growth could have on the environment.

Discussions with the Expert Panel revealed that area cities are expected to experience induced growth as a result of the proposed Grand Parkway Segment C project. In addition, many notable features identified within the AOI during Step 3 evaluations may be impacted as a result of the induced growth. The following provides a summary of the potential induced growth development impacts associated with the information received from Expert Panel when considered against the notable features.

Induced growth effects have the potential to create substantial socioeconomic effects. New development would impact the current "rural nature" for portions of the area AOI. Community cohesion may be affected as well by the influx of new residential developments and commercial centers influencing how current residential communities view their neighborhoods. Improved mobility may also expand what resident's view as their community. However, the new development could also improve the economic conditions of the community by providing new patrons to local businesses, adding new business opportunities to stimulate the local economy, and converting existing land to higher tax assessment land uses for community tax collection.

Induced development could also impact cultural resources including nonarcheological historic-age resources and archeological resources. This impact could include changes to the historic setting as well as direct removal of the resource.

Ecological resources would also be impacted by induced growth. New developments could further fragment the existing habitat and vegetation as well as impact waters of the U.S. and water quality throughout the AOI. Additionally, farmlands would be substantially impacted by the induced development, as much of the development may occur on farmed parcels.

The AOI is part of the EPA designated eight-county HGB nonattainment area for O_3. The AOI is currently in attainment for all other NAAQS pollutants, refer to Section 4.6. Based on the results of steps 1 through 4 that evaluated the possible project-related actions that can indirectly impact air, it was determined that the proposed project would not be anticipated to cause indirect air quality impacts in the AOI. No change in attainment status is anticipated within the AOI area as the result of emissions associated with the proposed project. In order for the region to achieve O_3 attainment, a variety of point, nonpoint, and mobile source emission reduction strategies must be implemented for the entire HGB area as outline in the

SIP. Indirect air quality impacts from MSATs are unquantifiable due to existing limitations to determine pollutant emissions, dispersion, and impacts to human health. Emissions would likely be lower than present levels in future years as a result of the EPA's national control regulations (i.e., new light-duty and heavy duty on road fuel and vehicle rules, the use of low sulfur diesel fuel). Even with an increase in VMT and possible temporary emission increases related to construction activities, the EPA's vehicle and fuel regulations, coupled with fleet turnover, will over time cause substantial reductions of on road emissions, MSATs, and the O_3 precursors VOC and NO_X. As the proposed project is not anticipated to result in indirect air quality impacts, further discussion in steps 6–7 below is not necessary.

Substantial indirect impacts to socioeconomic resources, cultural resources, ecological resources, air quality, and farmland resources may occur within the AOI. These resources will be further examined in steps 6 and 7, as appropriate.

5.7 STEP 6 – ANALYZE INDIRECT EFFECTS AND EVALUATE RESULTS

5.7.1 Land Use

Transportation projects located in rural areas such as the proposed Grand Parkway Segment C are likely to stimulate complementary land development. Complementary land development, such as highway-oriented businesses (gas stations, convenience stores, fast-food restaurants, motels), is more likely near interchanges in rural areas where property values were originally low. Factors influencing the likelihood and rate of development near rural interchanges include (1) the distance to a major urban area or regional center; (2) traffic volume on the intersecting road; (3) presence of a frontage road (greater potential for intensive development); and (4) availability of water and sewer and other infrastructure (NRC, 2002).

The AOI covers approximately 376,900 acres with approximately 189,200 acres (50.2 percent of AOI) being developed land.

The pattern of development anticipated for the proposed Grand Parkway Segment C includes interchange quadrants with US 59, FM 762, and SH 288. These quadrants have a higher visibility for motorists approaching the interchange from the main road and are often developed first (NRC, 2002). The Expert Panel has determined development at these interchanges would likely be new commercial development.

The proposed action is only one factor in creating favorable land development conditions. Other prerequisites for land development opportunities include the demand for new development, favorable local and regional economic conditions, adequate utilities, and supportive local land development regulations and policies.

Decisions to change current land-use patterns along these roadways could be a result of the indirect effects associated with travel demand of the Grand Parkway Segment C project. These effects on land use could mean that local jurisdictions would find opportunities to modify zoning, accommodate higher intensity uses, change local land-use type, or increase the

density of existing uses at these high-volume interchanges. These potential changes to land-use patterns, however, remain within the purview of local agencies.

Land-use controls exist in the form of comprehensive plans and zoning ordinances; therefore, proposed development would take place through the typical platting process. Cities within or adjacent to the AOI have adopted comprehensive plans and land-use plans including "Our Vision 2025 Comprehensive Plan (City of Sugar Land, 2012), the "2009 Comprehensive Plan" (City of Missouri City, 2009), and "Manvel A Visionary Future 2007 Comprehensive Plan" (City of Manvel, 2007); however, their ETJ only cover a portion of the AOI that may be affected by growth.

Based on discussions with the Expert Panel, it is anticipated under the Grand Parkway Segment C project, undeveloped land at or near entrance/exit ramps at highway interchanges and intersections would be anticipated to be developed for residential and commercial uses over time. Currently, there is a limited amount of undeveloped land at the US 59/Grand Parkway interchange with Riverpark Shopping Center located on the northeast corner of the interchange and Memorial Sugar Land Hospital on the northwest corner. Some undeveloped land exists northwest of the interchange (land along Ransom Road and US 59), with additional undeveloped land southeast of the interchange (land along US 59 service road), and on both sides of FM 2759. Current development at the proposed FM 762 interchange includes Brazos Gardens subdivision to the north and Bridlewood Estates to the south with undeveloped land along the existing Crabb River Road (FM 2759). It is anticipated that residential and commercial development would occur over time. Further south at the proposed Reading Road intersection there is currently residential development (Bridlewood Estates) to the west with undeveloped land north, east, and south. It is anticipated that residential development would occur over time. South of George Ranch a proposed interchange with FM 762 is located in an undeveloped area that would most likely be developed as residential over time. An additional FM intersection located south of Brazos Lakes subdivision is proposed in a currently undeveloped area. Over time, this area may become residential in nature. Just north of Brazos Bend Oaks subdivision, a proposed intersection with a future extension of Peters Road would provide access to Brazos Bend Oaks. Currently the land is undeveloped and it is anticipated that this area would become residential development over time. There is currently no development at the proposed interchange with FM 521. TDCJ Darrington Unit owns the land in all directions of this interchange; therefore, residential and commercial development is not anticipated to occur as a result of Grand Parkway Segment C in this area. Currently the area near the proposed intersection with CR 48 is comprised of scattered residential development and this type of development is anticipated over time. At the proposed SH 288 interchange, there is no current development; therefore, it is anticipated that potential commercial and residential development would occur over time.

Approximately 16,300 acres of developed land are within the Area of Potential Indirect Effect (4 percent of total AOI). Within the Area of Potential Indirect Effect, there are 67,626 acres of undeveloped land (18 percent of the total AOI) that could be indirectly impacted as a result of the Grand Parkway Segment C project. While nearly 18 percent of the AOI is available for development, indirect development would likely occur at interchanges and include a variety of land-use intensities such as convenience stores, gas stations, and residential. Due to the limited new access, exclusion of frontage

roads, indirect development as a result of the Grand Parkway Segment C project is only anticipated to occur along existing roadways and interchanges/intersections. There would be no indirect effects as a result of the No-Build Alternative.

5.7.2 Geology, Soils, and Farmlands

Construction of the proposed Grand Parkway Segment C and associated indirect development at proposed entrance/exit ramps and highway interchanges would result in a direct loss of some soils due to grading and soil removal at construction sites. Future construction may expose some geologic resources to erosion, but this type of exposure would be of short duration and is usually associated with grading, excavation, and placement of fill material. Typically, soils would be removed from the ROW and the remaining soils would be subject to compaction and increased erosion potential. These effects would be short term, localized, and manageable. Soil erosion and increased sedimentation of area waterbodies from indirect development that disturbs 1 or more acres are required to obtain authorization under the TPDES stormwater construction general permit; these impacts would be minimized through the requirement to prepare and obtain a TCEQ TPDES permit and associated SW3P.

Based on the development forecasted under the Grand Parkway Segment C project, additional prime farmland soils at proposed interchanges with US 59, FM 762, CR 48, and SH 288 would be converted to nonagricultural uses. Currently within the AOI, there are approximately 264,000 acres of prime farmland, of which 66,882 acres are within the Area of Potential Indirect Effect (18 percent of total AOI) that might be indirectly impacted as a result of the Grand Parkway Segment C project. There would be no indirect effects as a result of the No-Build Alternative.

5.7.3 Social

Indirect development may occur as a result of the Grand Parkway Segment C project and could affect residents nearby. Induced growth changes the intensity of the use of land caused by the project. For this proposed project, "induced growth is attributed to changes in accessibility caused by the project, which influences where development occurs" (NRC, 2002). The degree to which indirect development may occur is dependent on many variables and is difficult to predict. As previously mentioned, indirect development would likely occur at interchanges and include a variety of land-use intensities such as convenience stores, gas stations, and residential. In addition, indirect effects may include an increase in the density of existing residential areas as well as increases in utility and social service demands and the conversion of rangeland, cropland, and/or undeveloped land to additional residential or other urban forms of land use (NRC, 2002). Under the No-Build Alternative, land development would still occur in these interchange areas, but would likely be residential in nature as well as ancillary commercial development to support the anticipated residential growth.

Indirect development that may occur as a result of the proposed Grand Parkway Segment C could affect the daily lives of residents currently living within the AOI, particularly those that live in rural areas. The degree to which indirect development may occur is dependent on many variables and is difficult to predict. Existing residential areas may become more densely populated, utility and social service responsibilities may increase, and forest, pasture, and croplands may be converted to

additional residential areas or other urban forms of land use; thereby, decreasing area opportunities for a more rural lifestyle.

As suburbanization/development of the rural area continues, the rural connections between existing "neighbors" may be impacted as the forecasted development would occur in open areas and could potentially change the rural nature of the AOI. This could be perceived as a negative change to the existing rural community, if the community favors a rural lifestyle rather than a suburban lifestyle. To others, new development often means potential new jobs, increased economic utility, reduced travel times for users of the new roadway, and potentially reduced travel times for users on the current roadway network because of reduced congestion. For others, this change is unwanted and development is undesirable as land is converted to residential and commercial uses and area populations increase.

Within the AOI, there are minority and low-income communities that could be indirectly impacted by the Grand Parkway Segment C project. The minority communities are generally located adjacent to existing major thoroughfares and would not be directly impacted by the proposed project but could face changes in their existing travel patterns and commuting options. Additionally, communities and individuals that are considered to be low-income also exist in the AOI. These individuals could be indirectly impacted as they would pay a larger percentage of their income in tolls when compared to the general population, given the same level of use. If the toll is beyond the affordability of certain low-income travelers, they would have the alternative of utilizing the existing nontolled transportation network, along with the discontinuous access roads being developed as part of this project. As a result, those who are unable to afford the toll or could not maintain a toll tag could be denied the travel benefit (full reduction in travel time delay) associated with using the tolled facility. However, improvement in the local economy as discussed below could provide benefits to minority and low-income populations in the form of new job opportunities.

There would be no indirect effects as a result of the No-Build Alternative.

5.7.4 Economics

Indirect economic impacts would be tied to potential indirect development. An increase in commercial development would provide increased income, employment and earnings opportunities, and additional tax revenues. Residential growth could also increase tax revenues, which local governments could turn into increased and/or improved community services, use to maintain and improve local roadways, and improve and provide public recreational opportunities. Growth in residential/commercial development could increase the demand for consumer services, including but not limited to retail, banking, medical, and recreational. The Grand Parkway Segment C project would most likely encourage a mixture of residential and commercial, thereby potentially increasing the new employment and additional services within the AOI. There would be no indirect effects as a result of the No-Build Alternative.

5.7.5 Pedestrians and Bicyclists

Pedestrians and bicyclists could benefit from the indirect development of residential and commercial development including streets associated with the proposed Grand Parkway Segment C. This benefit could be further realized if pedestrian walkways and bicycle facilities are incorporated into plans for these new developments. Under the Grand Parkway Segment C project, proposed pedestrian walkways and bicycle facilities would be considered for incorporation where determined safe, reasonable, and feasible. The Grand Parkway Segment C project would not disrupt existing and planned pedestrian and bicycle facilities within the AOI. There would be no change in access to pedestrian and bicycle facilities under the No-Build Alternative.

5.7.6 Air Quality

Direct impacts on air quality and MSATs from the project are primarily those associated with the increased capacity and accessibility, as well as the resulting projected increases in VMT. EPA's new fuel and vehicle standards projected to reduce emissions of air pollutants and MSATs are expected to offset these impacts resulting from the increases in VMT. These net emissions reductions are expected to contribute to continued maintenance and improvement of air quality and MSAT levels in the AOI.

The potential indirect impacts on air quality and MSATs are primarily related to any expected development/redevelopment resulting from project's increased accessibility or capacity to the area. The project might be expected to cause an increased development in the area. This development would primarily consist of residential and commercial development. However, any increased air pollutant or MSAT emissions resulting from the potential development of the area must meet regulatory emissions limits established by the TCEQ and EPA, as well as obtain appropriate authorization from the TCEQ. Regulatory emission limits set by TCEQ and EPA are established to attain and maintain the NAAQS by assuring any emissions sources resulting from new development or redevelopment will not cause or contribute to a violation of those standards.

Therefore, because the project's potential direct and indirect impacts on air quality and MSATs are projected to be offset by federal fuel and vehicle control programs or state and federal regulatory programs, negative impacts on air quality are not anticipated.

5.7.7 Noise

Future increases in ambient noise levels associated with projected residential development are anticipated, especially in proximity to the proposed Grand Parkway Segment C. Under the Grand Parkway Segment C project, the network of future roadways and development would be expected to contribute to an increase in ambient noise levels. The density and type of future development within the AOI would contribute to the overall changes in noise levels. Current ambient noise levels would remain the same under the No-Build Alternative.

5.7.8 Water Quality

Development under the Grand Parkway Segment C project would result in some effects to water resources associated with projected regional and local developments resulting in increases in stormwater runoff levels and nonpoint source pollution. Development effects that contribute to water quality degradation include increased impermeable surface and increased nonpoint source pollution (e.g., from fertilizers, pesticides, sediments, and vehicle residues), which would result in increased stormwater runoff velocities and pollutant loads leading to impacts to surface waters, and subsequently, groundwater.

Increased stormwater runoff could potentially introduce pollutants leading to toxicity and behavioral effects of various species resulting in degradation of habitats, which could elicit changes in reproductive behavior and rates, as well as changes in food sources. Ultimately, this trend could result in changes in ecosystem structure and function.

The network of future roadways and subdivision streets associated with indirect development could contribute both the direct and indirect effects; however, the density and type of future development within the AOI would determine the amount and type of the runoff. Currently, there are approximately 1,059 miles of streams within the AOI, of those, approximately 307 miles of streams occur in the Area of Potential Indirect Effect. Regional and local stormwater regulations would minimize development effects as undeveloped land is developed; therefore, there are no substantial differences anticipated in water quality between the Build and No-Build alternatives.

5.7.9 Waters of the U.S., Including Wetlands

With the construction of the Grand Parkway Segment C project, some degradation of waters of the U.S., including wetlands, may occur from induced development within the AOI. Potential effects to waters of the U.S. from development include loss of wetland habitat as a result of placement of fill and degradation through encroachment and as a result of increased runoff.

The alteration of natural hydrological processes would indirectly alter energy flows, which would potentially change immigration and emigration of species and change the vegetative structure of the AOI. There are approximately 38,400 acres (10 percent of total AOI) of wetlands that occur within the AOI, of these, 9,633 (3 percent of total AOI) occur within the Area of Potential Indirect Effect. As described in Step 4 above, the proposed project is not anticipated to induce substantial new development in the AOI. Because planned development, rather than the proposed Grand Parkway Segment C, are driving changes in land use within the AOI, indirect effects to water resources from induced development associated with the proposed project would be insubstantial. However, the rate at which this planned development occurs could be enhanced by the proposed project, resulting in a faster occurrence of planned development.

Regardless of whether the indirect development would be public or private, these developments would have to comply with Sections 404 and 401 of the CWA, which regulates the filling of and encroachment on these resources. The USACE administers Section 404 of the CWA and operates under “no net loss” policy for wetlands, requiring avoidance and

minimization of impacts, and compensatory mitigation for unavoidable impacts. Compensatory mitigation may include mitigation banking under specific criteria defined and approved by the EPA and USACE; therefore, substantial indirect impacts to waters of the U.S., including wetlands, are not anticipated as a result of the Grand Parkway Segment C project. There would be no indirect effects to waters of the U.S., including wetlands as a result of the No-Build Alternative.

5.7.10 Vegetation and Wildlife Habitat

Development under the Grand Parkway Segment C project would impact vegetation and wildlife habitat through a continuing net loss of established, late successional woody and herbaceous vegetation, fragmentation of remaining vegetation resources, and reduction of habitat connectivity in the larger area.

With the construction of the Grand Parkway Segment C project, wildlife habitat is anticipated to be impacted by the indirect development resulting from the conversion of connected habitat to urban land uses. Currently, approximately 284,500 acres of pastureland/grassland/cropland and 74,600 acres of forestland exist within the AOI. Approximately 62,504 acres of pastureland/grassland/cropland (17 percent of total AOI) and 13,485 acres of forestland (4 percent of total AOI) occur within the Area of Potential Indirect Effect that would be potentially developed. There would be no indirect effects as a result of the No-Build Alternative.

5.7.11 Floodplains

The 100-year floodplains would pose a constraint to development under the Build and No-Build Alternative. This constraint relates to the regulation of these floodplains through federal, state, county, and local ordinances. While these ordinances do not prohibit development within the 100-year floodplain, they limit and regulate development to eliminate or reduce potential damage from future floods. There are approximately 135,800 acres of 100-year floodplains within the AOI, of which 26,328 acres (7 percent of total AOI) occur within the Area of Potential Indirect Effect.

EO 11988 (1977), Floodplain Management, and county and local ordinances would minimize floodplain encroachment to the extent allowable within the regulations, thereby preserving some of a floodplain's natural values. These values include retention of riparian vegetation buffers, which preserve wildlife habitat and provide natural filtration for improved water quality. Any indirect impacts to the 100-year floodplains would be required to comply with federal, state, county, and local regulations; therefore, indirect impacts as a result of the Build and No-Build Alternative are not anticipated.

5.7.12 Wild and Scenic Rivers

The proposed project is not situated in the vicinity of any river on the National Inventory of River Segments included in the National Wild and Scenic River System; therefore, no direct or indirect impacts to Wild and Scenic Rivers would occur.

5.7.13 Coastal Barriers

The proposed project is wholly outside any coastal barrier systems and would not directly or indirectly impact coastal barrier resources.

5.7.14 Coastal Zone Management

The proposed project is not within the Coastal Management Program boundary, and therefore coordination with the Coastal Zone Management Act is not required.

5.7.15 Essential Fish Habitat

The proposed project does not intersect tidally influenced coastal waters and would have no direct or indirect impact on EFH. Coordination with the NMFS is not required.

5.7.16 Threatened and Endangered Species

Upon review of information and maps provided by the TPWD, NDD, and USFWS, it was determined that two species, the Bald Eagle and the Texas prairie dawn-flower, would likely occur in the AOI and thus could potentially be impacted by the project.

To determine the potential indirect effects to threatened or endangered species, known occurrences of federally and state-listed species provided by the TPWD's NDD (TPWD, 2011b) were compared with forecasted development. This comparison revealed documented occurrences of threatened or endangered species within the forecasted development. Under the Grand Parkway Segment C project, any proposed development, public or private, would be subject to regulation under the ESA. Based on the protection provided under the ESA, indirect effects to threatened and endangered species are not anticipated. There would be no indirect effects as a result of the No-Build Alternative.

5.7.17 Cultural Resources

5.7.17.1 Nonarcheological Historic Resources

Potential indirect impacts to nonarcheological historic resources may include visual, noise, or other types of effects at distances well removed from the area of project construction. Increased development could increase incidences of looting and vandalism of historic resources. With the construction of the Grand Parkway Segment C project, the addition of commercial development near interchanges could have an indirect impact on nonarcheological historic resources. There would be no indirect effects as a result of the No-Build Alternative.

5.7.17.2 Archeological Resources

Indirect development could increase incidences of looting, vandalism, and nonscientific collecting of archeological resources. However, based on assumptions made by the Expert Panel, indirect project impacts would not be located within the AOI 100-year floodplains, which have a high probability for archeological resources. Under the Grand Parkway Segment C project, the addition of commercial development near interchanges could have an indirect impact on archeological resources. There would be no indirect effects as a result of the No-Build Alternative.

5.7.18 Hazardous Materials

Potential indirect impacts from hazardous materials locations could occur because of land disturbing activities from potential development, infrastructure, or utility improvements an indirect result of the proposed Grand Parkway Segment C construction. Under the Grand Parkway Segment C project, this risk could be minimized or avoided by conducting a Phase I ESA to identify potential hazardous materials prior to property acquisition and development. Under the No-Build Alternative, no indirect development would occur.

5.7.19 Visual and Aesthetic

The proposed Grand Parkway Segment C would alter the rural setting in which it is constructed. Effects to visual quality would take two forms: views of the proposed facility from various points, and views from the proposed facility of the surrounding landscape. With the construction of the Grand Parkway Segment C project, indirect development could alter the current visual landscape within the AOI. These developments, particularly commercial developments, would likely include streetlights and/or security lighting that would be expected to result in incremental and localized increases in ambient light levels, glare, and nightglow. The lighting, signage, landscape, and roadway designs would be used to enhance the aesthetics of the proposed AOI, not destroy it; therefore, indirect effects are anticipated to be minimal. Additional visual effects would potentially result from the elevated interchanges with US 59, FM 762, Reading Road, Peters Road, FM 521, CR 48, and SH 288. However, based on surrounding roadways, US 59, SH6, SH 288, and the urbanization of Brazoria and Fort Bend counties, these types of visual impacts would not be considered substantial. There would be no indirect effects as a result of the No-Build Alternative.

5.8 STEP 7 – ASSESS CONSEQUENCES AND CONSIDER/DEVELOP MITIGATION

5.8.1 Land Use

Long-term changes would occur to the land as a result of the Build Alternative and the No-Build Alternative. These changes are consistent with the goals/trends for the AOI as they would be approved and advanced by the impacted cities in accordance with a majority of the community planning initiatives. The land development would generally be private ventures and impacts that require mitigation would be included in the site design and construction. Although land changes

would occur as a result of the Build Alternative, it is anticipated that community planning initiatives would oversee and regulate the impacts to ensure that the changes are not adverse.

5.8.2 Geology, Soils, and Farmland

Prime farmland soils and local farm operations would be affected by the forecasted development under the Build Alternative. However, the farmers and ranchers of the various operations would be willing sellers as these ventures are private developments. Therefore, the resource of concern is actually the loss of prime farmland soils. The NRCS and other private entities are making concerted efforts to support the preservation of farmland by funding programs designed to purchase easements to limit land development. Additionally, the NRCS is working in partnership with local conservation districts and Resource Conservation and Development Councils to provide local jurisdictions with natural resource information, land use planning tools, and other technical assistance that can help communities develop comprehensive growth management plans.

It is anticipated that the Grand Parkway Segment C induced development would indirectly impact prime farmland soils within the AOI. However, as the induced development will primarily be associated with interchange areas, the indirect effects to prime farmland soils from induced growth resulting from the Grand Parkway Segment C would be considered moderate.

5.8.3 Social

It is anticipated that the construction of Grand Parkway Segment C project would increase the rate of development within the AOI, which may alter the sense of rural community that currently exists in some locations. Development in the AOI is already underway and more development is expected to occur both with and without the proposed Grand Parkway Segment C facility. However, the location and speed of development would also be dependent on how and where the communities within the AOI upgrade infrastructure, such as water, wastewater, and adjoining transportation facilities to support this new development. While forecasted development under the Build Alternative and the No-Build Alternative would potentially change the rural nature of the AOI, this development would potentially lead to additional supporting community services, such as recreational and emergency services throughout the AOI. Accordingly, increased community and recreational facilities would likely result in increased community and civic interaction. It is not anticipated that the induced development resulting from the implementation of the Build Alternative would have an adverse indirect effect on community cohesion or neighborhoods within the AOI. However, the induced development could be perceived as having adverse effects on those communities and persons who prefer a rural lifestyle to a more suburban lifestyle.

5.8.4 Economics

Long-term employment and economic benefits would be favorable as a result of the Grand Parkway Segment C project. Current industrial development and educational opportunities are transitioning this area from small suburban and semi-rural communities to a more suburbanized area. This transition would result in the area cities serving as residential and

service-providing supporting communities whose futures are more fully integrated into the economic dynamics of the Houston area. Although tax revenues could initially decrease within the AOI as a result of the Grand Parkway Segment C, this initial reduction would be offset by future increases in tax revenues anticipated with the new development, which would in turn pay potentially higher tax revenues. It is anticipated that the induced development resulting from the implementation of the Build Alternative would have a beneficial indirect effect on economic conditions within the AOI.

5.8.5 Pedestrians and Bicyclist

There is minimal potential for indirect impacts to existing pedestrian and bicyclist facilities. Some of the forecasted residential development would likely provide additional pedestrian and bicycle facilities. It is not anticipated that the induced development resulting from the implementation of the Build Alternative could have an adverse indirect effect on pedestrian and bicyclist facilities within the AOI.

5.8.6 Air Quality

The indirect impacts on air quality from the Build Alternative are addressed at the regional level by analyzing the air quality impacts of transportation projects in the H-GAC's 2035 RTP Update approved on January 25, 2011, and FY 2011–2014 TIP, as amended and proposed by H-GAC. The RTP and TIP were found to conform to the SIP on July 21, 2010.

A variety of federal, state, and local regulatory controls as well as local plans and projects have had a beneficial impact on regional air quality. The CAA, as amended, provides the framework for federal, state, tribal, and local rules and regulations to protect air quality. The CAA required the EPA to establish NAAQS for pollutants considered harmful to public health and the environment. In Texas, the TCEQ has the legal authority to implement, maintain, and enforce the NAAQS. The TCEQ establishes the level of quality to be maintained in the state's air and to control the quality of the state's air by preparing and developing a general comprehensive plan. Authorization in the Texas Clean Air Act (TCAA) allows the TCEQ to do the following: collect information and develop an inventory of emissions; conduct research and investigations; prescribe monitoring requirements; institute enforcement; formulate rules to control and reduce emissions; establish air quality control regions; encourage cooperation with citizens' groups and other agencies and political subdivisions of the state as well as with industries and the federal government; and to establish and operate a system of permits for construction or modification of facilities. Local governments having some of the same powers as the TCEQ can make recommendations to the commission concerning any action of the TCEQ that may affect their territorial jurisdiction, and can execute cooperative agreements with the TCEQ or other local governments. In addition, a city or town may enact and enforce ordinances for the control and abatement of air pollution not inconsistent with the provisions of the TCAA or the rules or orders of the TCEQ.

The CAA also requires states with areas that fail to meet the NAAQS prescribed for criteria pollutants to develop a SIP. The SIP describes how the state would reduce and maintain air pollution emissions in order to comply with the federal standards. Important components of a SIP include emission inventories, motor vehicle emission budgets, control strategies to reduce emissions, and an attainment demonstration. The TCEQ develops the Texas SIP for submittal to the EPA. One

SIP is created for each state, but portions of the plan are specifically written to address each of the non-attainment areas. These regulatory controls, as well as other local transportation and development initiatives implemented throughout the Houston area by local governments and other entities provide the framework for growth throughout the area consistent with air quality goals. As part of this framework, all major transportation projects, including the Build Alternative, are evaluated at the regional level by the H-GAC for conformity with the SIP.

5.8.7 Noise

Changes in the development within the AOI are anticipated to increase the ambient noise for the entire area. However, such impacts are not anticipated to be substantial.

5.8.8 Water Quality

Section 401 of the CWA Water Quality Certification of Federal Actions, such as permits for work in jurisdictional waters, requires BMPs be used to control erosion, sedimentation, and post-construction total suspended solids. In addition, water quality effects from development would be minimized by implementing an SW3P in compliance with TPDES requirements and Municipal Separate Storm Sewer System (MS4) in conjunction with city improvements. For construction projects disturbing more than 5 acres under the TPDES, an NOI is required to be submitted to the TCEQ prior to construction. In addition to the federal and state regulations in place, many local government ordinances include provisions that provide some level of water pollution prevention. This includes varying levels of water quality protection measures through processes such as site plan approval and construction site inspections to verify implementation of SW3Ps. Substantial indirect effects to water quality are not anticipated. The potential exists for some indirect effects to water resources from induced growth or from roadway contaminants from the Grand Parkway Segment C facility. However, by implementing mitigation measures these impacts would be considered minimal.

5.8.9 Waters of the U.S. including Wetlands

Changes in land use and related effects on wetlands and waters of the U.S. are currently occurring and are expected to continue. Induced development and corresponding excavation or increases in stormwater flow could encroach upon and/or affect aquatic resources by changing vegetation/wildlife habitat or hydrology and therefore potentially changing the size, functions, or value of the resources.

Regardless of whether the forecasted development would be public or private, these developments would have to comply with sections 401 and 404 of the CWA, which regulate the filling of and encroachment on these resources. The USACE administers Section 404 of the CWA and operates under a “no net loss” policy for protected wetlands, requiring avoidance and minimization of impacts, and compensatory mitigation for unavoidable impacts. Because of the USACE regulations, any potential loss of waters of the U.S. from the indirect developments would be mitigated to compensate the loss by the entity advancing the development.

5.8.10 Vegetation and Wildlife Habitat

The proposed project would indirectly affect undeveloped land or potential wildlife habitat through permanent conversion of these habitats into homes and commercial sites. Although no current direct mechanisms exist to mitigate directly for impacts to vegetation and wildlife habitat, some vegetation and habitat is protected. Any vegetation associated with a federal threatened or endangered species habitat would be protected under the ESA and would require mitigation, if impacted. Additionally, the USACE regulates wetlands, which can include bottomland hardwood forest, and other wetland areas defined by the USACE. This vegetation and associated wildlife habitat would be mitigated for through the USACE permitting process for any impacts to these resources. Additionally, forecasted indirect development could incorporate parks, green space, and tree coverage into their developments to provide some wildlife shelter and habitat and potentially offset some of the impacts to vegetation and wildlife habitat that was incurred.

5.8.11 Cultural Resources

5.8.11.1 Nonarcheological Historic-Age Resources

The forecasted development in the AOI under any alternative, including the No-Build Alternative, may fall under federal or state regulatory resource protection review based on development funding sources. Transportation projects using federal funding require consideration of effects to historic (NRHP-listed or -eligible) resources under Section 4(f) of the DOT Act and under Section 106 of the National Historic Preservation Act. Additionally, most development requiring federal permits would also require consideration of historic properties under Section 106. Finally, development using state or county funds could require consideration of impacts to significant resources qualifying for SAL designation under the Antiquities Code of Texas. If development in the AOI was sponsored by federal, state, or local entities or used federal funds or permits, the historic properties in the AOI could be protected or preserved. However, if development was privately sponsored and no federal permit or action was necessary, the historic resource could be impacted with no investigation or mitigation. The potential exists for indirect impacts from forecasted development for both the Build and No-Build Alternatives. As mentioned above, these impacts could be offset depending on the type of development advanced. Overall, the impacts to these resources would not be considered substantial.

5.8.11.2 Archeological Resources

A possibility exists for indirect impacts to archeological resources in the AOI as land is converted to residential and commercial uses. Development in the floodplain would be minimized, thereby protecting the areas with some of the greatest potential for buried and preserved archeological resources. Some of the development under these alternatives may fall under federal or state regulatory resource protection review; therefore, future archeological investigation for induced development would be conducted for archeological sites for integrity and significant by others. Mitigation of the sites that offer potential to provide additional scientific information would be conducted by others.

5.9 SUMMARY

The degree to which indirect development may occur is dependent on many variables. Based on discussions with the Expert Panel, indirect development would likely occur at the interchange with US 59, FM 762, CR 48, and SH 288 and include a variety of land uses such as convenience stores, gas stations, retail strip malls, restaurants, office buildings, and residential, including multifamily. In addition, indirect effects may include an increase in the density of existing residential areas as well as increases in utility and social service demands and the conversion of rangeland, cropland, and/or undeveloped land to additional residential or other urban forms of land use.

This summary does not account for the potential decreases or increases in impacts associated with the potential redistribution of development from other parts of the region. The effects of induced development from the proposed Grand Parkway Segment C include increased development at or near interchanges resulting in loss of farmland and ecological resources, such as streams and wetlands and wildlife habitat; a shift in the rural character of the corridor as development occurs; and a degradation of water quality, due to changes in land use and increased impervious surfaces.

While the proposed Grand Parkway Segment C could potentially cause indirect effects from induced development, this development and its resulting effects are not considered substantial due to the continual urbanization of Brazoria and Fort Bend counties, including planned developments within the AOI, when compared with the No-Build Alternative. The anticipated indirect effects to the resources evaluated in this analysis are not likely to be substantial. Table 5-4 summarizes the indirect effects anticipated as a result of the proposed Grand Parkway Segment C.

TABLE 5-4
SUMMARY OF INDIRECT EFFECTS

Resource/Issue	Indirect Impacts
Land Use	67,626 acres of indirect impacts (18% of the AOI). Indirect development in the AOI would be consistent with all local and state government plans and policies.
Geology, Soils, and Farmlands	66,882 acres of indirect impacts to prime farmlands (18% of the AOI).
Social	In the AOI, rural areas are anticipated to continue to transition into a suburban setting near the intersections of US 59 FM 762, CR 48, and SH 288. New development would provide services, offices, and some housing for residents living within the AOI.
Economics	An increase in commercial development would provide increased income, employment and earnings opportunities, and additional tax revenues within the AOI. Residential growth could also increase tax revenues, which local governments could turn into increased and/or improved community services, maintain and improve local roadways, and improve and provide public recreational opportunities.
Pedestrians and Bicyclists	Pedestrians and bicyclists could benefit from the indirect development of future residential and commercial development including streets associated with the proposed Grand Parkway Segment C. However, because the proposed project would be on new location it would not indirectly impact existing pedestrian or bicyclist facilities.
Air Quality	The MSAT analysis does not indicate an appreciable difference in MSAT emissions in 2035 between the Build and No-Build alternatives.

TABLE 5-4, CONT'D

Resource/Issue	Indirect Impacts
Noise	Future increases in ambient noise levels associated with projected development are anticipated, especially in proximity to the proposed Grand Parkway Segment C. The network of future roadways and development would be expected to contribute to an increase in ambient noise levels.
Water Quality	307 miles of streams have been identified within the Area of Potential Indirect Effect. Development could result in adverse effects to water resources through degradation of surface water and groundwater, more rapid discharge to stormwater, and additional pollutant loadings of waterways
Waters of the U.S. including Wetlands	Some degradation of waters of the U.S., including wetlands from induced development potentially affecting 9,633 acres of wetlands (2% of the total AOI) occur in the Area of Potential Indirect Effect.
Vegetation and Wildlife Habitat	Induced development may affect approximately 62,504 acres of pastureland/ grassland/cropland (17% of the AOI) and 13,485 acres of forestland (4% of the AOI) in the Area of Potential Indirect Effect.
Floodplains	Indirect development would not occur within 100-year floodplains. Access points to the proposed Grand Parkway Segment C are limited to intersection with US 59 and SH 288, outside of the 100-year floodplains to minimize any potential for future floodplain development.
Wild and Scenic Rivers	The AOI is outside of any river on the National Inventory of River Segments included in the National Wild and Scenic River System; no indirect impacts to wild and scenic rivers.
Coastal Barriers	The AOI is outside of any coastal barrier systems; no indirect impacts to coastal barrier systems.
Coastal Zone Management	The AOI is outside of any coastal zone management; no indirect impacts to coastal zone management.
Essential Fish Habitat	The AOI is outside of any tidally influenced coastal waters; no indirect impacts to EFH.
Threatened and Endangered Species	Based on the limited occurrence of the Bald Eagle and the Texas prairie dawn-flower within the AOI and the protection provided under the ESA, indirect effects to threatened and endangered species are not anticipated.
Nonarcheological Historic Resources	There is a possibility for indirect impacts to nonarcheological historic resources in the AOI as land is converted to residential and commercial uses.
Archeological Resources	There is a possibility for indirect impacts to archeological resources in the AOI as land is converted to residential and commercial uses. Development in the floodplain would be minimized; thereby, protecting the areas with some of the greatest potential for archeological resources.
Hazardous Materials	Risk associated with land disturbing activities could be minimized or avoided by conducting a Phase I ESA to identify potential hazardous materials prior to property acquisition and development.
Visual and Aesthetics	Effects include alteration of the rural setting and indirect development would result in increases in ambient light levels.

Source: Study Team (2012).

5.10 REGIONAL INDIRECT EFFECTS OF TOLL FACILITIES AND MANAGED LANES

The freeway and toll road system is a major component of the Houston-Galveston regional roadway network. Currently, the freeway/toll road system represents nearly 19 percent of regional lane miles. The 2009 regional roadway network consists of nearly 24,571 total lane miles. This includes nearly 658 tolled lane miles and 289 managed lane miles (Table 5-5). By 2035, these numbers are expected to increase to 27,997 lane miles of which 1,584 are tolled lane miles, and 425 are managed lane miles.

TABLE 5-5
REGIONAL ROADWAY NETWORK (LANE MILES)

	Freeway	Toll Roads	Managed Lanes	Arterial	Total Lane Miles
2009 Network	3,669	658	289	19,955	24,571
2035 Network	3,862	1,584	425	22,126	27,997

Source: GP-GEC (2012).
Note: Table data is based on the 2035 RTP Update conducted by H-GAC in 2011.

In addition, the transit system has 485,000 daily passenger boardings and is expected to increase to nearly 725,000 by 2035. This increase will be attributed to:

- Expansion of transit services (increased bus and rail transit services),
- New transit modes (commuter rail transit and signature express bus service),
- Transit connectivity to multiple employment centers, and
- Coordination of transit services among regional public transportation providers.

METRO's 2035 Long Range Plan recommends significant expansion of the current transit system and includes a network of integrated high capacity transit facilities on major travel corridors. This plan also identifies service expansions beyond the METRO service area. New improvements scheduled for implementation through the year 2035 include high-occupancy tolls, a new intermodal terminal, park-n-ride facilities, and several new high capacity transit corridors throughout the region. Additional key elements of the plan include:

- 89 miles of fixed guideway transit – Light Rail Transit (LRT)
- 84 miles of Commuter Rail Transit (CRT)
- 40 miles of Signature Bus (H-GAC, 2009)

Figure 5-1 shows the future corridor and capital facilities projects in the 2035 METRO Long Range Plan.

Figure 5-1
2035 Future Corridor and Capital Facilities Projects

Source: H-GAC (2009).

Conclusion

The expanding regional roadway network, including tolled facilities and managed lanes, along with the expanding transit network could have indirect and cumulative impacts. However, the impacts are not isolated to one location and would be better considered at the regional level. As a result, the consideration of the regional tolled roadway network is included in the cumulative impacts portion of this document.

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SECTION 6: CUMULATIVE IMPACTS ANALYSIS

This section presents the CIA conducted for the proposed Grand Parkway Segment C project. This section includes an introduction to the background and project specific requirements for the evaluation, followed by a description of the methodology utilized to perform the analysis. Subsequent subsections provide the resource specific cumulative effects evaluation, followed by a summary of the results of the analysis.

6.1 INTRODUCTION

Cumulative effects include a project's direct and indirect effects, as well as other actions that are not caused by the project, but in combination with the project, add to the overall effect, whether adverse or beneficial, on the environment. It is the objective of the CIA to focus on key resource issues, potential effects to these resources, and potential mitigation opportunities. This analysis will determine the magnitude of the potential cumulative effects on the resources and will compare those effects to the expected direct effect documented in the FEIS.

This CIA was conducted to comply with the CEQ regulations (40 CFR 1500–1508), the FHWA Technical Advisory T 6640.8A (FHWA, 1987), FHWA Position Paper: Secondary and Cumulative Impact Assessment in the Highway Project Development Process (FHWA, 1992), and TxDOT's *Guidance on Preparing Indirect and Cumulative Impact Analyses* (TxDOT, 2010). The CEQ regulations for implementing the NEPA define Cumulative Effects as:

> "The impact on the environment which results from the incremental impact of the action (project) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7)

While the FHWA position papers and technical guidance require that cumulative effects be evaluated, the agency recognizes there is no standard approach or methodology, area of effect, or predefined impact categories. Therefore, it is necessary to evaluate each project on an individual basis.

Cumulative effects (impacts) include both direct and indirect effects that would result from the project, as well as the effects from other projects (past, present, and reasonably foreseeable future actions) not related to or caused by the proposed Grand Parkway Segment C. Therefore, the CIA includes the direct effects discussed in Section 4, the indirect effects as discussed in Section 5, and effects of other past, present, and reasonably foreseeable actions. The CIA considers the magnitude of the cumulative effect on the resource health. Health refers to the general overall condition, stability, or vitality of the resource and the trend of that condition. Therefore, the resource health and trend are key components of the CIA. Laws, regulations, policies, or other factors that may change or sustain the resource trend will be considered to determine whether more or less stress on the resource is likely in the foreseeable future. The potential cumulative effect will be

compared with that documented in Section 4. Opportunities to mitigate adverse cumulative effects on a stressed resource, or a resource that will continue to be stressed will be presented.

To determine which resources would be carried through the CIA, the Study Team identified those resources that the proposed Grand Parkway Segment C had a substantial direct or indirect impact. The following resource categories are considered for CIA: Land Use, Prime Farmland, Air Quality, Water Quality, Waters of the U.S. including Wetlands, and Vegetation and Wildlife Habitat.

6.2 METHODOLOGY USING THE TXDOT EIGHT-STEP PROCESS

The TxDOT eight-step process is intended to provide an efficient, consistent, and logical method of evaluating cumulative effects of a project. Table 6-1 describes the general eight-step CIA methodology as set forth in the TxDOT *Guidance on Preparing Indirect and Cumulative Impact Analyses* (TxDOT, 2010) and used in this analysis.

TABLE 6-1
EIGHT STEPS FOR IDENTIFYING AND ASSESSING CUMULATIVE EFFECTS

Step 1	Identify the Resources to Consider in the Analysis
Step 2	Define the Study Area for Each Resource
Step 3	Describe the Current Status/Viability and Historical Context for Each Resource
Step 4	Identify Direct and/or the Indirect Impacts of the Project that Might Contribute to a Cumulative Impact
Step 5	Identify Other Reasonably Foreseeable Future Effects
Step 6	Identify and Assess Cumulative Impacts
Step 7	Report the Results
Step 8	Assess the Need for Mitigation

The following sections describe each of the eight steps used in this CIA and the resource specific cumulative effects.

6.2.1 Step 1: Identify the Resources to Consider in the Analysis

Evaluation of cumulative effects should be completed for any resource that was found to be directly or indirectly affected by the proposed project. The first step in performing the cumulative impact analysis was to identify which resources to consider in the analysis. The cumulative impact analysis focused only on (1) those resources significantly impacted (directly or indirectly) by the proposed project, and (2) resources currently in poor or declining health or at risk even if the proposed project impact is relatively small. Table 6-2 summarizes each resource impact and presents a determination of which resources would be carried forward and evaluated in the CIA. The following resource categories were found to have both direct and potential indirect impacts from the proposed Grand Parkway Segment C and will be considered in this cumulative analysis: Land Use, Prime Farmland, Air Quality, Water Quality, Waters of the U.S., including Wetlands, and Vegetation and Wildlife Habitat.

TABLE 6-2
DETERMINATION OF RESOURCES INCLUDED IN THE CUMULATIVE EFFECTS ANALYSIS

Resource	Summary of Direct Effects	Indirect Effects	Topic to be included in Cumulative Effects Analysis	Reason Eliminated from Cumulative Effects Analysis
Land Use	1,538 acres of existing land uses converted to roadway ROW; compatible with local land-use plans.	Approximately 67,600 acres of undeveloped land is within area of potential indirect development.	Yes	N/A
Prime Farmland	651 acres of prime farmland converted to roadway ROW.	Approximately 67,000 acres of prime farmland is within the area of potential indirect development.	Yes	N/A
Social	No communities would be bisected by proposed roadway; roadway would increase access and mobility for developing land uses.	In the AOI, rural areas are anticipated to continue to transition into a suburban setting near the intersection of US 59, FM 762, FM 521, CR 48, and SH 288. New development provides potential for new jobs and increased economic vitality.	No	Within the AOI, rural areas would continue to transition into a suburban setting. New development provides potential for new jobs and increased economic utility. Social impacts are tied to land-use development and potential change in travel patterns; therefore, the evaluation of land use will identify social impacts as well.
Economics	Potential positive and negative effects to property values may occur; positive economic effects during construction and operation.	An increase in commercial development would provide increased income, employment and earnings opportunities, and additional tax revenues. Residential growth could also increase tax revenues, which local governments could turn into increased and/or improved community services, maintain and improve local roadways, and improve and provide public recreational opportunities.	No	Within the AOI, increased commercial and residential growth at US 59 and SH 288 interchanges could generate additional tax revenues, which could improve community services, maintain local roadways, and improve/ provide recreational opportunities. There are no substantial indirect impacts as a result of the Grand Parkway Segment C project. Economic impacts are directly tied to land use; therefore, land use will identify economic impacts as well.
Pedestrians and Bicyclists	None anticipated.	Pedestrians and bicyclists could benefit from the indirect development of residential and commercial development including streets associated with the proposed Grand Parkway Segment C.	No	The Proposed Grand Parkway Segment C would be located on new location and would not indirectly impact pedestrian or bicyclist facilities.
Air Quality	MSAT emissions associated with Segment C are less than 1 ton per year.	Any new transportation projects proposed in the Houston metropolitan area would be required to be analyzed and added to a conforming plan prior to construction.	Yes	N/A

TABLE 6-2, CONT'D

Resource	Summary of Direct Effects	Indirect Effects	Topic to be included in Cumulative Effects Analysis	Reason Eliminated from Cumulative Effects Analysis
Noise	Noise impacts to 20 receivers, 1 noise barrier.	Future increases in ambient noise levels associated with projected development are anticipated, especially in proximity to the proposed Grand Parkway Segment C. The network of future roadways and development would be expected to contribute to an increase in ambient noise levels.	No	The AOI would continue to change from a rural setting to a suburban setting; therefore, altering ambient noise levels in the area. The H-GAC traffic demand model assumes reasonable and foreseeable development in the AOI; therefore, cumulative impacts of noise are accounted for in the existing noise analysis.
Water Quality	Increase of impervious cover due to the construction of roadway ROW would result in a substantial increase in runoff, 997 acres draining into individual streams.	Approximately 300 miles of streams have been identified within the Area of Potential Indirect Effect. No indirect impacts are anticipated, through strict adherence to regulations laid out by the TCEQ, as well as the utilization of BMPs, no adverse indirect impacts to water quality would occur as a result of the proposed project.	Yes	N/A
Waters of the U.S., including Wetlands	33 acres of jurisdictional wetlands and waters of the U.S. would be permanently impacted. These wetlands would most likely be impacted by the placement of fill material in the wetland to elevate the road.	Approximately 9,600 acres of wetlands occur in the area of potential indirect effect.	Yes	N/A
Vegetation and Wildlife Habitat	843 acres of pastureland/ grassland/cropland and 94.1 acres of forestland would be directly affected by roadway ROW.	Approximately 62,500 acres of pastureland/grassland/cropland and 13,500 acres of forestland are within the area of potential indirect effect.	Yes	N/A
Floodplains	330 acres of 100-year floodplains affected by proposed project.	Approximately 26,300 acres of floodplains are within the area of potential indirect effect.	No	Cumulative effects to floodplains are expected to be minimal. County and local ordinances regulate development in 100-year floodplains; so not to negatively affect existing floodplains; therefore, indirect impacts would not occur in 100-year floodplains.
Wild and Scenic Rivers	None present in the study area.	The AOI is outside of any river on the National Inventory of River Segments included in the National Wild and Scenic River System; no indirect impacts to wild and scenic rivers.	No	This resource not present in the AOI.
Coastal Barriers	None present in the study area.	The AOI is outside of any coastal barrier systems; no indirect impacts to coastal barrier systems.	No	This resource not present in the AOI.

TABLE 6-2, CONT'D

Resource	Summary of Direct Effects	Indirect Effects	Topic to be included in Cumulative Effects Analysis	Reason Eliminated from Cumulative Effects Analysis
Coastal Zone Management	None present in the study area.	The AOI is outside of any coastal zone management; no indirect impacts to coastal zone management.	No	This resource not present in the AOI.
Essential Fish Habitat	None present in the study area.	The AOI is outside of any tidally influenced coastal waters; no indirect impacts to EFH.	No	This resource not present in the AOI.
Threatened and Endangered Species	Grand Parkway Segment C project would pass within the secondary management zone of the southernmost Bald Eagle nest. There are no direct impacts to the Texas Prairie dawn-flower.	There are no indirect impacts to federally protected species in the AOI.	No	No direct or substantial indirect impacts are anticipated to the Bald Eagle species or Texas prairie dawn-flower.
Non-Archeological Historic Resources	No NRHP properties would be impacted by the proposed project.	There is a possibility for indirect impacts to nonarcheological historic resources in the AOI as land is converted to residential and commercial uses. Existing patterns of development are equally likely to affect historic resources as the proposed Grand Parkway Segment C.	No	No direct or substantial indirect impacts are anticipated.
Archeological Resources	Four previously recorded and four newly recorded archeological sites located within proposed ROW. Further study and coordination with the agencies would minimize impacts to these resources.	There is a possibility for indirect impacts to archeological resources in the AOI as land is converted to residential and commercial uses. Development in the floodplain would be minimized; thereby, protecting the areas with some of the greatest potential for archeological resources.	No	Sites either lack the potential information that would warrant listing on the NRHP or sites would be avoided during construction.
Hazardous Materials	A total of 6 hazardous material sites were identified within the project area.	Any new project would be required to conduct a Phase I ESA to identify potential hazardous materials prior to property acquisition and development.	No	Risk associated with land disturbing activities could be minimized or avoided by conducting a Phase I ESA to identify potential hazardous materials prior to property acquisition and development.
Visual and Aesthetics	Changing – Transition from a rural to suburban/developed landscape.	Increases in ambient light levels would not result in appreciable increases beyond that anticipated under the No-Build Alternative.	No	The AOI would continue to change from a rural to suburban setting. From a visual standpoint, this change is neither positive nor negative, but would present a different visual landscape to the viewer from what is currently present.

Source: Study Team (2012).

6.2.2 Step 2: Define the Study Area for Each Resource

The CIA considered both geographic and temporal study limits. The geographic study limits were developed for each resource based on the extent of each specific resource and identified as the resource study area (RSA). Because cumulative impacts include both direct and indirect impacts that would result from the project, as well as the impacts from other projects (past, present, and reasonably foreseeable future actions), all cumulative impacts were quantified using impact calculations within the previously identified AOI (Exhibit 37) (confines direct and indirect impacts to identified resources).

Additionally, the temporal limits were considered for the CIA. The time frame was established as the period from a past environmental reference point, in this case the year 1985 to 2035, the planning year for the project. The early date was chosen by determining the decade with the highest percent change in historical population estimates as reported by the U.S. Census Bureau within Fort Bend and Brazoria counties.

In 1960, the population of Fort Bend was 40,527. The population increased in 1970 to 52,314 and continued to increase in 1980 to 130,962 and 1990 to 225,421 persons. From 1990 to 2000, the population increased by approximately 64 percent. The population increased by approximately 61 percent between 2000 and 2010. Brazoria County had a population of 76,204 in 1960, which increased to 108,312 in 1970, 169,587 in 1980, and 191,707 in 1990. Brazoria County's population increased by approximately 79 percent between 1990 and 2000 and approximately 77 percent between 2000 and 2010. The year 1985 was chosen as the past date as a result of available historical aerial photographs. Historical developments for the years 1985, 1995, and 2000 are provided in Exhibit 35.

This established a development or urbanization baseline for the CIA; however, specific historical information was often not available to establish a baseline for each resource. The latter date, 2035, equates to the planning year for the project and the planning year for the Houston-Galveston Area RTP, "2025 Houston-Galveston Area Regional Transportation Plan." Development would continue past 2035; therefore, these scenarios do not represent the ultimate development for these jurisdictions.

Unless noted, temporal boundaries for all resources will be 1985 to 2035; however, some historical context presents information prior to 1985 in order to provide additional background information that helps explain current conditions and patterns of development. The results of the Step 1 evaluation identified six resource categories that warrant further discussion. These include land use, prime farmland, air quality, water quality, waters of the U.S., including wetlands, and vegetation and wildlife habitat.

Land Use

The RSA for land use was identified as the AOI used in the indirect impact analysis. This study limit was identified as an area that confines the direct and indirect impacts to the identified resource. After an evaluation of the roadway system within the project vicinity and an analysis of whether any induced development-shifting circumstances were present, the

AOI was determined to be about 588 square miles (376,900 acres) and is within or adjacent to the communities of Needville, Fairchilds, Pleak, Thompsons, portions of Missouri City, portions of Sugar Land, and Arcola.

Prime Farmland

The RSA for prime farmland was developed using the Land-Use RSA. Land use was used to establish the prime farmlands RSA because impacts to land use have a direct effect to the overall health of prime farmlands. The RSA includes the southeastern portion of Fort Bend County and the southwest portion of Brazoria County. The total acreage of prime farmland is 264,000 acres (70 percent of the RSA).

Air Quality

Evaluating Air Quality in relation to cumulative impacts requires looking at three distinct RSAs, as described below:

- Ozone – The RSA for evaluating the O_3 NAAQS was designated as the HGB 8-hour O_3 nonattainment area, which includes Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller.
- Carbon Monoxide – The RSA for CO was based on the ROW line, which represents the locations with the highest potential for CO concentrations.
- MSATs – Unlike the other resources evaluated, air quality impacts from MSATs have been evaluated qualitatively in this proposed project by TxDOT and FHWA. MSATs are regulated by EPA on a national basis through requirements for fuels and vehicle technology. The MSAT RSA qualitatively evaluated emission changes based upon the proposed project.

The model area was derived from the 2035 No-Build scenario compared to the 2035 Build scenario to determine which roadway links in the model achieved a ±5 percent volume change. These links were then compared to the 2035 model in order to extrapolate a baseline traffic network. The application was adopted as the basis to determine the model area RSA located within the H-GAC Metropolitan Planning Area.

Water Quality

The RSA for water quality was developed by the Study Team identifying the watersheds that intersect the indirect effects AOI (Exhibit 38). The RSA for water quality is over 1,981,000 acres in the southwest Houston metropolitan area and includes the following watersheds: Rabbs Bayou, Dry Creek, Big Creek, Waters Lake Bayou, Brazos River, Oyster Creek, and Hayes Creek. For quantification purposes, only those streams identified within the AOI were used to determine the cumulative effect within the water quality RSA.

Waters of the U.S., including Wetlands

The RSA for waters of U.S., including wetlands was developed using the watershed approach. Watersheds were used to establish the wetlands RSA because impacts to wetlands can affect the overall health of a watershed. Impacts to wetlands can greatly affect watershed health because wetlands are directly connected to watershed hydrology through sheet flow or direct hydrologic connections. The RSA for waters of the U.S., including wetlands, is identical to the watershed boundary developed for water quality and is shown in Exhibit 38.

Vegetation and Wildlife Habitat

The Vegetation and Wildlife RSA encompasses the Gulf Coast Prairies and Marshes ecoregion and within the Texan biotic province as shown in Exhibit 39. This ecological region is characterized by nearly level topography with precipitation averaging 48 inches per year. The regional elevation extends from sea level along the coast up to 250 feet msl in the uplands of Fort Bend and Brazoria counties with little topographic relief within the study area (Hatch et al., 1990). This RSA is approximately 9,405,000 acres.

6.2.3 Step 3: Describe the Current Status/Viability and Historical Context for Each Resource

The historical context and health of each resource is important to establish the baseline condition and trend affecting each of the resources. The historical context is first described to provide an explanation of the factors that have caused the current health of the resource. Health refers to the general overall condition, stability, or vitality of the resource and the trend of that condition.

Where possible, spatial information for past and present actions were derived from historical aerial photographs, and a quantitative assessment of the current health condition and the trend it is experiencing was provided; however, for many resources, quantitative data were not available to document the current health or trend of the resource. For these resources, a qualitative discussion of the resource health and trend is presented, and the types of actions that have caused or influenced resource health and trends are discussed.

Land Use

Historic Context

Primarily rural until the 1970s, the suburban growth of Fort Bend and Brazoria counties has been closely tied to the economic prosperity of Houston. The lower cost of land in Fort Bend and other counties surrounding Houston has drawn residential development away from the central city to areas more affordable for the developer and homeowner. As bedroom communities increased throughout the 1980s, decentralization of Houston continued as jobs and retail sales began to follow homeowners to the suburbs. Over time, the Houston region has become a central city surrounded by smaller edge cities, large enough to support shopping and labor markets.

Much of the area in the Houston vicinity has been developed in a "leap frog" pattern. New subdivisions are built in outlying areas when land closer to the city is still undeveloped. Fitting this growth model, land in the region is developed if it is relatively close to existing subdivisions, is near transportation arteries and is large enough to make the private construction of stand-alone infrastructure economically efficient (Fort Bend Parkway Toll Road Traffic and Revenue Study, 1999). As shown in Exhibit 35, the only residential developments within the RSA in 1985 including nine subdivisions: Brazos Landing, Colony Meadows, Crescent Lakes, First Colony, Greatwood, Lake Point, Laurel Oaks, Sandy Point Estates, and Williams Glen. By 1996, residential development included the following 26 subdivisions: Alcorn Bend, Austin Meadows, Brazos Town Center, Avalon Villages of Avalon, Belgrand Estates, Bridgewater, Clairmont Acres, Commonwealth Estates, Dove Meadows, Fairchild Estates, Fairchild Manor, New Territory, Oaks of Rosenberg, Palmcrest, Plantation Lakes, Rivers Mist, Royal Meadow Lakes, Sandy Point Estates, Schlumberger, Seven Oaks, Sovereign Shores Estates, Sunrise Meadows, Sutton Forest, Sweetwater, Villages at Rosenberg, and Villages at Town Center. By 2011, expansion of residential development among the existing developments included 29 additional subdivisions: Benton Park, Bonbrook Plantation, Brazos Bend Oaks, Brazos Lake, Bridlewood Estates, Canyon Gate at the Brazos, Canyon Lakes at Brazos, First Colony, Double M Ranch, Klobouk Fields, The Lakes, Lakes of Williams, Lincoln Park, Oak Lake Village, The Oaks at Sun Creek, Randy Ridge, Ridge Estates, River Park, River Park West, River Run at Brazos, Royal Lakes Estates, Royal Lakes Manor, Sienna Point, Sovereign Shores Estates, Sterling Lakes, Summer Lakes, Suncreek Ranch, The Retreat, and Valley Vistas Estates (Table 6-3).

This type of growth, master-planned communities developed by private entities, is rapidly occurring in the RSA. Such communities are large enough to lower the per-unit costs of private development of capital infrastructure while at the same time offering open space and community facilities. Often, such communities are annexed by surrounding cities in efforts to improve that city's tax base, providing the residents of the affected area approve it by referendum. Houston and its surrounding edge communities have typically expanded in this way (Fort Bend Parkway Toll Road Traffic and Revenue Study, 1999).

Current Health

The majority of the RSA is located in the southeast portion of Fort Bend County with a smaller portion located in northwest Brazoria County. The area falls within Gulf Coast State Planning Region 16 and is governed by the H-GAC. While the northern reaches of the RSA have seen elements of new residential growth from the Houston metropolitan area, much of the RSA is still characterized by sparse commercial and residential development, with the bulk of the land being level farmland.

Existing land uses within the AOI include numerous residential subdivisions, the George Ranch Historical Park, Thompsons Oil Field, the Darrington Prison Unit, Brazos Bend State Park and scattered urban development (commercial, residential, industrial, and institutional). Existing development within the RSA includes a power plant and residential communities in various stages of completion. In addition, there are numerous projects already in the planning stages, including extensions of master planned communities.

TABLE 6-3
RESIDENTIAL DEVELOPMENTS 1985–2011

1985	1996	2011
Brazos Landing	Alcorn Bend	Benton Park
Colony Meadows	Austin Meadows	Bonbrook Plantation
Crescent Lakes	Brazos Town Center	Brazos Bend Oaks
First Colony	Avalon Villages of Avalon	Brazos Lakes
Greatwood Subdivision	Belgrand Estates	Bridlewood Estates
Lake Point	Bridgewater	Canyon Gate at the Brazos
Laurel Oaks	Clairmont Acres	Canyon Lakes at the Brazos
Sandy Point Estates	Commonwealth Estates	First Colony
Williams Glen	Dove Meadows	Double M Ranch
	Fairchild Estates	Klobouk Fields
	Fairchild Manor	The Lakes
	New Territory	Lakes of Williams
	Oaks of Rosenberg	Lincoln Park
	Palmcrest	Oak Lake Village
	Plantation Lakes	The Oaks at Sun Creek
	Rivers Mist	Randy Ridge
	Royal Meadow Lakes	Ridge Estates
	Sandy Point Estates	River Park
	Schlumberger	River Park West
	Seven Oaks	River Run at the Brazos
	Sovereign Shores Estates	Royal Lakes Estates
	Sunrise Meadows	Royal Lakes Manor
	Sutton Forest	Sienna Point
	Sweetwater	Sovereign Shores Estates
	Villages at Rosenberg	Sterling Lakes
	Villages at Town Center	Summer Lakes
		Suncreek Ranch
		The Retreat
		Valley Vistas Estates

Source: Study Team (2011).

The primary industrial land uses in the RSA include Thompsons Oil Field and Schlumberger Industrial Testing Facility. Thompsons Oil Field is located in the north/central portion of the RSA. Much of this area is wooded or used as pasture. Industry-related dirt roads and buildings owned by various oil companies course through this property. The Schlumberger Facility is located in the eastern portion of the RSA. At this facility, Schlumberger performs underground explosive testing (Exhibit 37). New development is not limited due to the proximity of industrial uses such as Thompson's Oil Field; however, there may be limitations to development immediately adjacent to the Schlumberger facility.

During public involvement activities (see Section 7 of this volume), citizens indicated that they would use the proposed project as a link to the existing interstate or state highways for travel to areas outside Houston. Major roadways located within or bordering the AOI include US 59, SH 6, FM 2759 (Crabb River Road), FM 762, FM 521, FM 1462, and SH 288. US 59 and SH 288 are two radial highways connecting Houston to its suburbs and beyond. No reasonable freeway alternative connecting major radial facilities exists in the AOI and travelers are forced to access SH 6 or Beltway 8 for east-west travel. Secondary roads include FM 2759, FM 762, FM 521, and FM 1462; however, none provide a continuous connection from US 59 to SH 288 and the majority of RSA land is undeveloped and lacks transportation infrastructure.

The most intensive development is found in the rapidly growing northwestern portion of the RSA adjacent to the US 59 interchange. Suburban residential and commercial growth has recently occurred along Crabb River Road near US 59. Newer and planned urban development extends to the south and west. Subdivisions (Greatwood and Canyon Gate) have been constructed on both the east and west sides of Crabb River Road, south and west of the intersection of Crabb River Road and FM 762 along the western edge of Berdett Road and south of Smithers Lake along FM 762 (Exhibit 35). Commercial uses such as convenience stores, fast-food restaurants, and shopping centers are concentrated along Crabb River Road. The remainder of the RSA is characterized by agricultural land uses, primarily rice farms, scattered small residential clusters, parklands, and the TDCJ as discussed in Section 3.1.2.

Recent development, primarily in the northern third of the RSA, is in the form of suburban style master-planned communities consisting of fairly high-density, single-family homes along curvilinear streets. Greatwood, located at US 59 and Crabb River Road, sits on 2,050 acres and includes a golf course, lakes, recreation complex, and nature parks. Bridlewood Estates, located on the west side of Berdett Road, is a master-planned community where residents construct their own homes on 1- to 3-acre tracts. Additional existing communities include Brazos Lakes (south of Smithers Lake), Brazos Bend Oaks, Plantation Lakes, Sandy Point Estates, and Double M Ranch.

Other existing and proposed residential development within the AOI include River Run at the Brazos, Bonbrook Plantation, Brazoria Bend Country Club Estates, Colony Estates, Suncreek Estates, The Oaks at Suncreek Estates, and Klobouk Fields.

The residential pattern of recent developments, master-planned communities, contrasts sharply with the rural nature of traditional residences, clusters of homes or individual farm homesteads along FM roads, located within the southern and eastern portions of the RSA. Many of the residences in more rural settings include farm-related structures such as

garages, barns, storage buildings, and other agricultural outbuildings. Many also appear to be smaller than the new homes more recently built in the northwestern portion of the RSA. Commercial and industrial land uses in the RSA are minimal and the bulk of the commercial land uses are in the northern portion of the RSA near residential communities. Travel-related gas stations and fast food restaurants are concentrated near US 59 and along Crabb River Road. Extending south along Crabb River Road are additional commercial services including auto mechanic shops, dry cleaners, storage areas, and mini-markets.

An important aspect of this growth is the steady conversion of rural land to developed land, a shift that is readily apparent within the RSA. As previously described in Section 3.3.1, the population growth forecasted over the next 25 years (165 percent for Fort Bend County and 48 percent for Brazoria County) suggests that the trend toward urbanization within the RSA will likely continue for the foreseeable future with the continued conversion of agricultural land and open space land to urban land uses.

Farmlands

Historic Context

A study released by the American Farmland Trust (AFT) in October 2002, reported that the United States is losing 2 acres of mostly prime farmland every minute to development. The loss is occurring on the edge of the "outer suburbs." The report made a distinction between sprawl and development and concluded that it was sprawl, not development itself that caused the disappearance of 6 million acres of farmland between 1992 and 1997 (Texas Environmental Profiles, 2007). From 1970 to 1980, the population of Fort Bend County increased by 150 percent, and continued to increase by 57 percent between 1990 and 2000. From 1970 to 1980, the population of Brazoria County increased by 57 percent and continued to increase by 27 percent between 1990 and 2000. This population growth has resulted in development occurring in the RSA, which has decreased the amount of agricultural land. In Brazoria County, crops such as rice have declined over the past two decades. In 1987, approximately 95 rice farms harvested 28,975 acres of rice (hundredweight). In 1997, there were only 57 farms that harvested 19,111 acres of rice (hundredweight). By 2002, there were only 42 rice farms in operation that harvested 13,066 acres of rice (hundredweight) (USDA, 1987, 1997, 2002). The number of acres of rice fields lost between 1987 and 2002 was approximately 55 percent. Fort Bend County has experienced a slight decline (decrease of 9 percent) in the number of acres harvested for rice from 1987 (10,136 acres) to 2002 (10,998 acres) with the number of operations remaining fairly constant with 30 farms in 1987 compared with 29 farms in 2002 (USDA, 1987, 2002).

Current Health

The RSA is located in a growing area within Fort Bend and Brazoria counties. An important aspect of this growth is the steady conversion of agricultural and rural land to developed land. Within the RSA, there are 264,063 acres of prime farmland that accounts for nearly 70 percent of the RSA. Forecasted population growth suggests that the trend towards urbanization will likely continue, especially in the northwestern and southeastern portions of the RSA, leading to the

potential for additional loss of farmland. Only a few rice fields have been identified within the RSA. They are located along SH 288, south of Stoneridge Lakes and Sandy Meadows Estates, with a small amount located along FM 521 southwest of the proposed Colony Estates. However, it should be noted that the rice fields within the RSA were identified by appearances of terraced fields using 2008 aerial photography and other fields plowed for crop rotation may still be used in rice farming.

Air Quality

Historic Context

The Air Pollution Control Act of 1955 was passed "…to provide research and technical assistance relating to air pollution control." This law led to all future clean air legislation including the Federal CAA of 1970, which required the EPA to publish the NAAQS for specific pollutants within 120 days of the law being signed. The "criteria pollutants" that were to be regulated were CO, NO_X, sulfur oxides, photochemical oxidants, hydrocarbons, and PM. Standards were set for each of the criteria pollutants based on a collection of current research and information with a margin of safety. The CAA was last amended in 1990 and addressed five main areas: air quality standards, motor vehicle emissions and alternative fuels, toxic air pollutants, acid rain, and stratospheric O_3 depletion.

The EPA is the lead agency for administering Section 202 of the CAA and has certain responsibilities regarding MSATs (EPA400-F-92-004 [August 1994]). The EPA has issued a Final Rule on controlling emissions of HAPs from mobile sources (66 FR 17229 [March 29, 2001]). Below is a summary regarding the effects and control of MSATs, which is issued under the authority in the CAA.

> HAPs refer to a range of compounds that are known or suspected to have serious health or environmental impacts. Motor vehicles are substantial contributors to national emissions of several HAPs, notably benzene, formaldehyde, 1,3-butadiene, acetaldehyde, DPM, and diesel exhaust organic gases.

There are 21 compounds emitted from motor vehicles that are known or suspected to cause cancer or other serious health effects. Various VOCs and metals, as well as DPM and diesel exhaust organic gases are included in the MSAT list. The EPA also examined the mobile source contribution to national inventories from these emissions and the impacts of existing and newly launched mobile source control programs, including the reformulated gasoline program, national low emission vehicle standards, Tier 2 motor vehicle emissions standards, and gasoline sulfur control requirements. From the study, the EPA proposed heavy duty engine and vehicle standards, and on-highway emissions for benzene, formaldehyde, 1,3-butadine, and acetaldehyde by 67 to 76 percent, and reduce on-highway DPM emissions by 90 percent.

In an ongoing review of MSATs, the EPA completed another set of rules under authority of CAA Section 202(l) to further reduce MSAT emissions. The EPA issued the set of Final Rules on Control of HAPs from Mobile Sources (72 FR 8427, February 26, 2007) under 40 CFR 59, 80, 85, and 86. As a result of this review, the EPA adopted the following new requirements to significantly lower emissions of benzene and the other MSAT toxics by (1) lowering benzene content in

gasoline; (2) reducing exhaust emissions from passenger vehicles operated at cold temperatures (under 75 degrees); and (3) reducing emissions that evaporate from, and permeate through, portable fuel containers.

Beginning in 2011, refiners must meet an annual average gasoline benzene content standard of 0.62 percent by volume on all their gasoline, both reformulated and conventional, nationwide. The national benzene content of gasoline in 2007 is about 1.0 percent by volume. The EPA adopted standards to reduce nonmethane hydrocarbon exhaust emissions from new gasoline-fueled passenger vehicles. The standards phase in between 2010 and 2013 for the lighter vehicles and between 2012 and 2015 for the heavier vehicles. In addition, the EPA is adopting more stringent evaporative emission standards for new passenger vehicles. The new standards are equivalent to California's standards, with implementation in 2009 for lighter vehicles and in 2010 for the heavier vehicles. Starting with portable gas containers manufactured in 2009, the standard limits evaporation and permeation emissions from these containers to 0.3 gram of hydrocarbons per gallon per day.

In addition to the reductions from the 2001 rule, by 2030, the new rules should further reduce annual national emissions by 330,000 for MSAT (including 61,000 tons of benzene), VOCs by more than 1,000,000 tons, and PM2.5 by more than 19,000 tons.

Current Health

The Houston area monitors for various air pollutants using an established air-monitoring network. This network of monitors measures air quality and determines the levels of the various pollutants in the air. As can be seen in Table 6-4, not all monitors sample for the same pollutants, and not all monitors have 1 year of complete data to compile an annual average for any given pollutant. For this reason, data from multiple monitors must be examined in order to analyze the pollution concentrations in the proposed project area. Air quality monitors are located between 9 and 30 miles from the proposed Grand Parkway Segment C. The official monitor data is found on the EPA's national air quality monitor web site (www.epa.gov/air/data).

The EPA establishes limits on atmospheric pollutant concentrations through enactment of the NAAQS for six principal, or criteria, pollutants. The EPA designated eight counties in the HGB area as nonattainment for O_3. The region is currently in attainment for all other criteria pollutants. Although there have been year-to-year fluctuations, the O_3 trend continues to show improvement. The trend of improving air quality in the region is attributable in part to the effective integration of highway and alternative modes of transportation, cleaner fuels, improved emission control technologies, and H-GAC regional clean air initiatives.

TABLE 6-4
LOCAL MONITOR DATA

EPA Monitor ID (TCEQ ID)	Location	Distance From Preferred Alternative	MSATs Monitored
48-039-1004 (CAMS 84)	Brazoria County, Manvel	9 miles	N/A
48-167-0053 (CAMS 100)	Galveston County, Texas City	30 miles	1,3-Butadiene, Benzene
48-201-0051 (CAMS 409)	Harris County, Houston	15 miles	N/A
48-201-0066 (CAMS 410)	Harris County, Houston	13 miles	N/A
48-167-0005 (CAMS 1022)	Galveston County, Texas City	30 miles	1,3-Butadiene, Benzene

Source: EPA AirData; Study Team (2010).

Note: The EPA disclaimer regarding this data: "Readers are cautioned not to infer a qualitative ranking order of geographic areas based on AirData reports. Air pollution levels measured in the vicinity of a particular monitoring site may not be representative of the air quality of a county or urban area. Pollutants emitted from a particular source may have little impact on the immediate geographic area, and the amount of pollutants emitted does not indicate whether the source is complying with applicable regulations."

Water Quality

Historic Context

Current water resources within the Water Quality RSA have been altered from their predeveloped conditions to varying degrees. For example, stream channel alteration has been induced by such influences as clearing of native riparian vegetation in agricultural areas as well as areas where residential and commercial development has occurred. As agricultural lands were converted to developed land uses in the northwestern and eastern portions of the RSA, stream channels have responded to changes in the magnitude of peak flow runoff events and other hydrologic changes associated with impervious cover and stormwater drainage systems. Channel response includes down-cutting erosion in some reaches with sediment deposition downstream, which in turn, leads to further destabilization as channels widen in response to sediment inputs or streambed aggradation. In a limited number of cases, smaller intermittent and ephemeral stream channels have been channelized. The rapid growth in Fort Bend and Brazoria counties has led to the need for flood control as more agricultural land is converted to developed land and thereby has an increased amount of impervious cover. Historical influences on water quality that continue to the present day include the effects of treated wastewater discharges from upstream communities into some of the perennial streams in the RSA, construction and post-construction stormwater discharges from developed areas, and agricultural runoff from croplands.

Surface Water

Historic Context

In 1985, a total of 71,716 and 364,805 acre-feet of surface water were used in Fort Bend and Brazoria counties, respectively (Table 6-5). In Fort Bend County, the majority of surface water was used for steam electric (47 percent of total) and irrigation (31 percent of total) with 4 percent used for municipal services (TWDB, 2007b). The majority of surface water in Brazoria County was used in manufacturing (53 percent of total) and irrigation (46 percent of total) with less than 1 percent used for municipal services (TWDB, 2007a).

TABLE 6-5
FORT BEND AND BRAZORIA COUNTIES HISTORICAL SURFACE WATER USE SUMMARY (ACRE-FEET)

Year	Municipal	Manufacturing	Steam Electric	Irrigation	Mining	Livestock	Total
Fort Bend County							
1985	2,969	11,986	33,770	22,486	136	369	71,716
1990	1,975	15,231	59,887	5,940	0	445	83,478
1995	2,538	15,447	30,713	12,581	0	351	61,630
2000	827	401	57,999	24,619	0	468	84,314
Brazoria County							
1985	1,423	194,437	0	168,146	323	476	364,805
1990	8,400	195,719	0	108,410	736	504	313,769
1995	8,887	205,606	0	101,033	795	441	316,762
2000	13,286	109,722	0	91,732	2,537	645	217,922

Source: TWDB (2007a, 2007b).

Throughout the 1980s and 1990s, the amount of surface water used for irrigation in Fort Bend County showed a slight decrease. The amount of surface water used for irrigation increased from 22,486 acre-feet (31 percent of total) in 1985 to 24,619 (29 percent) in 2000. This was due to a combination of several factors including increased urbanization, reduced surface-water contracts, and improved irrigation methods (Thorkildsen, 1990).

In Brazoria County, the amount of surface water used for irrigation decreased from 168,146 acre-feet (46 percent of total) in 1985 to 91,732 acre-feet (42 percent of total) in 2000 while surface water used for municipal services increased from 1,423 acre-feet (0.4 percent of total) in 1985 to 13,286 acre-feet (6 percent of total) in 2000 (TWDB, 2007b).

The TCEQ is required under Section 303(d) of the CWA, to identify waterbodies for which effluent limitations are not stringent enough to implement water quality standards. Three stream segments identified as impaired waters occur within the water quality RSA. They include Oyster Creek above Tidal from a point 110 yards upstream of FM 2004 in Brazoria County to the BRA diversion dam 1.1 miles upstream of SH 6 in Fort Bend County (Segment 1110), Brazos River from the confluence of Cottonwood and Coon Creeks, 5 miles north of Needville in Fort Bend County (Segment 1202, which was modified to Big Creek Segment 1202 J in 2002), and Upper Oyster Creek from Steep Bank Creek/Brazos River confluence in Fort Bend County to the pumping station on the Jones Creek confluence at the Brazos River in Fort Bend County (Segment 1245). Historical data for these impaired stream segments are included in Table 6-6.

TABLE 6-6
SECTION 303(D) – LISTED WATERBODIES WITHIN WATER QUALITY RSA

Segment Number	Segment Name	Comments
1992		
1110	Oyster Creek Above Tidal	Moderate PS, high RV, fish kills, DO, eutrophic
1202	Brazos River Below Navasota River	High PS, concern NPS, high RV, some toxics, algae, FC
1245	Upper Oyster Creek	Known NPS, high PS, fish kills, DO, algae, FC
1994		
1110	Oyster Creek Above Tidal	Fish kills, DO, FC, P
1202	Brazos River Below Navasota River	NPS, DO, Alg, P, Cl
1245	Upper Oyster Creek	Tox, fish kills, NPS, DO, N, P, Alg
1996		
1110	Oyster Creek Above Tidal	DO, FC
1202	Brazos River Below Navasota River	FC
1245	Upper Oyster Creek	DO, PS, NPS
1998		
1110	Oyster Creek Above Tidal	DO, NPS, B
1202	Brazos River Below Navasota River	B
1245	Upper Oyster Creek	DO
2000		
1110	Oyster Creek Above Tidal	DO, B
1202	Brazos River Below Navasota River	N/A
1245	Upper Oyster Creek	Atrazine and Alachlor, DO
2002		
1110	Oyster Creek Above Tidal	DO
1202 J	Big Creek	B
1245	Upper Oyster Creek	DO, B
2004		
1110	Oyster Creek Above Tidal	DO
1202 J	Big Creek	B
1245	Upper Oyster Creek	DO, B

Source: TCEQ (2008).
Alg – chlorophyll a + pheophytin a levels were relatively high
B – bacteria levels sometimes exceed the criterion established
Cl – chloride levels were relatively high
DO – low dissolved oxygen
FC – fecal coliform
N – ammonia nitrogen + nitrate nitrogen levels were relatively high
NPS – nonpoint sources
P – phosphorus levels were relatively high
PS – point sources
RV – resource value
Tox – toxic substances
Eutrophic – algae and nutrients high

Current Health

The watersheds within the region of influence of the project are located in the Brazos River Basin in Fort Bend and Brazoria counties. The area consists of undeveloped acreage such as farmlands and wooded areas. Major channels in this area are the Brazos River, Rabbs Bayou, Dry Creek, Big Creek, and Oyster Creek. Major lakes in this area are Lake Worthington and Smithers Lake.

As previously discussed, three classified segments transverse the water quality RSA. In 2006 and 2008, Segments 1110 and 1245 were still listed within the categories of bacteria and depressed dissolved oxygen. Segment 1202 J had historically been listed with bacteria as the pollutant. In 2006 two additional categories were listed under Segment 1202 J, these included impaired fish community and impaired habitat. In 2008, Segment 1202 J continued to be listed as having impaired fish community and bacteria, but was no longer listed impaired.

Field reconnaissance of streams within the RSA near the Grand Parkway Segment C project indicates that sediment is the most common pollutant affecting surface water resources. The primary sediment sources in the RSA are agricultural and development (construction site) runoff as well stream channel erosion. The watersheds have an adequate water supply for future development.

Groundwater

Historic Context

Although Fort Bend County had experienced only small amounts of subsidence prior to the 1980s, several characteristics of the area increase the potential for increasing subsidence in the future. These include rapid growth, water supply dependent almost entirely on groundwater, and proximity to significant water-level declines in Harris County. Currently, total water use in the District is comprised of 60 percent groundwater and 40 percent surface water; the surface water, however, is primarily used for manufacturing and agricultural uses (FBSD, 2007).

According to data supplied by the TWDB, 6,492 acre-feet of groundwater was pumped from the Gulf Coast Aquifer in the project area in 1960. In 1970, a total of 12,418 acre-feet of groundwater was pumped from this aquifer. The total pumpage increased to 36,780 acre-feet in 1980 and to 59,936 acre-feet in 1990. According to the 10th Annual Ground Water Report of the FBSD, the 1999 groundwater pumpage from the regional aquifers within the district totaled 76.5 mgd, compared with 62.6 mgd in 1990. This is a 22 percent increase in the last decade. In 1999, 66 percent of the total pumpage was used in public supply, 8 percent was used for industrial purposes, and 26 percent was used for agricultural purposes. Total public supply has increased 45 percent since 1990, while industrial use has remained fairly constant. Total irrigation use varies considerably from year to year. Regional aquifers provided 50 percent of the total water supply in 1999, while the Brazos River provided the remaining 50 percent. By comparison, regional aquifers provided 60 percent of the total water supply in 1990.

Throughout the 1980s and 1990s, the amount of groundwater used for municipal services increased for both Fort Bend and Brazoria counties (Table 6-7).

TABLE 6-7
FORT BEND AND BRAZORIA COUNTIES HISTORICAL GROUNDWATER USE SUMMARY (ACRE-FEET)

Year	Municipal	Manufacturing	Steam Electric	Irrigation	Mining	Livestock	Total
Fort Bend County							
1985	31,639	3,997	1,900	32,094	274	556	70,460
1990	36,712	3,678	2,918	47,236	161	668	91,373
1995	41,834	3,949	4,523	29,931	205	526	80,968
2000	68,257	5,717	3,762	24,267	192	703	102,898
Brazoria County							
1985	25,558	3,335	0	13,587	156	715	43,351
1990	19,082	3,523	0	4,979	218	757	28,559
1995	19,364	2,242	0	10,902	699	662	33,869
2000	26,795	1,344	0	7,022	794	968	36,923

Source: TWDB (2007a, 2007b).

Current Health

Recognized aquifers in the RSA, which contain freshwater (i.e., water having not more than 1,000 mg/l total dissolved solids), include the Chicot and Evangeline aquifers (Wesselman, 1972). Quaternary alluvial deposits along the Brazos River may also be a source of fresh groundwater, but no published or open-file information on hydraulic characteristics or use of this water-bearing unit were identified. There are several sources of groundwater in the Chicot and Evangeline aquifers. The primary source is precipitation, which is abundant (Thorkildsen, 1990). All groundwater occurs under either water table or artesian conditions.

The Chicot Aquifer is the shallowest major aquifer of the lower Gulf Coastal Plain and consists of all strata between ground surface and the top of the Evangeline Aquifer. The boundaries of the Chicot Aquifer are not distinct, but the upper Chicot is generally correlated to the Beaumont Formation, and the lower Chicot generally correlated to the Montgomery, Bentley, and Willis formations. Groundwater in the upper Chicot may exist under confined (i.e., artesian) or unconfined (i.e., water table) conditions, while groundwater in the lower part is under confined or leaky confined conditions. The elevation of the base of the Chicot Aquifer is estimated to be about 700 feet below msl at the RSA.

The Evangeline Aquifer underlies the Chicot Aquifer and is generally correlated with the Pliocene-age Goliad Formation. The Evangeline is estimated to be about 1,850 feet thick beneath the RSA. Sand strata constitute about 33 to 40 percent of the aquifer. Wesselman (1972) also concluded that there is hydrologic communication between sands of the Evangeline and sands of the lower Chicot in some areas of eastern Fort Bend County.

Waters of the U.S., including Wetlands

Historic Context

Conversion of native grasslands and woodlands to agricultural uses over the last century likely contributed to an overall decrease in wetland density within the RSA. According to the USFWS's "Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s," the total acreage of wetlands in the 48 conterminous United States in the 1950s was 108.1 million acres. In the 1970s it was 99.0 million acres, a net loss of 9 million acres, an average annual net loss of 458,000 acres (Frayer et al., 1983). In the mid-1970s there were an estimated 105.9 million acres of wetlands in the conterminous United States and 103.3 million acres of wetlands in the mid-1980s, a net loss of over 2.6 million acres (Dahl and Johnson, 1991). Wetland losses from the mid-1970s to the mid-1980s were more evenly distributed between agricultural land use and "other" land use (than from the 1950s to the mid-1970s). Conversion to agricultural land uses accounted for 54.0 percent and "other" land uses accounted for 41.0 percent of the losses. This is an appreciable change from earlier trends in which agricultural conversion represented 87.0 percent of all wetland losses (Dahl and Johnson, 1991). Between 1986 and 1997, the net loss of wetlands was 644,000 acres with an annual loss of 58,500 acres (Dahl, 2006).

However, a new report by the USFWS, "Status and Trends of Wetlands in the Conterminous United States 1986 to 1997," indicates the rate of wetland loss in the United States has decreased by 80 percent in the past decade. In addition, the National Resources Inventory conducted a survey on the nation's private lands for the period 1992 to 1997. This survey showed a rate of wetland loss has declined even more between 1992 and 1997, primarily due to wetland policies and programs enacted in the past decade that have helped reduce draining and filling of wetlands (USFWS, 2007b). Data collected for the 1998 to 2004 status and trends report concludes that for the first time there was a net wetland gain of 191,750 acres nationwide, which equates to an average annual net gain of 32,000 acres (Dahl, 2006).

Current Health

Wetlands within the RSA are mostly upland (i.e., nonjurisdictional); however, several wetlands and intermittent and perennial streams (waters of the U.S.) occur within the RSA and were documented during Section 404 evaluations conducted within the RSA.

Different guilds or groups of wildlife species may use one or more types of wetlands in the RSA. Human recreational and commercial uses are important functions/values of wetlands. Wetland areas provide multiple recreational uses, such as hiking, wildlife viewing, hunting, and fishing. Of particular interest in the RSA is Brazos Bend State Park. The park provides excellent opportunities to view wildlife in typical floodplain forests and wetlands (forested and nonforested) of southeastern Texas.

Nonforested wetlands or PEM (Cowardin et al., 1979) are scattered throughout the RSA. The majority of the nonforested wetlands observed are considered early successional communities experiencing secondary succession. Many of the

nonforested wetlands may have been forested wetlands prior to conversion of the forests to pastureland or agricultural lands. Although these areas may have been forested wetlands in the past, the length of time these wetlands have been converted indicates that the community observed represents the new normal circumstances or community type expected. Due to the ongoing agricultural practices and increasing urban development within the project area, the probability for these areas to revert to forested wetland communities is remote.

Forested wetlands, or PFO (Cowardin et al., 1979), are concentrated in the northern and southern regions of the RSA. In the northern portion of the RSA, forested wetlands are associated with the Rabbs Bayou-Big Creek drainages and the Brazos River floodplain in Thompsons Oil Field. Forested wetlands in the southern portion of the RSA are associated with the Big Creek-Brazos River floodplain and Pilant Lake wetland complex, both of which are primarily located in Brazos Bend State Park.

In addition to the areas considered to be converted nonforested wetlands, several of the wetlands observed are likely remnant prairie-pothole wetlands that are known to have occurred historically in portions of the RSA. Due to the conversion of the land to agricultural uses, these wetlands are also considered early successional wetlands. Continual agricultural practices and other urban development within the majority of the RSA make the potential for these wetlands to reach a climax community stage remote. Streams cover a total of 446 miles within the RSA while wetlands comprise 22,442 acres or 10.5 percent of the RSA. Measures to minimize and/or mitigate for any impacts to wetlands have been developed in conjunction with the USACE and resource agencies for development activities. This, in addition to the rural setting and abundance of streams and wetlands within the RSA, the current health would be considered stable.

Vegetation and Wildlife Habitat

Historic Context

Like most of the United States, the Vegetation and Wildlife Habitat RSA has undergone extensive land-use changes. Recently, the area has undergone changes associated with urban sprawl but historically agricultural conversions were more common. Land-use changes have concomitantly influenced wildlife and habitats. Along with other grassland regions of North America (Sampson and Knopf, 1994), this area was converted from its natural state to grazed pastures and cropland. As such, wildlife assemblages associated with native grassland habitats have declined. Wildlife community shifts towards species more tolerant of human encroachment have occurred and include urban fauna like grackles, European starlings, house sparrows, opossums, raccoons, coyotes, squirrels, and other common, urban-tolerant species.

Texas has gone through land-use changes that simultaneously altered flora, fauna, associated habitats, and ecological functional integrity. Several major drivers are recognized as influencing plant and animal community dynamics (Telfair, 1999) and include:

- Water resource development and use
- Agricultural practices

- Forestry practices
- Mineral recovery and extraction
- Energy production
- Urban and industrial expansion and recreational and leisure developments
- Transportation projects
- Introduction of nonnative and/or invasive fauna and flora

Agricultural practices have changed wildlife and plants within the RSA. Creation of farms and ranches spatially fragment natural resources (e.g., native prairies). Poor grazing methods, a century of fire suppression, and introduction of nonnative grasses are commonplace and have resulted in woody plant encroachment. Furthermore, invasive, nonnative vegetation (relative to the region) like bermudagrass, johnsongrass, King Ranch bluestem, Chinese tallow, mesquite, yaupon, and Macartney rose are typical flora within the RSA where areas were converted or disturbed.

Within Fort Bend and Brazoria counties, the amount of pastureland and cropland has declined in the years 1982 to 1997 (Table 6-8). In 1982 Fort Bend County had approximately 168,000 acres of pastureland, which declined to approximately 116,000 acres in 1997, a 31 percent decrease. Subsequently, Brazoria County showed a 36 percent decrease in pastureland. During the same time period, cropland within Fort Bend and Brazoria counties also showed a decline of 30 and 23 percent, respectively.

TABLE 6-8
LAND-USE ESTIMATES FOR FORT BEND AND BRAZORIA COUNTIES
(THOUSANDS OF ACRES)

Year	Pastureland*	Grassland*	Cropland*	Forestland*
Fort Bend County				
1982	168	75	231	5
1987	176	69	216	4
1992	151	119	178	2
1997	116	155	161	2
Brazoria County				
1982	349	125	251	0
1987	380	117	215	0
1992	370	100	203	0
1997	225	163	193	2

Source: SCS (1984, 1992); NRCS (2000).
*Acres rounded to the nearest thousand.

The native vegetation of this region originally consisted of tall grass prairies intermixed with post oak savannahs and forested riparian corridors (Hatch et al., 1990; SCS, 1960). Most of this region is very productive farmland for growing row crops and rice, and because of the urbanization and agricultural activities, very little native prairie remains. The remnant

prairie that does exist is dominated by climax grasses such as little bluestem, big bluestem, indiangrass, and Gulf muhly. Most of these grasses have been replaced by invaders such as johnsongrass, great ragweed, Brazilian vervain, and woody species such as eastern baccharis and Chinese tallow-tree.

The integration of forests and grasslands in the area results in mixtures of vertebrate species typical of the two general habitats. The majority of native vegetation in the province has been replaced by cultivated crops, improved pasture grasses, invasive brush, or urban development; native wildlife populations and have declined as a consequence. Many habitat specialists, including least shrews, Texas horned lizards and Northern bobwhites, have declined and had their distributions altered, while other more generalist species such as coyotes, eastern meadowlarks, and mourning doves have increased in abundance.

Current Health

As previously mentioned, the native vegetation of this region originally consisted of tall grass prairies intermixed with post oak savannahs and forested riparian corridors (Hatch et al., 1990; SCS, 1960). Where there have been disturbances or alterations to the landscape, such as farming and ranching and urbanization, various shrubs, exotic trees, and undesirable herbaceous species have invaded. Most of this region is very productive farmland for growing row crops and rice, and because of the urbanization and agricultural activities, very little native prairie remains.

Pasturelands/grasslands/cropland category includes grazed pastures, fallow fields, agricultural fields, and native grasslands. Typical vegetation associated with this community includes Eastern gamagrass, snow-on-the-prairie, annual sumpweed, bermudagrass, bahiagrass, broomsedge bluestem, little bluestem, indiangrass, dallisgrass, vasey grass, knotroot bristle grass, southern carpet grass, johnsongrass, rescuegrass, Western ragweed, curly dock, Brazilian vervain, smutgrass, bull thistle, honey mesquite, wild onion, false garlic, huisache, sedge, big bluestem, giant ragweed, giant goldenrod, grassleaf rush, perennial ryegrass, southern dewberry, Macartney rose, narrowleaf sumpweed, common greenbriar, gerardia, dwarf palmetto, flatsedge, Chinese tallow-tree, yaupon, pecan, winged elm, cedar elm, green wild indigo, green flatsedge, and Eastern baccharis.

Forestlands in the project area typically include cedar elm, winged elm, live oak, sugarberry, and pecan. Bottomland forests typically support water oak, black gum, green ash, and Chinese tallow-tree. Understory and shrub species include yaupon, dwarf palmetto, Chinese privet, flowering dogwood, and Chinese tallow. Common vine species include greenbriars, southern dewberry, trumpet creeper, peppervine, Japanese honeysuckle, and Alabama supplejack. Herbaceous layer includes narrowleaf woodoats, Cherokee sedge, maidencane, and curly dock.

The wetland communities present within the RSA are typical of PEM, PSS, and PFO areas within the southeast (Cowardin et al., 1979). Nonforested wetlands may include wet meadows, sloughs, depressions, shrub-scrub vegetation, and pond fringes. Forested wetlands typically occur in depressional areas and along streams and rivers.

The Texan Biotic Province represents a transitional area between the forested province to the east and grassland provinces to the west. The integration of forests and grasslands in the area results in a mixture of vertebrate species typical of the two general habitats. The majority of the native vegetation in the province has been replaced by cultivated crops, improved pasture grasses, invasive brush, or urban development. Consequently, numerous native wildlife populations have declined. Many habitat specialists, including the least shrew, Texas horned lizard, and northern bobwhite have undergone reductions in numbers and had their distributions severely altered, while other more generalistic species such as the coyote, eastern meadowlark, and mourning dove apparently have increased in number and habitat occupation.

The RSA is situated in the Texas ecological region known as the Gulf Coast Prairies and Marshes (Gould, 1975). This ecological region is characterized by nearly level topography with precipitation averaging 48 inches per year. The regional elevation extends from sea level along the coast up to 250 feet msl in the uplands of Fort Bend and Brazoria counties with little topographic relief within the RSA (Hatch et al., 1990).

The northern portion of Fort Bend County and western portion of Brazoria County within the Vegetation RSA form an area of increasing urban development. The vegetative communities that are present include pastureland/grassland/cropland and forestland. The following vegetative community descriptions are based on McMahan et al. (1984) and were adjusted to reflect site-specific conditions based on field observations.

The pastureland/grassland/cropland community type usually results from the clearing of woody vegetation with the intent of growing a mixture of native and/or introduced grasses and forbs. This clearing practice is common throughout many parts of Texas, and may result in a community that resembles the early stages of a young forest (McMahan et al., 1984). This community type corresponds with McMahan et al. (1984) vegetation type 45. Cropland is defined by McMahan et al. (1984) as any “cultivated cover crop or row crop providing food and/or fiber for either man or domestic animals.” McMahan et al. designates this vegetation type 44.

The pastureland and grassland communities within the area are heavily disturbed, or in some cases, under rotational grazing. Due to intense grazing and the lack of a natural fire regime, these communities are dominated by less desirable grasses and forbs. The grasses within the RSA include perennial ryegrass, bermudagrass, southern carpet grass, smutgrass, dallisgrass, vasey grass, bahiagrass, and johnsongrass. Some native species such as indiangrass, little bluestem, and brownseed paspalum still exist. Forbs present include curly dock, giant ragweed, Canada goldenrod, Brazilian vervain, narrowleaf sumpweed, and western ragweed. Commonly occurring shrubs on disturbed pastureland include honey mesquite and Macartney rose. During the field evaluations, the pastureland/grassland communities were described as early successional communities as a result of past indicators of rotation farming practices. In the majority of the pasturelands/grasslands observed, old rice levees or indicators of ground leveling were documented. Cropland in the RSA is normally used to grow corn, rice, grain sorghum, and soybeans, but cotton and alfalfa are also present. In the abandoned fields, various invading species such as those mentioned above become common.

Forestlands in the RSA may include upland, riparian, and floodplain forests. Species overlap is common and an effort has not been made to differentiate between these forest communities. Based on field observations, the majority of the nonwetland forests in the RSA are considered late successional or climax forested communities (McMahan et al., 1984). Typical overstory trees are approximately 50 to 70 feet tall with average dbh ranging between 10 and 15 inches. In areas where the forested vegetation has not been cleared, canopy coverage ranges between 80 and 100 percent.

Wetlands and floodplains that offer aquatic habitats are located within the RSA. Aquatic habitats in the RSA support a diverse assemblage of biotic communities common to the Gulf prairies and marshes ecoregion. In addition to the Brazos River and its major tributaries, several small streams, oxbow lakes, wetlands, ponds, and ditches are found within the RSA.

The Brazos River in the RSA drains approximately 44,000 square miles. Brazos River hydrogeomorphology is typical of other Gulf Coast Plain Rivers. The TPWD listed the segment of the Brazos River from Austin/Waller County to the Gulf of Mexico as an "Ecologically Significant River" (TPWD, 2001). Common fish species include catfish, gar, crappie, freshwater drum, minnows, sunfish, largemouth bass, pirate perch, topminnows, bowfin, and numerous other species (Hubbs, 1982).

Macroinvertebrates in this area include those species typically found in lentic (i.e., slow water velocity or flow) aquatic systems. Examples include dragonflies, crayfish, caddisflies, snails, true bugs, midges, mayflies, snails, water scorpions, beetles, aquatic worms, and zooplankton. The Brazos River also supports mussels including paper pondshell, giant floater, yellow sandshell, and washboard.

Waterbodies within the RSA also provide important habitat and services to other semi-aquatic organisms such as American alligators, American beavers, turtles (such as the red-eared slider and Midland smooth softshell turtle), wading birds, and waterfowl.

6.2.4 Step 4: Identify Direct and Indirect Impacts of the Project that Might Contribute to a Cumulative Impact

This step identifies the direct and indirect effects that could result from the project that may contribute to a cumulative effect when added to nonproject related effects. Direct and indirect impacts are defined by CEQ regulation 40 CFR 1508.8 as follows:

> "Direct impacts are caused by the action and occur at the same time and place" (40 CFR 1508.8)
>
> "Indirect (secondary) impacts are caused by the action and are later in time and farther removed in distance, but are still reasonably foreseeable. Indirect impacts may include growth inducing effects and other effects related to induced changes in the pattern of land use,

> population density or growth rate and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8)

The CIA considers the direct effects as determined in the FEIS. A summary of the direct effects is presented for each resource.

The CIA also includes the indirect effects as previously presented in Section 5, Indirect Effects. The indirect effects were determined based on decisions by the Expert Panel and predictions of future development within the RSA that would be caused by the project.

Land Use

Summary of Direct Effects

Approximately 1,538 acres of existing land use (primarily agricultural) would be converted to transportation use within the ROW.

Summary of Indirect Effects

Construction of the proposed Grand Parkway Segment C may indirectly affect land use within the RSA, resulting in long-term land-use changes to the landscape. Like most new location highways, construction of the proposed Grand Parkway Segment C could enhance land development opportunities, helping create opportunities for the location of land uses that benefit from drive-by exposure or access to major transportation routes.

Indirect development may occur as a result of the Grand Parkway Segment C project and could affect residents nearby. Induced growth changes the intensity of the use of land caused by the project. For this proposed project, "induced growth is attributed to changes in accessibility caused by the project, which influences where development occurs" (NRC, 2002). The degree to which indirect development may occur is dependent on many variables and is difficult to predict. As previously mentioned, indirect development would likely occur at interchanges and include a variety of land-use intensities such as convenience stores, gas stations, retail strip malls, restaurants, office buildings, and residential, including multifamily. In addition, indirect effects may include an increase in the density of existing residential areas as well as increases in utility and social service demands and the conversion of rangeland, cropland, and/or undeveloped land to additional residential or other urban forms of land use. Under the Grand Parkway Segment C project, approximately 31,665 acres of land within area of potential indirect development would likely be developed by 2035. Under the No-Build Alternative, land development would still occur in these interchange areas, but would likely be residential in nature.

Prime Farmlands

Summary of Direct Effects

Approximately 955 acres of prime and statewide important farmlands would be converted to transportation ROW as a result of the proposed Grand Parkway Segment C. According to the scoring used in the NRCS Form CPA-106, the eight Representative Alternatives received a score totaling less than 160 points (Appendix I). Form CPA-106 was submitted for the Preferred Alternatives on December 13, 2011. Since the Preferred Alternative impacts were calculated using the most detailed 300- to 400-foot ROW (not available for the eight Representative Alternatives), the impacts to the Preferred Alternatives are greater. In a letter dated January 19, 2012, from the NRCS, the Preferred Alternative also received a score of less than 160 points (Appendix I). The project-related impacts to prime farmland in the two counties are determined minimal according to the land evaluation and site assessment scoring used by the NRCS. Therefore, the proposed project will be exempt from the FPPA requirements.

Summary of Indirect Effects

Based on current and forecasted development under the Build and No-Build alternatives, land dedicated to agricultural use is expected to be converted to roadway ROW through induced development. The proposed Grand Parkway Segment C would cause induced development at proposed entrance/exit ramps and highway interchanges. This development could segregate land dedicated to agricultural use (approximately 66,882 acres of prime farmlands) within the area of potential indirect development.

Air Quality

Summary of Direct Effects

Direct impacts on air quality and MSATs from the project are primarily those associated with the increased capacity, accessibility and the resulting projected increases in VMT. Emission reductions as a result of EPA's new fuel and vehicle standards are anticipated to offset impacts associated with VMT increases.

Indirect impacts on air quality and MSATs are primarily related to any expected development resulting from project's increased accessibility or capacity to the area. Any increased air pollutant or MSAT emissions resulting from the potential development of the area must meet regulatory emissions limits established by the TCEQ and EPA as well as obtain appropriate authorization from the TCEQ, and therefore are not expected to result in any degradation of air quality or MSAT levels.

Water Quality

Summary of Direct Effects

The Grand Parkway Segment C project would cross the Brazos River, 8 major streams, 24 minor streams, 5 irrigation canals, and 1 stock pond. To quantify the changes in impervious cover, the length of the proposed Grand Parkway Segment C project and each Representative Alternative draining into a stream within the RSA was delineated and the corresponding area of the ROW was calculated. Table 4-41 (Section 4.10.1) presents the lengths and areas for all the alternatives. The length shown in the table is the length of the portion of the proposed Grand Parkway Segment C draining directly to the corresponding stream and does not include the contribution from an upstream watershed. For example, Rabbs Bayou (above Smithers Lake) and Dry Creek drain into Rabbs Bayou (below Smithers Lake), which in turn drains into Big Creek.

Table 6-9 shows the acreage of the Grand Parkway Segment C project ROW that would drain to the streams. The areas shown include contributions from an upstream area. For example, the area for the Brazos River includes the areas of ROW draining to Rabbs Bayou, Dry Creek, Big Creek, and Walters Lake Bayou.

TABLE 6-9
ACREAGE OF ROW DRAINING INTO INDIVIDUAL STREAMS WITHIN RSA

Streams within RSA	Total area (in acres) of ROW[1] Draining to Streams
Rabbs Bayou[2]	92
Rabbs Bayou[3]	400
Dry Creek	210
Big Creek	616
Walters Lake Bayou	114
Brazos River	752
Oyster Creek	62
Hayes Creek	183
Total	996

Source: Study Team (2009).
[1] Grand Parkway Segment C project
[2] Rabbs Bayou above Smithers Lake
[3] Rabbs Bayou below Smithers Lake

Construction and operation of the proposed facility would have a nominal impact to regional groundwater resources. A review of well records of TCEQ (2011) and TWDB (2011b) indicate that a total of 20 public water supply wells and 11 private water wells are located within ¼ mile of the proposed Grand Parkway Segment C project ROW (Section 4.18.1). One public water supply well and two private water wells lie directly within the proposed ROW and would be directly impacted. As a result, each of these wells must be plugged according to the TCEQ regulations (16 TAC 76.1004). While

the public and private use of groundwater from these wells will be impacted, plugging of these seven wells will eliminate the potential impact to the groundwater resources.

The network of future roadways and subdivision streets associated with indirect development could contribute both the direct and indirect effects; however, the density and type of future development within the AOI would determine the amount and type of the runoff. Currently, there are approximately 1,059 miles of streams within the AOI, of those, approximately 307 miles of streams occurs in the Area of Potential Indirect Effect.

Summary of Indirect Effects

Based on current and forecasted development under the Build and No-Build Alternatives, land dedicated to agricultural use is expected to be converted to roadway ROW through induced development. The proposed Grand Parkway Segment C would cause induced development at proposed entrance/exit ramps and highway interchanges, which would increase impervious cover. Under the No-Build Alternative, growth would occur in some areas of the RSA resulting in the creation of more impervious surfaces causing increased stormwater runoff; however, these areas are expected to be residential in nature and would minimize the amount of stormwater runoff. Project sanitary wastewater flows as a result of planned developments would be analyzed to ensure adequate service.

To quantify the changes in rainfall runoff, the primary variable is the change in impervious cover. Other changes might include the elevation and grading of proposed developments that might alter the timing and distribution of runoff between watersheds. However, this information tends to only be available after detailed designs have been produced.

Approximately 307 miles of streams have been identified within the Area of Potential Indirect Effect. No indirect impacts are anticipated through strict adherence to regulations laid out by the TCEQ as well as the utilization of BMPs, no adverse indirect impacts to water quality would occur as a result of the proposed project.

Waters of the U.S., including Wetlands

Summary of Direct Effects

Each wetland community type has been identified (Cowardin et al., 1979) and quantified for potential impacts within the ROW. The location of each wetland area mapped is shown in Appendix I. The boundaries of all wetlands have been verified by the USACE and are therefore considered jurisdictional wetlands to be impacted by the project. According to the preliminary verification (April 1, 2010, Appendix I), 32 acres of waters of the U.S. also occur within the ROW of the Grand Parkway Segment C project.

Summary of Indirect Effects

Under the Build and No-Build Alternatives, some degradation of waters of the U.S., including wetlands, could occur from development that is forecasted to occur within the RSA. All proposed construction activities would impact wetlands and

aquatic systems to varying degrees. The initial clearing of the land during construction activities would remove the vegetative cover. These activities, whether taking place in grassland or forested communities, would increase the surface runoff and could lead to erosion.

Approximately 9,633 acres of wetlands occur in the area of potential indirect effect. Not all of these streams and wetlands would be considered jurisdictional by the USACE and subject to protection under Section 404 of the CWA. In addition, it is unlikely that all waters of the U.S., including wetlands within the RSA would be impacted. Regardless of whether the proposed development would be public or private, these developments would have to comply with Sections 404 and 401 of the CWA, which regulates the filling of and encroachment of these resources. It is difficult to determine the magnitude due to the laws and enforcement of those laws; however, our estimations under similar circumstances using current regional trends would be that 278 miles of additional jurisdictional waters could be indirectly impacted.

Vegetation and Wildlife Habitat

Summary of Direct Effects

Existing vegetation resources that would be directly affected by the Grand Parkway Segment C project includes 872 acres of pastureland/grassland/cropland and 153 acres of forestland, which would be permanently converted (i.e., as a maintained ROW or impervious road surface) as a result of the Grand Parkway Segment C project. The primary direct impact to vegetation resulting from site preparation and construction of the proposed highway project is removal or conversion of existing vegetation from the ROW and any construction staging areas.

Additionally, 27 acres of wetland (i.e., 21 and 6 acres of nonforested and forested wetlands, respectively) and 349 acres of floodplain would be directly affected (i.e., converted to a maintained ROW and/or paved) by the Grand Parkway Segment C project. Wetland and aquatic systems are impacted in a similar fashion through direct disturbance by heavy machinery resulting in soil compaction and scarification, placement of fill and construction materials, and the disruption of hydrological and nutrient cycling.

Impacts on wildlife from the construction of the Grand Parkway Segment C project can be divided into short-term effects resulting from physical disturbance during construction and long-term effects resulting from habitat modification. Direct and immediate impacts to fauna include construction-related mortality or injury. Clearing and construction would directly affect fauna that use proposed highway ROW as habitat. Larger, more mobile species may avoid initial clearing and construction activities and move into adjacent areas outside the proposed ROW. Some small, less mobile fauna may suffer direct mortality due to construction. Fossorial animals (i.e., those that live underground, such as moles and shrews) would be negatively impacted as a result of soil compaction caused by heavy machinery. The increased noise and activity levels during construction could disturb breeding or other activities of species inhabiting areas adjacent to the proposed ROW. Although normal behavior of many wildlife species including grackles, European starlings, house sparrows, opossums, raccoons, coyotes, squirrels, eastern meadowlark and mourning dove, and other common, urban-tolerant species would be disturbed during construction, the long-term damage to those species may be less severe.

Once construction is completed and the vegetation has recovered, some wildlife species may move back into vegetated portions of the proposed ROW. Species diversity of small mammals and other r-selected species (i.e., species that have a high birth and death rate, small body size, are opportunistic colonizers, and have high population resiliency) may be greater within the ROW than adjacent habitats (Begon et al., 2006). This increase in diversity may be attributed to the change and maintenance of vegetation along the proposed ROW. Highway construction, while producing largely temporary negative impacts to existing K-selected wildlife (i.e., species that have a low birth and death rate, larger body size, and have low population resiliency), generally increases habitat for r-selected, opportunistic colonizers like rodents.

The typical short-term construction effects include excess turbidity and siltation. Short periods of high turbidity are not considered lethal to fish; some species can tolerate increased turbidity loads or disperse from highly turbid waters and return when turbidity decreases to acceptable levels. High turbidity can clog gills and reduce the ability to extract oxygen from water, and interfere with the ability of fish to locate prey. While fish normally recover from such stresses, these circumstances during spawning seasons may reduce reproductive success until turbidity levels return to normal.

Sedimentation can bury food supplies of benthic feeders; however, within segments of streams with mud or silt bottoms, some sedimentation is of limited ecological concern. If the degree of siltation is minimal, the benthic species often survive. Many benthic species living in mud bottoms are very opportunistic and recolonization of such habitats is often rapid.

Individual mortality could occur when species are present at creek and river crossings during construction efforts, and there could be some localized reduction in population size if siltation and turbidity are not adequately controlled. Introductions of exotic aquatic plant species may be facilitated by human access provided by the new roadway and adversely affect biodiversity.

Summary of Indirect Effects

Based on current and forecasted development under the Build and No-Build alternatives, undeveloped land is expected to be converted to roadway ROW through induced development. Approximately 62,500 acres of pastureland/ grassland/cropland and 13,485 acres of forestland are within the area of potential indirect effect. The proposed Grand Parkway Segment C would cause induced development at proposed entrance/exit ramps and highway interchanges. Under the No-Build Alternative, growth would occur in some areas of the RSA resulting in the fragmentation of vegetative communities.

The construction of a new roadway affects the environment at different spatial scales (i.e., from the microscopic to the landscape level). On a landscape level, the ecological communities, systems, and functions (e.g., hydrogeomorphological dynamics) currently existing along the Grand Parkway Segment C project would be fragmented. Effects of habitat fragmentation are many and difficult to quantify primarily because there are numerous dynamic variables. Generalizations regarding the concept of habitat fragmentation are well accepted, but specific processes and functional relationships are site-specific, dynamic, and are interrelated or nested within temporal and spatial scales (arguably, fragmentation effects are largely unforeseen or unpredictable and some ecological ramifications of fragmentation are perhaps yet undiscovered).

On large spatial scales, the region has already suffered from fragmentation. Forest clearing, agriculture, roadways, and general human encroachment have all contributed to fragmentation over time.

Composition of vegetative communities may also be impacted by the spread of exotic species (such as nonnative grass, shrub, and tree species planted in the ROW and/or the locally invasive Chinese tallow-tree). In addition, unintentional and/or illegal introductions of exotic plant species may be facilitated by human access provided by the new roadway, potentially impacting biodiversity.

Considering potential impacts to wildlife discussed above, the primary concern is habitat fragmentation. Forests, particularly, are relatively static environments that have low resiliency to disturbances (i.e., natural or anthropogenic) relative to grassland or emergent wetlands (which are disturbance-dependent or disturbance-maintained habitats).

Shifts from existing wildlife assemblages to faunal communities more tolerant of urban habitats would be fostered by the Grand Parkway Segment C project and subsequent development. Additionally, the Gulf Prairies and Marshes offer grassland habitat, a biome, which has been altered more so than any other. Concurrent to grassland conversions, the grassland avian assemblage has also suffered in terms of population decreases and abundance reduction. The Grand Parkway Segment C project and indirect development would contribute to these biome-wide trends in habitat conversions and subsequent wildlife community shifts.

Additional indirect terrestrial wildlife impacts may occur due to increased spread of exotic or invasive species (such as nonnative grass, shrub, and tree species planted in the proposed ROW, the locally invasive Chinese tallow-tree, and brown-headed cowbird [*Molothrus ater*]) into previously undisturbed portions of the study area. Introductions of exotic terrestrial and aquatic plant and animal species may be facilitated by human access provided by the new roadway.

Contiguous forested tracts (the Austin's Woods for example) are important habitat for area-sensitive species (area sensitivity refers to the ecological phenomenon regarding a species' aversion to utilize habitat that is not of a minimal size, regardless of the floristics or physiognomy offered by a particular tract or potential habitat). Area-sensitive birds, particularly forest-nesting, neotropical migrants requiring interior forest habitat, are more sensitive to fragmentation than edge-adapted species and are particularly affected by predation, brood-parasitism (Johnson and Temple, 1993), and other impacts on nesting success (Paton, 1994; Thompson and Burhans, 2003; Winter et al., 2000). Nest parasitism by brown-headed cowbirds and nest predation typically increases when forest fragment size decreases (Martin, 1988), and thus nest success is often higher in contiguous tracts.

6.2.5 Step 5: Identify Other Reasonably Foreseeable Future Effects

A cumulative and indirect effects analysis requires consideration of past, present and reasonably foreseeable future actions. The approach used for this CIA included the identification of past, present and future actions with the purpose of characterizing the types of actions that are representative of past, present, and future development in the RSA. A review of public documents such as, but not limited to, adopted transportation and land-use plans and input from elected officials

where municipal planning departments do not exist was performed. This is important to provide a context for the types of development projects that have caused the current health of the land and other resources, and the trends the resources are experiencing.

According to USDOT (2005), "Factors that indicate that an action or project is reasonably foreseeable for the purposes of CIA include: whether the project has been federally approved, whether there is funding pending before any agency for the project, and whether there is evidence of active preparation to make a decision on alternatives to the project" (Clairton Sportsmen's Club v. Pennsylvania Turnpike Commission, 882 F. Supp 455 [W.D. Pa 1995]).

As previously stated, 1985 was selected as the baseline year for the CIA by determining the decade with the highest percentage change in historical populations. In many cases, historic quantitative or geographically referenced (mapped) information on the various resources (e.g., acres of a given resource, land use, or land cover type) for prior years is not available. A complete list of specific past actions is not available because no quantification was done. The CEQ NEPA regulations and guidance on cumulative effects do not require development of a catalog of specific past actions or quantification of these actions in a CIA, and CEQ recognizes that this may not be practical and information may not be available (40 CFR 1500–1508: and CEQ, 2005). Therefore, quantification of individual past actions was not performed. However, past actions are considered in describing the current health of each resource.

Spatial information for known reasonably foreseeable future actions included in the discussion of Past, Present, and Reasonably Foreseeable Future Actions is not available.

Land Use

Existing development trends of master planned communities on large tracts of previously undivided land are expected to continue. For example, the George Foundation owns approximately 20,000 acres in the vicinity of the George Ranch Historical Park, and this area is expected to be developed as a master-planned community. This type of residential development has been occurring at a steady pace in the study area and involves construction of a large number of homes and the infrastructure necessary to support it.

The extensive residential development is expected to saturate the residential market for this area. The Greater Fort Bend Economic Development Council (2006) indicated that by 2020, a total of 49 planned communities are expected to be in various phases of development and will likely exceed 400,000 persons.

Lamar Consolidated Independent School District School Complex has been constructed on a 200-acre site to facilitate the growing school district. Commercial and residential developments are already being developed at the future interchange of US 59. Developments include Canyon Gate at the Brazos, Royal Lake Estates, and Belgrand Estates. Canyon Gate at the Brazos, located on Grand Parkway at US 59 South, has been constructed as a 600-acre guard-gate community with amenities such as walking trails, picnic areas, pools, clubhouse, sand volleyball, basketball courts, and tennis courts. Royal Lake Estates, located at the proposed intersection of Grand Parkway and FM 2759, includes 48 acres of scenic

lakes with over 220 acres of wooded homesites. Belgrand Estates, located just north of the future Grand Parkway and SH 288 interchange, would total 110 acres. Table 6-10 contains a list of projects (by type) both underway and planned. It should be noted that only subdivisions in which acreage was available are included in Table 6-10; therefore, not all residential development will be listed.

In addition to nontransportation projects, various transportation projects are planned within or adjacent to the RSA (Exhibit 37). These transportation projects would result in impacts to land uses within the RSA regardless of the Segment C proposed project. Table 6-11 contains a list of transportation projects within or adjacent to the RSA. Note that some developments are not entirely within the RSA; therefore, acreages for cumulative impacts were calculated utilizing GIS for developments within RSA.

TABLE 6-10
NONTRANSPORTATION PROJECTS WITHIN THE RSA

Utilities/Infrastructure	Total Acres	Status*
Lamar Consolidated Independent School District School Complex	200	E
Residential Development		
Avalon Villages of Avalon	427	E
Belgrand Estates	110	IP
Bonbrook Plantation	800	IP
Brazos Lakes	1,240	E
Brazos Town Center	540	E
Bridlewood Estates/Benton Park	945	E
Canyon Gate at the Brazos	600	IP
Creekstone Village	60	IP
First Colony**	9,700	E
Greatwood	2,050	E
Oaks of Rosenberg	80	IP
Plantation Lakes	240	IP
Sienna Village of Anderson Springs	160	IP
Sovereign Shores Estates	180	IP
Summer Lakes	160	IP
Sun Creek Estates	1,100	E
Sun Creek Ranch	2,300	IP
Sunrise Meadows	4,870	IP

Source: Greater Fort Bend Economic Development Council (2006); Hunton Energy (2007, 2009).
*E – Existing, P – Planned, IP – In Progress
**First Colony includes the following subdivisions: Alcorn Bend, Austin Meadow, Colony Meadows, Commonwealth Estates, Crescent Lakes, Grants Lake, The Highlands, The Lakes, Sweetwater, Williams Glen

TABLE 6-11
TRANSPORTATION PROJECTS WITHIN THE RSA

	Sponsor	Street	From Limit	To Limit	Project Description	Fiscal Year	Total Project Cost ($)
Brazoria TIP	Brazoria County	SH 99	SH 288	Fort Bend C/L	Seg C-3: Plan Specifications & Estimates for 4-lane tollway with noncontinuous two 2-lane frontage roads and interchanges	2013	25,000,000
	TxDOT Houston District	CR 51	At Austin Bayou		Replace bridge (NBI # 12020D00946001)	2013	379,077
	TxDOT Houston District	CR 54	At Chocolate Bayou Water Co Canal		Replace bridge (NBI # 12020AA0519002)	2013	357,841
	TxDOT Houston District	CR 48	At W Fork Chocolate Bayou		Replace bridge (NBI # 12020U00010001)	2013	1,009,252
	Brazoria County	CR 51	SH 35	SH 288	Construct 2-lane roadway, rehab existing roadway, construct new bridge, replace existing bridge	2023	2 5,996,369
Brazoria RTP	Brazoria County	CR 63	SH 288	Chocolate Bayou West Fork	Rehabilitate 2-lane rural with shoulders	2018	5,725,908
	Brazoria County	FM 1128	SH 6	SH 288	Rehabilitate 2-lane rural w/shoulders	2018	9,243,619
	Brazoria County	SH 288	SH 6	SH 99	Construct rural interchanges 4 toll lanes	2025	531,287,520
	TxDOT Houston District	FM 1462	Fort Bend C/L	Super Speedway?	Widen from 2 to 4 lanes		135,994,809
Brazoria Unfunded	TxDOT Houston District	SH 288	SH 99	FM 1462	Upgrade roadway to freeway facility by adding overpasses and underpasses		278,655,798
	TxDOT Houston District	FM 521	Brazoria/Fort Bend C/L	FM 1462	Widen 2 to 4 lanes		71,342,115
	Unsponsored (Tbd)	Sienna Pkwy	Ft Bend C/L	SH 99	Construct 4-lane road on new location		10,165,176
	Unsponsored (Tbd)	Sienna Pkwy	Ft Bend C/L	SH 99	Smart street improvements		1,518,000
	City of Rosenberg	Benton Rd	FM 762	Meyer Road	Reconstruct existing 2-lane rural roadway to 4-lane curb-and-gutter boulevard with storm sewer	2011	1,345,706

TABLE 6-11, CONT'D

	Sponsor	Street	From Limit	To Limit	Project Description	Fiscal Year	Total Project Cost ($)
Fort Bend TIP	TxDOT Houston District	US 59	1.1 miles south of SH 99	0.4 mile south of SH 99	Base repair & overlay	2013	2,000,000
	TxDOT Houston District	US 59	0.45 mile north of Williams Way	0.85 mile north of Williams Way	Realign northbound frontage road	2011	382,000
	TxDOT Houston District	US 59 S	West of FM 2759	West of FM 762	Widen to 8 ml, frontage roads, ITS & TMS	2030	221,485,784
Fort Bend RTP	TxDOT Houston District	US 59 S	West of FM 762	West of FM 2759	Construct 2-way HOV lanes	2027	1 8,617,024
	Fort Bend County	Williams Way Blvd	US 59	FM 762	Construct 4-lane divided roadway in new location	2016	1 0,956,369
	TxDOT Houston District	FM 762	US 59	Crabb River Road	Widen 2- to 4-lane divided suburban arterial	2034	57,491,183
	TxDOT Houston District	FM 2759	US 59	FM 762/FM 2759 on Crabb River Rd	Widen to 4 lanes with flush median	2026	1,000,000
	TxDOT Houston District	FM 762	FM 762/FM 2759	South of Lamar CISD School on Crabb River Road	Widen to 4 lanes divided	2026	1,000,000
	FBCTRA	Fort Bend Pkwy Toll Road	SH 6	SH 99	Construct 4-lane toll road and Brazos bridge	2025	258,861,162
	Fort Bend County	Sawmill Road	Waters Lake Bayou		Replace bridge	2023	184,942
	TxDOT Houston District	FM 762	FM 1640	FM 2759	Widen from 2 to 6 lanes (in sections)		87,062,261
Fort Bend Unfunded	Unsponsored (Tbd)	Smithers Lake	FM 762	FM 1994	Widen from 2 to 4 lanes		12,924,912
	Unsponsored (Tbd)	FM 1994	SH 36	FM 762	Smart street improvements		13,616,000
	TxDOT Houston District	FM 762	FM 1994	FM 1462	Widen from 2 to 4 lanes w/bridge		77,607,292
	TxDOT Houston District	FM 1462	FM 762	Brazoria C/L	Widen from 2 to 4-lanes		41,196,362

Source: H-GAC (2011).

Prime Farmlands

As previously stated, existing development trends indicate the development of master planned communities on large tracts of previously undivided land. Current and planned developments were mapped, and it is anticipated that prime farmlands could be impacted in the RSA as a result of future development, regardless of construction of the proposed Grand Parkway Segment C.

Air Quality

Increased development and urbanization can result in increased air pollutant or MSAT emissions resulting from these actions. These must meet regulatory emissions limits established by the TCEQ and EPA as well as obtain appropriate authorization from the TCEQ and therefore are not expected to result in any degradation of air quality or MSAT levels. Reasonably foreseeable actions that could impact air quality within the RSA are listed in Table 6-11.

As previously stated, existing development trends indicate continued transportation projects within the RSA. Current and planned projects could impact air quality in the RSA regardless of construction of the proposed Grand Parkway Segment C.

Water Quality

As previously stated, existing development trends indicate the development of master planned communities on large tracts of previously undivided land. Current and planned developments were mapped, and it is anticipated that wetland streams could be impacted in the RSA as a result of future development, regardless of construction of the proposed Grand Parkway Segment C.

Surface Waters

As previously stated, existing development trends indicate the development of master planned communities on large tracts of previously undivided land as well as continued transportation projects within the RSA. It is anticipated that wetland streams could be impacted in the RSA as a result of future development, regardless of construction of the proposed Grand Parkway Segment C.

Groundwater

As previously stated, existing development trends indicate the development of master planned communities on large tracts of previously undivided land as well as continued transportation projects within the RSA. It is anticipated that groundwater could be impacted in the RSA as a result of future development, regardless of construction of the proposed Grand Parkway Segment C.

Waters of the U.S., including Wetlands

As previously stated, existing development trends indicate the development of master planned communities on large tracts of previously undivided land. Current and planned developments were mapped, and it is anticipated that streams could be impacted in the RSA as a result of future development, regardless of construction of the proposed Grand Parkway Segment C.

Vegetation and Wildlife Habitat

As stated previously, existing development trends indicate the development of master planned communities on large tracts of previously undivided land. Current and planned developments were mapped, and it is anticipated that vegetation and wildlife could be impacted in the RSA as a result of future development, regardless of construction of the proposed Grand Parkway Segment C.

6.2.6 Steps 6 and 7: Identify and Assess Cumulative Impacts and Report the Results

Quantitative assessment of the cumulative impacts on resource health and trends in the RSA was the goal of the CIA. However, incomplete or unavailable information precluded a quantitative assessment of all resources. In these cases, a qualitative assessment of the cumulative impact on each resource within the RSA was provided. To fully assess the potential for cumulative impacts on area resources, the analysis considered the project's direct and indirect impacts, as well as the potential indirect impacts identified for the No-Build Alternative in Section 4, along with the impacts associated with past, present, and reasonably foreseeable future projects. The reasonably foreseeable future projects include transportation projects identified in the RTP as well as any other development identified with in the RSAs. The magnitude of the cumulative impacts was determined by comparing the impact to the health and trends of the affected resource.

Land Use

Construction of the proposed Grand Parkway Segment C would contribute to a cumulative increase in the amount of agricultural land converted to residential, commercial, industrial, and public infrastructure land uses. Table 6-12 presents a summary of the anticipated potential cumulative land-use effects.

The estimated land-use cumulative effect presented in Table 6-12 is based on forecasted development through 2035 and includes current development as well as development predicted under the Build and No-Build alternatives. The proposed project has the potential to facilitate the rate of development, but the amount of development and the pattern of development as a result of the proposed Grand Parkway Segment C are not known. Under the Grand Parkway Segment C project, approximately 67,626 acres would be developed, which is approximately 18 percent of the RSA. Under the No-Build Alternative, land development would still occur but would be approximately 10,689 acres or 3 percent of the RSA. Under the No-Build Alternative, development would continue but would likely be residential in nature.

TABLE 6-12
SUMMARY OF CUMULATIVE EFFECTS

Resource	Direct Impact	Indirect Impact	Potential Impacts Associated with Area Reasonably Foreseeable Projects	Cumulative Effect on the Resource
Land Use	1,117 acres	Approximately 67,626 acres of undeveloped land is within area of potential indirect development.	Approximately 11,395 acres would be converted to residential, commercial, or institutional.	Potential acceleration of existing development trends
Prime Farmlands	955 acres	Approximately 66,882 acres of prime farmland is within the area of potential indirect development.	The reasonably foreseeable projects would potentially impact 9,159 acres of additional prime farmland within the RSA.	Potential acceleration of existing development trends. Farming/ranching operations effects not quantified; however, adverse cumulative effects from segmentation could be experienced.
Air Quality	NA	Any new transportation projects proposed in the HGB would be required to be analyzed and added to a conforming plan prior to construction.	N/A	Potential decrease in MSAT emissions. Because of a lack of dispersion modeling, health effects of the MSATs on public health cannot be determined.
Water Quality	2,429 acres draining into streams	307 miles of streams have been identified within the Area of Potential Indirect Effect. No indirect impacts are anticipated, through strict adherence to regulations laid out by the TCEQ, as well as the utilization of BMPs, no adverse indirect impacts to water quality would occur as a result of the proposed project.	The reasonably foreseeable projects would potentially impact 20 miles of additional steams within the RSA.	Potential acceleration of existing development trends leading to increased stormwater runoff.
Waters of the U.S. including Wetlands	32 acres	Approximately 9,633 acres of wetlands occur in the area of potential indirect effect.	The reasonably foreseeable projects would potentially impact 513 acres of additional wetlands within the RSA.	Potential acceleration of existing development trends that could fragment wetland communities.
Vegetation and Wildlife Habitat	872 acres of pastureland/grassland/ cropland and 153 acres of forestland	Approximately 62,504 acres of pastureland/grassland/cropland and 13,485 acres of forestland are within the area of potential indirect effect.	The reasonably foreseeable projects would potentially impact 4,424 acres of grassland/pastureland/cropland and 851 acres of forestland within the RSA.	Potential acceleration of existing development trends, which could result in fragmentation and diminished habitat quality.

Source: Study Team (2011).

Prime Farmlands

Construction of the proposed Grand Parkway Segment C would contribute to a cumulative increase in the amount of prime farmland converted to residential, commercial, industrial, and public infrastructure land uses. Table 6-12 presents a summary of the anticipated potential cumulative effects. The estimated land-use cumulative effect presented in Table 6-12 is based on forecasted development through 2035 and includes current development as well as development predicted under the Build and No-Build alternatives.

Air Quality

Any increased air pollutant or MSAT emissions resulting from increased capacity, accessibility and development are projected to be more than offset by emissions reductions from EPA's new fuel and vehicle standards or addressed by EPA's and TCEQ's regulatory emissions limits programs. Projected traffic volumes are expected to result in no impacts on air quality; improved mobility and circulation may benefit air quality. Increases in urbanization would likely have a negative impact on air quality. However, planned transportation improvements in the project area as listed in a conforming Metropolitan Transportation Plan and TIP, coupled with EPA's vehicle and fuel regulations fleet turnover, are anticipated to have a cumulatively beneficial impact on air quality.

The cumulative impact on air quality from the proposed project and other reasonably foreseeable transportation projects are addressed at the regional level by analyzing the air quality impacts of transportation projects in the H-GAC 2035 RTP Update and the 2011–2014 TIP, as amended. The proposed project and other reasonably foreseeable transportation projects were included in the H-GAC 2035 RTP Update and the 2011–2014 TIP, as amended, and have been determined to conform to the SIP. When combined, planned transportation improvements, revised EPA fuel and vehicle regulations, and fleet turnover are anticipated to have a cumulatively beneficial impact on air quality.

Water Quality

Construction of the proposed Grand Parkway Segment C would contribute to a cumulative increase in the amount of stormwater runoff and impervious cover as a result of undeveloped land being converted to residential, commercial, industrial, and public infrastructure land uses. Table 6-12 presents a summary of the anticipated potential cumulative effects.

Waters of the U.S., Including Wetlands

Construction of the proposed Grand Parkway Segment C would contribute to a cumulative increase over time in the amount of surface water runoff within the RSA. Development and subsequent land conversion would cause direct and indirect effects to waters of the U.S. The amount of impervious cover as a result of undeveloped land being converted to residential, commercial, industrial, and public infrastructure land-use segments hydric features. Table 6-12 presents a summary of the anticipated potential cumulative effects.

Vegetation and Wildlife Habitat

Past development in the study area has resulted in the loss of natural habitats through residential, commercial, and agricultural development. Habitat fragmentation from infrastructure construction or changes in land use have disrupted and dispersed fish and wildlife populations. The RSA has already suffered from fragmentation in a broader sense. Forest clearing, agriculture, roadways, irrigation systems, land use, and human encroachment have all contributed to fragmentation over time. In areas where fragmentation is known to have detrimental impacts (e.g., large stream and river corridors), structures would be provided to facilitate flood events and allow movement of animals and processes along the corridor.

The direct effects of construction, operation, and maintenance of the new ROW add an element of disturbance to the ecosystem. The cumulative effects of numerous indirect developments resulting from roadway developments could continue to displace existing species from an area, or potentially alter important migratory routes for others. The vegetation communities occurring along the Grand Parkway Segment C project would be directly impacted by construction-related activities. The inevitable fragmentation of contiguous habitat blocks, the severance of riparian forest corridors, and the potential modifications of hydrologic and nutrient cycling and transfer processes are also likely to have some impact on natural communities within the RSA. As with other elements of the ecosystem, wildlife communities are impacted by the permanent loss of habitat. In addition to direct construction-related mortality or injury, wildlife populations tend to suffer impacts associated with displacement into adjacent habitats, which may be at carrying capacity (i.e., the maximum sustainable level) for that species.

Composition of vegetative communities may also be impacted by the spread of exotic species (such as nonnative grass, shrub, and tree species planted in the ROW and/or the locally invasive Chinese tallow-tree). In addition, unintentional and/or illegal introductions of exotic plant species may be facilitated by human access provided by the new roadway, potentially impacting biodiversity.

6.2.7 Step 8: Assess the Need for Mitigation for all Adverse Impacts

Opportunities for mitigation of adverse effects are discussed for each resource. These are not meant to be mitigation measures that TxDOT would, or has the authority to, implement. Rather, they are intended to disclose steps or actions that could be undertaken by local, state, and federal agencies and organizations to minimize the potential cumulative effect on each resource health and trend.

Land Use

The Grand Parkway Segment C project would result in the reduction of prime farmlands, vegetative communities, and wildlife habitat. Activities to minimize the impacts from construction include minimizing devegetation of the construction area wherever safety allows, decreasing the amount of fill placement, and implementation of BMPs, including an erosion and sedimentation control plan. As TxDOT and FHWA do not have the authority to implement zoning or planning

regulations, mitigation for cumulative effects to land use or continued conversion of undeveloped land to developed land would require the collaborative efforts of local, county, and regional planners, the public, and private developers.

Local governments such as Sugar Land and Missouri City have adopted land-use plans to deal with the orderly growth within their jurisdictions; however, local governments that have not adopted these types of plans should consider taking such steps to minimize future adverse effects of unplanned growth. These plans could include provisions to protect green space in new residential and multi-use developments. An example would be local governments requiring developers dedicate 30 percent of their total development to open space.

There are Land Trust organizations that may be interested in preservation opportunities within the RSA. Such organizations involve a local, state, or regional nonprofit organization directly involved in protecting land for its natural, recreational, scenic, historical, or productive value. Preservation opportunities could involve land donations, fee acquisition, mitigation banks, land leases, or conservation easements.

Prime Farmland

The potential future loss of farmland could be limited by the implementation of more stringent local, state, and federal restrictions on the conversion of the farmland resource. Substantial gains in the area of conservation have been made in the 2008 Farm Bill (AFT, 2009). Conservation programs include:

- Improvement of the Farm and Ranch Lands Protection Program to allow greater flexibility at the local level. Funding raised from $97 to $200 million a year in 2012.
- Enhancement of the Conservation Stewardship Program to green farm support on working lands and reward farmers for stewardship. Over $1.2 billion added.
- Expansion of the Environmental Quality Incentives Program to allow for innovative approaches that generate public benefits such as wildlife and open space protection. Funding will rise from $1.2 to $1.75 billion in 2012.
- Creation of a cooperative conservation initiative as a way for producers and community groups to work together on common natural resource concerns.
- Greater flexibility with third party technical assistance providers to identify and implement the most effect conservation practices appropriate for the land.
- Extension of the tax deduction for donated easements to protect more land in the future.

Through programs such as these, producers may be able to continue farming operations without the pressure to sell their land to developers.

Air Quality

A variety of federal, state, and local regulatory controls as well as local plans and projects have had a beneficial impact on regional air quality. The CAA, as amended, provides the framework for federal, state, tribal, and local rules and regulations to protect air quality. The CAA required the EPA to establish NAAQS for pollutants considered harmful to public health and the environment. In Texas, the TCEQ has the legal authority to implement, maintain, and enforce the NAAQS. The TCEQ establishes the level of quality to be maintained in the state's air and to control the quality of the state's air by preparing and developing a general comprehensive plan. Authorization in the Texas Clean Air Act (CAA) allows the TCEQ to do the following: collect information and develop an inventory of emissions; conduct research and investigations; prescribe monitoring requirements; institute enforcement; formulate rules to control and reduce emissions; establish air quality control regions; encourage cooperation with citizens' groups and other agencies and political subdivisions of the state as well as with industries and the federal government; and to establish and operate a system of permits for construction or modification of facilities. Local governments having some of the same powers as the TCEQ can make recommendations to the commission concerning any action of the TCEQ that may affect their territorial jurisdiction, and can execute cooperative agreements with the TCEQ or other local governments. In addition, a city of town may enact and enforce ordinances for the control and abatement of air pollution not inconsistent with the provisions of the Texas CAA or the rules or orders of the TCEQ.

The CAA also requires states with areas that fail to meet the NAAQS prescribed for criteria pollutants to develop a SIP. The SIP describes how the state would reduce and maintain air pollution emissions in order to comply with the federal standards. Important components of a SIP include emission inventories, motor vehicle emission budgets, control strategies to reduce emissions, and an attainment demonstration. The TCEQ develops the Texas SIP for submittal to the EPA. One SIP is created for each state, but portions of the plan are specifically written to address each of the nonattainment areas. These regulatory controls, as well as other local transportation and development initiatives implemented throughout the H-GAC Metropolitan Planning Area by local governments and other entities provide the framework for growth throughout the area consistent with air quality goals. As part of this framework, all major transportation projects, including the proposed project, are evaluated at the regional level by the H-GAC for conformity with the SIP.

The cumulative impact of reasonably foreseeable future growth and urbanization on air quality within this area would be minimized by enforcement of federal and state regulations, including the EPA and TCEQ, which are mandated to ensure that such growth and urbanization would not prevent attainment with the O_3 standard or threaten the maintenance of the other air quality standards.

Water Quality

Water quality-related mitigation initiatives that may address cumulative effects in certain portions of the RSA include various programs implemented by the Texas State Soil and Water Conservation Board, TCEQ, River Authorities, and local

governments. The TCEQ's program for development of Total Maximum Daily Loads for waterbodies listed as impaired on the CWA 303(d) list may potentially result in mitigation programs affecting watersheds within the RSA.

Water quality mitigation for cumulative effects could potentially include collaboration among agencies to minimize impacts to the surface and groundwater resources. Regulatory compliance at the federal, state, and local level during continued development within the RSA could stabilize or prevent additional impacts to surface and groundwater supply or decline in water quality. Compliance with local regulations in watersheds and encouragement of setback standards to prevent increased sedimentation or low quality water intrusion of waterbodies could be adopted in order to preserve this resource.

Waters of the U.S., including Wetlands

All impacts to waters of the U.S. will be coordinated with the USACE and other applicable resource agencies through the CWA individual permit application process. Permittable activities are proposed for the Grand Parkway Segment C project under Section 10 of the Rivers and Harbors Act and Section 404 of the CWA. Although isolated wetlands are not regulated under Section 404, impacts to isolated wetlands have been identified and included in the alternatives analysis and the USACE Permit Application. Measures to minimize and/or mitigate for any adverse impacts have been developed in conjunction with the USACE and resource agencies.

Potential adverse impacts to waters of the U.S., including wetlands, are reduced floodwater storage, decreased surface water quality (due to loss of sediment trapping, nutrient removal, and chemical detoxification functions) near the proposed road alignment, reduction in wildlife habitat, and possibly a decrease in groundwater recharge. Mitigation measures will be implemented to reduce the potential adverse impacts from the unavoidable impacts.

The fact that some degree of impact is often unavoidable, regardless of the care applied during the planning, design, and construction of a highway, necessitates a plan for compensatory mitigation to replace function, values, and features or habitat that may be disturbed. This is required for unavoidable impacts, which remain after appropriate and practicable minimization has been achieved. Mitigation or replacement of unregulated habitat (habitat not under the USACE jurisdiction where legal compensation is required or under the ESA where project modification may be required) within transportation corridors may not be practical or safe. On occasion, on-site restoration of degraded wetland habitat or creation of man-made wetland habitat within the highway ROW through creative use of swales, borrow pit areas, detention basins, or drainage runoff channels may be appropriate.

On-site mitigation measures are not always practical or feasible within a highway ROW. In addition, such measures may not effectively restore resource values; thus, off-site mitigation measures may be more appropriate. Off-site mitigation projects for wetlands must be designed to reestablish, to the extent reasonable, similar wetland functions and type as the preexisting site. Off-site mitigation should be conducted in the same geographic vicinity or in proximity, and most likely within the same watershed as the project, particularly for wetlands. Mitigative action may include expanding existing wetlands, restoration with hydrophytic species, or regulating water levels in impoundments or streams. Construction or

improvement of the wetland habitat mitigation should not be considered unless post-project monitoring of the sites can be arranged.

Impact awareness and public education seminars could be conducted to address avoidance and minimization of permanent impacts to jurisdictional waters. This could potentially avoid future degradation of wetlands and functionality and help prevent alterations of stream beds and water quality. In addition to public awareness, future developers in the RSA should incorporate methods to avoid or minimize impacts to these resources during the planning and design processes in order to preserve existing riparian vegetation, stream bank conditions, and upland wetland features.

Vegetation and Wildlife Habitat

Mitigation includes measures, which avoid, minimize, eliminate, or compensate for impacts to resources. Initial mitigation measures in the planning or alignment of highway projects minimize the probable occurrence of habitat (vegetation communities) and wetland impacts through route location (avoidance) and construction practices. Activities to minimize the impacts to habitats from highway construction include minimizing devegetation of the construction area wherever safety allows, decreasing the amount of fill placement, and implementation of BMPs, including an erosion and sedimentation control plan. Specific impact minimization to wetland areas may include: the design (use of bridge crossings instead of filled embankment); the use of retention basins and vegetated swales to minimize runoff, sedimentation, turbidity, leaching of soil nutrients, and leaching of chemicals from petroleum products, pavement, and waste material; and alleviating flow alterations due to structures, which change established wetland drainage or flooding patterns.

Mitigation or replacement of unregulated habitat (habitat not under the USACE jurisdiction where legal compensation is required or under the ESA where project modification may be required) within transportation corridors may not be practical or safe. EO 13112 requires Federal agencies to prevent introduction of invasive species and provide for their control and then to minimize the economic, ecological, and human health impacts that invasive species cause. Native plant species of grasses, shrubs, or trees would be used in the landscaping and in the seed mixes. No invasive species would be used to revegetate the ROW, and soil disturbance would be minimized to ensure that invasive species do not establish within the ROW.

Other natural areas of special concern include blocks of Columbia Bottomland forest. The USFWS considers any coastal plain bottomland hardwood forest within a 500-year floodplain south of US 59, east of the Colorado River and west of SH 6 to the coast as Austin's Woods. An almost unbroken corridor of Austin's Woods adjacent to Rabbs Bayou, Waters Lake Bayou, and the Brazos River originates around Thompsons Oil Field arching to the west and south and terminating in the Pilant Lake wetland complex of Brazos Bend State Park. Due to the rapid urbanization of southeast Texas, wildlife resource agency staff have identified forested community types as a priority for protection, restoration and creation.

There are Land Trust organizations that could be interested in preservation opportunities in the RSA. Such organizations involve a local, state, or regional nonprofit organization directly involved in protecting land for its natural, recreational,

scenic, historical, or productive value. Preservation opportunities could involve land donations, fee acquisition, mitigation banks, land leases, or conservation easements.

A letter of commitment has been received from the George Foundation to dedicate approximately 500 acres of Brazos River floodway north of Brazos Bend State Park. This floodway habitat constitutes a portion of the riparian corridor and Austin's Woods and would be necessary to link the Lake Worthington Conservation Area with Brazos Bend State Park.

In lieu of a donation from the George Foundation, TxDOT may elect to contribute a donation to a nonprofit organization (e.g., National Fish and Wildlife Foundation). Resource agency staff has expressed an interest in this approach as it provides some fiscal flexibility in the acquisition and protection of key conservation properties that might otherwise be unattainable within the timeframe necessary to afford complete protection for the entire initiative. The in-lieu fee approach is offered as an option. The amount of the donation would be similar to the cost of acquiring or restricting development of an approximate 500-acre parcel within the Brazos River floodway.

Other measures to mitigate for wildlife include the implementation of wildlife underpasses that would include drift fencing to direct wildlife away from the roadway and into the underpass. Lastly, vegetation would be planted to buffer noise and other effects produced by transportation projects.

6.3 REGIONAL CUMULATIVE EFFECTS OF TOLL FACILITIES AND MANAGED LANES

As the MPO for the Houston-Galveston region, the H-GAC is charged with enabling and creating a regional perspective for transportation and mobility. The 2035 RTP Update provides the major strategies that would accommodate forecasted growth and preserve mobility in the region.

In 2009, H-GAC prepared a planning-level assessment, *Regional Cumulative and Indirect Effects of Toll Facilities*[1] report, to determine how the 2035 RTP regional toll roadway network could indirectly or cumulatively affect socioeconomic and natural resources. Resources evaluated in this planning study included EJ populations (low-income and/or minority populations as defined in EO 12898[2]), air quality, water resources, vegetation, and land use. However, the majority of the H-GAC analysis focused on the potential impact of the regional toll roadway network on EJ populations in the region. The RTP and the *Regional Cumulative and Indirect Effects of Toll Facilities* report were updated in 2010 to consider the impact of changes in toll rates on EJ populations. The RTP was again updated in 2011 to address changes in the projects that are included in the 2035 roadway network. For more information on the resources evaluated and for more detail on the EJ analysis, see the H-GAC *Regional Cumulative and Indirect Effects of Toll Facilities* report and the project technical files.

The indirect impact portion of this document identified the need to consider impacts of the expanding regional roadway network, specifically the expansion of toll facilities and managed lanes. An evaluation of the regional cumulative effects of

[1] HGAC, Regional Cumulative and Indirect Effects of Toll Facilities April 2009.

[2] Executive Order 12898: Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations.

these facilities was considered for potential impacts on EJ populations, air quality, water quality, vegetation, and land use. The RSA for this evaluation is the H-GAC eight-county region.

Environmental Justice

Methodology

H-GAC conducted an evaluation to determine the effects of a regional tolled roadway network on EJ populations. Initially, the evaluation identified those 2000 Census block groups that contained 51 percent or more of minority and/or low income populations. Once the EJ block groups were identified, EJ TAZs were identified if 50 percent or more of its area was identified as an EJ population. Approximately 46 percent of the TAZs are EJ TAZs. In addition, they contain nearly a third of the regional population (Table 6-13). Figure 6-1 depicts the EJ TAZ for low income populations and/or minority populations.

TABLE 6-13
TRAFFIC ANALYSIS ZONE DATA

	2000 Population	Percent of Regional Population	Number of TAZ	Percent of Total TAZ
Total EJ TAZ Population	1,634,500	31	1,383	46
Total Regional Population	5,214,051	100	3,000	100

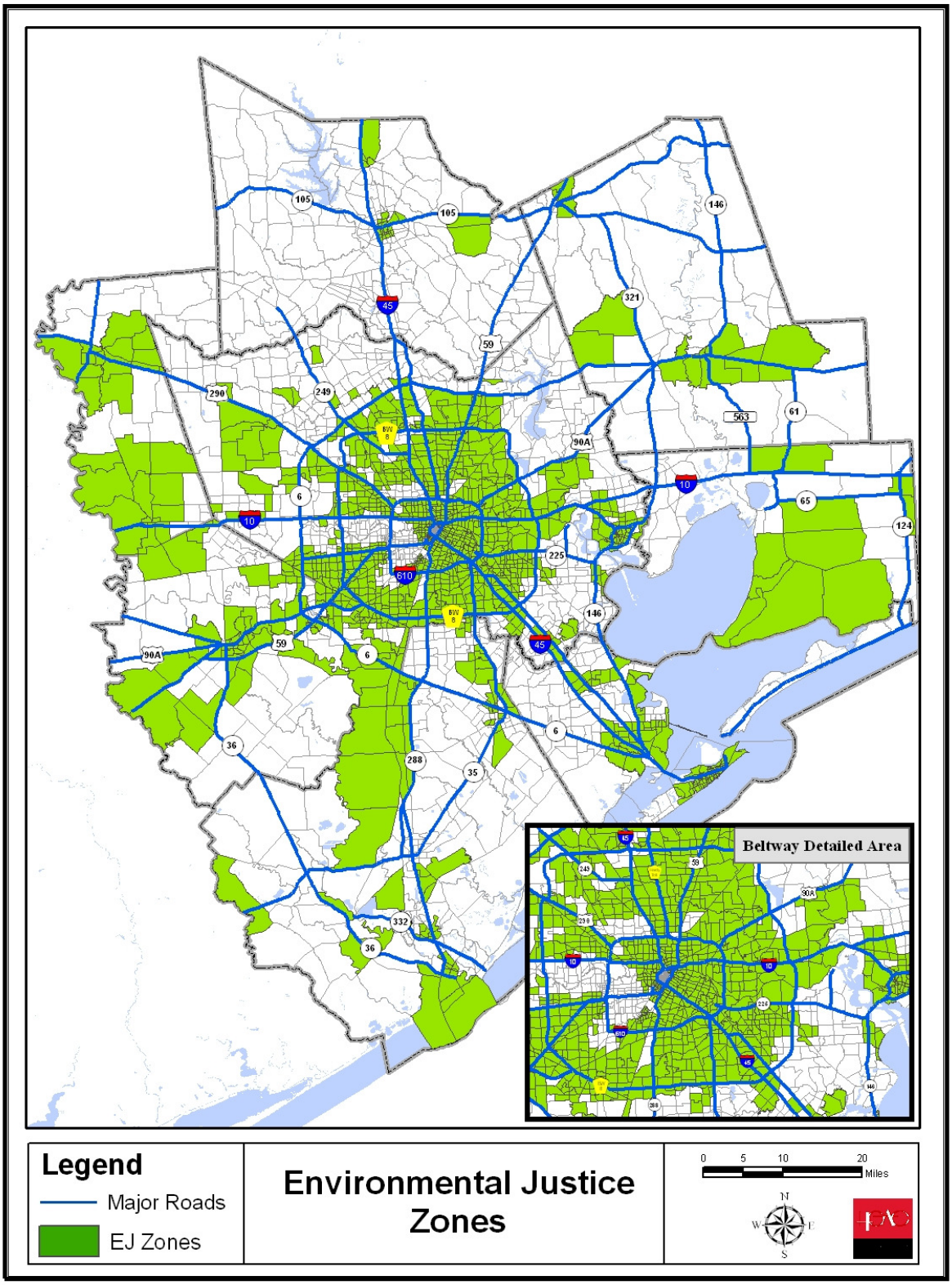
Source: H-GAC (2009).
Note: Table data is based on the original 2035 RTP but is consistent with the RTP Update conducted by H-GAC in 2011 as they did not change their growth scenarios for this update.

Following the identification of the EJ TAZs, two regional roadway network scenarios were utilized, the 2035 RTP Build Scenario and the 2035 RTP Update No-Build Scenario, to conduct an analysis on travel time for persons within the EJ TAZs and non-EJ TAZs. The Build Scenario includes the new tolled lanes, managed lanes, and HOT projects identified in the 2035 RTP Update (Figure 6-2). The No-Build Scenario includes the current roadway network, the fiscally constrained 2035 RTP Update roadway network and the Katy Freeway HOT lanes (Figure 6-3).

Analysis Assumptions and Limitations

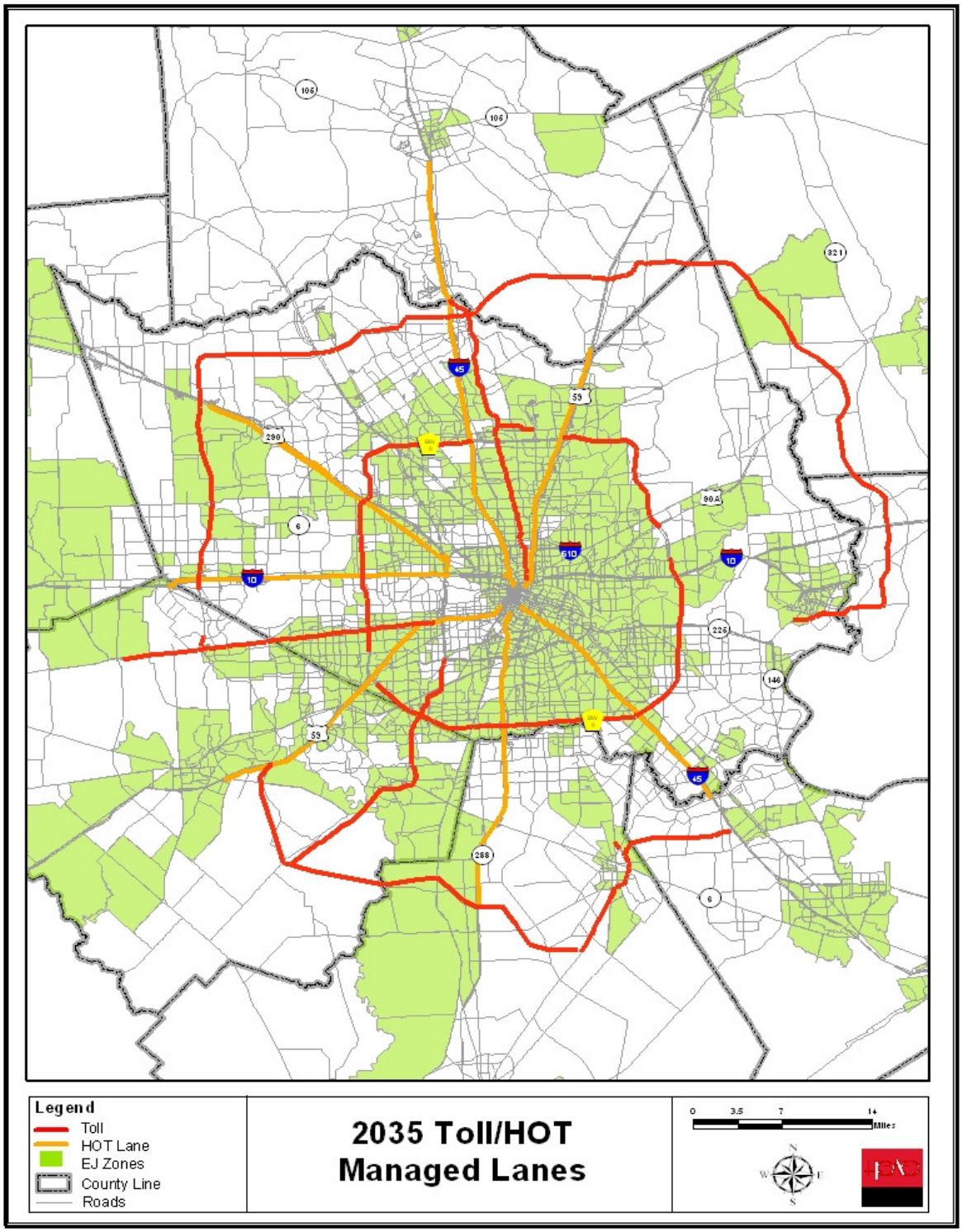
The region's travel demand models do not provide a means for tracking travel at an individual household level, but do provide a means for tracking travel at a zonal level. For purposes of the analyses, the zones are specified as either EJ zones or non-EJ zones based on the socioeconomic characteristics of the zonal populations. Some regional travel models employ a generalized cost assignment procedure for toll analyses. The H-GAC models perform toll analyses at the mode choice level. Hence, the H-GAC travel model uses a multi-class assignment procedure rather than a generalized cost procedure.

Figure 6-1
Environmental Justice Traffic Analysis Zones



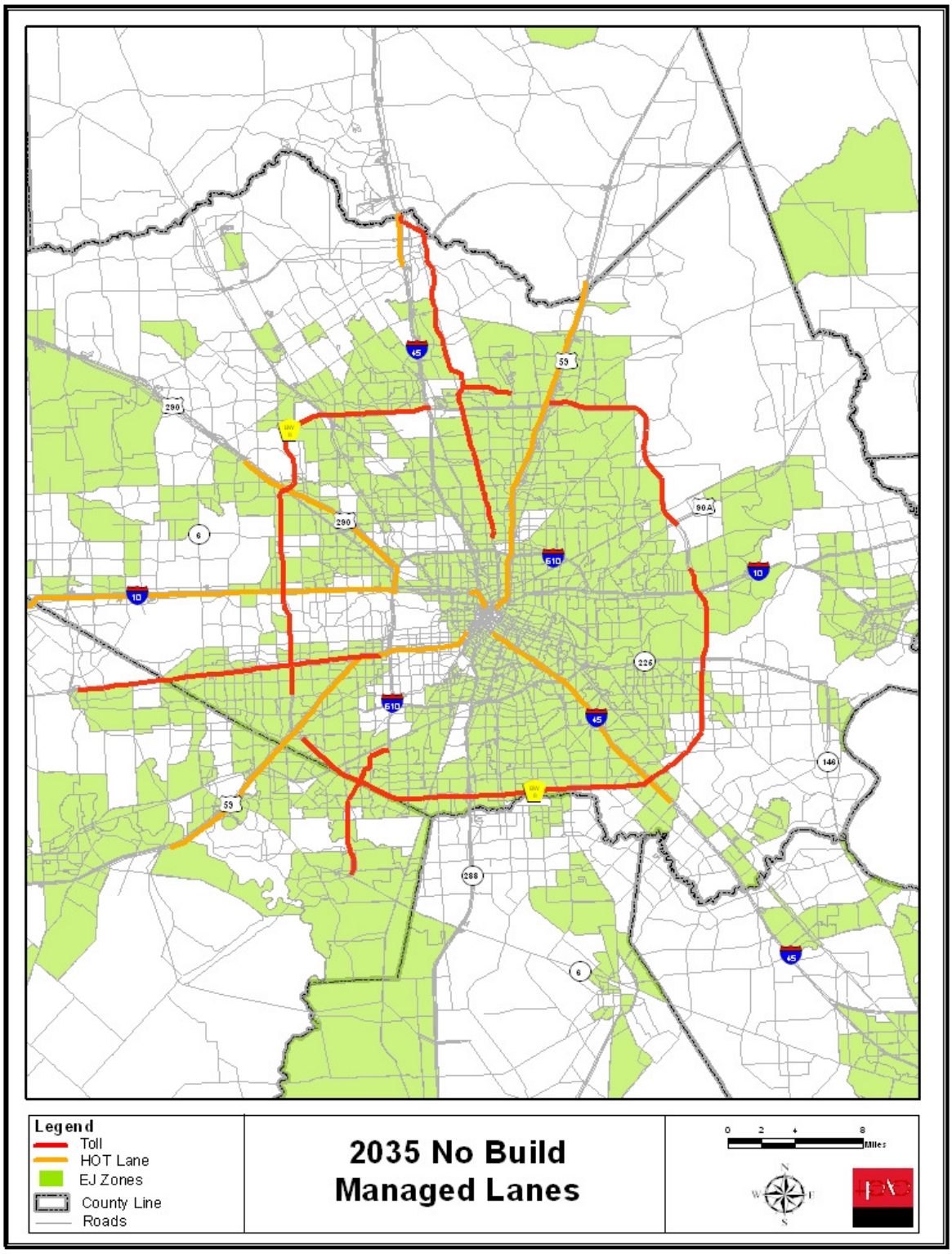
Source: GPA-GEC (2012).

Figure 6-2
2035 Toll/HOT Managed



Source: GP-GEC (2012).

Figure 6-3
2035 No-Build Managed Lanes Network



Source: GP-GEC (2012).

The mode choice models are applied by trip purpose. For the mode choice toll analyses, two travel time estimates are developed from each zone to all other zones: (1) the travel time using both toll and nontoll links (commonly referred to as "toll path" travel times), and (2) the travel time using only nontoll links (commonly referred to as the "free path" travel time). In the mode choice model, if the toll path does not offer a shorter travel time between two zones than the free path travel time, the trip is not considered a "candidate" for the toll facility. If a trip can save travel time using a toll path over a free path then it is considered a "candidate" trip. Of course, not all candidate trips will choose to use a tolled path. The probability of a candidate trip using a tolled path is a function of a number of variables such as the magnitude of the potential travel time savings, the toll costs and the income characteristics of the zones residents. Aspects of this approach are employed in the analyses presented in this report.

In mode choice model applications, there is a single highway network that is used to estimate the travel times for toll paths and free paths. For the regional toll analyses, there are two networks: the "Build" network (i.e., the forecasted roadway network containing the subject toll facilities) and the "No-Build" network (i.e., the network containing all the forecasted roadways except the subject toll facilities). Existing and committed toll facilities are contained in both networks. In this analytical setting, simply comparing the toll path versus free path option will not identify the candidate trips for only the new toll facilities being studied. Indeed, such a grouping would include trips using both existing and proposed toll facilities.

To focus on candidate trips for the new toll facilities, the travel time for toll paths in the Build network is compared to the toll path travel time in the No-Build network. Trips that have a shorter toll path travel time in the Build network than the toll path travel time in the No-Build network are defined as candidate trips for the new toll facilities. The trips from EJ zones are stratified as either candidate trips or noncandidate trips using the data from the two networks. Likewise, the trips produced by the Non-EJ zone are similarly stratified. Stated differently, the trips for a given trip purpose is segmented into four groups:

1. Trips produced by EJ zones that are classified as "Candidate" trips
2. The remaining trips produced by EJ zones are classified as non-"Candidate" trips
3. Trips produced by non-EJ zones that are classified as "Candidate" trips
4. The remaining trips produced by non-EJ zones are classified as non-"Candidate" trips

Using toll path travel times and free path travel times from the Build and the No-Build networks, there are four travel times for each trip, i.e., (1) Build network-toll path option, (2) Build network-free path option, (3) No-Build network-toll path option, and (4) No-Build network – free path option). By computing the ATLs for each of the options, the impacts of the two networks on the choice options can be quantified, compared, and analyzed.

Using this approach, the results allow the comparison of the toll and free path options for each network for each segmentation of trips. Clearly, the implementation of new toll facilities should be expected to benefit those who might

choose to use a toll facility. Of perhaps more interest is determining if there are any expected overall disadvantages to those who might chose not to use a toll facility or that are not candidates for using one of the new toll facilities.

One of the interesting side benefits of the approach used is that it calls attention to the fact that there will be some potential travel time savings realized for trip makers who chose not to use a toll facility. These time savings would be expected to accrue from the reduced congestion on free facilities due to trips diverted to toll facilities.

These analyses are regional level analyses and focus on average regional results. Such analyses do not isolate any zone specific analyses or the impacts in the immediate proximity of the new proposed facilities. These impacts were addressed by the analyses performed for the individual facilities. Indeed, the purpose of these analyses are to determine whether there are any cumulative regional impacts to the EJ populations represented by the zones designated as EJ zones.

To determine the time analysis for the different scenarios, trips were divided into HBW and HBNW for both tolled and free facilities.

Table 6-14 shows the 2035 HBW person trips and the ATL in minutes for the Build and No-Build Scenarios.

The results for the home based work trips analysis indicate:

- The addition of the tolled facilities to the regional roadway network under the Build Scenario results in a reduction of travel time in the EJ and Non-EJ Zones for all trips on tolled facilities (3.53 and 7.65 minutes, respectively).
- The addition of the tolled facilities to the regional roadway network under the Build Scenario results in a reduction of travel time in the EJ and Non-EJ Zones for all trips on free facilities (1.93 and 3.95 minutes, respectively).
- Overall, the Build Scenario provides a reduction in travel time for both the tolled and free facilities within the regional roadway network for all zones. As a result, there is no potential for a disproportionate negative effect to the EJ populations from the regional tolled roadway network. In fact, the entire region, including the EJ Zones, will recognize a benefit in travel time savings because of the added capacity the tolled roadway facilities provide to the regional roadway network.

Table 6-15 shows the 2035 HBNW person trips and the ATL in minutes for the Build and No-Build Scenarios.

TABLE 6-14
AM PEAK HOME BASE WORK TRIPS

			AM Peak Average Trip Length (ATL) in minutes for Free and Tolled Facilities under the Build and No-Build Network Scenarios				Difference in AM Peak ATL in minutes	
			Build Network Scenario		Non-Build Network Scenario			
Zones	**2035 HBW Trip Scenarios**	**Number of 2035 HBW Person Trips**	**ATL Using Tolled Facility**	**ATL Using Free Facility**	**ATL Using Tolled Facility**	**ATL using Free Facility**	**Difference in ATL for the Tolled Facility (No-Build – Build)**	**Difference in ATL for Free Facility (No-Build – Build)**
EJ Zone	Trips that save 0+ minutes using a new tolled facility	924,197	45.43	51.14	48.96	53.07	3.53	1.93
	Trips that cannot save 0+ minutes using a new tolled facility	1,726,782	24.78	24.83	25.52	25.57	0.74	0.74
Non-EJ Zone	Trips that save 0+ minutes using a new tolled facility	1,313,564	58.75	66.25	66.4	70.2	7.65	3.95
	Trips that cannot save 0+ minutes using a new tolled facility	1,793,534	29.30	29.35	30.66	30.71	1.36	1.36

Source: GP-GEC (2012).
Note: Table data is based on the 2035 RTP Update conducted by H-GAC in 2011.

TABLE 6-15
AM PEAK HOME BASED NON-WORK TRIPS

			AM Peak Average Trip Length (ATL) in minutes for Free and Tolled Facilities under the Build and No-Build Network Scenarios				Difference in AM Peak ATL in minutes	
			Build Network Scenario		Non-Build Network Scenario			
Zones	**2035 HBW Trip Scenarios**	**Number of 2035 HBW Person Trips**	**ATL Using Tolled Facility**	**ATL Using Free Facility**	**ATL Using Tolled Facility**	**ATL using Free Facility**	**Difference in ATL for the Tolled Facility (No-Build – Build)**	**Difference in ATL for Free Facility (No-Build – Build)**
EJ Zone	Trips that save 0+ minutes using a new tolled facility	674,267	32.23	34.32	35.54	36.51	3.31	2.19
	Trips that cannot save 0+ minutes using a new tolled facility	5,736,756	14.78	14.79	15.18	15.19	0.4	0.4
Non-EJ Zone	Trips that save 0+ minutes using a new tolled facility	1,019,058	45.77	49.01	54.84	55.61	9.07	6.60
	Trips that cannot save 0+ minutes using a new tolled facility	5,811,141	23.05	23.06	24.28	24.30	1.23	1.24

Source: GP-GEC (2012).
Note: Table data is based on the 2035 RTP Update conducted by H-GAC in 2011.

The results for the HBNW trips analysis indicate:

- The addition of the tolled facilities to the regional roadway network under the Build Scenario results in a reduction of travel time in the EJ and Non-EJ Zones for all tolled facilities (3.31 and 9.07 minutes, respectively).
- The addition of the tolled facilities to the regional roadway network under the Build Scenario results in a reduction of travel time in the EJ and Non-EJ Zones for all free facilities (2.19 and 6.60 minutes, respectively).
- Overall, the Build Scenario provides a reduction in travel time for both the tolled and free facilities within the regional roadway network for all zones. As a result, there is no potential for a disproportionate negative effect to the EJ populations from the regional tolled roadway network. In fact, the entire region, including the EJ Zones will recognize a benefit in travel time savings because of the added capacity the tolled roadway facilities provide to the regional roadway network.

In addition, the Build Scenario, which includes the regional tolled roadway network, provided an overall reduction in daily vehicle hours traveled (VHT). Essentially, daily VHT decreased by nearly 2 percent for the 2035 regional roadway network (Table 6-16). This reduction indicates that the 2035 roadway network with tolled facilities would improve system performance and provide travel time savings for EJ and non-EJ populations.

TABLE 6-16
2035 REGIONAL VMT AND VHT

	Build	No-Build
Daily VMT	273,728,894	272,667,394
Daily VHT	9,723,213	9,971,737
AM VMT	58,603,316	45,028,280

Source: GP-GEC (2012).
Note: Table data is based on the 2035 RTP Update conducted by H-GAC in 2011.

Overall Environmental Justice Toll Network Findings

For HBW and HBNW trips, EJ population trips that are candidate toll users are benefited by the introduction of the new toll facilities in terms of both the toll and free path travel times. Equally important, EJ population trips that are not candidate toll users benefit by the introduction of the new toll facilities as the free path travel time ATLs is reduced between the No-Build and Build scenarios. As such, EJ populations experience an overall benefit under the Build Alternative for their HBW and HBNW travel.

Although EJ zones are spread throughout the region, they are generally clustered within Beltway 8 and are not in close proximity to the majority of future toll facilities as the non-EJ zones are. Consequently, as the ATL of the EJ zones are less than the ATL of non-EJ zones, the EJ zones cannot derive as much travel time savings as the longer trips from non-EJ zones. A substantial amount of future transit improvements are targeted at EJ zones; the ATLs for the populations within those zones will tend to improve due to increased access to improved transit facilities. As previously mentioned, METRO's 2035 Long Range Plan recommends significant expansion of the current transit system and includes a network of integrated high capacity transit facilities on major travel corridors. This plan also identifies service expansions beyond the METRO service area. New improvements scheduled for implementation through the year 2035 include high-occupancy tolls, a new intermodal terminal, park-n-ride facilities, 40 miles of Signature Bus lines, and several new high capacity transit corridors throughout the region including the 89 miles of LRT, and 84 miles of CRT.

An analysis was also conducted to determine the annual financial burden of utilizing the toll road system for HBW trips. The analysis assumed a 2035 toll rate per mile of 19.96 cents (current toll rate of 10 cents per mile with an annual escalation rate of 2.5 percent). In addition the analysis assumed that an average HBW trip length is 23.30 miles and the SOV user makes 250 round-trips per year using the toll facility. Under this scenario, the annual cost would be approximately $2,325 per year. However, the accrual cost should be substantially less since the likelihood of a trip using only tolled facilities is diminutive.

Although EJ populations will see an increase in spending for toll facilities, the entire region will also see an increase in spending and usage as the toll and managed lane system expands. Both EJ and Non-EJ populations will benefit from future toll facilities. In fact, the 2035 RTP Update relies heavily on toll funding to finance a portion of future added capacity projects, both free and toll. Additionally, for both populations who choose to use nontoll options, the Build scenario for 2035 will provide a roadway network that will operate at better traffic conditions than the No-Build scenario and would provide an increased benefit for those users over the No-Build scenario. Consideration was included in the 2011 regional toll analysis for the 2035 RTP Update changes in the 2035 roadway network and toll increases, which were implemented and evaluated in 2010.

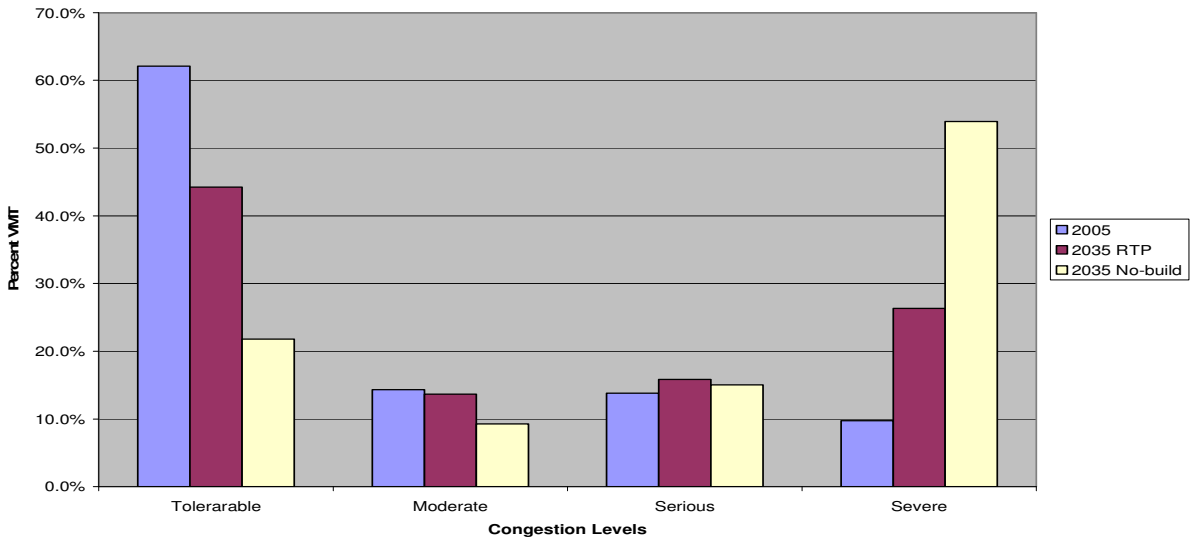
Based on the previous discussion and analysis, the Build scenario for the 2035 RTP Update, even with the network changes and the 2010 toll increases, would not cause cumulative disproportionately high and adverse effects on EJ populations as per EO 12898 regarding EJ.

Air Quality

The CAAA require transportation plans, programs, and projects in nonattainment areas, which are funded or approved by the FHWA or FTA, to conform to the SIP. This ensures that transportation plans, programs, and projects do not produce new air quality violations, worsen existing violations, or delay timely attainment of the NAAQS. Under the CAA, the EPA established criterion called the NAAQS to determine the health threat of criteria pollutants, generally located within CMSAs. If a CMSA has a health threat, it is designated as a “nonattainment” area until compliance is achieved. The Houston-Galveston region is classified as a nonattainment area for the 1997 8-hour Ozone standard, and it has been further classified as “severe.”

Transportation conformity is an analytical methodology that establishes the connection between projected on-road emissions from the RTP Update and the known reductions in the motor vehicle emission budget from the SIP. Through the process of transportation conformity, the RTP Update uses the SIP on-road mobile strategies and air quality targets to demonstrate if the RTP Update complies with the federal air quality requirements. Vehicle emissions resulting from the implementation of transportation projects in the 2035 RTP Update cannot exceed emission budgets established by the SIP. The Houston-Galveston region must demonstrate that the 2011–2014 TIP and the long-range plan (2035 RTP Update) result in less VOC and NO_X than established and approved by EPA for each analysis year. On January 25, 2011, the USDOT determined that the 2035 RTP Update and the 2011–2014 TIP conformed to the requirements of the SIP for the Houston-Galveston O_3 nonattainment area. The Level of Mobility (LOM) was developed to illustrate the degree of congestion on roadways within the region. Figure 6-4 shows the relative distribution of morning peak period congestion levels for the current and future regional roadway network as a percentage of VMT in each LOM category. Based on the forecasted growth predicted in the 2035 RTP Update, regional congestion levels would still exist on the regional roadway network. However, the 2035 RTP Update Regional Roadway Network would improve morning peak congestion approximately 50 percent to less than 30 percent when compared to the 2035 No-Build Scenario. (Note: Figure 6-4 is not listed in TOC)

Figure 6-4
Level of Mobility – AM Peak



Source: GP-GEC (2012).
Note: Data is based on the 2035 RTP Update conducted by H-GAC in 2011.

Air Quality Findings

The addition of tolled facilities and managed lanes into the existing regional roadway network would not have any cumulative impacts to air quality. Moreover, a tolled roadway network adds capacity to the regional roadway network, thus allowing a better flow of traffic and decreasing the amount of cars traveling at lower speeds or idling conditions. The improved traffic flow results in less fuel combustion and lower emissions including MSATs, CO, and O_3. As noted in the direct, indirect, and project level cumulative analysis discussions, EPA's vehicle and fuel regulations, coupled with fleet turnover, are expected to result in substantial reductions of on-road emissions, including MSATs, CO, and O_3 precursors.

Water Quality

The Houston-Galveston region has an abundance of water resources including rivers, lakes, and bays. The TCEQ, along with the Clean Rivers Program and numerous local agencies, are responsible for monitoring all major bodies of water and reporting those conditions in a biennial Texas Water Quality Inventory report. Section 303(d) of this report details those water bodies TCEQ has identified as impaired because of water contamination. The 303(d) list identifies several major water systems as impaired with pollutants and bacteria in the RSA. A majority of the waterways located in the Trinity-San Jacinto Coastal Basin, San Jacinto River Basin, San Jacinto-Brazos Coastal Basin, Brazos-Colorado Coastal Basin, including bays and estuaries that flow to the Gulf of Mexico, are impaired and included in the 303(d) list. The construction of the regional tolled roadway network would cross and impact the above mentioned water bodies at various locations and could cause water quality impacts. The increase of impervious cover from adding capacity to the regional roadway network greatly increases nonpoint source pollution and the potential to cause further impairment to the region's waterways. As

stated previously, TCEQ regulates water quality through SW3P, MS4, and BMPs. All construction of the regional tolled roadway network in the RTP Update would follow these water quality regulations that would aid in preventing further pollution to these impaired waters and to waters that are not impaired. Additionally, any land use development that would occur from the construction of these facilities would follow TCEQ's regulations for water quality through SWP3 and MS4.

Water Quality Findings

Although overall impacts cannot be avoided, the above-mentioned mitigation techniques will ensure that the regional tolled roadway network would not have significant cumulative impacts to water quality.

Vegetation

Prairie, Wetland, Bottomland Forest, Upland Forest, and Riparian Corridor ecosystems are all located in the Houston-Galveston region. Each of these resources provides vital functions such as flood protection, air quality, water quality and wildlife habitat. Protection of these natural resources that contribute to our region's quality of life is an important priority when planning for our region's future growth and transportation infrastructure. This sentiment was voiced strongly at the Envision Houston Region workshops and forums.

As growth and development are part of our region's future, it is not feasible that every undeveloped parcel be preserved. However, it is feasible that the region identifies and works to conserve those areas that are most ecologically sensitive. H-GAC identified areas that have sensitive environmental resources for special consideration in the transportation planning process. However, the identification is not intended to be used for project-level screening. The results are intended to be used for long-range planning purposes and screening to identify areas in which future transportation projects or development may potentially impact these sensitive resources. In addition, the identified environmental resources are areas in which mitigation efforts may be focused.

In some instances, disturbing natural resources may be unavoidable for regionally significant projects or projects located on facilities that are multiple-lane, limited access facilities, such as highways and toll roads. Currently, projects within the 2035 RTP Update are individually subject to environmental requirements but have no mechanism for cumulatively identifying or mitigating environmental impacts. At the project level, TxDOT Houston District can mitigate for loss of vegetation with the TPWD, and wetlands mitigation would occur through the permitting process under the jurisdiction of the USACE. Locally, cities can also curb vegetation loss by implementing measures to protect vegetation areas.

Vegetation Findings

Impacts to vegetation will undoubtedly occur from the regional tolled roadway network. However, these impacts are best evaluated and mitigated at the project level.

Land Use

While we can increase system capacity, manage demand, and improve the efficiency of the existing regional roadway network, the greatest potential effect upon improving mobility and quality of life is connecting transportation and land use planning. Land use has a direct impact on the ability of the region's transportation system and agencies to deliver a variety of travel choices. The 2035 RTP Update has shown that sustained major investments in roadway capacity will only moderate, and will not eliminate the level of future traffic congestion. However, improved mobility is possible through better coordinated land use and transportation planning.

The Envision Houston Region process was initiated by the H-GAC and its partners to engage residents in a discussion of the region's future growth and development. The process focused on land use and transportation alternatives. Citizen input from workshops was used to develop growth scenarios representing two different types of alternative development patterns. The objective was to provide information on the projected impacts of the alternatives and to highlight the difference between the two growth scenarios developed from the workshops and the Base Case or traditional growth scenario. Brief descriptions of each scenario are found below:

- Scenario A (Base Case) denotes the current growth and development pattern for the Houston-Galveston region, based on H-GAC's 2035 demographic forecasts. It is characterized by low-density housing development in currently undeveloped portions of the region with mixed-use development along major roadways. Jobs are concentrated in the central business district, and several other employment centers are scattered throughout the region.
- Scenario B denotes the workshop participants' ideal growth pattern, adjusted to the *regional forecast* of household and employment growth. This scenario is characterized by development along major roadways, in a radial pattern, creating centers at major intersections.
- Scenario C denotes the workshop participants' ideal growth pattern, adjusted to the forecast of household and employment *growth by county*. This scenario clusters mixed-use development in satellite cities and along major roadways in a radial pattern. Satellite employment centers emerge throughout the region.

Table 6-17 identifies the transportation related data associated with the growth scenarios.

TABLE 6-17
ALTERNATIVE GROWTH SCENARIOS

Data of Interest	Scenario A	Scenario B	Scenario C
Transit Boardings	758,000	+10%*	+20%*
Vehicle Miles Traveled	248M	-7%*	-7%*
Vehicle Hours Traveled	7M	-16%*	-15%*
NOx Emissions	46.58	46.43	43.74
VOC Emissions	50.72	48.65	47.65

Source: H-GAC (2009).
Note: Table data is based on the original 2035 RTP but is consistent with the RTP Update conducted by H-GAC in 2011 as they did not change their growth scenarios for this update.
*Denotes change over Scenario A

These results reinforce the public's intuitive notions about coordinated transportation and land use planning. H-GAC has identified a three-pronged land use and transportation coordination strategy that calls for the creation of bicycle and pedestrian friendly Centers; establishment of better Connections between the centers, and designs based on the Context of the surrounding land uses. This "3C's" strategy, in addition to enhancing mobility choices, is expected to produce economic, environmental and "quality of place" benefits for the region.

In order to integrate the 3C's concepts into regional transportation planning, H-GAC has identified the following five strategies:

1. Coordinate transit and roadway planning to connect existing and planned centers with the region's multi-modal transportation network,
2. Promote roadway designs appropriate for the context of the surrounding community to ensure safe, convenient travel choices for all user modes,
3. Coordinate transportation improvements and private sector development efforts to promote projects that combine sustainable mobility and economic benefits,
4. Help fund local planning studies to assist in the development of centers, and
5. Provide funding support for infrastructure projects that enhance connections within and between centers.

In addition to expanding the regional transit system, transit ridership and efficiency can be improved by coordinating transit and land use. Development along transit lines that increases density and integrates transit with development can make transit more accessible and decrease the need for SOV trips. Recommended strategies include:

- Promote community design that provides convenient access to transit systems,
- Promote transit-oriented development investments around regional transit facilities, and
- Enhance access opportunities for the transportation disadvantaged.

These land use/transportation coordination tools are tools that can be used in the H-GAC region to reduce the need for additional infrastructure, including utilities, transportation, water, and tolled facilities for the region. Without sustainable land use, the additional cost of new infrastructure items will increase beyond the current estimated costs.

The proposed 2035 regional roadway network is in support of the predicted land use changes and growth in the region. To meet the demand of the expansive growth and changes in land use from development, the aim of the 2035 regional roadway network is to supply the transportation portion of infrastructure requirements for the expanding growth and development. Current and future predicted available funds from the federal government for transportation alone will not be able meet the demands for the transportation infrastructure needed to support the predicted changes. Tolled roads and managed lanes are methods that the RTP Update employs to ensure the transportation demands from future growth is met when considering the limited transportation funds available.

Land Use Findings

The proposed 2035 regional tolled roadway network may affect land use within the MPO boundaries by creating land development and/or redevelopment opportunities. However, the regional tolled roadway network is only one factor in creating favorable land development conditions; other prerequisites for growth in the region include demand for new development, favorable local and regional economic conditions, adequate utilities, and supportive local land development policies. The proposed 2035 regional tolled roadway network may influence and facilitate the additional planned regional land use conversion, redevelopment, and growth.

Conclusion

The regional tolled roadway network would cause some impacts to natural and socioeconomic resources. However, the regional tolled roadway network would have a beneficial impact on EJ populations and air quality in the Houston-Galveston area. Overall, with the 2035 build scenario, which includes the regional tolled roadway network in place, travel efficiencies in the region will benefit both EJ and non-EJ populations. The net benefit may be slightly greater for the non-EJ populations because the ATL in these zones is greater than the ATL from the EJ zones. The additional vehicle lane miles that the regional tolled roadway network provides enables traffic to flow more efficiently thereby reducing emissions associated with cars traveling at lower speeds or idling conditions.

In addition, regional mitigation for air quality and EJ populations are also addressed by the H-GAC as part of 2035 RTP Update. The Transportation Planning Process at the MPO regional level is required to incorporate measures to minimize the potential to affect the environment and communities, including populations protected under Title VI of the Civil Rights Act of 1964 and EO 12898 and air quality, which is protected by the CAAA. Any transportation facility including the regional tolled roadway network would be required to meet these standards in order to be included in the TIP/ Statewide Transportation Improvement Plan (STIP) and RTP Update. Furthermore, all new projects to be added to the TIP/STIP and RTP Update must be in conformance with the SIP.

Although land use impacts cannot be mitigated at a regional level, they can at a municipal level because these entities have direct control over land use. However, the MPO can aid in land use impact avoidance at the regional level by only funding transportation projects consistent with the regional vision and by working with municipalities to address regional infrastructure changes in their comprehensive plans. State and federal regulatory agencies are required to institute policies and monitor project-level effects to the natural and cultural resources that are found in their jurisdictions. Avoidance, minimization, and mitigation strategies are used to support those policies in order to reduce impacts to these resources.

Finally, as required by NEPA, appropriate mitigation for direct impacts would occur at the project level. Because of these mitigation measures, the regional proposed tolled roadway network is not anticipated to have a substantial cumulative impact on the resources considered in this section.

SECTION 7: PUBLIC INVOLVEMENT

7.1 PREVIOUS PUBLIC INVOLVEMENT (DURING THE PROPOSED GRAND PARKWAY SEGMENT C-1 MIS)

This section discusses the public involvement for the proposed Grand Parkway Segment C and includes details about agency coordination, local official involvement, public workshops, and hearings. Volume 3 includes a list of public involvement from March 1997 to September 2007. This section also describes other means of public involvement such as the website and newsletters.

As discussed in Section 1.1 – Background, the MIS for the proposed Grand Parkway Segment C-1 was approximately 50 percent complete when it was stopped. During the proposed Grand Parkway Segment C-1 MIS, the following public involvement events occurred:

- An Initiation Meeting was held on March 5, 1998, with representatives attending from TxDOT, the FHWA, H-GAC, METRO, and Fort Bend County.
- An agency coordination meeting was also held on March 5, 1998, with representatives attending from the TPWD, USFWS, and USACE.
- A Public Workshop structured specifically for environmental interest groups was held on April 22, 1998.
- A Public Workshop structured for the general public was held on April 27, 1998, to solicit input.
- A Public Scoping Meeting was for MIS Initiation at George Ranch on August 20, 1998, to solicit input.

All input received during these public involvement events was utilized during the study of the proposed Grand Parkway Segment C.

7.2 AGENCY COORDINATION

Throughout this proposed Grand Parkway Segment C study, various agency officials from the TPWD, USFWS, USACE, THC, EPA, and TCEQ provided input that was considered in the development and screening of alternatives and evaluation of the Grand Parkway Segment C project. Input was requested from and provided by these agencies on a regular basis, as necessary, via telephone conversations, meetings, and letters. Important meetings and letters are described below:

- On November 19, 1998, the study team attended the Joint Processing Meeting at the USACE office in Galveston. In attendance were the USACE, USFWS, TPWD, and TCEQ. The study team described the study process and progress to the meeting attendees.

- On December 16, 1998, the study team met with the Brazos Bend State Park personnel and the TPWD. The meeting focused on potential impacts of the proposed Grand Parkway Segment C on existing hydrologic conditions of watersheds that feed into Brazos Bend State Park.
- On March 15, 2000, in accordance with 40 CFR 1500–1508 and 23 CFR 771, the FHWA sent coordination letters to the following tribal organizations: Comanche Tribal Business Committee, Coushatta Tribe, Apache Tribe of Oklahoma, Caddo Indian Tribe of Oklahoma, Alabama-Quassarte Tribal Town, Creek Nation of Oklahoma, United Keetoowah Band of Cherokee Indian, Cherokee Nation, Tonkawa Business Committee, Alabama-Coushatta Tribe of Texas, and Mescalero Apache Tribe (Appendix I). A response to the letter was received from the Tonkawa Tribe of Oklahoma and is also included in Appendix I.
- On May 5, 2000, the study team met with representatives of the USFWS, George Observatory, Fort Bend County Judge's Office, Brazoria County Judge's Office, Fort Bend County Commissioners, and TPWD at the George Memorial Library in Rosenberg. This meeting was held to discuss the route alternatives suggested by the TPWD and to discuss the route selection process the study team had followed to date.
- On August 2, 2000, the study team met with representatives of the USFWS, Fort Bend County Commissioners, George Observatory, USACE, Greater Fort Bend Economic Development Council, Fort Bend County Judge's Office, Brazoria County Judge's Office, and the TPWD at the George Memorial Library in Rosenberg. This meeting was held to discuss the route selection process that the study team was using to go from Representative Alternatives to the Build Alternative.
- On August 26, 2002, the study team attended a meeting with the THC to discuss their review of the archeological reconnaissance report and the archeological Phase I survey report.
- On November 6, 2002, the study team attended a meeting with the EPA. In attendance were personnel from the FHWA and H-GAC. The meeting was to review the comments the EPA had filed on the proposed Grand Parkway Segment C DEIS of July 26, 2000.

7.3 LOCAL OFFICIAL INVOLVEMENT

Throughout this proposed Grand Parkway Segment C study, local officials provided input that was considered in the development and screening of alternatives. Input was requested from and provided by these local officials on a regular basis, as necessary, via telephone conversations and meetings. Concerns of several local officials are noted below:

- Fort Bend County Commissioners provided input on ongoing land development projects, which might become constraints to the proposed Grand Parkway Segment C. They also relayed various concerns and opinions of property owners.

- Fort Bend County Engineer provided input regarding the County's Major Thoroughfare Plan and the proposed Grand Parkway Segment C's impact on the county's roadway network. The engineer also provided preliminary land plans and approval plats for new developments, which might become constraints to the project.
- Fort Bend County Drainage District Engineer provided input on 100-year floodplains and hydraulic characteristics of waterways in the study area.
- Brazoria County Commissioner provided input regarding Brazoria County's preference that the proposed Grand Parkway Segment C be located as far south as possible within the study area to more effectively serve the mobility needs of Brazoria County. He also relayed various concerns and opinions of property owners.
- Brazoria County Engineer provided input regarding the county's Major Thoroughfare Plan.
- City of Richmond City Manager provided input regarding land development projects in the city's ETJ, which might affect the project.
- City of Rosenberg engineering consultant provided input regarding street and land development projects in the city's ETJ, which might affect the project.

7.4 PUBLIC WORKSHOPS AND HEARING

A public involvement plan was formulated at the beginning of this proposed Grand Parkway Segment C study. The plan initially included five public involvement events. Another public involvement event was included later.

7.4.1 Public Scoping Meeting/MIS Initiation Meeting

The Public Scoping Meeting/MIS Initiation Meeting for the proposed Grand Parkway Segment C was held on August 20, 1998, at the Guy Lodge Hall at the George Ranch. Approximately 90 people including local residents, business owners, and city/county/state/federal officials attended the meeting. The meeting notice was published in the *Texas Register*, *Federal Register*, *Houston Chronicle*, and various local newspapers. Information was also posted at a local business within the study area. At the meeting, an overview of the Grand Parkway and of the proposed Grand Parkway Segment C study area was presented. The status of the proposed Grand Parkway Segment C study was also discussed, as well as the criteria for evaluating alternatives and the study process.

Comments were received from the public. These comments varied, and included concerns of impacts to residents, impacts to the natural environment, and impacts to the dark skies utilized by the George Observatory at Brazos Bend State Park. All of the comments received at the meeting, both verbal and written, have become a part of this study.

7.4.2 Public Workshop (Meeting) #1

On October 27, 1998, a Public Workshop for the proposed Grand Parkway Segment C was held at the George Ranch. Approximately 85 people attended the workshop. At the workshop, exhibits were presented that displayed the Reasonable

Alternatives to be carried forward for further investigation. Alternative corridors, which had been eliminated from the study, were also presented.

During the workshop, the study team received 63 written comments. The study team has evaluated all of the written comments and, as a result, made several changes to the group of Reasonable Alternatives.

7.4.3 Public Hearings

Two public hearings were held simultaneously on June 13, 2000, at the Sacred Heart Catholic Church in Brazoria County and Dickinson Elementary School in Fort Bend County to present the findings of the DEIS. Information on the two public hearings is available in Volume 3. A formal presentation was given and was followed by a public commenting period. Exhibits could be viewed before and after the presentation as well as during a break. Approximately 215 individuals were in attendance at the Fort Bend County hearing and 127 individuals at the Brazoria County hearing. The public hearing notice was published in the *Houston Chronicle*, *Angleton Times*, *Fort Bend Sun*, The *Herald-Coaster*, and The *Facts*. Six hundred thirty-two individual notices were mailed to elected officials, government agencies, local organizations, civic groups, businesses, landowners, and interested citizens. The public was invited to make either oral or written comments on a form available at both hearings. Many verbal and written comments were received during the hearings and are summarized in Volume 3. The responses corresponding to all comments are also included Volume 3. Public comments are provided for on a CD provided in Volume 3.

7.4.4 Public Workshop (Meeting) #2

Two public workshops were held simultaneously on November 14, 2000, at the Sacred Heart Catholic Church in Brazoria County and Manford-Williams Elementary School in Fort Bend County to present a Build Alternative for the proposed Grand Parkway Segment C (Volume 3). The public was given the opportunity to view exhibits displaying the Universe of Alternatives, Reasonable Alternatives, Representative Alternatives, Build Alternative, project schedule, and ROW mapping. Project team members individually discussed the project with the public and answered questions. A comment form was furnished to allow the public to submit written comments on the Build Alternative. Approximately 178 individuals attended the Fort Bend County workshop, including 4 elected officials. Approximately 79 individuals attended the Brazoria County workshop, including 3 elected officials and one member of the media. Many verbal and written comments were received during the hearings and are summarized in Volume 3. The responses corresponding to all comments are also included Volume 3. Public comments are provided for on a CD provided in Volume 3.

At the Fort Bend County workshop, the majority of the written comments regarded the northern portion of the Build Alternative and came from residents in the Bridlewood Estates neighborhood. These residents favored an alignment further to the west, away from populated areas, such as the Representative Alternative Segments B1, C1, C2, B3, and B4.1. Bridlewood residents mentioned that the Build Alternative would impact property values and quality of life and would be a source of noise and light pollution. Negative impacts were also expressed by residents in Canyon Gate, Greatwood, and Tara. Comments regarding the middle portion of the Build Alternative most often opposed the alignment along FM 762

(Segment X1). Instead, they supported the B5, B6, G2, and G3 segment alignment. Residents in the Brazos Lakes neighborhood mentioned that the Build Alternative would impact their aesthetics and recreation areas (including ball fields); increase noise, traffic, air pollution and crime; reduce property values; and degrade their quality of life. Neutral comments included issues such as sound barriers, flooding, surface water flow, access needs, relocation, lighting restrictions, and "open habitat" conservation.

At the Brazoria County workshop, many residents in Rosharon and a council member from Iowa Colony expressed support for the Build Alternative and expressed appreciation for the alignment change that responded to public comments made at the Public Hearings. Several residents asked that construction begin as soon as possible. Residents from the Brazos Bend Oaks neighborhood opposed the Build Alternative because of its close proximity. These residents mentioned that it would impact their property values, quality of life, and the wildlife in the area. Other issues mentioned included flooding; funding through tolls; intersection design; making use of public and private ROW currently on record with the county; the preference of elevating the roadway instead of constructing multiple bridges; and favorable access to farming and ranching.

7.4.5 Public Workshop (Meeting) #3

A third public meeting was held to receive comments regarding the construction of the proposed Grand Parkway Segment C as a toll facility. A copy of the schematics is presented in Exhibit 40. The meeting was held on August 30, 2007, at Guy Lodge Hall/Beasley Post Office on the George Ranch Historical Park in Richmond, Texas. The meeting consisted of an open house session, a formal presentation, and a public comment session. The open house session was held between 6:00 and 7:00 PM to allow viewing of reference materials and maps. Representatives from TxDOT, the GPA, and the consultant team were available to discuss the project and answer questions. The presentation began at 7:00 PM and included an animated flyover of the recommended Build Alternative.

A public comment session was also held, and a total of 18 verbal comments were received. One additional comment was made to a private court reporter located in the open house area. Throughout the meeting, attendees had the chance to submit written comments. Written comments could also be mailed or emailed by September 13, 2007. A total of 934 written comments were submitted within the comment period. A copy of the public meeting summary and response to public comments are available in Volume 3. Public comments are provided for on a CD provided in Volume 3.

There were 269 in attendance, including 9 elected officials and 5 media representatives.

7.5 WEBSITE AND NEWSLETTERS

A website (www.grandpky.com) was established to inform the public about the GPA and the proposed Grand Parkway roadway project, including the proposed Grand Parkway Segment C. The website defines the limits of each segment of Grand Parkway and the status of each segment. The website also provides an opportunity to make a comment or add a name to the mailing list.

Newsletters were also published to inform the public of the status of the proposed Grand Parkway Segment C. The public was given the opportunity to put their name on the mailing list at public meetings and on the website.

SECTION 8: LIST OF PREPARERS

This FEIS was directed by a Steering Committee comprising representatives from several public agencies:

The **Texas Department of Transportation** (TxDOT) is responsible for financing the construction of the Grand Parkway.

The **Houston-Galveston Area Council** (H-GAC) is the region's MPO and is responsible for the planning process for transportation projects in Harris County and its seven surrounding counties. It is also responsible of the conformance of all planned transportation projects with the CAA requirements.

The **Federal Highway Administration** (FHWA) is responsible for approving planned transportation projects that are expected to receive federal funding.

Fort Bend County is responsible for technical, fiscal, and political advice on the construction of a major thoroughfare within county limits, and approval of planned residential and commercial developments in that county.

Brazoria County is responsible for technical, fiscal, and political advice on the construction of a major thoroughfare within county limits, and approval of planned residential and commercial developments in that county.

The **Grand Parkway Association** (GPA) is a nonprofit corporation, authorized by TxDOT to facilitate the development of a third outer highway loop, serving the regional mobility needs of Harris County and its surrounding counties.

The FHWA and TxDOT personnel responsible for preparation/review of this report include the following:

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